

Forecasting a Fault: How California Plans for Quakes No One Can Predict

Learning target: I can use evidence from a text to explain the difference between predicting and forecasting an earthquake, and how forecasts built from hazard data guide ways to reduce harm.

Reading with evidence

About 40 min

Individual

MS-ESS3-2 · practice

MS-ESS2-3 · supports

reading

writing

Name _____

Date _____

Period _____

Directions

Read the whole passage once to get the big picture. Then read it again with a pencil: underline each place where the writer gives a number, and put a star next to each way people reduce earthquake harm. Paragraphs are numbered so that you can cite them. When a question says *cite*, name the paragraph number and use the passage's evidence in your own words.

You will need: This worksheet, Pencil, Highlighter (optional)

Forecasting a Fault

[1] **(1)** On October 17, 1989, about 60,000 fans were settling in at San Francisco's Candlestick Park for a World Series game. At 5:04 p.m. the stadium began to sway. For roughly fifteen seconds, the magnitude 6.9 Loma Prieta earthquake shook the Bay Area. A section of the Bay Bridge's upper deck dropped onto the deck below, and a double-decker freeway in Oakland collapsed. No one had warned the city. That is normal for earthquakes.

[2] **(2)** California sits on the boundary between two tectonic plates. West of the San Andreas Fault system, the Pacific Plate is grinding northwest past the North American Plate at a few centimeters per year, about as fast as your fingernails grow. The fault's rough sides lock together while the plates keep moving, so the rock on both sides slowly bends and stores energy, like a ruler bent between your hands. When the stress becomes greater than the friction holding the fault, the rock suddenly slips. The spot underground where the slip begins is the focus, and the stored energy rushes outward as seismic waves. Then the fault locks again and the cycle restarts.

[3] **(3)** A prediction would name the place, size and time of a coming earthquake closely enough to act on, such as 'a magnitude 7 in the East Bay next Tuesday.' No scientist has ever made a reliable prediction like that. Researchers have tested animal behavior, well water and electrical signals, but none shows up dependably before earthquakes. Some large quakes do follow smaller foreshocks, yet a foreshock looks like any other small quake until the bigger one arrives. Volcanoes are different: rising magma usually announces itself with swarms of small quakes, extra gas and swelling ground. Faults give no such dependable signal, so scientists make forecasts instead. A forecast gives the chance that an earthquake of a certain size will strike a region during a span of years.

[4] **(4)** Forecasts are built from patterns in data. Scientists map active faults and measure how fast each one is loading with stress, with GPS stations. They study the record of past earthquakes: seismograph readings from the last century, written accounts from before that, and soil layers that were torn and shifted by prehistoric quakes. They also count how often quakes of each magnitude occur. Magnitude is a number that describes an earthquake's size, and the scale is logarithmic. Each step up by one whole number means about 32 times more energy released, so a magnitude 7 releases about 1,000 times the energy of a magnitude 5. Small quakes are far more common: for each step up in magnitude, there are roughly ten times fewer quakes.

[5] **(5)** In 2015, the U.S. Geological Survey and its partners combined this evidence into a statewide forecast. It gave a 72 percent chance that the San Francisco Bay Area will have at least one earthquake of magnitude 6.7 or larger in the 30 years starting in 2014, and a 60 percent chance for the Los Angeles region. For California as a whole, the chance was greater than 99 percent. None of these numbers names a year. A 72 percent chance in 30 years means a large Bay Area quake is more likely than not in that window, but it could arrive in the first year, in the last year, or not at all before 2044.

[6] **(6)** Forecasts tell communities where to spend money and effort. To mitigate a hazard means to reduce the harm it causes, since nobody can stop the shaking itself. After a 1933 earthquake near Long Beach wrecked many school buildings, California passed the Field Act, which requires public schools to be built to stronger standards. A 1972 law keeps most new homes off the traces of active faults. Older freeways have been strengthened, and the Bay Bridge's eastern span was replaced by a new one, opened in 2013 and designed for the strongest shaking expected in about 1,500 years. Since 2019, the ShakeAlert system has sent phone alerts in California after a quake starts, giving people seconds of notice before strong shaking reaches them. It is a fast alarm, not a prediction.

Questions: answer from the passage

1. According to paragraph 3, what is the difference between an earthquake **prediction** and an earthquake **forecast**? 2 pts
 - ☐ A. A prediction uses data and a forecast is a guess.
 - ☐ B. A prediction names when, where and how big a quake will be; a forecast gives the chance of a quake of a certain size in a region over a span of years.
 - ☐ C. A prediction is for small quakes and a forecast is for large quakes.
 - ☐ D. A forecast names the exact day of a quake, while a prediction only names the region.
2. Paragraph 2 compares a locked fault to a bent ruler. Explain the comparison in your own words: what is being bent, what is stored, and what event matches the ruler snapping back? Cite the paragraph. 3 pts

3. Why can't scientists use foreshocks as a warning system? Cite the sentence in paragraph 3 that explains the problem, then explain it in your own words. 2 pts

4. Use paragraph 4. (a) How many times more energy does a magnitude 8 earthquake release than a magnitude 6? Show the multiplication. (b) If a region has about 200 magnitude 4 quakes in a century, about how many magnitude 6 quakes would you expect in the same century? 3 pts

5. Paragraph 4 lists three kinds of records of past earthquakes. Which two of them come from before seismographs existed, and why do scientists need records that old to forecast large quakes on one fault? 2 pts

6. A family in Oakland reads the 72 percent forecast in paragraph 5. Write one thing the number **does** tell them and one thing it **does not** tell them. Cite the paragraph. 3 pts

7. Paragraph 6 describes four ways California reduces earthquake harm. Complete the table. 4 pts

Type of mitigation (building rule, land-use rule, strengthening or replacing, or warning)	What harm it reduces
The Field Act (1933)	
The 1972 fault-trace law	
The new Bay Bridge east span (2013)	
ShakeAlert (2019)	

8. A website headline says: '**Scientists Predict the Big One Will Hit the Bay Area Soon.**' Use evidence from at least two different paragraphs to explain what is wrong with the headline. Then write a more accurate headline of no more than 15 words.

4 pts

Find it, then say it

Before you answer, find the paragraph. Use these frames: 'In paragraph __, the writer says that __. This means __.' For q4, remember that each whole-number step multiplies the energy by about 32 and divides the number of quakes by about 10, so two steps multiply by 32 twice and divide by 10 twice. For q7, the four types are already named in the column heading; match each law or project to one type.

Why fifteen seconds, and why so far away?

The Loma Prieta epicenter was in the Santa Cruz Mountains, nearly 100 km south of the Oakland freeway that collapsed. Some of the worst damage happened on soft, wet ground near the bay, where shaking grows stronger. Research how loose, water-soaked soil can make shaking worse (look up *liquefaction* and *site amplification* on a USGS page). Then write a paragraph explaining why a hazard map for a city might show different risk on two streets that are the same distance from a fault.