I

APPENDIX I QUALITY ASSURANCE

I.1 Background

Embedded in the SSHAC PSHA process described in NUREG/CR-6372 (*Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts*; Budnitz et al., 1997) and ANSI/ANS-2.29-2008 (*Probabilistic Seismic Hazard Analysis*; American Nuclear Society, 2008b) is "participatory peer review," defined as both process and technical review of the PSHA starting at an early stage and continuing through the life of a project. Participatory peer review is a fundamental element of ensuring the quality of the resulting PSHA product. Both ANSI/ANS-2.29-2008 and ANSI/ANS-2.27-2008 (*Criteria for Investigation of Nuclear Facility Sites for Seismic Hazard Assessments*; American Nuclear Society, 2008a) were developed to be consistent with ANSI/ASME NQA-1-2008 (*Quality Assurance Requirements for Nuclear Facility Applications*; ASME, 2008). Hence, for a regional study such as the EPRI (2004, 2006) GMM Review Project, following the guidance contained in NUREG/CR-6372, NUREG-2117 (NRC, 2012b), ANSI/ANS-2.29-2008, and ANSI/ANS-2.27-2008 will result in adequate products and output.

Within the SSHAC hazard assessment framework, a traditional verification and validation (V&V) program is limited to specific numerical tools, such as the software used to perform the PSHA calculations. A quality or "cross-check" protocol may also be used to ensure the accuracy of compiled tables, data sets, and other project products. However, it is not possible to apply a V&V program to the SSHAC process itself. Similarly, it does not make sense to impose a restriction on the use of data for cases where a formal quality assurance program for the collection of field data outside of the project cannot be verified (e.g., if a quality control program cannot be verified for a USGS or university data set such as the USGS shear-wave-velocity measurements provided to the project). The rejection of data sets in these cases could seriously diminish, instead of enhance, the process. This is because a key part of the SSHAC assessment process is the evaluation of data by the evaluator experts. Therefore, the evaluator experts are able to make an informed assessment of the quality of various data sets, regardless of whether those data were gathered within a formal quality program. This does not mean, however, that nonqualified data used in a SSHAC assessment process can be considered qualified after their use in the process.

Within the SSHAC hazard assessment framework, existing scientific information is collected and evaluated in order to ascertain the current state of knowledge regarding a specific issue. The majority of existing information that may be used in a SSHAC assessment process will have been published in some fashion previously. Moreover, the data, methods, and models considered and used will also undergo what effectively constitutes peer review by the TI Team, which is likely to be at least as rigorous as a peer review conducted for journal publication. Thus, that information has been reviewed and "vetted" by the broad technical community. The systematic compilation of all pertinent information from the scientific literature (e.g., specialized journals, technical reports, conference proceedings) or other relevant sources of information (e.g., databases of scientific data, historical or archival documents) is a vital element in a SSHAC PSHA study. In addition, nontraditional types of data that may be beneficial to the project may be available. It is important that data not be dismissed without appropriate consideration.

Beyond the assurance of quality arising from the external scientific review process, a fundamental component of the SSHAC assessment process is the *evaluation* of the data, models, and methods by the evaluator experts as a means of establishing the quality, relevance, technical basis, and uncertainties. Further, in the *integration* stage of the SSHAC assessment process, the TI Team or evaluator experts build models and apply weights to elements of the model based on due consideration of the technical support for various models and methods proposed by the technical community. Therefore, it is the collective, informed judgment of the TI Team (via the process of data evaluation and model integration) and the concurrence of the PPRP (via the process of participatory peer review), as well as adherence to the national standards described above, that ultimately lead to the assurance of quality in the process followed and in the products resulting from the SSHAC hazard assessment framework.

I.2 EPRI (2004, 2006) GMM Review Project

The TI Team, Project Manager, and Sponsor determined the approach for quality control for the EPRI (2004, 2006) Ground Motion Model (GMM) Review Project in 2012, taking into account the SSHAC assessment process and national standards described above. The approach was documented in the EPRI (2004, 2006) GMM Review Project Plan, dated June 2012. The technical assessments made as part of this project entailed the use of a new ground-motion database from a SSHAC Level 3 assessment process, shear-wave-velocity data from a USGS field program and a GEOVision field program funded from this project, and ground-motion models developed from scholarly research. In reviewing the EPRI (2004, 2006) GMM and developing the Updated EPRI (2004, 2006) GMM, the TI Team and Project Manager had extensive interactions with the technical community regarding new data, models, and methods. These interactions helped ensure a high level of review for the TI Team's technical assessments.

A participatory peer review process was used for both the technical and process elements of the project. The PPRP affirmed the following:

- The exemplary implementation of a SSHAC Level 2 assessment process in this project allows us to confidently endorse its procedural aspects.
- We concur that the full ranges of relevant data, models, and methods have been duly considered in the TI Team's assessment in the context of updating the EPRI (2004, 2006) GMM.
- We concur that all technical assessments have been adequately defended and documented by the TI Team.
- Based on our observation of the implementation of the SSHAC Level 2 assessment process and our review of the technical bases and justifications provided by the TI Team , we concur that the March 28, 2013, version of the Updated GMM appropriately captures the center, body, and range of the technically defensible interpretations.

This process provides high confidence that the project assessments and results will be accepted by the technical community. The level of assurance exceeds that associated with publication in a peer-reviewed technical journal. In addition to the participatory peer review process that is afforded by the enhanced SSHAC Level 2 assessment process used for the EPRI (2004, 2006) GMM Review Project, certain other activities were conducted as business best practices. These activities are described below.

I.3 Business Best Practices

A hazard input document (HID), which is provided in Appendix G, was developed that documents and summarizes the key elements of the Updated GMM. The HID specifies the exact inputs provided by the Updated GMM to the hazard calculations and thus provides a clear record of how the Updated GMM is translated into hazard calculations. As discussed in Task 2 of the EPRI (2004, 2006) GMM Review Project Plan, "Obtain Ground-Motion Database and Identify New CEUS GMPEs," and Task 3, "Obtain Shear Wave Velocity Measurements at Recording Stations," the management and documentation of the data were done in accordance with a data management procedure developed specifically for this project. Additional information on the management and documentation of the new ground-motion database provided by the PEER NGA-East Project is discussed in Chapter 7.

The EPRI (2004, 2006) GMM Review Project was tasked with updating, not replacing, the EPRI (2004, 2006) GMM using the conceptual framework of the EPRI (2004) GMM. The TI Team performed sensitivity analyses to examine and provide justification for within-cluster weights, cluster weights, and the confidence weights underpinning the Updated GMM. The following sensitivity analyses were performed:

- Effect of giving zero weight to data with $\mathbf{M} < 4.75$.
- Effect of not incorporating potential regional dependencies (besides the Midcontinent vs. Gulf regionalization).
- Effect of developing within-cluster weights based on comparisons to data only at frequencies of 10 Hz and 1 Hz.
- Effect of using a maximum value of 2/3 weight on any model within a cluster.
- Effect of increasing the relative importance of the confidence weights to 75%.

Recalculating weights after performing the last two sensitivity analyses above resulted in a more even distribution in weights, recognizing the limitations of the data. The TI Team also assessed whether there was adequate epistemic uncertainty in the Updated GMM. The TI Team incorporated uncertainty in magnitude scaling into the Updated GMM. More details regarding the development of the Updated GMM can be found in Chapter 7.

I.4 Approach for Adjusting Ground Motions to Reference Rock Conditions

The TI Team developed procedures to adjust the recorded ground motions to the reference rock conditions for which the hard-rock GMPEs have been defined. Adjusting recorded ground motions in the PEER NGA-East ground-motion database to the reference rock conditions reduced uncertainty in the Updated GMM. The reference profile adopted for this project is the same one used in the EPRI (1993) and EPRI (2004) projects, namely, a profile with shear-wave velocity of 2,800 m/s over the top 1.3 km and with kappa equal to 0.006 sec. Further details on this reference profile are provided in Chapter 7. Adjustments to the reference rock conditions were performed using two approaches: an analytical approach and an empirical approach. The two approaches were compared as a means of evaluating consistency in the results. See Chapter 7 for this discussion.

Both sets of adjustments were calculated twice. In the first round of calculations, a preliminary version of the database was used. In the second round, the final version of the database was used. With the analytical approach, refinements were introduced during the second round to make the approach more robust and consistent with the recommendations in Appendix B of EPRI (2013b). With the empirical approach, statistical tests were performed. With both approaches, a large number of graphical results were generated for diagnostic purposes.

I.5 Update of EPRI (2006) Aleatory Variability Model

The TI Team updated the EPRI (2006) Aleatory Variability Model using the published 2008 PEER NGA results and preliminary results from the PEER NGA-West 2 project. The use of the preliminary results from the PEER NGA-West 2 project is consistent with the approaches used in EPRI (2006), in which preliminary results from the original PEER NGA Project were used to develop the aleatory variability model.

I.6 Hazard Calculation Software

The hazard calculation software used for the EPRI (2004, 2006) GMM Review Project is qualified in accordance with Appendix B of 10 CFR 50. Hazard results using this hazard calculation software were compared with hazard results published in the CEUS SSC Report (EPRI/DOE/NRC, 2012) at seven test sites. The hazard calculation software used for the CEUS SSC Report was also qualified in accordance with Appendix B of 10 CFR 50.

Differences were resolved by going back to the original assumptions that were made in calculating hazard results at the seven test sites. Thus, the hazard software used for the current project has been verified to the same standard as the hazard software used in the CEUS SSC Project, and both software programs give the same hazard for the seven test sites. The use of the independent software provided a check that the results at the seven test sites are valid.