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GREAT LAKES REGION INVENTORY REPORT
NATIONAL SHORELINE STUDY

U.S. DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
NORTH CENTRAL DIVISION

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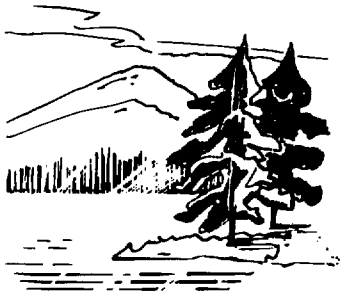

The National Shoreline Study

How will the shore be used ?

SEE

SHORE MANAGEMENT GUIDELINES

What is its condition ?

SEE

REGIONAL INVENTORY REPORTS

What can be done ?

to preserve or enhance the shore,
by using—

- Engineering techniques

SEE

SHORE PROTECTION GUIDELINES
REGIONAL INVENTORY REPORTS

- Management techniques

SEE

SHORE MANAGEMENT GUIDELINES

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NATIONAL SHORELINE STUDY OUTLINE

In 1968, the 90th Congress authorized this National appraisal of shore erosion and shore protection needs. This National Shoreline Study and the existing Federal shore protection programs recognize beach and shore erosion as problems for all levels of government and all citizens. To satisfy the purposes of the authorizing legislation, a family of 12 related reports has been published. All are available to concerned individuals and organizations in and out of government.

REGIONAL INVENTORY REPORTS (one for each of the 9 major drainage areas) assess the nature and extent of erosion; develop conceptual plans for needed shore protection; develop general order-of-magnitude estimates of cost for the selected shore protection; and identify shore owners.

SHORE PROTECTION GUIDELINES describe typical erosion control measures and present examples of shore protection facilities, and present criteria for planning shore protection programs.

SHORE MANAGEMENT GUIDELINES provide information to assist decision makers to develop and implement shore management programs.

REPORT ON THE NATIONAL SHORELINE STUDY, addressed to the Congress, summarizes the findings of the study and recommends priorities among serious problem areas for action to stop erosion.

FOREWORD

The Great Lakes Region Inventory Report is part of a study entitled "The National Shoreline Study." The work was initiated in 1968 and completed in August 1971.

The responsibility for preparation of this Inventory Report was assigned to the North Central Division Corps of Engineers. The report is a joint cooperative effort of the various State and Federal agencies who are represented on the Shore Use and Erosion Work Group for the Great Lakes Basin Framework Study.

Special acknowledgment is extended to the members of the Work Group. Their overall assistance in material contribution as well as review guidance were invaluable aids to the preparation of this report. Their agencies and field offices are listed below. The cartographic work was prepared by the National Ocean Survey, Lake Survey Center, United States Department of Commerce.

DEPARTMENT OF DEFENSE

Army Corps of Engineers . . . . . Buffalo, New York
Chicago, Illinois
Detroit, Michigan
St. Paul, Minnesota

DEPARTMENT OF AGRICULTURE

Soil Conservation Service . . . . . East Lansing, Michigan

DEPARTMENT OF COMMERCE

National Ocean Survey, Lake Survey Center . . . . . Detroit, Michigan

DEPARTMENT OF THE INTERIOR

Bureau of Outdoor Recreation . . . . . Ann Arbor, Michigan

ILLINOIS

Illinois Division of Waterways . . . . . Springfield, Illinois

INDIANA

Department of Natural Resources . . . . . Indianapolis, Indiana

MICHIGAN

Department of Natural Resources . . . . . Lansing, Michigan

MINNESOTA

Department of Conservation . . . . . St. Paul, Minnesota

NEW YORK

Department of Environmental Conservation . . . . . Albany, New York

OHIO

Department of Natural Resources . . . . . Columbus, Ohio

PENNSYLVANIA

Pennsylvania Department of Forest and Waters . . . . . Harrisburg, Pennsylvania

WISCONSIN

Department of Natural Resources . . . . . Madison, Wisconsin

GREAT LAKES BASIN COMMISSION . . . . . Ann Arbor, Michigan

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AUTHORITY

This report was prepared under the authority of Section 106 of Public Law 90-483 (August 13, 1968), quoted below:

> SEC 106. (a) The Chief of Engineers, Department of the Army, under the direction of the Secretary of the Army, shall make an appraisal investigation and study, including a review of any previous relevant studies and reports, of the Atlanta, Gulf, and Pacific coasts of the United States, the coasts of Puerto Rico and the Virgin Islands, and the shorelines of the Great Lakes, including estuaries and bays thereof, for the purpose of (1) determining areas along such coasts and shorelines where significant erosion occurs; (2) identifying those areas where erosion presents a serious problem because the rate of erosion, considered in conjunction with economic, industrial, recreational, agricultural, navigational, demographic, ecological, and other relevant factors, indicates that action to halt such erosion may be justified; (3) describing generally the most suitable type of remedial action for those areas that have a serious erosion problem; (4) providing preliminary cost estimates for such remedial action; (5) recommending priorities among the serious problem areas for action to stop erosion; (6) providing the State and local authorities with information and recommendations to assist the creation and implementation of State and local coast and shoreline erosion programs; (7) developing recommended guidelines for land use regulation in coastal areas taking into consideration all relevant factors; and (8) identifying coastal areas where title uncertainty exists. The Secretary of the Army shall submit to the Congress as soon as practicable, but not later than three years after the date of enactment of this Act, the results of such appraisal investigation and study, together with his recommendations. The views of concerned local, State, and Federal authorities and interests will be taken into account in making such appraisal investigation and study.

Section 1
INTRODUCTION

1.1 Purpose and Scope

This report concerns erosion and the need for protection of the shoreline zone of the United States portion of the Great Lakes. The shoreline zone or shorelands include the land, water, and land beneath the water in close proximity to the Great Lakes shoreline. They represent a unique natural resource, rich in aesthetic and ecological values, and their scenic attractiveness, many beaches and access to large water areas provide outstanding recreational opportunities. The shorelands are subject to unique problems of flooding and erosion when subject to unusually high lake levels and storms.

The information presented in this report is generally limited to the U. S. mainline shores of the five Great Lakes. The connecting rivers are excluded. Data on shores of islands in the Great Lakes are limited and treated separately.

The Great Lakes Regional Inventory Report to National Shoreline Study is an appraisal investigation intended only to define the order of magnitude of the regional shore erosion problems. A parallel study, the Shore Use and Erosion Appendix to the Great Lakes Region Framework study considers future shoreland use and development in greater detail. Both studies were accomplished and coordinated concurrently through the Shore Use and Erosion Work Group of the Great Lakes Basin Commission. The basic data used in the two studies are the same.

1.2 Study Methods and Criteria

In preparing this report, maximum use was made of available information from state and Federal agencies. In particular, detailed survey information on shoreland descriptions and other data collected for the current International Joint Commission study was used to a great extent. A major objective of this study was to systematically prepare a complete inventory of Great Lakes shoreland resources and uses to serve as a base for future more detailed planning and management.

1.2.1 Mapping Procedures

Inventory data were first compiled on base maps with scales of 1: 62500 and 1: 63360. Sources of these data included aerial photographs, U. S. Geological Survey quadrangle sheets and existing International, Federal, State, local public and university reports and publications. No extensive field surveys were made for this study.

This basic information is published in a set of 39 maps each 18 inches by 24 inches. These large scale maps show information in a more useful manner than the figures included in this report. Sets of these maps are on file with the Federal and State agencies participating in the Shore Use and Erosion Work Group.

The maps included in this report summarize the information on the larger map set. Three shoreland strip maps are used for each reach of shore. These maps were prepared at a scale of 1 inch equals 15 miles (1:950400). The reaches were selected on the basis of the Great Lakes Region Study planning subareas. The strip maps were broken at state lines and some have been subdivided for clarity. The following information is identified on the strip maps of the Great Lakes Mainland Shoreline.

Strip Map 1 - Shoreland Uses. Shore property uses are shown on the land side of shoreline.

All public lands and buildings, residential, commercial and industrial development.
Agricultural and rural open spaces (excluding forest land).
Recreation and other urban public open space uses.
Forests or woods.
The following items are shown on the lake side of the shoreline:
Public beaches
Public and private commercial deep-draft harbors.
Public and private recreational boat harbors.
Electric power generating stations.

Strip Map 2 - Environmental Values, Water Intakes, and Waste Outfalls. The following significant fish and wildlife, natural and unique ecological areas are shown on the land side of the shoreline:

Areas of significant fish and wildlife habitat and water oriented recreation resources.
Unique ecological or natural areas.
Individual Areas of the Great Lakes Shoreline having possible national environmental significance.
Significant potential recreation sites which have been identified in state or local recreation plans or reports.
Public and private waste water outfalls and water intakes are also identified.

Strip Map 3 - Physical Description, Ownership, and Erosion and Flooding Problem Reaches

Public ownership, Federal and non-Federal is shown on land side of shoreline.
Beach material is shown lake side of the shoreline as follows:
Sand and gravel
Ledge rock

Shore types are shown lakeward of the shoreline by the following code:

A	Artificial Fill Area
HBE	Erodible High Bluff, 30 Ft. or Higher
HBN	Non-Erodible High Bluff, 30 Ft. or Higher
LBE	Erodible Low Bluff, Less than 30 Ft. High
LBN	Non-Erodible Low Bluff, Less than 30 Ft. High
HD	High Sand Dune, 30 Ft. Higher
LD	Low Sand Dune, Less than 30 Ft. High
PE	Erodible Low Plain
PN	Non-Erodible Low Plain
W	Wetlands

Shoreland erosion and flooding problems are classified as follows:

Areas subject to erosion generally protected.
Critical erosion areas not protected.
Non-critical erosion areas not protected.
Reaches of shore subject to lake flooding.
Reaches of shore not subject to erosion or flooding.

Shoreline reference markers are shown at approximately 5-mile intervals on all three strip maps. These are based on shoreline mileages defined in 1966 for the International Joint Commission Great Lakes Water Levels Study. It is recognized that absolute shoreline mileages will change as lake levels change, new lake fills are constructed and erosion and accretion processes continue. Therefore, these markers are used as reference points for description purposes rather than as exact shoreline mileages.

This report aims at determining the areas along the shoreland "where erosion presents a serious problem because the rate of erosion, considered in conjunction with economic, industrial, recreational, agricultural, navigational, demographic, ecological, and other relevant factors, indicates that action to halt such erosion may be justified." Major studies beyond the scope of the National Shoreline Study authority must be made before definitive answers can be obtained. In this report critical erosion areas are defined as those existing high value economic and recreational shorelands that have a history of rapid loss of land and major damage. All other areas recording significant erosion and minor damage are classified as non-critical erosion areas.

1.2.2 Definition of Terms

The following listed technical terms are used throughout this report.

accretion: May be natural or artificial. Natural accretion is the gradual build-up of land over a long period of time. The forces of nature act on a beach by depositing water- or air-borne material. Artificial accretion is a similar build-up of land, but by an act of man, such as the accretion formed by a groin, breakwater, or beach fill deposited by mechanical means.

artificial nourishment: The process of replenishing a beach by artificial means, e.g. by the deposition of dredged materials.

agriculture and rural open space: Includes cropland, pasturelands, and all vacant and undeveloped lands, except forests, which are treated separately.

backrush: The return of the water seaward following the uprush of the waves to shore.

backshore: That zone of the shore or beach that lies between the foreshore and the coast line. Waves reach it only during severe storms, especially when the water level is very high.

barrier beach: A bar parallel to the shore, the crest of which is above high water.

bay: A wide indentation into the land formed by a lake.

beach: The zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation usually the effective limit of storm waves. The seaward limit of the beach includes foreshore and backshore.

beach width: The horizontal dimension of the beach as measured normal to the shoreline.

berm: A low, relatively flat bench lying between the high water mark on a shore and the cliff or scarp of bordering shore highland. Berms are a recognized feature of seashores and are recognized on the shores of the Great Lakes.

bluff: A high, steep bank or cliff.

breakwater: A structure for breaking the force of waves to protect craft anchored in a harbor or to protect a beach from erosion. An offshore barrier may be either an artificial structure or a natural formation. Sometimes it is connected at one, or both ends, with the shore.

bulkhead: A low wall of stones, concrete or piling built to protect a shore, or fills, from wave erosion. A bulkhead may be built to protect navigable waters and serve as a line, limiting filling, or beyond which filling of submerged lands is not permitted.

commercial: In general, includes building, parking areas, and other land directly related to retail and wholesale trade, and personal, business, and professional services. This category also includes small industrial or public building that occur in predominently commercial areas, and recreational boat marinas.

contour: (1) A line connecting the points, on a land or submarine surface, that have the same elevation; (2) In topographic or hydrographic work, a line connecting all points of equal elevation <u>above</u> or <u>below</u> a datum plane.

dike: A wall or mound built around a low-lying area to prevent flooding.

downdrift: The direction of predominant movement of littoral materials.

drift: (1) The speed at which a current runs; (2) Floating material deposited on a beach (driftwood); (3) A deposit of a continental ice sheet, as a drumlin; (4) Sometimes used as an abbreviation for littoral drift.

dunes: Ridges or mounds of loose, wind-blown material, usually sand.

erosion: The wearing away of land by the action of natural forces. On a beach, the carrying away of beach material by wave action, tidal currents, or littoral currents or by the action of the wind. Erosion can be further classified as critical erosion or non-critical erosion. Critical erosion areas are defined as those reaches of shoreline having existing high value economic and recreational resources and a historic record of rapid loss of land and/or structural damage. All other shoreline reaches recording erosion damages are classified as non-critical erosion areas.

fetch: In wave forecasting, the continuous area of water over which the wind blows in essentially a constant direction. Sometimes used interchangeably with fetch length.

fetch length: In wave forecasting, the horizontal distance (in the direction of the wind) over which the wind blows.

foreshore: The part of the shore, lying between the crest of the seaward berm and the ordinary low water mark, that is ordinarily traveled by the uprush and backrush of the waves as the tides rise and fall.

forests: All forests not designated as recreation lands.

freeboard: The additional height of a structure above design high water level to prevent overflow. Also, at a given time the vertical distance between the water level and the top of the structure. On a ship, the distance from the waterline to main dock or gunwale.

gabion: A specifically designed basket or box of corrosion resistant wire used to hold rock and other coarse aggregate. These gabions may be locked together to form groins, sea walls, revetments, deflectors and other structures. Their flexible construction permits minor adjustments of alignment resulting from undercutting, filling and settling.

Great Lakes Basin: The hydrographic area defined by the drainage areas of Lake Superior, Lake Michigan, Lake Huron, Lake Erie, Lake Ontario, and the St. Lawrence Seaway to the Canadian-New York International Boundary Line and including all closed basins within the topographic divides separating the Great Lakes Basin from adjacent major drainages.

Great Lakes Region: The boundary of the Great Lakes Basin defined by selected County lines for statistical data availability and economic analysis.

groin: A shore protective structure (built ususally perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore. It is narrow in width (measured parallel to the shoreline), and its length may vary from less than one hundred to several hundred feet (extending from a point landward of the shoreline out into the water). Groins may be classified as permeable or impermeable. Impermeable groins have a solid or nearly solid structure. Permeable groins have openings in them of sufficient size to permit passage of large quantities of littoral drift.

harbor: A stretch of water on the coast which affords shelter to sea-going vessels. It may have been formed naturally, or artificially, or by artificial improvement of a natural feature.

harbor of refuge: A name given to havens on the shores of the Great Lakes located between commercial harbors; designed mainly to be a place of refuge for small craft during storms.

industrial: Includes all industrial buildings, parking areas, adjacent yards, and grounds. Included are warehousing, mining and other mining industries, steel mills, private utilities and railroad facilities.

jetty: On open seacoasts, a structure extending into a bay of water, and designed to prevent shoaling of a channel by littoral materials and to direct and confine the stream or tidal flow. Jetties are built at the mouth of a river or tidal inlet to help deepen and stabilize a channel.

lee shore: The shore that lies in the direction of the prevailing winds. It is thus protected from strong wave action, and is often the swampy shore.

littoral: Pertains to the shore, either or both the shoreland and shore water and near shore bottom of a lake.

littoral drift: The material moved in the littoral zone under the influence of waves and currents.

littoral transport: The movement of material along the shore in the littoral zone by waves and currents.

low water datum: An approximation to the plane of mean low water that has been adopted as a standard reference plane.

nearshore (zone): An indefinite zone extending seaward from the shoreline somewhat beyond the breaker zone.

nodal zone: An area at which the main direction of littoral transport changes.

nonstructural measures: Managing, utilizing, or controlling water and related lands without structural development to achieve a desired objective.

planning subarea: A geographic area described by a group of counties with hydrologic and economic integrity. The Great Lakes Region is partitioned into fifteen planning subareas.

pier: A structure extending out into the water from the shore, to serve as a landing place, a recreational facility, etc., rather than to afford coastal protection.

pile: A long, slender piece of wood, concrete, or metal driven or jetted into the earth or sea bed to serve as a support or protection.

pile, sheet: A pile with a generally flat cross-section driven into the ground or sea bed and meshed or interlocked with like members to form a diaphragm, wall, or bulkhead.

private beach: A beach area in private ownership that is for the exclusive use of the property owner or his guests.

public beach: A beach available for the unrestricted use of the general public.

public buildings and related lands: Includes all buildings and related grounds belonging to public or quasi-public agencies, governments, or organizations, which are commonly referred to as institutions. This would encompass medical facilities, educational facilities, religious institutions, governmental administration and service buildings, military installations, sewage treatment and water treatment plants, and airports.

recreation and other urban public open space uses: Includes all designated outdoor recreation lands. Privately owned outdoor recreation lands, such as golf courses and tennis clubs, are also included, as are amusement parks, race tracks and cemeteries.

residential: Four or more single- or multi-family buildings adjacent to each other. Also included within this category are churches, elementary schools, small neighborhood parks, and small isolated commercial buildings, such as a neighborhood grocery store, within the boundaries of the residential area.

revetment: A facing of stone, concrete, etc., built to protect a scarp, embankment, or shore structure against erosion by the wave action or currents.

riparian rights (lake): The rights of a person, or group in common, has by virtue of ownership of land abutting the banks or fronting on the water of a lake.

riprap: A layer, facing, or protective mound of stones randomly placed to prevent erosion, scour, or sloughing of a structure or embankment; also the stone so used.

rubble-mound structure: A mound of random-shaped and random-placed stones protected with a cover layer of selected stones or specially shaped concrete armor units. (Armor units in primary cover layer may be placed in orderly manner or dumped at random.)

run-up: The rush of water up a structure on the breaking of a wave. The amount of run-up is the vertical height above still water level that the rush of water reaches.

seiche: A periodic oscillation of a body of water whose period is determined by the resonant characteristics of the containing basin as controlled by its physical dimensions. These periods generally range from a few minutes to an hour or more. (Originally the term was applied only to lakes, but now it applies also to harbors, bays, oceans, etc.)

shore: The strip of ground bordering any body of water. A shore of unconsolidated materials is usually called a beach.

shoreline: The intersection of a specified plane of water with the shore or beach. (E.g. the high water shoreline would be the intersection of the plane of mean high water with the shore or beach.)

shoreline protection: Structural measures designed to relieve erosion damage along the shoreline. Examples of structural measures are protective beaches, seawalls, and revetments.

slope: The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25 or 1 on 25, indicating 1 unit rise in 25 units of horizontal distance. It is sometimes described by such adjectives as steep, moderate, gentle, mild, or flat.

still water level: The elevation of the surface of the water if all wave action were to cease.

topography: The configuration of a surface including its relief, the position of its streams, roads, buildings, etc.

undeveloped recreation lands: Recreation lands that support developed area by providing a quality environment, buffer area, or scenic backdrop that provide for extensive recreation activities, such as hunting, hiking and nature walks, or that are characterized by (and may be set aside for) important wilderness, geologic or other natural values. Undeveloped recreation lands are also termed extensive recreation lands.

updrift: The direction opposite that of the main movement of littoral materials.

uprush: The rush of water up onto the beach following the breaking of a wave.

wetlands: Relatively flat lands that are wet during all or part of the year, being either covered by water or waterlogged. These lands are generally characterized by grasses, shrubs, cattails, bulrushes, and other low growing plants. Along the Great Lakes shoreline, they include marshes, swamps and other lands generally considered to be potential fish and wildlife areas.

SECTION 2
THE GREAT LAKES REGIONAL SUMMARY

2.1 General

The Great Lakes Region is located within the highly industrialized North Central United States. It covers about four percent of the United States land area, has 14.4 percent of the nation's population and produces 50 percent of the nation's steel. The Region consists of the land and water area of 183 counties in eight states (Figure 1). The dominant physical feature of the Region is the Great Lakes. The Great Lakes Coastal Resources are invaluable assets to the Region and the nation as a whole. This section describes the Great Lakes Region physical and economic character and summarizes the Great Lakes Shoreline, condition, uses, ownership, and erosion and flooding problem areas. The treatment of flooding problems, while outside the general scope of the National Shoreline Study is given in this report to provide a complete inventory of shoreline damages. This report also suggests suitable types of protection for those areas having critical erosion problems and provides preliminary cost estimates for such protection.

2.2 Geology

The basin occupied by the Great Lakes was created by glaciation, and its physical features and hydrology differ greatly from those of regions not glaciated or only modified by glaciation. Further, its construction was but recently completed in terms of earth history. The five Great Lakes, with their outlets and approximate lake levels as they are today, probably date back less than 5,000 years. The processes of stream and shoreline erosion have made slight change in the original topography.

Prior to the Pleistocene or Ice Age of earth history, the Great Lakes were non-existent--the area being traversed by the well-drained valleys and divides of several large rivers. When the continental ice cap developed to a thickness of several thousand feet over all of Canada, it spread southward into this lower area completely covering what is now the Great Lakes-St. Lawrence basin. Tremendous amounts of bedrock were eroded and the debris entrained in the ice mass. Then, as the ice sheet slowly melted and retreated progressively northward, this entrained debris was released and vast irregular deposits of overburden were laid down.

The present topography was thus entirely changed. Parts of the major pre-glacial valleys had been deepened by glacial scouring; other parts had been filled by glacial deposits so that the basins of five great lakes resulted. For example, the maximum depth of Lake Michigan is more than 900 feet, and while bedrock is buried under 600 feet of overburden along one reach of its east shoreline, it is exposed along several reaches of its west shore. The pre-glacial, well-drained divides had also been scoured and then completely buried under glacial deposits. The present land areas have therefore an irregular and varied topography, including depressions occupied by small lakes or marshes, level or sloping local plains, and low rolling hills or ridges. The overburden material varies greatly from place to place, ranging from clays to sand or gravel.

A minor aspect of the glaciation, but one very important in developing the topography and overburden conditions of the areas bordering the present shorelines, was the temporary occurrence of large glacial lakes. During the final northward recession of the ice front there was ponding of the melt waters between the ice and the exposed glacial deposits which resulted in a gradually enlarging body of lake waters at levels in some cases hundreds of feet above present lake levels and with overflow outlets across present watershed divides. As the ice border receded, the pattern and the levels of those lakes were repeatedly changed as new lower outlets were uncovered. The effect of these glacial lakes on present shorelines is illustrated by such features as the perched wave-cut cliffs of Mackinac Island, the lake-deposited clay flats of Chicago and Toledo, the variable stratified sands and silts constituting or overlying the bluffs along the Ohio shore of Lake Erie, and the sand tracts of the dune areas. Concurrent with the shrinking of the ice mass, there was differential uplift of the earth surface in the region, as evidenced by the now tilted positions of the shore features of the glacial lakes.

The outlets of Lakes Superior and Erie are controlled by bedrock uncovered by erosion at shallow depths under the glacial overburden at Sault Ste. Marie and the Niagara River below Buffalo, respectively. Although bedrock occurs at shallow depth in the Detroit River, the Lake Huron outlet control still remains in glacial overburden in the entire length of the St. Clair River.

The configuration of the Great Lakes remains but little altered since its glacial development. Except where bedrock is exposed or protective works constructed, the glacial overburden comprising the shores is still vulnerable to shoreline erosion.

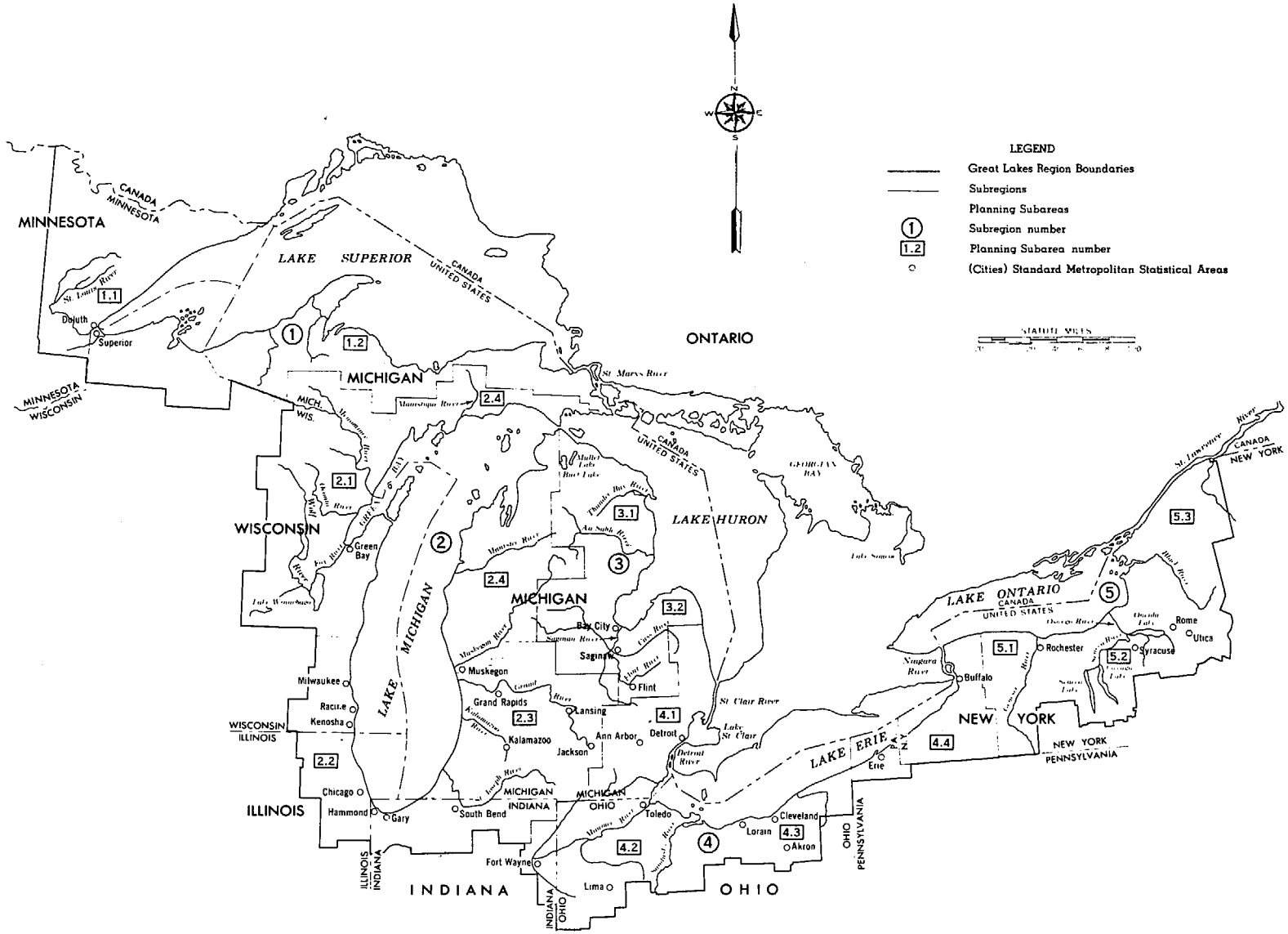

Figure 1. Great Lakes Region, Planning Subareas, Great Lakes Basin Commission.

2.3 Basin Description

The Great Lakes Region Basin Boundary combines the drainage areas within the United States of Lake Superior, Lake Michigan, Lake Huron, Lake Erie, Lake Ontario, the St. Mary's, Detroit and St. Clair Rivers, Lake St. Clair and those streams entering the St. Lawrence River within the United States. It includes a land area of 115,000 square miles and a water area of 61,000 square miles. About 176,000 square miles of the Great Lakes drainage is in the United States. This is 60 percent of the total 298,000 square miles.

The Great Lakes system extends over 2,000 miles and has a water surface area of about 95,000 square miles (U. S. and Canada areas combined). The Great Lakes Region covers all of Michigan and parts of seven other states. The Region has 3,680 miles of mainland shores.[1] The Great Lakes are connected by rivers: The St. Marys River - Lake Superior to Lake Huron; the Straits of Mackinac - Lake Michigan to Lake Huron; the St. Clair River - Lake Huron to Lake St. Clair; the Detroit River - Lake St. Clair to Lake Erie; the Niagara River - Lake Erie to Lake Ontario; and the St. Lawrence River - Lake Ontario to the Atlantic Ocean.

The International Boundary, which defines in general the northern geographic boundary of the Great Lakes Region, passes through all of the Great Lakes and their connecting channel. The only exception is Lake Michigan, which lies wholly within the United States. Four of the Great Lakes are thus boundary waters, dividing the United States and Canada. Improvements that affect the levels of all five Lakes and their connecting channels also affect Canada.

The tributary streams of the Great Lakes Region are generally small in area and short in length. The drainage areas of major tributaries in the United States vary. They range from 6,600 square miles for the Maumee River in Ohio, 5,600 square miles for Grand River, Michigan, and 6,300 square miles for the Saginaw River, Michigan, to small streams of a few square miles, that flow directly into the Lakes.

The Great Lakes Region ranges in elevation from 1,980 feet above sea level at Mt. Curwood to 152 feet above sea level at Massena, New York. Mt. Curwood is in the Huron Mountains south of Lake Superior. Massena is on the St. Lawrence River near the International Boundary. The mean, or average, lake surface elevations during the past 109 years have been 600.37 for Lake Superior, 578.68 for Lake Michigan-Huron, 570.37 for Lake Erie, and 244.77 for Lake Ontario (IGLD 1955).[2] Maximum recorded depths of the Great Lakes range from 1,333 feet in Lake Superior to 210 feet in Lake Erie. A profile of the Great Lakes System is shown in Figure 2. The physical characteristics of the Great Lakes are given in Table 1.

Since the Great Lakes Region is located between latitude 41 and 50 degrees, it could reasonably be expected to have the severe climate associated with these latitudes. The large surface area and depth of the Great Lakes, however, modulate the summer and winter temperatures along their shores. From 1883 to 1957, inclusive, the average annual temperature in the Great Lakes Basin ranged from 39.0 degrees on Lake Superior to 48.7 degrees on Lake Erie. On each lake, the minimum monthly temperature occurred in February; the monthly maximum temperature was reached in July.

The mean annual precipitation for the entire Basin during the same period of record was 31 inches. There was a minimum of 25 inches in 1930 and a high of 37 inches in 1950. The annual snowfall ranged from 40 to 120 inches.

2.4 Economic Development

The Great Lakes Region has accounted for a steady 14-15 percent of total United States population in the Census decades from 1940-1960. The Planning Subareas of Lake Michigan and Lake Erie have accounted for about 46 and 39 percent, respectively, of the total population for the Great Lakes Basin in the same period. The other Planning Subareas making up the remaining 15 percent of the Basin's projections are Lake Ontario (9 percent), Lake Huron (4 percent) and Lake Superior (2 percent).

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1 Exclusions: St. Marys River and connecting waters (88.6 miles), Detroit River (31 miles), St. Clair River (38 miles), Niagara River (39.3 miles), Sturgeon Bay and Lake Michigan Ship Canal (19.8 miles), Portage Lake and connecting waterways (98.2 miles) and all island shoreline.

2 All elevations and depths mentioned in this report are referred to the established low water datum planes of each of the Great Lakes. These datum planes are referred to mean water level in Fathers Point, Quebec, I.G.L.D. (1955 International Great Lakes Datum).

Table 1
Physical Characteristics of the Great Lakes System

Description	*Lake Superior*	*Lake Michigan*	*Lake Huron*	*Lake St. Clair*	*Lake Erie*	*Lake Ontario*
Low water datum (LWD) elevation in feet 1GLD (1955)	600.0	576.8	576.8	571.7	568.6	242.8
Dimensions in miles:						
Length	350	307	206	26	241	193
Breadth	160	118	183	24	57	53
Shoreline including islands	2,980	1,660	3,180	169	856	726
Areas in square miles:[a]						
Drainage basin in U. S.	37,500	67,900	25,300	2,370	23,600	16,800
Drainage basin in Canada	42,600	0	49,500	4,150	9,880	15,300
Total drainage basin (land and water)	80,100	67,900	74,800	6,520	33,500	32,000
Water surface in U. S.	20,600	22,300	9,100	162	4,980	3,460
Water surface in Canada	11,100	0	13,900	268	4,930	3,880
Total water surface	31,700	22,300	23,000	430	9,910	7,340
Volume of water in cubic miles:[a]	2,935	1,180	849	1	116	393
Depths of water in feet:[a]						
Average over lake	489	279	195	10	62	283
Maximum observed	1,333	923	750	21[b]	210	802
Outlet river or channel	St. Marys River	Str. of Mackinac	St. Clair River	Detroit River	Niagara River	St. Lawrence River
Length in miles	70	—	27	32	37	502
Average flow in cfs (1860-1968)	74,500	52,000	187,000	190,000	202,000	239,000
Monthly elevations in feet[c]						
Average (1860-1968)	600.37	578.68[d]	578.68[d]	573.01[e]	570.37	244.77
Maximum	602.06	581.94	581.94	575.70	572.76	248.06
Minimum	598.23	575.35	575.35	569.86	567.49	241.45
Average—winter low to summer high	1.1	1.1	1.1	1.6	1.5	1.8
Maximum—winter low to summer high	1.9	2.2	2.2	3.3	2.7	3.5
Minimum—winter low to summer high	0.4	0.1	0.1	0.9	0.5	0.7
Annual precipitation in inches (1900-1968)						
Average on basin (land and water)	30	31	31	—	34	34
Average on lake surface	30	30	31	—	33	33

a Lake level at low water datum elevation. LWD is a reference elevation for nautical charts and projects.

b Maximum natural depth.

c Lake elevations are as recorded at Marquette (L. Superior), Harbor Beach (L. Michigan-Huron), Grosse Pointe Shores (L. St. Clair), Cleveland (L. Erie), and Oswego (L. Ontario). Recorded elevations are affected by man-made changes such as: regulation of outflows from Lake Superior (1921) and Lake Ontario (1960); diversions of water from Hudson Bay basin into Lake Superior (1939) and from Lake Michigan basin into Mississippi basin at Chicago (before 1860); and regimen changes in the natural outlet channels from the lakes throughout the period of record.

d The Straits of Mackinac between Lakes Michigan and Huron is so wide and deep that the difference in the monthly mean levels of the lakes is not measurable.

e Lake St. Clair elevations are available only for the period 1898 to date.

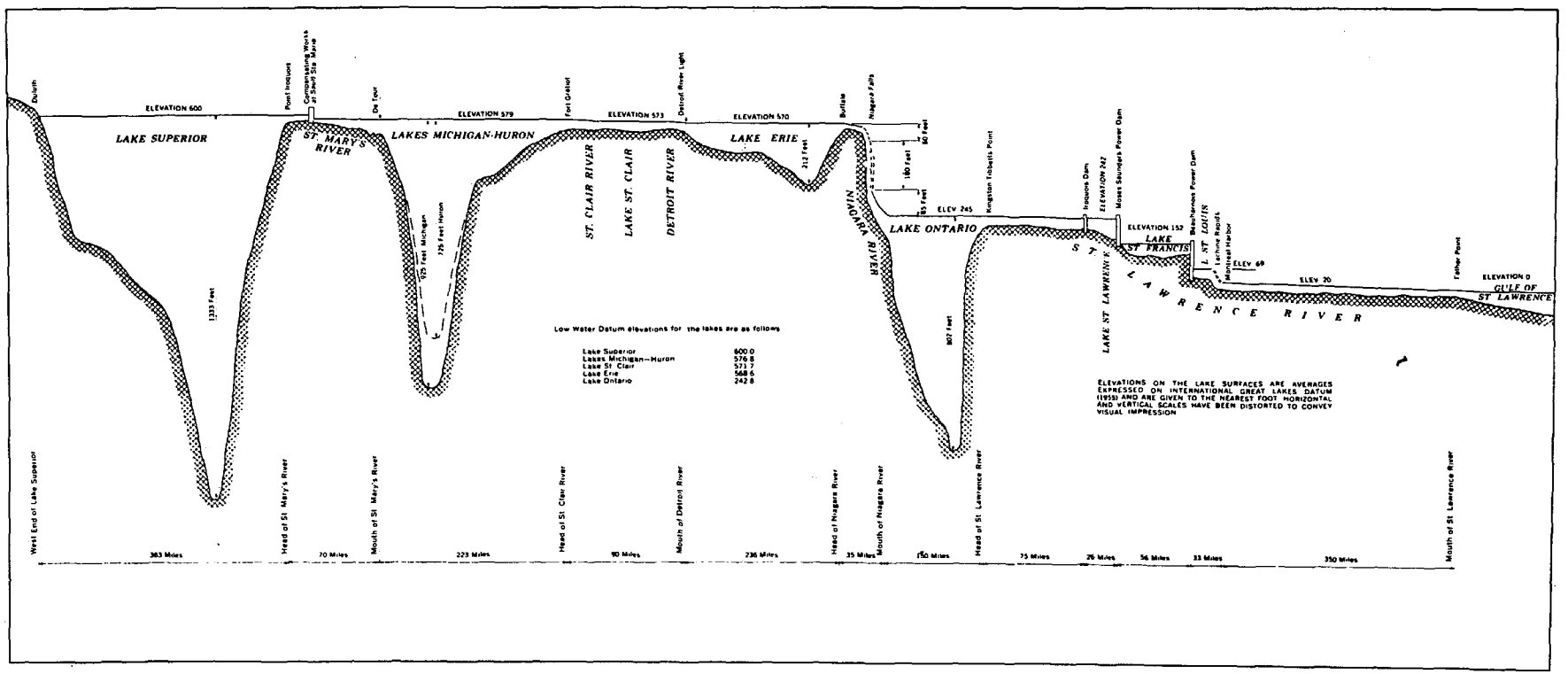
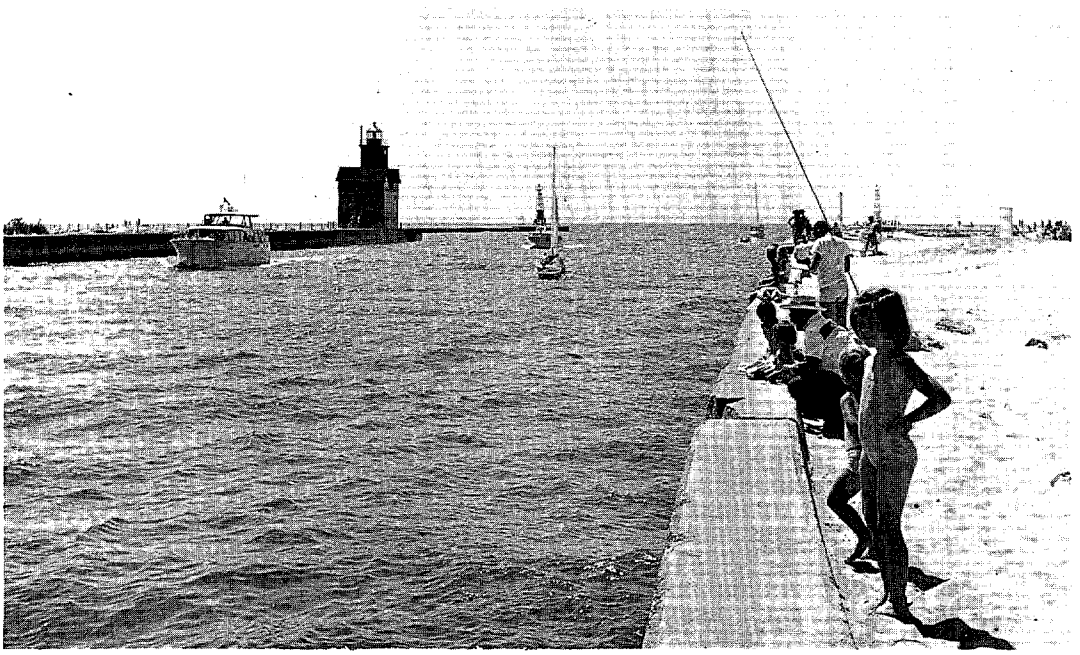


Figure 2. Great Lakes-St. Lawrence River, Profile.

(Chicago Tribune)

Photograph 1. The centuries-old sand dunes of the Indiana Dunes National Lakeshore are being eroded by the forces of Lake Michigan. In some cases there is almost no beach left and the waves are undercutting the 100-foot-high sand dunes.



(Michigan Department of Conservation)

Photograph 2. The shoreline zone serves a great variety of recreational uses. Boating, fishing, and swimming are popular at Hollands' Harbor in Ottawa County, Michigan.

In 1970 the population of the Great Lakes Region was 29 million, but the Basin is projected to decline slightly in its share of total U. S. population during the 1980-2020 period. It is expected to drop from about 14.3 percent in 1980 to 13.5 percent in 2020. In 2020 the population may rise to 53 million. Personal income is projected to increase from $2,420 in 1960 to over $12,000 in 2020. The Great Lakes Region population is concentrated in the shoreline counties. The eighty-three shoreline counties include parts of 17 standard metropolitan statistical areas. They have a population of 18 million, approximately 67 percent of the total region population (1970).

2.5 Condition of the Shoreline

The physical characteristics of the United States shore of the Great Lakes, are the results of development of the Great Lakes Region since the recession of the ice sheet. They range from high bluffs of clay and shale and rock, through lower rocky shores and sandy beaches, to low, marshy clay flats. Except where bedrock is exposed or protective works have been constructed, the glacial overburden comprising the shores of the Great Lakes is still vulnerable to shore erosion.

The principal causes of the erosion and flooding problems are the forces of nature and the characteristics of the shoreline area subjected to these forces.

The first major cause of the problems, the forces of nature, involves storms, lake levels, wave action, frost and ice action, underground water seepage and surface water runoff. Major storms create the largest changes in the shore. The direction, magnitude, duration of storms, and the fetch length determines wave heights and littoral currents.

The duration of a storm is an important consideration. If a storm persists, waves can build up to great heights and be superimposed upon high lake levels. Fetch can account for major variations in wave intensity. Of the forces which create large waves, fetch when combined with a wind of long duration, is probably the most important. When high lake levels are coincident with the other forces of nature cited here, they can greatly magnify total effects.

Levels of the Great Lakes fluctuate from year to year as well as from month to month. These fluctuations depend upon the volume of water entering and leaving the lakes. In addition, there are daily and even hourly fluctuations, known as seiches that result from a tilting of the lake surfaces by winds and barometric pressure differences. Seiches are generally more pronounced on Lake Erie because it runs west to east.

The source of Great Lakes water is rain and snow falling on the lakes and on the tributary land areas. Seasonal fluctuations, caused by the annual weather pattern, are superimposed on the long-term variations caused by extended periods of below- or above-normal precipitation. Unusual variations in the amount of water evaporated from the lakes can also alter the lake levels significantly. Because of the size of the Great Lakes and the limited amount of water their outflow rivers can discharge, extreme high or low levels and flows persist for a considerable time after the factors that caused them have changed. Releases of water from Lake Superior and Lake Ontario are artificially controlled, in accordance with a plan that is regulated in the best interest of all concerned.

Wave action works directly on the beach or at the toe of the bank, eroding clay, silt, sand, and gravel. This erosion is increased when lake levels rise, because the beaches are narrower or submerged, and the waves are able to attack the unprotected toe of the banks or bluffs directly. Thus, a wide beach is the best protection the upland shore can have from wave attack.

Seepage often comes through sandy layers in glacial till bluffs. When underground water seeps out of exposed bluffs of unstable; or loose material, it causes slumping and further weakens the material. This often results in large slides. Sometimes, man-made drainage works causes problems with underground water.

One of the most severe threats to the shore is erosion by frost and ice. In certain of the fine-grained silty soils along the Lakes, the alternate freezing and thawing can weaken the soil and cause it to slide. Frost and ice formation in fissures in clays, glacial tills, or shale bluffs may contribute to their erosion. Shore ice is another cause of damage when broken up and driven onto the beaches by on-shore storms. Lake bottom material may be scoured out and structures are often damaged. However, shore ice can be of benefit too. It protects the shore from erosion by winter storms.

Surface water runoff carries with it large amounts of erodible material, particularly where there are barren, steep-sloped bluffs. Where the surface is carried off by man-made drainage works, inadequate protection of the sewer outfall may cause increased erosion at that point.

A second major factor influencing erosion lies in the characteristics of the shoreline upon which the forces of nature impact. The principal characteristics here include the orientation, resiliency, and human value of the shoreline.

An unfavorable orientation can magnify lake levels and wave intensity. Winds, particularly of storm velocity, and sharp gradients in barometric pressures over short distances can cause a wide range of fluctuation in lake levels. When short-period fluctuations are superimposed on above-average levels, they may cause unusually high water levels. High storm levels at one end of a lake are accompanied by lower levels at the opposite end. Pronounced fluctuations from these causes are also experienced in bays and other shallow portions of each lake. Areas such as these are found in Green Bay on Lake Michigan, in Saginaw Bay on Lake Huron, and at both ends of Lake Erie.

The resiliency of the coastline to water dynamics depends upon the material of which the shorefront is composed. Of progressively diminishing resiliency in their ability to withstand wave forces are the rocky coasts of Minnesota, to the sandy beaches of Indiana, to the silty-clay bluffs of Ohio.

Beaches are energy dissipators. Their efficiency in this role, is greatly influenced by their profile. The nearer deep water is to the shore, the closer large waves can approach before their energy begins to dissipate because of bottom drag. The flatter the gradient both offshore and on the beach "run up" area, the longer and more gradual is this dissipation. A narrow, steep beach will be subject to much greater wave forces than a flatter beach. An offshore bar, breakwater or island will dissipate waves affording protection within the areas they shelter.

Human values of the shoreline are more concentrated in some areas than in others. A most significant aspect of shoreline use is the amount of shore classified as recreational, residential, commercial and industrial (urban serving). For example in the lower part of Lake Michigan (Planning Subarea 2.2 and 2.3) 86 percent of the shoreline is in these shoreline classifications. Similar percentages exist in the vicinity of Detroit (Planning Subarea 4.1) and on the shoreline of Lake Erie. Even in the relatively uninhabited shores of Lake Superior 30 percent of the shoreline is dedicated to urban serving uses. During the last 20 years forestry and agricultural uses of shoreline lands have declined in face of the demands of the urban population. A long run projection of this trend would demonstrate most of the Great Lakes shoreline in urban serving uses by 2020.

Economic losses result from mans' use of the shoreline. The only consistent shoreline damage information available for the Great Lakes is that compiled for the record high-water period, 1951-52. In May 1952, field damage surveys were made of the Great Lakes Shoreline and connecting channels within the United States. The Corps of Engineers supervised the surveys with the assistance of local coordinators from the States bordering the Lakes. The damage information collected pertained to the period from the spring of 1951 to the spring of 1952. Damages for each lake were grouped according to property use, property ownership, and cause of damage.

The estimate of total damage to all shore properties during the period 1951-1952 was $61 million. Of this wave action cost $50 million. Flooding accounted for the other $11 million (Table 2). Recurrence of storms of 1951-52 in this Region could cause a minimum of $120 million in property damage. This estimate is based only on the updated prices and does not include the damages to developments constructed after 1952.

Table 3 summarizes shoreline information. An analysis of the data suggests the following conclusions. For the total shoreline about a third is residential, one half is agriculture, forest, and undeveloped, ten percent is recreation (public), and seven percent commercial-industrial and public buildings. Only 17 percent of the Great Lakes shoreline is publicly owned; the rest is private. A third of the Great Lakes Shoreline is subject to significant erosion. In all of these locations the water is gaining at the expense of the land--part of the geologic process. Over the last 125 years the average annual rate of loss in many locations has been from 1 to 5 feet.

About 215 miles of shoreline has critical erosion where the loss of land, economic losses, and other considerations appear to justify protective measures. Table 4 identifies these areas and suggests the most suitable type of remedial action. The shore protective measures considered are: those that provide protection by means of a high beach; those that shield vulnerable portions of the shores from forces of waves; and those that reduce or prevent flooding of lower adjacent lands behind such protection sections. These measures include bulkheads, seawalls, revetments, groins, offshore breakwaters, and beach fills. The approximate first cost for the protective measures suggested for the total of the critical reaches is about $127 million.

Table 2
Total Damage to Great Lake's Shore Property
One-Year Period from Spring 1951 to Spring 1952
1952 Dollars

	Lake Superior	*Lake Michigan*	*Lake Huron*[a]	*Lake Erie*	*Lake Ontario*[b]	*Totals*
Minnesota	1,947,000	—	—	—	—	1,947,000
Wisconsin	982,000	5,179,000	—	—	—	6,161,000
Illinois	—	11,288,000	—	—	—	11,288,000
Indiana	—	5,195,800	—	—	—	5,195,800
Michigan	1,430,000	8,981,000	6,975,800	—	—	17,386,800
Ohio	—	—	—	11,299,300	—	11,299,300
Pennsylvania	—	—	—	448,500	—	448,500
New York	—	—	—	172,400	6,443,500	6,615,900
Totals	4,359,000	30,643,800	6,975,800	11,920,200	6,443,500	60,342,300

[a] Includes St. Marys River below locks, St. Clair River, Lake St. Clair, and Detroit River.
[b] St. Lawrence River not included.

Photograph 3. Critical erosion of the Lake Michigan Shoreline in Berrien County, Michigan.

Table 3
The Great Lakes Shoreline, Condition, Ownership, and Use, 1970

The Great Lakes Shoreline	*Miles*								
	Total	*Minnesota*	*Wisconsin*	*Illinois*	*Indiana*	*Michigan*	*Ohio*	*Pennsylvania*	*New York*
1. Physical characteristics									
With a beach zone	2,107.3	13.1	298.6	38.8	20.4	1,257.6	138.0	48.3	292.5
Without a beach zone	1,572.1	193.1	320.4	26.2	24.6	812.7	127.1	0	68.0
2. Use									
Residential	1,216.0	79.6	173.6	15.0	5.5	653.0	116.4	21.2	151.7
Commercial and industrial	188.6	11.8	33.4	10.5	21.8	53.9	23.8	3.6	29.8
Agricultural and undeveloped	633.5	11.0	140.5	0.6	0.1	290.3	44.8	11.9	134.3
Forest	1,159.4	69.7	183.9	0	0	900.9	4.9	0	0
Recreation (public)	364.6	28.6	58.5	30.9	17.0	131.3	48.6	11.6	38.1
Public building and related lands	60.3	4.3	10.9	8.0	0.6	13.6	16.3	0	6.6
Fish and wildlife wetlands	57.0	1.2	18.2	0	0	27.3	10.3	0	0
3. Ownership									
Federal	133.4	20.1	56.6	3.1	9.3	38.2	6.1	0	0
Non-Federal public	516.9	35.8	111.3	35.8	8.7	226.5	42.5	11.6	44.7
Private	3,029.1	150.3	451.1	26.1	27.0	1,805.6	216.5	36.7	315.8
4. Problem identification									
Noneroding	1,703.8	179.9	191.4	0	0	1,203.4	22.5	0	106.6
Significant erosion									
Critical	214.8	1.0	38.9	10.5	13.0	103.6	25.0	6.0	16.8
Noncritical	1,045.0	14.3	250.6	0	9.6	479.4	75.5	36.0	179.6
Subject to flooding	335.4	4.1	86.5	0	0	204.8	20.9	0	19.1
Protected	380.4	6.9	51.6	54.5	22.4	79.1	121.2	6.3	38.4
5. Total shoreline mileage	3,679.4	206.2	619.0	65.0	45.0	2,070.3	265.1	48.3	360.5

Notes: 1. Tabulation includes Duluth-Superior Harbor and Sandusky Bay.
2. Exclusions: St. Marys River and connecting waters (88.6 miles), Detroit River (31 miles), St. Clair River (38 miles), Niagara River (39.3 miles), Sturgeon Bay and Lake Michigan Ship Canal (19.8 miles), Portage Lake and connecting waterways (98.2 miles), and all island shoreline.

Table 4

Suitable Shoreline Protection Methods for Reaches of Shoreline with Critical Erosion Problems

County and State	*Lake*	*Critical Reach mile to mile*	*Suitable Protection*	*Reach Length miles*	*Cost per Mile $1,000*	*Total Cost $1,000*
St. Louis, Minnesota	Superior	939.1-940.1	Riprap and sandfill	1.0	1,400	1,400
Iron, Wisconsin	Superior	581.8-581.9	Combination	0.1	600	60
Ashland, Wisconsin	Superior	589.1-589.9	Protective beaches	0.8	600	480
Ashland, Wisconsin	Superior	615.0-627.0	Riprap or seawalls	12.0	600	7,200
Kenosha, Wisconsin	Michigan	628.0-633.0	Filled groins	5.0	800	4,000
Racine, Wisconsin	Michigan	651.0-655.0	Filled groins	4.0	800	3,200
Milwaukee, Wisconsin	Michigan	656.0-658.0	Stone revetment	2.0	500	1,000
Milwaukee, Wisconsin	Michigan	675.0-682.0	Filled groins	7.0	500	3,500
Ozaukee, Wisconsin	Michigan	682.0-690.0	Filled groins	8.0	500	4,000
Lake, Illinois	Michigan	223.5-625.0	Filled groins	1.5	800	1,200
Lake, Illinois	Michigan	625.0-628.0	Filled groins	3.0	800	2,400
Lake, Illinois	Michigan	609.0-615.0	Riprap and bulkheads	6.0	800	4,800
Porter, Indiana	Michigan	525.0-535.0	Filled groins	10.0	800	8,000
Porter, Indiana	Michigan	540.0-543.0	Filled groins	3.0	800	2,400
Berrien, Michigan	Michigan	488.5-493.5	Artificial beach fill	5.0	400	2,000
Berrien, Van Buren, and Allegan, Michigan	Michigan	461.0-480.0	Artificial beach fill	19.0	400	7,600
Allegan, Michigan	Michigan	450.0-455.5	Artificial beach fill	5.5	400	2,200
Allegan and Ottawa, Michigan	Michigan	435.0-437.7	Artificial beach fill	2.7	400	1,080
Ottawa, Michigan	Michigan	426.0-428.0	Artificial beach fill	2.0	400	800
Ottawa, Michigan	Michigan	414.2-415.0	Artificial beach fill	0.8	400	320
Ottawa and Muskegon, Michigan	Michigan	406.5-412.4	Artificial beach fill	5.9	400	2,360
Muskegon, Michigan	Michigan	390.0-401.0	Artificial beach fill	11.0	400	4,400
Oceana, Michigan	Michigan	368.2-370.5	Artificial beach fill	2.3	400	920
Oceana, Michigan	Michigan	360.2-361.0	Artificial beach fill	0.8	400	320
Mason, Michigan	Michigan	337.5-341.5	Artificial beach fill	4.0	400	1,600
Mason and Manistee, Michigan	Michigan	323.5-329.2	Artificial beach fill	5.7	400	2,280
Manistee, Michigan	Michigan	315.3-319.6	Artificial beach fill	4.3	400	1,720
Benzie, Michigan	Michigan	286.0-290.2	Artificial beach fill	4.2	400	1,680
Leelanau, Michigan	Michigan	266.0-270.0	Artificial beach fill	4.0	400	1,600
Leelanau, Michigan	Michigan	254.8-258.3	Artificial beach fill	3.5	400	1,400
Ontonagon, Michigan	Superior	522.2-525.4	Filled groins	3.2	400	1,280
Houghton, Michigan	Superior	371.7-372.3	Filled groins	0.6	400	240
Marquette, Michigan	Superior	252.3-252.8	Filled groins	0.5	400	200
Marquette, Michigan	Superior	215.9-216.8	Filled groins	0.9	400	360
Chippewa, Michigan	Superior	53.3- 63.2	Filled groins	9.7	800	7,760
Iosco, Michigan	Huron	255.2-263.0	Filled groins	7.8	800	6,240
Sanilac, Michigan	Huron	20.0- 20.2	Filled groins	0.2	800	160
Ottawa, Ohio	Erie	278.0-278.7	Filled groins	0.7	800	560
Erie, Ohio	Erie	244.0-248.0	Filled groins	4.0	800	3,200
Erie, Ohio	Erie	239.0-241.0	Filled groins	2.0	800	1,600
Lorian, Ohio	Erie	225.0-226.0	Stone revetment	1.0	500	500
Lorian, Ohio	Erie	218.1-218.4	Stone revetment	0.3	500	150
Lorian, Ohio	Erie	216.0-217.0	Stone revetment	1.0	500	500
Lorian, Ohio	Erie	213.3-213.5	Stone revetment	0.2	500	100
Cuyahoga, Ohio	Erie	200.0-203.0	Stone revetment	3.0	500	1,500
Cuyahoga, Ohio	Erie	185.5-186.0	Stone revetment	0.5	500	250
Cuyahoga, Ohio	Erie	176.3-181.3	Stone revetment	5.0	500	2,500
Lake, Ohio	Erie	173.0-176.3	Stone revetment	3.3	500	1,650
Lake, Ohio	Erie	171.7-172.1	Stone revetment	0.4	500	200
Lake, Ohio	Erie	164.0-165.0	Stone revetment	1.0	500	500
Lake, Ohio	Erie	159.0-159.3	Stone revetment	0.3	500	150
Ashtabula, Ohio	Erie	144.9-145.4	Stone revetment	0.5	500	250
Ashtabula, Ohio	Erie	140.0-140.8	Stone revetment	0.8	500	400
Ashtabula, Ohio	Erie	133.3-133.8	Stone revetment	0.5	500	250
Erie, Pennsylvania	Erie	92.0- 98.0	Filled groins	6.0	800	4,800
Niagara, New York	Ontario	288.6-289.6	Groins, fill, and breakwater	1.0	800	800
Niagara, New York	Ontario	285.5-286.1	Filled groins	0.6	800	480
Niagara, New York	Ontario	277.5-279.5	Stone revetment	2.0	500	1,000
Niagara, New York	Ontario	258.4-259.9	Filled groins	1.3	800	1,040
Orleans, New York	Ontario	246.1-247.6	Filled groins	1.5	800	1,200
Monroe, New York	Ontario	230.4-233.8	Filled groins	3.4	700	2,380
Monroe, New York	Ontario	218.0-219.1	Filled groins	1.1	1,000	1,100
Monroe, New York	Ontario	208.9-210.3	Filled groins	1.4	3,000	4,200
Wayne, New York	Ontario	173.0-175.0	Filled groins	2.0	800	1,600
Cayuga, New York	Ontario	160.0-161.4	Filled groins	1.4	800	1,120
Oswego, New York	Ontario	128.4-129.5	Filled groins	1.1	800	880
Totals				214.3		127,020

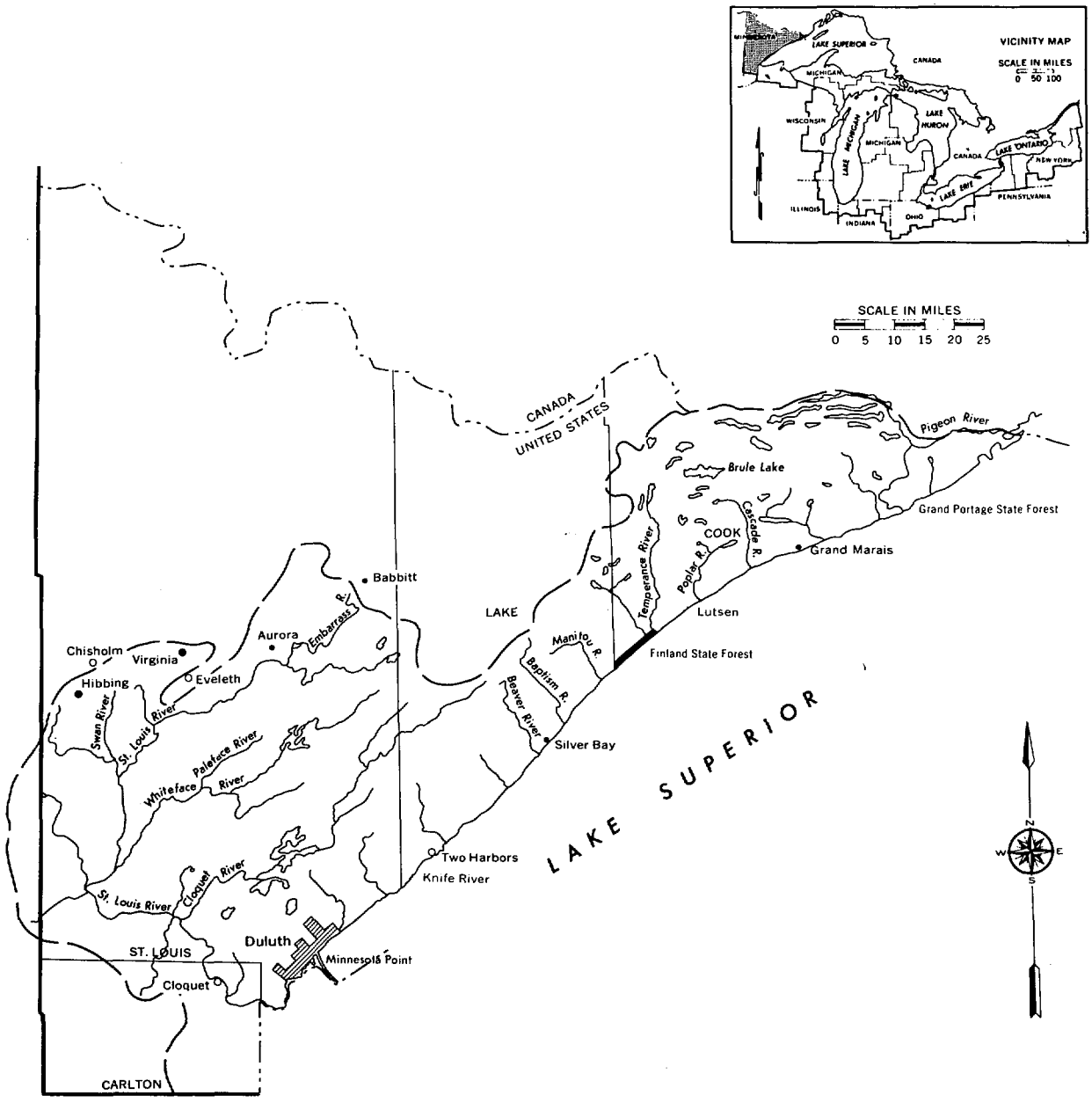


Figure 3. Lake Superior West Planning Subarea 1.1, Minnesota.

SECTION 3
STATE OF MINNESOTA

The Great Lakes Shoreline in Minnesota is located within the Lake Superior West planning subarea 1.1 (Figure 3). It is characterized by steep rocky bluffs in the northern reaches and low lying clay banks near Duluth. Of the 206 miles of shoreline, only 13 miles are beaches, located primarily near Duluth. A few scattered sand and gravel areas are also found in small coves and at the mouths of tributary rivers. The St. Louis River and a number of minor tributaries in the Superior Slope Complex drain this area. The four-county area has a population of 262,000 (1970). Duluth is the major urban center. The economy of the area is, to a large degree, dependent on mining and tourism.

Shoreline ownership is divided as follows: 20.1 miles Federal; 35.8 miles non-Federal Public; and 150.3 miles Private. All of the major use categories exist along the Minnesota Shoreline. These uses are: 79.6 miles residential; 11.8 miles industrial and commercial; 11 miles agricultural and undeveloped; 4.3 miles public buildings and related lands; 28.6 miles recreation (parks); 1.2 miles wildlife preserves and game lands; and 69.7 miles forest. Commercial deep draft harbors at Taconite, Silver Bay, Two Harbors and Duluth-Superior ship over 30 million tons of iron ore annually (1970). Three recreational boat harbors provide berthing facilities for about 1,500 recreational craft. Electric power generation stations are located at Duluth, Two Harbors, Silver Bay and Taconite Harbors.

In general, the Minnesota Shoreline is rock and not subject to significant erosion. About 15 miles of shoreline are subject to significant erosion. One critical erosion area exists along a one mile reach of Minnesota Point. A Federal study of this area is underway (1970). A suitable method of protecting this reach of shoreline is riprap and sand fills. The estimated first cost is about $1.4 million.

3.1 Shoreland Description

The Minnesota portion of the Lake Superior shoreline extends from the Minnesota-Wisconsin border at the Superior Entry to the Canadian border, a distance of about 174.9 miles. This portion of the shoreline is characterized by the steep, rocky bluffs in the northernmost reaches versus the low-lying clay and gravel covered banks near Duluth. There are about 32 additional shoreline miles within the Duluth-Superior Harbor (measured from the upstream end of the established U. S. Harbor Line). Minnesota Point, a narrow, elongated strip of land (a natural sandbar) about five miles long, separates the Duluth-Superior Harbor from Lake Superior. Bank heights vary from about 3 to 30 feet within the Duluth-Superior Harbor, to 30 feet along the shoreline just north of Duluth and over 100 feet along the rocky cliffs in the northernmost reaches. Bank heights along Minnesota Point vary from 5 to 10 feet above low water datum (LWD). Except for the sandy beach along Minnesota Point, the remaining beaches on the Minnesota shoreline consist of small scattered sand and gravel areas located in small coves and at the mouths of the tributary rivers.

Information on present shoreline values, uses, ownership, and problems are given in Table 5 and shown on Figures 4 and 5. Since 1952, there has been a moderate increase in shoreline miles in residential development and recreational use and a corresponding decrease in agricultural and undeveloped shorelands. Public ownership of shorelands increased about five percent since 1952, mainly through the acquisition of park lands by the State of Minnesota. A number of seasonal condominium-type developments have appeared in recent years on the north shore to take advantage of the summer and winter recreations. Snowmobiling and skiing are two of the winter sports.

The Minnesota Lake Superior shoreline has first-rate recreational facilities. It is one long parkway with many outstanding views. The strip of shoreline from the shore to the first waterfall along the tributary streams (about one quarter of a mile) is an important habitat for rainbows, brown and brook trout, and coho salmon.

The State of Minnesota identifies the offshore waters of the Lake Superior shoreline as good fishery and waterfowl value and generally good water quality. A local pollution situation exists in St. Louis Bay at Duluth due to inadequately treated sewage outflows and industrial wastes from the cities of Duluth and Superior and the St. Louis River.

There are nine state parks and four state waysides with frontage along the shoreline. The Finland State Forest borders the shoreline for about 10 miles, beginning about 70 miles from Duluth. The Grand Portage State Forest extends over the northernmost 42 miles of the shoreline. The 700-acre Grand Portage National Monument is the only national monument on the shoreline. The Superior National Forest extends a distance

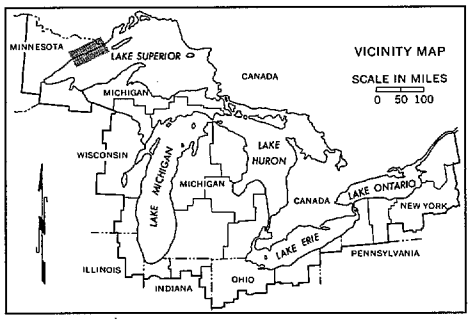
Table 5

Shoreline of the Great Lakes — St. Louis, Lake, and Cook Counties,[a] Minnesota

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public		Private	Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal		Critical	Noncritical			
Economic Uses											
Residential	79.6	38.6		0.8[b]	0	78.8	0	4.6	0	1.5	73.5
Industrial and commercial	11.8	5.7		0	0	11.8	0	2.2	6.9	0	2.7
Agricultural and undeveloped	11.0	5.3		0	5.0	6.0	0	1.2	0	1.0	8.8
Commercial harbors			5								
Electric power sites			4								
Public buildings and related lands	4.3	2.1		2.5	1.8	0	0	0.8	0	0.2	3.3
Recreational Uses											
Parks	28.6	13.9		0	28.3	0.3	1.0	5.5	0	0.6	21.5
Recreational boat harbors											
Beach zone	(13.1)	(6.4)		(0.6)	(6.1)	(6.4)					
Environmental Uses											
Wildlife perserves and game lands	1.2	0.6		0	0	1.2	0	0	0	0	1.2
Fish and wildlife wetlands (offshore)	(0)	(0)					0	0	0	0	0
Forest	69.7	33.8		16.8	0.7	52.2	0	0	0	0.8	68.9
Total	206.2	100.0		20.1	35.8	150.3	1.0	14.3	6.9	4.1	179.9

[a] Includes Duluth Superior Harbor shoreline in St. Louis County.

[b] Indian reservation land.



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SCALE IN MILES
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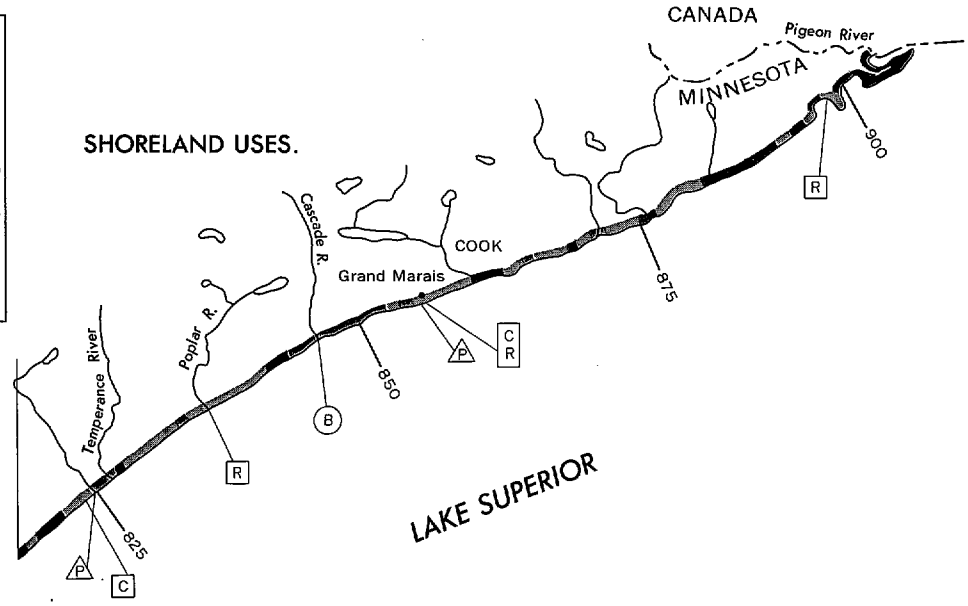
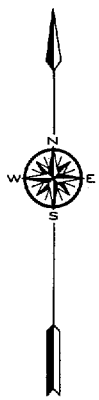
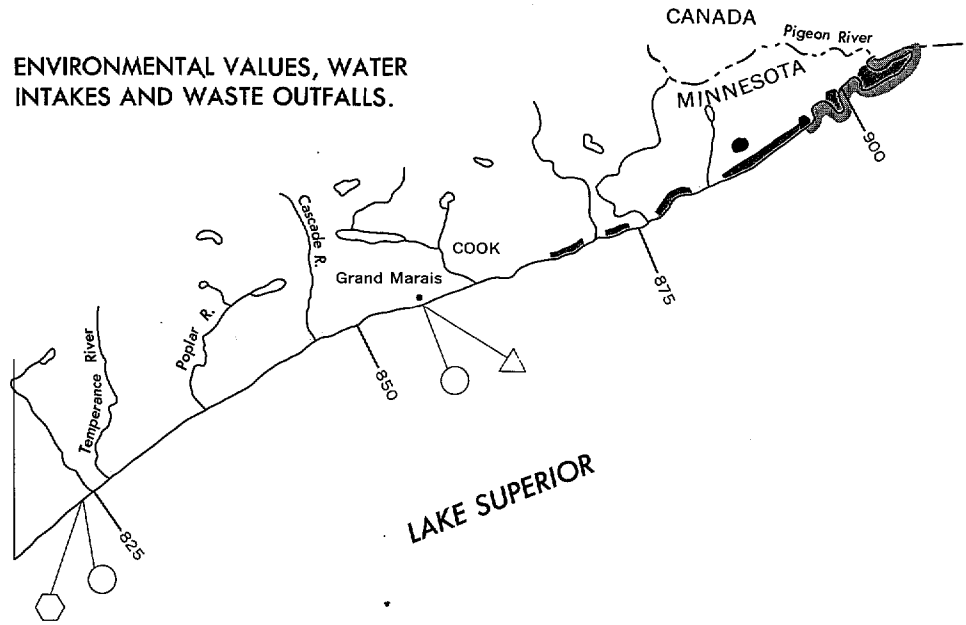
SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.





PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

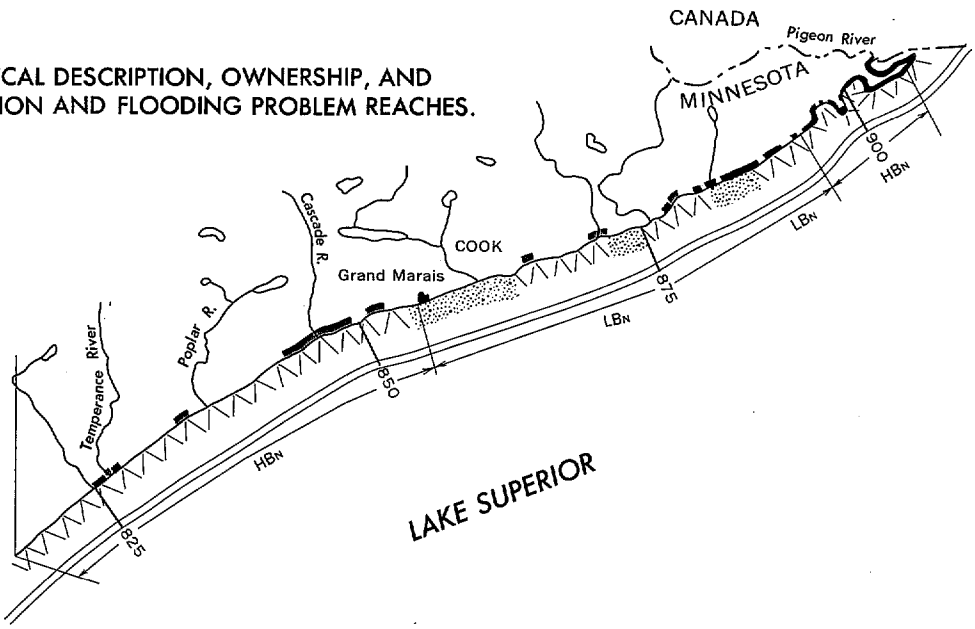


Figure 4. SHORELANDS OF THE GREAT LAKES, COOK COUNTY.

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings

Recreational and Urban Open Space

Agricultural and Undeveloped

Forest

Public Beaches (B)

Commercial Deep Draft Harbors [C]

Recreational Harbors [R]

Commercial Deep Draft and Recreational Harbors [C R]

Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values

Unique Ecological or Natural Areas

Outstanding Shoreland Areas of Possible National Interest

Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands

Non-Federal Public Lands

Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

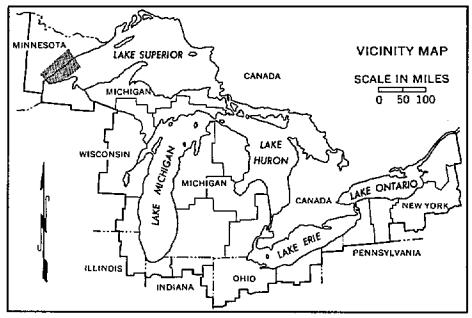
- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)



SEE REVERSE PAGE FOR LEGEND

SCALE IN MILES

0 5 10 15

SHORELAND USES.

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

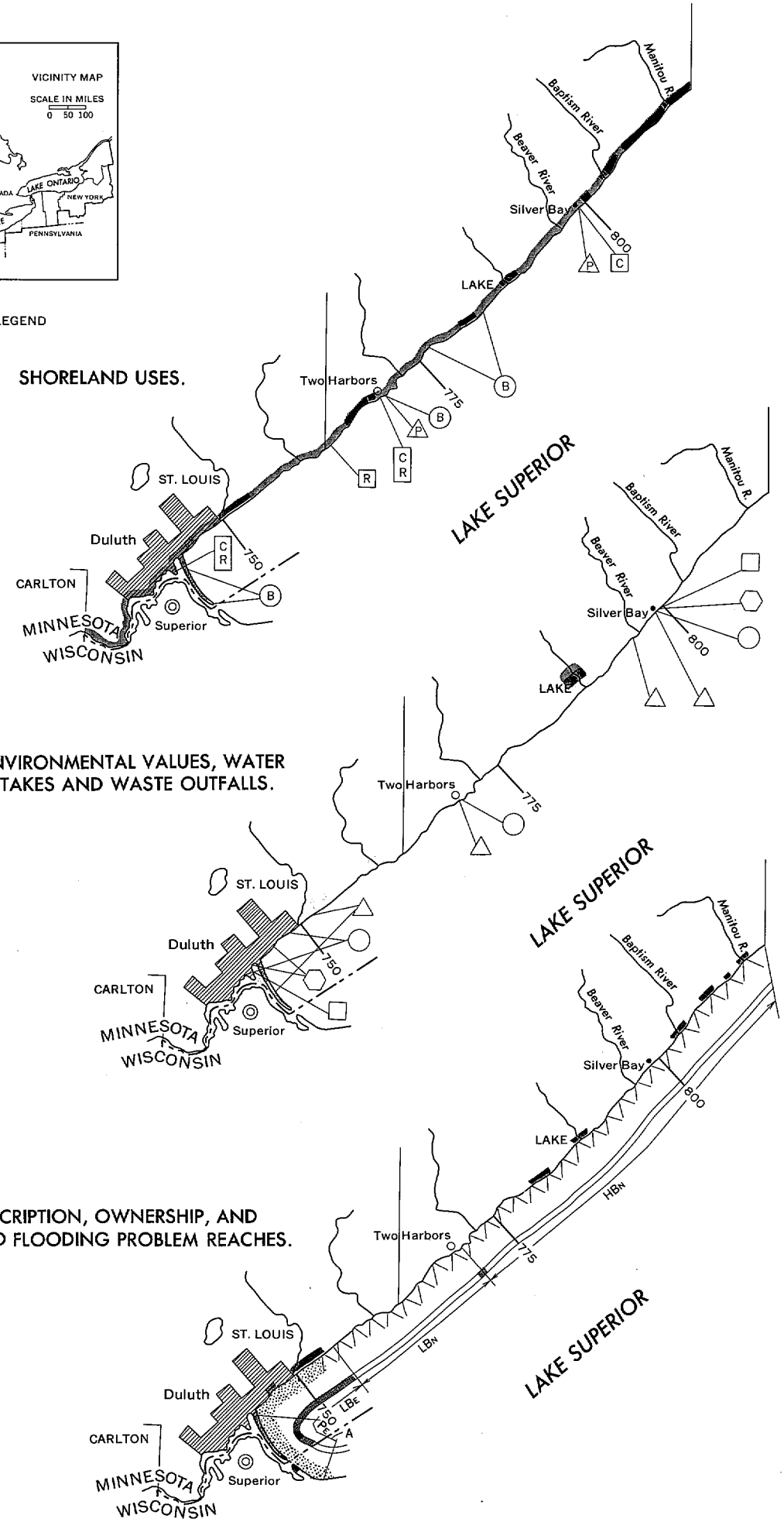


Figure 5. SHORELANDS OF THE GREAT LAKES, CARLTON, ST. LOUIS, LAKE COUNTIES.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors [C]
- Recreational Harbors [R]
- Commercial Deep Draft and Recreational Harbors [C R]
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites
- Waste Water Outfalls and Intakes
  - Public Outfalls
  - Public Intakes
  - Private Outfalls
  - Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

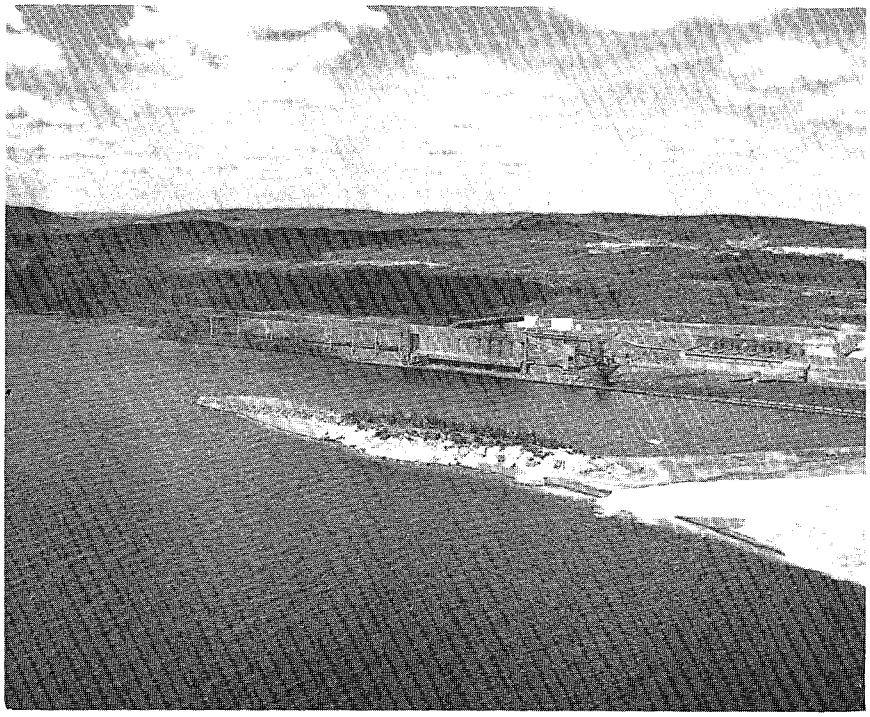
- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W
- Combinations Shown As: Example
  - Lakeward/Landward — W/P_E
  - Upper Bluff Material / Lower Bluff Material — HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)



Photograph 4. Silver Bay Harbor, Minnesota - a private commercial harbor on Lake Superior.

Photograph 5. Recreational use of the Minnesota Point Shoreline.

of about 40 miles along the shoreline, starting 80 miles north of Duluth. Much of the State and National Forest shoreline is in private ownership. The northernmost 26 miles of the shoreline are the Grand Portage Indian Reservation. These lands in public ownership are controlled by the tribal council and are not available to the general public.

There are Federal deep-draft navigation harbors at Duluth, Two Harbors, and Grand Marais, Minnesota. Private deep-draft harbors are located at Silver Bay and Taconite Harbor. Federal small-boat harbors are located at Grand Marais, Knife River, and Duluth and are authorized but not constructed at Beaver Bay and Lutsen, Minnesota. Provision of a Federal small-boat harbor is being studied at Grand Portage (by the Corps of Engineers).

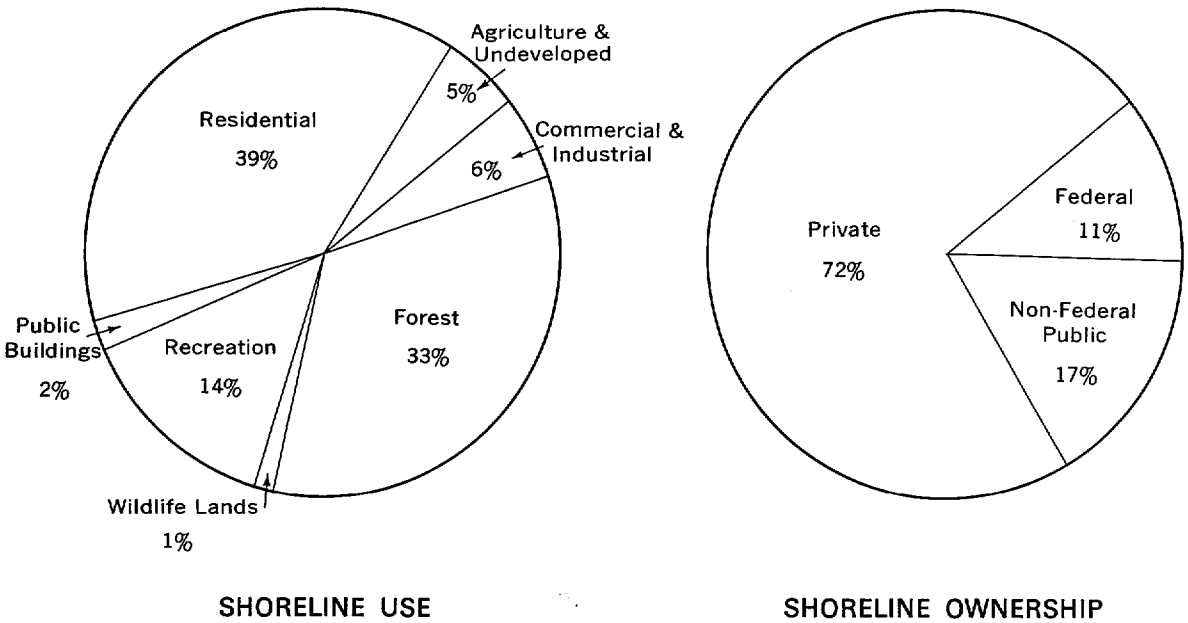


Figure 6. Distribution of Shoreline Use and Ownership in Minnesota.

3.2 Erosion and Flooding History

Except for the scattered sand and gravel beaches and Minnesota Point, the Minnesota Lake Superior shoreline is generally not subject to serious erosion. The rocky shoreline is generally stable during periods of low and average water levels. During the 1951-1952 high-water period, the shoreline eroded about five feet that year in the sand and gravel beach areas and about 25 feet that year along a gravel beach one-half mile long just east of Two Harbors. The sand beach along Minnesota Point was seriously eroded during this same period. In 1963, a one-half mile reach adjacent to the Duluth entry was restored by using dredge material from the harbor. This restored beach, which extended out about 600 feet from the property line, has been eroding 80 to 90 feet per year since. Damages during the 1968 high-water period included erosion of the sand and gravel beaches and banks, erosion damages to port structures at Duluth and Two Harbors, and flooding of industrial and commercial properties in the Duluth harbor and of residences along Minnesota Point. Erosion damages recorded along the Minnesota Shoreline during the 1951-1952 and 1968 high-water periods are summarized in Table 6. The estimates of 1951-1952 damages have been updated to April 1970 price levels.

Table 6
Total Damage to Shore Property on Lake Superior – Cook, Lake, and St. Louis Counties, Minnesota

Land Use	Damages, $ Actual 1951-52 Value	Damages, $ Updated 1970 Value
Private		
Residential	377,000	727,610
Industrial and commercial	338,000	652,340
Agricultural or undeveloped	32,000	33,600
Total, private property[a]	747,000	1,413,550
Public		
Parks and beaches	15,000	34,650
Utilities	66,000	152,460
Total, public property[b]	81,000	187,110
Total erosion damages	828,000	1,600,660

[a] Excludes $1,073,000 inundation damages (1952 price levels).
[b] Excludes $46,000 inundation damages (1952 price levels).

The above table shows that the large percentage of erosion damages was incurred by private residential and commercial interests. During the 1968 high-water period about three-fourths of the erosion damages were incurred by the Federal breakwater at Two Harbors, Minnesota. Significant flooding damages, footnoted in the above table, were suffered during the 1951-52 high-water period by commercial and transportation interests on the Duluth side of the Duluth-Superior harbor and by residences along Minnesota Point. The greatest average monthly lake level at this time was elevation 601.9. Major flooding in the Duluth harbor area and along Minnesota Point also occurred during the 1968 high-water period. The lake level rose at this time to a high of 601.8. About 110 permanent homes had flooded basements at this high stage. About 25 commercial and industrial establishments were affected in the Duluth Harbor area. The 1951-52 damages shown above include, in addition to the direct erosion damages, the costs of emergency measures taken during extreme high lake level conditions, the increase in business costs due to high lake levels, loss of wages, and increased operating costs to rail and highway transportation interests.

Current erosion problems on the Minnesota Lake Superior shoreline are generally limited to gradual erosion of the scattered sand and gravel beaches and banks and continued erosion of the Minnesota Point shoreline immediately east of the Duluth Ship Canal.

There are no major erosion control structures along the Minnesota shoreline. Scattered small protective measures such as masonry seawalls, riprapping and cribbing provided by individual shore-property interests protect about five miles of shoreline. Materials dredged from the Duluth harbor were placed on a severly eroded one-half mile reach of Minnesota Point in 1963. However, all of this material has since eroded away.

3.3 Solution to Erosion Damages

The erosion problem along the Minnesota Lake Superior shoreline, with the possible exception of Minnesota Point, does not appear to be severe enough to justify the cost of protection of the scattered sand and gravel beaches and bank areas. Erosion problems along a one-half-mile reach of Minnesota Point were recently considered under the Corps of Engineers beach erosion authority. A preliminary report recommended that this problem be further considered, since evidence indicates that it may be caused or aggravated by the Federally constructed breakwater piers at the Duluth Ship Canal. This study is now underway. A suitable method for rebuilding the one-mile eroded beach lakeward a distance of 300 feet and protection of this triangular shaped fill with stone. The dredge fill would be placed to an average height of three feet above low water datum, or elevation 603.0. Preliminary estimates indicate that total first costs for this plan would be about $1.4 million. Periodic beach nourishment would be required for this plan at an estimated annual cost of $6,000.

Section 4
STATE OF WISCONSIN

The Great Lakes Mainland Shoreline of Wisconsin is about 619 miles long and is located within three planning subareas: the Lake Superior West Planning Subarea 1.1, the Lake Michigan Northwest Planning Subarea 2.1, and the Lake Michigan Southwest Planning Subarea 2.2. The three planning subareas include a total of 31 counties with a population of 2.75 million (1970), about 63 percent of the total population of the State of Wisconsin. The major urban centers located on the shoreline are Superior, Green Bay, Manitowoc, Milwaukee, Racine, and Kenosha. Major drainage areas are: in the Lake Superior Subbasin, Apostle Island Complex, Bad River, and Montreal River Basins; and in the Lake Michigan Subbasin, Menominee, Peshtigo, Oconto and Fox River Basins, the Green Bay-Sheboygan Complex, and the Chicago-Milwaukee Complex.

A detailed description of the shoreline is contained in three following subsections. Of the 619 miles of mainland shoreline, about 299 miles have a beach zone and 320 miles are without beaches. The present shoreline uses in Wisconsin are as follows: 174 miles residential, 33 miles industrial and commercial, 11 miles public buildings and related land, 59 miles recreational, and 342 miles agricultural, forest, and undeveloped.

There are five commercial harbors and 35 recreational harbors. The recreational harbors provide facilities for about 3,000 boats. Shoreline ownership is divided 57 miles Federal, 111 miles non-Federal public, and 451 miles private.

Of the 619 miles of shoreline in Wisconsin it is estimated that about 39 miles sustain critical erosion processes, 250 miles are subject to non-critical erosion, 86 miles are subject to flooding, and 244 miles are non-eroding (stable, accreting, or protected). The current critical shoreline erosion problems exist at seven locations. The cost of protecting these areas is estimated at about $25 million.

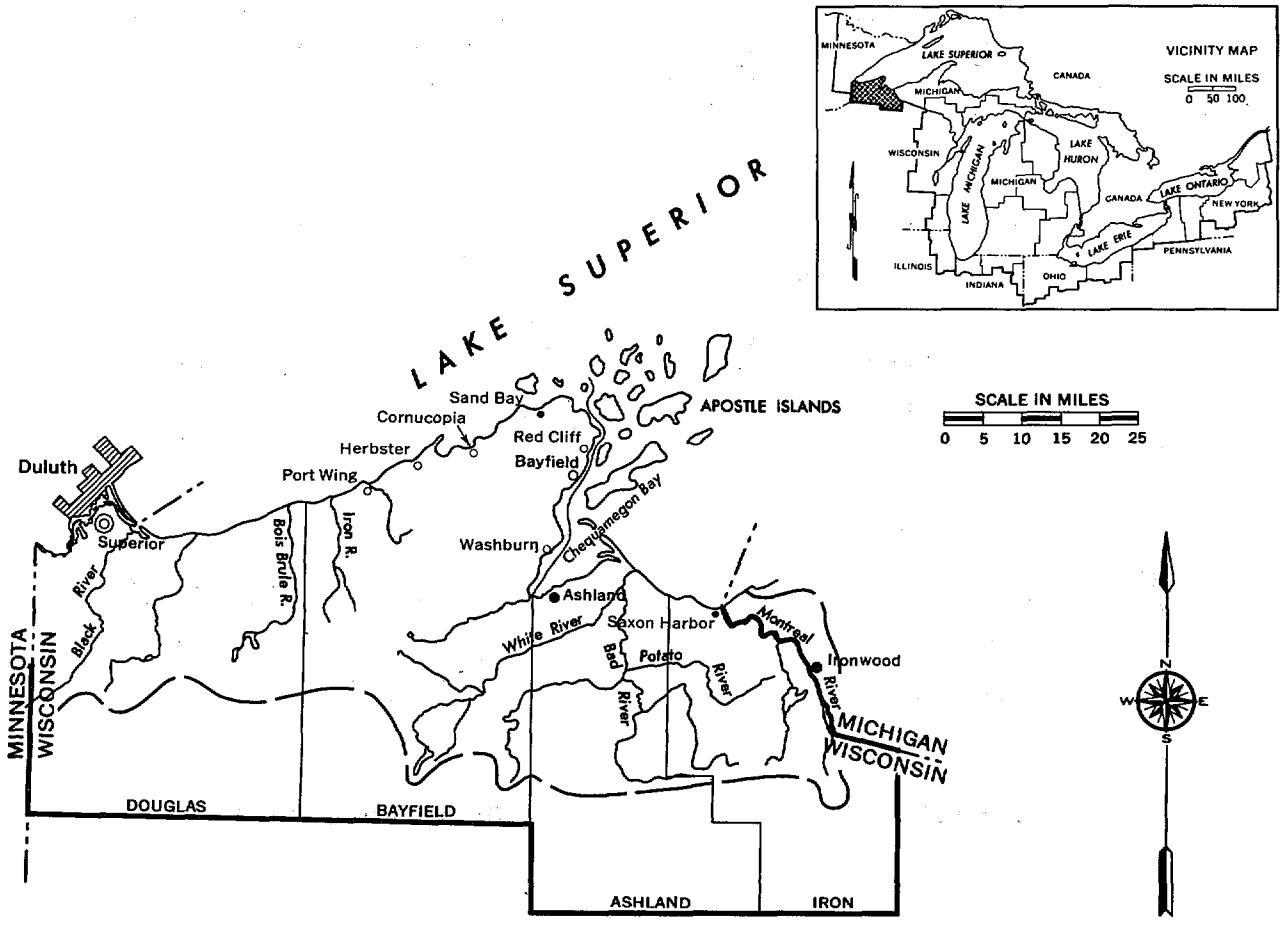


Figure 7. Lake Superior West Planning Subarea 1.1, Wisconsin.

4.1 Lake Superior West, Planning Subarea 1.1, State of Wisconsin

4.1.1 Shoreline Description

The Wisconsin Mainland Shoreline from the Minnesota-Wisconsin boundary at the Superior Entry to the Wisconsin-Michigan boundary, a distance of about 156.3 shoreline miles, has widely differing physical features. They include the spectacular sand beach at Kakagon Sloughs in Ashland County, the steep, erodible clay bluffs along the Douglas County Shoreline and western half of the Ashland County shoreline, and the low sand bluffs (spits) at Port Wing, Cornucopia, Sand Bay, and a few other places. There are, too, the bluffless slough reaches along Chequamegon Point, the tip of Chequamegon Bay, and scattered along the eastern shore of the Bayfield peninsula, and the vertical sandstone bluffs underlain by numerous caves along three and one-half miles of the shoreline between Cornucopia and Sand Point on the Bayfield County north shore. The Wisconsin portion of Duluth-Superior Harbor has 55.7 miles of shoreline. While not reported, the Apostle Islands, a group of 22 islands, contains about 175 miles of shoreline, which includes abrupt sandstone bluffs, sand and gravel beaches, and clay banks (Figure 7).

Bank or bluff heights along the Wisconsin Shoreline vary from no bank along the sloughs noted above, to one to three feet along the sand spits at Cornucopia and Port Wing, 30 to 70 feet along the sandstone bluffs on the Bayfield peninsula, and up to 100 feet along the high clay banks in Douglas County.

Beaches, generally of sand or gravel, vary in width from no dry beach adjacent to the steep sandstone or rocky bluffs to 50 to 70 feet along Chequamegon Point in Ashland County. Beach slopes vary from one-half percent in the low marshy Chequamegon Bay areas to 20 percent along the sand and gravel beaches between Ashland and Washburn and Bayfield and Red Cliff Bay. A physical description of the various shoreline types is shown on the inclosed strip maps of Figure 8. Table 7 gives data describing shoreline resources, uses, ownership, and problem areas.

The present distribution of land use and land ownership along the Wisconsin Lake Superior Shoreline is shown in Figure 9. Since 1952, the number of miles of shoreland in residential use has increased slightly, with a corresponding decrease in agricultural and undeveloped shorelands. Relatively little change in other shoreland uses and public ownership has occurred since 1952.

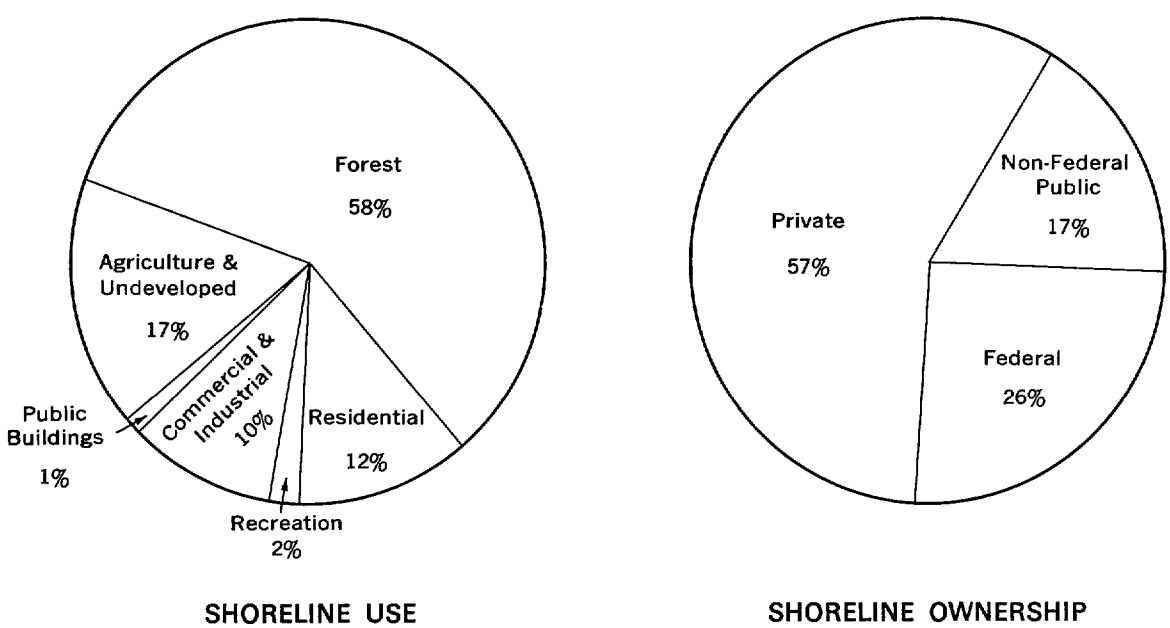


Figure 9. Distribution of Shoreline Use and Ownership, Douglas County to Iron County, Wisconsin.

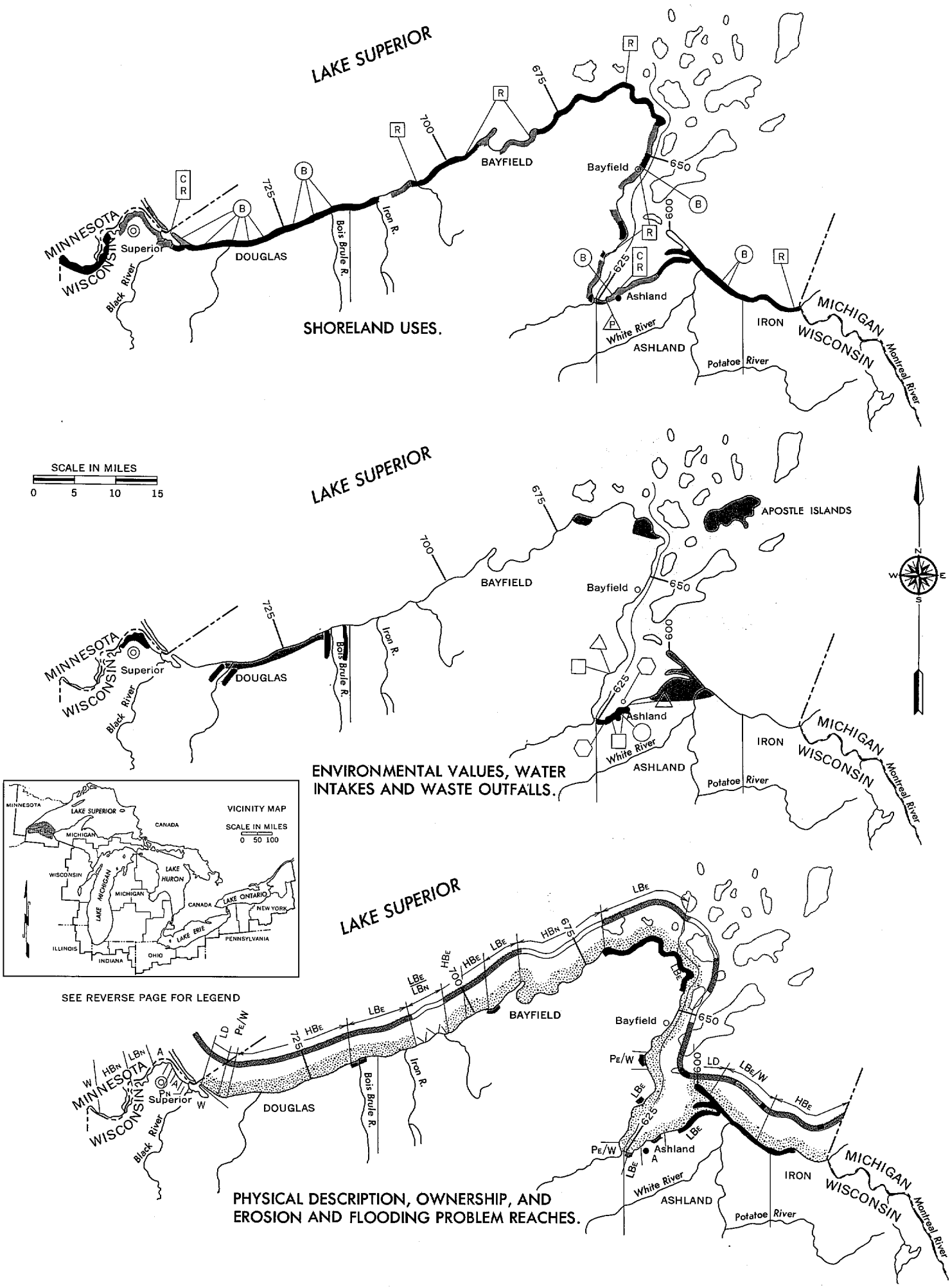


Figure 8. SHORELANDS OF THE GREAT LAKES, IRON, ASHLAND, BAYFIELD, DOUGLAS COUNTIES.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites
- Waste Water Outfalls and Intakes
  - Public Outfalls
  - Public Intakes
  - Private Outfalls
  - Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

Combinations Shown As:	Example
Lakeward/Landward	W/P_E
Upper Bluff Material / Lower Bluff Material	HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S

Table 7
Shoreline of the Great Lakes — Douglas County to Iron County, Wisconsin

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public		Private	Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal		Critical	Noncritical			
Economic Uses											
Residential	24.7	11.7		5.9	0	18.8	2.9	15.2	0	0.2	6.4
Industrial and commercial	20.5	9.7		4.7	0	15.8	0.4	5.3	10.7	3.8	0.3
Agricultural and undeveloped	36.7	17.3		0	5.3	31.4	0.6	17.3	0.1	7.3	11.4
Commercial harbors											
Electric power sites											
Public buildings and related lands	2.1	1.0		0.2	1.9	0	0	0.6	1.5	0	0
Recreational Uses											
Parks	4.1	1.9		0	3.7	0.4	0.7	2.4	0	0	1.0
Recreational boat harbors											
Beach zone	(100.8)	(47.6)		(25.7)	(6.7)	(68.4)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	123.9	58.4		45.8	25.2	52.9	8.3	63.6	0	13.3	38.7
Total	212.0	100.0		56.6	36.1	119.3	12.9	104.4	12.3	24.6	57.8

4.1.2 Erosion and Flooding History

A relatively large part of the Wisconsin Lake Superior shoreline is subject to some degree of erosion. Erosion is generally most pronounced along shoreline reaches comprised of heavy red clay bluffs. Erosion of these high bluffs is usually caused by frost and ice action, by runoff from upland areas, or by undercutting of steep banks by wave action. Critical erosion areas have been identified along the Wisconsin Lake Superior shoreline at the Federal small-boat harbor at Saxon, Wisconsin (mile 581.8 to mile 581.9), at a local park on the eastern shoreline of Ashland County (mile 589.1 to mile 589.9), and along a reach located east of the city of Ashland (mile 615.0 to mile 627.0).

Erosion at Saxon Harbor occurs over a 0.1 mile reach immediately west of the harbor. In September 1968 a severe storm, together with high lake levels, destroyed the existing shore protection and caused considerable damage to private property fronting this reach. A preliminary study of this erosion problem by the Corps of Engineers is currently under way. Critical erosion at the local park is confined to a 0.8-mile reach of high clay bluffs. Bluff heights and slopes along this reach are approximately 70 feet and 80 percent respectively. Continued erosion over this reach has resulted in substantial loss of the local park lands. Portions of shoreland, up to 400 feet long and 30 feet wide have been observed slipping into the lake. Critical erosion generally occurs over the 12-mile reach at Ashland. This erosion occurs along residential, commercial, recreational, forest and undeveloped property. During the 1968-1969 high water period over 40 residential structures and four commercial establishments suffered erosion damages.

Erosion damages recorded for the Wisconsin Shoreline during the 1951-52 high-water period are summarized and updated to April 1970 price levels in Table 8.

Table 8
Total Damage to Shore Property on Lake Superior – Douglas, Bayfield, Ashland, and Iron Counties, Wisconsin

	Damages, $	
Land Use	*Actual 1951-52 Value*	*Updated 1970 Value*
Private[a]		
Residential	188,000[a]	363,000
Industrial and commercial	266,000[b]	513,000
Agriculture, undeveloped and utilities	53,000	56,000
Total, private property	507,000[c]	932,000
Public		
Parks and beaches	142,000	328,000
Harbor installations and utilities	96,000	222,000
Total, public property	238,000[d]	550,000
Total erosion damages	745,000	1,482,000

[a] Includes $32,000 damage to Superior shore of Duluth-Superior Harbor and $41,000 damage to Apostle Islands (1952 price levels).

[b] Includes $10,000 damage to Superior shore of Duluth-Superior Harbor and $3,000 damage to Apostle Islands (1952 price levels).

[c] Excludes $167,000 inundation damages, of which $164,000 occurred at the Duluth-Superior Harbor (1952 price levels).

[d] Excludes $70,000 inundation damages incurred at Duluth-Superior Harbor (1952 price levels).

Much of the Wisconsin Lake Superior Shoreline has excellent recreational value. The shoreline of the Bayfield peninsula, with its occasional sand beaches and picturesque rocky cliffs, is of great geological interest and scenic beauty. Unique ecological and fine aesthetic areas include the Brule River, an excellent rainbow and brown trout stream, the Apostle Islands, the 12-mile sand beach along the Chequamegon Point, the Kakagon and Bad River Sloughs, and the Chequamegon Slough area. The slough areas are excellent as breeding, feeding, and nesting areas for migratory waterfowl. They are a prime habitat for several species of wildlife and contain excellent walleye and northern pike fishing grounds. The Apostle Islands group of 22 islands has been designated a high-priority area for future recreational planning and land acquisition. Other areas with excellent recreational resources are the Annicon River system, the Bad River - Kakagon Slough area, the Brule River system, the Chequamegon Bay and Slough area, and portions of the shoreline at the cities of Superior and Ashland.

There are no State parks along the Wisconsin Shoreline. There is a municipal park with about 300 feet of beach at Bayfield, and the Big Bay State Park Recreation area is on the west of Madeline Island. The Brule River State Forest, on the shoreline in eastern Douglas County, extends on both sides of the Brule River, beginning about 15 miles east of Superior, Wisconsin. The 9,801-acre Apostle Islands State Forest is on Stockton, Oak, and Basswood Islands, three of the islands in the Apostle group. Consistent information on the shoreline of the Apostle Islands is not available.

Federal deep-draft harbors are located at Superior and Ashland, and Federal small-boat harbors are situated at Port Wing, Cornucopia, Bayfield, La Pointe (Madeline Island), and at Saxon Harbor. Non-Federal small-boat harbors are found at Herbster, Sand Bay, Point Detour, and Red Cliff. There are electric power generating stations at Ashland, Bayfield, and Superior, Wisconsin.

The State of Wisconsin has identified the offshore waters as generally having excellent water quality. Local pollution problems are reported at Ashland, the Duluth-Superior Harbor area, and at an industrial outflow at Barksdale, Wisconsin. Other reported pollution problems along the Wisconsin Shoreline include the turbidity caused by the movement of taconite tailings from the Minnesota shore and the erosion of Wisconsin's high clay bluffs and red-clay area.

The Lake Superior waters adjoining Wisconsin have a limited commercial fishery of lake herring, whitefish, and chubs. There is sport fishing for lake trout, walleye, and whitefish throughout the Apostle Islands area.

4.1.3 Solutions to Erosion Damages

The critical erosion reaches identified along the Wisconsin Lake Superior Mainland Shoreline include 12.9 miles of shoreline. For the erodible high clay banks, a revetment mattress, riprap, or a protective beach would provide feasible solutions. A combination of seawalls, riprap slope protection, and protective beaches could protect the erodible reach east of Ashland.

Very preliminary estimates indicate that protective beaches would cost about $400,000 to $800,000 per mile. Seawalls and riprap slope protection are likewise estimated at about $500,000 per mile.

Estimated total first costs for shore protection along the Wisconsin Shoreline are estimated at about $7,800,000 for three unprotected areas subject to critical erosion. Annual beach nourishment costs are estimated at $60,000.

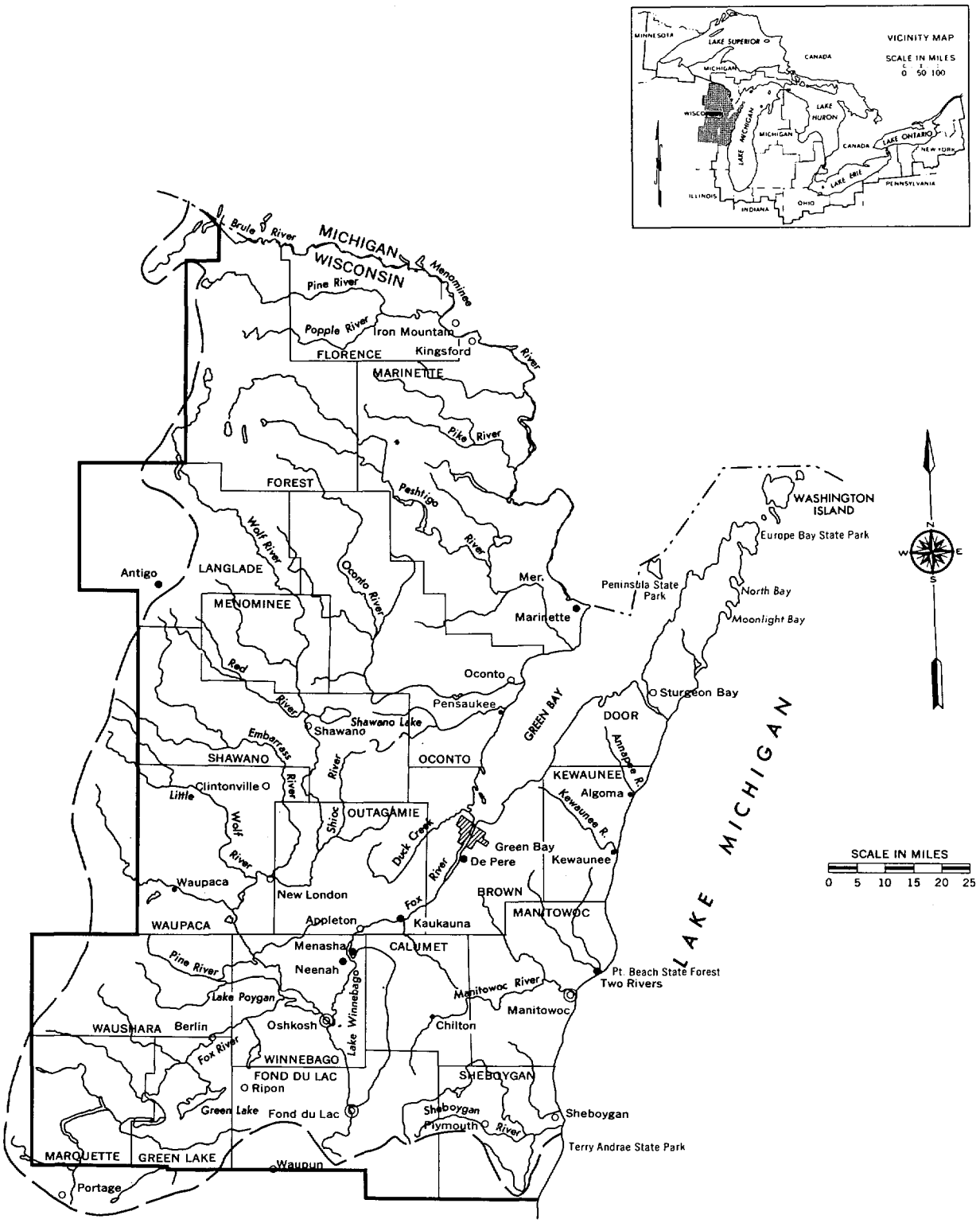
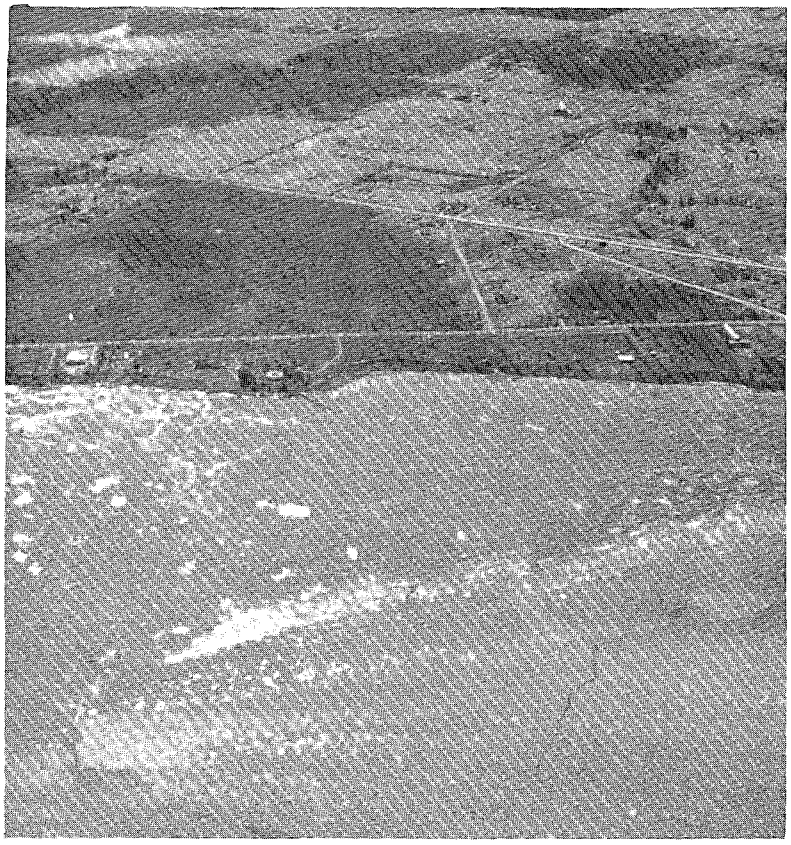


Figure 10. Lake Michigan Northwest Planning Subarea 2.1, Wisconsin.



Photograph 6. Erosion along Ashland County shoreline east of Ashland, Wisconsin.

4.2 The Lake Michigan Northwest Planning Subarea 2.1

The Great Lakes Mainland Shoreline of Wisconsin in planning subarea 2.1 is 326 miles long. The major drainage areas are the Menominee, Peshtigo, Oconto, and Fox-Wolf River Basins, and the Green Bay-Sheboygan Drainage Complex. The 20-county area has a population of 931,000 (1970). Major urban centers are Fond Du Lac and Oshkosh on the Fox River and Green Bay and Manitowoc on the Lake Michigan Shoreline (Figure 10). Information on the shoreline is given for three reaches: the Marinette, Oconto, and Brown Counties to the east city limits of Green Bay; the east city limits of Green Bay in Brown County to the northern tip of Door County; and the northern tip of Door County, Kewaunee, Manitowoc, and Sheboygan counties. Figures 11 and 14 illustrate resources, uses, ownership, and problem areas for this shoreline reach.

4.2.1 Marinette, Oconto, and Brown Counties to East City Limits of Green Bay

4.2.1.1 Shoreline Description

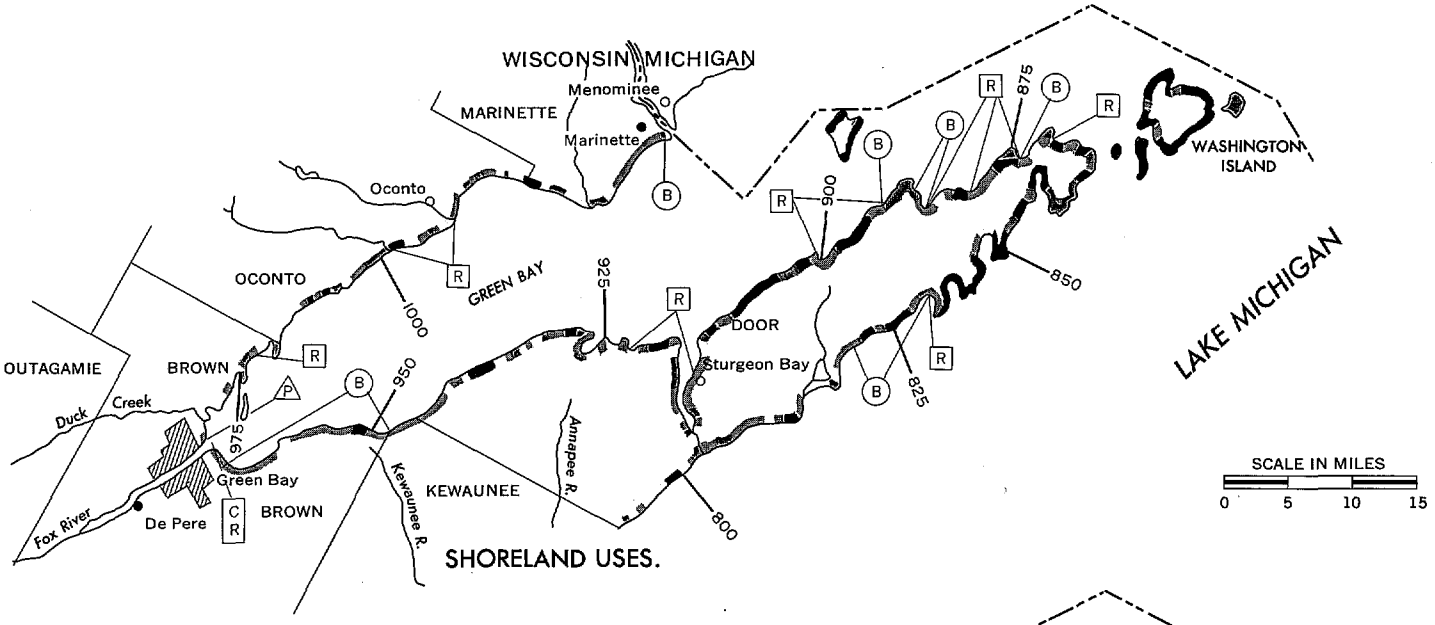
The Wisconsin Shoreline measures 76 miles. It extends from the mouth of the Menominee River at the Michigan-Wisconsin State line to and including the city of Green Bay on the southwest shore of Green Bay. Its shorelands consist of low sand banks up to five feet high and fronted by low wetlands.

The present use along this reach of shoreline is as follows: 25.9 miles residential; 1.1 miles industrial and commercial; 26.8 miles agricultural and undeveloped; 1.1 miles parks; 17.2 miles wildlife preserves and game lands; and 3.9 miles forest. Approximately 14.3 miles of these shorelands are in public ownership. Major shoreline cities include: Marinette, Oconto, and Green Bay. Existing development, ownership, and problem areas are summarized in Table 9.

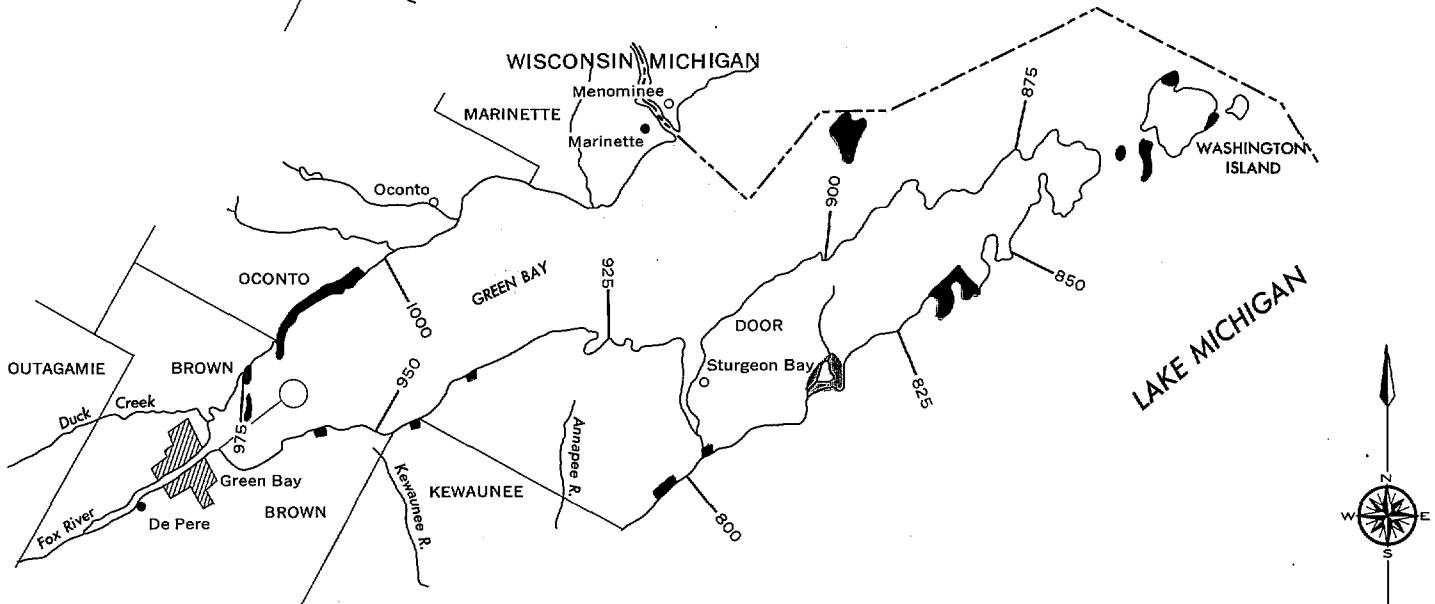
Table 9

Shoreline of the Great Lakes — Marinette, Oconto, and Brown Counties, Wisconsin

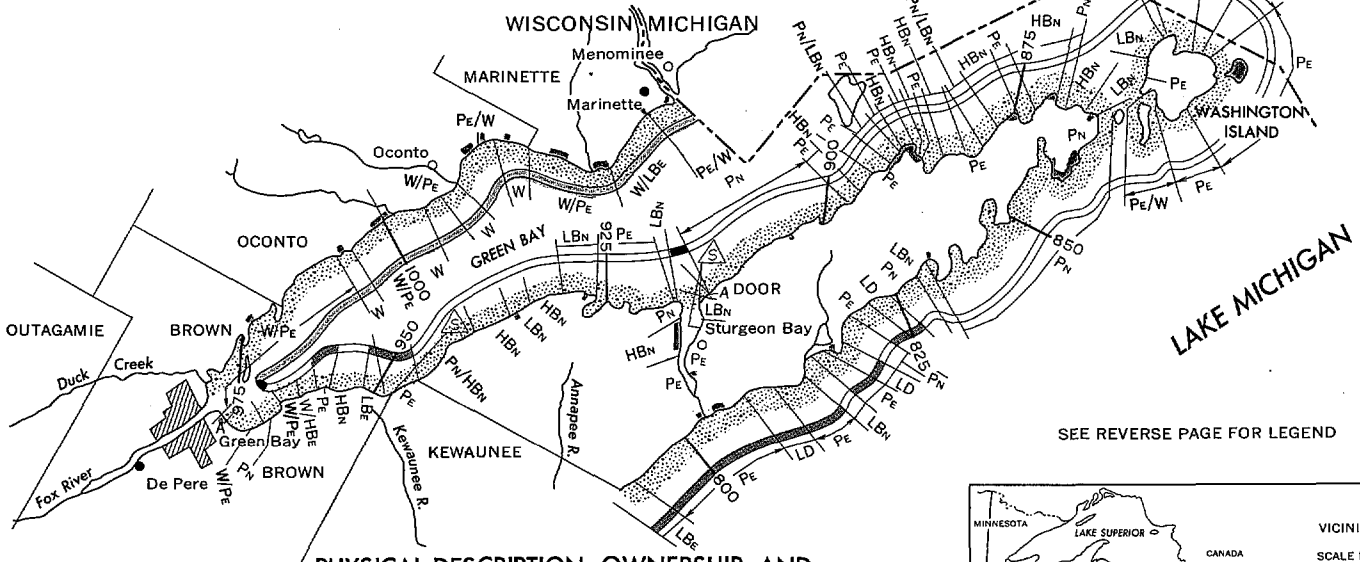
Shoreland Use Category	*Existing Shoreland Use*			*Miles of Shoreline*			*Problem Identification, Miles of Shoreline*				
	Miles of Shoreline	*Percent of Total*	*Number of Sites*	*Public*		*Private*	*Subject to Erosion*		*Protected*	*Subject to Flooding*	*Not Subject to Erosion or Flooding*
				Federal	*Non-Federal*		*Critical*	*Noncritical*			
Economic Uses											
Residential	25.9	34.2		0	0	25.9	0	7.5	1.9	16.5	0
Industrial and commercial	1.1	1.4		0	0	1.1	0	0	0	1.1	0
Agricultural and undeveloped	26.8	35.3		0	0	26.8	0	4.3	0	22.5	0
Commercial harbors			1								
Electric power sites			1								
Public buildings and related lands	0	0		0	0	0	0	0	0	0	0
Recreational Uses											
Parks	1.1	1.4		0	1.1	0	0	0.4	0	0.7	0
Recreational boat harbors			4								
Beach zone	(0)	(0)		(0)	(0)	(0)					
Environmental Uses											
Wildlife perserves and game lands	17.2	22.6		0	13.2	4.0	0	0	0	17.2	0
Fish and wildlife wetlands (offshore)	(NA)	0									
Forest	3.9	5.1		0	0	3.9	0	0	0	3.9	0
Total	76.0	100.0		0	14.3	61.7	0	12.2	1.9	61.9	0



SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

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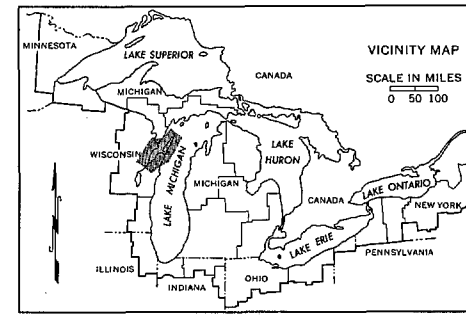


Figure 11. SHORELANDS OF THE GREAT LAKES, MARINETTE, OCONTO, BROWN, KEWAUNEE, DOOR COUNTIES.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites
- Waste Water Outfalls and Intakes
  - Public Outfalls
  - Public Intakes
  - Private Outfalls
  - Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands
- Shore type
  - Artificial Fill Area — A
  - Erodible High Bluff, 30 ft. or higher — HB_E
  - Non-Erodible High Bluff, 30 ft. or higher — HB_N
  - Erodible Low Bluff, less than 30 ft. high — LB_E
  - Non-Erodible Low Bluff, less than 30 ft. high — LB_N
  - High Sand Dune, 30 ft. or higher — HD
  - Low Sand Dune, less than 30 ft. high — LD
  - Erodible Low Plain — P_E
  - Non-Erodible Low Plain — P_N
  - Wetlands — W
  - Combinations Shown As: Example
    - Lakeward/Landward — W/P_E
    - Upper Bluff Material / Lower Bluff Material — HB_E / HB_N
- Beach Material
  - Sand and gravel
  - Ledge rock
  - No Beach
- Problem Identification
  - Areas subject to erosion generally protected
  - Critical erosion areas not protected
  - Non-critical erosion areas not protected
  - Shoreline subject to lake flooding
  - Shoreline not subject to erosion or flooding
  - Bluff seepage problems — S

There are Federal deep-draft navigation harbors at Marinette and Green Bay. Federally improved light-draft harbors at Oconto, Pensaukee, and Suamico, Wisconsin, are used primarily by commercial fishing vessels and recreational boats. It is estimated that there are 200 recreational boats permanently moored in these harbors.

Public parks and beaches along this reach of shore are generally limited to small county and local facilities. There are however, four State and one privately operated hunting and fishing grounds along this reach of shore. In addition, the Peshtigo Wildlife Refuge is situated on the shore in southeastern Marinette County.

The U. S. Bureau of Sport Fisheries and Wildlife has identified the wetlands along this reach of shore as having poor to good fishery and waterfowl value. Wetlands currently extend along most of this shoreline. In its 1966 Outdoor Recreation Plan, the State of Wisconsin identified several potential recreational park sites along this shore. These included two undeveloped sites with a total shoreline of 6.5 miles along the extreme southern shore of Oconto County and Little Tail Point and Long Tail Point in Brown County.

Shoreland use has changed a little since 1952. The development of seasonal residences and resorts has increased slightly. There has been a corresponding decrease in undeveloped lands. The amount of shore property in parks and game lands has not changed much since 1952.

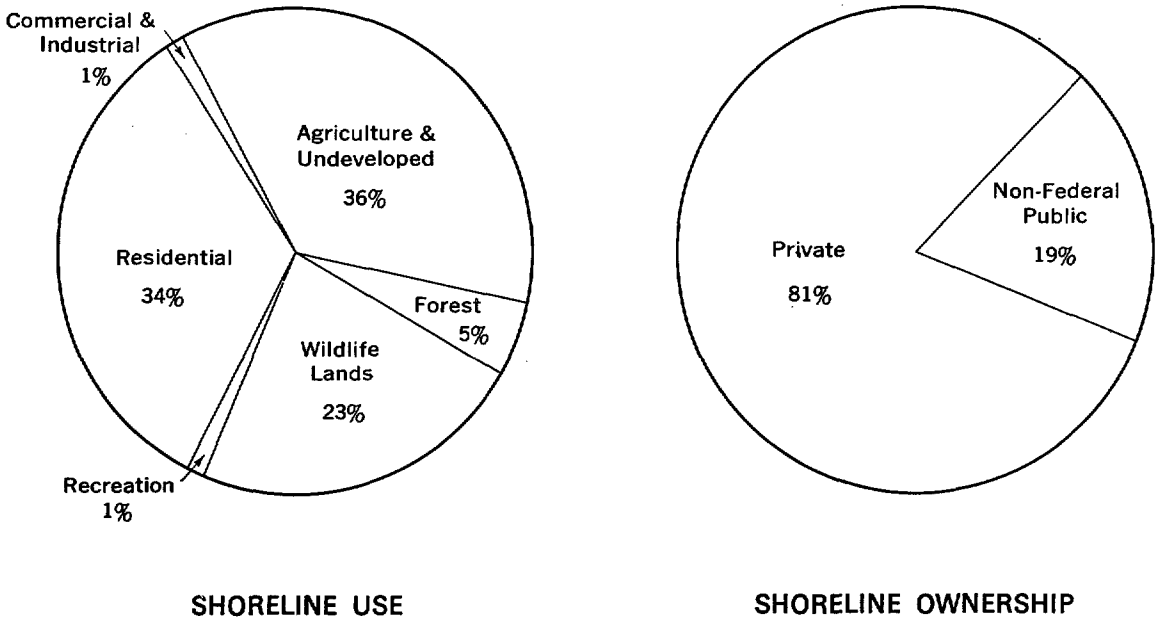


Figure 12. Distribution of Shoreline Use and Ownership, Marinette, Oconto and Brown Counties, Wisconsin.

4.2.1.2 Erosion and Flooding History

The shorelands between Menominee Harbor and the east city limits of Green Bay are generally subject to significant erosion and flooding damage only when extreme high-lake stages are accompanied by strong north or northeast winds. These conditions last occurred in 1951-52. At that time shore property damages due to flooding amounted to $527,000. Erosion damages amounted to $168,000. Table 10 summarizes these damages. The damages listed above generally included the loss of valuable trees and residential lawns due to eroding banks. Also included are substantial damages which occurred to recreational craft and boat docks.

Table 10

Total Damage to Shore Property on Lake Michigan — Marinette, Oconto, and Brown[a] Counties, Wisconsin

Land Use	Damages, $ Actual 1951-52 Value	Damages, $ Updated 1970 Value
Private		
Residential	39,000	75,300
Industrial and commercial	42,000	81,100
Agricultural	16,000	16,800
Total, private property	97,000	173,300
Public		
Parks and beaches	9,000	20,800
Utilities	62,000	143,200
Total, public property	71,000	164,000
Total erosion damages	168,000	337,200

[a] To the east city limits of Green Bay.

Several developed areas along this reach of shore were flooded due to high lake levels in 1951-52. These included portions of Marinette, Oconto, Pensaukee, Suamico, and Green Bay. The most extensive damage occurred at the mouth of the Fox River in the city of Green Bay. On 13 April 1952, strong northerly winds raised the water surface at Green Bay about two feet above mean lake level. Water overflowed the low-lying shore on both sides of the Fox River and flooded about 1,800 acres of the city of Green Bay. About 800 residences, petroleum tank farms, and a few commercial and industrial establishements were flooded. Since the water rose generally less than a foot deep, few if any of the homes were evacuated. The city installed pumps, and the area was dewatered and returned to normal in a relatively short time after the storm. Damage in the city of Green Bay was estimated at more than $500,000.

Only about 1.9 miles of erosion protective works have been constructed along this reach of shore, mostly stone fills, ripraps, and small seawalls, put up by individual property owners.

It is apparent, then, that flooding is the main problem along this reach of shore, rather than erosion. Further, substantial shore property damage only occurs during periods of extreme high lake stages. Flooding along the city of Green Bay shoreline begins when the level of Green Bay rises to elevation 581.3, or about 4.5 feet above low water datum. The shorelands north of Green Bay to Peshtigo, Wisconsin, begin flooding when the lake stage rises to elevation 579.3, or about 2.5 feet above low water datum. North of Peshtigo to Marinette, Wisconsin, the shorelands are more subject to slight erosion than to flooding.

4.2.1.3 Solutions to Erosion Damages

Shoreline erosion along the southwest shore of Green Bay does not require extensive structural protection.

Enforcement of the Wisconsin Shoreland Protection Ordinance, in accordance with the Wisconsin Water Resources Act of 1965, will help to reduce flooding and erosion damage to new structures along the southwest Green Bay shoreline. However, the zoning and setback requirements of this act will have a limited effect on reducing loss of land and damage to trees, lawns, recreational craft, and docks, such as occurred in the 1951-1952 high-water period. Marinette, Oconto, and Brown Counties have adopted shoreland zoning ordinances.

4.2.2 Lake Michigan Shoreline East City Limits of Green Bay to Northern End of Door County

4.2.2.1 Shoreline Description

The shoreline between the eastern city limits of Green Bay and the northern tip of Door County mainland peninsula is 93 miles long. Northeast of the city of Green Bay, for a distance of 60 miles, the shorelands generally consist of sand and gravel beaches backed by bluffs up to 100 feet high. The bluff material is glacial till and lacustrine (lake-bottom) sand and gravel. However, there are sections of limestone bluffs throughout this reach of shore. Continuing north along the Green Bay shore of Door County, the shorelands consist of rocky beaches backed by rugged ledge rock bluffs extending around the northern point of the Door peninsula. The bays within this reach of shore usually contain a finer beach material and less rugged bluffs.

The present use along this eastern shore of Green Bay is as follows: 48.8 miles residential, 0.9 mile public buildings and related lands, 10.8 miles agricultural and undeveloped, 9.5 miles recreational, 22 miles forest, and 1 mile wildlife preserves and game lands. About 10.4 miles of the shoreline is in public ownership. This is a popular summer resort area, well developed with numerous summer homes, cabins, resorts, and public parks. The only urban development is Sturgeon Bay. It is located on the Sturgeon Bay and Lake Michigan Ship Canal, which connects Green Bay with Lake Michigan. Table 11 summarizes the development, ownership, and erosion problem areas along the immediate Green Bay shoreline. Figure 13 illustrates the present distribution of use and ownership for this shoreline reach.

The shorelands along this reach of shore have high scenic and recreational value. They include two state parks, six county parks, and several local parks and beaches. Potawatomi and Peninsula State Parks in Door County cover a total area of 4,800 acres. The six county parks have a total area of 270 acres. Sport fishing along this reach of shoreline is excellent. There are, however, no extensive reaches of wetlands with significant fish and wildlife habitat value. Numerous natural harbors and publicly and privately operated recreational boating facilities are located along Green Bay and the Sturgeon Bay Canal. An estimated 500 recreational boats are permanently moored at these facilities. Many additional craft visit them each year. In addition, an estimated 200 recreational craft are moored at individual private docks.

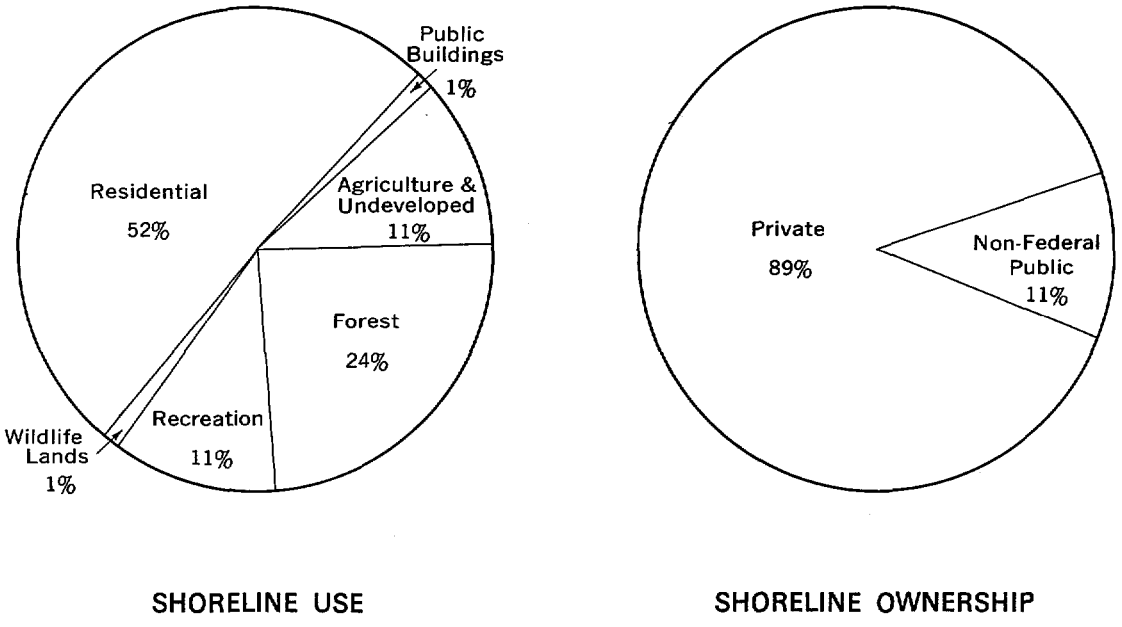


Figure 13. Distribution of Shoreline Use and Ownership, East City Limit of Green Bay to the North End of Door County, Wisconsin.

Table 11

Shoreline of the Great Lakes — East City Limit of Green Bay to North End of Door County, Wisconsin

Shoreland Use Category	*Existing Shoreland Use*			*Miles of Shoreline*			*Problem Identification, Miles of Shoreline*				
	Miles of Shoreline	*Percent of Total*	*Number of Sites*	*Public*			*Subject to Erosion*			*Subject to Flooding*	*Not Subject to Erosion or Flooding*
				Federal	*Non-Federal*	*Private*	*Critical*	*Noncritical*	*Protected*		
Economic Uses											
Residential	48.8	52.5		0	0	48.8	0	0	12.2	0	36.6
Industrial and commercial	0	0		0	0	0	0	0	0	0	0
Agricultural and undeveloped	10.8	11.6		0	0	10.8	0	0	0	0	10.8
Commercial harbors			0								
Electric power sites			0								
Public buildings and related lands	0.9	1.0		0	0.9	0	0	0	0	0	0.9
Recreational Uses											
Parks	9.5	10.2		0	9.5	0	0	0	0	0	9.5
Recreational boat harbors			7								
Beach zone	(36.0)	(38.7)		(0)	(3.5)	(32.5)					
Environmental Uses											
Wildlife perserves and game lands	1.0	1.1		0	0	1.0	0	0	0	0	1.0
Fish and wildlife wetlands (offshore)	(0)	0									
Forest	22.0	23.6		0	0	22.0	0	0	0	0	22.0
Total	93.0	100.0		0	10.4	82.6	0	0	12.2	0	80.8

4.2.2.2 Erosion and Flooding History

Erosion and flooding of shore property along the east shore of Green Bay is not a serious problem, even during periods of high-lake stages. Isolated reaches of shore are subject to some erosion damage. However, the vast proportion of the shoreline has rock bluffs or protected bays and is not subject to damage. In the 1951-52 high-water period, erosion damage was estimated at $196,000, as shown in Table 12. The damage shown above was primarily due to loss of trees, lawns, boat docks and boat houses. There was minor damage to residences, cottages, and beaches. Much of this damage was caused during the winter by ice, which acted higher on the shore than usual because of higher than normal lake levels. There has been no additional major damage along this reach of shore since 1952.

Table 12

Total Damage to Shore Property on Lake Michigan – East City Limit of Green Bay to Northern End of Door County, Wisconsin

	Damages, $	
Land Use	*Actual 1951-52 Value*	*Updated 1970 Value*
Private		
Residential	84,500	163,100
Industrial and commercial	73,300	141,500
Agricultural	25,000	26,200
Total, private property	182,000	230,800
Public		
Parks and beaches	13,200	30,500
Total, public property	13,200	30,500
Total erosion damages	196,000	361,300

During the 1951-52 period, the city of Sturgeon Bay suffered an estimated $564,000 in damages due to high lake levels. Most of the city's waterfront was flooded from a few inches to a foot or more in depth when the lake level in the canal rose to elevation 581.3 in early 1952. Damage included the washing out of fill behind revetments of extensive commercial docks, the undermining of foundations of 6 tourist cottages and 12 residences, the undermining of 600 feet of railroad siding, and damage to commercial and private docks by ice acting at a higher elevation than during periods of average lake levels. The residences and other buildings affected did not have to be abandoned or moved. There has been no significant damage to the shoreline along the canal since 1952.

4.2.2.3 Solutions to Erosion Damages

Since erosion and flooding damage along the east shore of Green Bay is not a serious problem, there is no need for extensive protective measures. The abundance of field stone along this reach of shore may make construction of gabion protection practicable, if protection of an individual property is desired.

4.2.3 Lake Michigan Shoreline of Door, Kewaunee, Manitowoc and Sheboygan Counties

4.2.3.1 Shoreline Description

The shoreline along the Lake Michigan shore of Door County north of the Sturgeon Bay Canal is generally a mixture of ledge rock cliffs and banks with numerous narrow beaches and shallow bays. The beaches are generally backed by low bedrock bluffs or a low plain of lacustrine sand and gravel. Behind the upper reaches of many of the bays are low wetland areas. Bluff heights along this reach of shore range up to 35 feet. The average height is about 12 feet. A red clay bluff ranging between 10 and 70 feet in height characterizes the shoreline between the Sturgeon Bay Canal entrance to a point about 2.5 miles north of Two Rivers, Wisconsin. Narrow sand and gravel beaches from 30 to 60 feet wide exist along this reach of shore. Immediately north of Two Rivers, there is a 2.5 mile reach of shore having sand dunes from 5 to 15 feet high. South of Two Rivers Harbor to Manitowoc, there are sand bluffs from 5 to 15 feet high, fronted by narrow sand beaches. Red clay bluffs and banks of 5 to 50 feet in height extend along the frontage of the city of Manitowoc. In front of these bluffs are narrow sand and gravel beaches. Red clay bluffs up to 60 feet high extend south from Manitowoc and decrease to low sand banks and beaches near the Manitowoc-Sheboygan County line. From this county line south to the city of Sheboygan, the shore is characterized by sandy clay bluffs that range up to 50 feet in height. The bluffs are fronted by narrow gravel beaches up to 25 feet wide. South of the city of Sheboygan to the Sheboygan-Ozaukee County line, the shorelands consist of sand dunes. The average height of these dunes vary from 10 to 20 feet. The beaches in this reach are sand and range from 0 to 100 feet wide, depending upon the level of the lake. Door County is a popular summer resort area. The Lake Michigan Shoreline of this county north of the Sturgeon Bay Canal is developed with numerous summer homes, cabins, resorts, and public parks. However, it is not as intensely developed as the county's Green Bay shoreline. South of the Sturgeon Bay Canal to the city of Sheboygan, development is generally situated immediately adjacent to the existing cities. The shoreline between these urban areas is generally undeveloped or farmland. South of Sheboygan to the Sheboygan-Ozaukee County line, the shoreline is lined with numerous summer homes and cottages. Table 13 summarizes the development and ownership along the Lake Michigan Shoreline between the northern end of Door County and the Sheboygan-Ozaukee County line.

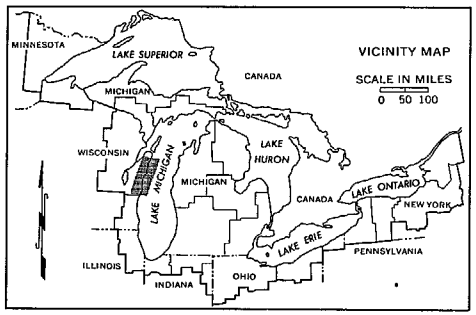
Photograph 7. Illustrates residential use of Green Bay Shoreline in the Little Harbor Area several miles north of Sturgeon Bay, Door County, Wisconsin. Gravel beach, nonerodible.

Table 13

Shoreline of the Great Lakes – North End Door County to Sheboygan County, Wisconsin

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public		Private	Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal		Critical	Noncritical			
Economic Uses											
Residential	38.7	24.6		0	0	38.7	0	24.3	0.5	0	13.9
Industrial and commercial	5.5	3.5		0	0	5.5	0	3.7	1.8	0	0
Agricultural and undeveloped	52.5	33.3		0	0	52.5	0	46.8	0.4	0	5.3
Commercial harbors			5								
Electric power sites			5								
Public buildings and related lands	2.5	1.6		0	2.5	0	0	0	2.5[a]	0	0
Recreational Uses											
Parks	24.8	15.7		0	24.2	0.6	0	17.2	1.1	0	6.5
Recreational boat harbors			6								
Beach zone	(91.1)	(57.8)		0	(7.6)	(83.5)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(5.1)	(3.2)					0	(5.1)	0	0	0
Forest	33.5	21.3		0	0	33.5	0	6.4	0	0	27.1
Total	157.5	100.0		0	26.7	130.8	0	97.8	6.3	0	52.8

[a] Includes 2.6 miles of shoreline between Two Rivers and Manitowoc protecting Highway 42 and classified under recreational uses as beach.



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SCALE IN MILES
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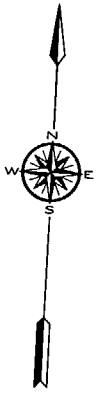
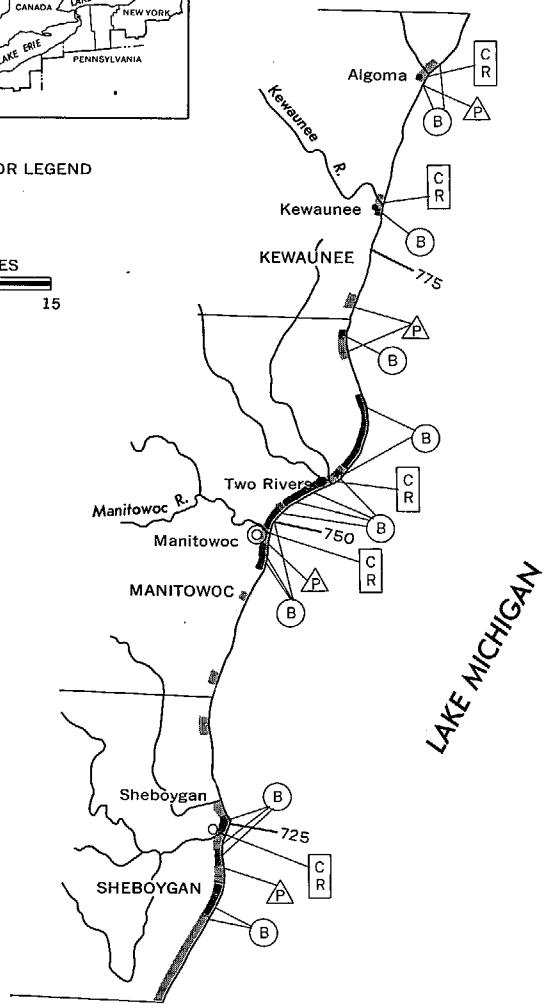
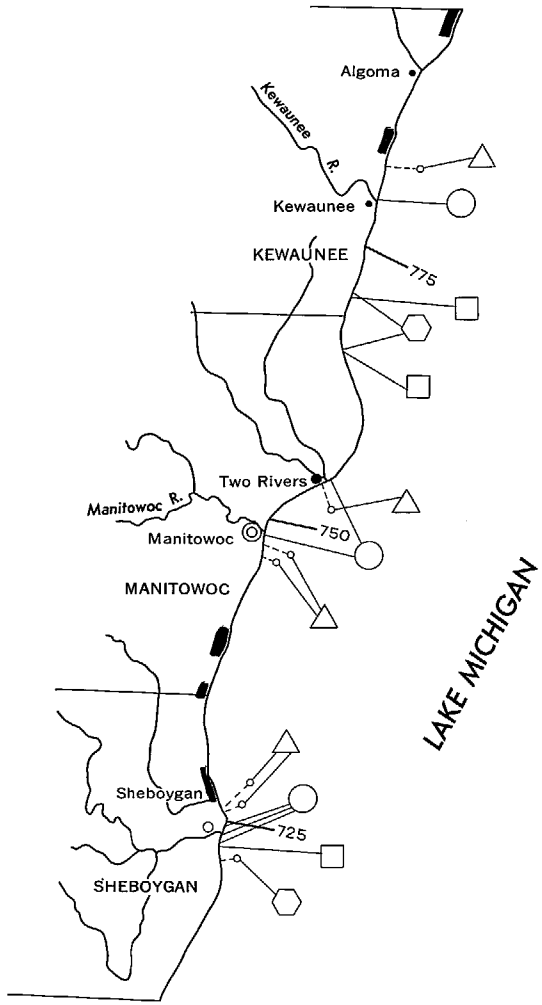
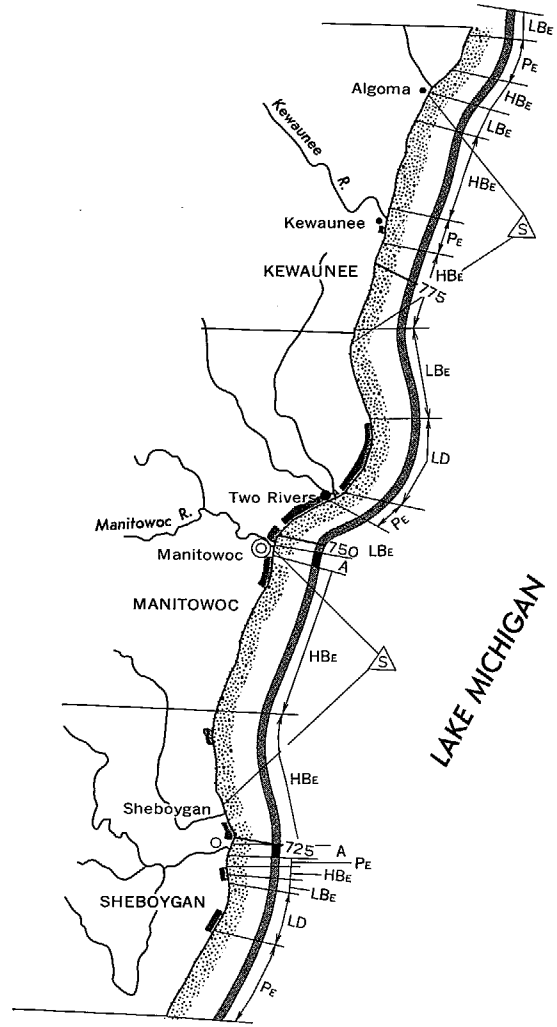




SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

Figure 14. SHORELANDS OF THE GREAT LAKES, SHEBOYGAN, MANITOWOC, KEWAUNEE COUNTIES.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors (C)
- Recreational Harbors (R)
- Commercial Deep Draft and Recreational Harbors (C R)
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

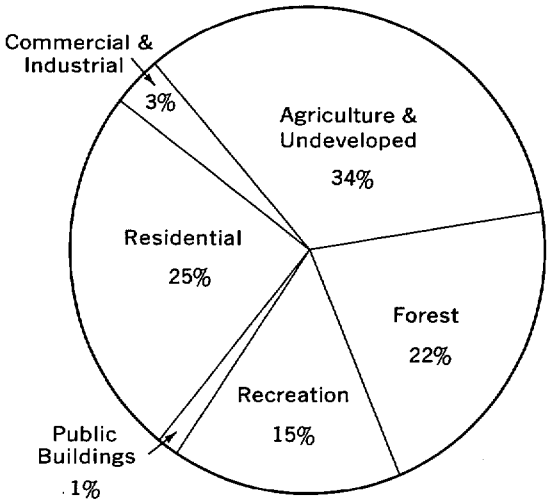
- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)

Photograph 8. Illustrates low density residential development along the Lake Michigan Shoreline, Door County, several miles south of the Sturgeon Bay canal mouth. (Sand, gravel beach, noncritical erosion.)

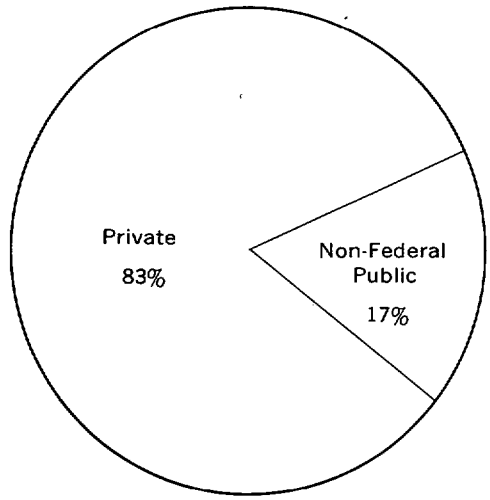
The present shoreline use between the north end of Door County and the south Sheboygan county line is as follows: 38.7 miles residential, 5.5 miles industrial and commercial, 52.5 miles agricultural and undeveloped, 24.0 miles public recreation, 33.5 miles forest, and 2.5 miles public lands and buildings. A total of 26.7 miles of the shoreline is publicly owned. Urban places located on the shoreline are Algoma, Kewaunee, Two Rivers, Manitowoc, and Sheboygan.

A comparison between 1952 use and existing shoreland use shows that there has been relatively little change in shore property use in the past 18 years. Some additional lands have been obtained for park use in Door and Sheboygan Counties. They include purchase of Europe Bay State Park in Door County, expansion of Terry Andrae State Park in Sheboygan, and purchase of additional park lands in the city of Sheboygan. Construction of two nuclear power plants is underway at sites in southern Kewaunee County and in northern Manitowoc County. There has also been some increase in residential development, particularly in Door County. The remaining shoreline development is essentially as it was in 1952. The present distribution of shoreline use and ownership is shown in Figure 15.

Federal deep-draft navigation harbors are located at Algoma, Kewaunee, Two Rivers, Manitowoc, and Sheboygan. These harbors are also used for refuge and mooring by recreational craft. A privately operated small-craft harbor is located at Baileys Harbor in Door County. It is estimated that there are about 150 recreational craft permanently based at these several harbors.



SHORELINE USE



SHORELINE OWNERSHIP

Figure 15. Distribution of Shoreline Use and Ownership, Door County, North End to Sheboygan County, Wisconsin.

There are two state parks and one state forest along this reach of shore-Europe Bay State Park in northeastern Door County, Terry Andrae State Park located south of the city of Sheboygan, and Point Beach State Forest north of Two Rivers in Manitowoc County. In addition, there are several county and local parks and beaches generally found in the vicinity of the major urban developments. In its 1966 Outdoor Recreation Plan, the State of Wisconsin identified 10 additional sites on Lake Michigan as having potential recreational park value. Four of these sites are in Door County, three are in Kewaunee County, one is within Manitowoc County, and one in Sheboygan County. There is also a potential site at the Manitowoc-Sheboygan County line. The Bureau of Sport Fisheries and Wildlife has identified the Wetlands in Moonlight Bay, in North Bay, and at the Mink River Outlet in Door County as having good fish and wildlife habitat values. There are no other major valuable wetland areas along the remainder of this shoreline.

4.2.3.2 Erosion and Flooding History

The entire shorelands from about eight miles north of the Sturgeon Bay Canal to the Sheboygan-Ozaukee County line are subject to erosion except where protected by structures. Flooding is not a problem along this reach of shore.

The erosion damages to shore property between the north end of Door County and the Sheboygan-Ozaukee County line during the one year 1951-52 high-water period are given in Table 14.

From the northern tip of Door County south to about eight miles north of the Sturgeon Bay Canal, the Lake Michigan shore is a mixture of ledge rock cliffs and banks, with numerous shallow bays and beaches. Erosion is not a significant problem in this area. In 1951-52, shore property damage totaled $90,000. This was primarily damage caused by ice and high-water to docks, boat houses and some cottages and resort dwellings.

North of the Sturgeon Bay Canal for about eight miles to Whitefish Point, the Lake Michigan Shoreline is subject to considerable change with increases in lake levels. It was reported that this shore eroded an average of 20 feet during 1951-52 and suffered about $11,000 damage. In the 11-year period, 1954-64, the shore has receded as much as 50 feet toward the northerly end of this reach, in sections 32 and 33 of Sevastopol Township.

Table 14

Total Damage to Shore Property on Lake Michigan — Northern End of Door Through Kewaunee, Manitowoc, and Sheboygan Counties, Wisconsin

	Damages, $	
Land Use	*Actual 1951-52 Value*	*Updated 1970 Value*
Private		
Residential	264,500	510,000
Industrial and commercial	157,000	303,000
Agricultural and undeveloped	150,200	157,700
Total, private property	571,700	970,700
Public		
Parks and beaches	88,300	204,000
Utilities	187,500	433,000
Total, public property	275,800	637,000
Total erosion damages	847,500	1,607,700

Photograph 9. Rock ledge shoreline characteristic of Door County on Lake Michigan, near Gravel Island National Wildlife Refuge.

Between the Sturgeon Bay Canal and Algoma, a distance of 15 miles, there is considerable erosion of the high clay banks close to the shore, particularly when the level of Lake Michigan is high. The low banks along this reach also suffer erosion, although the stony beaches reduce erosion at lower lake stages. South of Algoma to Kewaunee, a distance of 10 miles, the slow erosion of the banks increases at higher lake stages. In 1951-52, the shore between the Sturgeon Bay Canal and Kewaunee eroded an average of 15 feet. Total damages to private property for this section of the lake shore during this period were estimated at $95,000 to private property and $65,000 to public property. The yearly rate of recession of the bank north of Algoma ranges up to 0.5 foot. Between Algoma and Kewaunee the recession rate averages between 0.1 and one foot per year. The breakwaters of the Federal harbors at Algoma and Kewaunee are the only known major protective structures along this reach of shore.

South of Kewaunee for a distance of 13 miles to just north of Point Beach State Forest, narrow beaches front steep red clay banks ranging from 20 to 80 feet high. Erosion of these banks occurs at a rapid rate. The yearly rate of recession ranges from about 0.5 to 2.9 feet, increasing from north to south. The shoreline of Point Beach State Forest south to Two Rivers is characterized by irregular dunes and ridges. Recession of this shoreline is fairly slow; the average rate of recession from 1870 to 1954 was about 0.7 foot per year. In the six-mile reach between the cities of Manitowoc and Two Rivers, the average rate of erosion was about 1.9 feet per year for the period 1834-1957. Protection of 9,550 feet of shore along State Highway 42 was completed in 1963. This protection consists of stone riprap having a top elevation of about nine feet above low water datum. This protection has eliminated erosion along the state highway. However, erosion of private shore property between Manitowoc and Two Rivers continues. During the high-water period 1951-52, the average erosion loss between Kewaunee and Manitowoc was 15 feet. Private and public property losses along this reach of shore were estimated at $142,000 and $144,000 respectively.

The shoreline between Manitowoc and Sheboygan is 25 miles long. Its shoreline consists of steep clay bluffs with narrow beaches. These bluffs are subject to rapid undercutting by wave action during storms, particularly during periods of high lake levels. In 1951-52, erosion along this reach of shore averaged about 15 feet. Losses during this period were estimated at $242,000 to private property and $58,000 to public property. The average yearly rate of recession between 1834 and 1957 range from about 0.2 to 2 feet. However, the major portion of this shore had an average rate of recession of from one to two feet per year. The only major protection, other than the Federal breakwaters at Sheboygan and Manitowoc Harbors, is the few structures adjacent to these harbors, which generally protect public utilities and parks. The remainder of this reach is unprotected.

South of the city of Sheboygan to the Sheboygan-Ozaukee County line, the shorelands consist of sand beaches. The beaches front sandy banks sloping up to terrace levels of 10 to 15 feet. These banks are subject to erosion damage at high-lake stages. Erosion averaged about 0.5 feet per year during the period 1834-1957. During the high-water period 1951-52, this reach of shore eroded an average of 30 to 60 feet, and a total of $750,000 in shore property damages was reported. Along the six miles of shore immediately north of the county line, there are about 100 cottages and residences near the shoreline. In 1952, many of these cottages had to be moved to save them from being undermined. A variety of protective structures was also built to save additional residences.

4.2.3.3 Solutions to Erosion Damages

The annual rate of erosion along this reach of shoreline is rapid. However, the shoreline is relatively undeveloped. For this reason no critical erosion areas have been identified.

Enforcement of the Wisconsin Shoreland Protection Ordinance, in accordance with the Wisconsin Water Resources Act of 1965, will help to reduce erosion damage to new structures along this reach of shore. However, the zoning and setback requirements of this act will not affect future losses of land due to wave erosion. Door, Kewaunee, Manitowoc, and Sheboygan Counties have adopted shoreland zoning ordinances that follow very closely the standards suggested by the State of Wisconsin.

4.3 Lake Michigan Southwest, Planning Subarea 2.2 State of Wisconsin

The Great Lakes Mainland Shoreline of Wisconsin in planning subarea 2.2 measures 80.5 miles and has a population of 1.74 million (1970). The Chicago-Milwaukee Complex drains a small portion of this seven-county area (Figure 16).

Major villages and cities situated along the Lake Michigan Shoreline, are: Port Washington, Mequon, Fox Point, Whitefish Bay, Shorewood, Milwaukee, St. Francis, Cudahy, South Milwaukee, Racine, and Kenosha.

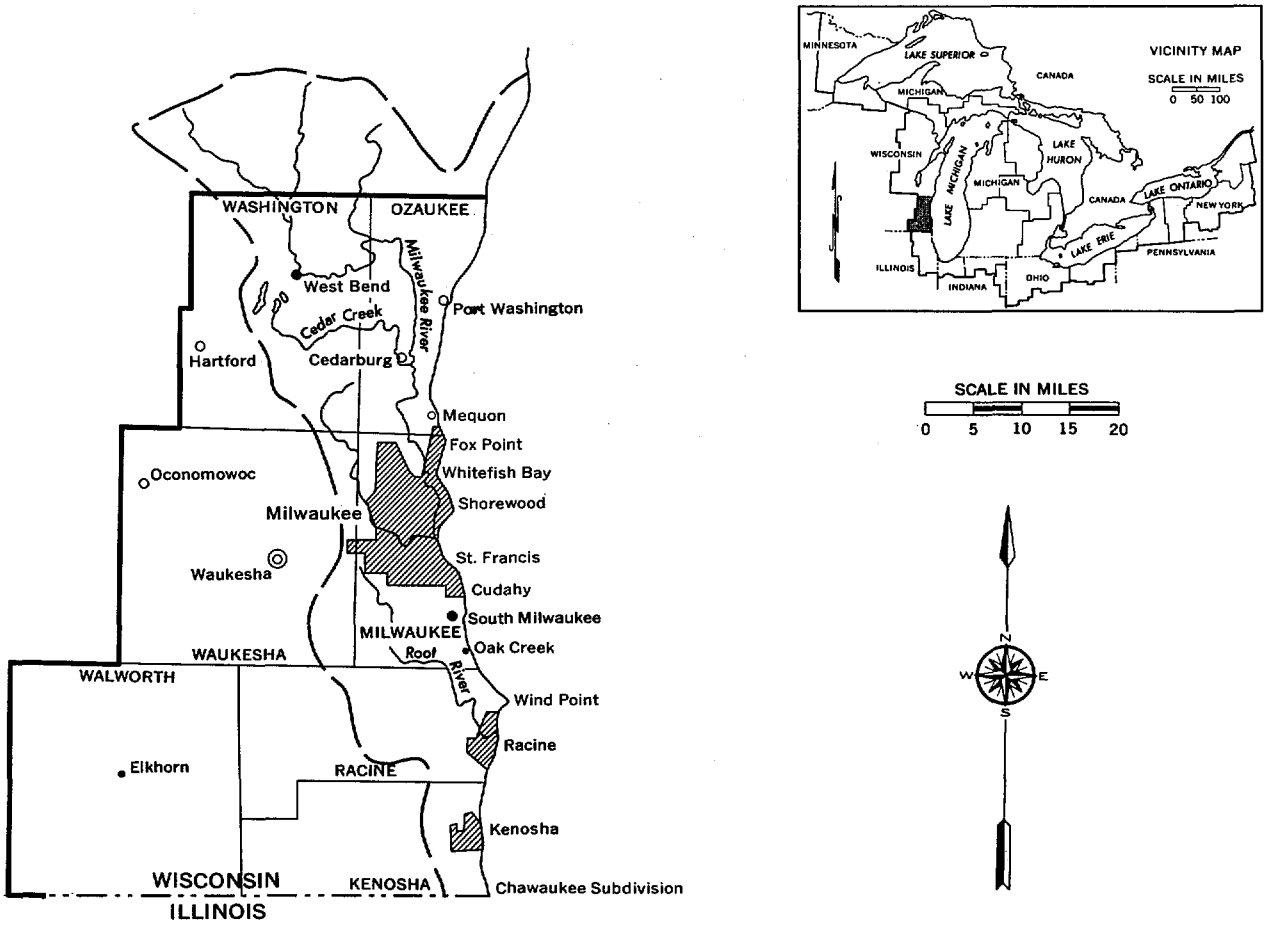


Figure 16. Lake Michigan Southwest Planning Subarea 2.2, Wisconsin.

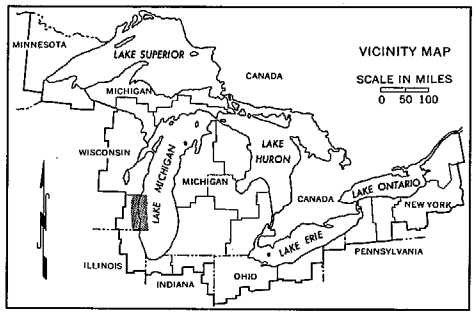
4.3.1 Shoreline Description

The shoreland of Ozaukee County from the north county line for a distance of seven miles south has gently sloping, low sand banks fronted by wide beaches. The banks range in height from 8 to 15 feet. The beach width ranges from 40 to 125 feet. South of this reach to Kenosha Harbor, a distance of 65 miles, the shoreline is generally backed by high glacial till bluffs. The line of bluffs recedes from the immediate shore at Fox Point in Milwaukee County, Wind Point in Racine County, and in the vicinity of Port Washington, Milwaukee, Racine, and Kenosha Harbors. Bluff heights north of Port Washington range from 70 to 100 feet. Between Port Washington and Milwaukee Harbor, they range from 90 to 140 feet. South of Milwaukee Harbor to Racine, the bluff heights decrease to 40 feet. Between the cities of Racine and Kenosha, the bluffs are generally 25 to 30 feet high. South of Kenosha Harbor to the Illinois-Wisconsin State line, sand banks along the shore are generally 10 feet high. Beaches along the entire shore are generally narrow and composed of sand and gravel.

Table 15

Shoreline of the Great Lakes — Kenosha County to Ozaukee County, Wisconsin

Shoreland Use Category	*Existing Shoreland Use*			*Miles of Shoreline*			*Problem Identification, Miles of Shoreline*				
	Miles of Shoreline	*Percent of Total*	*Number of Sites*	*Public*			*Subject to Erosion*			*Subject to Flooding*	*Not Subject to Erosion or Flooding*
				Federal	*Non-Federal*	*Private*	*Critical*	*Noncritical*	*Protected*		
Economic Uses											
Residential	35.5	44.1		0	0	35.5	16.0	13.7	5.8	0	0
Industrial and commercial	6.3	7.8		0	0	6.3	1.4	0.7	4.2	0	0
Agricultural and undeveloped	13.7	17.0		0	0	13.7	4.2	9.5	0	0	0
Commercial harbors			4								
Electric power sites			3								
Public buildings and related lands	5.4	6.7		0	5.4	0	0.6	2.0	2.8	0	0
Recreational Uses											
Parks	19.0	23.6		0	18.4	0.6	3.8	9.1	6.1	0	0
Recreational boat harbors			4								
Beach zone	(70.7)	(87.8)		(0)	(18.6)	(52.1)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0									
Forest	0.6	0.8		0	0	0.6	0	0.6	0	0	0
Total	80.5	100.0		0	23.8	56.7	26.0	35.6	18.9	0	0



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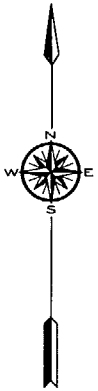
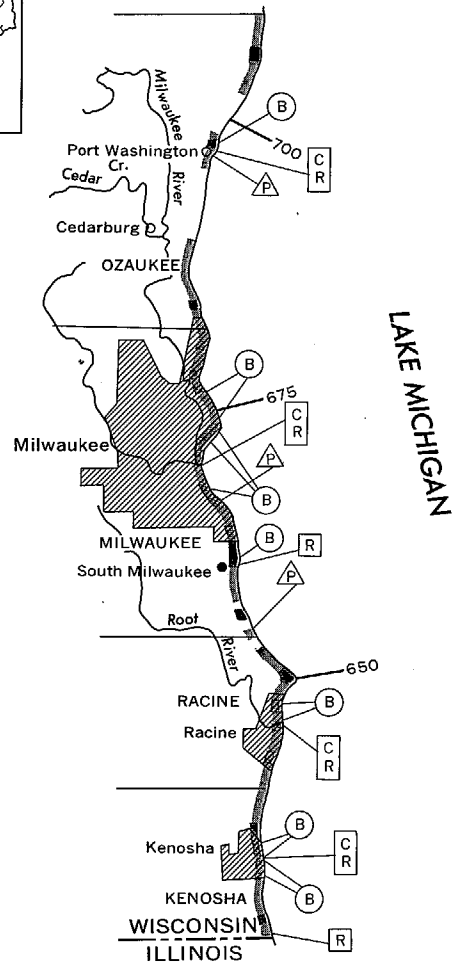
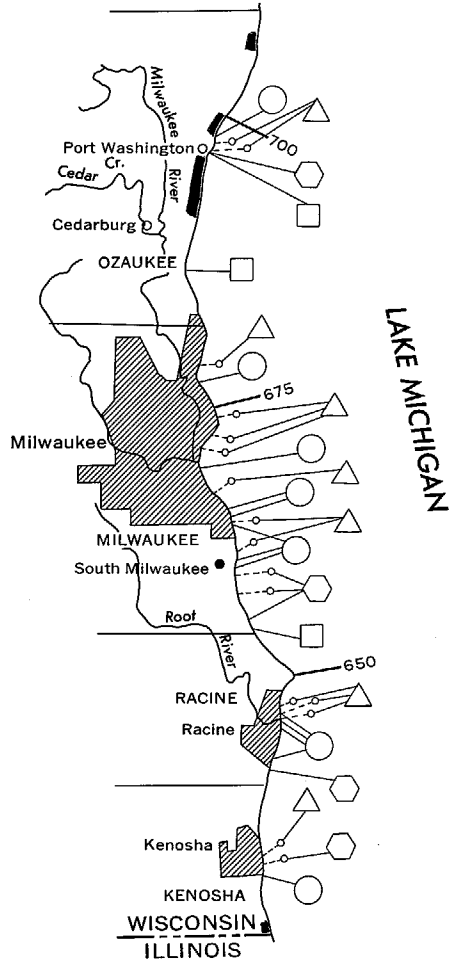
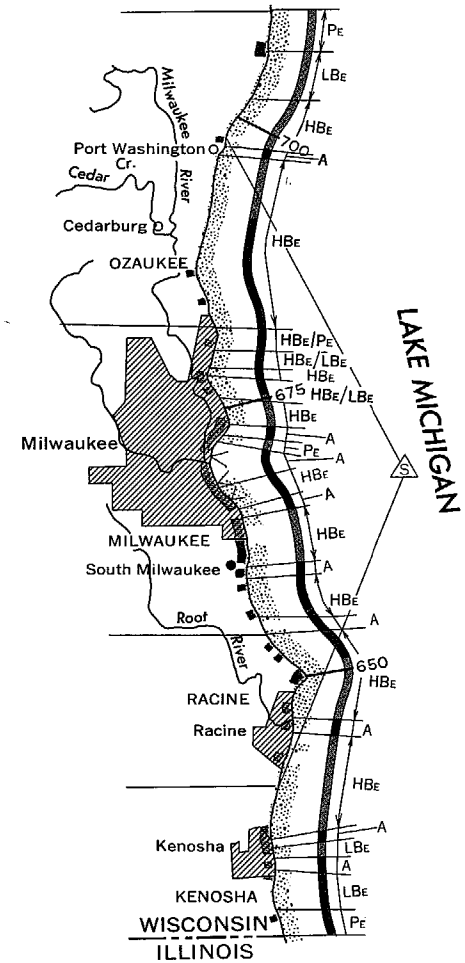




SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

Figure 17. SHORELANDS OF THE GREAT LAKES, OZAUKEE, MILWAUKEE, RACINE, KENOSHA COUNTIES.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors (C)
- Recreational Harbors (R)
- Commercial Deep Draft and Recreational Harbors (C R)
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

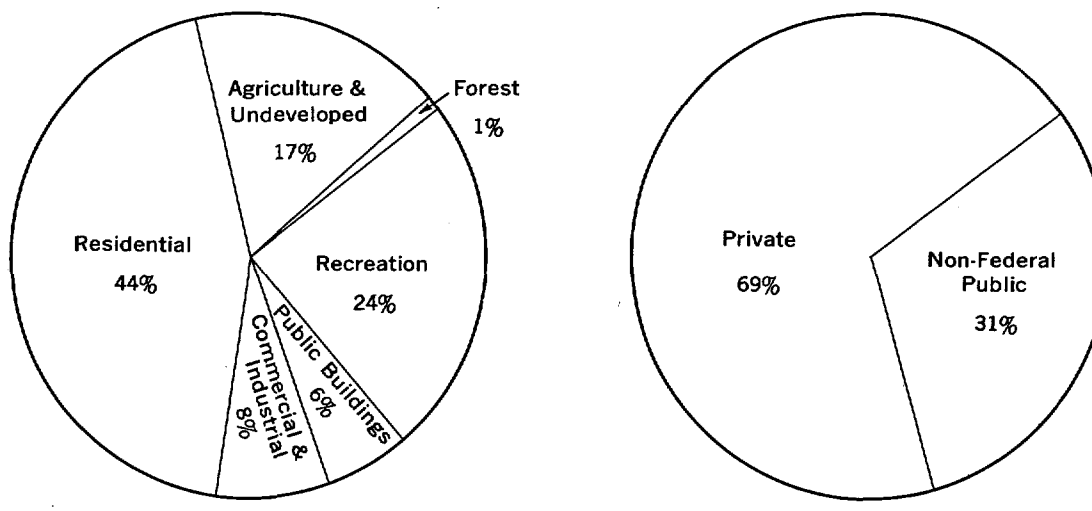
- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)

The present shoreline use in Ozaukee, Milwaukee, Racine, and Kenosha Counties is 35.5 miles residential, 6.3 miles industrial and commercial, 13.7 miles agricultural and undeveloped, 5.4 miles public buildings, 19 miles public recreation and 0.6 mile forest. A total of 23.8 miles of the shoreline is publicly owned.

Table 15 summarizes existing shoreline values, use, ownership, and problem areas for this reach of shoreline. Figure 17 illustrates these values and pinpoints the problem areas.

The use of the shorelands between the north Ozaukee County line and the city of Mequon, a distance of 19.5 miles, is a mixture of seasonal and moderate-value residences, agricultural and undeveloped lands. From the north city limits of Mequon to just north of Milwaukee Harbor, there is concentrated, high-value residential development. Small county and local parks are also scattered along this reach. Milwaukee Harbor extends four miles along the shore. This segment of shoreline has numerous deep-draft and recreational navigation facilities. South of Milwaukee Harbor to the Milwaukee-Racine County line, shoreline development consists generally of public parks and industrial and public-utility works. The Milwaukee County Park Commission owns 60 percent of this shoreline. Twenty-five percent is for public utility and industrial uses, including two electric power generating plants. The remaining 15 percent includes residential development and undeveloped lands. The shoreline between the Milwaukee-Racine County line and the Wisconsin-Illinois State line, a distance of 27 miles, is generally lined with private permanent residences and public parks. There are some industrial and public-utility developments in the immediate vicinity of Racine and Kenosha Harbors. There is no wetland along this reach of Lake Michigan shore.

The distribution of present shoreline use and ownership is shown in Figure 18. A comparison between 1952 and existing shoreland uses shows there has been relatively little change in shore property use in the past 18 years. During this period there was some minor increase in residential development. The Milwaukee County Park Commission obtained 3.5 miles of shore property in southern Milwaukee County for development of four parks-Sheridan, Pulaski, Warnimont, and Bender. The Commission also constructed a large public marina facility in the Milwaukee north outer harbor. Racine County acquired 3,000 feet of frontage in northern Racine County for development of its 200-acre Cliffside Park. An electric power generating plant was erected at the Milwaukee-Racine County line. A large private marina was constructed immediately north of the Wisconsin-Illinois State line. Most of the shore property taken for these improvements was previously undeveloped land or farmland.



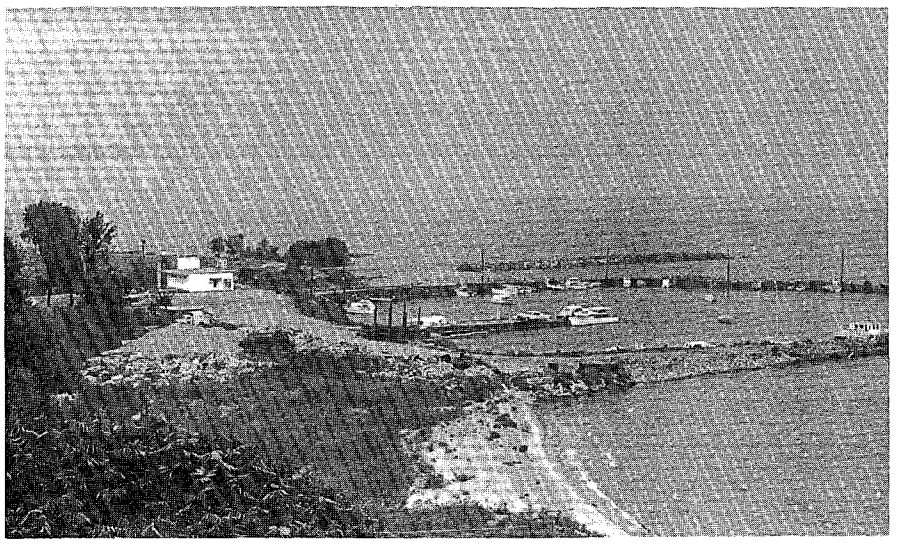
SHORELINE USE

SHORELINE OWNERSHIP

Figure 18. Distribution of Shoreline Use and Ownership, Kenosha County to Ozaukee County, Wisconsin.

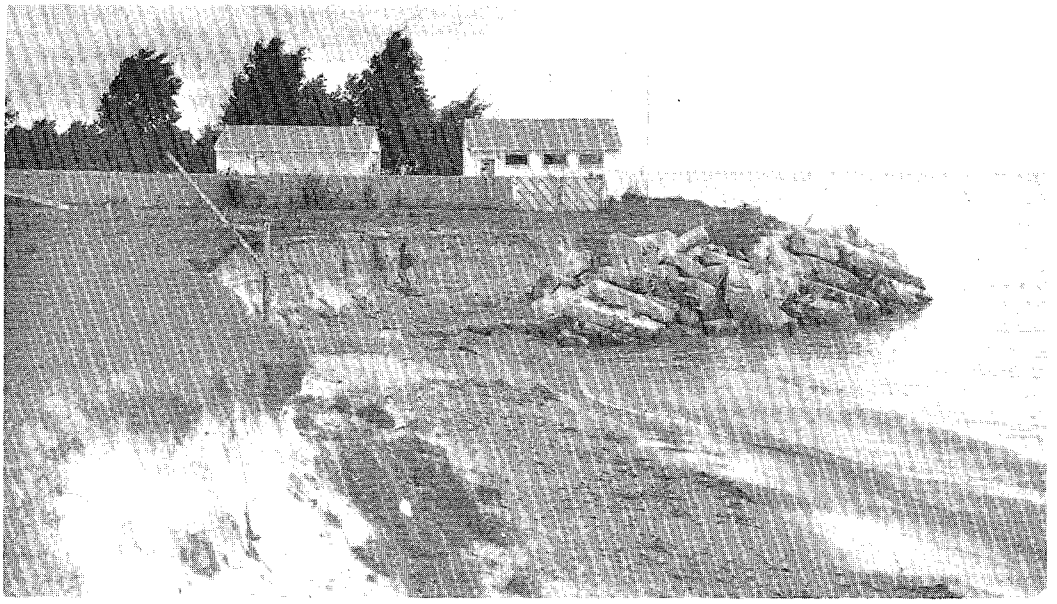
Federal deep-draft navigation harbors are located at Port Washington, Milwaukee, Racine, and Kenosha. All but Port Washington Harbor are used extensively by recreational craft for mooring and refuge. There are additional private recreational harbor facilities at the mouth of Oak Creek in South Milwaukee and immediately north of the Wisconsin-Illinois State line. An estimated 1,300 recreational boats are permanently based at these harbors. The breakwaters and piers of the Federal harbors provide excellent fishing opportunities for thousands of sport fisherman each year.

There are no major potential park sites available along the shore in Milwaukee, Racine, and Kenosha Counties. However, the local and county parks along the shore in these counties provide outstanding recreational opportunities. In its 1966 Outdoor Recreation Plan, the State of Wisconsin identified three potential shoreland park sites in Ozaukee County. Development of a state park on the northernmost site has been authorized.



Photograph 10. View of the South Milwaukee Yacht Club with a groin in the background. Since this picture was taken a large recreational beach has accreted north of this groin.

Photograph 11. Critical bluff erosion near the Milwaukee-Racine County line. Oak Creek Power Generating Station is shown in the background.



Photograph 12. Severe low bank erosion of residential shoreline two miles south of South Kenosha, Wisconsin. Broken concrete has been placed as riprap to protect residential structures from erosion damages.

Photograph 13. Groins constructed to protect shoreline at Sheridan Park, Cudahy, Wisconsin. Sand beach accreting on the northern side of the groins due to southward littoral drift.

4.3.2 Erosion and Flooding History

The entire shorelands from the Sheboygan-Ozaukee County line to the Wisconsin-Illinois State line are subject to erosion, except where protected. Flooding is not a problem. Extensive erosion damage occurred all along this reach during the record 1951-52 high-water period. Banks and bluffs were eroded an average of 10 feet on the shoreline between the north Ozaukee County line and Port Washington Harbor; from 5 to 20 feet between Port Washington and Milwaukee Harbors; and an average of 15 feet between Milwaukee and Racine Harbors. Damage between Racine Harbor and the Wisconsin-Illinois State line was concentrated in the vicinity of the city of Kenosha and the Chiwaukee subdivision just north of the State line. The shoreline eroded up to 75 feet in these areas. The damages recorded during that one year high-water period and updated to 1970 price levels are summarized in Table 16.

Generally, the shoreline between the north Ozaukee County line and the city of Port Washington is subject to erosion and recession only during periods of high lake levels. This reach of shore is 11.5 miles long. During the period 1833-1957, the northernmost seven miles eroded an average of 0.1 foot or less per year. The remaining 4.5 miles eroded an average of 1.25 feet per year during the same period. In the 1951-52 record high-water period, property damages along this shore totaled an estimated $125,000.

Between Port Washington and Milwaukee Harbors, 28 miles in distance, the high bluffs are subject to rapid erosion, except where they are protected by structures or wide beaches. Erosion damage along the five-mile reach immediately south of Port Washington is generally limited to loss of bluff material. The shoreline in this reach is for the most part undeveloped. South of this point to the vicinity of the north city limits of Milwaukee, the shorelands are heavily developed with high-value residences. Many of these residences have lost substantial bluff frontage and will be in danger of serious damage in the near future if erosion of the bluff continues. Private interests have made numerous attempts to delay erosion by putting up protective structures, particularly in Milwaukee County. However, many of these structures have been destroyed. The destructive forces have been direct wave actions, earth and hydraulic pressures from the bluffs, ground water seepages, frost action, and undermining by waves and currents. During the period from 1833 to 1957 inclusive, bluff recession between Port Washington and the Ozaukee-Milwaukee County line was up to 3.4 feet per year. House Document No. 526, 79th Congress, 2d Session, states that during the period from 1836 to 1941 inclusive, the average yearly rate of erosion between the Ozaukee-Milwaukee County line and Green Tree Road was 1.2 feet. The document further states that the rate of erosion from Green Tree Road south to the filtration plant just north of Milwaukee Harbor was 2.8 feet per year during the same period. These rates of erosion are considered to be representative of recent conditions. In the 1951-52 record high-water period, erosion damage to shore property between Port Washington and Milwaukee Harbors was estimated at $563,000.

Table 16

Total Damage to Shore Property on Lake Michigan — Ozaukee, Milwaukee, Racine, and Kenosha Counties, Wisconsin

	Damages, $	
Land Use	*Actual 1951-52 Value*	*Updated 1970 Value*
Private		
Residential	1,602,800	3,093,400
Industrial and commercial	92,800	179,100
Agricultural	85,100	89,400
Utilities	10,000	19,300
Total, private property	1,790,700	3,381,200
Public		
Parks and beaches	596,100	1,377,100
Utilities	152,200	351,200
Federal reservations	195,500	377,800
Total, public property	943,800	2,105,600
Total erosion damages	2,734,500	5,486,800

The shoreline between Milwaukee and Racine Harbors is 23 miles long. South of Milwaukee Harbor to the mouth of Oak Creek, the shoreline bluffs are usually subject to erosion only when periods of high-water are accompanied by wave action. South of Oak Creek to Wind Point in Racine County, the shorelands are subject to continuing erosion. Few shore protections have been put up along this reach of shore. Between Wind Point and the north city limits of Racine, the shore has been subject to recession of about 0.8 foot per year. There are many old groins along this frontage that need to be maintained in order to prevent continued serious erosion. The top elevation of many of the groins range from 2.5 to 5 feet. Due to their relatively low top elevation, severe erosion is a danger to the bluffs fronted by these groins, especially during high lake levels. Storm waves produced during period of high lake levels overtop the groins and neighboring beaches with enough energy to cause erosion. Minor erosion occurs between the north city limits of Racine and Racine Harbor at periods other than high lake levels. During the one year high-water period of 1951-52, erosion damage between Milwaukee and Racine Harbors totaled an estimated $206,000.

The shoreline of the city of Racine south of Racine Harbor is generally protected. Approximately 1.25 miles of shoreline south of the City of Racine have an average erosion rate of about one and one quarter feet per year. The remaining shoreline in Racine County is partially protected by a series of groins that are in poor condition. However, bank erosion continues, particularly during periods of high-lake stages. The shoreline between the Racine-Kenosha County line and the city of Kenosha is subject to rapid erosion that averages two feet per year. The shoreline from the south city limit of Kenosha to the Wisconsin-Illinois State line has rapid erosion, except where protected. The rate of recession along this 4.5-mile reach of shore ranges from four to over six feet per year. Shore property damage between Racine Harbor and the State line totaled $811,000 during the 1951-52 high-water period.

Based on present shore property development and rates of bluff recession, several critical erosion areas have been determined. They include the 18-mile reach of shoreline extending from 6 miles south of Port Washington Harbor to the filtration plant situated 2 miles north of the Milwaukee Harbor north breakwater; the 10-mile reach between the mouth of Oak Creek and Wind Point; the 5.5-mile reach between the south city limits of Racine and the north city limits of Kenosha; and the 4.5-mile reach from the south city limits of Kenosha to the Wisconsin-Illinois State line.

4.3.3 Solutions to Erosion Damages

A beach erosion study of the Milwaukee County Shoreline was completed in 1942, by the Corps of Engineers in cooperation with the Milwaukee County Park Commission. A report on the study was published in House Document No. 526, 79th Congress, 2d Session. The report suggests construction of a system of groins and artificially nourished beaches for the section of shore between the filtration plant just north of the Milwaukee Harbor and the Ozaukee-Milwaukee County line. Artificial beach nourishment would be needed, as the littoral drift along this reach of shore lacks natural beach-building material. It also points out the need for drainage of upland bluffs to prevent slumping. The report further states that short riprap revetments, small groin systems, or short seawalls are not desirable. The strictly local protection given by these structures and the disturbing effects they might have on nearby properties make them undesirable, except as a temporary measure. However, long, unbroken reaches of riprap revetment would be an acceptable alternative to the groin system and beaches. House Document 526/29/2 further suggests that the shore between the mouth of Oak Creek and the Milwaukee-Racine County line be protected by riprap revetments at the base of the bluffs. This same protection is suggested for the shore between Oak Creek and Milwaukee Harbor, where it is needed. The cost of constructing a groin system with artificial beaches is estimated at $800,000 per mile of shore protected. The cost of constructing riprap revetments is estimated at about $500,000 per mile.

The Corps of Engineers is making a review survey study of the erosion problems along the Milwaukee County shoreline. A preliminary study has indicated that construction of a combination of riprap revetments, a 75,000 square-foot recreational beach, and a recreational boat harbor along the shoreline of Bender Park appears to be justified and deserves further study. The preliminary study also indicates that there is no economic justification for riprap revetment protection of portions of Sheridan, Warnimont, and Grant Parks. However, other alternatives will be studied before a report is made on the preliminary study.

In 1951, the Corps of Engineers completed a shore erosion control study for the Racine County shoreline. A report on this study was published as House Document No. 88, 83d Congress 1st Session. That report concluded that erosion between the Milwaukee-Racine County line and Wind Point be controlled by the construction of groins and artificially nourished beaches. The report states that the littoral drift along this reach of shore is sufficient to maintain the beaches once they are constructed. However, more than one-half of the littoral material is from the bluffs along the south Milwaukee County shore. Therefore, if these bluffs are protected, beaches south of the County line will have to be artificially maintained. The document further points out that shore property south of the city of Racine to the south Racine County line can best be protected by riprap revetments. The cost of constructing a groin system with artificial beach fills is estimated at $800,000 per mile of shore protected. The estimated cost of constructing riprap revetments along this reach of shore is $500,000 per mile.

In 1955, the Corps of Engineers completed a study of the erosion problems along the shore of the city of Kenosha. The report on this study is published as House Document No. 273, 85th Congress, 2d Session. It identified the following plan for preventing erosion and stabilizing the shores of the city of Kenosha:

Alford Park - Maintenance of existing groin system.

Pennover Park - Stone revetment for 650-foot reach of shore.

Lake View Park - Reconstruct and extend southerly the rubble mound to protect 425 feet of shore. An alternative plan of steel sheet pile wall may be used for the southerly 125 feet of this reach.

Simmons Manufacturing Co. and Lake Front Park - Reconstruct 2,570 feet of breakwater.

Eichelman Park - Raise 250 feet of low concrete seawall and riprap entire length of 748 feet of seawall; reconstruct 670 feet of off-shore breakwater.

Eichelman Park to 75th st. - Maintain and reconstruct stone revetment.

Southport Park - Stone revetment for 2,090 feet of shore. An alternative plan provides for reconstruction of groin system and a protective beach of artificial fill for northerly 1,700 feet of problem area and revetment of stone for south 390 feet.

This report does not contain any suggestions for protection of shore property in Kenosha County outside the limits of the city of Kenosha. However, protection of these shores can best be accomplished by construction of a system of groins and beaches or extensive continuous riprap revetments. Costs of such improvements would correspond to those given above for similar improvements in Racine County.

Enforcement of the Wisconsin Shoreland Protection Ordinance, in accordance with the Wisconsin Water Resources Act of 1965, will help to reduce erosion damage to new structures along the Ozaukee, Racine, and Kenosha shorelines. The entire shoreline of Milwaukee County is in incorporated municipalities. The Act does not require shoreland zoning of such areas. Since the Racine and Kenosha County shorelines are already heavily developed, zoning will have limited effect on reducing erosion damages. A substantial portion of the Ozaukee County shoreline is still undeveloped, however, so shoreland zoning can help to reduce erosion damages in that county if properly enforced. Ozaukee and Kenosha Counties have adopted zoning ordinances. The Ozaukee ordinances follows very closely the standards suggested by the State of Wisconsin. The Kenosha County ordinance is more restricted.

SECTION 5
STATE OF ILLINOIS

The Great Lakes Mainland Shoreline of Illinois is located in the Lake Michigan Southwest Planning Subarea 2.2 (Figure 19). This six-county area has a population of 6.89 million (1970), about 62 percent of the total population of the State of Illinois. Cities and villages situated along the shoreline include Winthrop Harbor, Zion, Waukegan, North Chicago, Lake Bluff, Lake Forest, Highland Park, Glencoe, Winnetka, Kenilworth, Wilmette, Evanston, and Chicago.

A detailed description of the shoreline values, use, ownership, and problem areas, is contained in the following subsections. Of the 65.0 miles of shoreline, 38.8 miles have a beach zone and 26.2 miles of shoreline are without a beach zone. The present shoreline uses in Illinois are as follows: 30.9 miles recreational, 15.0 miles residential, 10.5 miles industrial and commercial, 8.0 miles public buildings and related land, and 0.6 miles agricultural and undeveloped. The shoreline reach contains 30.9 miles of public parks. There are four commercial harbors and ten recreational boat harbors. The recreational boat harbors provide berthing for about 3,700 recreational craft. Shoreline ownership is divided 3.1 miles Federal, 35.8 miles non-Federal public, and 26.1 miles private.

Of the 65.0 miles of Lake Michigan shoreline in Illinois, it is estimated that 10.5 miles are being critically eroded, and 54.5 miles are protected. The critical erosion problem areas exist at three locations - mile 609 to mile 615, mile 623.5 to mile 625, and mile 625 to mile 628. Suitable methods of protecting these reaches are described in this section. The first cost of protection is estimated at about $7.6 million.

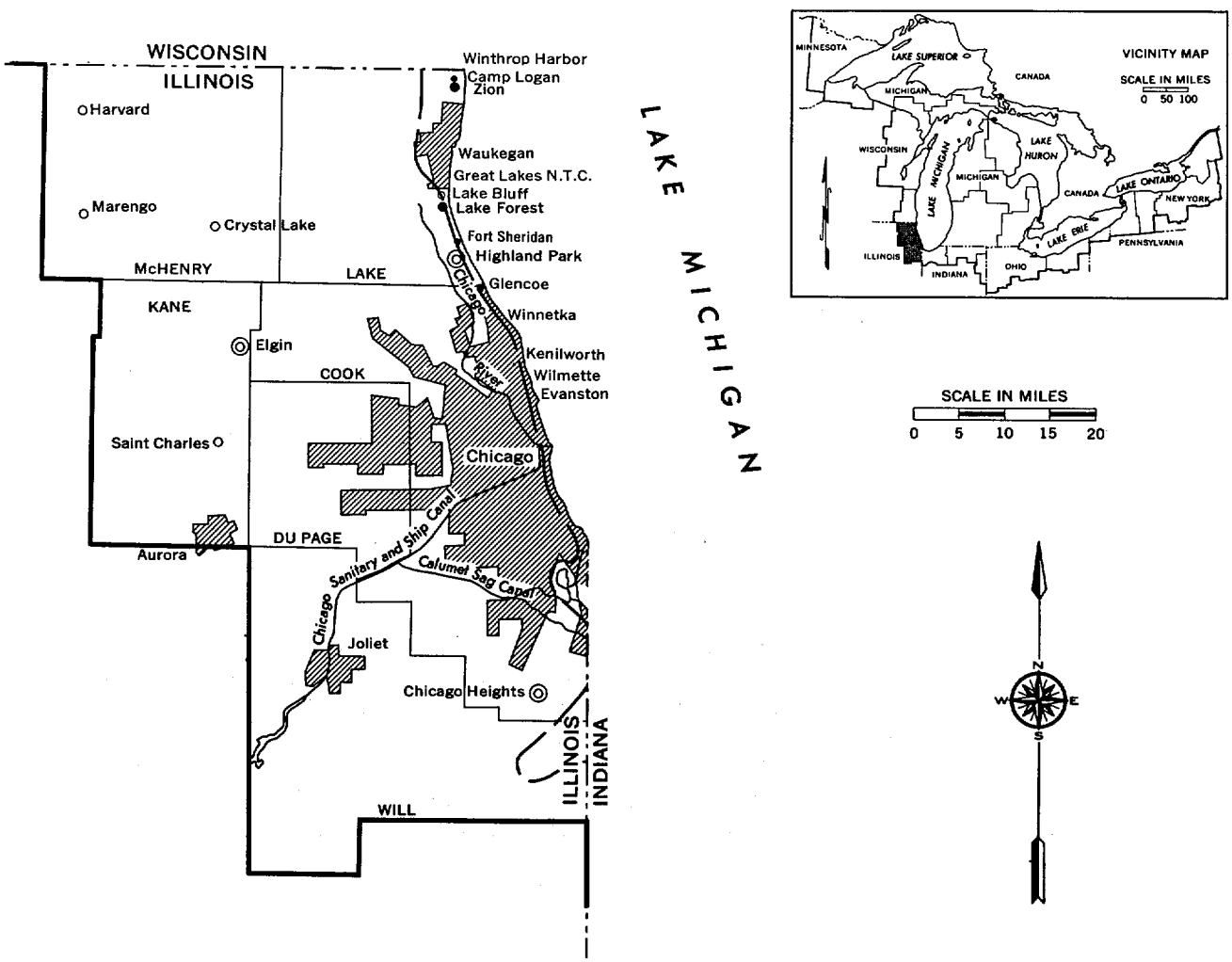


Figure 19. Lake Michigan Southwest Planning Subarea 2.2, Illinois.

5.1 Shoreline Description

The Illinois portion of the Lake Michigan Shoreline extends from the Wisconsin-Illinois State line mile 628.0 to the Illinois-Indiana State line mile 563.0, a shoreline distance of 65 miles. The shoreline from the Wisconsin-Illinois State line to Waukegan, a distance of 10 miles, consists of generally unprotected, gently sloping, sandy beach. The beaches vary from 50 to 350 feet in width and are backed by low, sand gravel plains. The shore from Waukegan to Glencoe, a distance of 14.6 miles, has high bluffs composed of glacial till and outwash deposits. The beach width ranges up to 150 feet. The berm height varies from three to eight feet above the lake levels. The glacial till material is a compact stony to pebbly clay. Prolonged exposure to the atmosphere deteriorates it, and so it is easily erodible. From Glencoe to the Illinois-Indiana State line, 40.4 miles of the shoreline consists mostly of protected areas. These include artificial fills, wide beaches, and navigation structures. The artificial fill areas have been protected and stabilized in a large measure by riprap, groins, and bulkheads.

Present shoreline values, use, ownership, and erosion problem areas are summarized in Table 17 and shown on Figure 20. The entire shoreline is urban in character. The present distribution of shoreline use and ownership is shown in Figure 21.

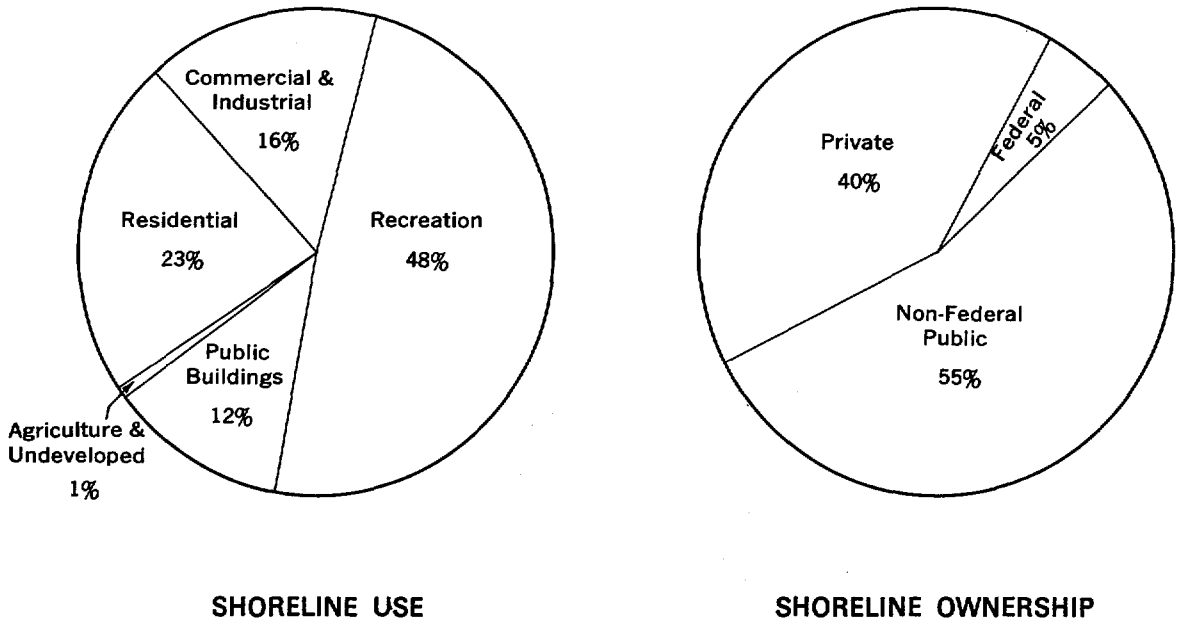


Figure 21. Distribution of Shoreline Use and Ownership in Illinois.

Heavy industrial facilities are situated near the Federally improved deep-draft navigation facilities at Calumet Harbor and River and Waukegan Harbor. The Calumet River industrial area is one of the nation's largest coordinated transfer facilities among various kinds of transportation. It is the junction of barges using the Mississippi River and the Illinois Waterway system and the deep-draft vessels using the Great Lakes and the St. Lawrence Seaway system. The Calumet area and the South Chicago industrial area are dominated by heavy industry-steel manufacturing, chemical plants, building supplies, and grain handling facilities. The Chicago Harbor is also dominated by commercial interests. A coal-fired electric power plant is located at Waukegan, and a nuclear electric power plant is under construction at Zion.

SHORELAND USES.

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

*M—Military Harbor

Figure 20. SHORELANDS OF THE GREAT LAKES, LAKE, COOK COUNTIES.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors (C)
- Recreational Harbors (R)
- Commercial Deep Draft and Recreational Harbors (C R)
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)

Table 17

Shoreline of the Great Lakes — Cook and Lake Counties, Illinois

Shoreland Use Category	*Existing Shoreland Use*			*Miles of Shoreline*			*Problem Identification, Miles of Shoreline*				
	Miles of Shoreline	*Percent of Total*	*Number of Sites*	*Public*			*Subject to Erosion*		*Protected*	*Subject to Flooding*	*Not Subject to Erosion or Flooding*
				Federal	*Non-Federal*	*Private*	*Critical*	*Noncritical*			
Economic Uses											
Residential	15.0	23.1		0	0	15.0	4.1	0	10.9	0	0
Industrial and commercial	10.5	16.2		0	0	10.5	0	0	10.5	0	0
Agricultural and undeveloped	0.6	0.9		0	0	0.6	0.6	0	0	0	0
Commercial harbors			4								
Electric power sites			2								
Public buildings and related lands	8.0	12.3		3.1	4.9	0	0	0	8.0	0	0
Recreational Uses											
Parks	30.9	47.5		0	30.9	0	5.8	0	25.1	0	0
Recreational boat harbors			10								
Beach zone	(38.8)	(59.7)		(3.1)	(14.8)	(20.9)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	0	0		0	0	0	0	0	0	0	0
Total	65.0	100.0		3.1	35.8	26.1	10.5	0	54.5	0	0

Residential development along the shore consists of several hotels, exclusive high rise apartments, and some of the finest residential areas in the suburbs north of Chicago.

Military installations located on the shoreline include Camp Logan (Illinois National Guard), the Great Lakes Naval Training Center, and Fort Sheridan. Other public buildings and related lands include water filtration plants, museums, and a small airport. The campuses of Northwestern University, Loyola University, and Mundelein College also are located on the shoreline.

There are 30.9 miles of parks on the shoreline. The Chicago Park District owns six miles of shoreline property. The Illinois Beach State Park includes 3.5 miles of shoreline property. Other community parks and beaches are located all along the shoreline. There are 10 recreational boat harbors with a total mooring capacity of 3,700 boats.

The aesthetic attractiveness of the shoreline landscape is an important consideration in resource planning. Most of the Illinois shoreline resources covering the cities of Evanston and Chicago can be classified as extrinsic resources, created by man-made changes, and adoptions of and additions to the natural resources. The National Estuarine Study, by the Department of the Interior, identified the beaches and offshore lakewaters as outstanding recreational resources for swimming and boating. Concentrated use of piers and breakwaters for fishing is a matter of record. The only intrinsic, or natural, resources of the shoreline zone identified in the National Estuarine Study is the Dead River area. This unique ecological area is a nature preserve within the boundaries of the Illinois Beach State Park.

In 1952, there were 62.9 miles of Illinois shoreline on Lake Michigan, with 33 miles in public ownerships and 29.9 miles privately owned. In 1970, there are 65.0 miles of shoreline, with 38.9 miles in public ownership and 26.1 miles in private ownership. The increases in shoreline mileage resulted from the construction of several lake fills. These are the Northwestern University fill and the fill for the new City of Chicago water filtration plant.

The basic problem in Illinois is that natural shoreline resources are not sufficient to meet the demands of the projected urban growth. For this reason, great pressure is now being exerted to increase the shoreline resources by additional artificial land fills and offshore protective structures.

Photograph 14. An example of the use of loose rock riprap shoreline protection, 650 feet long, on Evanston, Illinois, park shoreline.

5.2 Erosion and Flooding History

Except for isolated areas, the shoreline is generally protected by structures. Table 18 tabulates the damage recorded in Cook and Lake Counties, Illinois, for a one-year period from the spring of 1951 to the spring of 1952. Total reported erosion damages exceeded $8.7 million in that year ($17.7 million, 1970 value). Damages due to erosion and wave action included destruction of bulkheads and seawalls, the undermining of roads and other paved areas, and damage to power line poles and railroad facilities, park facilities and industrial plants. In addition, many residences were severely damaged or destroyed.

Table 18

Total Damage to Shore Property on Lake Michigan – Lake and Cook Counties, Illinois

	Damages, $	
Land Use	*Actual 1951-52 Value*	*Updated 1970 Value*
Private		
Residential	6,512,600	12,569,300
Industrial and commercial	105,400	203,400
Total, private property	6,618,000	12,772,700
Public		
Parks and beaches	1,576,200	3,641,000
Harbor installations	160,000	369,600
Public utilities	404,400	934,200
Total, public property	2,140,600	4,944,800
Total erosion damages	8,758,600	17,717,500

5.3 Solutions to Erosion Damages

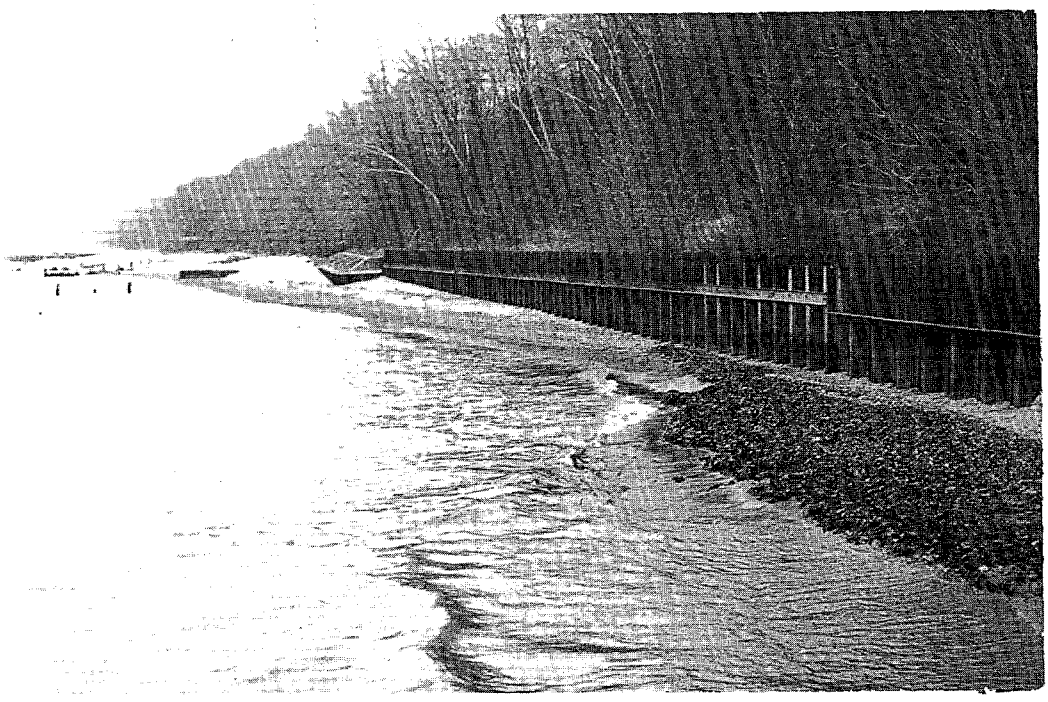
A cooperative beach erosion study of the entire Illinois shoreline was completed in 1949, by the Corps of Engineers at the request of the State of Illinois. A report on the study is published as House Document Number 28, 83d Congress, 1st Session. The report recommends methods of protection for various reaches of shore as follows:

Illinois-Wisconsin State line to Waukegan Harbor - Construction of groins is the best method of providing beaches for protecting the public shore and for recreation. Protection of small tracts of shore property can be best accomplished by armoring the shore. Groins should be low, with sloping outer ends, impermeable, and should extend lakeward approximately to the 6-foot depth contour. Spacing between groins should not exceed about two to three times the length of the structures, depending on the conformation of the shore. Not more than three groins per mile should be constructed per year to avoid starvation of down-drift areas.

Waukegan Harbor to Wilmette Harbor - Protection of shore property can be accomplished by placing riprap at the base of the bluffs or through construction of beach and groin systems. In the northern portion of this reach the littoral drift is very lean. Construction of groins and beaches in this reach will require artificially placed sand. Farther to the south, as the drift becomes richer, construction of groins would provide larger beaches by impounding natural drift. Groins should be low, impermeable, with sloping outer ends, and should extend approximately to the 6-foot depth contour. Spacing should vary from 1½ to 3 times

the groin length, depending on the conformation of the shore and the richness of the shore drift. The maximum number of groins per mile to be constructed each year should vary from one in the northern part of the section to three in the southern part of the section. As protective measures are intensified it can be expected that the denial of source material to the littoral drift will be reflected in expansion of the eroding areas.

Wilmette Harbor to the Illinois-Indiana State line - The placing of dumped riprap and the construction of bulkheads are the best methods of protection along this reach of shore.



Photograph 15. Steel pile bulkhead, constructed at Glencoe, Illinois. Erosion of beach up to face of bulkhead can be attributed to groin located a few feet north of the area in this photograph. A beach is located on north side of groin. This beach is four feet higher and extends 80 feet lakeward of the beach along this bulkhead.

SECTION 6
STATE OF INDIANA

The Great Lakes Mainland Shoreline of Indiana located within the Lake Michigan Southwest Planning subarea 2.2, is 45.0 miles long. The Indiana portion of this planning subarea (Figure 22) includes four counties with a population of 752,000 (1970). This is about 14.6 percent of the total population of the State of Indiana.

Cities and communities located along the shoreline include Hammond, Whiting, East Chicago, Gary, Ogden Dunes, Dune Acres, Beverly Shores, Michigan City, Long Beach, and Michiana Shores. West of Gary, heavy industry dominates the shoreline. East of Gary, the shoreline is used for recreational and residential purposes.

A detailed description of the shoreline is contained in the following subsection. Of the 45.0 miles of shoreline, about 20.4 miles have a beach zone and 24.6 miles are without a beach zone. The present shoreline uses in Indiana are 5.5 miles residential, 21.8 miles industrial and commercial, 0.6 miles public buildings and related lands, 17.0 miles recreational, and 0.1 miles agricultural and undeveloped.

Two boat harbors provide berthing facilities for recreational craft. They are Michigan City Harbor (520 craft) and Jeorse Park (40 craft). Mooring for about 200 small boats is also available in the Burns Waterway. Launching facilities are available at Gary, Indiana. Commercial deep-draft harbor facilities are located at Indiana Harbor, Buffington Harbor, Gary Harbor, Michigan City Harbor, and the Burns Waterway. Four electric power generation stations are located on this reach of the shoreline. Shoreline ownership is divided 9.3 miles Federal, 8.7 miles non-Federal public, and 27 miles private.

Of the 45 miles of shoreline in Indiana, it is estimated that 13 miles sustain critical erosion processes, 9.6 miles are subject to non-critical erosion, and 22.4 miles are non-eroding (stable, accreting, or protected). Critical shoreline erosion problems exist at two locations - mile 525 to mile 535 and mile 540 to mile 543. The first cost of protecting these reaches of shoreline is estimated at about $10.4 million.

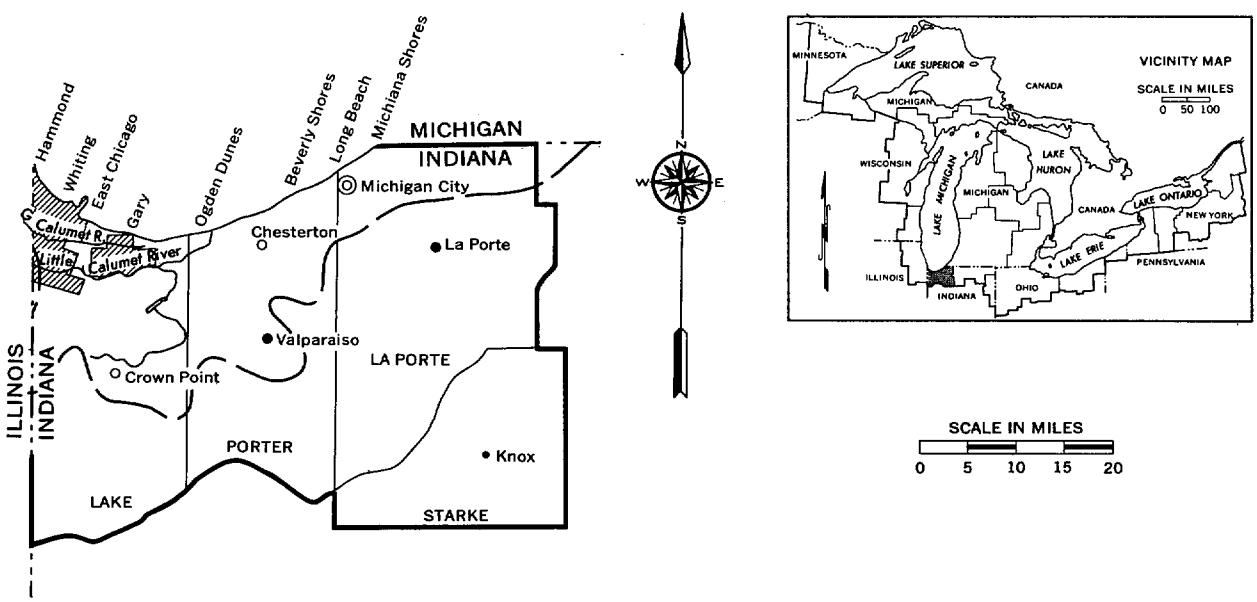


Figure 22. Lake Michigan Southwest Planning Subarea 2.2, Indiana.

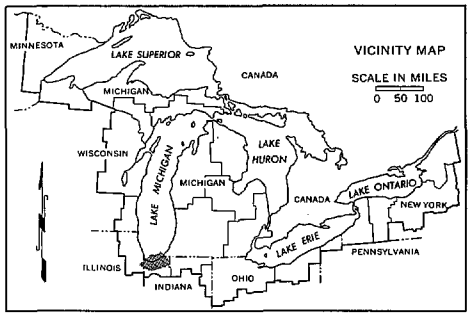
6.1 Shoreline Description

The Indiana shoreline between the Illinois-Indiana State line and the west limit of Marquette Park in Gary generally consists of well protected artificial industrial lake fills. This reach of shore covers a distance of 20.2 miles. From the west limit of Marquette Park to the mouth of Burns Waterway, a distance of 5.3 miles, the shoreline consists of low sand plains fronted by wide sand beaches. East of the Burns Waterway, an industrial

Table 19

Shoreline of the Great Lakes — Lake, Porter, and LaPorte Counties, Indiana

Shoreland Use Category	*Existing Shoreland Use*			*Miles of Shoreline*			*Problem Identification, Miles of Shoreline*				
	Miles of Shoreline	*Percent of Total*	*Number of Sites*	*Public*		*Private*	*Subject to Erosion*		*Protected*	*Subject to Flooding*	*Not Subject to Erosion or Flooding*
				Federal	*Non-Federal*		*Critical*	*Noncritical*			
Economic Uses											
Residential	5.5	12.2		0	0	5.5	3.0	2.5	0	0	0
Industrial and commercial	21.8	48.5		0	0.4	21.4	0	0	21.8	0	0
Agricultural and undeveloped	0.1	0.2		0	0	0.1	0.1	0	0	0	0
Commercial harbors			5								
Electric power sites			4								
Public buildings and related lands	0.6	1.3		0	0.6	0	0	0	0.6	0	0
Recreational Uses											
Parks	17.0	37.8		9.3	7.7	0	9.9	7.1	0	0	0
Recreational boat harbors			3								
Beach zone	(20.4)	(45.3)		(9.3)	(5.6)	(5.5)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	0	0		0	0	0	0	0	0	0	0
Total	45.0	100.0		9.3	8.7	27.0	13.0	9.6	22.4	0	0



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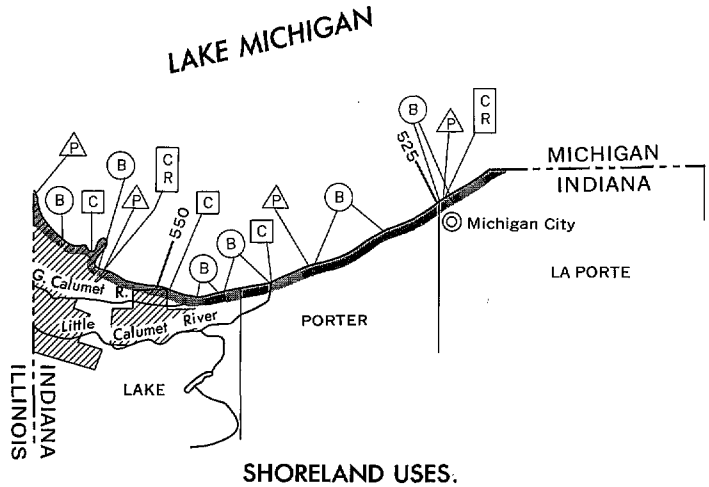
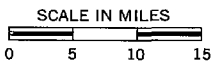
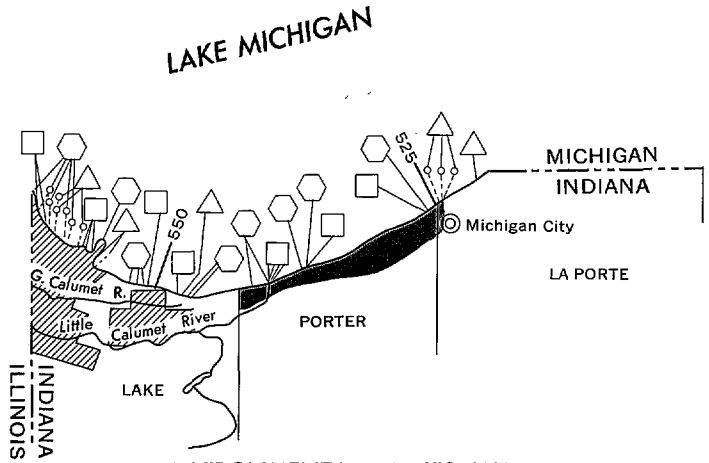
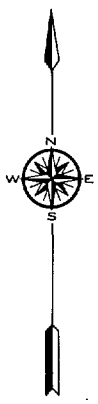


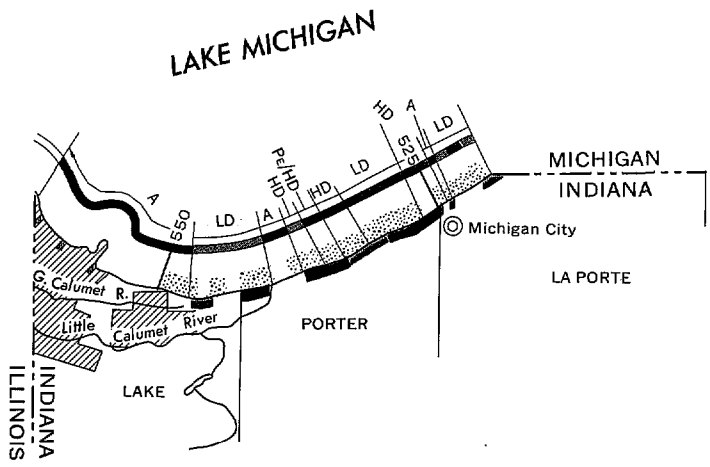
SHORELAND USES.





ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.





PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

Figure 23. SHORELANDS OF THE GREAT LAKES, LAKE, PORTER, LA PORTE, COUNTIES.

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings

Recreational and Urban Open Space

Agricultural and Undeveloped

Forest

Public Beaches (B)

Commercial Deep Draft Harbors [C]

Recreational Harbors [R]

Commercial Deep Draft and Recreational Harbors [C R]

Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values

Unique Ecological or Natural Areas

Outstanding Shoreland Areas of Possible National Interest

Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands

Non-Federal Public Lands

Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)

complex extends along the shore for a distance of 2.6 miles. This entire reach is well protected against wave erosion. East of this industrial area to a point one mile west of Michigan City Harbor the shore is lined with sand dunes fronted by sandy beaches. An industrial land fill which is protected by riprap is located along the one mile reach just west of Michigan City Harbor. From the harbor east to the Indiana-Michigan State line, a distance of 4.6 miles, the shore generally consists of high sand dunes fronted by sand beaches. Numerous residences along this reach of shore have been protected by massive bulkhead structures. Data describing shoreline values, use, ownership and problem areas are given in Table 19 and shown on Figure 23.

The present distribution of shoreline use and ownership is given in Figure 24. A comparison of present use to the shoreline use in 1952 shows industrial and commercial shoreline use has increased from 20.5 miles to 21.8 miles. The residential shoreline has decreased from 17.7 miles to 5.5 miles, public buildings and related lands have increased from 0.2 mile to 0.6 mile, and parks have increased from 6.4 miles to 17 miles. The authorized Indiana Dunes National Lakeshore includes the shoreline between Michigan City and Gary, with the exception of the 3.5-mile reach of the Burns Waterway Harbor industrial complex.

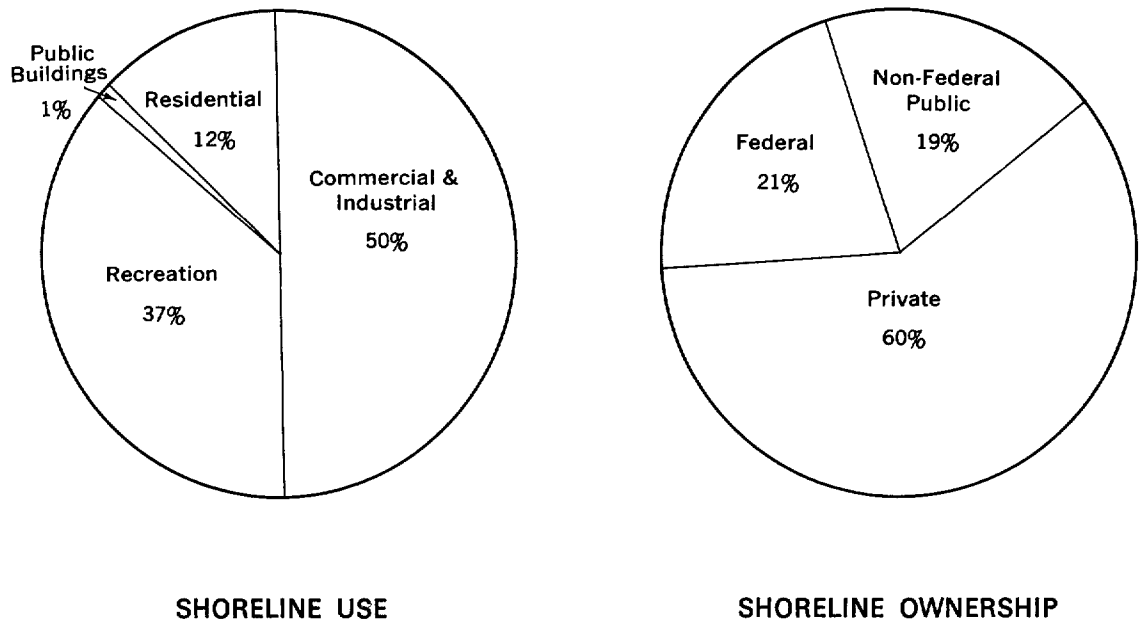
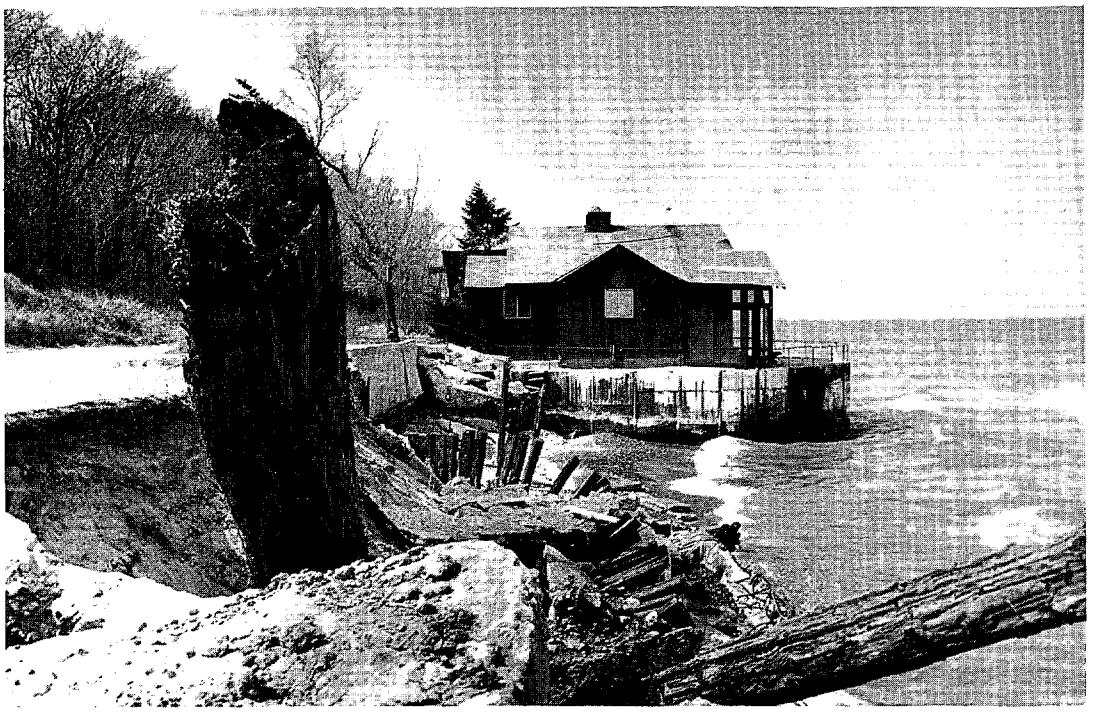


Figure 24. Distribution of Shoreline Use and Ownership in Indiana.

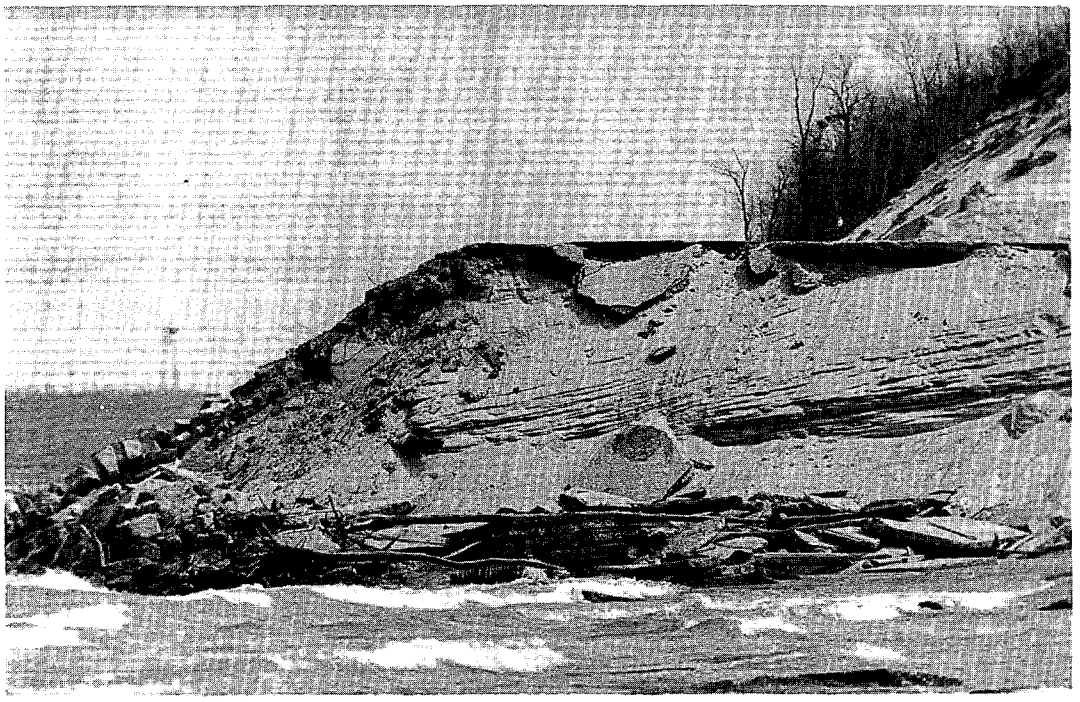
6.2 Erosion and Flooding History

Where no protective works have been constructed, the Indiana Shoreline is highly erodible by severe storms. Table 20 tabulates the damage along the Indiana shore for a one-year period, from spring 1951 to spring 1952. Total reported erosion damage exceeded $5 million in that year ($10 million, 1970 value). Damages due to erosion and wave action in 1951-52 included the destruction of seawalls, undermining of roads, paved parking lots, power line poles, and railroad facilities. In addition, many industrial plant operations were disrupted and many private residences and improvements were damaged; some were completely destroyed.



(Chicago Tribune)

Photograph 16. The waters of Lake Michigan relentlessly wear away the shoreline surrounding a home overlooking a beach at Beverly Shores in the Indiana Dunes.



(Chicago Tribune)

Photograph 17. The water eroded the roadway causing the pavement to break and slide into the lake at the Indiana Dunes.

Table 20

Total Damage to Shore Property on Lake Michigan — Lake, Porter, and LaPorte Counties, Indiana

	Damages, $	
Land Use	*Actual 1951-52 Value*	*Updated 1970 Value*
Private		
Residential	3,427,800	6,615,600
Industrial and commercial	786,800	1,518,500
Private utilities	123,200	237,800
Total, private property	4,337,800	8,371,900
Public		
Parks and beaches	639,300	1,476,800
Harbor installations	60,000	138,600
Public utilities	20,000	46,200
Total, public property	719,300	1,661,600
Total erosion damages	5,057,100	10,033,500

6.3 Solutions to Erosion Damages

Thirteen miles of critical erosion have been identified along the Indiana Shoreline.

Critical erosion of the dunes areas, especially of high dunes, is occurring. The National Park Service prefers artificial beaches, which would act as a protection against wave action. This solution involves restoring eroded beaches and the construction of groins and the continued maintenance of these beaches. Artificial beaches are a relatively low-cost method of holding long reaches of shoreline, where borrow material is available for the initial beach fill and occasional nourishment. Since this method of protection will provide needed beaches, there should be additional economic benefits from this recommended program of shoreline protection. The estimated first cost of providing a protective beach barrier with groins for 13 miles of shoreline is about $10.4 million.

SECTION 7
STATE OF MICHIGAN

The Great Lakes Mainland Shoreline of Michigan is located within seven planning subareas: the Lake Michigan Southeast Planning Subarea 2.3, the Lake Michigan Northeast Planning Subarea 2.4, the Lake Michigan Northwest Planning Subarea 2.1 (Menominee County), Lake Superior East Planning Subarea 1.2, Lake Huron North Planning Subarea 3.1, the Lake Huron Central Planning Subarea 3.2, and the Lake Erie Northwest Planning Subarea 4.1. The Michigan Mainland Shoreline is about 2,070.3 miles long. The entire State of Michigan is within the boundaries of the Great Lakes Region. The State has a population of 8.3 million (1970). Major urban centers situated on the shoreline are Holland, Muskegon, Bay City, and Port Huron. The City of Detroit is on Lake St. Clair and the Detroit River. The major drainage areas are the basins of the St. Joseph, Kalamazoo, Grand, Muskegon, Manistee, Manistique, Escanaba, Cheboygan, Thunder Bay, Au Sable, Rifle-Au Gres, Saginaw, Black, Clinton, Rouge, Huron, and Raisin rivers.

A detailed description of the shoreline is contained in seven following subsections. Of the 2,070.3 miles of mainland shoreline, 1,257.6 miles have a beach zone and 812.7 miles are without a beach zone. Shoreline uses in Michigan are as follows: 653.0 miles residential, 53.9 miles industrial and commercial, 13.6 miles public buildings and related land, 1,218.5 miles forest, agricultural and undeveloped, and 131.3 miles of public recreation. The shoreline of Michigan contains many public beaches. There are 30 commercial harbors. Mooring and berthing facilities are provided in Federal, State, and private harbors and marinas for 25,000 recreational craft. Shoreline ownership is divided 38.2 miles Federal, 226.5 miles non-Federal public, and 1,805.6 miles private.

Of the 2,070.3 miles of mainland shoreline in Michigan, it is estimated that 103.6 miles are being critically eroded, 684.2 miles are subject to non-critical erosion, or flooding and 1,282.5 miles are non-eroding (stable, accreting, or protected). Critical shoreline erosion problems exist at 22 locations. The estimated cost of protecting these reaches is about $51 million. The following tabulation identifies these reaches:

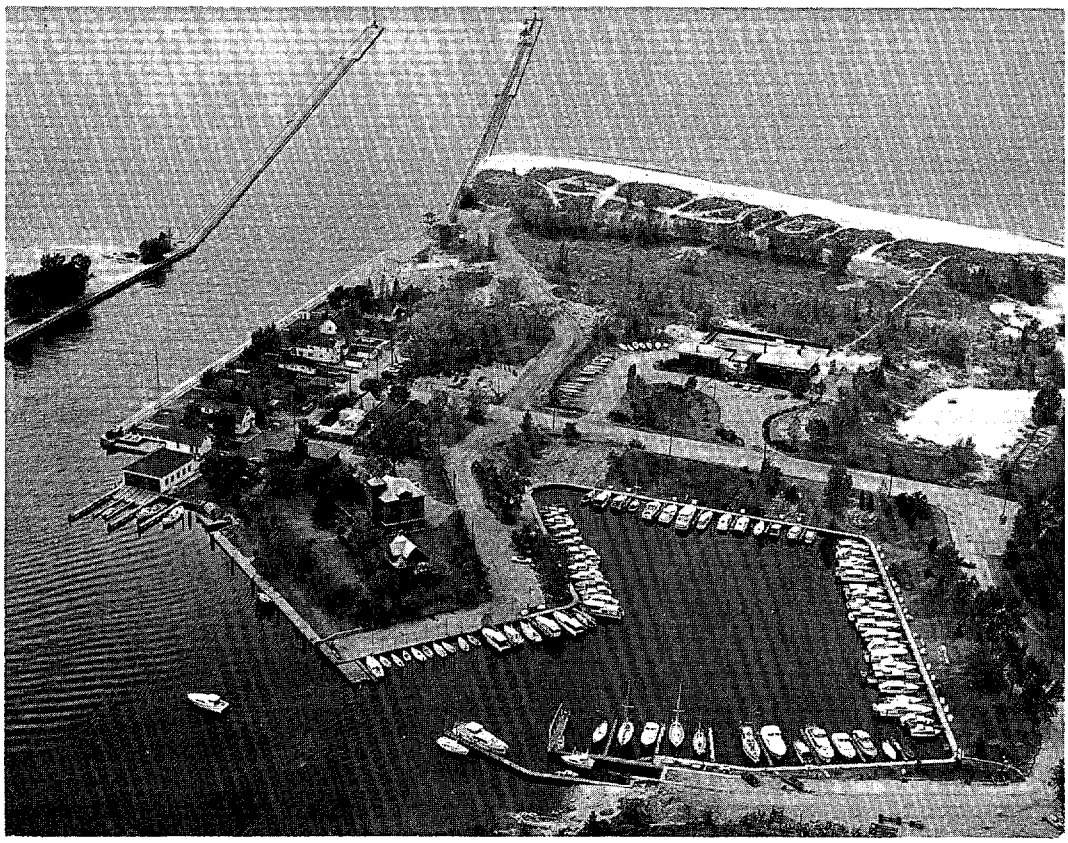
Lake	Mile	to Mile	Lake	Mile	to Mile
Michigan	488.5	493.5	Huron	255.2	263.0
	461.0	480.0		20.0	20.2
	450.5	455.5			
	435.0	437.7	Superior	53.3	63.0
	426.0	428.0		215.9	216.8
	414.2	415.0		252.3	252.8
	406.5	412.4		371.7	372.3
	390.0	401.0			
	368.2	370.5			
	360.2	361.0			
	337.5	341.5			
	323.5	329.2			
	315.3	319.6			
	286.0	290.2			
	266.0	270.0			
	254.8	258.3			

7.1 Lake Michigan Southeast, Planning Subarea 2.3

The Great Lakes Mainland Shoreline of Michigan in planning subarea 2.3 is 107.9 miles long, Figure 25. The major drainage areas are the river basins of the St. Joseph, the Kalamazoo, and the Grand. The 19-county area in Michigan has a population of about two million (1970). The shoreline counties are Ottawa, Allegan, Van Buren, and Berrien. Major communities along the shoreline are St. Joseph, Benton Harbor, South Haven, Holland, and Grand Haven. Figure 26 and Table 21 illustrate shoreline values, uses, ownership, and problem areas for this shoreline reach.

(Michigan Department of Natural Resources)

Photograph 18. The beaches at the Grand Haven State Park in Ottawa County are a most attractive recreational resource in the State of Michigan.



(Michigan Department of Natural Resources)

Photograph 19. The recreational boat harbor at St. Joseph, Michigan, provides berthing, launching, and access to the waters of Lake Michigan for recreational craft.

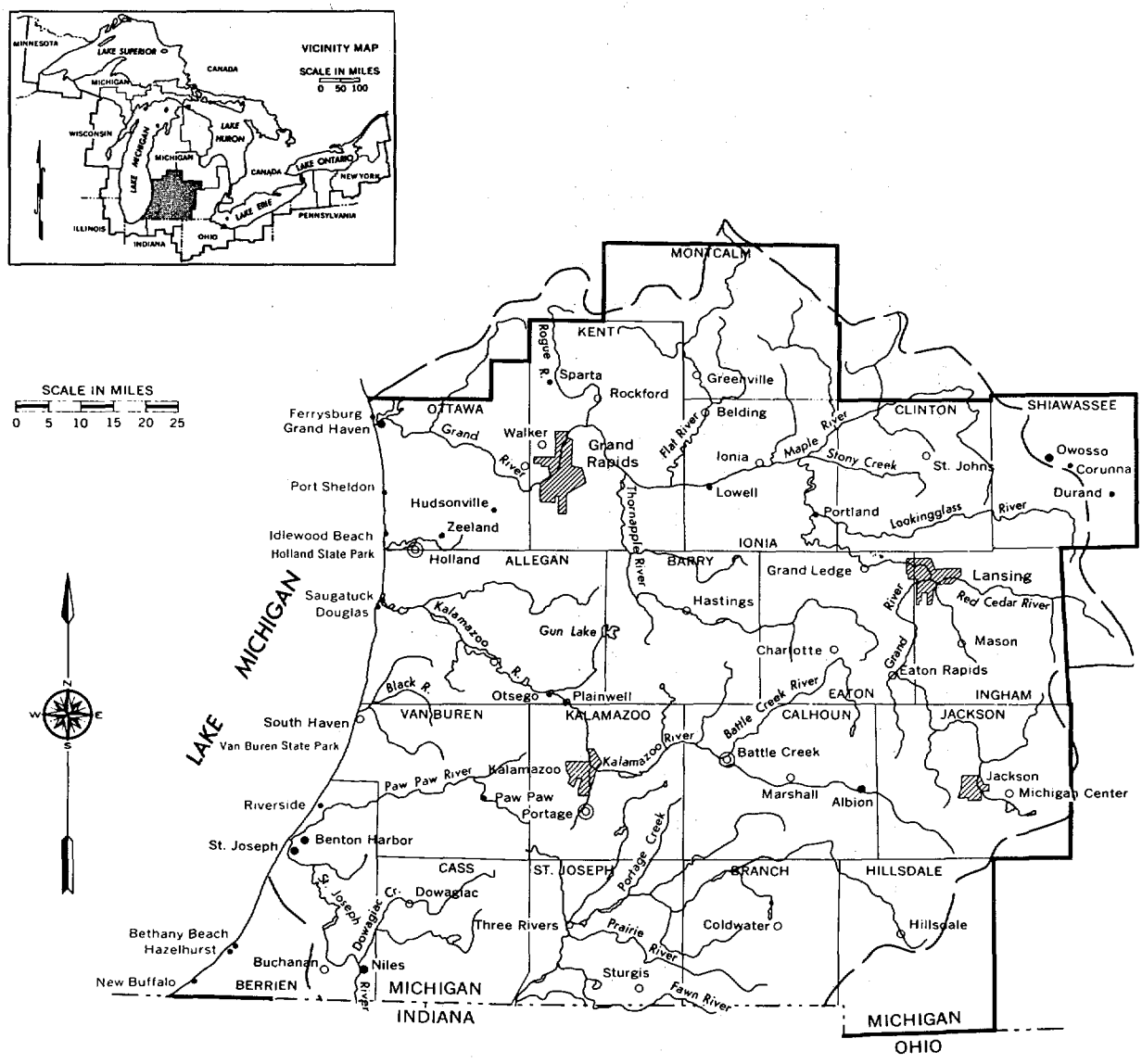


Figure 25. Lake Michigan Southeast Planning Subarea 2.3, Michigan.

7.1.1 Shoreline Description

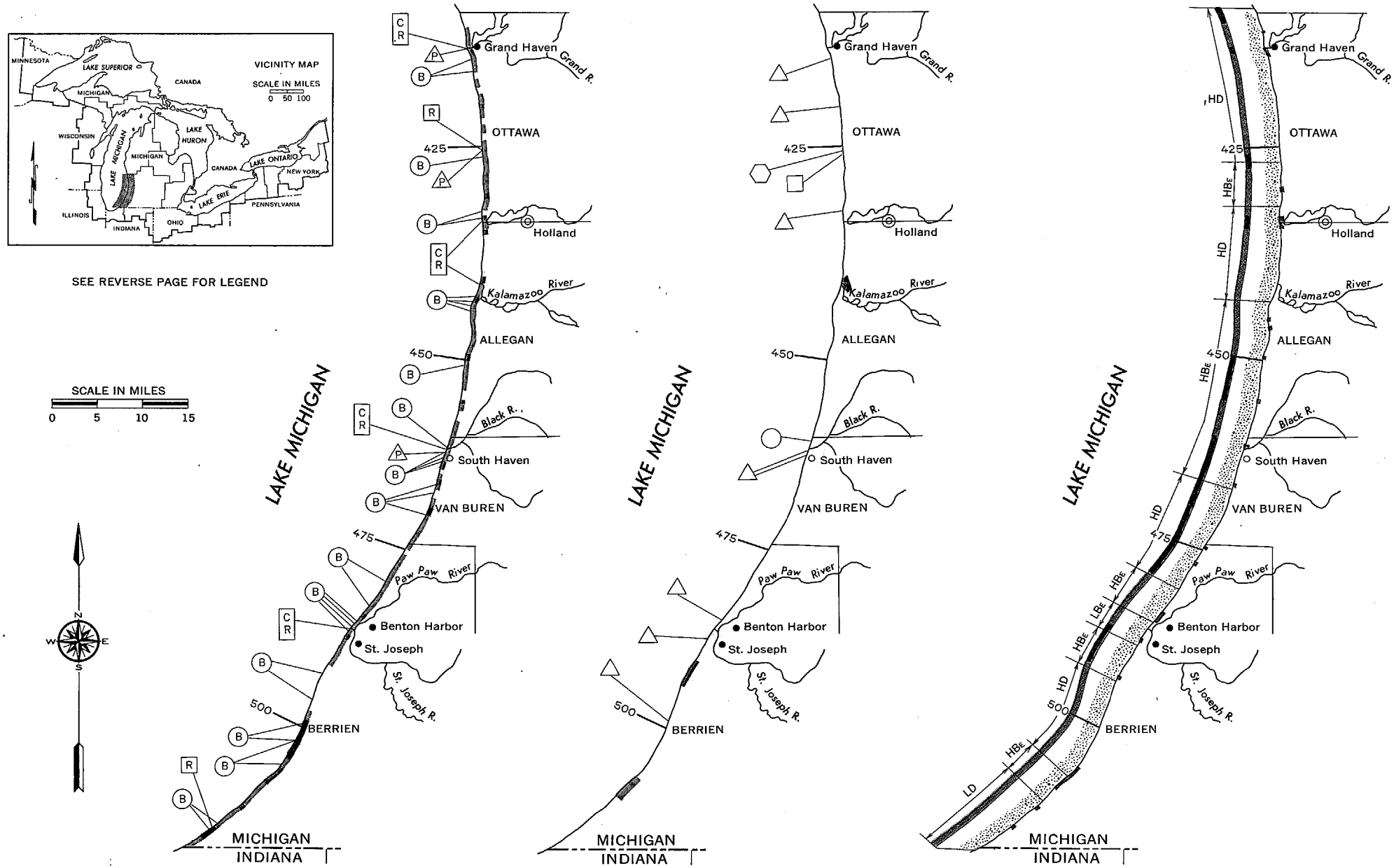
Generally, the Lake Michigan Shoreline in this reach consists of an almost continuous sand beach, bordered by occasional clay bluffs and sand dunes. In many places along the clay bluffs, especially during times of high lake levels, undercutting from wave and water action causes the bluff material to slump onto the beach. High dunes, up to 240 feet above lake level, form a series of sand hills parallel to the shoreline and up to a mile in width. On the landward sides of the dunes, deciduous (annual leaf shedding) trees help stabilize the dunes.

The shoreline from the Muskegon County line to a point just south of Port Sheldon in Ottawa County is 25.5 miles long, it consists of a gently sloping sand beach, 20 to 30 feet wide, backed by sand bluffs 30 feet high and high sand dunes up to 240 feet above lake level. From Port Sheldon south to Idlewood Beach,

Table 21

Shoreline of the Great Lakes — Berrien County to Ottawa County, Michigan

Shoreland Use Category	*Existing Shoreland Use*			*Miles of Shoreline*			*Problem Identification, Miles of Shoreline*				
	Miles of Shoreline	*Percent of Total*	*Number of Sites*	*Public*			*Subject to Erosion*			*Subject to Flooding*	*Not Subject to Erosion or Flooding*
				Federal	*Non-Federal*	*Private*	*Critical*	*Noncritical*	*Protected*		
Economic Uses											
Residential	75.8	70.3		0	0	75.8	28.6	46.1	1.1	0	0
Industrial and commercial	1.2	1.1		0	0	1.2	0.7	0.5	0	0	0
Agricultural and undeveloped	18.0	16.7		0	0.1	17.9	5.5	12.5	0	0	0
Commercial harbors			4								
Electric power sites			3								
Public buildings and related lands	0.1	0.1		0	0.1	0	0.1	0	0	0	0
Recreational Uses											
Parks	5.0	4.6		0	4.6	0.4	0.8	4.2	0	0	0
Recreational boat harbors			7								
Beach zone	(107.9)	(100.0)		(0)	(4.8)	(103.1)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	7.8	7.2		0	0	7.8	2.9	4.9	0	0	0
Total	107.9	100.0		0	4.8	103.1	38.6	68.2	1.1	0	0



SHORELAND USES.

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

Figure 26. SHORELANDS OF THE GREAT LAKES, BERRIEN, VAN BUREN, ALLEGAN, OTTAWA COUNTIES.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors [C]
- Recreational Harbors [R]
- Commercial Deep Draft and Recreational Harbors [C R]
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)

approximately six miles, high sand bluffs 40 to 60 feet above lake level predominate. This bluff is composed of slightly coarser sand than that of the high dunes to the north.

Continuing south 12 miles along the shoreline to Douglas in Allegan County, the shoreline consists of a gently sloping sand beach up to 60 feet wide, backed by sand bluffs and many high dunes of the same physical description as the first reach of shoreline described. From Douglas to a point six miles south of South Haven in Van Buren County, a distance of approximately 24 miles, the shore consists of erodible bluffs approximately 50 feet high, with an overlying glacial clay till. The beach width varies from 10 to 100 feet and is composed of fine sand, gravel, and scattered cobbles. When water levels are high, the bluffs are undercut and saturated, causing clay to slump onto the beach. From this point south to Riverside in Berrien County, the gently sloping beach is 30 to 80 feet wide and is backed by high sand dunes.

Continuing southward along the Berrien County shoreline, from Riverside to a point 5½ miles south of St. Joseph, there are high and low bluffs, with the only major interruption at the mouth of the St. Joseph River. These bluffs are composed of glacial clay till with sand and gravel and range in height from 6 to 60 feet. The beach is 10 to 50 feet wide and sandy, but strewn in many places with pebbles, sod, and clay, which has slumped from the bluff. In areas where clay has slumped, the beach consists of silty sand. From that point to just north of Bethany Beach, the shoreline consists of high dunes.

Continuing along the shoreline, from one-half mile north of Bethany Beach to one mile south of Hazelhurst, there are steep bluffs up to 50 feet high, composed of medium sand. The beach is 20 to 60 feet wide and composed of sand, except for a belt of gravel along the waterline. From there southward to the Indiana line, the shoreline consists of low dunes composed of fine sand. The beach is 60 to 80 feet wide and sandy, with some gravel near the waterline.

The present distribution of shoreline uses and ownership along this four-county reach are shown in Figure 27. Approximately 6.4 miles, or 6 percent, of the shoreline are publicly owned. Since 1952, the residentially owned shoreline has increased 26 percent, while industrial and commercial ownerhsip has declined 87 percent. Agriculture and undeveloped shorelands have also declined.

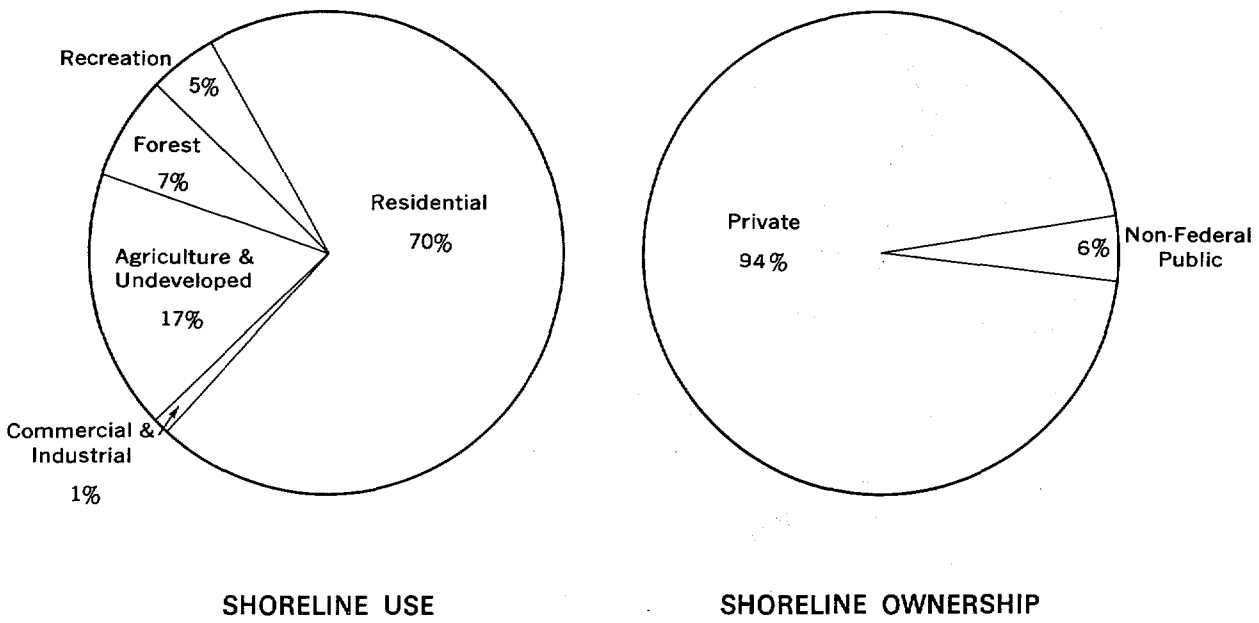
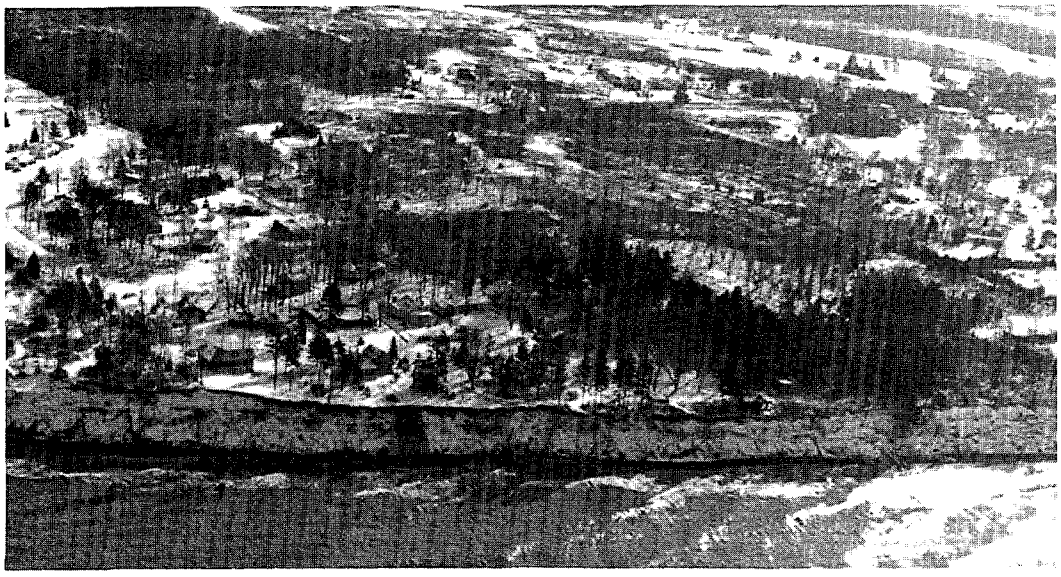


Figure 27. Distribution of Shoreline Use and Ownership, Berrien County to Ottawa County, Michigan.



(Michigan Department of Natural Resources)

Photograph 20. Residential development threatened by erosion of the shoreline south of South Haven, Michigan. High lake levels submerge beaches and allow waves to attack the dunes thus greatly accelerating the loss of land.

(Michigan Department of Natural Resources)

Photograph 21. A private residence undermined by erosion of a high dune shoreline in the South Haven area of Berrien County.

State parks on this reach of shoreline are Grand Haven, Holland, Van Buren, and Warren dunes. In addition, there are numerous city, township, and county parks and many public beaches. There are Federal deep-draft harbors at St. Joseph, South Haven, Holland, and Grand Haven, and recreational boat facilities for about 2,600 boats at New Buffalo, St. Joseph, South Haven, Saugatuck, Holland, and Grand Haven. Lake Michigan offers both lake and river spawning sport fishing. There are marshes with high waterfowl value upstream of the mouth of the Kalamazoo River.

7.1.2 Erosion and Flooding History

The entire four-county shoreline is subject to significant erosion of varying degrees, with critical erosion acting on 38.5 miles of the total 107.9 shoreline miles. This critical erosion takes place along scattered areas, the longest being the entire Van Buren County shoreline.

During the 1951-1952 high water levels, bluffs and dunes eroded up to 60 feet, resulting in significant damages to homes, cottages, stairs, sanitary and water supply facilities, piers, and docks, etc. The erosion damages recorded for the four-county shoreline during this period, adjusted to current dollar values, are summarized in Table 22.

Also during the 1952 high lake levels, flooding occurred along the shores of Lakes Kalamazoo, Macatawa, and Spring, and in the harbor at Grand Haven. Damage to all public property from flooding was $11,000. Damage to private property amounted to $238,000. Adjusted to 1970 values, these figures climb to $25,410 and $459,340.

Table 22

Total Damage to Shore Property on Lake Michigan – Berrien, VanBuren, Allegan, and Ottawa Counties, Michigan

	Damages, $	
Land Use	*Actual 1951-52 Value*	*Updated 1970 Value*
Private		
Residential	2,711,000	5,232,230
Industrial and commercial	299,000	577,070
Total, private property	3,010,000	5,809,300
Public		
Parks and beaches	270,000	623,700
Harbor installations	97,000	225,070
Total, public property	367,000	847,770
Total erosion damages	3,387,000	6,657,070

7.1.3 Solutions to Erosion Damages

Private property owners have attempted shore protection along this reach using steel piling, concrete revetments, groins, seaways, and temporary structures of stone riprap and fill material. However, the protective works along the shoreline are scattered, and most are damaged and no longer useful. Between the Michigan-Indiana State line and St. Joseph, extensive protective structures have been built, but no coordinated plan was followed in their construction.

The erosion problem along 38.5 miles of the shoreline of Ottawa, Allegan, Van Buren, and Berrien counties is such that shore protection and/or nourishment programs are suggested to prevent further damage and property loss. Detailed studies of shore processes are necessary in order to recommend and properly design a protective system. The programs' workability in one area would be offset if beaches on either side were gradually starved of littoral drift materials. A workable method of preventing erosion in the critical areas is protective beaches. If offshore borrow areas are available, protective beaches can be provided at a cost of about $400,000 per mile.

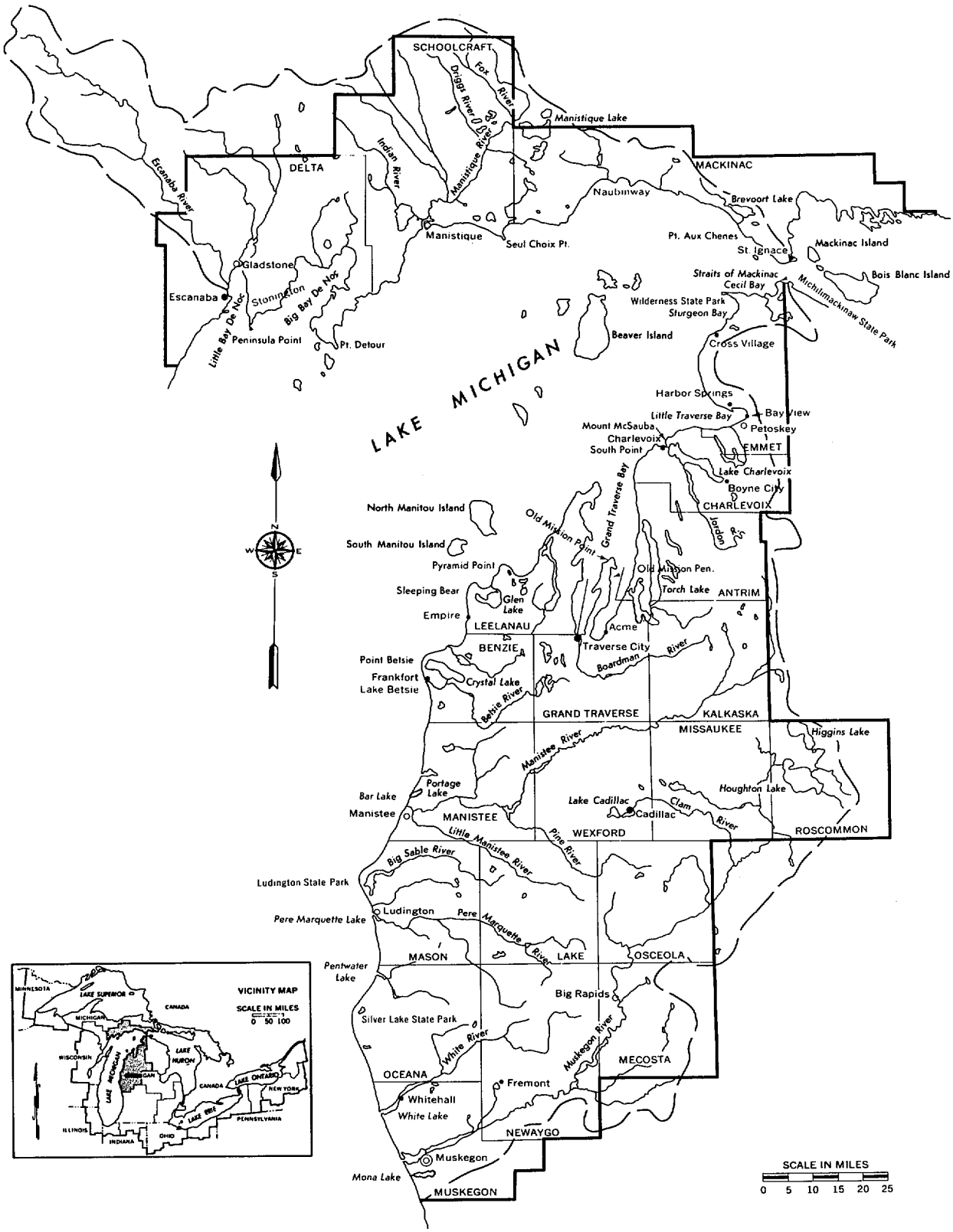


Figure 28. Lake Michigan Northeast Planning Subarea 2.4, Michigan.

7.2 The Lake Michigan Northeast Planning Subarea 2.4

The Great Lakes Mainland Shoreline of Michigan in planning subarea 2.4 is 788 miles long.[1] The major drainage areas are the Muskegon, Manistee, Traverse, Manistique, and Escanaba river basins and the Seul-Choix-Groscap Complex. The 21-county area has a population of 486,842 (1970). Shoreline communities include Muskegon, Ludington, Manistee, Frankfort, Traverse City, Charlevoix, Petoskey, St. Ignace, Manistique, Gladstone, and Escanaba, Figure 22. Information on the shoreline is given for three reaches: the South Muskegon County line to the Straits of Mackinac; the Straits of Mackinac west to the west Delta County line; and the Straits of Mackinac east to Point Detour in Chippewa County.

7.2.1 South Muskegon County Line to the Straits of Mackinac

7.2.1.1 Shoreline Description

This reach of Lake Michigan shoreline, approximately 410.1 miles, can be divied into two sections, based on shoretype. From the Straits of Mackinac to and including Grand Traverse Bay, the shoreline is characterized by narrow, cobble beaches, backed in some stretches by high bluffs. The second section, from the tip of Leelanau County south to Muskegon, contains clean sand beaches, with low and high dunes behind them. The offshore islands, Beaver, North and South Fox, and North and South Manitou, although not covered in this inventory report, have sand beaches backed by dunes. Manitou Islands sandy beaches front sand dunes and bluffs.

Information on property shoreline values, uses, ownership, and problem identification data are given in Table 23 and shown on Figures 29, 30, and 31.

The shoreline of Emmet County from the Straits of Mackinac to Petoskey, 62 shoreline miles, has several points and bays and is fairly uneven. The beaches are composed of cobbles and backed by glacial till bluffs (moraines), except for two areas of sandy beach backed by high dunes at Sturgeon Bay Point and the Petoskey Bathing Beach. From Fort Michilimackinac in Mackinaw City, around Waugoshance Island to the southern boundary of Wilderness State Park on Sturgeon Bay, the shoreline alternates between erodible low plain and marshes. The marshes are characterized by dense vegetation. The erodible low plains have beaches composed of sand, with concentrations of gravel. There is no bluff, but there are occasional hummocks of sand material, with scattered gravel and cobbles. Continuing southward to a point two miles below Sturgeon Bay Point, the shoreline is high sand dune. The beach varies in width from 15 to 50 feet and consists mostly of fine sand. From there to Ramona Park on Little Traverse Bay, approximately 26 miles, the shoreline is erodible high bluff. This moraine is made up of sand over clay. The beach is 30 to 40 feet wide and is sandy with scattered gravel and occasional boulders. From that point to the Menonaqua Beach area, the shoreland is a marsh, with a "shingle beach", so-called because it is composed of flat, waterworn cobbles, often referred to as "shingles". From Menonaqua to Bay View, the beach is 15 to 50 feet wide and composed of fine sand. High dunes rise as much as 50 feet above the beach and are composed of medium sand. From there to Nine-Mile Point in Charlevoix County the shoreland is characterized by low bluff, limestone bedrock outcrop, behind which are moraines (glacial deposits) composed of sand and gravel. The beach is limestone cobbles and boulders, and varies from 1 to 15 feet wide. In certain spots there is no beach, just sheer rock wall. From Nine-Mile Point to Mount McSauba Ski Area, the shoreland is non-erodible low plain, with no bluff behind the beach. The beach varies from 20 to 30 feet wide and is composed of limestone gravel and cobbles.

Continuing south along the shoreline from the ski area to Birch Hills, the shoreland is low erodible bluff. The beach is 40 to 60 feet wide and is gravel strand and low sand berm. From Birch Hills to a point two miles south along the shoreline of South Point, the shoreline and beach is non-erodible low plain.

The next 36 shoreline miles, all of Antrim County and to Grand Traverse County's Acme Park on the east arm of Grand Traverse Bay, are low erodible plain and beach. Beach and bluff composition is the same as that of the reach between the ski area and Birch Hills. For the next 32 miles, to Old Mission Point, the shoreland alternates between low and high erodible bluff. The beach varies in width from 10 to 30 feet and is composed of sand, gravel, cobbles, and scattered glacial boulders. Bluffs are glacial till, a mixture of sand, pebbles, cobbles, and boulders. The west shore of Old Mission Peninsula on the west arm of Grand Traverse Bay exhibits the same beach and bluff characteristics as the east shore. Although several of these shoretypes are classified erodible, they are generally free from serious shore erosion because the enclosed nature of Grand Traverse Bay protects them.

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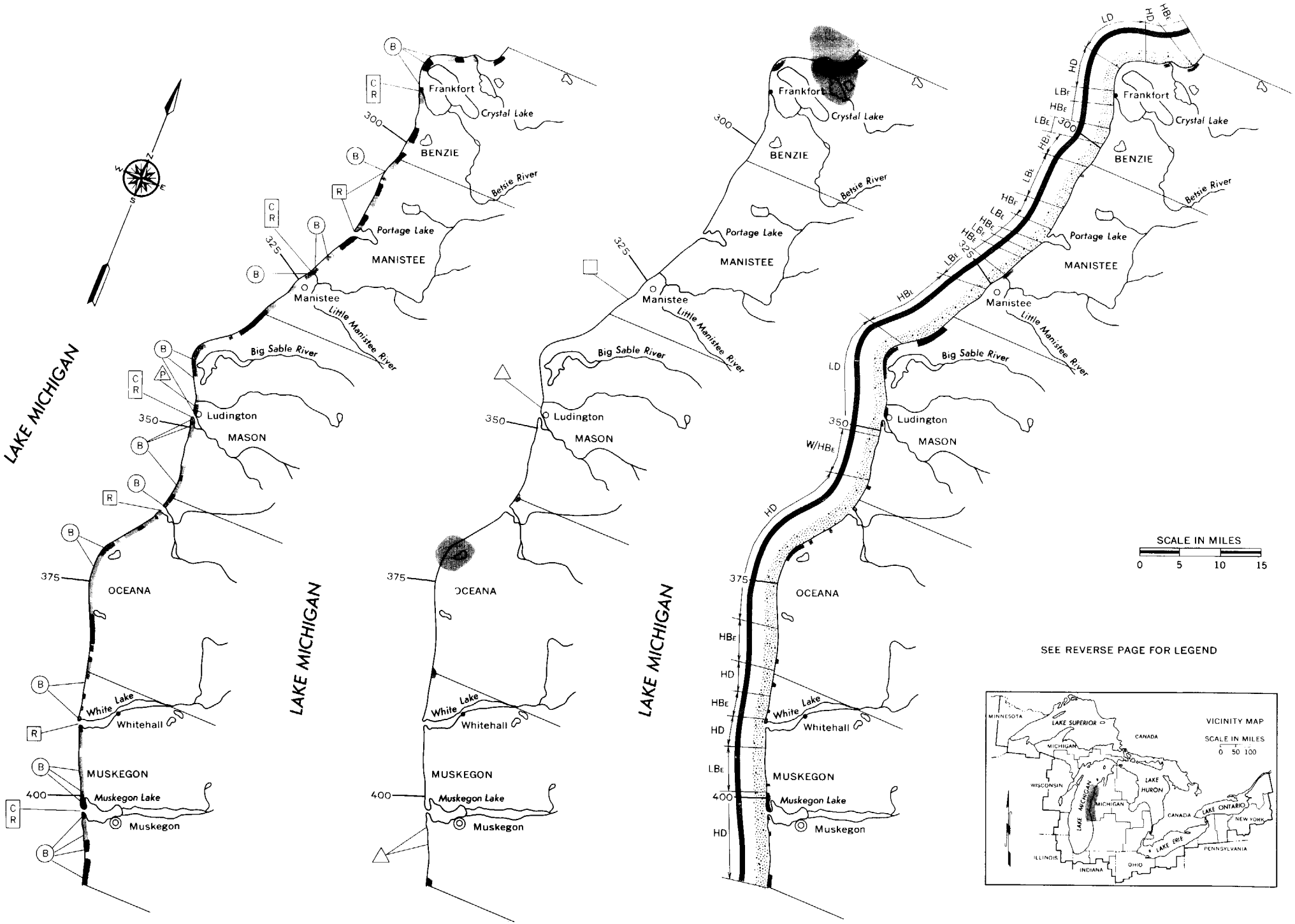
[1] Includes the Lake Huron shoreline from St. Ignace in Mackinaw County to Point Detour in Chippewa County, a distance of 100 miles.

Table 23

Shoreline of the Great Lakes — Emmet County to Muskegon County, Michigan

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public		Private	Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal		Critical	Noncritical			
Economic Uses											
Residential	141.5	34.5		0	0	141.5	21.0	52.3	2.4	0	65.8
Industrial and commercial	12.4	3.0		0	0	12.4	0	0.3	1.7	0	10.4
Agricultural and undeveloped	113.4	27.7		0	0	113.4	6.1	57.0	0	0	50.3
Commercial harbors			5								
Electric power sites			3								
Public buildings and related lands	3.3	0.8		0	3.3	0	0	0	0	0	3.3
Recreational Uses											
Parks	41.8	10.2		0	38.5	3.3	10.9	18.6	0	0	12.3
Recreational boat harbors			17								
Beach zone	(368.6)	(89.9)		(0)	(28.5)	(340.3)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	97.7	23.8		4.2	8.6	84.9	4.1	30.1	0	0	63.5
Total	410.1	100.0		4.2	50.4	355.5	42.1	158.3	4.1	0	205.6



SHORELAND USES.

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

Figure 29. SHORELANDS OF THE GREAT LAKES, BENZIE, MANISTEE, MASON, OCEANA, MUSKEGON COUNTIES.

LEGEND

SHORELAND USES

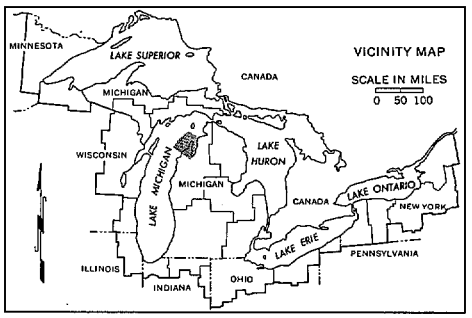
- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors (C)
- Recreational Harbors (R)
- Commercial Deep Draft and Recreational Harbors (C R)
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites
- Waste Water Outfalls and Intakes
  - Public Outfalls
  - Public Intakes
  - Private Outfalls
  - Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands
- Shore type
  - Artificial Fill Area — A
  - Erodible High Bluff, 30 ft. or higher — HB_E
  - Non-Erodible High Bluff, 30 ft. or higher — HB_N
  - Erodible Low Bluff, less than 30 ft. high — LB_E
  - Non-Erodible Low Bluff, less than 30 ft. high — LB_N
  - High Sand Dune, 30 ft. or higher — HD
  - Low Sand Dune, less than 30 ft. high — LD
  - Erodible Low Plain — P_E
  - Non-Erodible Low Plain — P_N
  - Wetlands — W
  - Combinations Shown As: Example
    - Lakeward/Landward — W/P_E
    - Upper Bluff Material / Lower Bluff Material — HB_E / HB_N
- Beach Material
  - Sand and gravel
  - Ledge rock
  - No Beach
- Problem Identification
  - Areas subject to erosion generally protected
  - Critical erosion areas not protected
  - Non-critical erosion areas not protected
  - Shoreline subject to lake flooding
  - Shoreline not subject to erosion or flooding
  - Bluff seepage problems (S)



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SCALE IN MILES

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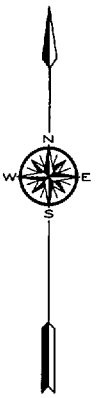
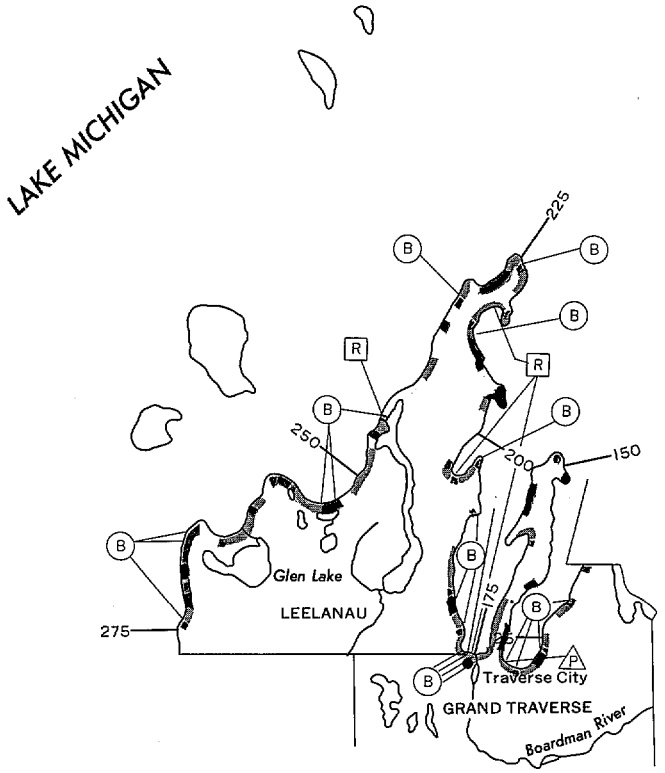
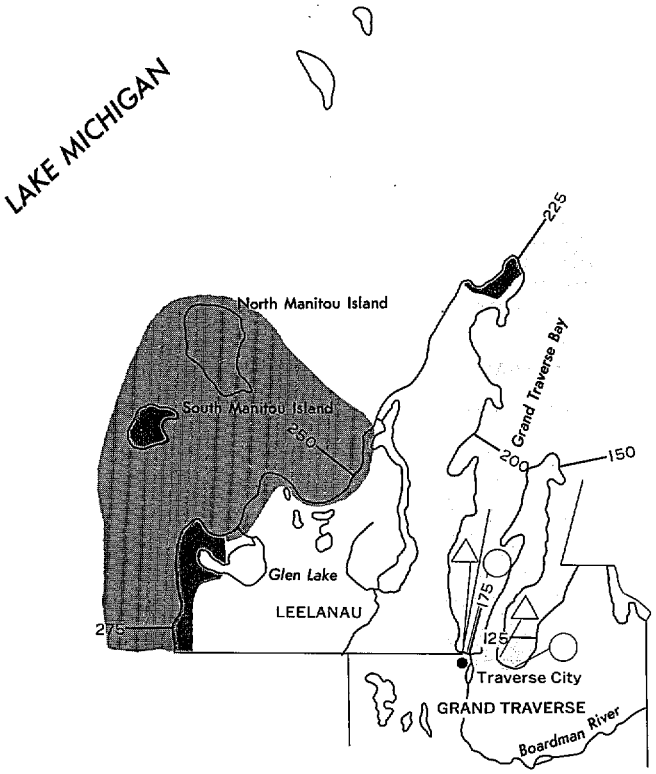
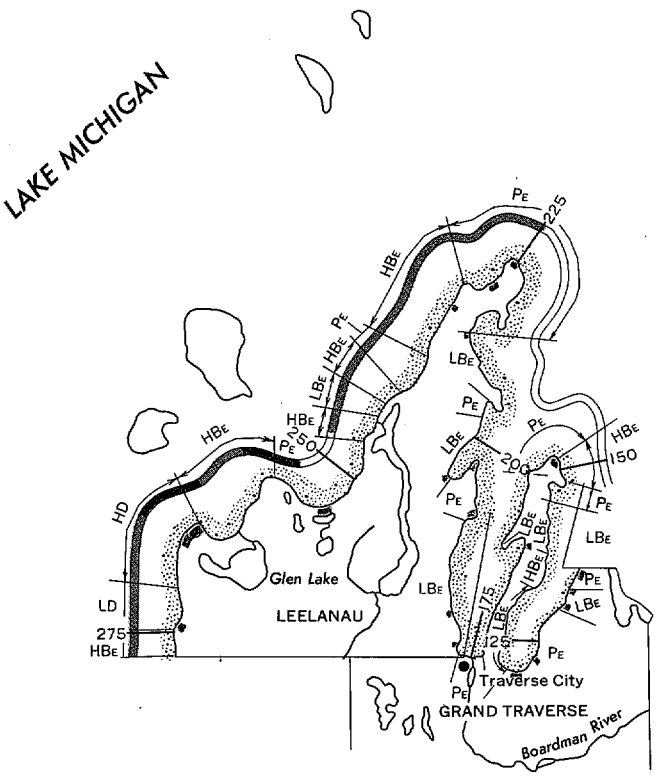




SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

Figure 30. SHORELANDS OF THE GREAT LAKES, GRAND TRAVERSE, LEELANAU COUNTIES.

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings

Recreational and Urban Open Space

Agricultural and Undeveloped

Forest

Public Beaches (B)

Commercial Deep Draft Harbors [C]

Recreational Harbors [R]

Commercial Deep Draft and Recreational Harbors [C R]

Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values

Unique Ecological or Natural Areas

Outstanding Shoreland Areas of Possible National Interest

Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands

Non-Federal Public Lands

Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

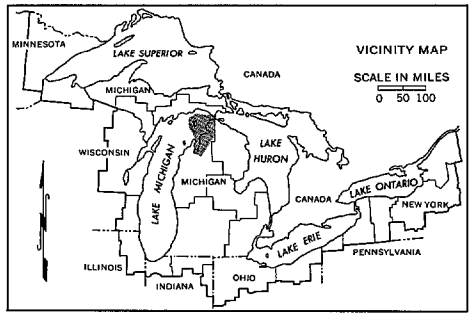
- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — $\frac{HB_E}{HB_N}$

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)



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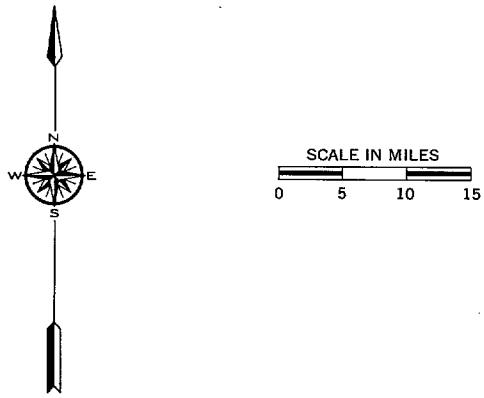
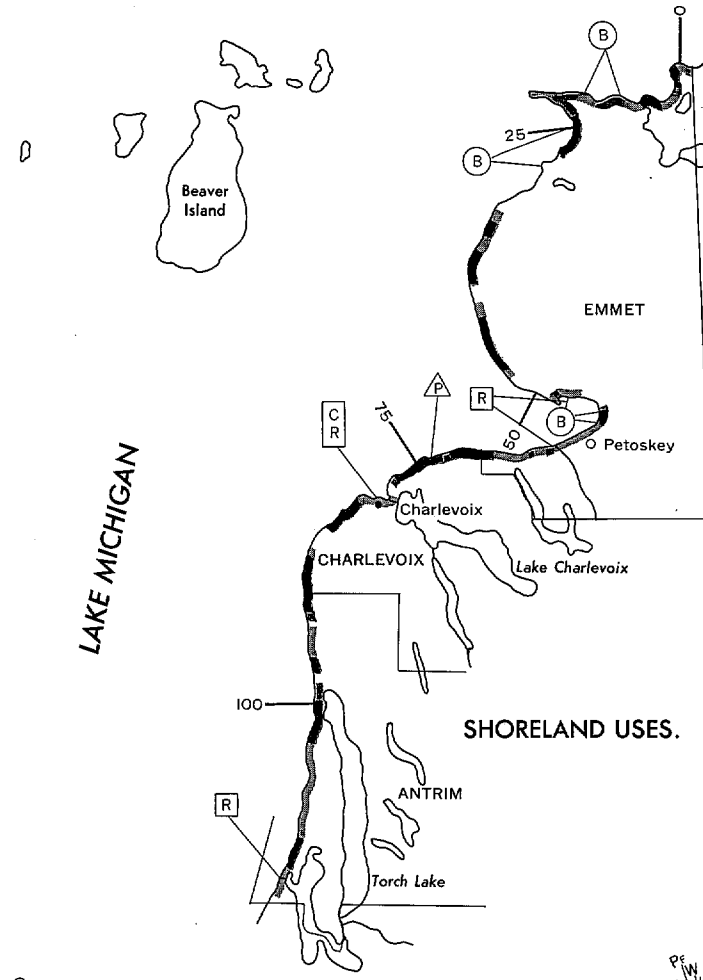
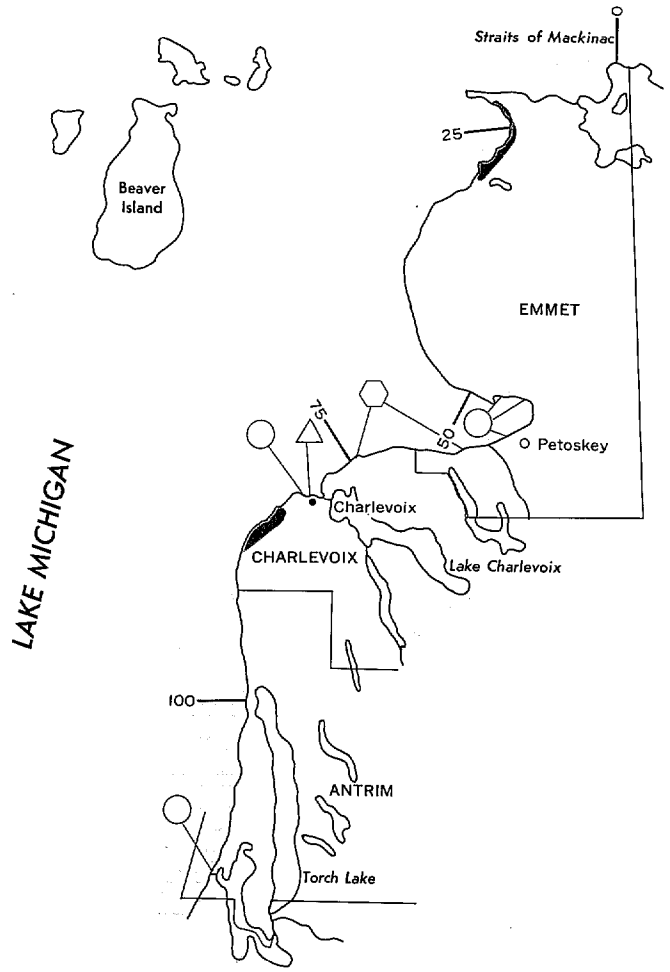
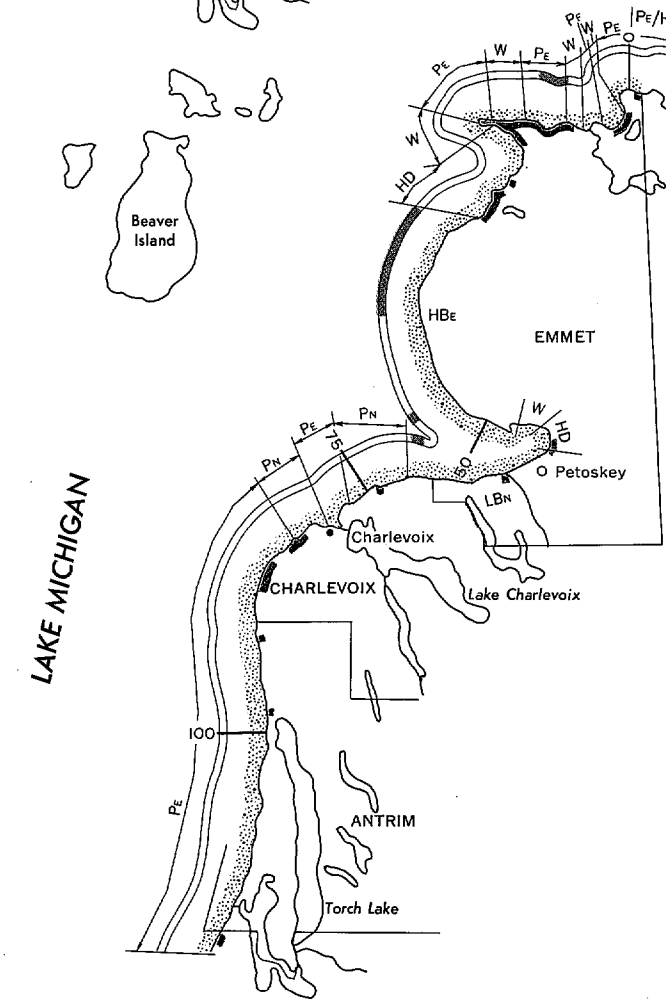




SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

Figure 31. SHORELANDS OF THE GREAT LAKES, EMMET, CHARLEVOIX, ANTRIM COUNTIES.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — (B)
- Commercial Deep Draft Harbors — [C]
- Recreational Harbors — [R]
- Commercial Deep Draft and Recreational Harbors — [C R]
- Electric Power Stations — (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites
- Waste Water Outfalls and Intakes
  - Public Outfalls
  - Public Intakes
  - Private Outfalls
  - Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

Combinations Shown As:	Example
Lakeward/Landward	W/P_E
Upper Bluff Material / Lower Bluff Material	HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — (S)

The west shore of Leelanau County to Sleeping Bear Bay (25 miles), also exhibits alternating shoretypes of high and low erodible bluff. Beaches range in width from 15 to 30 feet and are composed of low gravel berm, with cobbles and, occasionally, sand. Bluffs range upwards from 70 feet above lake level. From Sleeping Bear Bay to Empire, a distance of 10 miles, the Famous Sleeping Bear Sand Dune rises to 450 feet above lake level. There is no beach during high lake levels, but low water uncovers a rather wide sandy beach.

The shoreline to the south along 64 shoreline miles of Benzie and Manistee Counties to Big Sable Point in Mason County, alternates between erodible bluff and glacial lowlands. The morainic bluffs range from 25 to 175 feet high and are composed of coarse sand and clay and silt. Beaches are sandy with scattered pebbles. The lowlands consist of a bench up to 300 feet wide and approximately eight feet above lake level. Beaches are composed of medium to coarse sand, with a gravel belt along the waterline. The Big Sable Dunes of Mason County are of a fine sand and range up to 150 feet above lake level. The fine-sand beach is 30 to 50 feet wide. An extensive wooden groin system was constructed to protect Highway M-116.

From the southern boundary of the Big Sable Dunes, just two miles above Ludington, along the shoreline of Oceana County to Duck Lake in Muskegon County, the shoretype is alternating high sand dune and low clay bluff. In this reach, a distance of 46 miles, the beach is 30 to 60 feet wide and sandy. Bluffs are sand over clay and, occasionally in Muskegon County, sandstone outcrops in heavy clay. Dunes range up to 200 feet high and are composed of medium sand.

From Duck Lake south to Muskegon State Park, the shoreline is sand bluff, stabilized by extensive vegetation. The bluff is as much as 120 feet above lake level and the beach is 10 to 30 feet wide and sandy. The shoreline, from two and one-half miles north of Muskegon Lake in Muskegon County south to the Muskegon County line, consists of a gently sloping sand beach, 20 to 30 feet wide, backed by sand bluffs 30 feet high and high sand dunes rising to 240 feet above lake level.

The present distribution shoreline uses, and ownership are shown in Figure 32. Approximately 54.6 miles of the shoreline, are publicly owned.

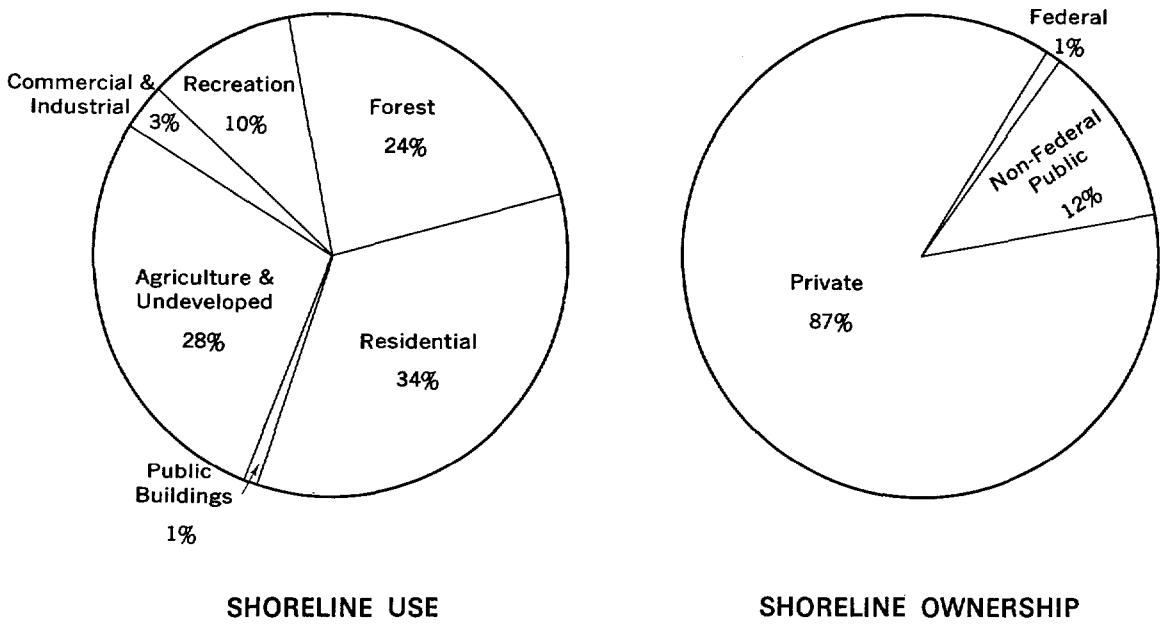


Figure 32. Distribution of Shoreline Use and Ownership, Emmet County to Muskegon County, Michigan.

About 41.8 miles of shoreline, or 10.2 percent of the total 410 shoreline miles, are used for recreation. State Parks along the shoreline are Michilimackinac, Wilderness, Traverse City, Glen Haven, Benzie, Orchard Beach, Ludington, Charles Mears, Silver Lake, Muskegon, and P. J. Hoffmaster. In addition, there are numerous city, township, and County parks and many public beaches.

The shoreline offers many significant fish and wildlife areas, as well as unique ecological areas. Lake Michigan has excellent lake and anadromous sport fishing, and waterfowl and game areas.

There are eight Federal Harbors and 11 Federally improved light-draft harbors along this reach of shoreline. It is estimated that about 2,000 recreational boats are permanently moored in these harbors.

7.2.1.2 Erosion and Flooding History

The erosion damages recorded for this shoreline during the one-year high-water period of 1951-52, adjusted to 1970 values, are given in Table 24.

During the 1952 high lake levels, flooding occurred at Harbor Springs in Emmet County, damaging docks and lawns along the waterfront. On Lake Charlevoix in Charlevoix County, flooding damaged homes, and commercial, public, and private docks, parks, commercial establishments, and resort areas. Basements flooded in Traverse City. Flooding damaged the shores of Portage Lake, North Ben Lake, and Lake Betsie in Manistee and Benzie counties. At Manistee, commercial docks, country roads, and some pasture lands were affected by the flooding, which was responsible for damages to homes and commercial establishments on the shores of White Lake, Pentwater Lake, and Pere Marquette Lake.

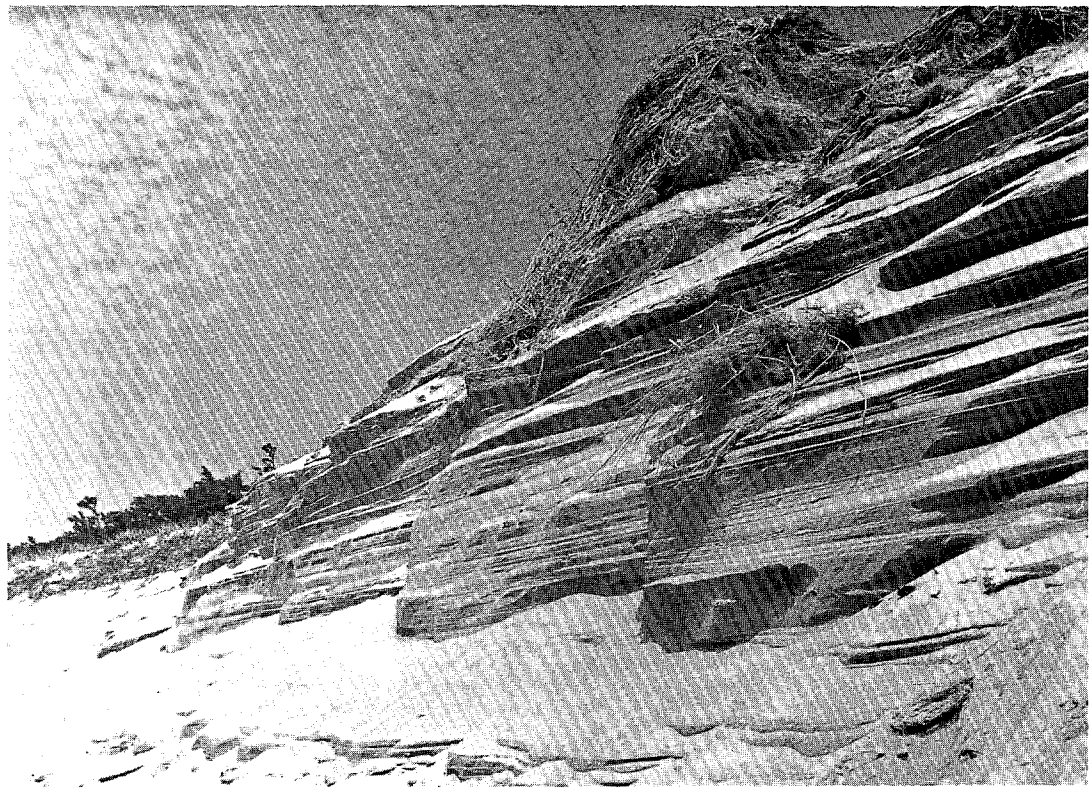
Damages from flooding in 1951-1952 to public property was $9,000, and to private property, $181,000. Adjusted to 1970 values, these figures are $20,800 and $349,330, respectively. All lands that are subject to flooding, however, are on lakes inland from the Lake Michigan Shoreline proper and are not, therefore, included in the Great Lakes shoreline.

Table 24

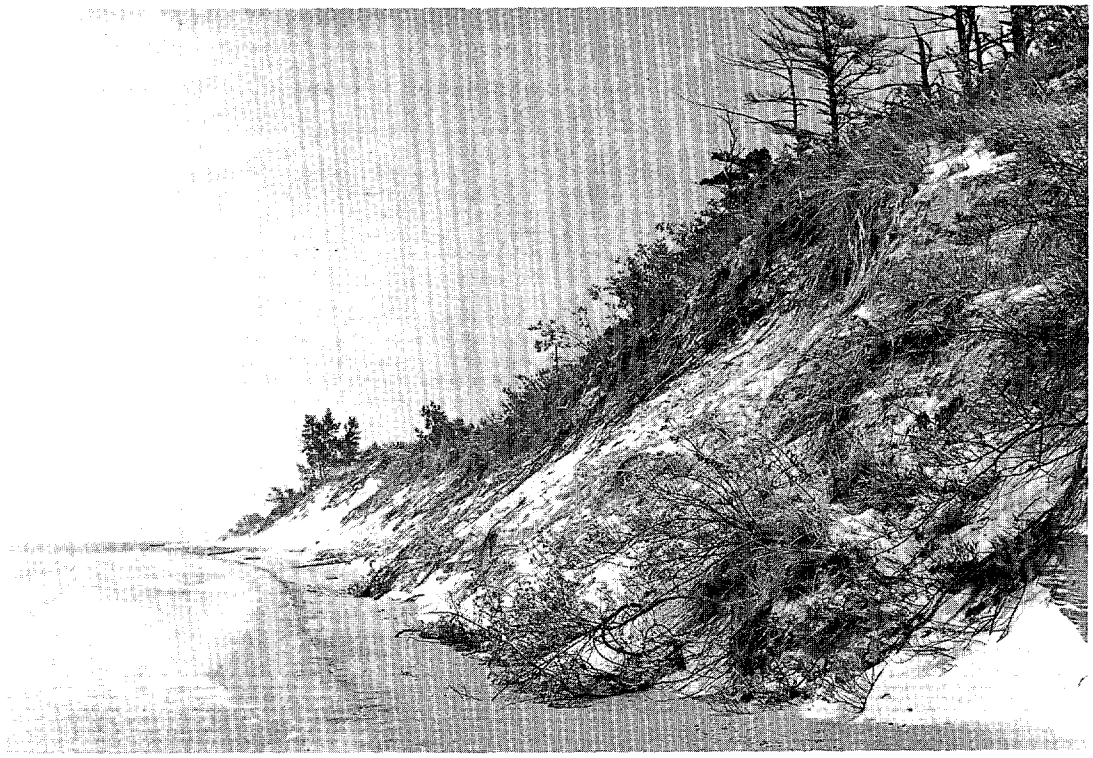
Total Damage to Shore Property on Lake Michigan – Muskegon, Oceana, Mason, Manistee, Benzie, Leelanau, Grand Traverse, Antrim, Charlevoix, and Emmet Counties, Michigan

	Damages, $	
Land Use	*Actual 1951-52 Value*	*Updated 1970 Value*
Private		
Residential	2,286,000	4,411,980
Industrial and commercial	515,000	993,950
Total, private property	2,201,000	5,405,930
Public		
Parks and beaches	182,000	420,420
Harbor installations	136,000	314,160
Total, public property	318,000	734,580
Total erosion damages	2,519,000	6,140,510

Many critical beach and shore erosion problems exist in this reach of shoreline, particularly from Manistee southward to Muskegon. The east shore of the lake is generally composed of fine sand, large quantities of which are set in motion by severe on-shore winds and storms. Erosion of bluffs and shorelines in the Manistee to Muskegon area increases or decreases as the lake level rises or falls. During period of high lake levels, storm-generated waves and currents cause recession of the upland bluff areas. During periods of low lake levels, the rate of recession is much less, but upland bluff areas once eroded remain lost forever.



Photograph 22. Shoreline erosion in the vicinity of Little Sable Point, Oceana County, Michigan.



Photograph 23. High-sand bluffs fronted by narrow sand beaches in the vicinity of Little Sable Point.

(Michigan Department of Conservation)

Photograph 24. A harbor of refuge located at Leland, Michigan. This harbor is designed mainly to be a place of refuge for small craft during storms.

The shoreline of Emmet County is generally not subject to erosion, with the exception of Wilderness State Park on Cecil Bay, Cross Village to Ryan's Corners, Forest Beach to Harbor Point, and near Bay View in Little Traverse Bay. The shoreline of Charlevoix County is generally not subject to erosion or flooding. The shoreline of Antrim and Grand Traverse, and the east shore of Leelanau Counties are all within the shelter of the Leelanau Peninsula, on Grand Traverse Bay. Grand Traverse Bay itself is divided into an east and west arm by Old Mission Peninsula. As a result, the shorelines are not often subject to erosion, since waves of sufficient height to cause erosion can not be generated in such short shore-fetch distances. Critical erosion occurs at Pyramid Point and Sleeping Bear Dunes, two points on the western side of the lakeshore of Leelanau County.

Most of the shoreline of Benzie County is subject to significant erosion, with critical erosion in an area two miles above and below Point Betsie. Protective works are located at two points on Point Betsie. The entire shoreline of Manistee County is subject to erosion, and scattered protective works are not effective. Areas of critical erosion include Point Camping, Bar Lake, and an area approximately one mile below the city of Manistee. The entire Mason County shoreline is subject to erosion, particularly along Big Sable Point, where it is critical. Wind and wave erosion required construction of wooden groins and snow fences to protect State Highway M-116. Oceana County is generally subject to erosion, with critical erosion south of Charles Mears State Park at Pentwater and along little Sable Point. Muskegon County's shoreline is subject to erosion and has only scattered protection. Severe erosion occurs from Wabaningo to Muskegon State Park and from Mona Lake to Ferrysburg in Ottawa County.

7.2.1.3 Solutions to Erosion Damages

Shore reaches recording critical erosion could be most economically protected by taking advantage of low-water periods to construct protective works. The selection of the shape, size, and location of such works must also consider their effects on adjacent shorelines. If any plan developed would result in stretching the critical area, the economic effect of such consequence would have to be considered. The most desirable method of shore protection would be revetments or construction of protective beaches. Protective beaches can be constructed for an estimated cost of $400,000 per mile. If groins are necessary, costs will rise. The cost of groins and artificial sand fills system is $800,000 per mile.

7.2.2 Straits of Mackinac to the West Delta County Line

7.2.2.1 Shoreline Description

The Lake Michigan shoreline of Delta, Schoolcraft, and Mackinac counties is about 288 miles in length. From the Straits of Mackinac to Manistique in Schoolcraft County, a distance of about 83 miles, the shoreland is generally irregular and contains many small bays. The reach between Point Aux Chenes and Brevort, a distance of about 15 miles, is the only exception. This 15-mile reach of shoreline is composed of a sand beach backed by dunes rising to about 30 feet above low water datum. The points of the bays are rocky, while the bay heads are generally sand beaches. The bluffs are low and seldom exceed 15 feet in height.

From Manistique to Galdstone in Delta County, about 191 shoreline miles, the shoreland is generally irregular, with numerous bays protected by natural breakwaters of rocky points reaching out into the lake. The shoreline between Manistique and the village of Garden, a distance of about 65 miles, consists of stone or gravel beaches, with short stretches of sand beach, especially at the heads of the bays.

With the exception of an eight-mile reach at Stonington, the remainder of the shoreline is predominately broad sand beaches with sections of gravel and stone here and there. This reach consists of a limestone precipice up to 30 feet in height. From Gladstone to the Delta-Menominee County line, the shoreline is a gently sloping sand beach. There are no bluffs. The banks along the shore average about eight feet above low water datum. Shoreline values, uses, ownership, and problem identification data are given in Table 25 and shown on Figures 33 and 34. The following paragraphs contain detailed description of this shoreline reach.

From St. Ignace to Point Aux Chenes, a distance of 10 miles, the shoreline is naturally protected by limestone cobbles, except for an area around the village of Gros Cap that is characterized by low bluffs. Point Aux Chenes to the Village of Epoufette 20 miles away, the shore consists of dunes and high clay bluffs.

Two miles along the shoreline to Scotts Bay the shoreland is a muddy marsh with abundant plant growth. From here 16 miles to Millecoquins Point at Kaubinway, the shoreline is low plains, with low sand dunes at Middle Point. Between Naubinway and the Mackinac-Schoolcraft County line, a distance of 27 miles, the shoreline alternates between low plains composed of sand and gravel and limestone outcrops. The shoreland is rock ledge and, occasionally, sheer rock wall from the County line, eight miles to Goudreau's Harbor in Schoolcraft County. From there six miles to the west along the shoreline, are low sand dunes. For the next 24 miles, to Point Aux Barques, the shoreline alternates between low plains of cobbles and low sand dunes, except for two areas of limestone outcropping on either side of Dutch John's Point and between Thompson and Wiggins Point. From Point Aux Barques to Little Harbor, about five miles, marshes are on top of flat lying limestone layers. From Little Harbor to the Schoolcraft-Delta County line, a distance of about five miles, the shoreline is characterized by cobbles, underlain by bedrock.

The shoreline of Delta County is very irregular and has many different shoreline forms. There are countless bays and inlets in Big Bay De Noc and Little Bay De Noc, which are protected by natural limestone breakwaters reaching out into Lake Michigan. Limestone cliffs rise up to 200 feet above lake level in the vicinity of Fayette. Generally, points and headlands are rocky, and bay heads are sandy or marshy.

The present distribution of shoreline uses and ownership in this reach is shown on Figure 35. Approximately 48.2 miles of the shoreline, are publicly owned. There appears to have been little change in shoreline use and ownership of this property since 1952.

About 6.7 miles of shoreline are used for parks. However, 172.4 miles, are forests that provide for fishing, hunting, camping and hiking. State parks, State forests, and National forests with shorelines on Lake Michigan are given in the following tabulation:

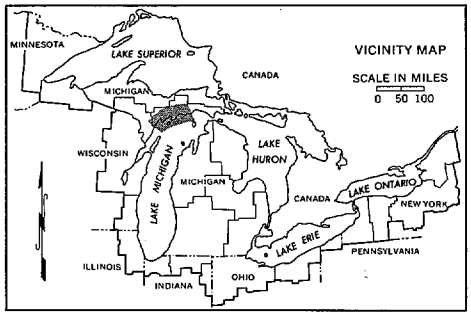
	Counties		
	Mackinac[1]	Schoolcraft	Delta
State Parks	-	-	Fayette
State Forests	Mackinac	Manistique River	Bay De Noc
National Forests	Hiawatha	Hiawatha	Hiawatha

[1] West of St. Ignace.

Table 25

Shoreline of the Great Lakes — Delta County to Straits of Mackinac Bridge, Michigan

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public			Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal	Private	Critical	Noncritical			
Economic Uses											
Residential	57.5	20.0		0	0	57.5	0	12.2	11.7	24.1	9.5
Industrial and commercial	8.2	2.8		0	0	8.2	0	2.1	0.6	4.7	0.8
Agricultural and undeveloped	43.2	15.0		0	2.3	40.9	0	3.8	8.2	7.1	24.1
Commercial harbors			2								
Electric power sites			3								
Public buildings and related lands	0	0		0	0	0	0	0	0	0	0
Recreational Uses											
Parks	6.7	2.3		2.0	4.7	0	0	0.7	1.6	1.0	3.4
Recreational boat harbors			4								
Beach zone	(100.6)	(34.9)		(0.7)	(15.9)	(84.0)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	172.4	59.9		6.7	32.5	133.2	0	17.2	18.5	41.9	94.8
Total	288.0	100.0		8.7	39.5	239.8	0	36.0	40.6	78.8	132.6



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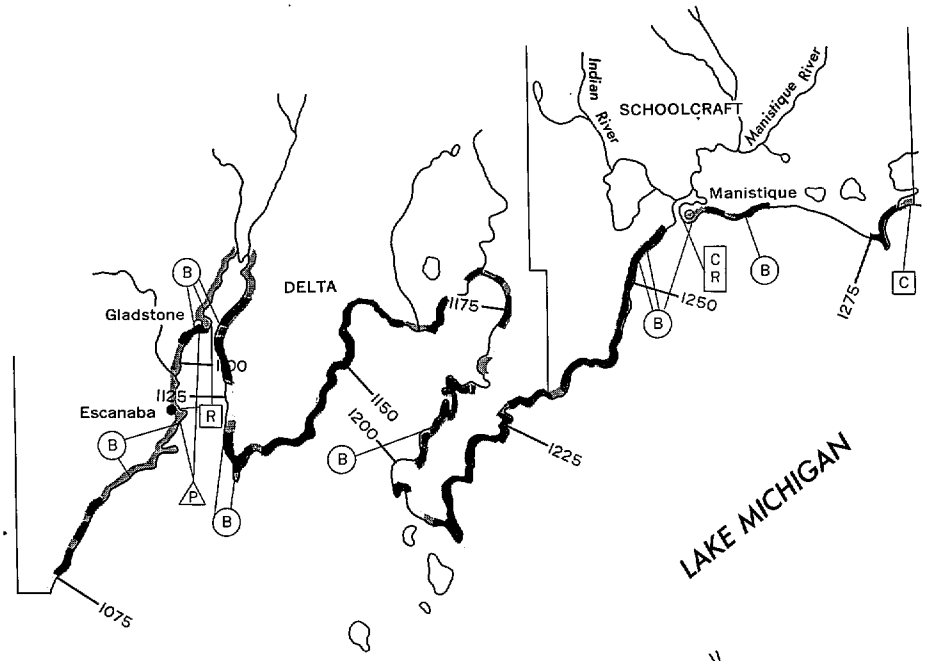
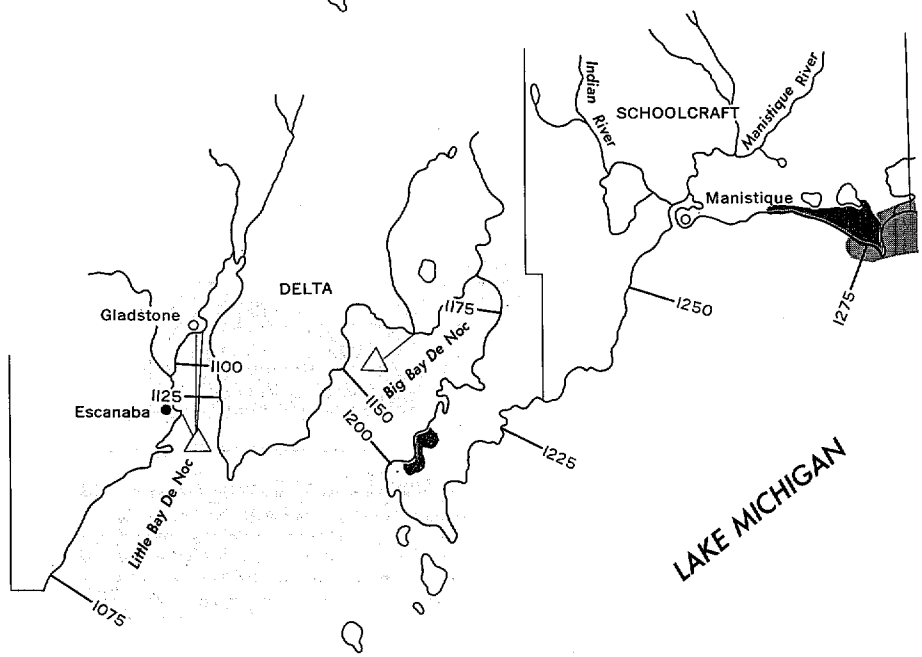
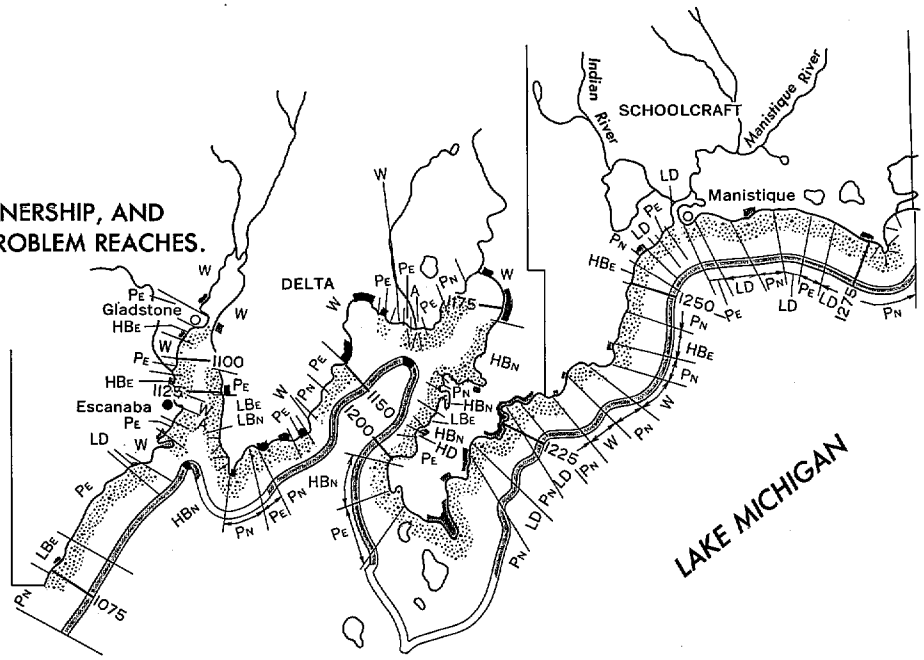
SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.



SCALE IN MILES
0 5 10 15

Figure 33. SHORELANDS OF THE GREAT LAKES, SCHOOLCRAFT, DELTA COUNTIES.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors [C]
- Recreational Harbors [R]
- Commercial Deep Draft and Recreational Harbors [C R]
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites
- Waste Water Outfalls and Intakes
  - Public Outfalls
  - Public Intakes
  - Private Outfalls
  - Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

Combinations Shown As:	Example
Lakeward/Landward	W/P_E
Upper Bluff Material / Lower Bluff Material	HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)

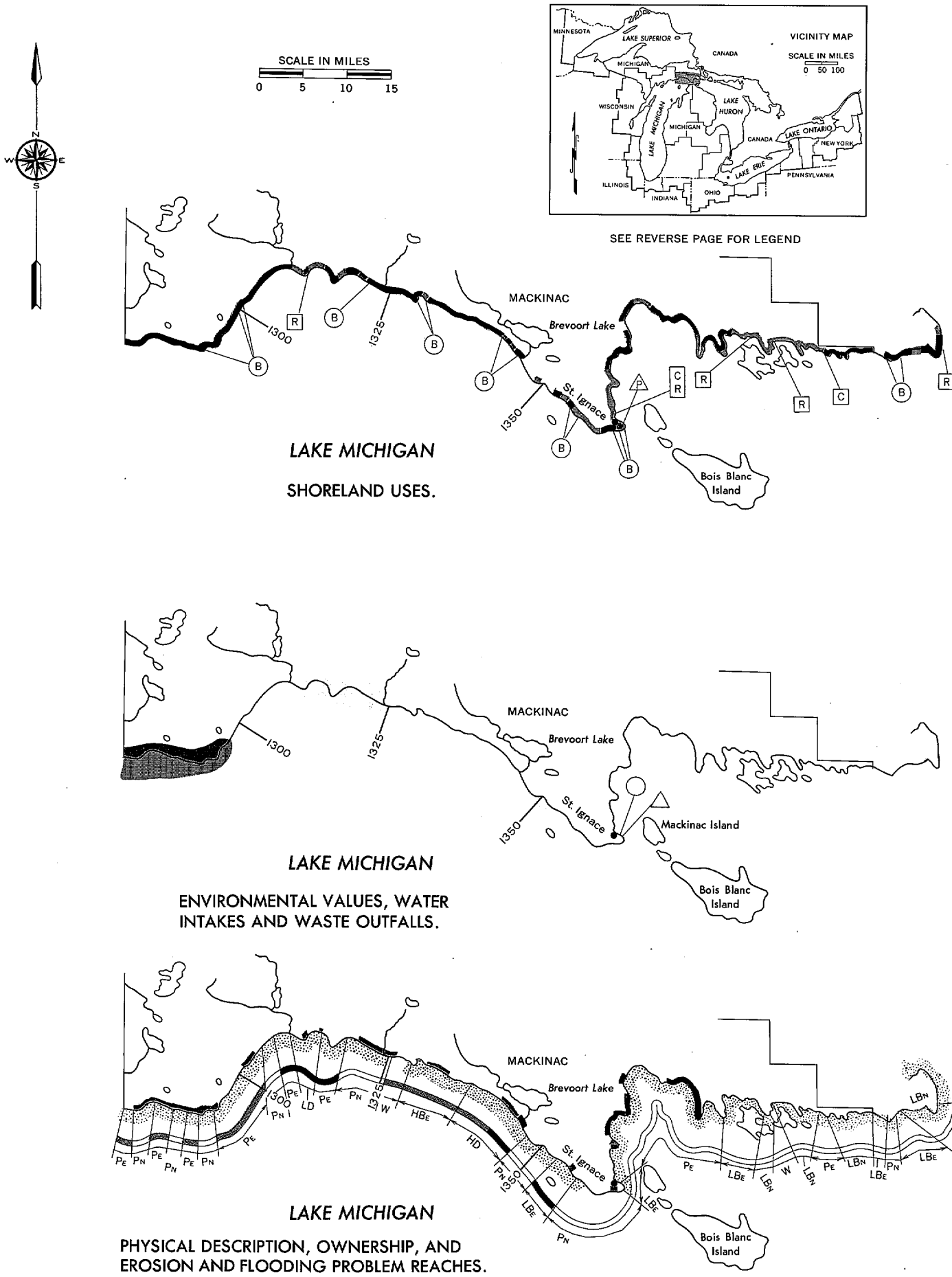


Figure 34. SHORELANDS OF THE GREAT LAKES, MACKINAC COUNTY AND CHIPPEWA COUNTY, EAST TO BRUSH POINT.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors (C)
- Recreational Harbors (R)
- Commercial Deep Draft and Recreational Harbors (C R)
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites
- Waste Water Outfalls and Intakes
  - Public Outfalls
  - Public Intakes
  - Private Outfalls
  - Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

Combinations Shown As: Example

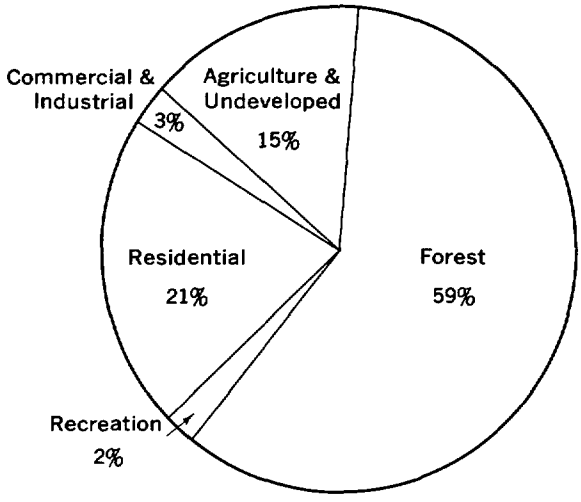
Lakeward/Landward	W/P_E
Upper Bluff Material / Lower Bluff Material	HB_E / HB_N

Beach Material

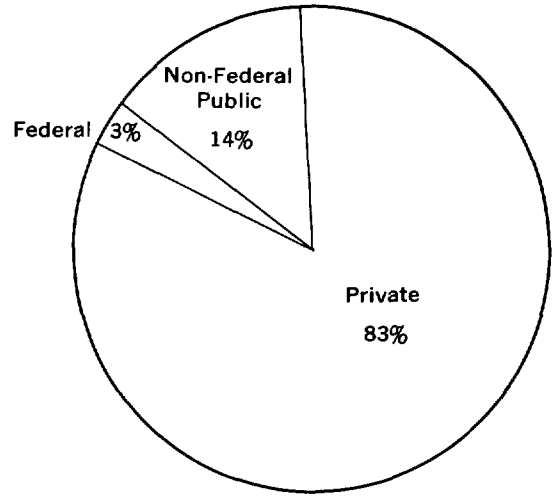
- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)



SHORELINE USE



SHORELINE OWNERSHIP

Figure 35. Distribution of Shoreline Use and Ownership, Delta County to Straits of Mackinac Bridge, Michigan.

7.2.2.2 Erosion and Flooding History

Table 26 gives the estimated 1951-52 high water damages recorded for the Lake Michigan Shoreline of Delta, Schoolcraft, and Mackinac counties. Shoreline damages from Gladstone to the Menominee-Delta County line are not available. Dollar figures are adjusted to reflect 1970 values.

This shoreline on Lake Michigan is generally not subject to critical erosion. Much of the shoreland is protected by outcropping limestone or gravel and cobble beaches. The shoreline of Delta County is irregular and has many bays and inlets that are protected by rocky points jutting into the lake. As a result, the wave heights necessary to cause erosion can not be generated in the short-fetch distances of Big Bay De Noc and Little Bay De Noc. Of the 288 shoreline miles, 36 miles are subject to non-critical erosion and 40.6 miles are protected. Much of the protected shoreland is where highway U.S. 2 follows the shoreline.

During the high lake levels of 1951-52, erosion did occur in the 15-mile reach of sand dunes of Mackinac County that is paralleled by highway U. S. 2. Sections of the highway shoulder located between two and eight miles east of Brevort were eroded to within a few feet of the pavement. To prevent the highway from being undermined, the shoulders ranging up to 20 feet above low water datum were built out with quarry-run gravel and protected with 10-ton stone. In addition to shoreline changes along the highway, extensive erosion ranging up to 250 feet occurred for a distance of about 1,000 feet east of the east breakwater at Manistique Harbor. There, it destroyed the shore connection of the east breakwater and piled up littoral drift in the navigation channel. The east breakwater has since been connected to shore with both landward and eastward extensions to prevent further erosion.

The other area of erosion on the three-county reach was from Gladstone to the Delta-Menominee County line. That reach consists of sand beaches backed by a low sand bank. Shoreline eroded to an average width of about 10 feet, because water levels were high enough to undercut the bluffs. Near Gladstone, approximately 1,500 lineal feet of highway U. S. 2 are protected with 5- to 10-ton stone. Other minor protective measures, such as riprapping and small masonry sea walls, were constructed by individual property owners to delay the erosion of their holdings. Approximately 74 miles of shoreline are subject to flooding. However these are mostly undeveloped and forested areas, and no property damage has occurred.

Table 26

Total Damage to Shore Property on Lake Michigan – Delta,[a] Schoolcraft, and Mackinac Counties, Michigan

Land Use	*Damages, $*	
	Actual 1951-52 Value	*Updated 1970 Value*
Private		
Inundation (all property)	6,000	11,580
Commercial	73,000	140,890
Residential	8,000	15,440
Agricultural or undeveloped	8,000	8,400
Total, private property	95,000	176,710
Public		
Parks and beaches	3,000	6,930
Harbor installations	5,000	11,550
Utilities	284,000	656,040
Total, public property	292,000	674,520
Total erosion damages	387,000	850,830

[a] Does not include that portion of Delta County from Gladstone to Menominee-Delta County line.

7.2.2.3 Solutions to Erosion Damages

This shoreline is not subject to critical erosion. The shoreline is protected in almost all the areas where erosion has been a problem in the past. The sandy shoreline from Gladstone to the Delta-Menominee County line could be subject to significant erosion if unusually high lake levels were to occur again. However, there is little existing data on the shore processes along that stretch of shoreline.

Photograph 25. The shoreline in Fayette State Park, Delta County, Michigan.

7.2.3 Straits of Mackinac east to Point Detour

7.2.3.1 Shoreline Description

The Lake Huron shoreline from St. Ignace in Mackinac County to Point Detour in Chippewa County is a distance of 100 shoreline miles. The shoreline generally consists of alternating non-erodible low plains of clay and marshes, with occasional non-erodible outcrops of limestone and dolomite. Table 27 and Figure 34 describe shoreline values, uses, and ownership and identifies erosion and flooding problem areas.

The present distribution of shoreline use and ownership is shown on Figure 36. Approximately 0.8 mile of shoreline is used for parks. In addition, 63.8 miles are classified as forest and provide significant opportunities for camping, fishing, and hunting. State parks with shoreline on Lake Huron include the Straits of Mackinac Island and Detour. Forest holdings include State forests at Munuscong and Black Lake (Bois-Blanc Island) and the Hiawatha National Forest. Recreational boat harbors are located at St. Ignace, Boise-Blanc, and Mackinac Island in Mackinac County, and Hessel in Chippewa County. This shoreline has significant fish and wildlife values.

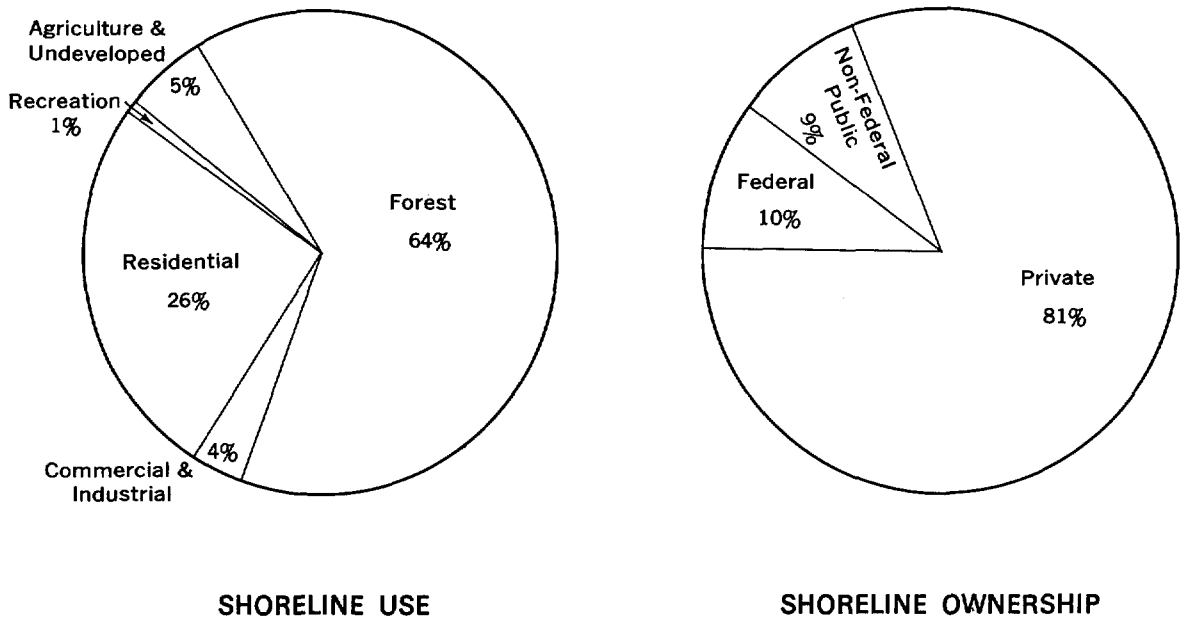


Figure 36. Distribution of Shoreline Use and Ownership, Straits of Mackinac Bridge East to Brush Point, Chippewa County, Michigan.

7.2.3.2 Erosion and Flooding History

This shoreline is not subject to erosion.

7.2.3.3 Solutions to Erosion Damages

Erosion damages are not a problem for this reach of the shoreline.

Table 27

Shoreline of the Great Lakes — Straits of Mackinac Bridge East to Brush Point, Chippewa County, Michigan

Shoreland Use Category	*Existing Shoreland Use*			*Miles of Shoreline*			*Problem Identification, Miles of Shoreline*				
	Miles of Shoreline	*Percent of Total*	*Number of Sites*	*Public*			*Subject to Erosion*			*Subject to Flooding*	*Not Subject to Erosion or Flooding*
				Federal	*Non-Federal*	*Private*	*Critical*	*Noncritical*	*Protected*		
Economic Uses											
Residential	26.5	26.5		0	0	26.5	0	0	0	0	26.5
Industrial and commercial	3.5	3.5		0	0	3.5	0	0	0	0	3.5
Agricultural and undeveloped	5.4	5.4		0	0	5.4	0	0	0	0	5.4
Commercial harbors			2								
Electric power sites			1								
Public buildings and related lands	0	0		0	0	0	0	0	0	0	0
Recreational Uses											
Parks	0.8	0.8		0	0.8	0	0	0	0	0	0.8
Recreational boat harbors			4								
Beach zone	(57.2)	(57.2)		(9.5)	(0.7)	(47.0)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	63.8	63.8		9.5	8.1	46.2	0	0	0	3.0	60.8
Total	100.0	100.0		9.5	8.9	81.6	0	0	0	3.0	97.0

7.3 The Lake Michigan Northeast Planning Subarea 2.1, State of Michigan

The Great Lakes Mainland Shoreline of Michigan in planning subarea 2.1 is located in Menominee County, Michigan, and has a total shoreline of 39 miles. The Michigan portion of planning subarea 2.1 contains three counties, Iron, Dickinson, and Menominee (Figure 37). The area population is 61,152 (1970).

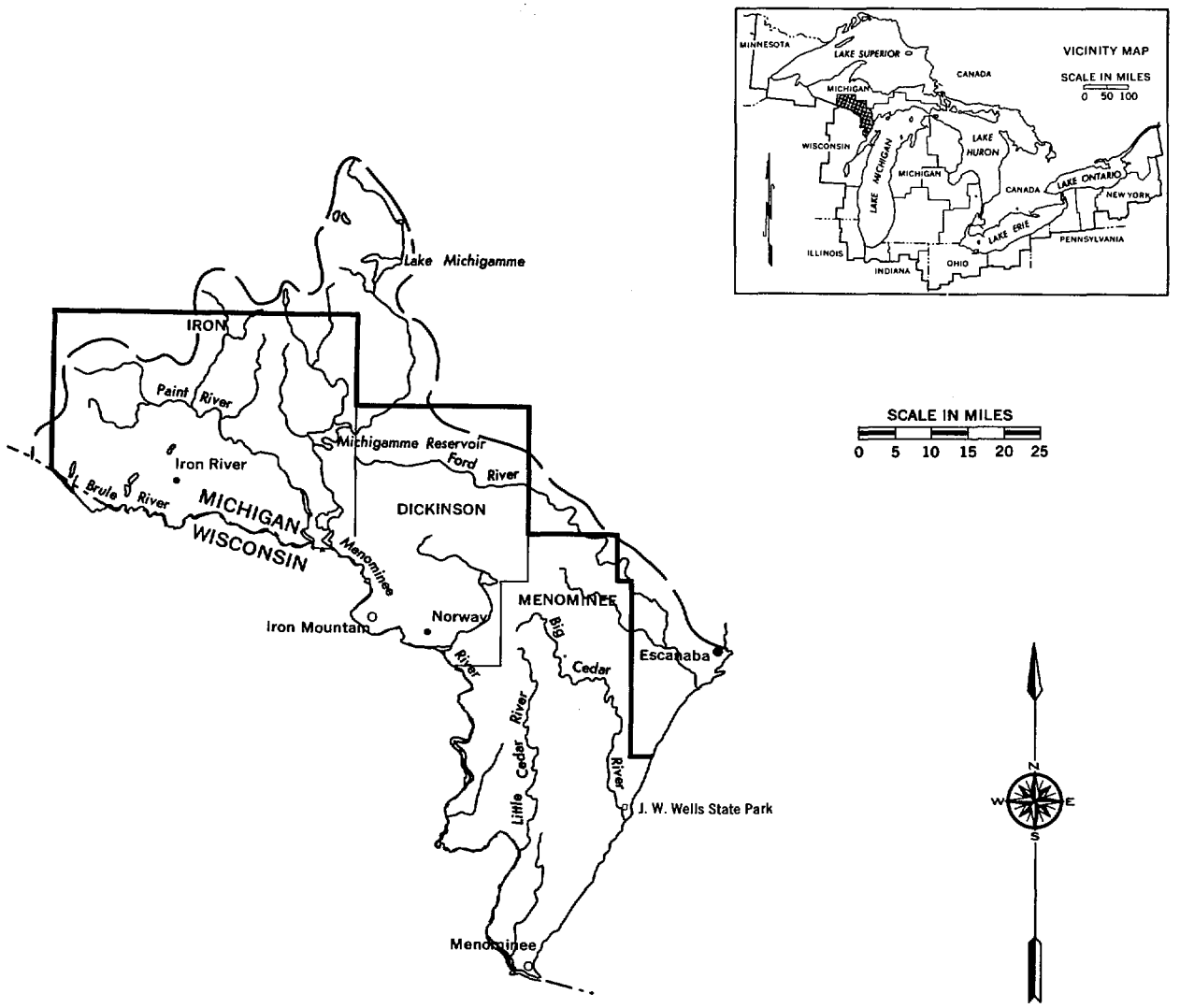


Figure 37. Lake Michigan Northwest Planning Subarea 2.1, Michigan.

7.3.1 Shoreline Description

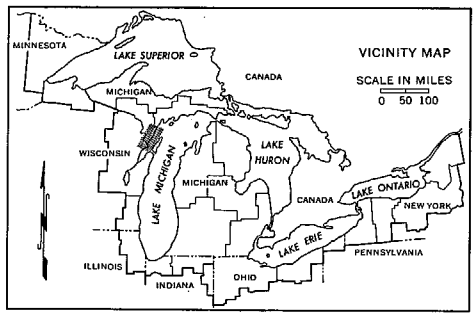
Menominee County is located on the west shore of Green Bay. The shoreline generally consists of gently sloping sand and gravel beaches backed by low sand banks. The banks range up to eight feet high. The beaches are generally 50 feet wide at low water datum.

Table 28 and Figure 38 summarize the existing shoreline values, use, ownership, and problem areas along the Menominee County shoreline. Since 1952, the number of miles of shoreline in residential development and recreational use has increased about 33 and 140 percent, respectively. There has been a corresponding decrease in agricultural and undeveloped shoreline use. There has been little change in other shoreline uses and public ownership since 1952. The distribution of the present shore property use and ownership is shown in Figure 39.

Table 28

Shoreline of the Great Lakes — Menominee County, Michigan

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public		Private	Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal		Critical	Noncritical			
Economic Uses											
Residential	17.4	44.6		0	0	17.4	0	17.4	0	0	0
Industrial and commercial	2.9	7.4		0	0	2.9	0	2.9	0	0	0
Agricultural and undeveloped	1.5	3.9		0	0	1.5	0	1.5	0	0	0
Commercial harbors			1								
Electric power sites			0								
Public buildings and related lands	0.1	0.3		0.1	0	0	0	0.1	0	0	0
Recreational Uses											
Parks	5.0	12.8		0	5.0	0	0	5.0	0	0	0
Recreational boat harbors			1								
Beach zone	(33.8)	(86.7)		(0)	(4.8)	(29.0)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(18.0)	(46.2)						NA			
Forest	12.1	31.0		0	0.5	11.6	0	12.1	0	0	0
Total	39.0	100.0		0.1	5.5	33.4	0	39.0	0	0	0



SCALE IN MILES

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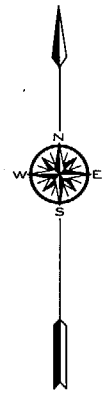
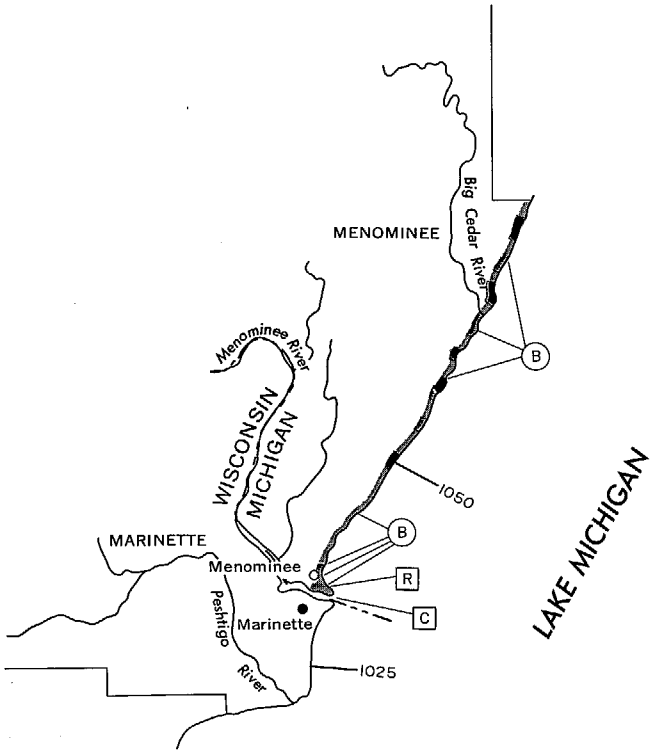
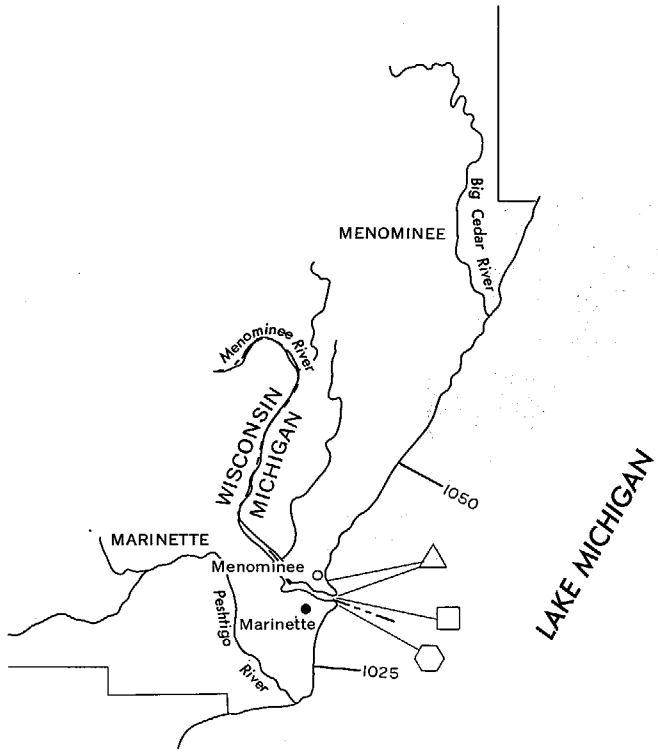
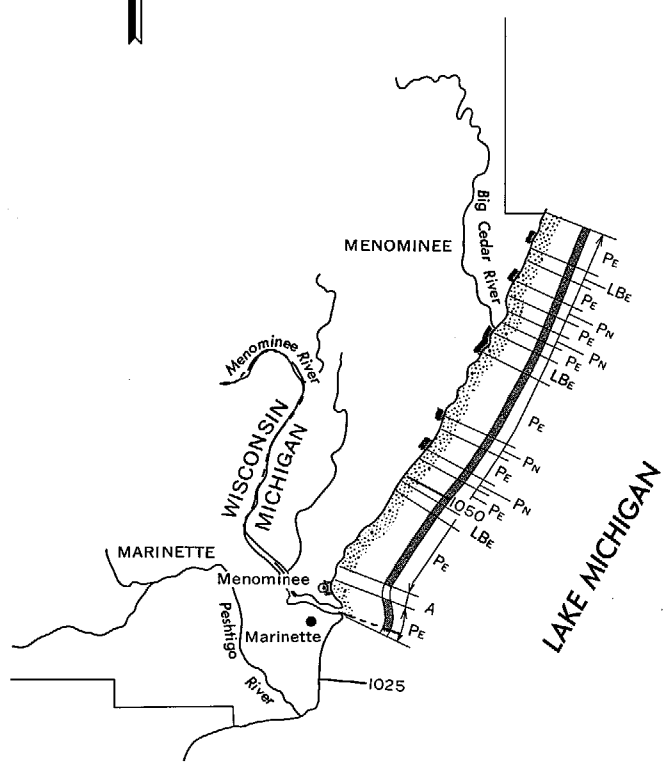




SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

Figure 38. SHORELANDS OF THE GREAT LAKES, MENOMINEE, COUNTY.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors (C)
- Recreational Harbors (R)
- Commercial Deep Draft and Recreational Harbors (C R)
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites
- Waste Water Outfalls and Intakes
  - Public Outfalls
  - Public Intakes
  - Private Outfalls
  - Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands
- Shore type
  - Artificial Fill Area — A
  - Erodible High Bluff, 30 ft. or higher — HB_E
  - Non-Erodible High Bluff, 30 ft. or higher — HB_N
  - Erodible Low Bluff, less than 30 ft. high — LB_E
  - Non-Erodible Low Bluff, less than 30 ft. high — LB_N
  - High Sand Dune, 30 ft. or higher — HD
  - Low Sand Dune, less than 30 ft. high — LD
  - Erodible Low Plain — P_E
  - Non-Erodible Low Plain — P_N
  - Wetlands — W
  - Combinations Shown As: Example
    - Lakeward/Landward — W/P_E
    - Upper Bluff Material / Lower Bluff Material — HB_E / HB_N
- Beach Material
  - Sand and gravel
  - Ledge rock
  - No Beach
- Problem Identification
  - Areas subject to erosion generally protected
  - Critical erosion areas not protected
  - Non-critical erosion areas not protected
  - Shoreline subject to lake flooding
  - Shoreline not subject to erosion or flooding
  - Bluff seepage problems (S)

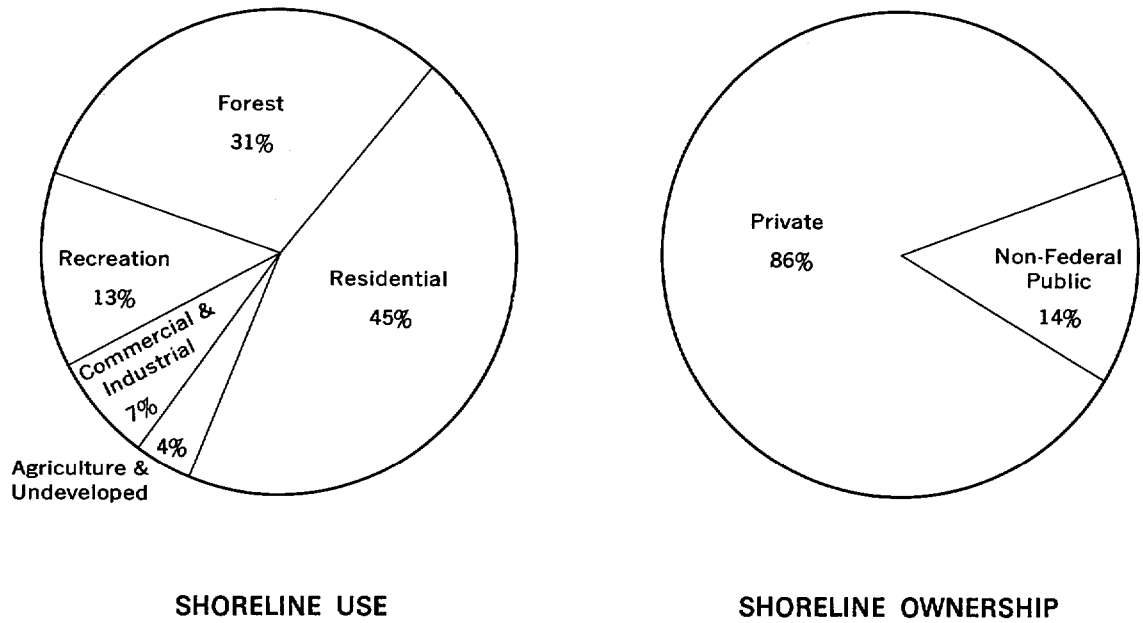


Figure 39. Distribution of Shoreline Use and Ownership, Menominee County, Michigan.

There is no comprehensive plan for future use or development of the Menominee County shoreline. The State of Michigan and the U. S. Bureau of Sport Fisheries and Wildlife have identified the offshore waters of Menominee County as having fair fishery and waterfowl value and good water quality. Wetlands extend along 18 miles of shoreline. The J. W. Wells State Park and several local parks and beaches are situated along this shoreline.

The Menominee State Forest is located adjacent to the shoreline in the northeastern portion of the county. The westerly boundary of the State forest is located six to seven miles from Green Bay. There is a Federal deep-draft navigation harbor at the city of Menominee, which is at the extreme southern end of the county. The city of Menominee also operates a large public harbor for recreational boats. In 1965, Congress authorized construction of an additional Federal small-boat harbor at Cedar River in the northern part of the county. This harbor has not yet been funded for construction.

7.3.2 Erosion and Flooding History

The Menominee County shoreline is generally subject to significant erosion damage only during extreme high lake stages accompanied by strong north- east winds. These conditions last occurred in 1951-52. The shoreline receives considerable protection from the Door County Peninsula, located 15 miles east across Green Bay. During the high water period 1951-52, much of the shoreline in Menominee County eroded from 5 to 20 feet. The average was about 10 feet. The erosion damages recorded during this period are summarized in the following Table 29. During the current high-water period there is apparently little active shore erosion and damage in this county.

There are no major erosion control structures along the Menominee County shoreline. A few minor protective measures, such as ripraping and small masonry seawalls, have been provided by individual property owners.

During the 1952 period of high lake levels, some flooding was reported along the river banks of the Menominee River. Flooding in that area begins when the level of Green Bay reaches elevation 579.8 feet, or about three feet above low water datum. A total of $3,600 in flooding damages was reported for this reach of the Menominee River in 1951-52.

Table 29

Total Damage to Shore Property on Lake Michigan – Menominee County, Michigan

Land Use	Damages, $ Actual 1951-52 Value	Damages, $ Updated 1970 Value
Private		
Residential	44,000	85,000
Industrial and commercial	3,000	5,800
Total, private property	47,000	90,800
Public		
Parks and beaches	2,400	5,500
Harbor installation	10,000	19,300
Total, public property	12,400	24,800
Total erosion damages	59,400	115,600

7.3.3 Solutions to Erosion Damages

The erosion problem along the Menominee County shoreline is not great enough to justify or require extensive protection of the shoreline.

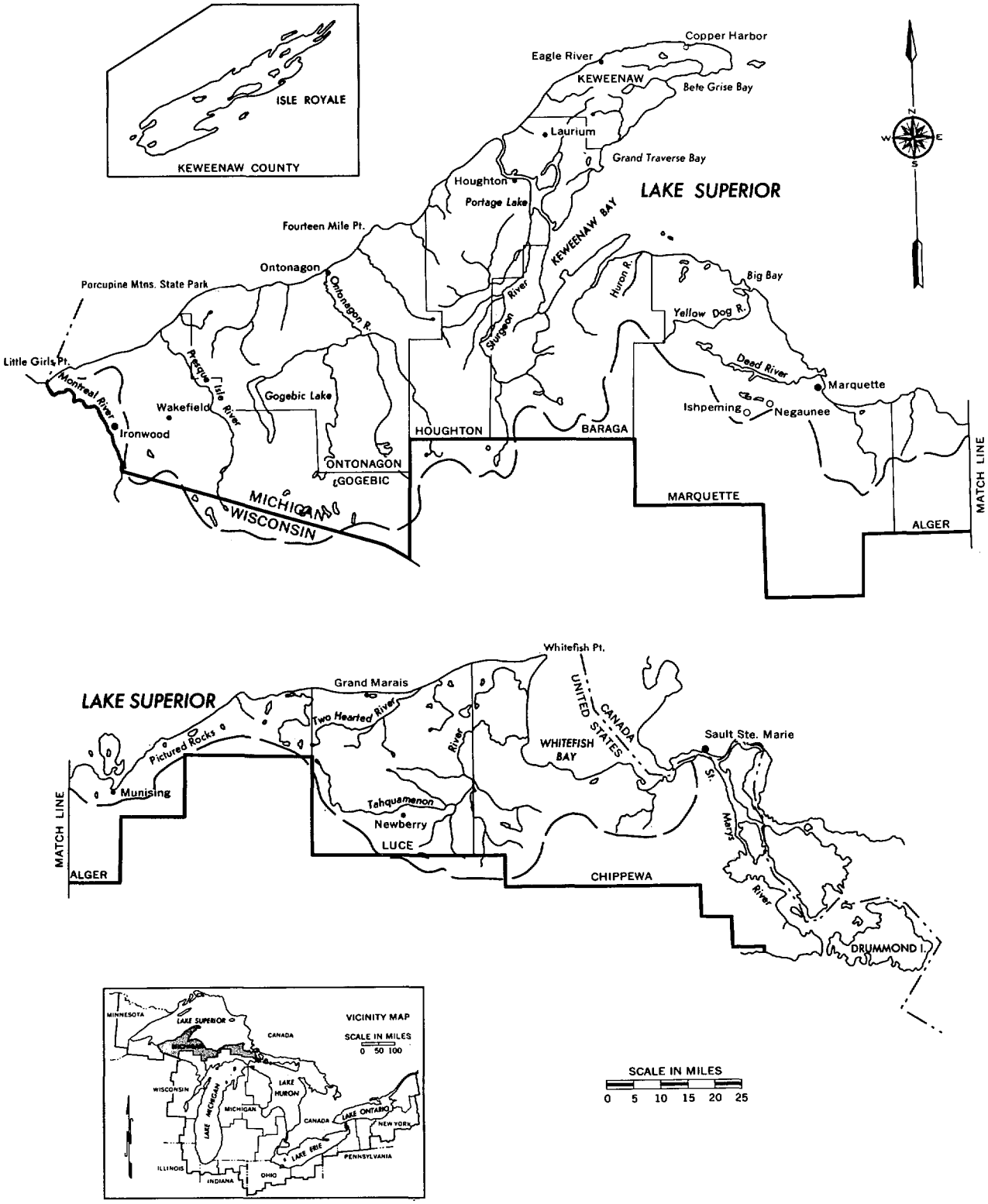


Figure 40. Lake Superior West Planning Subarea 1.2, Michigan.

7.4 The Eastern Lake Superior Planning Subarea 1.2

The Lake Superior Shoreline of Michigan located in planning subarea 1.2 extends from the Michigan-Wisconsin border at the mouth of the Montreal River to Brush Point in Chippewa County, a shoreline distance of 581 miles (Figure 40). The planning subarea also includes the Keweenaw waterway and Isle Royale, a large island located 50 miles northwest of the Keweenaw Peninsula. The information given in this report is generally limited to the mainland shoreline. This nine-county area has a population of 185,000 (1970). Larger communities located on the shoreline are Ontonagon, Marquette, Munising, and Sault Ste. Marie. Figures 41, 42, 43, and 44 and Table 30 present shoreline values, uses, ownership, and problem identification data for this mainland shoreline reach.

(Michigan Department of Natural Resources)

Photograph 26. The Pictured Rocks of Lake Superior, Alger County, Michigan.

7.4.1 Shoreline Description

Bordering and underlying much of Lake Superior and evident along the western and northern Upper Peninsula shoreline are outcrops of the earth's oldest and most stable land mass, the Canadian Shield. The eastern portion of the shoreline is generally underlain by sedimentary rocks, as evidenced by the Cambrian sandstones of the Pictured Rocks and the ledge rock of the Tahquamenon Falls.

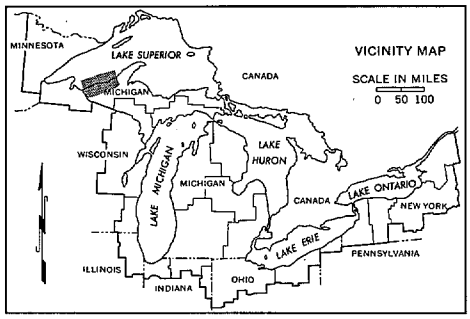
The shoreline is further characterized by the ragged rocky bluffs and occasional sand beaches along the western reaches and the collection of outcroppings along the tip of the Keweenaw Peninsula. There are also extensive sand beaches near the mouth of the Huron River in northern Marquette County, along a 13-mile reach east of the city of Marquette, and along a 12-mile continuous reach in the Pictured Rocks area. Other outstanding shoreline features are the 15 shoreline miles of multicolored sandstone cliffs in the Pictured Rocks area and the 5 shoreline miles of the towering Grand Sable sand dunes located west of Grand Marais, Michigan.

Bank heights along rocky sections of the Michigan portion of the Lake Superior shoreline vary from 15 to 80 feet along the rock and clay bluffs of Porcupine Mountain State Park; from 6 to 160 feet along the steep bluffs of the northern Keweenaw Peninsula; from 8 to 40 feet along the vertical cliffs on the southeastern shore of the Keweenaw Peninsula; from 10 to 100 feet along the steep rocky bluffs of northern Marquette County; and from 50 to 200 feet along precipitous sandstone cliffs on the Pictured Rocks reach.

Table 30

Shoreline of the Great Lakes — Gogebic County to Chippewa County, Michigan

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public		Private	Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal		Critical	Noncritical			
Economic Uses											
Residential	72.8	12.5		0	0	72.8	4.5	4.0	2.0	0	62.3
Industrial and commercial	9.2	1.6		0	0	9.2	0	0.1	0.9	0	8.2
Agricultural and undeveloped	21.2	3.7		0	0	21.2	0	3.0	0.7	0	17.5
Commercial harbors											
Electric power sites											
Public buildings and related lands	5.4	0.9		1.0	4.4	0	0	0.2	0	0	5.2
Recreational Uses											
Parks	42.3	7.3		0	42.3	0	1.3	2.2	0	0	38.8
Recreational boat harbors											
Beach zone	(347.0)	(59.7)		(13.0)	(32.8)	(301.2)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	429.9	74.0		14.7	5.8	409.1	9.1	14.0	1.3	0	405.5
Total	580.8	100.0		15.7	52.5	512.6	14.9	23.5	4.9	0	537.5



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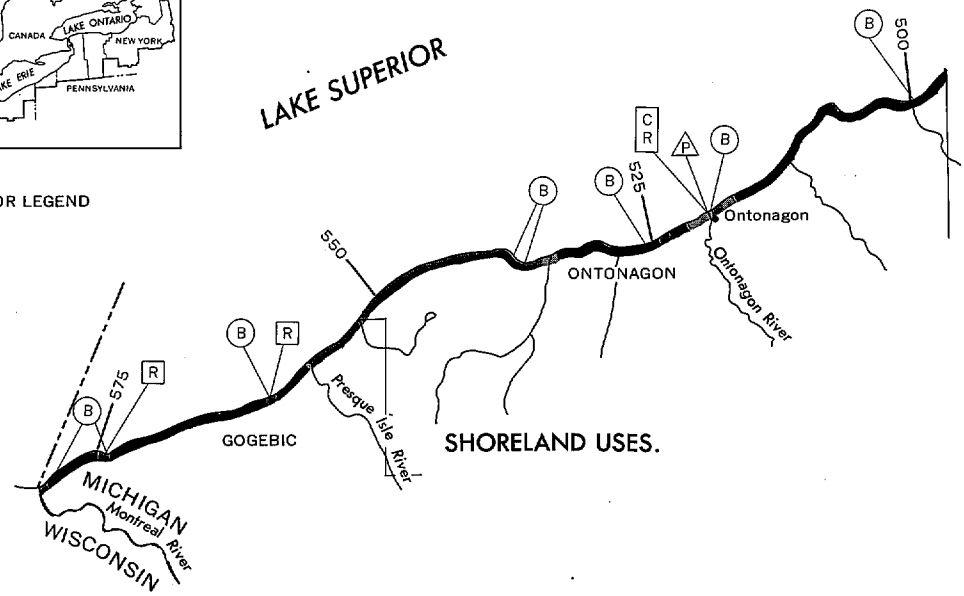
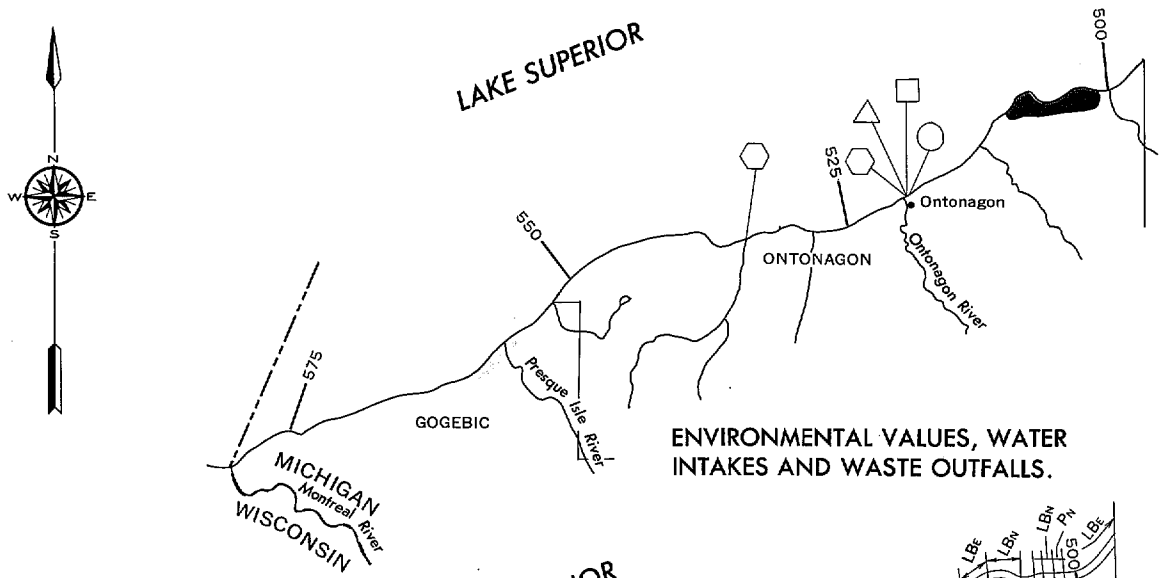
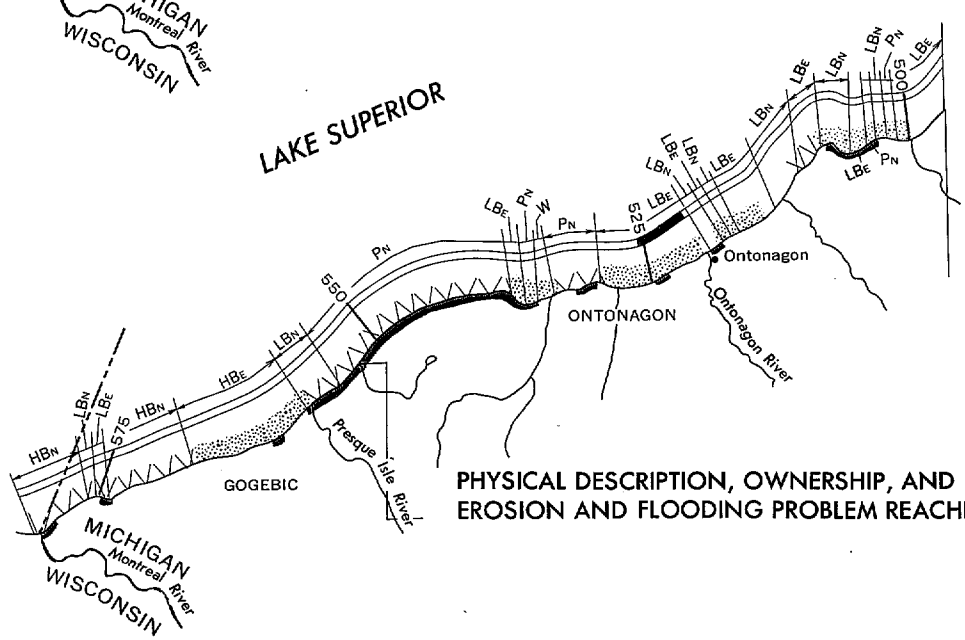


SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

Figure 41. SHORELANDS OF THE GREAT LAKES, ONTONAGON, GOGEBIC COUNTIES.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors (C)
- Recreational Harbors (R)
- Commercial Deep Draft and Recreational Harbors (C R)
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites
- Waste Water Outfalls and Intakes
  - Public Outfalls
  - Public Intakes
  - Private Outfalls
  - Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

Combinations Shown As:	Example
Lakeward/Landward	W/P_E
Upper Bluff Material / Lower Bluff Material	HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)

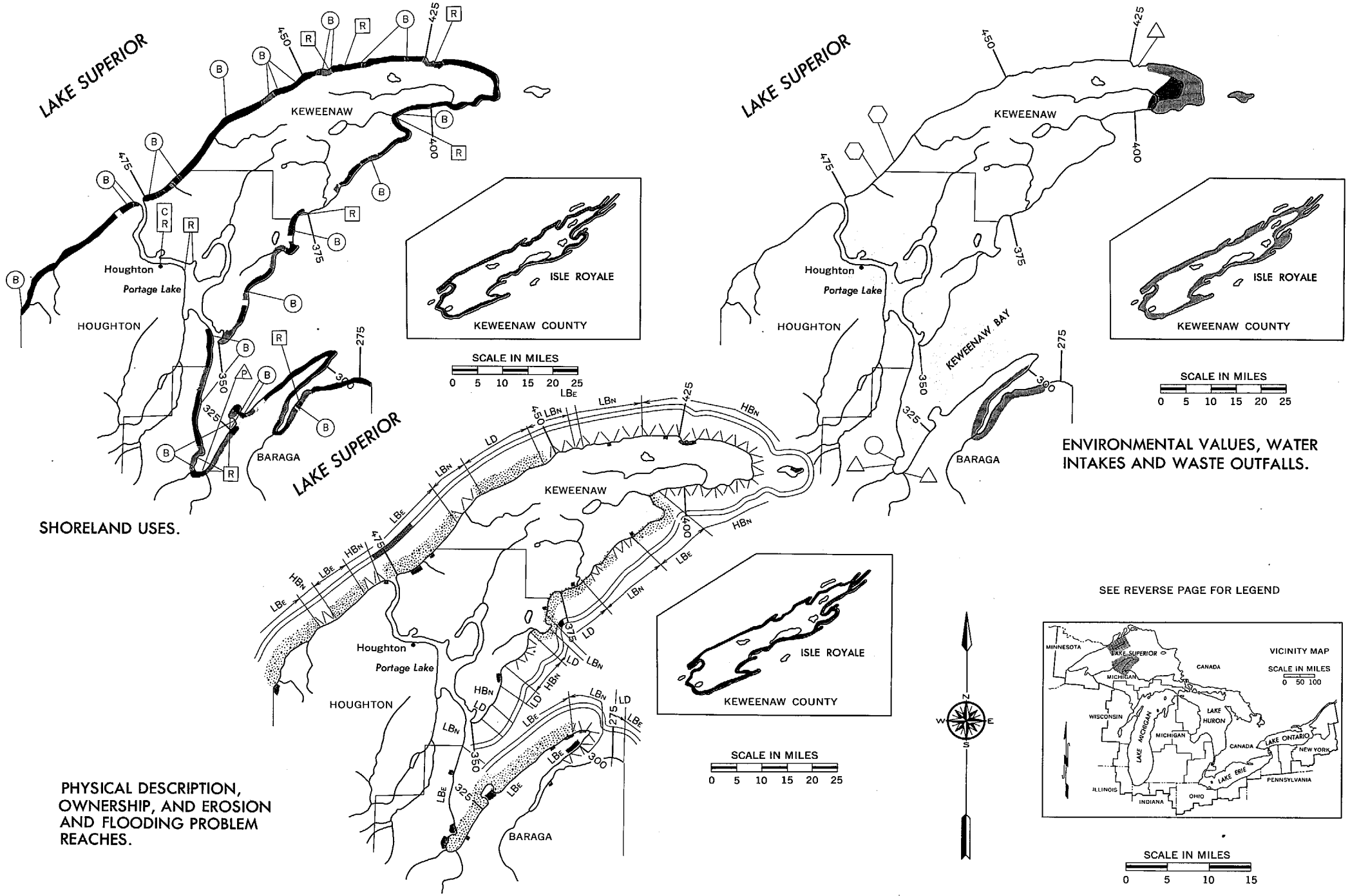


Figure 42. SHORELANDS OF THE GREAT LAKES, BARAGA, HOUGHTON, KEWEENAW COUNTIES.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors (C)
- Recreational Harbors (R)
- Commercial Deep Draft and Recreational Harbors (C R)
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

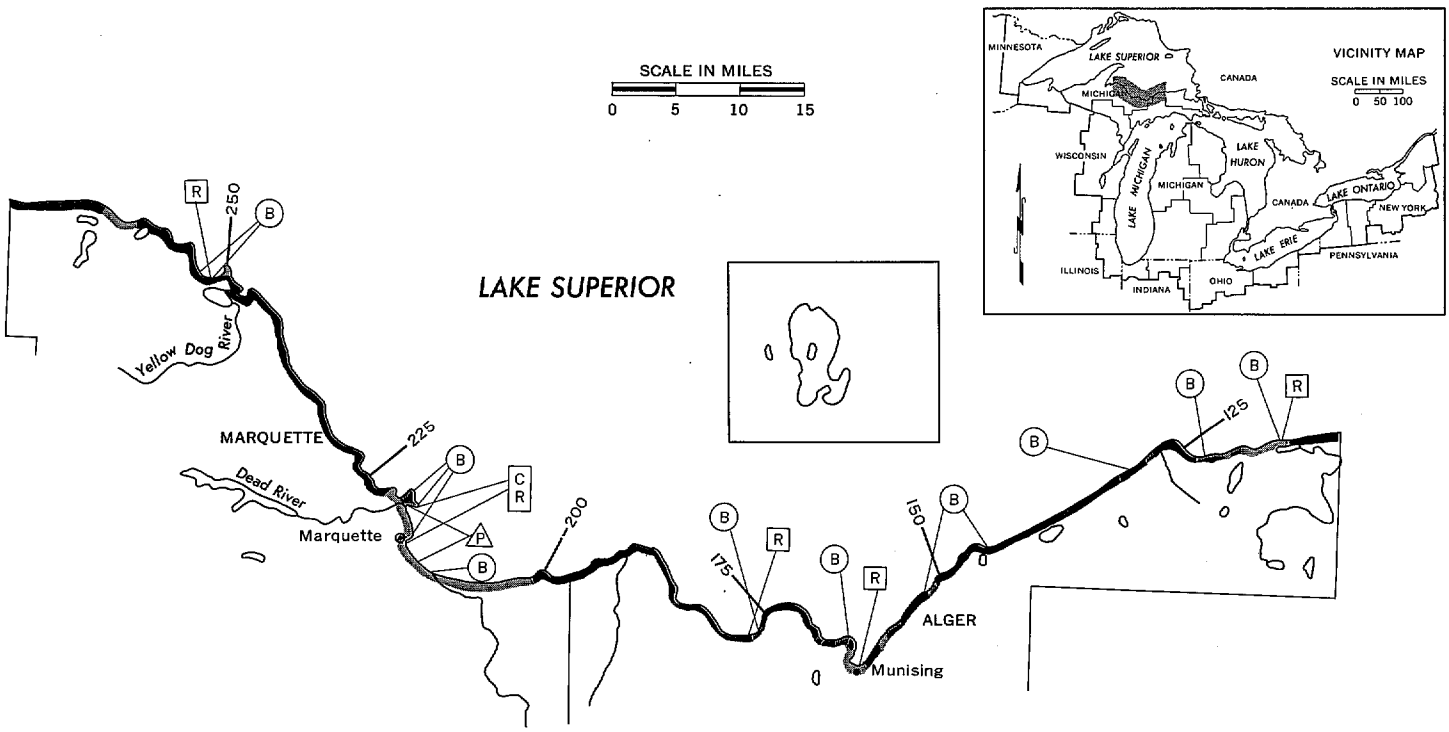
- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — HB_E / HB_N

Beach Material

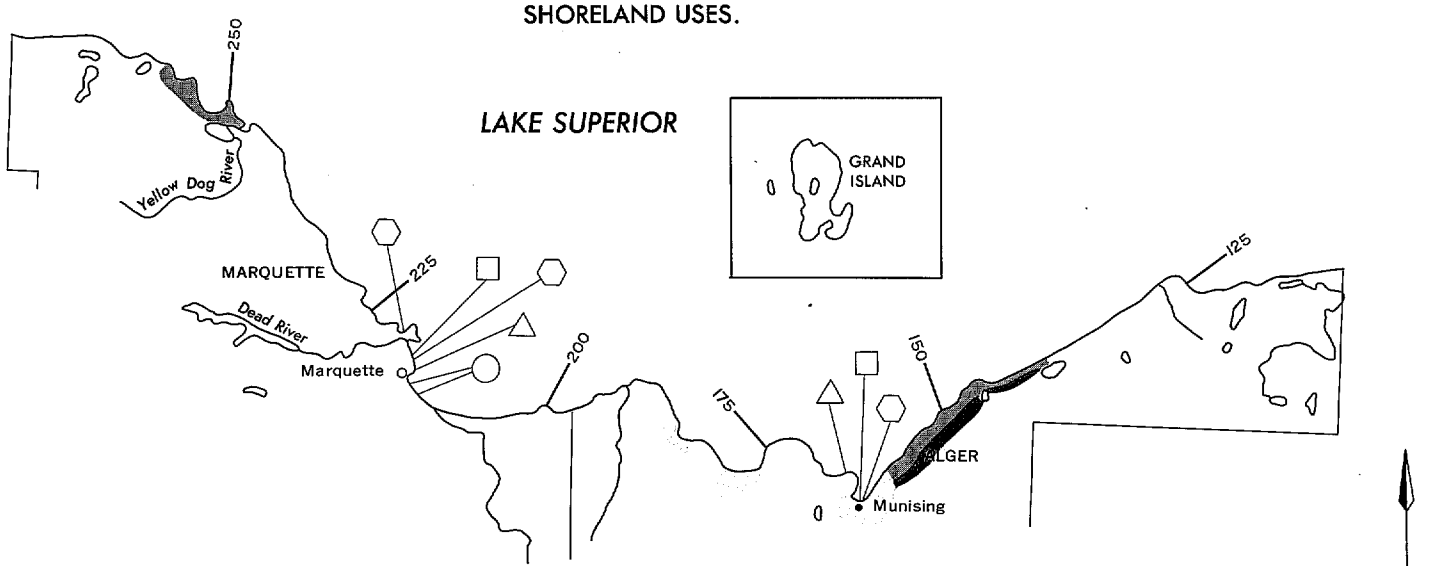
- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

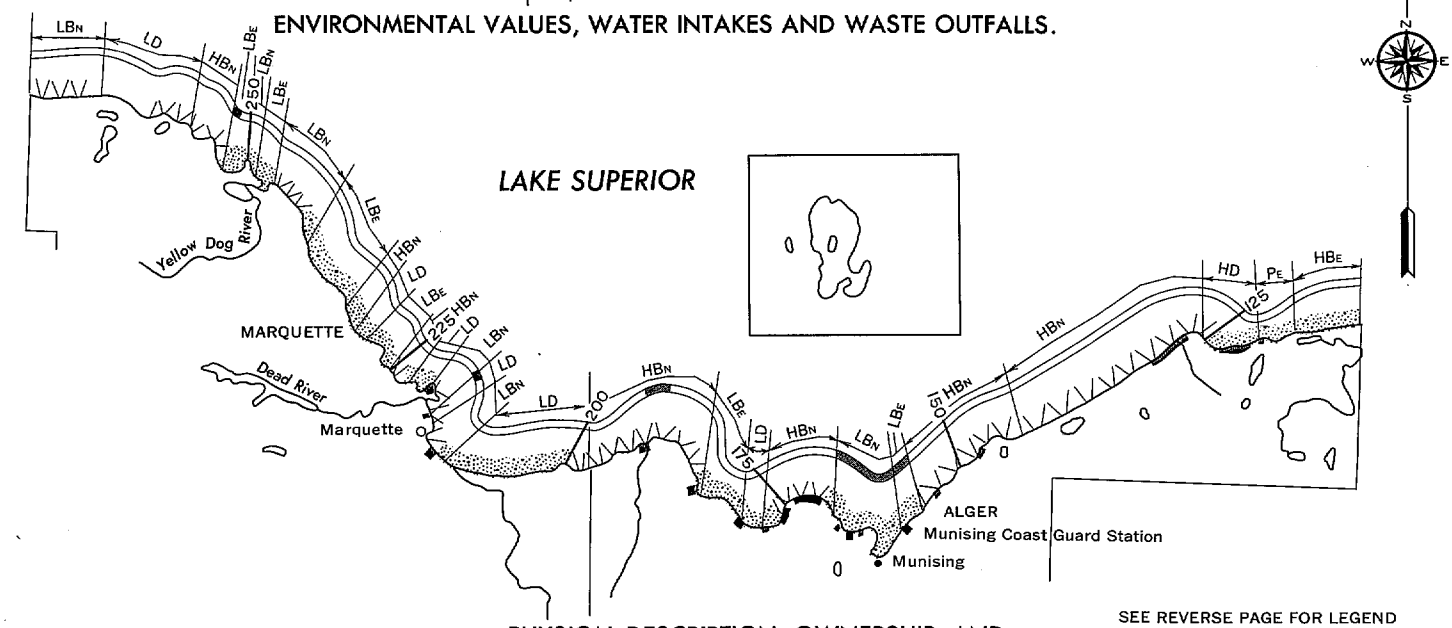
- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)



SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



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PHYSICAL DESCRIPTION, OWNERSHIP, AND
EROSION AND FLOODING PROBLEM REACHES.

Figure 43. SHORELANDS OF THE GREAT LAKES, MARQUETTE, ALGER COUNTIES.

LEGEND

SHORELAND USES

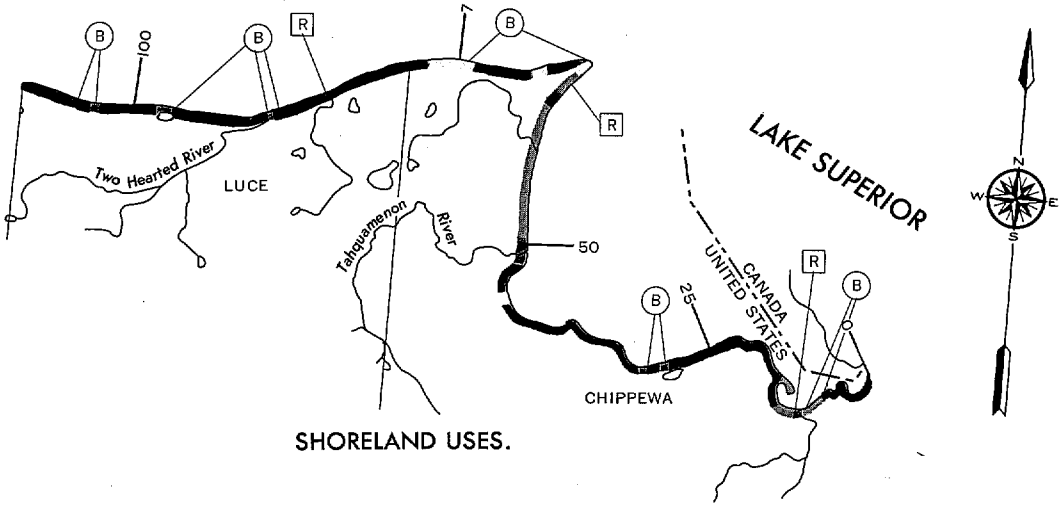
- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors (C)
- Recreational Harbors (R)
- Commercial Deep Draft and Recreational Harbors (C R)
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

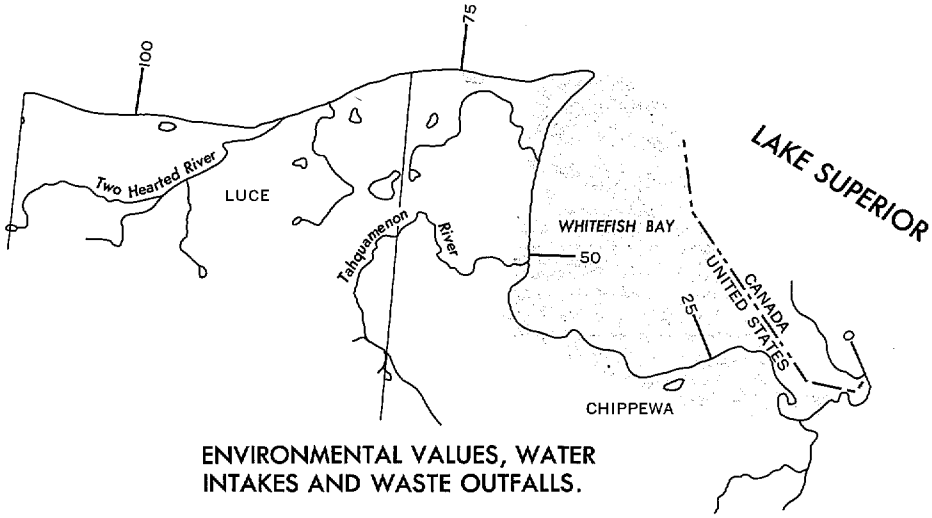
- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites
- Waste Water Outfalls and Intakes
  - Public Outfalls
  - Public Intakes
  - Private Outfalls
  - Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

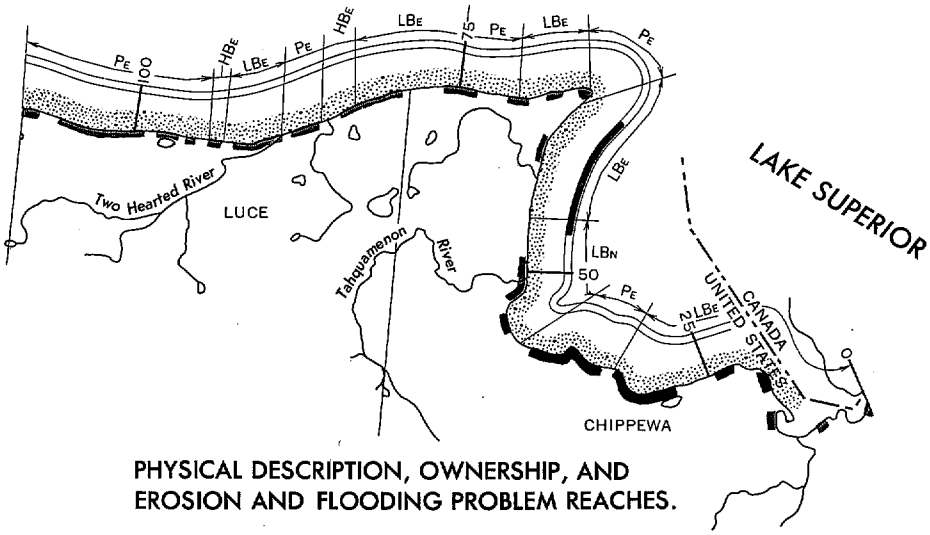
- Federal Lands
- Non-Federal Public Lands
- Private Lands
- Shore type
  - Artificial Fill Area — A
  - Erodible High Bluff, 30 ft. or higher — HB_E
  - Non-Erodible High Bluff, 30 ft. or higher — HB_N
  - Erodible Low Bluff, less than 30 ft. high — LB_E
  - Non-Erodible Low Bluff, less than 30 ft. high — LB_N
  - High Sand Dune, 30 ft. or higher — HD
  - Low Sand Dune, less than 30 ft. high — LD
  - Erodible Low Plain — P_E
  - Non-Erodible Low Plain — P_N
  - Wetlands — W
  - Combinations Shown As: Example
    - Lakeward/Landward — W/P_E
    - Upper Bluff Material / Lower Bluff Material — HB_E/HB_N
- Beach Material
  - Sand and gravel
  - Ledge rock
  - No Beach
- Problem Identification
  - Areas subject to erosion generally protected
  - Critical erosion areas not protected
  - Non-critical erosion areas not protected
  - Shoreline subject to lake flooding
  - Shoreline not subject to erosion or flooding
  - Bluff seepage problems (S)



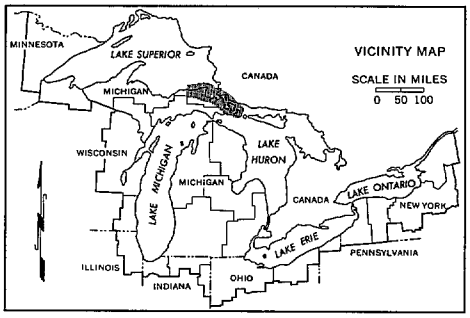
SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.



SCALE IN MILES

0 5 10 15

SEE REVERSE PAGE FOR LEGEND

Figure 44. SHORELANDS OF THE GREAT LAKES, CHIPPEWA, LUCE COUNTIES.

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings

Recreational and Urban Open Space

Agricultural and Undeveloped

Forest

Public Beaches — B

Commercial Deep Draft Harbors — C

Recreational Harbors — R

Commercial Deep Draft and Recreational Harbors — C R

Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values

Unique Ecological or Natural Areas

Outstanding Shoreland Areas of Possible National Interest

Potential Recreation Sites

Waste Water Outfalls and Intakes

Public Outfalls

Public Intakes

Private Outfalls

Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands

Non-Federal Public Lands

Private Lands

Shore type

Artificial Fill Area — A

Erodible High Bluff, 30 ft. or higher — HB_E

Non-Erodible High Bluff, 30 ft. or higher — HB_N

Erodible Low Bluff, less than 30 ft. high — LB_E

Non-Erodible Low Bluff, less than 30 ft. high — LB_N

High Sand Dune, 30 ft. or higher — HD

Low Sand Dune, less than 30 ft. high — LD

Erodible Low Plain — P_E

Non-Erodible Low Plain — P_N

Wetlands — W

Combinations Shown As: Example

Lakeward/Landward — W/P_E

Upper Bluff Material / Lower Bluff Material — HB_E/HB_N

Beach Material

Sand and gravel

Ledge rock

No Beach

Problem Identification

Areas subject to erosion generally protected

Critical erosion areas not protected

Non-critical erosion areas not protected

Shoreline subject to lake flooding

Shoreline not subject to erosion or flooding

Bluff seepage problems — S

Typical bank heights along the sandbank reaches vary from 6 to 10 feet along much of Ontonagon County; from 10 to 20 feet along Grand Traverse Bay; from 3 to 4 feet at the tip of Keweenaw Bay; from 5 to 8 feet along the northerly Marquette County shoreline; and up to 200 feet in the sand dunes located west of Grand Marais, Michigan. Beach widths vary from submerged shingle rock beaches to no beach along the rocky bluffs; from 10 to 90 feet along the sand and gravel beaches along Ontonagon County; and from 30- to 40-foot wide beaches of the eastern Marquette County shoreline. Beach slopes vary from flat beach to about 30 percent along sections of rock outcroppings.

The present distribution of shoreland use and ownership is given in Figure 45. Approximately 68 miles, or about 12 percent, of the shoreline are publicly owned. Since 1952, residential shoreline use has increased three percent. There has been a corresponding decrease in the length of agricultural and undeveloped shoreline. Public ownership of shorelands has increased about six percent since 1952 through the acquisition of park lands by the State of Michigan and local governmental units.

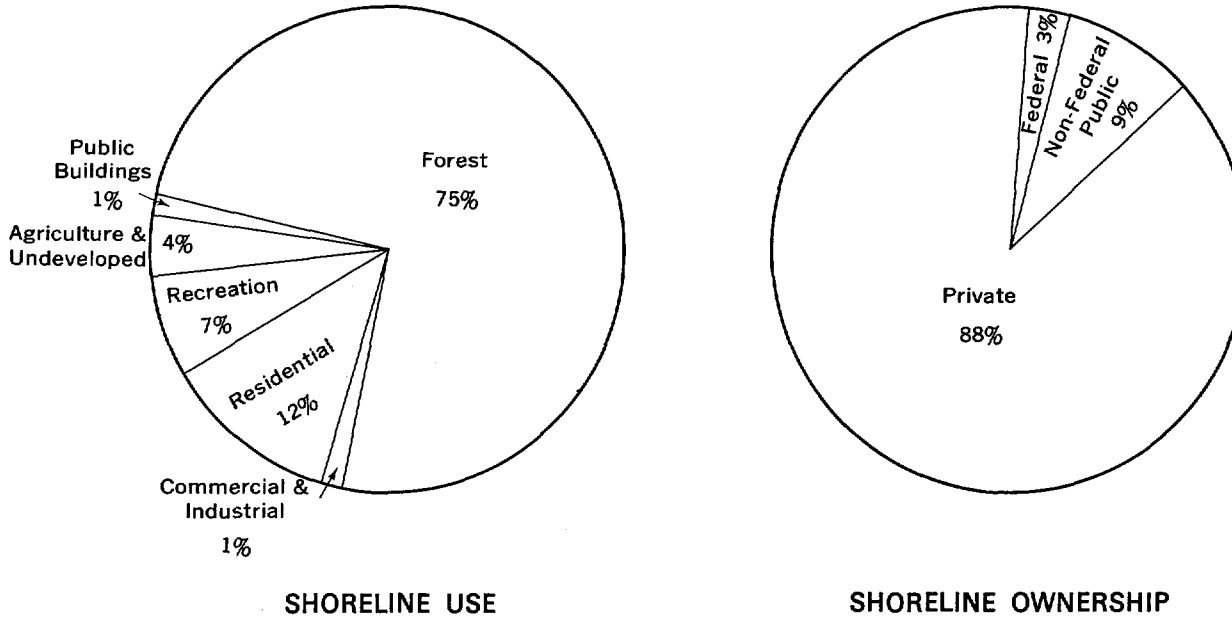


Figure 45. Distribution of Shoreline Use and Ownership, Gogebic County to Chippewa County, Michigan.

Many reaches of the Michigan portion of the Lake Superior shoreline are considered to possess excellent recreational value. Some of these reaches that deserve future study and possible preservation are: a 11.5-mile reach at Fourteen-Mile Point in northeastern Ontonagon County (miles 497.5-509); the northern tip of the Keweenaw Peninsula, including Manitou Island (miles 390-421); a 22-mile reach of shoreline extending westerly from Big Bay, Michigan (miles 254-276); the Pictured Rocks area (miles 121-157); Vermillion Beach extending eight miles west from Whitefish Point (miles 65-73); and a three-mile reach of sand beach along the western side of Whitefish Bay (miles 57-60).

Areas of unique ecological interest include Isle Royale, the northern tip of the Keweenaw Peninsula, including Manitou Island, the Huron Mountains shorelands in northern Marquette County, and the Pictured Rocks area. Important habitats in estuary waters include Bete Grise Bay in Keweenaw County, several bays on Isle Royale, the Sucker River mouth at Grand Marais (mile 117), the bay between Grand Island and the mainland near Munising, Au Train and Shelter Bays, the Presque Isle - Marquette offshore area, Copper Harbor (mile 421) and the mouth of Eagle River (mile 455) in Keweenaw County.

Several areas along the shoreline are considered to be prime lake trout and coho salmon sport fishing areas. The more important ones include Whitefish Bay, Keweenaw Bay, the Black River mouth, the Presque Isle - Marquette area, and the Pictured Rocks area. The Portage Channel marsh area has been proposed as a State waterfowl area.

The Michigan Lake Superior offshore waters are considered to be generally of excellent quality. Local pollution problems are for the most part, confined to places where there are industrial sewer outfalls. Pollution problems have been reported at Ontonagon, the Marquette area, and Whitefish Bay. Reduced water quality at Ontonagon is caused by sewage from an industrial plant and the clay-laden waters of the Ontonagon River.

There are seven State parks, three State roadside parks, and at least 21 county, township, or other local parks with frontage on Lake Superior. Isle Royale National Park is the only National park in Michigan with frontage on Lake Superior. Two National forests, the Ottawa and Hiawatha, and seven State forests front on the shoreline. The proposed Pictured Rocks National Lakeshore fronts along 38 miles of the Alger County shoreline. Federal deep-draft commercial harbors are located at Ontonagon and Marquette, Michigan. Federal small-boat refuge harbors are located at Black River, Eagle Harbor, Lac LaBelle, Grand Traverse Bay, Big Bay, Grand Marais, Little Lake, and Whitefish Point, Michigan. Non-Federal small-boat harbors (or marinas) are located at Little Girls Point, Ontonagon, Copper Harbor, Hancock, L'Anse, Marquette, the Chocolay and Au Train rivers, and Munising, Michigan. An electric power generating station is located at Marquette, Michigan.

7.4.2 Erosion and Flooding History

The maximum monthly Lake Superior level during the 1951-52 high-water period was elevation 601.0 (IGLD) recorded in October 1951. Damages recorded along the Michigan shoreline during the 1951-52 high-water period are updated to April 1970 price levels, and the damages that occurred in 1968 are summarized in Table 31.

Erosion problems along the shoreline are most severe during periods of high water and storms. The most shoreline damage occurred during the high-water periods of 1951-52 and 1968 and 1969. During the 1951-52 high-water period, up to 50 feet of shoreland were lost along some areas of the Ontonagon County shoreline.

Table 31

Total Damage to Shore Property on Lake Superior — Gogebic, Ontonagon, Houghton, Keweenaw, Baraga, Marquette, Alger, Luce, and Chippewa Counties, Michigan

	Damages, $	
Land Use	*Actual 1951-52 Value*[a]	*Updated 1970 Value*
Private		
Residential	500,000	965,000
Industrial and commercial	339,000	652,000
Agricultural or undeveloped	130,000	136,000
Total, private property	969,000	1,753,000
Public		
Parks and beaches	59,000	136,000
Harbor installations	43,000	100,000
Utilities	187,000	431,000
Total, public property	289,000[b]	667,000
Total erosion damages	1,258,000	2,420,000

[a] Includes Keweenaw Waterway, Isle Royale, and 8 miles of St. Mary's River.

[b] Excludes $150,000 inundation damages to a highway embankment along the Keweenaw Waterway.

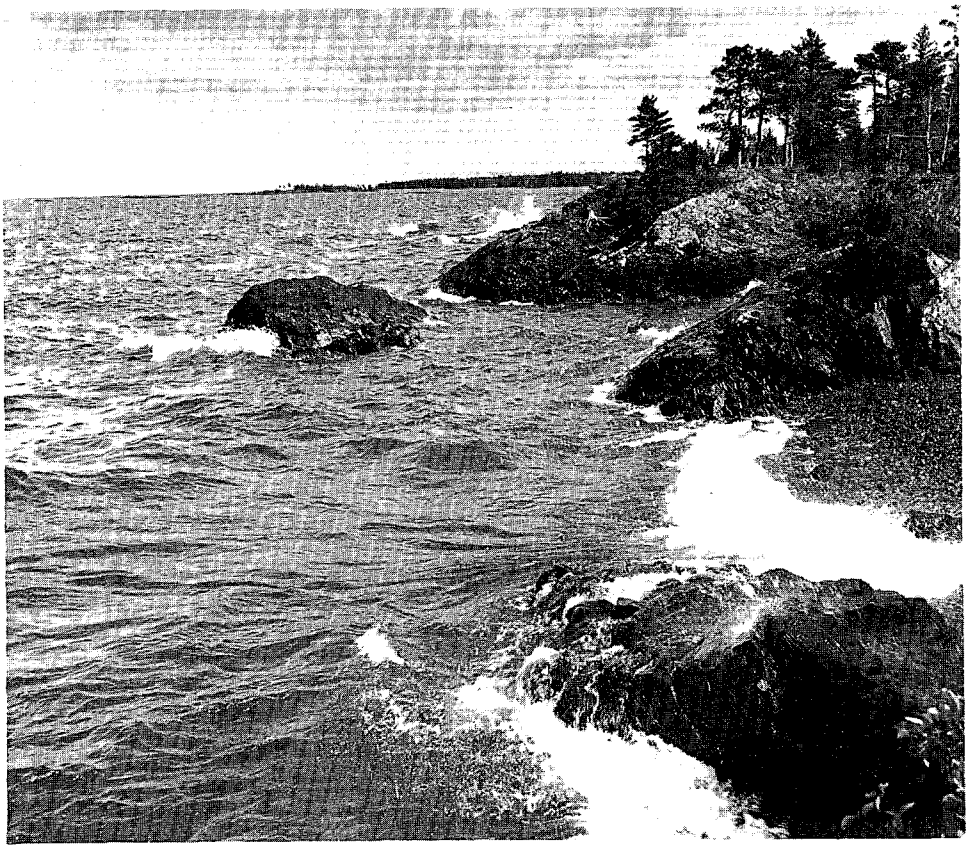
(Michigan Department of Natural Resources)

Photograph 27. The uncrowded beaches of Lake Superior offer the outdoors to people subject to the tensions of today's urban society.

About 100 homes and cabins along a 25-mile reach of Ontonagon County shoreline were destroyed or had to be moved. Considerable local erosion also occurred at Eagle Harbor, Bete Grise, Marquette, and sections of the Whitefish Bay shoreline. Erosion of the sand bank reaches during this period was about four feet per year. Prior to 1951, erosion along a short reach just east of Grand Marais Harbor averaged about 10 feet per year. This erosion rate increased to 20 feet per year during 1951 and 1952. Other damages reported included damages to a highway and railroad at Marquette and the loss or necessary removal of homes along many sections of the shoreline. Flood damage of $150,000 to a highway embankment in the Chassell reach of the Keweenaw Waterway was also reported.

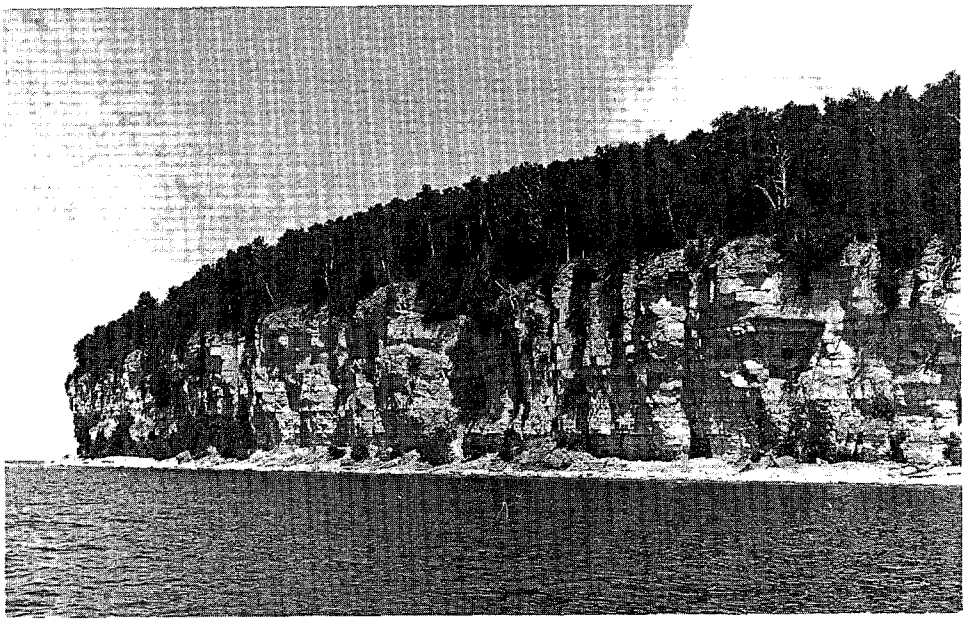
The most serious erosion that occurred in 1968 was along the sand bank reaches. The average erosion in these areas was about 4 feet per year and up to 50 feet of shoreland were lost along some sections of the Ontonagon County shoreline. Significant erosion damage to highway embankments was reported at Cat Harbor (near Eagle Harbor), Cedar Bay, Grand Traverse Bay, and near the eastern end of the Porcupine Mountain State Park. Damages to residential properties occurred at Ontonagon, Little Girls Point, Grand Traverse Bay, along the Keweenaw Waterway at Chassell, Michigan, and along a reach between the Tahquamenon River and Whitefish Point. Maximum lake level during this period was elevation 601.85 (IGLD), as recorded near Ontonagon, Michigan.

Flooding of shorelands during the 1968 high-water period caused substantial damages in the Keweenaw Bay Area and along portions of the Keweenaw Waterway. These damages were caused by seiche action affecting the high lake level. About 15 residences and 5 commercial establishments were affected in the Baraga area, and there was damage to several residential and commercial structures in the Portage Lake (Keweenaw Waterway) area. The seiche action in the Baraga-L'Anse area also caused erosion damages to an industrial plant and marina at L'Anse. Total flood damages during the 1968 high-water period amount to $54,000.



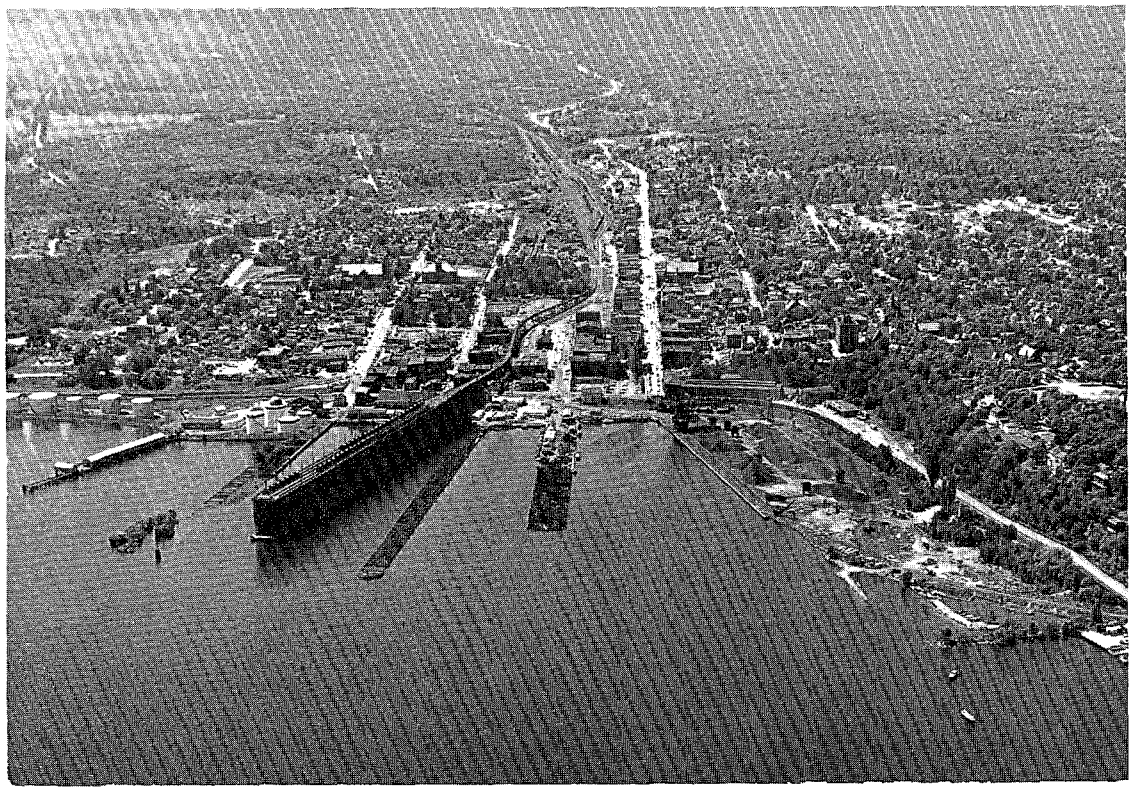
(Michigan Department of Natural Resources)

Photograph 28. Non-erodible-low bluff shoreline typical of the Lake Superior Shoreline in Michigan.



(Michigan Department of Natural Resources)

Photograph 29. Non-erodible-high bluff shoreline in the Pictured Rocks area in Alger County, Michigan.



Photograph 30. Commercial use of the Lake Superior Shoreline in Marquette, Michigan.

7.4.3 Solution to Erosion Damages

There are no major adjoining protective structures along the Michigan Lake Superior Shoreline. Private residential and commercial interests have constructed seawalls of various designs and materials along many sections of the shoreline. These local structures are generally from 100 to 300 feet long. Short groins from 10 to 50 feet long have been attempted in various places. Generally, these local measures have not been effective in preventing erosion damage. The short seawalls are threatened by undermining and lack the support of similar construction on adjoining property. If they are not destroyed, they soon become isolated headlands open to destruction from the flanks. Locally constructed groins commonly suffer from a lack of toe protection against scour, which ultimately leads to their failure. The longer erosion protections are generally built to protect highway embankments paralleling the shoreline. Such protections include a 1000-foot-long random stone seawall along the Porcupine Mountain State Park at Union Bay, a 200-foot-long section of random stone immediately east of the Big Bay small-boat harbor, and a 3,600-foot-long section of random stone seawall at Marquette, Michigan.

Approximately 14.9 miles of the unprotected Michigan Lake Superior Shoreline are subject to critical erosion. Another 23 miles of unprotected shoreline are subject to non-critical erosion. Erosion problems on this Michigan shoreline are generally the most severe along the sandy bank reaches. Critical erosion areas have been identified along a 3.2-mile reach west of Ontonagon, along 0.6 mile of shoreline immediately south of Grand Traverse Bay Harbor, along 0.9 mile of public park at Marquette, Michigan, along a short reach immediately east of Big Bay Harbor, and along 9.7 miles of shoreline on the west shore of Whitefish Bay.

A protective beach and periodic nourishment to a height of eight feet above low water datum are considered practical for the erodible reach at Grand Traverse Bay, Marquette, and Big Bay. A combined protective beach and groin system and periodic nourishment are considered a solution to the erosion problem along the critically erodible Whitefish Bay reach.

Total estimated first costs of the shore protection discussed above for this Michigan shoreline are $8,720,000. Total annual beach nourishment costs are estimated at $40,000.

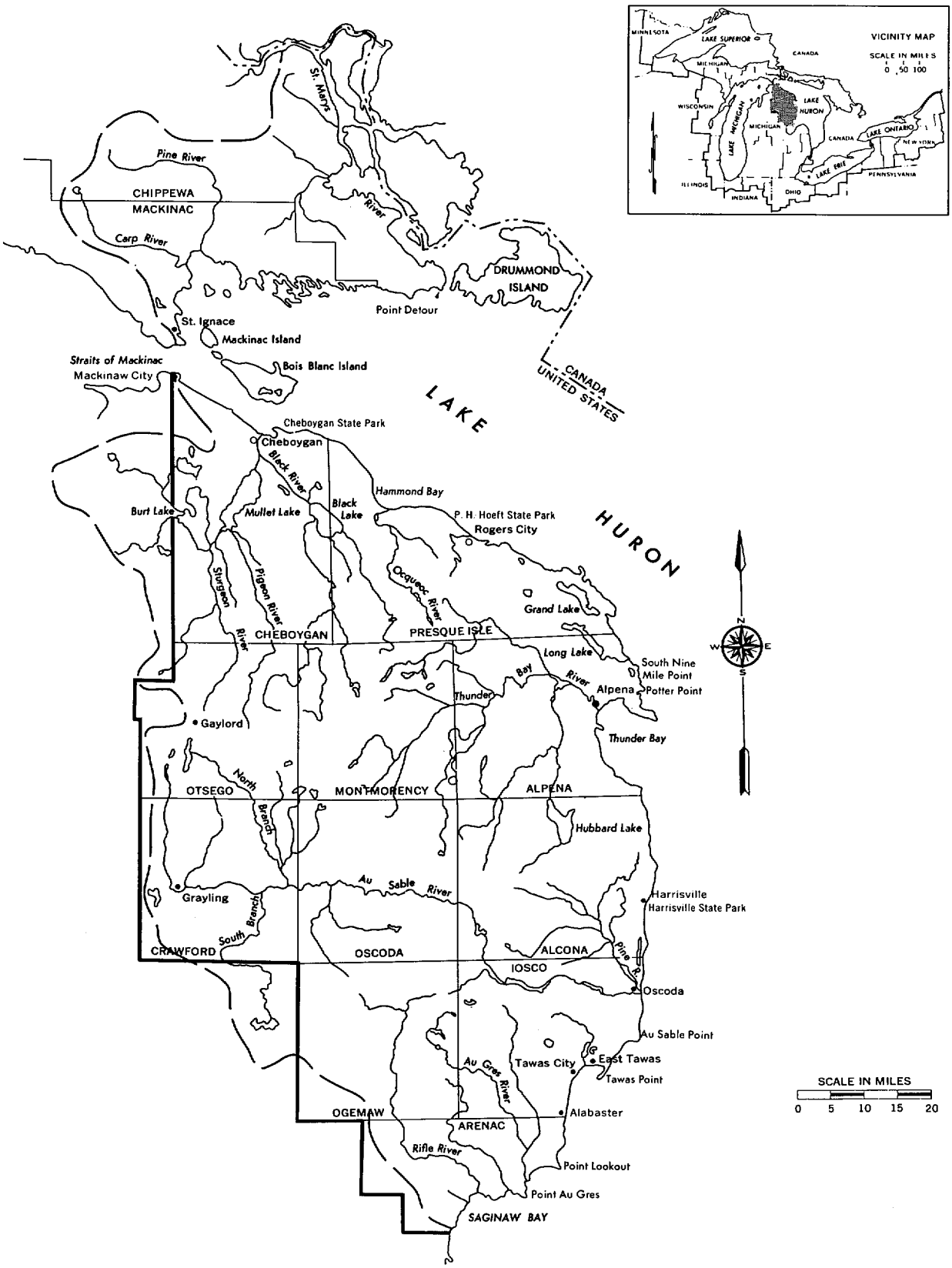


Figure 46. Lake Huron Planning Subarea 3.1, Michigan.

7.5 Lake Huron North Planning Subarea 3.1

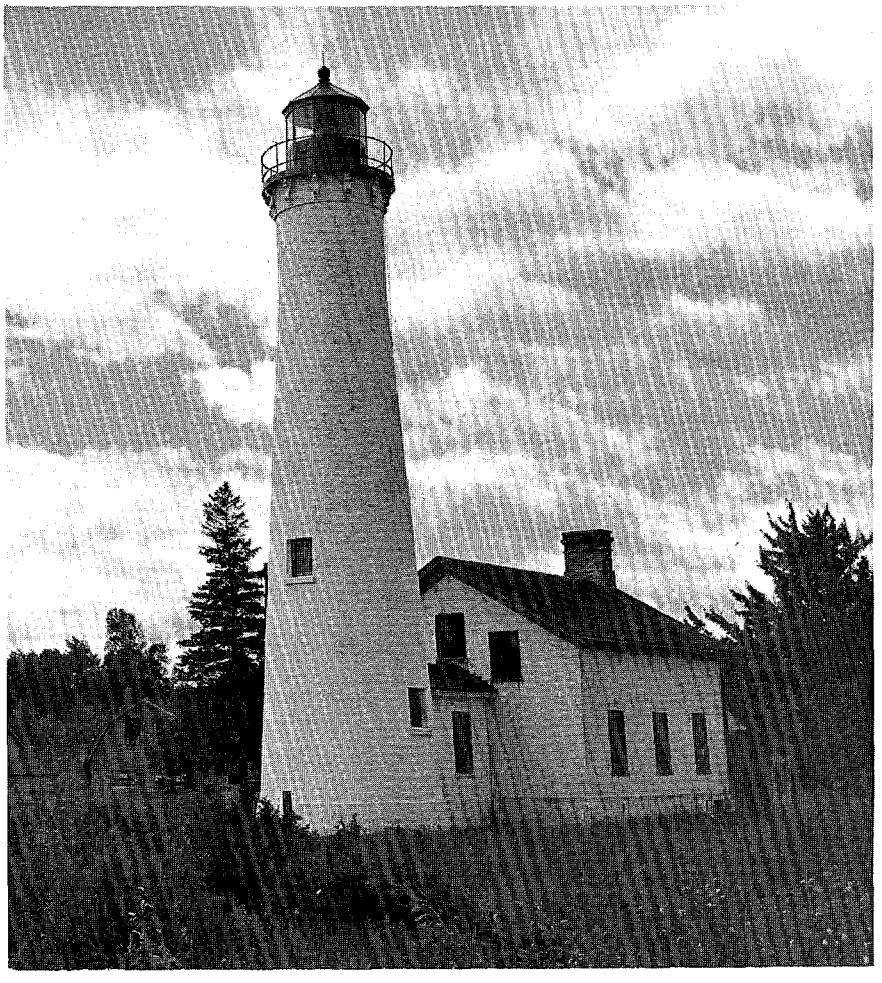
The Lake Huron Mainland Shoreline of Michigan in planning subarea 3.1 extends from the Straits of Mackinac to the Arenac County line, a shoreline distance of 263.3 miles (Figure 46). The 11-county area has a population of 137,000 (1970). Existing shoreline communities include Mackinaw City, Cheboygan, Rogers City, Alpena, Harrisville, Oscoda, East Tawas, Tawas City, Alabaster, and Au Gres.

The major drainage areas are Cheboygan River, Presque Isle Complex, Thunder Bay, Alcona Complex, Au Sable River, Rifle - Au Gres Complex, and Kawkawlin Complex.

Figures 47 and 48 and Table 32 present shoreline values, uses, ownership, and problem identification data for this mainland shoreline reach.

7.5.1 Shoreline Description

The Lake Huron shoreland from Mackinaw City to Harrisville is mainly a stone and boulder shore, with high bank beaches extending back into hills. From Harrisville to the southern part of Arenac County, the beaches are mostly sand, usually low, and with some high bluffs directly behind the beach. In that portion below Au Gres, the sand beaches are occasionally interrupted by marshes. In the rocky portion north of Harrisville, shore towns and settlements are widely separated by long, undeveloped, stretches of shoreline. Below here, the sandy beach areas are mostly used for summer cottages and resorts. Practically all the property in the reach is privately owned, though villages and towns own some property there. There are very few State or Federal lands along the shore, except for highway rights-of-way and a few State parks. The undeveloped and agricultural lands are gradually being converted to cottage and resort areas.



Photograph 31. Historic lighthouse on Sturgeon Point, Alcona County, Michigan.

Table 32

Shoreline of the Great Lakes – Sheboygan County to Arenac County, Michigan

Shoreland Use Category	*Existing Shoreland Use*			*Miles of Shoreline*			*Problem Identification, Miles of Shoreline*				
	Miles of Shoreline	*Percent of Total*	*Number of Sites*	*Public*		*Private*	*Subject to Erosion*		*Protected*	*Subject to Flooding*	*Not Subject to Erosion or Flooding*
				Federal	*Non-Federal*		*Critical*	*Noncritical*			
Economic Uses											
Residential	105.0	39.9		0	0	105.0	6.6	36.8	0	2.2	59.4
Industrial and commercial	9.7	3.7		0	0	9.7	0	2.7	0	0	7.0
Agricultural and undeveloped	29.0	11.0		0	0	29.0	1.2	18.6	0	1.5	7.7
Commercial harbors			5								
Electric power sites			1								
Public buildings and related lands	2.2	0.8		0	2.2	0	0	0.5	0	0	1.7
Recreational Uses											
Parks	18.9	7.2		0	18.9	0	0	0	0	0	18.9
Recreational boat harbors			12								
Beach zone	(130.0)	(49.4)		(0)	(10.3)	(119.7)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	98.5	37.4		0	3.2	95.3	0	4.3	0	3.5	90.7
Total	263.3	100.0		0	24.3	239.0	7.8	62.9	0	7.2	185.4

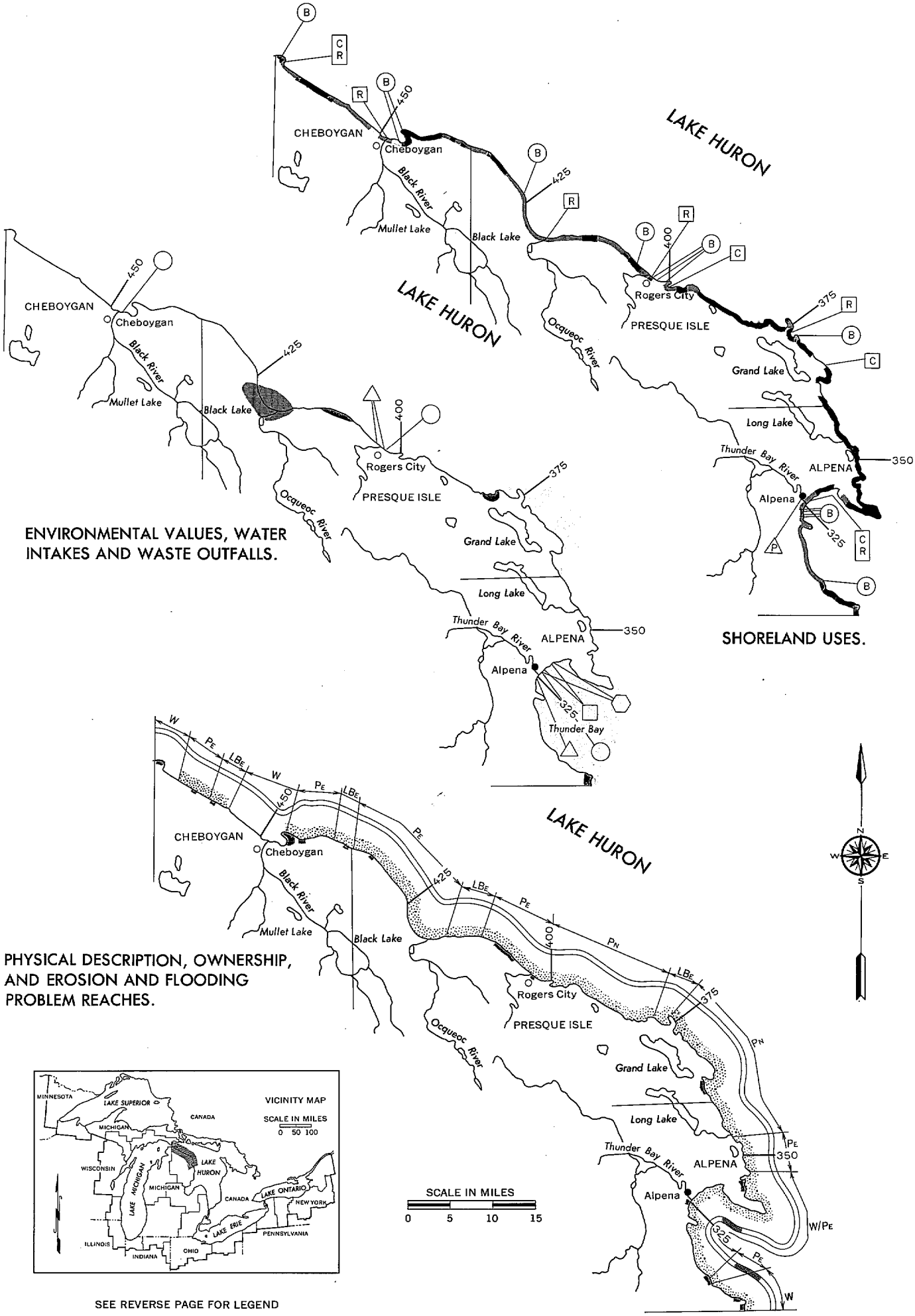


Figure 47. SHORELANDS OF THE GREAT LAKES, ALPENA, PRESQUE ISLE, CHEBOYGAN COUNTIES.

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings

Recreational and Urban Open Space

Agricultural and Undeveloped

Forest

Public Beaches (B)

Commercial Deep Draft Harbors [C]

Recreational Harbors [R]

Commercial Deep Draft and Recreational Harbors [C R]

Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values

Unique Ecological or Natural Areas

Outstanding Shoreland Areas of Possible National Interest

Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands

Non-Federal Public Lands

Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

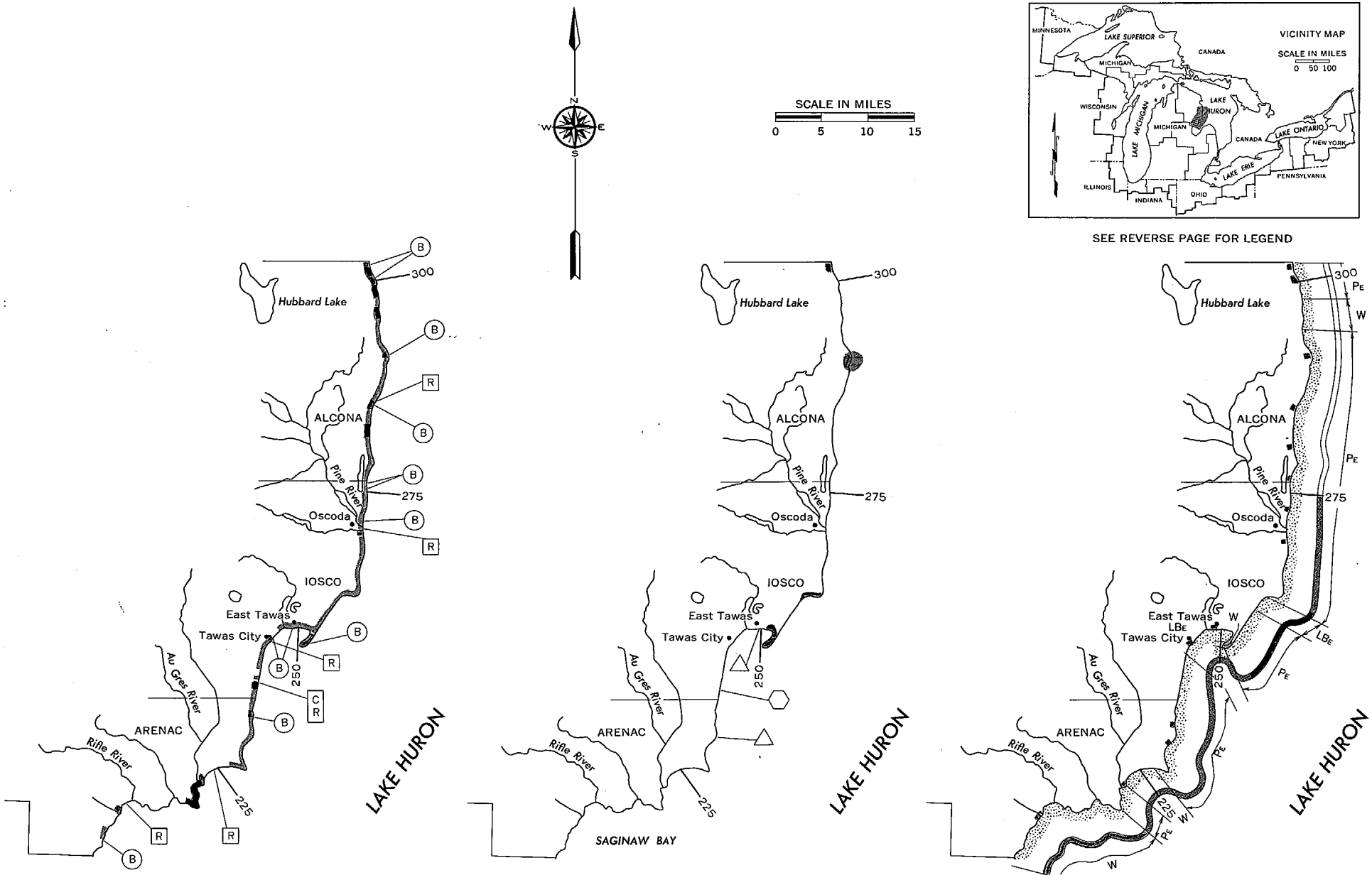
- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — HB_E/HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)



SHORELAND USES.

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

Figure 48. SHORELANDS OF THE GREAT LAKES, ARENAC, IOSCO, ALCONA COUNTIES.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors [C]
- Recreational Harbors [R]
- Commercial Deep Draft and Recreational Harbors [C R]
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)

The Cheboygan County shore is generally a low plain with several marshy reaches. The shoreline material, except for the marshy areas, is classified erodible. However, the shore is sheltered by Bois Blanc Island and is not generally subject to erosion damage. The Presque Isle County shoreline is quite similar to Cheboygan County shoreline from the county line south to Rogers City. The shoreline south of Rogers City is mostly low plain. There are extensive outcrops of limestone in the area, and so this reach of shoreline is considered non-erodible to a point in Alpena County about one mile north of South Nine-Mile Point. The next reach to Potter Point, a distance of approximately six miles, has a sand, erodible beach. From Potter Point south to the Alpena County line, the shoreline is marshy and not usually subject to erosion or flooding. Generally, the Alcona County shoreline is not subject to erosion or flooding, and is mainly a low plain, with about a five-mile marshy reach.

The Iosco County shoreline suffers from a considerable amount of erosion. From Alcona-Iosco County line southward to Au Sable Point, the shore is an erodible low plain and is subject to non-critical erosion. A critical erosion area is the shoreline from Au Sable Point southward for a distance of about eight miles to an area about one-half mile north of the Tawas Point State Park. The shore in this reach is an erodible low plain, with the exception of an area extending 1.8 miles from mile 258.4 to mile 260.2, which is classified as low-bluff erodible.

The Tawas Point State Park is an area where there has been considerable accretion. The area south of Tawas Point to Tawas City is generally protected by the Point from Lake Huron storms. Southward of Tawas City to Point Lookout in Arenac County, the shore is mainly marshy, with the exception of about three miles near Point Au Gres that are classified as erodible low plain. This shoreline is generally subject to erosion and has a few scattered protection works.

The present distribution of shoreline use and ownership is shown in Figure 49.

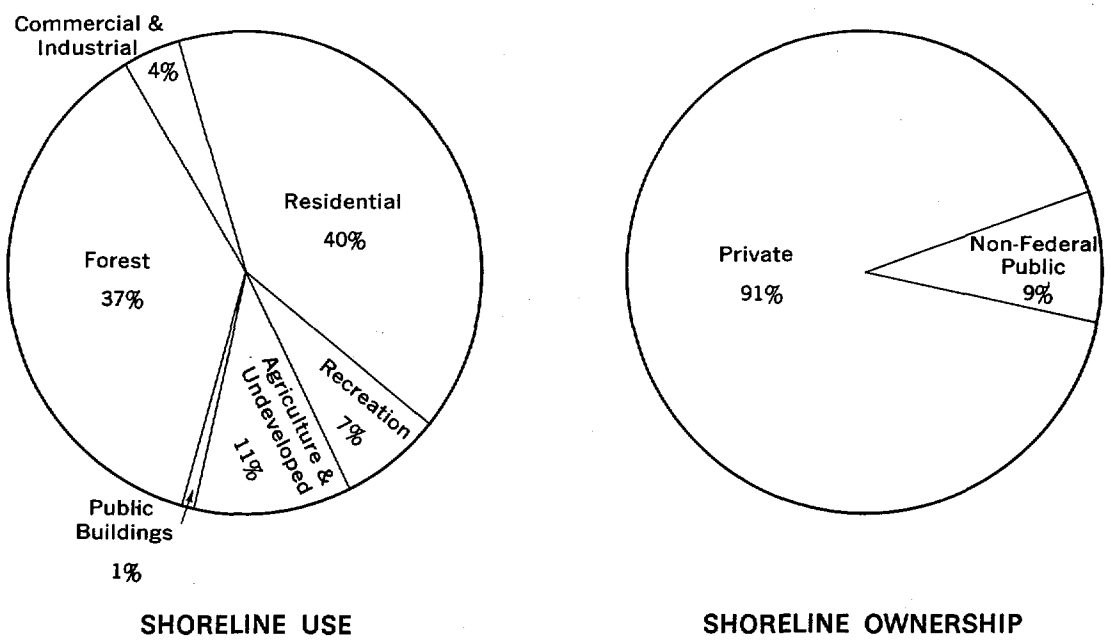


Figure 49. Distribution of Shoreline Use and Ownership, Cheboygan County to Arenac County, Michigan.

Lake Huron's recreational value is enhanced by the easily reached, low shoreline, with its sandy beaches bordered by shallow, offshore waters and islands. This region possesses a variety of lakefront sites suited to recreation and wildlife conservation. A number of these sites have already been recognized and set aside. Lake Huron, by virtue of the ready access provided by U. S. Highway 23, has had considerable private development. The level nature of the shore provides ideal sites for cottage construction. Because it is a lee shore, the general eastward movement of Great Lakes storms has carried their destruction power away from the western Huron beaches.

Recreational opportunities are provided by the Michigan State Parks located in this river basin group-Cheybogan State Park near Cheboygan, R. H. Hoeft State Park near Rogers City, Harrisville State Park near Harrisville, and the Tawas Point State Park near Tawas City. In addition, there are numerous county and township parks in this region.

There are Federal harbors at Cheboygan, Hammond Bay, Alpena, Harrisville, and Oscoda that provide mooring for about 880 recreational boats. The Corps of Engineers is studying seven additional small-boat harbors. Two of these harbors, Point Lookout and Tawas Bay, have been authorized.

7.5.2 Erosion and Flooding History

There is a general lack of data on erosion of the Lake Huron Shoreline. Aerial photographs are available. The earliest flights of the shoreline were made about 1938, but the quality of these photographs is such that only severe amounts of erosion, 30 feet or more between 1938 and the mid-1960's, can be determined by comparing photographs of various years. Shoreline erosion has been recorded during the period 1951-52 in the general areas indicated below:

The shoreline for a distance of about five miles south of Oscoda eroded an average of 20 feet.

The shore for a distance of about two miles east of Tawas City eroded an average of about 30 feet. A main highway is located along this shore and was damaged. At Tawas City, the shore eroded an average of 10 feet and also damaged the highway.

For a 10-mile reach to the north of Point Lookout, the average erosion was 30 to 40 feet. Also, a 3-mile reach south of Point Lookout eroded an average of 20 feet.

The 1952 damage data for Lake Huron are not available in sufficient detail to permit tabulation of the data by river basin groups.

Table 33 gives the damage data available for this planning subarea.

Table 33

Total Damage to Shore Property on Lake Huron – Straits of Mackinac to Bay City, Michigan

	Damages, $	
Land Use	*Actual 1951-52 Value*	*Updated 1970 Value*
Private		
Inundation (all property)	198,000	382,140
Commercial	52,000	100,360
Residential	557,800	1,076,554
Agricultural or undeveloped	201,000	211,050
Utilities	64,500	124,485
Total, private property	1,093,300	1,894,589
Public		
Inundation (all property)	23,000	44,580
Parks and beaches	18,000	41,580
Harbor installations	57,000	131,670
Utilities	45,000	103,950
Federal reservations	5,000	9,650
Total, public property	148,000	331,240
Total erosion damages	1,241,300	2,225,829

7.5.3 Solutions to Erosion Damages

The erosion problem along the Lake Huron shore in the upper part of the lower peninsula of Michigan does not seem to be critical enough to justify wide protection of the shoreline. However, an 7.8-mile stretch of shoreline in Iosco County, from Au Sable Point southward to just north of the Tawas Point State Park, has a critical erosion problem. Comparison of aerial photographs indicates that the shoreline along this stretch is receding an average of three feet per year. The most desirable method of shore protection would be revetments or construction of protective beaches. However, there is no detailed information on the littoral processes or amount of drift moving along the shoreline in the critical erosion area. Therefore, it is not known whether beaches could be developed naturally or would require artificial nourishment. An analysis of shore processes would be required in order to design a protective beach and groin system. Concrete or sheet pile bulkheads would also be effective in reducing erosion damage along this reach of shore. The cost of a protective beach and groin system for this reach of shoreline is about $6.2 million.

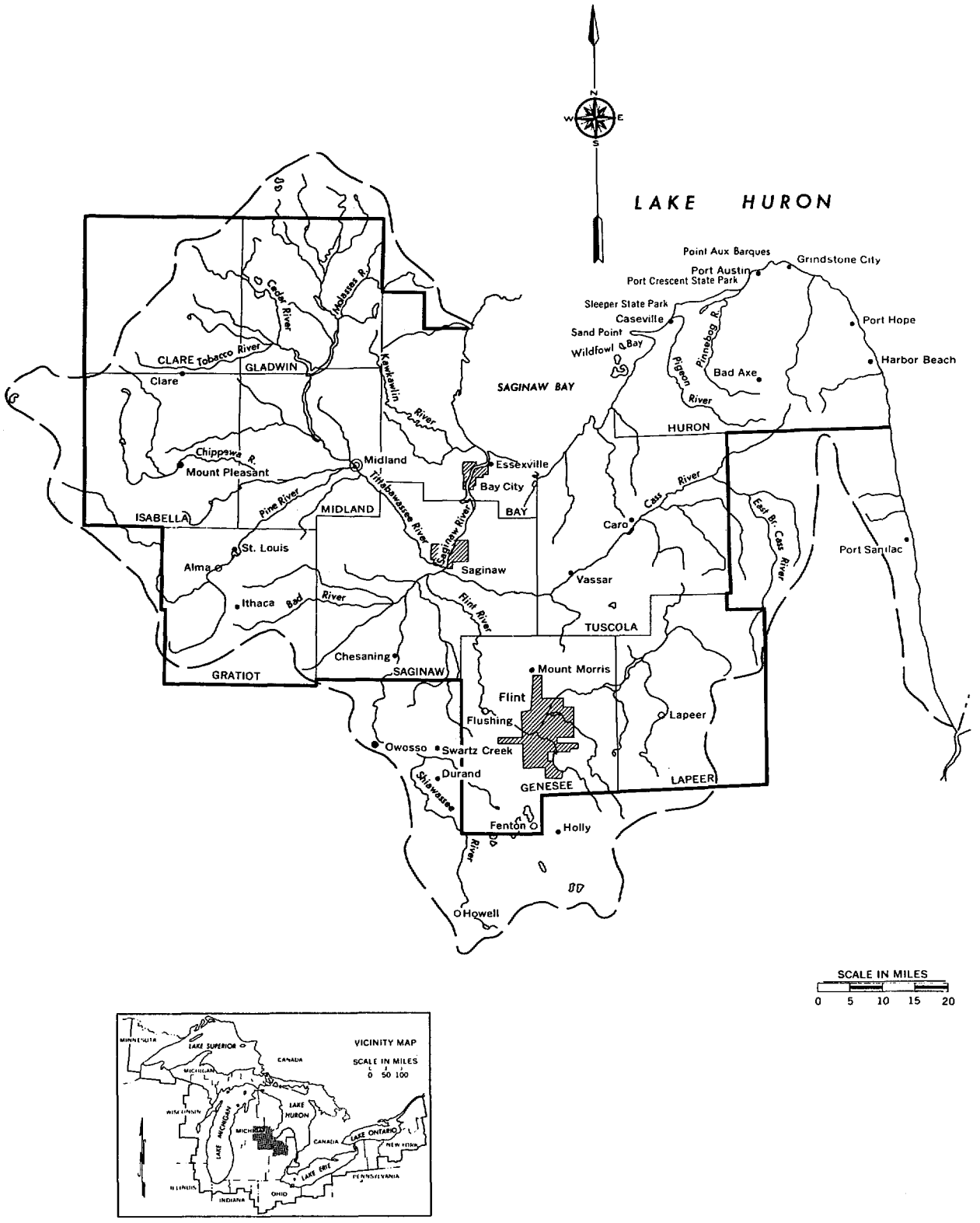


Figure 50. Lake Huron Central Planning Subarea 3.2, Michigan.

7.6 The Lake Huron Central Planning Subarea 3.2

The shoreline of Bay, Tuscola, Huron, and Sanilac counties is closely identified with planning subarea 3.2 (Figure 50). This 11-county area has a population of 1.08 million (1970). Existing communities on the shoreline include Essexville, Caseville, Port Austin, and Harbor Beach. Most of the population is concentrated in Saginaw and Bay City on the Saginaw River. The major drainage areas are the Saginaw River Basin, and the Thumb Complex. Table 34 and Figures 51 and 52 present shoreline values, uses, ownership, and problem identification data for this mainland shoreline reach.

7.6.1 Shoreline Description

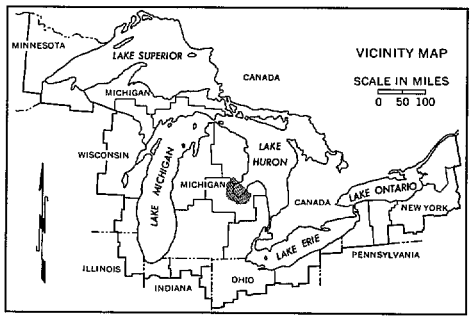
The Lake Huron Shoreline in northern Bay County is composed of beaches that are mostly sand, occasionally interrupted by marshes. Much of the southeastern side of Saginaw Bay is marshy, with shallow water inshore and without a noticeable bluff. Sand Point is a long narrow peninsula that juts westward into Saginaw Bay and forms the northern limit of Wildfowl Bay. From Sand Point to a point between Port Austin and Pointe Aux Barques, the shore is comprised of sand beaches, with generally shallow water inshore and a bluff of uneven sand ridges, some of which extend to 25 feet above the water. In the vicinity of Port Austin, there are outcroppings of bedrock at the bluff line. Deep water extends closer to shore in the vicinity of Port Austin, but the lake bed in this area contains several rocky reefs. From Pointe Aux Barques to a point eastward of Grindstone City, the shoreline is a sandstone bluff about 10 feet above the water. Southeastward to Port Hope, the shore and inshore water areas are boulder-strewn, and the land behind the shore rises gradually. From Port Hope southward to Harbor Beach, the shore is mostly boulder-strewn, but the shore bluffs become more pronounced and are principally clay. The same condition extends further south to Port Sanilac; there are few boulders, and, except for scattered patches, there is little sand beach. The high clay banks end about seven miles south of Lexington. From this point southward to the Sanilac-St. Clair County line, there is an almost continuous sand beach, with sand and clay bluffs varying from 8 to 25 feet in height.

Photograph 32. The marshes and wetlands of Saginaw Bay.

Table 34

Shoreline of the Great Lakes — Bay County to Sanilac County, Michigan

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public		Private	Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal		Critical	Noncritical			
Economic Uses											
Residential	94.2	49.8		0	0	94.2	0	72.1	0	14.6	7.5
Industrial and commercial	4.1	2.2		0	0	4.1	0	1.2	0	2.9	0
Agricultural and undeveloped	49.9	26.4		0	0	49.9	0	10.7	0	37.0	2.2
Commercial harbors			1								
Electric power sites			1								
Public buildings and related lands	0.2	0.1		0	0.2	0	0	0.1	0	0	0.1
Recreational Uses											
Parks	4.9	2.6		0	4.9	0	0.2	2.8	0	0	1.9
Recreational boat harbors			11								
Beach zone	(96.5)	(51.0)		(0)	(3.2)	(93.2)					
Environmental Uses											
Wildlife perserves and game lands	17.1	9.0		0	17.1	0	0	0	0	1.5	15.6
Fish and wildlife wetlands (offshore)	(0)	0									
Forest	18.7	9.9		0	0	18.7	0	4.6	0	8.7	5.4
Total	189.1	100.0		0	22.2	166.9	0.2	91.5	0	64.7	32.7



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SCALE IN MILES

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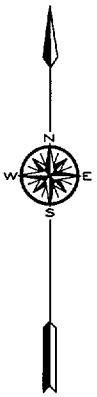
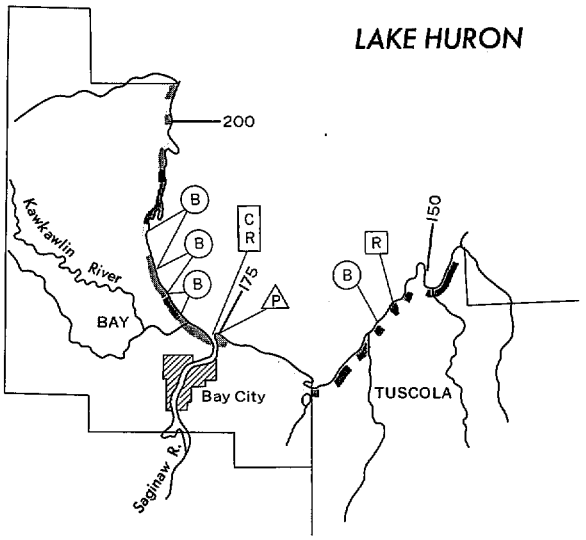
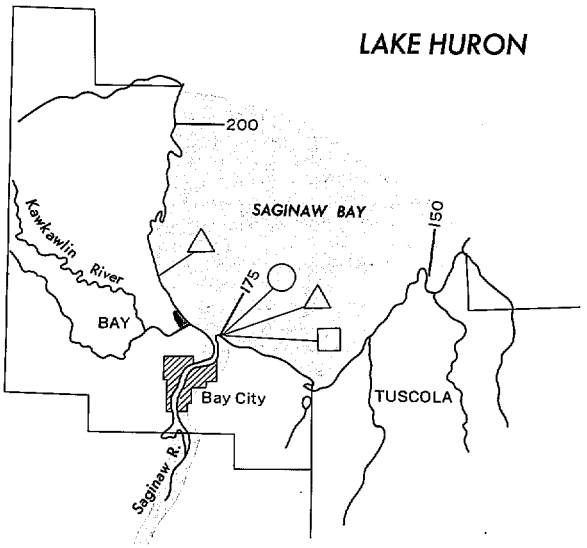
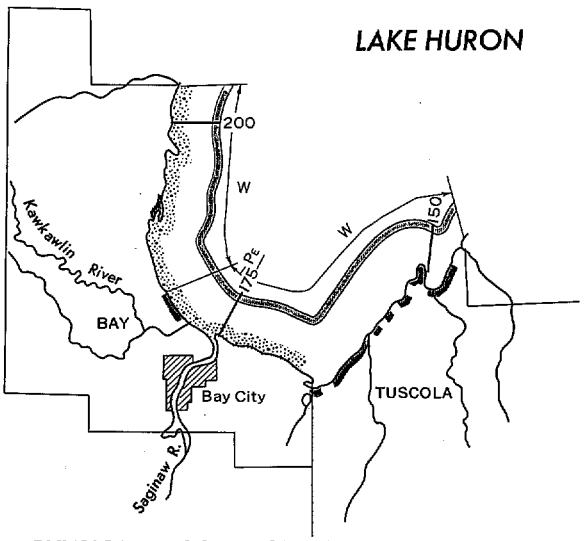




SHORELAND USES.



ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

Figure 51. SHORELANDS OF THE GREAT LAKES, TUSCOLA, BAY COUNTIES.

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings

Recreational and Urban Open Space

Agricultural and Undeveloped

Forest

Public Beaches (B)

Commercial Deep Draft Harbors [C]

Recreational Harbors [R]

Commercial Deep Draft and Recreational Harbors [C R]

Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values

Unique Ecological or Natural Areas

Outstanding Shoreland Areas of Possible National Interest

Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands

Non-Federal Public Lands

Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)

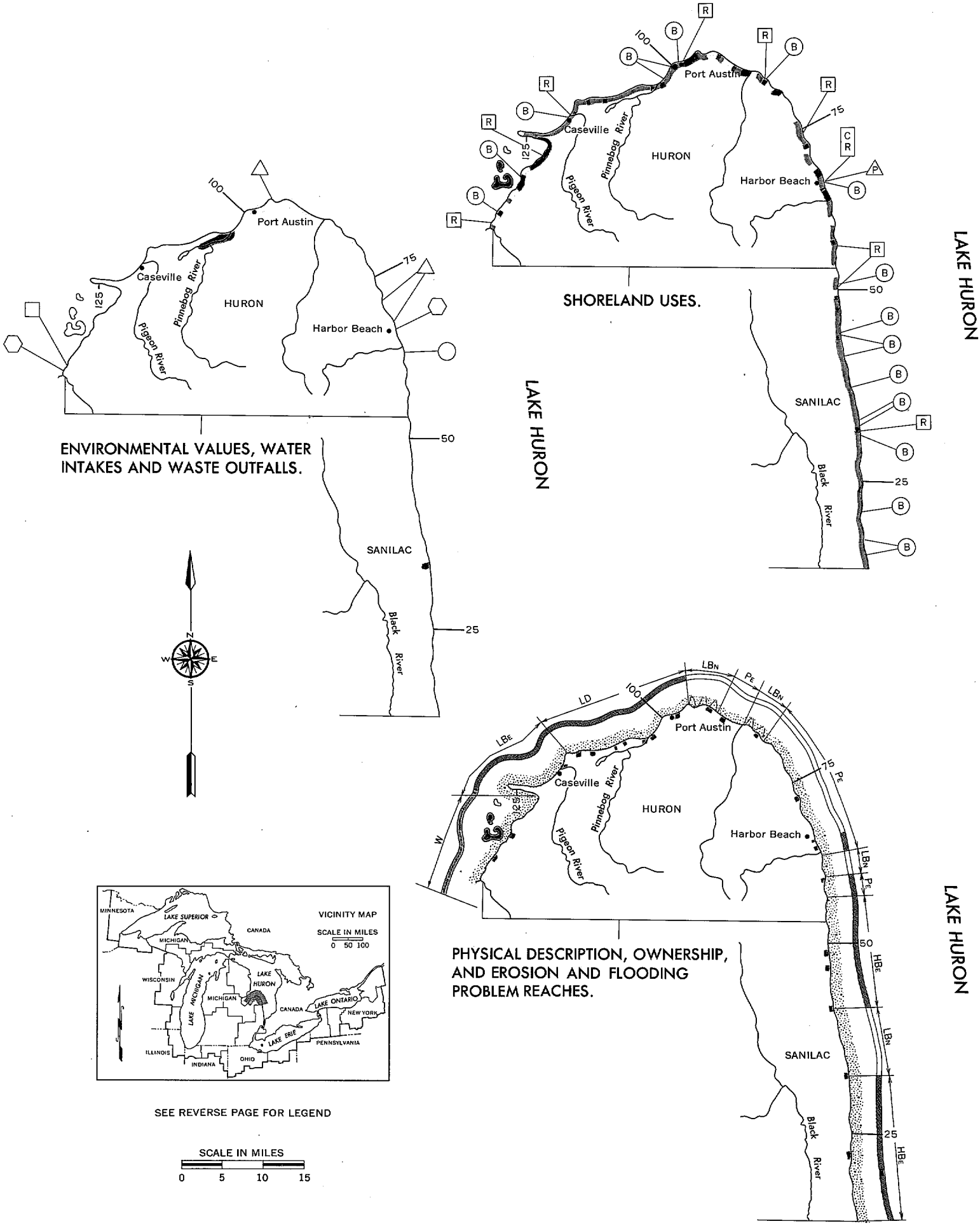


Figure 52. SHORELANDS OF THE GREAT LAKES, SANILAC, HURON COUNTIES.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches — B
- Commercial Deep Draft Harbors — C
- Recreational Harbors — R
- Commercial Deep Draft and Recreational Harbors — C R
- Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites
- Waste Water Outfalls and Intakes
  - Public Outfalls
  - Public Intakes
  - Private Outfalls
  - Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

Combinations Shown As:	Example
Lakeward/Landward	W/P_E
Upper Bluff Material / Lower Bluff Material	HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems — S

The present distribution of shoreline use and ownership of Bay, Tuscola, Huron, and Sanilac counties are shown in Figure 53.

Of the 189.1 miles of shoreline in this area 22.2 miles, are in public ownership. Land use data are not available for previous periods. However, much of the residential and recreational development of the northern half of this shoreline reach has occurred in the last twenty years; in the southern half most of the development is older.

There are two State parks in this area, Sleeper State Park near Caseville and Port Crescent State Park near Port Austin, and a large number of County and township parks.

There are two commercial harbors and 11 recreational boat harbors and marinas. These sites provide facilities for about 1,200 recreational boats.

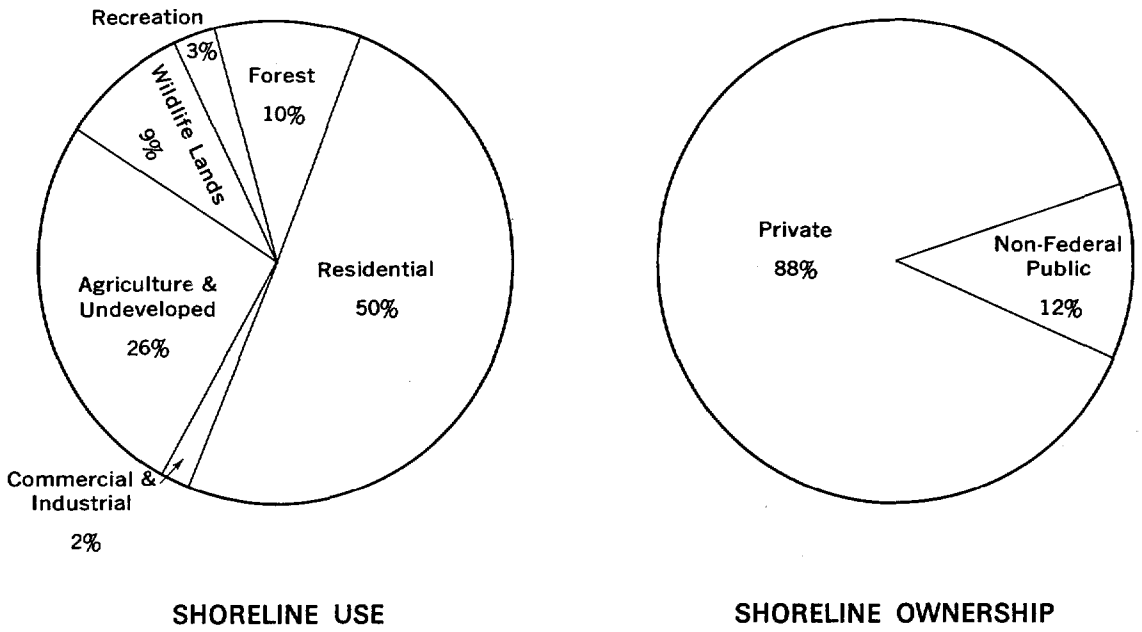


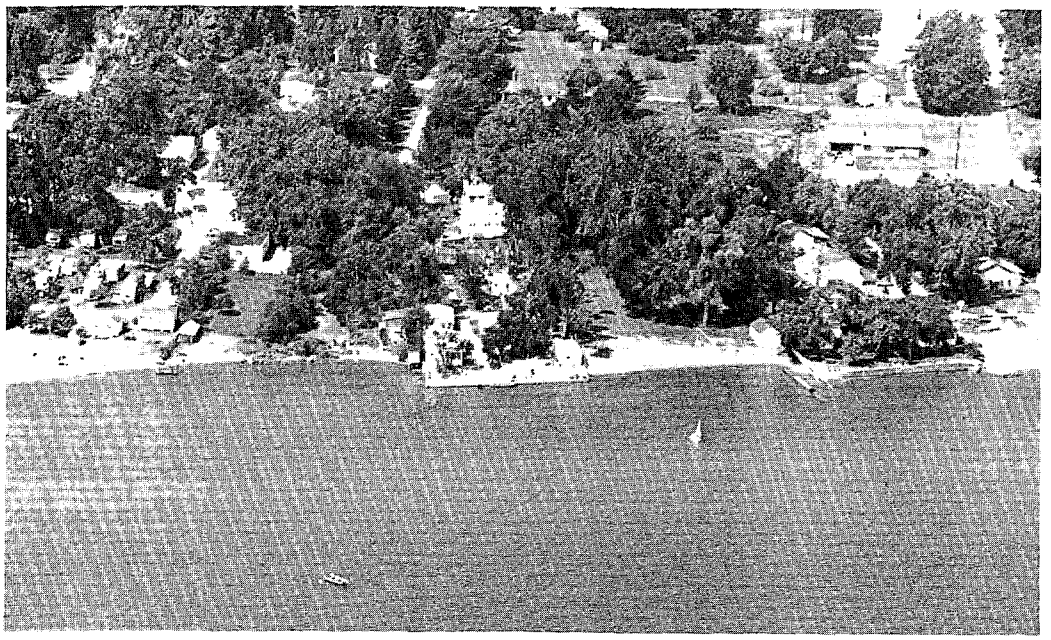
Figure 53. Distribution of Shoreline Use and Ownership, Bay County to Sanilac County, Michigan.

7.6.2 Erosion and Flooding History

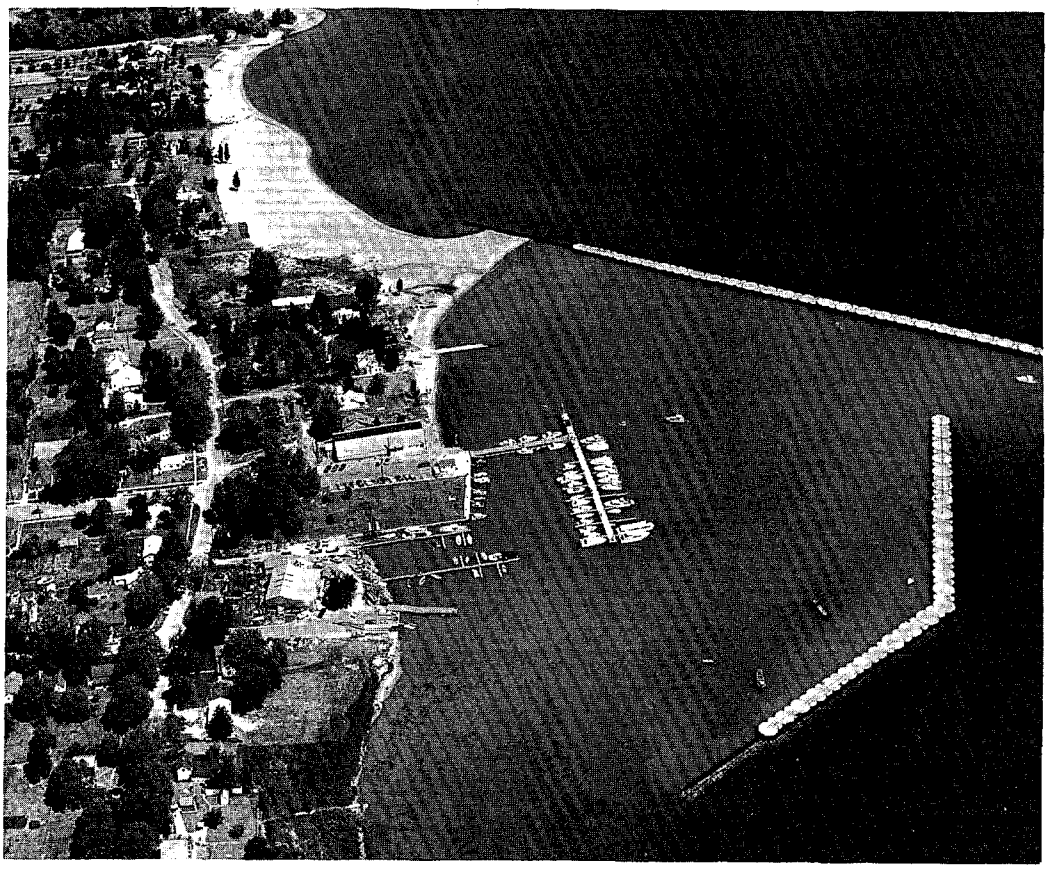
The 1952 damage data for Lake Huron are not available in sufficient detail to permit tabulating the data by planning subarea. Table 35 gives the damage estimates for the shoreline from Bay City to Port Huron.

During the high lake levels of 1951-52, erosion was slight in the northern part of the area.

However, the Bay County shoreline records a considerable amount of flooding and some scattered areas of erosion during periods of high lake levels. At the Kawkawlin River-Wenona Beach area, the flood area during the 1951-52 high water included about 18,000 feet of shoreline, extending from a point about 7,000 feet westward of the mouth of Kawkawlin River to the mouth of the Saginaw River. The effect of the high water reached about two miles upstream into the Kawkawlin River. The shoreline has both residential and undeveloped frontage, with development more concentrated at and upstream from the mouth of the Kawkawlin River. During the 1951-52



Photograph 33. Residential land use of Lake Huron Shoreline in Sanilac County, Michigan.



Photograph 34. Recreational Boat Harbor at Port Sanilac, Michigan.

high lake levels, about 160 cottages and homes were damaged by flooding; and seawalls, bulkheads, earth groins, and dikes were damaged by wave action in the flooded areas. State Highway M-47 and other access roads to beach properties were flooded. The area was under water to some extent during high lake levels of Lake Huron, but the greatest flooding occurred, and will continue to occur, during periods of temporary increases in lake levels in Saginaw River. The shoreline for a distance of about 20 miles to Port Austin eroded from 10 to 40 feet. The main cause of erosion in this reach is the temporary changes in the level of Saginaw Bay. East of Port Austin to Harbor Beach, erosion damages were slight in 1951-52. Erosion of the shoreline from Harbor Reach to the St. Clair County line amounted to 10 to 15 feet in the northern portion and about 25 feet in the southern portion, during the one year-period spring 1951 to spring 1952.

Table 35

Total Damage to Shore Property on Lake Huron – Bay, Tuscola, Huron, and Sanilac Counties,[a] Michigan

	Damages, $	
Land Use	*Actual 1951-52 Value*	*Updated 1970 Value*
Private		
Inundation (all property)	25,500	49,215
Commercial	40,500	78,165
Residential	491,400	948,402
Agricultural or undeveloped	5,500	5,775
Utilities	7,000	13,510
Total, private property	569,900	1,095,067
Public		
Inundation (all property)	6,400	14,784
Parks and beaches	10,000	23,100
Utilities	400	924
Total, public property	16,800	38,808
Total erosion damages	586,700	1,133,875

[a] Does not include area of Bay County from Bay City to Arenac – Bay County line; and includes that portion of St. Clair County from Sanilac – St. Clair County line to Port Huron.

7.6.3 Solutions to Erosion Damages

Shoreland erosion along the Lake Huron Central Planning Subarea is not critical enough to require large-scale protection of the shoreline. Only one critical erosion problem area exists at Port Sanilac and extends to about 0.2 mile south. This limited reach of shore can best be protected by placement of riprap or the construction of small seawalls, or protective beaches.

The first cost of protection for this area is estimated at about $160,000.

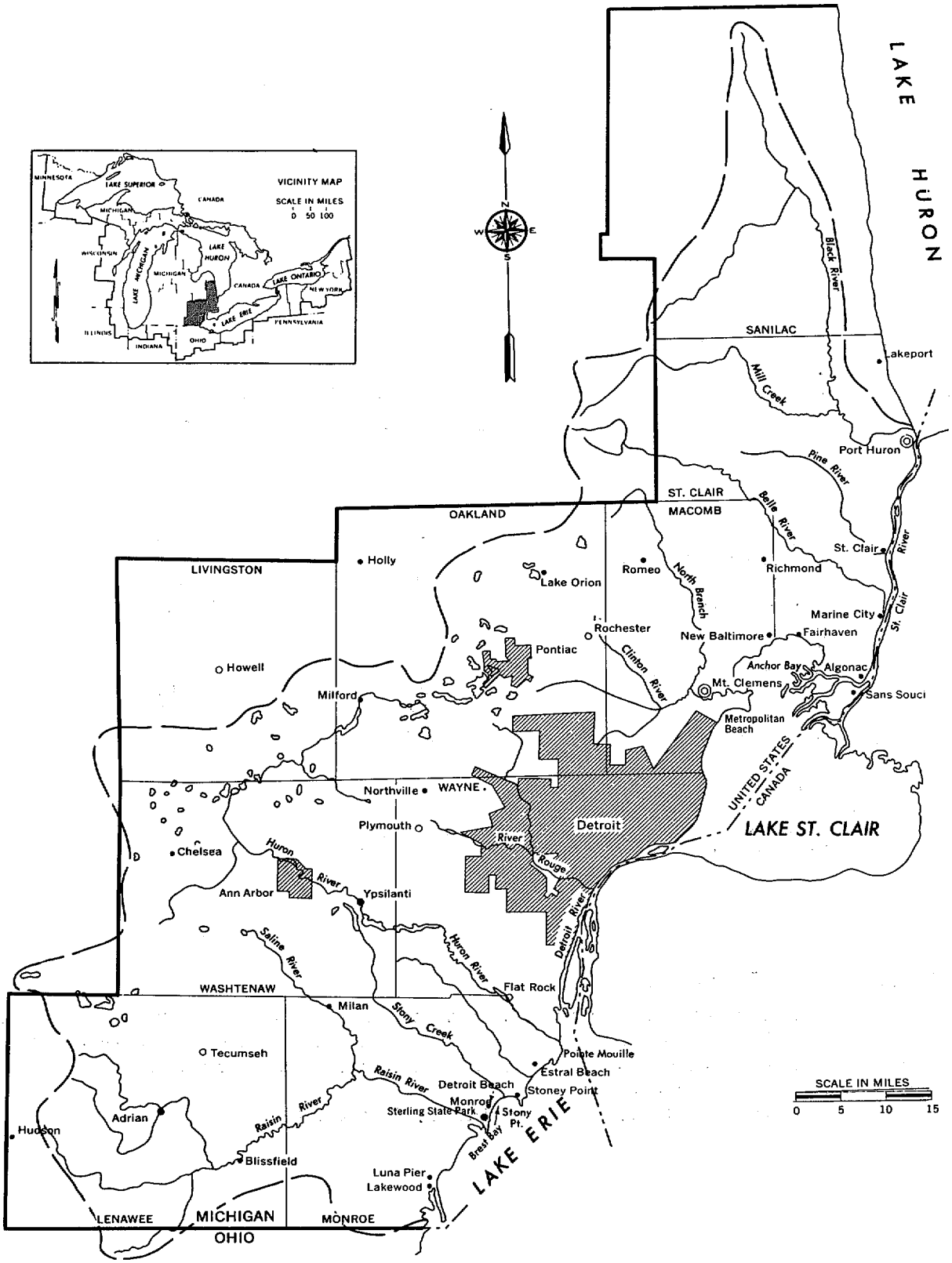


Figure 54. Lake Erie Northwest Planning Subarea 4.1, Michigan.

7.7 Lake Erie Northwest Planning Subarea 4.1

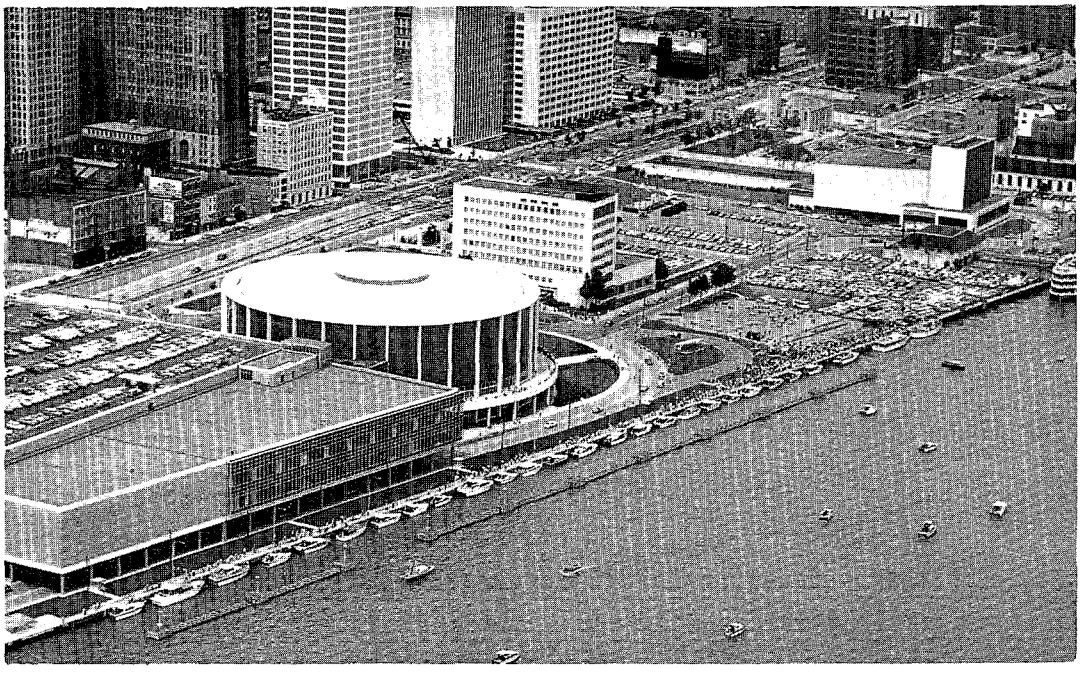
The Lake Erie Northwest Planning Subarea 4.1 contains 13 miles of St. Clair County shoreline on Lake Huron, 32 miles of Monroe County shoreline on Lake Erie, and 46 miles on the Lake St. Clair. The St. Clair - Detroit River System connecting Lake Huron to Lake Erie is 116 miles long. This river reach is not included as part of the Great Lakes Mainland Shoreline. The nine-county planning subarea has a population of 4.8 million (1970). Major drainage areas are the Black, Clinton, Huron, and Raisin river basins (Figure 54). Table 36 and Figure 55 give information on values, uses, ownership, and problem identification data for the Great Lakes Mainland Shoreline and Lake St. Clair.

7.7.1 Shoreline Description

The distance from Port Huron to the St. Clair - Sanilac County line, along the shore of Lake Huron, is approximately 12 miles. The shoreland is a bluff up to 40 feet high, composed of varying amounts of sand, gravel, and clay. In the vicinity of Lakeport, the bluff is interrupted by a lowland area. The beach is composed of sand, with gravel and cobbles. Along the 12-mile reach, the beach is from 20 to 200 feet wide.

The 32 miles of shoreline of Monroe County on Lake Erie is extremely variable. As a result, a shoreline breakdown of land forms and their characteristics is not practical in a report of this nature. Generally, the shore consists of low-lying marshes and sand beaches, with some areas below the average water surface of the lake. Marshes are turbid, with a great deal of water vegetation. At Stony Point on the shoreline of Brest Bay, a brecciated (rocks formed by fragments of older rocks) dolomite forms a rocky shoreland with boulders and sand.

The 46 shoreline miles of Lake St. Clair border on Wayne, Macomb, and St. Clair Counties. From the mouth of the Detroit River to Metropolitan Beach, in Macomb County, the shoreline has been intensively developed for residential and park use. Little remains that could be classified as natural shoreline except for a marshy area just to the west of Metropolitan Beach. From Metropolitan Beach to Fairhaven in St. Clair County the shoreland alternates between residential land which was artifically raised, and flat marshy areas. The St. Clair Flats area extends from Fairhaven to the village of Sans Souci on Harsens Island. This reach includes the island shoreline and delta channels at the mouth of the St. Clair River. Beach along the reach is sand clay till where not protected. It is nearly flat, marshy, and subject to periodic inundation by fluctuating water levels in Lake St. Clair.



Photograph 35. The Detroit Civic Center Waterfront and marina development in Wayne County, Michigan.

Table 36

Shoreline of the Great Lakes — St. Clair County to Monroe County, Michigan[a]

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public		Private	Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal		Critical	Noncritical			
Economic Uses											
Residential	62.3	67.6		0	0	62.3	0	0	21.3	29.8	11.2
Industrial and commercial	2.7	2.9		0	0	2.7	0	0	0.9	1.8	0
Agricultural and undeveloped	8.7	9.5		0	0	8.7	0	0	1.8	6.5	0.4
Commercial harbors			1								
Electric power sites			4								
Public buildings and related lands	2.3	2.5		0	2.3	0	0	0	2.3	0	0
Recreational Uses											
Parks	5.9	6.4		0	5.9	0	0	0	2.1	2.8	1.0
Recreational boat harbors			18								
Beach zone	(16.0)	(17.4)		(0)	(1.0)	(15.0)					
Environmental Uses											
Wildlife perserves and game lands	10.2	11.1		0	10.2	0	0	0	0	10.2	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	0	0		0	0	0	0	0	0	0	0
Total	92.1	100.0		0	18.4	73.7	0	0	28.4	51.1	12.6

[a] Excludes connecting waterways, Detroit and St. Clair Rivers.

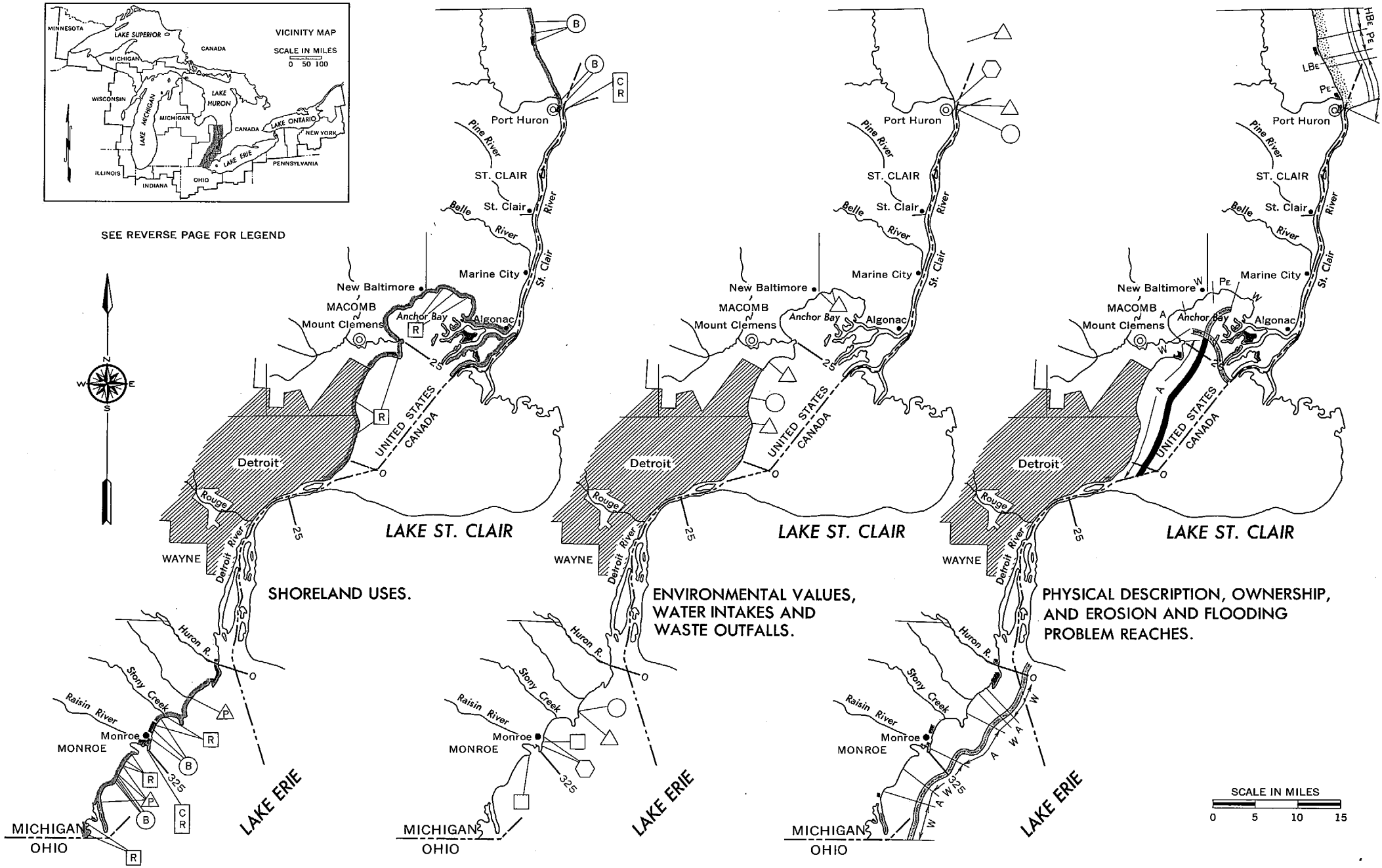


Figure 55. SHORELANDS OF THE GREAT LAKES, MONROE, WAYNE, MACOMB, ST. CLAIR COUNTIES.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors (C)
- Recreational Harbors (R)
- Commercial Deep Draft and Recreational Harbors (C R)
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)

The present distribution of land use and ownership along this four-county reach is shown in Figure 56. About 18.4 miles of the shoreline are publicly owned. Parks occupy approximately 5.9 miles of shoreline, or 6.4 percent of the total 92.1 shoreline miles, of this reach. Roughly 10.2 miles of shoreline are wildlife preserves and game lands. Offshore fish and wildlife wetlands parallel 1.9 miles of shoreline in Monroe County. State parks along the reach are Sterling (Monroe County) and Lakeport (St. Clair County). Significant fish and wildlife areas are located at Point Mouille and the Erie State Game areas on Lake Erie. There are recreational boat harbors at Port Huron, Balles Harbor, and Monroe. In addition, there are numerous privately owned marinas.

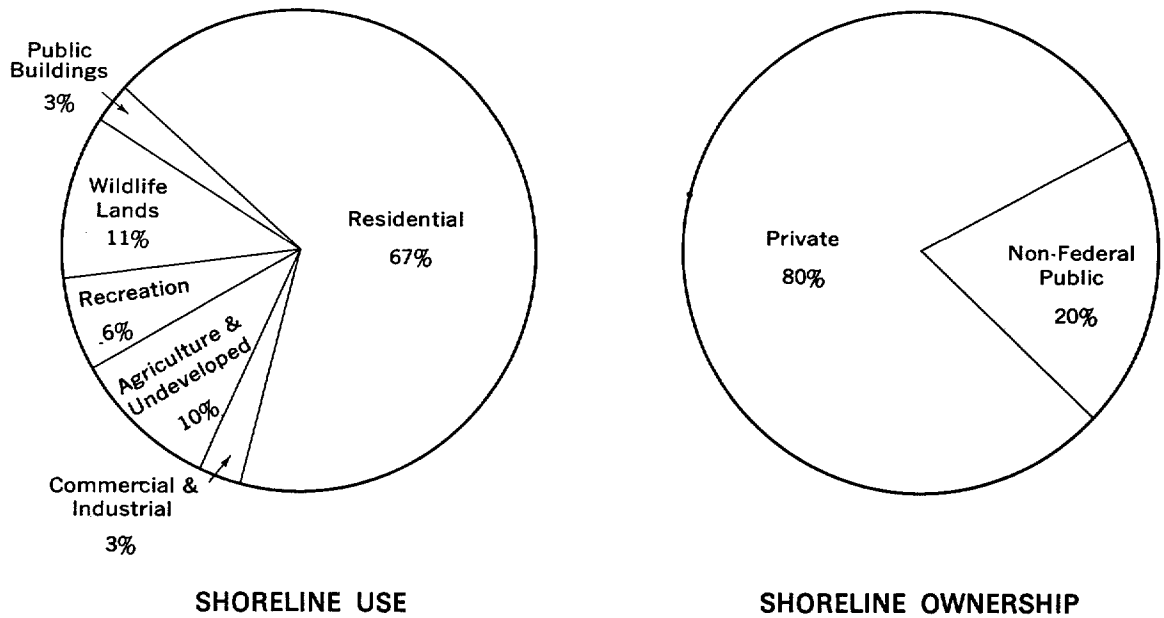


Figure 56. Distribution of Shoreline Use and Ownership, St. Clair County to Monroe County, Michigan.

7.7.2 Erosion and Flooding Damages

Flooding creates more of a problem than erosion, since approximately 51.1 miles are subject to flooding. The most serious conditions exist on Lake Erie. Damage information for individual reaches of shoreline in St. Clair and Monroe counties, Michigan, is not readily available. The total damage to shore property on the St. Clair - Detroit River System and the Lake Erie Shoreline in Monroe County, Michigan, is given in Table 37. Damage costs for the shoreline from Port Huron to the St. Clair-Sanilac County line are not included, as they can not be broken out of the Lake Huron data (see Table 35).

During the 1951-52 high-water period, widespread flooding occurred along the western shoreline of Lake Erie, causing a great amount of damage to shoreline communities within Monroe County. The development along the western part of Lake Erie in Monroe County is mainly villages and unincorporated communities and beach associations, with the exception of the cities of Monroe and Luna Pier. Many structures have been built along the shore by individual property owners, municipalities, or beach associations, and by the Federal Government, in an attempt to prevent flooding.

Most of the residences bordering the lakeshore had some type of protective seawall that was damaged during the April 1966 storm. Although these residences are mostly situated on high ground, there were additional damages from wind-driven waves and flood water that flowed inland, eroding soil and piling up debris. In a few cases, poor bulkhead protections allowed the large, damaging waves to penetrate inland and damage residences.

Following the floods and damaging high lake levels of 1951-52, Federal flood control projects were constructed at Silver Creek and Estral Beach. During the April 1966 storm, Estral Beach suffered minor erosion to frontal dikes. It is estimated that the Silver Creek project prevented $10,000 in damages and the Estral Beach project saved another $60,000.

Table 37

Total Damage to Shore Property on St. Clair River, Lake St. Clair, Detroit River, and Lake Erie[a]

	Damages, $	
Land Use	*Actual 1951-52 Value*	*Updated 1970 Value*
Private		
Inundation (all property)	3,702,780	7,146,364
Commercial	910,150	1,756,589
Residential	1,517,940	3,286,769
Agricultural or undeveloped	615,450	451,920
Utilities	339,500	655,235
Total, private property	7,085,820	13,296,877
Public		
Inundation (all property)	314,500	726,495
Parks and beaches	378,500	874,335
Utilities	148,850	343,844
Federal reservations	105,000	202,650
Total, public property	946,850	2,147,324
Total erosion damages	8,032,670	15,444,281

[a] State of Michigan shoreline only.

A few shoreline communities and private owners in Monroe County have recognized that potential flood hazards exist. They have put up a variety of protective works to reduce the flood damages produced by high lake levels and severe, wind driven storms. Most of these improvements were constructed after the damaging floods and high water levels of 1951-52. Beach associations and shoreline communities have erected various types of seawalls, groins, and other improvements to lessen erosion and to protect the area from normal lake levels. They have not provided for flood protection during higher stages, however, in general, these communities prefer to risk the hazard of flooding rather than build high flood control structures that would restrict the easy access to the water and beach and would block the open view of the lake.

The following is a description of non-Federal flood control projects at Luna Pier and Detroit Beach in Monroe County.

At Luna Pier, Michigan, structures of concrete, masonry, or steel sheet-pile walls, and groins were erected by local interests, after the floods and high lake levels of 1952. These works do not provide adequate flood protection against the hazardous combination of high lake stages and severe storms, as proved by the amount of damage suffered during the April 1966 storm. During this 1966 storm, the local partly protective, flood-control works saved only $20,000 in damages according to estimates.

In 1954, at Detroit Beach, Michigan, the community constructed a new steel-pile lake front wall with earth and sheet-pile side dikes to prevent a return of the damaging floods of 1952. The project provides enough protection, apart from the few lake shore residences that are in front of the community breakwall. These residents, who did not want the high wall obstructing their open view of the lake, incurred the majority of the losses during the April 1966 storm. The local project as built closely followed the recommended Federal project and averted an estimated $485,000 of damages.

The following recommended project for Monroe County has been reviewed by Congress but is not yet authorized. Details can be found in House Document No. 424, "Water Levels of the Great Lakes - Local Flood Protection Projects," 83rd Congress, 2nd Session, dated 7 June 1954.

Lakewood - Luna Pier, Michigan, has a recommended plan for improvement. It consists of a steel sheet-pile lake front dike 5,600 feet long, 10,400 feet of north and south earth side dikes, and improvements to the existing drainage system. The proposed project, which would protect about 1,000 acres of residential and agricultural lands, is considered workable and its costs justified. Non-Federal interests will have to bear $122,500 of the estimated total first cost of $1,099,500 (1970 prices and conditions). Damages that could have been prevented by this project during the April 1966 storm are estimated at $622,000.

7.7.3 Solutions to Erosion Damages

This shoreline is not subject to erosion. However, 51.1 miles are subject to flooding, which is difficult and expensive to protect against. Extensive levee, berm, and dike systems are alternative solutions, but they are difficult to justify.

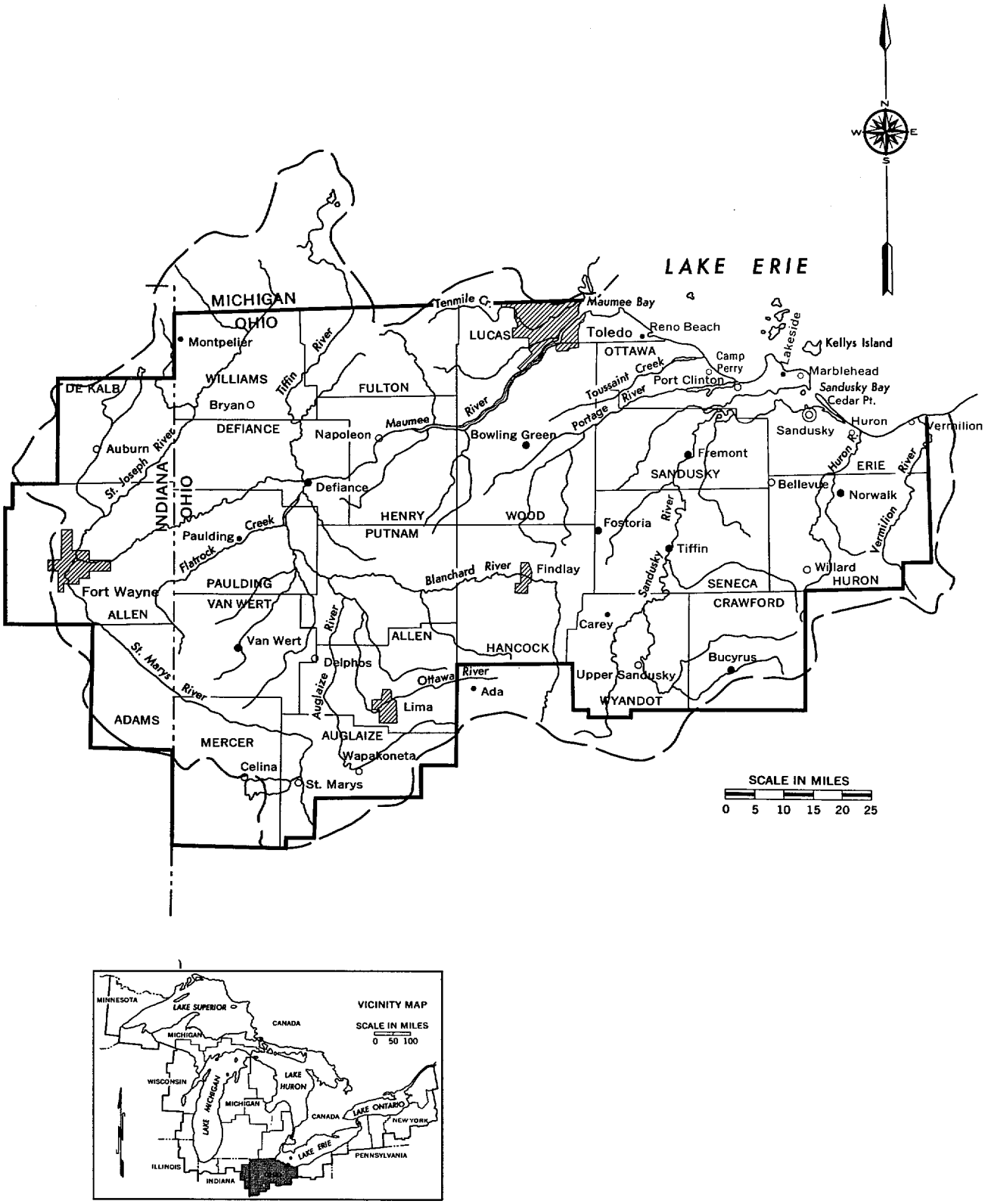


Figure 57. Lake Erie Southwest Planning Subarea 4.2, Ohio.

SECTION 8
STATE OF OHIO

The Great Lakes Mainland Shoreline of Ohio is located within two planning subareas, the Lake Erie Southwest Planning Subarea 4.2 and the Lake Erie Central Planning Subarea 4.3. The Ohio Mainland Shoreline is about 265.1 miles long. The two planning subareas include a total of 28 counties in Ohio, with a population of 4.4 million (1970). This is about 42 percent of the total population of the State of Ohio. Major urban centers on the shoreline are: Toledo, Sandusky, Lorain, Cleveland, Fairport Harbor, Ashtabula, and Conneaut. Major drainage areas are Maumee, Sandusky, Cuyahoga, and Grand River Basins.

A detailed description of the shoreline is contained in two following subsections. Of the 265.1 miles of mainland shoreline, about 138 miles have a beach zone and 127.1 miles are without a beach zone. The present shoreline uses in Ohio are as follows: 116.4 miles residential, 23.8 miles industrial and commercial, 16.3 miles public buildings and related land, 48.6 miles recreational and 60.0 miles agricultural, forest, and undeveloped.

There are 7 commercial harbors. The 27 recreational harbors and marinas provide facilities for about 17,700 recreational boats. Shoreline ownership is divided 6.1 miles Federal, 42.5 miles non-Federal public, and 216.5 miles private.

Of the 265.1 miles of shoreline in Ohio, 24.5 miles sustain critical erosion processes, 96.9 miles are subject to non-critical erosion or flooding and 143.7 miles are non-eroding (stable, accreting, or protected).

Critical shoreline erosion problems exist at 17 locations. The following tabulation identifies these reaches. The estimated first cost for protection of these reaches of shoreline is $12.5 million.

Lake	Mile to Mile		Mile to Mile	
Erie	278.0	278.7	185.5	186.0
	244.0	248.0	176.3	181.3
	239.0	241.0	173.0	176.3
	225.0	226.0	171.7	172.1
	218.1	218.4	164.0	165.0
	216.0	217.0	159.0	159.3
	213.3	213.5	144.9	145.4
	200.0	203.0	140.0	140.8
			133.3	133.8

8.1 Lake Erie Southwest Planning Subarea 4.2

The Great Lakes Mainland Shoreline of Ohio in planning subarea 4.2 is 157.3 miles long (Figure 57). The major drainage areas are the Maumee and Sandusky River Basins and the Toussaint-Portage and Huron-Vermilion drainage complexes. The 20-county area in Ohio has a population of 1.37 million (1970). The communities located along the shoreline are Toledo, Cedar Point, Locust Point, Port Clinton, Marblehead, Sandusky, Huron, and Vermilion. Table 38 and Figure 58 illustrate shoreline values, uses, ownership, and problem areas for this shoreline reach.

8.1.1 Shoreline Description

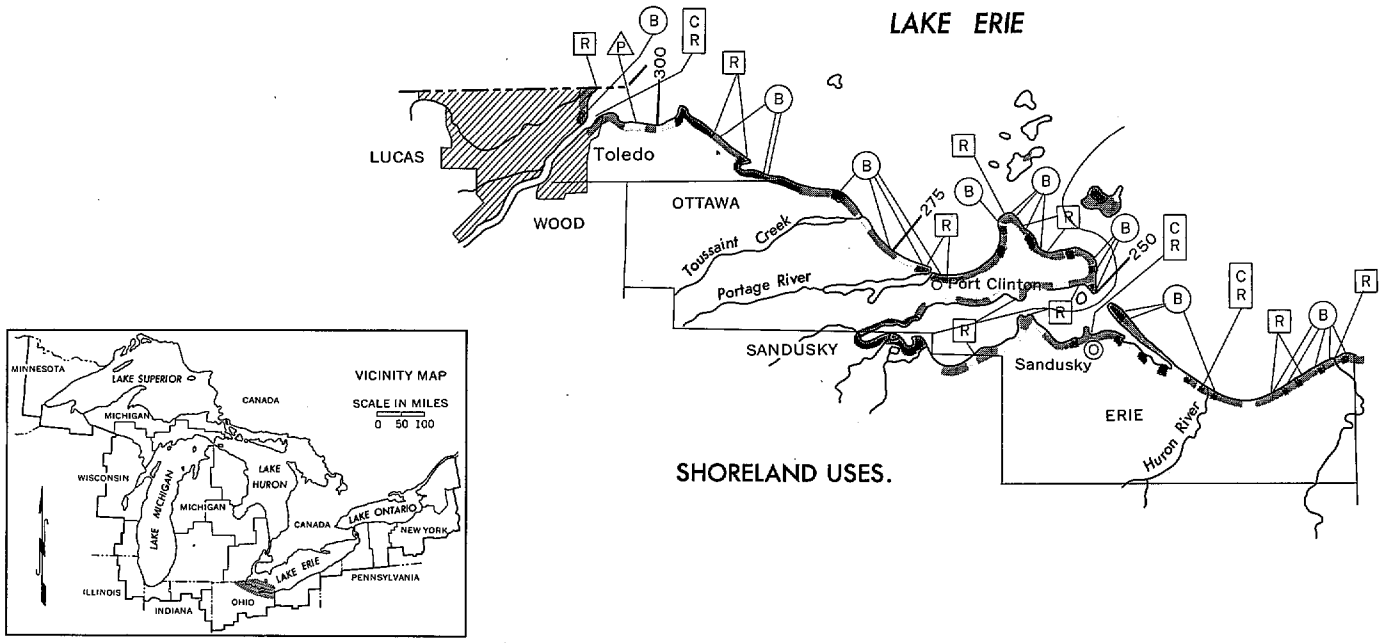
The shore of Lucas and Ottawa counties, extending from the Michigan-Ohio State line, just north of Toledo, Ohio, to Port Clinton at the mouth of the Portage River, is a shoreline distance of about 35 miles. In its natural state it is, generally, a marsh area fronted by low barrier beaches. It has occasional reaches of high ground at elevations less than four feet above mean lake level. One of these reaches is the shoreline of Maumee Bay in the city of Toledo. Dikes along the lake shore at Reno Beach and Howard Farms have reclaimed about three miles of the frontage for residential and agricultural use. Over 10 miles of adjacent marshlands on both sides are State and Federally owned and developed as wildlife preserves. Some of these areas are diked along the shore and farther back. Water in this unique development is maintained at desired levels in the various ponds by pumping stations. These pumping stations are located within the area capable of pumping from or discharging into the open lake.

Table 38

Shoreline of the Great Lakes — Lucas County to Erie County, Ohio[a]

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public		Private	Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal		Critical	Noncritical			
Economic Uses											
Residential	57.1	36.2		0	0	57.1	1.0	22.4	26.2	3.5	4.0
Industrial and commercial	13.7	8.7		0	0	13.7	0	0.1	9.8	3.7	0.1
Agricultural and undeveloped	30.6	19.5		0	0	30.6	0	24.5	2.8	3.1	0.2
Commercial harbors			4								
Electric power sites			1								
Public buildings and related lands	8.7	5.5		0.1	8.6	0	2.0	2.3	3.5	0.7	0.2
Recreational Uses											
Parks	33.5	21.3		0	9.2	24.3	3.7	9.4	14.2	3.2	3.0
Recreational boat harbors			25								
Beach zone	(49.6)	(31.5)		(0)	(5.9)	(43.7)					
Environmental Uses											
Wildlife perserves and game lands	10.3	6.6		6.0	4.3	0	0	3.7	0.3	6.3	0
Fish and wildlife wetlands (offshore)	(NA)						0	0	0	0	0
Forest	3.4	2.2		0	0	3.4	0	1.9	0.5	0.4	0.6
Total	157.3	100.0		6.1	22.1	129.1	6.7	64.3	57.3	20.9	8.1

[a] Includes Sandusky Bay and short reach of Sandusky County.



SHORELAND USES.

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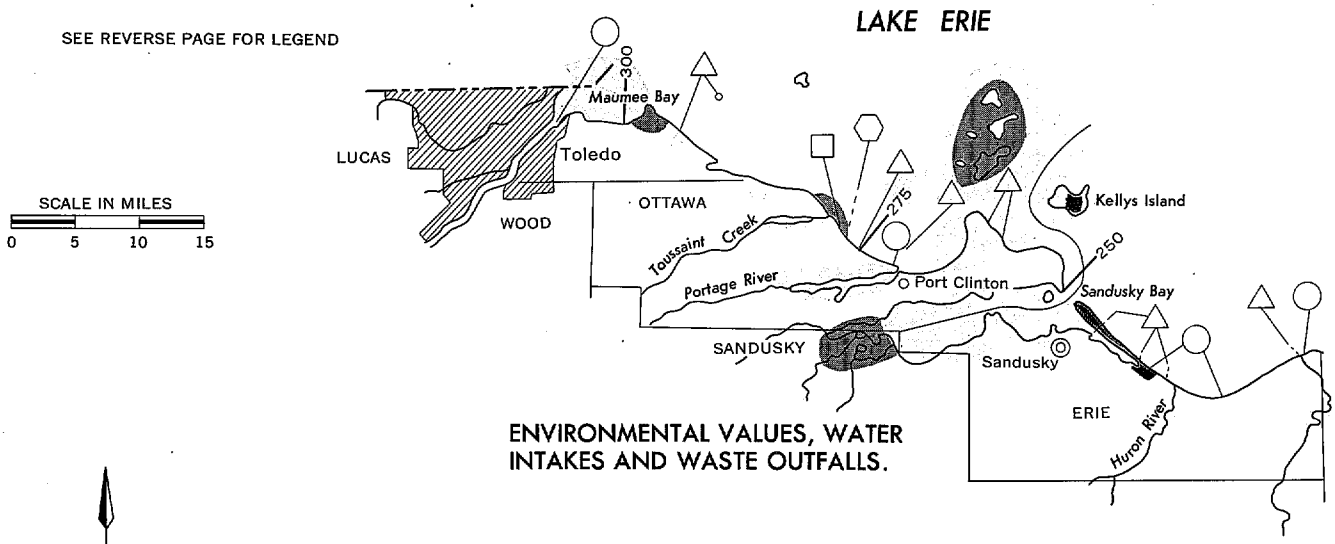
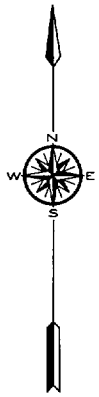
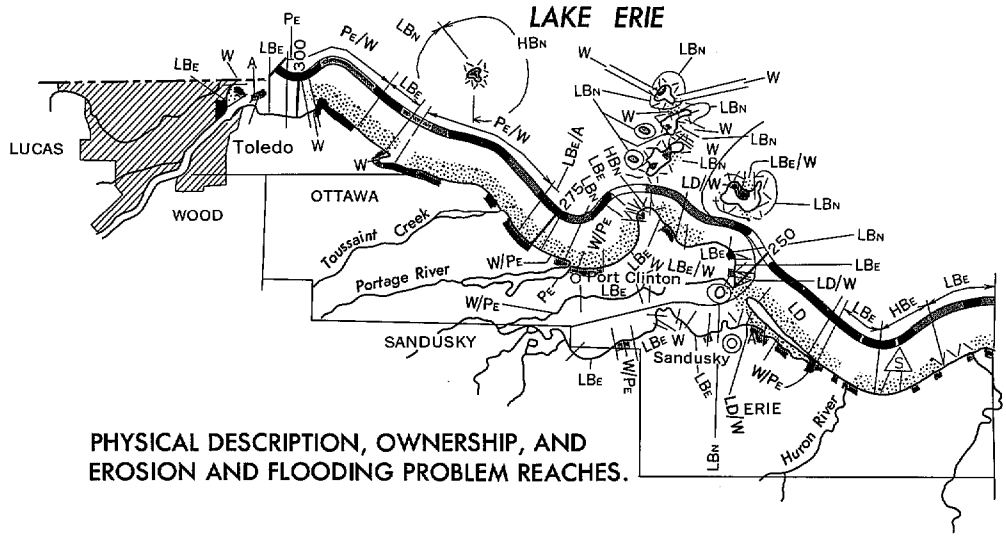


ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.





PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

Figure 58. SHORELANDS OF THE GREAT LAKES, ERIE, SANDUSKY, OTTAWA, LUCAS COUNTIES.

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings

Recreational and Urban Open Space

Agricultural and Undeveloped

Forest

Public Beaches (B)

Commercial Deep Draft Harbors [C]

Recreational Harbors [R]

Commercial Deep Draft and Recreational Harbors [C R]

Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values

Unique Ecological or Natural Areas

Outstanding Shoreland Areas of Possible National Interest

Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands

Non-Federal Public Lands

Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

Combinations Shown As:	Example
Lakeward/Landward	W/P_E
Upper Bluff Material / Lower Bluff Material	HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

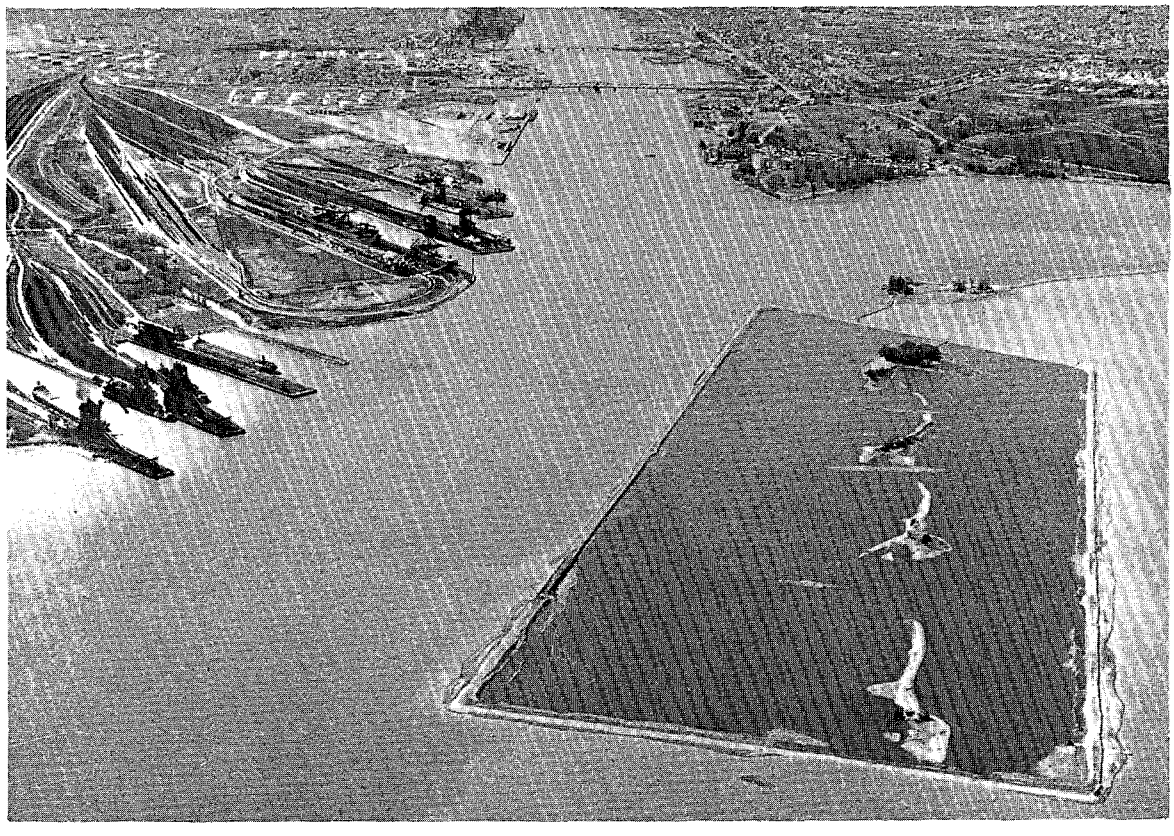
- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)

Easterly of Port Clinton, the shore characteristics change quite noticeably. The ground elevation rises, and at the headland known as Catawba Island, about seven miles to the east, the shore material is ledge rock and the bluffs for a short distance are over 30 feet high. To the east, a narrow strip of high ground connects the Catawba Island headland to another headland known as Marblehead. Behind this narrow crescent-shaped connecting strip are three open water and marsh areas called West Harbor, Middle Harbor, and East Harbor. The frontage of the narrow strip that separates these ponds from the open lake is nearly four miles long. A sand beach extends along its lakeward face. The Ottawa County shoreline extends about another seven miles around Marblehead, where it ends in a sand spit that reaches part way across the mouth of Sandusky Bay. The shore of Marblehead is a low bluff, with earth on the north and south sides but rock outcrop for two miles around its easterly tip.

The boundary between Ottawa County and Erie County is in the entrance to Sandusky Bay. The Erie County shore southeasterly of the bay entrance starts at the westerly tip of a long sand barrier beach known as Cedar Point, which extends for nearly seven miles to the east. The westerly one and one-half miles at the tip of Cedar Point is from one-quarter to one-half mile wide. The remainder is generally less than 500 feet wide. Between the barrier beach and the mainland are stretches of open water and marsh up to nearly a mile wide.

At the easterly end of Cedar Point, the shore characteristics change abruptly. The low marshy backshore, typical of most of the shore from Toledo to this point, disappears completely. The earth bluffs behind narrow sand and gravel beaches become from 10 to 30 feet high from here to the east line of Erie County, near Vermilion, Ohio. The Huron River at Huron Harbor, Ohio, enters the lake in this reach. The Lake Erie Shoreline of Lucas, Ottawa, and Erie counties totals about 82.5 miles.

In addition to this mainland shoreline, there is a group of about eight islands in Ottawa County, offshore from the Catawba Island headland. It is known as the Bass Island Group. There is a large island off Marblehead in Erie County, known as Kelleys Island. These islands have rock outcrops at the waters edge and are well protected against erosion or flooding by nonerodible bluffs from 10 to over 30 feet high. Pockets of sand and gravel



Photograph 36. The port facilities and industries at Toledo Harbor, Ohio. The diked area is used by the Corps of Engineers for the disposal of dredged material.

beaches occur in bays around their edges. They are highly developed for agricultural and residential use. A well known historical site is Perry's Monument at Put-in-Bay on South Bass Island. A State park of nearly 500 acres is located on Kelleys Island.

The shoreline of Sandusky Bay measures 61 miles. The Sandusky River enters the west end of this long shallow bay, which has an average depth of only six feet. The south shore and the west end of Sandusky Bay in Erie and Sandusky counties have low banks and marshy shores. The marshes at the westerly end have been diked, largely by private interests, to provide duck shooting areas and fish ponds. The north shore in Ottawa County is higher ground and is well developed for residential use.

Many streams enter the lake and the open water areas behind the barrier beaches, mainly the West Harbor, Middle Harbor, and East Harbor areas. For this reason, the total shoreline available for wildlife, recreational, residential, and other uses is much greater than the 82.5 miles measured along the shore outline of the main body of Lake Erie.

The present distribution of shore use and ownership in Lucas, Ottawa, and Erie counties, between the Michigan-Ohio line and Vermilion, Ohio, is given in Figure 59.

There are Federal deep-draft harbors at Toledo, Sandusky, and Huron. Federally improved light-draft harbors at Port Clinton, Put-In-Bay, and Vermilion are used by commercial fishing boats and recreational boats. It is estimated that there are 12,725 recreational boats permanently moored on this reach of Great Lakes Shoreline. The Corps of Engineers made studies for additional light-draft harbors at East Harbor, West Harbor and Kelleys Island, and Ottawa.

There have been only minor changes in shore use since 1952, perhaps less change than in most reaches of the Lake Erie shore because of the relatively high percentage of the shore in public ownership as game preserves and public parks. The low marshy nature of much of the rest of the shore makes it unattractive and too costly for additional development. There has been some increase in residential development, with a corresponding decrease in agricultural or undeveloped frontage.

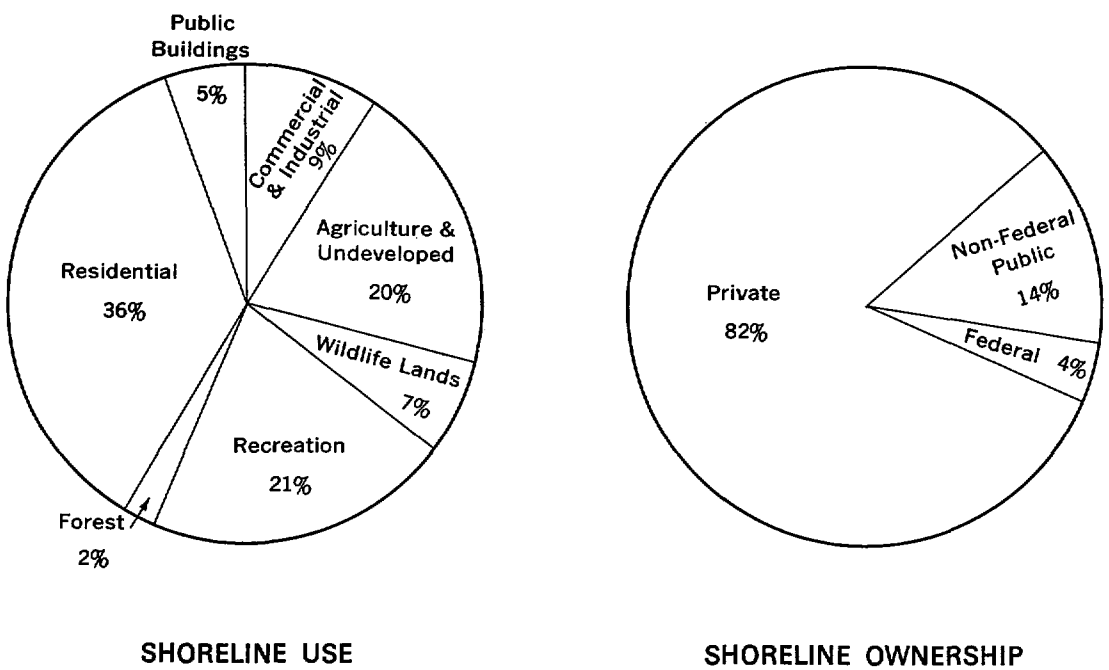


Figure 59. Distribution of Shoreline Use and Ownership, Erie County to Lucas County, Ohio.

8.1.2 Erosion and Flooding History

The shore from the Michigan-Ohio line to the National Wildlife Refuge easterly of Howard Farms, a total distance of about 20 miles, is generally subject to flooding during severe easterly storms, except where properly protected. Protection against all but the most extreme conditions has been provided in the residential section on the north shore of Maumee Bay and in the industrial area on the south shore. The same is true of the Reno Beach - Howard Farms area. Artificial earth dikes reinforced on the lakeside by bulkheads and short groins are intended to maintain narrow sand beaches. On at least two occasions, however, in 1943 and 1952, they have been breached, resulting in flooding of the lowlands behind the dikes.

The shore easterly to Port Clinton is more liable to damage from erosion than flooding. But portions of this shore, too, are flooded during extreme conditions. Protection against erosion has been provided for part of the frontage at Camp Perry by a seawall and short groins. Groins are not particularly effective in this area because of a lack of sufficient beach material. Except for large amounts of sand deposits at Little Cedar Point near Toledo and at Bay Point extending off Marblehead into Sandusky Bay, there is only a thin layer of fine sand overlying lacustrine and glacial till deposits found on the lake bottom between Toledo and Sandusky Bay. Private property owners have provided various kinds of protection for their property in this reach. These are timber and concrete seawalls, stone revetment, and groins.

The Cedar Point shoreline easterly of Sandusky Bay suffered critical erosion damages in 1952. Much of the narrow part of the peninsula was protected by stone riprap in 1952 to protect the access road. The remainder is subject to critical erosion at high lake levels. The shore bluffs between Cedar Point and Huron are subject to critical erosion during periods of high lake levels. The owners of this highly developed residential area have tried to protect it by means of a variety of timber and concrete walls and stone revetment. Few are strong enough to provide complete protection and critical erosion damage to these and to all unprotected parts of the shore occurs particularly during periods of high lake levels. In the 10-year period between surveys made in 1939 and 1949, the rate of erosion in much of this reach was four to five feet per year.

Erosion damages reported in the damage survey made in 1951-52 and the values updated to 1970 price levels in Lucas, Ottawa, and Erie counties are shown in Table 39.

Table 39

Total Damage to Shore Property on Lake Erie — Lucas, Ottawa, Sandusky, and Erie Counties, Ohio

	Damages, $	
Land Use	*Actual 1951-52 Value*	*Updated 1970 Value*
Private		
Residential	1,916,500	3,698,700
Industrial and commercial	2,087,900	4,029,600
Agricultural and undeveloped	482,500	506,700
Total, private property	4,486,900	8,235,000
Public		
Parks and beaches	587,200	1,356,400
Harbor installations	424,900	981,500
Utilities	137,000	316,000
Total, public property	1,149,100	2,653,900
Total erosion damages	5,636,000	10,888,900

8.1.3 Solutions to Erosion Damages

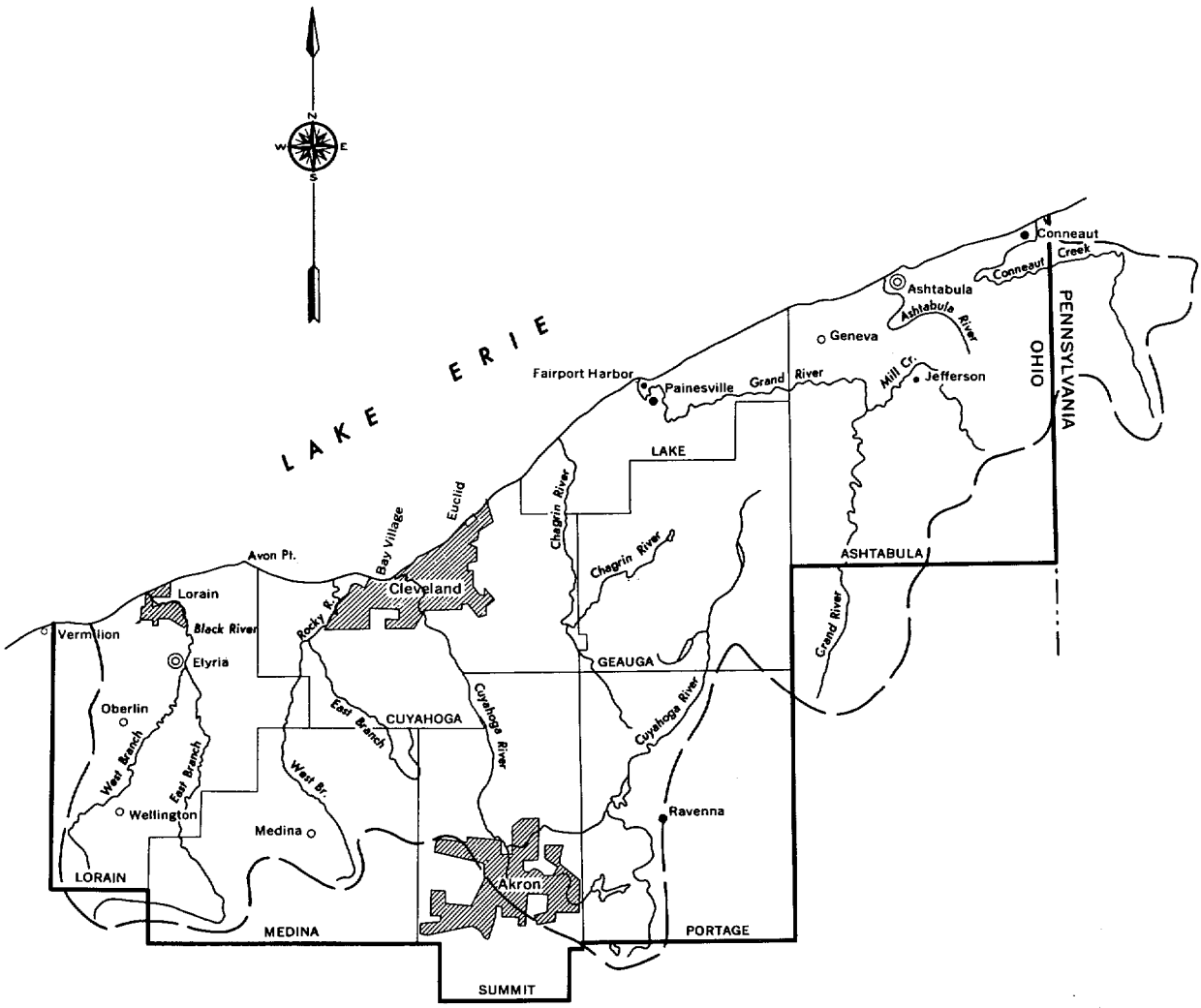
Shoreland erosion along this shoreline of Ohio is critical enough to require complete structural protection of the shoreline. Critical erosion problem areas in the vicinity of Camp Perry at Cedar Point and between Huron and Cedar Point have been identified. Limited reaches of shore can best be protected by placement of riprap, construction of small seawalls, or construction of adequate protective beaches. A summary of previous studies is given in the following paragraphs.

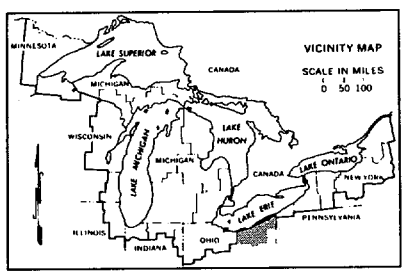
In 1960, the Corps of Engineers completed a review report on a cooperative beach erosion control study of the shoreline between the Michigan-Ohio State line and Marblehead. It was published in House Document No. 63, 87th Congress, 1st Session. This report recommended protection by means of stone revetment or timber or steel sheet-pile bulkheads backed by sand fill. The revetment is more suitable for protection of firm ground, the bulkheads and seawalls for protection of lower marshy frontages.

For protection and improvement of State park frontage in this reach, the use of artificial sand fill and groins was recommended. The estimated cost of this improvement is $800,000 per mile. The use of groins without sand fill is not workable, because there is not enough littoral drift to build any notable length of beaches by natural accretion (accumulation of sand). For this reason also the replenishment costs for the groin and beach fill plan are quite high, making it definitely too costly for use in protecting private property. Justifying the costs for protection of private residential property by even the least expensive means is questionable, except for high-value properties.

The Corps of Engineers completed a cooperative beach erosion control study of the Ohio Shoreline between Sandusky and Vermilion in 1952. This was Appendix VI of the overall study and was published in House Document No. 32, 83rd Congress, 1st Session. The report recommended an overall plan providing beach nourishment by stockpiling sand to the west of the harbor structures at Huron and Vermilion harbors and possibly at intermediate points. This comprehensive plan had been recommended in a previous beach erosion control report on a study of this same general area that was completed by the Corps in 1942 and published in House Document No. 220, 79th Congress, 1st Session.

Alternative plans were recommended for the protection of shorter reaches—short groins and artificial sand fill for the Cedar Point reach, for instance, and stone revetment and cellular sheet-pile seawalls for other areas.





SCALE IN MILES
0 5 10 15

Figure 60. Lake Erie Central Planning Subarea 4.3, Ohio.

8.2 Lake Erie Central Planning Subarea 4.3

The Great Lakes Ohio Mainland Shoreline in planning subarea 4.3 is 107.8 miles long (Figure 60). The major drainage areas are the Black-Rocky, Cuyahoga, Chagrin, and Grand river basins. The eight-county area has a population of 3 million (1970). The communities located along the shoreline are Lorain, Avon Point, Bay Village Cleveland, Rocky River Mentor Harbor, Fairport, Ashtabula, and Conneaut. Table 40 and Figure 61 illustrate shoreline values, uses, ownership, and problem areas for this shoreline reach.

8.2.1 Shoreline Description

This reach of the south shore of Lake Erie in Ohio extends from the Erie-Lorain County line near Vermilion, Ohio, to the Ohio-Pennsylvania line, about two miles to the east of Conneaut Harbor, Ohio. The total shoreline distance is about 107.8 miles. Two general types of shore bluffs, or combinations of the two, are found in this reach. The bluffs consist mostly of glacial till topped by lacustrine deposits of sand or silt. The height of the bluffs varies from about 5 feet to over 60 feet. The other general type of bluff material is a relatively soft shale. It first appears above lake elevation about four miles east of Lorain Harbor and gradually rises to the full height of the bluff within the next few miles to the east. The shore bluff around Avon Point to the Lorain-Cuyahoga County line is almost entirely shale. At the county line, the shale surface dips below lake level in a preglacial Rocky River valley that continues through the Bay Village shoreline, where the bluffs consist of easily eroded glacial till and lacustrine deposits. Between Bay Village and the mouth of Rocky River, the shale again becomes the main bluff material. It continues through the City of Lakewood to the west edge of Edgewater Park in Cleveland, on the west side of the Cuyahoga River. Here, the shale again dips below lake level in an old, drowned Cuyahoga River valley. Except for a short distance in the City of Euclid on the east side of Cleveland, where it appears in the lower part of the bluff face, there are no more notable outcrops in the Ohio Shoreline. However, except in the old river valleys, the rock surface is at or within a few feet of lake level throughout the Ohio Shoreline in these four counties.

About 75 percent of the material in the earth portion of the bluff face is fine enough to pass through a 200-mesh sieve. Perhaps 15 percent or less remains on a 60-mesh sieve and is coarse enough to stay in the beach area after being eroded from the bluff face. Some of the shale layers break down into broad, flat fragments that supply temporary beach cover, while other layers break down into soft clay. In general, the shore bluffs are fronted at mean lake stages by sand and shingle beaches 25 feet wide or more. At high lake stages, the beaches are almost flooded in many reaches, particularly in the shale bluff areas. The direction of the main littoral movement changes in the vicinity of Avon Point, near the Lorain-Cuyahoga County line. From there to the east end of Lake Erie, the main movement is from west to east.

The present shoreline use between Vermilion, Ohio, and the Ohio-Pennsylvania line is shown in Figure 62. There are two State parks and numerous County, city and township parks in this shoreline reach. Since 1952, there has been about a 50 percent increase in the number of shore miles developed for residential use. There has been about a 75 percent increase in commercial and industrial use, about an 11 percent increase in public parks, and a like decrease in agricultural and undeveloped frontage.

There are two State parks. Headlands Beach State Park, just west of Fairport Harbor, has an excellent bathing beach as its principal feature. A new State park at Geneva-on-the-Lake will, when fully developed, have a small-boat marina, a bathing beach, and picnic areas.

Federal deep-draft navigation projects within this four county area are located at Lorain, Cleveland, Fairport, Ashtabula, and Conneaut. There is a Federal small-boat-harbor project at Rocky River in Cuyahoga County. Federal projects have been authorized at Chagrin River in Lake County and at Conneaut in Ashtabula County. Studies of proposed small-boat harbors at Lorain Harbor, Fairport Harbor, Geneva-on-the-Lake, and Ashtabula Harbor are underway. Construction of harbors and harbors of refuge, spaced not more than 15 miles apart, are now underway.

Table 40

Shoreline of the Great Lakes — Lorain County to Ashtabula County, Ohio

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public		Private	Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal		Critical	Noncritical			
Economic Uses											
Residential	59.3	55.0		0	0	59.3	13.8	1.3	44.1	0	0.1
Industrial and commercial	10.1	9.4		0	0	10.1	0.7	0	4.5	0	4.9
Agricultural and undeveloped	14.2	13.2		0	0	14.2	0.3	9.1	4.4	0	0.4
Commercial harbors			5								
Electric power sites			6								
Public buildings and related lands	7.6	7.0		0	7.6	0	0.5	0	1.7	0	5.4
Recreational Uses											
Parks	15.1	14.0		0	11.3	3.8	2.5	0.5	8.5	0	3.6
Recreational boat harbors			14								
Beach zone	(88.4)	(82.0)		(0)	(9.0)	(79.4)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	1.5	1.4		0	1.5	0	0	0.8	0.7	0	0
Total	107.8	100.0		0	20.4	87.4	17.8	11.7	63.9	0	14.4

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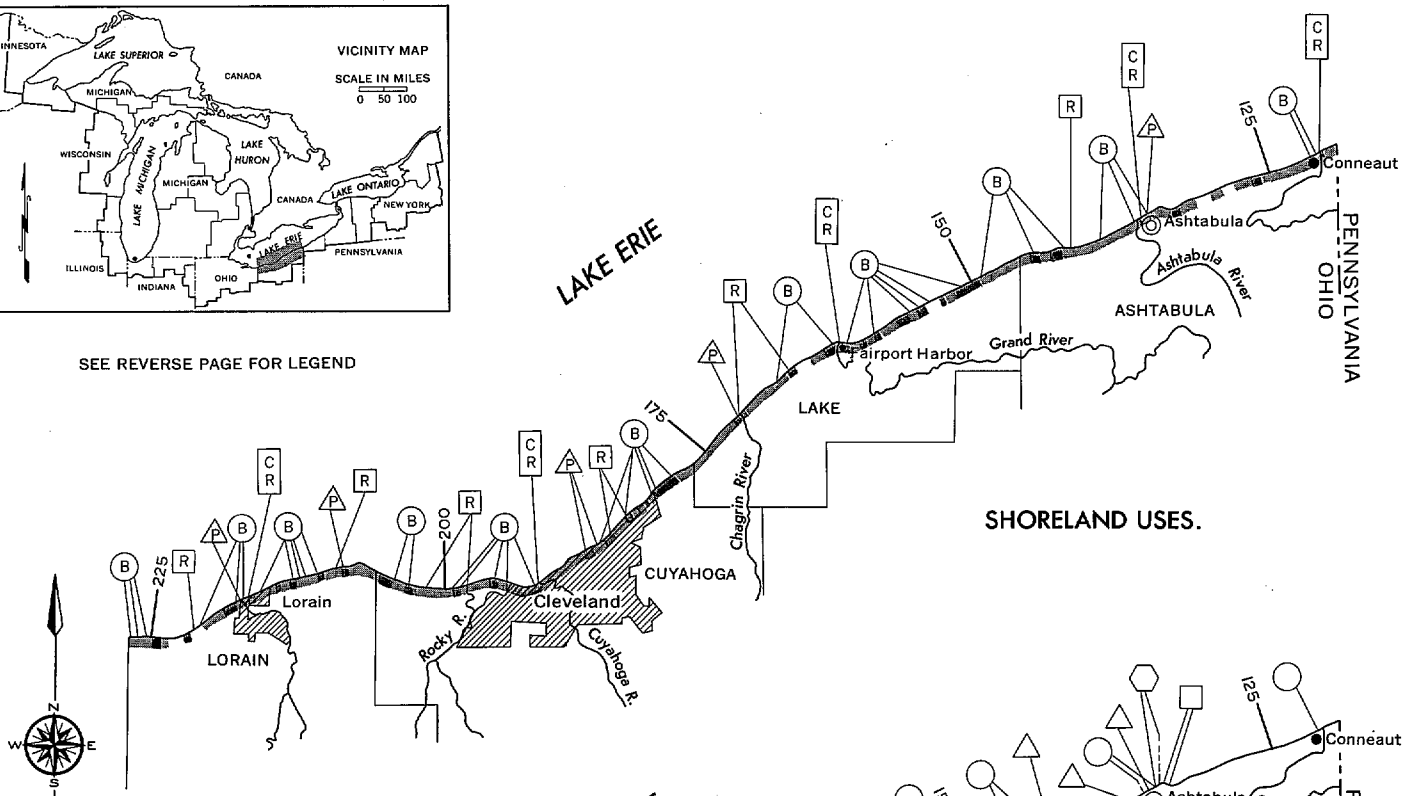
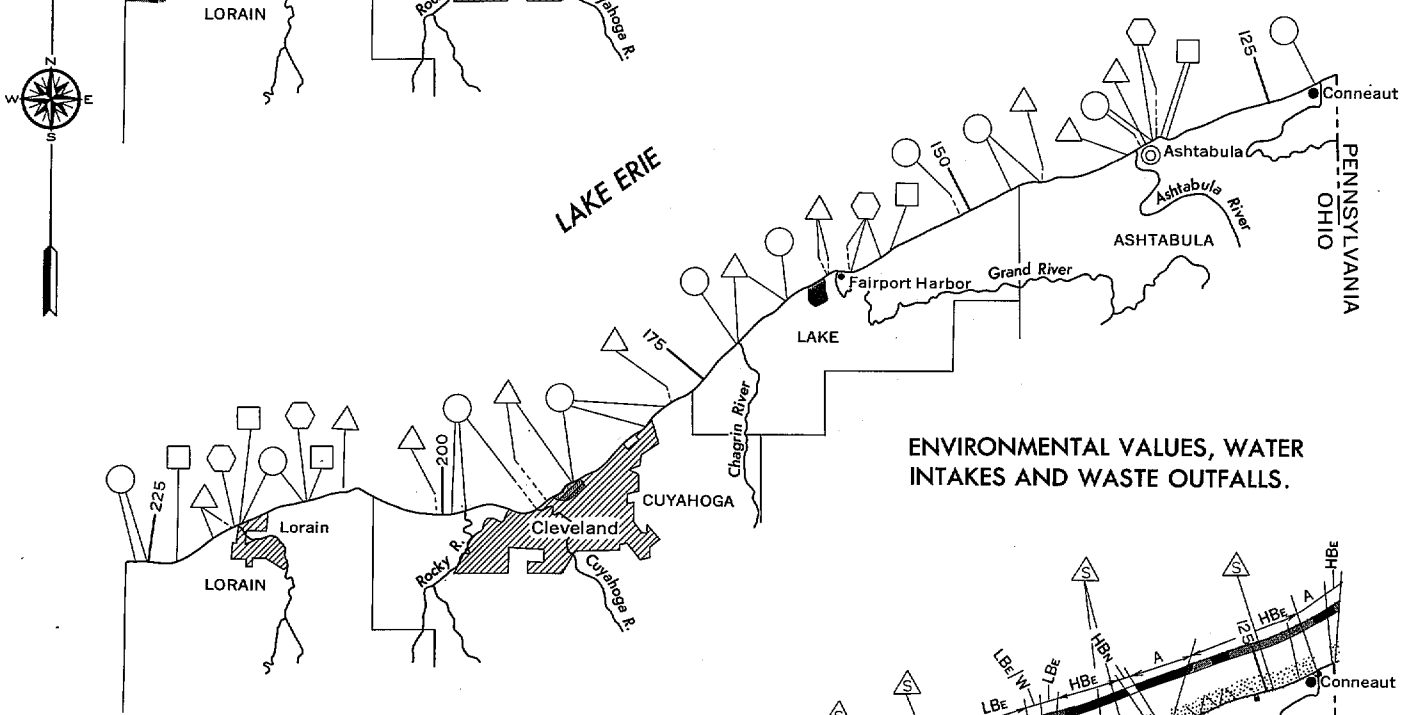




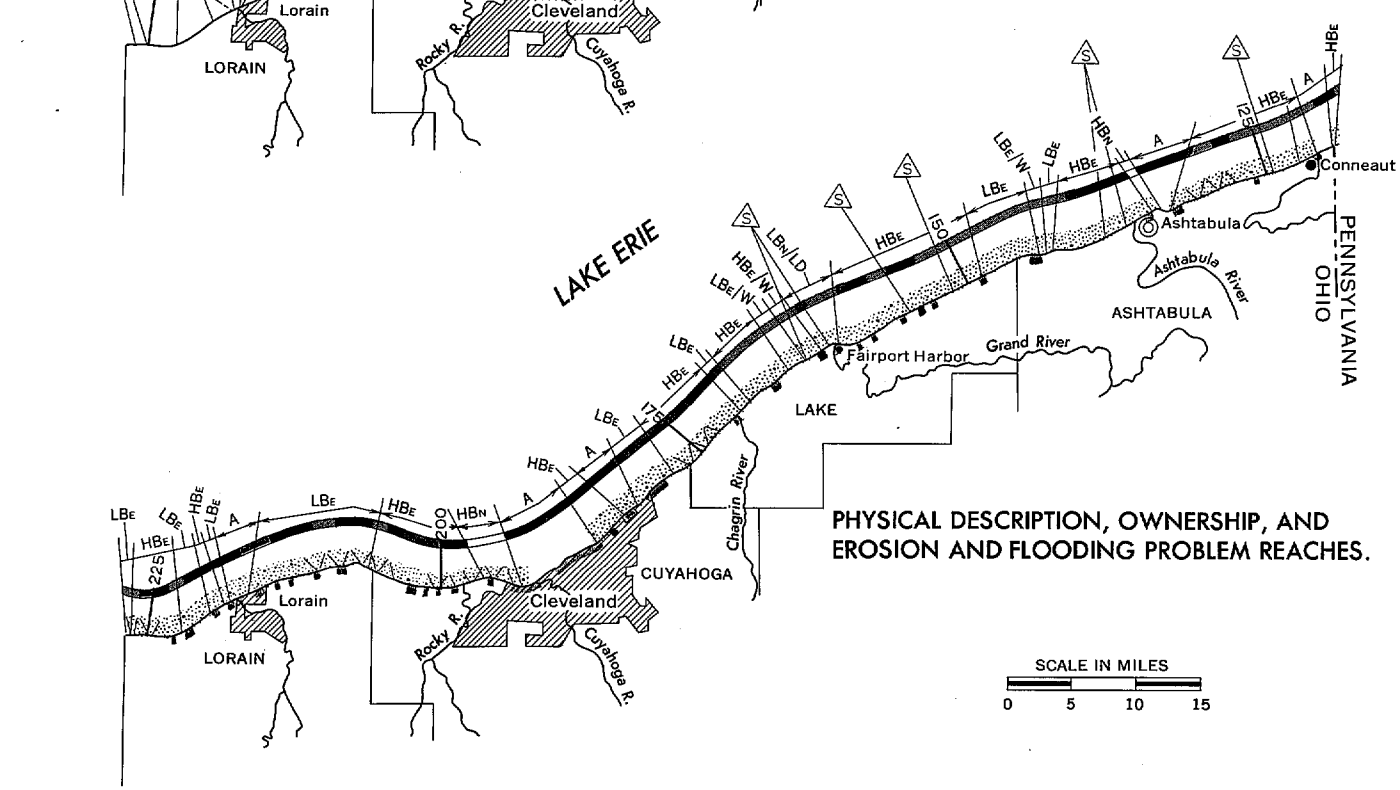


Figure 61. SHORELANDS OF THE GREAT LAKES, ASHTABULA, LAKE, CUYAHOGA, LORAIN COUNTIES.

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings

Recreational and Urban Open Space

Agricultural and Undeveloped

Forest

Public Beaches (B)

Commercial Deep Draft Harbors [C]

Recreational Harbors [R]

Commercial Deep Draft and Recreational Harbors [C R]

Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values

Unique Ecological or Natural Areas

Outstanding Shoreland Areas of Possible National Interest

Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands

Non-Federal Public Lands

Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

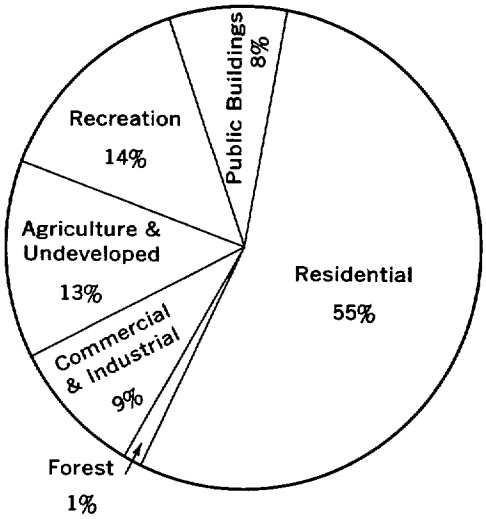
- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — $\frac{HB_E}{HB_N}$

Beach Material

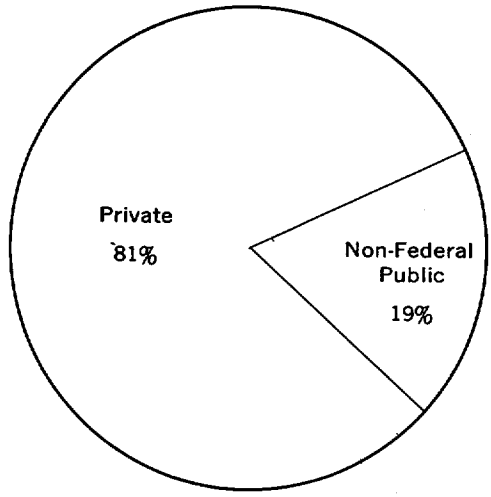
- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)



SHORELINE USE



SHORELINE OWNERSHIP

Figure 62. Distribution of Shoreline Use and Ownership, Ashtabula County to Lorain County, Ohio.

8.2.2 Erosion and Flooding History

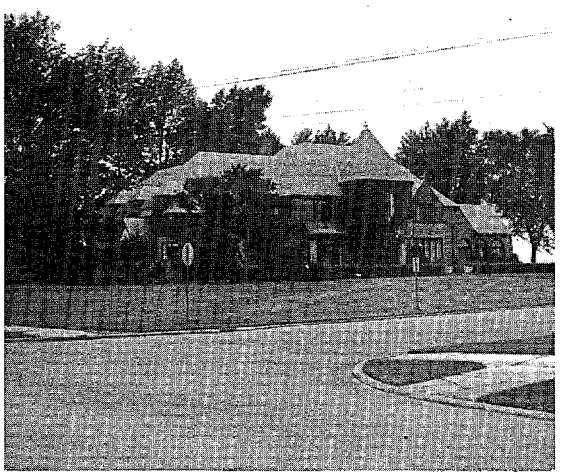
Severe damage occurred throughout this four-county area during the record high lake levels of 1951-52. Recorded damages between May 1951 and April 1952 are shown in Table 41.

Damage during 1969 was serious in some areas but apparently did not approach the overall damages that occurred in 1951-52. Over 60 percent of the shoreline is protected. Most of this protection has been provided by private property owners. At some of the public parks, such as Lakeview Park in Lorain, Avon Township Park, Geneva Township Park, and Painesville Township Park, the State of Ohio has assisted the local public agencies in erecting protective structures. These are mostly groins for improvement of park beaches. No Federal projects have been constructed.

This entire reach is subject to erosion wherever the shore is unprotected. In several highly developed areas this has become critical and many homes will be lost unless protected immediately. Although the prevailing winds are westerly, storms from the northeast are more damaging because of the longer fetch, the longer duration and severity of storm winds, and the temporary rise in lake levels due to storms from this direction. The shale bluffs are more resistant to erosion than the earth bluffs, but even the shale bluffs in the Lakewood area have had an average rate of erosion of nearly one foot per year. In several places, protection of the toe of the shale bluffs has been necessary to protect apartment buildings and other valuable improvements. Erosion of the earth bluffs is more rapid. The average rate of erosion is two to four feet per year. This does not occur at a uniform rate. It is greatly accelerated during periods of high lake levels and may be slight during low-water periods.

Because of the high bluffs, very few areas are subject to flooding from high lake levels. One exception is an area just to the east of the mouth of the Chagrin River, where a residential area on the right bank of the river floods during high lake stages. In 1952, flooding was particularly damaging. Parts of the area were flooded during storms in 1969. A proposed Federal small-boat harbor and flood control project at the mouth of Chagrin River will relieve this problem, since it will include protection of the shore to the east of the harbor structures.

Photograph 37. Picnic area, bathing beach, and entrance jetty to the small boat harbor at Rocky River, Cuyahoga County, Ohio.



Photograph 38. Example of residential development on top of the shale bluffs along this shoreline reach.

Photograph 39. Erosion of glacial till bluffs in the vicinity of Perry Township Park, Lake County, Ohio.

Table 41
Total Damage to Shore Property on Lake Erie — Lorain, Cuyahoga, Lake, and Ashtabula Counties, Ohio

Land Use	Damages, $ Actual 1951-52 Value	Damages, $ Updated 1970 Value
Private		
Residential	1,175,800	2,269,300
Industrial and commercial	387,600	748,100
Agricultural and undeveloped	180,300	189,300
Total, private property	1,743,700	3,206,700
Public		
Parks and beaches	304,400	703,300
Utilities	2,500	5,800
Total, public property	306,900	709,100
Total erosion damages	2,050,600	3,915,800

Bluff seepage adds to the erosion. At many places, surface water seeping through the previous upper layers finds its way to the bluff face on the top surface of older underlayers. The water lubricates and softens material at the face of the bluff and encourages shedding. One such area that has received considerable publicity is at Mentor Headlands, about two miles west of Fairport Harbor. However, it is a common occurrence, and examples can be found at many places in the high bluffs between Cleveland and the Ohio-Pennsylvania State line.

There are several places in this four-county area where erosion is considered critical. Homes have had to be abandoned and nearby homes are in immediate danger from recession of the bluffs. Areas that have received the most attention are Bay Village and Euclid in Cuyahoga County, and the area in Lake County between the Cuyahoga-Lake County line and the Chagrin River, including the cities of Willowick and Eastlake and the villages of Lakeline and Timberlake. Other areas of critical erosion in Lake County are the Mentor Headlands area, previously mentioned as one of the seepage problem areas, and Painesville-on-the-Lake. Here, homes and a section of State Highway Route 531 are seriously threatened, along with adjacent homes and public utilities. A study of this area was made in response to a request by the State of Ohio for Federal assistance in protecting the highway.

8.2.3 Solutions to Erosion Damages

Shoreland erosion along this shoreline of Ohio is critical and requires widespread structural protection. The critical erosion areas are: Bay Village, 3.0 miles of shore; City of Bratenahl, 0.5 miles; Euclid, 3.3 miles; Willowick-Timberlake, 3.3 miles; Eastlake, 0.4 miles; Mentor Headland, 1.0 miles; Painesville-on-the-Lake, 0.3 miles; Perry Township Park and vicinity, 0.5 miles; Highway Route 531, 0.8 miles; and Lakeshore Park at Ashtabula Harbor, 0.5 miles. These are areas where damage has been concentrated and has received public attention. Many other short reaches involving perhaps one or two properties have also been damaged.

Stone revetment, steel sheet-pile seawalls, or beach fill could be used to protect the areas where critical erosion is occurring. Costs for stone revetment are estimated at $500,000 per mile.

A Federal project recommended in a separate study of Sheffield Lake Community Park in the city of Sheffield Lake, a subburb of Lorain, Ohio, has also been authorized. It is not underway because of lack of local interest and cooperation. The report on this study was published in House Document 424, 87th Congress, 2nd Session.

In 1969, a study of the shoreline between the Cuyahoga-Lake County line and the Chagrin River was made for the State of Ohio, Department of Natural Resources, by a firm of engineering consultants. The consultants reported that about 11,700 feet of this seriously eroding area needed protection. They recommended slope treatment and gabion revetment at a total cost of $2,547,000; or about $217 per linear foot. The protection was justified by estimated benefits from the prevention of damages to both private and public property. This, in turn, prevented the loss of tax revenue by the state. There were also benefits due to reduction in pollution and improved appearance of the shoreline.

The improvements recommended in the earlier Corps reports on the Ohio Shoreline were largely protection by some form of seawall or revetment. Groins were not recommended for general use because there is a lack of beach sand and not enough littoral drift in most areas to create protective beaches. Artificial sand fill was recommended for park frontages where bathing beaches were wanted. The Corps report on the section of shore between Euclid and the Chagrin River also recommended a comprehensive plan to replenish beaches by artificial fill, as an alternative to protection of individual properties by seawalls or revetment. This plan could also be used in other areas. Offshore sand and gravel deposits in Ohio waters of Lake Erie have an abundance of deposits, enough for extensive replenishment of beaches.

It must be emphasized that these are the areas where erosion is critical at this time; other areas could become critical in the future. The houses now threatened or destroyed were, in most cases, built well back from the edge of the bluff. Houses in other areas, perhaps in newer suburban developments, will in the future become threatened. As erosion continues, new critical areas will develop.

Regulation of future construction by zoning of undeveloped property can reduce future losses. Improvements can be restricted to areas on the shore side of the limits of erosion that can be expected to occur during the useful life of the improvement. Then, the principal erosion damage will be loss of land. Protection costs will not be justified under these circumstances. However, zoning in many cases will only delay the problem. Other developments behind the original first-line properties will eventually become the shore front properties. The need for protection will become critical and may be justified.

Zoning of shore front property to prevent erosion is not entirely the same as zoning to prevent flood problems. In the latter case, the limits of the potential flood damage area in which development is to be controlled are well defined and generally fixed. In the case of shore front properties, an eroding shoreline continually changes the possible limits of the damage area. Zoning can be helpful in reducing early damages due to unwise development, but it is not in itself a permanent solution to the erosion problem. This is particularly true in this four-county reach, where new developments are largely residential and are frequently several blocks in depth.

Section 9
COMMONWEALTH OF PENNSYLVANIA

The Great Lakes Shoreline in Pennsylvania is located in the Lake Erie East Planning subarea 4.4 (Figure 63). The shoreline is 48.3 miles long and consists of high erodible bluffs fronted by sand and gravel beaches. Presque Isle Peninsula which encloses Erie Harbor is a large sand spit developed as a park by the State of Pennsylvania. The single county area has a population of 257,000 (1970). The major urban center is Erie.

The shoreline of Pennsylvania is divided 21.2 miles residential, 3.6 miles industrial and commercial, 11.6 miles public recreation, and 11.9 miles agricultural and undeveloped. Shoreline ownership is classified 11.6 miles non-Federal public and 36.7 miles private. The entire shoreline is subject to significant erosion except where protective works have been constructed. About 36.1 miles of shoreline are subject to noncritical erosion and 6.3 miles are protected. Six miles of shore on the Presque Isle Peninsula are subject to critical erosion. A suitable method of protecting this reach is groins and artifical beach fill. The estimated cost is about $5 million dollars.

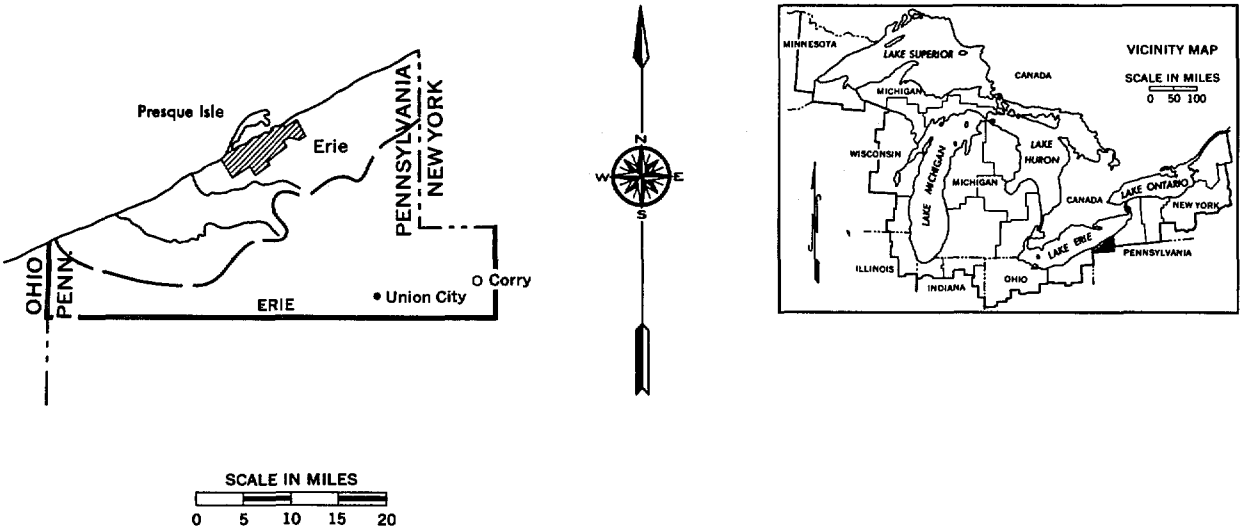


Figure 63. Lake Erie East Planning Subarea 4.4, Pennsylvania.

9.1 Shoreland Description

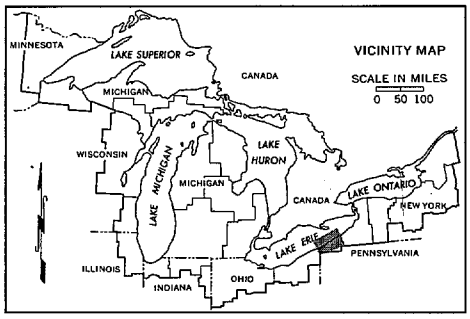
Erie County, Pennsylvania, which has a shore frontage of 48.3 miles, is the only Pennsylvania frontage on Lake Erie. It lies between Ashtabula County, Ohio, and Chautauqua County, New York. The shore bluffs are generally 50 feet to 75 feet high and rise to 100 feet high in a few places. Between the Ohio-Pennsylvania line and Erie, which includes the westerly half of the shore, the bluffs are entirely silt, clay, and granular material, with shale bedrock at about water level. To the east of Erie Harbor, the shale bedrock is frequently from 15 to 35 feet above the lake level, and the upper part of the bluff is composed of silt, clay, and granular material. Sand and gravel benches up to 150 feet wide extend along the toe of the bluffs. Figure 64 and Table 42 illustrate shoreline values, uses, ownership, and problem areas for this shoreline reach.

The westerly eight miles of the shore, from the Ohio-Pennsylvania line to the mouth of Elk Creek, is thinly populated. In the first two miles, where a highway closely follows the lakeshore, a single row of residences and summer homes borders the lakeshore. The next three miles are mostly occupied by organizational camps, and the two miles of shoreline west of Elk Creek are undeveloped and quite heavily wooded. Between Elk Creek and Erie Harbor, the shore development increases. Many of the shore properties in this reach are high-value permanent homes.

Table 42

Shoreline of the Great Lakes — Erie County, Pennsylvania

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public		Private	Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal		Critical	Noncritical			
Economic Uses											
Residential	21.2	43.8		0	0	21.2	0	20.5	0.7	0	0
Industrial and commercial	3.6	7.4		0	0	3.6	0	3.1	0.5	0	0
Agricultural and undeveloped	11.9	24.8		0	0	11.9	0	11.9	0	0	0
Commercial harbors			1								
Electric power sites			1								
Public buildings and related lands	0	0		0	0	0	0	0	0	0	0
Recreational Uses											
Parks	11.6	24.0		0	11.6	0	6.0	0.5	5.1	0	0
Recreational boat harbors			4								
Beach zone	(48.3)	(100.0)		(0)	(11.6)	(36.7)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	0	0					0	0	0	0	0
Total	48.3	100.0		0	11.6	36.7	6.0	36.0	6.3	0	0



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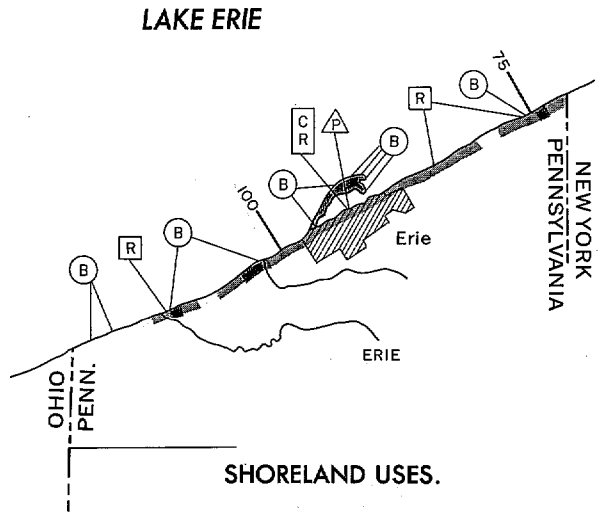

SHORELAND USES.

SCALE IN MILES

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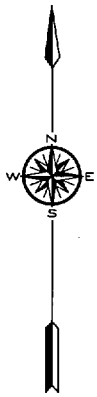
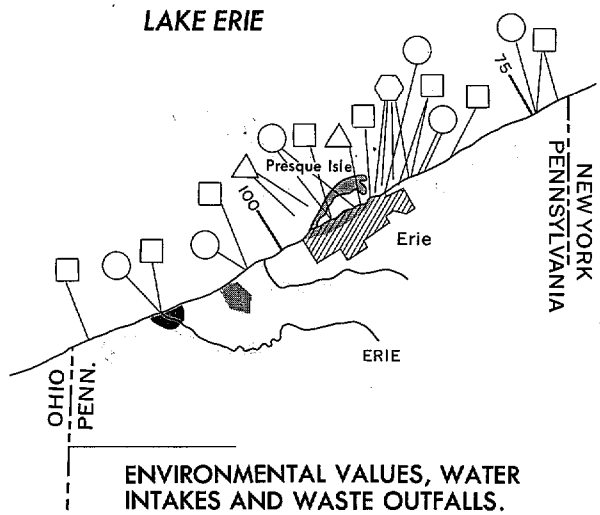
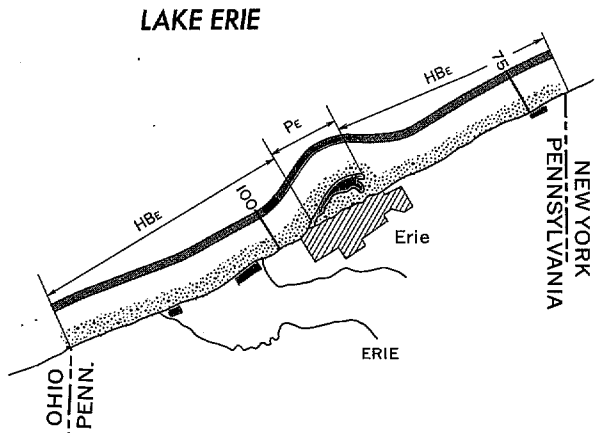




ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS.



PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES.

Figure 64. SHORELANDS OF THE GREAT LAKES, ERIE COUNTY.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors (C)
- Recreational Harbors (R)
- Commercial Deep Draft and Recreational Harbors (C R)
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites
- Waste Water Outfalls and Intakes
  - Public Outfalls
  - Public Intakes
  - Private Outfalls
  - Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W
- Combinations Shown As: Example
  - Lakeward/Landward — W/P_E
  - Upper Bluff Material / Lower Bluff Material — HB_E/HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)

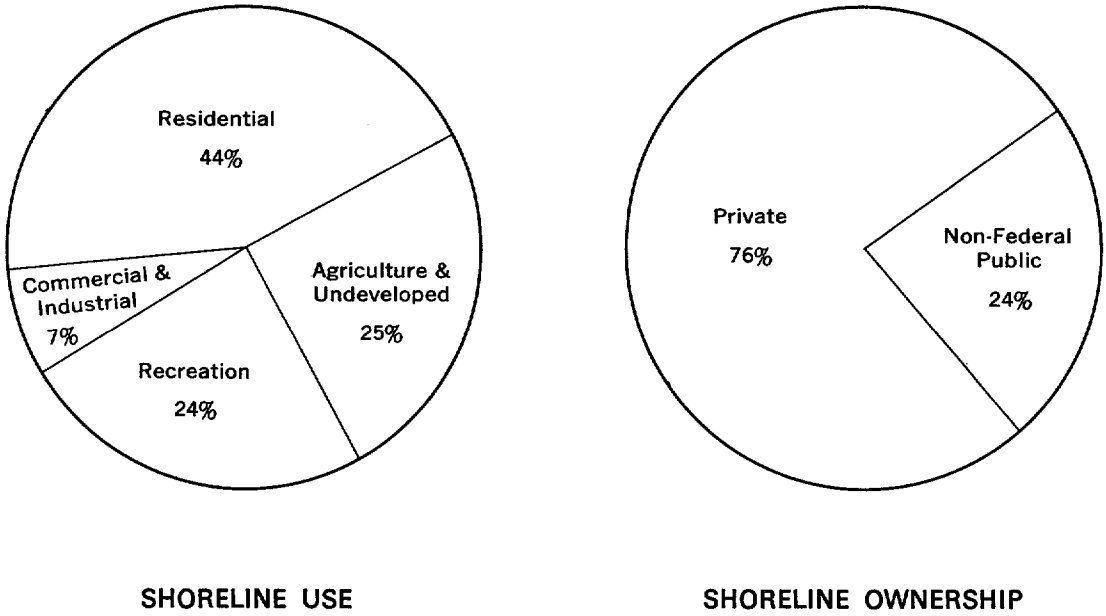


Figure 65. Distribution of Shoreline Use and Ownership, Erie County, Pennsylvania.

The first mile of shore east of Erie Harbor is occupied by a steel mill and a paper mill. The next eight miles, to the mouth of Twelve-mile Creek, are developed with residences and a golf course. The next four miles, to near Sixteen-mile Creek, is generally undeveloped. The shore from there to the Pennsylvania-New York line is being developed for residential use. The westerly half of the mainland shore in the city of Erie within Presque Isle Bay is residential. The easterly half is commercial and industrial. Presque Isle Peninsula, which encloses Erie Harbor, is a large sand spit developed as a state park. The distribution of shoreline use and ownership is shown in Figure 65.

Presque Isle State Park has the largest and best public beach on Lake Erie. It has a total shoreline of over seven miles on its lakewood edge and almost as much on the bay side of the peninsula. Its unique formation and development are of considerable ecological and botanical interest. Perry's Monument on the peninsula is of historical interest as a memorial to Commodore Perry, whose fleet defeated the British in Put-in-Bay in 1813.

In addition to this 3,200-acre park, the Commonwealth owns lake frontage at the mouth of Walnut Creek and at the Borough of Northeast, about two miles west of the New York State line. These areas are managed by the Pennsylvania Fish Commission. There is a local community park in the Borough of Lake City located near the mouth of Elk Creek. For its future recreational needs, Erie County has proposed six new lake front park developments. These would be located at the mouths of the following tributary streams: Racoon Creek, Crooked Creek, Elk Creek, Eight-Mile Creek, Sixteen-Mile Creek, and Twenty-Mile Creek. In addition, Erie County would like to preserve the tributary valleys as natural areas for hiking trails and fishing.

There is a Federal deep-draft navigation project at Erie Harbor. A Federal small-boat harbor has been authorized at Elk Creek, where there are private marina facilities. And a study is underway for a new Federal small-boat harbor at Northeast, Pennsylvania, about two miles from the Pennsylvania-New York line. The Commonwealth is planning further improvement at the mouth of Walnut Creek to accomodate small boats now using its public launching ramp. There is a large marina operated by the Commonwealth in Presque Isle State Park. There are also private marina facilities and a yacht club in Presque Isle Bay.

Table 43
Total Damage to Shore Property on Lake Erie — Erie County, Pennsylvania

Land Use	Damages, $ Actual 1951-52 Value	Damages, $ Updated 1970 Value
Private		
Residential	400	800
Industrial and commercial	1,800	3,500
Agricultural and undeveloped	4,300	4,500
Total, private property	6,500	8,800
Public		
Parks and beaches	442,000	1,021,000
Total, public property	442,000	1,021,000
Total erosion damages	448,500	1,029,800

9.2 Erosion and Flooding History

Erosion of the bluffs is generally noncritical, since sand and gravel beaches provide good protection. Beaches in some of the highly developed residential and camp areas between the Ohio-Pennsylvania line and Erie have been improved by construction of groins. Erosion of the frontage east of Erie Harbor is further slowed by the shale in the lower part of the bluffs. In general, the development is well back from the bluff face and, expect in a few isolated cases there has been no critical erosion damage, apart from the lakeward edge of Presque Isle Peninsula.

Erosion damages reported in the damage survey made in 1951-52 in Erie County are shown in Table 43. The principal damages shown occurred at Presque Isle State Park.

Presque Isle Peninsula has a history of serious and continuous erosion. It consists entirely of fine sand, with a surface elevation averaging about seven feet above low water datum. Parts of the peninsula are low marshes, which are flooded during extreme high lake stages. Its principal problem, however, is erosion of its lakeward edge. Due to littoral forces, the peninsula tends to move in an esterly direction, and several wide breaks have occurred in the narrow neck in the past 150 years. Between 1872 and the present time, much of the peninsula has been progressively protected by groins, bulkheads, and sand fill. This work has been done by the city of Erie, the Commonwealth, and the Federal Government. The latest Federal project, in cooperation with the Commonwealth, provided for construction of groins along the neck of the peninsula and placement and replenishment of sand fill where needed along the entire lakeward edge.

9.3 Solutions to Erosion Damages

The cooperative beach erosion project at Presque Isle was authorized as recommended in a report of the Chief of Engineers in October 1952, published in House Document No. 231, 83rd Congress, 1st Session. A later report, published in House Document No. 397, 86th Congress, 2nd Session, recommended Federal help in beach replenishment for the original project, in which about 4,200,000 cubic yards of sand fill were placed and 11 groins were constructed. Replenishment requirements have been greater than originally estimated, and a review study is now underway to find means of reducing those requirements. The rate of natural accretion is obviously not enough to maintain the extensive park beaches. Costs of the cooperative project to date have been a little over $4 million. An additional $2 million to $5 million may be required for additional groins or other project changes and replenishment of the beach fill, to restore the project. The rate of littoral drift, particularly west of Presque Isle, is sufficient that groins have successfully protected long lengths of privately owned shore.

Other than further participation in the Presque Isle project, there are no other critical erosion or flooding problems along the Lake Erie shore of Pennsylvania of interest to the Federal Government at this time.

Section 10

STATE OF NEW YORK

The Great Lakes Mainland Shoreline of New York is located within four planning subareas: Lake Erie East Planning Subarea 4.4, Lake Ontario West Planning Subarea 5.1, Lake Ontario Central Planning Subarea 5.2, and the Lake Ontario East Planning Subarea 5.3. The mainland shoreline is 360.5 miles long. The four planning units contain a 25-county area with a population of about 4 million (1970). This is about 22 percent of the total population of the State of New York. The major urban centers located on the Great Lakes Shoreline are Dunkirk, Buffalo, Rochester, and Oswego. The larger drainage areas are the Genesee and Oswego river basins and the Erie-Chautauqua, Niagara-Orleans, and Wayne-Cayuga Complexes.

A detailed description of the shoreline is contained in four following subsections. Of the 360.5 miles of shoreline, 292.5 miles have a beach zone and 68 miles of shoreline are without a beach zone. The present shoreline uses in New York are: 151.7 miles residential, 29.8 miles industrial and commercial, 6.6 miles public buildings and related lands, 38.1 miles parks, and 134.3 miles agricultural, forest, and undeveloped. The shoreline reach contains 38.1 miles of public parks with the 22 public beaches having a total area of 118 acres. There are 5 commercial harbors and 35 light-draft harbors and marinas that provide facilities for about 4,500 recreational boats. Shoreline ownership is divided 44.7 miles non-Federal public and 315.8 miles private.

Of the 360.1 miles of shoreline in New York, it is estimated that 16.8 miles sustain critical erosion processes, 179.6 miles are subject to noncritical erosion, 19.1 miles are subject to flooding, and 106.6 miles are noneroding (stable or accreting or protected). The critical shoreline erosion problems exist at 11 locations. Suitable methods of protection are described in the following subsections. The estimated first cost for suggested protection is about $16 million.

Photograph 40. Cooperative beach erosion project at Presque Isle Peninsula, Erie, Pennsylvania.

Photograph 41. Shale bluff and narrow beach about eight miles west of Buffalo, New York. This is typical of shoreline characteristics in Chautauqua and Erie Counties, New York.

Photograph 42. Narrow beach and glacial till bluff west of Olcott Harbor, New York.

10.1 The Lake Erie East Planning Subarea 4.4

The Great Lakes Mainland Shoreline of New York in planning subarea 4.4 is 102.1 miles long (Figure 66). The major drainage areas are: the Tonawonda-Buffalo river basins and the Erie-Chautauqua Drainage Complex. The four county area has a population of 1.53 million (1970). The urban centers located on the shoreline are Barcelona, Dunkirk, Silver Creek, Buffalo on Lake Erie, and Wilson and Olcott on Lake Ontario. Information on the shoreline is given for two reaches; Chautauqua and Erie counties on Lake Erie and Niagara County on Lake Ontario. Figure 67 and Tables 44 and 46 illustrate shoreline values, uses, ownership, and problem areas for this shoreline reach.

10.1.1 Chautauqua and Erie Counties

10.1.1.1 Shoreland Description

The shores of Chautauqua and Erie counties bordering Lake Erie measure 70.9 miles and have very similar physical characteristics. The average height of the shore bluffs is 40 to 50 feet and up to 100 feet in short reaches. The lower part of the bluffs, generally well above the limit of wave uprush, is shale. In some places, shale extends the full height of the bluff, but more generally the top half is earth. For some distance on either side of river mouths, the bluffs are lower and may be entirely granular material or silt and clay. Narrow gravel and shingle beaches, 40 to 50 feet wide at average lake levels, extend along some of the shale bluff reaches. Several wider sand beaches occur mainly between Silver Creek and Cattaraugus Creek and in the town of Evans.

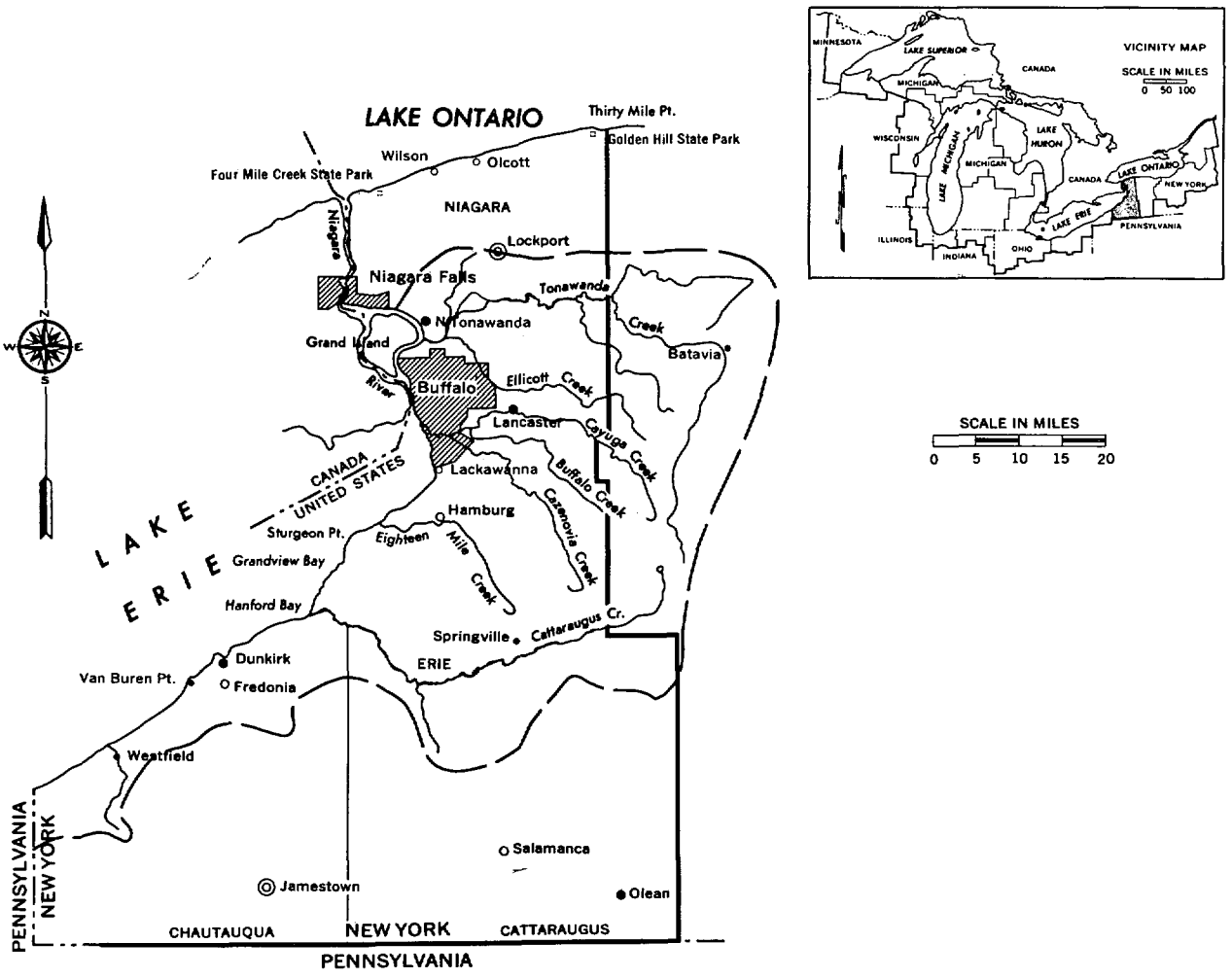


Figure 66. Lake Erie East Planning Subarea 4.4, New York.

Table 44

Shoreline of the Great Lakes — Chautauqua and Erie Counties, New York

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public		Private	Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal		Critical	Noncritical			
Economic Uses											
Residential	24.7	34.9		0	0	24.7	0	1.4	3.4	0.3	19.6
Industrial and commercial	9.0	12.7		0	0	9.0	0	0.3	6.0	0.3	2.4
Agricultural and undeveloped	24.4	34.4		0	0	24.4	0	1.0	0	0.1	23.3
Commercial harbors			1								
Electric power sites			1								
Public buildings and related lands	4.9	6.9		0	4.9	0	0	0	3.4	0	1.5
Recreational Uses											
Parks	7.9	11.1		0	7.9	0	0	7.9	0	0	0
Recreational boat harbors			5								
Beach zone	(59.9)	(84.5)		(0)	(8.9)	(51.0)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(NA)						0	0	0	0	0
Forest	0	0		0	0	0	0	0	0	0	0
Total	70.9	100.0		0	12.8	58.1	0	10.6	12.8	0.7	46.8

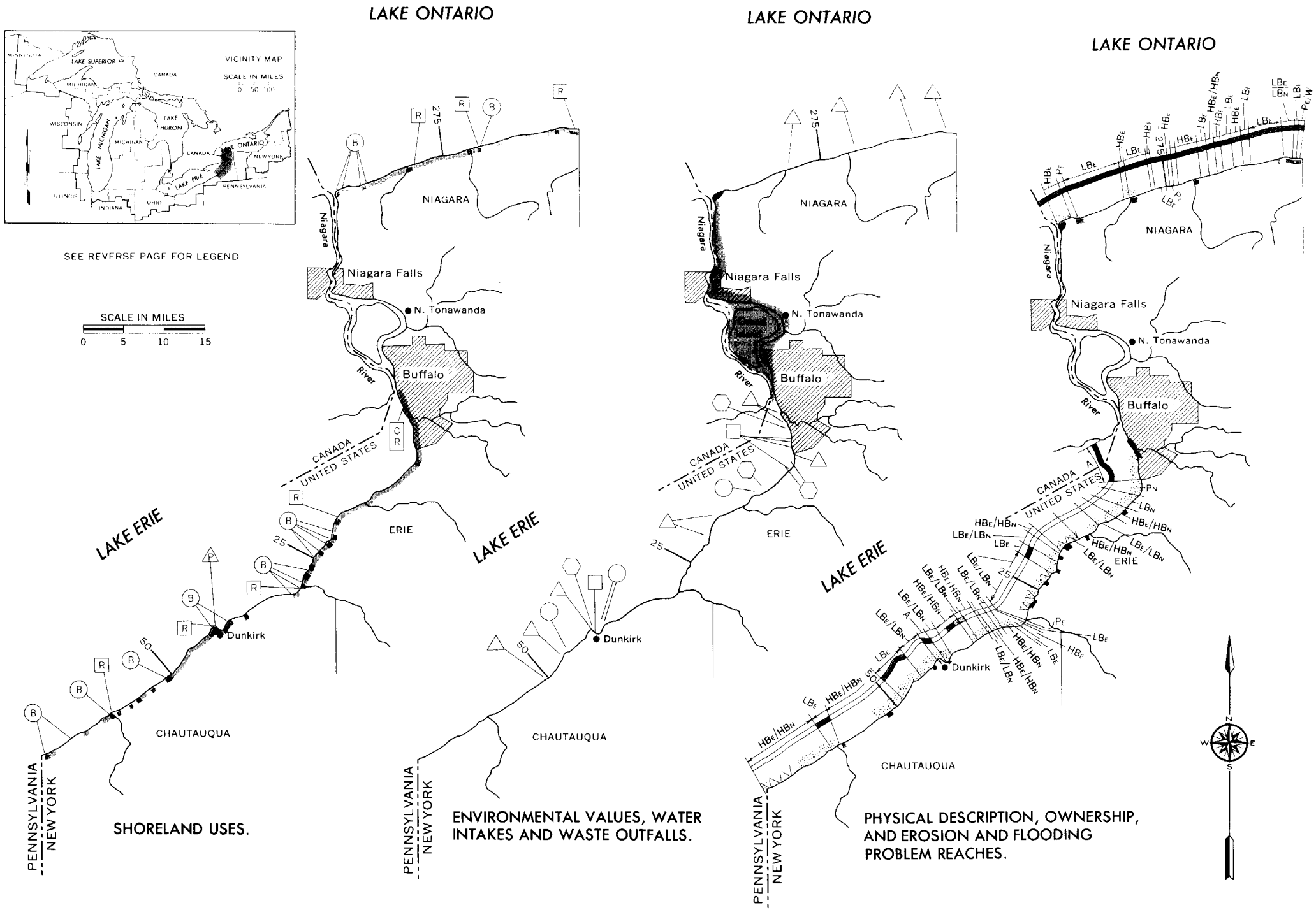


Figure 67. SHORELANDS OF THE GREAT LAKES, NIAGARA, ERIE, CHAUTAQUA COUNTIES.

LEGEND

SHORELAND USES

- Commercial, Industrial, Residential and Public Buildings
- Recreational and Urban Open Space
- Agricultural and Undeveloped
- Forest
- Public Beaches (B)
- Commercial Deep Draft Harbors [C]
- Recreational Harbors [R]
- Commercial Deep Draft and Recreational Harbors [C R]
- Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

- Significant Fish and Wildlife Values
- Unique Ecological or Natural Areas
- Outstanding Shoreland Areas of Possible National Interest
- Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

- Federal Lands
- Non-Federal Public Lands
- Private Lands

Shore type

- Artificial Fill Area — A
- Erodible High Bluff, 30 ft. or higher — HB_E
- Non-Erodible High Bluff, 30 ft. or higher — HB_N
- Erodible Low Bluff, less than 30 ft. high — LB_E
- Non-Erodible Low Bluff, less than 30 ft. high — LB_N
- High Sand Dune, 30 ft. or higher — HD
- Low Sand Dune, less than 30 ft. high — LD
- Erodible Low Plain — P_E
- Non-Erodible Low Plain — P_N
- Wetlands — W

Combinations Shown As: Example

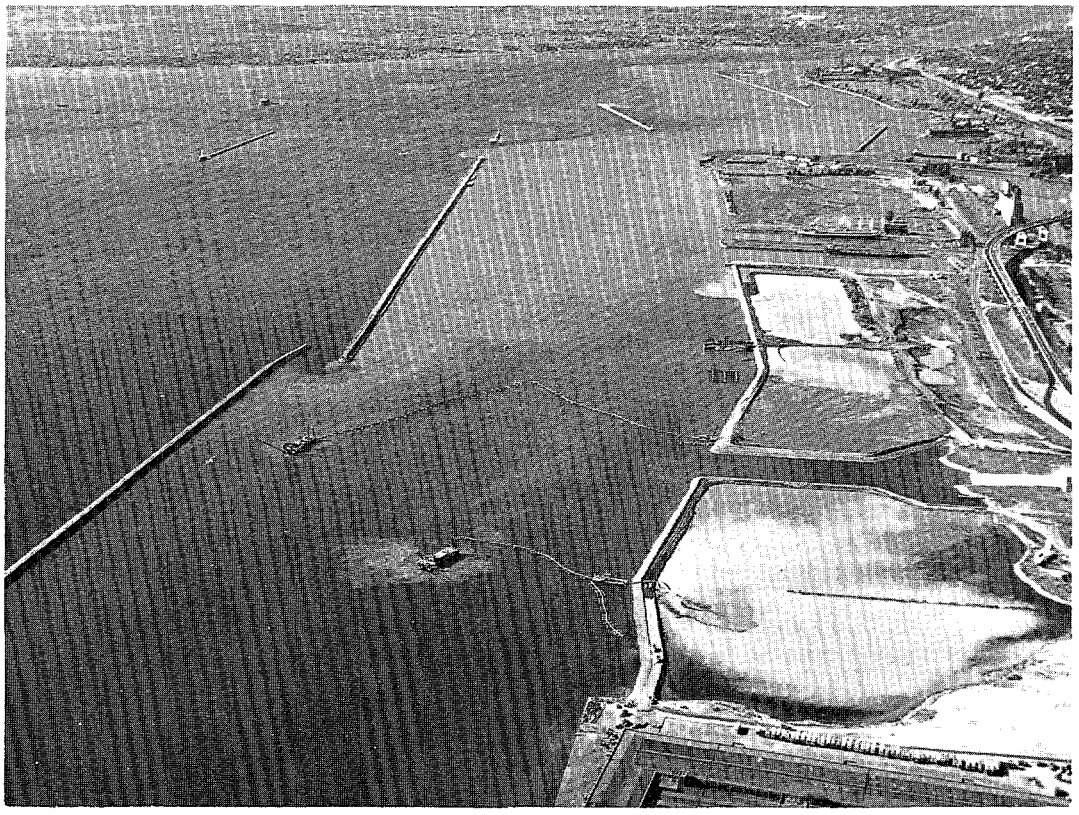
- Lakeward/Landward — W/P_E
- Upper Bluff Material / Lower Bluff Material — HB_E / HB_N

Beach Material

- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)



Photograph 43. Aerial view of the Buffalo outer harbor. Hydraulic dredges are deepening the Federal Project areas and depositing dredged materials behind retaining dikes. The new land will be used by the Niagara Frontier Port Authority for additional port terminal and industrial development.

Except for these beaches and occasional pockets of sand trapped by natural headlands or shore structures, there is little sand in this entire reach. What there is, is usually a thin layer over the shale bottom.

In general, the shoreline of Chautauqua County is used for agriculture or is undeveloped. Between the Pennsylvania-New York State line and Van Buren Point, a shoreline distance of about 20 miles, only a few small scattered residential areas exist. Lake Erie State Park is located at the east end of this reach. The next nine miles of shoreline development, between Van Buren Point and two miles east of Dunkirk Harbor, consist of permanent and summer residences. Exceptions are the commercial and industrial frontage in Dunkirk, and the city owned Gratiot Point Park and Wright Park, and another one-quarter-mile frontage in the harbor. Eight miles of shore between Dunkirk and Silver Creek contain only scattered residential areas. The shoreline from Silver Creek to the County line at the mouth of Cattaraugus Creek is a highly developed summer resort area.

The Lake Erie Shoreline of Erie County, between Cattaraugus Creek and Lackawanna, a distance of about 22 miles, is a highly developed residential area. There are occasional open spaces, and Evangola State Park and about seven smaller public recreation areas are located in this reach. The shoreline of Lackawanna and Buffalo, to the mouth of Buffalo River is used for heavy industry and commercial purposes. The mouth of Buffalo River, for purposes of this study, is considered to be the east end of Lake Erie. This is considered to be the head of the Niagara River, too. Erie County also borders the upper 12 miles of the East Branch of Niagara River, leading to the entrance to the New York State Barge Canal at North Tonawanda. Erie County also includes Grand Island in the Niagara River, which has a shoreline edge of about 23.5 miles. The Grand Island shore is mostly residential but includes several small-boat marinas and Beaver Island State Park. Between the mouth of the Buffalo River and North Tonawanda, the United States shore of Niagara River is developed almost exclusively

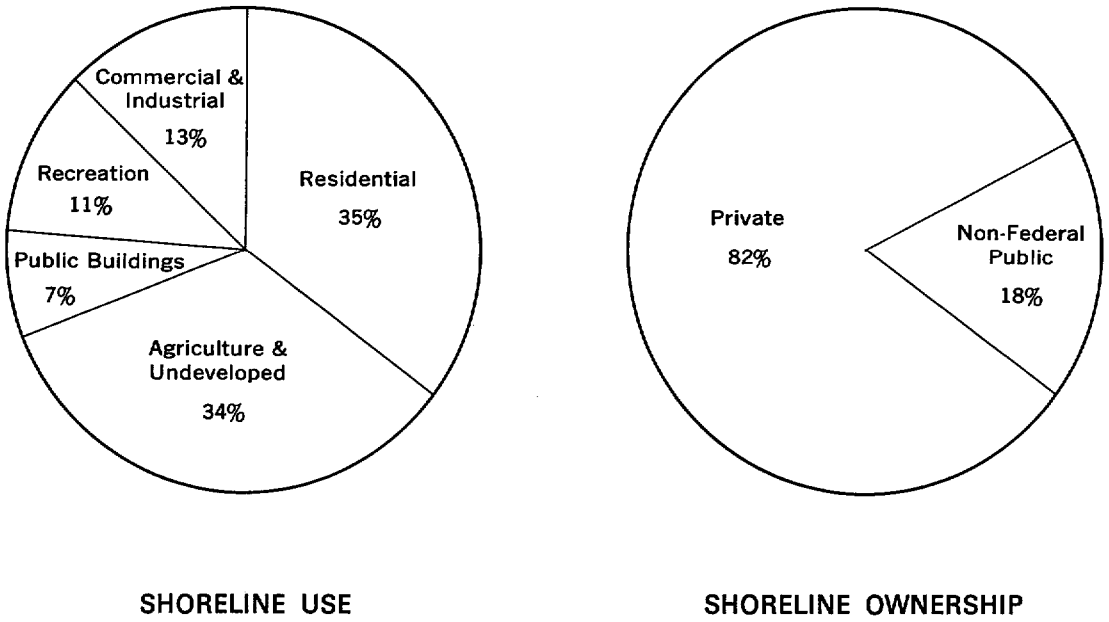


Figure 68. Distribution of Shoreline Use and Ownership, Chautauqua and Erie Counties, New York.

for commercial and industrial use. An expressway closely follows the river. The downstream portion of the Niagara River below North Tonawanda is in Niagara County and from North Tonawanda to Niagara Falls it has a mixture of industrial, commercial, and residential development. Below Niagara Falls, the river is in a deep gorge to its outlet in Lake Ontario. There are no serious erosion or flooding problems caused by Lake Erie or Lake Ontario. The most serious problems have been due to ice jams. But the power companies have installed an ice boom at the head of the river and Lake Erie during the winter months since the winter of 1964-65. This has reduced the problem.

The present use and ownership along this reach of shoreline are shown in Figure 68.

There is a light-draft commercial navigation harbor at Dunkirk and a deep-draft harbor at Buffalo. There is a Federal small-boat harbor at Barcelona, New York, with private marina facilities and a State launching ramp. Federal small-boat harbors at Cattaraugus Creek and Grand View Bay have been authorized but not constructed. There are private marina facilities at Cattaraugus Creek and at Sturgeon Point. Extensive public and private small-boat facilities are available in Buffalo Harbor and along the Niagara River.

Lake Erie State Park near Dunkirk in Chautauqua County and Evangola State Park, about two miles east of Cattaraugus Creek in Erie County, have frontages of over one mile each. Both provide bathing, picnicking, and camping facilities.

10.1.1.2 Erosion and Flooding History

Because of the relative stability of the high shale bluffs, erosion and flooding problems in Chautauqua and Erie counties are few. Erosion of the bluffs and deterioration from weathering and frost action do occur, and improvements close to the top of the bluffs become threatened. Occasional requests for advice and assistance in erosion control are received from property owners. Preliminary discussions of considered beach erosion control studies for the improvement of Gratiot Point Park at Dunkirk and Evangola State Park were held with public officials over 10 years ago. In both instances, improvement of public bathing beaches was the principal purpose of the suggested improvements, with erosion control a secondary purpose.

Table 45

Total Damage to Shore Property on Lake Erie – Chautauqua and Erie Counties, New York

Land Use	Damages, $ Actual 1951-52 Value	Damages, $ Updated 1970 Value
Private		
Residential	43,200	83,300
Industrial and commercial	74,000	142,800
Total, private property	117,200	226,100
Public		
Parks and beaches	2,500	5,800
Total, public property	2,500	5,800
Total erosion damages	119,700	231,900

A flooding problem at the mouth of Cattaraugus Creek is due mainly to ice jams on the river-mouth bar during heavy spring outflows from the creek. The authorized Federal project at Cattaraugus Creek is a combined flood control and navigation project that is designed to correct this condition.

Due to the influence of westerly storms, the lake levels at the east end of Lake Erie are subject to large temporary changes. A temporary rise of five feet occurs on an average of once a year. Changes of seven or eight feet are not uncommon. Flooding of low areas, including some of the docks in Buffalo Harbor, occasionally occurs during the most extreme changes. These extreme changes also increase the erosion, because larger waves can reach shore. Thus, heavier and higher protections are needed here than at any other point on Lake Erie, where changes are much less. Because these temporary changes are taken into account when docks and other shore installations are built, there is little, if any, damage from flooding at still water levels, even during high lake level cycles.

Damages to Chautauqua and Erie counties recorded in 1951-52, and the damages updated to 1970 price levels, are shown in Table 45.

10.1.1.3 Solutions to Erosion Damages

Because of the slow rate of erosion, no known criterial erosion areas exist along this reach of shoreline. Concrete seawalls have been used successfully to protect the toe of the shale bluffs in those few instances where protection has been necessary.

10.1.2 Niagara County

10.1.2.1 Shoreland Description

The Lake Ontario Shoreline of Niagara County is essentially straight. extending for about 31 miles in an east-northeast direction from the mouth of the Niagara River. The shore bluffs are from 30 to 60 feet high. For the most part, they are composed of glacial deposits consisting of till of various forms and layered drift in the form of kames, eskers, and sheets of outwash sand and gravel. The bluffs are open to wave attack, frost action, seepage, and surface erosion. Only a small amount of residual material from erosion of the bluff is coarse enough to remain in the beach zone. This accounts, in part, for the lack of wide beaches on the south shore of Lake Ontario in this county. Bedrock rises from about 10 feet below lake level, just east of the mouth of

Table 46

Shoreline of the Great Lakes — Niagara County, New York

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public		Private	Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal		Critical	Noncritical			
Economic Uses											
Residential	16.2	51.9		0	0	16.2	1.5	9.8	4.9	0	0
Industrial and commercial	0.2	0.6		0	0	0.2	0	0.2	0	0	0
Agricultural and undeveloped	8.7	27.9		0	0	8.7	0.3	8.4	0	0	0
Commercial harbors			0								
Electric power sites			0								
Public buildings and related lands	0	0		0	0	0	0	0	0	0	0
Recreational Uses											
Parks	6.1	19.6		0	6.1	0	3.1	2.7	0.3	0	0
Recreational boat harbors			3								
Beach zone	(29.8)	(95.5)		(0)	(5.0)	(24.8)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	0	0		0	0	0	0	0	0	0	0
Total	31.2	100.0		0	6.1	25.1	4.9	21.1	5.2	0	0

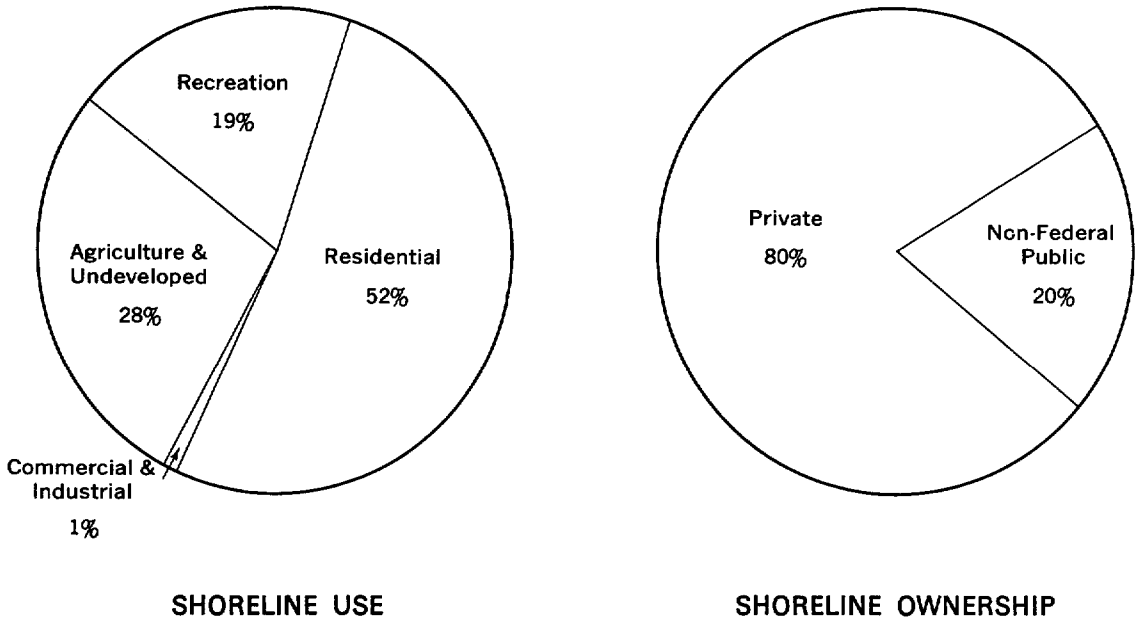


Figure 69. Distribution of Shoreline Use and Ownership, Niagara County, New York.

the Niagara River, to about 25 feet above lake level at Thirty-Mile Point, near the east county line. Rock outcrops occur above lake level just east of Olcott Harbor. Table 46 and Figure 67 illustrate shoreline values, use, ownership and problem areas for this shoreline reach.

The westerly 20 miles of shore, from the Niagara River to a mile east of Olcott Harbor, are quite generally developed, with a fringe of summer and permanent residences along the lake shore. The upland is agricultural land. Between Olcott and the Niagara-Orleans County line, residential developments are more widely scattered, and the shore is generally in agricultural use or undeveloped. The present shoreline use and ownership in Niagara County are shown in Figure 69. During the past 20 years, the main change in shore use has been a marked increased in residential use and park development, with a similar decrease mainly in agricultural use.

There are four State parks in Niagara County, with a shoreline frontage of about 3.75 miles. Local parks and other public and semipublic developments have a frontage of about 2.3 miles. All of the State park lands have been obtained within the past six years to meet the long range needs for public open space and recreational areas. The four State parks are Fort Niagara, Four-Mile Creek, Tuscarora Park near Wilson, and Golden Hill State Park, between Thirty-Mile Point and the Niagara-Orleans County line. All are in the early stages of development by the State.

Federal projects provide small-boat harbors at Wilson and Olcott harbors. Both have private marina and yacht club facilities. There are also private marinas and a launching ramp in the lower Niagara River at Youngstown. There is a small public marina and launching ramp at Golden Hill State Park. Studies of proposed Federal small-boat harbors at Four-Mile Creek and Golden Hill State parks are underway. Further improvements at Wilson and Olcott harbors are authorized or under study.

Table 47

Total Damage to Shore Property on Lake Ontario – Niagara County, New York

Land Use	Damages, $ Actual 1951-52 Value	Damages, $ Updated 1970 Value
Private		
Residential	386,700	746,300
Industrial and commercial	15,500	29,900
Agricultural and undeveloped	2,600	2,700
Total, private property	404,800	778,900
Public		
Parks and beaches	8,500	19,600
Utilities	20,500	47,300
Total, public property	29,000	66,900
Total erosion damages	433,800	845,800

10.1.2.2 Erosion and Flooding History

The loose bluff material of Niagara County is very open to erosion. A beach erosion study made about 30 years ago reported that in the 64-year period between 1875 and 1939 the highest rate of erosion, which occurred around Wilson Harbor, was nearly five feet per year. The erosion did not occur at a uniform rate and was accelerated during periods of high lake levels. Erosion rates in the easterly half of the county are much slower. However, it was found necessary to protect the lighthouse at Thirty-Mile Point with heavy stone revetment. This was done because of deterioration and erosion of the shale outcrop at the lake shore, which at this point appears as high and as strong as at any point in the county.

During the record high water levels that occurred in 1952, there was flooding of some of the commercial fishing docks at Wilson Harbor and of other low docks and land areas in Wilson and Olcott harbors.

Significant erosion of the bluffs, particularly just west of Wilson, but throughout the entire length of the Niagara County shore, occurred during the 1951-52 high-water period. Recorded damages are shown in Table 47, as reported in 1952 and updated to 1970 price levels.

Lake Erie established new high monthly mean levels in 1969 for the months of July and August, even exceeding the 1952 highs for these months. However, the levels of Lake Ontario were about two feet below the 1952 levels. Erosion and flood damages were therefore quite light during 1969, when compared to those on the upper lakes. One reason for this is that since April 1960, following completion of the St. Lawrence Seaway, the levels of Lake Ontario have been regulated by controlling outflows through the St. Lawrence River. The regulation plan, approved by the International Joint Commission, allows the peak level of the lake to be lowered about one foot below the highest level it reached under the most severe conditions in the past. For this reason, Lake Ontario should never again be exposed to the same damaging conditions as occurred in 1952.

A little over five miles of the Niagara County Shoreline is protected at this time. About 0.8 mile of this is stone revetment along the highway east of Wilson. Most of the protective structures are stone revetment or concrete seawalls. Groins have been constructed in a few places, at Krull Park for instance, just east of Olcott. Because of the scarcity of littoral drift, little accumulation of sand has occurred. The widest existing beaches are west of Wilson Harbor and Olcott Harbor, where long entrance jetties, in place for many years, have encouraged accretion of sand and gravel beaches.

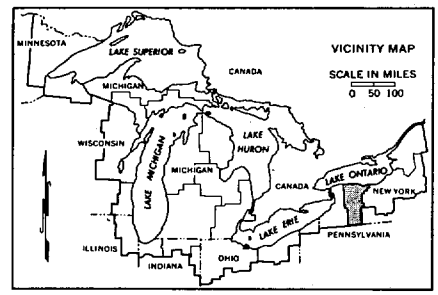
10.1.2.3 Solutions to Erosion Damages

Five miles of critical erosion reaches have been identified along the Niagara County Shoreline. Studies have been completed or are now underway for these miles of critical erosion reaches in public parks. The results of these studies are summarized in the following paragraphs.

The Beach Erosion Board of the Corps of Engineers, in cooperation with the Niagara Frontier Planning Board, completed a beach erosion study of Niagara County in 1942. The report was published in House Document No. 271, 78th Congress, 1st Session. It was concerned mainly with the protection and improvement of public parks at Tuscarora Park near Wilson and Krull Park at Olcott. Plans for protection of private property were also considered. This report recommended protection of the bluffs by stone revetment or concrete crib seawalls. The construction of groins and placement of sand fill were recommended for the improvement and protection of the parks where public bathing beaches were wanted. The groin construction done several years later at Krull Park generally conformed to this recommended plan, but the sand fill was not provided. No significant accretion of sand has occurred.

A beach erosion study recommending a project for Port Niagara State Park was completed by the Corps of Engineers in September, 1968. It was published in House Document 91-319. The recommended plan provides for sand beach fill protected by an offshore breakwater.

Studies are underway at Four-Mile Creek State Park and Golden Hill State Park concerning the improvement and protection of the shore. Groin and beach fill plans are being considered at both locations. Small-boat harbors are also under consideration, as previously noted. Stone revetment is considered the best and most economical protection for private property in this county. Approximately two miles of shore in the vicinity of and generally west of Wilson Harbor are most in need of protection. The cost of protection of two miles of shoreline would be about $1 million.



LAKE ONTARIO

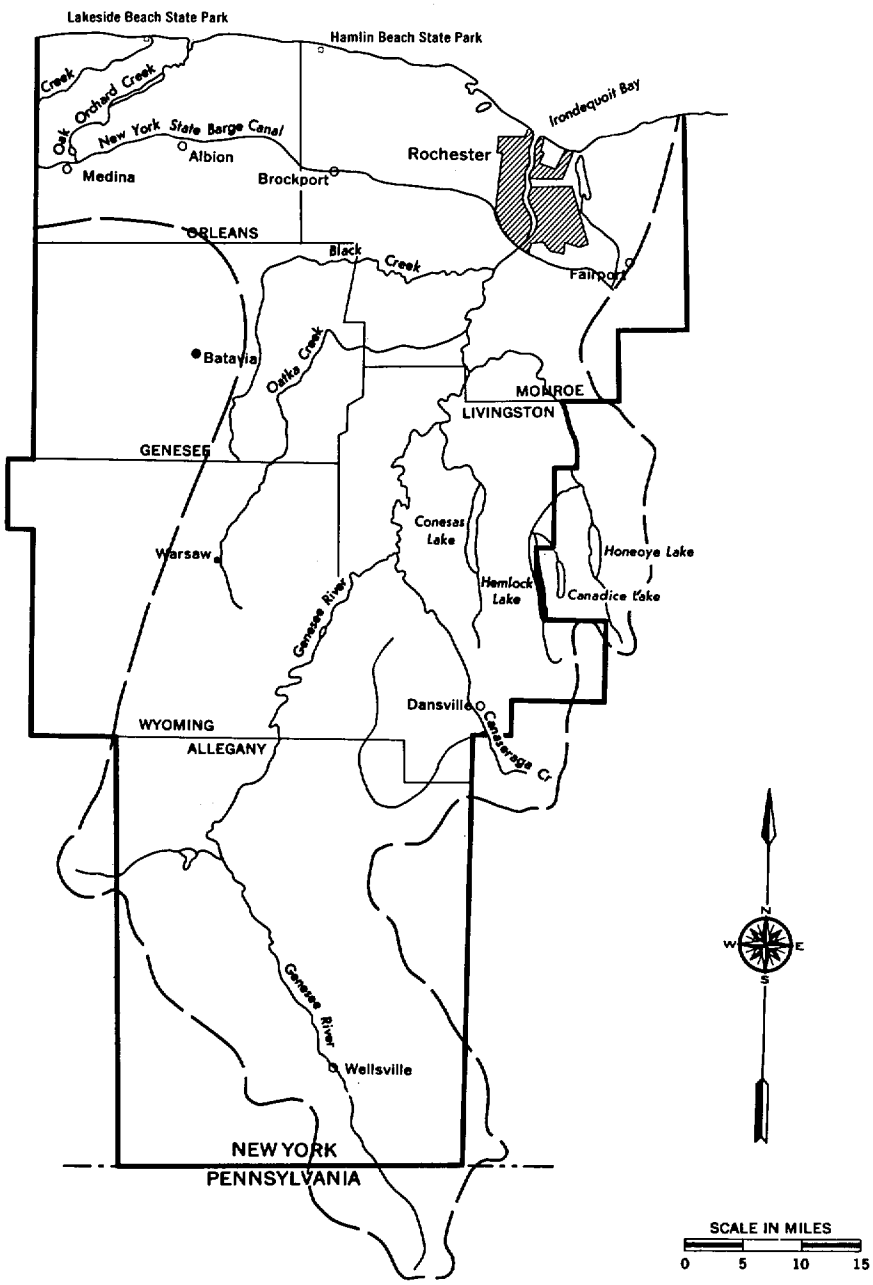


Figure 70. Lake Ontario West Planning Subarea 5.1, New York.

10.2 The Lake Ontario West Planning Subarea 5.1

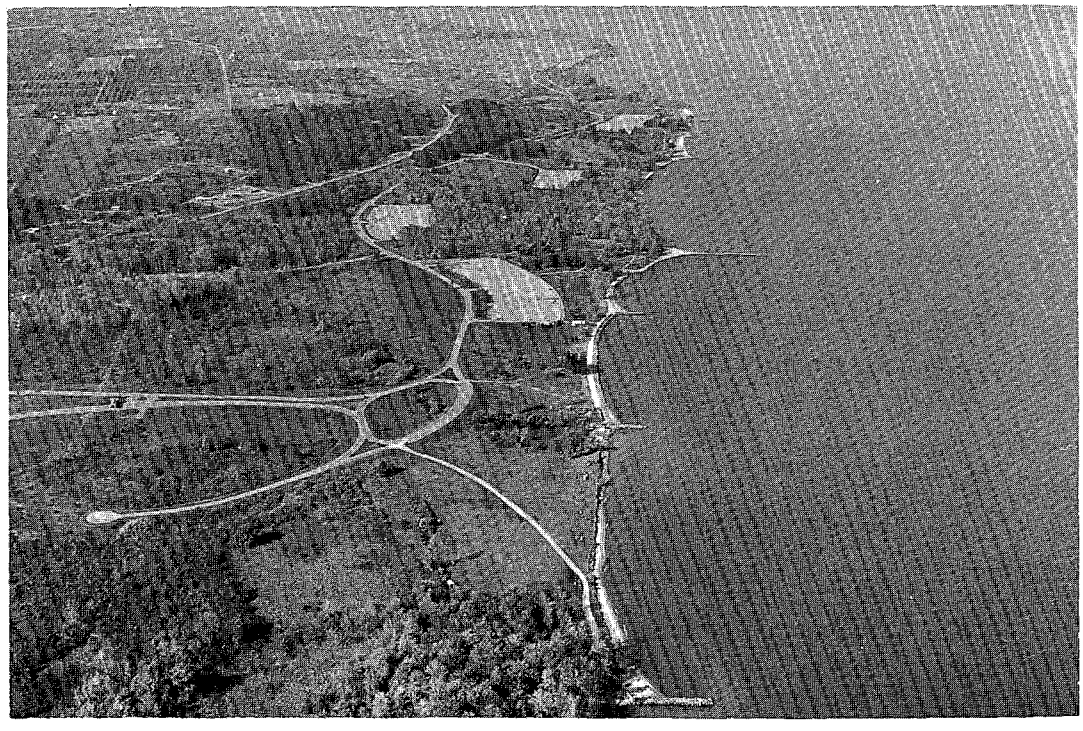
The Great Lakes Mainland Shoreline of New York in planning subarea 5.1 is 59.1 miles long (Figure 70). The major drainage areas are the Genesee River Basin and the Niagara-Orleans Drainage Complex. The six county area has a population of 937,392 (1970). Rochester is the only urban center located on the Lake Ontario Shoreline in this subarea. Table 48 and Figure 71 illustrate shoreline values, uses, ownership, and problem areas for this shoreline reach.

10.2.1 Shoreland Description

The shorelines of Orleans and Monroe counties have a combined frontage of about 59 miles, extending from the Niagara County line, near Thirty-Mile Point, to the Wayne County line, about 12 miles east of Rochester Harbor. The shore characteristics vary considerably, from the 20-foot or higher glacial till bluffs of Orleans County, to the low marshy shore that generally extends across Monroe County, except at the west end, between the Orleans County line and Hamlin Beach State Park, and at the east end, between Rochester Harbor and the Wayne County line. About 20 miles of the Monroe County shore west of Rochester is low marsh land with barrier sand and gravel beaches separating the marshes and open ponds from Lake Ontario. The easterly seven miles of the Monroe County shore through the town of Webster has silt and clay bluffs up to 55 feet high.

The beaches along the shore of both counties are too narrow to provide much protection. There is generally a narrow sand or gravel beach perhaps up to 30 feet wide but no wide beaches, except where held by major structures such as the U. S. West Pier at Rochester Harbor. There is considerable sand in some of the bluffs, notably at Devils Nose in Hamlin Beach State Park. The bluffs are eroding where unprotected over the entire length of Orleans County. Monroe County, which is more highly developed, has more of its shore protected. Less than one mile is protected in Orleans County. Monroe County has about 11-1/2 miles of protected shore.

The shore of Orleans County has a fringe of residential development along a little over half of its total frontage. The remainder is mostly open space, either agricultural, or undeveloped, or park lands. Twenty miles of Monroe County is in residential use, about seven miles are park land, and the remainder is undeveloped or used for commercial and industrial purposes. The distribution of shoreline use and ownership in the combined counties are shown in Figure 72. Within the past 20 years, there has been a reduction in agricultural and undeveloped property and a marked increase in residential and park properties.

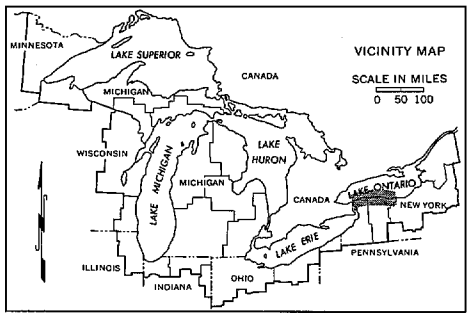


Photograph 44. The shoreline of Lake Ontario at Hamlin Beach State Park, New York.

Table 48

Shoreline of the Great Lakes — Orleans and Monroe Counties, New York

Shoreland Use Category	*Existing Shoreland Use*			*Miles of Shoreline*			*Problem Identification, Miles of Shoreline*				
	Miles of Shoreline	*Percent of Total*	*Number of Sites*	*Public*			*Subject to Erosion*				
				Federal	*Non-Federal*	*Private*	*Critical*	*Noncritical*	*Protected*	*Subject to Flooding*	*Not Subject to Erosion or Flooding*
Economic Uses											
Residential	35.2	59.6		0	0	35.2	0	18.4	6.9	9.9	0
Industrial and commercial	3.1	5.3		0	0	3.1	0.4	0	2.7	0	0
Agricultural and undeveloped	11.3	19.1		0	0	11.3	0.3	10.0	0	1.0	0
Commercial harbors			1								
Electric power sites			1								
Public buildings and related lands	0	0		0	0	0	0	0	0	0	0
Recreational Uses											
Parks	9.5	16.0		0	9.5	0	6.7	0.2	2.6	0	0
Recreational boat harbors			8								
Beach zone	(47.7)	(80.7)		(0)	(6.5)	(41.2)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	0	0		0	0	0	0	0	0	0	0
Total	59.1	100.0		0	9.5	49.6	7.4	28.6	12.2	10.9	0



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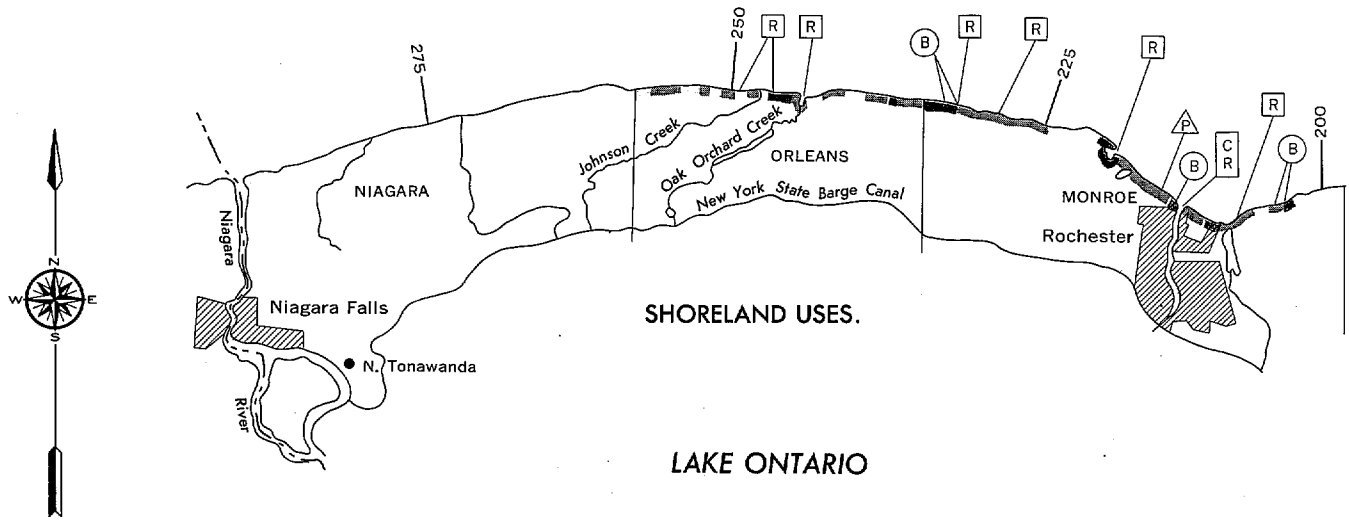
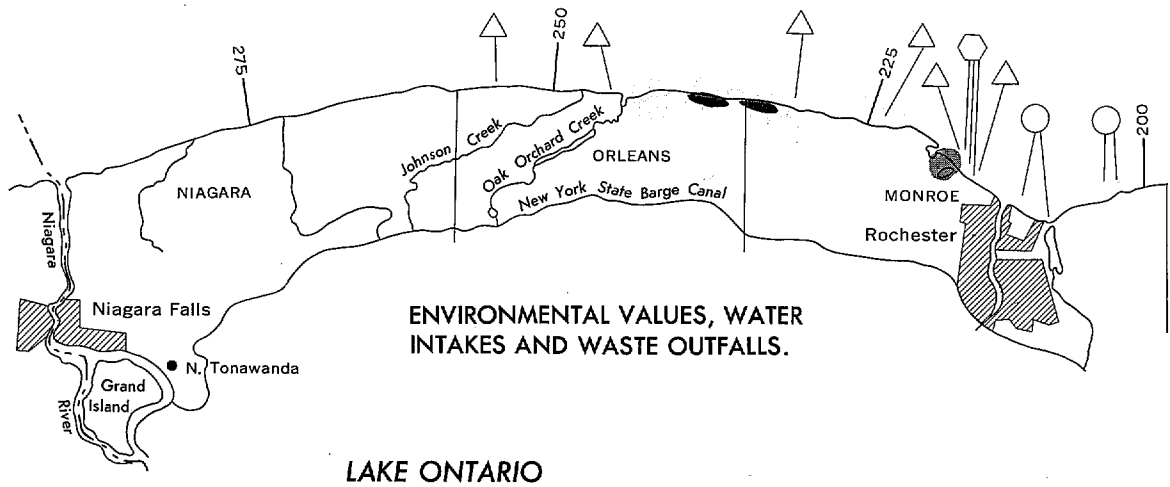




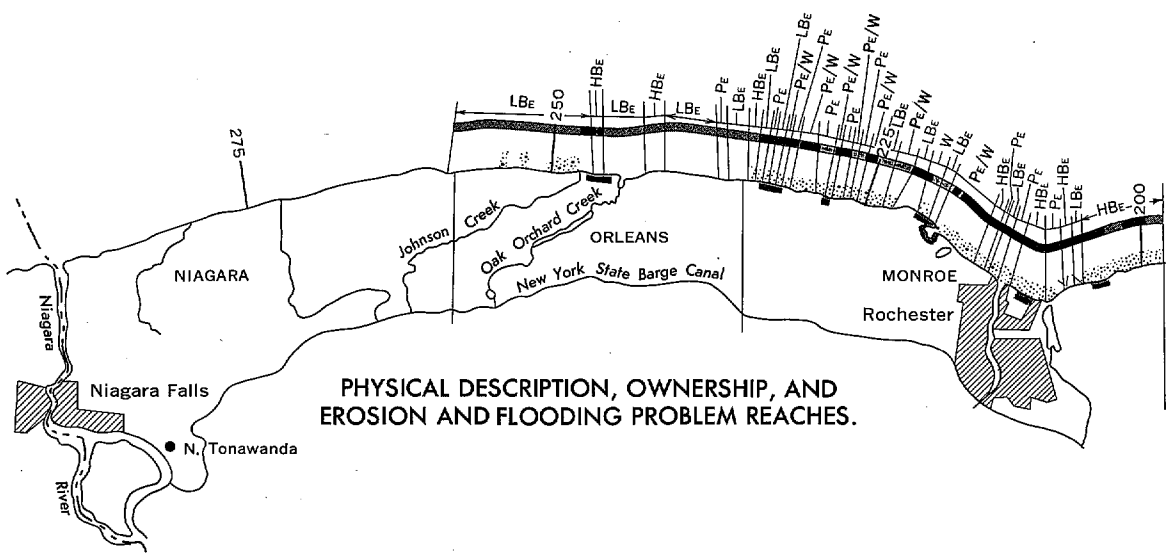


Figure 71. SHORELANDS OF THE GREAT LAKES, MONROE, ORLEANS COUNTIES.

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings

Recreational and Urban Open Space

Agricultural and Undeveloped

Forest

Public Beaches (B)

Commercial Deep Draft Harbors [C]

Recreational Harbors [R]

Commercial Deep Draft and Recreational Harbors [C R]

Electric Power Stations (P)

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values

Unique Ecological or Natural Areas

Outstanding Shoreland Areas of Possible National Interest

Potential Recreation Sites

Waste Water Outfalls and Intakes

- Public Outfalls
- Public Intakes
- Private Outfalls
- Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands

Non-Federal Public Lands

Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

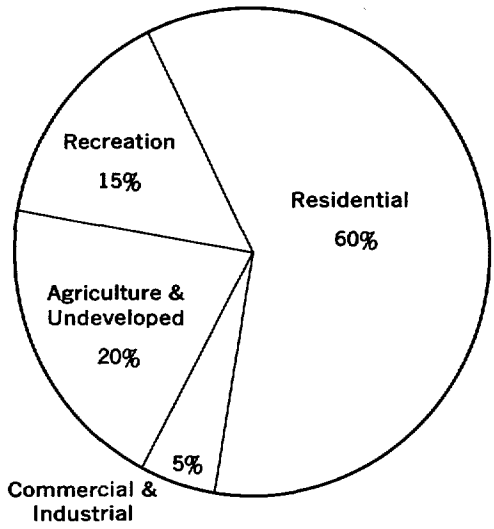
Combinations Shown As:	Example
Lakeward/Landward	W/P_E
Upper Bluff Material / Lower Bluff Material	HB_E / HB_N

Beach Material

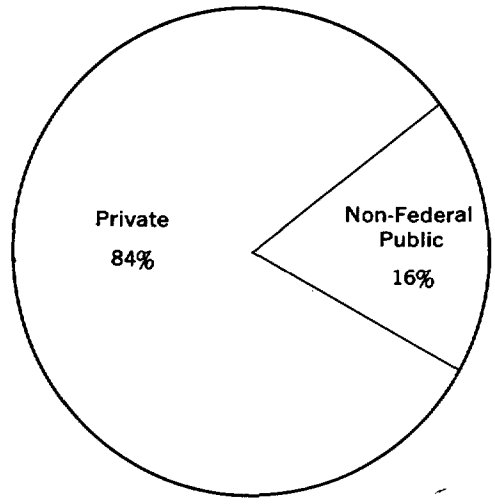
- Sand and gravel
- Ledge rock
- No Beach

Problem Identification

- Areas subject to erosion generally protected
- Critical erosion areas not protected
- Non-critical erosion areas not protected
- Shoreline subject to lake flooding
- Shoreline not subject to erosion or flooding
- Bluff seepage problems (S)



SHORELINE USE



SHORELINE OWNERSHIP

Figure 72. Distribution of Shoreline Use and Ownership, Monroe, and Orleans Counties, New York.

In 1964, the State of New York acquired some 1.5 miles of frontage in Orleans County, just to the east of Johnson Creek, as part of Lakeside State Park. The park frontage is a high bluff and is not improved or protected at the present time. Hamlin Beach State Park in Monroe County is an older park and has a frontage of about three miles that is partly protected and improved. The other main public parks in Monroe County are: Ontario Beach Park, just west of the U. S. West Pier at Rochester Harbor, owned by the city of Rochester; Durand Eastman Park, between Rochester Harbor and Irondequoit Bay, owned by the city of Rochester but leased to Monroe County; and Webster Park, a county park about four miles east of Irondequoit Bay.

There is a deep-draft navigation harbor at Rochester Harbor and public and private marina facilities. Federal small-boat harbors have been authorized at Oak Orchard, Hamlin Beach State Park and Irondequoit Bay. All are in various stages of planning. Public and/or private marina facilities are also available at Braddock Bay, Sandy Creek, and Johnson Creek.

The marshy frontage of Monroe County is a valuable wildlife resource. The ponds and marshes provide a habitat for muskrats, mink, and ducks, and spawning areas for game fish.

10.2.2 Erosion and Flooding History

The shore of these two counties suffered significant erosion and flood damage during 1951-52. Properties along the low shore between Hamlin Beach State Park and Rochester Harbor were the most heavily damaged. Summer homes and permanent residences on the barrier beaches were flooded for several months, and many suffered from wave action and erosion. Damages are shown in Table 49, as reported in 1951-52 and updated to present price levels.

During the 1969 high water levels that affected the upper lakes, Lake Ontario suffered relatively little damage because of lake regulation made possible by construction of the St. Lawrence Seaway. Levels of Lake Ontario were less than 0.5 foot above long-term average levels during the summer months and below normal during the rest of the year.

The existing protection provided by private property owners in Orleans and Monroe counties is mostly stone revetment or concrete seawalls. Groins have been built at Hamlin Beach State Park and Braddock Bay State Park to improve the recreational bathing beaches. Their effectiveness has been limited, due to the low rate of littoral drift, particularly at Braddock Bay.

Table 49

Total Damage to Shore Property on Lake Ontario — Orleans and Monroe Counties, New York

Land Use	Damages, $ Actual 1951-52 Value	Damages, $ Updated 1970 Value
Private		
Residential	4,599,300	8,876,700
Industrial and commercial	73,200	141,300
Agricultural and undeveloped	2,600	2,700
Total, private property	4,675,100	9,020,700
Public		
Parks and beaches	30,500	70,400
Utilities	2,000	4,600
Total, public property	32,500	75,000
Total erosion damages	4,707,600	9,095,700

10.2.3 Solutions to Erosion Damages

Shoreline erosion along this shoreline of New York is critical enough to require widespread structural protection. The critical erosion problem areas identified are: Hamlin Beach State Park, Braddock Bay State Park, and the Durand-Eastman Park in Rochester. Groins and beach fills are a suitable protection for these shoreline reaches. A summary of cooperative beach erosion control studies is given in the following paragraphs.

Beach erosion control studies of Hamlin Beach State Park and Braddock Bay State Park have been made by the Corps of Engineers, in cooperation with the State of New York. A Federal project for cooperating with the State in the protection and improvement of Hamlin Beach State Park has been authorized. The report used as the authorizing document was published in House Document 138, 84th Congress. The authorized plan provides for improvement of about 4,250 feet of frontage by changing an existing groin, constructing six new groins, and the placement of about 237,000 cubic yards of beach fill. The estimated cost of the improvement is $2.3 million (1970).

The considered improvements at Braddock Bay State Park include a small-boat harbor and improvement of the bathing beach. Planning of this improvement is complicated by conflicting interests. Some interests want to preserve the natural fish and wildlife aspects of Braddock Bay and its upland marshes. Others want the development of a small-boat marina and a bathing beach by widening and extending an existing barrier beach across the bay mouth. The estimated cost of a preliminary plan of improvement of the beach is about $1,100,000. The Federal share would be about $770,000.

A beach erosion study of Durand-Eastman Park in the city of Rochester has been authorized. It will consider the improvement of about 7,700 feet of frontage to provide a public bathing beach. The considered improvement will consist of groins and beach fill, similar to the Hamlin Beach plan. Cost estimates have not been prepared, but assuming the same cost per foot as for Hamlin, the costs would be about $4.2 million. The Federal share would be $2.9 million.

Continuing the practice of protecting private residential property by revetment or seawalls is considered most practical. In view of the reduced rate of erosion due to lake regulation, and the present degree of development, there are no critical areas that are unprotected. Undoubtedly, there are individual properties where erosion seriously threatens valuable improvements and some of the existing protection is losing its usefulness. Aside from the requested Federal help in the improvement of public works, there seem to be no problem areas in these two counties where Federal assistance might be justified.

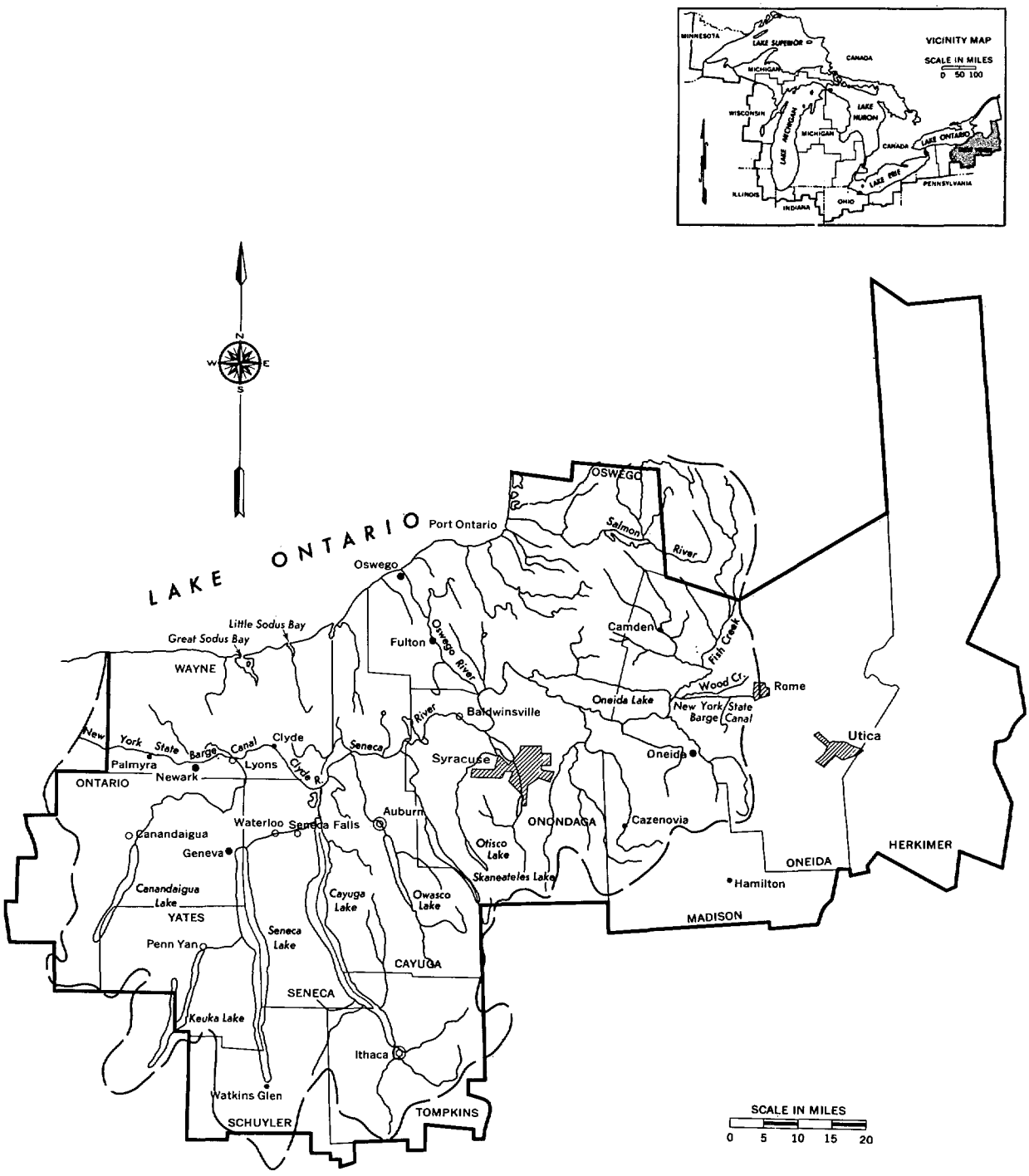


Figure 73. Lake Ontario Central Planning Subarea 5.2, New York.

10.3 Lake Ontario Central Planning Subarea 5.2

The Great Lakes Mainland Shoreline of New York in planning subarea 5.2 is 78.9 miles long (Figure 73). The major drainage areas are the Oswego River Basin and the Wayne-Cayuga Complex. The communities located along the shoreline are Putneyville, Sodus Point, Fair Haven, and Oswego. Table 50 and Figure 74 illustrate shoreline values, uses, ownership, and problem areas for this shoreline reach.

10.3.1 Shoreline Description

The total length of the shoreline of Wayne, Cayuga, and Oswego counties, from the Monroe County line, about 12 miles east of Rochester Harbor, to the Oswego-Jefferson County line, is about 78.9 miles. The latter county line ends approximately at the extreme east end of Lake Ontario about seven miles north of the mouth of the Salmon River at Port Ontario.

The westerly 22 miles of the Wayne County shore, between the Monroe-Wayne County line and Sodus Bay, have a quite continuous bluff from 10 to 70 feet high, with an average height of about 25 feet. The bluff material is mainly silt and clay. The average width of the beach is about 10 feet. The beach material is coarse gravel and shingle. Ledge rock is generally at or up to three feet above, lake level.

The easterly 15 miles of the Wayne County shore, between Sodus Bay and Little Sodus Bay, are a series of drumlins (low, narrow hills of glacial till) separated by marshes that extend several miles inland along small creeks that enter the lake. The drumlins are up to 150 feet high above lake level and one-quarter to one-half mile wide at their base. The material at the bluff face of the eroding drumlins is glacial till, containing from about 10 to 100 percent sand and gravel. Lake Bluff, just east of Sodus Bay, and Chimney Bluff, two miles farther east, are two of the highest. The former has houses dangerously close to the top of the receding bluff. The latter is undeveloped and is in State park property. Beaches at the base of the drumlins are generally less than 10 feet wide. Narrow sand and gravel barrier beaches have formed across the low marsh areas or open water between the drumlins.

The shore characteristics of the entire eight miles of the Cayuga County shore and the westerly five miles of Oswego County to the west city line of Oswege are similar to those in eastern Wayne County.

For about 13 miles east of the mouth of the Oswego River, the shore bluffs are from 5 to 25 feet high. Rock outcrops from lake level to 10 feet or more above lake level occur within this reach. The overlying material is glacial till. Gravel and shingle beaches up to 30 feet wide occur. From 13 miles east of Oswego to the Salmon River at Port Ontario, the shore contains occasional reaches of high ground separated by marsh areas that are fronted by barrier beaches. These beaches are similar to but less prominent and noticeable than the drumlin formations farther to the west.

The remaining Oswego County shoreline north of the Salmon River is generally a barrier beach and sand dunes up to 45 feet high, separating either marsh areas or open ponds from the lake. The dunes and wide flat beaches consist of fine sand.

The upland shore of Wayne County is used mainly for agricultural purposes. Fruit is the principal crop. A fringe of scattered residential developments borders the lakeshore. Chimney Bluffs State Park, just east of Sodus Bay, has a frontage of nearly two miles.

The present shoreline use and ownership in Wayne, Cayuga, and Oswego counties are shown in Figure 75. In the last 20 years, there has been an increase in industrial use, due to construction of the aluminum plant and nuclear power plants near Oswego. As in other parts of the south shore of Lake Ontario, residential and park use has also increased. Agricultural and undeveloped land use has decreased a like amount.

There is a State park in each of the three counties: Chimney Bluff State Park in Wayne County, Fair Haven State Park in Cayuga County, and Selkirk Shores State Park in Oswego County. County and town parks and other semipublic areas provide additional public access to the shore.

There are Federal deep-draft harbors at Great Sodus and Oswego harbors. There is an existing Federal small-boat harbor at Fair Haven that provides an entrance to Little Sodus Bay, and authorized by unconstructed projects at Port Bay and Port Ontario. There are existing private marina or yacht club facilities at Pultneyville, Fairbanks Point, and North Pond. There is a launching ramp at Mexico Bay, at the mouth of Little Salmon River, where the State of New York is considering further improvements. A study of a proposed Federal small-boat harbor at this location has been authorized.

A relatively large part of the frontage of Cayuga and Oswego counties is of particular interest as wildlife habitat because of large marsh areas and protected ponds along the shore.

Table 50

Shoreline of the Great Lakes — Wayne, Cayuga, and Oswego Counties, New York

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public		Private	Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal		Critical	Noncritical			
Economic Uses											
Residential	25.8	32.7		0	0	25.8	0	22.1	3.4	0	0.3
Industrial and commercial	5.9	7.5		0	0	5.9	0	5.5	0	0	0.4
Agricultural and undeveloped	35.8	45.3		0	0	35.8	0	35.2	0	0	0.6
Commercial harbors			2								
Electric power sites			2								
Public buildings and related lands	1.7	2.2		0	1.7	0	0	1.4	0	0	0.3
Recreational Uses											
Parks	9.7	12.3		0	9.7	0	4.5	4.9	0.3	0	0
Recreational boat harbors			8								
Beach zone	(60.3)	(76.4)		(0)	(9.3)	(51.0)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	0	0		0	0	0	0	0	0	0	0
Total	78.9	100.0		0	11.4	67.5	4.5	69.1	3.7	0	1.6

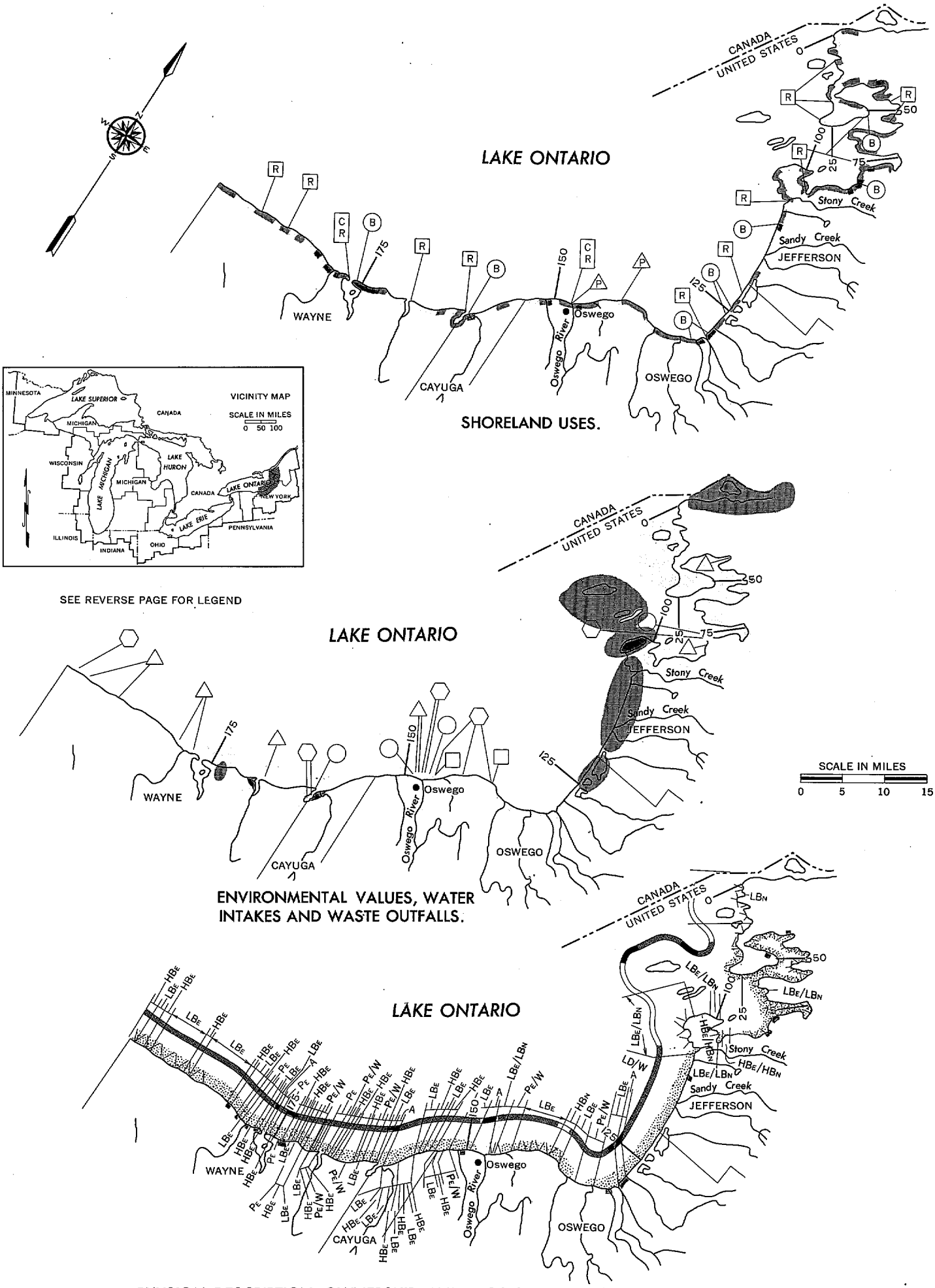


Figure 74. SHORELANDS OF THE GREAT LAKES, CAPE VINCENT, JEFFERSON, OSWEGO, CAYUGA, WAYNE COUNTIES.

LEGEND

SHORELAND USES

Commercial, Industrial, Residential and Public Buildings

Recreational and Urban Open Space

Agricultural and Undeveloped

Forest

Public Beaches — B

Commercial Deep Draft Harbors — C

Recreational Harbors — R

Commercial Deep Draft and Recreational Harbors — C R

Electric Power Stations — P

ENVIRONMENTAL VALUES, WATER INTAKES AND WASTE OUTFALLS

Significant Fish and Wildlife Values

Unique Ecological or Natural Areas

Outstanding Shoreland Areas of Possible National Interest

Potential Recreation Sites

Waste Water Outfalls and Intakes

Public Outfalls

Public Intakes

Private Outfalls

Private Intakes

PHYSICAL DESCRIPTION, OWNERSHIP, AND EROSION AND FLOODING PROBLEM REACHES

Federal Lands

Non-Federal Public Lands

Private Lands

Shore type

Artificial Fill Area	A
Erodible High Bluff, 30 ft. or higher	HB_E
Non-Erodible High Bluff, 30 ft. or higher	HB_N
Erodible Low Bluff, less than 30 ft. high	LB_E
Non-Erodible Low Bluff, less than 30 ft. high	LB_N
High Sand Dune, 30 ft. or higher	HD
Low Sand Dune, less than 30 ft. high	LD
Erodible Low Plain	P_E
Non-Erodible Low Plain	P_N
Wetlands	W

Combinations Shown As:	Example
Lakeward/Landward	W/P_E
Upper Bluff Material / Lower Bluff Material	HB_E/HB_N

Beach Material

Sand and gravel

Ledge rock

No Beach

Problem Identification

Areas subject to erosion generally protected

Critical erosion areas not protected

Non-critical erosion areas not protected

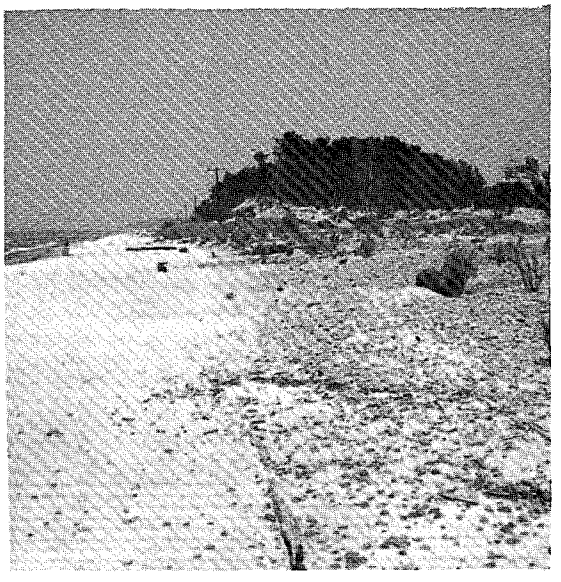
Shoreline subject to lake flooding

Shoreline not subject to erosion or flooding

Bluff seepage problems — S

Photograph 45. The shoreline of Lake Ontario at Oswego Harbor, New York.

Photograph 46. Eroding high bluff just east of Great Sodus Bay. Typical of high bluffs for several miles to the east.



Photograph 47. Typical sand beach and dunes extending north from the mouth of the Salmon River.

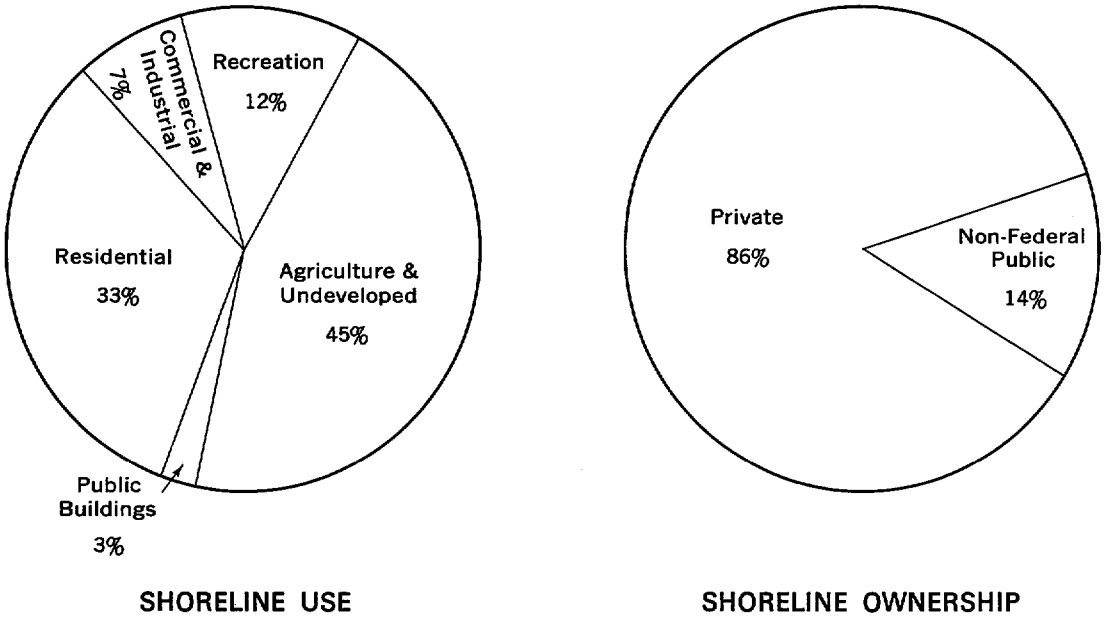


Figure 75. Distribution of Shoreline Use and Ownership, Oswego County to Wayne County, New York.

10.3.2 Erosion and Flooding History

The shore of these three counties is subject to significant erosion where unprotected, except for a few short reaches where bedrock rises high enough above lake level to armor the toe of the bluff against wave attack.

During the 1951-52 period of high lake levels, critical erosion occurred to residential property at Mexico Point and to State park property in Selkirk Shores State Park. Here, several hundred feet of concrete crib seawall were destroyed and land behind the seawall and adjacent unprotected land were lost. Afterwards, over 4,500 feet of frontage were protected under a Federal cooperative project, authorized after a cooperative beach erosion control study.

Significant flooding of low areas, particularly in Sodus Bay and around other bays, ponds, and barrier beaches, also occurred in 1951-52. Recorded damages to private and public property that occurred in 1951-52, as reported and updated to 1970 price levels, are shown in Table 51.

General information on rates of erosion throughout this three-county area is not available. Studies made at Fair Haven Beach State Park and Selkirk Shores State Park showed that at Fair Haven the average rate of erosion of the high bluff had been four feet per year between 1938 and 1952. The lower, 10-foot high bluff had eroded at a rate of 10 feet per year. At Selkirk Shores State Park, 40 feet of the bluff were lost following failure of a concrete crib seawall in 1952.

The regulation of Lake Ontario levels, in effect since 1960, following completion of the St. Lawrence Seaway, has reduced erosion and flood damage. In 1969, when record or near-record high levels occurred in the upper lakes, the levels of Lake Ontario were less than 0.5 foot above the long term average levels during the summer. They were actually below the long term average level for the rest of the year.

During an inspection of the shore made in 1966, it was found that about 0.8 mile of shore in Wayne County was protected, generally by seawalls or revetment; 0.4 mile was protected in Cayuga County; and 2.5 miles were protected in Oswego County. This included 1.4 miles behind the breakwaters at Oswego Harbor.

Table 51

Total Damage to Shore Property on Lake Ontario – Wayne, Cayuga, and Oswego Counties, New York

	Damages, $	
Land Use	*Actual 1951-52 Value*	*Updated 1970 Value*
Private		
Residential	646,900	1,248,500
Industrial and commercial	34,800	67,200
Total, private property	681,700	1,315,700
Public		
Parks and beaches	182,900	422,600
Total, public property	182,900	422,600
Total erosion damages	864,600	1,738,300

10.3.3 Solution to Erosion Damages

The need for recreational opportunities and the level of erosion damage justify protection of 4.5 miles of shoreline in public parks. Cooperative beach erosion control studies have been made at Fair Haven Beach State Park and at Selkirk Shores State Park. In both cases, the purpose of the study was to develop plans for improving the bathing beach along part of the frontage and for protecting the remainder against erosion. Groins and beach fill were recommended for improvement of the beach and stone revetment for the protection of the rest of the frontage. Federal projects have been authorized at both parks. No construction has been undertaken at Fair Haven. About one-half the authorized beach and almost all of the authorized revetment have been constructed at Selkirk Shores State Park. The estimated cost of the Fair Haven project is $689,000 (1970). The Federal share would be $482,000. The estimated cost of the remaining work at Selkirk Shores is $267,100.

The same type of stone revetment used at Selkirk and recommended for Fair Haven is suitable for protection of other parts of the shore in these counties. However, the rate of erosion has been reduced since Lake Ontario has been regulated. Because of this fact, and the nature of development of the shore, there are no critical areas where Federal help in protection and improvement appears justified. The only exceptions are public parks, where recreational benefits from improvement of bathing beaches are involved, as well as protection against erosion.

10.4 Lake Ontario East Planning Subarea 5.3

The Great Lakes Mainland shoreline of New York in planning subarea 5.3 is 120 miles long (Figure 76). The major drainage area above the head of the St. Lawrence River is the Black River Basin. Communities located along the shoreline are Henderson Harbor, Sackets Harbor, and Chaumont. Table 52 and the preceding Figure 74 illustrate the shoreline values, uses, ownership, and problem areas for this shoreline reach.

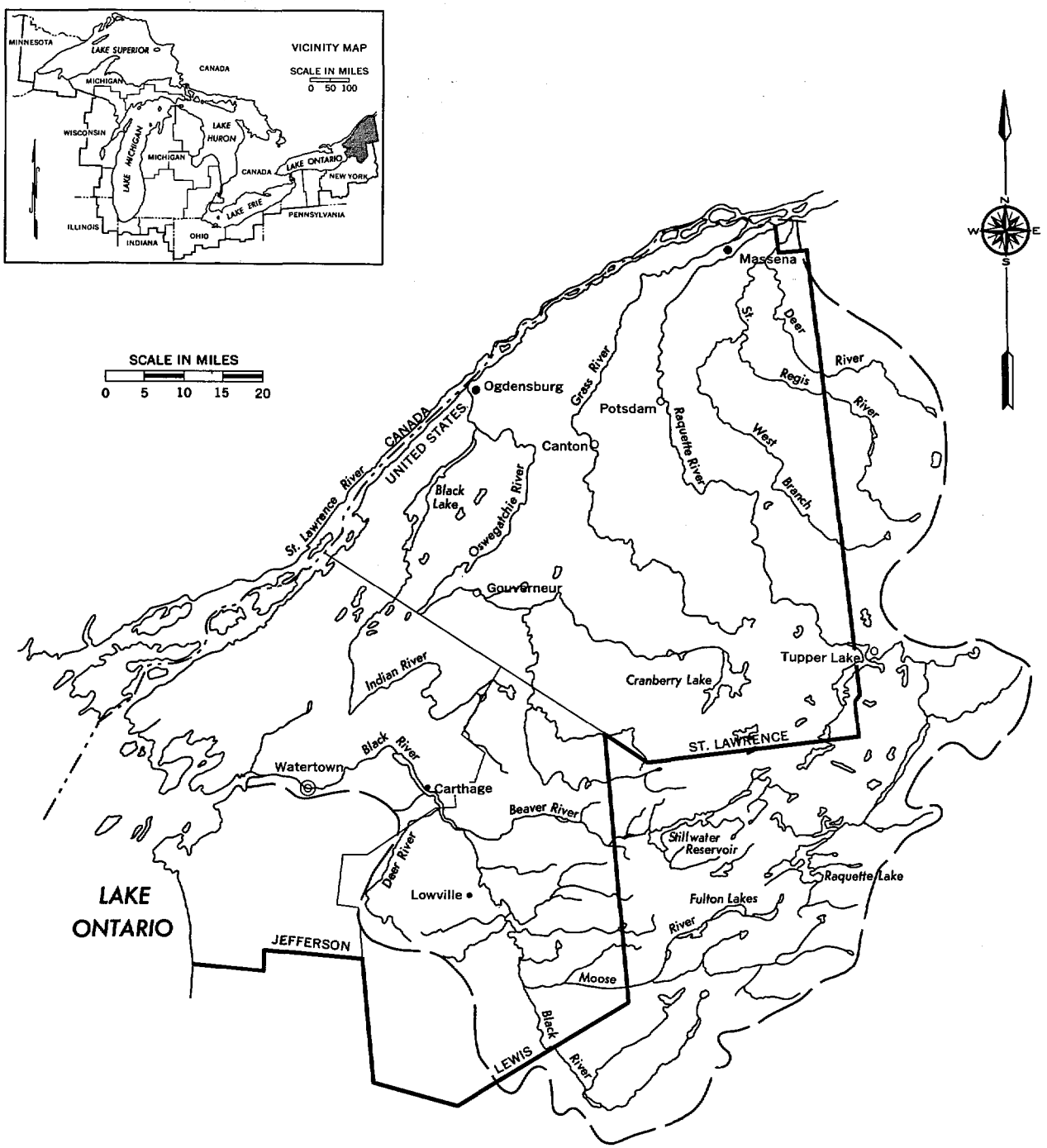


Figure 76. Lake Ontario East Planning Subarea 5.3, New York.

Table 52

Shoreline of the Great Lakes — Jefferson County, New York

Shoreland Use Category	Existing Shoreland Use			Miles of Shoreline			Problem Identification, Miles of Shoreline				
	Miles of Shoreline	Percent of Total	Number of Sites	Public		Private	Subject to Erosion		Protected	Subject to Flooding	Not Subject to Erosion or Flooding
				Federal	Non-Federal		Critical	Noncritical			
Economic Uses											
Residential	49.8	41.4		0	0	49.8	0	21.1	3.4	0	25.3
Industrial and commercial	11.6	9.6		0	0	11.6	0	6.8	1.1	0	3.7
Agricultural and undeveloped	54.1	44.9		0	0	54.1	0	21.1	0	7.5	25.5
Commercial harbors			0								
Electric power sites			0								
Public buildings and related lands	0	0		0	0	0	0	0	0	0	0
Recreational Uses											
Parks	4.9	4.1		0	4.9	0	0	1.2	0	0	3.7
Recreational boat harbors			9								
Beach zone	(94.8)	(78.8)		0	(4.5)	(90.4)					
Environmental Uses											
Wildlife perserves and game lands	0	0		0	0	0	0	0	0	0	0
Fish and wildlife wetlands (offshore)	(0)	0					0	0	0	0	0
Forest	0	0		0	0	0	0	0	0	0	0
Total	120.4	100.0		0	4.9	115.5	0	50.2	4.5	7.5	58.2

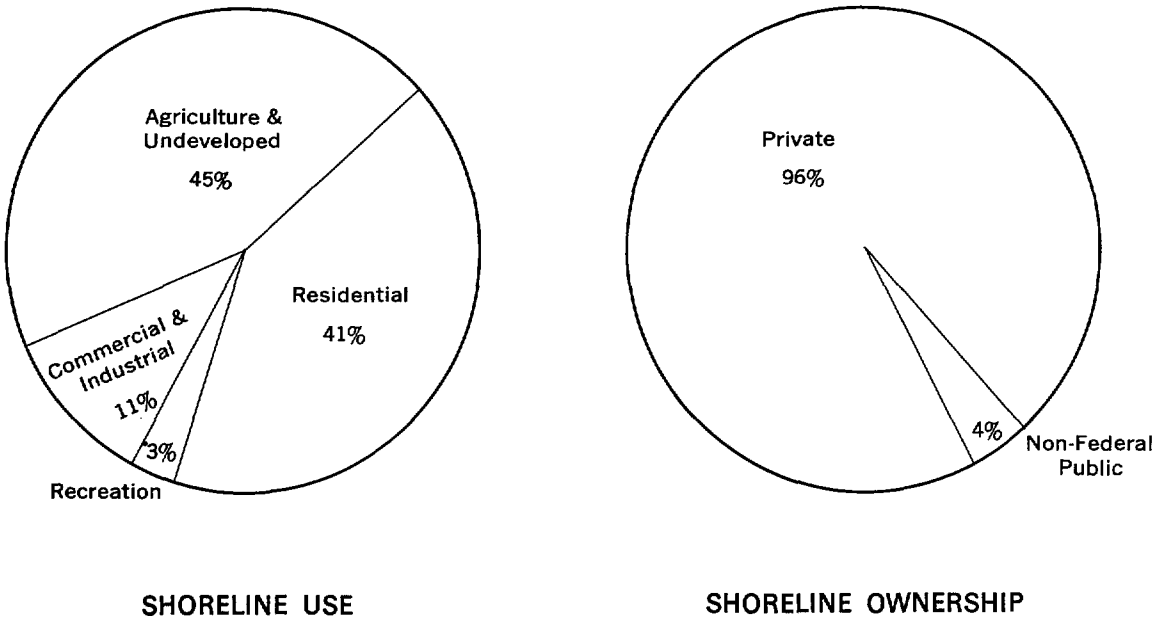


Figure 77. Distribution of Shoreline Use and Ownership, Jefferson County, New York.

10.4.1 Shoreland Description

The shore of Jefferson County, between the Oswego-Jefferson County line, seven miles north of the mouth of the Salmon River at Port Ontario, and Tibbett's Point at the head of the St. Lawrence River, is very uneven and contains several deep bays and prominent headlands. The total length of the shore is about 120 miles. For 10 miles north from the Oswego County line, a barrier beach and sand dune extend in nearly a straight line, separating marsh areas and small ponds from the open lake. The beach and dune are composed of very fine sand, and the beach has a very flat offshore slope and is relatively stable. At the end of this 10-mile reach, the shore characteristics change abruptly. Rock outcrops at the water's edge and rises gradually to a height of about 75 feet on the west side of Stony Point. It then falls gradually, as the shore continues around Stony Point into Henderson Bay. From Henderson Bay to the head of the St. Lawrence at Tibbett's Point, there is generally shale or limestone rock for several feet above lake level. The rock has a few feet of earth cover containing considerable granular material. There are a few pockets of sand beach, but the beach material is mostly gravel, shingle, or ledge rock. Marsh areas occur at the inner end of some of the deep bays.

About three of the 10 miles of barrier beach and dunes north of the Oswego County line have been developed for summer residential use. Much of the remaining shore in the county has occasional reaches of residential development, when accessible by roads. The distribution of use and ownership is shown in Figure 77. The principal change in the last 20 years is a large increase in residential development, with a similar decrease in agricultural and undeveloped frontage.

There are no deep-draft navigation harbors in Jefferson County. An oil terminal using an offshore mooring and pipeline to shore is the principal commercial navigation facility. The only Federal project in the county is a light-draft harbor at Sackets Harbor. Private marina facilities are available at nine locations, three of which have launching ramps. There are two other launching ramps at State parks, one at Westcott State Park on Henderson Bay, and another at Long Point State Park, which is in Chaumont Bay. A third State park in Jefferson County is Southwick Beach State Park, located near the northerly end of the dune area, about five miles north of the Oswego-Jefferson County line. The interest in boating and development of summer homes in this area are due in large measure to excellent fishing in the vicinity. The relatively protected bays offer shelter to small boats and permit their use at times when open lake use is hazardous.

Table 53

Total Damage to Shore Property on Lake Ontario — Jefferson County, New York

Land Use	Damages, $ Actual 1951-52 Value	Damages, $ Updated 1970 Value
Private		
Residential	265,000	511,400
Industrial and commercial	27,800	53,700
Agricultural and undeveloped	5,000	5,200
Total, private property	297,800	570,300
Public		
Parks and beaches	57,100	131,900
Harbors	1,500	3,500
Utilities	36,500	84,300
Total, public property	95,100	219,700
Total erosion damages	392,900	790,000

10.4.2 Erosion and Flooding History

In spite of the rocky shore around most of the shoreline, there was significant erosion damage during the record levels of 1952. Highways bordering the lake shore had to be protected by revetment. Many cottages and homes close to the shore also required protection. Damage was scattered throughout the area, rather than concentrated in any particular reach. Damages, as reported in 1952 and updated to 1970 price levels, are shown in Table 53. Damages, during 1969, in Jefferson County were relatively small. Due to regulation of the levels of Lake Ontario, in effect since 1960 under authority of the International Joint Commission, the lake levels were less than 0.5 foot above the long term average levels during the summer months. Only extreme levels, such as occurred in 1952, are particularly damaging. Many property owners interviewed at the time stated that levels only a foot lower than the 1952 highs would cause little damage. The 1969 levels were about two feet lower than the 1952 peak levels.

10.4.3 Solutions to Erosion Damages

No beach erosion control studies have been made in Jefferson County. Fewer requests for help or advice in erosion problems are received from this area than others on Lake Ontario. However, there are individual problems, and a total of about five miles of shore has been protected. About one-half of this is highway protection. The most common type of protection used in this area is stone revetment. Stone quarries in the vicinity of Chaumont make this one of the best and least expensive types of protection. In some cases, boulders and loose rock have been recovered from shallow offshore areas and used as shore protection. Concrete walls have also been used to protect individual properties.

Because of lower peak levels maintained by the regulation plan now in effect, and the natural resistance of the shore against erosion, there are no areas of critical erosion in this reach.