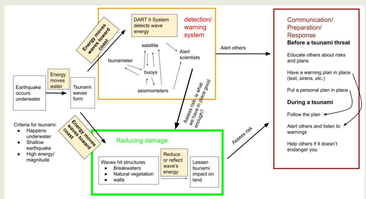
LESSON 8: How can we model the systems put into place to protect communities?

PREVIOUS LESSON *We listened to tsunami warning signals and read accounts of tsunami survivors from Japan and what they did when an earthquake and tsunami occurred. We identified community stakeholders, developed criteria and constraints for tsunami communication solutions, and evaluated different ways tsunami preparation and response are communicated. We read a case study about a school in Kamaishi that included education as part of their plan. From this we learned that there are many ways to communicate with community stakeholders before and during a tsunami event.*

THIS LESSON

PUTTING PIECES TOGETHER

2 days



We revisit past lessons to categorize and organize what we have learned about the systems and subsystems involved in detecting, warning people, and reducing damage from tsunamis. We work together in a Scientists Circle to develop a systems model that identifies the relationships within and between subsystems and understand how they work together to meet goals of the community. We generalize the process that engineers engage in to solve problems and use what we have learned to develop a plan to address a local natural hazard.

NEXT LESSON *We will gather and communicate information about a local hazard in our community. We will obtain information from a variety of sources, including agencies and organizations that focus on hazards and emergencies, and develop a plan and/or product to communicate the information to stakeholders in our community.*

BUILDING TOWARD NGSS

MS-ESS3-2, MS-ETS1-1, MS-ETS1-2

WHAT STUDENTS WILL DO

8.A Construct a system model to represent the interactions of subsystems designed to detect, warn communities, and reduce damage from a tsunami hazard.

WHAT STUDENTS WILL FIGURE OUT

- Engineers can design a system for responding to hazards that includes technologies to detect, warn people, and reduce damage.
- Each part of a hazard mitigation system is dependent on another part of the system; subsystems work together to meet the criteria for the overall system.
- Engineers engage in a generalized process to define problems, develop solutions, and optimize those solutions.

Lesson 8 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	8 min	**LOOK BACK AT SYSTEM COMPONENTS** Turn and Talk to a partner about parts of the tsunami system that have been identified. Create a chart and organize the parts of the system.	A-B	System Components chart
2	8 min	**CREATE AN INITIAL TSUNAMI PROTECTION SYSTEM MODEL** Using system components from the chart, construct a tsunami protection system model, including subsystem interactions.	C	
3	10 min	**COMPARE TSUNAMI SYSTEMS MODELS** Meet in a Scientists Circle to develop a systems model of tsunami detection/warning signals, damage reduction, and communication/preparedness.	D	System Components chart, chart paper, markers
4	15 min	**CREATE TSUNAMI SYSTEM CONSENSUS MODEL** Transfer the components of each subsystem into a consensus model to show how the subsystems interact across a larger more complex system.		
5	4 min	**EXIT TICKET** Complete an exit ticket considering the role of each component in the system.	E	notecard
				End of day 1
6	14 min	**ANALYZE SYSTEM AND SUBSYSTEM COMPONENTS** Determine how the subsystem components interact to meet the overall criteria of the system.	F-G	Large sticky notes or notecards with "What we do as Engineers" phrases, chart paper, markers
7	12 min	**CREATE WHAT WE DO AS ENGINEERS CHART** Create a process diagram to illustrate how the class used engineering ideas and practices to evaluate parts of the system.		"What we do as engineers" note cards or sticky notes, "What we do as engineers" poster, markers
8	14 min	**CONDUCT ENGINEERING SELF ASSESSMENT** Complete engineering self assessment.	H	*Engineering Self-Assessment*
9	5 min	**LOOK BACK AT LESSON 1 HAZARDS** Look back at hazards from Lesson 1 and determine what students can do to help with natural disasters.	I	Related Phenomena poster from Lesson 1
				End of day 2

Lesson 8 • Materials List

	per student	per group	per class
Lesson materials	• science notebook • notecard • *Engineering Self-Assessment*		• System Components chart • chart paper • markers • Large sticky notes or notecards with "What we do as Engineers" phrases • "What we do as engineers" note cards or sticky notes • "What we do as engineers" poster • Related Phenomena poster from Lesson 1

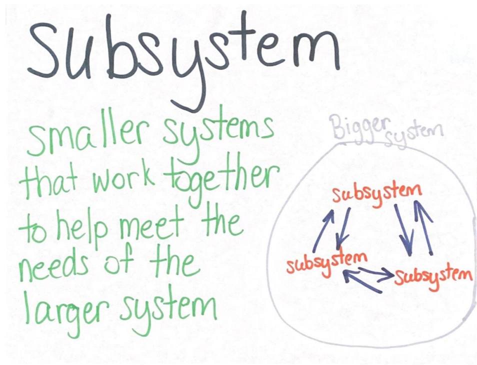
Materials preparation (10 minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Create a chart titled, "System Components."

- Create and label 3 columns
  - reducing damage
  - detection and warning
  - preparation, communication, and response



Create a chart titled, "What we do as Engineers."

Construct large 6x8 stickies or large notecards with the following phrases for "What we do as Engineers" chart:

- We evaluate and compare solutions among one another.
- We identify trade-offs when choosing one solution over another.
- We define our problem.
- We identify criteria and constraints.
- We identify our stakeholders.

Create a subsystem Word Wall card

Have the Related Phenomena poster from Lesson 1 available for the end of day 2.

Both the Related Phenomena poster from Lesson 1 and the Systems Components chart created in this lesson will be used again in Lesson 9.

Lesson 8 • Where We Are Going and NOT Going

Where We Are Going

This lesson will focus on helping students develop a model that will illustrate how the subsystems they have been learning about in Lessons 5-7, work together to protect communities. The lesson centers on taking stock of all these science and engineering ideas students have been considering, and helps to create a conceptual framework that students can then apply to other natural hazards. Equally important is making the engineering process explicit for students in this lesson and giving students an opportunity to assess themselves on different aspects of that process.

Where We Are NOT Going

The model will be used to explain the interactions of the subsystems, but the overall system model will not be used to predict or explain the behavior of the overall system. Students will not be assessing the reliability of the system nor testing the system. Students will also not identify the iterative testing cycle within the engineering process.

LEARNING PLAN for LESSON 8

1 · LOOK BACK AT SYSTEM COMPONENTS

8 min

MATERIALS: science notebook, System Components chart

Look back at tsunami system components. Remind students that we have been working to understand what can be done to protect people during tsunamis and other natural hazards.

Say, *Think back to Lesson 1. We brainstormed a lot of natural hazards that worried us. We wanted to be able to do something to help during these natural hazards. In order to do that, we looked at tsunamis and determined how the communities detected and were warned of the hazard, how they tried to reduce damage, and how they communicated, prepared, and responded to the hazard. Before we try to apply what we have learned to our local natural hazards, let's take stock of what we have learned about different systems that work together to protect communities from tsunamis.*

Compile tsunami protections system components chart. Display **slide A.** Direct students to draw and label the 3 columns on the next clean left-hand page in their notebooks. The three columns should have the same labels that were used in Lesson 1.

- reducing damage
- detection/warning signals
- communication/preparedness

Explain that we will reuse the categories from Lesson 1 to take stock of the components of the different systems. Say, *Over the last few lessons, we have been analyzing and investigating these three areas of a tsunami protection system. Why do you think it is called a system?* Students might say because it is made of parts that work together to protect people.

In partner pairs or triads, ask students to look back in their Progress Trackers and record what communities, engineers, and individuals have developed or designed for the three main areas of the tsunami protection system. Partners should record the components of the systems in the appropriate columns.

Determine tsunami system components. Project **slide B.** Ask students to share out what parts they identified from our past lessons. Chart their ideas using the same columns as slide A. As students share, ask which category they placed each part of the system into and why.

At this point, it is OK if students are missing parts of the system in their table, as students will get an opportunity to share and further develop a class list in the Scientists Circle. If students struggle to come up with the general parts of the system, or have entire columns empty, have them focus on one specific column of the chart and a corresponding lesson to begin. Below are the corresponding lessons:

- Reducing damage:
    - Lessons 3 &5
- Detection/warning signals:
    - Lesson 6
- Communication/preparedness:
    - Lessons 6 &7

Create a public record of system components. Display the "System Components" chart in front of students. Starting with the column on the left, *reducing damage*, ask students to share what components of this subsystem they have identified. Work across the chart and complete all 3 columns with students. The columns should include the components listed below:

Reducing damage	Warning and detection	Preparation, communication, and response

Design solutions such as:
• breakwaters
• walls
• natural vegetation
	The DART II System
	• seismometers
	• buoys
	• tsunameter
	• satellites
	• scientists
		• community education of how to respond
		• plan development
		• executing the plan when it happens
		• warning others that the threat is coming
		    ◦ sirens, text, TV
		• listen to warning signals
		• help others if it doesn't endanger you
		    ◦ children, elderly, etc.

ADDITIONAL GUIDANCE

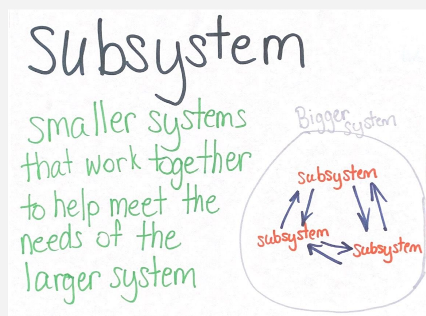
Students should develop a list of the components of the system in the chart above. If students are missing components on the class chart, use the following prompts to help guide students to include the needed components:

Reducing damage
- What did we learn about in Lesson 5 that helps reduce damage?
  What type of design solutions did we look at? What were the main categories?

Warning and detection:
- Think back to Lesson 6. How do we know a tsunami is coming? What system is already in place to detect tsunamis?
- What are the parts of the DART II system that we read about?

Preparation, communication, and response:
- In our last lesson, we learned how people felt and responded during a tsunami. What warned them that a tsunami was coming?
- What do we need to do ahead of time to make sure we are safe during the event?
- When people are alerted of a tsunami, what should they do?

Introduce the term subsystem. Take a moment and ask students to look at the parts that were identified in each of the systems.



Say, *We know that these areas we identified from Lesson 1 are systems. These systems are all parts of our larger tsunami protection system. When we have these smaller systems that are part of a larger system, we call them subsystems. These subsystems interact to help meet the overall criteria of the larger system.*

Add the term *subsystem* to the Word Wall.

Say, *Let's see if we can explain how these subsystems work together to meet the protection needs of the community.*

2 · CREATE AN INITIAL TSUNAMI PROTECTION SYSTEM MODEL

8 min

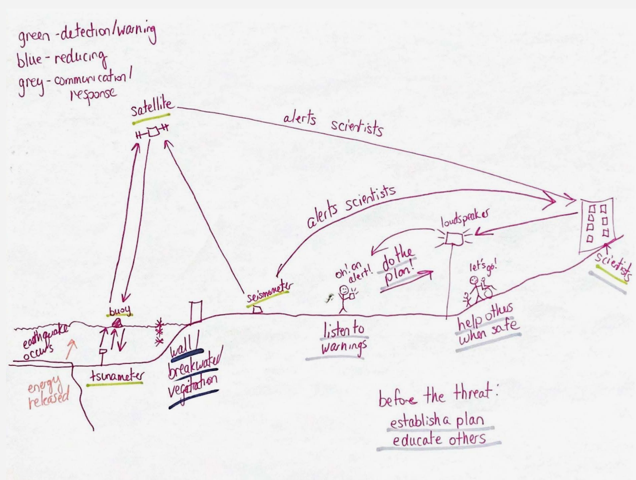
MATERIALS: science notebook

Connect tsunami protection measures in a systems model. Project **slide C.✱** Once students have completed their chart, ask students to consider how the subsystem components are connected to each other and how they work together as part of a system. Ask students to work with a partner or triad to draw a model of the tsunami protection system, starting with the onset of the earthquake on the right-hand page. Direct students to add in all the components and use arrows to show connections between the subsystem and system components.

Observe student system models. Circulate as students are completing their system models. Ask students guiding and clarifying questions, such as:

- What area of tsunami protections does this part of the system fall into on your chart?
- I see you added _____ to your system model. How does that connect to another part of the system or subsystem?
- Can you add arrows to show how the parts of the system or subsystem are connected?
- Have you shown parts of the subsystems for all 3 areas that protect communities from tsunamis?
- Have you shown how the tsunami begins, and what triggers certain parts of the system to start working, if they are not functioning all the time?

As students are working on their models, make a mental note of how students are representing their ideas to share in the Scientists Circle.✱ An example of a system model is seen to the right.



✱ SUPPORTING STUDENTS IN DEVELOPING AND USING SYSTEMS AND SYSTEM MODELS

Across Lessons 5-7, students have been figuring out how different subsystems function independently. This is the moment in the unit where students will build a larger, more complex system that connects the functions of the subsystems to show how they interact within one another to protect communities.

✱ ATTENDING TO EQUITY

Universal Design for Learning: Students may struggle creating a visual *representation* of the parts of subsystems to a larger system that allows them to perceive the connections between the parts of the subsystems or overall system. Encourage students to start with a more familiar approach by thinking about what events happen first and what parts of the system are involved in that work. As students consider what happens next, encourage students to begin making connections between components. Using color coding to represent components that work together for a category area may help them identify subsystems within the broader system and how those subsystems are connected.

3 · COMPARE TSUNAMI SYSTEMS MODELS

10 min

MATERIALS: science notebook, System Components chart, chart paper, markers

Share and consider initial models. Project **slide D**. Tell students to bring their notebooks and a pencil to the Scientists Circle. Have 2-3 students present their systems model to the full Scientists Circle. Ask one student to begin by showing the parts of their system model and show how they are connected to one another. As students share, direct the listening students to consider the questions presented on the slide. Allow students to ask clarifying questions to the student sharing their model. Once they have shared their system model, ask the 1-2 other students to share their system models.

Compare models. Ask students to share their thoughts on the three questions from **slide D**. Example prompts and responses are below.

Suggested prompt	Sample student response
How are the parts of the system connected?	*The detection system helps us alert others--they are connected.* *The tsunami reduction items are related to the warning people section.*
How are parts of the subsystems connected?	*There are connections between pieces in each system, like the DART II system, but we didn't all show the exact same connections.* *Some of us showed connections between components in the communication area.*
How are the models similar or different from each other?	*We all seem to have some of the same parts, but we drew them in very different ways.* *We have different connections.* *Some systems and drawings are more detailed than others, or have more or less connections.*

Say, *It seems that we have shown different connections and different ways of organizing our systems. Let's see if we can work together to create a system model that shows the components and connections that we can all agree upon.*✱

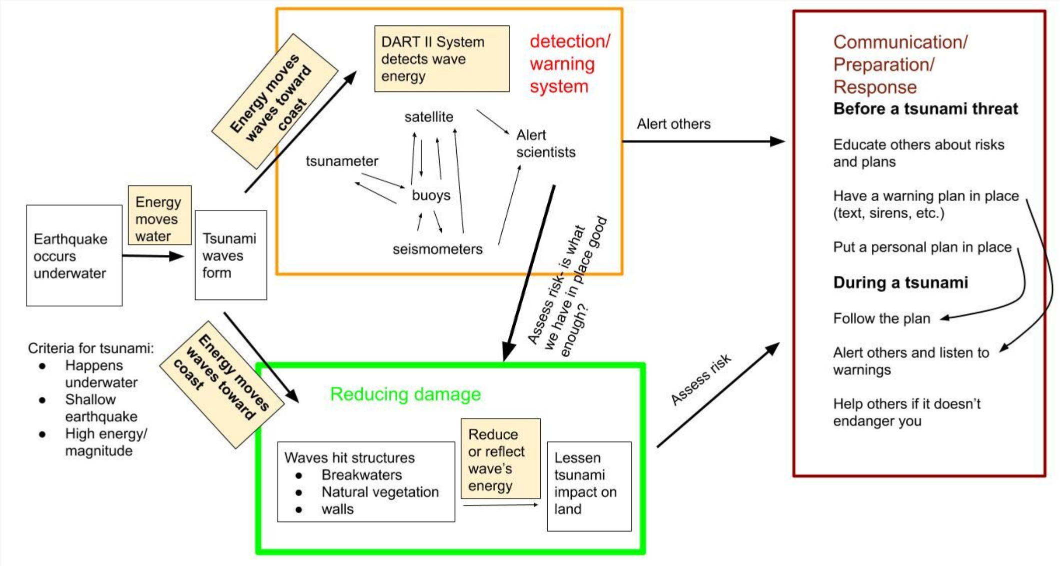
✱ SUPPORTING STUDENTS IN ENGAGING IN DEVELOPING AND USING MODELS

During this lesson, students are getting multiple opportunities to construct a model of a system and its interactions. Students gain exposure to this practice in multiple ways, including allowing students to categorize the parts of the subsystems, working with a partner to organize those parts into a visual representation, and then working together as a class to develop a consensus system model.

4 · CREATE TSUNAMI SYSTEM CONSENSUS MODEL

15 min

MATERIALS: None



Transition to developing a consensus model. Once all areas of the components chart are complete, display a blank piece of chart paper.

Say, *Now that we have all of our basic components of our system, let's see if we can arrange them in our system and show how they are connected.*

Point out to students that there seems to be three distinct areas of our tsunami protections system, and we should try to keep track of the parts as we add them to our larger system model. Ask students how we can put these ideas into our system and still clearly identify which component came from which subsystem. Students will likely determine color coding each subsystem a different color, as the system will provide for an easy visual of the subsystem components in the larger system. ✱

Guide students in constructing a system model to reflect what has been developed and designed to help keep people safe during a tsunami. See the example of the system model to the right.

Establish cause for system interactions. Remind students that tsunamis don't happen every day, and for the system to be used, it has to start with an event.✱ Start students by asking them what the first event is that has to occur for a tsunami. Students should say that an earthquake has to occur. Add earthquake to the chart paper on the far left hand side. Elicit earthquake criteria that need to be met before a tsunami will occur and record those below the earthquake event:

- shallow earthquake
- happens underwater
- releases a lot of energy (high magnitude)

List this criteria below the box labeled earthquake and dwell on the energy criteria.

✱ ATTENDING TO EQUITY

Universal Design for Learning: During this lesson, boxes have been color coded to make explicit in the *representation* the subsystems that interact within the bigger system. Create a key to track what colors, symbols, or letter or number codes represent different parts of the system. While color coding is a useful way to quickly reference the parts of the model, using letter or number coding to label the boxes in the system model can help ensure accessibility for any student who may be color blind. The colors used could easily be changed to boxes A, B, and C in the system model. If color coding is used, consider a color palette that uses orange, blue, black, or dark brown.

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING STABILITY AND CHANGE

Earthquake events occur suddenly and without warning. The gradual change in tectonic plate position leads to stress on plates, causing a sudden and unpredictable adjustment of those plates. This means an accompanying tsunami occurs rapidly and is also not predictable, but the tsunamis can be detected once they occur. Even though the earthquake is not predictable, a tsunami can be detected based upon the data gathered by this system and communicated with others. The early detection of the tsunami is key in community response.

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING ENERGY AND MATTER

Use matter and energy to connect back to the science ideas learned in Lessons 3 and 6. The earthquake's energy and the transfer of the energy to the water, drives the responses

Ask students, *Energy seems to be pretty important to a tsunami. What happens to this energy? Where does it go?*

Students should identify that the energy is transferred to the water, creating the tsunami waves.✱

Identify main system components. Direct students to the "Systems Components" chart. Ask students what categories will be utilized next, now that the wave's energy is moving towards the shore. Guide students to identify that the waves will be detected by the detection/warning system, and they will come into contact with some structure. Draw two separate boxes for these component areas: "detection/warning system" and "reducing damage."

Focus on completing the detection subsystem. Say, *How does the DART II System work? What happens when the first seismometer senses a tsunami?*

Guide students through identifying and connecting the components of each sub-system. Show connections between the components of the subsystem using arrows inside of the larger detection/warning system box.

ADDITIONAL GUIDANCE	If students are struggling to identify the connections between the components of the DART II system, direct them back to the Lesson 6 reading. The section called, "How do we locate a tsunami" outlines many important connections between the components of the subsystem. A completed subsystem diagram is also available for students to view during the completion of the detection/warning system in the component area of the tsunami system reading.

Make an energy connection. Ask students how this DART II system first knew to start collecting data. Students should say that this started with the earthquake. Ask students what the system was sensing that was released by the earthquake. Guide students to identify that the energy from the earthquake woke the DART II system out of sleep mode. Label the arrow going from the earthquake to the detection/warning area with "energy moves waves towards coast."

Make larger subsystem connections. Ask students what scientists do with the data after receiving the information from the DART II system. Students should identify that the scientists use it to warn people, and assess risks for people living in the community or area. Add this information over arrows leaving the subsystem and pointing towards the communication/reducing damage subsystem.

Complete the reducing damage subsystem. Direct students to look back at the reducing damage subsystem. Ask students what is travelling towards this subsystem that might cause damage. Students should respond with the high energy waves from the tsunami. Add this to the arrow connecting the beginning event and the reducing damage subsystem.

Work with students to complete the reducing damage system using the subsystem components identified on the areas of the tsunami preparation chart.

Say, *We have the reducing damage subsystem up here, and we have the detection/warning system on our model. What are we missing?*

Students will identify that the communication/preparation/response area is not on the model yet.

Complete preparation, communication, and response subsystem. Point out that the chart we had completed with the components seems to be divided into two areas--what we can do before the tsunami warning, and what we can do during the tsunami warning. Begin with what can be done before the tsunami strikes and record student ideas in the subsystem. Move to the during the tsunami warning once the before section is completed. Ask students which preparation activities are related to response activities, and draw arrows where students see connections in the subsystem.

to this system. From there, the wave and earthquake energy triggers other responses in the system, such as the DART II detection and data collection. To make this energy-driven connection more explicit for students, make sure to label these ideas as shown on the example consensus model.

5 · EXIT TICKET

4 min

MATERIALS: notecard

Introduce the system components exit ticket. Say, *Wow, we have mapped a pretty detailed and intricate system. There are so many arrows and relationships between the components. Let's consider the individual components of the system we just modeled.* Display **slide E** and give a notecard to each student to individually answer the questions on the slide.

- Our system has a lot of components. Why do you think it has so many components?
- Would the system work better, worse, or the same if a component was changed? Why?
- What would happen if a component of a subsystem was removed? Would there be effects on the overall system? Why or why not?

Ask students to hand in the exit ticket at the end of class.

End of day 1

6 · ANALYZE SYSTEM AND SUBSYSTEM COMPONENTS

14 min

MATERIALS: science notebook, Large sticky notes or notecards with "What we do as Engineers" phrases, chart paper, markers

Say, *Last class we created a system to show how communities prepare and respond to a tsunami. At the end of class, we considered the role the individual components played within the system. After looking at our exit tickets, we seem to have different ideas about those components. Let's talk about our ideas and see if we can figure out their role in the overall system.*✱

Project **slide F**. Allow the students a moment to turn and talk to their partners. Lead a discussion regarding the questions on the slide to understand the complexities of the subsystems and the criteria of the overall system.

Suggested prompts	Sample student responses	Follow-up questions
Look at each piece of the system. Why does this system have so many components and interactions?	*Because one part of the system can't do everything. You can't just detect it, or build a design solution and that's it.*	*Why can't you just have a single part of the system functioning on its own?*
	The components of the system have to talk to each other so they can figure out the threat and let people know. They all rely on each other.	*What do you think would happen if we removed a part of the system, such as the DART II subsystem, or even just the buoys in the DART II system?*
	We would lose a connection within the system and we may have more false alarms, or people may not get warned in time. It could be bad.	*Do you think there is even more to the system that we didn't learn about?*

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING SYSTEMS AND SYSTEM MODELS

This systems analysis helps students determine the connectivity between subsystems to support the goals of a larger system. By analyzing the subsystems and their larger contributions to the overall system, students can begin to see the interconnectivity of the tsunami subsystems to meet the overall criteria of the larger system.

Suggested prompts	Sample student responses	Follow-up questions
Each piece of the system had to meet certain criteria. What would you say the main, number one criteria of the entire system is?	*To keep people safe from a tsunami.*	*Can a single part do that on it's own?*
	No, the parts have to work together as parts of a whole system.	*So if a component were picked out of the system, does it meet the criteria, or is the whole system needed to meet the criteria? Why?*
What would happen if a component of a subsystem was removed? Would there be effects on the overall system? Why or why not?	*Some subsystems might not work as well.*	*Can you give an example, and predict what it would do to the overall system?*
	I think it depends on the component of the subsystem. Different components have different effects.	*Why would the specific component matter? Why would they have different effects?*
	Maybe it depends on the component. Like, if you got rid of something, then added something back in. For example, if you swapped out a wall for a breakwater, it wouldn't affect the system too much, but if you changed the way you warned people, that could be better or worse.	*How would you have to assess if that change was for better or worse? What would you use to evaluate the change in the system?*
We learned about Ryoishi, and considered specific trade-offs when looking at design solutions. What trade-offs do you think other towns would have to weigh in this system?	*Maybe they would want to have more public education because they can't put up a big seawall, which could put more people at risk.*	*Why would that be a trade-off?*
	Not having a seawall, like a recurved wall, is tricky, but if they have a recurved wall and not easy access to the beach, they miss out on tourism money to live.	*Are there other trade-offs that might have to be weighed with this system?*

ASSESSMENT OPPORTUNITY	**Building towards: 8.A** Construct a system model to represent the interactions of subsystems designed to detect, warn communities, and reduce damage from a tsunami hazard. **What to look for/listen for:** Connections should be determined between various parts of the subsystem. Students should be able to articulate: 1) systems are comprised of subsystems that work together as a system to meet the criteria of the community, 2) parts of the subsystem cannot meet the criteria on their own, and rely on feedback from other parts of the system to meet the criteria, and 3) while the system works to meet the needs of the individual community, the system components and interactions may have to be altered when applied to other communities or situations. **What to do:** If students are struggling with: 1. Subsystems working together as a system to meet the needs of the community, press students to explain how the system would be affected if the larger subsystem was taken out of the system, and if the system could still meet the criteria of the community as effectively. 2. Considering the importance of the subsystems to meet the goals of the larger system, place a hand or a sticky note over a single component of a subsystem. Ask students how the subsystem would change if the component was removed, and what effects it would have on the larger system. 3. Seeing the potential changes to the system to address the needs of other communities, push students to consider a change in location, like a crowded tourist destination. Ask students what new constraints would be prioritized, or if the system would have new constraints based upon the location, and what parts of the system would most likely have to be altered to meet the constraints of the community.

Say, *We have learned some pretty interesting things about these systems put into place to protect people. The systems and how they are constructed seem to depend on criteria specific to the event and the communities. They also seem like they have parts that are dependent on other parts to provide protection.*

Reflect on systems processes. Project **slide G**. Direct students to turn and talk to a partner about the questions on the slide.

- How did this system get developed? Was it developed by just one person?
- What process did we have to go through to figure out what would work best for this disaster?

Lead the class in a discussion about the system development. Example prompts and responses are below.

Suggested prompt	Sample student response
How do you think engineers develop systems like this?	*I think the system took a long time.* *It was definitely developed by a lot of people who knew what they were doing and knew the science behind it.* *The system was developed according to the criteria and constraints.* *It must have taken a lot of planning.*

Suggested prompt	Sample student response
What process did we have to go through to figure out what would work best for this disaster?	*We had to learn about the disaster first.* *We had to learn about how it worked and how it impacted people.* *We had to learn about design solutions and how they met the criteria and constraints of the people that lived there.* *We had to learn about other ways to protect people, like early warning systems and detection.*

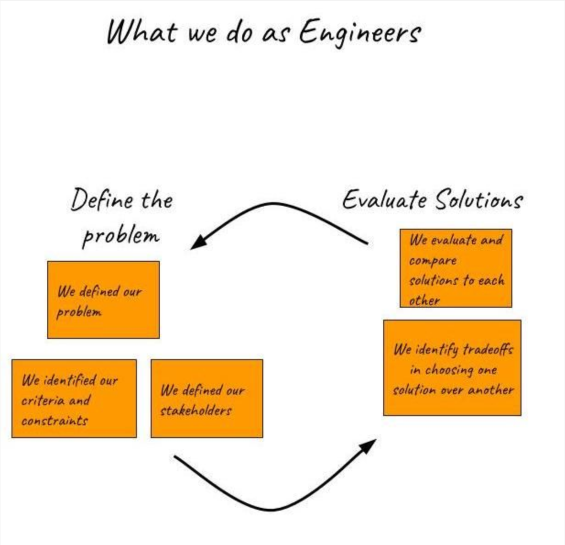
Display "What we do as Engineers" cards. As students are explaining the process, display any matching "What we do as Engineers" matching cards for students to see. If one card example is not given by students, question students about the lesson in which students conducted that step of the process.

7 · CREATE WHAT WE DO AS ENGINEERS CHART

12 min

MATERIALS: "What we do as engineers" note cards or sticky notes, "What we do as engineers" poster, markers

Reflect on engineering roles. Guide students through the development of the "What we do as engineers" chart. An example of the completed chart can be seen to the right.



Say, *We have gone through quite the process to figure out how to best protect from tsunamis. We have had to learn a lot, and in each lesson we went through a process to figure out the best solutions. These are things that all engineers do when they design solutions.*

Say, *If we were to try and create a system for what we did as engineers, do you think we could organize the process we went through to optimize our thinking?*

Create a "What we do as Engineers" chart. Start by asking students about the first thing we did as engineers--we learned about the problem. Pull this card out of the group and place it at the top of the chart paper. Ask students if any other cards would be a part of the process of defining a problem.
Lead students to identify the following cards that go into this category:

- We defined our problem.
- We identified our criteria and constraints.
- We identified our stakeholders.

Ask students what we did after we learned all we could about our problem. Lead students to identify that we evaluated and compared existing design solutions. Pull that card and place it in a different area of the board. Remind students that we also thought about those parts of the existing designs and how they work to help reduce energy, but also considered other constraints. Ask students if any other cards go with that. Students should select the last remaining card, identifying trade-offs in choosing one solution over another. At this point, these two cards should be placed together in a separate area of the chart paper:

- We evaluate and compare solutions to each other.
- We identify trade-offs in choosing one solution over another.

Remind students that at this point we started to look at parts of the system and did not get to continue with designing a solution. Instead, we went back and looked at our stakeholders and criteria one more time to evaluate how well the system met the needs of the community. Ask students if we currently have a step like that on the cards. Students should identify that we already have an area for defining a problem.

Say, *It seems that we already have an area for this. Are they connected? Is it OKto go back to this step and check our work?*

Give students a moment to verify that it is OKto go back and confirm the effectiveness of the solution against the criteria and constraints and needs of stakeholders.

Work with students to determine that 2 arrows should be added between the design process areas as seen in the diagram. Label the two sections Define a Problem and Evaluate Solutions.

Say, *We know the process engineers went through to design and analyze this system. Let's see how well we did working through the same process!*

8 · CONDUCT ENGINEERING SELF ASSESSMENT

14 min

MATERIALS: *Engineering Self-Assessment*

Conduct the self-assessment. Project **slide H**. Distribute *Engineering Self-Assessment*. Explain to students that this handout has broken down the notecards on the "What we do as Engineers" chart into smaller, easier to assess pieces. Tell students we can use these areas to check our individual progress on using these engineering ideas to develop a system of solutions. Show students how to use the 1-3 scale to evaluate themselves.

Point out that all students should explain their ratings using the last question on the handout. If students are stuck between two ratings, tell the students to pick one and give their reasoning in this space. Tell students they will hand this in when they are finished, and they will be given teacher feedback on the same form.

Give students time to complete the handout. Have students turn in the self-assessment when they are finished.

ASSESSMENT OPPORTUNITY

Self-assessments are valuable tools to gauge student understanding. Students rely on a feedback loop involving the student and teacher for personal academic growth. Use this assessment to determine any perceived areas of weakness and success from a student's perspective, and provide timely feedback for the students (either on the front or back of this paper) regarding their perceptions and reality. Remember to give some positive feedback for every critique to help build the student's self-efficacy in the engineering process.

9 · LOOK BACK AT LESSON 1 HAZARDS

5 min

MATERIALS: Related Phenomena poster from Lesson 1

Look back at related phenomena from Lesson 1. Project **slide I.** Bring the class back together once all self-assessments have been completed and turned in. Ask students to Turn and Talk regarding the questions on the slide. Have students share their ideas with the class. Example prompts and student responses are below.

Suggested prompt	Sample student response
In this unit, we studied a natural hazard that was really important to one community. Think back to what you wrote about in Lesson 1. What other natural hazards worry you?	*Tornadoes are scary.* *Hurricanes hit here a lot--that worries me.* *Snow storms can sometimes be scary.* *We have really big thunderstorms and high winds.* *Flooding happens since we are so close to the river.*
What can we do to help our community prepare for a natural hazard?	*We can make a plan and share it with others.* *We can teach people how to assess their risk and look for warning signs.* *We can help people prepare and take steps to protect themselves.*

ADDITIONAL GUIDANCE

If students are having trouble coming up with ways they can help prepare for a natural hazard, remind students that we have read about students who helped their community of Kamaishi during the 2011 tsunami. Ask students:

- What is something that others your age did that we learned about to help before and during the disaster?

Say, *Next class maybe we can use these ideas to look into how to help ourselves and help others during a natural disaster that worries you.*