SHORE PROCESSES

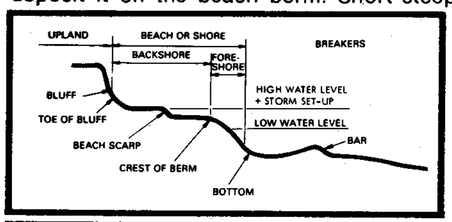
The beach profile is a relatively small physiographic feature whose limits are defined by the effects of waves. As waves approach the shore they react in special ways; they reflect, diffract and refract. The beach then acts as a natural defense against the attack from waves. The first defense against the waves is the sloping nearshore bottom which dissipates the energy,or weakens the force of the deepwater waves.

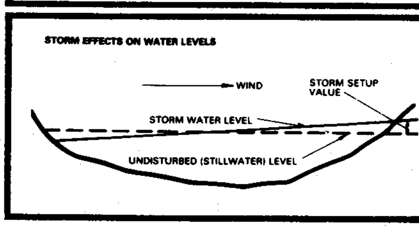
The shoreline erodes from the force of wave action. The erosive energy of a wave is a function of wave height and the depth of the water in which the wave acts. Wave energy is strongest in deep water but its effect is greatest thru the surf zone, from the start of breaking waves to the limit of run up.

The amount of energy delivered to the beach depends on the level of the lake and the storm set up or storm induced temporary rise in lake stage. The offshore depth is one of the most important parameters in the design of shore protection structures. During high lake levels the typical shore becomes a narrow unstable beach at the foot of a steep bluff or dune. Waves attack the toe of the bluff undercutting its face which falls on the beach. Waves wash out the fine bluff material, carry it offshore to deep water, or move it along the shore by littoral currents.

High lake levels change the effects that waves have on the beach profile as shown below. The natural beaches are submerged and waves act directly on the highly erodible backshore. The increased wave action on the beach increases the rate of erosion of the bluff. In the new balance, a beach will reform its equilibrium slope, but the foreshore would be moved landward. During high lake levels beaches may exhibit a steep and rather uniformly sloping profile and thus the effects of storm waves are greatly increased.

Material is moved and redistributed along the beach by the waves and wave generated currents. Long flat waves pick the sand up, move it forward, and deposit it on the beach berm. Short steep waves acting on the beach carry the sand lakeward. The direction of littoral transport depends on the direction of the wave generated energy which impinges upon a shore. Generalized data on storm water set up and the net direction of littoral transport are shown on the map of the Great Lakes on page 6.





Short period fluctuations of the lakes (Storm setup) result from meteorological disturbances and may last from a few hours to a few days. Wind and barometric pressure cause the lake surface to tilt as shown to the left. The amount of storm setup depends on local conditions. These values are shown in ( ) on the map for selected stations on the Great Lakes on page 6. The storm setup values are added to the projected lake levels to determine the design water level for the protective works illustrated in this pamphlet. This computation is described on page 16.

LAKE LEVELS

Levels of the Great Lakes fluctuate from year to year and also from month to month during each year depending upon the volume of water in the lakes. The source of the Great Lakes water is in the rain and snow which fall on the lakes themselves and on the land areas which drain them. When the net supply to one of the lakes exceeds the outflow, its level rises. When the net supply is less than the outflow, its level falls. For example, the lake levels reached record highs in the early seventies because the precipitation, in those years, over the Great Lakes Basin exceeded the basin averages.

Seasonal fluctuations, caused by the annual weather pattern are superimposed upon the long-term variations resulting from extended periods of below or above normal precipitation. During each year, the lake levels consistently fall to their lowest elevation in the winter because most precipitation in the watershed areas during the winter is snow and ice. The lake levels then rise to their highest elevation in the summer when the temperature rises and there is substantial runoff due to melting snow and ice. The probable maximum levels for the summer of 1978 are given in the table below and are generally one to two feet less than the recent record levels.

1978	Lake Superior	Lakes Michigan-Huron	Lake St. Clair	Lake Erie	Lake Ontario
End of August Elevation	601.1	579.0	574.4	571.5	245.0
End of May	600.5	578.9	574.7	572.4	246.5
Low Water Datum	600.0	576.8	571.7	568.6	242.8

Because of the size of the Great Lakes and the limited discharge capacities of their outflow rivers, extreme high or low levels and flows persist for considerable time after the factors which caused them have changed. Where the outflows from the lakes are controlled by regulatory works as is the case with Lakes Superior and Ontario, the releases of water are made in accordance with the plan for the regulation of the lakes levels and outflows which maintain the lakes within a range of water levels acceptable to all interests concerned. All regulation plans are approved by the Governments of the United States and Canada.