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July 06, 2016

ULNRC-06310

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

10 CFR 2.202

Ladies and Gentlemen:

DOCKET NUMBER 50-483
CALLAWAY PLANT UNIT 1
UNION ELECTRIC CO.
RENEWED FACILITY OPERATING LICENSE NPF-30
FINAL NOTIFICATION OF FULL COMPLIANCE
WITH 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)

References:
1. Letter dated March 12, 2012 from E. J. Leeds and M. R. Johnson, USNRC, to Adam C. Heflin, Callaway Plant, Union Electric Company, "Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession Number ML12054A736)
2. NRC Interim Staff Guidance JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," Revision 0, August 29, 2012 (ADAMS Accession Number ML12229A174)
3. ULNRC-05924, "Initial Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated October 29, 2012 (ADAMS Accession Number ML12305A283)
4. ULNRC-05962, "Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated February 28, 2013 (ADAMS Accession Number ML13063A459)

5. ULNRC-06024, "First Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated August 29, 2013 (ADAMS Accession Number ML13242A239)
6. ULNRC-06087, "Second Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 26, 2014 (ADAMS Accession Number ML14057A770)
7. ULNRC-06135, "Third Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated August 28, 2014 (ADAMS Accession Number ML14241A665)
8. ULNRC-06184, "Fourth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 26, 2015 (ADAMS Accession Number ML15057A303)
9. ULNRC-06240, "Fifth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated August 27, 2015 (ADAMS Accession Number ML15239B402)
10. ULNRC-06282, "Sixth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 23, 2016 (ADAMS Accession Number ML16054A836)

On March 12, 2012, the U. S. Nuclear Regulatory Commission (NRC) issued the order identified above as Reference 1 to Union Electric Company (dba Ameren Missouri) for Callaway Plant. Reference 1 was immediately effective and directs Ameren Missouri 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. Specific requirements are outlined in Attachment 2 of Reference 1.

Reference 1 required submission of an initial status report 60 days following issuance of final interim staff guidance from the NRC (Reference 2) and an Overall Integrated Plan pursuant to Section IV, Condition C. Reference 3 provided Ameren Missouri's initial status report regarding mitigation strategies. Reference 4 provided Ameren Missouri's Overall Integrated Plan.

Section IV, Condition C.2 of Reference 1 requires submission of a status report at six-month intervals following submittal of the overall integrated plan. NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," provides direction regarding the content of the status reports. References 5, 6, 7, 8, 9, and 10 provided Ameren Missouri's six-month status reports.

This letter along with its enclosures provides the notification required by Section IV, Condition C.3 of Reference 1 that full compliance with the requirements described in Attachment 2 of the Order has been achieved for Callaway Plant.

This letter does not contain new commitments. If you have any questions concerning the content of this letter, please contact Roger Wink, Regulatory Affairs Manager, at 573-310-7025.

I declare under penalty of perjury that the foregoing is true and correct.

Sincerely,

Executed on: 7/6/2016

Timothy E. Herrmann
Site Vice President

Enclosures:

1. NRC Order EA-12-049 Compliance Requirements Summary
2. FLEX Interim Staff Evaluation (ISE) Open and Confirmatory Items
3. NRC Audit Report Open and Pending Items
4. Final Integrated Plan (FIP)

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INTRODUCTION

Ameren developed an Overall Integrated Plan (Reference 1) for Callaway Plant Unit 1, documenting the diverse and flexible strategies (FLEX), in response to Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," (Reference 2). The OIP for Callaway Plant Unit 1 was submitted to the NRC on February 28, 2013 and was supplemented by Six-Month Status Reports (References 3, 4, 5, 6, 7, and 8), in accordance with Order EA-12-049.

Full Compliance with Order EA-12-049 was completed on May 9, 2016. This date corresponds to the relaxation date granted by the NRC under Reference 9 (spring 2016 refueling outage). The information provided herein documents full compliance with NRC Order EA-12-049 for Callaway Plant, Unit 1.

NRC ISE AND AUDIT ITEMS - COMPLETE

During the ongoing audit process (Reference 10), Ameren provided responses for the following items for Callaway Plant:

- Interim Staff Evaluations (ISE) Open Items
- ISE Confirmatory Items
- Audit Questions/Audit Report Open Items

A summary of the response to each of the issues is provided in Enclosures 2 and 3. The open and pending items do not affect the compliance of Unit 1 to Order EA-012-049.

MILESTONE SCHEDULE – ITEMS COMPLETE

Activity	Completion Date
Submit Overall Integrated Plan	February-2013
6 Month Status Updates	
Update 1	August-2013
Update 2	February-2014
Update 3	August-2014
Update 4	February-2015
Update 5	August-2015
Update 6	February-2016
FLEX Strategy Evaluation	April-2013
Perform Staffing Analysis	December-2013
Modifications	
Modifications Evaluation	April-2013
Engineering and Implementation	May 2016
N-1 Walkdown	April-2013
Design Engineering	March 2016
Unit 1 Implementation Outage	May-2016
On-site FLEX Equipment	
Purchase	March-2016
Procure	April-2016
Off-site FLEX Equipment	
Develop Strategies with National SAFER Response Center (NSRC)	November-2015
Install Off-site Delivery Station (if necessary)	September-2014
Procedures	
PWROG issues NSSS-specific guidelines	June-2013
Create Callaway FSG	May-2016
Create Maintenance Procedures	May-2016
Training	
Develop Training Plan	April-2014
Implement Training	May-2016
Submit Completion Report	July-2016

STRATEGIES - COMPLETE

Strategy related Open Items, Confirmatory Items, or Audit Questions have been addressed as documented in Enclosures 2 and 3 of this letter. The Callaway Plant Unit 1 strategies are in compliance with Order EA-12-049.

MODIFICATIONS - COMPLETE

The modifications required to support the FLEX strategies for Callaway Plant, Unit 1 have been implemented in accordance with the station design control process.

EQUIPMENT – PROCURED AND MAINTENANCE & TESTING - COMPLETE

The equipment required to implement the FLEX strategies for Callaway Plant, Unit 1 has been procured in accordance with NEI 12-06, Section 11.1 and 11.2, received at Callaway Plant, initially tested/performance verified as identified in NEI 12-06, Section 11.5, and is available for use.

Maintenance and testing will be conducted through the use of the Callaway Plant Preventative Maintenance program such that equipment reliability is maintained.

PROTECTED STORAGE - COMPLETE

The storage facility required to protect Beyond Design Basis (BDB) equipment has been completed for Callaway Plant, Unit 1. The BDB equipment is protected from the applicable site hazards and will remain deployable to assure implementation of the FLEX strategies for Callaway Plant, Unit 1.

PROCEDURES - COMPLETE

FLEX Support Guidelines (FSGs), for Callaway Plant, Unit 1 have been developed, and integrated with existing procedures. The FSGs and affected existing procedures have been approved and are available for use in accordance with the site procedure control program.

TRAINING - COMPLETE

Training of personnel responsible for the mitigation of beyond-design-basis events at Callaway Plant, Unit 1 has been completed in accordance with an accepted training process as recommended in NEI 12-06, Section 11.6.

STAFFING - COMPLETE

The staffing study for Callaway Plant Unit 1 has been completed in accordance with 10CFR50.54(f), "Request for Information Pursuant to Title 10 of the Code of Federal Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force review of Insights from the Fukushima Dai-ichi Accident," Enclosure 5 pertaining to Recommendation 9.3, dated March 12, 2012 (Reference 12), as documented in letter dated November 30, 2016, "Phase 2 Staffing Assessment Regarding Recommendation 9.3 (Staffing)" (Reference 13).

The staffing study confirmed that Callaway Plant has adequate staffing to perform the actions to mitigate beyond design basis events.

NATIONAL SAFER RESPONSE CENTERS - COMPLETE

Ameren 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 off-site facility coordination. It has been confirmed that PEICo is ready to support Callaway Plant with Phase 3 equipment stored in the National SAFER Response Centers in accordance with the site specific SAFER Response Plan (Reference 14).

VALIDATION - COMPLETE

Ameren has completed validation testing of the FLEX strategies for Callaway Plant, Unit 1 in accordance with industry developed guidance. The validations assure that required tasks, manual actions and decisions for FLEX strategies are feasible and may be executed within the constraints identified in the Overall Integrated Plan (OIP) / Final Integrated Plan (FIP) for Order EA-12-049.

FLEX PROGRAM DOCUMENT - ESTABLISHED

The FLEX Program Document has been developed in accordance with the requirements of NEI 12-06 and is in effect for Callaway Plant, Unit 1.

REFERENCES

The following references support the Callaway Plant, Unit 1 FLEX Compliance Summary:

1. ULNRC-05962, "Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated February 28, 2013.

2. NRC Order Number EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated March 12, 2012 (ML12229A174).

3. ULNRC-06024, "First Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated August 29, 2013.

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5. ULNRC-06135, "Third Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated August 28, 2014.

6. ULNRC-06184, "Fourth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 26, 2015.

7. ULNRC-06240, "Fifth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated August 27, 2015.

8. ULNRC-06282, "Sixth Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 23, 2016.

9. NRC letter to Ameren "Callaway Plant, Unit 1- Relaxation of the Schedular 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 11, 2013 (ML13319A668).

10. NRC letter to All Operating Reactor Licensees and Holders of Construction Permits, "Nuclear Regulatory Commission Audits of Licensee Responses to Mitigation Strategies Order EA-12-049," dated August 28, 2013 (ML13234A503).

11. NRC letter to Ameren "Callaway Plant, Unit 1 - Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spend Fuel Instrumentation Related to Orders EA-12-049 and EA-12-051," dated March 31, 2016 (ML16077A353).

12. 10CFR50.54(f), "Request for Information Pursuant to Title 10 of the Code of Federal Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force review of Insights from the Fukushima Dai-ichi Accident," Recommendation 9.3, dated March 12, 2012 (ML2073A348).

13. ULNRC-06267, "Phase 2 Staffing Assessment Regarding Recommendation 9.3 (Staffing)," dated November 30, 2016

14. NRC letter from Jack Davis, JLD, Office of NRR, to Joseph E. Pollock, Vice President, Nuclear Operations, NEI, "Staff Assessment of National Safer Response Centers Established in Response to Order EA-12-049," September 26, 2014 (ML14265A107).

INTERIM STAFF EVALUATION (ISE) OPEN ITEMS

Item Number	Description	Callaway Plant, Unit 1 Response
3.2.1.2.B	Additional review of the licensee's applicable analysis and relevant Reactor Coolant Pump (RCP) seal leakage testing data is needed to justify that (1) the integrity of the associated 0-rings will be maintained at the temperature conditions experienced during the ELAP event, and (2) the seal leakage rate used in the ELAP is adequate and acceptable.	Callaway Plant has installed Westinghouse Generation III SHIELD® Seals on each RCP which contain either compound C or D O-rings. CN-SEE-I-12-32, "Callaway Reactor Coolant System Inventory, Shutdown Margin, and Mode 5/6 Boric Acid Precipitation Control Analysis to Support the Diverse and Flexible Coping Strategy (FLEX), Revision 1-A", dated January 21, 2016, utilizes a constant RCP seal leakage rate of 1.25 gpm/RCP. This accounts for the SHIELD® design leak rate of 1.0 gpm/RCP and RCS total unidentified leak rate of 1.0 gpm (additional 0.25 gpm/RCP seal).
3.2.1.2.D	The acceptability of the use of the selected seals and the RCP seal leakages rates in the ELAP analysis must be justified.	Callaway Plant has installed Westinghouse Generation III SHIELD® Seals on each RCP. CN-SEE-I-12-32, utilizes a constant RCP seal leakage rate of 1.25 gpm/RCP. This accounts for the SHIELD® design leak rate of 1.0 gpm/RCP and RCS total unidentified leak rate of 1.0 gpm (additional 0.25 gpm/RCP seal). During an ELAP event, the RCPs trip at event initiation which is prior to RCP seal leakoff exceeding 235°F. Other seal leakage rates discussed in IN 2005-14 are not applicable to Callaway Plant as the Westinghouse Generation III SHIELD® RCP seals have been installed which are designed for a maximum RCP seal leakage of 1 gpm/RCP. Callaway Plant's lowest safety valve lift pressure is 1200 psia which establishes an RCS temperature of 567.2°F. Callaway Plant has installed Westinghouse Generation III SHIELD® Seals on each RCP which has been qualified to an RCS cold leg temperature of 571°F as documented in TR-FSE-14-1-P, "Use of Westinghouse SHIELD® Passive Shutdown Seal for FLEX Strategies".

Item Number	Description	Callaway Plant, Unit 1 Response
		TR-FSE-14-1-P is applicable for RCP models 93, 93A, and 93A-1. Callaway Plant has model 93A-1 RCPs and has installed Westinghouse Generation III SHIELD® Seals which has been qualified to a maximum leakage rate of 1 gpm/RCP as documented in TR-FSE-14-1-P. A constant leakage rate of 1 gpm/RCP is utilized in CN-SEE-I-12-32. Callaway Plant has model 93A-1 RCPs and has installed Westinghouse Generation III SHIELD® Seals which have been qualified to a maximum leakage rate of 1 gpm/RCP as documented in TR-FSE-14-1-P. The pump model and seal combination comply with the seal leakage model described in WCAP-17601 Section 5.7.1, "RCS Response With Little Or No RCS Leakage – Safe Shutdown Seals /Low Leakage Seals /Alternate Seal Cooling Systems – Westinghouse Generic Case Results." Per the FLEX Final Integrated Plan, and ECA-0.0, "Loss of All AC Power", Callaway Plant will perform a symmetric cooldown using all RCS loops. Per the FLEX Final Integrated Plan, ECA-0.0 and FSG-4, "ELAP DC Bus Load Shed Management", there is no impact to the Callaway Plant ELAP coping strategy due to load shed activities (including isolation of RCS leakage paths).
3.2.1.3.A	During the NRC audit process the licensee was requested to provide the following information: If the ANS 5.1-1979 + 2 sigma model is used in the ELAP analysis, specify the values of the following key parameters used to determine the decay heat: (1) initial power level, (2) fuel enrichment, (3) fuel	The following assumptions were applied to arrive at the overall normalized decay heat power: • Two standard deviations of uncertainty (+2σ). • Fission product decay heat from three fissile isotopes: • U-235, Pu-239, and U-238. The total recoverable energy associated with one fission for each isotope is assumed to be 201.8 MeV, 210.3 MeV, and 205.0 MeV, respectively. • The power fractions are typical values

Item Number	Description	Callaway Plant, Unit 1 Response
	burnup, (4) effective full power operating days per fuel cycle, (5) number of fuel cycles, if hybrid fuels are used in the core, and (6) fuel characteristics based on the beginning of the cycle, middle of the cycle, or end of the cycle. Address the adequacy of the values used. If the different decay heat model is used, describe the specific model and address the acceptability of the model and the analytical results.	expected for each of the three fissile isotopes through a three region burn-up for which the feed fuel U-235 enrichment is ~ 5%. This is typical of fuel cycle feeds. • Actinide contributions to the decay heat are from U-239 and Np-239. • A conversion ratio of 0.65 was used to derive the production of the two actinides: U-239 and Np-239. • Fission product neutron capture is treated per the ANS standard. • Finite burnup that utilizes a power history of three 540 day cycles separated by two 20 day outages, which bounds NEI 12-06, Diverse and Flexible Coping Strategies (FLEX) Implementation Guide, Revision 2, Section 3.2.1.2, Initial Condition 3.2.1.2(1). Minimum assumption of NEI 12-06 is that the reactor has been operated at 100% power for at least 100 days prior to event initiation. The primary system transient profile assumed for the Mode 1-4 reactor coolant system (RCS) inventory control and long-term subcriticality calculations performed for Callaway is based on the Westinghouse reference coping cases described in Section 5.7.1 and Section 5.2.1 of WCAP-17601-P, Revision 1, "Reactor Coolant System Response to the Extended Loss of AC Power Event for Westinghouse, Combustion Engineering, and Babcock & Wilcox NSSS Designs" and plant-specific parameters such as RCS nominal temperature(s), pressure(s), and volumes, and accumulator cover gas pressures. These calculations do not, however, include any decay heat model and rely on the case runs cited from WCAP-17601-P, Revision 1, regarding decay heat related phenomenon. The boil-off rates used in the plant-specific Mode 5/6 boric acid precipitation control calculations performed for Callaway are determined using a time step integration of the ANS 5.1-1979 and

Item Number	Description	Callaway Plant, Unit 1 Response
		1994 + 2σ decay heat models, and assume that the reactor has been shut down from 100% power operation for a duration bounding typical refueling outage time frames for steam generators being unavailable. The integration assumes a finite irradiation of the core, a three-region core, and two-year fuel cycles. The time for refueling is ignored. Also, during very early time frames, the power level has been increased to account for delayed fissions that are not calculated in ANS 5.1-1979 or 1994. This power history bounds Initial Condition 3.2.1.2 (1) of NEI 12-06, Revision 2. Finally, decay heat values determined in this manner bound both ANS 5.1-1979 and 1994.
3.2.1.8.B .	The Pressurized-Water Reactor Owners Group submitted to the NRC a position paper, dated August 15, 2013, which provides test data regarding boric acid mixing under single-phase natural circulation conditions and outlined applicability conditions intended to ensure that boric acid addition and mixing would occur under conditions similar to those for which boric acid mixing data is available. During the audit process, the licensee informed the NRC staff of its intent to abide by the generic approach discussed above; however, the NRC staff concluded that the August 15, 2013, position	The NRC has subsequently endorsed the position paper with some clarifications (Reference: ML13276A183 - NRC Endorsement of PWROG Boron Mixing White Paper). The following information is provided regarding boron mixing used for the re-criticality analysis in support of the plant FLEX mitigation strategies: (a) *Discuss whether the uniform boron mixing model was used in the ELAP analysis. If the perfect boron mixing model was used, address the compliance with the recommendations discussed in a PWROG whitepaper related to the boron mixing model. If a different model was used, address the adequacy of the use of the boron mixing model in the ELAP analysis with support of an analysis and/or boron mixing test data applicable to the ELAP conditions, where the RCS flow rate is low and the RCS may involve two-phase flow. If boron mixing test data exists that is applicable to the boron mixing model and the ELAP event, provide a discussion of how the model matches the data.*

Item Number	Description	Callaway Plant, Unit 1 Response
	paper was not adequately justified and that further information is required.	RESPONSE: The NOTRUMP computer code was used to simulate the RCS responses for generic Westinghouse pressurized water reactors (PWRs) during an ELAP. These responses, documented in WCAP-17601-P, Revision 1, and WCAP-17792-P, Revision 0, "Emergency Procedure Development Strategies for the Extended Loss of AC Power Event for all Domestic Pressurized Water Reactor Designs" demonstrate that mitigation strategies such as the one described in the Callaway Plant Final Integrated Plan and plant specific calculation CN-SEE-I-12-32, are adequate for coping with an ELAP event. The primary-system transient profile assumed for the plant-specific Mode 1-4 RCS inventory control and long-term subcriticality calculation performed for Callaway Plant is based on the Westinghouse reference coping cases described in Section 5.7.1 and Section 5.2.1 of WCAP-17601-P, Revision 1, and plant-specific parameters such as RCS nominal temperature(s), pressure(s), and volumes, and accumulator cover gas pressures. This application of plant-specific parameters with the WCAP-17601-P Revision 1 reference coping cases is consistent with the methods and guidance, as well as the restrictions and limitations, specified in PWROG-14064-P, Revision 0, Application of NOTRUMP Code Results for Westinghouse Designed PWRs in Extended Loss of AC Power Circumstances. Note that Callaway Plant has installed the Westinghouse Generation III SHIELD® (safe shutdown/low leakage) Reactor Coolant Pump (RCP) seals, and that the use of low leakage RCP seals significantly extends the time line relating to reflux condensation initiation (see, for example, Section 5.7.1 of WCAP-17601-P

Item Number	Description	Callaway Plant, Unit 1 Response
		Revision 1). The Mode 1-4 RCS inventory control calculation performed for Callaway Plant determined the makeup rate, and time by which makeup is required, necessary to maintain adequate core cooling for the duration of the ELAP event. These calculations account for primary-system specific volume changes resulting from RCS temperature and pressure changes, losses due to RCP seal package leakage, and losses due to primary-system operational leakage. In particular, the RCS inventory control calculations performed for Callaway Plant assume the RCS is cooled to approximately 415°F following the loss of all AC power. The Callaway Plant Final Integrated Plan documents that an RCS cooldown/depressurization to a target Steam Generator (SG) pressure of 290 psig will be initiated in Phase 1 following the loss of all AC power, a constant Westinghouse safe shutdown/low-leakage RCP seal package leak rate of 1 gpm per RCP, a constant primary-system Technical Specifications (TS) leak rate of 1 gpm, and that no makeup other than passive accumulator injection is provided during the initial phase of the ELAP. Based on these assumptions, the calculation shows that the RCS liquid inventory would be reduced to the minimum single-phase natural circulation level at approximately 45.1 hours following ELAP initiation, and would be reduced to the minimum two-phase natural circulation level at approximately 66.9 hours following ELAP initiation. The pumped RCS makeup strategy for Callaway Plant (per Callaway Calculation XX-136, Revision 0) includes providing RCS injection in excess of the maximum primary-

Item Number	Description	Callaway Plant, Unit 1 Response
		system leak rate of 5 gpm (1 gpm per RCP plus 1 gpm TS unidentified leakage) starting no later than 26 hours, following the loss of all AC power. Since this is well before the time when the RCS liquid inventory would be reduced to the minimum single or two-phase natural circulation level, the Callaway Plant RCS makeup strategy is sufficient to preclude reflex condensation cooling from occurring during an ELAP. The plant-specific Mode 1-4 RCS long-term subcriticality calculation performed for Callaway Plant is based on the uniform boron mixing model detailed in LTR-FSE-13-46-P, Westinghouse Response to NRC Generic Request for Additional Information (RAI) on Boron Mixing in Support of the Pressurized Water Reactor Owners Group (PWROG) which provides justification for, and limitations associated with, using the uniform boron mixing model in ELAP long-term subcriticality calculations. The Callaway Plant long-term subcriticality calculation (Ameren Calculation XX-136, Revision 0) meets the uniform boron mixing model limitations documented in LTR-FSE-13-46-P. *(b) Discuss how the boron concentration in the borated water added to the RCS is considered in the cooldown phase of the ELAP analysis, considering that it needs time for the added borated water to mix with water in the RCS.* RESPONSE: The RCS boration timeline to maintain subcritical conditions when performing an RCS cooldown to 350°F as detailed in Ameren Calculation XX-136, Revision 0, includes one hour of mixing following addition of the borated volume for complete mixing.

Item Number	Description	Callaway Plant, Unit 1 Response
		(c) Discuss the plant specific boration analysis and results, and show that the core will remain sub-critical throughout the ELAP event. RESPONSE: CN-SEE-I-12-32 (as discussed above) details how plant is maintained subcritical during the ELAP event. *NRC endorsement of the PWROG Generic Response for Boric Acid Mixing during ELAP events as documented in ML13276A183 with the following clarifications:* *(1) The required timing for providing borated makeup to the primary system should consider conditions with no reactor coolant system leakage and with the highest applicable leakage rate for the reactor coolant pump seals and unidentified reactor coolant system leakage.* RESPONSE: CN-SEE-I-12-32 assumes highest RCS leakage for RCS Inventory control. Ameren Calculation XX-136, Revision 0 assumes no RCS leakage for RCS Boration requirements. *(2) For the condition associated with the highest applicable reactor coolant system leakage rate, two approaches have been identified, either of which is acceptable to the staff:* *a) Adequate borated makeup should be provided such that the loop flow rate in two-phase natural circulation does not decrease below the loop flow rate corresponding to single phase natural circulation.* RESPONSE: The pumped RCS makeup/boration strategy for Callaway Plant (per Ameren Calculation XX-136, Revision 0) includes providing RCS injection in excess of the

Item Number	Description	Callaway Plant, Unit 1 Response
		maximum primary-system leak rate of 5 gpm (1 gpm per RCP plus 1 gpm TS unidentified leakage) starting no later than 26 hours following the loss of all AC power which is well before the time when the RCS liquid inventory would be reduced to the minimum single phase natural circulation level (45.1 hours). b) *If loop flow during two-phase natural circulation has decreased below the single-phase natural circulation flow rate, then the mixing of any borated primary makeup added to the reactor coolant system is not to be credited until one hour after the flow in all loops has been restored to a flow rate that is greater than or equal to the single-phase natural circulation flow rate.* RESPONSE: Not applicable (3) *In all cases, credit for increases in the reactor coolant system boron concentration should be delayed to account for the mixing of the borated primary makeup with the reactor coolant system inventory. Provided that the flow in all loops is greater than or equal to the corresponding single-phase natural circulation flow rate, the staff considers a mixing delay period of one hour following the addition of the targeted quantity of boric acid to the reactor coolant system to be appropriate.* RESPONSE: The RCS boration timeline to maintain subcritical conditions when performing an RCS cooldown to 350°F as detailed in Ameren Calculation XX-136, Revision 0, includes one hour of mixing following addition of the borated volume for complete mixing.

Item Number	Description	Callaway Plant, Unit 1 Response
3.2.4.9.A	Information is needed regarding plans for assuring and maintaining fuel oil quality.	All trailer mounted diesel-driven equipment housed inside the Hardened Storage Building (HSB) is individually equipped with a trailer mounted automatic fuel oil purification system that maintains the quality of the fuel oil inside the trailer's tank. After the ELAP, the only "guaranteed" source of fuel-oil (besides what is stored inside the HSB) will be the Emergency Diesel Fuel Oil Storage Tanks (TJE01A & B). Existing sampling requirements for TEJ01A/B are delineated in Diesel Fuel Oil Testing Program as required by T/S S/R 3.8.3.3. FSG-44, "FLEX Diesel Fuel Strategy", has been developed to provide direction for supplying diesel fuel for FLEX response equipment during an ELAP event. This FSG provides guidance for obtaining diesel fuel oil from the Emergency Diesel Day Tanks (TJE02 A/B), as well as the Emergency Diesel Fuel Oil Storage Tanks (TJE01A & B). Instructions for obtaining fuel from other non-robust diesel fuel tanks are also included in this FSG in the event the tank survives the event. Note: "Trailer mounted diesel-driven equipment includes 480VAC generators, SFP makeup/spray pumps, AFW/RCS makeup pumps, and diesel refuel trailer. FLEX equipment with smaller volume tanks will be periodically conditioned by a portable fuel conditioner; periodicity has not yet been defined but will be determined/performed within Callaway Plant's PM program.
3.4.A	Details are needed to demonstrate the minimum capabilities for offsite resources will be met per NEI 12-06 Section 12.2.	The National SAFER Response Centers (NSRC) in Memphis, TN., and Phoenix, AR., are operational. Callaway Plant has a contract with NSRC to provide Phase 3 FLEX portable equipment. The NRC Staff Assessment of the NSRCs is documented in NRC Letter from Mr. Jack Davis, Director Mitigating Strategies Directorate to Mr. Joseph E. Pollock, Vice President, Nuclear Operations, Nuclear Energy Institute, dated September 26, 2014

Item Number	Description	Callaway Plant, Unit 1 Response
		(ML14265A107). The Staff Assessment evaluated all the items listed in NEI 12-06, Section 12.2. "Safer Response Plan for Callaway Energy Center", Rev 002, dated 11/05/15, has provisions for site-specific helicopter support, identified staging Areas B, C, and D along with travel routes (primary and backup) to both staging area and site.

INTERIM STAFF EVALUATION (ISE) CONFIRMATORY ITEMS

Item Number	Description	Callaway Plant Response
3.1.1.2.A	Because the current CST is unprotected from seismic hazard, the licensee is planning to install a new CST. Verification of installation is necessary.	The new Hardened Condensate Storage Tank (HCST) has been completed. 81402-M-001 Rev. 1, HCST Sizing Justification Calculation, confirms that a minimum of 30 hours of tank inventory is available to support Auxiliary Feedwater heat removal. The calculations also include SFP cooling flows. The HCST is designed to provide a robust source of water for core cooling during an ELAP event. The HCST and its connection to the Auxiliary Feedwater System are designed to the standards of Seismic Category I as the system is required to remain structurally intact as well as remain functional during and after a safe shutdown earthquake (SSE). However, the system will not be formally categorized as Seismic Category I. All Seismic Category I structures required for safe shutdown are to be designed to withstand effects of a tornado and the most severe wind phenomena encountered at any of the Standardized Nuclear Power Plant System (SNUPPS) sites. Although the new system is not safety-related, it was subject to the same rigorous design criteria as Seismic Category I structures including tornado-induced wind pressures, internal differential pressures, externally generated missiles and those loads as required by NEI 12-06.
3.1.1.2.B	Information is needed regarding whether or not electrical power will be required to move or deploy FLEX equipment from storage.	Electrical power is not required to move or deploy FLEX equipment from storage. Ingress/egress of the storage building does not require electrical power nor are there any gates or barriers within the deployment routes requiring electrical power. Therefore, electrical power is not required to deploy Phase 2 equipment from the storage building.
3.1.2.A	Licensee stated that UHS and refueling water storage tank (RWST) are	The site grade level is Elevation 840.5 ft. mean sea level (MSL). While the RWST bottom slab is below the flood level, access for FLEX strategy

Item Number	Description	Callaway Plant Response
	below flood levels but the licensee needs to address potential consequences such as debris in the UHS or access to RWST. In addition, the staff noted that the deployment of FLEX equipment and associated procedural interfaces may be impacted by the UHS and RWST being below the design-basis flood level.	implementation is through the RWST valve house. The RWST valve house is Elevation 840.37 – 840.41 ft. MSL. This is above the maximum plant site flood level of Elevation 840.16 ft. MSL. Access to the RWST valve house would not be restricted and deployment of FLEX equipment would not be impacted. Thus, FLEX strategies that use the RWST are not impacted. Grading around the UHS Retention Pond is designed to prevent surface runoff from flowing into the pond. The plant yard is also graded away from the pond to prevent Site runoff from entering the pond. These design features limit debris entering the UHS Retention Pond and affecting FLEX strategies. Reference: Callaway Plant Flooding Hazard Reevaluation Report
3.1.3.3.A	The licensee did not provide information with regard to procedural interface considerations as they relate to tornados	The following has been included in the Callaway Plant Final Integrated Plan (FIP): "Tornados are generally fast moving events and over quickly. OTO-ZZ-00012, Severe Weather, provides instructions to prepare the plant for severe weather conditions and a potential station blackout prior to the severe weather reaching the station. Callaway Plant has identified multiple deployment routes for the FLEX portable equipment in the event of damage to the deployment routes. Callaway Plant has also developed FLEX Support Guideline FSG-5, Initial Assessment and FLEX Equipment Staging, to provide guidelines to establish clear access routes and for the deployment of the portable FLEX Equipment." FSG-5 includes a diagram that indicates the primary and alternate routes to take in order to move FLEX equipment from the HSB to the various locations that FLEX equipment will be utilized.

Item Number	Description	Callaway Plant Response
3.2.1.A .	The licensee needs to confirm that adverse quantities of nitrogen from accumulators will not be injected into the RCS during an ELAP event using an acceptable methodology that accounts for the potential for heat transfer from the containment building to the contents of the accumulator	Step 1 of FSG-10, "Passive RCS Injection Isolation (Rev. 0)," determines if isolation of Safety Injection (SI) Accumulators is desired. If the Steam Generators will be depressurized below 220 psig, then the SI accumulators are isolated by closure of their discharge isolation valves (if power is available from FLEX 480 VAC Generator) or vented to the containment atmosphere. Callaway Plant calculation, BB-180 Rev.0 Add. 5 "Minimum Steamline Pressure to Prevent Accumulator Nitrogen Injection," establishes the site specific value for the Westinghouse Owners Group Emergency Response Guidelines Setpoint O.07 that is used in the Emergency Operating Procedures (i.e., ECA-0.0, Step 18, Rev. 023). The site calculation takes into consideration the potential for nitrogen expansion/SI accumulator pressure increase from heat sources within the containment building (i.e., RCS).
3.2.1.B	The licensee needs to confirm that the potential failure of nonsafety-related portions of the turbine-driven auxiliary feedwater pump recirculation header piping would not (1) adversely affect the quantity of condensate required for secondary makeup or (2) result in adverse accumulation of water in the CST pipe chase or other areas of the plant.	Callaway Plant has revised ECA-0.0 to provide direction to realign the TDAFP recirculation header piping from the CST to the HCST within 3 hours of the HCST being placed in service. This loss of secondary water would have minimal effect on the surrounding area. The quantity of secondary water lost from the TDAFP recirculation header piping is accounted for in the calculation determining the minimum HCST volume required for a 30 hour supply of water to the SGs and the SFP.
3.2.1.1.A .	Reliance on the NOTRUMP code for the ELAP analysis of Westinghouse plants is limited to the flow	Callaway Plant has used generic plant ELAP analyses performed with the NOTRUMP computer code to support the mitigating strategy in its Overall Integrated Plan (OIP). The use of NOTRUMP was limited to the thermal-hydraulic

Item Number	Description	Callaway Plant Response
	conditions prior to reflux condensation initiation. This includes specifying an acceptable definition for reflux condensation cooling	conditions before reflux condensation initiates. The initiation of reflux condensation cooling is defined when the one-hour centered moving average (CMA) of the flow quality at the top of the SG U-tube bend exceeds 0.1 in any one loop. CN-SEE-I-12-32 determined that the RCS will not enter reflux cooling (greater than 10% vapor) for a minimum of 66.9 hours into the event. Per guidance provided in ECA-0.0, and FSG-8, Alternate RCS Boration, pumped RCS makeup/boration will be established prior to this time.
3.2.1.2.C	Further information is required to assess address the impacts of the Westinghouse 10 CFR Part 21 report, “Notification of the Potential Existence of Defects Pursuant to 10CFR Part 21,” dated July 26, 2013 (ADAMS Accession No. ML13211A168) on the use of the low seal leakage rate in the ELAP analysis.	The Part 21 issue on the Westinghouse low-leakage RCP SHIELD® seals has been resolved. Westinghouse Report TR-FSE-14-1-P, documents how the deficiencies in the Generation I and II seals have been addressed. The report also documents the qualification testing performed on the GEN III seals to ensure acceptable performance under ELAP conditions. The NRC Endorsement of TR-FSE-14-1-P, is documented in NRC Letter from Mr. Jack Davis, Director, Mitigating Strategies Directorate to Mr. James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company LLC, dated May 28, 2014, (ML14132A128) The Westinghouse Generation III SHIELD® seals have been installed in all RCPs.
3.2.1.5.A	The Integrated Plan did not address whether instrumentation credited in the ELAP analysis for automatic actuations and for indications required for the operators to take action are reliable and accurate in the containment harsh conditions. The licensee responded to this question in the audit process by	Modes 1-4: The Gothic Analysis of Containment (CN-SCC-13-001) demonstrates that the containment design pressure and temperature limits are not exceeded during an ELAP. All instrumentation (except Nuclear Instrumentation (NI)) remains functional in an ELAP in Modes 1 – 4. Contingency actions for the potential loss of the NIs have been developed for the control room staff to utilize other instrumentation (e.g., RCS temperature and pressure) as an aid for determination that reactor remains sub-critical. The contingency actions for the loss of NIs have

Item Number	Description	Callaway Plant Response
	pointing out that the licensee's self-identified open item related to the containment environment (O1.2) addresses this issue. The licensee also stated that Westinghouse will be asked to perform a GOTHIC analysis of the containment to demonstrate that acceptable temperature and pressure levels will not be exceeded.	been included in ECA-0.0. Modes 5-6: The Gothic Analysis (CN-SCC-13-001) determined that the containment remains below design pressure for an event in Modes 5 – 6 provided the containment is vented early in the event. Callaway Plant has included this containment venting in FSG-12, Alternate Containment Cooling. All instrumentation remains functional.
3.2.1.6.A	On page 11 of the Integrated Plan, following the sequence of events listed, the licensee stated that to confirm the times given, the licensee will prepare procedures for each task, perform time study walkthroughs for each of the tasks under simulated ELAP conditions, and account for equipment and tagging and other administrative procedures required to perform the task. Further review of the Sequence of Events will be required following this review.	FLEX Support Guidelines (FSGs) have been prepared for each task. Validation of the FSG's has been performed per NEI 12-06, Revision 2, Appendix E, Validation Guidance. The validations have assured that required tasks, manual actions, and decisions for FLEX strategies are feasible and may be executed within the constraints identified in the Final Integrated Plan (FIP) for Order EA-12-049. The Sequence of Events Timeline has been updated to include changes made to the Overall Integrated Plan since its submittal. The revised Sequence of Events Timeline has been included in the Final Integrated Plan (Enclosure 4 of this submittal). Changes to the Timeline are primarily associated with the addition of the new HCST as part of FLEX strategies.
3.2.1.8.A	Adequate basis is needed for the timing and quantity of the injection of borated coolant as well as justification that administrative procedures will ensure that subcriticality requirements	Callaway Plant has performed a calculation for the "Time after reactor trip when RCS boration is required" (V.08). This time has been included in the appropriate FSGs. Future core reloads will be bounded by EDP-ZZ-00014, Reload Design Control and Coordination, to ensure that the results of the calculation remain conservative.

Item Number	Description	Callaway Plant Response
	for future cores are bounded	
3.2.2.A .	The licensee stated the water supply for SFP cooling involves three connections points, all located on the exterior of the fuel building. The connection points on the exterior of the fuel building will need to be protected from high wind missile strikes. If protection is not possible, the connection points will need to be relocated to the inside of the building. The configuration needs to be resolved	The three connections (primary, alternate, and spray) for the Spent Fuel Pool Cooling strategy have been revised to place these connections just inside the Fuel Building, a Seismic Category 1 structure. An evaluation determined that the connection points would accessible early in the event.
3.2.2.B	The licensee stated that Westinghouse is being asked to clarify the basis for the 48 hour boil off time for the SFP level and the resulting information will be provided in a future 6-month update to the Integrated Plan.	The reference to 48 hours was an error from previous draft versions of the OIP predicated on a level of 10 feet above the fuel racks. The boil off time in the OIP to a level of 15 feet above the fuel racks should have been 35.2 hours. The basis is the time to boil from initial conditions of 140°F and atmospheric pressure is 5.46 hours. An additional time of 29.79 hours was calculated for the boil-off time to a level in the SFP 15 feet above the fuel racks. The time to boil of 5.46 hours plus the boil-off time of 29.79 hours (a total of 35.2 hours) is the basis for a required action time of 33 hours. The 33 hours basis allows for deployment time of SFP Make-Up portable equipment prior to reaching a level of 10 feet above the fuel racks. Westinghouse calculation CN-SEE-II-12-39, "Determination of the Time to Boil in the Callaway Spent Fuel Pool after an Earthquake", provides the basis for maximum and nominal boil off cases.

Item Number	Description	Callaway Plant Response
3.2.3.A	The licensee will use GOTHIC to analyze containment conditions and based on the results of this evaluation, will develop required actions to ensure maintenance of containment integrity and required instrument function. The licensee stated that a detailed discussion of the GOTHIC analysis will be provided in a future 6-month update to address containment cooling during an ELAP event.	Modes 1-4: The Gothic Analysis of Containment (CN-SCC-13-001) demonstrates that the containment design pressure and temperature limits are not exceeded during an ELAP. All instrumentation (except Nuclear Instrumentation (NI)) remains functional in an ELAP in Modes 1 – 4. Contingency actions for the potential loss of the NIs have been developed for the control room staff to utilize other instrumentation (e.g., RCS temperature and pressure) as an aid for determination that reactor remains sub-critical. The contingency actions for the loss of NIs have been included in ECA-0.0. Modes 5-6: The Gothic Analysis (CN-SCC-13-001) determined that the containment remains below design pressure for an event in Modes 5 - 6 provided the containment is vented early in the event. Containment venting has been included in FSG-12, Alternate Containment Cooling. All instrumentation remains functional. Requested evaluation of the concrete and steel supporting the Rx Vessel: Per Callaway Reactor Engineering/Accident Analysis, containment temperature analysis shows that the RV cavity temperatures closely follow RCS temperature. Temperature starts at around 580°F then cools down to 415°F and hits 350°F within 24 hours. Long term RCS temperature then reach cold shutdown conditions of 200°F or less. Concrete: ACI 216.1 (see attached) provides information for determining the fire resistance of concrete. While this standard is focused on fire effects, information is also presented on the effects of high temperatures in general on the strength of reinforced concrete. Per Figure 4.4.2.2.1c (a), the compressive strength of carbonate aggregate concrete would see virtually no reduction in the stressed condition and a reduction of approximately 10% to 12% in the unstressed condition. As the dead weight of the reactor

Item Number	Description	Callaway Plant Response
		vessel is always present, the stressed condition would be more applicable. Per Figure 4.4.2.2.1b, a reduction of approximately 18% could be seen in the yield strength of the reinforcing steel (hot-rolled steel)at a temperature of 580°F; however, as the primary load application is compression at this point in the scenario (i.e. no uplift from seismic), the strength reduction of the reinforcing steel is not critical. Therefore, the reinforced concrete supporting the reactor vessel would not experience a significant loss of capacity due to a BDBEE resulting in a loss of forced ventilation. Steel: Per "Steel Structures - Design and Behavior", Figure 2.7.1(a) (see attached), a 10% reduction can be seen in the yield strength of structural steel at 580°F versus room temperature. For evaluation purposed, a 15% reduction will be conservatively considered. Evaluation: The reactor vessel is supported by 4 supports as shown on Drawing C-2S2930. These supports are designed in Calculation C-02-61-F. Calculation C-02-61-F, Rev. 2, Add 1 refers to Calculation 32-9183012, rev. 1 which evaluates the supports for revised loadings associated with replacement of the reactor vessel head. Tables 3-1 and 3-2 of this calculation provide a comparison of the new design loads versus the old design loads associated with replacement of the reactor vessel integrated head assembly (IHA). As can be seen in Table 3-1, an additional 18% margin is made available with respect to the steel supports due to the reduced weight of the new IHA. This 18% is based on seismic loadings whereas 40% margin is available based on non-seismic loadings. As a 15% reduction in steel strength at 580°F has been postulated, it is apparent that this reduction is within the available margin provided by the IHA weight reduction alone. Thus the structural steel support as acceptable for the elevated temperature of 580°F. Table 3-2, documents an additional 59.2% margin that is made available with respect to the concrete due to the reduced weight of the new IHA. As no

Item Number	Description	Callaway Plant Response
		significant reduction in concrete strength is expected at 580°F, the concrete is also acceptable.
3.2.4.2.A	The licensee needs to provide details regarding a plan to prevent hydrogen accumulation in the battery room during phases 2 and 3.	Under conditions where there is no ventilation, H_2 concentration would reach 2% in 2.62 days in one of the Class 1E Battery Rooms (longer for the other three rooms). A ventilation flow of 100 CFM of air ensures that the concentration would not become critical. Temporary Ventilation for the Class 1E Battery Rooms will be established well before the H_2 concentration would reach 2% per FSG-45, "Temporary Ventilation and Lighting". FSG-45, Section 4.2 provides guidance for establishing battery room ventilation flow and H_2 monitoring. The blowers purchased for H_2 removal have a minimum flow rate of 1842 CFM. It should be noted that H_2 accumulation is only a concern during battery charging operations, which do not occur until 8 – 10 hours after the start of an ELAP. Reference: Callaway Plant Calculation M-GK-370, Revision 1, "Post-Accident Battery Room H2 Concentration Levels"
3.2.4.2.B	A discussion is needed specifically on the extreme low temperatures effects of the batteries capability to perform its function for the duration of the ELAP event.	A Gothic Analysis (Zachery Nuclear Engineering Calculation NAI-1871-001, Revision 0) was performed to determine if the temperature in the battery rooms fall below 60°F, due to extreme low outside temperatures, until such time that the FLEX generators are supplying the battery chargers. The analysis showed with the original minimum room temperature of 60°F the battery rooms will have a slight temperature increase through the ELAP event with no equipment heaters. The DC powered equipment in the room surrounding the battery room will provide sufficient heat to keep the battery room temperatures above 60°F.
3.2.4.2.C	The licensee stated that an assessment of room environmental conditions and effects on key	For coping times beyond 24 hours, temporary ventilation will be provided. Callaway Plant will utilize EOP Addendum 20, Control Room Cabinet Door List, FSG-45, and Attachment II of

Item Number	Description	Callaway Plant Response
	equipment was performed and the assessment determined that the near term actions were considered acceptable for 24 hours following a BDBEE scenario as outlined in NEI 12-06. However, the licensee further stated that a future action is required to evaluate coping times beyond 24 hours. This action should also address the capability to vent the SFP area.	Emergency Coordinator Supplemental Guide, Fuel Building Ambient Cooling, to address NEI 12-06 Section 3.2.2, Guideline 10. FSG-45 provides ventilation of areas of concern (e.g., TDAFP Room, Control Room) to ensure equipment will be able to perform as required. In addition, proximity suits, SCBAs will be available for personnel to enter high temperature areas to operate critical components (e.g., TDAFP) if required. The Fuel Building is vented early in the event prior to the environmental conditions preventing entry into the building.
3.2.4.3.A	The potential for (1) freezing of water in FLEX equipment and (2) crystallization of boric acid solution, and therefore the potential need for heat tracing on Chemical and volume control system lines, is still not addressed for long periods of time during the ELAP event scenarios. The licensee stated that additional work is required on these subjects to ensure that the potential for freezing and boron solidification is addressed.	Most FLEX equipment required to implement FLEX strategies is stored in the Hardened Storage Building (HSB). The HSB is maintained greater than 50°F. FSG-50, Freeze Protection for ELAP Response, provides direction for establishing freeze protection for installed plant and temporary equipment. The FLEX equipment not stored in the HSB is stored in the power block which is also maintained at greater than 50°F. Calculation NAI-1901-001, GOTHIC Analysis of the Boric Acid Tank Rooms for Extended Loss of A/C Power, determines the room temperature in the boric acid tank (BAT) rooms 1116 and 1117 on elevation 1974' and room 1407 on elevation 2026' during an extended loss of A/C power event. Although the temperature initially increases slightly above 60°F in each room the temperature then drops. In room 1116 the temperature drops below 59°F around 151,200 seconds (42 hours) and lies around 58°F at 72 hours. In room 1117 the temperature drops below 59°F around 133,200 seconds (37 hours) and lies just below 58°F after 72 hours. The temperature in Room 1407 drops below 59°F at approximately 48,600 seconds (13.5 hours) to just above 53°F at 72 hours.

Item Number	Description	Callaway Plant Response
		According to the 15th edition of Lange's Handbook of Chemistry (p. 5.11), a single batch of boric acid (7000 ppm) will remain in solution at temperatures as low as 40°F. FSG-47, Batching Boric Acid to the Boric Acid Storage Tanks, has provision to heat makeup water to 90°F. This Boric Acid solution when added to the BAT Tanks will contribute to maintaining the solution above the crystallization temperature. However, no credit is taken for this thermal addition in Calculation NAI-1901-001. The heat load required to maintain the temperature in the Auxiliary Building 1974' elevation Rooms 1116, 1117 and 1407 to above 59°F over 72 hours is 18,000 BTU/HR. FSG-50, Freeze Protection for ELAP Response, has direction to place an electric heater(s) capable of producing greater than 18,000 BTU/HR in the Auxiliary Building 1974' elevation in order to maintain the temperature in Rooms 1116, 1117 and 1407 to above 59°F over 72 hours. Additional direction is given to heat the Boron Injection Header room which, during an ELAP, will contain permanent and temporary piping/hoses used for boron injection. Furthermore, direction is given to establish temporary heating for the permanent and temporary piping/hoses going into the North Piping Penetration Room. The Callaway Plant FLEX Final Integrated Plan (FIP) states that FLEX equipment may be required to operate in temperatures as low as -26°F. The following provides a discussion of how that requirement is met. The Hardened Storage Building (HSB) design specification Z-1052 specifies a minimum ambient temperature of -26°F. The specification further requires the ventilation system to be capable of maintaining a minimum temperature of 50°F. Currently, the HSB is being maintained at 72°F or above to prevent low coolant temperature alarms on certain equipment. The HSB is checked daily by an Operations Technician making rounds.

Item Number	Description	Callaway Plant Response
		FLEX equipment was purchased non-safety related, commercial grade. The Equipment Specification for the Steam Generator/RCS Makeup FLEX Pump Rev. 0 dated 3/12/14, Section 3.3.1, states "the equipment shall be capable of continuous duty rated output at an ambient temperature between -40°F and 130°F". The Equipment Specification for the Spent Fuel Pool (SFP) Makeup Pump Rev. 0 dated 3/17/14, Section 3.3.1, states "the equipment shall be capable of continuous duty rated output at an ambient temperature between -30°F and 130°F". The Equipment Specification for the 480 VAC Diesel Generator Rev. 0 dated 6/9/14, Section 3.3.1, states, "The engine, generator and support equipment shall be capable of continuous duty rated output at an ambient temperature between -30°F to 130°F". The suppliers of this equipment have told Callaway Plant project personnel that the equipment manufacturers will not provide a minimum operating temperature for their equipment. Suppliers stated they have equipment operating in more severe low temperature environments than found at the Callaway Plant, and no supplier took exception to the low temperature specification requirement. Significant anecdotal information exists supporting equipment operation to -26°F and lower, as follows: <u>Steam Generator/RCS Makeup FLEX Pump</u> • John Deere engine Operator's Manual o Page 10-6, Minimizing the Effect of Cold Weather on Diesel Engines o Page 10-8, Engine oil viscosities to -40°F o Pages 10-14 and 10-15, Engine coolant concentrations to -62°F o Page 20-7, Cold Weather Operations to -40°F o Page 20-8, Warming Engine (in below freezing conditions) • Skid contains an engine block heater <u>SFP Makeup Pump</u> • John Deere engine Operating Manual o Page 10-6, Minimizing Effect of Cold

<table>
<tr><th>Item Number</th><th>Description</th><th>Callaway Plant Response</th></tr>
<tr><td></td><td></td><td>Weather on Diesel Engines
o Page 10-8, Engine oil viscosities to -40°F
o Page 10-12, Engine coolant concentrations to -62°F
• Skid contains Hotstart Thermosiphon coolant heater

<u>480 VAC Diesel Generator</u>
• Caterpillar Operations and Maintenance Manual
o Page 37, Cold Start Strategy
o Page 56, Cold Weather Starting
o Page 71, Cold Weather Operation
▪ Special Publication SEBU5898, “Cold Weather Operations”
• -26°F falls into Cold Weather Category 4, which goes down to -40°F.
• Skid contains heavy duty battery
• Skid contains coolant heater
• Oil heater, fuel heater and battery warmer are not required with shore power, and would not function without shore power
• OW40 or lower oil viscosity recommended
• Antifreeze concentration appropriate to -26°F and lower
• Skid contains JWHD032 Jacket Water Heater set to 100°F
• Engine controller, voltage regulator, gen set controller and digital I/O module rated to -40°F.
From the above information it has been determined with reasonable assurance that the FLEX equipment procured for Callaway will start and run at -26°F and even lower, given the use of appropriate oil viscosities, coolant concentrations, block/coolant heaters and HSB heating.</td></tr>
<tr><td>3.2.4.4.A</td><td>The licensee needs to provide information concerning the source of</td><td>The FLEX portable lighting equipment is stored in the Hardened Storage Building. Staging and deployment of temporary lighting is delineated in</td></tr>
</table>

Item Number	Description	Callaway Plant Response
	power, storage location and the procedures the operators will use to stage temporary lights.	FSG-45. This FSG identifies the various sources of electrical power available for temporary lighting in the Control Room and critical plant areas.
3.2.4.4.B	The NRC staff has reviewed the licensee communications assessment (ADAMS Accession Nos. ML12306A199 and ML13056A135) and has determined that the assessment for communications is reasonable. Confirmation is required to demonstrate that upgrades to the site's communication systems have been completed.	All upgrades to the site's communication systems have been completed. Callaway Plant has modified the plant radio passive antenna system in the power block to enhance radio communications. The portable radio cart has been procured and is stored in the Hardened Storage Building. External antennas have been installed in the Control Room, TSC, and EOF to support satellite phone communications. Acceptance Testing of the portable radio cart has been completed. Plant radios have been upgraded to provide line-of-sight communications.
3.2.4.6.A	There were several references in the Integrated Plan regarding the need for analyses and procedures to address ventilation of areas such as equipment rooms and the spent fuel pool area. The licensee responded to questions regarding habitability and stated that the subject of area ventilation will be addressed in a future 6-month update.	A review of areas/rooms that could be entered to implement FLEX strategies was performed. From this list, specific areas/rooms were identified that potentially would have elevated temperatures that could affect personnel access and/or equipment functionality. These areas/rooms were further evaluated to ensure the applicable FLEX strategies would not be affected. These areas/rooms are: • Control Room • TDAFP Room • Rooms associated with the Class 1E DC power sources • Fuel Building <u>Control Room:</u> GOTHIC modeling of the Control Room temperature response to the extended SBO indicates that main control room temperature will remain below 120ºF.

Item Number	Description	Callaway Plant Response
		Reference: Callaway Plant Calculation BO-05, Revision 1, Addendum 1 <u>TDAFP Room:</u> GOTHIC modeling of the TDAFP room's temperature response to an extended run demonstrates that long-term temperatures in the TDAFP room remain within the acceptable range (below design limits). Reference: Callaway Calculation M-GF-415, Addendum 5, Four Mode Turbine Driven Aux. Feedwater Pump room heat up with exhaust steam leak. <u>Class 1E DC Power Rooms:</u> GOTHIC modeling indicates that the temperatures in the rooms associated with the safety-related DC power sources will remain within acceptable ranges (below design limits) for the first 24 hours of an extended SBO event. Reference: Callaway Calculation GK-19, Revision 0, Addendum 2, "PRA – Calculation of DC and ESF Switchgear Room Heatup <u>Fuel Building:</u> The Fuel Building is vented and hoses for spent fuel pool spray and makeup are connected early in the event prior to the temperature and/or radiation levels rising significantly. <u>Additional Information:</u> Beginning at 6 hours post-event (additional resources arrive at the site), sufficient resources are available to deploy temporary ventilation per FSG-45 at the various areas/rooms that may need additional ventilation. The Atmospheric Steam Dumps (ASD) valves are operated remotely. Therefore, personnel access to Area 5 of the Auxiliary Building is not required. Temperatures do not reach levels that would impact equipment functionality.

Item Number	Description	Callaway Plant Response
3.2.4.7.A	The licensee stated the primary strategy for providing adequate cooling during Modes 5 and 6 will take suction from the new RWST connection on the RWST drain line. The licensee further stated that the RWST is seismically qualified but not missile protected. The licensee has noted a self-identified open item stating that the RWST will be missile protected to credit its use in core cooling with SGs not available strategies.	Callaway Plant has revised our Mode 5 – 6 Shutdown ELAP Strategy due to concerns that the RWST is not missile protected. Therefore, the RWST is not a credited source of makeup water for the high wind extreme hazard. The revised strategy for high winds will utilize the new Hardened Condensate Storage Tank (HCST) as a water source and the Boric Acid Batching Tank (BABT) as our boron source for make-up to the BATs. FSG-14 provides a blended flow strategy from the HCST and the BATs for protection against the high wind hazard.
3.2.4.10.A	With regard to the battery load shed evolution, the licensee did not address the general question as to whether the potential loss of plant functions and resulting consequences has been addressed. Also, the licensee explained that the main generator seal oil pump is powered from the balance of plant batteries but did not address generator hydrogen hazards when the balance of plant batteries are exhausted. Licensee is requested to address these concerns	FSG-4 load sheds those components that will allow the NK batteries to last 12 hours after the event. Calculation NK-05 Attachment O addresses ELAP conditions. Components shed are those components not needed (status panels) or no longer needed (e.g., steam line and feedwater isolation and reactor trip functions which would have already occurred). ECA-0.0 lists steps to vent hydrogen from the main generator. This task is accomplished early in the event so as to not allow hydrogen buildup becoming a hazard and is accounted for in the Phase 2 staffing analysis.

NRC AUDIT REPORT OPEN AND PENDING ITEMS

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CI 3.2.3.A	The licensee will use GOTHIC to analyze containment conditions and based on the results of this evaluation, will develop required actions to ensure maintenance of containment integrity and required instrument function. The licensee stated that a detailed discussion of the GOTHIC analysis will be provided in a future 6-month update to address containment cooling during an ELAP event.	Modes 1-4: The Gothic Analysis of Containment (CN-SCC-13-001) demonstrates that the containment design pressure and temperature limits are not exceeded during an ELAP. All instrumentation (except Nuclear Instrumentation (NI)) remains functional in an ELAP in Modes 1 – 4. Contingency actions for the potential loss of the NIs have been developed for the control room staff to utilize other instrumentation (e.g., RCS temperature and pressure) as an aid for determination that reactor remains sub-critical. The contingency actions for the loss of NIs have been included in ECA-0.0. Modes 5-6: The Gothic Analysis (CN-SCC-13-001) determined that the containment remains below design pressure for an event in Modes 5 - 6 provided the containment is vented early in the event. Containment venting has been included in FSG-12, Alternate Containment Cooling. All instrumentation remains functional. Requested evaluation of the concrete and steel supporting the Rx Vessel: Per Callaway Reactor Engineering/Accident Analysis, containment temperature analysis shows that the RV cavity temperatures closely follow RCS temperature. Temperature starts at around 580°F then cools down to 415°F and hits 350°F within 24 hours. Long term RCS temperature then reach cold shutdown conditions of 200°F or less. Concrete: ACI 216.1 (see attached) provides information for determining the fire resistance of concrete. While this standard is focused on fire effects, information is also presented on the effects of high temperatures in general on the strength of reinforced concrete. Per Figure 4.4.2.2.1c (a), the compressive strength of carbonate aggregate concrete would see virtually no reduction in the stressed condition and a reduction of approximately 10% to 12% in the unstressed condition. As the dead weight of the reactor

Item Number	Description	Callaway Plant Response
		vessel is always present, the stressed condition would be more applicable. Per Figure 4.4.2.2.1b, a reduction of approximately 18% could be seen in the yield strength of the reinforcing steel (hot-rolled steel)at a temperature of 580°F; however, as the primary load application is compression at this point in the scenario (i.e. no uplift from seismic), the strength reduction of the reinforcing steel is not critical. Therefore, the reinforced concrete supporting the reactor vessel would not experience a significant loss of capacity due to a BDBEE resulting in a loss of forced ventilation. Steel: Per "Steel Structures - Design and Behavior", Figure 2.7.1(a) (see attached), a 10% reduction can be seen in the yield strength of structural steel at 580°F versus room temperature. For evaluation purposed, a 15% reduction will be conservatively considered. Evaluation: The reactor vessel is supported by 4 supports as shown on Drawing C-2S2930. These supports are designed in Calculation C-02-61-F. Calculation C-02-61-F, Rev. 2, Add 1 refers to Calculation 32-9183012, rev. 1 which evaluates the supports for revised loadings associated with replacement of the reactor vessel head. Tables 3-1 and 3-2 of this calculation provide a comparison of the new design loads versus the old design loads associated with replacement of the reactor vessel integrated head assembly (IHA). As can be seen in Table 3-1, an additional 18% margin is made available with respect to the steel supports due to the reduced weight of the new IHA. This 18% is based on seismic loadings whereas 40% margin is available based on non-seismic loadings. As a 15% reduction in steel strength at 580°F has been postulated, it is apparent that this reduction is within the available margin provided by the IHA weight reduction alone. Thus the structural steel support as acceptable for the elevated temperature of 580°F. Table 3-2, documents an additional 59.2% margin that is made available with respect to the concrete due to the reduced weight of the new IHA. As no significant reduction in concrete strength is

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		expected at 580°F, the concrete is also acceptable.
CI 3.2.4.3.A	The potential for (1) freezing of water in FLEX equipment and (2) crystallization of boric acid solution, and therefore the potential need for heat tracing on Chemical and volume control system lines, is still not addressed for long periods of time during the ELAP event scenarios. The licensee stated that additional work is required on these subjects to ensure that the potential for freezing and boron solidification is addressed.	Most FLEX equipment required to implement FLEX strategies is stored in the Hardened Storage Building (HSB). The HSB is maintained greater than 50°F. FSG-50, Freeze Protection for ELAP Response, provides direction for establishing freeze protection for installed plant and temporary equipment. The FLEX equipment not stored in the HSB is stored in the power block which is also maintained at greater than 50°F. Calculation NAI-1901-001, GOTHIC Analysis of the Boric Acid Tank Rooms for Extended Loss of A/C Power, determines the room temperature in the boric acid tank (BAT) rooms 1116 and 1117 on elevation 1974' and room 1407 on elevation 2026' during an extended loss of A/C power event. Although the temperature initially increases slightly above 60°F in each room the temperature then drops. In room 1116 the temperature drops below 59°F around 151,200 seconds (42 hours) and lies around 58°F at 72 hours. In room 1117 the temperature drops below 59°F around 133,200 seconds (37 hours) and lies just below 58°F after 72 hours. The temperature in Room 1407 drops below 59°F at approximately 48,600 seconds (13.5 hours) to just above 53°F at 72 hours. According to the 15th edition of Lange's Handbook of Chemistry (p. 5.11), a single batch of boric acid (7000 ppm) will remain in solution at temperatures as low as 40°F. FSG-47, Batching Boric Acid to the Boric Acid Storage Tanks, has provision to heat makeup water to 90°F. This Boric Acid solution when added to the BAT Tanks will contribute to maintaining the solution above the crystallization temperature. However, no credit is taken for this thermal addition in Calculation NAI-1901-001. The heat load required to maintain the temperature in the Auxiliary Building 1974' elevation Rooms 1116, 1117 and 1407 to above 59°F over 72 hours is 18,000 BTU/HR. FSG-50, Freeze Protection for ELAP Response, has direction to place an electric heater(s) capable of producing greater than 18,000 BTU/HR in the

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		Auxiliary Building 1974' elevation in order to maintain the temperature in Rooms 1116, 1117 and 1407 to above 59°F over 72 hours. Additional direction is given to heat the Boron Injection Header room which, during an ELAP, will contain permanent and temporary piping/hoses used for boron injection. Furthermore, direction is given to establish temporary heating for the permanent and temporary piping/hoses going into the North Piping Penetration Room. The Callaway Plant FLEX Final Integrated Plan (FIP) states that FLEX equipment may be required to operate in temperatures as low as -26°F. The following provides a discussion of how that requirement is met. The Hardened Storage Building (HSB) design specification Z-1052 specifies a minimum ambient temperature of -26°F. The specification further requires the ventilation system to be capable of maintaining a minimum temperature of 50°F. Currently, the HSB is being maintained at 72°F or above to prevent low coolant temperature alarms on certain equipment. The HSB is checked daily by an Operations Technician making rounds. FLEX equipment was purchased non-safety related, commercial grade. The Equipment Specification for the Steam Generator/RCS Makeup FLEX Pump Rev. 0 dated 3/12/14, Section 3.3.1, states "the equipment shall be capable of continuous duty rated output at an ambient temperature between -40°F and 130°F". The Equipment Specification for the Spent Fuel Pool (SFP) Makeup Pump Rev. 0 dated 3/17/14, Section 3.3.1, states "the equipment shall be capable of continuous duty rated output at an ambient temperature between -30°F and 130°F". The Equipment Specification for the 480 VAC Diesel Generator Rev. 0 dated 6/9/14, Section 3.3.1, states, "The engine, generator and support equipment shall be capable of continuous duty rated output at an ambient temperature between -30°F to 130°F". The suppliers of this equipment have told Callaway Plant project personnel that the equipment manufacturers will not provide a minimum operating temperature for their equipment. Suppliers stated they have equipment operating in more severe low temperature

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		environments than found at the Callaway Plant, and no supplier took exception to the low temperature specification requirement. Significant anecdotal information exists supporting equipment operation to -26°F and lower, as follows:
		Steam Generator/RCS Makeup FLEX Pump
		• John Deere engine Operator's Manual
		  o Page 10-6, Minimizing the Effect of Cold Weather on Diesel Engines
		  o Page 10-8, Engine oil viscosities to -40°F
		  o Pages 10-14 and 10-15, Engine coolant concentrations to -62°F
		  o Page 20-7, Cold Weather Operations to -40°F
		  o Page 20-8, Warming Engine (in below freezing conditions)
		• Skid contains an engine block heater
		SFP Makeup Pump
		• John Deere engine Operating Manual
		  o Page 10-6, Minimizing Effect of Cold Weather on Diesel Engines
		  o Page 10-8, Engine oil viscosities to -40°F
		  o Page 10-12, Engine coolant concentrations to -62°F
		• Skid contains Hotstart Thermosiphon coolant heater
		480 VAC Diesel Generator
		• Caterpillar Operations and Maintenance Manual
		  o Page 37, Cold Start Strategy
		  o Page 56, Cold Weather Starting
		  o Page 71, Cold Weather Operation
		    ▪ Special Publication SEBU5898, "Cold Weather Operations"
		      • -26°F falls into Cold Weather Category 4, which goes down to -40°F.
		      • Skid contains heavy duty battery
		      • Skid contains coolant heater
		      • Oil heater, fuel heater and battery warmer are not required with shore

Item Number	Description	Callaway Plant Response
		power, and would not function without shore power • OW40 or lower oil viscosity recommended • Antifreeze concentration appropriate to -26°F and lower • Skid contains JWHD032 Jacket Water Heater set to 100°F • Engine controller, voltage regulator, gen set controller and digital I/O module rated to -40°F From the above information it has been determined with reasonable assurance that the FLEX equipment procured for Callaway will start and run at -26°F and even lower, given the use of appropriate oil viscosities, coolant concentrations, block/coolant heaters and HSB heating.
CI 3.2.4.6.A	There were several references in the Integrated Plan regarding the need for analyses and procedures to address ventilation of areas such as equipment rooms and the spent fuel pool area. The licensee responded to questions regarding habitability and stated that the subject of area ventilation will be addressed in a future 6-month update.	A review of areas/rooms that could be entered to implement FLEX strategies was performed. From this list, specific areas/rooms were identified that potentially would have elevated temperatures that could affect personnel access and/or equipment functionality. These areas/rooms were further evaluated to ensure the applicable FLEX strategies would not be affected. These areas/rooms are: • Control Room • TDAFP Room • Rooms associated with the Class 1E DC power sources • Fuel Building <u>Control Room:</u> GOTHIC modeling of the Control Room temperature response to the extended SBO indicates that main control room temperature will remain below 120ºF. Reference: Callaway Plant Calculation BO-05, Revision 1, Addendum 1 <u>TDAFP Room:</u> GOTHIC modeling of the TDAFP room's temperature response to an extended run demonstrates that long-term temperatures in the TDAFP room remain within the acceptable range

Item Number	Description	Callaway Plant Response
		(below design limits). Reference: Callaway Calculation M-GF-415, Addendum 5, Four Mode Turbine Driven Aux. Feedwater Pump room heat up with exhaust steam leak. Class 1E DC Power Rooms: GOTHIC modeling indicates that the temperatures in the rooms associated with the safety-related DC power sources will remain within acceptable ranges (below design limits) for the first 24 hours of an extended SBO event. Reference: Callaway Calculation GK-19, Revision 0, Addendum 2, "PRA – Calculation of DC and ESF Switchgear Room Heatup Fuel Building: The Fuel Building is vented and hoses for spent fuel pool spray and makeup are connected early in the event prior to the temperature and/or radiation levels rising significantly. Additional Information: Beginning at 6 hours post-event (additional resources arrive at the site), sufficient resources are available to deploy temporary ventilation per FSG-45 at the various areas/rooms that may need additional ventilation. The Atmospheric Steam Dumps (ASD) valves are operated remotely. Therefore, personnel access to Area 5 of the Auxiliary Building is not required. Temperatures do not reach levels that would impact equipment functionality.
AQ.2	Procedural interface considerations (seismic). The licensee's plan for the development of mitigating strategies with respect to the procedural interfaces, NEI 12-06 Section 5.3.3, considerations 2, 3, and 4 for seismic hazards associated with large internal flooding sources that are not seismically	The inventory of the CST is postulated to drain into the 1974' elevation of the Aux. Building through the break of a non-seismic pipe in the Auxiliary Feedwater piping room on the 1988' elevation of the Auxiliary. Building (AB). Rooms 1206/1207 do not flood over six inches, and that water drains from the rooms within several hours. Conservatively assuming available floor area in the AB 1974' elevation and assuming the maximum amount of CST inventory which could drain, the flood height would be approximately 4 ft. The flooding inventory from the CST bounds other

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	robust and do not require ac power; the use of ac power to mitigate ground water in critical locations; and the existence of non-seismically robust downstream dams, respectively, does not provide sufficient information to conclude that there is reasonable assurance that these aspects of NEI 12-06, Section 5.3.3 will be met. Please provide additional information to demonstrate conformance to NEI 12-06, Section 5.3.3, considerations 2, 3, and 4.	water sources which have the ability to drain into the Auxiliary Building. To account for the potential flooding in the Auxiliary Building basement, the following changes have been made: • The second FLEX Boron Injection\RCS Make-up pump is now stored in the Hardened Storage Building (HSB). • The electrical connection for this second pump has been revised such that the primary connection will be from a welding receptacle powered via TVPG28 independent of PG28. This change also provides electrical diversity for this strategy.
SE. 6	Provide a summary of the assessment of temperature effects on the Phase 2 and Phase 3 FLEX generators as a result of extreme temperature hazards.	The Callaway FLEX Final Integrated Plan (FIP) states that FLEX equipment may be required to operate in temperatures as low as -26°F. The following provides a discussion of how that requirement is met. The Hardened Storage Building (HSB) design specification Z-1052 specifies a minimum ambient temperature of -26F. The specification further requires the ventilation system to be capable of maintaining a minimum temperature of 50F. The current ventilation low temperature setpoint is 72°F to prevent low coolant temperature alarms on certain equipment. The HSB is checked daily by an Operations Technician making rounds. Thus, at the initiation of a Beyond Design Basis External Event (BDBEE), equipment temperatures will be ≥72°F. FLEX equipment was purchased non-safety related, commercial grade. The Equipment Specification for the Steam Generator/RCS Makeup FLEX Pump Rev. 0 dated 3/12/14, Section 3.3.1, states “the equipment shall be capable of continuous duty rated output at an ambient temperature between -40°F and 130°F”. The Equipment Specification for the Spent Fuel Pool (SFP) Makeup Pump Rev. 0 dated 3/17/14, Section 3.3.1, states “the equipment shall be capable of continuous duty rated output at an

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		ambient temperature between -30°F and 130°F". The Equipment Specification for the 480 VAC Diesel Generator Rev. 0 dated 6/9/14, Section 3.3.1, states, "The engine, generator and support equipment shall be capable of continuous duty rated output at an ambient temperature between -30 degrees F to 130 degrees F". The suppliers of this equipment have told Callaway project personnel that the equipment manufacturers do not and will not provide a minimum operating temperature for their equipment. Suppliers stated they have equipment operating in more severe low temperature environments than found at the Callaway site, and no supplier took exception to the low temperature specification requirement. Significant anecdotal information exists supporting equipment operation to -26°F and lower, as follows: Steam Generator/RCS Makeup FLEX Pump • John Deere engine Operator's Manual o Page 10-6, Minimizing the Effect of Cold Weather on Diesel Engines o Page 10-8, Engine oil viscosities to -40°F o Pages 10-14 and 10-15, Engine coolant concentrations to -62°F o Page 20-7, Cold Weather Operations to -40°F o Page 20-8, Warming Engine (in below freezing conditions) • Skid contains an engine block heater SFP Makeup Pump • John Deere engine Operating Manual o Page 10-6, Minimizing Effect of Cold Weather on Diesel Engines o Page 10-8, Engine oil viscosities to -40°F o Page 10-12, Engine coolant concentrations to -62°F • Skid contains Hotstart Thermosiphon coolant heater 480 VAC Diesel Generator • Caterpillar Operations and Maintenance Manual o Page 37, Cold Start Strategy

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		o Page 56, Cold Weather Starting o Page 71, Cold Weather Operation ▪ Special Publication SEBU5898, "Cold Weather Operations" • -26°F falls into Cold Weather Category 4, which goes down to -40°F. • Skid contains heavy duty battery • Skid contains coolant heater • Oil heater, fuel heater and battery warmer are not required with shore power, and would not function without shore power • OW40 or lower oil viscosity recommended • Antifreeze concentration appropriate to -26°F and lower • Skid contains JWHD032 Jacket Water Heater set to 100°F • Engine controller, voltage regulator, gen set controller and digital I/O module rated to -40°F From the above information it can be concluded with reasonable assurance that the FLEX equipment procured for Callaway will start and run at -26°F and even lower, given the use of appropriate oil viscosities, coolant concentrations, block/coolant heaters and HSB heating.
SE.17	NEI 12-06 tables 3-1 and D-3 both specify the baseline capability of make to the SFP via hoses on the refuel floor direct to the pool and spray capability via portable monitor nozzles. The licensee's primary makeup method the SFP uses installed piping and an installed spray nozzle. Also, the license uses separate, installed spray nozzles for the overspray capability. Please provide justification for the alternate approach to NEI 12-06	Callaway Plant has implemented an alternate approach from NEI 12-06, Diverse And Flexible Coping Strategies (FLEX) Implementation Guide, (Reference 3), Table 3-2, PWR FLEX Baseline capability Summary, for Spent Fuel Cooling. Callaway Plant has installed seismically robust piping to provide make-up and spray to the Spent Fuel Pool (SFP). Callaway Plant has installed a permanently mounted, seismically robust spray header to provide spray for the SFP. The spent fuel cooling strategy utilizes a portable pump to discharge through hoses that connect to this added installed piping to provide the required makeup and spray flow. These alternate methods exceed the requirements for performance attributes of NEI 12-06, Table D-3, Summary of Performance Attributes for PWR SFP Cooling Functions. Callaway Plant

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	involving the use of installed primary SFP cooling method and installed spray nozzles.	considers the seismically robust piping to provide make-up and spray to the Spent Fuel Pool (SFP) an upgrade over the minimal requirements of NEI 12-06, Table 3-2, which only require "Make-up via hoses direct to the pool" and "Spray via portable nozzles".
SE.18	Confirm the seismic protection of connection points (both electrical and mechanical) and the access to those points through seismically robust structures IAW with NEI 12-06 consideration 5.3.2.2.	Callaway Plant has revised the core cooling strategy such that there is one seismically robust pathway for the discharge hoses from the portable S/G feedwater pump. The pathway will be from the core cooling pump (staged near the Hardened Condensate Storage Tank (HCST)) through the containment tendon access gallery to AB 1974 elevation, and to the connection points in the Auxiliary Feedwater System. The continuous peripheral tendon access gallery is provided for the installation and inspection of the vertical post-tensioning system. The 8-foot-wide tendon access gallery, located beneath the perimeter of the reactor building mat, has a 4.25-foot-thick foundation slab, the bottom of which is 25.25 feet below grade and is considered part of the Seismic Category 1 Reactor Building. The hoses exit the tendon access gallery into the basement of the Auxiliary Building, another Seismic Category 1 structure. From this exit point, the hoses are routed to an area below the Auxiliary Feedwater Pumps and run up a ladder into the room below the Auxiliary Feedwater Pumps which are also located in the Seismic Category 1 Auxiliary Building. Therefore, the discharge hoses from the portable feedwater pump only run through seismically robust structures once the hose enters a structure.

FINAL
INTEGRATED
PLAN

Callaway Plant Unit No. 1

June 2016

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1. Background

In 2011, an earthquake-induced tsunami caused Beyond-Design-Basis (BDB) flooding at the Fukushima Dai-ichi Nuclear Power Station in Japan. The flooding caused the emergency power supplies and electrical distribution systems to be inoperable, resulting in an extended loss of alternating current (ac) power (ELAP) in five of the six units on the site. The ELAP led to (1) the loss of core cooling, (2) loss of spent fuel pool cooling capabilities, and (3) a significant challenge to maintaining containment integrity. All 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 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.

Based on NTTF Recommendation 4.2, the NRC issued Order EA-12-049 (Reference 3.1.2) on March 12, 2012 to implement mitigation strategies for Beyond-Design-Basis (BDB) External Events (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, and SFP cooling capabilities following a beyond-design-basis external event.

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

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, 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 and spent fuel pool (SFP) cooling capabilities.
- Phase 2 - The transition phase requires providing sufficient, portable, onsite equipment and consumables to maintain or restore these functions until they can be accomplished with resources brought from off site.
- Phase 3 - The final phase requires obtaining sufficient offsite resources to sustain those functions indefinitely.

NRC Order EA-12-049 (Reference 3.1.2) required licensees of operating reactors to submit an overall integrated plan, including a description of how compliance with these requirements would be achieved by February 28, 2013. 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, Diverse and Flexible Coping Strategies (FLEX) Implementation Guide, Revision 0 (Reference 3.1.3), which provided guidelines for nuclear stations to assess extreme external event hazards and implement the mitigation strategies specified in NRC Order EA-12-049. The NRC issued Interim Staff Guidance JLD-ISG-2012-01, Revision 0, (Reference 3.1.5), dated August 29, 2012, which endorsed NEI 12-06 with clarifications on determining baseline coping capability and equipment quality.

Subsequently, NEI 12-06, Revision 2, (Reference 3.1.4) and JLD-ISG-2012-01, Revision 1, (Reference 3.1.6) have been issued. JLD-ISG-2012-01, Revision 1, provides NRC endorsement of NEI 12-06, Revision 2, as an acceptable means of meeting the requirements of Order EA-12-049, subject to the exceptions, additions, and clarifications in the enclosure of the ISG. As such, Callaway Plant implementation of NRC Order EA-12-049 is in accordance with NEI 12-06, Revision 2, as modified by JLD-ISG-2012-01, Revision 1. References to NEI 12-06 later in this document refer to NEI 12-06, Revision 2.

NRC Order EA-12-051 (Reference 3.1.7) required licensees to install reliable SFP instrumentation with specific design features for monitoring SFP water level. This order was prompted by NTTF Recommendation 7.1 (Reference 3.1.1).

NEI 12-02, Industry Guidance for Compliance with NRC Order EA-12-051, To Modify Licenses with Regard to Reliable SFP Instrumentation, Revision 1 (Reference 3.1.8) provided guidance for compliance with Order EA-12-051. The NRC determined that, with the exceptions and clarifications provided in JLD-ISG-2012-03, Compliance with Order EA-12-051, Reliable SFP Instrumentation, Revision 0 (Reference 3.1.9), conformance with the guidance in NEI 12-02 is an acceptable method for satisfying the requirements in Order EA-12-051.

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

2.1 General Elements – Assumptions

The boundary conditions and assumptions used for the evaluations of Callaway Plant ELAP/Loss of Normal Access to the Ultimate Heat Sink (LUHS) event and the development of FLEX strategies are stated below.

2.1.1 Boundary Conditions and Assumptions

The following boundary conditions consistent with NEI 12-06 Section 2, Overview of Implementation Process, apply to the establishment of FLEX strategies:

- Beyond-design-basis external event occurs impacting Callaway Plant.
- The reactor is initially operating at power, unless there are procedural requirements to shut down due to the impending event.
- The reactor is successfully shut down when required (i.e., all rods inserted, no ATWS).
- On-site staff is at site administrative minimum shift staffing levels.
- No independent, concurrent events, e.g., no active security threat.
- All personnel on-site are available to support site response.
- Spent Fuel in dry storage is outside the scope of FLEX

Assumptions are consistent with those detailed in NEI 12-06, Section 3.2.1, General Criteria and Baseline Assumptions. Key industry guidance and site-specific assumptions are presented here.

2.1.2 Initial Plant Conditions:

The initial plant conditions are assumed to be the following:

1. Prior to the event the reactor has been operating at 100 percent rated thermal power for at least 100 days or has just been shut down from such a power history as required by plant procedures in advance of the impending event.

2. At the time of the postulated event, the reactor and supporting systems are within normal operating ranges for pressure, temperature, and water level for the appropriate plant condition. All plant equipment is either normally operating or available from the standby state as described in the plant design and licensing basis. The minimum conditions for plant equipment Operability or functionality do not need to be assumed in establishing the capability of that equipment to support FLEX strategies, provided in accordance with NEI 12-06, Section 11.2, there is an adequate basis for the assumed value (e.g., procedural controls). For example, the minimum Technical Specification value for level or volume of water for Operability of the Condensate Storage Tank does not need to be assumed for the site-specific ELAP analysis if the tank is normally maintained at a greater level or volume.

2.1.3 Initial Conditions

The following initial conditions are to be applied:

1. No specific initiating event is used. The initial condition is assumed to be a Loss of Off-Site Power (LOOP) at a plant site resulting from an external event that affects the off-site power system either throughout the grid or at the plant with no prospect for recovery of off-site power for an extended period.

2. All design basis installed sources of emergency on-site AC power and SBO alternate AC power sources (as defined in 10CFR50.2) are assumed to be not available and not imminently recoverable. Station batteries and associated DC buses along with AC power

from buses fed by station batteries through inverters remain available.

3. Cooling and makeup water inventories contained in systems or structures with designs that are robust for the applicable hazard(s) are available.

4. Normal access to the Ultimate Heat Sink is lost, but the water inventory in the UHS remains available and robust piping connecting the UHS to plant systems remains intact. The motive force for UHS flow, i.e., pumps, is assumed to be lost with no prospect for recovery. Fire or other pumps may be available provided they are robust for the applicable hazard(s).

5. Fuel for FLEX equipment stored in structures with designs which are robust for the applicable hazard(s) remains available.

6. Permanent plant equipment that is contained in structures with designs that are robust for the applicable hazard(s) are available.

7. Other equipment, such as portable AC power sources, portable back up DC power supplies, spare batteries, and LOLA equipment, may be used as on-site FLEX equipment provided it is reasonably protected from the applicable external hazards per Sections 5 through 9 and Section 11.3 of NEI 12-06 and has predetermined hookup strategies with appropriate procedures/guidance and the equipment is stored in a relative close vicinity to the site.

8. Installed electrical distribution system, including inverters and battery chargers, remain available provided they are protected consistent with current station design.

9. No additional events or failures are assumed to occur immediately prior to or during the event, including security events.

10. The fire protection system ring header as a water source is acceptable only if the header is robust for the applicable hazard(s).

2.1.4 Reactor Transient

The following additional boundary conditions are applied for the reactor transient:

1. Following the loss of all AC power, the reactor automatically trips and all rods are inserted.
2. The main steam system valves (such as main steam isolation valves, turbine stops, atmospheric dumps, etc.), necessary to maintain decay heat removal functions operate as designed.
3. The Safety/Relief Valves (S/RVs) or Power Operated Relief Valves (PORVs) initially operate in a normal manner if conditions in the reactor coolant system (RCS) so require. Normal valve reseating is also assumed.
4. No independent failures, other than those causing the ELAP/LUHS event, are assumed to occur in the course of the transient.

2.1.5 Reactor Coolant Inventory Loss

Sources of expected reactor coolant inventory loss include:

1. Normal system leakage
2. Losses from letdown unless automatically isolated or until isolation is procedurally directed
3. Losses due to reactor coolant pump seal leakage (rate is dependent on the RCP seal design)

Procedurally-directed actions can significantly extend the time to core uncovery in PWRs. However, RCS makeup capability is assumed to be required at some point in the extended loss of AC power condition for inventory and reactivity control.

2.1.6 SFP Conditions

The initial SFP conditions are:

1. All boundaries of the SFP are intact, including the liner, gates, transfer canals, etc.

2. Although sloshing may occur during a seismic event, the initial loss of SFP inventory does not preclude access to the refueling deck around the pool.

3. SFP cooling system is intact, including attached piping.

4. SFP heat load assumes the maximum design basis heat load

2.1.7 Containment Isolation Valves

It is assumed that the containment isolation actions delineated in current station blackout coping capabilities are sufficient.

2.1.8 Assumptions specific to the Callaway Plant site

1. An ELAP declaration will occur within 45 minutes in order to enable actions that place the plant outside of the current design and licensing basis.

2. Required staffing levels are consistent with guidance contained in NEI 12-06 for each of the site specific FLEX strategies. Assumed available staffing levels have been determined consistent with NEI 12-01, Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities, (Reference 3.1.15) as described below. The event impedes site access as follows:

- Post event time: 6 hours – No site access. This duration reflects the time necessary to clear roadway obstructions, use different travel routes, mobilize alternate transportation capabilities (e.g., private resource providers or public sector support), etc.

- Post event time: 6 to 24 hours – Limited site access. Individuals may access the site by walking, personal vehicle or via alternate transportation capabilities (e.g., private resource providers or public sector support).

- Post event time: 24+ hours – Improved site access. Site access is restored to a near- normal status and/or augmented transportation resources are available to deliver equipment, supplies and large numbers of personnel.

3. The designed hardened connections are protected against external events or are established at multiple and diverse locations.
4. 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 beyond-design-basis event 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).
5. The Westinghouse Spent Fuel Pool Level Instrumentation System is installed.
6. The Westinghouse Low-Leakage Generation III SHIELD® RCP seals have been installed on all RCPs.

2.2 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 reactor, 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 pre-staged off-site resources. This indefinite coping capability will address an ELAP – loss of off-site power, emergency diesel generators and any alternate AC source (as defined in 10 CFR 50.2) but not the loss of AC power to buses fed by station batteries through inverters – with a simultaneous loss of normal access to the ultimate heat sink (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/LUHS event. A safety function-based approach provides consistency with, and allows coordination with existing plant EOPs. FLEX strategies are implemented in support of EOPs using FLEX Support Guidelines (FSGs).

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

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

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 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 Callaway Plant. Though specific strategies have been developed, due to the inability to anticipate all possible scenarios, the strategies are also diverse and flexible to encompass a wide range of possible conditions. These pre-planned strategies developed to protect the public health and safety are incorporated into the Callaway Plant emergency operating procedures in accordance with established EOP change processes, and their impact to the design basis capabilities of the unit evaluated under 10 CFR 50.59.

2.3 Reactor Core Cooling and Heat Removal Strategy

Reactor core cooling involves the removal of decay heat through the secondary side of the Nuclear Steam Supply System (NSSS) and maintaining sufficient RCS inventory to ensure the continuation of natural circulation in the primary side of the NSSS. The FLEX strategy for reactor core cooling and decay heat removal is to release steam from the Steam Generators (SG) using the Atmospheric Steam Dump Valves (ASDs) and the addition of a corresponding amount of feedwater to the SGs via the Turbine Driven Auxiliary Feedwater Pump (TDAFP). The Auxiliary Feedwater (AFW) system includes the Condensate Storage Tank (CST) as the initial water supply to the TDAFP, if it is not damaged during the event. If the CST is rendered unusable during the event, then the Hardened Condensate Storage Tank (HCST) provides an alternate source of water. Operator actions to verify, re-align, and throttle AFW flow are required by the EOPs following an ELAP/LUHS event to prevent Steam Generator dryout and/or overfill.

At the beginning of the event, automatic protective actions occur such as insertion of all control rods, MSIV closure, turbine trip, and commencement of feeding steam generators (SGs) with the TDAFP.

Within 45 minutes of the BDBEE, an ELAP is declared. This declaration will require actions from the FSGs necessary to mitigate a long term loss of AC power. Some of the actions may place the plant and plant systems, structures and components (SSCs) outside of the current licensing basis. The National SAFER Response Center (NSRC) is notified as time permits to request delivery of off-site equipment.

Within 15 minutes of ELAP declaration, a DC Load Shed is performed. This load shed will ensure battery life is extended to twelve (12) hours. Portable generators will provide power to the Class 1E Battery Chargers prior to battery depletion.

RCS makeup and boron addition will be initiated by twenty-six (26) hours to ensure natural circulation, reactivity control, and boron mixing is maintained.

2.3.1 Phase 1 Strategy

Following the occurrence of an ELAP/LUHS event, the reactor will trip and the plant will initially stabilize at no-load RCS temperature and pressure conditions, with reactor decay heat removal via steam release to the atmosphere through the ASDs via natural circulation of the RCS. The TDAFP will provide flow from the CST or the HCST to the SGs to make-up for steam release.

Operators will respond to the event in accordance with Emergency Operating Procedures (EOPs) to confirm RCS, secondary system, and Containment conditions. ECA-0.0, Loss of All AC Power, (Reference 3.1.12), will be used upon the diagnosis of the total loss of AC power. This procedure directs isolation of RCS letdown pathways, confirmation of natural circulation cooling, verification of Containment isolation, reducing DC loads on the station Class 1E batteries, and establishment of electrical equipment alignment in preparation for eventual power restoration. The operators ensure auxiliary feedwater flow to all steam generators, and initiate a cooldown of the RCS to minimize inventory loss through the RCP seals. ECA-0.0 directs manual control of auxiliary feedwater flow to the steam generators and manual control of the Steam Generator ASDs to control steam release to control the RCS cooldown rate, as necessary.

Secondary Side - The Phase 1 strategy for reactor core cooling and heat removal relies upon installed plant equipment and water sources for auxiliary feedwater (AFW) supply to the steam generators and steam release to the atmosphere. The TDAFP automatically starts on the loss of offsite power condition, and does not require AC power to provide AFW to the Steam Generators (SGs). In the event that the TDAFP does not start on demand or trips after start, the operator will locally reset the turbine and the pump will be restarted. Sufficient time (just under one hour) will be available to restart the TDAFP to prevent Steam Generator dry-out.

Initially, AFW supply is provided by the CST. The CST volume is normally maintained greater than or equal to 396,925 gallons (85%) (Callaway Plant Tank Data Book, Reference 3.1.71) and will provide a suction source to the TDAFP for approximately twenty-four (24) hours of RCS decay heat removal assuming a concurrent RCS cooldown at 100°F/hr to a minimum Steam Generator pressure of 290 psig. In the event that the CST is depleted or unavailable (i.e., damaged), the TDAFP will take suction from the HCST. An automatic swapover from the CST to the HCST occurs at 11.66 psig AFW suction pressure. The HCST has a "Total Usable Volume" of 366,544 gallons (Reference 3.1.44) and will provide a suction source to the TDAFP for a minimum of thirty (30) hours.

Steam release from the SGs will be controlled remotely from the control room using air-operated Steam Generator ASDs. During an ELAP, the compressed air system will not be functional. By original design, the nitrogen accumulator tanks provide an eight (8) hour supply of nitrogen to back-up the compressed air system.

Primary Side (RCS) - Control of RCS inventory during Phase 1 is maintained by commencing a plant cooldown at a maximum rate of 100°F/hr to depressurize the RCS and allow injection of the Safety Injection Accumulators. In accordance with ECA-0.0, a RCS cooldown will be initiated at a maximum rate of 100°F/hr to a Steam Generator pressure of 290 psig minimum, which corresponds to an RCS core inlet temperature of approximately 419°F. The rapid RCS cooldown minimizes adverse effects of high temperature coolant on RCP shaft seal performance and reduces Steam Generator pressure to allow for eventual feedwater injection from a portable pump in the event that the TDAFP becomes unavailable. The minimum Steam Generator pressure is established high enough to prevent safety injection accumulator nitrogen gas from entering the RCS. RCS isolation is verified to have occurred automatically, and RCS leakage is assumed to be through the RCP seals (See Section 2.3.8). RCS boration is required to be initiated no later than 26 hours after the event (at 10 gpm). This ensures sufficient time for complete mixing of injected borated water throughout the RCS.

RCS inventory is not a significant concern for the ELAP scenario due to the installation of the low-leakage RCP seals. The Callaway Plant ELAP analysis indicates single phase natural circulation flow is maintained without additional RCS makeup for over 24 hours into the event.

Additionally, Ameren Calculation, XX-136, FLEX EOP Action Value V.08 "Time to Initiate Alternate RCS Boration" (Reference 3.1.62), concluded that the core maintains sufficient Shutdown Margin (SDM) for more than 31.5 hours following the event without additional boration (beyond SIT injection).

Electrical/Instrumentation – Load stripping of some non-essential loads from the Class IE 125 VDC power and 120 VAC instrument and control power would be completed within 60 minutes after the occurrence of an ELAP/LUHS. With load stripping, the useable station Class 1E Battery life is calculated to be at least twelve (12) hours. (See Section 2.3.11)

The Phase 1 strategy for Reactor Core Cooling stated above (i.e., RCS cooldown and depressurization) will allow passive injection of borated water from the Safety Injection Accumulators. This will maintain RCS Inventory Control until Phase 2 coping actions can be taken. Therefore, no additional installed SSCs are required for Reactor Core Cooling in Phase 1.

2.3.2 Phase 2 Strategy

The Phase 2 FLEX strategy for reactor core cooling and heat removal provides a supply of water for feeding the SGs using the installed TDAFP. In the event that the CST is damaged during the BDBEE, the HCST provides a minimum of a thirty (30) hour supply of condensate grade water to the TDAFP. Additionally, as required by NEI 12-06, Steam Generator water injection using one of the two portable FLEX AFW pumps is available through both primary and alternate connection locations.

The Class 1E Battery Chargers will be re-powered within twelve (12) hours using one of the two portable FLEX 480 VAC Diesel Generators (DG) stored onsite in the Hardened Storage Building (HSB). This will ensure that vital 120 VAC and 120 VDC circuits are re-powered prior to depletion of the usable battery power and will continue to be available to provide instrumentation and control power to key components (e.g., TDAFP Flow Control Valves, ASDs).

After any required debris removal, but prior to 7 hours after the event, deployment of at least one FLEX 480 VAC generator will commence. Placing the generator in service can be completed within ten (10) hours after the event. This includes time for debris removal, transport and setup time, and vital bus switching operations.

Strategies have been developed for deployment of the FLEX 480 VAC generators to supply power to the Class 1E battery chargers. The primary strategy for restoring vital 120 VAC and 120 VDC circuits is to deploy one of the two FLEX 480 VAC Diesel Generators and the Cable Trailer stored in the HSB to the staging area near the southwest side of the Auxiliary Building (AB). Cables are then run through the emergency doors (DSK13012 and DSK13012A) to TVPG28, AUX BLDG FLEX 480V DG CONNECTION PANEL. After the cable connections are complete, breakers and disconnect switches would be aligned to restore power to the Class 1E Battery Chargers.

The alternate strategy for supplying power to the Class 1E Battery Chargers is deploy the cable trailer and a FLEX 480 VAC diesel generator to the staging area near the ESF Switchgear Room B Doors, DSK 32013 and DSK 32013A. Cables will then be run through these doors and door DSK32012 to panel TVPG29, CTRL BLDG FLEX 480V DG CONNECTION PANEL, located on the west wall of ESF Switchgear Room 3302. Breaker alignment will then restore power to the Class 1E 480 VAC Load Centers to provide power to the Class 1E battery chargers.

TVPG28 and TVPG29 are seismically-designed, tornado missile protected, FLEX connection receptacles located within Seismic Category 1 buildings. FLEX connection receptacle, TVPG28, is connected to each 125VDC Vital

Battery Charger via pre-installed cable and conduit. Disconnects provide appropriate electrical separation. TVPG29 is connected to the Class 1E 480 VAC buses via pre-installed cable and conduit to Class 1E 480 VAC MCC breakers.

By original design, the ASDs are air operated valves backed by installed nitrogen accumulator tanks. Since the air system is assumed lost during an ELAP and the nitrogen accumulator tanks for the ASDs and TDAFP flow control valves are designed to last for 8 hours of valve operation, FSG-43, Nitrogen and Instrument Air Strategy, has been developed. The FLEX Air Compressors will provide sufficient compressed air for indefinite coping using the ASDs, if required.

The primary strategy for providing compressed air to the ASDs and TDAFP flow control valves is to deploy a diesel driven air compressor, stored in the HSB, to a staging area on the plant east side the Turbine Building. Required air hoses and a distribution manifold are stored in Area 5 of the Auxiliary Building below the Auxiliary Feedwater Pumps. The distribution manifold is placed in the Auxiliary Building 2000' elevation vestibule outside the Auxiliary Feedwater Pump Rooms. Air hoses are run from the air compressor through the Turbine Building and connected to the distribution manifold. Additional air hoses are then run to the four (4) nitrogen accumulator tanks. These tanks will then supply compressed air to the ASDs and the TDAFP flow control valves.

In the event that this path is rendered unusable by the BDBEE, then the air hoses are run through a robust pathway. This pathway utilizes the Tendon Access Gallery and the Auxiliary Building to reach the distribution manifold. Additional hose has been procured to ensure the feasibility of this robust pathway.

An alternate strategy utilizes an electric motor driven FLEX Air Compressor stored in the basement Auxiliary Building (Plant Elevation 1974') below the Auxiliary Feedwater Pumps. This strategy utilizes the same distribution manifold and air hose connections as the primary strategy. A FLEX 480 VAC receptacle has been installed near the compressor. Power to this 480 VAC receptacle is from the FLEX 480 VAC diesel generators through PG28. See Figure 16.

RCS boration and makeup will be initiated within 26 hours of the ELAP/LUHS event using an electric driven FLEX Boron Pump stored in the Auxiliary Building elevation 1974' to replenish RCS inventory and re-establish RCS level in the pressurizer. FSG-1, Long Term RCS Inventory Control, and, FSG-8, Alternate RCS Boration, provides guidance for RCS inventory control and to establish boration of the RCS to maintain subcritical conditions. The FLEX Boron Pump takes suction from one of the Boric Acid Tanks and discharges into one of three (3) preselected discharge paths in the Safety Injection System. Power to the FLEX Boron Pump is from a 480 VAC receptacle supplied by the FLEX 480 VAC diesel generators through PG28.

A second FLEX Boron Pump would be used if the BDBEE caused flooding in the basement of the Auxiliary Building. This FLEX Boron Pump is stored in the HSB. If needed, this pump would be deployed and staged just inside the Auxiliary Building 2000' Level (ground level) South West Missile Door, DSK13011. A FLEX 480 VAC receptacle has been installed in the Auxiliary Building 2000 level near this staging area for the FLEX Boron Pump. Power to this 480 VAC receptacle is from the FLEX 480 VAC diesel generators through TVPG28. In this scenario, the FLEX Boron Pump would take suction from the Refueling Water Storage Tank (RWST) and discharge to a connection point in the Safety Injection System. This strategy could also be used if the RWST were to remain available after a BDBEE. It should be noted that the RWST is not protected from all external hazards as it is not missile protected. However, the RWST would be available after a seismic event.

2.3.3 Phase 3 Strategy

At the beginning of Phase 3 Callaway Plant will continue with the strategies from Phase 2, removing decay heat from the reactor via the SGs using the ASDs. The TDAFP will continue to feed the SGs with water from the HCST, which will eventually require refilling. Use of the SGs for core cooling and decay heat removal is dependent on adequate reactor core decay heat generation for the operation of the TDAFP and an available supply of clean water from onsite sources or from water processing units provided from the NSRC. The Phase 3 strategy for restoring Residual Heat Removal (RHR) provides an alternate method for removing decay heat and/or RCS cooldown to Cold Shutdown.

For Phase 3, off-site equipment from the National SAFER Response Center (NSRC) is deployed, staged and available to support the Callaway Plant strategies. The NSRC will provide a complete set of FLEX replacement equipment for Callaway Plant existing Phase 2 equipment as well as additional equipment to process water, and assist in long term plant recovery (service water pumps, large generators for energizing complete Class 1E switchgear, etc.).

Restoration of RHR requires the restoration of 4160 VAC power and portions of the Component Cooling Water (CCW) and Essential Service Water (ESW) systems. FLEX 4160 VAC generators will be provided from the NSRC in order to supply power to one of the two Class 1E 4160 VAC buses. Additionally, by restoring a Class 1E 4160 VAC bus, power can be restored to the Class 1E 480 VAC via the 4160/480 VAC transformers to power selected 480 VAC loads.

Three (3) 1MW 4160 VAC turbine generators will be connected to a distribution panel (also provided from the NSRC) in order to meet the required 4160 VAC load requirements. The 4160 VAC Generators will be deployed outside the west wall of the Control Building and connected to one of the 4160 VAC Buses (NB01 or NB02). This will provide sufficient power for restoration of the RHR System and the needed portion of the CCW System.

The NSRC supplied FLEX High Performance Booster Pump Skid will provide the suction lift from the Ultimate Heat Sink to the NSRC Low Pressure/High Flow Pump. The NSRC Low Pressure/High Flow Pump has a discharge pressure of 150 psig. The FLEX High Performance Booster Pump Skid and the Low Pressure/High Flow Pump are both rated at 5,000 gpm. The Low Pressure/High Flow Pump discharges into a manifold. Hoses from the manifold are routed to flanges on the ESW cross-connect piping in the ESW Pumphouse. With flow returned to the ESW System piping via the NSRC Low Pressure/High Flow Pump, the Ultimate Heat Sink function is restored and the installed RHR heat exchangers can eventually be used for reactor core cooling and heat removal during the plant recovery phase.

Once cooling flow has been established via the NSRC provided Low Pressure/High Flow Pump, and the NSRC 4160 VAC Generators are connected to a Class 1E 4160 VAC bus, operators can re-power a CCW pump and a RHR pump to establish decay heat removal.

A Mobile Water Purification System will be provided by the NSRC to provide clean water for refilling of the HCST and other tanks as needed. The Mobile Water Purification System is sized to be able to meet the clean water needs of the SGs, RCS and SFP for decay heat removal.

2.3.4 Key Components

The following key components, and their associated FLEX function, are utilized for successful implementation of the FLEX coping strategy to ensure Reactor Core Cooling and RCS Inventory Control with the Steam Generators available. The installed components used for FLEX strategies are currently qualified as robust (as defined by NEI 12-06), except as noted.

2.3.4.1 Turbine Driven Auxiliary Feedwater Pump (TDAFP)

The TDAFP will automatically start and deliver AFW flow to all the SGs following an ELAP/LUHS event. Steam is supplied to the turbine from two main steam lines ('B' and 'C') upstream of the Main Steam Isolation Valves (MSIV); each steam line feeds one four-inch line to supply the turbine through ABHV0005 and ABHV0006. Each steam line also feeds a warm-up line in parallel through a one-inch air operated bypass valve, ABHV0048 and ABHV0049, to keep the supply lines warm. Upon receipt of a start signal, ABHV0005 and ABHV0006 open to supply steam to the turbine. A trip/throttle (T/T) valve, FCHV0312, and a governor valve, FCFV0313, are used to supply steam to the turbine. Exhaust steam from the turbine discharges to atmosphere above the Auxiliary Boiler Room.

In the event the TDAFP fails to start, procedures direct the operators to manually reset and start the pump (which does not require AC power for motive force or control). Approximately 50 - 60 minutes are available to manually start the pump and initiate flow prior to steam generator dryout (Reference 3.1.34). The TDAFP is sized to provide more than the design basis AFW flow requirements and is located in a structure designed for protection from applicable design basis external hazards.

2.3.4.2 Atmospheric Steam Dump Valves (ASD)

During an ELAP/LUHS event with the loss of all AC power and instrument air, reactor core cooling and decay heat will be removed from the SGs for an indefinite time period by opening/throttling the ASDs. The ASDs and associated exhaust piping and control circuits are used to control pressure in the steam generators and require an air or nitrogen supply for operation. The Steam Generator ASDs are safety-related, missile protected, seismically qualified valves. Power to the Atmospheric Steam Dump Valves controllers in the Control Room is provided by the Class 1E batteries. Phase 2 and 3 strategies are in place to ensure the Class 1E batteries are not depleted and compressed air is available to ensure continued operation of the ASDs from the Control Room.

2.3.4.3 Class 1E Batteries

The safety-related 125 VDC Class 1E batteries and associated DC distribution systems are located within safety-related structures designed to meet applicable design basis external hazards and will be used to initially power required key instrumentation and applicable DC components. Load stripping of non-essential equipment has been conservatively calculated to provide a total service time of 12 hours of operations. (Reference 3.1.42)

2.3.4.4 Condensate Storage Tank (CST)

If available, the Condensate Storage Tank (CST) provides an AFW source at the initial onset of the event. The CST is non-safety-related and is not designed to withstand all the applicable design basis external hazards stated in NEI 12-06. An analysis (Reference 3.1.43) determined that the CST meets the design basis seismic requirements; however, it is not missile protected. Therefore, its use may be credited only in limited scenarios. The CST volume is normally maintained greater than or equal to 396,925 gallons (85%) (Callaway Plant Tank Data Book, Reference 3.1.71) and is normally aligned to provide emergency makeup to the SGs.

2.3.4.5 Hardened Condensate Storage Tank (HCST)

The HCST is a single stainless steel tank protected from all applicable external hazards, as such is considered to be robust per NEI 12-06. The HCST will provide a reliable source of condensate to the TDAFP in the event of a BDBEE resulting in an ELAP. The total volume of the HCST is 506,796 gallons, with total usable volume of 366,544 gallons. The HCST is designed to provide for a mission time of at least 30 hours while supplying the required flow to both the TDAFP and the FLEX Spent Fuel Pool Cooling Pumps, when needed. Upon the loss or unavailability of the existing CST, the HCST will provide an instantaneous supply of water to the TDAFP. (Reference 3.1.44)

2.3.4.6 Safety Injection Accumulators

The Safety Injection Accumulators are passive devices that will inject borated water into the RCS when RCS pressure drops below approximately 600 psig for the Callaway Plant FLEX strategy. The Safety Injection Accumulators will provide RCS makeup capability to ensure natural circulation is maintained within the RCS as well as negative reactivity insertion to the RCS during Phase 1. The Safety Injection Accumulators are provided with a nitrogen cover gas. During the Phase 1 strategy, the Safety Injection Accumulators will inject but RCS pressure will be maintained above the cover gas pressure and therefore nitrogen intrusion will not occur. The Safety Injection Accumulators will be isolated later in the timeline before RCS pressure falls below cover gas pressure. The Safety Injection Accumulators are Seismic Category 1 tanks located inside Containment. Therefore, the Safety Injection Accumulators are fully protected and qualified for all applicable external events.

2.3.4.7 Boric Acid Tanks (BATs)

Two Boric Acid Tanks are located in the Auxiliary Building to store the 4 percent by weight boric acid. The tanks are constructed of stainless steel, each having a minimum capacity during Modes 1 through 4 of 17,658 gallons. The BATs are fully protected and qualified for all applicable external events.

2.3.4.8 Boric Acid Batching Tank (BABT)

The BABT is a non-seismic vertical stainless steel tank and is used to batch borated water for RCS makeup from the BATs. After completion of mixing, boric acid is gravity drained from the BABT to a BAT. Since the BABT is not seismically qualified, an evaluation was performed per the Expedited Seismic Evaluation Process. This evaluation (Reference 3.1.40) determined that the BABT and the piping from the BABT to the BAT are acceptable for use for implementation of FLEX Strategies. The BABT and the piping from the BABT to the BAT are located on the 2026' elevation of the Auxiliary Building, so they are fully protected from the other applicable external hazards.

2.3.4.9 Ultimate Heat Sink (UHS) Retention Pond

The UHS Retention Pond is a man-made pond containing a minimum of 48.2 acre feet of water (15.7 million gallons) per Callaway Plant Technical Specifications (Reference 3.1.41). The normal UHS Retention Pond level is maintained equal or greater than 51.2 acre feet (16.7 million gallons) per the Callaway Plant Tank Data Book (Reference 3.1.71). Since the ESW pumps are not available during a BDB ELAP event, the full volume of the Ultimate Heat Sink is available as a water source for AFW, RCS and Spent Fuel Pool Cooling. Refer to Section 2.15 for discussion of water quality.

2.3.4.10 Refueling Water Storage Tank (RWST)

The RWST is a Seismic Category 1 stainless steel tank and vented to the atmosphere with a minimum contained borated water (2350 – 2500 ppm boron) volume of 394,000 gallons (Modes 1 – 4). The RWST is not missile protected; therefore, it is not credited for all external hazards.

2.3.4.11 FLEX 480 VAC Diesel Generators

The FLEX 480 VAC Diesel Generators are 500 KW CAT C15 Diesel Generators and will provide temporary power to either the Class 1E battery chargers or the Class 1E 480 VAC Load Centers. The FLEX 480 VAC Diesel Generators are stored in the HSB.

2.3.5 FLEX Strategy Connections

2.3.5.1 AFW Pump Connections

The primary connections for the FLEX AFW Pump to supply AFW to the SGs are located on the HCST (suction) and in the 6” discharge line of the NSAFWP (discharge). Non-collapsible hose will be routed from one of two connections on the HCST to the suction of the FLEX Auxiliary Feedwater Pump. A flexible hose will be routed from the FLEX Auxiliary Feedwater Pump discharge through the Tendon Access Gallery, to the 1974' elevation of the Auxiliary Building, up the ladder to the 1988' elevation of the Auxiliary Building to a newly installed connection in the Non-Safety Auxiliary Feedwater Pump (NSAFP) discharge line. This routing provides a robust pathway for this strategy.

There are several alternate suction connections for the FLEX AFW Pump, which include connections on the CST, the Demineralized Water Storage Tank (DWST), and the Reactor Makeup Water Storage Tank (RMWST). See Section 2.15 for additional discussion on available water sources.

Alternate discharge connections include the use of a FLEX intermediate pipe from the CST Valve House to the AFW Tunnel in the Auxiliary Building, 1988' elevation. Hoses are run from the pump discharge to the intermediate pipe in the CST Valve House and another hose from the intermediate pipe in the Auxiliary Building 1988' elevation to a FLEX connection in the Non-Safety Auxiliary Feedwater Pump (NASP) discharge line or a FLEX connection in the 'B' MDAFP discharge line. Another FLEX AFW Pump discharge connection would be to run a hose through the Turbine Building east side rollup door, into the AFW corridor, by blocking open door DSK13291, down the ladder to the 1988' elevation of the Auxiliary Building and connecting the hose to the flange connection at one of the above locations.

2.3.5.2 <u>RCS Connections</u>

The primary suction connections for RCS makeup and boration are connections located on the drain lines from a BAT. A hose is run from one of the connections to a FLEX Boron Pump stored on the 1974' elevation of the Auxiliary Building.

The primary discharge path for this FLEX Boron Pump is to run a hose from the pump to a FLEX hose connection in the "Boron Injection Header" located in Auxiliary Building 1974' elevation in Room 1126. An alternate discharge path would be through a FLEX intermediate pipe running from Auxiliary Building 1974' elevation to Auxiliary Building 2000' elevation. The FLEX Boron Pump discharge would be routed to the intermediate pipe connection on

1974' elevation of the Auxiliary Building. A hose would then be run from the intermediate pipe connection on 2000' elevation of the Auxiliary Building to FLEX connection in the Safety Injection System in the North Piping Penetration Room (AB Room 1323).

Another FLEX Boron Pump is stored in the HSB and would be utilized if the BDBEE resulted in internal flooding of the 1974' elevation of the Auxiliary Building. In this case, a suction hose would be routed from a RWST piping flange connection located in the RWST valve house to the FLEX Boron Pump deployed to the Auxiliary Building, 2000' elevation. A discharge hose is run from the pump to the North Piping Penetration Room 1323 to one of two "Boron Injection Header" FLEX connections upstream/downstream of EMHV8801A and EMHV8801B.

An alternate discharge path for the second FLEX Boron Pump would be to run the discharge hose from the pump through the Auxiliary Building north corridor 1320 on the 2000' elevation where it is connected to the FLEX intermediate pipe. The FLEX intermediate pipe runs to the Auxiliary Building 1974' elevation. A discharge hose is run from this pipe to a FLEX hose connection in the "Boron Injection Header" located in Auxiliary Building 1974' elevation in Room 1126.

2.3.5.3 480 VAC Electrical Connections

New FLEX connection receptacles, TVPG28 and TVPG29, have been installed to provide connection for the FLEX 480 VAC FLEX Generators. One of the FLEX Generators will be deployed to a location outside either the plant southwest corner of the Auxiliary Building or the plant west side of the Control Building. Cables are run through doors to one of the FLEX connection receptacles. Switching operations then aligns power from the FLEX generator to Class 1E 480 VAC Load Centers which supply power to the Class 1E Battery Chargers.

2.3.5.4 4160 VAC Electrical Connections

Three (3) 1-MW 4160 VAC turbine generators delivered to the site from the NSRC will be connected to a distribution panel (also delivered from the NSRC). Cables from a breaker on one of the

Class 1E 4160 buses will be removed from the breaker. Then cables from the distribution panel will be connected to that Class 1E 4160 VAC breaker. This will allow the NSRC supplied 4160 VAC Generators to supply power to one of the Class 1E 4160 buses.

See Figure 20 for typical Class 1E 4160 VAC Bus Connection.

2.3.6 Vital Instrumentation

The instrumentation noted below is seismically robust, fed by Class 1E power, are located within the Seismic Category 1 Auxiliary Building/Containment Building/Control Building and as such are qualified and protected for all applicable external events. This instrumentation will be available in all three FLEX strategy phases for the duration of the BDBEE.

- AFW Flowrate - AFW flowrate indication will be available in the Control Room (CR). AFW flowrate indication will be available for all SGs throughout the event.
- AFW Suction Pressure – AFW Suction Pressure will be available in the Control Room (CR). AFW Suction Pressure indication will be available throughout the event.
- SG Level - Steam Generator wide range (WR) and narrow range (NR) level indication will be available in the CR. Steam Generator WR and NR level indication will be available for all SGs throughout the event.
- SG Pressure - Steam Generator pressure indication will be available in the CR. Steam Generator pressure indication will be available for all SGs throughout the event.
- RCS Temperature - RCS hot-leg and cold-leg WR temperature indication will be available from the CR. RCS hot-leg and cold-leg temperature indication will be available throughout the event.
- RCS Pressure - RCS wide range pressure indication will be available for the CR. RCS wide range pressure indication will be available throughout the event.
- Core Exit Thermocouple Temperature - Core exit thermocouple temperature indication will be available in the CR. This temperature indication will be available throughout the event.
- Pressurizer Level: Pressurizer Level indication will be available from the CR. Pressurizer level indication will be available throughout the event.

- Reactor Vessel Level Indication System (RVLIS): RCS level indication from the RVLIS will be available from the CR throughout the event.
- Containment Pressure: Wide Range Containment Pressure will be available for the CR. Wide Range Containment Pressure indication will be available throughout the event.
- Class 1E DC Bus Voltage: Class 1E DC Bus Voltage indication will be available from the CR. Class 1E DC Bus Voltage indication will be available throughout the event.
- SFP Level: New SFP Level Indication will be available in the Auxiliary Building. SFP Level Indication will be available throughout the event.

Portable FLEX equipment is supplied with the local instrumentation needed to operate the equipment. The use of these instruments is detailed in the associated FSGs and or operating guides for use of the equipment. These procedures are based on inputs from the equipment suppliers, operation experience, and expected equipment function in an ELAP.

In the unlikely event that bus infrastructure is damaged, alternate FLEX strategy guidelines for obtaining the critical parameters locally is provided in FSG-7, Loss Of Vital Instrumentation or Control Power, in accordance with the guidelines of NEI 12-06 Section 5.3.3 Item 1.

2.3.7 Thermal Hydraulic Analyses

Secondary Makeup Water Requirements

Calculations were performed to determine the inventory required for core decay heat removal, RCS cooldown, and to maintain steam generator levels and dryout times associated with the volumes of various onsite AFW sources. The conclusions from this analysis showed that the new HCST with a usable volume of 366,544 gallons (Reference 3.1.44) would be able to provide a minimum of thirty (30) hours supply to the TDAFP. This minimum supply capacity includes water to be used for Spent Fuel Pool Make-up and Spray, if needed.

An additional water source for secondary makeup at Callaway Plant is the UHS Retention Pond. This additional supply of water will be sufficient for more than seventy-two (72) hours of decay heat removal (Reference 3.1.25). NSRC equipment will be available for core cooling prior to this time. NSRC equipment includes a mobile water purification unit.

RCS Response

Callaway Plant will perform a symmetric cooldown using all RCS loops in response to an ELAP. The NOTRUMP computer code was used to simulate the RCS responses for generic Westinghouse pressurized water reactors (PWRs) during an ELAP. These responses, documented in WCAP-17601-P, Revision 0, Reactor Coolant System Response to the Extended Loss of AC Power Event for Westinghouse, Combustion Engineering, and Babcock & Wilcox NSSS Designs (Reference 3.1.34), and WCAP-17792-P, Revision 0, Emergency Procedure Development Strategies for the Extended Loss of AC Power Event for all Domestic Pressurized Water Reactor Designs (Reference 3.1.35), demonstrate that mitigation strategies such as the one described in the Callaway Plant Final Integrated Plan (this document) are adequate for coping with an ELAP event.

RCS inventory is not a significant concern for the ELAP scenario due to the installation of the Westinghouse Low-Leakage Generation III SHIELD® RCP Seals. RCS inventory makeup will begin within 26 hours following the onset of the ELAP condition (Reference 3.1.62). An analysis, CN-SEE-I-12-32 (Reference 3.1.28), demonstrated that the RCS liquid inventory would be reduced to the minimum single-phase natural circulation level at approximately 45.1 hours following ELAP initiation, and would be reduced to the minimum two-phase natural circulation level at approximately 66.9 hours following ELAP initiation. Therefore, the Callaway Plant RCS makeup strategy is sufficient to preclude reflux condensation cooling from occurring during an ELAP. The analysis performed to evaluate RCS shutdown margin is discussed in Section 2.3.9.

2.3.8 Reactor Coolant Pump (RCP) Seals

The RCP seals at Callaway Plant are Westinghouse Low-Leakage Generation III SHIELD® Seals. Based on the evaluation noted above, the Callaway Plant maximum RCS leak rate applied will be 1 gpm/RCP Seal for the purposes of determining long-term RCS makeup requirements.

2.3.9 Shutdown Margin Analysis

A Shutdown Margin (SDM) Analysis was performed for the reactor core from Callaway Plant, Cycle 21 (which was determined to be representative of a typical Callaway Plant reload core), and determined that at least 1% SDM (K_{eff} <0.99) is available for at least 36 hours following a reactor trip from full power. However, due to Xenon decay, additional core boron is needed after 36 hours in order to continue at the target (290 psig) Steam Generator pressure. The FLEX Boron Pumps will inject this additional boron. Calculation XX-136, Revision 0 (Reference 3.1.62) was performed to determine when RCS boration must occur to maintain the core subcritical. The calculation determined that starting the boron injection no later than 26 hours after the event with an injection rate of 20 gpm using the RWST injection source or 10 gpm using a BAT injection source, core subcriticality would be maintained. The Callaway Plant FLEX Boration Pumps are capable of 30 gpm at 1600 psig discharge. This makeup volume can easily be accommodated by RCS volume shrink due the cooldown without venting the RCS.

Since the RCS inventory makeup is initiated no later than 26 hours following an ELAP/LUHS event, the borated water injected into the RCS for inventory makeup is adequate to maintain core reactivity shutdown margin of 1 % following an ELAP/LUHS.

Callaway Plant performs checks for every reload core to verify that the FLEX inventory management and reactivity control strategy remains adequate to maintain $k_{-eff} < 0.99$ throughout the ELAP event.

The SDM calculation assumes a uniform boron mixing model. Boron mixing was identified as a generic concern by the NRC and was addressed by the Pressurized Water Reactor Owner's Group (PWROG). The NRC endorsed the PWROG boron mixing position paper (Reference 3.1.65) with the clarification that a one hour mixing time was adequate provided that the flow in all loops is greater than or equal to the corresponding single-phase natural circulation flow rate (Reference 3.1.66). The analyses and evaluations supporting the FIP demonstrate that the FLEX RCS make-up pump is being implemented before loop flow transitions out of single-phase natural circulation. Therefore, the boron mixing criteria are met.

2.3.10 Flex Pumps and Water Supplies

2.3.10.1 FLEX AFW Pump

Consistent with NEI 12-06, Appendix D, Steam Generator water injection capability is provided using a portable AFW pump through a primary and alternate connection. The FLEX AFW pumps are a nominal 500 gpm at 500 psig discharge pressure pump. The FLEX

AFW pump is a trailer-mounted, diesel engine driven centrifugal pump that is stored in the HSB.

The portable, diesel-driven FLEX AFW pump will provide a back-up method for Steam Generator injection in the event that the TDAFP pump can no longer perform its function due to insufficient turbine inlet steam flow from the SGs or TDAFP failure. Hydraulic analyses (Reference 3.1.53) has confirmed that the FLEX AFW pump is sized to provide the minimum required Steam Generator injection flowrate to support reactor core cooling and decay heat removal. Two FLEX AFW pumps are available to satisfy the N+1 requirement.

2.3.10.2 FLEX Boron Pump

The Callaway Plant analysis shows that a 10 gpm, 1600 psi pump can provide adequate means to borate the RCS from the BATs to achieve adequate shutdown margin with 31.5 hours into the ELAP event (Reference 3.1.62). The Callaway Plant FLEX Boration Pumps are a nominal 25 gpm at 2000 psig discharge pressure pump. Hydraulic analysis (Reference 3.1.52) of the FLEX Boron pump with the associated hoses and installed piping systems confirm that the FLEX Boron pump minimum flow rate and head capabilities exceed the FLEX strategy requirements for maintaining RCS inventory.

This pump also provides for RCS injection to compensate for shrink of the RCS inventory due to the cooldown and any RCS leakage, enabling refill of the RCS and eventually establishing level in the pressurizer.

Two FLEX Boron pumps are available at Callaway Plant. One is stored in the 1974' elevation of the Auxiliary Building. The second (N+1) pump is stored in the HSB.

2.3.10.3 NRSC FLEX High Performance Booster Pump Skid

The FLEX High Performance Booster Pump Skid from the NSRC will supply water (5000 gpm) from the UHS Retention Pond to the Low Pressure/High Flow diesel driven pump suction.

2.3.10.4 NSRC Low Pressure/High Flow Pump

The diesel driven Low Pressure/High Flow Pump from the NSRC will provide cooling water flow to the ESW System through a Callaway Plant supplied manifold. The pump will be supplied by the NRSC FLEX High Performance Booster Pump Skid and will discharge into the ESW System through flange connections installed on the ESW cross-connect piping in the ESW Pumphouse.

2.3.10.5 AFW Water Supplies

Condensate Storage Tank (CST)

If available, the Condensate Storage Tank (CST) provides an AFW source at the initial onset of the event. The CST is non-safety-related and is not designed to withstand all the applicable design basis external hazards stated in NEI 12-06. The CST does meet the seismic requirements; however, it is not missile protected. Therefore, its use may be credited only in limited scenarios. The CST volume is normally maintained greater than or equal to 396,925 gallons (85%) (Callaway Plant Tank Data Book, Reference 3.1.71) and is normally aligned to provide emergency makeup to the SGs.

Hardened Condensate Storage Tank (HCST)

The HCST is the credited source of AFW at the onset of a BDBEE. The HCST is a single stainless steel tank protected from all applicable external hazards, as such is considered to be robust per NEI 12-06. The HCST will provide a reliable source of condensate to the TDAFP in the event of a BDBEE resulting in an ELAP. The total volume of the HCST is 506,796 gallons, with total usable volume of 366,544 gallons. The HCST is designed to provide for a mission time of at least 30 hours while supplying the required flow to both the TDAFP and the FLEX SFP Pumps, when needed. Upon the loss or unavailability of the existing CST, the HCST will provide an instantaneous supply of water to the TDAFP.

Ultimate Heat Sink (UHS) Retention Pond

The UHS Retention Pond is a man-made pond containing a minimum of 48.2 acre feet of water (15.7 million gallons) per

Callaway Plant Technical Specifications (Reference 3.1.41). The normal UHS Retention Pond level is maintained equal or greater than 51.2 acre feet (16.7 million gallons) per the Callaway Plant Tank Data Book (Reference 3.1.71). Since the ESW pumps are not available during a BDB ELAP event, the full volume of the Ultimate Heat Sink is available as a water source for AFW, RCS and Spent Fuel Pool Cooling. Refer to Section 2.15 for discussion of water quality.

2.3.10.6 Borated Water Supplies

Safety Injection Accumulators

The Safety Injection Accumulators are passive devices that will inject borated water into the RCS when RCS pressure drops below approximately 600 psig for the Callaway Plant FLEX strategy. The Safety Injection Accumulators will provide RCS makeup capability to ensure natural circulation is maintained within the RCS as well as negative reactivity insertion to the RCS during Phase 1. The Safety Injection Accumulators are provided with a nitrogen cover gas. The Safety Injection Accumulators will be vented before RCS pressure falls below cover gas pressure to prevent nitrogen intrusion into the RCS. The Safety Injection Accumulators are Seismic Category 1 tanks located inside Containment. Therefore, the Safety Injection Accumulators are fully protected and qualified for all applicable external events.

Boric Acid Tanks (BATs)

Two Boric Acid Tanks are located in the Auxiliary Building to store the 4 w/o boric acid. The tanks are constructed of stainless steel and have a capacity of 28,000 gallons. The minimum volume of the BATs for Modes 1 – 4 per Surveillance Requirement 16.1.2.6 is 17,658 gallons of 7000 – 7700 ppm borated water. The BATs are fully protected and qualified for all applicable external events.

Boric Acid Batching Tank (BABT)

The BABT is a non-seismic atmospheric vertical stainless steel tank and is used to batch borated water for RCS makeup when the BATs are depleted. After completion of mixing, boric acid is gravity drained from the BABT to a BAT. Since the BABT is not seismically qualified, an evaluation was performed per the Expedited Seismic Evaluation Process. This evaluation (Reference 3.1.40) determined that the BABT and the piping from the BABT to the BAT are acceptable for use for implementation of FLEX Strategies. The BABT and the piping from the BABT to the BAT are located on the 2026' elevation of the Auxiliary Building, so it they are fully protected from the other applicable external hazards.

2.3.11 Electrical Analysis

2.3.11.1 Batteries

The installed 125 VDC Class 1E Batteries (NK11, NK12, NK13, and NK14)) are used to maintain power to critical instrumentation, controls and lighting following a loss of AC power. An ELAP will be declared within forty-five (45) minutes after the event (0.75 hours), when it becomes evident that AC power will not be restored from onsite or off-site sources. The declaration of an ELAP will initiate actions to perform a deep load shed to extend the life of the batteries. The load shed will complete by one (1) hour after the event. Per the validation of this Time Sensitive Activity, the time margin between the calculated battery duration for the FLEX strategy and the expected deployment time for FLEX equipment to supply the DC loads is approximately 3.9 hours for Callaway Plant.

2.3.11.2 FLEX Diesel Generator

During Phase 2 (and Phase 3 as appropriate), one (1) of the two (2) FLEX portable 480 VAC, 500 kW FLEX diesel generators is used to restore power to the Class 1E Battery Chargers, the electric driven FLEX air compressor and the electric driven FLEX Boron Pumps. The generator is sized to support the loads required by the FLEX Strategy. Additionally, margin exists to accommodate small miscellaneous loads as desired.

2.3.11.3 NSRC Generators

Additional 480 VAC generators and 4160 VAC generators are available from the National SAFER Response Center (NSRC) for the Phase 3 strategy. The nominal ratings for this equipment are listed in Table 2.

2.4 Spent Fuel Pool Cooling/Inventory

The basic FLEX strategy for maintaining SFP cooling is to monitor SFP level and provide makeup and spray water to the SFP sufficient to maintain 15 feet of water above the top of racks.

2.4.1 Phase 1 Strategy

The time to boil for the SFP, based on an initial pool coolant temperature of 140°F and water level of 24.25 ft. above the fuel racks, is calculated at 5.50 hours (for a partial fuel offload) and 2.35 hours (for a full core offload). After losing a maximum of 0.15 ft. of water level due to sloshing (at 1% damping), the time to boil is calculated as 5.46 hours (for a partial fuel offload) and 2.34 hours (for a full core offload) (Reference 3.1.29). After reaching 212°F, it will take an additional 29.75 hours for the SFP inventory to boil off to a level 15 feet above the top of fuel racks (Reference 3.1.32)

Access to the SFP area as a part of Phase 2 response could be challenged due to environmental conditions local to the pool. Action is required to vent the Fuel Building (FB) by opening the roll-up door within the first 5.4 hours of the event (Modes 1 – 4). Operators will have readily available access to this door such that it can be opened without undue delay following a BDBEE. The roll-up door will be opened prior to SFP boiling based on the heat load in the pool at the time of the event (as early as 5.4 hours). At this time the operators will also connect the SFP make-up and spray hoses inside the building prior to conditions worsening in the Fuel Building. The hoses will be run from the connections inside the building to outside of the building for connection later in the event. An additional hose is run from an installed intermediate pipe in the Fuel Building 2026' elevation for alternate SFP makeup.

2.4.2 Phase 2 Strategy

The transition to Phase 2 strategies will be implemented as the inventory in the SFP slowly declines due to boiling. An analysis (Westinghouse SCP-14-81 Revision 1, Reference 3.1.72) has determined that the SFP makeup with an intact pool is not required until just over 35 hours after the event for a normal decay heat load. The time to boil is based on an initial SFP temperature of 140°F and water level of 24.25 ft. above the fuel racks and is calculated at 5.46 hours (for a partial fuel offload) with boil off time of 29.79 hours. Therefore, Callaway Plant has set the Time Sensitive Action to initiate SFP Makeup to be 33 hours after the event. See Section 2.17, Sequence of Events.

The Phase 2 strategy for SFP cooling is to deploy a FLEX SFP Pump to provide makeup to the pool with water from the RWST, if available, or the HCST. Hoses are run from the RWST or HCST to the FLEX SFP Pump. The discharge of the FLEX SFP Pump is connected to the hoses that were connected to permanently installed piping during Phase 1 strategy implementation.

Callaway Plant will implement an alternate approach from NEI 12-06, Table 3-2, PWR FLEX Baseline Capability Summary, for Spent Fuel Cooling. The spent fuel cooling strategy utilizes a portable pump to discharge through hoses that connect to permanently installed piping to provide the required makeup flow. This alternate method meets the requirements for performance attributes of NEI 12-06, Table D-3, Summary of Performance Attributes for PWR SFP Cooling Functions. Callaway Plant considers the seismically robust piping to provide make-up to the Spent Fuel Pool (SFP) an upgrade over the minimal requirements of NEI 12-06, Table 3-2, which only require "Make-up via hoses direct to the pool".

JLD-ISG-2012-01, Revision 1, (Section 1.1 d), requires a SFP Spray strategy in addition to the SFP make-up capabilities required by NEI 12-06, Revision 2, Tables C-3 and D-3. Callaway Plant has installed a permanently mounted, seismically robust spray header to provide spray for the SFP to meet this requirement.

2.4.3 Phase 3 Strategy

The Phase 3 coping capabilities for SFP cooling will continue to utilize the Phase 2 strategies. An additional pump will be available from the NSRC as a backup to the onsite FLEX SFP pumps.

2.4.4 Structures, Systems, and Components

2.4.4.1 SFP Makeup Strategy

The primary connection point will be at a capped STORZ connector on the 2000' elevation in the Fuel Building near the roll-up door.

The primary connection pipe terminates at pool level so that the SFP makeup empties into the pool via permanently installed spray nozzles.

The alternate connection is a capped STORZ connector on the 2000' elevation in the Fuel Building near the roll-up door. FLEX intermediate piping has been installed from the 2000' elevation in the Fuel Building near the roll-up door up to the 2026’ elevation of the Fuel Building. A separate hose will connect the intermediate piping to a STORZ connection on the Fuel Pool Cooling Pump suction piping. This will provide a flow path directly into the SFP.

2.4.4.2 SFP Spray Strategy

The SFP Spray connection point will be a STORZ connector on the 2000' elevation in the Fuel Building near the roll-up door. Hard pipe has been installed from this connection to the Plant East wall on the 2068' 8"' elevation in the Fuel Building and terminate with two (2) monitor spray nozzles that will perform the spray function. Water will be provided from the same source as the primary SFP makeup strategy.

2.4.4.3 Ventilation

SFP bulk boiling will create adverse temperature, humidity, and condensation conditions in the SFP/Refuel Floor Area. NEI 12-06 requires a ventilation vent pathway to exhaust the humid atmosphere from the SFP/Refuel Floor Area with outside air. This requirement is met by manually opening the Fuel Building Rollup Door, DSK61022.

2.4.5 Key SFP Parameters

The key parameter for the SFP make-up 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.

2.4.6 Thermal-Hydraulic Analyses

An analyses was performed that determined, with the maximum expected SFP heat load immediately following a core offload, that the SFP will reach a bulk boiling temperature of 212°F in approximately 2.34

hours and boil off to a level 15 feet above the top of fuel in approximately 35 hours unless additional water is supplied to the SFP. A flow of 58.08 gpm for a partial core offload and 135.64 gpm for a full core offload (Reference 3.1.29) will replenish the water lost due to boiling. Deployment of the FLEX SFP Pump within 30 hours with a flow rate that exceeds the boil-off rate will provide for adequate makeup to restore the SFP level and maintain an acceptable level of water for shielding purposes. It is expected that the deployment of the FLEX SFP pump may occur sooner as Emergency Response Organization (ERO) resources become available.

2.4.7 FLEX SFP Pump and Water Supplies

2.4.7.1 FLEX SFP Pump

The FLEX SFP Pumps are a nominal 250 gpm at 92 psig discharge pressure pump. The FLEX SFP Pumps are a trailer-mounted, diesel engine driven centrifugal pump that are stored in the HSB. The pumps are deployed by towing the trailer to a designated location near the selected water source. One FLEX SFP pump is required to implement the spent fuel pool cooling and spray strategies for Callaway Plant. Two pumps are available to satisfy the N+1 requirement.

2.4.7.2 Hardened Condensate Storage Tank (HCST)

The HCST is a single, stainless steel tank protected from all applicable external hazards, and as such is considered to be robust per NEI 12-06. The HCST will provide a reliable source of condensate grade water to the FLEX SFP Pump. The HCST has sufficient inventory to supply the SFP cooling strategy as well as the AFW strategy for at least 30 hours. Refilling of the HCST with the mobile purification unit supplied by NSRC would provide additional capacity past 30 hours after the event for indefinite coping.

2.4.7.3 Refueling Water Storage Tank (RWST)

The RWST is a Seismic Category 1 stainless steel tank and is vented to the atmosphere with a minimum contained borated water (2350 – 2500 ppm boron) volume of 394,000 gallons (Modes 1 – 4).

The RWST is not missile protected; therefore, it is not credited for all external hazards.

2.4.8 Electrical Analysis

The Spent Fuel Pool will be monitored by instrumentation installed by Order EA-12-051. The power for this equipment has backup battery capacity for 72 hours. Alternative power will be provided within seventy-two (72) hours using onsite FLEX portable generators, if necessary, to provide power to the instrumentation and display panels and to recharge the backup battery. The FLEX portable generators are stored in the HSB.

2.5 Containment Integrity

Modes 1 – 4:

With an Extended Loss of All AC power (ELAP) initiated while in Modes 1-4, containment cooling is lost for an extended period of time. Containment temperature and pressure will slowly increase. Structural integrity of the reactor containment building due to increasing containment pressure will not be challenged during the first seventy-two (72) hours of a BDBEE ELAP event. The initiation of the Phase 2 and 3 reactor core cooling strategies will reduce the heat load into containment, thus reducing containment pressure and temperature.

Conservative evaluations and analysis (Reference 3.1.27) have concluded that containment temperature and pressure will remain below containment design limits and that key instrumentation subject to the containment environment will remain functional for a minimum of seventy-two hours, except for Nuclear Instrumentation, which is discussed later. Therefore, actions to reduce containment temperature and pressure and to ensure continued containment integrity will not be required. Eventual containment cooling and depressurization to normal values may utilize off-site equipment and resources during Phase 3.

Modes 5 – 6:

With an Extended Loss of All AC power (ELAP) initiated while in Modes 5 – 6, containment pressure and temperature will increase due to steam generation that is released into containment from decay heat. The containment pressure response is more pronounced for the ELAP event initiating from either Modes 5 or 6 when compared to an ELAP event starting from Mode 1 conditions. If containment is not vented, the containment structure would exceed design pressure. Callaway Plant has analyzed (Ameren Calculation GT-16, Revision 0, Mode 5-6 ELAP venting via Emergency Personnel Hatch, Reference 3.1.59) Containment response for an ELAP in Modes 5 – 6 using the Emergency Personnel Hatch (EPH) as a Containment vent path. In the conservative model, Containment bulk pressure remained below 18.0 psia while temperature rose to approximately 220°F to match the saturation temperature of water at the corresponding containment pressure. Both Containment pressure and temperature remain below design limits past seventy-two hours after the event.

2.5.1 Phase I

The Phase 1 coping strategy for Containment involves verifying Containment isolation per ECA-0.0, Loss of All AC Power, and monitoring Containment temperature and pressure using installed instrumentation. Control room indication for Containment pressure and temperature will be available for the duration of the ELAP.

2.5.2 Phase 2

The Phase 2 coping strategy is to continue monitoring Containment temperature and pressure using installed instrumentation. Phase 2 activities to repower key instrumentation (Section 2.9.4) are required to continue Containment monitoring. Since Containment pressure and temperature are not expected to rise sufficiently to challenge design limits, additional actions in Phase 2 are not required.

2.5.3 Phase 3

No additional specific Phase 3 strategy is required for maintaining containment integrity. With the initiation of RHR to remove core heat, the containment will depressurize without further action.

2.5.4 Structures, Systems, Components

Emergency Personnel Hatch (EPH)

The Emergency Personnel Hatch (EPH) is utilized to provide a Containment vent path in Modes 5 and 6 to ensure Containment integrity is maintained.

2.5.5 Key Containment Parameters

Instrumentation providing the following key parameters is credited for all phases of the Containment Integrity strategy:

- Containment Pressure: Containment pressure indication is available in the Control Room throughout the event.
- Containment Temperature: Containment temperature indication is available in the Control Room throughout the event.

2.5.6 Thermal-Hydraulic Analyses

CN-SCC-13-001, Callaway ELAP Containment Environment Analysis, Revision 2, (Reference 3.1.27) used GOTHIC analysis to determine the containment response for the initial 72 hours during an ELAP event. The basis for analyzing the response for the initial 72 hours is that the plant Technical Staff and NSRC equipment will be available beyond 72 hours into the event. These additional resources will be able to provide additional technical direction and equipment to provide for Containment Cooling.

For Modes 1 – 4, the analysis determined that Containment pressure will not be challenged during the first 72 hours of a BDBEE event resulting in an ELAP. The peak pressure in the first 72 hours is 21.5 psia, well below the containment design pressure of 60 psig.

Except for the lower reactor vessel cavity compartment, temperatures throughout Containment will remain less than 200°F, well below design Containment temperature of 320°F. In the lower reactor vessel cavity compartment, temperatures can reach 560°F. This temperature exceeds the qualified temperature profile for the Nuclear Instrumentation (NI) located in this compartment. Contingency actions have been developed and included in FSGs for the loss of the NIs. The actions include providing alternate means of monitoring core reactivity such as RCS pressure and temperature.

For a BDBEE in Modes 5 and 6, with Steam generators unavailable, the analysis determined that if Containment is not vented early, the containment structure will exceed design pressure. Callaway has analyzed the Emergency Personnel Hatch (EPH) for use as a Containment vent path for Modes 5 – 6. The analysis has determined that the EPH provides a significant vent path that will ensure Containment pressure remains relatively low during the event. Callaway Plant procedures have been revised to include the requirement while in Modes 5 and 6 to maintain the EPH open after a BDBEE resulting in an ELAP.

An analysis of the environmental qualifications of the key parameter instrumentation was performed (Reference 3.1.31). The analysis determined that key parameter instrumentation other than the NIs for an ELAP in Modes 1 – 4 will remain available. ECA-0.0 has been revised to contain compensatory action required for subcriticality monitoring if/when the NIs fail due to overheating. Containment temperatures for a BDBEE in Modes 5 and 6 remained well below design Containment temperature of 320°F. Since design limits are not exceeded, all key parameter instrumentation will remain available.

2.5.7 FLEX Pumps and Water Supply

Additional equipment is not specifically required for maintaining the Containment Integrity function. Containment Integrity is maintained by providing for reactor core cooling. The reactor core cooling strategy utilizes the NRSC FLEX High Performance Booster Pump Skid, the NSRC Low Pressure/High Flow Pump, and the Ultimate Heat Sink (UHS) Retention Pond. See 2.3.10.4, 2.3.10.5, and 2.3.10.6 for further discussion of the FLEX Pumps and Water Supplies.

2.5.8 Electrical Analysis

The 4160 VAC equipment being supplied from the NSRC will provide adequate power to perform the Phase 2 and 3 reactor core cooling strategies needed to ensure the Containment Integrity Safety Function is maintained. See Section 2.3.5.4 for details of this equipment.

2.6 Characterization of External Hazards

2.6.1 Seismic

Per Final Safety Analysis Report (FSAR) seismic input, for Callaway Plant the seismic criteria include two design basis earthquake spectra: Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE).

The site seismic design response spectra define the vibratory ground motion of the OBE and SSE. The maximum horizontal acceleration for the SSE is 0.20g, and the OBE has a maximum horizontal acceleration of 0.12g (Reference 3.1.46, Section 2.5.2.8).

All safety-related structures are founded on granular structural fill composed mainly of crushed limestone and dolomite or on Graydon chert conglomerate. Neither material is susceptible to liquefaction (Reference 3.1.46).

Per the FLEX guidance, seismic impact must be considered for all nuclear plant sites. As a result, the credited FLEX equipment was assessed based on the current Callaway Plant seismic licensing basis to ensure that the equipment remains accessible and available after a BDBEE and that the FLEX equipment does not become a target or source of a seismic interaction from other systems, structures, or components. This assessment included ensuring that any storage locations and deployment routes meet the FLEX criteria.

The Callaway Plant Expedited Seismic Evaluation Program (ESEP) Report was submitted to the NRC on December 22, 2014 (Reference 3.1.24). Any impacted equipment will be addressed as identified in that report under the ESEP.

2.6.2 External Flooding

The types of events evaluated to determine the worst potential flood included (1) potential maximum flood (PMF) due to nearby water sources, and (2) flood due to local intense precipitation equal to the potential maximum precipitation (PMP) at the plant site.

Specific analysis of flood levels resulting from ocean front surges and tsunamis is not required because of the inland location of the plant. Flood waves from landslides into upstream reservoirs landslide formation required no specific analysis due to the lack of topographic and geologic features conducive to landslide formation. Seiches pose no flood threats because of the size and configuration of the lake and the elevation difference between normal lake level and plant grade.

The maximum plant site flood level from any cause is Elevation 840.16 ft. mean sea level (MSL) (Reference 3.1.73). The grade level for all

SSCs (except UHS and RWST) is at an elevation of about 840.5 ft. MSL (Reference 3.1.46). This correlates to plant elevation 2000'. Per NEI 12-06, plants that are considered “dry” (i.e., the plant is built above the design basis flood level) are not susceptible to the external flooding hazard; therefore, the external flood hazard is screened out for Callaway Plant.

2.6.3 <u>Severe Storms with High Wind</u>

Figures 7-1 and 7-2 from the NEI 12-06 were used for this assessment.

Callaway Plant is not susceptible to hurricanes based on its location in central Missouri. The plant site is a significant distance from the final contour line shown in Figure 7-1 of NEI 12-06.

It was determined that the Callaway Plant site has the potential to experience damaging winds caused by a tornado exceeding 130 mph. Figure 7-2 of NEI 12-06 indicates a maximum wind speed of 200 mph for Region 1 plants, including Callaway Plant. Therefore, high-wind hazards are applicable to the Callaway Plant site.

In summary, (1) based on Figure 7-1 of NEI 12-06, Callaway Plant would not be susceptible to hurricanes so the hazard is screened out, and (2) based on Figure 7-2 of NEI 12-06, Callaway Plant has the potential to experience damaging winds; therefore, the hazard is screened in.

2.6.4 <u>Ice, Snow and Extreme Cold</u>

Per the FLEX guidance, all sites should consider the temperature ranges and weather conditions for their site in storing and deploying their FLEX equipment. That is, the equipment procured should be suitable for use in the anticipated range of conditions for the site, consistent with normal design practices.

Applicability of snow and extreme cold:

NEI 12-06 states plants above the 35th parallel should provide the capability to address the impedances caused by extreme snow and cold. The Callaway Plant site is above the 35th parallel; therefore, the FLEX strategies must consider the impedances caused by extreme snowfall with snow removal equipment, as well as the challenges that extreme cold temperature may present. Callaway Plant is located at Universal

Transverse Mercator Coordinates Latitude 38°45’40.7” North and Longitude 91°46’50.5” (Reference 3.1.46, Section 2.1.1.1).

Applicability of ice storms:

The Callaway Plant site is not a Level 1 or 2 region as defined by Figure 8-2 of the NEI 12-06; therefore, the FLEX strategies must consider the impedances caused by ice storms.

In summary, based on Figures 8-1 and 8-2 of NEI 12-06, the Callaway Plant site does experience significant amounts of snow or ice, and extreme cold temperatures; therefore, these hazards are screened in.

2.6.5 High Temperatures

Per NEI 12-06, 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. Sites that should address high temperatures should consider the impacts of these conditions on the FLEX equipment and its deployment.

The climate at the Callaway Plant site is temperate-continental with cold, snowy winters and warm, humid summers. Based on climatological data from nearby weather stations, the normal average temperature is 55°F in Columbia, Missouri. Extreme temperatures are 116°F and -26°F in Fulton, Missouri (Reference 3.1.46).

In summary, based on the available local data and industry estimates, the Callaway Plant site does not experience extreme high temperatures. However, per NEI 12-06, all sites will address high temperatures. Therefore, for FLEX equipment Callaway Plant considered the site maximum expected temperatures in their specification, storage, and deployment requirements, including ensuring adequate ventilation or supplementary cooling, if required.

2.7 Planned Protection of FLEX Equipment

The Hardened Storage Building (HSB) is a single 7,200 sq. ft. concrete building that was constructed to meet the requirements of NEI 12-06 Rev. 2 for seismic, flooding, high winds, snow, ice, extreme cold, and high temperatures for protection of FLEX equipment. The HSB is inside the Protected Area (PA) and is utilized to house most of the FLEX equipment. Some FLEX equipment is stored within the power block in Seismic Category 1 Buildings (e.g., Auxiliary Building, Fuel Building).

The debris removal equipment as well as the tow vehicle needed to support the implementation of the FLEX strategies is also stored inside the HSB in order to protect the equipment from the applicable external hazards. Therefore, the equipment will remain functional and deployable to clear obstructions from the pathway between the HSB and the FLEX equipment deployment location(s).

The HSB was designed using ASCE 7-10, Minimum Design Loads for Buildings and Other Structures. The Callaway Plant OBE and SSE were utilized as the design input for seismic design requirements (Reference 3.1.64). This will ensure that the portable FLEX equipment stored in this building will be protected from a seismic event.

The HSB was designed to protect FLEX equipment against high wind conditions associated with a BDBEE as specified in NEI 12-06, Section 7, including tornado driven missiles as defined in NRC Regulatory Guide 1.76, Rev 1.

The HSB was designed to withstand extreme temperatures by using the installed ventilation system. The ventilation system will maintain temperatures below the upper operating temperatures of the FLEX equipment stored in the building. Installed heaters provide heat for the building to maintain the building warmer than 50°F.

Deployment of the debris removal equipment and the Phase 2 FLEX equipment from the HSB is not dependent on offsite power. For normal ingress/egress from the building, the building equipment doors are opened manually.

Analysis of the components stored in the HSB has been performed to determine appropriate measures to prevent seismic interaction. RFR 201600447, Requirements for Securing FLEX Equipment stored in HSB, (Reference 3.1.48) provides appropriate guidance for the proper storage of FLEX Equipment within the HSB. This guidance has been incorporated into the Callaway Plant Beyond Design Basis Program Document (Reference 3.1.38).

2.8 Planned Deployment of FLEX Equipment

2.8.1 Haul Paths and Accessibility

Pre-determined, preferred haul paths have been identified and documented in the FLEX Support Guidelines (FSGs). Figure 1 shows the haul paths from the HSB to the various deployment locations. These haul paths have been reviewed for potential soil liquefaction and have been determined to be stable following a seismic event. However, high winds can cause debris from distant sources to interfere with planned haul paths. Debris removal equipment is stored inside the HSB and is protected from the severe storm and high wind hazards such that the equipment remains functional and deployable to clear obstructions from the pathway between the HSB and its deployment location(s). The Callaway Plant FLEX debris removal equipment is a Case 590SN backhoe.

Phase 3 of the FLEX strategies involves the receipt of equipment from offsite sources including the NSRC and various commodities such as fuel and supplies. Delivery of this equipment can be through airlift or via ground transportation. The Callaway Plant site staging areas are outside the protected area. On-site equipment would be utilized, if not damaged during the event, to move the security barriers out of the way and to clear debris to provide a clear path into the protected area from the NSRC Staging areas. Since the NSRC supplied equipment will not be arriving on site until after 24 hours after the event, sufficient time exists to be able to contact an existing Ameren vendor to provide this service, if required.

Debris removal for the pathway between the NSRC receiving "Staging Areas" locations and the various plant access routes to the FLEX deployment staging areas may be required. The same debris removal equipment used for onsite pathways may also be used to support debris removal to facilitate road access to the site once necessary haul routes and transport pathways onsite are clear.

Deployment of FLEX equipment is described in the subsequent sections below for each strategy and all modes. The broad-spectrum deployment strategies are unchanged for the different operating modes. The deployment strategies from the HSB to each staging area are identified, as well as the debris removal concerns, security barriers, and lighting needs as they apply to each deployment path.

To ensure the strategies can be implemented in all modes, areas adjacent to the equipment storage facilities and staging areas, as well as the deployment and routing paths will be kept normally accessible.

During winter conditions, the site is maintained for snow removal by the Maintenance Department to clear access roads, walkways and parking lots. Deployment paths are included in this effort to ensure the deployment paths are available for use, if required.

The tow vehicle is a Freightliner truck with service bed which is stored in the HSB. This vehicle is capable of towing all FLEX equipment stored in the HSB.

Tornados are generally fast moving events and over quickly. Callaway Plant procedure OTO-ZZ-00012, Severe Weather, provides instructions to prepare the plant for severe weather conditions and a potential station blackout prior to the severe weather reaching the station. Callaway Plant has identified multiple deployment routes for the FLEX portable equipment in the event of damage to the deployment routes FLEX Support Guideline FSG-5, Initial Assessment and Flex Equipment Staging, provides guidelines to establish clear access routes and for the deployment of the portable FLEX Equipment.

2.9 Deployment of Strategies

2.9.1 Auxiliary Feedwater (AFW) Makeup Strategy

The HCST provides a minimum of a thirty (30) hour supply of condensate grade water to the TDAFP or directly to the suction of the diesel driven FLEX AFW pump. The HCST will remain available for all applicable external hazards listed in Section 2.6. An additional source of water for this strategy is the UHS Retention Pond. The UHS Retention Pond is a safety-related, seismic Category I earthen structure and will remain available for all the external hazards listed in Section 2.6.

The portable, diesel driven FLEX AFW pump will be transported from the HSB to a staging area near the selected water source. A non-collapsible hose will be routed from the water source to the pump suction. A flexible hose will be routed from the FLEX AFW Pump discharge through the Tendon Access Gallery, to the 1974' elevation of the Auxiliary Building, up the ladder to the 1988' elevation of the Auxiliary Building to a newly installed connection in the Non-Safety Auxiliary Feedwater Pump (NASP) discharge line. This routing provides a robust pathway for this strategy. See Figure 2, FLEX AFW Pump Hose Routings.

Figures 2 and 3 provide diagrams of the hose routings to facilitate use of the FLEX AFW Pump through a robust structure (Tendon Access Gallery).

An alternate AFW Pump FLEX hose routing is through an intermediate pipe connection in the CST Valve House, which is not a robust structure per NEI 12-06. The discharge hose from the FLEX AFW Pump is connected to the FLEX intermediate pipe. Another hose is connected to the FLEX intermediate pipe in the Auxiliary Building 1988' elevation and run to a FLEX connection in the B MDAFP discharge line or a FLEX connection in the Non-Safety Auxiliary Feedwater Pump (NASP) discharge line.

An additional alternate AFW FLEX Pump routing is to run a discharge hose through the Turbine Building (non-robust structure) east side rollup door, into the AFW corridor, by blocking OPEN DSK13291, down the ladder to the 1988' elevation of the Auxiliary Building and connecting the hose to a FLEX connection in the Non-Safety Auxiliary Feedwater Pump (NASP) discharge line or a FLEX connection in the B MDAFP discharge line.

The electric driven FLEX air compressor (FLEXC-AIRE-2) that supports long-term Atmospheric Steam Dump Valves and AFW Flow Control Valve operation is powered by the diesel driven FLEX generator and staged within the Auxiliary Building, 1974' elevation. Electric power will be supplied from a 480V FLEX receptacle. Air hoses in the AFW valve rooms will run up ladders to the 2013' elevation and into the Auxiliary Feedwater Control/Main Steam Atmospheric Relief Valves Accumulators. All equipment and hoses for use of the electric driven FLEX air compressor are stored and deployed in robust structures. See Figure 4, Electric Air Compressor Deployment.

The diesel FLEX Air Compressor (FLEXC-AIRD-1) is stored in the HSB. If needed, it will be deployed outside the Turbine Building on the 2000' elevation. Air hoses in the AFW valve rooms will run up the ladders to the 2013' elevation and into the Auxiliary Feedwater Control/Main Steam Atmospheric Relief Valves Accumulators. See Figure 5, Diesel Air Compressor Deployment.

2.9.2 <u>Reactor Coolant System (RCS) Strategy</u>

One FLEX Boron Pump is stored in the HSB and the second FLEX Boron Pump is stored in the Auxiliary Building, 1974' elevation. The FLEX Boron Pump that is stored in the HSB is to address Auxiliary Building internal flooding concerns during a seismic event. Therefore, these pumps are protected against all external hazards described in Section 2.6.

The primary FLEX Boron Pump discharge connection is located in the Auxiliary Building and provides a flow path to the RCS. A permanently installed intermediate piping from the Auxiliary Building 1974' elevation to the 'A' Piping Penetration Room provides an alternate flow path.

The primary suction connection from the BATs for the FLEX Boron Pump is located in the Auxiliary Building. An alternate suction source from the RWST Is also located in the Auxiliary Building.

Accordingly, these connections are protected against all applicable external hazards listed in Section 2.6.

Power for the electric driven FLEX Boron Pumps is from a FLEX 480 VAC receptacle installed in Auxiliary Building near the FLEX Boron Pump deployment locations. Power to these 480 VAC receptacles is from the FLEX 480 VAC diesel generators.

If needed, the second FLEX Boron Pump would be deployed and staged just inside the Auxiliary Building 2000' Level (ground level) South West Missile Door. This FLEX Boron Pump would take suction from the Refueling Water Storage Tank (RWST) and discharge to either of the injection points listed previously. This strategy could also be used if the RWST were to remain available after a BDBEE. It should be noted that the RWST is not protected from all external hazards as it is not missile protected. However, the RWST would be available after a seismic event.

Figures 6 - 10 provide diagrams of the flowpath and equipment utilized to facilitate this strategy.

The Phase 3 NSRC Low Pressure/High Flow Pump will be connected to the Essential Service Water System (ESW) via permanently installed flanges on the ESW cross-connect piping in the ESW Pumphouse. This diesel driven pump will supply cooling water to the CCW system to remove reactor core decay heat via the RHR System. The NSRC supplied 4160 VAC generators will provide electrical power to the CCW and RHR Pumps.

2.9.3 Spent Fuel Pool Strategy

The initial actions required for the Spent Fuel Pool strategy include the establishment of a Fuel Building vent by manually opening the Fuel Building Roll-Up Door and connecting hoses to the primary, alternate, and spray connections prior to the SFP temperature reaching boiling, to ensure that the Fuel Building is habitable during the hose connection process. The hoses are then run outside the Fuel Building through either the Fuel Building Roll-Up Door or the personnel doors. An additional hose is run in the Fuel Building 2026' elevation for alternate makeup use.

The HCST provides the water source for the FLEX SFP Pump. The HCST will remain available for all applicable external hazards listed in Section 2.6. Additional sources of water for this strategy include the RWST and the UHS Retention Pond. The RWST will remain available for all applicable external hazards except for high winds as it is not missile protected. The UHS Retention Pond is a safety-related, seismic Category I earthen structure and will remain available for all the external hazards listed in Section 2.6.

The SFP makeup strategy will initiate makeup by deploying a FLEX SFP Pump from the HSB. The primary, alternate, or spray hose connected earlier in the event will be connected to the discharge of the FLEX SFP Pump.

The FLEX SFP makeup connections are sufficiently sized to restore SFP level long term following the loss of SFP cooling with a makeup rate of a minimum of 125 gpm (Reference 3.1.52). The FLEX SFP Spray connection and piping are sufficiently sized to provide at least 250 gpm spray over the SFP (Reference 3.1.52).

Figures 11 - 13 provide diagrams of the flowpath and equipment utilized to facilitate this strategy.

2.9.4 Electrical Strategy

The FLEX 480 VAC Diesel Generators are stored in the HSB and are, therefore, protected from the BDB external event hazards identified in Section 2.6.

For the primary strategy, a FLEX 480 VAC Diesel Generator will be deployed to a staging near the plant southwest corner of the Auxiliary Building. Color coded cables will connect the generator to a FLEX connection panel (TVPG28) located on the west wall of corridor 1301 in the Auxiliary Building, 2000' elevation.

For the alternate strategy, a FLEX 480 VAC Diesel Generator will be deployed to a staging near the plant west wall of the Control Building. Color coded cables will connect the generator to a FLEX connection panel (TVPG29) located on the west wall in ESF Switchgear Room 3302, Control Building 2000' elevation.

The three (3) Phase 3 NSRC 4160 VAC generators will be staged outside the plant west wall of the Control Building. They will be connected to a 4160 VAC Load Distribution Center, also supplied by the NSRC. Cables will then be run from the Load Distribution Center to one of the Class 1E 4160 VAC electrical bus, NB01 or NB02. The Load Distribution Center will be connected to Bus NB01 or NB02 using an existing breaker NB0109 (NB01) or NB0212 (NB02) on the bus.

Figures 14 – 17 provide diagrams of equipment deployment and cable routing.

2.9.5 Fueling of Equipment

FLEX equipment stored in the HSB is maintained in a fueled condition. The Fuel Trailer is also stored in the HSB and is maintained full (≈1,140 gallons). The Fuel Trailer has the capability to draw from the underground tanks and will be used to refuel the majority of the FLEX equipment.

For Phase 2, the expected fuel consumption will be less than 2000 gallons per 12 hour shift. Since not all FLEX Phase 2 equipment will be operating at the same time and not at full capacity, the expected fuel consumption is very conservative. Based on the expected fuel consumption for the first 24 hours after the event, the Fuel Trailer has the storage capacity to be able to refuel each piece of FLEX equipment that would require fuel based on time of deployment and fuel consumption.

After the fuel in the Fuel Trailer is depleted, the general fueling strategy will be to draw fuel oil out of any available existing diesel fuel oil tanks. The primary source of fuel oil for FLEX equipment will be the Emergency Fuel Oil Storage Tanks. These tanks are underground tanks and are fully protected from all applicable hazards as identified in Section 2.6. Per the Callaway Plant Technical Specifications (Reference 3.1.41), each tank contains greater than 80,900 gallons of fuel oil when its associated Emergency Diesel Generator is required to be OPERABLE.

Fuel usage increases significantly in Phase 3 due to the use of the three (3) one MW turbine generators. The fuel consumption for the first 72 hours after the BDBEE is expected to be almost 26,000 gallons. The daily (24 hour) fuel consumption rate starting after deployment of the FLEX equipment from the NSRC is approximately 13,000 gallons per day. Based on this consumption rate, one of the Emergency Fuel Oil Storage Tanks has sufficient fuel supply for the first seven days after a BDBEE. Provisions for receipt of diesel fuel from offsite sources are in place to facilitate long-term Phase 3 FLEX Equipment deployment. The two (2) Emergency DG Day Tanks also provide a robust source of fuel oil (600 gallons each).

Additional sources (non-robust) of fuel oil in the Callaway Plant Protected Area include the following:

<u>Above Ground Tanks:</u>

• Aux Fuel Oil Storage Tank	300,000 gal
• Fire Pump Day Tank	2 @ 600 gal
• Stores Diesel Fuel Oil Tank	1000 gal

In Ground Tank

- Technical Support Center Diesel 3,000 gal

For equipment with smaller fuel demands, a hand powered pump will be used to draw fuel from fuel tanks into one of the three 30 gallon fuel caddies and then distributed to the equipment as needed.

See Figure 18 for Emergency Fuel Oil Storage Tank A Supply (TJE01A) arrangement.

2.10 Offsite Resources

2.10.1 National SAFER Response Center

The industry has established two (2) National SAFER Response Centers (NSRCs) to support utilities during BDB events. Callaway Plant has established contracts with the Pooled Equipment Inventory Company (PEICo) to participate in the process for support from the NSRCs as required. Each NSRC will hold five (5) sets of equipment, four (4) of which will be able to be fully deployed when requested, the fifth set will have equipment in a maintenance cycle. In addition, on-site BDB equipment hose and cable end fittings are standardized with the equipment supplied from the NSRC.

In the event of a BDB external event and subsequent ELAP/LUHS condition, equipment will be moved from the NSRC to a local assembly area established by the Strategic Alliance for FLEX Emergency Response (SAFER) team. From there, equipment will be taken to the Callaway Plant site and staged at the SAFER onsite Staging Area "B" immediately outside the OCA on geographic west side of the plant by helicopter if ground transportation is unavailable.

Communications will be established between Callaway Plant personnel and the SAFER team. If normal communications have been interrupted then satellite phones would be used. Callaway Plant personnel and the SAFER Team will coordinate getting the required equipment moved to the site. First arriving equipment will be delivered to the site within 24 hours from the initial request. The order in which equipment is delivered is identified in the Callaway Plant's SAFER Response Plan (Reference 3.1.51).

2.10.2 Equipment List

The equipment stored and maintained at the NSRC for transportation to the local assembly area to support the response to a BDBEE at Callaway Plant is listed in Table 2. Table 2 identifies the equipment that is specifically credited in the FLEX strategies for Callaway Plant. The Table also lists the equipment that will be available for backup/replacement should onsite equipment be unavailable. Since all the equipment will be located at the local assembly area, the time needed for the replacement of a failed component would be minimal.

2.11 Equipment Operating Conditions

2.11.1 Ventilation

Following a BDBEE and subsequent ELAP event at Callaway Plant, ventilation providing cooling or exhaust paths 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.) following a BDBEE resulting in an ELAP/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.

The key areas identified for all phases of execution of the FLEX strategy activities are the Control Room (CR), Class 1E Switchgear Rooms, Class 1E Battery Rooms, Turbine Driven Auxiliary Feedwater Pump (TDAFP) Room, Boric Acid Tank Room and Boric Acid Batching Tank Room.

Control Room

Control Room instrumentation cabinet doors are opened as a 30 minute time-credited-action in the procedure for responding to loss of all AC power (ECA-0.0). The applicable procedure step is designed to open the cabinet doors as soon as possible. Vital instrument cooling is assured if the cabinet doors are opened within 30 minutes from loss of all AC power.

Ameren Calculation BO-05, Revision 1, Addendum 19, Revised Temperatures for 3601, 3605 and 3609 for Station Black Out (Reference 3.1.55) determined that the maximum temperature in the Control Room does not exceed 120°F. An assumption in this calculation is that all Control Room ventilation is unavailable and that additional ventilation is not provided. FSG-45, Temporary Ventilation and Lighting, establishes Control Room ventilation flow.

Class 1E Switchgear and Battery Rooms

Ameren Calculation, GK-19, Addendum 2, (Reference 3.1.58) determined that the maximum temperature in the ESF switchgear rooms and Class 1E 125 VDC equipment rooms do not exceed maximum analyzed room temperatures. A Gothic Analysis (Zachery Nuclear Engineering, Inc. Calculation NAI-1871-001, Revision 0, Reference 3.1.70) was performed to determine the temperatures that would be anticipated during an ELAP event in the vital battery rooms with minimum heat loads and extreme cold outdoor conditions for the Callaway site. The analysis determined that all the Class 1E Battery Rooms remain above 60°F.

An additional ventilation concern applicable to Phase 2 is the potential buildup of hydrogen in the battery rooms. Off-gassing of hydrogen from batteries is only a concern when the batteries are charging. Calculation M-GK-370, Post-Accident Battery Room H_2 Concentration Levels (Reference 3.1.60) determined that H_2 concentration may reach 2% in as little as 2.62 days with no ventilation in the Class 1E Battery Rooms. The calculation also determined that an exhaust flow of 100 CFM of air ensures that the concentration will not become critical. FSG-45, Temporary Ventilation and Lighting, establishes battery room ventilation flow and H_2 monitoring. The blowers purchased for H_2 removal have a minimum flow rate of 1842 CFM.

TDAFP Room

Ameren Calculation BO-05 Addendum 16, Temperature of Callaway Turbine Driven Auxiliary Feedwater Pump Room, (Reference 3.1.56) determined that with the TDAFP in service, after a station blackout, the steady state temperature the room would reach would be 144.47°F. This is slightly below the design maximum of 148.6°F. An assumption of this calculation is that all ventilation is lost and no actions taken to reduce heat load or to establish either active or passive ventilation (e.g., portable fans, open doors, etc.). To ensure that the temperatures remain within the acceptable range for equipment and personnel habitability guidance is provided to the operators (FSG-45, Temporary Ventilation, Lighting and Power) for ventilation of the TDAFP Room.

<u>Boric Acid Tank and Boric Acid Batching Tank Rooms</u>

Calculation NAI-1901-001, GOTHIC Analysis of the Boric Acid Tank Rooms for Extended Loss of A/C Power (Reference 3.1.75) determined the room temperature in the Boric Acid Tank (BAT) rooms 1116 and 1117 on elevation 1974' and the Boric Acid Batching Tank room 1407 on elevation 2026' during an extended loss of A/C power event. Although the temperature initially increases slightly above 60°F in each room, the temperature then drops. In room 1116 the temperature drops below 59°F around 151,200 seconds (42 hours) and stays around 58°F at 72 hours. In room 1117 the temperature drops below 59°F around 37 hours and stays just below 58°F after 72 hours. The temperature in Room 1407 drops below 59°F at approximately 13.5 hours to just above 53°F at 72 hours.

FSG-50, Freeze Protection for ELAP Response, has direction to place heater(s) capable of producing greater than 18,000 BTU/HR in the Auxiliary Building 1974' elevation in order to maintain the temperature in Rooms 1116, 1117 and 1407 above 59°F. Additional direction is given to heat the Boron Injection Header room which, during an ELAP, will contain permanent and temporary piping/hoses used for boron injection. Furthermore, direction is given to establish temporary heating for the permanent and temporary piping/hoses going into the North Piping Penetration Room.

FSG-47, Batching Boric Acid to the Boric Acid Storage Tanks, has provision to heat makeup water to 90 degrees F. This boric acid solution when added to the BAT Tanks will contribute to maintaining the solution above the crystallization temperature. However, no credit is taken for this thermal addition in Calculation NAI-1901-001.

2.11.2 Heat Tracing

Heat tracing to FLEX connections is not required. All FLEX connections for hose or piping carrying water are inside buildings. For hoses that are routed outside and are susceptible to freezing during extreme low temperatures a method of recirculation is provided such that flow can be maintained in the exposed hose at all times thereby preventing freezing of the hose line. These instructions are contained in FSG-50, Freeze Protection for ELAP Response. Also included in FSG-50 are instructions for the use of portable heaters for heating deployed FLEX equipment and hoses. The portable heaters are stored in the HSB.

Extreme cold is not expected to impact CST or HCST availability. The CST and HCST are insulated and adequately protected from extremes of hot and cold weather. The volume and initial temperature of the CST and HCST contents and associated piping would preclude the significant loss of heat required for freezing upon loss of all AC power within the Phase 1 timeframes. The HCST also has immersion heaters to maintain the water temperature in the HCST a minimum of 50°F.

The UHS Retention Pond would remain available as a water source during extreme cold conditions. In the event that the UHS Retention Pond was covered with a layer of ice, instructions are provided in FSG-50 for breaking through the ice to gain access to the water for the suction hoses and strainers.

2.12 Habitability

Habitability was evaluated as discussed in Section 2.11.1 in conjunction with equipment operability and determined to be acceptable.

2.13 Lighting

The Control Room is served by emergency DC lighting powered by the Class 1E Batteries. Prior to twelve (12) hours after the event the FLEX diesel generator will be deployed to provide power to the Class 1E Battery Chargers. This will ensure continued operation of emergency DC lighting.

Operators have flashlights available as necessary to provide lighting for operator actions outside the CR. Area lighting would be required for outside deployment of FLEX equipment during the night. FLEX Light Towers stored in the HSB provide this necessary lighting.

2.14 Communications

In the event of a BDBEE and subsequent ELAP, communications systems functionality could be significantly limited. The Callaway Plant communication plans are discussed in depth in letters to the NRC (References 3.1.19 and 3.1.20). A standard set of assumptions for an ELAP event is identified in NEI 12-01, Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities, May 2012 (Reference 3.1.15).

The Callaway Plant communications systems and equipment are designed and installed to assure reliability of on-site and off-site communications in the event of a Design Basis Accident scenario. However, in the event of an ELAP, it is assumed limited communications systems functionality will be available.

Communications necessary to provide onsite command and control of the FLEX strategies and offsite notifications at Callaway Plant can be effectively implemented with a combination of satellite phones, and hand-held radios.

On site:

Existing plant procedures include guidance for when normal communication means are not available. Radio Communication equipment used in normal plant operations (Fire Brigade and Callaway Plant Operations Radio Communications) will also be used in an emergency to communicate with mobile units. The Radio System consists of repeaters, antennas, and portable radios, which provide communication between the TSC, dispatched in-plant teams and the Callaway Plant Control Room. A radio repeater system provides communications via handheld radios to the operators during implementation of the BDBEE mitigation actions.

Portable hand-held radios are available for the implementation of the FLEX strategies. Sufficient batteries and chargers are also available. Use of the hand-held radios is somewhat limited (on a point to point basis). A Communications Trailer stored in the HSB is available to re-establish site radio communications, if necessary. This trailer is equipped with an antenna tower, an on-board diesel generator, and chargers for the plant radio batteries. The plant passive antenna system has been modified so that the portable radio cart can be directly connected to it. This will ensure adequate in-plant communications. Additionally, the radio cart will provide communication capability for the outside operating staff, the emergency repair teams, and the field monitoring teams.

Off-Site:

Existing telephone communications are assumed to be inoperable following a BDBEE and therefore are not credited. Communication links are assumed to be established via satellite phones and use of the credited site radio channel(s). Satellite phones are the only reasonable means to communicate off-site when the telecommunications infrastructure surrounding Callaway Plant is non-functional. The satellite phones connect with other satellite phones as well as normal communications devices.

NEI 12-01, Section 4.1 outlines the minimum communication pathways to the federal, state, and local authorities. A total of 11 satellite phones are available for offsite communications. These phones are distributed between the Main Control Room (CR), the Technical Support Center (TSC), and Emergency Operations Facility (EOF). Additionally, all of the local Offsite Response Organizations (OROs) have been provided a satellite phone.

2.15 Water sources

2.15.1 Secondary Water Sources

Section 2.3.10.5 provides the credited water sources that are used to provide cooling water to the SGs. The CST or the HCST would provide the initial inventory to the TDAFP at the initial onset of the event. The HCST provides a minimum of thirty (30) hours of inventory to the TDAFP and is fully protected for all applicable external events. The CST can provide approximately twenty-four (24) hours of inventory to the TDAFP for seismic or extreme temperature events.

Table 3 provides a list of potential water sources that may be used to provide cooling water to the Steam Generators (SGs), their capacities, and an assessment of availability following the applicable hazards identified in Section 2.6. Normal operating practices would maintain all the water sources available for high and low extreme temperatures.

Approximately 25 hours after the event, a mobile water purification unit from the NSRC will be available. This unit would be able to be placed in service prior to the depletion of the HCST. The mobile purification unit has sufficient capacity to be able to supply clean water for core cooling and SFP makeup. At this same time, a diesel driven NSRC Low Pressure/High Flow Pump will be available from the NSRC. This will allow switching core cooling to RHR, thus reducing the demand for clean water.

The water sources have a wide range of associated chemical compositions. Therefore, extended periods of operation with the addition of these various water sources to the SGs were evaluated for impact on Steam Generator performance resulting from Steam Generator material (e.g., tube) degradation and potential impact on the heat transfer capabilities of the SGs (References 3.1.25 and 3.1.30). Use of the available clean water sources are limited only by their quantities.

The results of the water quality evaluation show that the credited onsite water sources provide an adequate AFW supply source for a much longer time than would be required for the delivery and deployment of the Phase 3 NSRC reverse osmosis (RO)/ion exchange equipment to remove impurities from the onsite natural water sources. The RO unit has a capacity of up to 250 gpm. Once the reverse osmosis/ion exchange equipment is in operation, the onsite water sources provide a sufficient supply of purified water.

Although not fully protected for all applicable external events, additional water sources may be available following an ELAP. The preferred additional water sources are discussed below, with other available sources shown in Table 3.

Demineralized Water Storage Tank (DWST) - The Demineralized Water Storage Tank is located next to the CST and contains approximately 50,000 gallons of demineralized grade water. Since the DWST is not seismically qualified or protected from tornado missiles, it is not credited in the Callaway Plant strategy.

Reactor Water Makeup Storage Tank (RMWST) - The Reactor Water Makeup Storage Tank is located next to the RWST and contains approximately 126,000 gallons of reactor grade water. Since the

RMWST is not seismically qualified or protected from tornado missiles, it is not credited in the Callaway Plant strategy.

2.15.2 Water Sources - Primary Side

Two credited sources for borated water are available onsite: the Boric Acid Tanks (BAT) and the Refueling Water Storage Tank (RWST). These sources are discussed in Section 2.3.4.

Clean water sources for use in batching borated water in the Boric Acid Mixing Tank would be used in the same order of preference provided in Table 3 for the AFW sources, dependent on availability.

2.15.3 Spent Fuel Pool (SFP)

Water quality is not a significant concern for makeup to the SFP. The primary water source would be from the HCST via the FLEX SFP Pump. However, any of the water sources available would be acceptable for use as makeup to the SFP. Likewise, boration is not a concern since boron is not being removed from the SFP when boiling.

2.16 Shutdown and Refueling Analysis

Steam Generators Unavailable for Cooling (Modes 5 and 6)

FLEX mitigating strategies available during shutdown and refueling modes follow the guidance of NEI 12-06, Section 3.2.3. Hot Standby (Mode 3) and Hot Shutdown (Mode 4 RHR not in service) are all bounded by the FLEX strategy for power operation. For Mode 4 RHR in service, Cold Shutdown (Mode 5), and Refueling (Mode 6) the RCS and Steam Generator configurations may vary considerably.

Contingency actions are developed for high risk evolutions and time needed for such evolutions is minimized. Due to the heightened awareness of risk in shutdown modes, the time at which Phase 2 actions should begin for shutdown modes is likely to be much less than that assumed for at power scenarios.

Consideration is given in the shutdown risk assessment process to:

- Maintaining FLEX equipment necessary to support shutdown risk processes and procedures readily available, and

- How FLEX equipment could be deployed or pre-deployed/pre-staged to support maintaining the key safety functions in the event of a loss of shutdown cooling.

At present, Callaway Plant will not routinely pre-stage FLEX equipment. If necessary to eliminate delays associated with deployment of FLEX Equipment to minimize shutdown risk, an evaluation will be performed prior to pre-staging FLEX equipment. Evaluations that assess the impact to existing SSCs are controlled under the 10CFR50.59 process.

If an ELAP event results in a loss of RHR, the Operations staff is directed to establish "Containment Closure." This activity directs the evacuation of the containment and the closure of all open containment penetrations including the personnel access hatches and the equipment access hatch. The Modes 5 and 6 core cooling strategy will cause water/steam to "spill" into Containment causing the Containment pressure to slowly increase. In order to maintain the Containment within its design pressure limits, a vent path is necessary and will be procedurally established following an ELAP event while in Modes 5 or 6.

A Containment vent path will be established through the Emergency Personnel Hatch (EPH). The adequacy of this vent path for maintaining Containment pressure within design limits has been confirmed by analysis (Reference 3.1.27).

The primary shutdown strategy is to use the FLEX AFW Pump to take suction from the RWST and discharge to preselected FLEX connections in the Safety Injection System. These newly installed connections provide the ability to feed the RCS from various water sources utilizing FLEX Pumps.

In the event that the RWST is not available, strategies have been developed using the HCST or the CST as a source of water. Boric acid is batched in the Boric Acid Batching Tanks (BABT) and transferred to a BAT. FLEX Diesel Water Heaters are used to heat the incoming water, as needed to ensure proper mixing. Water to the BABT may be from the HCST or the NSRC Mobile Water Purification Unit. Blended flow to the RCS is obtained by use of a FLEX AFW Pump taking suction from either the HCST or the CST and a FLEX Boron Pump taking suction from a BAT. The pumps discharge into FLEX connections in the Safety Injection System.

2.17 Sequence of Events

Table 4, Sequence of Events Timeline, presents a Sequence of Events (SOE) Timeline for an ELAP/LUHS event at Callaway Plant. Validation of each of the FLEX time constraint actions has been completed in accordance with NEI 12-06, Appendix E, Validation Guidance, and includes consideration for staffing. Time to clear debris to allow equipment deployment is assumed to be 2 hours. This time is considered to be reasonable based on site reviews and the location of the HSB. Debris removal equipment is stored inside the HSB and is, therefore, protected from the external hazards described in Section 2.6.

2.18 Programmatic Elements

2.18.1 Overall Program Document

The Callaway Plant Program Document (APA-ZZ-00391, Beyond Design Basis (BDB) Program Document) (Ref. 3.1.38) provides a description of the Diverse and Flexible Coping Strategies (FLEX) Program for Callaway Plant. The key program elements provided in the Program Document include:

- Description of the FLEX strategies and basis
- Provisions for documentation of the historical record of previous strategies and the basis for changes
- The basis for the ongoing maintenance and testing programs chosen for the FLEX equipment
- Equipment Storage
- FLEX Procedures
- Validation of time sensitive operator actions
- Hazards considerations (Seismic, High Winds, Extreme Temperatures, etc.)
- Staffing, Training, and FLEX Drills
- Configuration Control

Design control procedures ensure that changes to the plant design, physical plant layout, roads, buildings, and miscellaneous structures will not adversely impact the approved FLEX strategies.

Future changes to the FLEX strategies may be made without prior NRC approval provided the revised FLEX strategy meets:

i. the provisions of NEI 12-06, Diverse and Flexible Coping Strategies Implementation (FLEX) Implementation Guide, or

ii. the change to the strategies and guidance implement an alternative or exception approved by the NRC, provided that the bases of the NRC approval are applicable to Callaway Plant, or

iii. an evaluation demonstrates that the provisions of NRC Order EA-12-049 continue to be met

2.18.2 Procedural Guidance

The inability to predict actual plant conditions that require the use of FLEX equipment makes it impossible to provide specific procedural guidance. As such, the FLEX Support Guidelines (FSGs) provide guidance that can be employed for a variety of conditions. Clear criteria for entry into FSGs ensures that FLEX strategies are used only as directed for BDBEE conditions, and are not used inappropriately in lieu of existing procedures. When FLEX equipment is needed to supplement EOPs or Abnormal Operating Procedures (AOPs) strategies, the EOP or AOP, Severe Accident Mitigation Guidelines (SAMGs), or Extreme Damage Mitigation Guidelines (EDGMs) direct the entry into and exit from the appropriate FSG procedure.

FLEX support guidelines have been developed in accordance with Pressurized Water Reactor Owner's Group (PWROG) guidelines. FLEX Support Guidelines provide available, pre-planned FLEX strategies for accomplishing specific tasks in the EOPs or AOPs. FSGs will be used to supplement (not replace) the existing procedure structure that establishes command and control for the event.

Procedural Interfaces are incorporated into Procedure ECA-0.0, Loss of All AC Power, to the extent necessary to include appropriate reference to FSGs and provide command and control for the ELAP. Additionally, procedural interfaces have been incorporated into a new off-normal procedure, OTO-NB-00005, Loss of All AC Power While on RHR, (Reference 3.1.39), to include appropriate reference to FSGs.

FSG maintenance will be performed by the Operations Department. In accordance with site administrative procedures, NEI 96-07, Revision 1, Guidelines for 10 CFR 50.59 Implementation (Reference 3.1.76), and NEI 97-04, Revision 1, Design Bases Program Guidelines (Reference 3.1.77), are to be used to evaluate changes to current procedures, including the FSGs, to determine the need for prior NRC approval. However, per the guidance and examples provided in NEI 96-07, Rev. 1, changes to procedures (EOPs, AOPs, EDMGs, SAMGs, or FSGs) that perform actions in response to events that exceed a site's design basis should screen out. Therefore, procedure steps which recognize the ELAP/LUHS has occurred and which direct actions to ensure core cooling, SFP cooling, or containment integrity should not require prior NRC approval.

FSGs have been reviewed and validated to the extent necessary to ensure the strategy is feasible. Specific FSG validation was accomplished in accordance with the requirements of NEI 12-06, Appendix E, and used table top evaluations and/or walk-throughs of the guidelines as appropriate.

2.18.3 Staffing

Using the methodology of NEI 12-01, *Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities*, an assessment of the capability of the Callaway Plant on-shift staff and augmented Emergency Response Organization (ERO) to respond to a Beyond Design Basis External Event (BDBEE) was performed. The results have been provided to the NRC in ULNRC-06267, Phase 2 Staffing Assessment Regarding Recommendation 9.3 (Staffing) (Ref. 3.1.23).

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

- an extended loss of AC power (ELAP)
- an extended loss of access to ultimate heat sink (UHS)

- impact on the unit (unit is operating at full power at the time of the event)
- impeded access to the unit by off-site responders as follows:
  - 0 to 6 Hours Post Event – No site access.
  - 6 to 24 Hours Post Event – Limited site access. Individuals may access the site by walking, personal vehicle or via alternate transportation capabilities (e.g., private resource providers or public sector support).
  - 24+ Hours Post Event – Improved site access. Site access is restored to a near-normal status and/or augmented transportation resources are available to deliver equipment, supplies and large numbers of personnel.

A team of subject matter experts from Operations, Operations Training, Radiation Protection, Chemistry, Security, Emergency Preparedness, FLEX Project Team personnel and Industry Consultants performed a staffing assessment in September 2014. A follow-up review meeting was held on October 29, 2015, to review the impact of changes made in the interim and ensure adequate staffing was available to implement the strategies. The participants reviewed the assumptions and applied existing procedural guidance, including applicable draft and approved FSGs for coping with a BDBEE using minimum on-shift staffing. Particular attention was given to the sequence and timing of each procedural step, its duration, and the on-shift individual performing the step to account for both the task and the estimated time to prepare for and perform the task.

The Phase 2 Staffing Assessment concluded that the current minimum on-shift staffing as defined in the Callaway Plant Emergency Plan is sufficient to support the implementation of the mitigating strategies (FLEX strategies) as well as the required Emergency Plan actions, with no unacceptable collateral tasks assigned to the on-shift personnel during the first 6 hours. The assessment also concluded that the on-shift staffing, with assistance from augmented staff, is capable of implementing the FLEX strategies necessary after the 6 hour period within the constraints. It was concluded that the Emergency response function would not be degraded or lost.

2.18.4 Training

Callaway Plant's Nuclear Training Program assures personnel proficiency in the mitigation of BDBEEs is adequate and maintained. These programs and controls were developed and have been implemented in accordance with the Systematic Approach to Training (SAT) Process.

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

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

ANSI/ANS 3.5, Nuclear Power Plant Simulators for use in Operator Training (Reference 3.1.74), certification of simulator fidelity is considered to be sufficient for the initial stages of the BDBEE scenario until the current capability of the simulator model is exceeded.

Where appropriate, integrated FLEX drills will be organized on a team or crew basis and conducted periodically; with all time-sensitive actions to be evaluated over a period of not more than eight years. It is not required to connect/operate equipment during these drills.

2.18.5 Equipment List

The equipment stored and maintained at the Callaway Plant FLEX Storage areas necessary for the implementation of the FLEX strategies in response to a BDBEE at Callaway Plant is listed in Table 1. This table identifies the quantity, applicable strategy, and capacity/rating for the major FLEX equipment components only, as well as, various clarifying notes. Specific details regarding fittings, tools, hose lengths, consumable supplies, etc. are not provided in Table 1.

2.18.6 N+1 Equipment Requirement

NEI 12-06 invokes an N+1 requirement for the major FLEX equipment that directly performs a FLEX mitigation strategy for core cooling, containment, or SFP cooling in order to assure reliability and availability of the FLEX equipment required to meet the FLEX strategies. Sufficient equipment has been purchased to address all functions 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. Therefore, where a single resource is sized to support the required function of both units a second resource has been purchased to meet the +1 capability. In addition, where multiple strategies to accomplish a function have been developed, (e.g., two separate means to repower instrumentation) the equipment associated with each strategy does not require N+1 capability.

The N+1 capability applies to the portable FLEX equipment that directly supports maintenance of the key safety functions identified in Table 3-2 of NEI 12-06. Other FLEX support equipment, vehicles, and tools provided for mitigation of BDB external events, but not directly supporting a credited FLEX strategy, are not required to have N+1 capability.

In the case of hoses and cables associated with FLEX equipment required for FLEX strategies, additional spares have been procured per the requirements of NEI 12-06, Section 3.2.2-16.

2.18.7 Equipment Maintenance and Testing

The FLEX equipment that directly performs a FLEX mitigation strategy for the core cooling, containment, or SFP cooling is subject to periodic maintenance and testing in accordance with NEI 12-06 to verify proper function. Additional FLEX support equipment that requires maintenance and testing will have Preventive Maintenance to ensure it will perform its required functions during a BDB external event.

Maintenance and testing of FLEX equipment is governed by the Callaway Plant Preventive Maintenance (PM) Program as described in APA-ZZ-00330, Preventive Maintenance Program (Reference 3.1.37). The Callaway Plant PM Program is consistent with INPO AP-913 and utilizes the EPRI Preventive Maintenance Basis Database as an input in development of the specific Callaway Plant FLEX PM Basis Templates. Based on this, the Callaway Plant PM program for FLEX equipment follows the guidance of NEI 12-06, Section 11.5.

The PM Templates include activities such as:

- Periodic Static Inspections
- Operational Inspections
- Fluid analysis
- Periodic functional verifications
- Periodic performance verification tests

The Callaway Plant PM Basis Templates provide assurance that FLEX equipment is being properly maintained and tested. In those cases where EPRI templates were not available for the specific component types, Preventative Maintenance (PM) actions were developed based on manufacturer provided information/ recommendations.

Additionally, the Emergency Response Organization (ERO) performs periodic facility readiness checks for equipment considered to be a functional aspect of the specific facility (Emergency Preparedness communications equipment such as UPSs, radios, batteries, battery chargers, satellite phones, etc.). These facility functional readiness checks provide assurance that the EP communications equipment is being properly maintained and tested.

The unavailability of equipment and applicable connections that directly perform a FLEX mitigation strategy for core cooling, containment, and SFP cooling will be managed such that risk to mitigation strategy capability is minimized. Maintenance/risk guidance conforms to the guidance of NEI 12-06 as follows:

- The unavailability of installed plant equipment is controlled by existing plant processes such as the Technical Specifications. When installed plant equipment which supports FLEX strategies becomes unavailable, then the FLEX strategy affected by this unavailability does not need to be maintained during the unavailability.
- The required FLEX equipment may be unavailable for 90 days provided that the site FLEX capability (N) is met. If the site FLEX (N)

capability is met but not protected for all of the site's applicable hazards, then the allowed unavailability is reduced to 45 days.

- One of the connections to plant equipment required for FLEX strategies can be unavailable for 90 days provided the remaining connection remains available such that the site FLEX strategy is available.
- The duration of equipment unavailability, discussed above, does not constitute a loss of reasonable protection from a diverse storage location protection strategy perspective.
- If FLEX equipment or connections become unavailable such that the site FLEX capability (N) is not maintained, initiate actions within 24 hours to restore the site FLEX capability (N) and implement compensatory measures (e.g., use of alternate suitable equipment or supplemental personnel) within 72 hours.
- If FLEX equipment or connections to permanent plant equipment required for FLEX strategies are unavailable for greater than 45/90 days, restore the FLEX capability or implement compensatory measures (e.g., use of alternate suitable equipment or supplemental personnel) prior to exceedance of the 45/90 days.

3. References

3.1 Mitigation Strategies (FLEX) References

3.1.1 SECY-11-0093, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," (ADAMS Accession No. ML111861807).

3.1.2 NRC Order EA-12-049, “Order to Modify Licenses With Regard to Requirements for Mitigation Strategies For Beyond-Design-Basis External Events,” dated March 12, 2012, (ADAMS Accession No. ML 12056A045).

3.1.3 Nuclear Energy Institute (NEI) 12-06, Diverse and Flexible Coping Strategies (FLEX) Implementation Guide, Revision 0, dated August 2012 (ADAMS Accession No. ML12221A205)

3.1.4 Nuclear Energy Institute (NEI) 12-06, Diverse and Flexible Coping Strategies (FLEX) Implementation Guide, Revision 2, dated December 2015 (ADAMS Accession No. ML16005A625)

3.1.5 NRC Interim Staff Guidance JLD-ISG-2012-01, “Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events”, Revision 0, dated August 29, 2012 (ADAMS Accession No. ML 12229A174).

3.1.6 NRC Interim Staff Guidance JLD-ISG-2012-01, “Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events”, Revision 1, dated January 22, 2016 (ADAMS Accession No. ML 12229A174).

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

3.1.8 Nuclear Energy Institute (NEI) 12-02, Industry Guidance for Compliance with NRC Order EA-12-051, To Modify Licenses with Regard to Reliable SFP Instrumentation, Revision 1, dated August 2012 (ADAMS Accession No. ML12240A307)

3.1.9 NRC Interim Staff Guidance JLD-ISG-2012-03, Compliance with Order EA-12-051, Reliable SFP Instrumentation, Revision 0, dated August 29, 2012 (ADAMS Accession No. ML12221A339)

3.1.10 LTR-PCSA-12-78, “Transmittal of PA-PSC-0965 Core Team PWROG Core Cooling Management Interim Position Paper,” November 9, 2012

3.1.11 Request for Information Pursuant To Title 10 of The Code of Federal Regulations 50.54(F) Regarding Recommendations 2.1, 2.3, And 9.3, Of The Near-Term Task Force Review Of Insights From The Fukushima Dai-Ichi Accident, March 12, 2012

3.1.12 Callaway Plant Emergency Operating Procedure ECA-0.0, LOSS OF ALL AC POWER

3.1.13 Callaway Plant Emergency Operating Procedure Basis, EOP-3.0, “Station Blackout Recovery Basis”, Revision 11

3.1.14 VP 12-0002 Callaway Plant response to INPO IER L1-11-4, "Near Term Actions to Address the Effects of an Extended Loss of All AC Power in Response to the Fukushima Daiichi Event," January 27, 2012.

3.1.15 Nuclear Energy Institute (NEI) 12-01, Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities, Revision 0, dated May 3, 2012 (ADAMS Accession No. ML12125A410)

3.1.16 Nuclear Energy Institute, Position Paper: Shutdown/Refueling Modes, dated September 18, 2013 (ADAMS Accession No. ML13273A514)

3.1.17 Mr. Jack Davis, Director, Mitigating Strategies Directorate, NRC letter to Mr. Joe Pollack, Vice President, Nuclear Operations, NEI, dated September 30, 2013 (ADAMS Accession No. ML13267A382), NRC Endorsement of NEI Position Paper: Shutdown/Refueling Modes

3.1.18 IEEE 344:2004, IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.

3.1.19 ULNRC-05922, AmerenMissouri Response to the March 12, 2012, Information Request Pursuant to 10 CFR 50.54(f) Regarding Recommendation 9.3 for Completing Emergency Communication Assessments, dated October 30, 2012

3.1.20 ULNRC-05959, AmerenMissouri Response to NRC Follow-up Letter on Technical Issues for Resolution Regarding Licensee Communication Submittals Associated with Near-Term Task Force Recommendation 9.3, dated February 20, 2013

3.1.21 ULNRC-05960, AmerenMissouri Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation (Order Number EA-12-051), dated February 28, 2013

3.1.22 ULNRC-05960, Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design Basis External Events (Order Number EA-12-049), dated February 28, 2013

3.1.23 ULNRC-06267, Phase 2 Staffing Assessment Regarding Recommendation 9.3 (Staffing), November 30, 2015

3.1.24 ULNRC-06161, AmerenMissouri Response To NRC Request For Information Pursuant To 10CFR50.54(f) Regarding The Seismic Aspects Of Recommendation 2.1 Of The Near-Term Task Force Review Of Insights From The Fukushima Dai-Ichi Accident- Expedited Seismic Evaluation Process Report, dated December 22, 2014

3.1.25 CN-CDME-12-9, Revision 0, Supporting Chemistry Calculations for Alternate Cooling Source Usage during Extended Loss of All A.C. Power at Plant Callaway

3.1.26 CN-FSE-12-11, Revision 1, Callaway FLEX Conceptual Design AFT Fathom Models

3.1.27 CN-SCC-13-001, Revision 2, Callaway ELAP Containment Environment Analysis

3.1.28 CN-SEE-I-12-32, Revision 1-A, "Callaway Reactor Coolant System (RCS) Inventory and Shutdown Margin Analyses to support the Diverse and Flexible Coping Strategy (FLEX)," dated January 21, 2016

3.1.29 CN-SEE-II-12-39, Revision 0, Determination of the Time to Boil in the Callaway Spent Fuel Pool after an Earthquake

3.1.30 DAR-SEE-II-12-17, Revision 0, Evaluation of Alternate Coolant Sources for Responding to a Postulated Extended Loss of All AC Power at the Callaway Energy Center

3.1.31 EQ-EV-200-SCP, Revision 1, Comparison of ELAP Environmental Conditions to the Qualified Environmental Conditions for In-Containment Equipment and Cabling at Callaway Plant.

3.1.32 SCP-14-81, Revision 1, Clarification on the Basis for the Boil Off Time of the Callaway Energy Center Spent Fuel Pool

3.1.33 TR-FSE-13-4, Revision 0, Callaway Plant FLEX Integrated Plan, dated February 2013.

3.1.34 WCAP-17601-P, Revision 0, Reactor Coolant System Response to the Extended Loss of AC Power Event for Westinghouse, Combustion Engineering and Babcock and Wilcox NSSS Designs

3.1.35 WCAP-17792-P, Revision 0, Emergency Procedure Development Strategies for the Extended Loss of AC Power Event for all Domestic Pressurized Water Reactor Designs

3.1.36 PWROG-14064-P, Revision 0, Application of NOTRUMP Code Results for Westinghouse Designed PWRs in Extended Loss of AC Power Circumstances,

3.1.37 APA-ZZ-00330, Preventive Maintenance Program

3.1.38 APA-ZZ-00391, Beyond Design Basis (BDB) Program Document

3.1.39 OTO-NB-00005, Loss of All AC Power While on RHR

3.1.40 Stevenson and Associates Document 15C4308-RPT-001, Revision 0, Seismic Evaluation of BABT and Associated SSC at Callaway for ELAP, dated June 2015

3.1.41 Callaway Plant Technical Specifications

3.1.42 Callaway Energy Center Calculation, NK-05, Attachment O, Revision 10, Fukushima Extended Loss of AC Power Load Shed Analysis

3.1.43 Burns and McDonnell Calculation 72328.3.40, Revision 0, Beyond-Design-Basis Seismic Evaluation of Condensate Storage Tank

3.1.44 Burns & McDonnell Calculation 81402-M-001, Revision 2, HCST Sizing Justification Calculation

3.1.45 Burns and McDonnell Calculation 8402-J-001, Revision 0, HCST Supply Valve ALHV0220 Opening Setpoint

3.1.46 Callaway FSAR, Revision OL-21d, “Callaway Final Safety Analysis Report (FSAR),” February 29, 2016.

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

3.1.48 RFR 201602860, Review of Containment Instrumentation Functionality after BDB Event

3.1.49 RFR 201600447, Requirements for Securing FLEX Equipment stored in HSB

3.1.50 RFR 201602466, Perform EQ Analysis of ELAP Equipment in Containment - Modes 5 and 6

3.1.51 Callaway Energy Center SAFER Response Plan, Revision 002, dated November 5, 2015, (Document Number 51-9242058)

3.1.52 Enercon Calculation No. AMN-003-CALC-016, Revision 4, FLEX RCS Inventory Control and Core Cooling Hydraulic Calculation for Callaway Energy Center Unit 1

3.1.53 Enercon Calculation No. AMN-003-CALC-017, Revision 2, AFW Hydraulic Calculation for FLEX Piping Configuration

3.1.54 Enercon Calculation No. AMN-003-CALC-018, Revision 1, SFP Hydraulic Calculation for FLEX Piping Configuration

3.1.55 Ameren Calculation BO-5, Revision 1, Station Blackout Room Temperature Analysis

3.1.56 Ameren Calculation BO-05, Revision 1, Addendum 16, Revision to Turbine Driven Auxiliary Feedwater Pump (TDAFP) Room Temperature for Station Blackout (SBO)

3.1.57 Ameren Calculation BO-05, Revision 1, Addendum 19, Revised Temperatures for 3601, 3605 and 3609 for Station Black Out

3.1.58 Ameren Calculation GK-19, Revision 0, Addendum 2, Calculation of DC and ESF Switchgear Room Heatup

3.1.59 Ameren Calculation GT-16, Revision 0, Mode 5-6 ELAP venting via Emergency Personnel Hatch

3.1.60 Ameren Calculation M-GK-370, Revision 1, Post-Accident Battery Room H_2 Concentration Levels

3.1.61 Ameren Calculation M-GK-415, Addendum 3, Temperature of Callaway Turbine Driven Auxiliary Feedwater Pump Room

3.1.62 Ameren Calculation XX-136, Revision 0, FLEX EOP Action Value V.08 "Time to Initiate Alternate RCS Boration

3.1.63 Ameren Calculation ZZ-359, Revision 0, Steam Generator Dry Out Time

3.1.64 Ameren Specification Z-1052, Revision 0, Technical Specification for the FLEX Equipment Storage Unit

3.1.65 "Westinghouse Response to NRC Generic Request for Additional Information (RAI) on Boron Mixing in Support of the Pressurized Water Reactor Owners Group (PWROG)," dated August 16, 2013 (ML13235A135).

3.1.66 Letter to Mr. J. Stringfellow (Westinghouse) from Mr. J. R. Davis (NRC) dated January 8, 2014 endorsing the Westinghouse Position Paper on Boron Mixing (ML13276A183).

3.1.67 EPRI Report 3002000623, September 2013, Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment

3.1.68 Nuclear Energy Institute, Position Paper: Shutdown/Refueling Modes, dated September 18, 2013 (ADAMS Accession No. ML 13273A514)

3.1.69 Letter to Mr. J.E. Pollock (NEI) from Mr. J. R. Davis (NRC) dated September 30, 2013 endorsing NEI Shutdown/Refueling Modes Position Paper, (ML13267A382)

3.1.70 Zachery Nuclear Engineering Analysis NAI-1871-001, Revision 0, Minimum Vital Battery Room Temperatures during an ELAP Event

3.1.71 TDB-001, Callaway Energy Center Tank Data Book, Revision 68

3.1.72 Westinghouse SCP-14-81, Revision 1, Transmittal of Revision 1 of Westinghouse Clarification on the Basis for the Boil Off Time of the Callaway Energy Center Spent Fuel Pool

3.1.73 Callaway Document SPA-18, Rev. 000, Addenda 1 – 8, PMP Quality Assurance Design Computations Union Electric Callaway Plant No. 1

3.1.74 ANSI/ANS 3.5, Nuclear Power Plant Simulators for Use in Operator Training and Examination

3.1.75 Numerical Applications Inc. Calculation NAI-1901-001, Revision 0, GOTHIC Analysis of the Boric Acid Tank Rooms for Extended Loss of A/C Power

3.1.76 NEI 96-07, Revision 1, Guidelines for 10 CFR 50.59 Implementation

3.1.77 NEI 97-04, Revision 1, Design Bases Program Guidelines

4. Acronyms

The following acronyms are used in this document.

AB	Auxiliary Building
ATWS	Anticipated Transient Without Scram
BDB	Beyond-Design-Basis
BDBEE	Beyond-Design-Basis External Event
CCW	Component Cooling Water
CFR	Code of Federal Regulations
CLB	Current Licensing Basis
CST	Condensate Storage Tank
DWST	Demineralized Water Storage Tank
EDMG	Extreme Damage Mitigation Guidelines
ELAP	Extended Loss of Alternating Current Power
EOP	Emergency Operating Procedure
EPH	Emergency Personnel Hatch
EPRI	Electric Power Research Institute
ESW	Essential Service Water
FIP	Final Integrated Plan
FLEX Strategies	Diverse and Flexible Coping Strategies
FSAR	Final Safety Analysis Report
FSG	FLEX Support Guideline
HCST	Hardened Condensate Storage Tank
HSB	Hardened Storage Building
IER	INPO Event Report
INPO	Institute of Nuclear Power Operations
ISG	Interim Staff Guidance
LOLA	Loss Of Large Area *(New term for B.5.b)*
LUHS	Loss of Ultimate Heat Sink
MDAFP	Motor Drive Auxiliary Feedwater Pump
NEI	Nuclear Energy Institute
NRC	Nuclear Regulatory Commission
NTTF	Near-Term Task Force
NSRC	National SAFER Response Center
NSSS	Nuclear Steam Supply System
OIP	Overall Integrated Plan
OTA	Alarm Response Procedure
OTG	General Operating Procedure

OTO	Abnormal Operating Procedure
PMF	Probable Maximum Flood
PWR	Pressurized Water Reactor
RAI	Request for Additional Information
RCS	Reactor Coolant System
RMWST	Reactor Makeup Water Storage Tank
RWST	Refueling Water Storage Tank
SAFER	Strategic Alliance For Emergency Response
SAMG	Severe Accident Mitigation Guidelines
SBO	Station Blackout
SECY	Secretary of the Commission, Office of the NRC
SER	Safety Evaluation Report
SFP	Spent Fuel Pool
SFPIS	Spent Fuel Pool Instrumentation System
SFPLI	Spent Fuel Pool Level Instrumentation
SRM	Staff Requirements Memo
TDAFP	Turbine Driven Auxiliary Feedwater Pump
UHS	Ultimate Heat Sink

Table 1 – FLEX Portable Equipment Stored Onsite

Portable Equipment	Use and (potential / flexibility) diverse uses					Nominal Equipment Rating/Notes
	Core	Containment	SFP	Instrumentation	Accessibility	
Diesel Driven FLEX AFW Pump (2) and associated hoses and fittings	X	X				500 gpm, 500 psig
Electric Driven FLEX Boron Pump (2) and associated hoses and fittings	X	X				25 GPM, 2000 PSIG
Diesel Driven FLEX SFP Pump (2) and associated hoses and fittings			X			250 gpm, 92 psig
480 VAC FLEX Diesel Generator (2) and associated cables and connectors	X	X	X	X		480VAC, 500 kW, 625kVA
Diesel Driven FLEX Air Compressor (1) and associated hoses and fittings	X	X				
Electric Driven FLEX Air Compressor (1) and associated hoses and fittings	X	X				
Debris Removal Vehicle (1)					X	Case N-590 Backhoe
FLEX Tow Vehicle (1)					X	Freightliner
FLEX Electric Water Heater (2) and associated hoses and fittings	X					
Communications Trailer (1)					X	Provides portable radio communications on site
Portable Light Towers (6)					X	

Table 1 – FLEX Portable Equipment Stored Onsite

Portable Equipment	Use and (potential / flexibility) diverse uses					Nominal Equipment Rating/Notes
	Core	Containment	SFP	Instrumentation	Accessibility	
Portable 120/240 VAC Generators (5)					X	11 KW each
Electric Blowers (5)					X	
Diesel Driven Hale Pump (1)	X	X	X		X	Defense-in-Depth

Table 2 – FLEX Portable Equipment from NSRC

Portable Equipment	*Use and (potential / flexibility) diverse uses*					Performance Criteria/Notes
	Core Cooling	**Containment**	**SFP**	**Instrumentation**	**Accessibility**	
Medium Voltage Generators (3)	X	X	X	X	X	4160 VAC, 1 MW
Low Voltage Generator (1)	X	X		X	X	480 VAC, 1 MW
High Pressure Injection Pump (1)	X					60 GPM, 2000 PSI
SG/RPV Makeup Pump (1)	X		X			500 GPM, 500 PSI
Low Pressure / Medium Flow Pump (1)	X					2500 GPM, 300 PSI 12 FEET LIFT
Low Pressure / High Flow Pump (1)	X					150 PSI, 5000 GPM 12 FEET LIFT
Suction Booster Lift Pump Skid (1)	X					5000 GPM 26 FEET LIFT
Mobile Lighting Tower (1)					X	440,000 LUMENS 30 FEET HEIGHT
Water Treatment (Pre-filter) (Non-Generic) (1)						500 GPM
Water Treatment (Reverse Osmosis) (Non-Generic) (1)						250 GPM

Table 3 – Water Sources

Water Source	Volume	Seismic	High Winds
Hardened Condensate Storage Tank (HCST)	Usable Volume: 366,544 gallons	Y	Y
Condensate Storage Tank (CST)	Normal Volume: 396,925 gallons	Y	N
Reactor Water Makeup Storage Tank (RMWST)	126,000 gallons	N	N
Demineralized Water Storage Tank (DWST)	50,000 gallons	N	N
Fire Protection Storage Tanks (2)	300,000 gallons (per tank)	N	N
Demineralized System Clearwell	50,274 gallons	N	N
Potable Water Storage Tank	23,000 gallons	N	N
Ultimate Heat Sink Retention Pond	38 acre-feet	Y	Y
Refueling Water Storage Tank (RWST)	394,000 gallons	Y	N
Cooling Tower Basin	Total: 11,000,000 gallons Usable: 7,800,000 gallons (usable between normal and minimum levels)	N	N
Mobile Bulk Liquid Carrier	Essentially unlimited at 40,000 pound capacity per load	N	N
Water Treatment Plant Clearwell	451,214 gallons	N	N
Water Treatment Plant Clarifiers	13 acre-feet	N	N
On-site Deep Well #3	Unlimited (if power avail.)	N	N

Table 4 – Sequence of Events Timeline

Action Item	Elapsed Time (hours)[1]	Action	New ELAP Time Constraint (Y/N)	Time Constraint (hours)	Expected Completion Time	Remarks / Applicability
0	N/A	Event Starts	N/A	N/A	N/A	Plant at 100% Power
1	N/A	Perform SBO Coping Action	N/A	N/A	N/A	SBO actions are proceduralized SBO Procedure ECA 0.0
2	0.75	Declare ELAP	Y	0.75	0.50	**Time sensitive -** Required to allow taking actions which place the plant SSCs outside License Basis alignments
3	0.75	Control Room Ventilation	N	N/A	0.50	Callaway Plant procedure, ECA-0.0, Loss of All AC Power, directs opening control room cabinet doors. Temporary ventilation will be utilized through Phase 2
4	1	NK Power Load Shed	Y	1	0.75	**Time sensitive -** Initiate load shed to start no later than 45 minutes to complete no later than 1 hour.
5	3	Realign TDAFP Recirculation from CST to HCST Isolate MDAFP Recirculation	Y	3 *(After HCST is supplying water)*	1	**Time sensitive –** Ensure adequate supply of Condensate Grade water is available to the TDAFP for greater than 24 hours.
6	5	Stage and setup Radio Communications Trailer	N	N/A	3	Radio Communications Trailer is deployed early in the event to ensure adequate communications capability.
7	5.4	Vent Fuel Building	Y	5.4	4	**Time sensitive –** Spent fuel pool (SFP) cooling is not challenged early in the event; however, access to the Fuel Building as a part of Phase 2 response could be challenged due to environmental conditions local to the pool so action would be prudent to establish ventilation in this area as early in the event as possible.

Table 4 – Sequence of Events Timeline

Action Item	Elapsed Time (hours)[1]	Action	New ELAP Time Constraint (Y/N)	Time Constraint (hours)	Expected Completion Time	Remarks / Applicability
8	6	Perform Damage Assessment	N	N/A	3	Needed to determine appropriate FLEX strategies.
9	7	Debris Removal	N	N/A	3	Debris removal will start shortly after the event and is an on-going activity. Priority will be determined based on actual needs. Completion of debris removal after 7 hours supports deploying Phase 2 FLEX Equipment as required to support initiation of mitigating strategies.
10	8	Deploy FLEX air compressors	Y	8	6	**Time sensitive –** Earliest need for compressed air to support operation of the ASDs and TDAFP Flow Control Valves.
11	9	Deploy FLEX SG Makeup Pump (Standby)	N	N/A	8	Stage as early as possible in event to provide defense in depth.
12	12	Perform Plant Cooldown to 415°F	Y	24	4	**Time sensitive** – Must be depressurized to initiate boration.
13	12	Energize NK Power 480V Generator	Y	12	10	**Time sensitive** – Earliest need for generator based on providing power for NK System (125 VDC).
14	12.5	Establish Battery Room Ventilation	N	N/A	10	Battery room ventilation will be established when battery charging is in progress.
15	24	Initiate RCS Makeup (boration) from BAT	Y	26	20	**Time sensitive:** Calculation XX-136, "Time to Initiate Alternate RCS Boration"

Table 4 – Sequence of Events Timeline

Action Item	Elapsed Time (hours)[1]	Action	New ELAP Time Constraint (Y/N)	Time Constraint (hours)	Expected Completion Time	Remarks / Applicability
16	18	FLEX Fuel Deployment	N	N/A	16	Assume 10 hours + equipment deployment time. Sufficient ERO resources would be available to perform this activity at this time.
17	24	TDAFP Room Ventilation	N	N/A	12	VP 12-0002, "Callaway's Response to INPO IER L1-11-4, states in part temperatures in the TDAFP Room, equipment cabinets, and the control room are considered acceptable for 24 hours following a beyond design basis external event (BDBEE)
18	30	Ultimate Heat Sink Pump	Y	30	30	**Time sensitive** – Need time based on HCST depletion.
19	33	Initiate SFP Makeup	Y	33	18.5	**Time sensitive** – Time for SFP water level to reduce to 15 ft. above the SFP racks assuming sloshing level, 140°F initial temperature, and normal heat load
20	72	4160V generator	Y	72	36	**Time sensitive** – Need time is based on eventual loss of capability to support Steam Generator feed strategy and implementation of long-term coping.
21	72	Large Debris Removal	N	N/A	30	Support deployment of FLEX Phase 3 Equipment
22	72	Establish Large Fuel Truck Service	N	N/A	36	Need time is based on depletion of on-site supplies and supplying larger equipment

Notes:

(1) Following completion of staffing studies, all validations of Time Sensitive Action have been completed. All Time Sensitive Actions will be completed prior to time constraint.

Figure 1: Site Layout – FLEX Equipment Staging, Storage, and Deployment Routes

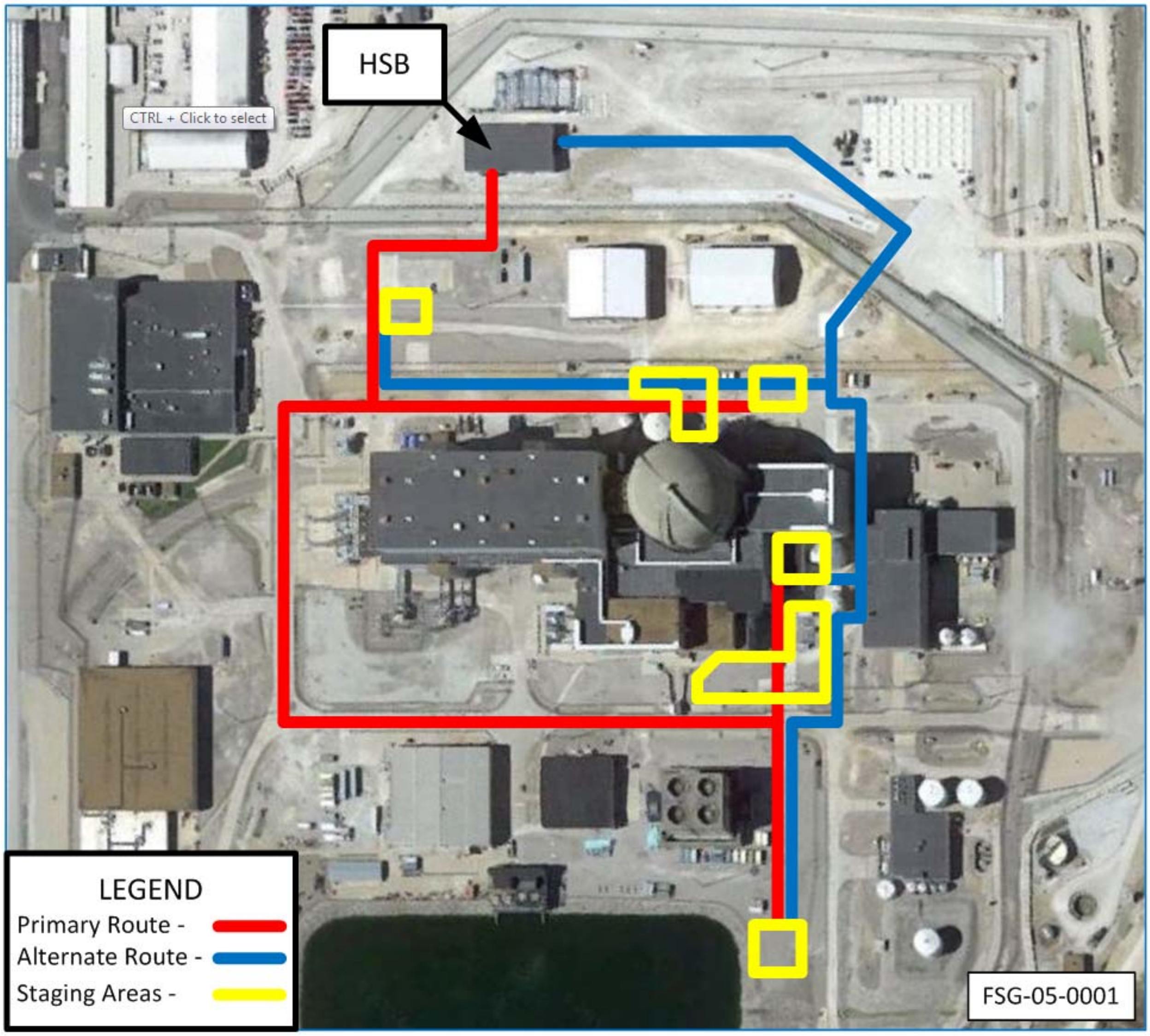


Figure 2: FLEX AFW Pump Hose Routings (External)

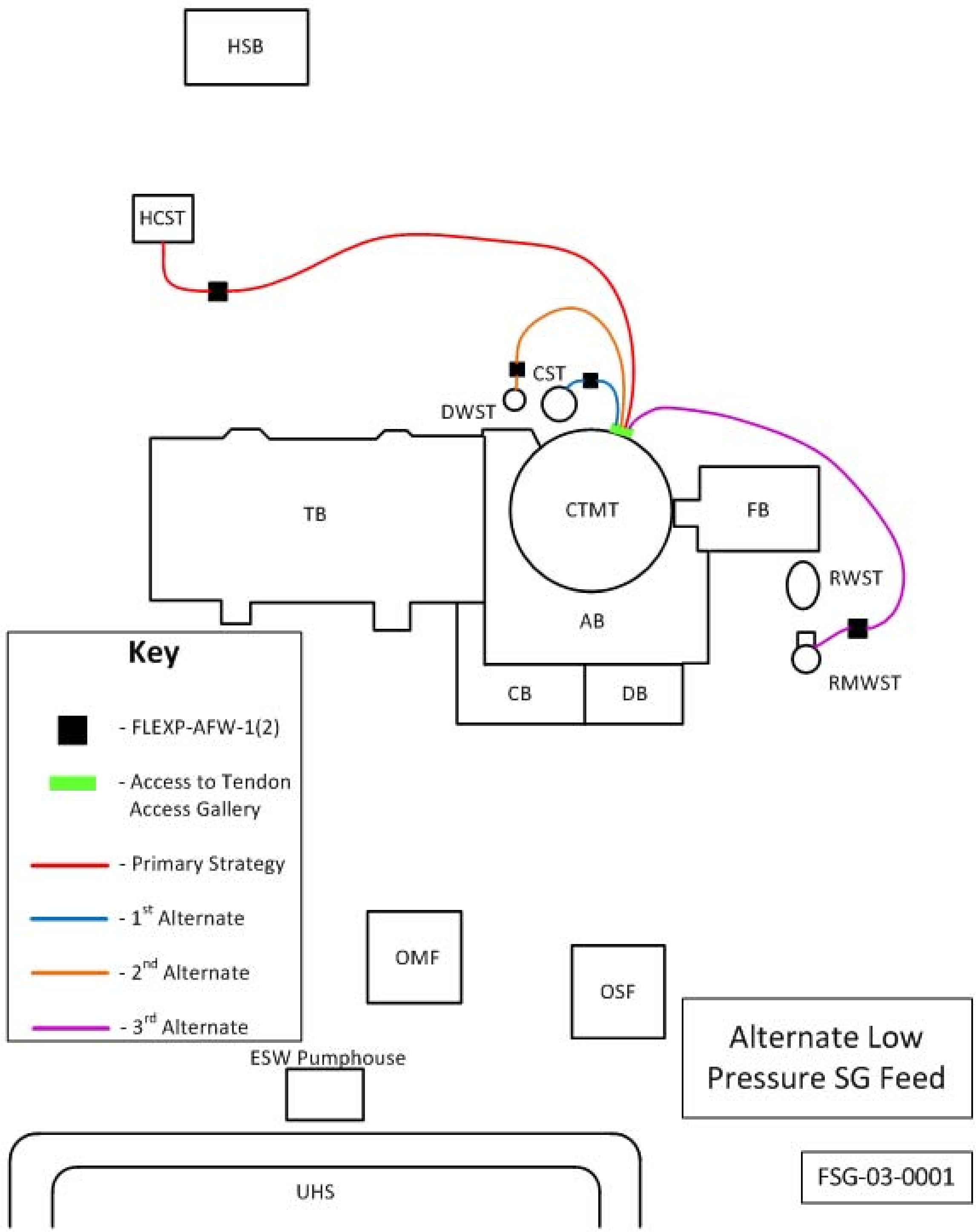


Figure 3: FLEX AFW Pump Hose Routings (Internal)

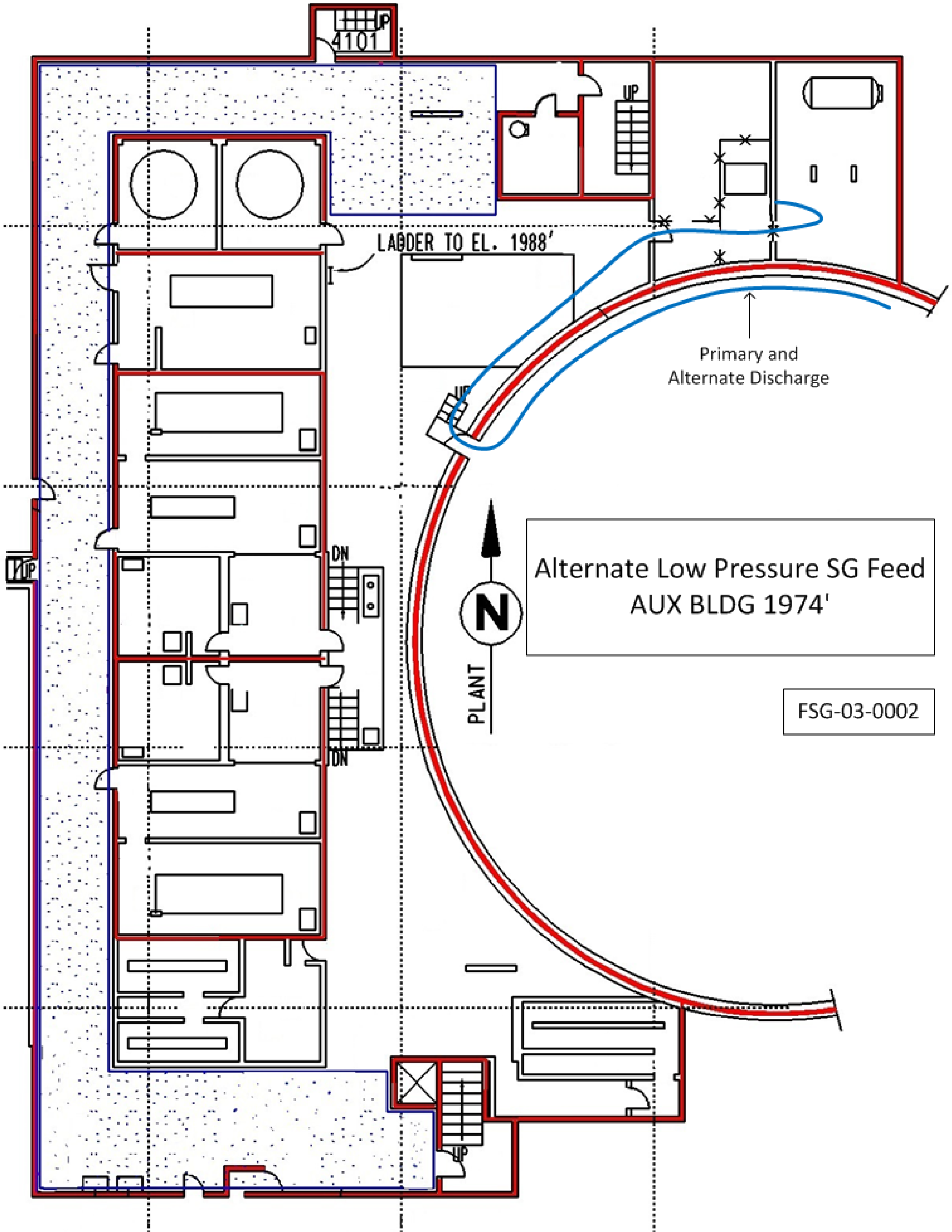


Figure 4: Electric Air Compressor Deployment

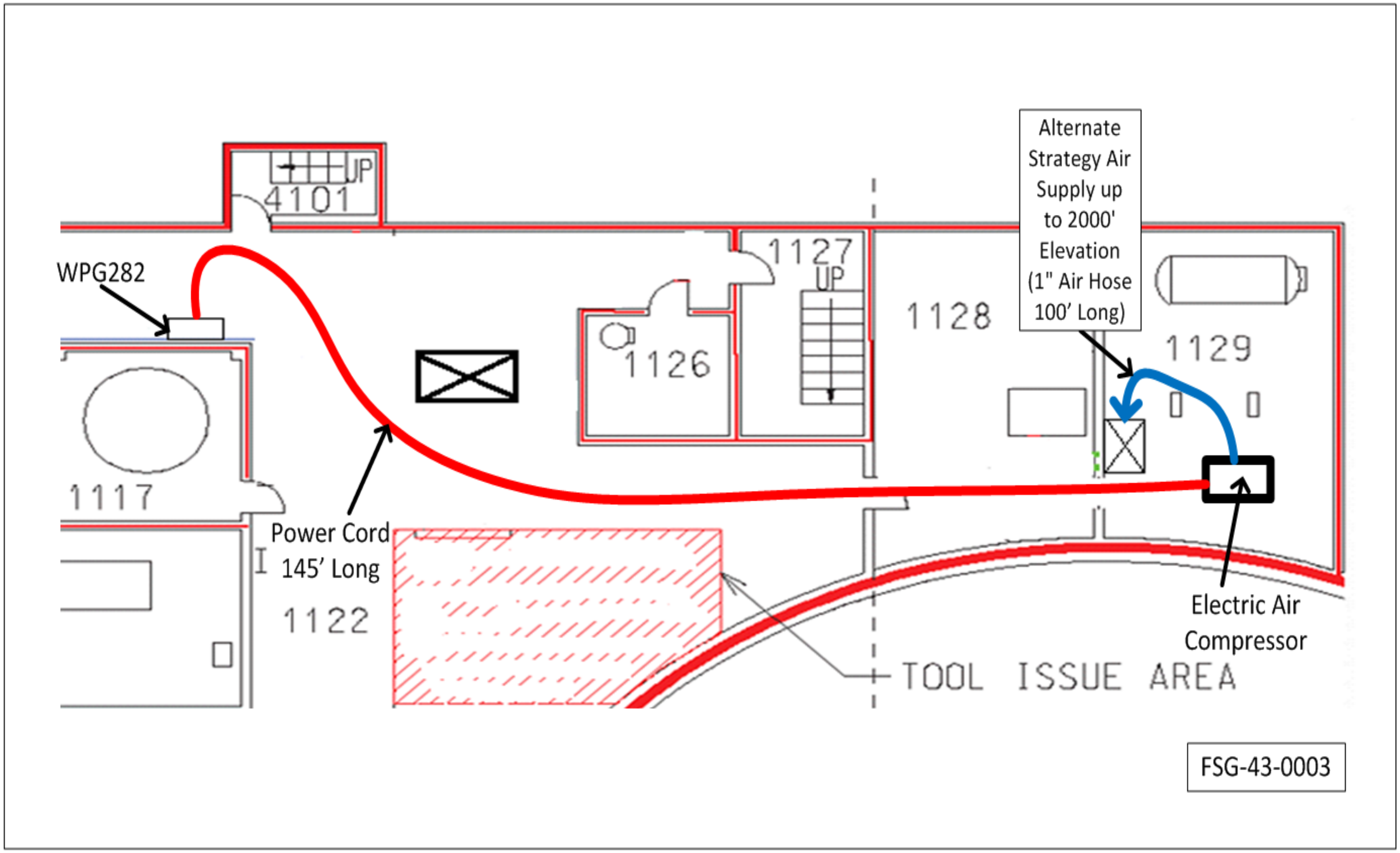


Figure 5: Diesel Air Compressor Deployment

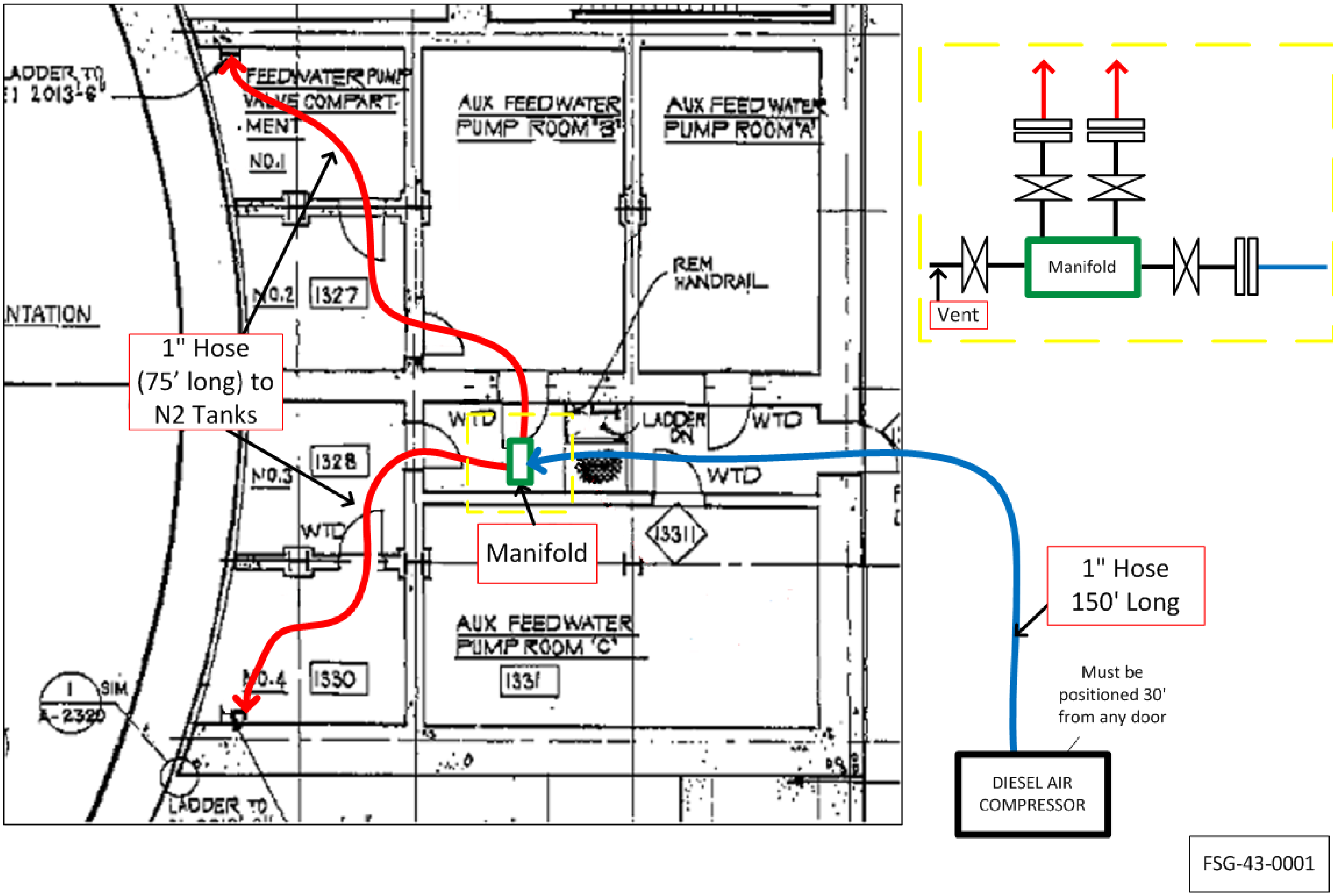


Figure 6: FLEX Boron Pump Hose Routing Primary Connection AB 1974' Elevation

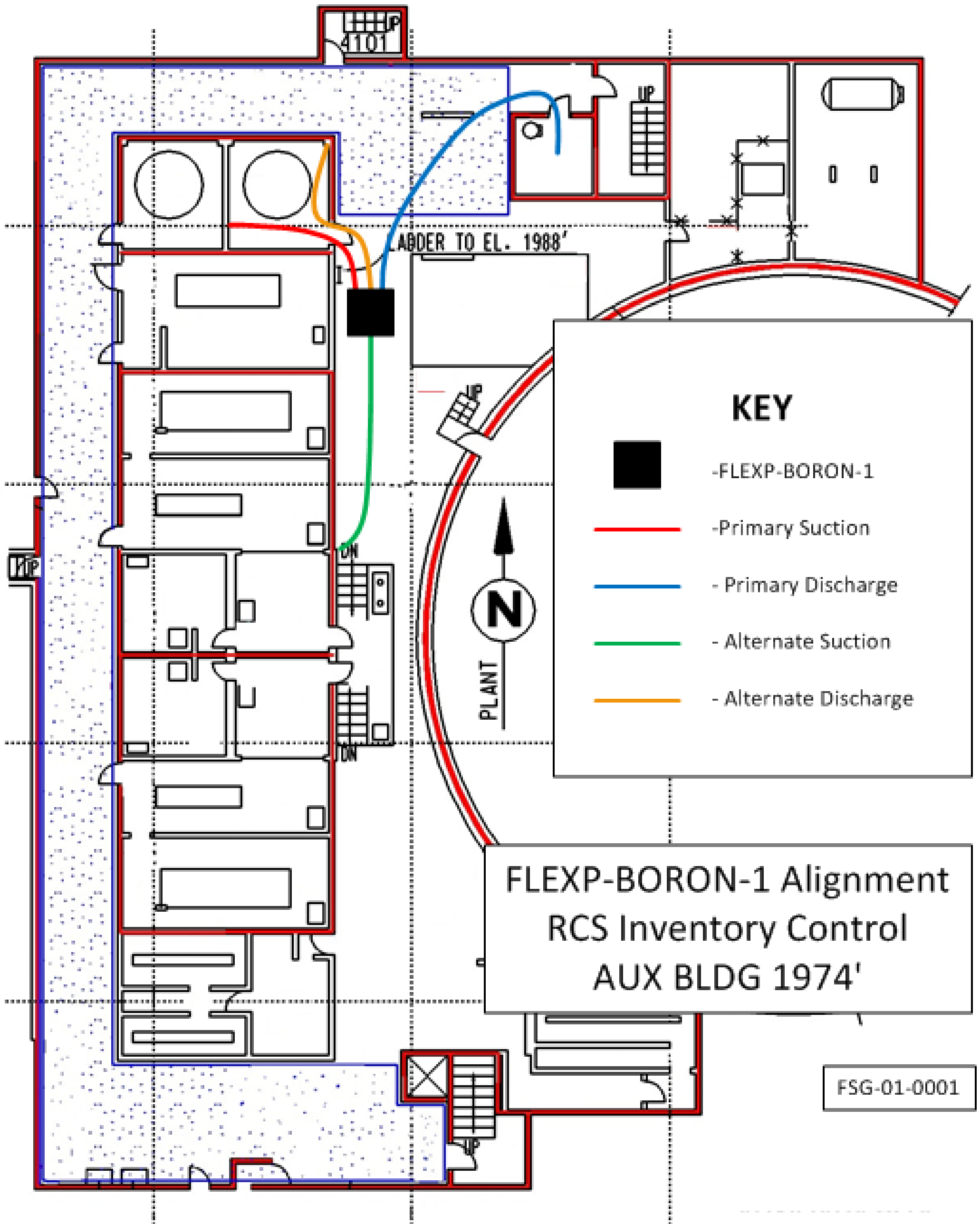


Figure 7: FLEX Boron Pump Hose Routing Primary Connection AB 2000' Elevation

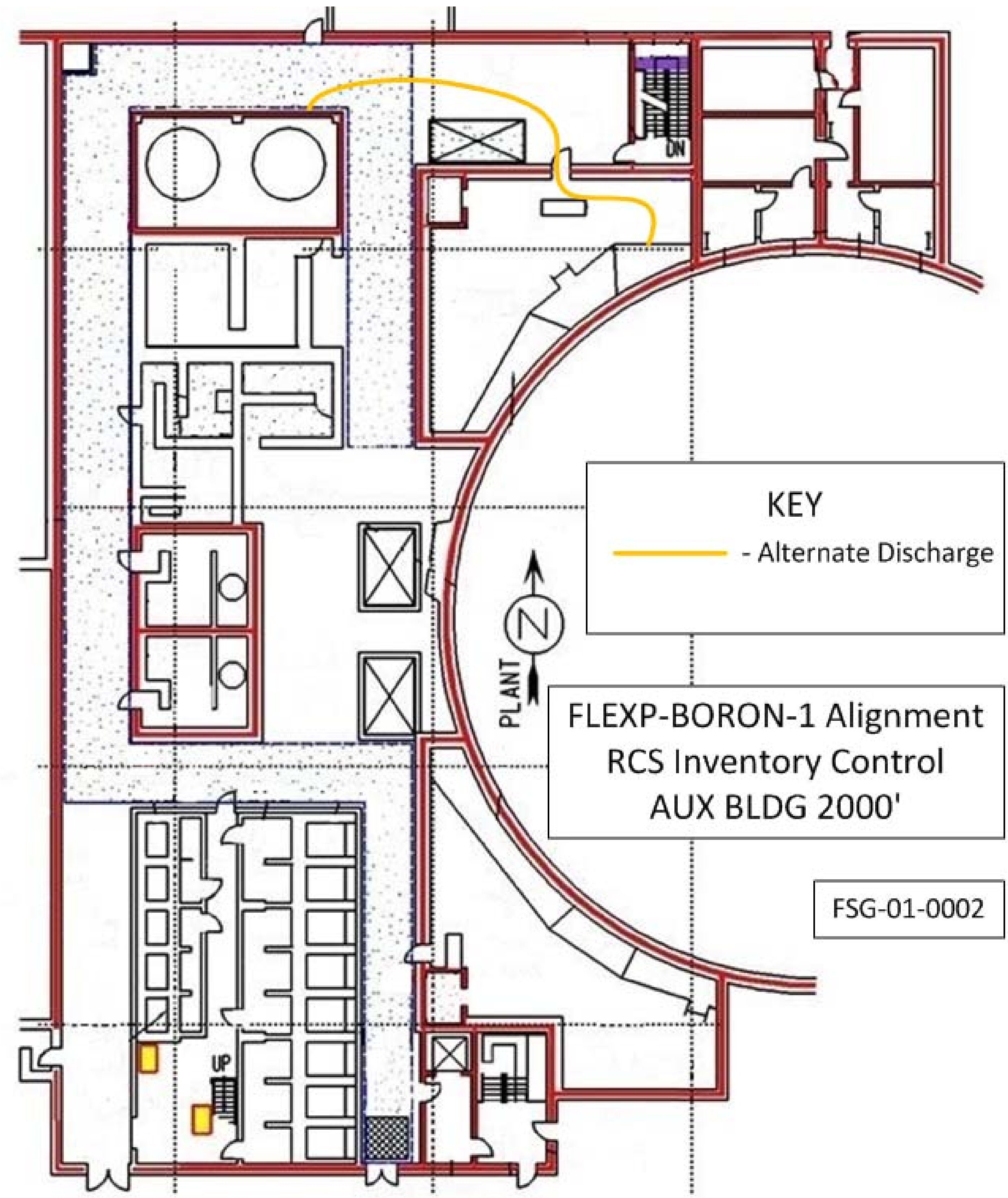


Figure 8: FLEX Boron Pump Hose Routing Alternate Connection AB 1974' Elevation

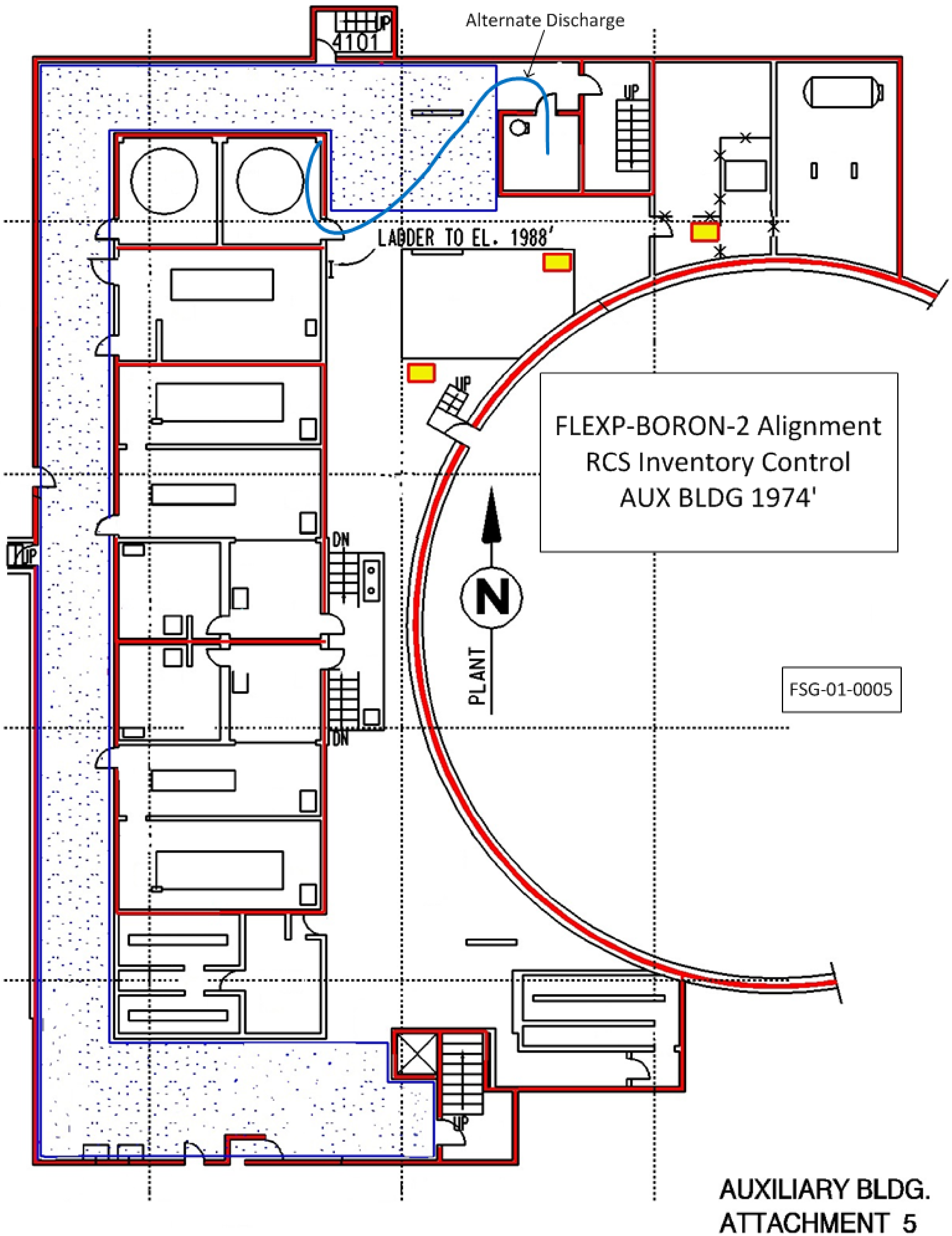


Figure 9: FLEX Boron Pump 2 Hose Routing

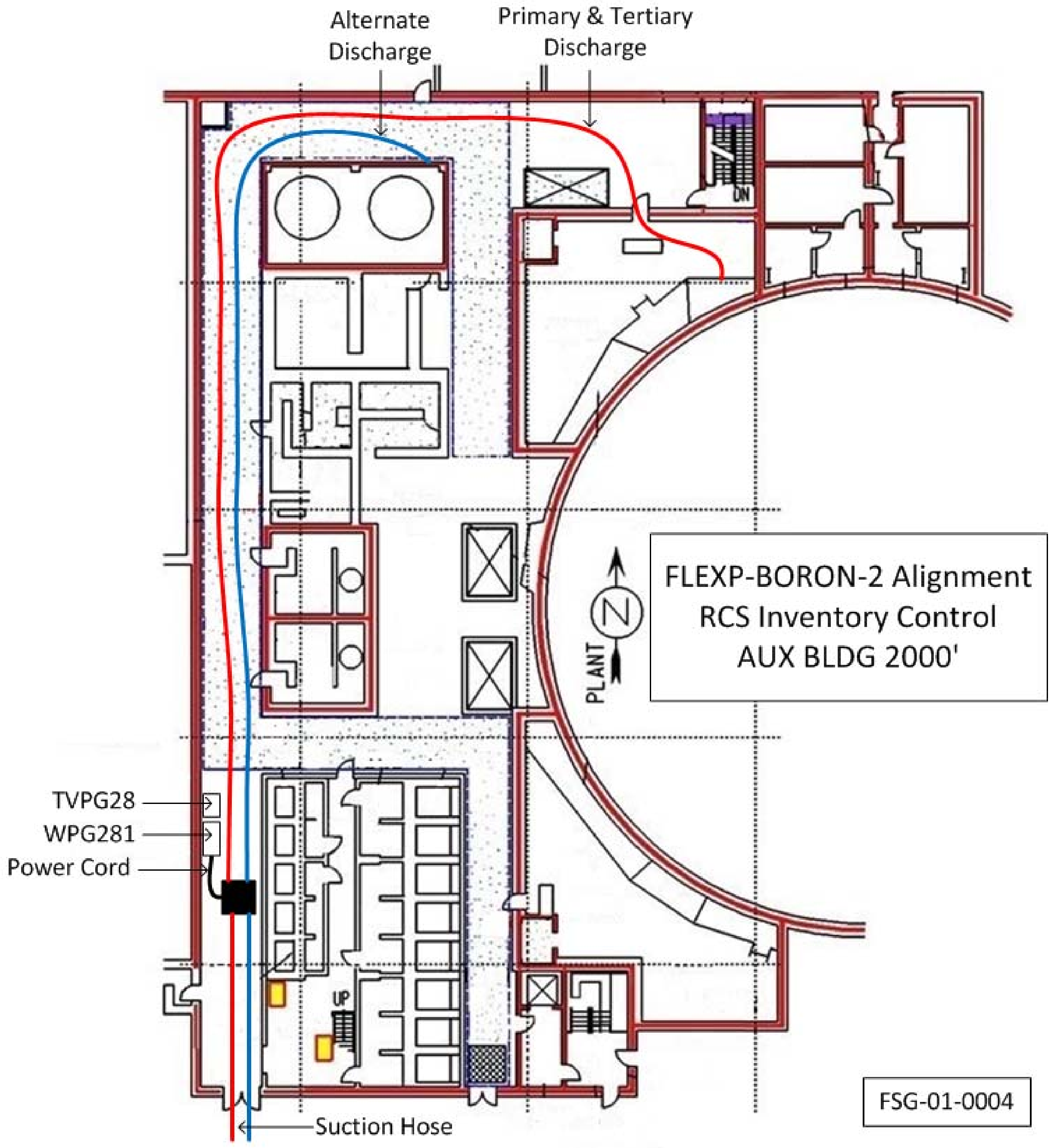


Figure 10: FLEX Boron Pump Hose Routing from RWST

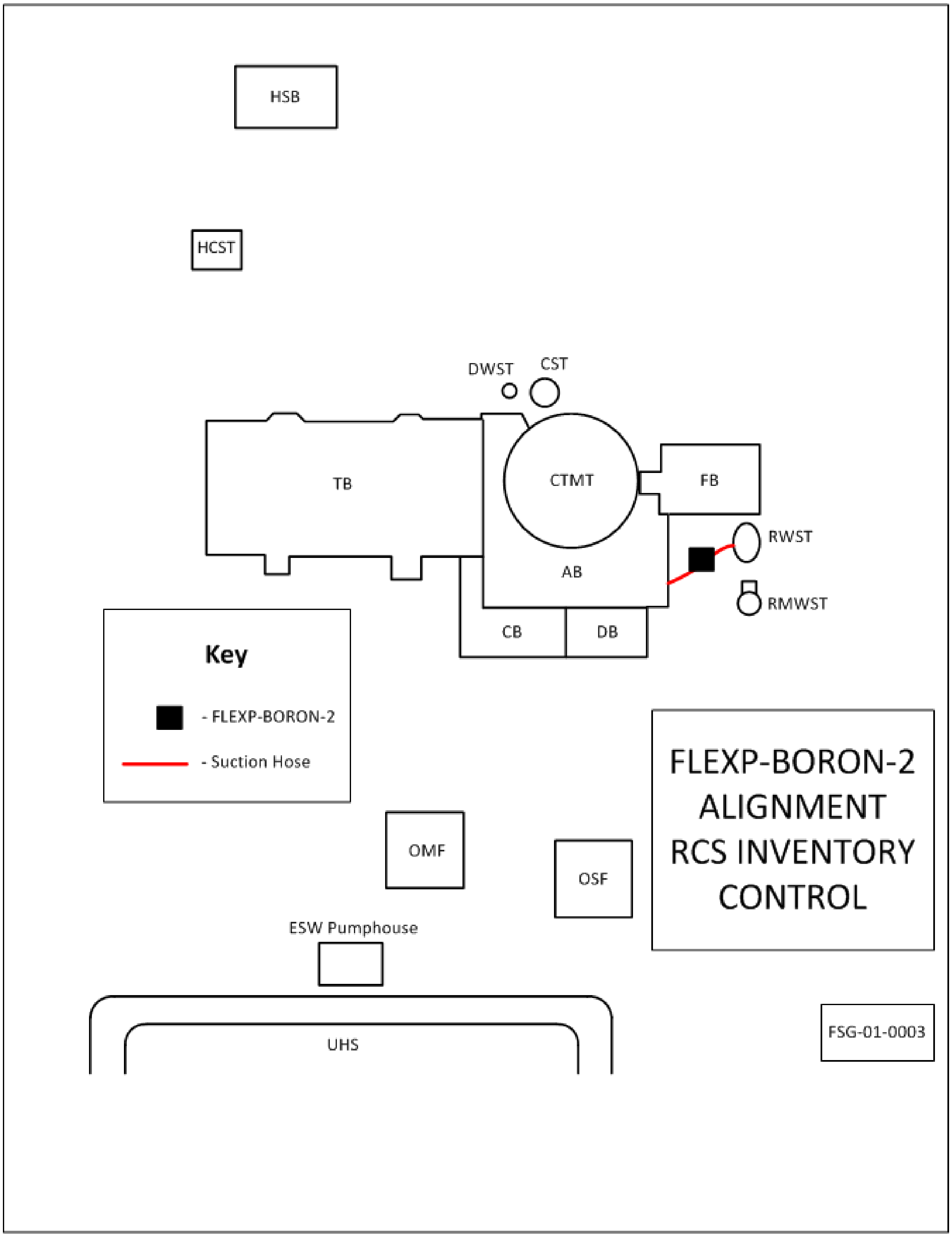


Figure 11: FLEX SFP Pump Hose Routing

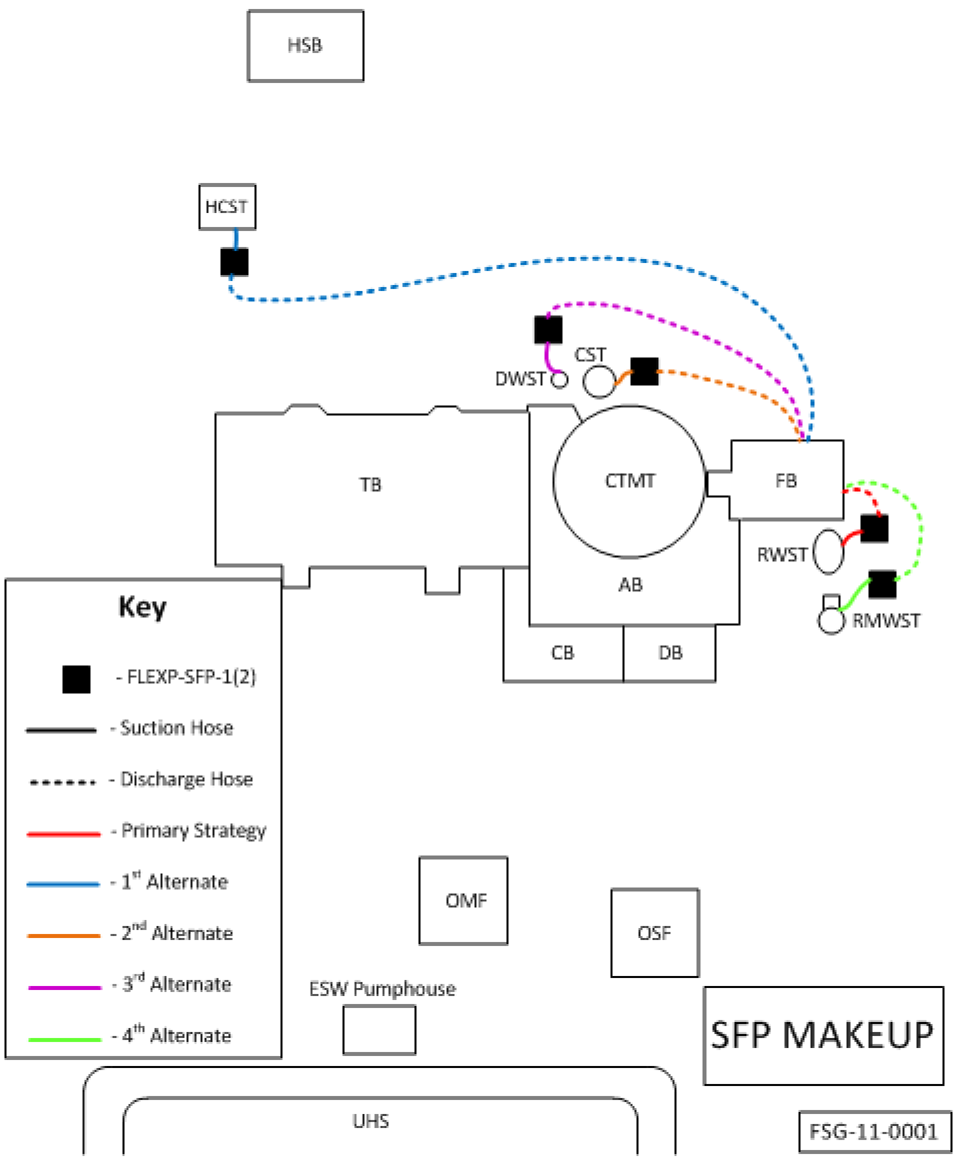


Figure 12: FLEX Pump Hose Routing and Fuel Building Connections

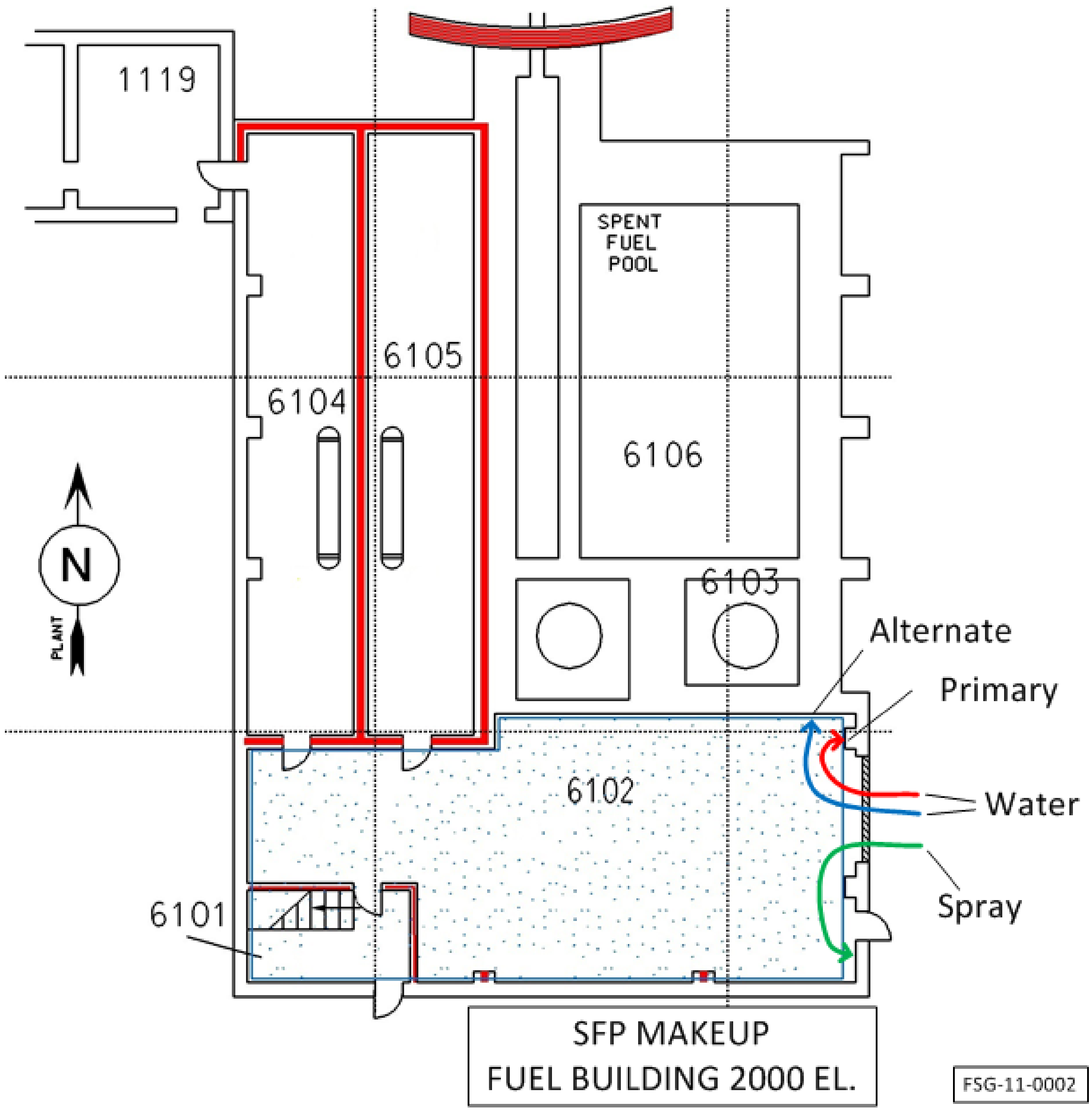


Figure 13: FLEX SFP Pump Hose Routing FB 2026' Elevation

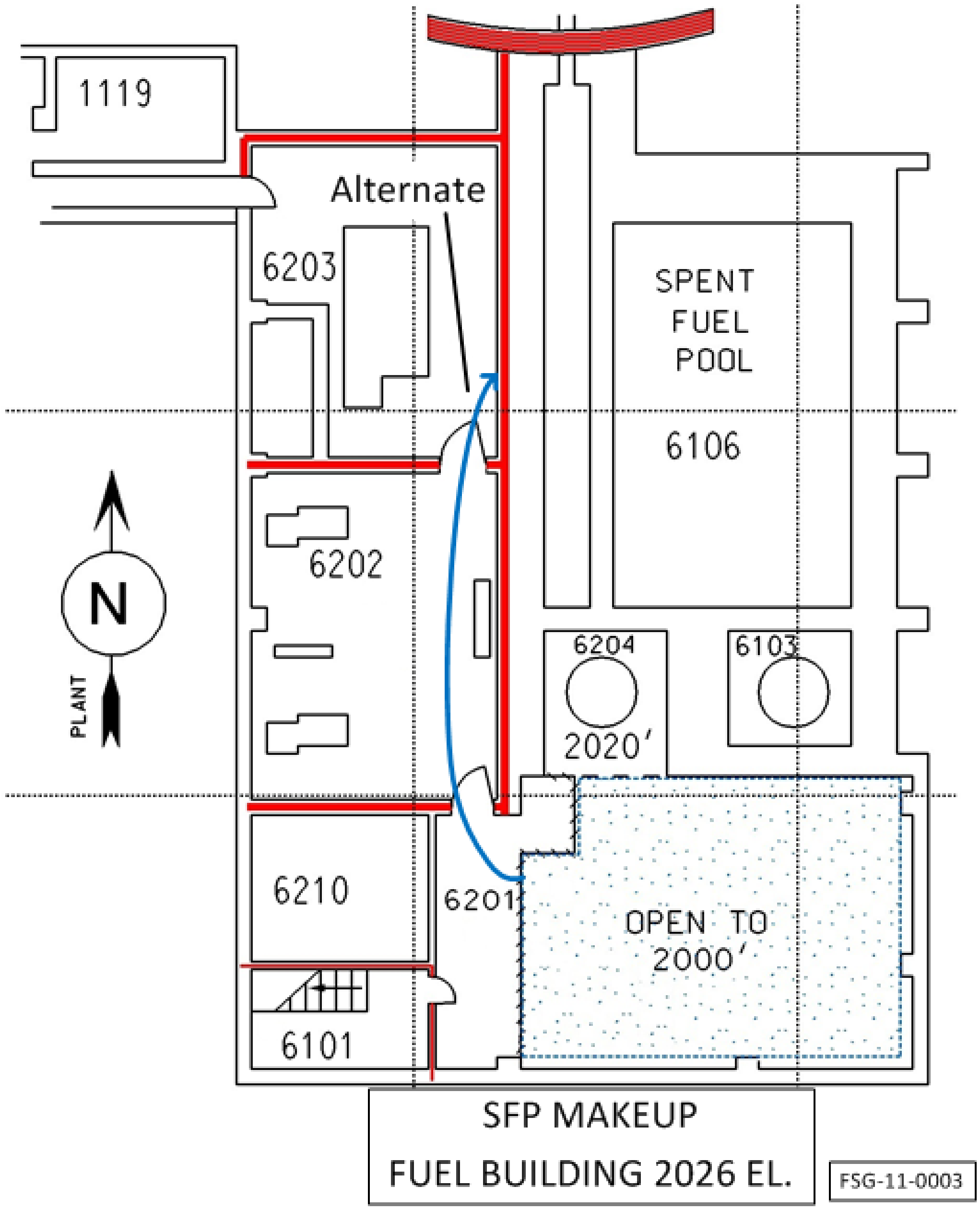


Figure 14: FLEX 480 VAC DG Deployment – Primary Strategy

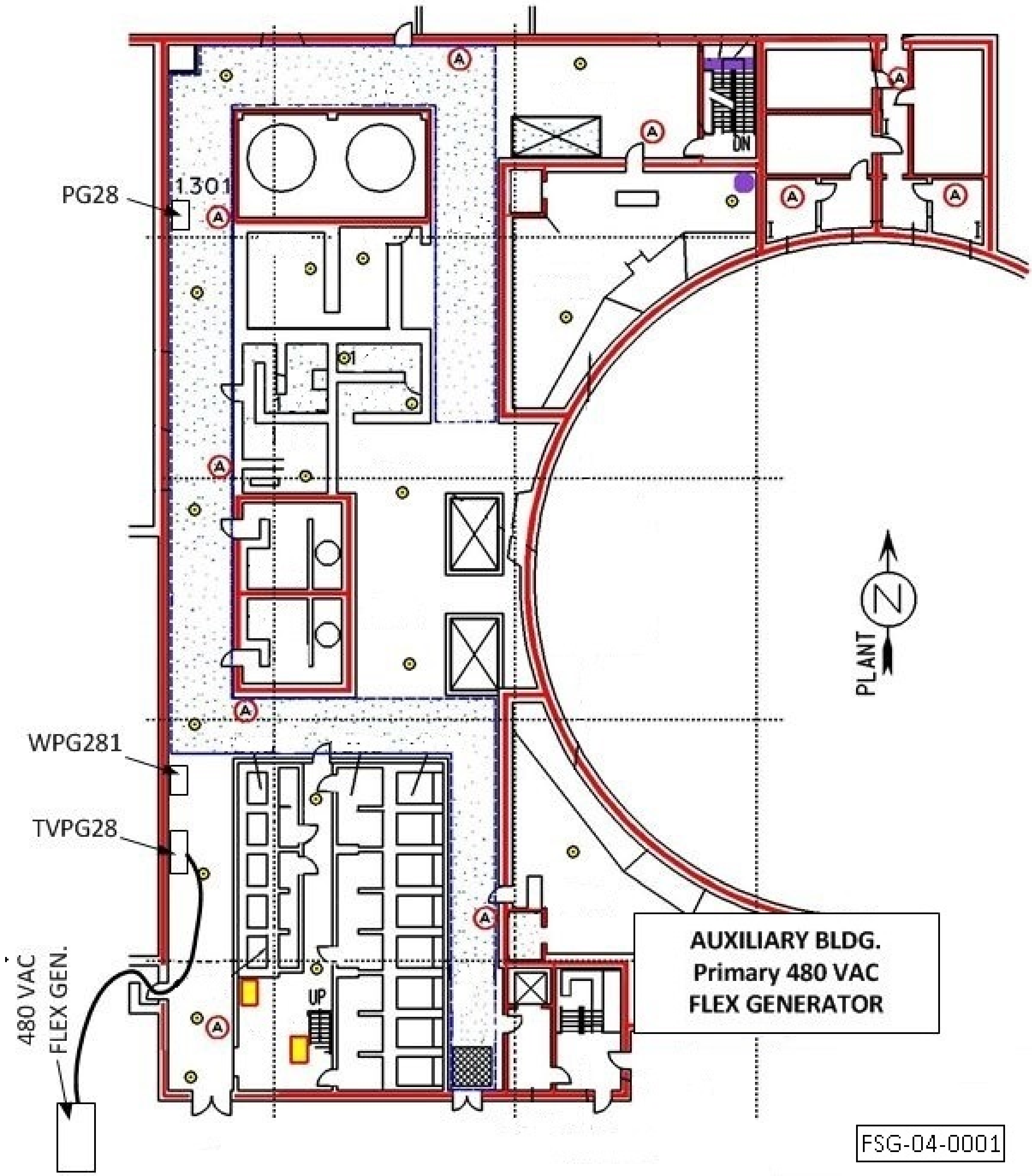


Figure 15: FLEX 480 VAC DG Deployment – Alternate Strategy

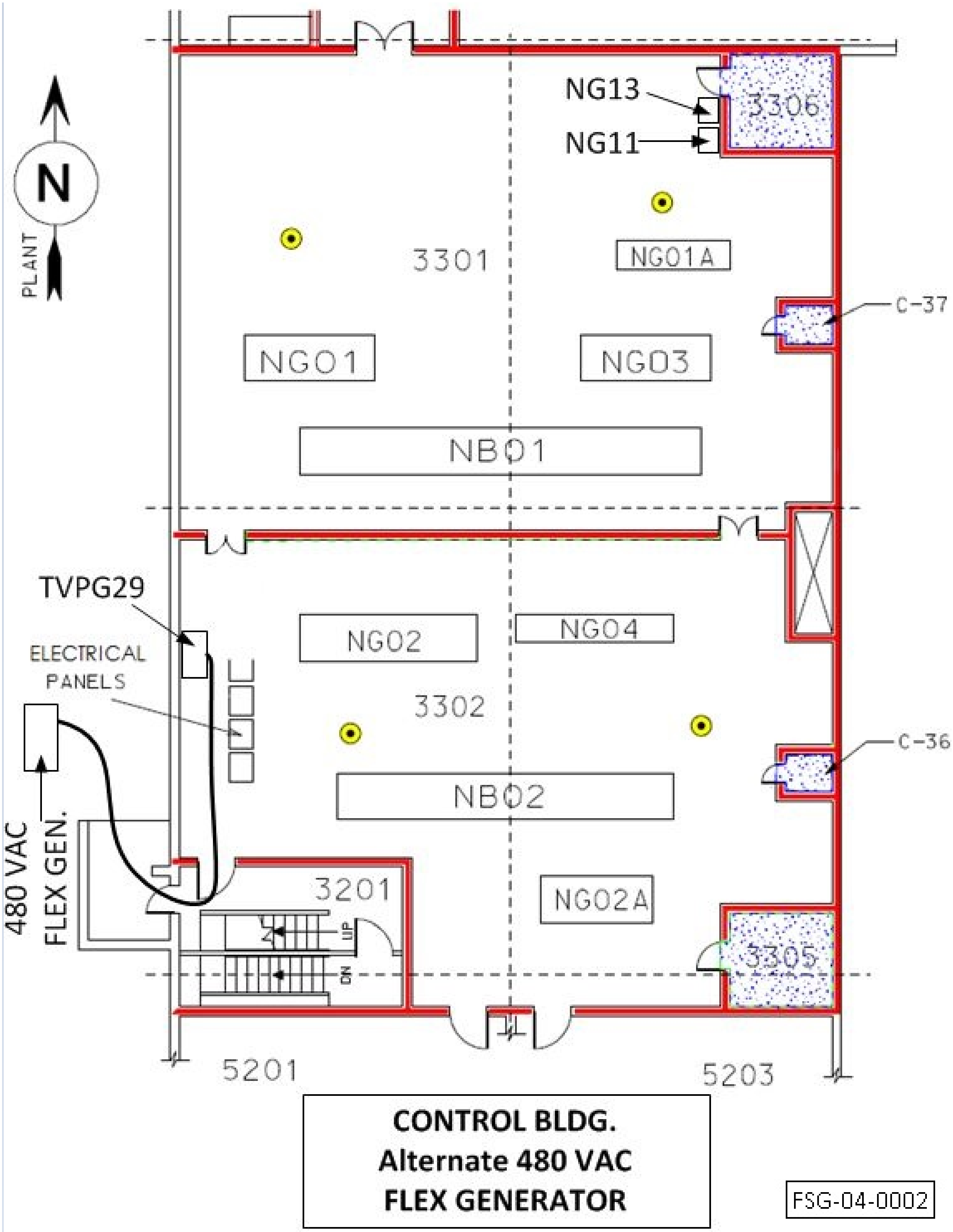


Figure 16: FLEX Electrical Schematic

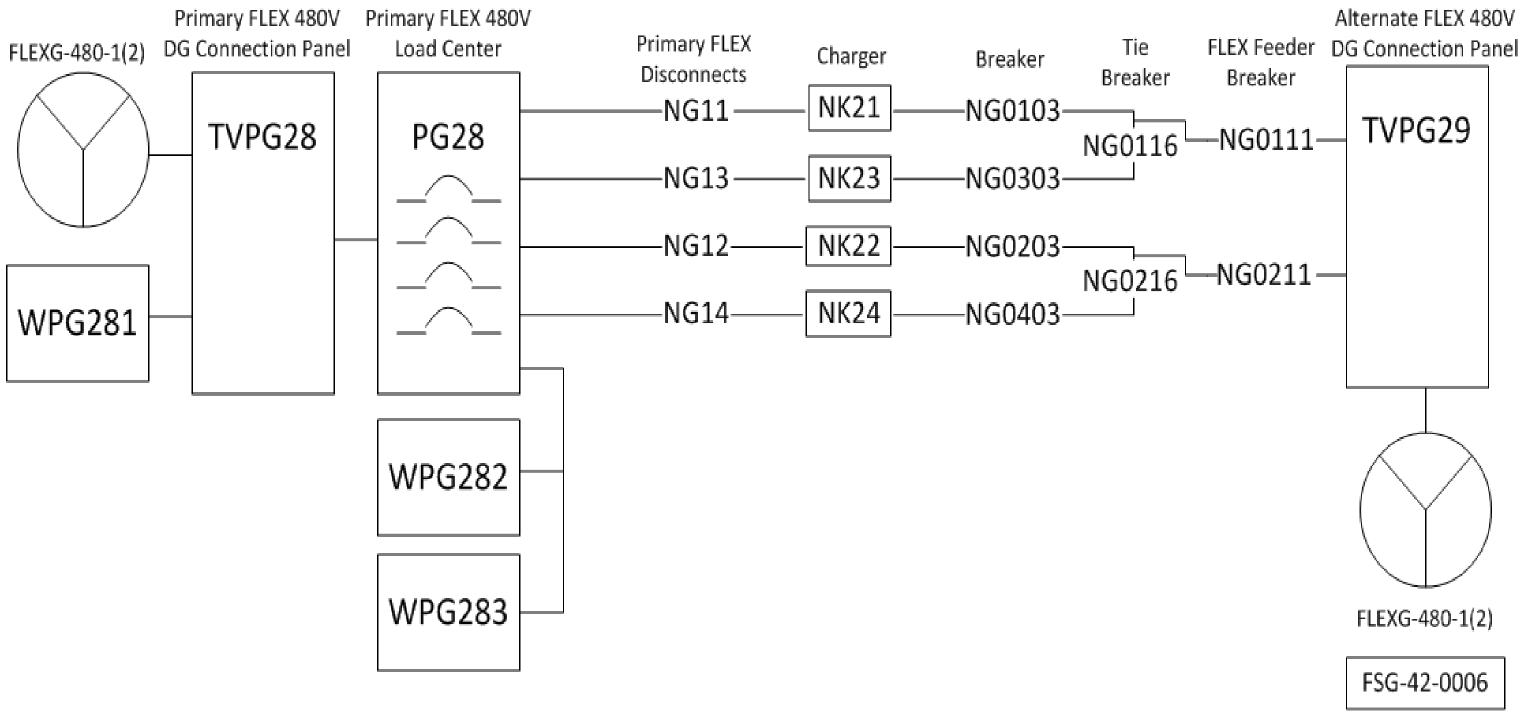


Figure 17: NSRC 4160 VAC Generators

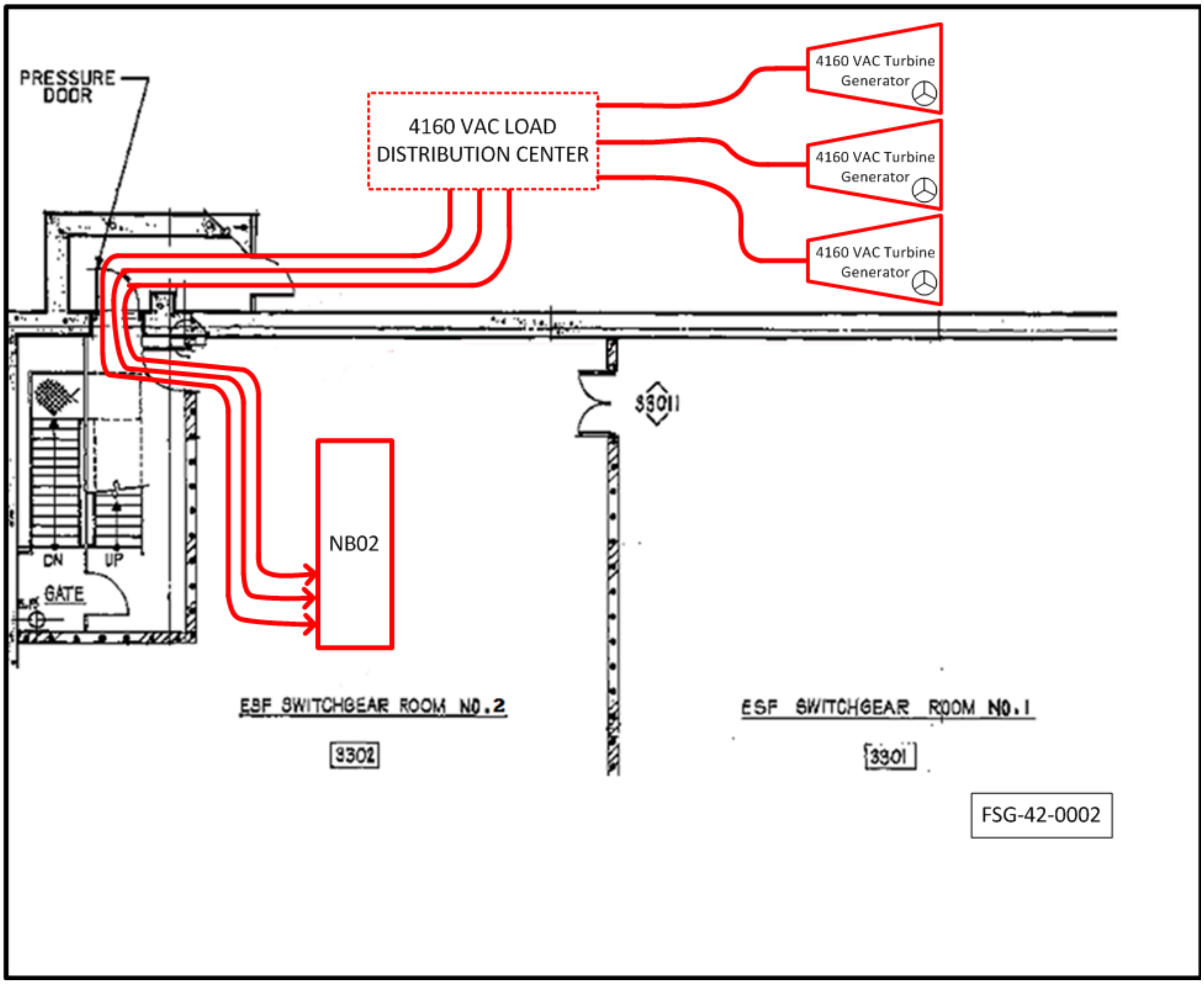
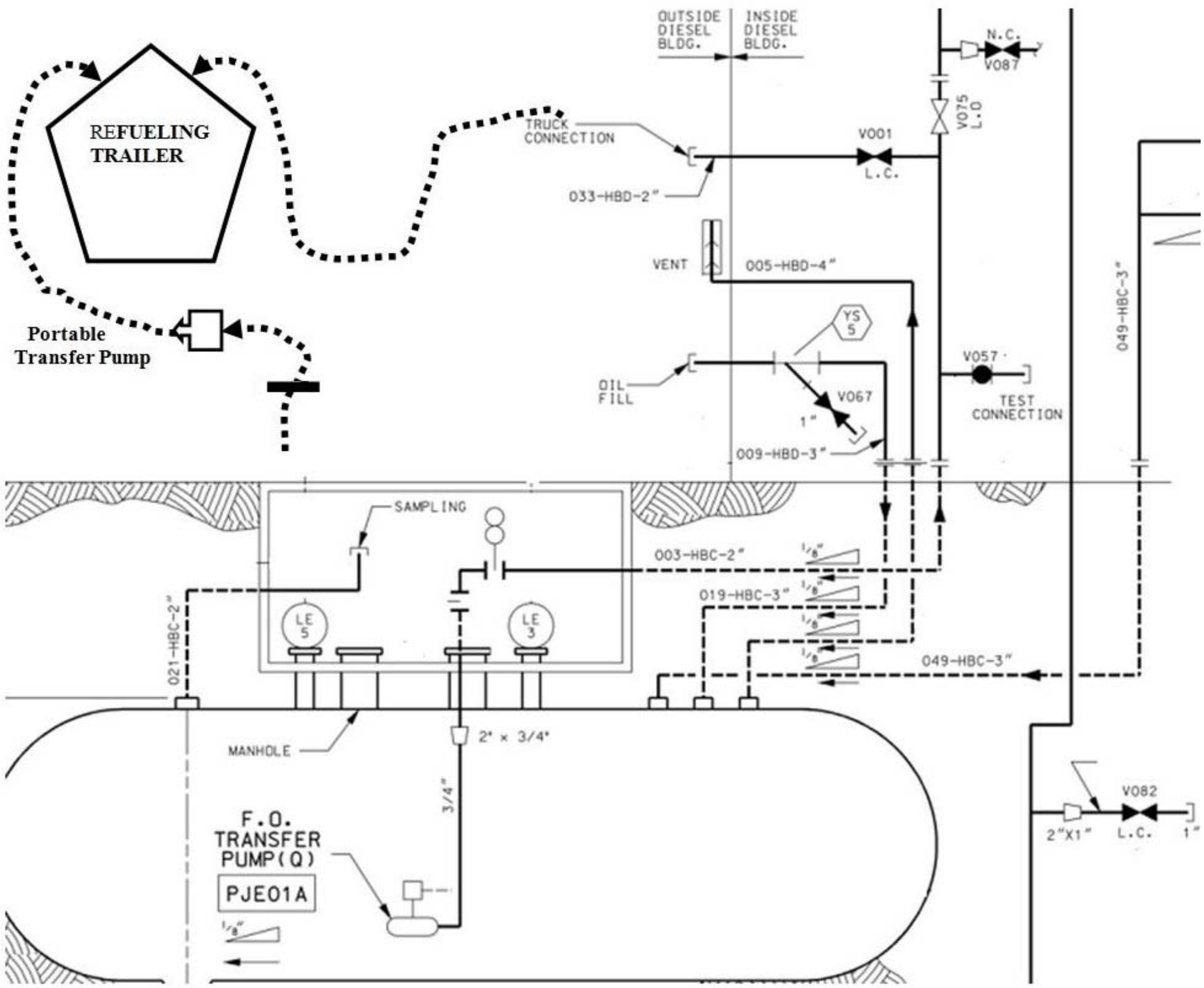


Figure 18: Emergency Fuel Oil Storage Tank A Supply (TJE01A)



FSG-44-0005

TJE01A arrangement is shown.

TJE01B arrangement is similar.

Figure 19: NSRC FLEX High Performance Booster Pump Skid Hose Routing

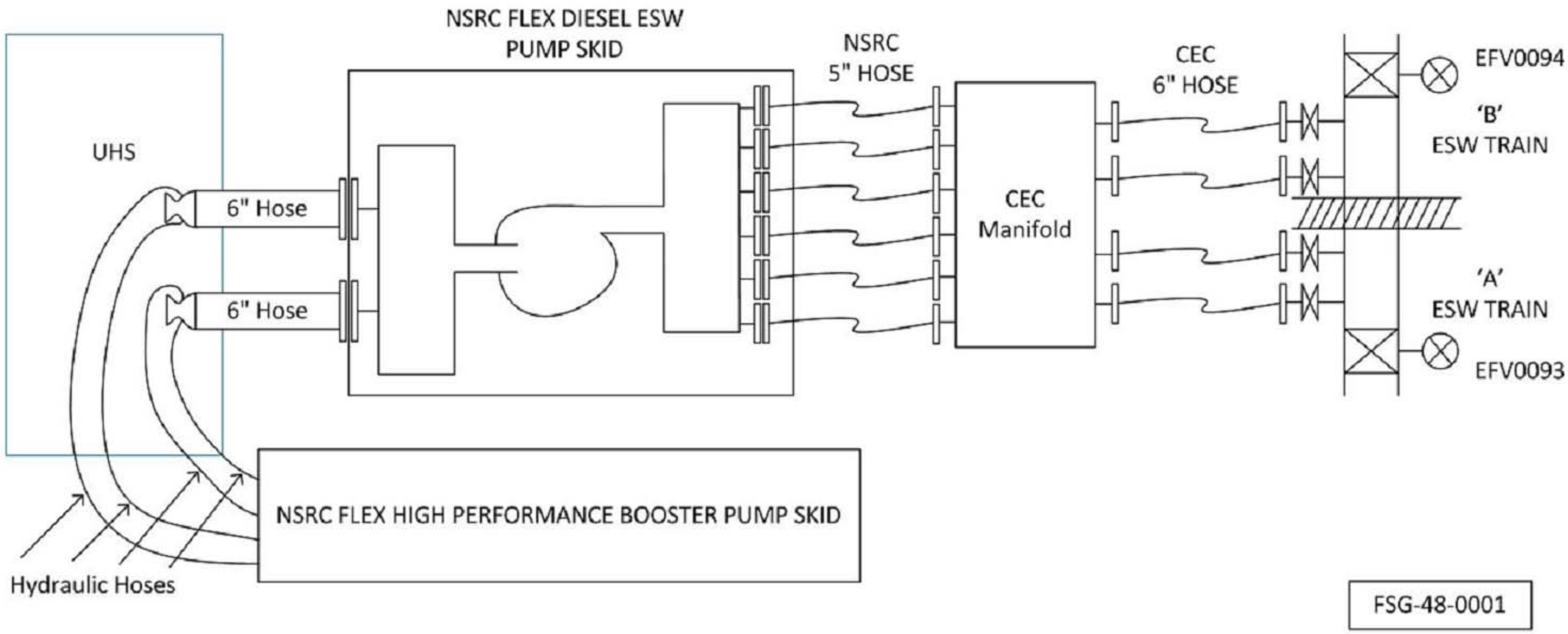


Figure 20: Class 1E 4160 VAC Bus Connection

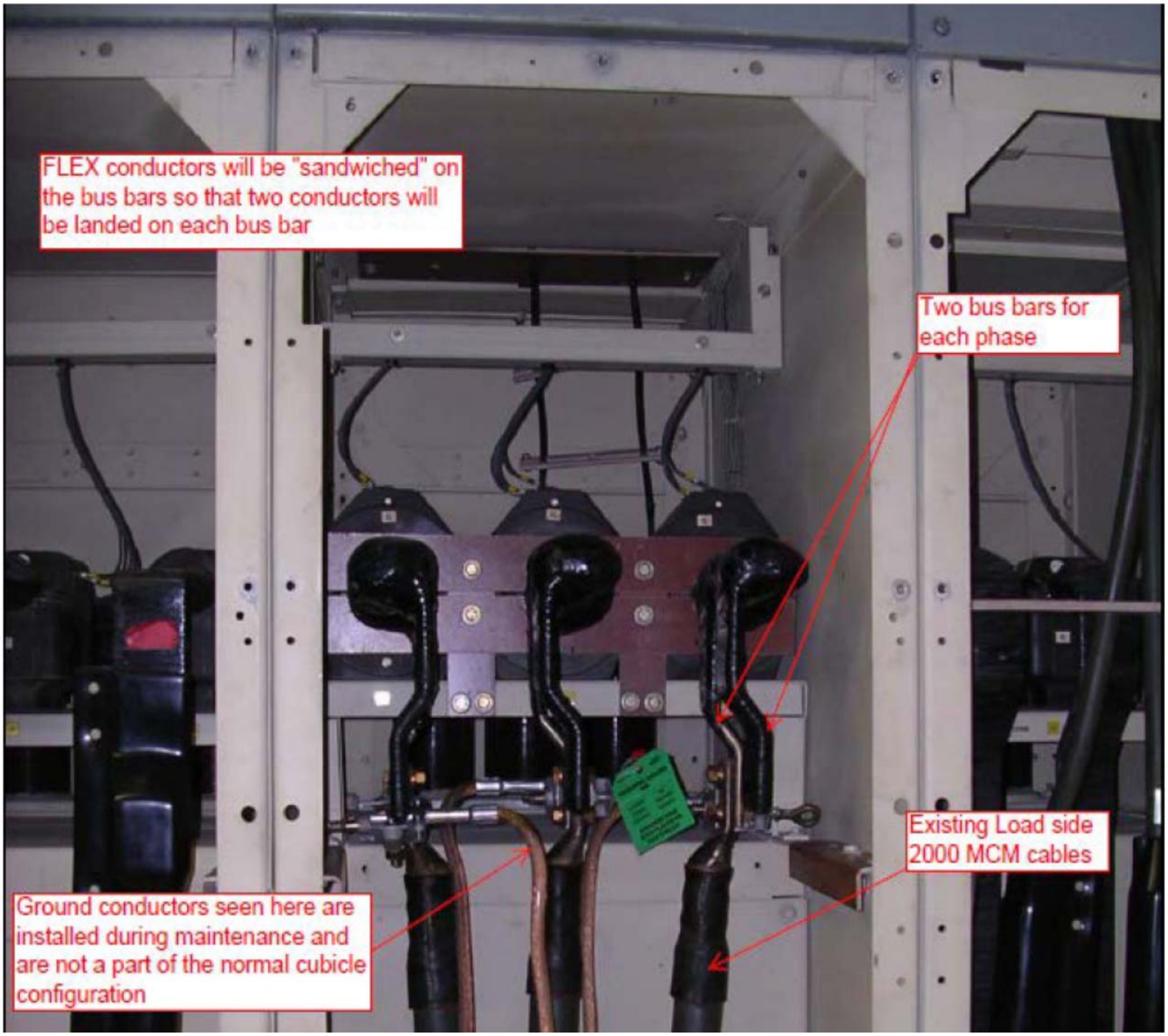


Figure 21: RCS Boration Modes 5 & 6 – RWST Available

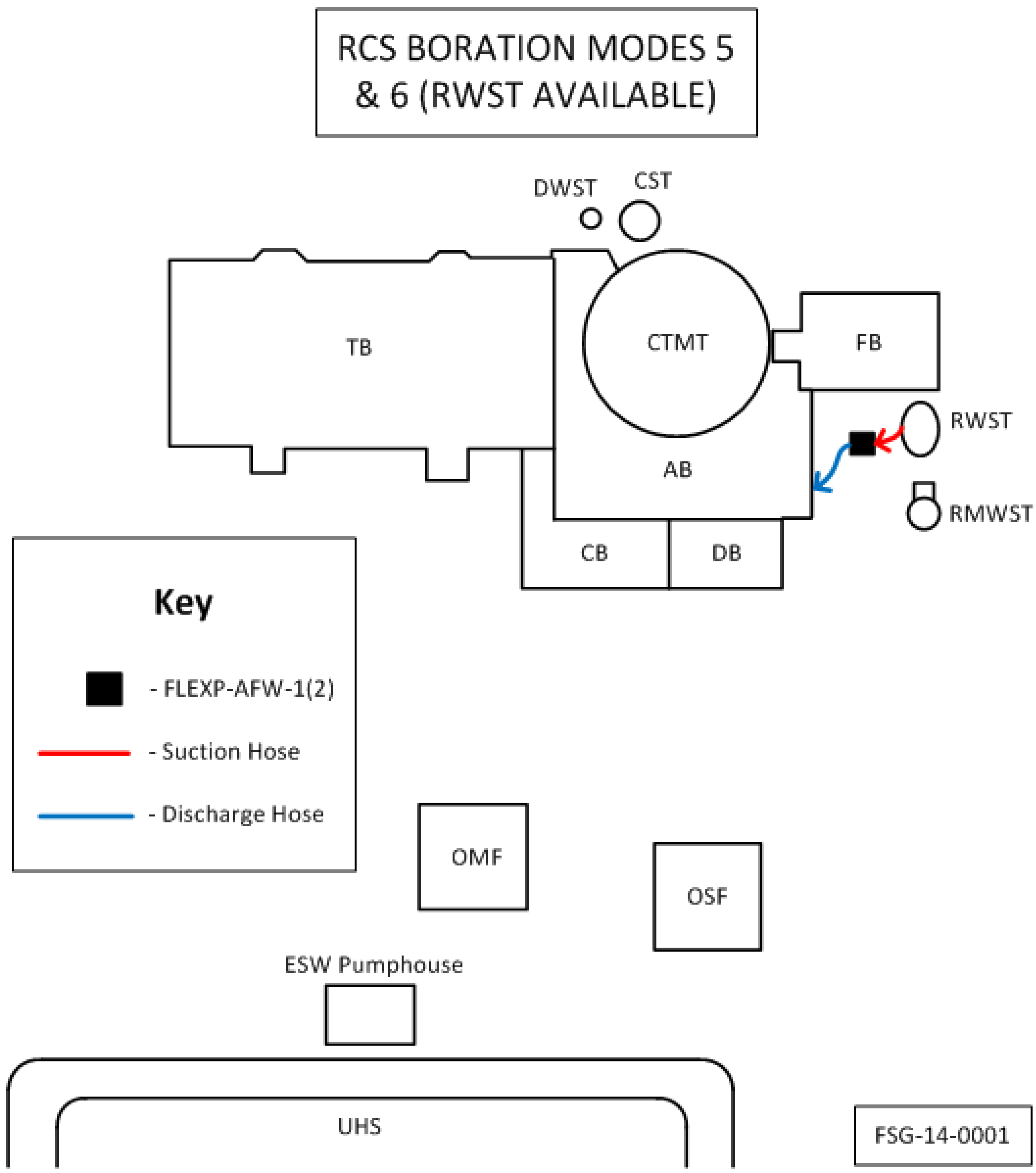


Figure 22: Primary & Alternate Boration Modes 5 & 6 RWST Available AB 2000' El.

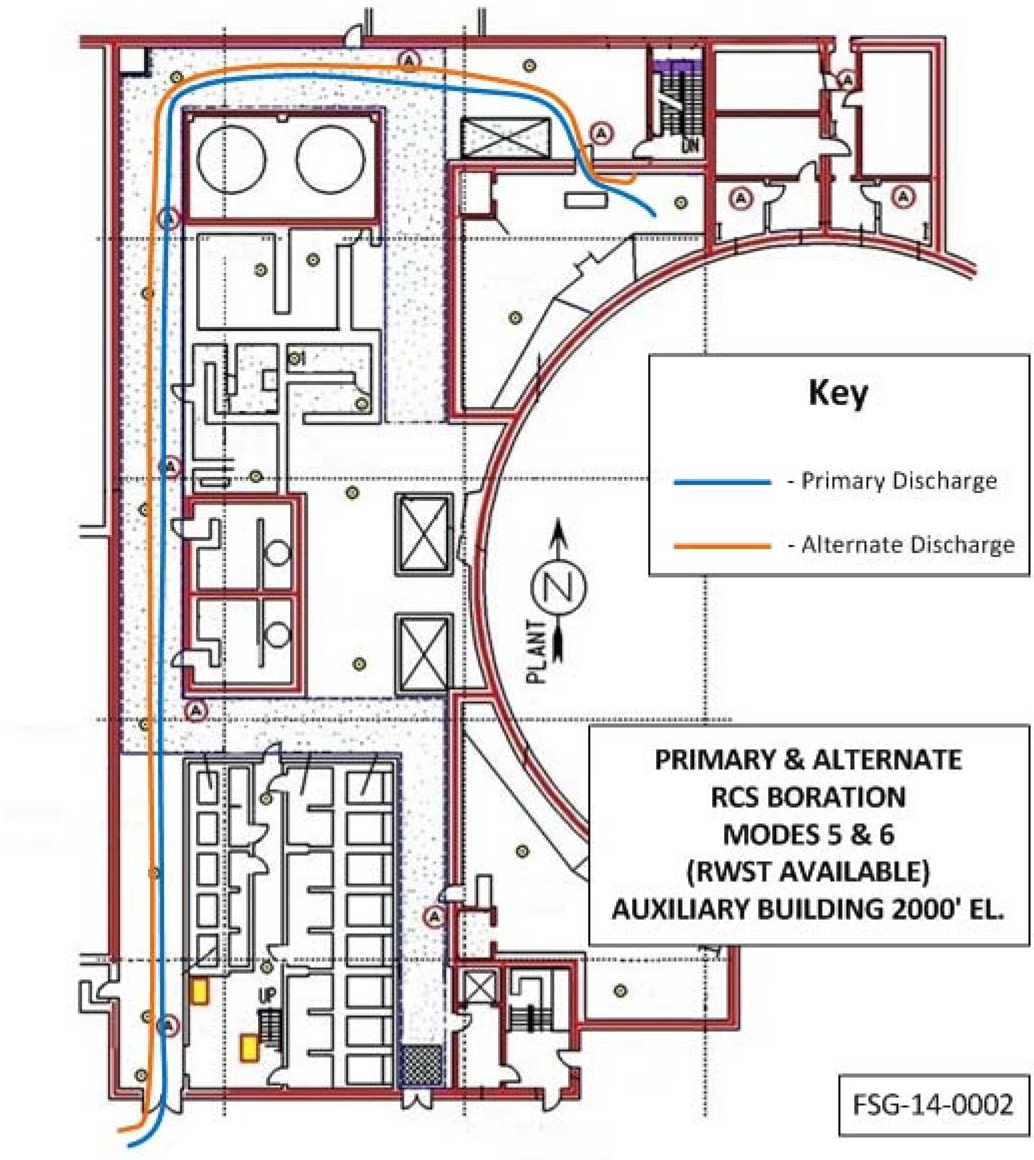


Figure 23: Primary & Alternate Boration Modes 5 & 6 RWST Available AB 1974' El.

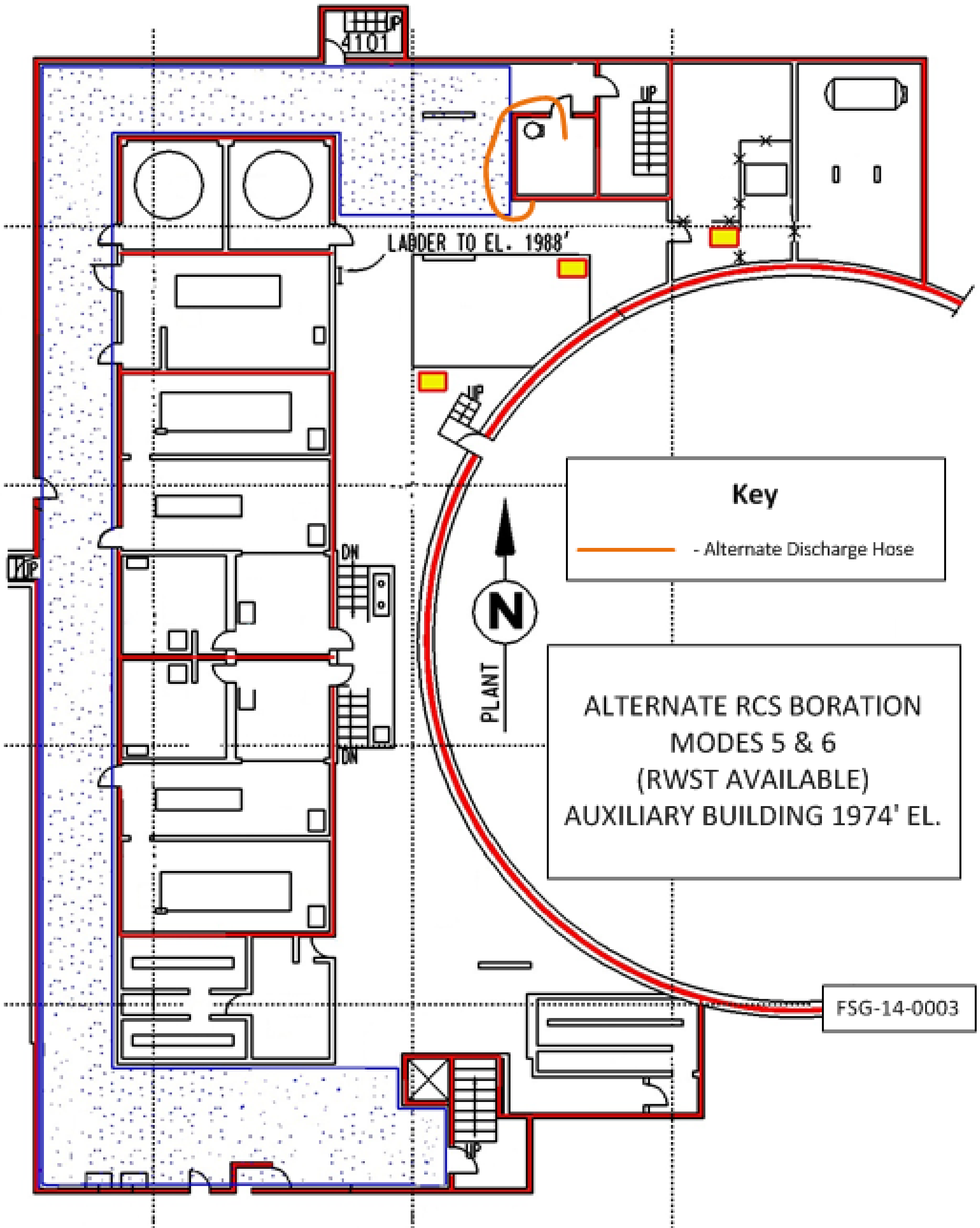


Figure 24: Blended Flow with BATs and HCST Modes 5 & 6 RWST Not Available

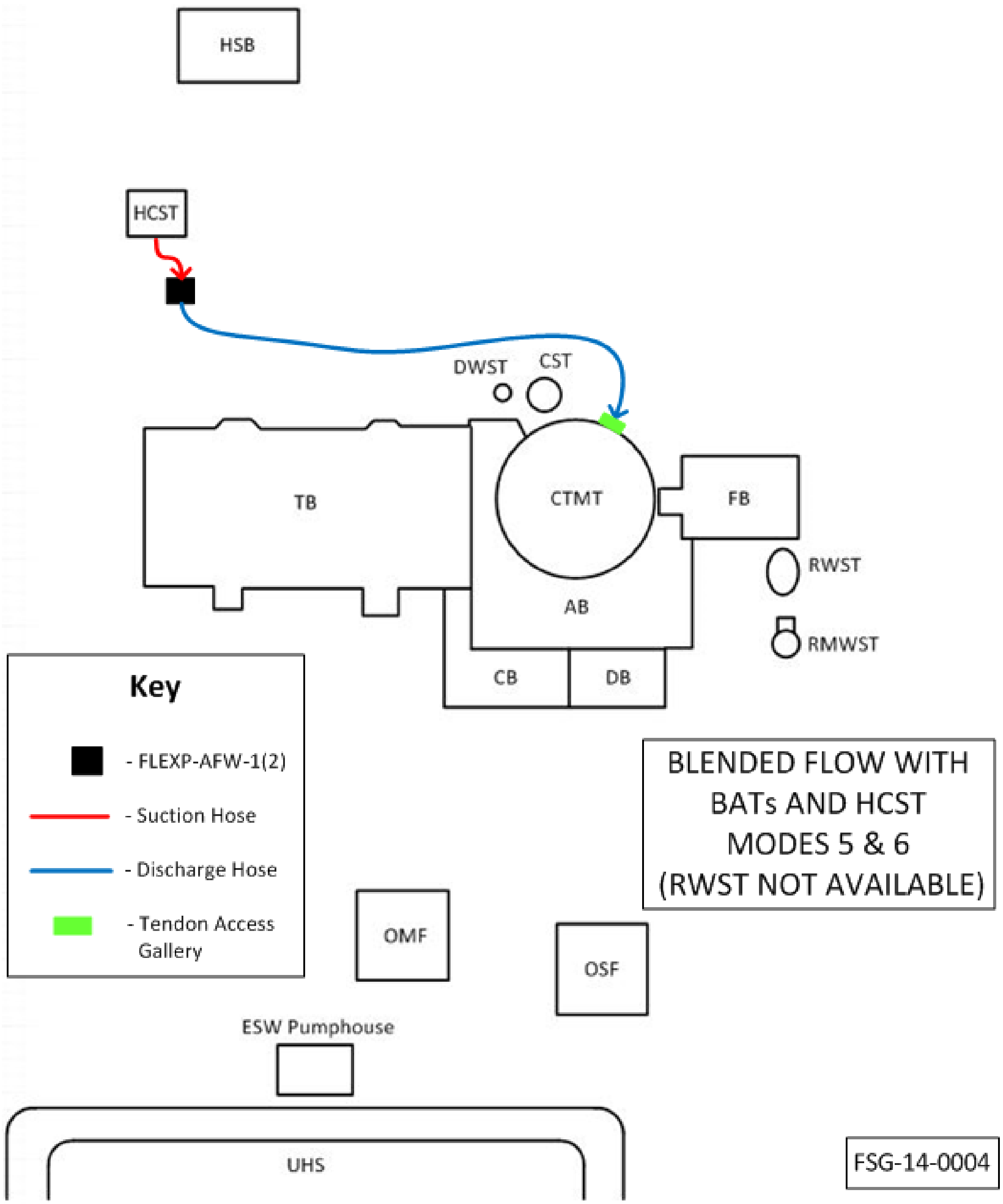


Figure 25: Blended Flow with BATs and HCST Modes 5 & 6 RWST Not Available AB 1974' El