Exelon Generation.

Order No. EA-12-049

RS-18-087

August 14, 2018

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

Quad Cities Nuclear Power Station, Units 1 and 2
Renewed Facility Operating License Nos. DPR-29 and DPR-30
NRC Docket Nos. 50-254 and 50-265

Subject: Report 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. NRC Order Number EA-12-049, "Issuance of Order to Modify Licenses with Regard to Requirements For Mitigation Strategies For Beyond-Design-Basis External Events," dated March 12, 2012
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 1, dated January 22, 2016
3. NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Revision 2, dated December 2015
4. Exelon Generation Company, LLC's 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 (Order Number EA-12-049), dated October 25, 2012
5. Exelon Generation Company, LLC Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049), dated February 28, 2013 (RS-13-025)
6. Exelon Generation Company, LLC 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 28, 2013 (RS-13-129)
7. Exelon Generation Company, LLC 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 28, 2014 (RS-14-015)

A151
NRR

8. Exelon Generation Company, LLC 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 (RS-14-213)
9. Exelon Generation Company, LLC 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 27, 2015 (RS-15-024)
10. Exelon Generation Company, LLC 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 28, 2015 (RS-15-215)
11. Exelon Generation Company, LLC 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 26, 2016 (RS-16-027)
12. Exelon Generation Company, LLC Seventh 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 26, 2016 (RS-16-150)
13. Exelon Generation Company, LLC Eighth 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 28, 2017 (RS-17-022)
14. Exelon Generation Company, LLC Ninth 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, 2017 (RS-17-097)
15. Exelon Generation Company, LLC Tenth 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 28, 2018 (RS-18-011)
16. NRC letter to Exelon Generation Company, LLC, Quad Cities Nuclear Power Station, Units 1 and 2 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049, (Mitigation Strategies) (TAC Nos. MF1048 and MF1049), dated November 22, 2013
17. NRC Letter, 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, dated March 12, 2012
18. Exelon Generation Company, LLC letter to USNRC, Response to March 12, 2012, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, Enclosure 5, Recommendation 9.3, Emergency Preparedness – Staffing, Requested Information Items 1, 2, and 6 - Phase 2 Staffing Assessment, dated November 3, 2014 (RS-14-280)

19. NRC letter to Exelon Generation Company, LLC, Quad Cities Nuclear Power Station, Units 1 and 2 – Report for the Onsite Audit Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051 (TAC Nos. MF1048, MF1049, MF1052, MF1053), dated June 25, 2015

On March 12, 2012, the Nuclear Regulatory Commission ("NRC" or "Commission") issued Order EA-12-049, "Order Modifying Licenses with Regard to Requirements For Mitigation Strategies For Beyond-Design-Basis External Events," (Reference 1) to Exelon Generation Company, LLC (EGC). Reference 1 was immediately effective and directed EGC 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 the final interim staff guidance (Reference 2) and an Overall Integrated Plan (OIP) pursuant to Section IV, Condition C. Reference 2 endorsed industry guidance document NEI 12-06, Revision 0 (Reference 3) with clarifications and exceptions identified in Reference 2. Reference 4 provided the EGC initial status report regarding mitigation strategies. Reference 5 provided the Quad Cities Nuclear Power Station, Units 1 and 2 OIP.

Reference 1 required submission of a status report at six-month intervals following submittal of the OIP. References 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15 provided the first, second, third, fourth, fifth, sixth, seventh, eighth, ninieth, and tenth six-month status reports, respectively, pursuant to Section IV, Condition C.2, of Reference 1 for Quad Cities Nuclear Power Station, Units 1 and 2.

The purpose of this letter is to provide the report of full compliance with the March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements For Mitigation Strategies For Beyond-Design-Basis External Events (Order Number EA-12-049) (Reference 1) pursuant to Section IV, Condition C.3 of the Order for Quad Cities Nuclear Power Station, Units 1 and 2.

Quad Cities Nuclear Power Station, Units 1 and 2 have developed, implemented, and will maintain the guidance and strategies to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities in the event of a beyond-design-basis external event in response to Order EA-12-049. The information provided herein documents full compliance for Quad Cities Nuclear Power Station, Units 1 and 2 with Reference 1.

OIP open items have been addressed and closed as documented in References 6, 8, 10, and 13 and are considered complete pending NRC closure. EGC's response to the NRC Interim Staff Evaluation (ISE) open and confirmatory items identified in Reference 16 have been addressed and closed as documented in References 7, 8, and 10, and are considered closed. EGC's response to the NRC audit questions and additional audit open items have been addressed and closed as documented in Reference 10, and are considered complete pending NRC closure. The following tables provide completion references for each OIP open item and NRC ISE open or confirmatory item, and NRC Audit Report open items.

Overall Integrated Plan Open Items

Section Reference	Overall Integrated Plan Open Item	Completion Response Reference
Sequence of Events (p.4)	The times to complete actions in the Events Timeline are based on operating judgment, conceptual designs, and current supporting analyses. The final timeline will be time validated once detailed designs are completed and procedures are developed, and the results will be provided in a future 6-month update.	Reference 10
Sequence of Events (p. 4, 5)	Issuance of BWROG document NEDC-33771P, "GEH Evaluation of FLEX Implementation Guidelines," on 01/31/2013 did not allow sufficient time to perform the analysis of the deviations between Exelon's engineering analyses and the analyses contained in the BWROG document prior to submittal of this Integrated Plan. This analysis is expected to be completed, documented on Attachment 1B, and provided to the NRC in the August 2013 Six-Month status update.	Reference 6
Sequence of Events (p. 6)	Additional work will be performed during detailed design development to ensure Suppression Pool temperature will support RCIC operation, in accordance with approved BWROG analysis, throughout the event.	Reference 8
Sequence of Events (p. 7)	Initial calculations were used to determine the fuel pool timelines. Formal calculations will be performed to validate this information during development of the Spent Fuel Pool Cooling strategy detailed designs, and will be provided in a future 6-month update.	Reference 8
Multiple Sections	Procedures and programs will be developed to address storage structure requirements, haul path requirements, and FLEX equipment requirements relative to the external hazards applicable to Quad Cities.	Reference 10
Programmatic Controls (p. 8)	Quad Cities Nuclear Power Station will implement an administrative program for FLEX to establish responsibilities, and testing and maintenance requirements.	Reference 10

Section Reference	Overall Integrated Plan Open Item	Completion Response Reference
Multiple Sections	Detailed designs based on the current conceptual designs will be developed to determine the final plan and associated mitigating strategies. Analysis will be performed to validate that the plant modifications, selected equipment, and identified mitigating strategy can satisfy the safety function requirements of NEI 12-06. Once these designs and mitigating strategies have been fully developed, Exelon will update the integrated plan for Quad Cities Nuclear Power Station during a scheduled 6-month update. This update will include any changes to the initial designs as submitted in this Integrated Plan.	Reference 13
Maintain Core Cooling Phase 1 (p.13)	Guidance will be provided to ensure that sufficient area is available for deployment and that haul paths remain accessible without interference from outage equipment during refueling outages.	Reference 10
Maintain Spent Fuel Pool Cooling Phase 1 (p.32)	Evaluation of the spent fuel pool area for steam and condensation has not yet been performed. The results of this evaluation and the vent path strategy, if needed, will be provided in a future 6-month update.	Reference 10
Safety Function Support (p. 42)	Habitability conditions will be evaluated and a strategy will be developed to maintain RCIC habitability.	Reference 10
Safety Function Support (p. 42)	Habitability conditions will be evaluated and a strategy will be developed to maintain Main Control Room habitability.	Reference 10
Safety Function Support (p. 43)	Battery Room Ventilation: Alternate ventilation will be provided to address Hydrogen generation and cold weather, as required.	Reference 10
Safety Function Support (p. 43)	Fuel Oil Supply to Portable Equipment: A detailed fuel oil supply plan will be developed.	Reference 10
Attachment 1A, Item 20 (p.59)	Provide alternate cooling to the RCIC rooms. Procedure to be developed.	Reference 10

Interim Staff Evaluation Open Items

Open Item	Completion Response Reference
Item No. 3.2.3.A	Reference 7
Item No. 3.2.4.6.A	Reference 10
Item No. 3.3.2.A	Reference 10
Item No. 3.4.B	Reference 7

Interim Staff Evaluation Confirmatory Items

Confirmatory Item	Completion Response Reference
Item No. 3.1.1.2.A	Reference 10
Item No. 3.1.1.2.B	Reference 10
Item No. 3.1.1.2.C	Reference 10
Item No. 3.1.1.3.A	Reference 10
Item No. 3.1.1.3.B	Reference 8
Item No. 3.1.2.2.A	Reference 10
Item No. 3.1.3.2.A	Reference 10
Item No. 3.1.3.2.B	Reference 10
Item No. 3.2.1.1.A	Reference 8
Item No. 3.2.1.1.B	Reference 8
Item No. 3.2.1.1.C	Reference 8
Item No. 3.2.1.1.D	Reference 8
Item No. 3.2.1.1.E	Reference 8
Item No. 3.2.1.2.A	Reference 10
Item No. 3.2.1.3.A	Reference 10
Item No. 3.2.1.3.B	Reference 10
Item No. 3.2.1.3.C	Reference 7
Item No. 3.2.1.4.A	Reference 10
Item No. 3.2.1.4.B	Reference 10
Item No. 3.2.1.4.C	Reference 10
Item No. 3.2.1.6.A	Reference 10
Item No. 3.2.2.A	Reference 10
Item No. 3.2.4.2.A	Reference 8
Item No. 3.2.4.2.B	Reference 8
Item No. 3.2.4.4.A	Reference 10
Item No. 3.2.4.4.B	Reference 10
Item No. 3.2.4.5.A	Reference 10
Item No. 3.2.4.6.B	Reference 7
Item No. 3.2.4.6.C	Reference 10
Item No. 3.2.4.8.A	Reference 10
Item No. 3.2.4.9.A	Reference 10
Item No. 3.2.4.10.A	Reference 10
Item No. 3.4.A	Reference 10

NRC Audit Report Open Items

Audit Open Item	Completion Response Reference
ISE CI 3.1.1.2.B	Reference 10
AQ 28-B	Reference 10
AQ 49-B, SE 3-E	Reference 10
SE 9-E	Reference 10
SE 10-E	Reference 10

MILESTONE SCHEDULE – ITEMS COMPLETE

Milestone	Completion Date
Submit 60 Day Status Report	October 25, 2012
Submit Overall Integrated Plan	February 28, 2013
Contract with National SAFER Response Center	November 29, 2012
Submit 6 Month Updates:	
Update 1	August 28, 2013
Update 2	February 28, 2014
Update 3	August 28, 2014
Update 4	February 27, 2015
Update 5	August 28, 2015
Update 6	February 26, 2016
Update 7	August 26, 2016
Update 8	February 28, 2017
Update 9	August 28, 2017
Update 10	February 28, 2018
Modification Development:	
Phases 1 and 2 modifications	March 2015
National SAFER Response Center Operational	December 2014
Procedure Development:	
Strategy procedures	March 2015
Validate Procedures (NEI 12-06, Sect. 11.4.3)	March 2015
Maintenance procedures	March 2015
Staffing analysis	November 2014
Modification Implementation:	
Phases 1 and 2 modifications	April 2016
Storage plan and construction	April 2016
FLEX equipment acquisition	March 2015
Training completion	March 2015
Unit 1 implementation date	June 15, 2018
Unit 2 implementation date	June 15, 2018

ORDER EA-12-049 COMPLIANCE ELEMENTS SUMMARY

The elements identified below for Quad Cities Nuclear Power Station, Units 1 and 2 as well as the site OIP response submittal (Reference 5), the 6-Month Status Reports (References 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15), and any additional docketed correspondence, demonstrate compliance with Order EA-12-049.

Strategies - Complete

Quad Cities Nuclear Power Station, Units 1 and 2 strategies are in compliance with Order EA-12-049. There are no strategy related Open Items, Confirmatory Items, or Audit Questions/Audit Report Open Items. The Quad Cities Nuclear Power Station, Units 1 and 2 Final Integrated Plan for mitigating strategies is provided in the enclosure to this letter.

Modifications - Complete

The modifications required to support the FLEX strategies for Quad Cities Nuclear Power Station, Units 1 and 2 have been fully implemented in accordance with the station design control process.

Equipment – Procured and Maintenance & Testing – Complete

The equipment required to implement the FLEX strategies for Quad Cities Nuclear Power Station, Units 1 and 2 has been procured in accordance with NEI 12-06, Sections 11.1 and 11.2, and has been received at Quad Cities Nuclear Power Station, Units 1 and 2; and initially tested/performance verified as identified in NEI 12-06, Section 11.5, and is available for use.

Periodic maintenance and testing will be conducted through the use of the Quad Cities Nuclear Power Station, Units 1 and 2 Preventative Maintenance program such that equipment reliability is achieved.

Protected Storage – Complete

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

Procedures – Complete

FLEX Support Guidelines (FSGs) for Quad Cities Nuclear Power Station, Units 1 and 2 have been developed and integrated with existing procedures. The FSGs and affected existing procedures have been verified and are available for use in accordance with the site procedure control program.

Training – Complete

Training for Quad Cities Nuclear Power Station, Units 1 and 2 has been completed in accordance with an accepted training process as recommended in NEI 12-06, Section 11.6.

Staffing – Complete

The Phase 2 staffing study for Quad Cities Nuclear Power Station, Units 1 and 2 has been completed in accordance with 10CFR50.54(f), "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," Recommendation 9.3, dated March 12, 2012 (Reference 17), as documented in Reference 18.

National SAFER Response Center – Complete

EGC 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 Quad Cities Nuclear Power Station, Units 1 and 2 with Phase 3 equipment stored in the National SAFER Response Centers in accordance with the site specific SAFER Response Plan.

Validation – Complete

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

FLEX Program Document - Established

The Quad Cities Nuclear Power Station, Units 1 and 2 FLEX Program Document has been developed in accordance with the requirements of NEI 12-06.

This letter contains no new regulatory commitments. If you have any questions regarding this report, please contact David J. Distel at 610-765-5517.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 14th day of August 2018.

Respectfully submitted,

Patrick R. Simpson
Manager - Licensing & Regulatory Affairs
Exelon Generation Company, LLC

Enclosure: Quad Cities Nuclear Power Station, Units 1 and 2 Final Integrated Plan Document – Mitigation Strategies for a Beyond-Design-Basis Event (NRC Order EA-12-049)

cc: Director, Office of Nuclear Reactor Regulation
NRC Regional Administrator - Region III
NRC Senior Resident Inspector – Quad Cities Nuclear Power Station
NRC Project Manager, NRR – Quad Cities Nuclear Power Station
Mr. Peter J. Bamford, NRR/JLD/JOMB, NRC
Mr. John P. Boska, NRR/JLD/JOMB, NRC
Illinois Emergency Management Agency – Division of Nuclear Safety

Enclosure

Quad Cities Nuclear Power Station, Units 1 and 2

Final Integrated Plan Document – Mitigation Strategies for a Beyond-Design-Basis External Event (NRC Order EA-12-049)

(110 pages)

Exelon Generation®

QUAD CITIES
NUCLEAR POWER STATION
UNITS 1 and 2

FINAL INTEGRATED PLAN DOCUMENT

MITIGATING STRATEGIES
NRC ORDER EA-12-049

August 14, 2018

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 & 2 and after some period of time on 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 contained many recommendations to fulfill this charter, including assessing extreme external event hazards and strengthening station capabilities for responding to beyond-design-basis external events (BDBEEs).

Based on NTTF Recommendation 4.2, the NRC issued Order EA-12-049 (Reference 1) on March 12, 2012 to implement mitigation strategies for BDBEEs. The Order provided the following requirements for strategies to mitigate BDBEEs:

1. Licensees shall develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and Spent Fuel Pool (SFP) cooling capabilities following a BDBEE.

2. These strategies must be capable of mitigating a simultaneous loss of all AC power and loss of normal access to the ultimate heat sink (LUHS) 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 - Initially cope relying on installed equipment and on-site resources.
- Phase 2 - Transition from installed plant equipment to on-site BDB equipment
- Phase 3 - Obtain additional capability and redundancy from off-site equipment and resources until power, water, and coolant injection systems are restored or commissioned.

NRC Order EA-12-049 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 (Reference 2), which provides guidelines for nuclear stations to assess extreme external event hazards and implement the mitigation strategies specified in NRC Order EA-12-049. The NRC issued Interim Staff Guidance JLD-ISG-2012-01 (Reference 3), which endorsed NEI 12-06 with clarifications on determining baseline coping capability and equipment quality.

NRC Order EA-12-050 superseded by NRC Order EA-13-109 (Reference 65) requires licensees to take actions to ensure that the nuclear stations have a hardened containment vent system to remove decay heat from the containment and maintain control of containment pressure within acceptable limits following events that result in loss of active containment heat removal capability while maintaining the capacity to operate under sever accident conditions resulting from an Extended Loss of AC Power.

The Nuclear Energy Institute (NEI) developed NEI 13-02 (Reference 66), which provides guidelines to assist the nuclear stations with identification of measures to comply with the requirements of Order EA-13-109.

NRC Order EA-12-051 (Reference 4) required licensees to install reliable SFP instrumentation with specific design features for monitoring SFP water level, capable of supporting identification of required wide range level conditions.

The Nuclear Energy Institute (NEI) developed NEI 12-02 (Reference 5) which provided guidance for compliance with Order EA-12-051. The NRC determined that, with the exceptions and clarifications provided in JLD-ISG-2012-03 (Reference 6), conformance with the guidance in NEI 12-02 is an acceptable method for satisfying the requirements in Order EA-12-051.

Near-Term Task Force (NTTF) Recommendation 9.3 proposed that facility emergency plans provide for a means to power communications equipment needed to communicate onsite (e.g., radios for response teams and between facilities) and offsite (e.g., cellular telephones and satellite telephones) during a prolonged station blackout.

The Nuclear Energy Institute (NEI) developed NEI 12-01, "Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities." (Reference 7) which provided the nuclear stations guidance for assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities and implement the Recommendation 9.3.

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

2.1 <u>Assumptions</u>

The assumptions used for the evaluations of a Quad Cities Power Station ELAP/LUHS event and the development of FLEX strategies are stated below.

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

- The BDB external event occurs impacting both units at the site.
- The reactors are initially operating at power unless there are procedural requirements to shut down due to the impending event. The reactors have been operating at 100% power for the past 100 days.
- The reactors are successfully shut down when required (i.e., all control rods inserted, no ATWS). Steam release to maintain decay heat removal upon shutdown functions normally, and reactor coolant system (RCS) overpressure protection valves respond normally, if required by plant conditions, and reseat. The emergency cooling system initiates and operates normally, providing decay heat removal, thus obviating the need for further overpressure protection valve operation.
- 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.
- The reactor and supporting plant equipment are either operating within normal

ranges for pressure, temperature and water level, or available to operate, at the time of the event consistent with the design and licensing basis.

The following plant initial conditions and assumptions are established for the purpose of defining FLEX strategies and are consistent with NEI 12-06 Section 3.2.1, *General Criteria and Baseline Assumptions*, for Quad Cities Power Station (Reference 75):

- No specific initiating event is used. The initial condition is assumed to be a loss of off-site power (LOOP) with installed sources of emergency on-site AC power unavailable with no prospect for recovery.

- Cooling and makeup water inventories contained in systems or structures with designs that are robust with respect to seismic events, floods, and high winds and associated missiles are available. Permanent plant equipment that is contained in structures with designs that are robust with respect to seismic events, floods, and high winds and associated missiles, are available.

- Normal access to the ultimate heat sink is lost, but the water inventory in the ultimate heat sink (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. The discharge bay and diffuser pipes remain available as a source of water inventory. This is due to the robust construction of the bay and two redundant diffuser pipes.

- Fuel for FLEX equipment stored in structures with designs that are robust with respect to seismic events, and high winds and associated missiles, remains available.

- Installed Class 1E electrical distribution systems, including inverters and battery chargers, remain available since they are protected.

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

- RCS leakage is 42 gpm (including reactor recirculation pump seals leakage), conservatively assumed to begin at t=0. This includes 5 gpm unidentified leakage (Tech. Spec. maximum), 1 gpm identified leakage, and 18 gpm recirculation pump seal leakage per pump. The leakage is modeled as a hole of fixed size on the RPV at the height of the pumps which yields 42 gpm leakage at 1000 psig. At lower RPV pressure, the flow rate will decrease.

- For the spent fuel pool, the heat load is assumed to be the maximum design basis heat load. In addition, inventory loss from sloshing during a seismic event does not preclude access to the pool area.

Additionally, key assumptions associated with implementation of FLEX Strategies are as follows:

- Exceptions for the site security plan or other (license/site specific) requirements of 10CFR may be required.
- Site access is impeded for the first 6 hours, consistent with NEI 12-01. Additional resources are assumed to begin arriving at hour 6 with limited site access up to 24 hours. By 24 hours and beyond, near-normal site access is restored allowing augmented resources to deliver supplies and personnel to the site.

This plan defines strategies capable of mitigating a simultaneous loss of all alternating current (AC) power and loss of normal access to the ultimate heat sink resulting from a BDB event by providing adequate capability to maintain or restore core cooling, containment, and spent fuel pool (SFP) cooling capabilities. 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 have been incorporated into the emergency operating procedures in accordance with established emergency operating procedure (EOP) change processes, and their impact to the design and license bases capabilities evaluated under 10 CFR 50.59.

The plant Technical Specifications contain the limiting conditions for normal unit operations to ensure that design safety features are available to respond to a design basis accident and direct the required actions to be taken when the limiting conditions are not met. The result of the BDB 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). This position is consistent with the previously documented Task Interface Agreement (TIA) 2004-04, "Acceptability of Proceduralized Departures from Technical Specification (TSs) Requirements at the Surry Power Station", (TAC Nos. MC42331 and MC4332), dated September 12, 2006 (Reference 8).

3 Strategies

The objective of the FLEX Strategies is to establish an indefinite coping capability 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 spent fuel pool (SFP) using installed equipment, on-site portable equipment, and pre-staged off-site resources. This indefinite coping capability will address an extended loss of all AC power (ELAP) – loss of off-site power and emergency diesel generators, but not the loss of AC power to buses fed by station batteries through inverters – with a simultaneous loss of access to the ultimate heat sink (LUHS) and loss of motive force for UHS pumps, but the water in the UHS remains available and robust piping connecting the UHS to plant systems remains intact. The station UHS is not utilized for makeup water following the LUHS event. A seismic deep well and the plant discharge bay with river diffuser piping remain intact to provide an alternate makeup water supply source (Mississippi river). This condition could arise following external events that are within the existing design basis with additional failures and conditions that could arise from a BDBEE.

The plant indefinite coping capability is attained through the implementation of pre-determined strategies (FLEX strategies) that are focused on maintaining or restoring key plant safety functions. The FLEX strategies are not tied to any specific damage state or mechanistic assessment of external events. Rather, the strategies are developed to maintain the key plant safety functions based on the evaluation of plant response to the coincident ELAP/LUHS event. A safety function-based approach provides consistency with, and allows coordination of, existing plant emergency operating procedures (EOPs). FLEX strategies are implemented in support of EOPs using FLEX Support Guidelines (FSGs), which are located in the station QCOP 0050 procedure block.

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 BDB equipment.
- Phase 3 – Obtain additional capability and redundancy from off-site equipment and resources until power, water, and coolant injection systems are restored.

The duration of each phase is specific to the installed and portable equipment utilized for the particular FLEX strategy employed to mitigate the plant condition.

The strategies described below are capable of mitigating an ELAP/LUHS resulting from a BDB external event by providing adequate capability to maintain or restore core cooling, containment, and SFP cooling capabilities at Quad Cities Power Station. 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 Quad Cities Power Station Emergency Operating Procedures (EOP) in accordance with established EOP change processes, and their impact to the design basis capabilities of the unit evaluated under 10 CFR 50.59.

Before discussing the strategies that provide coping capability for reactor core cooling, containment integrity, and spent fuel pool cooling, a discussion of the fundamental strategies for restoring a source of AC power and a source of cooling water is provided below.

3.1 Electrical Strategies

3.1.1 480 VAC Power

The electrical support approach complies to the conditions endorsed by the NRC in NEI 12-06. This is a robust design and will withstand the BDBEE hazards scoped in for Quad Cities Power Station (Reference 75).

The Quad Cites electrical strategy consists of the following components (Refer to Figure 1; FLEX Electrical Strategy):

- Two mobile 500 KW diesel generators stored in the Robust FLEX Building, with a N+1 mobile generator in the N+1 Storage Building
- Permanent, seismically installed electrical connections located in the rear compartment of both division safety related 480 volt buses 18(28) and 19(29),
- Interconnecting cable stored on reels located in the Reactor Building and Turbine Building stored per the station procedures to prevent equipment interaction during a seismic event.
- Procedures for AC load shedding, connection of temporary equipment and portable diesel generator operation.

Quad Cities has developed a primary and alternate strategy for supplying power to equipment required to provide core, containment, and spent fuel pool cooling. The 480 VAC system provides power for 250 VDC and 125 VDC battery chargers, residual heat removal (RHR) system motor-operated valves (MOVs) used for FLEX RPV and Containment water addition. The primary strategy uses Division 1 connections and the alternate strategy uses Division 2 connections. Either connection will allow repowering the other division using the Division crosstie. All the necessary FLEX response equipment will then be repowered from the S/R 480 VAC system using the installed seismically mounted equipment.

The Quad Cities electrical strategy meets the requirements of the order by providing multiple generator deployment locations and connection cable paths. Based on the assessment of the damage and debris caused by the initiation event, the portable generators could be staged outside the Reactor Building (RB) trackway or the U2 Turbine Building (TB) trackway and connection cables deployed from either location to the 480 VAC div 1 or 2 buses to restore power to the required FLEX equipment. The connection cables are stored in the RB and TB 639' elevation to allow top down deployment of power cable which reduces the operator deployment burden and time. The cable at three storage locations provides sufficient cable for the N+1 requirement of NEI 12-06 as only cable from two of the three locations has sufficient length for deployment.

The FLEX 500 kW generator instruments measure line to line and line to neutral voltage, phase current, and power output.

Figure 1 FLEX Electrical Strategy, illustrates the connections to the Station 480 VAC distribution system and important loads utilized during an ELAP event.

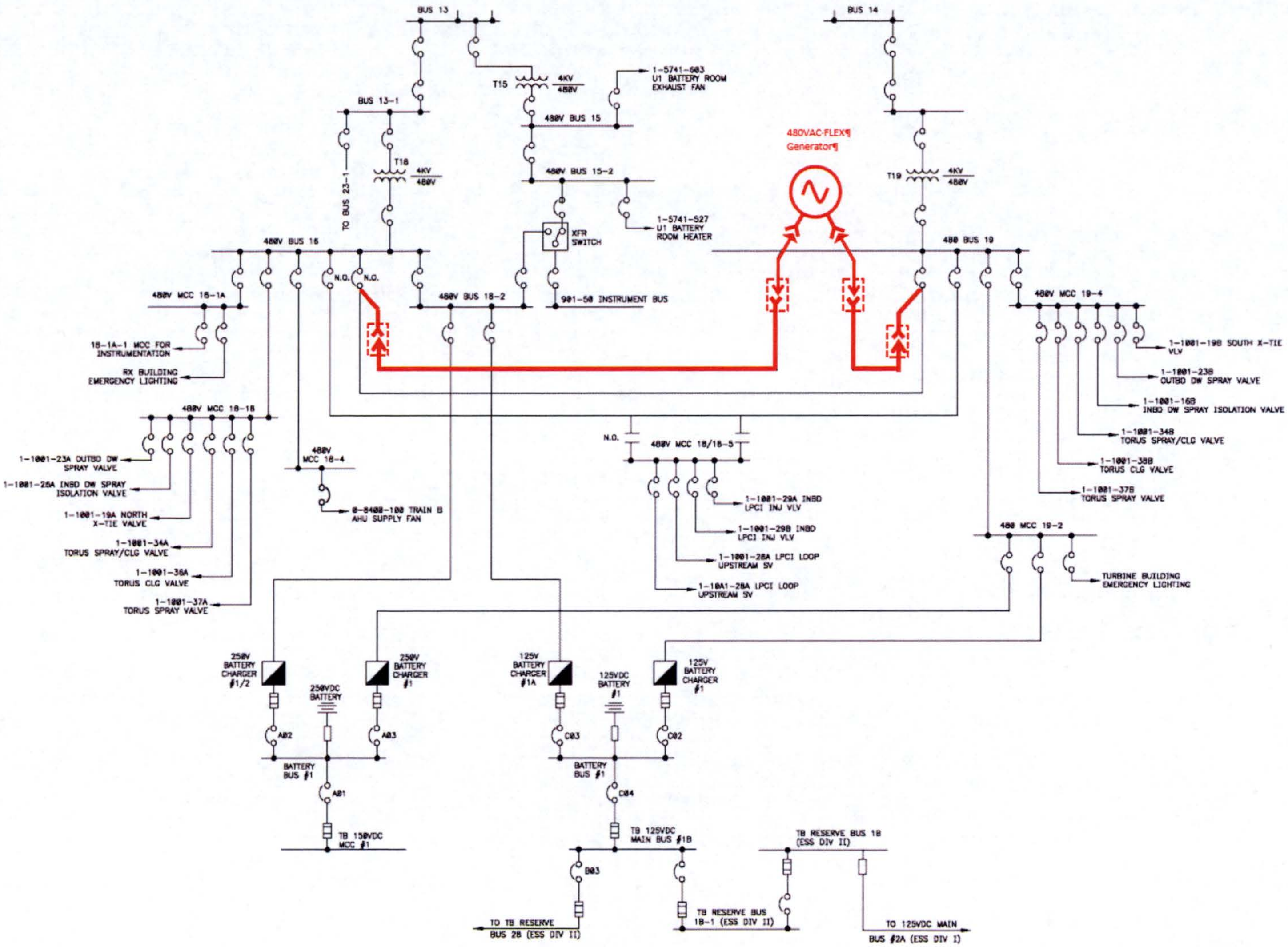

Figure 1: FLEX Electrical Strategy

3.1.2 DC Power

The Quad Cites DC electrical strategy consists of the following components:

- Procedures for DC load shedding for elimination of non-essential DC loads and restoring power to the 125 VDC and 250 VDC Battery chargers after the 480 VAC power is restored from the FLEX generators.
- Permanently installed electrical connections on the alternate S/R 125 V battery and electrical distribution system, and Non-S/R 250 VDC battery and electrical distribution system. EC 396323, 396324, 396354 (Reference 42, 39, 40)
- Interconnection cable located in the Turbine Building for 125 V and 250 V battery connections.

Station batteries are provided as a source of DC power for specific vital loads and control power. Two station battery systems (250 VDC and 125 VDC) are utilized for each unit during an ELAP event (Figure 2, DC Power Supplies). The 125 VDC and 250 VDC system supplies power to the following loads:

- Reactor Core Isolation Cooling (RCIC) MOVs
- RCIC control components
- Main Steam Electromatic Relief valves
- RPV and Primary Containment monitoring instruments

The 125 VDC and 250 VDC loads are powered using seismically installed, safety-related batteries and chargers, which receive power from the 480 VAC division 1 or 2, therefore both the primary and alternate 480 VAC power restore and sustain the batteries and DC loads for long term operation.

The 250 V battery systems are provided to serve the larger loads such as RCIC motor-driven pumps, valves, and the Essential Service System. A separate non-essential 250 VDC system is installed on each unit and provides additional FLEX 250 VDC power utilizing staged cables and installed connections (References 39 and 40) if required. The staged connection cables are solely purposed for FLEX and reduces deployment time and operator burden.

The 125 V battery systems are provided to supply power required for DC control functions such as that required for control of 480 V breakers, Main Steam Electromatic Relief Valve actuation and RPV monitoring instruments. An alternate 125 V battery is installed on each unit, which can be connected to the distribution system using staged cables and connections providing additional FLEX DC power, (EC 396323), if required. The staged connection cables and connections are solely purposed for FLEX and reduces deployment time and operator burden (Reference 42).

Station Blackout (SBO) and FLEX battery load shedding procedures (Reference 72) will ensure battery life is extended. The SBO 125 VDC load shed of all non-essential loads would begin when it is recognized that the station is in a Station Blackout (SBO) condition and continue with the FLEX DC load shed which involves both 125 VDC and 250 VDC systems when the ELAP condition is declared upon failure to restore AC power from off-site sources or installed standby generators.

Battery load profiles have been evaluated and documented in calculations QDC-8300-E-2100 and QDC-8350-E-2101 (References 9 and 10). QCOP 0050-01 and 02, Unit 1(2) FLEX DC Load Shed, have been issued to provide procedural guidance for performance of the FLEX load shed of both the 125 V and 250 V batteries.

Figure 2, DC Power Supplies (Typical), illustrates the system configuration and alternate battery connections.

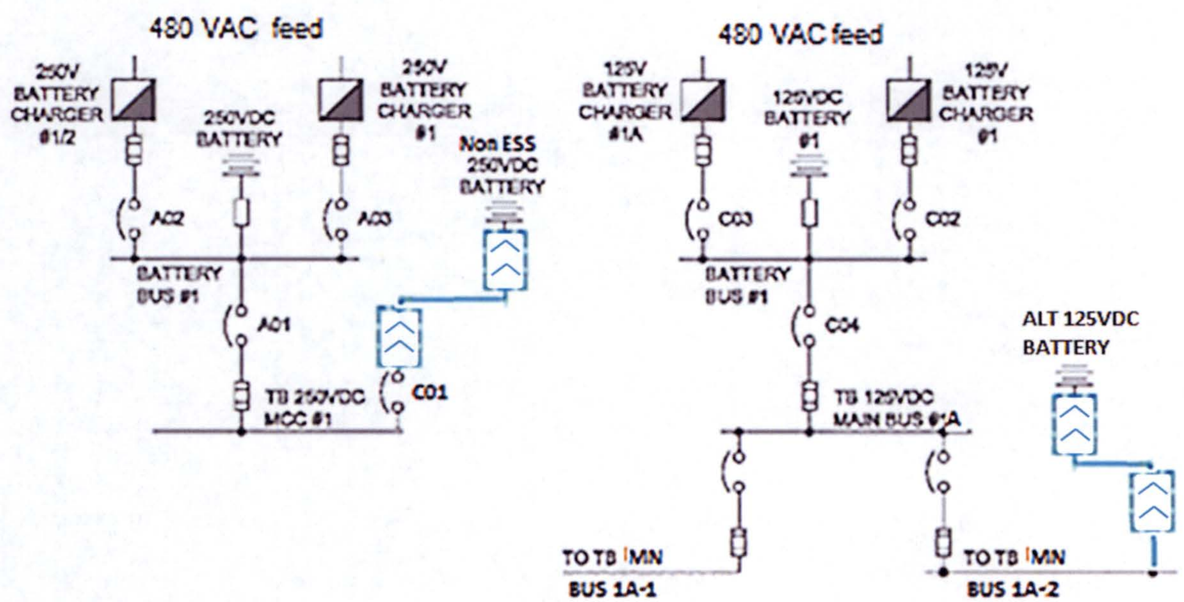

Figure 2: DC Power Supplies (Typical)

3.1.3 120 V Essential Service System and Uninterruptable Power Supply

The Quad Cities Essential Service System (ESS) Bus is a 120/240 VAC distribution center supplying loads important to FLEX response i.e. RCIC and HPCI Flow Controllers, RPV and Containment monitoring instruments. The ESS bus is normally supplied by an Uninterruptable Power Supply (UPS) that provides noise free, voltage-regulated and frequency-controlled "clean" power to enhance the reliability of connected components. Power to the UPS is supplied, in order of preference, by Bus 18 (28), the Unit 250 V battery system or MCC 18-2(28-2). The power source from Swgr 17(26) will not be available during an ELAP event or recovery.

Figure 3 Essential Service Power Supplies (Typical) illustrates the system configuration.

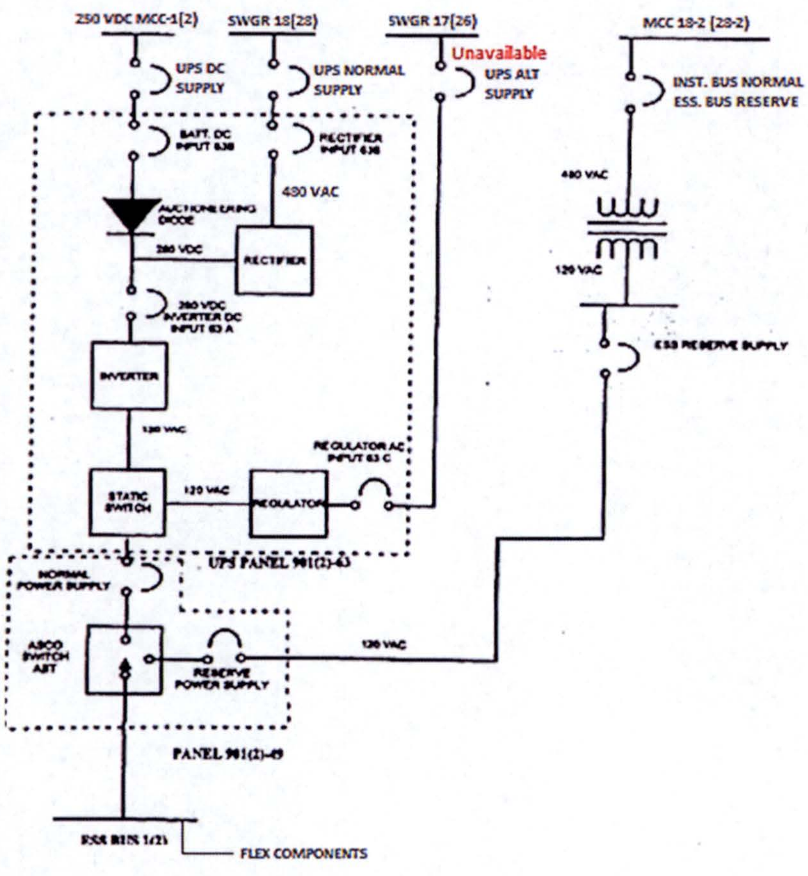

Figure 3: Essential Service Power Supplies (Typical)

3.1.4 120/240 VAC Auxiliary Power

Quad Cities has six (6) portable diesel generators in the FLEX and FLEX +1 buildings to provide a power supply for low voltage portable equipment. Below are examples of the equipment requiring 120/240 VAC power:

- Portable fans for Control Room, Aux Electric Room, Battery and Battery Charger room ventilation
- Portable fuel transfer pump
- Tripod lights
- Backup power to Main Control Room (MCR)/Outage Control Center (OCC) satellite communications equipment

3.1.5 Electrical Analysis

Quad Cities has two safety-related 250 VDC systems, one per unit. The basic function of the 250 V battery is to supply electrical power to the dc distribution systems whenever the battery charger, which supplies the normal source of power, is de-energized. The 250 V battery system of each unit is sized to start and carry the normal dc loads plus all dc loads required for safe shutdown on one unit, and the operational loads required to limit the consequences of a design-basis event on the other unit, for a period of four hours following loss of offsite power plus a single active failure without taking credit for the battery charger (Reference 11). Additionally, as previously discussed the Non-Essential 250 VDC battery and electrical distribution has been modified to allow connection for addition battery capacity.

Engineering calculation QDC-8350-E-2101 (Reference 10) was performed and determined that with the FLEX actions the total coping time for the Unit 1 and Unit 2 250 V Battery is 9 hours. The estimated timeline for connection of the FLEX generator to restore the 480 VAC power and system battery charger is 5 hours which is shorter than the battery coping period (Reference 78).

Quad Cities has two 125 V Battery systems, one per unit. The basic function of the 125 V battery is to supply electrical power to the DC distribution systems whenever the battery charger, which supplies the normal source of power, is de-energized. The 125 VDC power system supplies power to control circuits, switchgear, the turbine system and safety injection systems (Reference 12). Additionally, as previously discussed the Alternate 125 V battery and electrical distribution has been modified to allow connection for addition battery capacity.

Engineering calculation QDC-8300-E-2100 (Reference 9) was performed and determined that with the FLEX actions the total coping time for the Unit 1 (Unit 2) 125 V Battery is 10 hours. The estimated timeline for connection of the FLEX generator to restore the 480 VAC power and system battery charger is 5 hours which is shorter than the battery coping period (Reference 78).

The strategy to sustain the station's safety-related DC bus requires the use of a 480 VAC diesel powered FLEX Generator to re-power the selected battery charger(s) via permanent connection points in the AC distribution system that supplies the battery charger. The circuit for supplying the bus connection points from the FLEX generator is described in section 3.1.1 and Figure 1.

The FLEX Generators, one per unit, are trailer-mounted and stored in the FLEX Storage Building. Both are rated at 500 kW/625 kVA, 480 VAC, 3 phase, 60Hz, with integral 500 gallon fuel tank capable of supporting 14.5 hours of operation at full load. Per the FLEX diesel generator and cable sizing calculation (Reference 13), the FLEX generator will be capable of supplying the Unit FLEX loads. There is an identical FLEX generator stored in the FLEX +1 building as required by NEI 12-06.

For FLEX Phase 3, the National SAFER Response Center (NSRC) will supply two (2) Turbine Marine 1.1 MW, 480 VAC, 3 Phase 60 Hz generators. This NSRC equipment is a backup to on-site Phase 2 equipment. NSRC generators come with the same style and size connectors as the on-site Phase 2 FLEX generators (Reference 32).

3.1.6 Impact of Battery Room Temperature

The following is a discussion of the impact of loss of normal ventilation to the Unit 1 and Unit 2 Battery Rooms.

3.1.6.1 Battery Rooms

The 125 V and 250 V batteries used at Quad Cities for the station battery systems have a robust design and extensive operating history. Analysis to calculate the temperature response of the Unit 1 and 2 Battery Rooms, the 125/250 V Batteries, the Battery Charger Rooms, and the DC Panel Rooms and to determine the required mitigating actions under an ELAP condition was performed in EC 399874, Battery and Charger Room Temperature Response for FLEX Evaluation Fukushima – Habitability Studies. (Reference 53) identified high and low temperature limits for the Battery, DC Panel, and Battery Charger Rooms. The low temperature limit for the Battery Rooms is the battery electrolyte low temperature limit. The high temperature limit for the analysis is based on the high temperature limit for the battery charger.

Compensatory actions such as opening doors and activating fans are modeled in the analysis. These actions are performed, if necessary, to maintain the Battery, Battery Charger, and DC Panel rooms and the 125 V / 250 V batteries at acceptable temperatures. With compensatory actions modeled, rooms in the scope of this analysis do not reach temperatures which would cause activation of the fire dampers. Fire dampers are assumed to be open to the Turbine Building unobstructed throughout the transient for all scenarios. Otherwise, doors are assumed to be initially closed. Portable fans that are deployed as part of a compensatory action are assumed to have a supply air temperature equal to the outdoor temperature. The compensatory actions are performed with QCOP 0050-10, FLEX Battery Room Ventilation.

3.2 Water Strategies

Each unit's RCIC system provides the water necessary for RPV level restoration and control during ELAP Phase 1 response. As backup to RCIC, the HPCI system is also capable of providing makeup water to the RPV. Either system can utilize the Suppression Chamber water as a water source or the CCST tanks if available following the initiating ELAP event.

During Phase 2, two water sources are utilized to provide the necessary water for coping with the ELAP event. The Primary source for all events is provided by an installed, seismically designed Well, EC 398197, Fukushima FLEX – Install Deep Well, (Reference 57), which is located in the isolation zone east of the Reactor Building. The well head has power connections for a FLEX diesel generator to operate the submerged pump motor and a Storz connection for attaching fire hose for providing water to the reactor, containment and spent fuel pools. The power to the well pump is controlled by a motor controller. The two auxiliary hose trailers (N and N+1) each carry a motor controller.

The alternate source of water for all events utilizes the circulating water discharge bay. A FLEX diesel driven pump would be positioned on a ramp at the discharge bay and lightweight suction hoses and floating suction strainer would be deployed. Discharge hose would then be connected to the reactor, containment and fuel pool using 5" fire hose to provide makeup water.

The FLEX pump, FLEX generator, and FLEX hose trailer are located in the FLEX Storage Building (FSB). The FSB is constructed at the North end of the protected area.

Water is transported to the RHR system and the Fuel Pool system with 5" and 3" fire hose. The Fire hose is used connect the pump (Well or FLEX) to the distribution header which utilizes standard fittings used in fire protection systems to allow distribution of water to both units RHR system for RPV or Torus makeup and/or the spent fuel pool cooling system for fuel pool makeup.

Two separate connections are available on the RHR systems on both units to supply water to the RPV assuring core submergence or Torus makeup for inventory lost during Wetwell venting. These connections utilize the existing "A" RHR DW spray piping connection or the Condensate Transfer fill system to the RHR system. EC 395697, Install Storz Connections for Alternate Reactor Vessel Injection (Condensate Transfer) – Fukushima - Flex Strategy (Reference 51), installed the connection fittings. The needed RHR system valve operations to direct water for RPV makeup or Torus makeup can be completed using the normal power from the 480 V FLEX generators discussed within the electrical strategy or by use of the valve manual operators.

The RHR system MOV interlocks were reviewed and procedural steps to defeat the low pressure system interlock are provided in QCOP 0050-05, restoring full operation of the RHR system MOVs for FLEX use.

Sufficient fire hose and fittings are staged in the Reactor Building 595' within a FLEX equipment box, to allow for ease of deployment of the internal building equipment and alternate action should external building conditions delay immediate deployment. This equipment reduces the operator deployment burden. The FLEX equipment storage box, which is inspected under QCOS 0050-03 (Reference 79), contains equipment for connection of hoses to both units RHR systems and the connection to the SFP system.

Two separate methods are available to provide makeup water to the spent fuel pool(s). The Unit One and Two SF Pools are connected by a normally open transfer canal to create essentially one pool. The primary makeup method would utilize a Storz connection on the Unit 1 RHR Fuel Pool assist supply line and opening system valve 1-1901-64 to provide FLEX water to the SFP. EC 395698, Unit 1 Spent Fuel Pool Assist (Discharge Line) – Fukushima FLEX Strategy (Reference 52), installed a FLEX connection on the U1 Spent Fuel Pool Assist discharge line and procedures QCOP 0050-04, QCOP 0050-05, and QCOP 0050-06 provide direction for hose deployment and establishing restoration of water to the spent fuel pool. The alternate method would be to use 3" fire hose to directly provide water to the fuel pool. The 3" fire hose has been staged on the refuel floor to allow top down deployment of the fire hose easing operator hose deployment burden.

Figure 4 FLEX Water Strategy provides an illustration of supply pumps, hoses and system connection points.

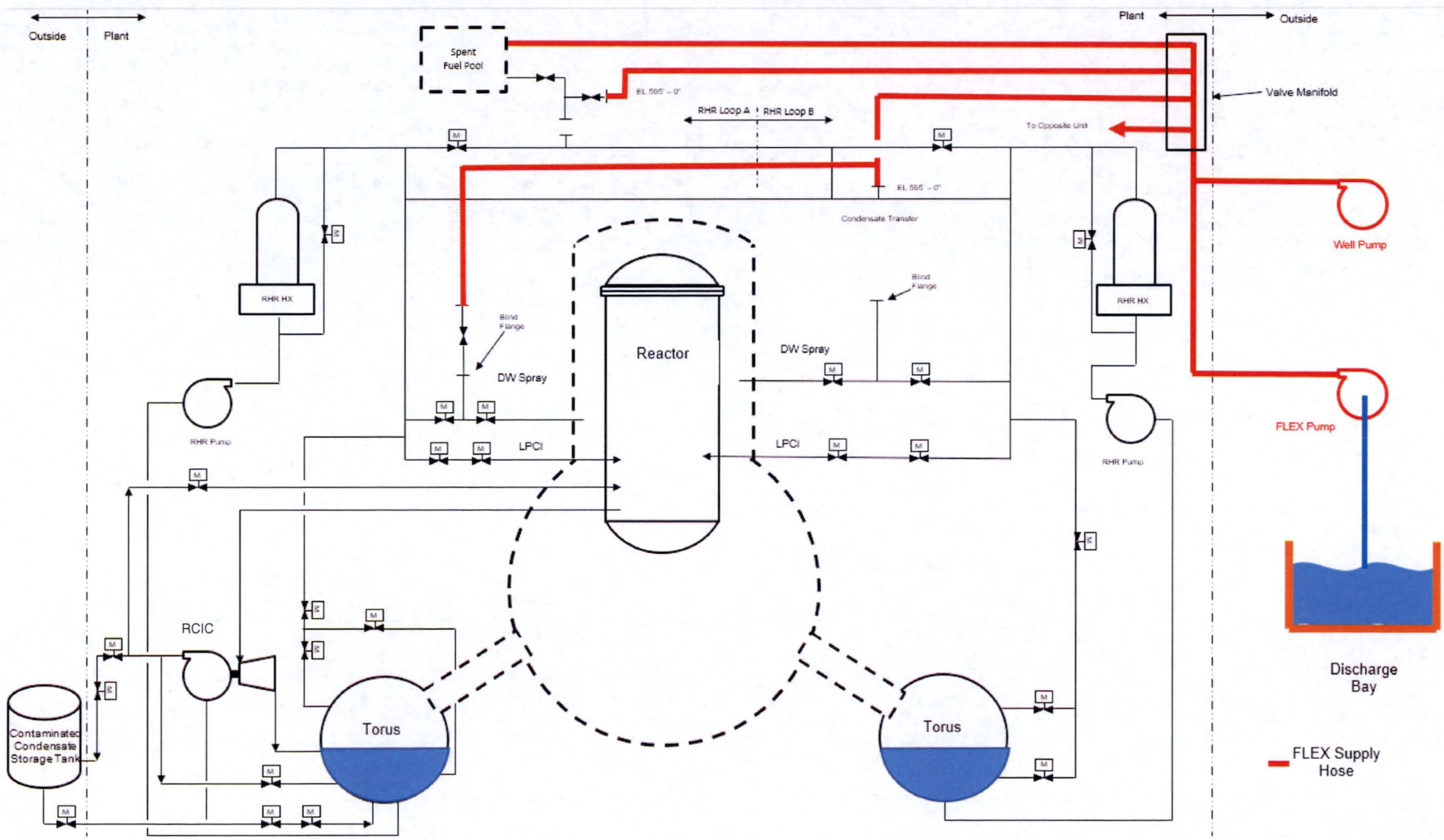

Figure 4: FLEX Water Strategy

3.2.1 Hydraulic Analysis

The Deep Well pump is rated and tested to supply greater than 1000 gpm with a discharge pressure of at least 200 psig. The FLEX Pump is a diesel engine driven, trailer mounted pump. The FLEX Pump is located in the FSB. The FLEX pump draws via suction lift from the Discharge Bay. After a seismic event, the Discharge Bay may eventually drop below the suction lift capability of the FLEX pump alone, but this is not expected to happen in less than 72 hours. In this case, Quad Cities has contracted with SAFER to deliver a submersible booster pump within 24 hours.

The full hydraulic analysis is contained in QDC-0000-M-2097, Pipe FLO Analysis of FLEX Strategy (Reference 34). Below is a summary of the flow requirements per strategy:

Strategy	Flow	Basis
Suppression Pool Makeup	88.5 gpm	MAPP Analysis QC-MISC-013 (Reference 20). Not needed simultaneously with RPV makeup.
RPV Makeup	196 gpm	NEDC 33771P Rev 1, Table 4.5.2-5 Required Vessel Inventory Makeup Rate vs Decay Heat (Reference 27)
Fuel Pool Makeup	92 gpm	Calculation QDC-1900M-2079 (Reference 17)
Spent Fuel Pool Spray	500 gpm	NEI 12-06 Table C-3 for two connected pools.

The hydraulic analysis in QDC-0000-M-2097 (Reference 34) was used to provide guidance with regard to supplying flow to the various water demands based on pressure seen at gauges integral to the fire hose fittings. The analysis was also used to determine a configuration that would not cause a deadhead condition upon starting either the Deep Well pump or the FLEX diesel powered pump, and pressure relief protection is provided at the Deep Well head and in the fire hose fittings. This guidance is reflected in QCOP 0050-06, FLEX RPV, Suppression Pool and Spent Fuel Pool Level Control.

3.2.2 Specific River Flood Strategy

The strategy for action in response to a Mississippi River Flood is as was previously provided in the USFAR section 3.4.1.1 (Reference 123).

As described in the Quad Cities Station Flooding Integrated Assessment Report (Reference 80), the Mitigating Strategy Assessment (MSA) for Quad Cities Nuclear Power Station (QCNPS) was submitted with Reference 104. The mitigating (FLEX) strategy for QCNPS is based on the design-basis flood mitigation strategy. The re-evaluated flooding parameters confirmed that adequate time exists to implement the design-basis flood mitigation strategy and that all flood preparation activities would be completed prior to the flood level exceeding the plant grade. These activities would be initiated a minimum three days prior to the predicted arrival of a flood exceeding the plant grade. As part of the preparations, both units would be shut down and decay heat removed using normal procedures, as specified for the RHR system. Therefore, the MSA concluded that the FLEX strategy can be successfully implemented as designed, without modification, and further assessment of the strategy was not required. The MSA for QCNPS was approved by the NRC in Reference 103.

3.3 Reactor Core Cooling and Heat Removal

The FLEX strategy for reactor core cooling and decay heat removal is to run the RCIC system and provide makeup to the RPV until the connection and startup of FLEX Phase 2 equipment. The RCIC injection source will be maintained for as long as possible, since it is a closed loop system using relatively clean suppression pool water. During prolonged RCIC operation warming of the suppression water will begin to impact RCIC turbine and pump component reliability. Therefore, the RCIC system suction will utilize Contaminated Condensate Storage Tank (CCST) water, if available, to provide cooler water to extend operation of the system.

RPV pressure control will utilize the Main Steam Relief valves (ERV) as directed by the station emergency operating procedures (EOPs) to control vessel depressurization to keep sufficient pressure to support RCIC turbine operation (see section 12.3). Following connection and startup of Phase 2 water injection system the ERVs will finish the RPV blowdown to reduce RPV pressure allowing FLEX pump injection.

Low pressure RPV makeup from the well pump or FLEX pump will be available by $t_0 + 6$ hours to ensure that reactor water level will remain above the Top of Active Fuel (TAF) (Reference 75).

3.3.1 Phase 1 Strategy

3.3.1.1 Power Operation, Startup, and Hot Shutdown

At t_0 in a Station Blackout (SBO) event (Reference 41) the reactor will scram on a load reject signal. Following a reactor scram, steam generation will continue at a reduced rate due to core fission product decay heat. In the event the reactor vessel is isolated, and the feedwater supply unavailable, ERVs/SRV will operate automatically to maintain reactor vessel pressure within desired limits. The water level in the reactor vessel will drop due to continued steam generation by decay heat. Upon reaching Reactor Vessel Water Level–Low Low, (Level 2) the HPCI and RCIC Systems will be initiated automatically to restore RPV level. Both systems can also be initiated manually from the Main Control Room or locally (Reference 72).

After determination that installed emergency diesel generators cannot be restarted and off-site power cannot be restored, the operating crew determines the event is an ELAP. It is assumed that this determination is made less than one hour into the event. Overall coping time for core cooling in Phase 1 is greater than 6 hours (References 20 and 21).

Four (4) ERVs and one (1) Target Rock S/RV are installed on the main steam lines inside the drywell. The valves can be actuated in three ways: 1) they will relieve pressure automatically by a pressure transmitter 2) operate automatically from Automatic Depressurization System (ADS) logic or 3) by manual actuation from the Main Control Room, all methods require 125 V battery power. The TR S/RV also requires external air in relief mode, which limits the amount of actuations. This valve will also self-actuate in the safety mode. The suppression pool provides a heat sink for steam relieved by these valves. ERV operation may be controlled manually from the control room to hold or reduce the desired reactor pressure. Each ERV are actuated from an installed DC solenoid valves which open to the valve operating piston.

During Phase 1 reactor vessel makeup is provided from RCIC with suction from the suppression pool and reactor vessel pressure control is provided by the ERVs. Since these are loads on the 125 V battery, shedding of non-essential loads on the battery is performed to extend the DC coping time.

A gradual cooldown of the reactor vessel will be performed with ERVs and reactor vessel pressure will be controlled between approximately 150 and 250 psig. RPV makeup will continue to be provided from RCIC until reactor vessel pressure requires a transition to Phase 2 methods.

3.3.1.2 Impact of Elevated RCIC Area Temperatures

The results of calculation 2014-02948 (Reference 18) show that the RCIC room will reach 150°F in approximately 9 hours. All analyzed BDBEEs except Localized Intense Precipitation (LIP) allow FLEX equipment deployment before this duration and are thus bounded by this result. A LIP event may prevent external equipment deployment up to 8 hours. These results assume RB doors are opened to start natural circulation, which are already implemented in QCOP 0050-04. There are no other compensating actions planned.

Note that even if Localized Intense Precipitation (LIP) were to prevent FLEX deployment for 10 hours, the ELAP is an extended version of the Station Blackout evaluated in NUMARC 87-00, Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Nuclear Power Plants (Reference 35). In Appendix G of that report, the topical report on the relevant equipment shows reasonable assurance of operability up to 180°F. Per the calculation (Reference 18) the RCIC Pump Room never reaches 180°F for the 72 hours of the event that were analyzed. Based on this, there is reasonable assurance of RCIC operability throughout all BDBEEs.

3.3.1.3 Cold Shutdown and Refueling

The overall strategy for core cooling for Cold Shutdown and Refueling are, in general, similar to those for Power Operation, Startup, and Hot Shutdown.

If an ELAP occurs during Cold Shutdown, water in the reactor pressure vessel (RPV) will heat up. When temperature reaches 212°F the RPV will begin to pressurize. During the heat up, RCIC can be returned to service, or ERVs can be opened to prevent reactor heat up and re-pressurization. The primary strategies for Cold Shutdown are the same as those for Power Operation, Startup, and Hot Shutdown as discussed above for core cooling.

During Refueling, many variables impact the ability to cool the core. In the event of an ELAP during Refueling, there are no installed plant systems to provide makeup water to cool the core. Thus, the deployment of Phase 2 equipment will begin immediately. To accommodate the activities of RPV disassembly and refueling, water levels in the RPV and the reactor cavity are often changed. The most limiting condition is the case in which the reactor head is removed and water level in the RPV is at or below the reactor vessel flange. If an ELAP/LUHS occurs during this condition, then (depending on the time after shutdown) boiling in the core may occur in a relatively short period of time (Reference 81).

Per NEI Shutdown/Refueling Position Paper (Reference 14) endorsed by the NRC (Reference 15), pre-staging of FLEX equipment can be credited for some predictable hazards but cannot be credited for all hazards per the guideline of NEI

12-06. Deployment of portable FLEX equipment to supply injection flow should commence immediately from the time of the event. This is possible because more personnel are on site during outages to provide the necessary resources. During outage conditions, sufficient area and haul paths should be maintained in order to ensure FLEX deployment capability is maintained.

3.3.2 Phase 2 Strategy

During Phase 2 high pressure RPV makeup is provided from RCIC and RPV pressure control is provided from RCIC and the ERVs. A portable 480 VAC FLEX Generator will be connected to the AC distribution system to repower the 125 V and 250 V battery chargers to enable the continued use of RCIC, ERVs, and vital instrumentation as directed by QCOP 0050-07.

To accomplish low pressure RPV makeup when RCIC is no longer available, two methods are available per QCOP 0050-05: (1) primary makeup to the RPV from the well pump via either of two Storz hose connections point on the RHR system and (2) makeup to the RPV using water in the discharge bay with a FLEX pump, using the same RHR Storz hose connections. Hoses stored in the FLEX building on a hose trailer allow the connection to the RHR system. The low pressure coolant injection (LPCI) injection valves for these two systems are located outside the primary containment and can be operated manually with the handwheel or electrically via the FLEX generator power.

RPV pressure will be further reduced with ERVs to achieve the flow rate necessary from the external water connection. The external connection is capable of meeting the decay heat boil-off rate, plus the maximum allowable Technical Specification leakage and the pressure dependent system leakage from reactor recirc pump seals.

3.3.2.1 Preferred RPV Make Up

RCIC is the preferred RPV makeup system for as long as RCIC operation is viable. At Quad Cities the suppression pool peak temperature during the ELAP/LUHS is 232°F per QC-MISC-013, MAAP Analysis to Support FLEX Initial Strategy (Reference 20, case 6) well below the temperature that challenges long-term RCIC operation. Additionally, the RCIC pump suction source may be re-aligned to the Contaminated Condensate Storage, if available, following suppression pool heat up. The CCST water is significantly cooler and will ensure RCIC can provide RPV makeup for an extended period.

As part of the overall ELAP effort, the Boiling Water Reactor Owners Group (BWROG) had General Electric Hitachi (GEH) evaluate RCIC turbine and pump mechanical components assuming pump suction from the suppression pool at elevated temperatures (Reference 30). The evaluation concluded that except for the turbine journal bearings and the pump seal, the mechanical components would remain functional with a pool temperature up to 300°F and a seven (7) day mission time.

The primary Phase 2 strategy is capable of providing makeup to the RPV before steam pressure to RCIC is lost, allowing for a controlled transition of RPV level control from RCIC to FLEX equipment. The expected time for transition from Phase 1 to Phase 2 is T_0 = +6 hours for all event except the Local Intense Precipitation event when the deployment of FLEX equipment is expected to be delayed due to building external water levels, which will require longer use of RCIC for core cooling. LIP FLEX Equipment deployment is expected at T_0 = +8 hours when water levels in the deployment areas has receded to 12".

The expanded RPV level control band of TAF to 100" in procedure QGA 100 RPV Control (Reference 31) encompasses a wide variety of circumstances, including ELAP. During an ELAP, RPV water level will normally be maintained between 0" and 48" provided when RCIC or HPCI are utilized. When FLEX equipment is available and used the level control band upper limit is expanded to 100" to provide a flow path that addresses the concern of core entry strainer blockage by low quality water and follows the recommendations of BWROG-TP-14-006, Fukushima Response Committee Raw Water Issue: Fuel Inlet Blockage from Debris (Reference 59). When the RCIC system is no longer available, the preferred RPV makeup supply comes from the FLEX Well. This water source is low quality. Thus, the level control band is expanded and will allow flooding from above the core. A level of 100" is above the RVP Steam Separator spillover level.

Five-inch fire hose is used to connect the well pump discharge to a distribution header consisting of standard fire fittings with ball valves. This header will allow operators to connect the discharge to the plant connections and control flow to the necessary loads, both unit RPVs and Suppression chamber via the RHR system and SFP. The station FSG procedures also allow for making plant connections to the ECCS room coolers (Reference 56). This has three purposes, 1) to provide water to the room coolers for reducing RB temperature and 2) allow a path for additional flow (pump minimum flow protection) after the flow to the RPVs, SCs, and SFPs subsides and 3) to keep elevated flow in the external hose for cold weather freeze protection.

FLEX Well operation will require deployment of a 480 VAC FLEX generator to provide power to the submerged well pump motor and a hose trailer which has a motor starter mounted on the trailer, (Figure 5). Power cables for connection are carried with the hose trailer and generator.

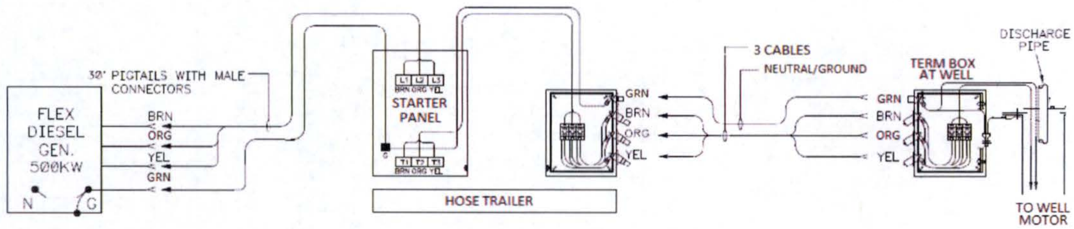

Figure 5: FLEX Well Power Supply

3.3.2.2 <u>Alternate RPV Make Up</u>

If RPV makeup from the Discharge Bay becomes necessary due to FLEX Well unavailability, a FLEX pump will be deployed to the pad at the discharge bay and hose trailer to the area. Sections of lightweight suction hose with a floating suction strainer will be connected at the suction lift pump connection. A floating suction strainer is utilized to minimize debris obstruction of the strainer and ease of retrieval, cleaning and redeployment when necessary. This water source is low quality. Thus, the level control band is expanded to 100" which is above the RVP Steam Separator spillover level and will allow flooding from above the core. The pump discharge is identical to that previously discussed.

3.3.3 <u>Phase 3 Strategy</u>

The station is capable of indefinite coping with Phase 2 equipment. The Phase 3 strategy is to use the Phase 2 connections, both mechanical and electrical, but supply water using Phase 3 portable pumps and AC power using Phase 3 portable generators if necessary. The Phase 3 equipment will act as backup or redundant equipment to the Phase 2 portable equipment and is deployed from an off-site facility and delivered to Quad Cities Power Station. The off-site facility supplying this equipment is the National SAFER Response Center (NSRC) through executed contractual agreements with Pooled Equipment Inventory Company (PEICo). The NSRC will support initial portable FLEX equipment delivery to the site within 24 hours of a request for deployment per the Quad

Cities SAFER Response Plan. The SAFER Response Plan defines the actions necessary to deliver pre-specified equipment to station (Reference 32). Designated local staging areas have been selected to support deliveries of requested SAFER equipment. Resources will be available, and sufficient, at the times required for Phase 3 implementation.

QCOP 0050-16, FLEX National SAFER Response Center Interface has been issued to provide direction for the use of NSRC equipment in support of the Quad Cities Station FLEX strategy. The SAFER Playbook has been developed and contains details of the equipment that will be provided and delivery methods.

No plant modifications have been installed to support mitigating strategies for Phase 3. The connection of the majority of Phase 3 equipment can be made to connection points established for Phase 2 equipment and strategies. The remaining Phase 3 non-redundant equipment will be deployed as needed utilizing field established connections. Other Phase 3 equipment that is not a backup or redundant to Phase 2 can be applied towards recovery efforts. All equipment described above is generic equipment.

Quad Cities station also requested one non-generic piece of equipment, a specific hydraulic driven submersible pump to be used to provide additional suction pressure to the FLEX pump discussed in Section 3.3.2.2. The specific event scenario that this pump may be necessary is a seismic event which disables the well pump or begins when the pump is unavailable combined with significant damage to the nearest downstream dam, Mississippi River Lock and Dam 14. In this case the lowest level of the discharge bay would require a suction booster pump to support continued FLEX pump operation. The NSRC pump would be capable of providing the flow and pressure to the flooded suction of the FLEX pump. Pump delivery is within 24 hours and the low river level condition was calculated to occur at ~90 hours (Reference 124). Hose fittings for connection of the discharge hose to the FLEX pump are stored in the FLEX building.

3.3.4 Systems, Structures, Components

3.3.4.1 Reactor Core Isolation Cooling

The Reactor Core Isolation Cooling System (Reference 122) is designed to assure that sufficient reactor water inventory is maintained in the reactor vessel thus assuring continuity of core cooling. Reactor vessel water is maintained or supplemented by the RCIC during the following conditions:

(1) When the reactor vessel is isolated and yet maintained in the hot standby condition;

(2) When the reactor vessel is isolated and accompanied by a loss of normal coolant flow from the reactor feedwater system;

(3) When a complete plant shutdown under conditions of loss of normal feedwater system is started but before the reactor is depressurized to a level where the reactor shutdown cooling mode of the RHR system can be placed into operation.

When actuated, the RCIC system pumps water from either the Contaminated Condensate Storage Tanks (CCSTs) or the Suppression Pool (SP) to the reactor vessel. Once the FLEX water strategy has been lined up, the RCIC pump can be shutdown and FLEX pumps provide all makeup water needs.

Evaluation of RCIC NPSH under ELAP conditions has been performed as documented in QDC-1300-M-2074 (Reference 24) and QC-MISC-013, MAAP Analysis to Support FLEX Initial Strategy, (Reference 20) Additional supporting information is provided in BWROG-TP-14-018, Beyond Design Basis RCIC Elevated Temperature Functionality Assessment. (Reference 30)

The RCIC system includes one turbine-driven pump, one condensate pump, one vacuum pump, a gland seal barometric condenser, automatic valves, control devices for this equipment, and sensors and logic circuitry.

The RCIC logic is powered by the 125 VDC Bus 1A-2 system, except the inboard isolation valves logic which is powered by the 125 VDC Division 2 system. Motive power for inboard isolation valve is by Division 1 standby AC power, while outboard isolation valves are driven by Division 2 250 VDC power RB bus 1(2)B. The AC driven containment isolation valve is normally open and is expected to remain open following the onset of the ELAP/LUHS. The remaining valves are driven by the Division 2 250 VDC system.

A failure of the control logic for the RCIC speed control system is the functional equivalent of a loss of power (DC) to the control logic. The end result is the inability of the control system to automatically control the speed/flow of the RCIC turbine/pump. In this failure situation, the RCIC system could be operated manually in accordance with QCOP 1300-09, RCIC Local Manual Operation (Reference 125). This procedure provides the guidance for manually throttling the steam flow to RCIC to maintain pump discharge pressure greater than RPV pressure and verifying that RPV level is responding as expected.

The normal procedure for RPV injection using RCIC under emergency conditions is EOP flowchart, QGA 100 RPV CONTROL directing the use of QCOP 1300-02, RCIC System Manual Startup (INJECTION/PRESSURE CONTROL) (Reference

126). Although not an actual failure of control logic, procedure QCOP 0201-10 (Reference 127) contains the direction for defeating RCIC isolation signals to help maintain the operation of RCIC under emergency conditions. These defeats include:

- Low Reactor Pressure Isolation
- RCIC Room High Temp Isolation
- RCIC Steam Line Hi Flow Isolation
- RCIC trip from system isolation
- High RPV Water Level trip
- High Exhaust Pressure trip
- Low Pump Suction Pressure
- High Suppression Pool Water Level Suction Transfer

The RCIC pump takes a normal suction from the CCSTs and will switch to the unit Suppression Pool automatically when a low level in the CCSTs or hi level in the SP occurs. This actuation also occurs when logic power is de-energized. During an ELAP event the actuation of this logic is expected, therefore RCIC pump suction with be transferred to the preferred protected source. To change the suction to the CCSTs as discussed in section 3.3.2.1, RCIC turbine shutdown and restart are necessary to allow alignment of the system suction valves. This can be performed following stabilization of reactor level without a detrimental effect on core cooling.

EC 399998, Fukushima – Operation of RCIC and HPCI During FLEX, (Reference 62) evaluated the operation of RCIC during an extended loss of AC power ELAP event. This evaluation assisted in the performance of the 250 VDC ELAP load profile.

3.3.4.2 Batteries

The safety related batteries and associated DC distribution systems are located within structures designed to meet applicable design basis external hazards and will be used to initially power required key instrumentation and applicable DC components required for monitoring RPV level and RCIC operation. Load shedding of non-essential equipment provides an estimated total service time of approximately 9 hours of operation. Installed modifications of Alternate 125 VDC and Non-Safety-related 250 VDC battery system can extend the service time an additional 10 hours for the 125 V Battery (Ref. 9) and 2 hours for the 250 V Battery (Reference 128).

The minimum voltage required for DC Buses and basis is contained in Quad Cities UFSAR section 8.3.2., which defines 105 VDC as the limiting voltage for the 125 V battery, and 210 VDC for the 250 V battery. These are the values that were utilized for the FLEX event analyses. Calculations QDC-8300-E-2100 and QDC-8350-E-2101 (References 9 and 10) are for the 125 and 250 Volt systems respectively. There is not a specific limiting component.

3.3.4.3 RHR / LPCI System

The purposes of the RHR system during an ELAP event are primarily to provide a flow path to maintain reactor water level, and alternately to provide a flow path for water addition to the Torus using the FLEX/SAWA pumps. Either of two Storz connections on the RHR system will allow the Seismic Deep Well pump, or a trailer-mounted diesel-powered pump, to supply water at sufficient pressure and flow to maintain RPV and Torus water levels within the desired bands. The primary connection (Reference 51) will use the Condensate Transfer system, and normal system fill connections. A secondary connection uses the “A” train of Drywell Spray piping. The hydraulic calculation (Reference 34) results were satisfactory for both methods. RHR system RHR/LPCI MOVs (EPNs 1(2)-1001-28A/B and 1(2)-1001-29A/B) provide the path for RPV injection. All these system MOVs are re-powered from the normal power supplies following connection and operation of the FLEX Diesel Generators.

Operation of the MOVs from the Main Control Room is accomplished by de-energizing the RHR system logic circuits and blocking closed the Low Reactor Pressure interlock relays. These actions will allow operation of all MOVs required to provide the path for make-up water to the RPV or Suppression Pools and eliminates the impact of RHR valve control logic failures or interlocks on desired valve operation. These actions are performed in procedure QCOP 0050-05, FLEX/SAWA Fire Hose Deployment.

By taking the approach of de-energizing and blocking the specified control relays in the RHR logic prior to RHR valve operation from the Main Control Room for implementation of the FLEX strategies, any normal or failed operation of the RHR valve control logic (interlocks) is avoided. As a result, there are no identified control logic failures that can impede the core cooling flow path for the Phase 2 FLEX water supply strategy for core cooling.

Motor Control Center (MCC) 18/19-5 (28/29-5) provides power to Reactor Recirculation (RR) Pump isolation valves and RHR/LPCI injection valves and is required to be energized to allow operation of these valves for the FLEX strategies. Operation of the RR pump isolation valves will allow pump seal isolation following the re-energizing of the 480 V MCCs. Operation of the LPCI injection valves is required for FLEX Pump RPV injection, as mentioned previously. Therefore, proper restoration of power to this MCC is also important to the FLEX strategies.

Under normal conditions, this MCC is normally powered from Division 2 source (Bus 19/29). Should this division be disabled, logic exists to change the source to Division 1 (Bus 18/28) to assure restoration of the MCC power. During the ELAP event, when power is lost to Division 2 and not restored, MCC 18/19-5 will swap to the Division 1 source and remain in this lineup until the logic is reset. The logic power will then be disabled during execution of the 125 VDC load shed procedures, QCOP 0050-01 and 02. Therefore, following restoration of the 480 VAC power using a FLEX generator, power will be restored to this MCC and the supplied MOVs.

Logic power is also de-energized to Buses 18(28) and 19(29) during the execution of QCOP 0050-01 and 02. This is to prevent logic interlocks or failures from causing/preventing operation of breakers. All breaker operation is manual during the restoration procedure QCOP 0050-08, FLEX Electrical Restoration. These actions will assure proper restoration of equipment necessary to support the FLEX Phase 2 Strategies.

3.3.5 Key Reactor Parameters

Instrumentation providing the following key parameters is credited for all phases of the FLEX strategy with the indication available in the MCR:

- RPV Level
- RPV pressure

The above instrumentation is available before and after load shedding of the DC busses during an SBO/ELAP response procedure implementation. Additional instruments for monitoring of parameters are restored following AC power during entry into Phase 2 recovery.

QCOP 0050-09, FLEX Response Instrumentation, provides detailed lists of all instrumentation, including Main Control Room, Local Instrument Racks, and the associated power supplies. In addition, indicators on local racks that are not dependent on power are provided. Alternate methods for obtaining the necessary pressure and reactor levels are also detailed in the procedure.

3.3.6 Thermal Hydraulic Analysis

Modular Accident Analysis Program version 4 (MAAP4) computer code was used to simulate the Extended Loss of AC Power (ELAP) event for Quad Cities and is an acceptable method for establishing a timeline which meets the intent of NRC Order EA-12-049. Figure 6 below uses data from the MAAP case of record (Reference 20, Case 6), and illustrates that RPV level remains above the Top-of-Active-Fuel (TAF) using RCIC for RPV makeup during the event. RPV level is stabilized with RPV pressure in the 150 – 250 psig band.

The Quad Cities Overall Integrated Plan (OIP) states the operators would commence a cooldown of the RPV at a rate of 80°F/hr after the RPV water level reaches +40", which is within the technical specifications limit of 100°F/hr. The following plot of the RPV pressure from the MAAP analysis uses a cooldown initiation setpoint of +40" water level in the RPV.

For the representative MAAP run (Case 6), the collapsed RPV water level inside the shroud remains above TAF for the duration of the analysis. The plot below shows that the lowest RPV level, calculated by MAAP, was approximately -40" below Instrument Zero. TAF is located at -142" relative to Instrument Zero, which is +503" Above Vessel Zero. As shown in the following plot, the collapsed RPV water level remains at least 8.5' above TAF for the duration of the analysis.

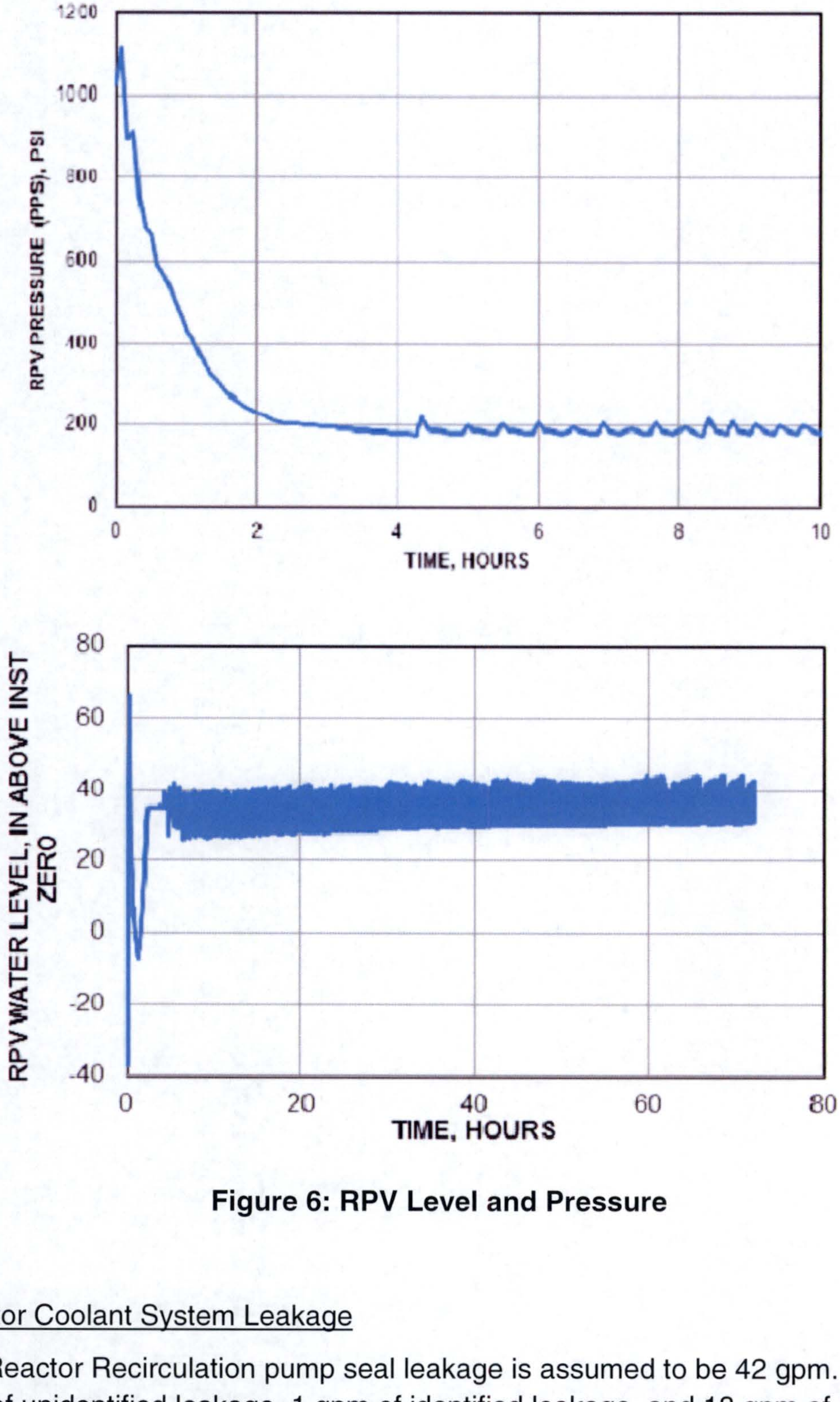

Figure 6: RPV Level and Pressure

3.3.7 Reactor Coolant System Leakage

The Reactor Recirculation pump seal leakage is assumed to be 42 gpm. This includes 5 gpm of unidentified leakage, 1 gpm of identified leakage, and 18 gpm of RR pump seal leakage per pump. Per QC-MISC-013 (Reference 20), this is modeled in MAAP as a hole of fixed size which yields 42 gpm leakage at 1000 psig. Therefore, the leakage is limited by reactor pressure. For phase flow, QC-MISC-014 Rev 0, use of MAAP in support of FLEX Implementation, (Reference 21) discusses the phase flow from reactor vessel leakage. Reactor Recirculation seal leakage is single-phase liquid, due to the location of the break (low in the RPV) with RPV level continually maintained above TAF.

QCOS 1600-07, Reactor Coolant System Leakage in the Drywell (DWFDS and DWEDS Available) (Reference 82), provides administrative controls for monitoring and responding to changes in Drywell leakage rates. Historical data demonstrates normal Drywell Leakage rates at Quad Cities Station are relative to NEI 12-06 section 3.2.1.5, Reactor Coolant Inventory Loss. Also, QCOP 0050-08, FLEX Electrical Isolation, provides direction to isolate RR Pump Seals upon restoration of 480 VAC via the FLEX Diesel Generators.

3.4 Containment Integrity

During an ELAP, Suppression Pool (SP) temperature rises as the Electromatic Relief Valves (ERVs) relieve RPV pressure to the SP and operators conduct a controlled cool-down. RCIC will be used for RPV level control, and the RCIC turbine exhaust also adds heat to the SP. As SP temperature rises, Wetwell air space temperature and Containment pressure also rise. A strategy to remove heat from the SP using the Hardened Containment Vent System (HCVS) mitigates the challenge to the Primary Containment Pressure Limit (PCPL) and controls Containment and SP temperature at values that do not threaten Primary Containment integrity.

A generic concern is related to adoption of Revision 3 to the BWROG EPG/SAG concerning potential detrimental effects on Containment pressure. On January 9, 2014, the NRC informed NEI (Reference 129) that changes to Containment venting strategies as described in the BWROG information report "BWR Containment Venting" Revision 1, dated October 29, 2013, (References 130, 131 and 132) are acceptable for Order EA-12-049.

3.4.1 Phase 1

During Phase 1, Containment integrity is maintained by normal design features of the Containment, such as the Containment Isolation Valves. In accordance with NEI 12-06, the Containment isolation actions delineated in the SBO procedure are sufficient.

Reactor Pressure Vessel pressure will be gradually reduced with ERVs to approximately 150 psig, while the SP has sufficient heat capacity to absorb a portion of the sensible heat in the reactor. The pressure will be controlled between 150 – 250 psig. Decay heat will continue to heat-up the SP during the initial phase through RCIC turbine exhaust and

ERV operation. The HCVS will be utilized at EOP direction as necessary to reduce Containment pressure.

Suppression Pool Level, Containment Pressure and Suppression Pool temperature instruments remain available during Phase 1 since they are powered from the Essential Service System (ESS). (See Section 3.1.3.)

Containment heat removal will be through use of the HCVS, designed and constructed to NEI 13-02 (Reference 66) to comply with NRC order EA-13-109 (Reference 65). The HCVS requires no external power or motive air for 24 hours.

3.4.2 Phase 2

During Phase 2, Containment pressure control and heat removal will continue to be maintained using the HCVS. Reactor water level control will transfer from the RCIC system to the use of FLEX/SAWA pumps. This will initially create a greater heat input to the Containment as reactor pressure is reduced while the RPV blowdown is completed.

Suppression Pool water addition is necessary to maintain level to replenish water lost through the Containment vent. The SP water level band specified in QGA 200, Primary Containment Control (Reference 36), allows the operators to maintain level in the range below the Suppression Chamber vacuum breakers (17 feet) and above the downcomers (11 Feet). The FLEX supply manifold to the Condensate transfer connection to RHR, or alternatively the "A" RHR Drywell spray header, will allow water to be diverted through the Torus Spray SV (MOV 1(2)-1001-37A/B) or Torus Cooling SV (MOV 1(2)-1001-36A/B). These two valves are located outside the Primary Containment and can be operated either manually with the handwheel, or electrically with power supplied by a FLEX diesel generator.

The HCVS batteries can be recharged by restoring the battery charger AC feed from a FLEX diesel generator through MCC 19-3. The motive power for cycling HCVS AOV valves is from a bank of gas bottles located to allow replacement as needed.

3.4.3 Phase 3

The Phase 3 strategy is to use the Phase 2 connections, both mechanical and electrical, but supply water using Phase 3 portable pumps and AC power using Phase 3 portable generators as necessary. The Phase 3 equipment will act as backup or redundant equipment to the Phase 2 portable equipment and is deployed from an off-site facility to Quad Cities Power Station. The off-site facility supplying this equipment is the National SAFER Response Center (NSRC) through contractual agreements with the Pooled Equipment Inventory Company (PEICo). The NSRC supports initial FLEX equipment delivery to the site within 24 hours of a request per the Quad Cities SAFER Response

Plan (Reference 32). The SAFER Response Plan defines the actions necessary to deliver specified equipment to Quad Cities. Designated local staging areas have been selected for deployment of the requested SAFER equipment. Resources will be available, and sufficient, at the times required for Phase 3 implementation.

No plant modifications have been installed to support mitigating strategies for Phase 3. The majority of Phase 3 equipment can mate to connection points established for Phase 2 equipment and strategies. Other Phase 3 equipment that is neither backup nor redundant to Phase 2 may be applied towards recovery efforts.

3.4.4 Systems, Structures, and Components

3.4.4.1 Hardened Containment Vent System (HCVS)

The HCVS consists of the piping, valves, solenoid valves powered by a dedicated battery system, compressed argon purge gas, and compressed nitrogen motive gas to allow venting directly from Primary Containment to an elevated release point. It was designed to meet the requirements of EA-13-109, but support for RCIC operation as part of the FLEX response was included in the design. To support FLEX, the HCVS meets the following design bases (References 83, 84, and 85):

- The HCVS limits the long-term bulk temperature of the Suppression Pool to 240°F without spray operation. It does this through continuous venting of the Suppression Pool starting at 25 psia, which then responds as a saturated water system.

- The solenoid valves allow remote operation from the MCR. Local bypass valves allow operation of the system at the HCVS Remote Operating Station (ROS) located near the centerline of the Mezzanine Level of the Turbine Building (EL 611').

- The HCVS is designed to perform its functions following a BDBEE, especially tornados and seismic events.

- The HCVS is principally required to vent the steam flow equivalent of 1% of reactor power by EA-13-109. The ability to vent and limit temperature of the Suppression Pool was included in vent sizing during design and bounds the 1% flow requirement.

- Due to Quad Cities being a multiple Unit Site, the impacts of a Severe Accident were included in HCVS design, with the attendant radiation impacts upon FLEX response actions. Even if one Unit progresses to a

Severe Accident, the Site is capable of FLEX actions in the Unit that is not undergoing a Severe Accident.

3.4.4.2 RHR / Torus Water Addition

Connections of FLEX water system, power supplies and logic failures for the RHR system is discussed in section 3.3.4.3 (RHR / LPCI system).

In addition, RHR system MOV's 1(2)-1001-34A/B, 1(2)-1001-36A/B and 1(2)-1001-37A/B provide the path for Torus water addition. All these system MOVs are re-powered from the normal power supplies following connection and operation of the FLEX Generators.

3.4.5 Key Containment Parameters

Instrumentation providing the following key parameters is credited for all phases of the FLEX strategy with the indication available in the MCR (Reference 2):

- Drywell Pressure
- Containment level
- Suppression Pool Temperature
- Suppression Pool Pressure

The above instrumentation is available prior to and after DC load shedding of the DC busses during SBO/ELAP response procedure implementation for up to 6 hours. Additional instruments for monitoring many of the parameters listed, are restored after restoration of AC power during entry into phase 2 recovery.

Alternate methods for obtaining the critical parameters locally are provided in FLEX Support Guide QCOP 0050-09, FLEX Response Instrumentation and Communication Equipment.

3.4.6 Thermal-Hydraulic Analyses

The MAAP4 computer code was used to simulate the Extended Loss of AC Power (ELAP) event for Quad Cities and is an acceptable method for establishing a timeline which meets the intent of NRC Order EA-12-049 (References 20 and 21). Several Quad Cities Modular Accident Analysis Program (MAAP) cases were run to analyze methods of containment response using the FLEX strategy with multiple flow correction factors to assist in Hardened Containment Vent system piping design. The hardened containment vent path modeled in this analysis represents a design of the QCNPS hardened containment venting system.

The following initial conditions and time constraints were used as MAAP input parameters:

- Initial suppression pool (SP) level is 14.05 feet
- Initial suppression pool (SP) temperature is 92.5°F (conservative)
- Initial containment pressure is 0 psig to 1.2 psig (varies by location)
- Initial containment temperature is 92.5°F in the torus to 150°F in the drywell and pedestal
- RCIC and HPCI are started manually at t=5 minutes. HPCI is secured whenever RPV water level indication shows greater than 40" above instrument 0".
- RCIC operates with suction from the suppression pool and with no suppression pool cooling (i.e., CCST is not credited)

Specific manual actions or plant responses include the following:

- HPCI and RCIC are manually started at t=5 minutes. HPCI is secured when the RPV water level reaches +40". After HPCI is secured operators commence 80°F/hr cooldown using ERVs. RPV pressure is controlled between 150 and 250 psig.
- Once RPV cooldown is complete, RPV Pressure is controlled between 150 and 250 psig. The continued operation of RCIC at this RPV pressure range should be supported and justified by technical analysis.
- RCS leakage is 42 gpm (including RR pump seals leakage) conservatively assumed to begin at t=0. This includes 5 gpm unidentified leakage (Tech Spec maximum), 1 gpm identified leakage, and 18 gpm recirc pump seal leakage per pump. The leakage is modeled as a hole of fixed size which yields 42 gpm leakage at 1000 psig. At lower RPV pressure, the flow rate will decrease.
- When containment venting is credited, the vent is opened from the torus at a drywell pressure of 25 psia. This corresponds to a saturation temperature of 240°F and will maintain conditions below primary containment pressure limit (PCPL).
- When external injection to the suppression pool is credited, the injection is initiated at the time the containment vent is opened.

The MAAP Case 6 (Reference 20) results are summarized below and shown graphically in Figure 7 MAAP Containment Results.

Peak SP Temp (°F)	232
Peak Wetwell Airspace Temp (°F)	249
Peak Wetwell Airspace Press (psia)	25.2
SP Level (ft)	Min=13.8, Max=14.4
Peak Drywell Airspace Temp (°F)	262
Peak Drywell Airspace Press (psia)	25
Min RCIC NPSHA (ft)	14.4
HCTL Exceeded (hr)	5.5
SP Temperature > 230°F (hr)	14.2
PSPL Exceeded (hr)	Not exceeded
DW Temperature > 280°F (hr)	Not exceeded
PCPL Exceeded (hr)	Not exceeded(1)

(1) Containment vent opened prior to drywell pressure reaching 25 psia.

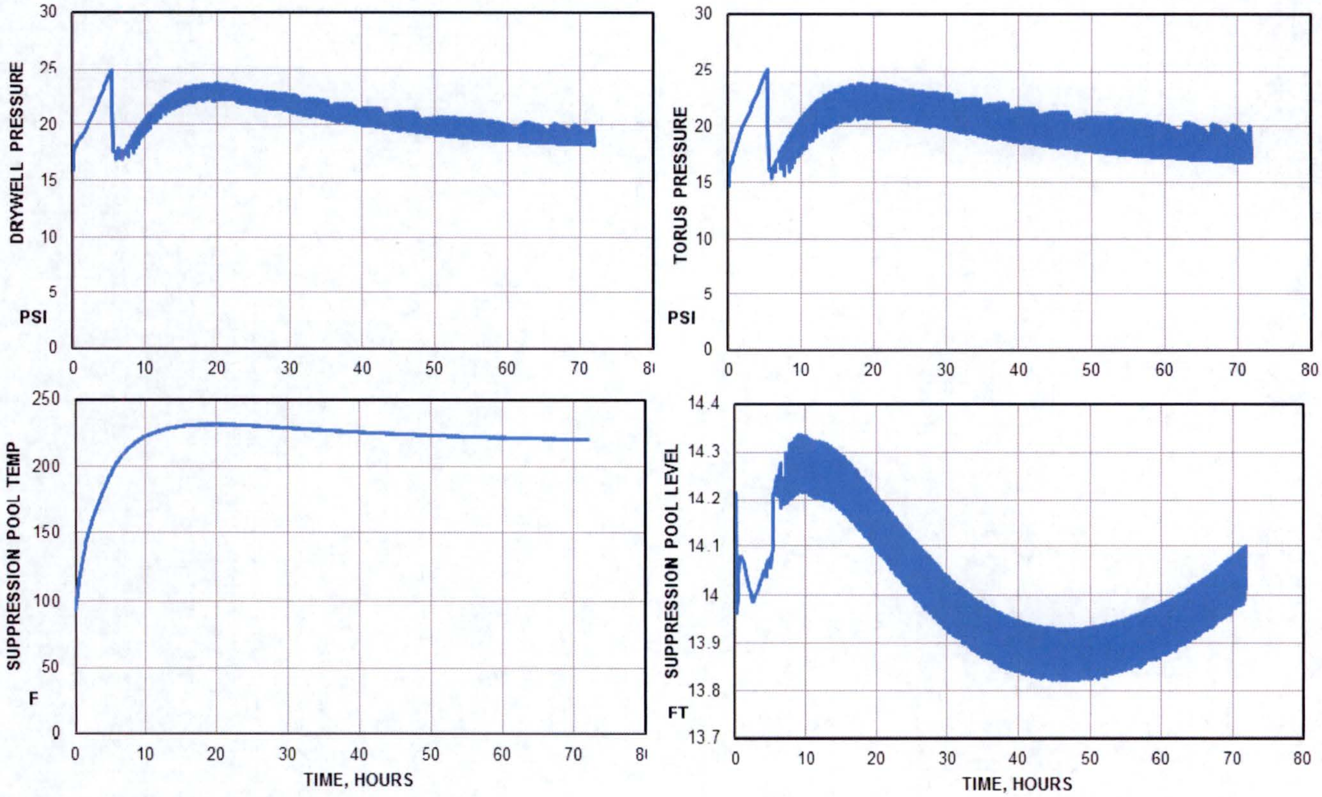

Figure 7: MAAP Containment Results (Reference 20)

3.4.7 Impact of Elevated Containment Temperatures

The Quad Cities MAAP scenario results indicate that at t_0 + 72 hours conditions in the drywell (i.e., pressures and temperatures) have either stabilized or are in a downward trend. Continued operation of HCVS after 72 hours combined with the relatively low decay heat in the reactor will prevent further rises in drywell pressures and temperatures. NUREG-2122 Glossary of Risk-Related Terms in Support of Risk-Informed Decision making (Reference 38) defines a safe stable state as:

- Condition of the reactor in which the necessary safety functions are achieved.
- In a PRA, safe stable states are represented by success paths in modeling of accident sequences. A safe stable state implies that the plant conditions are controllable within the success criteria for maintenance of safety functions.
- The ASME/ANS PRA Standard (Reference 63) defines the term safe stable state as "*a plant condition, following an initiating event, in which reactor coolant system conditions are controllable at or near desired values.*"

3.5 Spent Fuel Pool Cooling/Inventory

The Quad Cities Spent Fuel Pool (SFP) consists of two pools connected by an open transfer channel and located on the Refuel Floor 690' inside the Secondary Containment. It provides specially designed underwater storage space for the reactor spent fuel assemblies which require shielding and cooling during storage and handling. Normal makeup water source to the SFP is from Condensate Transfer System. The basic FLEX strategy for maintaining SFP cooling is to monitor SFP level and provide makeup water to the SFP sufficient to maintain substantial radiation shielding for a person standing on the SFP operating deck and cooling for the spent fuel pool (Reference 75).

3.5.1 Phase 1 Strategy

There are no Phase 1 actions required. The FLEX strategy beginning during Phase 1 of an ELAP/LUHS event for SFP cooling is to utilize the SFP water level instrumentation installed in response to NRC Order EA-12-051 (Reference 4) to monitor the SFP water level. Within the first 12 hours, stage a FLEX pump for the addition of makeup water to the SFP as it is needed to restore and maintain the normal level in Phase 2. Additionally, hoses stored on the Refuel Floor are deployed as a contingency to spray the pools or provide makeup water to maintain normal level should the primary method be unavailable.

3.5.2 Phase 2 Strategy

After the SFP reaches the boiling point a source of makeup water will need to be provided to ensure the fuel in the SFP remains cool and radiological conditions on the fuel handling floor do not degrade (Reference 75). The primary makeup water method uses the Unit 1 RHR to Fuel pool cooling return line to the SFP via a Storz hose connection on the ground floor of the RB to supply the required 100 gpm flow. Manual valve 1-1901-64, U1 RHR Sys To Fuel Pool SV, is opened to complete the valve lineup and allow makeup to the fuel pools from a FLEX pump as directed by QCOP 0050-06.

Alternatively, the hoses discussed in the Phase 1 strategy section can be connected to the FLEX Valve Manifold to provide makeup or spray the SFP if necessary. If required, the hoses can supply two monitor nozzles staged on the Fuel Handling Floor to provide the SFP with 250 gpm of spray flow. Oscillating monitor nozzles are used to provide spray flow to each of the Spent Fuel Pools.

3.5.3 Phase 3 Strategy

Phase 3 Strategy is to continue with the Phase 2 methodologies using a FLEX Pump. Additional Pumps will be available from the NSRC as a backup to the on-site FLEX Pumps.

3.5.4 Structures, Systems, and Components

The Fuel Pool Cooling and Cleanup (FC) System is designed to remove decay heat generated by the SFP assemblies from the spent fuel pool water. The FC System is also designed to clarify and purify spent fuel pool, transfer canal and refueling water.

The Fuel Pool FLEX connection has been installed and procedures provide direction for hose deployment and establishing restoration of water to the spent fuel pool.

Procedures QCOP 0050-04 FLEX Refuel Floor Actions, QCOP 0050-05 FLEX Hose Deployment, QCOP 0050-06 FLEX RPV, Suppression Pool, Spent Fuel Pool Level Control all have elements that support habitability of the area and actions to supply the SFPs with makeup.

The SFP is designed for the underwater storage of spent fuel assemblies and control rods after their removal from the reactor. Maintaining an adequate water level in the SFP ensures the integrity of the spent fuel racks and decreases the radiation dose rate in the area around the pool.

The existing SFPLI system is composed of a level switch that provides a signal to an alarm in the MCR when the water level in the SFP reaches either the high- or low-level setpoint. The existing SFP level instrumentation system does not meet the requirements set forth under NRC Order EA-12-051.

3.5.5 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 has been installed in response to Order EA-12-051, Reliable Spent Fuel Pool level Instrumentation and complies with the industry guidance provided by the Nuclear Energy Institute guidance document NEI 12-02.

Two new Westinghouse Guided Wave Radar (GWR) wide-range level instrumentation systems for primary and backup indication of the SFP level were installed EC 393703, Install Remote Readout Capability for Spent Fuel Pool Level Instrumentation – Fukushima (Reference 16). The new systems are composed of a GWR level sensor, level transmitter and a local electronics box that contains the level indication for the SFP. To ensure adequate channel separation, the level sensor for the primary channel will be mounted in the northeast corner of the Unit 1 SFP on an existing abandoned jib crane plate. The level sensor for the backup channel will be mounted in the southeast corner of the Unit 2 SFP on an existing abandoned jib crane plate. Since the two level probes are installed in separate SFPs, they are separated by a distance in excess of 33 feet, which is the length of the shortest SFP wall. Additionally, the interlocking gates connecting the Unit 1 and Unit 2 SFPs, which per procedure QCFHP 1200-14 (Reference 133) are normally left removed, will be administratively controlled to ensure a crosstie between the two bodies of water. This will allow the separate SFPs to be treated as a single body of water and satisfy the NRC Order requirement that a primary and backup channel be installed. The other associated components will be installed on different units with Unit 1 being the primary channel and Unit 2 being the backup channel.

The level transmitter and level indicating display for the primary and backup channels will be installed in Unit 1 and Unit 2 Turbine Buildings, respectively. The 120 VAC power for the primary and backup level indicating displays are provided from Unit 1 and Unit 2 instrument buses. The two installed systems will function as completely independent channels to ensure that a single power source failure will not disable both primary and backup indications. In addition to the normal 120 VAC power supply, each channel has battery backup that will last for at least 72 hours during loss of AC power due to a BDBEE. Before the batteries are depleted, FLEX mitigation strategy will restore power when the FLEX Diesel Generator is connected to the instrument bus. An additional utility plug was installed on the bottom of the indication panel which will allow a portable AC source to repower the system.

The power and instrument cables will be routed on the Unit 1 side for primary channel and on the Unit 2 side for the backup channel. Therefore, adequate separation is maintained between the primary and backup channels. Both primary and backup channels will utilize the same technology.

The Spent Fuel Pool levels of interest are listed below. These are not setpoints, but instead are meant to correlate the indicated water levels to the amount of coverage of fuel assemblies in the pool.

- Level 1 - This is the level that is adequate to support operation of the normal fuel pool cooling system. At Quad Cities, this corresponds to water level at elevation 686'-2" (approximately 20' above the top of the fuel rack).

- Level 2 – This is the level that is adequate to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck. Designation of this level should not be interpreted to imply that actions to initiate water make-up should be delayed until SFP water levels have reached or are lower than this point. At Quad Cities, this corresponds to water level at elevation 676'-2" (approximately 10' above the top of the fuel rack).

- Level 3 – This is the level where fuel remains covered and actions to implement make-up water addition should no longer be deferred. Designation of this level should not be interpreted to imply that actions to initiate water make-up should be delayed until this level is reached. At Quad Cities this is defined to be the bottom of the gate opening elevation 666'-8 1/2" rather than the top of the storage rack elevation of 666' 2" to demonstrate that both the primary and backup SFP level instrument channels can measure the same Level 3 elevation in both SFP's.

3.5.6 Thermal-Hydraulic Analyses

Below is a description of the SFP and the decay heat loading for the pool, effects from loss of cooling are also included which indicate no operator action is required for 74.1 hours (time to boil off to the top of fuel racks) after loss of cooling using the Full Core Offload (Reference 17).

Case 1 Full Core Offload (FCO) - This full-core discharge case assumes an initial pool temperature is 150 °F, the peak decay heat load in the pool is 44.3 MBtu/hr and the initial SFP water level is the Technical Specification minimum of 19 feet above fuel. The calculated time to boil is 6.7 hrs. The calculated time to reach 12 ft. of water above the fuel from the onset of the ELAP is 31.5 hrs. The calculated time to reach the top of fuel is 74.1 hrs.

Case 2 Partial Core Offload (PCO) - This normal batch discharge case assumes an initial pool temperature is 150 °F, the peak decay heat load in the pool is 22.3 MBtu/hr and the initial SFP water level is the Technical Specification minimum of 19 feet above fuel. The calculated time to boil is 13.5 hrs. The calculated time to reach 12 ft. of water above the fuel from the onset of the ELAP is 62.8 hrs. The calculated time to reach the top of fuel is 147.3 hrs.

The analysis of Case 1 shows that the spent fuel pool peak make-up rate to keep up with boil-off at 92 gpm with 95 °F water, which is less FLEX spent fuel pool water makeup system capability of 100 gpm. The analysis of Case 2 shows that the spent fuel pool peak make-up rate at 46 gpm with 95 °F water.

3.5.7 Impact of Elevated Refuel Floor Temperature

Calculation 2014-02948, Reactor Building Temperature Analysis Resulting from Extended Loss of AC Power (Reference 18) was developed to determine the habitability (temperature and humidity) throughout areas of interest in the Reactor Building during an ELAP based on the processes outlined in NEI 12-06. The results of this analysis are based on operator actions discussed in section 4.3.3.

Heat load inputs within the calculation included the following:

- RCIC piping, turbine/pump (including seal leakage) and support equipment while in operation
- Suppression Pool, Torus Airspace and Drywell temperature profiles taken from the MAAP Analysis used to support the FLEX strategy
- Electrical equipment – lighting and residual equipment heat
- Hardened Containment Vent Line
- Spent Fuel Pool
- Solar Radiation
- Maximum Outside temperature

Two cases were analyzed:

Case 1, the BDBEE with the EL. 690.5' equipment hatch covered by tarps.

Case 2, the BDBEE with the EL. 690.5' equipment hatch open.

Both Cases indicate that habitable conditions on the Fuel Handling Floor slowly worsen as temperature rises until t_0 + 25 hours when the rate of rise stops in the SFP area. This impacts the safety function strategies as follows:

1) Core Cooling – the RPV makeup from the FLEX pump building internal connections are located on the EL 595' and are completed in approximately 6 hours from t_0, therefore these temperatures will have minimal effect.

2) Containment Integrity – similar to the core cooling function, the Suppression Pool makeup from the FLEX pump uses the same hose connection and uses RHR system valves to divert flow, therefore these temperatures will have minimal effect.

3) Spent Fuel Pool Cooling – the SFP alternate fill and spray strategy uses hose connections, to monitor spray nozzles staged on the Refuel Floor. Priority is placed on these actions within QCOA 6100-04, Station Blackout Attachment D, ELAP actions, instructs performance of QCOP 0050-04, FLEX Refuel Floor Actions, which alerts the operators to complete the actions promptly due to habitability concerns on the Refuel floor.

4 Support Strategies

4.1 Refueling FLEX Equipment

The FLEX strategies for safety functions and/or maintenance of safety functions involves several elements including the supply of fuel to necessary diesel-powered generators, pumps, hauling vehicles, etc. The general coping strategy for supplying fuel oil to diesel driven portable equipment is:

1) maintain the FLEX 500 kW Generator fuel tanks at least 50% full,

2) maintain the FLEX pump fuel tanks near full

3) replenish supplies with fuel stored in an installed Emergency Diesel Generator Fuel Oil Storage Tank (FOST).

4.1.1. Minimum Diesel Fuel Available

The available fuel is verified daily to be ≥ 205 gallons in each Fuel Oil Day Tank (FODT) and ≥ 10,000 gallons in each Fuel Oil Storage Tanks (FOST). In actual practice, the Fuel Oil Transfer Pumps would normally auto-start with a minimum 592 gallons in each FODT. The administrative minimum FOST level is 12,000 gallons, but not to exceed 13,750 gallons. Since there are three sets of tanks, the minimum onsite fuel inventory is 3 x 12,592 = 37,776 gallons.

4.1.2. Diesel Fuel Potentially Available (not seismic, not wind protected)

SBO main storage tank lower limit 70% of 15,000 gallons = 10,500 gallons.
Two SBO Day Tanks at 530 per tank when level is at 42% (min level) = 1060 gallons.
Two Fire Diesel Day Tanks at 530 gallons per tank (min level) = 1060 gallons.
Security Diesel Fuel Tank capacity of 560 gallons, with minimum level of 400 gallons.
Total non-qualified oil on-site is 13,020 gallons

4.1.3. Diesel Fuel Consumption Rates

The FO consumption rates were calculated EC 399944, FLEX Diesel Fuel Plan (Reference 22) based upon the expected equipment use and loading. The following specifies the expected consumption.

1) Three Flex DGs

2) Four Portable DGs

3) One FLEX Diesel Pump

4) Diesel Transfer Truck

Therefore, the total fuel consumption rate 60.9 gallons/hour and site durations are 25 days for all diesel fuel on site and 8 days of operation for a single FOST.

4.1.4. Fuel Oil Transfer

The FLEX diesel generators would be stationed at or near the ½ Trackway, or U2 Trackway based on the chosen strategy. Both Trackways are less than 1000' from the FLEX fuel oil connection installed under EC 395862, Install Fuel Oil Connections for Transfer Operations to F750 Truck Fukushima- FLEX Strategy (Reference 44). Given this distance, stored hoses alone are capable of supplying fuel oil to the various engines. This method of fuel oil supply is not dependent on truck access and supply path.

If the FLEX Truck (Operations F-750), which has a bed mounted fuel storage tank and PTO driver fuel transfer pumps, is available, this equipment can be utilized. The pathway will be the roadway on the East side of the plant from the U1 Trackway to the Unit 2 Trackway. The stability of this path is among those areas considered by the FLEX Liquefaction study, QDC-0000-S-2134, FLEX Travel Path Liquefaction Evaluation (Reference 19).

QCOP 0050-12 FLEX Generator / Pump Refueling, provides the direction to the recovery personnel for refueling the FLEX equipment with multiple methods using both installed and portable transfer pumps. EC 399944 (Reference 22) evaluated the plan and responded to ISE audit report items. The multiple diverse methods are listed below:

1) U1 EDG Fuel Oil transfer system

2) Petro-Guard Fuel Oil transfer pump

3) Fill-Rite Heavy Duty Fuel Oil Transfer pump to truck fuel transfer tank

4) Gravity draining the EDG Day Tanks to the truck fuel transfer tank

4.2 Local Intense Precipitation (LIP)

The Local Intense Precipitation Event is a flooding scenario resulting from a localized extreme rainfall. The maximum water depth varies around the site with the most significant water depths primarily on the east side of the Reactor Building and Turbine

Building. In some locations the water depths approach 4.5 feet above plant grade elevation.

Prior to flood waters entering plant and impacting critical equipment, barriers are deployed at doorways and critical locations to provide a protection boundary around necessary critical equipment. Additionally, barriers are deployed at the FLEX Robust Building to protect portable FLEX equipment. Normally installed plant equipment will be utilized to maintain the plant in a safe condition until flood waters recede to an acceptable level at which time portable FLEX equipment can be deployed (References 45 and 46).

4.2.1 RCIC Room

The RCIC room will reach 150°F in approximately 9 hours (Reference 18). All analyzed BDBEEs except the LIP event allow FLEX equipment deployment before this duration and are thus bounded by this result. A LIP event may prevent external equipment deployment up to 8 hours. These results assume doors opened to start natural circulation, which are already implemented in QCOP 0050-04. There are no other compensating actions planned.

Note that even if Localized Intense Precipitation (LIP) were to prevent FLEX deployment for 10 hours, the ELAP is an extended version of the Station Blackout evaluated in NUMARC 87-00, Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Nuclear Power Plants. In Appendix G of that report, the topical report on the relevant equipment shows reasonable assurance of operability up to 180°F. Per the RB habitability study Appendix M, chart M1, the RCIC Pump Room never reaches 180°F for the 72 hours of the event that were analyzed. Based on this, there is reasonable assurance of RCIC operability throughout all BDBEEs (Reference 18).

EC 395571 Install Storz Connections on ECCS Room Cooler Supply Lines – Fukushima – FLEX Strategy and EC 395572 Unit 2 Storz Connection on ECCS Room Cooler Supply Line - Fukushima (Reference 56) installed Storz connections in the ECCS room cooler supply pipes. FLEX procedure QCOP 0050-17 FLEX RCIC Room Cooler Lineup provides contingency actions for providing FLEX water flow to the ECCS Room Coolers which includes the RCIC room. This procedure will cool the RCIC room if necessary.

4.2.2 Battery Rooms

This calculation, EC 399874 (Reference 53) showed results for Battery Room and Battery Charger Room temperatures during Winter, Summer, and Extreme Summer cases. Since the calculation indicated potential excessive temperatures during the summer cases, results that assumed compensating actions were also included. These compensating actions have been incorporated into QCOP 0050-10, which consist of deployment of portable fans to draw air from outside the Turbine Building to cool the Battery Charger Room. There are no further required actions.

EC 394892, Modify the Battery Room Exhaust Fan Electrical Supply from Emergency Lighting Cabinets (Reference 49), has been installed. Procedure QCOP 0050-10, FLEX Battery Room Ventilation, implements starting the fan, and displaced air is made up from the Turbine Building through the door to the Battery Room. The function of the fan is to prevent hydrogen buildup, and the modification allows powering the fan by a source that will survive a BDBEE.

For high external temperatures, QCOP 0050-10 contains steps for the installation of supplemental electrical fans for the battery and charger rooms with portable diesel generators for electrical feed if necessary.

4.2.3 Refuel Floor / Reactor Building

Ventilation for these areas is provided by opening external building doors on the refueling and ground floors of the Reactor Building thereby allowing natural convection within the building for habitability for personnel performing response action. Procedures QCOP 0050-04 FLEX Refuel Floor Actions, QCOP 0050-05 FLEX Hose Deployment, QCOP 0050-06 FLEX RPV, Suppression Pool, Spent Fuel Pool Level Control all have elements that support habitability of the area and actions to supply the SFPs with makeup.

4.2.4 Main Control Room / Aux Electric Room

A maximum temperature limit of 120°F for habitability of the main control room, the station is using 120°F as the upper limit for the Control Room based on plant's current design and licensing basis for compliance to the SBO. Applicable discussion of this limit is documented in the SER for the SBO rule, dated December 11, 1990 (Reference 41).

Quad Cities Station will employ a "Toolbox Approach" for coping with extreme temperatures during FLEX implementation (Reference 2). Examples of acceptable toolbox actions to cope with extreme temperatures are:

-Opening doors when room temperatures become elevated

-Rotation of personnel

-Use of ice vests, etc. when tasks are in high heat and humidity

-Utilizing small fans for air movement

-Warming/cooling in available vehicles

-Utilizing firefighting turn-out gear to cope with extreme low temperatures

Procedure QCOP 0050-11, FLEX Control Room Ventilation, provides the primary means to ventilate the room and will open the doors and use of portable fans.

4.3 Ventilation

4.3.1 RCIC Room

The RCIC room will reach 150°F in approximately 9 hours (Reference 18). All analyzed BDBEEs except the LIP event allow FLEX equipment deployment before this duration and are thus bounded by this result. A LIP event may prevent external equipment deployment up to 8 hours. These results assume doors opened to start natural circulation, which are already implemented in QCOP 0050-04. There are no other compensating actions planned.

Note that even if Localized Intense Precipitation (LIP) were to prevent FLEX deployment for 10 hours, the ELAP is an extended version of the Station Blackout evaluated in NUMARC 87-00, Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Nuclear Power Plants. In Appendix G of that report, the topical report on the relevant equipment shows reasonable assurance of operability up to 180°F. Per the RB habitability study Appendix M, chart M1, the RCIC Pump Room never reaches 180°F for the 72 hours of the event that were analyzed. Based on this, there is reasonable assurance of RCIC operability throughout all BDBEEs (Reference 18).

EC 395571 Install Storz Connections on ECCS Room Cooler Supply Lines – Fukushima – FLEX Strategy and EC 395572 Unit 2 Storz Connection on ECCS Room Cooler Supply Line - Fukushima (Reference 56) installed Storz connections in the ECCS room cooler supply pipes. FLEX procedure QCOP 0050-17 FLEX RCIC Room Cooler Lineup provides contingency actions for providing FLEX water flow to the ECCS Room Coolers which includes the RCIC room. This procedure will cool the RCIC room if necessary.

4.3.2 Battery Rooms

This calculation, EC 399874 (Reference 53) showed results for Battery Room and Battery Charger Room temperatures during Winter, Summer, and Extreme Summer cases. Since the calculation indicated potential excessive temperatures during the summer cases, results that assumed compensating actions were also included. These compensating actions have been incorporated into QCOP 0050-10, which consist of deployment of portable fans to draw air from outside the Turbine Building to cool the Battery Charger Room. There are no further required actions.

EC 394892, Modify the Battery Room Exhaust Fan Electrical Supply from Emergency Lighting Cabinets (Reference 49), has been installed. Procedure QCOP 0050-10, FLEX Battery Room Ventilation, implements starting the fan, and displaced air is made up from the Turbine Building through the door to the Battery Room. The function of the fan is to prevent hydrogen buildup, and the modification allows powering the fan by a source that will survive a BDBEE.

Additionally, for high external temperatures, QCOP 0050-10 contains steps for the installation of supplemental electrical fans for the battery and charger rooms with portable diesel generators for electrical feed if necessary.

4.3.3 Refuel Floor / Reactor Building

Ventilation for these areas is provided by opening external building doors on the refueling and ground floors of the Reactor Building thereby allowing natural convection within the building for habitability for personnel performing response action. Procedures QCOP 0050-04 FLEX Refuel Floor Actions, QCOP 0050-05 FLEX Hose Deployment, QCOP 0050-06 FLEX RPV, Suppression Pool, Spent Fuel Pool Level Control all have elements that support habitability of the area and actions to supply the SFPs with makeup.

4.3.4 Main Control Room / Aux Electric Room

A maximum temperature limit of 120°F for habitability of the main control room, the station is using 120°F as the upper limit for the Control Room based on plant's current design and licensing basis for compliance to the SBO. Applicable discussion of this limit is documented in the SER for the SBO rule, dated December 11, 1990 (Reference 41).

Quad Cities Station will employ a "Toolbox Approach" for coping with extreme temperatures during FLEX implementation (Reference 2). Examples of acceptable toolbox actions to cope with extreme temperatures are:

-Opening doors when room temperatures become elevated

-Rotation of personnel

-Use of ice vests, etc. when tasks are in high heat and humidity

-Utilizing small fans for air movement

-Warming/cooling in available vehicles

-Utilizing firefighting turn-out gear to cope with extreme low temperatures

Procedure QCOP 0050-11, FLEX Control Room Ventilation, provides the primary means to ventilate the room and will open the doors and use of portable fans.

4.4 Lighting

4.4.1 Station Lighting

Station installed lighting is not utilized during an ELAP event as steps in QCOP 0050-08 FLEX Electrical Restoration, for AC load shedding of lighting is required prior to connection of the FLEX diesel generators due to initial diesel generator loading concerns. As recovery efforts progress and DG load decreases, lighting is restored for habitability of plant areas and to address DG minimal load issues.

4.4.2 Appendix R light packs

Emergency lighting packs are installed throughout the plant to provide general area lighting to assist in installation of FLEX response power cables and hoses required for Phase 2 equipment connections. These lighting packs were not installed with seismic design criteria and are therefore not credited during the response measures but will be available following the initiating event. Walk-downs of the travel paths and connection points were reviewed, and the illumination provided by the light packs will provide sufficient lighting (Reference 50). One Flex light head was installed on an Appendix R battery pack to improve the lighting for U1 FLEX hose connection (Reference 52).

4.4.3 Personnel Lights

QCOP 0050 procedures – particularly QCOP 0050-03 - to be used for ELAP event response provide direction for the use of the Appendix R tools which includes hands free flashlights. Additionally, Equipment Operators are provided hands free hard hat lights as part of their normal complement of equipment for job performance, and there are staged flashlights in the Operations Ready Room.

The equipment purchased for the initial Fukushima response includes bar lights which are stored in the FSB.

4.5 Communications

Exelon employs a defense in depth approach to ensure a reliable communication system is available for the MCR and TSC. If during a BDBEE the telephone systems become non-functional, operators and Emergency Response Organization (ERO) personnel shall employ a diverse communications strategy (Reference 70, 144, 145, 146 and 147). Communications were upgraded consistent with the guidance contained in Exelon Position Paper "BDBEE Communications Strategy and Equipment Readiness, dated December 19, 2014 (Reference 69). The purpose of this position paper is to describe the communications strategy for communication systems after a BDBEE as defined in NEI 12-01. EC 399553, EP 9.3 Communications – Satellite Backup and FLEX Phone installation, was utilized to upgrade the communication system (Reference 54).

4.5.1 Fixed Satellite Telephone Systems

For the MCR a fixed satellite system is available with four (4) satellite phones. The MCR system has an uninterruptable back-up power supply and the capability to connect to an AC source supplied by the FLEX generator or a portable generator.

4.5.2 Handheld Iridium Satellite Phones

If the MCR satellite phone system becomes nonfunctional, MCR staff will have access to three (3) Iridium satellite phones available to meet the immediate communications requirements. These Iridium satellite phones are portable and must have a clear view of the southwest sky. The Iridium satellite phones along with spare batteries and battery chargers will be stored in the Aux Electrical Room area. A portable generator is staged in the FLEX building for recharging batteries.

4.5.3 Portable Satellite Systems

For the MCR, a portable back-up satellite dish and communication case is available if the permanently mounted satellite system fails after a BDBEE. The portable communication case and satellite dish can be deployed and connected into the hardwired system since most of the components, other than the non-seismically mounted satellite dish, are in safety-related or seismically rated structures.

TSC/OSC staff has access to a portable satellite communication case, satellite dish, and handsets. These portable satellite communication systems are mounted on trailers and stored in the FLEX Storage Building making them completely mobile and can be operated independent of the installed system.

4.5.4 Radios

Radio communications capability during a BDBEE exists via portable radio to radio talk around frequency. This feature allows station emergency workers to utilize existing station radios generally without the aid of a repeater or antenna system. This capability may be limited to line of sight communication. A total of twenty-five (25) radios are available for ELAP responder use. A total of fifteen (15) radios and three (3) batteries per radio are stored in the FLEX storage building. A portable generator is staged in the same area to charge the batteries if necessary.

4.5.5 Sound Powered Phone System

The function of the Sound Powered Telephone Subsystem is to provide an independent, reliable communications system for plant personnel. In a BDBEE the system allows the Control Room staff to provide direction to plant operators performing actions required during an ELAP when normal communications equipment is not functional.

The system consists of an independent network of connection jacks installed near the panels, racks and other selected locations vital to operation throughout the plant. Headsets are plugged into the jacks to permit communications between remote locations. Sound Powered Phone (SPP) headsets generate the required audio signal with no battery or external AC power to operate.

The station has two (2) headsets in the control room and six (6) additional sound-powered telephones with multiple 100-foot cables stored in the FLEX storage building. Twelve (12) station jacks have been identified that are in or near the locations where operator actions are required. A patch panel in the Main Control Room allows the stations to be interconnected in a network using a patch cord staged in the Main Control Room.

4.5.6 Bullhorns

The primary system to notify plant personnel is the Public Address system. NEI 12-01 states, if portions of the Public Address system are not powered from a battery-backed source, then reasonable alternate methods should exist to provide emergency notification to the plant staff in the areas that would not receive an announcement. To substitute for the non-credited Public Address system, three (3) bullhorns are stored in the Flex Storage building.

4.6 Extreme Cold Protection

The equipment used to support the FLEX strategies is stored either inside the plant or in the FLEX Storage Building which is protected from snow, ice, and extreme cold in accordance with NEI 12-06, and is temperature controlled. FLEX connection points are located inside qualified structures which are temperature controlled; therefore, heat tracing is not used or required.

4.7 Foul Weather Gear

The FLEX water and electrical strategies require outdoor deployment of pumps, generators, hoses, or cables. Operators and support personnel need to travel to the FLEX Storage Building from the power block. The haul vehicle, generators and pumps are stored in the FLEX Storage Building (Reference 50).

The primary (N) FLEX Generators are staged next to the Reactor Building equipment interlock door or U2 Turbine building trackway. Connection cables are stored on the third floor RB and TB to allow top down deployment. The weather proof cable connections at the generators and startup and operation of the generators will be external and may require personnel weather protection.

The FLEX primary water strategy which uses a well generator and motor starter trailer requires deployment done external to building protection. The FLEX alternate water strategy which uses a FLEX pump at the discharge bay is done external to building protection. A majority of the deployed hose is external to buildings. Therefore. fire protection turnout gear, documented in QCOS 4100-34, Fire Brigade Equipment Check Surveillance (Reference 141), is stored and available for use when weather conditions require additional protection. Haul/deployment paths are discussed in a different section of this report.

Procedure SA-AA-111, Heat Stress Control (Reference 142), addresses use of protective clothing, cooling garments and water use for rehydration and addresses protecting employees from adverse effects of performing work in high temperature environments. QCOS 0010-03, Safe Shutdown Equipment Inspection (Reference 143), documents some of the equipment that is maintained available including ice vests. Additionally, personal habitability supplies identified as part of the station FLEX response are being maintained via use of the storeroom inventory process.

5 Hazard Determination

5.1 Seismic

Per the Updated Final Safety Analysis Report Section 3.7, the seismic criteria Safe Shutdown Earthquake for Quad Cities Power Station is 0.24 g horizontal ground motion with a simultaneous vertical acceleration of 0.16 g. These values constitute the design basis of QCNPS. The Quad Cities site screens in for seismic hazard.

Quad Cities performed a Seismic Hazard Reevaluation for recommendation 2.1 of the Near-Term Task Force review of Insights from the Fukushima Dai-Ichi Accident. Initially the station conditionally screened-in and was subsequently notified on October 3, 2014 by NRC letter (Reference 134) that the safe shutdown earthquake (SSE) bounds the ground motion response spectrum (GMRS) and that the station therefore screens out of any further evaluation.

Quad Cities performed a design analysis to evaluate the liquefaction potential of the soil underneath the FLEX Travel Path and Robust FLEX Building for the SSE ground motion (Reference 19). This is in accordance with Section 5.3.2 of NEI 12-06. The calculation conclusions are:

1) There is potential of liquefaction at intermittent depths between about 20 ft. to 50 ft., due to SSE.
2) The SSE induced ground settlements for the Quad Cities FLEX Deployment Path and at the Robust FLEX Building location are a maximum ground settlement is 5 inches. These results were used during the building design or evaluated acceptable when possible ground settlement along the haul path was identified.

5.2 External Flooding

5.2.1 Mississippi River Flood

Quad Cities' UFSAR, Section 3.4, describes the External Flood Protection Measures taken by the station in the event of a Mississippi River Flood. The UFSAR indicates that for floods up to an elevation of 603 feet the plant can be safely shut down and maintained in a safe condition. Mississippi River floods stage levels are predicted several weeks in advance. Therefore, time is available to relocate equipment and stage necessary measures to support plant response to rising water levels. The mitigation measures necessary to safely shut down the plant and maintain it in a safe condition were validated as part of the response provided in the Flood Walkdowns Report NTTF Recommendation 2.3 Flood Walkdowns (Reference 86).

The Quad Cities Flood Hazard Reevaluation Report (Reference 25), was performed against present-day regulatory guidance and methodologies as part of NTTF Recommendation 2.1: Flooding. All applicable hazards were evaluated with the following results for the Mississippi River Flood Event:

- *Flooding of Rivers and Streams* – PMF peak elevation of 600.5 ft., below the design basis flood evaluation
- *Dam and Breaches and Failures* – PMF peak elevation 600.9 ft. below the design basis flood elevation
- *Storm Surge* – Not plausible
- *Seiche* – Not plausible
- *Tsunami* – Not plausible
- *Ice Induced Flooding* – PMF peak maximum 579.8 ft. below the design basis flood elevation
- *Channel Migration or Diversion* – Controlled by the US Army Corp on Engineers
- *Combined Effect Flood (including wind generated waves)* – PMF peak elevation 605 ft. outside building and 600.9 ft. inside building.
- *Debris Loading, Hydrodynamic and Impact Loads* – Hydrodynamic Load = 3.6 lbs./ft. and Impact Load = 480 lbs.

In accordance with NEI 12-06 section 6.2.1, Susceptibility to External Flooding, Quad Cities screens in for external flood hazard.

The results the Quad Cities Flood Hazard Reevaluation Report (Reference 25) were reviewed and it was determined that that mitigation measures necessary to safely shut down the plant and maintain it in a safe condition remain valid for the reevaluated external flooding hazards.

5.2.2 <u>Local Intense Precipitation</u>

The Local Intense Precipitation (LIP) event is not described in the UFSAR, therefore it is a beyond design basis event. As such the LIP has not been previously addressed.

The Quad Cities Flood Hazard Reevaluation Report (Reference 25) was performed against present-day regulatory guidance and methodologies as part of NTTF Recommendation 2.1: Flooding. All applicable hazards were evaluated, and it was determined that Local Intense Precipitation Event results in areas around the plant being inundated with flood waters. The report (Reference 25) summarizes the results of the LIP event.

The Local Intense Precipitation event is a theoretical measure of extreme rainfall which represents the upper limit of rainfall at a given location based on the 1-hour/1-square mile Probable Max Precipitation (PMP). The Quad Cities Specific PMP is 13.6 inches in 1 hour (Reference 87). LIP-QDC-001 Quad Cities Local Intense Precipitation Evaluation (Reference 88) contains a FLO-2D analysis performed to calculate the flooding depths, velocities, hydrodynamic impact loads, and hydrostatic loads associated with a Local Intense Precipitation at Quad Cities Generating Stations. LIP-QDC-001 concluded that a majority of the area surrounding the Reactor Building and Turbine Building will be inundated with flood waters. As such structures, penetrations and doorways up to the maximum LIP flood water depths must be able to protect the plant from water intrusion.

EC 393258 "Evaluate the Effects of the Local Intense Precipitation (LIP) Event and River Flood Event" (Reference 45) defines a flood protection boundary necessary to protect critical equipment from the LIP event. This EC also performs the following:

- Identifies potential leak paths in the flood boundary.
- Provides recommendation for preventing water in leakage through the identified leak paths.
- Assess overall adequacy of the flood boundary with respect to the impacts on structures, systems and components (SSCs) and FLEX equipment.
- Recommends parapet scupper modifications to address LIP rain water ponding on the Reactor Building and Turbine Building roofs.

EC 396297 "Above Grade Flood Barriers for the Local Intense Precipitation (LIP) Event – Fukushima" (Reference 46) implemented modifications to prevent critical plant equipment from being adversely impacted by flood water intrusion. This modification installed new deployable LIP flood barriers, performed modifications to existing structures, doors and penetration seals that compose the flood boundary defined in EC 393258 (Reference 45).

EC 399392 (Reference 47), "Reactor Building and Turbine Building Roof Parapet Alterations – Fukushima," implemented modifications to the roof parapets by cutting scuppers into the parapets to provide faster drainage of the LIP waters off the roofs. These scuppers have been sized to ensure the Reactor Building and Turbine Building roofs drain sufficiently quick to prevent overstressing of the roof structures.

EC 401224 "Determine Warning Time for Local Intense Precipitation (LIP) – Fukushima" (Reference 48), provides the applicable information for determination of the warning time for the LIP event. The warning time was developed in accordance with the "alternate action trigger" guidelines described in Section C.3 of NEI-15-05 (Reference 89).

The precipitation value utilized for the warning time was determined in LIP-QDC-004 (Reference 90). The purpose of this calculation was to determine the precipitation value associated with a consequential flooding event. A consequential flooding event corresponds to the point at which flood water elevations rise above the current protected elevation such that SSCs important to safety are not impacted. Without any barriers installed, a consequential flooding event occurs when water elevation exceeds the door thresholds. This conservative approach was selected rather than performing detailed analysis of flow paths internal to the plant and potential affected SSCs within the associated flow path. LIP-QDC-004 determined that at the most critical location (TB Trackway 1 Door) a 1-hour rainfall with a precipitation value of less than 1.5 inches results in water level above the TB Trackway 1 Door elevation. A 1.5-inch rainfall occurrence is sufficiently high enough that it would cause undue burden to the Operations Staff. As such, a 3.0-inch rainfall value was selected. To prevent flood water elevations impacting SSC important to safety, it is necessary to leave the lower stop log (6 inches tall) installed at the TB Trackway 1 Door and the Trackway 2 Extension Door locations. Additionally, an 8-inch tall berm was installed in the Service Building to facilitate similar protection; EC 401224 provides additional information regarding the installation of this berm.

The conclusions from EC 401224 (Reference 48) were utilized in the development of symptoms for QCOA 0010-22, Local Intense Precipitation Response Procedure (Reference 91), that if met prompts the Operators into subsequent actions which include the installation of the LIP barriers.

5.3 Severe Storms with High Wind

Per NEI 12-06, Figure 7-2, QCNPS is located in Region 1 (specifically, 41° 43' 46" north latitude and 90° 18' 40.2" west longitude) with respect to tornado design wind speeds.

5.4 Ice, Snow and Extreme Cold

QCNPS is located at 41° 43' 46" north latitude and 90° 18' 40.2" west longitude. The guidelines provided in NEI 12-06 section 8.2.1 generally include the need to consider extreme snowfall at plant sites above the 35th parallel, which includes the Quad Cities site. The Quad Cities site is located within the region characterized by EPRI as ice severity level 5, NEI 12-06, Figure 8-2, Maximum Ice Storm Severity Maps (Reference 2). Consequently, the Quad Cities site is subject to severe icing conditions that could also cause catastrophic destruction to electrical power lines.

5.5 High Temperatures

The guidelines provided in NEI 12-06, Section 9.2 include the need to consider high temperature at all plant sites in the lower 48 states. Extreme high temperatures are not expected to impact the utilization of off-site resources or the ability of personnel to implement the required FLEX strategies. Site industrial safety procedures currently address activities with a potential for heat stress to prevent adverse impacts on personnel. Operators will employ a toolbox approach (i.e. ice vests) to mitigate high temperature effects.

6 Storage Building/Haul Routes

6.1 Protection of FLEX Equipment/Storage Building

6.1.1 FLEX Storage Building

Quad Cities Station has constructed a hardened FLEX equipment storage structure to house an "N" set of portable Phase 2 response equipment. The structure is a nominal 60' x 90' building in the northeast corner of the site's protected area, just east of the Interim Radwaste Storage Facility building. EC 398181, Flex Storage Building, (Reference 43) and its associated analyses address the building structure's civil, HVAC, and electrical requirements, including the tie-in to a site power supply. The structure is built to withstand the effects of the applicable BDBEE hazards as discussed in Section 5. Design considerations include:

- Missile doors are installed to protect the roll-up equipment access doors. Concrete missile barriers consisting of stackable concrete blocks on each side of the missile doors are provided to withstand a direct horizontal or vertical hit of the site design basis missiles, ensuring missile door operability.

- For protection from a LIP event, the Robust FLEX Storage Building is elevated approximately 1 foot above grade. Removable LIP barriers are installed for the equipment doors, and the personnel doors are designed to withstand an elevated water condition.

- Large, portable FLEX equipment such as pumps, generators, hose trailers with well pump motor starters, vehicles, and satellite communications trailers stored in the building are secured with tie-down straps to floor anchors integrated into the floor slab to protect them during a seismic event.

No external power is necessary for personnel, roll-up, or missile door operation to deploy the FLEX equipment from the Robust FLEX Storage Building.

6.1.2 N+1 Storage Building

An additional storage building (not robust) was built in the southeast corner of the employee parking lot to house the additional "N+1" FLEX equipment and vehicles required for an ELAP event response (Reference 92).

6.2 Haul Routes/Equipment Deployment

6.2.1 Deployment During ELAP

FLEX Phase 2 response equipment, including pumps, generators, and hoses, is located on trailers which will be hauled to their deployment locations with capable haul vehicles through procedures QCOP 0050-03, Flex Damage Assessment; QCOP 0050-05, Flex/SAWA Fire Hose Deployment; and QCOP 0050-07, Flex Generator and Pump Power Cable Deployment. Power for starting the diesel engine-powered portable equipment will be from contained batteries. The Robust FLEX Storage Building design is such that equipment door operation will not require external power. A potential deployment path via the Reactor Building Trackway has an AC-powered closing wedge that could prevent door operation during an ELAP. The door's hydraulic circuit was modified under EC 398254, Fukushima – Install Connections on the ½ Trackway Door Wedge Hydraulic Lines, (Reference 60) to allow for a locally-connected portable hydraulic pump to retract the wedge. Therefore, no external power is necessary for deployment or operation of the FLEX equipment.

6.2.2 Debris Removal

Procedure QCOP 0050-03 provides the necessary steps in response to an ELAP event to assess the extent of damage to the site buildings and the identification of debris which could impact the deployment of FLEX equipment from the Robust FLEX Storage Building. Quad Cities Station has limited the need for debris removal in the first several hours of the BDBEE through these design considerations:

- Design and construction of the Deep Well water source (see Section 3.2) located close to the Reactor Building and Robust FLEX Storage Building creates short haul and hose deployment paths (see Figure 10).

- Design and construction of the Robust FLEX Storage Building close to the primary and alternate generator deployment locations creates short haul and cable deployment paths (see Figure 10).

- Existing intra-plant roadways around the perimeter of the power block provide two access routes to the FLEX pump deployment area (see Figure 10). These travel paths are wide; it is assumed at least one deployment path would remain traversable with minimal debris removal.

The debris removal equipment includes the plow on the FLEX truck, a 4-wheel drive tractor with a front bucket, and battery- and AC-powered tools for cutting through debris. Also, there is additional hose and cable for manual deployment across debris if the capabilities of the truck and the tractor are exceeded. Validation of deployment procedures is complete and provides times for non-debris deployment.

Debris removal equipment is stored inside the Robust FLEX Storage Building for protection from the applicable BDBEEs such that the equipment will be functional and deployable to clear obstructions from the paths between the equipment's storage and deployment locations. Deployment of the debris removal equipment from the Robust FLEX Storage Building is not dependent on electrical power (see Section 6.2.1).

6.2.3 Other Haul Path Considerations

Liquefaction evaluation (Reference 19) indicates that there is a potential of subgrade liquefaction at intermittent depths below grade during the SSE. The potential resulting SSE-induced ground settlements are less than 1 inch along the deployment paths and are a maximum 5 inches at the Robust FLEX Storage Building (see Section 5.1). This settlement will not affect the equipment deployment.

Procedure QCOS 0050-02, FLEX Haul Path Inspection, inspects external and internal deployment paths that, if blocked, could hamper the deployment of equipment in response to an ELAP event. Included in the procedure are actions to be taken when the surveillance is found unsatisfactory. Per procedure QCAP 1500-07 (Reference 140), Section 1.2.7, a blocked path for greater than 24 hours will be tracked unavailable for no longer than 90 days.

The clearing of FLEX deployment pathways has been incorporated into the site snow removal process. Additional equipment that may be needed include a bolt cutter and proximity voltage detector if downed power lines are encountered.

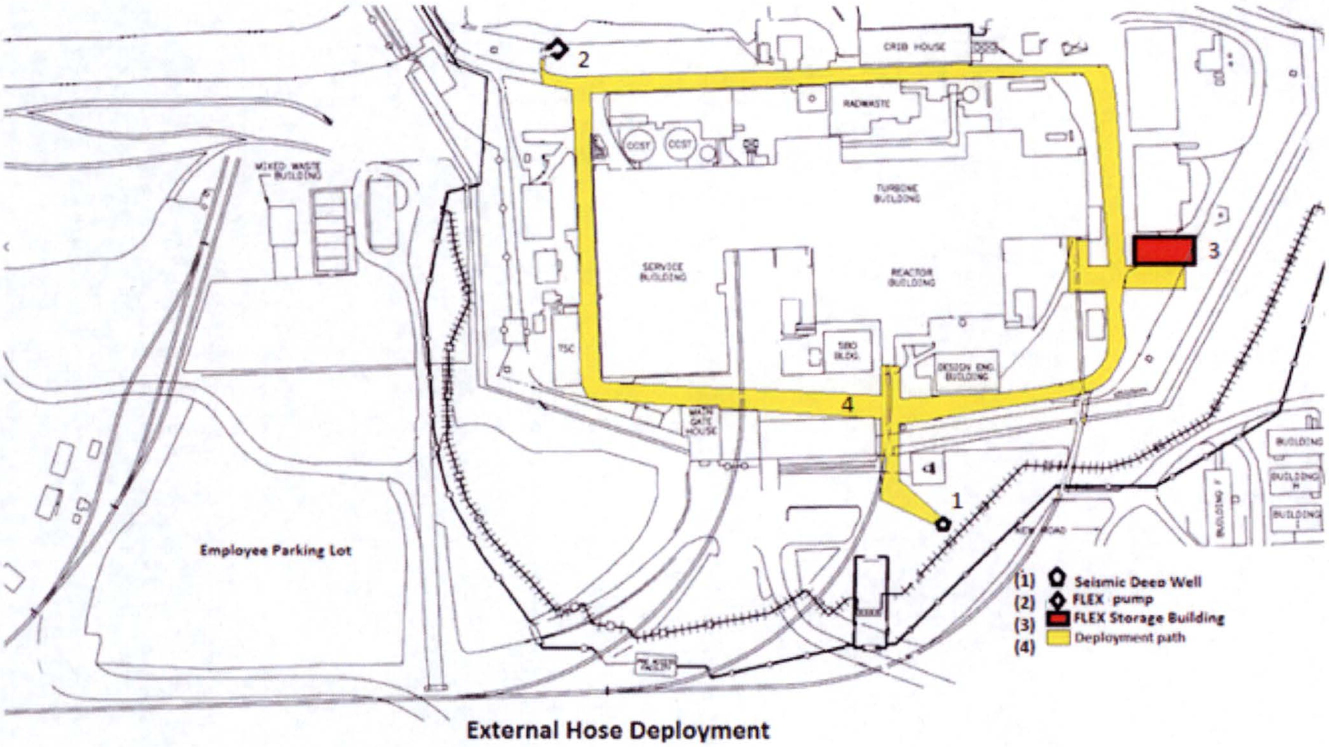

Figure 8: External Generator & Pump Deployment Paths

Figure 8 shows the haul paths from the FLEX Storage Building to the FLEX pump staging area. Included along these paths are the generator staging areas: the northeast corner of Turbine Building, the Deep Well, and the Reactor Building Trackway (see procedure QCOP 0050-07). These haul paths have been reviewed for potential soil liquefaction and have been determined to be traversable following a seismic event. This image comes from QCOP 0050-03 Attachment A.

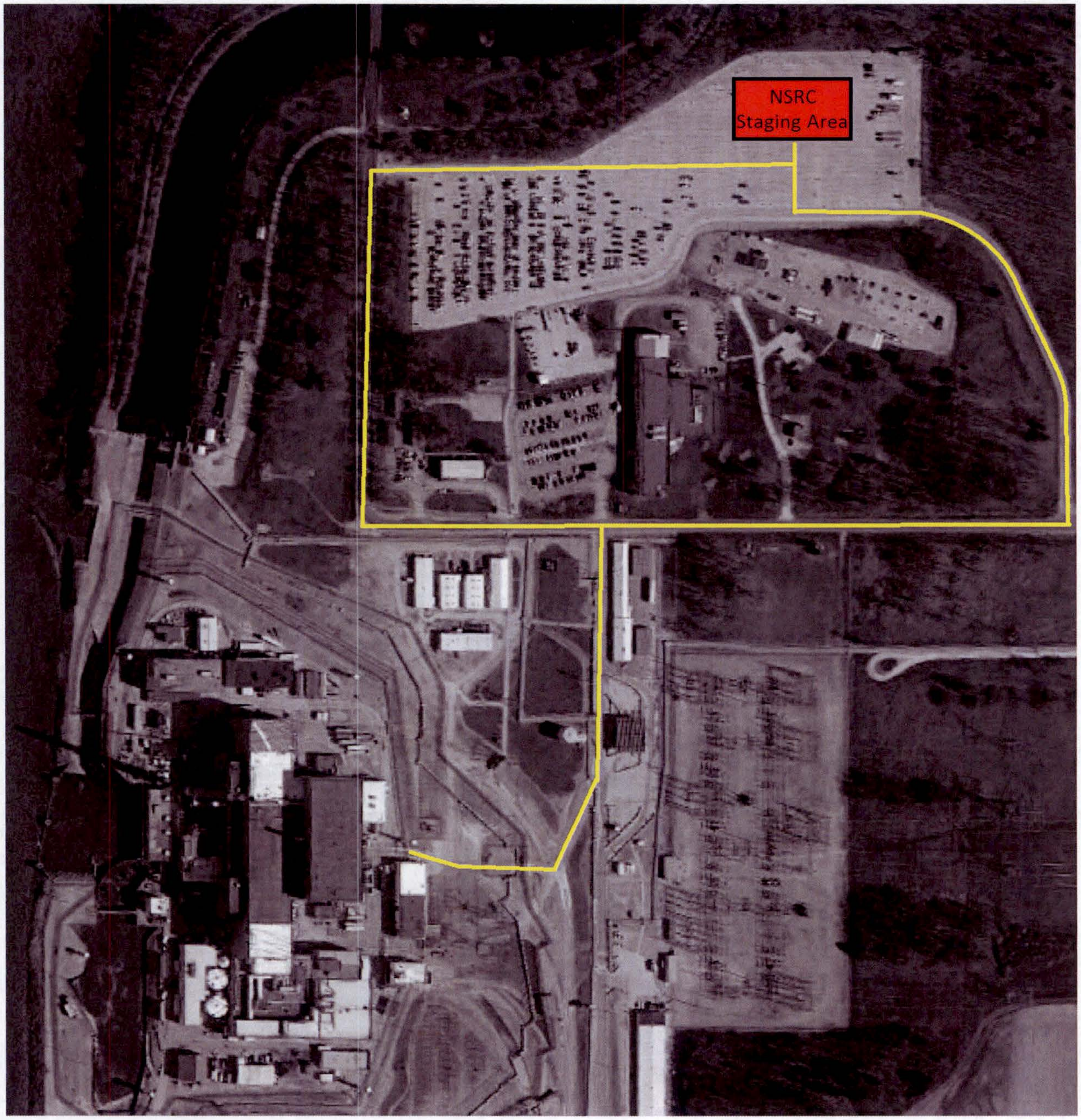

Figure 9: NSRC Staging Area and Haul Paths

Figure 9 shows the haul paths (in yellow) from the NSRC Phase 3 Site Staging area to the FLEX Phase 2 haul paths (see Section 3.3.3). These haul paths have been reviewed for potential soil liquefaction and have been determined to be traversable following a seismic event. See procedure QCOP 0500-16 for more information.

6.3 Accessibility

The potential impairments to required access are: 1) doors and gates, and 2) site debris blocking personnel or equipment access. The coping strategy to maintain site accessibility through doors and gates is applicable to all phases of the FLEX coping strategies but is required as part of the immediate activities during Phase 1.

Doors and gates serve a variety of barrier functions on the site. One primary function is security and is discussed below. However, other barrier functions include fire, flood, radiation, ventilation, tornado, and HELB. As barriers, these doors and gates are typically administratively controlled to maintain their function as barriers during normal operations. Following an a BDB external event and subsequent ELAP/LUHS event, FLEX coping strategies require the routing of hoses and cables through various barriers to connect FLEX equipment to station fluid and electrical systems. For this reason, doors will be opened and remain open. This relaxation of normal administrative controls is acknowledged and is acceptable during the implementation of FLEX coping strategies.

The ability to open doors for ingress and egress, ventilation, or temporary cables/hoses routing is necessary to implement the FLEX coping strategies. Security doors and gates that rely on electric power to operate opening and/or locking mechanisms are barriers of concern. Operators responding to the BDBEE possess keys for defeating security doors. Electrically operated gates on the site access roads and on the footpath leading to the FLEX Storage Building can be manually opened by a Security Officer.

QCOP 0050 procedures to be used for ELAP event response provide direction for the use of the Appendix R tools which includes necessary keys for access.

SY-QC-101-411, Active Vehicle Barrier System/Motorized Gate Manual Operation (Reference 135) provides direction for opening vehicle access points to the protected area without any power available.

7 Deployment of Strategies

7.1 Deployment of Electrical Strategy

The strategy uses portable FLEX diesel generators, one per unit, to energize portions of the existing 480 VAC distribution system, necessary to implement the core cooling, and restore additional monitoring instrumentation. Calculation QDC-7300-E-2099 (Reference 13) contains the basis of the FLEX Generator and feed cable sizing including the list of plant loads. This calculation also includes key excerpts of the Cummins Diesel Specifications. There is a primary strategy that utilizes Division 1 electrical busses and an alternate strategy that utilizes Division 2 busses (Figure 1). Connections to the 480 VAC system are made via pigtails with quick dis-connect type connectors installed at the tie breaker outputs at 480 VAC Buses 18, 19, 28, and 29 installed under EC 396321 (Reference 58).

The strategy is implemented by deploying four (4) 4/0 cables (one per phase, neutral) per unit between the portable diesel generators and Buses 18 and 19 for Unit 1 and Buses 28 and 29 for Unit 2 as directed by QCOP 0050-07. The cables are staged on portable reels at two locations in the Reactor Building (3rd floor Elv. 647') and one location on the Unit 2 Turbine Building Main Floor (Elv. 639'). These staging locations are along the cable deployment paths for the primary and alternate strategies. Two building access paths and deployment paths allow for a diverse plan for restoration of electrical power as shown in Figures 10 and 11.

A decision by the MCR to use either the primary or alternate strategy is based on an initial assessment of site damage and debris placement performed in QCOP 0050-03. The Electrical and Water strategies are physically independent except for building access points.

7.1.1 Primary Power Cable Deployment Path

The primary electrical deployment path requires cables to be deployed from two locations as directed by QCOP 0050-07:

1. 250-foot cable reels staged south of the RB 3rd floor interlock doors (also used in alternate deployment path, see section 7.1.2)

2. 250-foot cable reels staged by the U2 Turbine Building Main Floor Equipment hatch

This path uses conduit sleeves on the north face of the Unit 2 Turbine Building as a building entry point. The power cables are deployed from Buses 18/19 and 28/29 around the east side of Unit 2 Turbine Building Main Floor to the equipment hatch and are lowered to the ground level for connection to the FLEX generator (see Figure 10).

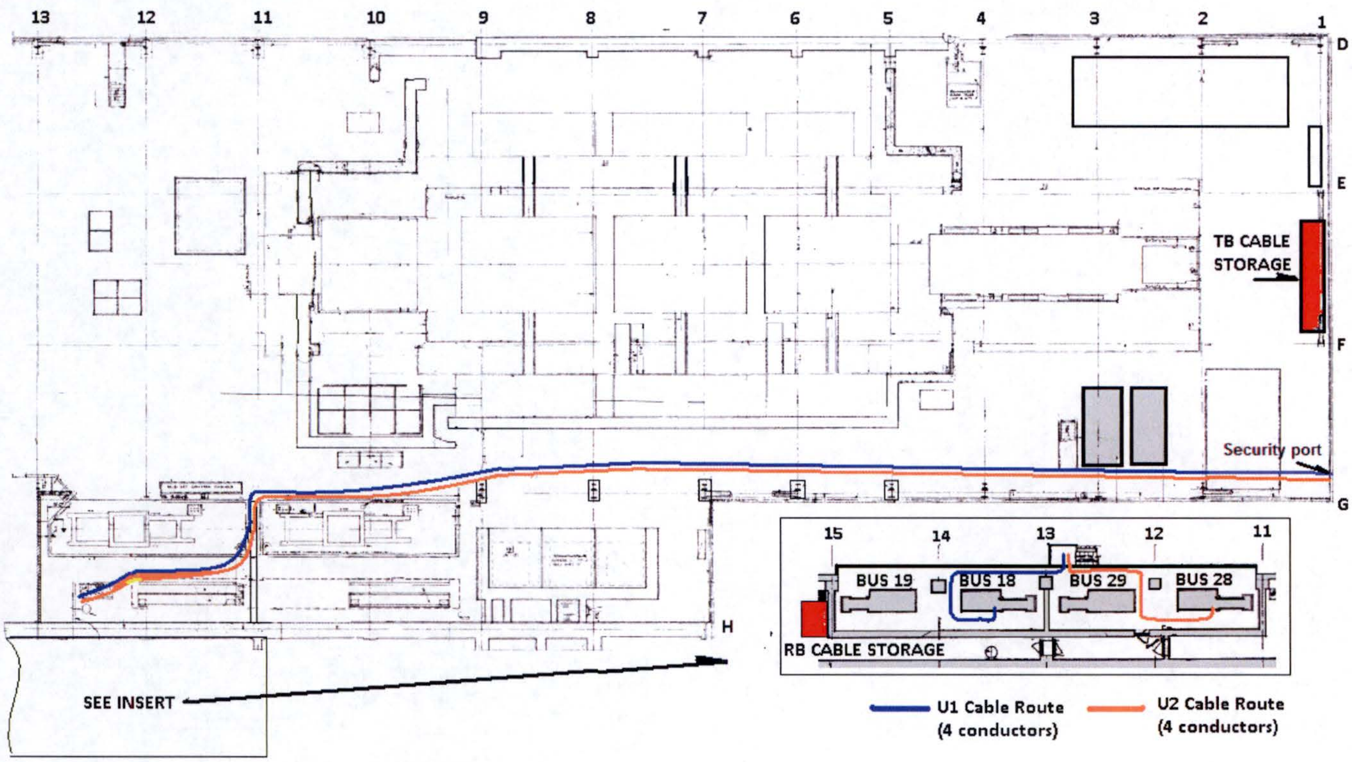

Figure 10: Primary Cable Deployment

7.1.2 Alternate Power Cable Deployment Path

The alternate electrical strategy requires cables to be deployed from two locations as directed by QCOP 0050-07:

1. 250-foot cable reels staged south of the Reactor Building 3rd floor interlock doors (also used in primary deployment path, see section 7.1.1)

2. 250-foot cables reels staged in the Reactor Building 3rd floor by the CRD repair room

The above two cable segments are conjoined via their male/female connectors to form a 500-foot cable run. This cable is then connected to the 100-foot segment that is staged with each generator for a total circuit length of 600 feet (Reference 13).

The alternate path uses the Reactor building equipment or personnel interlock doors as a building entry point. The power cables are deployed from Buses 18/19 and 28/29 around the south side of Unit 1 to the equipment hatch and are lowered to the ground level for connection to the FLEX generator (see Figure 11).

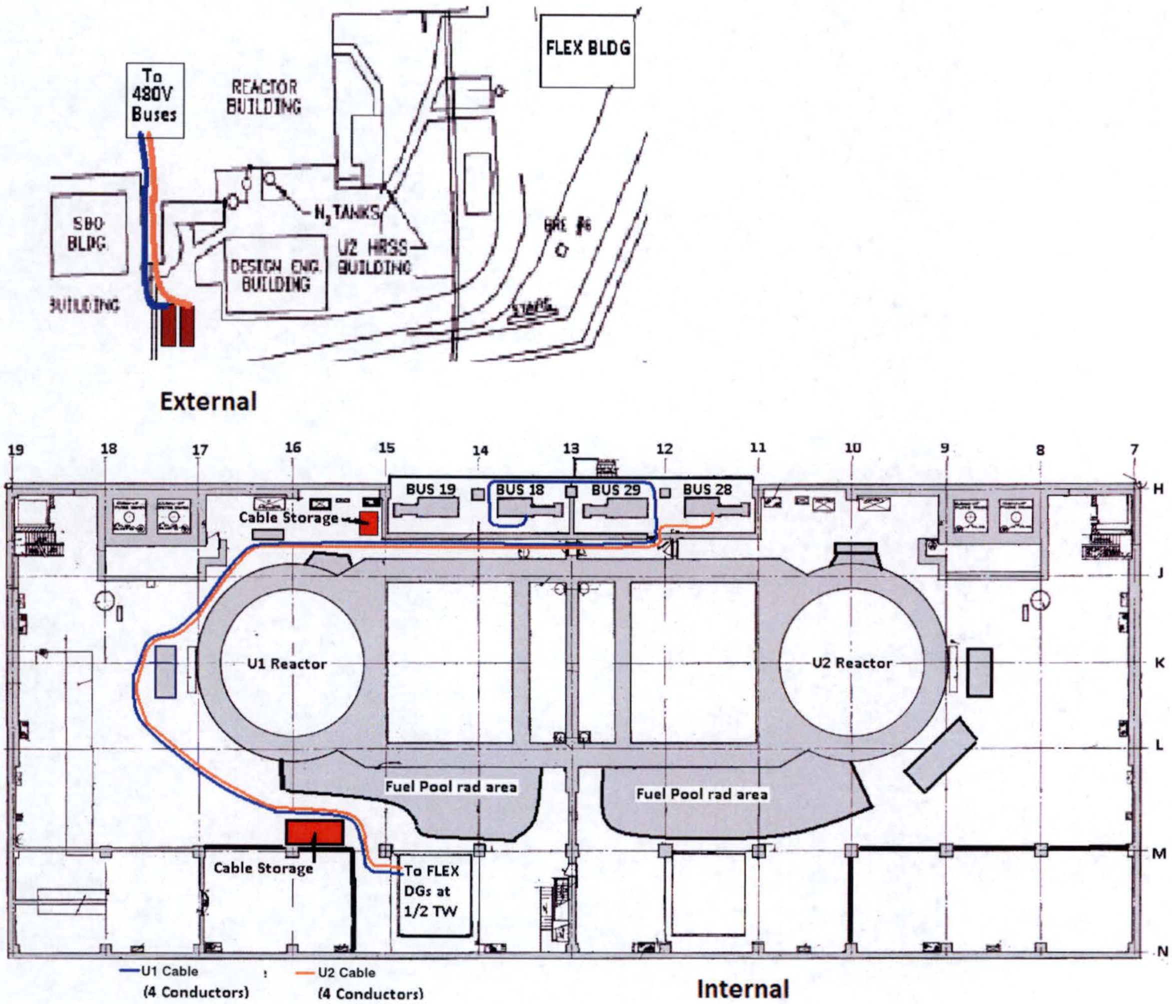

Figure 11: Alternate Cable Deployment

7.1.3 Power Restoration

After the power cables are connected the following steps will be performed as detailed in QCOP 0050-08, FLEX Electrical Restoration.

1. An initial load shedding of 480 VAC busses and connected Motor Control Centers is preformed to prevent overload of the generators or supply cables. This step could be done concurrently with the cable deployment actions if personnel are available. Equipment that have control room switches are shed from the control room. Equipment that will auto start and operate independent of CR action are disabled from the Bus/MCC.
2. Startup of the FLEX generator and manual closing of the output and bus crosstie breakers.
3. CR notification that the 480 V busses are energized.
4. CR isolation of both Reactor Recirculation pumps to minimize pump seal leakage.
5. Verify 125 VDC and 250 VDC Battery Chargers ON and providing voltage.
6. Verify that the Instrument Bus power has been restored.
7. Monitor FLEX Generator loading.

7.2 Deployment of Water Strategy

The Quad Cities water supplies use one of two sources of raw water to meet the FLEX flow requirements.

The primary source uses of a seismically designed and installed Well with an installed pump that has sufficient capacity and discharge pressure to inject directly into both reactors, the SFP and both Containments. This strategy requires a mobile Diesel Generator and hose trailer with a motor starter, which are deployed from the FSB. Electrical cables and 5" fire hoses are connected to complete deployment.

The alternate source uses a diesel driven pump that draws from the plant Discharge Bay and has sufficient capacity and discharge pressure to inject directly into both reactors, the SFP and both Containments. The Discharge Bay and diffuser pipes provide a connection with the Mississippi river channel. The UHS at Quad Cities is physically isolated, making access difficult and untimely to support the FLEX strategy. This strategy requires the diesel pump and hose trailer to be deployed from the FSB. Five-inch fire hose connections complete the deployment (Reference 23).

Independent of the source, both methods use a distribution header formed from standard 5" fire hose fittings to distribute the water. Five and three-inch hose is routed through the Reactor Building to connect the distribution header to RHR system of both units, which is used to supply water to both reactor vessels and both suppression chambers, to the SFP, and to both units ECCS room cooler connections that service the RCIC pump areas. The lowest rated service pressure identified for the components being deployed to support FLEX injection is 225 psig, and the FLEX flow models show these components would be exposed to less than 200 psig at any time. Procedure QCOP 0050-06, FLEX RPV, Suppression Pool, and Spent Fuel Pool Level Control, ensures a deadhead condition does not exist. A relief valve is installed at the discharge piping at the well head (Reference 57).

A decision by the MCR to use either the primary or alternate strategy is based on an initial assessment of site damage and debris placement performed in QCOP 0050-03.

7.2.1 Primary Water Supply (Well) Hose Deployment Paths

QCOP 0050-05, FLEX Fire Hose Deployment is used to initiate supplying well water to the plant following a BDBEE. Security opens the ½ Unit Trackway rail track gate (H-gate), and vehicle cable barriers are removed. A 500 kW FLEX Diesel Generator and hose trailer are then moved from the FSB to the well head. The electrical cables from the generator to the motor starter to the well are connected. Five-inch fire hose, stored on the hose trailer, is rolled out to the ½ Unit Trackway equipment doors and connected to the distribution header. As an alternative hose pathway, the U2 Trackway is used (Reference 23). The paths are shown in Figure 12 below.

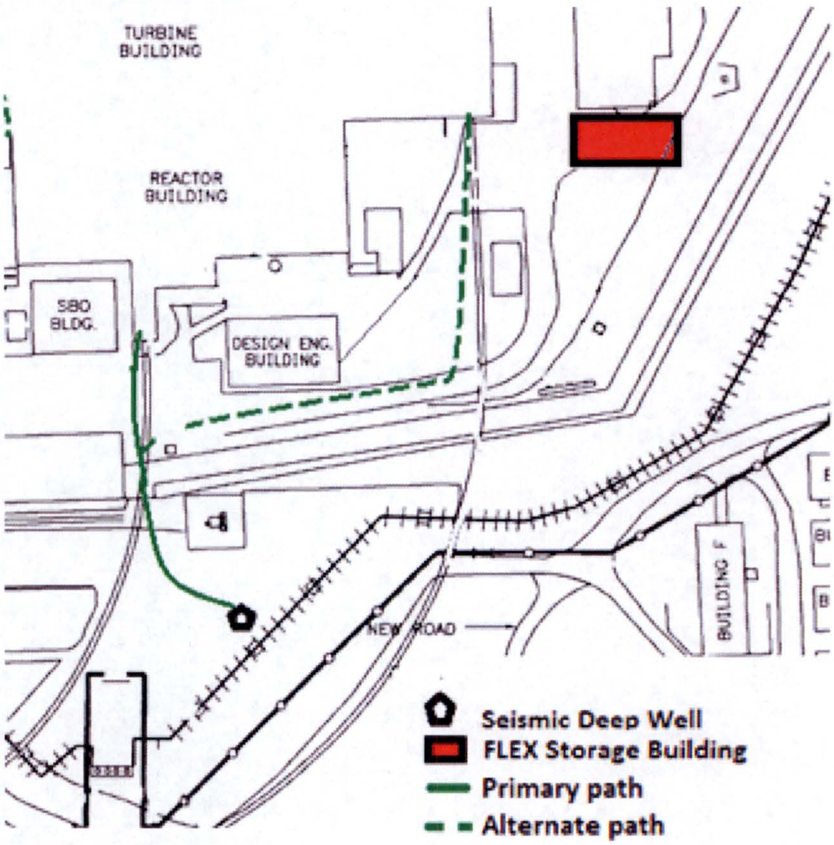

Figure 12: Primary Water Supply (Well) Hose Deployment Paths

7.2.2 Alternate Water Supply (Flex Pump) Hose Deployment Paths

QCOP 0050-05, FLEX/SAWA Fire Hose Deployment directs that the Diesel Pump and hose trailer be hauled to the ramp at the Discharge Bay, and a suction hose with a floating strainer be installed. Five-inch discharge hose is then rolled out to the ½ Unit Trackway for connection to the flow distribution header. As an alternate, a path through the Service Building MMD shop is used (Reference 72). The paths are shown in Figure 13 below.

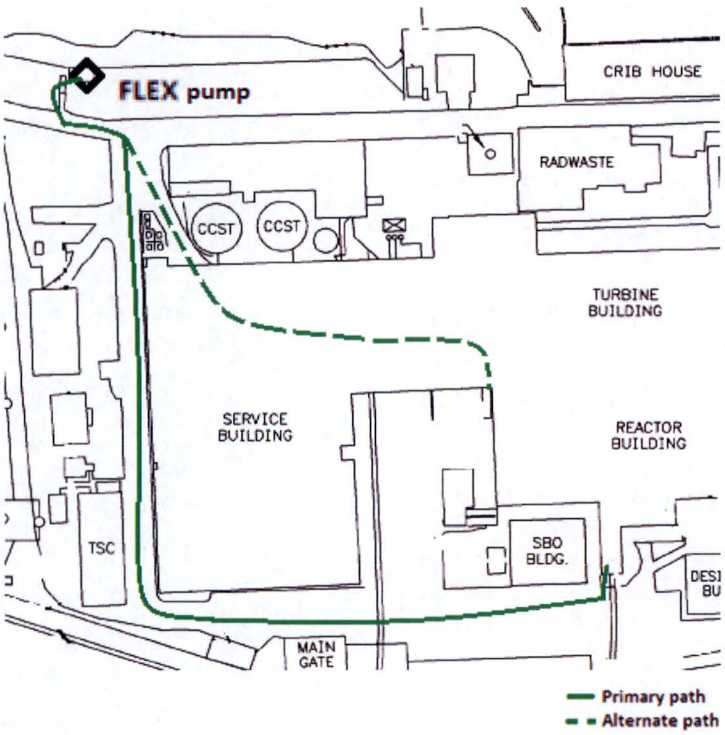

Figure 13: Alternate Water Supply (Flex Pump) Hose Deployment Paths

7.2.3 Internal Hose Deployment

A series of fire hose fittings are assembled to form a distribution header (Figure 15) allowing flow to be controlled and directed to multiple water demands simultaneously. The distribution header is assembled in QCOP 0050-05 and water flow is initiated in QCOP 0050-06.

From five-inch connections on the distribution header, hose connects to either the U1/U2 Condensate transfer to RHR or U1/U2 "A" Drywell Spray Header. These connections provide water for RPV level control when the RHR vessel injection valves (1(2)-1001-28A/B and 1(2)-1001-29A/B) are opened, or Suppression Chamber level control when the Torus spray (1(2)-1001-37A/B) or return valves (1(2)-1001-36A/B) are opened.

From the three-inch distribution header connections, three-inch hose is routed to either the RHR to Fuel Pooling Cooling assist header, or directly to the SFP, to provide water to makeup SFP level. Another hose is connected if use of SFP sprays are necessary per the FLEX order. Additional three-inch hoses are routed to the U1/U2 ECCS room coolers and can be used for dumping water for pressure control, providing flow through the system for freeze protection (winter conditions) and provide cooling to the ECCS room coolers, thus cooling the RB. (See Figure 14)

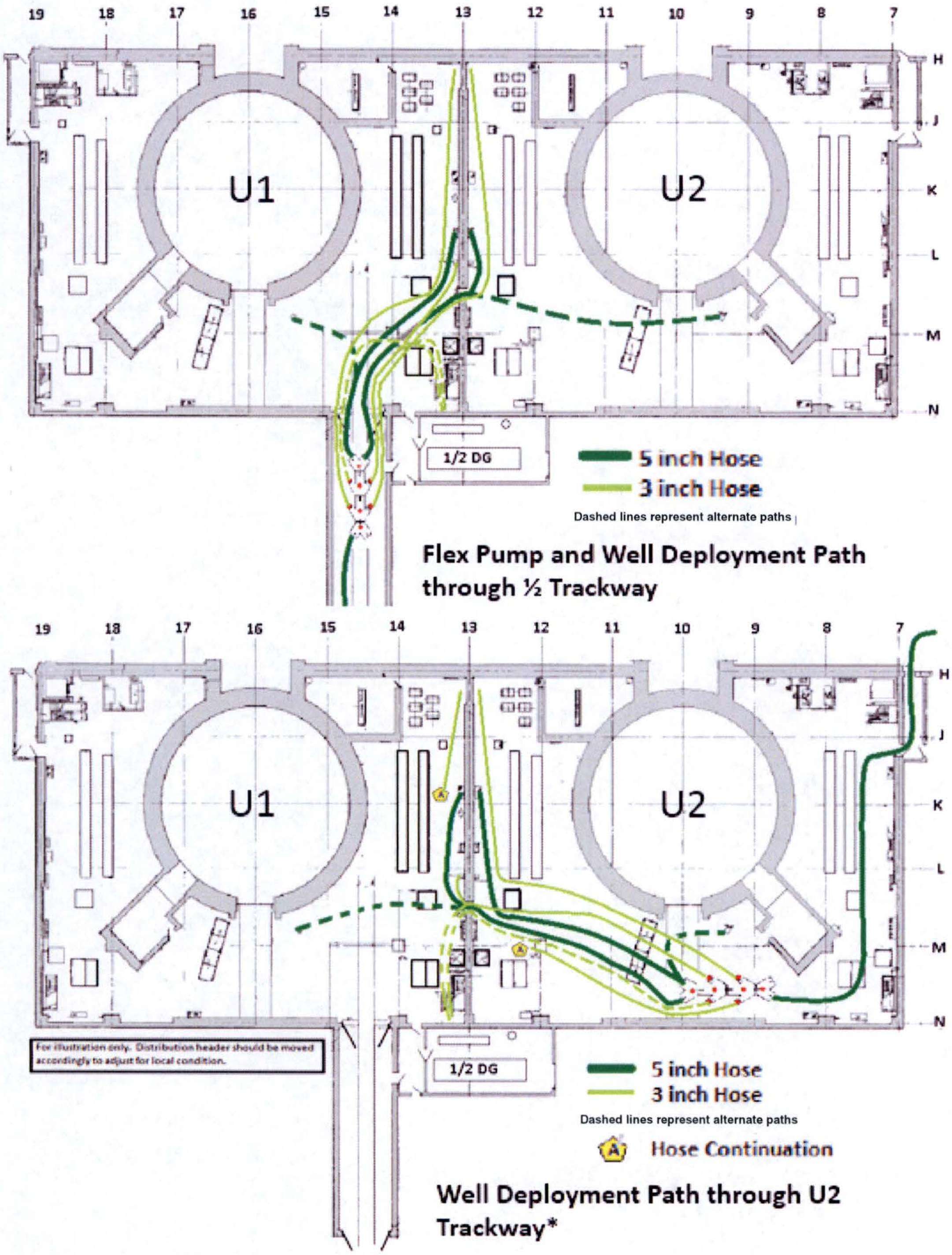

Figure 14: Internal Hose Deployment

*With the Flex pump, hoses and distribution header can be deployed in a similar configuration except on the U1 side (see Section 7.2.2)

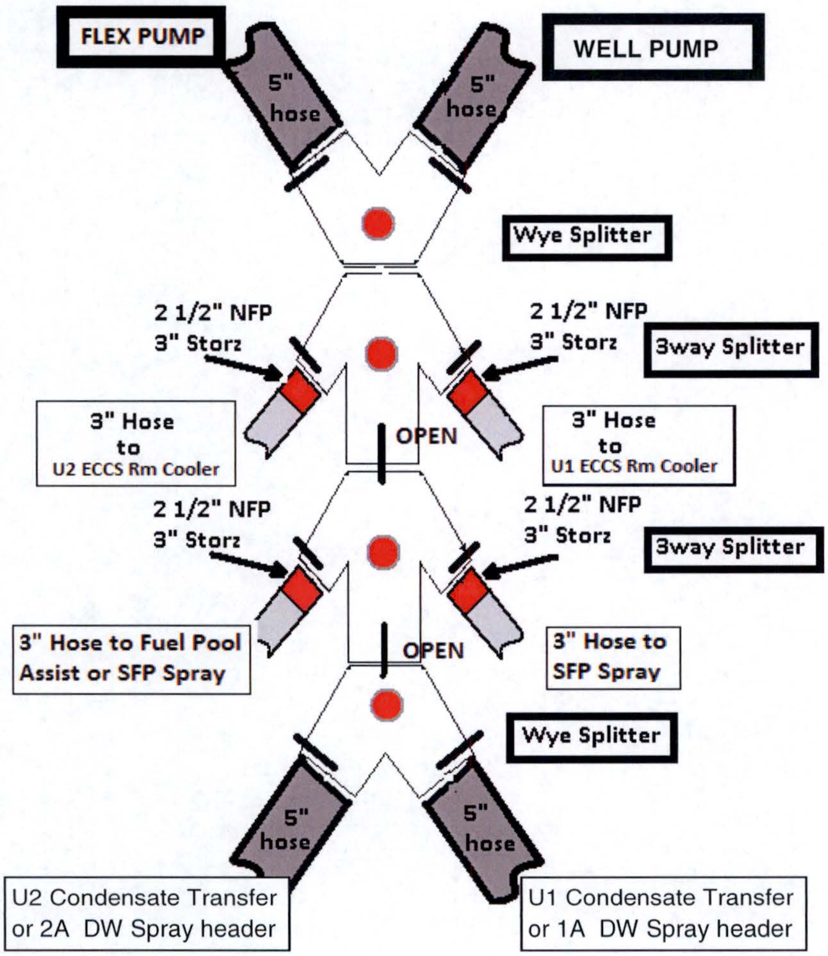

Figure 15 Distribution Header

8 Offsite Resources

8.1 National SAFER Response Center

The industry has established two (2) National SAFER Response Centers (NSRCs) to support utilities during BDB events (Reference 32). Quad Cities has established contracts and issued purchase orders to Pooled Inventory Management for participation in the establishment and support of two (2) National SAFER Response Centers (NSRC) through the Strategic Alliance for FLEX Emergency Response (SAFER). 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/FLEX equipment hoses 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 an NSRC to a local assembly area established by the Strategic Alliance for FLEX Emergency Response (SAFER) team.

For Quad Cities the local assembly area is the Whiteside County Airport in Rock Falls, Illinois. From there, equipment can be taken to the Quad Cities site and staged at Staging Area 'B', the supplemental work force packing lot, by helicopter if ground transportation is unavailable or inhibited. The Quad Cities Airport in Moline, Illinois is the alternate assembly area "D". The Quad Cities Congested Area Plan for the flight route is documented in CC-QC-118-1002 (Reference 73).

Communications will be established between the Quad Cities site and the SAFER team via satellite phones and required equipment moved to the site as needed. First arriving equipment will be delivered to the site within 24 hours from the initial request. The order at which equipment is delivered is identified in the Quad Cities SAFER Response Plan documented in procedure CC-QC-118-1001 (Reference 32).

8.2 Equipment List

The equipment stored and maintained at the NSRC for transportation to the Quad Cities Staging Area 'B' to support the response to a BDB external event is listed in Table 5. Table 5 identifies the equipment that is specifically credited in the FLEX strategies for Quad Cities but also lists the equipment that will be available for backup/replacement should on-site equipment break down. Since all the equipment will be located at the Quad Cities Staging Area 'B', the time needed for the replacement of a failed component will be minimal. The SAFER Operational Checklist confirms that the equipment is functional and that plans and processes are in place to get the equipment onsite if necessary (Reference 74).

9 Water Sources

Quad Cities use the Suppression Pool as the primary water source for RPV makeup during Phase 1. Contaminated Condensate Storage Tank (CCST) water will also be used, if available, but this source is not fully protected. During Phases 2 and 3, raw water sources (Seismic Deep Well or the Mississippi River) are used for RPV, Suppression Pool and Spent Fuel Pool makeup (Reference 23).

9.1 Suppression Pool/ CCST

The Quad Cities core cooling strategy uses RCIC to the maximum extent for RPV injection. The HPCI and RCIC systems normally take a suction from the CCSTs. The level in both CCSTs is maintained at or above 12 feet, which provides sufficient static head to ensure the discharge pipes of the HPCI and RCIC systems are maintained full of water (Reference 68).

The Suppression Pool and CCSTs offer clean sources of makeup water to the RPV using RCIC. Both sources are near reactor-quality water. Procedure QCOP 0050-12, "FLEX RCIC System Operation" provides guidance on using available water sources for injection into the RPV using RCIC. The water for Phase 1 operations will use the Suppression Pool, or CCST water if available. (The CCST tanks are neither seismically qualified nor durable against tornado winds and missiles.) These are the normal water sources used for RPV makeup via RCIC. As the Suppression Pool temperature and pressure rise, the HCVS is used cool the Containment, and water addition to maintain Suppression Pool level will be required. The use of raw water sources will degrade Suppression Pool water quality, but it will remain a favorable water source (Reference 23).

The temperature of the Suppression Pool water supplied to the RCIC pump will challenge its long-term availability. Once a FLEX pump is available at t_0 + 6 hours, the raw water sources are used to replenish the Suppression Pool and RPV.

9.2 Raw Water Sources

When RCIC is no longer available due to loss of steam at pressures needed to drive the turbine, the primary RPV makeup source will be from the FLEX Seismic Deep Well or a FLEX diesel-powered pump with suction from the Discharge Bay (Reference 23).

The FLEX Seismic Deep Well pump provides raw, non-demineralized well water to supply the FLEX distribution header. A strainer screen at the pump suction keeps large particles from entering the pump and discharge path. The FLEX diesel-powered pump takes suction on the Discharge Bay (which communicates with the Mississippi River) using a floating suction strainer. Using either supply, Operations raises RPV level to assure core cooling despite possible core inlet strainer obstruction. Raw water makeup addresses the following concerns:

1) The fuel in the SFP is expected to remain submerged with only enough water added from raw water to account for boil-off. Cooling of fuel in the SFP should not be affected by the material that could pass through the FLEX pump.

2) With respect to RPV makeup directly from the raw water sources, the RHR/LPCI connection points supply water outside the shroud region. Adequate cooling is assured when the outside shroud region is elevated to above the moisture separator spillover point, and water can enter the fuel through the top of the fuel channels, maintaining low fuel temperatures. This strategy is based on BWROG report, BWROG-TP-15-007 (Reference 67*)*. This report states:

   "BWR fuel can be adequately cooled when the core inlet is postulated to be fully blocked from debris injected with the make-up coolant. The fuel is effectively cooled when the inside shroud is flooded, and this is accomplished by either injecting makeup coolant inside the shroud or by maintaining the water level above the steam separator return elevation if injecting make-up in the downcomer."

   This report also references an analysis performed for Byron and Braidwood for steam generator fouling. In the worst case, the evaluations determined that a deposition of ~6 cubic feet of debris occurs in a 72-hour period in a steam generator. The resulting heat transfer degradation from the effective reduction in U-tube surface area from deposited solids and the buildup of scale caused by the boil-off of raw water was calculated to be 5.8% of rated heat transfer capability. This level of degradation is well below the threshold at which heat transfer capability is effectively lost for the decay heat load existing post-shutdown when the heat transfer degradation occurs. Applying these results to a BWR reactor vessel, which has a greater volume and more heat transfer surface area associated with the fuel cladding, would imply a similar order of magnitude in degradation of heat transfer capability is not anticipated. This will ensure cooling for at least 72 hours after commencing injection. During this time, Quad Cities will develop recovery methods that will utilize cleaner sources of water. The recovery methods could include transition back to the Suppression Pool, arranging for delivery of clean water sources, or other methods to filter water prior to injection into the core.

10 Shutdown and Refueling Analysis

Quad Cities Power Station will abide by the Nuclear Energy Institute position paper entitled "Shutdown/Refueling Modes" (Reference 14) addressing mitigating strategies in shutdown and refueling modes. This position paper, dated September 18, 2013, has been endorsed by the NRC staff (Reference 15). These strategies have been incorporated into NEI 12-06.

Using the NEI position paper to further develop and clarify the guidance provided in NEI 12-06 related to the industry's ability to meet the intent of Order EA-12-049 during shutdown and refueling modes of operation, the following Exelon fleet strategy objectives are established:

1. A defense in depth approach will be used to support FLEX strategies during shutdown/refueling modes. The defense in depth approach is selected over development of mode-specific FLEX Support Guidelines (FSGs) and supporting analyses for the following reasons:

    - Outage conditions are highly diverse, and will be a significant challenge to developing modifications, procedures, and supporting analyses that will be valid under all shutdown/refueling conditions.

    - The time duration of shutdown/refueling conditions is short compared to the duration at operating conditions, such that the risk of external initiating events concurrent with shutdown/refueling conditions is very small. Additionally, due to the large and diverse scope of activities and configurations for any given nuclear plant outage (planned or forced), a systematic approach to shutdown safety risk identification and planning, such as that currently required to meet §50.65(a)(4) along with the availability of the FLEX equipment, is the most effective way of enhancing safety during shutdown.

    - Resource availability is much greater and more diverse during outages, particularly during high risk evolutions such as shutdown and refueling mode operations and reduced inventory conditions (e.g., RPV water level below the vessel flange with irradiated fuel seated in the reactor vessel (BWR), mid-loop operation with fuel seated in the reactor vessel or reactor vessel head installed with Reactor Coolant System loops isolated (PWR)). This includes command and control structures to support event mitigation and recovery.

    - Shutdown Safety Management Program procedures require availability of a greater number of systems than required by plant Technical Specifications to ensure capability of key safety functions. Contingency plans are developed as required when the defense in depth is reduced below a specified minimum value. A defense in depth strategy is recognized by previous NRC and industry initiatives to improve shutdown safety.

2. No modifications, analyses, nor engineering evaluations need to be performed to support shutdown/refueling FLEX strategy implementation. This approach is fully

consistent with the NEI position paper on shutdown/refueling modes and the NRC endorsement letter of the NEI position paper.

11 Sequence of Events

The Table 1 below presents a Sequence of Events (SOE) Timeline for an ELAP/LUHS event at Quad Cities. Validation of each of the FLEX time constraint actions has been completed in accordance the FLEX Validation Process document issued by NEI and includes consideration for staffing.

Table 1 Sequence of Events Timeline (Reference 75)

Action item	Elapsed Time	Action	Time Constraint Y/N	Remarks / Applicability
1	0	Event starts.	NA	Plant at 100% power
2	0	Reactor Scram and SBO	NA	Event Initiation
3	0 min	Group1 isolation due to loss of power to instrumentation	N	Loss of AC power cause Group 1 isolation due to loss of power to trip system [UFSAR 7.3.2.2]
4	~2 min	Operating crew enters applicable EOPs and abnormal procedures for LOOP. EOP entry conditions; Low Reactor water level and High Reactor pressure.	N	QGA 100 RPV Control QCOA 6100-03 Loss of Off site Power
5	~2 min	RCIC Manually started and injects to restore level to normal operating band.	N	Reactor operator initiates or verifies initiation of reactor water level restoration with steam driven high pressure injection. [UFSAR Section 1.2.2.5] QGA 100 RPV Control QCOP 1300-02 RCIC System Manual Startup This is not time critical because if not completed automatic initiation will occur at the Low-Low level setpoint.
6	~2 min	ERV valves operation is monitored and manual operation initiated to control RPV pressure.	N	QGA 100 RPV Control QCOP 0203-01 Reactor Pressure Control Using Manual Relief Valve Actuation. Not time critical as automatic cycling of ERV sis controlling RPV pressure and manual control stabilizes system operation but does not impact key function control.

7	~5 min	Attempt to manually start emergency diesel generators (U1, U2 and U1/2), and enter SBO procedure.	N	QCOA 6100-03, Loss of Offsite Power. No success will occur from this action. QCOA 6100-04, Station Blackout
8	~5 min	DC load shedding initiated per QCOA 6100-03.	N	QOA 6900-07 Loss of AC Power to the 125 VDC Battery Charger with Simultaneous Loss of Auxiliary Electric Power. Initiation of load shedding is not time critical - completion of load shedding is time critical.
9	~5 min	Reactor Operator control RPV level with RCIC.	N	QGA 100, RPV Control QCOP 1300-02 This action controls the system operation to maintain parameters within the EOP specified band and is not time critical as system operation will continue without this action.
10	10 min	Commence RPV depressurization using ERV s at less than or equal to 80°F per hour.	N	QCOP 0203-01 Not time critical as initiation of depressurization controls the RPV pressure prior to EOP directed operation due to HCTL of suppression chamber temperature requiring an emergency depressurization.
11	30 mins.	DC load shedding completed.	Y	QOA 6900-07
12	30 mins.	Defeat RCIC Low Pressure Isolation Logic.	N	Not time critical since RPV depressurization will be stopped prior to the RCIC Low Pressure Isolation setpoint per QGA 100 (in accordance with EPG Rev 3). QCOP 1300-10
13	~60 mins.	Control Room crew has assessed SBO and plant conditions and declares an Extended Loss of AC Power (ELAP) event.	Y	Time sensitive in that decision drives timeline for setup of FLEX equipment and early venting. QCOA 6100-04
14	~60 mins.	Equipment Operators dispatched to begin setup/connection of FLEX equipment (480 VAC generators to power battery chargers and FLEX pump) and commence FLEX DC load shed.	Y	QCOP 0050-01, 02 QCOP 0050-05, 07 DC coping analysis shows the following DC battery capabilities: 125 VDC / 10 hrs, 250 VDC / 9 hrs
15	90 mins.	FLEX DC load shed complete.	Y	DC coping analysis assumes FLEX load shed is complete by 90 minutes. Therefore, this action is time critical.

16	2 hrs	Defeat RCIC High area temperature isolations.	Y	QCOP 1300-10. This action is critical at 8.7 hours when RCIC room temperature reaches 150°F, per Gothic analysis. The RCIC room temperature does not reach 180°F in the first 72 hours.
17	5 hrs	480 VAC FLEX generators connected to the Safety Related Busses. This supplies battery chargers for 125 VDC (Div. 1 and 2) and 250 VDC buses.	Y	Restore AC power to battery chargers prior to loss of each battery at: 125 VDC / 10 hrs, 250 VDC / 9 hrs
18	5 hrs	FLEX pumps connected and alignment for suppression pool injection established.	N	QCOP 0050-06 This action becomes time critical when early containment venting is initiated.
19	5.3 hrs	Initiate early containment venting strategy at a Containment pressure of 10 psig. Open the Reliable Hardened Containment Vent from the wetwell to maintain suppression pool temperatures less than ~230°F to support long term RCIC operation.	Y	QGA 200, Primary Containment Control (EPG Rev 3) 5.3 hrs is projected via MAAP analysis as when Containment pressure reaches 10 psig.
20	~5.5 hrs	Heat Capacity Temperature Limit (HCTL) curve projected to be exceeded via MAAP analysis, RPV blowdown to ~200 psig required. RPV pressure now maintained 150-250 psig range to support RCIC operation.	Y	QGA 200 (EPG Rev 3) RPV blowdown stops at ~200 psig in RPV to preserve RCIC operation.
21	~5.5 hrs	FLEX pumps connected and alignment for RPV injection established.	N	QCOP 0050-06 RPV blowdown is completed and RCIC is shut down.
22	12 hrs	Begin makeup to SFP with the FLEX pump to maintain level above top of fuel.	Y	QCOP 0050-06 QGA 300, Secondary Containment Control (EPG Rev 3) The worst case SFP heat load scenario shows a time-to-boil of 13.5 hours. The time to reach top of fuel is 147 hours.
23	24 hrs.	Initial equipment from National SAFER Response Center becomes available.	N	Per NEI 12-06, Section 12 (NSRC).
24	24 -72 hrs	Continue to maintain critical functions of core cooling (via FLEX pump injection), containment control, and SFP cooling (FLEX pump injection to SFP). Utilize initial NSRC equipment in spare capacity.	N	Not time critical/sensitive since Phase 2 actions result in indefinite coping times for all safety functions.

12 Programmatic Elements

12.1 Overall Program Document

Quad Cities procedure CC-QC-118 (Reference 50) provides a description of the Diverse and Flexible Coping Strategies (FLEX) Program. This procedure implements Exelon fleet program document CC-AA-118 (Reference 77) which contains governing criteria and detailed requirements. The key elements of the program include:

- Summary of the FLEX strategies
- Maintenance of the FSGs including any impacts on the interfacing procedures (EOPs, OPs, OAs, etc.)
- Maintenance and testing of FLEX equipment (i.e., SFP level instrumentation, emergency communications equipment, portable FLEX equipment, FLEX support equipment, and FLEX support vehicles)
- Portable equipment deployment routes, staging areas, and connections to existing mechanical and electrical systems
- Validation of time critical operator actions
- The FLEX Storage Building and the Regional Response Center
- Supporting evaluations, calculations, and FLEX drawings
- Tracking of commitments and FLEX equipment unavailability
- Staffing and Training
- Configuration Management
- Program Maintenance

The instructions required to implement the various elements of the FLEX Program and thereby ensure readiness of in the event of a BDBEE are contained in Exelon fleet program document CC-AA-118, Diverse and Flexible Coping Strategies (FLEX) and Spent Fuel Pool Instrumentation Program Document (Reference 77).

Design control procedure CC-AA-102, Design Input and Configuration Impact Screening (Reference 76) has been revised to ensure that changes to the plant design, physical plant layout, roads, buildings, and miscellaneous structures will not adversely impact the approved FLEX strategies.

Design control procedure CC-AA-309-101, Engineering Technical Evaluations (Reference 71) has been revised to ensure technical evaluations are performed when new information is received that potentially challenges the conservatism of current external event design assumptions.

Future changes to the FLEX strategies may be made without prior NRC approval provided that 1) the revised FLEX strategies meet the requirements of NEI 12-06 or a previously approved alternate approach, and 2) an engineering basis is documented that ensures that the change in FLEX strategies continues to ensure the key safety functions (core and SFP cooling, containment integrity) are met (Reference 77).

12.2 MAAP Analysis

The Modular Accident Analysis Program (MAAP) 4 was demonstrated to be the appropriate code for simulation of ELAP. The generic response provided by EPRI BWR Roadmap "Technical Basis for Establishing Success Timelines in Extended Loss of AC Power Scenarios in Boiling Water Reactors Using MAAP4" (Reference 136).

Acceptability of MAAP was analyzed in EPRI Technical Report 3002001785, "Use of Modular Accident Analysis Program (MAAP) in Support of Post Fukushima Applications" (Reference 137) and QC-MISC-014, Use of MAAP in Support of FLEX Implementation.

The MAAP analysis performed for Quad Cities was carried out in accordance with Sections 4.1, 4.2, 4.3, 4.4, and 4.5 of the June 2013 position paper, EPRI Technical Report 3002001785, "Use of Modular Accident Analysis Program (MAAP) in Support of Post-Fukushima Applications". Preparation and Review of the MAAP analysis was conducted under engineering training certification guide ENANRM08 (Reference 93).

The current MAAP 4.0.5 calculations were performed to estimate the containment pressure and temperature response to a variety of extended Station Blackout (SBO) events (Reference 23).

The MAAP analysis performed in support of the Quad Cities Integrated Plan (Reference 20), Case 6 was the specific MAAP run selected to represent the scenario as described in Table 1, Sequence of Events Timeline.

12.3 Procedural Guidance

The inability to predict actual plant conditions that require the use of BDB equipment makes it impossible to provide specific procedural guidance. As such, the FSGs will provide guidance that can be employed for a variety of conditions. Clear criteria for entry into FSGs will ensure that FLEX strategies are used only as directed for BDB external event conditions and are not used inappropriately in lieu of existing procedures. When FLEX equipment is needed to accomplish FLEX strategies or supplement EOPs, QCOA 6100-04, or Severe Accident Mitigation Guidelines (SAMGs) will direct the entry into and exit from the appropriate FSG procedure. A list of the FSGs are provided in Table 2.

FLEX strategy support guidelines have been developed in accordance with BWROG guidelines. FLEX Support Guidelines will provide available, pre-planned FLEX strategies for accomplishing specific tasks in the EOPs. FSGs will be used to supplement (not replace) the existing procedure structure that establishes command and control for the event.

The Quad Cites EOP procedures and support procedures were revised to implement BWROG EPG/SAG rev. 3 (Reference 96) including changes necessary for FLEX implementation. Major changes in these changes include:

- QGA 100 – FSG procedure references, partial RPV depressurization and expanded RPV level control bands
- QGA 200 – Early containment venting, maintain RCIC/HPCI operation
- QGA 500-1 – Maintain RCIC/HPCI operation (Reference 138)
- QCAP 0200-10 (Reference 139) – RCIC NPSH Curve EC 400007 (Reference 33)

Procedural interfaces have been incorporated into QCOA 6100-04, Station Blackout (Reference 72), to the extent necessary to include appropriate reference to FSGs and provide command and control for the ELAP.

Changes to FSGs are controlled by Exelon fleet procedure AD-AA-101, Processing of Procedures and T&RMs (Reference 94). FSG changes will be reviewed and validated by the involved groups to the extent necessary to ensure the strategy remains feasible. Validation for existing FSGs has been accomplished in accordance with the guidelines provided in NEI APC 14-17, FLEX Validation Process, issued July 18, 2014 (Reference 95).

QCOP 0050 procedures to be used for ELAP event response contain attachments that include HU tools such as layout diagrams, illustrations, and drawings to provide visual directions as well as written directions. Components used within the FLEX response procedures are designated using reflective green FLEX stickers, similar to Appendix R response or B.5.b response. OP-QC-116-101-1001 (Reference 97) has been implemented to document component labeling requirements for FLEX equipment.

As described in section 13.3, administrative controls have been established in procedure QCAP 1500-07 to track out of service Flex Equipment out of service.

Table 2: List of Flex Support Guidelines (FSGs)

Document No.	Title	Cross Reference to Applicable FLEX Strategy
QCOP 0050-01	UNIT ONE FLEX DC LOAD SHED	All
QCOP 0050-02	UNIT TWO FLEX DC LOAD SHED	All
QCOP 0050-03	FLEX SITE DAMAGE ASSESSMENT	All
QCOP 0050-04	FLEX REFUEL FLOOR ACTION	All
QCOP 0050-05	FLEX FIRE HOSE DEPLOYMENT	All
QCOP 0050-06	FLEX RPV, SUPPRESSION POOL, AND SPENT FUEL POOL LEVEL CONTROL	All
QCOP 0050-07	FLEX GENERATOR AND POWER CABLE DEPLOYMENT	All
QCOP 0050-08	FLEX ELECTRICAL RESTORATION	All
QCOP 0050-09	FLEX RESPONSE INSTRUMENTATION	All
QCOP 0050-10	FLEX BATTERY ROOM VENTILATION	All
QCOP 0050-11	FLEX CONTROL ROOM VENTILATION	All
QCOP 0050-12	FLEX RCIC SYSTEM OPERATION	All
QCOP 0050-13	FLEX GENERATOR REFUELING	All
QCOP 0050-15	FLEX 125/250 VDC OPERATION	All
QCOP 0050-16	FLEX NATIONAL SAFER RESPONSE CENTER INTERFACE	All
QCOP 0050-17	FLEX RCIC ROOM COOLER LINEUP	All

12.4 Staffing

Using the methodology of NEI 12-01, an assessment of the capability of Quad Cities on-shift staff and augmented Emergency Response Organization (ERO) to respond to a BDBEE was performed.

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

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

Quad Cities Operations personnel conducted a table-top review of the on-shift response to the postulated BDBEE and extended loss of AC power for the Initial and Transition Phases using the FLEX mitigating strategies. Resources needed to perform initial event response actions were identified from the Emergency Operating Procedures (EOPs) and QCOA 6100-04 Station Blackout. Particular attention was given to the sequence and timing of each procedural step, its duration, and the on-shift individual performing the step to account for both the task and time motion analyses of NEI 10-05, Assessment of On-Shift Emergency Response Organization Staffing and Capabilities.

This Phase 2 Staffing Assessment (Reference 98) concluded that the current minimum on-shift staffing as defined in the Emergency Response Plan for Quad Cities, as augmented by site auxiliary personnel, is sufficient to support the implementation of the FLEX strategies, as well as the required Emergency Plan actions, with no unacceptable collateral duties.

The Phase 2 Staffing Assessment also identified the staffing necessary to support the Expanded Response Capability for the BDBEE as defined for the Phase 2 staffing assessment. This staffing will be provided by the current Quad Cities site resources, supplemented by Exelon fleet resources, as necessary.

12.5 Training

Quad Cities Nuclear Training Program has been revised to assure personnel proficiency in the mitigation of BDB external events is adequate and maintained. These programs and controls were developed and have been implemented in accordance with the Systematic Approach to Training (SAT) Process.

Using the SAT process, Job and Task analyses were completed for the new tasks identified applicable to the FLEX Mitigation Strategies. Based on the analysis, training for Operations was designed, developed and implemented for Operations continuing training. "ANSI/ANS 3.5, Nuclear Power Plant Simulators for use in Operator Training" certification of simulator fidelity is considered sufficient for the initial stages of the BDB external event scenario training. Full scope simulator models have not been explicitly upgraded to accommodate FLEX training or drills; however, electrical and water source portions of Flex have been appropriately modeled in the simulator. Overview training on FLEX Phase 3 and associated equipment from the SAFER NSRCs was also provided to Quad Cities operators. Upon SAFER equipment deployment and connection in an event, turnover and familiarization training on each piece of SAFER equipment will be provided to station operators by the SAFER deployment/operating staff.

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 BDB external events have received the necessary training to ensure familiarity with the associated tasks, considering available job aids, instructions, and mitigating strategy time constraints.

Where appropriate, integrated FLEX drills will be conducted periodically; with all time-sensitive actions evaluated over a period of not more than eight years. It is not required to connect/operate temporary/permanently installed equipment during these drills (Reference 50).

12.6 Changes to Compliance Method

The following changes were provided as part of the FLEX program six-month updates and provide detailed descriptions of the deviations to JLD-ISG-2012-01 and NEI 12-06. The resolution of the change is provided following the description.

Change 1- Interim FLEX Equipment Storage Alternative Approach:

Quad Cities Station has completed construction of the FLEX equipment storage buildings for the N and N+1 equipment. Therefore, Alternative Approach Change 1 - Interim FLEX Equipment Storage Alternative Approach is no longer applicable (Reference 114).

Change 2 - Storage, Maintenance and Testing Alternate Approach:

NEI 12-06, Revision 2 incorporated this change in compliance method, therefore, this change is no longer necessary (Reference 99).

Change 3 - N+1 Hoses and Cables Alternative Approach:

NEI 12-06, Revision 2 incorporated this change in compliance method, therefore, this change is no longer necessary (Reference 99).

Change 4 - Seismic Water Source Alternative Approach

Issue

The station installed a single Deep Well as a seismically qualified source of water for the FLEX mitigation strategy. This single Deep Well is fully capable of supplying both Units 1 and 2 FLEX requirements simultaneously. Schedule relief for this well has been approved under References 100, 101 and 102. This configuration does not utilize a redundant seismic deep well. As such, Quad Cities will implement an Alternative Approach to meet the Order for allowed unavailability time on the single seismic deep well (Reference 23).

Background

Since only one deep well was installed, this alternative approach provides the actions that will occur upon unavailability of this deep well during maintenance and testing, or its unavailability during a FLEX event response. The plant circulating water discharge bay will be utilized as a source of backup water during deep well unavailability periods. The discharge bay has not been seismically evaluated but there is reasonable assurance that this water supply will remain available as a source of water following a seismic event due to the size of the two diffuser pipes which connect to the main channel of the Mississippi River.

To the extent to which the guidance of JLD-ISG-2012-01 and NEI 12-06 is being followed, deviations should be identified. The allowed unavailability time requirements are stated in NEI 12-06, Section 11.5.3 and are described as: "The unavailability of equipment and applicable connections that directly performs a FLEX mitigation strategy for core, containment, and SFP should be managed such that risk to mitigating strategy capability is minimized." As such, this alternative approach is an acceptable deviation from the guidance of JLD-ISG-2012-01 and NEI 12-06 as described below.

Alternative

Unavailability Alternative Approach (Consistent with NEI 12-06, Section 11.5.3)

1. The unavailability of the seismic deep well equipment and applicable connections that directly performs a FLEX mitigation strategy for core, containment, and SFP should be managed such that risk to mitigating strategy capability is minimized.
    a. The unavailability of installed plant equipment is controlled by existing plant processes such as the Technical Specifications (TS). 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.
    b. The required seismic deep well equipment may be unavailable for 90 days provided that the site seismic water supply capability is met. If the site seismic water supply capability is met but not fully protected for the site's applicable hazards, then the allowed unavailability is reduced to 45 days.
    c. If seismic deep well equipment or connections becomes unavailable such that the site seismic water supply capability is not maintained, initiate actions within 24 hours to restore the site seismic water supply capability and implement compensatory measures (ensure equipment for use of the discharge bay water supply is ready for deployment) within 72 hours, and then initiate a concurrent 45 day period to repair the seismic well to full availability.
    d. If seismic deep well permanently installed equipment required for FLEX strategies are expected to be unavailable for greater than 45 days, initiate actions to restore the seismic deep well capability and implement compensatory measures (e.g., use of alternate suitable equipment) prior to exceeding the 45 days.

<u>Actions During a Seismic FLEX Event</u>

For an ELAP event with a seismic initiator the station will perform the following actions:

1. Phase I Actions:

- Initiate RCCIC for Flex RPV water injection. RCIC will operate under these conditions for > 72 hours. This will allow time for station staff to deploy Phase 2 Flex Strategies.

2. Phase 2:
    - Deploy FLEX generator to power the deep well for primary source of water for FLEX requirements for Suppression Chamber level control, Spent Fuel Pool level and Reactor Pressure Vessel water level control. The deep well pump is powered by one FLEX generator and the well is sufficient to provide water to both Units. Two additional FLEX generators are deployed, one per unit, to restore voltage to the 480V buses.

3. ERO Response Actions:
    - Following the initial stabilization actions for Phase 2, establish a backup water supply using a FLEX pump taking suction from the discharge bay.
    - Monitor the condition of Lock and Dam 14 for a potential failure and/or the discharge bay for level change that may be indicating a degradation of this source.
    - Upon indication or prediction of degradation of the discharge bay level, deploy a submersible pump with the suction placed in low point of the discharge bay with the discharge of the submersible pump connected to the FLEX pump suction to provide additional NPSH should the discharge bay level drop.
4. Continue to operate well pump or the submersible and FLEX pumps as required to supply the FLEX water needs.

Actions 1 – 4, above can be performed within the minimum time requirements needed for FLEX injection.

The discharge bay used in this strategy provides access for use of NSRC Phase 3 equipment as a backup to Phase 2 equipment and addresses indefinite coping time.

<u>Actions During Maintenance or Testing Should the Deep Well Become Unavailable</u>

1. Initiate actions to restore well pump within 24 hours.
2. Verify FLEX and submersible pumps and necessary support components are ready for deployment and are protected from the seismic hazard. This contingency action is required to be completed within 72 hours.
3. Restore well pump to operation within 45 days.

Basis for An Alternative Approach

During times when the single seismic deep well is unavailable, Quad Cities will compensate by use of an Alternative Approach which consists of a FLEX pump and portable submersible pump that will take suction from Quad Cities Station discharge bay. The discharge bay will supply the necessary backup water supply. Access to the river as a water source remains available during this event. This method provides a compensatory separate and diverse FLEX water supply, should the single seismic deep well become unavailable.

As a result, if the single seismic deep well becomes unavailable for a FLEX event (specifically a seismic event), the Alternative Approach described herein, will be utilized. This Approach applies a reduced Unavailability Time to the single seismic deep well which when coupled with the associated compensatory measures, will be used to compensate when the seismic deep is not available. If the equipment is not protected from the applicable hazards, instead of the NEI recommended 90 day unavailability period, an allowed unavailability period of 45 days will apply. This is based on the 6-week short cycle work scheduling. This will allow the station to continue to manage work associated with equipment important to safety. Placing the seismic deep well equipment into the site work schedule at the 6-week period still allows proper planning and resource loading while maintaining schedule compliance and stability. This action will not cause the station to be distracted from other scheduled work.

The probability of an event causing an ELAP and loss of the UHS is low and reducing the allowed unavailability time will further reduce the probability of an event during this period. Therefore, it is reasonable to expect equipment availability during periods when it is required.

Supporting Plant Conditions

- Discharge Bay Water Level:
    - Normal discharge bay and Mississippi River level is 572 feet controlled by downstream Lock and Dam 14.
    - Per UFSAR 2.4.4 (Reference 148), the minimum elevation of the discharge bay is 561 feet, should Lock and Dam 14 fail, which is the normal elevation downstream of Lock and Dam 14.
    - Bottom elevation of discharge bay is 557 feet.
    - FLEX pumps will provide the necessary water to a suction level of 565 feet which will be reached 90 hours after the Lock and Dam 14 failure per UFSAR 2.4.4.

- At 565 feet or lower, the station plans to use a submersible booster pump to provide additional required NPSH for the FLEX pump.
- Torus and Reactor:
  - Per EC 395980 (Reference 149) and calc QDC-1300-M-2074 analysis, the RCIC system pump will have sufficient NPSH and is capable of operation greater than 72 hours.
- Spent Fuel Pool:
  - From Calculation QDC-1900-M-2079 for a Full Core Offload time to 12 ft. above fuel is 31.5 hours and the time to 10 ft. is 38.6 hours. The more restrictive time of 31.5 hours will be utilized for this alternative approach.
- Therefore, the shortest time that Phase 2 FLEX water injection is required is 31.5 hours based on Spent Fuel Pool water needs.
- Discharge bay remains open to the river following the event. The diffuser piping (Two-16 ft. pipes) remains open to allow sufficient backflow flow from the Mississippi river main channel to the discharge bay and remains open to the river following the event.
- The discharge bay bottom elevation is 557 feet. The minimum water level is 561 feet which is consistent with the normal water level downstream of Lock and Dam 14, should it fail. Therefore, a depth of 4 feet of usable water will remain available in the discharge bay and will be maintained by open path to the Mississippi River main channel via the diffuser piping.
- The discharge bay is expected to remain accessible following the event due to its construction that utilizes a sheet pile enclosure reinforced with rip-rap slope stabilization.
- The discharge bay pump pad was designed and installed to be seismically robust.
- The travel path to the discharge bay was evaluated for liquefaction.
- The station stores one FLEX pump in the FLEX storage building.
- The NSRC will provide a diesel driven hydraulic submersible booster pump to provide the additional NPSH for the FLEX pump if the discharge bay level continues to drop below or is expected to degrade below 565 feet. Changes to the SAFER Response plan for Quad Cities Station have been completed to provide this pump as part of the Quad Cities Power Station equipment package within 24 hours of notification (Reference 32).

12.7 Relief/Relaxation from Order EA-12-049

By letter dated February 27, 2014 (Reference 105), Quad Cities Station requested relaxation from certain schedule requirements of Order EA-12-049 (Reference 1) related to installation of the severe accident capable containment vent required by Order EA-13-109 (Reference 65). The NRC granted that schedule relief via letter dated April 15, 2014 (Reference 106).

In Reference 107, EGC requested an extension to comply with NRC Order EA-12-049 based on the earlier decision to permanently cease power operations at Quad Cities Nuclear Power Station, Units 1 and 2 by June 1, 2018, and engineering design and plant modification activities supporting Order implementation were discontinued. In Reference 108, as a result of the reversed cessation of operation decision, EGC withdrew this request for extension to comply and provided a revised request for extension to comply with NRC Order EA-12-049 based on the continued operation of both units. EGC has resumed work to complete full implementation of NRC Order EA-12-049 at Quad Cities Nuclear Power Station, Units 1 and 2.

This request for extension to comply with NRC Order EA-12-049 for Quad Cities Nuclear Power Station, Units 1 and 2 is in addition to the previous schedule relaxation granted by the NRC in Reference 106 and provides an additional schedule relaxation to June 30, 2018 for Quad Cities Nuclear Power Station, Units 1 and 2.

By letter dated March 4, 2015 (Reference 100) and supplemented by a letter dated March 6, 2015 (Reference 101) Quad Cities Station requested schedule relaxation of the requirements of Order EA-12-049 (Reference 1) related to the completion of installation of the mitigating strategies equipment and modifications to implement the strategies. The NRC granted the schedule relief via letter dated March 11, 2015 (Reference 102). The seismic deep well installation and associated modifications to implement the strategies were completed and made fully functional prior to the requested schedule relaxation date of December 11, 2015. As such, compliance with the requested schedule relaxation concerning the seismic deep well has been achieved.

No additional need for relief/relaxation relative to Order EA-12-049 (Reference 1), other than as described above, has been identified at this time.

13 FLEX Equipment

13.1 Equipment List

The equipment stored and maintained at the Quad Cities FLEX Storage Building, FLEX +1 Building and various pre-staged locations necessary for the implementation of the FLEX strategies in response to a BDB external event are listed in Table 4. Table 4 identifies the quantity, applicable strategy, and capacity/rating for the major BDB/FLEX equipment components only, as well as, various clarifying notes.

13.2 Equipment Maintenance and Testing

Periodic testing and preventative maintenance of the BDB/FLEX equipment conforms to the guidance provided in INPO AP-913 (Reference 150). A fleet procedure has been developed to address Preventative Maintenance (PM) using EPRI templates or manufacturer provided information/recommendations, equipment testing, and the unavailability of equipment (Reference 77).

EPRI has completed and has issued "Preventive Maintenance Basis for FLEX Equipment – Project Overview Report" (Reference 55). Preventative Maintenance Templates for the major FLEX equipment including the portable diesel pumps and generators have also been issued.

The PM Templates include activities such as:

- Periodic Static Inspections
- Fluid analysis
- Periodic operational verifications
- Periodic functional verifications with performance tests

The EPRI PM Templates for FLEX equipment conform to the guidance of NEI 12-06 providing assurance that stored or pre-staged FLEX equipment are being properly maintained and tested. EPRI Templates are used for equipment where applicable. However, in those cases where EPRI templates were not available, Preventative Maintenance (PM) actions were developed based on manufacturer provided information/recommendations and Exelon fleet procedure ER-AA-200, Preventive Maintenance Program. Refer to Table 3 for an overview. Detailed information on FLEX and FLEX support equipment PM's is contained in FLEX program document.

Table 3 Quad Cities FLEX Equipment Test and Maintenance Overview (Reference 50)

Equipment	Quantity	Weekly	Quarterly	6 Month	Annual	3 Year	Notes
Diesel Pump	2	Walk down		Functional Test and Inspection			Performance Test, Inspection & PM (Wet Run) once per cycle
Diesel Generator	5	Walk down		Functional Test and Inspection (Unloaded Run)	Performance Test, Inspection and PM (30% Loaded Run)	Performance Test, Inspection and PM (100% Loaded Run)	
Cables	Stored in Plant and FSB				Visual Inspection & assessment		Replace every 10 years or test and justify extension/life
Hoses (for both pumps and permanent connections hoses)	Stored in Plant and FSB				Visual Inspection & assessment		Replace every 10 years
Flex Deep Well	1			Functional test			Electrical testing every 5 years and motor starter surveillance every 10 years
Vehicles	1 Truck 1 Tractor	Walk down	Drive Truck around site	Drive Tractor around protected area			Periodic facilities maintenance

13.3 <u>Equipment Unavailability</u>

The unavailability of FLEX equipment and applicable connections that directly perform a FLEX mitigation strategy for core, containment, and SFP is controlled and managed per QCAP 1500-07 Administrative Tracking Requirements for Non-Functional FLEX Equipment, such that risk to mitigating strategy capability is minimized. The guidance in this procedure conforms to the guidance of NEI 12-06 as follows:

- Portable FLEX equipment may be unavailable for 90 days provided that the site FLEX capability (N) is available.
- If portable equipment becomes 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.

When FLEX equipment deficiencies are identified the following actions are taken:

1. Identified equipment deficiencies are entered into the corrective action program.
2. Equipment deficiencies that would prevent FLEX equipment from performing the intended function are worked under the station priority list in accordance with the work management process.
3. Equipment that cannot perform its intended functions is declared unavailable. Unavailability is tracked per QCAP 1500-07.

Table 4 Portable Equipment Stored On-Site (Reference 50)

Use and (Potential / Flexibility) Diverse Uses						
List Portable Equipment	**Core**	**Containment**	**SFP**	**Instrumentation**	**Accessibility**	***Performance Criteria***
FLEX diesel-driven pump (2) and assoc. hoses and fittings (Godwin HL130, Typical)	X	X	X			1500 gpm @ 147 psi, Supports core, containment and SFP cooling
FLEX generators (5) and associated cables, connectors (Cummins, Typical)	X	X	X	X		500 kW, 480 VAC, Supports core, containment and SFP cooling, instrumentation and controls
Hose trailer with well pump motor starter (2)	X	X	X			Motor starter mounted on the hose trailer required for well pump operation
Tow vehicle (2) [1] (1 F-750 and 1 Massey Ferguson Tractor, Typical)	X	X	X		X	Support large FLEX equipment deployment and debris removal
Portable fuel transfer pumps (2)[1]	X	X	X	X	X	Support adding fuel to diesel engine driven FLEX equipment

Table 4 Portable Equipment Stored On-Site (cont.)

Use and (Potential / Flexibility) Diverse Uses						
List Portable Equipment	***Core***	***Containment***	***SFP***	***Instrumentation***	***Accessibility***	***Performance Criteria***
Communications equipment [1] (SPP, spare radio batteries and chargers, handheld satellite phones)	X	X	X	X	X	Support on-site and off-site communications
Small portable generator. (6)[1] (Yanmar Generators, Typical)	X	X	X	X	X	5.5 kW, 120 VAC, Support communication and habitability equipment
Misc. debris removal equipment[1]					X	Support FLEX deployment
Misc. Support Equipment[1] (hand tools, flashlights & batteries, lanterns, extension cords, spill kits, rope)					X	Support FLEX deployment
NOTE 1: Support equipment. Not required to meet N+1.						

Table 5 BWR Portable Equipment from NSRC (Reference 32)

Use and (Potential / Flexibility) Diverse Uses									Performance Criteria		Notes
List Portable Equipment	**Quantity Req'd /Unit**	**Quantity Provided / Unit**	**Power**	**Core Cooling**	**Cont. Cooling/ Integrity**	**Access**	**Instrumentation.**	**SFP Cooling**			
Medium Voltage Generators	0	2	Jet Turb.	X	X		X		4.16 kV	1 MW	(1)
Low Voltage Generators	0	2	Jet Turb	X	X		X		480VAC	1000 KW	(1)
High Pressure Injection Pump	0	2	Diesel						2000psi	60 GPM	(1)
S/G RPV Makeup Pump	0	2	Diesel	X	X				500 psi	500 GPM	(1)
Low Pressure / Medium Flow Pump	0	2	Diesel	X	X				300 psi	2500 GPM	(1)
Low Pressure / High Flow Pump	0	2	Diesel	X	X			X	150 psi	5000 GPM	(1)

Table 5 BWR Portable Equipment from NSRC (cont.)

Use and (Potential / Flexibility) Diverse Uses									Performance Criteria		Notes
List Portable Equipment	**Quantity Req'd /Unit**	**Quantity Provided / Unit**	**Power**	**Core Cooling**	**Cont. Cooling/ Integrity**	**Access**	**Instrumentation.**	**SFP Cooling**			
Lighting Towers	0	6	Diesel			X			440,000 Lu		(1)
Diesel Fuel Transfer	0	2	AC/DC	X	X	X	X	X	264 gallons		(1)
Fuel Air-Lift Containers (Generic)	0	2							500 gallon		
Diesel Fuel Transfer Tank	0	2							264 gallon tank, with mounted AC/DC pumps		(1)
Portable Fuel Transfer Pump	0	2							60 gpm after filtration		(1)
Electrical Distribution System	0	2							4160 V	250 MVA, 1200 A	(1)
Portable Submersible Pump (Non-Generic)	1	1	Diesel	X	X			X	75 PSI	1400 GPM	(2)

Note 1	NSRC Generic Equipment – Not required for Phase 2 FLEX Strategy – Provided as Defense-in-Depth.
Note 2	NSRC Non-Generic Equipment needed to support use of NSRC Generic Pumps due to suction lift requirements using QC Discharge Bay as source of make-up water upon Loss of Lock and Dam 14 Scenario. – Not required for Phase 2 FLEX Strategy – Provided as Defense-in-Depth

14 References

1) NRC Order EA-12-049, Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events, March 12, 2012
2) NEI 12-06, Diverse and Flexible Coping Strategies (FLEX) Implementation Guide, Revision 2, December 2015
3) NRC JLD-ISG-2012-01, Revision 1, Compliance with Order EA–12–049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events, dated January 22, 2016
4) NRC Order EA-12-051, Issuance of Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation, March 12, 2012
5) NEI 12-02, Industry Guidance for Compliance with NRC Order EA-12-051, "To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation", Revision 1, August 2012
6) NRC JLD-ISG-2012-03, Compliance with Order EA-12-051, Reliable Spent Fuel Pool Instrumentation, Revision 0, August 29, 2012
7) NEI 12-01, Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities, Revision 0, April 2012
8) Task Interface Agreement (TIA) 2004-04, "Acceptability of Proceduralized Departures from Technical Specification (TSs) Requirements at the Surry Power Station"
9) QDC-8300-E-2100 Rev. 000 Unit 1(2) 125 VDC Battery Coping Calculation For Beyond Design Basis FLEX Event
10) QDC-8350-E-2101 Rev. 000 Unit 1(2) 250 VDC Battery Coping Calculation For Beyond Design Basis FLEX Event
11) QDC UFSAR Section 8.3.2.1, 250 V System
12) QDC UFSAR Section 8.3.2.2, 125 V System
13) QDC-7300-E-2099, Unit 1(2) 480 VAC FLEX Diesel Generator and Cable Sizing for Design Basis FLEX Event
14) NEI Position Paper Shutdown and Refueling: ADAMS Accession No. ML13273A514
15) NRC Endorsement of NEI Shutdown and Refueling paper: ADAMS Accession No. ML13267A382
16) EC 393703 Install Remote Readout Capability for Spent Fuel Pool Level Instrumentation – Fukushima
17) QDC-1900-M-2079, Fukushima – Spent Fuel Pool Time to Heat Up and Uncover Fuel

18) 2014-02948, Reactor Building Temperature Analysis Resulting from Extended Loss of AC Power
19) QDC-0000-S-2134, FLEX Travel Path Liquefaction Evaluation
20) QC-MISC-013 Rev. 2, MAAP Analysis to Support FLEX Initial Strategy
21) QC-MISC-014 Rev. 0, Use of MAAP in support of FLEX Implementation
22) EC 399944 Rev. 0, Quad Cities Diesel Fuel Oil Plan
23) Quad Cities Nuclear Power Station, Units 1 and 2- Fifth Six Month Status Report for the Implementation of FLEX, August 2015. (RS-15-215)
24) QDC-1300-M-2074, determination of RCIC NPSH during a Beyond Design Basis External Event (FLEX)
25) Quad Cities Flood Hazard Reevaluation Report Rev. 0, dated March 01, 2013
26) Quad Cities Local Intense Precipitation Evaluation Report, Rev. 7, dated March 11, 2013
27) NEDC 33771P R2, GEH Evaluation of FLEX Implementation Guidelines
28) UFSAR 9.1.3.3
29) RCIC Pump and Turbine Durability Evaluation – Pinch Point Study, February 2013, 0000-0155-1545-R0, DRF 0000-0155-1541, Revision 07.2
30) BWROG Fukushima Response Committee, BWROG-TP-14-018, Beyond Design Basis RCIC Elevated Temperature Functionality Assessment, December 2014, Rev 0
31) QGA 100 RPV Control
32) CC-QC-118-1001, Safer Response Plan For Quad Cities Generating Station
33) EC 400007, RCIC NPSH Cavitation Chart
34) QDC-0000-M-2097 Pipe Flo Analysis for FLEX Strategy
35) NUMARC 87-00 Rev 1, Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors
36) QGA 200 Primary Containment Control
37) EXC-WP-10_ RCIC Operation at Elevated Temperatures_Rev. 1 (Not Used)
38) NUREG-2122 Glossary of Risk-Related Terms in Support of Risk-Informed Decisionmaking
39) EC 396324, Fukushima Unit 1 FLEX – SR 250VDC Battery Crosstie to 250 VDC NSR Battery
40) EC 396354, Fukushima Unit 2 FLEX SR 250VDC Battery Crosstie to 250 VDC NSR Battery
41) Safety Evaluations of the Response to the Station Blackout Rule related to Dresden, Units 2 and 3, and Quad Cities, Units 1 and 2, dated December 11, 1990
42) EC 396323, Unit 1(2) 125 VDC Safety Related to Alternate Battery Crossties for FLEX
43) EC 398181, FLEX Storage Building

44) EC 395862, Install Fuel Oil Connections for Transfer Operations to F750 Truck Fukushima- FLEX Strategy
45) EC 393258, Evaluate the Effects of the Local Intense Precipitation (LIP) Event and the River Flood Event - Fukushima
46) EC 396297, Above Grade Flood Barriers for Local Intense Precipitation (LIP) Event - Fukushima
47) EC 399392, Turbine and Reactor Building Roof Parapet Modification (LIP)
48) EC 401224, Determine Warning Time for the Local Intense Precipitation (LIP) Event
49) EC 394892, Fukushima – Modify the Battery Room Exhaust Fan Electrical Supply from Emergency Lighting Cabinets
50) CC-QC-118, Site Implementation of Diverse and Flexible Coping Strategies (FLEX) and Spent Fuel Pool Instrumentation Program
51) EC 395697 Install Storz Connections on Alternate Reactor Vessel Injection (Condensate Transfer) – Fukushima – FLEX Strategy
52) EC 395698 Unit 1 Spent Fuel Pool Assist (Discharge Line) – Fukushima – FLEX Strategy
53) EC 399874, Battery and Charger Room Temperature Response for FLEX Evaluation Fukushima – Habitability Studies
54) EC 399553, EP 9.3 Communications – Satellite Backup and FLEX Phone Installation
55) EPRI: Preventive Maintenance Basis for FLEX Equipment – Project Overview Report
56) EC 395571, Install Storz Connections on ECCS Room Cooler Supply Lines – Fukushima – FLEX Strategy EC 395572 Unit 2 Storz Connection on ECCS Room Cooler Supply Line - Fukushima
57) EC 398197, Fukushima FLEX – Install Deep Well
58) EC 396321, Fukushima Unit 1 and 2 FLEX 480 VAC MCC/Bus Portable Diesel Generator Connections
59) BWROG-TP-14-006, Revision 0, March 2014, Fukushima Response Committee Raw Water Issue: Fuel inlet blockage from debris
60) EC 398254, Fukushima – Install Connections on ½ Trackway Door Wedge Hydraulic Lines
61) EC 399876, Interim Storage Pads for FLEX Equipment
62) EC 399998, Fukushima – Operation of RCIC and HPCI During FLEX
63) Standard For Probabilistic Risk Assessment For Nuclear Power Plant Applications
64) NRC JLD-ISG-2013-02, Compliance with Order EA-13-109, Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation under Severe Accident Conditions, dated November 14, 2013

65) NRC Order Number EA-13-109, "Issuance of Order to Modify Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions," dated June 6, 2013

66) NEI 13-02 rev. 1, Industry Guidance for Compliance with Order EA-13-109: BWR Mark I & II Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions, dated April 2015

67) BWROG-TP-15-007, Rev.0 dated June 2015, Raw Water Issue: Heat Transfer Capability

68) UFSAR 9.2.6 Condensate Storage Facilities

69) Exelon Position Paper "BDBEE Communications Strategy and Equipment Readiness, dated December 19, 2014

70) Exelon's Response to NRC Request for Information Pursuant to Co CFR 50.54(f) Regarding Emergency Communications Aspects of Recommendation 9.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, dated October 31, 2012 (RS-12-185)

71) CC-AA-309-101, Engineering Technical Evaluations

72) QCOA 6100-04, Station Blackout

73) CC-QC-118-1002, The Quad Cities Congested Area Plan

74) SAFER Operational Checklist, dated March 11, 2015

75) Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for BDBEE dated February 28, 2013 (RS-13-025)

76) CC-AA-102, Design Input and Configuration Impact Screening

77) CC-AA-118, Diverse and Flexible Coping Strategies (FLEX) and Spent Fuel Pool Instrumentation Program Document

78) EC 404409, Integrated Review of Flex Actions IAW NEI Validation Process Fukushima

79) QCOS 0050-03, Flex Equipment Surveillance

80) Exelon Response to March 12, 2012, Request for Information Enclosure 2, Recommendation 2.1, Flooding, Required Response 3, Flooding Integrated Assessment Submittal, dated June 29, 2018 (RS-18-045)

81) OU-AA-103, Shutdown Safety Management Program

82) QCOS 1600-07, Reactor Coolant System Leakage in the Drywell

83) EC 392256, Hardened Containment Vent System (Non-Outage Portion as Required by NRC Order EA-13-109, Units 1 & 2

84) EC 392257, Hardened Containment Vent System (Outage Portion) as Required by NRC Order EA-13-109 – Unit 1

85) EC 400666, Hardened Containment Vent System As Required by NRC Order EA-13-109 – Unit 2

86) Flood Walkdowns Report NTTF Recommendation 2.3 Flood Walkdowns, dated November 27, 2012 (RS-12-170)
87) QDC-0000-S-2131, Beyond Design Basis Site-Specific Local Intense Precipitation Analysis (Fukushima) For Exelon's IL Sites Including Quad Cities
88) LIP-QDC-001, Quad Cities Local Intense Precipitation Evaluation
89) NEI-15-05, External Flooding Assessment Guidelines, dated June 2016
90) LIP-QDC-004, Supplemental Consequential Flooding Study, Quad Cities
91) QCOA 0010-22, Local Intense Precipitation Response Procedure
92) EC 400708, Flex+1 Commercial Storage Building
93) Quad Cities Nuclear Power Station, Units 1 and 2- Third Six Month Status Report for the Implementation of FLEX, August 28, 2014. (RS-14-213)
94) AD-AA-101, Processing of Procedures and T&RMs
95) NEI APC 14-17, FLEX Validation Process, issued July 18, 2014
96) Boiling Water Reactor Owner's Group (BWROG) Emergency Procedures and Severe Accident Guidelines (EPG/SAG) Revision 3, dated February 2013
97) OP-QC-116-101-1001, Station Equipment Labeling Writers Guide
98) Quad Cities Nuclear Power Station NEI 12-01 Phase 2 Staffing Assessment Report, dated November 3, 2014 (RS-14-280)
99) Quad Cities Nuclear Power Station, Units 1 and 2- Seventh Six Month Status Report for the Implementation of FLEX, August 2016 (RS-16-150)
100) Quad Cities Nuclear Power Station's Request for Relaxation from NRC Order EA-12-049 "Order Modifying Licenses With Regard To Requirements for Mitigation Strategies for Beyond Design-Basis External Events," dated March 4, 2015 (Adams Accession No. ML 15064A090)
101) Quad Cities Nuclear Power Station's Request for Relaxation from NRC Order EA-12-049 "Order Modifying Licenses With Regard To Requirements for Mitigation Strategies for Beyond Design-Basis External Events," dated March 6, 2015 (Adams Accession No. ML 15068A064)
102) NRC Approval of Exelon/Quad Cities Unit 1 Request for Relaxation from NRC Order EA-12-049, dated March 11, 2015 (ADAMS Accession No. ML 15068A206)
103) NRC Letter, Quad Cities Nuclear Power Station, Units 1 and 2 – Flood Hazard Mitigation Strategies Assessment (CAC NOS. MF7966 and MF7967), dated October 4, 2017
104) Exelon Generation Letter to USNRC, Quad Cities Nuclear Power Station, Units 1 and 2, Mitigating Strategies Flood Hazard Assessment (MSFHA) Submittal, dated December 1, 2016 (RS-16-185)
105) Quad Cites Nuclear Power Station's Request for Relaxation from NRC Order EA-12-049, "Order Modifying Licenses With Regard To Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated February 27, 2014

106) NRC Approval of Exelon/Quad Cities Request for Relaxation from NRC Order EA-12-049, dated April 15, 2014 (ADAMS Accession No. ML14071A531)

107) Exelon Generation Company, LLC Request for Extension to Comply with NRC Order EA-13-109, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions" and NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated November 16, 2016 (RS-16-210)

108) Exelon Generation Company, LLC Request for Extension to Comply with NRC Order EA-13-109, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions" and NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated January 12, 2017 (RS-17-006)

109) Quad Cities Nuclear Power Station, Units 1 and 2 First Six Month Status Report for the Implementation of Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated August 28, 2013 (RS-13-129)

110) Quad Cities Nuclear Power Station, Units 1 and 2 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC NOS.MF 1048 and MF 1049), dated November 22, 2013

111) Quad Cities Nuclear Power Station, Units 1 and 2 Second Six Month Status Report for the Implementation of Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated February 28, 2014 (RS-14-015)

112) Quad Cities Nuclear Power Station, Units 1 and 2 Fourth Six Month Status Report for the Implementation of Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated February 27, 2015 (RS-15-024)

113) NRC Report for the Onsite Audit regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation related to Orders EA-12-049 and EA-12-51, dated June 25, 2015 (ADAMS Accession No. ML15156B134)

114) Quad Cities Nuclear Power Station, Units 1 and 2 Sixth Six Month Status Report for the Implementation of Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated February 26, 2016 (RS-16-027)

115) Quad Cities Nuclear Power Station, Units 1 and 2 Eighth Six Month Status Report for the Implementation of Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated February 28, 2017 (RS-17-022)

116) Quad Cities Nuclear Power Station, Units 1 and 2 Ninth Six Month Status Report for the Implementation of Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated February 28, 2017 (RS-17-097)

117) 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 2012

118) NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Revision 0, dated August 2012

119) Exelon Generation Company, LLC's 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 (Order Number EA-12-049), dated October 25, 2012

120) Exelon Generation Company, LLC, Tenth 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 28, 2018 (RS-18-011)

121) NRC Letter, 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 dated March 12, 2012

122) UFSAR Section 5.4.6, Reactor Core Isolation Cooling System

123) USFAR Section 3.4.1.1, External Flood Protection Measures

124) QCOA 0010-14, Lock and Dam 14 Failure

125) QCOP 1300-09, RCIC Local Manual Operation

126) QCOP 1300-02, RCIC System Manual Startup (Injection-Pressure Control)

127) QCOP 0201-10, Bypassing Isolation Signals to Support QGA Actions

128) QC-93Q-E-001 Rev 2, Unit 1(2) 250 VDC Non-Essential Battery Sizing Calculation

129) NEI Letter to NRC dated January 9, 2014. Adams Accession Nos: ML13358A206

130) EA-12-049 Mitigating Strategies Resolution with Respect to BWR MK I and II Anticipatory Containment Venting. Adams Accession Nos: ML13352A061

131) EA-12-049 Mitigating Strategies Resolution with Respect to BWR MK I and II Anticipatory Containment Venting. Adams Accession Nos: ML13352A066

132) EA-12-049 Mitigating Strategies Resolution with Respect to BWR MK I and II Anticipatory Containment Venting. Adams Accession Nos: ML13352A079

133) QCFHP 1200-14, Installation and Removal of Transfer Canal Gates

134) NRC Letter, Final Screening and Prioritization Results for Limerick, Clinton, Salem, Surry and Quad Cities Regarding Seismic Hazard Reevaluation for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident, dated October 3, 2014. Adams Accession Nos: ML14258A043

135) SY-QC-101-411, Active Vehicle Barrier System/Motorized Gate Manual Operation

136) EPRI Technical Report "Technical Basis for Establishing Success Timelines in Extended Loss of AC Power Scenarios in Boiling Water Reactors Using MAAP4," (EPRI Product ID 3002002749)

137) EPRI Technical Report "Use of Modular Accident Analysis Program (MAAP) in Support of Post Fukushima Applications" (EPRI Product ID 3002001785)

138) QGA 500-1, RPV Blowdown

139) QCAP 0200-10, Emergency Operating Procedure (QGA) Execution Standards

140) QCAP 1500-07, Administrative Tracking Requirements for Unavailable FLEX, HCVS and SAWA Equipment

141) QCOS 4100-34, Fire Brigade Equipment Check Surveillance

142) SA-AA-111, Heat Stress Control

143) QCOS 0010-03, Safe Shutdown Equipment Inspection

144) Dated February 22, 2013; RS-13-038

145) QCOS 9000-01, Quarterly Hand-Held Radio Check and Iridium Hand-Held Satellite Phone Test

146) QCOS 9000-2, Annual Plant Emergency Phone Surveillance

147) EP-AA-124-F-03, Site and Site-Specific EOF Communications 9.3 and EMNET Satellite Communications Systems Semi-Annual Testing and Inventory

148) UFSAR 2.4.4, Potential Dam Failures

149) EC 395980, Determination of RCIC NPSH During a Beyond Design Basis External Event (Flex)

150) INPO AP-913, Equipment Reliability Process Implementation Summaries (EPRI Product ID: 1003479)

151) Letter from QCNPS to NRC to report full compliance with Hardened Vent Order EA-13-109, dated August 14, 2018 (RS-18-089)

152) Letter from QCNPS to NRC to report full compliance with Flex Order EA-12-049, dated August 14, 2018 (RS-18-087)