



UNITED STATES  
**NUCLEAR REGULATORY COMMISSION**  
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June 1, 1995

MEMORANDUM TO: Mysore Nataraja, Acting Section Leader  
 Geosciences/Geotechnical Engineering Section  
 ENGB/DWM/NMSS

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SUBJECT: TRIP REPORT FOR DATA NEEDS WORKSHOPS ON SEISMIC SOURCE  
 CHARACTERIZATION AND GROUND MOTION CHARACTERIZATION, PART OF  
 DOE'S PROBABILISTIC SEISMIC HAZARD ANALYSIS FOR YUCCA MOUNTAIN

On April 17-21, 1995, we participated, as observers, at two consecutive workshops for expert panelists assembled by DOE. These workshops were the first in a series of an expert elicitation process. The elicitation will result in a probabilistic seismic hazard analysis (PSHA) for Yucca Mountain, which DOE can use in both preclosure and postclosure seismic design for the repository. Two elicitations are working in parallel with separate expert panels. One is devoted to characterizing the seismic sources near Yucca Mountain and the other to characterizing the ground motion at the site from seismic events. The Seismic Source Workshop was conducted by Geomatrix and the Ground Motion Workshop by Norm Abrahamson, Consultant, under contract to the M&O. The Seismic Source Workshop took place on April 17-19 and the Ground Motion Workshop on April 20-21, both in Salt Lake City, Utah. Each of these first workshops focused on the data needs for the experts to use in preparation for the actual elicitation.

The Seismic Source Characterization (SSC) Workshop was managed by Kevin Coppersmith (Geomatrix), who brought the meeting to order. The first presentation was by Tim Sullivan (DOE), who stated DOE's position that the database from seismic investigations is now adequate to begin a seismic hazard analysis and additional data will not significantly change conclusions. He then provided some information on the advanced conceptual design of the repository for those experts less familiar with the project. DOE's current thinking is that waste packages about 6 feet in diameter and 18 feet long will be emplaced in drifts of 14 feet diameter. Sullivan also discussed how the results of the expert elicitation will feed into postclosure package rupture

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studies and DOE's high-level findings (HLFs). He said the results of the PSHA will not be included in the tectonics HLF scheduled for FY 96, however, this does not agree with Progress Report 11, which shows the tectonics/volcanism HLF due in January 1997.

Carl Stepp (Woodward-Clyde Federal Services) discussed the objectives and organization of the PSHA project. The overall objective is to incorporate a broad range of expert knowledge, experience and interpretations of the scientific community into a PSHA and from that determine design basis fault displacement and vibratory ground motion values for the repository seismic design. The PSHA should also strive to capture the uncertainty in the results. As part of the effort to minimize uncertainty, the 18 experts will be split into 6 teams of 3, with each team comprising experts with complementary skills and knowledge in the areas of seismic source characterization, regional tectonic setting, and assessment of fault displacement. The teams will be created prior to the second workshop in October 1995. Stepp also described the roles of the various participants in the expert elicitation process. There is an oversight panel which leads discussions and provides overall technical quality control. The facilitation team assists in the development of seismic hazard analysis (SHA) inputs; they work with the experts to facilitate the experts' interpretations. The experts evaluate the data, prepare their interpretations for input to the SHA, and document their interpretations. The data management team is responsible for providing common data sets for use by the experts. Finally, the seismic design team takes the PSHA results and calculates the seismic design basis parameters. This is the team that will prepare the third seismic topical report which DOE plans to submit to NRC in late 1996.

Coppersmith followed with an introduction of the 18 experts, the guidelines for their selection, such as strong relevant experience, willingness to forsake the role of proponents, and specific knowledge of Yucca Mountain, and criteria which could lead to an expert being removed from the panel. He also pointed out that the experts should not be unnecessarily conservative in their calculations but just allow full consideration of all possible models and uncertainties. He outlined the schedule for the other four workshops which should be completed by FY 1996. Peter Morris (Applied Decision Analysis, Inc.) then presented more detail on the elicitation process and the treatment of uncertainty, as well as lessons learned from previous PSHA studies. Experts will be asked to play different roles throughout the process. They will not be expected to be dogmatic in adherence to a favored model but may at times be asked to be a proponent of a model so the other experts may better understand it. Morris also stated that consensus among experts is not a goal of this elicitation; differences of opinion are simply a part of the uncertainty in the results.

After these more programmatic presentations, the workshop was devoted to discussion of the key issues to consider in a SHA. Walter Arabasz (University of Utah) gave a presentation on the difficult issues involved with

interpreting a seismic data catalog. Bert Swan (Geomatrix) provided his perspectives on characterizing seismic sources, then Ivan Wong (WCFS) discussed the issues identified in the preliminary PSHA for the Exploratory Studies Facility.

The presentations of key issues were followed by a discussion among the panelists of what types of data would help them evaluate various seismic features in the Yucca Mountain region. After this, Mary-Margaret Coates (USGS) described for the panelists the data package which they had received just prior to the meeting. Most of the remaining workshop time was allotted to presentations on the existing tectonics-related data sets for the Yucca Mountain region. Speakers were asked to simply address the characteristics of data sets, not provide any interpretations of the data. Ken Smith and Jim Brune (University of Nevada-Reno) discussed the available seismic data catalog. They were followed by Larry Anderson (U.S. Bureau of Reclamation) on the age, distribution, and paleoseismic parameters of known and suspected Quaternary faults in the Yucca Mountain region. He mentioned that DOE hopes to construct an additional trench across the Bare Mountain fault during the 1995 summer. Ernie Anderson (USGS) provided additional information about Quaternary faulting studies which presently have results available. John Bell (UN-R) outlined the information available from the work completed by the State of Nevada. Among other things, the State has investigated the Cedar Mountain 1932 fault rupture, the Bare Mountain fault, and the age of the Pliocene basalt in Crater Flat. John Whitney (USGS) discussed the characteristics of the Quaternary faults at Yucca Mountain, including the current best estimates of slip rates on the faults. Jim Paces (USGS) addressed the state of knowledge of the ages of fault movement. He has very low confidence in the published ages which are based on the uranium trend technique, as the uranium migration rate varies with climate. Chris Potter (USGS) presented a summary of the structural characteristics within the repository block. Potter is presently working to map the Sundance fault zone in greater detail, and so far finds this zone to be somewhat discontinuous. The question of whether the Ghost Dance fault has Quaternary offset remains unanswered at this time. Finally, Vicki Langenheim (USGS) gave an overview of the geophysical data sets available for the Yucca Mountain area. She stated that results from the seismic reflection profile from Bare Mountain to Jackass Flats should be available in July.

It was decided that a seismicity working group composed of several project participants should be established to decide how the existing seismic catalog will be dealt with for this project. Likewise, a group will be formed to identify the site-specific data needed to address the fault displacement hazard. Concern was expressed that the project oversight committee should determine, at an early time, a distance from the site (perhaps 50 or 100 km) beyond which faults need not be considered in this PSHA. The final segment of the SSC Workshop was devoted to QA training, which was provided by Martha Mustard (USGS).

The Ground Motion Data Needs Workshop was brought to order by Abrahamson, and he discussed the objectives and organizational framework of the workshop. He indicated that the overall objective of the first workshop is to develop a list of additional data required for the experts to make reliable ground motion estimates for Yucca Mountain. Abrahamson indicated that the experts are expected to provide point estimates of ground motion for a matrix of magnitude and distance pairs. The range of frequency to be considered in the analyses is from 0.5 - 30 Hz. He discussed the different ground motion models based on empirical, hybrid empirical, and numerical simulation relationships. He indicated whether the existing ground motion models for the western U.S. are applicable to Yucca Mountain or need adjustment. Tim Sullivan (DOE) and C. Stepp (Woodward-Clyde) repeated their presentations given during the SSC Workshop. G. Toro (Risk Engineering) addressed uncertainty in ground motion prediction. He explained the differences between parametric variability and modeling variability and provided an example showing the steps used in calculation of these variabilities. J. Savy (LLNL) discussed how uncertainty is treated in the analysis and how the elicitation process will be conducted. He indicated that uncertainty will be addressed only if it significantly affects the earthquake hazard. He elaborated on the three types of elicitations (group, individual, and surveys). The elicitation will be guided by the Technical Facilitation Team (TFT). The functions of the TFT are: setting the right tone, active listening and integration between the experts. Savy indicated that the experts will function as evaluators, proponents, and a resource. S. Pezzopane (USGS) summarized the location and tectonic setting of Yucca Mountain, identified fault focal mechanisms, regional earthquakes with magnitude > 4, Yucca Mountain faults, structural cross sections, and relevant Type I faults in the Yucca Mountain region. J. Schneider (USGS) identified available data and significant issues and needs. He talked about stress drops in extensional regimes, travel path issues, attenuation factor (Q), and site effects. He indicated that stress drops in extensional regimes tend to be lower than in compressional regimes. Schneider also indicated that large lateral variability may contribute to focusing/defocusing, which may increase ground motion uncertainty. He presented different velocity cross sections at Yucca Mountain and demonstrated the variability in the structures as a function of the different travel paths. When discussing ground motion models, Schneider indicated that field mapping usually gives a larger displacement value than those calculated from earthquake data. He explained the six scenario earthquakes that were developed at the Denver workshop (Paintbrush, Solitario, Rock Valley, Bare Mountain, Furnace Creek, and Solitario/Fatigue Wash/Windy Wash). W. Sliva (Pacific Engineering) talked about attenuation models and cautioned about taking one model from one region and applying it to another one.

K. Smith (UNR) presented the seismic activities at the Yucca Mountain region and discussed the Skull Mountain earthquake and its after shocks. M. Walck (SNL) addressed the Nevada Test Site nuclear tests. There were 925 devices fired since 1950. The first station at Yucca Mountain was installed in 1980.

She indicated that multiple regression on yield and distance were performed, and they attempted to examine peak ground motion decay as a function of depth. P. Sommerville (Woodward-Clyde) discussed near field ground motion. He discussed distance saturation, site conditions, ratio of vertical to horizontal, rupture directivity, and style of faulting. He found that both empirical and numerical modeling studies indicate a leveling off in ground motion amplitude at close distances; and close to large earthquakes peak accelerations on rock exceed those on soil due to non-linear soil effects. Sommerville stated that peak vertical accelerations are about as large as horizontal at distances within 10 km and that for peak acceleration reverse slip fault is about 30 percent higher than strike slip fault. P. Spudich (USGS) stated that his goal is to examine if existing empirical attenuation relationships describe adequately the available ground motion data at Yucca Mountain, and, if not, develop correction factors for the existing relationships, or produce a new empirical relationship based on data assessment. He is assembling a world-wide data set from extensional regimes, such as Basin and Range, Southern Oregon, Eastern Sierra, extension part of Italy, Greece, Turkey, and South America. Following these presentations, Abrahamson indicated that more specific data is needed on site information (S-wave velocity, instrumentation housings), distribution of stress drops in the region (main shock, after shocks), and slip rates (especially shallow slip near faults).

After the presentations, there were open discussions among the experts and the oversight committee. A suggestion was made that any theoretical modeling should fit the empirical data, because in some instances the theoretical model proposed did not represent what is observed in the field. At the end of each session, time was allotted for the observers to ask questions and get clarification on any of the topics discussed.

At the meeting, we recommended that the ground motion experts should keep contact with the SSC experts and at least attend one of their workshops. Based on the data request from the ground motion experts, it appears that DOE has to gather more new site information.

The SSC and Ground Motion Workshops appear to be effectively managed, and they should yield useful input to repository designers. However, it should be mentioned at this time that several of the 25 expert panelists have significant ties to the Yucca Mountain Project. If it becomes necessary that all experts demonstrate no conflict of interest in order for elicitation results to be useful during licensing, DOE may encounter difficulty with some members of this panel, just as with some members of the probabilistic volcanic hazard analysis panel.

Attendance lists, agendas and a project organization chart from the workshops are attached. The authors have a complete set of handouts from the meetings, including biographies of the experts, for any interested parties to see. If there are any questions regarding this report, Bakr Ibrahim can be reached at 415-6651 and Steven McDuffie at 415-6684.

Attachments: As stated      Distribution see next page.

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## Attachments

**SEISMIC SOURCE CHARACTERIZATION AND FAULT DISPLACEMENT WORKSHOP**  
**17-19 APRIL 1995**  
**Attendance List**

<b>Name</b>	<b>Affiliation</b>
Norm Abrahamson	Consultant
Jon Ake	U.S. Bureau of Reclamation
Ernie Anderson	U.S. Geological Survey
Larry Anderson	U.S. Bureau of Reclamation
Walter Arabasz	University of Utah
Ann Becker	Woodward-Clyde Federal Services
John Bell	University of Nevada at Reno
Ron Bruhn	University of Utah
Jim Brune	University of Nevada at Reno
Bob Budnitz	Future Resources Associates, Inc.
Tom Chaney	U.S. Geological Survey
Mary-Margaret Coates	U.S. Geological Survey
Kevin Coppersmith	Geomatrix Consultants
Allin Cornell	Consultant
Tony Crone	U.S. Geological Survey
Craig dePolo	University of Nevada at Reno
Diane Doser	University of Texas at El Paso
Chris Fridrich	U.S. Geological Survey
Tom Hanks	U.S. Geological Survey
Robert Harpster	SAIC
Bakr Ibrahim	U.S. Nuclear Regulatory Commission
Dick Keefer	U.S. Geological Survey
Jerry King	SAIC
Vicky Langenheim	U.S. Geological Survey
Martha Mustard	U.S. Geological Survey
Jim McCalpin	GEO-HAZ Consulting
Steve McDuffie	U.S. Nuclear Regulatory Commission
Robin McGuire	Risk Engineering
Chris Menges	U.S. Geological Survey
Peter Morris	Applied Decision Analysis



**GROUND MOTION WORKSHOP****20-21 APRIL 1995****Attendance List**

<b>Name</b>	<b>Affiliation</b>
Norm Abrahamson	Consultant
John Anderson	University of Nevada at Reno
Ann Becker	Woodward-Clyde Federal Services
David Boore	U.S. Geological Survey
Jim Brune	University of Nevada at Reno
Ken Campbell	EQE International
Tom Chaney	U.S. Geological Survey
Mary-Margaret Coates	U.S. Geological Survey
Allin Cornell	Consultant
Tom Hanks	U.S. Geological Survey
Robert Harpster	SAIC
Renner Hofmann	Southwest Research Institute/CNWRA
Bakr Ibrahim	U.S. Nuclear Regulatory Commission
Art McGarr	U.S. Geological Survey
Robin McGuire	Risk Engineering
Martha Mustard	U.S. Geological Survey
Rick Nolting	Morrison-Knudsen
Sue Penn	Woodward-Clyde Federal Services
Silvio Pezzopane	U.S. Geological Survey
Rich Quittmeyer	Woodward-Clyde Federal Services
Jean Savy	Lawrence Livermore National Laboratory
John Schneider	Woodward-Clyde Federal Services
Walt Silva	Pacific Engineering & Analysis
Ken Smith	University of Nevada at Reno
Paul Somerville	Woodward-Clyde Federal Services
Paul Spudich	U.S. Geological Survey
Carl Stepp	Woodward-Clyde Federal Services
Bill Sublette	SAIC
Tim Sullivan	U.S. Department of Energy
David Tillson	Nevada Nuclear Waste Project Office/NWPO
Gabriel Toro	Risk Engineering
Engelbrecht von Tiesenhausen	Clark County Nuclear Waste Division
Marianne Walck	Sandia National Laboratory
John Whitney	U.S. Geological Survey
Ivan Wong	Woodward-Clyde Federal Services

**AGENDA**  
**SEISMIC SOURCE CHARACTERIZATION**  
**DATA NEEDS WORKSHOP**

April 17-19, 1995  
Doubletree Hotel, Salt Lake City, Utah

**GOAL OF THE WORKSHOP:** To develop a comprehensive list and specification of data required to characterize seismic sources for vibratory ground motions and fault displacement hazard at Yucca Mountain. The list should be as specific as possible (e.g., including formats, map scales, etc.) in order to provide the Data Management Team sufficient information to put the data sets together for distribution to the SSC experts.

Secondary but important goals of this first workshop are also to provide information on the overall study, the products to be developed and the schedule for doing so, basic approaches to expressing uncertainties, and ground-rules regarding communication and interaction throughout the course of the study.

**APPROACH:** The basic approach to the workshop is to identify first the technical issues of most significance to seismic hazards at Yucca Mountain and then to link the issues with the data that are most important to addressing the issues. It is important that the technical issues be specific to seismic *hazard* analysis and that the data identified are available within the Yucca Mountain project. In order for the Data Management Team to be responsive to the experts' needs, the data requests must be *specific* and *realistic*.

**MONDAY, APRIL 17**

**1:00 - 3:45 INTRODUCTION**

1:00 - 1:15 Welcome (T. Sullivan)

1:15 - 2:00 Yucca Mountain PSHA Project (C. Stepp)

2:00 - 2:30 Experts, probabilities, uncertainty (P. Morris)

**2:30 - 2:45 Break**

2:45 - 3:45 Expert selection process; roles of participants; format of workshops; ground-rules; volcanic hazard project; framework for ground motion and fault displacement analysis (K. Coppersmith)

**3:45 - 4:45 SEISMIC HAZARD ISSUES** *The purpose of these talks is to discuss the technical issues associated with various aspects of seismic hazard analysis. Each presentation will last about 45 minutes, followed by 15 minutes of discussion.*

3:45 - 4:45 Seismicity Analysis (W. Arabasz)

**4:45 - 5:15 STATEMENTS FROM OBSERVERS**

**TUESDAY, APRIL 18****8:30 - 10:30 SEISMIC HAZARD ISSUES (cont'd.)**

8:30 - 9:30 Fault Characterization (B. Swan)

9:30 - 10:30 Issues Identified in ESF study (I. Wong)

**10:30 -10:45 Break**

**10:45 -12:00 Association of Issues with Data Needs (Discussion with Expert Panel)**

**12:00 - 1:00 LUNCH**

**1:00 - 4:45 DISCUSSION OF YUCCA MOUNTAIN DATA SETS** *The purpose of these presentations is to discuss the data bases that have been developed for the Yucca Mountain region and vicinity. Each presentation will last about 45 minutes, with about 15 minutes for discussion.*

1:00 - 1:30 Description of Data Delivered (M. M. Coates)

1:30 - 2:30 Seismicity Data (J. Brune, K. Smith)

**2:30 - 2:45 Break**

2:45 - 3:45 Regional Geologic Data (L. Anderson; E. Anderson)

3:45 - 4:45 Studies by Nevada (J. Bell)

**4:45 - 5:15 STATEMENTS FROM OBSERVERS**

**WEDNESDAY, APRIL 19**

**8:30 - 2:00 YUCCA MOUNTAIN DATA SETS (cont'd.)**

8:30 - 9:30 Local Fault Studies (J. Whitney)

9:30 - 10:30 Age-dating Data (J. Paces)

**10:30 -10:45 Break**

10:45 -11:45 Studies of Repository Block (C. Potter)

**11:45 - 1:00 LUNCH**

1:00 - 2:00 Geophysical Data (V. Langenheim)

**2:00 - 3:00 WRAP-UP DISCUSSION OF DATA NEEDS (Expert Panel)** *The purpose of this discussion is for the experts to identify those data sets that they are most interested in receiving and to specify the formats required.*

**3:00 - 3:15 Break**

**3:15 - 4:30 QUALITY ASSURANCE TRAINING**

**4:30 - 5:00 STATEMENTS FROM OBSERVERS**

**5:00 ADJOURN**

## Day 1

<b>8:00-8:10</b>	<b>Welcome and introductions</b>	<b>Sullivan</b>
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<b>8:40-9:20</b>	<b>Purpose of the Workshop</b>	<b>Abrahamson</b>
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<b>9:20-9:40</b>	<b>Treatment of Variability</b>	<b>Toro</b>
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**9:40-10:10**      **Expert Elicitation Process**      **Savy**

**10:10-10:30 Break**

<b>10:30-11:10</b>	<b>Geologic Input</b>	<b>Pezzopane</b>
	General tectonics and local faulting	

<b>11:10-12:10</b>	<b>Seismic Input (source and path)</b>	<b>Schneider</b>
	Source, path and site properties	

**12:10-1:10      Lunch**

<b>1:10-1:40</b>	<b>Local site response</b>	<b>Silva</b>
	Site Effects	
	Differences between rock at Yucca Mtn and "California" rock	

<b>1:40-2:10</b>	<b>Local Earthquakes/Data</b>	<b>Smith</b>
	<b>Little Skull Mtn Earthquake</b>	

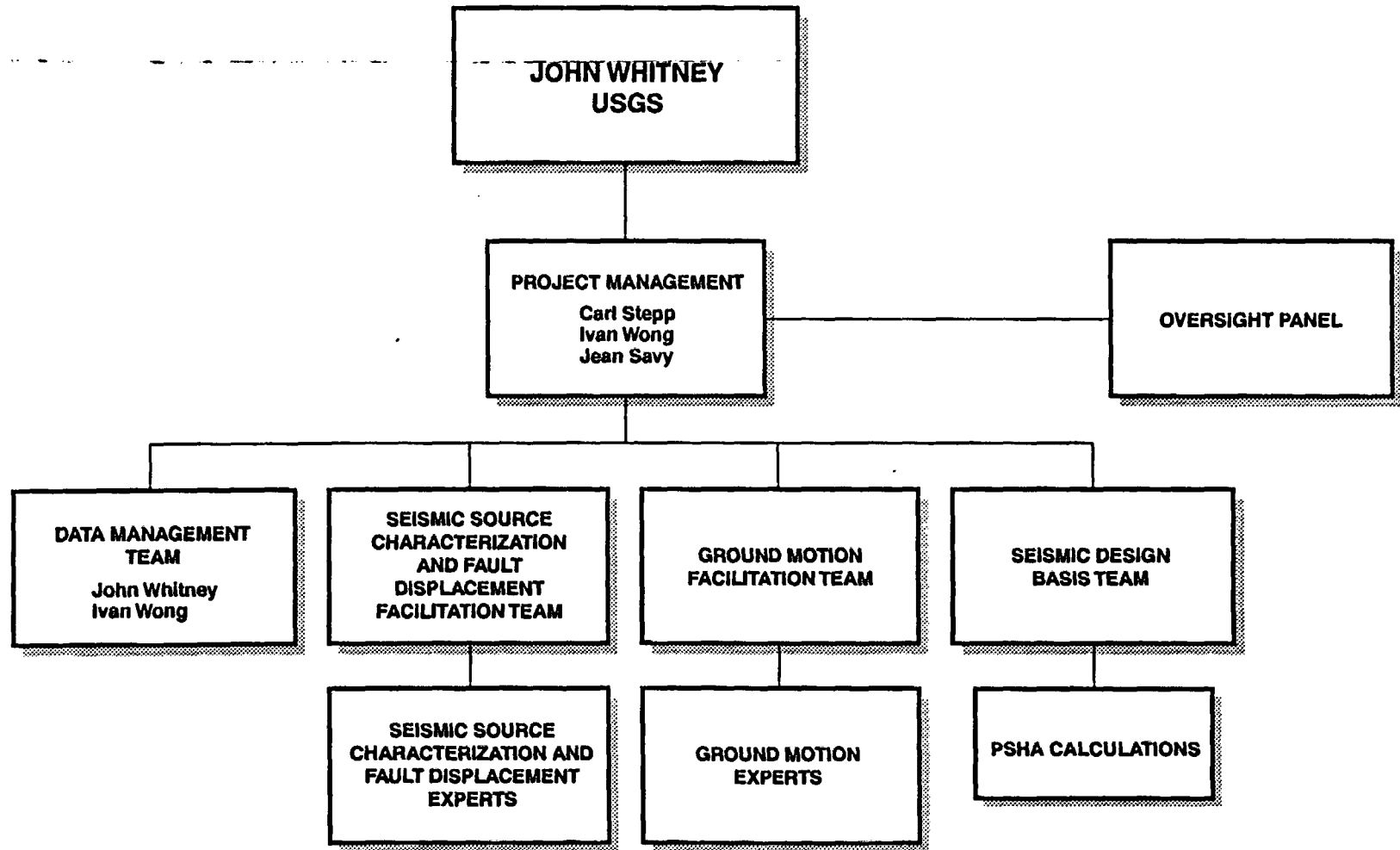
<b>2:10-2:40</b>	<b>Local Earthquakes/Data</b>	<b>Anderson</b>
	Site Amplification factors from UNR site-specific study	

<b>2:40-3:10</b>	<b>Explosion Data</b>	<b>Walck</b>
	Discussion of ground motions from NTS	

**3:10-3:30**      **Break**

# PROJECT ORGANIZATION

Yucca Mountain Seismic Hazards Evaluation Project



# PROPOSED SCHEDULE FOR YUCCA MOUNTAIN SEISMIC HAZARD ASSESSMENT

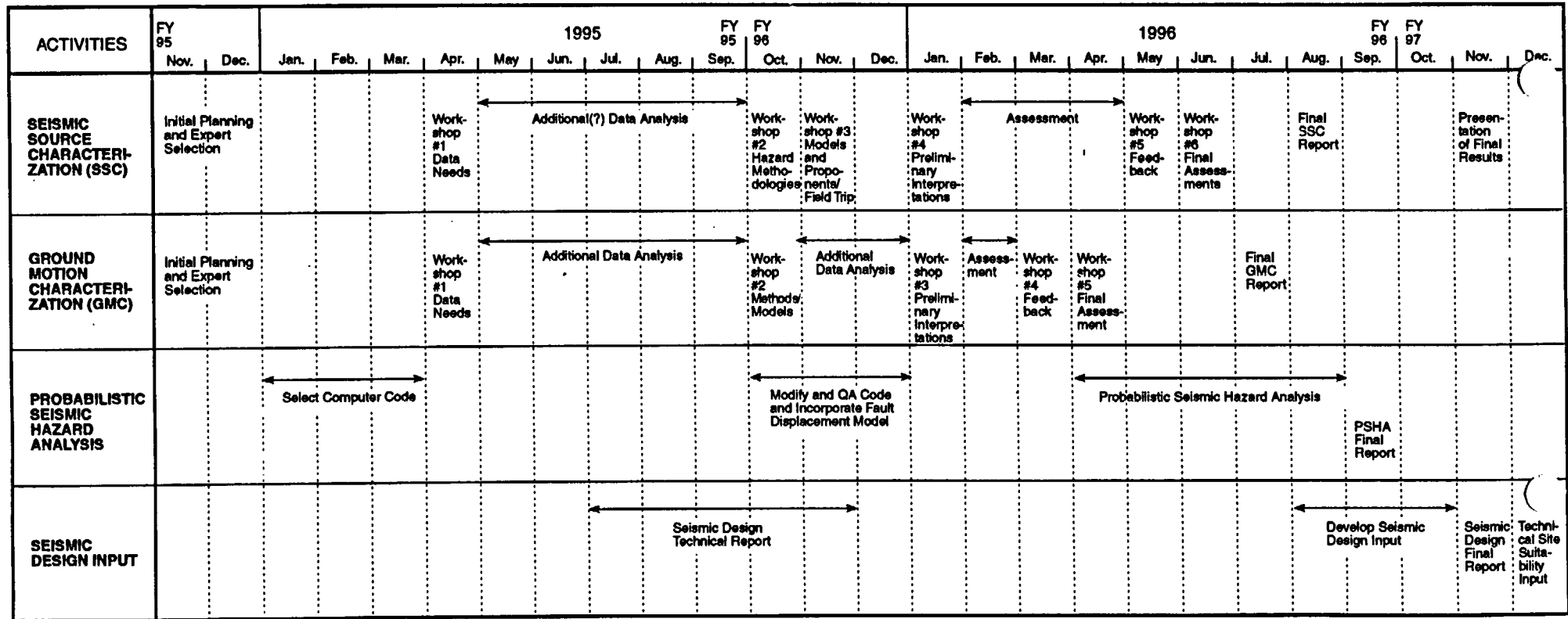


Figure 1