Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

CNL-18-056

May 31, 2018

10 CFR 2.202
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ATTN: Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Browns Ferry Nuclear Plant, Units 1, 2 and 3
Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

Subject **Tennessee Valley Authority, Browns Ferry Nuclear Plant, Units 1, 2, and 3, Completion of Required Action for NRC Order Number EA-12-049, Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (TAC Nos. MF0902, MF0903, and MF0904)**

References
1. NRC Order Number EA-12-049, "Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated March 12, 2012 (ML12054A735)
2. Letter from TVA to NRC, "Tennessee Valley Authority (TVA) - Overall Integrated Plan in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant," dated February 28, 2013 (ML13064A465)
3. Letter from TVA to NRC, "First Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant," dated August 28, 2013 (ML13247A284)
4. Letter from TVA to NRC, "Second Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904)," dated February 28, 2014 (ML14064A240)
5. Letter from TVA to NRC, "Third Six-Month Status Report and Revised Overall Integrated Plan in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904)," dated August 28, 2014 (ML14248A496)

6. Letter from TVA to NRC, "Fourth Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904)," dated February 27, 2015 (ML15064A162)
7. Letter from TVA to NRC, "Fifth Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904)," dated August 28, 2015 (ML15240A228)
8. Letter from TVA to NRC, "Sixth Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904)," dated February 26, 2016 (ML16063A470)
9. Letter from TVA to NRC, "Seventh Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904)," dated August 26, 2016 (ML16242A030)
10. Letter from TVA to NRC, "Eighth Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904)," dated February 28, 2017 (ML17060A187)
11. Letter from TVA to NRC, "Ninth Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904)," dated August 31, 2017 (ML17243A299)
12. Letter from TVA to NRC, "Tenth Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond- Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904)," dated February 23, 2018 (ML18057B345)
13. Letter from TVA to NRC, "Request for Relaxation from NRC Order EA-12-049, 'Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events'," dated August 28, 2014 (ML14247A447)

14. NRC Order EA-13-109, "Issuance of Order to Modify Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions," dated June 6, 2013 (ML13143A321)
15. Letter from NRC to TVA, "Browns Ferry Nuclear Plant, Units 2 and 3 - Relaxation of the Scheduled Requirements for Order EA-12-049 'Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events'," dated December 23, 2014 (ML14281A198)
16. Letter from NRC to TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3 - Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0902, MF0903, MF0904, MF0881, MF0882, and MF0883)," dated April 6, 2015 (ML15069A358)
17. Letter from NRC to TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3 - Report for the Audit of Licensee Responses to Interim Staff Evaluations Open Items Related to NRC Order EA-13-109 to Modify Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions (CAC Nos. MF4540, MF4541 and MF4542; EPID L-2014-JLD-0044)," dated February 21, 2018 (ML18038B606)

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued Order EA-12-049 (Reference 1) to Tennessee Valley Authority (TVA). Reference 1 was immediately effective and directed TVA to develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities in the event of a beyond-design-basis external event.

The purpose of this letter is to notify the NRC of compliance with Order EA-12-049 for BFN, Units 1, 2, and 3. Order EA-12-049, Section IV.A.2, Section IV.A.2 required completion of full implementation to be no later than two refueling cycles after submittal of the Overall Integrated Plan (OIP), as required by Condition C.1.a, or December 31, 2016, whichever came first. The Browns Ferry Nuclear Plant (BFN), Units 1, 2, and 3, OIP for Order EA-12-049 was submitted on February 28, 2013 (Reference 2). Reference 1, Section IV, Condition C.2, required submission of a status report at six-month intervals following the submittal of the OIP. References 3 through 12 provided these status reports.

In a letter from TVA to NRC (Reference 13), TVA requested relaxation for the implementation schedule requirements of NRC Order EA-12-049. The request was initiated based upon mitigation strategy dependence on the reliable hardened containment venting capability addressed in NRC Order EA-13-109 (Reference 14). In a letter from NRC to TVA dated December 23, 2014 (Reference 15), the Commission relaxed the Order EA-12-049 full implementation date for BFN, Unit 2, from the completion of the spring 2015 refueling outage to the completion of the spring 2017 refueling outage and for BFN, Unit 3, from the completion of the spring 2016 refueling outage to the completion of the spring 2018 refueling outage.

Reference 1, Section IV.C.3 required that licensees report to the NRC when full compliance is achieved. On April 1, 2018, upon entering Mode 2 following the Unit 3 refueling outage, BFN, Units 1, 2, and 3, achieved full compliance with NRC Order EA-12-049 and Phase 1 of NRC Order EA-13-109. BFN has developed, implemented, and will maintain the guidance and strategies to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities in the event of a beyond-design-basis external event, and the information provided herein documents full compliance with Order EA-12-049 and with Phase 1 of Order EA-13-109.

Enclosure 1 provides a brief summary of the key elements associated with compliance to Order EA-12-049.

Enclosure 2 provides a listing of 21 items that have not been docketed as closed by the NRC (Reference 16). Responses to these items are provided and are based on information and analyses that have been completed as of the date of this memorandum, and TVA considers these items complete pending NRC closure. Regarding NRC Order EA-13-109, Phase 1 items, TVA received a letter following the NRC audit (Reference 17) of interim staff evaluation open items indicating that the staff had no further questions on how BFN had addressed NRC Order EA-13-109, Phase 1 items. Therefore, BFN considers these items complete pending NRC closure, and no NRC Order EA-13-109, Phase 1 items are addressed within Enclosure 2.

Enclosure 3 provides a table of completed milestones. Enclosure 4 provides a summary of changes to the compliance method. Enclosure 5 provides the BFN, Units 1, 2, and 3, FLEX Final Integrated Plan.

There are no new regulatory commitments resulting from this submittal. If you have any question regarding this submittal, please contact Mike Oliver at (256) 729-7874.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 31st day of May 2018.

Respectfully,

J. W. Shea Digitally signed by J. W. Shea Date: 2018.05.31 15:34:00 -04'00'

J. W. Shea
Vice President, Nuclear Regulatory Affairs and Support Services

Enclosures:

1. Tennessee Valley Authority, Browns Ferry Nuclear Plant, Units 1, 2, and 3, Summary of Compliance Elements for Order EA-12-049
2. Tennessee Valley Authority, Browns Ferry Nuclear Plant Units, 1, 2, and 3, OIP Open Items, NRC ISE Open or Confirmatory Items, and NRC Audit Report Open Items
3. Tennessee Valley Authority, Browns Ferry Nuclear Plant Units, 1, 2, and 3, Milestone Schedule-Items Completed
4. Tennessee Valley Authority, Browns Ferry Nuclear Plant, Units 1, 2, and 3,Changes to Compliance Method
5. Tennessee Valley Authority, Browns Ferry Nuclear Plant, Mitigation Strategies for Beyond-Design-Basis External Events, Final Integrated Plan

cc (w/Enclosures):

NRR Director - NRC Headquarters
NRO Director - NRC Headquarters
NRC Regional Administrator - Region II
NRR Project Manager - Browns Ferry Nuclear Plant
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant

ENCLOSURE 1

Tennessee Valley Authority, Browns Ferry Nuclear Plant, Units 1, 2, and 3, Summary of Compliance Elements for Order EA-12-049

Introduction

Browns Ferry Nuclear Plant (BFN) developed an Overall Integrated Plan (OIP) for documenting the diverse and flexible strategies (FLEX) in response to Order EA-12-049, "Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated March 12, 2012 (ML12054A735). The information provided herein documents full compliance for BFN, Units 1, 2, and 3, with the order.

Strategies - Complete

BFN, Units 1, 2, and 3, strategies are in compliance with Order EA-12-049. Strategy related Open Items, Confirmatory Items, or Audit Questions/Audit Report Open Items have been addressed and are considered complete, pending NRC closure. BFN has provided responses to strategy related Open Items, Confirmatory Items, and Audit Questions/Audit Report Open Items as documented in Enclosure 2 of this letter.

Modifications - Complete

The modifications described in the Final Integrated Plan (FIP) required to support the Mitigation Strategies for Beyond-Design-Basis External Events (FLEX) strategies for BFN, Units 1, 2, and 3, are completed, and the equipment has been turned over to plant organizations, as applicable, with the Design Change Notices (DCNs) closed in accordance with the station design control process. In this letter, see Enclosure 3, Milestone Items Completed, for unit specific details.

Equipment – Procured and Maintenance & Testing - Complete

The equipment required to implement the FLEX strategies for BFN, Units 1, 2, and 3, has been procured in accordance with Nuclear Energy Institute (NEI) Report NEI 12-06, Sections 11.1 and 11.2, received at BFN, initially tested/performance verified as identified in NEI 12-06, Section 11.5, and is available for use.

Maintenance processes have been established through the BFN Preventative Maintenance program such that FLEX equipment reliability is achieved.

Protected Storage - Complete

The storage facilities required to implement the FLEX strategies for BFN, Units 1, 2, and 3, have been completed and provide protection from the applicable site hazards. The equipment required to implement the FLEX strategies BFN, Units 1, 2, and 3, is stored in its protected configuration.

FLEX Procedures - Complete

FLEX Support Instructions (FSIs) for BFN, Units 1, 2, and 3, and common procedures and have been developed and integrated with existing procedures. The FSIs and affected existing procedures have been verified and are available for use in accordance with the site procedure control program.

Training - Complete

Training for BFN, Units 1, 2, and 3, has been completed in accordance with the TVA accepted training process as recommended in NEI 12-06, Section 11.6.

Staffing - Complete

The staffing study for BFN has been completed in accordance with Title 10 of the Code of Federal Regulations (10 CFR) 50.54(f), as provided in "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," Recommendation 9.3, dated March 12, 2012 (ML12073A348).

National SAFER Response Centers - Complete

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

Validation - Complete

BFN has completed performance of validation in accordance with industry guidance to assure required tasks, manual actions, and decisions for FLEX strategies are feasible and may be executed within the constraints identified in the FIP for Order EA-12-049.

FLEX Program Document - Complete

The TVA, BFN, FLEX Program Document has been developed in accordance with the requirements of NEI 12-06. Both TVA Fleet and BFN documents have been issued.

ENCLOSURE 2

Tennessee Valley Authority, Browns Ferry Nuclear Plant, Units 1, 2, and 3, OIP Open Items, NRC ISE Open or Confirmatory Items, and NRC Audit Report Open Items

In support of the ongoing audit of the licensee's Overall Integrated Plan (OIP), as supplemented, the NRC staff conducted an onsite audit at Browns Ferry from January 5-9, 2015, per the audit plan dated November 26, 2014 (ML14323A295). The purpose of the onsite portion of the audit was to provide the NRC staff the opportunity to continue the audit review and gain key insights most easily obtained at the plant as to whether the licensee is on the correct path for compliance with the Mitigation Strategies (FLEX) and Reliable Spent Fuel Instrumentation (SFPI) orders. The onsite activities included detailed analysis and calculation discussion, walk-throughs of strategies and equipment laydown, visualization of portable equipment storage and deployment, review of staging and deployment of offsite equipment, and review of installation details for SFPI equipment.

The following are open items not docketed as closed by the NRC. This list contains those items listed in the letter from NRC to TVA, “Browns Ferry Nuclear Plant, Units 1, 2, And 3 - Report for the Onsite Audit Regarding Implementation of Mitigating Strategies And Reliable Spent Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF0902, MF0903, MF0904, MF0881, MF0882, and MF0883),” dated April 6, 2015 (ML15069A358).

1. NRC ISE Open or Confirmatory Items

#	Audit Item Reference	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
1	ISE CI 3.2.1.1.A	“From the June 2013 position paper, benchmarks must be identified and discussed which demonstrate that MAAP4 is an appropriate code for the simulation of an ELAP event at your facility.”	“The staff requests that the licensee make available for audit the final MAAP analysis when complete and ensure this item is discussed.”	MAAP 4.0.7, Thermal Hydraulic Calculations to Support Extended Loss of AC Power FLEX Strategies, Report 06050-RPT-13406, Revision 1, Attachment 1, addresses the request as stated in the Item Description.
2	ISE CI 3.2.1.1.B	“The collapsed level must remain above Top of Active Fuel (TAF) and the cool down rate must be within technical specification limits.”	“The staff requests that the licensee make available for audit the final MAAP analysis when complete and ensure this item is discussed.”	MAAP 4.0.7, Report 06050-RPT-13406, Revision 1, Attachment 1, addresses the request as stated in the Item Description.

#	Audit Item Reference	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
3	ISE CI 3.2.1.1.C	"MAAP4 must be used in accordance with Sections 4.1, 4.2, 4.3, 4.4, and 4.5 of the June 2013 position paper."	"The staff requests that the licensee make available for audit the final MAAP analysis when complete and ensure this item is discussed."	MAAP 4.0.7, Report 06050-RPT-13406, Revision 1, Attachment 1, addresses the request as stated in the Item Description.
4	ISE CI 3.2.1.1.D	"In using MAAP4, the licensee must identify and justify the subset of key modeling parameters cited from Tables 4-1 through 4-6 of the "MAAP4 Application Guidance, Desktop Reference for Using MAAP4 Software, Revision 2" (Electric Revision 1 Page 64 of 71 2013-12-18 Power Research Institute Report 1 020236). This should include response at a plant-specific level regarding specific modeling options and parameter choices for key models that would be expected to substantially affect the ELAP analysis performed for that licensee's plant."	"The staff requests that the licensee make available for audit the final MAAP analysis when complete and ensure this item is discussed."	MAAP 4.0.7, Report 06050-RPT-13406, Revision 1, Attachment 1, addresses the request as stated in the Item Description.

#	Audit Item Reference	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
5	ISE CI 3.2.1.1.E	"The specific MAAP4 analysis case that was used to validate the timing of mitigating strategies in the integrated plan must be identified and should be available on the ePortal for NRC staff to view. Alternately, a comparable level of information may be included in the supplemental response. In either case, the analysis should include a plot of the collapsed vessel level to confirm that TAF is not reached (the elevation of the TAF should be provided) and a plot of the temperature cool down to confirm that the cool down is within technical specification limits."	"The staff requests that the licensee make available for audit the final MAAP analysis when complete and ensure this item is discussed."	MAAP 4.0.7, Report 06050-RPT-13406, Revision 1, Attachment 1, addresses the request as stated in the Item Description.
6	ISE CI 3.2.1.2.A	"There is insufficient information provided to determine the adequacy of the determination of recirculation pump seal or other sources of leakage used in the ELAP analysis."	"No additional input form the licensee is needed at this time. Further review of the information provided is required by the NRC staff."	Based upon the Licensee Input Needed statement, no additional information is being provided by TVA.

#	Audit Item Reference	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
7	ISE CI 3.2.1.3.A	"On page 10 of the Integrated Plan, the licensee stated that the Main Steam Relief Valve (MSRV) control is maintained from the control room with sufficient dc [direct current] power and pneumatic pressure to operate the MSRVs throughout Phase 1 and Phase 2. The licensee describes that SRV actuation may require a higher than nominal dc voltage to actuate the MSRVs due to higher containment temperature with a longer duration event than an existing SBO [station blackout] coping time. The SRV pilot solenoid coil electrical resistance will increase due to a higher containment temperature with a longer duration event than an existing SBO coping time. The licensee is planning to evaluate MSRV qualification against the predicted containment response with FLEX implementation to ensure there will be sufficient [dc] bus voltage during the ELAP event. The licensee also provides that if required, there will be a modification to increase voltage as necessary to achieve the necessary coil current, or	"The NRC staff requests that the licensee demonstrate that the MSRVs will continue to operate as needed during the ELAP event, assuming that calculated drywell temperatures exceed the environmental qualification of the MSRVs for the duration of the event."	MAAP 4.0.7, Report 06050-RPT-13406, Revision 1, provides analysis for eight cases, and the peak Drywell temperature for each case is stated in Table 7-1. Comparison of the MAAP analysis Drywell temperature profiles of Report 06050-RPT-13406, Revision 1, to the test temperatures experienced during Loss of Coolant Accident (LOCA) simulation testing documented in Environmental Qualification (EQ) Report 2199 (found in Tab D-4 of EQ binder BFN0EQ SOL 009) reveals that the Drywell temperatures do not exceed the environmental qualification temperatures of the Main Steam Relief Valves (MSRVs) for the duration of the event. The MSRV solenoid test specimen was thermally aged at 342 degrees Fahrenheit (^{o}F) for 56.5 days (EQ Report 5074, BFN0EQ SOL 009 Tab D-1) and later subjected to accident simulation testing involving temperatures up to 355°F. The most thermally challenging Extended Loss of AC Power (ELAP) case from Report 06050-RPT-13406, Revision 1, is Case 8 where a peak drywell temperature of 305°F is reached at 62.1 hours into the 72 hour Beyond-Design-Bases External Event (BDBEE). It is difficult to determine if this temperature is maintained for the remainder of the event; therefore, for conservatism it is assumed that the temperature remains at the peak 305°F for the remaining 9.9 hours. The thermal aging performed at 342°F followed by accident simulation testing at temperatures up to 355°F provide assurance that the MSRV solenoid valves are qualified for a BDBEE ELAP and will perform their function for the required 72 hour duration.

#	Audit Item Reference	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
		modifications will be made to reduce the coil resistance under higher temperature conditions. Because the MSRV control system will be exhausting control gas to the containment and containment pressure will be higher, the licensee is evaluating methods to establish any required increases in pneumatic supply pressure and modifications that may be required to ensure a supply of control gas for the MSRVs over the longer ELAP interval. These two questions were asked during the audit process and the licensee stated that the analysis/evaluation has not vet been completed.”		It is noted that a peak temperature of 322°F was recorded for Case 6 of Report 06050-RPT-13406, Revision 1. However, this peak temperature is of short duration, and Case 8 remains the most thermally challenging case.
8	ISE CI 3.2.3.A	“The licensee has not provided finalized calculations which support the primary strategy timeline by concluding that venting or other heat removal activities will not be required during the first eight hours of the event, maintaining a suppression pool temperature low enough to support continued RCIC [Reactor Core Isolation Cooling] operation for this time period.”	“Once the design of the system is finalized, the NRC staff requests that the licensee make available for audit any formal calculations that will be performed for the configuration.”	BFN has finalized calculations that support the FLEX strategy timeline. MAAP 4.0.7, Report 06050-RPT-13406, Revision 1, concludes that primary containment venting is estimated to occur at approximately 4.5 hours and that suppression pool temperature is low enough to support continued Reactor Core Isolation Cooling (RCIC) operation for the first 8 hours of the event.

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9	ISE CI 3.2.4.2.A	"The licensee did not provide details regarding the effects of loss of ventilation in the HPCI [high-pressure coolant injection] /RCIC pump rooms to conclude that the equipment in the HPCI/RCIC pump rooms would perform its function and assist in core cooling throughout all Phases of an ELAP. During the audit process, the licensee stated that preliminary analysis has been performed, but the calculations have not been finalized. Based on preliminary analysis, the RCIC room would reach 140 degrees at 32 hours. The electronic governor module (EGM) for RCIC could fail with temperatures at 150 degrees Fahrenheit. RCIC has steam isolation at 165 degrees in the room or torus area. EOI [emergency operating instruction] Appendix 5C, Injection System Lineup RCIC, allows bypassing of the high temperature isolation using booted contacts in accordance with EOI Appendix 16K, Bypassing RCIC High Temperature Isolation. Core Spray room cooler strategy is being evaluated to aid in cooling of the Core Spray/RCIC room.	"The NRC staff requests the licensee clarify the timeline during which RCIC is relied upon and when it is not needed. Additionally, the NRC staff requests the licensee make available for audit the reactor building temperature calculation, MDQ0009992014000291, and also clearly identify any actions to address personnel habitability or room cooling."	<u>Clarify the timeline which RCIC is relied:</u> The BFN Mitigation Strategies for BDBEE Integrated Plan communicates that within seconds of the event RCIC will be relied upon for core cooling and reactor pressure vessel (RPV) level control. MAAP 4.0.7, Report 06050-RPT-13406, Revision 1, concludes that the suppression pool temperature does not exceed the functionality of RCIC established in BWROG-TP-14-018, Revision 0, Beyond Design Basis RCIC Elevated Temperature Functionality Assessment. <u>When is RCIC not needed:</u> The BFN Mitigation Strategies for BBDEE Integrated Plan communicates that within 8 hours of the event the Containment Integrated Leak Rate Test (CILRT) Pump System will be aligned and can provide RPV and spent fuel pool (SFP) makeup. The function of core cooling could be transferred to FLEX equipment in this time period. The timeframe for establishing the CILRT Pump System received validation in the "FLEX Strategy Validation Report for BFN, Units 1, 2, and 3, Implementation," dated March 22, 2018. Even though calculations document the favorable functionality environment for RCIC to be well beyond 8 hours, T=8 hours can be assumed as a time when RCIC is no longer required. As requested in Licensee Input Needed, MDQ0009992014000291, Revision 3, Temperature Response of the Reactor Building Following an Extended Loss of AC Power, will be made available on the e-portal for NRC review.

#	Audit Item Reference	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
		A detailed summary of the analysis and/or technical evaluation performed to demonstrate the adequacy of the ventilation provided in the HPCI/RCIC pump rooms to support equipment operation throughout all phases of an ELAP is requested."		
10	ISE CI 3.2.4.6.B	"RCIC Room Habitability and RHR/CS Room Habitability"	"The NRC staff requests the licensee make available for audit the reactor building temperature calculation, MDQ0009992014000291. The resolution of this item is related to the successful closure of ISE CI 3.2.4.2.A."	MDQ0009992014000291, Revision 3, is available for review. The response for ISE CI 3.2.4.2.A has been submitted.
11	ISE CI 3.2.4.10.A	"The Integrated Plan lacked information regarding battery availability, and lack of availability to review the battery load shed analysis, there is insufficient information presented in the integrated plan to conclude that the requirements of NEI 12-06, Section 3.2.2, consideration 6, regarding load reduction to conserve dc power will be implemented. During the audit process, the licensee provided a listing of the loads that would	"The NRC staff requests the licensee make available for audit any documentation to support the basis for the minimum required voltage."	Review of the minimum battery voltages in EDQ024820020042, Part I, LOCA/LOOP, Section 7.3, EDQ024820020042, Part II, SBO, Section 7.3, and EDQ0009992013000202, 250V DC Unit Batteries 1, 2, & 3 Evaluation for Beyond Design Basis External Event (BDBEE) Extended Loss of AC Power (ELAP), Section 7.2, reveals that in all cases the minimum battery terminal voltage calculated in EDQ0009992013000202 exceeded those previously calculated in Parts I and II of EDQ024820020042. In both calculations the worst case voltage occurred at the one (1) minute point of the analysis (documented in the Electrical Transient and Analysis Program (ETAP) Battery Discharge Tabulation output of EDQ024820020042, Parts I and II, and

#	Audit Item Reference	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
		be part of the initial load shed that extended the battery availability to twelve hours. The licensee also stated that the shedding of these loads were determined to have no detrimental effects on unit safety and that the described load shedding would be included in a future revision to 0-AOI-57-1A, Blackout Station Procedure."		EDQ0009992013000202. The worst case ETAP study case for each event (LOCA, SBO,ELAP) are ETAP cases 1, 5, and 9; as demonstrated in Part I of EDQ024820020042. The analysis in EDQ0009992013000202 is considered conservative, since comparison of each event, LOOCA/LOOP, SBO and ELAP, at the worst case voltage (one minute point) for each battery reveals that, for each battery, the ELAP worst case voltage is greater than the LOCA/LOOP and SBO worst case voltages. The battery loading (current) for LOCA/LOOP at the worst case voltage (one minute) is much greater than those modeled for SBO or ELAP. For each battery, the loading (current) is significantly less (roughly one-third) and the minimum voltage is higher in EDQ0009992013000202 than loading and voltage for Part I of EDQ024820020042, which is the worst case. The analysis for Part I of EDQ024820020042 is considered the bounding condition; therefore, the load flow analysis performed in Part I of EDQ024820020042 bounds EDQ0009992013000202. The 12-hour coping time was established by EDQ0009992013000202 and made possible by the proper load shedding and equipment alignment. The coping time of Unit Batteries 1, 2, and 3 was reduced from 12 to 11 hours to support extended load shedding time from one hour to two hours (EDQ0009992013000202, Revision 3). These actions are controlled by 0-FSI-1, FLEX Response Instruction, FLEX Response Flowchart Page 1, and 0-FSI-3F, Load Shed of 250V Main Bank Battery 1, 2, 3. During the BDBEE event, 0-FSI-1,

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				Attachment 1, will be performed by a Unit Supervisor designated as the FLEX Response Senior Reactor Operator (SRO). This flowchart directs performance of the battery load shed procedure, 0-FSI-3F. 0-FSI-3F will be performed by an Assistant Unit Operator. All breakers to be opened by this procedure are located in protected areas in close proximity to and accessible from the Main Control Rooms.

2. Audit Questions (AQs)

#	Audit Item Reference	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
12	AQ 35	“Page 54 of the Integrated Plan indicates that items such as hoses will be deployed to the refuel floor early in the ELAP event "to avoid having to access the refuel deck while the SFP is boiling.” Additionally, pages 70 and 71 of the Integrated Plan provide a discussion of how ventilation will be achieved to avoid over pressurization in the SFP area. However, no analysis or technical justification was provided to verify the adequacy of the ventilation and/or support the conclusion of habitability in the spent fuel pool area. Clarify whether any actions will be required in the SFP area and provide additional information relative to the ventilation and/or habitability analyses which provide the bases for concluding that the proposed strategies in this area will be successful as specified in NEI 12-06 Section 3.2.2 consideration 11.”	“The NRC staff requests the licensee make available for audit the calculation which supports the closure of this issue for review.”	Three actions will be required in the SFP area. The first action to be performed will be the opening of doors on the Refuel Floor (RFF) and Reactor Building roof to provide ventilation of the Refuel Floor and Reactor Building. This action will be completed within the first hour of the event. The next action will be to lay out pre-staged hoses for makeup/spray as required. This action will be performed in the first 2-3 hours of the event. Then access to the RFF will be made to open the SFP makeup valve as required for pool makeup. MDQ0009992014000291, Revision 3, has determined SFP area temperature profiles (Figures 6.65 through 6.67) and recommended compensatory actions (Table 6.1). These compensatory actions, the opening of doors on the Reactor Building roof, Refuel Floor, and elevation 565’, are implemented per procedure 0-FSI-1. Procedure 0-FSI-6E, FLEX Strategies during Severe Environments, establishes strategies for the management of work activities to control the detrimental effects of heat or cold stresses on employees working in severe temperature environments.

#	Audit Item Reference	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
13	AQ 39	"For RCIC room habitability in phases 1 and 2 and RHR/CS Room Habitability, page 66 of the Integrated Plan discusses the use of ice vests or other personnel protective measures implemented in accordance with Site Administrative and Safety Procedures and Processes. Several hours into an ELAP condition, the availability of ice vests may be questionable. Clarify what areas of the plant are anticipated to require personnel entry (including for the Alternate Phase 2 Strategy specified on page 29), what the anticipated habitability conditions will be in those environments at the anticipated time of personnel entry, and what personnel protection measures will be required to carry out those actions in high heat environments several hours into an ELAP."	"The NRC staff requests the licensee make available for audit the calculation for the RCIC room for review."	It is anticipated that the areas in the Reactor Building that will require entry are the RCIC room, 565' elevation general area, 593' elevation general area, 621' elevation general area, and the RFF. It is anticipated these areas will be entered in the first 8 hours of the event, and the temperatures in these areas will be in the 110-115°F range. Procedure 0-FSI-6E establishes strategies for the management of work activities to control the detrimental effects of heat stresses on employees. It also contains predicted temperatures in the areas that are being entered. MDQ0009992014000291, Revision 3, has determined area temperature profiles and recommended compensatory actions. These compensatory actions are implemented per procedure 0-FSI-1.

#	Audit Item Reference	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
14	AQ 52	"Open Items 3.2.1.6.C and 3.2.1.6.D. Provide a summary of the sizing calculation for the FLEX generators to show that they can supply the loads assumed in phases 2 and 3."	"The NRC staff requests the licensee make available for audit the sizing calculation for the calculation for the 4.16 kV FLEX generators that will be received from the National SAFER Response Center."	EDQ0003602015000325, Electrical Evaluation for 4kV Spare FLEX Turbine Generators, was completed to verify that the 4kV FLEX Generators (Turbine Marine 1MW 4160 VAC Trailer Mounted Combustion Turbine Generators) could provide sufficient power for the required FLEX ELAP loads. This calculation has verified that one generator provides sufficient power to these FLEX ELAP loads. Two generators are available and can be connected in parallel. The 4160V generators that will be received from the National SAFER Response Center are the same model and rating. These generators provide backup and additional capacity to the Phase 2 generators.

3. Licensee-identified OIP Open Items (OIs)

#	Audit Item	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
15	OIP OI #1	"Flood and seismic re-evaluations pursuant to the 10 CFR 50.54(f) letter of March 12, 2012, are not completed and therefore not assumed in this submittal. As the re-evaluations are completed, appropriate issues will be entered into the corrective action system and addressed."	"The NRC staff requests the licensee make available for audit the flood and seismic hazard re-evaluations."	Referenced are reports and studies that are pursuant to the 10 CFR 50.54(f) letter of March 12, 2012. Some assessments/evaluations continue to be in-progress and are indicated by date. These scheduled dates have received NRC concurrence. • Flood Hazard Reevaluation Report (ML15072A130) • Flood Hazard Mitigation Strategies Assessment (MSA) (ML16363A386) • Focused Evaluation (FE) / Integrated Assessments (IA) (June 2018) • Seismic Hazard and Screening Report (ML14098A478) • Expedited Seismic Evaluation Process Report (ML14365A046) • Seismic Probabilistic Risk Assessment (SPRA) (Scheduled for 4Q 2019) • Seismic Hazard Mitigation Strategies Assessment (MSA) (Scheduled for 4Q 2019) • Limited Scope Evaluations o Spent Fuel Pool Evaluation Supplemental Report (ML16356A596) o High Frequency Evaluation (Addressed in SPRA - Scheduled for 4Q 2019))

#	Audit Item Reference	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
16	OIP OI #7	"Browns Ferry will take actions as necessary to assure RCIC can operate at elevated temperatures."	"The NRC staff requests the licensee make available for audit the design of the hardened containment vent system, and the corresponding calculations and procedures."	In order to assure continued operation with high RCIC room temperatures, Two emergency operating instruction (EOI) appendices are directed to be performed by the Station Blackout (SBO) flowchart. 1/2/3-EOI Appendix-16K, Bypassing RCIC High Temperature Isolation, is performed to bypass the RCIC area high temperature isolations. 1/2/3-EOI Appendix-20M, RCIC Operations during Station Blackout, is performed, and it contains steps to disable the RCIC Woodward EG-M model governor and control flow with the RCIC trip/throttle valve, FCV-71-9. The EG-M model is susceptible to failure at room temperatures above 150°F, which occurs at approximately 7-8 hours into the event (MDQ0009992014000291). These appendices are performed as soon as the SBO flowchart is entered. In order to assure continued operation with high suppression pool temperatures, Design Change Notice (DCN) 71329 includes a connection point from the Emergency Equipment Cooling Water (EECW) header, which will supply cooling water to the RCIC oil cooler. This allows the normal cooling water supply (suppression pool) to be isolated and cooler water from the FLEX pumps via the EECW header to be aligned. BWROG-TP-14-018 states that for operation with pool temperatures under 250°F and operation for periods of time less than 24 hours, there is no expected loss of functionality or impact on RCIC reliability. For suppression pool temperatures of 250-300°F and operation for periods of time less than 24 hours, there is increased performance loss and seal leakage, but it is not expected to impact functionality. MAAP

#	Audit Item Reference	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
				4.0.7, Report 06050-RPT-13406, Revision 1, shows that the suppression pool does not exceed 250°F, peaking at slightly less than 249°F in approximately 13.9 hours. The cooling water supply from the EECW FLEX Pump System to the RCIC oil cooler has been validated to be available in less than 12 hours, and the Phase II RPV makeup supply, CILRT FLEX Pump System, has been validated to be available in less than 8 hours.

4. Spent Fuel Pool Level Instrumentation (SFPLI) RAIs

#	Audit Item	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
17	SFPI RAI #6	"Please provide information indicating what will be the maximum expected ambient temperature in the room in which the associated transmitter (electronics package) will be located under BDB [beyond-design-basis] conditions in which there is no AC power available to run Heating Ventilation and Air Conditioning (HVAC) systems."	"The NRC staff requests the licensee make available for audit calculation MDQ0009992014000291, "Temperature Response of the Reactor Building Following an Extended Loss of AC Power.""	The transmitters are located in the Reactor Building on elevation 639' on each unit, which is a separate environmental area than the SFP. The area is a Harsh Environment for design basis events, but this area will be a mild environment for an ELAP. BFN calculation MDQ0009992014000291, Revision 3, Figures 6.50 through 6.64, provide dry bulb temperatures, wet bulb temperatures, and relative humidity profiles for the Reactor Building on elevation 639'. Westinghouse Report EQLR-342, Revision 0, Environmental Design Verification Test for the Spent Fuel Pool Instrumentation System, confirms an acceptable environment for these transmitters.

5. Additional SE Audit Items

#	Audit Item	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
18	SE#4	“Verification of phase rotation for FLEX DGs”	“The NRC staff requests the licensee make available for audit information on how it will verify phase rotation after connecting the DGs to the equipment.”	The BFN FLEX generators were phase checked during factory acceptance testing and have been phased-checked by BFN (WO 116635595, BFN-0-GEN-360-0002A, Ensure Correct Phasing of Turbine Marine Generators). BFN procedures 0-FSI-3C, 4kV FLEX Generator Setup And Operation, and 0-FSI-3A, 480V FLEX Generator Setup And Operation, setup the generators and contain steps to perform independent verification (IV) of the cable connections ensuring upon setup that the proper phase rotation is established. The IV method is a proven and reliable technique and is safer than conducting a physical phase test upon generator startup.
19	SE #6	“Final SAFER Playbook”	“The NRC staff requests the licensee make available for audit the Browns Ferry SAFER Response Plan after the document is finalized.”	The Browns Ferry SAFER Response Plan is maintained in the Business Support Library and has been finalized.

#	Audit Item	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
20	SE#7	"Browns Ferry Nuclear Plant plans to diagnose ELAP and complete the load shed for the three units within one hour of the initiation of the event. Please provide validation that the timeframe that is required by the analysis is able to be completed by the operators."	"The NRC staff requests the licensee make available for audit validation of the ability to enter ELAP and complete the ELAP load shed within 1 hour of the event."	BFN has calculated the capability of 250V DC Unit Batteries 1, 2, and 3 to adequately supply Units 1, 2, and 3 loads necessary to cope with a BDBEE ELAP for a duration of twelve hours (EDQ0009992013000202). An assumption of this calculated capability was the electrical loads in 0-FSI-3F would be shed at one hour. The FLEX Strategy Validation Report for BFN Units 1, 2, and 3 Implementation was utilized to ensure the assumption was achievable. The FLEX Strategy Validation Report for BFN, Units 1, 2, and 3, Implementation, concluded that it was achievable to complete Action Item 10, Task-Load Shed of Vital DC Loads. In addition, EDQ0009992013000202, Revision 3 has added an additional coping time reduction case of the Unit Batteries 1, 2, and 3 from 12 hours to 11 hours to support extended load shedding time from one hour to two hours. This calculation now documents that in the unlikely event that load shedding does not occur within one hour, but within two hours, the capability of 250V DC Unit Batteries 1, 2, and 3 to adequately supply Units 1, 2, and 3 loads necessary to cope with a BDBEE ELAP for a duration of eleven hours. Eleven hours is well beyond the time validated to restore electrical power to the Unit Battery Chargers.

#	Audit Item	Item Description (NRC Provided)	Licensee Input Needed (NRC Provided)	TVA Response
21	SE #8	"The staff walked down the lay down site of the 480v generators. Due to the non-fully protected structures around the lay down area, the staff requests that Browns Ferry Nuclear Plant provide justification that the 480v generator will be able to be positioned, connected and put into operation in the time required. This should include justification of the ability to clear debris that may be in the way, access to the hallway to connect to the cables, and the the voltage drop across the cables if a longer cable run was necessary would still be acceptable."	"The NRC staff walked down the lay down site of the 480v generators. Due to the non-fully protected structures around the lay down area, the NRC staff requests the licensee make available for audit justification that the 480v generator will be able to be positioned, connected and placed into operation in the time required. The justification should include the ability to clear debris that may be in the way, access to the hallway to connect to the cables, and any impact of the voltage drop across the cables if a longer cable run was necessary."	As stated in NEI-12-06, "It is acceptable to have multiple strategies to accomplish a function (e.g., two separate means to repower instrumentation)." BFN has developed multiple strategies for providing power to the 250V Battery Chargers. Providing multiple strategies eliminates the single point vulnerability created with the Setup and Operation of the 480V FLEX Generator solely as an "all hazard deployment." The performance of 0-FSI-3A stages the FLEX 480V generator on a seismic/flood elevated pad. This pad may become vulnerable to excessive debris during seismic events due to structures in the surrounding area. To eliminate this vulnerability an additional strategy has be developed, 0-FSI-3C. This additional strategy, utilizes a 4kV generator versus 480V generator, is setup and operated in a spatially separate area, uses a separate set of electrical cabling, and uses distinctly different connection points. The ability of the 4kV generators to provide the required power to the 480V loads has been verified in EDQ0003602015000325.

ENCLOSURE 3

Tennessee Valley Authority, Browns Ferry Nuclear Plant, Units 1, 2, and 3, Milestone Items Completed

BFN OIP and 6 Month Updates

Activity	Status	References
Submit Overall Integrated Plan	Complete	Letter from TVA to NRC, "Tennessee Valley Authority (TVA) - Overall Integrated Plan in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant," dated February 28, 2013 (ML13064A465)
Update 1	Complete	Letter from TVA to NRC, "First Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant," dated August 28, 2013 (ML13247A284)
Update 2	Complete	Letter from TVA to NRC, "Second Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904)," dated February 28, 2014 (ML14064A240)
Update 3	Complete	Letter from TVA to NRC, "Third Six-Month Status Report and Revised Overall Integrated Plan in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904)," dated August 28, 2014 (ML14248A496)
Update 4	Complete	Letter from TVA to NRC, "Fourth Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904)," dated February 27, 2015 (ML15064A162)

Activity	Status	References
Update 5	Complete	Letter from TVA to NRC, “Fifth Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904),” dated August 28, 2015 (ML15240A228)
Update 6	Complete	Letter from TVA to NRC, “Sixth Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904),” dated February 26, 2016 (ML16063A470)
Update 7	Complete	Letter from TVA to NRC, “Seventh Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904),” dated August 26, 2016 (ML16242A030)
Update 8	Complete	Letter from TVA to NRC, “Eighth Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904),” dated February 28, 2017 (ML17060A187)
Update 9	Complete	Letter from TVA to NRC, “Ninth Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904),” dated August 31, 2017 (ML17243A299)
Update 10	Complete	Letter from TVA to NRC, “Tenth Six-Month Status Report in Response to the March 12, 2012, Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond- Design-Basis External Events (Order Number EA-12-049) for Browns Ferry Nuclear Plant (TAC Nos. MF0902, MF0903, and MF0904),” dated February 23, 2018 (ML18057B345)

FLEX Modifications

Activity	Status	References
U1 SFPI	Complete	DCN 71159, “Fukushima Modification Unit 1 Spent Fuel Pool Level Instrumentation”
U2 SFPI	Complete	DCN 71160, “Fukushima Modification Unit 2 Spent Fuel Pool Level Instrumentation”
U3 SFPI	Complete	DCN 71161, “Fukushima Modification Unit 3 Spent Fuel Pool Level Instrumentation”
Unit 1 Key Instrumentation	Complete	DCN 71162, “Fukushima Modification Unit 1 Battery Backed Power to Initial Coping Equipment”
Unit 2 Key Instrumentation	Complete	DCN 71335, “Fukushima Modification Unit 2 Battery Backed Power to Initial Coping Equipment”
Unit 3 Key Instrumentation	Complete	DCN 71336, “Fukushima Modification Unit 3 Battery Backed Power to Initial Coping Equipment”
Unit 1 Core Cooling	Complete	DCN 71387, “Install Alternate Supply to Unit 1 MSRV Fukushima Strategy”
Unit 2 Core Cooling	Complete	DCN 70810, “Install Alternate Supply to Unit 2 MSRV Fukushima Strategy”
Unit 3 Core Cooling	Complete	DCN 71386, “Install Alternate Supply to Unit 3 MSRV Fukushima Strategy”
Unit 1 Containment	Complete	DCN 71389, “Modify Hardened Containment Vent System to comply with NRC Order EA-13-109,” Unit 1
Unit 2 Containment	Complete	DCN 71390, “Modify Hardened Containment Vent System to comply with NRC Order EA-13-109,” Unit 2
Unit 3 Containment	Complete	DCN 71391, “Modify Hardened Containment Vent System to comply with NRC Order EA-13-109,” Unit 3
FLEX Pump System Connection Points	Complete	DCN 71329, “Add Connections to RHRSW and EECW Piping for Emergency Injections-Fukushima”
FLEX 480V Generator Connection Points	Complete	DCN 71470, “Stage 480V Power Supply And Support Equipment To Charge Unit Battery Chargers”
FLEX 4kV Generator Connection Points	Complete	DCN 71405, “Stage 4KV Diesel For Fukushima Event And Provide Connection Points”

FLEX Storage

Activity	Status	References
Equipment Storage	Complete	DCN 70745, “Site Bunker Building”
FLEX Equipment	Complete	0-FSI-8C, “FLEX Tools and Equipment Inventory Checklist”
FLEX Equipment Deployment and Staging	Complete	DCN 71454, “Install Deployment Roads and Pump Landings”
FLEX Strategy Support	Complete	DCN 71542, “Varied Plant Support Equipment For Fukushima Implementation”
FLEX Strategy Support	Complete	DCN 72434 Stage 2, “SAWA Line CILRT and CCS - Bore Holes/Load Carts for 4kV Generator Connection”
FLEX Strategy Support	Complete	DCN 71822, “Add Additional Storage Cabinets For FLEX Equipment And Staging Areas For SRV Carts”
Communications	Complete	DCN 70852, “Communication System 244 UHF/VHF Radio System”
NSRC Operational	Complete	Letter from NEI to the NRC, “Staff Assessment Of National Safer Response Centers Established In Response To Order EA-12-049,” dated September 26, 2014 (ML14265A107)
SAFER Response for BFN	Complete	SAFER Response Plan for Browns Ferry Nuclear Plant, AREVA Document No. 38-9233739-000, Revision 1, dated January 23, 2015

FLEX Staffing Analysis

Activity	Status	References
BFN Staffing Analysis	Complete	Letter from TVA to NRC, “Tennessee Valley Authority (TVA) - Response to March 12, 2012, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, Enclosure 5, Recommendation 9.3, Emergency Preparedness - Staffing, Requested Information Items 1, 2, and 6 - Phase 2 Staffing Assessment,” dated January 30, 2015
BFN Staffing Analysis Revised	Complete	Browns Ferry Nuclear Plant - NEI-12-01 Phase 2 Extended Loss of AC Power (ELAP) ERO Staffing Analysis Report, Revision 1, March 16, 2018

FLEX Procedures

Activity	Status	References
FLEX Procedures	Complete	0/1/2/3-FLEX Support Instruction - Series 1/2/3-EOI-Appendix 20 - Series 0-AOI-57-1A, "Loss of Offsite Power (161 and 500kV)/Station Blackout" 0-AOI-100-3, "Flood Above Elevation 558" 0-AOI-100-7, "Severe Weather"
FLEX Maintenance Procedures	Complete	Maintenance Procedures (Preventative Maintenance Activities)

FLEX Training

FLEX Training	Complete	• INPO Generic Basic Flex Training (NANTEL course) • INPO Generic Advanced Flex Training (NANTEL course) • TRN-30, Radiological Emergency Preparedness Training • Emergency Preparedness Training (EPT0017), Site Specific FLEX Training for CECC Personnel • Emergency Preparedness Training EPT-110, Emergency Response Organization Training • Emergency Preparedness Training EPT-112, TSC ERO Control Failures and FLEX System [BFN] • BFN-MGT-160.001, Fukushima FLEX Familiarization For Browns Ferry Maintenance Group • Simulator Exercise Guide (SEG), OPL173S359, Station Blackout and Extended Loss of AC Power (SBO/ELAP) Coping Strategies. NRC Order EA-12-049 • SEG OPL174S356, Earthquake, SFP Level, Limited ED • OT-FLEX-001, BFN FLEX Overview • OT-FLEX-003, FLEX Implementation • OT-FLEX-Key Readings-001, BFN - FLEX - Key Instrument Readings During Loss of DC Power • OT-FLEX-SBO-ELAP-001, SBO/ELAP 0-AOI-57-1A Station Blackout Flowchart

ENCLOSURE 4

Tennessee Valley Authority, Browns Ferry Nuclear Plant, Units 1, 2, and 3, Changes to Compliance Method

Changes to Compliance Method

NRC Order EA 13-109, as implemented by NEI 13-02, added additional requirements of a Severe Accident Water Addition (SAWA) and Severe Accident Water Management (SAWM) strategies. Additionally, the SAWA strategy is required to be implemented within 8 hours of the start of the event. In order to comply with these requirements, the Final Integrated Plan (FIP) Compliance Methods have been revised significantly from those provided in the last Overall Integrated Plan (OIP) update (February 28, 2017). This attachment gives a brief description of the strategy changes contained in the FIP.

In the OIP, the FLEX Pumping Systems are described as follows:

- i) FLEX Pump System 1 (FPS1) can be connected to one or more of the following:
  - (1) Three Containment Integrated Leak Rate Test (CILRT) penetrations through Reactor Building wall, elevation 565' (4" pipe) - inside 1A, 2A, 3A RHRSW pipe tunnel, (From inside the Reactor Building, connections can be made to the Condensate Storage & Supply System and then to the vessel through RHR Loop I & II LPCI injection lines and Core Spray Loop I & II injection lines, to SFP makeup (normal), or to the Containment and Torus via their respective RHR Loop I and II flowpaths),
  - (2) The EECW South header - At the intake structure (The EDGs will be isolated by manual action if needed to ensure adequate cooling to operating SSCs). The south header can be used for SFP makeup and for all normally supplied loads with the exception of the control air compressors.
- ii) FLEX Pump System 2 (FPS2) will be aligned to B RHRSW at the following location;
  (1) At the intake structure,
  Note: The B RHRSW can provide standby coolant to Unit 2 and/or Unit 3, if needed.
- iii) FLEX Pump System 3 (FPS3) will be aligned at the following location:
  (1) At the intake structure,
  Note : The D RHRSW can provide standby coolant to Unit 1 and/or Unit 2, if needed.
- iv) (FPS4) - (N+1), is a spare.

In the FIP, the FLEX Pumping Systems and connection points are described as follows:

<u>Preferred Phase 2 Core Cooling Strategy</u>

The Containment Integrated Leak Rate Test (CILRT) FLEX Pump System is staged at the FLEX Pump Staging Area SA-A1. Hoses will be connected from the pump system to the preferred connections on the CILRT header connections in the RHRSW tunnel for each unit. This flow path utilizes the CILRT penetration and is connected to the Condensate Storage and Supply (CS&S) piping that supplies charging water to the Core Spray (CS) System. On Unit 3, this connection is hard piped; on Unit 1 and 2 the connection is made using hoses as directed by plant procedures. Unit 1 and 2 connection will be hard piped at a later date. The CS injection valves, powered from 480V Reactor Motor-Operated Valve (RMOV) Boards, are opened and throttled as necessary to supply RPV makeup. Calculation demonstrates that this FLEX pump system can simultaneously supply required makeup flow to all three reactors, while also providing the required makeup flow to the SFPs for all three units.

Additional Phase 2 Core Cooling Strategy

The RHRSW FLEX Pump System is also staged at the FLEX Pump Staging Area. Discharge hoses from the FLEX Pump System will be connected to the RHRSW Header Connections; two (2) five inch hoses connected to RHRSW Header B, and three five-inch hoses connected to RHRSW Header D. This flow path uses the RHRSW/RHR Standby Coolant crosstie, with injection coming from the RHR low pressure injection (LPCI) valves. The RHRSW/RHR MOVs, powered from 480V RMOV Boards, are opened and throttled as necessary to supply RPV makeup. Calculation demonstrates this FLEX pump system can simultaneously supply required makeup flow to all three reactors, while also providing the required makeup flow to the SFPs for all three units.

CILRT FLEX Pump Connections

This connection is the preferred connection for both RPV and SFP makeup on all three units. The connection is located in the RHRSW tunnel on the south end of the Reactor Building for each unit, and is protected from hazards. Three flexible 5" hoses will be run from the CILRT FLEX Pump System, to the connection in each units RHRSW tunnel. The CILRT connection penetrates the Reactor Building wall, and from inside the Reactor Building, the piping is connected to the CS&S system piping. On Unit 3, this connection is hard piped; on Unit 1 and 2 the connection is made using hoses as directed by plant procedures. The Unit 1 and 2 connections will be hard piped at a later date. CS&S supplies CS Loops I and II, which is then injected to the RPV using the CS injection valves.

RHRSW FLEX Pump Connections

The RHRSW connection is an additional strategy to supply RPV and SFP makeup. Five quality-related manual valves are available on each of the 18" RHRSW B and D header piping in the intake structure, inside the intake structure pump rooms. These valves and the associated piping are protected by the existing missile shield grating, and are protected from BDBEE hazards. Following a BDBEE, two flexible 5" hoses will be connected from the RHRSW FLEX Pump System to the valves on RHRSW Header B to supply Unit 3, and three 5" hoses will be connected from the RHRSW FLEX Pump System to the valves on RHRSW Header D to supply Units 1 and 2. The RHRSW headers, which are cross tied with the RHR system, allow RPV injection using the LPCI injection valves.

EECW FLEX Pump Connection

To provide water to the EECW system, five quality-related manual valves are available on the 18" EECW South header piping in the intake structure, inside the intake structure pump room. These valves and the associated piping are protected by the existing missile shield grating, and are protected from BDBEE hazards. Following a BDBEE, five flexible 5" hoses will be connected from the EECW FLEX Pump System to the valves on the South EECW header. This alignment allows the FLEX pump to supply the South EECW header, which is connected to the RCIC oil coolers using hose connection to help ensure continued operation of RCIC. Plant procedures direct connection of the hoses to the RCIC system. In addition to maintaining RCIC available, the EECW header can provide cooling water to the Control Bay Ventilation System, area coolers, and makeup water to the Spent Fuel Pools."

In the OIP, the electrical strategy and connection points are described as follows:

- Two 850kw, 480V FLEX Generators will be permanently staged in the FLEX Equipment Storage Building (FESB). A single DG has sufficient capacity to supply all safety related 250v battery chargers via a load control center that will be used for distribution. These will be available by connection directly to the input supply breaker to the chargers. Also, the capability to back feed and supply power to motor operated valves required for FLEX is available using this connection point.

- Two 4kV FLEX Support Generators, temporary cable, and equipment necessary for connection will be staged in the FESB. The 4kV generators may be used to energize the safety related 4kV and 480V distribution systems to supply all safety related battery chargers, ventilation, pump motors, fan motors, and motor operated valves as needed. A single generator has sufficient capacity to supply all safety related 250v battery chargers and motor operated valves required for FLEX. For non-flood events, the generators will be available for staging adjacent to the U1/2 or the U3 Diesel Buildings and connected directly to the output of any selected Emergency Generator to energize the 4kV distribution system. For expected flood conditions, the generators will be pre-staged at either of two staging areas above the 578' maximum flood elevation. These temporary connections to the 4kV distribution system will be made through either the 1B or 3B 4kV Unit Boards.

In the FIP, the electrical strategy and connection points are described as follows:

Phase 2 Electric Power Strategy

Multiple strategies have been developed to provide electrical power during Phase 2. The preferred strategy uses one 4160V FLEX generator that can be connected to the 4160V safety related distribution system at multiple points. The power is then transformed to 480V to supply power to the 480V Shutdown Boards A and B on each unit. The 480V Shutdown Boards supply power to Unit Battery Chargers 1, 2A, 2B, and 3, which charge the unit batteries and supply DC loads. The 480V Shutdown Boards also supply the 480V Reactor Motor Operated Valve (RMOV) Boards, Control Bay Vent Boards, Standby Gas Treatment (SGT) Boards, and Diesel Generator Auxiliary Boards. These boards supply power to equipment necessary for the performance of all strategies. The generators are rated for 1 MW, sized to power the 250 VDC battery chargers, RCIC controls, MOVs, and other selected loads. Two generators and connection points are available; however, only one generator is needed to supply the power necessary to complete the FLEX strategies. The generators primary staging area is directly outside the Unit 3 DG rooms, with alternates available just outside the Turbine Building Breezeway area, or directly outside the Unit 1/2 DG rooms.

An additional strategy powers the 480V battery chargers using 480V FLEX generators. This strategy allows back feed from the battery charger supply to selected MOVs needed for the FLEX strategies. The 480V FLEX generators are rated for 850 KW, sized to power the battery chargers, RCIC controls, motor operated valves (MOVs), and other selected loads. Two generators are available; however, only one generator is needed to supply the power necessary to complete the FLEX strategies.

Preferred Electrical Connection (Non-Flood)

The preferred connection point uses 4160V FLEX generators that will be connected to 4160V Shutdown Boards 3EB or 3ED. The generators are deployed to Staging Area SA-A6, and power cables are routed from the generators, through the DG 3EA Room or the Cardox Tank Room, and through designated wall penetrations into the 4160V Shutdown Board Room 3EB/3ED. The cables are bolted to load carts that are racked in and connected to 4160V Shutdown Boards 3EB or 3ED. These Shutdown Boards are electrically connected by plant breakers to the Bus Tie Board that allows electrical power from the generators to be supplied to Unit 1 and 2 4160V Shutdown Boards B and D. From the 4160V Shutdown Boards, power is transformed to 480V to supply power to the 480V Shutdown Boards A and B on each unit. The 480V Shutdown Boards supply power to Unit Battery Chargers 1, 2A, 2B, and 3, which charge the unit batteries and supply DC loads. The 480V Shutdown Boards also energize the 480V

Reactor Motor Operated Valve (RMOV) Boards, Control Bay Vent Boards, Standby Gas Treatment (SGT) Boards, and Diesel Generator Auxiliary Boards. Operators energize equipment required to cope with the event from these boards while monitoring generator loading.

Preferred Electrical Connection (Flood)

For flood events, or if the preferred 4160V electrical connection is not able to be used for any reason, the electrical connection can be made at either 4160V Unit Board 1B or 3B. The generators are deployed to Staging Area SA-A5 if desired to connect to Unit Board 1B or Staging Area SA-A4 if desired to connect to Unit Board 3B. These connections also utilize load carts that the power leads from the FLEX generators are bolted to, where they are then racked in and connected to the Unit Boards. If the Unit Board 1B connection is selected, it is electrically connected by plant breakers to Shutdown Bus 2, where they are used to supply 4160V Shutdown Boards B and D, and the Bus Tie Board. The Bus Tie Board is electrically connected by plant breakers to 4160V Shutdown Boards 3EB and 3ED. From the 4160V Shutdown Boards, power is distributed.

If the Unit Board 3B connection is selected, it is electrically connected by plant breakers to 4160V Shutdown Board 3ED. This board is electrically connected to the Bus Tie Board, and the Bus Tie Board is electrically connected by plant breakers to 4160V Shutdown Boards 3EB, B, and D via Shutdown Bus 2. From the 4160V Shutdown Boards, power is distributed.

Additional Electrical Connections

Additional connection points for the 4160V FLEX generators are available at the B and D Diesel Generator output terminals. The generators are deployed to Staging Area SA-A3. The permanent plant Diesel Generator output leads are lifted, and the temporary cables from the FLEX generators are bolted to the output leads to the Unit 1 and 2 4160V Shutdown Boards B and D. The Shutdown Boards are electrically connected to the Bus Tie Board that allows electrical power from the generators to be supplied to Unit 3 4160V Shutdown Boards 3EB and 3ED. From the 4160V Shutdown Boards, power is distributed.

Another connection point consists of powering the 480V battery chargers directly from 480V FLEX generators. The generators are deployed to Staging Area SA-A2. Temporary cables connect the 480V FLEX generator to the FLEX distribution panel located on the Control Bay, elevation 586’. From the distribution panel, cables are connected directly to the charger supply breaker on the front of each of the chargers that charge 250V Unit Batteries 1, 2, and 3. This connection point also allows back feed to selected MOVs needed for RPV injection.

ENCLOSURE 5

Tennessee Valley Authority, Browns Ferry Nuclear Plant, Mitigation Strategies for Beyond-Design-Basis External Events, Final Integrated Plan

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT

MITIGATION STRATEGIES FOR BEYOND-DESIGN-BASIS EXTERNAL EVENTS

FINAL INTEGRATED PLAN

Prepared by:	Keith Benefield / Keith Benefield	4/25/18 Date
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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 alternating current (AC) power (ELAP). The ELAP led to (1) loss of core cooling, (2) loss of spent fuel pool cooling, and (3) a significant challenge to maintaining containment integrity on four of the units. All direct current (DC) power was lost early in the event on Units 1 and 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 United States (US) Nuclear Regulatory Commission (NRC) assembled a Near-Term Task Force (NTTF) to advise the Commission on actions the US 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 3.1.1) 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 Enforcement Action EA-12-049 (Reference 3.1.4) to implement mitigation strategies for BDBEEs. The order provided the following requirements for strategies to mitigate BDBEEs:

1. Licensees shall develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment integrity and spent fuel pool (SFP) cooling capabilities following a BDBEE.

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

3. 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 integrity and SFP cooling capabilities at all units on a site subject to the Order.

4. Licensees must be capable of implementing the strategies in all MODES.

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

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

- Phase 1 - The initial phase requires the use of installed equipment and resources to maintain or restore core cooling, containment integrity and SFP cooling capabilities.
- Phase 2 - The transition phase requires providing sufficient, portable, on-site equipment and consumables to maintain or restore these functions until they can be accomplished with resources brought from off site.
- Phase 3 - The final phase requires obtaining sufficient off-site resources to sustain those functions indefinitely.

NRC Order EA-12-049 (Reference 3.1.4) required licensees of operating reactors to submit an overall integrated plan by February 28, 2013, that included 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 3.2.1), 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 Japan Lessons Learned Interim Staff Guidance JLD-ISG-2012-01 (Reference 3.1.2), which endorsed NEI 12-06 Rev. 0 with clarifications on determining baseline coping capability and equipment quality. Since that time, NEI 12-06 Rev. 4 was issued (Reference 3.2.1) and endorsed by the NRC.

NRC Order EA-12-051 (Reference 3.1.5), issued coincident with EA-12-049, 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 3.1.1).

NEI 12-02 (Reference 3.2.2) 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 3.1.3), conformance with the guidance in NEI 12-02 is an acceptable method for satisfying the requirements in Order EA-12-051.

This Final Integrated Plan (FIP) addresses compliance with NRC Order EA-12-049. Compliance with Order EA-12-051 can be found in Reference 3.36.

2 NRC Order EA-12-049 – Mitigation Strategies (FLEX)

2.1 <u>General Criteria and Baseline Assumptions</u>

The assumptions used for the evaluations of a Browns Ferry Nuclear Plant (BFN) ELAP/loss of normal access to the ultimate heat sink (LUHS) event and the development of diverse and flexible coping strategies (FLEX) are stated below.

Boundary conditions consistent with NEI 12-06, Section 3.2.1, *General Criteria and Baseline Assumptions* (Reference 3.2.1), are established to support development of FLEX strategies, as follows:

- BDBEE impacts all three units at the site
- Each reactor is successfully shut down when required (i.e., all rods inserted)
- On-site staff is at site administrative minimum shift staffing level
- No independent, concurrent events (e.g., no active security threat)
- All personnel on-site are available to support site response
- The applicable boiling water reactor (BWR) general criteria and baseline assumptions listed in NEI 12-06, Revision 4 (Reference 3.2.1), Section 3.2.1 is applicable to BFN without exception.
- BDBEE hazards, when referred to in this document, are the applicable hazards from NEI 12-06, Section 2.2 (Reference 3.2.1). The applicable hazards for Browns Ferry are described in Section 2.7 in this document.
- Additional staff resources are expected to begin arriving at 6 hours and the site will be fully staffed 24 hours after the event (Reference 3.2.3).

This plan defines strategies capable of mitigating a simultaneous loss of all AC power and LUHS resulting from a BDBEE by providing adequate capability to maintain or restore core cooling, containment, and spent fuel pool (SFP) cooling capabilities at all units on a site. 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 to protect the public health and safety. Each unit's Emergency Operating Instructions (EOIs) have been revised, in accordance with established change processes, to clearly reference and identify appropriate entry and exit conditions for these pre-planned strategies. The EOIs retain overall command and control of the actions responding to a BDBEE. Also, the impact of these strategies on the design basis capabilities of the units has been evaluated under 10 CFR 50.59.

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). This position is consistent with the previously documented Task Interface Agreement (TIA) 2004-04, *Acceptability of Proceduralized Departures from Technical Specifications (TSs) Requirements at the Surry Power Station,* (TAC Nos. MC4331 and MC4332), dated September 12, 2006 (Reference 3.9).

2.2 General Strategies

The objective of the FLEX strategies is to establish an indefinite coping capability in order to 1) prevent damage to the fuel in the reactors, 2) maintain the containment function and 3) maintain cooling and prevent damage to fuel in the SFP using installed equipment, on-site portable equipment, and off-site resources. This indefinite coping capability will address an ELAP (loss of offsite power, emergency diesel generators and any alternate AC source, but not the loss of AC power to buses fed by Class 1E 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 Beyond-Design-Basis external event.

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 concurrent with LUHS event. A safety function-based approach provides consistency with, and allows coordination with, existing plant Emergency Operating Instructions (EOIs). FLEX strategies are implemented in support of EOIs using FLEX Support Instructions (FSIs) and EOI Appendices.

The strategies for coping with the plant conditions that result from an ELAP concurrent with 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 duration of each phase is specific to the installed and portable equipment utilized for the particular FLEX strategy employed to mitigate the plant condition.

The FLEX 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 all three BFN units. These pre-planned strategies which have been developed to protect the public health and safety are incorporated into the BFN EOIs in accordance with established change processes.

2.3 Electric Power Strategies

Overview

Following the simultaneous loss of all AC power and LUHS resulting from a BDBEE, the only power available is provided by three (3) Class 1E 250V DC Unit Battery banks. These batteries are adequate to supply the required Unit 1, 2 and 3 loads for the coping duration of four hours. The FLEX strategy is to extend battery coping duration by shedding unnecessary loads to minimize loading on the batteries, then using portable generators to repower the battery chargers prior to depletion of the batteries. In addition, the generators will be used provide power to operate motor operated valves (MOVs), room coolers, and other equipment to mitigate the event.

2.3.1 Phase 1 Electric Power Strategy

Following an ELAP/LUHS event, the Unit Batteries will maintain main control room (MCR) instrumentation and required control features. To extend battery life, steps (Reference 3.4.35) are taken to minimize the load on the batteries by shedding unnecessary loads. Load shedding of all non-essential loads will be completed within 1 hour after the start of the event. Battery calculations (Reference 3.3.2) demonstrate that when load shedding is complete within the first hour of the event, battery coping time is extended to 12 hours. This same calculation demonstrates that if the load shedding is complete within the first two hours, battery coping time is extended to 11 hours; however the plant goal is completion of the load shed within the first hour.

2.3.2 Phase 2 Electric Power Strategy

Multiple strategies have been developed to provide electrical power during Phase 2, and the connection points for these are described in Section 2.3.5. The preferred strategy uses one 4160V FLEX generator, that can be connected to the 4160V safety related distribution system at multiple points. The power is then transformed to 480V to supply power to the 480V Shutdown Boards A and B on each unit. The 480V Shutdown Boards supply power to Unit Battery Chargers 1, 2A, 2B and 3, which charge the unit batteries and supply DC loads. The 480V Shutdown Boards also supply the 480V Reactor Motor Operated Valve (RMOV) Boards, Control Bay Vent Boards, Standby Gas Treatment (SGT) Boards, and Diesel Generator Auxiliary Boards. These boards supply power to equipment necessary for the performance of all strategies. The generators are rated for 1 MW, sized (Reference 3.3.14) to power the 250 VDC battery chargers, RCIC controls, MOVs, and other selected loads. Two generators and connection points are available, however only one generator is required to supply the power necessary to complete the FLEX strategies.The generators primary staging area is directly outside the U3 DG rooms, with alternates available just outside the Turbine Building Breezeway area, or directly outside the Unit 1/2 DG rooms.

An additional strategy powers the 480V battery chargers using 480V FLEX generators. This strategy allows backfeed from the battery charger supply to selected MOVs needed for the FLEX strategies. The 480V FLEX generators are rated for 850 KW, sized (Reference 3.3.15) to power the battery chargers, RCIC controls, motor operated valves (MOVs), and other selected loads. Two generators are available, however only one is required to supply the power necessary to complete the FLEX strategies.

The deployment areas of the FLEX generators are shown in Figure 1.

2.3.3 Phase 3 Electric Power Strategy

The Phase 3 strategy for electrical includes additional equipment available from the National SAFER Response Center (NSRC) (Reference 3.12) to provide backup 4160V and the 480V generators.

Six (6) 4160V, 1MW generators and three (3) 480V, 1MW generators will be supplied by NSRC to provide backup and additional capacity. Also supplied are three (3) load distribution centers for connection to permanent plant switchgear. Instructions for connection and utilization of NSRC equipment for long term coping will be provided by Technical Support Center (TSC) personnel who will have assessed the condition of the plant and infrastructure, plant accessibility, and additional available off-site resources (both equipment and personnel) following the BDBEE. Connections points are available at the Turbine Building breezeway area that connect to the 4160V Unit Boards, or outside either of the Diesel Generator Buildings for connection to the 4160V Class 1E Shutdown Boards. Additionally, by restoring the Class 1E 4160V boards, power can be restored to the Class 1E 480V via the 4160/480V transformers to power selected 480V loads. Necessary cable and load centers for any of the above connections are also provided from the NSRC.

2.3.4 Electric Power Systems, Structures and Components

The safety related 250 VDC system for each unit consists of an independent and redundant switchgear assemblies, battery charger, two divisional inverters and battery. There is also one spare battery charger, capable of supplying any of the three unit batteries. The unit 250 VDC system provides power to critical instruments, Main Steam Relief Valves (MSRV) solenoids, RCIC system valves and controls, and other required DC loads. These DC systems are credited in the Phase 1 coping strategies to maintain loads until supplied by a FLEX generator. The safety-related batteries and associated DC distribution systems are protected from all BDBEE hazards (Reference 3.27).

2.3.5 Electric Power FLEX Connections

2.3.5.1 Preferred Electrical Connection (Non-Flood)

See Figure 1 for an illustration of staging areas, and Figure 2 for an illustration of the preferred electrical connection. The preferred connection point uses a 4160V FLEX generator that will be connected to 4160V Shutdown Boards 3EB or 3ED. The generators are deployed to Staging Area SA-A6, and power cables are routed from the generator, through the DG 3EA Room or the Cardox Tank Room, and through designated wall penetrations into the 4160V Shutdown Board Room 3EB/3ED. The cables are bolted to load carts that are racked in and connected to 4160V Shutdown Boards 3EB or 3ED. These Shutdown Boards are electrically connected by plant breakers to the Bus Tie Board, that allows electrical power from the generator to be supplied to Unit 1 and 2 4160V Shutdown Boards B and D. From the 4160V Shutdown Boards, power is transformed to 480V to supply power to the 480V Shutdown Boards A and B on each unit. The 480V Shutdown Boards supply power to Unit Battery Chargers 1, 2A, 2B and 3, which charge the unit batteries and supply DC loads. The 480V Shutdown Boards also energize the 480V Reactor Motor Operated Valve (RMOV) Boards, Control Bay Vent Boards, Standby Gas Treatment (SGT) Boards, and Diesel Generator Auxiliary Boards. Operators energize equipment required to cope with the event from these boards while monitoring generator loading.

2.3.5.2 Preferred Electrical Connection (Flood)

See Figure 1 for an illustration of staging areas, and Figure 3 for an illustration of the preferred electrical connection (flood). For flood events, or if the preferred 4160V electrical connection is not able to be used for any reason, the electrical connection can be made at either 4160V Unit Board 1B or 3B. The generators are deployed to Staging Area SA-A5 if desired to connect to Unit Board 1B or Staging Area SA-A4 if desired to connect to Unit Board 3B. These connections also utilize load carts that the power leads from the FLEX generators are bolted to, where they are then racked in and connected to the Unit Boards. If the Unit Board 1B connection is selected, it is electrically connected by plant breakers to Shutdown Bus 2, where they are used to supply 4160V Shutdown Boards B and D, and the Bus Tie Board. The Bus Tie Board is electrically connected by plant breakers to 4160V Shutdown Boards 3EB and 3ED. From the 4160V Shutdown Boards, power is distributed as described in Section 2.3.5.1.

If the Unit Board 3B connection is selected, it is electrically connected by plant breakers to 4160V Shutdown Board 3ED. This board is electrically connected to the Bus Tie Board, and the Bus Tie Board is electrically connected by plant breakers to 4160V Shutdown Boards 3EB, B and D via Shutdown Bus 2. From the 4160V Shutdown Boards, power is distributed as described in Section 2.3.5.1.

2.3.5.3 Additional Electrical Connections

Additional connection points for the 4160V FLEX generators are available at the B and D Diesel Generator output terminals. The generators are deployed to Staging Area SA-A3 (Figure 1). The permanent plant Diesel Generator output leads are lifted, and the temporary cables from the FLEX generators are bolted to the output leads to the Unit 1 and 2 4160V Shutdown Boards B and D. The Shutdown Boards are electrically connected to the Bus Tie Board, that allows electrical power from the generators to be supplied to Unit 3 4160V Shutdown Boards 3EB and 3ED. From the 4160V Shutdown Boards, power is distributed as described in Section 2.3.5.1.

Another connection point consists of powering the 480V battery chargers directly from 480V FLEX generators. Refer to Figure 4 for an illustration of this connection point. The generators are deployed to Staging Area SA-A2 (Figure 1). Temporary cables connect the 480V FLEX generator to the FLEX distribution panel located on the Control Bay, elevation 586. From the distribution panel, cables are connected directly to the charger supply breaker on the front of each of the chargers that charge 250V Unit Batteries 1, 2, and 3. This connection point also allows backfeed to selected MOVs needed for RPV injection.

2.3.6 Electric Power Electrical Analysis

2.3.6.1 Phase 1 Electric Power Equipment

Calculations demonstrate that the Unit battery capacity is sufficient to provide power for critical loads for 12 hours following a load shed (Reference 3.3.2). The Class 1E battery duty cycle of 12 hours for BFN was calculated in accordance with the IEEE-485 methodology using manufacturer discharge test data applicable to the licensee’s FLEX strategy as outlined in the NEI white paper on Extended Battery Duty Cycles (Reference 3.2.4), and as endorsed by the NRC (Reference 3.1.8). Plant validation (Reference 3.38) of the electrical strategy demonstrates the minimum time margin between the calculated battery duration for the FLEX strategy and the maximum deployment time for the FLEX generators to supply the DC loads is approximately 3 hours.

2.3.6.2 Phase 2 Electric Power Equipment

Multiple strategies have been developed to provide electrical power during Phase 2. These are described in detail in Section 2.3.5.

The strategy to re-power the stations vital AC/DC buses requires the use of combustion turbine generators. The selected FLEX generators have sufficient capacity to supply the Phase 2 loads as determined by the FLEX generators sizing calculations (Reference 3.3.14, 3.3.15). Only one generator, either 4160V or 480V, is required.

The 4160V DGs are 1 MW, three phase, 60Hz generators that are trailer mounted. The 480V DGs are 850 K W, three phase, 60 Hz generators that are trailer mounted. Two external, 1500 gallon double-walled diesel fuel tanks are available to supply fuel to the generators.

Refueling strategy for the generators is described in Section 2.10.

2.3.6.3 Phase 3 Electric Power Equipment

Six (6) 4160V, 1MW generators and three (3) 480V, 1000KW generators will be supplied by the NSRC (Reference 3.12) to provide backup and additional capacity. Also supplied are three (3) load distribution centers for connection to permanent plant switchgear. These generators will be used to power additional loads that are optional, and provide defense in depth to the Phase 2 loads. The specifications and ratings for this equipment are listed in Table 2.

2.4 Reactor Core Cooling Modes 1-3 Strategies

Overview

Reactor core cooling is accomplished by the removal of decay heat through the use of MSRVs, which discharge to the Suppression Pool. Makeup water to the RPV is provided by Reactor Core Isolation Cooling (RCIC) system, and eventually FLEX pumps to replace inventory lost from the use of MSRVs.

Within 20 minutes of the BDBEE initiation, a cooldown is initiated near the maximum allowable cooldown rate (100°F/hour). When reactor pressure is reduced to 150-300 psig, the cooldown is terminated and pressure maintained in this band in order to maintain sufficient steam pressure for continued RCIC operation.

At approximately four to eight hours, use of the Hardened Containment Vent System (HCVS) is initiated to provide long term core cooling capability through RCIC and to maintain containment parameters within limits.

At approximately eight hours, a FLEX pump is available to be placed in service to provide makeup to the RPV in the event RCIC becomes unavailable or it is desired to secure RCIC. Just prior to placing the FLEX pump in service, operators will use MSRVs to lower RPV pressure as low as possible to allow injection from the FLEX pumps.

2.4.1 Phase 1 Core Cooling Strategy

At the initiation of the BDBEE, the reactor scrams, Main Steam Isolation Valves (MSIVs) automatically close, feedwater is lost, and MSRVs automatically cycle to control reactor pressure, causing reactor water level to decrease. When reactor water level reaches 45 inches below instrument zero, RCIC and High Pressure Coolant Injection (HPCI) automatically start with normal suction from the Condensate Storage Tanks (CST) and inject to the RPV. CSTs at BFN are not qualified for all the hazards listed in Section 2.7 and therefore, are not credited for Phase 1 coping, but they would be used if available. If the CSTs are not available, the HPCI suction will automatically transfer on low CST level to the Suppression Pool, and HPCI will restore RPV level. Operators will manually transfer RCIC suction from the CST to the Suppression Pool (Reference 3.4.22), and RCIC will assist in restoring RPV level. HPCI will then be tripped and manually locked out. It remains available for injection if needed, but due to its larger DC load requirements, higher steam use, and higher injection rate, it is used only if RCIC is unavailable. All equipment and valves necessary to operate HPCI and RCIC are powered from the Class 1E unit batteries and remain available throughout the event. In addition, all necessary valves, piping and instrumentation are located inside the Reactor Building, and are protected from all external hazards.

At event initiation, the crew enters 0-FSI-1 FLEX Response (Reference 3.4.26). After determination that an ELAP exists, personnel will be dispatched to perform load shed of the unit batteries (Reference 3.4.35). This will be completed within one hour from the loss of AC power, and once complete, the DC battery coping time is extended to 12 hours.

Within 20 minutes, a cooldown is initiated near the maximum allowable cooldown rate (100°F/hour) (Reference 3.4.8). At 150-300 psig, the cooldown is terminated and pressure maintained in this band in order to maintain sufficient steam pressure for continued RCIC operation. Power for the MSRV solenoids is supplied by the Class 1E unit batteries and remains available throughout the event. Motive force for the MSRVs is the Drywell Control Air System, which can be supplied by the Nitrogen Storage Tanks (normal source), Containment Atmospheric Dilution (CAD) Tanks (emergency source), or the Alternate Nitrogen (N2) Supply (backup source for BDBEE). At event initiation the Nitrogen Storage Tank supplies pneumatic pressure for MSRV operation. If unavailable, the CAD tanks will be aligned for supply. However, neither of these supplies are qualified for all the hazards listed in Section 2.7 and are not credited for Phase 1 coping.

The Drywell Control Air Receivers, located in the Reactor Building, contain sufficient volume for the MSRVs until the Alternate N2 Supply is aligned (Reference 3.4.20). Also, each of the 6 Automatic Depressurization System (ADS) MSRVs are provided with an accumulator of sufficient volume to operate each valve through five open/close cycles (Reference 3.27). The Alternate N2 supply is available for manual connection (Reference 3.4.20) if needed, and contains the quantity of N2 required to meet system requirements for a BDBEE for 24 hours of operation (Reference 3.3.9).

RCIC exhaust and MSRV cycling will increase torus and drywell temperatures and pressures. During an extended SBO beyond the plant design basis, local temperatures may increase to the extent that the RCIC exhaust can no longer be completely condensed. It is appropriate to vent the relatively clean RCIC discharge through the containment vent path to maintain pressure suppression capability. Containment venting will be performed in accordance with EOIs (Reference 3.4.12) to limit containment parameters. The intent of opening containment vents is to limit the increase in Suppression Pool inventory, pressure, and temperature.

2.4.2 Phase 2 Core Cooling Strategy

The Phase 2 FLEX strategy for reactor core cooling uses portable, diesel driven, high capacity FLEX Pump Systems that draw water from the Wheeler Reservoir via the plant intake, and provide an indefinite supply of water. Multiple connection points are provided as described in Section 2.4.5. As parameters dictate, EOIs (Reference 3.4.11) direct the transfer of RPV makeup from RCIC to the FLEX Pump Systems. MSRVs will be opened to depressurize the RPV, and as pressure lowers injection from the FLEX pump will commence allowing RCIC to be removed from service. Plant validation (Reference 3.38) shows the FLEX Pump Systems will be staged and ready for injection in 8 hours or less. Refer to Section 2.4.10.1 for a FLEX Pump System description.

2.4.2.1 Preferred Phase 2 Core Cooling Strategy

Refer to Figure 5 for an illustration of the Containment Integrated Leak Rate Test (CILRT) FLEX Pump System flowpaths. The CILRT FLEX Pump System is staged at the FLEX Pump Staging Area SA-A1 (Figure 1). Hoses will be connected from the pump system to the preferred connections on the CILRT header connections in the RHRSW tunnel for each unit. This flowpath utilizes the CILRT penetration, and is connected to the Condensate Storage and Supply (CS&S) piping that supplies charging water to the Core Spray (CS) System. On Unit 3, this connection is hard piped; on Unit 1 and 2 the connection is made using hoses as directed by plant procedures (Reference 3.4.31). Unit 1 and 2 connection will be hard piped at a later date (Reference 3.5.11). The CS injection valves, powered from 480V RMOV Boards, are opened and throttled as necessary to supply RPV makeup. Calculation (Reference 3.3.12) demonstrates that this FLEX pump system can simultaneously supply required makeup flow to all three reactors, while also providing the required makeup flow to the SFPs for all three units.

2.4.2.2 Additional Phase 2 Core Cooling Strategy

Refer to Figure 6 for an illustration of the RHRSW FLEX Pump System flowpath which provides an additional RPV makeup flowpath. The RHRSW FLEX Pump System is also staged at the FLEX Pump Staging Area SA-A1 (Figure 1). Discharge hoses from the FLEX Pump System will be connected to the RHRSW Header Connections; two (2) five inch hoses connected to RHRSW Header B which supplies Unit 3, and three (3) five inch hoses connected to RHRSW Header D which supplies Units 1 and 2. This flowpath uses the RHRSW/RHR Standby Coolant crosstie, with injection coming from the RHR low pressure injection (LPCI) valves. The RHRSW/RHR MOVs, powered from 480V RMOV Boards, are opened and throttled as necessary to supply RPV makeup. Calculation (Reference 3.3.12) demonstrates this FLEX pump system can simultaneously supply required makeup flow to all three reactors, while also providing the required makeup flow to the SFPs for all three units.

2.4.3 Phase 3 Core Cooling Strategy

The Phase 3 strategy for core cooling and decay heat removal includes additional equipment available from the NSRC to provide backup to the FLEX Pumps. Table 2 is a list of equipment delivered to the site by the NSRC. Refer to Section 2.11 for a discussion on NSRC supplied equipment.

Instructions for connection and utilization of NSRC equipment for long term coping or recovery will be provided by TSC personnel who will have assessed the condition of the plant and infrastructure, plant accessibility, and availability of off-site resources (both equipment and personnel) following the BDBEE.

2.4.4 Core Cooling Systems, Structures, Components

2.4.4.1 Reactor Core Isolation Cooling System

The RCIC system consists of a steam-driven turbine-pump unit capable of delivering makeup water to the RPV. The system starts automatically upon receipt of a RPV Water Level Low-Low, Level 2 signal (-45”), and achieves rated flow within 30 seconds. If the system fails to start, EOIs (Reference 3.4.11) direct the operators to manually start the system. The steam supply to the turbine comes from the main steam line from the RPV, and the steam exhausts to the Suppression Pool. The pump normal suction is from the CST. If the CST is unavailable, procedures (Reference 3.4.22) direct the operator to manually swap the suction to the Suppression Pool. The pump capacity is sufficient to maintain the reactor core covered. All components required for initiating and operation of RCIC are DC powered from the Class 1E unit batteries and are completely independent of AC power. RCIC is a safety related, seismically qualified system which is located in the Reactor Building, a seismically qualified structure, and therefore protected from BDBEE hazards (Reference 3.27). RCIC will also remain fully functional under all steam quality conditions and with Suppression Pool temperatures up to 250°F (Reference 3.6.5). As detailed in Section 2.4.7, peak Suppression Pool temperature remains below 250°F for the duration of the event.

2.4.4.2 Main Steam Relief Valves

During Phase 1 and Phase 2, decay heat from the reactor is dissipated by manual control of the MSRVs. The MSRVs are seismically qualified components which are also protected from BDBEE hazards (Reference 3.27). Power for the MSRV solenoids is supplied by the Class 1E unit batteries and remains available throughout the event. Motive force for the MSRVs is supplied by the Nitrogen Storage Tanks (normal source), CAD Tanks (emergency source), or the Alternate N2 Supply (backup source for BDBEE). At event initiation, the Nitrogen Storage Tank supplies pneumatic pressure for MSRV operation. If unavailable, the CAD tanks will be aligned for supply. However, neither of these supplies are qualified for all the hazards listed in Section 2.7 and therefore, are not credited for coping. The Drywell Control Air Receivers, located in the Reactor Building, contain sufficient volume to supply the MSRVs until the Alternate Nitrogen Supply is aligned (Reference 3.4.20). In addition, each of the 6 Automatic Depressurization System (ADS) MSRVs are provided with an accumulator, which contain sufficient volume to operate each valve through five open/close cycles (Reference 3.27). The Alternate Nitrogen N2 supply is available for manual connection (Reference 3.4.20) if needed. The quantity of N2 required to meet system requirements for a BDBEE has also been established (Reference 3.3.9).

2.4.4.3 Batteries

The safety related Class 1E 250 VDC system for each unit consists of an independent and redundant switchgear assemblies, battery charger, two divisional inverters, and battery. The unit 250 VDC system provides power to critical instruments, MSRV solenoids, RCIC system valves and controls, and other required DC loads. These DC systems are credited in the Phase 1 coping strategies to maintain loads until supplied by a FLEX generator. The safety-related batteries and associated DC distribution systems are located within the Control Bay, and are protected from BDBEE hazards (Reference 3.27).

Following an ELAP/LUHS event, in order to extend battery life, steps (Reference 3.4.35) are taken to minimize the load on the batteries by shedding unnecessary loads. Load shedding of all non-essential loads will be completed within 1 hour after the start of the event. Battery calculations (Reference 3.3.2) demonstrate that when load shedding is complete within the first hour of the event, battery coping time is extended to 12 hours. This same calculation demonstrates that if the load shedding is complete within the first two hours, battery coping time is extended to 11 hours; however the plant goal is completion of the load shed within the first hour.

2.4.4.4 Suppression Pool

The Suppression Pool is part of Primary Containment (Reference 3.27). The pool serves as the heat sink for reactor vessel MSRV discharges and RCIC turbine steam exhaust during the ELAP/LUHS event. It is also the suction source for the RCIC pump for providing core cooling after the suction of the RCIC is swapped from the CST, if the CST is unavailable. The Suppression Pool is a safety-related seismically qualified structure which is protected from BDBEE hazards (Reference 3.27).

2.4.4.5 Hardened Containment Vent System

The use of HCVS per EOIs (Reference 3.4.12) is initiated to maintain containment parameters within the limits that allow continued use of RCIC and FLEX pumps. Anticipatory venting when containment pressure reaches 10-15 psig is performed. By venting at this pressure, containment limits and Suppression Pool temperature remains acceptable for RCIC operation (Reference 3.3.5). The power supply for the HCVS solenoids is the Class 1E unit batteries, which remain available for the duration of the event. In the event of failure of the batteries, the HCVS system contains its own battery which can be aligned to provide power to the HCVS solenoids (Reference 3.4.16). The HCVS also contains nitrogen bottles that can be manually aligned to supply motive force to the valves (Reference 3.4.16). The HCVS is a safety-related, seismically qualified system, which is protected from BDBEE hazards (Reference 3.27). The HCVS system is described in detail in Section 2.6.4.2.

2.4.4.6 Condensate Storage Tank

Each unit has one CST with an minimum inventory of 135,000 gallons of water (Reference 3.27). Based on the minimum volume of water available, the volume in the CST can support core cooling and heat removal requirements for approximately the first 13 hours of the event. If it remains available following the event, the CST is used as the initial source of water for RPV make-up and is the primary long term storage tank. However, the CST is not a safety-related, seismically qualified structure and may not remain available (Reference 3.27).

2.4.4.7 Ultimate Heat Sink (Tennessee River)

The FLEX pump will be available to be placed in service at approximately 8 hours to provide make up to the RPV from the Tennessee River. The UHS is designed to provide adequate cooling water to dissipate waste heat from the plant. In the event of a failure of the downstream dam (Wheeler) were to occur, a pool of water containing a volume of approximately 69.6×10^6 cubic feet of water would be available to the FLEX pumps at the plant intake (Reference 3.27).

2.4.5 Core Cooling FLEX Connections

2.4.5.1 CILRT FLEX Pump Connections

This connection is the preferred connection for both RPV and SFP makeup on all three units. The connection is located in the RHRSW tunnel on the south end of the Reactor Building for each unit, and is protected from hazards listed in Section 2.7. Three flexible 5” hoses will be run from the CILRT FLEX Pump System, to the connection in each units RHRSW tunnel. The CILRT connection penetrates the Reactor Building wall, and from inside the Reactor Building, the piping is connected to the CS&S system piping. On Unit 3, this connection is hard piped; on Unit 1 and 2 the connection is made using hoses as directed by plant procedures (Reference 3.4.31). The Unit 1 and 2 connection will be hard piped at a later date (Reference 3.5.11). CS&S supplies CS Loops I and II, which is then injected to the RPV using the CS injection valves (Refer to Figure 5).

2.4.5.2 RHRSW FLEX Pump Connections

The RHRSW connection is an additional strategy to supply RPV and SFP makeup. Five quality-related manual valves are available on each of the 18” RHRSW B and D header piping in the intake structure, inside the intake structure pump rooms. These valves and the associated piping are protected by the existing missile shield grating, and are protected from BDBEE hazards listed in Section 2.7. Following a BDBEE, two flexible 5” hoses will be connected from the RHRSW FLEX Pump System to the valves on RHRSW Header B to supply Unit 3, and three 5” hoses will be connected from the RHRSW FLEX Pump System to the valves on RHRSW Header D to supply Units 1 and 2. The RHRSW headers, which are cross tied with the RHR system, allow RPV injection using the LPCI injection valves. (Refer to Figure 6).

2.4.5.3 EECW FLEX Pump Connection

To provide water to the EECW system, five quality-related manual valves are available on the 18” EECW South header piping in the intake structure, inside the intake structure pump room. These valves and the associated piping are protected by the existing missile shield grating, and are protected from BDBEE hazards listed in Section 2.7. Following a BDBEE, 5 flexible 5” hoses will be connected from the EECW FLEX Pump System to the valves on the South EECW header. This alignment allows the FLEX pump to supply the South EECW header, which is connected to the RCIC oil coolers using hose connection (Figure 7) to help ensure continued operation of RCIC. Plant procedures (Reference 3.4.30) direct connection of the hoses to the RCIC system. In addition to maintaining RCIC available, the EECW header can provide cooling water to the Control Bay Ventilation System (Section 2.12.3), area coolers, and makeup water to the Spent Fuel Pools (Section 2.5).

2.4.6 Core Cooling Key Reactor Parameters

Key parameters and the instruments monitoring them are listed on Table 5 for reactor core cooling and decay heat removal strategy. These instruments are located in the Main Control Room and all are powered from Class 1E unit batteries or inverters that maintain operation of the instrument during the BDBEE.

In the unlikely event these instruments are unavailable, procedures (Reference 3.4.40) and equipment needed are available that provide methods for obtaining necessary instrument readings to support the implementation of the coping strategy. Guidance includes control room and non-control room readouts and also provides guidance on how and where to measure key instrument readings as close to containment penetrations, as possible, using portable instrument (e.g., a Fluke meter).

2.4.7 Core Cooling Thermal Hydraulic Analyses

A BFN plant specific Modular Accident Analysis Program 4 (MAAP4) analysis (Reference 3.3.5) was performed to provide the accident progression timeline and the primary system and containment thermal hydraulic response. MAAP4 code benchmarking for the program's use in support of post-Fukushima applications is discussed in detail in EPRI Report 3002001785 “Use of Modular Accident Analysis Program (MAAP) in Support of Post-Fukushima Applications” (Reference 3.23), which includes MELCOR code result comparisons as well as direct result comparisons to actual plant pressure and temperature data from Fukushima Dai-ichi Units 1, 2, and 3. The EPRI report concludes that the MAAP4 code is acceptable for use in support of the industry response to Order EA-12-049.

The BFN MAAP4 analysis was performed in accordance with Sections 4.1, 4.2, 4.3, 4.4, and 4.5 of the June 2013 position paper, EPRI Technical Report (Reference 3.23).

Key modeling parameters cited in Tables 4-1 through 4-6 of the "MAAP4 Application Guidance, Desktop Reference for Using MAAP4 Software, Revision 2" (Electric Power Research Institute Report 1020236 (Reference 3.24) are specifically addressed in the MAAP4 Analysis (Reference 3.3.5). The MAAP4 code is readily capable of analyzing the two-phase flow conditions from the RPV, and validations were performed for the key parameters that are checked for these two-phase level and flow conditions. Modeling of heat transfer and losses from the RPV, decay heat, and the plant-specific inputs are also described and followed standard practices.

Case 1 of the MAAP4 Analysis represents the scenario as described in the BFN FLEX strategy. The strategy is based on an RPV cooldown commencing at 20 minutes using the MSRVs to a pressure of 150-300 psig at less than 100°F per hour. After this point, the RPV pressure is maintained between 150 and 300 psig to allow continued operation of RCIC. RPV pressure is maintained in this range, even if Suppression Pool temperature exceeds the Heat Capacity Temperature Limit (HCTL) of the plant EOIs. This is acceptable based on the latest revision of the BWROG Emergency Procedure Guidelines (EPGs) (Reference 3.6.1), that allow the reactor to remain at pressure if emergency depressurization will result in the loss of the only source of injection. At approximately 4.5 hours, the HCVS Valves are opened. Peak Suppression Pool temperature remains below 250°F for the duration of the event.

This analysis demonstrates that the strategies provide the ability of BFN to successfully cope from the baseline conditions of the ELAP concurrent with a LUHS resulting from a postulated BDBEE using diverse and redundant combinations of installed and portable equipment. With regards to Reactor Core Cooling, the analysis demonstrates that the collapsed reactor water level remains above the Top of Active Fuel (TAF), that the cooldown rate is within Technical Specification limits, and that the timing of the BFN mitigating strategies are appropriate to successfully maintain core cooling.

2.4.8 Recirculation Pump Seal Leakage

The MAAP4 Analysis (Reference 3.3.5) assumed an initial primary system leakage of 61 gpm at full reactor pressure. This leakage rate includes 18 gpm per recirculation pump (References 3.1.13 and 3.8) and an assumed primary system leakage of 25 gpm. It is included to account for potential steam leakage in the drywell and the resulting temperature effects.

2.4.9 Shutdown Activity Analysis

A shutdown activity analysis is not applicable to BWRs for FLEX since all rods are assumed inserted and the analysis does not predict re-criticality.

2.4.10 Core Cooling FLEX Pumps and Water Supplies

2.4.10.1 FLEX Pump Systems

BFN FLEX strategies utilize three pump systems, CILRT, RHRSW, and EECW. The pump system is made up of two pumps connected in series; The Triton pump takes suction from the Tennessee River and provides suction to the Dominator pump. The Triton is a trailer-mounted, diesel driven centrifugal pump, that utilizes two floating submersible pumps. The Triton is capable of supplying up to 5000 gpm, has a 50' suction lift, and can supply a Dominator pump up to 150' away and 50' above the Triton. The Dominator is also a trailer-mounted, diesel driven centrifugal pump and is rated at 5000 gpm at 150 psig. The Dominator suction is supplied by the Triton pump, and discharge connections are detailed in Section 2.4.5.

The FLEX pump systems are deployed and ready for operation at approximately 8-12 hours into the event. The discharge of the FLEX pumps will be aligned via hose and adapters to the CILRT, RHRSW, and EECW connection points (Section 2.4.5). The FLEX pump is sized (Reference 3.3.12) based on the decay heat removal requirements at 300 minutes after reactor shutdown. This corresponds to a minimum flow rate of 184 gpm at 106 psig per unit, rounded up to 250 gpm to account for any leakage in the system, while simultaneously supplying 150 gpm SFP makeup.

2.4.10.2 Filtration of River Water

Evaluation by the BWROG (Reference 3.6.8) concluded that there is no expectation for a loss of core cooling capability resulting from the use of raw water in response to BDBEE conditions. It was also concluded that the fuel can be adequately cooled when the core inlet is postulated to be fully blocked from debris injected with the make-up coolant. The fuel is effectively cooled when the inside shroud is flooded, and this is accomplished by either injecting make-up coolant inside the shroud or by maintaining the water level above the steam separator return elevation if injecting make-up in the downcomer (Reference 3.6.4). Any clogging effect of raw water debris could be mitigated by adopting strainer screens. The two floating submersible pumps of the Triton are fitted with mesh screens to filter out debris in the river. Long term filtration is provided by NSRC supplied water treatment units (Reference 3.12). Three mechanical filtration units capable of processing 500 gpm each, and three reverse osmosis systems capable of processing 250 gpm each will be provided. Refer to Reference 3.14 for equipment specifications.

2.4.10.3 Suppression Pool (Torus)

The Suppression Pool is safety-related seismically qualified steel torus shaped pressure vessel located below and encircling the drywell, with a major diameter of approximately 111’ and a cross-sectional inside diameter of 31’. The Suppression Pool is protected from all applicable events. The Suppression Pool contains approximately 130,000 ft^3 (approximately 960,000 gallons) of water and has a minimum net airspace above the pool of ~ 120,000 ft^3 (Reference 3.27). The normal Suppression Pool water level is maintained between ≥ -6.25” (14.64’) and ≤ -1.0” (15.08’) per LCO 3.6.2.2 of the Technical Specifications (Reference 3.28). The initial volume of water in the Suppression Pool can provide over 16 hours of makeup to the RPV, by which time the FLEX pumps will be available for makeup to the Suppression Pool, or to the RPV if desired.

2.4.10.4 Tennessee River

The ultimate source of water for BFN is the Tennessee River. The FLEX pump will be available to be placed in service at approximately 8 hours to provide make up to the RPV from the Tennessee River. The UHS is designed to provide adequate cooling water to dissipate waste heat from the plant. In the event of a failure of the downstream dam (Wheeler) were to occur, a pool of water containing a volume of approximately 69.6×10^6 cubic feet of water would be available to the FLEX pumps at the plant intake (Reference 3.27).

2.5 Spent Fuel Pool Cooling/Inventory

In an ELAP event, the SFPs will initially heat up due to the unavailability of the normal cooling system. The structures, systems, and components (SSCs) of all three units associated with spent fuel pool cooling following an ELAP event are essentially identical and, therefore, the three phase strategy developed is the same for all units. The basic FLEX strategy for maintaining SFP cooling is to monitor SFP level utilizing the SFP level instrumentation and initiating SFP makeup as soon as resources are available.

2.5.1 Spent Fuel Pool Cooling/Inventory Phase 1 Strategy

An evaluation (Reference 3.3.4) estimated that with no operator action following a loss of SFP cooling at the maximum design heat load (full core offload), the SFP will reach 212°F in approximately 2.3 hours and minimum shielding distance (8.5' above the top of fuel) in 19 hours. The boil off rate for this case is 150 gpm. For a normally expected heat load in the pools, the time is 28 hours to reach 212°F and approximately 40-50 hours to reach the minimum shielding distance. The Phase 1 strategy is to calculate the SFP heatup rate and monitor level as required by plant procedures (Reference 3.4.10). Also, plant doors (References 3.4.36, 3.4.48) are opened within the first hour of the event in order to provide a vent pathway for steam and condensate from the SFP.

2.5.2 Spent Fuel Pool Cooling/Inventory Phase 2 Strategy

The Phase 2 strategy is to initiate SFP makeup or spray supplied by the FLEX pump system through one of three connections described in Section 2.5.5. The strategies for makeup are as follows (Figure 8):

- The preferred strategy is makeup from the normal Skimmer Surge Tank Makeup Valve, SHV-78-532, located on the Refuel Floor. This is supplied with water from the CILRT FLEX Pump System, via the CS&S system.
- An additional strategy is to use the EECW FLEX Pump System for makeup or spray to the Refuel Floor. Fire hoses, nozzles, and necessary valves for connection to the South EECW header are pre-staged on the Refuel Floor. These are positioned, as required, early in the event by plant procedures prior to the SFP reaching boiling (Reference 3.4.30), minimizing the need for access to the SFP area following degraded environmental conditions in the SFP area.
- Another strategy uses RHR Fuel Pool Cooling assist to deliver water from the RHRSW FLEX Pump System to the SFP cooling system and into the SFP. This strategy does not require access to the Refuel Floor.

The FLEX pump system is capable of providing makeup to the SFPs (150 gpm) simultaneously with RPV injection (250 gpm) for an indefinite period (Reference 3.3.12).

2.5.3 Spent Fuel Pool Cooling/Inventory Phase 3 Strategy

The long term strategy for SFP cooling is to continue the Phase 2 strategy supplemented by portable equipment delivered from off-site. See Table 2 for a list of equipment that will be delivered to the site, and Section 2.11 for a discussion on NSRC supplied equipment. Instructions for connection and utilization of NSRC equipment for long term coping or recovery will be provided by TSC personnel who will have assessed the condition of the plant and infrastructure, plant accessibility, and availability of off-site resources (both equipment and personnel) following the BDBEE.

2.5.4 Spent Fuel Pool Cooling/Inventory Structures, Systems, and Components

2.5.4.1 Spent Fuel Storage Pool

The SFP is a Category I reinforced concrete structure lined with stainless steel. The stainless steel liner is designed to remain in place and retain its leak-tight integrity during a Safe Shutdown Earthquake (SSE). The stainless steel liner plates are seam welded together and the liner is anchored to the concrete walls.

The design function of the SFP cooling system is to remove decay heat from the spent bundles, maintaining the SFP water temperature at or below 125°F during normal operating conditions or below a maximum of 150°F under all conditions. Temperature is monitored in each MCR by recorders. SFP level is monitored by two independent channels, with indication available in the Shutdown Board Rooms adjacent to the MCRs. A minimum of 21.5 feet of water is maintained over the top of the spent fuel.

2.5.4.2 Refuel Floor Ventilation

During the event, Reactor Building and Refuel Zone ventilation will be non-functional. Heat addition to the building will be from the SFP, RCIC operation, MSRV operation, and HCVS radiative heat. SFP bulk boiling will create adverse temperature, humidity, radiation and condensation conditions in the SFP area which requires a ventilation pathway. Plant doors (Reference 3.4.36, 3.4.48) are opened within the first hour of the event. The doors are open on the Reactor Building roof, Refuel Floor, and Reactor Building ground level to establish a natural circulation flowpath. Airflow through these doors provides adequate vent pathways through which steam generated by SFP boiling can exit the building.

2.5.5 Spent Fuel Pool Cooling/Inventory FLEX Connections

2.5.5.1 CILRT FLEX Pump Connections

The CILRT FLEX Pump connection is the preferred connection for SFP makeup on all three units. The connection piping is located in the RHRSW tunnel for each unit and are protected from BDBEE hazards listed in Section 2.7. Three flexible 5” hoses will be run from the CILRT FLEX Pump System to the CILRT connection in each units RHRSW tunnel. The CILRT connection penetrates the Reactor Building wall and, from inside the Reactor Building, the piping is connected to the CS&S system piping. On Unit 3, the connection from the CILRT piping to CS&S is a permanent hard pipe; on Units 1 & 2 the connection is made using hoses installed by plant procedure (Reference 3.4.31) during the event. CS&S supplies makeup to the SFP Skimmer Surge Tank, which overflows into the SFP (Figure 8).

2.5.5.2 RHRSW FLEX Pump Connections

The RHRSW connection is an additional strategy to supply SFP makeup. To provide water to the RHRSW system, 5 branches containing quality-related manual valves are connected to the existing 18” RHRSW B and D header piping in the intake structure. This connection piping is located inside the intake structure valve pit. These valves and associated piping are protected by the existing valve pit missile shield grating and are protected from BDBEE hazards listed in Section 2.7. Following a BDBEE, two flexible 5” hoses will be run from the RHRSW FLEX Pump System to the connections on RHRSW Header B, and three 5” hoses will be run from the RHRSW FLEX Pump System to the connections on RHRSW Header D. These connections connect the FLEX pump into the RHRSW permanent piping which is cross tied with the RHR system to allow SFP makeup using the FPC Assist valves. (Figure 8).

2.5.5.3 EECW FLEX Pump Connection

To provide water to the EECW system, 5 branches containing quality-related manual valves are connected to the existing 18” EECW South Header piping in the intake structure Figure 1. This connection piping is located inside the intake structure valve pit. These valves and the associated piping are protected by the existing valve pit missile shield grating and are protected from BDBEE hazards listed in Section 2.7. Following a BDBEE, 5 flexible 5” hoses will be run from the EECW FLEX Pump System to these connection points. Water from the EECW header is then supplied to the SFP using hoses and nozzles pre-staged on the Refuel Floor.

2.5.6 Key Spent Fuel Pool Parameters

The key parameter for the SFP makeup strategy is the SFP water level. The SFP water level is monitored by the instrumentation that was installed in response to Order EA-12-051, Reliable Spent Fuel Pool Level Instrumentation (Reference 3.1.5). These instruments are located in the Shutdown Board Rooms adjacent to each Backup Control Panel. There are two independent, redundant channels of indication, and each channel includes a UPS power supply and batteries capable of powering the instrument loops for a minimum of 4 days (Reference 3.5.8). The instrument loops are also capable of being powered from the FLEX generators when they become available.

2.5.7 Thermal-Hydraulic Analyses

During operation with a full core offload, BFN calculations (Reference 3.3.4) data shows the following:

- time for the SFP to boil is 2.3 hours
- required makeup to offset boil off is 150 gallons per minute
- time required for level to reach 8.5 feet above top of the fuel racks is 19 hours
- pool level will lower approximately 6 feet before makeup is available
- Approximately 17 feet of water remains above the top of the spent fuel.

During operation with a normal SFP heat load, the maximum heatup rate is approximately 3°F/hour. Starting from a Technical Specification maximum temperature of 150°F, the time to boil is approximately 21 hours. The FLEX pump system will be available within 8 hours, adequate time to provide makeup to the SFP prior to loss of inventory.

Calculations (Reference 3.3.12) demonstrate that the CILRT FLEX Pump System and the RHRSW FLEX Pump System are able to supply required makeup flow to the SFP while simultaneously supplying required makeup flow to the RPV. In addition, the same calculation demonstrates the EECW FLEX Pump System is capable of supplying the required SFP makeup or spray flow if required.

2.5.8 FLEX Pump and Water Supplies

2.5.8.1 FLEX Pump

BFN will use the same pumps for SFP makeup as for RPV makeup. For SFP makeup, the maximum requirement for providing flow is 150 gpm, which will offset the maximum boil-off rate. As discussed in Section 2.4, a hydraulic analysis concluded that any of the three FLEX Pump Systems are adequate for SFP makeup requirements.

A discussion of the pumps is provided in Section 2.4.10.

2.5.8.2 Ultimate Heat Sink

The Tennessee River is the ultimate heat sink and it is the primary source of water to provide makeup to the SFP. A description of the heat sink is provided in Section 2.4.10.4.

2.5.9 Electrical Analysis

The SFP water level is monitored by the instrumentation that was installed in response to Order EA-12-051, Reliable Spent Fuel Pool Level Instrumentation (Reference 3.1.5). These instruments are located in the Shutdown Board Room adjacent to each Backup Control Panel. There are two independent, redundant channels of indication, and each channel includes a UPS power supply and batteries capable of powering the instrument loops for a minimum of 4 days (Reference 3.5.8). The instrument loops are also capable of being powered from the FLEX generators when they become available.

2.6 Containment Integrity

BFN will utilize anticipatory venting using the Hardened Containment Vent System (HCVS) to maintain containment pressure and temperature within acceptable values. Venting is planned to be initiated in sufficient time to allow for continued RCIC operation and to maintain containment pressure below its design value.

2.6.1 Phase 1

During Phase 1, BFN will depressurize the RPV to the range of 150-300 psig using MSRVs, which direct steam into the Suppression Pool. This action will absorb the heat load in the Primary Containment, limiting the pressure rise and prolonging coping time. Containment response will vary, depending on the suction source for RCIC. Suppression pool level will lower if RCIC suction is from the Suppression Pool, or will rise if suction is from the CST. No action is required during Phase 1 to address level. BFN will utilize anticipatory venting using the installed Hardened Containment Vent System (HCVS) to maintain containment pressure and temperature within acceptable values. Anticipatory venting when containment pressure reaches 10-15 psig is performed. Calculations (Reference 3.3.5) demonstrate this pressure band will be reached within 4-6 hours from event initiation. By venting at this pressure, containment pressure limits are not exceeded and Suppression Pool temperature remains acceptable for RCIC operation (Reference 3.3.5).

2.6.2 Phase 2

Use of the HCVS is continued from Phase 1. Monitoring of containment (drywell) pressure and temperature is available via permanently installed plant instrumentation using the coping strategy described in Section 2.6.5 for instrumentation and controls. Calculation (Reference 3.3.5) demonstrates that Primary Containment limits are not reached and Suppression Pool temperature remains satisfactory during the event.

2.6.3 Phase 3

The long term strategy for containment cooling is to continue the Phase 2 strategy supplemented by portable equipment delivered from off-site. Additional generators supplied by NSRC will allow methods of containment cooling, such as Drywell Blowers, to be placed in service. See Table 2 for a list of equipment that will be delivered to the site. Refer to Section 2.11 for a discussion on NSRC supplied equipment. Instructions for connection and utilization of NSRC equipment for long term coping or recovery will be provided by TSC personnel who will have assessed the condition of the plant and infrastructure, plant accessibility, and additional available off-site resources (both equipment and personnel) following the BDBEE.

2.6.4 Structures, Systems, Components

2.6.4.1 Structures

BFN employs a GE BWR Mark I Primary Containment, which houses the RPV, reactor coolant recirculating loops, and other branch connections for the Reactor Coolant System. The pressure suppression system consists of a drywell, a pressure suppression chamber (alternatively referred to as the torus or wetwell), which stores a large volume of water (referred to as the Suppression Pool), a vent system between the drywell and pressure suppression chamber, and other service equipment. Refer to Reference 3.27 for a full description of the BFN Primary Containment, and a discussion of the design capabilities of the containment.

During the BDBEE which results in an ELAP concurrent with LUHS, containment integrity is maintained by normal design features of the containment. The drywell free volume is approximately 171,000 cubic feet, while the pressure suppression chamber free volume is approximately 120,000 cubic feet. The containment design pressure is 56 psig and the containment design temperature is 281°F (Reference 3.27).

In accordance with NEI 12-06 (Reference 3.2.1), the containment is assumed to be isolated following the event. As the Suppression Pool heats up and begins to boil, the containment will begin to heat up and pressurize. Additionally, because it is necessary to ensure the capability of MSRVs to perform the pressure relief function and it is necessary to maintain containment integrity, the containment will be vented to reduce Suppression Pool inventory and containment pressure. The HCVS has been enhanced to ensure required vent operations (References 3.4.16 and 3.5.10). HCVS will be operated with control from the MCR.

The Primary Containment and the HCVS valves are located within the Reactor Building. This is a Seismic Category I structure and provides protection from all applicable hazards.

The Diesel Generator buildings house the HCVS Remote Operating Station, backup nitrogen supply, and backup batteries. The buildings are Seismic Category I and provides protection from all applicable hazards.

2.6.4.2 <u>Hardened Containment Vent System (HCVS)</u>

During a BDBEE which results in an ELAP concurrent with LUHS, the HCVS provides a means of relieving excessive containment pressure. The vent flow path utilizes a 14” line which taps off of the 20” torus vacuum breaker. Two 14” pneumatically operated butterfly valves are located inside the Reactor Building. The piping penetrates the Reactor Building wall, and after exiting the Reactor Building, the piping elbows up and travels vertically up the exterior wall of the Reactor Building. The piping continues up the wall of the Reactor Building until it reaches approximate elevation 665’ where it turns and penetrates the siding of the Reactor Building superstructure. Once inside the superstructure, the piping is routed vertically adjacent to an existing steel column until it penetrates the roof of the superstructure, ultimately terminating at approximate elevation 741’-6”. Also, necessary equipment for operation of the HCVS is included: a HCVS nitrogen system, backup electrical power supplies, controls, monitoring instrumentation, and a Remote Operating Station.

The HCVS nitrogen system includes a nitrogen bottle rack in the Diesel Generator buildings, along with the Remote Operating Station (ROS) for the HCVS. The system provides enough motive air supplies to assure 24 hours of operation without bottle changeout. ROS includes pressure gauges to indicate system supply pressure both upstream and downstream of the pressure regulator and indicate when bottle change out is required.

The normal power supply for the HCVS solenoids is the Class 1E unit batteries, which remain available for the duration of the event. In the event of failure of the batteries, the HCVS system contains its own battery, which can be aligned to provide power to the HCVS solenoids (Reference 3.4.16). The HCVS batteries are sized to provide a minimum of 24 hours of power to HCVS related equipment.

Monitoring instrumentation includes the HCVS discharge pipe temperature and radiation instrumentation channels in the Main Control Room. The HCVS discharge pipe temperature and radiation instrumentation channels provide additional confirmation that the HCVS system is in use.

The HCVS system is designed to preclude hydrogen/carbon monoxide detonation. This is accomplished with the use of a vent discharge check valve to prevent the introduction of oxygen into the vent piping. A vent cap will keep debris out of the piping, until the valves are placed in service. The HCVS is a safety-related, seismically qualified system which is protected from BDBEE hazards (Reference 3.27).

The use of HCVS per EOIs (Reference 3.4.12) is initiated to maintain containment parameters below design limits and within the limits that allow continued use of RCIC. These procedures include steps for HCVS valve operation, as well as alignment of the backup nitrogen bottles and battery when necessary. Anticipatory venting when containment pressure reaches 10-15 psig is performed. By venting at this pressure, containment pressure limits are not exceeded and Suppression Pool temperature remains acceptable for RCIC operation (Reference 3.3.5).

2.6.5 Key Containment Parameters

Key parameters and the instruments monitoring them are listed on Table 5 for containment integrity strategy. Monitored parameters include Drywell temperature and pressure, Suppression Pool temperature and level, and Suppression Chamber pressure. These instruments are located in the Main Control Room and all are powered from unit batteries or inverters that maintain operation of the instrument during the BDBEE. In the highly unlikely event these instruments are unavailable, procedures (Reference 3.4.40) and equipment needed are available that provide methods for obtaining necessary instrument readings to support the implementation of the coping strategy. Guidance includes control room and non-control room readouts and also provides guidance on how and where to measure key instrument readings as close to containment penetrations, as possible, using portable instruments (e.g., a Fluke meter).

2.6.6 Thermal-Hydraulic Analyses

Calculation (Reference 3.3.5) demonstrates that containment temperature and pressures will not challenge containment limits. MAAP4 BWR Version 4.0.7 analysis software was utilized for the containment analysis. The MAAP4 analysis software was employed to analyze the specified FLEX scenarios during an ELAP concurrent with LUHS. MAAP4 is an EPRI sponsored computer code that simulates the response of light water nuclear power plants during severe accident sequences. MAAP4 can predict the progression of hypothetical accident sequences from a set of initiating events to a safe, stable, coolable state.

2.6.7 FLEX Pump and Water Supplies

The FLEX Pump Systems and water supplies are described in detail in Section 2.4.10. The FLEX Pumps will provide any required make-up water to the Suppression Pool.

2.6.8 Electrical Analysis

Power requirements for the HCVS and containment critical instrumentation are provided by the unit batteries. The FLEX generators are used to repower unit battery chargers that maintain unit batteries charged. See additional discussion in Section 2.3.2.

2.7 Characterization of External Hazards

BFN site has been evaluated using the Nuclear Energy Institute (NEI) Flexible and Diverse Coping Mitigation Strategies (FLEX) guidance and the following applicable hazards have been identified:

- seismic events,
- external flooding,
- storms with high winds and tornadoes,
- snow, ice, extreme cold, and
- extreme heat.

Browns Ferry Nuclear Plant has determined the functional threats from each of these hazards and identified FLEX equipment that may be affected. The FLEX equipment and FLEX strategies consider the impacts of the applicable external hazards and will address protection and deployment of FLEX equipment, procedural interfaces, and utilization of on-site and off-site resources.

2.7.1 Seismic

Per NEI 12-06 (Reference 3.2.1), seismic hazards must be considered for all nuclear sites. As a result, the credited FLEX equipment has been assessed based on current BFN seismic licensing basis to ensure that the credited FLEX equipment remains accessible and available after a Beyond-Design-Basis External Event (BDBEE) and that the FLEX equipment does not become a target or source of a seismic interaction from other systems, structures, or components. Per the BFN Units 1, 2, and 3 Updated Final Safety Analysis Reports (UFSAR) (Reference 3.27), the design of all Class I structures is based on a horizontal ground motion due to an acceleration of 0.10g horizontal (Operating Basis Earthquake). In addition, the design is such that the plant can be safely shut down during a ground acceleration of 0.20g (Design Basis Earthquake) horizontal. Vertical accelerations are 2/3 horizontal for both the Operating Basis Earthquake and Design Basis Earthquake.

In addition to the NEI 12-06 guidance, Near-Term Task Force (NTTF) Recommendation 2.1 , Seismic, recommended that facilities re-evaluate the site's seismic hazard. The NRC issued a 50.54(f) letter (Reference 3.1.11) that requested information to assure that these recommendations were addressed. The 50.54(f) letter required that the seismic hazards at sites be reevaluated against present-day NRC requirements. In accordance with the 50.54(f) request, a seismic hazard and screening evaluation was performed for Browns Ferry Nuclear Plant (Reference 3.33). BFN subsequently reevaluated the seismic hazard and developed a Ground Motion Response Spectra (GMRS) for the site based upon the most recent seismic data and methodologies and has found that the existing SSE does not envelop the new GMRS over the entire frequency range. This reevaluated seismic hazard is being addressed in the industry initiative referred to as the Augmented Approach (EPRI Report 3002000704). The Augmented Approach requires plants to address the GMRS by performing the Expedited Seismic Evaluation Process (ESEP) as an interim measure while completing the long-term seismic risk evaluation. The BFN Augmented Approach evaluates the seismic capability of a subset of FLEX-credited installed plant equipment to provide confidence that the equipment would retain function during and after a beyond design basis seismic event using seismic margins assessment to a Review Level Ground Motion (RLGM) above 2 x SSE from 1 to 10 Hz (Reference 3.34). NRC endorsement of use of the EPRI Augmented Approach was provided (Reference 3.1.7), and NRC staff review was performed (Reference 3.1.16). Additionally, a seismic evaluation of the SFP is necessary for BFN (Reference 3.1.17). This evaluation has been completed for the GMRS (Reference 3.35) and reviewed by the NRC staff (Reference 3.1.18). The BFN Seismic Risk Evaluation will include a High Frequency Evaluation; the due date of which is December 31, 2019 (Reference 3.1.17).

The Emergency Equipment Mobilization Routes for BFN Plant were evaluated (References 3.17, 3.18, 3.19, 3.20, 3.21). These evaluations covered the haul routes from off-site Staging Areas C and D to Staging Area B and from Staging Area B to the Protected Area Fence. It included a review of areas that were of concern for liquefaction and other possible failure modes. This evaluation concluded that the state routes from off-site Staging Areas C and D to the on-site Staging Area B may not be available subsequent to the occurrence of a significant seismic event and alternate means to transport equipment may be required. Two paths from each off-site staging area have been considered. In case of severe seismic and flood events, if the state routes are not passable for both primary and alternate path, alternate air transportation arrangements are available and included in the BFN SAFER Response Plan (Reference 3.12). In all other areas, including paths from Staging Area B to FLEX pump pads, the displacements were estimated not to exceed +/- 3" which is relatively small and therefore, considered acceptable for deployment paths and staging. For those deployment paths inside the protected area fence, the liquefaction study done for the ISFSI pad (Reference 3.3.10) demonstrates that the relatively short distance inside the protected area fence will not be susceptible to any significant liquefaction and hence is acceptable as a deployment path.

For FLEX strategies, the earthquake is assumed to occur without warning and result in damage to non-seismically designed structures and equipment. Non-seismic structures and equipment may fail in a manner that would prevent accomplishment of FLEX-related activities (normal access to plant equipment, functionality of non-seismic plant equipment, deployment of FLEX equipment, restoration of normal plant services, etc.). The diverse nature of the FLEX strategies has been previously discussed. The ability to clear haul routes from seismic debris to facilitate the deployment of the FLEX Phase 2 equipment is addressed in Section 2.9.

2.7.2 External Flooding

The Browns Ferry Nuclear Plant is located on the north bank of Wheeler reservoir at Tennessee River Mile (TRM) 294.0 with the lowest natural ground elevation in the site vicinity of about 560.0’. The Tennessee River above BFN site drains 27,130 square-miles. Guntersville Dam, 55 miles upstream, has a drainage area of 24,450 square-miles. Wheeler Dam, the next dam downstream, has a drainage area of 29,590 square-miles.

Browns Ferry Nuclear Plant is susceptible to flooding via two sources, local intense precipitation and river flooding. The term “Probable Maximum Flood (PMF)” is used to describe the hypothetical flood which would result from an occurrence of the probable maximum precipitation centered on the watershed, and includes allowances for failure of the west saddle dam at Watts Bar, and portions of earth embankments at Chickamauga, Nickajack, and Guntersville dams. A maximum flood elevation of 578' at BFN results from a combination of the PMF and wind wave run-up on a vertical wall per UFSAR (Reference 3.27). Plant grade is at elevation 565’ and Browns Ferry Nuclear Plant structures, located in the flood plain which house equipment important to safety, are designed to remain watertight by utilizing both permanently installed and temporary barriers (“wet site”). The inundation period is approximately 7.4 days above plant grade and reaches a maximum still water elevation of 572.5', per UFSAR section 2.4, Appendix 2-4A (Reference 3.27).

As the 10 CFR 50.54(f) letter dated March 12, 2012 (Reference 3.1.11) requested, TVA has completed and submitted the Flood Hazard Reevaluation Report (FHRR) (Reference 3.31) for BFN The reevaluation represents the most current flooding analysis for BFN. The reevaluation results were mostly bounded by the original BFN UFSAR site flooding vulnerabilities and characteristics, in that the non- events such as seiche, tsunami, and ice-induced events continued to be non-events. However, the reevaluation showed that flooding due to local intense precipitation (LIP) could exceed the Current Licensing Basis (CLB) level.

A Mitigating Strategies Assessment for Flooding at Browns Ferry Nuclear Station (Reference 3.32) was conducted. Because Mitigating Strategies Flood Hazard Information provided in the FHRR (Reference 3.31) concluded that the LIP height in certain areas is not bounded by the CLB, the reevaluated LIP level was included in the assessment.

The MSA concluded the reevaluated flood height will not impact the FLEX Strategy based on the following:

- Deployment paths and staging areas: Flood levels along the haul paths and staging areas necessary for FLEX deployment are minimal. The trucks and trailers used in the deployment of equipment will be able to traverse the depths. Given the shallow depths and rapid recession times, the FLEX strategies can be implemented as designed.

- Potential FLEX timeline impacts: Initial actions are conducted within the Control Buildings and are not impacted by the LIP event. The LIP event is of such short duration, the FLEX strategy deployment time may be delayed but does not prevent successful deployment.

- PMF Warning Time, Flood Event Duration: The reevaluated PMF flood height is bounded by the BFN design basis and was not required to be addressed in the MSA (Reference 3.32). However, since warning time and duration was not addressed in the FHRR (Reference 3.31), it was addressed by BFN. Validation (Reference 3.38, 3.39) results demonstrate FLEX generators and pump systems deployment and alignment can be accomplished within 10 hours. Based on these times, the reevaluated warning time (Reference 3.32) and flood event duration does not impact pre-flood FLEX deployment activities credited in the FLEX Mitigating Strategies.

- Flood Event Inundation Time-Access Roads: The inundation of BFN site access roads will not impact FLEX implementation. Although access from offsite is partially restricted, the BFN Safer Response Plan (Reference 3.12) includes multiple methods (i.e., trucks, airplanes, helicopters) and paths to transport equipment to the site.

2.7.3 Severe Storms with High Wind

Browns Ferry Nuclear Plant is susceptible to hurricanes; however, based on the contour lines shown in NEI 12-06 Figure 7-1 (Reference 3.2.1), BFN is not susceptible to winds exceeding 130 mph from hurricanes.

BFN site has the potential to experience damaging winds caused by tornado exceeding 130 mph. Figure 7-2 of NEI 12-06 (Reference 3.2.1) indicates a maximum wind speed of 200 mph for Region I plants, including BFN. Therefore, high-wind hazards are applicable to BFN. It should be noted that BFN was designed to 300 mph wind loads (Reference 3.27).

In summary, based on available local data and NEI 12-06 Figures 7-1 and 7-2 (Reference 3.2.1), BFN is susceptible to severe storms with high winds; therefore the hazard is considered to be credible.

2.7.4 Ice, Snow and Extreme Cold

As depicted in NEI 12-06 (Reference 3.2.1) for plants located below the 35th parallel, snow and extreme cold events are unlikely to present a significant problem. BFN is below the 35th parallel; however, based on historical data collected from both NEI 12-06 Figure 8-1 (Reference 3.2.1) and the BFN UFSAR (Reference 3.27), snowfalls in excess of 6 inches have occurred in the past. BFN UFSAR (Reference 3.27) references snowfall reports of 17.1, 10.1, and 10.0 inches near BFN. In a typical year, Decatur, Alabama (located approximately 10 miles southeast of BFN) has approximately 57 days per year with minimum temperatures equal to or less than 32°F with an extreme daily temperature record of -12°F. Therefore, the FLEX strategies considered the challenges caused by extreme snowfall and extremely cold temperatures.

BFN is located in either the ice severity level 4 or 5 region, defined by NEI 12-06 Figure 8-2 (Reference 3.2.1). BFN FLEX strategies consider impedances caused by ice storms.

In summary, based on the available local data and NEI 12-06, BFN does experience significant amounts of snow, ice, and extreme cold temperatures; therefore, the hazards are considered to be credible.

2.7.5 High Temperatures

Per NEI 12-06 (Reference 3.2.1) all sites must address high temperatures. Virtually every state in the lower 48 contiguous United States has experienced temperatures in excess of 110°F. Many states have experienced temperatures in excess of 120°F. In a typical year, Decatur, Alabama (located approximately 10 miles southeast of BFN) has approximately 70 days per year with maximum temperatures equal to or greater than 90°F, with an extreme daily temperature record of 108°F (Reference 3.27).

Therefore, for selection of BFN FLEX equipment, the BFN site has considered the site maximum expected temperatures in their specification, storage, and deployment requirements.

2.8 Protection of FLEX Equipment

BFN has constructed a FLEX Equipment Storage Building (FESB) which is adequately protected from the hazards listed in Section 2.7. The FESB slab is set at elevation 586.25’, located above the Probable Maximum Flood (PMF) level of 578’. The building is designed for a maximum tornado event with 360 MPH winds, tornado missiles, and a pressure drop of 3 psi. It is a Quality Related structure, designed to meet BFN design basis Safe Shutdown Earthquake (SSE) requirements, with a fire protection system that is designed to NFPA-13 standards. The FESB HVAC system maintains building temperature between 50°F and 90°F, sufficient to assure no adverse effects on the FLEX equipment.

The FESB is used to store Phase 2 equipment and items, including all major FLEX equipment listed on Table 1. Large portable FLEX equipment such as pumps and generators are secured, as required, inside the FLEX storage building to protect them during a seismic event. The FLEX storage building has tie downs integrated into the floor slab for this purpose. These tie downs are used to secure any equipment that is not considered stable to ensure the stored FLEX equipment remains protected from damage during a seismic event.

Deployments of the FLEX equipment from the FESB are not dependent on off-site power.

2.9 Deployment of FLEX Equipment

2.9.1 Haul Paths and Accessibility

Multiple haul routes are available from the FLEX storage building to any staging area (Figure 1). The appropriate haul routes have been evaluated for access per NEI 12-06 (Reference 3.17 through 3.21). These evaluations covered the haul routes from off-site Staging Areas “C” and “D” to Staging Area B and from Staging Area “B” to the Protected Area Fence. It included a review of areas that were of concern for liquefaction and other possible failure modes. This evaluation concluded that the state routes from off-site Staging Areas “C” and “D” to the on-site Staging Area “B” may not be available subsequent to the occurrence of a significant seismic event and alternate means to transport equipment may be required. Two paths from each off-site staging area have been considered. In case of severe seismic and flood events, if the state routes are not passable for both primary and alternate path, alternate air transportation arrangements are available and included in the BFN SAFER Response Plan (Reference 3.12). In all other areas, including paths from Staging Area “B” to FLEX pump pads, the displacements were estimated not to exceed +/- 3” which is relatively small and, therefore, considered acceptable for deployment paths and staging. For those deployment paths inside the protected area fence, the liquefaction study done for the ISFSI pad (Reference 3.3.10) demonstrates that the relatively short distance inside the protected area fence will not be susceptible to any significant liquefaction and hence is acceptable as a deployment path. For floods, sufficient warning time is available that will enable equipment to be pre-staged.

The equipment being transported for Phase 2 strategies will be towed by a heavy duty pickup truck or a track loader (Table 1). The tires for these vehicles and trailers are designed to withstand small debris punctures. One truck is equipped with a snow scraper blade, and both are equipped tire chains. The transport vehicles and debris clearing equipment are stored in the FLEX storage building.

AUO rounds (Reference 3.4.47) and monitoring by Site Security (Reference 3.4.48) ensure the deployment routes and staging areas remain clear.

2.9.2 Deployment of Strategies

All equipment is deployed using the two FLEX tow trucks or the FLEX track loader, that are stored in the FESB (Table 1). After performance of a Prompt Survey of Deployment Paths (Reference 3.4.38), the equipment is deployed using the selected haul paths to the selected staging area.

2.9.2.1 Deployment of Generators

Deployment of the 4160V FLEX generator requires transport of the generator, one cable trailer that contains the necessary cable for connection of the generator, and one trailer mounted fuel oil storage tank. These are deployed from the FESB to the selected staging area via the selected haul path (Figure 1). The generator is then connected as described in Section 2.3.5. If the 480V FLEX generator is to be transported, it requires only the Trailer mounted fuel oil storage tank to be deployed. All cable necessary for connection of the 480V generator is located in the FLEX Equipment Storage Room, located on Control Bay elevation 586. The generator is then connected as described in Section 2.3.5.

2.9.2.2 Deployment of Pumps

Each pump system requires transport of a Triton booster pump, Dominator Pump, and supporting hoses. One hose trailer contains hoses necessary for the Triton booster pumps, and a second hose trailer contains hoses for connection of the Dominator pumps. The pumps are deployed to the FLEX Pump Pad, SA-A1 (Figure 1). Hoses are run through a vehicle gate on the southeast corner of the security fence, and routed to the connection points. Connections are made as described in Section 2.4.5 and 2.5.5.

2.10 Fueling of Equipment

The general coping strategy for supplying fuel oil to the portable equipment is to pump fuel oil out of the eight permanent plant diesel generator 7 Day Tanks. Each of the tanks contain a Technical Specification minimum capacity of >35,280 gallons, for a combined Technical Specification minimum volume of 282,240 gallons. The combined consumption rate of three FLEX Pump Systems, two 4kV FLEX generators, and one 480V FLEX generator is approximately 460 gallons per hour (gph), for a total 72 hour consumption of approximately 33,120 gallons. The 7 Day Tanks are located below grade in the Diesel Generator Buildings and are protected from all hazards.

To remove fuel oil from the 7 Day Tanks, three Gorman-Rupp portable diesel engine driven 125 gpm pumps are used to transfer fuel oil from any of the 7 Day Tanks. Procedures (Reference 3.4.39) provide direction for connection and operation of the transfer pumps. For the FLEX Pump systems, the transfer pumps will fill a 500 gallon diesel fuel oil tank located on each of the two transport trucks. These trucks are each equipped with a 24Vdc, 25 gpm fuel oil transfer pump to transfer fuel from the 500 gallon tank to the FLEX pump systems. For the FLEX generators, the pumps will take suction from the 7 Day Tanks, and pump directly into the trailer mounted fuel oil storage tank located with the FLEX generators.

To supply the FLEX generators, two portable trailer mounted fuel oil storage tanks with 1200 gallon of No. 2 Diesel Fuel each are stored in the FESB, protected from all hazards, and available for deployment with the 480V and 4kV generators. Each trailer mounted fuel oil storage tank is equipped with adequate hose, valves, manual priming pump, and compatible connections necessary to support generator operation. One trailer mounted fuel oil storage tank will provide adequate fuel for the first 10 hours, or two trailer mounted fuel oil storage tanks will provide adequate fuel for the first 20 hours of operation. If the 480V generator is in use, one trailer mounted fuel oil storage tank will provide adequate fuel for the first 10 hours of operation.

Each of the three FLEX pump systems are made up of a Triton Pump with a 150 gallon fuel tank, and a Dominator Pump with a 300 gallon fuel tank. The Triton tank will provide 8 hours of full load operation, and the Dominator tank will provide 10 hours of full load operation.

In the flood event, the 7 Day Tanks will be inaccessible. Sufficient warning time is available for BFN offsite vendors to provide fuel oil trucks in quantities that exceed the Phase II and III FLEX fuel equipment requirements. Fuel tankers will be stationed at locations where a direct fill strategy can be deployed.

With a combined fuel consumption rate of approximately 460 gph, the portable fuel transfer pumps and tanks have sufficient capacity to support continuous operation of the FLEX equipment expected to be deployed and placed into service. In addition, sufficient inventory is available to supply support equipment such as lighting towers and small portable generators. At this rate, BFN has adequate capacity to provided onsite equipment with fuel for approximately 25 days.

Fuel oil quality is monitored in accordance with CI-130, Diesel Fuel Oil Testing and Monitoring Program. The 7 Day Tanks are tested monthly in accordance with BFN Technical Specification 3.8.3, Diesel Fuel Oil, Lube Oil, and Starting Air, and Technical Specification 5.5.9, Diesel Fuel Oil Testing Program. Fuel in the trailer mounted fuel oil storage tanks is tested at least annually in accordance with CI-404 Miscellaneous Sampling and Chemical Addition Procedures.

2.11 Off-site Resources

2.11.1 National SAFER Response Centers

The industry has established two National SAFER Response Centers (NSRCs) to support utilities during BDBEEs. Tennessee Valley Authority Company (TVA) has established contracts with the Pooled Equipment Inventory Company (PEICo) (Reference 3.12) to participate in the process for support of the NSRCs as required. On-site FLEX equipment hose and cable end fittings are standardized with the equipment supplied from the NSRC. In the event of a BDBEE and subsequent ELAP concurrent with LUHS condition, equipment will be moved from an NSRC to a local staging area established by the Strategic Alliance for FLEX Emergency Response (SAFER) team. FLEX strategy requests to the NSRC are directed by FLEX procedures.

Staging Area “C” is the Northwest Alabama Regional Airport in Muscle Shoals, Alabama, approximately 45 miles west of BFN. Staging Area “D” is the Pryor Field Regional Airport in Tanner, Alabama, approximately 15 miles southeast of BFN. Communications will be established between BFN and the SAFER team via satellite phones and required equipment moved to the site as needed. First arriving equipment will be delivered to the site within 24 hours from the initial request. (Reference 3.12).

NSRC personnel will commence delivery of a pre-selected equipment set upon notification. Typically deliveries will go by truck using preselected routes and with any necessary escort capabilities to ensure timely arrival at the plant site staging area “B” or to staging area “C”. The “B” staging area is a large hard-surfaced area of approximately 2 to 3 acres in size, “C” and “D” are regional airports with runways of over 6000 x 100’. Helicopter landing considerations are accounted for in selection of all these staging areas. These areas are designed to accommodate the equipment being delivered from the NSRC.

If necessary, equipment can be flown commercially to a major airport near the plant site and trucked or air lifted from there to the staging areas. The use of helicopter delivery is typically considered when routes to the plant are impassable and time considerations for delivery will not be met with ground transportation. Multiple pre-selected routes are one method to circumvent the effects of seismic events, floods, etc. and these routes will take into account potentially impassible areas such as bridges, rivers, heavily wooded areas and towns. The drivers will have the routes marked and will be in communication with the NSRC to ensure that the equipment arrives on time.

The equipment stored and maintained at the NSRC for transportation to the local assembly area to support the response to a BDBEE at BFN is listed in Table 2.

2.12 Habitability and Operations

Following a BDBEE and subsequent ELAP event at BFN, ventilation providing cooling to occupied areas and areas containing FLEX strategy equipment will be lost. Per the guidance given in NEI 12-06, FLEX strategies must be capable of execution under the adverse conditions (unavailability of installed plant lighting, ventilation, etc.) possible following a BDBEE resulting in an ELAP concurrent with LUHS. The primary concern with regard to ventilation is the heat buildup which occurs with the loss of forced ventilation in areas that continue to have heat loads. Loss of ventilation analyses were performed to quantify the maximum steady state temperatures expected in specific areas related to FLEX implementation to ensure the environmental conditions remain acceptable for personnel habitability or accessibility and within equipment limits. NUMARC 87-00 (Reference 3.8) has established 110°F as a conservative limit for control room habitability.

The key areas identified for all phases of execution of the FLEX strategy activities are the MCR, RCIC pump room, battery and shutdown board rooms.

2.12.1 RCIC Pump Room

Calculations (Reference 3.3.1) indicate RCIC room temperature will exceed 150°F, the RCIC EG-M limit, in approximately 7 hours. At this point, EG-M failure begins to occur (Reference 3.6.6). In order to assure continued operation with high RCIC room temperatures, 2 EOI appendices are directed to be performed during the event. EOI Appendix-16K (Reference 3.4.17) is performed to bypass the RCIC area high temperature isolations. EOI Appendix-20M (Reference 3.4.22) is performed, and it contains steps to disable the RCIC EG-M and control flow with the RCIC trip/throttle valve, FCV-71-9. These appendices are performed as soon as the event is entered and do not require entry into the RCIC room. At approximately one hour into the event, the room is entered for approximately 15 minutes is to perform initial lineup of the cooling water supply to the RCIC oil cooler (Reference 3.4.30). Ice vests are available for use if desired.

It is not anticipated that continuous habitability would be required in the RCIC pump room.

2.12.2 Battery and Shutdown Board Rooms

During battery charging operations in Phase 2 and 3, ventilation is required in the main battery rooms due to hydrogen generation. A calculation (Reference 3.3.8) indicates the earliest time to reach 2% hydrogen concentration is 65 hours after batteries are placed on charge. A calculation (Reference 3.3.7) gives the required minimum ventilation to maintain <2% hydrogen. Procedures (Reference 3.4.36) will establish required ventilation to maintain less than 2% hydrogen concentration.

For Phase 2, there is limited access required to these rooms, with none requiring continuous occupation. The battery rooms were evaluated (Reference 3.3.1) for temperatures and it was determined that none of the battery rooms exceeds 110°F if the required doors are opened and ventilation established. Procedures will be implemented (Reference 3.4.36, 3.4.48) to establish the open doors and ventilation required by the calculation.

For all phases, there is limited access required to the Shutdown Board Rooms with none requiring continuous occupation. Calculations (Reference 3.3.1) indicate the room temperatures at 72 hours to range from 105-112°F. A calculation (Reference 3.3.16) provides results that the equipment can adequately withstand these temperatures.

2.12.3 Main Control Room

The strategy for maintaining the environment of the MCR during Phase 2 will be by the employment of normal Control Bay Ventilation area coolers as directed by plant procedures (Reference 3.4.36). If necessary, portable fans and ductwork can be installed as needed (Reference 3.4.36). Calculations (Reference 3.3.1) verify that the portable fans alone will maintain MCR temperature below 110°F.

The Phase 3 strategy for MCR cooling is to continue the Phase 2 strategy supplemented by portable equipment delivered from off-site. See Table 2 for a list of equipment that will be delivered to the site by the NSRC after notification by the plant. Refer to Section 2.11 for a discussion on NSRC supplied equipment.

As resources become available, actions can be taken to transition away from extended Phase 2 coping strategies. Since no time sensitive Phase 3 actions have been identified, instructions for connection and utilization of NSRC equipment for long term coping or recovery will be provided by TSC personnel who will have assessed the condition of the plant and infrastructure, plant accessibility, and additional available off-site resources (both equipment and personnel) following the BDBEE.

2.13 Personnel Habitability

Personnel habitability was evaluated in Section 2.12 and determined to be acceptable.

2.14 Lighting

Flashlights are the primary means of lighting to accomplish FLEX actions. All operators are required to have flashlights. In addition, the TSC storage lockers, located on the Control Bay elevation 617 between the Unit 2 and 3 Control Rooms include a stock of flashlights and batteries to further assist the staff responding to a BDBEE event during low light conditions. Also, portable LED light units are stored in the FLEX equipment room Control Bay 1C elevation 593, the Relay Room Cage Control Bay elevation 617, and the FLEX Equipment Storage Building.

The majority of areas for ingress/egress and deployment of FLEX strategies contain emergency lighting fixtures (NFPA 805 Defense in Depth lighting) consisting of a battery, battery charger and associated light fixtures. These emergency lights are designed and periodically tested to ensure the battery pack will provide a minimum of 8 hours of lighting with no external AC power sources. Therefore, these currently installed emergency lighting fixtures provide lighting to light pathways for 8 hours.

There are no emergency lighting fixtures in the yard outside of the protected area to provide necessary lighting in those areas where portable FLEX equipment is to be deployed. Therefore, while not credited, the large FLEX pumps and generators are outfitted with lights that can be powered from either their respective diesel generators or batteries in order to support connection and operation. In addition to the lights installed on the FLEX equipment, the FESB contains 10 portable LED light units and 6 generator-powered light towers for use.

After approximately 8 hours, the 4160V FLEX Generators will restore power to the 480V distribution system. Restoration of the normal lighting boards in the Control Bay, Reactor Buildings, and Turbine Buildings is directed by procedure (3.4.33) when power is restored.

2.15 Communications

2.15.1 Telephone Switching System

The BFN telephone system is diverse and separated by three nodes. It provides the primary means for two-way voice communications throughout the site and off-site. Multiple nodes or switches are interconnected by a network of copper and fiber optic cable and powered by battery-backed supplies. Each Node has automatic switching to Uninterruptible Power Supplies (UPS) following the loss of normal AC power.

- Node 1: Provides service to and extends throughout the Reactor, Turbine, Control, Stack, Offgas and Intake Buildings (Power Block). Node 1 is connected to Nodes 2 and 3 by way of cabling which extends through Unit 2 Turbine Building and Switchyard tunnels. The server cabinet is anchored to the floor to maintain the seismic class II requirements. The Node 1 servers are powered by a 30 amp, 120V electrical feed. Node 1 is additionally powered by a 3 hour UPS. Node 1 can be powered by a portable generator power supply for indefinite coping (Reference 3.4.37).

- Node 2: Provides service to the plant telephone equipment located generally on the west side of the power block and includes areas such as the Service Building, Engineering Buildings, and the three administration buildings. Node 2 is located outside the PA on the west side of the plant. Node 2 provides the primary interface between BFN and the public switched network which provides local and long distance access.

- Node 3: Provides service to plant telephone equipment located generally on the east side of the power block and includes areas such as; the Modifications Buildings, the Materials Complex and the Training Center among others areas. Node 3 is located in the Node 3/Computer Communications Building.

	BDBEE - Seismic (ELAP / LUHS)	BDBEE - Flood (ELAP / LUHS)	BDBEE - High Winds (ELAP / LUHS)
Node 1	Credited to Survive in the Reactor, Control and Diesel Generator Buildings	Credited to Survive in the Reactor, Control and Diesel Generator Buildings	Credited to Survive in the Reactor, Control and Diesel Generator Buildings
Node 2	Not Credited to Survive	Not Credited to Survive	Not Credited to Survive
Node 3	Not Credited to Survive	Not Credited to Survive	Not Credited to Survive

2.15.2 In Plant Radio System

The Inplant Radio System consists of a UHF/VHF trunked system and an independent VHF channel (F4). The radio system is powered by Class 1E 480V DG Auxiliary Boards A and B. In the event of an ELAP/LUHS event, power to radio equipment will be automatically transferred to backup source.

The backup power source is a UPS with battery capacity to supply four (4) UHF channels for three hours. UPS conservation is accomplished by switching off one of the two UPSs until such time the active UPS reaches “low level” (Reference 3.4.37). Then the UPS previously switched off can be returned to service extending the overall time the radio system can remain operable without portable generator power to approximately 6 hours. The loads supplied via UPS can be alternatively supplied from portable generator via transfer switch (Reference 3.4.37).

BFN maintains a large number of handheld radios, batteries and charging units. The FLEX program does not maintain dedicated handheld radios. These units, spare batteries and chargers will be gathered, if not readily available, in the control rooms.

Handheld Radios can additionally be operated in “Radio-to-Radio” mode enabling communications not affected by shielding or distance.

	BDBEE - Seismic (ELAP / LUHS)	BDBEE - Flood (ELAP / LUHS)	BDBEE - High Winds (ELAP / LUHS)
Inplant Radio System (Internal Communications / Reactor and EDG Buildings)	Credited to Survive	Credited to Survive	Credited to Survive
Inplant Radio System (External Communications / Near Site)	Credited to Survive	Credited to Survive	Not Credited to Survive. Radio to Radio if available (Based upon external antennae location - some external communications may survive)

2.15.3 Satellite Telephone System

Fixed Satellite telephones are located in the Unit 1/2 and 3 Control Rooms along with the Technical Support Center (TSC) and Local Recovery Center. The Control Room and TSC fixed satellite telephones communicate to Node 1 and continue to Node 3 travelling through Node 2. The antennae and associated hardware supporting the fixed satellite telephones for the Control Rooms and the TSC is located in Node 3.

Portable satellite telephones are available in the TSC. The portable satellite telephones require continuous "Line-of-Sight" with the sky during operation. The batteries are rated for 8 hours continuous talking and 100 hours on standby. Portable satellite telephones can be recharged utilizing portable generators for indefinite coping.

	BDBEE - Seismic Availability	BDBEE - Flood Availability	BDBEE - High Winds Availability
Fixed Satellite Telephone	Not Credited to Survive	Not Credited to Survive	Not Credited to Survive
Portable Satellite Telephone	Credited to Survive	Credited to Survive	Credited to Survive

2.15.4 Other Communications Systems

Other communication systems may be available, however, none are credited to survive the BDBEE events:

- Paging System (Loudspeaker)
- Microwave System
- Emergency Radio System
- TPS UHF Radio System
- Sheriff's Radio System
- Radio Paging System
- NRC Emergency Notification System (ENS).

2.16 Water sources

2.16.1 Suppression Pool

The Suppression Pool or torus, is part of Primary Containment (Reference 3.27). The pool serves as the heat sink for reactor vessel MSRV discharges and RCIC turbine steam exhaust during the ELAP/LUHS event. It is also the suction source for the RCIC pump for providing core cooling after the suction of the RCIC is swapped from the CST, if the CST is unavailable. The Suppression Pool is a safety-related, seismically qualified structure which is protected from BDBEE hazards (Reference 3.27).

2.16.2 Condensate Storage Tank

Each unit has one (1) CST with an minimum inventory of 135,000 gallons of water (Reference 3.27). Based on the minimum volume of water available, the volume in the CST can support core cooling and heat removal requirements in for approximately the first 8 hours. If it remains available following the event, the CST is used as the initial source of water for RPV make-up and is the primary long term storage tank. However, the CST is not a safety-related, seismically qualified structure and may not remain available.(Reference 3.27).

2.16.3 Ultimate Heat Sink (Tennessee River)

The FLEX pump will be available to be placed in service at approximately 8 hours to provide make up to the RPV from the Tennessee River. The UHS is designed to provide adequate cooling water to dissipate waste heat from the plant. In the event of a failure of the downstream dam (Wheeler) were to occur, a pool of water containing a volume of approximately 69.6 x 10^6 cubic feet of water would be available to the FLEX pumps at the plant intake (Reference 3.27).

2.17 Shutdown and Refueling Analysis

BFN abides by the Nuclear Energy Institute position paper entitled "Shutdown/Refueling Modes" (Reference 3.2.5) addressing mitigating strategies in shutdown and refueling Modes. This paper has been endorsed by the NRC Staff (Reference 3.1.10).

The strategy for core cooling for Modes 4 and 5 are, in general, similar to those for Modes 1-3. BFN has also incorporated guidance from the BWROG technical paper BWROG-TP-15-019 (Reference 3.6.9).

Resulting from this guidance, BFN revised NPG-SPP-07.2.11, Shutdown Risk Management. The purpose of this procedure is to apply administrative controls to ensure that FLEX capabilities remain available during outages. The BWROG technical product expands upon the guidance provided in reference above by defining specific BWR shutdown refueling mode conditions that pose a higher risk of challenges to decay heat removal functions. For each such condition, specific actions are identified that should be considered as part of the outage risk management program that are commensurate with the risk and applicable for a given plant state. The use of FLEX Equipment for maintaining the FLEX Strategy under these conditions is within the scope of Reference 3.2.1.

2.17.1 FLEX Mode 4

If an ELAP occurs during Mode 4 (cold shutdown), water in the vessel will heat up. When temperature reaches 212°F, (Mode 3, hot shutdown) the vessel will begin to pressurize. The turbine driven systems (RCIC and HPCI) are generally available for emergency use at the beginning and end of an outage, thus during the pressure rise RCIC can be returned to service with suction from the CST to provide injection flow. When pressure rises to the MSRV setpoints then pressure will be controlled by MSRVs. The primary and alternate strategies for Mode 4 are the same as those for Modes 1 – 3 as discussed for core cooling (Section 2.4). It should be noted that the heatup from cold shutdown conditions through vessel pressurization will provide a significant amount of time to obtain FLEX water sources for makeup and cooling and DG for electrical power.

2.17.2 FLEX Mode 5

During Mode 5, many variables exist which impact the ability to cool the core. To accommodate the activities of vessel disassembly and refueling, water levels in the reactor vessel and the reactor cavity are often changed. The most limiting condition is the case in which the reactor head is detensioned and water level in the vessel is at or below the reactor vessel flange. If an ELAP concurrent with LUHS occurs during this condition then (depending on the time after shutdown) boiling in the core occurs quite rapidly. To mitigate the consequences of this scenario, a FLEX Pump System will be pre-staged.

With the reactor head removed and SFP gates removed in Mode 5, makeup to the RPV can also be accomplished via the SFP makeup strategy utilizing the FLEX pump.

2.17.3 Modes 4 and 5 SFP Cooling Strategy

For SFP considerations refer to Section 2.5.

2.17.4 Modes 4 and 5 Containment Strategies

Except for the specific containment closure requirements of Technical Specifications, equipment hatches and airlocks are often opened during outages. Each breach of containment integrity is administratively controlled. While the containment may not initially be isolated in operating Modes 4 and 5, plant operating procedures require that containment be manually isolated following the ELAP event. If the penetrations are closed then the Phase 1 and 2 FLEX strategy will be employed (i.e. use of HCVS) if containment limits should be approached. The coping strategy for maintaining containment integrity includes monitoring containment pressure.

2.18 Sequence of Events

Table 4 presents a sequence of events timeline for an ELAP concurrent with LUHS event at BFN. Validation of each of the FLEX time constraint actions has been completed in accordance the FLEX Validation Process document issued by NEI (Reference 3.2.3) and includes consideration for staffing). Time to clear debris to allow equipment deployment is assumed to be up to 2 hours. This time is considered to be conservative based on site reviews and the location of the FLEX storage building. Debris removal equipment is stored in the FLEX storage building.

2.19 Programmatic Elements

2.19.1 Overall Program Document

Tennessee Valley Authority's (TVA) program for FLEX in response to a BDBEE is described in two documents; the program description - for common elements applicable to all TVA sites (Reference 3.4.2) and a plant specific program document for BFN (Reference 3.4.5). Together, the two documents describe the FLEX program for BFN. Key elements of the BFN FLEX program include:

- A summary of FLEX strategies including validation methods
- A description of FLEX equipment including:
    - Quality attributes
    - Maintenance and testing
    - Functionality tracking
    - Storage
    - Requirements for deployment.
- A description of TVA's FLEX procedure development including:
    - The interface between design basis and beyond design basis procedures
    - Procedure maintenance
    - Application of procedures during emergencies
    - Plant configuration control
    - Changes to FLEX strategies
    - Configuration management
    - Activities that potentially affect FLEX strategies
    - Plant configuration control processes during emergencies
    - A summary of personnel related items including staffing and training.

2.19.2 Procedural Guidance

The inability to predict plant conditions following an extreme external event prompted the creation of a new set of procedures. These procedures, FLEX Support Instructions (FSIs), provide guidance for deployment of FLEX equipment. FSIs are written such that they can be implemented during a variety of post event conditions, and were developed to provide pre-planned strategies for accomplishing specific tasks associated with implementation of FLEX strategies. Clear criteria for entry into the FSIs will ensure that the FLEX strategies are used only as directed, and are not used inappropriately in lieu of existing procedures. When a BDBEE event occurs, plant operators are trained to recognize the entry requirements and enter 0-FSI-1 (Reference 3.4.26), the command and control procedure. This procedure will direct entry into the appropriate FSIs that deploy necessary FLEX equipment required to support plant EOIs when called upon. This procedure approach conforms to NEI 12-06 (Reference 3.2.1) guidance for the relationship between FLEX procedures and other relevant plant procedures.

Changes to plant procedures including FSIs are controlled by TVA procedures (Reference 3.4.3), and will be reviewed to ensure the strategy remains feasible and does not adversely alter the intent of this document or the FLEX Program Manual.

2.19.3 Staffing

Using the methodology of NEI 12-01 (Reference 3.2.3), assessments of the capability of the BFN on-shift staff and ERO to respond to a BDBEE were performed for Phase 1 and for Phase 2 (Reference 3.37).

2.19.4 Training

Training has been developed and delivered to the target populations (operations, maintenance, security, and ERO staff) using the systematic approach to training (SAT) process. This training TVA satisfies the requirements of NEI 12-06 (Reference 3.2.1).

The TVA general population is trained using NANTeL courses provided by the Emergency Response Training Development (ERTD) Working Group (INPO facilitated). The ERTD conducted a job analysis to identify common training topics and coordinated the design and development of common training materials. TVA staff responsible for the implementation of the FSIs also complete additional NANTeL training provided by the ERTD working group.

ERO decision makers receive additional training on directing actions and implementing strategies following a BDBEE.

2.19.5 <u>FLEX Equipment List</u>

The equipment necessary for the implementation of the FLEX strategies in response to a BDBEE at BFN is listed in Table 1. The table includes the quantity and equipment performance criteria for the required FLEX equipment. FLEX equipment is primarily stored in the FLEX storage building, however some equipment (spray nozzles for SFP makeup, cables, lights and miscellaneous items) are stored near their staging areas in the Reactor Building and Control Bay. Details regarding fittings, tools, hose lengths, consumables, etc. are not in Table 1, but are detailed in Reference 3.4.46.

2.19.6 <u>N+1 Equipment Requirement</u>

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

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

2.19.7 <u>Equipment Maintenance and Testing</u>

FLEX equipment (including support equipment) is subjected to initial acceptance testing and to periodic maintenance and testing utilizing the guidance provided in INPO AP 913, Equipment Reliability Process (Reference 3.26), to verify proper function.

The standard EPRI industry PM process (similar to the Preventive Maintenance Basis Database) is used to establish the maintenance and testing actions for FLEX equipment. This provides assurance that stored or pre-staged FLEX equipment is being properly maintained and tested.

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

The PM Templates include activities such as:

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

2.19.8 <u>FLEX Equipment Functionality Tracking</u>

The functional status of FLEX equipment and applicable connections that directly perform a FLEX mitigation strategy for core, containment, and SFP is managed such that risk to mitigating strategy capability is minimized. Maintenance/risk guidance conforms to the guidance of NEI 12-06 (Reference 3.2.1). Functional status of FLEX equipment and connections are tracked using procedures for out of service equipment (Reference 3.4.4).

FLEX equipment and connections will not normally be used for purposes other than emergency response. It is permissible, however, to pre-stage and/or use FLEX equipment and connections provided the following requirements are met:

- Permission is received from the Shift Manager or Emergency Director.
- The proper action to restore the equipment to an functional status is determined and the status of the affected equipment and/or connection is tracked per Reference 3.4.4.

3 References

3.1 NRC Documents

3.1.1 Recommendations for Enhancing Reactor Safety in the 21st Century, the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident, US NRC, July 12, 2011, ML112510271

3.1.2 JLD-ISG-2012-01, Rev. 1, Compliance with Order EA-12-049, “Order Modifying Licenses with Regard to Requirements for Mitigating Strategies for Beyond-Design-Basis External Events”; January 22, 2016, ML15357A163

3.1.3 JLD-ISG-2012-03, Rev. 0, NRC Interim Staff Guidance, Compliance with Order EA-12-051, Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation, ML12221A339

3.1.4 NRC EA-12-049, “Order to Modify Licenses With Regard To Requirements For Mitigation Strategies For BDBEE”

3.1.5 NRC EA-12-051 “Order to Enhance Spent Fuel Pool Instrumentation”

3.1.6 NRC EA-13-109, "BWR Mark I & II Reliable Hardened Containment Vents capable of Operation Under Severe Accident Conditions"

3.1.7 NRC Endorsement of EPRI Report: Augmented Approach for the Resolution of Fukushima NTTF Recommendation 2.1: Seismic, as an Acceptable Alternative to the March 12, 2012 Information Request, May 7, 2013, ML13106A331

3.1.8 NRC Endorsement Letter of NEI White Paper entitled “Battery Life Issue”, dated September 16, 2013, ADAMS Accession Number ML13241A188

3.1.9 NRC Endorsement Letter of NEI report “BWR Containment Venting” on behalf of the BWROG dated January 19, 2014, ADAMS Accession Number ML13358A206

3.1.10 NRC Endorsement Letter of NEI Position Paper “Shutdown/Refuel Modes”, dated September 30, 2013, ADAMS Accession Number ML13267A382

3.1.11 NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3 of the NTTF Force Review of Insights from the Fukushima Dai-ichi Accident, ML12053A340

3.1.12 Letter from NRC to NEI, "Trigger Conditions for Performing an Integrated Assessment and Due Date for Response, Dec. 3, 2012, ML12326A912

3.1.13 NRC GL 91-07 Reactor Coolant Pump Seal Failures and its Possible Effect on Station Blackout

3.1.14 NRC Letter to TVA, BFN Plant, Units 1, 2, and 3-Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request-Flood Causing Mechanism Reevaluation, ML15240A189

3.1.15 NRC Letter to TVA, BFN Plant, Units 1, 2, and 3-Staff Assessment of Information Provided in Response to 10 CFR 50.54(f) Information Request-Seismic Hazard Reevaluation for Recommendation 2.1, ML15090A745

3.1.16 NRC Letter to TVA, BFN Plant, Units 1, 2, and 3-Staff Review of Interim Evaluation Associated with Reevaluated Seismic Hazard Implementation of NTTF Recommendation 2.1, ML15203A875

3.1.17 Final Determination of Licensee Seismic Probabilistic Risk Assessments Under the Request for Information Pursuant to Title 10 CFR 50.54(f) Regarding Recommendation 2.1 "Seismic" of the NTTF Review, ML15194A015

3.1.18 NRC Letter to TVA, BFN Plant, Units 1, 2, and 3-Staff Review of SFP Evaluation Associated with Reevaluated Seismic Hazard Implementing NTTF Recommendation 2.1, ML17024A164

3.2 NEI Documents

3.2.1 NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide", Rev. 4

3.2.2 NEI 12-02, Industry Guidance for Compliance with NRC Order EA-12-051, To Modify License with Regard to Reliable SFP Instrumentation, Revision 1

3.2.3 NEI 12-01, "Guideline for Assessing Beyond-Design-Basis Accident Response Staffing and Communications Capabilities"

3.2.4 NEI White Paper entitled "Battery Life Issue", dated August 27, 2013 (ADAMS Accession Number ML13241A186

3.2.5 NEI White Paper entitled "Shutdown/Refueling Modes "(ADAMS Accession Number ML13190A157

3.3 BFN Calculations

3.3.1 CDQ000020080054 Rev. 4, PMF Determination for Tennessee River Watershed

3.3.2 EDQ0009992013000202 Rev. 1, 250V Unit Batteries 1, 2, and 3 Evaluation for Beyond Design Basis External Event Extended Loss of AC Power (ELAP).

3.3.3 MDQ0003602014000222 Rev. 2, BFN ELAP Transient Temperature Analysis

3.3.4 MDQ00778880333 Rev. 6, Spent Fuel Pool Heatup Rate No Cooling or Makeup

3.3.5 Jensen Hughes Report, # 06050-RPT-13406 Rev. 1, MAAP 4.0.7 Thermal Hydraulic Calculations to Support Extended Loss of AC Power FLEX Strategies, EDMS R06 180502 829

3.3.6 CDQ0009992014000268 BFN Expedited Seismic Evaluation Process HCLPF Capacity Evaluations

3.3.7 MDQ0031890069 Rev. 1, Hydrogen Concentration in the Control Bay 250V Battery Rooms

3.3.8 MDQ099920040019, Hydrogen Generation Rate in 250V Battery Rooms

3.3.9 MDQ0009992014000239, Alternate Nitrogen Supply Volume Requirements

3.3.10 CDQ007920030261, Soil Structure Interaction Analysis for the BFN ISFSI Pad

3.3.11 MDQ0009992014000291, Rev. 0, Reactor Building Transient Temperature

3.3.12 MDN0003602014000233, Hydraulic Analysis-Fukushima FLEX Modification

3.3.13 CDQ0003602013000136, FESB-Structural Calculations

3.3.14 EDQ0003602015000325, Electrical Evaluation for 4kV FLEX Turbine Generators

3.3.15 EDQ0003602014000281, Electrical Evaluation for Portable Power Supply for Unit Battery Chargers

3.3.16 GENSTP3-001, Upper Boundary Temperature for Mild Environments Related to Environmental Qualification of Electrical Equipment, B45 880121 200

3.3.17 MDQ0003502014000294, Diesel Fuel Transfer Pump Sizing for 480V Generator

3.3.18 SL-012570, Diesel Fuel Transfer Pump Sizing Evaluation for DCN 71405 1.0MW 4.16kV Generators

3.4 TVA Procedures

3.4.1 NPG-SPP-09.3 Plant Modifications and Engineering Change Control

3.4.2 NPG-SPP-09.22.2 Diverse and Flexible Coping Strategies (FLEX) Program Document

3.4.3 NPG-SPP-01.2, Administration of Site Technical Procedures

3.4.4 OPDP-8, Operability Determination Process and Limiting Conditions for Operation Tracking

3.4.5 0-TPP-ENG-632(Bases) Diverse and Flexible Coping Strategies (FLEX) Program Bases Document

3.4.6 1,2,3-OI-71, RCIC System

3.4.7 1,2,3-OI-73, HPCI System

3.4.8 0-AOI-57-1A Loss of Offsite Power/Station Blackout

3.4.9 0-AOI-100-3, Flood Above Elevation 558'

3.4.10 1,2,3-AOI-78-1 Fuel Pool Cooling System Failure

3.4.11 1,2,3-EOI-1 RPV Control

3.4.12 1,2,3-EOI-2 Primary Containment Control

3.4.13 1,2,3-EOI-3 Secondary Containment Control

3.4.14 1,2,3-EOI Appendix-8G, Crosstie CAD to Drywell Control Air

3.4.15 1,2,3-EOI Appendix-11A Alternate RPV Pressure Control Systems-MSRVs

3.4.16 1,2,3-EOI Appendix-13 Emergency Venting Primary Containment

3.4.17 1,2,3-EOI Appendix-16K Bypassing RCIC High Temperature Isolations

3.4.18 1,2,3-EOI Appendix-20E, SFP Injection Using FLEX Pump (Standby Coolant)

3.4.19 1,2,3-EOI Appendix-20G, SFP Injection/Spray Using FLEX Pump (EECW)

3.4.20 1,2,3-EOI Appendix-20H Alternate N2 Supply to SRVs

3.4.21 1,2,3-EOI Appendix-20K Suppression Pool Let Down using RCIC

3.4.22 1,2,3-EOI Appendix-20J Suppression Pool Level Makeup

3.4.23 1,2,3-EOI Appendix-20M RCIC Operation during Station Blackout

3.4.24 EOI Program Manual Sections 1,2,3-VI-N NPSH Worksheet 15

3.4.25 0-TI-394, Technical Support Guidelines for SAMGs

3.4.26 0-FSI-1, FLEX Response Instruction

3.4.27 0-FSI-2A, CILRT FLEX Pump System Setup and Operation

3.4.28 0-FSI-2B, RHRSW FLEX Pump System Setup and Operation

3.4.29 0-FSI-2C, EECW FLEX Pump System Setup and Operation

3.4.30 0-FSI-2E, FLEX Mechanical Hose Connections

3.4.31 0-FSI-2F, FLEX Alternate Mechanical Hose Connections

3.4.32 0-FSI-3A, 480V FLEX Generator Setup and Operation

3.4.33 0-FSI-3C, 4KV FLEX Generator Setup and Operation

3.4.34 1,2,3-FSI-3E, MSRV Cart Setup and Operation from Panel 25-32

3.4.35 0-FSI-3F, Load Shed of 250V Main Bank Batteries 1,2,3

3.4.36 0-FSI-4A, Control Bay/Reactor Building Lighting and Ventilation During ELAP

3.4.37 0-FSI-4B, FLEX Communication System Operation

3.4.38 0-FSI-6A, Damage Assessment

3.4.39 0-FSI-6B, FLEX Long Term Fuel Operations

3.4.40 1,2,3-FSI-6C, Key Instrument Readings During Loss of DC Power

3.4.41 0-FSI-6E, FLEX Strategies During Severe Hot and Cold Environments

3.4.42 0-FSI-6H, CST Refill Using FLEX Pump System

3.4.43 0-FSI-8B FLEX Strategy Validation Process

3.4.44 EPIP-12, Emergency Equipment and Supplies

3.4.45 SSI-7.4, Bullet Resistant Enclosures/Semi Static Posts

3.4.46 0-FSI-8C, FLEX Tools and Equipment Inventory Checklist

3.4.47 0-GOI-300-1/Attachment 12 Outside Operator Rounds Log

3.4.48 SSI-16.1, Compensatory Measures

3.5 BFN Design Change Notices (DCN)

3.5.1 DCN 70745 Construct Flex Equipment Storage Building (FESB)

3.5.2 DCN 71470 480V FLEX Generator

3.5.3 DCN 71405 4kV FLEX Generator

3.5.4 DCN 71329 Mechanical Connections (EECW, RHRSW, RCIC Oil Cooler)

3.5.5 DCN 711837 (U1), 70810 (U2), 71386 (U3), MSRV Alternate N2 Supply

3.5.6 DCN 71454 FLEX Equipment Deployment Pathway

3.5.7 DCN 71162 (U1), 71335 (U2), 71336 (U3), Battery Backed Instrumentation

3.5.8 DCN 71159 (U1), 71160 (U2), 71161 (U3), SFP Instrumentation

3.5.9 DCN 70852 Communication System 244 VHF Radio & MW Radio System

3.5.10 DCN 71389 (U1), 71390 (U2), 71391 (U3), Modification of Hardened Containment Vent System to Comply with NRC Order EA 13-109

3.5.11 DCN 72434 Installation of Severe Accident Water Addition Line to Comply with NRC Order EA 13-109

3.6 GEH & BWROG Documents

3.6.1 Emergency Procedure and Severe Accident Guidelines, Revision 3 (February 2013)

3.6.2 GEH Evaluation of FLEX Implementation Guidelines, NEDC-33771P, Revision 0

3.6.3 BWROG Report, NEDC-32988-A, Rev 2, "Technical Justification to Support Risk Informed Modification to Selected Required Action End States for BWR Plants," Section I (NRC's SE) and Section II (Responses to NRC's RAI), ML030170060

3.6.4 BWROG-TP-14-006, Revision 0 March 2014, “Fukushima Response Committee Raw Water Issue: Fuel inlet blockage from debris”

3.6.5 BWROG-TP-14-018 BWROG Fukushima Response Committee BDB RCIC Elevated Temperature Functionality Assessment, Rev. 0, November 2014

3.6.6 BWROG RCIC Pump and Turbine Durability Evaluation – Pinch Point Study, 0000-0155-1545-R0

3.6.7 BWROG RCIC System Operation in Prolonged SBO-Feasibility Study, 0000-0143-0382-R0

3.6.8 BWROG TP-15-007 BWROG Fukushima Response Committee, Raw Water Issue: Heat Transfer Capability

3.6.9 BWROG-TP-15-019, BWROG Fukushima Response Committee, BWR-Specific Shutdown Refueling Mode Guidance

3.7 2009 ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers) Handbook

3.8 NUMARC 87-00, “Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors”, Revision 1

3.9 Final Response to Task Interface Agreement (TIA) 2004-04, “Acceptability of Proceduralized Departures from Technical Specifications (TSs) Requirements at the Surry Power Station, (TAC Nos. MC4331 and MC4332),” dated September 12, 2006 (ADAMS Accession No. ML060590273)

3.10 10 CFR 50.54 Conditions of Licenses

3.11 10 CFR 50.63(a) Loss of All Alternating Current Power

3.12 AREVA Document No.38-9233739-000, SAFER Response Plan for Browns Ferry Nuclear Plant

3.13 Engineering Information Record Document No.: 51-9198045-000, “Browns Ferry Post Fukushima FLEX Response Evaluation”

3.14 Engineering Information Record Document No. 51-9199717-011 National SAFER Response Center Equipment Technical Requirements

3.15 Position Paper: Shutdown/ Refueling Modes" (Agencywide Documents Access and Management Systems (ADAMS) Accession No. ML13273A514)

3.16 FLEX Implementation HVAC Analysis Impact Study, Project No. 12938-012 (Corporate)

3.17 Report of Geotechnical Exploration, Additional Haul Paths Analysis, Parts 1 thru 4, August 19, 2014

3.18 Report of State Route Study by AMEC Environment and Infrastructure Inc., Dated July 11, 2014.

3.19 Report of Geotechnical Exploration, Alternative Travel Path Analysis, Dated June 19, 2014.

3.20 Report of Geotechnical Exploration, Commercial Grade "Bunker" Building, Dated December 11, 2012.

3.21 Addendum to Report of Geotechnical Exploration, Ground Motion and Liquefaction Studies, Commercial Grade "Bunker" Building, Dated March 7, 2013.

3.22 TVA Contract 6992 and 6993, Mansfield Oil Company of Gainesville, Inc.

3.23 EPRI Technical Report 3002001785, Use of Modular Accident Analysis Program (MAAP) in Support of Post-Fukushima Applications, June 2013

3.24 MAAP4 Application Guidance, Desktop Reference for Using MAAP4 Software, Revision 2" Electric Power Research Institute Report 1020236, July 2010

3.25 ASCE 7-10, Minimum Design Loads for Buildings and Other Structures

3.26 INPO AP 913, Equipment Reliability Process

3.27 BFN Updated Final Safety Analysis Report (UFSAR), Revision 26

3.28 BFN Technical Specifications

3.29 BFN Technical Requirements Manual

3.30 BFN General Design Criteria 50-7360 FLEX Mitigation System

3.31 TVA, Letter to US Nuclear Regulatory Commission, Flood Hazard Reevaluation Report for Browns Ferry Nuclear Plant, Response to NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident , ML15072A130

3.32 Mitigating Strategies Assessment for Flooding, TVA Browns Ferry Nuclear Plant Units 1, 2, and 3, Response to NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Retarding Recommendations 2.1, 2.3, and 9.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident , ML16363A386

3.33 TVA, Letter to US Nuclear Regulatory Commission, TVA's Seismic Hazard and Screening Report, Response to NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident , ML14098A478

3.34 TVA, Letter to US Nuclear Regulatory Commission, TVA's Browns Ferry Nuclear Plant Expedited Seismic Evaluation Report Response to NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident , ML14365A046

3.35 TVA, Letter to US Nuclear Regulatory Commission, Spent Fuel Pool Evaluation Report for BFN, Units 1, 2, and 3- Response to NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident , ML16356A596

3.36 Completion of Required Action by NRC Order EA-12-051, Reliable Spent Fuel Pool Instrumentation, for Browns Ferry Units 1, 2, and 3, ADAMS Accession Number ML16060A175.

3.37 Browns Ferry Nuclear Plant (BFN) NEI 12-01 Phase 2 Extended Loss of AC Power (ELAP) ERO Staffing Analysis Report, ML15030A513

3.38 BFN FLEX Strategy Validation Report, R69 180403 419

3.39 BFN Validation of 0-AOI-100-3 Flood Above Elevation 558 ft., R40 161020 704

3.40 BFN FLEX Fuel Strategy Overview White Paper

Use and (potential / flexibility) diverse uses						Performance Criteria
Equipment	Core	Containment	SFP	Instrumentation	Accessibility	
Four FLEX Low Pressure Pumps,	X	X	X			5000 gpm 150 psig
Four Floating Booster Pumps	X	X	X			5,000 gpm 50 ft lift capacity
Two 4160 V FLEX Generators	X	X	X	X		4160v 1 MW
Two 480 V FLEX Generators	X	X	X	X		480 V 850 KW
Twenty Portable LED light stands	X	X	X		X	
One Track Loader – CAT 299D					X	
Three Diesel Transfer Pumps	X	X	X			125 gpm, diesel driven
Two Tow Vehicles (One equipped with “scraper blades. Both equipped with tire chains.)	X	X	X	X	X	4wd, transfer with 500 gallon truck bed mounted fuel tank and 25 gpm fuel transfer pump
Cables for connecting portable generators	X	X	X	X	X	N/A
Twelve Portable ventilation fans and ductwork	X	X	X	X	X	4340/3875/1300 cfm, 120V

Table 1 On-Site Major FLEX Equipment

	Use and (potential / flexibility) diverse uses						Performance Criteria	Notes
List portable equipment	Quantity	Core	Containment	SFP	Instrumentation	Access		
Low Pressure High Flow Pumps	3	X	X	X			5000 gpm, 150 psig	
Suction Booster Lift Pumps	6	X	X	X			5,000 gpm, 26 ft Lift	
Low Pressure/Medium Flow Pumps	3	X	X	X			2500 gpm, 300 psig	
RPV Makeup Pumps	3	X					500 gpm, 500 psig	
High Pressure Injection Pumps	3	X					60 gpm, 2000 psig	
Medium Voltage Generators	6	X	X	X	X	X	4kV, 1 MW	
Low Voltage Generators	3	X	X	X	X		480 V, 1000 KW	
Adapters and connectors	N/A	X	X	X		X	As required to implement strategies	
Diesel Transfer Pumps	3	X	X	X	X		200 gpm	

Table 2 Major FLEX Equipment from NSRC

	Use and (potential / flexibility) diverse uses						Performance Criteria	Notes
List portable equipment	Quantity	Core	Containment	SFP	Instrumentation	Access		
Mobile Lighting Towers	9					X		
Portable Diesel Fuel Transfer Pumps	3					X	60 gpm	
Diesel Fuel Air Lift Containers	3					X	500 gal.	
Portable Diesel Fuel Tanks with attached Transfer Pumps	3					X	264 gal, 25 gpm DC, 30 gpm AC	
Mobile Water Purification Units	3	X	X	X		X	250 gpm ea., Reverse Osmosis	
Water treatment pre-filters	3	X	X	X		X	500 gpm ea.	

Table 2 Major FLEX Equipment from NSRC (Continued)

Makeup Water Source	Min. Normal Volume (gals.)	Water Chemistry	Source Qualification
Condensate Storage Tank	135,000 (1 per unit)	Clean	Non-seismic
Suppression pool	960,000	Clean	Seismic Category I
Condenser Hotwell	90,000	Clean	Non-seismic
UHS (Tennessee River)	Continuous Source	Unclean	Undefined[2]

Notes:

1. All Seismic Category I structures and components are designed for protection from wind/tornado loadings, flooding, and missiles.
2. The Tennessee River is not defined as Seismic or non-seismic, however the intake structure is Seismic Category I

Table 3 On-Site Makeup Water Sources

Sequence of Events Timeline				
Action Item	**Elapsed Time**	**Action**	**Time Constraint Y/N**	**Remarks/Applicability**
1	- ~198 hours	For floods, plant shutdown begins when river level reaches 558' and it is predicted that level will exceed 565’. If river level is predicted to rise to PMF flood level of 572.5’, per procedure AOI-100-3. FLEX deployment begins.	N	Plant meets required shutdown criteria approximately 190+ hours before design basis peak flood level is reached.
2	-186 hours	For Floods, the plant is now is in cold shutdown.	N	
3	-72 hours	Flood waters reach plant grade level, FLEX pumps and portable generators (4kV and 480V) deployment must be complete.	N	
4	0	Point at which a DBF level would be reached.	N	
5	0	All offsite power, and normal access to the ultimate heat sink is lost.	N	
6	60secs	HPCI and RCIC achieve full flow. After HPCI and RCIC recover RPV level, HPCI will be secured and RCIC will be the primary system for RPV level control	N	Design basis response to loss of offsite power.
7	15 min.	ELAP declared, ELAP procedures entered	Y	ELAP declared within 15 minutes to allow sufficient time to perform DC shed
8	15 min.	Commence load shedding of non-essential DC loads	N	Must be complete within 1 hour to extend battery coping time to 12 hours

Table 4 Sequence of Events Timeline

Sequence of Events Timeline				
Action Item	**Elapsed Time**	**Action**	**Time Constraint Y/N**	**Remarks/Applicability**
9	20 min	RPV depressurization commences at ≤ 100°F/hr.	Y	Requirement of 0-AOI-57-1A.
10	1 hour	DC load shed complete	Y	Battery coping period extended to 12 hours
11	1 hour	Refuel floor and Reactor Building doors opened	Y	Required to ventilate RFF and limit building temperatures (Reference 3.3.11)
12	1 hour	Commence deployment of the 4160V FLEX Generator	N	
13	1 hour	Commence deployment of the CILRT FLEX Pumping Systems	N	
14	2 hours	RPV depressurization complete, pressure maintained 150-300 psig	N	Pressure band allows continued operation of RCIC
15	4 hours	Control Bay doors opened	Y	Requirement of 0-FSI-4A to limit temperature increase per Reference 3.3.1
16	4-5 hours	Anticipatory venting of the containment via the hardened wetwell vent will commence.	Y	Time based on BFN Calculation. Venting provides a path for heat removal from the torus.
17	8 hours	4160V FLEX generator deployed and aligned to the safety related battery charger for each unit. Battery charging commences.	Y	4kV and 480V safety related distribution systems now energized. Loads may be energized as desired by site personnel.
18	8 hours	CILRT FLEX pumps deployed and aligned to provide RPV & SFP makeup	Y	

Table 4 Sequence of Events Timeline (continued)

Sequence of Events Timeline				
Action Item	**Elapsed Time**	**Action**	**Time Constraint Y/N**	**Remarks/Applicability**
19	12 hours	EECW FLEX pumps deployed and aligned.	N	
20	12 hours	Sustain coping by maintaining equipment fueled and in service	N	
21	20 hours	Control Bay ventilation in service	Y	Requirement of 0-FSI-4A to limit temperature increase per Reference 3.3.1
22	24 hours	FLEX equipment arrives from the NSRC and will be stored at staging area “B”	N	Aids in recovery and provides equipment redundancy.
23	65 hours	Manual actions to prevent excessive hydrogen accumulation in battery rooms if ventilation is not restored.	N	Reference 3.3.8 indicates the earliest time to reach 2% hydrogen concentration is 65 hours after batteries are placed on charge. Reference 3.3.7 gives required minimum ventilation to maintain <2% hydrogen. 0-FSI-4A (Reference 3.4.36) will establish required ventilation to maintain less than 2% hydrogen concentration.

Table 4 Sequence of Events Timeline (continued)

Discussion of time constraints identified in Table 4.

Item 7 & 10: ELAP declaration and commencement of DC load shed required within 15 minutes to ensure completion of load shed within 1 hour. This will ensure battery coping time extended to 12 hours (Reference 3.3.2).

Item 9: RPV depressurization starts at 20 minutes at a rate up to 100°F/hr. Operators are trained to recognize, initiate, and complete the depressurization in the required time.

Item 11: Required to ventilate RFF and limit building temperatures (Reference 3.3.11). Opening of specified doors will allow natural circulation to remove heat and assist in moisture removal from SFP heatup.

Item 15: Control Bay rooms were evaluated (Reference 3.3.1) for temperature and it was determined that none of the battery rooms exceeds 110°F if the required doors are opened and ventilation established. Procedures (Reference 3.4.36) will be performed to establish the required open doors, fans and ductwork required by the calculation.

Item 16: Time based on Reference 3.3.5. Venting provides a path for heat removal from the torus, and is performed in accordance with plant EOIs (Reference 3.4.12).

Item 17: 4160V FLEX generator is deployed and connected to the safety related battery charger for each unit. Battery charging commences. Based on battery coping life of 12 hours (Reference 3.3.2), this 8 hour requirement is sufficient to ensure battery life. In the event of unavailability of the 4160V FLEX generators, the 480V FLEX generator will be utilized. Validation was performed in accordance with 0-FSI-8B and demonstrated this action can be completed in less than 8 hours (Reference 3.38).

Item 18: CILRT FLEX pumps will be available to provide RPV makeup using Core Spray injection path, and SFP makeup using the normal CS&S supply. Eight hour makeup requirement is in accordance with Reference 3.1.6.

Item 21: Calculation(Reference 3.3.1) specifies manual actions to ensure acceptable room temperatures. 0-FSI-4A (Reference 3.4.36) will establish the required ventilation.

Table 5
Key Instrumentation

Parameter	UNID	Location	Power Supply
RPV Level	LI-3-52 LI-3-58A LI-3-208A LI-3-208C	9-3 9-5 9-5 9-3	DIV I ECCS INV
	LI-3-55 LI-3-62 LI-3-58B LI-3-208B LI-3-208D LI-3-53	9-3 9-3 9-5 9-5 9-3 9-3	DIV II ECCS INV
RPV Press	PI-3-74A PIS-3-74A	9-3 9-81	DIV I ECCS INV
	PI-3-74B PIS-3-74B	9-3 9-82	DIV II ECCS INV
DW Press	PI-64-67B	9-3	DIV I ECCS INV
	PR-64-50	9-3	DIV II ECCS INV
DW Temp	TI-64-52AB	9-3	DIV I ECCS INV
Suppr Chamber Press	PT-64-51	9-3	DIV I ECCS INV
Suppression Pool Level	LI-64-159A	9-3	DIV I ECCS INV
	LI-64-159B	9-3	DIV II ECCS INV
Suppression Pool Temp	TI-64-161	9-3	DIV I ECCS INV
	TI-64-162	9-3	DIV II ECCS INV

Table 5 Key Instrumentation

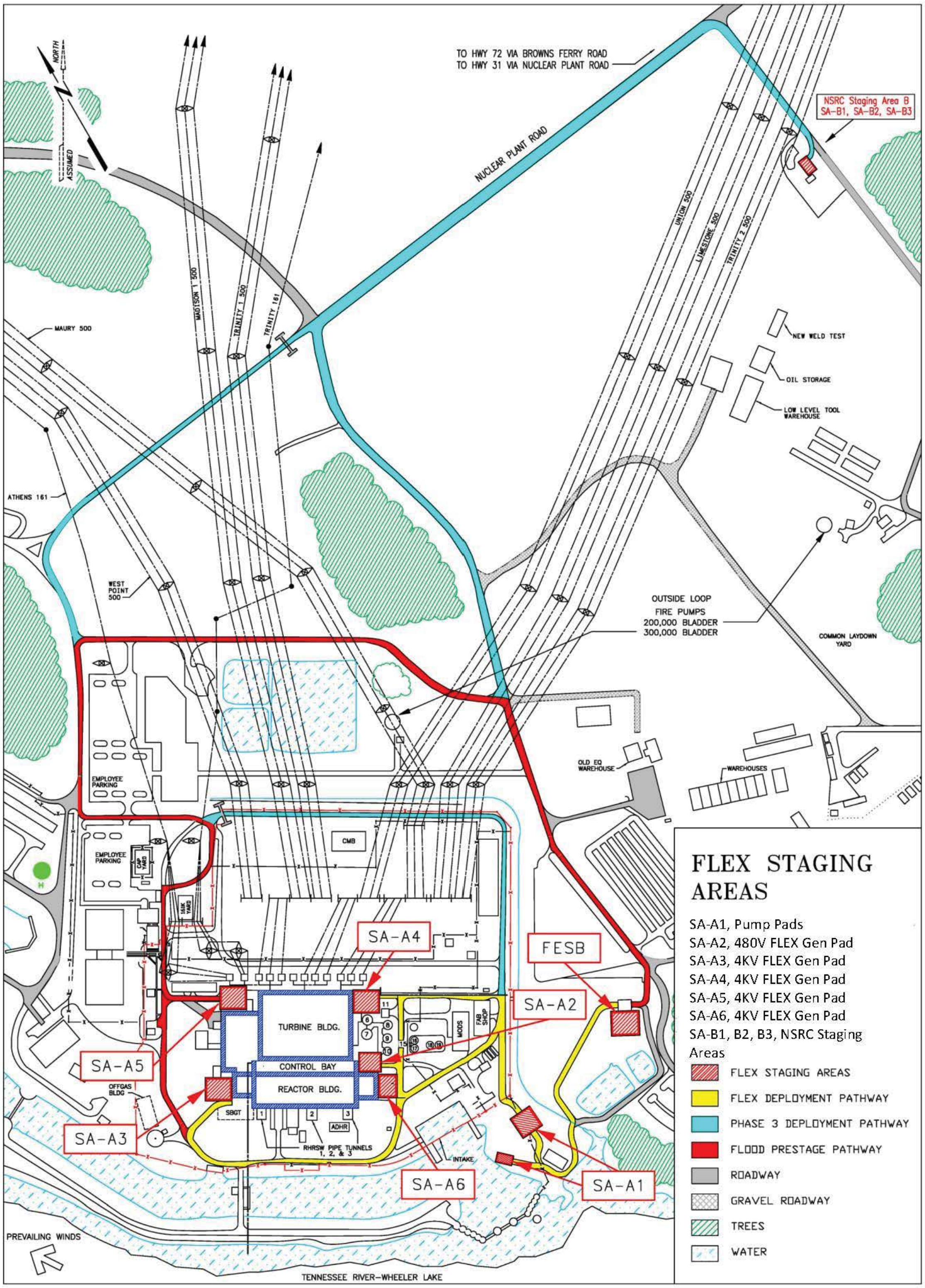

Figure 1 Site Layout and FLEX Staging Areas

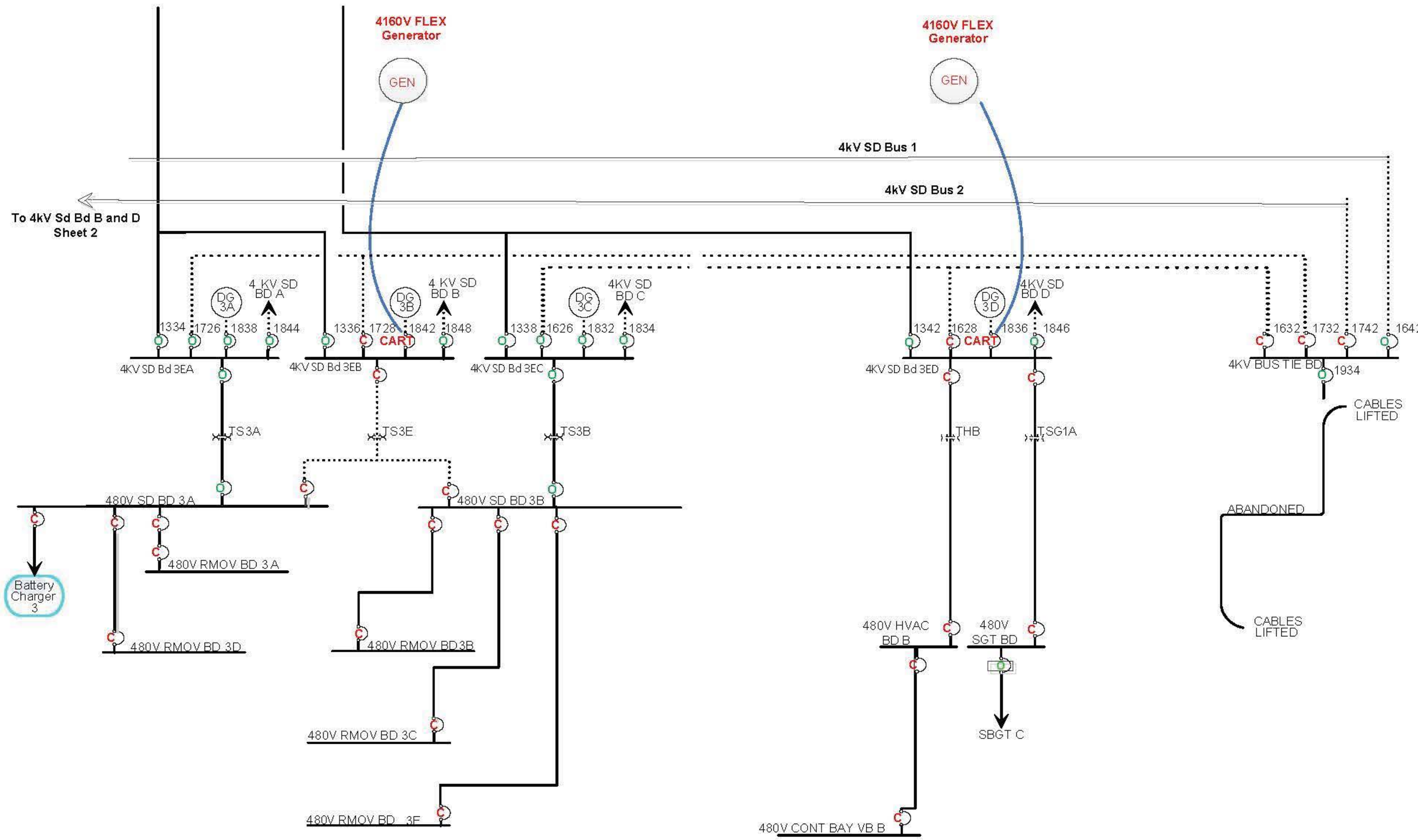

Figure 2 4KV SD Bds 3EB and 3ED 4kV FLEX Generator Connection Points Sheet 1

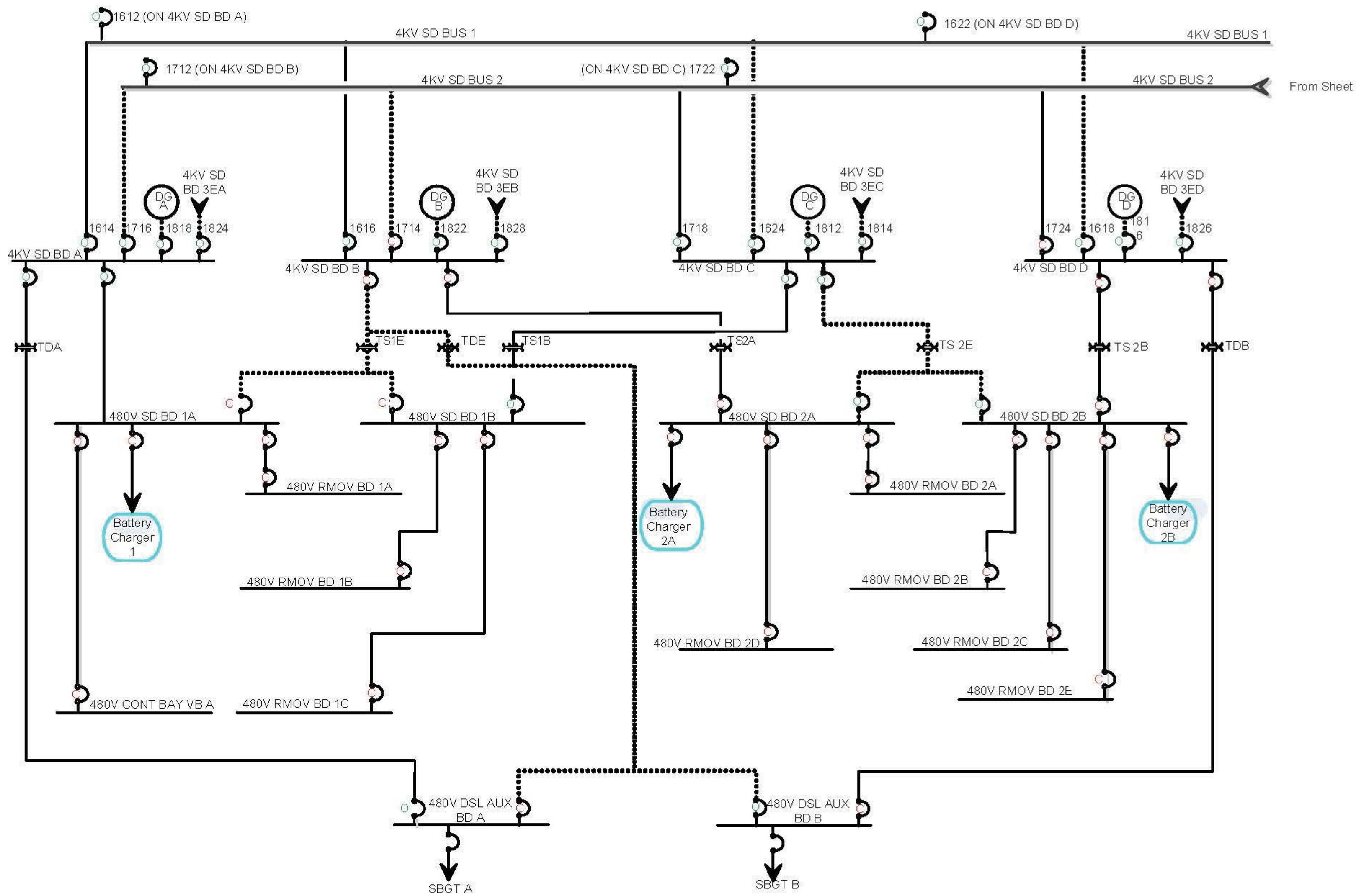

Figure 2 4KV SD Bds 3EB and 3ED 4kV FLEX Generator Connection Points Sheet 2

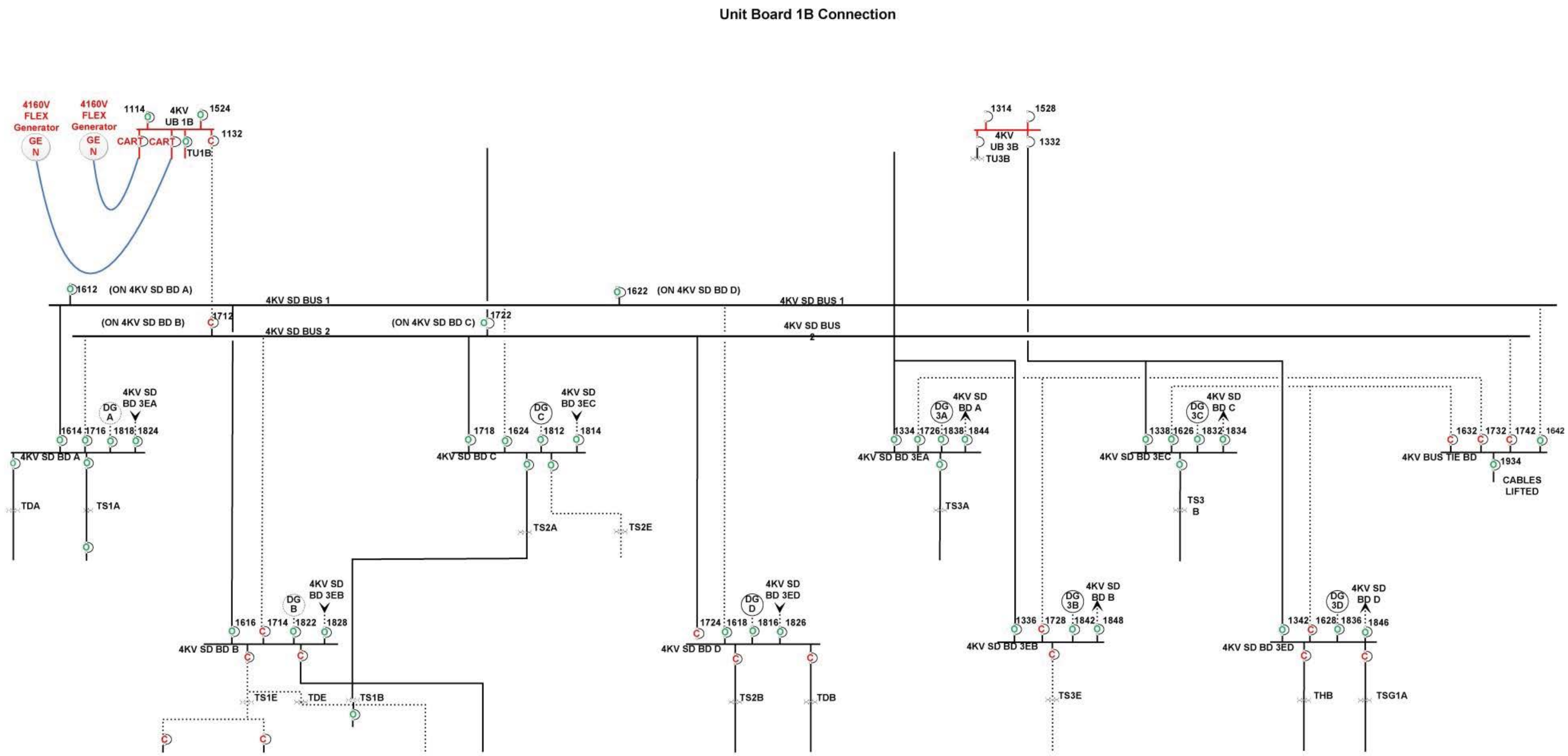

Figure 3 Unit Boards 1B and 3B 4kV FLEX Generator Connection Points Sheet 1

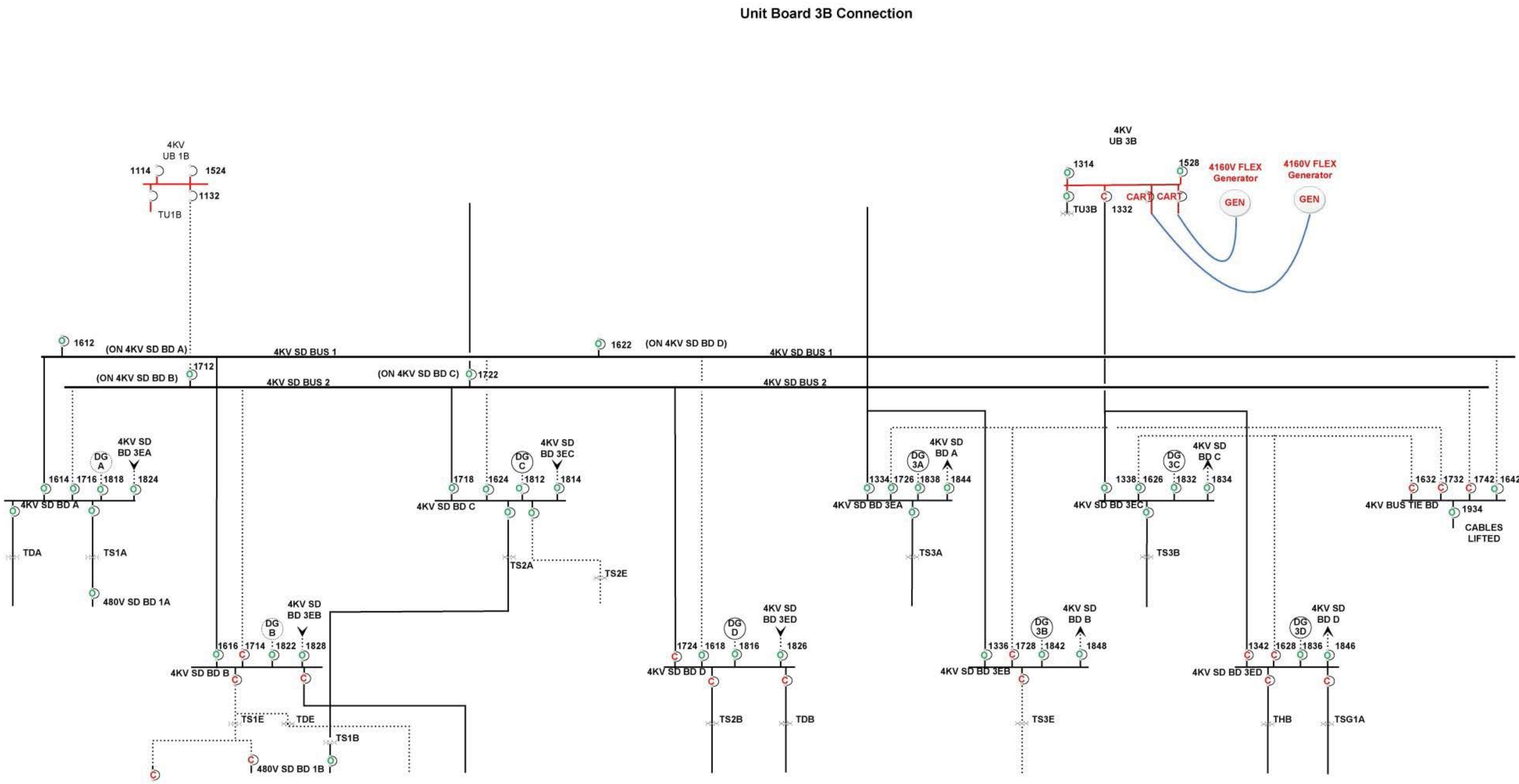

Figure 3 Unit Boards 1B and 3B 4kV FLEX Generator Connection Points Sheet 2

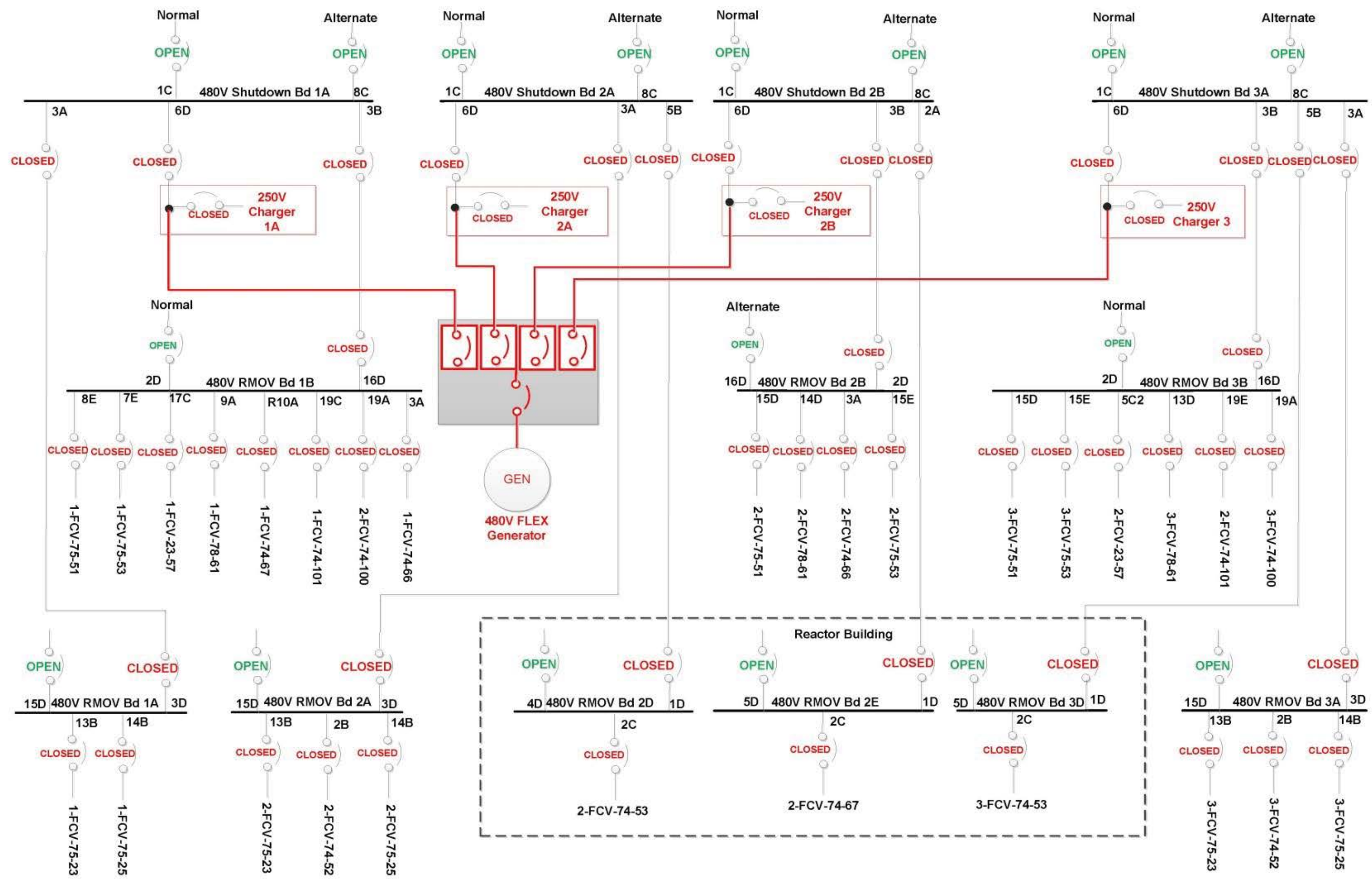

Figure 4 480V FLEX Generator Connection Points

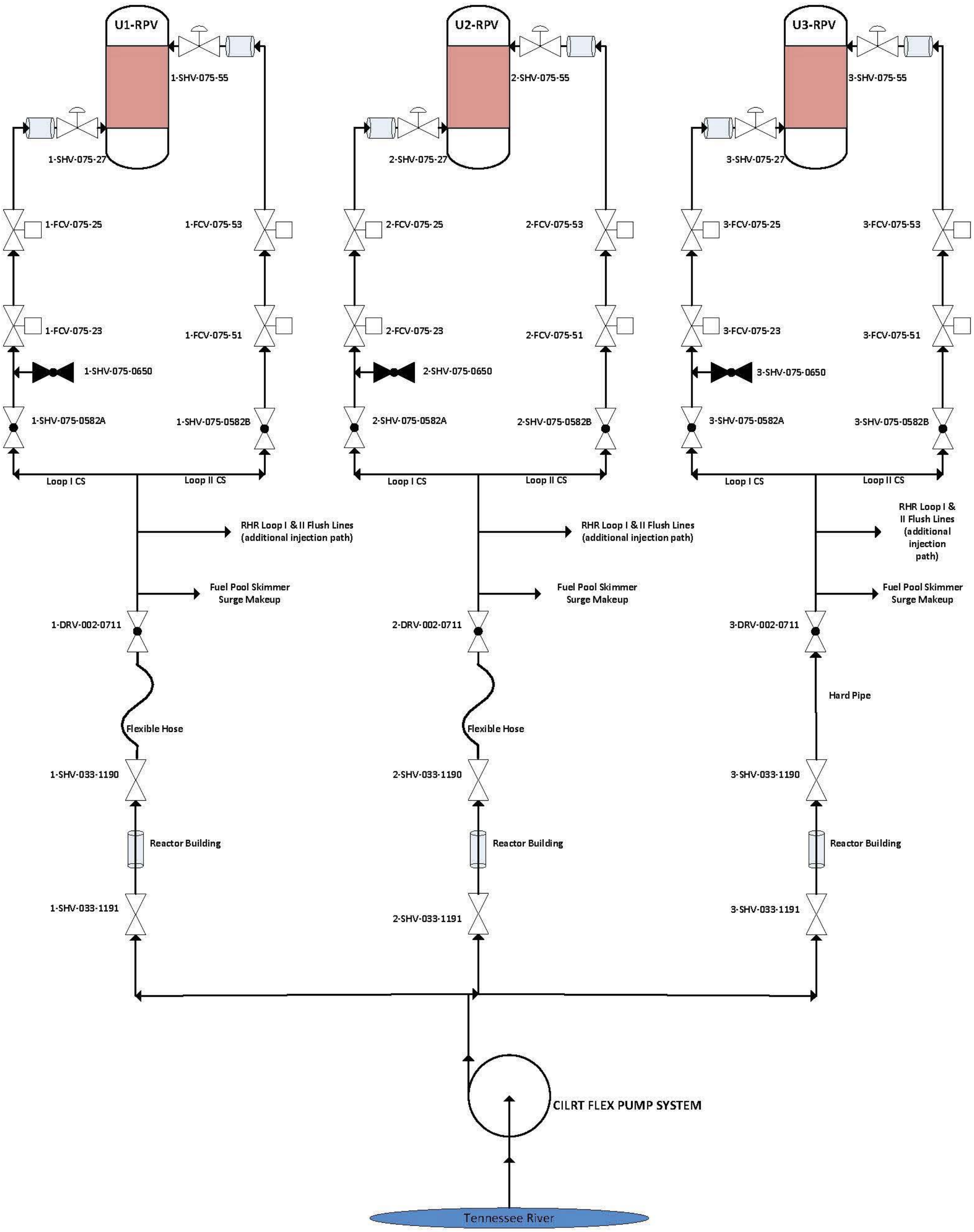

Figure 5 CILRT FLEX Pump System

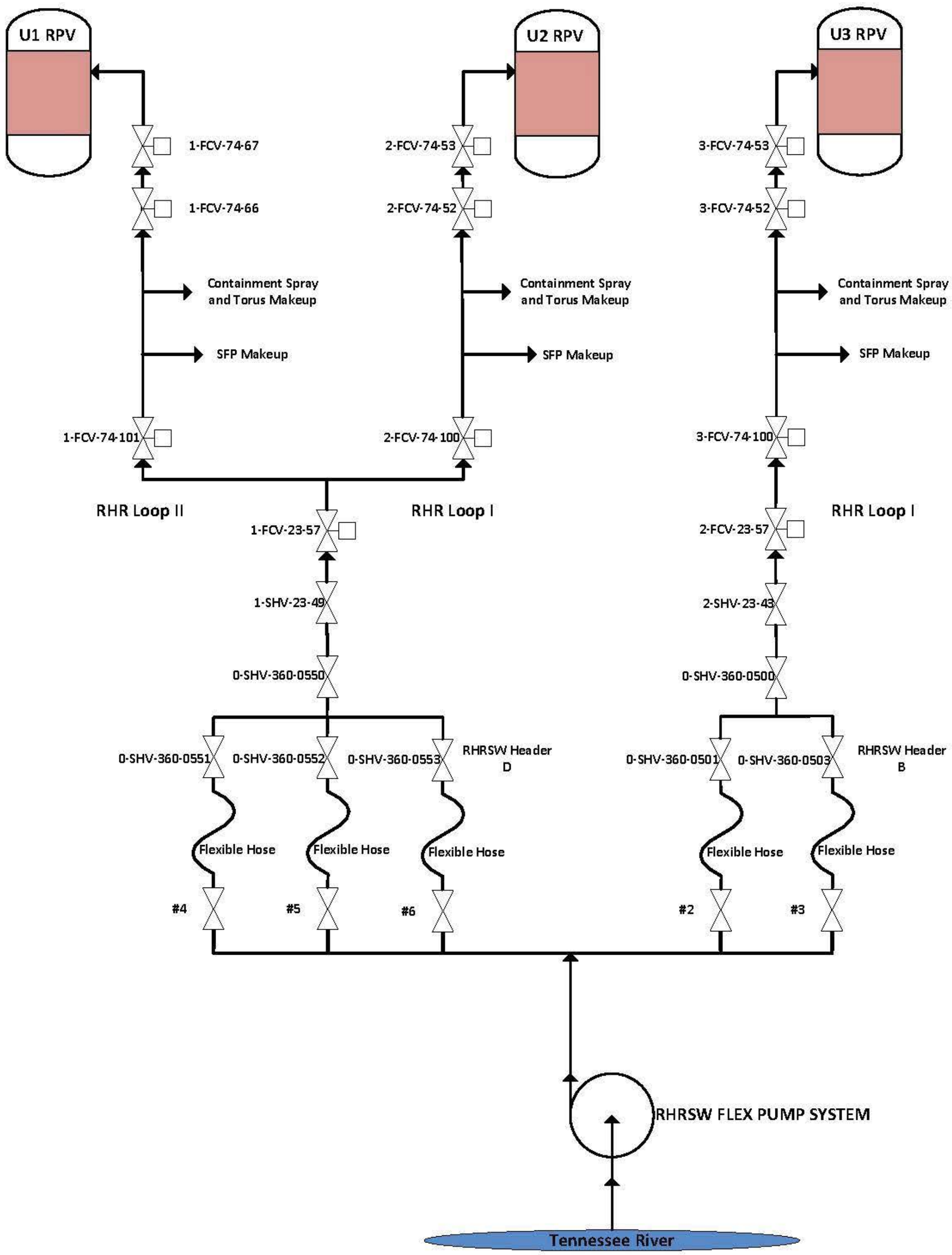

Figure 6 RHRSW FLEX Pump System

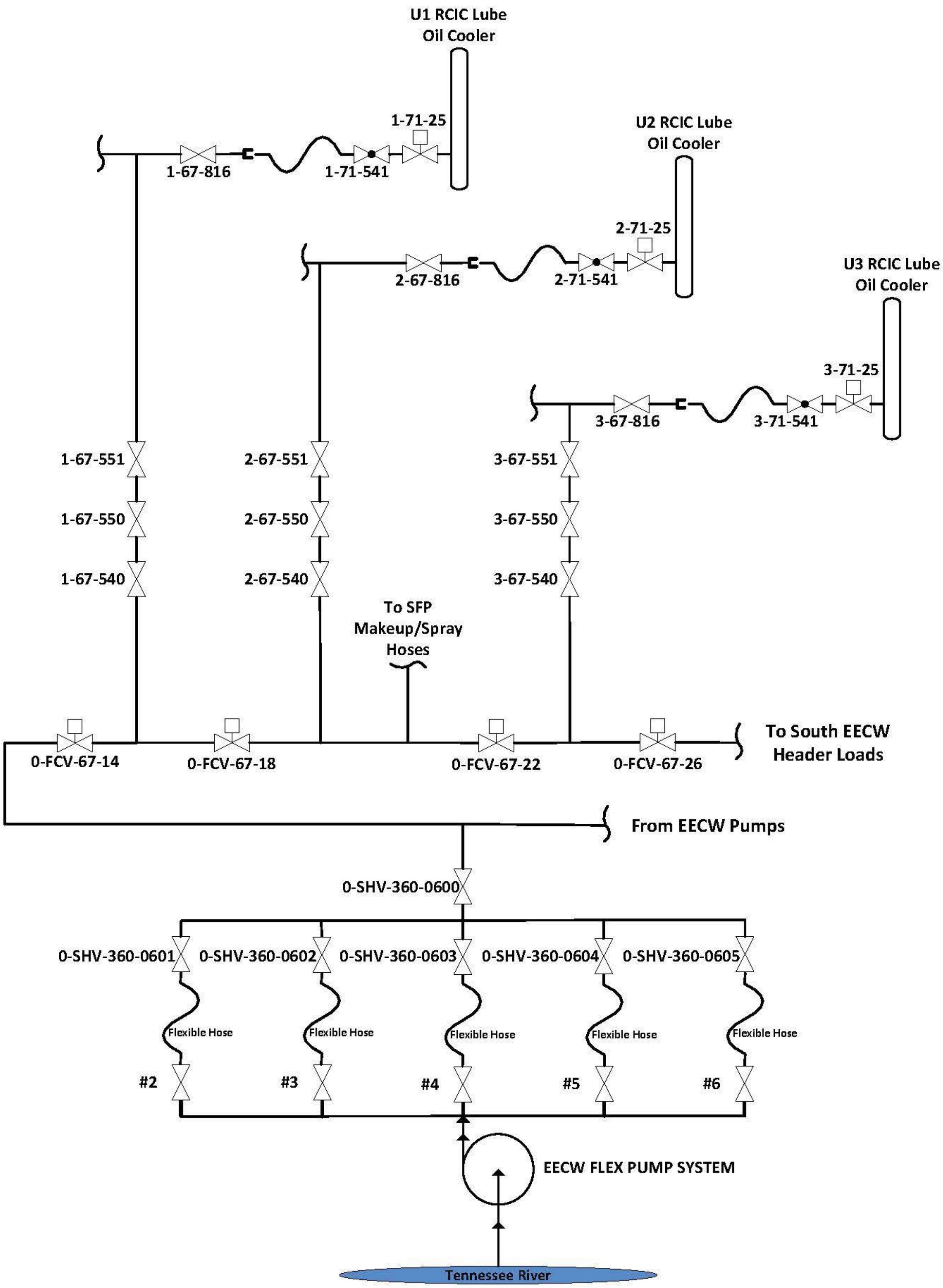

Figure 7 EECW FLEX Pump System

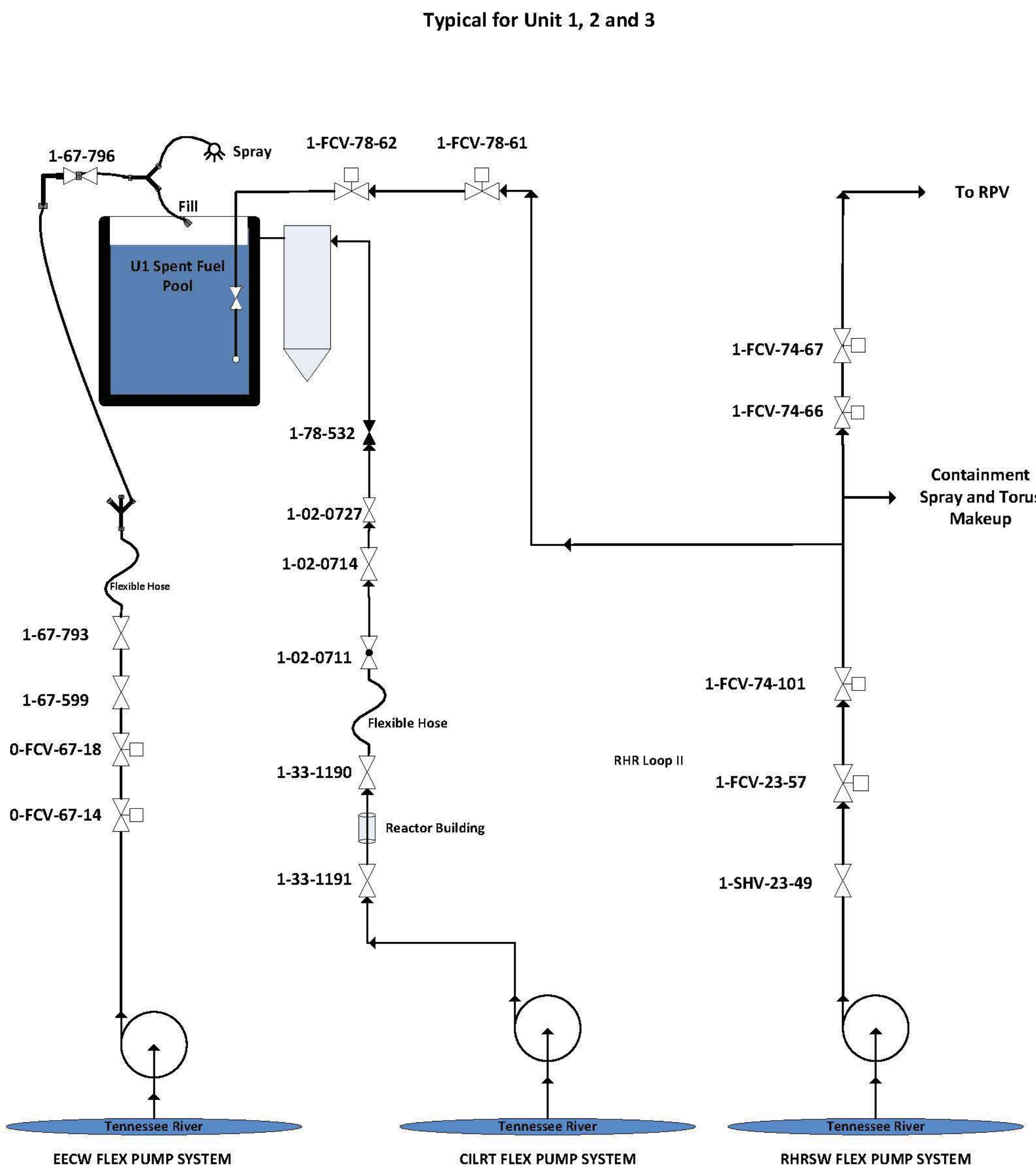

Figure 8 Spent Fuel Pool Makeup/Spray