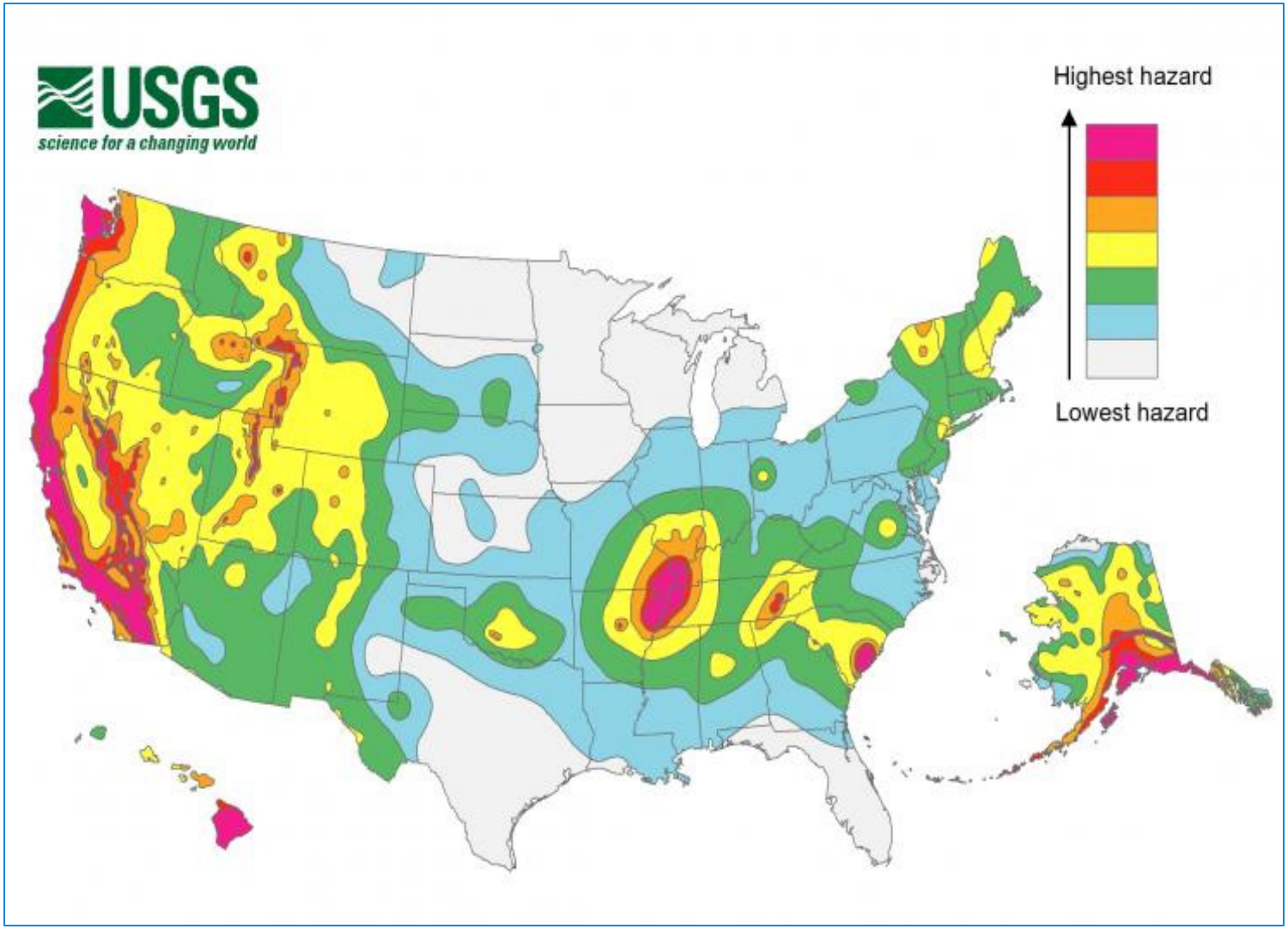
EPA United States Environmental Protection Agency

U.S. Approach to Sharing Seismic Awareness, Hazard Assessment and Mitigation Practices with a Larger Universe of Water and Wastewater Utilities

David Goldbloom-Helzner
U.S. EPA
Craig Davis
LADWP

Earthquake Hazard Areas



Utilities and Vulnerabilities

- 160,000 Community Drinking Water Systems
- 16,000 Publically Operated Treatment works

"Resilience by Design from the Los Angeles Mayoral Seismic Safety Task Force, "the water system is the utility most vulnerable to earthquake damage, and that damage could be the largest cause of economic disruption following an earthquake."

How can less informed small, medium, or even large water and wastewater utilities build resilience to earthquake hazards?

EPA's Approach in Bringing Attention to Earthquake Resilience

- Develop Partnerships
- Strong interest from small/medium utilities in at-risk areas
- Bring attention to earthquake threat including liquefaction
- National Approach
  - Suite of earthquake resilience products
  - Targeted outreach efforts to the water sector

Target Audience for Earthquake Resilience Products

- Utilities that know they are in at-risk areas, but have not taken steps to address the hazard
- Small and medium utilities that need to better understand their seismic hazards

Earthquake Advisory Review Team

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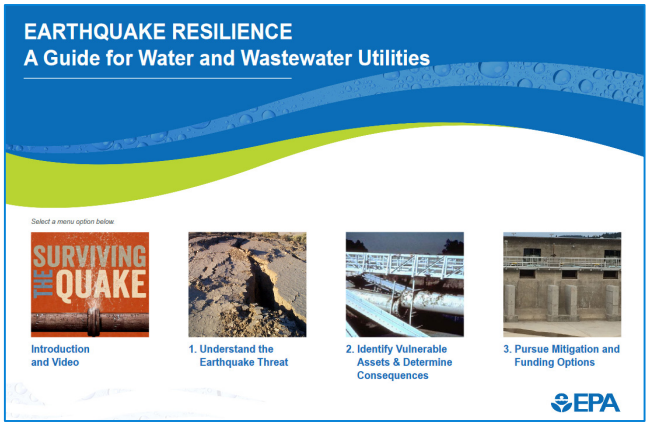
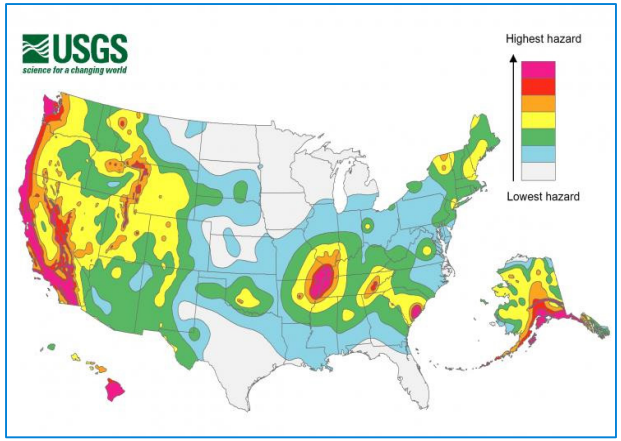
Earthquake Resilience Products

Video

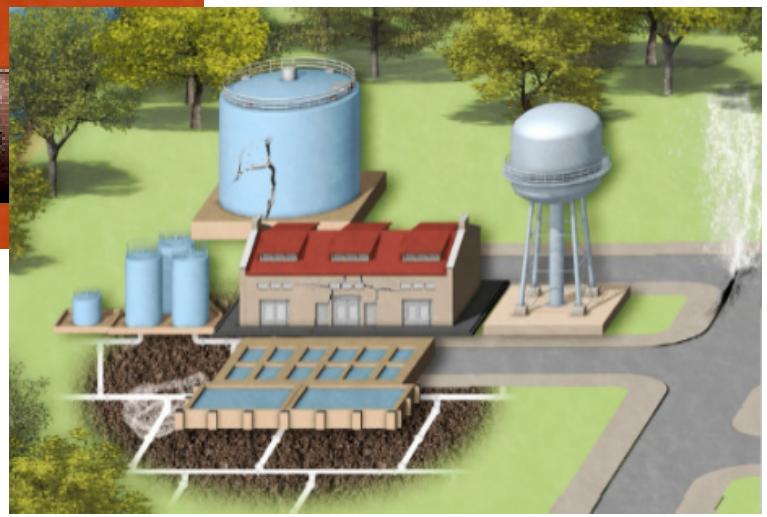
Guide



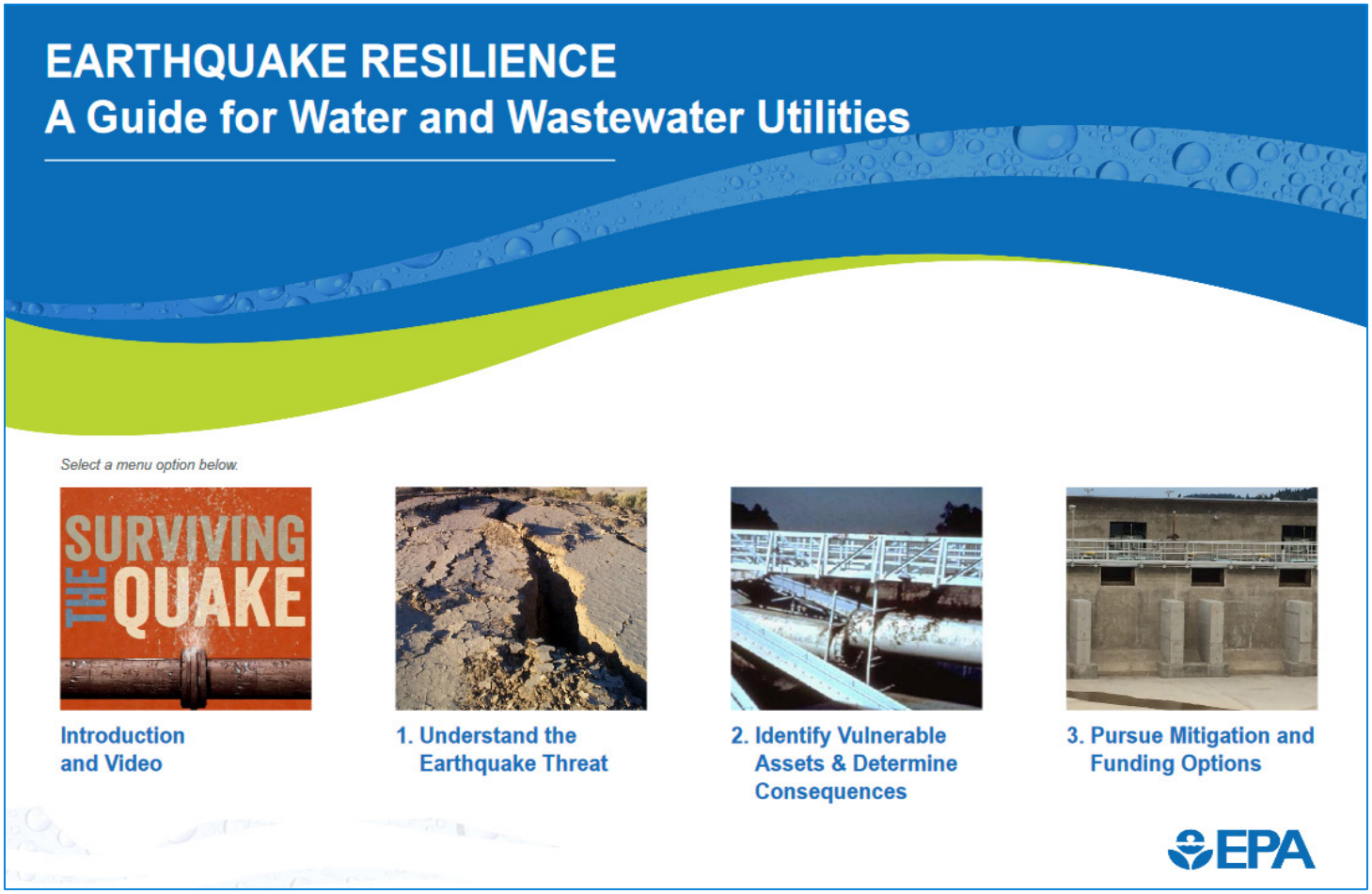
Maps



Demonstration of Video



Demonstration of Guide



EARTHQUAKE RESILIENCE
A Guide for Water and Wastewater Utilities

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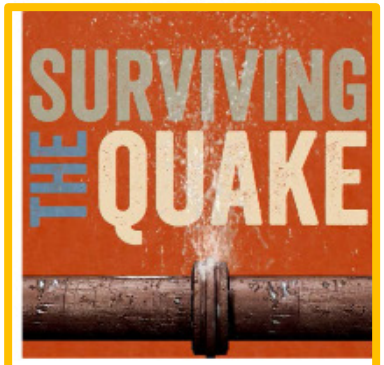

Introduction and Video

1. Understand the Earthquake Threat

2. Identify Vulnerable Assets & Determine Consequences

3. Pursue Mitigation and Funding Options

EPA

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A Guide for Water and Wastewater Utilities

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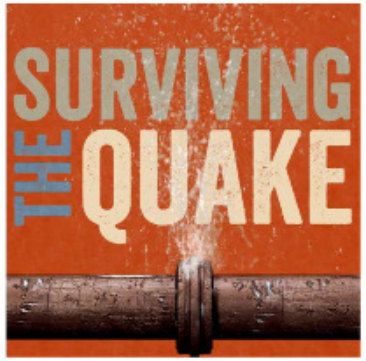

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1. Understand the Earthquake Threat

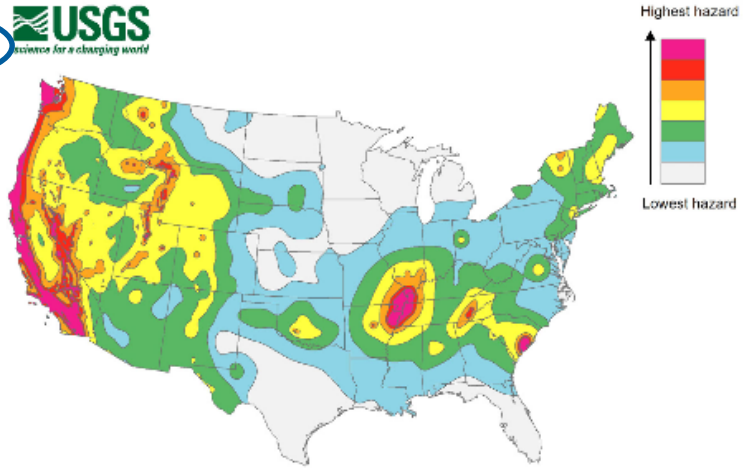
More than 143 million Americans live in areas that are vulnerable to earthquakes.

- The Western U.S. is particularly vulnerable due to a large number of faults or fractures in the earth's crust.
- In the Midwest, the New Madrid Seismic Zone is a significant threat to at least seven states.
- In the East, earthquakes are much less common; however, South Carolina has a significant seismic hazard.
- Both Alaska and Hawaii are prone to major earthquakes.

With thousands of water and wastewater utilities located across the country, there are many utilities located in earthquake hazard areas.

Is your Utility in an Earthquake Hazard Area?

- First, determine the earthquake hazard to your utility. Use EPA's Earthquake Interactive Maps to locate your utility on the hazard maps. Also, learn more about earthquakes below.
- Then, contact your state hazard mitigation officer and work with your local mitigation planner. They may have already assessed and characterized your local earthquake hazard.

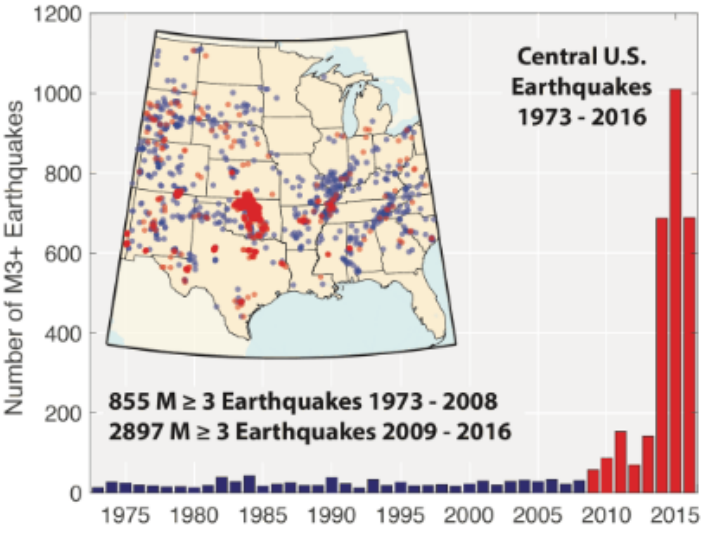


1. Understand the Earthquake Threat

Understand Earthquakes and Ground Movement

There are different types of earthquakes (e.g., natural and induced) and different types of ground movement (e.g., liquefaction, lateral spreading, and settling). Below are short descriptions.

- **Natural Earthquakes.** Large earthquakes occur on fault lines when rock bodies slip relative to each other. Seismic activity can happen deep in the earth or closer to the surface. The deepest earthquakes occur at subduction zones and can shake the ground over many hundreds of miles. In contrast, crustal earthquakes are generally shallower. They can still cause intense shaking, but in more localized areas and are more likely to have faults that rupture the ground surface.
- **Induced Earthquakes.** Induced earthquakes are caused by human activity and are typically attributed to the injection of wastewater fluid into deep wells as part of oil and gas extraction. When the fluid is injected near an earthquake fault, the increased pressure can reduce friction, prompting fault movement and inducing earthquakes. In the central U.S., the number of natural and induced earthquakes has increased dramatically since 2009 based on U.S. Geological Survey data. The chance of induced earthquakes that can damage buildings and infrastructure is increasing in north-central Oklahoma and southern Kansas.
- **Liquefaction.** When earthquakes occur near saturated, loose, sandy soils (e.g., by rivers, lakes, or high groundwater), the shaking can turn the ground to liquid. This phenomenon, called liquefaction, can be very



DETOUR

Learn about earthquake severity, or intensity scales

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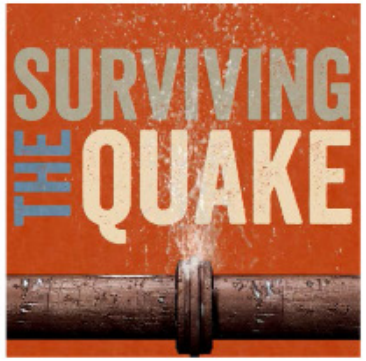

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EPA

2. Identify Vulnerable Assets & Determine Consequences

Building Structure	Anticipated Damage
Unreinforced masonry	Severely cracked or collapsed walls. Separation between floors and walls jeopardize vertical support of roof and floor systems, leading to collapse
Unreinforced brick	Substantial damage
Tilt up concrete	Connection between the roof and walls can fail causing roof collapse
Non-ductile concrete frame	Lateral movement can strain frame leading to catastrophic collapse
Non-Structural elements (e.g., chimney, cladding, shelving, etc)	Detach from building injuring people and impeding evacuation or access

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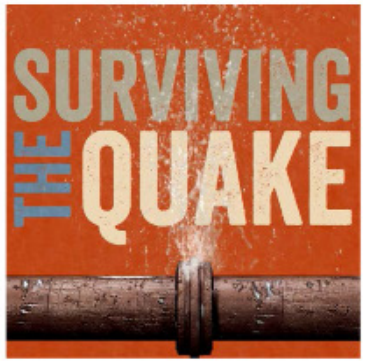

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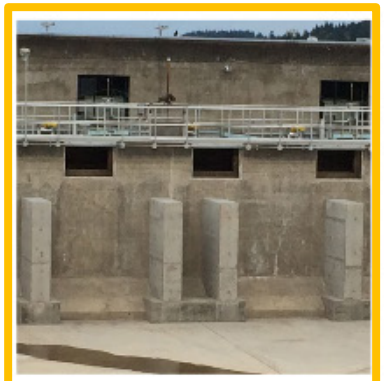

3. Pursue Mitigation and Funding Options

EPA

3. Pursue Mitigation and Funding Options

Mitigation refers to any action or project that can help utilities better withstand a hazardous event (e.g., an earthquake), minimize damage, and rapidly recover from disruptions to service. An example is to replace vulnerable buried pipe with seismic resistant pipe. Utilities should consider taking mitigation steps. Mitigation can improve your utility's ability to provide services after an earthquake. Your customers and community are depending on the lifeline services of safe drinking water and wastewater. Increasing your utility's resilience to earthquakes can be part of a long term capital improvement and asset management plan. As one strategy, when you replace aging equipment after its design life, add seismic upgrades, which are typically not major costs.

Mitigation Options

Fortunately, many utilities have evaluated the threat of earthquakes and taken actions to mitigate damage. From this utility experience, EPA assembled effective mitigation approaches including some low cost options. Select from mitigation:

For Immediate Life Safety

For Key Assets and Significant Vulnerabilities

Through Emergency Response

By Specific Asset

Funding Options

Utilities have many options to implement and fund earthquake mitigation projects. Click the following:

Funding Options

Learn more about mitigation from other sources

Learn more about seismic building codes

3. Pursue Mitigation and Funding Options

Mitigation for Immediate Life Safety

✓	Mitigation Options for Immediate Life Safety	Cost
1. Protect your employees		
	a. Make sure employees know your emergency response plans and practice emergency action drills.	$
	b. Maintain emergency generators (seismically certified) at employee locations to help mitigate widespread power outages.	$$
	c. Retrofit buildings to prevent collapse of occupied buildings. For seismic protection, follow the ASCE 7 Standard Minimum Design Loads for Buildings and Other Structures (2016) for new buildings and ASCE 41-06 for retrofit buildings. This could be accomplished by adding new seismic bracing or shear walls.	$$$
	d. Anchor equipment (e.g., computers, bookshelves) as well as laboratory equipment and chemical/fuel tanks.	$
	e. Identify people who can perform post-earthquake building inspections for safety.	$
2. Protect the public from catastrophic failures of vulnerable storage tanks or reservoirs		
	a. Seismically retrofit water tanks (e.g., anchoring to foundations).	$$$
	b. Strengthen concrete tank walls, replace non-flexible connections, and improve roof structures over large reservoirs.	$$$
	c. For new tank installations in high risk seismic zones, determine if liquefaction or other permanent ground movements are possible. If so, stabilize the foundation to minimize movement. Design the tank height to safely account for sloshing forces during an earthquake.	$$$
3. Plan for emergency public health and firefighting		
	a. Work with community and state officials to develop a plan to provide emergency drinking water.	$
	b. Develop a plan for emergency sewage capability, including portable or improvised chemical toilets.	$
	c. Plan for use of temporary bypasses to move wastewater flow away from the public following ground movement.	$$
	d. Address high consequence sewers like those that are difficult to repair (e.g., under rivers, highways, or buildings).	$$$
	e. Coordinate with firefighting agencies on a plan for obtaining alternate water supplies if the water system is disrupted. For example, consider swimming pools, reclaimed water, and pressurized seawater.	$

3. Pursue Mitigation and Funding Options

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3. Pursue Mitigation and Funding Options

Mitigation by Specific Asset

Click a photograph below and get information on specific earthquake mitigation options for that asset.

Pipelines

Buildings

Treatment Facilities, Pumps, Lift Stations, Sewers

Basins, Reservoirs, Impoundments

Above Ground Storage Tanks

Power Supply and Electrical Components

Wells, Source Water, and Dams

3. Pursue Mitigation and Funding Options

Pipelines

✓	Mitigation Options for Pipes	Cost
1. Above Ground Pipes		
	a. Brace pipes with ties or other methods; provide flexibility and connections to hard points.	$$
2. Underground Pipes – Non Liquefaction Areas		
	a. Use modern pipe (e.g., DIP, PVC) which is typically adequate for areas with small to moderate ground motions and no permanent ground deformation.	$$
	b. Replace vulnerable transmission and backbone piping first before distribution piping. For vulnerable pipelines, consider installing redundant pipes in locations with less seismic activity.	$$$
3. Underground Pipes – Liquefaction Areas		
	a. Use seismic resistant pipe such as steel with welded joints, HDPE pipes with fused joints, ductile iron pipe with seismic joints, or molecularly oriented PVC pipes with restrained joints (AWWA C909) for transmission pipelines subject to ground deformation from liquefaction and landslides.	$$
	b. Slip line existing pipe with HDPE to decrease the pipe's vulnerability.	$$
	c. Replace pipes in accordance with Seismic Guidelines for Water Pipelines (ALA, 2005) for pipes in areas with moderate to high liquefaction or that traverse active faults.	$$$
	d. Consider changing pipe alignment to avoid liquefiable areas or replace with new pipe. Intake pipes are often susceptible to liquefaction. Stabilization of soils (e.g., deep soil mixing and stone columns) is possible, but expensive.	$$$
	e. Install portable facilities (e.g., hoses, pumps) to allow pipelines to bypass areas of liquefaction.	$$

Cost Key (Provides relative costs of mitigation measures - actual costs may differ for your utility)
$ - Little to no cost. Some internal level of effort required, but no contractor support needed.
$$ - Moderate cost/complexity. Likely involves contractual costs.
$$$ - High cost/complexity. Will require one or more contractors to implement this option.

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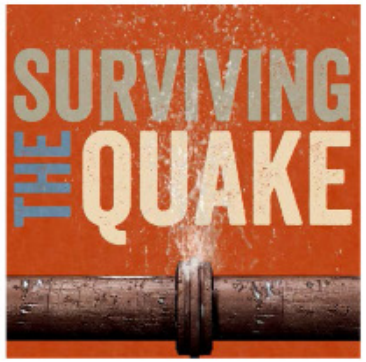

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Earthquake Interactive Maps

EPA

Introduction and Video | Natural Earthquakes | Faults | Liquefaction | Induced Earthquakes | Historical Earthquakes | Utility Examples

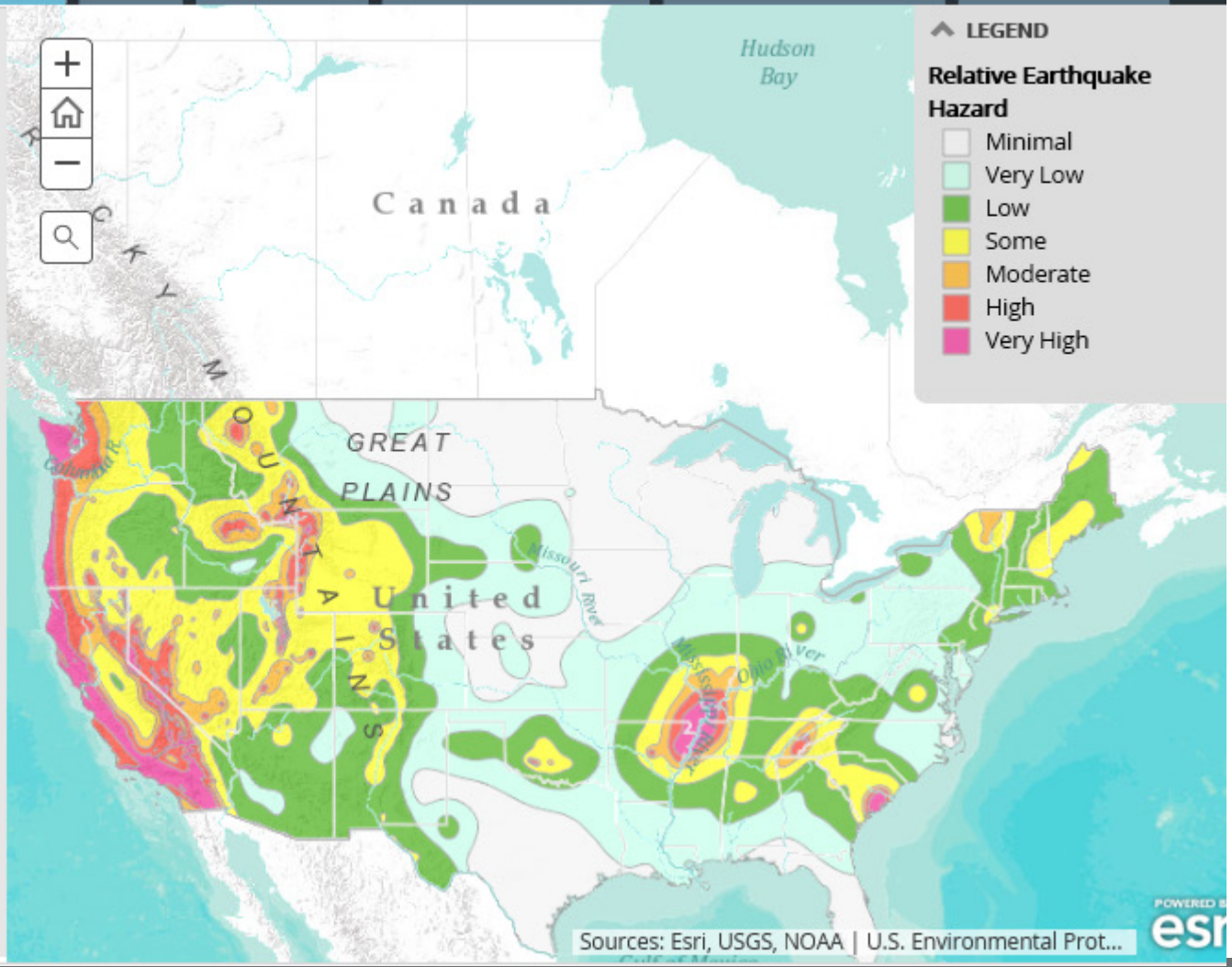
Natural Earthquakes

Some natural earthquakes occur deep in the earth and shake the ground over many miles. Other earthquakes are shallow, causing more localized impacts. This map presents the relative earthquake hazard* based on the likelihood that an earthquake will cause building damage over a particular timeframe.

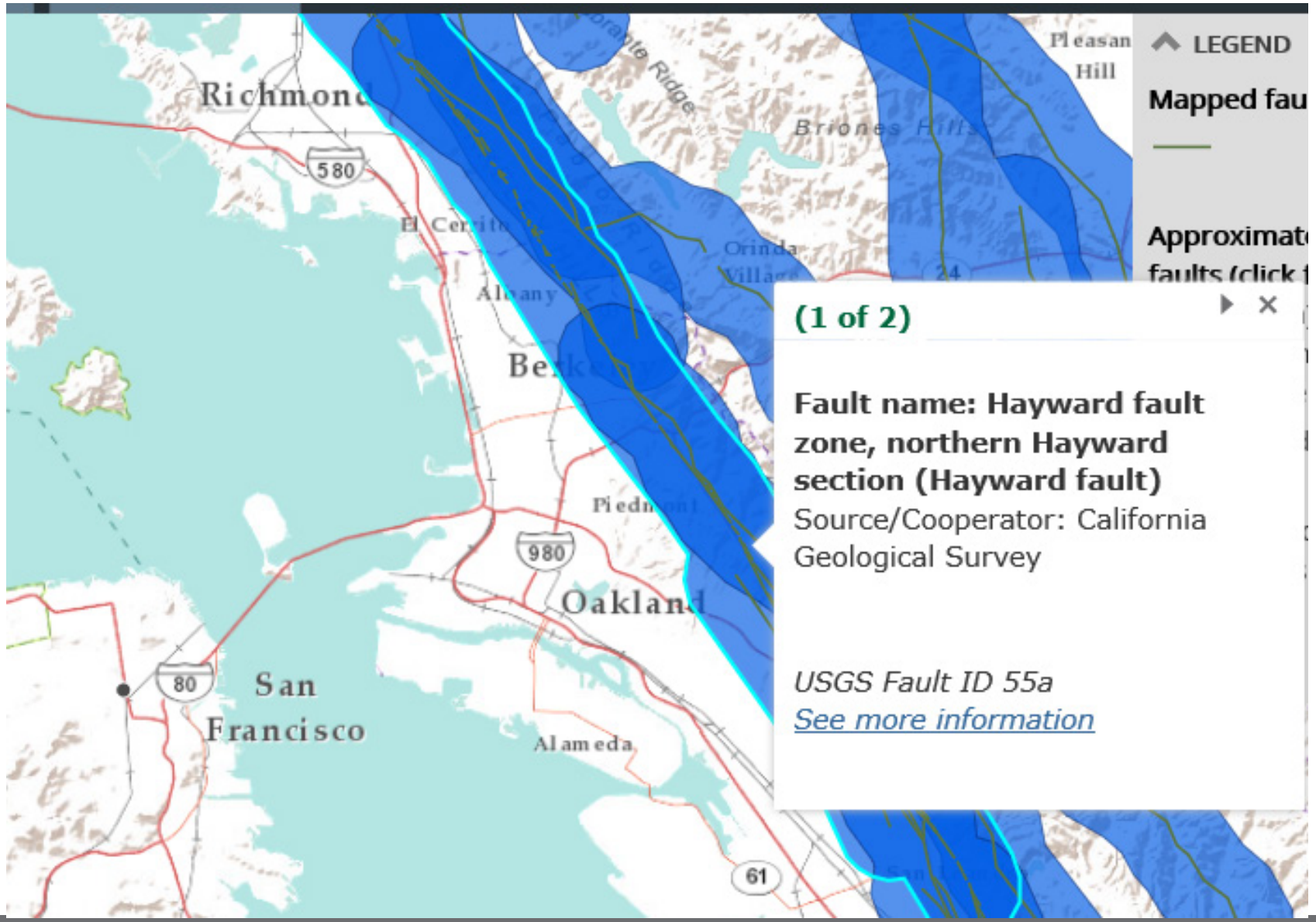
At the symbol, type in your location or use the map controls to zoom.

Click here for a hazard map of **Alaska (2005 data)** or **Hawaii (1998 data)**, or return to the **Continental United States (2014 data)**.

**Defined in this map as intensity level of IV or greater on the Modified Mercalli Intensity Scale equivalent to 2% Peak Ground Acceleration over 50 years.*



Faults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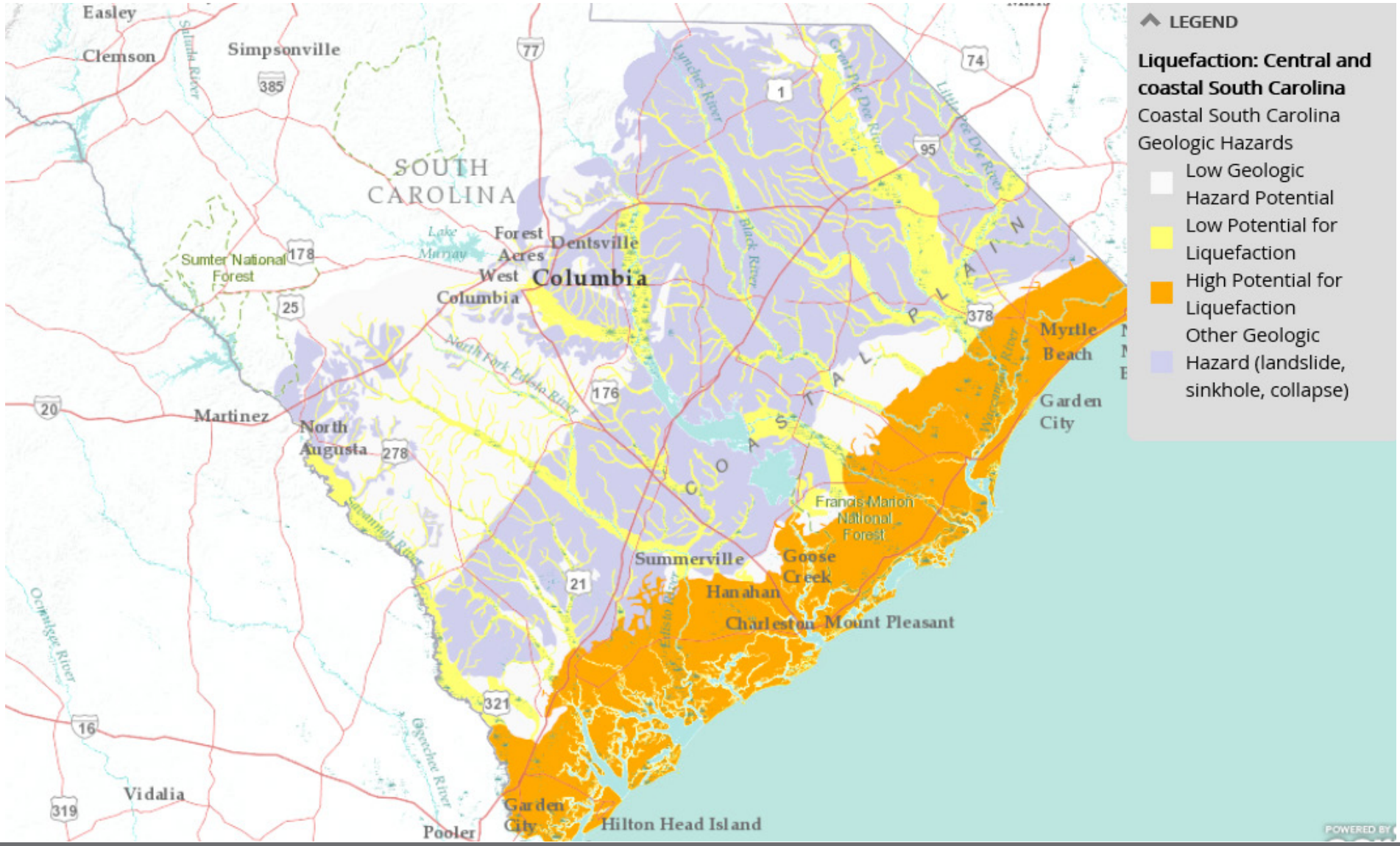
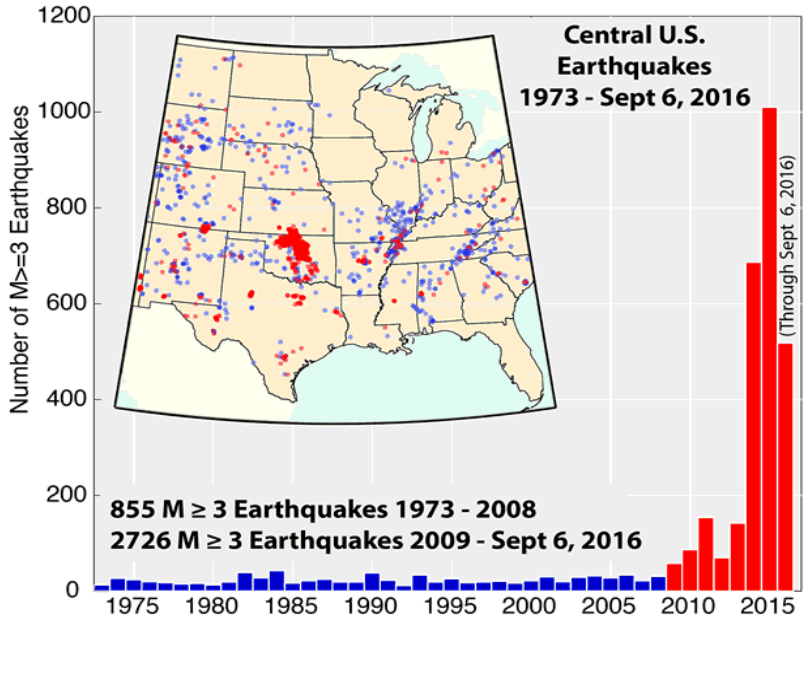
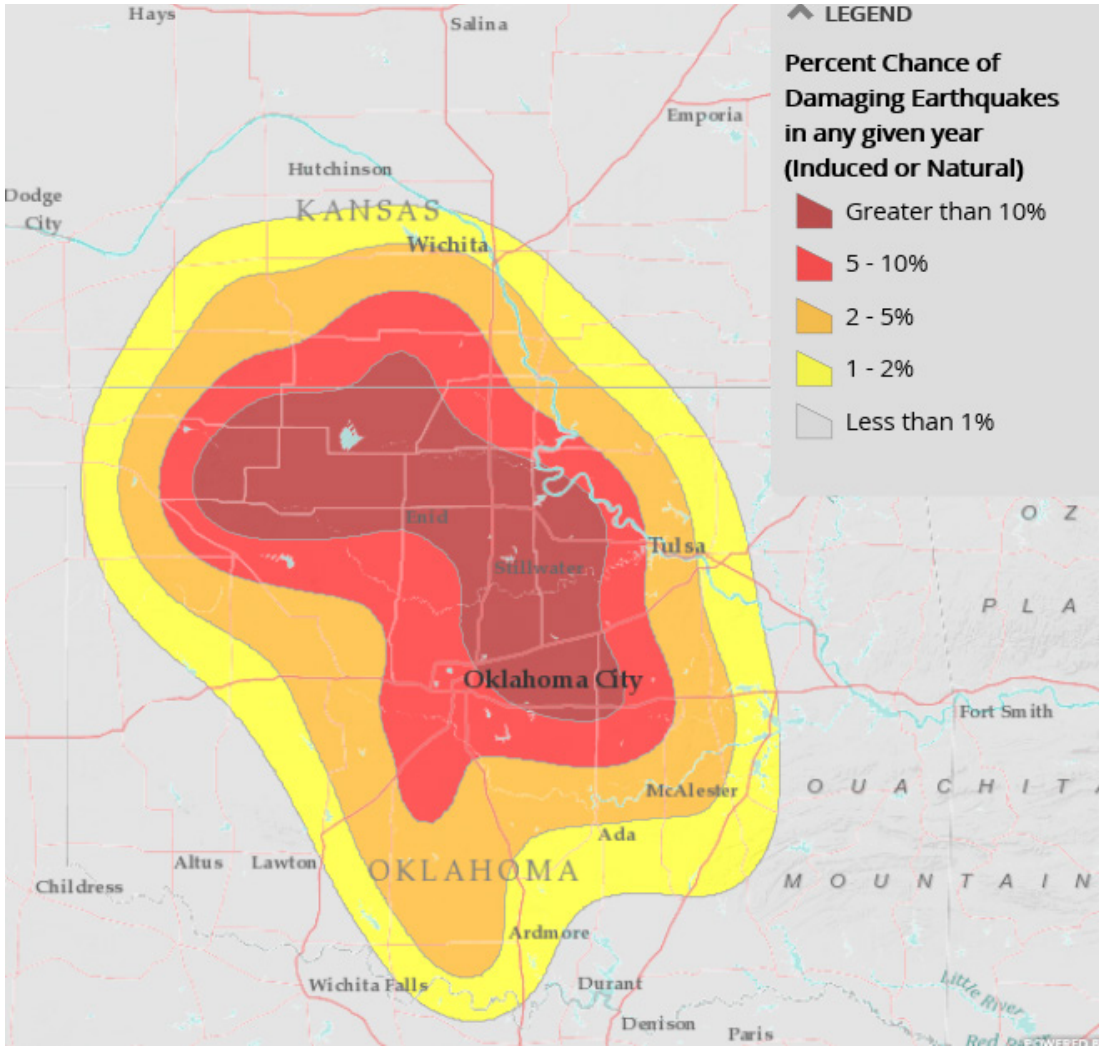
Mapped fau
Approximat
faults (click
(1 of 2)
Fault name: Hayward fault zone, northern Hayward section (Hayward fault)
Source/Cooperator: California Geological Survey
USGS Fault ID 55a
See more information
Richmond
Pleasant Hill
Orinda
Oakland
San Francisco
Alameda
580
980
80
61

Liquefaction

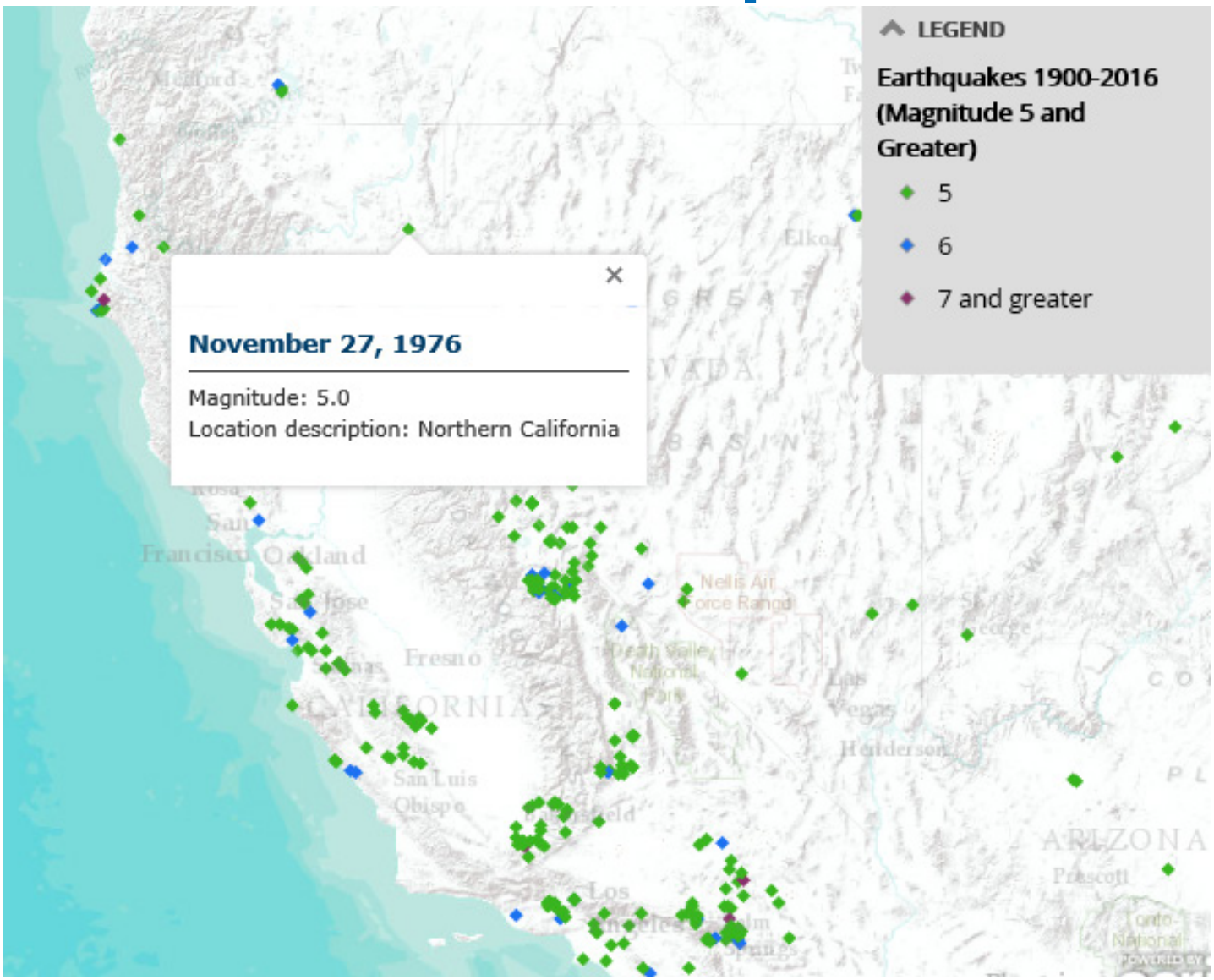


Induced or Natural Earthquakes





Historical Earthquakes



Utility Examples

East Bay Municipal Utility District

Jackson Energy Authority
One thing you can count on.

Jackson Energy Authority

Jordan Valley, Utah

City of Los Angeles

Los Angeles Department of Water and Power

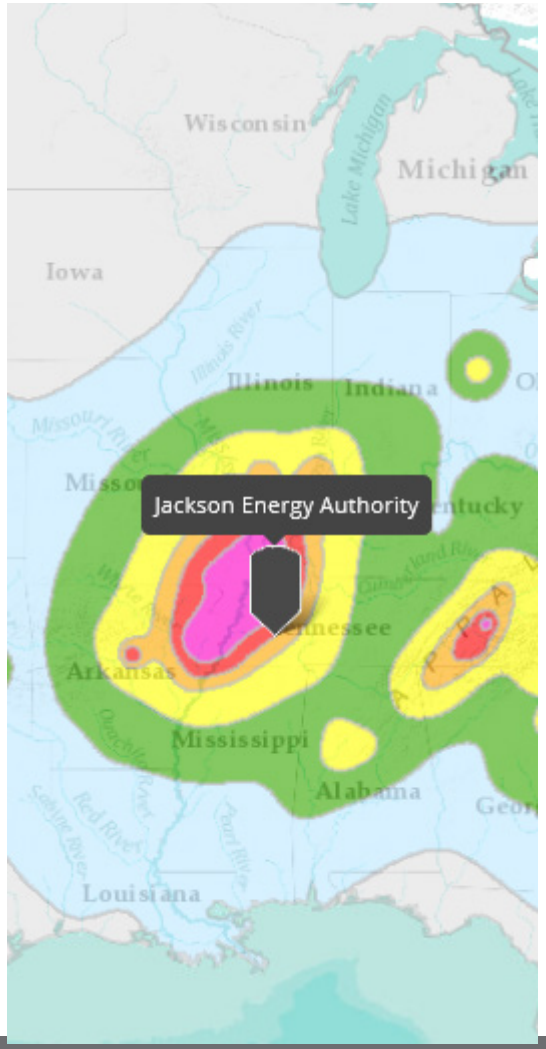
Oregon

PORTLAND WATER BUREAU
FROM FOREST TO FAUCET

Portland Water Bureau

Seattle Public Utilities

Utility Examples (continued)



Jackson Energy Authority

One thing you can count on.

Evaluations and Retrofits

Jackson Energy Authority (JEA) serves 40,000 residences, businesses and industry in Jackson, Tennessee and parts of Madison County. JEA had engineers conduct a seismic evaluation to identify which parts of the system were vulnerable to the effects of earthquakes. This evaluation was used to identify opportunities for retrofits and other mitigation measures. JEA has focused on strapping down equipment and shelving, particularly in laboratories. Storage of laboratory glassware has also been addressed and chlorine tanks are strapped down at JEA facilities.

Bypassing Damage

Wells are expected to remain intact but there are concerns about the effects of liquefaction on the distribution system. One JEA plant provides water to the majority of its customers but, five years ago, JEA developed a bypass pumping plan. If the wells and raw water lines remain intact when other parts of the system are damaged, it is possible to bypass those damaged sections and route water directly to the emergency backup pumping systems. Once this is accomplished, it is possible to isolate tanks and lines that are losing water.

Working with Response Partners

JEA works with many of its response partners to prepare for earthquakes. JEA participates in earthquake exercises with TNWARN and other organizations to test its response capabilities. Critical care partners are also included in JEA's earthquake plans: Established hospitals and potential field hospitals are included in a "red zone" contingency plan. Under this plan, JEA could construct a new system to supply water using temporary aboveground piping and hoses. Transportation throughout the service area is part of the logistics plan. Employees of JEA also have badges to get through checkpoints during an incident.

Communication

As with any emergency response, communication will be crucial when responding to an earthquake. JEA is prepared for communicating in an emergency and participates in GETS (Government Emergency Telecommunications Service) to help prioritize emergency

Where are Earthquake Resilience Products on EPA Website?

Emergency Response for Drinking Water and Wastewater Utilities

EPA has a variety of tools and guidance to support drinking water and wastewater utility preparedness and response. Our resources can help you become a more resilient utility.

Emergency Planning

- Develop emergency response plans
- Plan for emergency drinking water supplies
- Explore the Response Protocol Toolbox

Hazard Resilience

- Mitigate natural disasters
- Build flood resilience
- Respond to drought
- Build earthquake resilience

Related Information

- Water Resilience
- Water Utility Response On-The-Go Overview Video
- Community Water Resilience

Join Our Email List

Featured Tools

https://www.epa.gov/waterutilityresponse

Outreach on Earthquake Resilience

- Products posted on EPA website (available late Fall 2017)
- Presentations at conferences and poster sessions
- Possible journal articles
- Visits to communities in New Madrid Seismic Zone

Outreach on Earthquake Resilience
(continued)

- Expert panel webinar – presentation and Q&A
- Involvement in New Madrid Recovery Exercise in 2018
- Email flyer to utilities, state agencies in at-risk states and regions

EPA United States Environmental Protection Agency

Thank You!

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