U.S. Department of Energy
Office of Civilian Radioactive Waste Management

Probabilistic Volcanic Hazard Analysis (PVHA) for Yucca Mountain

Presented to:
Nuclear Waste Technical Review Board
Carson City, NV

Presented by:
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YUCCA MOUNTAIN PROJECT

PVHA for Yucca Mountain

- **Purpose of Talk: To provide an overview of the PVHA process and results**
  - **Expert elicitation process and rationale**
  - **Steps in PVHA**
  - **Examples of expert evaluations**
  - **Results and uncertainties**

Context and Rationale for PVHA

- **Purpose of Study: To develop a defensible assessment of the volcanic hazard at Yucca Mountain, with particular emphasis on the quantification of uncertainties.**
- **Rationale for Expert Elicitation:**
  - **Culmination of nearly 20 years of geologic investigations; strong basis for uncertainty quantification**
  - **Expert elicitation allows for quantitative assessment and incorporation of alternative models and parameter values**
  - **Elicitation process follows applicable guidance for explicitly incorporating expert judgment (e.g., NRC BTP)**
- **Product: Probability distribution of the annual frequency of intersection of a basaltic dike with the repository footprint.**
- **Application: Provides input to assessments of consequences of volcanic events**

Steps in PVHA

- Selecting expert panel members
- Identifying technical issues in workshops
  - Volcanic/geologic/geochronologic data
  - Volcanic hazard models
  - Temporal and spatial probability models
  - Preliminary interpretations
- Two field trips to review field relationships
- Individual elicitation interviews
- Feedback and finalization of evaluations
- Documentation of process and evaluations

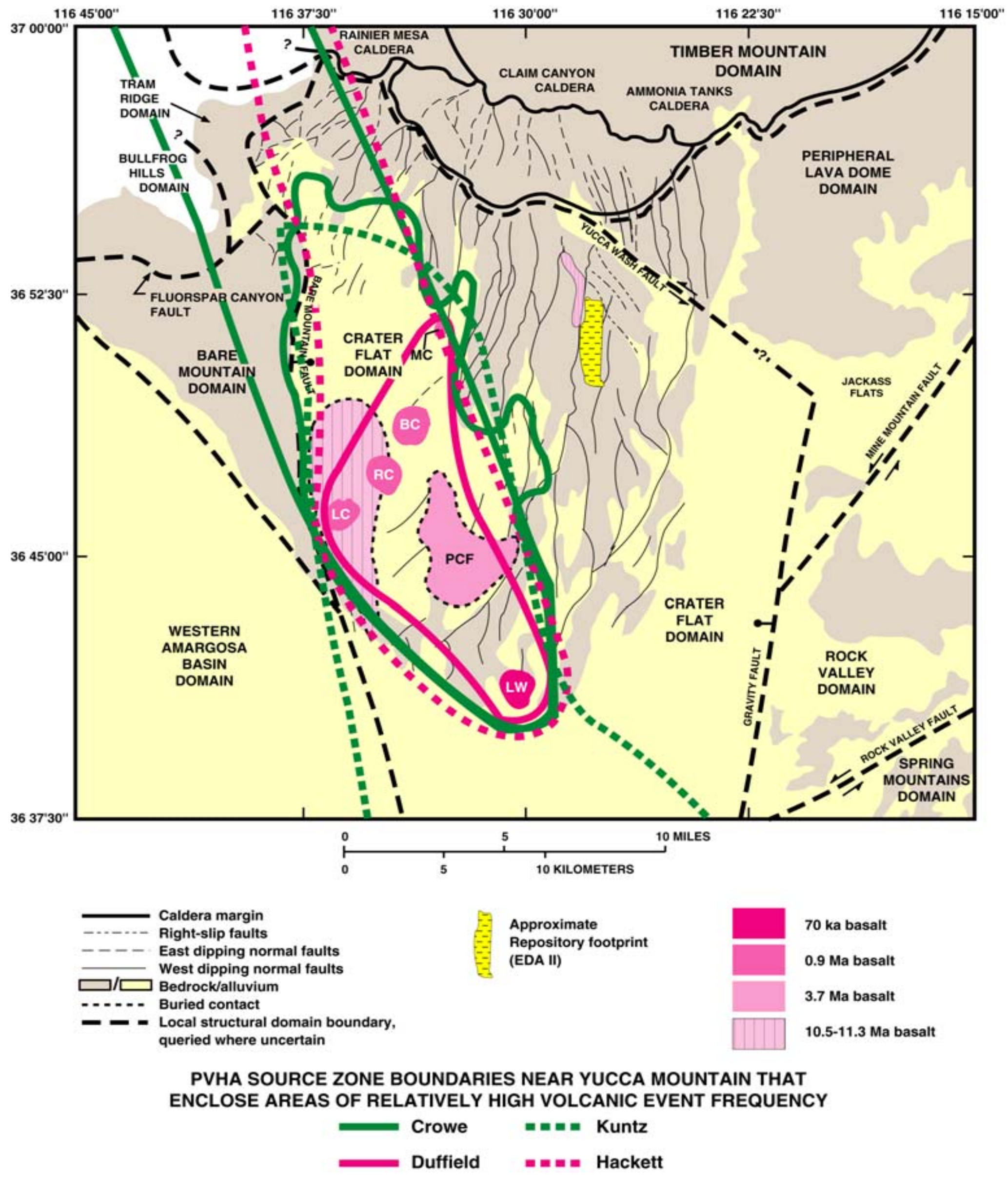
PVHA Expert Panel

Expert	Affiliation
Dr. Richard W. Carlson	Carnegie Institute of Washington
Dr. Bruce M. Crowe	Los Alamos National Laboratory
Dr. Wendell A. Duffield	USGS, Flagstaff
Dr. Richard V. Fisher	University of California, Santa Barbara
Dr. William R. Hackett	WRH Associates, Salt Lake City
Dr. Mel A. Kuntz	USGS, Denver
Dr. Alexander R. McBirney	University of Oregon
Dr. Michael F. Sheridan	State University of New York, Buffalo
Dr. George A. Thompson	Stanford University
Dr. George P. L. Walker	University of Hawaii, Honolulu

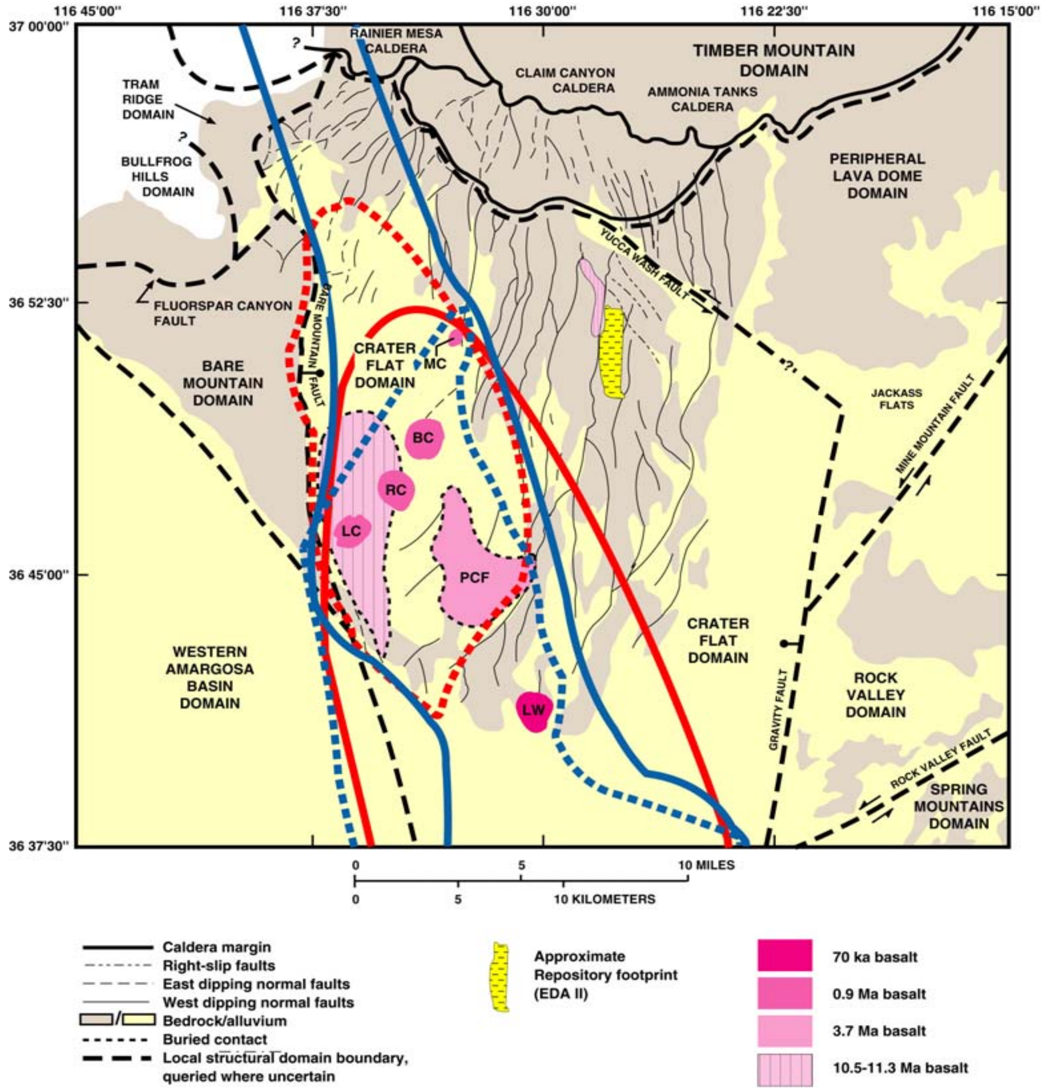
Examples of Temporal and Spatial Probability Models

- **Temporal Models**
  - **Homogeneous Poisson models**
  - **Nonhomogeneous models: volume-predictable, waxing or waning**
- **Spatial Models**
  - **Homogeneous**
    - **Locally homogeneous “source zones” defined by observed volcanoes, structural control, geochemical affinities, tectonic provinces, etc.**
  - **Nonhomogeneous**
    - **Parametric: bivariate Gaussian distribution for field**
    - **Nonparametric: kernel density function and smoothing operator**

Examples of Volcanic Source Zones from PVHA



Examples of Volcanic Source Zones from PVHA



PVHA SOURCE ZONE BOUNDARIES NEAR YUCCA MOUNTAIN THAT ENCLOSE AREAS OF RELATIVELY HIGH VOLCANIC EVENT FREQUENCY

Fisher | McBirney
Walker | Thompson

Logic Tree Structure to Characterize Uncertainty in Volcanic Hazard

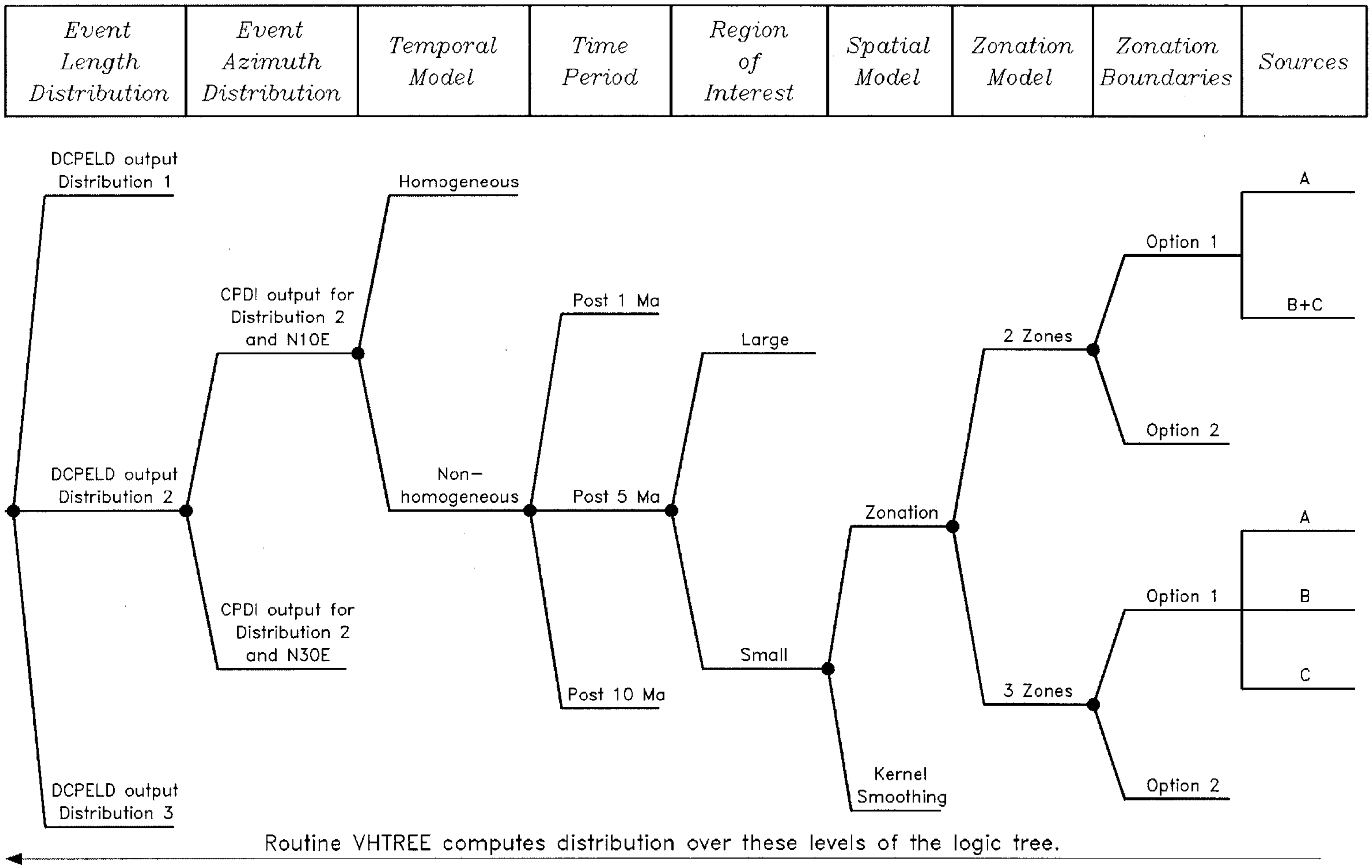
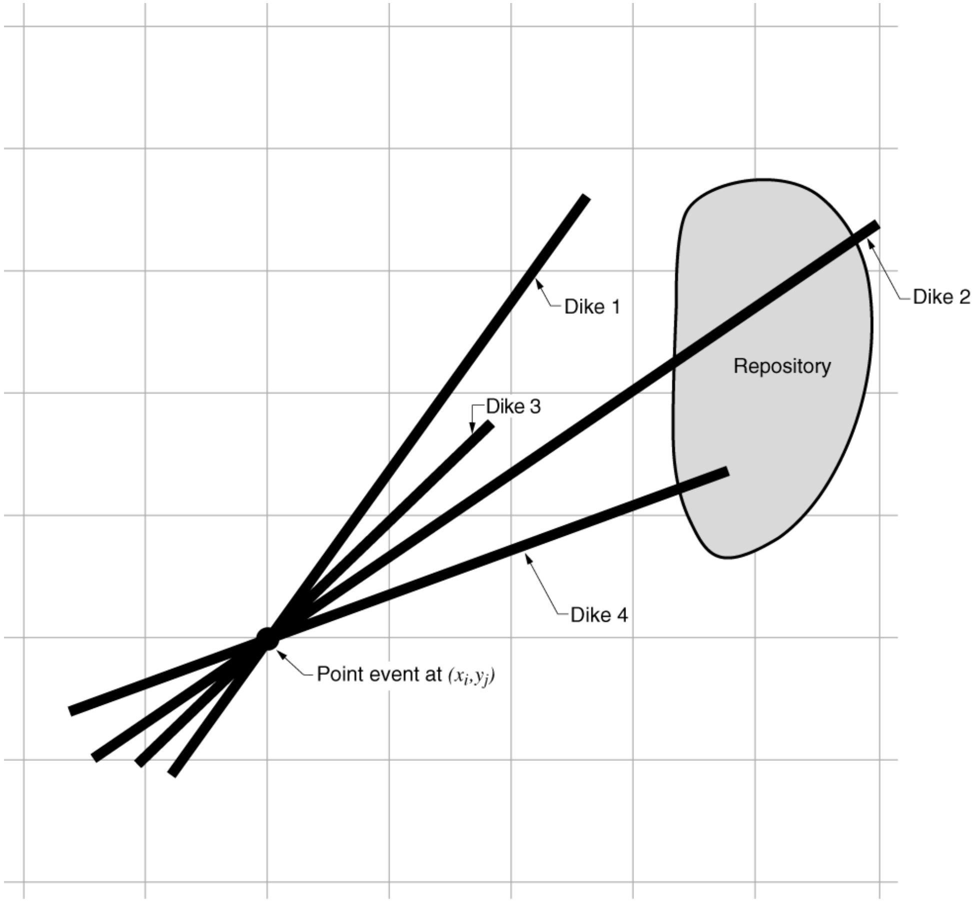


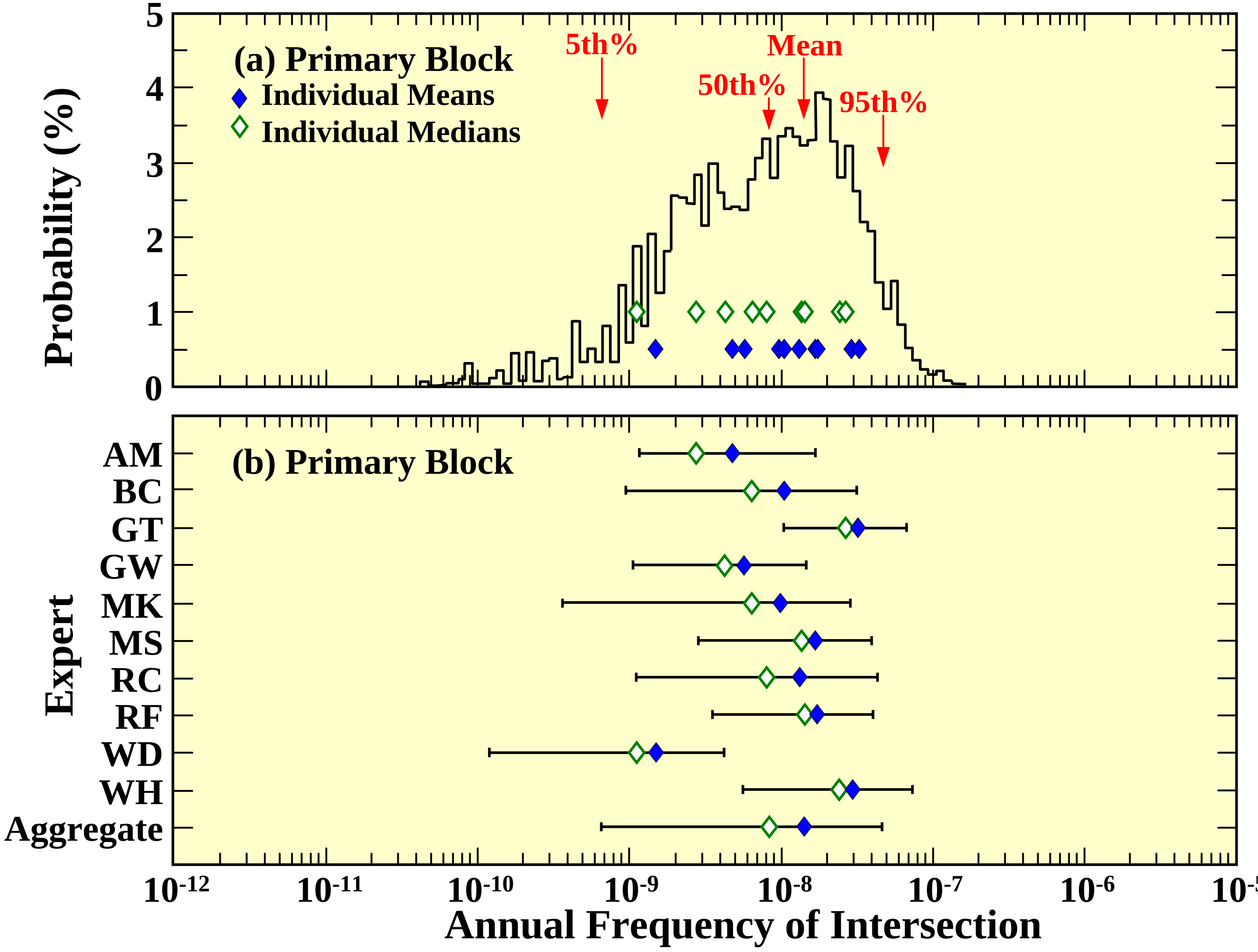
Illustration of Procedure for Computing Frequency of Intersection



Outputs of PVHA

- **Probability distributions of annual frequency of intersection of repository footprint by a dike**
- **Conditional joint probability distributions for length and azimuth of an intersecting dike, and number of eruptive centers within the repository footprint (AMR output)**
- **Conditional marginal distributions for length of intersecting dike within footprint (AMR output)**

Annual Frequency of Dike Intersection from PVHA



Conclusions

- **PVHA conducted to assess the volcanic hazard, with particular focus on quantifying uncertainties**
- **PVHA process followed all applicable guidance for formal expert elicitations**
- **Full range of temporal and spatial probability models used to characterize future volcanic occurrences**
- **PVHA/AMR outputs provide hazard frequencies and event descriptions that serve as inputs to consequence models**

Backup

Published Estimates of Probability of Intersection by a Volcanic Event

Reference	Intersection Probability (per year)	Comment	Event Representation
Crowe et al. (1982), pp. 184-185	$3.3 \cdot 10^{-10}$ – $4.7 \cdot 10^{-8}$		point
Crowe et al. (1993), p. 188	$2.6 \cdot 10^{-8}$	Median value of probability distribution	point
Connor and Hill (1995), pp. 10,121	$1–5 \cdot 10^{-8}$	Range of 3 alternative models	point
Crowe et al. (1995), Table 7.22	$1.8 \cdot 10^{-8}$	Median value of 22 alternative probability models	point
Ho and Smith (1998), pp. 507-508	(1) $1.5 \cdot 10^{-8}$ (2) $1.09 \cdot 10^{-8}$, $2.83 \cdot 10^{-8}$ (3) $3.14 \cdot 10^{-7}$	3 alternative models; 3rd model assumes a spatial intersection ratio (using a Bayesian prior) of 8/75 or 0.11, approximately one order of magnitude higher than other published estimates, because volcanic events are assumed to occur within a small zone enclosing Yucca Mountain	point
CRWMS M&O (1998c), Chapter 6, p. 6-84	$2.5 \cdot 10^{-8}$	Sensitivity analysis that conservatively assumes all aeromagnetic anomalies in Amargosa Valley are Quaternary age	point
Reamer (1999) pp. 61, 131, Figs. 29, 30	10^{-8}–10^{-7}	Value of 10^{-7} assumes event length of 20 km and that crustal density variations contribute to event location.	line