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Reiter

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Lawrence Livermore National Laboratory
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Dear Don:

This letter is to transmit our preliminary assessment of the second round questionnaire's impact on the results of the SEP analysis. Although a precise quantification of the induced variations is difficult without rerunning the analysis, it is possible in most cases to characterize the impact through a prescription of the variational bounds.

In the second round questionnaire the experts had the opportunity to modify their input regarding the seismicity models used in the analysis, namely: the seismic zonation, and for each source, the a and b values of the recurrence relationship, the upper magnitude cutoff M_u, the credibilities and self-ranking. In the analysis, these quantities were expert-dependent and directly extracted from each expert's response to the first questionnaire. In the second questionnaire, the experts were also asked to review and criticize other generic assumptions and interpretations that were part of the SEP methodology and applied to all experts. These assumptions were the intensity (MMI) vs. magnitude (m_b) correlation used in the analysis, the "background" vs. "no background" seismicity model, the ground motion model and its uncertainty.

The sensitivity of the results to some of these parameters is site-dependent and has been presented in both our Seismic Hazard Analysis: Results Report, and Sensitivity Results Report. However, for convenience, the major points are repeated as follows:

- For the sites located in the central United States (CUS), there is little sensitivity to zonation, whereas in some cases it may become important for a northeastern site (EUS).

- The a value of the recurrence relationship is a relative insensitive parameter because variations of 20 to 30 percent introduce only a few percent variation in the results.

- The b value of the recurrence relationship is a sensitive parameter, particularly for highly seismic source; 20 percent variation in the b value will introduce at least as large variations in the results, particularly for long return periods (1,000 years or greater)

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- The sensitivity to M_u variations is a function of a number of parameters such as the value of b and of M_u itself. Variations of half a magnitude are as large as 30 percent when applied to an upper magnitude of 5.0 and decrease to five percent for an upper magnitude of 7.0.

- The importance of the MMI vs. m_b correlation has not been studied in detail as it would have required us to reanalyze the whole data base. We do not believe that this is a very sensitive parameter because only some events are affected and this would not substantially modify the recurrence relationship. It is likely, however, that the model used thus far is slightly conservative.

- The sensitivity of the results to the "background" vs "no background" zonation is a function of the credibilities assigned by each expert to the zones, the location of the site and the attenuation law. The background zonation always generated results higher by up to and in a few cases greater than 20 percent over the no background zonation.

- The analysis is particularly sensitive to the attenuation relationship. The sensitivity lies at two levels. First, the mean of the attenuation is often ill-defined in the near and far field where limited data are available. The addition or exclusion of a few data points in the near field as well as the choice of a given mathematical model will often have a dramatic effect on the mean and consequently on the seismic exposure (50 percent). Second, the uncertainty associated with a fixed mean is a very sensitive parameter. In this analysis, the uncertainty is described by a log-normal distribution with two different values of sigma (0.6 and 0.9). The size of the sigma and the distribution truncation effect become more pronounced at longer return periods. Results variations of 50 percent are not uncommon for a 1,000-year return period. The importance of the attenuation uncertainty model is further dramatized by noting that the model is applied uniformly to each expert. Therefore, it has a generic effect on the results that cannot cancel out, as in the case of other elements in the input, e.g, Expert 5 with a steep b value and a large M_u or the compensating effect on the synthesis of Expert 8 and Expert 10.

With this background discussion, the effects of the responses to the second round questionnaire are described below:

Zonation and Seismicity (the percentage in parenthesis refers to the potential PGA variation at 1,000-year return period)

- With the exception of Expert 9 (E_9), who provided a significantly different model for the central United States, the experts left their zonations essentially unmodified and no effect should be expected on the results.

- The a values were left unmodified except for E_7 (5 to 10 percent increase in CUS) and E_8 (10 to 20 percent decrease throughout).

- The b values were left unmodified except for E_{11} (10 percent increase throughout) and E_8 (15 to 25 decrease throughout).

- The upper magnitude cutoff (M_u) was modified in many cases but seldom by an amount larger than half a magnitude unit. This change is important for the experts with low upper-magnitude cutoff: E_8 (50 to 60 percent increase in CUS and 15-percent increase in EUS) and E_{12} (30 percent increase in CUS and 15 percent increase in EUS).

- Expert 9 has deleted two and added three sources with different seismicities and M_u in the Central United States. This is a substantial revision of expert opinion. A precise assessment of these variations would require a reanalysis of this region. In a first approximation it appears that a combination of higher a values and M_u would lead to a 15- to 20-percent increase.

- The modifications in the zonation credibilities and experts' self rankings are difficult to quantify but they are expected to have a minor effect on the results synthesis.

The net effect of these variations in zonation and seismicity would lead to the following general modifications of the results. In the CUS: one expert with a 5 percent decrease, two experts with unchanged results, one expert with a 5 percent increase and four experts with a 10- to 30-percent increase. In the EUS, two experts with a 5 to 15 percent decrease, six experts with unchanged results and two experts with a 10- to 15-percent increase. It is expected that the

increase in the results synthesis due to seismicity and zonation modifications would certainly be less than 15 percent in the CUS and less than 10 percent in the EUS.

Generic Assumptions and Interpretations

- All except one expert recommended the use of other techniques for determining magnitude from intensity data. A majority (six) of the experts recommended the use of direct techniques such as felt area or intensity fallout to determine the magnitude from the intensity data. While such approaches require in depth reanalysis of the data, which is outside the scope of this analysis, it appears that in most cases they would lead to steeper b values of the recurrence relationship and lower M_u. The same conclusion applies to the other experts who recommended the use of other accepted MMI vs. m_b relationships. Hence, one may say that the relationship used in this analysis is on the conservative side although it would be difficult to quantify the amount.

- The zone superposition model and background zonation were strongly supported by the experts. Only two were undecided about the background and one totally opposed to this approach (E_8). E_8 recommended the use of the most credible zonation without superposition or background. Such an approach would reduce his results by 10 to 20 percent depending upon the site.

- Of the eight experts providing an opinion on attenuation relationships, three recommended the use of the Gupta-Nuttli based attenuation relationship applied in this study. The Cornell-Metz attenuation relationship, also mentioned, provides very similar results in terms of PGA. The impact of other more sophisticated techniques such as direct PGA or I_s regression on m_b cannot be assessed without in-depth studies.

- The range of uncertainties recommended for the attenuation law varied from a sigma of 0.5 to 0.9 with a marked preference for 0.6 - 0.7. Two experts had no opinion on this matter. The introduction of a distribution truncated at three sigmas with the favored reduced uncertainties compared to a distribution truncated at two sigmas with sigma of 0.9 would reduce the results as follows: two experts with a decrease of 20 percent, three experts with

a decrease of 15 percent, two experts with a decrease of 5 percent and one unmodified. Therefore, we believe that the effect on the synthesis results due to favored attenuation models would be a reduction of 10 to 15 percent.

In summary, the second round questionnaire resulted in an increase in seismicity particularly in the central United States. This was partially motivated by the recent Kentucky earthquake. It emphasized the potential problems and conservatism associated with direct correlation between MMI and m_b and consequently with attenuation models based on it. It supported reduced ground motion model uncertainty more in line with empirically determined values from the West Coast of the world data base.

The report summarizing the answer to this questionnaire for each individual expert will be ready by January 15, 1981. Please feel free to get in contact with us if you have any questions.

Very truly yours,

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Christian P. Mortgat
Project Manager

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