Creating Resilient Great Lakes Shorelines

The water of the Great Lakes has shaped their coastlines for over 10,000 years. The natural ecosystems that have developed over time to withstand variable conditions have often been replaced by human-made structures. With the changing environmental conditions we are experiencing, how can we adapt our Great Lakes shorelines to protect our communities and ecosystems?

Background

Since the last retreat of glaciers at the beginning of the Holocene Epoch, coastal processes have created the current shape of the Great Lakes. The movement of sediment along the shorelines, through erosion, transport, and deposition, occurs constantly throughout the year. However, as environmental conditions continue to change, these processes are being impacted by winters with less ice coverage, more frequent intense storms, and more water level fluctuation. At the same time, many natural shorelines ecosystems like wetlands and sand dunes have been altered with buildings, roads, and other infrastructure.

These human-made structures can be residential, commercial, or public infrastructure like roads, rail lines, or utility components like pipes, transmission lines, and drinking and wastewater treatment facilities. To protect these structures, as well as support the restoration of the ecosystems they replaced, communities are investing in shorelines that will be resilient in changing conditions.

Essential Questions

By the end of the lesson, students will understand how different shoreline protection strategies can increase the resilience of Great Lakes shorelines in changing environmental conditions. Additionally, they will be able to answer:

1. Why do seiche occur in the Great Lakes and what challenges do they pose to shorelines?
2. What is coastal erosion and how does it impact Great Lakes communities and ecosystems?
3. How do changing environmental conditions impact Great Lakes communities and ecosystems?
4. What are natural and nature-based features and what are the advantages and disadvantages of using them in shoreline protection?

Learning Goals

In this lesson, students will learn about:

- The cause and impact of seiche events in the Great Lakes
- Coastal erosion and other processes that shape the shores of the Great Lakes
- The impact that changing environmental conditions are having on the shores of the Great Lakes
- The variety of shoreline protection strategies, including natural and nature-based features.

Learning Objectives

Upon completion of this activity, students should be able to:

- Describe a seiche event and explain the conditions that cause it in the Great Lakes
- Explain how wave energy can lead to coastal erosion on the shores of the Great Lakes
- Use data and graphs from NOAA digital tools to demonstrate the relationship between wind strength and water levels in the Great Lakes
- Use data and graphs from NOAA digital tools to determine which areas of a community are vulnerable to flooding
- Design a sustainable shoreline that increases resilience for a community and ecosystem in the Great Lakes using a variety of protection standards

Recommended Grade Levels

While parts of this lesson can be used with grades 2-5, the entire set is recommended for grades 6-12.

Prerequisite Knowledge

Erosion is the geological process where rocks, soil, and sand are worn away and transported by natural forces such as wind or water.

Waves in water are a result of energy moving through water, resulting in it move in a circular motion.

Weather is the state of the atmosphere at a specific time and location and is characterized by temperature, moisture, wind speed and direction, barometric pressure, and cloudiness.

Climate is the long-term average of temperature, precipitation, and other weather variables at a given location.

Coastal resilience is the ability of a community and its ecosystems to withstand and recover from storms, changing water levels, flooding, and erosion. A resilience community can "bounce back" after an event like that – rather than simply reacting to impacts.

Learning Standard Alignment

Next Generation Science Standards

Crosscutting Concepts:

- Patterns
- Cause and Effect
- Systems and System Models
- Energy and Matter

- Structure and Function
- Stability and Change

Disciplinary Core Ideas:

- Earth Space Science
    - Earth Materials and Systems
    - The Roles of Water in Earth's Surface Processes
    - Weather and Climate
- Engineering, Technology, and the Application of Science
    - Developing Possible Solutions
    - Optimizing the Design Solution
- Human Impacts on Earth
    - Natural Hazards
    - Global Climate Change
- Physical Science
    - Wave properties

Science & Engineering Practices:

- Analyzing and Interpreting Data
- Designing Solutions
- Developing and Using Models
- Planning and Carrying Out Investigations
- Using Mathematics and Computational Thinking

Performance Expectations:

- 2-ESS2-1: Erosion Design Solution: Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.
- 3-ESS2-1: Seasonal Weather Conditions: Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.
- 4-PS4-1: Wave Model: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move
- ESS2-1: Weathering and Erosion: Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation
- 4-ESS3-2: Natural Hazard Design Solution: Generate and compare multiple solutions to reduce the impacts of natural earth processes on humans
- MS-PS4-1: Wave Properties: Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave
- MS-ESS3-2: Natural Hazards: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects
- HS-ESS3-5: Climate Change and Future Impacts: Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to earth systems.
- HS-ESS2-5: Interactions of the Hydrologic and Rock Cycles: Plan and conduct an investigation of

the properties of water and its effects on earth materials and surface processes

Great Lakes Literacy Principles Alignment

- Principle 2: Natural forces formed the Great Lakes; the lakes continue to shape the features of their watershed.
- Principle 3: The Great Lakes influence local and regional weather and climate.
- Principle 6: The Great Lakes and humans in their watersheds are inextricably interconnected.
- Principle 7: Much remains to be learned about the Great Lakes.
- Principle 8: The Great Lakes are socially, economically, and environmentally significant to the region, the nation and the planet.

Engage: *Dark and Stormy Nights*

Explore: *Can Your Shoreline Survive a Seiche?*

Explain: *Why do seiche events happen in Lake Erie?*

Elaborate: *Find a Seiche Event*

Evaluate: *How can we protect our most vulnerable places and communities?*

ENGAGE

Activity: Dark and Stormy Nights

In this activity, students will be introduced to a storm event in 2020 and its impact. They will reflect on their personal experiences in storms and discuss how events like this can impact other communities. Lastly, they will be introduced to the concepts of social vulnerability and coastal resilience.

Procedure

1. As a class, watch several news videos from a storm in Buffalo, New York on November 15, 2020.

- Before the storm – WKBW Seiche Lake Erie 11.15 *(particularly the first minute)*
- During the storm – Seiche of about 2-3ft in Lasalle Park in Buffalo, NY
- After the storm
    1. Lake Erie Seiche Devastates Hamburg Shoreline
    2. WGRZ High winds cause power outages across region:

2. If students are from Western, NY, ask students if they remember this storm or another storm with very strong winds. With a partner or in small groups, ask students to talk about their experiences during a storm with high winds. Have students write down several feelings, emotions, or memories from that event on the Dark and Stormy Night Worksheet.

> *Note: Storms often have personal impacts on individuals' lives, families, and communities that have lasting emotional effects. Allow students the space and time to share these experiences only if and when they are comfortable.*

3. After the students have discussed their experiences, use a tape measure or other measuring device to demonstrate how high 8 ft is. This could be done by marking 8 feet on a wall or finding an item in the class that is 8 feet high or tall (ie: bookcase). Next, ask students to think about what a shoreline might look like if the water level rose 8 ft like it did in the November 2020 storm.

4. Have students watch the time lapse video from Wilkenson Pointe on the shore of Lake Erie in Buffalo's Outer Harbor.

5. Have a class discussion about what places and/or resources in a community might be at risk if water levels rose above 8 ft (or more) during a storm. Make a list of these places and resources on a whiteboard. Group the assets into different categories based on their use. Examples could include buildings (ie: residential, hospitals, schools, etc.), public places like parks, utilities (ie: poles, water and sewer lines), or ecosystems.

6. Continue the class discussion by having students choose several places or resources from their list that may be the most vulnerable to flood damage and which are the most important to protect from flood damage.

> *Note: **Vulnerability** of a building or location can be impacted by its age and condition of buildings, construction materials (ie: wood, brick), location on a slope, etc.*

*Note: **Importance** of a building or location can be subjective to each person. Consider personal/individual importance vs. community importance.*

7. Have students write down this list on *the Dark and Stormy Night Worksheet* and complete the final question about which place or resource they feel is the most vulnerable and most important.

8. Show students the National Oceanic and Atmospheric Administration's Resilience video: https://oceanservice.noaa.gov/facts/resilience.html.

Name _____ Date_____

Dark and Stormy Nights Worksheet

Do you remember a storm like the one that happened in Buffalo, New York in November of 2020? If so, how did you feel during the storm and why? _____
_____
_____
_____

How did you feel after the storm and why?
_____
_____
_____
_____

The water level of Lake Erie and area rivers rose up to 8 feet during the storm. Make a list of places and resources in a community could be at risk if the water level rose that high. Examples of places are homes, parks, or schools. Examples of resources are roads, trees, or power lines.

Next, rate each place or resource on how vulnerable to flood damage they are and how important they are to you and your community.

Name	Place or Resource?	Vulnerability (Low, Medium, High)	Importance (Low, Medium, High)

Are there any places or resources that are both vulnerable and important to the community? Why?
_____
_____
_____
_____

EXPLORE

Activity: Can Your Shoreline Survive a Seiche?

In this activity, students will observe the impact of waves on shorelines, learn about several shoreline protection strategies that protect shorelines from erosion, and then design and build a shoreline that is resilient to fluctuating lake levels and waves.

Part 1: Coastal Erosion Demonstration

Materials

- Clear sided rectangular plastic bin
- Sand
- Water
- Empty plastic bottle (used to create wave action in water)
- Various craft materials such as popsicle sticks, plastic cutlery, pipe cleaners, fake plants, etc.

Procedure

1. Assemble the demonstration shoreline in a bin to demonstrate wave action and erosion on an unprotected shoreline.

- Place sand in 1/3 of bin and shape into a slope from bottom of the bin to the top of one end. Have students observe the shape of the shoreline from the top and from the side, through the clear side of the bin.
    - *Optional: Have students mark the shape of the shoreline with a dry erase marker on the side of the bin*.
- Gently pour water into the other side of the bin, careful not to create wave action that will cause erosion on the other side of the bin. Add enough water so that when the plastic bottle is pushed up and down in the next step, it will not hit the bottom and cause splashing.

2. Have students draw a picture of the shoreline on the *Can Your Shoreline Survive a Seiche? worksheet* before any waves begin.

- Have students make a prediction about what will happen once the teacher makes waves in the bin for 60 seconds.
- Create waves in the water by firmly and uniformly pushing the plastic bottle up and down for 60 seconds.
- Students should observe how the shoreline is changing due to the wave action.
- Have students draw a picture of the new shoreline and describe what they observed.
    1. To further demonstrate the process of shoreline erosion, you can also play "Shoreline Without Aquatic Vegetation" video from Tip of the Mitt Watershed Council

    Note: this demonstration can also be done by students in groups by creating demonstration shoreline bins for each group. Students can compare different erosion results between groups due to different shoreline slopes, different wave strength and or frequency, and other variables.

Part 2: Learn about Shoreline Protection Strategies

Procedure

1. Distribute the *Shoreline Protection Strategies Worksheet* to students.

2. As homework or in class, have students read about different shoreline protection strategies and complete the worksheet.

- *If students are interested in reviewing additional resources to learn more about shoreline protection strategies:*
    - Natural and Structural Measures for Shoreline Stabilization – National Oceanic and Atmospheric Administration
    - Working with Nature Guide: A Guide to Native Plants for New York's Great Lakes Shorelines – New York Sea Grant
    - Shoreline Stabilization Techniques – New York State Department of Environmental Conservation
    - Nature Based Shoreline Options for Great Lakes Coasts – Wisconsin Sea Grant

3. Once each student has completed the *Shoreline Protection Strategies Worksheet*, as a class count how many students would use each shoreline protection strategies to protect their shoreline. On a whiteboard, share the results and ask the class discussion questions:

- Which shoreline protection strategy was the most popular in the class? Which was the least popular? Why?
- What would happen if none of these strategies were used?
    - *Answer: erosion would continue and if there was building or infrastructure on the property, they may be at risk of damage or destruction.*

4. Design shorelines.

This part of the activity can be done in groups or as individuals, depending on access to materials. If it is done as a group, students will have to work together to decide which shoreline protection strategies the group will use and how to stay within their project budget.

- Assemble shorelines in bins similar to the way they were built for the shoreline erosion demonstration at the beginning of the activity.
- Distribute the *Build a Resilient Shoreline Worksheet* to the students. As individuals or as a group, have the students complete the first page of the worksheet by sketching or drawing their resilient shoreline design.
- Distribute and/or display the shoreline protection strategies materials price list.
    - *The price list provided is an example. You can also fill in the template based on the materials that are available to the class for this activity.*
    - Recommended craft materials for shoreline protection materials
        - Large Boulders – small rocks
        - Small rocks – pebbles or aquarium rocks
        - Sheet of steel – pieces of plastic; paint sticks
        - Sheet of vinyl – pieces of plastic; popsicle sticks
        - Concrete - modelling clay
        - Timbers – straws
        - Dune fencing – toothpicks
        - Dune grasses – pipe cleaners, small plastic plants
        - Shoreline plants – small plastic plants
        - Coir logs – pipe cleaners, corks

    ** Other materials can be used as well.*

- Once students have completed the second page of the *Build a Resilient Shoreline Worksheet* they can 'purchase' the items they would like to use for their shoreline.
- Students will use their materials to build their resilient shorelines.

5. Test the shoreline protection strategies.

- When the students have finished building their shorelines, gently pour water into the other side of the bin, careful not to create wave action that will cause erosion on the other side of the bin. Add enough water so that when the plastic bottle is pushed up and down in the next step, it will not hit the bottom and cause splashing.
- On the third page of the *Build a Resilient Shoreline Worksheet*, have students identify which shoreline protection strategies are being used by other students in class and record that in the middle column.
- Create waves in the water by firmly and uniformly pushing the plastic bottle up and down for 30 – 60 seconds.
- Have students observe the wave action and the shoreline protection strategies. They should record how resilient their shoreline and other students' shorelines are in the third column of the *Build a Resilient Shoreline Worksheet.*

6. Optional Part 3: Refine Designs

- *If there is time, allow students to propose changes to their designs and repeat step 5 to test the new design.*

Name _____ Date_____

Coastal Erosion Demonstration

1. Draw a picture of what the shoreline looks like before any waves:

2. Make a Prediction: Your teacher will now make waves for one minute. What do you think will happen when waves come up to this shoreline?

_____
_____
_____
_____
_____
_____

3. After one minute of waves, was there any erosion along the shore? Yes or No
4. Draw a picture of what the shoreline looks like after one minute of waves:

Name _____ Date_____

Shoreline Protection Strategies Worksheet

In this activity, you will learn about different shoreline protection strategies that can be used in the Great Lakes. Review the different strategies on this worksheet and pick **three** strategies to complete the table below.

Name of Shoreline Protection Strategy	Advantages	Disadvantages	Would you use this strategy to protect your shoreline?
	1. 2.	1. 2.	
	1. 2.	1. 2.	
	1. 2.	1. 2.	

Sea Grant
NEW YORK

Revetment

Description	A revetment is a structure made of large stones and rocks. Revetments are built along the water's edge, where the stream bank or a sloping shoreline meet the water. They are built on the shore to protect it from wave energy.
Cost	The cost of building a revetment can be between $30 to $200 per linear foot. The price can vary based on the size and amount of rock that is used, the cost to ship these rocks to the site, and the cost to pay contractors to build it.
Advantages	Revetments reduce the risk of erosion for areas that are upland from the shore. Revetments are a structurally sound shoreline protection strategy. They are less likely to have 'toe scour' than seawalls.
Disadvantages	Revetments require upkeep and maintenance over time. Since these structures reflect wave energy, they can cause erosion at their base. This is called 'toe scour'. Over time, this can cause stones and rocks to fall off from the shore. Since revetments reduce the amount of sediment entering the water, they can lead to increased erosion next to the structure. Revetments replace most shoreline plants and habitats, eliminating most of the ecosystem services they provide. The space between rocks, however, can provide some limited habitat.

Sea Grant
NEW YORK

Seawall

Description	A seawall is a vertical structure that is built parallel to the shore. It separates the land and the water. The goal of a seawall is to protect against erosion from wave damage and flood impacts by reflecting wave energy back into the water. A seawall can also help hold back the land behind it to prevent that land from eroding into the water. Seawalls can be made of concrete, sheets of metal, or timber.
Cost	The cost of a seawall depends on what material is used. Building a seawall made of steel can cost between $250 - $700 per linear foot. Steel seawalls require the use of heavy equipment. Building a seawall made of concrete can cost between $200 - $800 per linear foot. The cost can increase the higher the seawall is.
Advantages	Seawalls reduce the risk of erosion for areas that are upland from the shore. When seawalls are first built, they are the most structurally sound shoreline protection strategy.
Disadvantages	Seawalls require upkeep and maintenance over time. Since these structures reflect wave energy, they can cause erosion at the base of the wall. This is called 'toe scour'. Over time, this can cause the wall to collapse. Since seawalls reduce the amount of sediment entering the water, they can lead to increased erosion next to the structure.

	Seawalls replace shoreline plants and habitats and eliminate the ecosystem services they provide.

Sea Grant
NEW YORK

Groin

Description	A groin is a structure that is built perpendicular to the shore and extends out into the water. Groins are used to build up, widen a beach, or to protect and stabilize a beach by slowing down the rate of erosion. They do this by trapping and holding sediment passing through the area in which they are built. Groins can be used individually. They can also be used as a group, known as groin fields. Groins can be made out of timber, steel, concrete, or large stones.
Cost	The cost of a groin, or groin field, depends on what material is used. Building a groin of rocks can cost between $50 to $300 per linear foot. Building a groin with timber can cost between $100 to $400 per linear foot. Building a groin with steel or concrete can cost between $200 to $600 per linear foot.
Advantages	Groins do a good job capturing sand and other sediment on one of the side of the structure where the current flows from. The beach that results on this side of the going can create new shoreline habitat.
Disadvantages	Groins can cut off the source of sand and sediment for the shoreline on the down current side. This can lead to increased erosion on that side of the groin. To avoid this, extensive analysis or modeling is required. Due to the required analysis, privately owned groins are generally not permitted on New York's Great Lakes. Groins made out of timber have a shorter life span than those made out of rock, concrete, or steel.

Sea Grant
NEW YORK

Living Shorelines

Description	Shoreline erosion can be reduced by supporting the ecosystems that exist there and encouraging their natural processes. Planting native plants and installing dune fencing can help hold sand and sediment in place during storms. Over time, this allows the shoreline to sustain itself.
Cost	The cost to plant native plants, like dune grasses or native tree species, on a shoreline can range from $1 to $10 per plant. This cost includes the cost of the plant and to pay people to plant it. The cost to install a dune fence can range from $10 - $40 per linear foot. This depends on what materials are used. Dune fences can be made of plastic, wood, or wire mesh.
Advantages	Nature-based features provide habitat, nesting, or foraging opportunities to coastal species. Fencing and planting native plants are more affordable than other shoreline protection methods.
Disadvantages	The use of native plants and fencing to help stabilize and build dunes cannot guarantee protection against erosion from wind, waves, or human activities. Certain plants only work on specific types of shorelines. Dune grasses, for example, only work on sand dunes.

Sea Grant
NEW YORK

Nature Based Feature: Coir Logs

Description	Coir logs are cylinders of tightly wound, woven or netted coconut twine or fibers. They are placed at the bottom of a shoreline or streambank to protect or stabilize the shorelines.
Cost	The cost of using coir logs can be between $15-$65 per linear foot. Multiple rows of coir logs are often used together, instead of just one row. Coir logs also require anchors to keep them in place. If plants are used together with coir logs, they must also be purchased.
Advantages	Plants can be put on top of the coir logs and can take root in them. Over time, these plants encourage shoreline stabilization. The coir logs will biodegrade into the slope while roots stabilize the slope. These plants and lots can provide habitat, nesting, or foraging opportunities to coastal species.
Disadvantages	The living materials used with coir logs may have to be replaced over time, but this cost decreases as plants establish themselves. Coir logs work best in areas that have lower wave energy, such as bays or streams.

Sea Grant
NEW YORK

Nature Based Feature: Sills

Description	Sills are small structures located in the water just off the shoreline to break up wave energy and create an area of protected wetland near the shoreline. Sills can be made of rock, concrete, timber, coir logs, or other materials.
Cost	The cost of using sills can range between $50-$250 depending on the material used.
Advantages	Sills allow for sediment and sand to build up along the shore by reducing wave energy from hitting the shore and trapping sediment from moving away. Sills are more adaptable than permanent shoreline strategies and provide aquatic habitat, nesting, or foraging opportunities to coastal species
Disadvantages	Sills can cause erosion on the side that is facing away from the shoreline. Regular maintenance is required to clear any debris that builds up between the sill and the shoreline. Sills work best in areas that have lower wave energy, such as bays or wetlands.

Name _____ Date_____

Build a Resilient Shoreline Worksheet

In this activity, you will design and build a shoreline that will be more resilient to waves during storms and high water to:

- Reduce the amount of shoreline erosion
- Protect the shoreline ecosystems and communities
- Protect any property or infrastructure that is close to the shoreline

At the end of the activity, you will compete with the other students to see which shoreline was:

1. The most effective in preventing loss of property and sand on the shoreline
2. Able to stay within the project budget
3. Provided the most ecosystem services for native plant and animal species

Design Your ShorelineUsing what you have learned about the impact of waves on shorelines and different shoreline protection strategies, how would you design a shoreline that best withstand these challenges? Use the space below to sketch or draw your ideas.

Select Your Materials

To build your resilient shoreline, you must purchase materials. Your shoreline project has a budget of **$1,000**. Based on the price list displayed in your class, select which materials you would like to use and how many of each item you will select to complete your design.

Item	Price per Item	Quantity	Total Cost

(Must be less than $1,000)

Total

Did you have to change your design because of the budget? If so, describe how you had to change your design and if you think it will help or hurt your shoreline. _____

_____

_____

_____

How Did Your Shoreline Do?

Record how resilient your shoreline and other students' shorelines were.

Student Name	Shoreline Protection Strategies Used	How well did it work?

Which shoreline protection strategies prevented the most erosion (allowed the least amount of sand to leave the shoreline)? Why do you think that design worked the best? _____

_____

_____

Which shoreline protection strategies allowed the most erosion (allowed the most amount of sand to leave the shoreline)? How did this strategy put the ecosystems and communities on the shoreline at risk?_____

Build a Resilient Shoreline Price List

Item		What type of shoreline protection strategy uses this material?	Price per Item
Rocks	Large Boulders	Revetment, seawall, groin	$50/inch
Peebles	Small rocks	Revetment, groin, shoreline restoration, sill	$50/inch
Paint sticks	Sheet of steel	Seawall	$100/each
Popsicle sticks	Sheet of vinyl	Seawall	$20/each
Modeling Clay	Concrete	Seawall, groin, sill	$100/inch
Straws	Timbers	Seawall, groin, sill	$25/each
Plastic Forks	Dune fencing	Shoreline restoration	$50/each
Model plants	Shoreline plants	Shoreline restoration, coir logs, sill	$25/each
Pipe cleaners	Coir logs	Shoreline restoration, coir logs, sill	$50 each
		Earth moving	$10/inch

EXPLAIN

In this activity, students will learn about how seiche events happen in the Great Lakes from a meteorologist.

Presentation: Why do seiche events happen in Lake Erie?

Procedure

1. Hand out the Lake Erie Seiches notes page and/or one pager to students.
2. Show students the first 30 minutes of the *Seiche and Winter Weather Shoreline Preparedness.*
    - Students can also review the slides from a similar presentation "Lake Erie Coastal Events"
3. While watching this presentation Judy Levan, a retired meteorologist from the National Weather Service, students can use the One Pager Template, Notes Template, or other method to synthesize:
    - their knowledge about shoreline erosion in the Great Lakes
    - their understanding of the importance of shoreline resilience to ecosystems and communities of the Great Lakes
    - new information about the occurrence and impact of seiche events in the Great Lakes

Name _____ Date_____

Lake Erie Seiches Notes Page

Main Idea: _____
_____
_____

Idea 1 _____

Supporting Details/Examples

- _____
- _____
- _____
- _____
- _____

Idea 2 _____

Supporting Details/Examples

- _____
- _____
- _____
- _____
- _____

Idea 3 _____

Supporting Details/Examples

- _____
- _____
- _____
- _____
- _____

Lake Erie Seiches One Pager

A one pager is a way to visually share key ideas and information from what you have learned. When you create a one pager, you will use both visual symbols and important words to clearly and concisely share your most important takeaways with someone else.

Here's what it MUST include:

- A border – this should include the key themes of what you have learned
- A central image – this should represent what you consider to be the most important part of the presentation.
- Additional images, doodles, and words that add important topics from the lessons and notes.
- Page must be filled, only use one side of the paper

ELABORATE

In this activity, students will use two digital tools from the National Oceanic and Atmospheric Administration to record the water levels and weather data for seiche events that have happened in the recent past.

Activity: Find a Seiche Event

Procedure

1. Hand out the *Find a Seiche Event Worksheet* to students.
2. As a class, or as individuals, visit the National Oceanic and Atmospheric Administration's Tides and Currents website: https://tidesandcurrents.noaa.gov/.
3. By clicking on Lake Erie or New York, have students find the Buffalo, NY station.
4. Once they have located the Buffalo, NY station point, click on the point at Buffalo to open up the station's current conditions.
5. Once the Buffalo station's current data pops up, have students click on 'More Data' and select water levels.
6. Once the data page opens for Buffalo students enter December 22, 2022 and December 26, 2022 into date search and click 'Plot'.
7. Have students complete the questions 1-4 on the *Find a Seiche Event Worksheet* to record the water level data.

    Answers:

    1. *570.94 ft*
    2. *579.9 ft*
    3. *8.96 ft*
    4. *6 hours*
8. Next, have students click on 'Meteorological Obs.' at the top of the page and enter the same date range as they did for step 6.
9. Have students complete questions 5-7 on the *Find a Seiche Event Worksheet* to record the meteorological data.

    Answers:

    5. *a. 7.35 knots; b. ENE; c. 10 knots*
    6. *a. 43.1 knots; b. SW; c. 54.5 knots*
    7. *Average speed increased by 35 knots, direction changed from ENE to SW, gusts increased by 44.5 knots*
10. As a class, or as individuals, visit the National Oceanic and Atmospheric Administration's Tides and Currents Coastal Inundation Dashboard: https://tidesandcurrents.noaa.gov/inundationdb/.
11. Have students zoom in to find the Buffalo, NY station.
12. Once the Buffalo station pops up, scroll down and click on 'Inundation History'.
13. Have students enter the same date range as they did for step 6.
14. Have students answer questions 8-9 on the *Find a Seiche Event Worksheet.*

    Answers:

    8. *Yes*
    9. *Moderate*
15. Have students click on 'Top Ten Water Levels' at the top of the Inundation History page.
16. Ask students to select one of dates after 2002 (data not available prior to August 2002).

17. Have students use Tides & Currents to find water level and meteorological data for the high water level date they selected and answer questions 10-17 on the *Find a Seich Event* Worksheet.

Name _____ Date_____

Find a Seiche Event Worksheet

In this activity, you will use digital tools from the National Oceanic and Atmospheric Administration to record water level and meteorological data on seiche events in the Great Lakes.

Visit NOAA's Tides & Currents at https://tidesandcurrents.noaa.gov/.

Start Date: December 22, 2022

End Date: December 26, 2022

Location: Buffalo, NY

1. What was the water level on Lake Erie at the start date? _____
2. What was the water level on Lake Erie at the highest point during your date range? _____
3. How high did the water rise during your date range? _____
4. How many hours did it take for the water level to rise during your date range? _____
5. How was the wind at the start date?
    a. Average speed:____ _____
    b. Direction: _____
    c. Gusts: _____
6. How was the wind at the highest point during your date range?
    a. Average speed: _____
    b. Direction: _____
    c. Gusts: _____
7. How did the wind speed and direction change during your date range? _____

    _____

Visit NOAA's Coastal Inundation Dashboard at: https://tidesandcurrents.noaa.gov/inundationdb/

8. Did Buffalo, NY experience coastal flooding during the date range? Yes or No.

9. If yes, was it: Minor Moderate Major

10. Pick one of the dates from the Top Ten Water Level Dates.

Start Date: _____

End Date: _____

11. What was the water level on Lake Erie at the start date? _____

12. What was the water level on Lake Erie at the highest point during your date range? _____

13. How high did the water rise during your date range? _____

14. How many hours did it take for the water level to rise during your date range? _____

15. How was the wind at the start date?

    a. Average speed: _____

    b. Direction: _____

    c. Gusts: _____

16. How was the wind at the highest point during your date range?

    a. Average speed: _____

    b. Direction: _____

    c. Gusts: _____

17. How did the wind speed and direction change during your date range? _____

_____

_____

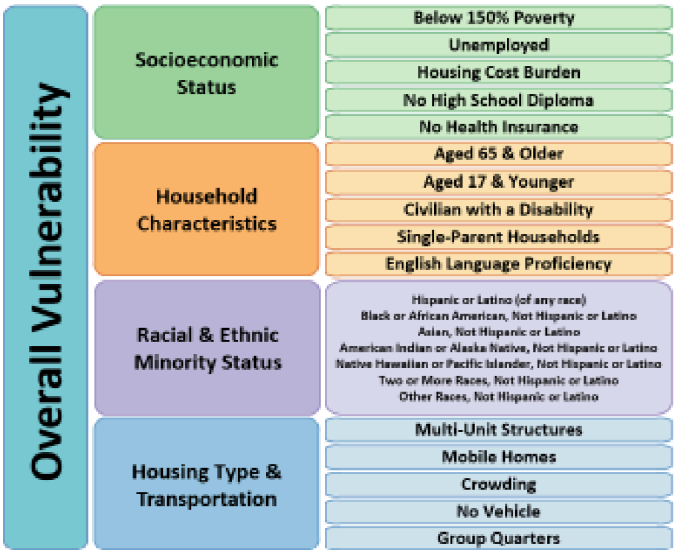
EVALUATE

Students will be tasked with identifying a location that is at risk of flooding if there is a seiche event that raises the water 5-10 feet. They will then research its social vulnerabilities. Finally, they will propose a strategy to protect this coastal community using their knowledge of resilient shorelines.

Activity: How can we protect our most vulnerable places and communities?

Procedure

1. Hand out the *Protecting Vulnerable Places Worksheet* to students.
2. As individuals, have students visit the National Oceanic and Atmospheric Administration's Lake Level Viewer website: https://coast.noaa.gov/llv/
3. Students should select a lake and explore which areas would be flooded by raising the water level.
4. Students should identify an area that would be flooded if the water level of the Great Lake they are looking at rises 10 feet. Have students use a street and city name to identify the location of their flooded community and record that on the *Protecting Vulnerable Places Worksheet.*
5. As a class, discuss the concept of social vulnerability and how the contributing factors could make recovering from flooding more challenging.
    - **Social vulnerability** refers to the demographic and socioeconomic factors that contribute to communities being more adversely affected by public health emergencies and other external hazards and stressors that cause disease and injury.
    - Factors such as poverty, lack of access to transportation, and crowded housing may weaken a community's ability to respond and adapt to public health emergencies.
    - *For more information on Social Vulnerability, how the scores were calculated, and what the data sources are, please visit:*
        - *SVI Factsheet – https://www.atsdr.cdc.gov/place-health/media/pdfs/2024/07/SVI-Fact-Sheet-H.pdf*
        - *CDC/ATSDR SVI 2022 Documentation- https://svi.cdc.gov/map25/data/docs/SVI2022Documentation_ZCTA.pdf*
6. Display the variable the CDC uses to determine a community's social vulnerability.



7. Ask students how various factors could increase or decrease a community's social vulnerability to flooding caused by a 10 foot rise in lake water levels. Example questions could be:
    a. Would it more or less difficult to respond to flooding if a community had a lot of people that were living under the poverty level?
    b. Would it more or less difficult to respond to flooding if a community had a lot of people that did not have health insurance?
    c. Would it more or less difficult to respond to flooding if a community had a lot of people that were over 65 years old? Or under the age of 18?
    d. Would it be more or less difficult to respond to flooding if a community had a lot people that did not have access to a car or other form of transportation?
8. As individuals, have students visit the Center for Disease Control's Social Vulnerability Index Interactive Map: https://www.atsdr.cdc.gov/place-health/php/svi/svi-interactive-map.html
9. Have students select 'statewide' for the Geographic Comparison and zoom in on the region of the community they identified in step 4.
10. Under Geographic Unit, have students select 'Zip Code Tabulation Area'.
11. Have students enter the street and city name of the location identified as at risk of flooding.
12. Have students explore the location's various vulnerability scores by selecting different vulnerabilities from the 'SVI Theme' box.
13. Have students record the different vulnerability scores in the table on the *Protecting Vulnerable Places Worksheet*.
14. Have students complete the *Protecting Vulnerable Places Worksheet* and the *Protecting Vulnerable Places by Creating Resilient Shorelines Project Proposal* template.

Protecting Vulnerable Places Project Idea Rubric: This rubric can be used or adapted to assess project proposals based on their content, creativity, and the application of concepts learned in this lesson.

Criteria	Excellent (4)	Proficient (3)	Developing (2)	Lacking (1)

Understanding of Seiche Events, Wave Energy, and Coastal Erosion	Accurately explains the conditions that cause seiche events in the Great Lakes and the coastal erosion they can cause. Proposal's connection to mitigating seiche impact is clear and well-justified.	Correctly defines seiche events, their causes, and their impacts but the connection to the project idea could be stronger.	Provides a basic or partially incorrect definition of a seiche event and partial understanding of their impact. The connection to the project is weak or not present.	Shows little/no understanding of seiche events and/or coastal erosion. Fails to make connection to project.
Application of Shoreline Protection Strategies	Proposes strategy using various shoreline protection methods. The proposal justifies the chosen methods with clear reference to their benefits for both the community and the ecosystem.	Proposes an appropriate and relevant shoreline protection strategy. Explains the benefits of the chosen methods, with some attention to ecosystem health.	Proposes a simple or common shoreline protection method without clear justification for why it is suitable for this specific problem.	Proposes an inappropriate or ineffective strategy, or fails to include a clear strategy.
Social Vulnerability	The proposal demonstrates an understanding of social vulnerabilities and proposes specific strategies to address them, ensuring the project benefits all community members, especially at-risk populations.	The proposal acknowledges social vulnerabilities and includes some strategies to address them, but the details or justification could be more thorough.	The proposal mentions social vulnerabilities in a general way but lacks specific strategies to address them, or the connection to the project is unclear.	The proposal does not address or show any understanding of social vulnerabilities.

Project Feasibility & Creativity	The project idea is innovative and appears feasible. The proposal includes a plan for implementation, including potential challenges and solutions.	The project idea is sound and practical. The proposal outlines a basic plan for implementation.	The project idea is generic or impractical. The proposal lacks a logical plan for implementation.	The project idea is absent or not relevant to the assignment's goals.

Name _____ Date_____

Protecting Vulnerable Places Worksheet

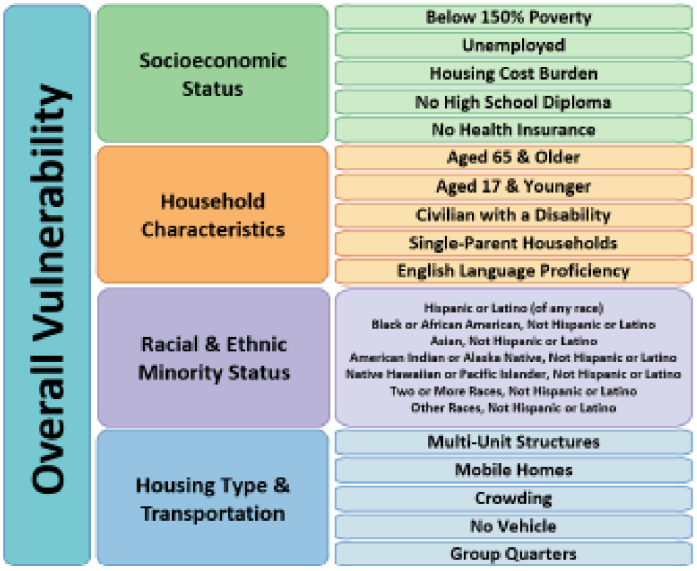
In this activity, you will use the Lake Level Viewer and Social Vulnerability Index to determine which communities are at the most risk of flooding and which communities are most vulnerable to the challenges of that flooding. After you have selected a community, you will brainstorm ways to help make this community more resilient to prepare for future storms.

1. Visit NOAA's Lake Level Viewer at https://coast.noaa.gov/llv/
2. Raise the water level to ten feet above the normal water levels, or Low Water Datum (LWD).
3. Find a community that would be flooded if the water level rose 10 feet. Write down the name of the street and city.

   _____

   _____

The social and economic characteristics of a community can affect how they can respond to natural disasters and public health emergencies. This is a community's **social vulnerability**. Things like poverty, lack of access to transportation, and crowded housing may make it harder for a community to respond and adapt to these emergencies. The Center for Disease Control and Prevention determines social vulnerability for communities across the United States by looking multiple characteristics.



4. Using your community location, write down the vulnerability scores on the table below.

Social Vulnerability Index (SVI)	Score	Low, Low-Medium, Medium-High, or High
Overall SVI		
Socioeconomic Status		
Household Characteristics		
Racial & Ethnic Minority Status		
Housing Type & Transportation		

Assignment

New York State has announced a new program that wants to improve the resilience of shoreline communities in areas that are at risk of flooding along the Great Lakes. Communities can apply for a grant to make their community more resilient to storms and flooding along the Great Lakes.

The mayor of your town has asked you to come up with an idea for your community. Put together a project idea based on your knowledge on the following topics:

- Seiche events and the conditions that cause them in the Great Lakes
- Wave energy and its impact on coastal erosion on the shores of the Great Lakes
- Shoreline protection strategies and various methods of creating resilient communities and ecosystems.
- Social vulnerabilities that can affect how a community can respond to natural disasters and public health emergencies

To begin your project proposal, complete the following questions.

1. Describe how your community is at risk from storms and changing water levels:

_____
_____
_____
_____
_____
_____
_____

2. The mayor would like to know how your community can be prepared and bounce back if a seiche or other event occurs. Describe your idea to increase the coastal resilience of your community:

_____
_____
_____
_____
_____

_____
_____
_____

3. The mayor is also concerned about the people of the community. Describe what, if any, social vulnerabilities your community has and how they could be considered in your idea.

_____
_____
_____
_____
_____
_____
_____

Using your answers, complete the project proposal template for the mayor's office to review.

Protecting Vulnerable Places by Creating Resilient Shorelines Project Proposal

Problem Statement
Social Vulnerabilities Addressed
Proposed Solution
Project Summary