

COASTAL ENGINEERING

Chapter 14

EROSION ALONG THE ILLINOIS SHORE OF LAKE MICHIGAN

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In the consideration of problems of coastal engineering in general, and of shore and beach erosion in particular, one is quite naturally apt to immediately focus attention upon our ocean shores to the exclusion of inland areas.

Many are perhaps not appreciative of the fact that the five inland fresh-water lakes comprising the Great Lakes system are bordered by eight states having a combined length of shore line of approximately 3,000 miles. (See Fig. 1) Only in recent years has there been a general awakening of interest in the many and varied problems of erosion which occur along these inland coasts.

The purpose of this paper is to summarize the problems existing on the Illinois shore and to outline the steps which have been taken at the State level in seeking a solution to those problems.

DESCRIPTION OF SHORE LINE

The Lake Michigan shore line of Illinois, while only 53 miles in length, has been highly developed into industrial, residential, and recreational areas. Located thereon are the cities of Chicago, Evanston and Waukegan and many lesser communities, all having an approximate aggregate total 1950 population of 3,800,000 and having property subject to the effects of erosion valued at in excess of \$125,000,000.

In prehistoric times, a glacier covered the Great Lakes area, extending as far south as southern Illinois. The present-day Lake Michigan was dug by the gouging action of tongues of the glacier. The various tongues alternately advanced and retreated, depositing at their termini ridges known as moraines. The final glacial tongue which entered Illinois deposited the Lake Border Moraine system, which follows in general the shape of Southern Lake Michigan, as shown in Figure 2.

It was this glacial action and the associated stages of the glacial lake which give rise to the present composition of the shores of Lake Michigan.

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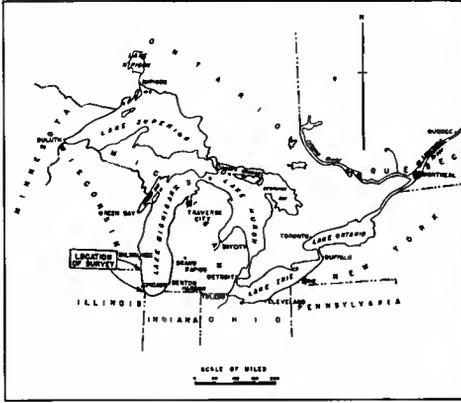


Fig. 1
Location Map

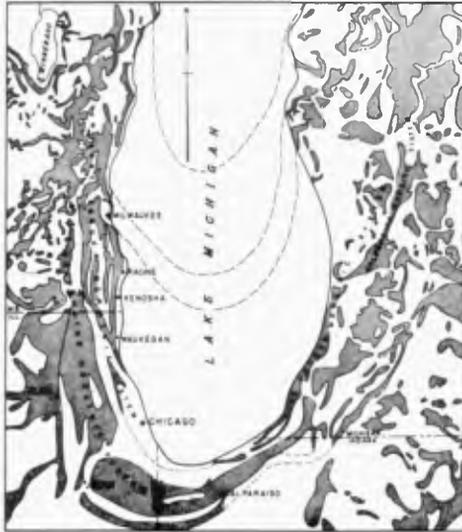


Fig. 2
Lobate distribution of glacial moraines around the southern part of Lake Michigan. (After Leverett, Alden, and Weidman, U. S. Geological Survey Prof. Paper 106, Pl. XXIII, 1918).

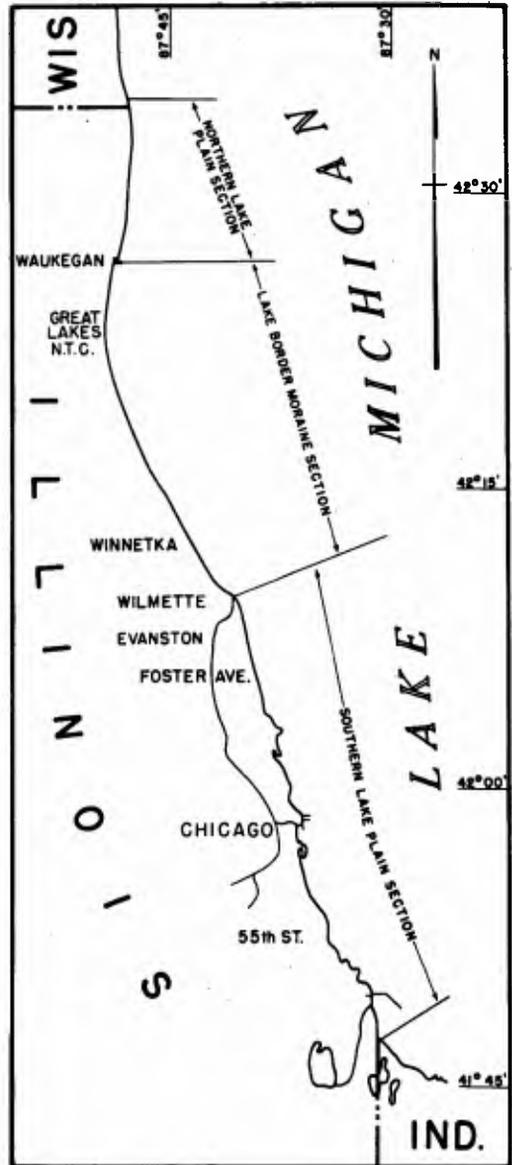


Fig. 3
Physiographic Divisions - Illinois shore of Lake Michigan.

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Based upon a combination of geomorphic and other features, the Illinois shore has been divided into three major segments, as follows: (See Fig. 3).

1. The Northern Lake Plain section extends from the Illinois-Wisconsin line to Waukegan. In this reach, the shore is fronted by a glacial lake plain generally on the order of 5 to 15 feet above the present lake, marked locally by ancient beach ridges and dunes, and composed of deposits associated with the earlier glacial lake or its shores. This section is generally eroding except immediately to the north of the Waukegan Harbor structures, which form an impounding area for the littoral drift. The present erosion essentially represents a recapture of the glacial lake deposits by the present lake.
2. Continuing southward, the reach from Waukegan to Wilmette, designated as the Lake Border Moraine section, is featured by the Lake Border glacial moraine which intersects the shore, giving rise to bluffs up to 90 feet in height composed of glacial till and associated outwash deposits. This section is generally eroding slightly as far south as southern Winnetka; from that point to Wilmette Harbor, there is an impounding area largely created by the harbor structures.
3. In the Southern Lake Plain section, extending from Wilmette southward to the Illinois-Indiana line, the shore is composed of the old lake plain of the glacial lakes, with deposits of ancient beaches, dunes, and lacustrine clay.

Under natural conditions, the reach from Wilmette to 55th Street, Chicago was largely subject to marked erosion, while that from 55th Street to Indiana was a natural impounding area for the littoral drift from the north. At the present time, the shore from Wilmette to Foster Avenue, Chicago has largely been protected by groins and bulkheads. Southward from Foster Avenue, the shore is largely one of artificial fill resulting from operations of park districts and industry.

EROSION PROBLEMS

At the present time, the Illinois shore northward of Foster Avenue, Chicago, is generally in a state of erosion save at the up-drift side of the harbor structures at Waukegan, Great Lakes Naval Training Center, and Wilmette, and at the projecting bulkheaded fill at Foster Avenue.

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The littoral drift, which is predominantly from north to south, is, at best, relatively lean as compared to the ocean shores. The available supply of drift is derived almost exclusively from shore erosion, since there are no streams of consequence entering the lake along this reach of the shore. A large portion of the drift is impounded by the previously mentioned harbor structures, thus impoverishing the shores southward thereof. In addition, the configuration of the shore line at Evanston is such that there is an apparent tendency for the available drift moving to that point to be deflected lakeward into deep water, thus starving the beaches to the south.

Erosional processes also vary to a very considerable extent with lake stage. During periods of high lake stage, the bluffs are within closer reach of wave attack, with a consequent increase in the rate of erosion. During periods of low stages, a wider beach is exposed and hence the bluffs are better protected.

Another problem for the State arises from the exercise of the permit powers conferred by statute. The proper analysis of permits for construction of groins, jetties, and other structures is greatly hampered by a lack of knowledge of the probable effectiveness of the proposed structure for its intended use and of its probable effect upon the property of others.

Time does not permit a detailed discussion of the various points and types of damage. Suffice it to say here, that erosion has been, and is, responsible for damage to recreational beaches, water plants, sewer outfalls, protective structures which have been constructed in the past, and the property and homes of many who thought that they were building at a safe distance back from the shore.

BEACH EROSION INVESTIGATIONS

COOPERATIVE STUDIES

It was not until the early nineteen-forties that serious attention was given to these problems on the State level. Preliminary consideration of the problem made it apparent that nothing less than a complete and far-reaching investigation could provide a basis for solution and that the desired results could perhaps best be attained through a cooperative beach study with the Federal Government.

Accordingly, the 64th General Assembly appropriated the sum of

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\$62,500 in 1945 for the purposes of a cooperative investigation. A formal agreement between the Beach Erosion Board, Corps of Engineers, Department of the Army, and the State of Illinois, acting through its Department of Public Works and Buildings, Division of Waterways, was executed in February 1946. The agreement specified that the purpose of the study was to determine the best method of preventing further beach erosion, of stabilizing existing beaches, and of restoring eroded and damaged beaches.

In addition, a supplemental agreement was signed in June 1947 whereby the scope of the study was enlarged to include the development of a plan of improvement and the determination of the extent to which the Federal Government could participate in the cost of improvement under the provisions of Public Law 727, 79th Congress.

The final report on the study has just recently been forwarded to the Secretary of the Army by the Chief of Engineers. The report sets forth in detail the results of the various studies involved and recommends Federal participation in the construction of shore protection measures for public property at Lake Bluff, Lake Forest, Winnetka, Kenilworth, Evanston, and Chicago.

Recommended protection measures at these locations range from groins, jetties, piers, and bulkheads to the placement of sand fill. In addition, the report suggests protective measures for adoption by owners of private property consisting chiefly of riprap or short groins.

INVESTIGATIONS BY STATE OF ILLINOIS

Subsequent to the initiation of the cooperative beach erosion study, it was found that reliable data on wave height and directions and the source, character, and movement of beach material were entirely lacking and that the most recent hydrography was dated 1909-11. Limitations of time, funds, and scope of project made it necessary that the cooperative study and report proceed on the basis of available information, supplemented by data obtained during the course of the survey.

Recognizing, however, the need for more information as to the fundamental processes involved in erosion problems, the 66th General Assembly appropriated the sum of \$35,000 in 1949 to carry out basic studies relative to shore erosion processes, either independently or in cooperation with the Federal Government and the 67th General Assembly appropriated a like sum this year for the same purpose.

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Contact with the Beach Erosion Board with reference to an additional cooperative study developed the fact that the Board lacked the necessary funds and it was then agreed to enter into an informal agreement whereby the Beach Erosion Board would act as consultants in developing and executing a program and that the State, through the Division of Waterways, would undertake the execution of all field and office investigations.

The program was initiated in early 1950 and has two major objectives, as follows: (1) The study of the character, source, and movement of beach material and (2) the determination of the magnitude and direction of the waves impinging on the beach.

The undertaking of such a program on the part of the State proved to be quite a task in that studies of this type still may be said to be in the pioneer stage even on the sea coasts and doubly so on the Great Lakes. The State lacked both the necessary equipment and the personnel trained in this type of work.

The equipment problem has been largely overcome by the acquisition of the necessary items, as will be discussed later, and the problem of personnel is being met by the development of our present staff through study, indoctrination courses, and experience.

STUDIES ON BEACH MATERIALS

Experience to date in prosecuting a study of the first objective, namely, the character, source, and movement of beach material, has been that such a study presents so many facets and ramifications that it is extremely hard to choose a course to pursue and, having done so, to keep on that course.

Field work on this phase of the program in 1950 consisted of taking soundings and bottom samples to a depth of 60 feet on ranges located approximately one mile apart with a DUKW and fathometer leased from the Corps of Engineers and using a drag-type sampler recommended by the Beach Erosion Board. Profiles were also run on the shore end of the ranges and beach and bluff samples taken. In addition, bluff samples were taken along the Wisconsin shore as far north as Milwaukee at intervals of one mile or less, since this reach is the apparent source of much of the beach material.

Laboratory work on the 1950 samples was confined, during that

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year, to gram-size analysis, using the 2 series sieves down to the No. 16 and an Emory settling tube for the remainder.

A comparison of the range profiles for the cooperative study in 1946 and the State's survey of 1950, together with the results of visual observation in the spring of this year lead to the conclusion that there is apparently little movement of material lakeward of the 5-fathom line and also that profiles at one-mile intervals on an annual basis were not adequate to determine the movement of material.

Therefore the sounding and sampling program for this year was revised to include a considerable number of intermediate ranges together with the taking of profiles on groups of seven ranges spaced at 200-foot intervals along the shore in critical locations.

In this connection, it was necessary for the State to procure equipment for the 1951 work and there has now been acquired an Army DUKW (amphibious truck), a fathometer, and two-way radio equipment consisting of a mobile 30-watt set mounted on the DUKW, and three portable sets for use on shore to maintain the DUKW on course, as shown in Fig. 4.

The acquisition of this equipment delayed the 1951 field program until September 15 and hence the work was not completed in its entirety because of the advent of bad weather. The work did, however, cover the northern end of the shore line where the most serious erosion is taking place.

Early in the spring of 1951, a conference was had with Dr. Martin A. Mason, then with the Beach Erosion Board, and at his suggestion, the program of sample analysis was considerably expanded.

Samples are now being analyzed as follows:

- a. Sieve analysis, using the 2 series sieves throughout the range down through the No. 325 mesh.
- b. Separation of light and heavy minerals, using bromoform.
- c. Magnetic mineral separation, using a weak magnet.
- d. Carbonate separation, using diluted hydrochloric acid.

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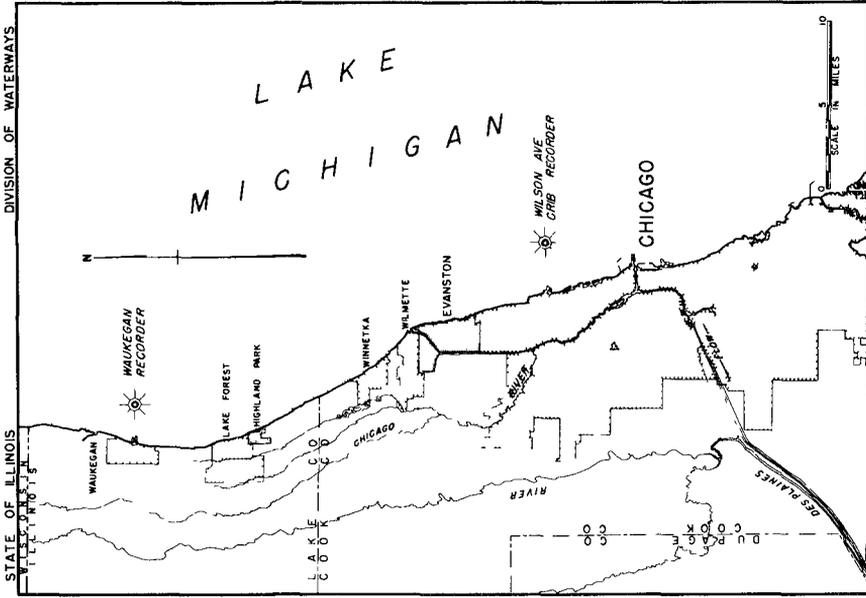


Fig. 5
Location of Lake Michigan wave recorders.

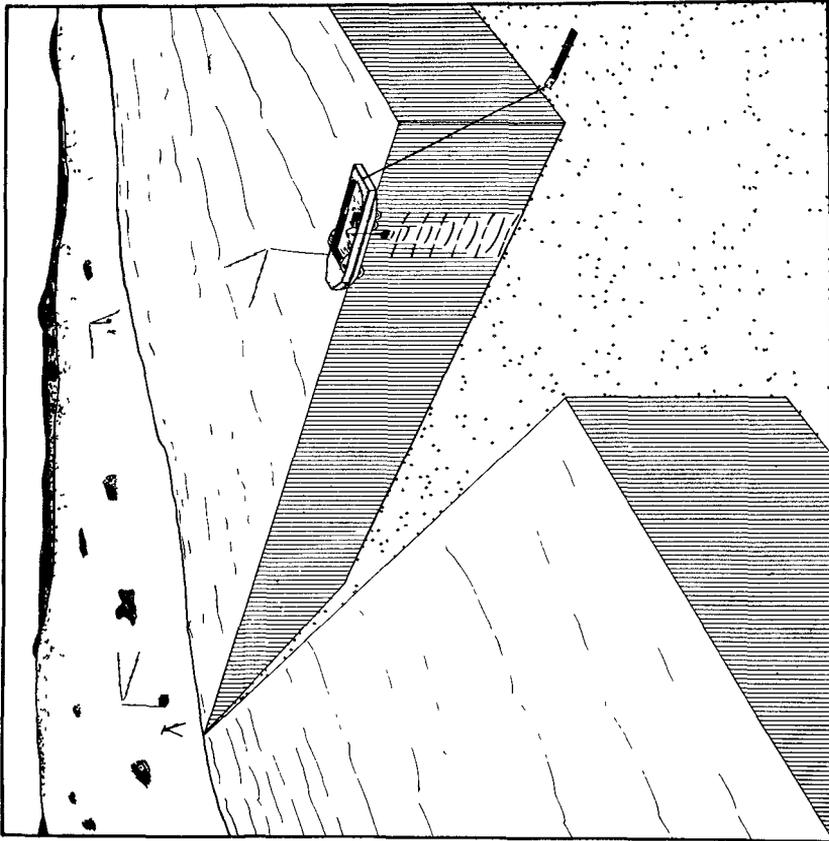


Fig. 4
Diagram of sounding and sampling operations from amphibious truck.

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This work is also being done by the staff, working in a small laboratory set up for that purpose. The analysis of these samples is as yet far from complete and hence conclusions cannot yet be drawn.

In planning for future work along these lines, it has been concluded that even the program of sounding and sampling carried out this year is not perhaps the best for the purpose. It is now believed that since the State has acquired its own equipment and can undertake operations at its discretion, future operations of this nature will be based on the study of both onshore and offshore changes taking place at selected locations during storm periods rather than simply on an annual basis.

STUDIES OF WAVES

In attacking the second objective of the present studies, that is, the determination of the magnitude and direction of the waves impinging on the beach, considerable progress has been made.

The Institute of Engineering Research of the University of California has developed and delivered to the State, one Mark IX Shore Wave Recorder system, which was installed in Lake Michigan in June 1951, about 300 feet northeast of the Wilson Avenue Waterworks Intake Crib of the City of Chicago, approximately 2 miles offshore and in 35 feet of water. In so far as is known, this is the first wave recorder to be installed in the Great Lakes. The University is also under contract for a similar unit which is to be installed off Waukegan Harbor next spring. The relative location of these installations is shown in Fig. 5.

The Wilson Avenue Crib unit is presently operated at a chart speed of three inches per hour with two daily periods of 15 minutes each at a speed of three inches per minute at noon and midnight.

It is planned that both the Wilson Avenue Crib and the Waukegan Harbor station shall both be more or less complete in so far as wind, waves, and lake stages are concerned. To that end, both stations have been equipped with wind recorders, which provide a continuous record of both wind direction and velocity, and with long-term stage recorders which provide a continuous record of lake stage.

While the Wilson Avenue recorder has been in operation for only a few months, the records obtained to date indicate that data as to the generation and duration of storm waves with respect to wind may be of particular interest in that the entire picture of storm occurrence may be studied from one period of flat calm to another.

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It is unfortunate that the wave recorders cannot be operated during the winter months. The hazard to the underwater pressure heads from floating ice is such that they must be removed for the period November-April of each year. There is one compensatory feature, however, in that during those months the beaches are generally heavily covered with ice and hence suffer little damage from wave action.

Visual observations of wave direction are being made by means of a transit equipped with a sighting bar from a station located on the bluffs at Lake Forest and it is anticipated that another station will be selected in the near future.

In the course of the previously mentioned conference with Dr. Mason early this year, it was concluded that the preparation of wave refraction diagrams for the entire Illinois shore would be of value in charting the program of field investigations, even though specific information on wave height, period, and direction was yet lacking.

The lack of personnel qualified to prepare such diagrams made it necessary that one of the engineering staff attend the beach erosion school held in Washington, D. C. in March of this year for training in those procedures. Dr. Mason, and the Beach Erosion Board were most cooperative in making the necessary arrangements for this training.

Following this training, the staff prepared wave refraction diagrams for various wave periods for the entire Illinois shore line. The so-called crestless or orthogonal method was used throughout.

In the course of this work, it was found that the complex pattern of sink holes and small offshore lumps made it necessary that much idealization of the submarine topography be done. In addition, the latest available hydrography was dated 1909-11 and had to be drastically revised to conform to the profile soundings of 1950.

These diagrams were, of course, entirely preliminary. The lack of definite information regarding average wave periods and predominant direction of travel, coupled with the antiquated hydrography, necessarily renders such diagrams of doubtful value, but they have been useful in the charting of the field program. However, data from the wave recorders, together with the results of pending new offshore hydrography by the U. S. Lake Survey, coupled with the present soundings, will permit the preparation of more complete and accurate diagrams in the future.

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CONCLUSION

It is hoped that this resume of the activities of Illinois in the study of erosion problems on Lake Michigan may have been of some interest in pointing out the steps which may be taken at the State level. The present study is as yet, not sufficiently advanced to predict the results that may be attained. Much remains to be done in what is, for Illinois, a new field.

However, it is felt that the results of the study will be of great value in charting the course of the State's activities in preserving and augmenting the important natural resources inherent in its shores, not only in planning and participating in such remedial and protective measures as the General Assembly may deem advisable but in the regulation of the location and type of private construction through the permit powers granted by statute.