



# **Mitigating Strategies for Beyond-Design-Basis External Events**

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# Background

On March 11, 2011, a major earthquake struck off the coast of Honshu, resulting in a large tsunami that caused widespread devastation and significantly affected the infrastructure and industry in the northeastern coastal areas of Japan. This led to damage to the nuclear fuel at Fukushima Dai-ichi Units 1, 2 and 3.

# NTTF Tier 1 Actions

- Order EA-12-049 on Mitigating Strategies
- Order EA-12-050 (now EA-13-109) on BWR Vents
- Order EA-12-051 on Spent Fuel Pool Instruments
- Seismic and Flooding Walkdowns
- Seismic and Flooding Re-evaluations
- Staffing and Communications Assessments

# Principles for Mitigating Strategies

In examining the operating experience at Fukushima Dai-ichi, the NRC noted that many of the post-9/11 strategies in the U.S. may have helped lessen the effects of the event. The NRC also noted that strategies similar to these were attempted by the operators at Fukushima Dai-ichi during the event.

Major differences exist between the localized damage assumptions of the post-9/11 strategies and the widespread damage in the operating experience in Japan.

## **Order EA-12-049**

**March 12, 2012**

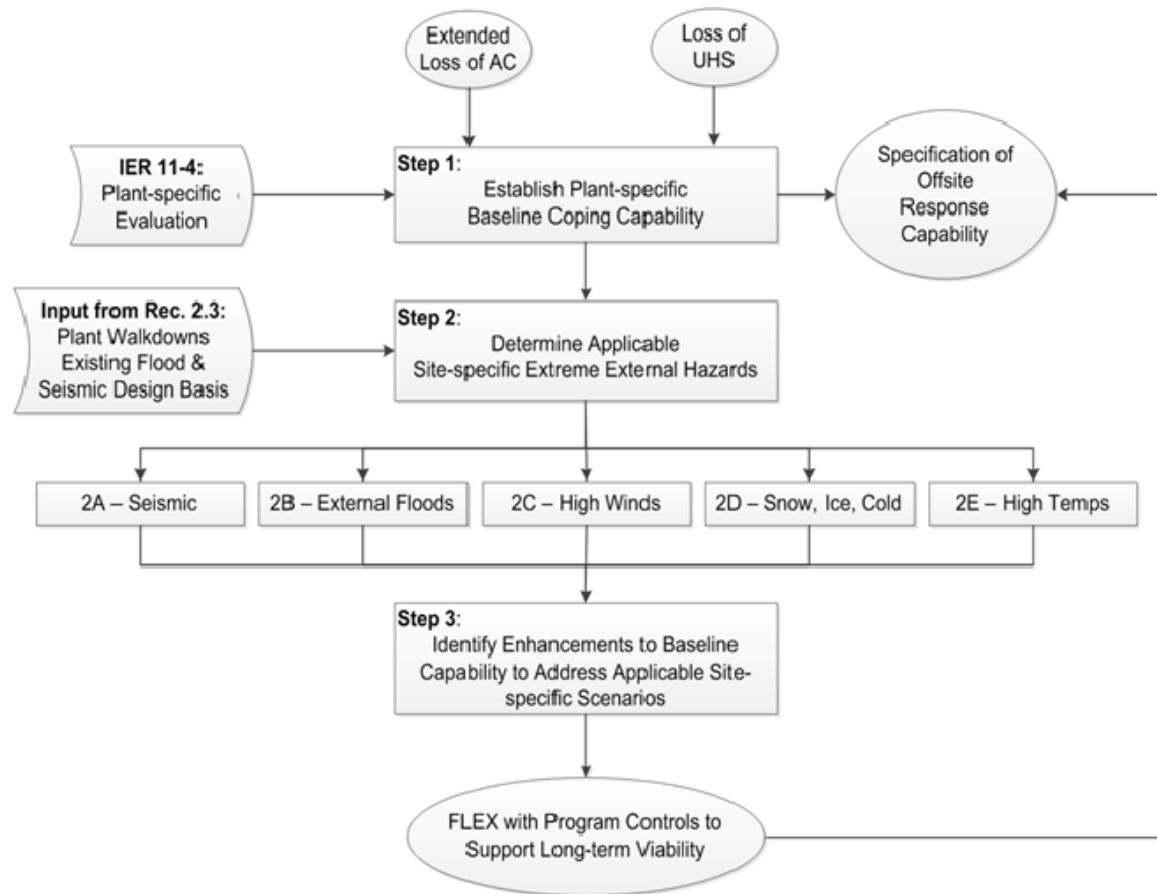
Licensees or construction permit holders shall develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment and spent fuel pool cooling capabilities following a beyond-design-basis external event.

## **Order EA-12-049**

### **Continued**

- Simultaneous loss of all ac power and loss of normal access to the ultimate heat sink
- Adequate capacity to address challenges to core cooling, containment, and spent fuel pool cooling capabilities at all units on a site
- Reasonable protection of associated equipment
- Capable of implementation in all modes
- Procedures, guidance, training, and acquisition, staging or installing of equipment

# NEI 12-06 Site Assessment Process



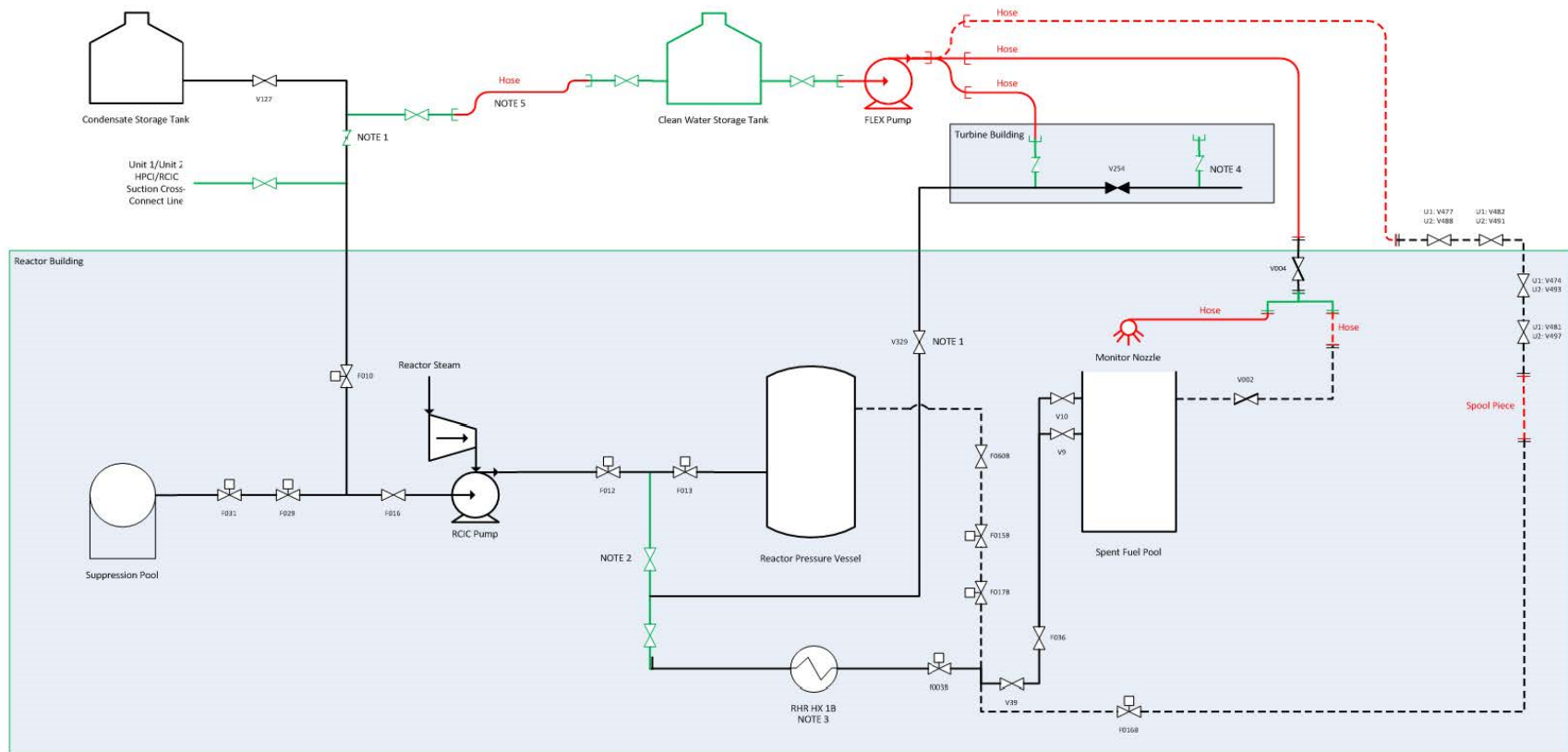
## BWR FLEX Baseline Capability Summary

Safety Function		Method	Baseline Capability
Core Cooling	Reactor Core Cooling	<ul style="list-style-type: none"> <li>• RCIC/HPCI/IC</li> <li>• Depressurize RPV for Injection with Portable Injection Source</li> <li>• Sustained Source of Water</li> </ul>	<ul style="list-style-type: none"> <li>• Use of installed equipment for initial coping</li> <li>• Primary and alternate connection points for portable pump</li> <li>• Means to depressurize RPV</li> <li>• Use of alternate water supply to support core heat removal makeup</li> </ul>
	Key Reactor Parameters	<ul style="list-style-type: none"> <li>• RPV Level</li> <li>• RPV Pressure</li> </ul>	<ul style="list-style-type: none"> <li>• (Re-)Powered instruments</li> <li>• Other instruments for plant-specific strategies</li> </ul>
Containment	Containment Pressure Control /Heat Removal	<ul style="list-style-type: none"> <li>• Containment Venting or Alternative Containment Heat Removal</li> </ul>	<ul style="list-style-type: none"> <li>• Reliable, hardened vent (per EA-12-050 for Mk I and II) or other capability.</li> </ul>
	Containment Integrity (BWR Mark III Containments Only)	<ul style="list-style-type: none"> <li>• Hydrogen igniters</li> </ul>	<ul style="list-style-type: none"> <li>• Re-powering of hydrogen igniters with a portable power supply.</li> </ul>
	Key Containment Parameters	<ul style="list-style-type: none"> <li>• Containment Pressure</li> <li>• Suppression Pool Temperature</li> <li>• Suppression Pool Level</li> </ul>	<ul style="list-style-type: none"> <li>• (Re-)Powered instruments</li> </ul>
SFP Cooling	Spent Fuel Cooling	<ul style="list-style-type: none"> <li>• Makeup with Portable Injection Source</li> </ul>	<ul style="list-style-type: none"> <li>• Makeup via hoses direct to pool</li> <li>• Makeup via connection to SFP makeup piping or other suitable means</li> <li>• Spray via portable nozzles</li> </ul>
	SFP Parameters	<ul style="list-style-type: none"> <li>• SFP Level</li> </ul>	<ul style="list-style-type: none"> <li>• Per EA 12-051</li> </ul>



# Example BWR Licensee Flow Diagram

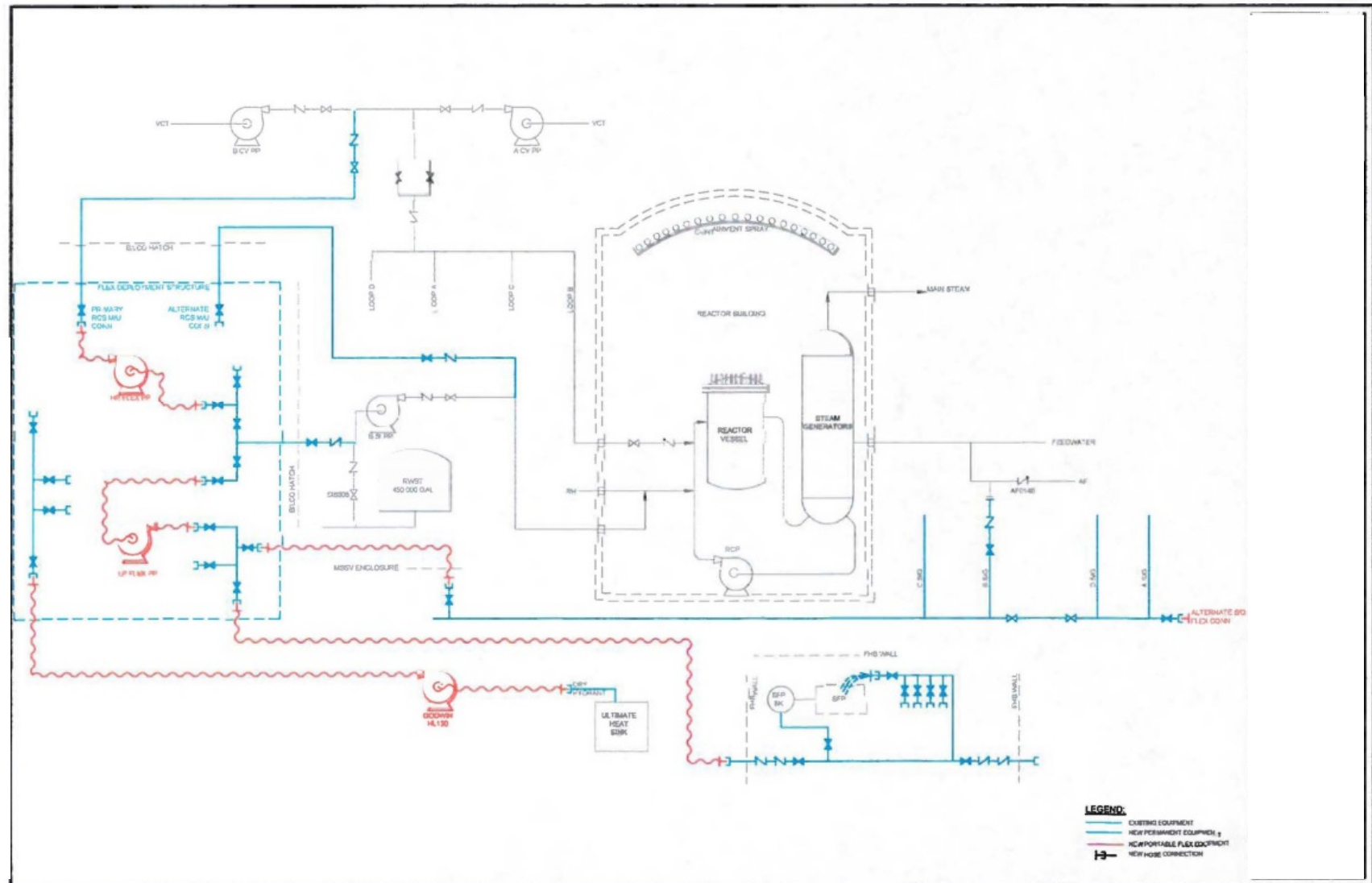
Flow Diagram for FLEX Strategies



## PWR FLEX Baseline Capability Summary

Safety Function		Method	Baseline Capability
Core Cooling	Reactor Core Cooling & Heat Removal (steam generators available)	<ul style="list-style-type: none"> <li>• AFW/EFW</li> <li>• Depressurize SG for Makeup with Portable Injection Source</li> <li>• Sustained Source of Water</li> </ul>	<ul style="list-style-type: none"> <li>• Use of installed equipment for initial coping</li> <li>• Connection for portable pump to feed required SGs</li> <li>• Use of alternate water supply to support core heat removal</li> </ul>
	RCS Inventory Control and Core Heat Removal (shutdown modes with steam generators not available)	<ul style="list-style-type: none"> <li>• Low Leak RCP Seals and/or RCS high pressure makeup</li> <li>• All Plants Provide Means to Provide Borated RCS Makeup</li> </ul>	<ul style="list-style-type: none"> <li>• Low-leak RCP seals and/or providing on-site high pressure RCS makeup capability</li> <li>• Diverse makeup connections to RCS for long-term RCS makeup and shutdown mode heat removal</li> <li>• Source of borated water</li> <li>• Letdown path if required</li> </ul>
	Key Reactor Parameters	<ul style="list-style-type: none"> <li>• SG Level</li> <li>• SG Pressure</li> <li>• RCS Pressure</li> <li>• RCS Temperature</li> </ul>	<ul style="list-style-type: none"> <li>• (Re-)Powered instruments</li> </ul>
Containment	Containment Pressure Control/Heat Removal	<ul style="list-style-type: none"> <li>• Containment Spray</li> </ul>	<ul style="list-style-type: none"> <li>• Connection point on containment spray header for use with portable pump or alternate capability or analysis demonstrating that containment pressure control is not challenged, e.g., MAAP analysis.</li> </ul>
	Containment Integrity (Ice Condenser Containments Only)	<ul style="list-style-type: none"> <li>• Hydrogen igniters</li> </ul>	<ul style="list-style-type: none"> <li>• Re-powering of hydrogen igniters with a portable power supply.</li> </ul>
	Key Containment Parameters	<ul style="list-style-type: none"> <li>• Containment Pressure</li> </ul>	<ul style="list-style-type: none"> <li>• (Re-)Powered instruments consistent</li> </ul>
SFP Cooling	Spent Fuel Cooling	<ul style="list-style-type: none"> <li>• Makeup with Portable Injection Source</li> </ul>	<ul style="list-style-type: none"> <li>• Makeup via hoses direct to pool</li> <li>• Makeup via connection to SFP makeup piping or other suitable means</li> <li>• Spray via portable nozzles</li> </ul>
	SFP Parameters	<ul style="list-style-type: none"> <li>• SFP Level</li> </ul>	<ul style="list-style-type: none"> <li>• Per EA 12-051</li> </ul>

## Example PWR Licensee Flow Diagram



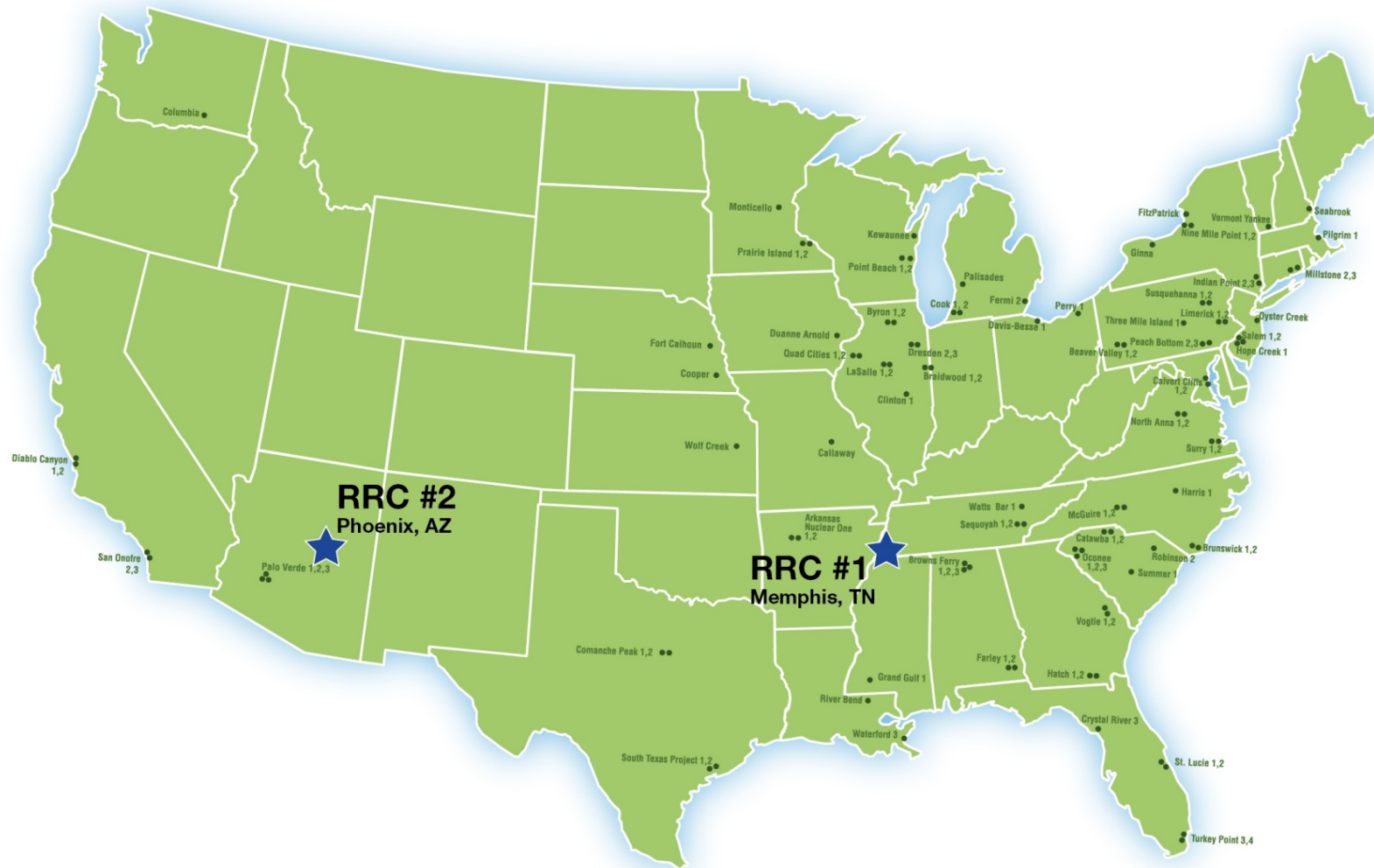
## **Additional Mitigating Strategies Characteristics**

- Strategies based on plant-specific analyses
- Time constraints identified with basis to show they can be met
- Ability to use portable pumps for RPV/RCS/SG makeup
- Spare equipment
- Maintenance and Testing
- Training

## Off-site Resources

- Licensees have set up off-site resource centers to provide additional equipment and supplies
- 24 hour delivery time
- Transportation by road or by air

# National SAFER Center Locations



# Alternative Approaches

NEI 12-06 provided one acceptable approach. Others that have been proposed include:

- Additional hardened generators
- Repowering installed pumps
- Other minor differences from NEI 12-06

# **MBDBE Rulemaking**

- Integrated Response Capability in new 10 CFR 50.155
- Adds requirements for reevaluated seismic and flooding hazard mitigation
- Specifies removal of requirements during decommissioning



# **Risk Credit for Mitigating Strategies**

- U.S. Power Reactor Licensees are in the process of incorporating mitigating strategies in their Probabilistic Risk Assessments of as built, as operated plants
- Degree of risk reduction varies based upon site and plant configurations

# Bibliography

Document	Accession No.
SECY-11-0093	ML11186A950
Order EA-12-049	ML12054A736
NEI 12-06, Revision 0	ML12242A378
JLD-ISG-2012-01, Revision 0	ML12229A174
NEI 12-06, Revision 2	ML15348A015
JLD-ISG-2012-01, Revision 1	ML15357A163
MBDBE Rulemaking	SECY-16-0142