

2.10 COASTAL EROSION

Coastal erosion is defined as the gradual wearing away of the earth's surface by the natural forces of wind and water. The constant action of wind, waves, and ice flow has affected the coastline of Lake Erie¹. Primarily, it is the waves and gravity that cause erosion. Waves undercut the land along the shore and gravity causes the land to slip into the water. As material from the bluff or bank slides into the lake, it too is eroded by waves. As this process continues, the shore moves farther landward². Many natural factors affect erosion of the lakeshore, including shore and nearshore geology, shore relief, nearshore bathymetry, beaches, shoreline orientation, lake level fluctuations (long-term, annual, and storm surges), and climate changes (storm frequency, temperature, and precipitation)³.

The Lake Erie owes its fundamental existence to the presence of a basin or lowland that originated long before the Pleistocene Ice Age began 2 million years ago. This lowland was known as the valley of an east-flowing river, known as the Erigan River. This geology in the basin included Silurian and Devonian carbonates (limestone and dolomite) on the west and by Devonian shales on the east. Glacial ice was able to erode the less resistant shales (than the more resistant carbonate rocks) to a greater extent in the central basin and eastern basins. The first of the 4 major glacial advances during the Pleistocene obliterated this drainage system and deepened and enlarged the basin. Succeeding glaciations further deepened and enlarged it. Lake Erie, the southernmost of the Great Lakes, is also the shallowest because the ice was relatively thin (therefore lacking significant erosive power) when it reached so far south⁴. During the advancement of the glaciers, they eroded rock and soil and carried it with the flowing ice to the glacier edge where it was deposited as till released from melting ice. Laminated silt and clay were also deposited in proglacial lakes that formed along the margin of the glacier. These geologic materials are exposed in Lake Erie's bluffs and banks⁵. Upon final retreat of the glacier moving out of Ohio, the water started to discharge via the Niagara River. Glacial rebound raised the Niagara outlet and increased the water level in the Lake Erie basin. Due to a rapid glacial rebound in the upper Great Lakes, these lakes began to drain through the Lake Erie basin⁶. There has been a continued slow rise following the rapid rise that has brought Lake Erie to its current mean level of 571 feet above sea level.

The geologic settings vary throughout the length of Ohio's coast. From the Ohio-Pennsylvania border to Huron, Ohio, moderate to high relief shore consists of bluffs and slopes composed of glaciolacustrine sands, silts, clay, till, and/or shale. From Huron around Sandusky Bay to Marblehead peninsula, the shore is a low-relief plain composed of glaciolacustrine sediments and till, with shale exposed west of Huron and limestone exposed around Marblehead peninsula. At Sandusky Bay, two

¹ Lake Erie Coastal Erosion Areas, included with 1998 CEA Designation packet

² Questions and Answers Regarding Ohio's Coastal Erosion Areas

³ Updating Lake Erie Coastal Erosion Area Maps, Donald E. Guy, Jr., July 2005

⁴ The History of Lake Erie by Michael C. Hansen

⁵ Erosion of Coastal Bluffs in the Great Lakes, Mickelson, Edil, and Guy, USGS Professional Paper 1693

⁶ The History of Lake Erie by Michael C. Hansen

barrier beach complexes extend across the baymouth. Around Marblehead Peninsula and Catawba Island, low to moderate banks/bluffs are composed of rock and till. West of Catawba Island, the landscape consists of low-relief lake plain and coastal wetlands (remnants of the Black Swamp). Nearshore slopes generally gentle and are composed of the same materials in bluff or bank. Beaches are typically narrow (<50 feet per 15 meters wide) to non-existent along much of the shore. Man-made features have affected the longshore transport of sand trapping sand on the updrift side at harbor jetties, power plant intakes, and long groins. Shore parallel structures have altered sand transport as well⁷.

Climate affects overall physical setting in the nearshore, beach, and shore zones. Long-term and annual fluctuations in lake level are due to changes in the volume of the lake resulting from changes in precipitation in the Great Lakes Basin. Short-term fluctuations are due to wind-driven storm surges, changes in barometric pressure, or inertial surges of water (seiches) that occur after lake level has been set up by either of the two previous agents. The greatest storm surges occur when the wind blows parallel to the long axis of the lake. Under extreme conditions, lake level at the confined ends of the lake may rise or fall more than six feet from pre-storm levels. Passage of storm systems through the Great Lakes can cause lake levels at the ends of the lake to fluctuate 10 to 11 feet over a period of several days. The most important storm surges along the western part of the Central Basin and all of the Western Basin are those generated by northeast winds because these storm surges are accompanied by large storm waves⁸.

The size of wind-generated waves depends upon wind speed and duration, open-water fetch distance, and water depth. The largest waves affecting the Ohio lakeshore are those generated by storm winds from the west through the northeast. Wave energy is highest from late fall through spring; however, lake level is at its lowest and shorefast ice typically forms a barrier between the waves and erodible shore material. Most wave erosion occurs during storms in early spring when the greatest amount of wave energy is expended on the shore. The largest waves to strike the shore are generated by onshore storms winds from the west to the northeast⁹. Wave erosion causes undercutting of the bluff or bank, mass wasting including block falls, rotational slumps, and debris flows, and lakebed downcutting of cohesive materials. Bedrock is not as easily eroded as the cohesive glacial sediments.

Although erosion of the bluff is necessary to sustain beaches, excessive erosion of the Lake Erie shoreline can be considered a hazard exposure.

⁷ Geologic Setting and Processes Along Lake Erie From Fairport Harbor to Marblehead, Ohio, D. Guy and L. Moore, 2006

⁸ Geologic Setting and Processes Along Lake Erie From Fairport Harbor to Marblehead, Ohio, D. Guy and L. Moore, 2006

⁹ Geologic Setting and Processes Along Lake Erie From Fairport Harbor to Marblehead, Ohio, D. Guy and L. Moore, 2006

RISK ASSESSMENT

Location

Lake Erie comprises 262 miles of the northern coast of Ohio bordering Lucas, Ottawa, Sandusky (Sandusky Bay), Lorain, Cuyahoga, Lake, and Ashtabula counties. Lake Erie, the 12th largest (area) lake in the world, it is about 210 miles long, 57 miles wide, and has a shoreline length of 871 miles (including the islands). With the exclusion of government-owned park and reserve areas, the coast is highly prized for commercial and residential development. In many cases, human activity has disrupted the natural function of beach formation and aquatic habitats. According to the Ohio Geological Survey, 95 percent of Ohio's Lake Erie shoreline is eroding.

LHMP Data

All of the LHMPs for the counties that border Lake Erie (Ashtabula, Cuyahoga, Erie, Lake, Lorain, Lucas, Ottawa, and Sandusky), except Sandusky County and Lucas County, indicate that coastal erosion is a recognized hazard and ranked them either fourth or fifth for their county. Almost all of the plans reference the same data (Figure 2.10.a) provided by the Ohio Geological Survey. Erie County's LHMP indicated that they had completed a structural inventory in the late 1990's; but that data was not available to them at the time of writing their plan.

According to the Ottawa County LHMP there are 367 parcels, 130 of which have residential structures, located within the CEA. Using the residential average values previously determined for two townships, the estimated loss that would result would be approximately \$886,048 in Carroll Township and \$787,941 in Put-in-Bay Township if the structures were destroyed.

Only the Lake County and the Cuyahoga County LHMP address the issue of mitigation. Lake County conducted a HAZUS review of their coastal areas and provided the HAZUS data along with their plan to Ohio EMA. Cuyahoga County spent a considerable amount of time looking at mitigation efforts to coastal erosion. They mention in their LHMP the "*Ohio Coastal Management Program*" through Ohio Department of Natural Resources as a means of mitigation. The Ohio General Assembly passed the Ohio Coastal Management Law in 1988. This law authorized ODNR to act as lead agency in developing and implementing a comprehensive Coastal Management Program (OCMP) that is to integrate the management of Ohio's Lake Erie coastal region in order to preserve, protect, develop, restore and enhance its resources. OCMP attempts to establish a balance between resource protection and development, and to provide guidance to coastal property owners as well as government agencies and commercial interests.

Past Occurrences

Unlike many of the other hazards affecting Ohio, Lake Erie is consistently undergoing coastal erosion. Although particular storms or development creates periods of increased occurrence, the shore is eroding slowly every day. To measure erosion, the net landward movement of the shore over a specific time is calculated. The position of characteristic shore features such as bluff lines can be determined from maps and aerial photographs. By analyzing the position of these features

Table 2.10.a

Ohio Lake Erie Erosion Statistics by County

Long-term: 1877 to 1973 *and* *Short-term: 1973 to 1990* *Recession* *Data* *by* *County*

| County | Long-term Distance (ft.) | Long-term Rate (ft./yr) | Short-term Distance (ft.) | Short-term Rate (ft./yr.) |
|---------------|--------------------------|-------------------------|---------------------------|---------------------------|
| Ashtabula | 82 | 0.9 | 28 | 1.6 |
| Lake | 160 | 1.7 | 32 | 1.9 |
| Cuyahoga | 60 | 0.6 | 8 | 0.4 |
| Lorain | 80 | 0.8 | 12 | 0.7 |
| Erie (lake) | 103 | 1.6 | 42 | 2.5 |
| Ottawa (lake) | 208 | 2.0 | 27 | 1.6 |
| Lucas | 520 | 5.4 | 46 | 2.7 |
| Erie (bay) | 241 | 2.8 | 32 | 1.9 |
| Ottawa (bay) | 61 | 2.0 | 21 | 1.2 |

Source: Ohio Division of Geological Survey <http://dnr.state.oh.us/geosurvey/>

(recession lines) through time, the amount of recession can be determined and rates of recession can be calculated. Long-term and short-term recession data have been developed for each county (see table 2.10.a).

During 1929-30, the mid-1940s, 1952, the fall of 1972, the spring of 1973, and 1985, storms and high lake levels caused property damage along the low-lying areas, such as low glacial till bluffs, low glaciolacustrine banks, and barrier beaches and eroded high glacial till or glaciolacustrine bluffs inducing mass wasting in Erie, Lake, Cuyahoga, and Ashtabula counties. The short-term and long-term rates indicate that the low-lying areas have been extremely affected.

Probability of Future Events

With shore structures increasing along the coastline, the shoreline becomes increasingly modified. Reports and studies suggest that wave erosion and mass wasting caused by Lake Erie will continue to erode the Ohio shore for the

foreseeable future. Damage to the built environment is inevitable without intervention and will warrant the full understanding of coastal processes within each stretch to rehabilitate the shoreline.

Environmental Impacts

Coastal erosion has a limited direct impact to the environment because it is a localized event. The impact that it does have is to the potential loss of habitat to both plants and animals.

Coastal erosion's secondary effects would be the potential to increase coastal flooding and landslides, depending on the geography of the region. Each of these events would then have their own potential effects to the environment.

VULNERABILITY ANALYSIS & LOSS ESTIMATION

Methodology

The Ohio Geological Survey is in the process of reassessing Ohio's vulnerability to coastal erosion. According to the Ohio Revised Code, coastal erosion area designation must be conducted every 10 years and parcels at risk must be listed as Coastal Erosion Areas. The initial evaluation utilized 1973 and 1990 data and the results were published in 1998. Researchers utilize aerial photography to delineate exposure based on observed shoreline characteristics. The new evaluation will utilize aerial photographs from 1990 and 2004.

Once the preliminary designations of the coastal erosion areas are determined with extensive quality checking and ground proofing support, GIS layers are created and preliminary maps generated. Impacted property owners are contacted by mail of their inclusion and public meetings are held to provide an opportunity to see the risk assessment. Property owners may dispute the determination, if they believe that the shore features were not picked correctly and with proof that erosion did not occur. After all comments have been addressed, final maps are generated and final notifications are sent by mail to the coastal erosion area property owners.

Under normal circumstances the revised data from the coastal erosion areas would be aggregated by county and presented in tabular format. However, several factors must be considered before providing loss estimates. The factors of the decennial update that is in progress and preliminary results indicate significant changes in coastal erosion areas are expected from 1998 to 2008 must be weighed.

Results

After extensive conversation with state partners and extensive consideration, the decision was made not to report losses on outdated data. Based on reports from the Ohio Geological Survey, data from the current update will be available in final format in late 2008 or early 2009. It is anticipated that the number of Coastal erosion area designations will decline from the 1998 designation. This is partially due to a marked increase in shoreline protection measures installed over the past ten years.

STATE-OWNED / CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

Coastal erosion has limited potential to affect all state-owned structures and critical facilities in the state and is confined mainly to Ohio Department of Natural Resources State Parks.