

## Risk Factors Worksheet

This activity addresses the following learning objective:

3. Students will evaluate information about seismic hazard, building construction, and population to quantify risk on the Pacific/North America plate boundary near San Francisco.

Although the 1906 San Francisco Earthquake devastated both life and property in the San Francisco Bay area, it also taught geologists and engineers a great deal about what makes for earthquake-safe buildings. In the prework, you saw some examples of buildings that failed in the 1906 earthquake. In this activity, you will collect information about several schools to assess their likelihood of failure. Most school buildings are built to fairly high standards. However, no building is perfect, and some schools in earthquake-prone California have a higher seismic *risk* than others. Risk here refers to the potential for loss, either of property or of life. Here we assess risk as the potential for loss of life. Factors that affect seismic risk include:

- *Hazard*: The chance that the building will experience strong shaking (see Unit 1a), soil liquefaction, or a landslide.
- *Vulnerability*: The likelihood that the building will collapse due to those geological hazards.
- *Value*: The number of lives potentially affected (number of students).

### Scenario


The city of San Francisco has passed a bond measure that will give \$10 million each to retrofit two schools out of a set of five that have the highest seismic risk. Your job is to identify which of the schools has the highest risk, and to give the city and the school board advice on where to use the \$20 million.

### Procedure

Download and open the San Francisco Earthquake Hazards Google Earth KMZ file (San Francisco Schools.kmz). Your group will be assigned to examine *one* of the schools.

While some of the steps in this risk analysis sound straightforward, others are somewhat subjective. To make sure that your reasoning is in line with that of your teammates, use the “think out loud” protocol: as you are discussing your group’s assessment of risk at your assigned site, **describe out loud the information you are using to come to a conclusion, and the reasoning you are using to come to your conclusion.**

1. Use the San Francisco Earthquake Hazards Google Earth KMZ file (San Francisco Earthquake Hazards.kmz) to determine the seismic hazard potential at the site of the school that you are investigating.
  - a. Put the school’s name in a new row of the seismic risk analysis spreadsheet.
  - b. Examine the Strong Shaking Potential layer (visible by default). This is a map of the peak ground acceleration (in terms of a fraction of free-fall acceleration due to gravity, g) that is 98% likely to occur in 50 years. Basically, the value of peak ground acceleration is a measure of the most violent shaking expected in a likely earthquake. The higher the acceleration, the stronger the shaking. Clicking on locations in the map will allow you to see the peak ground acceleration as a number (it is listed as “g:”) rather than trying to read the colors on the map. Use the following categories to score the seismic hazard due to strong shaking. Score each school’s location using the numbers in parentheses, based on the ground acceleration. Put the score in the column labeled A on the seismic risk spreadsheet.
    - i. <0.3 g: Low hazard (1)
    - ii. 0.3-0.6 g: Moderate hazard (2)

- iii. >0.6g: Significant hazard (3)
  - c. Examine the Liquefaction Susceptibility layer. You will need to turn this on by checking the box in Google Earth's Places panel. This is a map of the likelihood of liquefaction due to earthquake shaking. Clicking on locations in the map will allow you to see the liquefaction susceptibility (as an abbreviation) rather than trying to read the colors on the map. Score each school's location using the numbers in parentheses, based on the liquefaction hazard. Put the score in the column labeled B on the seismic risk spreadsheet.
    - i. Low / Very Low hazard (1)
    - ii. Moderate hazard (2)
    - iii. High / Very High hazard (3)
  - d. Examine the LIDAR Hillshade layer. You will need to turn this on by checking the box in Google Earth's Places panel. This is a detailed map of topography made using Light Distance and Ranging (LIDAR). Estimate the landslide hazard using the categories below. Score each school's location using the numbers in parentheses, based on the landslide hazard. Put the score in the column labeled C on the seismic risk spreadsheet.
    - i. Low hazard: on flat land (1)
    - ii. Moderate hazard: at foot of slope or on gradual slope (2)
    - iii. High hazard: Building is on a steep slope (3)
2. Building construction plays a large role in determining risk, as you've seen when looking at the destruction from the 1906 earthquake. You can assess some major construction issues using photos of the school buildings. You can find photos of most of the school buildings using Street View in Google Earth. To enter Street View mode, zoom close to one of the school locations. Click the "pegman" icon () and drag it to a street adjacent the school building you want to examine. You can then navigate using the arrow keys on your computer. Note that most schools have multiple buildings. Do your best to search all of the buildings and give the maximum score for each category (\$10 million is more or less enough to retrofit one school building).
  - a. Examine the building the see if there are any "soft stories," floors of the building with few supporting walls, such as parking garages or large auditoriums, that are underneath other floors of the building.
  - b. Buildings made of unreinforced masonry (brick or concrete without reinforcement) are particularly susceptible to earthquake damage. Unfortunately, you have little information besides the photos to go on. If there is clear evidence that a building is made of unreinforced masonry, that building gets a 2 in column C. If the building is made of masonry and it was built before 1970, give it a score of 1.5.
  - c. Buildings with a vertical irregularity (different parts at different heights) or plan irregularity (deviations from a box-shape) tend to fare poorly in earthquakes. Give each building with either type of irregularity a score of 0.5.
3. The "value" we are using when calculating risk in this exercise is the number of lives at risk. You can find additional information about the number of students by clicking on the markers at each school site in Google Earth. This will bring up a web page with student enrollment numbers.
4. Calculate risk using the following:

$$Risk = \frac{(A + B + C)}{9} \times \frac{(D + E + F)}{3.5} \times population$$

Once your group has determined a risk for your school, share your information with the class in the report-out session. *Also be ready to discuss which factors, aside from population, had the most influence on the risk that you calculated.* The risk that you and your classmates calculate will allow you to compare schools in terms of the number of students protected by an earthquake retrofit.