FEB 17 1983

MEMORANDUM FOR: James P. Knight, Assistant Director for
Components & Structures Engineering, DE

FROM: Robert E. Jackson, Chief
Geosciences Branch, DE

SUBJECT: COMMENTS ON DRAFT SEISMIC ANALYSIS RESEARCH PLAN

We have reviewed the draft plan and have provided directly to D. Guzy, ORES, a marked up copy for his use. It is our understanding that a major rewrite is currently underway.

Our most substantive comment regarding the plan is that the "Seismotectonic Program", as attached needs to be substantially updated to better incorporate our current approach in our new plan for addressing the U.S.G.S. clarification regarding the Charleston earthquake. We also disagree strongly with both A. Thadani (memorandum, A. Thadani to Z. Rosztoczy, February 7, 1983) and the draft NRR comments prepared by P. Williams regarding the need for research effort on seismogenic mechanisms. This research effort, properly implemented, will provide direct usable information in the short term (3-5 years) which will have a strong influence on the development of seismic hazard curves. This information contributes directly to how experts weigh various hypotheses and how credibilities should be assigned in probabilistic analyses. The comment that this work, "cannot be expected to yield results reasonably relevant to regulatory needs during the remaining operating lifetime of most current generation nuclear plants" is unfounded. In fact, such an observation would represent a major reversal in NRR's previous research requests in this area. This work contributes directly to our ability to evaluate whether or not probabilistic conclusions are intuitively reasonable or whether specific further actions are necessary at certain sites.

We also disagree that the major burden for such work remains with the [illegible]. The fact is that NRC, even at current funding levels, sponsors a small percent of total geological work in this country. Indeed, NRC has a specific focussed need to undertake research to reduce the number of hypotheses and reduce the large uncertainty in seismic hazard curves especially for long return periods as requested by the ACRS in their January 11, 1983 letter. We do agree that NRC's seismotectonic program should become increasingly focused towards contributing to hazard analyses.

We also agree with A. Thadani's observation that although seismic risk may be a major risk contributor, there is no current basis for the contention that it is, in fact, the such a major contributor.

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FEB 17 1983

The NRR draft comments, item d., infers that NRR's view of the seismotectonic program is that it is not necessary. I am not aware of this ever being NRR's position. Indeed, this would be inconsistent with overall Geosciences Branch planning and our current Charleston plan, which relies heavily on this work in the next three years.

Original Signed by
R. E. Jackson

Robert E. Jackson, Chief
Geosciences Branch
Division of Engineering

Attachments:
(1) NRR Comments
(2) Thadani Memorandum, February 7, 1983

cc: w/o attachments
T. Sullivan
P. Williams
Z. Rosztoczy
A. Thadani
CSD Staff
D. Guzy
L. Beratan

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

MAR 02 1983

MEMORANDUM FOR: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

FROM: Richard H. Vollmer, Director
Division of Engineering

SUBJECT: DIVISION OF ENGINEERING GEOSCIENCE PLAN TO ADDRESS USGS CLARIFICATION RELATING TO SEISMIC DESIGN EARTHQUAKES IN THE EASTERN SEABOARD OF THE UNITED STATES

A plan for our proposed program to address the U. S. Geological Survey's clarification of position relating to seismic design earthquakes in the Eastern Seaboard of the United States is attached (enclosure 1). This plan elaborates on the outline provided as an attachment to a memorandum entitled, "Clarification of U. S. Geological Survey Position Relating to Seismic Design Earthquakes in the Eastern Seaboard of the United States", which was sent from the Executive Director of Operations to the Commissioners on November 19, 1982.

The plan is divided into two parts. Part one is a short term probabilistic assessment utilizing an extensive new seismic hazard study currently being developed by Lawrence Livermore National Laboratory. Part two is a longer term deterministic assessment based primarily on long range ORES research with the possible need for utility sponsored investigations at some locations after an assessment of the long term research results. Additionally, we recommend that an industry sponsored seismic hazard study be solicited.

We estimate that the effort to establish the seismic hazard level for the sites and make appropriate comparisons will take approximately three years to complete, utilizing staff resources of about 2.5-3.0 SY per year, and $300K per year in technical assistance funds. Our preliminary recommendations on which plants, if any, may need further evaluation should be completed in mid-1984. Because of the required research effort, the deterministic element will not be synthesized until 1985.

The proposed program will complement ongoing PRA reviews and the seismic hazard spectra which are developed can also be used for future SEP evaluations. This program, therefore, is basically a continuation, with modification, of our ongoing work. This program does not include resources to complete a reevaluation effort for plants for which design spectra may need to be reevaluated. We recommend that this contingency be considered and included in the operating plan for FY 84. This plan also presupposes that our interim position for licensing reviews (enclosure 2) is found to be acceptable by ACRS and ASLB while we implement this program.

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There is evidence to support this assumption in the recent Appeal Board decision on Summer (ALAB-710).

We have also assessed our ability to implement this plan under the existing regulation, Appendix A to 10 CFR Part 100. We have concluded that, although Appendix A itself does not explicitly recognize the use of probabilistic methods, as a minimum they can be used to assist in reaching deterministic judgements (Seabrook Remand, CLI80-33). It is not clear whether they can be used as the primary tool in setting appropriate ground motion levels. Therefore, we recommend that we implement a limited modification or clarification of Appendix A as previously planned in conjunction with ORES as a parallel, yet independent effort, along with the Charleston plan. This modification has been recommended in SECY-79-300 and endorsed by the Siting Policy Task Force in NUREG-0625 and is necessary to reflect the current state of art. This modification will require an additional 1.0 SY per year for 2 years.

We recommend that you consider placing this effort equally under three resource areas - Operating Reactor Licensing Actions or Safety Technology, Systematic Evaluation Program for older operating plants, and Casework for ongoing OL review plants.

This plan has been developed as a result of extensive discussion within the Geosciences Branch, NRR; and discussions with the Earth Sciences Branch, ORES; and the U. S. Geological Survey.

Richard H. Vollmer, Director
Division of Engineering

Enclosure:
As stated

cc: w/enclosure

E. Case	A. Murphy
D. Eisenhut	T. Schmidt
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Recommended Plan
Eastern U. S. Earthquakes

Introduction

On November 18, 1982, the U. S. Geological Survey (USGS) forwarded a letter to the Nuclear Regulatory Commission clarifying their past position with respect to the 1886 Charleston earthquake. The USGS letter states that:

> "Because the geologic and tectonic features of the Charleston region are similar to those in other regions of the eastern seaboard, we conclude that although there is no recent or historical evidence that other regions have experienced strong earthquakes, the historical record is not, of itself, sufficient grounds for ruling out the occurrence in these other regions of strong seismic ground motions similar to those experienced near Charleston in 1886. Although the probability of strong ground motion due to an earthquake in any given year at a particular location in the eastern seaboard may be very low, deterministic and probabilistic evaluations of the seismic hazard should be made for individual sites in the eastern seaboard to establish the seismic engineering parameters for critical facilities."

We have evaluated the USGS clarification of position and have concluded that it can be addressed predominantly through existing programs at NRC with the possibility of additional requests for utility - sponsored work. We recommend that a two part program be implemented which will address both the deterministic and probabilistic elements mentioned by the USGS.

Part 1 of the proposed program is a short term probabilistic assessment of plants in the eastern seaboard. This part of the plan is necessary because many of the current tectonic working hypotheses are not amenable to investigation by deterministic methods in the short term.

Part 2 of the proposed program is a longer term deterministic assessment of the causes of large earthquakes, such as the Charleston earthquake, in the eastern seaboard. Specific areas of relatively high seismicity and tectonic structures are identified which we recommend be addressed through the ORES long range research plan.

Based on our evaluation of the research results, some applicants or licensees may be required to investigate tectonic structures which may not have been previously identified during the licensing procedure.

Part 1 - Probabilistic Assessment

Discussion

The November 18, 1982 letter from the USGS represents not so much a new understanding but rather a more explicit recognition of existing uncertainties with respect to the causative structure and mechanism of the 1886 Charleston earthquake. Many hypotheses have been proposed as to the locale in the eastern seaboard of future Charleston-size earthquakes. Some of these could be very restrictive in location while others would allow this earthquake to recur over very large areas. Presently, none of these hypotheses are definitive and all contain a strong element of speculation.

Traditional deterministic approaches such as that outlined in Section 2.5.2 of the Standard Review Plan are not generally designed to deal

with this situation. Probabilistic methods which allow for the consideration of many hypotheses, their associated credibilities, and the explicit incorporation of uncertainty are much better equipped to provide rational frameworks for decision making. The question that needs to be answered is:

> Taking uncertainties into account, have licensing decisions for plants in the eastern seaboard (i.e., in the region affected by the USGS clarified position on the Charleston Earthquake) resulted in acceptable levels of assumed seismic hazard (exposure to earthquake ground motion) at the individual sites?

One means for answering the above question is a probabilistic assessment of seismic hazard at all nuclear power plant sites east of the Rocky Mountains. Since adequate or acceptable levels of seismic hazard have not been explicitly defined in probabilistic terms, it is assumed that the probability of seismic ground motion exceeding design levels implicitly associated with licensing decisions based upon traditional methods in other regions of the U. S. east of the Rocky Mountains is adequate; these other regions include areas such as the Central Stable Region and the Gulf Coastal Plain. The prime tool for carrying out this assessment is an updated version of the Uniform Hazard Methodology developed for the Systematic Evaluation Program by Lawrence Livermore National Laboratory (LLNL) and its subcontractor TERA Corporation. This methodology relies upon the incorporation of diverse expert opinion with regard to the input parameters needed to make probabilistic estimates. As such, it does not rely upon single hypotheses which do not account for existing uncertainties but rather attempts to incorporate the

hypotheses and their uncertainties into the computations. Identification of plants (if any) in the eastern seaboard at which the probability of exceeding design-level ground motion is significantly greater than has been assumed at other locations may result in an integrated seismic evaluation and/or engineering reanalysis to assure the plant's ability to withstand a more severe earthquake. This study may also identify selected plants outside of the eastern seaboard whose design levels may be inappropriate, relative to other plants, with respect to the seismic hazard.

In addition, we are also initiating, through a technical assistance contract, a study to better estimate ground motion from a large earthquake the size of the 1886 Charleston event to gain a better understanding of how this ground motion should be represented.

Major Activities - Probabilistic Assessment

The probabilistic assessment portion of the proposed program is divided into the following elements.

1. January thru Dec 1983 - Continue development of LLNL study including expert opinion surveys on seismic hazard east of the Rocky Mountains. This study (Seismic Hazard Characterization of the Eastern U.S.) is presently underway as a joint effort of NRR and

ORES. No additional resources above those already allocated are needed.

2. ~~May 1983 thru December 1983~~ Jan 1984 May 1984 - Calculation of seismic hazard spectra by LLNL for all nuclear power plant sites (approximately 75) east of the Rocky Mountains. An estimation of the probability of seismic ground motion exceeding the design level at each site, taking into account specific site conditions, will be completed and provided as a report. An additional 2.0 SY is needed for LLNL and 0.3 SY for NRC effort during this period.

3. ~~September - December 1983~~ May 1984 - Dec 1984 - Comparison of LLNL study with existing probabilistic studies such as Algermissen and others (1982). An additional 0.2 SY is needed for LLNL effort.

4. ~~March 1983~~ Oct 1983 - December 1984 - Sponsorship by the utilities ~~of a~~ probabilistic estimation of seismic hazard for all nuclear power plants east of the Rocky Mountains. This study, while not a requirement, is strongly recommended so as to complement the LLNL study and provide another independent assessment of seismic hazard. An additional 0.1 SY needed for LLNL and 0.1 SY for NRC effort.

5. ~~December 1983-March 1984~~ May 1984 - ~~April 1985~~ Dec 1984 - Using LLNL and other studies, the NRC staff will integrate this information and make comparisons of the probability of seismic ground motion exceeding design levels in the eastern seaboard with probabilities calculated at plants in the rest of the Eastern and Central U. S. Comparisons will be made in several ways including comparison by region alone and by region and plant vintage. Plants in the eastern seaboard (if any) that are associated with significantly greater hazard than those elsewhere

First Assessment ~ June/July 1984

interact through EPEI program ~ Dec 1984

will then be identified. Other comparisons may be needed, but will be decided upon after review of initial results. An additional 0.7 SY is needed for NRC effort.

June 1984 – Dec 1984 (may go into early 1985 depending on EPRI program)

6. ~~April 1984-September 1984~~ - Assessment of initial conclusions regarding hazard in light of feedback from expert opinion on original input. A final letter report will be issued with a final recommendation on plants which need reevaluation. An additional 0.2 SY needed for LLNL and 0.2 SY for NRC effort.

7. January 1983-December 1983 - Ground motion estimates at different distances and site conditions from a large Charleston type earthquake. Both theoretical and empirical estimates using data from recent earthquakes will be made. This study is presently being initiated through a technical assistance contract with LLNL. No additional resources are required.

Status summary reports of research into probabilistic estimates of seismic hazard funded by ORES will be needed by December 1983 so as to incorporate them into task number 5.

no additional funds have been allocated in FY83

Implementation of Probabilistic Assessment Results

The implementation of results is outlined above in elements 5 and 6.

NRR Staff and Cost Requirements - Probabilistic Assessment

The additional effort required for this portion of the program will be 2.5 SY for LLNL (1.9 in FY 83, 0.6 in FY 84) and 1.3 SY for NRC (0.3 in FY 83, 1.0 in FY 84). This staff effort can be accommodated with the currently available resources in the Geosciences Branch because this

Seismic Hazard Charac. 130K FY84

New Probabilistic Study 360 FY84 120 FY85

0 FY83

program complements ongoing staff activities and may replace other staff activities for individual sites. This program does not include resources to complete the seismic evaluation and/or engineering reanalysis which some plants may require as a result of the probabilistic elements.

Utility-Sponsored Study in Conjunction with the Probabilistic Assessment

A recommended utility-sponsored study is outlined above in element 4.

Schedule - Probabilistic Assessment

The proposed schedule for implementing this plan appears in Table 1.

Part 2 - Deterministic Assessment

Discussion

The deterministic portion of the proposed program is designed to better understand the causes of large earthquakes, such as the Charleston earthquake, in the eastern seaboard. This effort may require some expansion of immediate and long term ORES programs. Increased understanding of the cause of seismicity in the eastern seaboard will allow a reduction in the uncertainty in estimating the seismic hazard for nuclear power plants. The primary problem with seismic hazard characterization in the eastern seaboard is that no causative mechanism for seismicity has been identified to date and no surface offsets due to earthquakes are known. Although there are literally thousands of crustal structures known in the eastern seaboard, which, if they were active, could produce strong earthquakes, none have been demonstrated to have been active during the Quaternary (the last two million years) or

proved to be capable. The result is that, to date, there has been no generally accepted association between eastern seismicity and crustal structure.

The overall approach of the deterministic assessment is to study areas of relatively higher seismicity in the eastern seaboard to determine if tectonic features and processes responsible for the seismicity can be identified and correlated. This will be pursued by crustal studies at hypocentral depths to determine if there is any correlation between crustal structures at hypocentral depths and the earthquake hypocenters. The primary tool for determining crustal structure at hypocentral depths will be the use of multi-channel seismic reflection profiles. The primary tools for locating the hypocenters will be the continued monitoring and analysis of earthquakes from the existing microearthquake nets. These nets will have to be maintained and upgraded in order to improve depth locations of hypocenters if there is to be an improved ability to correlate between hypocenters and tectonic structures at depths of up to 25 kilometers.

This research will be contracted and monitored by ORES, and does not represent a radical departure from past programs. Increased coordination between NRR and ORES will be required, however, to better define the problems that are to be resolved in order to improve our understanding of eastern seismicity in the licensing context. This portion of the program is designed to improve our ability to assess the adequacy of the design of nuclear facilities on the eastern seaboard. The result, in part, will be summary reports which will represent the current status of research including a review and synthesis of available

data. These results will be used to modify, if necessary, conclusions drawn from the probabilistic studies and identify individual features, if appropriate, for assessment by utilities.

Major Activities - Deterministic Assessment

The deterministic assessment portion of the proposed program is divided into the following elements appropriate to each region listed.

A. Charleston Region

Since the causative mechanism of the Charleston earthquake of 1886 continues to be one of the primary unresolved problems in evaluating seismicity in the eastern seaboard, research in the Charleston area should continue with the goal of testing the various hypotheses as to the cause of the earthquake. In particular, emphasis should be placed on determining if suggested features such as the Ashley River and Woodstock Fault zones constitute the source zones of the Charleston earthquakes.

COMPLETED 1. May 1983 - "Workshop on the 1886 Charleston Earthquake and Its Implications for Today" - the U. S. Geological Survey and the scientific community will present a summary and evaluation of the tectonics and seismicity at Charleston.

DATE WILL NOT BE MET. NO DATE ALTERNATE DATES GIVEN 2. September 1983 - ORES in consultation with the U. S. Geological Survey and the scientific community should have a program in place to test the most likely tectonic hypothesis for seismicity.

SUMMER 1984 3. June 1984 - ORES presents the results of the program

of testing the highest-weighted hypothesis.

Same as 2

4. January 1985 - ORES presents summary report describing the results of the Charleston work testing the highest-weighted tectonic hypothesis.

B. Ramapo Fault Zone

The Ramapo Fault Zone, a Precambrian fault zone that was intermittently active until the Mesozoic, is the northwestern boundary of the Newark Triassic Basin. Low level seismicity occurs in the area and may be associated with the fault zone, however, the seismicity in the region forms a band 40 kilometers wide. Detailed field work and limited trenching and core drilling suggest that the Ramapo Fault has not been recently reactivated. The purpose of studying the fault is to establish whether there is a causal relationship between Mesozoic or older faults such as the Ramapo Fault and current seismicity in this area by determining the location and geometry of these faults at hypocentral depths.

COMPLETED!

1. April 1983 - ORES initiates a new evaluation of the Ramapo Fault. The study should include multi-channel seismic reflection profiling and other geophysical techniques such as in-situ stress measurements and geodetic measurements to determine the current state of stress at hypocentral depths.

Probably will OR MET

2. January 1984 - ORES presents preliminary results of t e program to date, and plans for the coming year.

MAY BE MET

3. January 1985 - ORES presents summary report on this aspect of the Ramapo Fault Study including the identification and analysis of any seismic source zones.

C. Central Virginia Seismic Zone

Recent work by earth scientists at Virginia Polytechnic Institute have suggested that there may be a relationship between the seismicity in Central Virginia and the northeast trending thrust faults and decollement of the Piedmont crust of the Appalachian Orogenic Belt. The purpose of this part of the program is to continue evaluation of the relationship between the faults and the earthquakes.

In Place

1. April 1983 - ORES presents a plan for undertaking the seismic reflection profiling, and applying other geophysical techniques such as geodetic measurements and in-situ stress measurements.

Presently will be met

2. January 1984 - ORES presents the preliminary results or progress to date, and plans for the coming year.

Presently will be met.

3. January 1985 - ORES presents a summary report on the the Central Virginia Study including the potential identification and analysis of any seismic source zones.

D. Giles County, Virginia

The Giles County Seismic Zone is a northeast trending linear zone of seismicity which apparently is located beneath the decollement and thrust faults associated with the Valley & Ridge Province of the Appalachian Orogenic Belt. It has been suggested that the seismic zone has occurred as a reactivated northeast trending normal fault associated with the opening of the Proto-Atlantic (called the Iapatus) in the late Proterozoic and early Paleozoic (800-500 million years ago).

In Place with Conservatism.

1. April 1983 - ORES initiates planning for the proposed research.

IN PLACE WITH CONSORTIUM

2. August 1983 - ORES initiates study of the Giles County structure using seismic reflection profiling.

PROBABLY WILL BE MET

3. April 1984 - ORES presents preliminary results and plans for the coming year.

PROBABLY WILL BE MET.

4. April 1985 - ORES presents summary results of this phase of the research including the potential identification and analysis of any seismic source zones.

E. New England

The research in New England has been underway for several years and will be continued. Increased emphasis should be placed on evaluation of the source mechanism for the New Brunswick and Gaza, N.H. earthquakes, the neotectonics of seismically active areas, and the orientation and magnitude of the stress field in the seismically active areas of the region. An in-situ stress measurement at hypocentral depths will be conducted at Moodus. Depending on the results of the seismic reflection studies described above, additional seismic reflection surveys may be conducted in seismically active areas of New England such as Moodus, Connecticut; New Hampshire; Massena, New York and New Brunswick, Canada.

RFP IS BEING EVALUATED

1. April 1983 - ORES completes plans for stress measurement at Moodus.

WILL BE DELAYED BY SEVERAL MONTHS

2. August 1983 - Conduct stress measurements at Moodus.

MAY BE DELAYED

3. April 1984 - ORES presents preliminary results of stress measurements and their relationship to the local seismicity and tectonics.

MAY BE DELAYED

4. January 1985 - ORES presents summary results of stress measurements and other studies described above.

Implementation of Deterministic Assessment Results

As the results from the deterministic studies become available, they will be evaluated, and, the effect, if any, on operating plants and plants in the Operating License stage of review will be determined. The need for additional evaluations of particular structures by utilities will be assessed as the information becomes available. Two problems will be addressed by the deterministic portion of the program; (1) whether or not the deterministic findings warrant any reassessment of the conclusions drawn from the probabilistic study; and (2) whether there are any particular tectonic structures which are associated with or similar to tectonic structures associated with seismicity which, because of their proximity to individual sites, should be analyzed by the utilities. The above effort will take about two to three years (early 1985) to complete. The impact of this research on nuclear power plants will be determined by the NRC staff with technical assistance contracts, if necessary.

NRR Staff and Cost Requirements - Deterministic Assessment

This effort will require continuous communication among NRR, ORES and the contractors. As research funds are limited and the amount of time is short, careful interaction will be necessary to obtain the information required to allow a resolution of eastern seismicity. It is estimated that one staff year per year for three years will be necessary for NRR to implement this deterministic part of the overall plan. The research effort will be funded by ORES and technical assistance contracts will be funded by NRR. It is estimated that for the

deterministic assessment, $200,000 may be required to implement the NRR technical assistance program to determine the impacts of the findings on the nuclear facilities in the eastern U. S.

Utility-Sponsored Studies as Result of the Deterministic Asessment

During FY 1983 no deterministic work by the utilities is currently recommended, beyond that necessary to pursue their normal efforts to continue to assess any hazards identified by them for their sites. After the results of the research are available and if any source zones are identified which have particular importance to specific sites or have impact on the probabilistic program, some utilities may be required to investigate structures in the vicinity of their plants.

Schedule - Deterministic Assessment

The proposed schedule for implementing this plan follows as Table 1. Our ability to meet this proposed schedule may be somewhat optimistic and is contingent on implementing the appropriate contracts. We will be better able to assess this schedule when the work has been initiated.

REFERENCE

Algermissen, S. T., D. M. Perkins, P. C. Thenhaus, S. L. Hanson, and B. L. Bender, 1982, Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States, United States Department of Interior, Geological Survey. Open-File Report 82-1033, 99 p.

Calendar Year Schedule for Probabiilstic and Deterministic Seismic Hazard Program

Part 1 Short Term	1983	1984	1985
	Meet with ACRS to discuss Program	Meet with ACRS to to discuss Preliminary Recommendations	
1. Update LLNL Seismic Hazard Methodology	+Complete Methodology		
2. Calculate Seismic Hazard Spectra for Eastern Sites	+	+Report with Spectra	
3. Compare with other available probability studies		+ +Report with Comparisons	
4. Initiation of Industry-Sponsored Seismic Hazard Study	+	+Production of Study Results	
5. Comparison of Seismic Hazard at Sites		Letter Report with Preliminary Recommendations + +	+Final Recommendations
6. Assessment of Impact of Expert Feedback		Initate Feedback +	Assess Impact on +Previous Results
7. Charleston Ground Motion Study	Initiate Tac with LLNL +	+Issue Report	

Table 1

Calendar Year Schedule for Probabilistic and Deterministic Seismic Hazard Program

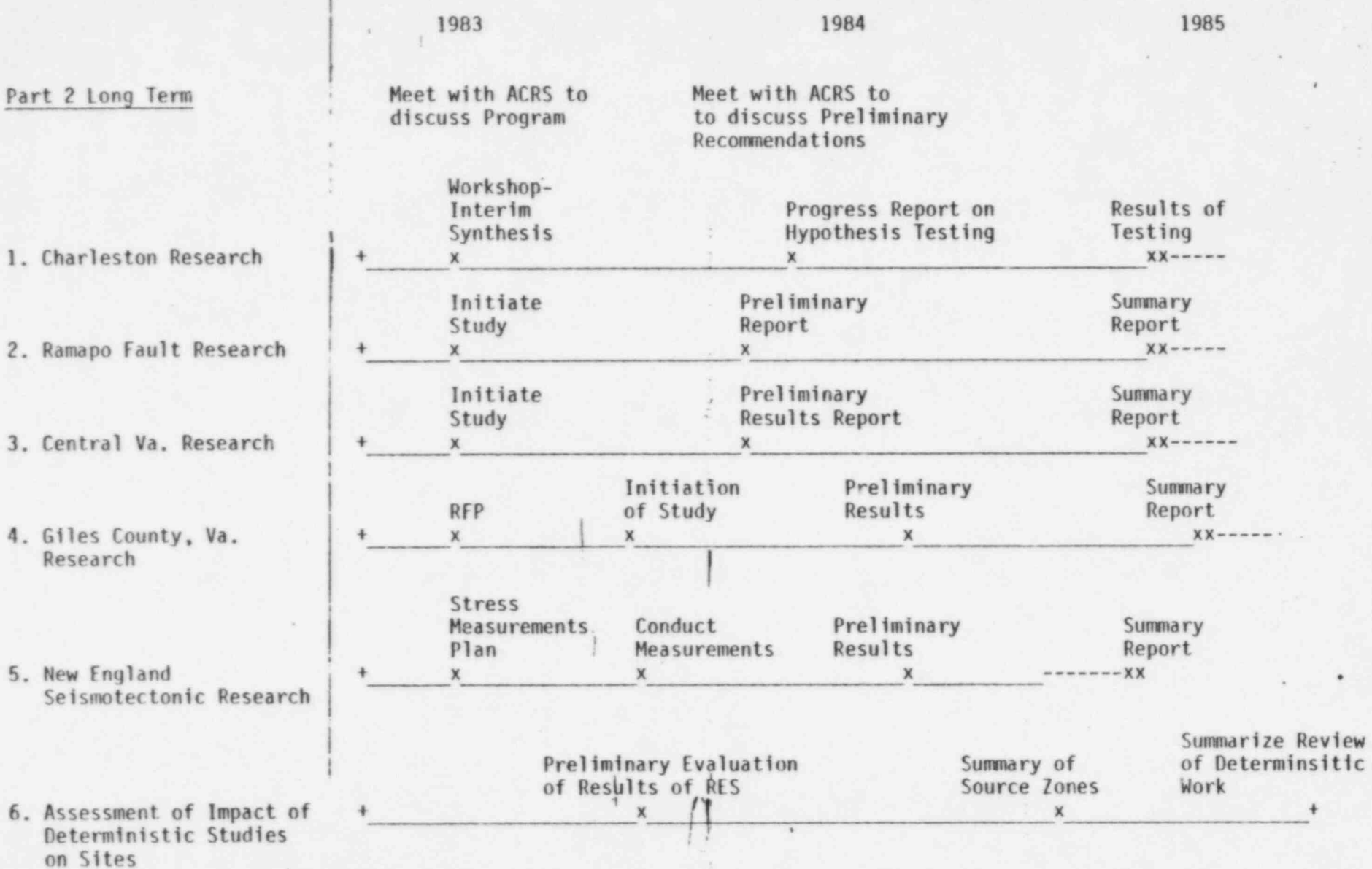

Table 1 (cont'd)

Interim Position on Charleston Earthquake for Licensing Proceeding

The NRR Staff position with respect to the Intensity X 1886 Charleston earthquake has been that, in the context of the tectonic province approach used for licensing nuclear power plants, this earthquake should be restricted to the Charleston vicinity. This position was based, in part, on information provided by the United States Geological Survey (USGS) in a letter dated December 30, 1980 from J. E. Devine to R. E. Jackson (see Summer Safety Evaluation Report). The USGS has been reassessing its position and issued a clarification on November 18, 1982 in a letter from J. E. Devine to R. E. Jackson. As a result of this letter, a preliminary evaluation and outline for NRC action was forwarded to the Commission in a memorandum from W. J. Dircks on November 19, 1982.

The USGS letter states that:

> "Because the geologic and tectonic features of the Charleston region are similar to those in other regions of the eastern seaboard, we conclude that although there is no recent or historical evidence that other regions have experienced strong earthquakes, the historical record is not, of itself, sufficient grounds for ruling out the occurrence in these other regions of strong seismic ground motions similar to those experienced near Charleston in 1886. Although the probability of strong ground motion due to an earthquake in any given year at a particular location in the eastern seaboard may be very low, deterministic and probabilistic evaluations of the seismic hazard should be made for individual sites in the eastern seaboard to establish the seismic engineering parameters for critical facilities."

The USGS clarification represents not so much a new understanding but rather a more explicit recognition of existing uncertainties with respect to the causative structure and mechanism of the 1886 Charleston earthquake. Many hypotheses have been proposed as to the locale in the eastern seaboard of future Charleston-size earthquakes. Some of these

could be very restrictive in location while others would allow this earthquake to recur over very large areas. Presently, none of these hypotheses are definitive and all contain a strong element of speculation.

We are addressing this uncertainty in both longer-term deterministic and shorter-term probabilistic programs. The deterministic studies, funded primarily by the Office of Research of the NRC should reduce the uncertainty by better identifying (1) the causal mechanism of the Charleston earthquake and (2) the potential for the occurrence of large earthquakes throughout the eastern seaboard. The probabilistic studies, primarily that being conducted for NRC by Lawrence Livermore National Laboratory (LLNL) will take into account existing uncertainties. They will have as their aim to determine differences, if any, between the probabilities of seismic ground motion exceeding design levels in the eastern seaboard (i.e. as affected by the USGS clarified position on the Charleston earthquake) and the probabilities of seismic ground motion exceeding design levels elsewhere in the central and eastern U. S. Any plants where the probabilities of exceeding design level ground motions are significantly higher than those calculated for other plants in the Central and Eastern U. S. will be identified and evaluated for possible further engineering analysis.

Given the speculative nature of the hypotheses with respect to the recurrence of large Charleston-type earthquakes as a result of our limited scientific knowledge and the generalized low probability associated with such events, we do not see a need for any action for

specific sites at this time. It is our position, as it has been in the past, that facilities should be designed to withstand the recurrence of an earthquake the size of the 1886 earthquake in the vicinity of Charleston. At the conclusion of the shorter-term probabilistic program and during the longer-term deterministic studies, we will be assessing the need for a modified position with respect to specific sites.

Leon Beratan
FYI Bob Jadson

SAINT LOUIS UNIVERSITY

DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES

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March 7, 1983

The Honorable Doug Walgren
Chairman, Subcommitte on
Science, Research and Technology
U.S. House of Representatives
2321 Rayburn House Office Building
Washington, D.C. 20515

Dear Congressman Walgren:

Enclosed please find 75 copies of my testimony to be given on March 15 at the authorizations hearings of your Subcommittee on the National Earthquakes Hazard Reduction Program. At your request I have focused my statement on the earthquake problem in the eastern United States. Also enclosed are 20 copies of a brief biographical sketch.

Thank you for inviting me to appear before your Subcommittee.

Sincerely yours,

Otto W. Nuttli

Otto W. Nuttli
Professor of Geophysics

OWN:leh
Enc.

For your information

Otto

26

TESTIMONY BY OTTO W. NUTTLI,

PROFESSOR OF GEOPHYSICS, SAINT LOUIS UNIVERSITY

SUBMITTED TO THE

HOUSE SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

MARCH 15, 1983

Mr. Chairman, I am pleased to appear before the House Subcommittee on Science, Research and Technology and to discuss, at your request, the current activities of the National Earthquake Hazards Reduction Program as it relates to earthquake problems in the eastern United States.

INTRODUCTION

There are two principal points I wish to make in this testimony. The first is that earthquake hazard in the United States is not restricted to the West, but also exists in varying degrees, in almost every state of the nation. The second point is that work accomplished under the Hazard Recuction Program has produced a number of significant accomplishments.

EARTHQUAKE HAZARD IN THE EAST

Earthquakes do not occur regularly in time. After great earthquakes, there is a period of relative quiet until the ever-acting geological forces are able to produce sufficient strain to cause more large earthquakes. The twentieth century has been such an interlude for catastrophic seismic activity in the eastern states. Therefore, because there have been no major eastern earthquakes in the memory of most of the people, the general populace is insufficiently informed about the earthquake hazard east of the Rockies. Recently we have had several small reminders of this threat in the form of moderately damaging earthquakes in New Brunswick, Canada and New Hampshire in January 1982, and of a 1980 Kentucky earthquake that was felt in fifteen states and in Canada and that caused several million dollars of property damage in Kentucky and Ohio.

In historical times structurally damaging earthquakes occurred in

Alabama, Arkansas, Connecticut, Delaware, Illinois, Indiana, Kansas, Kentucky, Maine, Massachusetts, South Carolina, Tennessee, Texas and Virginia. For some of them, damage was also experienced in neighboring states, such as Georgia, Mississippi and North Carolina.

Fortunately, the great eastern earthquakes occurred before the country was densely populated, and before the appearance of high-rise structures and the development of a sophisticated and vulnerable technological society. The 1886 Charleston, SC earthquake, of magnitude 7.5, killed 110 people. If it had happened 100 years later, the loss of life would have been at least ten times, and conceivably one hundred times, greater. Even more dramatic were the three great New Madrid earthquakes in the winter of 1811-1812, with epicenters in Arkansas and Missouri and magnitudes of 8.4, 8.6 and 8.7. Ground shaking caused by them was felt in all of the United States east of the Rockies, and perhaps farther to the west. Damage extended over most of the area consisting of the states of Missouri, Arkansas, Mississippi, Kentucky, Tennessee, Illinois, Indiana and Ohio. Other large nineteenth century earthquakes occurred in eastern Arkansas in 1843, in Charleston, Missouri in 1895 and in Giles County, Virginia in 1897.

From our studies of the New Madrid fault we know that enough energy is stored up along it to produce a magnitude 7.6 earthquake right now. This would cause damage over an area of 200,000 square miles. However, we are not yet able to predict when the next large earthquake will occur. The longer the time that elapses, the larger the earthquake will be. For the rest of the eastern United States we cannot be so specific about the seismic potential. Further data accumulation and research

are needed to provide us this information.

SOME ACCOMPLISHMENTS FOR THE BENEFIT OF THE EAST OF THE NATIONAL HAZARDS REDUCTION PROGRAM

The National Science Foundation, the U.S. Geological Survey, the Federal Emergency Management Agency and the U.S. Nuclear Regulatory Commission are the principal federal agencies that engage in earthquake-related activities in the eastern United States. Other important participants are state and local agencies, universities, private industry, and non-profit organizations such as the American Red Cross.

Significant accomplishments under the National Earthquake Hazards Reduction Program span the whole range of goals of earthquake hazard mitigation. I shall limit my examples to those with which I have personal experience, and they will reflect my background as a seismologist.

On the scientific level we are making progress in our ability to define the boundaries of the major earthquake source zones, to determine the frequency of occurrence of earthquakes within those zones, and to estimate the largest earthquake that each area is capable of producing. We also are acquiring quantitative information about the attenuation of high frequency seismic waves that produce damaging ground shaking. These kinds of information are needed to calculate the expected amount of ground shaking at any selected site, which in turn is needed for the design of earthquake-resistant structures. All of the seismic information comes from the continued operation of seismograph networks, from regional geological and geophysical studies, and from fundamental seismological research on the physics of the rupture process, the transmission of wave energy, and the geological structure of the Earth's

crust. The problems to be solved are especially difficult because eastern earthquakes, in general, do not rupture the Earth's surface (the faults can't be seen), the earthquakes occur relatvely infrequently, and the association between geological processes and earthquake occurrence is not as well known or understood as it is in the West. Therefore a long-term research effort is required for a better understanding of the seismicity and tectonics of the East, which comprise the most fundamental kinds of earthquake information.

In the past few years earthquakes in Arkansas, Kentucky, Missouri, New Brunswick, New Hampshire and South Carolina provided the first eastern strong ground-motion records. These kinds of data are essential to the engineers who design structures. Also seismologists use them to compare actual observations with those predicted from theoretical studies, to check their theory, and to determine similarities and differences with western earthquakes. Until now engineers have relied upon modified western data in designing seismic-resistant structures for the East, even though there is uncertainty as to how the data should be modified.

Strong ground-motion data still are lacking for large magnitude eastern earthquakes. Continued operation of strong ground-motion instruments in the East is needed to obtain these data. Along with this, fundamental studies of earthquake source physics and of wave propagation will enable us to better "scale up" motions from small to large earthquakes, to speed the acquisition of this essential information.

From personal experience I know that the results of the aforementioned studies already are being used by engineers in the design of

nuclear power facilities and reprocessing plants, large dams and selected high-rise structures. It is gratifying that this NEHRP-derived knowledge is being used so immediately to reduce earthquake risk in the eastern United States. In some cases ths is being done only because of requirements of federal regulatory agencies, or because of the initiative of individual engineers and architects who are responsible for the design of high-rise and/or critical stfuctures. In general, there are no seismic building code requirements in most of the eastern United States. However, progress is being made along these lines also.

The U.S. Geological Survey and the Federal Emergency Management Agency have taken the lead in bringing the earthquake hazard problem to the attention of state and local officials, structural engineers, and agencies responsible for building codes, land-use planning, and for engineering response to disasters. Well-attended conferences and workshops on these topics include:

Knoxville, Tennessee workshop in September 1981, "Preparing for and Responding to a Damaging Earthquake in the Eastern United States."

Saint Louis, Missouri workshop in May 1982, "Continuing Actions to Reduce Losses from Earthquakes in the Mississippi Valley Area."

Charleston, South Carolina conference in May 1982.

Three additional workshops are to be held in 1983 in Charleston, South Carolina, Boston, Massachusetts, and Little Rock, Arkansas. These conferences are organized by the U.S. Geological Survey, with support shared by the Federal Emergency Management Agency, the National Science Foundation and the U.S. Nuclear Regulatory Commission. The published proceedings of these conferences are widely distributed and have received attention not only from technical people and state and local

officials, but also from the press, TV and radio, insurance underwriter organizations, school officials, and other groups of concerned citizens. Because of these activities carried out under the NEHRP, the eastern earthquake hazard problem is beginning to get the attention of the public and of government officials responsible for mitigating earthquake effects or of responding to earthquake disaster. This educational process much be long-term and continuous in nature, if it is to achieve the desired goals.

At the state level, I am aware of some kind of governmental action regarding earthquakes in Kentucky, Massachusetts, Missouri, New York and Tennessee. There may be more, of which I am unaware. At the local level my experience is limited to metropolitan St. Louis. At present there is an Ad-Hoc Committee on Seismic Risk of the St. Louis Section of the American Society of Civil Engineers, and a continuing concern of St. Louis County Civil Defense for educating school children for safe behavior during an earthquake, and also for planning their response to earthquake-caused emergencies.

I have attempted to cover the range of NEHRP-related activities in the East. There is one final point I wish to make. It concerns the need to continue the research efforts. The members of the House Subcommittee on Science, Research and Technology are well aware of the inherent values of research, so there is no need for me to spell them out to you. But with regard to the National Earthquake Hazard Reduction Program, there is a cost-effective reason which may not be obvious. Critical facilities are designed to withstand the worst likely earthquake. Because our knowledge is incomplete, this can result in overdesign. As

we better understand the earthquake hazard through the research effort, we will find that for certain parts of the country, at least, the worst likely earthquake hazard will be less than is presently assumed. This will allow for a less costly, but equally safe, design of the structures. The expected savings in construction costs can conceivably be orders of magnitude larger than the entire cost of the NEHRP. In addition, more precision and detail in mapping earthquake hazard will make it easier to get local communities to adopt efffective building codes, for the additional construction costs will not be so burdensome.

I trust, Mr. Chairman, that my testimony will provide you and the members of the Committee on Science and Technology with a fuller knowledge of the actions, resulting from the NEHRP, that have been and are being taken to mitigate earthquake hazard in the East, and of the need for continuing efforts in all aspects of the Program.