Unit Summary
Is it possible to engineer ways to protect humans from natural Earth?
In this unit of study, students apply their knowledge of natural Earth processes to generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans. In order to describe patterns of Earth's features, students analyze and interpret data from maps. The crosscutting concepts of *patterns*, *cause and effect*, and the influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in planning and carrying out investigations, analyzing and interpreting data, and constructing explanations and designing solutions. Students are also expected to use these practices to demonstrate an understanding of the core ideas.
This unit is based on 4-ESS2-2, 4-ESS3-2 #, 3-5-ETS1-2, and 3-5-ETS1-3.
Designates Climate Change throughout the unit

Student Learning Objectives
Analyze and interpret data from maps to describe patterns of Earth's features. *[Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]* **(4-ESS2-2)**
Generate and compare multiple solutions to reduce the impacts of natural Earth processes and climate change on humans.* *[Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.]* [Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.*]* **(4-ESS3-2)**
Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. (3-5-ETS1-2)
Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. (3-5-ETS1-3)

Quick Links

Unit Sequence	
Part A: *What can maps tell us about the features of the world?*	
Concepts	**Formative Assessment**
● Patterns can be used as evidence to support an explanation. ● Maps can help locate the different land and water features of Earth. ● The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. ● Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. ● Major mountain chains form inside continents or near their edges.	*Students who understand the concepts are able to:* ● Support an explanation using patterns as evidence. ● Analyze and interpret data to make sense of phenomena using logical reasoning. ● Analyze and interpret data from maps to describe patterns of Earth's features. Maps can include: ✓ Topographic maps of Earth's land ✓ Topographic maps of Earth's ocean floor ✓ Locations of mountains ✓ Locations of continental boundaries ✓ Locations of volcanoes and earthquakes

Unit Sequence	
Part B: *In what ways can the impacts of natural Earth processes on humans be reduced?*	
Concepts	**Formative Assessment**
● Cause-and-effect relationships are routinely identified, tested, and used to explain change. ● Engineers improve existing technologies or develop new ones to increase benefits, decrease known risks, and meet societal demands. ● A variety of hazards result from natural processes (e.g., earthquakes, floods, tsunamis, volcanic eruptions). ● Humans cannot eliminate the hazards, but they can take steps to reduce their impacts. ● Research on a problem should be carried out before beginning to design a solution. ● Testing a solution involves investigating how well it performs under a range of likely conditions.	*Students who understand the concepts are able to:* ● Identify and test cause-and-effect relationships in order to explain change. ● Generate multiple solutions to a problem and compare them based on how well they meet the criteria and constraints of the design solution. ● Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans *(Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.)* Examples of solutions could include: ✓ Designing an earthquake-resistant building ✓ Improving monitoring of volcanic activity. ● Generate multiple possible solutions to a problem and compare them based on how well each is likely to meet the criteria and constraints of the problem.

● At whatever stage, communicating with peers about proposed solutions to a problem is an important part of the design process, and shared ideas can lead to improved designs. ● Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. ● Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.	● Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. ● Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

What It Looks Like in the Classroom

In this unit of study, students analyze and interpret data from maps to describe patterns of Earth's features. Students can use topographic maps of Earth's land and ocean floor in order to locate features such as mountains, mountain ranges, deep ocean trenches, and other ocean floor structures. As students analyze and interpret these types of maps, they begin to notice patterns in the types of structures and where these structures are found. Students learn that major mountain chains often form along or near the edge of continents. Once students locate continental boundaries, a further analysis of data can show students that there is a noticeable pattern of earth events, including volcanoes and earthquakes, which occur along these boundaries.

During this unit, students also learn that engineers develop or improve technologies to solve societal problems. A variety of hazards result from natural processes (e.g. earthquakes, floods, tsunamis, volcanic eruptions). Although we cannot eliminate the hazards, we can take steps to reduce their impacts. Students must have the opportunity to engage in the engineering design process in order to generate and compare multiple solutions that reduce the impacts of natural Earth processes on humans. This process should include the following steps:

- ✓ Students brainstorm possible problems that Earth processes can cause for humans. (Earth processes should be limited to earthquakes, volcanic eruptions, tsunamis, and floods.)
- ✓ Either as a class or in small groups, have students select one problem (such as the effects of volcanic eruptions on humans) to research.
- ✓ Small groups conduct research to determine possible solutions (such as consistent monitoring of volcanic activity and the use of early warning systems) that reduce the impacts of the chosen Earth process on humans.
- ✓ As a class, determine criteria and possible constraints on the design solutions. Criteria might include: saving lives and/or reducing property loss.
- ✓ Small groups investigate how well the solutions perform under a range of likely conditions. This may involve additional research and analysis of available data or planning and conducting investigations to produce data that will serve as the basis for evidence. During this process, students should plan and carry out fair tests in which variables are controlled and failure points are considered in order to identify elements of the design solution that do and do not meet criteria.
- ✓ Students compare the solutions based on how well they meet criteria and constraints, using data as evidence to support their thinking.

At every stage, communicating with peers is an important part of the design process, because shared ideas can lead to improved designs. Students should routinely identify and test cause-and-effect relationships and use these relationships to explain the changes that they observe as they test design solutions.

Engineering design performance expectations are an integral part of this unit of study. Students are expected to research a problem, generate and compare possible design solutions, and test the design solutions to determine how well each performs under a range of likely conditions. Using data as evidence, students identify

elements of each design that need improvement and determine which design solution best solves the problem, given the criteria and the constraints. This process is outlined in greater detail in the previous section.

Connecting with English Language Arts/Literacy and Mathematics

English Language Arts

To support integration of the CCSS for English Language Arts in this unit, students should have access to multiple sources of information about Earth's features and earth processes. Students should have opportunities to read, analyze, and interpret information from nonfiction text, charts, graphs, diagrams, timelines, and interactive elements on the Internet. Students use this information, along with data they collect during investigations, to help explain, both orally and in writing, the patterns they observe in the features of the Earth and in the natural hazards that occur on the Earth.

As students engage in the engineering design process, they need opportunities to conduct research to build their understanding of how earth processes affect humans and to find examples of ways in which engineers reduce the effect of volcanic eruptions, earthquakes, floods, and tsunamis. Students should take notes as they read and summarize or paraphrase their notes to support their work throughout the engineering design process.

In addition, students should provide a list of sources when using this type of information.

Mathematics

- Use measurements to determine how far earthquakes and volcanoes tend to occur from continental boundaries.
- Analyze data to determine patterns of change that occur in areas where volcanoes erupt, earthquakes occur, and in flood zones.
- Reason abstractly and quantitatively to draw diagrams to build scale models.
- Analyze timelines, charts, and graphs to determine patterns in Earth's features and patterns of change caused by earth processes.
- Reason abstractly and quantitatively when discussing the effects of an earth process on humans. For example, on average, 3,000 lives are lost every year due to tsunamis. When early warning systems are in place, fewer than 1,000 lives are lost annually.
- Analyze constraints on materials, time, or cost to in order to determine criteria for design solutions.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).

- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principles (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Research on Student Learning

Students of all ages may hold the view that the world was always as it is now, or that any changes that have occurred must have been sudden and comprehensive. The students in these studies did not, however, have any formal instruction on the topics investigated. (NSDL, 2015).

Prior Learning

Grade 2 Unit 4: The Earth's Land and Water

- Maps show where things are located. One can map the shapes and kinds of land and water in any area.
- Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.

Future Learning

Grade 5 Unit 4: Water on the Earth

- Nearly all of Earth's available water is in the ocean. Most freshwater is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.

Connections to Other Units

In Grade 4, students will engage in engineering design in two additional units of study: **Using Engineering Design with Force and Motion Systems**, and **Waves and Information.** During these grade levels, students will learn that:

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.
- Research on a problem should be carried out before design of a solution begins. Testing a solution involves investigating how well it performs under a range of likely conditions.
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.
- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

Sample of Open Education Resources

Natural Disasters Unit: Earthquakes, Volcanoes, Tornados, and More: This unit introduces students to natural hazards such as earthquakes, volcanoes, landslides, tsunamis, floods, tornados, fires, hurricanes, and thunderstorms. They see how natural events become disasters when they impact people, and how engineers help make people safe from them.

Engineering for the Three Little Pigs: This activity helps to demonstrate the importance of rocks, soils, and minerals in engineering and how using the right material for the right job is important. The students build 3 different sand castles composed of varying amounts of sand, water, and glue. The 'buildings' in this lesson are made of sand and glue, sand being a soil and glue being composed of different minerals. They then test them for strength (load bearing), and resistance to weathering. The students will then compare possible solutions and discuss how well each is likely to work while meeting the criteria and constraints of the problem. The students will be the engineers who figure out which materials are best for the buildings they are making, taking into consideration all the properties of materials that are discussed in the lesson.

Building for the Big One: This lesson plan details a Design Challenge in which students build and test structures while learning about the earthquakes that shake them. It is designed as a review or culmination of an Earthquake unit of study. The lesson plan allows teachers to connect back to previous lessons. The Tech Museum of Innovation also suggests that the lesson might be used as a form of introduction to a unit about earthquakes. The lesson would then be used to determine students' prior knowledge to set the stage for the design challenge. This resource often mentions the effects of tectonic plates on earthquake location. Grade 4 curriculum does not include tectonic plates in their earth science curriculum. Tectonic plate information is included in the lesson as a resource for the teacher.

Earthquakes in the Classroom: Students investigate which building types are structured to withstand earthquake damage. They take on the role of engineers as they design their own earthquake resistant buildings, then test them in a simulated earthquake activity. Students also develop an appreciation for the job of engineers who need to know about earthquakes and their causes in order to design resistant buildings. This lesson is one of several in the "Earthquakes Rock" unit provided by the Teach Engineering site. The unit "URL" listed here is not being reviewed for the Performance Expectation listed. It is offered as a supplemental concept and lesson background aid for teachers. https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_natdis/cub_natdis_lesson03.xml

Getting the Right Angle on the Story: This informational text shows students how tsunamis form and behave. It also describes how scientists are collecting data to create models that can be used to predict tsunamis. Animations/computer models are also included to enhance student knowledge of how tsunami warnings work. Models integrate new, unfamiliar vocabulary. Students could use the resource as a starting point for an earth systems unit; teachers could assign the site as a form of research where students gather data, take notes, and draw inferences from text. As students begin their study, they could generate a list of the earth's natural

disasters and define their impact on human life and the environment. Their possible solutions for lessening that impact could also be incorporated as an informal formative assessment to determine student prior knowledge.

Article: A New Way to Learn About Natural Disaster

How could you survive a landslide: In this lesson, students will learn about the types, causes, and dangers of landslides. Through a brainstorming process, students will become engineers who design solutions for preventing landslides, protecting property, and keeping people safe.

DLESE Earth Science Literacy Maps are a tool for teachers and students to find resources that relate to specific Earth science concepts. These maps illustrate connections between concepts and how they build upon one another across grade levels. Clicking on a concept within the maps will show DLESE resources related to the concept, as well as information about related AAAS Project 2061 Benchmarks and National Science Education Standards.

Videos:

Earthquakes; Floods; Tsunami; Volcanoes

Teacher Professional Learning Resources

Using the NGSS Practices in the Elementary Grades

The presenters were Heidi Schweingruber from the National Research Council, Deborah Smith from Penn State University, and Jessica Jeffries from State College Area School District. In this seminar the presenters talked about applying the scientific and engineering practices described in A Framework for K–12 Science Education in elementary-level classrooms.

Continue the discussion in the community forums.

***NGSS* Core Ideas: Earth's Systems**

The presenter was Jill Wertheim from National Geographic Society. The program featured strategies for teaching about Earth science concepts that answer questions such as "What regulates weather and climate?" and "What causes earthquakes and volcanoes?"

Dr. Wertheim began the presentation by introducing a framework for thinking about content related to Earth systems. She then showed learning progressions for each concept within the Earth's Systems disciplinary core idea and shared resources and strategies for addressing student preconceptions. Dr. Wertheim also talked about changes in the way NGSS addresses these ideas compared to previous common approaches. Participants had the opportunity to submit questions and share their feedback in the chat.

Continue the discussion in the community forums.

Appendix A: NGSS and Foundations for the Unit		
Analyze and interpret data from maps to describe patterns of Earth's features. *[Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]* **(4-ESS2-2)**		
Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* *[Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.]* [Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.] **(4-ESS3-2)**		
Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. (3-5-ETS1-2)		
Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. (3-5-ETS1-3)		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data ● Analyze and interpret data to make sense of phenomena using logical reasoning. (4-ESS2-2) **Constructing Explanations and Designing Solutions** ● Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-ESS3-2),(3-5-ETS1-2) **Planning and Carrying Out Investigations** ● Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	**ESS2.B: Plate Tectonics and Large-Scale System Interactions** ● The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth. (4-ESS2-2) **ESS3.B: Natural Hazards** ● A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. (4-ESS3-2) *(Note: This Disciplinary Core Idea can also be found in 3.WC.)*	**Patterns** ● Patterns can be used as evidence to support an explanation. (4-ESS2-2) **Cause and Effect** ● Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS3-2) - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Engineering, Technology, and Science on Society and the Natural World** ● Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. (4-ESS3-2) ● Engineers improve existing technologies or develop new ones to increase their benefits,

	ETS1.B: Designing Solutions to Engineering Problems ● Testing a solution involves investigating how well it performs under a range of likely conditions. *(secondary to 4-ESS3-2*) **ETS1.B: Developing Possible Solutions** ● Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) ● At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) ● Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) **ETS1.C: Optimizing the Design Solution** ● Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	decrease known risks, and meet societal demands. (3-5-ETS1-2)

English Language Arts	Mathematics
Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. (4-ESS3-2) **RI.4.1** Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. (4-ESS2-2) **RI.4.7**	Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale. 4-ESS2-2) **4.MD.A.2** Reason abstractly and quantitatively. (4-ESS3-2), (3-5-ETS1-2),(3-5-ETS1-3) **MP.2**

Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. (4-ESS2-2) **W.4.7** Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. (4-ESS3-2) **RI.4.9** Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (3-5-ETS1-2) **RI.5.1** Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (3-5-ETS1-2) **RI.5.1** Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (3-5-ETS1-2) **RI.5.9** Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (3-5-ETS1-3) **W.5.7** Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (3-5-ETS1-3) **W.5.8** Draw evidence from literary or informational texts to support analysis, reflection, and research. (3-5-ETS1-3) **W.5.9**	Model with mathematics. (4-ESS3-2), (3-5-ETS1-2),(3-5-ETS1-3) **MP.4** Interpret a multiplication equation as a comparison, e.g., interpret 35 = 5 × 7 as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations. (4-ESS3-2) **4.OA.A.1** Use appropriate tools strategically. (3-5-ETS1-2),(3-5-ETS1-3) **MP.5** Operations and Algebraic Thinking (3-ETS1-2) **3-5.OA**