GEOLOGIC AND ENGINEERING HISTORY OF PRESQUE ISLE PENINSULA, PA

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INTRODUCTION

Presque Isle is a unique and significant coastal feature on the south shore of Lake Erie at Erie, Pennsylvania. It is a compound, recurved sandspit that arches lakeward about two and one-half miles from an otherwise straight shore (Figure 1). The peninsula has a lake shoreline of about six and one-quarter miles from its narrow connection with the mainland to its distal end where it turns sharply shoreward. It is the only major positive depositional feature along the generally sand-starved south shore of Lake Erie. Presque Isle Peninsula is an old-age geomorphic feature which is migrating eastward into deeper water, thereby resulting in a net annual loss to the sand body. The processes responsible for the geological evolution of this feature will also be responsible for its eventual destruction unless attempts are undertaken to permanently stagnate its migration. The history of coastal engineering measures for shore protection has been played out on the peninsula beaches as man has employed a myriad of engineering efforts dating back to the early 1800's for the purpose of preservation of this migrating and diminishing feature. The peninsula is truly a rare ecological laboratory that allows the process of primary plant and animal succession to be studied in habitat diversity ranging from pioneer vegetation on newly formed shore zones to climax woodland communities on old beach ridges, all within a distance of about three miles. The peninsula is developed as a State park and is a popular recreational area which provides facilities for bathing, boating, hiking, fishing, bird watching, picnicking, and other recreational opportunities. The public has free and unrestricted access to the park and approximately 3,800,000 persons have visited the park annually for the past 10 years.

In 1922, Presque Isle Peninsula was conveyed from the Federal Government to the Commonwealth of Pennsylvania for park purposes, and the care and protection of the peninsula was shifted from prevention of breaches through the peninsula for the purpose of preserving Erie Harbor to the purpose of providing recreational beaches. In 1956, the Federal Government, in cooperation with the Commonwealth of Pennsylvania, completed an erosion control project on Presque Isle Peninsula. Since that time, the project has proven to be inadequate, and sand replenishment measures have been required in order to protect the Federal structures and State's park facilities. The Commonwealth of Pennsylvania, in 1968, requested the Corps of Engineers to make a complete restudy of the Presque Isle beach erosion control project in order to develop a more effective and permanent solution to the erosion problem. This field trip manuscript contains a small portion of the geological and engineering background which was developed by the authors in support of the

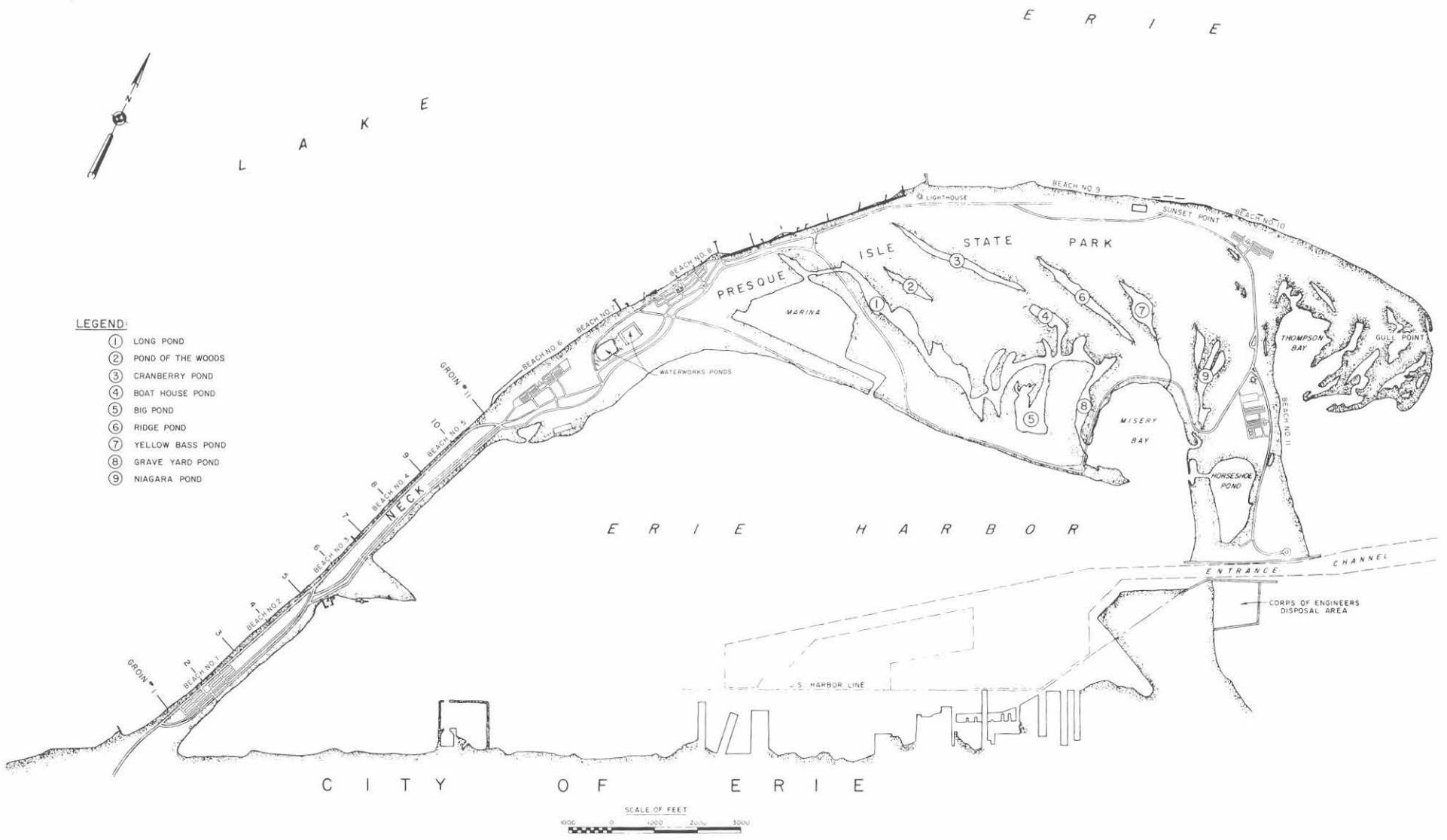

FIGURE 1. LOCATION OF BEACHES AND PONDS ON PRESQUE ISLE PENINSULA

1980 General Design Memorandum, which the Corps prepared for Congressional review and approval. In the interest of brevity, many of the complex geologic environmental, engineering, and socioeconomic issues which were part of the Corps study, could not be reproduced herein. This paper is taken from the context of the official study and its purpose is purely academic and is designed to enlighten the reader by providing an understanding of the fascinating geologic evolution of Presque Isle Peninsula and the history of man's attempts at stabilization. Should the reader desire additional insight into the Corps study, he/she is directed to the 1980 General Design Memorandum.

SITE DESCRIPTION

Presque Isle Peninsula, from its mainland root to its distal end where it turns sharply shoreward, is about six and one-quarter miles long. The eastern end of the peninsula terminates in several low, flat, recurving longshore bars. For a distance of about two miles from the westerly root, the peninsula is narrow and has an average width of generally less than 800 feet. This narrow section of the peninsula is called the neck. East of this narrow neck, the peninsula widens abruptly to a width of over one mile. Presque Isle Peninsula consists almost entirely of fine sand reworked from glacial deposits. The general ground elevation of the peninsula is relatively low, averaging about seven or eight feet above low water datum (LWD) which for Lake Erie is elevation 568.6 feet above mean water level at Father Point, Quebec, International Great Lakes Datum (IGLD 1955). There are four major and several minor beach ridges which extend across the peninsula, generally in an east-west direction and rise to a maximum elevation of about 20 feet above low water datum. The higher ground on the peninsula sustains a thick growth of a wide variety of trees and shrubs. The low areas between the beach ridges are comprised of several elongated lagoons and marshes.

The lakeward perimeter of Presque Isle is about nine miles. The lakeward shoreline has been segmented into 11 bathing beaches by the Pennsylvania State Park Service. These beaches vary in width and, with the exception of Beach No. 11, have had a history of serious erosion for at least 150 years. The bathing beaches are backed by picnic areas, and four major beach areas are provided with bathhouse and parking facilities. Roadside parking provides easy access to intervening beach and picnic areas. Numerous protective works consisting of groins, revetments, bulkheads, and offshore breakwaters have been constructed to halt erosion. The bay shoreline is characterized by numerous small bays, coves, and inlets. Encircled between the peninsula and the mainland is Presque Isle Bay, the easterly part of which has been improved as Erie Harbor. The north jetty for the Erie Harbor entrance channel is joined to the distal east end of Presque Isle Peninsula.

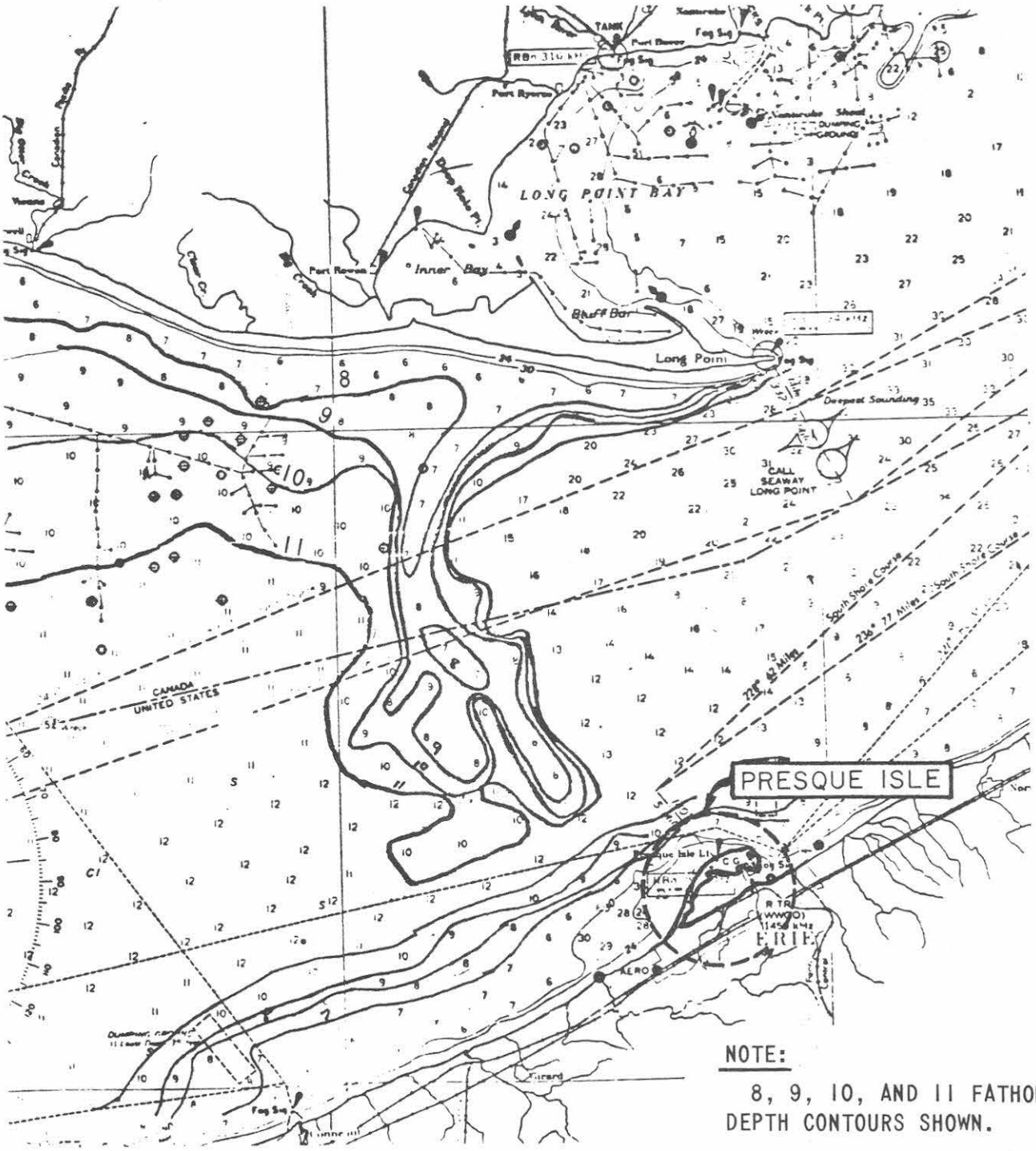

FIGURE 2. LAKE SURVEY CHART NO. 3 ILLUSTRATING THE LONG POINT - ERIE MORAINAL RIDGE.

GEOLOGIC SETTING

Physiography

The major physiographic divisions in northwest Pennsylvania are the eastern lake section of the Central Lowland Province and the glaciated section of the Appalachian Plateaus Province. The eastern lake section is a two to five-mile wide plain bordering Lake Erie. Bluffs along the Lake Erie shore in Pennsylvania are greater than 80 feet in height and are composed of glacial and lacustrine deposits. Bedrock is often found at the base of the bluffs. Sandy beach ridges, representing post-glacial lake strands, cross the lake plain on top of the bluffs. The topography of the glaciated section of the Appalachian Plateaus Province is that of an eroded plateau with gently rolling hills.

Bedrock

Bedrock exposed in Erie County, Pennsylvania, is predominantly Upper Devonian shales and siltstones of the Conneaut and Canadaway Groups. At Presque Isle, there is a lakeward slope of the rock surface with contours parallel to the mainland. At the junction of the neck of the peninsula with the general shore, the bedrock surface is only two feet below low water datum. A gas well drilled near the northeast corner of the Waterworks ponds shows rock to be about 112 feet deep. Borings taken in 1965 by a consulting firm for the State of Pennsylvania, extended in a line across the harbor entrance channel and showed that the rock surface sloped lakeward with a 1 on 125 slope with a depth of approximately 60 feet below LWD near Beach No. 11 (Rummel, Klepper & Kahl-Fertig Engineering Comany, 1968). The bedrock here is likely to be the gray shale of the Portage Formation.

Lake Erie Basin Deposits

Lake Erie can be divided into three separate subbasins. Presque Isle is located at the eastern end of the central basin. The bathymetry of the lake is mostly controlled by lithology and dip of bedrock. Superimposed on the bedrock are Pleistocene and recent deposits. The most prominent glacial features in the lake, are three ridges which traverse the lake between Pelee Point - Lorain, Erieau - Cleveland, and Long Point - Erie. These are thought to be end moraines and are composed of clay till veneered with sand or gravel (Lewis, 1966). The Long Point-Erie Moraine, largest of the three, is broad, flat-topped, and about 40 Km (25 miles) wide (Figure 2). Coring studies, conducted in 1978 by the Coastal Engineering Research Center of the Corps of Engineers, indicate that the sand and gravel overlying the moraine on the United States side is as much as 12.7 feet thick and averages about 7.4 feet. Seismic profiling shows the sand to be 15 to 20 feet thick along the ridge surface. Recent soft, gray mud covers most of the rest of the central basin. In some areas, the mud is 60 to 80 feet thick (Lewis, 1966).

Surficial Deposits

The surficial deposits of northwest Pennsylvania are dominated by the glacial history of this area. During the Pleistocene Epoch, a series of glacial advances and retreats modified the landscape and deposited material. Glacial deposits on the mainland consist of till and stratified drift. The till units are variable in texture and found in hilly end moraines and as ground moraine blanketing much of the area. The stratified deposits are in the form of kames and outwash. Petrographic analysis of the stratified deposits show them to be composed of hard and tough sandstone, siltstone, limestone, dolomite, quartz, and quartzite particles. Strand deposits of Glacial Lakes Whittlesey and Warren also consist of sand and pebble gravel. These deposits, formed about 12,800 years ago (Schooler, 1974), have not been found to be suitable for use as beachfill because of a predominance of shale and siltstone fragments.

Glacial History

The Late Wisconsin stage left the greatest impacts on the topography and the deposits of this region and starts the evolutional trail toward the existance of modern Presque Isle Peninsula. The earliest event of the late Wisconsin significantly affecting the project area occurred about 20,000 years B.P. during the Kent Phase. Deposits of Kent drift include till and stratified drift in the form of kames, crevasse fillings, and outwash. The main characteristic of the Kent Advance is extensive kame deposition. These are found on valley bottoms or perched on valley walls. Most of the sand which has been used in recent years for beach replenishment at Presque Isle is derived from these deposits. During the next event, the Lavery Phase, a glacier advanced to a location marked by the Lavery End Moraine. This occurred about 17,000 years B.P. The surface expression of this deposit varies from smooth hills and swales to moderately hummocky topography. Shepps and others (1959) have mapped morainal kames in locations where the Lavery moraine crosses valleys. Kames and outwash, deposited in valleys, supply some of the sand used for beach replenishment at Presque Isle.

After the Lavery advance, Fullerton (1971) believes that the ice margin retreated as far northeast as Toronto, Ontario, and he refers to this period as the Lake Erie Interval (approximately 15,500 years B.P.) during which both Lakes Erie and Ontario drained eastward through the Mohawk Lowland in New York. A glacial readvance in Port Stanley time (15,000 years B.P.) resulted in the deposition of the Hiram Moraine. Kames were not as well-developed as during the preceding Kent and Lavery advances. Outwash deposits also are not as extensive.

The last glacial advance into northwestern Pennsylvania, according to Shepps and others (1959), and White and others (1969) was the Ashtabula Advance. Fullerton (1971) shows this to have begun 14,100 years B.P. Its limit is marked by a series of end moraines exhibiting knob and

kettle topography. Kames are more common in the eastern portion of the moraine than in the western portion. Outwash occurs between the ridges.

The next major event of the Pleistocene is known as the Cary-Port Huron Interval when the ice margin was north of the Lake Erie Basin. At this time, a series of glacial Great Lakes developed in the Erie Basin. Strand lines of Lakes Maumee I, II, III, and Arkona were fairly well-developed in the western portion of the basin but are faint or absent in the eastern part (Leverett and Taylor, 1915). These lakes drained westward, outletting at Ft. Wayne, IN, through the Wabash River and also through the Huron Basin (Hough, 1958).

At 12,900 years B.P., a major glacial readvance, known as the Port Huron Advance, took place resulting in a rise of water in the Erie Basin to form Glacial Lake Whittlesey (Calkin, 1970). The Long Point-Erie Moraine of Lake Erie has been correlated with the deposits of the Port Huron Advance by Lewis (1966), Wall (1968), and Fullerton (1971).

Features of Lake Whittlesey can be found in the vicinity of Presque Isle at an elevation of about 735 feet above mean sea level (MSL). The Whittlesey strand occurs as a 10-foot high wave-cut cliff near the Pennsylvania-Ohio State line. About a mile east, it becomes a 15-foot high, gravelly ridge and then changes to a series of sand dunes south of West Springfield, PA. Across the rest of Erie County, PA, it is a well-defined ridge 15-20 feet high with a steep north slope and gentle south slope. East of Erie, the ridge is replaced by two low, wave-cut cliffs cut in glacial material and bedrock (Schooler, 1974).

Further retreat of the Port Huron glacier resulted in a series of lower lakes. The most important of these is Lake Warren which is evidenced as two ridges occurring at elevations of 725 to 735 feet and 715 to 725 feet (Schooler, 1974).

After the ice had retreated north of the Niagara Escarpment, water in the Erie Basin was allowed to drain into the Ontario Basin. Due to crustal depression caused by the weight of glaciers, the outlet at the escarpment was relatively much lower than the present outlet at Niagara Falls. The lake occupying the Erie Basin at this time was at an elevation of 470 feet MSL, approximately 100 feet lower than today. This stage known as Early Lake Erie existed between 12,370 and 12,790 years B.P. (Lewis and others, 1966). It was during this time that Lewis (1966) and Lewis and others (1966), believe that the sand and gravel overlying the Long Point-Erie Moraine developed.

As the outlet of Early Lake Erie was uplifted by crustal rebound, the elevation of the water surface was raised to its present level. Wave erosion of bluffs along the present shore and streams in addition to the Long Point-Erie Moraine, contributed sand and gravel for the development of beaches and the original Presque Isle sand body.

Modern Lake Erie

The water levels in the Lake Erie Basin have changed much in post-glacial times. This is due to crustal uplift, climatic changes, and diversion of water. The present outlet, the Niagara River, is controlled by a bedrock threshold at Buffalo, NY. During glacial times, this was blocked by ice, and lake water was diverted through higher outlets such as the Wabash, Grand, and Mohawk Rivers. After glacial retreat, the Niagara outlet was opened, but due to crustal downwarping caused by the weight of glaciers, this outlet was more than 100 feet lower than today.

Early investigators (Leverett and Taylor, 1915, and others) determined the differential uplift in the region by comparing the elevations of southern beaches with northern beaches of the glacial Great Lakes. They found that the beaches are horizontal to a point, known as a hinge line, from which the beaches rise vertically to the north. For example, Lake Whittlesey beaches are at an elevation of 735 feet (MSL) throughout most of Ohio and Pennsylvania, but starting at a point east of Erie, PA, they begin to rise up to an elevation of 910 feet (MSL) in New York State (Leverett and Taylor, 1912).

In another study of water levels, Lewis (1969) compared radiocarbon dates with known lake levels and developed the diagram shown as Figure 3. This shows the rate of change in water level in the Erie Basin during post-glacial time. Lewis prefers to use the curve near the upper envelope. If the lower curve is adopted, it would mean that levels in the eastern basin of the lake would have been lower than the channel along the southern margin of the Long Point-Erie Moraine for more than 1,500 years. Lewis' diagram also shows the steep rise of water from 5,000 to 3,800 years B.P. This initial rise corresponds to the abandonment of the North Bay transfering more flow into the lower Great Lakes.

GEOLOGY OF PRESQUE ISLE

INTRODUCTION

The observed sediment transport patterns at Presque Isle are the result of a modern wave climate acting on the glacial and post-glacial deposits of the area. Glacial deposits, some reworked during post-glacial lake level fluctuations, serve as the source for the littoral material. Lake level fluctuation and drainage pattern changes have been frequent in post-glacial time (for the past 12,000 years) and are responsible for denudating the glacial topography and producing many of the present, onshore, offshore, and coastal features including Presque Isle Peninsula. However, Presque Isle is a unique feature. It is the only major positive depositional feature along the southern shore of Lake Erie, and any explanation of its existence must be tied to some specific geologic event.

An understanding of the origin and historical development of Presque Isle Peninsula is necessary in order to understand the processes currently at work and to predict the future condition. Thus, the following discussion concerning the post-glacial development of Presque Isle is presented only as a brief overview in order to provide a better understanding of the observed condition. This discussion is hypothetical and, although it fits with the existing glacial information and theory, has not been rigorously tested.

HISTORICAL ORIGIN

In order for Presque Isle Peninsula to exist prior to recent lake levels, there must have been a substantial source of sand and a reason for that sand to collect in one area. The existence of the platform to the west of Presque Isle may very well be the key which explains how Presque Isle Peninsula evolved (Figure 2). The platform has a total length of 12 miles of which the eastern five miles is currently covered by the peninsula. its average width is about three to three and one-half miles from the average depth is 25 to 30 feet below LWD. Map documentation from the past 150 years shows that the sand of Presque Isle does migrate from west to east across this platform, building a new platform to the east as it moves in that direction. The origin of the platform can be explained as a total sand terrace which has been wave planed by rising lake levels or as a preexisting topographic high rock or glacial till which served as the original base for Presque Isle and was added to as the peninsula grew. Preliminary review of data collected in 1977 and 1978 by the Coastal Engineering Research Center suggests that the western end of the platform is underlain by till (S. J. Williams, personal communication, 1979). If the original platform at the western end is composed of glacial morainal till it is probably the southern end of the Long Point-Erie ridge (Figure 2) which has been traced to the Post Huron-glacial advance (12,800 $\pm$ 250 years B.P.). Hough (1958) describes the moraine as a distinct ridge on the bottom of Lake Erie lying west of the eastern deep basin, emerging on the south side of the lake where it extends eastward into New York as the Lake Escarpment Moraine System (Messenger, 1977). The surface of this moraine, both the ridge and the platform, was probably planed by wave action during lower lake levels, and the silts and clays were carried offshore leaving a lag deposit of sand and gravel. The platform lag deposit was well-sorted by wave action and possibly served as a depositional area for littorally transported material during the Early Lake Erie stage. As lake level rose to approximately 25 feet below today's lake level, about 4,000 years ago, littoral currents transported the sand on the platform toward the east, remolding it into an elongated sand beach. This historical sequence is described in Table 1 and shown on Figure 3.

Migration caused by waves from the west and rising lake levels caused the sand body to move toward the east side of the morainal root. As sand slumped off of the east side of the moraine, a sand platform was

Table 1 - HYPOTHETICAL CHRONOLOGY OF PRESQUE ISLE ORIGIN*

Period (Years B.P.)	Event	Discussion
12,900	Port Huron Advance	Long Point-Erie Moraine formed.
12,500-11,500	Early Lake Erie	Rapidly rising lake level from 120' to 60' below current LWD.
11,500-10,000	Early Lake Erie	Slower rising lake level (from 60' to 50' below current LWD). Crest of Long Point-Erie Moraine planed by rising lake level, beach deposits, and dune field develops from lag deposit.
10,000-4,500		Slowly rising lake level (from 50' to 40' below current LWD). Long Point-Erie Morainal ridge inundated.
4,500-3,500		Rapid rise in lake level (from 40' to 10' below current LWD). Platform of Presque Isle (landward extension of the Long Point-Erie Moraine is subjected to wave attack sand and gravel lag deposit from till released as source material for Presque Isle.
3,500 to present	Modern Lake Erie	Lake level rises at approximate rate of 1 foot per 300 years. Modern Presque Isle evolves as it migrates to the east.

*Based on the historical Lake Erie water levels presented in Lewis (1969) and on a hypothetical development sequence for Presque Isle.

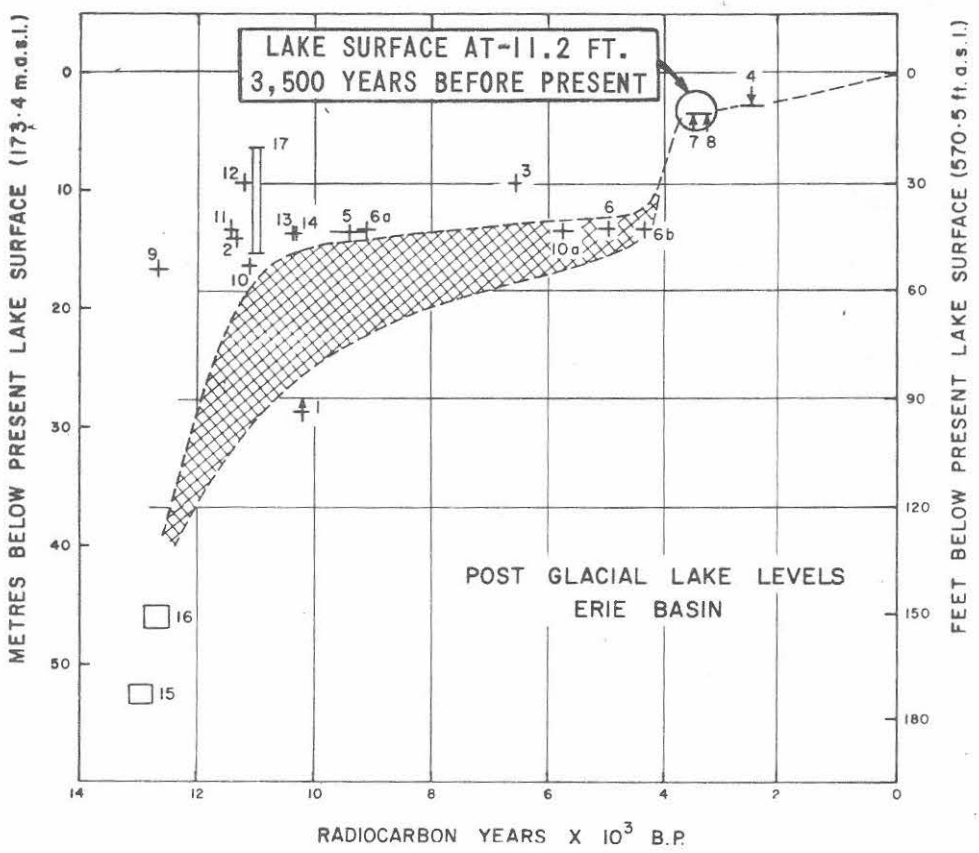

FIG. 12. Post glacial history of Lake Erie water levels. Points are keyed numerically to entries in Table 1.

FIGURE 3. POST GLACIAL HISTORY OF LAKE ERIE WATER LEVELS. LEWIS 1969

built. The feature we recognize as Presque Isle Peninsula evolved as it migrated onto this sand platform. As the sand platform built, the sand volume available for transport diminished. How much of the platform is till and how much is sand are unknown at this time, but subsurface foundation studies planned for the Phase II General Design Memorandum stage of the Corps of Engineers project may provide additional information on the platform and the formation of Presque Isle Peninsula.

Modern Coastal Processes - Migration

The west to east migration of Presque Isle has long been recognized (Figure 4). Presque Isle Peninsula was originally surveyed in 1819. In 1824, the original Erie Harbor project included action as needed to maintain the integrity of Presque Isle Peninsula in order to assure the harbor's future success. Since then, the migratory character of the peninsula has become very evident as erosion and breaching of the neck has demanded continual attention and as accretion at the east end of the peninsula has required jetty extension and dredging to remove shoal buildup in the entrance channel.

Evidence of long-term migration before Federal involvement with Presque Isle is clearly defined by the morphology of the peninsula's internal features, the platform to the west, and the shoreline of the mainland. A comparison of the sheltered shoreline inside Presque Isle Bay to the open shoreline east and west of Presque Isle Peninsula shows no offset. The bay shore should be a positive shoreline and be characterized by a gently sloping shore if it had experienced long-term sheltering by the peninsula. This is not the case. The shoreline is continuous from the west, through the bay, and to the east. The bay shore is characterized by steep, wave-cut bluffs identical to those outside the bay. The sequence of beach ridges, elongated beach ridge ponds, and fingering distal end ponds is repeated and preserved within the interior of the peninsula, documenting previous stages in Presque Isle's migration. The unknown factor is what has been the change in shape and size as Presque Isle has migrated.

The presence of relict features in Presque Isle Peninsula documents the migration from west to east and a continuation of the same general pattern and process of evolution. Presque Isle Peninsula has probably developed in cycles in order for the specific depositional features to be preserved. We can witness the yearly cycle and the long-term cycles of growth related to annual lake level fluctuations, but Presque Isle Peninsula may also be influenced by longer period climatic patterns about which we have no knowledge. High lake levels increase transport rates causing rapid loss of material from the neck area and rapid growth of the distal east end as sand is fed to the growing eastern platform. During lower lake levels, the distal east end matures as the bars are recurved and become subaerial and new material enters the system at the neck, partially healing the eroded areas and widening the neck.

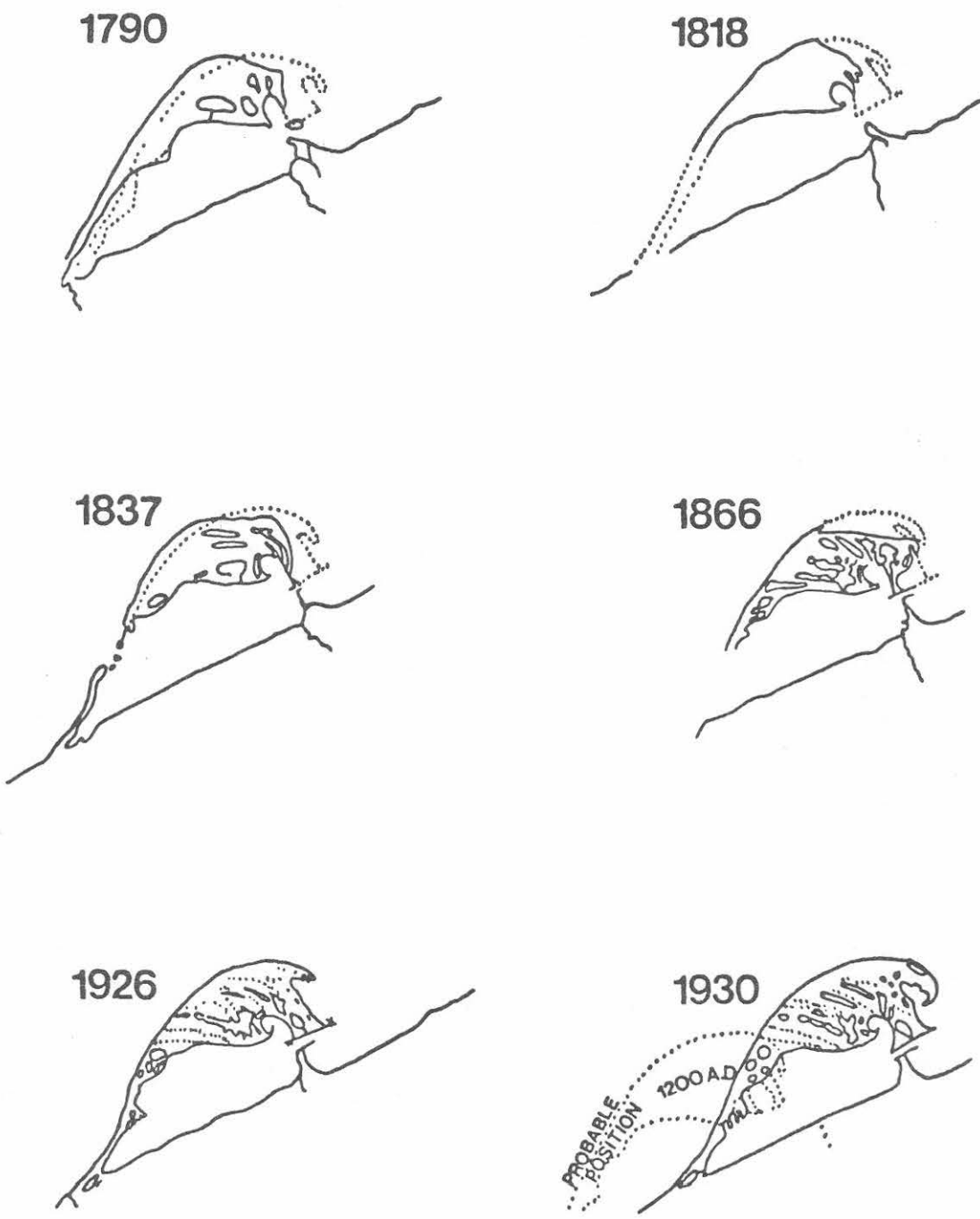

FIGURE 4. GROWTH AND MIGRATION OF PRESQUE ISLE

NOTE: THE DOTTED LINE ON THE 1790 THROUGH 1866 SKETCHES REPRESENTS THE 1930 POSITION OF THE PENINSULA. THE DOTTED LINE SHOWN ON THE 1930 SKETCH DOCUMENTS THE EASTWARD MIGRATION RELATIVE TO A 1200 A D POSITION AS HYPOTHESIZED BY JENNINGS, 1930.

The beach ridges evolve as the offshore bars migrate onshore and weld onto the shore as a subaerial bar. They probably build in height as they migrate onshore in response to the steeper waves of the surf zone. Sand is deposited in front of the bar; a lagoon is trapped behind it. Cottonwoods and other vegetation take root on the beach ridge, and dunes build on top of the ridge increasing its height to about 20 feet above low water datum. Low areas behind and between the beach ridges are submerged and appear as a series of elongated ponds oriented WNW-ESE. Examples of these ridge ponds are Long Pond, Cranberry Pond, and Ridge Pond (Figure 1). The recurving offshore bars at the distal east end form a finger shaped array of ponds which are oriented north-south. These distal ponds include Big Pond, Yellow Bass Pond, and Niagara Pond (Figure 1). The Presque Isle system is an eastward migrating system which feeds upon itself as it migrates. Within the system, material is eroded from the neck to the shifting nodal point, which has recently been in the vicinity of Beach 10, and is deposited along the depositional feature which is Gull Point or offshore to create new platform to the east, or landward where it shoals in the harbor entrance channel.

Recent rates for this migration are artificial and directly influenced by the large-scale replenishment operations of the late 1950's through early 1970's. The present migration rate of 289,100 cubic yards per year reflects the replenishment input which has averaged 259,300 cubic yards per year since 1955. Attempts to determine the natural migration rate suffer from a lack of sufficient historical data and the obvious masking influence of the 150-year effort to stabilize the neck. Historical maps extending back to 1819 and aerial photographs extending back to 1939 were used to document the natural drift rate.

Historical maps do suggest that the Gull Point feature is a recent morphological addition to the system. Maps from 1819 through 1907 show a smooth recurved east end to Presque Isle which merges directly with the harbor entrance structures. Since the early 1930's, isolated growth has extended Gull Point as a "Mini Presque Isle" without sufficient recurving to weld this new growth back onto the shore. The original development of Gull Point may be related to a slug of sand which was released to the nearshore processes between 1917 and 1922 by breaching of the neck. The replenishment operations of the 1950's through 1970's continued adding new material to the accretionary end at a rate faster than easterly storms were able to recurve the bars and shoreline onto the Isle.

The incoming quantities of material never really replace the material left behind as the peninsula migrates and as the eastern end of the platform is built up. This continual loss of material plus the effect of a long-term, slowly-rising lake level (post-glacial rise of about one foot every 300 years) has probably caused Presque Isle to shrink. As Presque Isle migrates, it becomes smaller and migrates faster. Any attempt to identify the age and migration rate of Presque Isle must consider a measure of the rate of size change, as well as change in the

rate of migration. The background data for this sophisticated analysis does not yet exist.

In summary, a few general statements can be made about Presque Isle's natural development trend:

(1) Presque Isle is an old age feature which is migrating with a net annual loss.

(2) Gull Point is a recent feature which has grown at significant rates because of the effects of artificial nourishment.

(3) Presque Isle Peninsula is a fluid feature; any attempt to permanently stagnate its migration will meet with eventual failure, with respect to geologic time, as all such attempts in the past have. An acceptable beach erosion control alternative will retard migration and/or lengthen the peninsula's life by adding new material to the system to replace that which has been used to build the platform and is a net loss to the littoral system.

Modern Coastal Processes - A Sediment Budget

Gains. Any influx of sediments into the Presque Isle system must either come from the east, from the west, from offshore sources, or from artificial nourishment. Presque Isle Peninsula is probably largely dependent upon influx from the west and artificial nourishment for littoral gains to the system.

Presque Isle is an eastward migrating feature with the Erie Harbor entrance structure and channel blocking any influx of material from the east. In addition, the morphology of Gull Point, plus the known wave energy flux condition for the Erie, PA area (Saville, 1953) further documents the lack of littoral material influx from the east.

Considering the historical development of Presque Isle and the offshore bathymetry, there is little evidence that the offshore is active in supplying a net sediment gain to the Presque Isle system. The platform to the west is below wave base and no longer part of the active Presque Isle system. The offshore is the trailing edge of the migrating feature, and being in deeper water, it does not keep up with the subaerial part of Presque Isle. Thus, there is a continual net offshore loss to the system rather than any gains.

Offshore bars in the nearshore do migrate onshore, but this is simply a redistribution of sand within the system which may result in temporary onshore gains. During lower water periods, the bar system is driven offshore. The importance of the nearshore bar system in influencing the littoral transport patterns of the Presque Isle system has been documented during studies to monitor the shoreline changes to Presque Isle Peninsula and by sand tracer studies.

Thus, all natural influx to the system must come from the west. The approximately 20-mile long shoreline between Conneaut, OH, and the root of the Presque Isle Peninsula is generally unbroken by any dominate stick-out features, headlands, or major shoreline inconsistencies. The Federal harbor structures at Conneaut are a very effective block to any littoral material exchange with shores any f rther to the west. Therefore, this 20-mile section of shore is considered as a single section of shore closed at the west and open at the east where Presque Isle Peninsula serves as the eventual site of deposition for any littoral input. Any littoral sediment input to this section of shore must come from fluvial sources, onshore movement of offshore sands, or bluff recession. The shore to the west is characterized by 20- to 100-feet high eroding till bluffs. The typical section is about 60- to 70-feet high with shale at or just below the waterline, then a coarse-grained till (probably Ashtabula till), followed by a thick clay sequence, and overlain by a thin layer of lacustrine sands (Great Lakes Research Institute, 1975). The recession rate of this sequence ranges from 0.5 ft/year to 2.0 ft/year (Carter, 1977).

Streams in the area, for example Elk Creek and Walnut Creek, flow through steep, shale gorges and have drowned entrance mouths. This combination, plus field data gathered from Elk Creek in support of a proposed Elk Creek Small-Boat Harbor Project, suggest that sand and gravel input from streams is minimal. However, these creeks have such potential for high velocity during periods of discharge (i.e., a steep gradient) that any material which may have collected with the river bed could get washed out into the littoral zone. A field reconnaissance of the upper river basin would be necessary in order to ascertain the presence of any significant fluvial contribution to the littoral zone.

The beaches are generally small, pocket beaches on the updrift side of structures or occur as bay mouth bar complexes at the mouth of each creek. Occasionally, during a period of low water, a narrow beach may collect in front of the bluff areas. The beaches are generally composed of fine to coarse quartz and lithic sands and gravels with shingles of shales and siltstones. Frequently, the beach may appear as a shingle beach.

Little information exists on the offshore area to the west of Presque Isle Peninsula, but it is generally considered to be till or rock surfaced, with little evidence of an offshore sand source except in the area of the Presque Isle platform. The platform area is generally 20 to 30 feet below LWD and, therefore, is considered as below the active wave base. At creek mouths, a delta develops where the bay mouth bars are washed outward during a period of heavy discharge. Some of these delta areas may serve as sites for temporary storage with some minor onshore return from the delta shoals.

In summary, sediment input from the west is dominated by bluff recession rates. There is probably some creek input of a much more minor level, but it is impossible to quantify the level of this contribution at this

time. In order to develop a reasonable "ballpark" estimate of littoral transport rates from the west, it is necessary to make the following assumptions:

a. That the drift rate is controlled directly by the amount of material available for transport (This is a high energy shore where the wave energy is capable of transporting all the available littoral material).

b. That the primary source of littoral material is bluff recession.

c. That the major permanent littoral sink for this approximately 20-mile long section of coast is Presque Isle Peninsula. Other losses to the drift regime are limited to temporary storage in fillets associated with stick-out structures and small beaches and to permanent offshore losses. Offshore losses occur, particularly where small creeks divert littorally transported drift offshore into deltas and as material travels around the end of stick-out structures into deeper water. Offshore losses are assumed to be 20 percent.

The annual littoral input due to bluff recession between Conneaut and Presque Isle was calculated from bluff recession rates, bluff heights, reach length, and the stratigraphy presented by Carter (1977). Based on these computations, bluff recession contributes approximately 50,000 cubic yards of sands and gravels per year. Considering that 20 percent of this material is lost to the offshore, only about 40,000 cubic yards of littoral material per year are supplied to Presque Isle from the west (Figure 5).

Artificial nourishment has been a major factor influencing Presque Isle's development for the past 24 years. The need for replenishment reflects the highwater periods of the mid-1950's and the early 1970's which threatened to sever access to the outer peninsula. Over 6,200,000 cubic yards of material have been added to the system since 1955. This input has forestalled breaching of the neck, thus maintaining the neck's position and causing rapid growth at the accretionary east end (Gull Point). Replenishment has caused Presque Isle Peninsula to become elongated and has caused a net gain to the system.

The 4,150,000 cubic yards added in 1955-1956 was fine sand with a median size (50 percent size) of 0.20 mm which was obtained from borrow areas on the bayside of the peninsula. This sand was actually finer than the natural-sized beach material (0.35 mm) and was quickly eroded. The small amount of fill placed in 1965-1966 was medium sand (median size of 0.75 mm) and was considered as successful. As a result of this experience, the sandfill placed in the mid and late 1970's was a medium to coarse sand with a median size to the gradation band of about 1.8 mm. Prior to this period of nourishment, the neck was frequently breached. A major effect of a breach is to cause the neck to migrate eastward through overwash and bayside shoal development. Evaluation of

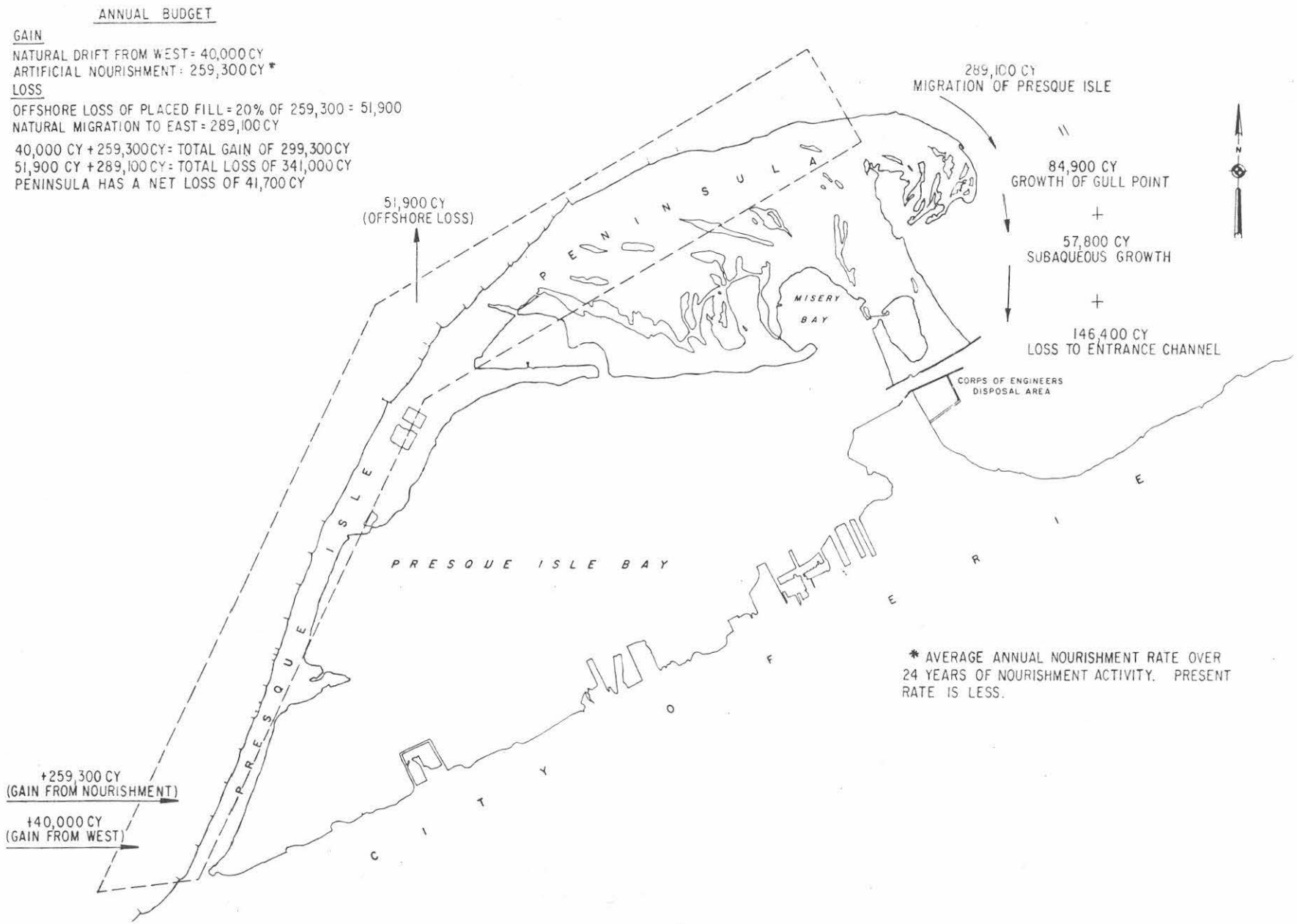

FIGURE 5. PRESENT CONDITION WITH ANNUAL NOURISHMENT SEDIMENT BUDGET

historical maps from the 1800's and early 1900's shows that the accretionary east end (Gull Point) has experienced sporadic growth possibly in response to migration of the neck.

Losses. Although Presque Isle Peninsula is a depositional feature, the dominate present activity is erosion. In 1877, the peninsula was described as eroding along the neck and eastward to a point which was 500' west of the lighthouse. A hundred years later, erosion characterizes the shore as far east as the east end of Beach 10. Thus, the nodal point between erosion and accretion has migrated 9,000 feet to the east in 100 years. Part of this nodal point shift is related to the natural migration of the system, and part is related to a net loss of material. The natural migration has been modified over the past 150 years by the many activities which have anchored and built the neck into a well-defined subaerial isthmus. According to Chief of Engineers reports from the early 1800's, the natural "neck" is a low, nominally vegetated, frequently overwashed, three and one-half mile-long sand spit. Efforts to stabilize the neck have resulted in the whole peninsula system being "stretched." As the distal end migrates, and the neck remains stable, the available littoral load is distributed over a longer shoreline. Thus, the Isle thins, the beaches narrow, and a greater length of shore erodes. This results in an "apparent" loss to the system.

Actual net losses are caused by offshore movement and platform building. Material leaves the system offshore around the total peninsula perimeter and at the distal east end.

Material is lost offshore as a result of bar formation and the migration of the peninsula away from its offshore platform. Typically, the offshore bar system migrates onshore and offshore in response to lake level changes and severe storms. During this cycle, there is a continual net offshore loss. The offshore bars at Presque Isle have been observed to be both complex and dynamic. Nummedal (1979) has identified four different bar forms and believes that substantial amounts of sediment may move along the bar systems. There are also offshore losses associated with the peninsula migrating eastward away from its western platform. That is, Presque Isle migrates east, leaving its platform behind. There is no present knowledge on the offshore losses from the Presque Isle system, but it has been estimated at 20 percent for use in developing a sediment budget (USAED Buffalo (1980)).

The main area of loss to the Presque Isle system is at the distal east end where the drifting sediment not only builds Gull Point, but also spills over the eastern end of the platform, building a new platform, and is recurved shoreward and landward, shoaling across the Erie Harbor entrance channel. Estimates have been made to summarize the losses at the east end based on historical changes at Gull Point, bathymetric charts, and dredging records for the Erie Harbor entrance channel. Based on these figures, the present condition (with replenishment) is

that 146,400 cubic yards of littoral material accumulate in the entrance channel per year, 84,900 cubic yards per year are involved in building Gull Point, and 57,800 cubic yards per year build the new platform at the distal end (Figure 5).

From 1960 to the present, the average annual volume dredged from the entrance channel has been about 225,950 cubic yards. Computations presented in USAED, Buffalo 1980, indicate that 146,400 cubic yards of the dredged material per year come from Presque Isle and the rest from the mainland to the east or from siltation of suspended sediments. The 1930 to the present dredging record does not identify the amount dredged each year from the entrance channel, but the bulk of the annual dredging probably is material which originated from Presque Isle Peninsula and was deposited in the entrance channel. The 1930-1977 dredging records show that dredging from 1960 to the present has averaged 95,150 cubic yards per year more than the 1930-1959 period. This probably reflects an increased influx of material as a result of the 1956-1971 beach replenishment operations and suggests that there is about a five to six-year lag between replenishment and increased dredging volumes in the entrance channel.

The annual rate of growth of the distal end (Gull Point) varies from a minimum of 18,400 cubic yards per year with shore protection structures, but no replenishment (1875-1950) to 84,900 cubic yards per year with replenishment (1950-1978). The natural growth rate without structures or replenishment appears to be about 43,600 cubic yards per year (1819-1875).

Therefore, the natural balance for Presque Isle without replenishment is summarized as a 40,000 cubic yard gain from the west, 51,300 cubic yard permanent loss to the entrance channel, 17,400 cubic yards used to build up the new eastern platform, and 18,400 cubic yards to develop Gull Point. The resultant system, therefore, has a migration rate of 87,100 cubic yards per year. Presently, the volume of Gull Point growth and the net loss to the entrance channel are higher (Figure 5), reflecting the additional available sediment load introduced by the replenishment activities.

ENGINEERING HISTORY OF PRESQUE ISLE

The Problem

The geological forces which have created Presque Isle are also gradually destroying it. The natural processes of erosion and deposition continue as Presque Isle continues to migrate. Destructive natural processes, although necessary in a migrating coastal feature, are considered as unacceptable on Presque Isle by the general human factor. Erosion of the lakeshore beaches and breaching of the neck have been counteracted by public and private efforts for over 160 years. A history of the human efforts to retard erosion of the peninsula is lengthy and complex.

History of Shore Protection

When the Federal project for Erie Harbor was first initiated back in the early 1800's, in addition to the work at the entrance, the project required protection of the shore at the neck of the peninsula of Presque Isle, which by its position, forms the harbor of Erie. The preservation of the peninsula is of vital importance to Erie Harbor, and it is for the purpose of preserving the harbor that protection of the long, narrow neck at the western end of the peninsula was originally deemed necessary. The protective works to date have been constructed to prevent breaching through the narrow neck during severe storms from the west. Such a breach would compromise the effectiveness of the harbor. A literature survey of the Chief of Engineers Reports (1867-1978) was undertaken, and the following paragraphs present a documentation on protective works which were implemented for preservation of Presque Isle Peninsula.

The attention of the United States Government was directed to Erie Harbor after the close of the War of 1812 from the fact that it was in Erie that Commodore Perry anchored his fleet after his memorable battle. In 1823, the Board of Engineers presented an elaborate report with a plan for the improvement of the entrance to Erie Harbor. Subsequently, the River and Harbor Act of 26 May 1824 authorized improvement of Erie Harbor and protection of Presque Isle Peninsula.

The first breach recorded appears to have taken place during the Winter of 1828-1829. Its location and extent were not reported, but the entire appropriation of $7,390.25 provided by the River and Harbor Act of 3 March 1829 was used in closing it. During the Winter of 1832-1833, another breach occurred. Nothing was done to close it, and in 1835, it was reported to be nearly one-mile wide. Plans were developed which provided for partially closing the breach with cribwork and to make a 400-foot wide western entrance to the bay. In 1836, work commenced and 420 feet of cribwork breakwater was completed, strengthened by piling, and partially filled with stone. This cribwork breakwater was extended 1,920 feet in 1837 for an aggregate length of 2,340 feet. It was reported that the progress in partially closing the breach was very satisfactory, and in 1838 an additional 1,035 feet of cribwork was built. Work continued in 1839 when 990 feet of cribwork was built. There were no appropriations nor work done during the years 1840 through 1843. In 1844, the breach was reported to be about 3,000-feet wide, and the erosion was such that 470 feet of cribwork was built to protect the barracks built for workmen in 1836. Nothing further was done and in 1852, the breach was reported as still existing, and the cribwork protection built in previous years had been almost destroyed. In 1853, efforts were made to prevent further erosion by protecting the shore with brush weighted with stone. The results were very satisfactory, and this mode of closing the breach was continued in 1854 through 1856. Work was suspended in 1857 due to lack of funds, and no further work was done until 1864. In 1864, it was reported that the breach at the west

end of the harbor was entirely closed, although about 500 feet of the peninsula was so low that waves would break clear across during high water and heavy gales. This low portion of the peninsula was strengthened in 1865 by placing old tree trunks, brush, saplings, etc., parallel to the shore, making a layer 30-feet wide.

During the years 1871 and 1872, 51,300 young trees, roots, and slips of silver poplar, American poplar, and willow were planted as an experiment on the west side of the peninsula for protection of the neck. Also, the beach at two exposed points was further protected by anchoring and picketing brush laid in rows and weighted with heavy stone. The Fall and Winter gales of 1873-1874 made alarming attacks on the shore of the peninsula, and in November 1874, the peninsula was once more breached. The breach was closed in 1875 with 400 feet of six-foot high pile and plank fence riprapped on both sides with stone. The protection proved to be successful, and an additional 1,080 feet of pile and plank fence was built at other weak points on the peninsula in 1875. This pile and plank fence was extended 3,056 feet in 1876, another 1,461 feet in 1877, and 550 feet in 1878, making a total length of 6,547 feet. In 1879, the protection fence was badly damaged at various points with the stone washed away, piles broken off, and planks destroyed.

In 1880, eight jetties 200 feet apart were built by driving lines of close piling out to a depth of 6 feet in the lake. A ninth jetty was built about two miles from the neck of the peninsula. In addition, about 2,000 feet of brush and stone protection was built along the lakefront to repair the protective fences which had been destroyed during the previous winter. Violent gales during the Winters of 1880-1881 and 1881-1882 destroyed several portions of the protective fencing built during the period from 1875 to 1878. In 1882, three additional piles were driven between every two old piles from the original protective fencing. About 1,000 feet of this type of protection was built to provide a nearly closed continuous row at a cost of nearly $2,500. This brought the total expenditures for work accomplished on Presque Isle during the period from 1829 through 1883 to approximately $220,000.

There was no work done for protection of Presque Isle Peninsula during the period from 1883 through 1887, and in 1887, it was reported that all the protection fences and pile jetties built in the previous years were so broken down and rotten that they were considered useless. The River and Harbor Act of 11 August 1888 authorized protection of the neck of the peninsula by construction of a 6,000-foot long timber pile and sheet pile breakwater located about 100 feet offshore. About 4,500 feet of breakwater was built by September 1889 at a cost of about $60,000 when a moderate storm badly wrecked all but 1,300 feet of the structure and work was ordered stopped since it was evident that the protection constructed was not going to prove serviceable. The remaining sheet piling and walings were washed away during a severe storm in October 1892.

No further work was done on protection of the peninsula during the period of 1890 through 1895. Several severe storms occurred during this period whereby waves would wash over the peninsula and into the bay, causing severe erosion along the western portion of the peninsula. In 1896, another experimental tree planting project was undertaken whereby 1,000 Carolina poplars, 200 Wisconsin willows, 200 yellow locusts, 200 Scotch pines, three bushels of blue grass, two bushels of orchard grass, one bushel of crimson clover, 300 willow cuttings, and about 60 native poplar trees were planted on the neck of the peninsula at a cost of $360. The purpose of the plantings was to make a growth that would catch drifting sand and increase the height and width of the neck, increase the resistance of the neck to erosion, and lessen the liability of a possible breach from waves washing over the neck of the peninsula. The trees planted in 1896 grew vigorously during the year and therefore, in 1897, about 2,400 yellow locust trees and two bushels of seeds of native shrubs were planted on the neck of the peninsula at a cost of $376. At that time, the plantings were regarded as an important part of the harbor works and further plant growth encouraged since those planted in previous years had thriven very well. Therefore, an additional 2,000 honey-locust trees and 200 willow cuttings were planted in 1898 at a cost of $210.

The River and Harbor Act of 3 March 1899 authorized construction of four protection jetties along the outer edge of Presque Isle Peninsula. The first jetty was built in 1900 and located 5,200 feet west of the Presque Isle Light. The structure cost about $5,390 and was of timber crib construction filled with stone and had a "T" across the outer end. The cribbing was 12-feet wide, 11-1/2-feet deep, and 290-feet long; the "T" was 10-feet wide, 11-1/2-feet deep, and 32-feet long. The second protection jetty was built in 1903 at a cost of $8,560 and located 7,800 feet west of the Presque Isle Light. In 1906, it was determined that the jetties built in 1900 and 1903 were not correcting the beach erosion along the peninsula and therefore, the remaining two jetties authorized by the River and Harbor Act of 1899 were never constructed.

There was no work done for protection of Presque Isle Peninsula during the period from 1904 through 1915. However, in 1916, about $316 was expended for planting 5,000 poplar trees and 2,725 linear feet of willow hedge on the neck of the peninsula to reinforce the existing growth. These trees and hedge grew well during the year and in 1917, an additional 2,310 poplar trees and 2,280 willow cuttings were planted to reinforce the existing growth at a cost of $195.

A severe storm occurred late in October 1917, causing waves to break over the neck of the peninsula and creating a breach about 150-feet wide. Work on closing the breach with a 300-foot timber bulkhead was initiated in mid-November and continued until early December with 270 feet being completed at a cost of $7,000 when another severe storm occurred, uprooting large trees, washing out small growth, destroying the completed portion of the timber bulkhead, and widening the breach to

479 feet. There were no further attempts made to close the breach during 1918, and storms during the Winter of 1918-1919 increased the width of the breach to 1,160 feet. Closure of the breach with sandfill protection was begun in the Fall of 1919 when a 500-foot section of fill protection at the east end of the breach was placed before operations were halted for the winter. When operations resumed in April 1920, the breach was 1,470-feet wide. During 1920, about 3,000 feet of sandfill protection and 1,700 feet of rubblemound protection were placed, and 4,800 small poplar trees were planted on the sandfill protection. In addition, 310 feet of riprap wall was placed on the lakeside of the sandfill protection. The sandfill protection was completed during 1921 with 1,500 feet being placed, and the riprap wall on the lakeside of the sandfill protection was extended 1,465 feet. During the period from October 1920 through November 1921, about 22,700 small poplar and 1,900 small willow trees were planted and 49 bushels of rye and six bushels of cowpeas sown to protect the sandfill. In 1922, the riprap stone wall on the lakeside of the sandfill protection was reinforced and extended 1,160 feet, thus completing the work in closing the breach. Approximately $282,000 was expended on work to close the breach.

The River and Harbor Act of 28 November 1922 reconveyed Presque Isle Peninsula to the State of Pennsylvania for park purposes, and its care and protection were no longer to be considered by the United States as part of the project for improvement of Erie Harbor. The State of Pennsylvania built six sand traps in 1927, a series of seven steel sheet pile groins during 1928 and 1929, and about 5,300 feet of steel sheet pile bulkhead in 1929 on the lakeside of the peninsula at various locations from the neck to the light-house.

The United States Government again became involved with Presque Isle Peninsula for the protection of Erie Harbor in 1930 and 1931 when 5,646 feet of steel sheet pile bulkhead (including shore returns) with 5,052 feet of stone facing, was constructed along the neck of the peninsula at a cost of about $165,400. The State of Pennsylvania extended this protection along the neck of the peninsula an additional 1,230 feet in 1931 and also built a steel sheet pile groin. In 1932, the State built two more steel sheet pile groins and extended the steel sheet pile bulkhead which they built in 1929 an additional 1,500 feet. This bulkhead was again extended 850 feet by the State in 1937.

In 1943 and 1944, the United States Government repaired shore protection works constructed in previous years and further protected the steel sheet pile bulkheads by construction of a rubblemound facing on the lakeside. In addition, 2,750 feet of rubblemound protection was constructed at the root of the peninsula, and two experimental 300-foot long rubblemound groins were built. The work undertaken in 1943 and 1944 was accomplished at a cost of about $1,041,700. Further repairs to the protection works along Presque Isle Peninsula were undertaken by the United States Government during the period from 1947 through 1952 at a total cost of $443,100. During the period from 1924 through 1948, it

was estimated that the Commonwealth of Pennsylvania had spent approximately $3,500,000 on maintenance of the peninsula.

Severe storms during the early 1950's led to the establishment of the cooperative beach protection program between the Federal Government and the Commonwealth of Pennsylvania as authorized by the River and Harbor Act of 3 September 1954. Work commenced in the Fall of 1955 and was completed in the Summer of 1956, during which time 4,150,000 cubic yards of sand were pumped on the beaches, ten new steel sheet pile groins constructed, two existing groins altered, and a badly damaged bulkhead section near the lighthouse groin was removed. The total cost of the cooperative project was $2,451,270, which includes a stone seawall 3,000-feet long built in 1952 on the neck of the peninsula.

An emergency sand replenishment was accomplished by the Commonwealth of Pennsylvania in the Winter of 1959-1960 at the cost of about $24,000. The cooperative beach protection program between the Federal Government and the Commonwealth of Pennsylvania was modifed by the River and Harbor Act of 14 July 1960 to include participation in periodic nourishment for a period of 10 years following the first major replenishment operation. The emergency protection in 1959-1960 prevented further damage to the project up to the time of the first major replenishment authorized by the 1960 River and Harbor Act. The first major replenishment was undertaken in 1960-1961 during which approximately 681,500 cubic yards of sand were pumped onto the beaches at a cost of $500,000. In 1963-1964, the Commonwealth of Pennsylvania repaired two groins which were built in 1956 by placing heavy stone at a cost of about $54,000. A second major replenishment authorized by the 1960 River and Harbor Act was required in 1964-1965, at which time approximately 402,300 cubic yards of sand were pumped on the beaches at a cost of $355,000. In 1965-1966, a third replenishment was undertaken whereby 45,000 tons of coarse-grained sandfill were placed, and six of the groins built in 1956 were modified by addition of a stone facing. The total cost for accomplishing the work undertaken in the third replenishment was about $166,000. A fourth major beach replenishment was undertaken in 1968-1969, with 102,700 tons of coarse sandfill being placed on the beaches at a cost of $348,000. The fifth and final beach replenishment operation under authorization of the 1960 River and Harbor Act was accomplished in 1971 when a 1,200-foot long barrier consisting of nylon bags filled with sand and grout was built at Beach No. 6, and 152,500 tons of sand were placed on the beaches at a total cost of $535,000.

In 1973, an emergency sand replenishment was undertaken by the Federal Government, whereby 100,000 tons of sand were placed along the neck of the peninsula at a cost of $240,000. Due to the severe erosion problem which still existed, the cooperative beach protection program between the Federal Government and the Commonwealth of Pennsylvania was again modified. The Water Resources Development Act of 1974 authorized the Federal Government to participate in beach nourishment for a five-year period. Actual work under the program was initiated in 1975 with the

placement of approximately 187,000 tons of sand and a total expenditure of $1,097,000. A second nourishment was completed in 1976 at a cost of about $1,097,000 for placement of 183,000 tons of sand. In 1977, sand from land sources was used instead of from an offshore borrow area as in the previous two years, and 287,000 tons of sand were placed at a cost of about $1,089,000. The fourth beach nourishment project was completed in 1978 at a cost of $1,074,000 and included construction of three experimental prototype breakwaters offshore from Budny Beach (Beach No. 10) and placement of 173,000 tons of sand. A fifth and sixth beach nourishment projects were completed in 1979 and 1980 at a cost of $1,061,000 and $1,082,000, respectively, for placement of 216,000 tons of sand on beaches along the lake shoreline each year. A seventh beach nourishment project requiring the placement of 236,000 tons of sand, was completed in 1981 at a cost of $1,213,000. An eighth replenishment operation, requiring the placement of 284,000 tons of sand, was completed in 1982 at a cost of $1,430,000.

During the past 25 years, the Commonwealth of Pennsylvania, in addition to contributing approximately $5.2 million to the cooperative beach nourishment program, has expended several million dollars for performing emergency repairs to roadways on the peninsula which were damaged during storms, for undertaking sand replenishment operations, for placement of stone protection at critical locations on the lakeside, as well as the bayside of the peninsula, and for grout-filled nylon bag barriers.

Existing Structures

The structures built for preservation of Presque Isle Peninsula during the 1800's and early 1900's were mainly of timber construction. These structures had a useful life of only a few years before being destroyed. During the period from 1920 through 1978, rubblemound and steel sheet pile construction methods were implemented. These types of construction are more durable and longer lasting. Structures built of these types of construction make up the majority of the protective structures presently in existence along the peninsula. The locations of protective structures presently in existence along Presque Isle Peninsula, the type of construction utilized, the date the structures were built, and who built them are presented on Figure 6. The types of some of the existing structures and experimental projects implemented at Presque Isle will be observed during the field trips.

PROPOSED PROJECT

Presque Isle is a migrating feature with a continual loss of material. Any project which is designed to stabilize Presque Isle must consider the system as a whole. It is impractical to protect only one portion of the system, as the system will continue to migrate and the bars will continue to carry sediment. Thus, the Corps of Engineers (USAED, Buffalo, 1980) designed a plan which is intended to protect the whole

peninsula unit, from serious erosion by utilizing the offshore bar system, to stabilize the shoreline.

The plan consists of construction of a system of 58 rubblemound breakwaters located about 400 feet offshore along the lakeward length of the peninsula, parallel to the shoreline, and positioned in the trough between the first and second offshore sand bars. Each structure would be 150 feet in length with a 350-foot gap between structures. In addition, 500,000 cubic yards of sandfill would be placed along the shoreline in the lee of the breakwaters to provide a recreational beach berm. The breakwaters are intended to attenuate the wave action to such a degree as to reduce littoral drift by approximately 75 percent, thus slowing the migration of the feature, reducing erosion and helping to maintain the beach area in the lee of the breakwaters.

SUMMARY

The Commonwealth of Pennsylvania summarizes the natural wonder which is Presque Isle in a sign which greets all visitors:

> "Welcome to Presque Isle Peninsula. Enjoy its unique botanical and geological evolution, historical background, bird and animal life."

ROAD LOG AND STOP DESCRIPTIONS

	Miles	Time
Buffalo Marriott Inn to entrance of Presque Isle Peninsula	115	2 Hr, 30 Min
Presque Isle entrance to Beach 10 (Bay Route)	8.2	14 Min
Beach 10 to Beach 6 (Lake Route)	3.6	7 Min
Beach 6 to Entrance	2.3	5 Min
Entrance of Presque Isle to Buffalo Marriott Inn	115	2 Hr, 30 Min

Stops Planned (Reference Figure 1)

Groins 1 and 2
Walk Groin 5 to Beach 6
Beach 10
Walk out to Gull Point Lighthouse
Walk Beach, 8 and 7

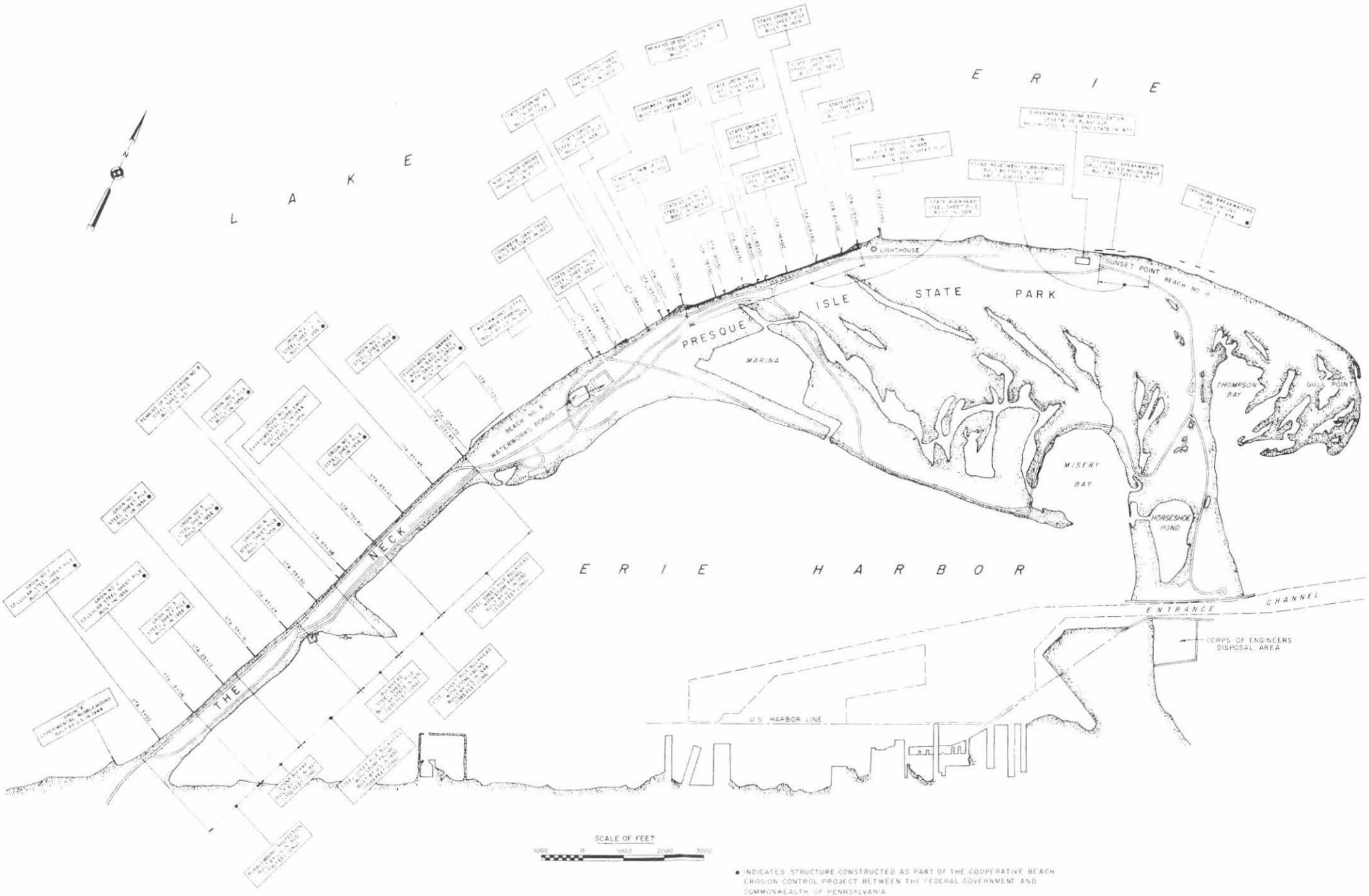

FIGURE 6. EXISTING PROTECTION STRUCTURES

REFERENCES

Calkin, P.E., 1970, Strand Lines and Chronology of the Glacial Great Lakes in Northwestern New York, The Ohio Journal of Science 70 (2): 78, p. 78-96.

Carter, C.H., 1977, Sediment Load Measurements Along the United States Shore of Lake Erie, Report of Investigations No. 102, State of Ohio, Department of Natural Resources, p. 24.

Fullerton, D.S., 1971, The Indian Castle Glacial Readvance in the Mohawk Lowland, NY, and its Regional Implications, Part II Correlations and Ages of Glacial Lakes, Moraines and Tills in Western and Central New York and Neighboring Regions. PhD dissertation, Princeton University, p. 92.

Great Lakes Research Institute, 1975, Shoreline Erosion and Flooding, Erie County, PA, Commonwealth of Pennsylvania, Department of Environmental Resources.

Hough, Jack L., 1958, Geology of the Great Lakes: Urbana, University of Illinois Press, p. 313.

Jennings, O. E., 1930, Peregrinating Presque Isle, Carnegie Magazine, V.4, p. 171-175.

Leverett, F., and Taylor, F.B., 1915, The Pleistocene of Indiana and Michigan and the History of the Great Lakes, U. S. Geological Survey Monograph LIII, p. 529.

Lewis, C.F.M., Anderson, T.W., and Berti, A.A., 1966, Geological and Palynological Studies of Early Lake Erie Deposits, in Proceedings Ninth Conference on Great Lakes Research, 1966, Institute of Science and Technology, The University of Michigan, Ann Arbor, p. 176-191.

Lewis, C.F.M., 1969, Late Quaternary History of Lake Levels in the Huron and Erie Basins, in Proceeding Twelfth Conference on Great Lakes Research, 1969, International Association for Great Lakes Research, Ann Arbor, Michigan, p. 250-270.

Lewis, C.F.M., 1966, Sedimentation Studies of Unconsolidated Deposits in the Lake Erie Basin, PhD dissertation, University of Toronto, p. 134.

Messinger, D.J., 1977, Form and Change of a Recurved Sandspit, Presque Isle, PA (6/22/74 - 11/20/75). MA Thesis, State University College, Fredonia, NY, p. 122.

Nummendal, D., 1979, Monitoring of Shoreline Changes, Presque Isle, PA, Annual Report for Contract DACW49-78-C-0020, Unpublished USAED, Buffalo report.

Rummel, Klepper and Kahl-Fertig Engineering Company, 1968, Final Engineering Report, Presque Isle Survey, Erie County, Pennsylvania, Commonwealth of Pennsylvania, General State Authority, Project No. G.S.A. 163-8, p. 131.

Saville, T., 1953, Wave and Lake Level Statistics for Lake Erie, Tech. Mem. No. 37, Beach Erosion Board, Corps of Engineers.

Schooler, E.E., 1974, Pleistocene Beach Ridges of Northwestern Pennsylvania, Commonwealth of Pennsylvania Dept. of Environmental Resources, General Geology Report 64, p. 38.

Shepps, W.C., White, G.W., Droste, J.B., Sitler, R.F., 1959, Glacial Geology of Northwestern Pennsylvania, Commonwealth of Pennsylvania, Dept. of Internal Affairs, Topographic and Geologic Survey, Bulletin G32, p. 59.

USAED, Buffalo, 1980, Phase I General Design Memorandum on Cooperative Beach Erosion Control Project at Presque Isle Peninsula, Erie, PA, 2 Vols.

Wall, Robert E., 1968, A Sub-Bottom Reflection Survey in the Central Basin of Lake Erie, Geological Society of America Bulletin, Vol. 79, p. 91-106.

White, G.W., Totten, S.M., and Gross, D.L., 1969, Pleistocene Stratigraphy of Northwestern Pennsylvania, Commonwealth of Pennsylvania State Planning Board, Bureau of Topographic and Geologic Survey, General Geology Report G55, p. 88.