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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT (YMP) VOLCANISM
EXPERT JUDGMENT PROJECT (SCPB: 8.3.1.8.1.1)

A study to assess the probability of a future volcanic event disrupting the potential repository at Yucca Mountain, Nevada, termed the Probabilistic Volcanic Hazard Analysis (PVHA) project, is being sponsored by the U.S. Department of Energy. Geomatrix Consultants, Inc. has been given the responsibility of managing the PVHA project. This assessment, which is focused on the volcanic hazard at the site, expressed as the probability of disruption of the potential repository, will eventually provide input to an assessment of the volcanic risk, which expresses the probability of radionuclide release due to volcanic disruption. To ensure that a wide range of approaches are considered in the hazard analysis, judgments of members of an expert panel will be elicited. The results of the individual elicitations will be combined to develop an integrated assessment of the volcanic hazard that reflects the diversity of scientific interpretations. The enclosure provides a detailed description of the PVHA project and is currently being included in the latest revision to Study Plan 8.3.1.8.1.1, Probability of Magmatic Disruption of the Repository.

The PVHA project is centered around four workshops which will provide an opportunity for technical discussion and interaction, with an objective of ensuring a common understanding of the issues to be assessed and the data sets available to provide the technical basis for assessment. Workshops 1 through 3 are currently planned for February 22-23, March 30-31, and May 16-17, 1995, respectively. Workshop 4 has not been scheduled, but is planned for September or October 1995.

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The panel of experts participating in this study is composed of the following individuals:

Richard W. Carlson	Carnegie Institution of Washington
Bruce M. Crowe	Los Alamos National Laboratory
Wendall A. Duffield	U.S. Geological Survey
Richard V. Fisher	University of California at Santa Barbara (Emeritus)
William R. Hackett	WRH Associates
Mel A. Kuntz	U.S. Geological Survey
Alexander R. McBirney	University of Oregon (Emeritus)
Michael F. Sheridan	State University of New York at Buffalo
George A. Thompson	Stanford University
George P. L. Walker	University of Hawaii at Manoa

A broad search for candidates for the expert panel was conducted. Guidelines for selecting panel members required that individuals have a high professional stature and help provide a panel that is balanced to include experts with diverse opinions, areas of technical expertise, and institutional/organizational backgrounds. Panel members are expected to represent their individual judgments and not to act as representatives of technical positions taken by their organizations.

Chuck Connor of the Center for Nuclear Regulatory Waste Analyses was invited to participate as a member of the expert panel. We regret to learn that Mr. Connor cannot participate on the panel due to a conflict of interest. Mr. Connor's research experience in the Yucca Mountain region and the probabilistic models he has developed to evaluate volcanic hazards are important sources of data for the PVHA project. Another mechanism to obtain Mr. Connor's technical input to the PVHA project is to have him participate as a presenter and as an observer at the workshop. In this way, Mr. Connor can present his data and interpretations to the expert panel and be available to answer questions at the workshop. Specifically, we anticipate that Mr. Connor will give a talk of about one hour in length at Workshop 1 and possibly Workshop 2, describing the volcanic hazard approaches that he has developed and the types of data required to conduct the analyses.

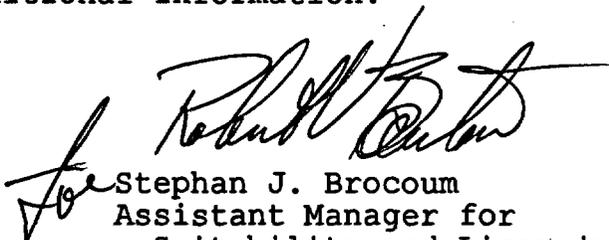
In preparation for that workshop, the Geomatrix staff would like to meet with Mr. Connor in Las Vegas, Nevada, to discuss the volcanic hazard approaches that he has developed, and if he is permitted to make a presentation at the workshop, to discuss the

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presentation. As part of the PVHA project, the Geomatrix staff has interviewed particular individuals with volcanic hazard experience to obtain insights into the hazard analysis approaches that the expert panel might wish to implement. Thus far, they have interviewed William Hackett and Richard Smith of Idaho National Engineering Laboratory, and Bruce M. Crowe of Los Alamos National Laboratory. As organizers of the PVHA project, it is essential that the Geomatrix staff fully understand Mr. Connor's hazard models as well. The meeting with Mr. Connor will allow discussion of the elements of his models and clarify the manner in which they should be implemented.

We will be happy to provide any additional information to the U.S. Nuclear Regulatory Commission about the PVHA project. All of the workshops and the informal meeting with Mr. Connor are open to the public. The YMP Affected Units of Government and other individuals have been invited to attend the four workshops as observers. The PVHA project has been specifically designed to minimize potential conflicts of interest: only the probability of disruption of the site due to future volcanism will be evaluated, not the suitability of the site; the panel members will be requested to provide their own technical interpretations and not act as representative of technical positions taken by their organizations; the judgments of the individual panel members will be documented; and consensus on the final product will not be sought.

Please contact Jeanne C. Nesbit at (702) 794-7930 if you have any questions or require additional information.



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Enclosure:
Appendix to Study
Plan 8.3.1.8.1.1

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PRELIMINARY DRAFT

**Appendix to
Study Plan 8.3.1.8.1.1
Probability of Magmatic Disruption of the Repository**

**The Use of Expert Judgment
for Volcanic Hazard Assessment**

ENCLOSURE

Appendix

THE USE OF EXPERT JUDGMENT FOR VOLCANIC HAZARD ASSESSMENT

1.0 INTRODUCTION

Study Plan 8.3.1.8.1.1 identifies the application of expert judgment to probabilistic volcanic hazard assessment for the proposed Yucca Mountain site. This appendix to the Study Plan describes the general procedures to be followed for the expert judgment process. A review of the available data pertaining to volcanic hazards, and the models used to make probability estimates and conduct simulation analyses, are described in Crowe et al. (1994).

Expert judgement of the confidence in, and adequacy of, the available data base and the models for assessing volcanic hazards is a necessary step toward achieving consensus on the volcanic hazards, and, ultimately, volcanic risk (consequences) at the site. Members of an expert panel, or specialists, will be asked to evaluate the uncertainty in the available data and apply appropriate models to assess the future volcanic hazards. A probabilistic approach will be used to completely describe the current state of knowledge, including all potential sources of uncertainty. All aspects of the expert judgment project will be conducted to ensure the highest level of independence and objectivity, including selection of an organization external to DOE to manage and conduct the project.

The three major goals for the use of expert judgment are as follows: 1) to review models for evaluating recurrence of volcanism to ensure that all appropriate models have been considered and properly represented; 2) to assign weights to the various models to arrive at representative cumulative probability distributions for probabilistic variables; 3) to evaluate all the appropriate variables for each model to ensure that the volcanic and tectonic processes active in the region are fully represented.

2.0 METHODOLOGY

In the study of any complex technical problem, expert judgment is used; however, this judgment is generally implicit and the basis for the judgments are undocumented. In recent years, formal studies have been conducted that explicitly include expert judgment by incorporating the judgments of multiple experts, and providing various levels of documentation of the reasoning on which the judgments are based. The process and procedures of obtaining and using expert judgments in complex technical problems have been significantly improved in the course of these studies, so that the accountability and defensibility of the analyses is high.

The use of expert judgment is a mechanism for quantifying and documenting scientific knowledge and bringing all available knowledge into the decision-making process. For certain analysis and design applications, the values of geotechnical parameters must be estimated. Since these parameters are often complex (varying with space and time) and the

available data base may be statistically limited, estimates of parameter values must incorporate subjective interpretations and judgments. Decision-makers do not rely on data alone, but on the interpretations of data. Data and expert judgment should not be considered interchangeable, since data must always be interpreted and it is the interpretation of data that results in scientific understanding. The degree of uncertainty in a body of data can be quantified, resulting in useful information for prioritizing future data collection efforts. Sensitivity studies can be performed to indicate parameters with the strongest influence on the outcome being assessed.

A formal process for conducting expert judgment elicitation can be divided into five basic steps, as follows:

- 1) selection of specialists
- 2) selection and refinement of issues
- 3) training for elicitation
- 4) elicitation
- 5) analysis and aggregation

Descriptions of each of these five steps, and their anticipated use in the assessment of volcanic hazard at Yucca Mountain, are described below. For the volcanic hazard assessment, a project team will be assembled to plan and conduct the expert elicitation process; this "Methodology Development" team will refine the procedures in the steps described below.

2.1 Selection of Specialists

Specialists that are widely recognized by their peers as experts in their particular field should be selected as members of an expert panel. A broad search for specialists should be conducted to emphasize the ranges of expertise relevant to the issues, and differences in interpretations. The selection of multiple specialists for a particular discipline, particularly individuals with strongly differing opinions, enhances the credibility of a panel. The optimum number of specialists selected for an expert panel is related to the complexity of the issues to be evaluated, and the importance of the parameters to be estimated.

Specialists selected to participate on the expert panel will be geologists with extensive experience relevant to assessment of volcanic hazards. It is anticipated that approximately 8 to 10 specialists will be needed to comprehensively cover the important issues. A list of potential panel members will be compiled by obtaining recommendations from organizations and individuals that are familiar with volcanic hazard assessments. Consideration will be given to each panel member's technical qualifications and to the ultimate composition and balance of the panel as a whole, in accordance with guidelines to be developed by the Methodology Development team. It is anticipated that these guidelines will include:

- 1) Geologist with good professional reputation and widely recognized competence based on academic training and relevant experience.

- 2) Experience collecting and analyzing research data for relevant studies in the southern Great Basin or similar regions; written documentation of these studies (e.g. in technical reports and refereed journals).
- 3) Availability and willingness to participate.
- 4) Panel balanced to contain specialists with diverse opinions, areas of technical expertise, and institutional/organizational backgrounds (e.g. from government agencies, academic institutions and private industry).

Prior familiarity with the data available for the Yucca Mountain site will be an asset, but not a requirement for participation. The specialists will be asked specifically to not act as representatives of technical positions taken by their organizations, but rather to provide their own technical interpretations and uncertainties.

2.2 Selection and Refinement of Issues

The purpose or goals of a project indicate the issues to be selected and assessed. The selected issues should be discussed and refined so that the events and quantities to be elicited are clearly defined. It is generally useful to decompose the events or quantities into smaller units (e.g., using logic tree format) that can be assigned discrete values, then these values can be combined mathematically.

Differences in assessments may arise from several sources, including:

- disagreement on the assumptions or definitions that underlie assessments
- judgments based on differing information sources
- disagreement on how to interpret available information
- different opinions or beliefs about the quantity of concern

To the greatest extent possible, differences in definitions and assumptions should be discussed and resolved at the beginning of a project. Careful definition of issues and sharing of data may lead toward consensus in interpretations. Differences in interpretations can arise from the failure to overcome assessment errors and biases (e.g., anchoring, overconfidence, etc.), which may be mitigated by training the specialists, as described below.

Alternative models for evaluating volcanic hazard at Yucca Mountain, including models presented by the State of Nevada and by the U.S. Nuclear Regulatory Commission and its contractors, have been reviewed by Crowe et al. (1994). These models, and the variables that must be considered for each model, will provide a starting point for the panel members. Each specialist, however, may identify their own significant variables, and develop their own models and inputs, as desired. Data and interpretations relevant to the basic issues will be presented and discussed in detail during workshops. The purpose of these discussions will be to ensure a common understanding of the issues being addressed and provide a forum for the discussion of alternative models and variables. Decomposition of the assessment issues, or structuring the analysis so that a series of simpler assessments can be made instead of one

complex assessment, will be a major objective of the discussions.

2.3 Training for Elicitation

Training specialists in elicitation methods, concepts of probability, and biases in probability assessments is an important part of expert judgment elicitation. For the volcanic hazard assessment, it is anticipated that a one-half to one-day training session will be held at an initial workshop. The training session will be conducted by an analyst, or normative expert, trained in subjective probability or decision analysis. The training will include an introduction to the elicitation and analysis methods (including the assessment process and documentation of probabilities), a discussion of probability and the techniques used in assessing probabilities (e.g., assessing probabilities for discrete events and for continuous events), complexities that affect probability assessment (e.g., unstated assumptions, motivational bias, and cognitive biases such as overconfidence and anchoring), and aggregation of probability assessments.

2.4 Elicitation of the Specialists

For the volcanic hazard assessment, it is anticipated that elicitations of the judgments of the specialists will be conducted in private, individual sessions. The sessions will be attended by an analyst and a generalist: the analyst will have the primary responsibility for leading the specialist through the assessment; the generalist will have the primary responsibility for ensuring that the technical reasoning or basis for each judgment is described and recorded in writing, and that all relevant technical issues are addressed. The format of the elicitations will follow the logic specified by the specialist. At each major step in the assessment, the specialist will be asked to provide the technical basis for the assessment being made, and to express the uncertainty in each assessment (e.g., as a range of discrete alternatives each having a relative weight, or by a cumulative probability distribution for continuous variables.) Following the elicitation, written documentation prepared by the generalist and analyst will be reviewed by the specialist. This review will help to ensure that the documentation properly reflected the judgments of the panelist. In addition, it will provide an opportunity for the specialist to revise any of the judgments made previously, and to fill any gaps identified during the documentation process.

2.5 Analysis and Aggregation

The results of the elicitations will be a range of judgments on the level on volcanic hazards at Yucca Mountain. These judgments will be in the form of individual probability distributions. The goal will be to aggregate the individual distributions assuming equal weights for all of the specialists; this process will preserve the uncertainties defined by each of the specialists.

After aggregations have been completed, each specialist will be provided with the important analyses and recompositions of the entire panel for review. The panel will convene at a workshop to discuss these results and their uncertainties. There will be an opportunity for each specialist to make revisions, and any changes made will be recorded and documented.

3.0 DOCUMENTATION

The results of the expert judgment elicitation to assess volcanic hazards will be fully documented and summarized in a report to DOE. Documentation will include: criteria used to select specialists and the qualifications of each of the specialists serving on the panel; summaries of each workshop or panel meeting; results of each of the individual elicitations, including the technical bases for each judgment; and the aggregated results and the range of uncertainty. All documentation will meet the requirements of OCRWM Quality Assurance Procedure 2.5, Peer Review.