EP-7

Ohio Sea Grant

COASTAL PROCESSES AND EROSION

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Ohio Sea Grant Education Program

TEACHER GUIDE

OEAGLS-Oceanic Education Activities for Great Lakes Schools

OEAGLS Investigation #7

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Figure 4 adapted from U.S. Army Corps of Engineers, "The Role of Vegetation in Shoreline Management," 1977.

TEACHER GUIDE

COASTAL PROCESSES AND EROSION TEACHER GUIDE

by

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OVERVIEW

In Activity A, students study the idea that shoreline geology affects the rate and amount of erosion that occurs along the edges of the ocean or a lake. They conduct an experiment comparing the stability of three geologically different beach bluffs as they are attacked by waves.

Activity B deals with methods of slowing the rate of shoreline erosion. Three types of shoreline protection structures and their purposes are discussed. The students examine illustrations of several structures and label them for the type of protection device they represent. Two of the devices are tested in a laboratory experiment similar to Activity A.

PREREQUISITE STUDENT BACKGROUND

None.

MATERIALS: Each lab team should be supplied with three rectangular plastic dishpans or plastic shoe boxes, one piece of board (2 x 4 or plank) as long as the dishpan is wide, one piece of board half as long as the width of the pan, about 1 liter of sand and 1 liter of potting soil per team, several pieces of rock 5-10 cm long, a 3 x 5 note card, a ruler to measure wave heights, and access to a supply of water. Each student will need a pencil or pen for recording data and answering questions.

OBJECTIVES

When students have completed this investigation they will be able to:

1. List the major natural forces of erosion along the lake shore.
2. Describe how the rate of erosion differs with different materials.
3. Explain the purposes of the three major categories of shoreline protection devices.

SUGGESTED APPROACH

To help cut down on the amount of equipment needed, Activity A could be done in large groups or by a single group of students acting as demonstrators.

Procedure 1 of Activity B is best done individually or by teams of two to three students. More students may work together on Procedure 2 of this activity.

The film "Beach - A River of Sand" (20 minutes, Encyclopaedia Britannica Films) can serve as an excellent introduction or conclusion to this activity. It illustrates how beaches are built and destroyed by waves, how longshore transport functions, and how groins and breakwaters affect the shoreline.

A visual aid useful for Activity B is the wall chart, "Help Yourself: A discussion of the critical erosion problems on the Great Lakes and alternative methods of shore protection." This is available free from the U.S. Department of the Army, North Central Division, Corps of Engineers, 536 South Clark Street, Chicago, Illinois 60605.

NOTE: Information to teachers is enclosed in boxes in this guide.

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INTRODUCTION

The major natural forces affecting the shoreline are wind, waves, and currents. These forces wear away and build up a shoreline. People can modify these forces and redirect them, but we will never totally control them.

Wind and Waves

The wind is the principal generator of waves. The longer and stronger the wind blows and the greater the distance over which it blows, the larger and more powerful the waves will be.

Waves have significant effects on shorelines. During storms, their energy can carry beach sands lakeward, erode cliffs and banks, and damage or carry away man-made structures. During calm periods, waves move off-shore sand onto the beaches, building them up.

Currents

Currents--streams of moving water within a body of water--are another major force affecting the shoreline. Perhaps the most important current causing the shoreline to change is the **longshore current**, which is generated by waves as they strike the coast at an angle. A longshore current runs parallel to the shoreline and varies in speed and direction with the angle of waves and their energy. It often transports large quantities of sand along the beach. This transportation is known as **littoral drift**.

If there is an abundant supply of sediment, as from eroding cliffs or sediment-laden streams flowing into the lake, the littoral drift will deposit sediment wherever its speed is reduced. When sediment is scarce, the littoral drift will carry sand away from the beaches, causing erosion.

Because wind and waves determine the directions and amount of littoral drift, the overall or **net** sand movement in Lake Erie is from west to east.

ACTIVITY A: WHAT CAUSES THE SHORELINE TO ERODE AWAY?

KEYWORDS: **erodible, resistant, wave height.**

MATERIALS: Three rectangular plastic pans or plastic shoe boxes, one piece of board (2 x 4 or plank) as long as the width of the pans, sand, soil, several broken pieces of rock, ruler, 3 x 5 note card cut in three long strips, pencil for recording data.

Be sure to provide an appropriate place to dispose of the muddied water, preferably outdoors away from the school building.

PROCEDURE

The student guide contains all instructions necessary for setting up Activity A. Stress that the water used in Step E be poured in **slowly**; otherwise beach bluffs may begin to collapse before waves are generated.

In recording data, it is suggested that the number and height of waves be recorded only once for each shore type, when the bluff collapses. Under "Effects on Sandy Bluff," the sequences of erosion events my be listed as in the example on the next page.

SANDY BLUFF

Number of Waves	Height of Waves	Effects on Sandy Bluff
10	2 cm	1. Lower front edge was undercut. 2. Top front edge slid down. 3. Waves cut farther into slope. 4. Bluff collapsed as waves washed over.

Figure TG 1. Sample Data

A. In the end of one of the plastic pans place three handfuls of wet sand.

B. Using a piece of board, mash the sand up against the end of the pan and flatten the top. Make this "beach bluff" about as wide as it is high.

C. Repeat Steps A and B with a second pan, building a beach bluff made of wet soil.

D. In one end of the third pan make a stack of rock pieces that will represent a rocky shoreline about the same size as the other bluffs.

You should now have three "beach bluffs" of various types and sizes of material. The three pans represent lakes.

E. Hold the pieces of board up against the sand bluff to protect it while you **slowly** add water to the empty end of the pan. Create a lake about 1-1.5 cm deep. Remove the board gently when the lake water is still.

F. Repeat Step E to create lakes in front of the soil and rock bluffs.

G. Gently place a strip of note card flat on top of each bluff.

H. You are now ready to act as the wind, making waves and causing erosion on the shoreline. Using a ruler or the pieces of board, make waves that move toward the beach bluff from the opposite end of the lake. Start gently, counting the number of waves you produce. Then gradually increase the strength of your waves as if the wind were becoming stronger. Record what happens to the beach bluffs as you repeat this process in each lake. Put your information on the Data Table on your work sheet.

I. When the section of note card slips toward the water, your bluff has collapsed. If collapse has not occurred after 100 waves, stop and record your observations of the bluff's condition. Put this information on your work sheet in the Data Table.

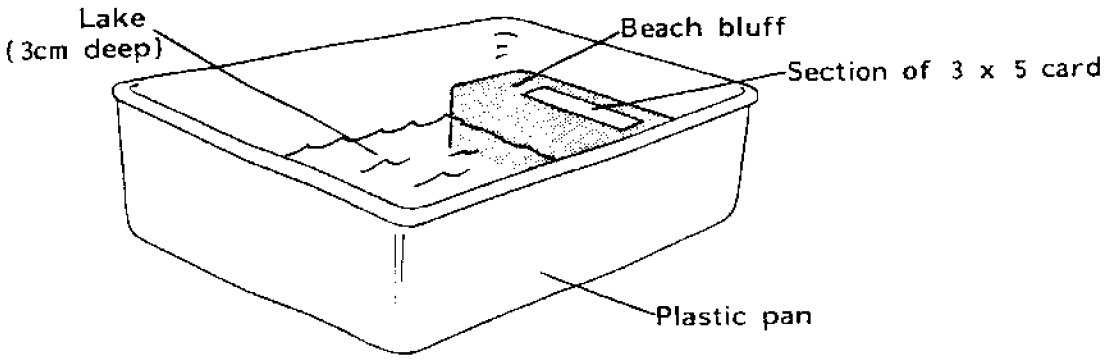


Figure 1. Shoreline Model

NOTE: To measure the height of waves, find the distance from the top (crest) of the wave to the lowest part (trough) of the wave. Do not measure from the bottom of the "lake" basin unless the bottom is actually exposed as the wave passes by. Refer to Figure 2.

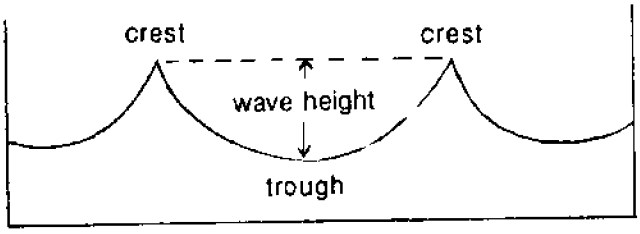


Figure 2. Determining Wave Height

Answer the following questions on your work sheet.

1. Which beach bluff is the least stable (collapsed first)?

T1. The sand bluff is the least stable. The small and fairly uniform grain size produces a permeable surface that is quickly penetrated and disrupted by the water. On the board, record wave heights and number of waves from different lab teams. Note that higher waves erode the bluff more quickly (fewer waves are needed).

2. Which beach bluff is the most stable (withstood the most waves)?

T2. The rock beach is the most stable. This is because of the resistant nature of the rocks. Students may want to discuss which types of rocks would be more resistant to erosion. An interesting experiment could be designed by the class using small rock polishers (tumblers) loaded with different kinds of local rocks. Slate in one tumbler, flint in another and sandstone in a third could be processed simultaneously for the same number of days. Comparing the mass of rocks before and after the erosion would indicate which rock types were more resistant. However, you should mention that shale, though a rock, is quite erodible and would not be a good site for construction.

Some beach bluffs on Lake Erie's shore are actually made of sand and some of clay similar to the soil bluff you constructed. The rocky bluffs of the lake shore may be of limestone or a soft shale.

3. What type of beach bluff would you pick if you were building a cottage on the shoreline? Why?

T3. If erodible characteristics are considered, students should choose the rocky bluff as a building site. However, you should mention that shale, though a rock, is quite erodible and would not be as good a site for construction. At the end of this Teacher's Guide are transparency masters and instructions for their use in illustrating the types of shorelands and beaches around Lake Erie and the present use being made of these areas. Students who have completed Activity A should be able to identify areas of potential erosion problems using these maps.

4. On your work sheet is a map of Lake Erie's shoreline. Based on what you have discovered about how different materials erode answer the following questions.

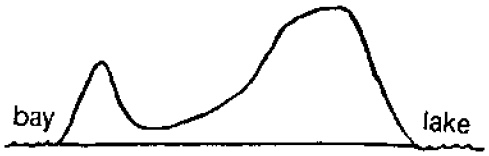
a. Put X's on the sections of shoreline that are probably made of rock.

b. Put O's on the sections of shoreline that are probably made of sandy material.

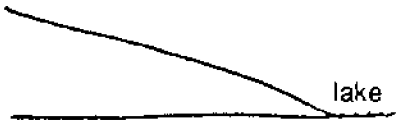
(You do not have to cover the shoreline with either X's or O's. The shape of the shore may not give you any clues about the type of material it has.)

T4. See Transparency Master #1 for approximate locations of sandy and rocky shorelines. Student maps should be accepted if an attempt has been made to label shoreline sections. Points of land projecting into the lake are commonly labeled "X" by students, and cut away sections of shore may be labeled "O." A discussion of students' responses and the transparency can lead to consideration of Question 5.

Figure TG 2 shows how the rocky and sandy bluffs look in cross-section. Rocky areas are generally steep and angular, while sandy bluffs have a gentle slope. The cross-sections shown were taken at areas marked A and B on Figure TG 3.



A. Rocky bluff profile (Eastern end of Marblehead)



B. Sandy bluff profile (West of Huron, Ohio).

Figure TG 2. Comparison of Lake Erie Coastline Features.

5. Some points of land sticking out into the lake may be made of sand. What process is probably responsible for carrying the sand and depositing it there? (You may need to reread the introduction at the beginning of this activity.)

T5. The lake's longshore current, or littoral drift, is responsible for creating many of the points of land projecting into the lake. The "spits," as they are called, are made of sediments carried from other areas. The current direction produced by the prevailing winds determines which way a spit curves.

6. How could you tell from their appearance which points of land might be sandy instead of rocky?

T6. The points of land that form smooth curves out into the lake are generally sandy. Those with ragged or angular shapes usually have a rock base. The two lakeward projections surrounding the mouth of Sandusky Bay illustrate these differences. The Marblehead area to the west of the bay is limestone, and Cedar Point to the east is a sandy deposit.

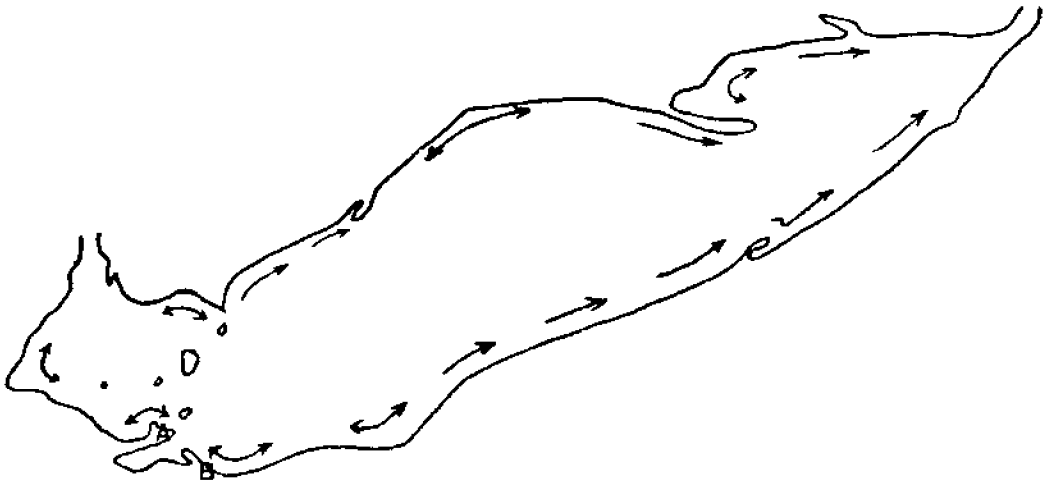


Figure TG 3. Net direction of littoral transport, and curvature of spits in Lake Erie.

Erosion of coastal areas, as you have seen, occurs at different rates depending upon the material making up the shoreline. The same processes act upon the ocean as upon large lakes. Some of the coast of England, for example, has been worn back more than 3 km since the time of the Romans. The shore of Cape Cod retreats at the rate of 25 to 150 cm each year. These coasts are composed of relatively weak material, but the same process takes place more slowly in the hardest rock.

7. On the map on your work sheet, draw your prediction of how the shoreline of Lake Erie will be shaped 100 years from now if the present rates of erosion and deposition continue.

T7. In predicting future shoreline characteristics it is hoped that students will apply what they have learned about coastal processes. Answers will vary, and the differences between predictions can furnish material for class discussion of erosion and deposition rates, the future of lake shore property, and how the shore could be protected.

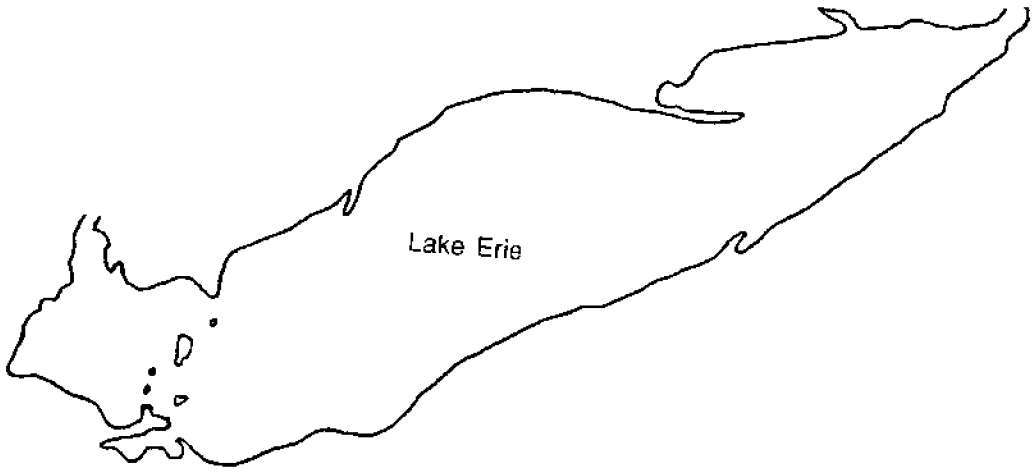


Figure 3. Lake Erie

ACTIVITY B: CAN EROSION BE STOPPED?

The introduction to Activity B indicates to students that erosion is a personal problem to coastal land owners. There are ways to redirect the natural forces at work on the shoreline so that the rate of erosion can be slowed.

KEYWORDS: breakwater, seawall, groin

The shores of the Great Lakes are subject to the attack of winds, waves, longshore currents, ice, and floating debris. Winds having an average velocity of more than 40 km per hour and lasting from 6 to 10 hours are capable of creating waves from 2 to 3 m high on many portions of the Great Lakes. Some shoreline areas suffer damage from smaller waves as well as from the larger ones.

The possibilities for erosion along ocean shorelines are even greater. For instance, at Minot's Ledge in Massachusetts, waves from severe storms destroyed a lighthouse several times during its construction. In 1851, when the lighthouse was finally completed, waves brought the entire structure crumbling into the sea, killing its two keepers and leaving little evidence that the lighthouse had ever been there.

About 83 percent of Lake Erie's erodible shoreline is privately owned. Therefore, land owners must protect their shorelines. Methods of erosion prevention involve attempts to keep the force of the waves away from the bluffs. Nature protects shorelines by building sand beaches where the waves can break and use up their energy before reaching the bluffs. People can construct devices which duplicate the effectiveness of natural sand beaches.

Erosion cannot be permanently stopped, but construction of the proper devices can slow erosion down. What are the devices available to the homeowner and to coastal communities in general?

MATERIALS: Same as Activity A, plus a section of 2 x 4 board equal to half the width of the lake pan.

PROCEDURE

Using descriptions of the three major types of shoreline protection devices, students should be able to label diagrams of these devices as shown on the following pages. It may be necessary to review with students the meanings of the terms "parallel" and "perpendicular."

1. A description of each of the three major methods of shore protection follows. After reading each description, carefully examine the diagrams located at the end of this activity. Label each diagram by letter (A, B, C) according to the method of shore protection which each one shows.

A. One method of shore protection involves the use of concrete, wood or steel structures built directly against and parallel to the shore. These structures are designed to help keep currents and waves from reaching the erodible shoreline. Some of these structures also serve as docking facilities.

B. A second method of beach protection is the construction of a device perpendicular to the shore and connected to it. This device traps the sand moving with the littoral drift. A beach is formed, which is excellent protection against shore erosion.

C. The third method of shore protection is an offshore structure. It usually consists of fairly large stones which are piled away from but parallel to the coastline. The wall of stone reduces wave attack on the shoreline much as a natural sand bar would.

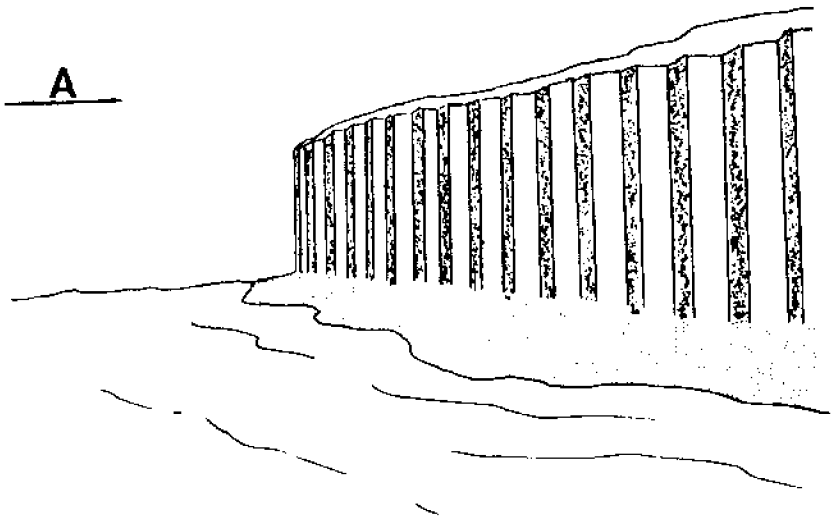
2. Now you can test the effectiveness of some of these shoreline protection devices:

A. Rebuild the sand bluff at one end of the lake.

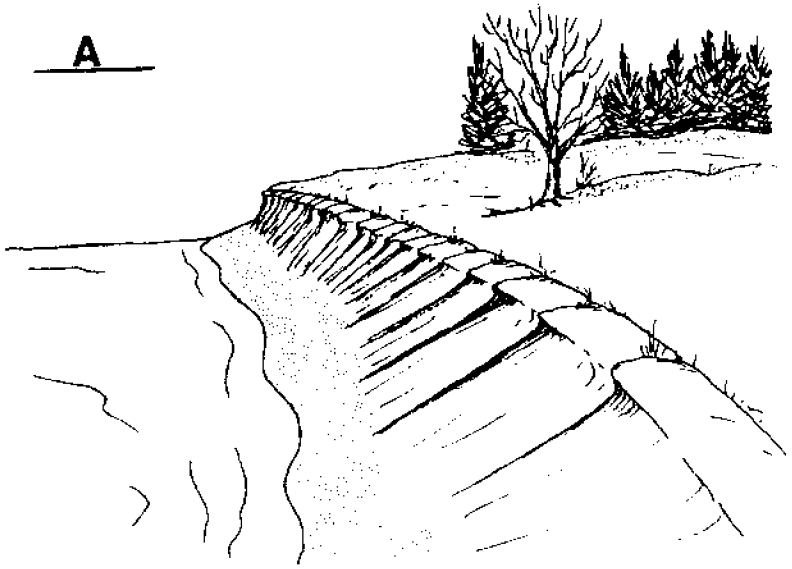
B. Put a short section of 2 x 4 firmly up against the bluff to act as a seawall.

C. Repeat the wave-making activity as before. Record the condition of the bluff after 5 waves and again after 10 waves. Put this information on the Data Table on your work sheet.

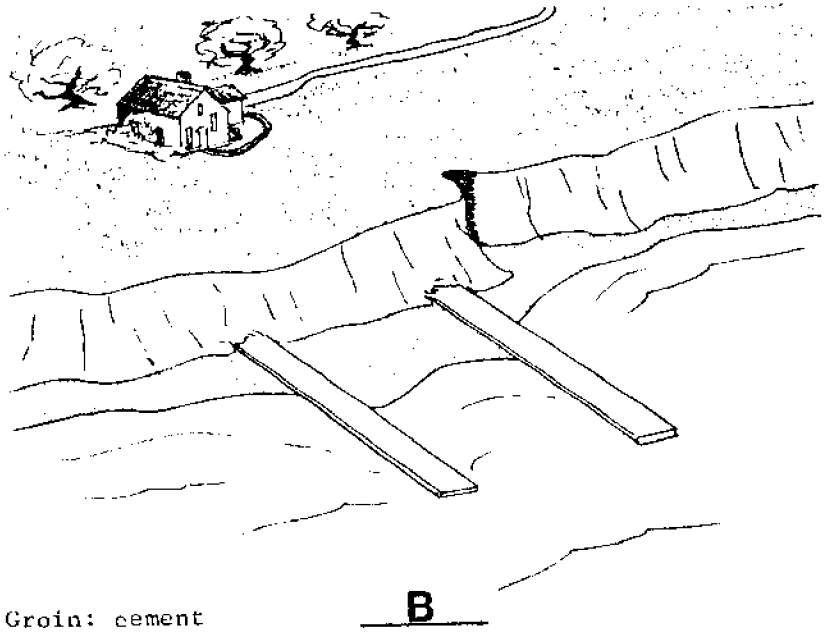
D. Repeat Step A above. This time place the short 2 x 4 in the center of the basin to form a breakwater about 5 cm from the sandy bluff.



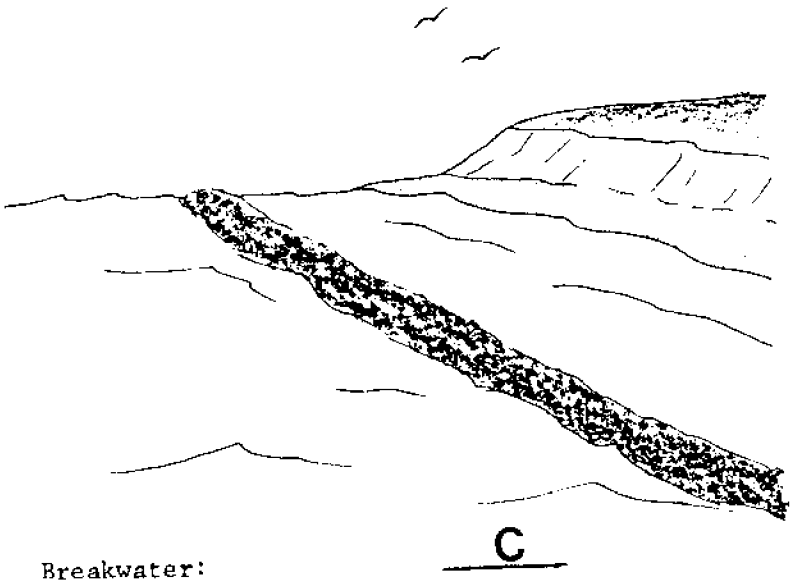
Sea Wall: sheet pile



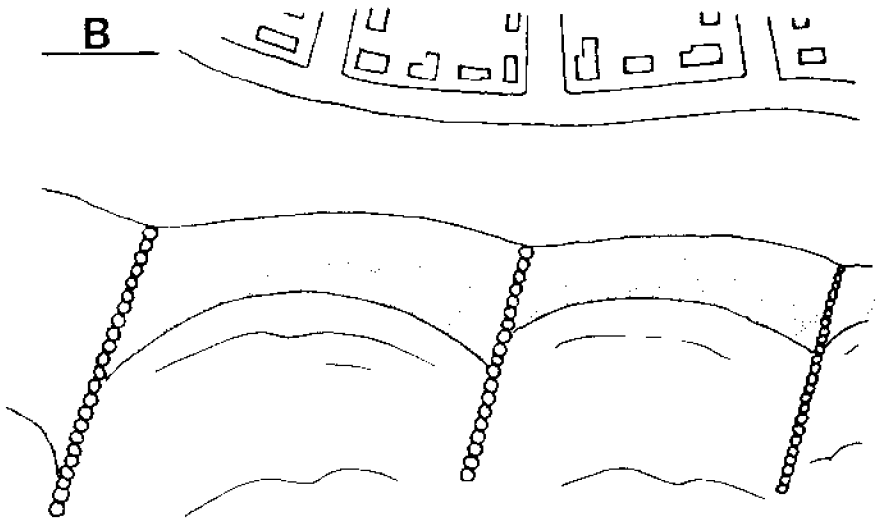
Sea Wall: cement



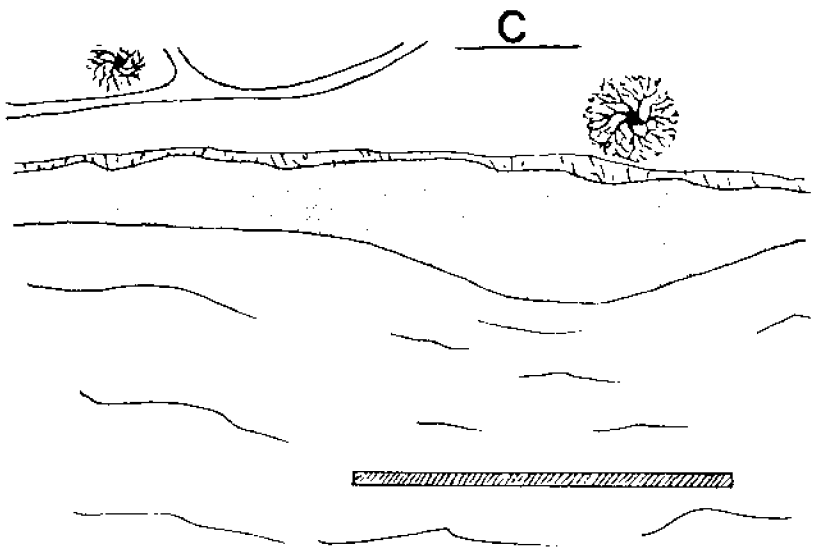
Groin: cement



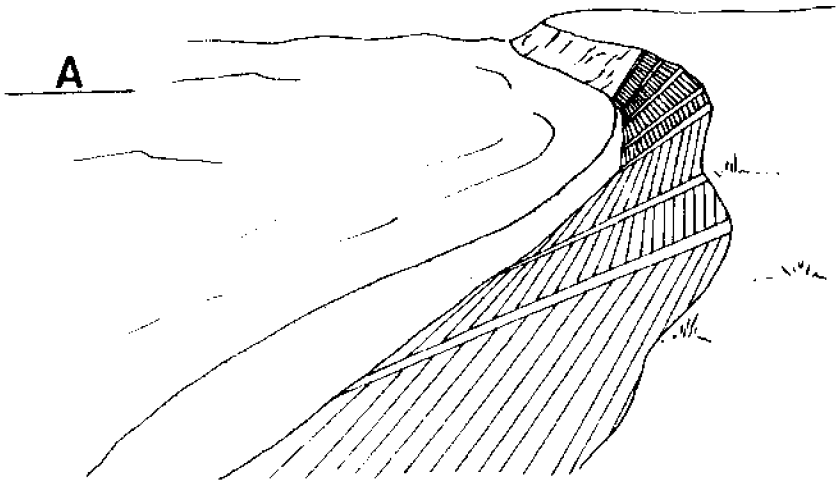
Breakwater:
piled stone



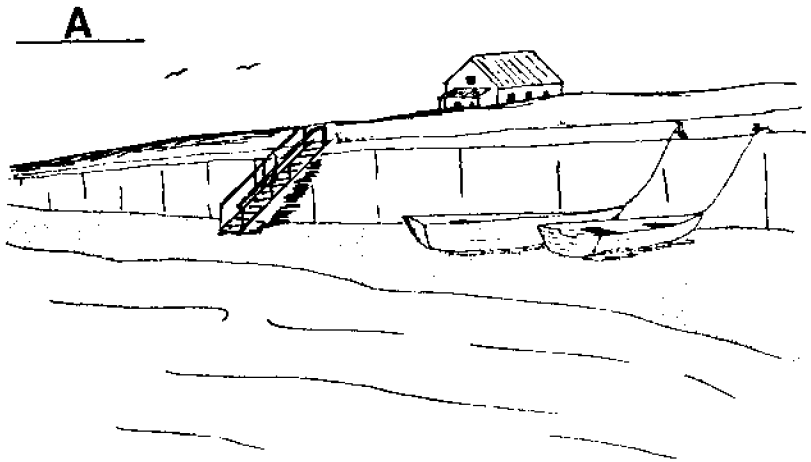
Groins: sheet pile



Breakwater: steel pile



Stepped Revetment



Sea Wall: Concrete

E. Make some waves again, and record what happens to the bluff after 5 waves and after 10 waves.

Instructions for completion of this procedure are complete within the student activity guide. Students should find that the sea wall type of device is more effective than the breakwater design in reducing bluff erosion.

If further investigation about effects of shore protection devices is desired, you may wish to use a stream table. Studies of the effect of groins in trapping sediment, filling in of sediments behind breakwaters, and formation of spits can be made using the guidelines of a reference such as Fisher Scientific's Stream Table Laboratory Manual. This can be ordered from Fisher (1988 price $4.00) 4901 W. LeMayne Street, Chicago, IL 60651; 1-800-621-4769.

As you may have observed, the water within your reconstructed sand bluff may have weakened it before wave erosion began. Groundwater and surface streams do the same thing on real lake shores. For this reason, trees, grasses, and shrubs are sometimes planted to go along with some other shore protection device. The life processes of plants remove ground water, the roots hold soil in place, and beach grasses trap sediment to actually help build the beach. (See Figure 4 below).

As Figure 4 indicates, lake processes are not the only ones involved in erosion of shoreline features. Precipitation and groundwater contribute to the erodible nature of shore areas. The Corps of Engineers' free booklet "The role of vegetation in shoreline management," explains these effects in detail and provides some illustrations that could be effective transparency masters for discussion of the topic.

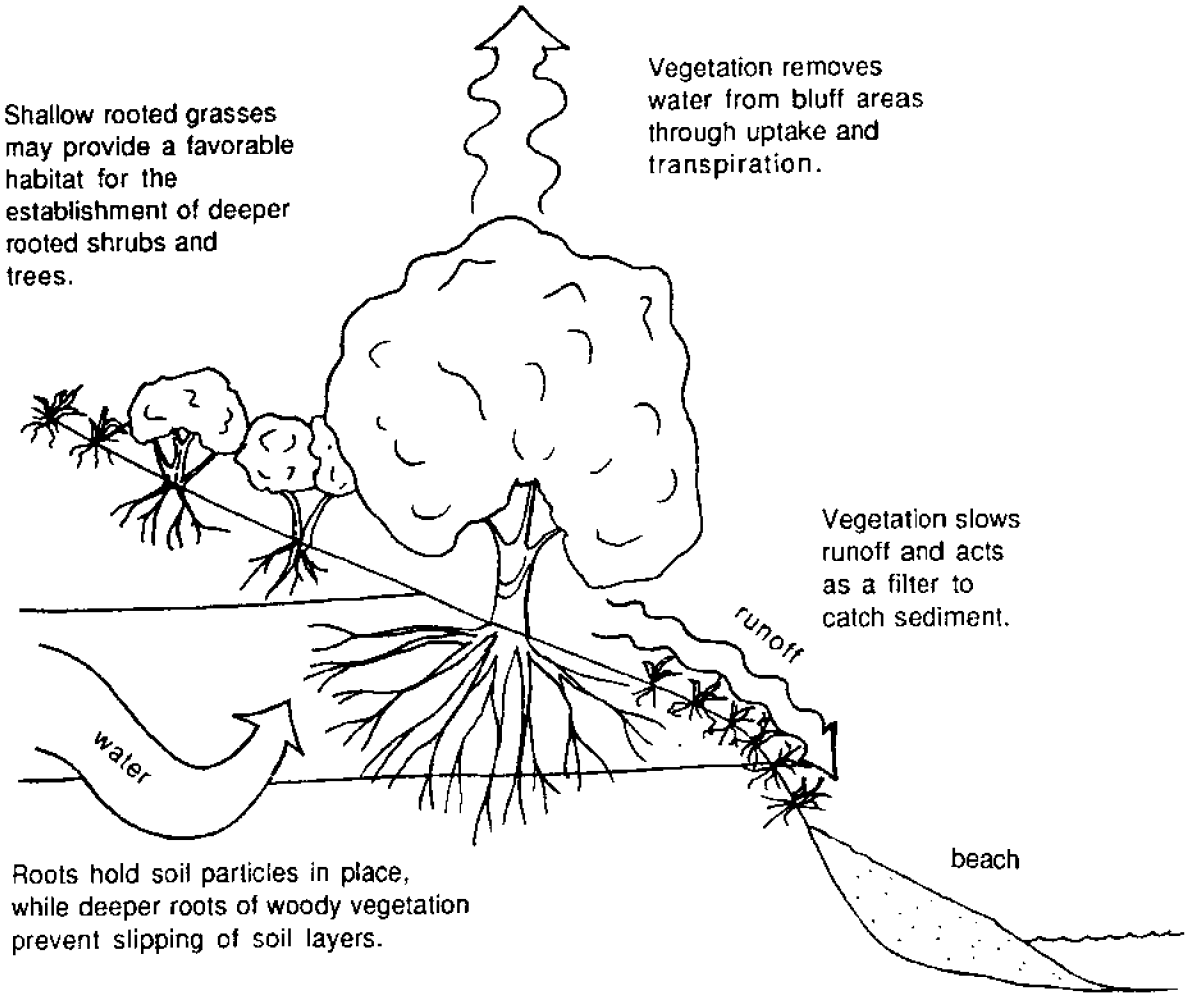


Figure 4. The Role of Plants in Erosion Control.

A bulkhead is a structure to retain or prevent sliding of the land. It has a secondary function of protecting the upland from direct wave action.

In recent years there has been growing concern about the uncontrolled construction of shore protection devices such as groins, sea walls, revetments, and bulkheads. Many people interested in maintaining and improving the environment are concerned about the placement of multiple bulkheads along stretches of shoreline. Evidence strongly indicates that groins speed up erosion in nearby areas and that bulkheads cause shore loss and water turbidity. Some argue, "What harm does a single 50-foot or 100-foot bulkhead do to the environment?" There are many miles of bulkheads, sea walls, and other protective devices added to our shoreline every year.

3. What is the long-term and the cumulative effect of these structures?

T3. There are advantages and disadvantages to each of the construction alternatives for shoreline protection. Construction costs, maintenance problems, and beach changes associated with some devices make them unsuitable for use by private landowners. Legal responsibilities to owners of adjoining land may also be factors in determining which shoreline protection method is used. To examine the pros and cons of each type of structure, refer to the Corps of Engineers' free "Help Yourself" wall chart listed in the "Suggested Approach" section on page 1.

REVIEW QUESTIONS

1. List the natural forces which cause erosion along the Lake Erie coastline.

R1. Wind, waves, and currents are natural forces which cause erosion along Lake Erie's coastline.

2. What types of shore materials erode faster? Slower?

R2. Loosely packed material with fairly uniform particle size (sand, in this activity) erodes faster. Erosion proceeds more slowly with resistant or tightly packed material.

3. Briefly describe the three major methods or categories of shoreline protection devices.

R3. (a) A wall built up against the shoreline to keep waves from actually hitting the land.

(b) A wall sticking out from the shoreline into the water to interrupt the longshore current and trap sand.

(c) A wall of rocks or pilings built out in the water parallel to the shoreline to break the force of waves as they come into shore.

4. If you had a beach cottage, which type of device would you build to protect your section of shoreline? Explain your choice.

R4. Answers will vary. Many students tend to choose a breakwater because they think there can be no beach with a seawall. Refer them to their work sheet in the student manual to see that beaches can still exist when either structure is used.

5. Would it be advisable to construct shore protection devices along all sections of Lake Erie's shoreline? Explain.

R5. There are several reasons for not putting shore protection devices all along the shore of Lake Erie:

(a) Some areas are not erodible to any great extent.

(b) Some areas are not developed, so erosion is not a critical problem.

(c) Shore protection devices cause a build-up of sediments in new places. This could be harmful to existing land use along the shore (i.e., filling in of harbors, redistribution of pollutants, filling in of wetlands that are valuable as widlife habitat).

On the other hand, the Great Lakes Basin Commission makes the following comments in their Framework Study of 1975 (Appendix 18):

"Lake Erie basin shore damage problems are complex. Most of the shorelands, 290 miles, are erodible and 162 miles of these are developed. Flooding is a problem on 44 miles of shorelands. Projections of future shoreland use show all of Lake Erie's shorelands committed to urban use by the year 2000. The percentage of developed shoreline and density of development suggest that structural shore protection would be the most effective method of reducing damages to existing development.

Future activities on undeveloped shorelands should be controlled to reduce future damages. Shoreland management measures including setbacks in zoning, acquisition and relocation could reduce future damges on Lake Erie."

EVALUATION ITEMS

1. Longshore currents are caused by

   *a. wind.
   b. river water moving into the lake.
   c. rotation of the earth.
   d. tides.

2. Trees and other plants are often placed on bluffs along a shore that is rapidly eroding. This is done to

   a. beautify the shoreline.
   b. reduce the wind.
   *c. hold soil in place.
   d. provide a source of firewood.

3. A breakwater is a device used to reduce erosion along a shore. It does this by

   a. slowing down the wind.
   b. changing the direction of the longshore currents.
   *c. blocking the waves.
   d. changing the shape of the bluffs.

4. A groin protects the shore by

   *a. trapping sand behind it.
   b. blocking the waves.
   c. stabilizing the bluffs.
   d. changing the direction of the wind.

5. What is the major cause of sand being transported along a shore?

   a. Wind blowing along the shore.
   b. Rivers that empty into the lake.
   *c. Longshore currents.
   d. Slumps occurring in lake bluffs.

6. Which of the following would increase shore erosion?

   *a. more waves
   b. fewer waves
   c. more pollution
   d. smaller waves
   e. less pollution

7. Which type of shoreline material resists erosion best?

   a. sand
   b. soil
   c. clay
   *d. rock

8. A structure built against and parallel to the shore to protect the shore from erosion is called a

   *a. sea wall.
   b. breakwater.
   c. groin.
   d. littoral drift.

9. The islands in western Lake Erie are mainly composed of

   *a. rock.
   b. sand.
   c. gravel.
   d. soil.

10. The movement of sand along the shore is called

    a. stepped revetment.
    b. a beach.
    c. a wave front.
    *d. littoral drift.

ADDITIONAL BACKGROUND INFORMATION

For a more complete discussion of wave dynamics and littoral drift effects, you may wish to read Willard Bascom's Waves and Beaches. Chapter X of this book, entitled "The Littoral Conveyor Belt," and Chapter XI, "Man Against the Sea," contain interesting supplements to the material presented in this investigation.

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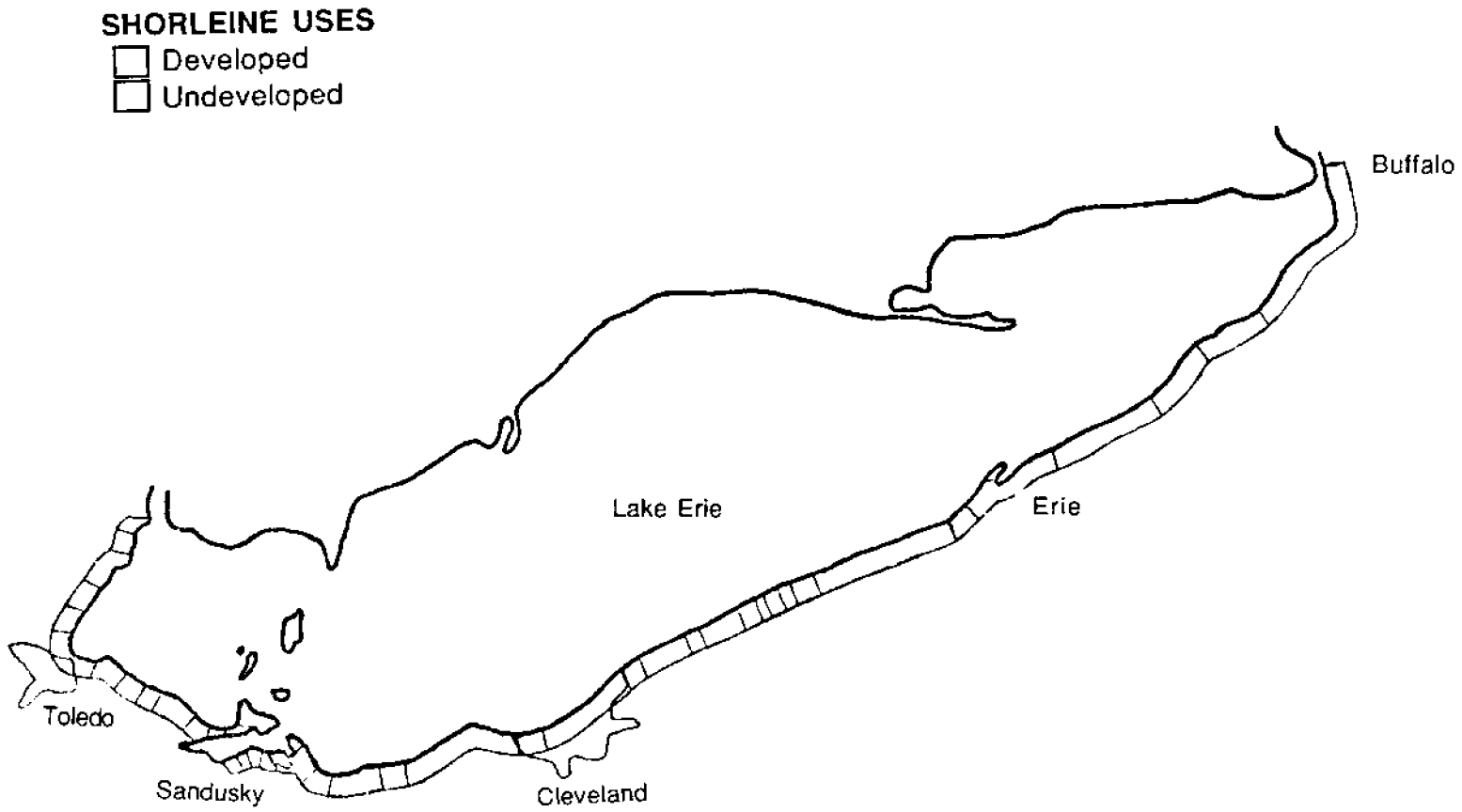
TRANSPARENCY MASTER #1

INSTRUCTIONS FOR USE

This diagram is adapted from the Great Lakes Commission Framework Study of 1975. The study dealt only with U.S. lands bordering the Great Lakes, so information concerning the Canadian side is incomplete. Note that most of the lakeward projections of land are erodible spits built in the direction in which the longshore current flows.

The size of the map does not permit inclusion of an interesting feature of Pelee Island. Though the island itself is rocky, it has a spit at its southern tip. Changes in the direction of the longshore current around the islands in that area cause the spit to curve eastward at some times and westward at others. Sailors on the lake, therefore, speak of Pelee as "the island that wags its tail."


SHORLEINE USES
Developed
Undeveloped
Buffalo
Lake Erie
Erie
Toledo
Sandusky
Cleveland

TRANSPARENCY MASTER #2

INSTRUCTIONS FOR USE

This diagram shows in general terms how the lake shore is being used. A transparency made from this master may be used as an overlay for Transparency #1. In order to make the sections of developed and undeveloped shoreline apparent, the transparent sheet itself (not the master) should be colored with marking pens according to the coloring guide. Green and orange are suggested, but you may use any light colors that will let the information from Transparency #1 show through.

When this overlay is added, it should be apparent that the shoreline is heavily developed in some erodible areas (such as between Erie and Cleveland). When a developed area (orange) overlies erodible bluffs ( ) or plains ( ) there is a potential problem in the form of destruction of coastal property by erosion. Erosion of undeveloped areas, while it may have an equally severe effect on the land, is generally not considered so great a problem since man-made structures are not threatened.

As an extension of the discussion generated by these transparencies, the following are recommended:

1. Have students investigate what erosion control methods are being used to protect the problem areas (use aerial photos or topographic maps).

2. Investigate what the undeveloped areas are actually being used for, and recommend land uses that are productive but do not require shoreline portection (e.g. wildlife preserves, tree farming). Sources of this information may be road maps, topographic maps, or the Soil Conservation Service's land capability classification for each county.

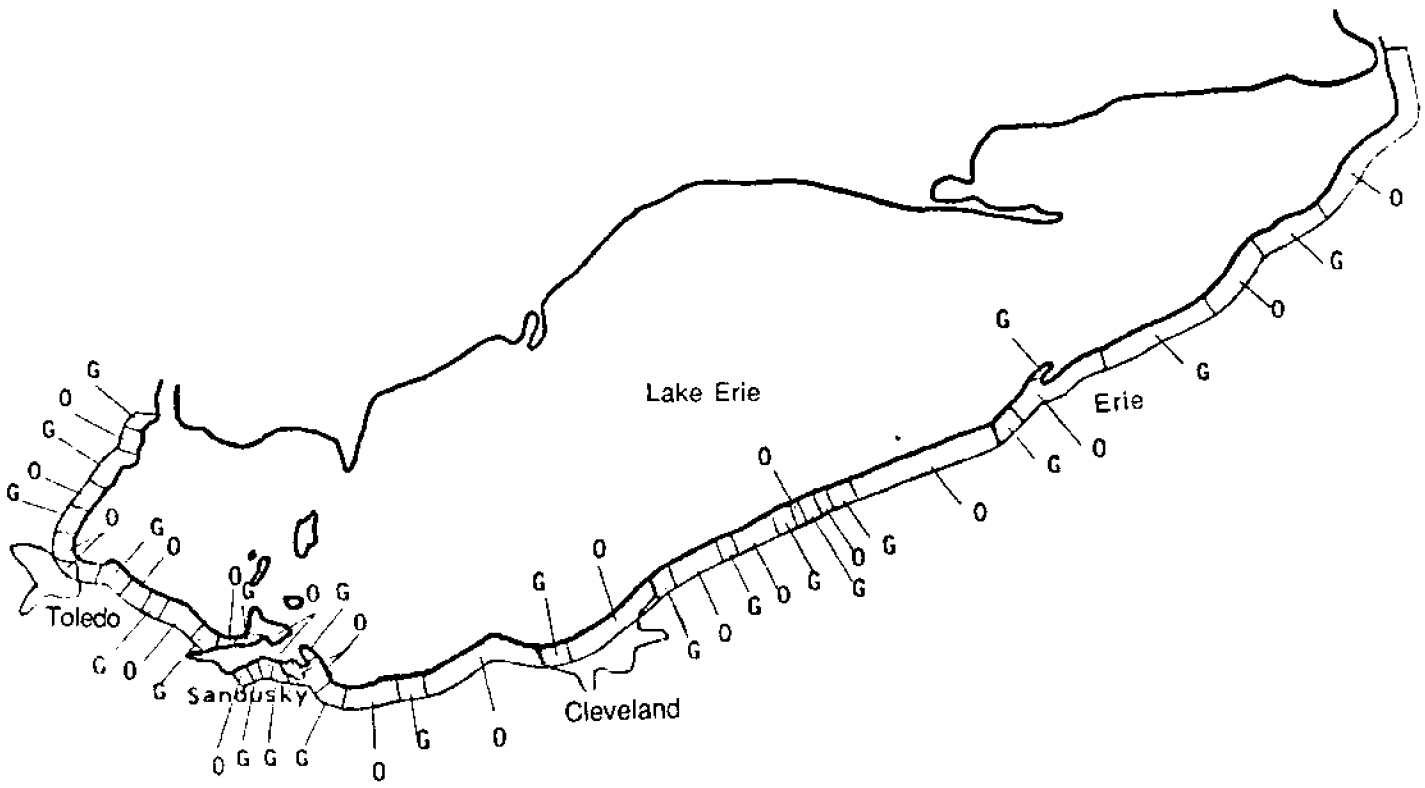
SHORELINE USES

O Developed

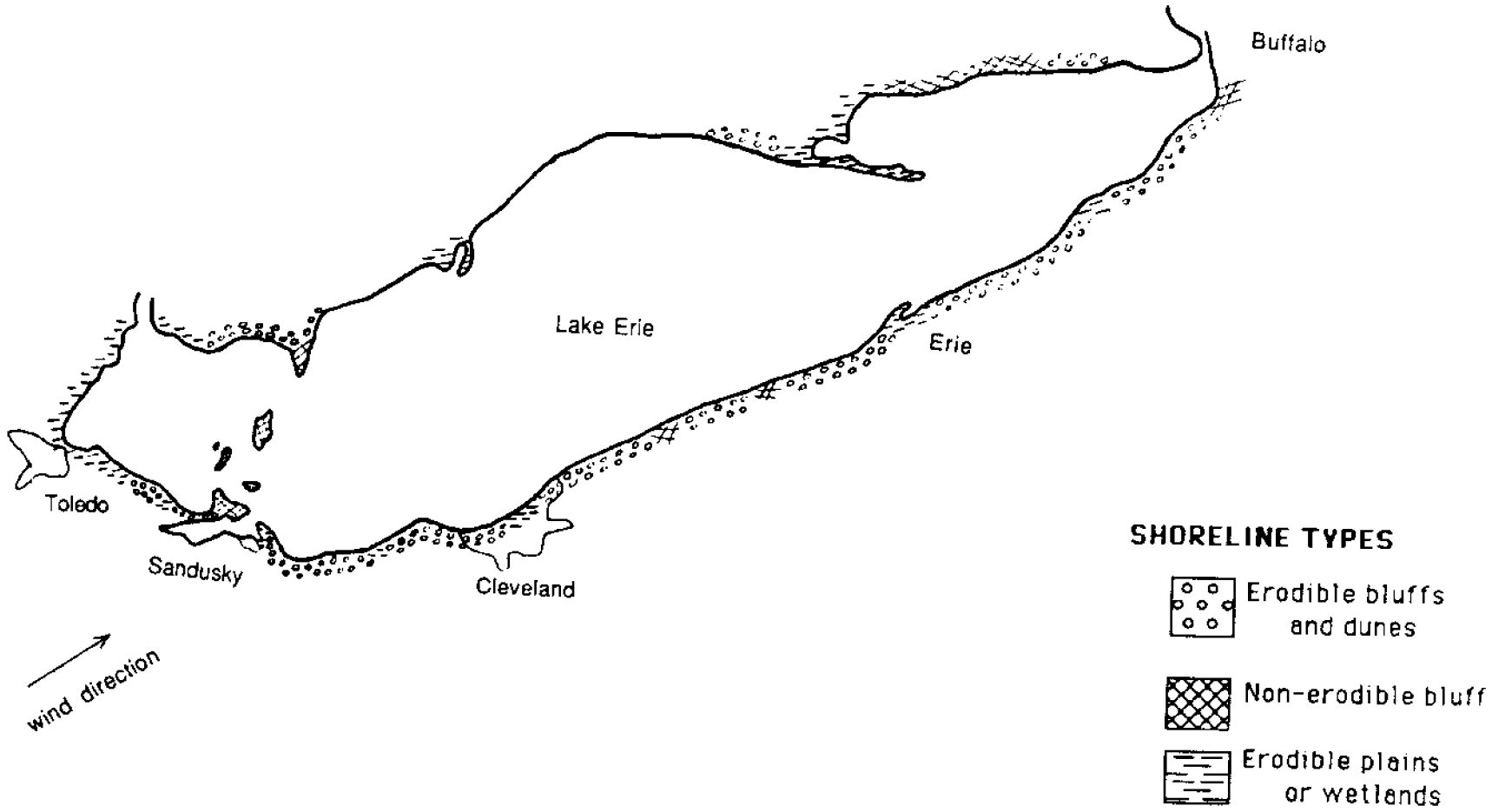
G Undeveloped

G = Green

O = Orange



TRANSPARENCY #2
COLORING GUIDE


Buffalo
Lake Erie
Erie
Toledo
Sandusky
Cleveland
wind direction
SHORELINE TYPES
Erodible bluffs and dunes
Non-erodible bluff
Erodible plains or wetlands

Other titles of Oceanic Education Activities for Great Lakes Schools

for middle schools:

The Effect of the Great Lakes on Temperature
The Effect of the Great Lakes on Climate
Ancient Lake Shores
How to Protect a River
Changing Lake Levels on the Great Lakes
Erosion Along the Great Lakes
Coastal Processes and Erosion
Pollution in Lake Erie: An Introduction
Yellow Perch in Lake Erie
Evidence of Ancient Seas in Ohio
To Harvest a Walleye
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Geography of the Great Lakes
Ohio Canals
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Getting to Know Your Local Fish
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We Have Met the Enemy
It's Everyone's Sea: Or Is It?
PCBs in Fish: A Problem?
A Great Lake Vacation
Storm Surge
River Trek
Waves on the Great Lakes

for primary grades:

Lake Erie -- Take a Bow!
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Supplemental Curriculum Activity for Holling Clancy Holling's Paddle-to-the Sea

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EP-7

COASTAL PROCESSES AND EROSION

by
Beth A. Kennedy, Newark Public Schools
and
Rosanne W. Fortner, The Ohio State University
Ohio Sea Grant Education Program

OEAGLS-Oceanic Education Activities for Great Lakes Schools

OEAGLS Investigation #7

Completed February 1979
Revised June 1980, July 1982 and August 1988

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Figure 4 adapted from U.S. Army Corps of Engineers, "The Role of Vegetation in Shoreline Management," 1977.

COASTAL PROCESSES AND EROSION

by

Beth A. Kennedy and Rosanne W. Fortner
Ohio Sea Grant Education Program

INTRODUCTION

The major natural forces affecting the shoreline are wind, waves, and currents. These forces wear away and build up a shoreline. People can modify these forces and redirect them, but we will never totally control them.

Wind and Waves

The wind is the principal generator of waves. The longer and stronger the wind blows and the greater the distance over which it blows, the larger and more powerful the waves will be.

Waves have significant effects on shorelines. During storms, their energy can carry beach sands lakeward, erode cliffs and banks, and damage or carry away man-made structures. During calm periods, waves move off-shore sand onto the beaches, building them up.

Currents

Currents--streams of moving water within a body of water--are another major force affecting the shoreline. Perhaps the most important current causing the shoreline to change is the **longshore current**, which is generated by waves as they strike the coast at an angle. A longshore current runs parallel to the shoreline and varies in speed and direction with the angle of waves and their energy. It often transports large quantities of sand along the beach. This transportation is known as **littoral drift**.

If there is an abundant supply of sediment, as from eroding cliffs or sediment-laden streams flowing into the lake, the littoral drift will deposit sediment wherever its speed is reduced. When sediment is scarce, the littoral drift will carry sand away from the beaches, causing erosion.

Because wind and waves determine the directions and amount of littoral drift, the overall or **net** sand movement in Lake Erie is from west to east.

OBJECTIVES

When you have completed this investigation you will be able to:

1. List the major natural forces of erosion along the lake shore.
2. Describe how the rate of erosion differs with different materials.
3. Explain the purposes of the three major categories of shoreline protection devices.

ACTIVITY A: WHAT CAUSES THE SHORELINE TO ERODE AWAY?

MATERIALS: Three rectangular plastic pans or plastic shoe boxes, one piece of board (2 x 4 or plank) as long as the width of the pans, sand, soil, several broken pieces of rock, ruler, 3 x 5 note card cut in three long strips, pencil for recording data.

PROCEDURE

A. In the end of one of the plastic pans place three handfuls of wet sand.

B. Using a piece of board, mash the sand up against the end of the pan and flatten the top. Make this "beach bluff" about as wide as it is high.

C. Repeat Steps A and B with a second pan, building a beach bluff made of wet soil.

D. In one end of the third pan make a stack of rock pieces that will represent a rocky shoreline about the same size as the other bluffs.

You should now have three "beach bluffs" of various types and sizes of material. The three pans represent lakes.

E. Hold the pieces of board up against the sand bluff to protect it while you **slowly** add water to the empty end of the pan. Create a lake about 1-1.5 cm deep. Remove the board gently when the lake water is still.

F. Repeat Step E to create lakes in front of the soil and rock bluffs.

G. Gently place a strip of note card flat on top of each bluff.

H. You are now ready to act as the wind, making waves and causing erosion on the shoreline. Using a ruler or the pieces of board, make waves that move toward the beach bluff from the opposite end of the lake. Start gently, counting the number of waves you produce. Then gradually increase the strength of your waves as if the wind were becoming stronger. Record what happens to the beach bluffs as you repeat this process in each lake. Put your information on the Data Table on your work sheet.

I. When the section of note card slips toward the water, your bluff has collapsed. If collapse has not occurred after 100 waves, stop and record your observations of the bluff's condition. Put this information on your work sheet in the Data Table.

NOTE: To measure the height of waves, find the distance from the top (crest) of the wave to the lowest part (trough) of the wave. Do not measure from the bottom of the "lake" basin unless the bottom is actually exposed as the wave passes by. Refer to Figure 2.

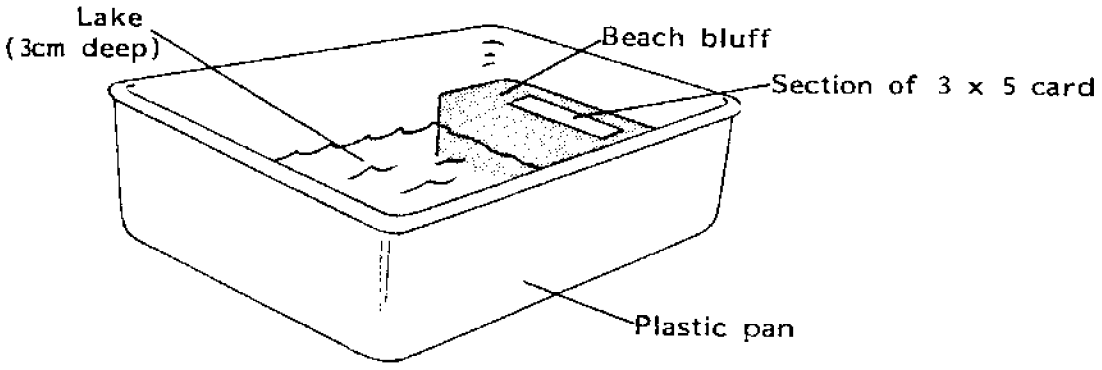


Figure 1. Shoreline Model

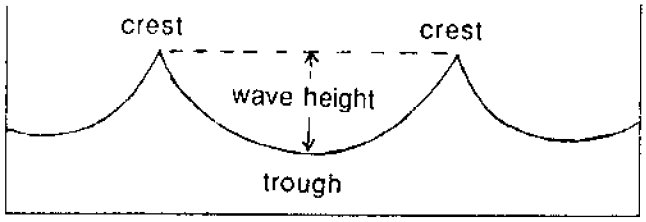


Figure 2. Determining Wave Height

Answer the following questions on your work sheet.

1. Which beach bluff is the least stable (collapsed first)?

2. Which beach bluff is the most stable (withstood the most waves)?

Some beach bluffs on Lake Erie's shore are actually made of sand and some of clay similar to the soil bluff you constructed. The rocky bluffs of the lake shore may be of limestone or a soft shale.

3. What type of beach bluff would you pick if you were building a cottage on the shoreline? Why?

4. On your work sheet is a map of Lake Erie's shoreline. Based on what you have discovered about how different materials erode answer the following questions.

a. Put X's on the sections of shoreline that are probably made of rock.

b. Put O's on the sections of shoreline that are probably made of sandy material.

(You do not have to cover the shoreline with either X's or O's. The shape of the shore may not give you any clues about the type of material it has.)

5. Some points of land sticking out into the lake may be made of sand. What process is probably responsible for carrying the sand and depositing it there? (You may need to reread the introduction at the beginning of this activity.)

6. How could you tell from their appearance which points of land might be sandy instead of rocky?

Erosion of coastal areas, as you have seen, occurs at different rates depending upon the material making up the shoreline. The same processes act upon the ocean as upon large lakes. Some of the coast of England, for example, has been worn back more than 3 km since the time of the Romans. The shore of Cape Cod retreats at the rate of 25 to 150 cm each year. These coasts are composed of relatively weak material, but the same process takes place more slowly in the hardest rock.

7. On the map on your work sheet, draw your prediction of how the shoreline of Lake Erie will be shaped 100 years from now if the present rates of erosion and deposition continue.

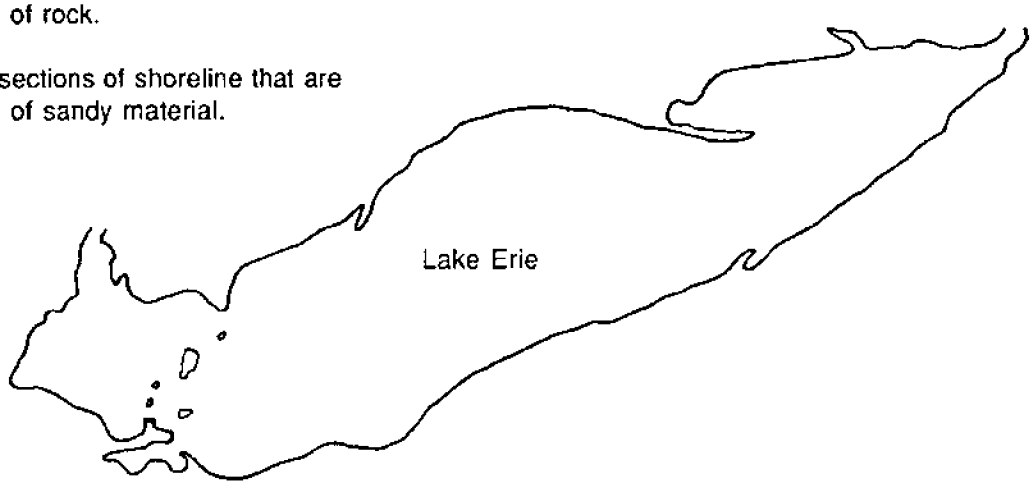


Figure 3. Lake Erie

ACTIVITY B: CAN EROSION BE STOPPED?

The shores of the Great Lakes are subject to the attack of winds, waves, longshore currents, ice, and floating debris. Winds having an average velocity of more than 40 km per hour and lasting from 6 to 10 hours are capable of creating waves from 2 to 3 m high on many portions of the Great Lakes. Some shoreline areas suffer damage from smaller waves as well as from the larger ones.

The possibilities for erosion along ocean shorelines are even greater. For instance, at Minot's Ledge in Massachusetts, waves from severe storms destroyed a lighthouse several times during its construction. In 1851, when the lighthouse was finally completed, waves brought the entire structure crumbling into the sea, killing its two keepers and leaving little evidence that the lighthouse had ever been there.

About 83 percent of Lake Erie's erodible shoreline is privately owned. Therefore, land owners must protect their shorelines. Methods of erosion prevention involve attempts to keep the force of the waves away from the bluffs. Nature protects shorelines by building sand beaches where the waves can break and use up their energy before reaching the bluffs. People can construct devices which duplicate the effectiveness of natural sand beaches.

Erosion cannot be permanently stopped, but construction of the proper devices can slow erosion down. What are the devices available to the homeowner and to coastal communities in general?

MATERIALS: Same as Activity A, plus a section of 2 x 4 board equal to half the width of the lake pan.

PROCEDURE

1. A description of each of the three major methods of shore protection follows. After reading each description, carefully examine the diagrams located at the end of this activity. Label each diagram by letter (A, B, C) according to the method of shore protection which each one shows.

A. One method of shore protection involves the use of concrete, wood or steel structures built directly against and parallel to the shore. These structures are designed to help keep currents and waves from reaching the erodible shoreline. Some of these structures also serve as docking facilities.

B. A second method of beach protection is the construction of a device perpendicular to the shore and connected to it. This device traps the sand moving with the littoral drift. A beach is formed, which is excellent protection against shore erosion.

C. The third method of shore protection is an offshore structure. It usually consists of fairly large stones which are piled away from but parallel to the coastline. The wall of stone reduces wave attack on the shoreline much as a natural sand bar would.

2. Now you can test the effectiveness of some of these shoreline protection devices:

A. Rebuild the sand bluff at one end of the lake.

B. Put a short section of 2 x 4 firmly up against the bluff to act as a seawall.

C. Repeat the wave-making activity as before. Record the condition of the bluff after 5 waves and again after 10 waves. Put this information on the Data Table on your work sheet.

D. Repeat Step A above. This time place the short 2 x 4 in the center of the basin to form a breakwater about 5 cm from the sandy bluff.

E. Make some waves again, and record what happens to the bluff after 5 waves and after 10 waves.

As you may have observed, the water within your reconstructed sand bluff may have weakened it before wave erosion began. Groundwater and surface streams do the same thing on real lake shores. For this reason, trees, grasses, and shrubs are sometimes planted to go along with some other shore protection device. The life processes of plants remove ground water, the roots hold soil in place, and beach grasses trap sediment to actually help build the beach. (See Figure 4 below)

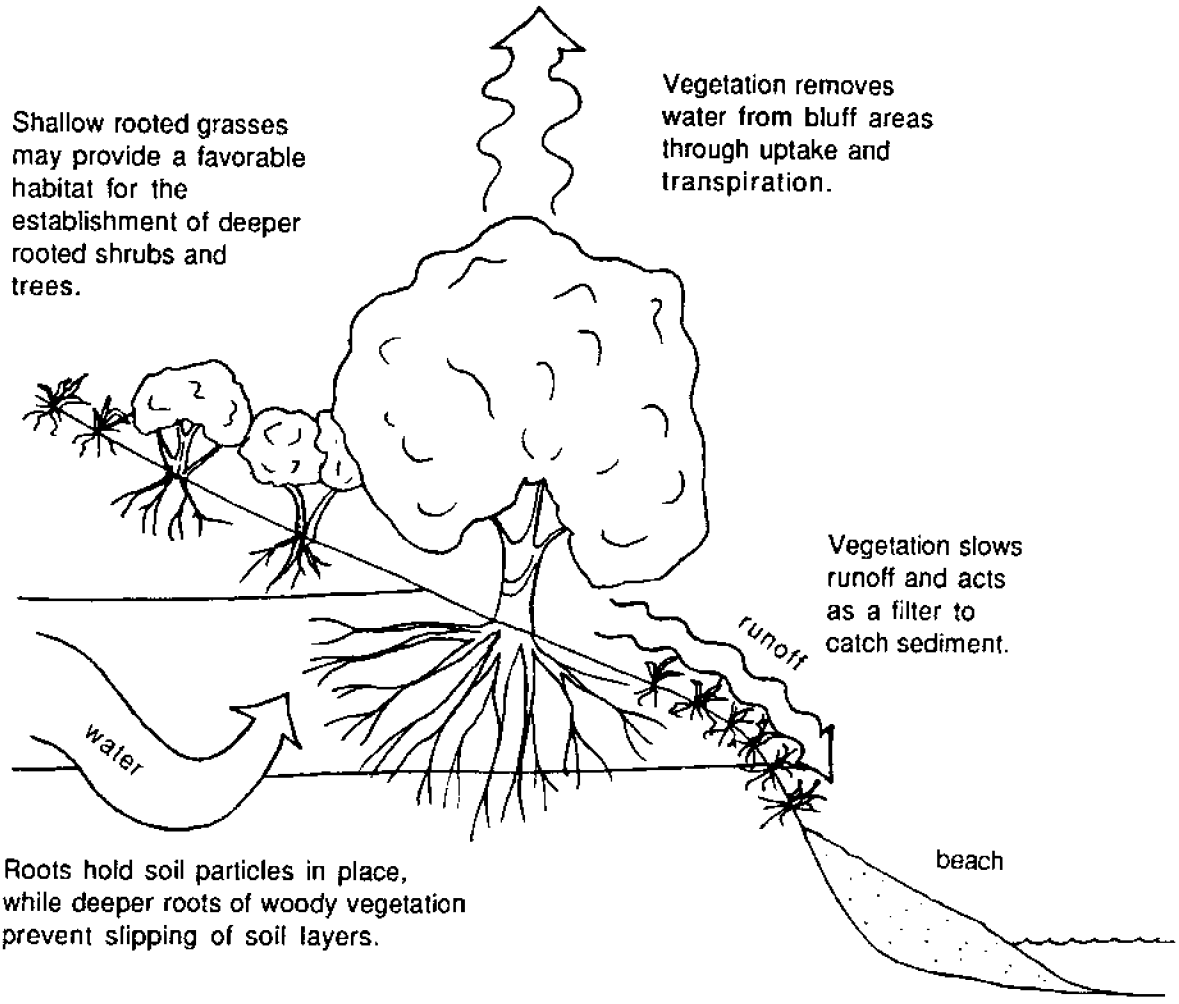


Figure 4. The Role of Plants in Erosion Control

In recent years there has been growing concern about the uncontrolled construction of shore protection devices such as groins, sea walls, revetments, and bulkheads. Many people interested in maintaining and improving the environment are concerned about the placement of multiple bulkheads along stretches of shoreline. Evidence strongly indicates that groins speed up erosion in nearby areas and that bulkheads cause shore loss and water turbidity. Some argue, "What harm does a single 50-foot or 100-foot bulkhead do to the environment?" There are many miles of bulkheads, sea walls, and other protective devices added to our shoreline every year.

3. What is the long-term and the cumulative effect of these structures?

REVIEW QUESTIONS

1. List the natural forces which cause erosion along the Lake Erie coastline.

2. What types of shore materials erode faster? Slower?

3. Briefly describe the three major methods or categories of shoreline protection devices.

4. If you had a beach cottage, which type of device would you build to protect your section of shoreline? Explain your choice.

5. Would it be advisable to construct shore protection devices along all sections of Lake Erie's shoreline? Explain.

Name _____

Coastal Processes
Work sheet

Activity A: What causes the shoreline to erode away?

DATA TABLE:

	Number of Waves	Height of Waves	Effects of Bluff
SANDY BLUFF			
SOIL BLUFF			
ROCKY BLUFF			

1. Which beach bluff is the least stable (collapsed first)? _____

2. Which beach bluff is the most stable (withstood the most waves)? _____

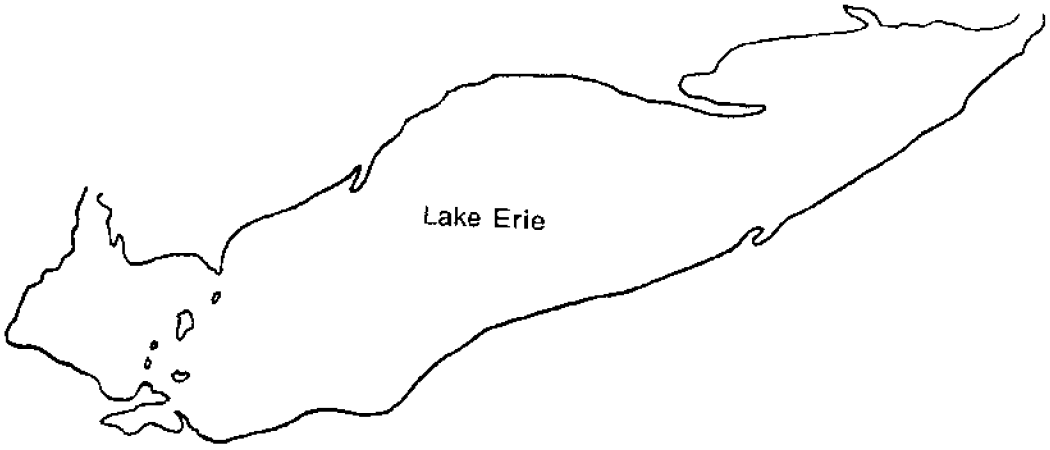
3. What type of beach bluff would you pick if you were building a cottage on the shoreline? Why?

_____

_____

_____

4. Put X's on the sections of shoreline that are probably made of rock. Put O's on the sections of shoreline that are probably made of sandy material.



Lake Erie's shoreline

5. What process is probably responsible for carrying the sand and depositing it there?

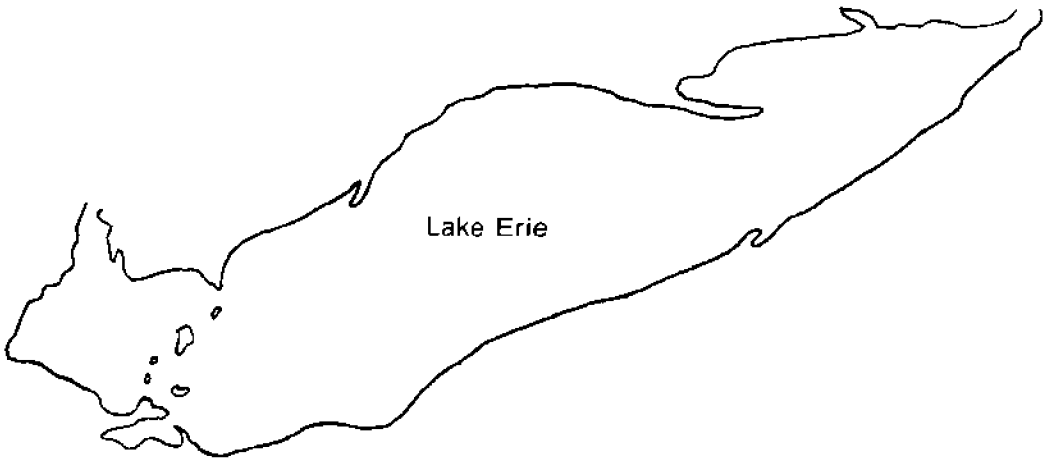
_____

6. How could you tell from their appearance which points of land might be sandy instead of rocky?

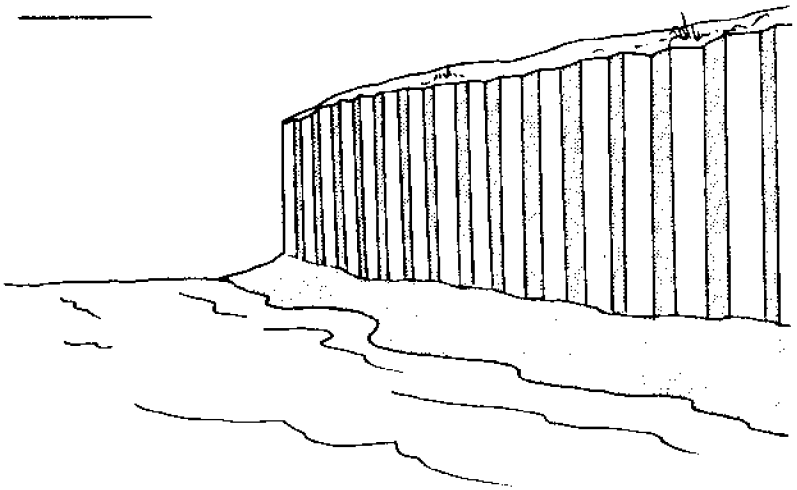
_____

_____

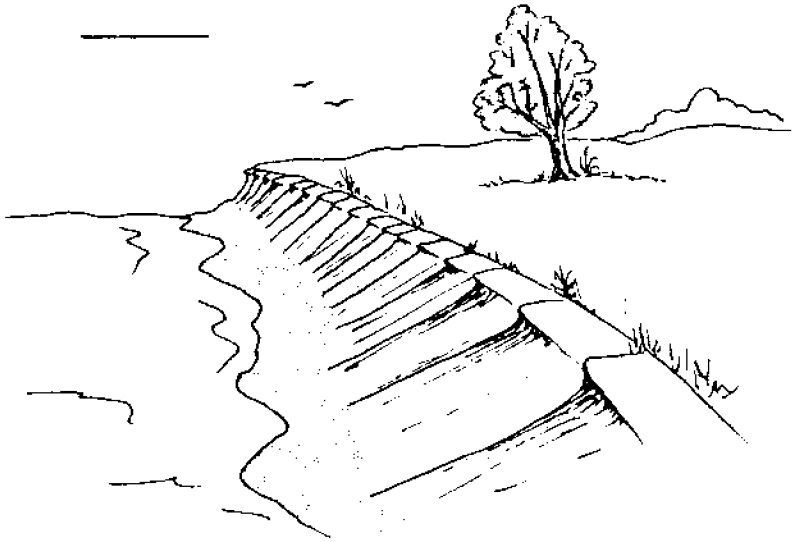
7. On the map on your work sheet, draw your prediction of how the shoreline of Lake Erie will be shaped 100 years from now if the present rates of erosion and deposition continue.



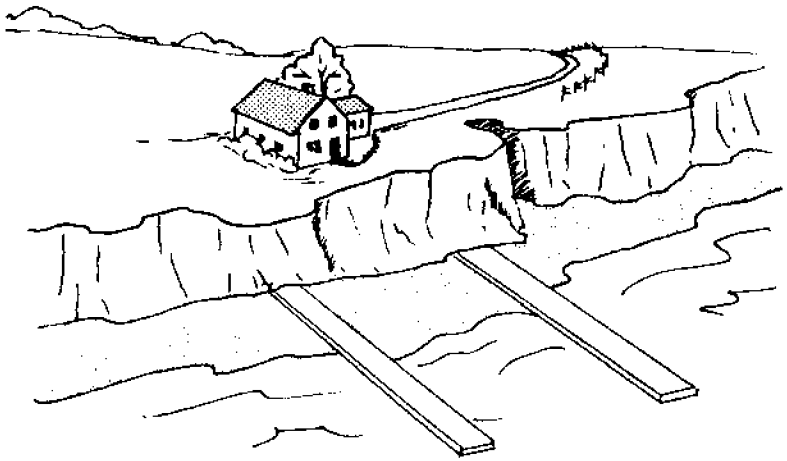
Predicted Shoreline of Lake Erie 100 Years From Now (Present Shape given).



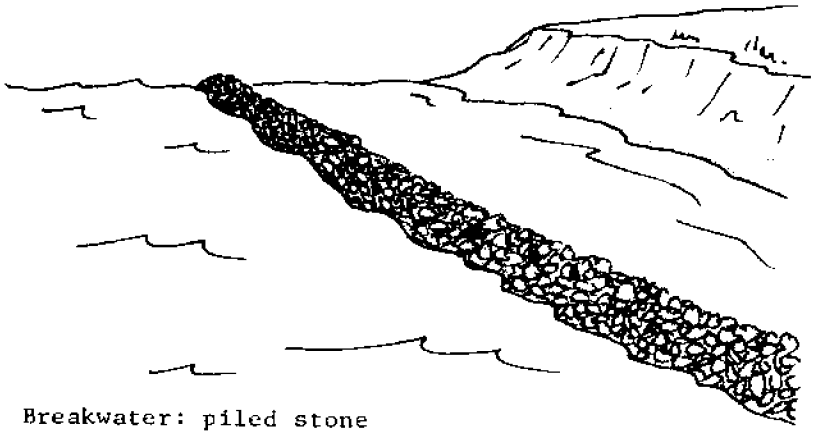
Sea Wall: sheet pile



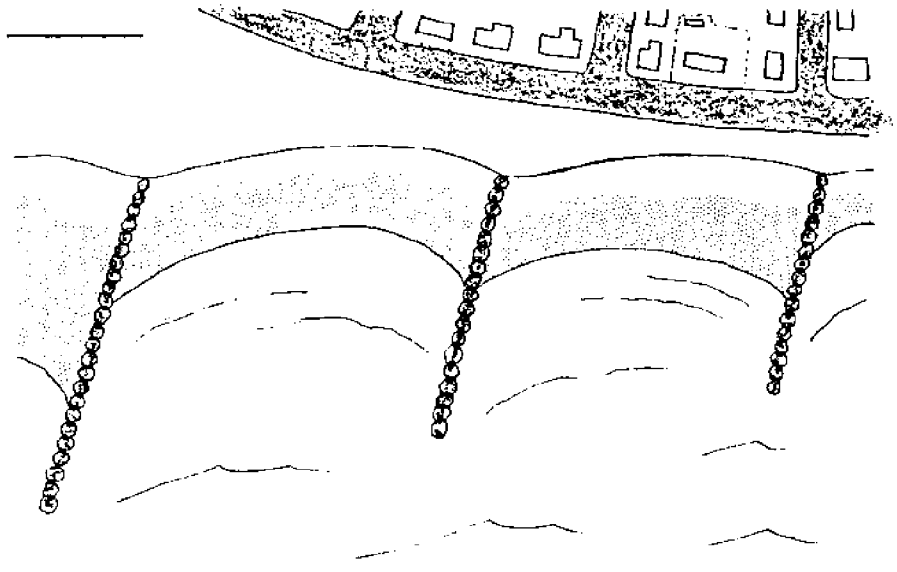
Sea Wall: cement



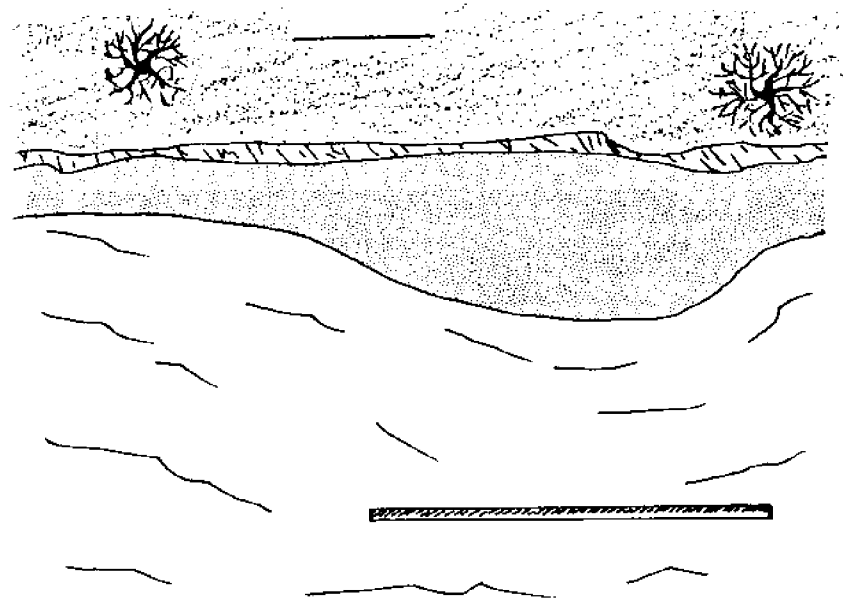
Groin: cement



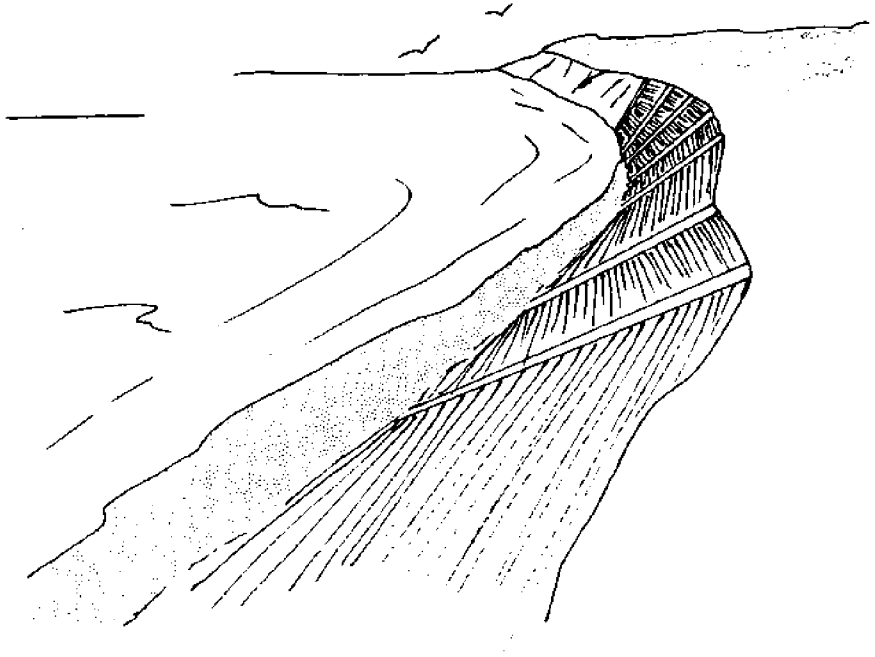
Breakwater: piled stone



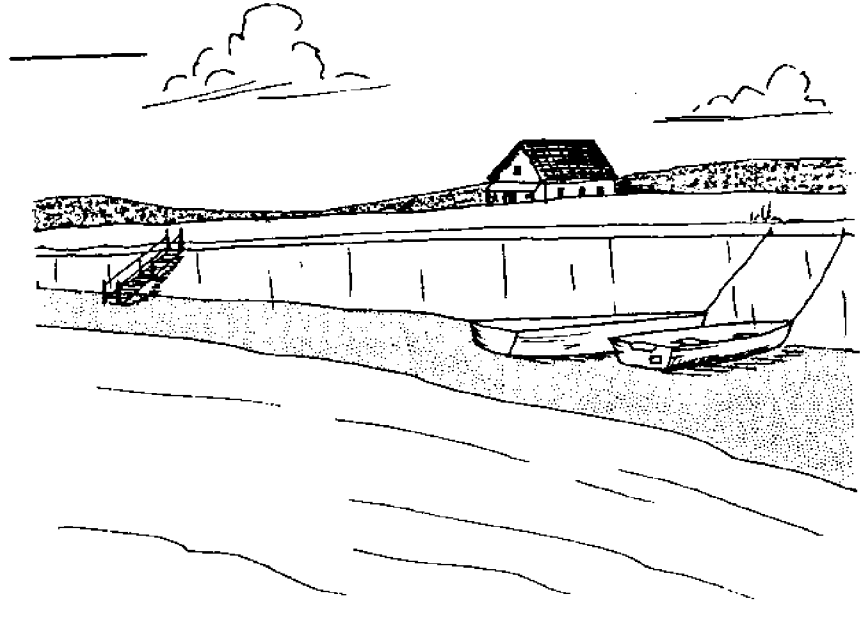
Groins: sheet pile



Breakwater: steel pile



Stepped Revetment



Sea Wall: concrete

Sea Wall: concrete

Activity B: Can erosion be stopped?

SEAWALL EFFECTS

Number of waves	Effects on Bluff: Behind seawall	Effects on Bluff: Unprotected
5		
10		

BREAKWATER EFFECTS

Number of waves	Effects on Bluff: Behind breakwater	Effects on Bluff: Unprotected
5		
10		

3. What is the long-term and the cumulative effect of these structures?

_____

_____

REVIEW QUESTIONS

1. List the natural forces which cause erosion along the Lake Erie coastline.

_____

2. What types of shore materials erode faster? _____

   Slower? _____

3. Briefly describe the three major methods or categories of shoreline protection devices.

_____

_____

_____

4. If you had a beach cottage, which type of device would you build to protect your section of shoreline? Explain your choice.

5. Would it be advisable to construct shore protection devices along all sections of Lake Erie's shoreline? Explain.

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