



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D. C. 20555

JUN 08 1991

CF  
*T. Cheng*

LETTER TO ALL SEP OWNERS  
(EXCEPT SAN ONOFRE)

Gentlemen:

SUBJECT: SITE SPECIFIC GROUND RESPONSE SPECTRA FOR SEP PLANTS  
LOCATED IN THE EASTERN UNITED STATES

Reference: Letter to SEP Group II Plant (Big Rock Point, Dresden 1,  
Haddam Neck, La Crosse, Yankee Rowe) Licensees from  
D.G. Eisenhut, NRC dated August 4, 1980

Our letter dated August 4, 1980 (reference) issued the preliminary version of site specific ground response spectra for the eastern United States SEP plants. Recently, these spectra have been finalized by the staff. Enclosure 1 includes the recommended ground response spectra (5% damping) for the eastern SEP sites. The bases of our final decision regarding the spectra and the digitized spectral acceleration values (5% damping) for these spectra are documented in Enclosure 2.

The site specific spectra (SSS) included in Enclosure 1 establish the ground motion acceleration values to be input into the structural reevaluation analyses to determine the resultant seismic loads. The geology reviews for Palisades, Ginna and Dresden 2 have been completed by the staff. The results of the review did not identify any geologic features that would affect the site specific spectra for those facilities. Based on our review to date for the remainder of the SEP facilities located in the eastern United States, we do not expect the SSS to be changed due to local geologic considerations.

Sincerely,

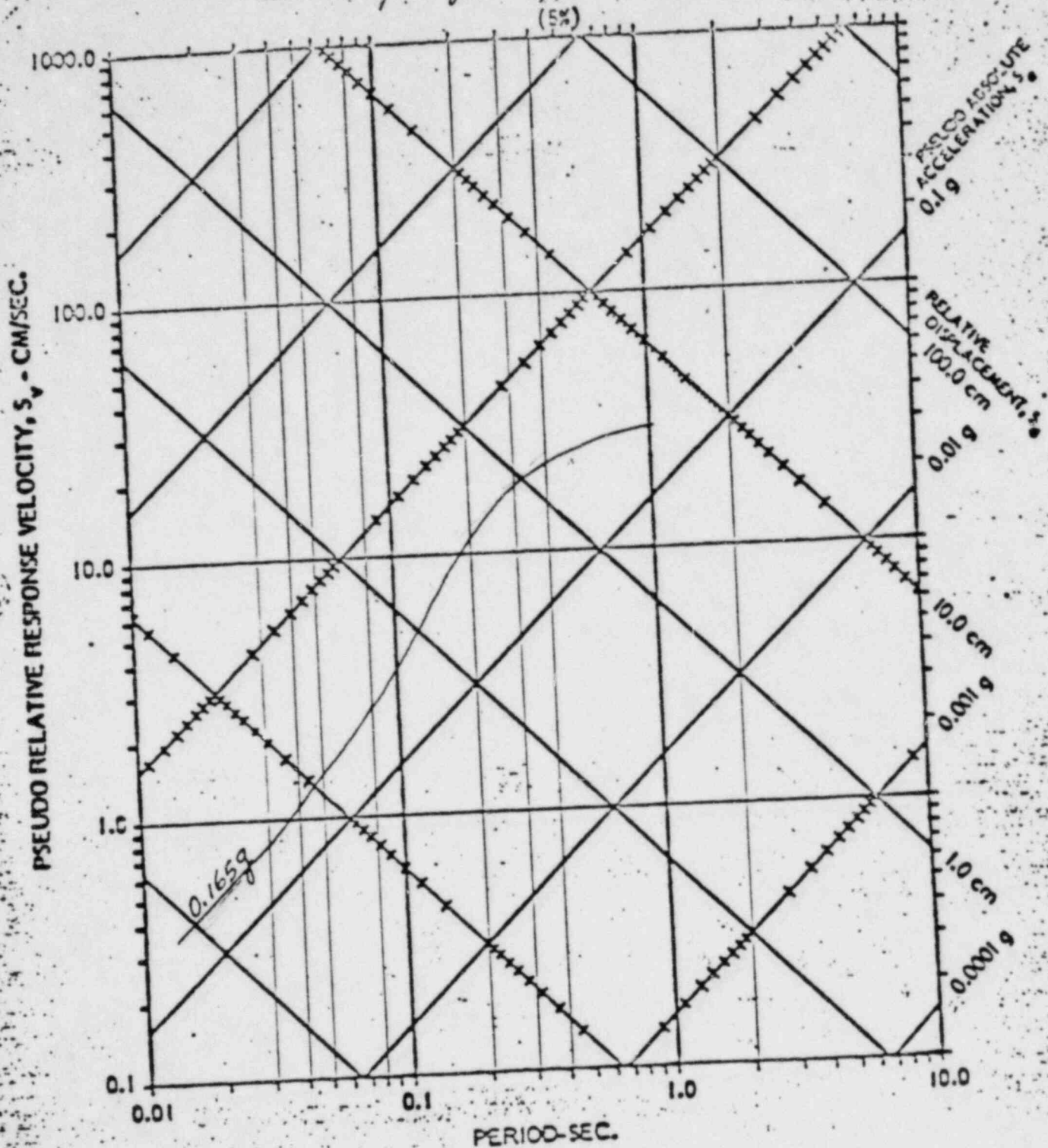
*Dennis M. Crutchfield*  
Dennis M. Crutchfield, Chief  
Operating Reactors Branch No. 5  
Division of Licensing

Enclosure:  
As stated

cc:  
D. Eisenhut  
J. Knight  
G. Lainas  
R. Jackson  
G. Lear  
W. Russell  
R. Hermann  
T. Cheng  
P.Y. Chen

Attachment 1

Site Specific Spectrum



Oyster Creek Site  
(5% Damping)

Attachment 2



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D. C. 20555

MAY 20 1981

MEMORANDUM FOR: William Russell, Chief  
Systematic Evaluation Program Branch  
Division of Licensing

THRU: *JK* James F. Knight, Assistant Director  
for Components and Structures Engineering  
Division of Engineering

FROM: Robert E. Jackson, Chief  
Geosciences Branch  
Division of Engineering

SUBJECT: FINAL REVIEW AND RECOMMENDATIONS FOR SITE SPECIFIC  
SPECTRA AT SEP SITES

On April 24, 1981, we received the most important outstanding items related to the Site Specific Spectra Study, Drafts of Volumes 4 and 5 of Seismic Hazard Analysis (Lawrence Livermore Laboratories). Please find enclosed our final review of this study with respect to the SEP. This review and our recommendations were prepared by Dr. Leon Reiter of the Geosciences Branch and are attached to this memorandum. A summary of these recommendations is:

1. We reaffirm the spectra recommended in the "Initial Review and Recommendations for Site Specific Spectra at SEP Sites" (Memorandum from R. Jackson to D. Crutchfield, June 23, 1980)."
2. We find no need to reduce the spectra at rock sites. This possibility was raised in the June 23, 1980 Memorandum.
3. We have not taken into account possible anomalous site conditions at Palisades, LaCrosse or Yankee Rowe.
4. Application of this study and its review recommendations to other sites or other programs should be examined on a case by case basis.

We consider the recommended spectra and the evaluation of their conservatism as described in the section entitled "Conservatism of Recommended Spectra" in the attached review to be consistent with the general SEP approach. The assessment of these spectra with respect to safety and design adequacy should be considered within the context of structural and mechanical performance of plant structures, piping and equipment.

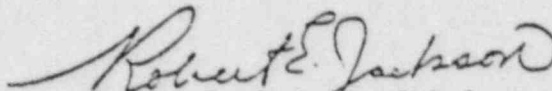
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MAY 20 1981

William Russell

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Based upon our ongoing review of site geology to satisfy SEP Topics II-4; Geology and Seismology, and II-4B: Proximity of Capable Structures to the Site, we do not anticipate that our final review of these topics will have any impact upon the recommended spectra.



Robert E. Jackson, Chief  
Geosciences Branch  
Division of Engineering

Enclosure:  
As stated

cc: w/enclosure  
R. Vollmer  
D. Eisenhut  
G. Lainas  
W. Russell  
T. Cheng  
D. Crutchfield  
F. Schauer  
H. Levin  
L. Wight, TERA Corp.  
G. Lear  
L. Heller  
D. Bernreuter, LLNL  
GSB Personnel

## FINAL REVIEW AND RECOMMENDATIONS FOR SITE SPECIFIC SPECTRA AT SEP SITES

### Purpose and Scope

This review presents final recommendations for Site Specific Spectra to be used in the reevaluation of SEP plants. It supplements "Initial Review and Recommendations for Site Specific Spectra at SEP Sites" (Memorandum from R. Jackson to D. Crutchfield, June 23, 1980, and referred to below as Initial Review) and is based upon those items reviewed for the Initial Review plus the following documents.

- (1) Seismic Hazard Analysis: Volume 4, NUREG/CR-1582, Application of Methodology, Results and Sensitivity Studies (Draft) D. L. Bernreuter, LLNL April 1981 NUREG/CR-1582. (Referred to below as Volume 4).
- (2) Seismic Hazard Analysis: Volume 5, NUREG/CR-1582, Peer Review, Eastern Ground Motion Panel and Formal Feedback (Draft) D. L. Bernreuter LLNL, April 1981 (Referred to below as Volume 5).
- (3) Final Report Seismic Hazard Analysis: Results, TERA Corporation, February 1981.
- (4) Introduction to Ground Motion Panel, TERA Corporation, February 1980.
- (5) Second Round Questionnaire, TERA Corporation, September 1980.
- (6) Seismic Hazard Analysis: Solicitation of Expert Opinion Second Round Questionnaire, TERA Corp., January 1981.

All of the above documents and many of those listed in the initial review will appear in their final form as text or appendices in volumes 4 and 5 of NUREG/CR-1582 Seismic Hazard Analysis. Two segments of this study, Volume 2, "A Methodology for the Eastern U.S.," and Volume 3, "Solicitation of Expert Opinion," have already been published. Volume 1 of this series, which represents an executive summary of the study, has not yet been submitted. Items originally listed in the Initial Review which have not been received are:

- (1) Review of the Draft Seismic Hazard Analysis by the USGS,
- (2) Additional Review and Comments by Drs. Newmark and Hall.

Licensee submittals for individual SEP sites are being handled by the SEP Branch separately on a case by case basis.

#### Recommendations

In the Initial Review the following recommendation was made.

"It is recommended that the following spectra presented in the Sensitivity Results (May 1980) be used as site specific free field spectra.

Eastern U.S. (Yankee Rowe, Connecticut Yankee, Millstone, Ginna, Oyster Creek) - "1000 year" spectra assuming no background and Ossippee Attenuation.

Central U.S. (Dresden, Palisades, LaCrosse, Big Rock Point) - "1000 yr" spectra assuming no background and Gupta-Nuttli Attenuation.

These spectra account for gross site conditions (soil or rock) and do not take into account any specific conditions which may result in amplification (LaCrosse, Yankee Rowe, Palisades).

It is also recommended that a minimum be established for which no spectra be allowed to go below. It is suggested that this minimum be the median (50th percentile) representation of real spectra for a magnitude 5.3 earthquake. This minimum exceeds the "1000" yr spectra for Big Rock Point, LaCrosse and Palisades at frequencies greater than 2 to 3 Hz."

Based upon review of the documents and information received since preparation of the Initial Review, we conclude that the recommended spectra as described above in the Initial Review are appropriate for use in the Systematic Evaluation Program. The rationale for this conclusion is discussed below.

Digitized response spectral values (5% damping) for each site and a scaling relationship which can be used to derive spectra at other damping values are attached to this review (Enclosure 1).

#### Basis for Previous Recommendation

As described in the Initial Review the above recommended spectra depend upon several important assumptions by the staff. They are:

- (1) The appropriate ground motion model to be used in the Central-U.S. was that based upon a modification of the Gupta and Nuttli (1976) relation.
- (2) The appropriate ground motion model to be used in the northeastern U.S. was that calculated from the 1940 Ossipee earthquake. The particular version of the Ossipee model to be used is that which was originally presented since it is more analagous to that used by Gupta and Nuttli (1976) for the central U.S. and falls closest to theoretical models of ground motion.

- 3) The appropriate zonation assumptions should be intermediate between those labeled "Background" and "No Background".
- 4) The appropriate dispersion assumed for ground motion estimation should be  $\sigma = 0.7$  (natural logarithms) truncated at  $\pm 3\sigma$ .
- 5) The recommended spectra can be associated with return periods of the order of 1,000 to 10,000 years.

The additional review herein concentrates upon the appropriateness of the preceding assumptions in light of the new material received.

#### Feedback and Second Round Questionnaire

The most important item received since the previous review centers about convening the experts for a round table discussion and the submittal by them of answers to a second-round questionnaire. At the meeting of the experts the results of the first questionnaire, calculated results, and sensitivity parameters were presented and discussed. This meeting was followed by submittal of a second round questionnaire which gave each expert the opportunity to modify his input to the study regarding the seismicity models used in the LLNL/TERA analysis. In addition each expert was asked to explicitly address those issues which were not adequately discussed previously and were shown to have an important effect upon the calculated spectra. It is important to point out that in the interim (between responding to the first and second questionnaires) there occurred an  $m_{big} = 5.2$  earthquake in Kentucky.



This was the largest event to occur in the U.S. east of the Rocky Mts. since the southern Illinois earthquake of 1968 and it provided an opportunity to test the effect of new information upon the experts' input and the calculated spectra.

#### Change in Seismicity Models

Most of the experts suggested some changes in their seismicity models. While many of these changes were minor, some had possible major impact upon the calculated results. One expert provided a significantly different seismic zonation than he previously had provided, several changed their upper magnitude cut-off and two experts suggested modified b values. Qualitative assessments of the impact of these changes on calculated results were originally made (Volume 5) indicating net changes in resulting ground motion for individual experts ranging from a 5% decrease to a 30% increase in the central U.S. and from a 15% decrease to a 15% increase in the eastern U.S. It was also felt that the effects of these individual changes in the input would lead to changes in the synthesis that would certainly be less than 15% in the central U.S. and less than 10% in the eastern U.S. LLNL recalculated results (Volume 5) for four of the experts. (The generic parameters were the same as those recommended in the Initial Review). The experts selected were those for whom most of the larger changes were indicated. Many of the changes were not as large as originally anticipated particularly for the expert who had large changes in zonation. As a result of the recalculations it was estimated (LLNL) that the change in any synthesis would be less than 10%. Based upon our

examination of the individual results we believe that this can be even further restricted to less than about 5%. This net change in synthesis ground motion would be least (a very slight increase or decrease) in the eastern U.S. and reach an increase of perhaps several percent in the central U.S. It is important to note that probabilistic estimates remain quite stable in particular those based upon a syntheses of opinion even though some of the input parameters may vary significantly. This is due primarily to the balancing effects which result from the changes in different input parameters for the same expert and the balancing effects which result from changes in input parameters from different experts.

#### Feedback on Generic Assumptions

The experts were asked to provide their input on generic assumptions previously assumed in the study which were applied to all the inputs uniformly. With respect to the assumption of "background" vs. "no background" most of the experts (6) supported the original assumption of background (and zone supposition) while the others were either unsure, rejected this concept or offered no opinion on the subject.

With regard to the choice of the ground motion model the opinion was diversified. Different models including some which were not previously considered were recommended. There seemed to be a preference for intensity attenuation based upon several earthquakes and the use of different models for

the central and northeastern regions. Some recommended the use of theoretical models. With respect to the uncertainty assumed in the ground motion model the experts recommended the use of standard deviations ( $\sigma$ ) which ranged from  $\sigma = 0.5$  to  $\sigma = 0.9$  with some preference for the 0.6 to 0.7 range.

Effect of Second Round Questionnaire Upon Conclusions of the Initial Review

As indicated above the preferred model for calculating risk suggested in the Initial Review assumed Gupta-Nuttli intensity attenuation in the central U.S., Ossipee Intensity attenuation in the eastern U.S., a dispersion of  $\sigma = 0.7 \pm 3\sigma$  and an intermediate position between "background" and "no background". Zone superposition was assumed to be coincident with the assumption of background. Since calculations were not carried specifically for this model of dispersion and background, existing models were examined and we concluded that the calculations based upon  $\sigma = 0.9 \pm 2\sigma$  and no background would approximate the desired results. The higher level of ground motion (+7 to +10%) in the calculated result which was caused by assuming greater dispersion was balanced by the lower level of ground motion (-7 to -10%) in the calculated result which was caused by assuming no background.

With respect to generic assumptions in the Initial Review, input from the Second Round Questionnaire can be summarized as follows.

- 1) There is no preferred guidance from the experts as to which intensity attenuation relation should be used.
- 2) The use of a standard deviation of  $\sigma = 0.6$  to  $0.7 \pm 3\sigma$  (Second Round expert preference) as compared to the use of  $\sigma = 0.9 \pm 2\sigma$  would result in a decrease of 10 to 15% in estimated ground motion at the level recommended in the Initial Review (Volume 5).
- 3) The use of a generic seismicity model which favored the use of background (Second Round expert preference) with respect to a model which assumed no background would result in an increase of about 10% or more in estimated ground motion at the level recommended in the Initial Review.
- 4) The use of revised inputs for seismicity and zonation would result in an estimated change of 5% or less in estimated ground motion at the level recommended for the various sites in the Initial Review.

Based upon the above discussion, we estimate that inclusion of input from the Second Round Questionnaire would lead to calculated site specific spectra which would be roughly similar to those recommended in the Initial Review differing at most by several (less than 10) percentage points. This is not to say however that an individual expert would not or could not provide input that would lead to calculated spectra that were different. Slight variations in the choice of attenuation model and ground motion dispersion alone could have a major impact upon the results. What these results do indicate however is the relative stability of integrated-estimates synthesized from different individual input assumptions.

### Comparison with Other Studies

The Final Report Seismic Hazard Analysis: Results, (TERA Corporation, 1981) includes a comparison with several other seismic hazard studies. In general it was found that when using input taken from other studies with the TERA computer code, the same results were obtained and that the difference between these results and those obtained using input from the expert panel could be explained by differences in assumptions. One of the studies compared was a probabilistic assessment of ground motion carried out to assess the likelihood of liquefaction at LaCrosse (Dames and Moore, 1980). Taking into account the variations in input, the Dames and Moore (1980) study and that performed by TERA-LLNL are in close agreement.

An interesting comparison was also made utilizing a "pseudo-historical" analysis at Dresden and Yankee Rowe. In this analysis, no zonation is assumed and the probability of exceeding a given level of ground motion is determined entirely from the historical record. Lacking instrumental records the ground motion itself is estimated from a given attenuation model. These estimates are sensitive to the inclusion of rare events such as the 1811, 1812 New Madrid Series and have not been corrected for homogeneity or upper magnitude cutoff. They do however yield results that are generally within the range of ground motion estimates calculated from the inputs of the individual experts for these sites.

Adequacy of Spectra for Rock Sites

In the cover letter to the Initial Review it was indicated that a reduction in spectra at intermediate and low frequencies may be called for at rock sites (Dresden, Ginna, Haddam Neck and Millstone). The change (Table 5-2, Final Report Seismic Hazard Analysis: Results, TERA Corporation, 1981) was recommended by TERA Corporation based upon its restructuring (weighting) of the strong motion data set used in ground motion estimation primarily to avoid overemphasis upon the 1971 San Fernando Earthquake. While this restructuring may be valid for estimating ground motion as a function of magnitude and intensity or distance, LLNL has pointed out (Volume 4) that it also results in a significant reduction in the number of rock records since many such records resulted from the San Fernando Earthquake. We agree therefore with LLNL's assessment that the original nonweighted model is more appropriate for determining differences in ground motion between rock and soil sites and no reduction is called for.

Conservatism of Recommended Spectra

Our estimate in the Initial Review was that although the recommended spectra were labelled "1000 year" spectra the actual return periods associated with these spectra were longer. TERA Corporation had estimated these actual return periods to be closer to 5,000 or 10,000 years. While we were not sure what the precise estimates were we concluded that they were consistent with the previous implicit acceptance of design spectra that were assumed to have return periods of the order of 1,000 or 10,000 years. As a result of this final review we find no new information that changes our previous estimate.

Since other levels of ground motion-spectra could fit into this range of probabilities it is worthwhile reexamining the criteria by which the recommended spectra were found to be appropriate.

1. These spectra, whatever their true return periods actually are, represent approximately equivalent levels of seismic hazard at the different SEP sites currently being considered and represent a more consistent estimate to be used in seismic analysis than standard "deterministic" procedures. These "deterministic" procedures generally rely upon tectonic provinces and controlling earthquakes regardless of the size of the tectonic province or the frequency of earthquake occurrence. As a result, these procedures can lead to the acceptance of different levels of seismic hazard at different locations. The recommended spectra generally indicate a relatively greater earthquake hazard associated with sites in the northeast when compared to sites in the upper midwest.
2. When compared to the deterministic procedure recommended for use in the SEP in NUREG/CR-0098 the recommended spectra as a group bracket the 50th and 84th percentile deterministic spectra as calculated in the Initial Review.
3. When compared to non-probabilistic site specific spectra derived from real records, an approach currently being pursued with many OL reviews, the recommended spectra vary from the 84th percentile to the 50th percentile representation of a magnitude 5.3 earthquake. The 50th percentile of the

spectra from real records was specified in the Initial Review as the minimum which recommended spectra would not be allowed to fail. The 84th percentile is that level which has been used in OL reviews.

4. The recommended spectra form a band centered about the Regulatory Guide spectrum anchored at 0.1g. New plants licensed in these areas would most likely utilize peak accelerations of 0.12 to 0.20 g to anchor the Regulatory Guide Spectrum.

Based upon the above discussion we consider this approximate overlap of the higher of the recommended spectra with the mid to lower range of those spectra estimated applying current deterministic criteria to indicate that the recommended spectra can be generally associated with the higher end of the range of implicitly assumed seismic hazard that has been found acceptable using current criteria.

Lacking more defined levels of acceptable seismic hazard and a prescribed method for calculating this hazard, the use of individual and often non-quantifiable judgement cannot be avoided in assessing the results of this study so as to integrate it with other techniques into a decision-making framework.

Based upon the above comparison it is our position that the recommended spectra represent the appropriate levels of free field ground motion to be used in the SEP for the purpose of evaluating the seismic design adequacy of the selected plants.



Application of this study and its review recommendation to other sites or other programs should be examined on a case by case basis.

Anomalous Site Conditions

As was indicated in the Initial Review these spectra only account for gross site conditions (soil or rock). No attempt was made to consider soil amplification beyond that already inherent in the soil records used in the study. LaCrosse, Palisades, and Yankee Rowe have been identified as having site conditions which may be anomalous with respect to those site conditions associated with the soil records used in this study.