

U.S. DEPARTMENT OF ENERGY  
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

**NUCLEAR WASTE TECHNICAL REVIEW BOARD  
PANEL ON STRUCTURAL GEOLOGY & GEOENGINEERING**

**SUBJECT: SITE CHARACTERIZATION  
AT YUCCA MOUNTAIN AND  
ISSUES RELATED TO SEISMIC  
VULNERABILITY**

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# Scope of Presentation

- **Identify site characterization concerns derived from seismic vulnerability concerns**
- **Discuss how site characterization activities address seismic vulnerability concerns**

**Preclosure  
Postclosure**

**Surface  
Underground**

# Concerns

## Fault displacement

- **Surface facilities**
  - **Preclosure - Release from WHB**
- **Underground**
  - **Preclosure - Retrieval option**
  - **Postclosure - Release from waste container**

## Ground motion

- **Surface facilities**
  - **Preclosure - Release from WHB**
- **Underground**
  - **Preclosure - Retrieval option**
  - **Postclosure - Release from waste container**

# **Fault Displacement - Surface Facilities (FITS)**

- **Preliminary seismic vulnerability assessment**
  - **Reasonably Available Technology allows for design to accommodate small displacements (e.g., differential settlement)**
  - **Current WHB design will accommodate a few inches of displacement**
  - **Amount of future displacement along a new or unrecognized fault is thought to be small (accommodated by design)**
- **Strategy**
  - **Detect and avoid fault locations**
  - **Design to accommodate any residual uncertainties**

# Design for Local Fault Rupture

- **Issues**
  - Displacement
  - Strength
  - Limiting force
  - Effect of embedment

- **Estimated level of resistance**
  - Vertical 1.0 to 2.5 inches
  - Horizontal 5 to 15 inches

- **Mitigative measures**

# **Fault Displacement - Surface Facilities (FITS)**

- **Where are the active faults, and what is the expected displacement along them during the preclosure period?**
- **Data to address seismic vulnerability concerns:**
  - **Detection**
  - **Displacement**
  - **Tectonic framework**

# **Fault Displacement - Surface Facilities (FITS)**

- **Site Characterization Plan studies and activities**
  - **Quaternary geologic mapping**
  - **Paleoseismic studies**
  - **Geophysical studies**
  - **Tectonic model studies**

**Figure Showing Midway Valley  
Trenching Plans**



# Fault Displacement - Underground

- **Preliminary seismic vulnerability assessment**
  - The most vulnerable areas are those where faults intersect an underground opening
  - Reasonably Available Technology allows design of tunnels to accommodate some fault displacement
- **Strategy**
  - Avoid significant faults in siting waste containers
  - Provide appropriate design of access ramps and tunnels to maintain retrieval option
  - Emplacement design to accommodate residual uncertainties

# Fault Displacement - Underground

- **Where are the active faults, and what is the expected displacement along them during the preclosure and postclosure period?**
- **Data to address seismic vulnerability concerns:**
  - **Detection**
  - **Displacement**
  - **Tectonic framework**

# **Fault Displacement - Underground**

- **Site Characterization Plan studies and activities**
  - **Quaternary geologic mapping**
  - **Paleoseismic studies**
  - **ESF studies of faults, fractures and rock characteristics**
  - **Borehole studies**
  - **Geophysical studies**
  - **Tectonic model studies**

# Vibratory Ground Motion - Surface Facilities

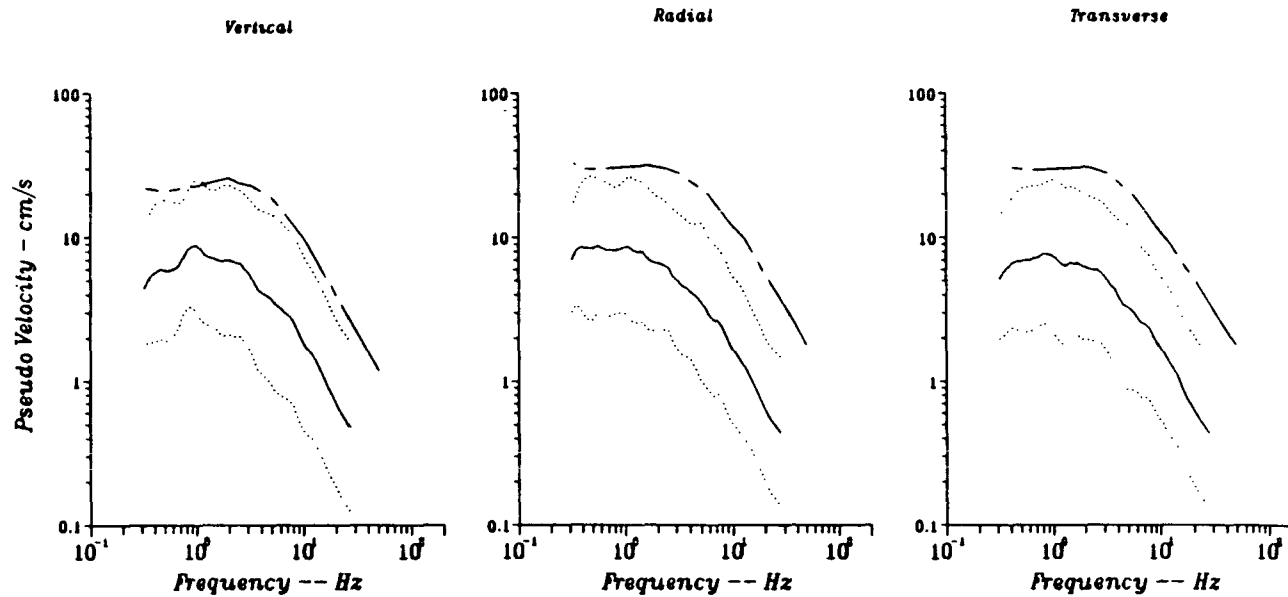
- **Preliminary seismic vulnerability assessment**
  - Design basis earthquake probably has a magnitude between 6-1/4 and 7-1/4
  - Earthquake ground motion spectra adequately envelope those from UNE's
  - Reasonably Available Technology allows design for potential range of ground motions
- **Strategy**
  - Determine appropriate seismic design basis for surface facility

# Earthquake Scenarios

	<u>Magnitude</u>
• <b>Scenario 1</b> - Individual faults	6.3 - 6.8
• <b>Scenario 2</b> - Multiple fault rupture	6.9 - 7.1
• <b>Scenario 3</b> - Strike-slip system	7.2

# UNE Vibratory Ground Motion

## RADIOACTIVE WASTE MANAGEMENT

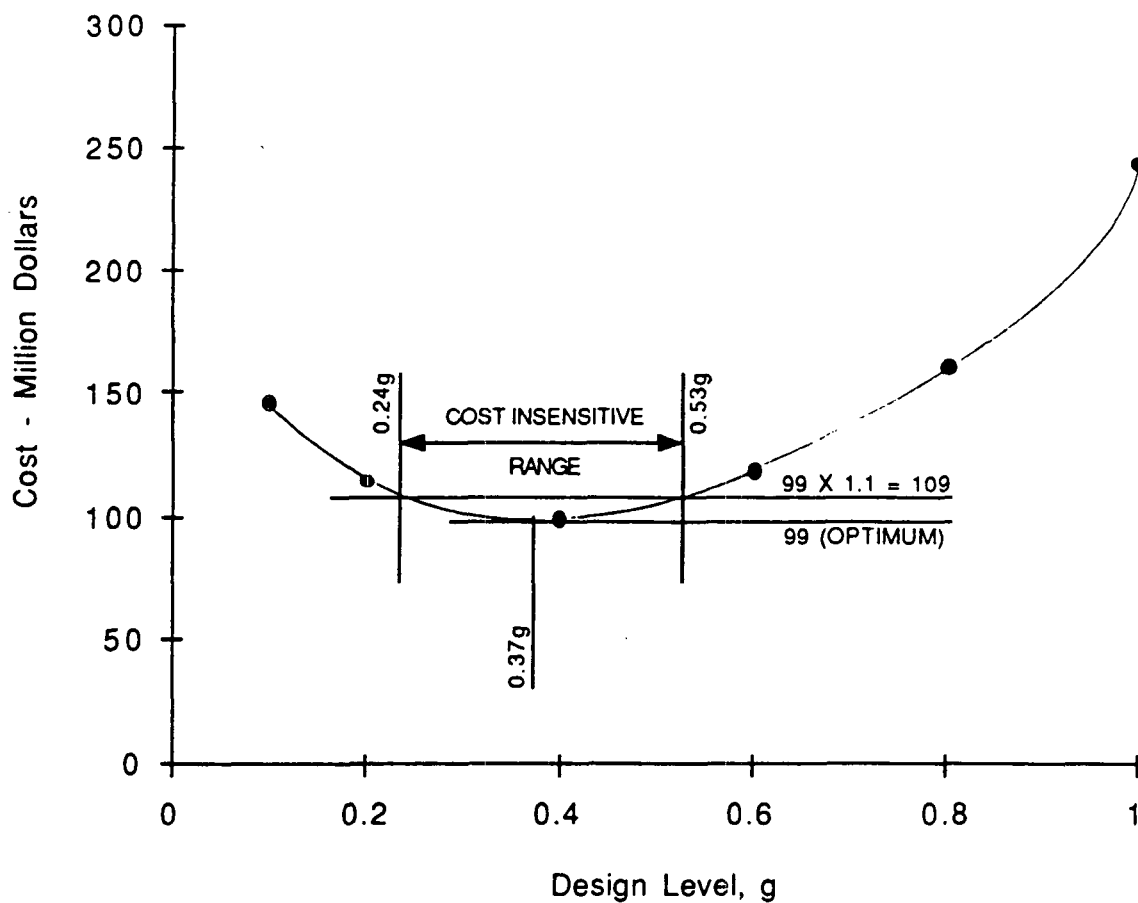


### LEGEND

- UNE Best Estimate* (solid line)
- UNE 2σ Bounds* (dashed line)
- URS/Blume Earthquake Estimate* (dotted line)

# Total Nonaccident-Related Costs as a Function of Design Acceleration

## Subramanian and Others (1989)



# **Vibratory Ground Motion - Surface Facilities**

- **What is the appropriate seismic design basis for the surface facilities?**
- **Data to address seismic vulnerability concerns**
  - **Seismic sources**
  - **Earthquake recurrence**
  - **Earthquake size**
  - **Ground motion model**



# **Vibratory Ground Motion - Surface Facilities**

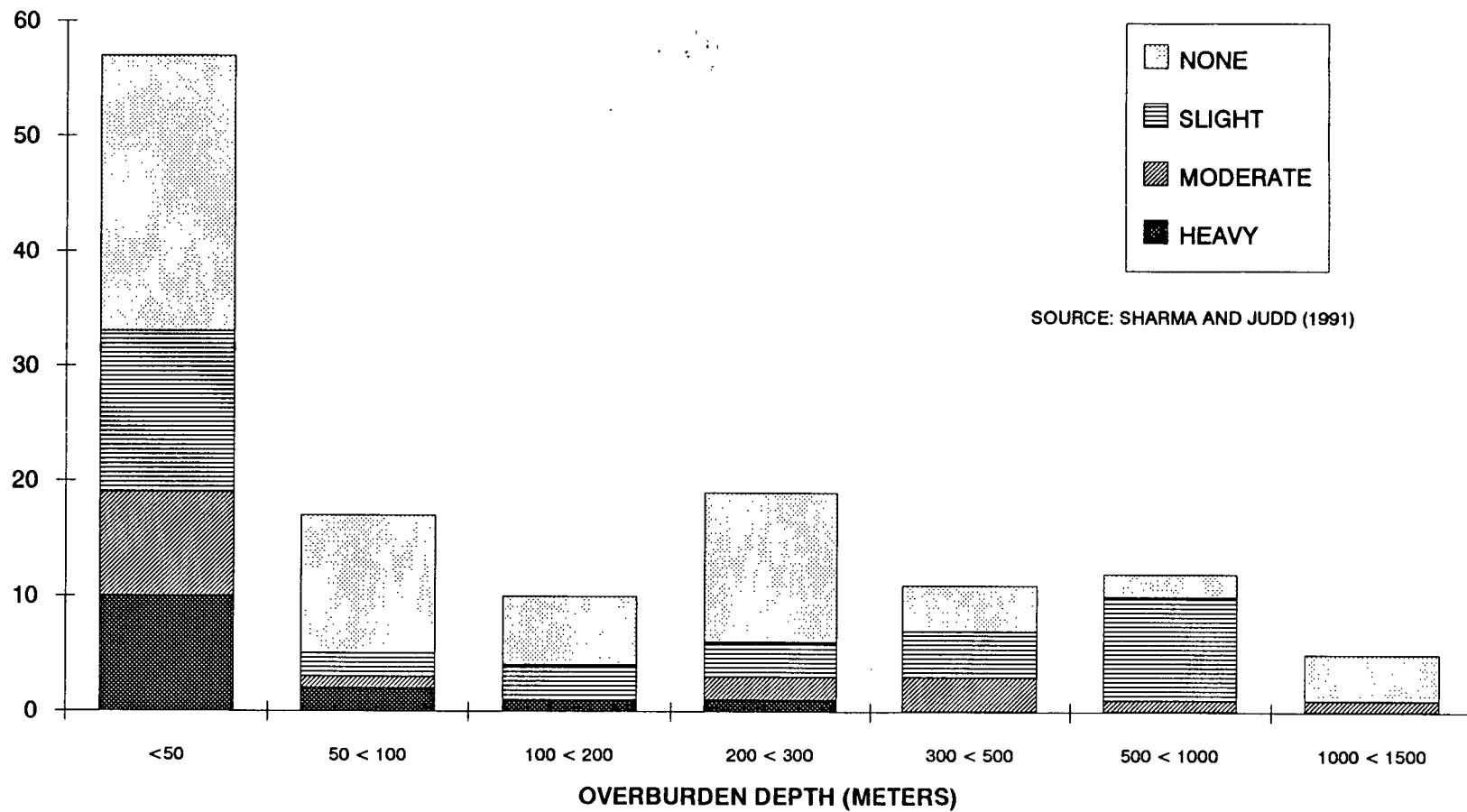
- **Site Characterization Plan studies and activities**
  - **Quaternary geologic mapping**
  - **Paleoseismic studies**
  - **Seismic monitoring studies**
  - **Stress studies**
  - **Geophysical studies**
  - **Tectonic model studies**
  - **Seismic hazard studies**

# **Vibratory Ground Motion - Underground**

- **Preliminary seismic vulnerability assessment**
  - **Shallow portions of underground openings and portals are most vulnerable**
  - **Reasonably Available Technology allows design of tunnels to mitigate effects of expected vibratory ground motion**
  - **Effects of UNE's on nearby tunnels suggest that expected ground motions will produce only minimal damage**
- **Strategy**
  - **Design underground openings to remain stable under expected ground motions during the preclosure period using Reasonably Available Technology**
  - **Provide seismic design values for waste container/emplacement design**

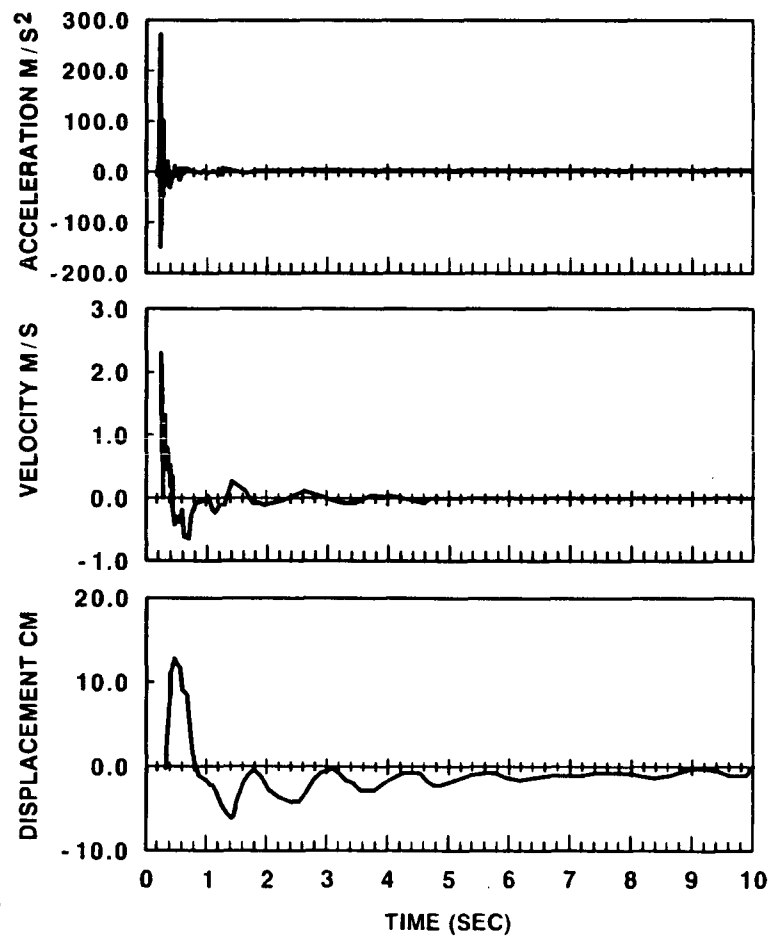
# Effects of Overburden Depth on Damage

Sharma and Judd (1991)



SOURCE: SHARMA AND JUDD (1991)

# Results from the Tunnel Dynamics Experiment Radial Free-Field Ground Motions



# **Vibratory Ground Motion - Underground**

- **What is the appropriate seismic design basis for the underground excavations?**
- **Data to address seismic vulnerability concerns**
  - **Seismic sources**
  - **Earthquake recurrence**
  - **Earthquake size**
  - **Ground motion model**

# **Vibratory Ground Motion - Underground**

- **Site Characterization Plan studies and activities**
  - **Quaternary geologic mapping**
  - **Paleoseismic studies**
  - **Seismic monitoring studies**
  - **Stress studies**
  - **ESF studies**
  - **Geophysical studies**
  - **Tectonic model studies**

# Summary

- **Faults will be identified and avoided in siting the surface facilities and waste emplacement boreholes**
- **Secondary faulting, undetected faulting, and new faulting need to be further evaluated, but their rates of occurrence and effects appear at this time to be small**
- **Anticipated seismic ground motion levels and fault displacements can be designed for using Reasonably Available Technology**