



**The 1994 Northridge Earthquake:  
Impacts, Outcomes, and Next Steps**

January 16-17, 2014  
Los Angeles, CA

# **Fire Following Earthquake**

## ***LA Case Study and future directions***

**Charles Scawthorn, S.E.**

**SPA Risk  
and**

**Pacific Earthquake Engineering Research Center  
University of California at Berkeley**



**PEER**

PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER



# Outline

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- The Problem
- Analysis
- Mitigation Options



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# Acknowledgments

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- **Seismic Safety Commission, State of California**  
*Richard McCarthy, Executive Director*
- **Pacific Earthquake Engineering Research Center**  
*Stephen Mahin, Director*
- **National Science Foundation**  
*Dennis Wenger, Program Officer*
- **U.S. Geological Survey: *The ShakeOut Scenario***  
*Lucille Jones, Science Advisor for Risk Reduction*
- **Numerous Fire and Water Agency officials**
- **Others too numerous to list here**



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# Northridge 1994

NIST-GCR-98-743

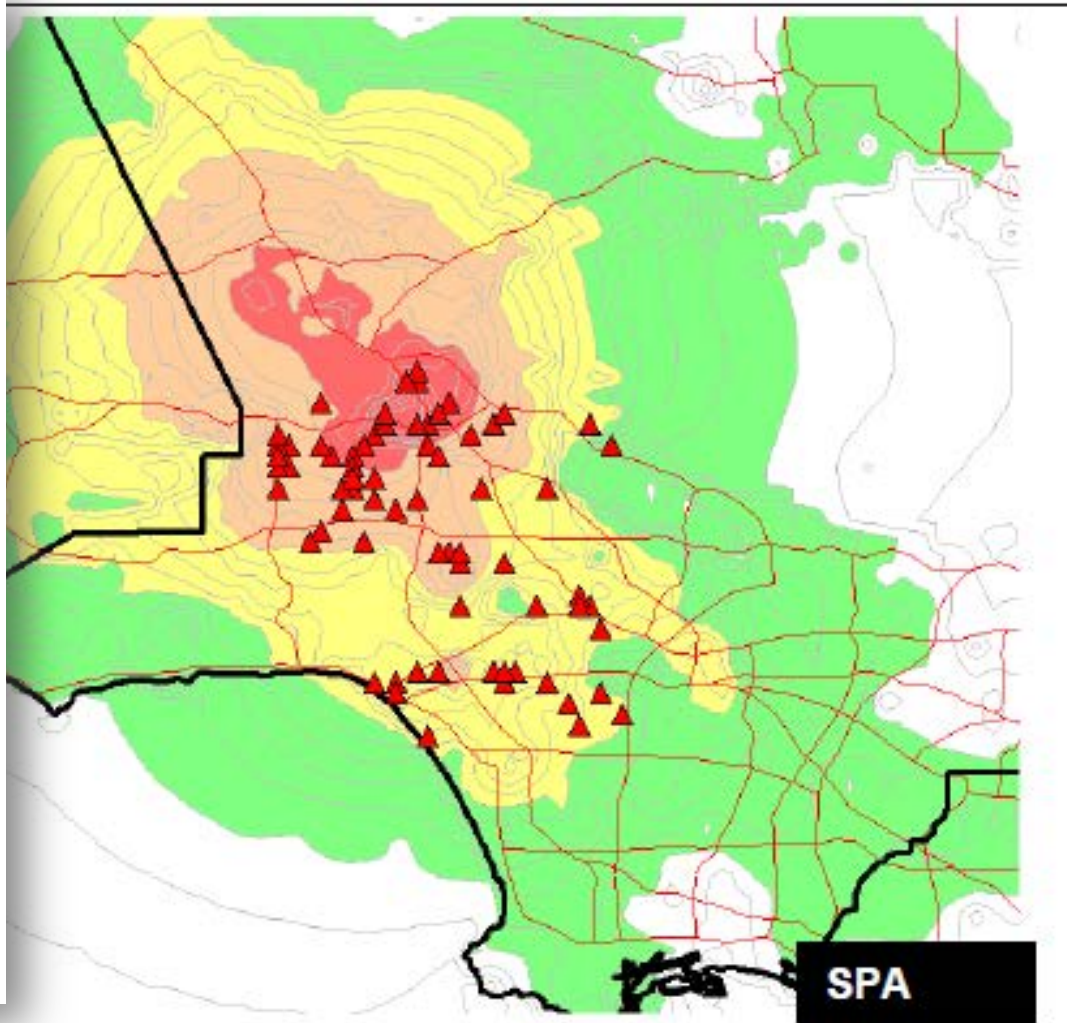
## FIRE-RELATED ASPECTS OF THE NORTHRIDGE EARTHQUAKE

Charles Scawthorn, Andrew D. Cowell  
and Frank Borden

EQE International, Inc.  
San Francisco, CA 94104

### NIST

United States Department of Commerce  
Technology Administration  
National Institute of Standards and Technology



# The Problem

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## Urban Conflagration

- Northridge 1994 Earthquake
- First Interstate Bank Building fire (1988)
- East bay hills fire (1991)
- San Bruno gas explosion (2011)
- Numerous Southern California WUI fires
- ShakeOut (2008) Scenario → 1,600 ignitions



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# High rise building fires

- ❑ 1988 First Interstate Bank building fire
- ❑ Tallest building in California
- ❑ Required 1/3 LAFD for response



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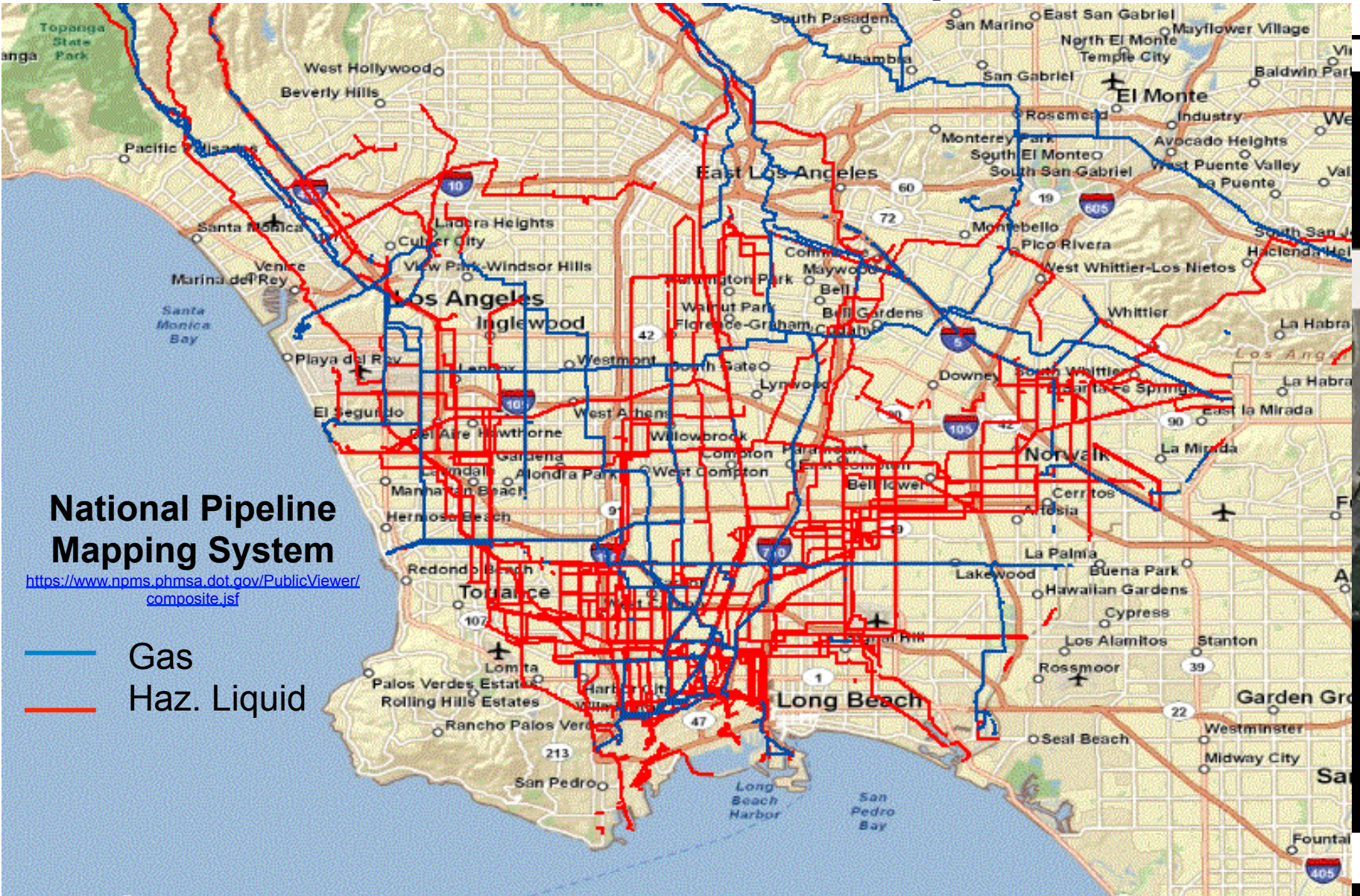
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# San Bruno Gas Explosion



## National Pipeline Mapping System

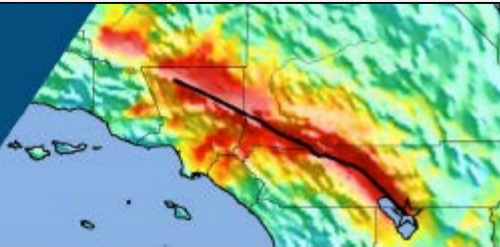
<https://www.npms.phmsa.dot.gov/PublicViewer/composite.jsf>

- Gas
- Haz. Liquid



# USGS ShakeOut Exercise

## The ShakeOut Scenario Supplemental Study



### Fire Following Earthquake

Prepared for  
United States Geological Survey  
Pasadena CA

and

California Geological Survey  
Sacramento CA

By  
Charles R. Scawthorn, S.E.  
SPA Risk LLC  
Berkeley CA

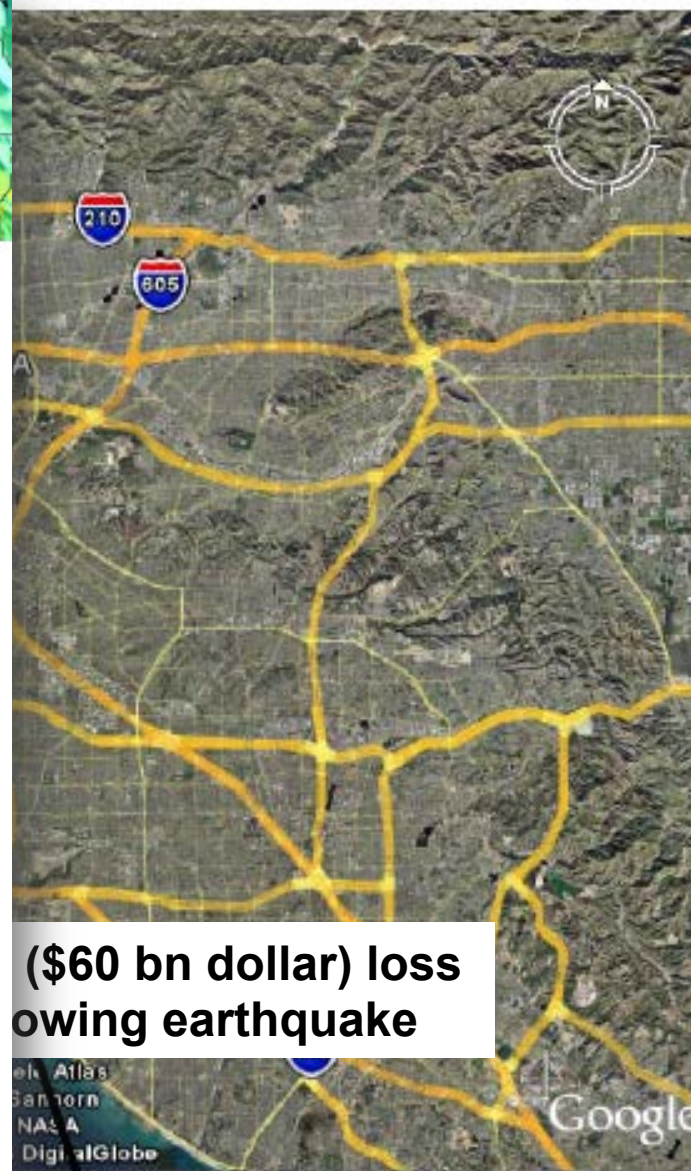
March 3, 2008



The ShakeOut Scenario:  
U.S. Geological Survey Open File Report 2008-1150  
California Geological Survey Preliminary Report 25 version 1.0  
U.S. Geological Survey Circular 1324  
California Geological Survey Special Report 207 version 1.0



Note: over the course of the ShakeOut Scenario, the project name evolved. Where a study mentions the ShakeOut Scenario or San Andreas Fault Scenario, it refers to what is now named the ShakeOut Scenario.





# Water Supply in re FFE

*Seismic Safety Commission / PEER*

## Questions:

- how well do water departments understand the potential damage to their distribution system? (focus to date has been on transmission)
- what are their current estimates of post-event firefighting water reliability?
- how well do fire departments understand this situation?
- how well are fire departments prepared for alternative water supply?
- how can this situation be improved?



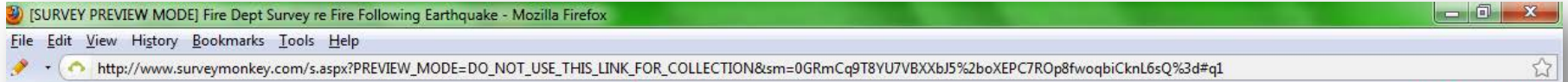
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# Online Surveys





## Fire Dept. Survey re Fire Following Earthquake



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[Exit this survey](#)

1. Water Damages

1. Intro

This survey was made in order to provide information on fire following earthquakes. This survey is available to all fire departments in California. While California firefighters are in order to provide information on fire following earthquakes. This survey is available to all fire departments in California. While California firefighters are in order to provide information on fire following earthquakes. This survey is available to all fire departments in California.

We thank you for your interest and participation in this survey which will help contribute to improving California's earthquake preparedness.

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**1. Introduction**

1. How many firefighters are there in your department?

2. What is the population size of your department?

3. What is your name?

4. What is your email?

5. What is your telephone number?

Page 1

**2. Basic Information**

1. What is the size of your fire department?

2. What is the population size of your department?

3. What is your name?

4. What is your email?

5. What is your telephone number?

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**3. Fire Following Earthquake**

1. Does your department have a special unit or unit of a number of damaged buildings, for example, change to water supply and other special water supply units for fire?

2. If so, what is a special water supply unit you use for? (Please specify the equipment, fuel or apparatus, size, and location)

3. And, if so, about how many times do you make use of it?

4. Repeat further or provide more detail if you wish.

Page 3

**4. Water Supply**

1. In a major earthquake, do you anticipate major loss of water water supply?

2. If so, how long would it take to restore the water supply?

3. If you are not sure, please indicate how long it would take to restore the water supply.

4. When has the last time your department provided firefighting water more than one day?

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**5. What special equipment does your department use for firefighting or other water supply?**

1. How many firefighters are there in your department?

2. What is the population size of your department?

3. What is your name?

4. What is your email?

5. What is your telephone number?


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**6. Conclusion**

1. How important is it to the fire following earthquake issue for your department? What key take away from your department's design to improve the safety or response?


2. How are you looking for help? What is the survey about, and what are the key take away from your department's design to improve the safety or response?

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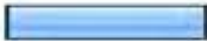

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# Findings – Fire Agencies

18. When was the last time your department practiced relaying water more than one mile?

		Response Percent	Response Count
Within last 6 months		0.0%	0
Within last year		25.0%	5
Within last five years		0.0%	0
Do not know		75.0%	15

Special pump stations and high pressure system		10.0%	2
Fire boat		25.0%	5
Other (explain further below)		25.0%	5
None		40.0%	8



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# Key Findings from the Fire Agencies Survey

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- ❑ See earthquake as a very important issue.
- ❑ But, could be better informed as to earthquake risk
- ❑ Have infrequent communication with their water departments.
- ❑ Consider their normal water supplies as seismically unreliable.
- ❑ Are improving water supply capability but efforts are piecemeal, not coordinated and often are 'reinventing the wheel'.
- ❑ Have identified alternative water sources, but These sources are often not particularly well documented, nor kept up to date nor regularly drilled.
- ❑ The very difficult task of moving water from these sources to the fire scene is in many cases not well thought out, not adequately equipped and not regularly drilled.



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# Findings – Water Agencies

14. If so, w

19. In a major earthquake, do you anticipate major loss of normal water supply will occur, in a significant portion of your service area? This might include loss of distribution piping pressure in one or more neighborhoods, even if transmission integrity is preserved.

Response  
Percent    Response  
Count

31. If so, how often are these meetings?

Response  
Percent    Response  
Count

Frequency	Response Percent	Response Count
Monthly	7.7%	1
Quarterly	30.8%	4
More than once a year	15.4%	2
Annually	15.4%	2
Every few years	30.8%	4

Response	Response Percent	Response Count
Yes	46.7%	7
No	33.3%	5
Do Not Know	6.7%	1
Sort of - I'll explain below	13.3%	2



# Key Findings from the Water Agencies Survey

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- ❑ **Most larger urban water agencies not aware of the specifics of the earthquake risk they are exposed to (i.e., two thirds had had no analysis in the last ten years).**
- ❑ **Earthquake is seen as a key issue by most water departments, but that provision of potable water has a higher priority in some cases than firefighting.**
- ❑ **Even where water departments have knowledge of the vulnerabilities of their systems, this is not often (only 22%) communicated to fire departments.**
- ❑ **Both water and fire departments expect major loss of water supply in a major earthquake, with the water department informing the fire department of the details of this about half the time.**
- ❑ **Many water departments are currently addressing their seismic vulnerabilities with significant engineering programs.**
- ❑ **Information on when water would be restored is sparse.**
- ❑ **Some water departments have alternatives given loss of normal water supply, but only a fraction (~1/3) are reasonably equipped to actually move water.**
- ❑ **Fire and water department liaison is not very good, and are often somewhat indirect, through larger enterprise-wide coordination meetings. Emergency water supply is not a focus.**



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# What do we do?

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## Water Supply

- LADWP (1970-80s, and ongoing)
- EBMUD, Hetch Hetchy...upgrades

## Special Systems

- San Francisco AWSS (1906)
- San Francisco PWSS (1986 → Loma Prieta Earthquake)
- Vancouver DFPS (1990s)
- Vallejo, Oakland, Berkeley (mini-PWSSs, 1990s)
- **Los Angeles? (ShakeOut → review of LA**

**NERT / CERT citizen training programs**

**Gas / Electric Seismic Shutoff Valves**



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# Portable Water Supply Systems



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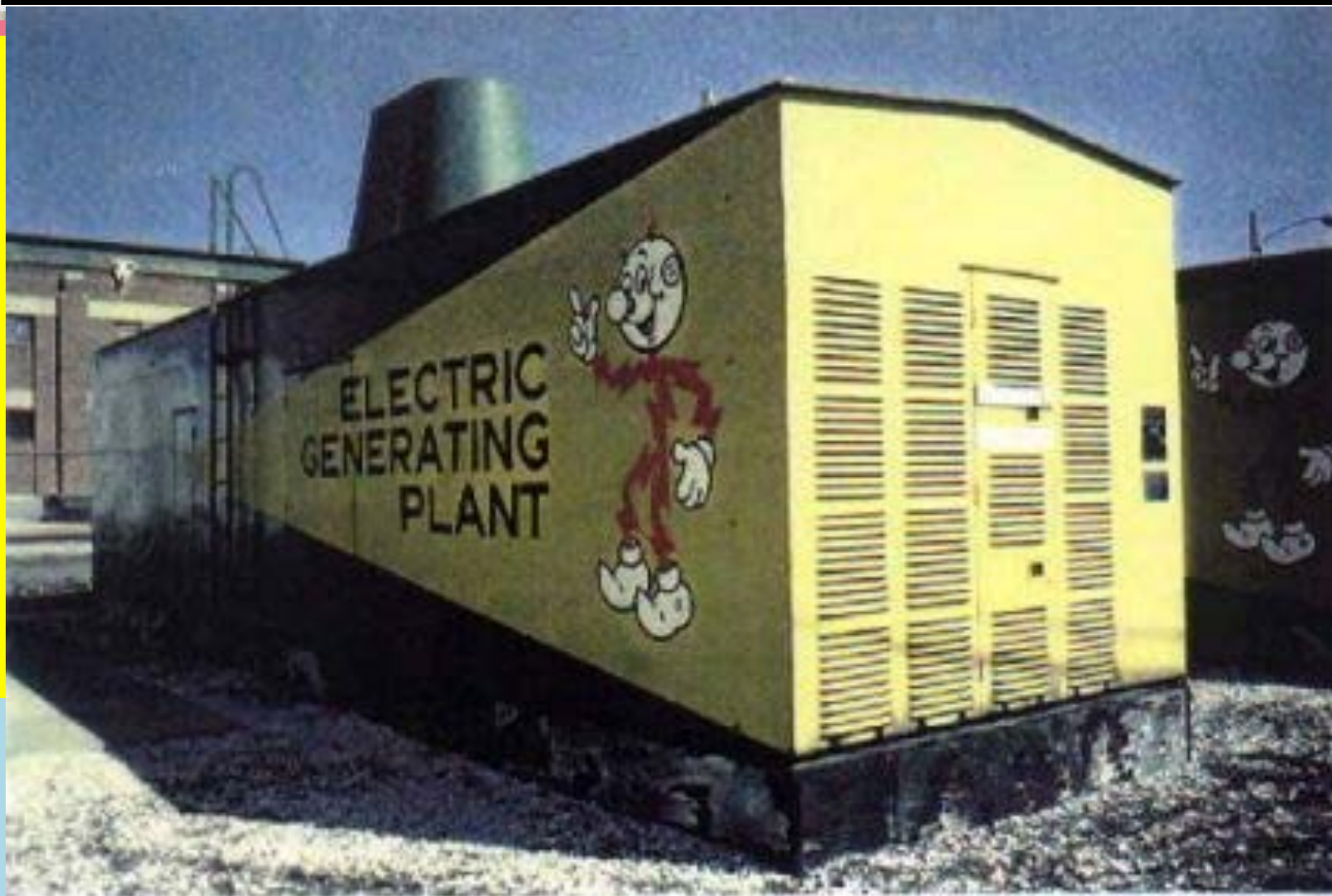
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# LA Basin HP system - feasibility



2,000 K.W. MP-36 EMD PACKAGED DIESEL ELECTRIC GENERATOR

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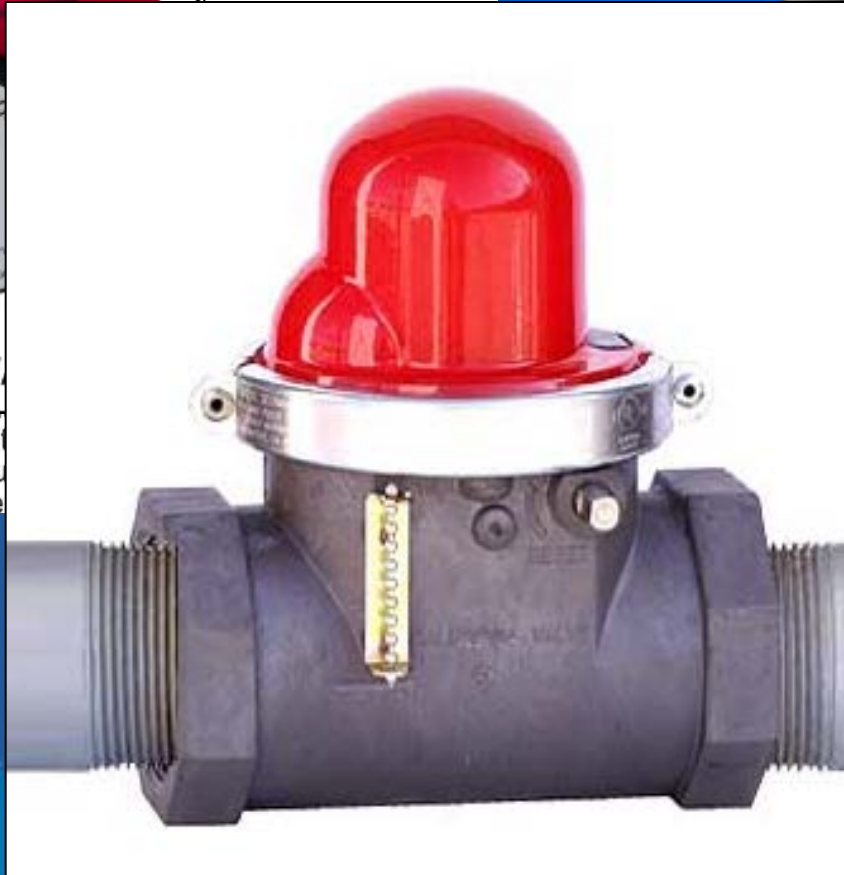
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# Shut-



**NORTHRIDGE V**

(Edition) require  
 Seismic gas shut  
 during a major e



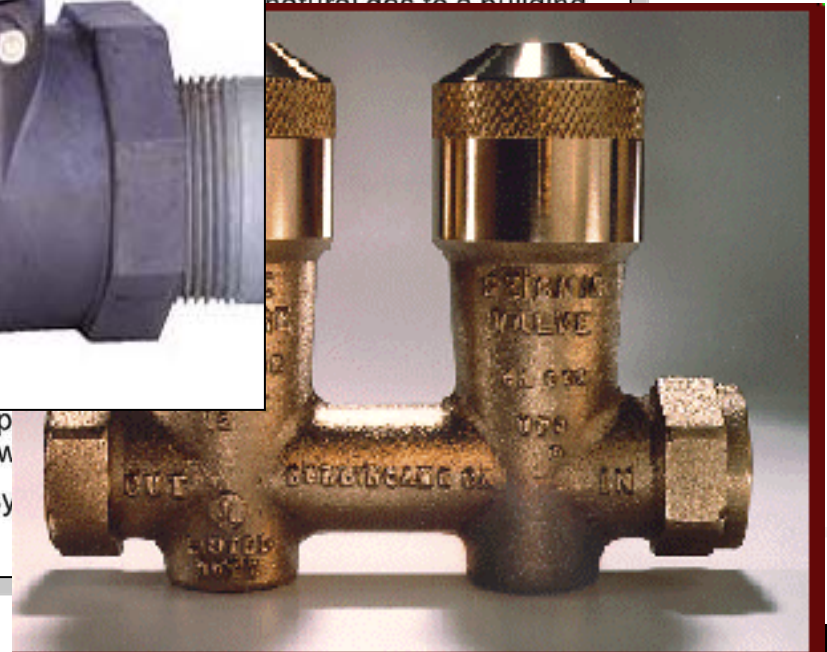
**1" NPT GAS VALVE  
 (2" VALVE ALSO AVAILABLE)**



**GAS VALVE CONTROLLER**

**Certified to ASCE 25-97**

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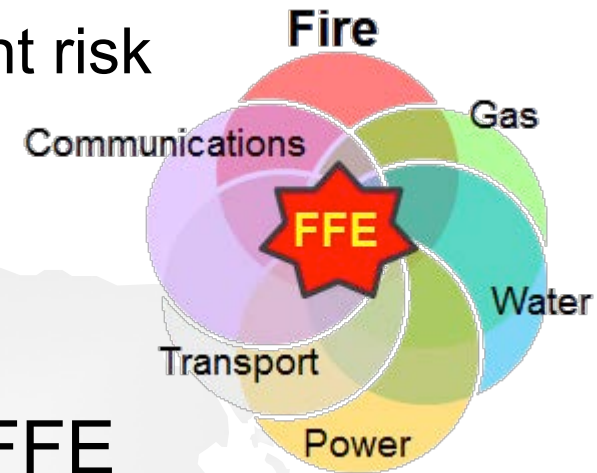


# Summary / Recommendations

- Fire following earthquake a very significant risk
- FFE complex
- Limited emergency response capacity

## Recommendations

- Fire and lifeline agencies focus on FFE
- Require analysis of FFE risk
- Create a state-wide PWSS
- Create an LA basin High Pressure system
- Require gas and power shut-off devices for all conflagration prone areas







2010 San Bruno Gas Pipeline Explosion; Source: National Geographic Pictures

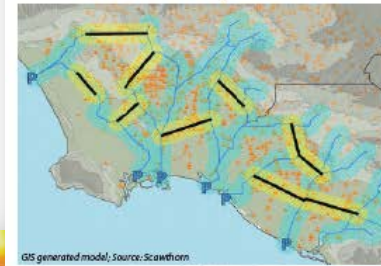


# PEER

## SALTWATER HIGH PRESSURE SYSTEMS

as alternative sources of water

San Francisco has already developed and maintains a high pressure seawater-supplied Auxiliary Water Supply System (AWSS). SF recently, in June 2010, approved a \$412 million bond issue to enhance their system.



Central Los Angeles and Orange County could benefit from building a saltwater high pressure system since they are at great risk due to fire following earthquake.

This map shows Los Angeles and Orange County high pressure salt water system pipe network in storm drain channels (blue lines) with proposed connectors (black lines) overlaid on ShakeOut scenario ignitions. The pipe network is supplied from pump stations (P). Blue and yellow buffer zones around pipelines would be areas reachable by a PWSS.

GIS generated model; Source: Scawthorn



One of the largest drain channels in LA; Source: hcn.org

2008 ShakeOut Exercise Mw 7.8 San Andreas earthquake analysis found that  
**APPROXIMATELY 1,600 IGNITIONS OCCUR IN SOUTHERN CALIFORNIA, WITH THE CENTRAL LA BASIN EXPERIENCING HUNDREDS OF LARGE FIRES.**

### FIRE FOLLOWING EARTHQUAKE

Fire following earthquakes in California have shown that a major earthquake



Los Angeles basin; Source: johndand.com

### CALIFORNIA IS HIGHLY EXPOSED

there are about **9.5 million** residential properties

**1 MILLION** commercial property insurance policies in CA

**\$4.7 trillion** is the total value of insured property

guidance provided by the insurance industry for adequacy of public water supplies **DOES NOT mention or consider EARTHQUAKES**

Source: Statistics from the CA Department of Insurance, 2009

### MOST FIRE AND WATER DEPARTMENTS IN CALIFORNIA

could be **BETTER INFORMED** about the specifics of their earthquake risk

generally believe most municipal water supplies are **UNRELIABLE** in a major earthquake

do **NOT FULLY UNDERSTAND** water department system vulnerabilities

Source: Survey of fire and water agencies conducted by PEER, 2011



Tokyo oil refinery following the 2011 Mw 9.0 earthquake; Source: dashantibo.co.kr



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for more information, download PEER Report 2011/08  
**Water Supply in regard to Fire Following Earthquake by Charles Scawthorn**

at: [www.seismic.ca.gov](http://www.seismic.ca.gov)  
OR  
[http://peer.berkeley.edu/publications/peer\\_reports\\_complete.html](http://peer.berkeley.edu/publications/peer_reports_complete.html)

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Fax: (510) 642-1655  
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urban areas. This PWSS would suffice for the San Francisco Bay Area.

quite feasible if existing large storm drain channels could be used for pipeline rights-of-way.

- Develop and deploy neighborhood equipment container caches to enhance post-disaster fire-fighting capabilities. These would be used by NERT, CERT, and other volunteers.



Portable Water Supply System (PWSS), Vallejo, CA; Source: Scawthorn



Berkeley FD #28512 mobile ultra LDH; Source: Berkeley FD

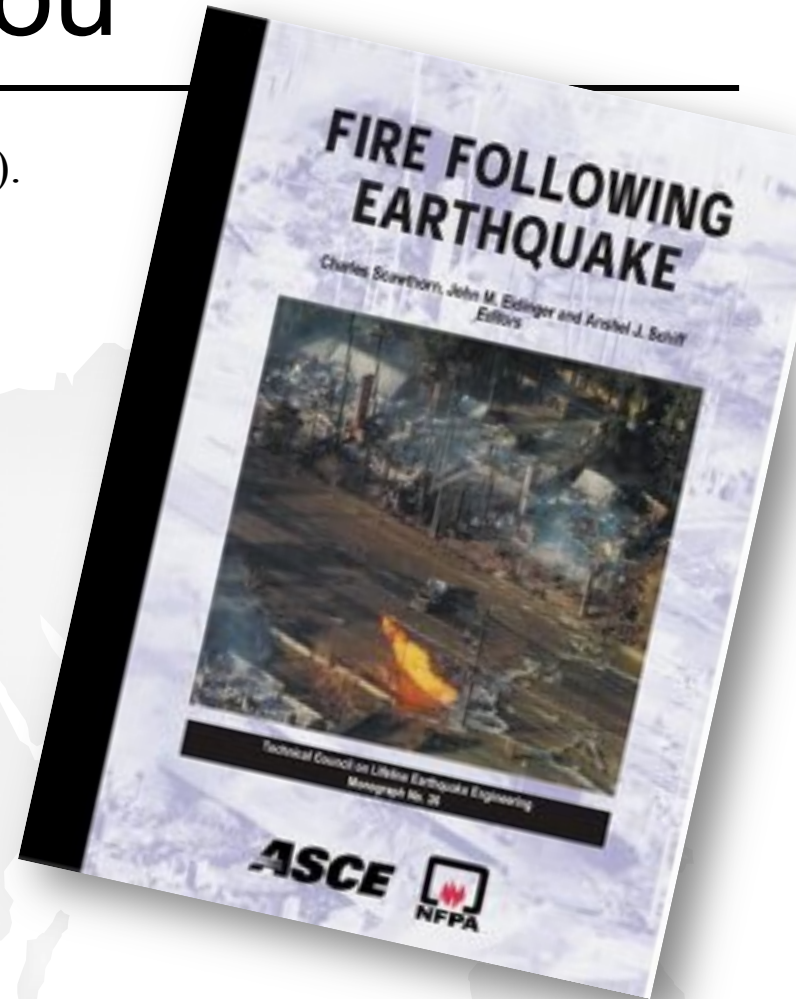


### SPA RISK

# Thank You

Scawthorn, C., Eidinger, J. M., and Schiff, A. J. (2005). "Fire Following Earthquake." Technical Council on Lifeline Earthquake Engineering Monograph No. 26, American Society of Civil Engineers, Reston, 345pp.

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