

March 10, 2009

Via e-mail

Lawrence A. Salomone  
 Washington Savannah River Company  
 Savannah River Site  
 Building 730-4B, Room 3125  
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Dear Mr. Salomone:

Reference: *Central and Eastern United States Seismic Source Characterization for Nuclear Facilities: Participatory Peer Review Report on Workshop No. 2.*

#### Acronyms

CEUS	Central and Eastern United States
EPRI	Electric Power Research Institute
GPS	Global Positioning System
PPRP	Participatory Peer Review Panel
PSHA	Probabilistic Seismic Hazard Analysis
SSC	Seismic Source Characterization
SSHAC	Senior Seismic Hazard Analysis Committee
TI	Technical Integrator

This letter constitutes the report of the Participatory Peer Review Panel (PPRP) on Workshop No. 2 (WS-2), “Alternative Interpretations,” for the referenced project. The workshop was held February 18–20, 2009, at EPRI headquarters in Palo Alto, California.

Following guidance described in the Project Implementation Plan for the PPRP<sup>1</sup>, and consistent with the expectations of the SSHAC process<sup>2</sup>, the PPRP participated in WS-2 in order to be informed and to review both procedural and technical aspects of the workshop. All eight members of the PPRP (J. P. Ake, W. J. Arabasz, W. J. Hinze, A. M. Kammerer, J. K. Kimball, D. P. Moore, M. D. Petersen, and J. C. Stepp) attended WS-2 and were able to fully observe all aspects of the workshop.

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<sup>1</sup> *Implementation of the PPRP’s Participation in the CEUS SSC Project*: Written statement communicated by J. Carl Stepp to L. Salomone and the TI Team on June 16, 2008.

<sup>2</sup> 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.

## General Observations

We observed that the workshop generally achieved the goal of compiling the range of basic data and proponent experts' interpretations that together constitute the current state of knowledge of the technical community, which the TI Team must evaluate for assessing the seismic source model for the CEUS region. We noted that potential field data remain to be compiled and incorporated into the TI Team's evaluation. We understand from the discussion of actions remaining to be taken prior to WS-3 that this important compilation and evaluation will be accomplished as part of planned working meetings of the TI Team prior to WS-3.

We observed that the skillful organization of the workshop stimulated lively inquiry and debate among proponent experts and members of the TI Team. The results will be useful for the TI Team in subsequent evaluations and assessments of uncertainties both in elements and parameters of the CEUS seismic source model. The questions provided by the TI Team to the proponent experts in advance of the workshop proved to be useful and effective. The questions focused the presentations by the invited experts and they stimulated interactions not only between the TI Team and proponents of specific hypotheses and interpretations of data but also among proponent experts.

## Specific Comments and Recommendations

Provided below are comments and recommendations for follow-up actions by the TI Team for completing its evaluations and the CEUS seismic source model assessment. We note that many of these comments were touched on by Kevin Coppersmith in the final presentation of the workshop in which he described the actions that the TI Team already plans to take to complete its evaluations and the model assessment. If the TI Team successfully implements those actions, then most of the items described below would be adequately addressed.

1. *Need for a Tectonic Framework:* The range and complexity of alternative hypotheses and interpretations presented at WS-2 reinforce our previous recommendations concerning the need, first, to evaluate an overall tectonic framework for the study region and, second, to properly incorporate this evaluation into the CEUS seismic source model assessment.

We consider a transparent evaluation of uncertainty to be a necessary element of the tectonic framework evaluation. The tectonic framework should have a universal role in the seismic source model assessment. This would establish the approach and scale for the seismic source model assessment, and it would provide a transparent, consistent assessment (weighting) of the complex alternative interpretations and hypotheses that constitute the current state of knowledge of the technical community.

We observed that some proponent interpretations regarding seismic sources and the origin of the seismicity in the CEUS pointed to the significance of evaluating the geological and seismological characteristics of the entire lithosphere—including the upper brittle crust, the ductile lower crust, and the upper mantle. Geological and geophysical evidence indicates that these various zones of the lithosphere are laterally heterogeneous, which could have

profound impact on the seismicity of the brittle upper crust. As a result, we recommend that the TI Team should include the attributes of the entire lithosphere in their evaluation of the tectonic framework and their seismic source model assessment.

2. *Approach to Seismic Source Assessment and Scale:*

a) “Granularity” of Seismic Source Model (i.e., the scale of uniform scrutiny): During the workshop, geological structures ranging in scale from very local to continental-scale were described and discussed. We recommend that the TI Team provide early assurance, through assessment criteria that are explained and justified, that a systematic approach and procedure are being used for defining and assessing seismic sources in terms of scale.

These assessment criteria will facilitate subsequent use of the model for a site-specific PSHA at any site in the study region. The assessment criteria should be at a level of detail that appropriately incorporates the state of knowledge of the sources and the current understanding of their inherent complexity. Using the criteria, one should be able to distinguish specific sources that have significant, identifiable, and relatively consistent seismic hazard potential. This systematic approach should be applied consistently across the study region.

b) Approach to Smoothing: We observed that there was little discussion or consideration of uncertainty involved in smoothing recorded seismicity versus deductive seismic source assessment, and there was no evaluation of alternative smoothing parameters. We consider this to be an important part of the assessment for the CEUS seismic source model and we recommend greater attention to the issue of smoothing and corresponding documentation.

3. *Integrated Evaluation of Paleoliquefaction and Interpretations of Paleo-Fault Displacements:*

a) Uncertainties in age dating: Multiple proponent experts discussed their interpretations of evidence for recent fault movement or the dating of geologic surfaces related to the formation of paleoliquefaction features. The proponents did not sufficiently describe the uncertainties in the age dating within their respective studies, and as such, the overall quality and reliability of this information is in question. The TI Team should strive to better understand the overall quality of these studies and develop a cohesive understanding of how the results can and cannot be used to establish recurrence information for various seismic sources. We recommend that the TI Team perform an integrated analysis of the body of paleoseismic investigation results in the vicinity of the New Madrid Seismic Zone using appropriate statistical methods. The study should incorporate uncertainty in the interpretations, to the extent that the uncertainty is described in or can be reasonably interpreted from the study results, in order to better correlate event times and rates of activity.

b) Size of paleoearthquakes: Paleoliquefaction is widely accepted to be a useful basis for assessing a seismic source model for the CEUS region; it is likely to gain even more importance in the future. The new approaches presented at WS-2 for assessing uncertainty in the observed data and interpretations and for using the interpretations for estimating the

size of causal earthquakes have great promise and should be pursued in the future. At present, the uncertainties resulting from both the current and the newly presented methods are poorly constrained. We recommend that particular care be taken in estimating magnitude and in assigning corresponding uncertainties. We further recommend that the lack of evidence of paleoliquefaction not be used to determine maximum magnitude.

c) Time-dependent models: Given the importance of paleoliquefaction studies for evaluating the New Madrid and Charleston seismic zones, the TI Team should make a fundamental decision whether the incorporation and use of time-dependent recurrence models should be pursued. While this topic came up during the workshop, there was no discussion focused on what weight should be given to time-dependent recurrence models. It was not clear how the TI Team would assess the views of the technical community on this issue.

4. *Documentation of how alternative views are used:* At WS-2 a wide range of proponent views within the scientific community were presented about a number of important seismic source related issues. It is clear that, when assessed in detail, most CEUS locations are complex, with heterogeneities playing an important role in creating the data observed in the field. The TI Team needs to document how alternative views are accounted for in the assessment of the seismic source model to be presented in May 2009.

5. *The hypothesis of late aftershocks:* During the workshop, a proponent, using chiefly qualitative evidence, offered the view that much of the contemporary seismicity observed in the CEUS represents late aftershock activity of prior moderate to large earthquakes. If this view is used by the TI Team as a working hypothesis, it should first be critically examined. Standard seismological and statistical tools exist for verifying whether observed contemporary seismicity can plausibly be related to prior earthquakes, consistent with aftershock decay models such as the modified Omori model or Ogata's epidemic-type aftershock sequence (ETAS) model. Modern aftershock sequences in the CEUS, for example, can provide Omori parameters that can be used to test the hypothesis of long-lived aftershock sequences in the region.

6. *Temporal Clustering:* One uncertainty that was briefly discussed is whether the New Madrid seismic source zone is coming out of a cluster in terms of short repeat times for larger earthquakes. Some proponents cited GPS data that indicate little if any measurable strain in the New Madrid seismic zone region over the past 20 years, and one proponent presented geologic evidence that could be interpreted to indicate a history of clustering with very long geologic time intervals between clusters. The available data and overall lack of understanding of the mechanisms that may drive a clustering model for the New Madrid seismic source zone warrant caution about the supposition that a clustered sequence of higher recurrence behavior is ending.

7. *SSHAC process issues:* Under SSHAC guidelines, the makeup of the TI team has implications for ownership issues relating to the seismic source model and subsequent hazard results. As evident during the workshop, there are blurred boundaries between the TI Team specified in the CEUS SSC organization chart and the TI Staff. The working "TI

Team” appears to consider itself a larger group than listed in the Project Plan. The makeup of the “TI Team” in terms of individuals who will be responsible for ownership of the SSC inputs should be clarified.

We also note that in the SSHAC framework there conventionally is a distinction between the TI (or TI Team) and the hazard analyst. In the CEUS SSC project this distinction is blurred with Robin McGuire having a dual role as a member of the TI Team and as one of the key analysts responsible for computing hazard at seven demonstration sites. This is not a conflicting role and indeed adds strength to the project. We suggest, however, that this circumstance be explained in the final project report.

Do not hesitate to contact us if you wish to discuss any of our observations, comments, or recommendations.

Sincerely,

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