Screening, Prioritization and Implementation Details (SPID) Guide for the Primary Approach – Fukushima NTTF 2.1:

Category	Reference Number	Position	Figure 1 Flow Chart Reference
Hazard	1	Use of updated EPRI attenuation model	1
Hazard	2	Use of existing site conditions	1
Risk Analysis	3	Use of existing structural models	6a, 6b
Risk Analysis	4	Scaling of responses to develop ISRS	6a, 6b
Risk Analysis	5	Screening criteria for SSCs	6a, 6b
Screening	6	Use of IPEEE HCLPF to compare GMRS for screening	3, 5
Screening	7	Treatment of HF	3, 6a, 6b
Risk Analysis	8	Use of CDFM and separation on variables methods	6a
Risk Analysis	9	Approach for SFP evaluations	7a, 7b
Risk Analysis	10	Overall approach relative to RG 1.200 and ANS/ASME EE standard	ALL
Risk Analysis	11	Consideration of rock founded structures for developing ISRS	6a, 6b

<u>Position #1 / Figure #1 Step 1:</u> Review and, if necessary, revise the EPRI (2004, 2006) attenuation model

<u>Position:</u>

Industry will review, and if necessary, revise the EPRI (2004, 2006) attenuation model before calculating the ground motion response spectra at existing nuclear power plant sites.

<u>Justification:</u>

Based on discussions with ground motion experts beginning in October 2011, it is evident that there are now new / relevant data model and methods available that warrant a review and possible revision to the EPRI 2004/2006 attenuation model. It has been ten (10) years since the EPRI (2004) SSHAC Level 3 workshops were held in 2002 and eight (8) years since the sigma component of the model assessment was updated beginning in 2005.

<u>Follow-up studies under consideration for incorporation into the SPID:</u>

1. EPRI to complete the 2004/2006 Attenuation Model review and, if necessary, revise.

Position #2 / Figure #1 Step 1 Bullet 4: Use of Existing Site Information

Position:

1. The industry will use available soil/site characteristic information. Utilities have the option to gather further information should they choose.
2. Subsurface site response models will go deep enough to characterize the lowest frequency of interest to the structure. (3 seconds is industry proposal)
3. 30 convolution analyses will be used to define the mean and standard deviation of the site response
4. The GMRS to SSE comparison will be performed at control point(s) defined in the FSAR. If no control point is defined in the FSAR, the comparison will be conducted at the highest competent layer.

Justification:

1. For the purpose of meeting the requirements of 2.1, the existing soil/site characteristic information will provide a sufficient accuracy.
2. Subsurface site response models are not needed down to depths that would be necessary to capture responses below frequencies of interest to nuclear facilities.
3. Statistical analyses have been done to demonstrate that 30 convolution analyses are sufficient to define the mean and standard deviation of the site response. The technical basis for this is contained in the February 22, 2010 Duke Power letter on the Lee Plant FIRS to the Document Control Desk of the NRC (Docket 05200018, Duke Power letter WLG2010.02-01, ADAMS ML100550350)

Follow-up studies under consideration for incorporation into the SPID:

1. Guidance on development of the site amplification factors will be included in the SPID.
2. Industry to develop guidance for selecting the control point elevation for screening (GMRS vs IPEEE HCLPF Spectrum) and for soil/rock modeling for SSI (in layer, outcrop, etc.) for future risk assessments. This will ensure proper identification of required hazard data and locations. Two workshops will be conducted involving several industry experts to formulate a consensus on the appropriate control point and soil/rock strata characterization for screening and for SSI.

Position #3 / Figure 1 Step 6a/6b - Use of Existing Structural Models for Seismic Response Analyses

Position:

Existing structural models (i.e., those used for design basis or in USI-A-46 / IPEEE studies) could be used in structural dynamic analyses that are performed to support SPRAs or SMAs required as part of the response to the 50.54(f) letter on 2.1. This requires a review of the existing models be performed by an experienced structural engineer(s) (and a peer reviewer) to determine the adequacy of the models for dynamic analysis for application in risk assessments for 2.1. If necessary the existing structural models can be enhanced using the structural modeling criteria discussed below.

Justification:

The existing structural models that have been used, such as lumped-mass stick models (LMSM) in dynamic analyses to develop seismic responses for the design, licensing and qualification of plant SSCs are reasonably complex for their original intended purpose, and were used to capture the overall structural frequencies, mode shapes, and seismic responses. Typically, if a model complexity is increased, the contribution of the modes within the simpler model is decreased as modal mass is shifted to other modes, resulting in lower spectral peaks for the significant modes of the structure.

Using the existing structural models will facilitate the timely completion of the SPRA/SMA effort within the desired accuracy required as part of the response to the 50.54(f) letter on 2.1.

The criteria against which structural engineer(s) should review the existing models are listed below.

1. If there is significant coupling between the horizontal and the vertical responses, one combined structural model shall be used for analyzing all three directions of the earthquake. See ASCE 4-98 section 3.1.1.1 “Models for Horizontal and Vertical Motions.”

2. Structural mass (total structural, major components and appropriate portion of live load) shall be lumped so that the total mass, as well as the center of gravity is preserved. Rotational inertia should be included if it affects response in the frequency range of interest. See ASCE 4-98 section 3.1.4.1 “Discretization of Mass” part (b) 1.

3. The number of nodal or dynamic degrees of freedom shall be sufficient to represent significant structural modes. All modes up to structural natural frequencies of about 20 Hz in all directions shall be included (vertical floor slab flexibility will generally not be considered because it is expected to have frequencies above 15 hz). This will ensure that the seismic responses and ISRS developed in the 1 to 10 Hz frequency range are reasonably accurate. See ASCE 4-98 Section 3.1.4.1 “Discretization of Mass” part (b) 2.

4. Torsional effects resulting from eccentricities between the center of mass and the center of rigidity shall be included. The center of mass and the center of rigidity may not be coincident at all levels and the torsional rigidity shall be computed. See ASCE 4-98 section 3.1.8.1.3 “Requirements for lumped-mass stick models” parts (b) and (c). Alternatively, a multiple LMSM may be used if the stiffness elements are located at the centers of rigidity of the respective groups of element and the individual models are properly interconnected.

5. For complex structures, the analyst shall review if one stick model sufficiently represents the structure. For example, two stick models could be appropriate for the analysis of internal and external structures of the containment founded on a common mat.

<u>Follow-up studies under consideration for incorporation into the SPID:</u>

None.

Position # 4 / Figure #1 Step 6a and 6b:

Scaling of in-structure response spectra (ISRS) based on previous analyses

Position:

Scaling can be used in developing ISRS for those cases where the new uniform hazard spectrum (UHS) shape is approximately similar to the spectral shape previously used to generate the ISRS. Scaling of responses will be based on:

- previously developed ISRS
- shapes of the previous UHS/review level earthquake (RLE)
- shapes of the new UHS, and
- structural natural frequencies, mode shapes and participation factors

Justification:

Scaling of ISRS is considered a technically sound approach and has been used in previous SPRAs. Scaling was recently used in a Surry pilot SPRA. Guidance on scaling is provided in industry documents such as EPRI report NP-6041-SL Rev. 1 and EPRI report 103959.

Scaling will reduce the effort involved in performing detailed soil structure interaction (SSI) analyses for the new hazard/UHS, facilitating the timely completion of the SPRA effort for those plants that are screened-in.

Scaling of rock or soil sites where the shape of the new hazard spectrum is not similar to the previous spectrum is not recommended without justification that demonstrates the validity of the scaling approach.

Follow-up studies under consideration for incorporation into the SPID:

1. A summary of the methods and processes (e.g. NP-6041SL rev 1, EPRI Report #1002988) used for scaling that have been documented in the past will be incorporated into the SPID. An example approach for the scaling of “non-similar” shapes conducted for the Surry Pilot SPRA project will also be described in the SPID.

Position #5 / Figure #1 Step 6a and 6b:

Develop and use criteria to screen structures, systems and components (SSCs) that will be included in the SPRA/SMA systems analysis models (i.e., plant logic model).

Position:

Screening criteria have been developed that reflect a sound engineering basis to ensure proper focus is given to those SSCs that have the potential to be risk significant. The following screening approaches can be used:

- Some SSCs are inherently very rugged and consequently have a very low probability of failing as a result of a seismic event. Consistent with longstanding practice in seismic PRA, seismic failure of such SSCs need not be included in the PRA logic models. Exclusion of such SSCs from the logic models does not affect the seismic core-damage frequency or the insights derived from the seismic PRA.

- Some SSCs may be less rugged but would still have sufficient capacity such that their failures would be unlikely to contribute significantly to the seismic core-damage frequency. Failures of SSCs in this category are retained in the seismic PRA model, but detailed fragility calculations are not warranted. Retention of such failures ensures that changes or sensitivities that could increase their importance are not overlooked.

The criteria applied for each of these two approaches are summarized below:

1. For SSCs with seismic capacity sufficiently high that they can be excluded from the systems logic model, two different criteria may be employed:

    - A threshold can be established against which a point-estimate frequency of failure for the SSC in question can be compared. For example, if the overall seismic core-damage frequency is approximately 1E-5/yr, a threshold value could be set at 1% of that value, or 1E-7/yr. If an estimate of the frequency of failure for that individual SSC (without further consideration of additional failures that would be necessary for core damage to result) is less than this threshold, the analyst can be confident that the SSC need not be retained in the seismic PRA model. The point-estimate frequency would be obtained by convolving the mean hazard curve with a mean fragility curve for that type of SSC.

    - Alternatively, components that have high confidence of low probability of failure (HCLPF) capacities above an established threshold (e.g., 2 x GMRS) can be screened out.

Capacity estimates of certain types of rugged components (e.g., manual valves) can be based on guidance from EPRI NP-6041-SL, Rev. 1. Therefore, detailed fragility or HCLPF calculations are not needed for these inherently rugged SSCs.

For SSCs for which evidence of inherent ruggedness is less clear, PRA insights can be used to prioritize the fragility calculations of the SSCs. Screening or ranking of SSCs from a preliminary SPRA plant logic model can be done by performing parametric sensitivity analyses with assumed initial fragilities and ranges of fragility values. Those SSCs that do not contribute significantly to the SCDF of an accident sequence may be screened out from having to perform detailed fragility calculations. These components can be retained in the SPRA model but modeled with capacity equal to the screening level.

Justification:

1. The above screening methods will ensure that the time and effort to develop detailed fragilities is focused on the most risk important SSCs.

2. A frequency of failure on the order of 1E-7 (or capacity >2xGMRS; specific criteria yet to be established) would correspond to a contribution on the order of 1% to the SCDF for most plants. A plant-specific criterion against which the HCLPF can be compared can be developed from the 1E-7 criterion using a mean point estimate approach, an assumed composite variability, and the site hazard. The calculated HCLPF criterion can be used in reviewing previous IPEEE, A-46, or design basis calculations to determine and judge if explicit fragility/HCLPF calculations are needed.

3. Those SSCs that do not significantly affect the sequence quantification will be retained in the model and the accident sequences with fragility parameters corresponding to the established screening level. This should not have a significant impact on the ranking of sequences, sequence CDFs, or the overall SCDF. If it is subsequently found that SSCs employing these screening fragility estimates do contribute, more detailed fragility analyses would be required.

It is expected that the above screening methods could substantially reduce the scope of the fragility or margin calculations required in the SPRA or SMA, and still meet the objective of identifying and ranking safety-significant SSCs.

Follow-up studies under consideration for incorporation into the SPID:

To support the above, sensitivity analysis will be performed by the industry using logic models from at least one previous seismic PRA to validate the screening criteria to be used in the SPID. Parametric analysis will be done to justify the screening criteria based on the impact on CDF.

<u>Position #6 / Figure #1 3, 5:</u> Use of IPEEE HCLPF spectrum, in addition to the SSE, to compare to GMRS for screening/prioritizing plants

<u>Position:</u>

For plants that conducted an SPRA, focused scope SMA or full scope SMA during the IPEEE, the screening/prioritizing will be done by first comparing the plant SSE to the new GMRS, and then optionally comparing the IPEEE HCLPF spectrum to the new GMRS. If the IPEEE HCLPF is used for screening, the IPEEE will have been judged to pass an adequacy review.

<u>Justification:</u>

The IPEEE established levels of plant seismic safety that should be incorporated into the screening process. The industry supports NRC recommendation for utilizing the IPEEE HCLPF spectrum results for screening that was offered during the March 1st and April 2-3 public meetings.

<u>Follow-up studies under consideration for incorporation into the SPID:</u>

1. All plants choosing to employ the HCLPF screen will complete an adequacy review as follows:
   - Verify that the commitments made under the IPEEE have been met. If not, address and close those commitments.
   - Verify that any identified deficiencies or weaknesses to NUREG-1407 in the plant specific NRC SER are properly justified or corrected to ensure that the IPEEE conclusions remain valid.
   - Verify that any major plant modifications since the completion of the IPEEE have not degraded/impacted the conclusions reached in IPEEE.
   - Focused scope plants choosing to employ the HCLPF screen will perform the reviews above and any updates necessary to meet the full scope criteria.
     - Address soil failure evaluations
     - Provide justification that low ruggedness relay review is sufficient

2. Industry will develop the process to generate the HCPLF spectrum for plants that performed SPRA during IPEEE.

<u>Position #7 / Figure #1: 3f, 6a, 6b:</u> Treatment of High Frequency Response and High Frequency Capacity

<u>Position:</u>

Plants with GMRS > SSE or IPEEE HCLPF only above 10 Hz will provide confirmation that SSCs, which may be affected by high-frequency ground motion, will maintain their functions important to safety. In addition, plants where GMRS > SSE or IPEEE HCLPF only above 10 Hz do not need to perform dynamic analyses of structures to develop ISRS.

<u>Justification:</u>

The majority of nuclear plant SSCs that have been seismically qualified are not sensitive to high frequency seismic input. This is because the displacements are much higher for low frequency seismic motion, as opposed to high frequency seismic motions. Past shake table testing has demonstrated that SSCs that fail in a ductile manner are not appreciably affected by high frequency seismic loading. Whereas high frequency seismic loads can potentially cause structural failure in brittle components and functional failure in high frequency sensitive contact type components.

The test program will use accelerations or spectral levels that are sufficiently high to address anticipated responses of various plants. Therefore, it would not be necessary for those few plants where GMRS > SSS only above 10 hz to perform structural analyses.

<u>Follow-up studies under consideration for incorporation into the SPID:</u>

1. Prior to endorsement of the SPID, the following activities would be undertaken as part of Phase 1:
    - Develop a project plan and roadmap incorporating past studies on high frequency effects (2 past EPRI studies and a white paper, along with other papers on the topic) to inform the draft plan
    - Conduct workshop to review draft project plan and roadmap
    - Conduct workshop to develop and review a test plan
    - Initiate pilot test program to collect feedback and validate project and test plan.

2. Upon completion of Phase 1, the broader test program will be initiated (Phase 2), including:
    - Survey to gather information on types of potentially high frequency sensitive equipment (type, manufacturer #, model, etc.)
    - Utilize results from survey and pilot test program to finalize test plan (workshop to review)
    - Conduct test program
    - Utilize results from test program to confirm adequacy of high frequency input motions for plants that screen out (step 3f) and for plants that are undertaking further risk evaluations (step 6a, 6b).

Position #8 / Figure #1 6a: Use of either CDFM (hybrid approach) or the separation of variable methods to develop fragilities

Position:

The hybrid / CDFM approach is an acceptable method for generating fragilities within a SPRA.

Use the CDFM approach, as much as possible, to calculate fragilities for seismic PRAs. The CDFM method will determine a HCLPF value. Using an assumed composite variability (e.g. in the range of 0.35 - 0.45) the median value can be calculated to define the fragility parameters. The fragility parameters are then used in the systems model to convolve with the hazard. One disadvantage is that the assumed composite variability may give conservative estimates of seismic CDF. For those SSC that are determined to be the dominant risk contributors in the seismic accident sequences, better estimates of Am and Beta(u) and Beta(r) can be done using the fragility approach and then used in the integration.

Justification:

CDFM is a simpler method for the majority of engineers to learn and apply, as compared to the fragility method.

Follow-up studies under consideration for incorporation into the SPID:

1. Provide examples using multiple sequences with comparison of CDFM and separation of variables fragility parameters to determine the impact on ranking of sequences and CDF values.

Position #9 / Figure #1 Step 7a and 7b:

Approach for spent fuel pool (SFP) evaluations

Position:

The only failure modes to be evaluated are associated with the reinforced concrete SFP enclosure

Justification:

By design, a failure of the systems connected to the SFP cannot result in a rapid, significant loss of inventory of the SFP. In addition, there are redundant and diverse means to provide make up water to the SFP for losses of inventory. Seismically induced internal flooding (inventory loss from mechanisms such as sloshing) are beyond the scope of NTTF Recommendation 2.1 and are included in NTTF Recommendation 3 and therefore should be excluded from the scope of this evaluation.

Follow-up studies under consideration for incorporation into the SPID:

1. Develop guidance for using the results of the 2.3 seismic walkdown to show that seismic-induced failure of systems connected to the SFP cannot result in rapid drain down of the SFP
2. Identify potential methods to supplement inventory loss from the SFP (e.g. FLEX, B.5.b).

Position #10 / Figure #1 Steps 6a and 6b: Use of requirements for seismic PRA and SMA from Regulatory Guide 1.200 and the ASME/ANS PRA Standard.

Invoke criteria in R.G. 1.200 and ASME/ANS PRA Standard for Level 1 / Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications that are consistent with the nature of this application in performing a SPRA or SMA.

Position:

For this application, the requirements corresponding to Capability Category II of the ASME/ANS PRA Standard will generally be applied in the performance of elements of a SPRA. In limited cases, exceptions to the Standard requirements may be taken. The intent of the Standard will be met.

Justification:

The PRA Standard is intended to identify the degree of detail and plant specificity in a risk assessment that reflects the nature of the application for which the risk assessment is being used. In any PRA performed for a risk-informed application, the intent is that the analyses meet at least the minimum requirements that could be relevant for the application, at the capability category corresponding to the nature of the application. The application in this case is to gain an updated understanding of the risk of seismic events at nuclear power plants in light of new information about seismic hazard. This includes developing a new or changed understanding of risk outliers due to seismic events.

Because of the significance of this application, an attempt will be made to meet the requirements for Capability Category II wherever feasible. To meet Capability Category II, the PRA must account for plant-specific configuration and design and reflect plant-specific reliability data where it could affect the important risk contributors.

For this application, which is aimed at developing an improved understanding of the impact of new hazard estimates, screening approaches will be used to limit the scope of detailed analyses for some elements of the seismic PRA. Where more detailed analyses are essential to achieve an adequate level of understanding (e.g., with respect to "realism"), these analyses will be performed or alternative measures will be taken (such as making plant changes to address the impacts).

Applying the approach that has been specified for the seismic hazard is expected to satisfy Capability Category II in most respects. Some limitations in the approach may be employed to support timely completion of the SPRAs likely to be required across the nuclear industry. The Supporting Requirements will be examined in light of these limitations to assure that the limitations do not affect the usefulness of the results or insights from the seismic PRA.

Follow-up studies under consideration for incorporation into the SPID:

As part of development of the SPID, each Supporting Requirement will be reviewed against the planned technical approach to assess the Capability Category that applies. This review will be performed for all of the following:

- Regulatory Guide 1.200, Rev. 2 (the currently approved version of the Regulatory Guide that endorses the ASME/ANS PRA Standard);
- ASME/ANS RA-Sa–2009, the currently approved version of the ASME/ANS PRA Standard;
- Addenda B to ASME/ANS RA-Sa-2009, the version of the Standard that is currently undergoing balloting.

In some cases, Regulatory Guide 1.200 provides further clarification or specification beyond the details in the Standard. Because the newest version of the Standard is likely to be the approved version by the time these seismic PRAs are performed, it may be valuable to examine the specific implications for both the current standard and the newer version.

<u>Topic #11 / Figure #1 6, 6a:</u> Consideration of rock founded structures for developing ISRS

<u>Position:</u>

The original definition of rock (> 3,500 ft/sec) can be used for the development of the ISRS. Fixed based models can be used in the dynamic analyses of rock-founded structures using this original definition of rock.

<u>Justification:</u>

Past experience has shown that the amplified response spectra in the 1-10 Hz are approximately the same from a fixed based model vs. a model that uses soil-structure interaction (SSI) analysis. Therefore, it is conservative to use fixed base dynamic analyses for rock-founded structures even when the shear wave velocities are not as high as 9200 ft/sec.

<u>Follow-up studies under consideration for incorporation into the SPID:</u>

1. Further justification will be provided as part of the SPID. An example of the Containment Structure at a plant is being analyzed to demonstrate the validity of this position and will be shared when complete. The main steam valve house at North Anna will also be analyzed.