Appendix B

IPEEE Adequacy Review

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1.0 Background

In accordance with Section 3.3 of EPRI Report 1025287, Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1, this appendix has been prepared to demonstrate plant seismic adequacy for PPL Susquehanna, LLC (SSES) based on a review of the Ground Motion Response Spectrum (GMRS) to the IPEEE high confidence of low probability of failure (HCLPF) Spectrum. As outlined in Section 3.3.1 of SPID, to credit the internal plant evaluation of external events (IPEEE) as a means of screening from further review, certain criteria must be satisfied. These criteria are as follows:

- General Considerations – Section 2.0 below
- Prerequisites – Section 3.0 below
- Adequacy Demonstration – Section 4.0 below
- Documentation – addressed by the information in Sections 2.0, 3.0 and 4.0 below

The approach to satisfying each of these criteria for SSES is outlined in this appendix.

The Nuclear Regulatory Commission (NRC) staff issued Generic Letter (GL) 88-20, Supplement 4 on June 28, 1991 (Reference 6.1), requesting that each licensee conduct an individual plant examination of external events (IPEEE) for severe accident vulnerabilities. Concurrently, NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities" (Reference 6.2) was issued to provide utilities with detailed guidance for performance of the IPEEE.

A seismic margin assessment (SMA) was performed for the seismic portion of the SSES IPEEE (Reference 6.4) using the EPRI SMA methodology, EPRI NP-6041-SL (Reference 6.3) with enhancements identified in NUREG-1407 (Reference 6.2). The results of the SSES IPEEE were provided to NRC in a letter PLA-4162 dated June 27, 1994.

The NRC staff submitted two requests for additional information (RAI) in letters dated June 10, 1996 (Reference 6.7), and March 26, 1998 (Reference 6.8). SSES responded to the RAI's with additional information by letters PLA-4490 dated August 9, 1996 (Reference 6.5), and PLA-4983 dated October 15, 1998 (Reference 6.6). On August 4 and 5 of 1998, the NRC conducted an audit of SSES's IPEEE with the PPL staff at SSES. The NRC issued its Staff Evaluation Report (SER) on April 27, 1999 for the SSES IPEEE (Reference 6.9). The SER concluded that the SSES IPEEE process was capable of identifying the most likely severe accidents and severe accident vulnerabilities, meeting the intent of Supplement 4 to Generic Letter 88-20.

2.0 General Considerations

Based on SPID Section 3.3.1, the IPEEE reduced scope margin assessment cannot be used for screening. Focused scope margin submittals may be used after having been enhanced to bring the assessment in line with the full scope assessment. The enhancements include (1) a full scope detailed review of relay chatter for components such as electrical relays and switches, and (2) a full evaluation of soil failures, such as liquefaction, slope stability, and settlement.

SSES performed a focused scope SMA utilizing a NUREG/CR0098 (Reference 6.10) median spectral shape for a rock site anchored to a 0.3g PGA. The Review Level Earthquake (RLE) In-structure Response Spectra (IRS) were developed by scaling up the Safe Shutdown Earthquake floor response spectra. The scaling factors were determined using the EPRI recommendation for determining the scaling factor by the ratio of spectral amplitudes at the dominant structural frequency.

The SSES IPEEE conservatively estimated the plant seismic capacity, in terms of high confidence of low probability of failure (HCLPF) value to be 0.21g due to a low seismic capacity of 4 components. However, these low-capacity components were not strictly required for safe shutdown of the plant or their failures could be rectified through manual recovery actions and as such the SSES IPEEE SMA concluded that SSES Units 1 and 2 could be safely shutdown for the RLE anchored at 0.3g PGA using the Structures, Systems, and Components (SSC's) associated with the two safe shutdown paths.

In 2010, the NRC issued Information Notice 2010-18 (Reference 6.11), which documented the risk assessment for Generic Issue 199 in "Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants" (Reference 6.12). In response to NRC Information Notice 2010-18, PPL SSES generated a corrective action (Reference 6.13), to initiate efforts to increase the HCLPF values of the 4 items, reported to have HCLPF values less than 0.3g in the IPEEE report, to 0.3g.

The IPEEE calculations were revised and physical changes to the plant were made to increase the HCLPF values of the 4 items to 0.3g by:

1. Removing excessive conservatism associated with the computation of the RLE displacements.
2. Determining that impact during a RLE would not prevent the SSEL item from performing its safety related function.
3. Increasing the clear space to the adjacent item in the plant to prevent impact from occurring during a RLE.

Verification of the completion of these commitments and modifications were provided in the SSES Response to 10 CFR 50.54(f) Request for Information (Reference 6.14) Recommendation 2.3 Seismic (Reference 6.15) and are further discussed below in Section 3.0 Prerequisites. Confirmation that these modifications are still in place is described in the Prerequisites section of this report.

Although, as described above, each of the components from the IPEEE that caused the HCLPF to be rated at less than 0.3g has subsequently been evaluated for acceptability at the 0.3g level and corrective actions, as appropriate, have been implemented, for screening purposes, a conservative interpretation of Section 3.3.2 of the SPID (Reference 6.16), results in a plant IPEEE HCLPF Spectrum (IHS) of 0.21g.

The following sections summarize the results of the IPEEE adequacy evaluation according to the guidance of the SPID Section 3.3.1 General Considerations.

2.1 Relay Chatter

The results of the seismic qualification test reports (located in Seismic Qualification Review Team (SQRT) binders) were used to evaluate the functional adequacy of the electrical equipment on the Safe Shutdown Equipment List (SSEL) for the RLE. Since SSES is a Non A-46 plant, all safety related equipment was seismically qualified to the IEEE344 standard (Reference 6.17). Typically, an example / test specimen of the safety related electrical equipment (Control Panels, Distribution Panels, Motor Control Centers, Switchgear, Load Centers, Automatic Transfer Switches, etc.) was seismically qualified through shaker table testing. Any relay or switch whose performance was found to be unacceptable during seismic testing would have been noted to be an anomaly in the test report and evaluated separately for acceptability. Typically, relay chattering in excess of 2 msec was considered to be an anomaly.

The SSES IPEEE compared the actual Test Response Spectra (TRS) used in the shaker table testing to the required levels associated with the RLE in-structure response spectra. In cases where the RLE exceeded the TRS levels, the methodology presented in Appendix Q of EPRI NP-6041-SL was used to demonstrate adequacy.

As part of the SSES IPEEE adequacy review, a review of all of the IPEEE calculations associated with electrical equipment that included relays (125V/250V DC Load Centers, 125V DC Distribution Panels, 120V AC Distribution Panels, 125V Panels, 125V & 250V DC Fuse Boxes, 480V AC Load Centers & Transformers, 4KV Switchgear, Motor Control Centers, Automatic Transfer Switches, Control and Instrumentation Panels, Battery Chargers and Inverters) was performed to assure that the approach taken is as described herein. This is consistent with the statement made in Section 3.5.2.6 of the

IPEEE that "all relays, contactors, switches and breakers associated with SSEL equipment were evaluated for chattering using the results of the seismic qualification shaker table test reports."

Based on the review described above, it is concluded that the SSES IPEEE effort exceeded the focused scope requirement of locating and evaluating low-seismic-ruggedness relays (bad actor list), since the review conducted as a part of this submittal demonstrated that the functional adequacy of all electrical components in all systems was included within the IPEEE scope. This evaluation has confirmed that the IPEEE relay chatter evaluations performed meet the requirements presented in Section 3.2.4.2 of NUREG-1407 for a Full Scope SMA of a Non A-46 plant.

2.2 Soil Failure Evaluation

The major safety related structures (Containments, Reactor and Control Building, Emergency Diesel Generator 'A-D' Building and the associated four Diesel Fuel Oil Storage Tanks, and Emergency Diesel Generator 'E' Building) are all founded directly on top of sound competent bedrock that has a shear wave velocity of about 7,500 ft./sec. Rock was previously defined as material with a shear-wave velocity greater than 3,500 ft./sec, therefore soil failure effects (such as liquefaction, slope stability and settlement) are considered negligible for these safety related structures. As stated in NUREG-1407, Section 3.2.1, a plant in the full-scope category that is located on a rock site is not required to perform a soil failure evaluation.

The Emergency Diesel Generator 'E' underground fuel oil storage tank was determined not to be susceptible to soil induced failures, other than an inconsequentially small level of settlement, due to the fact that it is supported on a large reinforced concrete mat placed on top of highly compacted material and had its excavation backfilled with sand-cement-fly ash fill.

The Emergency Safeguards Service Water (ESSW) Pumphouse and the Spray Pond are the only major structures that are not founded on sound competent bedrock. These structures along with the following buried safety related components received a soils evaluation as part of the original SSES IPEEE submittal:

1) Electrical duct banks
2) Emergency Service Water (ESW) piping
3) Residual Heat Removal Service Water (RHRSW) piping

The evaluation for various soil failures is described in Section 3.11.4 of the IPEEE report. Section 3.11.4.1 describes the relevant soil data and conditions for SSES. Section

3.11.4.2 provides the following soil-related issues that could potentially affect the two safe shutdown success paths:

1) Liquefaction potential for the terrace deposits below the Spray Pond
2) Post-earthquake settlement of the terrace deposits, especially below the Emergency Safeguards System Water Pumphouse (ESSWPH), Safety Related (SR) ESW and RHRSW piping and SR electrical ductbanks
3) Stability of the pond slopes
4) Lateral sliding, especially of the ESSWPH
5) Seismic distortions in buried pipelines

a. <u>Liquefaction potential for terrace deposits below the spray pond</u>

The potential for liquefaction during a RLE was determined to be the highest below the spray pond. The realistic factor of safety for liquefaction of the soil under the spray pond due to an RLE was calculated to be 1.37. This factor of safety provides a high level of confidence that the soil under the spray pond will not liquefy during a RLE.

b. <u>Post-earthquake settlement of the terrace deposits</u>

The settlement due to the RLE below the Emergency Safeguards Service Water Pumphouse was estimated to be 0.5" and the settlement of the safety related piping and duct banks was estimated to be 0.1". These settlements were determined to be inconsequential for the safe shutdown of the plant.

c. <u>Stability of the spray pond slopes</u>

An evaluation of the Spray Pond slopes determined that there is a factor of safety greater than 3 against a sliding failure of the most critical pond slope during a RLE and that a large or massive failure of the pond slope is unlikely. However, local sloughing or shallow surface material sliding may occur if there are any pockets of loose material. A local failure will not cause any significant reduction in the volume of free water in the pond. An adequate quantity of water required for cooling the plant systems during shutdown will be available.

d. <u>Lateral sliding, especially of the ESSWPH</u>

The lateral sliding of the ESSWPH or other Safety Related buildings is not likely. The actual active-side lateral earth pressures on the subsurface walls of these

buildings were based on very conservative soil parameters that bound those side pressures developed during a RLE. Therefore, the current design strength of the walls is also adequate to sustain the increased earth pressures during a RLE.

e. Seismic distortions in buried pipelines

In the original design basis calculations, the ESW and RHRSW pipes were qualified to an SSE maximum ground acceleration of 0.2g in lieu of 0.1g for rock-supported structures and 0.15g for soil-supported structures. This conservative increase in the SSE seismic demand, in conjunction with the utilization of simple conservative methods and assumptions in estimating piping stresses, and the fact that the seismic stress contributes a small portion of the overall piping stresses, allows this item to be screened out from further detailed seismic margin assessment.

The soil stability screening, reviews, and analyses performed for the Seismic IPEEE concluded that any soil induced failures for the RLE are not significant enough to warrant detailed state-of-the-art soil evaluations. This determination is supported by the Technical Evaluation Report, which is part of the Staff Evaluation Report (Reference 6.9). Specifically, page 34 of the Technical Evaluation Report, identified the comparatively broad analysis of soil failures as a strength of the SSES seismic IPEEE. In light of the above, the soil failure evaluations performed for the IPEEE are in compliance with the requirements of a Full Scope SMA, as described in Section 3.2.4.3 of NUREG 1407.

3.0 Prerequisites

Section 3.3.1 of the SPID requires that the following items be addressed in order to use the IPEEE analysis for screening purposes and to demonstrate that the IPEEE results can be used for comparison with the ground motion response spectra (GMRS):

1.) Confirmation that commitments made under the IPEEE have been met.

2.) Confirmation that all of the modifications and other changes credited in the IPEEE analysis are in place.

3.) Confirmation that any identified deficiencies or weaknesses to NUREG-1407 in the SSES IPEEE NRC SER are properly justified to ensure that the IPEEE conclusions remain valid.

4.) Confirmation that major plant modifications since the completion of the IPEEE have not degraded/impacted the conclusion reached in the IPEEE.

Response:

Items 1 and 2

The responses to these items were addressed as part of the NTTF Recommendation 2.3: Seismic walkdowns submittal. Refer to Section 7 of the Seismic 2.3 Walkdown Reports (Reference 6.15).

All IPEEE commitments and modifications have been completed. Verification of the completion of these commitments and modifications were provided in the SSES Response to 10 CFR 50.54 Request for Information Recommendation 2.3 Seismic (Reference 6.15).

Item 3

The NRC transmitted to PPL a Staff Evaluation Report (SER) for the SSES Seismic IPEEE on April 27, 1999 (Reference 6.9). The SER included a Technical Evaluation Report (TER) and a Supplemental Technical Evaluation Report (STER) that was provided by Energy Research Incorporated (ERI), the NRC's contractor.

The initial TER identified concerns and questions that were later resolved through information submitted by PPL in responses to Requests for Additional Information and an audit held at SSES on August 4-5, 1998. In Section 3 "Overall Evaluation and Conclusions" of the STER it was noted that there were no major weaknesses in the seismic IPEEE.

A review of the SER and STER reports determined that there are no unresolved seismic deficiencies related to NUREG-1407. In Section 4 "Supplemental IPEEE Insights, Improvements and Commitments" of the STER, it was noted that "Although the plant HCLPF capacity has been assessed in the SSES seismic IPEEE as being 0.21g, this capacity is governed by potential interaction concerns that may not be sufficiently severe to disable associated success paths." The STER also noted in Section 4 that "No licensee commitments resulted from the supplemental seismic reviews."

While the SSES seismic IPEEE was conservatively calculated to be 0.21g, there were no commitments made to increase the value to 0.3g. However, in response to NRC Information Notice 2010-018, SSES has completed the necessary actions to increase the HCLPF values for the four items from the original IPEEE that were less than 0.3g.
The seismic conclusions drawn in the IPEEE remain valid since they are not impacted by having any NUREG-1407 deficiencies and the identified weakness has been properly resolved with the increase of all component HCLPF values to 0.3g.

Item 4

No Major Changes to the Safety Systems Relied Upon for the IPEEE's Two Safe Shutdown Paths

None of the safety systems, relied upon for the IPEEE's two safe shutdown paths, have been replaced or have undergone major changes since the completion of the Seismic IPEEE in June of 1994. Some SSES systems like Neutron Monitoring and Seismic Monitoring systems have been replaced, however, these systems are not on the IPEEE SSEL. Minor changes associated with component replacements to address obsolescence and wear have occurred to the systems associated with the two safe shutdown paths. Examples include: replacement/refurbishment of motors for various pieces of mechanical equipment including RHR pump motors and MOVs, replacement batteries, replacement of electrical components housed in Motor Control Center buckets, replacement of electro-mechanical devices with solid state devices in various electrical panels, replacement of CRTs with LCD monitors, replacement of breakers of various sizes, and transformers, etc. The replacement of safety related components were performed via the SSES modification program, which provides assurance that the replacement components will perform their safety related function during and after design basis seismic and hydrodynamic events. The discussion below demonstrates how the seismic qualification program used at SSES will maintain the seismic margins for any replacement components installed through the plant modification process.

Program Requirements Preserve Seismic Margin

The SSE ground motions were used to design the plants with conservative methods, resulting in significant seismic margins within structures, systems and components (SSCs). These conservatisms are reflected in several key aspects of the seismic design process, including:

- Safety factors applied in design calculations
- Damping values used in dynamic analysis of SSCs
- Bounding synthetic time histories for in-structure response spectra calculations
- Broadening criteria for in-structure response spectra
- Response spectra enveloping criteria typically used in SSC analysis and testing applications
- Response spectra based frequency domain analysis rather than explicit time history based time domain analysis
- Bounding requirements in codes and standards

- Use of minimum strength requirements of structural components (concrete and steel)
- Bounding testing requirements, and
- Ductile behavior of the primary materials (that is, not crediting the additional capacity of materials such as steel and reinforced concrete beyond the essentially elastic range, etc.).

The design considerations of the modification program make reference to existing programs and requirements that assure the inherent conservatisms associated with the seismic qualification of original components also exist with the seismic qualification of replacement components. Some of the design considerations invoked by the modification process that are directly related to seismic margin are as follows:

- Dynamic Qualification
- II Over I Safety Impact
- Design Assessment
- Materials Compatibility
- Valves and Actuators
- Physical Clearances
- Risk Management
- Component Criticality
- Comparison of Critical Characteristics
- Digital Upgrades
- Operational Margin
- Failure Modes and Effects Analysis

The dynamic qualification adequacy of the replacement components is typically performed using the same required levels as those considered for the original component. In light of the above, the seismic margin associated with a replacement component is similar to that of an original component.

Observations Made During 2.3 Seismic Walkdowns Support the Conclusion That There Are No Significant Impacts From Modifications

The walkdowns provided confirmation that SSES has a high quality program that controls how items are replaced in the plant. The 2.3 walkdowns did not identify any potentially adverse seismic conditions that would compromise any plant equipment's ability to perform their required design function during or after a Design Basis

Earthquake. From this, it can be concluded that existing plant programs are preventing modifications from impacting the seismic performance of safety related equipment. The walkdown efforts associated with the Expedited Seismic Evaluation Process will provide another opportunity to support this conclusion.

Long Term Involvement of Seismic Efforts by In-house Engineers

Over the years of plant ownership, PPL has maintained a policy of performing the SSES seismic efforts with in-house engineering resources to the maximum extent possible. This policy has resulted in a benefit of having long term employees that are knowledgeable about the performed modifications and their associated dynamic qualification efforts over the duration of time between the IPEEE effort and the current NTTF 2.1 and 2.3 efforts. One of the PPL seismic engineers was involved with 1) the Seismic IPEEE, 2) the seismic qualification of replacement components over the past 20 years and 3) the NTTF 2.1 and 2.3 efforts. The long term involvement of the SSES seismic efforts by in-house engineers assures continuity in maintaining seismic margins for replacement components. This assures replacement components installed through the modification process have the same or similar seismic capability as those evaluated under the IPEEE.

Conclusion

The above discussions provide assurance that the conclusions reached in the Seismic IPEEE have not been impacted by modifications made to the plant since the completion of the Seismic IPEEE in June of 1994.

4.0 Adequacy Demonstration

4.1 Structural Models and Structural Response Analysis

Methodology Used:

Structural Models

The dynamic models, for all Seismic Category I structures, are lumped mass stick models. For all models, the masses are located at elevations of mass concentrations, such as floors and roofs. However, in the case of the containment, which is a structure of continuous mass distribution, masses are lumped at 10 to 15 feet intervals along the containment shell and reactor pedestal. The stiffness properties of the major structural elements that comprise the Seismic Category I structures are represented by the stiffness values assigned to the structural models' springs, stick elements, and beam elements.

The Primary Containments, Reactor/Control Building, and Diesel Generator Buildings are founded on sound rock. The Primary Containments were assumed to have flexible bases to account for the flexibility of the rock. The rock is assumed to be a homogeneous material comprising an entire elastic half-space. The structural models for the Reactor/Control Building and Diesel Generator Buildings have fixed bases since the flexibility of the rock was not considered.

Since the ESSW Pumphouse was founded on soil, soil conditions were explicitly considered. The soil was considered as a homogeneous material modeled with equivalent linear springs and soil viscous dampers. Additional information is presented in Sections 3.4.3.3 "Dynamic Models of Seismic Category I Structures" and 3.4.3.4 "Soil Structure Interaction" of the IPEEE report.

Structural Response Analysis Method

The structural responses for the RLE were determined by scaling up the SSE responses from existing dynamic analyses. The dynamic models of the structures were used to perform:

1) Time history analyses to generate in-structure response spectra
2) Response spectrum analyses to determine displacements and strains to verify structural adequacy.

Additional information with respect to the generation of in-structure response spectra is presented in Section 3.4.3 of the IPEEE report. All Category I structures are analyzed for three orthogonal components of motion (two horizontal and one vertical).

Compliance with NUREG-1407:

This methodology meets the guidance and requirements of EPRI NP-6041-SL and the enhancements specified in NUREG-1407.

Adequate for Screening:

The methodology used is in compliance with NUREG-1407 and the IPEEE structural modeling results are adequate for screening purposes.

4.2 In-Structure Demands and ISRS

Methodology Used:

The Review Level Earthquake (RLE) in-structure response spectra were developed by applying scaling factors to the Safe Shutdown Earthquake (SSE) in-structure response spectra. Refer to Section 3.8.4 of the IPEEE report. The margins associated with and extracted from the SSE synthetic time history response spectrum were used in determining the appropriate scaling factors. The NUREG/CR-0098 median rock spectrum anchored at 0.3g and the EPRI recommendation of using the ratio of spectral amplitudes at dominate structural frequency were also used in determining the scaling factors.

The three prerequisites (listed below) for scaling as outlined in Section 4 of EPRI NP-6041-SL were fulfilled by SSES.

1. The structures should be founded on rock.
2. A review of the structural models used for design should be conducted to determine ability to properly predict response.
3. The shape of the RLE ground response spectra should not be significantly different from the SSE ground response spectra.

The inherent assumption made when factoring up the previous SSE results is that the structural response is linearly elastic. This assumption was confirmed during the seismic IPEEE project.

Compliance with NUREG-1407:

This methodology meets the guidance and requirements of EPRI NP-6041-SL and the enhancements specified in NUREG-1407.

Adequate for Screening:

The methodology used is in compliance with NUREG-1407 and the IPEEE in-structure demands and in-structure response spectra results are adequate for screening purposes.

4.3 Selection of Seismic Equipment List (SEL)/Safe Shutdown Equipment List (SSEL)

Methodology used:

The EPRI methodology (Reference 6.3) was used as guidance along with previous SSES Individual Plant Examination (IPE) (Reference 6.18) to develop the list of structures, systems and components that would be used for the safety functions required to establish and maintain a safe shutdown condition, including a primary and alternate success path. The following safety functions were satisfied by the IPEEE success paths: reactivity control, reactor coolant pressure control, reactor coolant inventory control, decay heat removal, and containment function.

Functional success paths were developed with the aid of the IPE event tree models. Support system requirements for the above functional success paths were identified. A list of components was developed for each system with an indication of the component location. The location of equipment was used to ensure that the list of structures was complete for seismic capability screening and analysis.

The type of components considered under the civil/structural review (passive components) were those required to remain intact and provide physical support for mechanical and electrical components.

The passive and active components included in the IPEEE scope are identified in Table 3.6 in the SSES IPEEE submittal.

Compliance with NUREG-1407:

This methodology meets the guidance and requirements of EPRI NP-6041-SL and the enhancements specified in NUREG-1407. Section 3.2.5.1 of NUREG-1407 requires a complete set of potential success paths be identified and the narrowing/elimination of paths to be documented in detail. Section 3.5.2 of the SSES IPEEE (Reference 6.4) documents in detail the system analysis and the component selection process used in defining the Safe Shutdown Equipment List (SSEL) used in the SMA.

Adequate for Screening:

The methodology used is in compliance with NUREG-1407 and the IPEEE seismic equipment selection results are adequate for screening purposes.

4.4 Screening of Components

Methodology used:

The Seismic Review Team (SRT) screened from further margin review structures and components for which the SRT could document HCLPFs at or above the specified RLE of 0.3g based on their combined experience and judgment and use of earthquake experience data.

Screening of equipment and subsystems is based on Tables 2-3 and 2-4 of NP-6041-SL. Prior to screening out equipment and subsystems, walkdowns were performed by the SRT to confirm the seismic ruggedness of the item in conjunction with the recommended screening guidelines and criteria. In addition, the screening caveats or footnote restrictions from the screening criteria tables are evaluated to satisfy their concern/requirements or provide a resolution if they cannot be satisfied. Anchorage adequacy and seismic interaction are addressed for all equipment items regardless of the screening criteria and guidance presented. Refer to Section 3.10.2 "Screening Criteria" of the IPEEE report.

Structures and equipment that could not be screened were further evaluated as documented in the IPEEE submittal and back up calculations/evaluations. Screening evaluations included spatial interactions, such as assessment of the effects of seismic induced flooding, proximity to other structures or components, etc. (also see walkdown methodology discussion below).

Compliance with NUREG-1407:

The above methodology meets the requirements of NUREG-1407 Section 3.2.5.5 Screening Criteria, which states that screening guidance given in Tables 2-3 and 2-4 of NP-6041-SL (Reference 6.3) may be used provided review/screening is performed at the appropriate RLE. NUREG-1407 also requires that spatial interaction evaluations such as assessing the effects of flooding as noted in EPRI NP-6041-SL be performed.

Adequate for Screening:

The methodology used is in compliance with NUREG-1407 and the IPEEE screening of component results are adequate for screening purposes.

4.5 Walkdowns

Methodology used:

Prior to performing a walkdown, a significant amount of preparation work was performed to obtain maximum benefit from the walkdown. The preparation work included:

1) A review of equipment arrangement drawings to determine the location of the walkdown items.
2) A review of design basis documentation (SQRT Binders, qualification reports, anchorage calculations, and equipment foundation drawings).
3) A review of IPEEE reference material to obtain an understanding as to what are adverse seismic features for the class of equipment being walked down.
4) Establishing the methodology used to address functional adequacy to identify what caveats, if any, must be met.

A description of walkdown preparation is presented in Section 3.10.4 of the IPEEE report (Reference 6.4).

Seismic walkdowns were performed in support of the IPEEE on an equipment class basis. Walkdowns results were documented on Screening and Evaluation Walkdown Sheets (SEWS) and the walkdown checklists in accordance with EPRI NP-6041-SL (Reference 6.3). The walkdown documentation is contained in the IPEEE calculations that were prepared for each class of equipment.

Walkdowns were conducted by several Seismic Review Teams (SRT) who were Seismic Qualification Utility Group (SQUG) trained and certified. Electrical maintenance personnel assisted the SRT, on an as needed basis, by opening up electrical equipment for inspection. The Safe Shutdown Equipment List based on the success path systems was used to define the walkdown scope.

Any adverse seismic features associated with the equipment were identified during the walkdown. The approach used for addressing the functional capability of the equipment dictated the need for fulfilling certain equipment caveats.

During the walkdown, the equipment's anchorage (i.e. type, number, size, etc.) was reviewed for conformance with the documents gathered during the walkdown preparation efforts.

The potential for spatial system interactions was considered during seismic walkdowns. Specific items looked for during the walkdowns included

1) Overhead potential safety impact hazards

2) Good housekeeping practices
3) Adequate anchorage capacity of nearby Non-Q items
4) Potential impact from swinging items
5) Adequate space between SSEL item and another item
6) Flexible connections between points of differential movement.

All spatial interaction issues were evaluated to determine if the component's HCLPF value was adequate for 0.3g.

Additional information on the performed equipment walkdowns is presented in Section 3.10.5 of the IPEEE report (Reference 6.4).

Compliance with NUREG-1407:

Walkdowns were conducted and documented in accordance with EPRI NP-6041-SL as required by Section 3.2.5.2 of NUREG-1407.

Adequate for Screening:

The methodology used is in compliance with NUREG-1407 and the IPEEE walkdown results are adequate for screening purposes.

4.6 Fragility Evaluations

Methodology used:

Analyses were performed for all structures and components that could not be screened to a HCLPF earthquake of 0.3g. The seismic capacities of structures and components were calculated in accordance with the guidance contained in EPRI NP-6041-SL (Reference 6.3) and are documented in the IPEEE report (Reference 6.4).

Seismic capability levels in excess of 0.3g were not determined. The qualification reports found in the SQRT binders along with the methodology presented in Appendix Q of EPRI NP-6041-SL (Reference 6.3) were used to assess the capability of the equipment for the RLE. All equipment and structures in the SMA success path have a HCLPF of 0.3g peak ground acceleration (PGA) or greater except for 4 items that were found to have seismic interaction issues. Refer to Section 3.14.2.1 of the IPEEE report (Reference 6.4). The HCLPF values of these 4 items were later increased to at least 0.3g. Refer to the discussion presented in Section 2.0 herein.

Compliance with NUREG-1407:

SSES calculated HCLPFs for all outlier components in accordance with the guidance of EPRI NP-6041-SL and NUREG-1407 Section 3.2.5.7. Components that did not initially meet the 0.3g RLE screening criteria were later shown to have a HCLPF value of at least 0.3 g.

Adequate for Screening:

The methodology used is in compliance with NUREG-1407 and the IPEEE fragility evaluation results are adequate for screening purposes.

4.7 System Modeling

Methodology used:

Functional success paths were developed with the aid of the IPE event tree models to identify systems needed to mitigate the consequences of an earthquake. The Functional Success Diagram shows the front line and the associated support systems that can be used for the safety functions required to establish and maintain a long term safe shutdown condition (i.e., reactivity control, pressure and inventory control and decay heat removal). Refer to Figures 3.22- 3.25 of the IPEEE report (Reference 6.4).

All potential success paths were evaluated and eliminated based on not meeting the 72-hour mission time, the inability to meet the review level earthquake, the inability to cope with a small LOCA, etc. The systems considered and the reasons for being eliminated are documented in the IPEEE (Reference 6.4). Specifically, the system modeling, development of the preferred and alternate safe shutdown paths, and the development of the SSEL are discussed in Section 3.5 of the IPEEE report (Reference 6.4). The guidance presented in NUREG 1407 (Reference 6.2) and in EPRI NP-6041-SL (Reference 6.3) was followed.

The evaluation of non-seismic failures and human actions was considered in the IPEEE evaluation of seismic risk. Additional information on these topics was provided in PLA-4490 (Reference 6.5) in response to a NRC Request for Additional Information. The systems and components in the success path with the highest non-seismic unreliability were identified and the impact on risk was evaluated and documented in the IPEEE.

The identification of success paths and components was based on minimal credit for operator actions. The operator actions required to support the primary and alternate success path were identified and evaluated in the IPEEE.

Compliance with NUREG-1407:

NUREG-1407, Section 3.2.5.1 states that for IPEEE purposes, it is desirable that to the maximum extent possible, the alternate path involve operational sequences, systems, piping runs and components different from those used in the preferred path. As indicated above and documented in the IPEEE, this requirement was met based on the design of SSES.

The treatment of non-seismic failures and human actions in the SSES IPEEE meets the requirements of Section 3.2.5.8 of NUREG-1407.

Adequate for Screening:

The methodology used is in compliance with NUREG-1407 and the IPEEE system modeling results are adequate for screening purposes.

4.8 Containment Performance

Methodology used:

The Seismic IPEEE evaluations determined that the effects of the Review Level Earthquake are not considered to be adverse to the integrity of the SSES Containments.

The Containment performance evaluation included an assessment of the concrete Containment structure, Containment internal structures (diaphragm slab, reactor pedestal, reactor shield wall, suppression chamber columns, drywall platforms, and seismic truss) and Containment penetrations. Sections 3.10.1 through 3.10.7 of the seismic IPEEE report provide additional information on these Containment items. The Containment performance evaluation was based on the methodology and guidance found in EPRI NP-6041-SL.

Since the LOCA-related design loads considered in the design, which are not required to be considered coincident with the RLE, provided an inherent increased seismic resistance capability and all SSES Category I structures are designed for an SSE level of 0.1g horizontal ground acceleration, the SSES containment and containment internal structures are considered to be seismically rugged and were screened out from further review.

No containment vulnerabilities were found during the seismic IPEEE.

Compliance with NUREG-1407:

The review of containment meets the requirements of Section 3.2.6 of NUREG-1407 to evaluate the containment integrity, isolation, and suppression functions to identify vulnerabilities that involve early failure of the containment functions.

Adequate for Screening:

The methodology used is in compliance with NUREG-1407 and the IPEEE containment performance results are adequate for screening purposes.

4.9 Peer Review

Methodology used:

An in-house independent review team was established outside the IPEEE team. As part of the peer review the following was performed:

- An independent equipment walkdown on a representative sample of SSEL equipment.
- An independent review of a representative sample of SRT calculations.
- An independent review of the seismic portion of the IPEEE report.

The independent review team consisted of a cross disciplinary review by various in-house engineering groups. All reviewer comments were discussed and resolved by the SRT members.

The composition of the review team, a description of the review performed, the results of the review teams's findings (major comments and resolutions) are documented in Section 6 of the IPEEE report (Reference 6.4).

Compliance with NUREG-1407:

The above review process, using an Independent In-house Review Team, meets the requirements of Section 7 of NUREG-1407 for peer review.

Adequate for Screening:

The methodology used is in compliance with NUREG-1407 and the IPEEE peer review results are adequate for screening purposes.

5.0 Conclusion

The SSES IPEEE was a focused scope margin submittal that meets the requirements of a full-scope assessment. A soil failure analysis, which included a liquefaction analysis, was completed as part of the seismic IPEEE with satisfactory results. A relay evaluation consistent with a full scope IPEEE, as described in NUREG-1407, was performed as part of the seismic IPEEE using shaker table test reports found in the SSES SQRT binders. Based on the IPEEE adequacy review performed consistent with the guidance contained in EPRI 1025287 [SPID] and documented herein, the SSES IPEEE results are considered adequate for screening and the risk insights gained from the IPEEE remain valid under the current plant configuration.

6.0 References

6.1 Nuclear Regulatory Commission (NRC) Generic Letter (GL) 88-20, Supplement 4 on June 28, 1991.

6.2 NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities" June 1991.

6.3 EPRI NP-6041-SL, "A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1)" August 1991.

6.4 PPL Letter (PLA-4162) "Submittal of the IPEEE Report" June 27, 1994.

6.5 PPL Letter (PLA-4490) "Response to Request for Additional Information (RAI) Regarding IPEEE, SSES Units 1 and 2" August 9, 1996.

6.6 PPL Letter (PLA-4983) "Response to Audit Issues on IPEEE Submittal" October 15, 1998.

6.7 NRC Letter "Request for Additional Information on IPEEE Submittal, SSES, Units 1 and 2" June 10, 1996.

6.8 NRC Letter "Request for Additional Information (RAI) Regarding IPEEE, SSES Units 1 and 2" March 26, 1998.

6.9 NRC SER Letter "SSES, Units 1 and 2 – IPEEE Submittal" April 27,1999.

6.10 NUREG/CR-0098 "Development of Criteria for Seismic Review of Selected Nuclear Power Plants," May 1978.

6.11 NRC Information Notice 2010-18 Generic Issue 199, "Implications of Updated Probabilistic Seismic Hazard Estimates In Central and Eastern United States on Existing Plants" September 2010.

6.12 NRC Generic Issue 199 in "Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants."

6.13 PPL ACT 1321984 "Nuclear Design - Civil to determine the feasibility of increasing the Seismic IPEEE plant-level fragility from 0.21g to 0.25g or 0.30g." November 2010.

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

6.15 PPL Letter (PLA-6941) "SSES Response to Request for Information Pursuant to 10 CFR 50.54(f) Regarding Results of Seismic Walkdown" November 26, 2012.

6.16 EPRI 1025287 "Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1" November 2012.

6.17 IPEEE 344-75 "Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations" January 1975.

6.18 PPL Technical Report NPE-91-001 "Susquehanna Steam Electric Station Individual Plant Evaluation" December 1991.