ELECTRIC POWER RESEARCH INSTITUTE

Project Plan: Central and Eastern United States Seismic Source Characterization for Nuclear Facilities

1016756

Effective June 25, 2008, this report has been made publicly available in accordance with Section 734.3(b)(3) and published in accordance with Section 734.7 of the U.S. Export Administration Regulations. As a result of this publication, this report is subject to only copyright protection and does not require any license agreement from EPRI. This notice supersedes the export control restrictions and any proprietary licensed material notices embedded in the document prior to publication.

Project Plan: Central and Eastern United States Seismic Source Characterization for Nuclear Facilities

1016756

Technical Update, June 2008

EPRI Project Managers

R.P. Kassawara
J.F. Hamel

Cosponsor

U.S. Department of Energy

Project Manager
M. Shields

ELECTRIC POWER RESEARCH INSTITUTE
3420 Hillview Avenue, Palo Alto, California 94304-1338 ▪ PO Box 10412, Palo Alto, California 94303-0813 ▪ USA
800.313.3774 ▪ 650.855.2121 ▪ askepri@epri.com ▪ www.epri.com

DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITIES

THIS DOCUMENT WAS PREPARED BY THE ORGANIZATION(S) NAMED BELOW AS AN ACCOUNT OF WORK SPONSORED OR COSPONSORED BY THE ELECTRIC POWER RESEARCH INSTITUTE, INC. (EPRI). NEITHER EPRI, ANY MEMBER OF EPRI, ANY COSPONSOR, THE ORGANIZATION(S) BELOW, NOR ANY PERSON ACTING ON BEHALF OF ANY OF THEM:

(A) MAKES ANY WARRANTY OR REPRESENTATION WHATSOEVER, EXPRESS OR IMPLIED, (I) WITH RESPECT TO THE USE OF ANY INFORMATION, APPARATUS, METHOD, PROCESS, OR SIMILAR ITEM DISCLOSED IN THIS DOCUMENT, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, OR (II) THAT SUCH USE DOES NOT INFRINGE ON OR INTERFERE WITH PRIVATELY OWNED RIGHTS, INCLUDING ANY PARTY'S INTELLECTUAL PROPERTY, OR (III) THAT THIS DOCUMENT IS SUITABLE TO ANY PARTICULAR USER'S CIRCUMSTANCE; OR

(B) ASSUMES RESPONSIBILITY FOR ANY DAMAGES OR OTHER LIABILITY WHATSOEVER (INCLUDING ANY CONSEQUENTIAL DAMAGES, EVEN IF EPRI OR ANY EPRI REPRESENTATIVE HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES) RESULTING FROM YOUR SELECTION OR USE OF THIS DOCUMENT OR ANY INFORMATION, APPARATUS, METHOD, PROCESS, OR SIMILAR ITEM DISCLOSED IN THIS DOCUMENT.

ORGANIZATION(S) THAT PREPARED THIS DOCUMENT

Coppersmith Consulting, Inc.

Washington Savannah River Company

This is an EPRI Technical Update report. A Technical Update report is intended as an informal report of continuing research, a meeting, or a topical study. It is not a final EPRI technical report.

NOTE

For further information about EPRI, call the EPRI Customer Assistance Center at 800.313.3774 or e-mail askepri@epri.com.

Electric Power Research Institute, EPRI, and TOGETHER…SHAPING THE FUTURE OF ELECTRICITY are registered service marks of the Electric Power Research Institute, Inc.

Copyright © 2008 Electric Power Research Institute, Inc. All rights reserved.

CITATIONS

This document was prepared by

Coppersmith Consulting, Inc.
2121 North California Blvd., Suite 290
Walnut Creek, CA 94596

Principal Investigator
K. Coppersmith

Washington Savannah River Company
Savannah River Site
Building 730-4B, Room 3125
Aiken, SC 29808

Principal Investigator
L. Salomone

This document describes research sponsored by the Electric Power Research Institute (EPRI) and the U.S. Department of Energy (U.S. DOE).

This publication is a corporate document that should be cited in the literature in the following manner:

Project Plan: Central and Eastern United States Seismic Source Characterization for Nuclear Facilities. EPRI, Palo Alto, CA and U.S. DOE: 2008. 1016756.

PRODUCT DESCRIPTION

This project plan outlines the Central and Eastern United States Seismic Source Characterization for Nuclear Facilities (CEUS SSC) Project, which will replace the *Seismic Hazard Methodology for the Central and Eastern United States*, EPRI report NP-4726, July 1986. The objective of the CEUS SSC project is to develop an up-to-date assessment of probabilistic seismic hazard analysis (PSHA) SSC for CEUS. Input to a PSHA consists of both seismic source and ground motion characterization. These two components are used to calculate probabilistic hazard results (or seismic hazard curves) at a particular site.

Results & Findings

The product of this report is a vetted plan to develop a generic CEUS SSC model. This model includes consideration of an updated database, full assessment and incorporation of uncertainties, and the range of diverse technical interpretations from the informed scientific community. The SSC model will be widely applicable to the entire CEUS, so this project will use a ground motion model that includes generic variations to allow for a range of representative site conditions (deep soil, shallow soil, hard rock). Hazard and sensitivity calculations will be conducted at six demonstration sites representative of different CEUS hazard environments.

Challenges & Objective(s)

The generic CEUS SSC model will be of value to readers who are involved in PSHA work, and who wish to use an updated SSC model. This model will be based on a comprehensive and traceable process, in accordance with Senior Seismic Hazard Assessment Committee (SSHAC) guidelines in NUREG/CR-6372, *Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts*. The model will be used to assess the present-day composite distribution for seismic sources along with their characterization in the CEUS and uncertainty. In addition, this model will be in a form suitable for use in PSHA evaluations for regulatory activities, such as Early Site Permit (ESP) and Combined Operating License Applications (COLA).

Applications, Values & Use

Development of a generic CEUS seismic hazard model will provide value to members who 1) have submitted an ESP or COLA for Nuclear Regulatory Commission (NRC) review before 2010, 2) will submit an ESP or COLA for NRC review after 2010 and 3) must respond to safety issues resulting from NRC Generic Issue 199 (GI-199) for existing plants. This work replaces a previous study performed approximately 20 years ago. Since that study was completed, substantial work has been done to improve the understanding of seismic sources and their characterization in the CEUS. Thus, a new generic SSC model will provide a consistent, stable basis for computing PSHA for a future time span. Use of a new SSC model will reduce the risk of delays in new plant licensing due to more conservative interpretations in the existing and future literature.

EPRI Perspective

The purpose of this study, jointly sponsored by EPRI and the U.S. Department of Energy (DOE), is to develop a new CEUS SSC model. The team assembled to accomplish this purpose is comprised of distinguished subject matter experts from industry, government, and academia. The resulting model will be unique, and because this project will solicit input from the present-day informed scientific community, it is not likely to be repeated for a number of years.

Approach

The goal of this report was to present the work plan for developing a generic CEUS SSC model. The work plan, formulated by a technical integration team, consists of a series of tasks designed to meet the project objectives. This report was reviewed by a participatory peer review panel (PPRP) and sponsor reviewers. Comments from the PPRP are reflected in the report. EPRI held a meeting on May 8, 2008, to facilitate resolution of comments received regarding the project plan. The SSC model is slated for completion in mid-2010.

Keywords

Seismic Sources
Probabilistic Seismic Hazard Assessment (PSHA)
Seismic Source Characterization (SSC)
Seismic Source Characterization Model
Central and Eastern United States (CEUS)

ABSTRACT

The Central and Eastern United States Seismic Source Characterization for Nuclear Facilities (CEUS SSC) Project—jointly sponsored by EPRI and the U.S. Department of Energy (DOE)—is aimed at developing a comprehensive seismic source model for any site in the CEUS. Thus, it will be important to evaluate the sensitivity of specific source parameters at sites in different geographic regions and under different conditions.

The objective of the CEUS SSC Project is to develop an up-to-date assessment of probabilistic seismic hazard analysis (PSHA) seismic source characterization (SSC) for the CEUS that includes 1) full assessment and incorporation of uncertainties, 2) the range of diverse technical interpretations from the informed scientific community, 3) consideration of an up-to-date database, 4) proper and appropriate documentation, and 5) peer review. The success of the CEUS SSC project will lead to stability and longevity. Stability means that the study enjoys public and regulatory confidence, that it receives general acceptance from the technical community. Longevity means that the technical underpinnings will remain valid in the future, despite the development of new scientific findings. Experience has shown that stability and longevity are best achieved through proper characterization of current knowledge and uncertainties, coupled with the involvement of the technical community, regulators, and oversight groups. Accordingly, the project will be conducted using Senior Seismic Hazard Analysis Committee (SSHAC) processes, as described in *Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts*, U.S. Nuclear Regulatory Commission report, NUREG/CR-6372, Washington, D.C.

The CEUS SSC project team is comprised of program and project management, a technical integration (TI) team, TI Staff, a participatory peer review panel (PPRP), specialty contractors, sponsors, and agency experts.

The work consists of several tasks and three workshops over a three-year period. The major tasks and workshops consist of the following:

- Develop a project plan defining an SSHAC study level 3 approach, team personnel and functions, work plan, and schedule.
- Develop a CEUS geological, geophysical, and seismological database in geographic information system (GIS) format, with emphasis on data important for the source characterization efforts.
- Update the CEUS earthquake catalog that merges and reconciles several regional catalogs and develops uniform moment magnitudes.
- **Workshop 1:** Identify hazard-significant SSC issues and identify and discuss important databases with resource experts (to be scheduled in July 2008).
- **Workshop 2:** Present, discuss, and debate alternative interpretations of significant seismic source issues with proponents of alternative models (to be scheduled in February 2009).
- Construct a preliminary SSC model and perform hazard calculations and sensitivity analyses.
- **Workshop 3:** Present the preliminary SSC model and discuss hazard feedback and sensitivity analyses. Discuss uncertainties and obtain feedback from resource experts (to be scheduled in August 2009).

- Finalize the SSC model, including quantifying all uncertainties.
- Develop the draft CEUS SSC project report for review.
- Support reviews by PPRP, sponsors, and oversight groups.
- Finalize the report, incorporating review comments.

ACKNOWLEDGEMENTS

The authors of the report wish to acknowledge the contributions from the Technical Integration (TI) Team, the Participatory Peer Review Panel (PPRP) and Sponsor Reviewers. Their knowledge of the current state of practice provided important insights and support during the preparation of this report. The agreement from this distinguished group of subject matter experts from industry, government and academia to participate in this "landmark" study is greatly appreciated.

CONTENTS

LIST OF FIGURES

1 INTRODUCTION AND CONTEXT OF THE STUDY

This Project Plan outlines the Central and Eastern United States Seismic Source Characterization for Nuclear Facilities (CEUS SSC) project, which will replace the seismic source characterization that is part of the EPRI-SOG seismic hazard analysis. The CEUS SSC project will take full advantage of the data used to develop the EPRI-SOG, the United States Geological Survey (USGS) seismic hazard model and other hazard analyses, the data and information developed over the past 20 years, and the information developed as part of ongoing COLA and ESP submittals.

Input to a probabilistic seismic hazard analysis (PSHA) consists of two elements: seismic source characterization (SSC) and ground motion characterization (GMC). These two components are used to calculate probabilistic hazard results (or seismic hazard curves) at a particular site. The 1986 EPRI-SOG study included both an SSC and GMC component. The SSC component was developed through an expert elicitation process. The SSC model was developed so that it would be appropriate for any site within the CEUS and calculations were made for 59 sites in the central and eastern US. The ground motion component was not developed using an elicitation process. Three GMC models were used to represent epistemic uncertainty in median motions and a single value of aleatory variability was used.

Following completion of EPRI SOG, EPRI performed a major CEUS ground motion study targeted on developing an understanding of aleatory variability. The study resulted in the EPRI (1993) Ground Motion Model, which included an assessment of epistemic uncertainty in the median motions and an assessment of aleatory variability. The study involved nearly all of the then active ground motion modeling experts and stimulated follow-on research by a number of the participants that produced an equal number of ground motion models. The EPRI (1993) model together with models developed by individual researchers formed the body of information for development of the EPRI (2004) GMC model, which provided an assessment of epistemic uncertainty in the median models and aleatory variability. This model, together with an updated assessment of aleatory variability (EPRI, 2006) are the most current and applicable ground motion studies for the CEUS and are currently being used in ground motion analyses for COLAs.

The SSC component of the 1986 EPRI-SOG has not been replaced. Current licensing applications have followed regulatory guidance by using the EPRI-SOG study as a starting point, with updates as appropriate on a site-specific basis. The CEUS SSC project is aimed at replacing the SSC component of the EPRI-SOG study. As was the case for EPRI-SOG, the CEUS SSC seismic source model will be applicable to any site within the CEUS and can be used with the EPRI (2004, 2006) GMC model to calculate seismic hazard at any site of interest. Long-term efforts to replace the EPRI (2004, 2006) GMC are just beginning (the NGA East project) and results are not expected for at least five years.

Because the EPRI CEUS SSC Project is aimed at developing a comprehensive seismic source model for any site in the CEUS, it will be important to evaluate the sensitivity of specific source parameters on the hazard at sites in different geographic regions and under different site conditions. Thus, seismic hazard calculations will be conducted solely for the purpose of assisting in the development of the SSC model. A diverse range of site locations (six sites) will be identified and a representative range of site conditions will be assumed for purposes of evaluating the important components of the seismic source characterization. For example, sites will be selected that are near and at a distance from the Charleston source in order to examine the relative importance of seismic source characteristics such as source geometry, Mmax, and recurrence. This Project Plan anticipates that sensitivity analyses will be conducted at two levels: 1) the relative importance to seismic source parameters (e.g., the impact of alternative approaches to assessing Mmax on the Mmax distribution for a seismic source, or the impact of different smoothing parameters on the spatial distribution of a-values within a region or source); and 2) the importance of source characteristics to mean hazard.

The EPRI CEUS SSC Project will allow for a replacement of the 1986 EPRI-SOG seismic source model. Following the completion of the EPRI CEUS SSC Project, seismic hazard results can be calculated using the EPRI (2004, 2006) GMC models at any site of interest. To so implement a site-specific analysis, assessment must be made of the effect of local site conditions (site amplification). In order to use the results for site licensing, applicable regulatory guidance must be followed (e.g., RG 1.208) that calls for evaluating the site region (200 mile radius) and site vicinity (25 mile radius or 40 kilometers) for any detailed seismic sources that would not be identified from the new EPRI CEUS SSC Project. By incorporating site-specific conditions, defendable ground motion response spectra (GMRS) can be developed.

2
OBJECTIVES

The objective of the CEUS SSC Project is to develop an up-to-date assessment of PSHA seismic source characterization for the CEUS that includes(1) full assessment and incorporation of uncertainties, (2) the range of diverse technical interpretations from the informed scientific community, (3) consideration of an up-to-date database, (4) proper documentation, and (5) peer review. If this objective is achieved, the CEUS SSC project will lead to stability and longevity. Experience has shown that stability and longevity are best achieved through proper characterization of our knowledge and uncertainties, coupled with the involvement of the technical community, regulators, and oversight groups. SSHAC (1997) specifically addresses this issue and concludes that the goal of <u>all</u> probabilistic hazard analyses should be the same:

> "To represent the center, the body, and the range of the technical interpretations that the larger informed technical community would have if they were to conduct the study."

In this context, the "informed" community is one that is familiar with all relevant data.

The focus of the CEUS SSC Project is the seismic source characterization model and not the ground motion attenuation or site-response models. However, there is a need in this project to establish the hazard-significance of various SSC issues in order to properly prioritize the work activities and the uncertainty characterization efforts. Therefore, the use of an appropriate ground motion model, which will be "held constant" to isolate the relative importance of SSC issues will be required. The SSC model will be widely applicable to the entire CEUS, so this project will use a ground motion model that includes generic variations to allow for a range of representative site conditions (deep soil, shallow soil, hard rock). Hazard and sensitivity calculations will be conducted at six representative demonstration sites representative of different hazard environments.

3
SELECTION OF SSHAC STUDY LEVEL

SSHAC defines four Study Levels, with Level 4 being the most elaborate, that can be used to capture the knowledge and uncertainties of the larger technical community. The higher the Study Level, the higher the assurance that the views of the community have been captured and represented. The SSHAC guidance allows for specific technical issues to be addressed using a particular Study Level, although, in practice, the entire project often employs a particular Study Level for all issues. Balancing the need for stability and longevity with the need to expedite the study, the CEUS SSC project will be conducted using a Study Level 3 process for the key SSC issues. Lesser emphasis and Level 2 processes will be given to those issues having lesser hazard significance or are not subject to large uncertainty. The identification of key issues will be based on experience and sensitivity analyses conducted for this study and for recent Probabilistic Seismic Hazard Analysis (PSHAs) at a number of sites in the CEUS.

As discussed above, all SSHAC Study Levels have the same goal of capturing the knowledge and uncertainties of the larger technical community. Higher Study Levels increase the likelihood that the community views are represented, particularly because these levels call for the direct participation of the community. Study Level 4 structures and formalizes the processes in which judgments of members of the expert community are elicited. The experts are charged with representing not only their personal views, but to also act as “evaluators” of the views of the larger community. Experience has shown that Level 4 processes can be resource intensive relative to both time and budget. It is viewed by project management and the sponsors that the potential benefits of higher levels of assurance that the larger community views have been represented are outweighed by the cost in time and money to implement a Level 4 analysis for the CEUS SSC Project. A Level 4 Study would likely cost $8 -10 million and require 4-5 years to implement.

For Study Levels 1 to 3 the assessments are made by the Technical Integrator (TI) team, who intellectually “owns” the assessments and the results. Process and technical peer review (defined in SSHAC 1997, p. 49), using a participatory peer review process, are key to ensuring the success of these Study Levels. The peer reviewers, for example, can assist in helping the TI team to identify the range of community viewpoints. Study Level 3 formalizes the process of interaction with the community through a series of workshops, which can also be attended by the peer reviewers and other oversight groups. These public interactions lead to higher levels of acceptance and assurance that the community views have been considered.

4

WORK PLAN

The Work Plan consists of a series of tasks designed to meet the project objectives. The Plan is based on the assumption that a Level 3 process will be used for most SSC issues (the actual identification of key SSC issues will occur as part of Task 4). The tasks are described below.

Task 1: Development of Project Plan and Approval by Participatory Peer Review Panel (PPRP)

Principally, this task entails the development of this Project Plan. It also includes a decision by the TI team regarding the region of interest that will be used for: 1) data compilation, and 2) defining seismic sources. The TI team will also identify six representative sites that will be used for hazard calculations and sensitivity analyses at the appropriate time in the project schedule (Task 4). The Project Plan will be reviewed by the PPRP and comments will be addressed in the finalization of the Plan. A Task 1 meeting will be held to facilitate resolution of comments received regarding the Project Plan.

Task 2: Database Development

The goal of this task is to develop a comprehensive, uniform regional database for use in seismic source characterization. The task will be conducted by a database contractor with knowledge of seismic source characterization issues. Where appropriate, data will be placed in a common GIS format that is readily usable for SSC model development. Task 2 Data Compilation will begin at the time of project authorization. The Database Contractor will take an active role in identifying data and data sources, including the information made available at the first workshop (Task 5) and interactions with members of the PPRP and the technical community. Data sources will include, as appropriate, readily available information from the following:

- professional literature,
- data held in the public domain by groups such as the USGS and state geological surveys,
- private domain data developed as part of recent licensing activities for nuclear power plants and other critical facilities,
- available data in the academic sector,
- data from the original EPRI study, and
- Selected data sets developed for federal facilities such as DOE sites.

The database will be designed to include the following regional data layers to provide coverage of the entire CEUS and extend a minimum of 200 miles beyond the coastline (or the edge of the continental slope if it is less) and 200 miles from the US borders with Canada and Mexico. The western boundary of the study region will be the foothills of the Rocky Mountains (about longitude 105° W), except that it will include the Rio Grande Rift system:

- Aeromagnetic (USGS and DNAG)
- Bouguer gravity (USGS and DNAG)
- Free air gravity (USGS and DNAG)

- Crystalline basement geology
- Tectonic features and tectonic/crustal domains
- Tectonic stress field
- Thickness of sediments
- Crustal thickness
- Vp and Vs at top of crystalline basement
- Seismic reflection data at Charleston
- Earthquake Catalog (developed in Task 3)
- Quaternary faulting and potential Quaternary features
- Mesozoic rift basins
- Paleoliquefaction sites
- Topography and bathymetry
- Liquefaction dates from published literature for the Wabash zone, New Madrid zone, and Charleston zones
- Index map showing locations of published crustal scale seismic profiles and geologic cross sections

It is anticipated that study participants (TIs, PPRP, and resource experts) will request additional data sets (regional and local) be incorporated into the GIS database. The current budget for this task reflects the incorporation of the above listed regional data sets as well as a few local data sets for specific seismic sources. However, given that the database development is designed to support the needs of the TIs, future decisions by the TIs and others developing the SSC will dictate the amount, type, extent, and scale of data required to develop the SSC. We recognize that some data requests made during the course of the project may be outside the scope estimated for this task. The TIs and Project Manager may need to assess the need for additional data and prioritize what data should be incorporated into the database based on the particular dataset's usefulness in defining seismic sources and the available budget provided to the database contractor. Costs for the database development will likely be reevaluated after reviews by the PPRP and completion of Workshop #1 (Task 5), which is designed to identify any additional data required to address significant issues.

In addition to the GIS database, a comprehensive bibliography of literature will be compiled for use by the TIs. Copies of key papers will be provided to the TIs for their review as required.

In addition to the compilation of data, this task will also include (1) the management and documentation of data and (2) the presentation of data for the TIs and TI staff to use in development of the seismic source model. The management and documentation of the data will be done in accordance with data management procedure developed specifically for this project. Although the fundamental user of the database is the TI Team, the database will also be made available to the PPRP and Project Sponsors in a manner that allows for distribution based on user requests. Data will be assessed by project geologists and GIS analysts to ensure completeness and appropriateness of the data for use in the SSC model development. The GIS database will be stored on a server in the WLA Walnut Creek office and updated by the project GIS Manager. For completeness and transparency, each GIS data layer developed for this project will include thorough metadata information. The data will be presented for the TIs, TI staff, and workshop participants as directed by the TI's. This may involve both map sheets of data compilations as well as real-time plotting of data on screen or projector. A GIS analyst will be present at each of the workshops to facilitate the display of GIS data.

All data in the CEUS SSC database will be made publicly available at the conclusion of the study.

Task 3: Seismicity Catalog Development
The goal of this task is to develop a uniform and up-to-date catalog of historical and instrumental events in the CEUS that can be used for seismic source characterization. Consistent with modern ground motion models, the catalog will provide moment magnitudes (**M**) for all events.

The 1986 EPRI-SOG study developed a comprehensive earthquake catalog for the CEUS. The EPRI-SOG catalog was extensively reviewed by Seeber and Armbruster (1991), leading to the NCEER-91 catalog. The NCEER-91 catalog was ultimately incorporated into the catalog used by the USGS in the National Seismic Hazard Mapping project (Mueller et al., 1997). The subtasks needed to update this catalog for use in the CEUS SSC project consist of following:

- Earthquakes that have occurred post March 1984 will be added to the catalog. These will be obtained from the ANSS catalog and from regional catalogs (e.g. SECSSN, CERI, New England, USGS PDE, and Canadian Seismic Network). Use will be made of the catalogs developed for recent COLAs.
- Review modifications to the EPRI-SOG catalog made by subsequent researchers (e.g. Seeber and Armbruster, 1991; Mueller et al., 1997; COLA applications). These modifications include additional data on size and location, and reclassifying some events as non-tectonic. Quantitative assessments of location uncertainty will be included for older events.
- Examine the results of studies that have identified additional historical events (e.g. Metzger, 2000; Metzger et al., 2000; Munsey, 2006). Assess the adequacy of the size and location estimates provided by authors and add uncertainty estimates.
- Review archives for additional earthquakes in areas not previously studied. (Optional Task dependent on budget and schedule constraints)
- If practical, consider the development of a catalog of prehistoric events based on existing studies of paleoseismic events.
- Review and develop as necessary, relationships to provide estimates of moment magnitude, **M**, for earthquakes as a function of the available size estimates (e.g. m_{bLg}, other magnitude scales, maximum intensity, felt area, extent of liquefaction effects). This will include Hermann's catalog of regional earthquakes and the CMT catalogs that include moment calculations (to make the conversion between mblg and Mw). The EPRI-SOG project provided a mathematical framework and software for developing a catalog of uniform magnitudes with uncertainty estimates. This framework will be adapted to using **M** as the uniform magnitude scale.
- Identify dependent events within the catalog. The EPRI-SOG project provided a mathematical framework and software for performing this analysis. This framework will be adapted to using **M** as the uniform magnitude scale. Alternative approaches will be examined.

- Assess catalog completeness. The EPRI-SOG project provided a mathematical framework and software for assessing catalog completeness. This framework will be adapted to using **M** as the uniform magnitude scale.

Task 4: Assessment of Hazard-Significant Issues
Prior to the workshop, the TI team will make a preliminary assessment of the key SSC issues that would be most important to the hazard at the range of demonstration sites. This assessment will be based on the following assessments: 1) identify about six test sites in the CEUS and develop seismic hazard representations at those sites using the EPRI-SOG sources and the EPRI (2004) ground motion equation with revised sigmas (EPRI, 2006), 2) conduct Phase 1 sensitivity studies on parameters (e.g., Mmax, smoothing assumptions on seismicity parameters, source boundaries) to illustrate the importance of these assumptions, and 3) develop the technical basis for establishing the precision of mean seismic hazard estimates, considering such effects as (a) differences in mean hazard among interpretations, (b) differences in mean hazard caused by estimates of parameters based on random events (earthquake history), (c) difference in mean surface hazard caused by statistical (borehole) data for example on shear wave velocities and (d) differences in mean hazard caused by different software/analysts, given the same input.

The six test sites will be identified based on their potential to illustrate the significant seismic source characterization issues. For example, sites that are near the large earthquake sources such as Charleston and/or New Madrid will be considered, sites near zones of known seismicity, and sites that lie within background zones of observed low seismicity. The goal is to use the sites to illustrate the relative importance of various components of the SSC model to seismic hazard. Chosen sites will be as generic as possible.

The sensitivity studies will concentrate on a subset of the test sites that illustrate the importance of certain parameters, e.g. the importance of M_{max} for sites dominated by sources with M_{max} less than 6.0, and the importance of smoothing assumptions for large regional sources where historical seismicity varies spatially. These sensitivity studies will be documented to illustrate to project participants when and why the mean values and uncertainties of these parameters are important. Precision estimates will be developed on a quantitative basis using examples from past seismic hazard studies, from historical data (i.e. calculating and integrating uncertainties in rates and b-values into hazard estimates, and calculating the resulting uncertainty in mean hazard), and from common unstated assumptions (e.g. the precision associated with uncertainties in source boundaries).

NRC-sponsored studies regarding updated ground motion models for the Central and Eastern U.S. (the NGA - East project) will not be available for at least five years and, as a result, will have no impact on the CEUS SSC project.

Three hypothetical site conditions will be applied at each site: hard rock, shallow soil, and deep soil. This will span the range of effects of site conditions on surface spectra.

Task 5: Workshop #1 Significant Issues and Databases
The goal of this workshop is to identify the issues of highest significance to a SSC model for the CEUS and to identify the data and information that will be required to address those issues. The workshop will assemble the Management Team, TI Team, and TI Staff, Resource Experts, PPRP, and observers to discuss the significant issues and to identify the existing databases. To assist with identifying hazard-significant issues, the TI team will present the sensitivity studies conducted in Task 4 as motivation for identifying important assessment issues in PSHA that

should be addressed with new data. An initial scanning of the existing COLAs and ESPs will also provide a basis for identifying important issues, as will discussions with the PPRP and Sponsors, who have considerable PSHA experience at nuclear facility sites. The effects as a function of site location will be shown (chosen to illustrate different hazard environments) and site conditions (rock, shallow soil, deep soil). A model will be presented for determining the precision of mean seismic hazard estimates. The sensitivity studies and precision model will be documented in a written handout.

The resource experts present at the workshop will include researchers who have been involved in the development of pertinent databases, such as the USGS and university-based groups. Resource experts involved with the development of seismicity catalogs will also participate in the workshop. Discussions will be held regarding all databases that may be available for use by the project, and identification of researchers who should be contacted to gain access to the data.

In this workshop and subsequent workshops, it is anticipated that a select group of international observers will be in attendance to monitor the methodology being carried out. NRC sponsors will work with EPRI management to identify potential observers and to arrange for their attendance.

This task includes the workshop planning, identifying and contacting participants, preliminary identification of significant issues, presentations, and documentation of the workshop. Documentation of the workshop will be provided on a CD and will include a workshop summary and copies of all presentations. This workshop is anticipated to last two days.

Task 6: Workshop #2: Alternative Interpretations
The goals of this workshop are: to present, discuss, and debate alternative viewpoints regarding key SSC issues; to identify the technical bases for the alternative hypotheses and to discuss the associated uncertainties; and to provide a basis for the subsequent development of an SSC model that includes these alternative viewpoints. The workshop will also provide an opportunity to review the progress being made on the database and catalog activities and to elicit additional input regarding these activities. Proponents and resource experts will be invited to present their interpretations and the data supporting them. Alternative viewpoints will be juxtaposed and facilitated discussion will occur with a focus on implications to SSC for hazard analysis (not just on scientific viability) and on uncertainties (e.g., what conceptual models would capture the range of interpretations and what weights should be applied). Individuals and their interpretations will also be identified who are not present at the workshop.

The preparation for the workshop will draw upon the significant issues identified in the existing COLAs and ESPs (submitted and under preparation). A basis for the estimated level of effort is that the COLAs and ESPs all are readily available to the project team for use on this project. Preparation for the workshop will involve compiling these issues and identification of the appropriate resource people to present the relevant data and interpretations.

This task includes preparation for the workshop, identification of appropriate proponents and resource experts, facilitation of discussions, presentations, and documentation of the workshop. Documentation of the workshop will provided on a CD and will include a workshop summary and copies of all presentations. This workshop is anticipated to last three days.

Task 7: Construct Preliminary SSC Model
Based on the results of the first two workshops (which identify the key issues, available data, and alternative interpretations) as well as the database and earthquake catalog, a preliminary SSC model will be developed. A key component of the SSC model will be the quantification of uncertainties in alternative conceptual models as well as in parameter values. The SSC model will include the spatial distribution of future events, maximum magnitudes, and recurrence, as discussed below.

Spatial Distribution
The spatial distribution of future earthquakes will include the following: 1) definition of the locations of future earthquakes using area zones, spatial smoothing, combinations of both zones and smoothing, faults, etc.; 2) identification of alternative conceptual models regarding spatial distribution (e.g., alternative source zone boundaries due to different interpretations of tectonics or structure) and assignment of weights to the alternatives, including the probability that particular tectonic features are seismogenic in the present tectonic regime; 3) assessment of parameters required to exercise the spatial models such as smoothing operator, smoothing distance, nature of zone boundaries, etc.; and 4) assessment of characteristics of future events including rupture orientations, magnitude-dependent rupture dimensions, depth distribution and magnitude dependency, styles of faulting, and geometries of specific fault sources. Due consideration will be given to the criteria for identifying and characterizing seismic sources (seismogenic sources, capable tectonic sources) given in NRC Regulatory Guide 1.165.

Maximum Magnitude Assessment
A first task will be to update the EPRI maximum magnitude data and associated regressions (Johnston et al. 1994), which allow for a Bayesian approach to be used to evaluate maximum magnitudes. The update will incorporate studies of large SCR events that have occurred over the past 15 years and will provide prior distributions of maximum magnitude for various source types, which will then be updated using likelihood functions based on the observed seismicity associated with a source of interest. Consideration will also be given to the range of supportable interpretations in LLNL (1989, 1993), LLNL/TIP (2002), Chapman and Talwani (2002, SCDOT study), USGS (1996, 2002, 2007), research that occurred in the southeastern United States and published in USGS open file reports, the Bulletin of the Seismological Society of America, university publications and contractor and consultant reports (e.g., Westinghouse Savannah River Company). A current project for the evaluation of Mmax in the CEUS is being conducted by the USGS with support from the NRC. The results and methodologies developed as part of that study will be considered as part of this task.

If data are available, constraints on maximum magnitude may also be developed based on maximum rupture dimensions. Consideration will also be given to the use of updated empirical models between rupture dimensions and magnitude.

Earthquake Recurrence
The earthquake catalog will have been prepared for recurrence analysis as part of Task 3 (including completeness, declustering, and magnitude uncertainty analysis). This task will entail the assessment of recurrence models and calculation of recurrence parameters and associated uncertainties for identified seismic sources. It is anticipated that new computer codes will be developed for the estimation of seismicity rates and b-values. These codes will apply algorithms that remove the restrictions of previous methods (i.e. the estimation of a- and b-values in geographical degree cells that arbitrarily depend on longitude and latitude lines) and generalize

those concepts into smoothing functions that can be estimated on a finer grid, even in the presence of low historical rates of activity. These computer codes will be documented and made available as part of project documentation. Where data are available, paleoseismic recurrence will be incorporated and merged with constraints on recurrence from observed seismicity.

Task 8: Develop Hazard Input Document and SSC Sensitivity Analyses
Based on the assessments made in Task 6, a hazard input document (HID) will be developed that documents and summarizes the key elements of the SSC model including logic trees, parameter distributions, and derived Mmax and recurrence parameters. To support Workshop #3 Feedback, several sensitivity studies will be conducted of intermediate results using the preliminary SSC. These will include importance of various parameter values to maximum magnitude and recurrence distributions and their uncertainty, summed moment rates based on recurrence models, comparison of predicted and observed seismicity rates, and predicted spatial intensity maps. Sensitivity to catalog analysis (e.g., completeness) will also be considered. The seismicity parameters will be generated in this task. Following finalization of the SSC Model, a final HID will be developed, and it will be included in the Project Report.

Task 9: Perform Preliminary Hazard Calculations and Sensitivity Analyses
Using the HID developed in Task 8, the preliminary SSC model will be used to develop Phase 2 sensitivity studies on seismic hazard, presenting means and fractal hazards at the six test sites (discussed previously in Task 4). These sensitivity studies will show changes from EPRI-SOG sources, effects of alternative source parameters and smoothing assumptions (following the format of the sensitivity studies conducted for WS#1), and estimates of precision on a quantitative basis. This task will use the updated earthquake catalog, and will compare hazard results with the updated catalog (through 2008 using moment magnitude M) with hazard results presented in WS#1. Sensitivity results will be presented both with and without CAV filter applied to ground motions. De-aggregation analyses and sensitivity analyses will be conducted to identify important sources and source characteristics such as M_{max} and source boundaries, contributions to uncertainty, and the effect of impact of alternative competing hypotheses.

Task 10: Workshop #3 Feedback
The goal of this workshop is to present and discuss the preliminary SSC model in a public forum with the opportunity for feedback from resource experts and proponents from the technical community. Feedback will also be given in the form of SSC sensitivity analyses (Task 8) and hazard results and sensitivity analyses (Task 9) to shed light on the most important technical issues. The feedback gained at this workshop will ensure that no significant issues have been overlooked and will allow the TI team to gauge the reaction of the community to the SSC model, uncertainties, and assessments of weights. This information will provide a basis for the finalization of the SSC model.

The approach planned for this workshop will begin with the TI team presenting the preliminary SSC model, with particular emphasis on the manner in which alternative viewpoints and uncertainties have been captured. The technical bases for the assessments and weights will be described to allow for a reasoned discussion of the constraints provided by the available data. Presentation of the hazard calculations and sensitivity analyses will provide a means of focusing the discussions on those SSC issues having the greatest hazard significance, including the largest contributors to uncertainty. The effects will be shown as a function of site location (chosen to illustrate different hazard environments) and site conditions (rock, shallow soil, deep soil). Prior to the workshop, streamlined hazard calculations will be developed so changes can be made in real time, to determine effects of alternatives suggested at the meeting, in order to promote final approval of a revised model. The final precision model will be applied to preliminary and final sets of seismic sources.

This task includes preparation for the workshop, identification of appropriate proponents and resource experts, facilitation of discussions, presentations, and documentation of the workshop. Documentation of the workshop will be provided on a CD and will include a workshop summary and copies of all presentations. This workshop is anticipated to last two days.

Task 11: Finalize SSC model

In light of the feedback discussed in Workshop #3 and using the final database and seismicity catalog, the TI team will finalize the SSC model as part of this task. Uncertainties will be fully characterized using logic trees (for alternative conceptual models) and probability distributions (for continuous parameter distributions). Alternative models will be weighted and the technical basis for relative weights developed. Finalization of the software used for developing seismicity parameters will occur in this task.

Task 12: Document CEUS SSC Project in Draft Report

This task includes the documentation of the CEUS SSC project in a draft report. The documentation of the report will include all process and technical aspects of the study and will provide the fundamental basis for the acceptance and subsequent use by other parties. The draft report will include:

- A description and justification for the methodology followed, including justification for the SSHAC Study Levels for the various SSC issues, identification of the participants, etc.
- The databases developed and used in the analysis; a description of the seismicity catalog development.
- Description of SSC model including all elements, uncertainties, logic trees, and weights. The technical basis for all assessments will be included in the documentation, including the data that were relied upon.
- The finalized Hazard Input Document providing sufficient documentation for users to implement the SSC model in PSHA calculations for future applications.
- Descriptions of the sensitivity analyses conducted to show the importance of various inputs to intermediate SSC parameters.
- Description of sensitivity studies at the six test sites. Sensitivity results will be presented both with and without CAV filter applied to ground motions, and for the three site conditions at each of the test sites; documentation of the precision model and its application to the test sites, and general conclusions on how the estimate of precision can be translated to "significant" or "non-significant" changes in future hazard; documentation of computer files with final sources representing HID, i.e. the geometry of seismic sources and their seismicity parameters sufficient for calculating hazard.
- Documentation and test cases for any new software developed to estimate seismicity parameters.
- Discussion of implementation guidance for use of the CEUS SSC at specific sites (e.g., interface issues with ground motions, relation to existing studies).

Task 13: Review of draft report by PPRP
The PPRP will function in the Project as defined in the SSHAC Guidelines. Panel members will attend workshops, meet with the TI Team to provide feedback and summarize its comments in a report following each workshop. Members of the PPRP may participate in working meetings, workshop planning and workshops as resource experts. The task includes the review of the draft project report by the Management Team, PPRP and reviewers selected by the sponsors. As defined in SSHAC guidelines, the PPRP will be reviewing the report from the standpoint of both the *technical* content as well as the *process* followed. The draft report will be sent to the PPRP and the Sponsor reviewers. A meeting will be held with the PPRP and the Sponsor reviewers to discuss their comments and the manner in which they will be addressed.

Task 14: Finalize and Issue CEUS SSC report
Review comments made by the PPRP and Sponsor reviewers will be resolved and the final CEUS SSC report developed. The report will be issued as an EPRI Technical Report.

Task 15: Brief NRC, DOE, and DNFSB on CEUS SSC Study
Meetings will be held with the NRC and the Defense Nuclear Facility Safety Board (DNFSB) in two-1-day meetings in Washington, DC. Preferably a single meeting can be held with all groups. The meetings will be held to present the methodology, the seismic source model, and to explain how to apply the results. In addition, the "lessons learned" from the study will be discussed. As part of that discussion, the key uncertainties will be identified and potential long-term research approaches to reducing the uncertainties will be identified.

Task 16: Participatory Peer Review Panel (PPRP)
This task includes the activities associated with participation on the PPRP. Meetings of the PPRP will occur at the initiation of the project to review the Project Plan, meetings in association with the three workshops, and a meeting to review the CEUS SSC draft report. It is also expected that additional meetings or teleconferences will occur throughout the course of the project as required to monitor progress. As discussed above in Task 13, the members of the PPRP may also participate in interactions with the TI Team to provide their feedback. The PPRP will be asked to review the list of hazard-significant issues, to provide written comments following each workshop, and to review the draft report. Written comments from the PPRP developed following each of these project activities will be developed into a single consensus letter that reflects the views of the entire Panel. Other functions may be requested by the Project Manager.

Task 17: Project Management and Oversight
This task includes the activities associated with the management of the CEUS SSC project by the EPRI Program Manager, EPRI ANT Project Manager and Project Manager as discussed in the section that follows.

5 PROJECT ORGANIZATION

The project organization is shown on Figure 5-1, and the functions are summarized below:

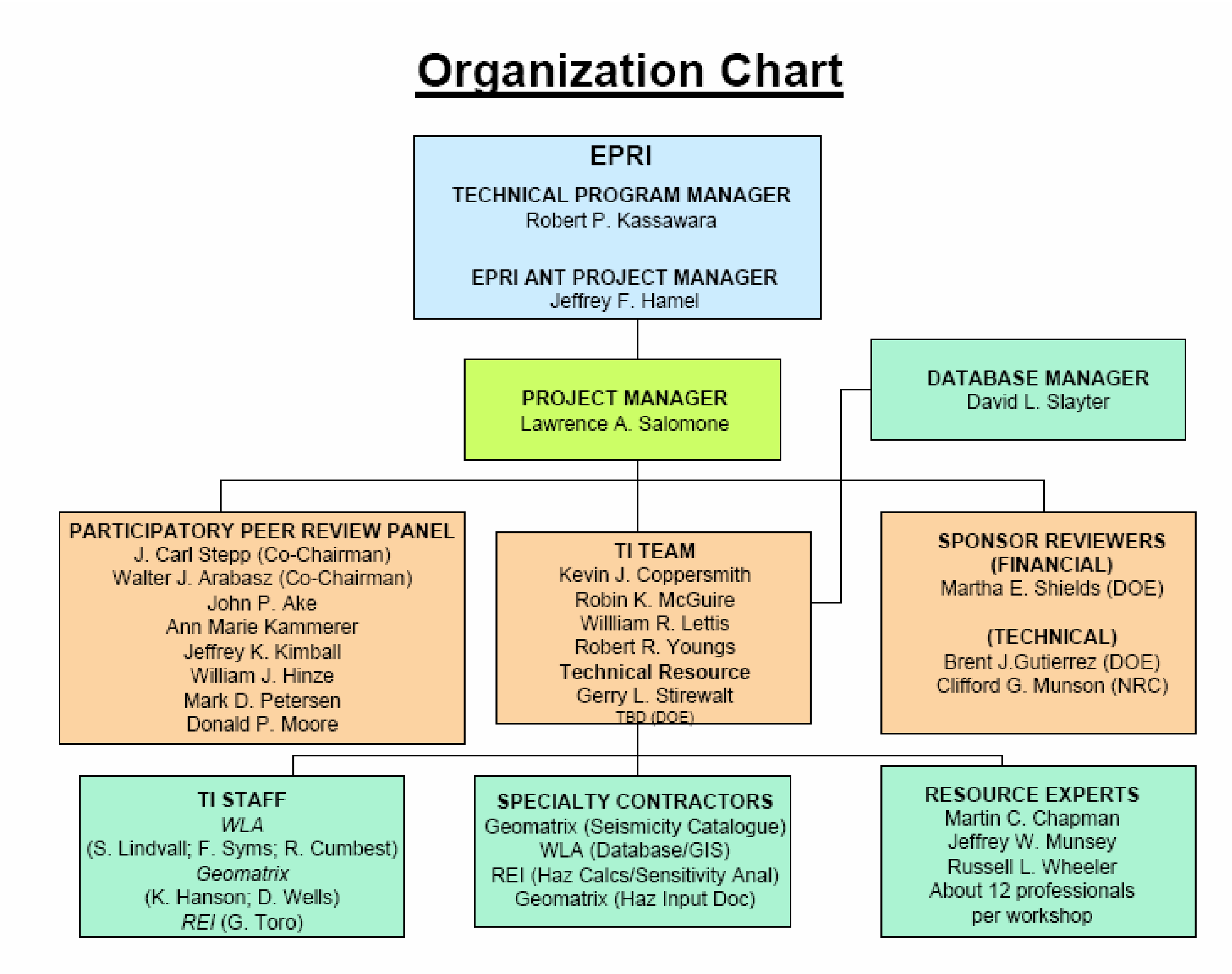

Figure 5-1
CEUS SSC Project Organization Chart

<u>EPRI Management</u>

- Responsible for contracting with all project participants
- Responsible for establishing and maintaining project budgets and schedules
- Interfaces with utilities

Project Manager

- Assist EPRI Management, as requested, in establishing and maintaining project budgets and schedules
- Principal interface with PPRP, TI Team, Sponsors and Utilities
- Review of technical products
- Primary responsibility for all technical products
- Principal spokesperson for project to external community, including NRC and DNFSB

Participatory Peer Review Panel (PPRP)

- Provide timely reviews of process and technical assessments
- Individual members may work with TI Team to review details
- Attend workshops, meet with the TI team to provide feedback and summarize its comments in a report following each workshop
- Participate in working meetings, workshop planning and workshops as resource experts
- Review and approval of CEUS SSC draft and final report

TI Team

- Develop input to Project Plan
- Responsible for maintaining scope, schedule, and budget for respective organizations
- Responsible for developing and implementing SSHAC Study Level methodology
- Responsible for all technical products, technical assessments and for defending their bases
- Responsible for documentation and responding to reviews

Database Manager

- Responsible for retrieving and compiling applicable data for the seismic source characterization
- Provides datasets in appropriate formats for the TI Team's deliberations

Sponsors

- Financial and technical sponsors monitor spending and adherence to Project Plan
- As sponsor availability allows, technical sponsors may assist and interact with the PPRP and the TI team
- Review and approval of CEUS SSC draft and final report
- Work at the direction of the TI Team on technical assessments

Specialty Contractors

- Provide specific activities and products supporting the activities by the TI Team and the TI Staff

Resource Experts

- Provide knowledge and experience regarding specific topics of discussion at the workshops

6
LINES OF COMMUNICATION AND POINTS OF CONTACT

The lines of communication and points of contact are given in Figure 6-1. Figure 6-1 is provided to assist in the flow of information and ensure that the appropriate members of the SSC team are aware of project developments and communications in a timely manner. EPRI Management and the Project Manager shall be copied on all correspondence and work products. The Project Manager shall be the point of contact for transmitting correspondence and work products to and from the PPRP and the Sponsors and for sending invitations to the resource experts proposed for the workshops by the Project team. The Project Manager with the assistance of the TI Team shall inform the Chairmen of the PPRP and Sponsors of process and technical developments. The TI Team shall ensure that the TI Staff, Specialty Contractors and the Resource Experts have the required information to support the project.

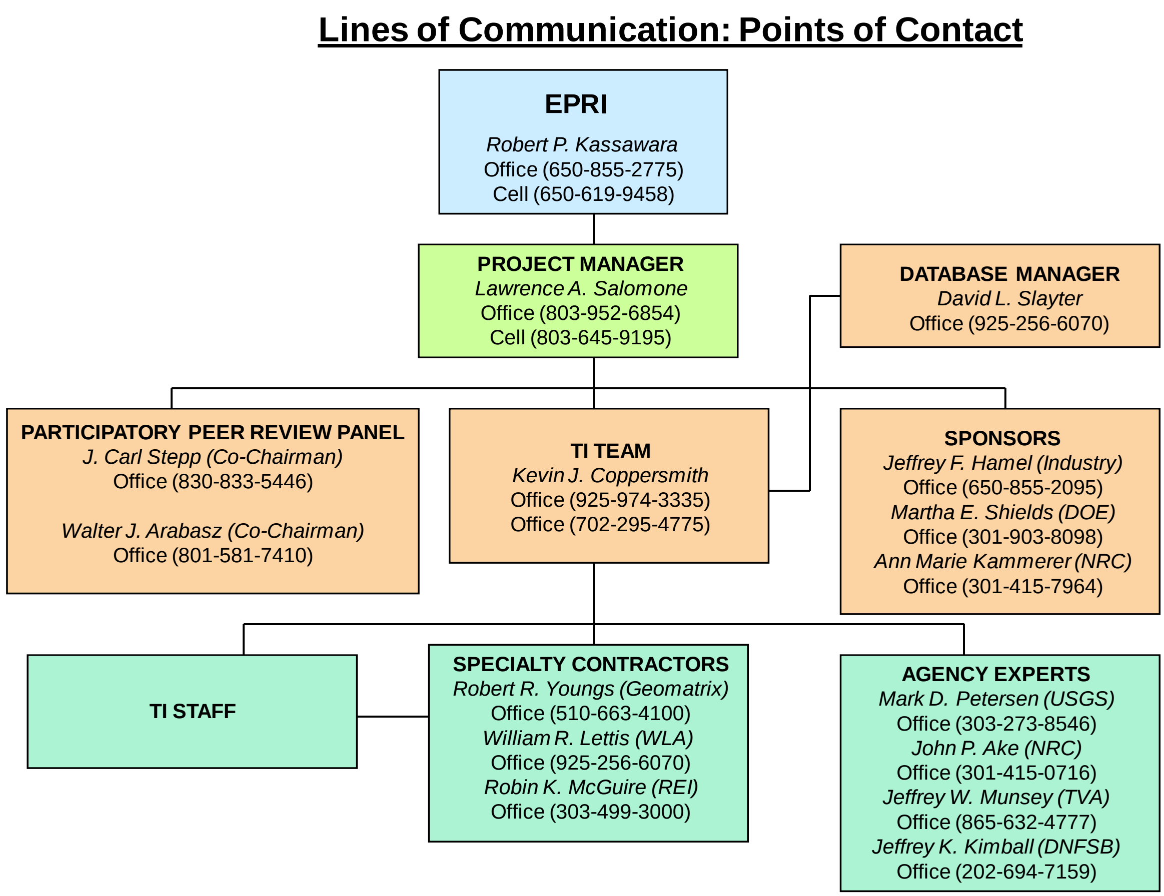

Figure 6-1
Lines of Communication and Points of Contact for CEUS SSC project

7 SCHEDULE

The schedule for the project is shown in Figure 7-1. Figure 7-1 shows the timelines for the 16 tasks that comprise the CEUS SSC project. Inputs to and from one task to another are indicated by the arrows. The three workshops and the associated task inputs are shown. The exact dates for the workshops have not yet been identified. Meetings of the PPRP are indicated as occurring in May to review this Project Plan, in association with each of the workshops, and following review of the Draft Report. Additional meetings and/or teleconferences with the PPRP are not shown.

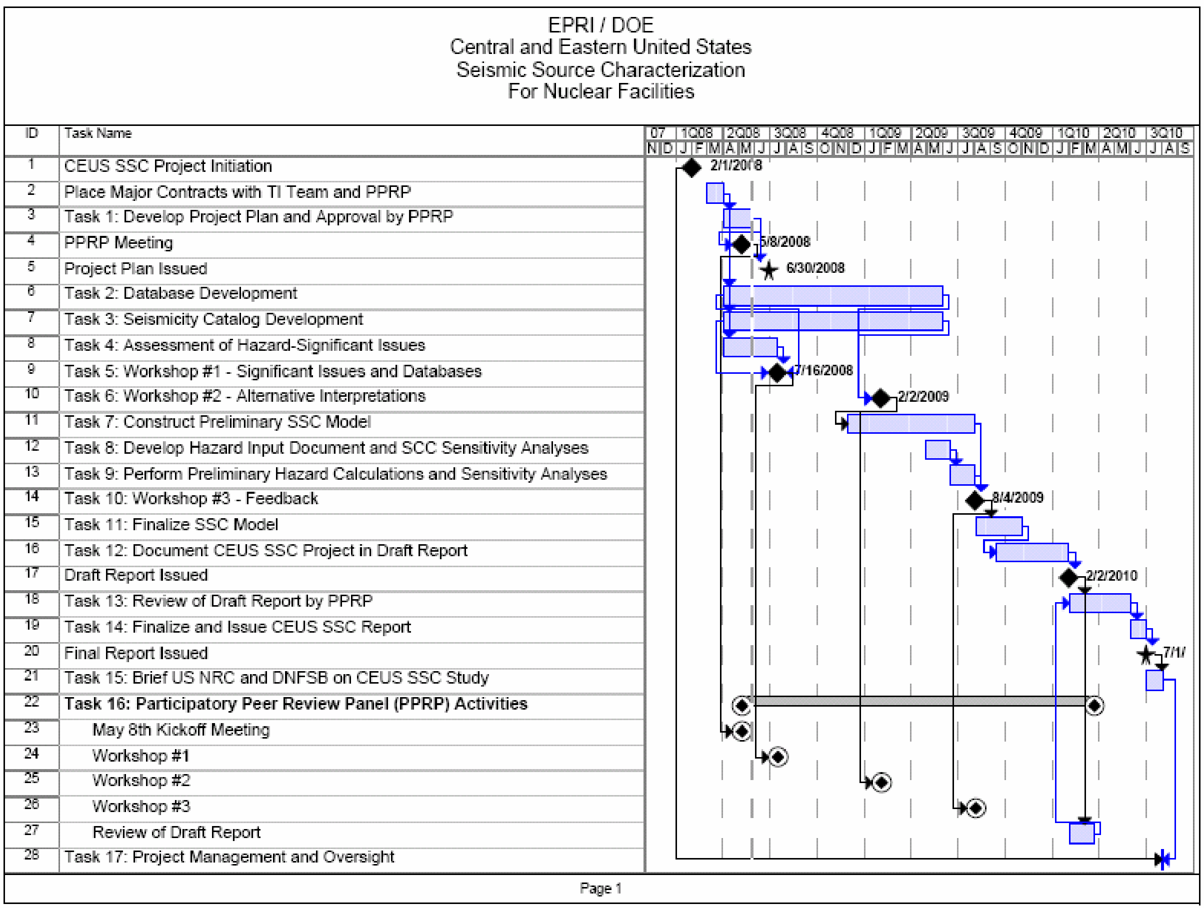

Figure 7-1
Project Schedule

Key project milestones are:

EPRI Technical Update: CEUS SSC Project Plan	June 2008
Workshop #1	July 2008
Workshop #2	February 2009
Workshop #3	August 2009
Draft EPRI Technical Report	February 2010
Final EPRI Technical Report	July 2010

8 QUALITY ASSURANCE

The technical assessments made as part of the CEUS SSC will entail the use of a wide range of databases, including those that have been subject to peer review in the professional literature, those that have been gathered for scholarly research, and those that have been developed for site-specific commercial application. The methodology planned, which includes extensive interactions with the technical community in the identification of data, evaluation of alternative hypotheses, and feedback regarding all assessments, will provide a high level of review of the technical assessments made by the TI Team. Further, a participatory peer review process is planned for both the technical and process elements of the project. These methodology attributes will provide assurance with high confidence that the project assessments and results are accepted by the technical community. The level of assurance will meet or exceed that associated with publication in a peer-reviewed technical journal.

In addition to the peer review process that is afforded by the SSHAC Level 3 process, certain other work activities will be conducted that serve to provide best business practices. A hazard input document (HID) will be developed that documents and summarizes the key elements of the SSC model including logic trees, parameter distributions, and derived Mmax and recurrence parameters. The HID specifies the exact inputs provided by the SSC model to the hazard calculations and thus provides a clear record of the manner in which the SSC model has been represented for purposes of calculations. As discussed in Task 2 Database Development, the management and documentation of the data will be done in accordance with a data management procedure developed specifically for this project. As part of Task 7 Construct Preliminary SSC Model, it is anticipated that new computer codes will be developed for the estimation of seismicity rates and b-values. These computer codes will be documented and made available as part of project documentation.

All hazard calculations will be conducted using software that has been qualified according to 10 CFR 52, Appendix B requirements. Also, an internal documentation package will be prepared to archive the hazard calculations. The results will be documented in the project report as example calculations. This approach follows the EPRI and LLNL example calculations from the 1989 studies.

9 REFERENCES

Chapman, M.C. and Talwani, P., Seismic Hazard Mapping for Bridge and Highway Design in South Carolina, Prepared for South Carolina Department of Transportation, December 2002, also published as SC DOT Report No. FHWA-SC-06-09, December 2006.

Electric Power Research Institute (EPRI), Seismic Hazard Methodology for the Central and Eastern United States, Team Technical Interpretations, Volumes 5-10, EPRI NP-4726, July 1986.

Electric Power Research Institute (EPRI), Guidelines for Determining Design Basis Ground Motions, EPRI Report TR-102293, Project 3302, Final Report, November 1993.

Electric Power Research Institute (EPRI), CEUS Ground Motion Project Final Report, EPRI Report 1009684, December 2004.

Electric Power Research Institute (EPRI), Program on Technology Innovation: Truncation of the Lognormal Distribution and Value of the Standard Deviation for Ground Motion Models in the central and Eastern United States, EPRI Report 1013105, Technical Update, February 2006.

Johnston, A.C., Coppersmith, K.J., Kanter, L.R. & Cornell, C.A. 1994: The Earthquakes of Stable Continental Regions. Volume 1, Assessment of Large Earthquake Potential.

Final Report Submitted to Electric Power Research Institute (EPRI) TR-102261-VI, v. 1.

Lawrence Livermore National Laboratory (LLNL), Seismic Hazard Characterization of 69 Nuclear Plant Sites East of the Rocky Mountains, NUREG/CR-5202, 1989.

Lawrence Livermore National Laboratory (LLNL), Eastern U.S. Seismic Characterization Update, UCRL-ID-115111, 1993.

Lawrence Livermore National Laboratory (LLNL), Guidance for Performing Probabilistic Seismic Hazard Analysis for a Nuclear Plant Site: Example Application to the Southeastern United States, LLNL/TIP Report, NUREG/CR-6607, 2002.

Metzger, A.G, 2000, Documentation, Location and Size-Estimation of "New" Historical Earthquakes in the Central United States: Continuation. U.S. Geological Survey Contract No. 1434-HQ-97-GR-03064. Final Technical Report. March.

Metzger, A.G., J.G. Armbruster, and L. Seeber. 2000, Documentation, Location and Size-Estimation of "New" Historical Earthquakes in the Central United States: Continuation, U.S. Geological Survey Contract No. 1434-HQ-97-GR-03064. Final Technical Report. March.

Mueller, C., M. Hopper, and A. Frankel. 1997. Preparation of Earthquake Catalogs for the National Seismic-Hazard Maps: Contiguous 48 States. U.S. Geological Survey Open-File Report 97-464.

Munsey, J.W., 2006, "Identification of 'New' Historic Earthquakes in the Central and Eastern United States through Online Keyword Searches," Unpublished Report of River Operations, February, Tennessee Valley Authority.

Regulatory Guide 1.165. 1997. *Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion.* Washington, D.C.: U.S. Nuclear Regulatory Commission.

Seeber, L., and J.G. Armbruster. 1991. The NCEER-91 Earthquake Catalog: Improved Intensity-Based Magnitudes and Recurrence Relations for U.S. Earthquakes East of New Madrid. National Center for Earthquake Engineering Research, NCEER-91-0021.

Senior Seismic Hazard Analysis Committee (SSHAC), Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts, U.S. Nuclear Regulatory Commission Report, NUREG/CR-6372, 1997.

United States Geological Survey (USGS), Frankel et al, National Seismic-Hazard Maps: Documentation, USGS Open-File Report 96-532, 1996.

United States Geological Survey (USGS), Frankel et al, Documentation for the 2002 Update of the National Seismic Hazard Maps, USGS Open-File Report 02-420, 2002.

United States Geological Survey (USGS), Petersen et al, Documentation for the 2007 Update of the United States National Seismic Hazard Maps, draft in review.

Wells, D. L., and K. J. Coppersmith, New Empirical Relationships Among Magnitude, Rupture Length, Rupture Width, Rupture Area, and Surface Displacement, Bulletin of the Seismological Society of America, Vol. 84, p. 974, 1994.

A

LETTER REPORT FROM PARTICIPATORY PEER REVIEW PANEL

May 22, 2008

Lawrence A. Salomone
Washington Savannah River Company
Savannah River Site
Building 730-4B, Room 3125
Aiken, SC 29808

Dear Mr. Salomone:

Reference: *Central and Eastern United States Seismic Source Characterization for Nuclear Facilities*, Draft Project Plan, Rev 00, April 14, 2008: Participatory Peer Review Panel review meeting, May 8, 2008

This letter states the observations and recommendations of the designated Participatory Peer Review Panel (PPRP) for the referenced project relating to the draft project plan and the plan review meeting held in Palo Alto on May 8, 2008. The PPRP was able to review the draft project plan and provided its written comments prior to the meeting. Members of the Panel are listed in Attachment 1; the Panel's written comments on the draft project plan together with additional comments provided by sponsor agencies are in Attachment 2. We want to express our appreciation for the opportunity to meet with the Project Team and project sponsor representatives and for the responsive and thorough discussions of our written comments during the meeting. We believe the discussions and follow-on actions that grew out of them satisfactorily resolve our written comments.

The paramount goal of the project is to develop a seismic source characterization (SSC) model for the central and eastern United States (CEUS) that can be adopted by the sponsoring organizations as an accepted starting basis model for performing a site-specific probabilistic seismic hazard analysis (PSHA) at any geographic location within the region. In order to achieve this overarching goal the SSC model must have the stability of being broadly accepted by the informed scientific and technical community and must remain valid for a period into the future. The CEUS SSC assessment will implement current practice and guidance on the use of experts and assessment of uncertainty described in Budnitz, et al., 1997[1] (the SSHAC process). The planned approach is to use a SSHAC Level 3 process for assessing key SSC issues and a Level 2 process for assessing issues that have lesser hazard significance.

Our written comments on the draft project plan were satisfactorily resolved by discussions during the meeting and with planned revision of the plan. We have the following additional observations and recommendations following the meeting.

---

[1] Budnitz, R. J., G. Apostolakis, D. M. Boore, L. S. Cluff, K. J. Coppersmith, C. A. Cornell, and P. A. Morris, 1997. *Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts.* NUREG/CR-6372, Washington, DC, U.S. Nuclear Regulatory Commission.

1. We endorse the planned use of a SSHAC Level 3 process for key issues of the CEUS SSC model. However, the planned use of Level 2 processes for "those issues having lesser hazard significance or are not subject to large uncertainty" is potentially problematic vis-à-vis desired stability. At a minimum, decisions to use Level 2 processes in developing aspects of the CEUS SSC model should be carefully scrutinized both by the Technical Integrator (TI) team and the PPRP. We recommend that consideration be given to using the Level 3 process for assessment of *all* SSC issues regardless of the level of uncertainty about the issue or its hazard significance. The planned early identification of the most hazard-significant issues should serve to more efficiently focus the workshops and assessments. However, a uniformly implemented Level 3 assessment will assure uniform thoroughness and completeness of the assessments and will raise scientific and public confidence in the result. Implemented this way, we are confident that the Level 3 assessment will result in a SSC model that properly reflects the uncertainty of the informed scientific community and that will serve as a stable starting basis for performing site-specific PSHA's.

2. The TI Team should make every effort to comprehensively address proponent positions on the various SSC issues and to thoroughly evaluate the issues in workshops. The workshop proceedings and the assessments of the issues should be thoroughly documented and summarized within the main body of the report, with more detail provided in the appendix of the report. It is clear that scientific investigations will continue to expand the available database and to improve scientific understanding of earthquake processes into the future. Organizations that adopt the SSC model should develop and implement procedures for evaluating the significance of such advances in scientific knowledge in order to fully achieve the desired longevity goal for use of the study results into the future. We consider the development of such procedures to be a user function beyond the scope of this project since the appropriate procedures and evaluations would be specific to each organization as required to meet its seismic regulations.

3. The TI Team is constituted of individuals who are among the most experienced available for implementation of the SSHAC process. However, considering that the paramount goal of the study is to develop a broadly accepted CEUS SSC model that will remain stable into the future, we strongly recommend expanding the TI Team. Specifically, we urge the inclusion of experts—either as full members of the Team or as heavily involved resource experts—who have expert knowledge about CEUS tectonic and earthquake processes and experience with other seismic source assessments for seismic hazard mapping programs that may elect to adopt the study results. We consider achievement of this level of participation across programs to be essential.

4. We understand that the project is limited by available resources and must be optimized to the extent achievable. Nevertheless, we consider six test sites for development of hazard results feedback to be minimum. We strongly endorse the plan to select locations for the test sites so as to optimally capture the sensitivity of hazard to elements and parameters of the CEUS SSC model. In order to optimize the benefit of the feedback workshop, arrangements should be made to

provide real-time analysis of the sensitivity of hazard to elements and parameters of the SSC model.

5. The project database is clearly fundamental for performing the assessments for development of the SSC model. A complete and well-qualified database should be the essential objective in order to reduce data uncertainty to the extent achievable. We recommend efficient open electronic access to the database by the project participants, to the extent achievable.
6. We endorse the planned briefings for the project sponsors on the SSC model and how to use the model to perform a site-specific PSHA. We recommend that the project prepare a document describing lessons learned at the end of the project and include this as part of the briefings and as an appendix to the final report.
7. In order to promote broad user community participation in, and subsequent use of, the CEUS SSC results, the PPRP was intentionally constituted to include qualified individuals from sponsoring organizations that expect to adopt the results and from other hazard mapping programs. Accordingly, the PPRP believes it is important to state the following. The PPRP intends to appropriately perform its function to provide critical review of procedural and technical aspects of the project. The Panel participants will focus their comments primarily on technical validity, technical completeness, and conformity to the SSHAC process. We expect the sponsoring organizations to communicate explicit statements of their views to the Project Team independently of the PPRP.

These observations and recommendations are our primary ones at this time. The Panel intends to provide, in a timely way, further comments regarding specific issues for consideration by the Project Team in planning Workshop 1.

Do not hesitate to contact us to discuss any of our observations and recommendations.

Sincerely,

J. Carl Stepp
871 Chimney Valley Road
Blanco, TX 78606-4643
Tel: 830 833 5446
cstepp@moment.net

Walter J. Arabasz
2460 Emerson Avenue
Salt Lake City, UT 84108
801 581 7410
arabasz@seis.utah.edu

Attachments
- PPRP Members and Sponsor Representatives
- Consolidated Written Comments on Draft Project Plan

CEUS SSC for Nuclear Facilities
Participatory Peer Review Panel and Sponsor Representatives

J. Carl Stepp Co-chairman 871 Chimney Valley Road Blanco, TX 78606-4643 Tel: 830 833 5446 Fax: 830 833 5724 cstepp@moment.net	Walter J. Arabasz Co-chairman 2460 Emerson Avenue Salt Lake City, UT 84108 Tel: 801 581 7410 Fax: 801 585 5585 arabasz@seis.utah.edu
Jon P. Ake USNRC Washington, DC 20555-0001 Tel: 301 415 0716 Jon.ake@nrc.gov	William J. Hinze Purdue University 30 Brook Hollow Lane West Lafayette, IN 47906 Tel: 765 583 2530 Wjh730@comcast.net
Jeffrey K. Kimball 17636 Wheat Fall Drive Derwood, MD 20855 Tel: 202 694 7181 jeffreyk@dnfsb.gov	Donald P. Moore Consulting Engineer Southern Nuclear Operating Company, Inc. 42 Inverness Center Parkway Birmingham, AL 35242 Office: 205-992-6672 Fax: 205-992-5145 dpmoore@southernco.com
Mark D. Petterson USGS Box 25046, MS 966 DFC Denver, CO 80225 Tel: 303 273 8546 Fax: 303 273 8600 mpetterson@usgs.gov	Annie Kammerer USNRC Washington, DC 20555-0001 Tel: 301 415 7964 Annie.kammerer@nrc.gov
Clifford Munson USNRC Washington, DC 20555-0001 Tel: 301 415 6947 Clifford.munson@nrc.gov	Brent J. Gutierrez NPH Engineering Manager USDOE – SR Tel: 803 208 2969 Fax: 803 208 0343 Brent.gutierrez@srs.gov

Consolidated PPRP Comments on
DRAFT PROJECT PLAN: CENTRAL AND EASTERN UNITED STATES SEISMIC SOURCE CHARACTERIZATION FOR NUCLEAR FACILITIES, REV 00 04/14/08

For discussion and resolution at Project Planning Meeting #2, May 8, 2008

For discussions at the May 8, 2008 EPRI CEUS SSC Project meeting to address the PPRP review of the draft Project Plan, non-editorial PPRP review comments that require discussion are consolidated in this document. No effort has been made to integrate the comments; some address overlapping issues and can be grouped under a single agenda item. In addition, some comments go to details of implementation and may more appropriately be addressed in the detailed task implementation planning.

Jon P. Ake, Annie Kammerer, Clifford Munson

NRC staff generally has a positive response to the DPP. However, we do have a few specific comments, which are summarized below according to section of the DPP. Some high-level concerns we have identified include:

- The ability to fulfill the project objectives with only three workshops,
- The timeline, which seems fairly aggressive,
- The specific roles and responsibilities of the participatory peer review panel (PPRP) and the sponsor representatives. In particular the relationship between the PPRP, sponsors, and TI team needs to be clarified.
- In general the Project Plan needs more detail if the aggressive timeline laid out is to be met.
- The project documentation is to be captured as an EPRI Technical Report, it needs to be explicitly stated that this information will be readily available to the general public at nominal cost (i.e. for reproduction) or through download at the NRC or DOE website.
- The makeup of the TI team is entirely industry representatives, some thought should be given to the potential addition of an NRC or DOE person to the team.
- Given that the objective of this project is to produce a new seismic source characterization model, the role of the ESPs in this project is not clear. The ESPs focused on updating or modifying the EPRI-SOG model.

Executive Summary
On a philosophical note, the purpose of the project is to produce an up-to-date, comprehensive, robust and defensible characterization of seismic sources in the CEUS. As a result of following a disciplined, structured process (such as that in the SSHAC guidelines) we will achieve stability and longevity. However, stability and longevity is not the purpose in itself.

Given that the first meeting of project personnel, the peer review team and project sponsors will not occur until May 8th, it seems that scheduling the first workshop in July is somewhat optimistic. Perhaps more detailed discussion of exactly what needs to be done by the time of the meeting would make the basis for this timeline clearer.

After the review of the draft report by the PPRP it would be appropriate to have a final meeting (not necessarily a workshop) to close out any remaining comments from PPRP and project staff prior to production of the final report.

Introduction and Context of Study
The specification of six sites to be used in the seismic hazard calculations may be premature. To fully capture and understand the effects of certain source model assumptions or choices it may necessary to evaluate more than six sites. To assess the impact of seismicity boundaries and smoothing assumptions it may useful to look at a larger number of sites in a small area.

The discussion in this section (second paragraph on page 3) regarding Mmax leads to some questions regarding the conduct of a Level 3 versus Level 4 study. In a Level 4 study the experts/teams would each develop a distribution for Mmax and by integrating across the teams we have a measure of the range of technical interpretations of the broader informed community. Achieving that goal in a Level 3 study is somewhat more challenging. It appears that achieving the goal of broad community input will be a shared responsibility of the participatory peer review panel and TI team. This will lead to additional interactions between the PPRP and TI team. It would be beneficial to specifically schedule time before each of the workshops for the PPRP to meet and "get on the same page" and then to meet and debrief with the TI team immediately after each of the workshops. This additional meeting time would be an opportunity to effectively maximize the usefulness of participatory peer review. If this work is not performed in a thoughtful and thorough way, we will probably not achieve the goal of representing the full spectrum of community opinion.

Objectives
Please see the comment above regarding the philosophy of study objectives.

The specification of six sites to be chosen from next generation power plants and/or sites within the DOE complex for the sensitivity calculations needs to be carefully considered and justified.

Selection of SSHAC Study Level
In the first paragraph, there is discussion of the possibility of specification of lower levels of evaluation (SHAC Level 2) for some issues that are not as important. When will the importance of issues be defined? It seems like that will be done in Task 4 which should be done prior to Task 5 (Workshop #1), which is scheduled for July of 2008. Any decision making in this regard should be conducted with input from the PPRP.

Work Plan
Task 2: Database Development

Any literature compiled for use by the TI team should also be made available to the PPRP, and should ultimately be compiled into a publically available database.

Task 3: Seismicity Catalog Development
There is lots of good detailed discussion in this section. In the last bullet it seems an assessment of hazard sensitivity to catalog completeness estimates is needed (perhaps this will be done in Task 9?).

Task 4: Assessment of Hazard-Significant Issues
It is noted that three hypothetical site conditions will be assumed for each demonstration site to be evaluated (hard rock, shallow soil, and deep soil). Will these be the same conditions and amplification functions used in EPRI-6395 or will new functions be developed? If so, when will the PPRP be able to evaluate the choice of properties for the profiles?

Task 5: Workshop #1-Significant Issues and Databases
Please note the comment above regarding the timing of this workshop. It also not clear exactly who the resource experts will be and if it is possible to make arrangements (i.e. contract or travel or USGS support) to have them participate in a meeting in July.

Task 6: Workshop #2-Alternative Interpretations
This is the key task in the project. The objectives for this workshop described in the DPP are broad in scope and will be complex. The challenge of evaluating and incorporating alternative viewpoints into a hazard model that is flexible and broad enough to incorporate the evaluation of alternative conceptual models that might arise at a later date will be challenging. It seems that specifying a workshop duration of two days a priori is somewhat optimistic. This workshop should be of whatever duration is required to explore the reasonable alternative interpretations.

Task 7: Construct Preliminary SSC Model
Alternative methods for the assessment of maximum magnitude, such as those used in the PEGASOS Project, should also be evaluated. A current project for the evaluation of Mmax in the CEUS is being conducted by the USGS with support from the NRC. The results of that study should be considered or incorporated in Task #7.

Task 9: Perform Preliminary Hazard Calculations and Sensitivity Analyses
The DPP suggests that the sensitivity studies will show changes with respect to alternative source parameters, smoothing assumptions and relative to the EPRI-SOG sources. Since the objective of the project is to develop a SSC model that replaces the EPRI-SOG model, we assume this comparison is only of use to illustrate the change in hazard due to the evolution in our (the earthquake community) perceptions of hazard. Is this correct or is there another reason for this comparison?

Task 12: Document CEUS SSC Project in Draft Report
The discussion of the approach for documentation seems sound. Based on our reading of this section of the DPP it is not clear how many documents will be prepared. Will there

be a document that summarizes the technical bases for the assessments used in the hazard model and a separate Hazard Input Document or a single document? This is important from the standpoint of assessing how realistic the schedule and budget is. The development of complete and transparent documentation is essential for the longevity of the results by allowing for new information to be appropriately assessed.

Task 13: Review of Draft Report by PPRP
We assume the meeting described in this section will be between the TI team, PPRP, and Sponsor reviewers. What is not defined is when this meeting will take place (we find it hard to see from the spreadsheet) and exactly how the incorporation of comments will be done. There is a need to define the relationship between the various entities (TI team, PPRP, and Sponsor reviewers) and to consider how PPRP and Sponsor reviewer comments will be incoroporated. Some thought needs to be given to this beyond the box charts shown in Figures 1 and 2. We believe that the Sponsor reviewers should be treated as de facto members of the PPRP, in addition to the special responsibilities of representing the sponsor agencies.

Task 15: Brief NRC and DNFSB on CEUS SSC Study
DOE should be explicitly identified in the list of groups to be briefed.

Task 16: Participatory Peer Review Panel
Given the significant amount of material that will need to be reviewed and evaluated by the PPRP, and the responsibility that the PPRP has to assure that the breadth of the informed technical community is represented, it seems meetings of the PPRP beyond what is outlined in this section will be needed. This may or may not need to be physical meetings in all cases; teleconferences may work for some issues.

<u>Walter J. Arabasz</u>

1. The Draft Project Plan is well organized and structured—reflecting considerable thought and effort. Key information I lack as a reviewer is some indication of the qualifications of the individuals or teams or contractors who will perform some of the tasks (perhaps outside the scope of desired comment at this point). As an example, will some expert(s) in statistics be involved in Task 3 (Seismicity Catalog Development) or only seismologists? My confidence in the expected products and their stability and longevity depends not only on knowing task breakdowns but also on having some idea of who will be doing the work.

2. Will there be a Web-based resource (possibly managed by the database contractor) to facilitate controlled access to basic project information and data—e.g., project documents, bibliographic literature, data and/or information products associated with relevant data, PowerPoint presentations made at workshops, etc.? Given the complexity and duration of the project, participants (including the PPRP) will be able to function far more efficiently and incisively if they don't have to be their own information managers. (We've all been there!)

3. *Figure 1:* Given the long intervals between the activity points (stars) for the PPRP, I suggest there be at least one teleconference, or some other form of communication, for the PPRP between each milestone to keep them informed and reasonably engaged. Access to a well-designed project Web site would motivate them to stay engaged (even on unpaid time).

4. *Task 2 (Database Development), page 6:* Regarding "available data in the academic sector," expect the usual problem of quality control for data and peer-reviewed status for information that may be introduced. Guidelines will likely have to be established by the TI team for using unpublished data and information from the academic sector (a common source of "red herrings").

5. *Task 3 (Seismicity Catalog Development), page 8:* The task breakdown includes tasks that, in my judgment, need to be performed or overseen by one or more experts in statistics. The plan importantly states that alternative approaches will be examined for the identification of dependent events within the catalog. Various stochastic approaches have been developed by statisticians since the work of Veneziano and Van Dyck as part of the EPRI-SOG project, so stability and longevity are issues here. Similarly, other approaches have subsequently been developed for assessing catalog completeness, and alternative approaches should be considered in order to give confidence to other practitioners about the stability of results.

6. *Task 7 (Construct Preliminary SSC Model), page 10:* Many practitioners in seismic source characterization tend not to use terms identical to those defined in Appendix A of NRC Regulatory Guide 1.165 (e.g., *capable tectonic source, seismogenic source*). The project may want to consider adopting—or at least incorporating—terms consistent with NRC terminology to avoid having to translate later.

7. *Task 7 (Construct Preliminary SSC Model), Earthquake Recurrence, page 11:* Mention is made of "Where data are available, paleoseismic recurrence will be incorporated…" If fault sources are identified, moment balancing may need to be considered for fault rupture models.

8. *Task 11 (Finalize SSC Model), page 13, paragraph 1:* What does it mean that, "Alternative models considered will be discussed"? Draft documentation part of this task?

9. *Task 12 (Document CEUS SSC Project in Draft Report), page 13:* Apart from "documentation" of software, are there project requirements for validation or other forms of quality control?

10. *Project Organization, page 15:* Other than the Database Manager, it's not clear how other Specialty Contractors (mentioned in the Executive Summary) fit into the Project Organization.

Brent J. Guetierrez (DOE)

1. *Executive Summary, 2nd paragraph;* clarify the overall purpose of the CEUS SSC project is in achieving stability and longevity; e.g., in what? Isn't the real purpose of the project to develop a new and updated CEUS SSC model with the benefits of wide

acceptance in the technical community and with sufficient technical robustness that affords longevity of the SSC model?

2. *Executive Summary, 2nd paragraph;* the sentences defining stability and longevity at present appear somewhat incongruous as written. How can you achieve the longevity as defined and expect the technical underpinnings to remain valid when new scientific findings becomes generally accepted by the technical community?

3. Page 7, 2nd paragraph; make the copies of the key papers available to the project sponsors and agency technical representatives.

4. *Page 7, last paragraph before Task 3 and Page 16, Quality Assurance:* This paragraph describes the management and documentation of data in accordance with a data management procedure, data assessment, and data storage, yet the quality assurance "tone" for this project is described as that meeting or exceeding the quality assurance associated with publication in a peer reviewed technical journal without being under the auspices of a project quality assurance program. Given the apparent vast nature of the data to be complied across several existent databases and sources, a more defined quality assurance/quality control program should be implemented for this project.

5. *Page 3 and Page 9;* on both of these pages reference is made to the NGA East project. For completeness, suggest you add additional text describing how the results of the NGA East project will be incorporated into this project (as they are available) and what potential impacts the results may have on this project.

William J. Hinze

1. *Executive Summary:* The two sentences – "*Stability means that the study enjoys public and regulatory confidence that it is generally accepted by the technical community. Longevity means that the technical underpinnings will remain valid in the future, despite the development of new scientific findings.*" - are the lynchpin of the Project Plan. I understand the stability issue and this is well documented in the SSHAC report. However, I do have concerns about the "longevity" issue. Longevity is an ambiguous term. Its meaning will change depending on the user. I find no reference to longevity in the SSHAC report. The "experience" that shows longevity is " … best achieved…" needs to be documented to make this a credible statement. I am concerned that longevity will mean to some users of the results of the proposed study that we can anticipate no improvements in seismic source characterization in the central and eastern U.S in the foreseeable future. This is potentially dangerous because science and databases continue to improve. Examples are the perceived need for this study and DOE's Probabilistic Volcanic Hazard Analysis – Update of Yucca Mountain. I suggest that some constraints be placed on the longevity issue to clarify its meaning in this context. Furthermore the results of Earth Scope studies in the central and eastern US are likely to impact seismic source characterization.

2. *Selection of SSHAC Study Level:* "*Balancing the need for stability and longevity with the need to expedite the study, the CEUS SSC project will be conducted using a Study*

Level 3 process for the key SSC issues. Lesser emphasis and Level 2 processes will be given to those issues having lesser hazard significance or are not subject to large uncertainty." Is it possible that these two criteria may work contrary to each other, i. e., some regions of lesser hazard may have a larger uncertainty? Which will take precedence?

<u>Jeffery W. Kimball</u>

1. *CEUS SSC Objective:* The DPP states that the overall objective of this work is to achieve stability and longevity. It is suggested that stability and longevity should be desired attributes for the work being performed, but not the objective. The objective of the CEUS SSC Project should be to develop an up-to-date assessment of probabilistic seismic hazard analysis (PSHA) seismic source characterization for the CEUS that (1) includes full assessment and incorporation of uncertainties, (2) appropriately includes the range of diverse technical interpretations from the informed scientific community, (3) includes consideration of an up-to-date data base, (4) that is properly documented, and (5) peer reviewed. If these objectives are achieved then the product (CEUS SSC input) should have stability and longevity.

2. *Focus on replacing 1986 EPRI-SOG:* In a number of places the DPP speaks to replacing the 1986 EPRI-SOG PSHA work. It is not clear why this emphasis is necessary. The introduction properly notes that the project will take full advantage of data from several seismic hazard studies. If all participants agree that we should work towards developing a community based CEUS PSHA, then this effort becomes a key part of that goal. If that goal is achieved all users, including critical facility owners, would be comfortable with using the results.

3. *Role of the United States Geological Survey (USGS):* The DPP appropriately includes a representative from the USGS on the participatory peer review panel. To work towards a community based CEUS PSHA it may be good to add an appropriate USGS person to both the TI Team and TI Staff. That would work if the USGS would agree to support the time and travel of these people. This would have the added benefit of increasing USGS confidence that the CEUS SSC products should become the national map products (supporting a community based PSHA). While it is understood that USGS personnel are not "officially" representing their agency (neither am I, for example), getting the right people throughout the organizational framework of this effort will provide long term benefits.

4. *SSHAC Level:* The DPP states that the higher the Study Level, the higher the assurance that the views of the community have been captured and represented. While this tends to be true, the intent of the SSHAC guidance report would be to have adequate confidence with any Study Level, otherwise how could you support anything less than SSHAC Study Level 4? Following SSHAC guidelines, the responsibility for assuring that the views of the community have been captured and represented rests with the Technical Integrator (TI) or Technical Facilitator/Integrator (TFI). The DPP is based on the assumption that an overall SSHAC Study Level 3 is appropriate for this effort, thus the overall approach is based on using a TI. As a starting basis this approach is workable,

but this should be confirmed at the end of Task 5, once it is determined which CEUS SSC issues are most significant. While all PSHA's assign an overall SSHAC Study Level to the project, the SSHAC guidance can be read as intending that SSHAC Study Levels apply to issues, not projects. The DPP recognizes that some issues may be addressed at Study Level 2. It may be that certain issues require some aspects of a Study Level 4. They key is to manage this appropriately given the available resource and time constraints.

5. *Task 4 – Assessment of Hazard-Significant Issues:* While in concept the completion of sensitivity studies on PSHA parameters is an important aspect of assessing the significance of PSHA SSC issues, care must be taken to ensure that no bias is introduced into this assessment. It is assumed that the purpose of the sensitivity studies will be to prioritize PSHA issues, and that the CEUS SSC input will be a "complete" update; not relying on existing SSC input from the 1986 EPRI-SOG study. It may be appropriate for the TI Team to request that the participatory peer review panel provide their PSHA experience in listing those PSHA SSC issues that could be significant. For example, experience with CEUS PSHAs would suggest that the following issues may be potentially significant. Many of these issues represent state-of-practice advances since the EPRI-SOG work.

Potentially Significant CEUS PSHA SSC Issues:

- Relationship between moment magnitude and source dimension such as source area or fault length.
- Treating seismic sources as point sources versus extended sources, for both specific seismic source zones (such as New Madrid, Charleston), and within broader areas of lower seismicity.
- Magnitude distribution approach, such as characteristic magnitude distribution versus truncated magnitude distribution. When to use which relationship.
- Magnitudes assigned to earthquakes found via paleoliquefaction evidence. In particular, the proper assessment of site response impacts on assignment of magnitudes.
- Approach to establishing maximum magnitude for regions of low seismicity.
- The seismic source approach to areas of low seismicity, specifically defined source zones versus use of smoothed seismicity.
- Approach to modeling faults for well defined source zones such as New Madrid and Charleston. Should faults be oriented randomly, or with specific orientations?

6. *Project Documentation:* The DPP could be improved in terms of listing expected documentation for each of the tasks and/or expected from project participants. In terms of the participatory peer review panel, will it operate as a unit, with written comments provided from the panel as a whole?

<u>Donald P. Moore</u>

I have reviewed the draft project plan and find it to be an excellent document that provides sufficient detail of the tasks required. As a SSHAC Level 3 effort and issues related to QA I think it is very important to retain complete documentation of all tasks and interactions that will form the basis for the new seismic source characterization. Also this documentation should be stored in a controlled fashion to allow easy recover of information. Possibley a procedure could be developed for this purpose.

Mark D. Petterson

The U.S. Geological Survey recently completed a national seismic hazard model considering many of the Central and Eastern U.S. hazard issues that will be discussed by the TI team. There has been some discussion about whether or not the USGS should participate on the TI team. After internal discussions, we feel that we should not be involved as technical integrators because of a perceived conflict of interest. The plan needs to make it clear that my participation on the review panel does not imply an endorsement by the USGS. I plan to contribute as an advisor to the NRC in reviewing this new source characterization.

The success of this project will depend on new databases of input data (e.g., moment magnitude catalogs, magnitude uncertainty and round-off estimates, liquefaction data, etc.); as well as objective and reproducible assessments of earthquake sources, rates, and magnitudes. We expect that all of this will be open to the public.

Section Objectives page 4 states: “the use of an appropriate ground motion model, which will be held constant” to isolate the relative importance of SSC issues will be required. Recent ground models vary by a factor of two between median ground motions for most magnitudes and distances. It seems like you may want to apply two equations that span the epistemic uncertainty within the relations.

Task 2: Database Development

The list of datasets should also include :

(1) the liquefaction dates from published literature. This is the basis for the recurrence models of the Wabash zone, New Madrid zone, and Charleston zones.

(2) Reflection data in localized or regional areas such as Charleston SC where the data indicated folded Miocene strata in the offshore region, Helena Banks fault zone.

(3) Bob Hermann’s catalog of regional earthquakes and the CMT catalogs that include moment calculations (to make the conversion between mblg and Mw – Task 3).

Task 7: Construct Preliminary SSC Model

Spatial distribution: I was confused by the meaning of item 2) identification of alternative conceptual models regarding spatial distribution and assignment of weights to the alternatives. How will zones be delineated?

Maximum magnitude Assessment: I am confused by the Baysian estimation procedure (i.e., how the prior distribution is obtained and how the short catalog gives information that can update the maximum magnitude prior distribution. Are other models going to be considered?

Earthquake Recurrence: I was confused by the statement that these codes will be updated to produce a- and b-values on a finer grid and in low historical activity rates. What methods will be used to determine rates?

Export Control Restrictions

Access to and use of EPRI Intellectual Property is granted with the specific understanding and requirement that responsibility for ensuring full compliance with all applicable U.S. and foreign export laws and regulations is being undertaken by you and your company. This includes an obligation to ensure that any individual receiving access hereunder who is not a U.S. citizen or permanent U.S. resident is permitted access under applicable U.S. and foreign export laws and regulations. In the event you are uncertain whether you or your company may lawfully obtain access to this EPRI Intellectual Property, you acknowledge that it is your obligation to consult with your company's legal counsel to determine whether this access is lawful. Although EPRI may make available on a case-by-case basis an informal assessment of the applicable U.S. export classification for specific EPRI Intellectual Property, you and your company acknowledge that this assessment is solely for informational purposes and not for reliance purposes. You and your company acknowledge that it is still the obligation of you and your company to make your own assessment of the applicable U.S. export classification and ensure compliance accordingly. You and your company understand and acknowledge your obligations to make a prompt report to EPRI and the appropriate authorities regarding any access to or use of EPRI Intellectual Property hereunder that may be in violation of applicable U.S. or foreign export laws or regulations.

The Electric Power Research Institute (EPRI), with major locations in Palo Alto, California; Charlotte, North Carolina; and Knoxville, Tennessee, was established in 1973 as an independent, nonprofit center for public interest energy and environmental research. EPRI brings together members, participants, the Institute's scientists and engineers, and other leading experts to work collaboratively on solutions to the challenges of electric power. These solutions span nearly every area of electricity generation, delivery, and use, including health, safety, and environment. EPRI's members represent over 90% of the electricity generated in the United States. International participation represents nearly 15% of EPRI's total research, development, and demonstration program.

Together…Shaping the Future of Electricity

© 2008 Electric Power Research Institute (EPRI), Inc. All rights reserved. Electric Power Research Institute, EPRI, and TOGETHER…SHAPING THE FUTURE OF ELECTRICITY are registered service marks of the Electric Power Research Institute, Inc.

Printed on recycled paper in the United States of America

1016756

Electric Power Research Institute
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com