C
APPENDIX C
DOCUMENTATION FOR INTERVIEWS

C.1 Introduction

In accordance with Task 2 of the Project Plan (EPRI, 2012) for the EPRI (2004, 2006) Ground-Motion Model Review Project, part of the data evaluation process is compilation and evaluation of new, relevant information that became available after 2003. This appendix documents interviews with resource and proponents experts.

The TI Team interviewed Resource Experts and Proponent Experts who are working on CENA ground motions and related topics (Section C.2). The purpose of the interviews was to obtain an update on the experts' ongoing work, to understand their current views regarding ground motion modeling issues for CENA, and to obtain copies of papers under review or in press. To facilitate the interview process and provide structure, the TI Team prepared a questionnaire beforehand (Section C.3). In most cases the interview was carried out in person or by telephone. In a few cases the expert filled out the questionnaire and then returned it to the TI Team.

The interviews are documented in tables (Section C.4). The interviews and their documentation support the SSHAC goal of representing the center, body, and range of technically defensible interpretations by proactively interacting with the technical community in a structured, systematic, and open fashion. References cited are documented in Chapter 9 – References.

C.2 Experts Interviewed

Table C-1 Norm Abrahamson – June 21, 2012

Table C-2 Gail Atkinson – July 6, 2012

Table C-3 Jack Boatwright – October 4, 2012

Table C-4 David Boore – June 26, 2012

Table C-5 Kenneth Campbell – June 20, 2012

Table C-6 Chris Cramer – July 3, 2012

Table C-7 Arthur Frankel – July 31, 2012

Table C-8 Bob Herrmann – September 11, 2012

Table C-9 Shahram Pezeshk – June 26, 2012

Table C-10 Walter Silva – July 17, 2012

Table C-11 Paul Somerville – July 9, 2012

C.3 Questions Posed to Resource and Proponent Experts

1. What are the key issues we should be considering in updating the model for median amplitudes (and the associated epistemic uncertainty) as a function of magnitude and distance?
2. Which data are the most relevant in addressing these issues?
3. Has your model (specific to each expert), which was used in EPRI (2004), been superseded? If so, by which model?
4. What are the key issues we should be considering in updating the model for the aleatory uncertainty as a function of magnitude and distance?
5. In addition to your published papers, do you have any papers in preparation or under review that you can share with our project?
6. Do you know of interesting work in progress by other researchers?
7. Additional information from expert.

C.4 Interview Tables

Table C-1

Expert Name: Norm Abrahamson	Date of Call: 6/21/2012
Prepared by: Gabriel Toro	Date Prepared: 7/1/2012

1. What are the key issues we should be considering in updating the model for median amplitudes (and the associated epistemic uncertainty) as a function of magnitude and distance?

a. Single-corner point-source models should get less weight because they overestimate data (they may get some weight at high frequencies [>2 Hz] if weights are made frequency-dependent).
b. Kappa value of 0.006 s is probably too low. Understands the need to keep value in this study, but should provide guidance on how to adjust on a site-specific basis
c. Traditional hybrid-empirical models overestimate high-frequency motions: need to use Al-Atik et al. (2012) approach
d. Stress parameters are probably OK
e. Would not assign weights by cluster; would judge models instead

2. Which data are the most relevant in addressing these issues?

a. Kappa:
   i. collect and analyze hard rock data (records) from around the world (this is being done by PEGASOS (PRP); will try to get report for us (may turn out to depend on Vs30 and on region)
   ii. Van Houtte et al.; problem: mostly soil data; real question is value of kappa for Vs30> 800m/s
b. For stress parameter: use NGA-East (some records too noisy)
c. Mineral, Virginia, aftershocks: some people (e.g., Archuleta SSA presentation) see R-1.3, others do not (e.g., Herrmann).

3. Have your Abrahamson-Silva hybrid model of 2001 and Toro et al. model of 1997 (which were used in EPRI, 2004) been superseded? If so, by which model?

a. Would not use Abrahamson-Silva hybrid models
   i. Based on obsolete Western United States (WUS) models
   ii. See earlier comments about hybrid models and kappa effects
b. Would not use Toro et al. (see earlier comments about single corner)
c. Somerville et al. (Norm is a co-author) not working well, especially for lower magnitudes (could be replaced by Atkinson's extended-rupture stochastic)
d. We should look at residuals and eliminate models that don't work.

4. What are the key issues we should be considering in updating the model for the aleatory uncertainty as a function of magnitude and distance?

Recommends that we follow the same EPRI (2006) framework but update the model using NGA (2008) results for sigma, some of which include magnitude-dependence.

5. In addition to your published papers, do you have any papers in preparation or under review that you can share with our project?

Al-Atik et al. manuscript on kappa

6. Do you know of interesting work in progress by other researchers?

Nothing that was not mentioned earlier.

7. Additional information from expert

Some regional differences are becoming apparent: NGA East will consider four regions. This may be beyond the scope of EPRI GMM Review project.

Table C-2

Expert Name: Gail Atkinson	Date of Call: 7/6/2012
Prepared by: Gabriel Toro	Date Prepared 7/7/2012

1. What are the key issues we should be considering in updating the model for median amplitudes (and the associated epistemic uncertainty) as a function of magnitude and distance?

a. How to account for recent data
b. How to treat Saguenay earthquake
c. How to update models in EPRI (2004) clusters and how to include new ones

2. Which data are the most relevant in addressing these issues?

a. For characterizing source, all data with M>4
b. For characterization of attenuation, all data with M>~3.4 (a lot more data than M>4)
c. Has used Mineral, Virginia, data only for ongoing Empirical Green's Function work with D. Boore
d. Information on site conditions for the Ottawa region maintained by Dariush Motazedian (http://http-server.carleton.ca/~dariush/Microzonation/main.html)

3. Have your 1995 two-corner model and your 2001 hybrid model (which were used in EPRI, 2004) been superseded? If so, by which model(s)?

a. Yes. Both models have been superseded. AB95 should be replaced by AB06' (AB06 with modifications in Atkinson and Boore, 2011, paper). The hybrid model should be replaced by A08' (Atkinson, 2008, with modifications in Atkinson and Boore, 2011, paper). Note that A08' is a Referenced Empirical rather than Hybrid Empirical (new method; uses empirical data more directly). Also likes the Pezeshk hybrid model, which is a good recent hybrid-empirical GMPE.
   i. The magnitude saturation in the AB06 model is a consequence of source finiteness, which is characterized using 60% of the Wells-Coppersmith dimensions (based on Paul Somerville's work on source scaling). AB06' adds a decreasing stress parameter to mimic magnitude saturation seen in BA08'.
   ii. The magnitude saturation in the A08' model is adopted from WUS because this model changes only the absolute level and the distance dependence. Note that it is similar to the hybrid empirical model in this regard (that model also mimics WUS saturation).

4. What are the key issues we should be considering in updating the model for the aleatory uncertainty as a function of magnitude and distance?

a. No problem in decoupling the calculation of sigma from the calculation of the median GMPE and its epistemic uncertainty.
b. Analysis of residuals in Atkinson (2012; see below) suggests that sigma may be similar or slightly lower than those in WUS.

5. In addition to your published papers, do you have any papers in preparation or under review that you can share with our project?

a. Atkinson (2012). Empirical evaluation of aleatory and epistemic uncertainty in eastern ground motions, Submitted to Seism. Res. L., Eastern Section, June. (copy provided)
b. Babaie Mahani, A., and G.M. Atkinson (2012). Moment Magnitude Estimates for Moderate Earthquakes in North America. Submitted to Bull. Seism. Soc. Am. (copy provided)
c. Atkinson, G.M., and Gail M. Atkinson and A.Babaie Mahani (2012). Estimation of Moment Magnitude from Ground Motions at Regional Distances. For Submission to Bull. Seism. Soc. Am., May 2012. (copy provided)
d. Work in progress with Dave Boore (will provide papers when submitted, scheduled for the end of the summer). Preliminary results suggest that geometric decay is different for different frequencies (this compensates for the higher stress drops one infers from the Empirical

Green's functions).
6. Do you know of interesting work in progress by other researchers? Motazedian, D., J.A. Hunter, A. Pugin, K. Khaheshi Banab, H.L. Crow (2011). "Development of a Vs30 (NEHRP) Map for the City of Ottawa, Ontario, Canada", Canadian Geotechnical Engineering Journal. doi:10.1139/T10-081. [NSERC and GSC].
7. Additional information from expert H/V ratios (especially if calculated for more than one event) is a good diagnostic for unusual site response

Table C-3

Expert Name: John Boatwright	Date of Call:
Prepared by John Boatwright	Date Prepared 10/4/12
1. What are the key issues we should be considering in updating the model for median amplitudes (and the associated epistemic uncertainty) as a function of magnitude and distance? a. We need to understand how to use small earthquakes (2.5 < M < 3.5) to help predict strong ground motion from large earthquakes. In particular, we need to include hypocentral depth as a third parameter. b. We need to model how directivity and radiation pattern can distort near-source ground motion. c. We need to be extremely careful in using regional data for small earthquakes.	
2. Which data are the most relevant in addressing these issues? Fourier spectra, PGA, and PGV, from near-field to regional distance (500 km).	
3. What are the key issues we should be considering in updating the model for the aleatory uncertainty as a function of magnitude and distance?	
4. In addition to your published papers, do you have any papers in preparation or under review that you can share with our project? The Variation of Brune Stress Drop with Hypocentral Depth for Moderate Earthquakes in Northeastern North America, by Boatwright, MacDonald, and Seekins.	
5. Do you know of interesting work in progress by other researchers? "The Frequency Dependence of Q in Eastern North America" by Dineva, Mereu, and Atkinson shows that the present NENA ground motion data can be fit by a range of attenuation models.	
6. Additional information from expert	

Table C-4

Expert Name: David Boore	Date of Call: 6/26/2012
Prepared by: Gabriel Toro	Date Prepared: 7/7/2012

1. What are the key issues we should be considering in updating the model for median amplitudes (and the associated epistemic uncertainty) as a function of magnitude and distance?

a. Geometric-decay rate in first 70 km: $R^{-1.3}$ or R^{-1}? This question makes a big difference in predictions. Unfortunately, no event contains good data over this distance range (best ones are Riviere-du-Loup). Faster geometric decay requires a higher value of stress parameter (higher amplitudes at short distances).
b. Source: 1 vs. 2 corner. Choice is strongly tied to geometrical spreading.
c. Geometric attenuation may be regionally dependent, contributing to epistemic uncertainty.
d. Very important to maintain internal consistency.

2. Which data are the most relevant in addressing these issues?

See items 1 and 5

3. Has your Atkinson-Boore 1995 model (which was used in EPRI, 2004) been superseded? If so, by which model?

It has been superseded by AB06' (Atkinson-Boore 2006 as revised by Atkinson and Boore, 2011). Reason for large difference in M scaling (M 5 to 7.5, as compared to Toro et al., 1977): finite source (EXSIM) and Atkinson-Boore 2011 decreasing stress parameter.

4. What are the key issues we should be considering in updating the model for the aleatory uncertainty as a function of magnitude and distance?

5. In addition to your published papers, do you have any papers in preparation or under review that you can share with our project?

Work in progress with Gail Atkinson using Empirical Green's Functions: provides constraints on stress parameters (considering Val-des-Bois, Riviere-du-Loup, and Saguenay).

6. Do you know of interesting work in progress by other researchers?

Boatwright-Seekins paper in BSSA.

7. Additional information from expert

N/A

Table C-5

Expert Name: Kenneth W. Campbell	Date of Call: Via email
Prepared by: Kenneth W. Campbell	Date Prepared: June 20, 2012

1. What are the key issues we should be considering in updating the model for median amplitudes (and the associated epistemic uncertainty) as a function of magnitude and distance? This is too complicated to discuss over the phone in a few minutes. Please see my recent literature on the subject (from a Hybrid Empirical modeling point of view) as listed, for example, in my Blue Castle presentation. If you don't have access to the Blue Castle presentation, I can send it to you. *(Editor's note, see Campbell, 2011.)*
2. Which data are the most relevant in addressing these issues? This is too complicated to discuss over the phone in a few minutes. I would need some time to think about this issue.
3. Has your model (Campbell, BSSA 2003) been superseded? If so, by which model? I would consider the Pezeshk et al. (2011) Hybrid Empirical model published in the BSSA to have superseded my 2003 model in that it uses virtually the exact same methodology but with updated seismological and empirical models. It is also consistent with the approach used in my 2007 NEHRP research report and subsequent conference papers (see Blue Castle presentation).
4. What are the key issues we should be considering in updating the model for the aleatory uncertainty as a function of magnitude and distance? This is too complicated to discuss over the phone in a few minutes. I would need some time to think about this issue.
5. In addition to your published papers, do you have any papers in preparation or under review that you can share with our project? There are some plots showing comparisons of Hybrid Empirical models in the Blue Castle presentation, which I intend to publish as a Comment to the Pezeshk et al. (2011) BSSA paper. My research on the PEER NGA-East Ground Motion project is too preliminary to share.
6. Do you know of interesting work in progress by other researchers? There is a lot of interesting work being done as part of the PEER NGA-East Ground Motion project, but it is too preliminary to share. You will need to ask other experts in the field to see what new studies they are working on.
7. Additional information from expert I have no additional information to provide.

Table C-6

Expert Name: Chris Cramer	Date of Call: 7/3/2012
Prepared by: Gabriel R. Toro	Date Prepared: 7/10/2012

1. What are the key issues we should be considering in updating the model for median amplitudes (and the associated epistemic uncertainty) as a function of magnitude and distance?

a. EPRI (2004) did not have enough separation between experts and TI Team. More independence needed.
b. EPRI (2004) gave large weights to one Proponent Expert (Silva).
c. Silva's single-corner model should be treated as a 2-corner model because the low Q value used with single-corner leads to identical predictions as double-corner. This is shown in Cramer (2006) BSSA paper.

2. Which data are the most relevant in addressing these issues?

a. The NGA-East database.
   i. Comparisons presented at the NGA-East Workshops and poster at 2012 SSA meeting show interesting trends. Comparisons suggest that models overpredict at long periods.
   ii. Currently working on report for NGA-East project.
   iii. Working with Christine Goulet of PEER on cleanup and Quality Assurance (QA).

3. What are the key issues we should be considering in updating the model for the aleatory uncertainty as a function of magnitude and distance?

No specific comments. EPRI (2006) did a good job at estimating sigma.

4. In addition to your published papers, do you have any papers in preparation or under review that you can share with our project?

a. Cramer (2006) BSSA
b. Cramer (2012) SSA Poster
c. Cramer (2010) paper at US/Canadian Earthquake Conference (Toronto)

5. Do you know of interesting work in progress by other researchers?

a. The NGA-East Source and Path working group is doing interesting work, but there is nothing ready.
b. Vs measurement by USGS and others (Alan Yong, Rob Kayen, etc.)

6. Additional information from expert

N/A

Table C-7

Expert Name: Art Frankel	Date of Call: 7/31/2012
Prepared by: Robert Youngs	Date Prepared: 8/02/2012

1. What are the key issues we should be considering in updating the model for median amplitudes (and the associated epistemic uncertainty) as a function of magnitude and distance?

a. Geometrical spreading at distances less than 100 km: is decay steeper than 1/R observed widely across CEUS, is it perhaps a result of radiation pattern
b. Moho bounce: is it as prominent in other areas as in southeastern Canada.
c. Source spectra – single versus double corner: Although the single corner model is perhaps too simplistic, a good physical explanation of the basis for a double corner model is needed.
d. The concept of a single corner type model with 1/R spreading (<100 km) and nearly constant stress should be given some weight in developing updated ground motion characterization. This model in point source form also has issues with overestimation of ground motions from large earthquakes at short distances.
e. Modeling using finite faulting sources is an important step forward, but there should be a good physical basis for the source spectra (see c. above)
f. Scaling of stress drop with seismic moment. Needs to be consistent with the faulting model. A finite-fault model with constant stress drop explains NGA west observations. CEUS median stress drop is higher than WUS.
g. Characterization of site response in Central and Eastern United States (CEUS).

2. Which data are the most relevant in addressing these issues?

a. Detailed studies of recent earthquake data, such as the Riviere du Loup event using careful time domain modeling
b. Suggest consideration of coda normalization technique developed by Aki to remove site response and instrument response from data

3. Has your Frankel et al. 1996 model (which was used in EPRI, 2004) been updated or superseded? If so, by which model?

It has not been updated or specifically superseded. In the early stages of an update. The basic characteristics of the model should be considered in CEUS ground motion characterization with the caveats mentioned in 1d above.

4. What are the key issues we should be considering in updating the model for the aleatory uncertainty as a function of magnitude and distance?

No strong opinion about use of NGA West data, but suggest that NGA aleatory variability may be a minimum. The Saguenay earthquake suggests that there may be more source to source variability in Central and Eastern North America (CENA). There does not appear to be a Saguenay type earthquake in the NGA West database.

5. In addition to your published papers, do you have any papers in preparation or under review that you can share with our project?

Nothing at this point

6. Do you know of interesting work in progress by other researchers?

Believe that Hartzell and Mendoza are doing some work that may be relevant to the issue.

7. Additional information from expert

Table C-8

Expert Name: Bob Herrmann	Date of Call: 9/11/2012

Bob Herrmann was interviewed on September 11, 2012. Bob Herrmann provided a paper entitled, "Ground Motions for Recent Earthquakes in Eastern North America," updated October 12, 2012, with highlights to document the interview. This paper provided an overview of data sets available for recent, significant earthquakes in eastern North America. The update adds the M_w=4.83 Northeast Texas earthquake of May 17, 2012. The ground motion at larger distances was demonstrably lower than any of the model predictions, which indicated the need for different ground motion scaling for paths in the Gulf Coastal Plain. Dr. Herrmann focused on this earthquake because of the large difference between observed and predicted intensities.

Dr. Herrmann suggested that one should entertain a California-like ground-motion attenuation model for the Gulf Coastal Plain. Such a model may have a major effect on hazard calculations in this region. Plots in the paper raise another issue underlying any prediction model – the ability of the model to reflect the data sets in their creation. There is very little modern digital broadband data at distances less 100 km, and especially less than 20 km. Confidence in the model at these shorter distances would have to be based on other evidence (e.g., behavior of western U.S. data sets, or even theoretical wave propagation considerations).

Dr. Herrmann states in the paper that Dr. Martin Chapman has access to a unique data set acquired from the Mineral, Virginia, aftershocks. A linear array with a station separation on the order of km's was deployed to about 70 km. This data set may elucidate the nature of geometrical spreading, for this one azimuth, for this type of source mechanism. Although we have better observations, Dr. Herrmann recommended that sponsoring agencies be proactive to acquire new data sets by deploying seismographs as earthquakes occur, so that we can acquire data sets to better constrain ground motion scaling.

Table C-9

Expert Name: Shahram Pezeshk	Date of Call: 6/26/2012
Prepared by: Shahram Pezeshk, G. Toro	Date Prepared: 7/2-7/2012

1. What are the key issues we should be considering in updating the model for median amplitudes (and the associated epistemic uncertainty) as a function of magnitude and distance?

Since due to lack of data, the ground–motion must rely on numerical simulation, especially the stochastic simulations, following are the issues that should be considered in such a modeling:

Types of stochastic modeling and the combination

- Single-Corner point-source
- Double-Corner point-source
- Finite fault

Single-corner point-source and finite fault models have been updated in term of compatible seismological parameter and modeling procedure; however, the existing double-corner point-source models for CEUS have not been examined and updated for consistency with the newly recorded data.

The most critical issue in point source modeling is to use consistent seismological parameters corresponding to each source, path, and site terms. In other words, the correlations between these terms should be considered in modeling. This means that the stress drop being used for instance in the single-corner point-source modeling should be consistent with the choice of geometrical spreading and quality factor function (path effect) and also the site term.

Sensitivity analysis should be performed with different set of correlated parameters to prevent redundancy; therefore, decreasing the epistemic uncertainty. For instance, if two sets of correlated seismological parameters would result in similar estimation of ground motion, what is the point of using the two?

Another critical issue is the regionalization. Is the choice of seismological parameters the same in the New Madrid seismic zone and for example the southeastern Canada? Of course, lack of strong motion data is an obstacle to verify the regionalization; however, the small magnitude events may be used to detect regionalization. Again, if regionalization is detected, in each region consistent correlated seismological parameters should be used.

Another interesting issue is the geometric decay within 50-70 km. Some investigators see R-1.3, others see R-1. Could this be explained by regional differences?

The correlation between seismological parameters will affect the parametric uncertainty in the stochastic modeling. By using different sets of correlated seismologic parameters in a logic tree scheme the parametric uncertainty could be quantified appropriately.

The distance measure: Different modifications have been introduced for the distance measure used in the point-source modeling to mimic the effect of finite faults. These modifications are necessary when using the point-source method for ground motion estimation at close distances. However, if the distance modification is developed to make point-source simulations very close to finite fault modeling what is the point of using both models and maybe one is enough!

In CEUS, the reference site is a very hard rock. There are different site responses of the hard rock of CEUS based on different generic profiles, empirical H/V ratios, etc. Again, whatever the choice of site response would be, consistent seismological parameters for source and path should be used.

Data from recent earthquakes in CEUS such as Mt. Carmel, Arkansas, Kentucky, and Central Virginia can be used to evaluate different models (at least in the small to moderate magnitude range) and study possible regionalization.

Another modeling technique will be hybrid empirical modeling. Also, since hybrid empirical modeling uses stochastic simulation to map the empirically derived GMPEs from a host region to CEUS, the same issues for stochastic modeling are applicable. For Hybrid empirical modeling:

- The choice of stress parameter for both host and target region plays an important role in the HEM estimations, especially at high frequencies (PGA). For, the host region, this parameter can be constrained with empirical data. For the target region, due to lack of strong motions stress parameter is not well constrained. The issue is that whether the stress parameter from small event can be used for the large events as well. One alternative is to use the same magnitude scaling observed in the host to constrain the stress parameter in target. This procedure may result in using the same degree of magnitude scaling in both regions and cancel out this effect. On the other hand the purpose of using HEM is to map the same magnitude scaling observed in host to target. Therefore, by using, e.g., the small magnitude stress parameters for both WNA and ENA it can be assumed that the HEM does the rest and model the same magnitude scaling observed in the Western North America (WNA) for Eastern North America (ENA).
- In WNA the dependency of stress parameters with magnitude is observed using a point-source stochastic model. This dependency might be weakened if higher order stochastic model, where the definition of stress parameter is different, is used to model ground-motions. Therefore, the choice of stress parameter should be exclusively limited to the specific stochastic model being used in HEM.
- The stress parameter is correlated with the choice of path effect in the inversion problem of going from observations to the stochastic predictions. Therefore, the choice of stress parameter should be consistent with the path effect being used in the stochastic simulations. On the other hand, based on the systematic difference between path effect between WNA and ENA, the choice of path effect, affect the shape of HEM estimations. Therefore, enough evidence and rationalizations should be used to select the path effect for both WNA and ENA. Using different alternatives with appropriate weighting to consider the epistemic uncertainty is recommended.

Table C-10

Expert Name: Walt Silva	Date of Call: 7/17/12
Prepared by: Robin McGuire	Date Prepared: 7/18/12

1. What are the key issues we should be considering in updating the model for median amplitudes (and the associated epistemic uncertainty) as a function of magnitude and distance?

a. Appropriate accommodation of a spectral sag at large M (e.g., Nahanni and results of Boatwright and Choy).
b. Appropriate stress parameter at large M.
c. Saturation of high-frequency with M ($\Delta\sigma$ (M) and/or fictitious depth).
d. Smooth simple G(R) for widespread applicability as crusts vary across CENA.
e. Appropriate contribution of R-1.3 based on empirical and modeling (access potential contributions of source mechanism and vertical component to apparent R-1.3).
f. Consistency of Q(f) with G(R).

2. Which data are the most relevant in addressing these issues?

Large and small M earthquakes in ENA and modeling.

3. **Has your model (Silva et al., 2002) been superseded? If so, by which model?**

No, but it needs to be updated (see #5 below). 2002 model only good to 500-600 km because of Q effects.

4. What are the key issues we should be considering in updating the model for the aleatory uncertainty as a function of magnitude and distance?

Aleatory variability at high frequency has to exceed the aleatory of stress drop. Key issue is how many standard deviations is Saguenay? Stress drop dependence on source depth should be examined empirically, clearly seen in WNA but only over top 5 km. Consider increase in aleatory around 70 to 150 km, examine empirically. Also site component of the aleatory at high frequency should not be lower than the aleatory in kappa from inversions of the Saguenay main shock in the BNL report.

5. In addition to your published papers, do you have any papers in preparation or under review that you can share with our project?

Will prepare an update to Silva 2002 model, expected in 1 month or so, with added Q term. Note 2002 models have $\Delta\sigma$ (M) and fictitious depth for saturation. Since each affects saturation differently they should be treated as epistemic with weights based on NGA WNA GMPEs.

6. Do you know of interesting work in progress by other researchers?

Boore and Atkinson may have new 2C model.

7. Additional information from expert

a. Older Atkinson 2C model has too much sag in source spectrum; Nahanni shape lies lie between spectra for 1C and 2C models.
b. If done correctly, 1C and 2C (Atkinson) point source models should have about equal weights.
c. Geometrical attenuation models with a flat or increasing portion at R~70 km for Moho bounce over-interpret data for forward predictions. This model may possibly apply for the Canadian shield where crust is laterally continuous and homogenous, but will not apply for travel paths through the Appalachians, coastal plain, etc. A better model may have a change in slope at R~100 km, or several changes in slope, but will not be flat.
d. 2C model works well in WUS compared to NGA GMPEs and doesn't produce as much of a spectral sag as in eastern North America (ENA).
e. Observe minimum Q at ~0.5 Hz, and slowly increasing Q at lower frequencies—not a symmetrical parabolic shape with f.

f. Jack Boatwright did some good work on large M source spectra in ENA (stable regions), needs to be encouraged to update this for more recent large M EQs in CSR—e.g., using records from Bhuj in 2001. He documented source spectral sag at large M in past studies.
g. Regarding correcting earthquake records in Eastern United States (EUS) for V_{S30}, need to be careful with ground motions from narrow-band (40 SPS) data, some records may have been double-filtered and will have long-period drift. Broad-band data are better.
h. Correction for V_{S30} depends on whether site is located in a glaciated region. Glaciated regions which are typified by shallow soils show lower amp factors at low frequencies, for the same V_{S30} than deep soils (e.g., Mississippi embayment). This comes through in empirical CENA amps. Has maps of V_{S30}, glaciated regions, and soil thickness for EUS, these should be used to develop site correction factors for records, don't throw all data into the same category. Michigan and Illinois glacial basins are in glaciated regions but have deep soils, but we may not have many records in those basins.

Table C-11

Expert Name: Paul Somerville	Date of Call: 7/09/2012
Prepared by: Robert Youngs	Date Prepared: 7/09/2012

1. What are the key issues we should be considering in updating the model for median amplitudes (and the associated epistemic uncertainty) as a function of magnitude and distance?

a. Crustal structure and source depth are likely to be important. Should perhaps be distinctions between EPRI (1993) zones 1 and 3. Regions of the crust where there is no significant Conrad boundary may produce a more distinctive "Moho bounce" as well as faster near source attenuation (R<-1) as opposed regions where the Conrad layer is present the more uniform gradient of velocity with depth will weaken the Moho bounce and lead to R-1 attenuation. In particular, areas of extremely hard crust with very shallow earthquakes (e.g,, Western Australia) will produce ground motion behavior that is difference from most of the CEUS. Data from Western Australia shows very strong RG waves. The type of crust may be present only in Zone 11 of EPRI (1993).
b. Source area uncertainties are not greatly important. Earthquakes with smaller area, and thus larger slip (to maintain moment) also appear to have longer rise times such that the slip velocity is not greatly different from more tectonically active areas.
c. Geometric attenuation may be regionally dependent, contributing to epistemic uncertainty.
d. Very important to maintain internal consistency.

2. Which data are the most relevant in addressing these issues?

a. US traveling array data should provide very valuable data, as well as the data from the recent earthquakes. Should provide a basis for looking for regional differences, azimuthal differences, crustal structure effects, etc.
b. Data from western Australia (the Yilgarn craton) may not be relevant because of the crustal structure and very shallow depth of the earthquakes

3. Has your Somerville et al. 2001 model (which was used in EPRI, 2004) been updated or superseded? If so, by which model?

It has not been updated. It has also not been superseded as it is still good for $M \geq 6$, especially for frequencies ≤ 1 Hz. Not aware of other models that represent a replacement. Does not consider Atkinson and Boore (2006, 2006) a replacement as they do not use full wave propagation to compute seismograms, but instead rely on RVT and empirical attenuation

4. What are the key issues we should be considering in updating the model for the aleatory uncertainty as a function of magnitude and distance?

No strong opinion about use of NGA West data, but suggest that the new data from the east, especially the US Array data, be examined to validate the assumption of similarity between east and west aleatory variability.

5. In addition to your published papers, do you have any papers in preparation or under review that you can share with our project?

Work in Australia (attached) especially for non-cratonic Australia should be useful, with the caveat that larger kappas were used compared to what is assumed for the CEUS.

6. Do you know of interesting work in progress by other researchers?

Trevor Allen has a new stochastic model for SE Australia calibrated using data that would be useful to compare to the Somerville et al. 2009 model based more purely on modeling. The Allen model is expected to be more similar to ENA stochastic models than the Somerville model, which is similar to the NGA West models.

7. Additional information from expert

Somerville, P.G., R.W. Graves, N.F. Collins, S.G. Song, S. Ni, and P. Cummins (2009). Source

and ground motion models of Australian earthquakes. Proceedings of the 2009 Annual Conference of the Australian Earthquake Engineering Society, Newcastle, December 11-13.