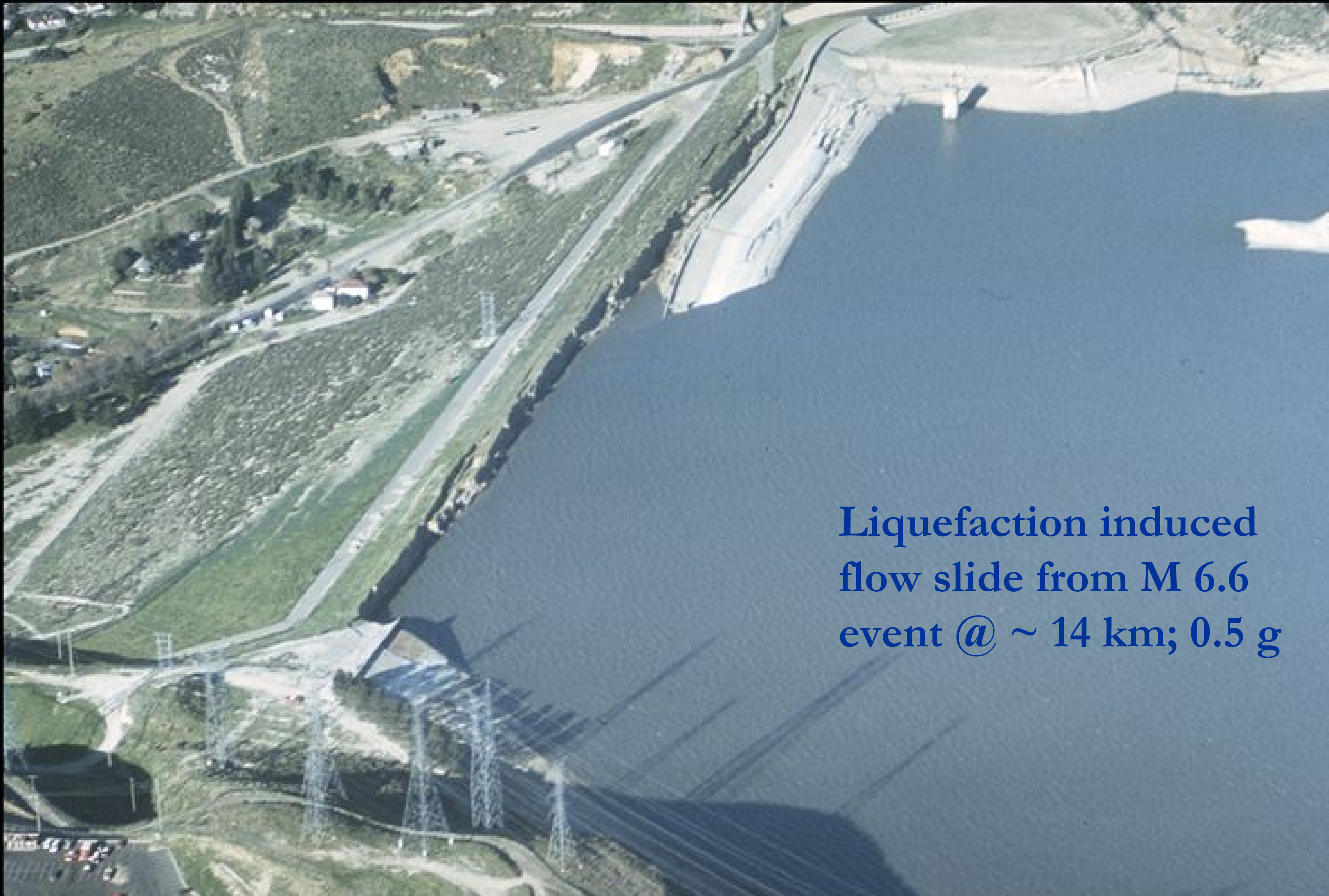
Probabilistic Seismic Hazard Assessment

Seismic Failure Modes

- Sliding failure through weak lift line
- Horizontal cracking
- Liquefaction of dam or foundation
- Cracking from severe shaking
- Surface fault displacement through the foundation
- Overtopping from landslide failure into reservoir


Liquefaction induced
flow slide from M 6.6
event @ ~ 14 km; 0.5 g

Fault surface rupture –
Chelongpu fault
M 7.6 Chi-Chi
earthquake, Taiwan

PSHA

"Probabilistic seismic hazard analysis **(PSHA)** is a methodology that estimates the likelihood that various levels of earthquake-caused ground motions will be exceeded at a given location in a given future time period. The results of such an analysis are expressed as estimated probabilities per year or estimated annual frequencies."

Senior Seismic Hazard Analysis Committee **(SSHAC)**

PSHA

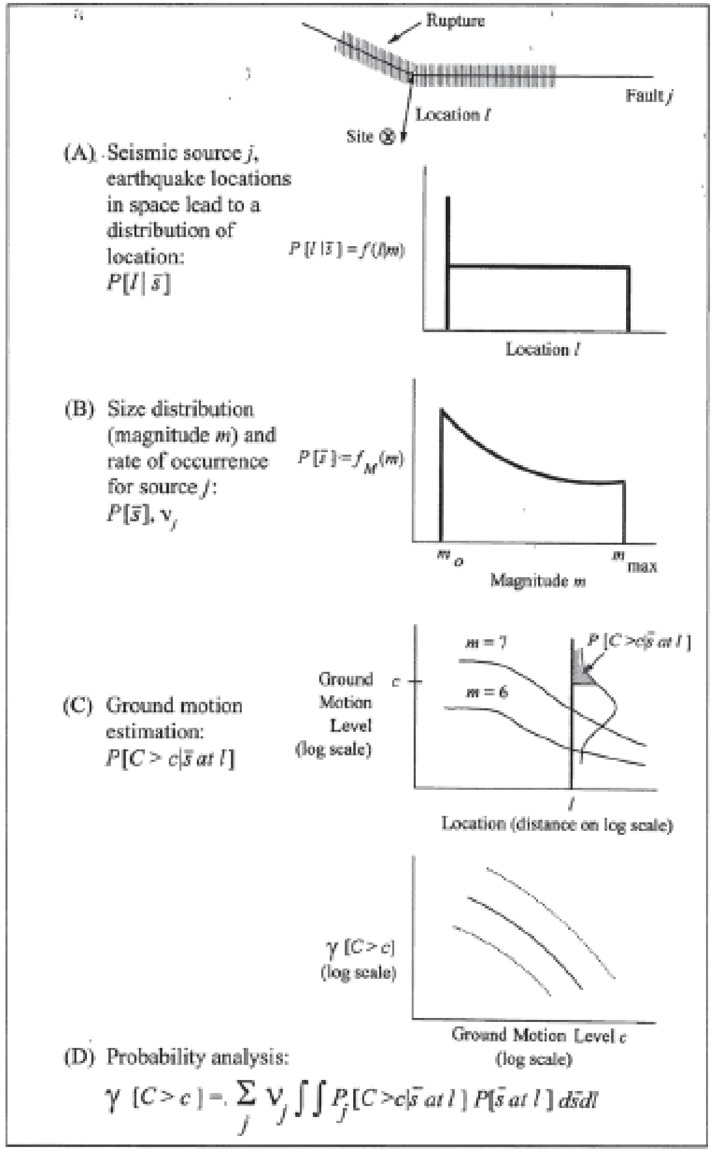
"While there is considerable information on earthquake ground motions and potential future locations of earthquakes, there is also considerable uncertainty in the inputs to the analysis."

PSHA

"Recognizing the need to identify and address these uncertainties as part of a PSHA, the Senior Seismic Hazard Analysis Committee (SSHAC, 1997) established the goal for all PSHA's to quantitatively assess these uncertainties and to represent the distribution of the informed technical community of alternative models and parameter values."

PSHA

- Considers the contribution from all potential sources of earthquake shaking collectively
- Considers the likelihood of those events
- Uncertainty is treated explicitly
- Annual probability of exceeding specified ground motions is computed



Source: McGuire, 2004

	Project No. 22238854	THE STEPS IN PERFORMING A PSHA	Figure 2-1
	Mid-Columbia Dams PSHA		

Basic Components of a PSHA & All Seismic Hazard Analyses

I Seismic source characterization

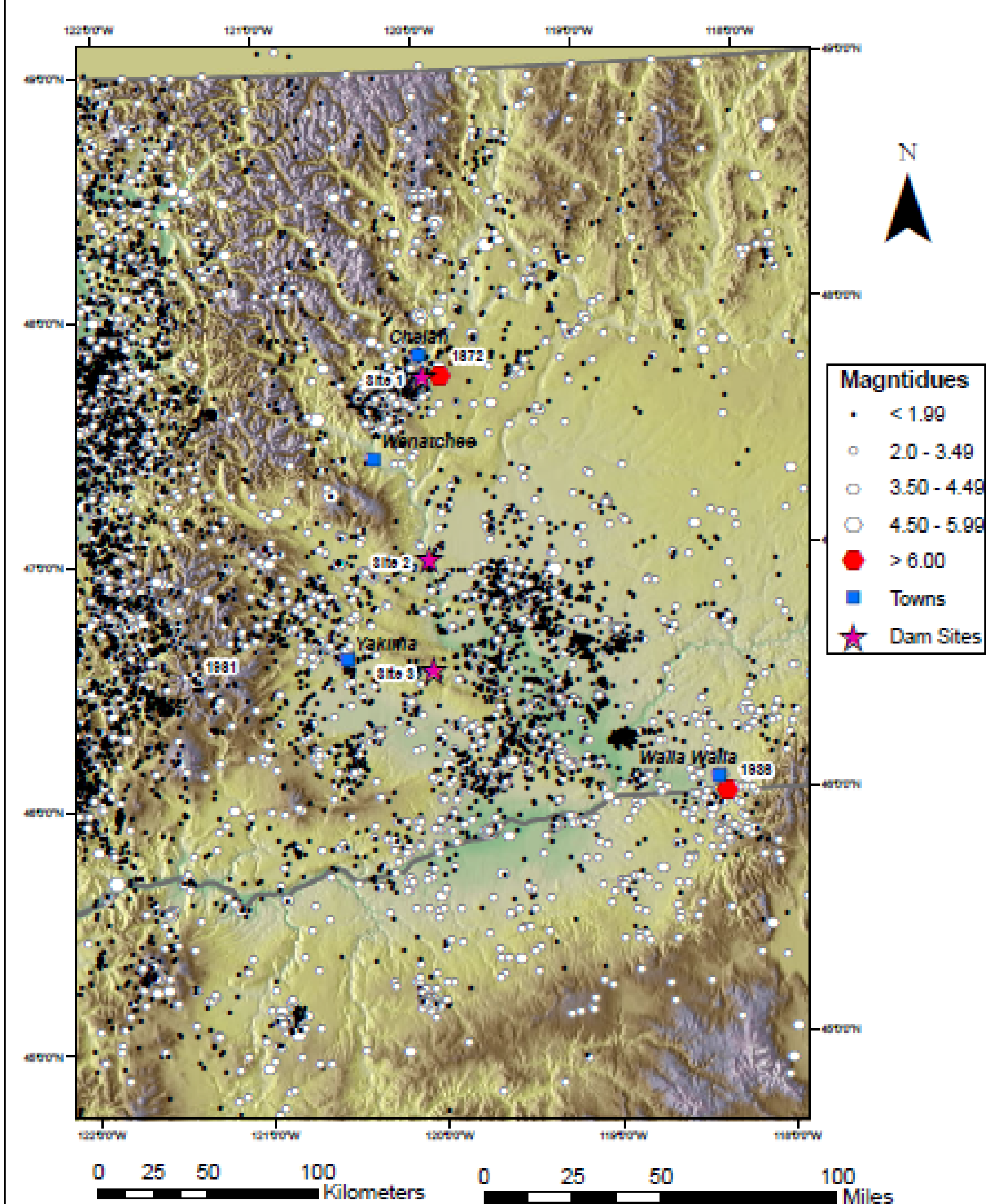
II Development of hazard curves

III Development of uniform hazard spectra (UHS)

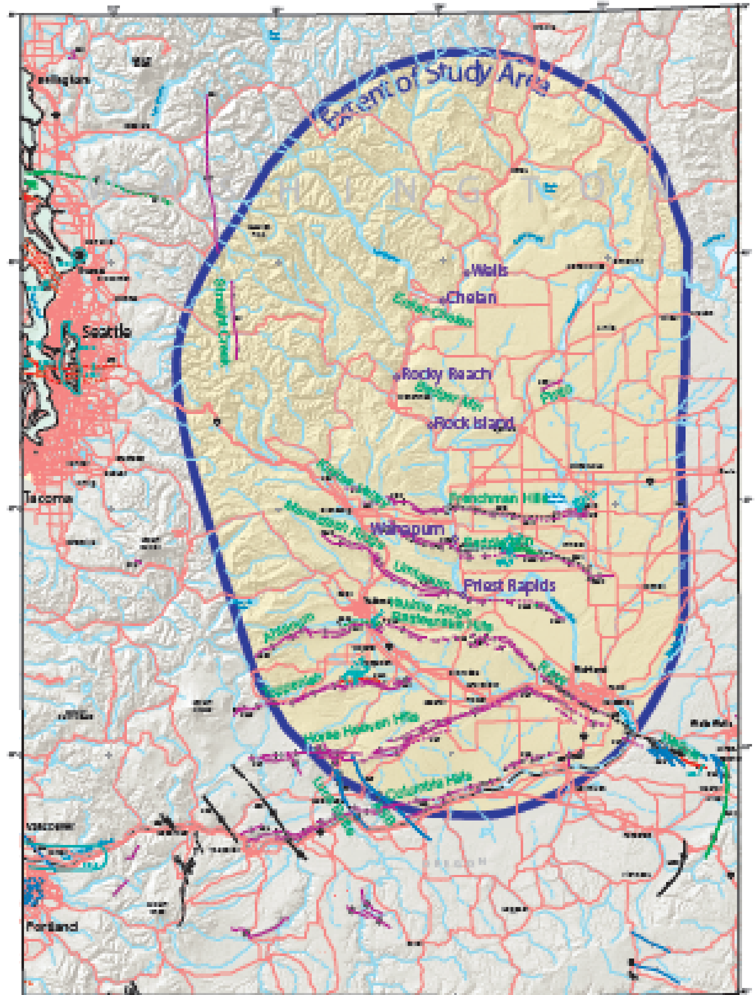
IV Development of acceleration time histories

SEISMIC SOURCE CHARACTERIZATION

- Known faults
- Areal or Background sources (i.e., random seismicity)



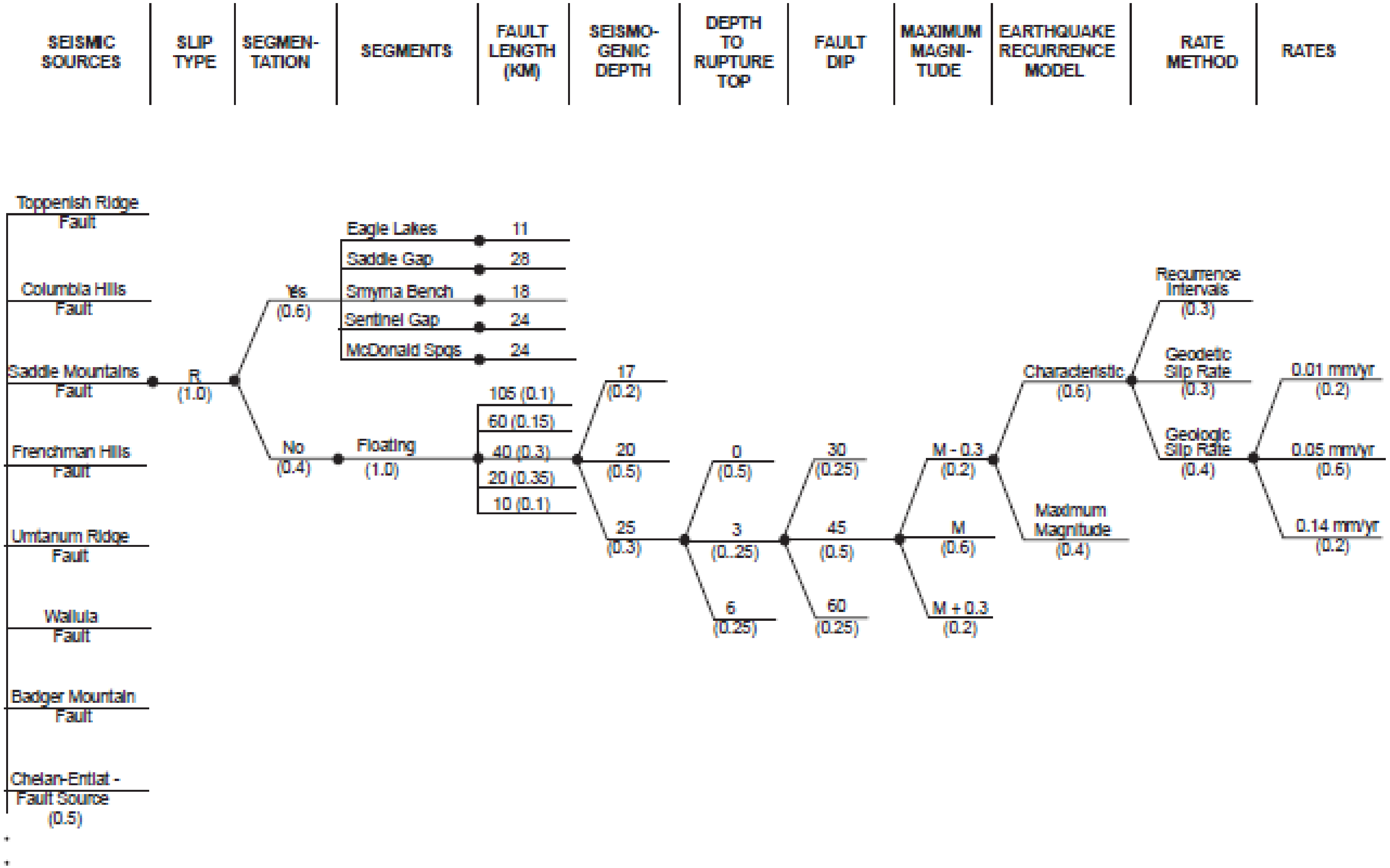
Project No. 22238854	HISTORICAL SEISMICITY OF SOUTH-CENTRAL WASHINGTON AND NORTH- CENTRAL OREGON, 1841-2010	Figure
Mid Colombia Dams PSHA		1-2



Modified from Lidke, et al., 2003

• Dam/Hydro site

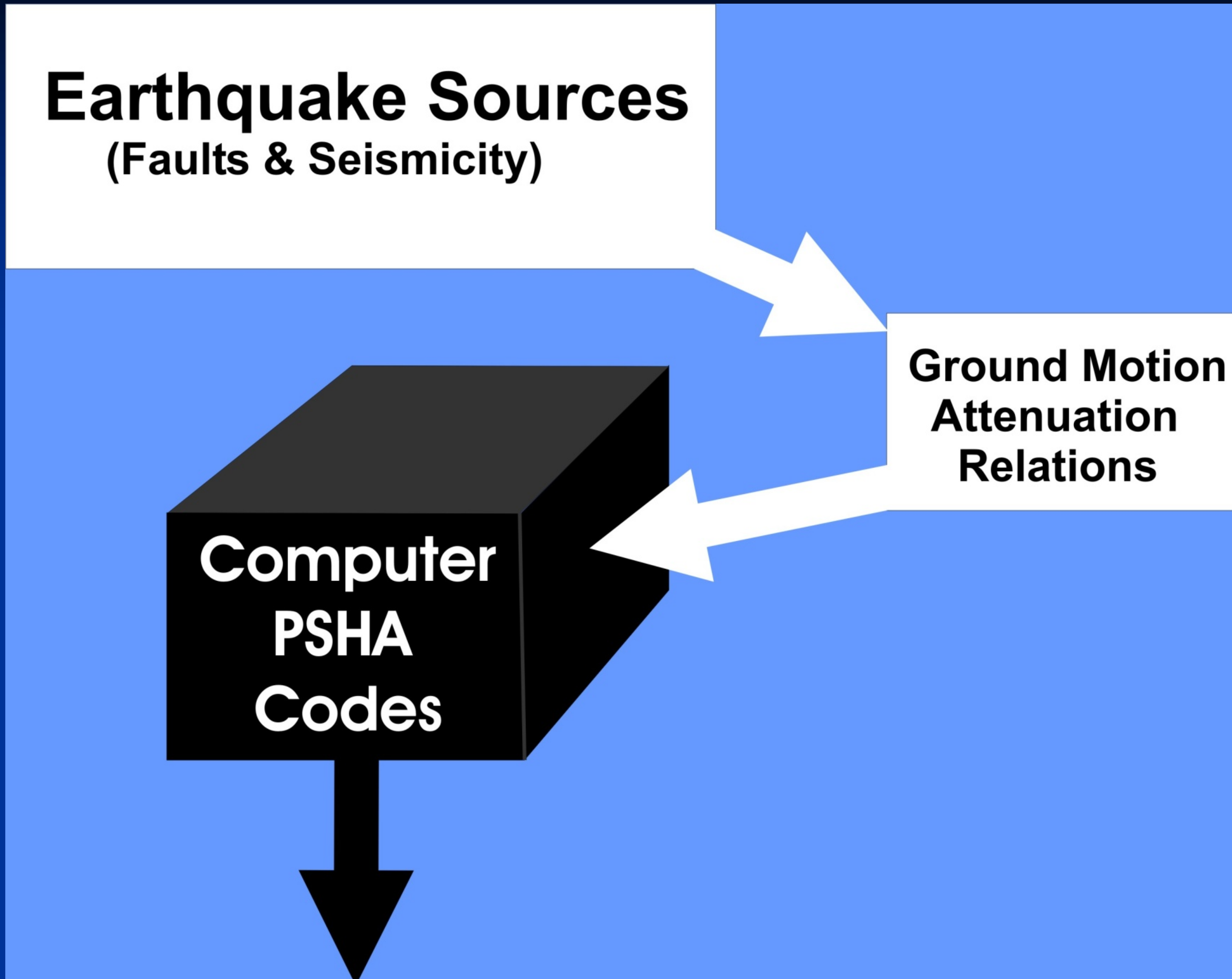
Project No. 22238854	PRELIMINARY MAP OF ACTIVE AND POTENTIALLY ACTIVE FAULTS, CENTRAL WASHINGTON	Figure 1-1
Mid-Columbia Dams PSHA		



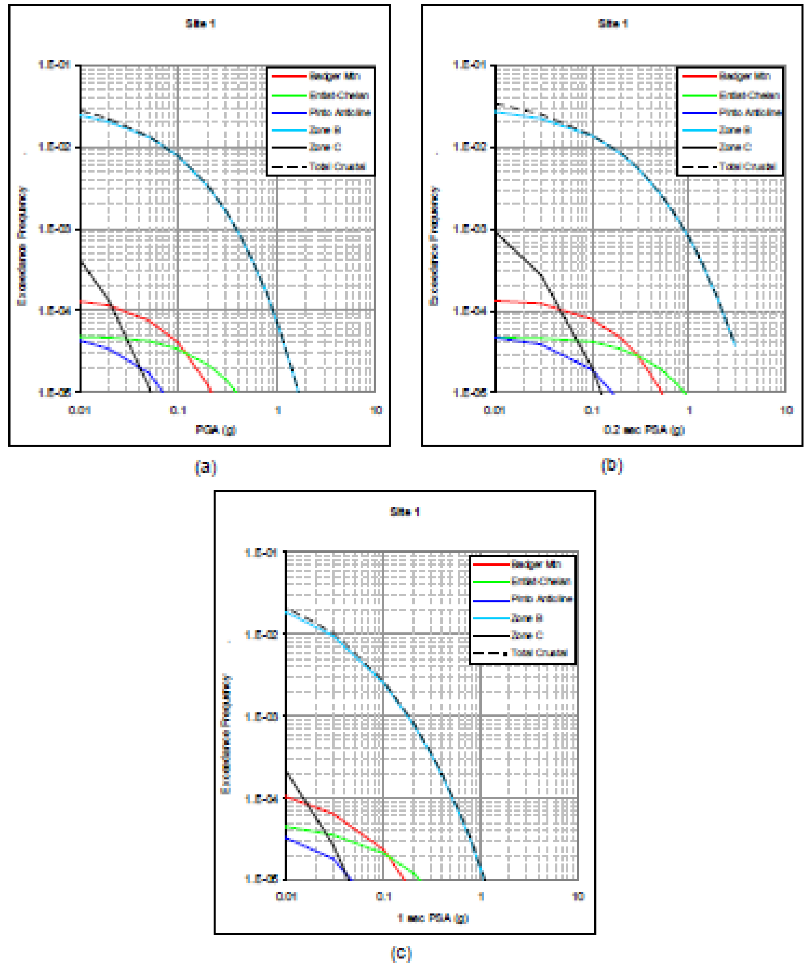
Project No. 22238854 Mid-Columbia Dams PSHA	GENERALIZED SEISMIC SOURCE MODEL LOGIC TREE	Figure 2-2

SEISMIC HAZARD CURVES

- Produced from several available computer codes
- Incorporate uncertainties in slip rate, magnitude, faults lengths
- Use ground motion attenuation relationships that relate PGA and SA to distance between source and site and earthquake magnitude - **NGA** Next Generation Attenuation models
- Site conditions very important; i.e., “soil” versus “rock”


Earthquake Sources
(Faults & Seismicity)
Ground Motion Attenuation Relations
Computer PSHA Codes

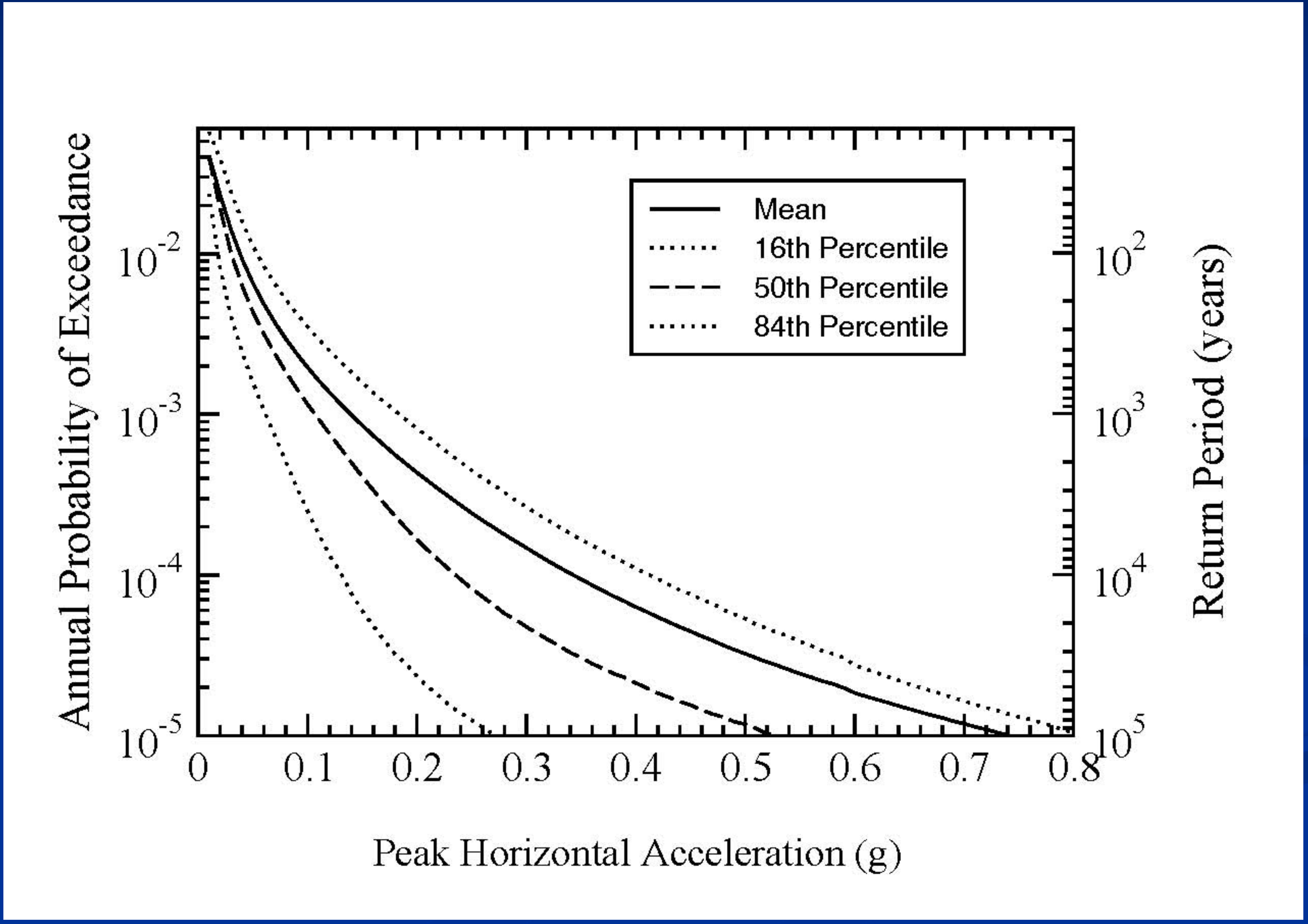
Mean Hazard Curves by Source



(a) (b) (c)

DRAFT	Project No. 22238854 Mid-Columbia Dams PSHA	SEISMIC HAZARD RESULTS FOR SITE 1 FOR INDIVIDUAL FAULTS AND SEISMIC SOURCE ZONES FOR (a) PGA, (b) 0.2 SEC SA, AND (c) 1.0 SEC SA	Figure 6-4

Mean & Fractile Curves for PHA



Site Response

- Period of structure-

  Concrete (sensitive to short period, 0.2-0.4-sec SA) verses Embankment (sensitive to long period, 1-sec SA)

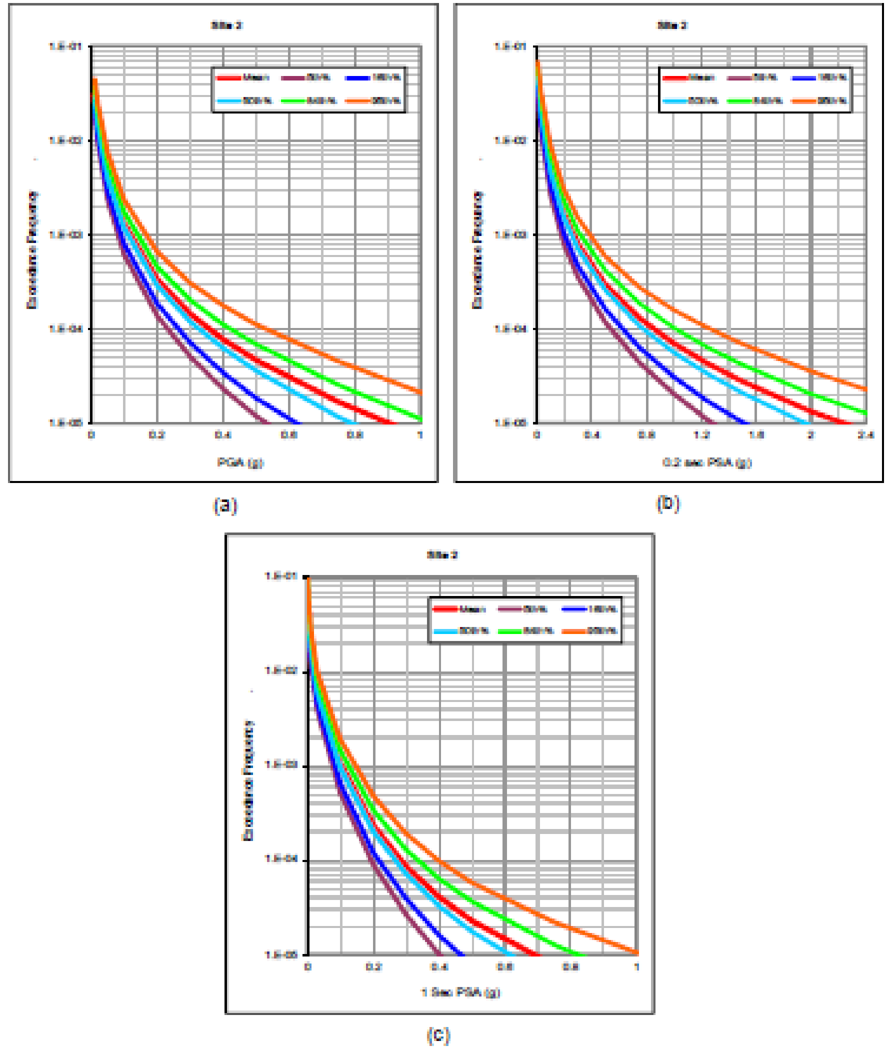
- Site conditions-

  Soil verses rock

- Shear wave velocity (V_S30) – Shear wave velocity in upper 100 ft - Important, because most NGA relationships now incorporate this)

UNIFORM HAZARD SPECTRA

Uniform hazard spectra (UHS) are computed or developed from the seismic hazard curves. This is done by developing hazard curves (i.e. spectral acceleration vs. exceedance probability) for several vibration periods to define the response spectra. Then, for a given exceedance probability or return period, the ordinates are taken from the hazard curves for each spectral acceleration, and an "equal hazard" response spectrum is generated.

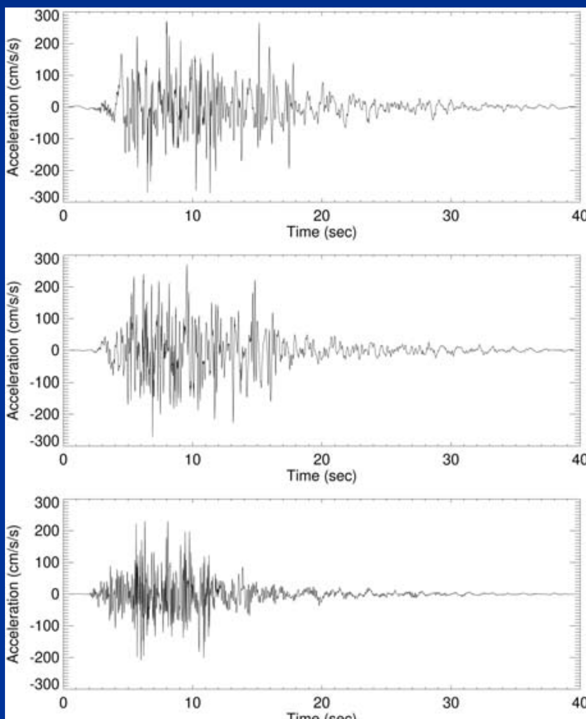


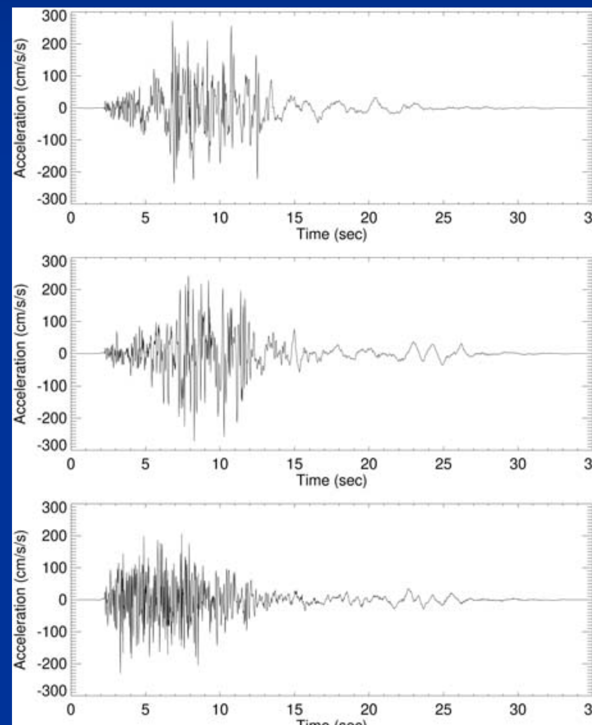
DRAFT	Project No. 22238854 Mid-Columbia Dams PSHA	SEISMIC HAZARD RESULTS FOR SITE 2 FOR (a) PGA, (b) 0.2 SEC SA, AND (c) 1.0 SEC SA	Figure 6-12

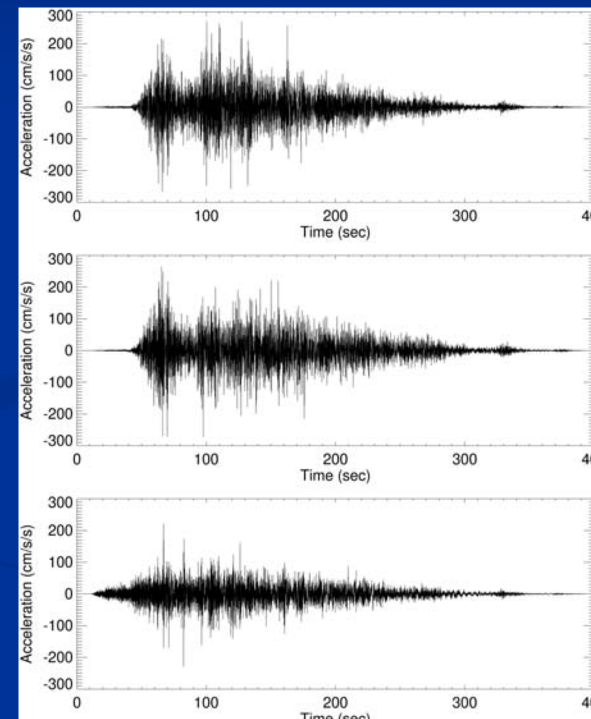
TIME HISTORIES

- For higher level studies, accelerograms, or acceleration time histories, are developed for the site that represents the seismic hazard at the return periods of interest.
- The suites of motions at each return period are usually selected to span the likely variability in spectra responses at different periods, and to account for differences in distance, magnitude, and site conditions. The selected ground motions are then used for dynamic analyses using programs such *FLAC*, *SHAKE*, or *LS-DYNA*

Time Histories (10K) Scaled to Mean UHS

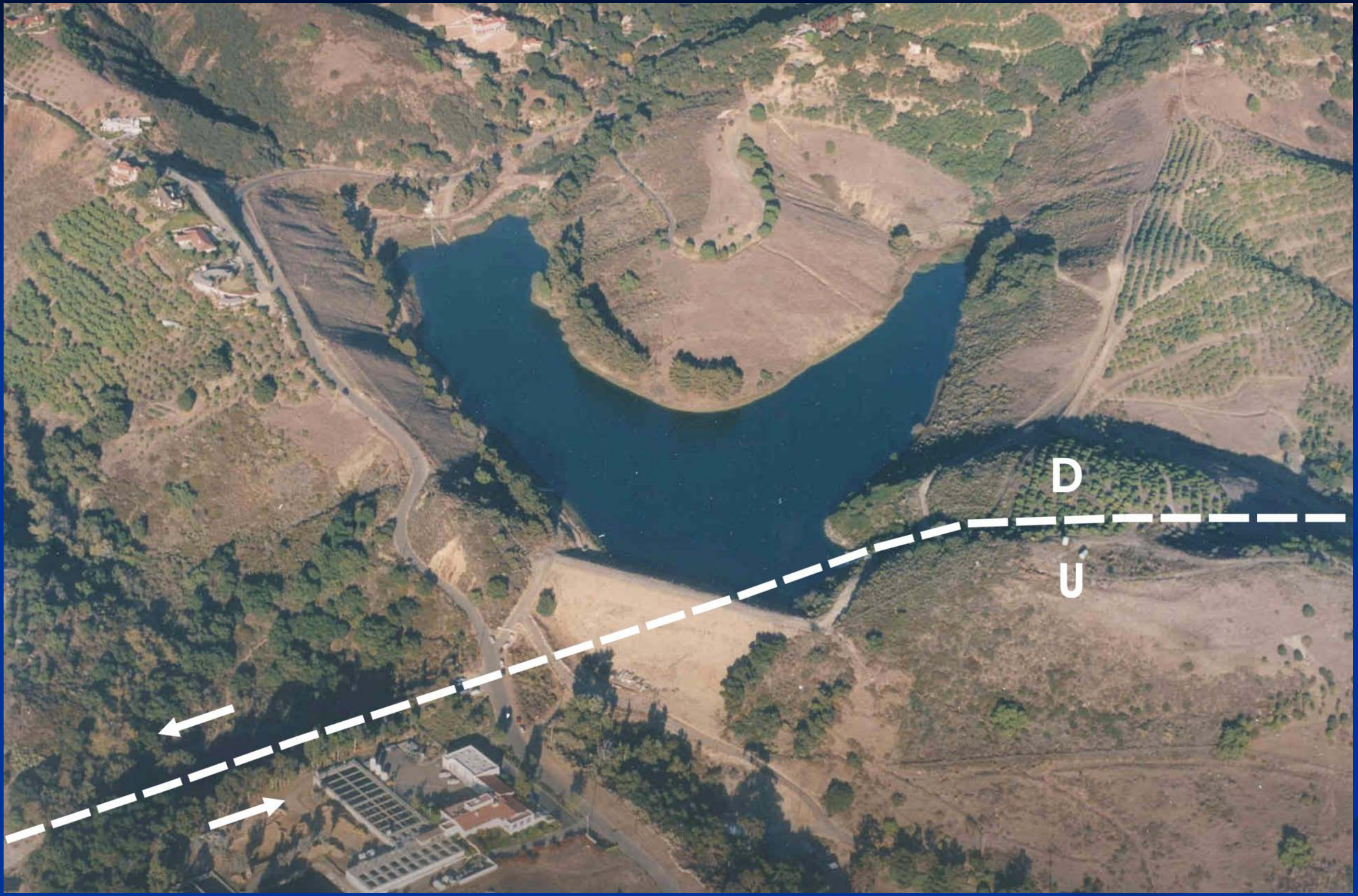






Fault Displacement Hazard Analysis (PFDHA)

- Some sites it may be a major concern (i.e., Lauro & Terminal Dams, CA; Helena Valley Dam, MT)
- Hazards calculations are analogous to probabilistic ground motion methodology
- Methodology originally set forth by Stepp and others (2001) for Yucca Mtn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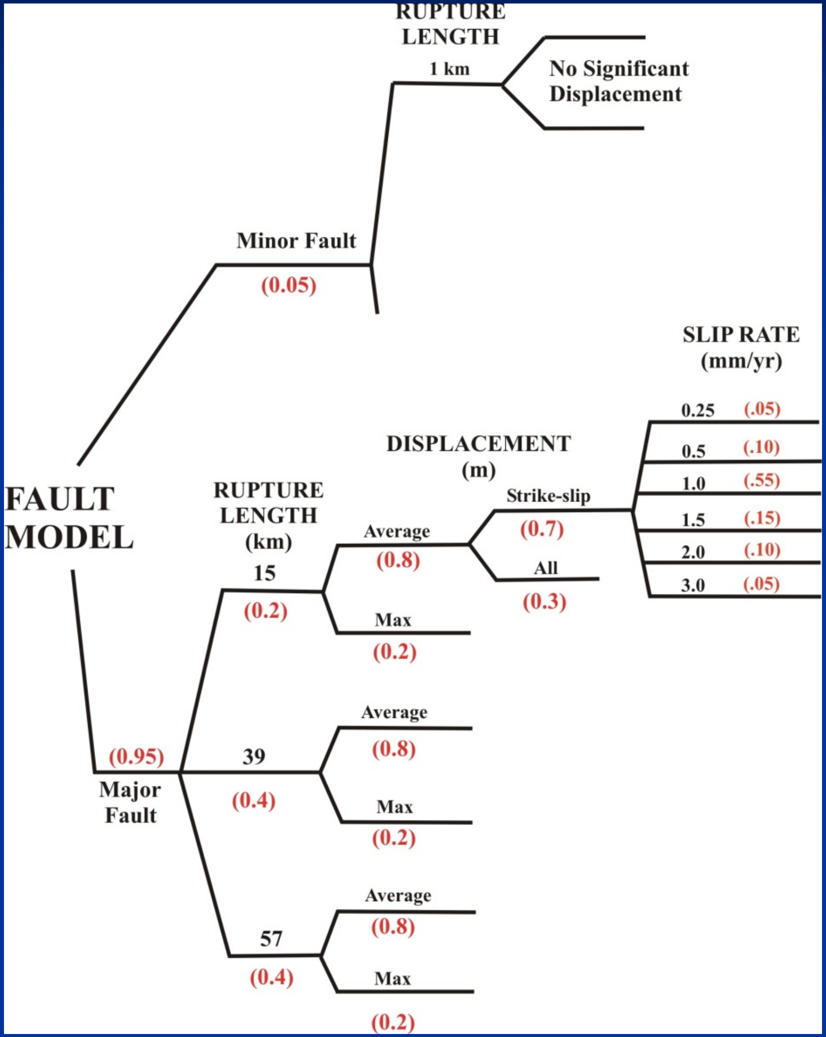
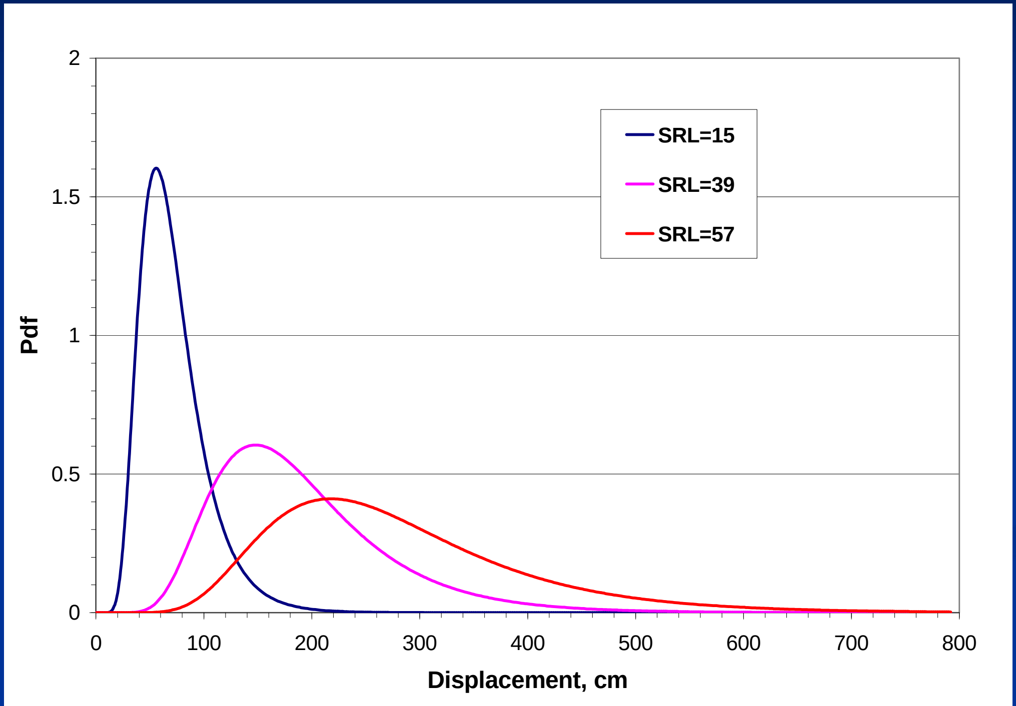
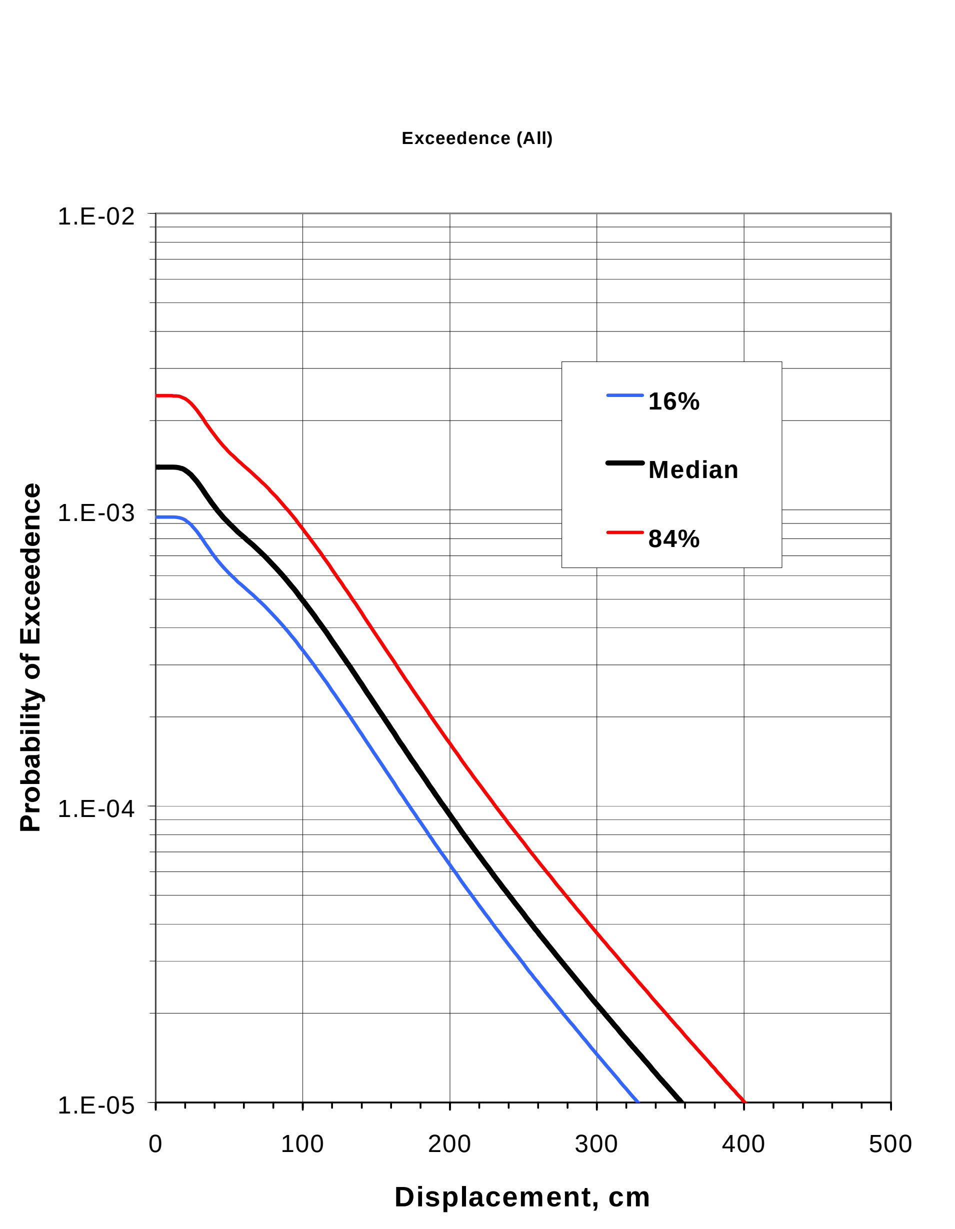
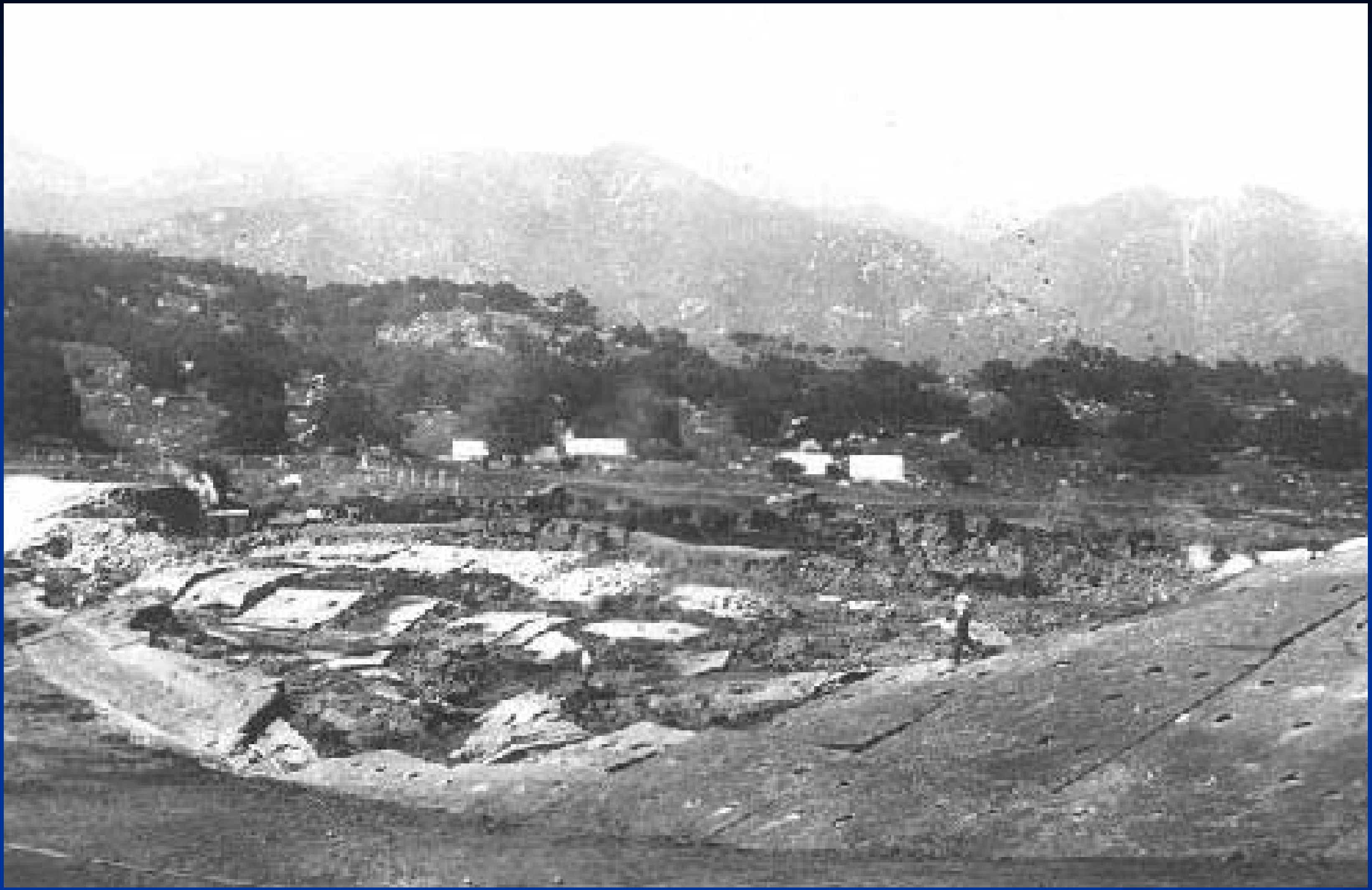
Lauro Dam
Fault Investigations

Rupture Length vs Displacement






Exceedence (All)
Probability of Exceedence
1.E-02
1.E-03
1.E-04
1.E-05
0
100
200
300
400
500
Displacement, cm
16%
Median
84%



Sheffield Dam - 1925

QUESTIONS?