Understanding Risks Along the Great Lakes:

THE IMPACT OF COASTAL ARMORING STRUCTURES ON FLOOD HAZARDS

The Great Lakes Coastal Flood Study is a comprehensive analysis of coastal hazards by the Federal Emergency Management Agency (FEMA) that is using the latest models, data, and technology to create an updated Flood Insurance Rate Map (FIRM) for all Great Lakes lakefront communities. This fact sheet offers information about how FEMA's mapping studies consider coastal armoring structures in determining flood risks.

Coastal Armoring Structures, also referred to as "shore protection structures," and "erosion control structures," include seawalls, bulkheads, and revetments that are typically installed to stabilize bluffs and banks and protect property along the lakefront.

Coastal Armoring Structure along Lake Erie

Along the Great Lakes, coastal armoring structures were the method of choice for decades to protect public and private waterfront property and to maintain safe, navigable waters. An extensive network of coastal armoring structures has been installed along Great Lakes shorelines to protect land and infrastructure from damage by storms, waves, erosion, ice, and high lake levels.

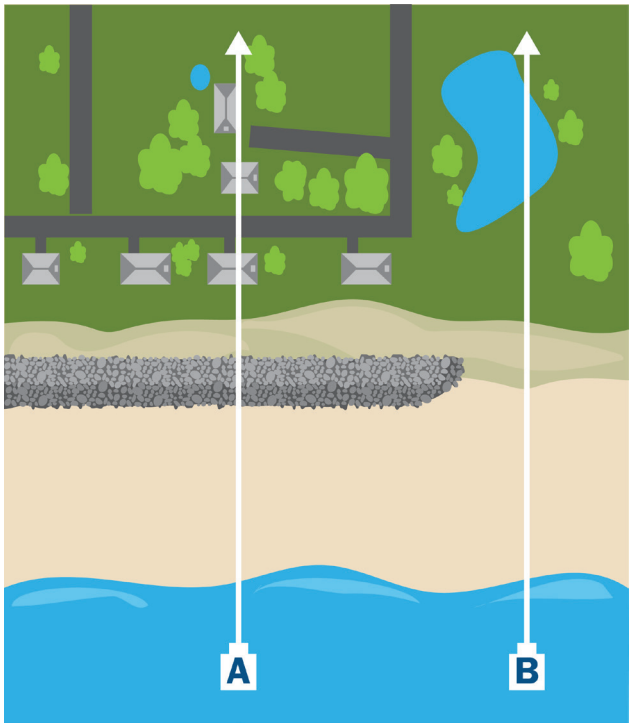
Most lakefront armoring structures are constructed to reduce erosion, while some, depending on their location and height, may also lessen the amount of water that floods upland areas behind them. However, most of these armoring structures are not designed and maintained to withstand the forces associated with a 1-percent-annual-chance flood event. During major flood events, coastal armoring structures may collapse, allowing the shoreline to erode and water and waves to advance upon the land that these structures shield. Even though an armoring structure may be damaged during the 1-percent-annual-chance flood event, it may still serve to reduce the impacts of erosion and lessen the inland extent of flooding compared to a non-armored shoreline.

Structures and Flood Hazard Analysis

Since coastal armoring structures can play a role in reducing erosion and flood impacts, the Great Lakes Coastal Flood Study accounted for the presence of these structures along the lakefront. The study process included detailed erosion and wave hazard analyses at specific points along the shore represented by transects. Each transect was placed at a location that is representative of conditions along the lakefront within its vicinity. A transect profile containing ground elevations along the transect line was created for use in the flood hazard analysis.

For transects that intersected reaches of shoreline with a coastal armoring structure, study engineers determined how the structure is likely to influence flood hazards at that location. The engineers assessed these armoring structures during field reconnaissance. High resolution oblique imagery was also used to evaluate the types, location, and condition of structures along the shoreline in between transects or in areas inaccessible during the field reconnaissance.

Since coastal armoring structures are not typically designed to survive a major storm event, the study team often modified the representation of the structure within the transect profile to reflect anticipated damage to, and erosion behind, the structure from the 1-percent-annual-chance flood. The study team conducted flood hazard analyses and floodplain mapping using the adjusted transect profiles to account for the partial protection provided by the damaged armoring structure. The following table describes how coastal armoring features are handled in the various analyses.



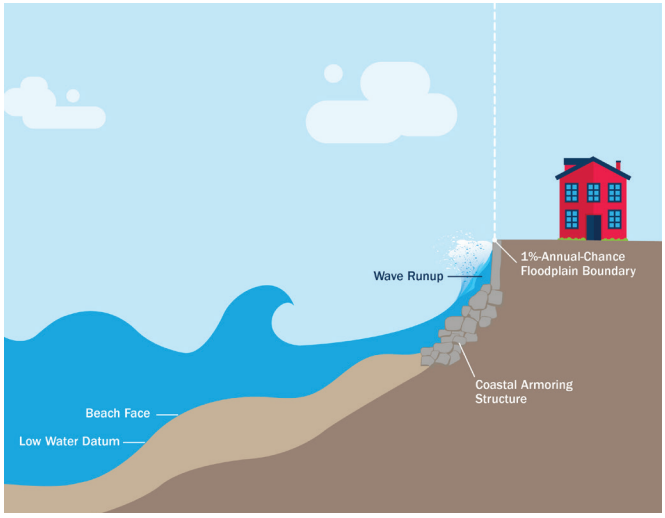
Transect Lines

Flood Hazard	Description of Hazard	Effect of Coastal Armoring Structure on Hazard	Implications for Great Lakes Coastal Flood Hazard Analysis	
			Coastal armoring is assumed to withstand a 1-percent annual-chance flood.	Coastal armoring is assumed to be damaged during a 1-percent-annual-chance flood.
Storm-Induced Erosion	The wearing away of shoreline sediment by currents and waves during a flood event.	Shoreline stabilization is placed to shield property from strong currents and waves that attack and wash away the shoreline	Erosion is limited and edge of property is held in place.	Coastal armoring is modified in transect profile and erosion of upland area behind structure occurs.
Wave Runup and Overtopping	**Wave runup** occurs when a wave encounters a barrier—whether a beach, bluff, or armoring structure at the shoreline—and produces an uprush of water on the face of the barrier. **Wave overtopping** occurs when wave runup exceeds the top of the barrier and flows or splashes into the area beyond.	The slope, height, and materials of the structure all affect the behavior of wave runup and how high and far inland the water will reach.	The structure slope, height, and other characteristics of the coastal armoring are factored in to the wave runup and overtopping analyses	Wave runup and overtopping analyses are conducted on the modified, eroded profile.
Overland Wave Propagation	Elevated lake levels can inundate low-lying lakefront areas, allowing waves to pass over ground that is typically dry. This process is known as **Overland Wave Propagation**.	Low-lying structures that become submerged by elevated lake levels serve to break waves and reduce wave action behind them.	The full armoring structure height is factored in to the overland wave propagation analysis.	Overland wave propagation is conducted on the modified, eroded profile.

Coastal Armoring Structures and Floodplain Mapping

The study team used results obtained from the flood hazard analyses to map the floodplain along the lakefront. In cases where the armoring structure, or the eroded ground behind it, is higher than the 1-percent-annual-chance runup elevation, flooding is limited to the shoreline. In these scenarios, the inland extent of the floodplain is determined by the distance that the land behind the armoring structure is expected to erode. In cases where the 1-percent-annual-chance runup exceeds the height of the armoring structure and the eroded ground behind it, the floodplain boundary location is determined by the erosion distance and how far inland water will flow past the overtopped crest. For low-lying shorelines submerged by elevated lake levels during the 1-percent-annual-chance flood, the floodplain extends inland to the point where the ground elevation becomes higher than the 1-percent-annual-chance lake level, with reduced wave conditions behind the coastal armoring structure.

Examples of two floodplain mapping scenarios for coastal armoring structures. Mapping flood hazards for individual structures will vary based on site-specific flood conditions and structure configuration.



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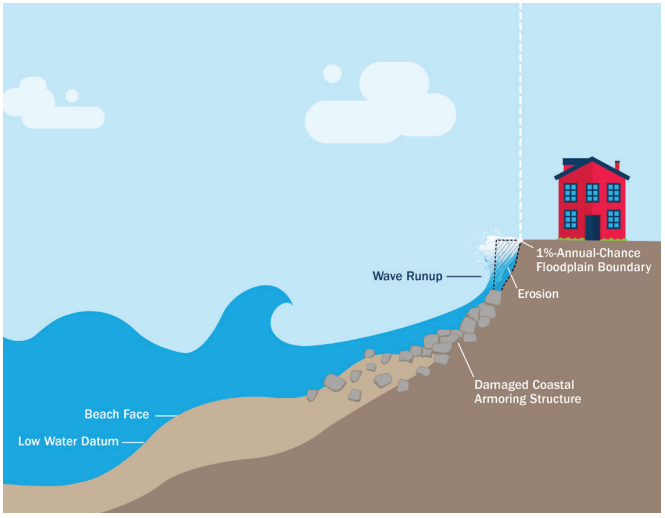

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ADDITIONAL INFORMATION

Coastal Hazards and Mapping: A Visual Guide
https://www.fema.gov/media-library/assets/documents/172026

An Introduction to FEMA Coastal Floodplain Mapping
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