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Fact Sheet 019

Lake Erie shore erosion

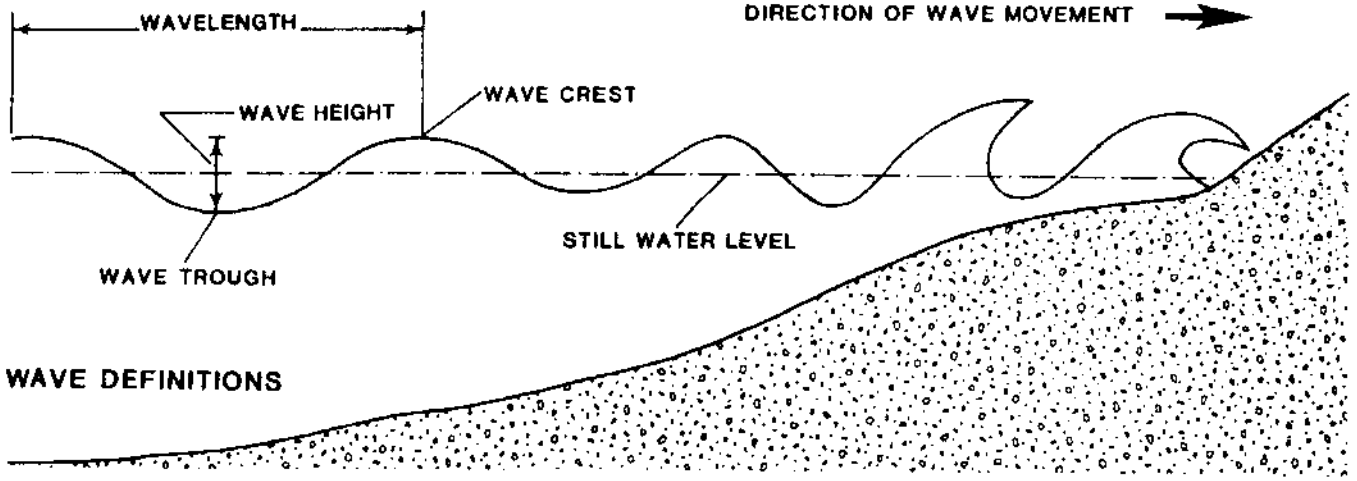
Frank R. Lichtkoppler, District Specialist, Ohio Sea Grant

The two primary shore erosion processes at work along Ohio's Lake Erie shoreline are wave erosion and mass wasting. Although wave erosion is the more significant of the two, rates of erosion are highly variable. For example, erosion rates in Lake County vary from less than one foot per year to nine feet per year. These rates depend upon a variety of factors including the weather and physical setting of the shore. Weather can also influence the size and frequency of waves striking the shoreline. The physical setting of the shore—shore orientation, presence or absence of a beach and/or man-made structures as well as shore geology also contribute to erosion variability.

WAVE EROSION

Wave erosion is the primary coastal erosion process at work in northeastern Ohio. Wind blowing across Lake Erie transfers energy to the water and generates waves. Much of this energy is released when the waves break upon the shoreline.

Although waves come in all sizes, they all have essentially the same characteristics. Every wave has a top (crest) and a bottom (trough). Wave height is measured vertically from the wave's crest to its trough. Wave length is measured from any specific point to that same point of an adjacent wave (for example, from the trough of one wave to the trough of the next wave). Wave period is the time it takes a wave, trough to trough or crest to crest, to travel the distance equal to one wave length. Waves, with a short period, are moving very quickly.



A wave breaks when the depth of the water is four-thirds its height. A wave one foot high will break in 16 inches of water while a three-foot wave will break in water four feet deep. Waves break against the shore releasing varying amounts of energy. The amount is dependent upon the slope of the bottom and the wave height. The steeper the bottom slope (and the smoother it is) the more abruptly a wave will slow down and break and the greater the damage it can create.

The amount of energy contained in a wave is directly proportional to its height. For instance, a two-foot wave with a period of five seconds between crests contains over 4,000 foot-pounds of energy per foot of wave crest (horizontal linear foot of wave crest). A four-foot wave with the same period contains over 16,000 foot-pounds of energy per foot of wave crest. Therefore, the higher the wave, the more energy it contains.

A series of two-foot waves with five-second periods will break upon the shoreline at a rate of 720 waves per hour. This amounts to 17,280 waves in one 24-hour day and a total of 71 million foot-pounds of energy per foot of shoreline per day. That slamming force is equivalent to a 1-1/2 horsepower engine pounding continuously on a one-foot strip of beach. This uncontrolled energy continuously erodes material away from the shore transporting sand along the shoreline and cutting away at bluffs.

For several reasons, however, wave energy arriving at the shoreline is not constant. Wind neither blows continuously nor from the same direction. Wide beaches, shallow nearshore slopes and nearshore bars all absorb energy thus reducing the amount of wave energy that reaches the shore. Shallow nearshore slopes and nearshore bars cause large waves to break and expend much of their energy offshore. The resulting smaller waves contain less energy and cause less shoreline erosion.

Weather directly influences coastal erosion rates because it affects the size of wave-related forces. Storm-generated winds can increase erosion rates due to temporary high water levels (surges) and large waves. For example, on April 6, 1979, westerly storm winds blew the 242 mile length of Lake Erie creating a 14-foot difference in the water level of Lake Erie when measured simultaneously at Toledo, Ohio and

THE OHIO STATE UNIVERSITY

Ohio Sea Grant College Program
1314 Kinnear Road
Columbus, Ohio 43212-1194
614/292-8949

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Buffalo, New York. This storm surge created one of the highest water level differences ever recorded on Lake Erie. More erosion occurs during storms and high water levels than at any other time.

Ice can have a moderating effect on erosion as it serves to protect the nearshore area from the effect of late winter storms and waves. A solid sheet of ice covering the lake or nearshore areas of the lake can prevent wind from hitting the surface of the water and can in turn prevent new waves. However, once the ice sheet has broken, this moderating effect is no longer felt.

MASS WASTING

Mass wasting, the downward movement of a large mass of material, is another common erosion phenomenon along the northeastern shore of Ohio. This downward movement has various and sometimes complex causes. Waves can undercut the foot of a bluff reducing the stability of the material above. Groundwater can compound this problem by adding weight to the material above and reducing the bluff's resistance to shear. Groundwater seepage out the face of a bluff between different sediment layers acts as a lubricant between layers and further reduces the stability of the bluff. When this occurs the material in an upper layer may slide downward in a mass. Rain saturating a bluff can increase the rate of erosion in a similar fashion by adding weight to the bluff and decreasing the shear resistance of the shore deposit. Rain also produces runoff which can cause surface erosion creating gullies and ravines and steepening bluffs.

Erosion occurs in a seasonal sequence. In the summer and fall, a steepening and undercutting of bluffs occurs as material is removed from the toe of the bluffs by wave action. Winter is a fairly static period because of freezing temperatures and lake ice. In the spring, however, frequent rains, storm runoff, increased groundwater levels and storm waves cause already steep, undercut bluffs to become unstable and mass wasting occurs.

As long as wave energy carries material away from the base of the bluff and groundwater saturates the bluff to create an unstable situation, the bluff will never reach a point of equilibrium and will continue to recede. Thus, recession of the shoreline is continuous. The rate of recession, however, is not constant because the amount of wave energy reaching the shoreline is not constant. It varies with the weather (primarily lake level and windstorms) and the physical setting of the shoreline (primarily the nature of the material being eroded, beach width and the presence or absence of man-made structures).

While wide beaches always serve as protective barriers against erosion, the same cannot be said of man-made structures—even those constructed for that purpose. Many bulkheads and sea walls do slow erosion but many others are useless or even worse. Poor design and/or construction of a shore erosion abatement structure may turn a minor erosion problem into a severe one. A man-made structure may worsen erosion problems at the site where it has been constructed or it may increase rates of erosion of a neighbor's property.

A discussion of erosion is not complete without considering the nature of the material being eroded. Softer, looser materials like clay and sand erode more quickly than more durable materials like shale and limestone. Indeed, the makeup of the shoreline is one of the most crucial variables when considering erosion rates.

Because shore erosion is a very complex process it could not to be discussed in depth here. Along Lake Erie, shore erosion is very site-specific and highly variable. Some of the important variables influencing shore erosion are the nature of the material being eroded, the physical setting of the shore including the presence or absence of beaches and/or man-made structures, shore orientation and exposure to waves, lake levels and weather.

Many shoreline property owners are faced with erosion problems and must make decisions concerning these problems. Any effort to slow down and lessen the effects of this natural process requires the investment of large sums of money. Shore property owners should try to learn and understand as much about it as possible.

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FOR TECHNICAL INFORMATION ON EROSION

District Extension Specialist, Sea Grant
Camp Perry, Bldg. 3, Room 12
Port Clinton, OH 43452
419/635-4117

District Extension Specialist, Sea Grant
Lake County Extension Office
99 East Erie Street
Painesville, OH 44077
216/357-2582

District Extension Specialist, Sea Grant
Lorain County Extension Office
42110 Russia Road
Elyria, OH 44035
216/322-0127

Lake Erie Section
Division of Geological Survey
Ohio Department of Natural Resources
P.O. Box 650
Sandusky, OH 44870
419/626-4296

Office of the Chief Engineer
Ohio Department of Natural Resources
Fountain Square, Building D
Columbus, OH 43224
614/265-6947

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