# *Coastal Processes and Causes of Shoreline Erosion and Accretion*

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Photo by Brittney Rogers, New York Sea Grant

Waves breaking on the eastern Lake Ontario shore.

A shoreline is a dynamic environment that evolves under the effects of both natural and human influences. Many areas along New York's shorelines are naturally subject to erosion. Although human actions can impact the erosion process, natural coastal processes, such as wind, waves or ice movement are constantly eroding and/or building up the shoreline. This constant change may seem alarming, but erosion and accretion (build up of sediment) are natural phenomena experienced by the shoreline in a sort of give and take relationship. This relationship is of particular interest due to its impact on human uses and development of the shore. This fact sheet aims to introduce these processes and causes of erosion and accretion that affect New York's shorelines.

## Waves

Wind-driven waves are a primary source of coastal erosion along the Great Lakes shorelines. Factors affecting wave height, period and length include:

1. Fetch: the distance the wind blows over open water
2. Length of time the wind blows
3. Speed of the wind
4. Water depth
5. Distance the wave has traveled from the wave's area of generation

    Closer to origin – choppier wave

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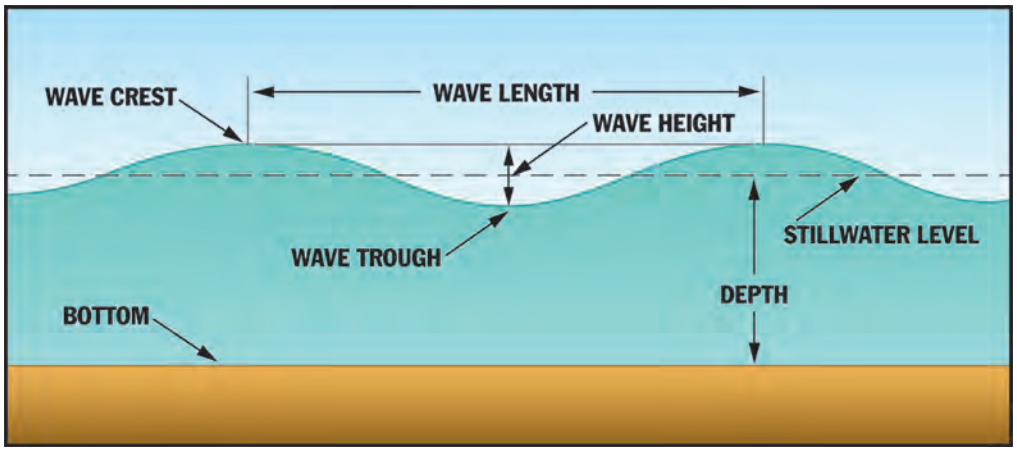
As a wave approaches shallow water, the wave shoals (increase in wave height). Bottom friction compresses the wave length, which in turn increases the wave height until the water depth is insufficient to support the height. Breaking typically occurs when the wave height is approximately 80% of the water depth. The breaking of a wave disturbs bottom sediment, which can then be moved. A steeply sloping shore will cause waves to break closer to shore, causing more erosion than on a gently sloping shore. Waves that are less steep and farther apart (common in summer) tend to bring sediment onshore while waves that are choppy, steeper and closer together (common in winter storms) tend to erode beaches. This seasonality affects the beach profile, which is why a less steep beach profile may be observed in the summer and a narrow, steeper beach profile in the winter.



Characteristics of a wave.

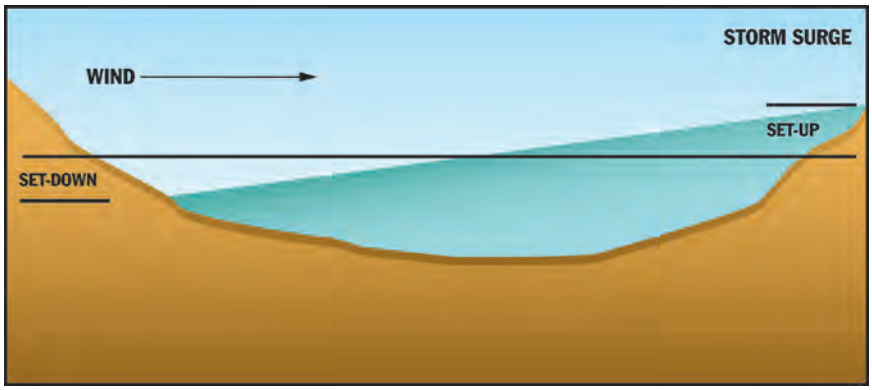
Storm surge is an increase in water level primarily due to winds building/pushing water up onshore during a storm event. This wind-induced increase in water level (also called wind set-up) can allow waves to reach areas that are not typically exposed to wave action, which may cause erosion or damage. The corresponding drop in water level is known as set-down.

Seiches are caused when the buildup of water associated with storm surge is followed by a rebound of water when the wind stops. The result is a bathtub-like effect where the water sloshes or oscillates back and forth from one end of the water body to the other until reaching an equilibrium. Seiching can cause tremendous erosion to the shoreline in the same manner as storm surge. Lake Erie is well known for its seiches, which are a result of southwest winds pushing lake waters from Toledo, Ohio to Buffalo, New York.

## Sediment Transport

Littoral (intertidal zone) transport is the movement of sediments in the nearshore by wave action and currents. A lack of sediment within the littoral system contributes to erosion. The quantity, energy and direction of waves and currents along the shore, in proportion to the size and weight of available sediment, determine the capacity of the system to transport littoral sediment.

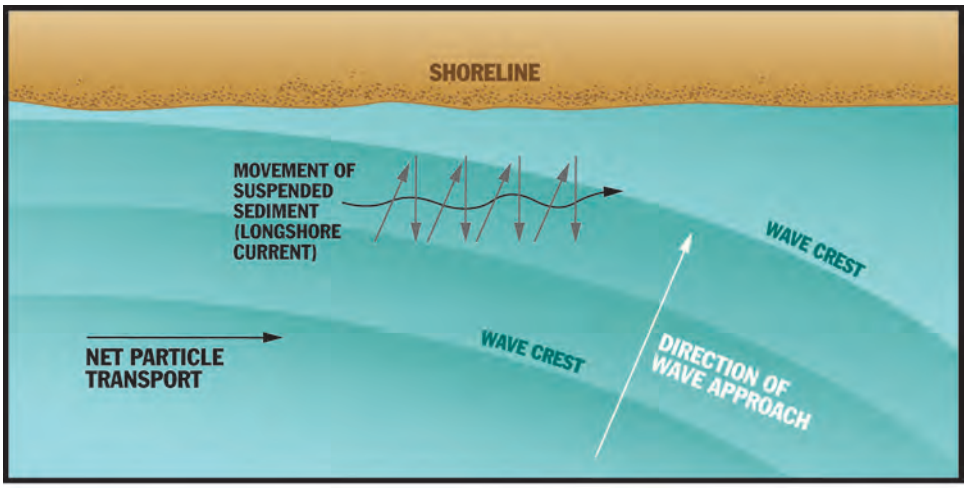
1. Littoral drift is the material moved by nearshore waves and currents.
2. Longshore transport is the movement of the material parallel to shore.
3. Onshore-offshore (or cross-shore) transport is the movement of material perpendicular to shore.



Wind-induced storm surge can lead to seiching, which is of particular importance in enclosed bodies of water such as lakes.

Waves that approach the shoreline at an angle will break on the beach at an angle, which in turn moves beach sediment along the shore in the direction of the incoming waves. Sediment washes back in a direction perpendicular to the shoreline and then the incoming wave movement repeats, creating a zig-zag pattern and driving longshore transport. For example, waves approaching the shoreline from the southwest will likely move sediment along the shore from west to east. The breaking waves create a longshore current which also drives longshore transport.

As described previously, steep, short waves tend to move material offshore, while less steep, longer waves move material onshore. If the offshore transport of sediment is greater than the onshore transport, erosion of the coastal landform will occur over time. The opposite is true if the onshore transport is greater than the offshore transport.



Longshore transport of sediment caused by breaking waves.

## Wind

Wind is an important factor for sandy, loose particle environments such as beaches and dunes. Wind moves unprotected particles, and can cause an accretion of sediment if something such as vegetation or fencing acts as a barrier to transported sediment. Wind can also erode sediment, which can cause dune blowouts or a decrease in sand in the local system.

## Rain and Sheetwash

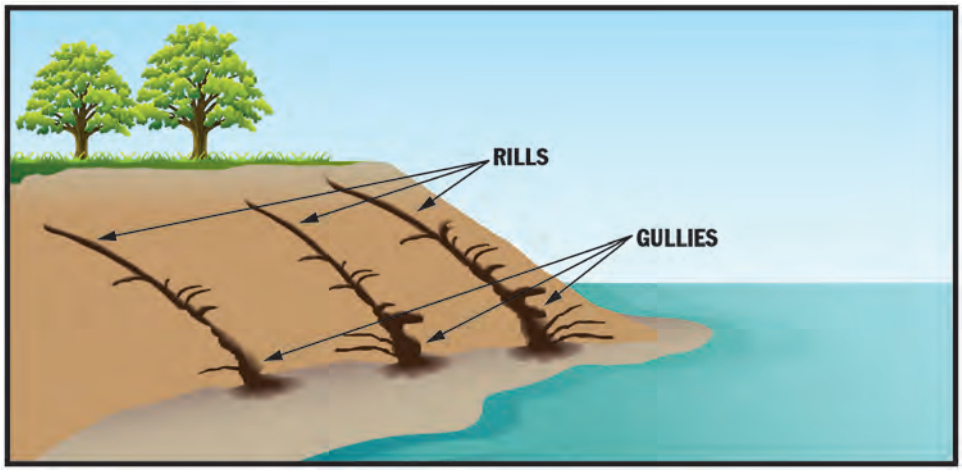
Rain and sheetwash (unconfined flow over the ground surface after rainfall) are important causes of erosion for sloped landforms such as bluffs. Raindrops strike and disturb upland soil particles, which are moved by the flow of water over the slope. Sheetwash progresses and becomes concentrated, potentially forming grooves and rills, (shallow channels) which then widen into gullies. Runoff from these flow channels can reach higher velocities than sheetwash, dislodging and carrying away larger particles.

Factors affecting the amount of soil displaced:

1. Amount and velocity of runoff
2. Slope steepness
3. Surface roughness/vegetation cover
4. Size, shape and weight of soil particles
5. Intensity of falling rain

## Groundwater Seepage

Groundwater seepage is an important factor for sloped landforms such as bluffs. Water can fill in voids, adding weight to the landform and potentially causing the sediment to flow from its own and/or accumulated weight. The flow of water throughout a landform can cause seep zones (dark bands of moist soil) and springs, which may lead to rill and gully erosion.



Rills and gullies formed by concentrated water flowing over a slope.

Sources of groundwater include:

1. Natural precipitation
2. Septic-system leaching
3. Roof drains
4. Lawn sprinklers or irrigation
5. Runoff from impervious surfaces such as paved driveways and parking lots

*All illustrations by Loriann Cody*

# Causes of Shoreline Erosion and Accretion

Photo by Barbara A. Branca

Wind-driven ice can cause scouring along shoreline structures like those at the Port of Oswego on Lake Ontario.

## Ice

While anchored or stabilized ice can form a protective barrier from erosion, thawed and/or detached ice can be moved onshore or along the shore by wind and waves. This can cause scouring and can damage erosion control structures. Ice can also form impermeable dams along or within coastal landforms, impeding groundwater and surface flow. In addition, ice and moisture can enter cracks of a landform and widen these crevices, allowing additional water to enter. This reduces the landform's stability and potentially causing slumps and slides along cracks.

## Summary

A shoreline is constantly morphing through erosion and accretion influenced by each of the coastal evolution processes described above. Many of these phenomena are natural, but their effects may seem alarming. From narrowing beaches to eroding bluffs, the results of these processes can impact not only human-made coastal features, but also the opportunities for humans to interact with the shoreline, creating a fragile relationship between natural coastal changes and human use of the coast. To learn more about these processes, their effects on different coastal landforms, and how you can protect your shoreline, please visit New York Sea Grant's website (**www.nyseagrant.org/glcoastal**) for additional publications.

## References

The information presented here was derived from a number of publications and technical reports. Principal sources include: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