UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

November 29, 2016

MEMORANDUM TO: Gregory T. Bowman, Chief
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Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

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SUBJECT: UPDATED DRAFT ASSESSMENT OF FUKUSHIMA RECOMMENDATIONS RELATED TO: 1) EVALUATION OF NATURAL HAZARDS OTHER THAN SEISMIC AND FLOODING, 2) ONGOING ASSESSMENT OF NATURAL HAZARDS, AND 3) REAL-TIME RADIATION MONITORING

The purpose of this memorandum is to document the updated draft U.S. Nuclear Regulatory Commission (NRC) staff assessment of Fukushima Tier 2 and 3 recommendations that was provided to the Advisory Committee on Reactor Safeguards (ACRS) on November 4, 2016. The attached updated assessment is an intermediate work product and does not necessarily represent the final NRC staff or agency position.

During an October 19, 2016, ACRS Fukushima Subcommittee meeting, the NRC staff briefed the ACRS members on the NRC staff's assessment found in a September 22, 2016, document titled "White Paper for Staff Assessment of Fukushima Lessons Learned Associated with Other Natural Hazards, Periodic Confirmation of Natural Hazards, and Real Time Radiation Monitoring" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16230A384).

As a result of member comments received during the October 19, 2016, ACRS Fukushima Subcommittee meeting, the NRC staff identified potential changes to its assessment found in the September 22, 2016, white paper. To facilitate the ACRS Full Committee discussion on this topic scheduled for November 30, 2016, NRC staff provided the ACRS with an updated assessment reflecting the changes that the NRC staff was considering making to the document as a result of ACRS member comments. To this end, on November 4, 2016, the staff provided the following three enclosures:

1) a redline/strikeout version of changes that the staff was considering making to Enclosure 1 of the September 22, 2016, white paper regarding the staff's other natural hazards assessment

2) a redline/strikeout version of changes that the staff was considering making to Enclosure 2 of the September 22, 2016, white paper regarding the staff's ongoing assessment of natural hazards.

3) a new proposed Enclosure 4 to the staff's September 22, 2016, white paper that provides a description and disposition of the ACRS member comments from the October 19, 2016, ACRS Fukushima Subcommittee meeting.

No changes were identified in Enclosure 3 of the September 22, 2016, white paper as a result of the October 19, 2016, ACRS Fukushima Subcommittee meeting.

Please direct any inquires to me at 301-415-1132 or Joseph.Sebrosky@nrc.gov

Enclosures:

1) Redline Strikeout Showing Potential Changes to the NRC staff's assessment of Natural Hazards other than Seismic and Flooding

2) Redline Strikeout Showing Potential Changes to the NRC staff's Ongoing Assessment of Natural Hazards

3) Draft Enclosure 4 Providing a Description and Disposition of ACRS Member Comments from the ACRS October 19, 2016, ACRS Fukushima Subcommittee Meeting

2) a redline/strikeout version of changes that the staff was considering making to Enclosure 2 of the September 22, 2016, white paper regarding the staff's ongoing assessment of natural hazards.

3) a new proposed Enclosure 4 to the staff's September 22, 2016, white paper that provides a description and disposition of the ACRS member comments from the October 19, 2016, ACRS Fukushima Subcommittee meeting.

No changes were identified in Enclosure 3 of the September 22, 2016, white paper as a result of the October 19, 2016, ACRS Fukushima Subcommittee meeting.

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Evaluation of Natural Hazards other than Seismic and Flooding

Contents

1.0. Summary

As described in SECY-15-0137, “Proposed Plans for Resolving Open Fukushima Tier 2 and 3 Recommendations,” dated October 29, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15254A008), and SECY-16-0074, “Assessment of Fukushima Tier 2 Recommendation Related to Evaluation of Natural Hazards other than Seismic and Flooding” (ADAMS Accession No. ML16102A297), the staff undertook a series of screening-type evaluations to determine if there is a need to take additional regulatory action to address external hazards other than seismic and flooding ~~warranted~~. The screening-type evaluations for external hazards other than seismic and flooding cover a variety of potential natural events that were either: (1) not addressed within existing licensing basis documents (e.g., final safety analysis reports), or (2) calculated to be more severe than described in licensing basis documents when reevaluated using present~~-~~-day information and methodologies.

In assessing whether the NRC should take additional regulatory action ~~is warranted~~, the staff took a holistic approach ~~considering~~that considered the likelihood of the event, the assumed severity of the event, and the plant’s ability to respond to the event. When evaluating the plant’s ability to respond, the staff considered both the protection provided by structures, systems and components (SSCs) in pre~~-~~-Fukushima configurations and capabilities that have been added as part of post-Fukushima upgrades. The primary post-Fukushima upgrade relevant to this analysis is the additional capabilities required by Order EA-12-049, “Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events,” dated March 12, 2012 (ADAMS Accession No. ML12054A735). The ~~staff’s~~staff performed evaluations ~~were performed~~ using guidance such as Management Directive 8.4, “Management of Facility-Specific Backfitting and Information Collection,” to determine if the agency was justified in taking additional regulatory actions ~~were justified~~.

The NRC divided the review process into the following four tasks:

1. Define natural hazards other than seismic and flooding to determine those hazards that could potentially pose a threat to nuclear power plants and perform a screening to determine which of those should be reviewed generically. As part of this task, the staff also screened hazards for additional reviews if new information or guidance was issued ~~since~~after the plant received its operating license.

2. Determine and apply screening criteria to remaining hazards from Task 1 and appropriately exclude certain natural hazards from further generic evaluations, or exclude some plants from considering certain hazards. Examples of screening criteria include conservatism in design, low frequency of occurrence of a given hazard, and available warning time.

3. Perform a technical evaluation to assess the need for additional actions if the hazard or plant was not screened out generically in Task 2.

4. ~~As discussed in SECY-15-0137,~~ Determine if the ~~last task in the process would be for the staff~~agency needs to ~~determine if~~take additional actions, such as a plant-specific backfit~~, are needed.~~.

The Commission approved the resolution plan for this issue in the staff requirements memorandum (SRM) to SECY-15-0137, dated February 8, 2016 (ADAMS Accession No. ML16039A175), and directed the staff to provide the Commission the results of Task 2 by the end of May 2016.

As directed by the Commission in SRM to SECY-15-0137, in SECY-16-0074 the staff provided the Commission with the results of Task 2 of its evaluation. As discussed in SECY-16-0074, the staff's assessment performed in accordance with Task 1 screened out all natural hazards (other than seismic and flooding, which are being addressed separately as part of an ongoing activity) with the exception of high winds, extreme ambient temperatures, drought and other low-water conditions, and winter precipitation that results in snow and ice loading on structures. As documented in SECY-16-0074, based on its assessment in accordance with Task 2 of the process, the NRC staff determined that additional regulatory actions are not warranted for extreme ambient temperatures and drought and other low-water conditions. The hazards proceeding to the third task in the screening process include high winds and snow and ice loads. As such, Task 1 and Task 2 activities are complete, as the staff documented in SECY-16-0074.

This ~~paper~~enclosure provides the staff's ~~preliminary~~ assessment for high winds and snow loads, in accordance with Task 3 of the process outlined in SECY-15-0137, and SECY-16-0074. Based on the assessment that follows, the ~~staff's preliminary conclusion is~~staff concludes that additional regulatory actions for high winds and snow loads are not warranted.

2.0. Discussion

As discussed in SECY-16-0074, the staff identified high winds and snow loads for evaluation in accordance with Task 3 of the process described above. The staff made this decision in part because the NRC had developed new regulatory guidance ~~was developed~~ for ~~these hazards since~~high winds and snow loads after the majority of the currently operating reactors received their operating licenses. The purpose of the Task 3 evaluation is to determine if application of the new guidance to currently operating plants would result in identification of the need for additional regulatory action for these plants, such as a plant-specific backfit.

Tornado and Hurricane Missile Loads

Many of the currently operating plants were licensed before the 1975 version of ~~the,~~ "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition (NUREG-0800, formerly issued as NUREG/75-087)."[1] As such, the staff determined that it

[1] Both current and previous versions of the SRP are publicly available in ADAMS and can be accessed at the following ~~web~~Web address: http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/

would be appropriate to review the design-basis tornado missile protection for these older plants against the current ~~standard review plan~~Standard Review Plan (SRP) and Regulatory Guide (RG) 1.76, “Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants,” Revision 1, dated March 2007 (ADAMS Accession No. ML100541776). The NRC staff also reviewed current operating plants that were licensed against the 1975 version of the ~~Standard Review Plan (~~SRP~~)~~ using the current version of the SRP and RG 1.76, Revision 1.

The staff determined that additional review of hurricane-driven missiles was warranted because of recently issued guidance in this area. ~~In~~Specifically, in October 2011 the staff issued RG 1.221, “Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants” (ADAMS Accession No.~~-~~ ML110940300). RG 1.221 notes that, because of the potential size of a hurricane, hurricane-driven missiles can be subjected to high winds throughout their trajectory~~, resulting in higher missile speeds.~~. In contrast, for a tornado, the wind field is smaller, so tornado-driven missiles are subjected to the strongest winds only at the beginning of their flight. This results in the same missile potentially having a higher maximum velocity in a hurricane wind field than in a tornado wind field with the same maximum wind speed.

~~The~~Section 2.1 of this enclosure provides the staff’s evaluation of high wind hazards~~ is provided in Section 2.1~~.

Snow and Ice Loads

On June 23, 2009, the staff issued interim staff guidance (ISG) DC/COL-ISG-007, “Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures” (ADAMS Accession No. ML091490556). ~~This~~The agency issued this guidance ~~was issued~~ for new reactor reviews ~~since~~because the existing guidance in NUREG-0800 did not provide specific approaches to consider snow loads at ground and roof levels due to normal and extreme winter precipitation events for the design of seismic Category I structures. The staff determined it was appropriate to advance this external natural event through the screening process because the recent updated guidance provides approaches for considering snow loads that were not used when some of the operating plants were initially licensed.

~~The~~Section 2.2 of this document provides the staff’s evaluation of snow and ice loads~~ is provided in Section 2.2~~.

2.1. Evaluation of High Winds

The staff’s evaluation of high wind hazards is broken into five parts:

1. a comparison of current tornado and hurricane guidance to previous guidance used to license the currently operating reactor fleet,

2. a discussion of the licensing basis for the currently operating reactor fleet~~,~~

3. insights from recent inspection findings related to tornadoes that led to the generation of a generic communication~~,~~

4. an evaluation comparing results from analyses completed by the staff using current guidance against the licensing basis of operating reactors, and

5. the NRC staff's preliminary conclusion for its evaluation of tornado and hurricane winds.

2.1.1. Comparison of Current Guidance to Previous Guidance for Tornado and Hurricane Missile Protection

To characterize the change in missile protection requirements for nuclear power plants, the NRC staff compared the current guidance to the guidance in place during the licensing of operating plants. The existing regulatory guidance documents that the staff used are as follows:

- Tornado Missiles
  - RG 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," Revision 1, March 2007 (ADAMS Accession No. ML070360253)
  - RG 1.76, Revision 1, is based on tornado hazard curves provided in NUREG/CR-4461, "Tornado Climatology of the Contiguous United States" (ADAMS Accession No. ML070810400)
- Hurricane Missiles
  - RG 1.221, "Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plant," October 2011 (ADAMS Accession No. ML110940300)
  - RG 1.221 is based on data provided in NUREG/CR 7005, "Technical Basis for Regulatory Guidance on Design Basis Hurricane Wind Speeds for Nuclear Power Plants," December 2009 (ADAMS Accession No. ML11335A031) and NUREG/CR 7004, "Technical Basis for Regulatory Guidance on Design-Basis Hurricane-Borne Missile Speeds for Nuclear Power Plants," February 2011 (ADAMS Accession No. ML11341A102)

The NRC staff reviewed both RG 1.76, Revision 1, and RG 1.221,[2] because improved understanding and enhanced models have indicatedindicate that for some sites, hurricane winds, (which often have lower speeds than design basis tornado winds,) may produce more intense missiles than tornado winds. RG 1.221 notes that because the size of the hurricane zone with the highest winds is large relative to the size of the missile trajectory, the hurricane missile is subjected to the highest wind speeds throughout its trajectory. In contrast, the tornado wind field is smaller, so the tornado missile is subject to the strongest winds only at the beginning of its flight. This results in the same missile having a higher maximum velocity in a hurricane wind field than in a tornado wind field witheven if both have the same maximum wind

[2] The staff also reviewed RG, 1.117, "Protection Against Extreme Wind Events and Missiles for Nuclear Power Plants," Rev 2 (ADAMS Accession No. ML15356A213). This RG notes that RG 1.76 tornado wind speeds may not bound hurricane wind for certain portions of the Atlantic and gulf coasts and notes for these cases that structures, systems and components should also be designed for hurricane-generated missiles as defined in RG 1.221. Because RG 1.117, Rev 2 does not provide wind or missile speeds design criteria the staff determined that it did not need to be reviewed further for this evaluation.

speed. ThusIn other words, even though the maximum wind speed in a hurricane may be boundbounded by the maximum tornado wind speed, the missile generated from a hurricane may reach a higher maximum speed than the tornado missile.

The following example illustrates the changes in the missile spectrum characteristics over time:

- Based on Standard Review Plan Section 3.5.1.4, "Missiles Generated by Natural Phenomena," Revision 2, dated July 1981, one of two missile spectrums could be used by licensees. SRP Section 3.5.1.4 previously provided the missile spectrum and velocities to be considered in a plant's design. The missile spectrum and velocity profiles were moved to RG 1.76, Revision 1, during an update to SRP 3.5.1.4. Regardless, many of the currently Regardless, many of the currently operating plants were designed following the guidance of an earlier version of the SRP that assumed either Spectrum I or Spectrum II missiles. Both spectrums include consideration of automobile missiles:

operating plants were designed to the earlier version of the SRP that assumed either Spectrum I or Spectrum II missiles. Both spectrum include consideration of automobile missiles:

- Spectrum I missiles – a: an 1800--kilograms (3970--pound) automobile in the region of the United States susceptible to tornadoes that are capable of generating the highest wind speed would have a velocity of 56 meters per second (126 miles per hour).

- Spectrum II missiles— a: an 1810--kilogram (3990--pound) automobile would have a velocity of 59 meters per second (132 miles per hour).

- This regulatory guide contained additional guidance that allowed applicants who were required to design to the 1975 version of the SRP at the construction permit stage to have the option at the operating licensing stage of showing conformance with their original commitment. The 1975 version of the SRP included an automobile of 4000 pounds having a velocity of 100 feet per second (68 miles per hour).

- Based on RG 1.76, Revision 1, a 4000--pound automobile in the region of the United States susceptible to tornadoes that are capable of generating a maximum wind speed of 230 miles per hour would have a characteristic velocity of 135 feet per second (93 miles per hour).

- Based on RG 1.221, a 4000 pound automobile in a 235 mile--per--hour hurricane would have a characteristic velocity of 156 miles per hour.

Based on the example above, the staff notes that depending on the time a plant was licensed, it could have a range of assumed automobile-type missile speeds, including:

- In some cases the automobile missile speeds went down from 126 miles per hour to 93 miles per hour based on comparing the 1981 SRP Spectrum I missile characteristic to the current RG 1.76, Revision 1, characteristics for tornadoes.

- Also, the automobile-type missile speed went down from 132 miles per hour to 93 miles per hour based on comparing 1981 SRP Spectrum II missile characteristics to current RG 1.76, Revision 1, guidance.

- Based on the options provided in the 1981 version of the SRP, if plants used the option of demonstrating compliance with commitments made at the construction permit stage, an automobile missile velocity could increase from 68 miles per hour to 93 miles per hour based on comparing this option to the guidance in RG 1.76, Revision 1.

- However, the automobile speed increased from 126 miles (Spectrum I missile characteristics) or 132 miles per hour (Spectrum II missile characteristics) to 156 miles per hour based on comparing the 1981 SRP characteristics to the current RG 1.221 characteristics for hurricanes.

Because of the various options provided above and noting that some plants were licensed

before the 1975 version of the SRP existed, the staff performed a review of the licensing basis for the current operating fleet and compared the licensing basis automobile missile speed (if applicable) to that found in RG 1.76, Revision 1. Based on this review, the staff found that approximately two~~-~~-thirds of plants have design-basis automobile missile speeds lower than that ~~found in~~suggested by the latest regulatory guidance (i.e., Revision 1 to RG 1.76 or RG 1.221).

In addition to the automobile missile described above, other missiles were identified in RG 1.76 and RG 1.221. RG 1.76, Revision 0, and the 1975 version of SRP 3.5.1.4 had six different missile characteristics, while the RG 1.76, Revision 1, and RG 1.221 have three. Regardless of the version of the regulatory guidance, the missile characteristics that were chosen included at least one of the following: (1) a massive high~~-~~ kinetic~~-~~ energy missile that deforms on impact (i.e.,~~-~~ an automobile), and (2) a rigid missile that tests penetration resistance. Later guidance provided a small rigid missile of a size sufficient to pass through openings in protective barriers. Below is a comparison of the missile characteristics of the various versions of the regulatory guidance. Note that different speeds were assumed for each type of missile, based on the corresponding tornado or hurricane wind speed characteristics.

Table 1: Comparison of Missile Characteristics in Versions of Regulatory Guidance

Missile Type	Tornadoes		Hurricanes
	RG 1.76, Revision 0, and SRP 3.5.1.4 1975 Version	RG 1.76, Revision 1	RG 1.221
Massive high-kinetic energy missile that deforms on impact	Automobile	Automobile	Automobile
A rigid missile that tests penetration resistance	• Wood plank~~,~~: 4 inches ~~x~~by 12 inches ~~x~~by 12 feet~~ long~~, weighing 200 lbs • Steel pipe~~,~~: 3 inches in diameter~~, 10~~ by10 feet~~ long~~, weighing 78 lbs • Steel pipe~~,~~: 6 inches in diameter by 15 feet ~~long~~, weighing 285 lbs • Steel pipe~~,~~: 12 inches in diameter~~,~~ by 15 feet~~ long~~, weighing 743 lbs • Utility pole~~,~~: 13.5 inches in diameter~~,~~ by 35 feet ~~long~~, weighing 1490 lbs	Schedule 40 pipe: 6.625 inches in diameter ~~x~~by 15 ft~~ long~~, weighing 287 lbs	Schedule 40 pipe~~,~~: 6.625 inches in diameter ~~x~~by 15 ft~~ long~~, weighing 287 lbs

Missile Type	Tornadoes		Hurricanes
	RG 1.76, Revision 0, and SRP 3.5.1.4 1975 Version	RG 1.76, Revision 1	RG 1.221
A small rigid missile of a size sufficient to pass through openings and protective barriers	Not applicable	Solid steel sphere: 1 inch in diameter, weighing 0.147 lbs	Solid steel sphere: 1 inch in diameter, weighing 0.147 lbs

Conclusion

For some plants, although the speed of the tornado may have decreased based on a comparison of the licensing basis to current guidance found in RG 1.76, Revision 1, the speed of the automobile missile may have increased. In addition, for some coastal sites, hurricane~~-~~-driven automobile missile speeds increased from that found in the current licensing basis to ~~that~~those found in RG 1.221.

2.1.2. Licensing Basis for Currently Operating Reactors

Currently operating power plants have been analyzed against tornado missiles. The extent of the evaluation conducted for tornado missiles varies and is based on when the plant was originally licensed. However, as described above, hurricane-generated missiles were not specifically modeled as they were previously considered to be bounded by tornado events.

In 1977, the NRC initiated the Systematic Evaluation Program (SEP) to review the designs of 51 older, operating nuclear power plants. The SEP was divided into two phases. In Phase I, the staff defined 137 issues for which regulatory requirements had changed enough over time to warrant an evaluation of those plants licensed before the issuance of the 1975 version of SRP. In Phase II, the staff compared the designs of 10 of the 51 older plants to the SRP issued in 1975. Based on these reviews, the staff identified 27 of the original 137 issues that required some corrective action at one or more of the 10 plants that were reviewed. The staff referred to this smaller list as the SEP lessons-learned issues and concluded that they would generally apply to operating plants that received operating licenses before the ~~SRP was~~NRC issued the SRP in 1975. The staff used NUREG-1742, “Perspectives Gained from the Individual Plant Examination of External Events (IPEEE~~),” ~~)” (available at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1742), as an aid in identifying the current fleet of operating units that ~~were~~the staff evaluated under the SEP. NUREG- 1742, Table 5.6, “GSI 156, Systematic Evaluation Program,” provides a listing of plants that ~~were~~the staff evaluated under the SEP.

Plants Included in the Systematic Evaluation Program

The staff used its generic safety program to track the resolution of the SEP issues. As documented in NUREG-0933, “Resolution of Generic Safety Issues” (available at: http://nureg.nrc.gov/sr0933~~),”~~”), the staff identified the resolution of this issue as Generic Safety Issue (GSI) 156: “Systematic Evaluation Program.” GSI 156 was comprised of various issues the staff identified under the SEP program, including Issue 156.1.5 related to protection against

tornadoes. The objective of GSI 156.1.5~~:~~ “Tornado Missiles,” was to ensure that safety-related SSCs can withstand the impact of an appropriate postulated spectrum of tornado-generated missiles. At the time, the NRC’s focus was on evaluating plants that received operating licenses before 1976 to ensure they were adequately protected against tornado-generated missiles~~;~~. The NRC was particularly interested in ~~particular,~~ those reviewed before 1968 ~~when~~(which was the year criteria on tornado protection were first developed~~.~~).

As a result of the SEP review, all current operating plants have been analyzed for tornado-generated missiles to some degree as reflected in the current version of the plant’s ~~Updated Final Safety Analysis Report~~updated final safety analysis report (UFSAR) or in the IPEEE evaluation. The criteria used to evaluate these plants vary greatly and in some cases consist of two missiles (e.g., a rigid steel pipe and a telephone pole) and in other cases rely on probabilistic risk assessments (PRA) methodologies. In some cases plants were backfit to provide additional tornado missile protection or took steps as a result of insights gained from their IPEEEs to provide more robust protection from tornado missiles.

Later Generation Plants

The staff reviewed the tornado-missile spectrum and velocities assumed for plants that were licensed in accordance with the 1975 version of the SRP and, in general, found the following:

- For rigid missiles that test penetration resistance, these plants have robust tornado missile protection design basis requirements for their safety-related SSCs when compared to the newer criteria found in RG 1.76, Revision 1, and RG 1.221.

- However, speeds for tornado-generated automobile-type missiles increased by around 50 percent for many sites based on RG 1.76, Revision 1, as compared to the 1975 version of the SRP, and based on RG 1.221 criteria for hurricanes, automobile missile speeds for coastal sites are generally not bounded by the tornado-generated automobile missile speeds found in the 1975 version of the SRP.

The staff notes that some of the plants performed a PRA of tornadoes,[3] which indicated that based on conformance with the 1975 version of the SRP or completion of a PRA, these plants were adequately protected against the effects of tornadoes. The NRC staff considered IPEEE insights when evaluating this issue for later generation plants.

Conclusion

Tornado missile protection for operating power plants has been reviewed under previous NRC initiatives to determine the appropriate design basis for the plant:

[3] The majority of plants that were reviewed against the 1975 version of the SRP did not perform a high~~-~~-winds PRA. The IPEEE process allowed licensees to forgo a high-winds PRA if the plant was reviewed against this version of the SRP and plant walkdowns confirmed the licensing basis assumptions associated with this regulatory guidance.

- Plants licensed before the 1975 version of the SRP was available were evaluated in accordance with the SEP process.

- Tornado missile protection for later generation plants was reviewed in accordance with the guidance found in the 1975 version of the SRP.

- During the IPEEE process, licensees evaluated high winds, including tornado missile protection, and verified through reviews and walkdowns that their plant met the guidance found in the 1975 version of the SRP or alternatively performed a ~~probabilistic risk assessment~~PRA.

As a result of these regulatory programs, a number of licensees took actions to upgrade tornado missile protection, as appropriate.

2.1.3. Insights from Regulatory Issue Summary 2015-06, "Tornado Missile Protection"

To further assess the risk posed by tornadoes, the NRC staff considered insights from the agency's recent assessments and enforcement discretion related to tornado missile protection. The background and the risk insights related to this issue are summarized below.

The SSCs of nuclear power plants are designed to withstand natural phenomena, such as earthquakes, tornadoes, hurricanes, and floods, without the loss of capability to safely maintain the plant. In general, the design bases for these SSCs reflect: (1) appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated; (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena; and (3) the importance of the safety functions to be performed.

In designing SSCs for the consequences of design-basis tornadoes, tornado-generated missiles must be considered. The specific tornado missile protection criteria for each nuclear power plant are contained in the individual plant's licensing basis. There are several design methods typically used for protecting SSCs from tornado-generated missiles. These include placing the SSC within a structure designed to withstand tornado missiles, designing the SSC to withstand the tornado missile, or installing a barrier designed to withstand tornado missiles around the SSC. In addition to physical design methods, the NRC allows the use of probability analysis to demonstrate that the probability of a tornado-generated missile striking a component required to safely maintain the plant is sufficiently low that no additional measures are required.

Most facilities use deterministic methods when evaluating protection from tornado-generated missiles and as a basis for complying with these regulations. However, NUREG-0800, Section 3.5.1.4, Revision 0, includes acceptance criteria that permit the use of an alternative approach if it can be demonstrated that the probability of strike to unprotected essential safety-related features is sufficiently small. Some licensees used this alternative approach by incorporating the NRC-approved, ~~EPRI~~Electric Power Research Institute-developed TORMIS methodology, or another NRC-approved ~~probabilistic risk assessment~~PRA methodology

~~via~~through the license amendment process. Over the past several years, licensees and the NRC have identified facilities that have not conformed to their licensing basis for tornado-generated missile protection and are therefore not in compliance with applicable regulations. ~~These noncompliances have been~~The staff has documented these noncompliances in NRC inspection reports and in some cases, these noncompliances have resulted in license amendment requests. Some of the nonconforming SSCs included Technical Specification(TS~~-~~)-required equipment (e.g., emergency diesel generator exhaust header/ductwork, pipe risers, fan motors, etc.), which required an operability determination. In cases where the licensee concluded that the TS-required SSC was inoperable, the licensee was required to complete any actions specified by the TS.

As a result of ~~non-conformances~~nonconformances, the NRC issued Regulatory Issue Summary (RIS) 2015-06, "Tornado Missile Protection" (ADAMS Accession No. ML15020A419). The intent of the RIS was to reinforce the need to conform to a plant's current, ~~site~~plant-specific licensing basis for tornado-generated missile protection, and provide examples of recently-identified failure to conform to a plant's tornado-generated missile licensing basis.

~~The~~ RIS 2015-06 notes that the NRC may grant enforcement discretion in accordance with Enforcement Guidance Memorandum (EGM) 15-002, "Enforcement Discretion for Tornado Missile Protection Noncompliance" (ADAMS Accession No. ML15111A269), to licensees who are in ~~non-compliance~~noncompliance with their plant-specific licensing bases for issues related to tornado missile protection. EGM 15-002 provides a basis for granting enforcement discretion, including that tornado missile scenarios that may lead to core damage are generally low probability events. For a tornado-missile-induced scenario to occur, a tornado would have to hit the site and result in the generation of missiles that would hit and fail vulnerable, unprotected safety-related equipment and/or unprotected safety-related subcomponents in a manner that is nonrepairable and nonrecoverable. In addition, because plants are designed with redundancy and diversity, other trains may be available to achieve safe shutdown if a tornado missile were to impact a single train of a safety system.

~~The~~ EGM 15-002 included a generic risk analysis of potential tornado missile protection noncompliances to examine the risk significance of these scenarios. This assessment (ADAMS Accession No. ML14114A556) uses tornado hazard curves to provide a bounding estimate of the initiating event frequency of a damaging tornado missile and then it uses PRA tools to analyze the failure of SSCs that have typically been found to not meet the licensing basis for tornado missile protection for selected plant facilities. This analysis used tornado hazard curves provided in NUREG/CR-4461, "Tornado Climatology of the Contiguous United States," Revision 2 (ADAMS Accession No. ML070810400), and Regulatory Guide 1.76, "Design-Basis Tornado and Tornado Missile for Nuclear Power Plants," Revision 1 (ADAMS Accession No.~~-~~ ML070360253).

The generic risk analysis performed by the Office of Nuclear Reactor Regulation (NRR), Division of Risk Assessment, concluded that the ~~non-conformance~~nonconformance with tornado missile protection requirements does not rise to the level of an adequate protection concern or require immediate plant shutdown because the risk is bounded by the initiating event frequency of 4E-4 per year even in the most severe tornado region, which is well below the 1E-3 per year threshold provided in NRR Office Instruction LIC-504, "Integrated Risk-Informed Decision-

Making Process for Emergent Issues." Therefore, the EGM concluded that enforcement discretion of up to 5 years, accounting for differences in initiating event frequency based on the geographical location of the plants, will not impose significant additional risk to public health and safety. The EGM notes that the enforcement discretion will expire 3 years after the issuance date of RIS 2015-06 for plants of a higher tornado missile risk (Group A plants) and 5 years after RIS issuance for plants of a lower tornado missile risk (Group B plants).

Therefore, regarding the tornado licensing basis for operating plants:

- The staff notes that the tornado missile protection design basis requirements are generally conservative.
- The staff has taken advantage of current licensing processes to ensure that licensees continue to meet their tornado missile protection design basis by alerting licensees to issues the NRC has identified in various inspections as documented in RIS 2015-06.
- EGM 15-002 provides a basis for granting enforcement discretion that notes in general tornado missile scenarios that may lead to core damage are low probability events, because safety-related SSCs are typically designed to withstand the effects of tornadoes. In addition, because plants are designed with redundancy and diversity, other trains may be available to achieve safe shutdown if a tornado missile were to impact a single train of a safety system.

2.1.4 Evaluation of Current Operating Plants' Tornado Wind Protection Against Current Tornado and Hurricane Guidance

The risk study discussed above indicates that the risk from tornadoes is low. Nevertheless, the NRC staff performed a deterministic evaluation to identify insights based on its review of current tornado and hurricane guidance against the licensing basis for current operating plants. The staff's deterministic review process had three parts:

- assessment of wind loads based on wind speeds from current guidance in RG 1.76, Revision 1, and RG 1.221, as compared to the current licensing basis wind speed loads for operating plants;
- assessment of the ability of tornado or hurricane missiles to damage structures protecting safety-related SSCs based on current guidance in RG 1.76, Revision 1, and RG 1.221, as compared to the current licensing basis missile design spectrum for operating plants; and
- assessment of structural loads from a large missile (i.e., an automobile) based on current guidance in RG 1.76, Revision 1, and RG 1.221, as compared to the margin provided in current licensing basis structural design-basis.
    - For this assessment the NRC staff reviewed the automobile missile structural loads from current guidance as compared to those used to establish the current licensing basis for the plant. In cases where the use of current-day guidance resulted in a potentially more damaging missile than addressed in a plant's licensing basis, the staff then assessed the new information against the structural margin in the operating power plant. The NRC staff believesperformed a margin assessment of structural loads from an automobile missile impact is a logical first stepas one of the steps in determining if additional regulatory action might be warranted to request additional information or require

licensees for current operating plants to perform analyses using RG 1.76, Revision 1, and RG 1.221 guidance.

2.1.4.1. High Wind Velocity Pressure Loads

To assess wind velocity pressure loads, the staff relied on licensees' UFSARs and on licensees' integrated plans provided in response to the mitigating strategies Order EA-12-049. Licensees' UFSARs typically provide a discussion of the design-basis tornado wind speed loads assumed in the structural analysis. The ~~licensee's~~licensees' integrated plan response to Order EA-12-049 included a discussion of whether the plant met the criteria for a high wind evaluation.

Figure 2.1.4-1, "Comparison of Current Design Basis Tornado Wind Speeds vs Updated Tornado and Hurricane Wind Speed," located at the endo of this enclosure, plots the data that the NRC staff collected. As noted with the blue shade plot in Figure 2.1.4-1, the majority of nuclear power plants were designed for a tornado wind speed of 360 miles per hour. Figure 2.1.4-1 shows that for the majority of the sites, the RG 1.76, Revision 1, tornado wind speeds (shown as the purple line in the plot) are less than those assumed in the design of the plant. Regarding hurricanes, Figure 2.1.4-1 shows that not every plant has an associated hurricane wind speed (shown by the red bars in the plot). This is consistent with the guidance found in RG 1.221 that does not provide hurricane wind speeds for plants that are far inland because of the assumption that the tornado wind speed will bound a hurricane wind speed for these sites. Regardless, Figure 2.1.4-1 shows that for the majority of sites, the hurricane wind speed is bounded by the design-basis tornado wind speed provided in the UFSAR.

The staff notes that for one site (Ginna), on the far right of the horizontal axis in Figure 2.1.4.1-1, the design-basis tornado wind speed is less than that found in RG 1.76, Revision 1 (for tornados), or RG 1.221 (for hurricanes). One of the ~~sites~~site's design basis tornado wind speed is not the same for all safety-related SSCs (Oyster Creek). In addition, not every ~~site~~plant was licensed with a design-basis tornado wind speed (Nine Mile Point 1 and Indian Point 2).

The staff reviewed the IPEEEs for the four ~~sites~~plants whose tornado design-basis wind speed does not exist or whose tornado design-basis wind speed is lower than the RG 1.76, Revision 1, tornado wind speed or the RG 1.221 hurricane wind speed. The safety evaluations associated with the IPEEEs noted core damage frequencies (CDFs) due to high winds for two of the sites to be less than 5E-6 per year for high winds (Oyster Creek and Nine Mile Point 1). One of the sites had a CDF due to high winds of 3E-5 per year with the ~~dominate~~dominant contributor being a loss of all alternating current (AC) power resulting in loss of reactor coolant pump (RCP) seal cooling (Indian Point 2). For this site, the staff notes the low CDF contribution and also notes that loss of AC power resulting in loss of RCP seal cooling is a scenario that is addressed as part of the mitigating strategies order. The last site (Ginna) did not calculate a CDF, instead noting that as part of the SEP review it made several modifications to the plant to increase the protection from high winds. Based on walkdowns, coupled with a review of the SEP results, the licensee for Ginna concluded that the CDF was less than 1E-6 in accordance with Section 5.2.4, "Determine if the Hazard Frequency is Acceptably Low," of NUREG 1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities" (ADAMS Accession No. ML063550238).

The staff concludes that for the majority of sites, the design basis tornado wind speed bounds updated wind speed guidance provided in RG 1.76, Revision 1, and RG 1.221. Therefore, for these sites the staff has determined that additional regulatory action is not warranted in this area. For the four sites whose design basis tornado wind speed does not bound wind speed guidance provided in RG 1.76, Revision 1, and RG 1.221, the staff performed a review of the IPEEEs to determine if additional regulatory action is needed. Based on the insights from the IPEEEs ~~and the additional capability provided in response to the mitigation strategies order,~~for these sites the staff ~~has~~ determined that additional regulatory actions would likely not be justified. As described in Section 2.1.4.4 of this report the staff considered additional safety insights to determine if additional regulatory action are ~~not~~ warranted to address high wind velocity pressure loads.

2.1.4.2. Tornado and Hurricane ~~Missile's Ability To Penetrate Structures~~Penetrating Missile Evaluation

In evaluating ~~missile hazards, the staff compared tornado- or hurricane~~a wind-borne ~~missiles believed to be able~~missile's capability to penetrate ~~concrete walls in place~~structures that are designed to protect safety-related SSCs~~.~~, the staff compared design-basis missile characteristics for the current operating fleet to the design-basis missile characteristics from RG 1.76. Revision 1, and RG 1.221. The staff ~~used these calculations to determine~~calculated the minimum concrete thickness needed to prevent perforation of the structure by the bounding tornado missile in the current licensing basis for operating plants, as described in the UFSAR, against the bounding missile's minimum concrete thickness to prevent perforation for either tornadoes or hurricanes based on RG 1.76, Revision 1, or RG 1.221. The staff used this method of comparison because the tornado missiles described in the operating plant UFSARs differ from the missiles described in RG 1.76, Revision 1, and RG 1.221. Converting a missile's energy and contact area to a concrete penetration depth allows for comparison of the existing missile protection requirements for operating plants against current-day regulatory guidance.

The staff used a formula to convert a missile's mass, velocity, and contact area into a concrete penetration depth based on guidance found in SRP Section 3.5.3, "Barrier Design Procedures," March 2007 (ADAMS Accession No. ML070570004). SRP 3.5.3 notes that several empirical equations, such as the modified National Defense Research Council equation, proposed in "A Review of Procedures for the Analysis and Design of Concrete Structures to Resist Missile Impact Effects," by R.P. Kennedy, Nuclear Engineering and Design (the Kennedy paper), are available to estimate missile penetration into concrete.

Figure 2.1.4-2 is an NRC staff-developed plot using the Kennedy paper formula to develop minimum concrete thickness to prevent perforation based on design-basis tornado missile characteristics found in a plant's UFSAR as compared to the minimum concrete thickness to prevent perforation when struck by a schedule 40 pipe based on guidance in Revision 1 to RG 1.76 or RG 1.221 guidance (whichever results in the higher velocity missile). Figure 2.1.4-2 presents concrete thicknesses that are calculated values at various sites based on tornado missile characteristics found in the UFSAR and does not represent actual value of concrete thickness of safety-related structures at a given site. The staff performed this calculation to use

as one of the screening tools to aid it in determining whether additional regulatory action is warranted related to tornado and hurricane missile protection.

Based on this assessment, the staff found that the majority of the current operating plants have design-basis missile characteristics that bound the missile characteristic of the rigid pipe found in RG 1.76, Revision 1, or RG 1.221. There are six sites (Brunswick, D.C. Cook, Saint Lucie, Robinson, Turkey Point, and Ginna) for which this is not the case. Four of these six sites have a ratio of the calculated penetration depth for the RG 1.76, Revision 1, or RG 1.221 missile characteristic that is within a factor of 1.5 or less of the UFSAR design basis value. Based on structural margins associated with safety-related structures, the staff believes it is unlikely that safety-related SSCs will fail at the higher velocities assumed for the schedule 40 pipe in RG 1.76, Revision 1, or RG 1.221.

Two of the 6six sites have a ratio that is higher than 1.5. (Turkey Point and Ginna). The staff reviewed the IPEEEs for these two sites. For one of the sites (Turkey Point), the CDF waslicensee calculated the CDF to be less than 1E-6 from tornadoes. Tornado-induced failure of the condensate storage tanks and the failure of a fossil-fired smoke stack falling on one of the units' emergency diesel generators were found to dominate all other tornado hazards. The staff notes that the risk based on the calculated tornado CDF of 1E-6 is small. In addition, although the contributor of tornado-induced failure of the condensate storage tank remains, the failure of the fossil-fired smoke stack falling is no longer germane because the smoke stack is no longer needed and is being removed from the site. The other site (Ginna) is discussed above.in Section 2.1.4.1 of this report. The licensee for Ginna did not calculate a CDF, instead noting that as part of the SEP review, it made several modifications to the plant to increase the protection from high winds. Based on walkdowns coupled with a review of the SEP results, the licensee concluded that the CDF was less than 1E-6 in accordance with Section 5.2.4 of NUREG 1407.

In addition to the six sites whose missile penetration capability is not bounded by the FSAR design basis value, two sites do not have a tornado design basis tornado and associated missile spectrum (Indian Point 2 and Nine Mile Point 1). The results of the staff's review of the IPEEE for these two sites are discussed in the previous section.

In summary, the staff reviewed the IPEEEs for the eight combined sites whose calculated missile penetration capability is not bounded by the value calculated by the staff using the UFSAR tornado missile characteristics to determine if a basis for additional regulatory action to address missile penetration protection exists. Highlights from the staff's review of the IPEEEs include:

- Five of the eight sites had a calculated CDF due to high winds of less than 3E-5 per year.

- Three of the eight sitesites performed a bounding CDF analysis based on compliance with the 1975 version of the SRP and concluded that their CDFs due to high winds was less than 1E-6 per year.

The staff compared the CDF values to those found in NUREG/BR-0058, Revision 4, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission" (available at: http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0058/br0058r4.pdf).

NUREG/BR-0058, Section 3.3.1 provides a process for evaluating whether a proposed regulatory action to prevent or reduce the likelihood of sequences that can lead to core damage should be pursued. If a calculated change in CDF is less than 1E-5, then it is recommended that no action be pursued. The staff notes that the eight sites who calculated a tornado-induced CDF fall in this range. The staff also notes that the IPEEE ~~analysis~~analyses, which were performed in the 1990s, ~~does~~do not credit mitigating strategies equipment ~~or~~required by Order EA-12-049or equipment required to comply with loss of large areas of the plant due to fire or explosion in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 50.54(hh)(2~~)~~)), since these requirements were imposed after the ~~IPEEE~~IPEEEs were performed. The staff ~~believes~~notes that if this equipment is credited, the IPEEE calculated values would be even lower.

Therefore, the staff concludes that, for the majority of sites, the design-basis tornado missile characteristic associated with missile penetration depth bounds the missile characteristic for a schedule 40 pipe provided in Revision 1 to RG 1.76 and RG 1.221. For these sites, the staff has determined that additional regulatory action is not warranted in this area. For the eight sites whose tornado or hurricane-~~born~~borne rigid missile design basis speed does not bound rigid missile speed guidance provided in Revision 1 to RG 1.76 and RG 1.221, the staff performed a review of the IPEEEs to determine if additional regulatory action is needed. Based on the insights from the IPEEEs and the additional capability provided in response to the mitigation strategies order, the staff ~~has~~ determined that additional regulatory actions are likely not justified. As described in Section 2.1.4.4 of this report the staff considered additional safety insights to determine if additional regulatory action are warranted to address a tornado or hurricane-borne missile's ability to penetrate structures designed to protect safety-related SSCs.

2.1.4.3. Tornado and Hurricane Automobile Missile Evaluation

The staff assessed the automobile missile loads from a tornado or a hurricane. As indicated above, both ~~tornadoes and~~ hurricanes, and in some instances, tornadoes have the potential to produce more intense automobile missiles than that assumed in previous guidance. The staff notes that the automobile missile can be considered a surrogate for a spectrum of missiles that can be found at a site, including objects like heating, ventilation, and air conditioning units on roof tops.

Figure 2.1.4-3 provides a plot of the 1E-7 tornado and hurricane missile speeds based on RG 1.76, Revision 1, and RG 1.221 guidance, respectively. Figure 2.1.4-3 also provides a plot of 5.9E-4 hurricane-driven automobile missile speeds based on wind speed data from American Society of Civil Engineers (ASCE) 7-10, "Minimum Design Loads for Buildings and Other Structures," and the corresponding automobile missile speed for the given hurricane wind speed from RG 1.221. The staff chose the 5.9E-4 automobile missile speed data because this information was readily available and it is at the frequency that provides useful insights to the staff's consideration of whether additional regulatory actions are warranted based on guidance provided in NUREG/BR-0058 (i.e., while wind speeds from less frequent events may result in higher missile speeds, they would be less likely to result in the need for a plant-specific backfit based solely on event frequency). For many sites RG 1.76, Revision 1, automobile missile speeds for a 1E-7 event are in the 90 miles per hour range and for some coastal sites, the RG 1.221 automobile missile speeds for a 1E-7 event are above 120 miles per hour.

The staff used a conservative approach to assess the impact of the increased automobile missile speed as compared to the current plant's missile protection requirements. The staff used a systematic screening method to assess the potential impact that the updated automobile missile speeds could have on the operating fleet. Current guidance uses the automobile as the most limiting missile for a high-wind scenario. However, some plants were licensed using relatively lower velocities for their automobile missiles (as low as 33 miles per hour). At some sites, the utility pole missile was considered the most limiting impact load in the current licensing basis due to its relatively high weight, large diameter, and high speed. Thus, the automobile missile was not always the most limiting case in the staff's ~~re-analysis~~reanalysis.

The first step in the staff's screening evaluation was to compare the peak force calculated using a plant's UFSAR missile data to the calculated peak force from missiles using current guidance. The staff determined the highest-impact load for each site based on the licensing basis (e.g., tornado-driven automobile or tornado-driven telephone pole). This load was then compared to the load calculated using automobile characteristics from RG 1.76 traveling at either NUREG-4461 tornado missile speeds or NUREG-7005 hurricane missile speeds, whichever was greater.

The initial insights from the comparison indicated that the automobile missile speeds estimated using present-day guidance are higher than similar missiles within the licensing basis for many plants. The difference in estimated missile speeds is mainly driven by the fact that for 1E-7 tornado and hurricane events, the velocity of the automobile was increased by a median factor of two from automobile speeds found in the current operating plants' licensing bases. Thus, the kinetic energy of the automobile was increased by a median factor of four based on the kinetic energy of an object being equivalent to half the mass of an object times the velocity squared. Some UFSARs described automobile-type missiles with higher velocities, but many UFSARs discussed estimated speeds between 50 and 75 miles per hour.

To provide additional context to the missile-resistance capacity of reinforced concrete walls, the staff performed a calculation of representative concrete walls of varying thicknesses to determine the speed at which automobile missile impact loads could be expected to exceed the structural capacity. The staff chose representative reinforced concrete walls that are 12~~-~~-inches, 18~~-~~-inches and 24~~-~~-inches thick. The staff chose this range of thicknesses because safety related structures have a range of concrete thicknesses. For example, service water intake structures and auxiliary ~~building~~buildings typically have concrete thicknesses in the 12 to 18~~-~~-inch range, while containments typically have greater than 24~~-~~-inch thick concrete protecting systems and components.

The staff performed these calculations using ~~a~~ targeted ductility factors of both 10 and 30. Ductility is a measure of the ability of structures/structural elements to deform prior to ultimate failure, once the structure has surpassed its yield strength (i.e., in the inelastic range). The staff calculated a ratio comparing the deformation caused by the impact loading and the representative walls' ultimate deformation, and compared it against the targeted ductility factors. Once the deformation ratio exceeded the targeted ductility factor (10 or 30), the staff assumed the wall had failed. A flexural ductility factor of 10 was chosen because code design requirements for impactive and impulsive loads from the American Concrete Institute limits the

allowable ductility to 10. However, topical report BC-TOP-9A, “Design of Structures for Missile Impact,” suggest that a higher maximum ductility ratios in flexure of up to 30 may be justified; so the staff used that value as a sensitivity case to provide further context to the magnitude of missile speeds expected to be required to cause a structural failure of a reinforced concrete wall. The results of this calculation are shown in the following table.

Table 2: Staff Calculated Automobile Missile Speed to Exceed Ductility Factor for Various Concrete Wall Dimensions

Thickness of Representative Concrete Wall	Automobile Impact Speed to Exceed Ductility of 10 in miles per hour	Automobile Impact Speed to Exceed Ductility of 30
12 inches	110 mph	200 mph
18 inches	180 mph	275 mph
24 inches	240 mph	360 mph

The staff notes that based on the above simplified calculation and assuming a ductility of 10, a 12-inch representative concrete wall would have sufficient structural capacity to withstand the following:

- all of the 1E-7 tornado automobile missile speeds associated with RG 1.76, Revision 1.
- the majority of the 1E-7 automobile missile speeds associated with RG 1.221, noting that the 18 inch wall would have capacity to withstand all 1E-7 hurricane automobile missile speeds.
- all of the 5.9E-4 automobile missile speeds.

Assuming a ductility factor of 30 for the conservative 12-inch wall would bound all 1E-7 tornado and hurricane automobile missile speeds from RG 1.76, Revision 1, and RG 1.221.

Based on the results of the deterministic screening approach, and recognizing that each plant’s licensing basis areis unique, the staff also considered insights from high wind risk studies.

2.1.4.4. Additional Safety Insights

The NRC staff notes that early insights from recent PRAs do not identify extreme tornadoes and hurricanes as dominant risk contributors to a plant’s CDF. Rather, the more common tornado and hurricanes that fail offsite power and damage important non-safety nonsafety-related equipment have been identified as needing further study. This was described in a meeting summary dated May 28, 2015, which (ADAMS Accession No. ML15187A266) for a meeting between the NRC Office of Nuclear Regulatory Research and Applied Research Associates. The meeting summary discusses technical aspects of high wind probabilistic risk methodologies (ADAMS Accession No. ML15187A266). The summary and includes the following insights:

- Challenges exist in the characterization of a hazard curve with respect to straight winds, hurricanes, and tornadoes. Peak wind gusts between 115 and 150 miles per hour would typically represent the range where potential damage to buildings due to debris and structural impacts could be observed. There is a need for stochastic modeling in hazard characterization, given the potentially large uncertainties involved. Two important aspects not typically considered were: (1) consideration of directional wind analysis for vulnerable structures to reduce the level of conservatism in straight winds analysis, and (2) assessment of the impact of rain on plant equipment, as this phenomenon often accompanies high wind events.

- The National Institute of Standards and Technology plans to update current guidance on tornado wind risk, aimed at leveraging new data that became available over the past decade to derive tornado risk maps for the United States. As part of this work, factors affecting hazard modeling, such as the inconsistent reporting of tornadoes across different time periods, path area uncertainties, and the wind speed relationship across commonly used scales (e.g., Fujita and Enhanced Fujita Scale) will be taken into account to better reflect the extremely large epistemic uncertainties associated with tornado hazard modeling.

Based on the early insights from ongoing high wind PRAs and insights gained from the IPEEEs, the NRC staff believes that long-term activities are better focused on updating its PRA tools for high wind events. Examples of this work include the following:

- The NRC identified issues in an August 10, 2015, letter, “User Need Request for Support in the Development and Enhancement of NRC Risk Analysis Tools” (ADAMS Accession No.~~-~~ ML15110A210, non-public). The letter requests that the NRC’s Office of Nuclear Regulatory Research enhance existing tools to make external event analysis more risk informed.

- A September 21, 2011, SRM (ADAMS Accession No. ML112640419) directed the staff to conduct a full-scope comprehensive site Level 3 PRA, as described in SECY-11-0089, “Options for Proceeding with the Future Level 3 Probabilistic Risk Assessment Activities” (ADAMS Accession No. ML11090A041). Southern Nuclear Company volunteered to cooperate with the staff and offered Vogtle Units 1 and 2 to be the subject of this study. This work includes assessments of external hazards and involves the development of high wind PRA.

While the NRC staff believes this work can improve the understanding of the risk profiles for plants and provide insights for future licensing and oversight decisions, it does not believe these activities need to be completed to support the Task 3 assessment for tornadoes and hurricanes. The consideration of deterministic and risk-informed approaches within the Task 3 assessment is sufficient to determine if NRC-imposed actions on licensees might be warranted.

As discussed above, the staff considered the following factors ~~were considered by the staff~~ in ~~its assessment of~~assessing the need for additional regulatory actions for high winds:

- While a tornado and tornado-generated missiles impacting a nuclear power plant are low frequency events, hurricane force winds impacting a nuclear power plants are not low frequency events for nuclear power plants along the Atlantic Coast and the Gulf of Mexico

Coast. The staff notes that based on preliminary recent PRA insights and past IPEEE insights, CDF for high winds from hurricanes is typically driven by wind-induced failure of offsite power and wind-induced damage to important ~~non-safety~~ nonsafety-related equipment. For example, for one site, the IPEEE risk insights notes that the dominant high wind core damage sequences are station blackout sequences, responsible for 87~~%~~ percent of the high wind CDF. Due to the resulting station blackout, RCP seal cooling is lost, resulting in loss of coolant accident through the RCP seals with no RCS make up capability.[4]

- Based on hurricane weather forecasts and the warning time associated with these forecasts, licensees take preplanned actions to prepare for the onset of high winds ~~on the site~~, including shutting down the plant if it expects winds greater than a certain speed ~~are expected on the site~~. Based on these insights, the staff reviewed the severe weather procedures for four coastal plants related to hurricanes (i.e., Saint Lucie, Turkey Point, Brunswick, and Waterford). In all cases the severe weather procedures direct the operators to ~~shutdown~~shut down the plant prior to hurricane force winds arriving onsite. In addition, procedures direct staff personnel to perform walkdowns to look for and address potential hurricane-induced missiles and to ensure emergency diesel generators have adequate fuel supplies and have been recently tested to ensure high reliability if a loss of offsite power should occur. Licensee actions~~, based on warning time,~~ prior to a hurricane impacting a site can reduce the risk of core damage ~~from these events~~.

- NRC-endorsed guidance document NEI 12-06 Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guidance~~,"~~," (ADAMS Accession No. ML16005A625~~)~~), provides implementation guidance for the mitigation strategies described in Order EA-12-049 ~~that~~. For plants dealing with the possible effects of hurricanes and tornadoes, NEI-12-06, Revision 2, includes additional capabilities beyond the protection of safety-related equipment ~~for plants dealing with the possible effects of hurricanes and tornadoes~~. Step 2C, "Assess Impact of Severe Storms with High Winds," in NEI 12-06 notes that severe storms with high winds can create a significant challenge to plant safety, namely through the simultaneous extended loss of ~~ac~~AC power and loss of the ultimate heat sink. NEI 12-06 Section 7.3 includes provisions for the protection and deployment of FLEX equipment that include guidance for the configuration of the storage of this equipment and deployment of the equipment. Therefore, the staff ~~believes~~concludes that implementation of FLEX strategies reduces risk from high wind events leading to loss of core or spent fuel pool cooling.

  As described in previous sections of this enclosure, the staff's high wind evaluation considered insights from the IPEEEs and/or the review of hurricane procedures for the following plants: Brunswick 1 and 2, D.C. Cook 1 and 2, Ginna, Indian Point 2, Nine Mile Point 1, Oyster Creek, Robinson, Saint Lucie 1 and 2, Turkey Point 3 and 4, and Waterford 3. The staff reviewed these plants' plans for complying with the mitigation strategies order EA-12-049 from a high winds perspective as a check to determine if additional regulatory actions are needed. Table 2.1.4.4-1 provides a summary of the high winds mitigation strategies for these nuclear power plants. The staff notes that it has not yet completed its evaluation of the final integrated plan associated with Order EA-12-049 for all of these sites. The staff also notes that licensees may change their plans, either prior to

[4] As noted above since the IPEEEs were performed additional capabilities have been provided in response to the mitigation strategies orders that should reduce the risk from this sequence.

their compliance date, or after their compliance date under the configuration control provision of NEI 12-06. The staff will take appropriate action if it identifies a concern with a licensee's compliance with Order EA-12-049. Nevertheless, based on the staff's review of the licensee's plans for complying with Order EA-12-049, the staff reaffirms its conclusion for these plants that the actions taken in response to the Order reduce risk from high wind events leading to the loss of core or spent fuel pool cooling and additional regulatory action, beyond those being taken to comply with the Order are not warranted.

- The NRC staff has continually assessed regulatory requirements related to tornadoes and hurricanes as part of the operating experience lessons learned process. As an example, GI-178, "Effect of Hurricane Andrew on Turkey Point," documents the steps the NRC took to compile lessons that might benefit other nuclear facilities. These efforts are summarized in NUREG-1474, "Effect of Hurricane Andrew on the Turkey Point Nuclear Generating Station from August 20 through 30, 1992," which ~~was~~the NRC distributed to all power reactor licensees. In addition, the NRC conducted similar lessons~~-~~-learned activities~~ were~~ associated with the effects of Hurricane Katrina and Hurricane Sandy.

2.1.5. Conclusion of Evaluation of Tornado and Hurricane Missile Protection

The NRC ~~staff's preliminary conclusion is~~staff concludes that additional regulatory actions are not warranted to address beyond-design-basis tornadoes and hurricanes based on: low risk; conservatism in design; additional capabilities to address these events based on compliance with the mitigation strategies Order EA-12-049; lessons learned from past events being incorporated into ~~licensees'~~licensee and NRC actions; and for hurricanes, the additional warning time associated with these events.

2.2. Evaluation of Snow Loads

The evaluation of snow and ice loads is focused on the potential challenge to seismic Category I structures at a nuclear power plant, such that additional regulatory action (beyond what the NRC currently requires) is warranted to address the hazard. The staff performed the evaluation to assess the differences in snow load estimates using assumptions described in present-day guidance and methods as compared to operating plants' licensing bases information. The staff applied the following three criteria as part of its evaluation:

1. conservatism of design safety margins~~;~~

2. low frequency of occurrence/low risk~~; and~~

3. warning time available to allow licensees to take measures to ~~be taken to~~ prevent an accident from occurring~~.~~

On June 23, 2009, the staff issued interim staff guidance (ISG) DC/COL-ISG-007, "Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures" (ADAMS Accession No. ML091490556). ~~This~~The staff issued this guidance~~ was issued~~ for new reactor reviews because at the time of the issuance of the ISG, the SRP did not provide specific approaches for considering snow loads at ground level due to normal and extreme winter precipitation events for the design of seismic Category I structures. The

currently operating reactor fleet was designed to guidance that predates DC/COL-ISG-007. Given the recently updated guidance for snow loads, the staff determined that it was appropriate to further assess this external natural event as part of Task 3 in the staff's evaluation process.

DC/COL-ISG-007 guidance notes the following:

> Seismic Category I structures are required to be designed to withstand the effects of natural phenomena to meet the requirements of GDC [General Design Criterion] 2 in Appendix A to 10 CFR Part 50. Therefore, Seismic Category I structures must be designed to withstand the effects of winter precipitation events.
>
> Roofs of Seismic Category I structures not protected by a shield building will be subject to loading due to accumulation of winter precipitation. In SRP Section 2.3.1 identifies winter precipitation event site characteristics/site parameters at ground level. Therefore, these site characteristics/site parameters must be converted to corresponding roof loads.
>
> Currently, no guidance is included in any of the SRP sections regarding how snow loads at ground level should be converted to snow loads on the roofs of Seismic Category I structures. Further, SRP sections pertaining to design of Seismic Category I structures do not provide any guidance as to how roof loads due to normal and extreme winter precipitation events should be included in loading combinations for design of Seismic Category I structures. This ISG includes guidance for NRC staff members for acceptable methods for (a) converting winter precipitation site characteristics/site parameters (as ground snow loads) to roof loads, and (b) including roof loads due to normal and extreme winter precipitation events into loading combinations for the design of Seismic Category I structures.

The DC/COL ISG-007 is consistent with the guidance for the plants that were reviewed against the 1975 version of the SRP. In accordance with the 1975 version of the SRP, roofs were designed and evaluated for snow, and negative pressure due to tornado suction, and were checked for the effects of probable maximum precipitation. Live loads were considered in combination with other loads (e.g., dead loads, like those from the weight of structures and equipment, and accident loads like those associated with earthquakes) and were evaluated using guidance found in SRP ~~Sections~~Section 3.8.1, "Concrete Containments," and Section 3.8.4, "Other Seismic Category I Structures." In addition, as discussed in a March 24, 1975, branch technical position, "Site Analysis Branch Position – Winter Precipitation Loads" (ADAMS Accession No. ML050630277), a 48-hour probable maximum precipitation (PMP) ~~were~~event was to be considered in addition to the 100-year snow load event.

The winter precipitation events to be included in the combination of extreme winter precipitation roof loads are based on the weight of the antecedent snowpack resulting from the normal winter precipitation event plus the larger resultant weight from either (1) the extreme frozen winter precipitation event or (2) the extreme liquid winter precipitation event. The NRC staff recognizes that an ice storm can lead to loss of offsite power. However, because the additional weight of the ice is evaluated as part of the 48-hour PMP, the staff considers its evaluation of the 48-hour PMP under "extreme snow loads" to bound ice storm structural loads.

Plants licensed before the 1975 version of the SRP did not consider the additional weight of the 48-hour probable maximum winter precipitation at ground level for the month corresponding to the selected snowpack. The purpose of the staff's assessment of this issue is to determine if the treatment of snow loads in accordance with DC/COL ISG-007 leads to a determination that additional regulatory action is needed. As discussed above, the staff identified several screening criteria in evaluating a hazard, including comparing new hazard information against the safety structural margins inherent in the design of nuclear power plants.

In assessing the conservatism of design safety margins relative to snow loads, the staff evaluation has two parts: plants that were licensed before the 1975 version of the SRP and plants reviewed against the 1975 version of the SRP. The staff's evaluation is divided into these two parts because, based on the application of review guidance at the time, plants that were licensed against the 1975 version of the ~~standard review plan~~SRP, in general, are expected to have additional design safety margins associated with load combinations compared to plants licensed before the 1975 version of the ~~standard review plan~~SRP existed.

Plants Included in the Systematic Evaluation Program

As was discussed under the tornado evaluation, the staff used its generic safety program to track the resolution of the SEP issues. As documented in NUREG-0933, "Resolution of Generic Safety Issues" (available at: http://nureg.nrc.gov/sr0933), the staff identified the resolution of this issue as Generic Safety Issue (GSI) 156, "Systematic Evaluation Program." The objective of GSI 156.2.1, "Severe Weather Effects on Structures," was to identify those meteorological conditions that should be considered in structural reviews to determine the ability of structures to withstand these conditions. The staff's resolution of this issue noted that snow and ice loads, when accompanied by strong winds, caused several complete and partial losses of offsite power and had the potential of causing severe accidents and would be evaluated under the Individual Plant Evaluation program. The staff's evaluation at that time also stated that snow and ice loads alone are judged, based on limited PRA experience, to be unlikely to cause significant structural failure that might lead to severe accidents at nuclear power plants.

NUREG-1742, "Perspectives Gained from the Individual Plant Examination of External Events (IPEEE) Program," Section 4.1.3.2, "Guidance for Conduction IPEEE HFO [High Winds, Floods, and Other External Events] Analyses," provides a screening approach that includes a determination of whether the plant conforms to the guidance in the 1975 ~~standard review~~SRP plan, and performance of a plant walkdown. The majority of the plants licensed before the 1975 SRP was available used this method for dispositioning snow loads, as documented in NUREG-1742, Table 4.1, "Methodologies and results for the HFO [High Winds Floods and Other External Events] external events." Only the Haddam Neck nuclear plant (which ceased operations in 1996) performed a snow and ice PRA and reported a CDF contribution of 7E-6 from snow and ice. It is not clear whether or not the assessment of these plants against the 1975 version of the SRP also considered the March 24, 1975, branch technical position. Regardless, snow loads were considered as part of the IPEEEs that were performed for plants included in the SEP and ~~it was~~the agency determined that additional regulatory action was not needed to address snow loads.

Plants Evaluated Using the 1975 Version of the Standard Review Plan

Plants that were evaluated using the 1975 version of the SRP include snow loading (if applicable) as part of the load combinations for structural analysis associated with Category I structures. The NRC staff reviewed the IPEEEs for these plants, and notes that these licensees did not identify snow-load related vulnerabilities for safety-related structures~~ for plants in this category~~.

2.2.1. Snow Load Deterministic Evaluation

The NRC staff calculated the 100-year snow load and extreme snow load for the current operating fleet based on guidance provided in DC/COL-ISG-7. Figure 2.2-1 provides a plot of the staff-calculated 100-year snow load and extreme snow loads for current operating nuclear power plants (ten sites whose 100-year snow load is zero based on ASCE-7 information are not plotted on this figure). The staff performed additional structural assessments for these sites by developing equivalent roof loading for a representative reinforced concrete roof. The staff's evaluation included developing the dead load for this representative roof. Figure 2.2-1 plots double the dead load of a representative concrete roof that equates to a 225 pounds per square foot roof loading. Doubling the representative roof dead load is within the structural design margin of the representative roof.

The extreme roof snow loads are within the structural margins for a representative concrete roof slab, providing confidence that such roofs will not fail due to extreme roof snow load conditions. This is based, in part, on the margin inherent in the design due to the use of linear analysis approaches, lower-bound material properties, and conservative estimates of structural capacities. Other considerations include roof load path redundancy, such that the loads are distributed from structural members approaching its design capacity to other parts with available design margin.

The staff recognizes that roof structures that protect safety-related equipment vary across the fleet of U.S. operating ~~fleet~~reactors. For example, pressurized water reactor (PWR) concrete containment domes are sloped in such a manner that they prevent the accumulation of snow and are also typically very thick. PWR auxiliary building roofs and roofs protecting safety-related PWR and boiling water reactor (BWR) intake structures are typically flat reinforced concrete structures. BWR Mark I and II reactor building roofs are not typically reinforced concrete structures. Instead, for the purposes of missile protection, such BWR designs typically rely on safety-related equipment being protected against vertical missiles by concrete floor slabs, with missile shields protecting the containment. To protect the spent fuel pool, many BWR Mark I and Mark II containments rely on 24 feet or more of water above the top of the spent fuel, preventing gross structural damage to the spent fuel and the spent fuel pool from a vertical missile. The spent fuel pools are typically constructed of thick concrete walls, which provides protection against missiles in the horizontal direction. For Mark I and Mark II containments and other structures that may not have reinforced concrete roofs (e.g., some intake structures have a similar design for missile protection as that found in Mark I and Mark II containments), the staff notes that such structures would typically exhibit roof deformations in the event that snow loads significantly exceed the design margin, which would alert operators to take appropriate actions.

In addition to the structural assessment discussed above, the staff reviewed the UFSARs for the operating fleet to determine if the design-basis roof loading for a power plant may warrant additional regulatory actions when compared to an extreme roof snow loading calculated in accordance with DC/COL-ISG-7. Based on the UFSAR review and insights from the structural assessments, the staff identified five northern sites for additional assessment (Point Beach, Prairie Island, Nine Mile Point 1, Fitzpatrick, and Susquehanna).

For these five sites, the staff applied the screening criteria of warning time associated with extreme snow events. In addition to the warning time provided by the weather forecasting, the roof loading associated with an anticipated extreme snow event would take days to develop. The staff reviewed the severe weather procedures for these five sites and confirmed that these procedures direct licensees to take precautionary actions prior to winter events and to monitor potential adverse effects at these sites.

2.2.2. Qualitative Considerations

The NRC's post-Fukushima mitigating strategies order, EA-12-049, also serves to provide additional protection again extreme snow and ice. Step 2D, "Assess Impact of Snow, Ice and Extreme Cold," of NEI 12-06, the NRC-endorsed guidance document for compliance with Order EA-12-049, notes that snow, ice storms, and extreme cold can ~~be contributors~~contribute to simultaneous extended loss of AC power and loss of normal access to the ultimate heat sink. NEI 12-06, Section 8.3, includes provisions for protection and deployment of FLEX equipment and notes that for sites subject to significant snowfall and ice storms, portable FLEX equipment should be stored in one of two configurations:

a. in a structure that meets the plant's design basis for the snow, ice, and cold conditions~~; or~~

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

Accordingly, mitigating strategies developed by licensees in response to Order EA-12-049 provide defense in depth should a site be adversely affected by snow and ice.

The staff also notes that:

- ~~a~~A structural failure of a roof due to extreme snow loads does not necessarily lead to loss of spent fuel pool or core cooling.

- ~~it~~It is unlikely that a roof collapse would disable multiple trains (at different physical locations) of safety-related systems.

- The extreme snow load calculation in present-day regulatory guidance is based on water being retained by a snow pack. The staff notes that in response to Generic Letter 89-22, "Potential for Increased Roof Loads and Plant Area Flood Runoff Depth at Licensed Nuclear

Power Plants Due to Recent Change in Probable Maximum Precipitation Criteria Developed by the National Weather Service," some licensees made changes to their roof drain designs to provide additional paths to prevent roof ponding.

In the staff guidance for performing IPEEEs (NUREG-1407), the staff stated:

> "for existing plants, the NRC recommended that licensees review the information contained in Generic Letter 89-22 and determine if they need to take additional action. For the IPEEE, the severe accident risk from PMP should be assessed. The licensees should assess the effects of applying this new PMP criterion to their plants in terms of onsite flooding and roof ponding to determine whether that would lead to severe accidents."

Roof drains were also within the scope of the flooding walkdowns performed in accordance with NTTF Recommendation 2.3 of the NRC's March 12, 2012, request for information issued pursuant to 10 CFR 50.54(f). ~~Actions~~As appropriate, actions were taken as a result of Generic Letter 89-22 and in response to the March 12, 2012, request for information that should reduce the likelihood of gross amounts of water being trapped on roofs that are assumed under extreme snow load conditions.

2.2.3. Snow Load Conclusion

The NRC ~~staff's preliminary conclusion is~~staff concludes that additional regulatory actions are not warranted to address beyond-design-basis snow loads. This conclusion is based on conservatism in design, warning time associated with the event, additional capabilities to address these events based on compliance with the Order EA-12-049, and the fact that roof failures from such an events would not necessarily ~~leading~~lead to loss of spent fuel pool or core cooling.

3.0. Stakeholder Interactions

As documented in SECY-15-0137, the staff supported several public meetings during the development of the processes described in this paper. This included a meeting held on October 6, 2015, in which the NRC staff provided the Advisory Committee on Reactor Safeguards (ACRS) Fukushima Subcommittee an overview of the staff's plans to resolve the open Tier 2 and 3 recommendations. A similar meeting occurred with the ACRS Full Committee on November 5, 2015. In addition, the staff provided an overview of its proposed resolution plans for all the open Tier 2 and 3 recommendations during a Category 2 public meeting held on October 20, 2015. The staff also briefed the Commission on the status of Tier 2 and 3 activities in public meetings held on November 17, 2015, and May 17, 2016.

~~In addition to the meetings to support SECY-15-0137, the staff~~The staff also held a number of public meetings to solicit input on its evaluation of natural hazards other than seismic and flooding~~.~~ that is found in SECY-16-0074. The NRC staff provided a draft white paper to stakeholders for their review and comment prior to the public meetings (ADAMS Accession No. ML16039A054), which contained much of the staff's assessment found in ~~this document.~~SECY-16-0074. The staff held a Category 3 public meeting on April 5, 2016. In addition, the NRC staff provided an email address and accepted comments on the draft white paper through April

12, 2016. A summary of the April 5, 2016, public meeting is available in ADAMS at Accession No. ML16106A234.

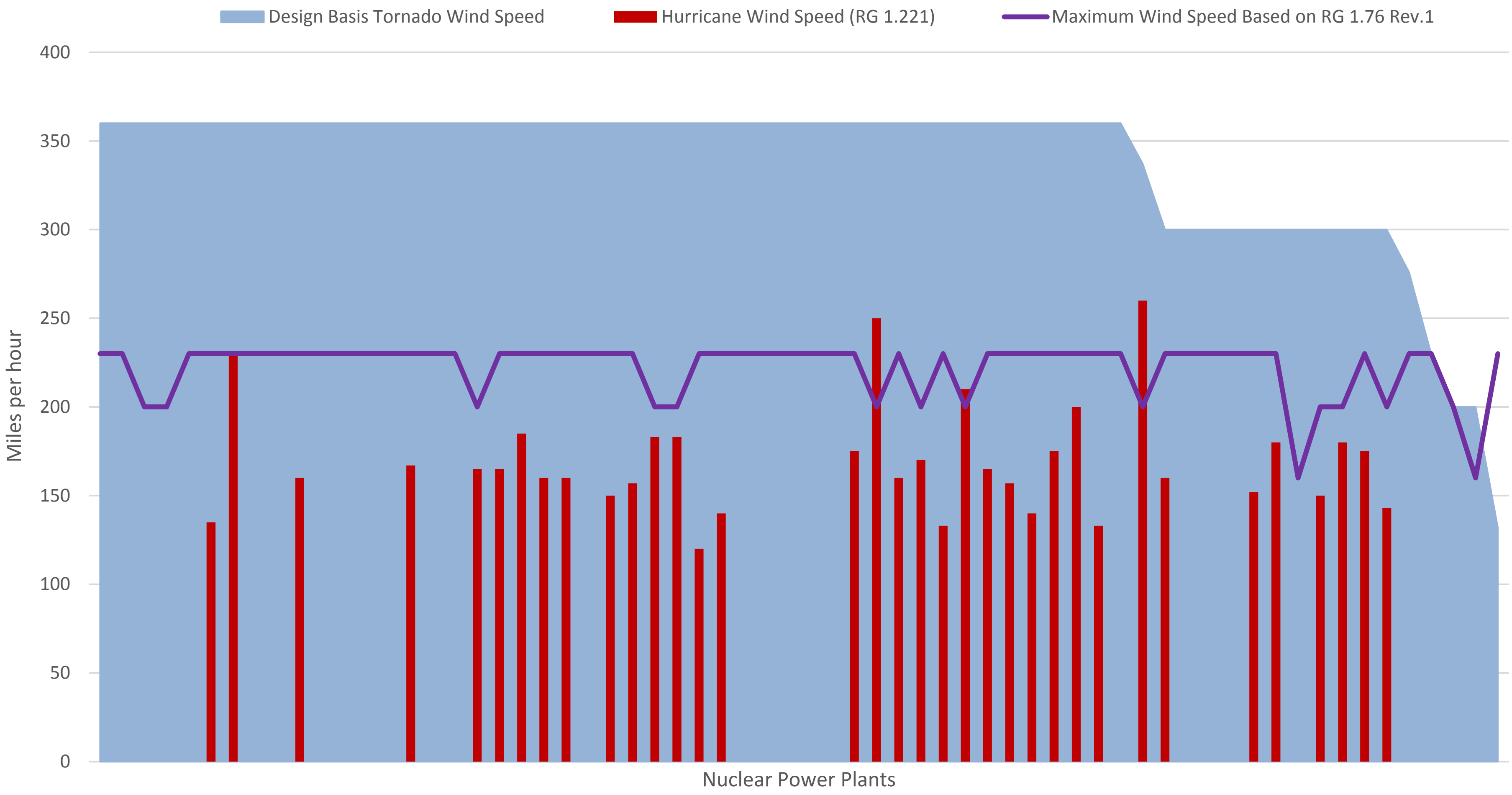
The NRC staff also briefed the ACRS Fukushima Subcommittee on April 21, 2016, and ACRS Full Committee on May 5, 2016, on the staff's assessment of natural hazards other than seismic and flooding. found in SECY-16-0074. The ACRS issued a letter on May 17, 2016 (ADAMS Accession No. ML16130A254), providing its conclusions and recommendations associated with the staff's assessment. The NRC staff intends to engage the ACRS again as it completes its assessment for high winds and snow loads and during these interactions will brief the ACRS on changes that were made to the assessment based on the ACRS's May 17, 2016.

More recently the staff held a public meeting on July 21, 2016, to solicit stakeholder comments on its approach to addressing high winds and snow loads. The summary of the meeting can be found in ADAMS at Accession No. ML16207A436. In addition, the staff issued a white paper on September 22, 2016 (ADAMS Accession No. ML16230A384), which provides much of the staff's assessment found in this enclosure. The staff briefed the ACRS Fukushima Subcommittee on October 19, 2016, and the ACRS Full Committee on December xx, 2016. The ACRS issued a letter on December xx, 2016 (ADAMS Accession No. ML16xxxxxx) providing its conclusions and recommendations associated with the staff's assessment.

4.0. Conclusion

Based on its assessment provided above, the staff's preliminary conclusionstaff concludes from the Task 3 process described in SECY-16-0074 is that high winds and snow loads do not warrant additional regulatory action, and that the staff's evaluation of external hazards other than seismic and flooding is complete.

Figure 2.1.4-1 Comparison of Current Design Basis Wind Speeds vs Updated Tornado and Hurricane Wind Speeds*



*Note that not every plant has a hurricane wind speed associated with it. For example, plants that are located away from the coast do not have a hurricane wind speed value.

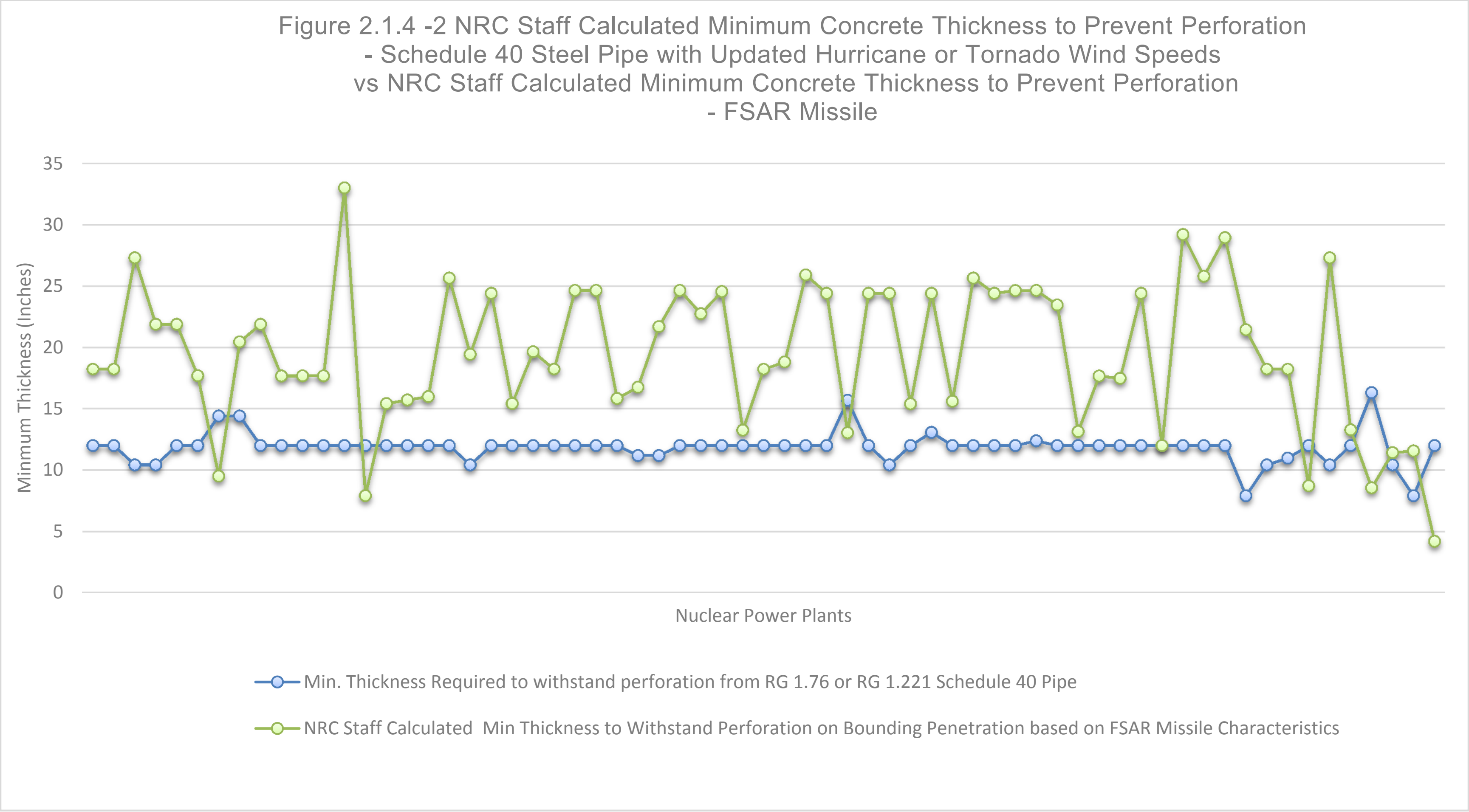


Figure 2.1.4 -2 NRC Staff Calculated Minimum Concrete Thickness to Prevent Perforation
- Schedule 40 Steel Pipe with Updated Hurricane or Tornado Wind Speeds
vs NRC Staff Calculated Minimum Concrete Thickness to Prevent Perforation
- FSAR Missile
Minmum Thickness (Inches)
35
30
25
20
15
10
5
0
Nuclear Power Plants
Min. Thickness Required to withstand perforation from RG 1.76 or RG 1.221 Schedule 40 Pipe
NRC Staff Calculated Min Thickness to Withstand Perforation on Bounding Penetration based on FSAR Missile Characteristics

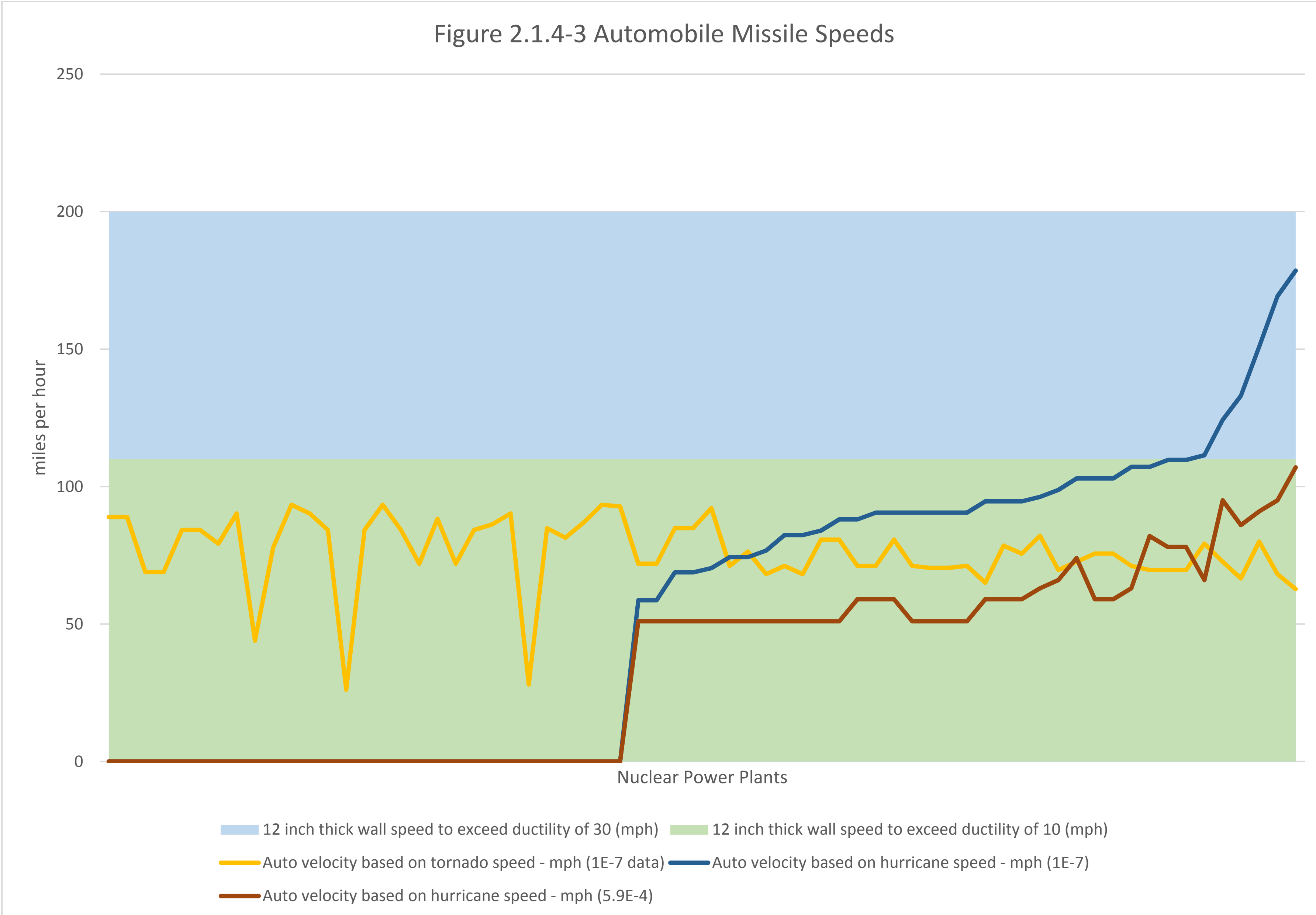


Figure 2.1.4-3 Automobile Missile Speeds
250
200
150
100
50
0
miles per hour
Nuclear Power Plants
12 inch thick wall speed to exceed ductility of 30 (mph)
12 inch thick wall speed to exceed ductility of 10 (mph)
Auto velocity based on tornado speed - mph (1E-7 data)
Auto velocity based on hurricane speed - mph (1E-7)
Auto velocity based on hurricane speed - mph (5.9E-4)

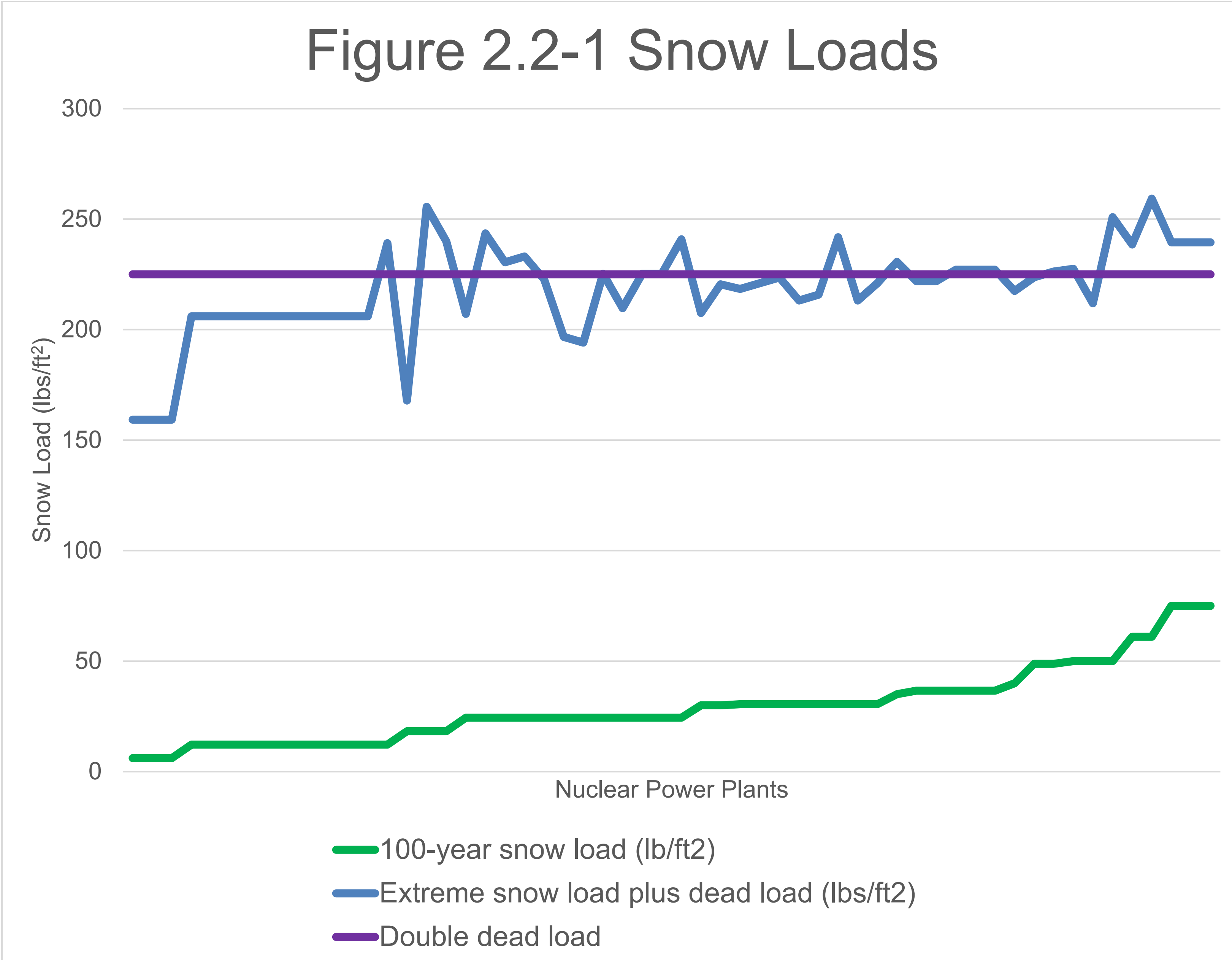


Figure 2.2-1 Snow Loads
300
250
200
150
100
50
0
Snow Load (lbs/ft²)
Nuclear Power Plants
100-year snow load (lb/ft2)
Extreme snow load plus dead load (lbs/ft2)
Double dead load

Table 2.1.4.4 – 1 Summary of High Winds Mitigation Strategies for Select Nuclear Power Plants

Site	**Summary of High Winds Mitigation Strategy**
Brunswick	As described in the final integrated plan for the Brunswick site dated May 19, 2016 (ADAMS Accession No. ML16146A604), the FLEX storage building (FSB) was designed to withstand tornado loading based on RG 1.76, Rev. 1 wind speeds and tornado missile speeds. The FLEX diesel generators are pre-staged in the FLEX diesel generator enclosure that meets the requirements of ASCE 7-10 for hurricane and tornado wind loading and the range of tornado missiles specified in Section 3.5.1.4 of the Brunswick updated final safety analysis report which has the following tornado missile characteristics: • Corrugated sheet of siding 4 feet x 8 feet, weighing 100 lb, traveling at 225 mph • Bolted wood decking 12 feet x 4 feet, weighing 450 lb, traveling at 200 mph • A vehicle with a frontal area of 25 ft^2, weighing 4000 lb, traveling on the ground at 50 mph • Cedar fence post, 33 lb, 6 inches x 6 inches, traveling end-on at 150 mph. Core cooling during an extended loss of ac power (ELAP) is via safety-relief valve (SRV) discharge to the suppression pool. The steam from the reactor pressure vessel (RPV) drives the reactor core isolation cooling (RCIC) turbine, removing heat that would otherwise go directly to the suppression pool via the SRVs. The steam exhaust from the RCIC pump is discharged to the suppression pool to be quenched. The condensate storage tank (CST) will initially provide suction to the RCIC pump until the licensee transfers suction to the suppression pool. RCIC pump suction will be transferred back to the CST when the suppression pool temperature reaches 190°F. Using this approach, the CST inventory is expected to support coping for approximately 52 hours following an event. The CST is a preferred source of water, since it is maintained to reactor coolant grade specifications. Although the CST for Unit 2 is located within the fall zone of the plant stack, the licensee's analyses have determined that the stack would not fail under tornado wind loading or two times the safe shutdown earthquake (SSE). Additionally, missile barriers are positioned around the CSTs to provide protection from tornado missiles. Therefore, the CST for each unit is protected from applicable hazards and will be available following a beyond design basis external event. Using electric power from the station batteries and pneumatic supplies from the nitrogen backup systems, the SRVs will remain functional following an ELAP. In addition to powering the SRVs, the station 125/250 VDC Division II batteries will also power the RCIC system and vital instrumentation. The licensee has permanently pre-staged FLEX diesel generators (DGs) that can provide power within 1 hour of event initiation. If these FLEX DGs are not immediately available, the licensee can perform battery load shedding,

Site	Summary of High Winds Mitigation Strategy
	which will extend availability of DC power from the batteries to two hours and ten minutes.
D.C. Cook	As noted in the staff's safety evaluation for the licensee's mitigation strategies dated November 9, 2015 (ADAMS Accession No. ML15264A851), the FLEX storage building (FSB) was designed for tornado wind loads resulting from a maximum tornado wind velocity of 360 mph (a tornado with a forward progression of 60 mph with rotational wind speed of 300 mph) and a coincidental pressure drop of 3 psi applied within three seconds, which is consistent with the DC Cook UFSAR. The building was designed for protection against the following tornado-generated missiles per UFSAR Table 5.1-1: • Bolted wood decking of 12 ft. x 12 ft. x 4 in., 450 lbs. traveling at 200 mph. • Corrugated sheet siding of 4 ft. x 4 ft. 100 lbs. traveling at 225 mph. • Passenger car of 4000 lbs. traveling along the ground at 50 mph. The licensee stated that the two front-end loaders stored outdoors are sufficiently separated such that there is assurance that at least one of the front-end loaders would survive the applicable site hazards, such as a tornado. During the audit, the licensee stated that the front-end loaders are stored approximately 1500 feet apart and roughly perpendicular to the predominant tornado path. In addition, one diesel fuel transport trailer is stored near the ISFSI area, another one is stored near the switchyards, and the third is stored inside the FSB. The auxiliary building and the portion of the turbine building supporting the mitigation strategies are designed to withstand high winds and tornado borne missiles. The staff's safety evaluation also notes that each unit has one condensate storage tank (CST), which provides a qualified source of water for the TDAFW pumps to provide water to the SGs for heat removal from the RCS. During an audit of the calculations that support the FLEX strategies, the NRC staff noted that the licensee performed evaluations (calculation No. 32-9222624-004 and calculation No. 32-9222496-002) that determined the CSTs will survive impact from the design-basis missiles up to a tank height of 16' 7". The licensee indicated that the survival of the CSTs up to a height of 16' 7" ensures that there is sufficient water available for suction to the Unit 1 and 2 TDAFW pumps for at least 12 hours, which allows time for portable Phase 2 FLEX equipment to be deployed.

Site	Summary of High Winds Mitigation Strategy
Ginna	As discussed in the staff's safety evaluation of Ginna's mitigation strategies dated July 14, 2016 (ADAMS Accession No. ML16124A038), at the onset of an extended loss of ac power decay heat is removed by steaming from the steam generators (SG) through the SG atmospheric relief valves or SG safety valves, and makeup to the SGs is initially provided by the turbine-driven auxiliary feedwater (TDAFW) pump if available, taking suction from the condensate storage tank (CST). Since the non-robust TDAFW pump may not be credited for certain beyond design basis external events, operators can be sent to the standby auxiliary feedwater (SAFW) building to make up to the SGs using one of two installed SAFW pumps powered from the new SAFW diesel generator (DG), taking suction from the new 160,000 gallon (usable capacity), robustly designed SAFW deionized (DI) water storage tank. Subsequently, the operators would begin a controlled cooldown and depressurization of the RCS by manually operating the SG atmospheric relief valves. Section 3.6.1.3 of the staff's safety evaluation notes that in its final integrated plan association with the mitigation strategies order, the licensee stated that, consistent with NEI 12-06, Section 7.3.1.1.a., the structural walls and roof of the new "robust structure" housing the "N" set of FLEX mitigation equipment were designed to the Regulatory Guide 1.76 tornado wind speed and suite of tornado missiles. However, the building's entranceway and openings (e.g., as needed for ventilation) are designed to withstand the plant's design basis tornado (i.e., 132 mph wind speed) and tornado missile spectrum.
Indian Point 2	The Indian Point 2 final integrated plan dated August 12, 2016 (ADAMS Accession No. ML16235A292), notes that Indian Point 2's licensing basis does not include tornado protections for the design of the buildings, structures, and components. Nevertheless, to provide additional protection over and above the current design and licensing basis, all tanks credited for the Indian Point 2 strategies have been designed to or have been evaluated to survive a 360 mph wind loading. In addition, the effects of one missile acting at any time has been addressed by ensuring that two water sources are available to support each required strategy to provide defense in depth. This ensures that no single tornado missile occurring at the Indian Point site will prevent the fulfillment of the strategy. Since the credited tanks have been evaluated to exceed the current licensing basis, they are considered a robust source of water.

Site	Summary of High Winds Mitigation Strategy
Nine Mile Point 1	The unit is an early generation boiling water reactor with two emergency cooling loops that includes two condensers consisting of a tube bundle in a tank located above the reactor vessel. During operation of the emergency cooling loops, steam rises from the reactor vessel to the condenser tubes where it is condensed by boiling the condenser shell water. As the water condenses, it returns by gravity flow to the reactor vessel. As stated in the Nine Mile Point 1 final integration plan dated June 8, 2015 (ADAMS Accession No. ML15163A097), although the reactor water level will remain above the top of active fuel for at least 5.7 hours, upon recognition of an extended loss of ac power (ELAP), plant personnel will proceed immediately with deployment of a portable FLEX diesel driven pump that will take suction from Lake Ontario at one of two pre-staged locations in the screen house and discharge to the installed control rod drive return header. This capability will be achieved within 4 hours from the onset of the ELAP. Alternate injection capability for core cooling from a portable FLEX diesel driven pump through the feedwater system can also be deployed in approximately 4 hours. The portable FLEX Pump will be installed to take suction with non-collapsible hose from the screen house intake/Lake Ontario. Nine Mile Point has constructed a single hardened FLEX storage structure of approximately 8,400 square feet that will meet the requirements for the external events identified in NEI 12-06, such as earthquakes, external floods, storms (high winds and tornadoes), extreme snow, ice, extreme heat, and cold temperature conditions. The building design is based on SDC-1, "Structural Design Criteria," Revision 07 (NMP2's current licensing basis design for SSC for external hazards), which envelopes NMP1 requirements. Cooling and makeup water inventories contained in systems or structures with designs that are robust with respect to seismic events, floods, and high winds and associated missiles are available. Permanent plant equipment that is contained in structures with designs that are robust with respect to seismic events, floods, and high winds and associated missiles, are available. The portion of the fire protection system that is robust with respect to seismic events, floods, and high winds and associated missiles is available as a water source.

Site	Summary of High Winds Mitigation Strategy
Oyster Creek	In an August 26, 2016, status report update to the mitigation strategies order (ADAMS Accession No. ML16239A034), the licensee noted that it would be in full compliance with the order in October 2016. The staff expects to receive the licensee's final integrated plan associated with the order in December 2016. In the August 26, 2016, status report the licensee provides a status of the open and confirmation items from the overall integrated plan safety evaluation that the NRC staff issued on February 19, 2014 (ML14030A513). The staff's February 19, 2014, interim staff evaluation notes that a simplified description of the Oyster Creek Nuclear Generating Station (OCNGS) integrated plan to mitigate the postulated extended loss of ac power (ELAP) event is that the licensee will initially remove core decay heat by using the isolation condenser (IC) system. This system passively transfers heat from the reactor to the atmosphere. The system functions to remove decay heat as long as the proper valve lineup is maintained and the shell side of the IC is replenished with sufficient cooling water. The use of this system also helps to minimize the heat input into containment. Makeup to the shell side of the IC is provided by a diesel engine-driven FLEX pump taking suction from the ultimate heat sink (UHS). For OCNGS the UHS supply is from the intake or discharge canal which is connected to Barnegat Bay and ultimately the Atlantic Ocean. Reactor makeup is provided by a FLEX pump, supplied from the UHS, flowing through one train of the core spray system. A portable generator will be used to provide power to essential motor control centers to operate valves and other essential loads. This portable generator will also provide power to the installed battery chargers. The licensee's August 26, 2016, letter notes that the licensee is addressing open items that the NRC staff identified in the February 19, 2016, interim staff evaluation related to protection of the FLEX equipment from tornadoes and hurricanes. The staff will review the licensee's response to these open items and issue a safety evaluation documenting the results of the review. Although the staff has not completed its review of the licensee's response to the open items, the staff notes that the licensee's plans for addressing tornado protection relies on two sets of equipment being stored on site with an orientation and sufficient separation distance between them such that it is unlikely that a tornado will impact both sets of equipment. For hurricane protection the August 26, 2016, letter notes that the licensee plans for addressing the staff's open items is to revise their procedures to relocate the two sets of equipment to the turbine building and N+1 equipment to another truck bay.

Site	Summary of High Winds Mitigation Strategy
Robinson	As discussed in the staff's safety evaluation of Robinson's mitigation strategies dated March 31, 2016 (ADAMS Accession No. ML16075A377) the permanent FLEX storage building (PFSB) is designed in accordance with ASCE 7-10 for high winds. The condensate storage tank is not protected against wind-generated missiles. EC94741 modified the circulating water (CW) inlet bay at the main condenser with a FLEX connection in the bay to access the ultimate heat sink from within the turbine building which provides protection from wind-generated missiles. Two portable low pressure diesel pumpers are staged in the turbine building protected by the turbine pedestal structure and are easily deployable at the CW inlet bay. The Phase 2 wind/missile strategy for AFW supply connects a pre-staged pumper to the CW inlet bay FLEX connection and discharges directly to the suction of the steam driven auxiliary feedwater pump (SDAFWP) downstream of isolation valve AFW-4. This strategy can be accomplished in less than 1 hour with margin for debris removal. The inlet bay FLEX connection and low pressure pumpers can also be used to refill the AFW tanks. There are no installed means to provide borated makeup following an ELAP. The primary method of boration and inventory control is to use a portable high pressure, low volume pump connected directly to the charging lines or safety injection headers from the refueling water storage tank (RWST) or a portable tanker containing borated water. Currently, the RWST is seismically qualified but is not protected from wind or missiles. Portable high pressure pumping and portable tanker capability will be stored in the permanent FLEX storage building to support this function. EC90622 added a FLEX connection to the exposed end downstream of normally locked closed drain valve (SI-837) located at the base of the RWST to access this borated water if it is available.

Site	**Summary of High Winds Mitigation Strategy**
Turkey Point	As described in the final integrated plan for the Turkey Point site dated June 20, 2016 (ADAMS Accession No. ML16181A189) the FLEX equipment storage building (FESB) meets the plant's design basis for tornado driven missiles. The licensee's strategy for the plant initially at 100% power removes the core decay heat by maintaining feedwater flow to the steam generators (SGs) and releasing steam from the SGs through the main steam safety valves (MSSV) or the steam dump to atmosphere valves (SOTA), if available. The flow will initially be added by one of three redundant turbine-driven auxiliary feedwater (TDAFW) pumps taking suction from a condensate storage tank (CST). A portable diesel-driven pump, FLEX well pump, is used to refill the CST from an artesian well, designated as the FLEX well, for the duration of the TDAFW pump operation. When the TDAFW pumps can no longer be operated reliably, the FLEX well pump supplied-from the FLEX well will be used to add water to the SGs directly. When CST makeup is available from the FLEX well or alternate sources, the reactor coolant system (RCS) will be cooled down and depressurized utilizing the SGs. Upon RCS depressurization, the safety injection accumulators will partially inject into the RCS assisting with inventory and reactivity control. Both CSTs are designed to withstand wind events; however, the tanks are not designed to withstand the design basis missiles. Nevertheless, the current licensing basis considers one tank to be lost due to impact by a tornado missile with the other surviving since they are at opposite ends on the east side of the turbine building, separated by several hundred feet. Per UFSAR, Chapter 5, Appendix SE, redundancy and spacing of the CSTs provide the required system capability in the event of damage to one component by a tornado missile. Therefore, if the CST of one unit was impacted by a tornado missile, the CST from the opposite unit would be available to provided water to the turbine drive auxiliary feedwater pump until the FLEX well pump can be used to supply a source of water to refill the surviving CST or for use in feeding the SGs.

Site	Summary of High Winds Mitigation Strategy
Saint Lucie	As discussed in the mitigating strategies staff's safety evaluation for Saint Lucie dated July 5, 2016 (ADAMS Accession No. ML16167A473), all FLEX equipment is stored in a building capable of withstanding the site design-basis high wind conditions (including tornado missiles). In the event of an extended loss of ac power the reactor coolant pumps (RCPs) coast down and flow in the reactor coolant system (RCS) transitions to natural circulation. Operators will take prompt actions to minimize RCS inventory losses by isolating potential RCS letdown paths. Decay heat is removed by steaming from the steam generators (SGs) through the atmospheric dump valves (ADVs) or main steam safety valve (MSSV), and make-up to the SGs is initially provided by the turbine-driven auxiliary feedwater (TDAFW) pump taking suction from the condensate storage tank (CST). Subsequently, the operators would begin a controlled cooldown and depressurization of the RCS by operating the SG ADVs. The RCS cooldown would commence at a rate of 75 degrees Fahrenheit (°F)/hr within 2 hours of the initiation of the ELAP event. At this cooldown rate, the intended RCS cooldown could be completed within an additional 2.5 to 3 hours. According to the licensee's revised FIP, the SGs are depressurized in a controlled manner to about 120 pounds per square inch atmosphere (psia). This SG depressurization will also reduce RCS temperature and pressure. Therefore, during the depressurization, operators would monitor RCS pressure and ensure that it is maintained above 170 psia during Phase 1 to avoid injection of the nitrogen cover gas from the safety injection tanks (SITs) into the RCS. The reduction in RCS temperature will further result in inventory contraction in the RCS, with the result that the pressurizer level is expected to indicate empty for some time. Some leakage from the RCP seals is also expected. However, passive injection of SIT inventory will maintain natural circulation in the RCS throughout Phase 1 without reliance upon FLEX RCS injection. The water supply for the TDAFW pump is initially from the CST. The fully protected (including from tornado missiles) inventory of both CSTs can be shared between Unit 1 and Unit 2 and will provide 17 hours of residual heat removal per unit. Prior to emptying, the operators will deploy a FLEX CST pump to restore CST inventory. The FLEX CST pump will draw water from the most preferable, available water supply that is available and discharge it to the CST.

Site	Summary of High Winds Mitigation Strategy
Waterford	As described in the final integrated plan for the Waterford site, dated July 21, 2016 (ADAMS Accession No. ML16203A321) the "N" set of FLEX equipment is stored within the nuclear plant island structure (which is designed to withstand tornado winds and tornado-borne missiles), a FLEX diesel generator enclosure built on the reactor building roof (also designed to withstand tornado winds and tornado-borne missiles). The N+1 set of equipment described in NEI 12-06 is stored within the N+1 storage building that is designed to meet ASCE 7-10 guidance which includes protection for high winds. Phase 1 core cooling and heat removal strategy relies upon natural circulation in the RCS through the steam generators. The existing turbine driven emergency feedwater pump (TDEFW) pump will provide feedwater from the condensate storage pool (CSP) to the steam generators (S/G). The CSP is protected against tornado winds and tornado-driven missiles. Steam generated within the S/Gs is exhausted directly to the atmosphere via the atmospheric dump valves (ADVs). During Phase 1, an initial plant cooldown and depressurization is performed to protect the reactor coolant pump (RCP) seals to minimize RCS leakage. This cooldown and depressurization will also enable safety injection tank (SIT) injection for reactivity control and to maintain natural circulation within the RCS. DC bus load shedding ensures station Class 1E battery life is extended beyond 12 hours. Prior to depletion of the selected train of station Class 1E batteries, a FLEX diesel generator is placed in service on the associated Class 1E AC bus to repower the credited FLEX Phase 2 equipment. At Phase 2, suction to the TDEFW pump is transferred to the wet cooling tower (WCT) basin. After the FLEX diesel generator is placed in service, SITs are isolated to preclude nitrogen cover gas injection into the RCS, and a charging pump is placed into service to maintain RCS inventory during the second plant cooldown. The charging pump also provides boron addition to ensure adequate shutdown margin is maintained. The Phase 2 strategy utilizes a permanently staged, electrically-driven FLEX core cooling pump (FCCP) to back up the TDEFW pump to maintain steam generator water levels. The FCCP is capable of operation after the FLEX diesel generator is placed into service, the SITs are isolated, and the second plant cooldown is completed.

Recommendation 2.2: ~~Evaluation of Periodic Confirmation~~Plan to Ensure Ongoing Assessment of Natural ~~Hazards~~Hazard Information

Contents

Acronym list

ACRS	Advisory Committee on Reactor Safeguards
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
EHCOE	External Hazards Center of Expertise
FTE	Full Time Equivalent
NOAA	National Oceanic and Atmospheric Administration
NRC	U.S. Nuclear Regulatory Commission
NRO	Office of New Reactors
NTTF	Near-Term Task Force
R2.1	NTTF Recommendation 2.1
R2.2	NTTF Recommendation 2.2
R2.3	NTTF Recommendation 2.3
RES	Office of Nuclear Regulatory Research

1. Background

The U.S. Nuclear Regulatory Commission'sCommission (NRC's) post-Fukushima Near-Term Task Force (NTTF) Recommendation- 2.2 recommended(R2.2) recommends that the U.S. Nuclear Regulatory Commission (NRC) initiate a rulemaking tothat would require licensees to confirm seismic and flooding hazards every 10 years. To confirm seismic and flooding hazards, licensees would have to address any new and significant information including, if necessary,and may need to take actions that could include updating the design basis for structures, systems, and components important to safety to protect against the updated hazards. Other studies conducted after Fukushima included similarinclude recommendations that also emphasized the importance of assessing new information. For example, Finding 3.1 of the National Academies of Science report, "Lessons Learned from the Fukushima Nuclear Accident for Improving Safety of U.S. Nuclear Plants," dated July 2014 states: "The "[t]he overarching lesson learned from the Fukushima Dai-ichi accident is that nuclear plant licensees and their regulators must actively seek out and act on new information about hazards that have the potential to affect the safety of nuclear plants."

The NRC staff's subsequent assessment indicated that the NRC can meet the intent of Recommendation R2.2.2 can be met using an alternate approach ratherother than rulemaking. Specifically, in Enclosure 2 ofIn SECY--15--0137, "Proposed Plans for Resolving Open Fukushima Tier 2 and 3 Recommendations," Enclosure 2, the staff found that current practices to assess new external hazard information are generally effective, but identified a number of ways to enhance existing processes. In addition, the staff recognized that there is no dedicated NRC process that systematically seeks to determine if there is new hazard information available and to comprehensively assess its significance promptly.in an appropriate and timely manner. In SECY--15--0137, staff identified the following potential shortcomings associated with theopportunities to enhance existing practice:practices:

- There is a potential for delays in theEnsure more timely identification and evaluation of new information (e.g., data, models, and methods).

- When new information is identified, there is the potential that the information could be evaluated in isolation, rather than throughFacilitate a methodical evaluation of the cumulative effect of new data, models, and methods that accrue over time.

- Because Routinely update existing hazard models are not routinely updated with new information, additional resources and time are required to update those methods and models when the agency determines that new information should be evaluated, which leads to decreased predictability and efficiency so they are readily available.

As a result, in SECY-15-0137, staff proposed to enhance existing processes and develop associated staff procedures to ensure that staff proactively and routinely aggregateaggregates and assessassesses external hazard information. The staff proposed that the enhanced internal process would leverage and augment existing programs and agreements with domestic and international organizations.

The proposed enhanced process will collect, aggregate, review, and assess information on an ongoing basis. This would allow staff to achieve the underlying intent of R2.2 in a manner that is timely, integrates well with NRC's existing regulatory framework, and is less burdensome than imposing a new rule. To ensure the process is durable and executed consistently, the proposed

enhanced process will be institutionalized via an NRO office instruction that will define a series of activities associated with periodic technical engagement, information management, assessment of information, and documentation of program activities.

2. Introduction

The purpose of this enclosure is to provide the Commission with additional details regarding the staff's plan to enhance existing processes to ensure ongoing assessment of new information and reconfirmation of externalnatural hazards consistent with NTTF Recommendation R2.2. While R2.2. The staff's focused on seismic and flooding hazards, the proposed framework for hazard reevaluation (i.e., Recommendation 2.2 framework) is shown in Figure 1 and consistsintended to accommodate a range of three primary components:natural hazards (e.g., seismic, flooding, and extreme weather).

The staff's proposed framework for hazard reevaluation is shown in Figure 1 and consists of three primary components:

1. **Knowledge base activities** which include (1) a series of preparatory, near-term activities to develop infrastructure that will gather and preserve, in a retrievableretrieval manner, materials that have been docketed by licensees or developed by NRC staff as part of the NTTF Recommendation 2R2.1 and /2.3 activities, new reactor reviews, and other regulatory activities related to externalnatural hazards, and (2) longer-term activities to preserve, maintain, and update thethese materials.

2. **Active technical engagement and coordination** which involves leveraging and enhancing ongoing interactions with internal and external partners (including other Federal agencies;, academia;, industry;, regulators from other countries; and other technical and scientific organizations, such as American National Standards Institute (ANSI) and American Society of Civil Engineers (ASCE) to ensure that staff routinely and systematically collectcollects new hazard information from a variety of sources.

3. **Assessment activities** which include aggregation and evaluation of new information, as well as referral of potentially significant issues to appropriate regulatory programs.

DetailsSection 4 of this enclosure provides greater detail on the above components are provided in Section 4..

3. Attributes of the Framework

The framework described in this enclosure has the following key attributes:

- ***Enhances safety***: A large cohort of organizations and researchers investigate natural hazards in the United States. The results of these investigations could identify new information that affects a single plant or multiple sites. The proposed Recommendation 2.2 framework enhances the ability of the NRC to (1) identify new information affecting individual sites or larger geographic regions whichthat might otherwise go unrecognized and (2) evaluate whether the information has potential safety

significance.

- ***Leverages and integrates with existing processes***: The Recommendation 2.2proposed framework integrates with existing regulatory activities (e.g., collects information from research and oversight activities as well as from operating experience), uses the NRC's risk-informed regulatory framework, requires coordination between relevant regulatory offices, and facilitates transfer of issues to the appropriate regulatory program. The Recommendation 2.2In addition, the proposed framework also better integrates NRC processes with the broader externalnatural hazards technical community.

- ***Efficiencies:*** The Recommendation 2.2proposed framework achieves efficiencies because it focuses solely on issues specific to externalnatural hazards rather than more generic topics. The framework also gains efficiencies through maintenance of appropriate infrastructure and use of staff capabilities:

  - *Infrastructure*: The proposed framework realizes efficiencies by leveraging the knowledge base that the staff will be initially developeddevelop using information from the NTTF Recommendation 2R2.1 and /2.3 activities and new reactor reviews (including software and models), which will be routinely updated.). Availability of the knowledge base ensures the agency continues to benefit from resources expended as part of the Recommendation 2R2.1 and /2.3 activities. Moreover, development and routine updating of the information maintained by the NRC staff means the staff will be prepared and readily able to efficiently assess the significance of new information when it is identified and supports. The information will also support emergent event response and other regulatory activities.

  - *Staff capabilities*: The Recommendation 2.2 programWhile licensees' regulatory responsibilities related to identifying and evaluating new information have not changed, the proposed framework relies primarily on internal NRC resources, particularly the External Hazards Center of Expertise (EHCOE) staff, for implementation. It enhances the technical capabilities of the cohort of subject matter experts in the proposed EHCOE, as well as counterparts from the NRC'sthe Office of Nuclear Regulatory Research (RES),) counterparts who will remain involved in the broader scientific and technical community through deliberate engagement and periodic coordination with external organizations. This allowswill allow staff to proactively seek information rather than relyingrely on passive receipt of information from external parties. By leveraging existing staff resources, requests for action and information from licensees are limited to situations in which staff has demonstrated the potential significance of new information through a deliberate and systematic assessment. In addition, partnering with external organizations (including other federalFederal agencies) will increase consistency in the treatment of externalnatural hazards and permit overall cost-savings.

- ***Stability and predictability***: UnderStability of the proposed framework, stability is will be ensured by institutionalizing and clearly documenting the systematic framework by

~~management directive and (as appropriate)~~process in an NRO office ~~instructions or similar documentation. To~~instruction. In addition, to promote predictability, the process includes an ~~inter-office~~interoffice technical advisory committee, when warranted.

4. Description of Framework

~~NRC staff~~Staff has developed details of the proposed framework that expands upon the concepts described in SECY-15-0137 and provides a graded approach that allows NRC to proactively seek, evaluate, and respond to new hazard information. As noted previously, the framework consists of three key components, each of which are described below:

- Knowledge Base Activities (Section 0)
-
- Active Technical Engagement and Coordination (Section 0)
- Ongoing Assessment Activities (Section 4.3)

~~While NTTF Recommendation 2.2 focused on seismic and flooding hazards, the proposed framework is intended to accommodate a range of external hazards (e.g., seismic, flooding, and high winds).~~

4.1. Knowledge Base Activities

The knowledge base activities provide the foundation for the ~~Recommendations 2.2~~proposed framework. Program preparation activities include the development of the knowledge base, which involves ~~infrastructure activities as well as~~ the compilation and organizing of currently available data, models, documentation, and other insights to ensure availability for future staff use. As part of the program implementation, the ~~knowledge base~~ staff will ~~be maintained~~maintain and routinely ~~updated~~ update the knowledge base to reflect information collected as part of ~~the Recommendations 2.2~~ activities performed under the proposed framework as well as other regulatory activities and operating experience.

4.1.1. Knowledge Base Development and Organization

Knowledge base development will include a series of near-term activities to gather and preserve relevant existing information related to ~~external~~natural hazards that has been submitted by licensees or developed by ~~NRC~~ staff as part of the ~~Recommendation 2~~R2.1~~ and ~~/2.3 activities, new reactor reviews, and other regulatory activities (e.g., Generic Issues and Individual Plant Examination of External Events). ~~To populate~~In addition to supporting the activities associated with the proposed framework, the knowledge base~~, staff~~ will ~~organize the existing~~also ensure information ~~gathered through previous work so that staff can readily~~is available and ~~easily retrieve it. The knowledge base will preserve critical information that will enable efficient review of new hazards information and supports a variety of~~can be used to support other agency activities~~.~~, including:

- ~~Staff will compile information (e.g., data, models, and methods), insights, and lessons-learned from~~assisting the ~~Recommendation 2.1 and 2.3 activities, new reactor review activities and other regulatory actions into an organized knowledge base. The compilation will include currently available information that licensees have already docketed (or will docket) or made available as part of the Recommendation 2.1 and 2.3 and new reactor review activities. Staff will also compile information and~~agency in responding to events associated ~~documentation developed~~ with natural hazards by ~~NRC~~

staff and contractors to support Recommendations 2.1 and 2.3, new reactor review activities, and other regulatory activitiespromptly providing relevant information

- responding to emergent issues, such as the 2011 Great Tohoku earthquake in Japan
- engaging external stakeholders, including allegations and petitions
- evaluating natural hazard-related inspection findings under the significance determination process (i.e., significance determination process)
- implementing research plans associated with natural hazards
- updating regulatory and staff calculation packages and use of softwareguidance

To populate the knowledge base, staff will organize the existing resources and plant specific information gathered through previous work (e.g., data, models, methods, insights, and lessons-learned) so that staff can readily and easily retrieve it. Examples of available seismic hazard resources include: data, models, and methods used to estimate site-specific hazards (e.g., seismic source characterization, ground motion prediction equations, and site characterization); results of assessments (e.g., ground motion response spectra and site-specific hazard curves); and tools used to perform assessments (e.g., hazard and site-response software).characterizations). Examples of available flood hazard resources include: climatologic and meteorological assessments (e.g., site-specific probable maximum precipitation assessments);, as well as hydrologic and hydraulic models, (including input/output files). Staff will also identify and compile relevant information regarding mitigating strategies for beyond design basis external events (e.g., ; and results of assessments (e.g., flood heights, associated effects, and flood event duration). FLEX strategies and alternate and targeted hazard mitigating strategies).

StaffIn addition, staff will also identify information and analyses that provide insights on plant margins that are relevant to demands from externalnatural hazards. This detailed information is needed so that the appropriate technical basis is available to conduct an efficient evaluation of new hazard information. Examples of plant-specific information related to seismic hazards include: plant fragility information; results of high-frequency analyses; and results and insights from seismic probabilistic risk assessments (e.g., high-confidence of low probability of failure values, seismic core damage frequencies, and seismic large early release frequencies). Examples of plant specific information related to flooding hazards include: descriptions of plant protection; available physical margin and cliff-edge effects; frequency of consequential flooding; and results of focused evaluations and integrated assessments. Staff will also identify and compile relevant information regarding mitigating strategies for beyond design basis external events (e.g., post-Fukushima migrating strategies, as well as alternate and targeted hazard mitigating strategies).

Information related to hazards and plant margins will include a wide range of disparate information and files types as well as potentially large file sizes. This information may include text documents as well as geographic information system data, software, input/output files, and data that is updated periodically by external organizations. To ensure the knowledge base is readily accessible and can be updated in response to new information, staff will develop infrastructure that is capable of preserving and cataloguing diverse and dynamic information types. This infrastructure will include digital archives containing the aforementioned existing licensee- or staff-generated information.

A portion of the knowledge base development work is already underway. For example, EHCOE staff has developed a relational database that contains site-specific information related to

flooding design bases and reevaluated flooding hazards. In addition, RES (with support from the EHCOE) is developing a flood hazard information resource (often referred to as the "flood information digest") as part of the flooding research activities, which will be leveraged in the knowledge base development.

4.1.2. Knowledge Base Maintenance and Update

Staff will maintain and routinely update the knowledge base to reflect the information collected, aggregated, and assessed as part of the ~~Recommendation 2.2 activities,~~framework for ongoing assessment of natural hazards as well as from other regulatory programs and operating experience. The maintenance of the knowledge base will include updating of site-specific information and hazard models~~,~~ as well as relevant plant-specific information, as needed. In addition, staff will maintain cumulative information records for potentially significant topics, which document the accumulation of new ~~external hazard~~natural hazards information over time (i.e., occurrences of extreme natural phenomena; changes to the state of practice, including new data, models, and methods). The cumulative information records will facilitate the aggregation of information and allow staff to identify when further assessments are warranted.

~~In addition to supporting the Recommendation 2.2 activities, the knowledge base will also ensure information is available and can be used to support other agency activities, including:~~

- ~~Assisting the agency in responding to events associated with external hazards by promptly providing relevant information~~
- ~~Responding to emergent issues, such as the 2011 Great Tohoku earthquake in Japan~~
- ~~Engaging with external stakeholders (e.g., through allegations and petitions)~~
- ~~Evaluating inspection findings related to external hazard under the NRC's Significance Determination Process~~
- ~~Implementing research plans associated with external hazards~~
- ~~Updating of regulatory guidance~~

4.2. Active Technical Engagement and Coordination

The active technical engagement and coordination component of the ~~Recommendation 2.2~~proposed framework involves periodic interactions with internal and external organizations (e.g., ~~federal~~Federal agencies, industry, and international counterparts) as well as academia and other technical and scientific organizations. These activities will ~~augment staff activities and~~help facilitate identification of new data, models, and methods. As part of program preparation activities, staff will augment existing technical coordination activities and establish new agreements or leverage existing partnerships to ensure ~~ongoing and periodic~~the appropriate frequency of interactions between ~~NRC~~ staff and the following groups:

- Federal partner agencies (e.g., Department of Energy; United States Geological Survey for seismic hazards; National Oceanic and Atmospheric Administration~~ ~~(NOAA~~);~~), United States Army Corps of Engineers~~;~~, Federal Energy Regulatory Commission~~;~~, United States Bureau of Reclamation~~;~~, and Department of Homeland Security/Federal Emergency Management Agency for flooding hazards; and NOAA and National Institute of Standards and Technology for wind hazards)

- ~~Industry~~industry stakeholders (e.g., ~~Electrical~~Nuclear Energy Institute, Electric Power Research ~~Institute~~InstituteI)

- Internationalconsensus standards organizations (e.g., ANSI/ANS, ASCE, American Society of Heating, Refrigerating and Air-Conditioning Engineers)

- international counterparts (e.g., Canadian Nuclear Safety Commission;, Organisation for Economic Co-operation and Development/Nuclear Energy Agency, International Atomic Energy Agency)

To ensure NRC staff maintains awareness of new developments for an appropriate range of externalnatural hazards to support program implementation, staff will coordinate periodic interactions with organizations that develop externalnatural hazards data and models. Specifically, NRC staff will periodically coordinate and document the outcomes of meetings during which NRC and the aforementioned groups will review and discuss the evolution in knowledge (e.g., changes in data, models, and methods). In addition, staff will remain engaged in the broader technical and scientific community, which will ensure staff are aware of, and are contributors to, advances in data, models, and methods (including opportunities for leveraging more sophisticated models and refinements). This systematic engagement effort also ensures staff has the appropriate knowledge and capabilities to assess the potential significance of new information. In general, this external engagement enhances staff capabilities, which will allow significant portions of the Recommendation 2.2 framework to proceed using staff resources and minimize the while minimizing burden placed on licensees. This is achieved by allowing the staff to gather and evaluate information on an ongoing basis and applicants. Focusrequiring licensees to provide information only when the responsible program office deems it necessary. This avoids requiring that licensees evaluate information at a predefined periodicity regardless of its potential significance to a site or group of sites. The staff will identify focus areas for technical engagement and coordination, including identification of key partner organizations, will be identified in hazard-specific research plans.

4.3. Ongoing Assessment Activities

As part of the program implementation, staff will collect information from the ongoing technical coordination and engagement activities, as well as other NRC sources (e.g., operating experience, licensing experience, and long-term research activities). When the staff identifies new hazard information is identified, the staff, it will promptly aggregate the information with previously collected information. Thus, the staff will assess new information will be assessed for potential significance in the context of accumulated hazards information, rather than in isolation. This assessment will evaluate the change in the hazard represented by the aggregated information, and consider available risk insights, to determine whether the change in the hazard has a potentially significant effect on plant safety.

The assessment of hazard significance initially involves determination of whether the new information indicates that the hazard is more severe than that considered in previous evaluations. To assess the potential significance of an increase in hazard severity, staff will use available information and risk insights. For example, additional information may be available based on the outcomes of activities associated with Recommendation 2.1, such asR2.1. Such additional information could include changes in seismic capacities, available physical margin for flooding, and cliff-edge effects. As another example, to inform the assessment of hazard significance, staff can consider the characteristics of the increased hazard severity (e.g., screening criteria used in Recommendation 2R2.1 seismic reevaluations). These insights will help determine whether the new information has a potentially significant effect on plant safety and, thus, warrants further consideration or assessment.

Depending on the nature of the new information, the assessment of hazard significance may be based on site-specific assessments, consider groups of representative sites (e.g., based on geographic location), or use generic assessments. The assessment will be performed by subject matter experts in the EHCOE, augmented, as needed, by staff from other NRC organizations. Assessment activities are intended to require limited resources and use information contained within the knowledge base to perform a limited scope quantitative or qualitative assessment to determine if the change in hazard is potentially significant.

The division director ~~of~~ responsible for the EHCOE can also convene a technical advisory committee ~~to assess~~for the assessment of hazard significance and to recommend appropriate next steps to address the issue. The technical advisory committee will be comprised of senior technical staff with expertise in relevant technical fields (e.g., ~~external~~natural hazards assessments) and will be expanded, as needed, to include other program offices and relevant personnel to address site-specific issues and ensure ~~assessment~~ results are presented in a manner that supports an assessment of next steps to be ~~taken~~considered by relevant program offices.

If the significance assessment indicates that new hazard information does not significantly affect plant safety, the staff will document the results of the assessment in updates to the cumulative information records. These updates will include a short summary of the new hazard information and the information used to reach a determination of ~~non-significance~~nonsignificance.

If staff finds that the new hazard information ~~is found to have~~has a potentially significant effect on plant safety, it will refer the issue ~~will be referred~~ to appropriate regulatory programs for detailed assessment and further action. Regulatory programs for these referrals include:

- ~~Transfer~~transfer of an issue to the relevant program office for resolution (e.g., via plant-specific assessment and regulatory action~~)~~,)

- ~~Transfer~~transfer of the issue to the Generic Issues Program, if the new information could potentially affect safety at multiple plants and meets other Generic Issues Program screening criteria, or

- ~~Identification~~identification of the need for further research if a better understanding of the new information could improve staff's understanding of the hazard and the resulting potential effects on plant safety.

The relevant program office will decide if the agency should issue requests for additional information ~~should be issued to a licensee~~, and whether ~~they are issued~~to issue these generically or on a site-specific basis. The program office will also decide whether and how regulatory analysis and ~~decision-making~~decisionmaking should proceed, consistent with existing regulatory processes (e.g., backfit~~)~~., operability). In addition, staff will document the results of the assessment in updates to the cumulative information records and the periodic (e.g., annual) report to be released publically. Consistent with current NRC practices, staff will engage external stakeholders at the appropriate times in the process.

5. Infrastructure, Roles, and Responsibilities

~~The majority of information needed to initially develop the knowledge base will be gathered by technical~~Technical staff responsible for the execution of the ~~Recommendation 2~~R2.1~~ and ~~/2.3 activities and new reactors reviews (i.e., staff in the EHCOE, with support from RES~~). Support~~) will gather the majority of information the agency needs to initially develop the knowledge base. The effort will require support from staff in RES and ~~the NRC's ~~Office of ~~the Chief ~~Information ~~Officer will be required~~Services to support development of the infrastructure associated with the knowledge base.

Consistent with current functions, RES will have the primary responsibility for facilitating the technical coordination and engagement between NRC and ~~partner~~external organizations~~ and other external stakeholders~~. The EHCOE and RES staff will jointly participate in the periodic information exchange meetings and other activities to remain engaged in the broader technical and scientific communities. ~~Technical~~Research plans for the relevant natural hazards will include technical coordination and engagement activities~~ will be included within the research plans for the relevant external hazards~~.

~~Information~~EHCOE and RES staff will share responsibility for information collection and aggregation~~ will be the joint responsibility of EHCOE and RES staff, and~~. The efforts will likely include input and participation from other program offices and the NRC's regional offices. The assessment of hazard significance will ~~utilize~~use subject matter experts from the EHCOE, augmented (as needed) by representatives from other offices and external organizations. ~~Regulatory decisions will be made by the~~The appropriate regulatory office~~ in conjunction~~, with ~~the regions~~appropriate coordination with the regional offices and other internal stakeholders, ~~as appropriate. Procedures, roles, and responsibilities associated with the Recommendation 2.2 framework will be institutionalized through an office instruction developed and maintained by the EHCOE~~will make regulatory decisions.

To ensure successful execution of the proposed framework for ongoing collection, aggregation, review, and assessment of natural hazards information, staff recognizes the importance of having defined structure and process. Therefore, procedures, roles, and responsibilities associated with the framework for ongoing assessment of natural hazards will be institutionalized through an office instruction developed and maintained by the EHCOE and will be supplemented, as needed, by additional documents (e.g., RES office instruction, user needs, or research plans). The office instruction(s) will provide details regarding roles and responsibilities, as well as relevant activities, such as: the expected structure and minimum periodicity of technical engagement and coordination activities, the conduct of the information aggregation and assessment processes, procedures to ensure timely updates to the cumulative information record and knowledge base, and periodic reporting.

6. Stakeholder Interactions

Staff discussed the framework described in this enclosure with external stakeholders during a Fukushima Joint Steering Committee meeting held on August 25, 2016. In addition, the staff issued a white paper on September 22, 2016 (ADAMS Accession No. ML16230A384) which provided much of the staff's assessment found in this enclosure. The staff intends to discussdiscussed the framework during an additionala public meeting scheduled forheld on September 28, 2016 (see Agencywide Documents Access and Management System. A summary of the September 28, 2016, public meeting can be found in ADAMS at Accession No. ML16245A004), and withML16277A609. The staff briefed the Advisory Committee on Reactor Safeguards (ACRS) Fukushima Subcommittee on October 19, 2016, and ACRS'sthe ACRS Full Committee during meetings in October 2016 and December 2016, respectivelyon December xx, 2016. A description of the comments and the staff's changes to its evaluation as a result of the October 19, 2016, ACRS Subcommittee meeting can be found in Enclosure 4 of this SECY paper. The ACRS issued a letter on December xx, 2016 (ADAMS Accession No. ML16xxxxxx) providing its conclusions and recommendations associated with the staff's assessment.

7. Resource Timelines and Estimates

While the framework described above leverages existing processes and activities, it is recognizedthe staff recognizes that a commitment of a limited amount of resources is needed to support implementation. It is noted that fullFull-time equivalent (FTE) allocations will come from prioritizing work activities rather than adding new FTE. The following table provides estimated timelines and resources required for the Recommendation 2.2 activities:

Table 1: Estimated Timelines and Resources Required for Recommendation 2.2 Activities

	Timelines		Resources	
	Near-Term	Longer-Term	Near-Term	Longer-Term for Program Maintenance*
Knowledge Base Development and Activities	End 2017	Ongoing	[information withhed]	EHCOE: [information withheld] RES: [information withheld]
Active Technical Engagement and Coordination	End 2017	Ongoing (periodic)	[information withheld]	Continuous RES: [information withheld] EHCOE: [information withheld]
Assessment Activities	N/A	Ongoing	N/A	RES: [information withheld] EHCOE: [information withheld]

* Resource needs for program-specific maintenance requirements.

▫ Contract resources ~~made~~may be needed if internal capabilities not available.

8. Conclusion

Based on the evaluation described in this enclosure, the staff recommends that the Commission approve the process outlined in this enclosure to provide for an ongoing assessment of natural hazards information through the enhancement of internal processes. The process will establish a more routine, proactive, and systematic program for identifying and evaluating new information related to natural hazards.

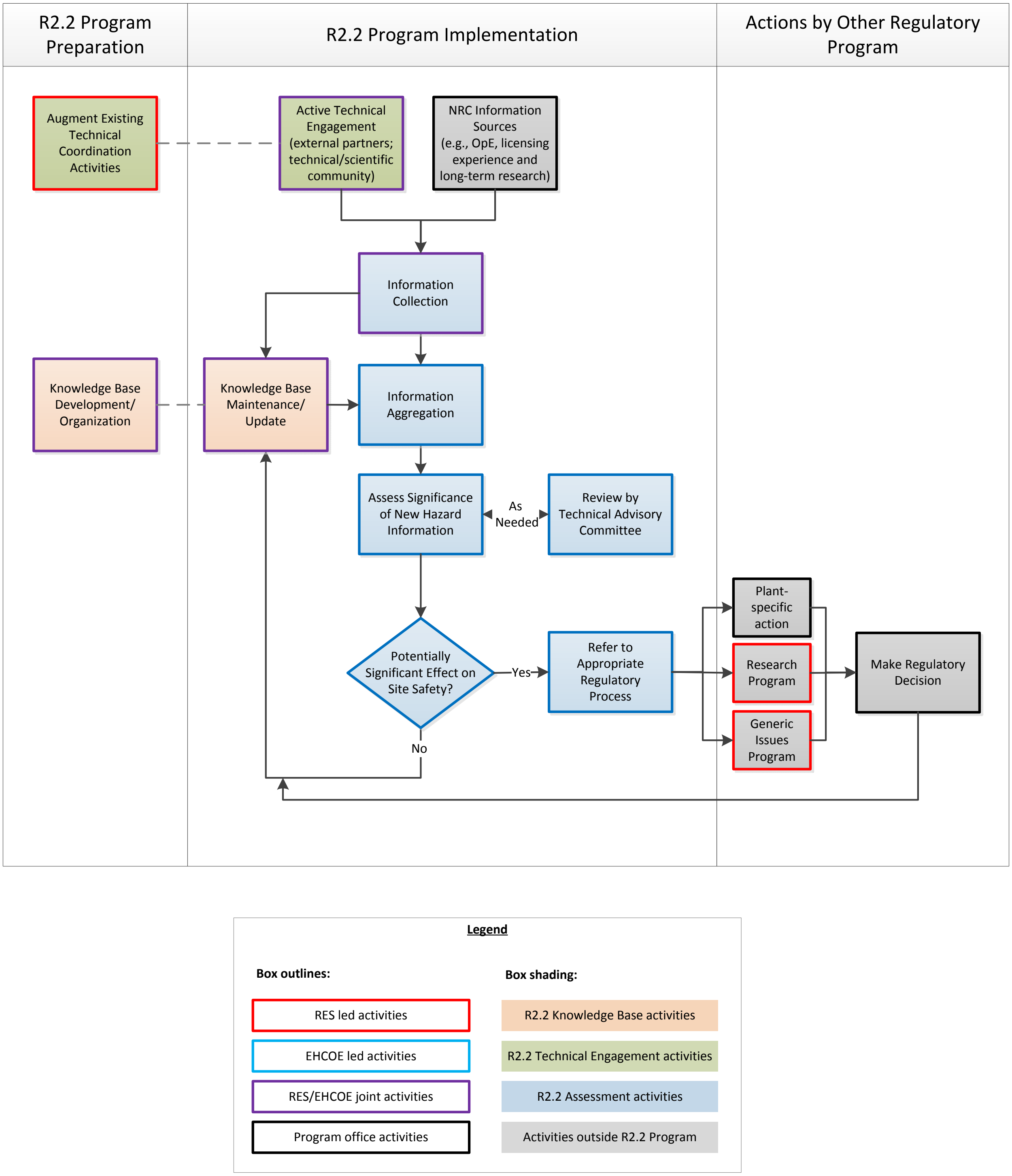


Figure 1: Key elements of proposed R2.2 Program

Discussion of Comments Received on Staff's Draft Assessment of Natural Hazards other than Seismic and Flooding and Periodic Confirmation of Natural Hazards

On September 22, 2016, the staff made a white paper publicly available to support interactions with stakeholders on the Group 3 recommendations (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16230A384). This white paper was the subject of an October 19, 2016, meeting with the Advisory Committee on Reactor Safeguards (ACRS) Fukushima Subcommittee. During that meeting, members of the Subcommittee provided comments on various portions of the staff's white paper. The table below provides a description and the disposition of the comments received during the meeting. The ACRS Full Committee was briefed by the staff on the staff's assessment found in the white paper, and also on changes that the staff made to its assessment as a result of ACRS member comments during the Fukushima Subcommittee meeting. The ACRS issued a letter on December xx, 2016 (ADAMS Accession No. ML16xxxxxx), providing its conclusions and recommendations associated with the staff's assessment.

ID#	Section of Paper	Issue	Disposition
1	All sections	Staff needs to inform the Advisory Committee on Reactor Safeguards (ACRS) on what changes it intends to make to address the ACRS member comments and the plan for informing the ACRS of these changes prior to the Full Committee meeting.	The ACRS was provided a redline/strikeout with changes to Enclosure 1 (other natural hazards) and Enclosure 2 (periodic confirmation of natural hazards) of the white paper on November xx, 2016, to support the December xx, 2016, ACRS Full Committee meeting. Enclosure 3 was not changed as a result of the Subcommittee meeting.
2	Periodic Confirmation	The staff evaluation should be updated to include a discussion that the staff intends to continuously review changes to man-made hazards and the potential impact on nuclear power plants (e.g., addition of gas pipelines around nuclear power plants, changes to aircraft patterns around nuclear power plants).	The staff clarified during the ACRS meeting that the proposal described in Enclosure 2 is only related to natural hazards. Staff emphasized that man-made hazards are part of External Hazards Center of Expertise, but not within the scope of the continuous assessment program. To increase clarity, “external hazards” was changes to “natural hazards” throughout the paper.
3	Periodic Confirmation	The staff should consider revising the discussion to include providing evaluations on a periodic basis. The original Near-Term Task Force recommendation was for rulemaking requiring licensees to do this on a 10 year basis. The staff is encouraged to keep the spirit of the recommendation.	The framework described in Enclosure 2 is intended to allow for ongoing assessment of new information. However, it is recognized that performance of certain activities (e.g., technical engagement activities and development of summary reports) on a defined or periodic schedule provides important institutional structure. As a result, the paper was modified to better emphasize: (1) the types of activities that will be performed and (2) that the specific details regarding the activities (e.g., periodicity of documentation) will be defined via an office instruction.
4	Periodic Confirmation	Staff is encouraged to develop a process that does not look at events in isolation but develop a process that will aggregate information and consider trends over time.	The white paper emphasizes the importance of looking at information in aggregation. For example, Section 4.3 states: “When new hazard information is identified the staff will aggregate the information with previously collected information. Thus, the new information will be assessed for potential significance in the context of accumulated hazards information, rather than in isolation.” Because aggregation of information is an integral part of the proposed framework (and discussed throughout the white

ID#	Section of Paper	Issue	Disposition
			paper), no further changes were made to the paper in response to this comment.
5	Periodic Confirmation	The process is silent on whether the NRC process affects licensee's responsibility as it relates to evaluating new information.	Several statements have been added to the paper to note that licensees' responsibilities with respect to identification and evaluation of new information have not changed.
6	Periodic Confirmation	The process does not provide assurance that the process described in the white paper will be institutionalized.	The white paper noted that an office instruction will be used to institutionalize the program. However, additional text was added to the paper to more strongly emphasize that the details of programmed activities will be defined in an office instruction.
7	Other natural hazards – high winds	Figure 2.1-4-3 on automobile missile speeds uses 5.9E-4 per year automobile missile speed data that is developed using based on American Society of Civil Engineers (ASCE) 7-10, "Minimum Design Loads for Buildings and Structures," and results in inconsistencies when compared to NUREG CR-7005, "Technical Basis for Regulatory Guidance on Design-Basis Hurricane Wind Speeds for Nuclear Power Plants" (ADAMS Accession No. ML11335A031), 1E-7 frequency data. The staff should consider developing a graph extracting data from NUREG CR-7005 for higher frequency hurricanes such that these inconsistencies are resolved.	No changes to the staff's assessment were made. The staff assessed the comments and concluded that development of the data was resource intensive, while not necessary to support its conclusion. Based on a review of NUREG CR-7005, the staff did not identify a readily available method for obtaining higher frequency values (e.g., 1E-4 per year) for hurricane wind speeds for nuclear power plants sites susceptible to high winds from a hurricane. The staff notes that Enclosure 1, Figure 2.1.4-3, is based on American Society of Civil Engineers (ASCE) 7-10, "Minimum Design Loads for Buildings and Structures." ASCE 7-10 includes a figure for hurricane wind speeds that is based on a recurrence of one in 1700 year frequency (i.e., 5.9E-4 per year). NUREG CR-7005 references the methodology found in ASCE 7-05 (the predecessor to ASCE 7-10) as the model it used for developing the 1E-6 and 1E-7 per year frequency data that is provided in the NUREG. Because ASCE 7-10 is a national consensus standard that has been endorsed by the NRC as a source for wind information and analysis methodology, the staff believes using data from ASCE 7-10 is appropriate. The staff also notes that the development of the 5.9E-4 automobile wind speed is based on a figure in ASCE 7-10

ID#	Section of Paper	Issue	Disposition
			that provides wind speed contour lines for various locations in the United States. The staff used judgement in using the contour lines that are closest to nuclear power plant sites. In contrast NUREG CR-7005 provides a 1E-7 per year hurricane wind data in a digitized format that minimizes the amount of interpolation that the staff had to use to obtain the high wind values for nuclear power plant sites. Therefore, the way the data was developed partially explains why the two graphs (i.e., 5.9E-4 and 1E-7 frequency) are not highly consistent at all nuclear power plant sites. The staff notes that the figure is intended to provide a sense of the margin inherent in the design relative to a more frequent events than a 1E-7 per year event. While changing the data for the 5.9E-4 per year frequency could improve the information provided in the graph, it would not change the staff's conclusion that existing design basis requirements provide adequate design margin against auto missile impact loads. Regarding extracting 1E-4 per year frequency data from NUREG CR-7005, the NUREG provides figures for hurricane wind speeds of 1E-2 and 1E-3 per year frequency events and includes figures and tables for 1E-6 and 1E-7 per year frequency events. The NUREG also provides plots for 24 example locations for plotting changes in design-basis wind speed versus annual exceedance probability. However, the plotted locations do not correspond to nuclear power plant sites. As such, data interpolation and judgement would be necessary to obtain 1E-4 per year hurricane wind speeds at nuclear plant sites, likely rendering a graph with similar accuracy to that of the 5.9E-4 per year graph used by the staff.
8	Other natural hazards – high winds	Staff has an overreliance on Individual Plant Examination of External Events (IPEEE) results that were not based on	Staff added clarification to its assessment that IPEEE did not consider the higher hurricane and tornado borne missile speeds found in RG 1.76, "Design-Basis Tornado and

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		missile considerations. Staff is misapplying use of risk insights from the IPEEE.	Tornado Missiles for Nuclear Power Plants," Revision 1 (ADAMS Accession No. ML070360253), and RG 1.221, "Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants" (ADAMS Accession No. ML110940300). The staff used the IPEEE insights as another screening tool in addition to the screening tools that are described in Enclosure 1 of this document. The additional screening tools discussed in Enclosure 1 of this document include staff-developed deterministic calculations, insights from tornado risk assessments, and mitigation strategies for high wind events that licensees have developed in response to EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated March 12, 2012 (ADAMS Accession No. ML12054A735). The staff considers high wind risk insights from the IPEEEs important when determining whether there is a basis for additional regulatory action. However, in no case did the staff rely on the risk insights from the IPEEE as the sole basis for its determination that additional regulatory action to address high wind events is not warranted.
9	Other natural hazards – high winds	There appears to be an overreliance on use of mitigating strategies for high wind protection. Mitigation strategies are based on current design basis, so if a plant does not have a design basis tornado, there is no assurance that the mitigation strategies will be able to work in the aftermath of a high-wind event at the site.	Staff added clarification to Enclosure 1, Section 2.1.4.4, including the addition of Table 2.1.4.4-1 to place in perspective the staff's use of response to the mitigation strategies order (EA-12-049) and assumptions for protection of such equipment from high wind events including missiles generated by such events. The staff's table includes the mitigation strategies assumptions for the 10 sites that are referenced in the staff's high wind evaluation (i.e., Brunswick, D.C. Cook, Ginna, Indian Point 2, Nine Mile Point 1, Oyster Creek, Robinson, Saint Lucie, Turkey Point, and Waterford).
10	Other natural hazards – SECY-16-0074 – low	The logic for the low water evaluation found in Appendix B of SECY-16-0074, "Assessment of Fukushima Tier 2 Recommendation Related to Evaluation	No changes were made to the staff's assessment in SECY-16-0074. The staff's assessment found in Appendix B of SECY-16-0074 is based on a simultaneous loss of all ac power and loss of the ultimate heat sink. Mitigation strategies

ID#	Section of Paper	Issue	Disposition
	water conditions due to a seiche	of Natural Hazards other than Seismic and Flooding" (ADAMS Accession No. ML16102A297), for D.C. Cook, Ginna, Calvert Cliffs, and Davis Besse is not clear. Specifically, it is not clear how these plants cope with loss of the ultimate heat sink and the basis for staff's recommendation that no additional regulatory action is needed.	that is provided in the staff's assessments accounts for the loss of the safety-related ultimate heat sink.
11	Other natural hazards – SECY-16-0074 – loss of ultimate heat sink and intake air quality	Both of the staff's assessment for loss of the ultimate heat sink (LUHS) and intake air quality rely in part on additional capabilities provided by mitigation strategies equipment. The staff should assess LUHS without loss of alternating current (ac) power. Such a sequence could lead to PWR reactor coolant pump (RCP) seal loss of coolant accident (LOCA) because RCPs continue to run without seal injection or lube oil cooling. In addition, cooling is lost to other important equipment.	No changes to the staff's assessment in SECY-16-0074 were made. The staff discussed the postulated sequence (i.e., loss of the ultimate heat sink without loss of ac power) with NRC staff who previously possessed reactor operator licenses (both PWR and boiling water reactors) and with industry. The staff also reviewed the abnormal operating procedures (AOPs) for a representative PWR as a check of the information obtained from these sources. The staff notes that the site will, or may have electrical power, so loss of power to major pumps may not occur at T=0 as assumed in FLEX strategies. To address concerns such as the loss of seal cooling/seal degradation concern, the staff notes that most, if not all, sites have a loss of or degraded UHS (lowering UHS level or pumps) AOP. This AOP will address issues such as: • When to trip the reactor • When to trip the RCPs • When to isolate major heat loads cooled by closed loop cooling which is ultimately cooled by the UHS: - Reactor water cleanup - Major power train pumps If not addressed by loss or degraded UHS AOP, plants will have AOPs to respond to loss or degraded closed loop

ID#	Section of Paper	Issue	Disposition
			cooling. These will address: • When to trip the reactor • When to trip RCPs • When to secure major loads cooled by the respective system As such, existing procedures will provide the necessary guidance to provide core cooling, which will include the use of prioritized (most to least preferred) available on-site water sources and installed pumps or FLEX pumps, as needed. The staff concludes that existing procedures are sufficient to address loss of or degraded UHS as a stand-alone event and that the mitigation strategies provided in response to the order provide additional capabilities to address such an event.