Unit 5

Natural Hazards:

Where do natural hazards happen, and how do we prepare for them?

Student Work Pages

GRADE 6 Core Knowledge Science®

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how do we prepare for them?

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Science Literacy Exercise Pages

Name: ______________________ Date: ______________________

Tsunami: Japan 2011

A tsunami reaches Miyako, Japan.

Part 1: Read about a natural hazard

On March 11, 2011, a 9.0-magnitude earthquake struck underwater off the eastern coast of Japan. This was felt on land at 2:45 p.m. local time. There were multiple aftershocks and at 3:14 p.m., a tsunami warning was announced for coastal areas along the Pacific Ocean, predicting water waves of up to 33 feet high (10 m). Some people living near the coast had only 8 minutes of warning before the waves hit their city, while residents in other areas had more time. Low-lying cities closer to the earthquake experienced taller waves than those farther away.

The tsunami had a major impact on the people who lived in the affected cities across Japan:

- Over 10,000 people died, many of them carried away by fast-moving water.
- Over 100,000 buildings totally collapsed.
- Over 4 million households in Japan were left without electricity for over a week.
- Over 1 million households were left without fresh water for over a week.

Prior to the 2011 tsunami in Japan, Indonesia experienced a tsunami on December 26, 2004, triggered by a 9.2-magnitude earthquake in the Indian Ocean. The Indonesian tsunami generated waves as high as 100 feet (30 m) and killed approximately 227,000 people in 14 different countries along the shorelines of the Indian Ocean, including more than 126,000 in Indonesia.

Images of the 2011 tsunami hitting the eastern coast of Japan:

Part 2: Think like an engineer

Often, after a natural disaster like these, scientists and engineers try to develop technologies to reduce future impacts on people. **Brainstorm these ideas on your own:**

Technologies to help detect a tsunami	Technologies to give people more advance warning that a tsunami is approaching	Technologies that could help reduce the damage from a tsunami

Develop your design. Pick one of your ideas. Show how it would work using a diagram (with labels) and provide a brief explanation.

Pick another idea from a different category than your first one. Show how it would work using a diagram (with labels) and provide a brief explanation.

Part 3: Share designs

Use the middle column to record a list of developed ideas from 3 different classmates—one idea per row.

Person	Possible solution	Purpose (check at least one)
A		• detect a tsunami • give people more advance warning that a tsunami is approaching • reduce the damage of a tsunami
B		• detect a tsunami • give people more advance warning that a tsunami is approaching • reduce the damage of a tsunami
C		• detect a tsunami • give people more advance warning that a tsunami is approaching • reduce the damage of a tsunami

Part 4: Evaluate designs

Look at your peers' ideas listed above.

1. Choose the one that you think would be the most promising solution to implement and explain why.

2. Choose the one that you think would be the most challenging solution to implement and explain why.

Part 5: Related phenomena

In earlier units, we found out about other natural hazards that people experience, such as hailstorms, thunderstorms, earthquakes, and volcanoes. Engineers design technologies to help communities handle these hazards as well!

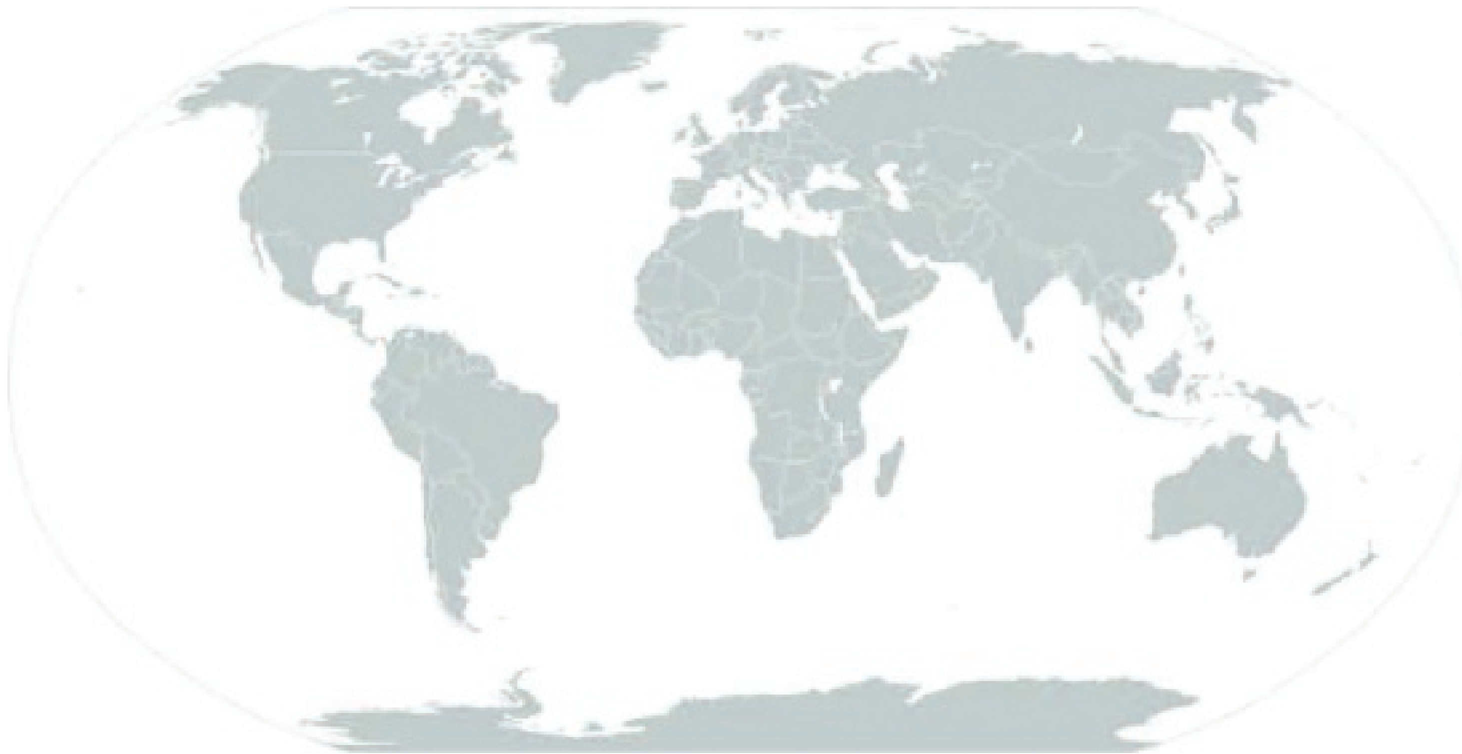
List natural hazards that you:

- have experienced
- were affected by
- heard or read about
- are interested in learning more about

Some places are more at risk from certain natural hazards than others. Which natural hazards are more likely to affect your community?

Are there things you know about those hazards that could help us design ideas to detect tsunamis, warn people of their approach, or reduce the damage they cause?

Tsunami Predictions



Explain your predictions.

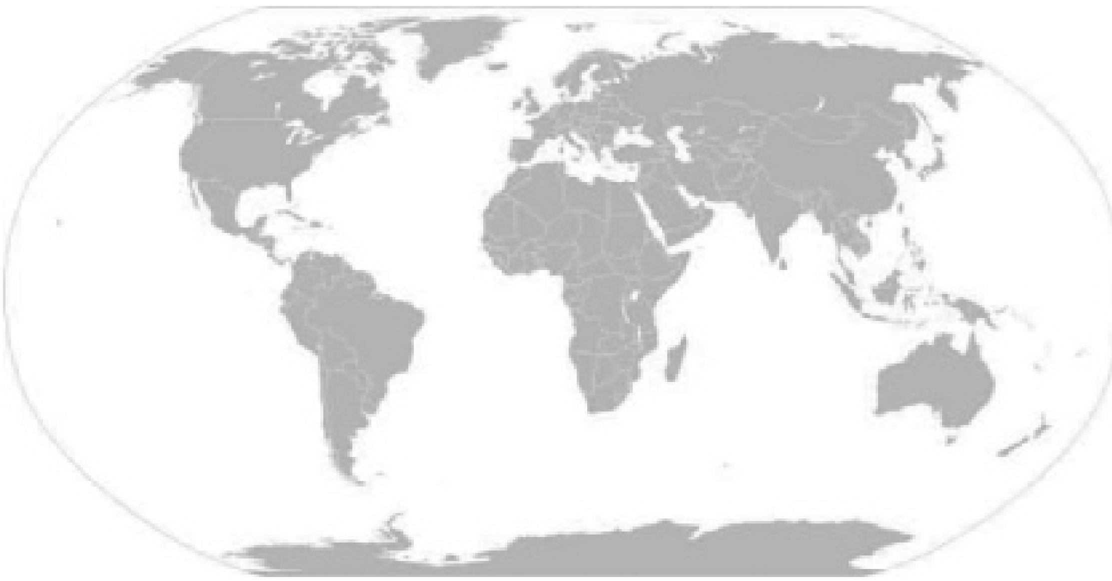
Where do tsunamis happen?

Part 1: Orient to the Map

Before you make observations, consider these things:

- The **title and text** with the map. What information are these providing?
- The **legend** of the map. What does it tell you about what is on the map?

Part 2: Make Observations

Sketch the locations of where tsunamis have occurred in the past based on the data.	
	
Describe the patterns you notice in where tsunamis occur.	**What causes the most tsunamis? How do you know?**

Name: ______________________ Date: ______________________

Comparing All Earthquakes to Earthquakes that Cause Tsunamis

Compare the map of all global earthquakes to earthquakes that cause tsunamis. Notice the following things:

- Where in the world do earthquakes and tsunamis happen in the same place?
- Where in the world do they not happen together?

Describe 1-2 interesting patterns between the data on the two maps.
Look closely at the plate boundaries. Do all earthquakes and tsunamis happen at similar plate boundaries, or is there a difference?

Connecting Earthquakes and Tsunamis

Step 1: Think first about how to make the graphs.

1. **Our questions.** We are curious about why some earthquakes cause tsunamis and others don't. We will investigate these two questions:
   - How does the magnitude (strength) of an earthquake affect tsunami formation?
   - How does the depth (how near or far from the surface) of an earthquake affect tsunami formation?

2. **Our variables.** Decide which variables go on which axis of the graph based on the questions above. Choose from this list and write them into the boxes below to complete the sentence:
   - earthquake magnitude
   - earthquake depth
   - tsunami wave height

	Independent variable(s) (*x*-axis)		Dependent variable(s) (*y*-axis)
How does…		affect	

As you work through the different characteristics of earthquakes that cause tsunamis, record your noticings and ideas in the tables provided with each graph. Follow these steps:

- Identify what is being measured by each variable.
- Make observations about the data on the graph. Record your noticings directly onto the graph. Helpful questions are provided with each graph.
- Interpret what you think the data mean about why some earthquakes cause tsunamis to form and other earthquakes do not. Here are some questions to help you:
  - Does the pattern support the idea that the strength or depth of the earthquake affects the tsunami? Why or why not?
  - How does the pattern help you decide what kinds of earthquakes cause tsunamis?

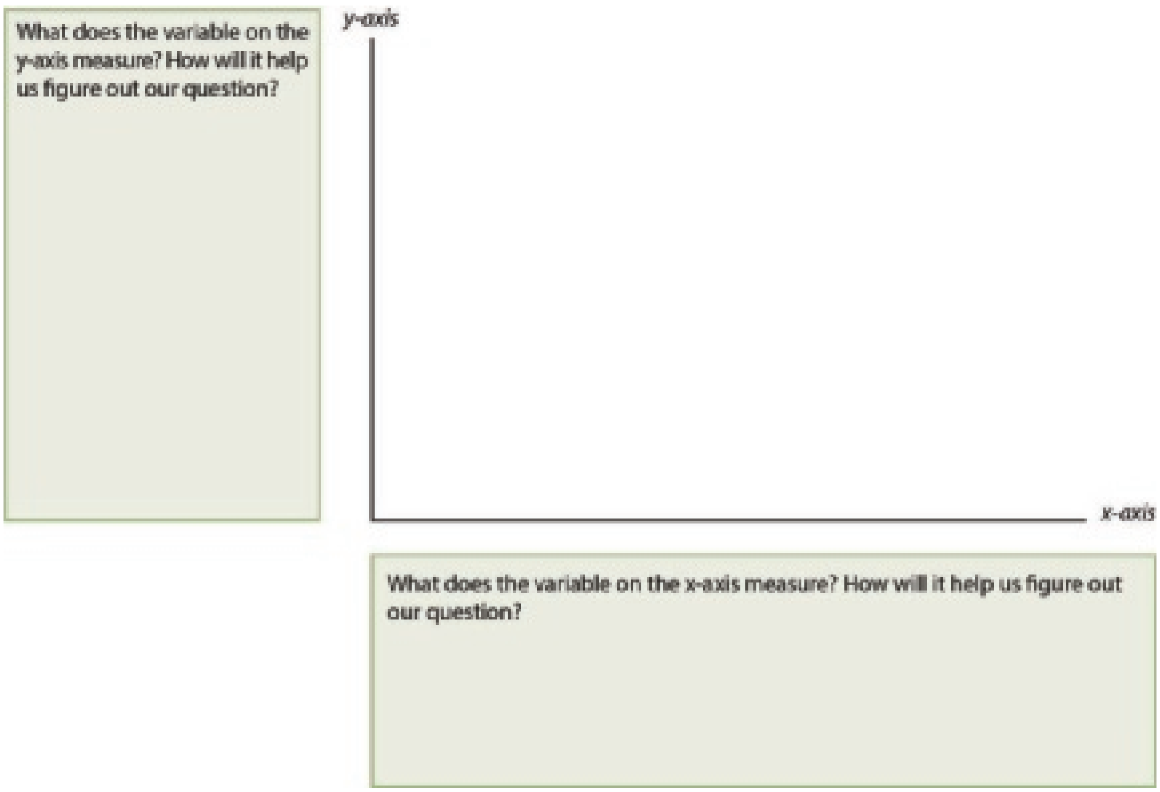
Navigate to www.openscied.org/tsunami-data-set to access the tsunami data.

Step 2: Consider the magnitude (strength) of the earthquake and tsunami formation.

Questions to consider:

- As magnitude (strength) increases, what happens to the tsunami wave height?
- As magnitude decreases, what happens to wave height?
- Do bigger waves happen with low-magnitude earthquakes or high-magnitude earthquakes?

Using space below, quickly sketch the pattern from the graph. You do not need to include all data points, but enough to capture the pattern.

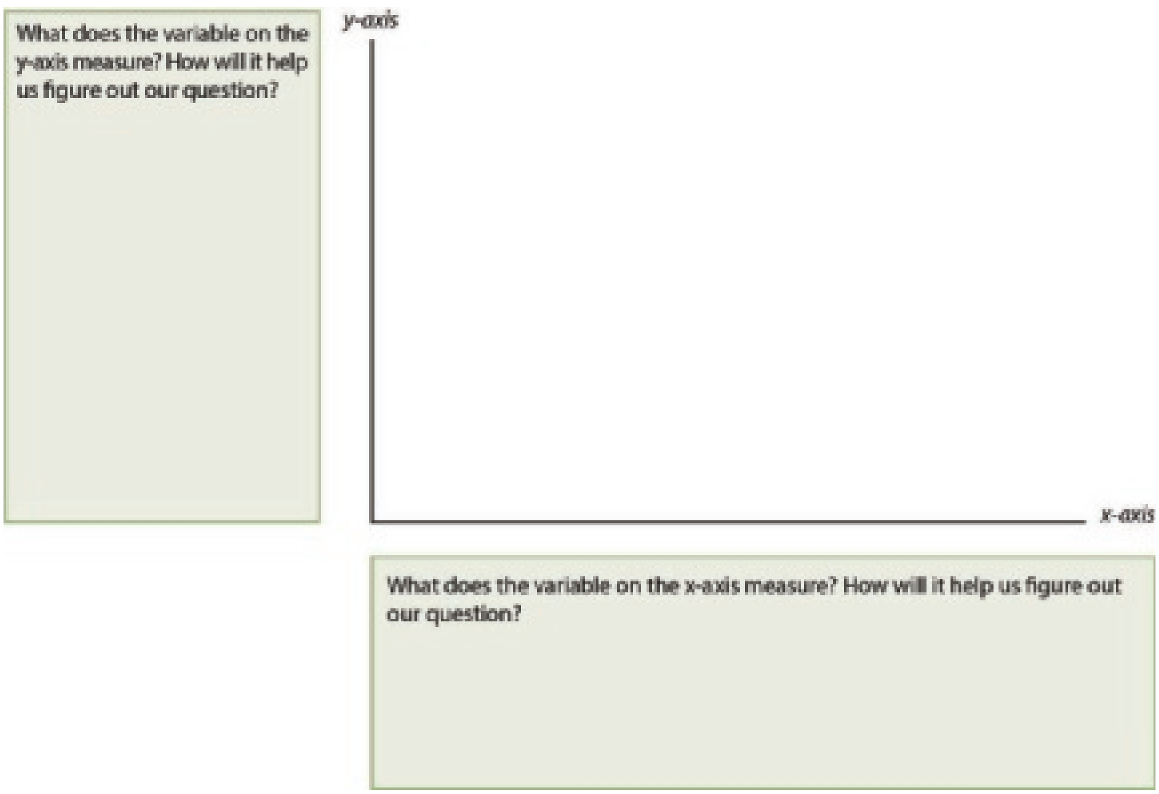


Question	Describe the pattern you notice.	What do you think this means?
How does the magnitude of an earthquake affect tsunami formation?		

Step 3: Consider the depth (how near or far from the surface) of the earthquake and tsunami formation.

Questions to consider:

- As depth increases (gets deeper), what happens to the tsunami wave height?
- As depth decreases (gets closer to the surface), what happens to the tsunami wave height?
- Do bigger waves happen with earthquakes near the surface or earthquakes deep in the crust?



Question	Describe the pattern you notice.	What do you think this means?
How does the depth of an earthquake affect tsunami formation?		

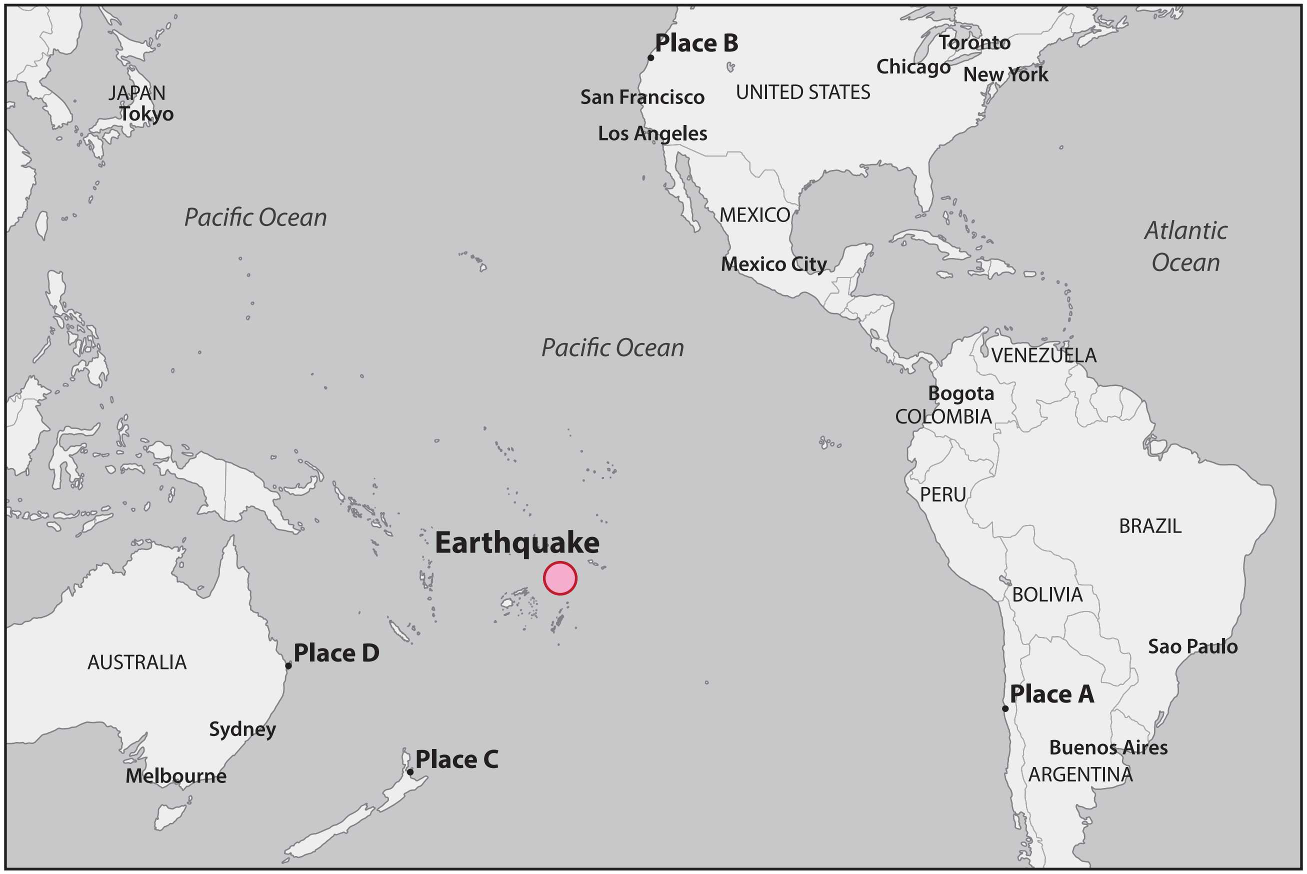
Step 4: Synthesize your ideas.

Based on the patterns noticed above and your interpretation, what type of earthquake will most likely cause a tsunami?

Name: ______________________ Date: ______________

Wave Investigations

	What I see (What is happening with the wave)	**What it means** (What it helps me figure out about how tsunamis form and move)
Foil Pan Model		
NOAA Tsunami Model		
Tsunami Wave Model		



Place B
JAPAN
Tokyo
San Francisco
UNITED STATES
Chicago
Toronto
New York
Los Angeles
MEXICO
Mexico City
Pacific Ocean
Pacific Ocean
Atlantic Ocean
VENEZUELA
Bogota
COLOMBIA
PERU
BRAZIL
BOLIVIA
Earthquake
AUSTRALIA
Place D
Sydney
Melbourne
Place C
Place A
Sao Paulo
Buenos Aires
ARGENTINA

Aerial photos of Ryoishi Bay before and after the tsunami

5/31/2010 (9 months prior to 2011 tsunami)

Google Earth

3/13/2011 (1-2 days after tsunami)

Google Earth

3/31/2011 (3 weeks later)

Google Earth

4/19/2019 (8 years later)

Google Earth

Name: ____________________ Date: ____________________

Evaluating Solutions to Protect Communities from Tsunamis

Part 1. Define the problem and the goal of a solution.

Problem: What is the problem we are trying to solve?

Goal: What do we need the solution to do?

Part 2. Identify the criteria for an effective solution.

What does our solution need to be able to do to protect the community from a tsunami?

Criteria	What science ideas are important for us to consider with these criteria?

Part 3. Evaluate existing solutions against the criteria.

The video we will watch was created by a company called JBA Group, a group of engineers and scientists focused on studying natural hazards in the Pacific region.

This is a quote from the JBA Group website: "We started our office in early 2016 with a clear focus; to increase community resilience to natural disasters...we want to study it, understand it, plan for it and propose ways to minimize impacts."

In the video, coastal engineer Daniel Rodger explains how JBA Group tests different existing solutions to protect communities from large waves. As you watch the video, think about how well the solutions work to protect against tsunamis.

Solution	Notes from the video	Rank performance
Beach		
Seawall		
Levee or sea dike		
Recurved wall		
Rock armor		
Submerged breakwater		
Mangrove forest		

Part 4. What else do we need to consider before making a decision for Ryoishi?

Consider these questions:

1. What is important to Ryoishi? Does the solution fit with the economy and culture of the residents?
2. Does the solution negatively impact one group of people over another?
3. Does the solution pose any safety risks or negative impacts to the environment?
4. How affordable is the solution? Is it easy to build and maintain?
5. Can you think of anything that might limit how well the solution would function for the community?

Let's make a list of constraints we need to think about that might impact how well an existing solution meets Ryoishi's needs.

Constraint	Why would this be an important constraint?

Name: ______________________ Date: ______________________

Existing Solutions for Coastal Communities
Proposed Solution #1: Walls

The first category of solutions advertised to reduce the damage from incoming ocean waves is to build walls. Engineers have designed several types of walls that are effective options to block the flow of water from a tsunami by absorbing some of the wave's energy and also reflecting that energy back out to the ocean.

An example of a vertical seawall.

These walls are typically made of a very hard material, like concrete, and are built high enough to block large waves. The *seawall* at Ryoishi was 30 feet high--some others are over 40 feet. Many walls are completely flat, vertical structures. Other types include *levees* or *sea dikes* as well as *recurved walls*. *Levees* or *sea dikes* are made of earth or concrete, and they use angled walls or mounds to hold back the water. A *recurved wall* is made of a hard material, like concrete, and uses a curved design to capture and reflect water from waves back to the ocean or sea.

Study the images of each wall type closely and use the data tables on the next page to review how well they perform.

An example of a levee (left) and a recurved wall (right).

Performance of a Seawall

A. SEAWALL		
Criteria & Constraints	**Score**	**Notes**
Ability to break or block waves	★★★☆☆	Can break apart with the force of a large tsunami. Water can flow over it.
Impact on boats/ocean traffic	★★★★★	Built on land, so it does not affect boat traffic.
Impact on marine life	★★★★☆	Marine life is not typically impacted, but creatures that need access to land at some point (like sea turtles) may not be able to reach their nesting grounds.
Impact on ocean view	★☆☆☆☆	In some places, can completely block ocean views.
Cost	★★★☆☆	Expensive to build, but the materials are affordable.
Time to build	★★★☆☆	Large walls can take years to build, but smaller walls can be put into place more quickly.
Maintenance	★★★☆☆	Can last decades, but requires ongoing maintenance to ensure proper functioning.

Performance of a Levee or Sea Dike

B. LEVEE OR SEA DIKE		
Criteria & Constraints	**Score**	**Notes**
Ability to break or block waves	★★☆☆☆	Best for smaller amounts of water, but perform worse when a large wave hits it.
Impact on boats/ocean traffic	★★★★★	Built on land, so it does not affect boat traffic.
Impact on marine life	★★★☆☆	Can impact the flow of water along the shore in coastal ecosystems and affect marine life.
Impact on ocean view	★★★★☆	Smaller than other solutions and usually does not block ocean views.
Cost	★★★★★	Affordable and typically made of rocks, soil, and grass.
Time to build	★★★★☆	Smaller than other solutions and can use local materials, so building it can be quicker.
Maintenance	★★★★☆	Relatively easy to maintain.

Performance of a Recurved Wall

C. RECURVED WALL		
Criteria & Constraints	**Score**	**Notes**
Ability to break or block waves	★★★★★	Can completely absorb and reflect large waves.
Impact on boats/ocean traffic	★★★★★	Built on land, so it does not affect boat traffic.
Impact on marine life	★★★★☆	Marine life is not typically impacted, but creatures that need access to land at some point (like sea turtles) may not be able to reach their nesting grounds.
Impact on ocean view	★★☆☆☆	Can be smaller than a vertical wall because it is curved, so it blocks ocean views less.
Cost	★★☆☆☆	Even more expensive than the other types of walls.
Time to build	★★★☆☆	Requires additional work and time to mold the concrete. A large recurved wall can take years to build, but a smaller one can be put in place more quickly.
Maintenance	★★★☆☆	Can last decades, but requires ongoing maintenance to ensure proper functioning.

Proposed Solution #2: Breakwaters

An example of tetrapods.

The second category of solutions advertised to reduce wave damage is to build *breakwaters,* or structures in the ocean or along the shore that are designed to break up a tsunami wave, absorb some of the wave's energy, and reflect the energy in all different directions, thus decreasing the wave's amplitude as it approaches the shore.

Breakwaters can be found underwater or above water, typically out in shallow parts of the ocean near the shore but also closer to the shoreline as well. Examples of breakwaters include *tetrapods, rock armor,* and *submerged rock walls. Tetrapods* are concrete structures that reduce a wave's amplitude by absorbing some of its energy while also letting some of the water flow through them. Tetrapods have been used alone but are often found in front of a seawall to help it absorb and reflect energy from waves. *Rock armor* is often found along the shoreline. As with tetrapods, a wave flows through the rock armor and begins to break apart as the water passes between the rocks and reflects off them. A final breakwater example is a *submerged rock wall* located offshore, designed to absorb and reflect the wave's energy before it reaches shore.

Study the images of each type of breakwater closely and use the data tables on the next page to review how well they perform.

An example of rock armor (left) and a submerged breakwater (right).

Performance of a Tetrapod

D. TETRAPODS		
Criteria & Constraints	**Score**	**Notes**
Ability to break or block waves	★★★★☆	Reduces the wave's energy by reflecting it in all different directions. Flooding can still occur as water flows through it.
Impact on boats/ocean traffic	★★★☆☆	Often above the surface, so boats must steer around it in small bays and along the shoreline.
Impact on marine life	★★☆☆☆	Shown to decrease fish populations and disrupt normal erosion along the shoreline.
Impact on ocean view	★★★★☆	Typically does not obstruct ocean views, but can be seen in the horizon.
Cost	★★★★☆	Concrete and molds are shipped to the building site to save costs.
Time to build	★★★★☆	Can be made and stacked quickly onsite.
Maintenance	★★★☆☆	Its sturdy, heavy concrete is more resistant than rock to being washed away, but it does erode from ocean currents.

Performance of Rock Armor

E. ROCK ARMOR		
Criteria & Constraints	**Score**	**Notes**
Ability to break or block waves	★★★☆☆	Can break up waves, but water can still pass through, resulting in flooding. The energy of the wave will be less than if there were no barrier at all.
Impact on boats/ocean traffic	★★★☆☆	Typically found along the shoreline, but can also be built into bays as walls. Boat traffic must navigate around it.
Impact on marine life	★★★☆☆	Provides habitat for some marine life, but may cause loss of habitat for other marine life.
Impact on ocean view	★★★★☆	Not very nice to view on land, but it typically does not obstruct ocean views.
Cost	★★★★★	Rock is an affordable material.
Time to build	★★★★☆	Can be built fairly quickly if the land is owned by the community where it needs to be built.
Maintenance	★★★☆☆	Rock wears down over time.

Performance of Submerged Breakwater

F. SUBMERGED BREAKWATER		
Criteria & Constraints	**Score**	**Notes**
Ability to break or block waves	★★★★☆	Effective at breaking up a wave, but it can trap water as it is reflected from the shore, which increases the water level near shore.
Impact on boats/ocean traffic	★★★★☆	Only larger, deeper-hulled boats are affected by submerged breakwater.
Impact on marine life	★★☆☆☆	Can influence the flow of water and the movement of marine life in the area.
Impact on ocean view	★★★★★	Underwater, so ocean views are not affected.
Cost	★☆☆☆☆	Can be very expensive to build, depending on the water's depth and the wall's length.
Time to build	★★☆☆☆	Requires heavy, specialized machinery and multiple layers of material, so it can take a significant amount of time to construct.
Maintenance	★★★★☆	When built well, it can last decades, but will slowly wear down due to wave action.

Proposed Solution #3: Natural Vegetation

The third category of solutions advertised to reduce wave damage is to use *natural coastal vegetation* (that is, plants that commonly grow along coastlines) to absorb and reflect the energy from a tsunami wave, similar to breakwaters. They have the added benefit of providing something for people to hold onto or climb for protection during a tsunami event.

Natural vegetation grows in particular climates that provide the right temperatures and rainfall. For example, *mangrove forests* typically grow in tropical and subtropical climates. They need warmer temperatures to grow, so in Japan they are only found in southern parts of the country. *Pine forests* grow in colder climates but take many years to fully mature, making them a less desirable option for communities that need immediate tsunami protection.

An example of mangroves.

An example of a pine forest Karl Hörnfeldt

Performance of a Mangrove Forest

G. MANGROVE FOREST		
Criteria & Constraints	**Score**	**Notes**
Ability to break or block waves	★★★☆☆	Can block much of the energy of a smaller tsunami wave, but is less effective in larger tsunamis.
Impact on boats/ocean traffic	★★★★★	Does not impact normal ocean traffic.
Impact on marine life	★★★★★	Offers a natural coastal environment.
Impact on ocean view	★★★★☆	Can block some ocean views, as it can grow up to 30 feet tall in the southernmost parts of Japan and 80 feet in more tropical areas of the world.
Cost	★★★★☆	Considerably less expensive than concrete structures.
Time to build	★☆☆☆☆	Can only grow in the southernmost parts of Japan. They are tropical plants and will not grow in northern parts of Japan. Can take 10–15 years to fully mature.
Maintenance	★★★★☆	Once established, the forest requires limited maintenance to keep it thriving and free of pollution.

Performance of a Pine Forest

H. PINE FOREST		
Criteria & Constraints	**Score**	**Notes**
Ability to break or block waves	★★☆☆☆	Can break up the energy of a small tsunami, but is less effective for larger tsunamis.
Impact on boats/ocean traffic	★★★★★	Does not impact normal ocean traffic.
Impact on marine life	★★★★★	Offers a natural coastal environment.
Impact on ocean view	★★★☆☆	Grows an average of 20 feet tall when planted on a beach, and its branches spread out, making it difficult to see the ocean.
Cost	★★★★★	Inexpensive to build compared to concrete and rock structures.
Time to build	★☆☆☆☆	Can take decades to fully mature.
Maintenance	★★★★☆	Once established, it requires limited maintenance to keep it thriving and free of pollution.

Tsunami Ranking Cards

A. SEAWALL		
Criteria & Constraints	**Score**	**Notes**
Ability to break or block waves	★★★☆☆	Can break apart with the force of a large tsunami. Water can flow over it.
Impact on boats/ocean traffic	★★★★★	Built on land, so it does not affect boat traffic.
Impact on marine life	★★★★☆	Marine life is not typically impacted, but creatures that need access to land at some point (like sea turtles) may not be able to reach their nesting grounds.
Impact on ocean view	★☆☆☆☆	In some places, can completely block ocean views.
Cost	★★★☆☆	Expensive to build, but the materials are affordable.
Time to build	★★★☆☆	Large walls can take years to build, but smaller walls can be put into place more quickly.
Maintenance	★★★☆☆	Can last decades, but requires ongoing maintenance to ensure proper functioning.

B. LEVEE OR SEA DIKE		
Criteria & Constraints	**Score**	**Notes**
Ability to break or block waves	★★☆☆☆	Best for smaller amounts of water, but perform worse when a large wave hits it.
Impact on boats/ocean traffic	★★★★★	Built on land, so it does not affect boat traffic.
Impact on marine life	★★★☆☆	Can impact the flow of water along the shore in coastal ecosystems and affect marine life.
Impact on ocean view	★★★★☆	Smaller than other solutions and usually does not block ocean views.
Cost	★★★★★	Affordable and typically made of rocks, soil, and grass.
Time to build	★★★★☆	Smaller than other solutions and can use local materials, so building it can be quicker.
Maintenance	★★★★☆	Relatively easy to maintain.

C. RECURVED WALL		
Criteria & Constraints	**Score**	**Notes**
Ability to break or block waves	★★★★★	Can completely absorb and reflect large waves.
Impact on boats/ocean traffic	★★★★★	Built on land, so it does not affect boat traffic.
Impact on marine life	★★★★☆	Marine life is not typically impacted, but creatures that need access to land at some point (like sea turtles) may not be able to reach their nesting grounds.
Impact on ocean view	★★☆☆☆	Can be smaller than a vertical wall because it is curved, so it blocks ocean views less.
Cost	★★☆☆☆	Even more expensive than the other types of walls.
Time to build	★★★☆☆	Requires additional work and time to mold the concrete. A large recurved wall can take years to build, but a smaller one can be put in place more quickly.
Maintenance	★★★☆☆	Can last decades, but requires ongoing maintenance to ensure proper functioning.

D. TETRAPODS		
Criteria & Constraints	**Score**	**Notes**
Ability to break or block waves	★★★★☆	Reduces the wave's energy by reflecting it in all different directions. Flooding can still occur as water flows through it.
Impact on boats/ocean traffic	★★★☆☆	Often above the surface, so boats must steer around it in small bays and along the shoreline.
Impact on marine life	★★☆☆☆	Shown to decrease fish populations and disrupt normal erosion along the shoreline.
Impact on ocean view	★★★★☆	Typically does not obstruct ocean views, but can be seen in the horizon.
Cost	★★★★☆	Concrete and molds are shipped to the building site to save costs.
Time to build	★★★★☆	Can be made and stacked quickly onsite.
Maintenance	★★★☆☆	Its sturdy, heavy concrete is more resistant than rock to being washed away, but it does erode from ocean currents.

E. ROCK ARMOR

Criteria & Constraints	Score	Notes
Ability to break or block waves	★★★☆☆	Can break up waves, but water can still pass through, resulting in flooding. The energy of the wave will be less than if there were no barrier at all.
Impact on boats/ocean traffic	★★★☆☆	Typically found along the shoreline, but can also be built into bays as walls. Boat traffic must navigate around it.
Impact on marine life	★★★☆☆	Provides habitat for some marine life, but may cause loss of habitat for other marine life.
Impact on ocean view	★★★★☆	Not very nice to view on land, but it typically does not obstruct ocean views.
Cost	★★★★★	Rock is an affordable material.
Time to build	★★★★☆	Can be built fairly quickly if the land is owned by the community where it needs to be built.
Maintenance	★★★☆☆	Rock wears down over time.

F. SUBMERGED BREAKWATER

Criteria & Constraints	Score	Notes
Ability to break or block waves	★★★★☆	Effective at breaking up a wave, but it can trap water as it is reflected from the shore, which increases the water level near shore.
Impact on boats/ocean traffic	★★★★☆	Only larger, deeper-hulled boats are affected by submerged breakwater.
Impact on marine life	★★☆☆☆	Can influence the flow of water and the movement of marine life in the area.
Impact on ocean view	★★★★★	Underwater, so ocean views are not affected.
Cost	★☆☆☆☆	Can be very expensive to build, depending on the water's depth and the wall's length.
Time to build	★★☆☆☆	Requires heavy, specialized machinery and multiple layers of material, so it can take a significant amount of time to construct.
Maintenance	★★★★☆	When built well, it can last decades, but will slowly wear down due to wave action.

G. MANGROVE FOREST

Criteria & Constraints	Score	Notes
Ability to break or block waves	★★★☆☆	Can block much of the energy of a smaller tsunami wave, but is less effective in larger tsunamis.
Impact on boats/ocean traffic	★★★★★	Does not impact normal ocean traffic.
Impact on marine life	★★★★★	Offers a natural coastal environment.
Impact on ocean view	★★★★☆	Can block some ocean views, as it can grow up to 30 feet tall in the southernmost parts of Japan and 80 feet in more tropical areas of the world.
Cost	★★★★☆	Considerably less expensive than concrete structures.
Time to build	★☆☆☆☆	Can only grow in the southernmost parts of Japan. They are tropical plants and will not grow in northern parts of Japan. Can take 10–15 years to fully mature.
Maintenance	★★★★☆	Once established, the forest requires limited maintenance to keep it thriving and free of pollution.

H. PINE FOREST

Criteria & Constraints	Score	Notes
Ability to break or block waves	★★☆☆☆	Can break up the energy of a small tsunami, but is less effective for larger tsunamis.
Impact on boats/ocean traffic	★★★★★	Does not impact normal ocean traffic.
Impact on marine life	★★★★★	Offers a natural coastal environment.
Impact on ocean view	★★★☆☆	Grows an average of 20 feet tall when planted on a beach, and its branches spread out, making it difficult to see the ocean.
Cost	★★★★★	Inexpensive to build compared to concrete and rock structures.
Time to build	★☆☆☆☆	Can take decades to fully mature.
Maintenance	★★★★☆	Once established, it requires limited maintenance to keep it thriving and free of pollution.

Name: ____________________ Date: ____________________

Decision Matrix

Evaluating the solution against our criterion and constraints:

Solution	Criterion	Constraint 1	Constraint 2	Constraint 3	Constraint 4	Constraint 5	Constraint 6
A. **Wall-** Seawall							
B. **Wall-** Levee or sea dike							
C. **Wall-** Recurved wall							
D. **Breakwater-** Tetrapods							
E. **Breakwater-** Rock armor							
F. **Breakwater-** Submerged breakwater							
G. **Natural vegetation-** Mangrove forest							
H. **Natural vegetation-** Pine forest							

Name: ______________________________ Date: ______________________

Community Stakeholders

Part 1. Identify the stakeholders and their needs.

Consider the following:

- Who are the people that live in places where tsunamis might happen?
- Will they need special help during a tsunami? Describe those needs.
- Who can help them?

Who is this community member? (Stakeholders)	Will they need special help during a tsunami?	Describe their needs.	Who can help them?
	☐ yes ☐ no		
	☐ yes ☐ no		
	☐ yes ☐ no		
	☐ yes ☐ no		

Part 2. Define the problem and the goals of a tsunami communication system.

What is the problem that engineers are trying to solve in developing a tsunami communication system?

What would that system need to do to address all the needs of the community members?

Part 3. Identify the specific criteria and constraints for communication systems.

Identify criteria. **What *must* the system be able to do to work?**	**Why is this an important criterion?**

Identify constraints. What might limit what is possible in the communication system?	**Why is this constraint important to consider?** Are there particular community member needs that we should consider?

Name: ____________________ Date: ______________

Evaluation Matrix

Evaluate the solution against our criteria and constraints.

Use the following rating scale to consider how well the communication system performs:

● ● ● ● ● Performs really well.

● ● ● Performs well.

● Does not perform well or is absent.

List the Communication System Solution	Criteria 1	Criteria 2	Criteria 3		List possible constraints.

Name: ______________________ Date: ______________

Obtaining Information Notetaking Guide

What is the question we are trying to figure out today with this text?

Obtaining information from scientific text	
Read for the gist—skim the title, headings, images.	What is the central idea or claim?
If using a paper copy, mark up the text.	Select methods for marking the text. • Keep track of questions you have in the margins. • Circle key words. • Put question marks by words you want to learn more about. • Underline main ideas. • ______________________ (another method of your own)
If using the digital StoryMap, track questions and key words here.	
Examine any images, graphs, or tables.	Write one sentence about the central point of each image, graph, or table.

Sending Warning Signals

How we communicate with one another, including how we warn others in an emergency, looks very different today than in the past. As you read this text, consider how technologies have changed over time to make communication between people more reliable, faster, and overall easier.

The History of Sending Warning Signals

If you lived a very long time ago, the only way you could warn others about danger would have been to use something that another person could detect directly using one or more of their senses. To alert them using their sense of hearing, for example, you might have yelled or hit something like a hollow tree trunk or a drum. To alert them using their sense of sight, you might have created a fire with a bright flame or a lot of smoke.

Great Wall of China.

In the past, humans set up chains of communication where warnings could be passed from one person to the next over longer distances faster than someone could run in a short period of time. For example, evidence suggests that, up to 4,000 years ago, soldiers along the Great Wall of China lit fires to send smoke signals from tower to tower to warn each other if they saw an enemy army approaching.

The Telegraph. During the 1800s, people started sending warning messages over much longer distances using signals generated by electricity. The telegraph is an example of using signals generated by electricity to send messages. A telegraph used a series of long and short taps called Morse code to send a signal.

A telegraph message could be sent over very long distances very quickly, but this method of communication required someone trained to send the signal in Morse code and also someone to be able to read Morse code to receive it. Another disadvantage is that telegraphs were mostly sent by wire, and the signal could only be sent through a wire to another telegraph location.

After a warning message was received by telegraph, it then had to be delivered by hand or verbally from one person to another. The people that needed the message could be miles away and a lot of messages were delivered by people traveling from place to place, or by using bells or sirens.

Morse code.

The Telephone. In the late 1800s and early 1900s, the use of telephones replaced telegraphs because telephones allowed people to communicate by voice, without relying on the codes of telegraphs. As telephone technology improved, the telephone wires were brought all the way to people's homes and businesses.

At first, people had to connect the many different phone lines that were wires by hand, but soon technology was made to allow any telephone to be connected to any other telephone by a system of switches.

The image shows phone line operators connecting wires by hand. Each phone had to be called separately, making it a slow way to warn people of any hazard, and only some households had phones. Even today, most people can only place one phone call at a time.

Telephone switch operators.

Loudspeakers and Sirens. Another way that people are alerted to warnings is by loudspeaker. The speaker could be much louder and be heard further away than someone who is only yelling on the street, and could be used by someone who just received a warning signal.

Loud sirens became a common way to alert people during an emergency, and sirens are still used today. An example of this is the tornado siren. Unfortunately, sirens like a tornado siren are mostly designed to alert people who are outside of their houses, and can be hard to hear inside buildings.

The Radio. After the development of the telegraph, scientists and engineers designed radios. Radios send signals and messages wirelessly across an area. We still use radios in our homes, schools, businesses, and cars today. One advantage of the radio is the ability to send messages out to a large area, and not just to one location using a wire.

Stop and Think: How have emergency communication systems changed over time?

Modern Warning Signals Sent by Radio

The most reliable system we have to send messages to large groups of people is by radio. Unfortunately, traditional radio signals can be unreliable because of old equipment and other signals interrupting the message. Also, in order to hear an alert on the radio, the radio has to be turned on all the time.

Consider listening to a radio station. If you are listening near the source of the station, like the radio tower, the signal comes in clearly to your car or radio. But as you move further away from the station, the signal can become weak or have more static. As the signal becomes weaker, it is called a degraded radio signal. Radio signals become degraded, or reduced, as they travel over long distances. This happens partly because the signal becomes weaker as it travels away from its source. This is like when light gets dimmer further away from the light source and tsunami waves get smaller as they travel away from their source. The radio signal is carried by energy and the energy spreads out more and more as it travels. This means there is less energy traveling through any location farther from the source than there is closer to the source.

The problem of radio signals getting weaker as they travel can be solved by adding devices called repeaters. A repeater receives a weak signal and then retransmits it as a stronger signal. Unfortunately, these devices can be expensive to build and maintain in remote locations.

Another solution is to encode the radio signal in a digital format. This solution can be much less expensive than installing repeaters.

Signals encoded in a digital format can be transmitted over longer distances than signals that are sent using the analog format that radios have traditionally used. Like analog signals, digital radio signals get weaker as they travel. However, digital radio receivers can translate much weaker signals back into their original format better than analog radio receivers can.

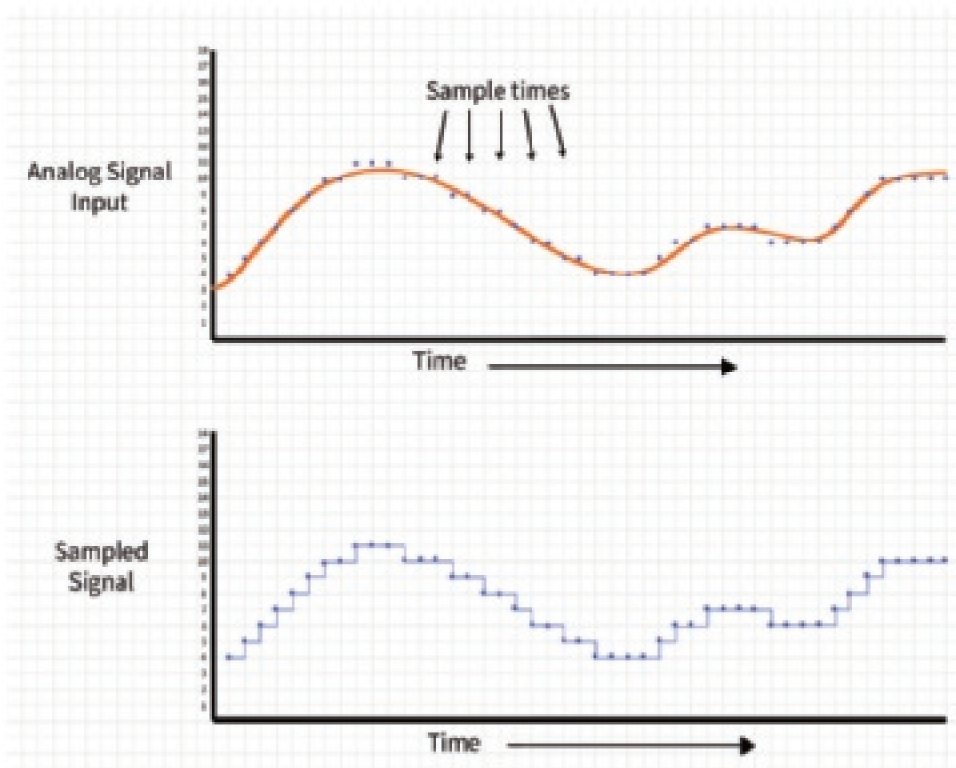
How Digital Signals Transmit Messages

Let's think about how digital signals like a tsunami warning over a loudspeaker start. First, a person speaks into a microphone. The microphone converts the sound of the person's voice into an electrical signal that can be transmitted along a wire. (You will learn how microphones convert sounds into electrical signals and how speakers convert them back into sounds in the *Magnets Unit*.) The electrical signal can be displayed as a graph.

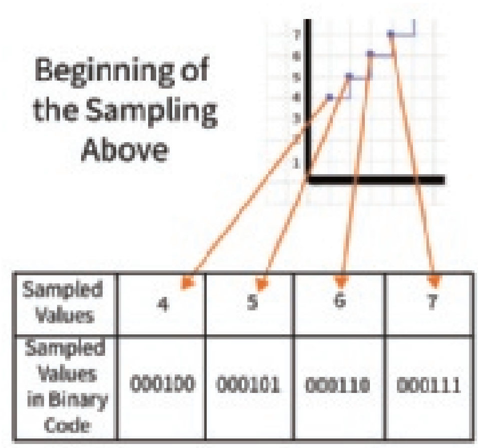
This graph is of a person saying "The quick dog ran across the yard."

This analog electrical signal can be converted to a digital signal by recording the value, or location, of the signal at regular intervals. These values are called samples of the original analog signal. Sometimes the signal we see generated, like in the image above, shows the values sampling of the audio on the Y-axis. The image below shows an analog signal in orange and also shows the times when data in the signal is turned into a digital signal (the sample times, shown by the lines on the graph). The blue dots show the sampling.

Stop and Think: Look at the blue dots on both the analog signal and the digital sampling. How do they compare?



The sampling that happened above is the first step of analog encoding. The second step is changing the sample values from the graph above into a sequence of 1s and 0s (similar to Morse Code) that encode the digital output. For example, if the digital output section that was sampled above was at a 2, it would be encoded in the signal to 000010. See the image to see how the sound wave that was recorded and sampled above is turned into a digital signal.

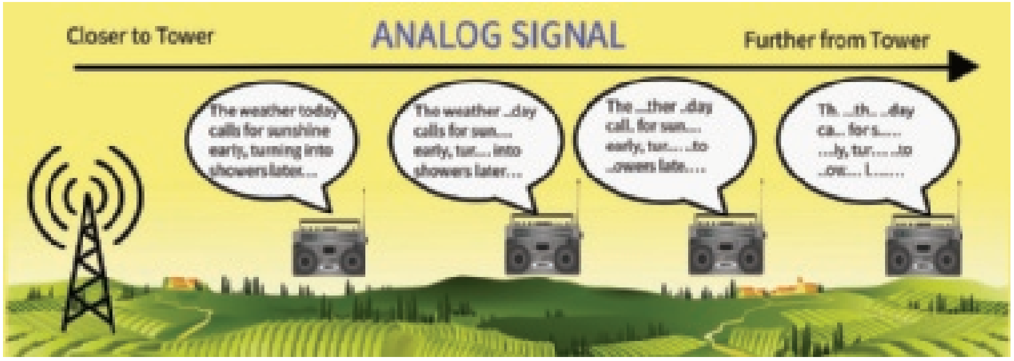


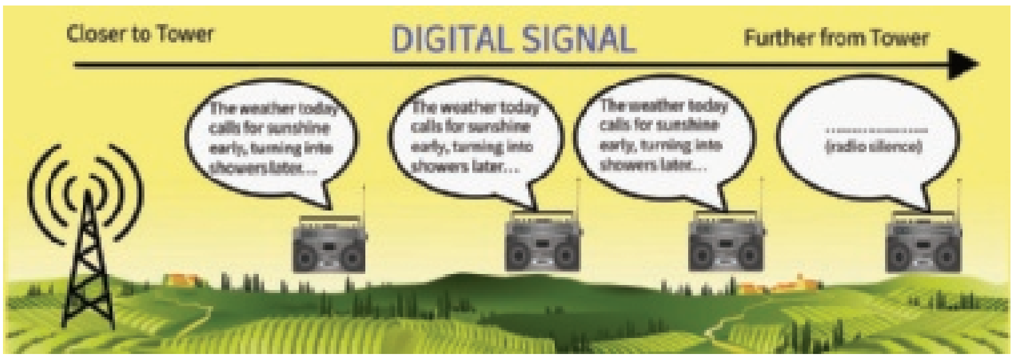
An analog signal, now converted to a digital signal, can then be sent by a radio transmitter as a series of pulses that are either "on" for 1s and "off" for 0s. The radio receiver decodes the digital signal by converting the sequence of pulses back into sampled values (like turning 000010 back into 6) which can then be converted into an analog, electrical signal. When this analog, electrical signal is connected to a speaker, the speaker will recreate the voice spoken into the original microphone.

The Benefit of Digital Signals for Transmitting Messages over Long Distances

Think about what happens when an analog signal, like a hazard warning signal sent over a radio, has to travel a long distance. The further the signal goes, the weaker the signal gets.

Now let’s think about a digital signal. In this case, the size of the pulses on the signal is smaller, but the receiver only has to be sensitive enough to distinguish between something that is a 1 or a zero, not the difference between a .6 and a .5 or a .7. Because of this, the digital signal has a clearer sound further away than an analog signal. Once the 0s and 1s cannot be interpreted by the radio, the signal is no longer played through the radio.





Cell Phones and Digital Push Notifications

Today we have systems, like apps and push notifications, that allow us to warn thousands of people at once when a hazard, like a tsunami, is occurring. These digital signal notifications have helped to save thousands of lives during different emergencies by quickly alerting large groups of different people at once. The signal can also be translated by the phone system into the language the user is the most comfortable using. But, getting hazard warnings to people in some remote locations is still a challenge. Consider cell phone coverage maps from any cell phone provider. Do you ever notice that there are some areas that are not covered? While many people have cell phones, there are still remote places that do not have reliable telephone or cell phone service.

Public Safety Alert
3h ago
Orange County Sheriff advises the Tsunami Advisory remains in effect. Avoid beaches and harbors.

A tsunami alert sent out in Orange County CA after the 2022 Hunga Tonga-Hunga Ha'apai eruption.

Tsunamis can occur in many locations, and affect many different people. We also know that many of those people may live in remote areas.

- When considering our stakeholder groups, what type of warning signals might make the most sense to alert them of a hazard?
- What would be a more reliable signal for them to receive, digital or analog? Why?
- Is a warning signal, like a radio signal or a loudspeaker broadcast, the only signal needed to warn people?
- If yes, why? If no, what other method(s) would we want to consider for all of the stakeholder groups we have identified?

Engineering Self-Assessment Rubric

Category	1	2	3
Identify criteria	Describe a given problem.	Describe some criteria for an effective design solution.	Document a complete set of criteria for an effective solution focused on a given problem.
Identify constraints	Describe the context where a given problem is relevant.	Describe some constraints for a given context.	Document a complete set of constraints for an effective solution to a given problem in a given context.
Consequences to people of a design solution	Share ideas for how the problem might impact people.	Describe some of the possible positive and/or negative impacts on people in this problem context.	Document positive and negative consequences on people when solving a given problem, including how some solutions positively impact some while negatively impacting others.
Environmental consequences of a design solution	Share ideas for how the problem might impact the environment.	Describe some of the possible positive and/or negative impacts on the environment in this problem context.	Clearly document positive and negative consequences on the environment of solving a given problem, including how some solutions positively impact parts of the environment while negatively impacting other parts.
Impacts on people and the environment limit possible solutions	Share ideas about how impacts on people and the environment might influence a possible design solution.	Identify and describe how impacts on people and/or the environment might serve as a constraint to possible solutions.	Clearly document how specific impacts on people and/or the environment might serve as a constraint for potential solutions, but these impacts might be prioritized when choosing one solution over another.
Using a defined process to evaluate design solutions	Design solution was **not** evaluated using a design matrix.	Design solution was evaluated using a design matrix that includes **some** criteria and constraints or **non-specific** criteria and constraints.	Design solution was evaluated using a design testing matrix that included **all specific** criteria and constraints. Design solution evaluation includes a full analysis of how well the design will detect, warn, or communicate to people and/or reduce the impact of a tsunami wave.
Prioritizing criteria and constraints and identifying tradeoffs	The criteria and constraints are **not** prioritized.	The criteria and constraints are prioritized in order to produce or evaluate a design solution. There is a rationale for the priority order.	The criteria and constraints are prioritized and weighted in order to produce or evaluate a design solution for use in a particular context. Tradeoffs are identified. There is a clearly stated rationale, including science ideas for the priority and weighing decisions.
Identify and consider the needs of stakeholders	Stakeholders have not been identified, or their needs have not been included in the evaluation process.	Some relevant stakeholders and their needs have been identified and partially included in the evaluation process.	Relevant stakeholders and their needs have been considered and incorporated into the evaluation process.

Name: ______________________ Date: ________________

Determining Stakeholder Needs

1. Design solutions and hazard warning system technologies are influenced by criteria and constraints from stakeholders. Pick two stakeholder groups to communicate with from our Community Stakeholders chart and add them to the first column in the table below. Use the other columns in the table below to identify considerations for communicating with the stakeholders.

Consider your Stakeholder Group's Criteria, Constraints, and Communication Sources

Stakeholder group(s) I want to communicate with	Criteria (what would make communication effective for stakeholders)	Potential constraints the stakeholders might have in receiving information	Does your stakeholder group require assistance during a hazard?	Who can assist them?	Sources and types of communication the stakeholders trust for important information
			☐ yes ☐ no		
			☐ yes ☐ no		

2. Consider your stakeholder groups. What type of a communication plan would make sense to use to share information with your stakeholder group and why? How would you want to present the information to them?

____

____

____

Project Options

Different presentation options for your hazard awareness project are below. This list is meant to help you think of ways to present your information, and you also may think of a way that is NOT on this list. Check with your teacher if you would like to explore a project option that is not listed below. If you choose a digital option, make sure that you can access at least 1 digital resource on your device that can help you assemble your project.

Project option	Project details	Materials needed	Digital resources available to assemble project
Poster	Create a poster to be displayed in a public place.	Hard copy: paper, pencils, markers Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote
Commercial	Film a commercial to air during a popular TV show.	Digital: computer (may need camera), phone, editing software	iMovie, Adobe Spark, Animaker, Powtoon, Flipgrid, Clips, Scratch
Podcast	Record an informative podcast.	Digital only: phone or computer with audio recording capabilities	GarageBand, Anchor, phone audio recording, QuickTime
Brochure	Create a brochure to be either handed out or displayed.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Docs, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word
Flyer	Create a flyer to be passed out to people.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Piktochart, Adobe Spark
Infographic	Create an infographic to be passed out or shared with others.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Piktochart, Adobe Spark
Billboard	Design an eye-catching billboard. Include a "check out this website" link and accompanying materials.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word
Newscast	Film a newscast as a news anchor or reporter.	Digital: computer (may need camera), phone, editing software	iMovie, Adobe Spark, Animaker, Powtoon, Flipgrid, Clips, Scratch
Children's book	Write and illustrate a children's book to inform kids about a natural hazard.	Hard copy: paper, pencils, colors Digital: computer	Book Creator, Google Slides, PowerPoint, Keynote, Google draw, iMovie, Animaker, Scratch

Newspaper article	Write a newspaper article about the hazard.	Hard copy: paper, pencil Digital: computer	Google Slides, Google Docs, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word
Fake TikTok, etc.	Record a story to share with others.	Digital: computer	iMovie, Adobe Spark, Animaker, Powtoon, Flipgrid, Clips, Scratch, social media platform (with your teacher's permission!)
Write a song	Write a song to communicate hazard information with others. This could be made Karaoke style or as a song parody!	Hard copy: paper, pencil Digital: computer, phone or computer with audio recording	GarageBand, Auxy studio, phone audio recording, Google docs, QuickTime
Radio jingle	Record a catchy radio jingle for people to "get stuck in their heads."	Digital: phone or computer with audio recording	GarageBand, Auxy studio, phone audio recording, QuickTime
Website	Create an informative website for people to get more information.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word, Google Sites
Natural hazard app	Design an app to educate and warn others.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word Multiple free printables available
Comic strip	Create a comic strip of how to prepare for a natural hazard.	Hard copy: paper, pencils, colors Digital: computer	Pixton, Google Slides, Google Docs, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word Multiple free printables available
Facebook page with resources/ posts	Design a Facebook page and posts to educate others.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word Multiple free printables available
Series of tweets	Craft a series of informative tweets others would read to learn more about a hazard.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word Multiple free printables available

Name: ______________________ Date: ______________

Hazard Communication Planning

Part 1: Gathering Information about Your Natural Hazard

Now that we have assessed what needs our stakeholders might have, we can think about what the stakeholders need to know about our hazard. Use the template below to help collect data about your hazard and determine what information might need to be communicated to your stakeholders.

What hazard are you sharing information about with your stakeholder group(s)?

About the Hazard	
Where and when does the hazard occur? Other questions to investigate: • How often does it happen? • Does it happen fast, or is there time to prepare? • How strong or severe can it get?	
What type of damage can this hazard cause?	
Is there a rating scale or something else to communicate the threat levels to our stakeholders?	
Are there certain areas that are more likely to get damaged from this natural hazard?	

Forecast and Detect	
How can we detect this hazard?	
How will your stakeholders know this natural hazard is coming?	
How much time do your stakeholders have between the warning and the hazard striking?	

Warn and Communicate	
Are there structures or plans already in place to help protect your stakeholders during a natural hazard?	
What should your stakeholders know about these structures or plans?	

Part 2: Plan to Communicate about Your Hazard to Your Stakeholder Group(s)

Now that you know more about the hazard and our stakeholders, we can use the tables below to help plan our communication project. Consider each stakeholder group, and think about the information they need to know about your chosen natural hazard.

Looking back to Lesson 7, we know talking about natural hazards can be scary for some people, especially if they have experienced a natural hazard in the past. This hazard awareness plan needs to be helpful and should **make sure that the information does not cause panic or fear, so we need to plan our hazard awareness plan carefully.** Use the areas below to help you develop a plan and determine how you will present your information:

Hazard Communication Plan Development	
Considerations	**What can we do to help inform your stakeholder group(s)?**
What criteria did you identify on *Determining Stakeholder Needs* for communicating with your stakeholders? What do we need to communicate with them?	
What method are you going to use to communicate with your stakeholders?	
What will you tell your stakeholders about the cause(s) of the natural hazard?	
What will you tell the stakeholders about warning signs and detection methods?	
How will this group of stakeholders know that the hazard is going to happen?	
What can you mention that is already in place to help keep them safe?	
What should stakeholders do to prepare for the hazard?	

Name: ______________________ Date: ________________

Stakeholder Criteria and Constraints Peer Feedback Form

List your stakeholder group(s) here: ____

Look back at the criteria and constraints for your stakeholder group that you identified on *Determining Stakeholder Needs*. List the criteria and constraints you identified for your stakeholders in the first column below. Add rows to the back of this handout if needed. Then, give your handout to another student to evaluate your project for the use of your criteria and constraints.

Criteria and Constraints for this Stakeholder Group	Evidence of using the criteria/constraints in the communication plan	Feedback and potential ways to better address the criteria and constraints

Name: ______________________ Date: ______________

Self-Assessment: Giving and Receiving Feedback

Self-Assessment: Giving Feedback

How well did you give feedback today?

Today, I …	YES	NO
Gave feedback that was **specific and about science ideas.**		
Shared a suggestion to help improve my peer's work.		
Used evidence from investigations, observations, activities, or readings to support the feedback or suggestions I gave.		

One thing I can do better the next time I give feedback is:

Self-Assessment: Receiving Feedback

How well did you receive feedback today?

Today, I …	YES	NO
Read the feedback I received carefully.		
Asked follow-up questions to better understand the feedback I received.		
Said or wrote why I agreed or disagreed with the feedback.		
Revised my work based on the feedback.		

What is one piece of feedback you received?

What did you add or change to address this feedback?

Name: ______________________ Date: ______________

Family Hazard Plan

Before, During, and After Checklist

During some natural hazards, the best plan is to shelter in place, which means you find the safest place in the house or building you are in. But, if necessary and if you have time, evacuation is often a safe response to an approaching natural hazard. Use this resource to learn about best practices for developing a family disaster plan, including how you might evacuate if necessary.

Below is a list of important considerations for you and your family. A comprehensive planning checklist is located here: https://www.ready.gov/plan.

BEFORE a disaster, plan for the following:	
• Learn about your local hazards and how to respond when they happen. Evacuation is NOT always the correct response.	• Sign up for emergency alerts, such as NOAA or FEMA alert systems. See https://www.ready.gov/alerts for a list of alert systems.
Plan how you will leave:	
• Identify the people who are safe for you to travel with (in case you are not at home).	• Know evacuation routes and identify alternate routes.
Plan where you will go:	
• Identify several destination options where you might go, such as the home of friends or family, or a safe motel or shelter where you can stay.	• Communities often identify local schools and community centers to serve as shelters for people who are evacuating.
Plan how you will meet with your family if you are separated:	
• Let out-of-area family members know where you are—they can help communicate for you. • Use social media to post that you are OK (but do not put your location for safety reasons).	• Call or text if cell service is good. • Contact local law enforcement or the American Red Cross, who can help reunite you with your family.
Plan what you will take:	
• Prepare a “go-bag” you can carry when you evacuate on foot or public transportation. Include supplies for traveling longer distances if you have a car. (See Kit List below.)	• Identify a safe place for family pets if you are unable to take them with you.

DURING a disaster:	
• Follow local evacuation instructions. Do not take short-cuts or go around roadblocks. • Take your emergency kit with you. Wear clothing that provides protection, such as long pants, a longsleeved shirt, and a hat. • Take family pets with you if possible.	• Call contacts on your communication plan to let them know where you are going. Also, leave a note at your home stating where you are going. • Lock your home and unplug appliances (if time allows). • Check with neighbors to see if they need help evacuating.

Before traveling home:
If you evacuated due to a storm, check with local officials where you are staying and with those back home before you travel. Before you travel home, do the following: • Let friends and family know before you leave and when you arrive. • Fill up the gas tank in your car and gather supplies, such as water and food. • Charge all devices.

AFTER a disaster, be aware of the following:
• Always avoid power lines and appliances that might have been damaged in the disaster. • Listen to local officials about which neighborhoods and areas are safe for people and which places to avoid. • Follow newpages on social media and pay attention to weather apps for up-to-date information about your hazard and the safety and response in your area. • Reflect on what went well with your family's response and what you can do better next time, should a natural hazard occur.

Kit Checklist

The minimum you should have for an emergency kit are the following items:

- Water for 3 days
- Food for 3 days (non-perishable food is the type of food that does not need to be refrigerated)
- Flashlight and extra batteries
- First aid kit and any important medications
- Cell phone with charger
- Cash
- Any important documents or IDs (driver's license, student ID)
- Emergency contact and family information
- House keys
- Any special items for you or a family member

See https://www.ready.gov/kit for other kit items.

Family Communication Plan

When we evacuate, we will meet at:			
First Choice:		Second Choice:	
Our "out-of-area" emergency contact is:			
Name:		Phone #:	
Important phone numbers:			
Local Police Department/Precinct		Phone #:	
Local Fire Department/Station		Phone #:	
Other emergency contacts are (list name and best phone number):			
Parent:		Phone #:	
Parent:		Phone #:	
Sibling/Family:		Phone #:	
Sibling/Family:		Phone #:	
Other:		Phone #:	
Other:		Phone #:	
Our two evacuation routes are (name and sketch):			
Route 1:		Route 2:	

Name: ______________________ Date: ______________

Roadmap for Reading

This week's reading collection focuses on presenting a range of natural hazards in different formats. The first selection focuses on patterns in numerical data displayed graphically. The second selection presents natural hazard events from an artistic point of view.

"Collection 1: Types and Frequencies of Hazards" consists of two selections.

1. Natural Hazards, Visualized
2. Hazards Depicted in Art and Literature

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Analyze how captions and graphics interact and whether it is better to read the caption first or look at the graphic first.
- Consider how different forms of art or literature approach a similar theme.

Written Response

Your writing exercise is to draft a script for a one-minute news video about one of the events depicted in literature or art in the second reading.

- Compose your script on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Copy the template shown for your script.
- Write the words the reporter will speak in the left column. About 125–140 words can be spoken in a typical one-minute video, so check that you stay within the limit.
- Use the right column to describe what the audience will see. Each time you change the visual, start a new row.
- Write the audio as a reporter who arrived at the location soon after the disaster. Inform the listeners where you are, what you see, and whom you talked to.
- Explain any science ideas and terms that you think the general public might not know.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Audio—dialogue and sound effects	Visuals—what the viewer will see

Evaluation Guidelines

Element	1	2	3	Feedback
Content	The script inadequately describes a scene from a work of art or literature resulting from a natural hazard event, with few details and causes and effects, many of them inaccurate.	The script adequately describes a scene from a work of art or literature resulting from a natural hazard event, with mostly accurate details about its cause and how it affected people or their structures	The script realistically describes the scene from a work of art or literature resulting from a natural hazard event, with accurate details about its cause and how it affected people and their structures	
Dialogue and tone	Dialogue and tone are inappropriate for a news video about a serious topic for the general public.	Dialogue and tone are mostly appropriate for a news video about a serious topic for the general public.	Dialogue and tone are appropriate for a news video about a serious topic for the general public.	
Script length and clarity	The audio is too brief, and the visual guide lacks details needed for a reporter to follow it.	The audio is too brief or too long, but the visual guide gives enough information so that a reporter can follow it.	The audio is close to 125–140 words, and the visual guide gives enough information so that a reporter can follow it.	
Grammar and mechanics	There are six or more errors in punctuation, capitalization, and spelling.	There are three to five errors in punctuation, capitalization, and spelling.	There are fewer than three errors in punctuation, capitalization, and spelling.	

Additional Feedback Notes:

Name: ______________________________ Date: ______________________

Roadmap for Reading

This week's reading collection focuses on how scientists monitor, predict, and measure the effects of natural hazards on humans and property. The selections include a mock ask-a-scientist newspaper feature and fictional online posts and comments. All the readings will help you develop understanding of the importance of mathematical thinking in science.

"Collection 2: Forecasting the Unpreventable" consists of five selections.

1 Tsunami Models

2 Dear Scientist Column

3 Cranky Yankee Blog

4 The Cascadia Subduction Zone

5 COVID Forecasts

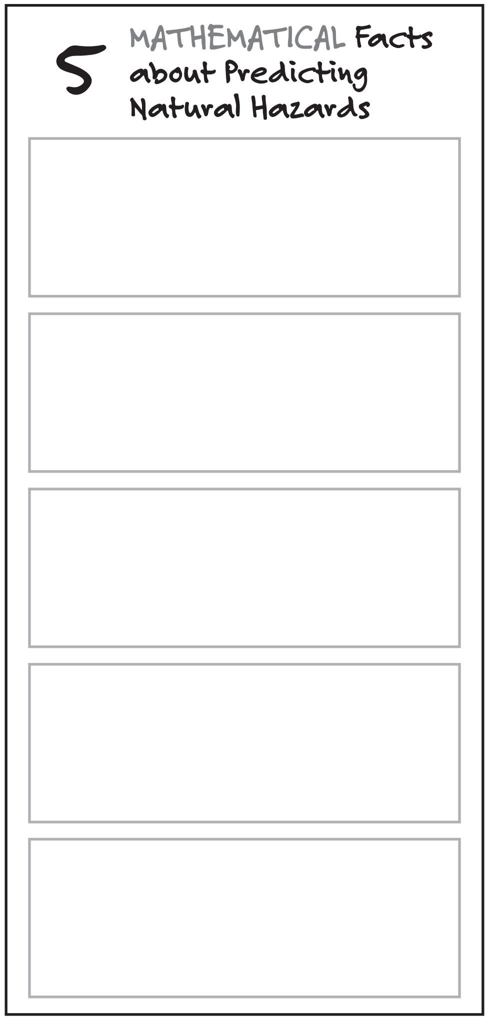
As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Consider how data and graphics support the narrative text and how narrative text clarifies the data and graphics.
- Look for examples of how scientists use numbers and math ideas to clarify the science.

Written Response

Your writing exercise is to develop an infographic highlighting several mathematical ideas presented in this collection to support the science.

- Compose your infographic on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Sketch a layout that helps "sell" your point. You can adopt the template shown on the next page or design your own layout.
- Indicate the number of examples you will communicate on your infographic. Then draw the same number of boxes to hold the examples.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.



Evaluation Guidelines

Content

- There are at least four well-chosen statements that explain how mathematical concepts support understanding the science in this collection.
- At least three readings are represented.
- The concepts are in the same order that they appear in the readings.

Text

- The title includes the number of ideas as its first word.
- The text is clearly worded and easy to read.
- Spelling, grammar, and punctuation are correct.

Design

- Math terms and data are set off with a different color than the rest of the text.
- There is a drawing or symbol for each math idea that is easy to interpret.

Additional Feedback Notes:

Name: ______________________________ Date: ______________________

Science Literacy Exercise Page 3 Use with Reading Collection 3

Roadmap for Reading

This week's reading collection focuses on using data to understand and prepare for natural disasters. The selections include an infographic that can help families prepare for most types of natural disasters and insights into what happened before, during, and after the tsunami that struck Japan in 2011.

"Collection 3: Minimizing Damage" consists of four selections.

1 Contrasting Natural Hazards
2 Natural Hazard Survival 101
3 Disaster Domino Effect
4 Tsunami Measurements

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Consider how data and graphics support the narrative text and how narrative text clarifies the data and graphics.
- Be on the lookout for unfamiliar science vocabulary, and use context clues to determine their meaning.

Written Response

Your writing exercise is to complete the summarizing outline provided on the opposite side of this page.

- Copy the partially completed outline on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Go back and review the readings, looking especially at topic sentences, vocabulary, and concluding paragraphs. Fill in missing main ideas needed to summarize each reading and complete the outline.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Science Literacy Exercise Page 3 continued

Minimizing Damage

I. Contrasting Natural Hazards

   A. Some natural hazards are more dangerous if there are more people in the area.

   B. On the earthquake magnitude scale, the severity of the earthquake increases by 10 times from one whole number on the scale to the next.

II. Natural Hazard Survival 101

   A Try to live in areas that are not prone to natural disasters.

   B.

   C. Make an evacuation plan with the people you live with.

   D.

III. Disaster Domino Effect

   A.

   B. Far from where the tsunami hit, 4 million people in Tokyo lost electrical power.

IV. Tsunami Measurements

   A.

   B.

Evaluation Guidelines

Element	1	2	3	Feedback
Content	The outline wording has more than two science errors, and some of the "main ideas" focused on are less important details.	The outline wording has one or two science errors but attempts to reflect important main ideas of each reading.	The outline wording is scientifically accurate and reflects important main ideas of each reading.	
Outline Wording	Content is substantially copied, rather than paraphrased; some main idea statements are missing.	Most statements are paraphrased, using own wording. There are at least two main ideas for each heading.	Statements are paraphrased, using own wording. There are at least two main ideas for each heading.	
Grammar and mechanics	Main ideas are not stated as complete sentences, and there are six or more errors in punctuation, capitalization, and spelling.	Most main ideas are complete sentences, and there are three to five errors in punctuation, capitalization, and spelling.	All main ideas are complete sentences, and there are fewer than three errors in punctuation, capitalization, and spelling.	

Additional Feedback Notes:

Name: ______________________ Date: ______________

Roadmap for Reading

This week's reading collection focuses on actions people can take to prevent harm to themselves and communities from natural hazard events. The selections include several maps containing data that citizens as well as emergency management teams use to protect communities.

"Collection 4: Communities and Cooperation" consists of four selections.

1 Radiation from Fukushima! Or Something Else?

2 Hazard Map Comparison

3 Katrina's Aftermath

4 Hazards on Hawaii's Islands

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Consider how data and graphics support the narrative text and how narrative text clarifies the data and graphics.
- Look for clues that help you decide whether a writer is credible or not.

Written Response

Your writing exercise is to complete a well-reasoned paragraph that will advise the family introduced in the Preface on where to live and what to consider after they move to try to stay safe from natural hazards.

- Compose your paragraph on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Make a claim in your topic sentence, stating what you think would be best for the family and answering the question "Where should the family move, and what can they do after they move to reduce the risks related to natural hazards?"
- Support your claim with detailed sentences that explain your reasoning and how it is supported by data, including data from the reading selections.
- Include details about future actions the family can take to stay safe once they move.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Evaluation Guidelines

Element	1	2	3	Feedback
Claim/topic sentence	The topic sentence lacks a claim relevant to the Preface scenario.	The claim is not completely clear or rambles but does address the Preface scenario.	The claim in the topic sentence is clearly worded, answers the question, and is appropriate to the Preface scenario.	
Reasoning and evidence/supporting sentences	Paragraph contains incomplete sentences, lacking reasoning or evidence from the unit, or containing details irrelevant to the topic sentence.	Paragraph contains complete sentences, but too few, includes reasoning, but lacking in evidence from the unit, or unclear relationship to the claim in the topic sentence.	Paragraph contains at least six complete sentences, strong reasoning, using evidence from the unit to clearly support the claim in the topic sentence.	
Organization and transitions	Paragraph contains statements with little clear relationship to the topic sentence or each other.	Paragraph contains key supporting details but transitiona are absent or choppy.	Paragraph presents ideas in an order that helps the topic make increasingly more sense.	
Grammar and mechanics	There are six or more errors in punctuation, capitalization, and spelling.	There are three to five errors in punctuation, capitalization, and spelling.	There are fewer than three errors in punctuation, capitalization, and spelling.	

Additional Feedback Notes:

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