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Compiled Seismic Questions for NRC Response to the March 11, 2011 Japanese Earthquake and Tsunami

This is current as of 3-17-11 at 2am.

The keeper of this file is Annie Kammerer. Please provide comments, additions and updates to Annie with CC to Clifford Munson and Jon Ake.

A SharePoint site has been set up so that anyone can download the latest Q&As. The site is found at NRC>NRR>NRR TA or at <http://portal.nrc.gov/edo/nrr/NRR%20TA/FAQ%20Related%20to%20Events%20Occuring%20in%20Japan/Forms/AllItems.aspx>

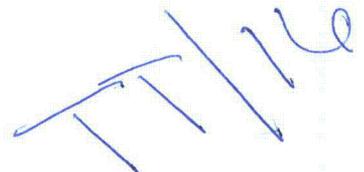
A list of topics is shown in the Table of Contents at the front of this document.

A list of all questions is provided at the end of the document.

We greatly appreciate the assistance of the many people who have contributed. The enclosed list of questions and answers has been compiled from multiple sources including, questions forwarded from NRC staff, GI-199 communications plan, Diablo Canyon communications plan, the NEI website, lists of questions that followed the 2007 earthquake that shut down the Kashiwazaki-Kariwa plant, and others. Please do not distribute beyond the NRC.

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CONTENTS

Natural Hazards and Ground Shaking Design Levels 1

Design Against Natural Hazards & Plant Safety in the US..... 6

About Japanese Hazard, Design and Earthquake Impact..... 12

What happened in US Plants during the earthquake? 14

Future Actions, Reassessment of US Plants and GI-199..... 15

Seismic Probabilistic Risk Assessment (SPRA) 22

Plant-Specific Questions 23

 SONGS questions 23

 Diablo Canyon Questions 27

 Indian Point Questions 30

Questions for the Japanese 32

Additional Information 34

 Table of Design Basis Ground Motions for US Plants 34

 Table of SSE, OBE and Tsunami Water Levels 36

 Plot of Mapped Active Quaternary Faults and Nuclear Plants in the US 41

 Nuclear Plants in the US Compared to the USGS National Seismic Hazard Maps 42

 USGS US National Seismic Hazard Maps 42

 Plot of Nuclear Plants in the US Compared to Recent Earthquakes 43

 Table of Plants Near Known Active Faults 44

 Table From GI-199 Program Containing SSE, SSE Exceedance Frequencies, Review Level Earthquakes,
 and Seismic Core Damage Frequencies 45

 Summary of seismological information from regional instrumentation 50

 Tsunami Wave Heights at the Japanese Plants (unofficial from NOAA) 51

 Fact Sheet on Protection of Nuclear Power Plants against Tsunami Flooding 52

 Seismicity of the Central and Eastern US Fact Sheet 54

 Design Basis Ground Motions and New Review Level Ground Motions Used for Review of Japanese
 Plants 56

 Status of Review of Japanese NPPs to New Earthquake Levels Based on 2006 Guidance 57

 US Portable Array briefing sheet for brief congressional staffers 58

List of Questions 60

Natural Hazards and Ground Shaking Design Levels

1) Did the Japanese underestimate the size of the maximum credible earthquake that could affect the plants?

Public response: The magnitude of the earthquake was somewhat greater than was expected for that part of the subduction zone by seismologists worldwide. The Japanese plants were recently reviewed to ground shaking similar to that observed. The review level ground motions were expected to result from a smaller earthquake closer to the sites.

Additional, technical, non-public information: None.

2) Can a very large earthquake and tsunami happen here?

Public response: This earthquake was caused by a "subduction zone" event, which is the type of mechanism that produces the largest magnitude earthquakes. A subduction zone is a tectonic plate boundary where one tectonic plate is pushed under another plate. In the continental US, the only subduction zone is the Cascadia subduction zone which lies off the coast of northern California, Oregon and Washington. So, an earthquake and tsunami this large could only happen in that region. The only plant in that area is Columbia, which is far from the coast and the subduction zone. Outside of the Cascadia subduction zone, earthquakes are not expected to exceed a magnitude of approximate 8, which is 10 times smaller than a magnitude 9.

Additional, technical, non-public information: Magnitude is on a log scale, so 9 is 10 times bigger than an 8.

3) Has this changed our perception of Earthquake risk?

Public Answer: This does not change the NRC's perception of earthquake hazard (i.e. ground shaking) at US plants. It is too early to tell what the lessons from this earthquake are from an engineering perspective. The NRC will look closely at all aspects of response of the plants to the earthquake and tsunami to determine if any actions need to be taken in US plants and if any changes are necessary to NRC regulations.

Additional, technical, non-public information: We expect that there would be lessons learned and we may need to seriously relook at common cause failures, including dam failure and tsunami.

4) What magnitude earthquake are US plants designed to?

Public Answer: Each plant is designed to a ground-shaking level that is appropriate for its location, given the possible earthquake sources that may affect the site and its tectonic environment. Ground shaking is a function of both the magnitude of an earthquake and the distance from the fault to the site. The magnitude alone cannot be used to predict ground motions. The existing plants were designed on a "deterministic" or "scenario earthquake" basis that accounted for the largest earthquake expected in the area around the plant. Several tables that include plant design ground motions are provided as the first table in the "additional information" section of this document.

Additional, technical non-public information: In the past, "deterministic" or "scenario based" analyses were used to determine ground shaking (seismic hazard) levels. Now a probabilistic method is used that accounts for possible earthquakes of various magnitudes that come from potential sources (including background seismicity) and the likelihood that each particular hypothetical earthquake occurs.

5) How many US reactors are located in active earthquake zones (and which reactors)?

Public Answer: Although we often think of the U.S. as having “active” and “non-active” earthquake zones, earthquakes can actually happen almost anywhere. Seismologists typically separate the U.S. into low, moderate, and high seismicity zones. The NRC requires that every plant be designed for site-specific ground motions that are appropriate for their locations. In addition, the NRC has specified a minimum ground shaking level to which plants must be designed.

Seismic designs at U.S. nuclear power plants are developed in terms of seismic ground motion spectra, which are called the Safe Shutdown Earthquake ground motion response spectra (SSE). Each nuclear power plant is designed to a ground motion level that is appropriate for the geology and tectonics in the region surrounding the plant location. Currently operating nuclear power plants developed their SSEs based on a “deterministic” or “scenario earthquake” that accounts for the largest earthquake expected in the area around the plant.

Generally speaking, seismic activity in the regions surrounding U.S. plants is much lower than that for Japan since most U.S. plants are located in the interior of the stable continental U.S. However, the most widely felt earthquakes within the continental U.S. are the 1811-12 New Madrid sequence and the 1886 Charleston, SC, which were estimated to be between about magnitude 7.0 to 7.75. Nuclear power plants in the U.S. are sited far away from these two earthquake zones as well as other identified potential seismic sources.

On the west coast of the U.S., the two nuclear power plants are designed to specific ground motions from earthquakes of about magnitude 7+ on faults located just offshore of the plants. The earthquakes on these faults are mainly strike-slip (horizontal motion) type earthquakes, not subduction zone earthquakes. Therefore, the likelihood of a tsunami from these faults is remote.

Additional, technical non-public information: None.

6) How many reactors are along coastal areas that could be affected by a tsunami (and which ones)?

Public Answer: Many plants are located in coastal areas that could potentially be affected by tsunami. Two plants, Diablo Canyon and San Onofre, are on the Pacific Coast, which is known to have tsunami hazard. There are also two plants on the Gulf Coast, South Texas and Crystal River. There are many plants on the Atlantic Coast or on rivers that may be affected by a tidal bore resulting from a tsunami. These include St. Lucie, Turkey Point, Brunswick, Oyster Creek, Millstone, Pilgrim, Seabrook, Calvert Cliffs, Salem/Hope Creek, and Surry. Tsunami on the Gulf and Atlantic Coasts occur, but are very rare. Generally the flooding anticipated from hurricane storm surge exceeds the flooding expected from a tsunami for plants on the Atlantic and Gulf Coast.

Additional, technical non-public information: A table with information on tsunami design levels is provided in the “Additional Information” section of this document.

7) If the earthquake in Japan was a larger magnitude than considered by plant design, why can't the same thing happen in the US?

Public response: *Discuss in terms of, IPEEE, Seismic PRA to be provided by Nilesh*

Additional, technical, non-public information: ADD

8) What if an earthquake like the Sendai earthquake occurred near a US plant?

Public response: ADD

Additional, technical, non-public information: ADD

9) What would be the results of a tsunami generated off the coast of a US plant? (Or why are we confident that large tsunamis will not occur relatively close to US shores?)

Public response: Request for answer by Henry Jones, Goutam Bagchi and/or Richard Raione (once the tsunami fact sheet is done and you have time).

Additional, technical, non-public information: ADD

10) Can this happen here i.e. an earthquake that significantly damages a nuclear power plant? Are the Japanese plants similar to U.S. plants?

Public Answer: All U.S. nuclear power plants are built to withstand environmental hazards, including earthquakes and tsunamis. Even those plants that are located within areas with low and moderate seismic activity are designed for safety in the event of such a natural disaster. The NRC requires that safety-significant structures, systems, and components be designed to take into account even rare and extreme seismic and tsunami events.

The Japanese facilities are similar in design to several US facilities.

Additional technical, non-public information: Currently operating reactors were designed using a “deterministic” or “maximum credible earthquake” approach. Seismic hazard for the new plants is determined using a probabilistic seismic hazard assessment approach that explicitly addresses uncertainty, as described in Regulatory Guide 1.208. The NRC requires that adequate margin beyond the design basis ground shaking levels is assured. The NRC further enhances seismic safety for beyond-design-basis events through the use of a defense-in-depth approach.

In addition, the NRC reviews the seismic risk at operating reactors as needed when information may have changed. Over the last few years the NRC has undertaken a program called Generic Issue 199, which is focused on assessing hazard for plants in the central and eastern US using the latest techniques and data and determining the possible risk implications of any increase in the anticipated ground shaking levels. This program will help us assure that the plants are safe under exceptionally rare and extreme ground motions that represent beyond-design-basis events.

11) What level of earthquake hazard are the US reactors designed for?

Public Answer: Each reactor is designed for a different ground motion that is determined on a site-specific basis. The existing plants were designed on a “deterministic” or “scenario earthquake” basis that accounted for the largest earthquake expected in the area around the plant. New reactors are designed using probabilistic techniques that characterize the hazard (i.e. ground shaking levels) and uncertainty at the proposed site. Ground motions from all potential seismic sources in the region are estimated and used to develop an appropriate site specific ground motion, which has a return period of 10,000 years on average over very long time periods.

Additional technical, non-public information: None

12) Does the NRC consider earthquakes of magnitude 9?

Public Answer: Earthquakes with very large magnitudes, such as the recent earthquake of the coast of Japan, occur only within subduction zones. Subduction zones are regions where one of the earth’s

tectonic plates is subducting beneath another. In the continental US, the only subduction zone is the Cascadia subduction zone, which lies off of the coast of northern California, Oregon, and Washington. The only nuclear power plant in that area is Columbia, which is far from the coast and the subduction zone.

Seismic designs at U.S. nuclear power plants are developed in terms of seismic ground motion spectra, which are called the Safe Shutdown Earthquake ground motion response spectra (SSE). Each nuclear power plant is designed to a ground motion level that is appropriate for the geology and tectonics in the region surrounding the plant location. Currently operating nuclear power plants developed their SSEs based on a "deterministic" or "scenario earthquake" basis that account for the largest earthquake expected in the area around the plant. Seismic activity in the regions surrounding U.S. plants is much lower than that for Japan since most U.S. plants are located in the interior of the stable continental U.S. The largest earthquakes within the continental U.S. are the 1811-12 New Madrid sequence and the 1886 Charleston, SC, which were estimated to be between about magnitude 7 to 7.5. On the west coast of the U.S., the two nuclear power plants are designed to specific ground motions from earthquakes of about magnitude 7 on faults located just offshore of the plants. The earthquakes on these faults are mainly strike-slip (horizontal motion) type earthquakes, not subduction zone earthquakes. Therefore, the likelihood of a tsunami from these faults is very remote.

Additional technical, non-public information: None.

13) What are the definitions of the SSE and OBE?

CLEAN UP BELOW information – late question

From RG1.208 Safe Shutdown Earthquake Ground Motion (SSE). The vibratory ground motion for which certain structures, systems, and components are designed, pursuant to Appendix S to 10 CFR Part 50, to remain functional. The SSE for the site is characterized by both horizontal and vertical free-field ground motion response spectra at the free ground surface

Appendix S to 10 CFR Part 50 (3) has the following information: Required Plant Shutdown. If vibratory ground motion exceeding that of the Operating Basis Earthquake Ground Motion or if significant plant damage occurs, the licensee must shut down the nuclear power plant. If systems, structures, or components necessary for the safe shutdown of the nuclear power plant are not available after the occurrence of the Operating Basis Earthquake Ground Motion, the licensee must consult with the Commission and must propose a plan for the timely, safe shutdown of the nuclear power plant. Prior to resuming operations, the licensee must demonstrate to the Commission that no functional damage has occurred to those features necessary for continued operation without undue risk to the health and safety of the public and the licensing basis is maintained.

The the ratio is provided in guidance as the ratio that the licensees can chose without additional analysis. The OBE mostly used to be half for existing plants, but now it's a 1/3 unless you do analyses to show why it should be 1/2.

Definition of Safe Shutdown Earthquake	The safe-shutdown earthquake (SSE) for the site is the ground motion response spectra (GMRS), which also satisfies the minimum requirement of paragraph IV(a)(1)(i) of Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," to Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities," of the Code of Federal Regulations (10 CFR Part 50).
Definition of Operating Basis Earthquake:	To satisfy the requirements of paragraph IV(a)(2)(A) of Appendix S to 10 CFR Part 50, the operating-basis earthquake (OBE) ground motion is defined as follows: (i) For the certified design portion of the plant, the OBE ground motion is one-third

	of the CSDRS.
(ii)	For the safety-related noncertified design portion of the plant, the OBE ground motion is one-third of the design motion response spectra, as stipulated in the design certification conditions specified in design control document (DCD).
(iii)	The spectrum ordinate criterion to be used in conjunction with Regulatory Guide 1.166, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Post-earthquake Actions," issued March 1997, is the lowest of (i) and (ii).

14) What is the likelihood of the design basis or "SSE" ground motions being exceeded over the life of the plant?

To estimate the probability of exceeding a specified ground motion level, such as an SSE, during a given time interval, the Poisson model is generally used. Using seismic hazard curves from the 2008 US Geological Survey National Seismic Hazard Map and assuming a 60-year life for a typical nuclear power plant, we can estimate the probability of exceeding the SSE over the life of the plant. The NRC recently performed these estimates as part of its GI-199 program (see Questions 54-59). The mean probability value for the plants in the Central and Eastern United States is less than 2%, with values ranging from a low of 0.1% to a high of 6%.

It is important to remember that there is margin above the design basis. In the mid to late 1990s, the NRC staff reviewed the potential for ground motions beyond the design basis as part of the Individual Plant Examination of External Events (IPEEE). From this review, the staff determined that seismic designs of operating plants in the United States have adequate safety margins for withstanding earthquakes built into the designs.

15) What is magnitude anyway? What is the Richter Scale? What is intensity?

ADD

16) We need to pull Q&As out of the Markey/Capp letter of March 15th...there's a lot there to answer...

ADD

17) How do magnitude and ground motion relate to each other?

ADD

18) How are combined seismic and tsunami events treated in risk space? Are they considered together?

the PRA Standard (ASME/ANS-Ra-Sa2009) does address the technical requirements for both seismic events and tsunamis (tsunami hazard under the technical requirements for external flooding analysis). **But together?** The standard does note that uncertainties associated with probabilistic analysis of tsunami hazard frequency are large and that an engineering analysis can usually be used to screen out tsunamis.

19) How are aftershocks treated in terms of risk assessment?

Seismic PRAs do not consider the affect of aftershocks since there are not methods to predict equipment fragility after the first main shock.

Design Against Natural Hazards & Plant Safety in the US

21) Are power plants designed for Tsunami's?

Public Answer: Yes. Plants are built to withstand a variety of environmental hazards and those plants that might face a threat from tsunami are required to withstand large waves and the maximum wave height at the intake structure (which varies by plant.)

Additional, technical, non-public information: Tsunami are considered in the design of US nuclear plants. Nuclear plants are designed to withstand flooding from not only tsunami, but also hurricane and storm surge; therefore there is often significant margin against tsunami flooding. However, it should be noted that Japanese experience has shown that drawdown can be a significant problem.

Currently the US NRC has a tsunami research program that is focused on developing modern hazard assessment techniques and additional guidance through cooperation with the National Oceanic and Atmospheric Administration and the United States Geological Survey. This has already lead to several technical reports and an update to NUREG 0-800. The NOAA and USGS contractors are also assisting with NRO reviews of tsunami hazard. A new regulatory guide on tsunami hazard assessment is currently planned in the office of research, although it is not expected to be available in draft form until 2012.

22) What level of Tsunami are we designed for?

Public Answer: Like seismic hazard, the level of tsunami that each plant is designed for is site-specific and is appropriate for what may occur at each location.

Additional, technical, non-public information: None.

23) Which plants are close to known active faults? What are the faults and how far away are they from the plants?

Public Answer: Jon to develop answer with Dogan's help. I created a placeholder table for your use "Table of Plants Near Known Active Faults" to be populated in the additional information section. The plots that Dogan made are in the additional information section under "Plot of Mapped Active Quaternary Faults and Nuclear Plants in the US" . This is really high priority after the congressional hearings.

Additional, technical, non-public information: ADD

24) How was the seismic design basis for an existing nuclear power plant established?

Public Answer: The seismic ground motion used for the design basis was determined from the evaluation of the maximum historic earthquake within 200 miles of the site, without explicitly considering the time spans between such earthquakes; safety margin was then added beyond this maximum historic earthquake to form a hypothetical *design basis earthquake*. The relevant regulation for currently operating plants is 10 CFR Part 100, Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants" (<http://www.nrc.gov/reading-rm/doc-collections/cfr/part100/part100-appa.html>).

Additional, technical, non-public information: See discussion at end of GI-199 section for discussion of safety margin and design basis.

25) Is there margin above the design basis?

Public Answer: Yes, there is margin beyond the design basis). In the mid to late 1990s, NRC staff reviewed the plants' assessments of potential consequences of severe earthquakes (earthquakes beyond the safety margin included in each plant's design basis), which licensees performed as part of the Individual Plant Examination of External Events (or IPEEE) program. From this review, the staff determined that seismic designs of operating plants in the United States have adequate safety margins, for withstanding earthquakes, built into the designs.

Additional, technical, non-public information: None.

26) Are US plants safe?

Public Answer: US plants are designed for appropriate earthquake shaking levels and are safe. Currently the NRC is also conducting a program called Generic Issue 199, which is reviewing the adequacy of earthquake design of US NPPs in the central and eastern North America based on the latest data and analysis techniques.

Additional, technical, non-public information: None.

27) Was the Japanese plant designed for this type of accident? Are US plants?

Public Answer: Plants in both the US and Japan area designed for earthquake shaking. In addition to the design of the plants, significant effort goes into emergency response planning and accident mitigation. This approach is called defense-in-depth.

Additional, technical, non-public information: None.

28) Why do we have confidence that US nuclear power plants are adequately designed for earthquakes and tsunamis?

Public Answer: Plants in both the US and Japan area designed for earthquake shaking. In addition to the design of the plants, significant effort goes into emergency response planning and accident mitigation. This approach is called defense-in-depth.

Additional, technical, non-public information: None.

29) Can this happen here i.e. an earthquake that significantly damages a nuclear power plant? Are the Japanese plants similar to U.S. plants?

Public Answer: All U.S. nuclear power plants are built to withstand environmental hazards, including earthquakes and tsunamis. Even those plants that are located within areas with low and moderate seismic activity are designed for safety in the event of such a natural disaster. The NRC requires that safety-significant structures, systems, and components be designed to take into account even rare and extreme seismic and tsunami events Nuclear power plants are designed to be safe based on the most severe natural phenomena historically reported for the site and surrounding area. The Japanese facilities are similar in design to several US facilities.

Additional technical, non-public information: Currently operating reactors were designed using a "deterministic" or "maximum credible earthquake" approach. Seismic hazard for the new plants is determined using a probabilistic seismic hazard assessment approach that explicitly addresses uncertainty, as described in Regulatory Guide 1.208. The NRC requires that adequate margin beyond the design basis ground shaking levels is assured. The NRC further enhances seismic safety for beyond-design-basis events through the use of a defense-in-depth approach.

In addition, the NRC reviews the seismic risk at operating reactors as needed when information may have changed. Over the last few years the NRC has undertaken a program called Generic Issue 199, which is focused on assessing hazard for plants in the central and eastern US using the latest techniques and data and is determining the possible risk implications of any increase in the anticipated ground shaking levels. This program will help us assure that the plants are safe under exceptionally rare and extreme ground motions that represent beyond-design-basis events.

The reactor design is a Boiling Water Reactor that is similar to some U.S. designs, including Oyster Creek, Nine Mile Point and Dresden Units 2 and 3.

30) Could an accident like the one at Japan's Fukushima Daiichi nuclear plant happen in the United States?

Public response: It is difficult to answer this question until we have a better understanding of the precise problems and conditions that faced the operators at Fukushima Daiichi. We do know, however, that Fukushima Daiichi Units 1-3 lost all offsite power and emergency diesel generators. This situation is called "station blackout." U.S. nuclear power plants are designed to cope with a station blackout event that involves a loss of offsite power and onsite emergency power. The Nuclear Regulatory Commission's detailed regulations address this scenario. U.S. nuclear plants are required to conduct a "coping" assessment and develop a strategy to demonstrate to the NRC that they could maintain the plant in a safe condition during a station blackout scenario. These assessments, proposed modifications and operating procedures were reviewed and approved by the NRC. Several plants added additional AC power sources to comply with this regulation.

In addition, U.S. nuclear plant designs and operating practices since the terrorist events of September 11, 2001, are designed to mitigate severe accident scenarios such as aircraft impact, which include the complete loss of offsite power and all on-site emergency power sources.

U.S. nuclear plant designs include consideration of seismic events and tsunamis'. It is important not to extrapolate earthquake and tsunami data from one location of the world to another when evaluating these natural hazards. These catastrophic natural events are very region- and location-specific, based on tectonic and geological fault line locations.

Additional technical, non-public information: None

31) Should U.S. nuclear facilities be required to withstand earthquakes and tsunamis of the kind just experienced in Japan? If not, why not?

Public response: U.S. nuclear reactors are designed to withstand an earthquake equal to the most significant historical event or the maximum projected seismic event and associated tsunami without any breach of safety systems.

The lessons learned from this experience must be reviewed carefully to see whether they apply to U.S. nuclear power plants. It is important not to extrapolate earthquake and tsunami data from one location of the world to another when evaluating these natural hazards, however. These catastrophic natural events are very region- and location-specific, based on tectonic and geological fault line locations.

The U.S. Geological Survey (USGS) conducts continuous research of earthquake history and geology, and publishes updated seismic hazard curves for various regions in the continental US. These curves are updated approximately every six years. NRC identified a generic issue (GI-199) that is currently undergoing an evaluation to assess implications of this new information to nuclear plant sites located in the central and eastern United States. The industry is working with the NRC to address this issue.

Additional technical, non-public information: None

32) Can you summarize the plant seismic design basis for the US plants? Are there any special issues associated with seismic design?

Public response: Please see one of the several tables provided in the "Additional information" section of this document

Additional, technical, non-public information: None

33) How do we know that the equipment in plants is safe in earthquakes?

Public response: All equipment important to safety (required to safely shutdown a nuclear power plant) is qualified to withstand earthquakes in accordance with plants' licensing basis and NRC regulations.

Additional, technical, non-public information: 10 CFR 50, Appendix A, General Design Criterion 2 and 4, 10 Part 100, and Appendix S. Guidance: Regulatory Guides 1.100, IEEE 344 and ASME QME-1

34) How do we know equipment will work if the magnitude is bigger than expected, like in Japan?

Public response: Plant systems are designed to mitigate a design basis earthquake which includes margin above the postulated site specific earthquake. (reviewers comment: this needs to be expanded)

Additional, technical, non-public information: See part 100 Reactor Site Criteria

35) Are US plants susceptible to the same kind of loss of power as happened in Japan?

Public response: NRC recognized that there is the possibility of a total loss of AC power at a site, called a 'Station Blackout', or SBO. Existing Regulations require the sites to be prepared for the possibility of an SBO. In addition to battery powered back-up system to immediately provide power for emergency systems, NRC regulations require the sites to have a detailed plan of action to address the loss of AC power while maintaining control of the reactor.

There has also been an understanding that sites can lose offsite power as well. Of course, this can be caused by earthquake. However, hurricane- or tornado-related high winds may potentially damage the transmission network in the vicinity of a nuclear plant as well. Flood waters can also affect transformers used to power station auxiliary system. These types of weather related events have the potential to degrade the offsite power source to a plant.

The onsite Emergency Diesel Generators need fuel oil stored in tanks that are normally buried underground. These tanks and associated pumps/piping require protection from the elements. Above ground tanks have tornado/missile protection.

In case both offsite and onsite power supplies fail, NRC has required all licensee to evaluate for a loss of all AC power (station blackout) scenario and implement coping measures to safely shutdown the plant law 10 CFR 50.63.

Additional, technical, non-public information: Some plants have safeguards equipment below sea level and rely on watertight doors or Bilge pumps to remove water from equipment required to support safe shutdown. Overflowing rivers can result in insurmountable volume of water flooding the vulnerable areas. SBO definition in 10CFR50.2, SBO plan requirements in 10CFR50.63

36) How do we know that the EDGs in Diablo Canyon and SONGS will not fail to operate like in Japan?

Public response: EDGs are installed in a seismically qualified structure. Even if these EDGs fail, plants can safely shutdown using station blackout power source law 10 CFR 50.63.

Additional, technical, non-public information: None.

37) Is all equipment at the plant vulnerable to tsunami?

Public response: Plants are designed law GDC 2 to withstand protection against natural phenomena such as tsunami, earthquakes. (reviewers comment: this needs to be expanded. I need assistance with this)

Additional, technical, non-public information: ADD

38) What protection measures do plants have against tsunami?

Public response: Plants are designed law GDC 2 to withstand protection against natural phenomena such as tsunami, earthquakes. (note from reviewer: add information on breakwater from songs and Diablo example. I need assistance with this)

Additional, technical, non-public information: ADD

39) Is there a risk of loss of water during tsunami drawdown? Is it considered in design?

Public response: Goutam, Henry and Rich, can you guys answer this?

Additional, technical, non-public information: ADD

40) Are nuclear buildings built to withstand earthquakes? What about tsunami?

Public response: There is language elsewhere in this document that answers that...copy here.

Additional, technical, non-public information: ADD

41) Are aftershocks considered in the design of equipment at the plants? Are aftershocks considered in design of the structure?

Public response: ADD

Additional, technical, non-public information: ADD

42) Are there any special issues associated with seismic design at the plants? For example, Diablo Canyon has special requirements. Are there any others?

Public response: Both SONGS and Diablo canyon are licensed with an automatic trip for seismic events. (can this be expanded? any others?) Mike Markley, can your group assist with this?

Additional, technical, non-public information: ADD

43) Is the NRC planning to require seismic isolators for the next generation of nuclear power plants? How does that differ from current requirements and/or precautions at existing U.S. nuclear power plants?

Public response: The NRC would not require isolators for the next generation of plants. However, it is recognized that a properly designed isolation system can be very effective in mitigating the effect of

earthquake. Currently the NRC is preparing guidance for plant designers considering the use of seismic isolation devices.

Additional, technical, non-public information: A NUREG is in the works in the office of research. It is expected to be available for comment in 2011.

44) Are there any U.S. nuclear power plants that incorporate seismic isolators? What precautions are taken in earthquake-prone areas?

Public response: No currently constructed nuclear power plants in the US use seismic isolators. However seismic isolation is being considered for a number of reactor designs under development. Currently seismic design of plants is focused on assuring that design of structures, systems, and components are designed and qualified to assure that there is sufficient margin beyond the design basis ground motion.

Additional, technical, non-public information: None.

45) Do you think that the recent Japan disaster will cause any rethinking of the planned seismic isolation guidelines, particularly as it regards earthquakes and secondary effects such as tsunamis?

Public response: Whenever an event like this happens, the NRC thoroughly reviews the experience and tries to identify any lessons learned. The NRC further considers the need to change guidance or regulations. In this case, the event will be studied and any necessary changes will be made to the guidance under development. However, it should be noted that Japan does not have seismically isolated nuclear plants.

Additional, technical, non-public information: None.

About Japanese Hazard, Design and Earthquake Impact

46) Was the damage done to the plants from the Earthquake or the Tsunami?

Public response: It is hard to tell at this point. In the nuclear plants there seems to have been some damage from the shaking. However, the tsunami lead to some of the biggest problems in terms of the loss of backup power. This is also true in the general population; the tsunami seems to have lead to most of the deaths.

Additional, technical, non-public information: None

47) What is the design level of the Japanese plants? Was it exceeded?

Public response: As a result of a significant change in seismic regulations in 2006, the Japanese regulator initiated a program to reassess seismic hazard and seismic risk for all nuclear plants in Japan. This resulted in new assessments of higher ground shaking levels (i.e. seismic hazard) and a review of seismic safety for all Japanese plants. The program is still on-going, but has already resulted in retrofit in some plants. Therefore, it is useful to discuss both the design level and a review level ground motion for the plants, as shown below.

Currently we do not have official information. However, it appears that the ground motions (in terms of peak ground acceleration) are similar to the S_s shaking levels, although the causative earthquakes are different. Thus the design basis was exceeded, but the review level may not have been.

Table: Original Design Basis Ground Motions (S_2) and New Review Level Ground Motions (S_s) Used for Review of Japanese Plants

Plant sites	Contributing earthquakes used for determination of hazard	New DBGM S_s	Original DBGM S_1
Onagawa	Soutei Miyagiken-oki (M8.2)	580 gal (0.59g)	375 gal (0.38g)
Fukushima	Earthquake near the site (M7.1)	600 gal (0.62g)	370 gal (0.37g)
Tokai	Earthquakes specifically undefined	600 gal (0.62g)	380 gal (0.39g)
Hamaoka	Assumed Tokai (M8.0), etc.	800 gal (0.82g)	600 gal (0.62g)

Additional, technical, non-public information: None

48) What are the Japanese S_1 and S_s ground motions and how are they determined?

Public response: Japanese nuclear power plants are designed to withstand specified earthquake ground motions, previously specified as S_1 and S_2 , but now simply S_s . The design basis earthquake ground motion S_1 was defined as the largest earthquake that can reasonably be expected to occur at the site of a nuclear power plant, based on the known seismicity of the area and local faults that have shown activity during the past 10,000 years. A power reactor could continue to operate safely during an S_1 level earthquake, though in practice they are set to trip at lower levels. The S_2 level ground motion was based on a larger earthquake from faults that have shown activity during the past 50,000 years and assumed to be closer to the site. The revised seismic regulations in May 2007 replaced S_1 and S_2 with S_s .

The S_5 design basis earthquake is based on evaluating potential earthquakes from faults that have shown activity during the past 130,000 years. The ground motion from these potential earthquakes are simulated for each of the sites and used to determine the revised S_5 design basis ground motion level. Along with the change in definition, came a requirement to consider "residual risk", which is a consideration of the beyond-design-basis event.

Additional, technical, non-public information: None

49) Did this earthquake affect Kashiwazaki-Kariwa NPP?

Public response: No, this earthquake did not affect Kashiwazaki-Kariwa NPP and all reactors remained in their pre-earthquake operating state. It also did not trip during an earthquake of magnitude **XX** that occurred on the western side subsequent to the 8.9 earthquake. This is very important for the stability of Japan's energy supply due to the loss of production at TEPCO's Fukushima NPPs.

Additional, technical, non-public information: None

50) How high were the tsunami at the plants?

Public response: The actual tsunami height at the plants is not currently known. However, NOAA has publically information on the recordings at sea for many areas.

Additional, technical, non-public information: A preliminary rough estimate of tsunami height at the plant locations was provided to NRC by NOAA shortly after the earthquake. This was developed using NOAA's global ocean model and is shown in the "additional information" section. Most notably, there was a 6 meter wave at Fukushima and the wave at Onogawa may have been between 18 and 23 meters.

51) Wikileaks has a story that quotes US embassy correspondence and some un-named IAEA expert stating that the Japanese were warned about this ... Does the NRC want to comment?

<http://www.dailymail.co.uk/news/article-1366721/Japan-tsunami-Government-warned-nuclear-plants-withstand-earthquake.html>

Public response: TBD Annie to explain the history of their recent retrofit program.

Additional, technical, non-public information: The article talks about that the plants and that were checked for a M=7, but the earthquake was a 9. The reality is the 7 close in (that they assumed) had similar ground motions to a 9 farther away. They did check (and retrofit) the plant to the ground motions that they probably saw (or nearly). The problem was the tsunami. We probably need a small write up so that staff understands, even if we keep it internal.

What happened in US Plants during the earthquake?

52) Was there any damage to U.S. reactors from either the earthquake or the resulting tsunami?

Public Answer: No

Additional, technical non-public information: Two US plants on the Pacific Ocean (Diablo Canyon and San Onofre) experienced higher than normal sea level due to tsunami. However, the wave heights were consistent with previously predicted levels and this had no negative impact to the plants. In response, Diablo Canyon Units 1 and 2 declared an "unusual event" based on tsunami warning following the Japanese earthquake. They have since exited the "unusual event" declaration, based on a downgrade to a tsunami advisory.

53) Have any lessons for US plants been identified?

Public Answer: The NRC is in the process of following and reviewing the event in real time. This, inevitably, leads to the indemnification of lessons that warrant further study. However, a complete understanding of lessons learned requires more information than is currently available to NRC staff.

Additional, technical non-public information: We need to take a closer look at common cause failures, such as earthquake and tsunami, and earthquake and dam failure.

Future Actions, Reassessment of US Plants and GI-199

54) What is the NRC doing about the emergencies at the nuclear power plants in Japan? Are you sending staff over there?

Public Answer: We are closely following events in Japan, working with other agencies of the federal government, and have been in direct contact with our counterparts in that country. In addition, we are ready to provide assistance if there is a specific request. An NRC staffer is participating in the USAID team headed to Japan.

Additional technical, non-public information: We are taking the knowledge that the staff has about the design of the US nuclear plants and we are applying this knowledge to the Japan situation. For example, this includes calculations of severe accident mitigation that have been performed.

55) With NRC moving to design certification, at what point is seismic capability tested – during design or modified to be site-specific? If in design, what strength seismic event must these be built to withstand?

Public Answer: During design certification, vendors propose a seismic design in terms of a ground motion spectrum for their nuclear facility. This spectrum is called a standard design response spectrum and is developed so that the proposed nuclear facility can be sited at most locations in the central and eastern United States. The vendors show that this design ground motion is suitable for a variety of different subsurface conditions such as hard rock, deep soil, or shallow soil over rock. Combined License and Early Site Permits applicants are required to develop a site specific ground motion response spectrum that takes into account all of the earthquakes in the region surrounding their site as well as the local site geologic conditions. Applicants estimate the ground motion from these postulated earthquakes to develop seismic hazard curves. These seismic hazard curves are then used to determine a site specific ground motion response spectrum that has a maximum annual likelihood of 1×10^{-4} of being exceeded. This can be thought of as a ground motion with a 10,000 year return period. This site specific ground motion response spectrum is then compared to the standard design response spectrum for the proposed design. If the standard design ground motion spectrum envelopes the site specific ground motion spectrum then the site is considered to be suitable for the proposed design. If the standard design spectrum does not completely envelope the site specific ground motion spectrum, then the COL applicant must do further detailed structural analysis to show that the design capacity is adequate. Margin beyond the standard design and site specific ground motions must also be demonstrated before fuel loading can begin.

Additional technical, non-public information: None.

56) Can we get the rankings of the plants in terms of safety? (Actually this answer should be considered any time GI-199 data is used to “rank” plants)

The objective of the GI-199 Safety/Risk Assessment was to perform a conservative, screening-level assessment to evaluate if further investigations of seismic safety for operating reactors in the central and eastern U.S. (CEUS) are warranted consistent with NRC directives. The results of the GI-199 SRA should not be interpreted as definitive estimates of plant-specific seismic risk. The nature of the information used (both seismic hazard data and plant-level fragility information) make these estimates useful only as a screening tool. The NRC does not rank plants by seismic risk.

Currently operating nuclear plants in the United States remain safe, with no need for immediate action. This determination is based on NRC staff reviews of updated seismic hazard information and the conclusions of the Generic Issue 199 Screening Panel. Existing plants were designed with considerable margin to be able to withstand the ground motions from the "deterministic" or "scenario earthquake" that accounted for the largest earthquake expected in the area around the plant. During the mid-to late-1990s, the NRC staff reassessed the margin beyond the design basis as part of the Individual Plant Examination of External Events (IPEEE) program. The results of the GI-199 assessment demonstrate that the probability of exceeding the design basis ground motion may have increased at some sites, but only by a relatively small amount. In addition, the Safety/Risk Assessment stage results indicate that the probabilities of seismic core damage are lower than the guidelines for taking immediate action.

57) Is the earthquake safety of US plants reviewed once the plants are constructed?

Public response: Yes, earthquake safety is reviewed during focused design inspections, under the Generic Issues Program (GI-199) and as part of the Individual Plant Evaluation of External Events program (IPEEE) that was conducted in response to Generic Letter 88-20 Supplement 4.

Additional, technical, non-public information: None.

58) Does the NRC ever review tsunami risk for existing plants?

Public Answer: The NRC has not conducted a generic issue program on tsunami risk to date. However, some plants have been reviewed as a result of the application for a license for a new reactor. In the ASME/ANS 2009 seismic probabilistic risk assessment standard, all external hazards are included.

Additional, technical, non-public information: None.

59) Does GI-199 consider tsunami?

Public response: GI-199 stems from the increased in perceived seismic hazard focused on understanding the impact of increased ground motion on the risk at a plant. GI-199 does not consider tsunami

Additional, technical, non-public information: In the past there has been discussion about a GI program on tsunami, but the NRC's research and guidance was not yet at the point it would be effective. We are just getting to this stage and the topic should be revisited.

60) What is Generic Issue 199 about?

Public Answer: Generic Issue 199 investigates the safety and risk implications of updated earthquake-related data and models. These data and models suggest that the probability for earthquake ground shaking above the seismic design basis for some nuclear power plants in the Central and Eastern United States is still low, but larger than previous estimates.

Additional, technical, non-public information: See additional summary/discussion of GI-199 and terms below.

61) Where can I get current information about Generic Issue 199?

Public Answer: The public NRC Generic Issues Program (GIP) website (<http://www.nrc.gov/about-nrc/regulatory/gen-issues.html>) contains program information and documents, background and historical information, generic issue status information, and links to related programs. The latest Generic Issue Management Control System quarterly report, which has regularly updated GI-199 information, is publicly available at <http://www.nrc.gov/reading-rm/doc-collections/generic->

[issues/quarterly/index.html](http://www.gpo.gov/quarterly/index.html). Additionally, the U.S. Geological Survey provides data and results that are publicly available at <http://earthquake.usgs.gov/hazards/products/conterminous/2008/>.

Additional, technical, non-public information: The GI-199 section of the NRC internal GIP website (<http://www.internal.nrc.gov/RES/projects/GIP/Individual%20GIs/GI-0199.html>) contains additional information about Generic Issue 199 (GI-199) and is available to NRC staff.

62) How was the seismic design basis for an existing nuclear power plant established?

Public Answer: The seismic ground motion used for the design basis was determined from the evaluation of the maximum historic earthquake within 200 miles of the site, without explicitly considering the time spans between such earthquakes; safety margin was then added beyond this maximum historic earthquake to form a hypothetical *design basis earthquake*. The relevant regulation for currently operating plants is 10 CFR Part 100, Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants" (<http://www.nrc.gov/reading-rm/doc-collections/cfr/part100/part100-appa.html>).

Additional, technical, non-public information: See discussion at end of GI-199 section for discussion of safety margin and design basis.

63) Is there margin above the design basis?

Public Answer: Yes, there is margin beyond the design basis. In the mid to late 1990s, NRC staff reviewed the plants' assessments of potential ground motion beyond the safety margin included in each plant's design basis, which licensees performed as part of the Individual Plant Examination of External Events (or IPEEE) program. From this review, the staff determined that seismic designs of operating plants in the United States have adequate safety margins, for withstanding earthquakes, built into the designs.

Additional, technical, non-public information: The goal of seismic engineering is to design structures, systems and components that explicitly do not fail at the design level. The application of specific codes, standards, and analysis techniques results in margin beyond the design level. The assessments carried out as part of the IPEEE program demonstrated that margin exists in the operating reactors against seismic demand.

64) Are all U.S. plants being evaluated as a part of Generic Issue 199?

Public Answer: The scope of the Generic Issue 199 (GI-199) Safety/Risk Assessment is limited to all plants in the Central and Eastern United States. Although plants at the Columbia, Diablo Canyon, Palo Verde, and San Onofre sites are not included in the GI-199 Safety/Risk Assessment, the Information Notice on GI-199 is addressed to all operating power plants in the U.S. (as well as all independent spent fuel storage installation licensees). The staff will also consider inclusion of operating reactors in the Western U.S. in its future generic communication information requests.

Additional, technical, non-public information: The staff is currently developing specific information needs to be included in a Generic Letter to licensees in the CEUS.

65) Are the plants safe? If you are not sure they are safe, why are they not being shut down? If you are sure they are safe, why are you continuing evaluations related to this generic issue?

Public Answer: Yes, currently operating nuclear plants in the United States remain safe, with no need for immediate action. This determination is based on NRC staff reviews associated with Early Site

Permits and updated seismic hazard information, the conclusions of the Generic Issue 199 Screening Panel (comprised of technical experts), and the conclusions of the Safety/Risk Assessment Panel (also comprised of technical experts).

No immediate action is needed because: (1) existing plants were designed to withstand anticipated earthquakes with substantial design margins, as confirmed by the results of the Individual Plant Examination of External Events program; (2) the probability of exceeding the *safe shutdown earthquake* ground motion may have increased at some sites, but only by a relatively small amount; and (3) the Safety/Risk Assessment Stage results indicate that the probabilities of seismic core damage are lower than the guidelines for taking immediate action.

Even though the staff has determined that existing plants remain safe, the Generic Issues Program criteria (Management Directive 6.4) direct staff to continue their analysis to determine whether any cost-justified plant improvements can be identified to make plants enhance plant safety.

Additional, technical, non-public information : The Safety/Risk Assessment results confirm that plants are safe. The relevant risk criterion for GI-199 is total *core damage frequency* (CDF). The threshold for taking immediate regulatory action (found in NRR Office Instruction LIC-504, see below) is a total CDF greater than or on the order of 10^{-3} (0.001) per year. For GI-199, the staff calculated seismic CDFs of 10^{-4} (0.0001) per year and below for nuclear power plants operating in the Central and Eastern U.S. (CEUS) (based on the new U.S. Geological Survey seismic hazard curves). The CDF from internal events (estimated using the staff-developed Standardized Plant Analysis of Risk models) and fires (as reported by licensees during the IPEEE process and documented in NUREG-1742), when added to the seismic CDF estimates results in the total risk for each plant to be, at most, 4×10^{-4} (0.0004) per year or below. This is well below the threshold (a CDF of 10^{-3} [0.001] per year) for taking immediate action. Based on the determination that there is no need for immediate action, and that this issue has not changed the licensing basis for any operating plant, the CEUS operating nuclear power plants are considered safe. In addition, as detailed in the GI-199 Safety/Risk Assessment there are additional, qualitative considerations that provide further support to the conclusion that plants are safe.

Note: The NRC has an integrated, risk-informed decision-making process for emergent reactor issues (NRR Office Instruction LIC-504, ADAMS Accession No. ML100541776 [not publically available]). In addition to deterministic criteria, LIC-504 contains risk criteria for determining when an emergent issue requires regulatory action to place or maintain a plant in a safe condition.

66) What do you mean by “increased estimates of seismic hazards” at nuclear power plant sites?

Public Answer: *Seismic hazard* (earthquake hazard) represents the chance (or probability) that a specific level of ground shaking could be observed or exceeded at a given location. Our estimates of seismic hazard at some Central and Eastern United States locations have changed based on results from recent research, indicating that earthquakes occurred more often in some locations than previously estimated. Our estimates of seismic hazard have also changed because the models used to predict the level of ground shaking, as caused by a specific magnitude earthquake at a certain distance from a site, changed. The increased estimates of seismic hazard at some locations in the Central and Eastern United States were discussed in a memorandum to the Commission, dated July 26, 2006. (The memorandum is available in the NRC Agencywide Documents Access and Management System [ADAMS] under Accession No. ML052360044).

Additional, technical, non-public information: See additional discussion of terms below.

67) What do the following terms mean?

- Annual exceedance frequency
- Core damage frequency
- Design basis earthquake or safe shutdown earthquake
- Ground acceleration
- High confidence of low probability of failure capacity
- Large early release frequency
- Seismic hazard
- Seismic margin
- Seismic risk

Public Answer: The terms are defined as follows:

Annual exceedance frequency (AEF) – Number of times per year that a site's ground motion is expected to exceed a specified acceleration.

Core damage frequency (CDF) – Expected number of core damage events per unit of time.

Core damage refers to the uncovering and heat-up of the reactor core, to the point that prolonged oxidation and severe fuel damage are not only anticipated but also involve enough of the core to result in off-site public health effects if released. *Seismic core damage frequency* refers to the component of total CDF that is due to seismic events.

Design basis earthquake or safe shutdown earthquake (SSE) – A *design basis earthquake* is a commonly employed term for the *safe shutdown earthquake (SSE)*; the SSE is the earthquake ground shaking for which certain structures, systems, and components are designed to remain functional. In the past, the SSE has been commonly characterized by a standardized spectral shape associated with a peak *ground acceleration* value.

Ground acceleration – Acceleration produced at the ground surface by seismic waves, typically expressed in units of *g*, the acceleration of gravity at the earth's surface.

High confidence of low probability of failure (HCLPF) capacity – A measure of *seismic margin*. In *seismic risk* assessment, *HCLPF capacity* is defined as the earthquake motion level, at which there is high confidence (95%) of a low probability (at most 5%) of failure of a structure, system, or component.

Large early release frequency (LERF) – The expected number of large early releases per unit of time. A *large early release* is the rapid, unmitigated release of airborne fission products from the containment building to the environment, occurring before the effective implementation of off-site emergency response and protective actions, such that there is a potential for early health effects. *Seismic large early release frequency* refers to the component of total LERF that is due to seismic events.

Seismic hazard – Any physical phenomenon, such as ground motion or ground failure, that is associated with an earthquake and may produce adverse effects on human activities (such as posing a risk to a nuclear facility).

Seismic margin – The difference between a plant's capacity and its seismic design basis (*safe shutdown earthquake, or SSE*).

Seismic risk – The risk (frequency of occurrence multiplied by its consequence) of severe earthquake-initiated accidents at a nuclear power plant. A severe accident is an accident that causes core damage, and, possibly, a subsequent release of radioactive materials into the environment. Several risk metrics may be used to express *seismic risk*, such as *seismic core damage frequency* and *seismic large early release frequency*.

68) Let's say there's an estimate expressed as "2.5E-06." (I'm looking at Table D-2 of the safety/risk assessment of August 2010.) I believe that this expression means the same as 2.5×10^{-06} , or 0.000025, or 2.5 divided by one million. In layman's terms, that means an expectation, on average, of 2.5 events every million years, or once every 400,000 years. Similarly, "2.5E-05" would be 2.5 divided by 100,000, or 2.5 events every 100,000 years, on average, or once every 40,000 years. Is this correct?

Public Response: Yes, at least partly. In the subject documents the frequencies for core damage or ground motion exceedance have been expressed in the form "2.5E-06". As you noted this is equivalent to 2.5×10^{-6} , or 0.000025 per year. If, for example, the core damage frequency was estimated as 2.5E-06, this would be equivalent to an expectation of 2.5 divided by a million per year. It is not really correct to think of these values as "once every 400,000 years," the two numbers are mathematically equivalent but do not convey the same statistical meaning within this context. Rather, you could characterize it as 1 in 400,000 per year of something occurring.

Additional, technical, non-public information: None

69) The GI-199 documents give updated probabilistic seismic hazard estimates for existing nuclear power plants in the Central and Eastern U.S. What document has the latest seismic hazard estimates (probabilistic or not) for existing nuclear power plants in the Western U.S.?

Public Response: At this time the staff has not formally developed updated probabilistic seismic hazard estimates for the existing nuclear power plants in the Western U.S. However, NRC staff during the mid- to late-1990's reviewed the plants' assessments of potential consequences of severe ground motion from earthquakes beyond the plant design basis as part of the Individual Plant Examination of External Events (IPEEE) program. From this review, the NRC staff determined that the seismic designs of operating plants in the U.S. have adequate safety margin. NRC staff has continued to stay abreast of the latest research on seismic hazards in the Western U.S. and interface with colleagues at the U.S. Geological Survey. The focus of Generic Issue 199 has been on the CEUS. However, the Information Notice that summarized the results of the Safety/Risk Assessment was sent to all existing power reactor licensees. The documents that summarize existing hazard estimates are contained in the Final Safety Analysis Reports (FSARS) and in the IPEEE submittals. It must be noted that following 9/11 the IPEEE documents are no longer publicly available.

Additional, technical, non-public information: None

70) The GI-199 documents refer to newer data on the way. Have NRC, USGS et al. released those? I'm referring to this: "New consensus seismic-hazard estimates will become available in late 2010 or early 2011 (these are a product of a joint NRC, U.S. Department of Energy, U.S. Geological Survey (USGS) and Electric Power Research Institute (EPRI) project). These consensus seismic hazard estimates will supersede the existing EPRI, Lawrence Livermore National Laboratory, and USGS hazard estimates used in the GI-199 Safety/Risk Assessment."

Public Response: The new consensus hazard curves are being developed in a cooperative project that has NRC, U.S. Department of Energy, U.S. Geological Survey (USGS) and Electric Power Research Institute (EPRI) participation. The title is: the Central and Eastern U.S. Seismic Source Characterization (CEUS-SSC) project. The project is being conducted following comprehensive standards to ensure quality and regulatory defensibility. It is in its final phase and is expected to be publicly released in the fall of 2011. The project manager is Larry Salamone (Lawrence.salamone@srs.gov, 803-645-9195) and the technical lead on the project is Dr. Kevin Coppersmith (925-974-3335, kcoppersmith@earthlink.net). Additional information on this project can be found at: <http://mydocs.epri.com/docs/ANT/2008-04.pdf>, and http://my.epri.com/portal/server.pt?open=512&objID=319&&PageID=218833&mode=2&in_hi_us_eriid=2&cached=true.

Additional, technical, non-public information: None

71) What is the timetable now for consideration of any regulatory changes from the GI-199 research?

Public Response: The NRC is working on developing a Generic Letter (GL) to request information from affected licensees. The GL will likely be issued in a draft form within the next 2 months to stimulate discussions with industry in a public meeting. After that it has to be approved by the Committee to Review Generic Requirements, presented to the Advisory Committee on Reactor Safeguards and issued as a draft for formal public comments (60 days). After evaluation of the public comments it can then be finalized for issuance. We expect to issue the GL by the end of this calendar year, as the new consensus seismic hazard estimates become available. The information from licensees will likely require 3 to 6 months to complete. Staff's review will commence after receiving licensees' responses. Based on staff's review, a determination can be made regarding cost beneficial backfits where it can be justified.

Additional, technical, non-public information: None

Seismic Probabilistic Risk Assessment (SPRA)

72) The NRC increasingly uses risk-information in regulatory decisions. Are risk-informed PRAs useful in assessing an event such as this?

Public response: Nilesh Chokshi to provide Q&As on SPRA

Additional, technical, non-public information: None

Plant-Specific Questions

SONGS questions

73) SONGS received a white finding in 2008 for 125VDC battery issue related to the EDGs that went undetected for 4 years. NRC issued the white finding as there was increased risk that one EDG may not have started due to a low voltage condition on the battery on one Unit (Unit 2). Aren't all plants susceptible to the unknown? Is there any assurance the emergency cooling systems will function as desired in a Japan-like emergency?

Public response: The low voltage condition was caused by a failure to properly tighten bolts on a electrical breaker that connected the battery to the electrical bus that would be relied on to start the EDG in case of a loss of off-site power. This was corrected immediately on identification and actions taken to prevent its reoccurrence. The 3 other EDGs at SONGS were not affected.

Additional, technical, non-public information: None

74) Has the earthquake hazard at SONGS been reviewed like DCNPP is doing? Are they planning on doing an update before relicensing?

Public Answer: Relicensing does not evaluate the potential change to seismic siting of a plant. If there is a seismic design concern, it would be addressed for the plant as it is currently operating.

The closest active fault is approximately five miles offshore from San Onofre, a system of folds and faults exist called the OZD. The Cristianitos fault is ½ mile southeast, but is an inactive fault. Other faults such as the San Andreas and San Jacinto, which can generate a larger magnitude earthquake, are far enough away that they would produce ground motions less severe than the OZD for San Onofre.

Past history relative to nearby major quakes have been of no consequences to San Onofre. In fact, three major earthquakes from 1992 to 1994 (Big Bear, Landers and Northridge), ranging in distance from 70-90 miles away and registering approximately 6.5 to 7.3 magnitude, did not disrupt power production at San Onofre. The plant is expected to safely shutdown if a major earthquake occurs nearby. Safety related structures, systems and components have been designed and qualified to remain functional and not fail during and after an earthquake.

Additional, technical, non-public information: None

75) Is possible to have a tsunami at songs that is capable of damaging the plant?

Public Information: The San Onofre Units 2 and 3 plant grade is elevation +30.0 feet MLLW. The controlling tsunami for San Onofre occurring during simultaneous high tide and storm surge produces a maximum runup to elevation +15.6 feet MLLW at the Unit 2 and 3 seawall. When storm waves are superimposed, the predicted maximum runup is to elevation +27 MLLW. Tsunami protection for the SONGS site is provided by a reinforced concrete seawall constructed to elevation +30.0 MLLW. A tsunami greater than this height is extremely unlikely.

Additional, technical, non-public information: None

76) Does SONGS have an emergency plan for tsunami?

Public Response: The SONGS emergency plan does initiate the emergency response organization and results in declaration of emergency conditions via their EALs. The facility would then make protective

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action recommendations to the Governor, who would then decide on what protective actions would be ordered for the residents around SONGS.

Additional, technical, non-public information: None

77) Has evacuation planning at SONGS considered tsunami?

Public Response: These considerations would be contained in the State and local (City, County) emergency plans, which are reviewed by FEMA. FEMA then certifies to the NRC that they have "reasonable assurance" that the off-site facilities can support operation of SONGS in an emergency.

Additional, technical, non-public information: None

78) Is SONGS designed against tsunami and earthquake?

Public Response: Yes. SONGS is designed against both tsunami and earthquake.

Additional, technical, non-public information: None

79) What is the height of water that SONGS is designed to withstand?

Public Response: 30 feet. Information for all plants can be found in the "Additional Information" section of this document.

Additional, technical, non-public information: None

80) What about drawdown and debris?

Public Response: *Good question...can HQ answer? Goutam, Henry, or Rich...can you help with this one?*

Additional, technical, non-public information: None

81) Will this be reviewed in light of the Japan quake.

Public Response: The NRC will do a through assessment of the lessons learned from this event and will review all potential issues at US nuclear plants as a result.

Additional, technical, non-public information: None

82) Could all onsite and offsite power be disrupted from SONGS in the event of a tsunami, and if that happened, could the plant be safely cooled down if power wasn't restored for days after?

Public Response: Seismic Category I equipment is equipment that is essential to the safe shutdown and isolation of the reactor or whose failure or damage could result in significant release of radioactive material. All Seismic Category I equipment at SONGS is designed to function following a DBE with ground acceleration of 0.67g.

The operating basis earthquake (1/2 of the DBE) is characterized by maximum ground shaking of 0.33g. Historically, even this level of ground shaking has not been observed at the site. Based on expert analysis, the average recurrence interval for 0.33g ground shaking at the San Onofre site would be in excess of 1000 years and, thus, the probability of occurrence in the 40-year design life of the plant would be less than 1 in 25. The frequency of the DBE would be much more infrequent, and very unlikely to occur during the life of the plant. Even if an earthquake resulted in greater than the DBE movement/acceleration at SONGS, the containment structure would ultimately protect the public from harmful radiation release, in the event significant damage occurred to Seismic category 1 equipment.

Additional, technical, non-public information: None

83) Are there any faults nearby SONGS that could generate a significant tsunami?

Public Response: Current expert evaluations estimate a magnitude 7 earthquake about 4 miles from SONGS. This is significantly less than the Japan quake, and SONGS has been designed to withstand this size earthquake without incident. Should discuss the different tectonic nature (not a subduction zone like Japan)?

Additional, technical, non-public information: None

84) What magnitude or shaking level is SONGS designed to withstand? How likely is an earthquake of that magnitude for the SONGS site?

Public Response: The design basis earthquake (DBE) is defined as that earthquake producing the maximum vibratory ground motion that the nuclear power generating station is designed to withstand without functional impairment of those features necessary to shut down the reactor, maintain the station in a safe condition, and prevent undue risk to the health and safety of the public. The DBE for SONGS was assessed during the construction permit phase of the project. The DBE is postulated to occur near the site (5 miles), and the ground accelerations are postulated to be quite high (0.67g), when compared to other nuclear plant sites in the U.S (0.25g or less is typical for plants in the eastern U.S.). Based on the unique seismic characteristics of the SONGS site, the site tends to amplify long-period motions, and to attenuate short-period motions. These site-specific characteristics were accounted for in the SONGS site-specific seismic analyses.

Additional, technical, non-public information: None

85) Could SONGS withstand an earthquake of the magnitude of the Japanese earthquake?

Public Response: We do not have current information on the ground motion at the Japanese reactors. SONGS was designed for approximately a 7.0 magnitude earthquake 4 miles away. The Japanese earthquake was much larger (8.9), but was also almost 9 miles away. The local ground motion at a particular plant is significantly affected by the local soil and bedrock conditions. SONGS was designed (.67g) to withstand more than 2 times the design motion at average US plants.

Additional, technical, non-public information: None

86) What about the evacuation routes at SONGS? How do we know they are reasonable?

Public Response: FEMA reviews off-site evacuation plans formally every 2 years during a biennial emergency preparedness exercise. NRC evaluates on-site evacuation plans during the same exercise. Population studies are formally done every 10 years, and evacuation time estimates are re-evaluated at that time. FEMA reviews these evacuation plans, and will conclude their acceptability through a finding of "reasonable assurance" that the off-site facilities and infrastructure is capable of protecting public health and safety in the event of an emergency at SONGS. The next such exercise is planned for April 12, 2011.

Additional, technical, non-public information: None

87) Regarding tsunami at Diablo and SONGS, is the tsunami considered separately from flooding in licensing? And from the design perspective, is the flood still the controlling event for those plants rather than the tsunami?

Public response: See below

88) What is the design level flooding for DNCPP and SONGS? Can a tsunami be larger?

Public response: Both the Diablo Canyon (main plant) and SONGS are located above the flood level associated with tsunami. However, the intake structures and Auxiliary Sea Water System at Diablo canyon are designed for combination of tsunami-storm wave activity. SONGS has reinforced concrete cantilevered retaining seawall and screen well perimeter wall designed to withstand the design basis earthquake, followed by the maximum predicted tsunami with coincident storm wave action

Additional, technical, non-public information: None

89) Is there potential linkage between the South Coast Offshore fault near San Onofre NPP and the Newport-Inglewood Fault system and/or the Rose Canyon fault? Does this potential linkage impact the maximum magnitude that would be assigned to the South Coast Offshore fault and ultimately to the design basis ground motions for this facility?

Public response: Stephanie and Jon to answer (you may want to change the question) based on the discussions in the articles sent by Lara U.

Additional, technical, non-public information: Proposed action is to check the FSAR for San Onofre and read the discussion on characterization of the offshore fault. A quick look at discussion of the Newport Inglewood from other sources suggest this is part of the "system". It would be helpful to check the basis for segmenting the fault in the FSAR. Probably have to dig on this a bit, may need to look at the USGS/SCEC/ model for this area.

Diablo Canyon Questions

90) Now after the Japan tragedy, will the NRC finally hear us (A4NR) and postpone DC license renewal until seismic studies are complete? How can you be sure that what happened there is not going to happen at Diablo with a worse cast quake and tsunami?

Public response: ADD

Additional, technical, non-public information: ADD

91) The evacuation routes at DCNPP see are not realistic. Highway 101 is small...and can you imagine what it will be like with 40K people on it? Has the evacuation plan been updated w/ all the population growth?

Public Response: FEMA reviews off-site evacuation plans formally every 2 years during a biennial emergency preparedness exercise. NRC evaluates on-site evacuation plans during the same exercise. Population studies are formally done every 10 years, and evacuation time estimates are re-evaluated at that time. FEMA reviews these evacuation plans, and will conclude their acceptability through a finding of "reasonable assurance" that the off-site facilities and infrastructure is capable of protecting public health and safety in the event of an emergency at DCNPP.

Additional, technical, non-public information: None

92) Are there local offshore fault sources capable of producing a tsunami with very short warning times?

Public Response: ADD- question forwarded to region

Additional, technical, non-public information: ADD

93) Are there other seismically induced failure modes (other than tsunami) that would yield LTSBO? Flooding due to dam failure or widespread liquefaction are examples.

Public Response: ADD question forwarded to region

Additional, technical, non-public information: ADD

94) Ramifications of beyond design basis events (seismic and tsunami) and potential LTSBO on spent fuel storage facilities?

Public Response: ADD question forwarded to region

Additional, technical, non-public information: ADD

95) Why did a Emergency Warning go out for a 'tsunami' that was only 6 ft high? Do these guys really know what they're doing? Would they know it if a big one was really coming? Crying wolf all the time doesn't instill a lot of confidence.

Public Response: The warning system performed well. The 6 foot wave was predicted many hours before and arrived at the time it was predicted. Federal officials to accurately predicted the tsunami arrival time and size; allowing local official to take appropriate measures as they saw necessary to warn and protect the public. It should be understood that even a 6 foot tsunami is very dangerous. Tsunami have far more energy and power than wind-driven waves.

Additional, technical, non-public information: ADD

96) How big did the Japanese think a quake/tsunami could be before 3/11? Why were they so wrong (assuming this quake/tsunami was bigger than what they had designed the plant for)?

Public Response: ADD can HQ answer?

Additional, technical, non-public information: ADD

The Japanese were supposed to have one of the best tsunami warning systems around. What went wrong last week (both with the reactors and getting the people out...see #1, evacuation plan above)?

Public Response: ADD can HQ answer?

Additional, technical, non-public information: ADD

97) Regarding tsunami at Diablo and SONGS, is the tsunami considered separately from flooding in licensing? And from the design perspective, is the flood still the controlling event for those plants rather than the tsunami?

Public Response: Both the Diablo Canyon (main plant) and SONGS are located above the flood level associated with tsunami. However, the intake structures and Auxiliary Sea Water System at Diablo canyon are designed for combination of tsunami-storm wave activity. SONGS has reinforced concrete cantilevered retaining seawall and screen well perimeter wall designed to withstand the design basis earthquake, followed by the maximum predicted tsunami with coincident storm wave action

Additional, technical, non-public information: ADD

NOTE: need to add to SONGS and DCNPP... Canyon and San Onofre IPEEEs - based on the Technical Evaluation Reports, Diablo did consider a locally induced tsunami in a limited way (the aux service water pumps were assumed to become flooded following a seismic event) while SONGS did not consider a coupled seismic/tsunami event.

98) Shouldn't the NRC make licensees consider a Tsunami coincident with a seismic event that triggers the Tsunami?

ADD

99) Given that SSCs get fatigued over time, shouldn't the NRC consider after-shocks in seismic hazard analyses?

ADD

100) Did the Japanese also consider an 8.9 magnitude earthquake and resulting tsunami "way too low a probability for consideration"?

ADD

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101) GI-199 shows that the scientific community doesn't know everything about the seismicity of CEUS. And isn't there a prediction that the West coast is likely to get hit with some huge earthquake in the next 30 years or so? Why does the NRC continue to license plants on the west coast?

ADD

Work the following into Q&As as time permits.

After an earthquake, in order to restart, in practice a licensee needs to determine from engineering analysis that the stresses on the plant did not exceed their licensed limits. That would be a very tall order for a plant that experienced a beyond design basis quake, and probably is why it had taken Japan so long to restore the KK plants following the earlier quake.

Has industry done anything on tsunami hazards? Also, has anyone done work to look at the effect of numerous cycles of low amplitude acceleration following a larger event. I would expect we would have some information because how do we know a plant would be fit to start back up after an event? We cannot possibly do NDE on everything to determine if flaws have propagated to the point where they need to be replaced.

Indian Point Questions

102) Why is Indian Point safe if there is a fault line so close to it?

Public Response: The Ramapo fault system, which passes through the Indian Point area, is a group of Mesozoic age faults, extending from southeastern New York to northern New Jersey, as well as further southwest. The fault system is composed of a series of southeast-dipping, northeast-striking faults. Various faults of the system contain evidence of repeated slip in various directions since Proterozoic time, including Mesozoic extensional reactivation. However, the USGS staff, who reviewed 31 geologic features in the Appalachian Mountains and Coastal Plain and compiled a National Database on Quaternary Faulting (Crone and Wheeler, 2000), listed the Ramapo fault system as low risk because the fault system lacks evidence for Quaternary slip. They further pointed out that the Ramapo fault system, and 17 other geologic features, "have little or no published geologic evidence of Quaternary tectonic faulting that could indicate the likely occurrence of earthquakes larger than those observed historically" (Wheeler and Crone, 2004). Among these faults, the Ramapo fault system is one of the three that underwent a paleoseismological study. In two trenches excavated across the Ramapo fault, no evidence of Quaternary tectonic faulting was found (Wheeler and Crone, 2000). Because the Ramapo fault system is relatively inactive, because the Indian Point plants are built on solid bedrock, and because the plants are designed to safely shutdown in the event of an earthquake of the highest intensity ever recorded in that area, the NRC has concluded that the risk of significant damage to the reactors due to a probable earthquake in the area is extremely small.

Additional, technical, non-public information: The Question asks: Why is Indian Point safe if there is a fault line beneath it? The response focuses on the Ramapo fault (within a couple of miles not directly beneath) specifically and also states that the plant is designed for the largest observable earthquake. The information is consistent with the literature and the UFSAR for IP related to the Ramapo fault.

The letter that was sent to the NRC from Rep Lowey refers to the Ramapo seismic zone (RSZ) and the Dobbs Ferry fault. The letter incorrectly states that the Dobbs Ferry fault is located within the Ramapo seismic zone. Based on the literature, it is not. It is close, but it is considered to be in the Manhattan Prong more to the east (more like 10-15 miles away) while the Ramapo fault system is considered to be in the Reading Prong (a couple of miles away from IP). Also for clarification, the seismicity is considered to be within the Precambrian/Paleozoic basement at depths greater than the Mesozoic Newark Basin where the RSZ is situated.

103) Comments From the letter received 3/16/11 from Congresswoman Lowey:

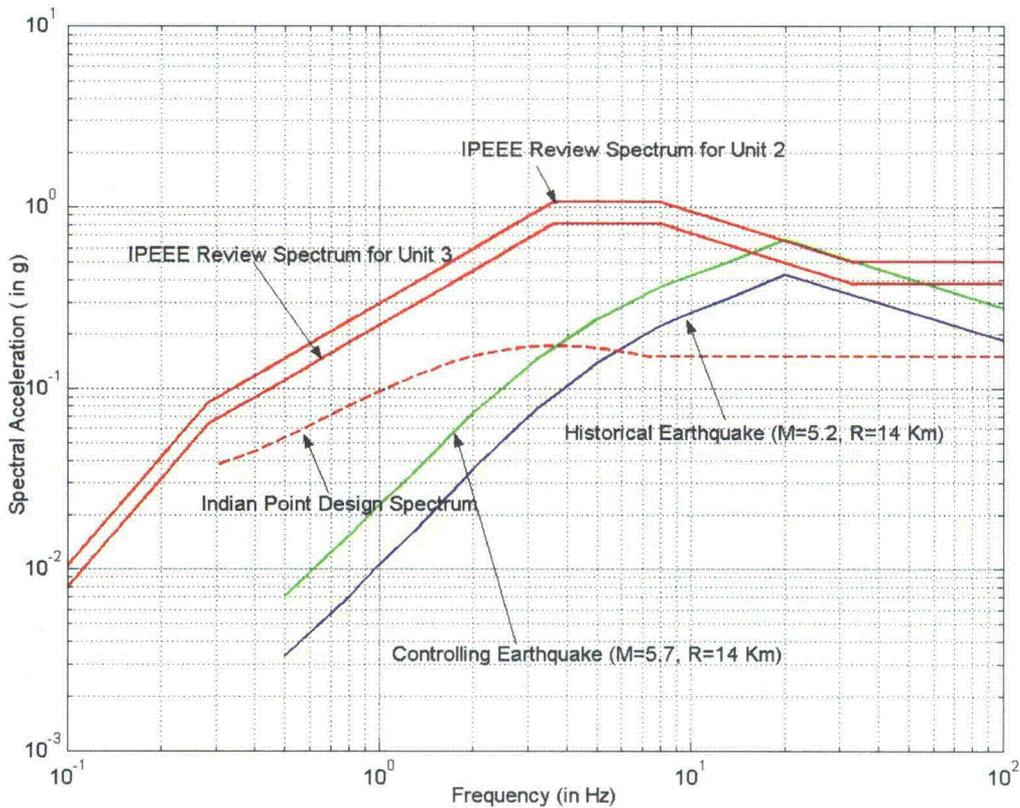
Text of the letter:

A 2008 study by seismologists at the Columbia University Lamont-Doherty Earth Observatory found that earthquakes in the New York metropolitan area are common and that risks are particularly high due to infrastructure and high population. A 3.9 magnitude earthquake occurred in the Atlantic Ocean approximately 80 miles off Long Island as recently as November 30, 2010. In fact, there have been five earthquakes in the same area in the past two decades, including a 4.7 magnitude earthquake in 1992.

The Ramapo Seismic Zone is a particular threat because the zone passes within two miles of Indian Point. The Ramapo Seismic zone includes the Dobbs Ferry fault in Westchester, which generated a 4.1 magnitude earthquake in 1955. The Columbia University study suggests that this pattern of subtle but active faults increases the risk to the New York City area and that an earthquake with a magnitude of 7.0 on the Richter scale is within reach. Disturbingly, Entergy measures the risk of an earthquake near Indian Point to be between 1.0 and 3.0 on the Richter scale, despite evidence to the contrary.

As our nation stands ready to assist the Japanese to calm this potential nuclear meltdown and disaster, we must not let the same mistakes happen on our shores. The NRC should study Indian Point's risk of, and ability to sustain a disaster, including the impact of earthquakes and hurricanes, as well as collateral impacts such as loss of power, inability to cool reactors and emergency evacuation routes. The NRC should evaluate how a similar incident in the New York metropolitan area could be further complicated due to a dramatically higher population and the effectiveness of the proposed evacuation routes.

NRR has the lead in response. We can assist NRR at their request. Either way, we need to turn this into appropriate questions and then provide answers consistent with the formal response.



Questions for the Japanese

NOTE: These were all collected from what we produced after the KKNPP earthquake. These need to be gone through and revised for this event. We should separate into high, medium and low priorities:

The below is pulled from an KKNPP summary...to be reviewed...

- What seismic monitoring equipment exists at the plants? Can we get the recordings from the
- Are there recordings of the tsunami at the plant location?
- What is the geology and soil profile at the plants?
- NOAA has a prediction of very large tsunami waves at Onagawa. Are these accurate?

The below is pulled from an KKNPP summary...to be reviewed...

DESIGN BASES: Exactly what is the design basis ground motion for each of the plants? Did it change through time (i.e. from the first plant to the seventh)? Where was the design basis motion defined, at the top of rock, at the ground surface, at the floor level or somewhere else? Were the site-specific geotechnical properties used in the development of the design basis ground motions for each plant?

SEISMIC HAZARDS: What assumptions were used in the seismic hazard evaluation to arrive at the design basis ground motions? What faults were considered, what magnitudes and geometries were assumed? What activity rates were assumed for both fault sources and "background" earthquakes?

OBSERVATIONS-GROUND MOTIONS: What ground motions were recorded and where were they recorded? Specifically, what free-field, in-structure and down-hole recordings were obtained? What are the locations of the instruments that obtained records? Did all the instruments respond as planned, or are there lessons to be learned? Can the digital data be shared with the NRC? Is there any way of evaluating how well the existing analysis methods predicted the observed motions at different points within the plant?

OBSERVATIONS-DAMAGE: What damage was observed at the plants? How well did equipment such as cranes perform? Were there observations of displacements of equipment from anchorages, were cracks observed in any of the buildings? How well did non-nuclear safety type of buildings and equipment perform? What types of geotechnical phenomena were observed, was there ground deformation/slope failures, lateral spreading or liquefaction near the facility? Did the ABWRs perform better or similar to the older designs?

And another set from the KKNPP earthquake...to be reviewed...

Please provide the following information in the time frame indicated:

Highest Priority Questions – as soon as possible

- A timeline describing the order of events and the individual plant responses to the earthquake
- Confirmation that all operating and shut down units achieved or maintained safe-shutdown conditions without manual operator intervention or complications. Did all safety-related systems respond to the seismic scram as designed? Please note if there were any unexpected plant responses to the event, including any spurious signals.
- A more detailed description of the impacts of the earthquake on the plant (e.g., what systems were involved, which pipes were damaged, where did the leakage occur (pipe wall, joints, fittings,,etc).
- A description of seismic instrumentation at the site and at each of the 7 units, soil/rock shear wave properties through depth, instrument location and mounting condition, all the recorded

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data on the basis of unified starting time, such that the coherency of motion through the surface or the foundations and at depth can be determined

- Full spectrum seismic design basis for the plant.
- What actually caused the Unit 3B house transformer fire?

Additional Questions – please provide answers as more information is developed

- Damage to buildings, slope failures, intake structure failure, if any
- Behavior of cranes, cables and conduits
- Failures of any large pumps and valves, pipe mounted control or valve failure
- Instances of any relay or vibration sensitive components malfunctioning
- Nature of damage to service water and fire-suppression piping - their diameter, material they are made of including their elastic properties, design standards used for the piping design, nature of failure (at support, anchor motion, failure of anchors, subsidence differential movement etc)
- Were there any systems that changed state?
- Impact on physical security, and any vulnerabilities identified
- Were there any impacts on the grid because of the event?
- Please describe the switchyard performance?
- What emergency preparedness concerns have been identified as a result of the event?

3B Transformer Specific Questions – please respond when there is time and other issues have been addressed

- What are the primary and secondary voltages of the transformer?
- What type of transformer - liquid or dry-type (air-cooled)?
- Who was the manufacturer of the transformer?
- What are the physical dimensions of the transformer?
- How are the transformer coils restrained within the cabinet?
- What is the clearance between transformer energized component and cabinet?
- What is the relative displacement for connection between the high voltage leads and the first anchor point (adequate slack?) in the transformer?
- What was the natural frequency of the burned transformer, if known?
- What was the acceleration level (or the response spectrum, if available) at the support location of the burned transformer?
- What seismic requirements exist for the burned transformer? Was the transformer tested or analyzed to a specific acceleration or response spectra, and if so, what are they?
- Are there any of the same type of transformer installed at other locations in the plant?

Additional Information

Table of Design Basis Ground Motions for US Plants

Design Basis Earthquake Information					
Nuclear Plant By State/Location	Maximum Observed Or Inferred Intensity (MMI Scale)	Relative Distance Of Seismic Source	Design SSE Peak Acceleration, <i>g</i>	OBE Peak Acceleration, <i>g</i>	Soil Condition
New York					
Fitzpatrick	VI	Near	0.15	0.08	Soil
Ginna 1	VIII/IX	>60 miles	0.2	0.08	Rock
Indian Point 2, 3	VII	Near	0.15	0.1	Rock
Nine Mile Point 1	IX-X	>60 miles	0.11	0.06	Rock
Nine Mile Point 2	VI	Near	0.15	0.075	Rock
New Jersey					
Salem 1,2	VII-VIII	Near	0.2	0.1	Deep Soil
Connecticut					
Millstone 1, 2, 3	VII	Near	0.17	0.07	Rock
Vermont					
Vermont Yankee	VI	Near	0.14	0.07	Rock
Ohio					
Davis Besse 1	VII	Near	0.15	0.08	Rock
Perry 1	VII	Near	0.15	0.08	Rock
Georgia					
Hatch 1, 2	VII	Near	0.15	0.08	Deep Soil
Vogtle 1, 2	VII-VIII	Near	0.2	0.12	Deep Soil
Tennessee					
Seqouyah 1, 2	VIII	Near	0.18	0.09	Rock
Watts Bar 1	VIII	Near	0.18	0.09	Rock
California					
San Onofre 2, 3	IX-X	Near	0.67	0.34	Soil
Diablo Canyon 1, 2	X-XI	Near	0.75	0.20	Rock
Florida					

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Crystal River 3	V	Near	0.10	0.05	Rock
St. Lucie 1, 2	VI	Near	0.10	0.05	Soil
Turkey Point 3, 4	VII	Near	0.15	0.05	Rock

NOTES:

MMI=Modified Mercalli Intensity, a measure of observed/reported damage and severity of shaking.
Relative distance measure used in FSAR to develop SSE acceleration, "Near" indicates distance less than 10 miles.

SSE=Safe Shutdown Earthquake ground motion, for horizontal acceleration, in units of earth's gravity, *g*.

OBE=Operating Basis Earthquake ground motion, level of horizontal acceleration, which if exceeded requires plant shutdown.

Table of SSE, OBE and Tsunami Water Levels

Nuclear Plant Name By State/ Location	Safe Shutdown Earthquake (SSE) Peak Acceleration (g)	Operating Basis Earthquake (OBE) Peak Acceleration, (g)	Probable Maximum Tsunami OR Maximum Tsunami Water Level
Alabama			
Browns Ferry	0.200	0.100	N/A (Non-Coastal)
Farley	0.100	0.050	N/A (Non-Coastal)
Arkansas			
Arkansas Nuclear	0.200		N/A (Non-Coastal)
Arizona			
Palo Verde	0.200	0.100	N/A (Non-Coastal)
California			
Diablo Canyon	0.400	0.200	The design basis maximum combined wave runup is the greater of that determined for near-shore or distantly-generated tsunamis, and results from near-shore tsunamis. For distantly-generated tsunamis, the combined runup is 30 feet. For near-shore tsunamis, the combined wave runup is 34.6 feet, as determined by hydraulic model testing. The safety-related equipment is installed in watertight compartments to protect it from adverse sea wave events to elevation +48 feet above MLLW.
San Onofre	0.670	0.340	The controlling tsunami occurs during simultaneous high tide and storm surge produces a maximum runup to elevation +15.6 feet mean lower low water line (mllw) at the Unit 2 and 3 seawall. When storm waves are superimposed, the predicted maximum runup is to elevation +27 mllw. Tsunami protection for the SONGS site is provided by a reinforced concrete seawall constructed to elevation +30.0 mllw.
Connecticut			
Millstone	0.170	0.090	18 ft SWL
Florida			
Crystal River	0.050	0.025	N/A (Non-Coastal)

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Nuclear Plant Name By State/ Location	Safe Shutdown Earthquake (SSE) Peak Acceleration (g)	Operating Basis Earthquake (OBE) Peak Acceleration, (g)	Probable Maximum Tsunami OR Maximum Tsunami Water Level
St. Lucie	0.100	0.050	No maximum tsunami level, bounded by PMH surge of +18 MLW wave runup, with plant openings at +19.5 MLW
Turkey Point	0.150	0.050	No maximum tsunami level, bounded by PMH surge of +18.3 MLW water level, site protected to +20 MLW with vital equipment protected to +22 MLW
Georgia			
Hatch	0.150	0.080	N/A (Non-Coastal)
Vogtle	0.200	0.120	N/A (Non-Coastal)
Illinois			
Braidwood	0.200	0.090	N/A (Non-Coastal)
Byron	0.200	0.090	N/A (Non-Coastal)
Clinton	0.250	0.100	N/A (Non-Coastal)
Dresden	0.200	0.100	N/A (Non-Coastal)
LaSalle	0.200	0.100	N/A (Non-Coastal)
Quad Cities	0.240	0.120	N/A (Non-Coastal)
Iowa			
Duane Arnold	0.120	0.060	N/A (Non-Coastal)
Kansas			
Wolf Creek	0.120	0.060	N/A (Non-Coastal)
Louisiana			
River Bend	0.100	0.050	
Waterford	0.100		Floods – 30 feet MSL
Maryland			
Calvert Cliffs	0.150	0.080	14 ft design wave
Massachusetts			
Pilgrim	0.150	0.080	*Storm flooding design basis - 18.3ft
Michigan			
D.C. Cook	0.200	0.100	N/A
Fermi	0.150	0.080	N/A
Palisades	0.200	0.100	N/A

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Nuclear Plant Name By State/ Location	Safe Shutdown Earthquake (SSE) Peak Acceleration (g)	Operating Basis Earthquake (OBE) Peak Acceleration, (g)	Probable Maximum Tsunami OR Maximum Tsunami Water Level
Missouri			
Callaway	0.200		N/A (Non-Coastal)
Mississippi			
Grand Gulf	0.150	0.075	N/A
Minnesota			
Monticello	0.120	0.060	N/A (Non-Coastal)
Prarie Island	0.120	0.060	N/A (Non-Coastal)
Nebraska			
Cooper	0.200	0.100	N/A (Non-Coastal)
Fort Calhoun	0.170	0.080	N/A (Non-Coastal)
New York			
Fitzpatrick	0.150	0.080	N/A (Non-Coastal)
Ginna	0.200	0.080	N/A
Indian Point	0.150	0.100	15 ft msl
Nine Mile Point, Unit 1	0.110	0.060	N/A
Nine Mile Point, Unit 2	0.150	0.075	N/A
New Hampshire			
Seabrook	0.250	0.125	(+) 15.6' MSL Still Water Level (Tsunami Flooding -Such activity is extremely rare on the U.S. Atlantic coast and would result in only minor wave action inside the harbor.)
New Jersey			
Hope Creek	0.200	0.100	35.4 MSL The maximum probable tsunami produces relatively minor water level changes at the site. The maximum runup height reaches an elevation of 18.1 feet MSL with coincident 10 percent exceedance high tide)
Oyster Creek	0.184	0.092	(+) 23.5' MSL Still Water Level (Probable Maximum Tsunami - Tsunami events are not typical of the eastern coast of the United States and have not, therefore, been addressed.)

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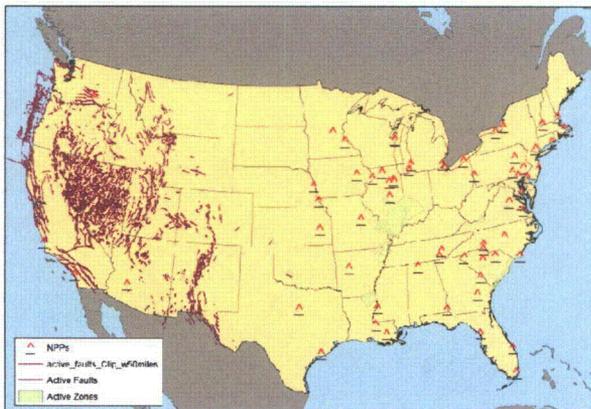
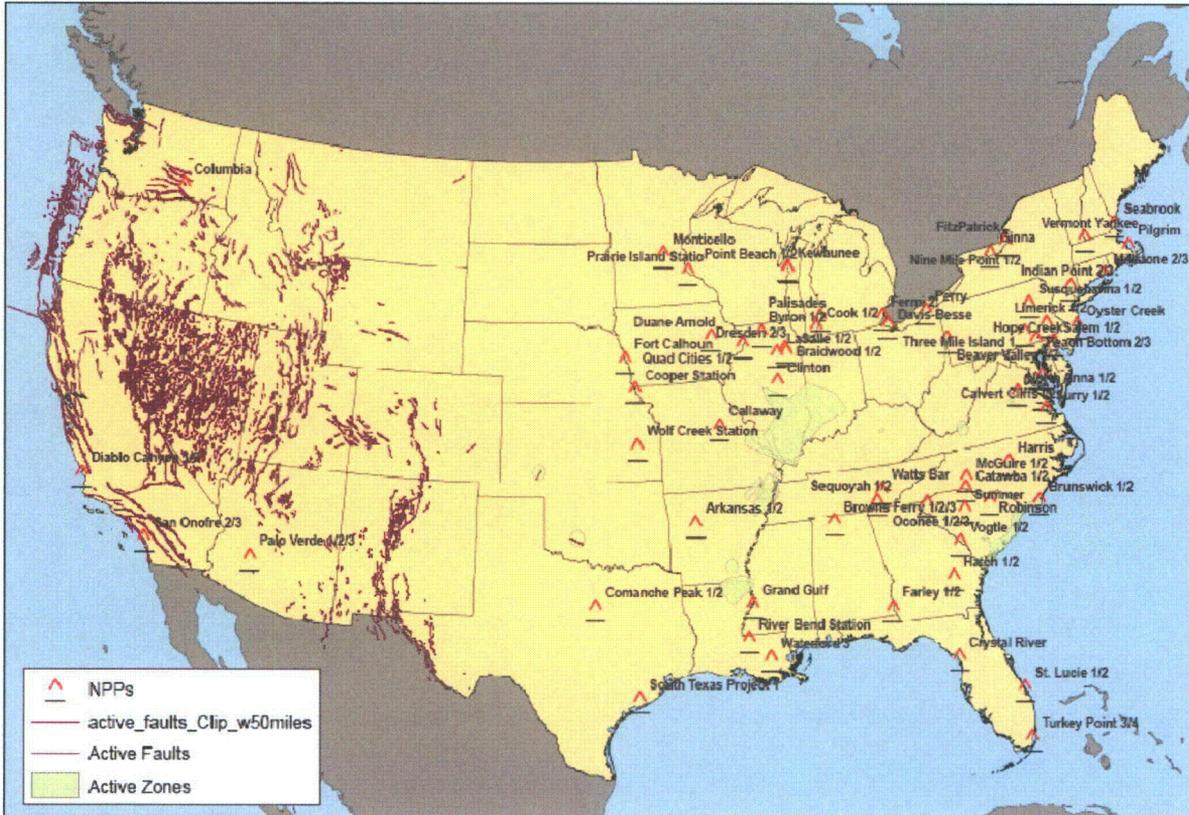
Nuclear Plant Name By State/ Location	Safe Shutdown Earthquake (SSE) Peak Acceleration (g)	Operating Basis Earthquake (OBE) Peak Acceleration, (g)	Probable Maximum Tsunami OR Maximum Tsunami Water Level
Salem	0.200	0.100	21.9 MSL (There is no evidence of surface rupture in East Coast earthquakes and no history of significant tsunami activity in the region)
North Carolina			
Brunswick	0.160	0.030	N/A
McGuire	0.150	0.080	N/A (Non-Coastal)
Shearon Harris	0.150		N/A (Non-Coastal)
Ohio			
Davis-Besse	0.150	0.080	N/A
Perry	0.150	0.080	N/A
Pennsylvania			
Beaver Valley	0.130	0.060	N/A (Non-Coastal)
Limerick	0.150	0.075	N/A (Non-Coastal)
Peach Bottom	0.120	0.050	N/A (Non-Coastal)
Three Mile Island	0.120	0.060	N/A (Non-Coastal)
Susquehanna	0.150	0.080	N/A (Non-Coastal)
South Carolina			
Catawba	0.150	0.080	N/A (Non-Coastal)
Oconee	0.150	0.050	N/A (Non-Coastal)
Robinson	0.200	0.100	N/A (Non-Coastal)
V.C. Summer	0.250	0.150	N/A (Non-Coastal)
Tennessee			
Sequoyah	0.180	0.090	N/A (Non-Coastal)
Watts Bar, Unit 1	0.180	0.090	N/A (Non-Coastal)
Texas			
Comanche Peak	0.120	0.060	N/A
South Texas Project	0.100	0.050	N/A
Vermont			

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Nuclear Plant Name By State/ Location	Safe Shutdown Earthquake (SSE) Peak Acceleration (g)	Operating Basis Earthquake (OBE) Peak Acceleration, (g)	Probable Maximum Tsunami OR Maximum Tsunami Water Level
Vermont Yankee	0.140	0.070	N/A
Virginia			
North Anna	0.180		N/A
Surry	0.150	0.080	N/A
Washington			
Columbia	0.250		N/A (Non-Coastal)
Wisconsin			
Kewaunee	0.120	0.060	N/A
Point Beach	0.120		N/A
Definition of Safe Shutdown Earthquake	The safe-shutdown earthquake (SSE) for the site is the ground motion response spectra (GMRS), which also satisfies the minimum requirement of paragraph IV(a)(1)(i) of Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," to Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities," of the Code of Federal Regulations (10 CFR Part 50).		
Definition of Operating Basis Earthquake:	<p>To satisfy the requirements of paragraph IV(a)(2)(A) of Appendix S to 10 CFR Part 50, the operating-basis earthquake (OBE) ground motion is defined as follows:</p> <ul style="list-style-type: none"> (iv) For the certified design portion of the plant, the OBE ground motion is one-third of the CSDRS. (v) For the safety-related noncertified design portion of the plant, the OBE ground motion is one-third of the design motion response spectra, as stipulated in the design certification conditions specified in design control document (DCD). (vi) The spectrum ordinate criterion to be used in conjunction with Regulatory Guide 1.166, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Post-earthquake Actions," issued March 1997, is the lowest of (i) and (ii). 		

Plot of Mapped Active Quaternary Faults and Nuclear Plants in the US

It is important to note that this plot somewhat misleading as faults in the central and eastern US are not well characterized. For example, the faults responsible for very large historic events, such as the 1811 and 1812 New Madrid Earthquakes, and the 1886 Charleston Earthquakes have not been conclusively located.

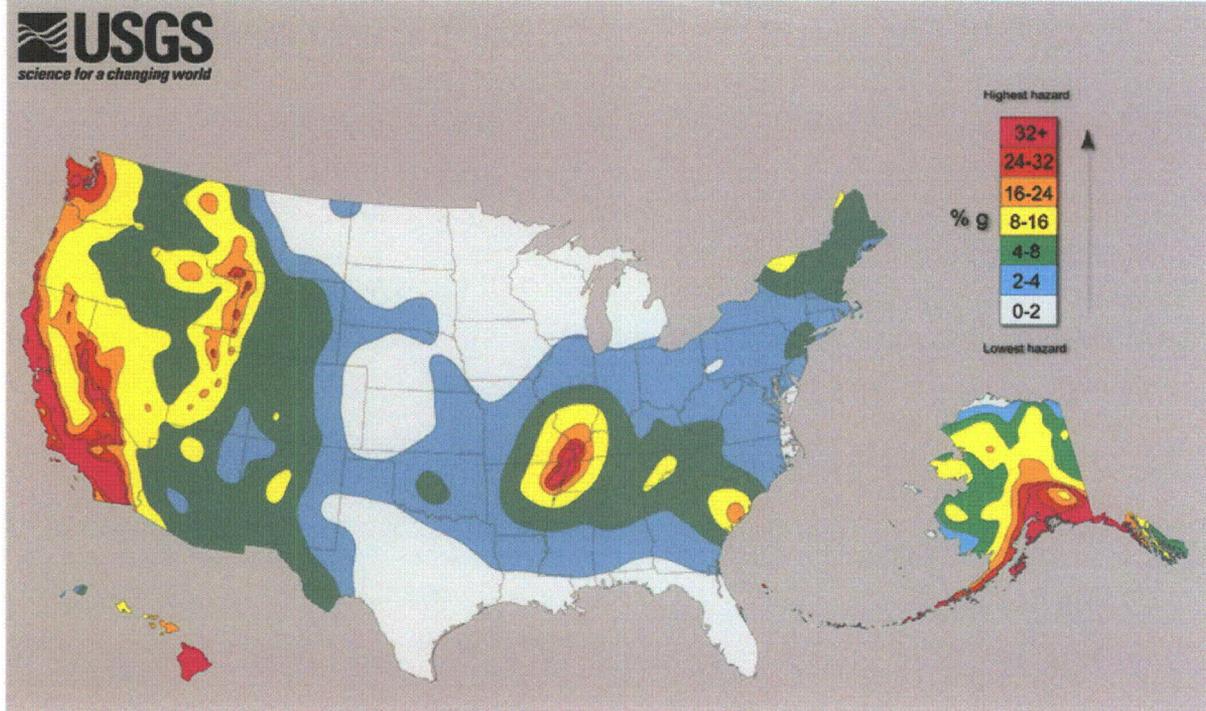


Nuclear Plants in the US Compared to the USGS National Seismic Hazard Maps

Dogan to create the map

USGS US National Seismic Hazard Maps

Many version of this map are available at the USGS website at <http://earthquake.usgs.gov/hazards/>



Plot of Nuclear Plants in the US Compared to Recent Earthquakes

Not sure of the date on this...It's an awesome plot. can we get this updated with a date? Who made this originally (NRO?RES?)

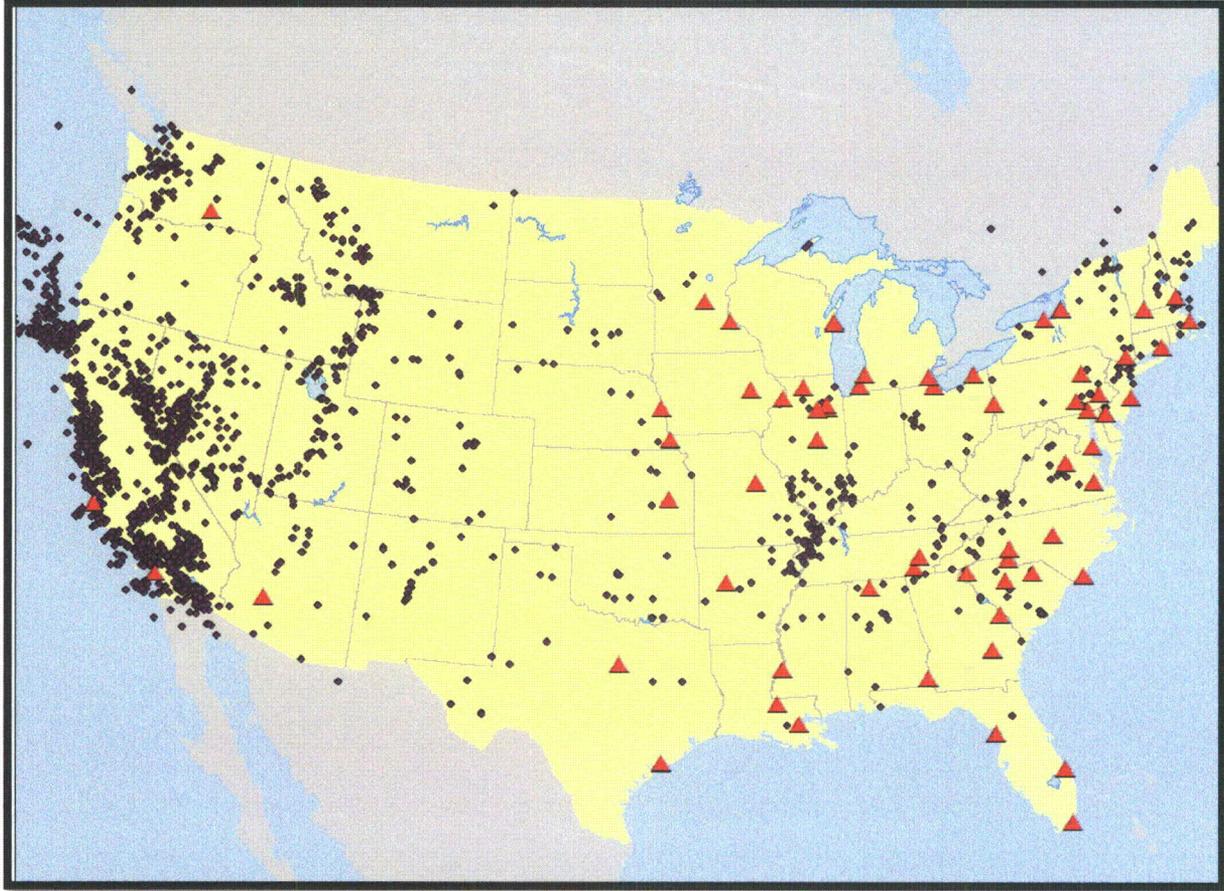


Table of Plants Near Known Active Faults

It should be noted that in much of the Central and Eastern US, the seismicity comes from "background" seismicity. Background seismicity is earthquake activity, where the earthquakes cannot be tied to known faults.

Jon Ake and Dogan Seber to complete. High priority to support chairman in response to questions asked by congress.

PLACEHOLDER ONLY...TO BE COMPLETED ON 3/17/11 PLEASE DON'T USE!!!

Plant (state)	Nearest Active Fault or Fault Zone	Distance to Fault or Range of Distances to Zones	Type of Faulting Mechanism	Range of Maximum Magnitude (M_w)	OBE (g)	SSE (g)
Columbia						
Diablo Canyon (CA)	Hosgri Fault	5 miles	Predominantly Strike Slip	7.5		
	Shoreline Fault	0.5 miles	Strike Slip	6.25 to 6.75 best estimate by NRC staff in RIL 09-001. Final report on the fault in review by NRC staff		
San Onofre (CA)						
Comanche Peak	Meers					

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Table From GI-199 Program Containing SSE, SSE Exceedance Frequencies, Review Level Earthquakes, and Seismic Core Damage Frequencies

Plant	Docket	SSE (g's)	Frequency of Exceeding the SSE (per year)	RLE (HCLPF) (g's)	Seismic Core Damage Frequency (per year)	IPEEE Method	Source
Arkansas 1	05000313	0.2	2.8E-04	0.3	4.1E-06	0.3g full-scope EPRI SMA	GI-199
Arkansas 2	05000368	0.2	9.7E-05	0.3	4.1E-06	0.3g focused-scope EPRI SMA	GI-199
Beaver Valley 1	05000334	0.12	3.3E-04	n/a	4.8E-05	seismic PRA	GI-199
Beaver Valley 2	05000412	0.12	2.7E-04	n/a	2.2E-05	seismic PRA	GI-199
Braidwood 1	05000456	0.2	6.7E-05	0.3	7.3E-06	0.3g focused-scope EPRI SMA	GI-199
Braidwood 2	05000457	0.2	6.7E-05	0.3	7.3E-06	0.3g focused-scope EPRI SMA	GI-199
Browns Ferry 1	05000259	0.2	2.5E-04	0.3	3.7E-06	0.3g focused-scope EPRI SMA	GI-199
Browns Ferry 2	05000260	0.2	2.5E-04	0.26	5.4E-06	0.3g focused-scope EPRI SMA	GI-199
Browns Ferry 3	05000296	0.2	2.5E-04	0.26	5.4E-06	0.3g focused-scope EPRI SMA	GI-199
Brunswick 1	05000325	0.16	7.3E-04	0.3	1.5E-05	0.3g focused-scope EPRI SMA	GI-199
Brunswick 2	05000324	0.16	7.3E-04	0.3	1.5E-05	0.3g focused-scope EPRI SMA	GI-199
Byron 1	05000454	0.2	5.2E-05	0.3	5.8E-06	0.3g focused-scope EPRI SMA	GI-199
Byron 2	05000455	0.2	5.2E-05	0.3	5.8E-06	0.3g focused-scope EPRI SMA	GI-199
Callaway	05000483	0.2	3.8E-05	0.3	2.0E-06	0.3g focused-scope EPRI SMA	GI-199
Calvert Cliffs 1	05000317	0.15	1.9E-04	n/a	1.0E-05	seismic PRA	GI-199
Calvert Cliffs 2	05000318	0.15	1.9E-04	n/a	1.2E-05	seismic PRA	GI-199
Catawba 1	05000413	0.15	1.4E-04	n/a	3.7E-05	seismic PRA	GI-199
Catawba 2	05000414	0.15	1.4E-04	n/a	3.7E-05	seismic PRA	GI-199
Clinton	05000461	0.25	5.8E-05	0.3	2.5E-06	0.3g focused-scope EPRI SMA	GI-199
Columbia	05000397	0.25	1.7E-04	n/a	2.1E-05	seismic PRA	IPEEE
Comanche Peak 1	05000445	0.12	1.6E-05	0.12	4.0E-06	reduced-scope EPRI SMA; SSE = 0.12g	GI-199
Comanche	05000446	0.12	1.6E-05	0.12	4.0E-06	reduced-scope EPRI SMA; SSE =	GI-199

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Plant	Docket	SSE (g's)	Frequency of Exceeding the SSE (per year)	RLE (HCLPF) (g's)	Seismic Core Damage Frequency (per year)	IPEEE Method	Source
Peak 2						0.12g	
Cooper	05000298	0.2	1.5E-04	0.3	7.0E-06	0.3g focused-scope EPRI SMA	GI-199
Crystal River 3	05000302	0.1	8.9E-05	0.1	2.2E-05	reduced-scope EPRI SMA; SSE = 0.1g	GI-199
D.C. Cook 1	05000315	0.2	2.1E-04	n/a	2.2E-05	seismic PRA	GI-199
D.C. Cook 2	05000316	0.2	2.1E-04	n/a	2.2E-05	seismic PRA	GI-199
Davis Besse	05000346	0.15	6.3E-05	0.26	6.7E-06	reduced-scope EPRI SMA	GI-199
Diablo Canyon 1	05000275	0.75	2.0E-04	n/a	4.1E-05	seismic PRA	IPEEE
Diablo Canyon 2	05000323	0.75	2.0E-04	n/a	4.1E-05	seismic PRA	IPEEE
Dresden 2	05000237	0.2	9.7E-05	0.26	1.9E-05	0.3g focused-scope EPRI SMA	GI-199
Dresden 3	05000249	0.2	9.7E-05	0.26	1.9E-05	0.3g focused-scope EPRI SMA	GI-199
Duane Arnold	05000331	0.12	2.3E-04	0.12	3.2E-05	reduced-scope EPRI SMA; SSE = 0.12g	GI-199
Farley 1	05000348	0.1	1.0E-04	0.1	2.8E-05	reduced-scope EPRI SMA; SSE = 0.1g	GI-199
Farley 2	05000364	0.1	1.0E-04	0.1	2.8E-05	reduced-scope EPRI SMA; SSE = 0.1g	GI-199
Fermi 2	05000341	0.15	1.0E-04	0.3	4.2E-06	0.3g focused-scope EPRI SMA	GI-199
Fitzpatrick	05000333	0.15	3.2E-04	0.22	6.1E-06	0.3g focused-scope NRC SMA	GI-199
Fort Calhoun 1	05000285	0.17	3.7E-04	0.25	5.4E-06	0.3g focused-scope NRC SMA	GI-199
Ginna	05000244	0.2	1.0E-04	0.2	1.3E-05	0.3g focused-scope EPRI SMA	GI-199
Grand Gulf	05000416	0.15	1.0E-04	0.15	1.2E-05	reduced-scope EPRI SMA; SSE = 0.15g	GI-199
Hatch 1	05000400	0.148	3.9E-04	0.29	2.3E-06	0.3g focused-scope EPRI SMA	GI-199
Hatch 2	05000321	0.15	2.7E-04	0.3	2.5E-06	0.3g focused-scope EPRI SMA	GI-199

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Plant	Docket	SSE (g's)	Frequency of Exceeding the SSE (per year)	RLE (HCLPF) (g's)	Seismic Core Damage Frequency (per year)	IPEEE Method	Source
Hope Creek	05000366	0.2	9.7E-05	0.3	2.5E-06	0.3g focused-scope EPRI SMA	GI-199
Indian Point 2	05000354	0.15	4.9E-04	n/a	2.8E-06	seismic PRA	GI-199
Indian Point 3	05000247	0.15	4.9E-04	n/a	3.3E-05	seismic PRA	GI-199
Kewaunee	05000286	0.12	2.8E-04	n/a	1.0E-04	seismic PRA	GI-199
LaSalle 1	05000305	0.2	1.7E-04	n/a	5.1E-06	seismic PRA	GI-199
LaSalle 2	05000373	0.2	1.7E-04	n/a	2.8E-06	seismic PRA	GI-199
Limerick 1	05000374	0.15	1.8E-04	n/a	2.8E-06	seismic PRA	GI-199
Limerick 2	05000352	0.15	1.8E-04	0.15	5.3E-05	reduced-scope EPRI SMA	GI-199
McGuire 1	05000353	0.15	9.5E-05	0.15	5.3E-05	reduced-scope EPRI SMA	GI-199
McGuire 2	05000369	0.15	9.5E-05	n/a	3.1E-05	seismic PRA	GI-199
Millstone 1	05000370	0.254	9.3E-05	n/a	3.1E-05	seismic PRA	GI-199
Millstone 2	05000336	0.17	8.3E-05	0.25	1.1E-05	0.3g focused-scope EPRI SMA	GI-199
Millstone 3	05000423	0.17	8.3E-05	n/a	1.5E-05	seismic PRA	GI-199
Monticello	05000263	0.12	9.3E-05	0.12	1.9E-05	modified focused/expended reduced-scope EPRI SMA	GI-199
Nine Mile Point 1	05000220	0.11	1.5E-04	0.27	4.2E-06	0.3g focused-scope EPRI SMA	GI-199
Nine Mile Point 2	05000410	0.15	4.8E-05	0.23	5.6E-06	SPRA and focused-scope EPRI SMA	GI-199
North Anna 1	05000338	0.12	2.1E-04	0.16	4.4E-05	0.3g focused-scope EPRI SMA	GI-199
North Anna 2	05000339	0.12	2.1E-04	0.16	4.4E-05	0.3g focused-scope EPRI SMA	GI-199
Oconee 1	05000269	0.1	9.7E-04	n/a	4.3E-05	seismic PRA	GI-199
Oconee 2	05000270	0.1	9.7E-04	n/a	4.3E-05	seismic PRA	GI-199
Oconee 3	05000287	0.1	9.7E-04	n/a	4.3E-05	seismic PRA	GI-199
Oyster Creek	05000219	0.17	1.5E-04	n/a	1.4E-05	seismic PRA	GI-199
Palisades	05000255	0.2	1.4E-04	n/a	6.4E-06	seismic PRA	GI-199
Palo Verde 1	05000528	0.258	3.5E-05	0.3	3.8E-05	0.3g full-scope EPRI SMA	IPEEE
Palo Verde 2	05000529	0.258	3.5E-05	0.3	3.8E-05	0.3g full-scope EPRI SMA	IPEEE

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Plant	Docket	SSE (g's)	Frequency of Exceeding the SSE (per year)	RLE (HCLPF) (g's)	Seismic Core Damage Frequency (per year)	IPEEE Method	Source
Palo Verde 3	05000530	0.258	3.5E-05	0.3	3.8E-05	0.3g full-scope EPRI SMA	IPEEE
Peach Bottom 2	05000277	0.12	2.0E-04	0.2	2.4E-05	modified focused-scope EPRI SMA	GI-199
Peach Bottom 3	05000278	0.12	2.0E-04	0.2	2.4E-05	modified focused-scope EPRI SMA	GI-199
Perry	05000440	0.15	2.2E-04	0.3	2.1E-05	0.3g focused-scope EPRI SMA	GI-199
Pilgrim 1	05000293	0.15	8.1E-04	n/a	6.9E-05	seismic PRA	GI-199
Point Beach 1	05000266	0.12	2.0E-04	n/a	1.1E-05	seismic PRA	GI-199
Point Beach 2	05000301	0.12	2.0E-04	n/a	1.1E-05	seismic PRA	GI-199
Prairie Island 1	05000282	0.12	2.0E-04	0.28	3.0E-06	0.3g focused-scope EPRI SMA	GI-199
Prairie Island 2	05000306	0.12	2.0E-04	0.28	3.0E-06	0.3g focused-scope EPRI SMA	GI-199
Quad Cities 1	05000254	0.24	8.2E-04	0.09	2.7E-05	0.3g focused-scope EPRI SMA	GI-199
Quad Cities 2	05000265	0.24	8.2E-04	0.09	2.7E-05	0.3g focused-scope EPRI SMA	GI-199
River Bend	05000458	0.1	2.4E-04	0.1	2.5E-05	reduced-scope EPRI SMA; SSE = 0.1g	GI-199
Robinson (HR)	05000261	0.2	1.1E-03	0.28	1.5E-05	0.3g full-scope EPRI SMA	GI-199
Saint Lucie	05000335	0.1	1.4E-04	0.1	4.6E-05	reduced-scope EPRI SMA; SSE = 0.1g	GI-199
Salem 1	05000389	0.2	2.6E-04	0.1	4.6E-05	reduced-scope EPRI SMA; SSE = 0.1g	GI-199
Salem 2	05000272	0.2	2.6E-04	n/a	9.3E-06	seismic PRA	GI-199
San Onofre 2	05000361	0.67	1.2E-04	n/a	1.7E-05	seismic PRA	IPEEE
San Onofre 3	05000362	0.67	1.2E-04	n/a	1.7E-05	seismic PRA	IPEEE
Seabrook	05000311	0.25	1.3E-04	n/a	9.3E-06	seismic PRA	GI-199
Sequoyah 1	05000443	0.18	7.1E-04	n/a	2.2E-05	seismic PRA	GI-199
Sequoyah 2	05000327	0.18	7.1E-04	0.27	5.1E-05	0.3g full-scope EPRI SMA	GI-199
Shearon Harris 1	05000328	0.15	4.6E-05	0.27	5.1E-05	0.3g full-scope EPRI SMA	GI-199
South Texas 1	05000498	0.1	3.0E-05	n/a	6.2E-06	seismic PRA	GI-199

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Plant	Docket	SSE (g's)	Frequency of Exceeding the SSE (per year)	RLE (HCLPF) (g's)	Seismic Core Damage Frequency (per year)	IPEEE Method	Source
South Texas 2	05000499	0.1	3.0E-05	n/a	6.2E-06	seismic PRA	GI-199
Summer	05000395	0.15	3.9E-04	0.22	3.8E-05	0.3g focused-scope EPRI SMA	GI-199
Surry 1	05000280	0.15	2.2E-04	n/a	5.7E-06	seismic PRA	GI-199
Surry 2	05000281	0.15	2.2E-04	n/a	5.7E-06	seismic PRA	GI-199
Susquehanna 1	05000387	0.1	1.9E-04	0.21	1.3E-05	0.3g focused-scope EPRI SMA	GI-199
Susquehanna 2	05000388	0.1	1.9E-04	0.21	1.3E-05	0.3g focused-scope EPRI SMA	GI-199
Three Mile Island 1	05000289	0.12	1.0E-04	n/a	4.0E-05	seismic PRA	GI-199
Turkey Point 3	05000250	0.15	3.8E-05	0.15	1.0E-05	site-specific approach; SSE=0.15g	GI-199
Turkey Point 4	05000251	0.15	3.8E-05	0.15	1.0E-05	site-specific approach; SSE=0.15g	GI-199
Vermont Yankee	05000271	0.14	1.2E-04	0.25	8.1E-06	0.3g focused-scope EPRI SMA	GI-199
Vogtle 1	05000424	0.2	1.5E-04	0.3	1.8E-05	0.3g focused-scope EPRI SMA	GI-199
Vogtle 2	05000425	0.2	1.5E-04	0.3	1.8E-05	0.3g focused-scope EPRI SMA	GI-199
Waterford 3	05000382	0.1	1.1E-04	0.1	2.0E-05	reduced-scope EPRI SMA; SSE = 0.1g	GI-199
Watts Bar	05000390	0.18	2.9E-04	0.3	3.6E-05	0.3g focused-scope EPRI SMA	GI-199
Wolf Creek	05000482	0.12	3.7E-05	0.2	1.8E-05	reduced-scope EPRI SMA	GI-199
25th percentile			9.6E-05		6.0E-06		
min			1.6E-05		2.0E-06		
median			1.7E-04		1.5E-05		
mean			3.1E-04		2.1E-05		
max			3.9E-03		1.0E-04		
75th percentile			2.6E-04		3.2E-05		

Summary of seismological information from regional instrumentation

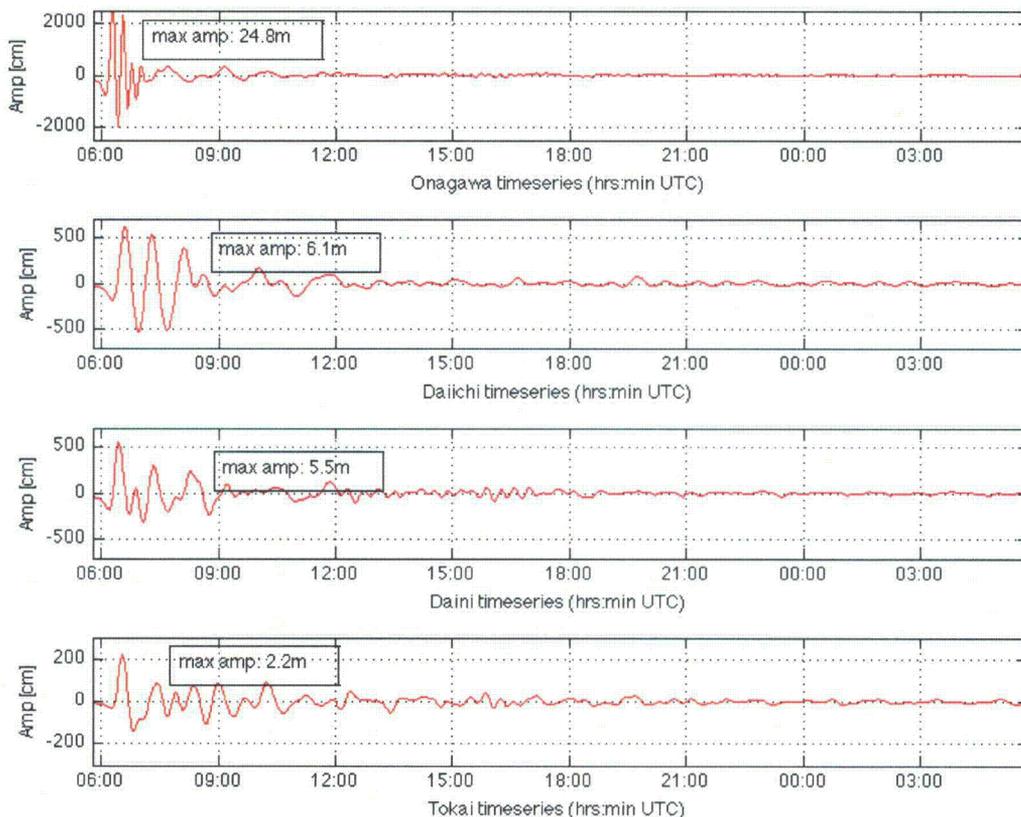
Placeholder: Rasool Anoooshehpoor is developing.

Tsunami Wave Heights at the Japanese Plants (unofficial from NOAA)

The below plots were developed for NRC seismic staff a few hours after the earthquake and tsunami by the PMEL group of NOAA. This group is responsible for scientific development of the models and tools used by the US tsunami warning system, as well as notification elements of system itself.

On 3/16/11, the PMEL NOAA team informed NRC staff that additional analyses have generally confirmed the below estimates and so they don't expect the final official numbers at the plant locations to change much.

Offshore wave amplitudes, scaled to the coastline



Fact Sheet on Protection of Nuclear Power Plants against Tsunami Flooding

Nuclear power plants are designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. The word tsunami literally means harbor wave. Tsunamis can be generated by large offshore earthquakes (usually greater than magnitude 6.5), submarine or on shore land slides or volcanoes. Some large onshore earthquakes close to the shoreline can generate tsunami. The Nuclear Regulatory Commission (NRC) requires all nuclear power plants to be protected against earthquakes, tsunamis and other natural hazards.

Background

Protection against tsunami effects was required for all operating plants and is required for all new reactors. Following the Indian Ocean tsunami on December 26, 2004, the President moved to protect lives and property by launching an initiative to improve domestic tsunami warning capabilities. This plan was placed under the auspices of the National Science and Technology Council through the President's initiative in July 2005 in the context of a broad national effort of tsunami risk reduction, and United States participated in international efforts to reduce tsunami risk worldwide. In response to the president's initiative, the NRC reviewed its licensing criteria and conducted independent studies and participated in international forums under the auspices of the International Atomic Energy Agency with many participating countries including India and Japan. The final report of the study was published in April 2009 as NUREG/CR 6966, "Tsunami Hazard Assessment at Nuclear Power Plant Sites in the United States of America," ADAMS Accession # ML0915901933. NRC revised its Standard Review Plan for conducting safety reviews of nuclear power plants in 2007. Section 2.4.6 specifically addresses tsunamis. The Office of Nuclear Regulatory Research is conducting tsunami studies in collaboration with the United States Geological Survey and has published a report on tsunami hazard in the Atlantic, Gulf and Pacific coastal areas. Selected nuclear power plants now get tsunami warning notification. The agency requires plant designs to withstand the effects of natural phenomena including effects of tsunamis. The agency's requirements, including General Design Criteria for licensing a plant, are described in Title 10 of the *Code of Federal Regulations* (10 CFR). These license requirements consist of incorporating margins in the initiating hazard and additional margins are due to traditional engineering practices such as "safety factors." Practices such as these add an extra element of safety into design, construction, and operations.

The NRC has always required licensees to design, operate, and maintain safety-significant structures, systems, and components to withstand the effects of natural hazards and to maintain the capability to perform their intended safety functions. The agency ensures these requirements are satisfied through the licensing, reactor oversight, and enforcement processes.

Tsunami Hazard Evaluation

Tsunami hazard evaluation is one component of the complete hydrological review requirements provided in the Standard Review Plan under Chapter 2.4. The safety determination of reactor sites require consideration of major flood causing events, including consideration of combined flood causing conditions. These conditions include Probable Maximum Flood (PMF) on Streams and Rivers, Potential Dam Failures, Probable Maximum Surge and Seiche Flooding and Probable Maximum Tsunami Hazards, among others. The most significant flooding event is called the design basis flood and flooding protection requirements are correlated to this flood level in 2.4.10.

The Probable Maximum Tsunami (PMT) is defined as that tsunami for which the impact at the site is derived from the use of best available scientific information to arrive at a set of scenarios reasonably expected to affect the nuclear power plant site taking into account (a) appropriate consideration of the most severe of the natural phenomena that have been historically reported or determine from geological and physical data 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, (b) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena, and (c) the importance of the safety functions to be performed.

Site-specific tsunami data are collected from historical tsunami records, paleotsunami evidence, regional tsunami assessments, site-specific tsunami mechanisms, site-specific data, such as submarine survey of

sea bed and approach channel geometry. Effects of tsunami on a nuclear power plant can be flooding due to water run up, hydro-dynamic pressure on exterior walls of structures, impact of floating debris, and foundation scouring. In addition, tsunami can draw down water from the intake source of plant cooling water.

The tsunami database is available for interactive search and downloads on the internet at <http://www.ngdc.noaa.gov/hazard/tsu.shtml>.

Tsunami Safety Assessment

The licensing bases for existing nuclear power plants are based on historical data at each site. This data is used to determine probable maximum tsunami and the tsunami effects are evaluated for each site with potential for tsunami flooding. The potential for tsunami hazard is determined on a hierarchical analysis process that can identify tsunami potential based primarily on distance from tsunami source and site elevation. The NRC also required existing plants to assess their potential vulnerability to external events, as part of the Individual Plant Examination of External Events Program. This process ensured that existing plants are not vulnerable to tsunami hazard, and they continue to provide adequate public health and safety.

Today, the NRC utilizes a risk-informed regulatory approach, including insights from probabilistic assessments and traditional deterministic engineering methods to make regulatory decisions about existing plants (e.g., licensing amendment decisions). Any new nuclear plant the NRC licenses will use a probabilistic, performance-based approach to establish the plant's seismic hazard and the seismic loads for the plant's design basis.

Operating Plants

The NRC is fully engaged in national international tsunami hazard mitigation programs, and is conducting active research to refine the tsunami sources in the Atlantic, Gulf Coast and Pacific Coast areas. Diablo Canyon (DC) and San Onofre (SONGS) are two nuclear plant sites that have potential for tsunami hazard. Both the DC (main plant) and SONGS are located above the flood level associated with tsunami. However, the intake structures and Auxiliary Sea Water System at DC are designed for combination of tsunami-storm wave activity to 45 ft msl. SONGS has a reinforced concrete cantilevered retaining seawall and screen well perimeter wall designed to withstand the design basis earthquake, followed by the maximum predicted tsunami with coincident storm wave action, designed to protect at approximately 27 ft msl. These reactors are adequately protected against tsunami effects. Distant tsunami sources for DC include the Aleutian area, Kuril-Kamchatka region, and the South American coast (for Songs the Aleutian area). Distant sources for SONGS is limited by the presence of a broad continental shelf. Local or near sources for DC include the Santa Lucia Bank and Santa Maria Basin Faults (for Songs the Santa Ana wind).

Additional Information

To read more about risk-related NRC policy, see the fact sheets on Probabilistic Risk Assessment (<http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/probabilistic-risk-asses.html>) and Nuclear Reactor Risk (<http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/reactor-risk.html>). Each provides more information on the use of probability in evaluating hazards (including earthquakes) and their potential impact on plant safety margins. Other regulatory framework includes General Design Criterion 2, 10 CFR Part 100.23, Regulatory Guide 1.102 "Flood Protection for Nuclear Power Plants", Rev. 1 1976, Regulatory Guide 1.59 "Design Basis for Nuclear Power Plants" Rev. 2 1977 (update in progress), and USNRC Standard Review Plan "Probable Maximum Tsunami Flooding" Section 2.4.6, Rev. 2.

March 2011

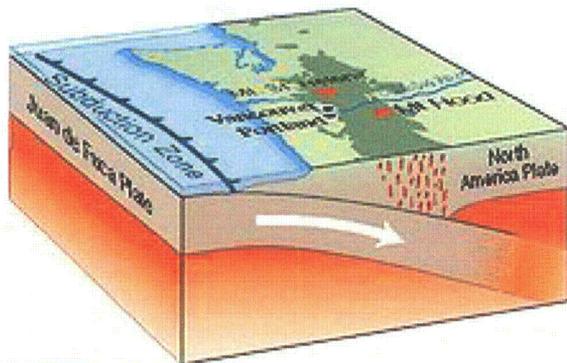
Seismicity of the Central and Eastern US Fact Sheet

Key Points:

- To date, very large earthquakes (Magnitudes greater than 8.25) have only occurred in specific geological settings, in particular the interfaces between tectonic plates in major **subduction zones**. The only subduction zone that potentially impacts the continental U.S. is the Cascadia zone off the coast of northern California, Oregon and Washington.
- Recent analyses of the magnitudes of the largest earthquakes **not associated** with subduction zones indicates magnitudes are less than ~8.25.
- The size (magnitude) of earthquakes is proportional to the fault area that slips in a given earthquake. The prediction of earthquake magnitudes for a specific fault considers the dimensions of the fault. Extremely large earthquakes do not occur on small faults.
- Nuclear power plants are licensed based on vibratory ground shaking, not earthquake magnitude. The ground shaking (accelerations) are used to estimate forces which are used in the seismic design process. In many cases smaller magnitude earthquakes closer to a site produce more severe ground shaking than larger, more distant earthquakes. Hence it is important to consider all potential earthquake sources regardless of magnitude.

Discussion: Earthquakes with very large magnitudes such as the March 2011 earthquake off the northeast coast of the Japanese island of Honshu occur within subduction zones, which are locations where one of the earth's tectonic plates is subducting beneath (being thrust under) another. The fault that defines the Japan Trench plate boundary dips to the west, i.e., becomes deeper towards the coast of Honshu. Large offshore earthquakes have historically occurred in the same subduction zone (in 1611, 1896, and 1933) all of which produced significant tsunami waves. The magnitudes of these previous large earthquakes have been estimated to be between 7.6 and 8.6. Prior to March 2011, the Japan Trench subduction zone has produced nine earthquakes with magnitudes greater than 7 just since 1973.

The only subduction zone that is capable of directly impacting the continental US is the Cascadia subduction zone, which lies off of the coast of northern California, Oregon, and Washington. The fault surface defined by this interface dips to the east (becomes deeper) beneath the coast. The Cascadia subduction zone is capable of producing very large earthquakes if all or a large portion of the fault area ruptures in a single event. However, the rate of earthquake occurrence along the Cascadia subduction zone is much less than has been observed along the Japan Trench subduction zone. The only operating nuclear power plant in that area is Columbia, which is far from the coast and the Cascadia subduction zone. *The occurrence of earthquakes on the Cascadia subduction zone has been considered in the evaluation of the Columbia NPP.*



Schematic Illustration of the Cascadia Subduction Zone

The size (magnitude) of earthquakes is proportional to the surface area of a fault that slips in a given earthquake. Large earthquakes are associated with large (long) faults. Hence, the prediction of earthquake magnitudes for a specific fault considers the dimensions of the fault. Identification of fault size is usually based on geologic mapping or the evaluation of spatial patterns of small earthquakes. To provide **a point of comparison**, the length of the fault that slipped during the March 11, 2011 magnitude 9 Japanese earthquake was >620 km, the length of the fault(s) that slipped during the magnitude 7.3 1992 Landers, CA earthquake was ~90 km and the estimated length of the Hosgi fault near Diablo Canyon NPP is 140 km and a magnitude of 7.5 is assigned to that fault. A number of major crustal faults or fault zones (not associated with the Cascadia subduction zone) have been identified that have produced earthquakes of magnitude 7.5 to 8 in the continental US (including California). **These fault sources have been identified and characterized in seismic hazard assessments.**

Seismic designs at U.S. nuclear power plants are developed in terms of seismic ground motion spectra, which are called the Safe Shutdown Earthquake ground motion response spectra (SSE). Each nuclear power plant is designed to a ground motion level that is appropriate for the geology and tectonics in the region surrounding the plant location. Currently operating nuclear power plants developed their SSEs based on a "deterministic" or "scenario earthquake" basis that account for the largest earthquake expected in the area around the plant. Seismic activity in the regions surrounding U.S. plants is much lower than that for Japan since **most U.S. plants are located in the interior of the stable continental U.S.** The largest earthquakes within the continental U.S. are the 1811-12 New Madrid sequence and the 1886 Charleston, SC, which were estimated to be between about magnitude 6.8 to 7.5. On the west coast of the U.S., the two nuclear power plants are designed to specific ground motions from earthquakes of about magnitude 7+ on faults located just offshore of the plants. The earthquakes on these faults are mainly strike-slip (horizontal motion on near vertical planes) type earthquakes, not subduction zone earthquakes. This fault geometry does not produce large tsunamigenic waves. Therefore, the likelihood of a significant tsunami from these faults is very remote.

Design Basis Ground Motions and New Review Level Ground Motions Used for Review of Japanese Plants

Plant sites	Contributing earthquakes	New DBGM S ₁	Original DBGM S ₂
Tomari	Earthquakes undefined specifically	550 Gal	370 Gal
Onagawa	Soutei Miyagiken-oki (M8.2)	580	375
Higashidoori	Earthquakes undefined specifically	450	375
Fukushima	Earthquake near the site (M7.1)	600	370
Tokai	Earthquakes undefined specifically	600	380
Hamaoka	Assumed Tokai (M8.0), etc.	800	600
Shika	Sasanami-oki Fault (M7.6)	600	490
Tsuruga	Urazoko-Uchiikemi Fault (M6.9), etc. →Mera-Kareizaki - Kaburagi(M7.8), Shelf edge+B+Nosaka (M7.7)	800	532
Mihama	C, Fo-A Fault (M6.9)→ Shelf edge+B+Nosaka(M7.7)	750	405
Ohi	C, Fo-A Fault (M6.9)→Fo-A+Fo-B (M7.4)	700	405
Takahama	Fo-A Fault (M6.9) →Fo-A+Fo-B(M7.4)	550	370
Shimane	Shinji Fault (M7.1)	600	456
Ikata	Central Tectonic Structure (M7.6)	570	473
Genkai	Takekoba F. (M6.9) → Enhanced uncertainty consideration	540	370
Sendai	Gotandagawa F.(M6.9), F-A(M6.9)	540	372
Kashiwazaki-Kariwa	F-B Fault (M7.0), Nagaoka-plain-west Fault (M8.1)	2300 (R1 side) 1209 (R5 side)	450
Monju (Proto Type FBR)	Shiraki-Niu F.(M6.9) , C F.(M6.9)→Shelf edge+B+Nosaka(M7.7), Small Damping	760	408
Shimokita Reprocessing F.	Deto-Seiho F.(M6.8), Yokohama F.(M6.8)	450	320

Status of Review of Japanese NPPs to New Earthquake Levels Based on 2006 Guidance

Utility	Site (Unit)	Type	Dec.2010
Hokkaido	Tomari	PWR	△
Tohoku	Onagawa (Unit1)	BWR	◎
	Higashi-dori	BWR	△
Tokyo	Kashiwazaki-Kariwa	BWR	Unit 1,5,6,7 ◎
	Fukushima-No1	BWR	Unit 3 ◇, 5 ◎
	Fukushima-No2	BWR	Unit 4,5 ◎
Chubu	Hamaoka	BWR	△
Hokuriku	Shika (Unit 2)	BWR	◎
Kansai	Mihama(Unit 1)	PWR	◎
	Ohi(Unit 3,4)	PWR	◎
	Takahama (Unit 3,4)	PWR	◎
Chugoku	Shimane (Unit 1, 2)	BWR	◎
Shikoku	Ikata (Unit 3)	PWR	◎
Kyushu	Genkai (Unit 3)	PWR	◎
	Sendai (Unit 1)	PWR	◎
Japan Atomic Power	Tokai-Daini	BWR	○
	Tsuruga	BWR/PWR	△
JAEA	Monjyu	Proto Type FBR	◎
Japan Nuc. Fuel	Rokkasyo	Reprocessing	◎
◎: NSC review finished, ○: NISA review finished and in NSC review, △: Under review by NISA			

US Portable Array briefing sheet for brief congressional staffers

NOTE: This is provided because IRIS participants let us know that here was a discussion about the NRC's involvement in this program. We have been involved in this for the last couple years.



The Incorporated Research Institutions for Seismology is the Consortium of United States Universities with Major Research Programs in Seismology and Related Fields.

The Transportable Array: A Science Investment that Can Be Leveraged

IRIS is installing the Transportable Array – a set of 400 broadband seismic instruments – in each of more than 1600 sites across the contiguous United States. The instruments operate at each site for two years and then are removed and redeployed further east. Roughly 1100 stations have been installed since 2003, and instruments have been removed from more than 600 of those sites in the western United States.

The National Science Foundation is funding the full cost to “roll” the Transportable Array across the US, more than \$90,000,000 over ten years. Comparatively small incremental investments could add significant data that are relevant to the safety of nuclear power plants. These efforts would be uniquely cost effective, since NSF is already funding installation, and they would feed data into an existing, standardized and widely used data management system that already incorporates the vast majority of seismic data from US networks. But these opportunities are time constrained: the array will be fully installed in the contiguous 48 states by late 2013.

More Value from Longer Term Regional Observations

A dense, uniform seismic network is necessary for long-term, broad-area seismic monitoring of the central and eastern United States due to low event recurrence rates and the risk of significant earthquakes ($M > 5$) anywhere in the region. Monitoring seismicity in the central and eastern US can be improved by turning selected sites into permanent seismic stations. A total of more than 35 Transportable Array stations have already been “adopted” by several organizations, creating a permanent legacy, but only in the western United States.

A strategic “1-in-4” plan would involve “adoption” of systematically selected stations in the central and eastern United States – every other station in both the east-west and north-south directions, creating a uniform grid of some 250 stations. Long-term regional operation could be combined with two optional enhancements to create a unique observatory for the study of seismicity, source characteristics, attenuation, and local ground acceleration.

Enhancement 1: Acquire Higher Frequency Data

Crustal rigidity in the central and eastern US makes it desirable to record high frequency characteristics of local and regional earthquakes. The existing instruments could be reconfigured to record high frequencies but doing so would nearly triple the data flow, necessitating improvements to the communications infrastructure.

Enhancement 2: Add Strong Motion Sensors

Acquiring strong motion sensors and reconfiguring field computers that record and telemeter the data would help to measure unique effects of severe shaking. The design anticipated this augmentation, and several stations in California and Washington were operated that way. Upgrade would be more efficient at sites that have not yet been installed.

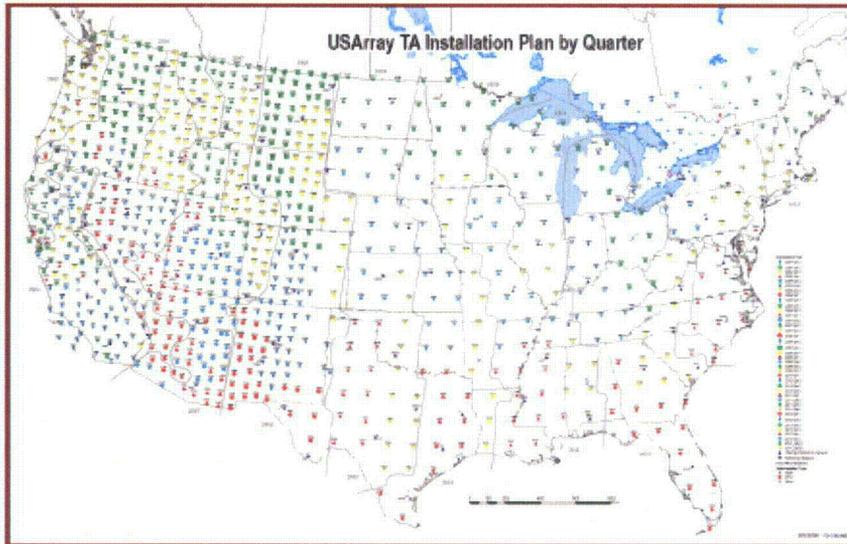
Estimate of annual acquisition and O&M costs for the 1-in-4, 250-station network in central and eastern US.

Year	Stations	Acquisition ¹	O&M ²	Total
2011	50	\$1,800,000	\$ 400,000	\$2,200,000
2012	50	\$1,800,000	\$ 800,000	\$2,600,000
2013	50	\$1,800,000	\$1,200,000	\$3,000,000
2014	50	\$1,800,000	\$1,600,000	\$3,400,000
2015	50	\$1,800,000	\$2,000,000	\$3,800,000
2016	–	–	\$2,000,000	\$2,000,000

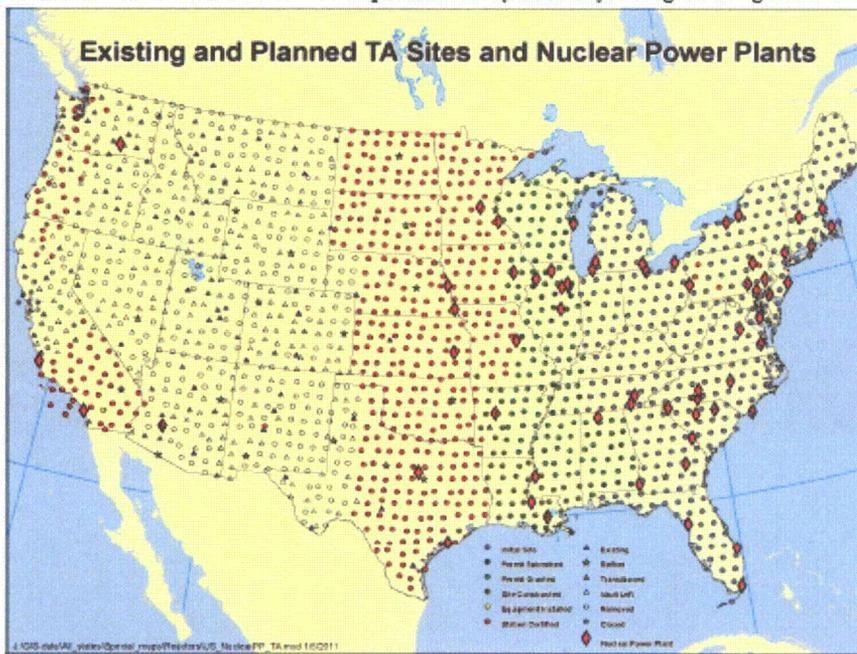
¹ Assumes upgrades to six channel data loggers with strong motion sensors.

² Assumes a conservative estimate of \$8,000/station/year.

The 1-in-4, 250-station network that could be created in the central and eastern US by "leaving behind" one out of every four Transportable Array stations during the years 2011 through 2015.



A large majority of nuclear power plants are located in the central and eastern parts of the US, where it is still possible to "leave behind" 1-in-4 Transportable Array stations for long-term regional observations.



List of Questions

Natural Hazards and Ground Shaking Design Levels	1
1) Did the Japanese underestimate the size of the maximum credible earthquake that could affect the plants?	1
2) Can a very large earthquake and tsunami happen here?	1
3) Has this changed our perception of Earthquake risk?	1
4) What magnitude earthquake are US plants designed to?	1
5) How many US reactors are located in active earthquake zones (and which reactors)?	2
6) How many reactors are along coastal areas that could be affected by a tsunami (and which ones)?	2
7) If the earthquake in Japan was a larger magnitude than considered by plant design, why can't the same thing happen in the US?	2
8) What if an earthquake like the Sendai earthquake occurred near a US plant?	3
9) What would be the results of a tsunami generated off the coast of a US plant? (Or why are we confident that large tsunamis will not occur relatively close to US shores?)	3
10) Can this happen here i.e. an earthquake that significantly damages a nuclear power plant? Are the Japanese plants similar to U.S. plants?	3
11) What level of earthquake hazard are the US reactors designed for?	3
12) Does the NRC consider earthquakes of magnitude 9?	3
13) What are the definitions of the SSE and OBE?	4
14) What is the likelihood of the design basis or "SSE" ground motions being exceeded over the life of the plant?	5
15) What is magnitude anyway? What is the Richter Scale? What is intensity?	5
16) We need to pull Q&As out of the Markey/Capp letter of March 15 th ...there's a lot there to answer	5
17) How do magnitude and ground motion relate to each other?	5
18) How are combined seismic and tsunami events treated in risk space? Are they considered together?	5
19) How are aftershocks treated in terms of risk assessment?	5
Design Against Natural Hazards & Plant Safety in the US.....	6
21) Are power plants designed for Tsunami's?	6
22) What level of Tsunami are we designed for?	6

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23) Which plants are close to known active faults? What are the faults and how far away are they from the plants? 6

24) How was the seismic design basis for an existing nuclear power plant established? 6

25) Is there margin above the design basis? 7

26) Are US plants safe? 7

27) Was the Japanese plant designed for this type of accident? Are US plants? 7

28) Why do we have confidence that US nuclear power plants are adequately designed for earthquakes and tsunamis? 7

29) Can this happen here i.e. an earthquake that significantly damages a nuclear power plant? Are the Japanese plants similar to U.S. plants? 7

30) Could an accident like the one at Japan’s Fukushima Daiichi nuclear plant happen in the United States? 8

31) Should U.S. nuclear facilities be required to withstand earthquakes and tsunamis of the kind just experienced in Japan? If not, why not? 8

32) Can you summarize the plant seismic design basis for the US plants? Are there any special issues associated with seismic design? 9

33) How do we know that the equipment in plants is safe in earthquakes? 9

34) How do we know equipment will work if the magnitude is bigger than expected, like in Japan? 9

35) Are US plants susceptible to the same kind of loss of power as happened in Japan? 9

36) How do we know that the EDGs in Diablo Canyon and SONGS will not fail to operate like in Japan? 10

37) Is all equipment at the plant vulnerable to tsunami? 10

38) What protection measures do plants have against tsunami? 10

39) Is there a risk of loss of water during tsunami drawdown? Is it considered in design? 10

40) Are nuclear buildings built to withstand earthquakes? What about tsunami? 10

41) Are aftershocks considered in the design of equipment at the plants? Are aftershocks considered in design of the structure? 10

42) Are there any special issues associated with seismic design at the plants? For example, Diablo Canyon has special requirements. Are there any others? 10

43) Is the NRC planning to require seismic isolators for the next generation of nuclear power plants? How does that differ from current requirements and/or precautions at existing U.S. nuclear power plants? 10

44) Are there any U.S. nuclear power plants that incorporate seismic isolators? What precautions are taken in earthquake-prone areas? 11

45) Do you think that the recent Japan disaster will cause any rethinking of the planned seismic isolation guidelines, particularly as it regards earthquakes and secondary effects such as tsunamis?

11

About Japanese Hazard, Design and Earthquake Impact..... 12

46) Was the damage done to the plants from the Earthquake or the Tsunami? 12

47) What is the design level of the Japanese plants? Was it exceeded? 12

48) What are the Japanese S_1 and S_s ground motions and how are they determined? 12

49) Did this earthquake affect Kashiwazaki-Kariwa NPP? 13

50) How high were the tsunami at the plants? 13

51) Wikileaks has a story that quotes US embassy correspondence and some un-named IAEA expert stating that the Japanese were warned about this ... Does the NRC want to comment? 13

What happened in US Plants during the earthquake? 14

52) Was there any damage to U.S. reactors from either the earthquake or the resulting tsunami? 14

53) Have any lessons for US plants been identified? 14

Future Actions, Reassessment of US Plants and GI-199..... 15

54) What is the NRC doing about the emergencies at the nuclear power plants in Japan? Are you sending staff over there? 15

55) With NRC moving to design certification, at what point is seismic capability tested – during design or modified to be site-specific? If in design, what strength seismic event must these be built to withstand? 15

56) Can we get the rankings of the plants in terms of safety? (Actually this answer should be considered any time GI-199 data is used to “rank” plants) 15

57) Is the earthquake safety of US plants reviewed once the plants are constructed? 16

58) Does the NRC ever review tsunami risk for existing plants? 16

59) Does GI-199 consider tsunami? 16

60) What is Generic Issue 199 about? 16

61) Where can I get current information about Generic Issue 199? 16

62) How was the seismic design basis for an existing nuclear power plant established? 17

63) Is there margin above the design basis? 17

64) Are all U.S. plants being evaluated as a part of Generic Issue 199? 17

65) Are the plants safe? If you are not sure they are safe, why are they not being shut down? If you are sure they are safe, why are you continuing evaluations related to this generic issue? 17

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66) What do you mean by "increased estimates of seismic hazards" at nuclear power plant sites? 18

67) What do the following terms mean? 19

68) Let's say there's an estimate expressed as "2.5E-06." (I'm looking at Table D-2 of the safety/risk assessment of August 2010.) I believe that this expression means the same as 2.5×10^{-6} , or 0.0000025, or 2.5 divided by one million. In layman's terms, that means an expectation, on average, of 2.5 events every million years, or once every 400,000 years. Similarly, "2.5E-05" would be 2.5 divided by 100,000, or 2.5 events every 100,000 years, on average, or once every 40,000 years. Is this correct? 20

69) The GI-199 documents give updated probabilistic seismic hazard estimates for existing nuclear power plants in the Central and Eastern U.S. What document has the latest seismic hazard estimates (probabilistic or not) for existing nuclear power plants in the Western U.S.? 20

70) The GI-199 documents refer to newer data on the way. Have NRC, USGS et al. released those? I'm referring to this: "New consensus seismic-hazard estimates will become available in late 2010 or early 2011 (these are a product of a joint NRC, U.S. Department of Energy, U.S. Geological Survey (USGS) and Electric Power Research Institute (EPRI) project). These consensus seismic hazard estimates will supersede the existing EPRI, Lawrence Livermore National Laboratory, and USGS hazard estimates used in the GI-199 Safety/Risk Assessment." 21

71) What is the timetable now for consideration of any regulatory changes from the GI-199 research?..... 21

Seismic Probabilistic Risk Assessment (SPRA) 22

72) The NRC increasingly uses risk-information in regulatory decisions. Are risk-informed PRAs useful in assessing an event such as this? 22

Plant-Specific Questions 23

SONGS questions 23

73) SONGS received a white finding in 2008 for 125VDC battery issue related to the EDGs that went undetected for 4 years. NRC issued the white finding as there was increased risk that one EDG may not have started due to a low voltage condition on the battery on one Unit (Unit 2). Aren't all plants susceptible to the unknown? Is there any assurance the emergency cooling systems will function as desired in a Japan-like emergency? 23

74) Has the earthquake hazard at SONGS been reviewed like DCNPP is doing? Are they planning on doing an update before relicensing? 23

75) Is possible to have a tsunami at songs that is capable of damaging the plant? 23

76) Does SONGS have an emergency plan for tsunami? 23

77) Has evacuation planning at SONGS considered tsunami? 24

78) Is SONGS designed against tsunami and earthquake? 24

79) What is the height of water that SONGS is designed to withstand? 24

80) What about drawdown and debris? 24

81) Will this be reviewed in light of the Japan quake. 24

82) Could all onsite and offsite power be disrupted from SONGS in the event of a tsunami, and if that happened, could the plant be safely cooled down if power wasn't restored for days after? 24

83) Are there any faults nearby SONGS that could generate a significant tsunami? 25

84) What magnitude or shaking level is SONGS designed to withstand? How likely is an earthquake of that magnitude for the SONGS site? 25

85) Could SONGS withstand an earthquake of the magnitude of the Japanese earthquake? 25

86) What about the evacuation routes at SONGS? How do we know they are reasonable? 25

87) Regarding tsunami at Diablo and SONGS, is the tsunami considered separately from flooding in licensing? And from the design perspective, is the flood still the controlling event for those plants rather than the tsunami? 25

88) What is the design level flooding for DNCPP and SONGS? Can a tsunami be larger? 26

89) Is there potential linkage between the South Coast Offshore fault near San Onofre NPP and the Newport-Inglewood Fault system and/or the Rose Canyon fault? Does this potential linkage impact the maximum magnitude that would be assigned to the South Coast Offshore fault and ultimately to the design basis ground motions for this facility? 26

Diablo Canyon Questions 27

90) Now after the Japan tragedy, will the NRC finally hear us (A4NR) and postpone DC license renewal until seismic studies are complete? How can you be sure that what happened there is not going to happen at Diablo with a worse cast quake and tsunami? 27

91) The evacuation routes at DCNPP see are not realistic. Highway 101 is small...and can you imagine what it will be like with 40K people on it? Has the evacuation plan been updated w/ all the population growth? 27

92) Are there local offshore fault sources capable of producing a tsunami with very short warning times? 27

93) Are there other seismically induced failure modes (other than tsunami) that would yield LTSBO? Flooding due to dam failure or widespread liquefaction are examples. 27

94) Ramifications of beyond design basis events (seismic and tsunami) and potential LTSBO on spent fuel storage facilities? 27

95) Why did a Emergency Warning go out for a 'tsunami' that was only 6 ft high? Do these guys really know what they're doing? Would they know it if a big one was really coming? Crying wolf all the time doesn't instill a lot of confidence. 27

96) How big did the Japanese think a quake/tsunami could be before 3/11? Why were they so wrong (assuming this quake/tsunami was bigger than what they had designed the plant for)? 28

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The Japanese were supposed to have one of the best tsunami warning systems around. What went wrong last week (both with the reactors and getting the people out...see #1, evacuation plan above)?..... 28

97) Regarding tsunami at Diablo and SONGS, is the tsunami considered separately from flooding in licensing? And from the design perspective, is the flood still the controlling event for those plants rather than the tsunami? 28

98) Shouldn't the NRC make licensees consider a Tsunami coincident with a seismic event that triggers the Tsunami? 28

99) Given that SSCs get fatigued over time, shouldn't the NRC consider after-shocks in seismic hazard analyses? 28

100) Did the Japanese also consider an 8.9 magnitude earthquake and resulting tsunami "way too low a probability for consideration"? 28

101) GI-199 shows that the scientific community doesn't know everything about the seismicity of CEUS. And isn't there a prediction that the West coast is likely to get hit with some huge earthquake in the next 30 years or so? Why does the NRC continue to license plants on the west coast? 29

Indian Point Questions 30

102) Why is Indian Point safe if there is a fault line so close to it?..... 30

103) Comments From the letter received 3/16/11 from Congresswoman Lowey:..... 30

Questions for the Japanese 32

Additional Information 34

Table of Design Basis Ground Motions for US Plants 34

Table of SSE, OBE and Tsunami Water Levels..... 36

Plot of Mapped Active Quaternary Faults and Nuclear Plants in the US..... 41

Nuclear Plants in the US Compared to the USGS National Seismic Hazard Maps..... 42

USGS US National Seismic Hazard Maps..... 42

Plot of Nuclear Plants in the US Compared to Recent Earthquakes 43

Table of Plants Near Known Active Faults 44

Table From GI-199 Program Containing SSE, SSE Exceedance Frequencies, Review Level Earthquakes, and Seismic Core Damage Frequencies 45

Summary of seismological information from regional instrumentation 50

Tsunami Wave Heights at the Japanese Plants (unofficial from NOAA)..... 51

Fact Sheet on Protection of Nuclear Power Plants against Tsunami Flooding..... 52

Seismicity of the Central and Eastern US Fact Sheet 54

Design Basis Ground Motions and New Review Level Ground Motions Used for Review of Japanese Plants..... 56

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Status of Review of Japanese NPPs to New Earthquake Levels Based on 2006 Guidance 57
US Portable Array briefing sheet for brief congressional staffers 58
List of Questions 60

Beasley, Benjamin

From: Beasley, Benjamin
Sent: Thursday, March 17, 2011 7:02 AM
To: Kauffman, John
Subject: FW: Calls for answering questions on earthquakes, etc, in support of Japanese event activities
Attachments: Seismic Questions for Incident Response 3-16-11 3am.pdf

From: Kammerer, Annie
Sent: Wednesday, March 16, 2011 12:18 PM
To: RES Distribution
Cc: Karas, Rebecca
Subject: FW: Calls for answering questions on earthquakes, etc, in support of Japanese event activities

All,

Please read Becky's email below and follow the procedures she laid out to NRO staff.

It is important that we keep the NRC's message consistent and moving through appropriate channels. I have added the latest version of the seismic Q&As for the convenience of those of you who are getting in-house questions related to your projects and responsibilities. Currently we are updating this daily with the questions (and answers) we collect each day.

Thanks,
Annie

From: Karas, Rebecca
Sent: Wednesday, March 16, 2011 12:05 PM
To: NRO_DSER Distribution
Cc: Chokshi, Nilesh; Kammerer, Annie; Munson, Clifford
Subject: Calls for answering questions on earthquakes, etc, in support of Japanese event activities

All,

Based on what just happened, individuals within NRC appear to be either randomly calling geologists/geophysicists/hydrologists or people they happen to know to answer questions.

For callers who are NRC staff who ask you a question, please direct them to call the Ops Center and ask to be connected to the RST seismologist (Cliff on day shift, Annie on evening shift). That person will coordinate all question responses (if Cliff or Annie call you, provide any support they need to help answer these questions).

For callers who are NOT NRC staff (including people from other agencies), please continue to follow the direction of the EDO here:

THIS IS NOT A DRILL

The Office of Public Affairs is expecting a large volume of calls from media and the general public regarding the latest statements from the State Department and the NRC regarding the situation in Japan. ALL CALLS from media or the general public on this topic must be referred to the 301-415-8200 number.

The NRC is coordinating its actions with other Federal agencies as part of the U.S. government response to the events in Japan. The NRC is examining all available information as part of the effort to analyze the event and understand its implications both for Japan and the United States. The NRC's Headquarters Operations Center in Rockville, MD has been stood up since the beginning of the emergency in Japan and is operating on a 24-hour basis.

NRC Incident Responders at Headquarters have spoken with the agency's counterpart in Japan and offered the assistance of U.S. technical experts. NRC representatives with expertise on boiling water nuclear reactors have deployed to Japan as part of a U.S. International Agency for International Development (USAID) team. USAID is the Federal government agency primarily responsible for providing assistance to countries recovering from disasters.

U.S. nuclear power plants are built to withstand environmental hazards, including earthquakes and tsunamis. Even those plants that are located outside of areas with extensive seismic activity are designed for safety in the event of such a natural disaster. The NRC requires that safety significant structures, systems, and components be designed to take in account the most severe natural phenomena historically estimated for the site and surrounding area.

The NRC will **not** provide information on the status of Japan's nuclear power plants. For the latest information on NRC actions see the NRC's web site at www.nrc.gov or blog at <http://public-blog.nrc-gateway.gov>.

Two important reminders:

It is possible that some of us will be requested by colleagues in another country to provide technical advice and assistance during this emergency. It is essential that all such communications be handled through the NRC Operations Center. Any assistance to a foreign government or entity must be coordinated through the NRC Operations Center and the U.S. Department of State (DOS). If you receive such a request, contact the NRC Operations Officer (301-816-5100 or via the NRC Operator) immediately.

If you receive information regarding this or any emergency (foreign or domestic) and you are not certain that the NRC's Incident Response Operations Officer is already aware of that information, you should contact the NRC Operations Officer (301-816-5100 or via the NRC Operator) and provide that information.

Other Sources of Information:

USAID – www.usaid.gov

U.S. Department of State – www.state.gov

FEMA – www.fema.gov

White House – www.whitehouse.gov

Nuclear Energy Institute – www.nei.org

International Atomic Energy Agency – www.iaea.org/press

No response to this message is required.

THIS IS NOT A DRILL

Rebecca Karas, Chief
Geosciences and Geotechnical Engineering Branch 1
Division of Site and Environmental Reviews
Office of New Reactors
U.S. Nuclear Regulatory Commission
Phone: 301-415-7533
Fax: 301-415-5397

Bensi, Michelle

From: GIP Resource [GIP.Resource@nrc.gov]
Sent: Thursday, March 17, 2011 4:00 PM
To: Kauffman, John; Reisifard, Mehdi; Lane, John; Perkins, Richard; Killian, Lauren; Beasley, Benjamin; Smith, April; Bensi, Michelle; Ibarra, Jose
Subject: FW: Response from "Contact a GIP Representative"

From: miller@decysive.com[SMTP:MILLER@DECYSIVE.COM]
Sent: Thursday, March 17, 2011 4:00:18 PM
To: GIP Resource
Subject: Response from "Contact a GIP Representative"
Auto forwarded by a Rule

Below is the result of your feedback form. It was submitted by
[\(miller@decysive.com\)](mailto:miller@decysive.com) on Thursday, March 17, 2011 at 16:00:17

comments: W.R.T. the situation in Japan at Fukushima Daiichi etc., what fraction of the water volume could be expected to have been sloshed out of the spent fuel pools during the 9.0 earthquake oscillations, leaving the remaining water fraction (without replenishment) to evaporate/boil at a faster rate, leading to uncovered fuel rods, hydrogen production, fires, etc.?

name: Ronald L. Miller

organization: Decysive Systems

address1: 813 Calle David

address2:

city: Santa Fe

state: NM

zip: 87506

country: USA

phone: 505.988.7502

TT/18