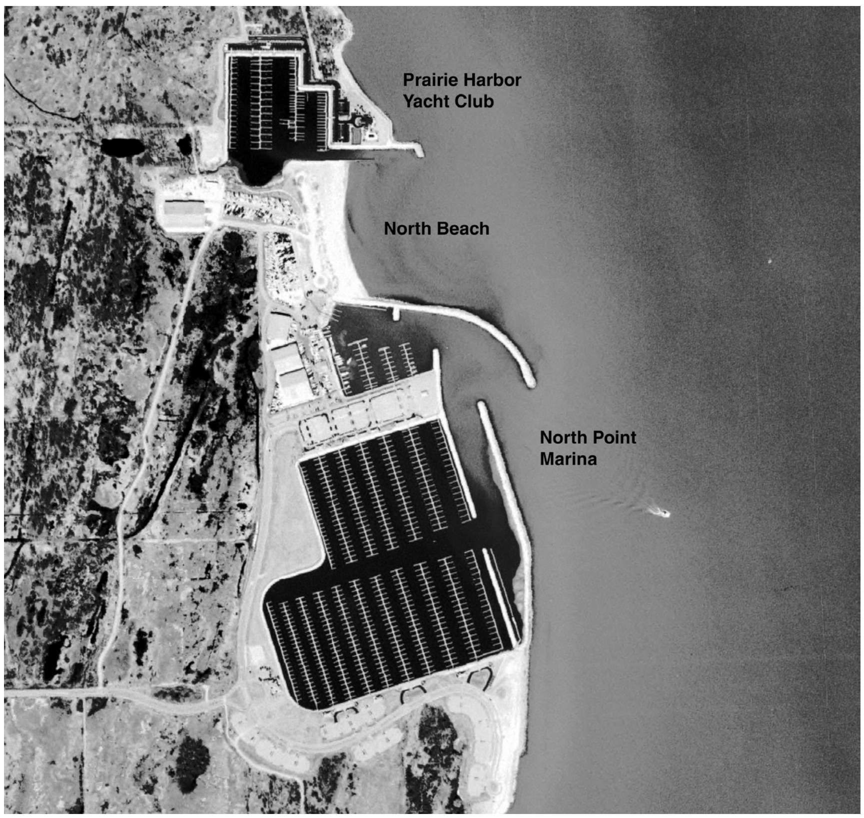
Evaluation of 1988–2002 Lake-Bottom Changes in the Vicinity of North Point Marina

Michael J. Chrzastowski
Illinois State Geological Survey
Champaign, IL 61820-6964



Prepared for:

Illinois Department of Natural Resources
Office of Capital Development
Division of Engineering
One Natural Resources Way
Springfield, IL 62702-1271

March 2003 **ISGS Open File Report 2003-2**

Table of Contents

List of Figures

List of Tables

Executive Summary

A bathymetric survey of the North Point Marina vicinity was completed in July 2002 to document lake-bottom configuration and to compare with similar data collected in 1988. This comparison provides a record of net lake-bottom changes for the first 14 years following marina construction. This study was completed by the Illinois State Geological Survey (ISGS) at the request of the Engineering Section of the Illinois Department of Natural Resources (IDNR) Office of Capital Development.

Nearly the entire July 2002 lake bottom is a smooth, gently sloping surface consistent with a sand-dominated bottom. At the marina entrance, on a west to east cross section, there is both a shoal and an erosional trough. The shoal is near the end of the south breakwater and has a minimum depth of 4 ft Low Water Datum (LWD). This depth is 8.1 ft less than the marina entrance project depth (12.1 ft LWD). Between this shoal and the end of the north breakwater is an elongate erosional trough that has a maximum depth of 17.5 ft LWD, which is 3.7 ft beneath the 1987 preconstruction depth and about 3 ft beneath the base elevation of the north breakwater. An erosional trough has been a persistent feature in this location for some time. It is likely maintained by currents associated with contrasts in water level between the marina and lake. The 17.5-ft depth is the deepest yet recorded in the trough.

Volumetric analysis of 1988-2002 lake-bottom changes indicates that between the state line and the southern end of the North Point Marina south parking area, the dominant change in this 14-year interval has been accretion. Accretion totals 224,800 cubic yards (cu yds), and erosion totals 88,000 cu yds, a net gain of 136,800 cu yds. Because all of this area was net erosional prior to marina construction, this net accretion documents that the marina has acted as a partial barrier to net littoral transport. These values are minimum accretion volumes because they do not account for the net gain of sediment within the marina basin beyond the entrance. The accretion is primarily (87%) along a pathway extending from the state line to the marina entrance and continuing southward along the North Point Marina south breakwater. This pathway indicates that the primary source of sand infilling the marina entrance is sand moving southward across the state line. The gain in sand at North Beach accounts for 13% of the total accretion. Based on lateral shift of the 0 LWD contour, the sediment gain at North Beach has resulted in a 14-year average gain in beach width of about 170 ft.

Recommendations for dredging give priority to removing sand in the marina entrance, followed by dredging along the accretion pathway from the state line to the North Point Marina south breakwater. If dredging reestablishes preconstruction depths and focuses on several key areas of concentrated accretion, approximately 93,000 cu yds would be dredged. Long-term sand management could be facilitated by dredging a depression area just south of the state line to function as a sand trap. A dredging schedule could capture sand from this trap and transport it to downdrift beaches before this sand migrates southward and is deposited in or near the marina entrance.

Part 1: Introduction

1.1 Overview

This report summarizes results from a 2002 bathymetric survey in the vicinity of North Point Marina and comparisons with similar data collected in 1988. The primary purpose of this work was to document net changes in the local bathymetry over this 14-year period.

North Point Marina is located on the Illinois shore of Lake Michigan just south of the Illinois-Wisconsin state line and adjacent to the north end of the North Unit of Illinois Beach State Park (Figure 1-1). The marina contains 1,500 slips, making this the largest marina in the Great Lakes. The rubble-mound outer breakwaters that define the marina footprint and the 72-acre basin make the marina complex a prominent feature on the Illinois coast (Figure 1-2). As such, the marina breakwaters, the marina entrance channel, and the varied shoreline infrastructure associated with the marina all have the potential to interact with the natural wave-induced transport of littoral sediment along this reach of the Illinois shore. This study determined the distribution, thickness, and volume of sediment that has accreted and/or eroded from the lake bottom in the marina vicinity since the marina was constructed.

North Point Marina is owned and operated by the Illinois Department of Natural Resources (IDNR). This survey was conducted at the request of the IDNR Office of Capital Development Division of Engineering. The findings presented here will assist IDNR in managing the sand resources on the beaches and across the lake bottom in the marina vicinity as well as in incorporating the marina sand management with ongoing sand management along the shore of Illinois Beach State Park (IDNR Task Force for Coastal Stewardship, 2001). This report is a deliverable for IDNR Contract G02163E (ISGS Contract 1-5-39763).

1.2 Background

Construction of North Point Marina began in summer 1987 and reached peak activity in 1988. The construction involved the creation of a protected marina basin by a combination of excavating into the preexisting beach and backshore area and constructing lakeward protruding rubble-mound breakwaters. As a result, the marina straddles the preconstruction shoreline. The north breakwater has the most lakeward extent reaching to about 1,000 feet east (lakeward) of the preconstruction (1987) shoreline (Figure 1-3).

Prior to the start of construction, a study was conducted by Moffatt and Nichol Engineers (1986) addressing the potential impacts to the local alongshore (littoral) transport of sediment in the marina vicinity. This study was done because it was recognized that the lakeward protrusion of the north breakwater would form a partial barrier to the net southward transport of littoral sediment. The result would be an accumulation of sediment on the north (updrift) side of the marina forming shoaling and an expanded beach. The associated deficit of littoral sediment to the shore immediately south (downdrift) of the marina was a factor that would contribute to shore erosion.

In planning for the marina construction, the potential for downdrift erosion was to be mitigated by supplying this shore with the sand and gravel hydraulically dredged from the marina basin. Between 1987 and 1989, an estimated 2.5 million cubic yards (cu yds) of sand and gravel were discharged to the shore area on the south side of the marina. The hydraulic discharge of this sediment formed an expansive delta that at one time protruded farther lakeward than the most lakeward extent of the south breakwater. This delta was intended to erode and act as a feeder beach to supply sand to the state park shore to the south. Erosion along the lakeward margin of this delta was allowed to proceed

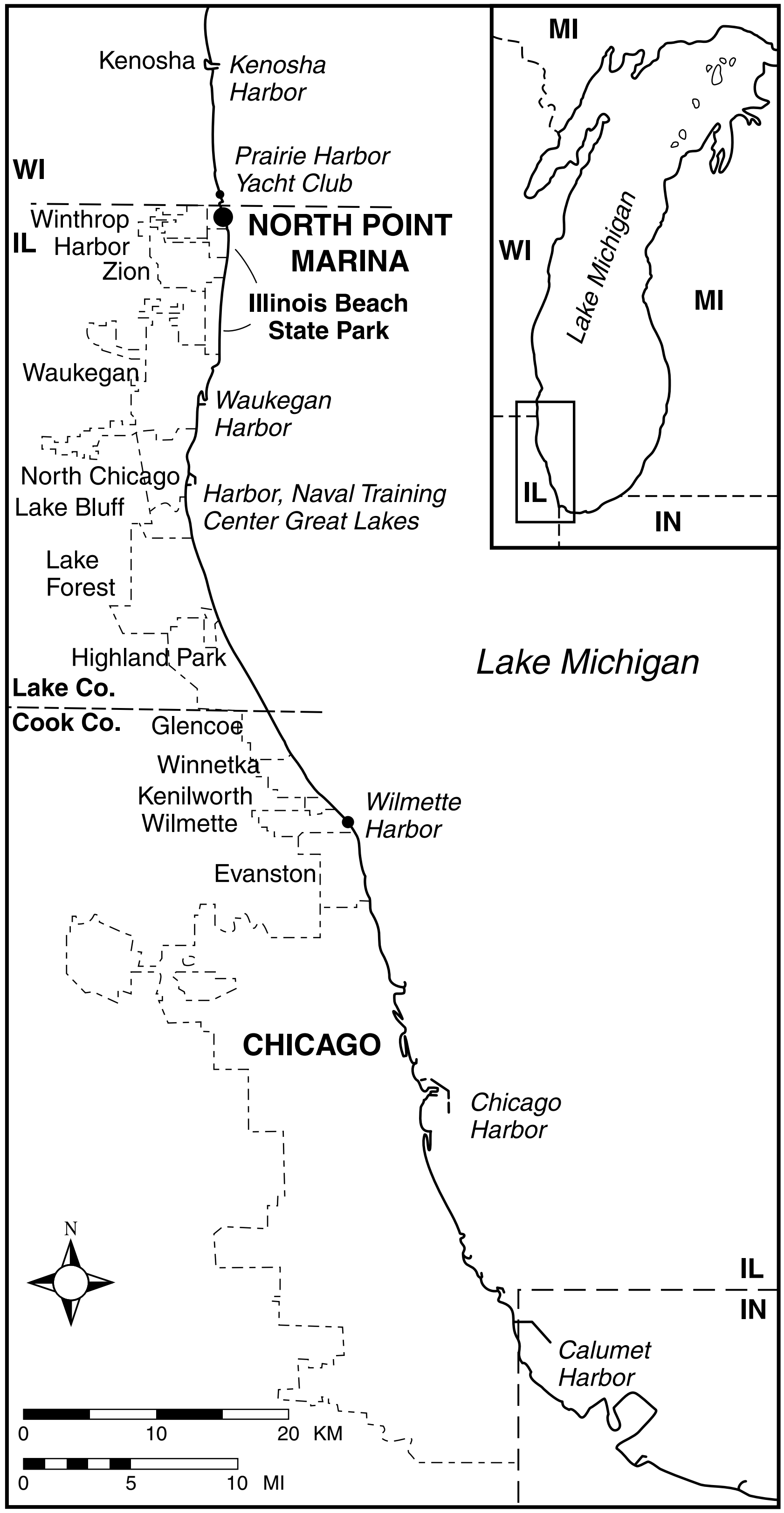


Figure 1-1 *The Illinois coast of Lake Michigan showing location of North Point Marina and other major harbors.*

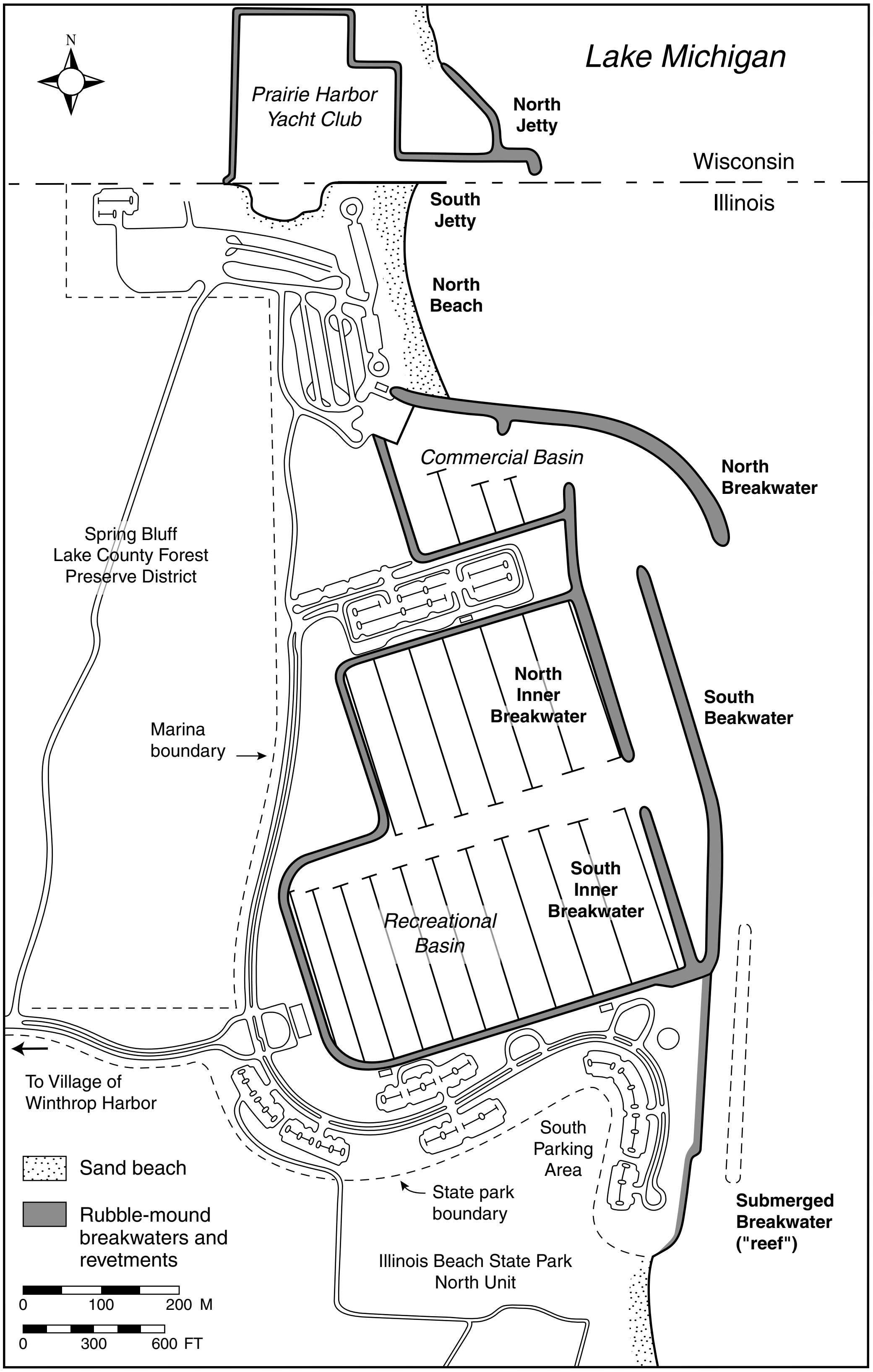


Figure 1-2 *Map of the North Point Marina (NPM) vicinity.*

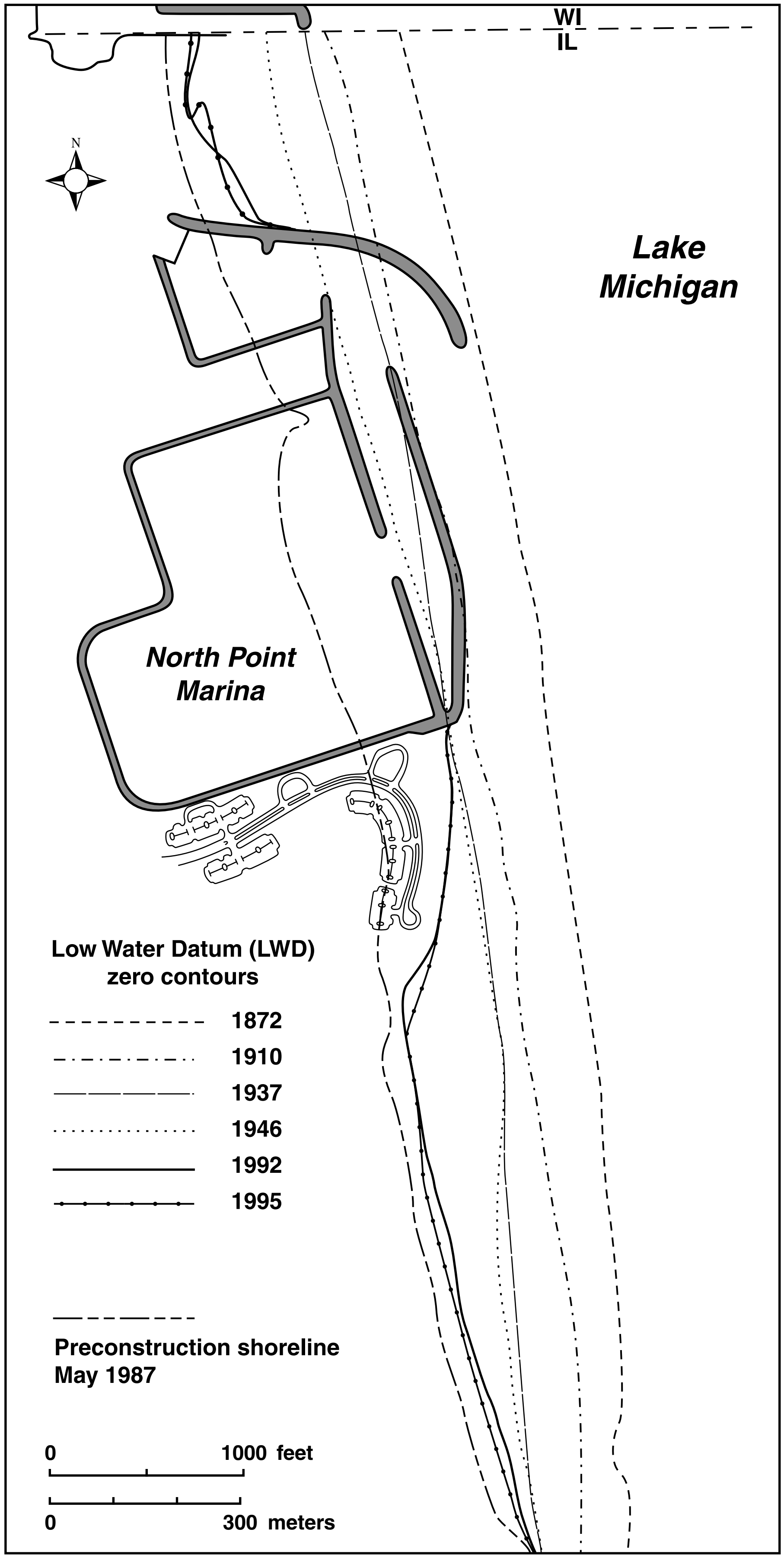


Figure 1-3 *Record of Low Water Datum (LWD) zero contours in the North Point Marina vicinity spanning 1872 to 1995. This shore has had persistent erosion and the highest rate of historical shore erosion along the entire Illinois coast.*

unimpeded until November 1989 when a first phase of shore protection was installed to protect the marina's south parking area, which is constructed atop the landward half of the delta.

Since late 1989, the beach immediately south of the marina's south parking area has been a feeder beach supplied with sand and gravel (1) bought from inland sand pits; (2) obtained from dredging in the cooling water channels at the Waukegan coal-fired power station (present owner MidWest Generation Co.; previous owner Commonwealth Edison Co.); (3) obtained from dredging by the U.S. Army Corps of Engineers in the approach channel to Waukegan Harbor; and, (4) to a limited degree, obtained from dredging in the entrance at the neighboring marina (Prairie Harbor Yacht Club) located just north of the Wisconsin-Illinois state line.

The marina project called for a recreational beach to be maintained along the shore immediately north of the north breakwater. Moffatt and Nichol Engineers (1986) stated in their report that anticipated entrapment of sand against the north breakwater would need to be monitored over time. Additional sand along this beach (North Beach) would increase the beach width and improve opportunities for beach recreation. However, with time, this sand accretion against the north breakwater could reach sufficient volume that the addition of sand would build around the breakwater and lead to accretion at or near the marina entrance. Accretion near the entrance could reduce the water depth in the channel needed for safe boat traffic.

The rate of sand accretion against the north breakwater was primarily a function of the annual volume of littoral sand that was coming across the Wisconsin-Illinois state line. This transport volume varies from year to year according to the intensity, frequency, and duration of storm waves, lake-level variations, and the volume of sand available from updrift erosion or stream input. Moffatt and Nichol Engineers modeled the sand accretion based on the best available estimates of the littoral sediment supply crossing the state line. Several different volumes were used in the modeling ranging from a low of 10,000 cu yds to a high of 140,000 cu yds. The "best estimate" was considered to be 60,000 to 80,000 cu yds per year (cu yds/yr).

Figure 1-4 shows the predicted (Moffatt and Nichol Engineers 1988) shoreline changes at North Beach for the first five years following breakwater construction using a sediment influx of 60,000 cu yds/yr. North Beach was predicted to assume more of a triangular shape with time as the shore built farther to the east against the north breakwater. The shoreline and lake-bottom contours would eventually become tangential to the north breakwater. The model predicted that this tangential configuration would develop in about 2 to 3 years. Sand would then begin to naturally bypass the north breakwater. The model predicted that continued beach accretion would occur until year 5 when the accretion would reach capacity. After this time, all sediment would bypass the north breakwater. The model also predicted that the accretion at the far north end of North Beach could cause shoaling at the entrance to the neighboring marina located on the Wisconsin side of the state line (presently Prairie Harbor Yacht Club, then known as Trident Harbor).

The modeling indicated that a maximum capacity of about 200,000 cu yds could occur at North Beach by the time of initial natural bypass. The mitigation that Moffatt and Nichol Engineers (1986) proposed was to monitor the accretion and to schedule dredging and excavation of the entrapped sand prior to the time of initial natural bypass. The sand removed from the North Beach area would be placed on the beach or shallow nearshore south of the marina, allowing it to continue in net southward transport along the shore of Illinois Beach State Park.

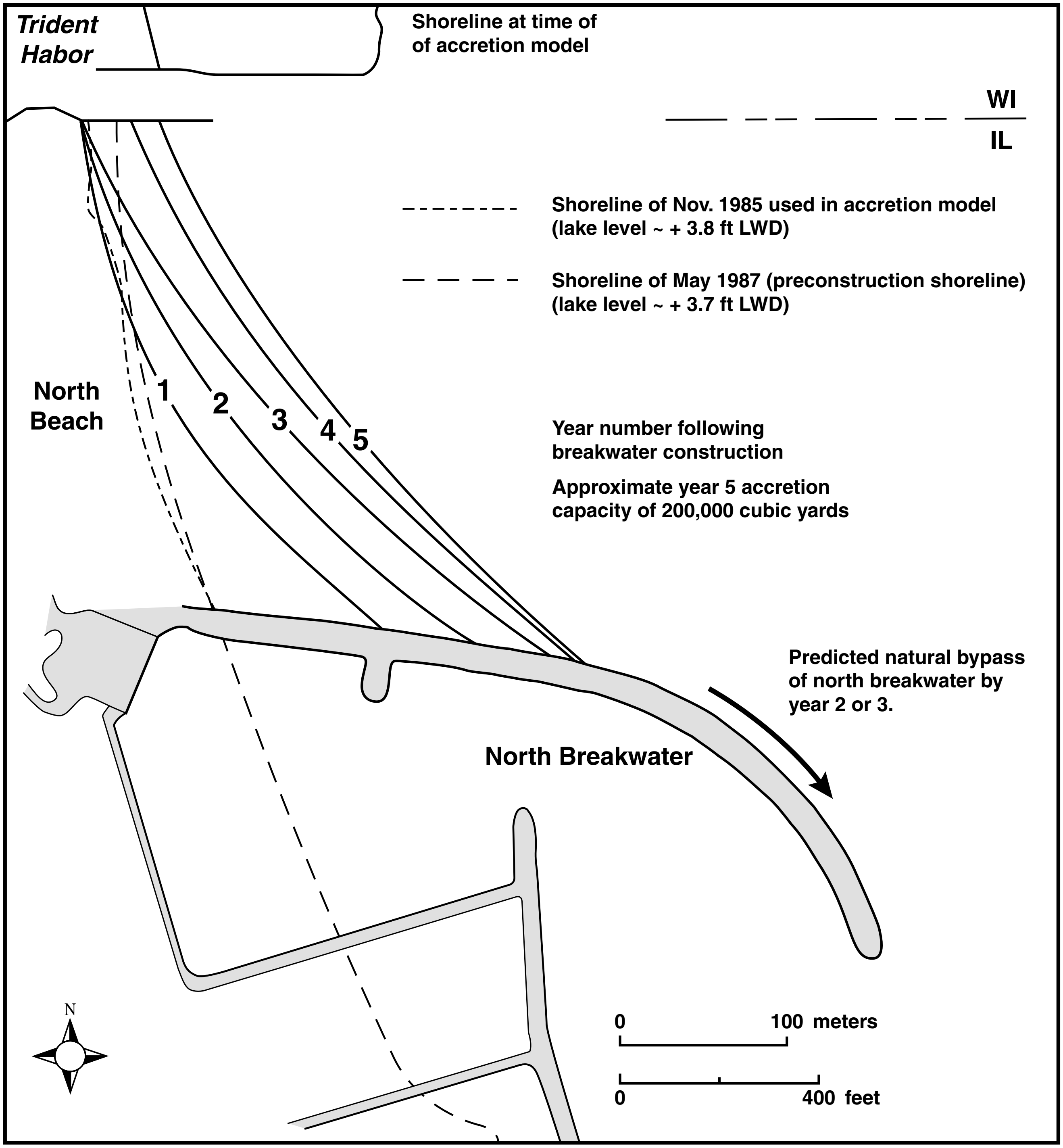


Figure 1-4 *Anticipated shoreline accretion at North Beach for the first five years following breakwater completion (1988-1992) based on a littoral sediment influx of 60,000 cubic yards per year (cu yds/yr) (modified from Moffatt and Nichol Engineers, 1986).*

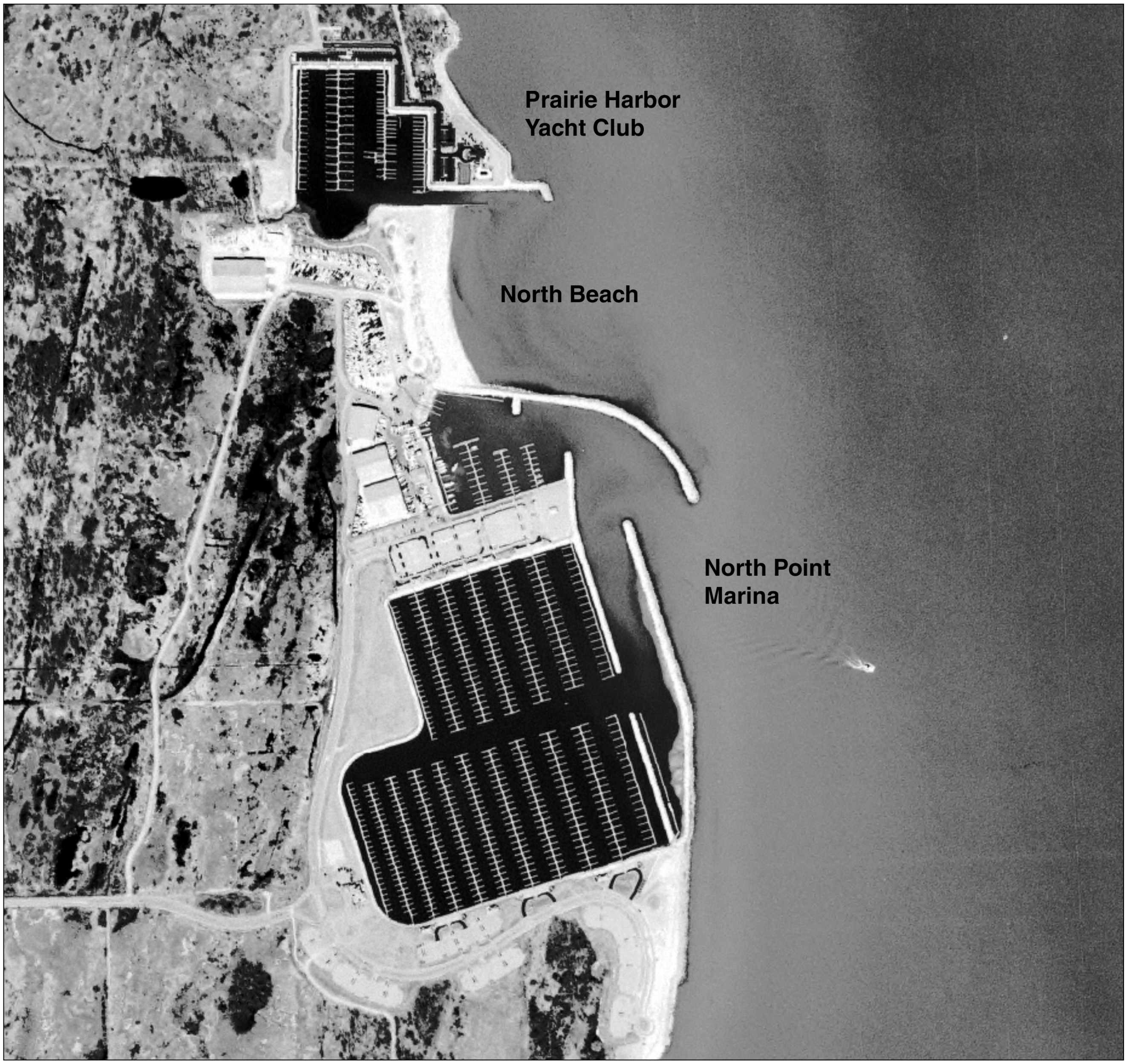


Figure 1-5 *Aerial photograph (1991) of the North Point Marina vicinity.*

Subsequent to the completion of North Point Marina, monitoring of shoreline position and lake-bottom morphology at North Beach and the vicinity of the north breakwater determined that the predicted triangular growth of North Beach did not occur. As shown in Figure 1-5, the shoreline does have a slightly more lakeward extent along the north breakwater. However, since completion of the breakwater, North Beach has essentially maintained a concave lakeward configuration. One factor in this unanticipated shape is an overestimate of the volume of littoral sediment coming across the state line. In addition, changes to the design of shore structures at the entrance to Prairie Harbor may have contributed to a sediment influx, transport, and accretion pattern at North Beach that was different from the prediction. Although the North Beach response was different from the modeling prediction, what did occur, as predicted, was shoaling at the entrance to North Point Marina. Shoaling also became a problem at the entrance to Prairie Harbor Yacht Club.

By summer 2002, considerable maintenance dredging was needed at the entrance to North Point Marina. There were questions as to the pathway that sand was taking to reach the marina entrance. There was also a question as to what dredging might be needed in the North Beach area or along the north breakwater to restore lake-bottom depths to what they were at the time of marina construction. The bathymetric survey reported here was conducted to address these questions.

1.3 Scope

The Illinois State Geological Survey (ISGS) collected bathymetric data in the vicinity of North Point Marina on an annual basis from 1987 though 1991 and from 1995 through 1998. These data provided a means for annual comparisons of lake-bottom change. This current survey, conducted in 2002, had the objective of providing the data needed to determine net lake-bottom changes since the marina breakwaters began to influence sediment transport. Data collected in 1987 and 1988 were the baseline for this comparison. The primary data set used in the comparison was 1988 because of that survey's greater accuracy and because the data collection procedures used then could be more readily duplicated in the 2002 survey. The specific tasks of the 2002 study are as follows:

- conduct a bathymetric survey of the North Point Marina vicinity from the Wisconsin-Illinois state line to a point about 500 ft south of the marina's south parking area,
- produce 1-ft contour interval maps of the 2002 bathymetry corrected to Lakes Michigan-Huron Low Water Datum (LWD),
- compare the 2002 and 1988 data sets to produce one-foot contour interval maps of the extent and thickness of net lake-bottom accretion and erosion,
- compute the volume of lake-bottom accretion and erosion for selected areas, and
- make recommendations for short- and long-term sand management in the marina vicinity.

1.4 Field Procedures

The 2002 bathymetric survey was conducted from July 8 through July 14, 2002. The survey followed the same procedures used in 1988. The grid used for the survey was the Illinois State Plane Coordinate System. Bathymetric profiles were collected on east-west lines of this grid at a 100-ft line spacing. The northernmost line was Northing 2122500N located just south of the Wisconsin-Illinois state line; the southernmost line was Northing 2117400N. This spacing resulted in 52 lines covering a north-south coastal reach of 5100 ft. Several supplemental profiles not on this grid were run in the marina entrance. Each of the 52 profile lines extended to Easting 645500E. This ensured that all profile lines extended beyond the 20-ft (6-m) contour, which is considered the depth of closure for profile change along the shore of southern Lake Michigan.

The bathymetric data were collected from a 12.5-ft inflatable boat with a 15-hp outboard motor equipped with a Ross Model 803 Portable Survey Recorder having a 100-kHz transducer. Depth calibration was checked daily at the beginning of each day.

The data collection required a two-person onshore team and a two-person team in the survey boat. During the profiling, the boat was maintained on the desired profile line (Y) by a person onshore using a transit fixed on the azimuth of the line (N090°E). Radio and visual signals to the boat operator were used to keep the boat within one boat width (5.6 ft) of the line.

Offshore distance to the boat (X) was measured by a Motorola Mini-Ranger III system (accurate to +/- 10 ft; 3 m) that uses a microwave to determine the distance between a transceiver mounted on the boat and an onshore transponder. The onshore transponder was placed at the profile origin, which was a marked point for which the easting (and northing) had previously been determined. The Mini-Ranger III system includes a control console onboard the survey boat that provides an LED display of distance in meters from the onshore transponder. The fathometer operator monitored the console display to make fix marks and annotations on the fathometer record at every 10-m (32.8-ft) increment to provide a location reference (X, Y) for the depth (Z) data.

For the ten profile lines that crossed the shallow water less than 3 ft deep at North Beach and extended up and across the beach, profile data were collected using a total station and prism pole. The total station was set at a surveyed reference point on the west end of the north breakwater. A person with the prism pole traversed the profile line from shallow water to the upper limits of the beach. The overlap of prism pole data and fathometer data in the shallow nearshore provided a check on the fathometer records.

1.5 Data Processing

All of the water depths reported here are referenced to the Lakes Michigan-Huron Low Water Datum (LWD; also called Chart Datum). Relative to the International Great Lakes Datum of 1985 (IGLD 1985) the Lakes Michigan-Huron LWD has an elevation of 577.5 ft (176.0 m). In order to correct the field data to LWD, water levels for the NOAA National Ocean Service lake gauges at Calumet Harbor, Illinois (Station 9087044) and Milwaukee, Wisconsin (Station 9087057) were referenced for the nearest 6-minute reading compared with the time of running each profile line.

The Calumet Harbor and Milwaukee data were averaged (since North Point is approximately a mid-point location) and this lake elevation was subtracted from the elevation for LWD. This procedure provided a correction factor to adjust water depths to LWD. For this 2002 survey, the corrections varied from minus 1.1 ft to minus 1.4 ft. By using vertical scale templates with the required water-level correction to reference depths to LWD, the fathometer traces were read to mark the locations of 1-ft LWD integer depths. The offshore distance to these integer depths was determined by measuring between the nearest 10-m distance-increment marks. The depths and the corresponding offshore distance were used to plot 1-ft contour interval bathymetric maps at a scale of 1:1,200.

Part 2: 2002 Bathymetry

2.1 Overview

The lake bottom in the vicinity of North Point Marina is predominantly sand that ranges in thickness from as much as about 20 ft along the shoreline at North Beach to less than a foot thick about 1.5 miles offshore. Underlying this sand is compact gray clay (clayey till) that was deposited beneath the glacial ice that receded from this area about 14,000 years ago. Diver inspection has determined that this clayey till is exposed on the lake bottom about 1,000 ft east of the entrance to North Point Marina and forms a hummocky bottom configuration in that area. The entire sand-dominated lake bottom has a regular configuration of broad, gentle slopes.

The sand lake bottom is dynamic and changes seasonally and from year to year as the result of storm frequency and intensity, wave and current movement, the gain and loss of sand, and fluctuations in lake-level. Year-to-year changes from 1987 through 1997 are depicted on bathymetric maps in previous reports by the ISGS (Chrzastowski et al., 1996; Foyle et al., 1997, 1998). Data from an unpublished 1988 survey are on file at the ISGS (Chrzastowski, 1999). The following text summarizes the bathymetry that was mapped during summer 2002 and refers to the bathymetric mapping shown in Figures 2-1, 2-2, and 2-3. Appendix A contains a composite bathymetric map that shows the entire surveyed area from the state line to just south of the North Point Marina south parking area.

2.2 State Line to North Breakwater *(Figure 2-1)*

From the state line to the eastern end of the north breakwater, the lake bottom in general is a rather featureless plain with a gentle eastward slope. There are no troughs or erosional features along the toe of the north breakwater like those found in some previous years (1989 through 1990, 1992, 1995, 1997, 1998; see Figure 3-7 in Foyle et al., 1998). The overall configuration of the contours in this area shows that the lake bottom has adjusted to facilitate the natural transport of sand from the state line southward to bypass the North Point Marina north breakwater. This adjustment is apparent from the 8- to 15-ft LWD contours, which follow a NW-SE orientation. Farther offshore, the 16- to 20-ft LWD contours shift progressively to a more N-S orientation, nearly parallel to the orientation of the lake-bottom contours in this area in 1987 prior to marina construction.

In the shallow nearshore along North Beach, the 0- to 5-ft LWD contours have a general arcuate form with their north ends pointing northeastward near the entrance to Prairie Harbor Yacht Club and their south ends pointing southeastward adjacent to the North Point Marina north breakwater. In the area immediately south of the Prairie Harbor entrance, the depth ranges between 1 and 2 ft LWD near the end of the steel sheetpile south jetty and reaches a maximum depth of 8 ft LWD in a localized depression just off the hook of the rubble-mound north jetty.
As of 2002, the North Beach nearshore has several small and localized ridge-like features, but no distinct elongate bar along the bottom. The localized ridges are shown by the 4-ft LWD contours south of the entrance to Prairie Harbor and also near the North Point Marina north breakwater. A small bar is shown by the 7-ft LWD contours just south of the Prairie Harbor north jetty.

Although there is no major bar, the lake-bottom slope flattens to form a broad shelf between the 4- and 8-ft LWD contours, which is shown by the widely spaced contours in this depth range. The slope from the 0- to 4-ft LWD is about 1:40. Between the 4- and 8-ft LWD contours the slope decreases to an average of 1:138. Beyond the 8-ft LWD contour, the slope is typically 1:80 to 1:100. As discussed in the section on lake-bottom changes (Part 3), the low-slope area between the 4- and 8-ft LWD

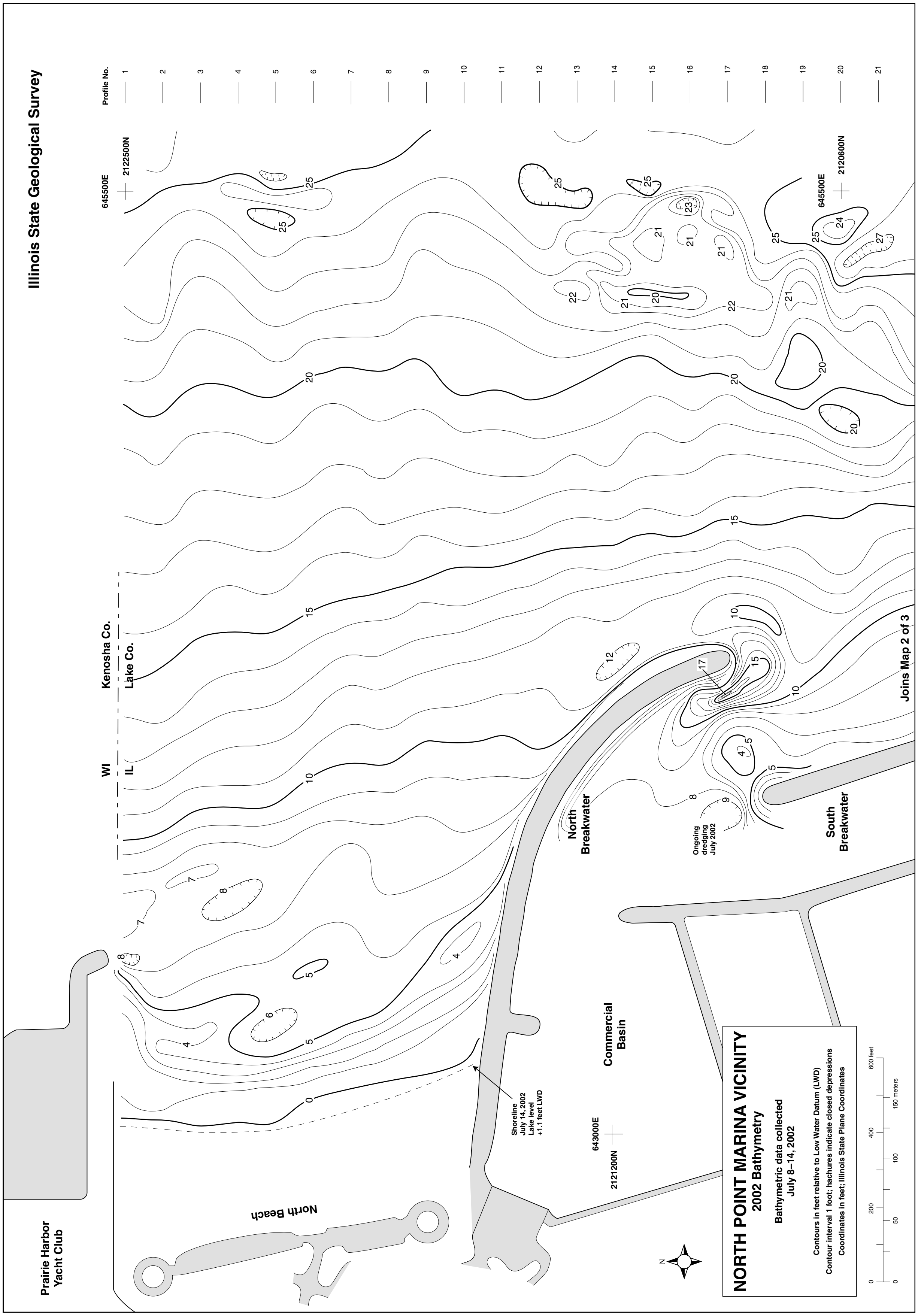


Figure 2-1 *2002 bathymetry from the WI-IL state line to the North Point Marina entrance (Bathymetry Map 1 of 3).*

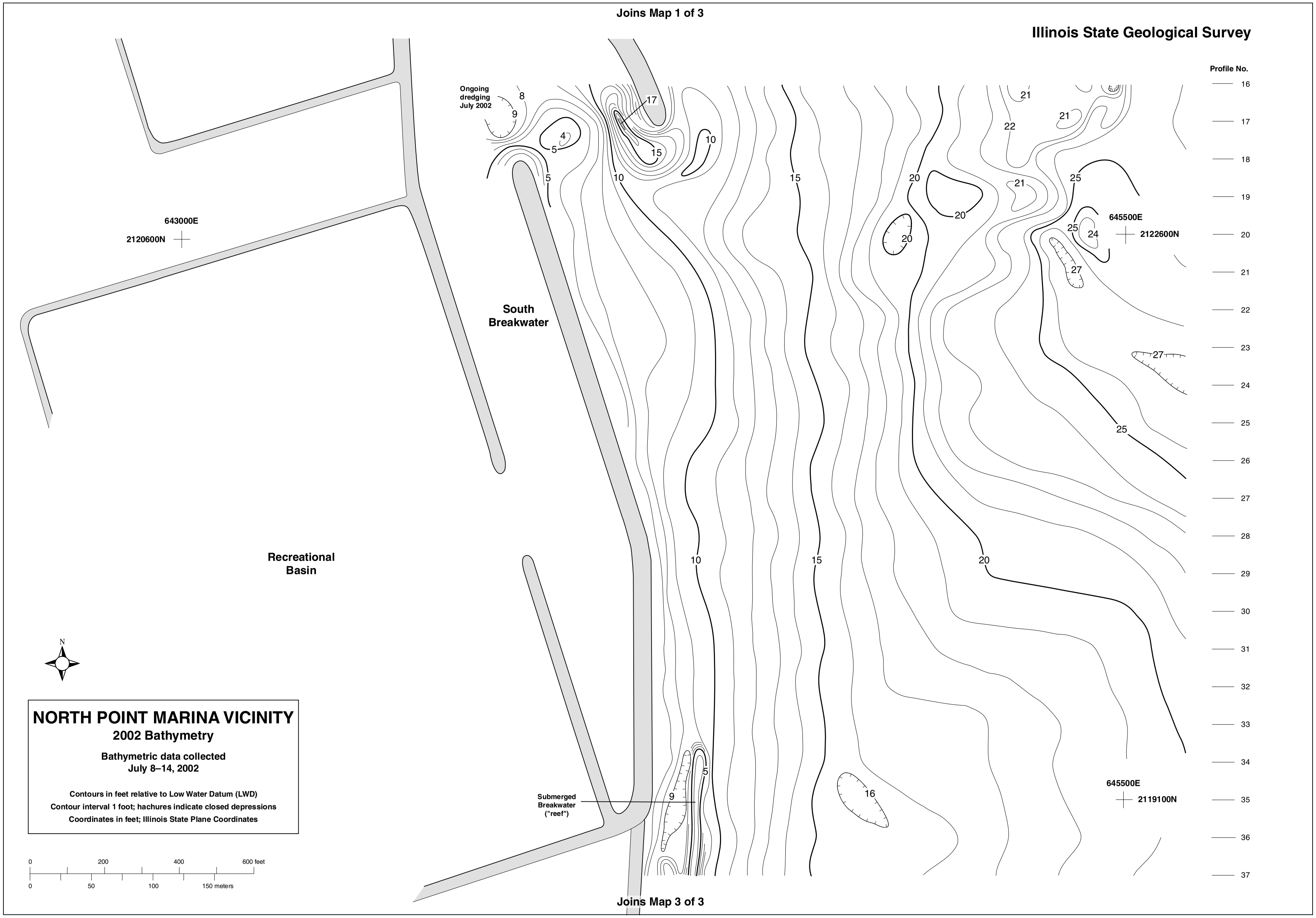


Figure 2-2 *2002 bathymetry from the North Point Marina entrance to the southern end of the south breakwater (Bathymetry Map 2 of 3).*

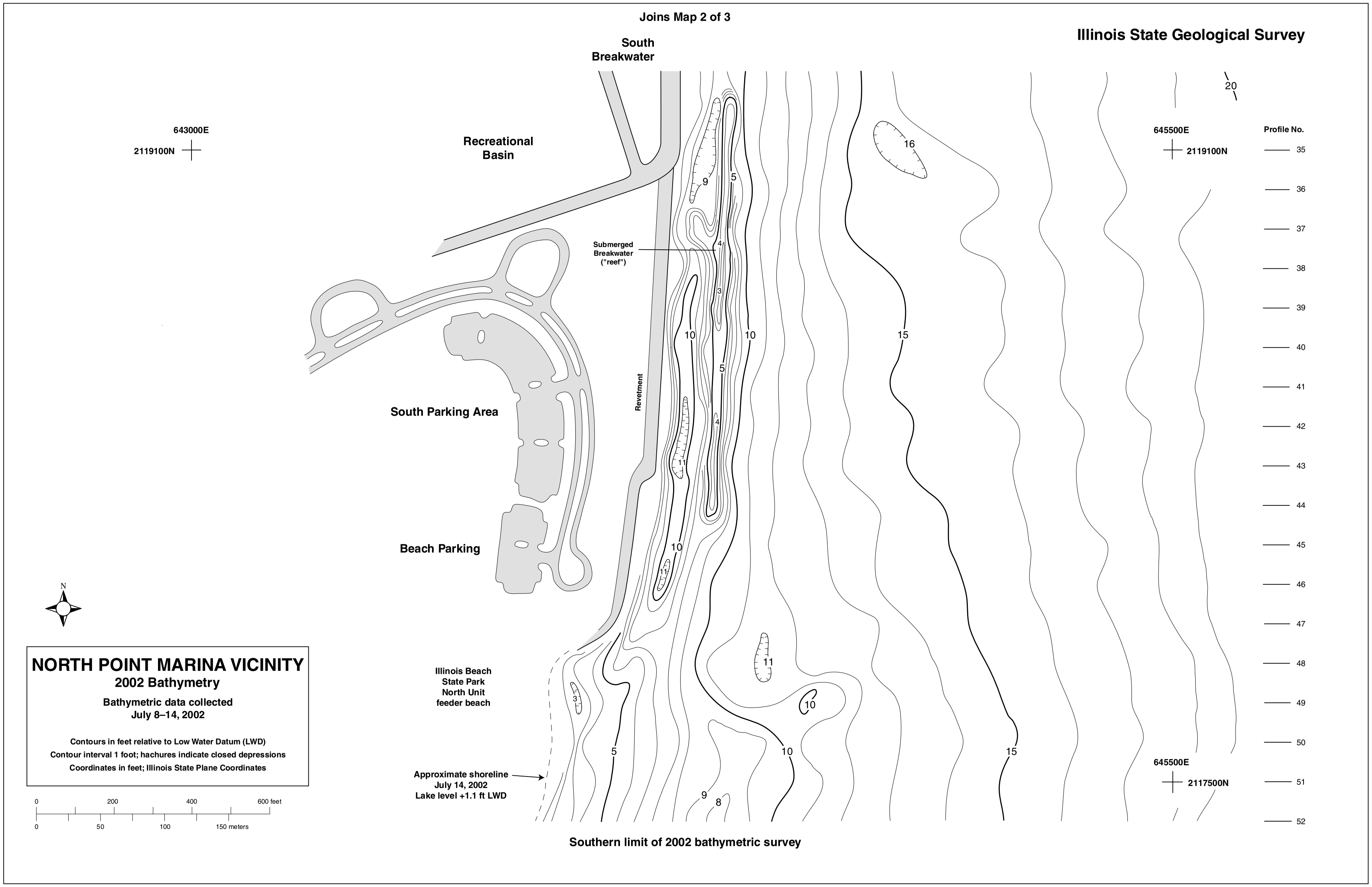


Figure 2-3 *2002 bathymetry offshore of the North Point Marina south parking area (Bathymetry Map 3 of 3*

contours is apparently a subdued version of the North Beach bar that has been a distinct bottom feature in several previous years.

2.3 Marina Entrance Vicinity *(Figures 2-1 and/or 2-2)*

At the time of the 2002 bathymetric survey, maintenance hydraulic dredging was underway in the marina entrance. This work was located to the north of the north end of the south breakwater. No dredging had occurred across the entrance on a line between the ends of the north and south breakwaters. Thus, mapping in the marina entrance in the area between the ends of the two breakwaters documented a bottom configuration that had not been altered by dredging. The bottom configuration at the marina entrance and the lakeside approach to the entrance consists of a minor and major shoal to either side of a deep-water trough.

The minor shoal is just east of the south end of the north breakwater where the water is little less than 10 ft deep. Depths in this area are generally 11 to 12 ft LWD. Thus, this shoal only rises about 2 ft above the surrounding lake bottom and it is at a depth that poses no hazard to small-boat traffic. The significance of this feature is that it documents a localized area of lake-bottom accretion just off the end of the north breakwater. This shoal has apparently formed recently. In the previous ISGS survey done in 1998, this area ranged in depth from 13 to 14 ft LWD. In 1997, this area was a closed depression defined by the 17-ft LWD contour. In earlier surveys, there were some years when an accretion area extended southward off the end of the north breakwater (1990 and 1995) and other years when the accretion had dispersed and deeper water prevailed (1988, 1989, 1991, and 1992). The accretion found in the 2002 survey is apparently temporary as this sand is migrating toward and/or past the marina entrance.

A major shoal occupies most of the western half of the marina entrance. The shoal has a continuation to the south along the lakeward side of the south breakwater which is discussed later. As of this survey in July 2002, the shoal had least depth of 4 ft LWD located about 40 ft west of the midpoint between the two breakwaters. This shoal restricts boat traffic from using the western half of the marina entrance.

The deepest water in the marina entrance occurs in an elongate trough on the east side of the entrance adjacent to the north breakwater. The 10- and 11-ft LWD contours that extend along the lakeward side of the north breakwater hook into the marina entrance and loop around this trough. The 2002 maximum depth recorded in this trough was 17.5 ft LWD. A trough has been recorded in this area in all previous bathymetric surveys since 1989. Changes in the shape and maximum depth over time indicate that this feature is both dynamic and persistent. The maximum depth of 17.5 ft LWD is the greatest yet recorded in this trough. The trough is further addressed in Part 3, describing lake-bottom change (Section 3.6), and in the Discussion (Part 5).

2.4 South Breakwater *(Figure 2-2)*

The configuration of the south breakwater consists of a southern north-south segment and a northern segment that is oriented slightly west of north. The lake bottom contours from the south breakwater out to the 17-ft LWD contour are generally oriented north-south parallel to the southern segment of the south breakwater. The contours greater than 17-ft LWD progressively show less of this north-south alignment and also have greater spacing, indicating a reduced slope.

Directly east of the marina entrance there is a hummocky lake bottom associated with a local outcrop of the lake-bottom clay (clayey till). The notable exception to the north-south contour trend along the south breakwater occurs between the marina entrance and a distance of about 800 ft to the south where the slope is gentler and the distance out to the 9 and 10 ft LWD contours greater than along the segment of the breakwater farther to the south. This area of sediment accumulation is a southward continuation of the prominent shoal that occurs at the northern tip of the south breakwater. Depths across this area are 6 ft LWD near the toe of the breakwater and 10 ft LWD at a maximum distance of 140 ft lakeward of the breakwater. The water over this area of sand accumulation is deep enough that the shoal poses no threat to boat traffic. However, it documents that the prominent shoaling at the northern end of the south breakwater has a less prominent continuation that extends along the lakeward side of the south breakwater.

2.5 South Parking Area *(Figure 2-3)*

During marina construction and in the first few years following construction, the North Point Marina south parking area was the site of the most pronounced changes in shoreline positions and lake-bottom configuration. This is the location where, in 1987 and 1988, the sand and gravel hydraulically dredged to form the marina basin was discharged to form a broad protrusion on the shore much like a delta but having maximum elevations well above the surrounding land area. The south parking area was built atop this dredged material resulting in the elevation of the parking area being more than 10 ft above average lake level.

The lakeward margin of the delta was allowed to erode essentially unimpeded until November 1989 when a first generation of shore protection was installed to protect the parking area. Undermining and displacement of that shore protection led to installation of a second generation of shore protection between November 1987 and February 1998. This second generation of shore protection consists of a rubble-mound revetment along the shore and a submerged rubble-mound breakwater (also called a submerged "reef") located about 120 ft offshore and extending along about 1,100 ft of shoreline between ISGS profile lines 34 (Figure 2-2) and 45 (Figure 2-3). The submerged breakwater trips the larger incoming waves and thus reduces the wave height and wave energy before the waves expend their remaining energy against the revetment (Patrick Engineering, 1995).

The submerged breakwater is a prominent feature on the bathymetric map. The least depth contour along the crest of the breakwater is 3 ft LWD. Since the winter 1998 completion of the submerged breakwater, an elongate erosional trough has developed on the landward side of this structure. At its northern end, the erosional trough corresponds to the northern limit of the submerged breakwater. At its southern end, the trough extends about 350 ft farther to the south than the southern limit of the submerged breakwater.

Development of this elongate trough was expected based on observations from similar submerged breakwaters built in sand-dominated settings. The maximum depth contour along this trough was 11 ft LWD as of the July 2002 survey. When the ISGS collected bathymetric data across this area in July 1998, five months after completion of the submerged breakwater, a trough had already developed. Comparison of the 1998 and 2002 bathymetry indicates that no notable depth changes have occurred along the northern half of the trough during this four-year interval, but there has been as much as 2 ft of erosion along the southern half of the trough. The 11-ft LWD contours on the 2002 survey are within the 9-ft LWD contours mapped in 1998. There has also been southward extension of the trough. Although there is no apparent threat to the structure of the revetment or the submerged breakwater now, continued monitoring of this trough is warranted.

2.6 Illinois Beach State Park - North Unit Feeder Beach *(Figure 2-3)*

South of the North Point Marina south parking area is a sand reservoir used as a feeder beach for the dispersion of sand along the North Unit of Illinois Beach State Park. The 2002 bathymetric survey extended along this reach of shore to determine how the lake bottom here compares with that lakeward of the south parking area. A question to be answered was whether any bar or other lake-bottom feature suggested any net transport of sand from the feeder beach northward toward the marina.

The lake bottom opposite the feeder beach is somewhat irregular. Although this is a sandy shore like that at North Beach, the slope of the shallow nearshore here is steeper. About 450 ft offshore, a bar is defined by the 8 and 9 ft LWD contours. Based on previous surveys by ISGS, this is the northern end of a bar that extends southward along the shore of the State Park North Unit and is the pathway for sand eroded from the feeder beach and transported southward. During times of southerly waves, sand from the feeder beach will be transported northward. However, the exposure of this shore segment predominantly to northerly waves is sufficient to maintain the net southerly sand transport.

Part 3: 1988-2002 Lake-Bottom Change

3.1 Overview

One of the objectives of this study was to compare the 2002 bathymetry with similar data collected prior to completion of the marina in order to document lake-bottom changes since marina construction. A bathymetric survey of the North Point Marina vicinity was completed by the ISGS during the summer of 1987. At that time, construction was beginning on the north and south breakwaters, dredging was getting started on the marina basin, and dredged material was being discharged to the shore south of the marina. The ISGS again surveyed the bathymetry during the summer of 1988.

The 1988 survey is the baseline survey used for comparison in this report. Compared with the 1987 survey, the 1988 survey had a more rigorous sampling grid and used more accurate navigation. More importantly, the 1987–1988 data comparison indicated that lake-bottom changes to that point were minimal in the North Beach area and along the North Point Marina north and south breakwaters. The major bathymetric changes occurred in the area of dredge discharge just south of the marina. An exception to the use of the 1988 data is in the vicinity of the marina entrance, where 1987 data provided a baseline. Ongoing breakwater construction prevented this area from being surveyed in 1988.

3.2 Generating Lake-Bottom Change Maps

Maps showing contours of 1988–2002 lake-bottom accretion and erosion were generated by registering contour maps from the two surveys in superposition, plotting all contour intercepts, and recording the depth difference. These locations (X, Y) and depth (Z) differences were used as control points to generate contour maps of the thickness of lake-bottom change. These maps are shown in Figures 3-1, 3-6, and 3-7. Appendix B contains a composite map showing the 1988–2002 lake-bottom change across the entire survey area from the state line to just south of the North Point Marina south breakwater.

The maps use shades of green to highlight areas of accretion and red to highlight areas of erosion. These maps provide a record of total change that has occurred in the 14 years since the marina breakwaters were completed. Similar maps of lake-bottom changes compiled annually from 1987 through 1997 are shown in previous ISGS reports. An unpublished map of 1997–1998 lake-bottom change is on file at the ISGS. The advantage of the maps in this report is that they provide a single picture of the net change over the entire 14 years since marina construction.

3.3 State Line to North Breakwater *(Figures 3-1 and 3-2)*

In the area from the state line to the marina entrance end of the north breakwater, the 1988–2002 lake-bottom changes are focused along three distinct bands. Two of these bands are accretional and one is erosional. The erosional band extends along an arc from just south of the Prairie Harbor north jetty to a point just north of the North Point Marina north breakwater (about 150 ft east of the north breakwater spur). Erosion along this band is minimal, at most slightly more than 1 ft. The configuration of this erosional area is influenced by the present jetties to the north and the North Point Marina breakwater to the south. The erosion can be attributed to the shift in position (or loss) of a bar that was located in this general area in 1988 (see Section 3.5 North Beach Bar).

In terms of total area (and volume), the smaller of the two accretion bands is the one in the beach and shallow nearshore area of North Beach. The maximum accretion contour here is 5 ft. This maximum accretion closely approximates the 2002 shoreline, indicating that the 2002 shoreline

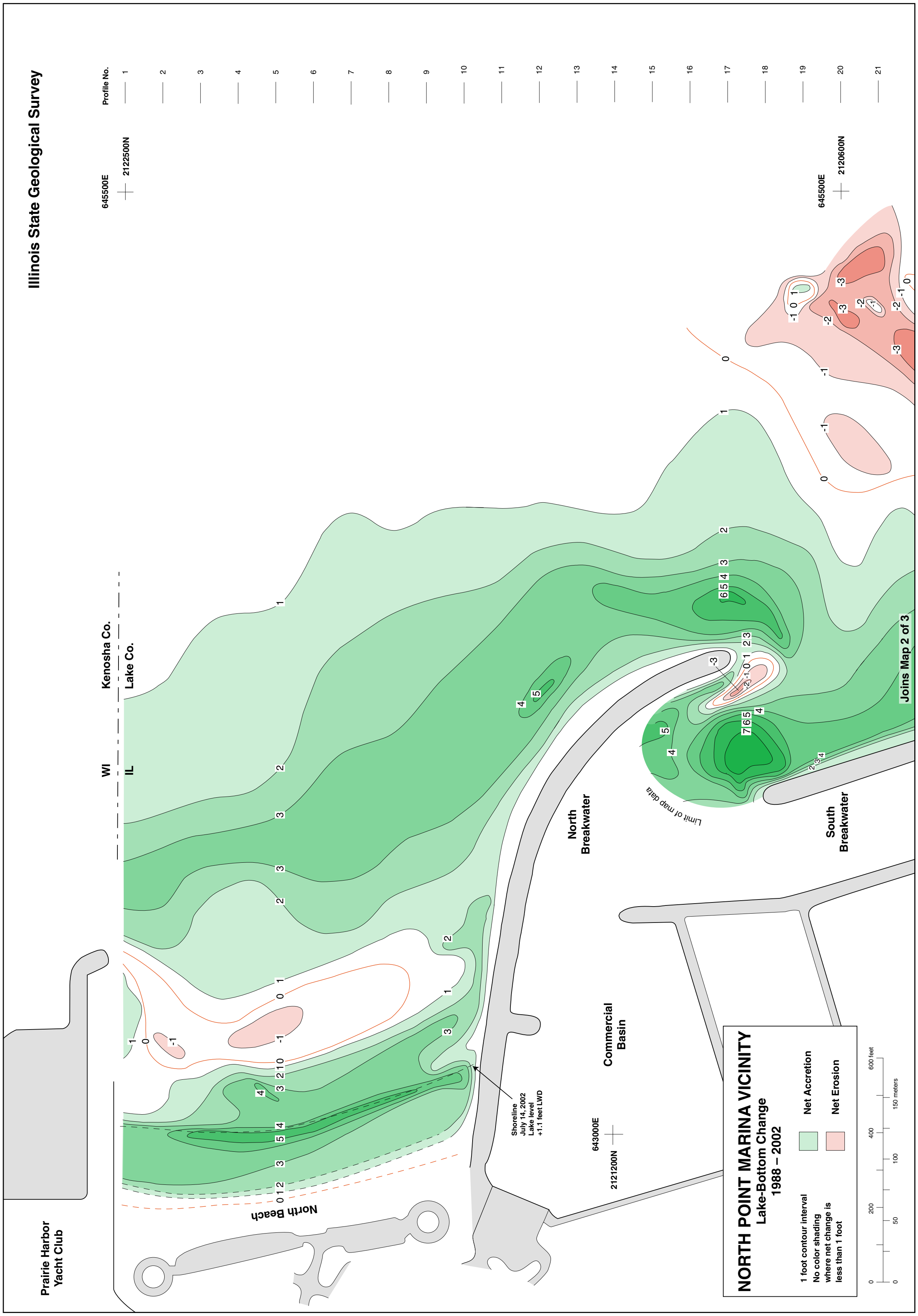
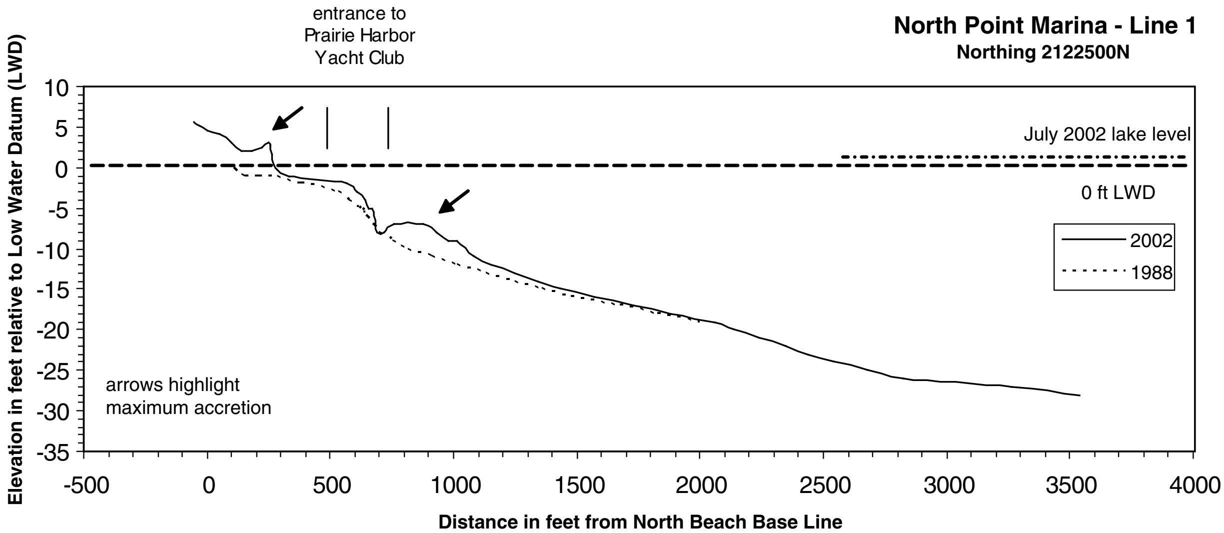
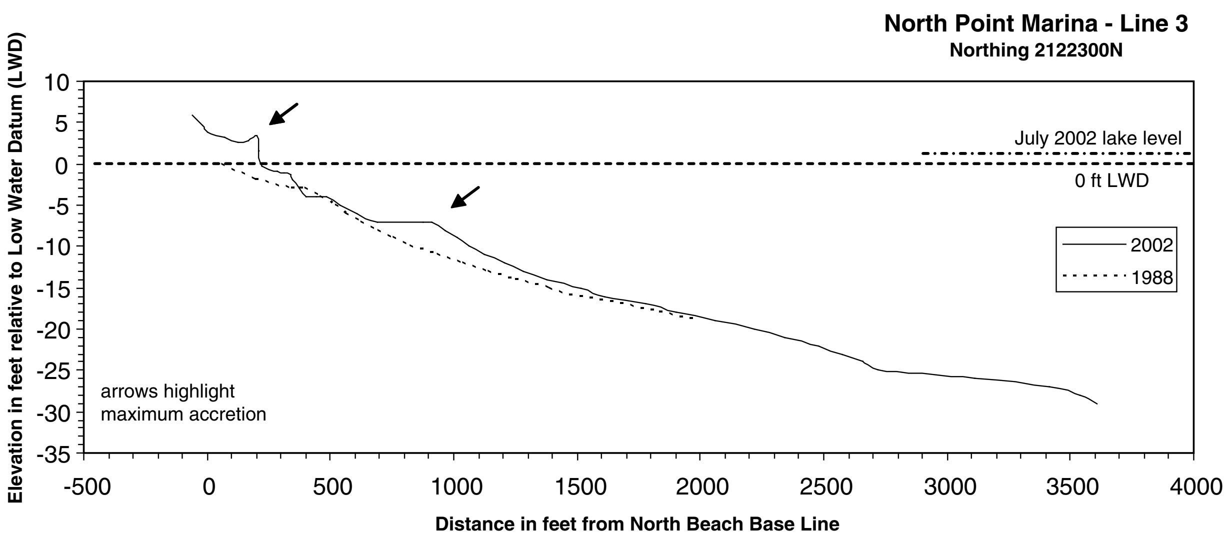


Figure 3-1 1988-2002 lake-bottom change from the WI-IL state line to the North Point Marina entrance (Lake-bottom Change Map 1 of 3).





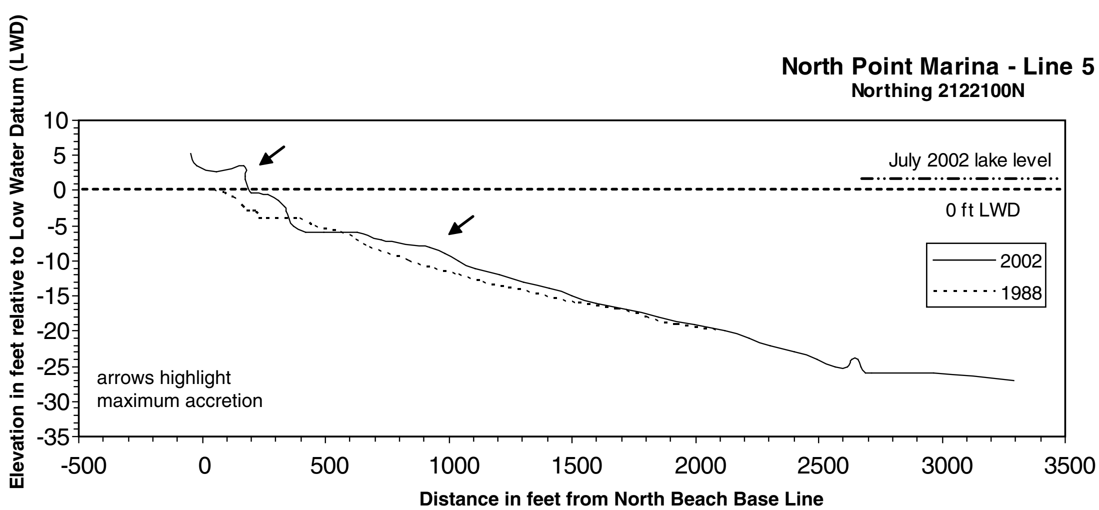
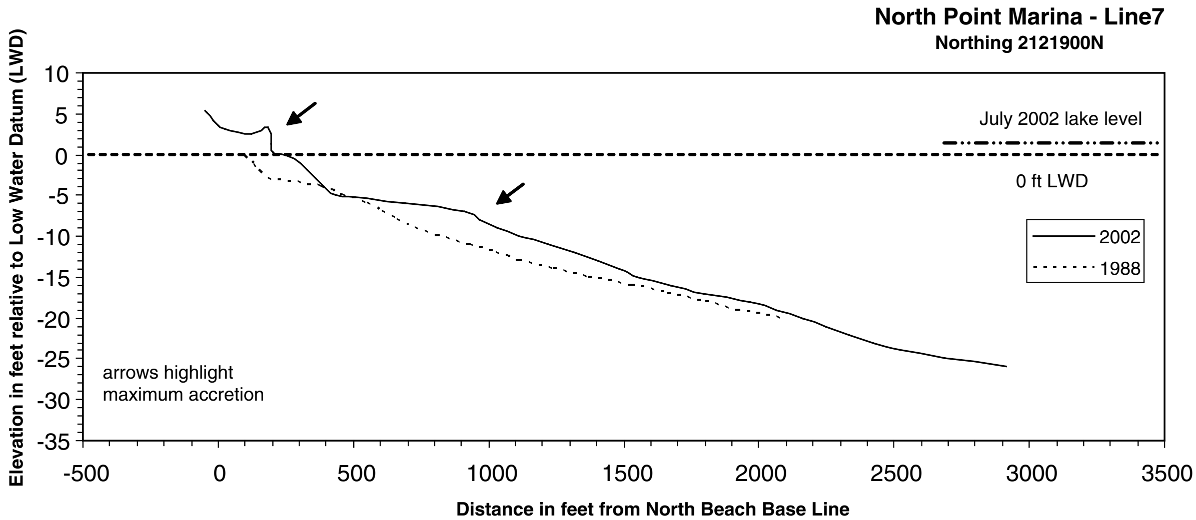
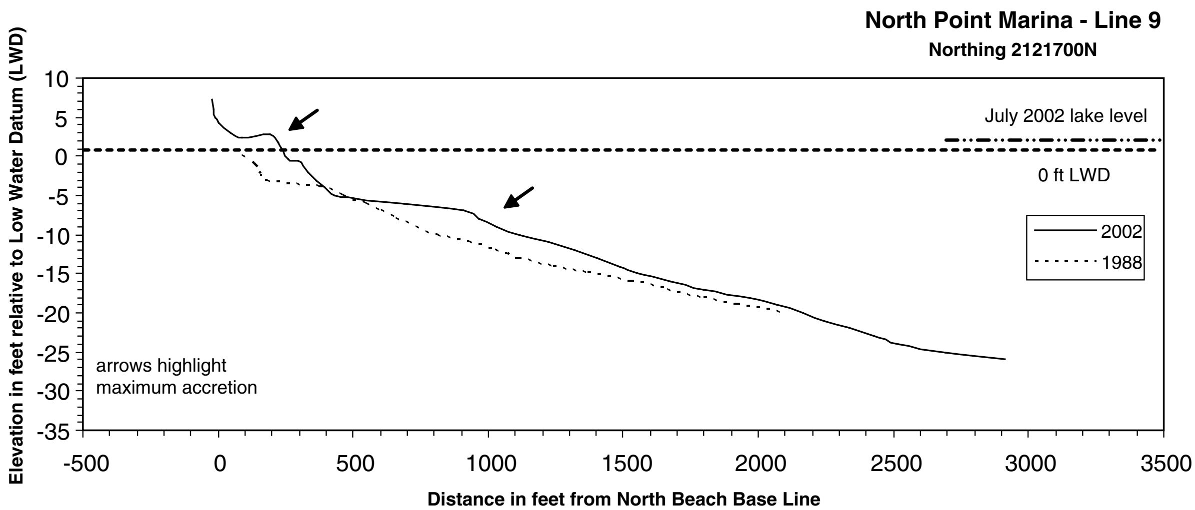
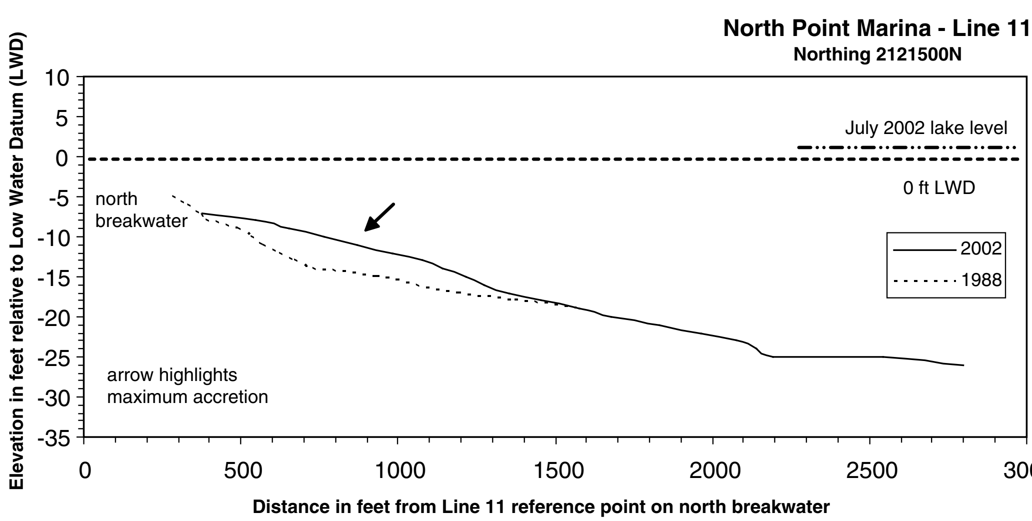


Figure 3-2 *1988-2002 profile comparison for select profile lines between the state line and the north breakwater at North Point Marina. Arrows highlight maximum accretion. Where two areas are shown, the upper arrow is accretion on North Beach, the lower arrow is the accretion lens extending from the state line to the north breakwater.*


North Point Marina - Line7
Northing 2121900N
July 2002 lake level
0 ft LWD
2002
1988
arrows highlight
maximum accretion
Elevation in feet relative to Low Water Datum (LWD)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-500
0
500
1000
1500
2000
2500
3000
3500
Distance in feet from North Beach Base Line


North Point Marina - Line 9
Northing 2121700N
July 2002 lake level
0 ft LWD
2002
1988
arrows highlight
maximum accretion
Elevation in feet relative to Low Water Datum (LWD)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-500
0
500
1000
1500
2000
2500
3000
3500
Distance in feet from North Beach Base Line


North Point Marina - Line 11
Northing 2121500N
July 2002 lake level
0 ft LWD
north
breakwater
2002
1988
arrow highlights
maximum accretion
Elevation in feet relative to Low Water Datum (LWD)
10
5
0
-5
-10
-15
-20
-25
-30
-35
0
500
1000
1500
2000
2500
3000
Distance in feet from Line 11 reference point on north breakwater

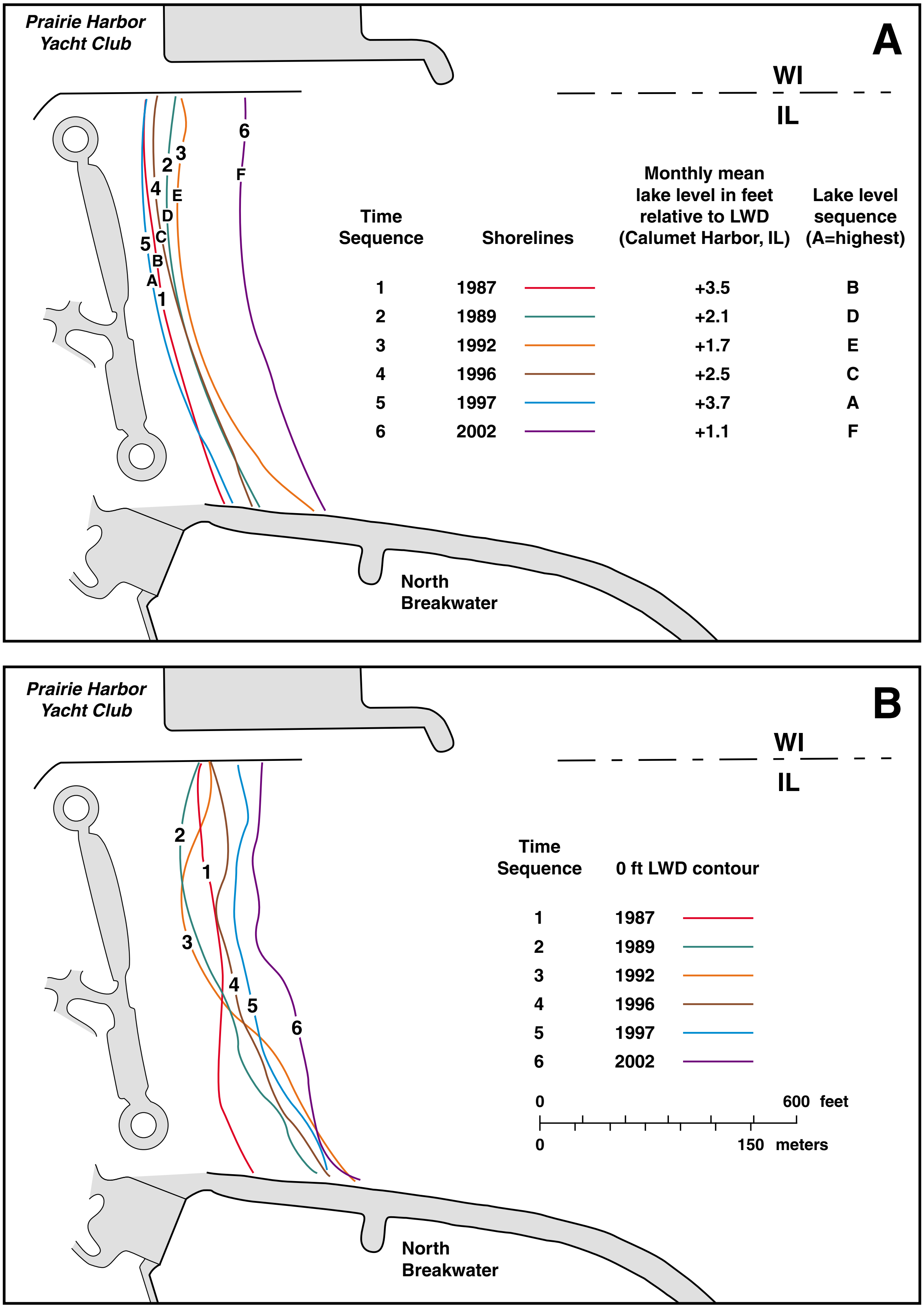


Figure 3-3 *Record of changes to the beach width at North Beach for select years from 1987 to 2002. Upper figure (A) shows change in shoreline position and corresponding lake level; lower figure (B) shows change in position of the 0 ft Low Water Datum (LWD) contour, which is independent of lake level.*

position is approximately where water depths were about 5 ft in 1988. In the onshore-offshore direction, the width of accretion is greater in the south (against the North Point Marina north breakwater) than in the north (against the Prairie Harbor south jetty). However, the difference in width is much less than had been predicted by the preconstruction modeling (Figure 1-4).

The larger accretion area is a band that begins at the state line just east of the Prairie Harbor north jetty, extends southward to become tangential to the east side of the North Point Marina north breakwater, and partially hooks around the south end of the north breakwater. The maximum accretion contour along most of this band is 3 ft, but a localized area off the northeast side of the breakwater has had 5 ft of accretion and a larger area just east of the end of the breakwater has had 6 ft. This band of accretion indicates a transport pathway for sand coming across the state line and making its way southward around the north breakwater and into the marina entrance.

If the 1988–2002 accretion from the state line to the end of the north breakwater (Figure 3-1) is compared with the 2002 bathymetric contours for this area (Figure 2-1), two similarities exist. First, the 2002 shoal area just east of the end of the north breakwater generally corresponds to the area of maximum accretion here. Second, the eastern (lakeward) limit of the accretion band corresponds to where the orientation of the contours changes from a west of north orientation to one that is more north-south. This orientation was previously discussed in the section describing the bathymetry between the state line and the north breakwater.

Figure 3-2 contains a series of profiles that illustrate lake-bottom changes from 1988 and 2002 from the state line to the north breakwater. These profiles, for ISGS profile lines 1, 3, 5, 7, 9, and 11, provide a 200-ft spacing of profile comparisons from the state line (Profile 1) southward to where the accretion becomes tangent to and begins to bypass the north breakwater (Profile 11). The points of maximum thickness have been highlighted on each profile. The maximum accretion is about 3.5 ft. The accretion has transformed the overall profile from concave upward in 1988 to mostly convex upward in 2002. Along profiles 5, 7, 9, and 11, the accretion occurs across a broad area. Along profiles 1 and 3, the accretion is more localized.

3.4 North Beach Shoreline Changes *(Figure 3-3)*

In summer 2002, the increased width of North Beach was readily apparent to any visitor familiar with the beach over the previous four or five years. The change in beach width over the five years between 1997 and 2002 is shown in Figure 3-3A. Over 200 ft of shoreline change occurred. This figure summarizes a record of North Beach shoreline changes for 1987 through 2002.

The shoreline position is influenced by the gain or loss of sand along this beach, but also is strongly influenced by changes in lake level. To show the lake level's influence, the shoreline positions are numbered 1 through 6, colored to indicate the year in which they occurred, and given letter designations according to the associated lake level. The highest lake level in this sequence (+3.7 ft LWD; 1997) is letter "A"; the lowest lake level (+1.1. ft LWD; 2002) is letter "F," giving the letter designations an apparently orderly lakeward progression from highest to lowest.

In the time sequence (Figure 3-3A), shorelines 1, 2, and 3 (1987, 1989, and 1992) show a lakeward shift, shorelines 4 and 5 (1996 and 1997) show a landward shift, and shoreline 6 (2002) again shows a lakeward shift. Times of higher lake level have resulted in a narrower beach; times of lower lake levels have resulted in a wider beach. For purposes of making sand management decisions, therefore, using the shoreline position as an indicator of whether the beach has gained or lost sediment can be misleading.

The change in beach width that is reflective of gain or loss of sediment independent of lake level influence can be determined using the 0-ft LWD contour. Figure 3-3B shows the series of 0-ft LWD contours corresponding to the same color and time sequence used in the shoreline mapping (A). There has been a short-term landward shift of the 0-ft LWD contour in the northern half of the beach (contours 1, 2, and 3; 1987, 1989, 1992) and just north of the North Point Marina north breakwater (contours 3 and 4; 1992, 1996). The 0-ft LWD contours for 1989 and 1992 (contours 2 and 3) apparently record times when there was a localized erosional phase along the northern half of the nearshore as sand was temporarily shifted to the south to build shallower water along the North Point Marina north breakwater.

The overall change in position of the 0-ft LWD contour from 1987 to 2002 has been lakeward. The lakeward shift ranges from a minimum of 85 ft in the central part of North Beach to a maximum of 220 ft near the North Point Marina north breakwater. A best value for the gain in beach width at North Beach from the time of marina construction to 2002 is the average lakeward shift of about 170 ft.

3.5 North Beach Bar *(Figure 3-4)*

In previous bathymetric surveys of the marina vicinity, a notable lake-bottom feature off North Beach has been the North Beach bar. This bar is part of a regional bar system that extends along nearly the entire length of shoreline from the state line southward to Waukegan. A bar occurred here before the marina was constructed and has been present to a greater or lesser degree in all bathymetric surveys since the construction. In the foregoing discussion of the bathymetry in this area, it was mentioned that no notable bar or bars occur in this area. However, the shelf area noted between the 4- and 8-ft LWD contours is apparently an expression of the North Beach bar (Figure 2-6). Similar broad, low-slope areas have been mapped in years intermediate to when the bar has been mapped as a distinct ridge along the lake bottom.

A time series showing changes in the location and configuration of the North Beach bar is shown in Figure 3-4. In several previous years (1990, 1992, 1995, and 1996), the bar formed a single distinct ridge rising a foot or more above the adjacent lake bottom. There have also been occurrences of a double bar with one closer in to North Beach and one in deeper water. The outer bar has been a factor in building the accretion pathway from the state line to the North Point Marina north breakwater. The inner bar has apparently been a factor in the transport and addition of sand to North Beach.

3.6 Marina Entrance *(Figures 3-1 and 3-5)*

The greatest thickness of sediment accretion in the entire area covered by this survey occurred within and near the marina entrance. The shoal area adjacent to the north end of the south breakwater has a 7-ft contour. As previously noted, there is also an accretion area just off the east end of the north breakwater where a 6-ft contour occurs. The degree to which the marina entrance has been a sediment trap between 1988 and 2002 is even under-represented in this map because the data extend only about 300 ft into the marina. Thus, this map does not show the accretion that has occurred toward the commercial basin and around the end of the south breakwater in the channel leading toward the recreational basin. Even if the map comparison extended further into the entrance, it would still be an under-representation of change for this 14-year comparison because of several years of maintenance dredging in this area that has removed sand.

The erosion at the marina entrance has occurred along an elongate trough that has an axis subparallel to the end of the north breakwater. The axis of the trough is located about 65 ft to the west of the west side of the north breakwater. This erosional area corresponds to the depression at

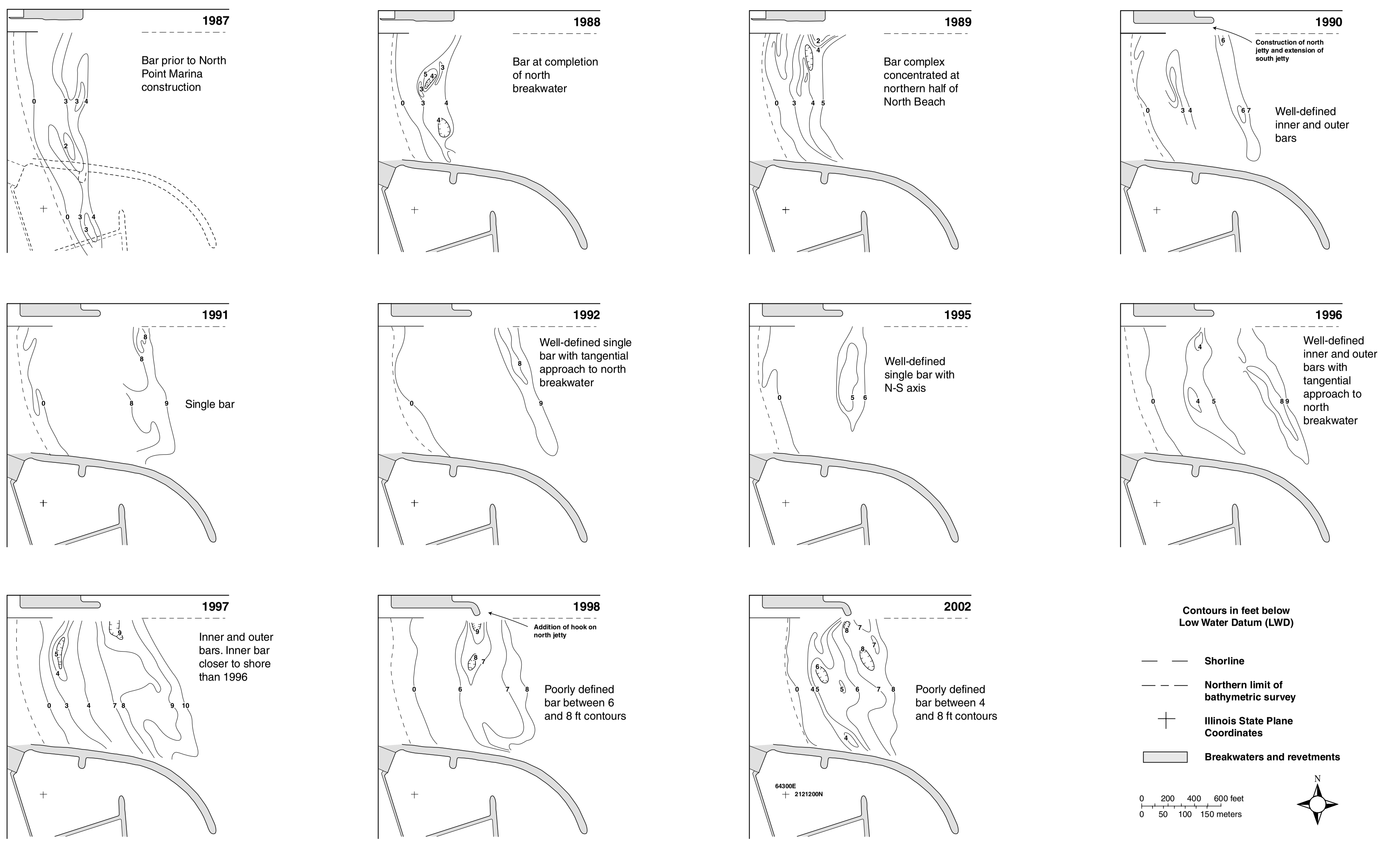


Figure 3-4 *Changes in location and configuration of the North Beach bar between 1987 and 2002.*

the marina entrance shown on the 2002 bathymetry (Figures 2-6 and 2-7). The maximum erosion recorded by the surveys between 1987 and 2002 is 3.7 ft.

Figure 3-5 is a cross-sectional profile view of the 2002 bathymetry aligned between the lights/daymarkers at the ends of the breakwaters showing the accretion and erosion in the marina entrance. Data collected in 1987 were used as the baseline for this area. The 1987 bathymetry shows a gently eastward sloping bottom that ranges from 11 ft LWD near what is now the tip of the south breakwater to about 14.5 ft LWD along the center line near the tip of the north breakwater. This is the surface atop which the base stone was placed for the breakwaters. The project depth for the entrance (i.e., planned least depth) was 12.1 ft LWD. The accretion against the south breakwater has caused shoaling to depths less than half the project depth and reduced the cross-sectional area of the entrance by about one third. The erosion along the trough has produced a depth that is about 3 ft below the elevation of the base of the nearby west side of the north breakwater. As further mentioned in the Discussion section, neither this shoal nor the trough is a recent development.

3.7 South Breakwater *(Figure 3-6)*

Accretion extends along all but the very southern end of the south breakwater. The maximum thickness of accretion occurs at the north (more than 4 ft) and diminishes to the south. The accretion pattern shows that this is a southward continuation of the accretion that extends from the state line to the marina entrance. The area of maximum accretion, ranging from 3 to 5 ft, is along a band that lies within about 300 ft of the east side of the breakwater and extends from the marina entrance to approximately 800 ft to the south.

In an extensive area lakeward of the accretion band, slightly more than 5 ft of erosion has occurred. This area of lake bottom is sufficiently distant from the marina breakwaters that the erosion can not be attributed to any impact from the marina. This erosion is consistent with the naturally occurring regional, long-term, net erosion across the lake bottom in the marina vicinity (Figure 1-3) (U.S. Army Corps of Engineers, 1953). Some sand from this erosional area may contribute to the accretion along the south breakwater and the marina entrance, but the overall pattern of maximum erosion in the north and decreasing erosion to the south indicates net southerly transport.

3.8 South Parking Area and North Unit Feeder Beach (Figure 3-7)

Erosion dominates most of the lake bottom offshore from the south parking area and offshore from the state park feeder beach. Areas of accretion are patchy and distant from shore. Thus, despite all of the sediment that was supplied along this shore during the marina construction and in subsequent beach nourishment, a net loss of bottom sediment has occurred. What is noteworthy is that, although the total erosion has been extreme across much of the lake bottom, the 1988–2002 net erosion is rather minimal. Across a broad area on the lakeward side of the submerged breakwater the 1988–2002 erosion is in the range of 1 to 1.5 ft. Different results would be expected if the 2002 configuration of this area were compared with the 1987 lake-bottom configuration. The reason is that by 1988 the lake bottom in this area had gained sand from the hydraulic dredging and building of the delta on the south side of the marina.

The greatest erosion documented by this 1988–2002 comparison occurs just offshore of the south end of the south parking area and the state park feeder beach. The erosional band shown on the map is truncated along its western side and also along its northern extent on the landward side of the submerged breakwater. The reason for the truncation is that in 1988 the large, elevated delta built from the dredging of the marina basin was located here. The 1988 bathymetry does not

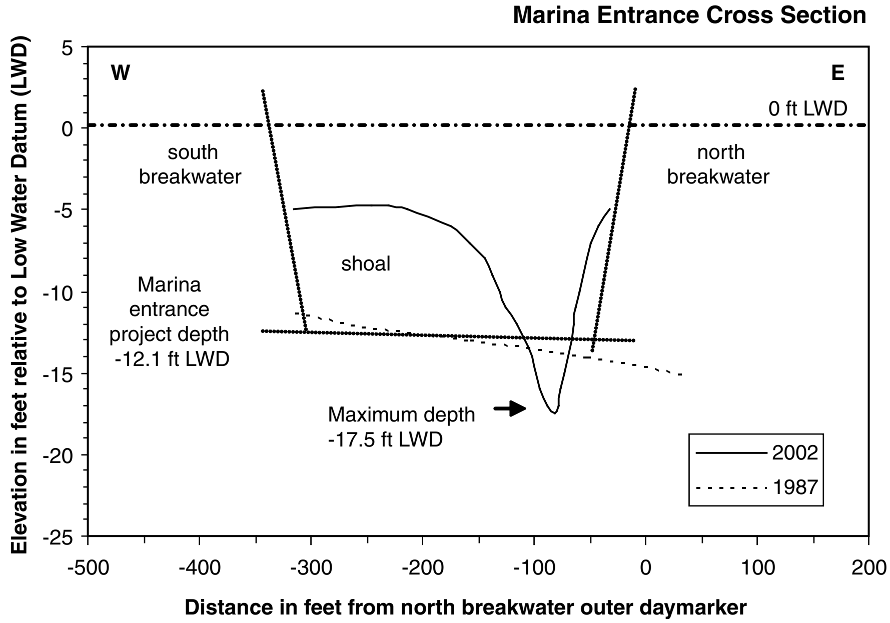


Figure 3-5 *Cross section at the marina entrance comparing 1987 and 2002 bathymetry.*

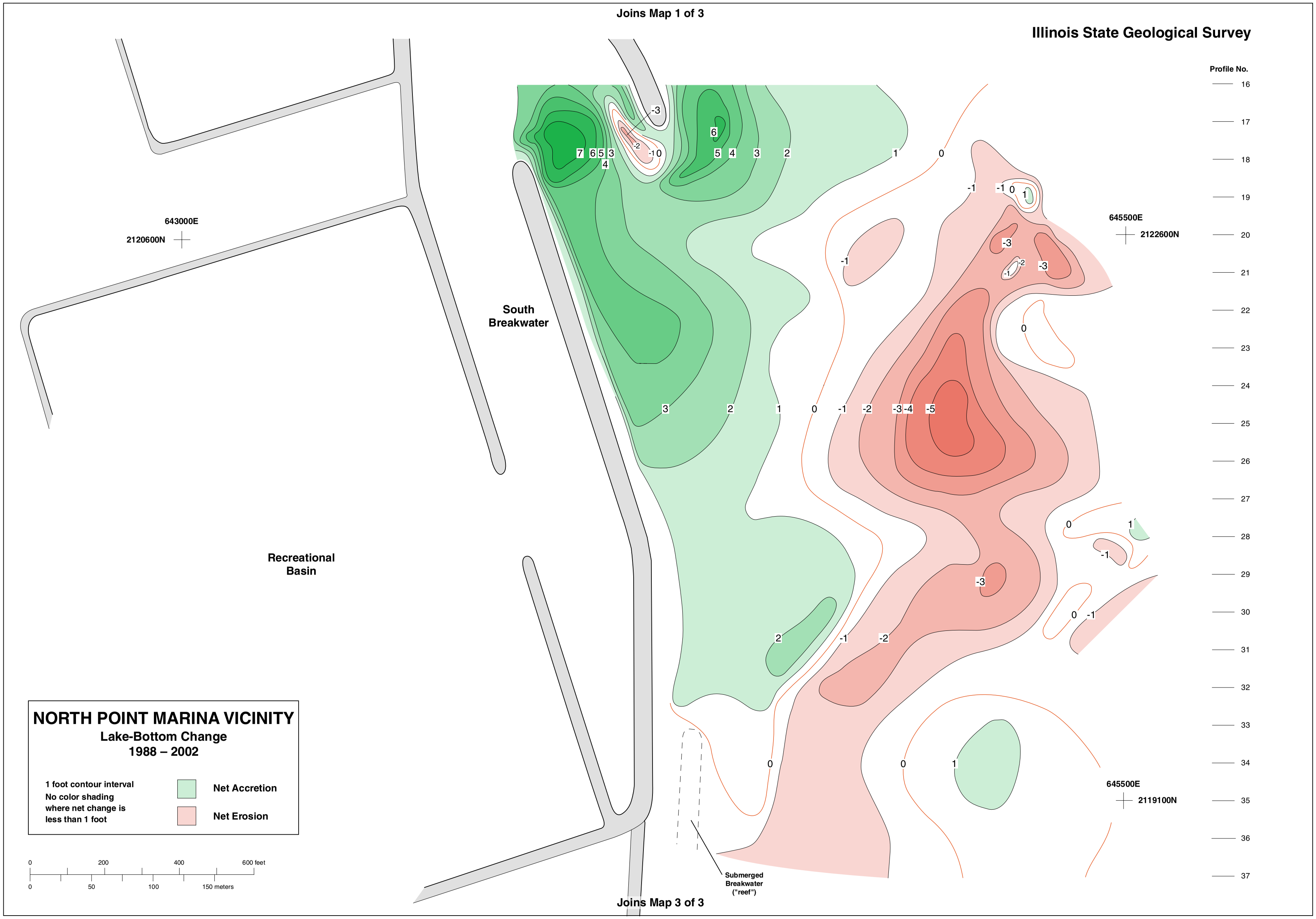


Figure 3-6 *1988-2002 lake-bottom change from the North Point Marina entrance to the southern end of the south breakwater (Lake-Bottom Change Map 2 of 3).*

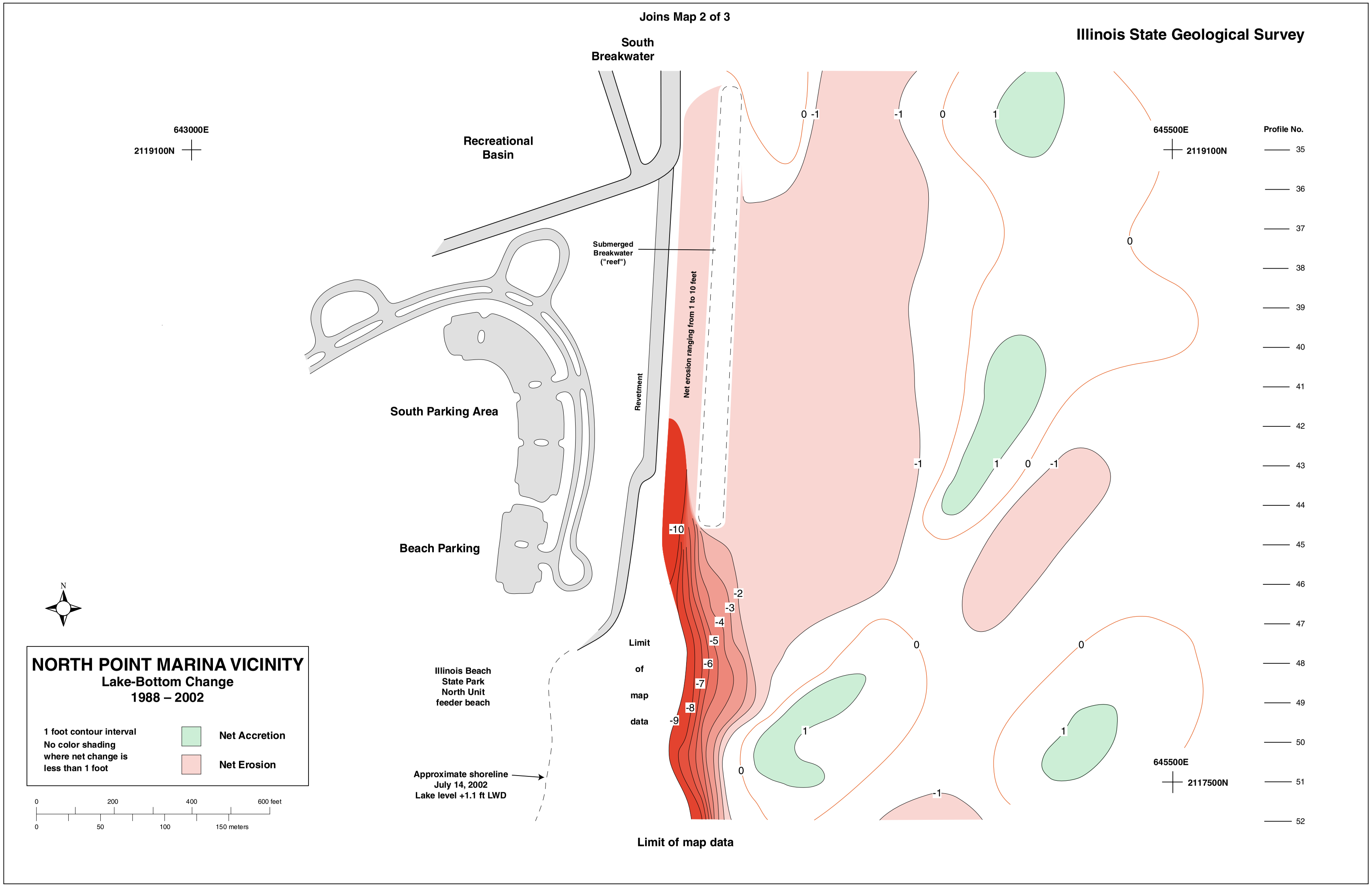


Figure 3-7 *1988-2002 lake-bottom change offshore of the south parking area (Lake-Bottom Change Map 3 of 3).*

provide a “preconstruction” baseline for this area. The appropriate comparison would use the 1987 bathymetry. A detailed presentation of the erosion in this area was beyond the scope of this study but is presented in previous ISGS reports (Chrzastowski et al., 1996; Foyle et al., 1997, 1998).

Erosion in this area was planned as part of the IDNR sand management plan for Illinois Beach State Park. Sand eroded from this area was to be transported southward along the state park shore. Thus, unlike the other erosion areas in the shallow nearshore at North Beach, in the marina entrance, in the south breakwater offshore area, or to either side of the submerged breakwater, the erosion at and near the state park feeder beach is intentional and desirable. This erosion has been increased artificially by the addition of sand to this area first during the time of marina construction and subsequently during replenishment of the feeder beach.

In terms of volume, the erosion on the south end of the marina complex and in the state park North Unit has been an order of magnitude greater than all accretion in the marina vicinity. Monitoring is needed is to keep track of erosion that may threaten to undermine the revetment that protects the beach parking located just south of the North Point Marina south parking area (Figure 3-7). Compared with the south parking area, the beach parking has a less robust revetment that it is not completely fronted by the submerged breakwater. IDNR Engineering has designated the beach parking as “at risk,” recognizing the lesser degree of shore protection. Continued lake-bottom monitoring is warranted to determine if and when mitigation may be necessary.

Part 4: Volumetric Analysis

4.1 Volume Measurement *(Figure 4-1)*

The volume of accretion and erosion in the marina vicinity was determined by measuring the area within the thickness contours and multiplying by the mid-contour value. For example, an accretion area between the 2- and 3-ft contour was measured in square feet, multiplied by 2.5 ft to give cubic feet, and then converted to cubic yards. The summation of the inter-contour volumes provides a total volume for a specified location or area. Computed total volumes were rounded to the nearest 100 cu yds. Map areas between contours were measured with a PLANIX-7 digital planimeter. The volumes were computed only for areas of accretion or erosion greater than 1 ft. The pattern of accretion and erosion provides a means to compute volumes for distinct sub-areas of the marina vicinity as shown in Figure 4-1.

4.2 North Beach *(Area A)*

A band of erosion just offshore from North Beach provides a convenient means to determine the North Beach accretion separate from the accretion farther offshore. Accretion at North Beach is 30,600 cu yds. The rate of accretion has varied from year to year depending on sediment supply, lake-level change, and wave dynamics. However, looking only at the annual increment of gain over the 14-year record, the accretion has averaged about 2,200 cu yds/yr. No artificial beach nourishment has been done at North Beach. All of this sediment gain is from the capture of littoral sediment.

4.3 North Beach Erosion *(Area B)*

The erosional band in the North Beach nearshore has two areas that reach more than 1-ft thickness. Together these have a volume of 900 cu yds.

4.4 State Line to Marina Entrance *(Area C)*

The band of accretion that extends from the state line comes around the north breakwater and then hooks toward the marina entrance. The total accretion along this band is 136,200 cu yds. Over the 14-year record period, average annual accretion along this band is 9,700 cu yds/yr.

Based on the configuration and thickness of this accretion area and its relationship to the North Point Marina north breakwater, the area can be divided into two subunits. One subunit extends from the state line southward to where the accretion first becomes tangential to the north breakwater. This location is approximately the location of ISGS profile line 11 (Northing 2121500N). The other subunit is from ISGS profile 11 southward to where the accretion hooks around the end of the north breakwater and into the marina entrance. The advantage of this division is that it distinguishes the accretion volume to the north of the breakwater in the open-water offshore from North Beach from the accretion volume that is marginal to the north breakwater. The northern subunit has the greater accretion at 85,400 cu yds (63%). The southern subunit has a volume of 50,800 cu yds (37%).

4.5 Marina Entrance Trough *(Area D)*

The erosion volume in the marina entrance, computed for all erosion within the -1 ft contour of the erosion trough, totals 300 cu yds.

4.6 South Breakwater *(Area E)*

The south breakwater accretion is computed for all accretion marginal to the south breakwater from the limit of accretion mapping within the marina entrance and extending southward. The accretion

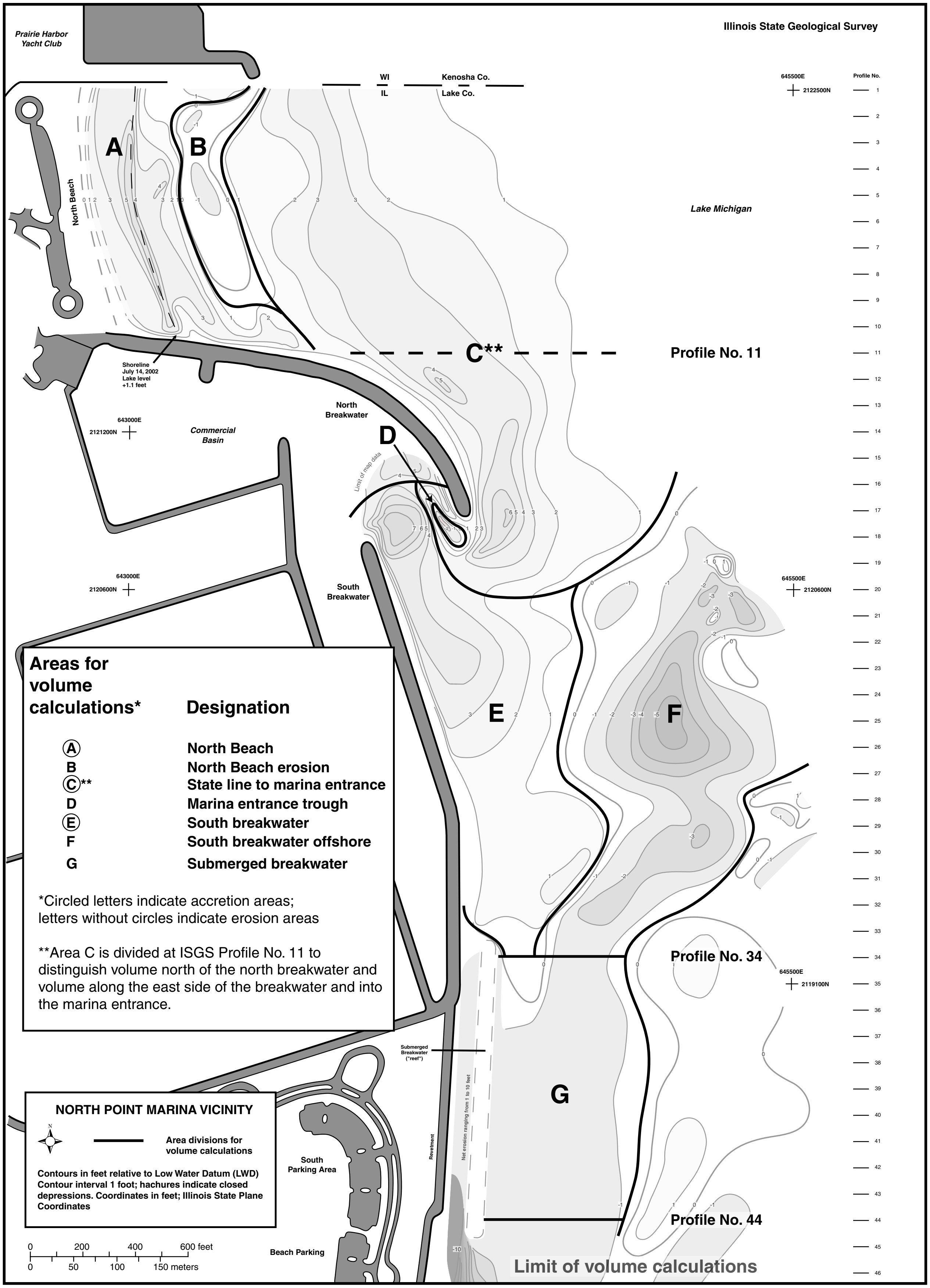
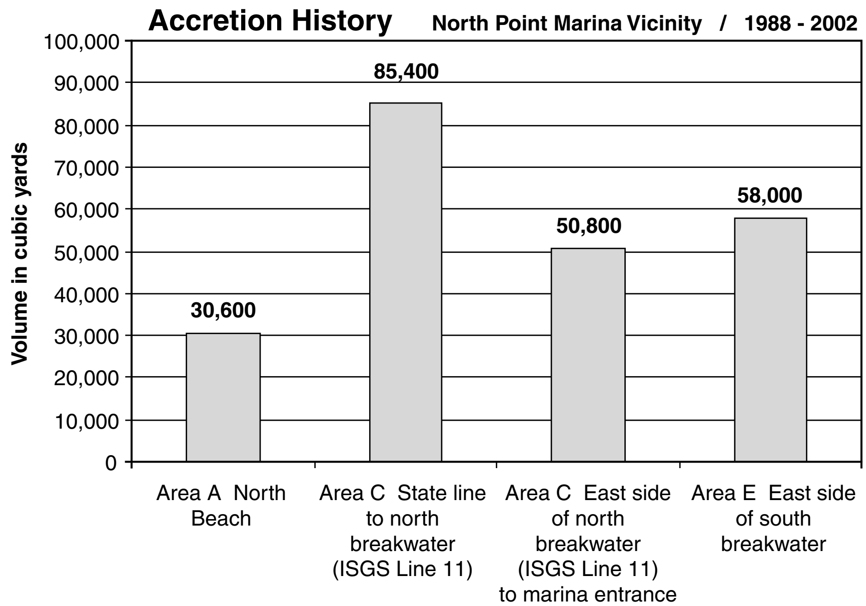


Figure 4-1 *Division of accretion and erosion areas used in volume calculations.*



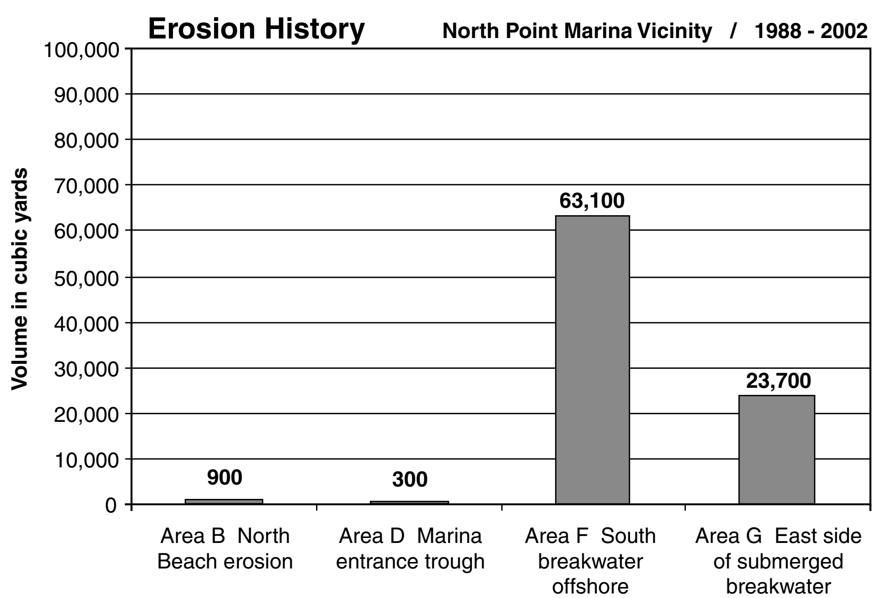


Figure 4-2 *Bar graph summary of the 1988–2002 accretion and erosion volumes for the lake-bottom change.*

volume is 58,000 cu yds (4,100 cu yds/yr), which is slightly more than the accretion volume marginal to the north breakwater (50,800 cu yds).

The accretion pattern lends itself to division into two subunits. One is the area of accretion greater than the 2-ft contour; the other is the area between the 1- and 2-ft contours. This division distinguishes the area of thicker accretion closer to the marina entrance from the extensive area of thinner accretion (1 to 2 ft) that extends along the southern part of the breakwater. The area greater than the 2-ft contour contains 42,000 cu yds (72%); the area between the 1- to 2-ft contours has 16,000 cu yds (28%).

4.6 South Breakwater Offshore *(Area F)*

The erosion volume offshore from the south breakwater was computed with a southern limit set at ISGS profile 34 (Northing 2119200N), which approximates the northern limit of the submerged breakwater. The erosion volume for Area F is 63,100 cu yds (4,500 cu yds/yr).

4.7 Submerged Breakwater *(Area G)*

Erosion volume is computed for the lake bottom on the lakeward side of the submerged breakwater; the erosional trough between the submerged breakwater and the shoreline revetment was excluded. The northern and southern limits for the volume calculations are, respectively, ISGS profile 34 (Northing 2119200N) and ISGS profile 44 (Northing 2118200N). The erosion volume is 23,700 cu yds (1,700 cu yds/yr).

4.8 Volume Changes Summary *(Figure 4-2)*

Figure 4-2 graphically summarizes the erosion and accretion volumes. The total accretion volume is 224,800 cu yds (16,100 cu yds/yr). Of this total, the least accretion volume (14%) has been at North Beach (Area A). The greatest accretion volume (38%) has been in the northern subunit of Area C between the state line and the north breakwater. The combination of the two subunits of Area C (136,200 cu yds) accounts for 61% of the total accretion volume in the marina vicinity.

The total erosion volume is 88,000 cu yds, which is 2.5 times (40%) less than the total accretion volume. The resulting net gain of sediment is 136,800 cu yds. The greatest erosion has occurred in the south breakwater offshore area (72%).

The erosional trough in the marina entrance is the site of the greatest depth of erosion (max. 3.7 ft) but has the least erosion volume. The small area of the erosional trough limits the erosion volume to only 300 cu yds. Erosion in the nearshore at North Beach has removed less than 2 ft of sediment from the 1988 profiles but occurred across a broader area so the volume is three times greater than the deep erosion in the marina entrance.

Part 5: Discussion

5.1 Overview

The bathymetry collected in 2002 and the maps showing 1988–2002 lake-bottom change together provide useful information related to the sediment dynamics in the marina vicinity as well as guidance for several sand-management issues. Three areas are worthy of discussion: the marina entrance, North Beach, and the lake bottom along the approach to the entrance to Prairie Harbor.

5.2 Marina Entrance

Of all the areas mapped, the marina entrance raises the greatest issues regarding water depth, accretion, and erosion. Shoaling at the north end of the south breakwater presents a navigation hazard and essentially precludes boat traffic from using the western half of the marina entrance. The depth of the erosion of the trough adjacent to the north breakwater extends below the base elevation of the breakwater. This erosion poses a potential threat to the integrity of the north breakwater if the erosion extends closer to the base of the structure.

This shoaling and erosion have been persistent lake-bottom features since construction of the breakwaters. Shoaling at the north end of the south breakwater was identified in 1989 within one year of completion of the breakwaters (Moffatt and Nichol Engineers, 1990). Development of the erosional trough was also noted in bathymetric mapping completed in 1989 (Chrzastowski et al., 1996). Maintenance dredging has never been sufficient to remove all accumulated sediment and return the marina entrance to the preconstruction (1987) depths. Sand volumes removed during one year of maintenance dredging have been restored in a short time, possibly as soon as one winter season of storm events.

The presence of the marina entrance shoal is likely a key factor in the development of the marina entrance erosional trough. Field observations suggest that this trough is maintained by the flow of water into and out of the marina on hourly or daily time scales in response to local changes in lake level (set up) caused by wind action. For example, easterly winds will elevate the lake level along the Illinois shore, which will result in water flowing into the marina entrance. Once those winds subside and westerly winds blow water away from the shore, lake level declines, water then flows out of the marina basin and must bypass the shoal. At times when water is leaving the marina basin, a strong current is visible just off the end of the north breakwater generally corresponding to the location of the trough. The overall pattern of accretion and erosion is similar to what occurs along a river meander with maximum erosion along the cut bank (trough area) and accretion on a point bar (shoal area).

Past surveys have shown that the erosional trough has changed shape and maximum depth over time. These changes can be attributed to changes in the shape and extent of the shoal area and accompanying changes in the hydrodynamics of the marina entrance. An important question is whether the trough is getting deeper with time.

In 1995, the maximum recorded depth was 15 ft LWD. By 1997, maximum depth had increased to 16.6 ft LWD, and, in the following year, it reached 17.0 ft LWD (Chrzastowski et al., 1996; Foyle et al., 1997; 1998). The maximum depth of 17.5 ft LWD recorded in 2002 is 0.5 ft deeper than the maximum recorded four years earlier in 1998 and the greatest depth yet recorded in the marina entrance (Table 5-1). The record of annualized change from 1996 to 2002 suggests that the rate of erosion is decreasing (1996 = -1.0 ft/yr to 2002 = -0.1 ft/yr). However, the lack of data for 1999, 2000, and 2001 presents the possibility that during those years erosion reached a depth greater than 17.5 ft

Table 5-1. Maximum recorded depth in the erosional trough at the entrance to North Point Marina.

Year	Maximum recorded depth (ft)	Annualized change from previous survey (ft)
1987[1]	13.8	NA
1988	-	-
1989	16.1	-1.2
1990	14.3	+1.8
1991	14.5	-0.2
1992	14.9	-0.4
1993	-	-
1994	-	-
1995	15.0	-0.0
1996	16.0	-1.0
1997	16.6	-0.6
1998	17.0	-0.4
1999	-	-
2000	-	-
2001	-	-
2002	17.5	-0.1

[1]1987 maximum depth is the preconstruction depth along the present trough axis.
Erosional trough first recorded in 1989 survey.
Dash entries for years without bathymetric data.

LWD but that by 2002 accretion had reduced the depth. Continued annual monitoring of the trough is warranted.

Future dredging to eliminate the marina entrance shoal will have the dual benefit of not only reestablishing unobstructed navigation through the marina entrance but also of increasing the cross-sectional area of the entrance and therefore no longer restricting water flow along the north breakwater. The trough would then likely accumulate sediment and adjust to a common depth through the marina entrance. If no dredging is done and an ever-larger shoal area develops in the marina entrance, in order to accommodate water flow through the entrance, the potential exists for erosion to widen and, with time, possibly deepen the trough. A limiting depth to the erosion would be the interception of the glacial clay (i.e., clayey till) that underlies the sandy lake bottom. Erosion of this clay proceeds at a rate much slower than the overlying sand. There are no data to define the depth to this clay in the marina entrance area.

The pattern of lake-bottom net accretion in the marina vicinity illustrates that the primary source of sand that has accumulated in the marina entrance is sand that has been transported southward across the state line (Figure 5-1). Northeasterly waves can bring some sand into the marina entrance as the waves refract around the end of the north breakwater. Northeasterly waves can also transport sand past the marina entrance and bring sand to the lake bottom adjacent to the south breakwater. Once sand reaches this south breakwater location, two pathways of net transport are possible. Northeasterly waves can continue to move sand southward toward the submerged breakwater and then farther southward resulting in a complete bypass of the marina complex. Southeasterly waves, in contrast, will move sand northward along the south breakwater. This northward transport becomes a net transport direction if sand is moved near and into the west side of the marina entrance. This area is an effective sediment trap. Once southeasterly waves bring sand northward near the north end of the south breakwater, there is no wave or current action to reverse this transport.

5.3 North Beach

Between the state line and the north breakwater, the net southward transport of sand primarily remains offshore, moving from the state line to a tangential approach to the north breakwater. The volume of sand to move inshore to add to North Beach has been minimal compared with the total volume coming southward across the state line. All accounted 1988–2002 net accretion in the marina vicinity totals 224,800 cu yds. North Beach accretion is 30,600 cu yds or only 14% of this total. The gain of this sand combined with the naturally occurring low slope of the North Beach nearshore have caused the net gain in beach width over the past 14 years. As previously mentioned (section 3.4) and shown in Figure 3-3B, the average gain based on comparison of the 0 ft LWD contour is about 170 ft.

The beach accretion at North Beach has not formed the typical triangular shape of a beach fillet predicted in preconstruction modeling. Rather, there has been a persistent lakeward progression of concave-lakeward shorelines. Modifications to the structures at the entrance to Prairie Harbor have contributed to the shape of North Beach. The key factor was the lengthening of the steel sheetpile jetty on the south side of the entrance between 1989 and 1990. This jetty on the north and the North Point Marina north breakwater on the south have allowed North Beach to grow like a typical pocket beach, a concave-lakeward (or seaward) beach built “in the pocket” between two shore promontories.

As more sand gradually accumulates at North Beach, the shoreline will continue to advance lakeward in this concave lakeward configuration until the shoreline is near the end of the Prairie Harbor south jetty. Additional sand will then likely cause all of the North Beach accretion to occur at its southern end against the North Point Marina north breakwater. If the present Prairie Harbor south jetty is

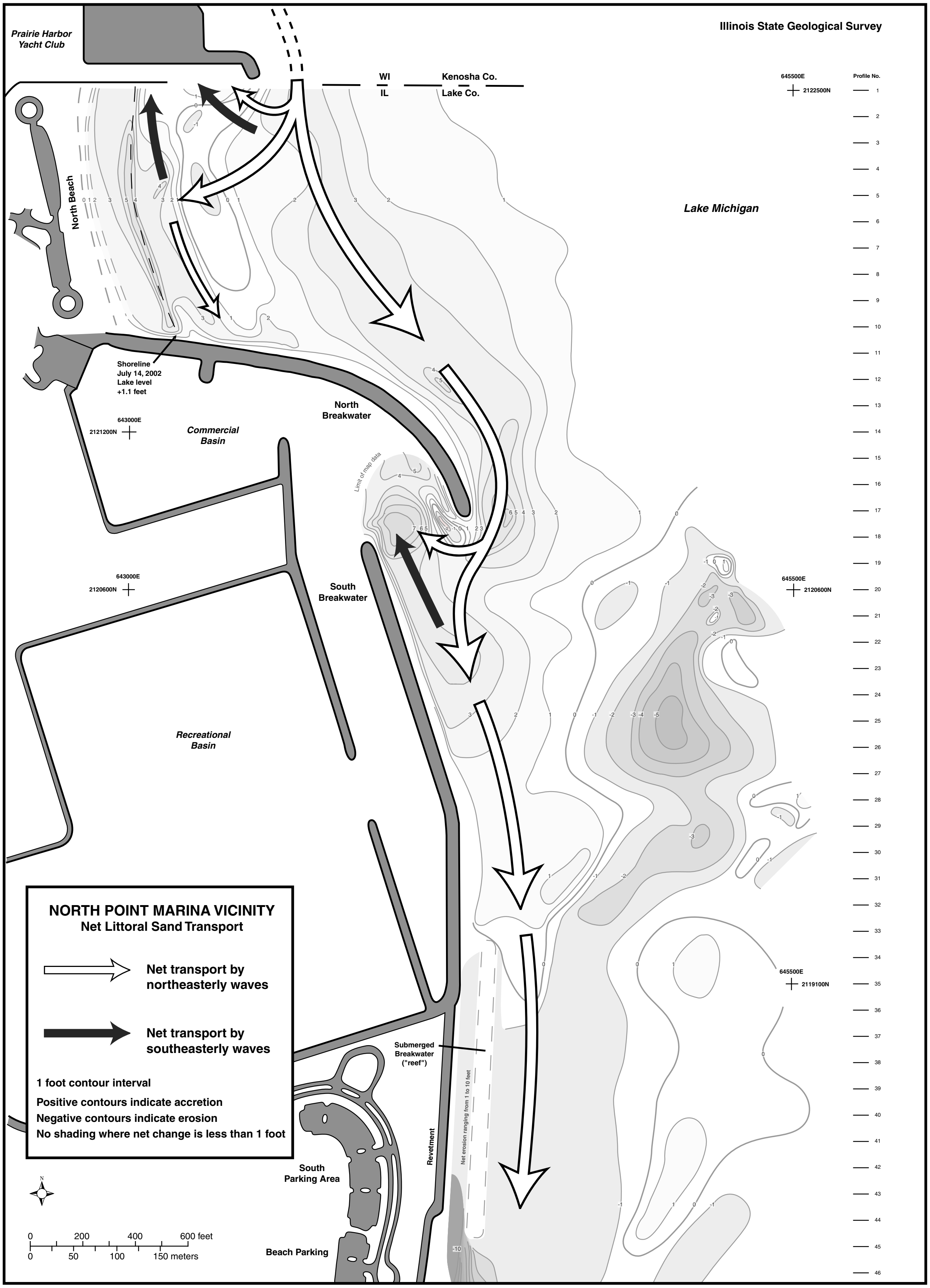


Figure 5-1 *Overview of net littoral transport patterns in the North Point Marina vicinity.*

extended farther lakeward, the potential exists for continued lakeward advance of this arcuate, concave-lakeward shoreline.

As of winter 2003 when this report was completed, the management at Prairie Harbor is considering options for a Phase 1 removal of the hook in the north rubble-mound jetty and lengthening the south steel sheetpile jetty by 200 ft. A proposed Phase 2 of the project, if built, would add 100 ft in length to the north jetty and an additional 200 ft in length (400 ft total) to the south jetty (Prairie Harbor Yacht Club, 2003). The Phase 1 lengthening of the south jetty could increase the opportunity for North Beach to advance lakeward. The Phase 2 lengthening could further increase this opportunity.

5.4 Approach to Prairie Harbor Entrance Channel

Sand accretion in the entrance channel to Prairie Harbor has required yearly to twice-yearly maintenance dredging. In 2002, the accretion was sufficient to prevent Prairie Harbor from opening for the boating season. An evaluation of the shoaling in the Prairie Harbor entrance channel is beyond the scope of this study, but the proximity to North Beach and North Point Marina warrants some discussion.

The 1988–2002 net lake-bottom change shows that the lake bottom on the Illinois side of the state line at the approach to the Prairie Harbor entrance has had minimal net change over this 14-year period (Figure 3-1). On an annual basis, however, there have been times of lake-bottom accretion in this approach area. This accretion was temporary as sand moved onshore to North Beach or into the entrance channel of Prairie Harbor. There have been times such as 1989, 1996, and 1997 when the North Beach bar was positioned such that it essentially extended into the Prairie Harbor entrance channel (Figure 3-4). Presence of a single or double bar in this nearshore area predates construction of the North Point Marina north breakwater (Figure 3-4; 1987 map). Thus, the North Point Marina breakwater construction is not linked to the development of a bar in this area.

The accretion in the Prairie Harbor entrance channel can be attributed to processes like those occurring at the entrance to North Point Marina. Northeasterly waves bring sand southward past the rubble-mound jetty and the refraction of those waves around the end of the north jetty can bring sand into the Prairie Harbor entrance channel. Sand that initially crosses the state line and bypasses the Prairie Harbor entrance can be moved toward and into the entrance channel by southeasterly waves (Figure 5-1). This entrance is an efficient sediment trap. Once southeasterly waves bring sand into this entrance, there is no wave or current action to remove this sand.

Part 6: Recommendations

The 2002 bathymetric data collected in the vicinity of North Point Marina and the results from analysis of the 1988 and 2002 bathymetric data support several recommended actions to assist in the management of sand in the marina vicinity. North Point has a sand issue that is opposite that faced to the south along the shore of Illinois Beach State Park. At North Point there is a surplus of sand caused by the configuration and location of the marina breakwaters forming a partial barrier to the natural southward migration of littoral sediment. The result of this partial barrier has been net sand accretion in the marina vicinity. To the south, along the shore of the state park, there is a deficit of sand.

The sand deficit is not a direct result of the construction of North Point Marina. The state park shore in the North Unit and the northern half of the South Unit has a record of persistent net erosion since the earliest shoreline mapping in 1872. Even the North Point Marina vicinity was subject to erosion prior to marina construction (Figure 1-3). What the marina has done is to partially capture the sand in transport along the shore and prevent this sand from reducing the rate of net erosion farther south along the state park shore.

Successful sand management at North Point therefore involves dredging from the most critical accumulation areas and bypassing this dredged sand to the shore south of the marina. All of the following recommendations for dredging assume that the dredged sand would be placed on the beach or in the shallow nearshore along the shore south of the marina. The nearshore next to the state park North Unit feeder beach would be the minimum distance to the south to place the sand. If mechanical dredging is done with the dredged sand loaded into a barge, some sand could be taken farther south along the North Unit shore and placed at or near identified areas of severe erosion, thus eliminating the time lag necessary for the sand to reach the location by natural migration southward from the North Unit feeder beach.

All of the dredging recommended here is beyond the capability of the hydraulic dredge operated by North Point Marina as of 2002. This dredge (800 rpm; 100-ft run; 5,000 gallons/hour) can safely and efficiently perform maintenance dredging within the protection of the marina breakwaters. The recommended dredging is outside the breakwaters and will require larger and more robust equipment. Either hydraulic or mechanical (clam-shell) dredging could be done. The three dredging recommendations for the area outside the marina breakwaters are as follows:

1. The highest priority should be clearing the marina entrance to improve the safety of boat traffic into and out of the marina and to capture sand from the area of greatest localized accretion. The dredging should restore minimum depth through the entrance to the project depth of -12.1 ft LWD. The marina entrance dredging should remove the shoal near the end of the south breakwater (Figure 6-1; Area 4), as much as is feasible of the shoal area along the lakeward side of the south breakwater (Area 5) and the shoal area off the end of the north breakwater (Area 3).

2. The recommended second-level priority is to dredge along the pathway of sand transport from the state line to the end of the north breakwater (Figure 6-1; Areas 1 and 2). This sand is likely to be transported into or near the marina entrance and to contribute to future marina entrance shoaling.

3. No dredging should be done along the shallow nearshore at North Beach. The 1988–2002 accretion has increased the area for beach recreation, and the popularity of this beach warrants

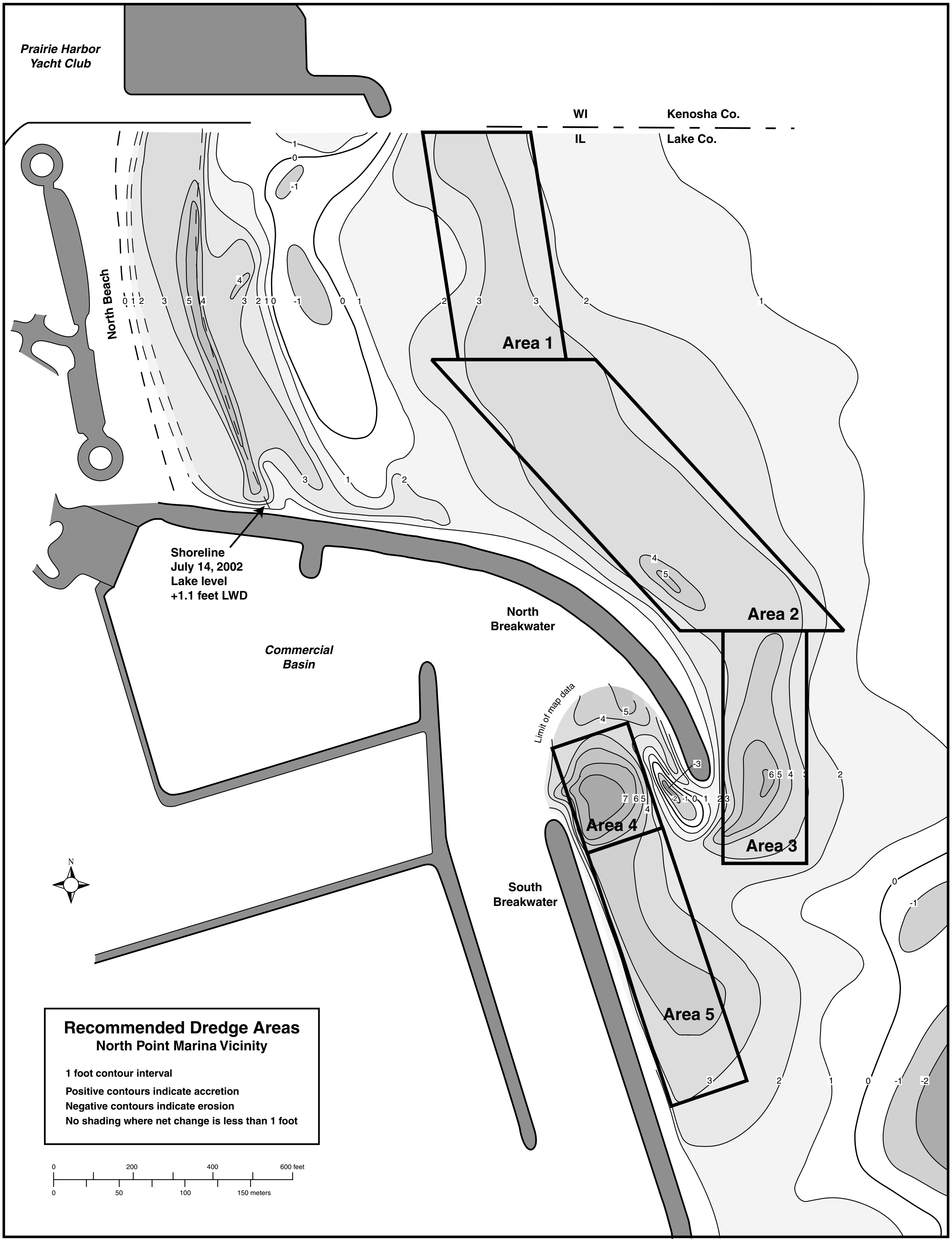


Figure 6-1 *Areas delineated for recommended maintenance dredging between the WI-IL state line and the North Point Marina south breakwater.*

Table 6-1. Dimensions, dredge depth, and dredge volumes for select areas of recommended dredging in the North Point Marina vicinity.[1]

Area	Dimensions (ft)	Dredge depth (ft)[2]	Dredge volume (cu yds)[3]	Percentage of total dredge volume
1	250 x 600	3	16,700	18
2	300 x 890	3	29,700	32
3	200 x 580	4	17,200	18
4	190 x 270	6	11,400	12
5	190 x 650	4	18,300	20
				100
			Total: 93,300	

[1] Areas shown on map in Figure 6-1.
[2] Depth of dredging below the July 2002 lake bottom.
[3] Volume rounded to the nearest 100 cubic yards (cu yds).

the greater beach width. The proposed plans for lengthening the Prairie Harbor south jetty will alleviate much of the problem of sand from the shallow nearshore at North Beach being transported into the Prairie Harbor entrance channel.

Figure 6-1 shows the recommended dredge areas as polygons centered on the areas where accretion thickness is greatest. The assumption is that dredging to reestablish preconstruction depths across the entire marina vicinity is not practical where the accretion is a broad layer less than 3 ft thick. The recommended approach is to focus dredging in the areas of maximum accretion. Five different areas are identified. The recommended depth of dredging for each area is based on the maximum thickness of accumulation in the 1988–2002 bathymetric comparison. For example, from the state line to the north breakwater, the recommended dredge depth is 3 ft; at the shoal in the marina entrance, the dredge depth is 6 ft.

Table 6-1 lists the assumed dimensions for each of the dredge areas, recommended depth of dredging, and the volume that would be dredged based on these area and depth values. The total recommended dredge volume is 93,300 cu yds. This is 41% of the total accretion volume of 224,800 cu yds. Discounting the 30,600 cu yds that have accumulated at North Beach, the total dredge volume is 47% of the accretion along the transport pathway from the state line to the south breakwater.

The littoral sediment budget along the state park shore to the south of the marina requires an annual sediment supply of about 80,000 cu yds/yr to maintain a dynamic equilibrium with no net erosion (Foyle et al., 1997, 1998). The total dredge volume of 91,300 cu yds, if supplied to the state park beach and nearshore, could provide a one-year supply needed for a balanced sediment budget and no net erosion.

Following completion of all recommended dredging from the state line to the south breakwater, it would be beneficial to consider constructing a sand trap to capture sand that comes across the state line. The sand trap would consist of a designated area dredged to a depth below the surrounding lake bottom that would act as a “hole” into which sand in southward transport would accumulate and could be periodically dredged on a maintenance schedule. The U.S. Army Corps of Engineers presently uses such a sand trap on the north side of the entrance to Waukegan Harbor to reduce the rate of sand accumulation in that entrance channel. Locating a trap just south of the state line would allow the capture of sand prior to its migration toward the North Point Marina entrance (Figure 6-2).

The total volume of sand accretion computed in the 1988–2002 bathymetric comparison is 224,800 cu yds. Assuming this sand all came from transport south across the state line, the minimum annual transport across the state line is about 16,000 cu yds/yr. This amount is a minimum because it does not account for sediment that is either captured in the entrance to Prairie Harbor, is transported into North Point Marina, or that completely bypasses North Point Marina.

Based on an estimated average annual transport rate of 16,000 cu yds/yr, a sediment trap could be designed to capture five years of transport (80,000 cu yds) such that maintenance dredging of the trap would have a five-year recurrence schedule. For example, a trap 4 ft deep with dimensions 900 ft by 600 ft has a capacity of 80,000 cu yds. Different dredging recurrence intervals would dictate different trap dimensions with different volumes.

The location and dimensions of the trap would need to be evaluated. The benefit would be that such a trap could eliminate or greatly diminish the dredging needs at the entrance to North Point Marina.

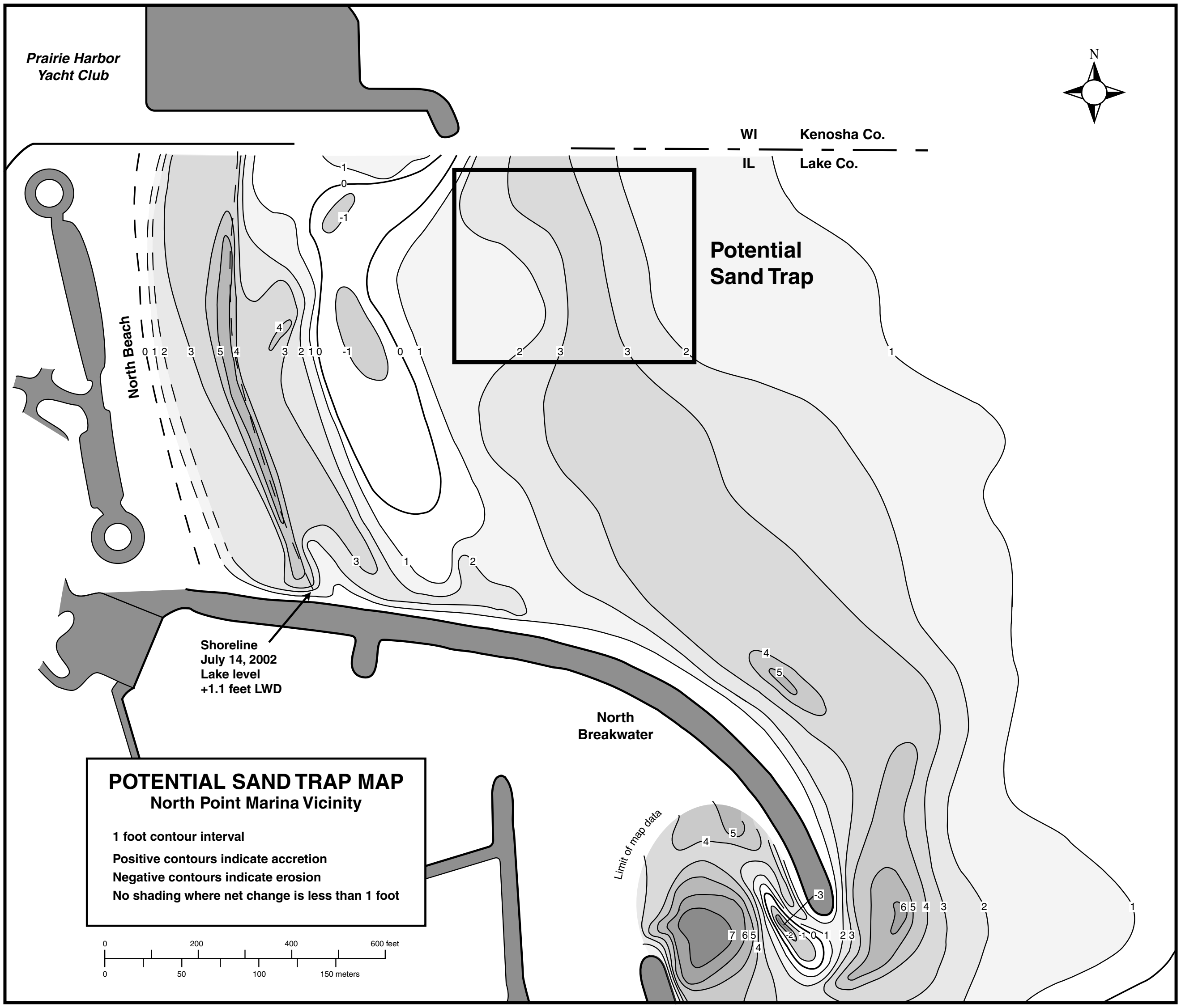


Figure 6-2 *Location of potential sand trap that could be constructed to capture littoral sand prior to its net southward transport toward and into the entrance to North Point Marina.*

Such a trap, if appropriately located, could also benefit Prairie Harbor by reducing the sediment available for shoaling that harbor entrance. Sand dredged from the trap would be transported to the beach or nearshore at the state park feeder beach located just south of the North Point Marina south parking lot. This would ensure that the state park shore would not be deprived of sand supply that would otherwise reach this shore by natural bypass of North Point Marina.

Part 7: Summary

Fourteen years after the outer breakwaters were constructed at North Point Marina, it is clear that the marina has formed a partial barrier to the net southerly transport of sand along the Lake Michigan shore. The pattern of net accretion indicates that some sand naturally migrates past the marina complex. The shore to the south of the marina is erosional, but the partial blockage of sand by the marina is not the cause of this erosion. What the accretion at the marina has done is to prevent this sand from reducing the naturally occurring net erosion along the shore to the south.

The potential for entrapment of littoral sand was recognized prior to marina construction, but the pattern of sand entrapment differs from the original models. The major difference is that North Beach has not been the major area of accretion. Sand that is transported southward across the state line has primarily remained offshore along a pathway that provides for a bypass around the North Point Marina north breakwater. This pathway has allowed sand to reach and accumulate in the marina entrance without traveling by way of North Beach as predicted in the preconstruction model. The modeling did predict that the result of not having a maintenance program to remove sand accretion updrift of North Point would be the eventual natural bypass of the north breakwater and shoaling in the marina entrance. That has been the case.

A major dredging effort is needed to restore the design depths through the marina entrance. There is also need to dredge outside the marina to remove sand along the transport pathway that leads to the marina entrance. The maps of 1988–2002 lake-bottom change provide a means to delineate the recommended dredge areas. However, this lake bottom is dynamic, and the location, orientation, and thickness of accretion above the 1988 profile will change with time. Continued annual monitoring of the bathymetry would be prudent.

Acknowledgments

This project was funded by contract with the Engineering Section of the Illinois DNR Office of Capital Development. Robert Roads (P.E.) of that office is acknowledged for his assistance in obtaining this contract. Additional financial assistance was provided by general revenue funds of the ISGS used to support applied studies of Lake Michigan coastal geology. The management at North Point Marina provided logistical assistance during the 2002 bathymetric survey. For that assistance gratitude is extended to Roger Mellem (Harbormaster), David Suthard (Business Manager), and Virginia Wood (General Manger). ISGS personnel who participated in the bathymetric survey were Mark Collier, Anne Erdmann, and C. Brian Trask. Daniel Byers of ISGS completed all the digital graphics used in this report. Technical review of the report at the ISGS was provided by C. Brian Trask, Beverly Herzog, and Jonathan Goodwin.

References Cited

Chrzastowski, M. J., 1999, Erosion and accretion trends along the Lake Michigan shore at North Point Marina and Illinois Beach State Park, Year-4 (1998) report of a four-year study of coastal geology and coastal geologic processes: Illinois State Geological Survey, Champaign, IL, unpublished maps with text.

Chrzastowski, M. J., A. M. Foyle, and C. B. Trask, 1996, Erosion and accretion trends along the Lake Michigan shore at North Point Marina and Illinois Beach State Park, Year-1 (1995) report of a four-year study of coastal geology and coastal geologic processes: Illinois State Geological Survey, Open File Series 1996-1, Champaign, IL, 146 p.

Foyle, A. M., M. J. Chrzastowski, and C. B. Trask, 1997, Erosion and accretion trends along the Lake Michigan shore at North Point Marina and Illinois Beach State Park, Year-2 (1996) report of a four-year study of coastal geology and coastal geologic processes: Illinois State Geological Survey, Open File Series 1997-8, Champaign, IL, 107 p.

Foyle, A. M., M. J. Chrzastowski, and C. B. Trask, 1998, Erosion and accretion trends along the Lake Michigan shore at North Point Marina and Illinois Beach State Park, Year-3 (1997) report of a four-year study of coastal geology and coastal geologic processes: Illinois State Geological Survey, Open File Series 1998-3, Champaign, IL, 100 p.

IDNR Task Force for Coastal Stewardship, 2001, Long-term coastal stewardship for the IDNR shore of Lake Michigan at North Point Marina and Illinois Beach State Park: report submitted to the Illinois Department of Natural Resources Office of Capital Development, Springfield, IL, 34 p.

Moffatt & Nichol Engineers, 1986, Potential impacts of the Illinois State Park Marina on littoral processes: Walnut Creek, California, Moffatt & Nichol Engineers (prepared for Epstein Engineering, Inc., Chicago), 132 p.

Moffatt & Nichol Engineers, 1990, On the shoaling of the entrance to North Point Marina: Walnut Creek, California, Moffatt & Nichol Engineers (prepared for Epstein Engineering, Inc., Chicago), 40 p.

Patrick Engineering, Inc., 1995, Joint application for Section 404 permit/erosion protection, south end North Point Marina, Lake County, Illlinois (CDB Project No. 102-350-002:IDOC File No. 2-93-03): Glen Ellen, Illinois, Patrick Engineering Inc., 14 p. plus photographs, drawings, and appendices.

Prairie Harbor Yacht Club, 2003, Engineering Feasibility Study for Prairie Harbor Yacht Club, Shabica and Associates, Inc. www.prairieharbor.com (Web site viewed January 17, 2003.)

U.S. Army Corps of Engineers, 1953, Illinois shore of Lake Michigan, beach erosion control study, 83rd Congress, 1st Session, House Doc. 28, 137 p. plus 21 sheets.

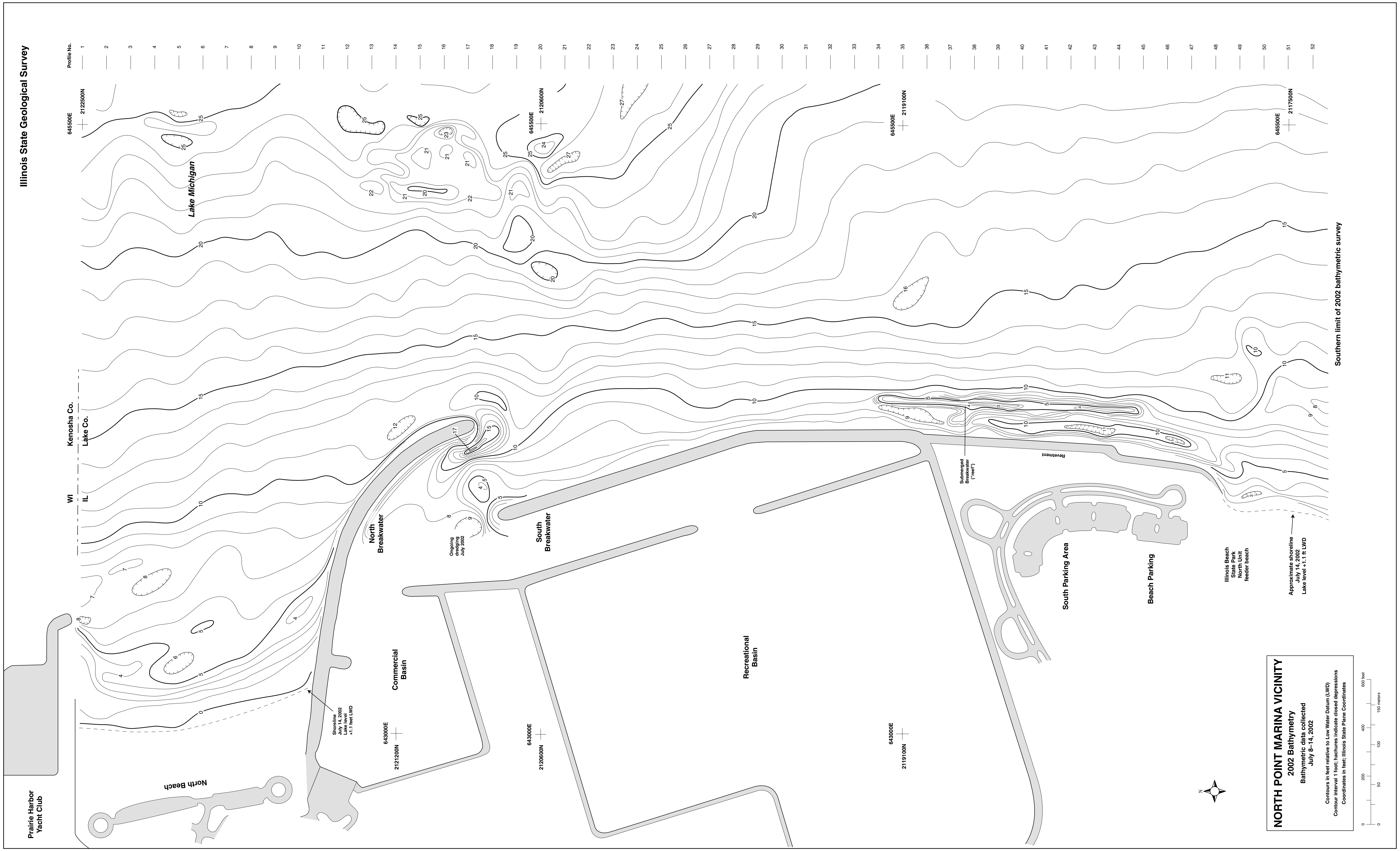


Figure 6-1 Areas delineated for recommended maintenance dredging between the WI-IL state line and the North Point Marina south breakwater.

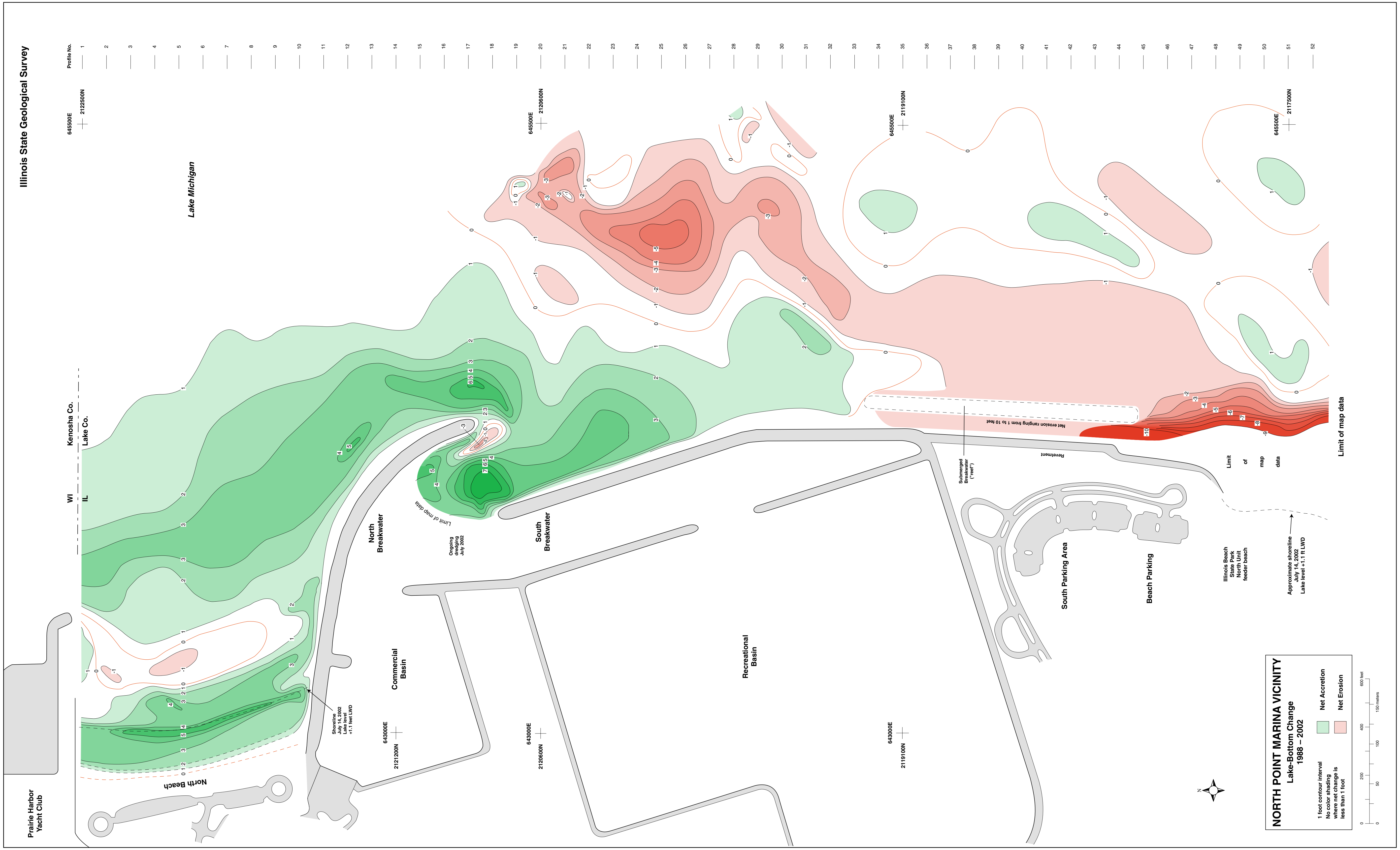


Figure 6-2 *Location of potential sand trap that could be constructed to capture littoral sand prior to its net southward transport toward and into the entrance to North Point Marina.*