Lawrence Livermore National Laboratory
NUCLEAR SYSTEMS SAFETY PROGRAM

L-95

September 15, 1983

Dr. Andrew J. Murphy, Project Manager
Earth Sciences Branch/RES
U.S. Nuclear Regulatory Commission
MS 1130ss
Washington, D.C. 20555

SUBJECT: DRAFT 189 PROPOSAL, Rev. 2
FIN #A0390 and A0428

Dear Dr. Murphy:

Attached, please find the subject DRAFT 189 Proposal under the project "Seismic Hazard Characterization of the Eastern United States."

If this proposal meets with your approval, we will request formal approval by LLNL management.

Sincerely yours,

Dae H. Chung
Principal Co-Investigator

DHC/lc
Attachment: 189 pg 1&2 plus pg 15

Distribution:

NRC:

H. E. Lefevre, NRR/DE/GSB
J. Kimball, NRR/DE/GSB
D. J. Guzy, RES
C. Poslusny

LLNL:

D. L. Bernreuter
P. D. Smith
R. T. Langland
J. M. Johnson/J. Stuart

(2-81)

PROJECT AND BUDGET PROPOSAL FOR NRC WORK

September 19, 19[illegible]

☐ NEW
☒ REVISION NO. 2 pg 1&2 on

DRAFT

PROJECT TITLE Seismic Hazard Characterization of the Eastern United States	FIN NUMBER A0390 A0428
NRC OFFICE Nuclear Regulatory Research (RES), Division of Health, Siting, & Waste Mgt	NRC B&R NUMBER 60-19-42 20-19-40-42-2
DOE CONTRACTOR Lawrence Livermore National Laboratory (LLNL)	CONTRACTOR ACCOUNT NUMBER
SITE Livermore, California 94550	DOE B&R NUMBER

COGNIZANT PERSONNEL	ORGANIZATION	FTS PHONE NUMBER	PERIOD OF PERFORMANCE
NRC PROJECT MANAGER A. J. Murphy	NRC/RES/ESBR	427-4615	STARTING DATE 5/1/82
OTHER NRC TECHNICAL STAFF H. E. Lefevre/J. Kimball/D.J. Guzy	NRC/DE/GSB NRC/NSEB	492-7732 443-5997	COMPLETION DATE 9/30/84
DOE PROJECT MANAGER William J. Hallagher	DOE/SAN	536-7916	
CONTRACTOR-PROJECT MANAGER L. L. Cleland	LLNL	532-4948	
PRINCIPAL INVESTIGATOR(S) D. L. Bernreuter D. H. Chung J. M. Johnson, Resource Manager	LLNL LLNL LLNL	532-0305 532-0268 532-4949	

STAFF YEARS OF EFFORT (Round to nearest tenth of a year)	FY 82	FY 83	FY 84	FY	FY
Direct Scientific/Technical					
Other Direct (Graded)					
TOTAL DIRECT STAFF YEARS					
COST PROPOSAL					
Direct Salaries					
Material and Services (Excluding ADP)					
ADP Support					
Subcontracts					
Travel Expenses — Foreign					
Travel Expenses — Domestic					
Indirect Labor Costs					
Other (Specify) TID					
General and Administrative (%)					
TOTAL OPERATING COST					
CAPITAL EQUIPMENT FIN CHARGED:					
TOTAL PROJECT COST					

DRAFT

FY 84

MONTHLY FORECAST EXPENSE

NRC FORM 189
(2-81)

PROJECT AND BUDGET PROPOSAL FOR NRC WORK

DATE 9/15/83

PROJECT TITLE

Seismic Hazard Characterization of the Eastern U.S.

DRAFT

PROPOSING ORGANIZATION

Lawrence Livermore National Laboratory

FORECAST MILESTONE CHART: Scheduled to Start — △ ▲ — Completed (Shown in Quarter Year)
PROVIDE ESTIMATED DOLLAR COST FOR EACH TASK FOR EACH FISCAL YEAR

TASK		FY 82 1st	2nd	3rd	4th	FY 83 1st	2nd	3rd	4th	FY 84 1st	2nd	3rd	4th	FY 1st	2nd	3rd	4th	FY 1st	2nd	3rd	4th
1. Develop Initial Earthquake Occurrence Models	SCHEDULE																				
	COST																				
2. Methodology Improvements	SCHEDULE																				
	COST																				
3. Sensitivity Studies	SCHEDULE																				
	COST																				
4. Stability of Results	SCHEDULE																				
5. Feedback	COST																				
6. Peer Review's Final Results	SCHEDULE																				
	COST																				
TOTAL ESTIMATED PROJECT COST																					

PROJECT DESCRIPTION: (Provide narrative descriptions of the following topics in the order listed. Attach on plain paper to this NRC Form 189. If an item is not applicable, so state.)

1. OBJECTIVE OF PROPOSED WORK
2. SUMMARY OF PRIOR EFFORTS
3. WORK TO BE PERFORMED AND EXPECTED RESULTS
4. DESCRIPTION OF ANY FOLLOW-ON EFFORTS
5. RELATIONSHIP TO OTHER PROJECTS
6. REPORTING SCHEDULE
7. SUBCONTRACTOR INFORMATION
8. LIST NEW CAPITAL EQUIPMENT REQUIRED
9. DESCRIBE SPECIAL FACILITIES REQUIRED
10. CONFLICT OF INTEREST INFORMATION

DRAFT

SEE NRC MANUAL CHAPTER 1102 FOR ADDITIONAL INFORMATION

APPROVING AUTHORITY—SIGNATURE | DATE

ATTACHMENT I

SEISMIC HAZARD CHARACTERIZATION OF THE EASTERN

U.S. - ESTIMATED BUDGET BREAKDOWN

(FIN No. A0390 and A0A28)

DRAFT

TASK	RES			NRR		
	82	83	84	82	83	84
1. Develop Initial Eq Occurrence Models						
2. Methodology Improvements						
2.1 Sol. & Use of Expert Opinion						
2.2 Expanded Ground Motion Panel						
2.3 Alternative Uncertainty Modeling & Propagation						
2.4 Validation						
3. Sensitivity Studies						
3.1 Encode Results						
3.2 RES Sensitivity Studies						
3.3 NRR Sensitivity Studies						
3.4 USGS Sensitivity Studies						
4. Stability of Results						
5. Feedback						
6. Peer Review's Final Results						
6.1 Assess Feedback						
6.2 Peer Review Panel						
6.3 Assess Peer Review						

Total FY'84 Budget = $220K

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NRC FORM 189 (3-81)

U.S. NUCLEAR REGULATORY COMMISSION

PROJECT AND BUDGET PROPOSAL FOR NRC WORK

DATE OF PROPOSAL	5/15/82
☐ NEW	9/15/83
☒ REVISION NO.	2 pg 1&2only
PROJECT TITLE	Seismic Hazard Characterization of the Eastern United States
FIN NUMBER	A0390 A0428
NRC B&R NUMBER	60-19-42 20-19-40-42-2
NRC OFFICE	Nuclear Regulatory Research (RES), Division of Health, Siting & Waste Mgmt
DOE CONTRACTOR	Lawrence Livermore National Laboratory (LLNL)
CONTRACTOR ACCOUNT NUMBER	6358, 6359
SITE	Livermore, California 94550
DOE B&R NUMBER	40-10-01-06-42 40-10-01-02-40-42-2

COGNIZANT PERSONNEL	ORGANIZATION	FTS PHONE NUMBER
NRC PROJECT MANAGER: A. J. Murphy	NRC/RES/ESBR	427-4615
OTHER NRC TECHNICAL STAFF: H. E. Lefevre/J. Kimball/D.J. Guzy	NRC/DE/GSB NRC/MSFB	492-7732 443-5997
DOE PROJECT MANAGER: William J. Gallagher	DOE/SAN	536-7916
CONTRACTOR-PROJECT MANAGER: L. L. Cleland	LLNL	532-4948
PRINCIPAL INVESTIGATOR(S): D. L. Bernreuter	LLNL	532-0305
D. H. Chung	LLNL	532-0268
J. M. Johnson, Resource Manager	LLNL	532-4949

PERIOD OF PERFORMANCE

STARTING DATE: 5/1/82

COMPLETION DATE: 9/30/84

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STAFF YEARS OF EFFORT *(Round to nearest tenth of a year)*	FY 82	FY 83	FY 84	FY	FY
Direct Scientific/Technical					
Other Direct (Graded)					
TOTAL DIRECT STAFF YEARS					
COST PROPOSAL $K					
Direct Salaries					
Material and Services (Excluding ADP)					
ADP Support					
Subcontracts					
Travel Expenses — Foreign					
Travel Expenses — Domestic					
Indirect Labor Costs					
Other *(Specify)* TID					
General and Administrative (%)					
TOTAL OPERATING COST					
CAPITAL EQUIPMENT FIN CHARGED: N/A					
Actual Costs FY 82 & 83 TOTAL PROJECT COST					

DRAFT

FY 84

MONTHLY FORECAST EXPENSE

NRC FORM 189 (3-81)

NRC FORM 189 (3-81)

U.S. NUCLEAR REGULATORY COMMISSION

FIN NUMBER: A0390 & A0428

DATE: 9/15/83

PROJECT AND BUDGET PROPOSAL FOR NRC WORK

PROJECT TITLE

Seismic Hazard Characterization of the Eastern United States

DOE PROPOSING ORGANIZATION

Lawrence Livermore National Laboratory

FORECAST MILESTONE CHART: Scheduled to Start – △——▲ – Completed (Shown in Quarter Year)
PROVIDE ESTIMATED DOLLAR COST FOR EACH TASK FOR EACH FISCAL YEAR

TASK		FY 82				FY 83				FY 84				FY				FY			
		1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
1. Develop Initial Earthquake Occurrence Models	SCHEDULE																				
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Peer Review's Final ults	SCHEDULE																				
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PROJECT DESCRIPTION: *(Provide narrative descriptions of the following topics in the order listed. Attach on plain paper to this NRC Form 189. If an item is not applicable, so state.)*

1. OBJECTIVE OF PROPOSED WORK
2. SUMMARY OF PRIOR EFFORTS
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DRAFT

SEE NRC MANUAL CHAPTER 1102 FOR ADDITIONAL INFORMATION

APPROVAL AUTHORITY–SIGNATURE

DATE

Project Title:	Seismic Hazard Characterization	FIN No.	A0390 & A0428
	of the Eastern United States	B&R No.	20-19-40-42-2
		Wang No.	0293t

1. OBJECTIVES OF PROPOSED WORK

Objective

The objective of this program is the development of a seismic hazard characterization methodology for the entire region of the United States east of the Rocky Mountains. Associated tasks are:

1. Develop the seismicity and ground motion parameters[(1)] for the entire U.S. region east of the Rocky Mountains. These parameters will be at such stage that they can be used to develop the seismic hazard in a form useful for PRA studies for any U.S. site east of the Rocky Mountains with relatively little additional effort.

2. Assist the NRC staff in addressing current NRC problem areas such as changes in the USGS position on the Charleston earthquake and the implications of recent eastern U.S. (EUS) earthquakes in New Brunswick and New Hampshire. This will be done through additional quality control, methodological improvements and ample sensitivity analysis.

3. Test the methodology at approximately eight sites east of the Rocky Mountains.

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(1) The seismicity and ground motion parameters we will develop are characterized as follows:
- o Seismo-tectonic zonation.
- o Rate of earthquake occurrence
- o Distribution of earthquake magnitudes.
- o Largest earthquake with its associated uncertainty.
- o An identification of which available ground motion models, including uncertainty, should be used in site-specific studies.

Approach

Our approach to achieve this objective is to expand, improve, and apply methods developed in the SEP/SSMRP, including:

- o Use of expert panels.
- o Retention of multiplicity of expert models rather than looking for a concensus.
- o Use of sensitivity studies to identify key parameters.
- o Develop characterization of uncertainty about best estimates (or median) of results.

2. SUMMARY OF PRIOR EFFORTS - BACKGROUND

This Project was initially formulated to meet the needs of a simplified methodology for routine probabilistic risk assessment. However, several larger EUS earthquakes occurred and at the January 28 & 29, 1982 meeting of the ACRS Subcommittee on Extreme External Phenomena, the USGS indicated that it might change its position on the Charleston earthquake putting the NRR in the position of needing to assess the possible safety implications of the recent earthquakes and for any USGS change in position regarding the location of the Charleston earthquake.

On November 18, 1982, the USGS position letter was filed with the NRC. The NRC Commissioners were informed of this development on November 19th. An open public meeting was held on November 30th to discuss the background and implications of the USGS position letter in relation to nuclear power plants on the eastern Seaboard. In January 1983, the NRC identified the NRC/NRR/DE Geosciences Branch plan to address the USGS clarification relating to seismic design earthquakes in the eastern Seaboard of the United States.

In the proposed scope of work two sets of the NRC needs are recognized. First, there is the need to perform seismic hazard analysis sensitivity studies at particular sites to provide the staff with sufficient information to assist them in making their safety assessments. The second need is to incorporate improvements into LLNL's approach to reduce the uncertainty in their results and provide rapid peer review of approach and results so that the NRC can confidently use the results in their safety assessments and at hearings.

Specifically, the NRC has requested LLNL to assist the NRC in meeting the needs described above by expanding and improving the SEP/SSMRP methodology. This methodology was developed under the SEP project by LLNL with the TERA Corporation as a subcontractor and then improved upon and extended under the SSMRP/Seismic Input (SI) Project. (In the following, we will refer to this methodology as the SEP/SSMRP study or seismic hazard analysis). As detailed later, LLNL was requested to expand the range of the EUS Seismicity Modeling Panel by adding expertise (specialists) for the southern portions of EUS; to improve the SEP/SSMRP questionnaire; to improve the EUS ground motion model; and to re-execute the SEP/SSMRP codes on the new data base.

3. WORK TO BE PERFORMED AND EXPECTED RESULTS

There are six (6) tasks as follows:

Task 1: Development of Initial Earthquake Occurrence Models
Task 2: Methodology Improvements
Task 3: Sensitivity Analysis
Task 4: Stability of Results
Task 5: Feedback and Development of Finalized Models
Task 6: Peer Review and Final Results

TASK 1 - Development of Initial Earthquake Occurrence Models

Background

The objective of this task is to develop and convene an EUS Seismicity Modeling Panel and obtain from them the necessary information (e.g. zonations, largest earthquakes, etc.) to develop for each panel member an overall earthquake occurrence model for the EUS in a form suitable for hazard analysis programs.

Subtask 1.1 - Select Panel Members

Interact with the geophysical community to select a panel with NRC concurrence that is representative of the diversity of opinion about the seismotectonics of the EUS. The main requirements for being a panel member are recognized expertise and willingness to put in the time required (estimated to be about 3 manweeks of effort per panel member including the feedback-loop). Initial attempt should be made to setup a single panel of 10-15 members to cover the entire EUS.

Subtask 1.2 - Expand LLNL EUS Earthquake History Data Tape

Add Bollinger's catalog to our data tape, add results from the NRC support EUS network, and quality control the data tape.

Subtask 1.3 - Develop Improved Questionnaire

Review results from the past questionnaire developed under the SEP program and develop and recommend, with close interaction with the NRC staff through the Project Manager, a new questionnaire for the seismicity modeling panel. Incorporate results from Subtask 2.1.

Subtask 1.4 - Interaction with Panel and Obtaining Panel Responses

Interact with seismicity modeling panel members to explain program and use of their input. Provide, when requested, earthquake history for various zones defined by panel members.

TASK 2 - Methodology Improvements

Background

The approach used for the SEP/SSMRP seismic hazard analysis has been extensively reviewed. A number of improvements have been suggested particularly in the areas of expert opinion solicitation and use and in theoretical modeling to make probabilistic estimates of the seismic hazard at a site. Additional work is currently ongoing as part of the SSMRP to improve our ground motion modeling including correction for site factors. This work will be subject to peer review and incorporate additional improvements in LLNL results. To account for the systematic error introduced by the ground motion model requires a large number of runs for each expert's earthquake occurrence model. This makes it difficult to come up with the final best estimate hazard results which includes all of the random and systematic uncertainty of both the earthquake occurrence and ground motion models. Under this task, approximate methods will be developed to handle this problem and still keep the amount of analysis and data management reasonable.

Subtask 2.1 - Solicitation and Use of Expert Opinion

Review the approach, results and recommendations of the Subjective Opinion Review Panel and other peer review comments and incorporate improvements into the approach used to solicit and use expert opinion. This subtask provides input into Subtask 2.3 where we develop an improved approach to estimate the seismic hazard at a site.

Subtask 2.2 - Review of Ground Motion Models

Convene a panel of experts with the concurrence of the NRC Project Manager, to review Subtasks being carried out as part of the SSMRP effort to improve our ground motion modeling and site amplfication effects. Incorporate recommendations as schedule and budget allow into the methodology. This is the EUS Ground Motion Modeling Panel. As in the SEP/SSMRP study, a panel consisting of five members was initially suggested. Because of the complexity and diversity of the eastern United States problems, we expanded the panel to include one additional expert. It was then suggested by the NRC that we expand this Panel even further to include another member to the panel. Thus, the total number of the EUS Ground Motion Modeling Panel is now seven.

At the January 5-6, 1983 meeting of the EUS Ground Motion Panel, the panel suggested additional work for LLNL, such as data gathering (e.g., New Brunswick and New Hampshire events of January 1982) and performing added regression analysis to extend the Joyner-Boore and Campbell models to lower magnitude values. In addition, we need to develop a document for the panel which defines the various EUS ground motion models and makes comparison of various ground motion models to all available EUS strong ground motion data. The Panel needs this information to provide weights to the models. The result of this additional work will become an important additional input to the program. In particular additional work will be completed on intensity attenuation using actual distance/intensity data points. The advantages/disadvantages of this method will be compared to relationships such as Gupta-Nuttli and Ossippee to determine which is the better method to use. In addition the spectral strong motion data base will be expanded to include important earthquakes such as 1979 Imperial Valley (and aftershocks), 1979 Coyote Lake, 1980 Livermore, 1980 Mammoth Lakes (and aftershocks), and 1983 Coalinga (and aftershocks). This expansion will add credibility to the attenuation equations utilized and will provide better estimates of absolute hazards estimates.

Subtask 2.3 - Alternative Ways to Propagate the Systematic Uncertainty

This subtask has been redefined because preliminary results from Subtask 2.1 and from the ground motion panel point to the need to develop improved ways to propagate both systematic and random error through the hazard analysis. The purpose of this task is twofold. The first step is to restructure the HAZARD computer program to do this in an efficient manner. The difficultly with the current configuration of hazard computer program is that to evaluate any systematic change in any variable (say rate of seismicity) requires a complete evaluation of the geometry, seismicity, and ground motion models. Where as, in actual fact, all that really needs to be reevaluated are the seismicity distributions. Thus, we propose to restructure our computer program into three main subelements so that it will be much more efficient to make the many runs required and to implement different approaches to propagating the uncertainty. The second step is to examine simplified ways of propagating systematic error to reduce the number of computations that must be made to define the best estimate curve and its uncertainty.

Subtask 2.4 - Validation of Computer Programs

The importance of the LLNL/Tera computational codes to the Seismic Hazard Characterization Project cannot be overemphasized. An effort must be undertaken to validate these codes. There are two aspects of the codes that need to be validated. The first requires a validation that the code faithfully replicates the subelement interactions upon which the codes is based and that the code correctly manages the data which is analyzed. This aspect might be most efficiently handled as a subcontract to a software shop to improve the efficiency of the code.

The second aspect requiring validation is that numerical application of the theory via the codes produce results which are consistent and meaningful. An approach to accomplish this validation might be to solve problems with a closed-form solution such as a circular source zone, or a square source zone in one case compared to the same area divided up into several blocks (with the same unit area recurrence). A check could be made between the closed-form solution and the numerical code solution to determine if the two results are consistent.

TASK 3 - Sensitivity Analysis

Background

The first objective of this task is to provide each expert sufficient information about the sensitivity of the computed hazard in different regions of the EUS for him to assess the physical reasonableness of their responses to the questionnaire and make adjustments to their model as required during the feedback-loop. The second objective is to provide NRC with an early preliminary assessment of implications of the USGS position regarding the Charleston earthquake and recent EUS earthquakes.

Subtask 3.1 - Encode Results of Questionnaire

Translate the responses to the questionnaire into a form suitable for input into hazard analysis program. Digitize boundaries of zones supplied by panel members. Interact with panel members as required to ensure proper interpretation of both the question and response.

Subtask 3.2 - Sensitivity Studies for Feedback Needs

Perform analysis using each panel member's model so that panel members can assess the physical reasonableness of their model.

Subtask 3.3 - Results at Specific Sites for NRC and Interim Report

Interact with and expand upon the sensitivity studies of Subtask 3.2 to address current NRR licensing needs using initial models. Experience from SEP suggests that feedback changes will not be significant except at a few isolated locations. Perform a "historical" hazard analysis for eight (8) selected sites for comparison. Write an interim report that provides the results of the analysis. Our interim report for this task is planned to be a report similar in format as Appendix B of Volume 4 of our SEP reports for NRR use. At this time, the scope of this subtask is uncertain. If additional work is required, we will prepare a proposal that outlines the work required, level of effort, costs, period of performance, etc., and submit it to the Director, Division of Health, Safety and Waste Management, RES and to the Director, Division of Engineering, NRR.

Subtask 3.4 - Additional Sensitivity Studies with Reference to the USGS Open-File-Report 82-1033

Perform sensitivity studies utilizing the source zones and recurrence data contained in the US Geological Survey document, Open-File-Report 82-1033 using the ground motion models developed as part of this project. This subtask work involves a close interaction of LLNL staff with USGS staff members (especially with Messrs. Algermissen and Perkins) in Denver, Colorado and may require a meeting with them.

TASK 4 - Stability of Results

Background

The objective of this task is to establish the relative stability of our approach using a comparison of the seismic hazard results between the SEP/SSMRP study and this study. Recent EUS earthquakes will allow us to assess the impact of new information.

Subtask 4.1 - Analysis and Assessment

Perform additional analysis required using both the earthquake occurrence models developed in Task 3 and the SEP/SSMRP study. In particular, as the recent EUS earthquakes occurred in regions not analyzed as part of the SEP/SSMRP, LLNL will have to compute the seismic hazard in these regions using both the SEP/SSMRP models and the models developed as a result of this study. Compare results using the synthesis hazard results from both this study and the SEP/SSMRP study, and the individual results from the seismicity modeling panel members who participated in both this study and the previous one.

TASK 5 - Feedback and Development of Finalized Models

Background

The objectives of this task are to give the seismicity modeling panel members an opportunity to review the physical reasonableness of their inputs, review LLNL interpretation of their inputs and finally make any changes to their earthquake occurrence models that they feel is necessary to make their models physically reasonable. It will also provide the panel members a chance to discuss their views and possibly narrow the differences in opinion about key parameters.

Subtask 5.1 - Reconvene Panel and Develop Feedback Questionnaire

Put results of Task 3 and 4 in a form suitable for seismicity modeling panel members review. Hold a meeting with the panel and discuss sensitivities, importance of various parameters, and significance of any differences between panel members. Allow panel members to discuss their differences and hopefully narrow the differences between panel members. However, SEP/SSMRP results suggest that there will be little movement towards concensus positions. Isolate the key items and develop a feedback questionnaire to address open items.

Subtask 5.2 - Make Changes to Models

Make changes to each expert's model as required using the responses obtained in Subtask 5.1.

TASK 6 - Peer Review and Final Results

Background

The objective of this task is to help maintain the scientific merit and credibility of this program by subjecting it to a formal peer review panel.

Subtask 6.1 - Assessment of Feedback

Analysis will be carried out to assess the implications of the feedback-loop on the results reported in Subtask 3.3. We have only budgeted for a limited amount of assessment such as was performed for the SEP study. Develop an interim report on the assessment of the feedback-loop.

Subtask 6.2 - Convene Peer Review Panel

Select a peer review panel similar in make-up to the one used for the SEP. Meet with the panel and provide them with an updated methodology report, results report from Task 3 and the feedback assessment reported from Subtask 6.1.

Subtask 6.3 - Assess Peer Review Recommendations

Perform sensitivity studies to assess the implication of Peer Review Panel recommendations in a manner similar to what was done for the SEP.

Establishment and Purpose of Model and Peer Review Panels

During the course of this project, it is necessary to convene three panels of experts:

1. Eastern U.S. Seismicity Modeling Panel, Task 1
2. Ground Motion Modeling Panel, Subtask 2.2
3. Overall Peer Review Panel, Subtask 5.1

Each of these panels is being convened by the contractor to obtain the expert opinion of each expert individually and not to obtain a consensus opinion of the panel. Several of the panels are being brought together in meetings to permit the free-flow of all available information that may contribute to the formulation of individual expert opinion. The contractor may, as part of the program effort, form its opinion of an average or consensus opinion of the panel's individual opinions.

Project Title: Seismic Hazard Characterization	FIN No.	A0390 & A0428
of the Eastern United States	B&R No.	20-19-40-42-2
	Wang No.	0293t

Seismic Hazard Characterization of the Eastern U.S.
Milestones

Milestone Task Subtasks	Task	Target Date
1.	Develop Initial Earthquake Occurrence Models	
	1. Complete selection of panel and development of first round questionnaire.	9/1/82
	2. Zonations developed from panel's responses.	12/15/82
	3. Panel members complete questionnaire.	7/1/83
2.	Methodology Improvement	
	1. Start work on statistical improvements.	5/1/82
	2. Complete effort on improvements to solicitation of expert opinion.	2/1/83
	3. Convene expanded Ground Motion Panel.	1/15/83
	Questionnaire	7/15/83
	Response	10/30/83 (Pacing Item)
	4. Complete work on statistical improvements on use of expert opinion and alternative approachs to propagate systematic error	7/15/83
	5. LLNL documents in-house validation effort.	(FY'84)
	6. Validation RFP sent out.	(FY'84)

Milestone Task Subtasks	Task	Target Date
	7. Contractor selected for independent validation effort.	(FY'84)
	8. Validation completed by contractor.	(FY'84)
3.	Sensitivity Analysis	
	1. Start encoding zonations.	12/15/82 5/1/83C
	2. Complete sensitivity studies and provide NRR with initial assessments.	9/15/83 12/15/83 12/22/83
	3. Compare with USGS results.	12/15/83
4.	Complete assessment of stability of results.	12/15/83
5.	Feedback Loop	
	1. Hold feedback meeting(1)*.	11/30/83
	2. Send out second round questionnaire(2)*.	12/30/83 depends on
	3. Results from second round questionnaire encoded.	3/1/84

*Note: (1) This is an approximate date as it depends upon the schedule of panel members. Our experience from the SEP study indicates that it was difficult to find a date to gather in one place at the same time sufficient number of the panel members.

(2) This date is approximate. The actual date is dependent upon when the feedback meeting was held.

Project Title:	Seismic Hazard Characterization of the Eastern United States	FIN No.	A0390 & A0428
		B&R No.	20-19-40-42-2
		Wang No.	0293t

Milestone Task Subtasks	Task	Target Date

6. Peer Review and Final Results

   1. Assessment of implications of feedback.
4/15/84

   2. Peer Review Panel meeting. 6/15/84

   3. Assessment of Peer Review. 9/15/84

4. DESCRIPTION OF ANY FOLLOW-ON EFFORTS

Uncertain at this time.

5. RELATIONSHIP TO OTHER PROJECTS

The state-of-the-art findings from this project will assist three other projects in progress at LLNL: (1) One is the SSMRP, Phase II studies (FIN No. A0126-2), (2) the Geoscience Case Review Project (FIN No. A0406-2), and (3) the Probablistic Assessment of the Seismic Hazard of Eastern U.S. Power plant Sites (FIN No. A0448).

6. REPORTING SCHEDULE

A monthly business letter report shall be submitted by the 15th of the month covering details of the proceding month to the cognizant NRC Project Manager with copies to B. L. Grenier, NRR, and W. Batson, RES. These reports shall contain:

a. A listing of the amount of effort (staff months), broken down by task, expended during the reporting period;

b. A listing of any efforts completed during the period; milestones reached, or if missed, an explanation provided;

c. The amount of funds expended for staff, computer, subcontracting, and travel during the period and cumulative to date for each task;

d. Any problems or delays encountered or anticipated, itemized by task and subtask; and

e. A brief but thorough summary of progress during the reporting period.

An interim report will be issued upon completion of Task 3. This interim report we envision is a report similar in format to Appendix B of Volume 4 of our SEP reports.

In our final report, we will provide a complete technical description of our effort and results of Task 3 along with the following products:

a. Seismic data (zonation, occurrence rates, magnitude distributions, attenuation models, etc.) in sufficient detail to be applied to a seismic hazard analysis of any location in the Eastern United States (east of the Rocky Mountain). The forms of this data should be such that it can be directly input as a computer file into the SSMRP HAZARD Code, or be used in whole or part by the general public in performing other types of seismic hazard evaluations.

b. Complete documentation, in the form of NUREGs, of the data and the procedures by which it was obtained.

NOTE: It is important both to this project and to the SSMRP that this report (in a draft form) be available on or about mid-January 1984. We expect by this time that the SSMRP will have access to our data and the results of our analysis from this project.

A draft version of the final report shall be submitted to the NRC for review and comment thirty (30) calendar days prior to the contract expiration, with fifteen (15) copies to the Project Manager. This report shall contain a comprehensive recapitulation of the entire contract effort and shall be documented, produced, and disseminated in accordance with NRC Manual Chapter 3202, "Publication of Regulatory and Technical Documents Prepared by NRC Contractors." The final report shall include, as a minimum, a summary of two to three pages written in clear, unambiguous language and fully substantiated in the body of the report. The summary shall be suitable for use as a press release. The contractor shall submit one (1) camera-ready copy and two copies of the Final Report to the Project Manager.

7. SUBCONTRACTOR INFORMATION

The TERA Corporation has been identified as our sole subcontractor for the project. The TERA Corporation was involved with the SEP and the SSMRP work, as a subcontractor to LLNL.

The TERA Corporation has performed all types of seismic hazard determinations--empirical, deterministic, and probabilistic. Many site-specific analyses have been performed under LLNL contracts. These include (1) nine eastern SEP sites and the Zion site; (2) six sites for NMSS as part of their licensing effort; and (3) 26 sites of DOE facilities. More recently, the TERA group has performed a variety of seismic hazard analyses for such sites as San Onofre, Diablo Canyon, and Humboldt Bay for other clients. In view of this, we are structuring our work under the subject project such that we remove TERA from a central role in the hazard analysis.

Regarding the principal project staff at TERA, we expect Lawrence H. Wight will provide all the necessary corporate direction; Drs. Chris Mortgat, and Mansour Niazi will provide task level technical direction, with support from other TERA staff as appropriate.

8. LIST NEW CAPITAL EQUIPMENT REQUIRED

None.

9. DESCRIBE SPECIAL FACILITIES REQUIRED

None.

10. CONFLICT OF INTEREST INFORMATION

None.

11. MEETINGS AND TRAVEL

We have budgeted for 3 one-person trips to Bethesda, Maryland, to attend meetings with NRC staff, 2 two-person trips to expert panel meetings, and one three-person trip to a feedback meeting. Location of these meetings is unknown at this time.

12. NRC FURNISHED MATERIAL

NRC will furnish the FSARs and other appropriate reports requiring review for each of the sites under this contract.

13. PROPRIETARY DATA

In the event any proprietary information is submitted by the NRC in connection with this project, it must be specifically identified. The University agrees to exercise its best efforts to avoid release of proprietary data. Nevertheless, neither the University, its employees, nor the government shall be liable in any way in the event such information is released. Furthermore, limitation shall not be imposed on the use of any information and data previously delivered to the University or government without limitations or previously published in any form as to be generally available.

14. PATENT STATUS

This proposal is being transmitted in advance of patent review for evaluation purposes only. No further dissemination or publication shall be made without prior approval of the Assistant General Counsel for Patent, DOE.

15. TASK X ON CALL ASSISTANCE

Not applicable at this time.

16. SUMMARIZE DELIVERABLES

- Monthly Management Letter Report
- An interim technical report summarizing our findings on Task 3.
- Final technical report (of a NUREG quality)

Lawrence Livermore National Laboratory

NUCLEAR SYSTEMS SAFETY PROGRAM

October 18, 1983
EG-83-092/1125u

TO: Jeff Kimball

FROM: Jean Savy

SUBJECT: Definition of the LLNL "Best Estimate Hazard Curves" and Method of Obtention of the Hazard Percentiles

1. Best Estimate Curve

The seismic zonation data as provided by the experts is a random variable. The experts gave us a best estimate map and some information describing the variability in the variable. Those same experts provided quantitative values on the seismicity, recurrence upper magnitude cutoff for each zone that they identified in their zonation maps. Their description of these parameters for each zone was, again, in terms of a best estimate and some description of the variability.

Similarly, the ground motion experts provided a best estimate attenuation model and a set of alternative models and associated weights, to describe the variability. In our calculation of the best estimate hazard curve, we start from the best estimate zonation map for the s^{th} ($s = 1, 2, \ldots, S$) seismicity expert and choose the best estimate ground motion identified by the g^{th} ground motion experts. $g = 1, 2, \ldots, G$

The "best estimate" of the hazard for the s^{th} seismic expert is a weighted average of the hazard calculated for seismicity expert number s and each of the G ground motion experts.

That is:

$$P_s(A > a) = \sum_{g=1,G} W_{sg}\, P_{sg}(A > a) \Big/ \left(\sum_{g=1,g} W_{sg} \right)$$

where $P_{sg}(A > a)$ is the estimated hazard based on the best estimate zonation and seismicity for expert s and best estimate ground motion model for ground motion expert g.

Similarly, the final estimate of the "best estimate" hazard is obtained by a weighting average of $P_s(A > a)$ over the S seismicity experts.

$$P(A > a) = \sum_{s=1,S} P_s(A > a)\, W_s \Big/ \left(\sum_{s=1,S} W_s \right)$$

2. Evaluation of Uncertainty

Four each couple (s,g) of (seismicity-ground motion) experts, a Monte Carlo simulation process is used to generate the cumulative distribution function of the probability of exceedance $p = P(A > a)$, for a given value of the acceleration a.

In this simulation process, the zonation is now a random variable and the sample zonations are drawn from all possible maps provided by the expert with distribution determined by the weights computed from the expert's information. The ground motion models are drawn in a similar fashion with distribution determined from the weights assigned to each model. All the other random variables are drawn from their specified distributions.

For example, for a given acceleration a, and with seismicity expert number 6, and ground motion expert number 3, we obtain a CDF of p as shown in Fig. 1.

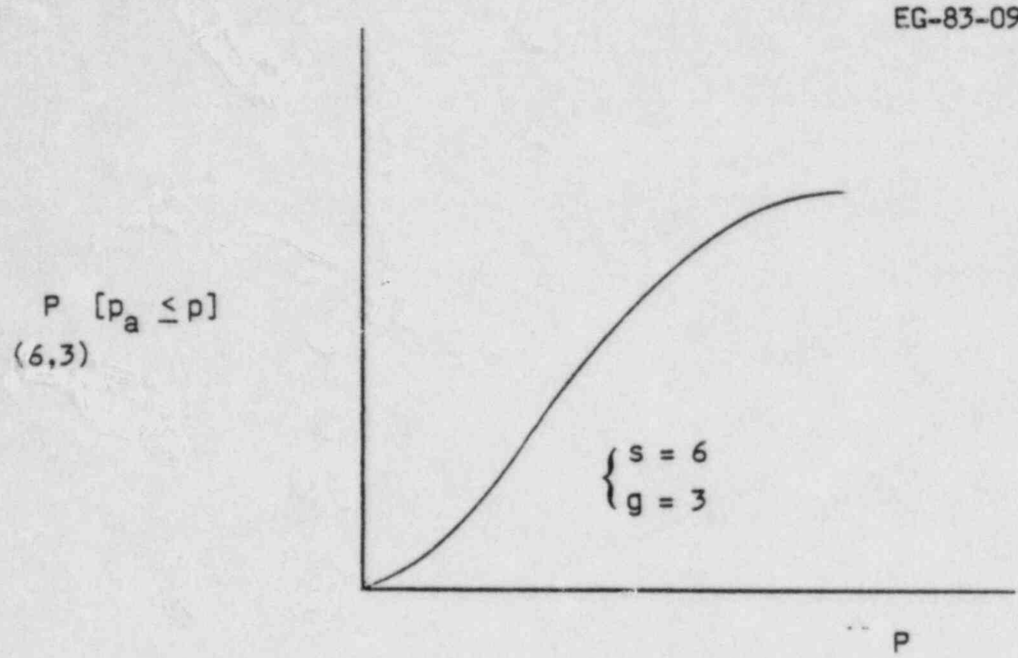

Figure 1

Now, if we have S = 11 and G = 5 we are going to have all the possible combinations of s and g (i.e., 55) curves such as the one presented in Fig. 1 (for a given value of a). We combine all of these 55 probability distribution functions using standard probabilistic methods.

$$P\left[p_a \le p\right] = \sum_{s=1,11} \sum_{g=1,5} W_s W_g P_{sg} \left\{p_a \le p\right\} \Big/ \left(\sum_s \sum_g W_s W_g\right)$$

That is, the distribution of the probability of exceedance due to the uncertainties in the zonation, seismicity and ground motion models expressed by the experts, is the weighted average of the individual distribution for each pair of experts. Thus, for each value of the acceleration a we obtain a single distribution of p from which we infer the 5, 15, 50, 75 and 95th percentiles.

cc: D. L. Bernreuter, LLNL
D. H. Chung, LLNL