Chapter 4
Coastal Erosion and Erosion Mitigation Planning

Introduction

The Illinois coast of Lake Michigan is a dynamic setting influenced by waves, ice and changing lake levels. The potential for erosion exists along nearly the entire Illinois coast, but along this coast, erosional processes are commonly kept in check by coastal engineering or by various means of mitigation. The Coastal Zone Management Act (CZMA) requires a state participating in the coastal management program to have a planning process for assessing the effects of erosion, studying and evaluating ways to control or lessen the impact of erosion, and to restore areas adversely impacted by erosion.

This chapter provides a review of the coastal erosion processes and impacts along the Illinois coast from a historical perspective as well as related to the present day. The discussion then addresses how erosion along the Illinois coast is studied and evaluated and means that have been successfully used in mitigating erosion and restoring areas adversely impacted by erosion. Chapter 9, "Management Authorities," describes the legal mechanisms used in Illinois to manage coastal erosion.

Erosional Trends in the Natural Setting

Prior to any human modifications, the natural setting along the Illinois coast was nearly all erosional (Chrzastowski, Thompson and Trask 1994). There was an abundant supply of littoral sand moving along the shore, possibly as much as 100,000 cubic yards per year passing what is now the central Chicago lakeshore, but this sand was in transport to a depositional zone along the central Indiana coast. This sand had minimal residence time along the Illinois shore and thus erosional trends predominated over any short-lived accretion. The exception to the erosional trends was the southern part of the Zion beach-ridge plain from near the mouth of Dead River southward to the North Chicago shoreline. This was an accretional shore resulting from the ongoing southward translation of the beach-ridge plain. Erosion dominated along the beach-ridge plain between the Wisconsin-Illinois state line and Dead River.

Historical photographs along the bluff coast document the dominance of erosion along this part of the Illinois coast. The bluff faces were commonly devoid of vegetation because of the active slumping of the bluff face (Atwood and Goldthwait 1908; Illinois Division of Waterways 1958). Much of the shore contained fallen trees, which had grown on the flat land atop the bluffs but later displaced to the shore as bluff erosion undermined the trees. A remnant of what the bluff coast was like in its naturally erosional state exists today in a few select locations including the shore of the Lake Forest Nature Preserve in southern Lake Forest.

There is geologic evidence that even the natural setting near the mouth of the Chicago River and the site of Fort Dearborn was an erosional shore. Historical sketches and etchings of the Fort Dearborn setting commonly show a broad beach and low dunes (Andreas 1884), but shoreline recession was apparently occurring along this shore. Sand deposition of the Graceland spit is preserved north of the Chicago River, but is absent in the vicinity of the historic Chicago River mouth, and then is preserved again on Chicago's near south and south lakeshore as far south as the vicinity of Stony Island (Figure 4-1). These separated spit deposits were once continuous forming an arcuate shoreline lakeward of the earliest historical shoreline near the Chicago River mouth. Based on lake-level history and other geologic evidence, this erosion occurred sometime over the past 2,500 years and was likely still in progress at the time of earliest settlement at Chicago.

Geologic maps also document substantial shore erosion along Chicago's far south lakeshore between the Stony Island area and the Illinois-Indiana state line (Figure 4-2). This area has had a complex history or

Figure 4-1. The present central and south Chicago lakefront previously had a shoreline farther lakeward than the present-day madeland shoreline. This is demonstrated by the Graceland spit which is preserved north and south of the Chicago Loop but is absent in the Loop vicinity. The erosion of the former land area occurred within the past 2,500 years and was likely in progress at the time of early settlement at Chicago (modified from Chrzastowski 2005).

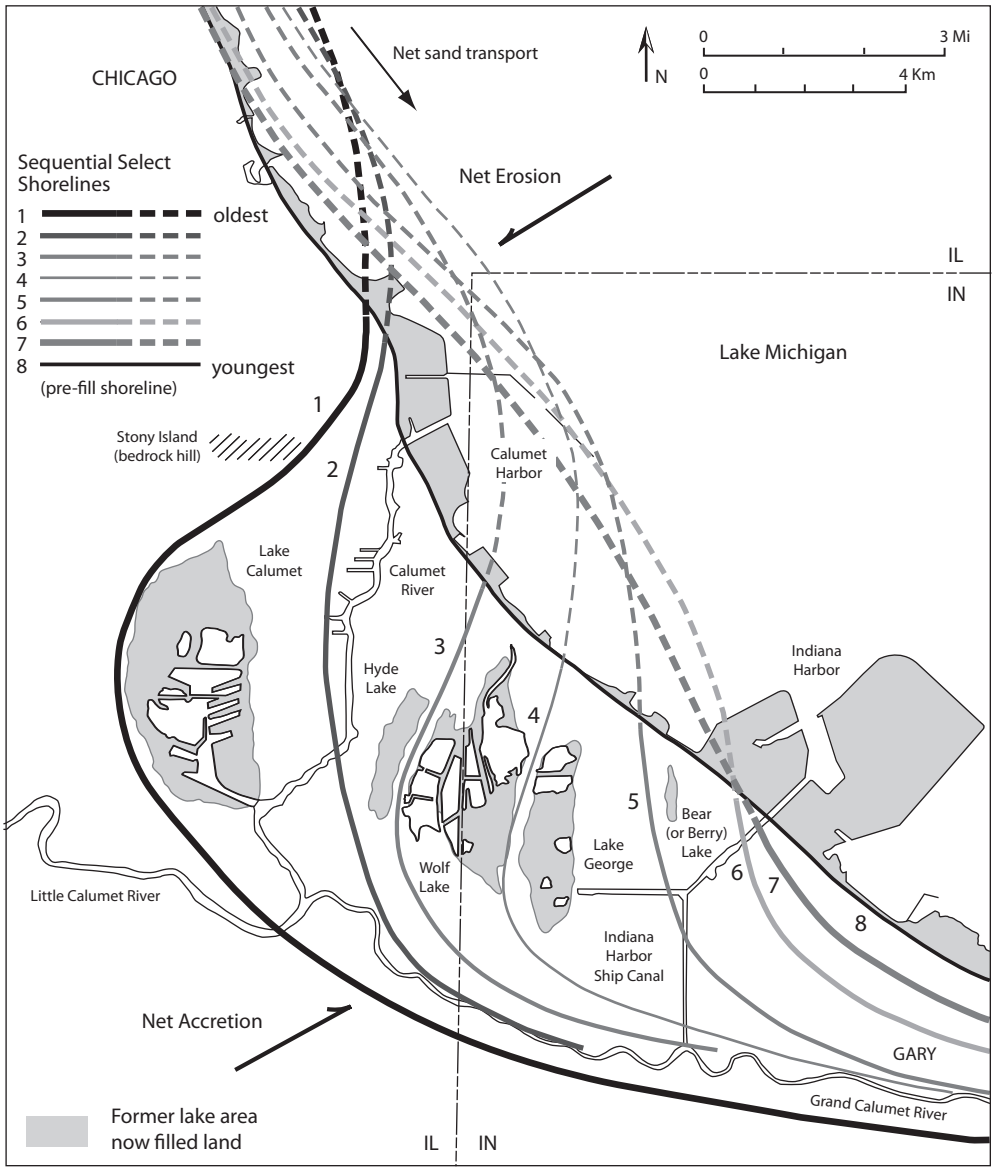

Figure 4-2. The Calumet area has had a complex history of net accretion of littoral sand that built arcuate shorelines across the area followed by net erosion that has worked to reshape the Lake Michigan shoreline. Relict shorelines are truncated by the modern shoreline and indicate considerable land area that has been removed by erosion. All of this coastal change in the Calumet area has occurred within the past 1,000 to 2,000 years (modified from Chrzastowski - in review).

coastal change. Beginning about 2,500 years ago there was the accretion of sand resulting in the arcuate beach ridges that form the borders of the lakes of the area including Lake Calumet and Wolf Lake. The configuration of these beach ridges indicates that they once continued across what is now the open water of Lake Michigan in the state line vicinity. The deposition was followed by erosion as wave action reshaped this lakeshore. This erosional phase would have still been active even at the time of earliest settlement in the area.

Lake Level Influence on Coastal Erosion

Erosion along the Illinois coast gains considerable public and media attention during times of high lake levels such as occurred in 1986-1987 when record highs were reached. This attention relates to the high water causing partial to total submergence of some beaches, storm waves impacting, damaging and overtopping shore structures, and even localized coastal flooding in low-elevation areas.

Coastal flooding is not common along the Illinois coast, but during times of high water, the lower elevation land that borders Lake Michigan, Calumet River, Lake Calumet or Wolf Lake can be vulnerable to coastal flooding, particularly when storm conditions create a set-up that further raises lake level. Such occurred in February 1987 when high lake level and storm set-up combined to bring waves onto Chicago's Lake Shore Drive between North Avenue and Oak Street resulting in an unprecedented closure of this segment of the Drive (Chicago Shoreline Protection Commission 1988).

The coincidence of high lake levels and detrimental impacts contributes to a common misconception that coastal erosion is limited to times of high lake levels. The reality is that changing lake level shifts the erosion zone either landward or lakeward and thus erosion can be an ongoing process regardless of lake level. At times of high lake level, the erosion and negative impacts are easily seen because of the impact on beaches and shore structures that are otherwise above the influence of wave action. At lower lake levels, although beaches may be wide and shore protection may have minimal or no impact from wave action, erosion can be occurring across the nearshore lake bottom.

Three Categories of Illinois Coastal Erosion

Three categories of coastal erosion have been and continue to be an issue along the Illinois coast. These correspond to three different locations on the coastal topographic/bathymetric profile:

- Shore erosion
- Bluff erosion
- Lakebed erosion

Shore Erosion Shore erosion refers to the erosion of the exposed beach or land area adjacent to the shoreline. Shore erosion results in a landward translation of the shoreline and the loss of beach area or land area. In considering shore erosion along the Illinois coast, a related process is the damage and deterioration of engineered structures that occur along the shore such as revetments, riprap, groins, bulkheads and breakwaters. Because of the important role of shore-protection structures along the Illinois coast to stabilize the land/water interface, damage and deterioration of these structures can be equally important as any erosional loss of beach area or land area.

Shore erosion along the Illinois coast is geographically varied and ranges from insignificant to severe. Along the Chicago lakeshore, stepped revetments protect much of the lakeward edge of the made land for the lakeshore parks. The first generation of revetments, primarily built in the late 1800s and early 1900s, consist of stone-filled timber cribs supporting dolomite quarry blocks arranged in a stepped configuration. By the late 1980s, most of these original stepped revetments had suffered from long-term deterioration by

wave, ice, and multiple cycles of submergence and emergence by changing lake level and have exceeded their useful life. A second generation of revetments built with steel sheetpile and stepped reinforced concrete have been designed and built to provide decades of durability and low maintenance.

Most of the beaches along the Chicago lakeshore have been designed with terminal groins or submerged breakwaters to hold beach sand. Many of the beaches have also been built with an orientation toward the northeast, which is the approach for the most energetic waves. This orientation results in a perpendicular wave approach resulting in waves primarily moving sand up and down the beach and limiting the alongshore transport that can contribute to sand loss. The Chicago beaches are subject to reduced width caused by submergence during times of high lake level, and beach nourishment and sand redistribution are maintenance issues. However, the design of these engineered beaches help to minimize erosional processes.

Shore erosion along the bluff coast (*i.e.*, North Chicago south to Winnetka), and along the Wilmette and Evanston shore, has the potential to be more severe than along most of the Chicago lakefront. This is because the degree and extent of shore protection is not as prominent as along the Chicago shore. Nearly all of the bluff coast shore is now engineered with some variety of shore protection (*e.g.*, groins, revetments, riprap, and shore-attached breakwaters). Thus shore erosion can occur locally, but wide-scale erosion along this reach is mitigated by structural means.

Comparison of Low Water Datum shoreline mapping between 1872 and 1955 provides a reference for what the shoreline recession was along the bluff coast prior to the shore reaching its present advanced degree of shore protection. The most severe shore erosion during this 83-year record averaged about 6 feet (2 m) per year. This occurred along the Lake Bluff shoreline to the south (downdrift) of Great Lakes Harbor (Illinois Division of Waterways 1958). The shore erosion at this location can be attributed to sand deprivation caused by the harbor breakwaters. The rate of 6 feet per year of shore recession provides an upper limit for the potential shore erosion that could occur along the bluff coast if shore protection were not present.

The most severe shore erosion along the Illinois coast, both historically and in the present day, occurs along the shore in the North Unit of Illinois Beach State Park. As previously discussed in Chapter 2 (Figure 2-7A), long-term shoreline recession has occurred here at the average rate of 10 feet (3 m) per year. The rate of shore erosion is most severe at the northern end of the North Unit. The rate progressively decreases toward the south and becomes negligible in the South Unit in the vicinity of the mouth of Dead River. As discussed in Chapter 2, this erosion relates to the natural dynamics of the Zion beach-ridge plain, which is a migratory coastal landform. Erosion along the northern extent of the plain and deposition along the southern extent of the plain is related to the plain's long-term southward migration that has been operating for several thousand years.

Bluff Erosion The natural setting along the bluff coast in Illinois was one of nearly continuous bluff erosion along the approximate 19 miles (30 km) of shore from North Chicago south to Winnetka. This is indicated in historical photographs that show these bluffs typically devoid of vegetation due to the continual sliding, slumping, and breaking away of the till as erosion progressed (*e.g.*, Atwood and Goldthwait 1908; Illinois Division of Waterways 1958). The process of bluff erosion commonly involved wave erosion cutting into the toe of the bluff and undermining the bluff slope. The undermining would lead to slumping along the bluff face and the displacement of bluff materials onto the beach. Subsequent wave action would disperse these materials. The bluffs could also erode due to the influence of either surface runoff or ground water respectively moving over or through the bluff materials.

Variations in the sediment types within the bluffs accounted for some variation in historical rates of bluff erosion. More sandy sections of bluff exposure would be more susceptible to erosion than where

cohesive materials were dominant such as clayey till. Considering the regional erosional trend, comparison of historical maps and photographs spanning a 115-year record from 1872 to 1987 indicate that through this time the Illinois bluffs were eroding at an average rate of approximately 0.7 to 1.0 feet per year (0.20 to 0.30 m/yr). Taking into consideration the variations in bluff materials, rates for individual sections of the bluff define a much broader range from 0.3 to 2.5 feet per year (0.10 to 0.75 m/yr) (Jibson, Odum and Staude 1994). Much of this erosion likely occurred through the earlier time of this 115-year interval prior to the introduction of more extensive and more elaborate shore protection.

Bluff erosion along the Illinois coast was a significant erosion management issue in past decades. In the 1970s, much of the bluff coast was actively eroding and this erosion presented challenges for development of private and public properties along the bluff crest (Berg and Collinson 1976; DuMontelle, Stoffel and Brossman 1976). In the late 1980s, bluff erosion was an issue as record-high lake levels allowed direct wave impact along the toe of the bluff where shore protection was absent, minimal, or in a deteriorated state.

The record-high lake level of 1986 was an impetus for considerable private sector and public investment in improved shore protection to halt bluff erosion as well as grading, terracing and landscaping many of the bluff faces to maximize slope stability. The 1987 building of the 22-acre park and beach complex at Forest Park in Lake Forest was the most notable of the municipal efforts along the bluff coast to provide shore protection, eliminate bluff erosion, and increase beach and park facilities for lakeshore recreation (Anglin *et al* 1987). A similar but smaller-scale complex was built at Sunrise Park Beach in Lake Bluff.

The expanded and enhanced shore protection that occurred during the late 1980s and 1990s was such that by 2000 a survey of the bluff coast determined that bluff erosion was active along no more than about 600 feet of the entire bluff coast (Chrzastowski 2000). Although bluff erosion along the Illinois coast has essentially been contained, this containment is dependent on the maintenance of shore protection along the bluff toe, the management of runoff and groundwater discharge across the bluff face, maintaining a vegetation cover across the bluff face, and prudent land uses and land cover atop the bluff.

Slope stability and erosion is also a mitigation issue along the ravines of the bluff coast. Although wave-induced erosion is not an issue within the ravines, runoff, storm-water discharge and slope processes are all critical aspects in the stewardship of this distinct coastal setting.

Lakebed Erosion The term *lakebed erosion* refers to underwater erosion across the bed of the lake. This erosion does not refer to the sand or gravelly sand that may occur along the lake bottom. Lakebed erosion refers to the erosion across the cohesive layers of glacial till or clay that underlie the sand. This type of erosion is also referred to as *lakebed downcutting*, or simply *downcutting* (USACE 2006). This erosion is common in parts of the Great Lakes where cohesive glacial sediments form the lakebed. Because this erosion occurs underwater, it is out of sight and can proceed without indication. However, the long-term detrimental impact to the coast can be severe.

Lakebed erosion is caused by wave and current action and can also be directly or indirectly caused by ice. The process of lakebed erosion occurs in the nearshore area, which is the zone between the shoreline and the most lakeward extent of breaking waves. Along the Illinois coast, the nearshore zone is generally considered to be the water area with depths less than 18 feet (6 m). A layer of sand and/or gravelly sand will commonly blanket this nearshore area and overly the cohesive layers of glacial till or clay. If the sand cover is depleted such as may result because of a reduced supply of littoral sediment, wave, current and ice action can act directly against the cohesive sediments and downwardly erode this surface. Wave or current action that includes the movement of a thin layer of sand across the cohesive sediment can act as an abrasive material, comparable to sand paper, and exacerbate the downward erosion.

Lakebed erosion is non-reversible erosion because the loss of the cohesive material cannot be replaced other than by a new glacial episode. This contrasts with the erosion of coastal sand, which can be counteracted by the supply and deposition of new littoral sand. The long-term impact of lakebed erosion is the lowering of the lake-bottom profile. As a result, deeper water occurs closer to shore and the profile is steeper between the beach and nearshore. The deeper water and steeper profile allows larger waves to impact the shore, which can increase the potential for erosion along the beaches and along the toe of the bluffs. The deeper water potentially can result in the weakening and undermining of shore protection structures, and makes shore-protection structures more vulnerable to larger waves.

Lakebed erosion is a coastal process that has been documented at various locations throughout the Great Lakes, with considerable study along the eastern shore of Lake Michigan downdrift from the harbor jetties at St. Joseph, Michigan (Parson, Morang and Nairn 1996; Foster *et al.* 1992). Nearly the entire Illinois coast is underlain by glacial till and thus the potential exists along the Illinois coast for lakebed erosion to be a common problem. Profile comparisons have documented the reduced sand cover at several locations along the Illinois coast (Shabica and Pranscke 1994), and sidescan-sonar mapping has shown there are areas along the nearshore where glacial till is exposed on the lakebed and thus these areas are susceptible to lakebed erosion.

Because of limited data, it is uncertain as to what extent or degree the process is occurring along the Illinois coast. However, lakebed erosion is apparently most active along the northern part of the bluff coast particularly along the Lake Bluff nearshore area. Comparison of lake-bottom profiles for the period 1974-1991 in the Lake Bluff nearshore indicate an average rate of lakebed erosion in the range of about 0.2 to 0.3 feet per year (0.06 to 0.09 m per year) (Chrzastowski and Trask 1995).

The process of lakebed erosion along the Illinois coast is a symptom of the reduced volume of littoral sand along this coast. Reduced sand supply is one of the consequences of arresting the bluff erosion that once provided the primary source of beach and nearshore sand. The severe lakebed erosion along the Lake Bluff nearshore can be attributed to the deprivation of nearshore sand supply caused by the interruption of littoral sediment transport by the harbor breakwaters at Great Lakes Naval Training Center.

Lakebed erosion is in its early phase of being recognized as a coastal management issue along the Illinois coast. Although no mitigation has occurred to date, mitigation considered has included periodically adding sand nourishment to the nearshore to cover the glacial till, or a more permanent effort to blanket the lake bottom with cobbles, which would be large enough to resist littoral transport. Lakebed erosion will be an important coastal management issue in the future of the Illinois coast.

Assessment of Erosion along the Illinois Coast

Erosion along the Illinois coast was first documented by shoreline surveys beginning in the 1840s focusing on the erosion downdrift (south) of jetties constructed at the mouth of the Chicago River. The assessment of erosion along the coast since the mid 1900s has involved aerial photography, bathymetric and topographic mapping, and scientific/technical studies that have compiled previous work as well as provided new data. The following describes the major sources of data providing information on Illinois coastal erosion.

Assessment by Aerial Photography The earliest aerial photography of the Illinois coast was collected in 1939 by the U.S. Department of Agriculture (USDOA) and is archived by the National Archives and Records Administration. The USDOA has a record of vertical aerial photography of this coast at one to ten year intervals for the period 1946 through 1988. In the private sector, a prominent Chicago area firm

(Chicago Aerial Survey) is the source of aerial photography along the Chicago lakefront in the 1930s when major lakefill projects were underway.

The IDNR Office of Water Resources (OWR) arranges for full-color, vertical aerial photographic coverage of the entire Illinois coast every three years or more frequently when conditions warrant. This work is done by IDOT and their equipment commonly used by their Aerial Surveys office in photo coverage for highway projects and planning. The photography is printed on 36 inch by 36 inch sheets at a nominal scale of 1:3000. The OWR provides copies of the photo prints to each lakeshore municipality for their municipal shoreline extent. Copies are maintained on file with the OWR in Chicago and in the library of the Illinois State Geological Survey (ISGS) in Champaign. This vertical aerial photography was first done in 1956 and provides the most thorough documentation of Illinois coastal change. This aerial photography provides the most thorough monitoring of conditions along the Illinois coast.

The ISGS maintains a collection of low altitude oblique aerial photography along the Illinois coast spanning the interval 1974 to 1990. These full-color slides provide annual as well as limited semi-annual coverage. This collection also includes a limited selection of color ground photography during this 17-year record. Since 1970, aerial photography along the Illinois coast has also been done by the Northeastern Illinois Planning Commission (NIPC) at varying time intervals.

Digital, on-line imagery for northeastern Illinois is available for download through the Illinois Clearing House maintained by the IDNR and the ISGS (www.isgs.uiuc.edu/nsdihome/). This full-color imagery was collected in 2005. The imagery covers the six-county Chicago Urban Area and thus the Lake Michigan shoreline, the entire breadth of the inlands coastal zone, and all of the inland waterways, as well as their connection to the Illinois/Mississippi River system.

Assessment by Bathymetric Mapping Bathymetric data can be a critical component in evaluating coastal erosion. These data document changes to the nearshore by comparing bathymetric data from different times, as well as the documentation of changes to the position of the zero depth Low Water Datum (LWD) which can be used as a reference shoreline that is independent of lake-level change.

The earliest bathymetric surveys to cover the entire Illinois coast were done by the former U.S. Lake Survey, which was part of the USACE and was headquartered in Detroit, Michigan. This agency was established in 1841 and grew out of the Corps of Topographical Engineers (Woodford 1991). The U.S. Lake Survey existed until 1970 when it was removed from the USACE and absorbed into the National Ocean Survey (renamed National Ocean Service in 1983) of NOAA.

Two intervals of earliest U.S. Lake Survey bathymetric mapping along the Illinois coast provide baseline bathymetric data for the late 1800s and early 1900s. The earliest bathymetric surveys by the U.S. Lake Survey were completed in 1872 and/or 1873. The succeeding bathymetric surveys were completed during the interval 1909 through 1911. The U.S. Lake Survey did additional bathymetric surveys along the Illinois coast in the 1930s (1932, 1936, 1937), 1943, the 1950s (1955, 1958) and in 1964.

The ISGS collected bathymetric data along the Illinois Coast between 1974 and 1977. This bathymetric mapping is presented in 5-foot depth contours in a map portfolio titled Coastal Atlas, Illinois Shore of Lake Michigan (ISGS 1988). Copies of this unpublished atlas are on file in the library of the ISGS.

Assessment by Scientific and Technical Studies The earliest comprehensive study of Illinois coastal erosion was done by the USACE and published in 1953 (USACE 1953). This study included a comparison of shoreline position, bathymetric data, and beach and nearshore profiles for the years 1872-73, 1909-11, as well as shoreline positions for 1937-38 and 1946-47. All of the shoreline and bathymetric mapping is referenced to Low Water Datum (LWD) allowing comparison without the influence of

changing lake level. A subsequent study by the Illinois Division of Waterways expanded on the USACE study and included LWD shoreline and profile data collected between 1952 and 1954 (Illinois Division of Waterways 1958). These two studies provide valuable baseline data for coastal changes along the Illinois coast prior to the intensive coastal development that has occurred along the North Shore and the Far-North Coast since the 1950s.

The Chicago District of the USACE has prepared draft and final Interim Illinois Shoreline Erosion Reports for three designated coastal reaches of the Illinois coast (Illinois-Wisconsin state line to Waukegan Harbor; Waukegan Harbor to Wilmette Harbor; Wilmette Harbor to Illinois-Indiana state line) (*e.g.*, USACE 1988). These studies build on the previously mentioned primary report completed in 1953. As part of the study for the Waukegan Harbor to Wilmette Harbor, the ISGS contributed an evaluation of nearshore lake-bottom changes for the interval 1910 to 1994 as well as evaluated the impact to littoral transport caused by Waukegan Harbor and the Great Lakes Harbor at Great Lakes Naval Training Center (Chrzastowski and Trask 1995).

From 1988 through 1993, the USGS in cooperation with the ISGS conducted a variety of studies that addressed coastal-erosion issues along the Illinois coast. A compilation of these studies is included in a 1994 Special Issue of the Journal of Great Lakes Research (Volume 20, Number 1). An overview of this erosion study is presented by Folger, Colman and Barnes (1994). A key aspect of this study was the development of a sediment budget for the Illinois and Indiana coastal systems (Colman and Foster 1994).

Erosion studies that have focused on a particular segment of the Illinois coast have been studies at Illinois Beach State Park (*e.g.*, Tetra Tech 1978), North Point Marina (*e.g.*, Chrzastowski, Foyle and Trask 1996; Terpstra and Chrzastowski 1992), Forest Park Beach in Lake Forest (Chrzastowski and Trask 1995), and the deterioration of first-generation revetments along the Chicago lakefront (Chrzastowski and Schlee 1988; Chicago Shoreline Commission 1988). An evaluation of beach and nearshore sand thickness at select sites along the North Shore and Far-North Coast provided the first documentation of diminishing littoral sand volumes along the Illinois coastal zone (Shabica and Pranschke 1994).

This is not meant to be an inclusive listing of all erosion studies for the Illinois coast. However, the studies listed here are comprehensive and several of the most frequently referenced erosion studies. The references cited in these reports provide citations for important supporting studies.

Mitigation of Coastal Erosion

Efforts to mitigate erosional processes along the Illinois coast date to the early 1850s and the need to halt erosion along the Chicago lakeshore to the south (downdrift) of the jetties at the entrance to the Chicago River. The erosion defense involved building an offshore alignment of trestles for the tracks of the Illinois Central Railroad and a breakwater along the lakeward side of these trestles (Andreas 1884; Chrzastowski 1991). This construction halted erosion that had threatened Michigan Avenue and also allowed the Illinois Central Railroad to gain access to the Chicago Central Business District. This effort set the stage for later lakefilling between the offshore trestles and the shore, and later yet lakeward of the trestles. This lakefilling created what is today Grant Park, which is the centerpiece of Chicago's lakefront parks.

Mitigation of coastal erosion along the Illinois coast has taken a variety of approaches through time. Hardening the shore with engineered structures has been the most common practice. In recent decades, there has been greater interest in using "soft" solutions such as beach nourishment or beaches in combination with hard structures built to retain sand supply. The following discussion provides an overview of the erosion mitigation common along the Illinois shore.

Shore-Protection Structures: A wide variety of shore-protection structures occur along the Illinois coast such as groins, riprap, revetments, and breakwaters. Abundant local supply of dolomite provided the stone for revetments, riprap and breakwaters since the late 1800s. Many of the early shore-protection structures relied on timber to form the walls for rock-filled cribs in breakwaters and groins. Many of these timber structures were later faced with steel sheet pile. Use of steel sheetpile in shore protection, now a common coastal building technique, had its origin on the Chicago lakefront in the 1930s (Young 1932) and is now the primary material of use in facing groins, jetties, and the base of stepped revetments along the Chicago lakeshore. The Chicago stepped revetments are a unique design that provide shore protection as well as public access and shoreline aesthetics.

Headland Beach Systems: In recent decades, a type of shore protection that also provides recreational and aesthetic benefits is engineered pocket beaches held by groins or rubble-mound breakwater headlands. These headland beach systems have the advantage of: 1) creating a contained beach that is not dependent on any influx of sand supply from littoral transport, and 2) creating a beach that will have minimum loss of sand to littoral transport. During the 1990s, headland beach systems grew in popularity along many of the private lakeshore properties of the North Shore. Headland beaches have been built at municipal beaches in Lake Bluff (Sunrise Park Beach) and Lake Forest (Forest Park Beach). The concept of headland beach systems was used along the Chicago lakefront in the 1920s and 1930s in building many of the lakefront beaches. These systems rely on a large terminal groin to prevent the beach sand from being lost to littoral transport, and orienting the beach toward the principal wave approach so that wave-induced sediment transport is primarily up and down the beach and alongshore sediment transport is minimized. Examples along the Chicago lakefront are Montrose Avenue Beach, North Avenue Beach, 31st Street Beach, 63rd Street (Jackson Park) Beach, and Rainbow Beach.

Lakefill: Filling into the shallow nearshore area to create new land and establish a new more lakeward shoreline position has been used as a means of shore protection at many sites along the Illinois coast, particularly along the Chicago lakefront. The lakefill results in a new shoreline edge that can be built in a durable way to withstand direct wave and ice impact, and thus be more erosion-resistant than the pre-lakefill shoreline. Much of the lakefill along the Chicago lakefront has been built into an average water depth of about 10 feet (3 m), but as much as 20 feet (6 m) along the far east end of the parkland near Montrose Harbor.

The hard edge along the Chicago lakefill provides several shoreline management advantages: 1) there is no major change in shoreline position with changing lake levels; 2) littoral transport and the associated gain or loss of beach and nearshore sand is not an issue; and 3) the design of the hard edge includes an apron of rock forming toe protection that armors the lake bottom from any erosion that could result from downward directed energy of waves impacting the hard edge. Lakefill has proven an effective means of shore protection along the Chicago lakefront as well as a means of enhancing the recreational amenities of this urban shore.

Beach Nourishment: Although beach nourishment is a maintenance issue along many of the municipal beaches along the Illinois coast, no beach nourishment reaches a scale of operation as what has been done in the past by the IDNR at Illinois Beach State Park. Maintaining the state park shore to be free of any additional shore protection or offshore structures is a long-term coastal management objective for the state park (IDNR 2001). As a result, beach nourishment has been the primary means of erosion mitigation along the state park shoreline. Feeder beaches have been established at the north ends of both the North Unit and the South Unit of the state park.

Sediment budget studies have determined that a minimum beach nourishment of 80,000 cubic yards per year is necessary for a balanced sediment budget (Foyle, Chrzastowski and Trask 1998). Sources for the sand supply have been from dredging at nearby marina entrance channels (North Point Marina or Prairie

Harbor Yacht Club on the Wisconsin side of the state line), the entrance channel to Waukegan Harbor, and the cooling channel intake at the Midwest Generation Power Plant in Waukegan. Sand has also been purchased from inland sand pits.

Permitting Projects for Coastal Erosion Control

Two authorities are responsible for reviewing and permitting construction along the Illinois coast having the purpose of controlling coastal erosion. On the state level, the permitting is done by the OWR, Lake Michigan Management Section. On the federal level, permitting is done by the USACE, Chicago District Regulatory Branch. In general, for both the IDNR and the USACE, no projects are permitted that are deemed potentially disruptive to the movement of littoral transport along the beaches and nearshore. An exception to this restriction might include structures that will trap sand but will have a sand management plan, which provides for the bypass or backpass of sand that is captured by the structures.

A requirement of permitting by the IDNR requires that any shore protection that involves building a beach include the filling of the beach to the maximum capacity of computed sand retention and then, in addition to this capacity volume, include a 20 percent overfill. The overfill assures that if there is any unforeseen adjustment to the beach and nearshore profile, the additional sand is in-place if needed in the profile adjustment. The IDNR distributes public notices concerning any permit applications, allows for the public review of plans for the proposed project, and allows a 30-day period for written comments. No work can begin until the permit is issued.

The wide range in historical lake-level fluctuation in Lake Michigan (6.3 feet; see Chapter 2) results in the need for some shore protection that has direct interaction with lake water only during times of extreme high lake levels. An example is the revetments built at the toe of the bluffs along the bluff coast. Although these revetments may have some wave impact during extreme storms, commonly a beach may exist adjacent to the revetment, and only at times of higher lake levels might the still water be in contact with the structure.

The permitting process allows shore-protection structures for both private and public lakeshore property to be built extending onto the lake bottom. This is despite the lake bottom being state land held in public trust. Filling of lakeshore land is permitted by Illinois state law conditional that the filling serves a public benefit. An example is the creation of lakeshore parkland such as the parkland of the Chicago lakefront.

For both the IDNR and the USACE, Chicago District, the upper limit to which state and federal permitting of lakeshore construction applies is the Ordinary High Water Mark (OHWM). How that reference elevation is defined is discussed in the following section.

Delineating the Ordinary High Water Mark

The Ordinary High Water Mark (OHWM) is an elevation defined by the USACE corresponding to the typical or “ordinary” high level to which the lake water will rise in its long-term fluctuation. Lake level may at times exceed the OHWM. Most often, lake level is below this elevation. Because Lake Michigan is federal and state navigable water, the OHWM is important in regulatory activities as the upper limit to which federal and state regulation occurs in managing the navigable water of the lake. The OHWM is the upper limit of jurisdiction under Section 10 of the Rivers and Harbors Act for federal projects in the United States.

In some coastal states, the OHWM defines the boundary between private property and public beach and water. This is not the case in Illinois. Private property and riparian rights along the either Illinois coast

extend to the calm water shoreline and migrate landward or lakeward with changing lake level (Illinois case law: Brundage v. Knox, 1917).

The OHWM along the Illinois coast has been defined by the USACE as having an elevation of 581.5 feet (177.2 m) relative to the International Great Lakes Datum (IGLD) 1985. Only shore construction that occurs below this elevation is subject to permitting by the IDNR and the USACE. Compared to a mean lake level of 579 feet (IGLD 1985), the OHWM is 4 feet (1.21 m) above this mean.

Coastal Erosion Areas of Significance

Areas along the Illinois coast that have been of greatest concern for coastal erosion have changed with time. Fluctuating lake levels and changes in the degree and extent of shore protection have influenced where and when coastal erosion has been an issue. In the 1970s, most of the bluff coast was a critical erosion area. Since then, extensive shore protection and bluff stabilization has substantially reduced the concern for bluff erosion. During the record high lake levels of 1986 and 1987, deterioration of the beaches and shore protection along the Chicago lakefront became a major issue. The Chicago Shoreline Protection Project has rebuilt the most seriously deteriorated shoreline revetments and has refurbished beaches and built new beaches.

During times of high lake levels, any location along the Illinois coast can have some degree of erosion concerns as the high water allows storm waves and ice to impact the shore at a higher elevation and a more landward position. Two areas along this coast have persistent erosion concerns that are independent of lake-level changes. These two locations will have long-term erosion management issues.

1) Illinois Beach State Park: This park lakeshore is dependent on an adequate supply and transport of littoral sand in order to maintain a balanced sediment budget and maintain a stable shoreline position. The most severe state park erosion is presently in the North Unit. However, the potential for severe erosion exists along any segment of the state park shore if there is deprivation of littoral sediment supply. All of the unarmored shore in the South Unit of the park could become net erosional if there is no longer a supply of littoral sand from erosion in the North Unit.

2) Nearshore Lakebed: Depletion of sand cover across nearshore lake bottom and erosion of the glacial till lakebed will permanently alter the nearshore profile. Deeper water closer to shore will allow greater wave energy to be expended against existing beaches and shore-protection structures. There is also the potential for undermining existing shore protection. The most advanced lakebed erosion is apparently in the nearshore off Lake Bluff. All of the nearshore between Lake Bluff and the most northern extent of lakefill on the Chicago lakefront has the potential for lakebed erosion.

The importance of shore-protection structures in preventing erosion along the Illinois coast makes the monitoring, maintenance, upgrading and replacement of these structures a critical component of coastal management along the Illinois coast.

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