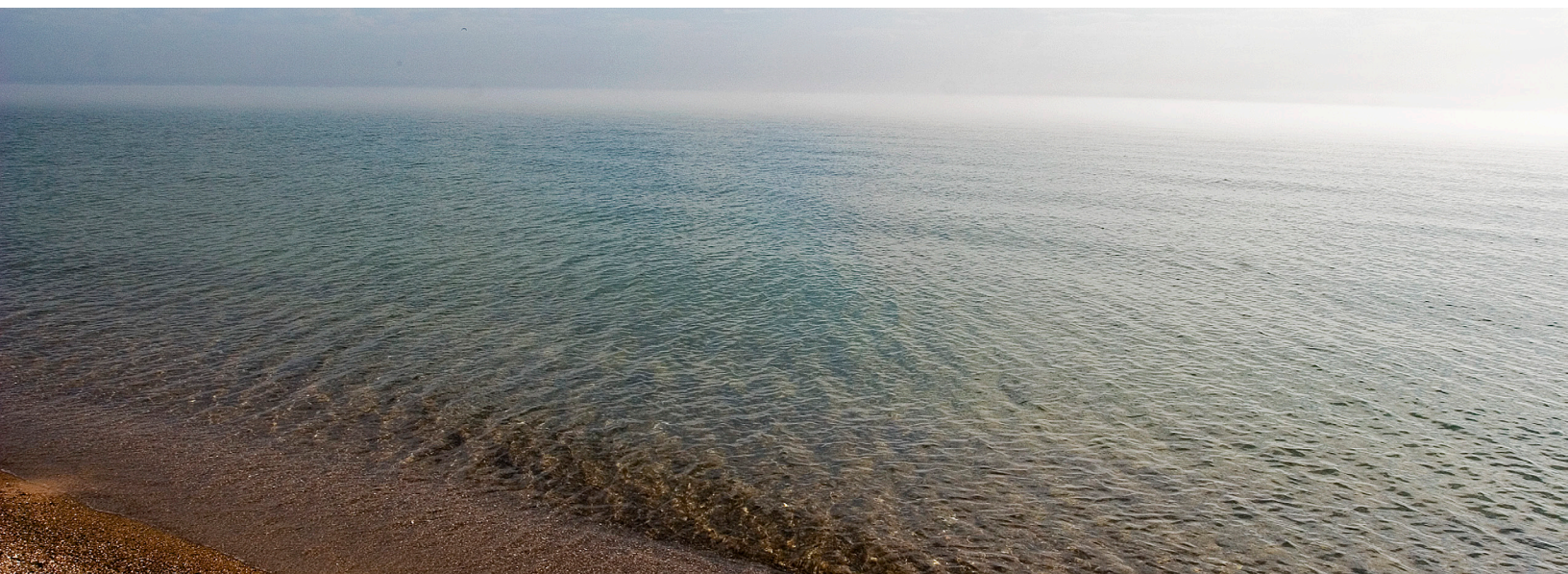


Exploring Illinois' Lake Michigan Coast

THE GEOLOGY OF OUR EVOLVING SHORELINE



The 63-mile long Lake Michigan shoreline of Illinois varies in shape, land cover, and land use. The physical features of the landscape were shaped by past geologic processes and separate the coast into three zones—the Zion beach-ridge plain, the Lake Border moraines, and the Chicago lake plain—based on their distinct landforms.

IT ALL BEGAN WITH AN ICE SHEET

Between ~2.5 million years and ~10,000 years ago, Earth's climate fluctuated between ice ages and milder periods. In response, the Laurentide Ice Sheet expanded and retreated across the region. These events carved the Great Lakes basin.

THE FINAL RETREAT

Lake Michigan began to form around 14,500 years ago as meltwater filled the scoured depression left behind during the final retreat of ice. During the last 2,500 years, the coastline generally settled into its current configuration, which continues to be modified through erosion and accretion.

DEVELOPMENT ALTERED THE LANDSCAPE

While past glaciation and coastal processes carved the natural features along this terrain, coastal engineering has influenced nearly all of Illinois' shoreline (more than any other coastal area in the Great Lakes). The diverse arrangement of these features effects shoreline response to lake processes involving waves, currents, lake level changes, and winter ice.

CLIMATE PLAYS A ROLE IN THE OUTLOOK FOR THE FUTURE

Our region is experiencing higher average temperatures (and therefore less winter ice), more extreme precipitation patterns, stronger storms, and rapid and pronounced water level fluctuation in Lake Michigan. Now and into the future, we can expect regional climate trends (in addition to future coastal development) to influence Lake Michigan's shoreline.

Coastal Zones

Where are our three coastal zones located and what do these zones look like? Here's a quick preview!

ZION BEACH-RIDGE PLAIN: THE SANDY SHORELINE

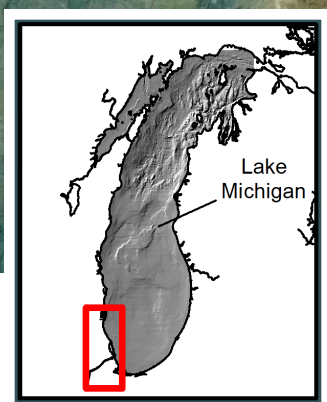
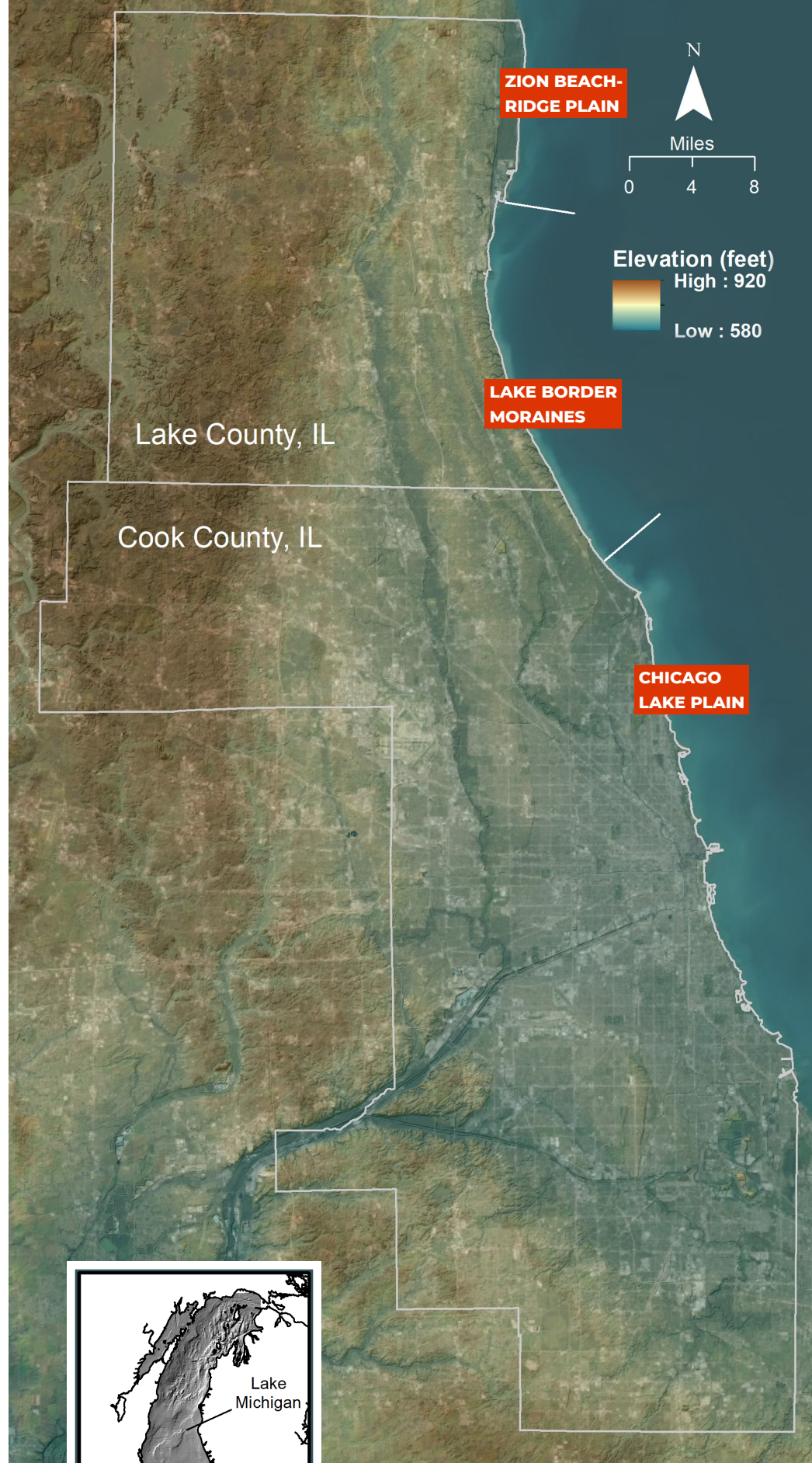
- ▶ Extends ~13 miles from the Wisconsin border to the town of North Chicago
- ▶ This low-elevation terrain is characterized by alternating beach ridges and swales.
- ▶ A notable feature is Illinois Beach State Park, which covers 4,160 acres and 6.5 miles of shoreline.

LAKE BORDER MORAINES: THE BLUFF SHORELINE

- ▶ Extends ~20 miles from North Chicago to Winnetka.
- ▶ This terrain is characterized by bluffs and ravines
- ▶ Bluffs as tall as 90 feet form the highest landscape along the Illinois coast

CHICAGO LAKE PLAIN: THE URBANIZED SHORELINE

- ▶ Extends ~25 miles from Winnetka to the Indiana border.
- ▶ The broad and shallow lake plain is predominantly flat with little variation in topographic texture.
- ▶ Best defined by Chicago's shoreline, where nearly the entire coast has been developed.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGA, AeroGRID, IGN, and the GIS User Community

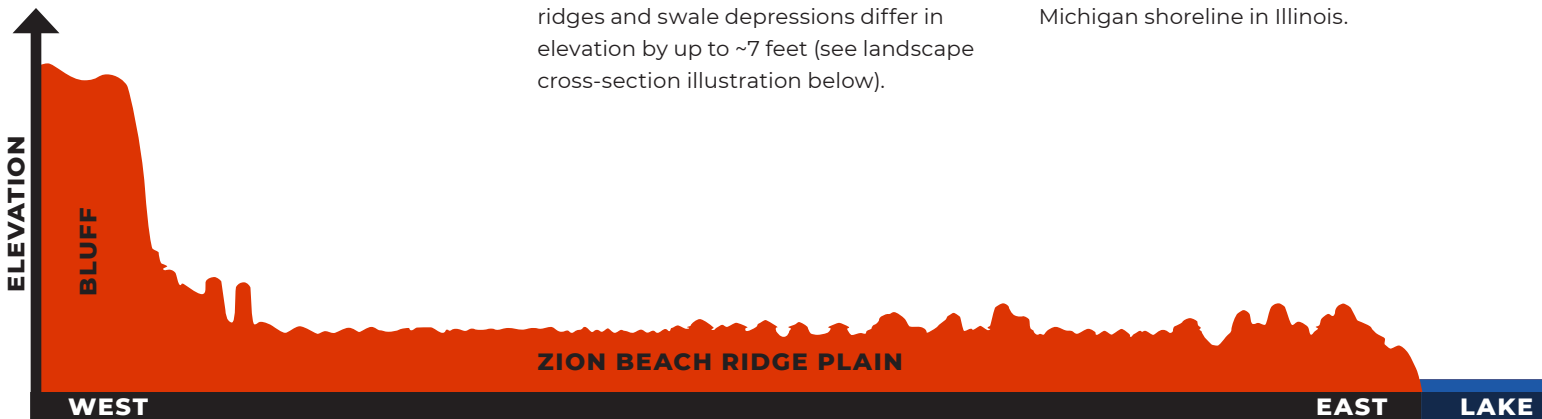


Zion Beach-Ridge Plain: The Sandy Shoreline

The northernmost portion of the Illinois coast, extending ~13 miles from the Wisconsin border to the town of North Chicago, is a sandy shoreline called the Zion beach-ridge plain.

The Zion beach-ridge plain is bounded by coastal bluffs to the west and the shoreline to the east. This low-lying terrain is characterized by a “wash-board”-like topography of alternating ridges and swales. The curved sand ridges and swale depressions differ in elevation by up to ~7 feet (see landscape cross-section illustration below).

The majority of the ~5,900-acre beach-ridge plain is comprised of Illinois Beach State Park, which covers 4,160 acres and 6.5 miles of shoreline. The park preserves the last remaining dune and swale coastal wetlands of the Lake Michigan shoreline in Illinois.



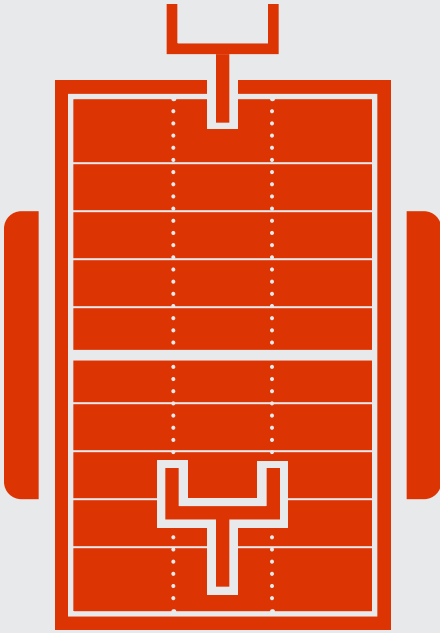
LOOKING INTO THE PAST

Past coastal processes have shaped the landforms that comprise the Zion beach-ridge plain. Ridgelines, formed by sand and gravel pushed landward by wave action, chronicle former shoreline positions over the last several thousand years.

These sands are thought to have originated around 4,000 years ago from a riverine source about 20 miles to the north, in the vicinity of Racine, WI.

Within ~12 miles offshore, waves and currents have moved sand southward through a process called littoral drift (which can still be witnessed today).

This movement of sand has shaped the boundaries of the plain and its position over time. Much of this transported sand remains within the plain, with very little sand drifting south of this zone. This process is likely influenced by the shape of the underlying geologic surface.



THE PAST 80 YEARS OF SHORELINE CHANGE

The Illinois State Geological Survey has monitored long- and short-term change along a half-mile stretch of shoreline in the far northern portion of the Zion beach-ridge plain.

From 1939 to 2020, 39 acres (~29.5 football fields) of shoreline have been eroded.

The erosion rate has accelerated significantly in the past few years: Until 2017, the rate of erosion was about 0.4 acres per year, but since 2017 that has increased to 2 acres per year.

A plain of contrasts: loss in the north, gain in the south

In the northern portion of the plain, shoreline retreat of up to ~820 feet (~3 football field lengths) between 1939 and 2017 has been measured.

Over the same time period, the shoreline advanced by up to 1,100 feet (~4 football field lengths) along the southern portion of the plain.

1939-2020

CONDITIONS TODAY


The Zion beach-ridge plain is the sandiest portion of the Illinois Lake Michigan coast. However, the geology and dynamics of the plain produce both deficits and surpluses of coastal sand from place to place.

As sand drifts from north to south, the shoreline is continuously re-shaped by processes of erosion (the loss of land) and accretion (land gain), changing lake levels, storm impacts, and winter ice cover.


Regional climate changes that produce stronger storms and reduce winter ice covers may be exposing the shore to greater wave energy and stronger currents, thereby intensifying erosion. Lake levels likely determine which parts of the coastal landscape experience these impacts.

Although currently much of the plain is comprised of Illinois Beach State Park, the shoreline has experienced development. The southern portion of the plain, around Waukegan Harbor, has been altered for port and industrial land use. North of the Harbor, southern-moving littoral sands have built up, resulting in ~420 acres of accreted land that extends as far north as the South Unit of IBSP.

WHAT DOES THE FUTURE HOLD?

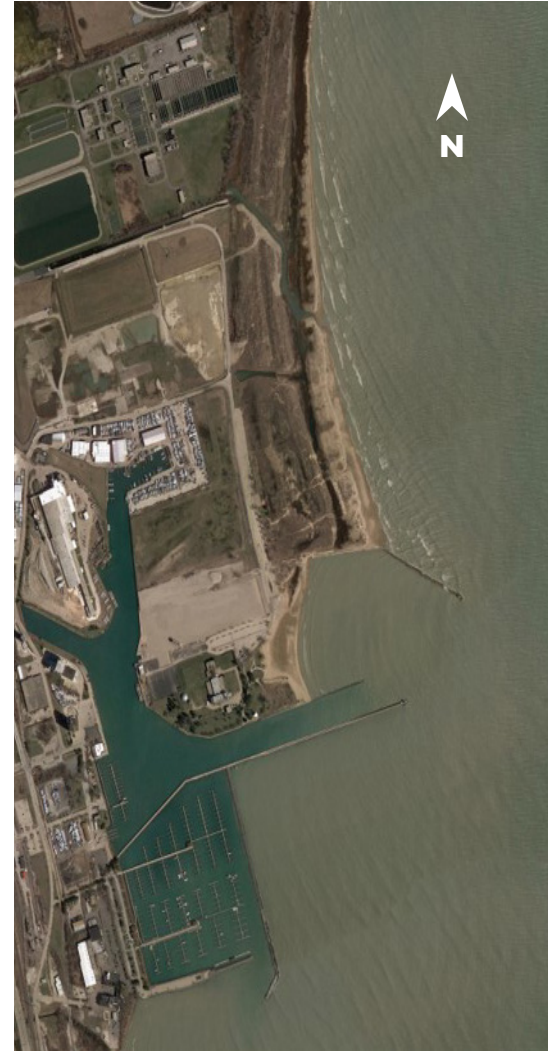
 Continued lake-level fluctuations, particularly those that are high-magnitude and occur rapidly, will continue to significantly shape this highly dynamic part of the Illinois coast.

High lake-level periods are likely to be accompanied by enhanced erosion and land loss, particularly in the northern portion of the plain.

 We expect ice impacts on the shoreline to be highly unpredictable along this part of the coast, based on past trends.

However, the overall decrease in winter ice and the increased potential for open lake conditions during some stormy winter seasons will likely be accompanied by heightened levels of shoreline erosion.

Waukegan Harbor exemplifies the development that has occurred along the Zion beach-ridge plain.

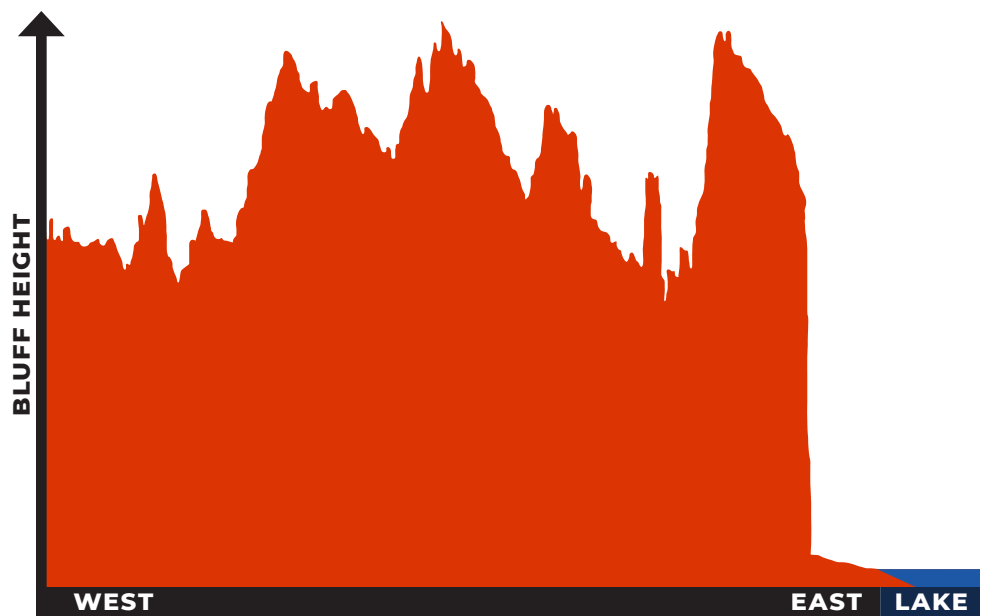




Lake Border Moraines: The Bluff Shoreline

The central portion of the Illinois shoreline, between North Chicago and Winnetka, is where Lake Michigan meets the Lake Border moraine system. The moraines also occur west of the Zion beach-ridge plain and along the perimeter of the Chicago lake plain, only intersecting with Lake Michigan along the central coast.

Four moraines comprise this system, which extends ~6 miles inland from the coast, and whose topographic highs and lows differ by around 60 feet. This wavy topography resembles the Zion beach-ridge plain, but on a much larger spatial scale. The shoreline terrain here is characterized by coastal bluffs and ravines (see landscape cross-section illustration to right).



LOOKING INTO THE PAST

When glaciers advanced, they scraped up and pushed along sediment, similar to a bulldozer pushing materials along the ground. As the glaciers began to retreat, they left behind ridge-like deposits, known as moraines.

The Lake Border moraines were deposited ~14,500 years ago as the Laurentide Ice Sheet began its last retreat from the Lake Michigan area.

Thousands of years of interaction with lake waves and currents has eroded the bluff shoreline. This process is also influenced by precipitation and groundwater levels, which can vary through time.

Sculpted by erosion, the interface of moraine and lake has resulted in the state's highest and steepest landscape, with bluffs up to 90 feet tall and slopes ranging from near vertical to about 45°. Elsewhere along this portion of the coast, a series of steep-sided v-shaped ravines, which originate up to a mile inland, connect with the lakeshore.

“MASS WASTING” OF COASTAL BLUFFS

Bluffs are comprised of materials that are not well consolidated (mainly glacial clays and silts). This makes them susceptible to mass wasting, a process that involves the slumping of materials into the lake. Mass wasting is aided by erosion to the bluff toe by waves, currents, and ice.

CONDITIONS TODAY

The majority of the bluff shoreline has been impacted by human landscape modifications. Aside from the areas around Fort Sheridan and few small municipal parks, the entire ~20 mile stretch of bluff shoreline butts up against private homes, most of which are <50 yards from the bluff edge.

Urbanization atop the bluffs has altered groundwater flow and impacted slope stability. There is limited sand transport and accumulation along shore across this area, often leaving the bluff toe (the base) without protection.

Isolated, narrow strips of sand have fronted the bluffs at times, but these tend to be short-lived features. Along the shore, protection features designed to trap sand and help buffer against wave attack are common. Because of land limitations at the bluff base, some lakefront municipalities in this area have constructed new land (lakefilling) of varying sizes for beaches and public utilities. These modifications were generally on the scale of a few acres, although Lake Forest constructed a 22-acre lakefill for the Forest Park Beach facility in 1987.



WHAT DOES THE FUTURE HOLD?



If lake levels continue to fluctuate more often and to greater extremes, the bluffs may be threatened by the effects of elevated lake levels more frequently, likely accelerating rates of bluff retreat.



Based on past trends, shorter periods of ice cover with less ice are expected in the future. For the bluffs, this may be problematic as the

winter season holds a high potential for strong, prolonged winds and storms. The absence of a thick and extensive ice cover in the nearshore would offer less protection from direct wave attack.



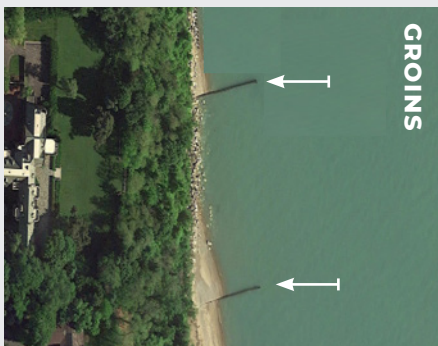
A heightened intensity in precipitation events may affect the structural stability of the bluffs. An increase in water content could destabilize the features by adding weight and decreasing soil strength, exacerbating mass wasting processes.

WHAT DOES SHORELINE PROTECTION LOOK LIKE?

Engineered structures are commonly built to reduce coastal erosion. These can include groins, breakwaters, revetments, and seawalls.

These types of structures are frequently used along this portion of the coast primarily to help stabilize and retain materials at the bluff toe. These features are designed to accumulate sand and help buffer against wave attack

Although they provide site-specific protection and beaches, these barriers trap sediment in an already sediment-limited area, leaving other sections of coast sand-depleted and vulnerable to erosion.





Chicago Lake Plain: The Urbanized Shoreline

The southern portion of the Illinois Coast, stretching around 25 miles from Winnetka to the Indiana border, is defined by the Chicago lake plain. This broad and shallow terrain is characterized by very low gradients and little topographic texture. A more defining characteristic of the Chicago lake plain is that it's predominantly urbanized. The majority of shoreline along this stretch (around 22 miles) is located within the City of Chicago. While urbanization has spared neither the Zion

beach-ridge plain nor the Lake Border moraines, it is most characteristic of Chicago's shoreline, where nearly the entire coast has been engineered.

LOOKING INTO THE PAST

The topography of the Chicago lake plain is connected to the area's deglaciation and associated lake-level phases. As the Laurentide Ice Sheet receded northward from the region, the area was

covered in water by the precursor to Lake Michigan, Lake Chicago, which was up to 60 feet higher than current average lake levels.

The flat and level terrain we see today was caused by this submersion and the deposition of an extensive layer of lake bottom sediment. Lake Chicago retreated, lowering water levels to those of present day Lake Michigan and exposing the Chicago lake plain.

A TIMELINE OF CHANGE: THE ERA OF SHORELINE ENGINEERING

Prior to the 1800s, the coast was predominantly comprised of low-lying dunes and marsh extending a quarter mile landward of the shoreline. The arrival of European settlers brought industrialization and urbanization, which began the legacy of human-engineered shoreline modification and lake filling.

Along the Chicago shoreline, which comprises the majority of the lake plain, the entire coast was built out further into the lake beginning in the 1800s. The lake plain's long, shallow nearshore geology was well-suited for an ambitious lakefilling project of this scale. Other municipalities along the lake plain have also constructed lakefills.

1833	1871–early 1900s	1907	1909	1920–1940	1960s
<p>Jetty constructed to trap littoral sands near the mouth of the Chicago River.</p> <p>Between 1833 and 1860, nearly 70 acres of sand accumulated north of the Chicago River jetty, protruding 1900 ft lakeward.</p>	<p>Low-lying Chicago shoreline continued to be filled to create more than 5.5 miles of new land for commercial infrastructure, public parks, beaches, and piers.</p>	<p>Wilmette constructed a 30-acre lakefill to create Gillson Park</p>	<p>Burnham's <i>Plan of Chicago</i> completed. The plan centered around the continuation of lake filling efforts and the construction of a new, public, park-dominant shoreline.</p>	<p>Major expansion of Chicago's coast with lakefilling projects extending up to a mile away from the original shoreline.</p>	<p>A 73-acre lakefill was constructed in Evanston to expand the Northwestern University campus.</p>



CONDITIONS TODAY

Today, much of the plain's shoreline is heavily armored and artificially modified, especially from Evanston to the Indiana border. In *The Plan of Chicago*, Burnham suggested that the construction of man-made land include as many beaches as possible, but the land was often built into waters averaging 10 feet deep.

Because of this, beaches comprise only one-sixth of Chicago's shoreline, while the rest of the shoreline features hard edges. Prominent on this hardened landscape are concrete seawalls, revetments, piers, harbors, and a series of groins.

While groins were built elsewhere on Illinois' lakefront to trap littoral sand, along the Chicago lake plain they were primarily added to retain built beaches.

Because of its location along Lake Michigan, Chicago's shoreline periodically experiences large wave events and wind-driven tides. Storms and wave action have caused shoreline erosion, flooding, and infrastructure damage. Recent efforts to repair, restore, and strengthen the hardened shoreline are focused on protection from storm events. As a result, the coast is unable to evolve naturally in equilibrium with changing environmental conditions.

WHAT DOES THE FUTURE HOLD?



Future elevated lake levels and extreme events may cause the shoreline and coastal infrastructure to be more prone to attack by wind and wave processes.



Reductions in winter ice-cover extents and durations may translate into more wave impact on the shoreline.



An increase in the frequency of extreme rainfall events may translate into more flash flooding.

NOT A LOT OF SAND DOWN HERE

Contrary to the sand-rich Zion beach ridge plain, very little sand has been present in the littoral system within the Chicago lake plain, even historically. You can see this reflected in early plans to create man-made beaches along the Chicago shoreline. While the sand deficit is in part due to the geology of the shoreline, human disturbance has exacerbated the natural patterns of erosion and accretion.



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ABOUT THE ILLINOIS COASTAL MANAGEMENT PROGRAM (CMP)

CMP provides guidance, technical support, and some financial assistance to municipal, county, and state government agencies that are working within the coastal region of northern Illinois in support of the Lake Michigan Coastal Program (LMCP). The mission of the CMP is to protect and enhance natural, cultural and historical coastal resources, and to foster coordination and partnerships among local, state and federal agencies, and local organizations.

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