

INFORMAL COMMUNICATION

To: Larry Salomone
From: Walter Arabasz and Carl Stepp
Date: September 26, 2011
Subject: PPRP Non-Mandatory Comments on Installments 1 and 2 of Final Report

As an addition to our PPRP letter report to you on this same date, we are providing here a list of Non-Mandatory Comments on both Installments 1 and 2 of the *Central and Eastern United States Seismic Source Characterization for Nuclear Facilities, Final Report* (June–August 2011).

These non-mandatory comments are intended to help improve the Final Report. We understand that they will be handled by the TI Team as feasible and at their discretion.

Notes:

1. *August 5, 2011, document now obsolete:* All of our review comments on Installment 1 that we submitted in draft form on August 5, 2011, have subsequently been flagged as either “mandatory” or “non-mandatory.” The former are included in our companion PPRP letter report and the latter have been incorporated into this Informal Communication. Hence, the August 5, 2011, document is obsolete.
2. *Comprehensive Technical Editing Not Done by the PPRP in this Review Cycle:* In reviewing the CEUS SSC Draft Report of July 31, 2010, the PPRP made diligent efforts to identify shortcomings in the clarity and completeness of documentation, and we offered numerous comments to help improve the reporting. In reviewing the revised 2011 version of the Final Report, we have not assumed responsibility for *comprehensive* technical editing, leaving that task to the Project Team’s support staff. Our non-mandatory review comments do, however, include a significant number of minor editorial comments and point out some typographical errors. Also, individual members of the PPRP have provided added information to the Project Manager to help in final-stage editing.

If you need more information or clarification, please contact either of us.

For the PPRP,

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KEY TO LABELING OF PPRP REVIEW COMMENTS

Central and Eastern United States Seismic Source Characterization for Nuclear Facilities Final Report, June–August, 2011

Format for Numbered Comments: X Y-N		
(FR)	Final Report*	
X	Type of Comment:	G (General), S (Specific), or CC (comment relating to clarity, completeness, or error in documentation)
Y	Part of Report:	1, 2, . . . , 11 (Chapter 1, 2, . . . , 11) A, B, . . . , K (Appendix A, B, . . . , K) Acr = Acronyms ES = Executive Summary FM = Front Matter
N	Sequence Number:	1, 2, . . . , n

* The flag “(FR)” is included to indicate that the review comment applies to the CEUS SSC Final Report—to avoid confusion with similarly labeled PPRP review comments on the Draft Report of July 2010).

Example: Review Comment **(FR) G 3-1** applies to the Final Report, is a General Comment, applies to Chapter 3, and is the first comment of this type for that chapter.

FRONT MATTER

PRODUCT DESCRIPTION

Minor Editorial Comments and Typographical Errors

- In the third line of the first paragraph, the EPRI reference should be to the NRC-accepted report: EPRI Report EPRI-NP-4726-A (1988).
- Under **Keywords**, change “Probabilistic seismic hazard assessment (PSHA)” to “Probabilistic seismic hazard analysis (PSHA)” [e.g., see Glossary in Chapter 11].

EXECUTIVE SUMMARY

General Comments

(FR) G ES-1. In general, the Executive Summary is complete, very informative of the Project, and well written. However, because this part of the report will be read by the largest number of readers, and ideally written as a “stand-alone” part, it should (a) strive to use language that will be generally understandable, (b) eliminate acronyms or at least explain them (e.g., SCR is not explained), and (c) avoid references. Consider including subheadings to guide the reader, and consider referring to particular chapters or sections of the report (as is done in some parts of the Executive Summary) to make it easier for the reader to focus on a topic of particular interest.

Comments for Clarity and Completeness

(FR) CC ES-1. (Limitations of historical seismicity record): The sentence in the last paragraph of page xii dealing with the relationship of the locations of small- to moderate-magnitude earthquakes to locations of future large earthquakes is very important. In the initial description of this topic in the first paragraph of Section 5.1.1, limitations to this relationship are discussed. It would be useful in the Executive Summary to similarly note that there are limitations to this relationship and also note the importance of using geology and geophysics in identifying and characterizing seismic source zones in cratonic regions.

It would be informative to the reader if the Executive Summary stated that the CEUS SSC Model is based to a large extent on the assumption, typical in PSHA studies, that spatial stationarity of seismicity is expected to persist for a time period of approximately 50 years. The report has a definite lifetime.

(FR) CC ES-2. (“Reasonable” results): The third full paragraph of page xvi (regarding the seven demonstration sites) distills one of the most important parts of the report. The TI Team may wish to re-examine the conclusion in the last sentence that the CEUS SSC model provides “reasonable” seismic hazard results. Can a more definitive term be used?

Minor Editorial Comments and Typographical Errors

- Page ix, 1st para., last line: Consider changing “considered” to the more precise word (with respect to the SSHAC process), “represented”

- Page ix, 2nd para., line 6: EPRI (2006) . . . 2006a, 2006b, or both?
- Page xi, 1st partial para., line 2: Consider inserting “stresses in the crust and” following “near-surface indications of”; line 3: “stresses” should be “strains” and “identify” should be “quantify”; line 4: “future earthquakes”
- Page xii, 3rd para., line 1: In the word string: “the conceptual SSC framework and” change “and” to “, which”; line 2: instead of “identifies” use the more properly descriptive word “depicts”; line 3: use the more precisely descriptive word “interpretations” instead of “approaches”; replace “will be used” with “represent the range of defensible interpretations”; replace “establishes” with “depicts” and replace “assigned to” with “assessed for”; line 4: delete “main”
- Page xii, 1st bullet following the second full para.: Consider replacing “consideration” with the more properly descriptive word “representation”; 3rd bullet: Consider replacing “consideration of” with the more directly informative “representation of uncertainty in”; 4th bullet: replace “consideration” with “representation”
- Page xiii, top line: Insert “uncertainty in” following “assessment” and delete “have been relatively”; line 10 “uses”
- Page xiv, last full para., line 8: Replace “reflects the relative degree of belief” with “represents the uncertainty in the interpretation”; line 12: Delete first “resulting”
- Page xvi, 3rd full para., line 9: Change “characteristics for” to “characteristics of”; last line: change “adequately” to “appropriately”
- Page xvii, 3rd full para., next to last line: change “10⁻⁶” to “10⁻⁷” [Note: Per discussion at the PPRP Closure Briefing on September 7, 2011, the AFE of 10⁻⁶ is correct if the reason for focusing on 10⁻⁴ to 10⁻⁶ is explained in Chapter 9.]

ACKNOWLEDGMENTS

Depending on resolution among the sponsors for wording to be used on the title page, similar wording might be used for emphasis in the first sentence here. For example: “This study was jointly sponsored by the following three entities: . . .”

SPONSORS’ PERSPECTIVES

No comment.

ACRONYMS

The revised 2011 version appears to be reasonably complete (not exhaustively checked).

CHAPTER 1 — INTRODUCTION

General Comments

(FR) G 1-1. Chapter 1 has been substantively revised from the July 31, 2010 draft. The current June 2011 version (Installment 1 of the Final Report) suitably responds to the PPRP’s earlier review comments, as summarized in the TI Team’s *PPRP Comment Resolution Table*. The chapter is now well structured and relatively complete in scope. However, the PPRP has some continuing concerns about clarity (see *Comments on Clarity and Completeness*, below). (See also PPRP Mandatory Comments Nos. 1, 2, 7, and 8.)

Comments on Clarity and Completeness

(FR) CC 1-1. (Clarity of wording in Section 1): Comments going to the issue of clarity of wording in Section 1, particularly Sections 1.1 through 1.2.2 are extensive. By agreement with the Project Manager, they have been made as edits in “Track Changes” format and have been submitted separately.

(FR) CC 1-2. (Adding helpful citations in Section 1.1.1): Although the USGS SSHAC implementation report and the NRC SSHAC implementation guidance (NUREG-XXXX, out for comment) are referenced later in the report, it would be helpful to reference them here.

(FR) CC 1-3. (Community-based model): Section 1.1.4 is titled “Community-Based Region SSC Model for Nuclear Facilities.” While the concept of “community-based” has come up in several instances as part of broad PSHA efforts, these words could spark needless debate and are not necessary here.

(FR) CC 1-4. (Aid to locating key products in the report): In Section 1.4.4, consider referencing locations in the report where the identified key products are described.

(FR) CC 1-5. (Website “being developed”): Mention of the project website in Section 1.4.4.2 should not refer to development but rather the availability of the website at a specific address.

(FR) CC 1-6. (Use of earthquake catalog): In the last sentence of Section 1.4.4.3, we suggest describing that the project earthquake catalog was used in identifying and characterizing seismic source zones as well as for characterizing recurrence and Mmax parameters.

Minor Editorial Comments and Typographical Errors

- Throughout the report there is inconsistent style in the figure captions and table titles. In some cases, only the first letter of the first word is capitalized whereas in others the first letters of all major words are capitalized. There is similar inconsistency in using an ending period at the end of figure captions and table titles.

Some miscellaneous editorial comments and suggestions relating to Chapter 1 have been provided separately to the Project Manager. See also Comment **(FR) CC 1-1** regarding suggested edits provided separately to the Project Manager.

CHAPTER 2 — SSHAC LEVEL 3 ASSESSMENT PROCESS AND IMPLEMENTATION

General Comments

(FR) G 2-1. Chapter 2 has been extensively revised from the July 31, 2010 draft, and we commend the TI Team for this important effort and for diligently responding to the PPRP’s earlier review comments, as summarized in the TI Team’s *PPRP Comment Resolution Table*. The restructured chapter is greatly improved. To help with some further refinement, we offer one specific comment (see PPRP Mandatory Comment No. 2, “Identification and Engagement of Experts”) together with a number of comments on clarity and completeness.

Comments on Clarity and Completeness

(FR) CC 2-1. (Meeting of May 28): In Section 2.2 (Table 2.2-1), the meeting of May 28, 2008, which played an important role in the project, is not included.

(FR) CC 2-2. (Section 2.3, PPRP): In describing the role of the PPRP in Section 2.3 on page 2-7, the last sentence should be revised to read, “PPRP responsibilities included review of both the Draft Project Report and the Final Technical Report developed by the TI Team.” Also, it seems appropriate to mention the role of the PPRP in finalizing the Project Plan, which was a significant and important activity of the PPRP.

(FR) CC 2-3. (Section 2.3, TI Team): In describing the TI Team in Section 2.3, consider mentioning the size of the TI Team. Given the unique SSHAC role of an “evaluator,” one of the key aspects of this project was to help train some new “evaluators,” able to lead or participate in future PSHAs as needed.

(FR) CC 2-4. (AFEs for nuclear facilities): In the first paragraph of Section 2.4.2, the AFEs of interest for nuclear facilities should be 10^{-3} through 10^{-7} (see also Comment **(FR) CC 1-6**).

(FR) CC 2-5. (PPRP involvement): The discussions in Sections 2.4.9 (*Finalization and Review of SSC Draft and Final Model*) and 2.5.2 (*Reviews and Feedback*) do not reflect the PPRP’s participation in identifying key issues that required resolution. For example, while the TI Team did continue to refine the SSC Model associated with the initial Draft Report during the PPRP review, the PPRP independently identified a number of critical technical issues that required resolution. A few minor edits in these sections could convey a better sense of the PPRP’s participation in the process.

(FR) CC 2-6. (Confusing descriptions in Section 2.4.10): The writing in Section 2.4.10 contains confusing descriptions, including tense, relating to the chronology of developments, and there is ambiguity as to whether products described relate to the draft or final versions of the project report. A markup of Chapter 2, provided separately to the Project Manager, contains numerous suggested edits for improving the clarity of Section 2.4.10.

(FR) CC 2-7. (Another key activity for Section 2.4.10): In Section 2.4.10, as part of the documentation of “Key Tasks and Activities” (title of Section 2.4), consider explicit mention of

the development of a “Conceptual Seismic Source Characterization Framework”—now the subject of Chapter 4 in the Final Report.

(FR) CC 2-8. (Placement of PPRP closure letter in the report): The last sentence in Section 2.5.3 on p. 2-20 now reads, “The final activity conducted by the PPRP was the development of its closure letter, which is appended in this report.” If our closure letter is placed after the Executive Summary (see Comment **(FR) S I-1**), this sentence will need to be revised.

(FR) CC 2-9. (Uniform data base to all experts): In Section 2.6, Item 3 (*Provide a uniform data base to all experts*) on p. 2-22, the text needs to make it clear that the Data Summary and Evaluation tables are viewed by both the TI Team and the PPRP as critical to the success of the project. This is the first project to rigorously and systematically document this information, and it is viewed by the PPRP as essential information to support the descriptions and discussion eventually found in Chapters 6 and 7. Early in the project, the PPRP encouraged the TI Team to create the Data Summary and Date Evaluation tables.

(FR) CC 2-10. (Confusing descriptions of the number of working meetings): In Section 2.6, in the first paragraph under Item 5 on p. 2-23, reference is made to “Nine multiple-day working meetings.” To avoid confusing the reader (given the information in Table 2.2-1 and Section 2.4.5 describing 11 working meetings), consider writing: “Nine of the 11 working meetings (see Section 2.4.5) were multi-day meetings of the TI Team to review data and develop the SSC assessments.” Similarly, the first sentence of the second paragraph can be clarified by writing, “One or more members of the PPRP participated as observers in six of the nine multi-day working meetings and in eight of the 11 total working meetings.”

Minor Editorial Comments and Typographical Errors

- In the third subheading within Table 2-2.2 (“Technical Experts Contacted During Course of CEUS SSC Project”), would it be more descriptive to replace “Contacted” with “Who Contributed” or “Who Were Interviewed”?
- In Section 2.4.1, replace “aeromagnetic” with “magnetic”
- In the final paragraph of Section 2.4.1, it would be helpful to give the website address.
- In Section 2.4.8, first paragraph, the citation “(NRC, in review)” presumably will be updated, together with a corresponding entry in the list of references, to point the reader to an identifiable source of information.

In addition to the editorial comments listed above, a markup of Chapter 2 provided separately to the Project Manager includes many other editorial suggestions for improving the text.

CHAPTER 3 — EARTHQUAKE CATALOG

General Comments

(FR) G 3-1. Revisions made to Chapter 3 in the August 2011 installment of the Final Report, as summarized in the TI Team’s *PPRP Comment Resolution Table*, suitably respond to the PPRP’s earlier review comments. The revised chapter, with its 43 pages of text plus 87 pages of tables and figures, vastly improves the documentation in the 2010 draft version, which had 13 pages of text plus 20 pages of tables and figures to describe essentially the same subject matter. We commend the authors for their painstaking efforts, not only in developing the milestone Project catalog but also in effectively documenting and completely describing the many steps involved.

Comments on Clarity and Completeness

(FR) CC 3-1. (Units of Modified Mercalli Intensity): On pp. 3-6 and 3-7, differences in MMI are described in terms of “degrees.” Richter (1958, p. 136) refers to “levels of intensity,” which is a more common descriptor in connection with the MMI scale than “degrees of intensity.” Consider substituting “level” for “degree” in the three occurrences on pp. 3-6 and 3-7.

(FR) CC 3-2. (Reduced standard errors): On p. 3-28, the text states: “The value of $\sigma_{M|mb} = 0.24$ reflects the value of 0.29 obtained from the regression reduced by the average value of $\sigma[M|\hat{M}] = 0.16$ for the earthquakes used in the regression (Equation 3.3.1-8).” Is the referenced equation indeed the correct one? To reproduce this result, does the reader need to know a value for b ? In subsequent sections where a reduced standard error is described (§3.3.2.5, §3.3.2.6, §3.3.2.7, and §3.3.2.8) no similar reference is made to Equation 3.3.1-8 to guide the reader.

(FR) CC 3-3. (Seismic source zones): The caption, or legend, on Figure 3.2-7 should explain the bold lines outlining the seismic source zones. Also, because the seismic source zones and their geometries have neither been discussed nor presented prior to Chapter 3, the caption should contain a note to provide an advance reference informing the reader about them.

(FR) CC 3-4. (Description of declustering results): In the first full paragraph on page 3-39 describing Figure 3.4-3, the reader should be cautioned of pitfalls in interpreting the figure. For example, the data points from EQCLUSTER plotted in the right-hand part of the figure (described as “the maximum distance between earthquakes assigned to a cluster”) represent a nearest-neighbor distance and not the same distance “window” used by Gardner and Knopoff (1974), i.e., the maximum distance between the largest shock in a sequence (the main shock) and one of its dependent events. Also, while the “average” space-time dimensions of the EPRI (1988) procedure can be compared with the space-time windows of Gardner and Knopoff (1974), the latter represent optimized *envelopes* to their data, not *average* dimensions.

The last sentence of the paragraph, referring to Figure 3.4-3, states: “The EPRI (1988) procedure does identify some clusters that have a much longer duration than the published time windows.” Examining the left-hand side of Figure 3.4-3, this is clearly an understatement—particularly for parent events smaller than about $E[M]$ 3.5. [The latter suggests that the EPRI approach is identifying significantly more events in the catalog as dependent events, compared to the Gardner and Knopoff approach—but the effects of “thinning” as opposed to “removal” have to

be kept in mind.] A point that passes without comment is the fact that in their 1974 study, Gardner and Knopoff identified approximately one-third of their catalog as independent events. In contrast, more than three-fourths of the earthquakes in the CEUS SSC catalog are identified as independent events (Table 3.4-1). Bottom line: If correct, Table 3.4-1 is what it is, and attention to those results is appropriately emphasized in the subsequent paragraph.

(FR) CC 3-5. (McLaughlin et al., 1977, and USNSN): On p. 3-43, an analysis by McLaughlin et al. (1997) of the USNSN is described to address the probability of detection in the CEUS for 1995–2008. As a matter of up-to-date reporting, the USNSN is an obsolete term insofar as the network has been superseded by the ANSS national backbone network of nearly 100 stations (see <http://earthquake.usgs.gov/monitoring/anss/backbone.php>). The ANSS backbone network, including many of the original USNSN stations, was upgraded and expanded in 2004–2006, and many other ANSS regional network stations have been added in the CEUS during the last decade. Consider something like the following at the end of the first paragraph on p. 3-43: “During 2004–2006, the USNSN was upgraded and expanded to become the current ANSS backbone national network of nearly 100 stations, and many ANSS regional network stations have been added in the CEUS during the last decade. For our purposes, the USNSN analysis still serves as a useful baseline.”

Minor Editorial Comments and Typographical Errors

- Pagination of the tables and figures should be sequential with the text.
- On p. 3-5, in line 5 of the last paragraph: consider changing “The magnitudes clearly line up” to “Nearly all the magnitudes line up”
- On p. 3-8, in the first line of the second paragraph: unclear word string: “the specific magnitude time reported”
- On p. 3-8, in line 5 of Section 3.2.4: change “SEUSSN, Lamont” to “SUSN, LDO”
- On p. 3-9, line 1: change “published in literature” to “published in the literature”
- On p. 3-9, in line 6 of Section 3.2.5: change “Dr. Chuck Mueller” to “Dr. Charles Mueller” for consistency elsewhere (e.g., p. 3-3); in this same paragraph, change “Dr. Talwani” to “Dr. Talwani; also in this same paragraph, in the next-to-last line: change “the event is considered” to “the classification is considered”
- Search the chapter globally and change (where appropriate) M to **M**; also, N* to *N** (multiple corrections are needed on p. 3-17).
- In the table on p. 3-12, column 1 has incorrect symbols: e.g., change “Number $4.0 \geq M > 4.5$ ” to “Number $4.0 \leq M < 4.5$ ” and so on (see also a similarly incorrect occurrence on p. 3-16).
- On p. 3-20, in the next-to-last line of the first paragraph of Section 3.3.2.2: change “observe value” to “observed value”
- On p. 3-22, in line 2 of the second paragraph of Section 3.3.2.3: change “in northeastern United States” to “in the northeastern United States”
- On p. 3-23, in line 2 of the second paragraph: delete “)” after 1997.

- On p. 3-40, in the fifth line from the bottom: change “imposes the ideas that” to “imposes the idea that”
- In Table 3.3-1, in column 2 for M_L reported by GSC, should be $m_b = M_L - 0.21$ (not 21, typo).
- The figure captions on Figures 3.3-2 to 3.3-4 reference “Table B-X” in Appendix B; this should be Table B-2 (Moment Magnitudes).

CHAPTER 4 — CONCEPTUAL SEISMIC SOURCE CHARACTERIZATION FRAMEWORK

General Comments

(FR) G 4-1. Revisions made to Chapter 4 in the June 2011 installment of the Final Report, as summarized in the TI Team’s *PPRP Comment Resolution Table*, suitably respond to the PPRP’s earlier review comments. Comments on clarity and completeness for additional consideration are provided below. (See also PPRP Mandatory Comments Nos. 3 and 4.)

Comments on Clarity and Completeness

(FR) CC 4-1. (Potentially problematic statement): In the second paragraph of Chapter 4 on p. 4-1 it is stated that “nearly all of the PSHAs developed for nuclear facilities in the CEUS have been conducted by members of the TI Team” This part of the sentence is not needed and is not the critical aspect of why the TI Team was qualified to perform this study (we recommend avoiding language that could be read as a bias).

(FR) CC 4-2. (Need for conceptual SSC framework): In Section 4.1, consider noting that the need for a conceptual SSC framework was something the PPRP encouraged the TI Team to develop in order to strengthen the overall basis of the SSC model. Many of the operative words in the three items were voiced early by the PPRP.

(FR) CC 4-3. (GPS studies and crustal strain in the CEUS): One of the more important scientific advances in seismic hazard studies since the mid-1980s has been the use of GPS to investigate current strain in the CEUS. The studies available to date have been set aside in the report because of the immaturity of the science and the studies—that is, in the modeling and also the measurements. Justification for neglecting these studies (e.g., in Section 4.1.2.2) is based on a few declarative statements without supporting evidence from knowledgeable experts in the discipline. Neglecting GPS studies would have much more credence if the report cited some appropriate literature or reports, e.g., the recent report prepared for the USGS on the use of GPS in determining the hazard in the NMSZ.

(FR) CC 4-4. (Paleoliquefaction data compilation): In Section 4.1.3, the text should briefly mention that after Workshop 2, the Project and the TI Team were encouraged to develop and complete the paleoliquefaction task to help support the final TI Team assessments. The paleoliquefaction data compilation represents a major accomplishment that needs to be emphasized more in the text.

(FR) CC 4-5. (Significant differences in hazard): On page 4-10 in the last sentence of the first paragraph, the text discusses the consideration of site-specific refinement of the CEUS SSC model “only if such refinement would lead to significant differences in hazard.” Consider referring the reader to the appropriate section(s) of Chapter 9 for insights on “significant differences” in hazard.

(FR) CC 4-6. (Four criteria for identifying seismic sources): In Section 4.1.3.3 four criteria are given that are used in the Project for identifying seismic sources. They are described as being used sequentially in the process, not simultaneously or without priority, and text on pages 4-15 through 4-17 provide useful details on the importance and use of these criteria. However,

it is never explicitly explained why the order of the criteria as listed on page 4-15 is used. Is there a criterion used to establish the sequential order? If so, please explain.

(FR) CC 4-7. (Details relating to Table 4.1.3-1): In Section 4.1.3.3, in the second paragraph on page 4-17, reference is made to Table 4.1.3-1 serving as a summary of criteria used in the identification of each of the seismic source zones. Please explain that the X in the matrix indicates that this criterion was applied, if indeed that is the case, and identify somewhere on the table the significance of the X. Also, note that this table does not include the probability of activity of tectonic features, which is one of the criteria used to identify seismic source zones. This needs to be clarified where the table is introduced in the text, and it would be helpful to include a statement to that effect in a footnote to the table; otherwise, this criterion (probability of activity) is lost to the identifiable criteria in the table. (See also Comment **(FR) CC 7-2**).

(FR) CC 4-8. (Descriptions relating to draft vs. final model): Chapter 4 will need to be checked carefully for statements of technical detail that do not reflect the *final* model (described in Chapters of Installment 2, not yet available at the time of this review). For example, the third full paragraph on page 4-22, refers the reader to discussion in Section 5.3 and describes approaches that do not appear to correspond to cases A, B, and E for the weighting of magnitude bins.

Minor Editorial Comments and Typographical Errors

Some miscellaneous editorial comments and suggestions relating to Chapter 4 have been provided separately to the Project Manager.

CHAPTER 5 — SSC MODEL: OVERVIEW AND METHODOLOGY

General Comments

(FR) G 5-1. Revisions made to Chapter 5 in the August 2011 installment of the Final Report, as summarized in the TI Team’s *PPRP Comment Resolution Table*, suitably respond to the PPRP’s earlier review comments. (Besides the comments on clarity and completeness below, see also PPRP Mandatory Comment No. 5, “Evaluation of Cases A, B, and E.”)

Specific Comments

(FR) S 5-1. *RLME Recurrence Rate Calculations*

In general, the description of the recurrence methodology is relatively brief compared to descriptions of methodology in other parts of the report. Given the supporting use of a single figure (incorrectly identified as a normalized probability density function), it’s likely that only knowledgeable practitioners will fully understand the details of the recurrence-rate methodology, particularly for the recurrence-interval approach. Treating paleoearthquake information correctly to calculate earthquake rates is a common requirement in PSHA. As presently described, it is unclear whether the recurrence-interval approach used for the Poisson case is the most appropriate statistical method or just one alternative (e.g., when paleoearthquake dates are available, it is common to observe others calculating λ as the inverse of the mean inter-event time).

In scrutinizing the RLME rate calculations in Chapter 6 and the HID, some key information is unavailable for review, notably the distribution of numerical ages for the oldest paleoearthquakes that propagate into the RLME Poisson recurrence-frequency distributions when the earthquake-recurrence-interval approach is used. Tabulation of these data would be useful for future readers.

Comments on Clarity and Completeness

(FR) CC 5-1. (AFEs for nuclear facilities): In the first paragraph of Section 5.2, the text states: “However, at annual frequencies of interest for nuclear facilities ($\leq 10^{-4}$) . . .” Change the parenthetical statement to (10^{-3} to 10^{-7}). (See PPRP Mandatory Comment No. 8, “AFEs for Nuclear Facilities.”)

(FR) CC 5-2. (Number of superdomains): In Section 5.2.1.1, in the last sentence of the second paragraph on page 5-11, the text states: “The result was 15 active (i.e., containing earthquakes) non-extended superdomains and 15 active extended superdomains.” These values are inconsistent with those on Figure 5.2.1-4; the numbers on the figure appear to be correct.

(FR) CC 5-3. (Discrepancy between text and Figure 5.3.2-1): Text in the fourth paragraph on p. 5-36 is inconsistent with Table 5.3.2-1. (See PPRP Mandatory Comment No. 5, “Lack of table defining Cases A, B, and E.”)

(FR) CC 5-4. (Error in Table 5.2.1-6?): The Mmax values listed in Table 5.2.1-6 for MESE-N appear to be a five-point distribution for the Kijko results and not for the Composite Distribution used in the hazard calculations, as stated in the text in the second paragraph on p. 5-21.

Minor Editorial Comments and Typographical Errors

- Pagination of the tables and figures should be sequential with the text.
- Search the chapter globally and change M and M_w to **M**.
- On p. 5-13, line 10: change “earthquaks” to “earthquakes”
- On p.5-13, in the next-to-last sentence of the second full paragraph: change “After evaluation the the results” to “After evaluating the results”
- On p. 5-15, in the first sentence of Section 5.2.1.1.5: change “criticized” to “criticized”
- On p. 5-16, in the next-to-last line of the first full paragraph: change “distributin” to “distribution”
- On p. 5-23 in introducing Equation 5.3.2-1, delete or change the ending words “with mean rate:” What follows the semi-colon is not a formulation for mean rate, it is a formulation for the number of earthquakes.
- On p. 5-24 in the paragraph beginning “In general”: The third sentence incorrectly states: “If the data are scarce, the likelihood function has a broad shape, indicating low uncertainty.” Substitute “high” or “large” uncertainty for “low uncertainty.”
- On p. 5-25, in the last line of the second paragraph: change “function for for” to “function for”
- On p. 5-26, first line: change “aren not” to “are not”
- On p. 5-26, in the last sentence of the second full paragraph: change “We note that expression” to “We note that the expression”
- Section 5.3.2.2.1: The zone acronym for Midcontinent-Craton defined in Table 4.2.4-1, and used in most of the figures in the report, is “MidC” as opposed to “Mid-C” or “MID-C” as written on p. 5-36. [Note: List of Abbreviations uses “Mid-C.”]
- On p. 5-32, in line 6 of Section 5.3.2.1.2: change “Equation 5.3.-18” to “Equation 5.3.2-18”
- On p. 5-35, line 3: in “latin hypercube sampling” note that Latin Hypercube is capitalized on p. 5-44.
- On p. 5-36, in the first line of the next-to-last paragraph: change “Table 5.3.2-1 shows the five cases were” to “Table 5.3.2-1 shows the five case that were”
- On p. 5-38, in line 4 of Section 5.3.2.2.2: change “mostlikely” to “most likely”
- On p. 5-40, in the last sentence of paragraph 3: change “Nonetheless, the the” to “Nonetheless, the”
- On p. 5-40 in the first sentence of Section 5.3.2.3.2: consider changing “has experienced multiple $M > 5.0$ earthquakes” to “has experienced two **M** > 5 earthquakes”

- On p. 5-41, in line 4 of the third paragraph of Section 5.3.2.3.3: It appears that “0.1 earthquake” should be “0.01 earthquake”
- On p. 5-43, in line 5 of the last paragraph: change “rate densitiy” to “rate density”
- On p.5-45, in line 3 of Section 5.3.2.6: change “but catalog of main shocks deviate from” to “but the catalog of main shocks deviates from”
- In Section 5.3.2.4, in the first paragraph on p. 5-43, the discussion cites Figures 5.2.3-1 and 5.2.3-2; these appear to be incorrect figure numbers.
- The figure caption for Figure 5.3.3-1 references Equation 5.3.3-1; however, it appears that the results are from Equation 5.3.3-2 (the Likelihood function).
- On the second line of p. 5-46, change “1900–2001” to “1990–2001”
- On p. 5-54, in line 6 of the second paragraph of Section 5.4.4: change “conept” to “concept”
- On p. 5-55, in line 5 of the first paragraph: change “the criterion of D_{90} is correct interpretation” to “the criterion of D_{90} is the correct interpretation”
- On p. 5-55, in line 3 of the second paragraph: change “resplved” to “resolved”
- On p. 5-55, in the next-to-last line of the third paragraph: change “reprenting” to “represent”

CHAPTER 6 — SSC MODEL: MMAX ZONES BRANCH

General Comments

(FR) G 6-1. Revisions made to Chapter 6 in the June 2011 installment of the Final Report, as summarized in the TI Team’s *PPRP Comment Resolution Table*, suitably respond to the PPRP’s earlier review comments—with one exception noted in a Specific Comment. The chapter is well written and complete. A few comments on clarity and completeness are provided below.

Specific Comments

(FR) S 6-1. *Remark on the TI Team’s PPRP Comment Resolution Table*

In the top comment on page 30 of the *PPRP Comment Resolution Table*, the TI Team response is “Revision made as suggested.” However, the title of Chapter 6 has not been changed, as suggested by the PPRP. The chapter title, which refers only to the Mmax zones branch, should recognize that the description of the RLME zones takes up ~74 of the total 79 pages of text. Only the final five pages of text deal with Mmax zones.

Comments on Clarity and Completeness

(FR) CC 6-1. (Variously described number of RLMEs): In Section 6.1, in the second paragraph on p. 6-1, the reader is informed: “Detailed maps of the RLME sources, along with their alternative geometries, are given in the individual subsections describing each of the **nine** [emphasis added] RLME sources (Sections 6.1.1 through 6.1.9).” Earlier in Chapter 4 the Conceptual SSC Framework is outlined for the reader to include **12** RLME sources (plus various alternatives, Table 4.2.2.-1, p. 4-40).

For understandable reasons, the TI Team assesses and depicts various combinations of RLMEs, but there needs to be a clear roadmap somewhere in the report to guide the reader and avoid confusion about something so fundamental as the number of RLMEs in the model. (The reader’s first challenge is comparing the list of RLMEs in Table 4.2.2-1 to the map in Figure 4.2.2-2—even allowing for alternative source geometries.)

(FR) CC 6-2. (Presentation of logic trees): In Chapter 6, as well as elsewhere, figures showing complicated logic trees are shown with unduly small point size. In some cases, available white space may allow enlargement. Constraints are understood, but these nearly illegible figures detract from the quality of the report and will pose a challenge for many readers.

Minor Editorial Comments and Typographical Errors

Some miscellaneous editorial comments and suggestions relating to Chapter 6 have been provided separately to the Project Manager.

CHAPTER 7 — SSC MODEL: SEISMOTECTONIC ZONES BRANCH

General Comments

(FR) G 7-1. Revisions made to Chapter 7 in the June 2011 installment of the Final Report, as summarized in the TI Team’s *PPRP Comment Resolution Table*, suitably respond to the PPRP’s earlier review comments. The chapter is well written and overall an excellent presentation. Some comments to help improve clarity and completeness are provided below. (See also PPRP Mandatory Comment No. 5.)

Comments on Clarity and Completeness

(FR) CC 7-1. (Basis for slip rates): In Section 7.3.7 (*Extended Continental Crust—Atlantic Margin Zone*), on p. 7-52 the basis for the slip rates cited in the last sentence of the top paragraph is not clear. Are these post-Cretaceous rates based on total displacement Cretaceous to Miocene (5.3 Ma)? Logically, given no measurable displacement in the past 5.3 Ma, the displacement rate for purposes of SSC model characterization is zero.

(FR) CC 7-2. (Source zones and P_a): In the last sentence of the first paragraph of Section 7.1 (p. 7-1), the statement is made that “A seismotectonic zone may also be defined if tectonic features are identified that have a significant probability of activity (Section 4.1.3.3).” It would be useful to the reader if these tectonic features were identified and the probability of activity assigned them were described. Could this be included in Table 4.1.3-1? Are any of the source zones as indicated in Table 4.1.3-1 based in part on the probability of activity of identified tectonic features in the zone—that is, they are judged to have a $P_a > 0.5$?

(FR) CC 7-3. (Mid-C vs. MidC): In Section 7.2.12 (p. 7-71), the abbreviation “Mid-C” is used for the Midcontinent-Craton seismotectonic zone. This differs from “MidC” specified in Table 4.2.4-1 and used in most figures throughout the report.

(FR) CC 7-4. (Conflicting comparison): In the third sentence of Section 7.3.1.1.7 on p. 7-11, the title “Grenville-age dike swarms” conflicts with Cambrian age of 590 Ma of the Sutton Mountains.

(FR) CC 7-5. (Triggering threshold of paleoliquefaction): In the part of Section 7.3.12.1.4 on p. 7-77 dealing with the “Nemaha Ridge–Humboldt Fault Seismic Zone,” reference is made in the second paragraph to the Olson et al., 2006 article indicating that available data suggest the triggering of paleoliquefaction features at magnitudes significantly lower than the threshold of M 6.5 used elsewhere in the project report for RLMEs. Should this be explained further?

(FR) CC 7-6. (Potentially confusing figures): Figures 7.1-5, 7.1-6, and 7.1-8 superpose one variation (unspecified) of seismotectonic source zones upon geophysical base maps. The text on p. 7-2 conveys that the figures are examples of how the TI Team examined available geophysical data sets as part of the process of defining source zones. However, the captions for these figures may mislead some readers to interpret that the underlying geophysical maps (particularly the magnetic and gravity maps) define the boundaries of the source zones that are shown.

(FR) CC 7-7. (Abbreviated figure captions): In the caption for Figure 7.5.2-1, important information in the second sentence is omitted in the captions for the following Figures 7.5.2-2 and 7.5.2-3. Similarly, in the caption for Figure 7.5.2-4, important information in the second sentence is omitted in the captions for the following Figures 7.5.2-5 through 7.5.2-51. Figure captions should stand alone. Readers will miss important information unless they examine the first figure in each of these series. For the second series, one could write, “Error bars as in Figure 7.5.2-4.”

Minor Editorial Comments and Typographical Errors

- In the caption of Figure 7.1-5, “aeromagnetic” should be replaced with “total intensity magnetic anomaly.” In the text of this section all instances of “aeromagnetic” should be replaced with “magnetic.”
- Late, Early, and Middle used as adjectives to geologic time units (e.g., Paleozoic) should be capitalized. In the current draft the capitalization of these terms is inconsistent.
- In Section 7.1, the first sentence of the first paragraph on p. 7.1 should also include recurrence rate.
- “Appalachian Mountains” rather than “Appalachians” as in the second paragraph of Section 7.3.1.3.
- Should the title of Section 7.3.4 be “Paleozoic Extended Crust Zone” (as introduced in Table 4.2.4-1) rather than excluding the word “Crust”?
- Global search should be used to change M_w to **M**.

In addition to the editorial comments listed above, some miscellaneous editorial comments and suggestions relating to Chapter 7 have been provided separately to the Project Manager.

CHAPTER 8 — DEMONSTRATION HAZARD CALCULATIONS

General Comments

(FR) G 8-1. Revisions made to Chapter 8 in the August 2011 installment of the Final Report, as summarized in the TI Team’s *PPRP Comment Resolution Table*, suitably respond to the PPRP’s earlier review comments. The revised chapter greatly improves the documentation in the 2010 draft version and provides helpful information for evaluating the CEUS SSC model. The reorganization of text and figures makes the chapter easy for the reader to navigate.

Specific Comments

(FR) S 8-1. *Observation Regarding Relative Hazard from the USGS and CEUS SSC Models*

There are several examples where hazard from the USGS model lies *above* the 85th-percentile fractile of hazard from the CEUS SSC model. For example, for the Chattanooga site, comparing Figures 8.2-2b and 8.2-2k for 1 Hz rock hazard shows that the USGS curve is much higher than the 85th-percentile fractile of the CEUS SSC model.

Comments on Clarity and Completeness

(FR) CC 8-1. (Terse information): On p. 8-2, in the last sentence of the top paragraph, how were the standard deviations ranging from 0.07 to 0.25 calculated to include “the effect of uncertainties in V_S versus depth and in soil parameters”?

Minor Editorial Comments and Typographical Errors

- In the captions for Figures 8.2-1c, 8.2-2c, 8.2-3c, etc., delete “Hz” in “PGA Hz rock hazard”
- The authors can consider whether they wish to report the V_S profiles (Figures 8.1-2 and 8.1-3) in units of ft and fps or in m and m/sec; the latter are used in the text (Section 8.1) as the primary units for V_S .
- As written, the last paragraph of Section 8.2 on p. 8-3 seems to apply to “*Figures ee, ff, and gg,*” To better guide the reader, insert a header before this important paragraph such as “*Sensitivity to in-cluster and out-of-cluster assumption:*”
- In the paragraph 4 of Section 8.2.2 on p. 8-5, change “but at approximately 0.6 g and 0.3 g” to “but above approximately 0.6 g and 0.3 g”

CHAPTER 9 — USE OF THE CEUS SSC MODEL IN PSHA

General Comments

(FR) G 9-1. Revisions made to Chapter 9 in the August 2011 installment of the Final Report, as summarized in the TI Team’s *PPRP Comment Resolution Table*, suitably respond to the PPRP’s earlier review comments. The revised chapter adds helpful information for implementing the CEUS SSC model and for understanding sensitivities in the model.

(FR) G 9-2. The revised Section 9.4.3 markedly improves guidance on understanding the precision in seismic hazard estimates and how the results presented should be interpreted. After going through extensive detail on COVs, presented in about 9½ pages of text and 34 figures, the reader arrives at Section 9.4.3 to learn that the critical information for the conclusions is contained in the *minimum* observed COV_{MH} values. The reader should be prepared at the outset for this detail in order to pay attention as the relevant information unfolds. For example, a simple informative statement could be added at the end of Section 9.4.1.

Comments on Clarity and Completeness

(FR) CC 9-1. (Precision and weights): In the second paragraph of Section 9.4.2.2, there is the statement: “It is notable that weights on alternatives are generally given to one-decimal-place precision, and that while these weights indicate quantitative preferences on alternatives, an independent evaluation by another investigator might assign somewhat different weights.” This sentence leaves unclear whether it is the precision with which weights are quantified or the different weights that different evaluators would assess, or both that are being evaluated. The distinction is conceptually important since the precision of the weights is a matter of how precise qualitative assessments typically are or can be quantified, while the difference in weights assessed by two TIs using the same data and SSHAC process is a matter of the limiting precision of the SSHAC Methodology itself.

(FR) CC 9-2. (Basis for following SSHAC guidelines): In the first paragraph of Section 9.1 on p. 9-1, the text refers to a SSHAC Level 3 process and states that “all the required steps were taken to implement the letter and the spirit of the SSHA guidelines (Budnitz et al., 1997).” The next sentence then refers the reader to [Chapter] 2. Consistent with Chapter 2, consider expanding the sentence containing “all the required steps were taken” to refer not only to Budnitz et al. (1997) but also to the draft NUREG.

(FR) CC 9-3. (Sections 9.3.2 and 9.3.3): Sections 9.3.2 and 9.3.3 are missing—for reasons explained in the text (“to be written later”).

(FR) CC 9-4. (Section 9.4.2.2): The addition of Equation 9-5 and associated discussion on p. 1-13 is particularly helpful. On this same page, the cluster model is referred to. It seems like the authors should at least provide a reference (e.g., Toro and Silva) and possibly an equation.

(FR) CC 9-5. (Seismogenic crustal thickness and hazard calculations): The text and figures (e.g., Figure 9.3-18 through 20) address sensitivity to seismogenic crustal thickness. Revisiting Section 5.4.4, there does not appear to be discussion of how seismogenic crustal thickness is used in the calculation of hazard. How are ruptures distributed with depth? [Reviewer’s note: If

this is clearly stated somewhere else in the report, then this comment can be disregarded. Otherwise, some discussion is appropriate.]

(FR) CC 9-6. (Description of figures vs. actual content): The amount of text and the number of figures devoted to COVs invites the interested reader to carefully examine the material presented. When reference is made to a figure, the reader will be confused if he/she observes something different than described. Two examples:

- In the last paragraph of Section 9.4.2.1 appearing on p. 9-11, the conclusion is drawn from Figures 9.4-1 through 9.4-3—for area sources—that “typical COV_{MH} will range from 0.15 at a mean annual frequency of 10^{-4} **to perhaps 0.25** [emphasis added] at a mean annual frequency of 10^{-6} , with a wide variation in that range.” This statement cannot be squared with the *range* of values observed on Figures 9.4-1 through 9.4-3 unless “typical” is explained. On Figure 9.4-2, there are many COV values at 10^{-6} in the 0.3 to 0.45 range, and in Figure 9.4-3 (bottom), half the COV values at 10^{-6} are > 0.25 .
- Text in the middle of p. 9-13 states: “From Figures 9.4-4 through 9.4-6, the COV_{MH} for annual frequencies in the range of 10^{-4} to 10^{-6} is 0.25 to 0.4, with a minimum of 0.25.” Given the curves on Figure 9.4-4 and 9.4-6, why not “0.25 to 0.45”?

Minor Editorial Comments and Typographical Errors

- In Section 9.1, in line 6 of the first paragraph on p. 9-1, change “Section 2 describes” to “Chapter 2 describes”
- On p. 9-1, at the end of line 1 in the second paragraph: consider changing “to calculate seismic hazard at locations of nuclear facilities” to “calculate seismic hazard for nuclear facilities”
- The second sentence of Section 9.4 states: “Once a PSHA is completed, it is expected that new data, models, and methods will emerge within the technical community.” [This makes it sound like new information is expected to arise *immediately*, once the PSHA is completed.] Suggestion: “After a PSHA is completed, it is expected that new data, models, and methods will subsequently emerge within the technical community.”
- In Table 9.4-1, in column 3 relating to site response: Clarify whether EPRI (2005) refers to EPRI (2005a), EPRI (2005b), or both in the list of references.
- In Section 9.4.2.1, the last paragraph on p. 9-10 (continuing on p. 9-11) refers to Figures 9.4-3a and 9.4-3b. However, Figure 9.4-3 contains no “a” and “b” parts; the figure caption refers only to “top” and “bottom.” Text needs to be revised to avoid confusion.
- In Section 9.4.2.3, on p. 9-15 (third paragraph, line 2): change the parenthetical reference from “Figure 9.4-13” to “Figure 9.4-12.” In the following sentence, consider writing: “The reason is that the 1 Hz hazard curves (Figure 9.4-13) show . . .”
- In Section 9.4.2.3 the abbreviation GMPE [presumably, for ground-motion prediction equations] is used on pp. 9-16 and 9-17. The abbreviation is not included in the list of Abbreviations and Symbols, and a prior definition of the abbreviation couldn’t be found in either Chapter 9 or Chapter 8.

CHAPTER 10 — REFERENCES

General Comments

(FR) G 10-1. *Content, Accuracy of List of References*

The PPRP leaves the technical editing of the list of References, including systematic cross-checking with the main body of the text to the TI Team and its support staff.

Comments on Clarity and Completeness

(FR) CC 10-1. (Some missing references): The following citations encountered in the text of Installment 2 are not included in list of references in Chapter 10. No systematic attempt was made to identify missing references.

- p. ix: (NRC, 2011)
- p. 3-37: (Reasenberg, 1985)
- p. 5-25: Utsu (1965)
- p. 5-29: (Fukuda and Johnson, 2008)
- ubiquitous in Chapter 5: EPRI-SOG (1986)
- p. 5-37, p. 5-44, and elsewhere: EPRI-SOG (1988); [a 1988 citation abbreviated (EPRI) appears in the list of references, but not (EPRI-SOG).]

CHAPTER 11 — GLOSSARY OF KEY TERMS

General Comments

(FR) G 11-1. Revisions made to Chapter 11 in the August 2011 installment of the Final Report suitably respond to the PPRP's earlier review comments. The revised glossary is a great improvement over the 2010 draft version and will provide helpful information for many readers.

Comments for Clarity and Completeness

(FR) CC 11-1. (Definitions still to be added): The following definitions still need to be added to the Glossary:

- ***a*-value** (This term is used in many places in the final report; the companion term, *b*-value, is suitably described.)
- **Database, Data Set** (There was agreement at the PPRP Closure Briefing on September 7, 2011, that these terms would be added to the Glossary.)

APPENDIX A — DESCRIPTION OF THE CEUS SSC PROJECT DATABASE

General Comments

(FR) G A-1. The PPRP stated in its review of the July 2010 draft of this appendix (see the TI Team’s *PPRP Comment Resolution Table*) that “The CEUS SSC Project has assembled and archived a comprehensive suite of data sets of the CEUS that are important to the characterization and assessment of the SSC model of the region by the TI Team and that significantly contribute to the community knowledge-base.” In our July 2010 review, numerous general and specific comments were made aimed at helping to improve Appendix A.

Appendix A in the June 2011 installment of the Final Report is notably improved, both editorially and with regard to clarity and completeness. Nonetheless, further improvements in quality can still be made. To this end, we offer a few specific comments, and we also offer numerous editorial comments on the metadata summary sheets that accompany the figures of the CEUS-scale data layers.¹

Specific Comments

(FR) S A-1. *Remarks on the TI Team’s PPRP Comment Resolution Table*

The TI Team’s *PPRP Comment Resolution Table* pertaining to Appendix A generally provides a useful and positive summary of the revisions made to the report in response to the PPRP comments on the July 2010 draft report. However, there are the following exceptions:

- a. In our original Comment **S A-1** the suggestion was made to clarify for the reader the availability of and access to datasets and metadata on the Project website. This suggestion is not commented upon or adopted in the revision. The website address of the project and links to the metadata files should be presented in the introduction to this appendix.
- b. In our original Comment **S A-4** the suggestion was made to have a technical editor review Appendix A. However, the response to this suggestion apparently did not extend in the revision to the metadata summary sheets. These sheets still need review by a technical editor.
- c. Our original Comment **S A-10** noted that the citations in the tables were not in consistent format. This has not been addressed in the metadata summary sheets. Note the varied use of italics.
- d. In our original Comment **S A-11** a suggestion was made to include a data file showing areas where reliable earthquake hypocenter depths are available. No response to this comment is given in the resolution table. Such a data file (or map) would be useful in validating the probabilities placed on the seismogenic crust thickness in Table 5.4-2 (July 2010 draft

¹ In order to help the Project Team in its technical editing of Appendix A, a fundamentally important appendix, we include the complete comments made by one diligent PPRP reviewer. Separately, additional editorial comments on Appendix A, made by this same reviewer, are being provided to the Project Manager.

report). The seismogenic crustal thickness is identified in Section 7.1 of the June 2011 version of the report as a criterion for defining seismotectonic zones. Thus, supporting information on this criterion is particularly important.

- e. In our original comment on **Sheet A-20** the suggestion was made to check the legend of the figure. Here and in the case of other sheets, this has generally been done, but problems still remain. For example, the units used in the horizontal and vertical derivatives of the gravity anomalies are incorrect. The units have to be mGals/length unit, either km or m. The units of the similar magnetic anomaly maps should also be checked to be certain that the nT/length unit is correct. Other editorial suggestions for Appendix A are being provided separately to the Project Manager.

(FR) S A-2. *Lack of Suitable Information on Regional Heat Flow*

A regional heat flow dataset, which can provide important information on crustal properties and tectonic activity, is not included in the data compilation of the CEUS SSC, despite being identified as a potential database in the preliminary evaluation of data significant to recognizing and mapping seismic source zones in the CEUS. For example, the January 9, 2009, file of database status recognizes both the University of Michigan (Henry Pollack) and the Southern Methodist University (David Blackwell) maps of the heat flow of North America that include the CEUS region, but neither of these are included in the final datasets. What is included is the heat flow point data in the USGS Crustal Database (Sheet A-13, Figure A-15). Unfortunately, this database includes only six heat flow values in the entire CEUS. Thus, this database is of limited value, if any, to mapping seismic source zones. It can be assumed that the data points in this file are relatively recent updates to the US heat flow database.

It needs to be emphasized that even a heat flow map that shows minimal variation over a region has tectonic significance. Thus, even though heat flow over the CEUS is not highly variable, the dataset should be included in the project. A metadata file was prepared in the CEUS SSC project for the University of Michigan's global 1993 heat flow dataset (File: NorthAmerica_HeatFlow_R0_20080617). However, the Southern Methodist University map is dated 2004 (it is an update of the GSA DNAG heat flow map, 1993) and thus should be used if possible because it is the most recent dataset. It is recommended that Figure A-15 be removed because of its limited utility.

Comments on Clarity and Completeness²

(FR) CC A-1. (Consistent labeling desirable): The GIS Layer/File Name in column 2 of Table A-1 should be consistent with titles of the Metadata Summary Sheets. They are not for at least two of the Data Theme entries for Tectonic Features.

(FR) CC A-2. (Reference to Ravat et al., 2009): In Table A-1 for Data Theme entitled Magnetic on page A-11 and the associated Metadata Summary Sheets and Figures, the reference is to the Ravat et al.'s USGS Open-File Report dated 2009. That reference is only appropriate for the original total magnetic intensity anomaly data as shown on Figure A-40, page A-80, and the associated shaded relief maps. All subsequent derived magnetic anomaly

² See footnote 1 for additional information.

data sets and figures (e.g., differentially reduced to pole magnetic anomaly data shown on Figure A-42) should refer to personal communication from Ravat. The processed derived data as provided by Ravat is not included in the USGS Open-File Report.

(FR) CC A-3. (Geon): The term Geon is used in the legend of a figure in Appendix A. Because, this is not a widely known term, we suggest that Geon be added to Glossary.

(FR) CC A-4. (Figure A-6): The addition of a Source number reference on the cross-sections shown in Figure A-6 would greatly help the user of the dataset.

(FR) CC A-5. (Figure A-13): Just what is shown on Figure A-13 is unclear. Is crustal thickness or basement thickness presented? The statement is made in the legend that the labels are basement thickness, but the title of the figure refers to crustal thickness. Which are the symbols for the sediment thickness? The label indicates that the sediment thickness is not given, but the symbol identification indicates that they are. The legend and title are confusing.

(FR) CC A-6. (Figure A-14): Referring to Figure A-14 (and Summary Sheet A-13), why does the title refer to both P- and S-wave velocity, but the legend indicates that only P-wave velocities are shown. One can presume that the velocities refer to average velocity of the crust. Is that correct? If so, modification of the title to indicate this would be appropriate.

(FR) CC A-7. (Figure A-49): On Figure A-49 there is no indication of the COCORP lines in south Texas. Should they be there as in a preliminary copy of this figure?

(FR) CC A-8. (Figure A-16): Comparison between Figure A-16 (Sediment thickness derived from USGS Crustal Database), page A-52, and the figure of the same data presented by Walter Mooney on page 6 of his handout at Workshop #1 indicates significant discrepancies. Are these only caused by differences in contour interval? This should be checked to verify the information shown in Figure A -16 and the associated dataset.

APPENDIX B — EARTHQUAKE CATALOG

General Comments

(FR) G B-1. Revisions made to Appendix B in the August 2011 installment of the Final Report suitably respond to the PPRP's earlier review comments. Once again, the PPRP commends the TI Team on the monumental efforts that went into compiling the earthquake catalog.

Minor Editorial Comments and Typographical Errors

- Section B.3, Page B-3, cites Equations 3.3-9 and 3.3-10; the correct citation is Equations 3.3.1-9 and 3.3.1-10.

APPENDIX C — DATA EVALUATION TABLES

General Comments

(FR) G C-1. Revisions made to Appendix C in the June 2011 installment of the Final Report, as summarized in the TI Team’s *PPRP Comment Resolution Table*, suitably respond to the PPRP’s earlier review comments, with one exception, noted below as a Specific Comment. A few items for improved clarity are offered for consideration by the Project Team.

Specific Comments

(FR) S C-1. *Remark on the TI Team’s PPRP Comment Resolution Table*

Our original Comment **S C-1**, reproduced on p. 50–51 in the *PPRP Comment Resolution Table*, stated in its final sentence that “All seismic source zones including Mmax zones should have a Data Evaluation table.” The corresponding resolution column in the table states that “All seismic sources have an applicable Data Evaluation table.” Nonetheless, no evaluation tables could be found in Appendix C for the Mmax zones, and these tables are not identified in the listing of tables in the introductory text to Appendix C.

Comments on Clarity and Completeness

(FR) CC C-1. (Explanation of labeling of the Data Evaluation tables): It would be helpful to explain that the labeling of the Data Evaluation tables is keyed to a specific chapter and section where the corresponding source zone is described and discussed—e.g., Table C-7.3.3 is keyed to Section 7.3.3, *Northern Appalachian Zone (NAP)*.

(FR) CC C-2. (Potential confusion about “No Table”): The entry in the index on page C-1 indicating “[No Table C-7.3.11]” may confuse some readers. An explanation of the labeling scheme for the tables, suggested in Comment **(FR) CC C-1** above, would help clarify the matter.

(FR) CC C-3. (Reader-friendly guide to locating information): To help the reader locate a specific Data Evaluation table, it would be helpful if the index on page C-1 (and perhaps also the Table of Contents) included page numbers for finding the table for a specific source zone.

APPENDIX D — DATA SUMMARY TABLES

General Comments

(FR) G D-1. Revisions made to Appendix D in the June 2011 installment of the Final Report, as summarized in the TI Team’s *PPRP Comment Resolution Table*, suitably respond to the PPRP’s earlier review comments. A few items for improved clarity are noted below for consideration by the Project Team.

Comments on Clarity and Completeness

(FR) CC D-1. (Explanation of labeling of the Data Summary tables): It would be helpful to explain that the labeling of the Data Summary tables is keyed to a specific chapter and section where the corresponding source zone is described and discussed—e.g., Table D-7.3.3 is keyed to Section 7.3.3, *Northern Appalachian Zone (NAP)*.

(FR) CC D-2. (Potential confusion about “No Table”): The entries in the index on page D-1 indicating “[No Table . . .]” may confuse some readers. An explanation of the labeling scheme for the tables, suggested in Comment **(FR) CC D-1** above, would help clarify the matter.

(FR) CC D-3. (Absence of Data Summary tables for the Mmax source zones): Why are there no Data Summary tables for the Mmax seismic source zones? Include or explain their omission in appropriate text in an introduction to Appendix D (see also Comment **(FR) S C-1**).

(FR) CC D-4. (Reader-friendly guide to locating information): To help the reader locate a specific Data Summary table, it would be helpful if the index on page D-1 (and perhaps also the Table of Contents) included page numbers for finding the table for a specific source zone.

(FR) CC D-5. (Intentional or accidental repetition?) Page D-34 repeats pages D-31, and D-36 repeats D-33.

(FR) CC D-6. (Mix-up in Tables D-7.3.1 and D-6.1.9): Pages D-119 to D-145, ostensibly Table D-7.3.1 and identified in the header as a Data Summary table for the St. Lawrence Rift, are a repeat of pages for the Wabash Valley RLME given in Table D-6.1.9.

(FR) CC D-7. (Inconsistent labeling of magnitude): Both **M** and M_w appear in the table descriptions. For consistency with the rest of the report, **M** should be used (unless some magnitude scale other than moment magnitude is referred to).

APPENDIX E— CEUS PALEOLIQUEFACTION DATABASE, UNCERTAINTIES ASSOCIATED WITH PALEOLIQUEFACTION DATA, AND GUIDANCE FOR SEISMIC SOURCE CHARACTERIZATION

General Comments

(FR) G E-1. This appendix represents a thorough and well expressed compendium of methodology, data, and guidance related to paleoliquefaction studies in the CEUS. Revisions made to Appendix E in the June 2011 installment of the Final Report, as summarized in the TI Team's *PPRP Comment Resolution Table*, fully address the PPRP's earlier review comments. The only need for further attention is the item noted below.

Comments on Clarity and Completeness

(FR) CC E-1. (Figure E-6): Incorrect figure? It appears that the figure provided as Figure E-6 is Figure E-5 repeated. The two figures have different captions.

Minor Editorial Comments and Typographical Errors

Miscellaneous editorial comments and suggestions, provided separately to the Project Manager, include several comments on Appendix E.

APPENDIX F — WORKSHOP SUMMARIES

General Comments

(FR) G F-1. This appendix remains basically unchanged from the July 2010 draft. As the PPRP commented in its earlier review (see the TI Team’s *PPRP Comment Resolution Table*), “The summaries of the workshop provided in Appendix F are well-written accounts of the presentations and subsequent discussions that transpired.” The only remaining issue is a clear instruction to the reader about the availability and location of companion materials for understanding the summaries (see Comment **(FR) S F-1** below).

Specific Comments

(FR) S F-1. *Remark on the TI Team’s PPRP Comment Resolution Table*

In our review comments on the July 2010 draft (see TI the TI Team’s *PPRP Comment Resolution Table*), the PPRP suggested that it would be helpful to add the agenda and list of participants for each workshop, and we noted our assumption that copies of visual presentations made at the workshops would become available in some conveniently accessible form. The TI Team’s Comment Resolution Table (response to Comment **S F-1**) states: “No change. The workshop agendas and lists of participants, as well as copies of all presentations, will be provided on the Project website.”

Because the extra information is important for understanding of context, as well as for completeness of documentation, there should be a clear instruction to the reader—perhaps as a footnote to the title of Appendix F—that for each workshop the agenda, list of participants, and copies of all presentations can be accessed on the Project website.

Minor Editorial Comments and Typographical Errors

Because tables consistently appear *at the end* of all other parts of the report, the placement of Table 1 after the narrative for Workshop and #2 and before the narrative for Workshop #3 may confuse some readers. Perhaps a footnote to the Appendix title on p. C-1 could be added stating something like: “Note that references and any tables for each workshop appear at the end of that workshop’s summary.”

APPENDIX G — BIOGRAPHIES OF PROJECT TEAM

General Comments

(FR) G G-1. The revised Appendix G suitably responds to the PPRP’s review comments on the July 2010 draft, as summarized in the TI Team’s *PPRP Comment Resolution Table*. Appendix G remains a straightforward compilation of biographical sketches for members of the CEUS SSC Project. The addition of an introduction gives the reader a helpful overview and provides guidance for understanding the grouping and ordering of the individual biographies.

Minor Editorial Comments and Typographical Errors

- In the biographical sketch for Tom J. Mulford, there is the following word string:
“ . . . has had extensive interface with utilities around the world, including the U.S. Nuclear Regulatory Commission (NRC) . . . ”

In the syntax, “including” refers to “utilities”; because the NRC is not a utility, this sentence needs to be reworded.

APPENDIX H — CEUS SSC MODEL HAZARD INPUT DOCUMENT (HID)

General Comments

(FR) G H-1. The revised HID usefully includes more cross-references to text and figures in the report to help guide the user, and it appears to be complete. Three members of the PPRP will eventually be using the HID at their respective agencies (USGS, NRC, and DFNSB), but it wasn't feasible for them to implement the HID before completing this review. The adequacy of the HID remains to be verified by these and other users in the near future.

APPENDIX I — PPRP AND USGS REVIEW COMMENTS¹

General Comments

(FR) G I-1. Revisions made to Appendix I in the June 2011 installment of the Final Report, as summarized in the TI Team’s *PPRP Comment Resolution Table*, suitably respond to the PPRP’s earlier review comments. Three matters needing further attention are described below.

Specific Comments

(FR) S I-1. *Placement of PPRP Closure Letter in CEUS SSC Final Report*

As discussed with the Project Team at the PPRP Briefing on June 22, 2011, the PPRP recommends that its Final Letter Report, to be delivered to the Project Manager in October 2011, appear in the CEUS SSC Final Report immediately following the Executive Summary. We believe that executive readers will be eager to know how the PPRP views the project and its outcome, and that this information should be readily accessible—rather than in Appendix I. (Note that the last sentence on p. 2-20, referring to the location of the PPRP’s closure letter in the report, would need to be revised.)

(FR) S I-2. *PPRP Review Comments to be Included in Appendix I*

As also discussed with the Project Team at the PPRP Briefing on June 22, 2011, it is our expectation that the following PPRP report be included in Appendix I:

Letter dated October 4, 2010, to Mr. Salomone: *Central and Eastern United States Seismic Source Characteristics for Nuclear Facilities: PPRP Review Comments on CEUS SSC Draft Report of July 31, 2010.*

The above letter, although lengthy, provides full context for our review comments and gives the reader a sense of the extent and incisiveness of the PPRP’s review. Insofar as the TI Team’s *PPRP Comment Resolution Table* is partly repetitious, the latter might appear only on the Project website. We assume that, after they are finalized in September 2011, the PPRP’s combined review comments on Installments 1 and 2 of the CEUS SSC Final Report will also be included in Appendix I.

(FR) S I-3. *Inclusion of Two PPRP Informal Communications in Appendix I*

Despite their designation, we request that two specific PPRP “Informal Communications” be included in Appendix I. The following two communications contain important perspectives at critical junctures of the project, and we believe that they warrant inclusion in the Project’s formal documentation:

- Memorandum dated October 13, 2010, to Mr. Salomone: Key Issues for TI Team to be Attentive to as They Revisit the CEUS SSC Model and Revise the Project Report.
- Memorandum dated February 23, 2011, to Mr. Salomone: PPRP Feedback on CEUS SSC Working Meeting #9.

¹ Some comments here regarding the content of Appendix I are superseded by later decisions made with the Project Team after the PPRP Closure Briefing on September 7–8, 2011.

APPENDIX J — MAGNITUDE-RECURRENCE MAPS FOR ALL REALIZATIONS AND ALL SOURCE-ZONE CONFIGURATIONS

General Comments

(FR) G J-1. Revisions made to Appendix B in the August 2011 installment of the Final Report suitably respond to the PPRP's earlier review comments. Reviewers cannot be certain that each map is the correct one corresponding to the caption, but the maps appear to be logical in terms of degree of smoothing, and so on.

APPENDIX K — SCR DATABASES USED TO DEVELOP MMAX PRIOR DISTRIBUTIONS

General Comments

(FR) G K-1. The addition of explanatory text, figures, and cross-references to relevant sources of information all greatly improve this revised 2011 version of the Appendix K. No further comments.

APPENDIX L — QUALITY ASSURANCE

General Comments

(FR) G L-1. Appendix L is a new appendix that was not contained in the 2010 version of the Draft Project Report. The PPRP offers one specific comment that deals with the transparency (or lack thereof) in merely citing the previous EPRI-SOG verification efforts as adequate verification for several key pieces of software.

Specific Comments

(FR) S L-1. *Adequate Verification of Software*

On page L-4, a discussion of the use of Verified Computer Programs indicates that the two principal computer codes used in the development of the earthquake catalog are EQCLUST and EQPARAM. The text asserts that “both of these programs were part of the verification program of the EPRI-SOG” study. These programs and the associated results/documentation of the EPRI-SOG verification effort have not been publicly available. The CEUS SSC Project Team should strongly consider reproducing/placing the relevant portions of the EPRI-SOG verification documentation on the Project website. This would significantly improve the transparency and completeness of the CEUS SSC documentation.

PPRP Comment Response Table

Comment	Summary of Revisions to Report
<p>CHAPTER 1—INTRODUCTION</p> <p>General Comments</p> <p>G 1-1. (NAR) This chapter is well structured and introduces the reviewer to all elements of this complex project report. The chapter usefully discusses the need for community-based studies and comparisons with other approaches. Here and throughout this Draft Report, we recognize the great effort that has gone into the writing and documentation, and we commend the TI Team for its diligent efforts to distill and report a massive amount of detail. Mindful of the criteria we have been given to guide our critical review (see cover letter), we proceed to specific comments.</p>	<p>Comment noted and appreciated.</p>
<p>S 1-1. (SSHAC) Justification for Using the SSHAC Level 3 Assessment Process</p> <p>A key issue related to the selection of the SSHAC assessment level, specifically a Level 4 assessment versus Level 3, relates to the ability of the selected experts to act as impartial evaluators—the perceived higher level of assurance provided by Level 4 comes with significant additional costs, some of which are associated with making sure the use of experts or expert teams as impartial evaluators is being done properly. The Hanks (2009) Open File reports notes, appropriately, that most geosciences experts are quite inexperienced in one or more of several matters important to higher level SSHAC assessments. But generally, they are not experienced evaluators of uncertainty, given competing hypotheses and interpretations that require evaluation using diverse sets of geological, geophysical, and seismological data. This particular point needs to be brought out more in the draft report, both here and in Chapter 2.</p> <p>Experience has shown, even for some projects that have claimed SSHAC Level 4 assessment, that the actual success of experts or expert teams as evaluators has been limited. At the present time for the CEUS it may be that the technical community is best able to implement a SSHAC Level 3 assessment (high confidence that a TI Team can be selected to act as impartial evaluator) versus a Level 4 assessment. While some could view this point as less important, it is a key point that those outside the project (other agencies, ACRS, others) must appreciate and understand.</p> <p>Based on cumulative experience using the SSHAC Methodology, particularly given the time constraints, we have confidence that this project can be successfully implemented using a SSHAC Level 3 assessment versus Level 4.</p>	<p>Explanation added regarding why Level 4 projects cost more and take more time than Level 3 studies. We are unaware of any Level 4 projects that have not been successful with regard to the experts acting as evaluators.</p>
<p>S 1-2. (CC, SSHAC) Clear Communication is Essential. Chapter 1 and Entire Report</p> <p>Keeping in mind that words are the stuff of thought and that clear communication of thought is essential, especially for regulatory guidance documents intended for long term use, usages of words and terms must clearly and accurately convey the concepts that are being described. It is also essential that the words and terms be used in their proper meaning consistently throughout the report.</p> <p>The practice of using nuanced words as synonyms contributes to a lack of essential clarity. For example, throughout Chapter 1 the word “study” is used interchangeably in multiple meanings. In most instances “study” is used to mean either “project” or “assessment”; it is used in its proper meaning in only a few instances, for example in subsection 1.4.4.4. Serious miscommunication will result from incorrectly using the word “study” to convey the activities that constitute a SSHAC assessment process—or that constitute a “SSHAC Study Level 3 Approach” or a “SSHAC Study Level 3 Methodology.”</p>	<p>Changes made to clarify the use of “study,” “project,” and “assessment.” We agree with the term “SSHAC assessment process” and text has been revised accordingly. However, the term “Study Level” is given in the SSHAC Guidelines and cannot be easily changed by this report without confusion. For clarity, SSHAC Study Levels are always indicated with capital letters. Use of “event” has been clarified or revised.</p>