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DIVERSE AND FLEXIBLE COPING STRATEGIES (FLEX) IMPLEMENTATION GUIDE

August 2012

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Nuclear Energy Institute

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DIVERSE AND FLEXIBLE COPING STRATEGIES (FLEX) IMPLEMENTATION GUIDE

1 INTRODUCTION

One of the primary lessons learned from the accident at Fukushima Dai-ichi was the significance of the challenge presented by a loss of safety-related systems following the occurrence of a beyond-design-basis external event. In the case of Fukushima Dai-ichi, the extended loss of alternating current (ac) power (ELAP) condition caused by the tsunami led to loss of core cooling and a significant challenge to containment. The design basis for U.S. nuclear plants includes bounding analyses with margin for external events expected at each site. Extreme external events (e.g., seismic events, external flooding, etc.) beyond those accounted for in the design basis are highly unlikely but could present challenges to nuclear power plants.

In order to address these challenges, this guide outlines the process to be used by licensees, Construction Permit (CP) holders, and Combined License (COL) holders to define and deploy strategies that will enhance their ability to cope with conditions resulting from beyond-design-basis external events.

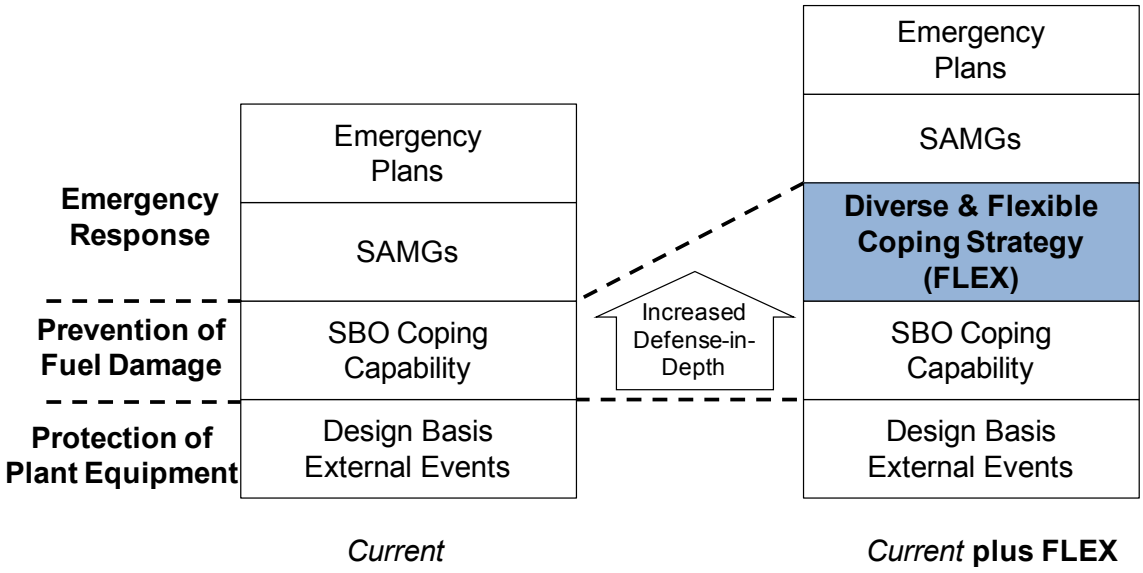
1.1 BACKGROUND

The Fukushima Dai-ichi accident was the result of a tsunami that exceeded the plant's design basis and flooded the site's emergency power supplies and electrical distribution system. This extended loss of power severely compromised the key safety functions of core cooling and containment integrity and ultimately led to core damage in three reactors. While the loss of power also impaired the spent fuel pool cooling function, sufficient water inventory was maintained in the pools to preclude fuel damage from loss of cooling.

The size of the tsunami that hit Fukushima Dai-ichi was not accounted for in the plant's design basis. Although the ability to predict the magnitude and frequency of beyond-design-basis external events (BDBEE) such as earthquakes and floods may be improving, and design bases for plants include some margin, some probability will always remain for a beyond-design-basis external event. As a result, though unlikely, external events could exceed the assumptions used in the design and licensing of a plant, as demonstrated by the events at Fukushima. Additional diverse and flexible strategies that address the potential consequences of these "beyond-design-basis external events" would enhance safety at each site.

The consequences of postulated beyond-design-basis external events that are most impactful to reactor safety are loss of power and loss of the ultimate heat sink. This document outlines an approach for adding diverse and flexible mitigation strategies—or FLEX— that will increase defense-in-depth for beyond-design-basis scenarios to address an ELAP and loss of normal access to the ultimate heat sink (LUHS) occurring simultaneously at all units on a site. (See Figure 1-1).

Figure 1-1
FLEX Enhances Defense-in-Depth



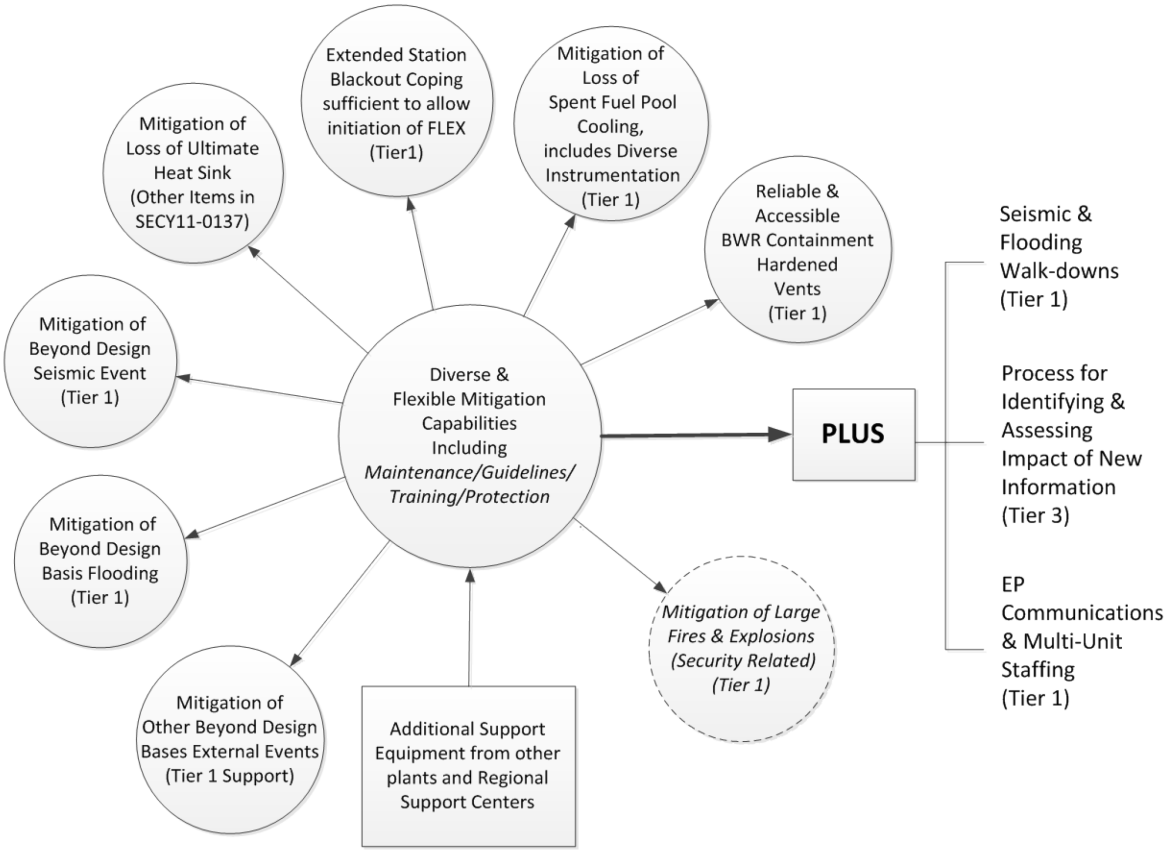
FLEX consists of the following elements:

- **Portable equipment that provides means of obtaining power and water to maintain or restore key safety functions for all reactors at a site.** This could include equipment such as portable pumps, generators, batteries and battery chargers, compressors, hoses, couplings, tools, debris clearing equipment, temporary flood protection equipment and other supporting equipment or tools.
- **Reasonable staging and protection of portable equipment from BDBEEs applicable to a site.** The equipment used for FLEX would be staged and reasonably protected from applicable site-specific severe external events to provide reasonable assurance that N sets of FLEX equipment will remain deployable following such an event.
- **Procedures and guidance to implement FLEX strategies.** FLEX Support Guidelines (FSG), to the extent possible, will provide pre-planned FLEX strategies for accomplishing specific tasks in support of Emergency Operating Procedures (EOP) and Abnormal Operating Procedures (AOP) functions to improve the capability to cope with beyond-design-basis external events.
- **Programmatic controls that assure the continued viability and reliability of the FLEX strategies.** These controls would establish standards for quality, maintenance, testing of FLEX equipment, configuration management and periodic training of personnel.

The FLEX strategies will consist of both an on-site component using equipment stored at the plant site and an off-site component for the provision of additional materials and equipment for longer-term response.

By providing multiple means of power and water supply to support key safety functions, FLEX can mitigate the consequences of beyond-design-basis external events. Figure 1-2 depicts how FLEX can provide a common solution to mitigate multiple risks in an integrated manner. The figure also shows how FLEX comprehensively addresses the majority of the NRC's Tier 1 recommendations.

Figure 1-2
Overview of FLEX Concept



1.2 PURPOSE

The purpose of this guide is to outline the process to be used by individual licensees to define and implement site-specific diverse and flexible mitigation strategies that reduce the risks associated with beyond-design-basis conditions.

1.3 FLEX OBJECTIVES & GUIDING PRINCIPLES

The objective of FLEX is to establish an indefinite coping capability to prevent damage to the fuel in the reactor and spent fuel pools and to maintain the containment function by using installed equipment, on-site portable equipment, and pre-staged off-site resources. This capability will address both an ELAP (i.e., loss of off-site power, emergency diesel generators

and any alternate ac source[1] but not the loss of ac power to buses fed by station batteries through inverters) and a LUHS which could arise following external events that are within the existing design basis with additional failures and conditions that could arise from a beyond-design-basis external event. Since the beyond-design-basis regime is essentially unlimited, plant features and insights from beyond-design-basis evaluations are used, where feasible, to inform coping strategies.

The FLEX strategies are focused on maintaining or restoring key plant safety functions and are not tied to any specific damage state or mechanistic assessment of external events. In some cases, additional hazard-specific boundary conditions are applied in order to cause the implementation strategies to be focused on the nature of challenges that are most likely for that hazard. A safety function-based approach is in keeping with the symptom-based approach taken to plant emergency operating procedures (EOPs) and facilitates the utilization of the FLEX strategies in support of the operating and emergency response network of procedures and guidance.

The underlying strategies for coping with these conditions involve a three-phase approach:

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

Plant-specific analyses will determine the duration of each phase. Recovery of the damaged plant is beyond the scope of FLEX capabilities as the specific actions and capabilities will be a function of the specific condition of the plant and these conditions cannot be known in advance.

To the extent practical, generic thermal hydraulic analyses will be developed to support plant-specific decision-making. Justification for the duration of each phase will address the on-site availability of equipment, the resources necessary to deploy the equipment consistent with the required timeline, anticipated site conditions following the beyond-design-basis external event, and the ability of the local infrastructure to enable delivery of equipment and resources from off-site.

While FLEX strategies are focused on the prevention of fuel damage, these strategies would be available to support accident mitigation efforts following fuel damage. However, coordination of the FLEX equipment with Severe Accident Management Guidelines (SAMGs) is not within the scope of this guideline.

[1] Alternate AC source as defined in 10 CFR 50.2

1.4 RELATIONSHIP TO OTHER TIER 1 REQUIREMENTS

Effective implementation of FLEX requires coordination with the following on-going activities:

- Seismic walkdowns (NRC RFI dated March 12, 2012 on Recommendation 2.3) – These walkdowns provide the basis for the capability of the plant to successfully respond to design basis seismic events, which is a foundation for the FLEX strategies.
- Flood walkdowns (NRC RFI dated March 12, 2012 on Recommendation 2.3) – These walkdowns provide the basis for the capability of the plant to successfully respond to design basis flooding events, which is a foundation for the FLEX strategies.
- Boiling Water Reactor (BWR) Mk I and II reliable hardened vents (NRC Order EA-12-050) – Mk I and II containment venting will be a required function to cope with an ELAP or LUHS event.
- SFP level instrumentation (NRC Order EA-12-051) – The enhanced SFP instrumentation will support the implementation of FLEX strategies for maintaining SFP water level to prevent fuel damage.
- EOP/SAMG activities (Recommendation 8) – Implementation of FLEX will require coordination with plant EOPs and supporting procedures and guidance.
- Staffing and communications (NRC RFI dated March 12, 2012 on Recommendation 9.3) – Implementation of FLEX will utilize on-site and off-site communications capabilities, and the on-shift and augmented staff will implement appropriate FLEX strategies in response to a beyond-design-basis external event affecting all units on a site.

1.5 APPLICABILITY

This guidance document is applicable to operating reactors, construction permit holders, and COL holders and addresses the development of mitigation strategies for beyond-design-basis external events. The NRC issued Order EA-12-049 modifying the licenses for certain facilities. Attachments 2 and 3 of the Order are provided in Tables 1-1 and 1-2.

Table 1-1

Order for Operating Reactors and Construction Permit Holders

REQUIREMENTS FOR MITIGATION STRATEGIES FOR BEYOND-DESIGN-BASIS EXTERNAL EVENTS AT OPERATING REACTOR SITES AND CONSTRUCTION PERMIT HOLDERS

This Order requires a three-phase approach for mitigating beyond-design-basis external events. The initial phase requires the use of installed equipment and resources to maintain or restore core cooling, containment and spent fuel pool (SFP) cooling capabilities. The transition phase requires providing sufficient, portable, on-site equipment and consumables to maintain or restore these functions until they can be accomplished with resources brought from off-site. The final phase requires obtaining sufficient off-site resources to sustain those functions indefinitely.

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

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

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

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

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

Table 1-2

Order for Combined Operating License Holders

REQUIREMENTS FOR MITIGATION STRATEGIES FOR BEYOND-DESIGN-BASIS EXTERNAL EVENTSAT COL HOLDER REACTOR SITES [AP1000 COLs]

Attachment 2 to this order for Part 50 licensees requires a phased approach for mitigating beyond-design-basis external events. The initial phase requires the use of installed equipment and resources to maintain or restore core cooling, containment and spent fuel pool (SFP) cooling capabilities. The transition phase requires providing sufficient, portable, on-site equipment and consumables to maintain or restore these functions until they can be accomplished with resources brought from off-site. The final phase requires obtaining sufficient off-site resources to sustain those functions indefinitely.

The design bases of [AP1000 COL] includes passive design features that provide core, containment and SFP cooling capability for 72 hours, without reliance on alternating current (ac) power. These features do not rely on access to any external water sources since the containment vessel and the passive containment cooling system serve as the safety-related ultimate heat sink. The NRC staff reviewed these design features prior to issuance of the combined licenses for these facilities and certification of the AP1000 design referenced therein. The AP1000 design also includes equipment to maintain required safety functions in the long term (beyond 72 hours to 7 days) including capability to replenish water supplies. Connections are provided for generators and pumping equipment that can be brought to the site to back up the installed equipment. The staff concluded in its final safety evaluation report for the AP1000 design that the installed equipment (and alternatively, the use of transportable equipment) is capable of supporting extended operation of the passive safety systems to maintain required safety functions in the long term. As such, this Order requires [AP1000 COL] to address the following requirements relative to the final phase.

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

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

2 OVERVIEW OF IMPLEMENTATION PROCESS

The accident at Fukushima Dai-ichi highlighted the potential challenges associated with coping with an ELAP. ELAP and LUHS have long been identified as contributors to nuclear power plant risk in plant-specific PRAs.

FLEX strategies will be determined based on two criteria. Each plant will establish the ability to cope with the baseline conditions for a simultaneous ELAP and LUHS event. Each plant would then evaluate the FLEX protection and deployment strategies in consideration of the challenges of the external hazards applicable to the site. Depending on the challenge presented, the approach and specific implementation strategy may vary.

Each plant and site has unique features and for this reason, the implementation of FLEX capabilities will be site-specific. This guideline is organized around the site assessment process shown in Figure 2-1. The guidance is provided to outline the steps, considerations, and ultimate FLEX strategies that are to be provided for each site.

Boundary Conditions

The following general boundary conditions apply to the establishment of FLEX strategies:

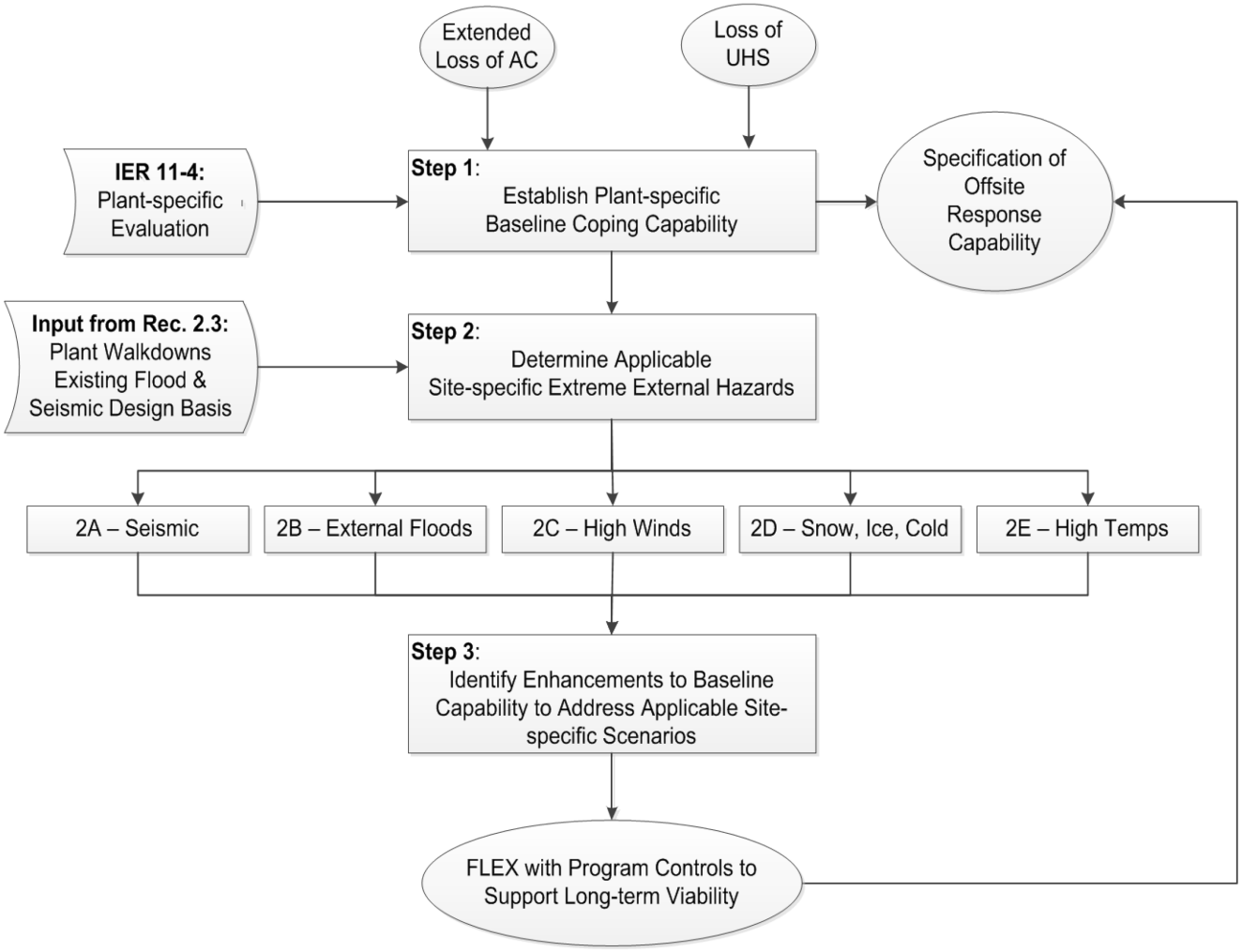
- Beyond-design-basis external event occurs impacting all units at site.
- All reactors on-site initially operating at power, unless site has procedural direction to shut down due to the impending event.
- Each reactor is successfully shut down when required (i.e., all rods inserted, no ATWS).
- On-site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

In some cases, additional hazard-specific boundary conditions are defined for various types of external hazards.

The boundary conditions for core cooling and containment strategies assume all reactors on the site are initially at power because this is more challenging in terms of core protection, and containment integrity. The FLEX strategies have been designed for this condition. However, the FLEX strategies are also “diverse and flexible” such that they can be implemented in many different conditions as it is not possible to predict the exact site conditions following a beyond-design-basis external event. As such, the strategies can be implemented in all modes by maintaining the portable FLEX equipment available to be deployed during all modes.

Though the FLEX strategies are not explicitly designed for outage conditions due to the small fraction of the operating cycle that is spent in an outage condition, generally less than 10%, consideration is given in the requirements of this document that support outage conditions as follows:

Figure 2-1
Site Assessment Process



- Provision of primary and alternate connection points provides higher reliability and helps address equipment being out of service.
- Specific makeup rates and connections will be sized to support outage conditions, i.e., connection points for RCS makeup will be sized to support core cooling.

While equipment required for compliance with 50.54(hh)(2) may be used to support FLEX implementation, this document does not address compliance with 50.54(hh)(2). The guidance of NEI 06-12 still applies in that case.

The main body of this guidance is written for current generation LWRs. Appendix F provides guidance on the development of mitigation strategies for the AP1000 design. As additional new plant designs are deployed, additional addenda will be added to this document to address the specific application of FLEX to those designs.

2.1 ESTABLISH BASELINE COPING CAPABILITY

The first step of FLEX capability development is the establishment of the baseline coping capability to address a simultaneous ELAP and LUHS event. In general, the baseline coping capability is established based on an assumed set of boundary conditions that arise from a beyond-design-basis external event. Each plant will establish the ability to cope for these baseline conditions utilizing a combination of installed, temporary, and off-site equipment. These capabilities will also improve the ability of each plant to respond to other causes of a simultaneous ELAP and LUHS not specifically the result of an external event.

Examples of the types of capabilities identified on a plant-specific basis include:

- Battery load shedding to extend battery life.
- Provision of additional small ac and/or direct current (dc) power sources to recharge batteries or energize key equipment and instrumentation.
- Enhancement of capabilities previously deployed under 10 CFR 50.54(hh)(2).

In nearly all cases, the deployment of these enhanced coping strategies will require revisions to plant procedures/guidance, as current plant procedures were largely oriented to the conditions defined under 10 CFR 50.63.

The process for establishing a baseline coping capability is described in Section 3.

While initial approaches to FLEX strategies will take no credit for installed ac power supplies, longer term strategies may be developed to prolong Phase 1 coping that will allow greater reliance on permanently installed, bunkered or hardened ac power supplies that are adequately protected from external events.

2.2 DETERMINE APPLICABLE EXTREME EXTERNAL HAZARDS

This step of the site assessment process involves the evaluation of the external hazards that are considered credible to a particular site. For the purposes of this assessment, external hazards have been grouped into five classes to help further focus the effort:

- seismic events
- external flooding
- storms such as hurricanes, high winds, and tornadoes
- extreme snow, ice, and cold
- extreme heat

Each plant will evaluate the applicability of these hazards and, where applicable, address the implementation considerations associated with each. These considerations include:

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

The process for determining the applicable external hazards and enhancing the baseline FLEX strategies to address these hazards is described in Sections 4 through 9.

2.3 DEFINE SITE-SPECIFIC FLEX STRATEGIES

This step involves the consideration of the hazards that are applicable to the site, in order to establish the best overall strategy for the deployment of FLEX capabilities for beyond-design-basis conditions.

Considering the external hazards applicable to the site, the FLEX mitigation equipment should be stored in a location or locations such that it is reasonably protected such that no one external event can reasonably fail the site FLEX capability. Reasonable protection can be provided for example, through provision of multiple sets of portable on-site equipment stored in diverse locations or through storage in structures designed to reasonably protect from applicable external events.

The process for defining the full extent of the FLEX coping capability is described in Section 10.

2.4 PROGRAMMATIC CONTROLS

The programmatic controls for implementation of FLEX include:

- quality attributes
- equipment design
- equipment storage
- procedure guidance
- maintenance and testing
- training
- staffing
- configuration control.

Procedures and guidance to support deployment and implementation including interfaces to EOPs, special event procedures, abnormal event procedures, and system operating procedures, will be coordinated within the site procedural framework.

The storage requirements for the FLEX equipment will be based on the results of the analysis performed in Sections 4 through 9.

The programmatic controls for FLEX strategies are described in Section 11.

2.5 SYNCHRONIZATION WITH OFF-SITE RESOURCES

The timely provision of effective off-site resources will need to be coordinated by the site and will depend on the plant-specific analysis and strategies for coping with the effects of the beyond-design-basis external event. Arrangements will need to be established by each site for the off-site equipment and resources that will be required for the off-site phase.

The off-site response interfaces for FLEX capabilities are described in Section 12.

3 STEP 1: ESTABLISH BASELINE COPING CAPABILITY

The primary FLEX objective is to develop a plant-specific capability for coping with a simultaneous ELAP and LUHS event for an indefinite period through a combination of installed plant capability, portable on-site equipment, and off-site resources. Each plant will establish the ability to cope for these baseline conditions based on the appropriate engineering analyses and procedural framework.

3.1 PURPOSE

All U.S. plants have a coping capability for station blackout (SBO) conditions under 10 CFR 50.63. In some cases, plants rely on installed battery capacity to support operation of AC-independent core cooling sources. While in other cases, stations rely on SBO diesel generators, gas turbines, or ac power from other on-site sources to mitigate the blackout condition. The U.S. plants also developed emergency response strategies to mitigate the effects of large fires and explosions under 10 CFR 50.54(hh)(2).

While existing capabilities for coping with SBO conditions are robust, it is possible to postulate low-probability events and scenarios beyond a plant's design basis that may lead to a simultaneous ELAP and LUHS. The purpose of this step is to identify reasonable strategies and actions to establish an indefinite coping capability during which key safety functions are maintained for the simultaneous ELAP and LUHS conditions.

3.2 PERFORMANCE ATTRIBUTES

This baseline coping capability is built upon strategies that focus on a simultaneous ELAP and LUHS condition caused by unspecified events. The baseline assumptions have been established on the presumption that other than the loss of the ac power sources and normal access to the UHS, installed equipment that is designed to be robust with respect to design basis external events is assumed to be fully available. Installed equipment that is not robust is assumed to be unavailable. The baseline assumptions are provided in Section 3.2.1.

3.2.1 General Criteria and Baseline Assumptions

The following subsections outline the general criteria and assumptions to be used in establishing the baseline coping capability.

3.2.1.1 General Criteria

Procedures and equipment relied upon should ensure that satisfactory performance of necessary fuel cooling and containment functions are maintained. A simultaneous ELAP and LUHS challenges both core cooling and spent fuel pool cooling due to interruption of normal ac powered system operations.

For a PWR, an additional requirement is to keep the fuel in the reactor covered. For a BWR, reactor core uncovery following RPV depressurization is allowed as long as it can be shown that adequate core cooling is maintained using analytical methods, e.g., MAAP analysis. For BWRs it is understood that containment venting may be required for decay heat removal purposes.

For both PWRs and BWRs, the requirement is to keep fuel in the spent fuel pool covered.

The conditions considered herein are beyond-design-basis. Consequently, it is not possible to bound all essential inputs to these evaluations. This document provides the appropriate rationale and assumptions for developing plant-specific strategies.

3.2.1.2 Initial Plant Conditions

The initial plant conditions are assumed to be the following:

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

(2) At the time of the postulated event, the reactor and supporting systems are within normal operating ranges for pressure, temperature, and water level for the appropriate plant condition. All plant equipment is either normally operating or available from the standby state as described in the plant design and licensing basis.

3.2.1.3 Initial Conditions

The following initial conditions are to be applied:

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

(2) All installed sources of emergency on-site ac power and SBO Alternate ac power sources are assumed to be not available and not imminently recoverable.

(3) 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.

(4) Normal access to the ultimate heat sink is lost, but the water inventory in the UHS remains available and robust piping connecting the UHS to plant systems remains intact. The motive force for UHS flow, i.e., pumps, is assumed to be lost with no prospect for recovery.

(5) Fuel for FLEX equipment stored in structures with designs which are robust with respect to seismic events, floods and high winds and associated missiles, remains available.

(6) 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.

(7) Other equipment, such as portable ac power sources, portable back up dc power supplies, spare batteries, and equipment for 50.54(hh)(2), may be used provided it is reasonably protected from the applicable external hazards per Sections 5 through 9 and Section 11.3 of this guidance and has predetermined hookup strategies with appropriate procedures/guidance and the equipment is stored in a relative close vicinity of the site.

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

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

(10) Reliance on the fire protection system ring header as a water source is acceptable only if the header meets the criteria to be considered robust with respect to seismic events, floods, and high winds, and associated missiles.

3.2.1.4 Reactor Transient

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

(1) Following the loss of all ac power, the reactor automatically trips and all rods are inserted.

(2) The main steam system valves (such as main steam isolation valves, turbine stops, atmospheric dumps, etc.), necessary to maintain decay heat removal functions operate as designed.

(3) Safety/Relief Valves (S/RVs) or Power Operated Relief Valves (PORVs) initially operate in a normal manner if conditions in the RCS so require. Normal valve reseating is also assumed.

(4) No independent failures, other than those causing the ELAP/LUHS event, are assumed to occur in the course of the transient.

3.2.1.5 Reactor Coolant Inventory Loss

Sources of expected PWR and BWR reactor coolant inventory loss include:

(1) normal system leakage

(2) losses from letdown unless automatically isolated or until isolation is procedurally directed

(3) losses due to reactor coolant pump seal leakage (rate is dependent on the RCP seal design)

(4) losses due to BWR recirculation pump seal leakage

(5) BWR inventory loss due to operation of steam-driven systems, SRV cycling, and RPV depressurization.

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

3.2.1.6 SFP Conditions

The initial SFP conditions are:

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

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

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

(4) SFP heat load assumes the maximum design basis heat load for the site.

3.2.1.7 Event Response Actions

Event response actions follow the command and control of the existing procedures and guidance based on the underlying symptoms that result from the event. The priority for the plant response is to utilize systems or equipment that provides the highest probability for success. Other site impacts as a result of the event would be addressed according to plant priorities and resource availability. The FLEX strategy relies upon the following principles:

1) Initially cope by relying on installed plant equipment.
2) Transition from installed plant equipment to on-site FLEX equipment.
3) Obtain additional capability and redundancy from off-site resources until power, water, and coolant injection systems are restored or commissioned.
4) Response actions will be prioritized based on available equipment, resources, and time constraints. The initial coping response actions can be performed by available site personnel post-event.
5) Transition from installed plant equipment to on-site FLEX equipment may involve on-site, off-site, or recalled personnel as justified by plant-specific evaluation.
6) Strategies that have a time constraint to be successful should be identified and a basis provided that the time can reasonably be met.

3.2.1.8 Effects of Loss of Ventilation

The effects of loss of HVAC in an extended loss of ac power event can be addressed consistent with NUMARC 87-00 [Ref. 8] or by plant-specific thermal hydraulic calculations, e.g., GOTHIC calculations.

3.2.1.9 Personnel Accessibility

Areas requiring personnel access should be evaluated to ensure that conditions will support the actions required by the plant-specific strategy for responding to the event.

3.2.1.10 Instrumentation and Controls

Actions specified in plant procedures/guidance for loss of ac power are predicated on use of instrumentation and controls powered by station batteries. In order to extend battery life, a minimum set of parameters necessary to support strategy implementation should be defined. The parameters selected must be able to demonstrate the success of the strategies at maintaining the key safety functions as well as indicate imminent or actual core damage to facilitate a decision to manage the response to the event within the Emergency Operating Procedures and FLEX Support Guidelines or within the SAMGs. Typically, these parameters would include the following:

PWRs	BWRs
• SG Level • SG Pressure • RCS Pressure • RCS Temperature • Containment Pressure • SFP Level	• RPV Level • RPV Pressure • Containment Pressure • Suppression Pool Level • Suppression Pool Temperature • SFP Level

The plant-specific evaluation may identify additional parameters that are needed in order to support key actions identified in the plant procedures/guidance (e.g., isolation condenser (IC) level), or to indicate imminent or actual core damage.

3.2.1.11 Containment Isolation Valves

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

3.2.1.12 Qualification of Installed Equipment

Equipment relied upon to support FLEX implementation does not need to be qualified to all extreme environments that may be posed, but some basis should be provided for the capability of the equipment to continue to function. Appendix G of Reference 8 contains information that may be useful in this regard.

3.2.2 Minimum Baseline Capabilities

Each site should establish the minimum coping capabilities consistent with unit-specific evaluation of the potential impacts and responses to an ELAP and LUHS. In general, this coping can be thought of as occurring in three phases:

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

In order to support the objective of an indefinite coping capability, each plant will be expected to establish capabilities consistent with Table 3-1 (BWRs) or Table 3-2 (PWRs). Additional explanation of these functions and capabilities are provided in Appendices C and D.

The overall plant response to an ELAP and LUHS will be accomplished through the use of normal plant command and control procedures and practices. The normal emergency response capabilities will be used as defined in the facility emergency plan, as augmented by NEI 12-01, Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities. As described in Section 11.4, the plant emergency operating procedures (EOPs) will govern the operational response. This ensures that a symptom-based approach is taken to the response, available capabilities are utilized, and control of the plant is consistent with EOP requirements, e.g., control of key parameters, cooldown rate, etc. The FLEX strategies will be deployed in support of the EOPs using separate FLEX Support Guidelines (FSGs) that govern the use of FLEX equipment in maintaining or restoring key safety functions.

The following guidelines are provided to support the development of guidance to coordinate with the existing set of plant operating procedures/guidance:

(1) *Plant procedures/guidance should identify site-specific actions necessary to restore ac power to essential loads. If an Alternate ac (AAC) power source is available it should be started as soon as possible. If not, actions should be taken to secure existing equipment alignments and provide an alternate power source as soon as possible based on relative plant priorities.*

While initial actions following the event may focus on restoration of ac power to essential loads, procedural guidance needs to assure a timely decision is made on whether or not the beyond design basis (BDB) external event (BDBEE) has resulted in a SBO condition that is an ELAP. This is an important decision to ensure that actions to maintain or restore key safety functions are taken consistent with the timelines required for the successful implementation of the FLEX strategies for the initial response phase.

(2) *Plant procedures/guidance should recognize the importance of AFW/HPCI/RCIC/IC during the early stages of the event and direct the operators to invest appropriate attention to assuring its initiation and continued, reliable operation throughout the transient since this ensures decay heat removal.*

The risk of core damage due to ELAP can be significantly reduced by assuring the availability of AFW/HPCI/RCIC/IC, particularly in the first 30 minutes to one hour of the event. Assuring that one of these systems has been initiated to provide early core heat removal, even if local initiation and control is required is an important initial action. A substantial portion of the decay and sensible reactor heat can be removed during this

period. AFW/HPCI/RCIC/IC availability can be improved by providing a reliable supply of water, monitoring turbine conditions (particularly lubricating oil flow and temperature), bypassing automatic trips, and maintaining nuclear boiler/steam generator water levels. These actions help ensure that the core remains adequately covered and cooled during an extended loss of ac power event.

(3) *Plant procedures/guidance should specify actions necessary to assure that equipment functionality can be maintained (including support systems or alternate method) in an ELAP/LUHS or can perform without ac power or normal access to the UHS.*

Cooling functions provided by such systems as auxiliary building cooling water, service water, or component cooling water may normally be used in order for equipment to perform their function. It may be necessary to provide an alternate means for support systems that require ac power or normal access to the UHS, or provide a technical justification for continued functionality without the support system.

(4) *Plant procedures/guidance should identify the sources of potential reactor inventory loss, and specify actions to prevent or limit significant loss.*

Actions should be linked to clear symptoms of inventory loss (e.g., specific temperature readings provided by sensors in relief valve tail pipes, letdown losses, etc.), associated manual or dc motor driven isolation valves, and their location. Procedures/guidance should establish the priority for manual valve isolation based on estimated inventory loss rates early in the event. If manual valves are used for leak isolation, they should be accessible, sufficiently lighted (portable lighting may be used) for access and use, and equipped with a hand wheel, chain or reach rod. If valves are locked in position, keys or cutters should be available. Procedures/guidance should identify the location of valves, keys and cutters.

(5) *Plant procedures/guidance should ensure that a flow path is promptly established for makeup flow to the steam generator/nuclear boiler and identify backup water sources in order of intended use. Additionally, plant procedures/guidance should specify clear criteria for transferring to the next preferred source of water.*

Under certain beyond-design-basis conditions, the integrity of some water sources may be challenged. Coping with an ELAP/LUHS may require water supplies for multiple days. Guidance should address alternate water sources and water delivery systems to support the extended coping duration. 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 assumed to be available in an ELAP/LUHS at their nominal capacities. Water in robust UHS piping may also be available for use but would need to be evaluated to ensure adequate NPSH can be demonstrated and, for example, that the water does not gravity drain back to the UHS. Alternate water delivery systems can be considered available on a case-by-case basis. In general, all condensate storage tanks should be used first if available. If the normal source of makeup water (e.g., CST) fails or becomes exhausted as a result of the hazard, then robust demineralized, raw, or borated water tanks may be used as appropriate.

Heated torus water can be relied upon if sufficient NPSH can be established. Finally, when all other preferred water sources have been depleted, lower water quality sources may be pumped as makeup flow using available equipment (e.g., a diesel driven fire pump or a portable pump drawing from a raw water source). Procedures/guidance should clearly specify the conditions when the operator is expected to resort to increasingly impure water sources.

(6) *Plant procedures/guidance should identify loads that need to be stripped from the plant dc buses (both Class 1E and non-Class 1E) for the purpose of conserving dc power.*

DC power is needed in an ELAP for such loads as shutdown system instrumentation, control systems, and dc backed AOVs and MOVs. Emergency lighting may also be powered by safety-related batteries. However, for many plants, this lighting may have been supplemented by Appendix R and security lights, thereby allowing the emergency lighting load to be eliminated. ELAP procedures/guidance should direct operators to conserve dc power during the event by stripping nonessential loads as soon as practical. Early load stripping can significantly extend the availability of the unit's Class 1E batteries. In certain circumstances, AFW/HPCI /RCIC operation may be extended by throttling flow to a constant rate, rather than by stroking valves in open-shut cycles.

Given the beyond-design-basis nature of these conditions, it is acceptable to strip loads down to the minimum equipment necessary and one set of instrument channels for required indications. Credit for load-shedding actions should consider the other concurrent actions that may be required in such a condition.

(7) *Plant procedures/guidance should specify actions to permit appropriate containment isolation and safe shutdown valve operations while ac power is unavailable.*

Compressed air is used to operate (cycle) some valves used for decay heat removal and in reactor auxiliary systems (e.g., identifying letdown valves or reactor water cleanup system valves that need to be closed). Most containment isolation valves are in the normally closed or failed closed position during power operation. Many other classes of containment isolation valves are not of concern during an extended loss of ac power.

(8) *Plant procedures/guidance should identify the portable lighting (e.g., flashlights or headlamps) and communications systems necessary for ingress and egress to plant areas required for deployment of FLEX strategies.*

Areas requiring access for instrumentation monitoring or equipment operation may require portable lighting as necessary to perform essential functions.

Normal communications may be lost or hampered during an ELAP. Consequently, in some cases, portable communication devices may be required to support interaction between personnel in the plant and those providing overall command and control.

(9) *Plant procedures/guidance should consider the effects of ac power loss on area access, as well as the need to gain entry to the Protected Area and internal locked areas where remote equipment operation is necessary.*

At some plants, the security system may be adversely affected by the loss of the preferred or Class 1E power supplies in an ELAP. In such cases, manual actions specified in ELAP response procedures/guidance may require additional actions to obtain access.

(10) *Plant procedures/guidance should consider loss of ventilation effects on specific energized equipment necessary for shutdown (e.g., those containing internal electrical power supplies or other local heat sources that may be energized or present in an ELAP.*

ELAP procedures/guidance should identify specific actions to be taken to ensure that equipment failure does not occur as a result of a loss of forced ventilation/cooling. Actions should be tied to either the ELAP/LUHS or upon reaching certain temperatures in the plant. Plant areas requiring additional air flow are likely to be locations containing shutdown instrumentation and power supplies, turbine-driven decay heat removal equipment, and in the vicinity of the inverters. These areas include: steam driven AFW pump room, HPCI and RCIC pump rooms, the control room, and logic cabinets. Air flow may be accomplished by opening doors to rooms and electronic and relay cabinets, and/or providing supplemental air flow.

Air temperatures may be monitored during an ELAP/LUHS event through operator observation, portable instrumentation, or the use of locally mounted thermometers inside cabinets and in plant areas where cooling may be needed. Alternatively, procedures/guidance may direct the operator to take action to provide for alternate air flow in the event normal cooling is lost. Upon loss of these systems, or indication of temperatures outside the maximum normal range of values, the procedures/guidance should direct supplemental air flow be provided to the affected cabinet or area, and/or designate alternate means for monitoring system functions.

For the limited cooling requirements of a cabinet containing power supplies for instrumentation, simply opening the back doors is effective. For larger cooling loads, such as HPCI, RCIC, and AFW pump rooms, portable engine-driven blowers may be considered during the transient to augment the natural circulation provided by opening doors. The necessary rate of air supply to these rooms may be estimated on the basis of rapidly turning over the room's air volume.

Temperatures in the HPCI pump room and/or steam tunnel for a BWR may reach levels which isolate HPCI or RCIC steam lines. Supplemental air flow or the capability to override the isolation feature may be necessary at some plants. The procedures/guidance should identify the corrective action required, if necessary.

Actuation setpoints for fire protection systems are typically at 165-180°F. It is expected that temperature rises due to loss of ventilation/cooling during an ELAP/LUHS will not be sufficiently high to initiate actuation of fire protection systems. If lower fire protection system setpoints are used or temperatures are expected to exceed these temperatures during an ELAP/LUHS, procedures/guidance should identify actions to avoid such inadvertent actuations or the plant should ensure that actuation does not impact long term operation of the equipment.

(11) *Plant procedures/guidance should consider accessibility requirements at locations where operators will be required to perform local manual operations.*

Due to elevated temperatures and humidity in some locations where local operator actions are required (e.g., manual valve manipulations, equipment connections, etc.), procedures/guidance should identify the protective clothing or other equipment or actions necessary to protect the operator, as appropriate.

FLEX strategies must be capable of execution under the adverse conditions (unavailability of installed plant lighting, ventilation, etc.) expected following a BDBE resulting in an ELAP/LUHS. Accessibility of equipment, tooling, connection points, and plant components shall be accounted for in the development of the FLEX strategies. The use of appropriate human performance aids (e.g., component marking, connection schematics, installation sketches, photographs, etc.) shall be included in the FLEX guidance implementing the FLEX strategies.

(12) *Plant procedures/guidance should consider loss of heat tracing effects for equipment required to cope with an ELAP. Alternate steps, if needed, should be identified to supplement planned action.*

Heat tracing is used at some plants to ensure cold weather conditions do not result in freezing important piping and instrumentation systems with small diameter piping. Procedures/guidance should be reviewed to identify if any heat traced systems are relied upon to cope with an ELAP. For example, additional condensate makeup may be supplied from a system exposed to cold weather where heat tracing is needed to ensure control systems are available. If any such systems are identified, additional backup sources of water not dependent on heat tracing should be identified.

(13) *Use of portable equipment, e.g., portable power supplies, portable pumps, etc., can extend plant coping capability. The procedures/guidance for implementation of these portable systems should address the transitions from installed sources to portable* are available as well as to address delivery capabilities.

(14) *Procedures/guidance should address the appropriate monitoring and makeup options to the SFP.*

Traditionally, SFPs have not been thoroughly addressed in plant EOPs. In the case of an ELAP/LUHS, both the reactor and SFP cooling may be coincidently challenged. Monitoring of SFP level can be used to determine when SFP makeup is required.

(15) *Procedures/guidance for units with BWR Mark III and PWR Ice Condenser containments should address the deployment of portable power supplies for providing backup power to the containment hydrogen igniters, including a prioritization approach for deployment.*

Hydrogen igniters support maintenance of containment integrity following core damage. While the FLEX strategies are focused on prevention of fuel damage, the igniters need to be in-service prior to significant hydrogen generation due to fuel damage in order to be effective. However, in the extreme conditions postulated in this guidance, a prioritization

approach should be outlined to support on-site staff decision-making on whether resources should focus on deployment of FLEX capabilities for fuel damage prevention versus for containment protection following fuel damage. For example, if there are indications that installed equipment reliability is compromised by the beyond-design-basis condition, then a priority might be placed on re-powering the hydrogen igniters. Similarly, if the plant staff determines that the installed plant equipment is functioning well, then priority could be given to deployment of coping equipment.

In order to assure reliability and availability of the FLEX equipment required to meet these capabilities, the site should have sufficient equipment to address all functions at all units on-site, plus one additional spare, i.e., an N+1 capability, where "N" is the number of units on-site. Thus, a two-unit site would nominally have at least three portable pumps, three sets of portable ac/dc power supplies, three sets of hoses & cables, etc. It is also acceptable to have a single resource that is sized to support the required functions for multiple units at a site (e.g., a single pump capable of all water supply functions for a dual unit site). In this case, the N+1 could simply involve a second pump of equivalent capability. In addition, it is also acceptable to have multiple strategies to accomplish a function (e.g., two separate means to repower instrumentation). In this case the equipment associated with each strategy does not require N+1. The existing 50.54(hh)(2) pump and supplies can be counted toward the N+1, provided it meets the functional and storage requirements outlined in this guide. The N+1 capability applies to the portable FLEX equipment described in Tables 3-1 and 3-2 (i.e., that equipment that directly supports maintenance of the key safety functions). Other FLEX support equipment only requires an N capability.

Unlike 50.54(hh)(2), the intention of this guidance is to have permanent, installed connection points for portable fluid and electrical equipment. The portable fluid connections for core and SFP cooling functions are expected to have a primary and an alternate connection or delivery point (e.g., the primary means to put water into the SFP may be to run a hose over the edge of the pool). Electrical diversity can be accomplished by providing a primary and alternate method to repower key equipment and instruments utilized in FLEX strategies. At a minimum, the primary connection point should be an installed connection suitable for both the on-site and off-site equipment. The secondary connection point may require reconfiguration (e.g., removal of valve bonnets or breaker) if it can be shown that adequate time is available and adequate resources are reasonably expected to be available to support the reconfiguration. Both the primary and alternate connection points do not need to be available for all applicable hazards, but the location of the connection points should provide reasonable assurance of at least one connection being available. Appendices C and D provide more details on how this is to be accomplished.

Table 3-1
BWR FLEX Baseline Capability Summary

Safety Function		Method	Baseline Capability
Core Cooling	Reactor Core Cooling	• RCIC/HPCI/IC • Depressurize RPV for Injection with Portable Injection Source • Sustained Source of Water	• Use of installed equipment for initial coping • Primary and alternate connection points for portable pump • Means to depressurize RPV • Use of alternate water supply to support core heat removal makeup
	Key Reactor Parameters	• RPV Level • RPV Pressure	• (Re-)Powered instruments • Other instruments for plant-specific strategies
Containment	Containment Pressure Control /Heat Removal	• Containment Venting or Alternative Containment Heat Removal	• Reliable, hardened vent (per EA-12-050 for Mk I and II) or other capability.
	Containment Integrity (BWR Mark III Containments Only)	• Hydrogen igniters	• Re-powering of hydrogen igniters with a portable power supply.
	Key Containment Parameters	• Containment Pressure • Suppression Pool Temperature • Suppression Pool Level	• (Re-)Powered instruments
SFP Cooling	Spent Fuel Cooling	• Makeup with Portable Injection Source	• Makeup via hoses direct to pool • Makeup via connection to SFP makeup piping or other suitable means • Spray via portable nozzles
	SFP Parameters	• SFP Level	• Per EA 12-051

Table 3-2
PWR FLEX Baseline Capability Summary

Safety Function		Method	Baseline Capability
Core Cooling	Reactor Core Cooling & Heat Removal (steam generators available)	• AFW/EFW • Depressurize SG for Makeup with Portable Injection Source • Sustained Source of Water	• Use of installed equipment for initial coping • Connection for portable pump to feed required SGs • Use of alternate water supply to support core heat removal
	RCS Inventory Control and Core Heat Removal (shutdown modes with steam generators not available)	• Low Leak RCP Seals and/or RCS high pressure makeup • All Plants Provide Means to Provide Borated RCS Makeup	• Low-leak RCP seals and/or providing on-site high pressure RCS makeup capability • Diverse makeup connections to RCS for long-term RCS makeup and shutdown mode heat removal • Source of borated water • Letdown path if required
	Key Reactor Parameters	• SG Level • SG Pressure • RCS Pressure • RCS Temperature	• (Re-)Powered instruments
Containment	Containment Pressure Control/Heat Removal	• Containment Spray	• Connection point on containment spray header for use with portable pump or alternate capability or analysis demonstrating that containment pressure control is not challenged, e.g., MAAP analysis.
	Containment Integrity (Ice Condenser Containments Only)	• Hydrogen igniters	• Re-powering of hydrogen igniters with a portable power supply.
	Key Containment Parameters	• Containment Pressure	• (Re-)Powered instruments consistent
SFP Cooling	Spent Fuel Cooling	• Makeup with Portable Injection Source	• Makeup via hoses direct to pool • Makeup via connection to SFP makeup piping or other suitable means • Spray via portable nozzles
	SFP Parameters	• SFP Level	• Per EA 12-051

3.3 CONSIDERATIONS IN UTILIZING OFF-SITE RESOURCES

Once the analysis determines the equipment requirements for extended coping, the licensee should obtain the required on-site equipment and ensure appropriate arrangements are in place to obtain the necessary off-site equipment including its deployment at the site in the time required by the analysis.

The site will need to identify staging area(s) for receipt of the equipment and a means to transport the off-site equipment to the deployment location.

It is expected that the licensee will ensure the off-site resource organization will be able to provide the resources that will be necessary to support the extended coping duration. A list of possible off-site equipment is provided in Section 12.

In addition, the licensee will need to ensure standard connectors for electrical and mechanical equipment compatible with the site connections are provided.

4 STEP 2: DETERMINE APPLICABLE EXTREME EXTERNAL HAZARDS

The design basis of U.S. nuclear power plants provides protection against a broad range of extreme external hazards. However, it is possible to postulate BDB external hazards that exceed the levels of current designs. In Section 3, a baseline coping capability scenario was established for a simultaneous ELAP and LUHS. The nature of the specific BDBEE could, however, contribute to and/or complicate the plant and off-site response.

The potential scope of these beyond-design-basis conditions makes it impossible to bound all possible conditions. However, general risk insights from PRAs that have previously been performed in the industry can inform the important scenarios even without a plant-specific PRA.

To this end, Appendix B provides an assessment of a broad spectrum of possible external hazards as a means to organize and focus the site-specific assessment process on classes of extreme external hazards. The purpose of this section is to identify the potential complicating factors to the deployment of FLEX equipment for the baseline coping scenarios based on site-specific vulnerabilities to BDBEEs. The strategies that result from this assessment are intended to provide greater diversity and flexibility to cope with a wider range of potential damage states. All possible scenarios are not intended to have the same rigorous analytical basis, training, or step by step procedural implementation requirements of the baseline strategies as it is not possible to postulate all of the possible scenarios.

4.1 SITE-SPECIFIC IDENTIFICATION OF APPLICABLE HAZARDS

This step of the process focuses on the identification and characterization of applicable BDBEEs for each site. Identification involves determining whether the type of hazard applies to the site. Characterization focuses on the likely nature of the challenge in terms of timing, severity, and persistence.

As outlined in Appendix B, for the purposes of this effort, hazards have been grouped into five classes to help further focus the assessment:

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

Table 4-1 provides a high-level summary of the types of challenges and potential challenges presented by these five classes of hazards.

Table 4-2 provides a description of the general attributes that are used in assessing the applicability of a class of hazards to a particular site. Further detail on these considerations is provided in Sections 5 through 9.

Table 4-1
Challenges Posed by External Hazards

Hazard Class	Example Potential Site Threats	Potential Considerations
Seismic	• Loss of off-site power • Damage to non-robust electrical equipment • Damage to non-robust flat bottom tanks • Flooding due to damage to on-site water sources that are not seismically robust	• No warning time • Widespread infrastructure damage • Diversion of national/state resources
External flooding	• Loss of off-site power • Inundation of plant structures • Inundation of key equipment • Loss of intake/UHS	• Substantial warning time possible • Possible long duration event • Increased flow in groundwater e.g., streams • Widespread infrastructure impacts • Diversion of national/state resources
Storms with High Winds (Hurricanes, tornadoes, etc.)	• Loss of off-site power • Loss of intake/UHS • Equipment performance issues	• Warning possible for some • Limited duration event • Widespread infrastructure impacts • Diversion of national/state resources
Snow, Ice, Low Temperatures	• Loss of off-site power • Loss of intake/UHS • Equipment performance issues	• Warning likely • Limited duration event • Widespread infrastructure impacts
Extreme High Temperatures	• Loss of off-site power • Loss of intake/UHS • Equipment performance issues	• Warning likely • Limited duration event • Infrastructure impacts

Table 4-2
Considerations in Assessing Applicability of External Hazards

Hazard Class	Applicability Considerations
Seismic	• All sites will consider seismic events
External flooding	• Variability in design basis considerations • Potential for large source floods at site • Margin in current external flood design basis
Storms with High Winds (Hurricanes, tornadoes, etc.)	• Coastal sites exposed to hurricanes/large storms • Regional history with tornadoes
Snow, Ice, Low Temperatures	• Regional experience with extreme snow, ice, and low temperatures
Extreme High Temperatures	• Regional experience with extreme high temperatures

4.2 SITE-SPECIFIC CHARACTERIZATION OF HAZARD ATTRIBUTES

For those hazards considered applicable to a particular site, the focus is on the proper consideration of the challenge presented. Sites will consider the beyond-design-basis hazard levels for all applicable site hazards in order to evaluate impact of these hazards, as described in Sections 5 through 9, on the deployment of the strategies to meet the baseline coping capability. With the potential impacts characterized, potential enhancements can be identified for each hazard that will increase viability of strategy deployment for these extreme conditions. These enhancements can take the form of changes to the equipment deployment strategy (e.g., relocation or addition of a connection point to address flood conditions) or changes to the procedural implementation of the strategies by incorporation into event response procedures (e.g., addition of FLEX preparatory action to hurricane response procedures for hurricanes in excess of a certain level).

Characterization of a hazard for a site includes the following elements:

- Identification of the realistic response timeline for the applicable hazards, e.g., tornadoes generally have very little warning to enable anticipatory plant response, whereas hurricanes have considerable warning time.
- Characterization of the functional threats caused by the hazard, e.g., equipment that may be inundated by a BDB external flood.
- Development of a plant strategy for responding to events with warning, e.g., procedure changes to support anticipatory actions.
- Development of a plant strategy for responding to events without warning, e.g., response actions that may be required to a particular hazard such as debris removal following a tornado.

5 STEP 2A: ASSESS SEISMIC IMPACT

Beyond-design-basis seismic events have been extensively studied in seismic margin assessments (SMAs) and seismic PRAs (SPRAs). These studies have demonstrated that an ELAP is a dominant contributor to seismic risk. These evaluations provide many insights that can help guide the evaluation and enhancement of the baseline coping capability for BDB seismic events.

5.1 RELATIONSHIP TO LOSS OF AC POWER & LOSS OF UHS

Beyond-design-basis seismic events are known to directly contribute to the risk from a simultaneous ELAP and LUHS, depending on the site. In addition, severe seismic events can present a challenge to both on-site and off-site resources relied upon for plant response.

Beyond-design-basis seismic evaluations (SMAs and SPRAs) consistently identify loss of off-site power as an important contributor. The loss of off-site power is generally attributed to damage to the grid and/or on-site power transmission equipment that is essentially unrecoverable in the near-term. The next most likely failures observed in these evaluations involve failures of non-robust flat bottom tanks, e.g., large storage tanks that are not seismically robust, and failures of electrical equipment [Ref. 9].

Seismic events can also impact the availability of the UHS for sites that rely on a not seismically robust downstream dam to contain water that is used as the source of water for the UHS.

These insights are used to inform the approach to consideration of seismically-induced challenges.

5.2 APPROACH TO SEISMICALLY-INDUCED CHALLENGES

All sites will address BDB seismic considerations in the implementation of FLEX strategies, as described below. The basis for this is that, while some sites are in areas with lower seismic activity, their design basis generally reflects that lower activity. There are large, and unavoidable, uncertainties in the seismic hazard for all U.S. plants. In order to provide an increased level of safety, the FLEX deployment strategy will address seismic hazards at all sites.

These considerations will be treated in four primary areas: protection of FLEX equipment, deployment of FLEX equipment, procedural interfaces, and considerations in utilizing off-site resources.

5.3 PROTECTION AND DEPLOYMENT OF FLEX STRATEGIES

5.3.1 Protection of FLEX Equipment

1. FLEX equipment should be stored in one or more of following three configurations:
    a. In a structure that meets the plant's design basis for the Safe Shutdown Earthquake (SSE)(e.g., existing safety-related structure).

b. In a structure designed to or evaluated equivalent to ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures*.

c. Outside a structure and evaluated for seismic interactions to ensure equipment is not damaged by non-seismically robust components or structures.

2. Large portable FLEX equipment such as pumps and power supplies should be secured as appropriate to protect them during a seismic event (i.e., Safe Shutdown Earthquake (SSE) level).
3. Stored equipment and structures should be evaluated and protected from seismic interactions to ensure that unsecured and/or non-seismic components do not damage the equipment.

5.3.2 Deployment of FLEX Equipment

The baseline capability requirements already address loss of non-seismically robust equipment and tanks as well as loss of all AC. So, these seismic considerations are implicitly addressed.

There are five considerations for the deployment of FLEX equipment following a seismic event:

1. If the equipment needs to be moved from a storage location to a different point for deployment, the route to be traveled should be reviewed for potential soil liquefaction that could impede movement following a severe seismic event.
2. At least one connection point of FLEX equipment will only require access through seismically robust structures. This includes both the connection point and any areas that plant operators will have to access to deploy or control the capability.
3. If the plant FLEX strategy relies on a water source that is not seismically robust, e.g., a downstream dam, the deployment of FLEX coping capabilities should address how water will be accessed. Most sites with this configuration have an underwater berm that retains a needed volume of water. However, accessing this water may require new or different equipment.
4. If power is required to move or deploy the equipment (e.g., to open the door from a storage location), then power supplies should be provided as part of the FLEX deployment.
5. A means to move FLEX equipment should be provided that is also reasonably protected from the event.

5.3.3 Procedural Interfaces

There are four procedural interface considerations that should be addressed.

1. Seismic studies have shown that even seismically qualified electrical equipment can be affected by BDB seismic events. In order to address these considerations, each plant should compile a reference source for the plant operators that provides approaches to obtaining necessary instrument readings to support the implementation of the coping strategy (see Section 3.2.1.10). This reference source should include control room and

non-control room readouts and should also provide guidance on how and where to measure key instrument readings at containment penetrations, where applicable, using a portable instrument (e.g., a Fluke meter). Such a resource could be provided as an attachment to the plant procedures/guidance. Guidance should include critical actions to perform until alternate indications can be connected and on how to control critical equipment without associated control power.

2. Consideration should be given to the impacts from large internal flooding sources that are not seismically robust and do not require ac power (e.g., gravity drainage from lake or cooling basins for non-safety-related cooling water systems).
3. For sites that use ac power to mitigate ground water in critical locations, a strategy to remove this water will be required.
4. Additional guidance may be required to address the deployment of FLEX for those plants that could be impacted by failure of a not seismically robust downstream dam.

5.3.4 Considerations in Utilizing Off-site Resources

Severe seismic events can have far-reaching effects on the infrastructure in and around a plant. While nuclear power plants are designed for large seismic events, many parts of the Owner Controlled Area and surrounding infrastructure (e.g., roads, bridges, dams, etc.) may be designed to lesser standards. Obtaining off-site resources may require use of alternative transportation (such as air-lift capability) that can overcome or circumvent damage to the existing local infrastructure.

1. The FLEX strategies will need to assess the best means to obtain resources from off-site following a seismic event.

6 STEP 2B: ASSESS EXTERNAL FLOODING IMPACT

The potential challenge presented by external flooding is very site-specific and is a function of the site layout, plant design, and potential external flooding hazards present. Typically, plant design bases address the following hazards:

- local intense precipitation
- flooding from nearby rivers, lakes, and reservoirs
- high tides
- seiche
- hurricane and storm surge
- tsunami events.

There are large uncertainties in predicting the magnitude of beyond-design-basis flooding events. Consequently, it is necessary to evaluate the FLEX deployment strategies for sites where there is potential for such extreme flooding.

6.1 RELATIONSHIP TO LOSS OF AC POWER & LOSS OF UHS

A beyond-design-basis external flooding event can create a significant challenge to plant safety. This could include the following:

- loss of off-site power
- loss of UHS and/or
- impact safe shutdown equipment.

In addition, severe flooding events can present a challenge to both on-site and off-site resources relied upon for coping.

6.2 APPROACH TO EXTERNAL FLOOD-INDUCED CHALLENGES

The evaluation of external flood-induced challenges has three parts. The first part is determining whether the site is susceptible to external flooding. The second part is the characterization of the applicable external flooding threat. The third part is the application of the flooding characterization to the protection and deployment of FLEX strategies.

6.2.1 Susceptibility to External Flooding

Susceptibility to external flooding is based on whether the site is a "dry" site, i.e., the plant is built above the design basis flood level (DBFL) [Ref. 10]. For sites that are not "dry", water intrusion is prevented by barriers and there could be a potential for those barriers to be exceeded or compromised. Such sites would include those that are kept "dry" by permanently installed

barriers, e.g., seawall, levees, etc., and those that install temporary barriers or rely on watertight doors to keep the design basis flood from impacting safe shutdown equipment.

Plants that are not dry sites will perform the next two steps of the flood-induced challenge evaluation.

6.2.2 Characterization of the Applicable Flood Hazard

Most external flooding hazards differ from seismic and other events in that the event may provide the plant with considerable warning time to take action and the flood condition may exist for a considerable length of time. Table 6-1 summarizes some of these considerations for various flood sources.

Table 6-1
Flood Warning and Persistence Considerations

Flood Source	Warning	Persistence
Regional precipitation (PMF)	Days	Many Hours to Months
Upstream dam failures	Hours to Days	Hours to Months
High tides	Days	Hours
Seiche	None	Short
Hurricane and storm surge	Days	Hours
Tsunami events	Limited	Short

Each site that has identified that external flooding is an applicable hazard should review the current design basis flood analyses to determine which external floods are limiting. In general, a site will have one flood source that has been identified as the far limiting condition, with respect to DBFL. However, in some cases, there can be multiple sources that yield similar DBFLs, e.g., various river flood scenarios involving combinations of dam failures and other input conditions. The limiting hazards should be characterized in terms of warning time, i.e., the time from when the flood is known to present a threat to the plant and the time the flood level could exceed the design protections, and persistence following the creation of a flood condition. Such information is generally available in UFSARs and supporting analyses. It is not the intention to define precise time windows, simply to gauge the timing so that plant response actions can be considered.

6.2.3 Protection and Deployment of FLEX Strategies

In view of the characterization of the applicable flood hazard, the site should consider means to reasonably assure the success of deployment of FLEX strategies such as flood protection of FLEX equipment, relocation of FLEX connection points, etc.

6.2.3.1 Protection of FLEX Equipment

These considerations apply to the protection of FLEX equipment from external flood hazards:

1. The equipment should be stored in one or more of the following configurations:
    a. Stored above the flood elevation from the most recent site flood analysis. The evaluation to determine the elevation for storage should be informed by flood analysis applicable to the site from early site permits, combined license applications, and/or contiguous licensed sites.
    b. Stored in a structure designed to protect the equipment from the flood.
    c. FLEX equipment can be stored below flood level if time is available and plant procedures/guidance address the needed actions to relocate the equipment. Based on the timing of the limiting flood scenario(s), the FLEX equipment can be relocated[2] to a position that is protected from the flood, either by barriers or by elevation, prior to the arrival of the potentially damaging flood levels. This should also consider the conditions on-site during the increasing flood levels and whether movement of the FLEX equipment will be possible before potential inundation occurs, not just the ultimate flood height.
2. Storage areas that are potentially impacted by a rapid rise of water should be avoided.

6.2.3.2 Deployment of FLEX Equipment

There are a number of considerations which apply to the deployment of FLEX equipment for external flood hazards:

1. For external floods with warning time, the plant may not be at power. In fact, the plant may have been shut down for a considerable time and the plant configuration could be established to optimize FLEX deployment. For example, the portable pump could be connected, tested, and readied for use prior to the arrival of the critical flood level. Further, protective actions can be taken to reduce the potential for flooding impacts, including cooldown, borating the RCS, isolating accumulators, isolating RCP seal leak off, obtaining dewatering pumps, creating temporary flood barriers, etc. These factors can be credited in considering how the baseline capability is deployed.
2. The ability to move equipment and restock supplies may be hampered during a flood, especially a flood with long persistence. Accommodations along these lines may be necessary to support successful long-term FLEX deployment.
3. Depending on plant layout, the ultimate heat sink may be one of the first functions affected by a flooding condition. Consequently, the deployment of the FLEX equipment should address the effects of LUHS, as well as ELAP.
4. Portable pumps and power supplies will require fuel that would normally be obtained from fuel oil storage tanks that could be inundated by the flood or above ground tanks

[2] Allowance for relocation is consistent with no concurrent independent events assumption per section 2.0 provided it is of limited duration.

that could be damaged by the flood. Steps should be considered to protect or provide alternate sources of fuel oil for flood conditions. Potential flooding impacts on access and egress should also be considered.

5. Connection points for portable equipment should be reviewed to ensure that they remain viable for the flooded condition.
6. For plants that are limited by storm-driven flooding, such as Probable Maximum Surge or Probable Maximum Hurricane (PMH), expected storm conditions should be considered in evaluating the adequacy of the baseline deployment strategies.
7. Since installed sump pumps will not be available for dewatering due to the ELAP, plants should consider the need to provide water extraction pumps capable of operating in an ELAP and hoses for rejecting accumulated water for structures required for deployment of FLEX strategies.
8. Plants relying on temporary flood barriers should assure that the storage location for barriers and related material provides reasonable assurance that the barriers could be deployed to provide the required protection.
9. A means to move FLEX equipment should be provided that is also reasonably protected from the event.

6.2.3.3 Procedural Interfaces

The following procedural interface considerations that should be addressed.

1. Many sites have external flooding procedures. The actions necessary to support the deployment considerations identified above should be incorporated into those procedures.
2. Additional guidance may be required to address the deployment of FLEX for flooded conditions (i.e., connection points may be different for flooded vs. non-flooded conditions).
3. FLEX guidance should describe the deployment of temporary flood barriers and extraction pumps necessary to support FLEX deployment.

6.2.3.4 Considerations in Utilizing Off-site Resources

Extreme external floods can have regional impacts that could have a significant impact on the transportation of off-site resources.

1. Sites should review site access routes to determine the best means to obtain resources from off-site following a flood.
2. Sites impacted by persistent floods should consider where equipment delivered from off-site could be staged for use on-site.

7 STEP 2C: ASSESS IMPACT OF SEVERE STORMS WITH HIGH WINDS

The potential challenge presented by severe storm with high winds can be very site-specific and is a function of the site layout, plant design, and potential high wind hazards present. Typically, plant design bases address the following hazards:

- hurricanes
- extreme straight winds
- tornadoes and tornado missiles.

While extreme straight winds can present a challenge to off-site power supplies, these conditions are not judged to be significant factors in contributing to a simultaneous ELAP and LUHS and will not be further considered in this guidance.

7.1 RELATIONSHIP TO LOSS OF AC POWER & LOSS OF UHS

A beyond-design-basis high wind event can create a significant challenge to plant safety. This could include the following:

- loss of off-site power
- loss of UHS
- Impact safe shutdown equipment.

In addition, high wind events can present a challenge to both on-site and off-site resources desired to assist in plant response. However, while the damage from hurricanes can be quite widespread, the damage from tornadoes is generally relatively localized, even for extreme tornadoes.

7.2 APPROACH TO HIGH WIND CHALLENGES

The evaluation of high wind-induced challenges has three parts. The first part is determining whether the site is potentially susceptible to different high wind conditions. The second part is the characterization of the applicable high wind threat. The third part is the application of the high wind threat characterization to the protection and deployment of FLEX strategies.

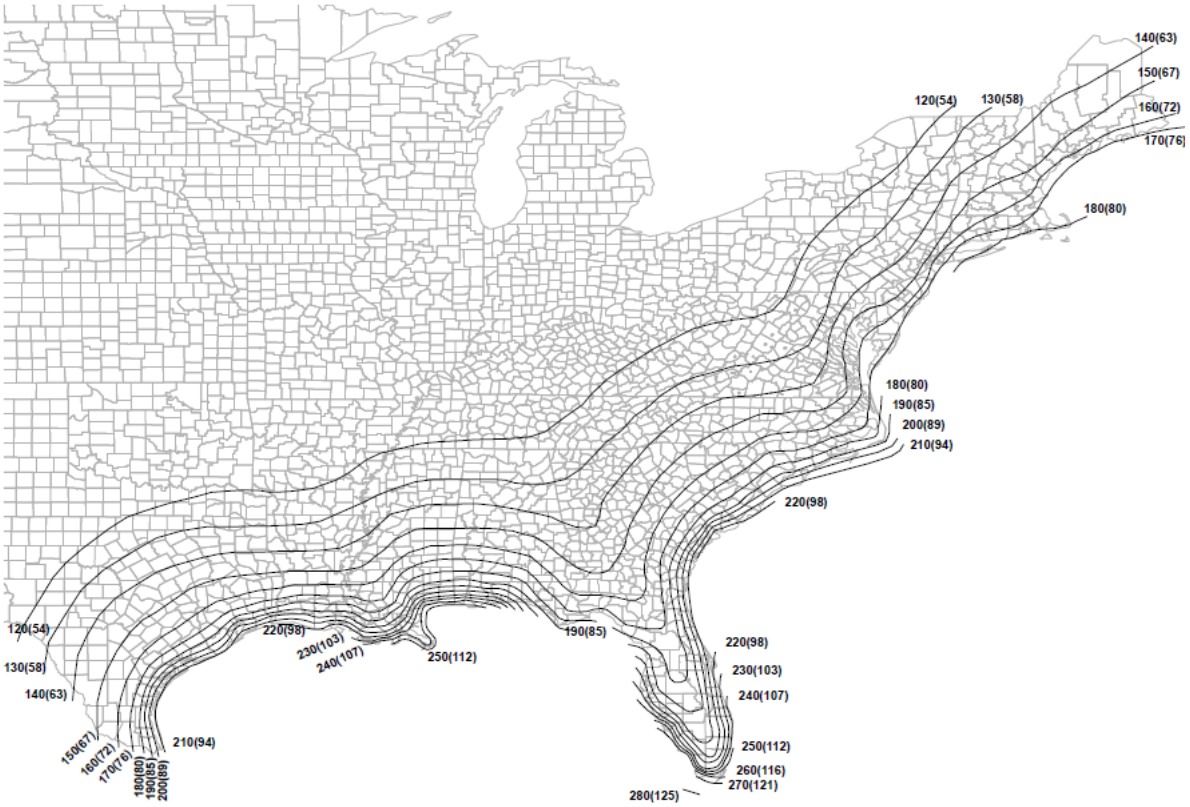
7.2.1 Applicability of High Wind Conditions

A screening process is used to identify whether a site should address high wind hazards as a result of hurricanes and tornadoes.

Hurricanes are extremely uncommon on the West Coast of the U.S. Furthermore, even in regions like the Gulf, Southeast and Northeast where hurricanes do occur, the high winds from hurricanes are generally only within some distance from the coast. Figure 7-1 provides contours for hurricane wind speeds expected to occur at a rate of 1 in 1 million chance of per year. These maps can be used to guide the identification of sites with the potential to experience severe winds from hurricanes based on winds exceeding 130 mph.

Figure 7-1

Contours of Peak-Gust Wind Speeds at 10-m Height in Flat Open Terrain, Annual Exceedance Probability of 10^{-6} [Figure 3-1 of Ref. 13]



For considering the applicability of tornadoes to specific sites, data from the NRC's latest tornado hazard study, NUREG/CR-4461, is used. Tornadoes with the capacity to do significant damage are generally considered to be those with winds above 130 mph. Figure 7-2 provides a map of the U.S. in 2 degree latitude/longitude blocks that shows the tornado wind speed expected to occur at a rate of 1 in 1 million chance of per year. This clearly bounding assumption allows selection of plants that are identified in blocks with tornado wind speeds greater than 130 mph. All other plants need not address tornado hazards impacting FLEX deployment.

Each site should use the information in Figures 7-1 and 7-2 to determine whether the site needs to address storms involving high winds. In general, plants west of the Rockies will be screened out, but most other sites will have to address at least tornadoes.

7.2.2 Characterization of the Applicable High Wind Hazard

The characterization of hurricanes includes the fact that significant notice will be available in the event a severe hurricane will impact a site. This can allow plants to pre-stage FLEX equipment for the most severe storms. Hurricanes can also have a significant impact on local infrastructure, e.g., downed trees and flooding, that should be considered in the interface with off-site resources.

The characterization of tornadoes is such that pre-staging of equipment in advance is not likely to be effective. However, the impact on the local infrastructure is much more limited than hurricanes and largely limited to debris dispersal.

7.3 PROTECTION AND DEPLOYMENT OF FLEX STRATEGIES

7.3.1 Protection of FLEX Equipment

These considerations apply to the protection of FLEX equipment from high wind hazards:

1. For plants exposed to high wind hazards, FLEX equipment should be stored in one of the following configurations:

    a. In a structure that meets the plant's design basis for high wind hazards (e.g., existing safety-related structure).

    b. In storage locations designed to or evaluated equivalent to ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures* given the limiting tornado wind speeds from Regulatory Guide 1.76 or design basis hurricane wind speeds for the site.

        - Given the FLEX basis limiting tornado or hurricane wind speeds, building loads would be computed in accordance with requirements of ASCE 7-10. Acceptance criteria would be based on building serviceability requirements not strict compliance with stress or capacity limits. This would allow for some minor plastic deformation, yet assure that the building would remain functional.

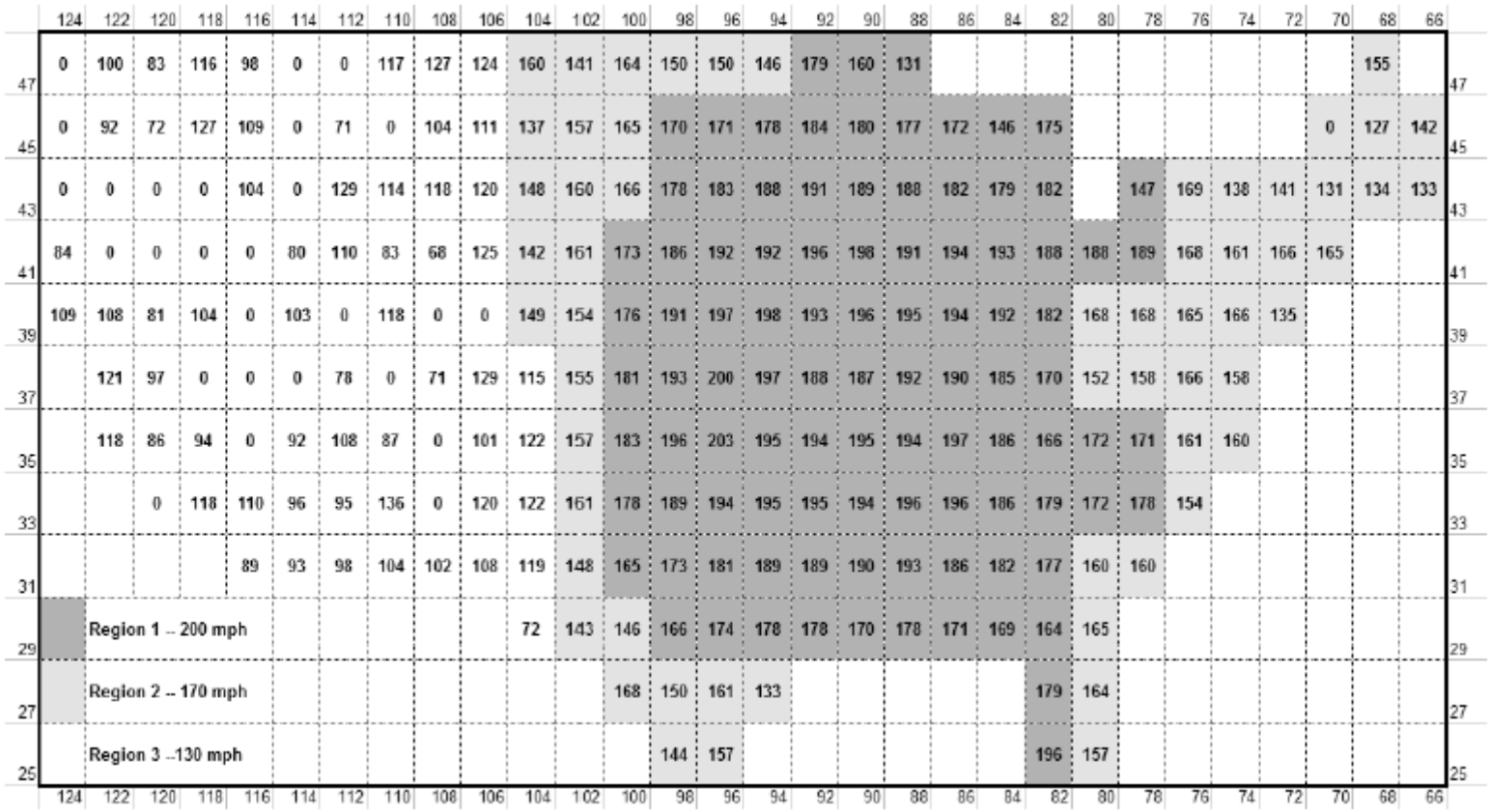
- Tornado missiles and hurricane missiles will be accounted for in that the FLEX equipment will be stored in diverse locations to provide reasonable assurance that N sets of FLEX equipment will remain deployable following the high wind event. This will consider locations adjacent to existing robust structures or in lower sections of buildings that minimizes the probability that missiles will damage all mitigation equipment required from a single event by protection from adjacent buildings and limiting pathways for missiles to damage equipment.
- The axis of separation should consider the predominant path of tornados in the geographical location. In general, tornadoes travel from the West or West Southwesterly direction, diverse locations should be aligned in the North-South arrangement, where possible. Additionally, in selecting diverse FLEX storage locations, consideration should be given to the location of the diesel generators and switchyard such that the path of a single tornado would not impact all locations.
- Stored mitigation equipment exposed to the wind should be adequately tied down. Loose equipment should be in protective boxes that are adequately tied down to foundations or slabs to prevent protected equipment from being damaged or becoming airborne. (During a tornado, high winds may blow away metal siding and metal deck roof, subjecting the equipment to high wind forces.)

c. In evaluated storage locations separated by a sufficient distance that minimizes the probability that a single event would damage all FLEX mitigation equipment such that at least N sets of FLEX equipment would remain deployable following the high wind event. (This option is not applicable for hurricane conditions).

   - Consistent with configuration b., the axis of separation should consider the predominant path of tornados in the geographical location.
   - Consistent with configuration b., stored mitigation equipment should be adequately tied down.

Figure 7-2

Recommended Tornado Design Wind Speeds for the 10^{-6} /yr Probability Level [Ref. 14]



7.3.2 Deployment of FLEX Equipment

There are a number of considerations which apply to the deployment of FLEX equipment for high wind hazards:

1. For hurricane plants, the plant may not be at power prior to the simultaneous ELAP and LUHS condition. In fact, the plant may have been shut down and the plant configuration could be established to optimize FLEX deployment. For example, the portable pumps could be connected, tested, and readied for use prior to the arrival of the hurricane. Further, protective actions can be taken to reduce the potential for wind impacts. These factors can be credited in considering how the baseline capability is deployed.
2. The ultimate heat sink may be one of the first functions affected by a hurricane due to debris and storm surge considerations. Consequently, the evaluation should address the effects of ELAP/LUHS, along with any other equipment that would be damaged by the postulated storm.
3. Deployment of FLEX following a hurricane or tornado may involve the need to remove debris. Consequently, the capability to remove debris caused by these extreme wind storms should be included.
4. A means to move FLEX equipment should be provided that is also reasonably protected from the event.
5. The ability to move equipment and restock supplies may be hampered during a hurricane and should be considered in plans for deployment of FLEX equipment.

7.3.3 Procedural Interfaces

The overall plant response strategy should be enveloped by the baseline capabilities , but procedural interfaces may need to be considered. For example, many sites have hurricane procedures. The actions necessary to support the deployment considerations identified above should be incorporated into those procedures.

7.3.4 Considerations in Utilizing Off-site Resources

Extreme storms with high winds can have regional impacts that could have a significant impact on the transportation of off-site resources.

1. Sites should review site access routes to determine the best means to obtain resources from off-site following a hurricane.
2. Sites impacted by storms with high winds should consider where equipment delivered from off-site could be staged for use on-site.

8 STEP 2D: ASSESS IMPACT OF SNOW, ICE AND EXTREME COLD

The potential challenge presented by snow, ice and extreme cold can be very site-specific and is a function of the site layout, plant design, and regional weather hazards present. Typically, plant design bases address snow from the perspective of building roof loadings and ice and extreme cold temperatures from the perspective of potential impacts on the intake structure and safety-related equipment.

This general category of snow, ice and extreme low temperatures includes the following hazards:

- avalanche
- frost
- ice cover
- frazil ice
- snow
- extreme low temperatures

Extreme low temperatures may also present challenges and could follow a significant snow/ice storm such that a combination of significant snowfall, ice, and extreme cold cannot be ruled out.

This set of hazards presents more of a challenge to the deployment of the FLEX equipment than the other aspects of the evaluation.

8.1 RELATIONSHIP TO LOSS OF AC POWER & LOSS OF UHS

Snow and ice storms and extreme low temperatures can present a challenge to both off-site power and on-site capabilities, e.g., intake structures. Depending on the plant design, these may be contributors to a simultaneous ELAP and LUHS, e.g., loss of off-site power with loss of cooling water due to extreme cold and frazil ice formation. In addition, if applicable, such storms could impact deployment of both on-site and off-site coping resources.

8.2 APPROACH TO SNOW, ICE, AND EXTREME COLD CHALLENGES

Snow, ice, and extreme cold can, in principle, occur at any site. However, for the purposes of this guideline, we are interested in extreme events that could impede or prevent the deployment of the baseline FLEX capability.

8.2.1 Applicability of Snow, Ice, and Extreme Cold

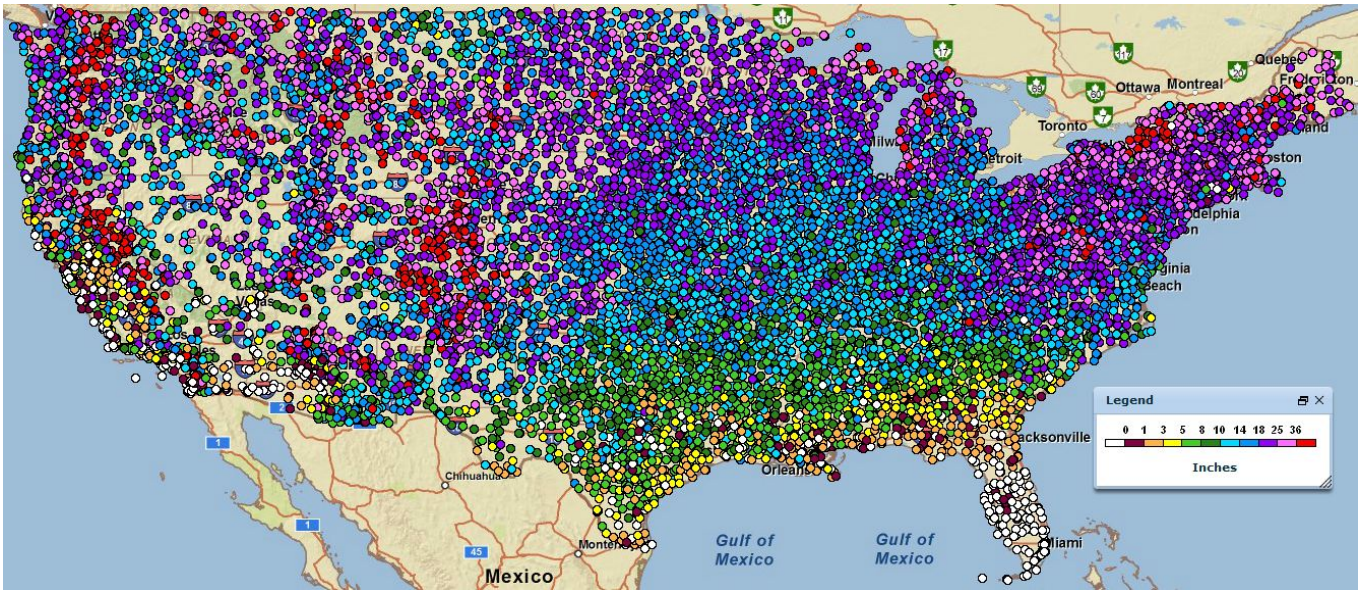
All sites should consider the temperature ranges and weather conditions for their site in storing and deploying their FLEX equipment. That is, the equipment procured should be suitable for use in the anticipated range of conditions for the site, consistent with normal design practices.

In general, the southern parts of the U.S. do not experience snow, ice, and extreme cold. However, it is possible at most sites, except sites in Southern California, Arizona, the Gulf Coast, and Florida, to experience such conditions. Consequently, all other sites are expected to address FLEX deployment for these conditions.

The map in Figure 8-1 provides a visual representation of the maximum three day snowfall records across the U.S, with Red being max, Blue, Purple, and Pink being significant, and Green, Yellow, and White being low accumulations. The Green dots represent a record that is approximately 6 inches accumulation over three days. Such snowfalls are unlikely to present a significant problem for deployment of FLEX. This region is generally below the 35th parallel. Thus, excluding plants in Arizona and Southern California, plants above the 35th parallel should provide the capability to address the impedances caused by extreme snowfall with snow removal equipment.

It will be assumed that this same basic trend applies to extreme low temperatures.

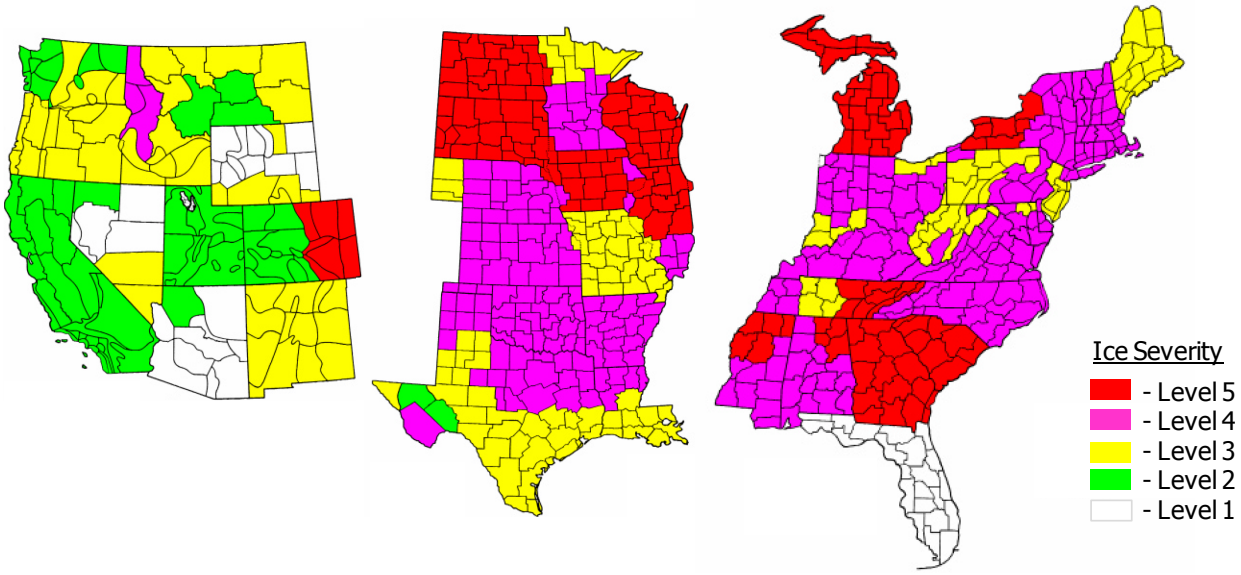
Figure 8-1
Record 3 Day Snowfalls [Ref. 15]



Applicability of ice storms is based on a database developed by EPRI for the United States [Ref. 16]. The database summarized ice storms that occurred in any area of the United States from 1959 to April 1995. Regional ice severity, ice event, and maximum level maps were generated based on the information in the ice storm database. Specifically, one set of maps developed by EPRI characterizes the expected maximum severity of ice storms across the U.S. Figure 8-2 collects the EPRI data. The white and green regions (Levels 1 and 2) identify regions that are not susceptible to severe ice storms that may impact the availability of off-site power. Sites in all other regions (i.e., yellow, purple and red) should consider ice storm impacts on their FLEX strategies, as outlined in Sections 8.3.1 through 8.3.4.

Figure 8-2

Maximum Ice Storm Severity Maps [Ref. 16]



Level 5 - Catastrophic destruction to power lines and/or existence of extreme amount of ice
Level 4 - Severe damage to power lines and/or existence of large amount of ice
Level 3 - Low to medium damage to power lines and/or existence of considerable amount of ice
Level 2 - Existence of small amount of ice
Level 1 - No ice

8.2.2 Characterization of the Applicable Snow, Ice, and Low Temperature Hazard

In this case, sites that should address snow, ice and low temperatures should consider the impacts of these conditions on the storage and deployment of the FLEX equipment.

8.3 Protection and Deployment of FLEX Equipment

8.3.1 Protection of FLEX Equipment

These considerations apply to the protection of FLEX equipment from snow, ice, and extreme cold hazards:

1. For sites subject to significant snowfall and ice storms, portable FLEX equipment should be stored in one of two configurations:
    a. In a structure that meets the plant's design basis for the snow, ice and cold conditions (e.g., existing safety-related structure).

b. In a structure designed to or evaluated equivalent to ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures* for the snow, ice, and cold conditions from the site's design basis.

c. Provided the N FLEX equipment is located as described in a. or b. above, the N+1 equipment may be stored in an evaluated storage location capable of withstanding historical extreme weather conditions and the equipment is deployable.

2. Storage of FLEX equipment should account for the fact that the equipment will need to function in a timely manner. The equipment should be maintained at a temperature within a range to ensure its likely function when called upon. For example, by storage in a heated enclosure or by direct heating (e.g., jacket water, battery, engine block heater, etc.).

8.3.2 Deployment of FLEX Equipment

There are a number of considerations that apply to the deployment of FLEX equipment for snow, ice, and extreme cold hazards:

1. The FLEX equipment should be procured to function in the extreme conditions applicable to the site. Normal safety-related design limits for outside conditions may be used, but consideration should also be made for any manual operations required by plant personnel in such conditions.
2. For sites exposed to extreme snowfall and ice storms, provision should be made for snow/ice removal, as needed to obtain and transport FLEX equipment from storage to its location for deployment.
3. For some sites, the ultimate heat sink and flow path may be affected by extreme low temperatures due to ice blockage or formation of frazil ice. Consequently, the evaluation should address the effects of such a loss of UHS on the deployment of FLEX equipment. For example, if UHS water is to be used as a makeup source, some additional measures may need to be taken to assure that the FLEX equipment can utilize the water.

8.3.3 Procedural Interfaces

The only procedural enhancements that would be expected to apply involve addressing the effects of snow and ice on transport the FLEX equipment. This includes both access to the transport path, e.g., snow removal, and appropriately equipped vehicles for moving the equipment.

8.3.4 Considerations in Utilizing Off-site Resources

Severe snow and ice storms can affect site access and can impact staging areas for receipt of off-site materials and equipment.

9 STEP 2E: ASSESS IMPACT OF HIGH TEMPERATURES

The potential challenge presented by extreme high temperatures can be very site-specific and is a function of the site layout, plant design, and regional weather hazards present. Extreme temperatures can present a challenge to both off-site power (e.g., grid issues) and on-site capabilities (e.g., inadequate DG cooling). However, such conditions would not be expected to impact deployment of on-site and off-site coping resources.

9.1 RELATIONSHIP TO LOSS OF AC POWER & LOSS OF UHS

Extreme high temperatures can present a challenge to both off-site power and on-site capabilities by stressing the grid and making cooling systems, such as the UHS, less effective due to high water temperatures.

9.2 APPROACH TO EXTREME HIGH TEMPERATURE CHALLENGES

All sites will address high temperatures. Virtually every state in the lower 48 contiguous United States has experienced temperatures in excess of 110˚F. Many states have experienced temperatures in excess of 120˚F.

In this case, sites should consider the impacts of these conditions on deployment of the FLEX equipment.

9.3 PROTECTION AND DEPLOYMENT OF FLEX EQUIPMENT

9.3.1 Protection of FLEX Equipment

The equipment should be maintained at a temperature within a range to ensure its likely function when called upon.

9.3.2 Deployment of FLEX Equipment

The FLEX equipment should be procured to function, including the need to move the equipment, in the extreme conditions applicable to the site. The potential impact of high temperatures on the storage of equipment should also be considered, e.g., expansion of sheet metal, swollen door seals, etc. Normal safety-related design limits for outside conditions may be used, but consideration should also be made for any manual operations required by plant personnel in such conditions.

9.3.3 Procedural Interfaces

The only procedural enhancements that would be expected to apply involve addressing the effects of high temperatures on the FLEX equipment.

9.3.4 Considerations in Utilizing Off-site Resources

Extreme high temperatures are not expected to impact the utilization of off-site resources.

10 STEP 3: DEFINE SITE-SPECIFIC FLEX CAPABILITIES

10.1 AGGREGATION OF FLEX STRATEGIES

This step involves the consideration of the aggregate set of on-site and off-site resource considerations for the hazards that are applicable to the site. That is, the site should aggregate all of the considerations related to:

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

In order to establish the best overall strategy for the storage and deployment of FLEX capabilities over a broad set of beyond-design-basis conditions an aggregated assessment is needed of the site-specific considerations identified for the applicable hazards.

Provision of at least N+1 sets of portable on-site equipment stored in diverse locations or in structures designed to reasonably protect from applicable BDBEEs is essential to provide reasonable assurance that N sets of FLEX equipment will remain deployable to assure success of the FLEX strategies. Procedures and guidance to support deployment and implementation including interfaces to EOPs, special event procedures, abnormal event procedures, and system operating procedures, will be coordinated within the site procedural framework.

11 PROGRAMMATIC CONTROLS

This section summarizes the programmatic controls that are to be considered in the implementation of the plant-specific FLEX strategies.

11.1 QUALITY ATTRIBUTES

Equipment associated with these strategies will be procured as commercial equipment with design, storage, maintenance, testing, and configuration control as outlined in this section. If the equipment is credited for other functions (e.g., fire protection), then the quality attributes of the other functions apply.

11.2 EQUIPMENT DESIGN

1. Design requirements and supporting analysis should be developed for portable equipment that directly performs a FLEX mitigation strategy for core, containment, and SFP that provides the inputs, assumptions, and documented[3] analysis that the mitigation strategy and support equipment will perform as intended. When specifying portable equipment, the capacities should ensure that the strategy can be effective over a range of plant and environmental conditions. This documentation should be auditable, consistent with generally accepted engineering principles and practices, and controlled within the configuration document control system.

    a. The basis for designed flow requirements should consider the following factors:

        i. Pump design output performance (flow/pressure) characteristics.

        ii. Line losses due to hose size, coupling size, hose length, and existing piping systems.

        iii. Head losses due to elevation changes, especially for spray strategies.

        iv. Back pressure when injecting into closed/pressurized spaces (e.g., containment, steam generators).

        v. Capacity, temperature, and availability of the suction sources needs to be considered given the specific external initiating events (condensate storage tank (CST)/refueling water storage tank (RWST)/circulating water basin/fire main/city water supply/lake/river, etc.) to provide an adequate supply for the pumps (fire engines, portable pumps, fire protection system pumps, etc.).

        vi. Potential detrimental impact on water supply source or output pressure when using the same source or permanently installed pump(s) for makeup for multiple simultaneous strategies.

[3] FLEX documentation should be auditable but does not require Appendix B qualification. Manufacturer's information may be used in establishing the basis for the equipment use.

vii. Availability of sufficient supply of fuel on-site to operate diesel powered pumps for the required period of time.

viii. Availability of an adequate and reliable source of electrical power to operate electric powered pumps for the required period of time.

ix. Potential clogging of strainers, pumps, valves or hoses from debris or ice when using rivers, lakes, ocean or cooling tower basins as a water supply.

2. Portable towable equipment that is designed for over the road transport typically used in construction/remote sites are deemed sufficiently rugged to function following a BDB seismic event.
3. Note that the functionality of the equipment may be outside the manufacturer's specifications if justified in a documented engineering evaluation.
4. It is desirable for diverse mitigation equipment to be commonly available (e.g., commercial equipment) such that parts and replacements can be readily obtained.

11.3 EQUIPMENT STORAGE

1. Detailed guidance for selecting suitable storage locations that provide reasonable protection during specific external events is provided in Sections 5 through 9.
2. A technical basis should be developed for equipment storage for portable equipment that directly performs a FLEX mitigation strategy for core, containment, and SFP that provides the inputs, assumptions, and documented[2] basis that the mitigation strategy and support equipment will be reasonably protected from applicable external events such that the equipment could be operated in place, if applicable, or moved to its deployment locations. This basis should be auditable, consistent with generally accepted engineering principles, and controlled within the configuration document control system.
3. FLEX mitigation equipment should be stored in a location or locations[4] informed by evaluations performed per Sections 5 through 9 such that no one external event can reasonably fail the site FLEX capability (N).
4. Different FLEX equipment can be credited for independent events.
5. Consideration should be given to the transport from the storage area following the external event recognizing that external events can result in obstacles restricting normal pathways for movement.
6. If portable FLEX equipment is pre-staged such that it minimizes the time delay and burden of hook-up following an external event, then the equipment should be evaluated to not have an adverse effect on existing SSCs and the primary connection point should be as close to the intended point of supply as possible, e.g., a staged power supply to recharge batteries should be connected as close to the battery charger as practicable to maintain diversity and minimize the reliance on other installed equipment.

[4] Location or locations may include areas outside the owner controlled area provided equipment can be relocated in time to meet FLEX strategy requirements.

7. FLEX equipment should be stored and maintained in a manner that is consistent with assuring that it does not degrade over long periods of storage and that it is accessible for periodic maintenance and testing.
8. If 50.54(hh)(2) equipment is credited in the FLEX mitigating strategies, it should meet the above storage requirements in addition to the 50.54(hh)(2) requirements.
9. If debris removal equipment is needed, it should be reasonably protected from the applicable external events such that it is likely to remain functional and deployable to clear obstructions from the pathway between the FLEX equipment's storage location and its deployment location(s).
10. Deployment of the FLEX equipment or debris removal equipment from storage locations should not depend on off-site power or on-site emergency ac power (e.g., to operate roll up doors, lifts, elevators, etc.).

11.4 PROCEDURE GUIDANCE

11.4.1 Objectives

The purpose of this section is to describe the procedural approach for the implementation of diverse and flexible (FLEX) strategies. This approach includes appropriate interfaces between the various accident mitigation procedures so that overall strategies are coherent and comprehensive. This approach is intended to provide guidance for responding to BDBEE events while minimizing the need for invoking 50.54 (x).

1. FLEX Support Guidelines (FSG) will provide available, pre-planned FLEX strategies for accomplishing specific tasks. FSG will support EOP, EDMG, and SAMG strategies.
2. Clear criteria for entry into FSG will ensure that FLEX strategies are used only as directed for BDBEE conditions, and are not used inappropriately in lieu of existing procedures.
3. FLEX strategies in the FSG will be evaluated for integration with the appropriate existing procedures. As such, FLEX strategies will be implemented in such a way as to not violate the basis of existing procedures.
4. When FLEX equipment is needed to supplement EOP/AOP strategies, the EOP/AOP will direct the entry into and exit from the appropriate FSG procedure.
5. FSG will be used to supplement (not replace) the existing procedure structure that establish command and control for the event (e.g., AOP, EOP, EDMG, and SAMG).
6. The existing command and control procedure structure will be used to transition to SAMGs if FLEX mitigation strategies are not successful.
7. If plant systems are restored, exiting the FSGs and returning to the normal plant operating procedures will be addressed by the plant's emergency response organization and operating staff dependent on the actual plant conditions at the time.

11.4.2 Operating Procedure Hierarchy

1. The existing hierarchy for operating plant procedures remains relatively unchanged with the following exceptions:
    a. A new group of FSG for implementation of FLEX strategies will be created.
    b. Existing AOP and EOPs will be revised to the extent necessary to include appropriate portions or reference to FSG.
2. Where FLEX strategies rely on permanently installed equipment, changes may be required to AOPs and EOPs.
3. Transition from the current procedure structure to the modified procedure structure that incorporates the FLEX strategies is illustrated in Figure 11-1.

11.4.3 Development Guidance for FSGs

The inability to predict actual plant conditions that require the use of FLEX equipment makes it impossible to provide specific procedural guidance. As such, the FSG will provide guidance that can be employed for a variety of conditions.

1. FSG should be reviewed and validated by the involved groups to the extent necessary to ensure the strategy is feasible. Validation may be accomplished via walk-throughs or drills of the guidelines.
2. FSGs will be controlled under the site procedure control program.

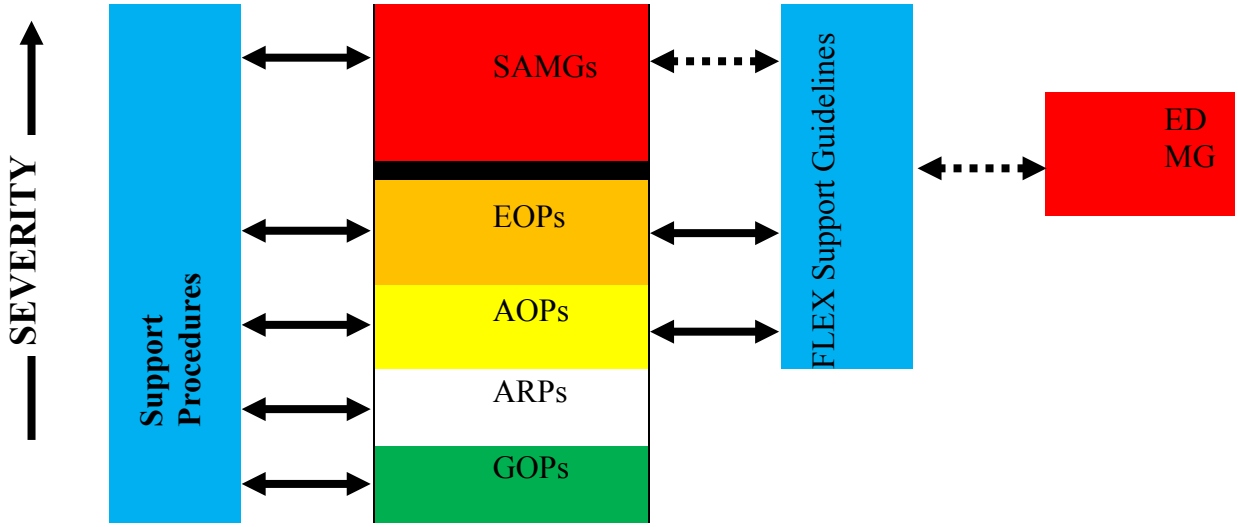
11.4.4 Regulatory Screening/Evaluation

NEI 96-07, revision 1, and NEI 97-04, revision 1 should be used to evaluate the changes to existing procedures as well as to the FSG to determine the need for prior NRC approval. Changes to procedures (EOPs or FSGs) that perform actions in response events that exceed a site's design basis should, per the guidance and examples provided in NEI 96-07, Rev. 1, screen out. Therefore, procedure steps which recognize the beyond-design-basis ELAP/LUHS has occurred and which direct actions to ensure core cooling, SFP cooling, or containment integrity should not require prior NRC approval.

Figure 11-1

(a) Existing View of Typical Operating Procedure Hierarchy

(b) Future View of Typical Operating Procedure Hierarchy



Notes:

- The central column represents the procedure set that is in "command and control" of plant functions dependent upon plant conditions, shown in sequence of severity (e.g., risk to protection of the core). EDMG/B5b Guidelines currently establish a separate command and control that is not recognized by the EOPs and SAMGs.
- Clear entry conditions and transitions exist between procedure sets as severity increases exist. Note that there may be some overlap on an Owner's Group specific basis where some AOPs, Alarm response and Normal plant procedures may be used to support each other or support the EOPs. However, there will be a clear controlling procedure in effect.
- Support procedures and FSGs are used to support the execution of plant strategies as shown, without exiting the controlling procedure. The double arrows mean that you may pull a specific strategy from the support procedure set without leaving the procedure in effect. Note, not all sites have AOPs that would refer to FSGs. Interface with SAMGs and EDMGs (dotted arrows) are not within the scope of this guide.

Notes (continued):

- FSGs would be similar in intent as the current 50.54(hh)(2) guides. The future EDMG may rely upon FSGs.
- The heavy line between EOPs and SAMGs represents the procedure transition due to imminent core damage or damage to SFP fuel.

11.5 MAINTENANCE AND TESTING

1. FLEX mitigation equipment should be initially tested or other reasonable means used to verify performance conforms to the limiting FLEX requirements. Validation of source manufacturer quality is not required.
2. Portable equipment that directly performs a FLEX mitigation strategy for the core, containment, or SFP should be subject to maintenance and testing[5] guidance provided in INPO AP 913, Equipment Reliability Process, to verify proper function. The maintenance program should ensure that the FLEX equipment reliability is being achieved. Standard industry templates (e.g., EPRI) and associated bases will be developed to define specific maintenance and testing including the following:
    a. Periodic testing and frequency should be determined based on equipment type and expected use. Testing should be done to verify design requirements and/or basis. The basis should be documented and deviations from vendor recommendations and applicable standards should be justified.
    b. Preventive maintenance should be determined based on equipment type and expected use. The basis should be documented and deviations from vendor recommendations and applicable standards should be justified.
    c. Existing work control processes may be used to control maintenance and testing. (e.g., PM Program, Surveillance Program, Vendor Contracts, and work orders).
3. 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.
    a. The unavailability of installed plant equipment is controlled by existing plant processes such as the Technical Specifications. When installed plant equipment which supports FLEX strategies becomes unavailable, then the FLEX strategy affected by this unavailability does not need to be maintained during the unavailability.
    b. Portable equipment may be unavailable for 90 days provided that the site FLEX capability (N) is available.
    c. Connections to permanent equipment required for FLEX strategies can be unavailable for 90 days provided alternate capabilities remain functional.

[5] Testing includes surveillances, inspections, etc.

d. Portable equipment that is expected to be unavailable for more than 90 days or expected to be unavailable during forecast site specific external events (e.g., hurricane) should be supplemented with alternate suitable equipment.

e. The short duration of equipment unavailability, discussed above, does not constitute a loss of reasonable protection from a diverse storage location protection strategy perspective.

f. 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.

11.6 TRAINING

1. Programs and controls should be established to assure personnel proficiency in the mitigation of beyond-design-basis events is developed and maintained. These programs and controls should be implemented in accordance with an accepted training process[6].
2. Periodic training should be provided to site emergency response leaders[7] on beyond-design-basis emergency response strategies and implementing guidelines. Operator training for beyond-design-basis event accident mitigation should not be given undue weight in comparison with other training requirements. The testing/evaluation of Operator knowledge and skills in this area should be similarly weighted.
3. Personnel assigned to direct the execution of mitigation strategies for beyond-design-basis events will receive necessary training to ensure familiarity with the associated tasks, considering available job aids, instructions, and mitigating strategy time constraints.
4. "ANSI/ANS 3.5, Nuclear Power Plant Simulators for use in Operator Training" certification of simulator fidelity (if used) is considered to be sufficient for the initial stages of the beyond-design-basis external event scenario until the current capability of the simulator model is exceeded. Full scope simulator models will not be upgraded to accommodate FLEX training or drills.
5. Where appropriate, the integrated FLEX drills should be organized on a team or crew basis and conducted periodically; with all time-sensitive actions to be evaluated over a period of not more than eight years. It is not the intent to connect to or operate permanently installed equipment during these drills and demonstrations.

[6] The Systematic Approach to Training (SAT) is recommended.
[7] Emergency response leaders are those utility emergency response personnel assigned leadership roles, as defined by the Emergency Plan, for managing emergency response to design basis and beyond-design-basis plant emergencies.

11.7 STAFFING

1. On-site staff are at site administrative minimum shift staffing levels, (minimum staffing may include additional staffing that is procedurally brought on-site in advance of a predicted external event, e.g., hurricane).
2. No independent, concurrent events, e.g., no active security threat, and
3. All personnel on-site are available to support site response.

11.8 CONFIGURATION CONTROL

1. The FLEX strategies and basis will be maintained in an overall program document. This program document will also contain a historical record of previous strategies and the basis for changes. The document will also contain the basis for the ongoing maintenance and testing programs chosen for the FLEX equipment.
2. Existing plant configuration control procedures will be modified to ensure that changes to the plant design, physical plant layout, roads, buildings, and miscellaneous structures will not adversely impact the approved FLEX strategies.
3. Changes to FLEX strategies may be made without prior NRC approval provided:
    a. The revised FLEX strategy meets the requirements of this guideline.
    b. An engineering basis is documented that ensures that the change in FLEX strategy continues to ensure the key safety functions (core and SFP cooling, containment integrity) are met.

12 OFF-SITE RESOURCES

12.1 SYNCHRONIZATION WITH OFF-SITE RESOURCES

The timely provision of effective off-site resources will need to be coordinated by the site and will depend on the plant-specific analysis and strategies for coping with the effects of the beyond-design-basis external event. Arrangements will need to be established by each site addressing the scope of equipment that will be required for the off-site phase, as well as the maintenance and delivery provisions for such equipment.

As previously noted, the underlying strategies for coping with these events involve a three phase approach:

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

The plant-specific analyses previously described in this document will determine the duration of each phase. Justification for the duration of each phase should address the on-site availability of equipment, the resources necessary to deploy the equipment consistent with the required timeline, anticipated site conditions following the beyond-design-basis external event, and the ability of the off-site supplier and local infrastructure to enable delivery of equipment and resources from off-site.

On-site resources will be used to cope with the first two phases of the casualty for a minimum of the first 24 hours of the event. The site-specific ELAP analysis will dictate the deployment schedule for off-site equipment. The delivery schedule for the off-site equipment must allow for sufficient margin to meet the deployment times of the off-site equipment. The schedule for initial delivery of off-site equipment (equipment needed to back up on-site equipment and extend the coping duration) needs to be contractually arranged with the off-site facility.

Site procedures for Phase 3 implementation should address early notification to mobilize the off-site response, establishment of a point of delivery for the off-site equipment, arrangements for delivery and deployment at the site, and sufficient supplies of commodities to support the equipment and site personnel.
Table 12-1 provides a sample list of the equipment expected to be provided to each site from off-site within 24 hours. The actual list will be specified by each site as part of the site-specific analysis.

Subsequently, additional equipment and commodities are intended to be made available as often as needed to support an indefinite coping capability. The list of this equipment and commodities will also be developed by the site from the site-specific analysis. Table 12-2 provides a potential list of the additional equipment that may be considered.

12.2 MINIMUM CAPABILITIES OF OFF-SITE RESOURCES

Each site will establish a means to ensure the necessary resources will be available from off-site. Considerations that should be included in establishing this capability include:

1) A capability to obtain equipment and commodities to sustain and backup the site's coping strategies.
2) Off-site equipment procurement, maintenance, testing, calibration, storage, and control.
3) A provision to inspect and audit the contractual agreements to reasonably assure the capabilities to deploy the FLEX strategies including unannounced random inspections by the Nuclear Regulatory Commission.
4) Provisions to ensure that no single external event will preclude the capability to supply the needed resources to the plant site.
5) Provisions to ensure that the off-site capability can be maintained for the life of the plant.
6) Provisions to revise the required supplied equipment due to changes in the FLEX strategies or plant equipment or equipment obsolescence.
7) The appropriate standard mechanical and electrical connections need to be specified.
8) Provisions to ensure that the periodic maintenance, periodic maintenance schedule, testing, and calibration of off-site equipment are comparable/consistent with that of similar on-site FLEX equipment.
9) Provisions to ensure that equipment determined to be unavailable/non-operational during maintenance or testing is either restored to operational status or replaced with appropriate alternative equipment within 90 days.
10) Provision to ensure that reasonable supplies of spare parts for the off-site equipment are readily available if needed. The intent of this provision is to reduce the likelihood of extended equipment maintenance (requiring in excess of 90 days for returning the equipment to operational status).

Table 12-1

~24 Hour Response

COMPONENT DESCRIPTION	FUNCTION
High capacity pump (Diesel driven)	RPV/SG makeup SFP makeup CST refill
High pressure pump (Diesel driven)	RCS/RPV makeup & boron injection
Suction, discharge hose, suction strainers, fittings	Connection to water source and injection points
Portable Diesel Generator sets	Battery charger supply Control room lighting Communications gear Emergency response
Cables for connecting portable generators	Connection to loads
Portable air compressor or nitrogen bottles & regulators (if required by plant strategy)	AOVs (AFW valves, S/G Atmospheric Dump Valves, if required)
dc power supplies	Critical instruments AOV operation (if required)
Portable ventilation fans	Maintain accessible conditions Battery room H2 control when battery charging is relied upon. Equipment operability
Diesel Generator fuel transfer pump & hoses to ensure transfer capability of site fuel to portable equipment for sites where gravity drain is not effective OR have the ability to gravity drain to a fuel transfer container.	Resupply of portable generators and pumps
Communications gear—satellite phones, radios	Off-site & on-site communications

NOTE:
The plant-specific requirements for pump head are a function of the strategy employed and the thermal hydraulic response of the plant.

Table 12-2

> 24 Hour Response

COMPONENT DESCRIPTION	FUNCTION
4 kv and 6.9 kv DG • Switchgear • Transformer	Repower plant busses and/or components
Radiation Protection Equipment • Survey instruments • Dosimetry • Off-site monitoring/sampling	Off-site and on-site radiological monitoring
Commodities • Food • Potable water	Support for site personnel
Provision for Diesel Fuel resupply	Resupply of pumps and DGs
Portable lighting	Improve operations
Containment berms	Support access to flooded areas
Dewatering pumps	Support access to flooded areas

13 SUBMITTAL GUIDANCE

In accordance with NRC Order EA-12-049 Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events the following reporting requirements are established:

C. 1. a. All holders of operating licenses issued under Part 50 shall by February 28, 2013, submit to the Commission for review an overall integrated plan including a description of how compliance with the requirements described in Attachment 2 will be achieved.

b. All holders of CPs issued under Part 50 or COLs issued under Part 52 shall, within one (1) year after issuance of the final lSG, submit to the Commission for review an overall integrated plan including a description of how compliance with the requirements described in Attachment 2 or Attachment 3 will be achieved.

2. All Licensees and holders of CPs shall provide an initial status report sixty (60) days following issuance of the final ISG and at six (6)-month intervals following submittal of the overall integrated plan, as required in Condition C.1, which delineates progress made in implementing the requirements of this Order.

3. All Licensees and CP holders shall report to the Commission when full compliance with the requirements described in Attachment 2 or Attachment 3 is achieved.

The following describe the expected inclusions for these reports.

13.1 OVERALL INTEGRATED PLAN SUBMITTAL

The Overall Integrated Plan should include a complete description of the FLEX strategies, including important operational characteristics. The level of detail generally considered adequate is consistent to the level of detail contained in the Licensee's Final Safety Analysis Report (FSAR). The plan should provide the following information:

1. Extent to which this guidance, NEI 12-06, is being followed including a description of any alternatives to the guidance, and provide a milestone schedule of planned actions.
2. Description of the strategies and guidance to be developed to meet the requirements contained in Attachment 2 or Attachment 3 of the order.
3. Description of major installed and portable FLEX components used in the strategies, the applicable reasonable protection for the FLEX portable equipment, and the applicable maintenance requirements for the portable equipment.
4. Description of the steps for the development of the necessary procedures, guidance, and training for the strategies; FLEX equipment acquisition, staging or installation, including necessary modifications.

5. Conceptual sketches, as necessary to indicate equipment which is installed or equipment hookups necessary for the strategies. (As-built piping and instrumentation diagrams (P&ID) will be available upon completion of plant modifications.)
6. Description of how the portable FLEX equipment will be available to be deployed in all modes.

13.2 STATUS REPORTS

The reports should include an update of milestone accomplishments since the last status report, including any changes to the compliance method, schedule, or need for relief and the basis, if any.

13.3 FINAL REPORT

The report shall include the date full compliance was achieved along with the availability of necessary reports, analysis and other information necessary for the NRC staff to conduct an inspection.

14 REFERENCES

1. U.S. NRC, "Recommendations for Enhancing Reactor Safety in the 21st Century", July 12, 2001.
2. U.S. NRC, "Recommended Actions To Be Taken Without Delay From The Near-Term Task Force Report", SECY-11-0124, September 9, 2011.
3. U.S. NRC, "Prioritization of Recommended Actions To Be Taken In Response to Fukushima Lessons Learned", SECY-11-0137, October 3, 2011.
4. U.S. NRC, "Staff Requirements – SECY-11-0124 – Recommended Actions To Be Taken Without Delay From The Near-Term Task Force Report", SRM-11-0124, October 18, 2011.
5. U.S. NRC Glossary (http://www.nrc.gov/reading-rm/basic-ref/glossary/beyond-design-basis-accidents.html).
6. NEI, "B.5.b Phase 2 & 3 Submittal Guideline," NEI 06-12, Revisions 2 and 3, December 2006 and July 2009, respectively.
7. NEI, INPO, EPRI, "The Way Forward, U.S. Industry Leadership in Response to Events at the Fukushima Daiichi Nuclear Power Plant", June 8, 2011.
8. NUMARC, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors", NUMARC 87-00, Rev. 1, August 1991.
9. U.S. NRC, "Perspectives Gained From the Individual Plant Examination of External Events (IPEEE) Program", NUREG-1742, Volume 1, April 2002.
10. U.S. NRC, "Flood Protection For Nuclear Power Plants", Reg. Guide 1.102, Rev. 1, September 1976.
11. U.S. NRC, "Design Basis Floods for Nuclear Power Plants", Reg. Guide 1.59, Rev. 2, August 1977.
12. U.S. NRC, "Standard Review Plan", NUREG-0800, Sections 2.4.2 through 2.4.6, March, 2007.
13. U.S. NRC, "Technical Basis for Regulatory Guidance on Design Basis Hurricane Wind Speeds for Nuclear Power Plants", NUREG/CR-7005, December, 2009.
14. U.S. NRC, "Tornado Climatology of the Contiguous United States", NUREG/CR-4461, Rev. 2, February 2007.
15. NOAA, United States Snow Climatology website, Extreme 1-Day, 2-Day, and 3-Day Snowfall Amount from NCDC Snow Climatology, http://www.ncdc.noaa.gov/ussc/index.jsp.
16. EPRI, Ice Storm Data Base and Ice Severity Maps, TR-106762, www.epri.com, September 1996.

APPENDIX A
GLOSSARY OF TERMS

This glossary provides definitions of key terms used in this guidance document. These definitions have been made consistent with other external definitions, to the degree possible, but the definitions herein represent the expressed intent of the terms as used in this guideline.

Applicable external hazard: an external hazard that meets the screening criteria of the applicable section for a particular site. Not all sites will find the same hazards to be applicable.

Baseline Coping Capability: a basic set of strategies for providing essentially indefinite coping capability for extended loss of ac power and loss of the ultimate heat sink scenarios through the use of installed equipment, on-site portable equipment, and pre-staged off-site resources.

*Beyond-design-basis external event*s: for the purpose of this document are considered events initiated by natural phenomena that either exceed the protections provided by design basis features or involve natural phenomena within the design basis in combination with beyond-design-basis failures leading to an extended loss of ac power and/or loss of ultimate heat sink. Appendix B provides an assessment of the potentially applicable natural phenomena and the basis for the grouping of hazard classes used in this guideline.

Essentially indefinitely: See *Sustaining functions indefinitely*.

Extreme external event: an external event that exceeds the plant design basis.

FLEX Capability: a site-specific set of equipment strategies implemented through plant-specific procedures/guidance that provides essentially indefinite coping capability through the use of installed equipment, on-site portable equipment, and pre-staged off-site resources for the external hazards that are applicable to the site.

FLEX Strategies: the plant-specific functional approaches taken to maintain or restore core cooling, SFP cooling, and containment function.

Loss of normal access to the ultimate heat sink: Loss of ability to provide a forced flow of water to key plant systems (i.e., the pumps are unavailable and not restorable as part of the coping strategy). [Order language]

N+1 capability: provision of a spare capability to support the safety functional requirements beyond the minimum necessary to support the "N" units on-site.

Off-site equipment: equipment that is located away from the plant site and has to be transported from its storage location to the plant site for use.

On-site FLEX equipment: diverse and flexible equipment that is dedicated for use in FLEX strategies and is stored within the owner-controlled area or in close proximity to the site.

Sustaining functions indefinitely: Establishing strategies and resources to maintain a stable plant condition until recovery actions can be implemented. [Order language]

Robust (designs): the design of an SSC either meets the current plant design basis for the applicable external hazards or has been shown by analysis or test to meet or exceed the current design basis.

APPENDIX B
IDENTIFICATION OF BEYOND-DESIGN-BASIS EXTERNAL EVENTS TO BE CONSIDERED

B.1 Purpose

The purpose of this paper is to provide an evaluation of potential beyond-design-basis external hazards that could significantly challenge a U.S. nuclear power plant by causing a simultaneous ELAP and LUHS. The identified hazards will be addressed in the industry process developing site-specific FLEX capabilities.

B.2 Approach

Utilize the list of beyond-design-basis external hazards considered in the current ASME/ANS PRA Standard [Ref. B-1]. The PRA Standard explicitly addresses requirements for PRAs of seismic, high wind, and external flood hazards and provides a non-mandatory appendix (Appendix 6-A) that provides a comprehensive list of hazards that may be applicable to a specific site. Each of the hazards from Appendix 6-A is reviewed. Any that cannot be screened out as clearly irrelevant to a simultaneous ELAP and LUHS are retained for consideration as part of the site assessment process.

B.3 Results

The results of the review of the ASME/ANS list of external hazards are provided in Table B-1. A summary of where/how each applicable hazard will be addressed is provided below.

Some hazards could contribute to the potential for a simultaneous ELAP and LUHS, but do not significantly challenge the structures and internal plant equipment[8]. These hazards are therefore considered to be enveloped by baseline ELAP in Step 1:

- forest fire
- grass Fire
- lightning
- sandstorm
- volcanic activity

[8] - NOTE: Solar-Geomagnetic disturbances could also lead to extended loss of off-site power due to geomagnetically-induced currents in electrical power transmission systems. However, this hazard was not included in Reference B-1 so it is not explicitly listed here. Nevertheless, while such disturbances could cause an extended loss of off-site power, they are not expected to impact the on-site safety-related equipment (e.g., diesel generators and internal distribution equipment) due to their being housed in reinforced concrete structures and would not change the approach to devising FLEX strategies.

Some hazards could contribute to the potential for a Loss of UHS in Step 1:

- biological events
- coastal erosion
- ice cover
- low lake or river water level
- river diversion

Seismic activity is explicitly considered as part of Step 2A.

Some hazards contribute to External Flooding and will be addressed in Step 2B:

- external flooding
- high tide
- precipitation
- seiche
- storm surge
- tsunami events
- waves
- hurricane.

Some hazards involve High Winds and will be addressed in Step 2C:

- hurricane
- extreme winds and tornadoes.

Some hazards involve Snow/Ice/Extreme Cold that may impede response actions. These will be addressed in Step 2D:

- avalanche
- ice cover
- snow
- low winter temperature.

Some hazards involve Extreme High Temperatures and will be addressed in Step 2E:

- high summer temperature.

The following hazards are either already covered by other regulations or were judged to be not applicable or insignificant contributors to a simultaneous ELAP and LUHS and were screened from further consideration:

- accidental aircraft impacts
- drought
- fog
- frost
- hail
- industrial or military facility accident
- landslide
- meteorite/satellite strikes
- pipeline accident
- release of chemicals from on-site storage
- ship impact
- sink holes
- soil shrink-swell
- toxic gas
- transportation accidents
- turbine-generated missiles
- vehicle impact
- vehicle/Ship explosion.

B.4 References

B-1. American Society of Mechanical Engineers and American Nuclear Society, Addenda to ASME/ANS RA-S-2008 Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications, ASME/ANS RA-Sa-2009, New York (NY), February 2009.

Table B-1
Evaluation of External Hazards Identified in the ASME/ANS PRA Standard [Ref. A-1]

External Hazard	Potentially Applicable for ELAP/LUHS?	Disposition
Accidental aircraft impacts	Y	Screened. Already enveloped by 10 CFR 50.54 (hh)(2).
Avalanche	Y	Consider as part of treatment of Snow/Ice Effects
Biological events	Y	Consider as part of LUHS
Coastal erosion	Y	Consider as part of LUHS
Drought	N	Slow developing event not a short-term challenge to LUHS
External flooding	Y	Consider as part of External Flooding
Extreme winds and tornadoes	Y	Consider as part of High Winds
Fog	N	Screened
Forest fire	Y	Consider as enveloped by baseline treatment of ELAP
Frost	N	Consider as enveloped by treatment of Snow/Ice Effects
Grass Fire	Y	Consider as enveloped by baseline treatment of ELAP
Hail	N	Screened
High summer temperature	Y	Consider as part of treatment of Extreme Temperatures
High tide	Y	Consider as part of External Flooding
Hurricane	Y	Consider as part of External Flooding & High Winds
Ice cover	Y	Consider as part of LUHS and treatment of Snow/Ice Effects
Industrial or military facility accident	N	Screened
Landslide	N	Screened
Lightning	Y	Consider as enveloped by baseline treatment of ELAP
Low lake or river water level	Y	Consider as part of LUHS
Low winter temperature	Y	Consider as part of treatment of Snow/Ice Effects
Meteorite/satellite strikes	N	Screened
Pipeline accident	N	Screened
Precipitation	Y	Consider as part of External Flooding
Release of chemicals from on-site storage	N	Screened
River diversion	Y	Consider as part of LUHS

Table B-1
Evaluation of External Hazards Identified in the ASME/ANS PRA Standard [Ref. A-1]

External Hazard	Potentially Applicable for ELAP/LUHS?	Disposition
Sandstorm	Y	Consider as enveloped by baseline treatment of ELAP
Seiche	Y	Consider as part of External Flooding
Seismic activity	Y	Consider as part of Seismic
Ship impact	N	Screened
Sink holes	N	Screened
Snow	Y	Consider as part of treatment of Snow/Ice Effects
Soil shrink-swell	N	Screened
Storm surge	Y	Consider as part of External Flooding
Toxic gas	N	Screened
Transportation accidents	N	Screened
Tsunami events	Y	Consider as part of External Flooding
Turbine-generated missiles	N	Screened
Vehicle impact	N	Screened
Vehicle/Ship explosion	N	Screened
Volcanic activity	Y	Consider as enveloped by baseline treatment of ELAP
Waves	Y	Consider as part of External Flooding

APPENDIX C
APPROACH TO BWR FUNCTIONS

Table C-1
Summary of Performance Attributes for BWR Core Cooling Function

Safety Function		Method	Baseline Capability	Purpose	Performance Attributes
Core Cooling/	Reactor Core Cooling	• RCIC/HPCI/IC	• Use of installed equipment for initial coping	Provide initial makeup sufficient to maintain or restore RPV level with installed equipment and power supplies to the greatest extent possible to provide core cooling	• Extend installed coping capability through procedural enhancements (e.g., load shedding), provision of portable battery chargers and other power supplies. • Objective is to provide extended baseline coping capability with installed equipment. • Procedures/guidance to include local manual initiation of RCIC/IC, consistent with NEI 06-12. • If HPCI is relied upon as part of the Phase 1 coping strategy, provide means to manually initiate

*Note: Items are subject to generic or plant-specific analysis

Table C-1
Summary of Performance Attributes for BWR Core Cooling Function

Safety Function		Method	Baseline Capability	Purpose	Performance Attributes
					locally.
		• Depressurize RPV for Injection with Portable Injection Source	• Diverse connection points for portable pump	Provide RPV makeup sufficient to maintain or restore RPV level with diverse and flexible capability.	• Diverse injection points are required to establish capability to inject through separate divisions/trains, i.e., should not have both connections in one division/train. • RPV makeup rate should be capable of removing the decay heat levels at the time of deployment in order to support restoring RPV water level, e.g., 300* gpm.
			• Multiple means to depressurize RPV	Multiple means improves the reliability of the depressurization function.	• Capability to manually depressurize the RPV to allow low head injection. • Procedure should address transition from installed makeup/cooling source to portable equipment.

Table C-1
Summary of Performance Attributes for BWR Core Cooling Function

Safety Function		Method	Baseline Capability	Purpose	Performance Attributes
					This includes the appropriate approaches to initiating the transition to avoid prolonged core uncovery. • Multiple means established to assure reliability. • Analysis should demonstrate that guidance and equipment for combined RPV depressurization and makeup capability supports continued core cooling.
		• Sustained Source of Water	• Use of alternate water supply up to support core and SFP heat removal	Water is a critical resource in sustaining coping capability.	• Water source sufficient to supply water indefinitely including consideration of concurrent makeup or spray of SFP.
	Key Reactor Parameters	• RPV Level	• (Re-)Powered instruments	Instrumentation is vital to implementation of the coping	• Identify instruments to be relied upon, including control room

*Note: Items are subject to generic or plant-specific analysis

Table C-1
Summary of Performance Attributes for BWR Core Cooling Function

Safety Function		Method	Baseline Capability	Purpose	Performance Attributes
				procedures/guidance.	and field instruments
		• RPV Pressure	• Other instruments for EOP-driven strategies		• Depending on strategy employed, some additional instrumentation may be required.

Table C-2
Summary of Performance Attributes for BWR Containment Function

Safety Function		Method	Baseline Capability	Purpose	Performance Attributes
Containment	Containment Function	• Containment Venting or Alternative	• For Mk I and II a venting capability and, if desired, an alternative capability • For others, a reliable, hardened vent or other capability.	Containment heat removal will be required for long-term coping.	• Reliable means to assure containment heat removal. • For Mark I and II containments, capability must credit required changes associated with Order EA-12-050 at a minimum
	Containment Integrity (BWR Mark III Containments Only)	• Hydrogen igniters	• Re-powering of hydrogen igniters with a portable power supply.	Maintain containment integrity post-core damage	• Diverse power connection points are required to establish capability through separate divisions/trains, i.e., should not have both connections in one division/train. • Procedures/guidance to prioritize deployment strategies.
	Key Containment Parameters	• Containment Pressure	• (Re-)Powered instruments	Required for containment venting and other coping actions.	• Identify instruments to be relied upon, including control room and field instruments • Depending on strategy employed, additional parameters may be required.
		• Suppression Pool Temperature		Required to determine HCTL to guide other actions	
		• Suppression Pool Level		Required for venting decisions	

*Note: Items are subject to generic or plant-specific analysis

Table C-3
Summary of Performance Attributes for BWR SFP Cooling Function

Safety Function		Method	Baseline Capability	Purpose	Performance Attributes
SFP Cooling	Spent Fuel Cooling	• Makeup with Portable Injection Source	• Makeup via hoses on refuel deck	Exceed SFP boil-off to support long-term cooling of spent fuel with sufficient makeup	• Minimum makeup rate must be capable of exceeding boil-off rate for the boundary conditions described in Section 3.2.1.6.
			• Makeup via connection to SFP cooling piping or other alternate location	Exceed SFP boil-off and provide a means to supply SFP makeup without accessing the refueling floor.	• Minimum makeup rate must be capable of exceeding boil-off rate for the boundary conditions described in Section 3.2.1.6.
			• Vent pathway for steam & condensate from SFP	Steam from boiling pool can condense and cause access and equipment problems in other parts of plant.	• Plant-specific strategy should be considered as needed
			• Spray capability via portable monitor nozzles from refueling deck using portable pump	Cooling of spent fuel if leakage from the pool exceeds makeup capability	• Minimum of 200 gpm per unit to the pool or 250 gpm per unit if overspray occurs consistent with 10 CFR 50.54(hh)(2)
	SFP Parameters	• SFP Level	• Reliable means to determine SFP water level per Order EA-12-051 to prevent undue distraction of operators and identify conditions when makeup/spray is required	Confirm SFP level is adequate to provide cooling or direct the use of spray.	• Per EA 12-051

APPENDIX D
APPROACH TO PWR FUNCTIONS

Table D-1
Summary of Performance Attributes for PWR Core Cooling Functions

Safety Function		Method	Baseline Capability	Purpose	Performance Attributes
Core Cooling	Reactor Core Cooling & Heat Removal (steam generators available)	• AFW/EFW	• Use of installed equipment for initial coping	Provide SG makeup sufficient to maintain or restore SG level with installed equipment and power supplies to the greatest extent possible to provide core cooling	• Extend installed coping capability through procedural enhancements (e.g., load shedding), provision of portable battery chargers and other power supplies. • Objective is to provide extended baseline coping capability with installed equipment. • Procedures/guidance to include local manual initiation of ac-independent AFW/EFW pumps consistent with NEI 06-12.
		• Depressurize SG for Makeup with Portable	• Connection for portable pump	Provide SG makeup sufficient to maintain or	• Primary and alternate injection points are

*Note: Items are subject to generic or plant-specific analysis

Table D-1
Summary of Performance Attributes for PWR Core Cooling Functions

Safety Function		Method	Baseline Capability	Purpose	Performance Attributes
		Injection Source		restore SG level with diverse and flexible capability	required to establish capability to inject through separate divisions/trains, i.e., should not have both connections in one division/train. • Makeup paths supply required SGs • SG makeup rate should exceed decay heat levels at time of planned deployment in order to support restoring SG water level, e.g., 200* gpm. • Analysis should demonstrate that the guidance and equipment for combined SG depressurization and makeup capability supports continued core cooling.
		• Sustained Source of Water	• Use of alternate water supply up to support core and SFP heat	Water is a critical resource in sustaining coping capability.	• Water source sufficient to supply water indefinitely including

Table D-1
Summary of Performance Attributes for PWR Core Cooling Functions

Safety Function		Method	Baseline Capability	Purpose	Performance Attributes
			removal		consideration of concurrent makeup or spray of SFP.
	RCS Inventory Control/Long-Term Subcriticality	• Low Leak RCP Seals and/or borated high pressure RCS makeup required	• Site analysis required to determine RCS makeup requirements • Boration and/or letdown path may be required	Extended coping without RCS makeup is not possible without minimal RCS leakage. Plants must evaluate use of low leak RCP seals and/or providing a high pressure RCS makeup pump.	• Makeup capability to maintain core cooling*. • Sufficient letdown to support required makeup and ensure subcriticality*.
	Core Cooling and Heat Removal (Modes 5 and 6 with steam generators not available)	• All Plants Provide Means to Provide Borated RCS Makeup **	• Diverse makeup connections to RCS for long-term RCS makeup and residual heat removal to vented RCS	Long-term sustained coping will require RCS makeup and boration.	• Diverse injection points or methods are required to establish capability to inject through separate divisions/trains, i.e., should not have both connections in one division/train. • Connection to RCS for makeup should be capable of flow rates sufficient for simultaneous core heat removal and boron

*Note: Items are subject to generic or plant-specific analysis
** Note: There may be short periods of time during Modes 5 & 6 where plant configuration may preclude use of this strategy.

Table D-1
Summary of Performance Attributes for PWR Core Cooling Functions

Safety Function		Method	Baseline Capability	Purpose	Performance Attributes
					flushing (combined makeup flow exceeding 300* gpm). • On-site pump (portable or installed) for RCS makeup. This can be the SG makeup pump since both will not be required at same time. • In order to address the requirement for diversity, if re-powering of installed charging pumps is used for this function, then either (a) multiple power connection points should be provided to the charging pump, or (b) provide a single power supply connection point for the charging pump and a single connection point for a portable makeup pump.
			• Source of borated water required	A source of borated water will be required to	• Could be an on-site tank, or could be

Table D-1
Summary of Performance Attributes for PWR Core Cooling Functions

Safety Function		Method	Baseline Capability	Purpose	Performance Attributes
				support RCS makeup.	provided by off-site resources.
	Key Reactor Parameters	• SG Level	• (Re-)Powered instruments	Necessary to control heat removal.	• Identify instruments to be relied upon, including control room and field instruments • Depending on strategy employed, additional parameters may be required.
		• SG Pressure		Necessary to support transition to portable pump	
		• RCS Pressure		Necessary to assure depressurization to gain access to inventory for RCS makeup in safety injection accumulators	
		• RCS Temperature		Necessary to monitor subcooling.	

*Note: Items are subject to generic or plant-specific analysis
** Note: There may be short periods of time during Modes 5 & 6 where plant configuration may preclude use of this strategy.

Table D-2
Summary of Performance Attributes for PWR Containment Function

Safety Function		Method	Baseline Capability	Purpose	Performance Attributes
Containment	Containment Function	• Containment Spray	• Connection to containment spray header or alternate capability or Analysis	In the long-term containment pressure may rise due to leakage from RCS adding heat to containment. Containment spray can help manage containment pressure.	• Due to the long-term nature of this function, the connection does not need to be a permanent modification. However, if a temporary connection, e.g., via valve bonnet, then this should be pre-identified.
	Containment Integrity (Ice Condenser Containments Only)	• Hydrogen igniters	• Re-powering of hydrogen igniters with a portable power supply.	Maintain containment integrity post-core damage	• Diverse power connection points are required to establish capability through separate divisions/trains, i.e., should not have both connections in one division/train. • Procedures/guidance to prioritize deployment strategies.
	Key Containment Parameters	• Containment Pressure	• (Re-)Powered instruments	Monitor long-term pressure buildup in containment.	• Identify instruments to be relied upon, including control room and field instruments

Table D-3
Summary of Performance Attributes for PWR SFP Cooling Functions

Safety Function		Method	Baseline Capability	Purpose	Performance Attributes
SFP Cooling	Spent Fuel Cooling	• Makeup with Portable Injection Source	• Makeup via hoses on refuel floor	Exceed SFP boil-off to support long-term cooling of spent fuel with sufficient makeup	• Minimum makeup rate must be capable of exceeding boil-off rate for the boundary conditions described in Section 3.2.1.6.
			• Makeup via connection to SFP cooling piping or other alternate location	Exceed SFP boil-off and provide a means to supply SFP makeup without accessing the refueling floor.	• Minimum makeup rate must be capable of exceeding boil-off rate for the boundary conditions described in Section 3.2.1.6.
			• Vent pathway for steam & condensate from SFP	Steam from boiling pool can condense and cause access and equipment problems in other parts of plant.	• Plant-specific strategy should be considered as needed
			• Spray capability via portable monitor nozzles from refueling floor using portable pump	Provide spent fuel cooling when makeup rate is not sufficient.	• Minimum of 200 gpm per unit to the pool or 250 gpm per unit if overspray occurs consistent with 10 CFR 50.54(hh)(2). • This capability is not required for sites that

*Note: Items are subject to generic or plant-specific analysis
** Note: There may be short periods of time during Modes 5 & 6 where plant configuration may preclude use of this strategy.

Table D-3
Summary of Performance Attributes for PWR SFP Cooling Functions

					have SFPs that cannot be drained.
	SFP Parameters	• SFP Level	• Reliable means to determine SFP water level to prevent undue distraction of operators and identify conditions when makeup/spray is required per Order EA 12-051	Confirm SFP level is adequate to provide cooling or direct use of spray.	• Per EA 12-051

APPENDIX E
NOT USED

APPENDIX F
GUIDANCE FOR AP1000 DESIGN

F.1 Introduction

The purpose of this Appendix is to outline, using the framework defined in Sections 1.0 to 13.0 and adapting to the AP1000 design features as necessary, the process to be used by AP1000 COL Holders and Applicants to define and implement site-specific diverse and flexible mitigation strategies that reduce the impact associated with beyond-design-basis conditions resulting from an extended loss of ac power.

By nature of the passive safety approach and its licensing basis, AP1000 is designed to provide a significant coping period for a station blackout. The strengths of the design approach for mitigation of extended loss of ac power events are acknowledged in the NRC Order for AP1000 COL holders (the main body being provided in Table 1-2 of this document), which clarifies that "*this Order requires [AP1000 COL] to address the following requirements relative to the final phase*". Hence, the focus on this guidance is to define the required review of the AP1000 design relative to the transition from passive systems operation and their initial coping capabilities (i.e., 72 hr.), to indefinite, long term operation of the passive cooling systems with support using off-site equipment and resources.

The principles identified in this appendix thus discuss the extension of the passive systems operation indefinitely during an extended loss of ac power (ELAP) and the loss of ultimate heat sink makeup (LUHS). These principals have been applied during the design and development of the AP1000 and thus, the extended coping strategies are accomplished with existing passive safety and coping systems within the standard design utilizing existing connection points for FLEX equipment. Specifically, coping with extended loss of ac power in the AP1000 is covered by design and by post-72 hour procedures described in Section 1.9.5.4 of the AP1000 Design Control Document (DCD), Revision 19.

The use of passive systems with their extended coping times is an important difference because whereas active plants are expected to show primary and diverse connection points for maintaining core cooling, AP1000 core cooling is maintained by the passive safety systems without reliance on ac power. The passive safety systems, however, should have the ability to have their operation extended indefinitely. The standard design licensing basis demonstrates safety-related means of providing core cooling, containment cooling, and SFP cooling for at least 72 hours. The standard design also demonstrates primary and alternate means of extending passive safety system cooling indefinitely as part of the baseline capability assessment as described in Section 1.9.5.4 of the Design Control Document (DCD), Revision 19.

The assessment of the AP1000 design is expected to be the same as for the site specific evaluation and is documented by this process:

Step 1: Establish standard design baseline coping capability considering design basis hazards.

Step 2: Apply beyond-design-basis (BDB) external hazards and perform margin assessment, and confirm the capability to extend core, containment and spent fuel pool cooling also under beyond-design-basis conditions.

Step 3: Identify any enhancements to baseline capability to address BDB scenarios, if applicable.

Whereas a site-specific evaluation can screen out and screen in applicable extreme hazards, the assessment defined in this Appendix evaluates beyond-design-basis seismic and flooding hazards as part of margin assessments, to evaluate the strength of the design basis against a threshold effect. For the flooding margin assessment, the approach considers two site-specific outcomes based on the amount of margin between the site-specific maximum probable flooding level and the standard AP1000 design basis flooding level; Section F.6 describes this approach.

F.2 Overview and Implementation Process

This appendix (F) incorporates the entirety of Section 2.0 of this document. Specifically, the process outlined in Figure 2-1 also provides the framework for the assessment of the AP1000.

F.3 Step 1: Establishing Baseline Coping Capability

For the AP1000, the underlying strategies for coping with extended loss of ac power events involve a three phase approach:

1) Initial coping is through installed plant equipment, without any ac power or makeup to the UHS. For the AP1000, as discussed in EA-012-049 and Table 1-2, this phase is already covered by the existing licensing basis and is not discussed further herein. This covers the 0 to 72-hours basis for passive systems performance for core, containment and spent fuel pool cooling.
2) Following the 72-hour passive system coping time, support is required to continue passive system cooling. This support can be provided by installed plant ancillary equipment or by off-site equipment installed to connections provided in the AP1000 design. The installed ancillary equipment is capable of supporting passive system cooling from 3 to 7 days.
3) In order to extend the passive system cooling time to beyond 7 days (to an indefinite time) some off-site assistance is required. As a minimum, this would include delivery of diesel fuel oil. As requested by EA-012-049 and Table 1-2, the rest of this guidance focuses on the off-site FLEX equipment and its definition, protection and deployment. General Criteria and Baseline assumptions consistent with Section 3.2.1 will be used for the AP1000 assessment

For AP1000, it is recognized that strategies for dealing with ELAP, LOOP, SBO, and LUHS are significantly different due to the passive nature of the plant design. As discussed in previous sections, the fundamental difference is in the significantly longer coping period available before FLEX equipment may be required (i.e. at least 72 hours) and in the reduced size and number of this equipment. Thus, many of the strategies detailed in Section 3.2 are not required for the

AP1000. The AP1000 will demonstrate the capability to meet the functional requirements of Section 3.2, even though the employed strategies will generally be different.

F.3.1 Performance Attributes

This baseline coping capability is built upon strategies that focus on an ELAP condition caused by design basis hazard events. The baseline assumptions have been established on the presumption that other than the loss of the ac power sources, equipment that is protected and designed to withstand design basis natural phenomena is assumed to be fully available. The baseline assumptions are provided in Section 3.2.1, and will be used for the assessment of indefinite extension of passive systems cooling.

F.3.2 Qualification of Installed Equipment

Equipment relied upon to support FLEX implementation does not need to be qualified to all extreme environments that may be posed, but some basis should be provided for the capability of that equipment to remain functional or to be easily repaired. Appendix G of Reference 8 contains information that may be useful in this regard.

Equipment that is stored far enough from the site such that it would not be subjected to the hazard that affected the site need not be designed or qualified for any of the assumed hazards. In addition, the storage arrangements (building, etc.) would not be required to have any hazard capability. Since AP1000 has a 72-hour passive system coping time, there is significant time to transport equipment from off-site. Use of more than one storage location is not necessary as long as the storage site is far enough away from the site(s) such that the same extreme hazard could not affect both the plant(s) and the storage location. In this way, the storage location would not be required to be built to nuclear safety standards for hazard protection. This approach is reasonable considering the small number and size of the equipment needed for AP1000 long term passive system cooling, and the significant coping period provided by the AP1000 before the equipment would be needed.

Table F.3.2-1 summarizes the AP1000 baseline coping capability and a list of FLEX equipment that should be provided.

Table F.3.2-1

AP1000 Preliminary FLEX Capability Summary

Safety Function		Method	Baseline Capability	FLEX Equipment
Core Cooling	Core cooling	- PRHR HX	- PRHR HX provides long-term cooling	- None
			- ADS and IRWST actuation provides long-term passive cooling alternate	- None
	RCS inventory / boration	- CMT water / boron makeup - Canned RCPs	- CMTs provide long-term water / boron makeup	- None
			- ADS and IRWST actuation provides long-term passive makeup alternate	- None
	RCS instruments	-Class 1E PAMS(4)	- 72 hr. batteries with on- or off-site DGs afterwards	- Shared equipment, see Support - Electrical Power
Containment	Pressure / temp control	- PCS	- Provides cooling for 72 hr.	- None
			- Use Ancillary Tank for next 4 days or off-site equipment as alternate	- Off-site self-powered pump & alt. water supply(1)
	Cont. instruments	- Class 1E PAMS (4)	- 72 hr. batteries with on- or off-site DGs afterwards	- Shared equipment, see Support – Electrical Power
SF Cooling	SF cooling	- Initial inventory & Ancillary makeup.	- Initial inventory provides 72 hr.	- None
			- Use Ancillary Tank for next 4 days or off-site equipment as alternate	- Shared equipment, see Containment
	SFP instruments	- Class 1E PAMS (4,5)	- 3 S/R level transmitters each powered by 72 hr. batteries	- None
			- After 72 hr. power from on- or off-site DGs	- Shared equipment, see Support – Electrical Power
Support	Electrical power	- 1E batteries	- Provides 72 hr. indication	- None
			- After 72 hr. power from on- or off-site DGs	- Off-site electrical generator(2)
	Other support	- Communications	- as needed after 72 hr.	- None
		- Hoses, couplings, tools	- as needed after 72 hr.	- Off-site hoses, couplings
		- Delivery of fuel oil - Makeup water(3)	- Needed after 7 days for on- or off-site DGs - Needed for makeup to passive systems(3)	- Fuel oil - Makeup water(3)

Notes:

1. FLEX self-powered pump – one pump is required to provide makeup to the PCS and SFP. A capability of 135 gpm and 273 ft. head is sufficient.
2. FLEX electrical generator – one generator is required to provide post-accident monitoring and emergency lighting. A capacity of 15 kW and 480 volts is sufficient assuming that the FLEX pump is self-powered. Note that multiple connection points (see Section F.12) are provided such that portable instrumentation is not necessary.

3. Off-site makeup water is only required if on-site makeup water is not available.
4. The post-accident monitoring system (PAMS) class 1E instrumentation provides the monitoring of these functions. This instrumentation is powered for the first 72 hours by the safety-related batteries and is powered thereafter by on-site or off-site (i.e., FLEX) diesels for indefinite coping. Note that there are multiple connection points (see Section F.12) for the FLEX electrical generator such that portable instrumentation is not necessary. This instrumentation includes the following:

Instrumentation	Function
Neutron flux	Reactivity control
RCS wide range pressure	RCS integrity, core cooling
RCS wide range Thot	RCS integrity, core cooling
Containment water level	RCS integrity
Containment pressure	RCS integrity, containment
Pressurizer level	RCS inventory
Hot Leg level	RCS inventory
Core exit temperature	Core cooling
PRHR flow	Heat sink
PRHR outlet temperature	Heat sink
PCS water storage tank level	Heat sink
PCS water flow rate	Heat sink
Spent fuel pool level (see note 5)	Spent fuel cooling

5. Refer to NEI 12-02, Industry Guidance for Compliance with NRC Order EA-12-051, "To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation", Appendix A-4 for AP1000 guidance

F.4 Step 2: Determine Applicable Extreme External Hazards

In Step 2 for AP1000, the approach is to perform a generic assessment of the capability of a standard plant design licensed under 10 CFR 52. This appendix details an alternative approach from that indicated in Sections 4.1 and 4.2, which is based on the concept of evaluating the design to a specified beyond design basis, review level hazard to verify the robustness of the design against threshold effects. This approach allows for a one time standard assessment, review, and approval of mitigating strategies for all AP1000 plants.

F.5 Step 2A: Standard Design Seismic Impact Assessment

For the AP1000 standard design, the Seismic Margin Assessment (SMA) demonstrates the robustness of the passive safety systems and the associated structures to beyond-design-basis conditions and is already included in the AP1000 licensing basis for design certification.

For the survivability and deployment of the FLEX equipment, if the equipment is stored sufficient distance from the site such that it would not reasonably be subject to the same seismic hazard, it would not need to be stored in a nuclear seismic building and would be expected to be operational following the 72-hour coping period for AP1000 as described in Section F.3.2.

F.6 Step 2B: Standard Design External Flooding Margin Assessment

The AP1000 design basis (see Table 2-1, Site Parameters, of the AP1000 site-specific [Final

Safety Analysis Report] FSAR) demonstrates the wide range of extreme environmental conditions covered by the design. Because of the conservatisms that are incorporated into the selection of these site environmental conditions, they are expected to bound extreme site-specific values.

For the indefinite extension of the passive system coping time, the environmental condition should be assessed, consistent with the plant licensing basis, to verify the capability of the FLEX equipment to perform its mission to extend the coping time indefinitely under this range of conditions. In general, FLEX equipment, as described in Section F.3.2, may be stored at a sufficient distance from the site such that it would not reasonably be subject to the same external hazard and would therefore be expected to be available following the 72-hour coping period for AP1000. However, appropriate conditions will need to be defined to ensure the FLEX equipment, once deployed, will maintain its operability over the appropriate range of external conditions considering the site conditions that may exist 72 hours after the initial event.

Considering the deployment, procedural interfaces, and off-site resources for FLEX equipment,

Sections 6.2.3.2 – 6.2.3.4 are incorporated in their entirety into this Appendix. This ensures that the AP1000 FLEX equipment is designed to function under the extreme conditions of external flooding.

F.7 Step 2C: Assess Impact of Severe Storms with High Winds

See considerations provided for Section F.6.

Considering the deployment, procedural interfaces, and off-site resources for FLEX equipment, Sections 7.3.2 – 7.3.4 are incorporated in their entirety into this Appendix. This ensures that the AP1000 FLEX equipment is designed to function under the extreme conditions of severe storms with high winds.

F.8 Step 2D: Assess Impact of Snow, Ice, and Extreme Cold

See considerations provided for Section F.6.

Considering the deployment, procedural interfaces, and off-site resources for FLEX equipment, Sections 8.3.2 – 8.3.4 are incorporated in their entirety into this Appendix. This ensures that the AP1000 FLEX equipment is designed to function under the extreme conditions of snow, ice, and extreme cold.

F.9 Step 2E: Assess Impact of High Temperatures

See considerations provided for Section F.6.

Considering the deployment, procedural interfaces, and off-site resources for FLEX equipment, Sections 9.3.2 – 9.3.4 are incorporated in their entirety into this Appendix. This ensures that the AP1000 FLEX equipment is designed to function under the extreme conditions of high temperatures.

F.10 Step 3: Define Site-Specific FLEX Capabilities

This Appendix (F) replaces the entirety of Section 10.0 of this document. Note that considering the extended AP1000 coping capabilities and the limited amount of equipment required, the AP1000 FLEX equipment shall be stored at a sufficient distance from the site such that it would not reasonably be subject to the same external hazard and would therefore be expected to be available following the 72-hour coping period for AP1000.

F.11 Programmatic Controls

The AP1000 design has a graded QA approach; the QA applied to non-safety-related equipment with short-term availability controls (DCD Table 17-1) will be applied to the AP1000 FLEX equipment. Because of the differences in the AP1000 design vs. operating plants, the use of installed ancillary equipment and off-site equipment is utilized in the plant design basis and operation of this equipment has been integrated into the plant procedures. AP1000 has a graded approach to availability and testing as shown in DCD Section 16.3. This graded approach will be applied to the FLEX equipment. The FLEX equipment will be maintained in accordance with Section 11.5 of this document.

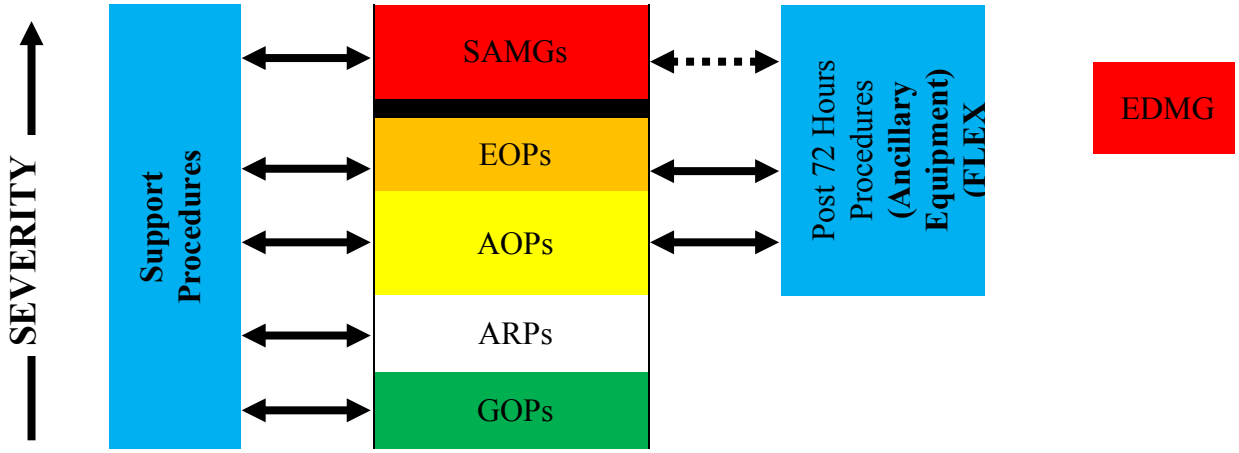
F.11.1 Post-72 Hours Procedures

The AP1000 design and licensing basis as described in AP1000 DCD Section 1.9.5.4 already provides a set of procedures (referred to as “Post-72 Hour Procedures”) which address the actions that would be necessary 72 hours subsequent to an extended loss of all ac power (extended SBO) to maintain core, containment, and SFP cooling for an indefinite period of time.

The post-72 hour procedures and their relationship to other procedures and guidelines should be reviewed to confirm integration with the FLEX guidance provided in the previous sections, including consideration of capability for beyond-design-basis external events as discussed in previous sections. Figure F.11.1 depicts the relationship of the Post-72 Hour Procedures to other plant procedures.

Figure F.11-1

View of AP1000 Operating Procedure Hierarchy



F.12 Off-site Response

This Appendix (F) incorporates the entirety of Section 12.0 of this document. Note that the AP1000 only requires a few, small pieces of FLEX equipment. Table F.3.2-1 defines the AP1000 FLEX equipment. In addition, it is not required for at least 72 hours because of the large passive system coping time.

The off-site response entity will provide the equipment with the specified standard mechanical and electrical connections as follows (It is noted that these are safety-related, seismically qualified connections for FLEX equipment. Other non-safety-related means for makeup and power are also available. Single point vulnerabilities in the connection of FLEX equipment will be considered and evaluated):

a. The safety-related flange located in the yard connected to the Passive Containment Cooling System, which allows makeup to the SFP and to the Passive Containment Cooling Water Storage tank, is fitted with a 4" standard fire nozzle fitting per local fire regulations.

b. The IDS voltage-regulating transformers B & C provide a safety-related 480V connection point for power for post-accident monitoring, MCR lighting, MCR and I&C rooms B & C ventilation from the FLEX diesel generator.

F.13 Submittal Guidance

This Appendix (F) incorporates the entirety of Section 13.0 of this document.

F.14 References

This Appendix (F) incorporates the entirety of Section 14.0 of this document.

APPENDIX G
GUIDANCE FOR U.S. EPR™ DESIGN

Guidance for coping with an extended loss of ac power and loss of normal access to the UHS as a result of a beyond-design-basis external event will be developed at a later date.