

Seismic Risk: Pre-Work

Paper Maps Version

Early on the morning of April 16, 1906, a magnitude 7.8 earthquake struck on the San Andreas Fault. The 1906 San Francisco earthquake revolutionized our understanding of the damage an earthquake could do, as well as the possible measures that communities could take to avoid earthquake damage.

The *magnitude* of the San Francisco earthquake only tells part of the story about the earthquake’s damage. One way to examine the effects of an earthquake is to assess how strong the ground shook during the tremor. This can be done quantitatively using instruments that record ground shaking (like the accelerometer in your smartphone or computer!), or qualitatively using people’s reports of strong shaking.

Before exploring the effects of the 1906 earthquake, watch the video on ground shaking and liquefaction at:

https://www.youtube.com/watch?v=536xSZ_XkSs

The following questions will guide you through your exploration.

1. Based on the video, predict the types of locations that might experience the most earthquake damage due to strong ground shaking and/or liquefaction.

On page 3 of this handout is a map that illustrates the intensity of shaking, based on reports, from the 1906 earthquake. The color scale corresponds to the severity of shaking, with red the strongest shaking. As you might expect, the shaking was very intense near the San Andreas Fault, where the earthquake motion occurred. But there are several pockets of intense shaking far from the fault. Four of these areas – two in the north part of San Francisco Bay, and two in the east – are identified on the map. Find the four case study areas labeled N1 (North Bay 1), N2 (North Bay 2), E1 (East Bay 1), and E2 (East Bay 2) on the map. Note that the circled numbers refer to material in a later question.

1. Use the color on the map and the legend to estimate the average shaking intensity in each case study area. Write this in the table below (North Bay 1 is done for you).
2. On page 4 are geological maps of each case study area. On these maps, each colored region represents a different rock type and age. The colors are illustrated on the legend at the bottom of the page. Estimate what rock type or types cover the majority of each case study area. Make sure your estimates are similar to what is in the table below.

	North Bay 1	North Bay 2	East Bay 1	East Bay 2
Shaking Intensity	Violent			
Rock Type	Alluvium (loose river sediments)	Bedrock/ Very Old Sediments	Artificial Fill	Bedrock/ Very Old Sediments & Young Sediments

In summary, what groups of rocks might make a region more or less susceptible to shaking in an earthquake? How does this match your predictions from question 1?

Besides the intensity of shaking, damage to structures in earthquakes is due to four main factors: strong shaking, liquefaction, ground deformation, and landslides. In many cases these effects are compounded by construction as well as by fires and other types of post-earthquake damage. On pages 5-6 of this handout are five firsthand accounts and photographs of effects from the 1906 earthquake. The numbers refer to locations on the shakemap. Read through and look at these documents.

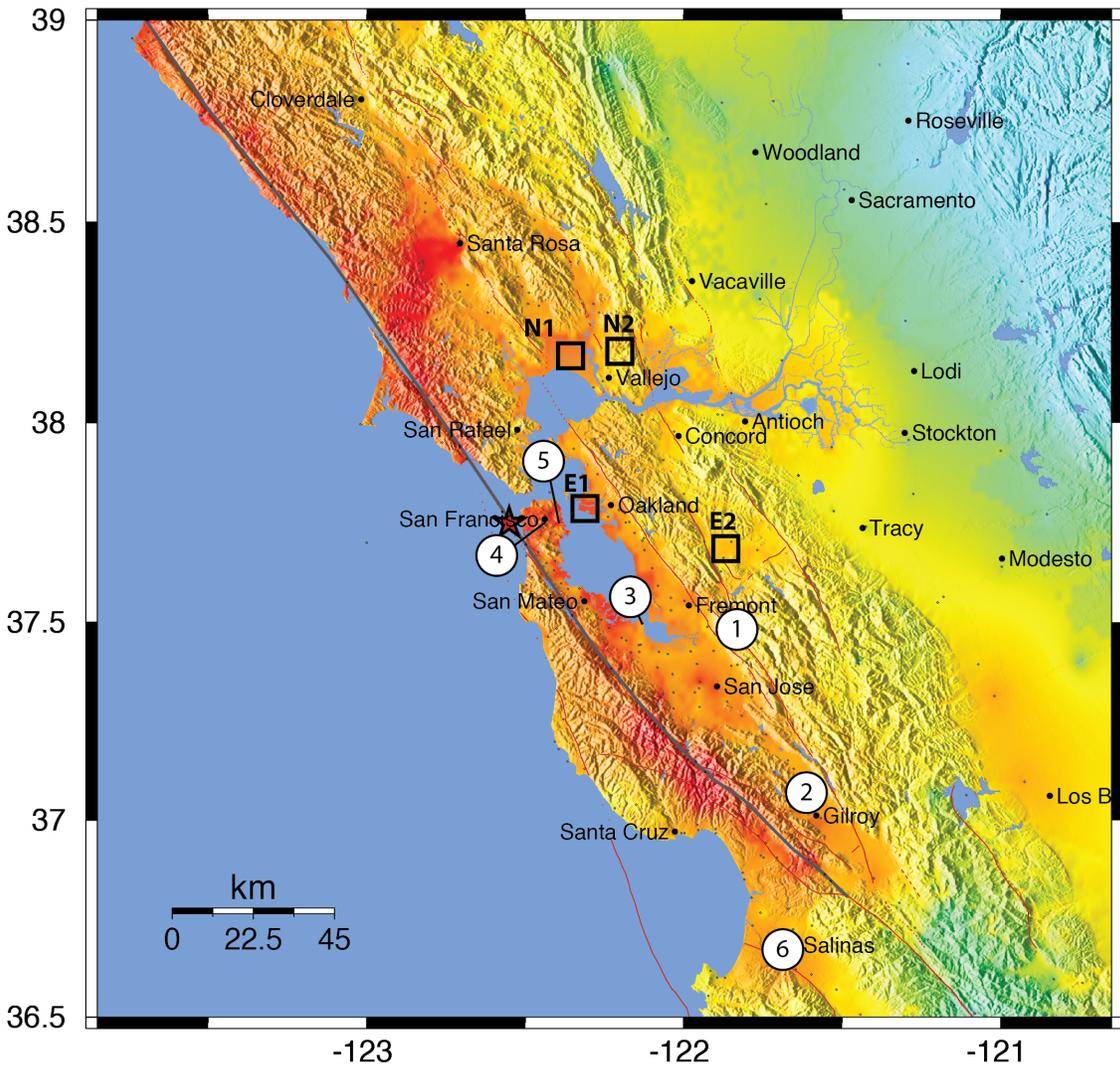
3. You will notice some commonalities among the effects of the earthquake in the photos and accounts. What can you infer about the following from these common characteristics?
 - a. Where, specifically, around San Francisco is liquefaction likely to occur?

 - b. What characteristics of buildings and building sites make them unlikely to survive an earthquake?

The map on page 7 of this handout illustrates the populated areas of present-day San Francisco.

2. Suppose that modern fire and rescue crews, responding to an earthquake similar to the 1906 quake, had to prioritize which of the case study areas (North Bay 1/2, East Bay 1/2), to search first for earthquake survivors and casualties. Which area should get priority? Why?

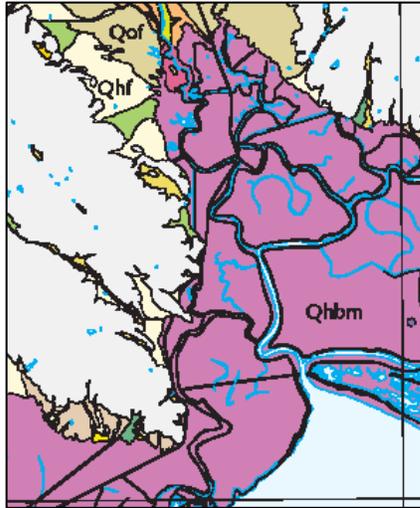
1906 Earthquake, M7.8, Depth 10 km, Epicenter N37.75 W122.55



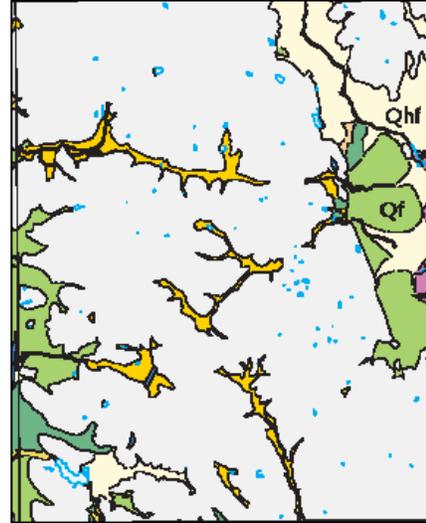
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Shakemap for 1906 earthquake showing case study areas. Source: USGS (<http://earthquake.usgs.gov/regional/nca/1906/shakemap/>)

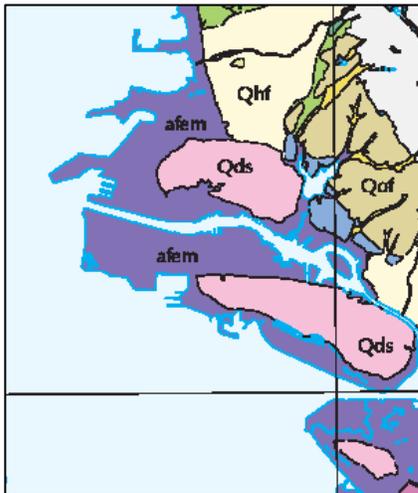
North Bay 1



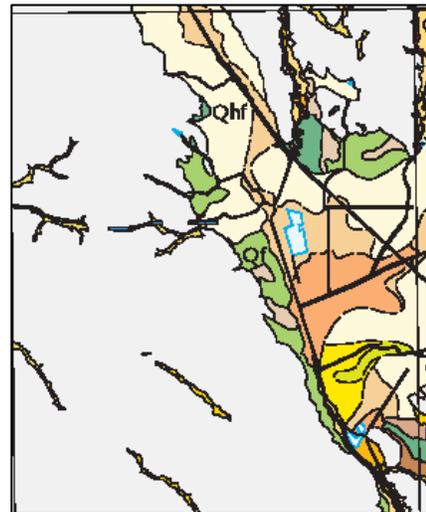
North Bay 2



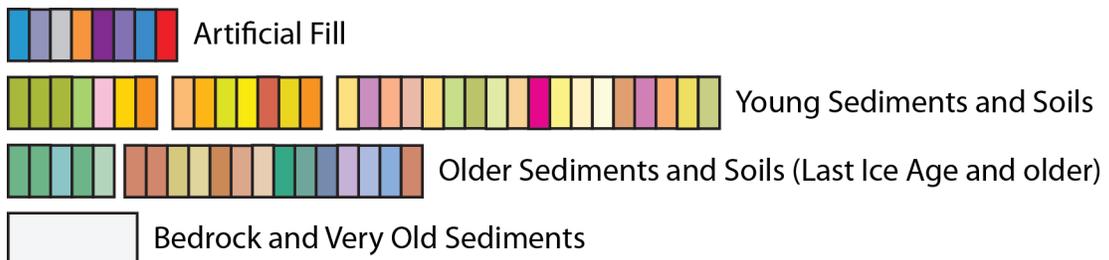
East Bay 1



East Bay 2



Geological maps of case study areas. Colors refer to rock or soil types at the ground surface. Colors explained below. Source: USGS Open File Report OF06-1037.



1906 Earthquake Accounts and Photos

Source for all images and quotes: USGS (<http://earthquake.usgs.gov/regional/nca/virtualtour/>)

1: Calaveras Valley

"All the brick chimneys were thrown down, tho there were only a few ...No damage to houses is reported."

2: Gilroy

"Nearly every chimney fell, fire-walls of brick buildings were thrown down."

3: Cooley's Landing, near Dumbarton Bridge

"No damage but broken chimneys was noticeable ...One house on a poor foundation was knocked down."

4: Valencia Street, San Francisco



Valencia Street Hotel between 18th and 19th Streets. Left photograph shows the hotel before 1906. Right photograph shows the hotel after the earthquake, before it was lost to the fire. The hotel collapsed so that occupants of the fourth story could step out into the street. There were at least 100 casualties.

5: Ferry Building, San Francisco



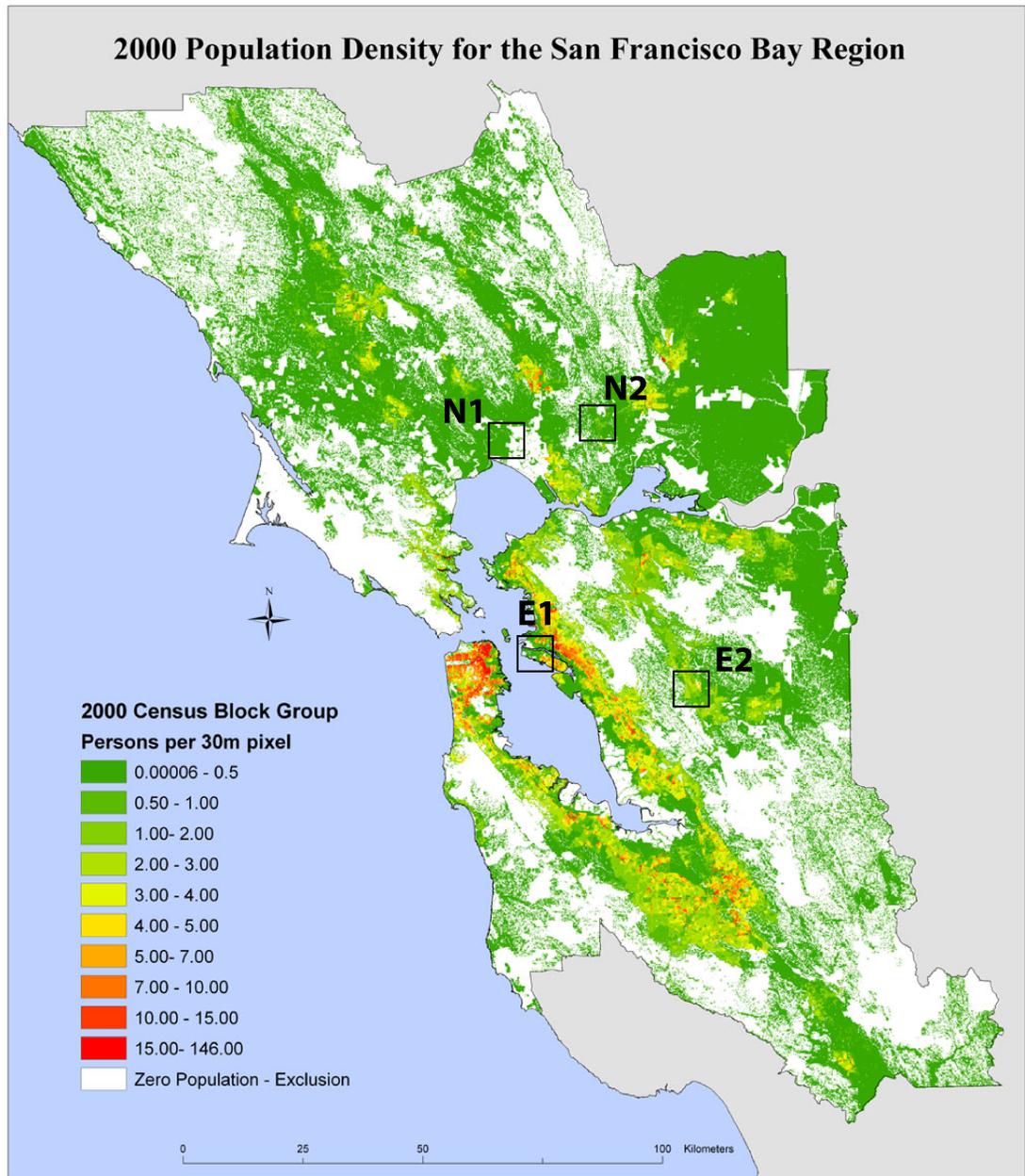
"Sunken area on Market Street near Ferry building. "About the Ferry Building, at the foot of Market Street, is a district of 'made' land, in which high (shaking) intensity was manifested. Here the fire burned fiercely and caused great havoc...much of the damage due directly to the shock

was thereby concealed or obliterated, that no adequate knowledge of the direct effects of the earthquake could be obtained in this part of the city..." From Lawson, 1908.

6: Spreckels



"County road disrupted by slumping and lateral spreading along Salinas River, near Spreckels. Location approximate."



Population of the San Francisco Bay Area. Source: USGS Fact Sheet FS2008-3010 (<http://geography.wr.usgs.gov/science/dasymetric/>).