AMP IT UP

Advanced Manufacturing & Prototyping Integrated to Unlock Potential

6TH GRADE SCIENCE

Data Visualization

SHAKE AND BREAK

Earthquake Challenge

Annotated Teacher's Edition

6DVS

SECTION 1 – THE EARTHQUAKE CHALLENGE

1.1 INTRODUCTION

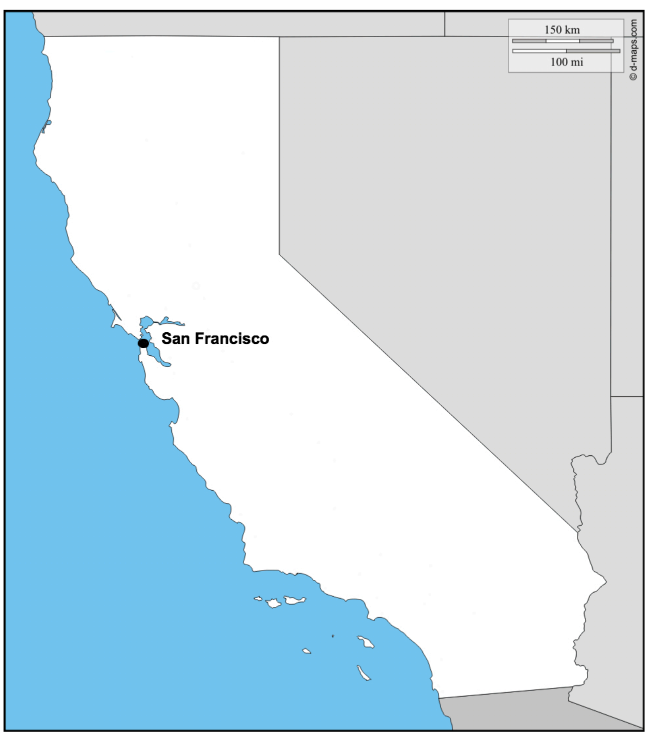
Technology devices like cell phones, tablets and laptops are very common in our modern world. There are nearly 7 billion (7,000,000,000) cell phones in use world-wide. In the United States alone, there are 300 million (300,000,000) in use. Likewise, 42% of adult Americans own a tablet device, like an iPad™ or Galaxy Tab™. The devices help people gather information, stay informed, and connect with people and places.

This technology is a large industry. It supports the lives of many people. Cell phone and tablet companies employ thousands of people. It provides jobs in product design, manufacturing, delivery, sales and repair. Communities all around the world like having these companies in their area. By providing jobs to their residents, these companies help to improve the quality of life in the community.

BuzzTech is a smartphone and tablet computer company that has recently experienced a large increase in sales. BuzzTech products are very popular and the business is growing fast. BuzzTech currently has *only one* manufacturing plant open in Mexico. The company cannot make phones and tablets fast enough to keep up with customer demand. The company needs to open a second plant near their headquarters. This will allow them to keep up with the heavy demand for their products.

BuzzTech's headquarters are in the state of California, near the city of San Francisco. They want to open a very large manufacturing plant within 100 miles of the company's headquarters. This will allow them to manage the plant and their business well.

BuzzTech has identified three possible sites to build the plant in an area just northeast of San Francisco. The three locations are all located within the area marked in red on the map.



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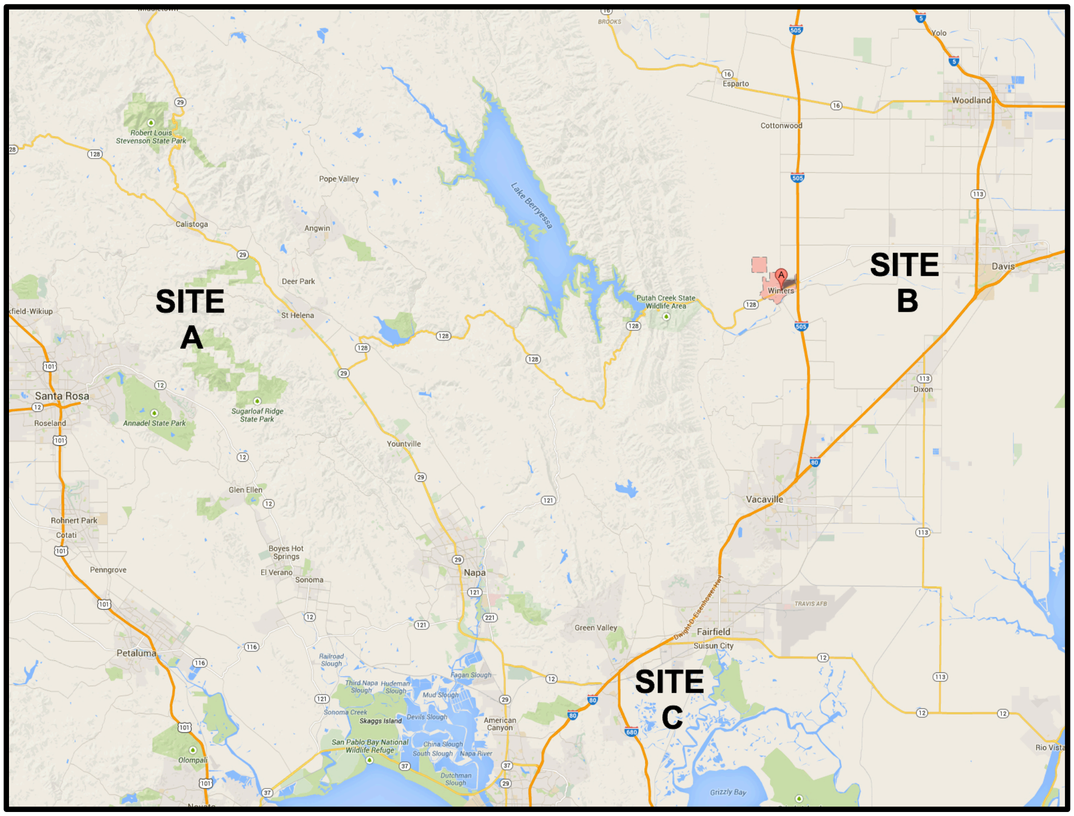
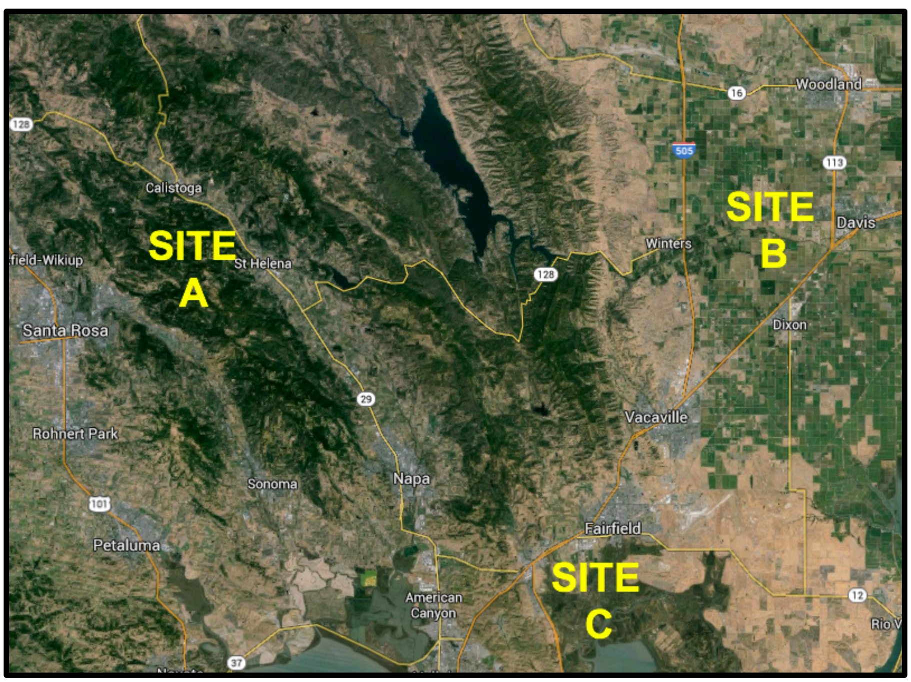
The two images both show the area marked in red. The first image is a simple highway map of the area. The other image shows the terrain of the area in what's called a **relief map**.





** If you want to discuss reading a map, longitude and latitude, topography, elevation changes etc. – this would be a great spot to discuss this content.*

BuzzTech must consider the following factors as they select the site:

1. cost of purchasing the site to build the plant,
2. employees commuting to and from the plant, and
3. options for transporting finished products to the world.

**You may need to clarify these factors (what is necessary for transport to world (airport, seaport), what does it mean to commute etc.*

Each of the three sites has advantages (pros) and disadvantages (cons) across these three factors. Your teacher will review with the class the pros and cons of each site and their locations using a large map.

Site A	Site B	Site C
• Near the popular city of Santa Rosa • Expensive land • Highly populated, short commute • Educated work force • Desirable area to live • Near major highways, but very high traffic causes delays in shipping products	• Isolated location, small town • Cheap land • Small population, need to recruit talent • Long commute for workers from surrounding communities • Expensive transportation costs to ship products	• Near water-front area • Medium-priced land • Highly populated area • Commute is short distance • Desirable area to live • Nearby seaport offers low transportation costs to ship products

Each of these factors is important. BuzzTech needs to balance these sometimes competing factors. For example, Site B has cheaper land. At the same time, Site B also creates a longer commute for a large number of employees. The longer commute might make it difficult for BuzzTech to hire the best employees. Site A has a well-educated workforce. The land, however, is very expensive.

1.2 ONE MORE FACTOR

California is known for its beautiful landscape ranging from mountains to beaches to farmland. It is the number-one producer of fruits and vegetables in the United States. The climate is usually very nice, with pleasant temperatures during most of the year. California is also known for having earthquakes. An earthquake is the result of a sudden release of energy in the Earth's crust, or surface. When the energy is released it creates seismic ('sīz-mik) waves.

At the Earth's surface, these waves cause the ground to shake. Scientists measure the strength of earthquakes using the **Richter Scale.** The scale runs from 1.0 to 10.0, with 1 being the weakest earthquake and 10 Earthquakes sometimes shake the ground violently and cause very serious damage to buildings - even collapse!

KEY TERMS

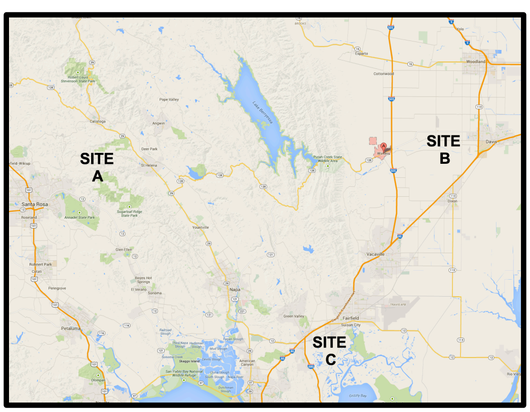
Earthquake: the result of a sudden release of energy in the Earth's crust, or surface

BuzzTech must spend millions of dollars to build their new manufacturing plant. If they build the plant in an area where earthquakes occur, that could possibly lead to employees being hurt (or worse). If BuzzTech's new plant were to be damaged or collapse, it would be a large waste of their money. An event like this might force BuzzTech to go out of business.

1.3 YOUR CHALLENGE

You and your classmates must review the three locations and decide which site is best for the new BuzzTech plant. Consider that earthquakes cannot be your only factor in deciding where to put the plant, and the decision may not be crystal clear right away. Work with your classmates as a team to make an informed and careful decision.

The challenge is going to be for the students to evaluate each site according to how many earthquakes have historically occurred in that site and how severe those earthquakes were (an overall picture of seismic activity) and then evaluate that with other information (provided on the previous page) about each site.



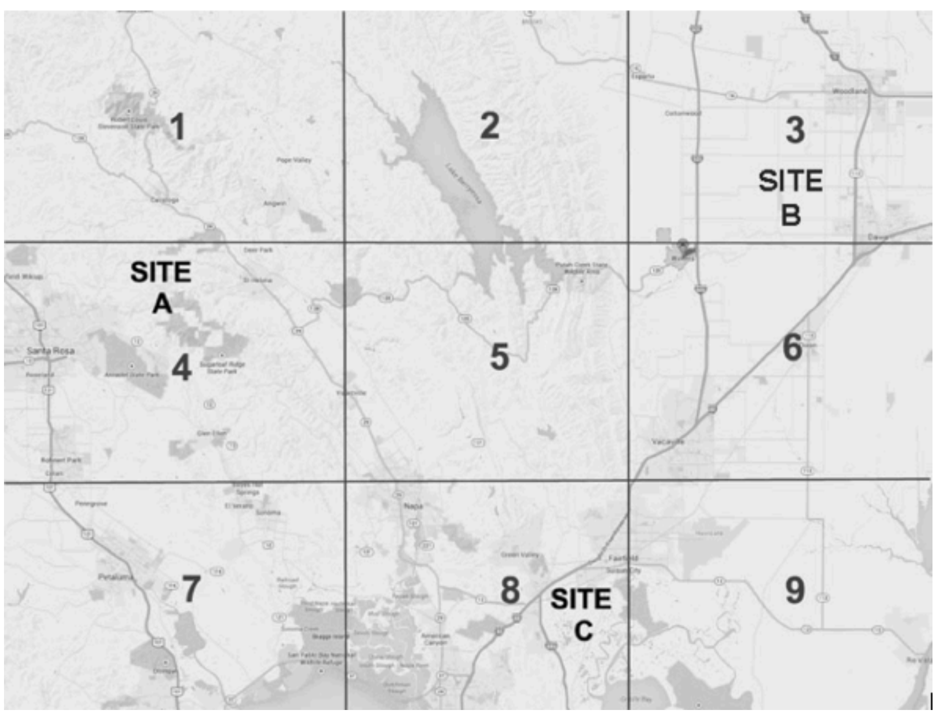
SECTION 2 – INVESTIGATE THE EARTHQUAKE DATA

2.1 PLANT LOCATION AND EARTHQUAKES

It is clear that BuzzTech needs to learn how earthquakes might affect their choice of location. The company is pouring a lot of money into this project. The plant is expected to serve the company for many years... up to 50 years. BuzzTech is aware of the earthquake risk in northern California. They want to learn more about the history of earthquakes in the area.

The United States Geological Survey (USGS) keeps historical records of earthquakes in the U.S. and all around the world. The USGS records the location, the Richter scale reading, and the date of the earthquake. You and your classmates are going to help BuzzTech review earthquake data and learn more about earthquakes at the proposed sites.

You will divide into teams to map earthquake data in 1 of 9 sections of the area. Your teacher will show you how to plot, or mark, points on the map that tell readers the location, size, and date of the earthquake.



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2.2 EARTHQUAKE DATA INVESTIGATION

Please follow the following instructions, working in a group.

Procedure:

1. Your teacher will assign a section of the map (1, 2, 3, 4, ... 9) to your group. Before you begin the investigation, your teacher will explain to the class how to use section map and gridlines to plot earthquake data. ** If you have more than nine groups, you will have to double up on some groups – two groups may be assigned section 1 etc. – we provided extra copies of the maps for this purpose.*
2. Collect the following materials:
   - 1 – Section Map, matching your assigned section
   - 1 – Set of Green, Yellow, and Red sticker dots ** You will have to cut strips of dots ahead of time (There are only 10 points – so they won't need that many stickers (3-4 of each color)*
   - 1 – Copy of the 10-year earthquake data for your assigned section ** At this point make sure to only pass out the 10 year data*
3. Using the 10-year earthquake data, plot the location of the earthquakes listed in the table. Once you have plotted the earthquake check it off the list. *(Review this with students)*
   - Use **GREEN** stickers for earthquakes measuring **0.0 to 3.0** on the Richter scale
   - Use **YELLOW** stickers for earthquakes measuring **3.1 to 6.0** on the Richter scale
   - Use **RED** stickers for earthquakes measuring **6.1 to 10.0** on the Richter scale

   If multiple earthquakes happen at the same location, simply place the stickers next to each other. Do not stack the stickers on top of each other.

INTERPRET YOUR DATA PLOTS

Review the earthquakes you plotted on your section map. As a group, discuss the following questions. Your teacher may have you record your answers on a separate sheet of paper.

Discuss these questions with your group:

1. If you have a possible site in your section, does your section seem like a good choice for the plant location? Why or why not?

-or-

2. If your section does not have a possible site, do you think it might be a good option based on the earthquake data you plotted? Why or why not?

*Only 3 groups will have a site located on their map , the remaining six groups need to answer Question 2

Lead the class in a discussion to review everyone's thoughts on the group interpretations. Encourage students to hold up their section maps to share data.

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SECTION 3 – ADD TO YOUR UNDERSTANDING

3.1 EARTHQUAKE BASICS

To better understand this challenge, we need to understand how the earthquakes are part of life in northern California and how they might affect the plant. Later this semester or year, you will learn more about the specifics of how and when an earthquake occurs. For now, we will provide some basic information to help you in this challenge.

When you are asked to think about the structure of the earth, you might visualize dirt and rocks. You might see vast oceans or high mountains. You might think about clouds surrounding it. When we talk about earthquakes, we need to think of earth a little differently. If we were to remove all of the water (oceans, lakes, and rivers) from the surface of the earth, we would see something very different.

As you can see, the land and continents actually continue along under the surface of the oceans. The planet is actually one continuous chunk of land. Watch the video to get a better sense of the actual surface of the planet.

Watch ***Earth Without Water*** Video #1 *(only about 50 seconds – a simulation of removing water on the earth—shows deep trenches and mountains)*

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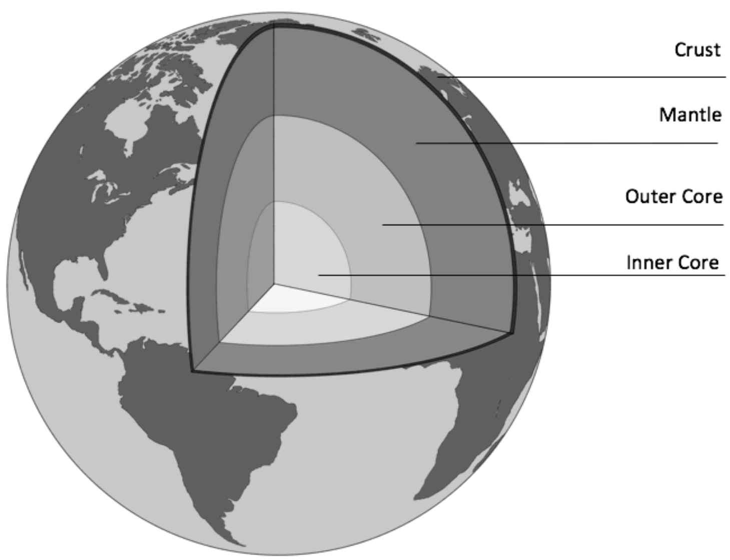
The Earth is actually covered by a layer of rock called the **crust**. On average, the Earth's crust is 20-22 miles deep. The thickest parts of the crust, under the continents, can be 46 miles thick. The thinnest parts, under the oceans, are as little as 3 miles thick. The very top of the crust contains all of the features we see on Earth. All of the water, soil, plants, buildings, roads, homes, animals, and people sit on top of the crust.

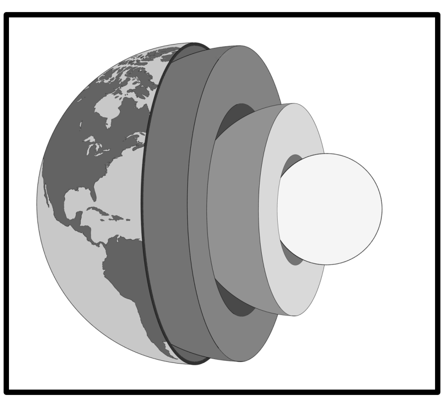
KEY TERMS

Earth's crust: the outermost layer of the planet

If we were able to remove a slice out of the earth like cutting a slice out of a cake, we would see that the earth has even more layers under the crust.



Below is another view of the inside of the earth, showing the different layers.



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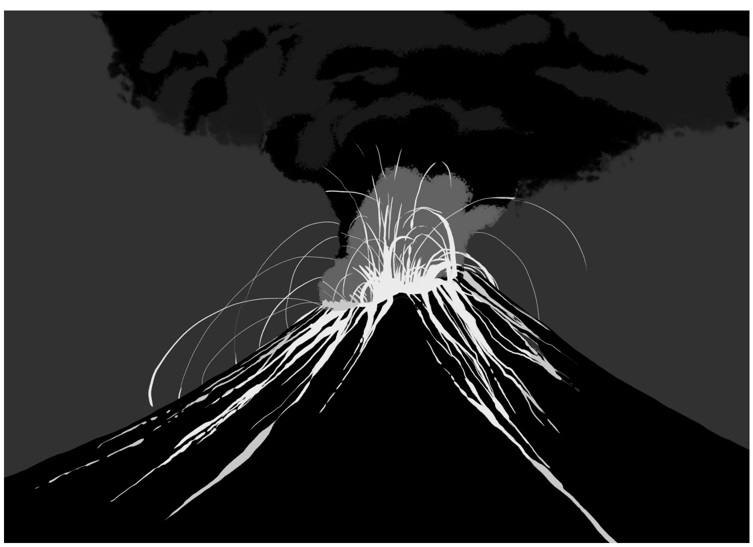
The crust is not one continuous, unbroken sphere of rock. The crust is actually broken up into chunks that are all fitting to together, sort of like a puzzle. It is sort of like the shell of a hard-boiled egg that has been cracked. We call these chunks **plates**.

The plates of crust sit on top of the mantle layer. The rock making up the mantle is so hot that it is actually melted. You may have seen pictures or video of volcanoes erupting. The lava is melted rock that came from the border between the crust and the mantle.



The crust plates float on the mantle and are constantly in motion; they move at about the same rate as human fingernails grow, so it is not easy for humans to sense that the plates are moving. Earthquakes occur when these plates grind against each other. Energy is released through the rock in the crust and travels in waves, which results in sometimes violent shaking at the surface.

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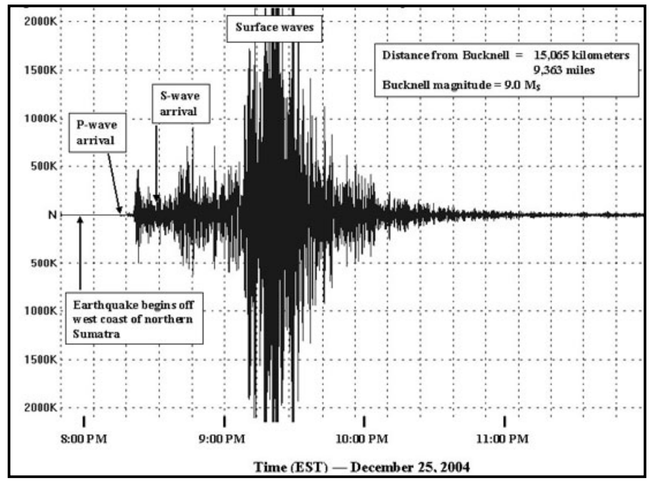
3.2 DETECTING EARTHQUAKES

As we mentioned earlier, California has experienced many earthquakes during its history. Scientists use a special piece of equipment, called a **seismograph** (syhz-mo-graf), to monitor and record earthquakes. Using a network, or chain, of seismographs linked together scientist can monitor earthquakes all over the world. Below we see a group of seismographs recording earthquakes. The seismograph creates a print out that tells the scientists the location and the size of the earthquake.



One example of a seismograph print out is shown above. The print out shows that an earthquake on an island in Southeast Asia, called *Sumatra*, experienced an earthquake between 8:00pm and 11:00pm. The longer lines show that the strongest surface waves from the earthquake were detected by the seismograph between 9:15pm and 9:30pm.

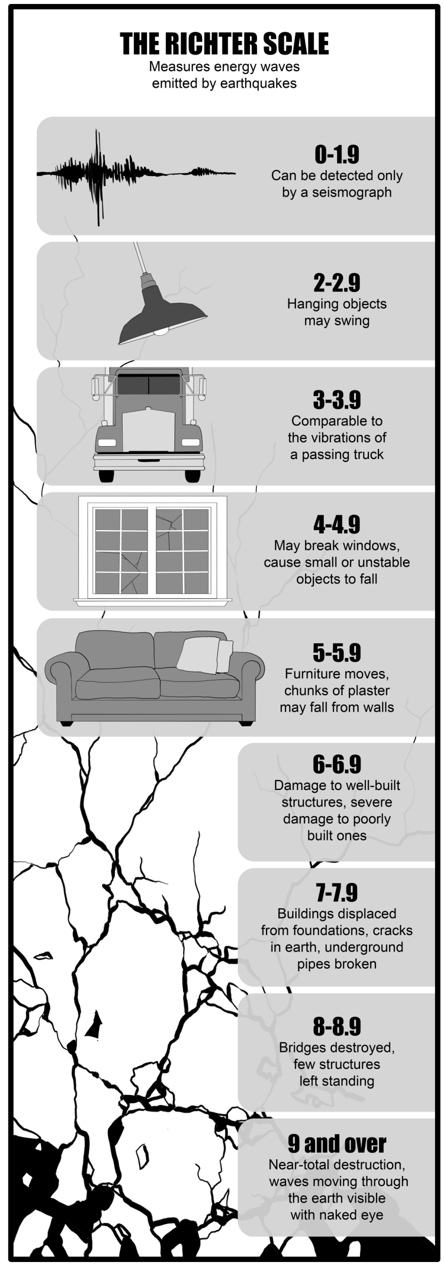
**Here is a link to a good guide sheet on reading a Seismograph for supplemental material:* http://www.iris.edu/hq/files/programs/education_and_outreach/aotm/17/SeismicSignatures_SeismogramMSH%20addition.pdf

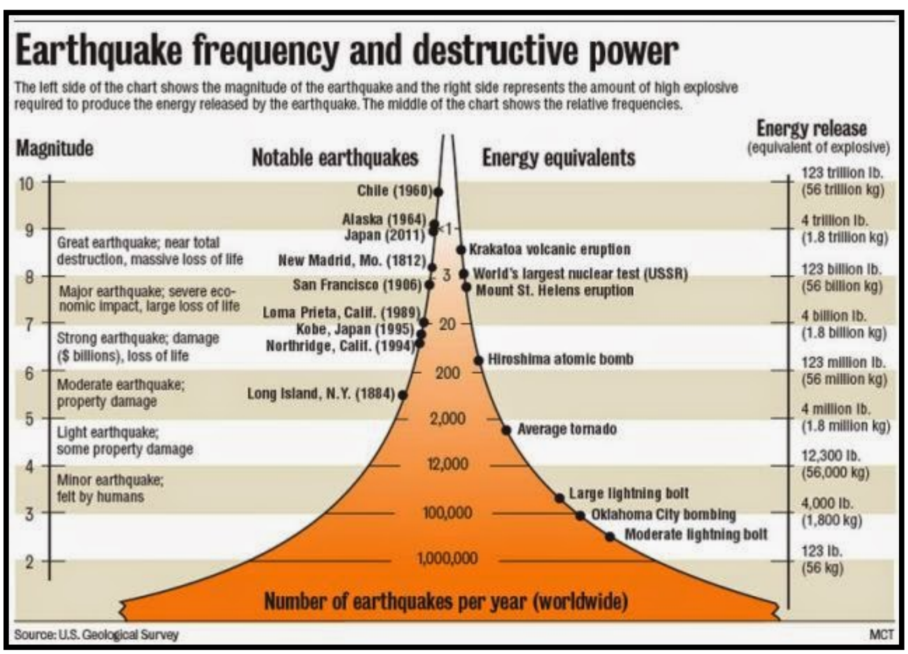
** This is a good site for seeing current seismic activity in your zip code:* http://rev.seis.sc.edu/

3.3 MEASURING EARTHQUAKES

Not all earthquakes are equal in strength. Depending on many factors, each earthquake will release different amounts of energy. Some are very small and would not even be felt by people living in the area or at the surface. Others are very strong and can cause major damage and loss of life.

Scientist measure different sizes of earthquakes using the **Richter Scale**. The scale runs from 1.0 – 10.0, with 1 being the smallest earthquake and 10 being the largest. As you go up the scale from 1 to 10, each level brings more damage, destruction, and danger. In fact, when you move up one level on the scale, the power of the earthquake increases by 10! So, a 4.0 earthquake is ten times more powerful than a 3.0 earthquake. A 7.0 earthquake is ten times more powerful than a 6.0 earthquake. As a class review these two graphics explaining the Richter scale with your teacher.





Watch these videos of earthquakes, each with different Richter Scale readings. Some will show you what happens during a small earthquake. Others will show you what happens during a large earthquake. Afterward, your class will review and discuss the questions below.

*Watch **Earthquake Samples** Video #2 (2:46 – Video shows the damage from a 4.4 Earthquake, a 7.2 Earthquake, a 7.6 Earthquake, and a 9.0 Earthquake (Japan (Tsunami)).*

Discuss these questions as a class:

1. What do you see happening to property during the videos? *(should have seen difference from a piece of ceiling panel falling to houses collapsing and roads and bridges splitting)*

2. What differences do you see in the video between large and small earthquakes? What is similar between them? *(type of destruction, all include ground movement—shaking)*

3. What do you think BuzzTech will need to think about as they prepare to build their plant in a state that has earthquakes? *(the seismc activity in that area)* What problems might occur if they build the plant in an active earthquake area? *(Building suffering damage, production stopping)*

4. What do you think BuzzTech could further learn about the three sites that might help them make their decision? *(# of earthquakes in the past, severity of those earthquakes, current seismc activity)*

5. Do you think there is an acceptable number and size of earthquakes that BuzzTech could tolerate? What if a desirable site has some earthquakes, but most are under 4.0? Should BuzzTech locate the plant there? *(Answers will vary – they might say that Earthquakes can be under a 4.0 or 5)*

SECTION 4 – VISUALIZING DATA

4.1 ADDITIONAL EARTHQUAKE DATA

Your discussion of the earthquake data probably revealed that the earthquake risk is low in many areas. That said, it is clear that this area of California does experience earthquakes. In Part 2, we will continue to map earthquakes in each of your sections. This time you will add data from the past 40 years to see if the 10-year results continue.

Please follow the following instructions, working in a group of three.

Procedure:

1. Your teacher will provide a copy of the earthquake data, dating back years 10-40.
2. Using the new data, continue plotting the location of the earthquakes listed in the table. Once you have plotted the earthquake check it off the list
   - Use **GREEN** stickers for earthquakes measuring **0.0 to 3.0** on the Richter scale
   - Use **YELLOW** stickers for earthquakes measuring **3.1 to 6.0** on the Richter scale
   - Use **RED** stickers for earthquakes measuring **6.1 to 10.0** on the Richter scale

PLEASE DO NOT WRITE IN THIS BOOK.

4.2 INTERPRET YOUR 10-40 YEAR DATA PLOTS

Review the earthquakes you plotted on your section map. As a group discuss the following questions. Your teacher may have you record your answers on a separate sheet of paper.

Discuss these questions with your group:

1. If you have a possible site in your section, does your section seem like a good choice for the plant location? Remember to pay attention to the number and size of earthquakes before you answer.
2. If your section does not have a possible location, do you think it might be good option for the plant based on the earthquake data you plotted? Why or why not?
3. What did adding 30 more years of data reveal about your section? Does it affect how you feel about locating the plant in your section?

Once every group has completed their answers, your teacher will once again lead the class in a discussion to review everyone's thoughts on the group interpretations.

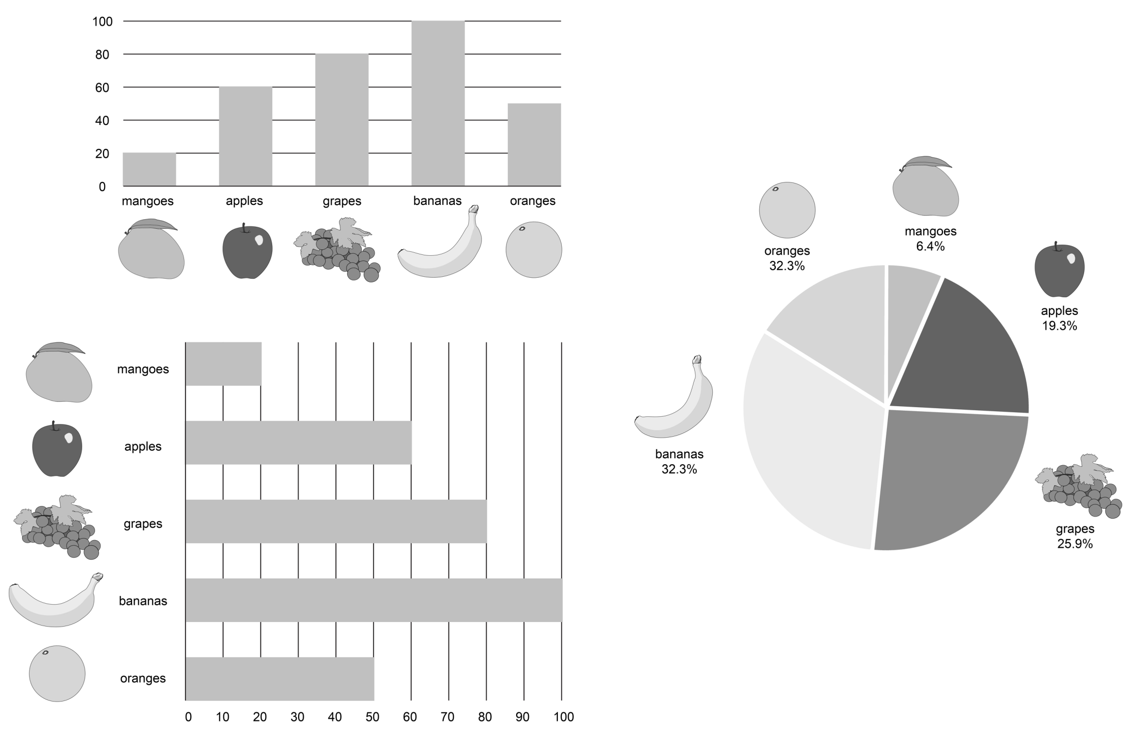
4.3 COMMUNICATING RESULTS

Your class probably noticed that 40 years of data showed a difference in many of the sections in the area. When you look at earth science data and events, it is very important to realize that the earth is very old. Many of the processes working on earth today or in the recent past have been happening over many years - millions and billions of years, in fact.

Earth scientists look at data from very long periods of time to look for patterns in the data. These patterns can reveal a fact or truth about how the earth works. They can also reveal what we can expect in the future. In this case, using a longer period of time revealed that some sections of the area have more earthquake activity. This might be very important information for BuzzTech as they try to identify where to build their plant.

The ability to communicate scientific findings to other scientists and the public is very important. We use visuals of the data collected to help us tell the story of what is happening. You have most certainly have seen a graph or pie chart similar to the graphs below.

Favorite Fruits Among Students



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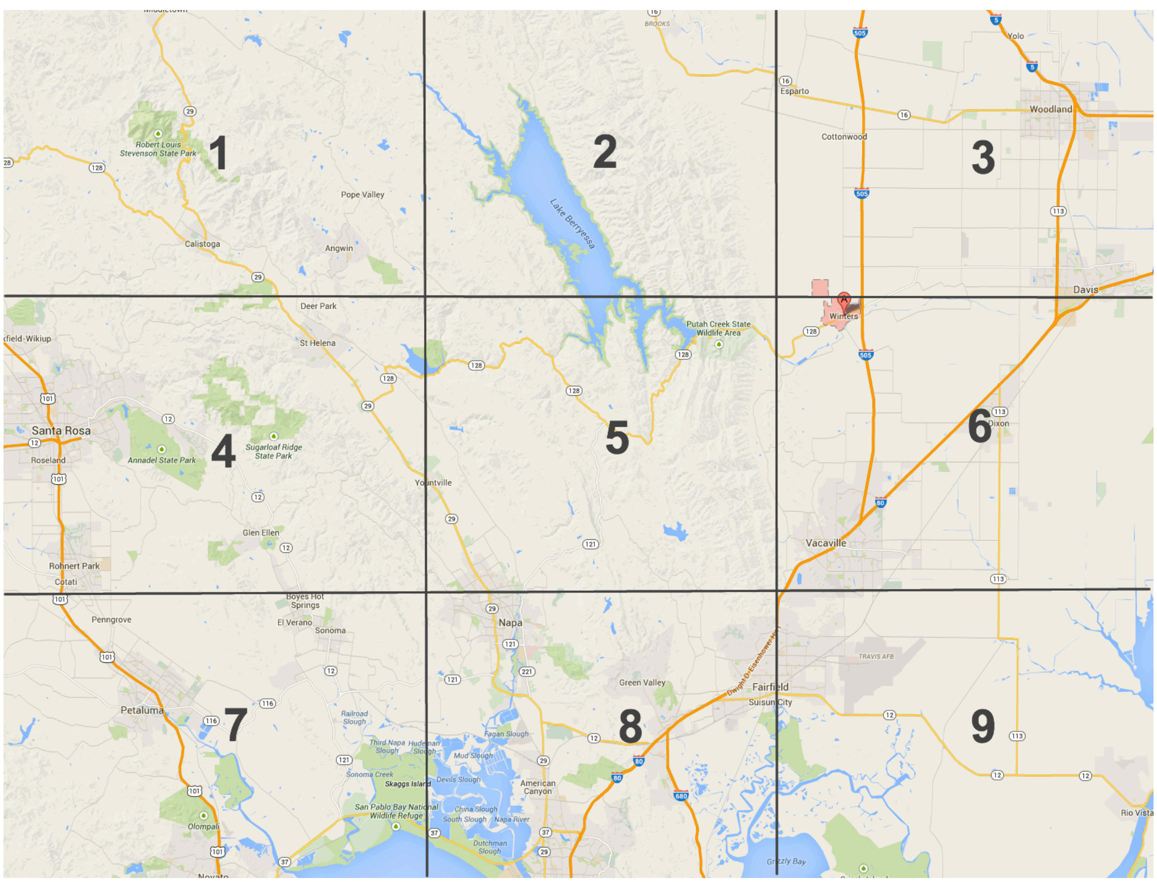
In both cases, *visualizing data* helps the reader make sense of the data collected easily and more quickly.

As your class discussed the results of the expanded 40-year data, you may have changed your early opinion about your section or other sections. You saw that when we looked at a very small period of time, we did not get a full understanding of earthquake activity. Data that actually changes its pattern over time is called **temporal data**.

KEY WORD

Temporal data: data that actually changes its pattern over time

Let us look at the data you collected in another interesting way. If you remember, each of the nine sections combines to make up the map of the area BuzzTech is considering for the plant. In a moment, your teacher will help your class reassemble the large map.



4.4 ONE OTHER VIEW OF THE DATA

Data that changes across a geographic area is called **spatial data**. This view of the area reveals some clear patterns of earthquake activity. If you were to focus on only one section, you might not think earthquakes are too much of a problem in the area. By combining sections and looking over a wider area, it is easy to see if earthquakes are a concern for Sites A, B, and C.

KEY TERMS

Spatial data: data that changes across a geographic area

?

Discuss these questions as a class:

1. Now that the large map is reassembled, what new earthquake patterns are you able to see?
2. How does this new way of looking at the data affect your thoughts on each of the sites?
3. Are there new locations that BuzzTech might want to consider for building the plant? Explain why those areas would possibly be better than Sites A, B or C.

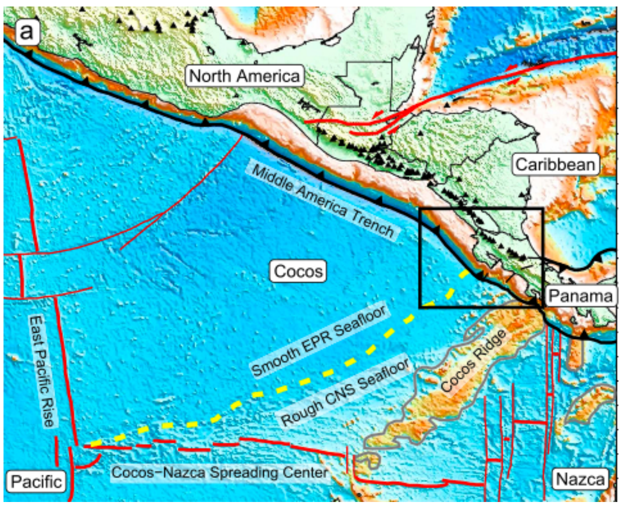
4.5 GEORGIA TECH PROFESSOR USES DATA VISUALIZATION TO FORECAST EARTHQUAKES

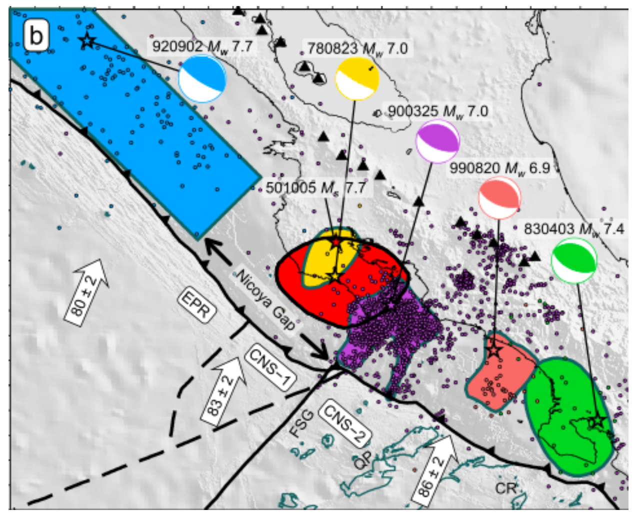
As large plates of crust move around on the Earth's mantle, the plates press into one another. To the right is a diagram showing two plates moving toward each other. The plate on the left rests below the ocean water. The edge of the plate on the right forms the land and the coast next to the ocean. In this example, the plate on the left is colliding and then moving underneath the plate on the right. This, of course, happens very slowly over a very long time.

As these two plates collide, the left plate eventually melts into magma under the surface. The melting and colliding causes the shape of the right plate to change. In this diagram we would expect to see the right plate's surface become more mountainous and rise higher, or increase its elevation.

This activity causes the surface of the right plate to bend and bulge. This bending is not something you can see with your own eyes. The movement of the plates is very slow and humans do not easily detect the pressure that builds in the plate. Like we said earlier, when the plates move and bend, the stress builds in the plate. When that stress is released, an earthquake occurs.

Knowing when and where an earthquake might strike would be a powerful tool in saving lives in earthquake areas. Unfortunately, that sort of information is hard to know ahead of time. In fact, it has never really been possible... until now. Dr. Andrew Newman is a geophysics professor and researcher at Georgia Tech. Dr. Newman, pictured on the next page, uses satellites and global positioning systems, or GPS. He tracks how much the surface of the earth of bending and bulging in areas where earthquakes are likely to occur. He collects and visualizes data to measure how much the surface is moving due to the bending and bulging of the crust.





He is not able to predict exactly when or where earthquakes will occur. His data, however, allows him to forecast when earthquake activity is likely to occur. Dr. Newman and his team used GPS to study changes in the Earth's shape in Costa Rica. They accurately forecasted the size and location of the magnitude 7.6 earthquake before it occurred in 2012 in Costa Rica.

This advancement in forecasting earthquakes can provide government and community officials time to prepare for a future event. They can gather resources and create plans for certain areas that would help people in the aftermath of the earthquake.

PLEASE DO NOT WRITE IN THIS BOOK.

SECTION 5 – ANSWER THE EARTHQUAKE CHALLENGE

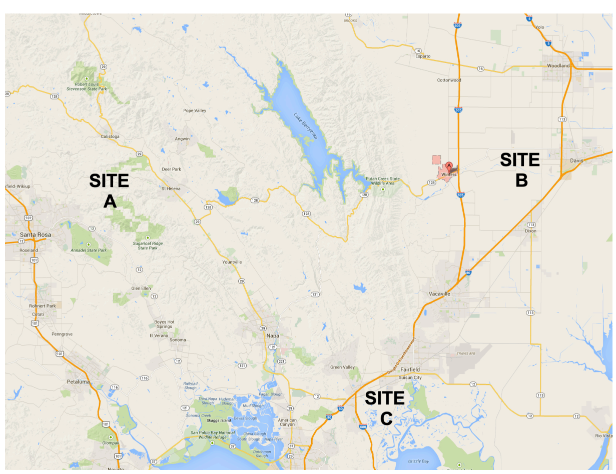
You and your classmates were asked to review the three locations and decide which is a good location to build the new BuzzTech plant. Remember, earthquakes cannot be your only factor in deciding where to put the plant. There were other factors listed in the chart below.

Site A	Site B	Site C
• Near the popular city of Santa Rosa • Expensive land • Highly populated, short commute • Educated work force • Desirable area to live • Near major highways, but very high traffic causes delays in shipping products	• Isolated location, small town • Cheap land • Small population, need to recruit talent • Long commute for workers from surrounding communities • Expensive transportation costs to ship products	• Near water-front area • Medium-priced land • Highly populated area • Commute is short distance • Desirable area to live • Nearby seaport offers low transportation costs to ship products

Procedure:

1. Complete the *Letter to BuzzTech* student sheet and explain which section you recommend along with how the earthquake data supports your recommendation.

(Other options include having groups make a presentation of their decision. In either case, please use the data visualizations to support your decision).



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