

# Water Distribution Seismic Performance 1994 Northridge-1995 Kobe Earthquakes

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# OUTLINE

- Earthquakes
- Distribution
- Emergency Water
- Restoration
- Future Seismic Mitigation
- Conclusions

# Earthquakes

Northridge January 17, 1994, 4:31 am

$M_w$  6.7 (USGS)

Blind Fault

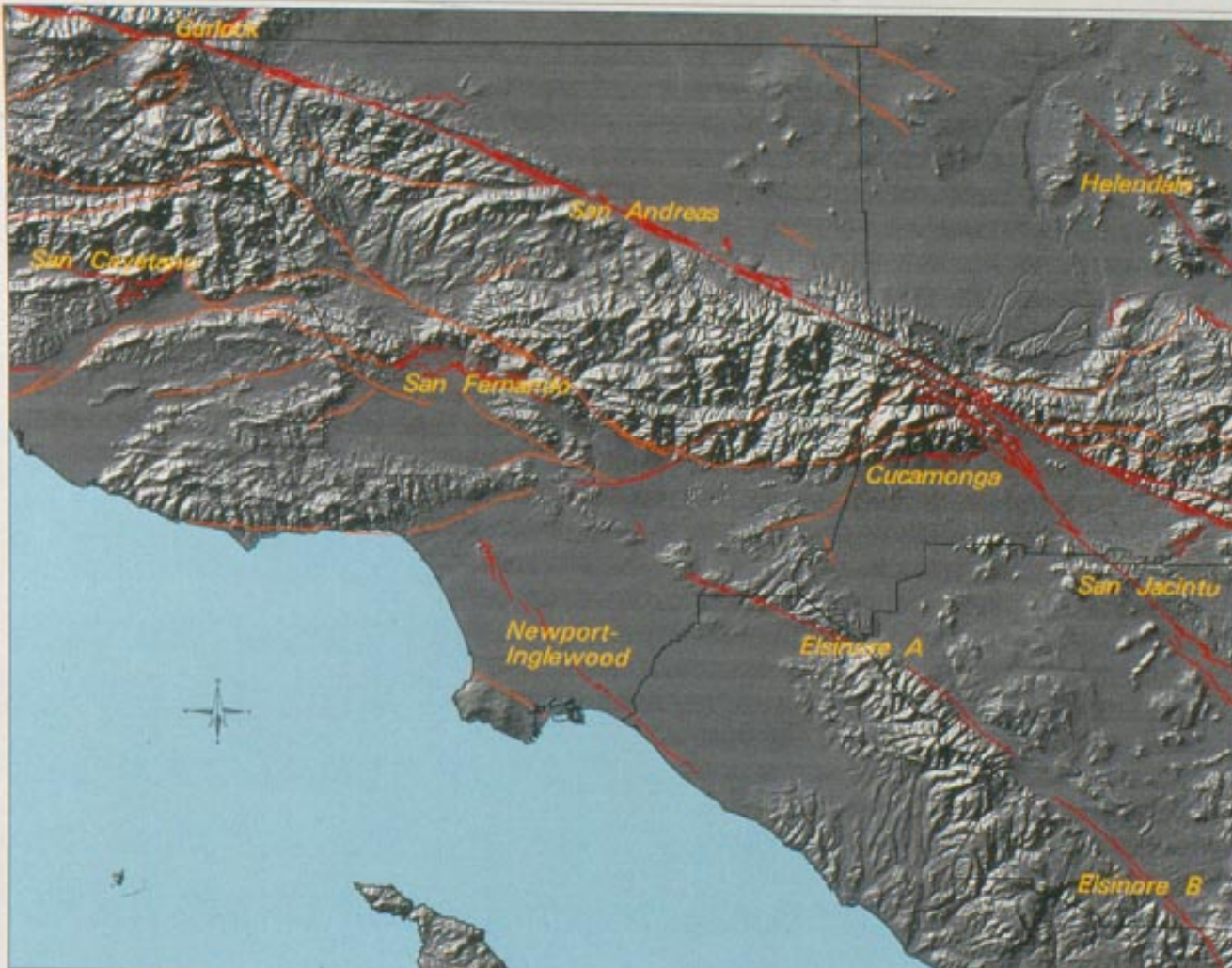
Kobe January 17, 1995, 5:46 am

M 7.2 (JMA)  $M_w$  6.7 (USGS)

Nojima Fault

# SOUTHERN CALIFORNIA FAULTS

Northridge Earthquake Disaster DR-1008



## ALBERT-PRICHO FAULTS

These faults were designated by the Albert-Pricho Special Studies Zones Act of 1972 as representing hazards to structures from surface faulting or fault creep. Projects located within the Albert-Pricho zones require a geologic report concerning the associated seismic risk. The fact that a property is located within a Special Studies Zone must be disclosed by real estate or other sales agents upon the transference of the property. These faults represent most but not all faults younger than 10,000 years.

Indicators of these faults include surface ruptures, fault creep slipage, or displaced survey lines. Older Holocene faults are characterized by sag pond scarpes showing little erosion, or certain geomorphic features in Holocene age deposits, offset stream courses, linear scarps, shatterlines and irregular fault spurs.

## OTHER FAULTS

The majority of these faults are older than 10,000 years. Associated geomorphic features are either indistinct or insufficient to determine age.

Source: Data originated at California Division of Mines and Geology

Coverage obtained through Southern California Earthquake Center

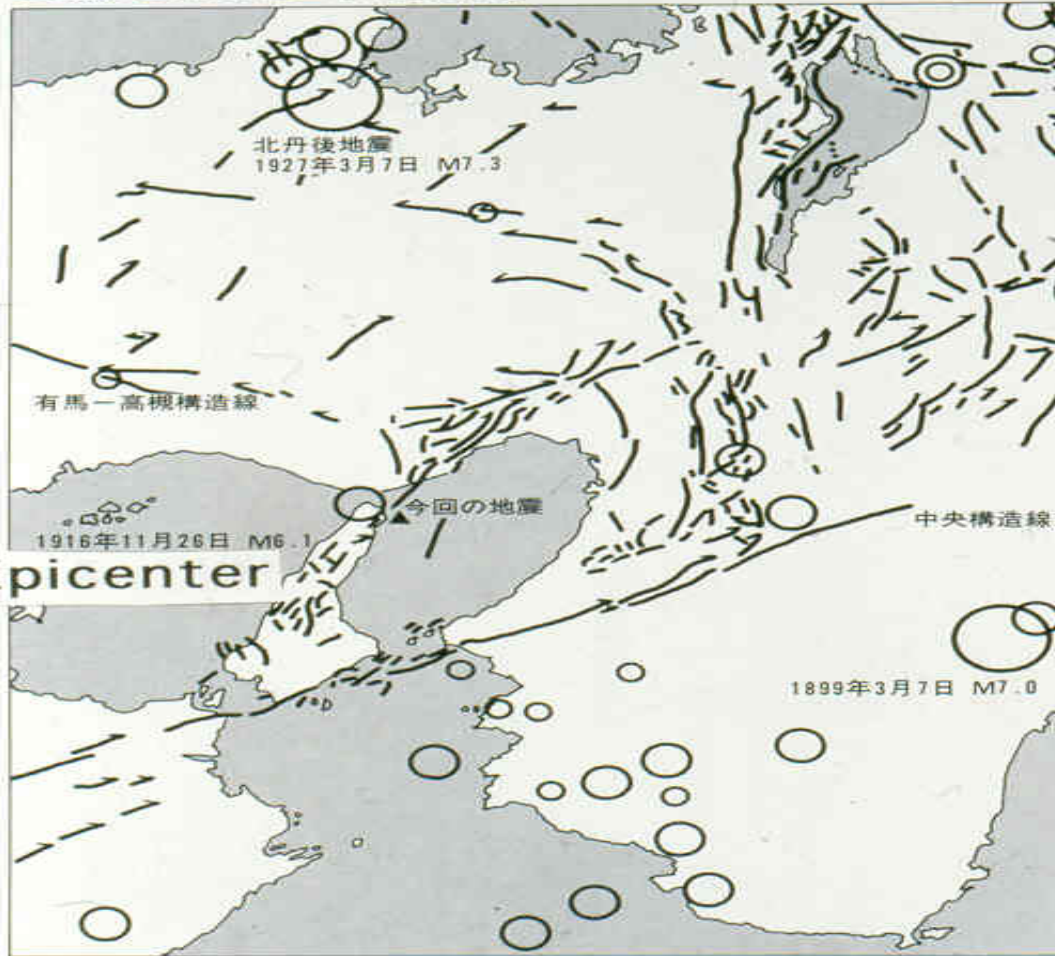
Fault locations are approximate. Do not use data for analysis.



Scale bar: 0 to 10 miles

and information should not be used for any purpose other than that for which it was prepared. This map was prepared by the California Division of Mines and Geology, 9789 University Ave., Sacramento, California 95823.

# 近畿地方の主な活断層



「新編・日本の活断層」(活断層研究会編)より

円の大きさはマグニチュードの大きさに対応する

# Water Supply

Los Angeles - Population 4 million

- Los Angeles Aqueducts-50%
- Metropolitan Water District - 26 Agencies-34%
- Local groundwater-15%
- Water Recycling -1%

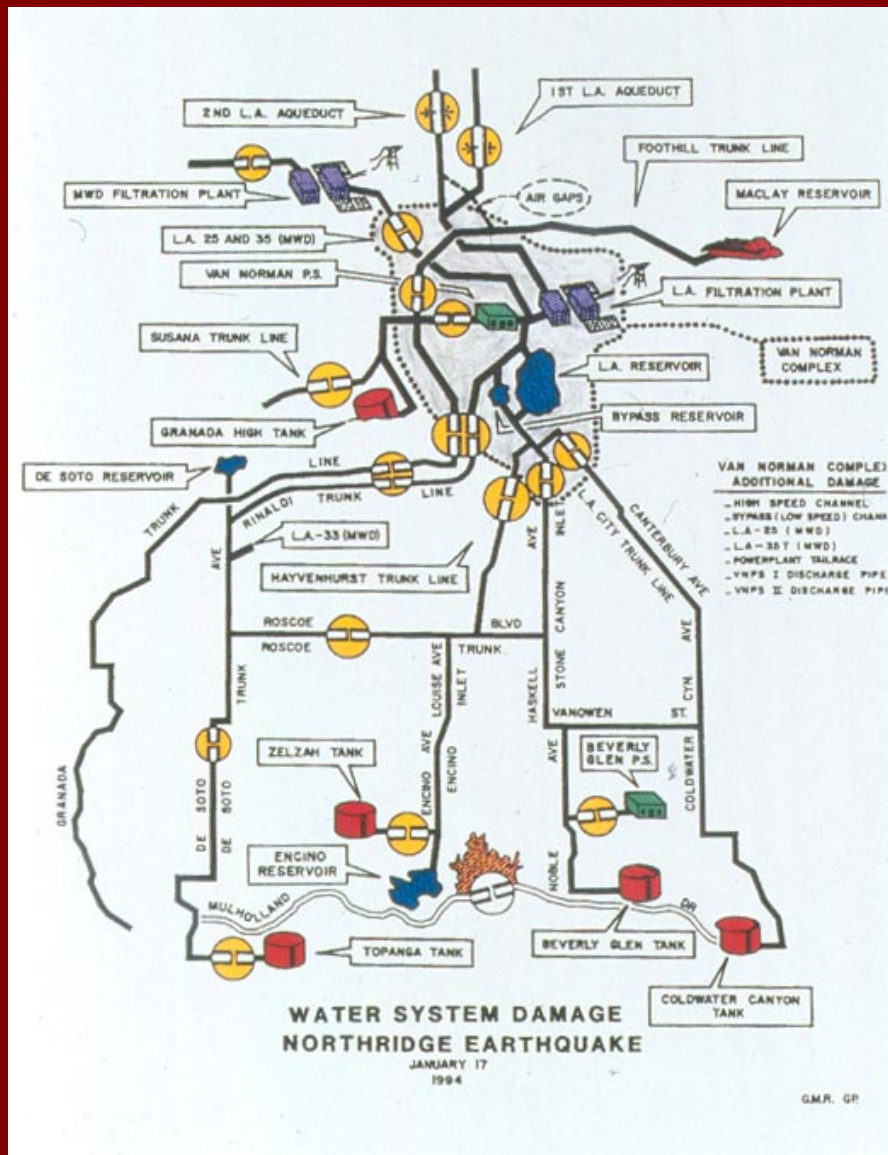
Kobe - Population 1.5 million

- Hanshin Water Authority - 9 cities+4 towns-75%
- Local- 25%

# Distribution System Performance

## San Fernando Valley

- Compression or tension bell and spigot joints
- Rigid joints
- Corrosion older steel mains
- Old riveted tanks
- Pumping and chlorinating stations good performance





# Los Angeles Damage

Facility	Damage (damage/total)		Cost (Million \$)
Dam	0	/14 dams	0.32
Treatment plant	1	/1 plant	2.1
Raw water conduit (aqueduct)	14 repairs	/ *	4.5
Transmission main (Trunk Line)	60 repairs	/700 km	**
Distribution Reservoir	7	/86	12.0
Distribution pipe	1,013 repairs	/11,740 km	5.2
Service connection (w/o cust. pipe)	208+ repairs	/700,000 lines	**
Other (including bldg)	District Yards, etc.		17.0
Total			41.0

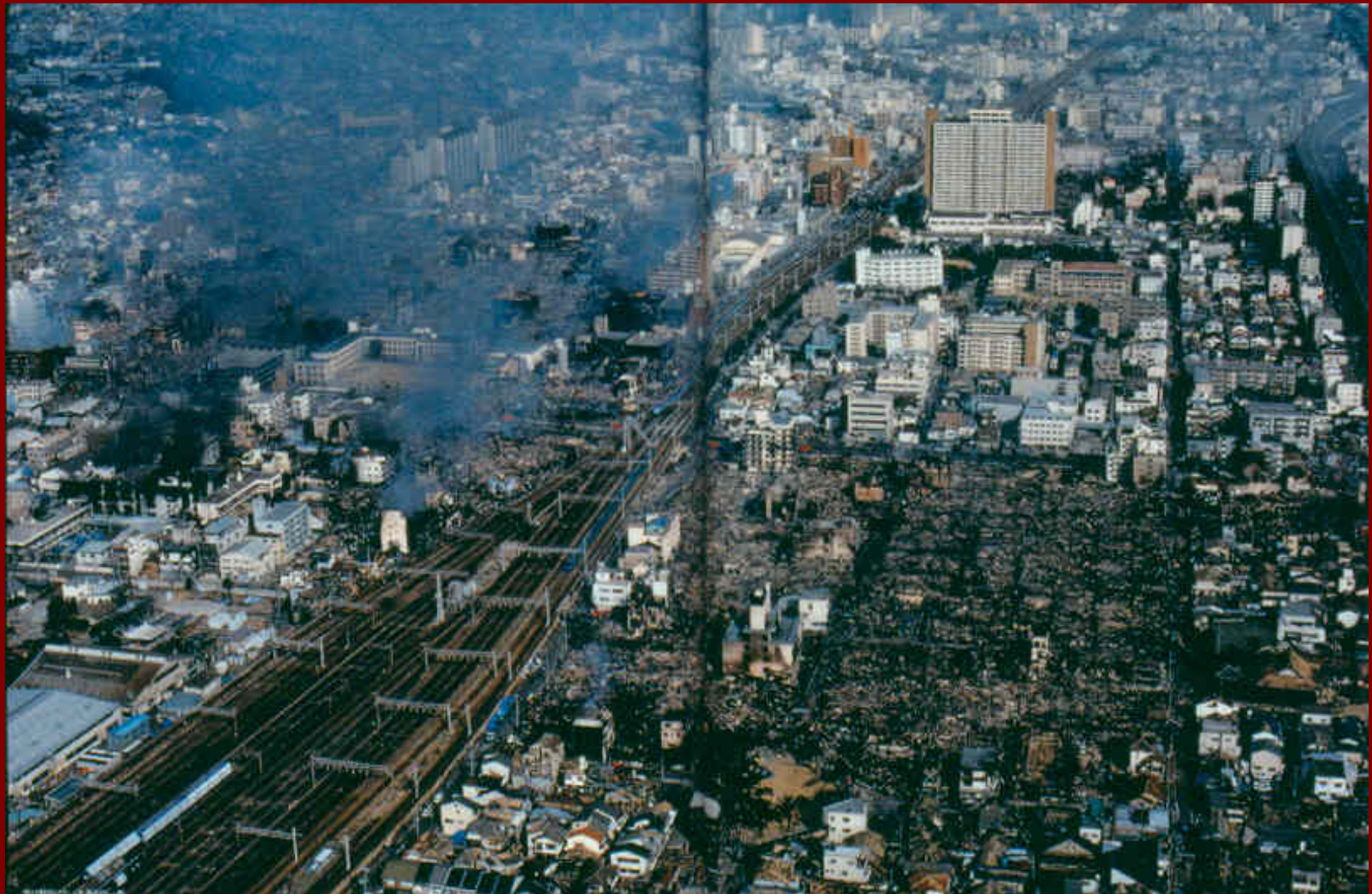
\* 65km of 660 km of aqueducts in the seismic region

\* \* Distribution pipe costs includes all pipe

# Distribution System Performance

## Kobe

- Cracked pipe body
- Joint failure
- Fitting damage
- Property pipes due to building collapse
- S and S-II joints good performance
- Flexible joints good performance
- Tanks and pumping stations good performance





# Kobe Damage

Facility	Damage (damage/total)		Cost (billion ¥)
Dam	1	/3 dams	7.0
Treatment plant	2	/7 plants	
Raw water conduit (aqueduct)	2 lines	/43 km	
Transmission main (Trunk Line)	6 lines	/260 km	
Distribution Res. and tanks	1	/119 tanks	1.9
Distribution pipe	1,757 failures	/4,002km	13.5
Service connection/ customer pipe	89,584 repairs lines	/650,000	2.5
Other (including building)	Head office, Tobu Branch, etc.		4.1
Total			29.0

# Emergency Water Supply

## San Fernando Valley

- Public and private tanker trucks
- Bottled water companies
- Fire Engine interdepartmental pumping
- Boil water notice issued for drinking and cooking



# Emergency Water Supply

## Kobe

- Dual tanks
- Underground cisterns
- Tank trucks
- Fire hydrant spigots
- Portable tanks
- No boil water notice-concern gas+fire









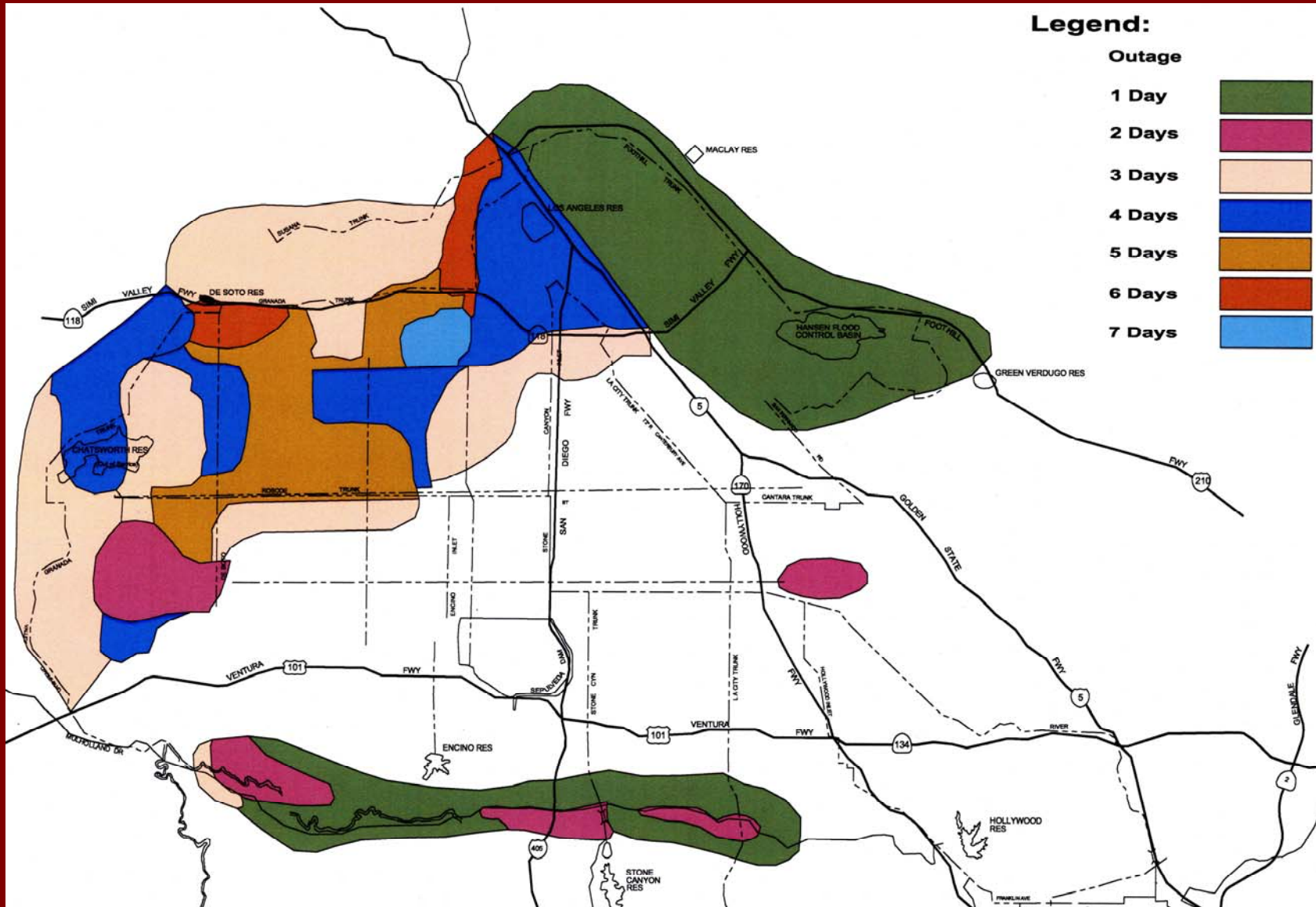
# Water System Restoration

## San Fernando Valley

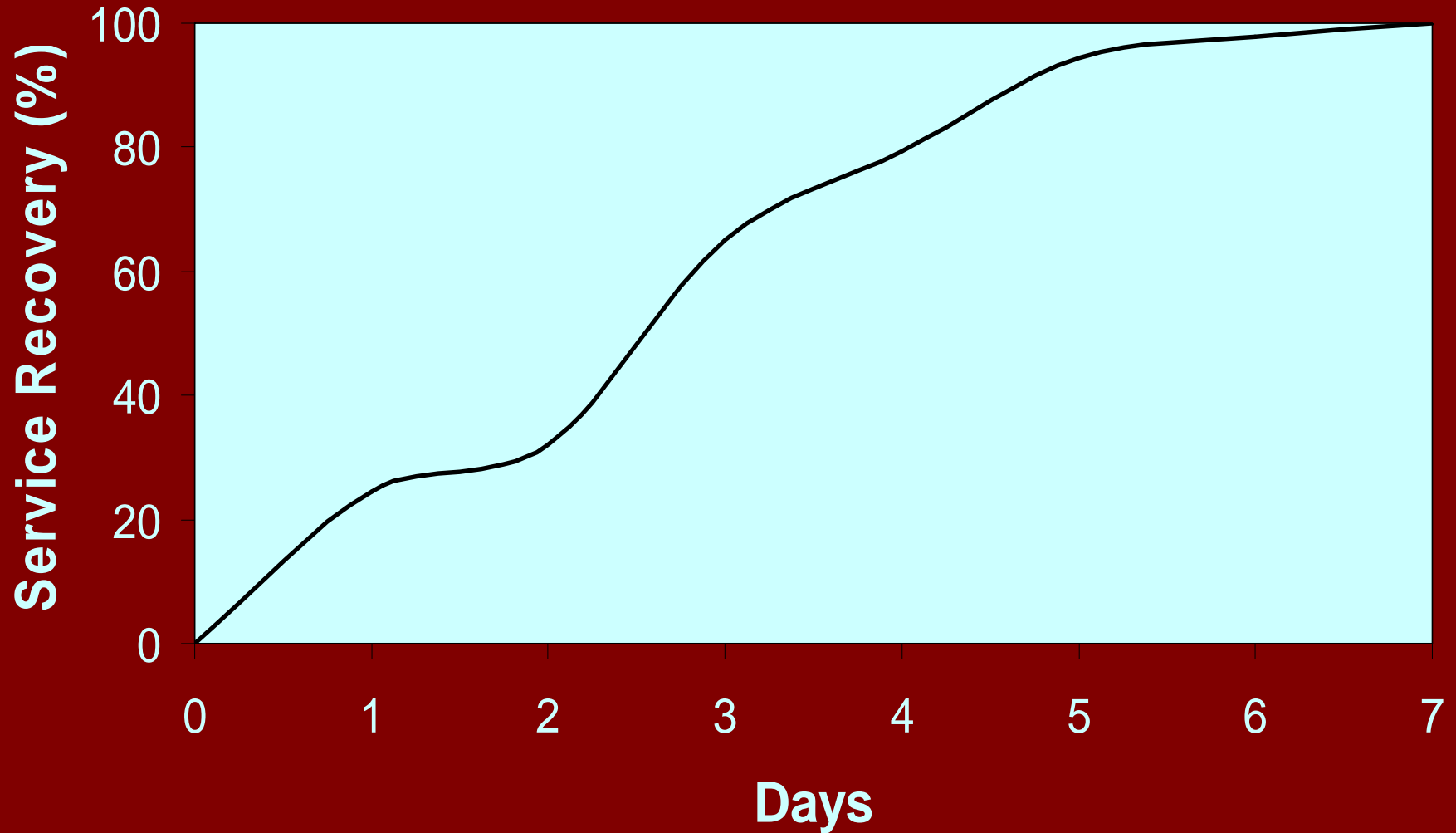
- Seven operating districts
- Mutual aid
- Specialized private contractors
- Block by block after cleared for pressure and water quality



# Los Angeles Water System Restoration



# Recovery Rate



# Water System Restoration

## Kobe

- Five operating districts
- Mutual aid
- Repairs hampered by blocked streets from collapsed buildings
- Access to city limited by damaged highways and railroads
- System water pressure not sufficient to locate leaks

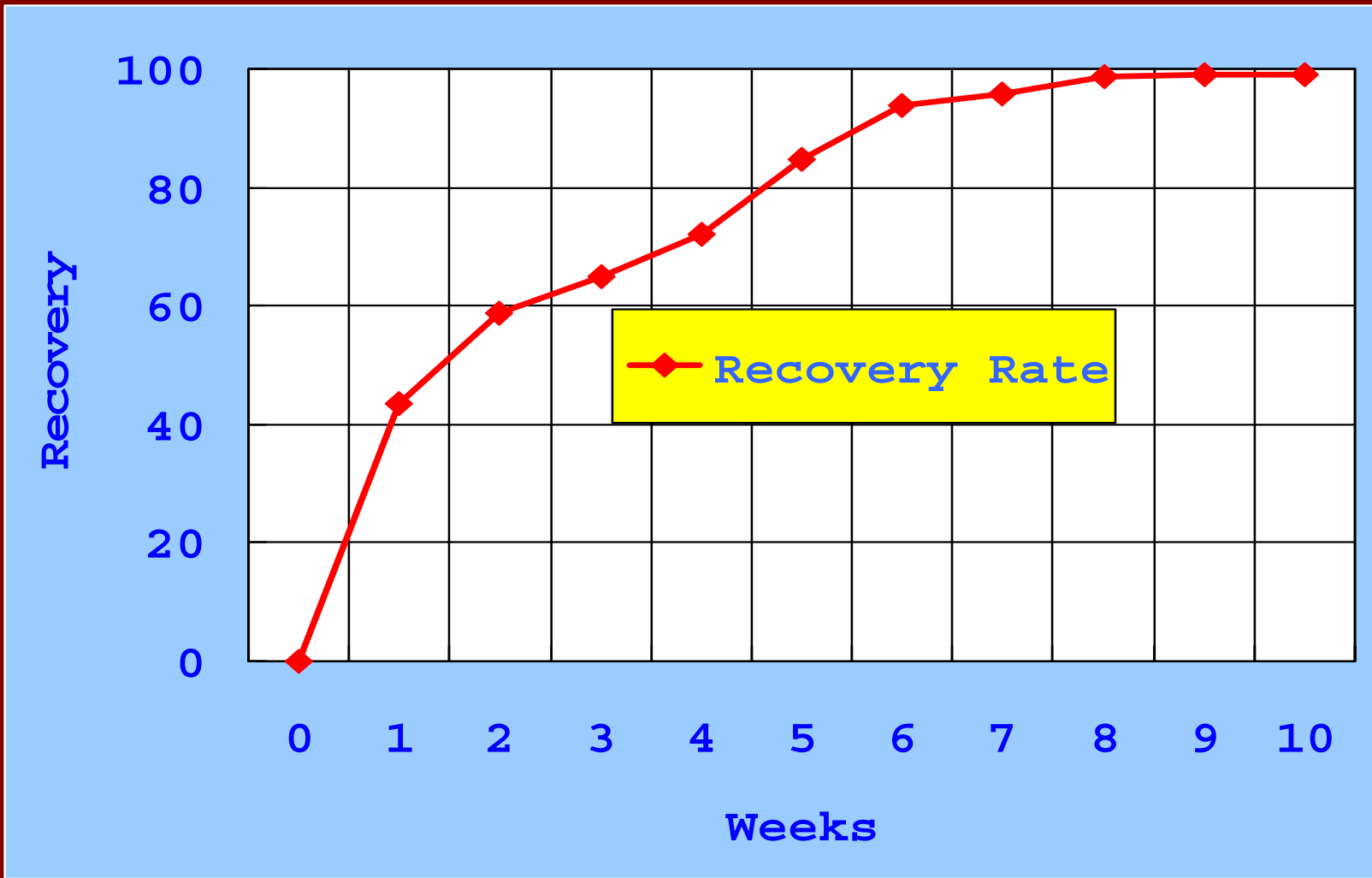








# Kobe Water System Restoration



# Future Seismic Mitigation

## San Fernando Valley

- Prestressed concrete tanks
- Trenchless technology
- Riveted steel pipe replacement
- Combination with water quality improvements
- SLAA Terminal Hill improvements
- Dams analysis

# Future Seismic Mitigation

## Kobe

- Expand use S and S II Joints
- Expand use flexible joint installation
- Enhance telemeter control for emergency shut off valves for tanks and service zones
- Large Capacity Transmission Main
- Water supply stations for citizens, water trucks, fire engines
- Hanshin combined Amagasaki and Kabutoyama WTP by constructing a new Amagasaki WTP

# Conclusions

- Same magnitude EQ
- Previous seismic improvements good for tanks, some pipe, pumping and chlorinating stations
- Difference in pipe breaks and restoration time
- Permanent ground deformation
- Liquefaction
- Building Collapse
- Difference infrastructure configuration, geotechnical siting, construction, social needs, political and financial philosophies

# Acknowledgements

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USC Trojans  
Fight On