NLS2017092

ATTACHMENT 2

Mitigating Strategies Assessment for Flooding, Revision 1 - Cooper Nuclear Station

Cooper Nuclear Station, Docket No. 50-298, DPR-46

(Redacted)

Mitigating Strategies Assessment for Flooding, Revision 1
Cooper Nuclear Station

List of Acronyms:

AC	Alternating Current
AMS	Alternative Hazard Mitigating Strategy
BDB	Beyond-Design-Basis
BWR	Boiling Water Reactor
CNS	Cooper Nuclear Station
DAM	Dam Accident Mitigation
DAMS	Dam Accident Mitigation System
DB	Design Basis
DC	Direct Current
DBA	Design Basis Accident
EOF	Emergency Operations Facility
EOP	Emergency Operating Procedure
ERO	Emergency Response Organization
EDG	Emergency Diesel Generator
ELAP	Extended Loss of AC Power
FHRR	Flood Hazard Reevaluation Report
FIP	Final Integrated Plan
FLEX	Diverse and Flexible Coping Strategies
FSB	FLEX Storage Building
FSG	FLEX Support Guide
HP	Horsepower
LIP	Local Intense Precipitation
LOCA	Loss of Coolant Accident
LOLA	Loss of Large Areas
LOOP	Loss of Off-site Power
LUHS	Loss of Ultimate Heat Sink
MSA	Mitigating Strategies Assessment
MSFHI	Mitigating Strategies Flood Hazard Information
MSL	Mean Sea Level
N/A	Not Applicable
NAVD88	North American Vertical Datum of 1988 Elevation
NEI	Nuclear Energy Institute
NGVD29	National Geodetic Vertical Datum of 1929 Elevation
NICDB	Not Included in Current Design Basis
NPPD	Nebraska Public Power District
NRC	Nuclear Regulatory Commission
NSRC	National SAFER Response Centers
NTTF	Near-Term Task Force
OTR	Over-the-Road
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
RB	Reactor Building
RCIC	Reactor Core Isolation Cooling
RPV	Reactor Pressure Vessel

SAFER	Strategic Alliance for FLEX Emergency Response
SAMG	Severe Accident Management Guideline
SAT	Systems Approach to Training
SBO	Station Blackout
SDC	Shutdown Cooling
SFP	Spent Fuel Pool
SSC	System, Structure, Component
THMS	Targeted Hazard Mitigating Strategy
TSC	Technical Support Center
UHS	Ultimate Heat Sink
USACE	U.S. Army Corps of Engineers
USAR	Updated Safety Analysis Report
WSEL	Water Surface Elevation

On March 12, 2012, the NRC issued Reference 1 to request information associated with NTTF Recommendation 2.1 for Flooding. One of the Required Responses in Reference 1 directed licensees to submit a FHRR. For CNS, the FHRR was submitted on February 3, 2015 (Reference 2). The reevaluated flood hazard was further developed in response to requests for additional information (References 3, 4 and 5) and a white paper was developed to describe how NPPD would evaluate the remaining dam failure scenarios (Reference 6). A final revised FHRR was submitted on September 29, 2016 (Reference 7). Per Reference 12, the NRC considers the reevaluated flood hazard to be "beyond the current design/licensing basis of operating plants."

Concurrent to the flood hazard reevaluation, CNS developed and implemented mitigating strategies in accordance with NRC Order EA-12-049, "Requirements for Mitigation Strategies for Beyond-Design-Basis External Events." In Reference 8, the Commission affirmed that licensees need to address the reevaluated flooding hazards within their mitigating strategies for BDB external events, including the reevaluated flood hazards. Guidance for performing MSAs is contained in Appendix G of Reference 11, endorsed by the NRC (with conditions) in Reference 10. For the purpose of the MSAs, the NRC has termed the reevaluated flood hazard, summarized in Reference 9, as the "Mitigating Strategies Flood Hazard Information." Reference 11, Appendix G, describes the MSA for flooding as containing the following elements:

- Section G.2 – Characterization of the MSFHI
- Section G.3 – Comparison of the MSFHI and FLEX DB Flood
- Section G.4.1 – Assessment of Current FLEX Strategies (if necessary)
- Section G.4.2 – Assessment for Modifying FLEX Strategies (if necessary)
- Section G.4.3 – Assessment of Alternative Mitigating Strategies (if necessary)
- Section G.4.4 – Assessment of Targeted Hazard Mitigating Strategies (if necessary)

The following provides the MSA results for CNS.

1. Documentation

1.1 NEI 12-06, Rev. 2, Section G.2 – Characterization of the MSFHI

Characterization of the MSFHI is summarized in Table 1 of Reference 9; the NRC's interim response to the FHRR (Reference 2) and amended submittals (References 3, 4 and 5). Additionally, Reference 9 requested CNS to perform additional 2D TUFLOW analyses for several other dam failure scenarios and to develop flood event duration parameters and applicable associated effects to conduct the MSA. A white paper was developed to describe the revised evaluation (Reference 6). A more detailed description of the MSFHI, along with the basis for inputs, assumptions, methodologies, and models, is provided in the following references:

- Local Intense Precipitation: See Section 2.1 of Reference 7, Attachment 1.
- Flooding in Streams and Rivers: See Section 2.2 of Reference 7, Attachment 1.
- Dam Breaches and Failures: See Section 2.3 of Reference 7, Attachment 1.
- Storm Surge: See Section 2.4 of Reference 7, Attachment 1.
- Seiches: See Section 2.5 of Reference 7, Attachment 1.
- Tsunami: See Section 2.6 of Reference 7, Attachment 1.
- Ice-Induced Flooding: See Section 2.7 of Reference 7, Attachment 1.
- Channel Migration or Diversion: See Section 2.8 of Reference 7, Attachment 1.
- Combined Effects (including wind-waves and runup effects): See Section 2.9 of Reference 7, Attachment 1, and References 3 and 4.
- Other Associated Effects (i.e., hydrodynamic loading, including debris; effects caused by sediment deposition and erosion; concurrent site conditions; and groundwater ingress): See Sections 3.10 of Reference 7, Attachment 1, and References 3 and 4.
- Flood Event Duration Parameters (i.e., warning time, period of site preparation, period of inundation, and period of recession): See Sections 3.10 of Reference 7, Attachment 1, and References 3 and 4.

In Reference 9, the NRC concluded that the "reevaluated flood hazards information [i.e., MSFHI], as summarized in the Enclosure [Summary Tables of the Reevaluated Flood Hazard Levels], is suitable for the assessment of mitigating strategies developed in response to Order EA-12-049" for CNS.

In Reference 9, the NRC summarized in the Enclosure [Summary Tables of the Reevaluated Flood Hazard Levels, Table 2] the flood causing mechanisms that were not bounded by the current design basis:

- Local Intense Precipitation
- Streams and Rivers
- Failure of Dams and Onsite water Control/Storage Structures
- Ice-induced Flooding
- Channel Migration/Diversion

1.2 NEI 12-06, Rev. 2, Section G.3 – Comparison of the MSFHI and FLEX DB Flood

External Flood Hazard Assessment from the FLEX FIP (Reference 13):

> *Per USAR Section II-4, the design basis flood is a value of 903.0 Mean Sea Level (MSL) for the Probable Maximum Flood (PMF). The general ground elevation surrounding CNS Class I Structures is elevated 13 feet above the natural floodplain to 903 feet MSL. The finished floor elevation of all Class I Structures is placed at elevation 903.5 feet MSL, or 1/2 feet above the PMF event. These structures were designed for a hydraulic load equivalent to a groundwater elevation of 903 feet. The station site grade level of 903 feet MSL has been raised 13 feet above the natural grade level of 890 feet MSL, in order to bring final grade one foot above the existing 902 feet MSL levee constructed by the Corps of Engineers. This levee was raised above its original design level and presently has a three foot minimum free board over the 1952 flood of record (899 feet MSL).*
>
> *Per Reference 11, the site is considered a "dry" site, i.e., the plant is built above the design basis flood level and the external flooding hazard need not be considered.*

Based on the above, the FLEX DB flood is equivalent to the current design-basis flood.

As presented in USAR Chapter II, Section 4.2.2.2, the finished floor elevation of SSCs is at 903.5 ft Plant Datum (903.87 ft NAVD88 ~903.9ft) and the general site grade elevation is at 903.0 ft Plant Datum (903.37 ft NAVD88 ~903.4ft).

The vertical datum used was the CNS Plant Datum (MSL). NGVD29 is equal to Plant Datum elevation plus 0.11 ft (Reference 7). NAVD88 is equal to NGVD29 elevation plus 0.26 ft (Reference 7). The NAVD88 elevation is equal to Plant Datum elevation plus 0.37 ft. All directions are with respect to the Plant North direction, which is oriented to the west of the true north direction.

The following tables compare the FLEX DB Flood to the MSFHI for each unbounded flood causing mechanism:

Flood Scenario Parameter Local Intense Precipitation		**FLEX Design Basis Flood Hazard**	**MSFHI**	**Bounded (B) or Not Bounded (NB)**
Flood Level and Associated Effects	1. Max Stillwater Elevation	NICDB	903.9	NB
	2. Max Wave Run-up Elevation	NICDB	N/A	NB
	3. Max Hydrodynamic/Debris Loading (psf)	NICDB	N/A	NB
	4. Effects of Sediment Deposition/Erosion	NICDB	minimal	NB
	5. Concurrent Site Conditions	NICDB	none	NB
	6. Effects on Groundwater	NICDB	none	NB
Flood Event Duration	7. Warning Time (hours)	NICDB	0	NB
	8. Period of Site Preparation (hours)	NICDB	0	NB
	9. Period of Inundation (hours)	NICDB	0	NB
	10. Period of Recession (hours)	NICDB	0	NB
Other	11. Plant Mode of Operations	normal	normal	N/A
	12. Other Factors	none	none	N/A

1. Datum given in NAVD88 (typical). This elevation meets the floor elevation of the plant structures. The analysis method used to determine this WSEL is a conservative 1D approximation of the site.

2. All runoff moves as sheet flow away from the power block. The water is not deep enough for waves.

3. None.

4. USACE Engineering Manual EM 1110-2-1601 recommends a maximum permissible flow velocity of 6.0 fps to prevent erosion of channels with fine-gravel surfacing. The potential for erosion in the main plant area is low, as the velocities do not exceed 6 fps and are generally less than 3 fps. Velocities on the steep slope at the periphery of the main plant area may cause local erosion of the sloped surface, but there would be no effect on safety-related facilities.

5. No concurrent events are assumed to occur with the LIP event.

6. Groundwater would vary normally due to the short duration of the event.

7. No warning time is assumed as no actions need to be taken to protect the plant.

8. No barriers need to be deployed to protect the plant.

9. The plant is raised above the flood plain, and 3/4ths of the vehicle barriers are deployed at the bottom of the island the plant is built allowing water to quickly flow off the site. Aside from isolated patches of standing water, the site will shed all water shortly after the LIP event.

10. The site will shed all water shortly after the LIP event.

11. None. 12. None.

Flood Scenario Parameter Streams and Rivers			FLEX Design Basis Flood Hazard	MSFHI	Bounded (B) or Not Bounded (NB)
Flood Level and Associated Effects	1. Max Stillwater Elevation	Other SSCs	903.4	903.6	NB
		Intake Structure	903.4	903.0	
	2. Max Wave Run-up Elevation	Other SSCs	N/A	904.1	NB
		Intake Structure	N/A	908.4	
	3. Max Hydrodynamic/Debris Loading (psf)		N/A	negligible for main structures; barge impact is similar to previous	NB
	4. Effects of Sediment Deposition/Erosion		N/A	minimal	NB
	5. Concurrent Site Conditions		NICDB	55 mph wind	NB
	6. Effects on Groundwater		NICDB	none	NB
Flood Event Duration	7. Warning Time (hours)		NICDB	3-12 hrs	NB
	8. Period of Site Preparation (hours)		NICDB	3-12 hrs	NB
	9. Period of Inundation (hours)		NICDB	not inundated	NB
	10. Period of Recession (hours)		NICDB	456	NB
Other	11. Plant Mode of Operations		normal	normal	N/A
	12. Other Factors		see below	see below	N/A

1. Elevations given in NAVD88 (typical).

2. None.

3. Power block structures are not affected by debris due to shallow depth. Waves dissipate before reaching the Power block structures.

4. The potential for erosion of the embankments due to wave action was assessed using erosion threshold guidance from the USACE ERDC/CHL TR-10-7 (ERDC/CHL TR-10-7,). Inputs included a safety coefficient, grass quality factor, design wave height (H1%), embankment slope, and duration of waves. The potential maximum erosion depth was calculated to be 0.26 foot. This erosion depth was based on the wave exposure at WEmbN, which is the largest (most conservative) wave height.

5. A wind speed of 55 mph, which represents a 2-year mean recurrence interval at 30 feet above ground, is used to generate the wind driven waves.

6. According to CNS personnel, site groundwater level normally fluctuates between 875 ft MSL to 885 ft MSL with the highest recorded level of 900.8 ft MSL during the May 2011 Missouri River flood event. Floodwaters are assumed to cause a surcharge up to flood level.

7. The trigger point for constructing the first line of Presray flood barriers is the river WSEL being 898 ft MSL or is forecast to be >902 ft MSL within 36 hrs. The 2nd line of flood barriers is at 900 ft MSL and shutdown is at 902 ft MSL. The time to 902 ft MSL is about 150 hrs for the worst case PMP. For a subsequent storm PMP the time is about 3 hrs, though this it is closer to 12 hrs from 895 ft MSL.

8. The trigger point for entering the site flood procedures is a river WSEL of 895 ft MSL. The trigger point for constructing the first line of Presray flood barriers is the river WSEL being 898 ft MSL or is forecast to be >902 ft MSL within 36 hrs. The 2nd line of flood barriers is at 900 ft MSL and shutdown is at 902 ft MSL. The time to 902 ft MSL from 898 ft MSL is about 150 hrs for the worst case PMP. For a subsequent storm PMP the time is about 3 hrs, though this it is closer to 12 hrs from 895 ft MSL.

9. The period of inundation is based off the time between floodwaters rising to site grade (903 ft MSL) until the water drops below site grade. Because the barriers are not challenged by flood waters, the site is not considered inundated.

10. The site may be accessible when floodwaters are below 895 ft MSL, but due to the extreme nature of the flood, the topography may have changed.

11. None.

12. Flood water does not reach the main site buildings and wave action is negligible. A barge could impact the foundation of the intake structure in a similar manner to the current design basis barge impact.

<table>
<tr><th colspan="2">Flood Scenario Parameter
Failure of Dams and Onsite Water Control/Storage Structures</th><th>FLEX Design Basis Flood Hazard</th><th>MSFHI</th><th>Bounded (B) or Not Bounded (NB)</th></tr>
<tr><td rowspan="6">Flood Level and Associated Effects</td><td>1. Max Stillwater Elevation</td><td colspan="3" rowspan="12">[SECURITY-RELATED INFORMATION]</td></tr>
<tr><td>2. Max Wave Run-up Elevation</td></tr>
<tr><td>3. Max Hydrodynamic/Debris Loading (ksf)</td></tr>
<tr><td>4. Effects of Sediment Deposition/Erosion</td></tr>
<tr><td>5. Concurrent Site Conditions</td></tr>
<tr><td>6. Effects on Groundwater</td></tr>
<tr><td rowspan="4">Flood Event Duration</td><td>7. Warning Time (hours)</td></tr>
<tr><td>8. Period of Site Preparation (hours)</td></tr>
<tr><td>9. Period of Inundation (hours)</td></tr>
<tr><td>10. Period of Recession (hours)</td></tr>
<tr><td rowspan="2">Other</td><td>11. Plant Mode of Operations</td></tr>
<tr><td>12. Other Factors</td></tr>
<tr><td colspan="5">1.

2.

3.

4.

[SECURITY-RELATED INFORMATION]

5.

6.</td></tr>
</table>

7.

8.

[SECURITY-RELATED INFORMATION]

9.

10.

11.

12.

Flood Scenario Parameter Ice-induced Flooding		FLEX Design Basis Flood Hazard	MSFHI	Bounded (B) or Not Bounded (NB)
Flood Level and Associated Effects	1. Max Stillwater Elevation	NICDB	896.9	NB
	2. Max Wave Run-up Elevation	NICDB	none	NB
	3. Max Hydrodynamic/Debris Loading (psf)	NICDB	none	NB
	4. Effects of Sediment Deposition/Erosion	NICDB	none	NB
	5. Concurrent Site Conditions	NICDB	normal winter flows	NB
	6. Effects on Groundwater	NICDB	none	NB
Flood Event Duration	7. Warning Time (hours)	NICDB	none	NB
	8. Period of Site Preparation (hours)	NICDB	none	NB
	9. Period of Inundation (hours)	NICDB	none	NB
	10. Period of Recession (hours)	NICDB	none	NB
Other	11. Plant Mode of Operations	normal	normal	N/A
	12. Other Factors	none	none	N/A

1. Datum given in NAVD88 (typical). This WSEL does not exit the river banks, and the plant floor elevation is 7' above this level.
2. None.
3. None.
4. None.
5. Normal cold season mean monthly river flows are added to the breach flow.
6. Site groundwater level normally fluctuates between 875 ft MSL to 885 ft MSL with the highest recorded level of 900.8 ft MSL during the May 2011 Missouri River flood event.
7. No warning time required.
8. No site preparations required.
9. No site inundation occurs.
10. Site does not flood.
11. None.
12. None.

Flood Scenario Parameter **Channel Migration/Diversion**		**FLEX Design Basis Flood Hazard**	**MSFHI**	**Bounded (B) or Not Bounded (NB)**
Flood Level and Associated Effects	1. Max Stillwater Elevation	NICDB	N/A	NB
	2. Max Wave Run-up Elevation	NICDB	N/A	NB
	3. Max Hydrodynamic/Debris Loading (psf)	NICDB	N/A	NB
	4. Effects of Sediment Deposition/Erosion	NICDB	N/A	NB
	5. Concurrent Site Conditions	NICDB	N/A	NB
	6. Effects on Groundwater	NICDB	N/A	NB
Flood Event Duration	7. Warning Time (hours)	NICDB	N/A	NB
	8. Period of Site Preparation (hours)	NICDB	N/A	NB
	9. Period of Inundation (hours)	NICDB	N/A	NB
	10. Period of Recession (hours)	NICDB	N/A	NB
Other	11. Plant Mode of Operations	normal	normal	N/A
	12. Other Factors	none	none	N/A

1. The CNS site is elevated slightly above, and forms part of, the levee system that keeps the Missouri River restrained in its channel and protects the surrounding areas from flooding. Channel migration/diversion cannot cause water levels to rise at the site and is therefore not a flood causing mechanism.
2. None.
3. None.
4. None.
5. None.
6. None.
7. None.
8. None.
9. None.
10. None.
11. None.
12. None.

1.3 NEI 12-06, Rev. 2, Section G.4 – Evaluation of Mitigating Strategies for the MSFHI

1.3.1 NEI 12-06, Rev. 2, Section G.4.1 – Assessment of Current FLEX Strategies

The current CNS FLEX strategies utilize a combination of Phase 1 (RCIC) and Phase 2 (portable pumps and generators) to maintain core cooling, containment and spent fuel pool cooling functions. The FIP (Reference 13) does not specifically list the strategy for a flood condition. CNS will utilize the current flood emergency procedure, 5.1FLOOD, for FLEX DB, MSFSHI and current design basis flood, including flood induced ELAP and LUHS (FLEX) events. This procedure will be initiated upon river level of 895 ft MSL, notification of an upstream dam failure or if river level is forecast to be 902 ft MSL or greater within 36 hours.

1.3.1.1 FLEX viability

a. Local Intense Precipitation - FLEX is viable

1. MSFHI impact on ELAP/LUHS - MSFHI does not result in an ELAP/LUHS as the EDGs remain available since the water level only reaches the floor elevation. Therefore the ELAP/LUHS was assumed to occur at the peak water level. The LIP used in the analysis is the 1-hour, 1-square mile PMP at the CNS site (Reference 7). The CNS FLEX strategy allows one hour for assessment prior to the declaration of the ELAP and start of FLEX. By this time, the water level will have subsided from the peak height.

2. MSFHI impact on screening/evaluation - LIP was not included in the current design basis. The maximum estimated water level due to LIP at CNS is 903.9 ft NAVD88, which is equal to the finished floor elevations for Principal Class 1 Structures and the FSBs. The analysis was performed with the conservative assumption that the local storm drainage system (culverts, ditches, storm sewers, dry wells, etc.) would not be functional during the LIP event. This results in a maximum depth of water six inches above plant grade at the peak.

3. MSFHI impact on storage/deployment - The finished floor of the FSBs is equal to the maximum water level from the LIP. The doors on the FSBs have seals however there may be some small amount of seepage of rainwater through the door at the peak water level. The major pieces of FLEX equipment are pumps, generators and air compressors that are OTR capable, i.e., mounted on trailers and the remaining items in the FSBs are stored on shelves off the floor and will not be impacted by the water. At the time of deployment, water level will have receded from the peak height and will not impact deployment since, as discussed, the FLEX equipment is OTR capable, hoses will be unaffected by the water and cable connections can be positioned above the water level. The small increase in deployment times was judged to not adversely affect the FLEX strategy since margin for uncertainties was included in the validation.

4. MSFHI impact on robustness of plant equipment - Plant equipment is not affected by LIP since the peak water level only reaches the floor elevation and does not inundate the buildings.

5. MSFHI impact on connection point location - Connection points are not affected by LIP since all connections are located inside the Principle Class 1 Structures and are not inundated.

6. MSFHI impact on flood protection features - The flood protection features for LIP are the buildings themselves i.e., walls, and the site drainage system. The site drainage system was conservatively assumed to not be available and due to the relatively short duration of the flooding event and the shallow depth of inundation, the effects of wind-waves were considered negligible. Additionally, debris loading and transportation were also considered negligible in the analysis due to the relatively low velocity and shallow depth of LIP flood waters near CNS safety related facilities, and due to the lack of debris sources in the CNS main plant area.

b. Streams and Rivers - FLEX is viable

1. MSFHI impact on ELAP/LUHS - MSFHI does not result in an ELAP/LUHS as the EDGs remain available. Therefore the ELAP/LUHS was assumed to occur at the peak water level.

2. MSFHI impact on screening/evaluation - The MSFHI results in a water level that is higher than the FLEX DB water level of 903.4 ft NAVD88. The maximum stillwater elevation due to flooding in streams and rivers is 903.6 ft NAVD88 plus an additional 0.5 ft for waves/runup for a reevaluated hazard elevation of 904.1 ft NAVD88. This results in a standing water depth of 2.4 inches with an additional 6 inches due to waves.

3. MSFHI impact on storage/deployment - The finished floor of the FSBs at 903.9 ft NAVD88 are above the maximum stillwater level from MSFHI, however the wave/runup level is slightly above the finished floor level. The doors on the FSBs have seals however there may be some small amount of leakage of water through the door from waves/runup. The major pieces of FLEX equipment are pumps, generators and air compressors that are OTR capable, i.e., mounted on trailers and the remaining items in the FSBs are stored on shelves off the floor and will not be impacted by the water. Procedure 5.1FLOOD will be entered when river level reaches 895 ft MSL or is projected to reach 902 ft MSL in the next 36 hours. This will allow actions to be taken prior to exceeding the FLEX DB water level.

4. MSFHI impact on robustness of plant equipment - Plant equipment relied on for the FLEX strategies is not affected since Procedure 5.1FLOOD directs installation of temporary flood barriers that provide protection of plant equipment up to a water level of 906.4 ft NAVD88.

5. MSFHI impact on connection point location - Plant connection points are also not affected since Procedure 5.1FLOOD directs installation of temporary flood barriers that provide protection of plant equipment up to a water level of 906.4 ft NAVD88.

6. MSFHI impact on flood protection features - The flood protection features for this event are the temporary flood barriers that are directed to be installed by Procedure 5.1FLOOD. These barriers are designed for a water level of 906.4 ft NAVD88 which is higher than the MSFHI water level.

c. Failure of Dams and Onsite Water Control/Storage Structures - FLEX is not viable

1. MSFHI impact on ELAP/LUHS - MSFHI does result in an ELAP/LUHS as the bounding scenario exceeds the protection level provided by the temporary flood barriers and renders off-site power and the EDGs unavailable.

2. MSFHI impact on screening/evaluation - In Reference 6, NPPD submitted the rationale for and described the bounding scenario to be used in this MSA for evaluation of upstream dam failures. This bounding scenario exceeds the FLEX DB.

3. MSFHI impact on storage/deployment - MSFHI results in a water level that inundates the site, the FSBs and the deployment paths.

4. MSFHI impact on robustness of plant equipment - MSFHI results in a water level that exceeds the protection level provided by the flood protection features (temporary flood barriers) resulting in an inundation of the interior of the plant and plant equipment.

5. MSFHI impact on connection point location - MSFHI results in a water level that exceeds the protection level provided by the flood protection features (temporary flood barriers) resulting in an inundation of the interior of the plant and plant equipment and unavailability of the connection points.

6. MSFHI impact on flood protection features - MSFHI results in a water level that exceeds the protection level provided by the flood protection features (temporary flood barriers) resulting in an inundation of the interior of the plant and plant equipment.

d. Ice-induced Flooding - FLEX is viable

1. MSFHI impact on ELAP/LUHS - MSFHI does not result in an ELAP/LUHS as the EDGs remain available since the water level does not rise above site grade. Therefore, the ELAP/LUHS was assumed to occur at the peak water level.

2. MSFHI impact on screening/evaluation - The MSFHI results in a water level that is lower than site grade of 903.4 ft NAVD88. The maximum stillwater elevation due to ice-induced flooding is 896.9 ft NAVD88.

3. MSFHI impact on storage/deployment - MSFHI water level is below the site grade, therefore there is no impact on storage/deployment.

4. MSFHI impact on robustness of plant equipment - MSFHI water level is below the site grade, therefore there is no impact on robustness of plant equipment.

5. MSFHI impact on connection point location - MSFHI water level is below the site grade, therefore there is no impact on connection point location.

6. MSFHI impact on flood protection features - MSFHI water level is below the site grade, therefore there is no impact on flood protection features.

e. Channel Migration/Diversion - FLEX is viable. The CNS site is elevated slightly above, and forms part of, the levee system that keeps the Missouri River restrained in its channel and protects the surrounding areas from flooding. Channel migration/diversion cannot cause water levels to rise at the site and is therefore not a flood causing mechanism.

1. MSFHI impact on ELAP/LUHS - N/A, not a flood causing mechanism.

2. MSFHI impact on screening/evaluation - N/A, not a flood causing mechanism.

3. MSFHI impact on storage/deployment - N/A, not a flood causing mechanism.

4. MSFHI impact on robustness of plant equipment - N/A, not a flood causing mechanism.
5. MSFHI impact on connection point location - N/A, not a flood causing mechanism.
6. MSFHI impact on flood protection features - N/A, not a flood causing mechanism.

1.3.2 Section G.4.2 – Assessment for Modifying FLEX Strategies

For the remaining flood causing mechanism that FLEX is not viable for, upstream dam failure, the severe inundation of the site makes modifying the existing FLEX Strategies not practical without extensive modifications to plant SSCs and flood protection features.

1.3.3 Section G.4.3 – Assessment of Alternative Mitigating Strategies

For the remaining flood causing mechanism that FLEX is not viable for, upstream dam failure, the severe inundation of the site makes modifying the existing FLEX Strategies not practical without extensive modifications to plant SSCs and flood protection features.

1.3.4 Section G.4.4 – Assessment of Targeted Hazard Mitigating Strategies

For the remaining flood causing mechanism that FLEX is not viable for, upstream dam failure, the severe inundation of the site makes opening the containment and placing cooling equipment on rooftops and above flood levels the only practical option.

1.4 Conclusions

The current FLEX strategies were developed using the DB flood information per CNS USAR Section II-4. The new MSFHI is higher and therefore, the MSFHI is not bounded by the FLEX DB. The containment function will not be maintained and therefore a targeted mitigation strategy will be utilized. The river height of this flood will require the unit to be shut down and cooled down to < 212°F. This will also require opening the containment and flooding the reactor and reactor cavity to maintain cold shutdown. Because of not fully maintaining the containment function, a THMS is required.

The following summarizes all the applicable flooding hazards at CNS and the status of FLEX for each:

- LIP – FLEX works as designed
- Streams and Rivers - FLEX works as designed
- Failure of Dams and Onsite Water Control/Storage Structures - FLEX does not work as designed, the containment needs to be opened to implement a THMS
- Ice-induced Flooding - FLEX works as designed
- Channel Migration/Diversion - FLEX works as designed

2. A detailed description of the THMS:

2.1 Maintain Core and Spent Fuel Pool Covered:

In the event of significant dam breaches or spillway gate openings upstream of CNS and the resulting inundation of the Missouri River valley/flood plain; a new temporary water makeup system will be provided to maintain the SFP and reactor cavity water level above the top of fuel in the SFP; with river levels up to the reevaluated hazard levels. This procedure provides instructions for coordinating the water makeup system installation and subsequent operation. Actual installation, assembly, and operation will be governed by an engineering evaluation, procedures, and instructions. Note that this event is considered to be beyond the CNS design basis. Installation/operation of this water makeup system will require the following general plant conditions:

- MODE 5 with RPV head removed.
- Dryer and Moisture Separator remain in RPV.
- Reactor cavity and dryer separator pool flood up.
- Fuel Pool gates removed.
- Shutdown of all other plant systems, including all AC power sources.

This water makeup system, referred to as the Dam Accident Mitigation System, is comprised of two redundant trains. These trains contain a submersible pump, booster pump, and filter that operate to replenish the water level in the Reactor cavity and SFP.

Hose routing for the DAMS will start from submersible pumps within the Torus or Torus area and proceed up to the 903'-6" NW corner of the Reactor Building. The routing will continue up the NW stairwell to 958'-3" supplying water to the booster pumps. The discharge of the booster pumps will then be routed through a filter and up the NW stairwell to the 1001'-0" elevation where it will be connected to a discharge leg within the combined SFP, reactor cavity, and dryer/separator pit volume.

Hosing utilized for the DAMS may be a combination of 4, 5, or 6 inch rubber hose, using Bauer connections, STORZ connections, flanges and other appropriate mating connections.

Five 1600 gallon fuel tanks provide the necessary fuel to supply the temporary diesel generators (FLEX or NSRC) which can provide up to 175 kW (1000 kW for NSRC generator) to the DAM system. Diesel generator refueling will be accomplished by ERO coordination with SAFER and the NSRC which has the capability to provide helicopter transport if necessary (refer to SAFER Roles and Responsibilities).

The diesel generator and fuel tanks will be placed outside on the Control Building roof per plant procedures. All the piping, hoses, cables and distribution panels making the connections between the trains, diesel generator, and fuel tanks will be installed per plant procedures.

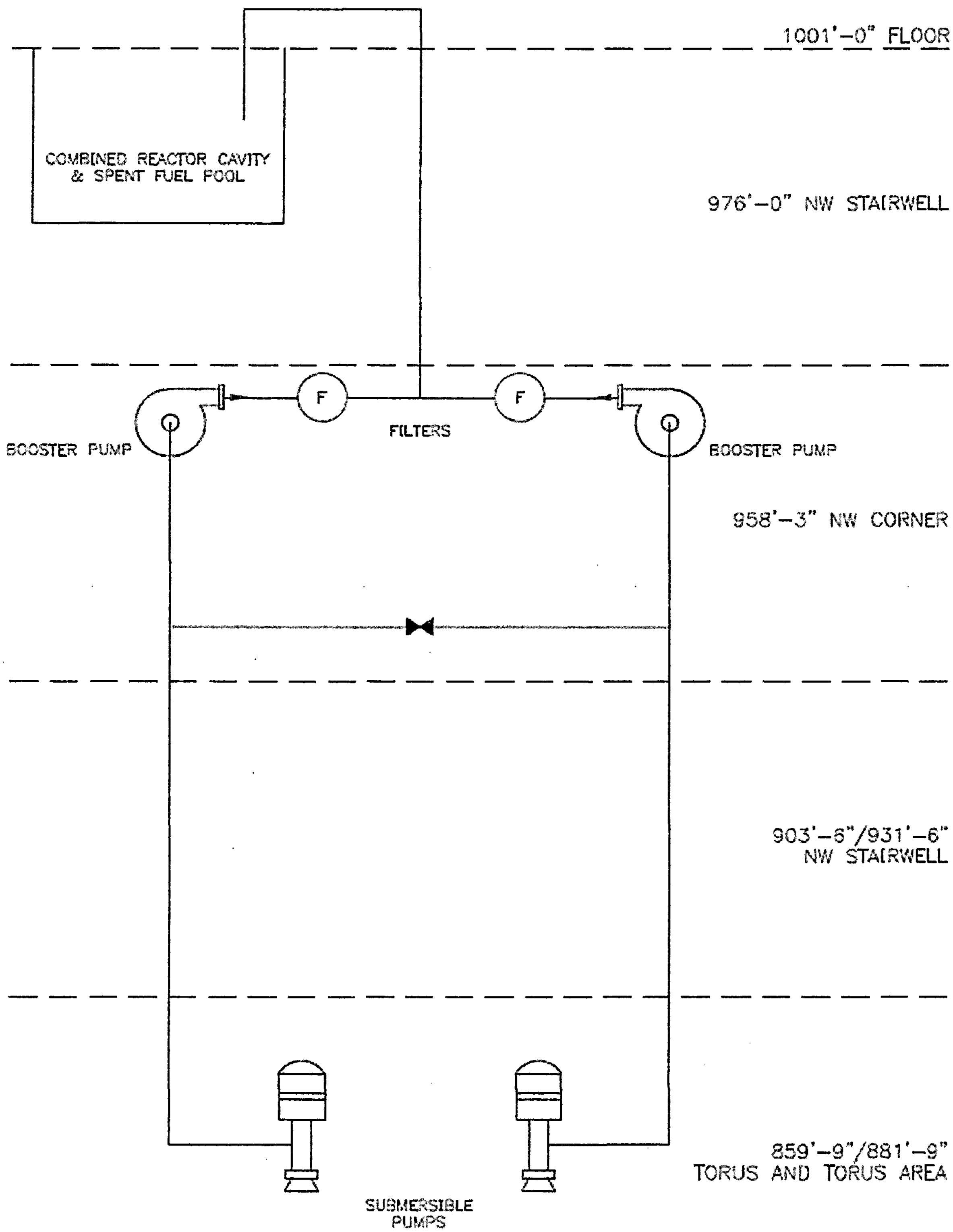
Access between the building roofs and refueling floor will be by ladder/scaffolding through the 958'-3" RB ventilation louvers and northwest stairwell.

The instructions for the DAMS implementation are written with the assumption that initial plant conditions are MODE 1 with the main turbine generator tied to the grid. If other plant conditions exist at the time of dam failure or spillway gate opening, actual plant conditions will be evaluated and a strategy developed to reach the same end point; including any necessary revisions to this procedure. This process would include the expertise of the TSC and EOF staff that would be in place, as well as additional expertise that could be made available by phone or transported to CNS if necessary.

3. A detailed list of equipment necessary for the mitigating strategies:

3.1 The temporary DAMS contains the following equipment:

- One distribution panel located on the Controlled Corridor roof.
- One submersible pump starter and control panel for both pumps located on the Controlled Corridor roof.
- Two booster pump starter and control panels located on the Controlled Corridor roof.
- Two 175 kW FLEX diesel generators located on the Control Building roof or one 1000 kW turbine diesel generator from the NSRC.
- Portable 6 kW FLEX generators located on Controlled Corridor roof.
- Five 1600 gallon diesel fuel tanks located on the Control Building roof.
- Two submersible pumps; one located within the Torus and one within the Torus area.
- Two mechanical filters located in the NW corner on the RB 958'-3" elevation.
- Two 2x3-6, 5.75 in. impeller - 15 HP booster pumps located in the NW corner on the RB 958'-3" elevation.
- One 2000 lb. Davit Crane located on the RB 903'-6" elevation, near the Torus hatch.


1001'-0" FLOOR
COMBINED REACTOR CAVITY & SPENT FUEL POOL
976'-0" NW STAIRWELL
F
F
FILTERS
BOOSTER PUMP
BOOSTER PUMP
958'-3" NW CORNER
903'-6"/931'-6" NW STAIRWELL
859'-9"/881'-9" TORUS AND TORUS AREA
SUBMERSIBLE PUMPS

4. Sequence of events for the flood hazard:

Action item	Elapsed Time (hrs)	Action	Time Constraint Y/N	Remarks / Applicability
1	T=0	Upstream dam failure	N	
2	T=1	Notification to CNS Entry into Procedure 5.1FLOOD	N	Notification from USACE
3	T=1	CNS notifies NPPD to begin delivery of mobile crane	N	Interface operating agreement
4	T=1	Shut down plant per Procedure 2.1.4	N	Directed by Procedure 5.1FLOOD
5	T=1	Begin disassembly of RPV and Containment	N	Directed by Procedure 5.1FLOOD
6	T=7	Plant in MODE 4	Y	
7	T=19.6	Mobile crane set up on site	Y	NPPD and CNS personnel
8	T=62	RPV and containment disassembly complete, cavity flooded to refueling level	Y	
9	T=71.5	DAM equipment staged on rooftops and within RB	Y	NPPD and CNS personnel perform
10	T=84	DAMS assembly complete	Y	NPPD and CNS personnel perform
11	T=90	DAMS tested	Y	CNS personnel
12	T=95.75	Flood waters reach plant grade	N	

5. A description of how the provisions in Sections 3, 6, and 11 of NEI 12-06, Rev. 2 have been addressed:

NOTE - For ease of review, Sections 3, 6 and 11 of NEI 12-06 have been reproduced herein as italicized text. Information pertaining to the THMS has been inserted as **bold and underlined** text.

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 plant equipment and FLEX equipment. 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 loss of large areas (LOLA) of the plant due to large fires and explosions. 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, plant equipment that is designed to be robust with respect to design basis external events is assumed to be fully available. Plant 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. 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.

For the THMS the containment is opened to facilitate flooding the combined vessel and SFP cavities. The DAM System will provide makeup water and maintain the fuel in the combined pools covered.

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.*

   The current fuel pool and reactor cavity heat loading is such that without SDC in service the heat up rate is approximately 14.5°F/hr. This however is corresponding to 4 days following shutdown, this heat load will continue to decrease with increasing time since shutdown. To eliminate uncertainty the combined reactor cavity, SFP, and dryer/separator pit are assumed to begin to boil when flood waters reach site.

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

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 plant site.*

   As allowed by Appendix G, Section G.4.4, for the THMS, the flood can be considered to be the initiating event. The LOOP will be caused when plant staff removes power from the site due to the flood conditions.

2. *All design basis installed sources of emergency on-site ac power and SBO alternate ac power sources[2] are assumed to be not available and not imminently recoverable. Station batteries and associated dc buses along with ac power from buses fed by station batteries through inverters remain available.*

[2] *Alternate AC source as defined in 10 CFR 50.2*

For the THMS station batteries and DC busses will be removed from service and not utilized due to the flood.

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

   Water contained in the combined reactor cavity and spent fuel storage pools, a fully filled suppression pool, and flood water from within the reactor building will be utilized to provide makeup to compensate for the boil off rate. These structures are designed/capable to contain the water during the event.

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., service water or circulating water pumps, is assumed to be lost with no prospect for recovery. Fire or other pumps may be available provided they are robust for the applicable hazard(s).*

   No water inventory in the UHS will be utilized prior to flood water receding. After flood waters have receded below site grade, well water or flood water that had filled the basement elevations of the RB may be used.

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

   Fuel for the THMS will be stored in tanks which will be located on the roof of the Control Building prior to floodwater arrival.

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

   Plant equipment will be used to place the DAM system into service prior to flood water arrival. Once the flood waters exceed plant grade, no plant equipment, other

[3] *Equipment only needs to be robust for the hazards for which it is relied on for mitigation.*

than the RPV and the spent fuel pool, will be utilized for implementation of the THMS.

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

   The THMS is being implemented via a DAMS which has its own specific equipment in addition to existing FLEX equipment. No "other plant equipment" as referenced above is being utilized.

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

   No installed electrical distribution systems will be utilized in the implementation of the THMS.

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

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

   The fire protection system ring header will not be utilized in the implementation of the THMS, with the exception of using the Fire Protection system to fill the Torus prior to the flood waters reaching the site.

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.*

For the implementation of the THMS, the reactor is shut down and cooled down, the vessel disassembled and the reactor/SFP cavities flooded to the refueling level using normal plant procedures prior to the flood waters causing a loss of all AC power and access to the UHS.

3.2.1.5 Reactor Coolant Inventory Loss

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

1. *losses from letdown unless automatically isolated or until isolation is procedurally directed*

2. *losses due to reactor coolant pump seal leakage (rate is dependent onthe RCP seal design)*

3. *losses due to BWR recirculation pump seal leakage*

4. *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.

The coolant losses will be reduced as compared to the initial MSA. The reactor recirculation pumps will be isolated which will isolate any leakage due to pump seal leakage. Loss due to boiling will be offset by the use of the DAM system to provide makeup water to the reactor cavity and SFP.

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.*

The unit will be in a condition where the cavity and SFP are connected. For the THMS, the flood is considered to be the event and sloshing due to a seismic event is not considered.

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 plant equipment.*

2. *Augment or transition from plant equipment to on-site FLEX equipment and consumables to maintain or restore key functions.*

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 plant equipment to 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.*

The response is based on the timeline established for the flood event. Additional plant staff will be available to complete all actions specified in the THMS.

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.

The implementation of the THMS does not rely on any plant equipment once the DAM System is placed in service. For the DAM System itself, the majority of the components are located outside on rooftops where they will be sufficiently cooled by the outside air or submerged in Torus/flood water. The booster pumps located on the 958'-3" elevation will be cooled by the ambient air which will be influenced by the temperature of the combined reactor cavity, SFP, flood water temperature, and outside air temperature. The RB roof hatch and various outside doors will be opened to create a chimney effect to reduce the temperature inside of the building. Portable fans may also be utilized to increase outside air exchange with the RB to further reduce temperatures in areas operators will frequent.

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.

Plant staff will be able to access the Control and Reactor Buildings during the event via the rooftops. A boat will be utilized in some areas of the site for access. This will not impede any actions in the THMS.

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*	• *RPV Level*
• *SG Pressure*	• *RPV Pressure*
• *RCS Pressure*	• *Containment Pressure*
• *RCS Temperature*	• *Suppression Pool Level*
• *Containment Pressure*	• *Suppression Pool Temperature*
• *SFP Level*	• *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.

All instruments and controls will be available for use during the warning period. After the plant staff removes power from the units, instrumentation will be lost. Indication of pool level will be done with the use of a buoy located in the SFP attached to rope across two pulleys down to the 958'-3" elevation where level can be determined.

3.2.1.11 *Containment Isolation Valves*

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

All valves will be in the isolated position and do not require operation during the event.

3.2.1.12 Qualification of Plant Equipment

Plant 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.

Prior to the flood water reaching plant grade, all plant equipment required for the THMS is qualified to current plant design. After the flood reaches grade and the staff removes power from the units, only portable equipment will be required.

3.2.1.13 FLEX Analyses, Methodologies and Generic Topics

As described above, in order to establish the FLEX capabilities, plant-specific analyses are required. Generally, best-estimate analyses are appropriate for this purpose. For some analyses, methodologies were established through the development of supplemental guidance. Additionally, generic topics were addressed similarly. The references to the supplemental guidance for these topics are as follows:

Topic	*Subject*	*Guidance*	*NRC Endorsement*	*Notes Concerning Endorsement*
Battery Duty Cycles	*Extended battery life calculations for batteries*	*Nuclear Energy Institute (NEI) August 27, 2013 "Extended Battery Duty Cycles"*	*ML13241A188*	*Letter contains limitations*
Boron Mixing	*PWR Boron mixing*	*PWROG LTR- FSE-13-46, Rev. 0*	*ML13276A183*	*Letter contains limitations*
BWR Anticipatory Venting	*EOP override limits when only steam driven pump available*	*BWROG-13059 November 1, 2013*	*ML13358A206*	*None*
CENTS Thermal-Hydraulic Code	*Code handling of 2 phase flow and reflux cooling in PWRs*	*PWROG LTR- TDA-13-20-P, Rev. 0November 20, 2013*	*ML13276A555*	*Letter contains limitations.*
Maintenance Guide for FLEX	*PM basis from EPRI Template*	*EPRI 3002000623*	*ML13276A224*	*None*

MAAP analysis	*Use of MAPP analysis for FLEX conditions*	*EPRI 3002001785*	*ML13275A318*	*Letter contains limitations*
Shutdown/ Refueling Modes	*Provides required guidance for Shutdown/ Refueling Modes*	*Nuclear Energy Institute (NEI) September 18, 2013, "Position Paper: Shutdown/ Refueling Modes"*	*ML13267A382*	*The information for shutdown modes was incorporated into Section 3.2.3*
NOTRUMP Thermal-Hydraulic Code	*Code handling of 2 phase flow and reflux cooling in PWRs*	*PWROG-14064-P Revision 0 PWROG-14027-P Revision 3*	*ML15061A442*	*Letter contains limitations*
SHIELD Reactor Coolant Pump Seals	*Seal leakage values*	*TR-FSE-14-1-P, Revision 1 and TR-FSE-14-1-NP, Revision 1,*	*ML14132A128*	*Letter contains limitations*
FLOWSERVE Reactor Coolant Pump Seals	*Seal leakage values*	*PWROG LTR-OG-15-313, August 5, 2015*	*ML15310A094*	*Letter contains limitations*
Original Westinghouse Reactor Coolant Pump Seals	*Seal leakage values*	*PWROG-14008-P, Revision 2 PWROG-14015-P, Revision 2 PWROG-14027-P, Revision 3 PWROG-14074-P, Revision 0*		
National SAFER Response Centers	*Conformance of the NSRCs to the guidance in Section 12*	*NEI September 11, 2014, "National SAFER Response Center Operational Status" Letter*	*ML14265A107*	*None*
Change Processes	*Application of regulatory change processes to BDBEEs*	*NEI August 19, 2014, "Change Process with respect to BDB applications"*	*ML14147A073*	*None*
Maintenance Rule	*Application of the Maintenance Rule to FLEX equipment*	*NEI June 24, 2015 letter Revision 4B to NUMARC 93-01.*	*ML15097A034*	*None*

Hoses and cables	*Quantity of spare lengths of hoses and cables*	*NEI May 1, 2015 letter, "Alternative Approach to NEI 12-06 Guidance for Hoses and Cables"*	*ML15125A442*	*Letter contains clarification.*

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 plant equipment.*
- *Phase 2: Augment or transition from plant equipment to on-site FLEX equipment and consumables to maintain or restore key functions.*
- *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.

For the THMS implementation, the Containment Cooling functions of Table 3-1 are not maintained since the containment is opened, i.e., drywell head removed.

Justification for not maintaining the containment capability:

The function of the primary containment is to isolate and contain fission products released from the RPV following a design basis LOCA and to confine the postulated release of radioactive material. The primary containment consists of a drywell, which is a steel pressure vessel, enclosed in reinforced concrete, and a suppression chamber, which is a steel torus-shaped pressure vessel, connected by vent pipes. The primary containment surrounds the Reactor Primary System and provides an essentially leak tight barrier against an uncontrolled release of radioactive material to the environment.

The safety design basis for the primary containment is that it must withstand the pressures and temperatures of the limiting

DBA without exceeding the design leakage rate. The DBA that postulates the maximum release of radioactive material within primary containment is a LOCA. In the analysis of this accident, it is assumed that primary containment is OPERABLE such that release of fission products to the environment is controlled by the rate of primary containment leakage.

In MODES 1, 2, and 3, a DBA could cause a release of radioactive material to primary containment. In MODES 4 and 5, the probability and consequences of these events are reduced due to the pressure and temperature limitations of these MODES. Therefore, primary containment is not required to be OPERABLE in MODES 4 and 5 to prevent leakage of radioactive material from primary containment.

In this configuration, there will be approximately 470,000 gallons of water above the reactor core. The reactor recirculation system will be isolated preventing inventory loss due to normal pump seal leakage. The reactor will be able to be maintained in cold shutdown for the duration of the event via natural circulation and water makeup.

The THMS for CNS will require the unit to be shut down and cooled down prior to the predicted arrival of a flood above site grade. The unit will be in MODE 4 prior to the removal of the containment head.

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.

For the THMS implementation, site procedures will drive the plant response and deployment of the DAM System. Trigger points, currently in EDP-048 (Reference 14), and notification of an upstream dam failure will direct entry into Emergency Procedure 5.1FLOOD (Reference 15). Prior to floodwaters reaching site, the Emergency Plan (Reference 20)

will be entered and the ERO will be staffed and available for THMS implementation. Procedure 5.1FLOOD will direct shut down of the plant per Operating Procedure 2.1.4 (Reference 16), disassembly and flood up of the reactor per Operating Procedure 2.1.20.3 (Reference 17) and Maintenance Procedure 7.4DISASSEMBLY (Reference 18) and installation/operation of the DAM System per plant procedures. Once plant operators remove AC and DC systems from service Emergency Procedure 5.3SBO (Reference 19) and the EOPs (Reference 21) will govern plant response.

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 BDBEE has resulted in an 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.

   Plant procedures will control the implementation of the THMS well in advance of the rising flood waters. The ELAP declaration will also happen prior to flood water arrival as plant operators remove the AC and DC systems from service. The DAM System has the capability to maintain core and SFP level for greater than 30 days without external water (other than water stored in the Torus) while ERO personnel determine how best to recover power and plant systems to restore cooling/makeup capability.

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.*

<u>For the implementation of the THMS, the reactor is shut down and cooled down, the vessel disassembled and the reactor/SFP cavities flooded to the refueling level using normal plant procedures prior to the flood waters causing a loss of all AC power and access to the UHS. The use of RCIC to remove heat early in the event is not required.</u>

3. *Plant procedures/guidance should specify actions necessary to assure that plant 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 plant 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.

   <u>The THMS is being implemented via a DAM System which has its own specific equipment. No other support systems as referenced above are being utilized.</u>

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.*

Reactor coolant inventory loss will be primarily due to boiling from the combined pools. This will be monitored visually and not rely on any plant equipment for level monitoring. Any leaks in the hosing of the DAM system will be routed back to the Torus area via the floor drain system and not lost.

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 plant or FLEX equipment (e.g., a diesel driven fire pump or a 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. A heat transfer analysis is not required when crediting an alternate makeup water source using raw water, provided the procedures/guidance include actions to be taken to transition to a more preferable water source as soon as is practical.*

The DAM System provides makeup water to the reactor cavity and SFP primarily from the filled Torus. Torus water will consist of water currently in the Torus, available water transferred from the Hotwell, and Fire Protection water from the Fire Protection tanks as the condensate storage tanks will have been used to fill the dryer separator pit and reactor cavity. Once the flood waters reach the site, the raw water will interact with the Torus water via the open Torus hatch where the submersible pump is located. Beyond the use of the Torus, the next preferred water source would be Condensate Storage Tank A if it was able to be filled with demineralized water and is still available after the flood waters recede. The next water source to be used is from available wells within the Owner Controlled Area. If none of the previous sources are available, raw river water within the Reactor Building may be used. Raw river water may be required to be used to equalize level outside and within the Torus to prevent collapse, but this would not be a concern until the flood level has dropped below 903'-6" elevation.

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 plant 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.*

For the implementation of the THMS, plant DC power is removed from service prior to the arrival of the flood waters. The DAM System is a stand-alone system that does not require plant DC power.

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.

   For the implementation of the THMS, the reactor is shut down and cooled down, the vessel disassembled and the reactor/SFP cavities flooded to the refueling level using normal plant procedures prior to the flood waters causing a loss of all AC power and access to the UHS. Operation of containment isolation or safe-shutdown valves is not required.

8. *Plant procedures/guidance should identify the 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 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.

   Since the THMS is implemented prior to flood water arrival and the flood itself is considered the event, the site's FLEX equipment is available for use. This includes FLEX portable lighting, portable fans, and small portable generators that will be staged in needed areas. Communications will be via the site's satellite phones with spare batteries that will also be charged by the site's small FLEX portable generators.

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.

The THMS is implemented prior to flood waters arriving at the site, so power will be available for area and plant access. Once the DAM System is in service, access to rooftops and areas containing the DAM System for monitoring the system and relief personnel will be via a boat.

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.

The implementation of the THMS does not rely on any plant equipment once the DAM System is placed in service. For the DAM System itself, the majority of the components are located outside on rooftops where they will be sufficiently cooled by the outside air or submerged in Torus/flood water. The booster pumps located on the 958'-3" elevation floor will be cooled by the ambient air which will be influenced by the temperature of the combined reactor cavity and SFP, flood water temperature, and outside air temperature. The RB roof hatch and various outside doors will be opened to create a chimney effect to reduce the temperature inside of the building. Portable fans may also be utilized to increase outside air exchange with the RB to reduce temperatures in areas operators will frequent.

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.

The implementation of the THMS does not rely on any plant equipment once the DAM System is placed in service. For the DAM System itself, the majority of the components are located outside on rooftops or submerged in Torus/flood water which will not be a hazardous environment. The booster pumps located on the 958'-3" elevation floor will be cooled by the ambient air which will be influenced by the temperature of the combined reactor cavity and SFP, flood water temperature, and outside air temperature. The RB roof hatch and various outside doors will be opened to create a chimney effect to reduce the temperature inside of the building. Fire protection gear may be required for entry into portions of the RB but will be staged for use prior to flood arrival. Portable fans may also be utilized to increase outside air exchange with the RB to reduce temperatures in areas operators will frequent.

12. *Plant procedures/guidance should consider loss of heat tracing effects for plant 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.

The heat that is being transferred from the combined reactor cavity and SFP will maintain the system available.

13. *Use of FLEX equipment, e.g., power supplies, pumps, etc., can extend plant coping capability. The procedures/guidance for implementation of the FLEX equipment should address the transitions from plant equipment to the FLEX equipment.*

The use of FLEX equipment to charge batteries or locally energize plant equipment may be needed under ELAP/LUHS conditions. Appropriate electrical isolations and interactions should be addressed in procedures/guidance.

Regardless of installed coping capability, all plants will include the ability to use FLEX equipment to provide RPV/RCS/SG makeup as a means to provide a diverse capability beyond plant equipment. The use of FLEX equipment to provide RPV/RCS/SG makeup requires a transition and interaction with installed systems. For example, transitioning from RCIC to FLEX equipment as the source for RPV makeup requires appropriate controls on the depressurization of the RCS and injection rates to avoid extended core uncovery. Similarly, transition to FLEX equipment for SG makeup from the TDAFW pump may require cooldown and depressurization of the SGs in advance of using the portable pump connections.

Guidance should address both the proactive transition from plant equipment to FLEX equipment and reactive transitions in the event plant equipment degrades or fails. Preparations for reactive use of FLEX equipment should not distract site resources from establishing the primary coping strategy. In some cases, in order to meet the time-sensitive required actions of the site-specific strategies, the FLEX equipment may need to be stored in its deployed position.

The fuel necessary to operate the FLEX equipment needs to be assessed in the plant-specific analysis to ensure sufficient quantities are available as well as to address delivery capabilities.

The DAM System will be placed into service without reliance on the site's FLEX equipment except for the generators used for powering the DAM equipment, portable lighting, portable fans, and recharging communications equipment batteries. As described earlier, plant procedures will transition the plant from operating to shutdown with the DAM System in service prior to

flood water arrival. External fuel tanks are used with the DAM System to provide ~25 days of run time (Reference 20). Refueling may be accomplished via helicopter and SAFER equipment.

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.

    The sizing of FLEX equipment used to cool the SFP should be based on the maximum design basis heat load for the site. For the purposes of determining the response time for the SFP strategies when fuel is in the reactor vessel, the rate of inventory loss of the SFP should be calculated based on the worst case conditions for SFP heat load assuming the plant is at power.

    For the implementation of the THMS the reactor cavity and the SFP are combined. The DAM System has been sized to support the heat load generated in both and the highest boil off rate expected 4 days after shutdown. SFP and reactor cavity level monitoring is provided by use of a buoy in the SFP pool and remote monitoring of an attached line to the 958'-3" elevation.

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

    Hydrogen igniters support maintenance of containment function 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 plant 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 plant equipment is functioning *well, then priority could be given to deployment of FLEX equipment.*

<u>CNS is a BWR Mark I containment.</u>

16. *In order to assure reliability and availability, sufficient FLEX equipment should be provided.*

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 FLEX pumps, three sets of FLEX ac/dc power supplies, 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 FLEX equipment associated with each strategy does not require N+1. The existing LOLA 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 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.

Each site should have N sets of FLEX hoses and cables. In addition, each site should have spare hose and cable in a quantity that meets either of the two methods described below:

Method 1: Provide additional hose or cable equivalent to 10% of the total length of each type/size of hose or cable necessary for the "N" capability. For each type/size of hose or cable needed for the "N" capability, at least 1 spare of the longest single section/length must be provided.

- *Example 1-1: An installation requiring 5,000 ft. of 5 in. diameter fire hose consisting of 100 50 ft. sections would require 500 ft. of 5 in. diameter spare fire hose (i.e., ten 50 ft. sections).*
- *Example 1-2: A pump requires a single 20 ft. suction hose of 4 in. diameter, its discharge is connected to a flanged hard pipe*

connection. One spare 4 in. diameter 20 ft. suction hose would be required.

- *Example 1-3: An electrical strategy requires 350 ft. cable runs of 4/0 cable to support 480 volt loads. The cable runs are made up of 50 ft. sections coupled together. Eight cable runs (2 cables runs per phase and 2 cable runs for the neutral) totaling 2800 ft. of cable (56 sections) are required. A minimum of 280 ft. spare cable would be required or 6 spare 50 ft. sections.*

- *Example 1-4: An electrical strategy requires 100 ft. of 4/0 cable (4 cables, 100 ft. each) to support one set of 4 kv loads and 50 ft. of 4/0 (4 cables, 50 ft. each) to support another section of 4 kv loads. The total length of 4/0 cable is 600 ft. (100 ft. x 4 plus 50 ft. x 4). One spare 100 ft. 4/0 cable would be required representing the longest single section/length.*

Method 2: Provide spare cabling and hose of sufficient length and sizing to replace the single longest run needed to support any single FLEX strategy.

- *Example 2-1 – A FLEX strategy for a two unit site requires 8 runs each of 500 ft. of 5 in. diameter hose (4000 ft. per unit). The total length of 5 in. diameter hose required for the site is 8000 ft. with the longest run of 500 ft. Using this method, 500 ft. of 5 in. diameter spare hose would be required.*

For either alternative method, both the N sets of hoses or cables and the spare hoses and cables would need to remain deployable following the BDBEE. Note: if a longer spare hose or cable length is substituted for a shorter length the capability of the flow path or circuit must be confirmed.

Sufficient FLEX equipment is provided via two redundant trains to provide makeup water to the combined reactor cavity and SFP. The strategy is to provide makeup water from the Torus/Torus area via a submersible pump, booster pump, and filter to maintain level in the combined pools above the level of the fuel.

Hoses/cables will meet the 10%/longest section requirement.

17. *Diversity and flexibility should be considered in the connection points for the FLEX strategies.*

The intention of this guidance is to have permanent, installed connection points for FLEX fluid and electrical equipment.

The FLEX 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 plant equipment and instruments utilized in FLEX strategies. For example a strategy to have the primary connection on an 'A' Train electrical bus (e.g., 4kV) and the alternate connection to the equivalent bus on the 'B' Train is acceptable.

At a minimum, the primary connection point should be an installed connection suitable for both the on-site and off-site FLEX 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.

If separate strategies are used as delineated in paragraph 16 above, then the two strategies do not each need a primary and alternate connection point provided the connection points for the two strategies are separate.

Appendices C and D provide more details on how this is to be accomplished.

There are no permanent plant connection points as the strategy in paragraph 16 above uses a discharge leg positioned at the edge of the combined pools.

3.2.3 Shutdown Modes

Due to the small fraction of the operating cycle that is spent in an outage condition, generally less than 10%, the probability of a beyond design basis external event occurring during any specific outage configuration is very small. Additionally, due to the large and diverse scope of activities and configurations for any given nuclear plant outage (planned or forced), *a systematic approach to shutdown safety risk identification and planning, such as that currently required to meet §50.65(a)(4) along with the availability of the FLEX equipment, is the most effective way of enhancing safety during shutdown.*

In order to effectively manage risk and maintain safety during outages, plants maintain contingencies to address the precautions and response actions for loss of cooling. These contingencies direct actions to minimize the likelihood for a loss of cooling but also direct the actions to be taken to respond to such an event.

In order to further reduce shutdown risk, the shutdown risk process and procedures will be enhanced through incorporation of the FLEX equipment. Consideration will be given in the shutdown risk assessment process to:

- *Maintaining FLEX equipment necessary to support shutdown risk processes and procedures readily available, and*
- *Determining how FLEX equipment could be deployed or pre-deployed/pre-staged to support maintaining or restoring the key safety functions in the event of a loss of shutdown cooling.*

In cases where FLEX equipment would need to be deployed in locations that would quickly become inaccessible as a result of a loss of decay heat removal from an ELAP event, pre-staging of that equipment may be required.

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, the provisions for the shutdown modes should include:

- *Primary and alternate connection points for core cooling,*
- *Core cooling pumps sized to provide core cooling for outage conditions,*
- *Identify a source of borated water for core cooling (the borated water source does not need to be robust for all external events)[4],A means to remove heat from containment, e.g., venting,*

Analyses are only needed to support the sizing of the makeup pump/connections and to ensure sufficient containment heat removal

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[4] *The key is to have sufficient water sources. If the borated water source is not robust for an external hazard applicable to the site, other water sources robust for that hazard should be identified to back it up. If the backup water source is not borated, then consideration should be given to controlled use to minimize dilution.*

capability exists. Analyses are not needed for the purposes of determining the sequence of events of an ELAP during shutdown conditions.

The implementation of THMS is not dependent on plant mode. Having the plant already shutdown will not affect the implementation time or the strategy itself.

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 FLEX Injection Source* • *Sustained Source of Water*	• *Use of plant equipment for initial coping* • *Primary and alternate connection points for FLEX 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*	• *Containment vent or other capability.*
	Containment Integrity (BWR Mark III Containments Only)	• *Hydrogen igniters*	• *Re-powering of hydrogen igniters with a FLEX power supply*
	Key Containment Parameters	• *Containment Pressure* • *Suppression Pool Temperature* • *Suppression Pool Level*	• *(Re-)Powered instruments*
SFP Cooling	*Spent Fuel Cooling*	• *Makeup with FLEX Injection Source*	• *Makeup via hoses direct to pool* • *Makeup via connection to SFP makeup piping or other suitable means*
	SFP Parameters	• *SFP Level*	• *Wide-range spent fuel pool level instruments*

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 FLEX Injection Source* • *Sustained Source of Water*	• *Use of plant equipment for initial coping* • *Connection for FLEX pump to feed required SGs* • *Use of alternate water supply to support core heat removal*
	RCS Inventory Control	• *Low Leak RCP Seals and/or RCS high pressure makeup*	• *Low-leak RCP seals and/or providing on-site high pressure RCS makeup capability*
	Core Heat Removal (shutdown modes 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 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 FLEX pump or alternate capability (e.g., venting) or analysis demonstrating that containment pressure control is not challenged*
	Containment Integrity (Ice Condenser Containments Only)	• *Hydrogen igniters*	• *Re-powering of hydrogen igniters with a FLEX power supply*
	Key Containment Parameters	• *Containment Pressure*	• *(Re-)Powered instruments*
SFP Cooling	*Spent Fuel Cooling*	• *Makeup with FLEX Injection Source*	• *Makeup via hoses direct to pool* • *Makeup via connection to SFP makeup piping or other suitable means*
	SFP Parameters	• *SFP Level*	• *Spent fuel pool level instruments*

3.3 CONSIDERATIONS IN UTILIZING OFF-SITE RESOURCES

Once the analysis determines the FLEX 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 for the purposes of sustaining functions indefinitely. In planning the coping strategies, water and fuel resources, among other things, needed to cope indefinitely would imply the need for an infinite source of supply. Since site access is considered to be restored to near-normal within 24 hours, by 72 hours from the event initiation, outside resources should be able to be mobilized by that time such that a continuous supply of needed resources will be able to be provided to the site. Within these first 72 hours a site will have deployed its FLEX strategies which should result in a stable plant condition on the FLEX equipment and plans will have been established to maintain the key safety functions for the long term. Therefore, FLEX strategies and/or resources are not required to be explicitly planned in advance for the period beyond 72 hours.

The site will need to identify staging area(s) for receipt of the off-site FLEX 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.

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

CNS has developed staging areas and coordinated the use of those areas with the NSRC (Reference 22). The only off-site resource needed after the DAM System is in service will be diesel fuel. The on-site storage tanks have capacity for 25 days of run time (Reference 20) which is beyond the 72 hours deployment time from the NSRC.

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.

This is assessed in Appendix G to NEI 12-06 presented earlier in this document.

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 on safe shutdown equipment.*

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

This is assessed in Appendix G to NEI 12-06 presented earlier in this document.

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 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 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. If warning time is credited, the evaluation of the adequacy of warning time includes review of the flooding event and warning time triggers needed to implement any flood protection or mitigating strategies. Multiple triggers or a single trigger can be established for milestones if the *response to a flood hazard is done in graduated steps (e.g. stage equipment, assemble equipment, and complete implementation).*

<u>This is assessed in Appendix G to NEI 12-06 presented earlier in this document.</u>

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 such that no one external event can reasonably fail the site FLEX capability (N):*

    a. *Stored above the flood elevation from the most recent design basis 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 addresses the needed actions to relocate the equipment. Based on the timing of the limiting flood scenario(s), the FLEX equipment can be relocated[6] 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*

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

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.*

The DAM System equipment will be stored in a commercial building located below the FLEX DB and MSFHI. As stated in the Appendix G discussion earlier in this document a minimum of 96 hours is available prior to flood waters reaching site. Procedures 5.1FLOOD (Reference 15) and EDP-048 (Reference 14) provide actions to stage and deploy the DAM System equipment well in advance of the rising flood waters.

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 FLEX 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. *FLEX equipment will require fuel that would normally be obtained from fuel oil storage tanks that could be inundated by the flood or above ground tanks 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 FLEX 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.*

The DAM System equipment will be stored in a commercial building located below the FLEX DB and MSFHI. As stated in the Appendix G discussion earlier in this document a minimum of 96 hours is available prior to flood waters reaching site. Procedures 5.1FLOOD (Reference 15) and EDP-048 (Reference 14) provide actions to stage and deploy the DAM System equipment well in advance of the rising flood waters.

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.*

Guidance for implementation of the THMS via a DAM System has been incorporated into site procedures, see Section 3.2.2 discussion.

6.2.1.3 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.*

See section 3.3.3 discussion.

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

FLEX 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.

<u>The commercial equipment CNS has procured for the DAM System is not used for any other purposes.</u>

11.2 EQUIPMENT DESIGN

1. *Design requirements and supporting analysis should be developed for FLEX equipment that directly performs a FLEX mitigation strategy for core, containment, and SFP that provides the inputs, assumptions, and documented[7] analysis that the mitigation strategy and support equipment will perform as intended. When specifying FLEX 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.*

      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, FLEX 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.*

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[7] 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.*

The design considerations above are contained in an engineering evaluation.

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.*

   No portable OTR transport equipment is used in the DAM System, with the exception of the FLEX diesel generators.

3. *Note that the functionality of the equipment may be outside the manufacturer's specifications if justified in a documented engineering evaluation.*

   The DAM System equipment is used within the manufacturer's specification.

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.*

   Commonly available equipment is used in the DAM System.

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.*

   Section 6 guidance was used in the development of the storage location for the DAM System.

2. *A technical basis should be developed for equipment storage for FLEX equipment that directly performs a FLEX mitigation strategy for core,*

containment, and SFP that provides the inputs, assumptions, and documented[8] 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.

The FHRR provides the technical basis of the flood levels for the site. The DAM System equipment will be stored in a commercial building located below the FLEX DB and MSFHI. As stated in the Appendix G discussion earlier in this document a minimum of 96 hours is available prior to flood waters reaching site. Procedures 5.1FLOOD (Reference 15) and EDP-048 (Reference 14) provide actions to stage and deploy the DAM System equipment well in advance of the rising flood waters.

3. *FLEX equipment should be stored in a location or locations[9] informed by evaluations performed per Sections 5 through 9 such that no one external event can reasonably fail the site FLEX capability (N).*

   The DAM System equipment is credited only for the THMS event and is stored as described in #2 above. The site's FLEX equipment remains available for all other external events.

4. *Different FLEX equipment can be credited for independent events.*

   See #3 above.

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.*

   The DAM System will be placed into service prior to the arrival of the flood waters.

6. *If FLEX equipment is installed or 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. The primary and alternate connection criteria and N+1 criteria of Section 3.2.2 still apply. The FLEX equipment must be reasonably protected in accordance with Section 11.3.3 above. The primary*

[8] *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.*
[9] *Location or locations may include areas outside the owner controlled area provided equipment can be relocated in time to meet FLEX strategy requirements.*

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 plant equipment.

The DAM System will not be installed until after the plant is shut down, the containment opened and the reactor cavity and SFP are combined and filled with water. The DAM System will have no adverse impact on any SSCs.

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.*

   The DAM System equipment will be stored in a commercial building and will be accessible.

8. *If LOLA equipment is credited in the FLEX mitigating strategies, it should meet the above storage requirements in addition to the LOLA requirements*

   LOLA equipment will not be used for the THMS.

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).*

   Debris removal equipment will not be required as the DAM System will be placed into service prior to any debris arrival.

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.).*

    The DAM System will be placed into service prior to the loss of AC or DC power.

11.4 PROCEDURE GUIDANCE

CNS has already implemented FSGs in accordance with this guidance for compliance with Order EA-12-049. The implementation of the THMS will continue to do so. There is no further discussion in this section (11.4).

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.[10] *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, 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:*

[10] *Additional industry guidance concerning emergency response procedure coordination is provided in NEI 14-01.*

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 plant 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 in accordance with Appendix E. Validation may be accomplished via walk-throughs or drills of the guidelines.*

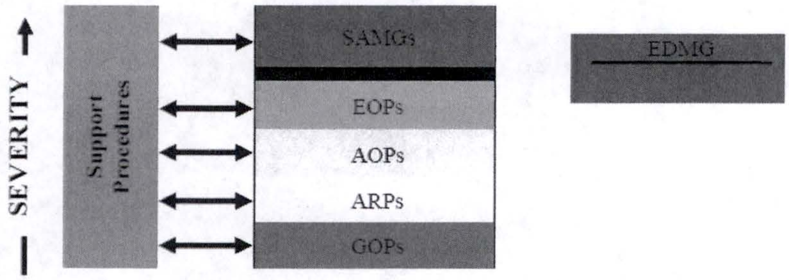
2. *FSGs will be controlled under the site procedure control program.*

11.4.4 Regulatory Screening/Evaluation

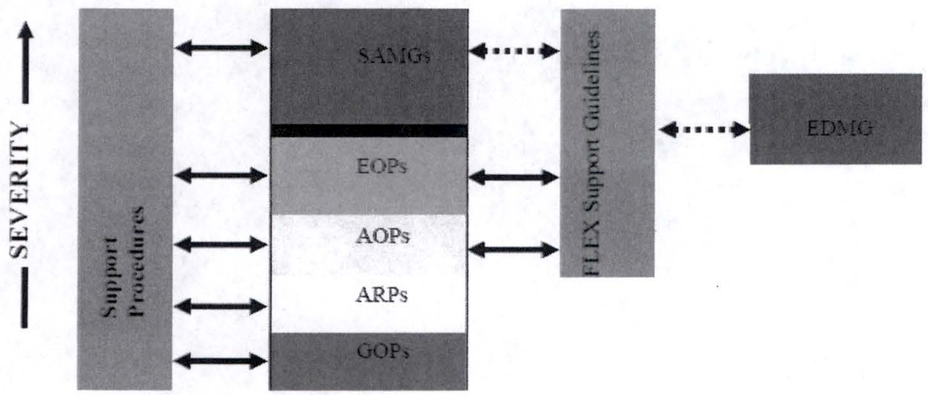
NEI 96-07, revision 1, and NEI 97-04, revision 1 should be used to evaluate the changes to existing procedures as well as to the FSG to determine the need for prior NRC approval. Changes to procedures (EOPs or FSGs) that perform actions in response events that exceed a site's design basis should screen out per the guidance and examples provided in NEI 96-07, Rev. 1. 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 function should not need to be evaluated in accordance with the regulatory processes associated with the UFSAR (i.e., 10 CFR 50.59 and 50.71). The same is true for other key licensing basis documents such as the security plan and emergency plan, and their related change control and reporting requirements, provided the changes being evaluated impact only mitigating strategies for BDBEEs and do not affect the content of the other licensing basis documents.

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 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) is addressed in NEI 14-01.*

- *FSGs would be similar in intent as the current EDMGs. 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 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.*

   The DAM System equipment is commercial "off-the-shelf" equipment that meets or exceeds the performance requirements of the system. No "specialty" or "custom" equipment is used. Testing was done to confirm the functionality of the purchased equipment.

2. *FLEX equipment that directly performs a FLEX mitigation strategy for the core, containment or SFP should be subject to maintenance and testing[11] guidance provided in INPO AP 913, Equipment Reliability Process, to verify proper function. The maintenance program should ensure that the FLEX reliability is being achieved. Standard industry templates (e.g., EPRI) and associated bases (i.e., site-specific) 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).*

   The DAM System equipment will be included in the CNS Preventative Maintenance Program the same as the site's other FLEX equipment.

3. *Maintenance and testing for plant equipment is conducted in accordance with existing plant processes.*

4. *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.*

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[11] *Testing includes surveillances, inspections, etc.*

a. *The unavailability of plant equipment is controlled by existing plant processes such as the Technical Specifications. When plant equipment which supports FLEX strategies becomes unavailable, then the FLEX strategy affected by this unavailability does not need to be maintained during the unavailability.*

b. *The required FLEX equipment may be unavailable for 90 days provided that the site FLEX capability (N) is met. If the site FLEX (N) capability is met but not protected for all of the site's applicable hazards, then the allowed unavailability is reduced to 45 days.*[12]

c. *One of the connections to plant equipment required for FLEX strategies can be unavailable for 90 days provided the remaining connection remains available such that the site FLEX strategy is available.*

d. *If FLEX equipment is likely to be unavailable during forecast site specific external events (e.g., hurricane), appropriate compensatory measures should be taken to restore equivalent capability in advance of the event.*

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

f. *If FLEX equipment or connections become unavailable such that the site FLEX capability (N) is not maintained, initiate actions within 24 hours to restore the site FLEX capability (N) and implement compensatory measures (e.g., use of alternate suitable equipment or supplemental personnel) within 72 hours.*

g. *If FLEX equipment or connections to permanent plant equipment required for FLEX strategies are unavailable for greater than 45/90 days, restore the FLEX capability or implement compensatory measures (e.g., use of alternate suitable equipment or supplemental personnel) prior to exceedance of the 45/90 days.*

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[12] *The spare FLEX equipment is not required for the FLEX capability to be met. The allowance of 90 day unavailability is based on a normal plant work cycle of 12 weeks. In cases where the remaining N equipment is not fully protected for the applicable site hazards, the unavailability allowance is reduced to 45 days to match a 6 week short cycle work period. Equipment being unprotected does not make it unavailable. Aligning the unavailability to the site work management program is important to keep maintenance of spare FLEX equipment from inappropriately superseding other more risk-significant work activities.*

The unavailability of the DAM System equipment will be controlled via the same method controlling the site's other FLEX equipment.

11.6 TRAINING

1. *Training should be provided to key personnel relied upon to implement the procedures and guidelines for responding to a beyond design basis event (see NEI 13-06, Enhancements to Emergency Response Capabilities for Beyond Design Basis Events and Severe Accidents). Training materials, delivery methods and frequencies, and evaluation techniques should be developed using established processes that address the "Systems approach to training" (SAT) elements listed in 10 CFR 55.4.*

   The SAT process will be used to develop and implement training on the DAM System and its implementation.

2. *Periodic training should be provided to site emergency response leaders [13]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.*

   The SAT process will determine the appropriate frequency and content of any additional training.

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.*

   The SAT process will determine the appropriate frequency and content of any additional training.

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.*

   The plant simulator has not been upgraded to accommodate FLEX training or drills.

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[13] Emergency response leaders are those site and corporate 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.

5. *Where appropriate, the integrated FLEX drills should be organized on a team or crew basis and conducted periodically; all time-sensitive actions to be evaluated over a period of not more than eight years.[14] It is not the intent to connect to or operate plant equipment during these drills and demonstrations.*

   Drill objectives have been included in the FLEX Program Document.

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.*

   As this event has sufficient warning time, plant personnel will be called in to supplement the minimum staff and the ERO will be staffed prior to flood water arrival.

11.8 CONFIGURATION CONTROL

1. *The FLEX strategies and basis will be maintained in an overall program document. This program document will 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.*

   The FLEX Program Document will be revised to either include this MSA by reference or include the THMS itself in the document.

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.*

   Plant configuration control procedures already have hooks in them to evaluate the effect of changes on the FLEX Strategies.

[14] *Industry guidance for conducting FLEX drills is provided in NEI 13-06.*

3. *Changes to FLEX strategies may be made without prior NRC approval provided:*

   a. *The revised FLEX strategy meets*

      i. *the provisions of this guideline, or*

      ii. *the change to the strategies and guidance implement an alternative or exception approved by the NRC, provided that the bases of the NRC approval are applicable to the licensee's facility, or*

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

AND

   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 function) are met.*

4. *If the change is determined to require prior NRC approval, a written request shall be submitted for prior NRC approval.*

5. *Documentation of all changes, including the evaluations required by paragraph 3 above shall be maintained for as long as the plant is required to have FLEX strategies.*

Administrative Procedure 0.22 (Reference 23) controls changes to the FLEX FIP and the FLEX Program Document. As such, any changes to the THMS implementation will be controlled and documented by that process.

Validation items:

Action item	Elapsed Time	Action	Time Constraint Y/N	Remarks / Applicability
6	T=7	Plant in MODE 4	Y	Validated by past outage data; validation to be performed in accordance with NEI 12-06 and documented in the FLEX Program Document.
7	T=19.6	Mobile crane set up on site	Y	Validated by ER 2016-039; validation to be performed accordance with NEI 12-06 and documented in the FLEX Program Document.
8	T=62	RPV and containment disassembly complete, cavity flooded to refueling level	Y	Validated by past outage data; validation to be performed in accordance with NEI 12-06 and documented in the FLEX Program Document.
9	T=71.5	DAMS equipment staged on rooftops	Y	Bounded by ER 2016-039; validation to be performed in accordance with NEI 12-06 and documented in the FLEX Program Document.
10	T=84	DAMS assembly complete	Y	Bounded by ER 2016-039; validation to be performed in accordance with NEI 12-06 and documented in the FLEX Program Document.
11	T=90	DAMS in service	Y	Bounded by ER 2016-039; validation to be performed in accordance with NEI 12-06 and documented in the FLEX Program Document.

References:

1. NRC Letter, "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated March 12, 2012

2. NPPD Letter to NRC, "Nebraska Public Power District's Response to Request for Information Pursuant to 10 CFR 50.54(F) Regarding the Flooding Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated February 3, 2015

3. NPPD Letter to NRC, "Response to Nuclear Regulatory Commission Request for Additional Information Regarding Near Term Task Force Recommendation 2.1- Flood Hazard Reevaluation Report," dated June 18, 2015

4. NPPD Letter to NRC, "Addendum to Nebraska Public Power District's Response to Nuclear Regulatory Commission Request for Information Pursuant to 10 CFR 50 .54(f) Regarding the Flooding Aspects of Recommendation 2.1 of the Near Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated July 31, 2015

5. NPPD Letter to NRC, "Addendum to Nebraska Public Power District's Response to Nuclear Regulatory Commission Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated October 29, 2015

6. NPPD Letter to NRC, "Nebraska Public Power District's Dam Failure Modeling White Paper in Regard to Nuclear Regulatory Commission Interim Staff Response to Reevaluated Flood Hazards for Cooper Nuclear Station," dated July 28, 2016

7. NPPD Letter to NRC, "Revision to Nebraska Public Power District's Flood Hazard Reevaluation Report ," dated September 29, 2016

8. NRC Staff Requirements Memorandum to COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards," dated March 30, 2015

9. NRC Letter, "Cooper Nuclear Station - Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request - Flood-causing Mechanism Reevaluation (TAC No. MF4712)," dated December 22, 2015

10. NRC Interim Staff Guidance JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," Revision 01, dated January 22, 2016

11. Nuclear Energy Institute, Report NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Revision 2, dated December 2015

12. NRC Letter, "Supplemental Information Related to Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated March 1, 2013

13. NPPD Letter to NRC "Completion of Required Action by NRC Order EA-12-049 - Mitigation Strategies for Beyond-Design-Basis External Events ," dated January 4, 2017

14. EDP-048, Flood Hazard Re-Evaluation Interim Action Monitoring And Trigger Points

15. Emergency Procedure 5.1FLOOD, Flood

16. Operating Procedure 2.1.4, Normal Shutdown

17. Operating Procedure 2.1.20.3, RPV Refueling Preparation (Wet Lift of Dryer and Separator)

18. Maintenance Procedure 7.4DISASSEMBLY, Reactor Vessel Disassembly

19. Emergency Procedure 5.3SBO, Station Blackout

20. Nebraska Public Power District Emergency Plan for Cooper Nuclear Station

21. Emergency Operating Procedure 5.8, Emergency Operating Procedures (EOPs)

22. NSRC-005 Rev. 001 38-9247609-000, CNS SAFER Response for Cooper Nuclear Station

23. Administrative Procedure 0.22, Emergency Operating Procedure And Severe Accident Management Program Maintenance

24. Engineering Report 2016-039, Timing for Setup of Beyond Design Basis Flooding Equipment