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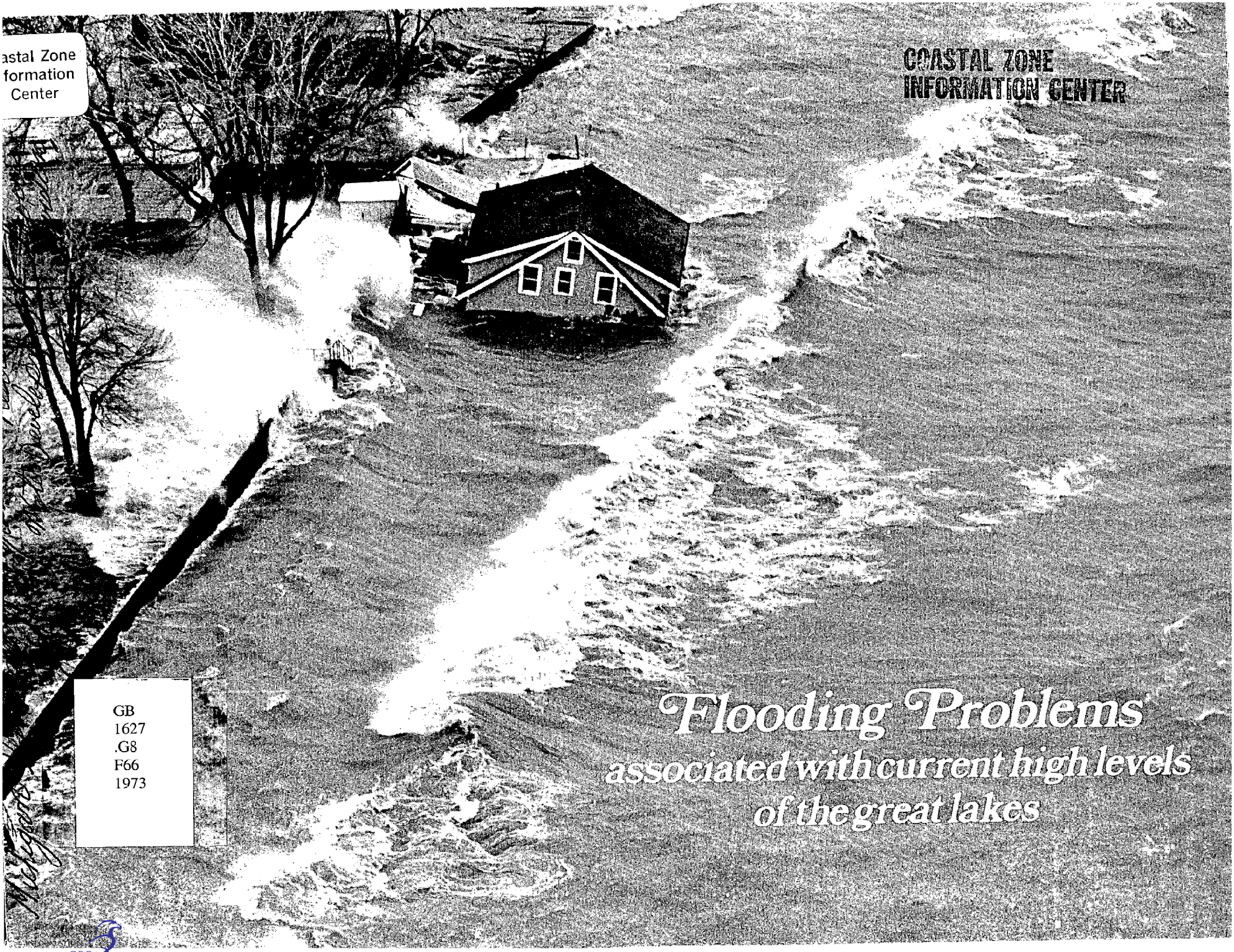

Flooding Problems associated with current high levels of the great lakes

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Flooding Problems

associated with current high levels of the great lakes

prepared by the

Water Development Services Division,

of the Michigan Department of Natural Resources.

December 1974

PREFACE

300 miles of Michigan Great Lakes shoreland are currently subject to flooding by the high levels of the Great Lakes.

Over 9,000 homes are susceptible to the effects of this flooding.

Upwards of 12,000 people in a single storm have been evacuated from their homes or otherwise suffered from high water.

At least 8 million dollars in private damage has occurred.

The public cost for 12 months from November 1972 to November 1973 was over 46 million dollars.

This report presents an overview of the Great Lakes high water flooding problem: its causes; effects; solutions; and possible future alternatives.

Prepared by the Water Development Services Division of the Michigan Department of Natural Resources with assistance from the Emergency Services Division of the Department of State Police, the Detroit District of the United States Army Corps of Engineers, the United States Department of Housing and Urban Development and the County Civil Defense Directors.

Sheriff's Deputy Michael Davison carries baby to safety at Estral Beach on Lake Erie, April 9, 1973. Photo by Detroit News.

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Photo by Detroit News

INTRODUCTION

In response to the concerns of Governor Milliken, legislative inquiry and the responsibilities of the Department of Natural Resources, a reconnaissance level survey of the flood problems associated with the current high levels of the Great Lakes was undertaken during the summer and fall of 1973. This report contains a summary of that investigation as well as a compilation of damage estimates and possible alternative courses of future action.

In brief, a problem of major consequence exists which affects thousands of Michigan people, millions of dollars in private and public monies, and a substantial amount of land. Approximately 33 Michigan counties encompassing over 300 miles of Great Lakes shoreland* and over 45,000 acres of land area are currently subject to flooding by the high levels of the Great Lakes (Map 1 and Tables 1 and 2). The scope of the problem has increased to a very significant degree since the last major high water event on the Great Lakes in the early 1950's. Without either State or local actions to control additional developments prone to flood damage, the next period of high water will witness a greater expansion of the flooding problem.

Investigation of the flooded lands adjacent to the Great Lakes was accomplished by on-site observations. The geographical areas covered in the field survey are as follows: Lake Erie shoreline north from Toledo, Ohio to Milleville Beach, Michigan (Map 2); the mouth of the Detroit River in the vicinity of Grosse Isle and Gibralter; Lake St. Clair from Metropolitan Beach to Harsen's Island (Map 3); the St. Clair River from Algonac to Port Huron; Lake Huron, Saginaw Bay (Map 4) and certain estuarine lakes along Lake Michigan. A discussion of the use and development, ownership and shore types associated with the shoreland areas investigated is presented in the Appendix.

Primary interest was focused on undeveloped lands. At each location surveyed, photographs were taken and written and taped records made of each location, weather conditions, and other observations. Field observations are referenced to U.S.G.S. Topographic Quadrangle sheets; a list of these maps is included in the Appendix, Table C.

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*The miles of shoreland subject to flooding were estimated by the staff of the Michigan Department of Natural Resources from DNR data and information supplied by the Ohio-Michigan Disaster Housing Office, U.S. Department of Housing and Urban Development. The 300 mile estimate includes 200 miles of mainland shoreline and approximately 100 miles of island shoreline.

MAP 1

Michigan Counties Where Great Lakes Flooding Occurred, 1972 - 1973

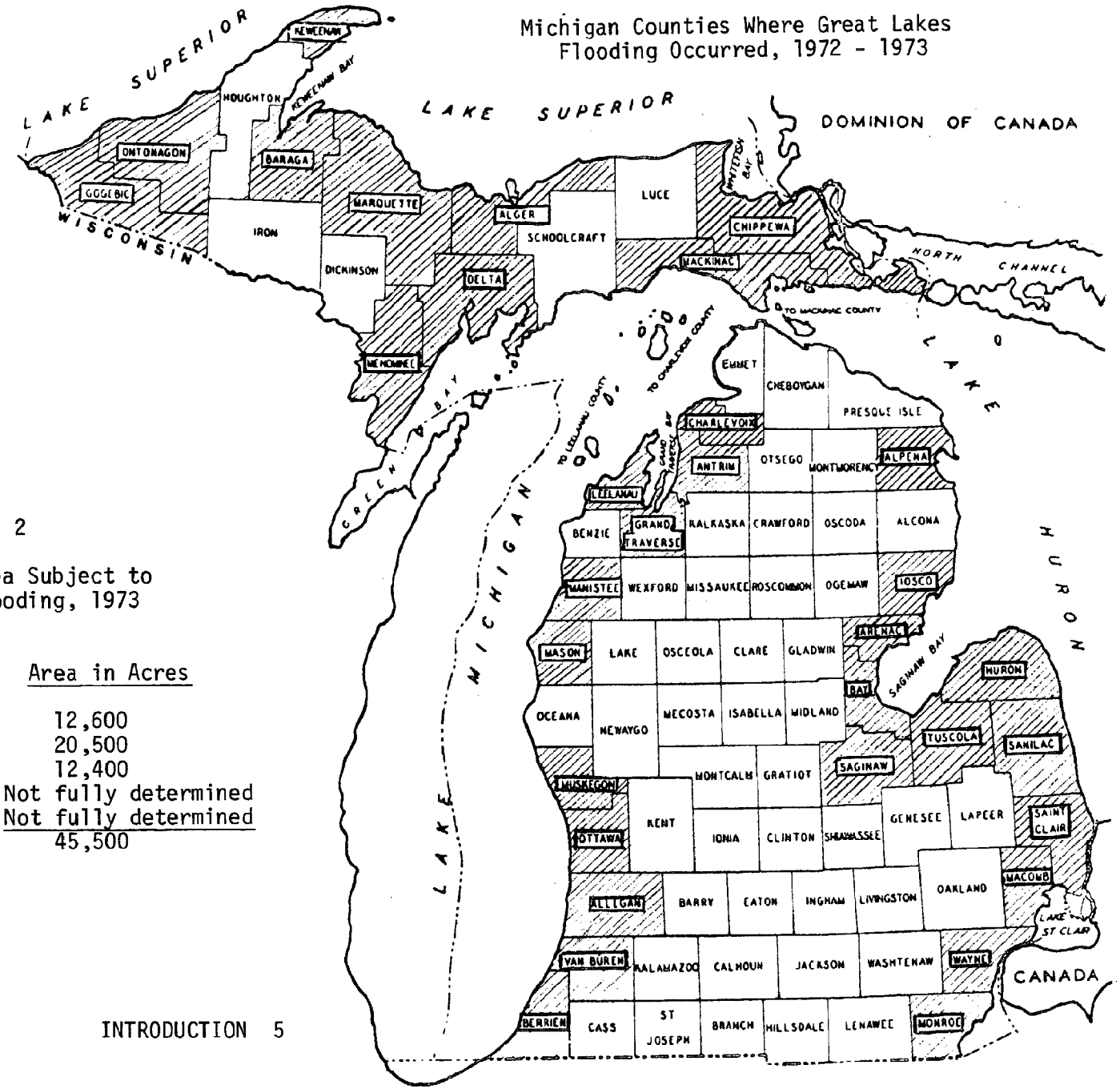


TABLE 2

Michigan Land Area Subject to Great Lakes Flooding, 1973

Lake	Area in Acres
Erie	12,600
St. Clair	20,500
Huron - Saginaw Bay	12,400
Michigan	Not fully determined
Superior	Not fully determined
Total	45,500

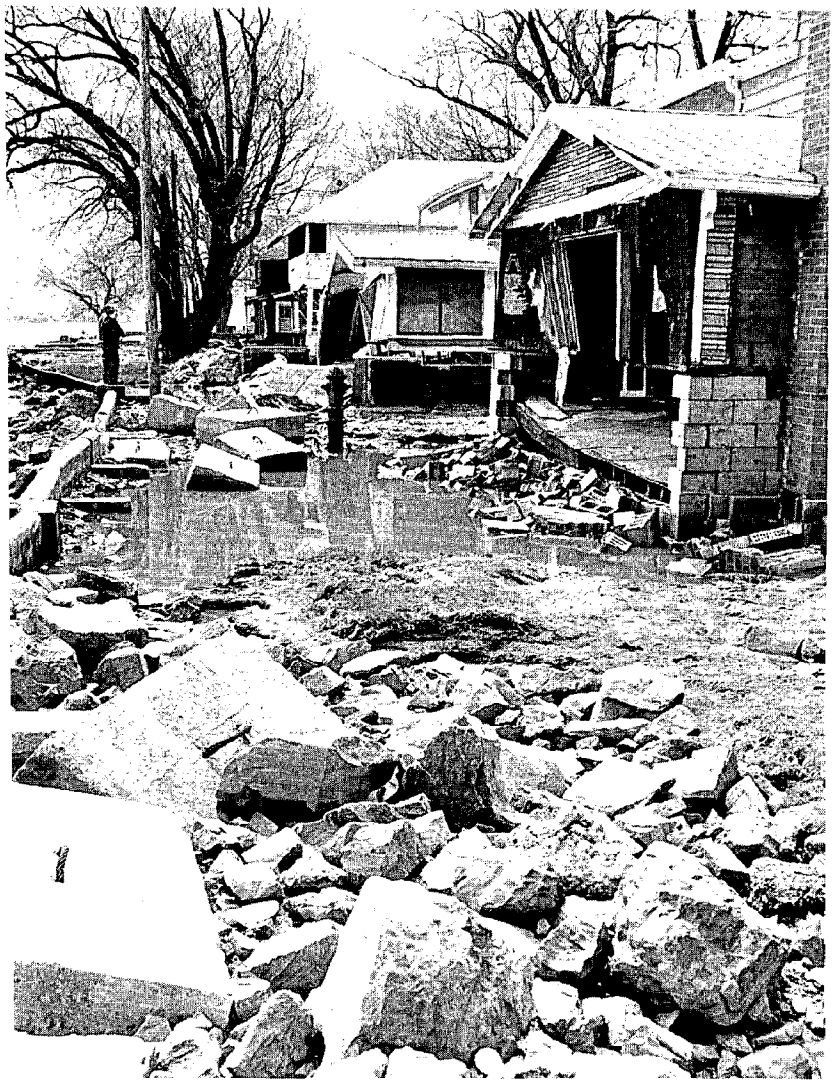
A March, 1973 storm brought extensive flooding to the Bay City area on the south shore of Saginaw Bay. Photo by Detroit News.

TABLE 1

Michigan Counties Where Great Lake Flooding Occurred, 1972-73*

Lake or River	County
Lake Erie and Detroit River	Monroe
	Wayne
Lake St. Clair and St. Clair River	Macomb
	St. Clair
Lake Huron	Sanilac
	Huron
	Tuscola
	Saginaw
	Bay
	Arenac
	Iosco
	Alpena
	Mackinaw
	Chippewa
Lake Superior	Chippewa
	Alger
	Marquette
	Baraga
	Keweenaw
	Ontonagon
	Gogebic
Lake Michigan	Berrien
	Van Buren
	Allegan
	Ottawa
	Muskegon
	Mason
	Manistee
	Leelanau
	Grand Traverse
	Antrim
	Charlevoix
	Mackinac
	Delta
	Menominee

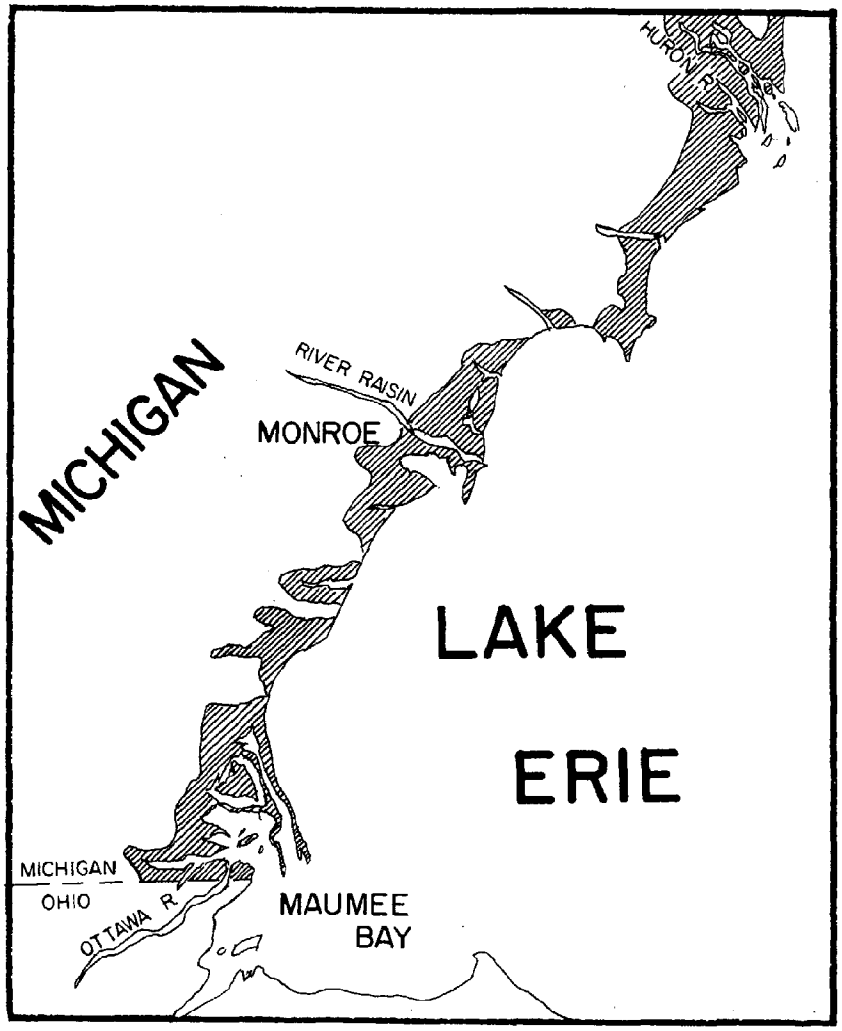
*State or Federal highway assistance was requested and/or Operation Foresight aid was required.



Property damage at Luna Pier on Lake Erie April 10, 1973. Photo by Detroit News.

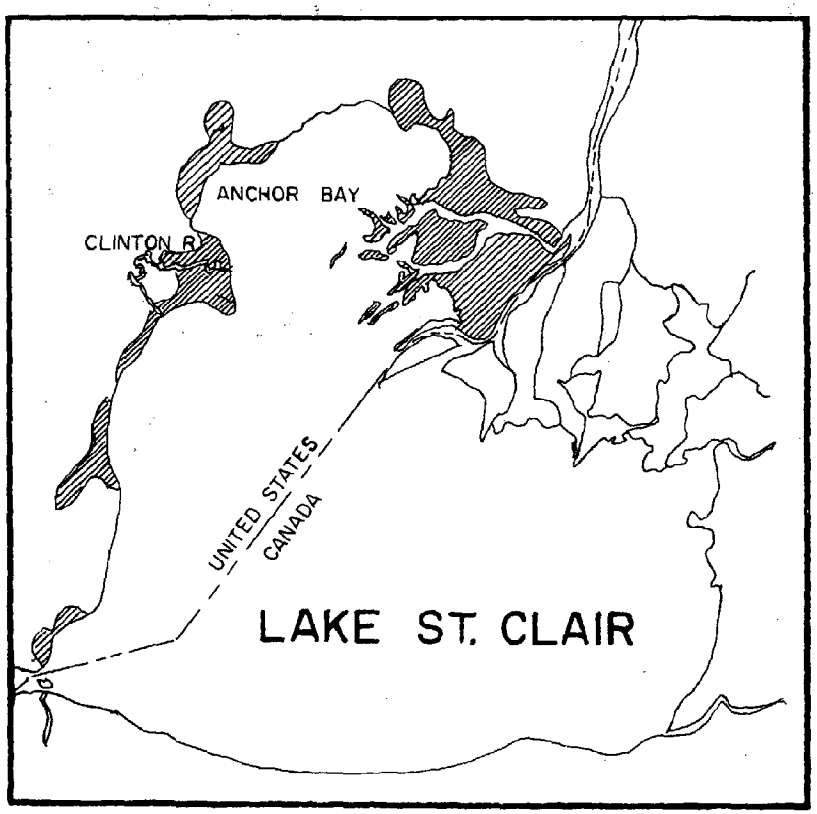
MAP 2

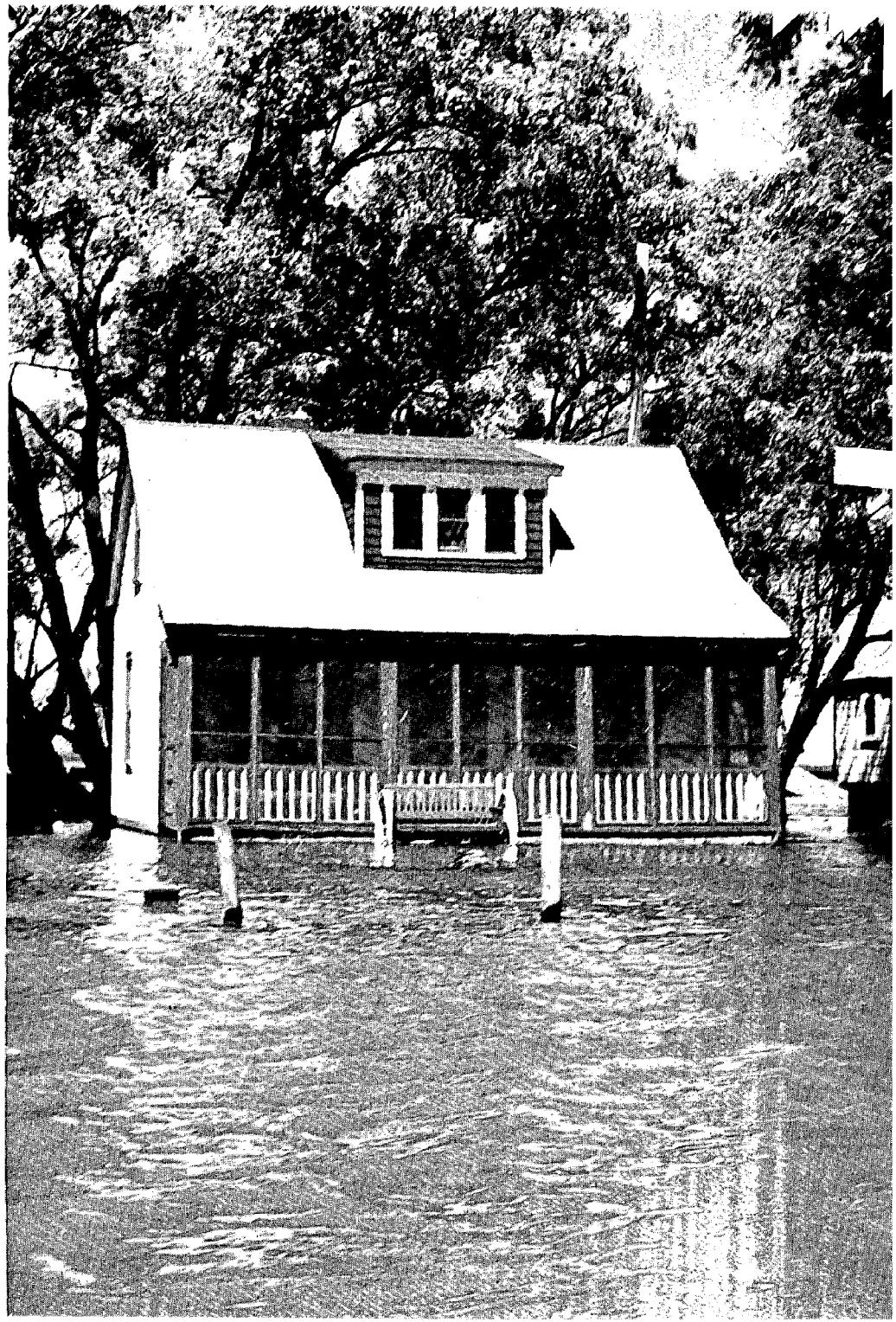
Average Extent of Lake Erie Flooding, July, 1973



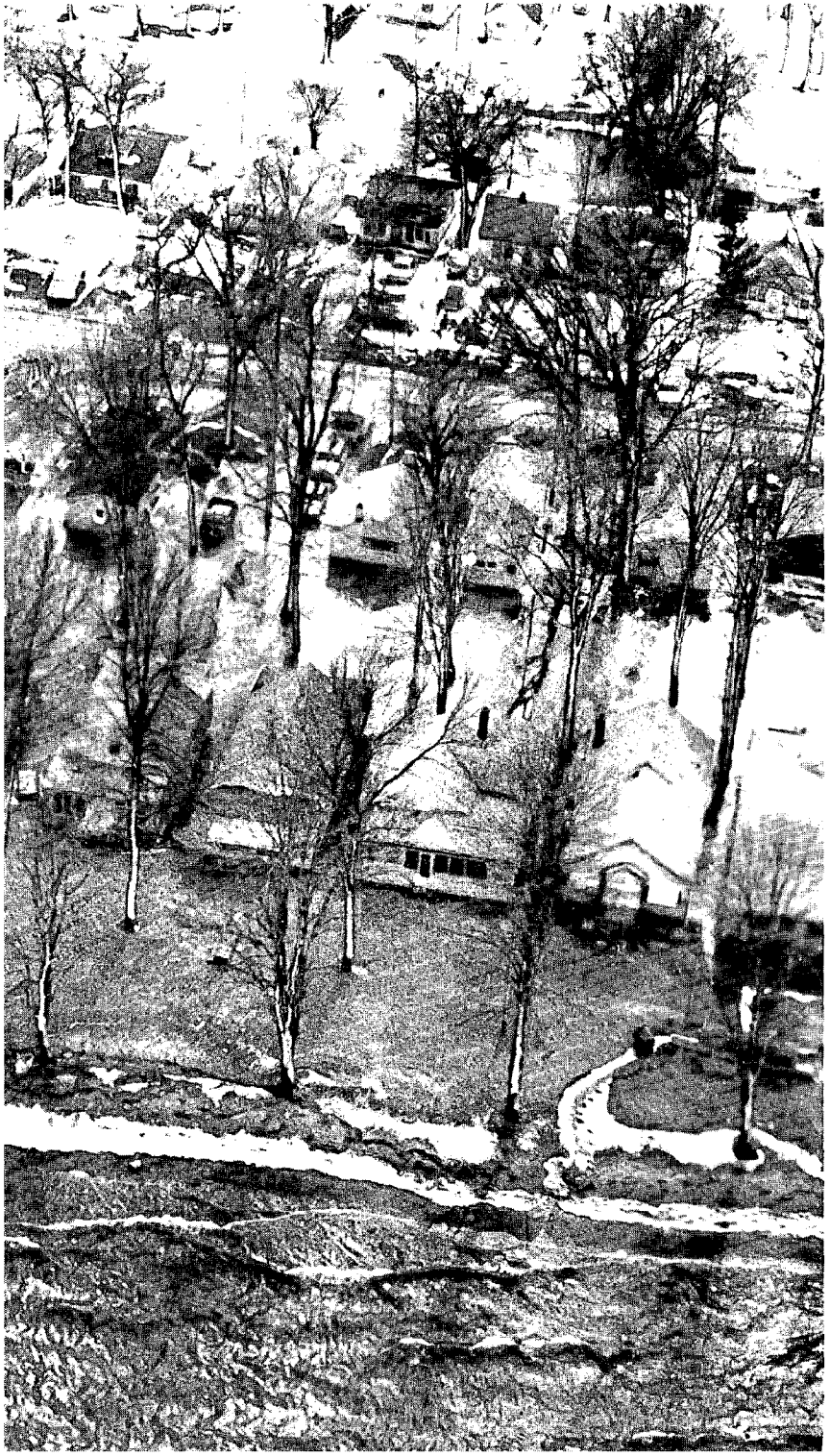
MAP 3

Average Extent of Lake St. Clair Flooding, July 1973



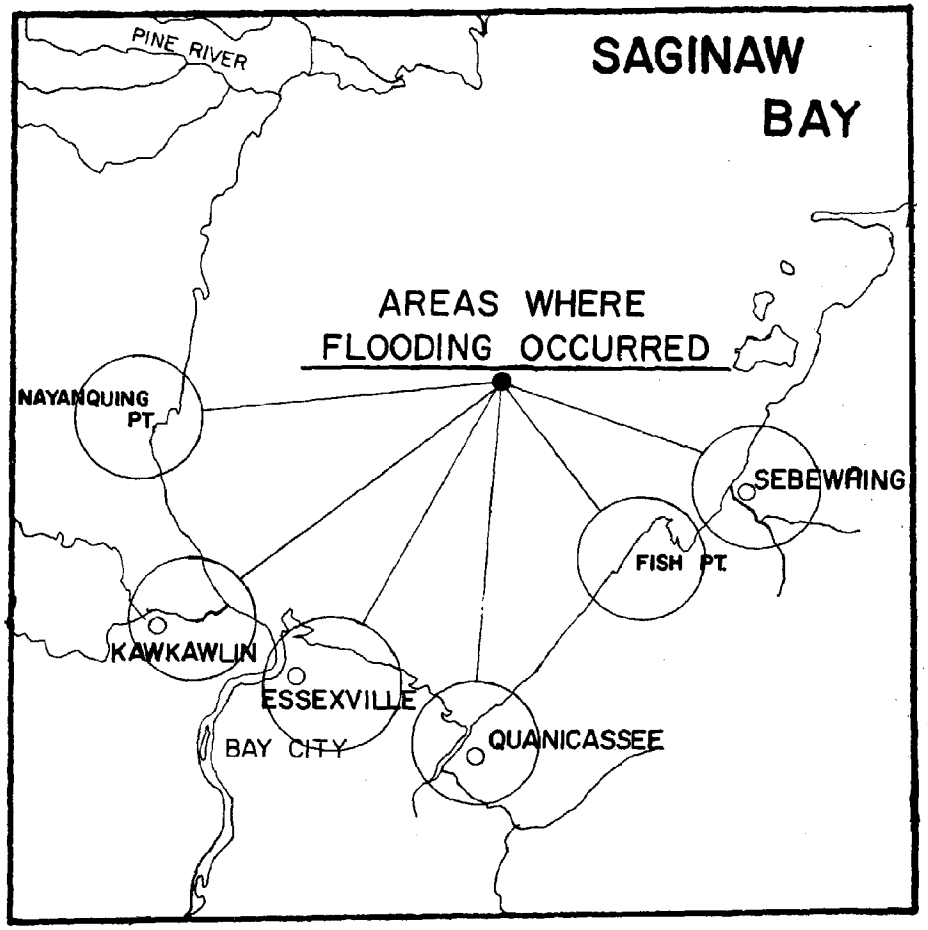


Typical residential flooding on Harsen's Island, Lake St. Clair, July 1973.



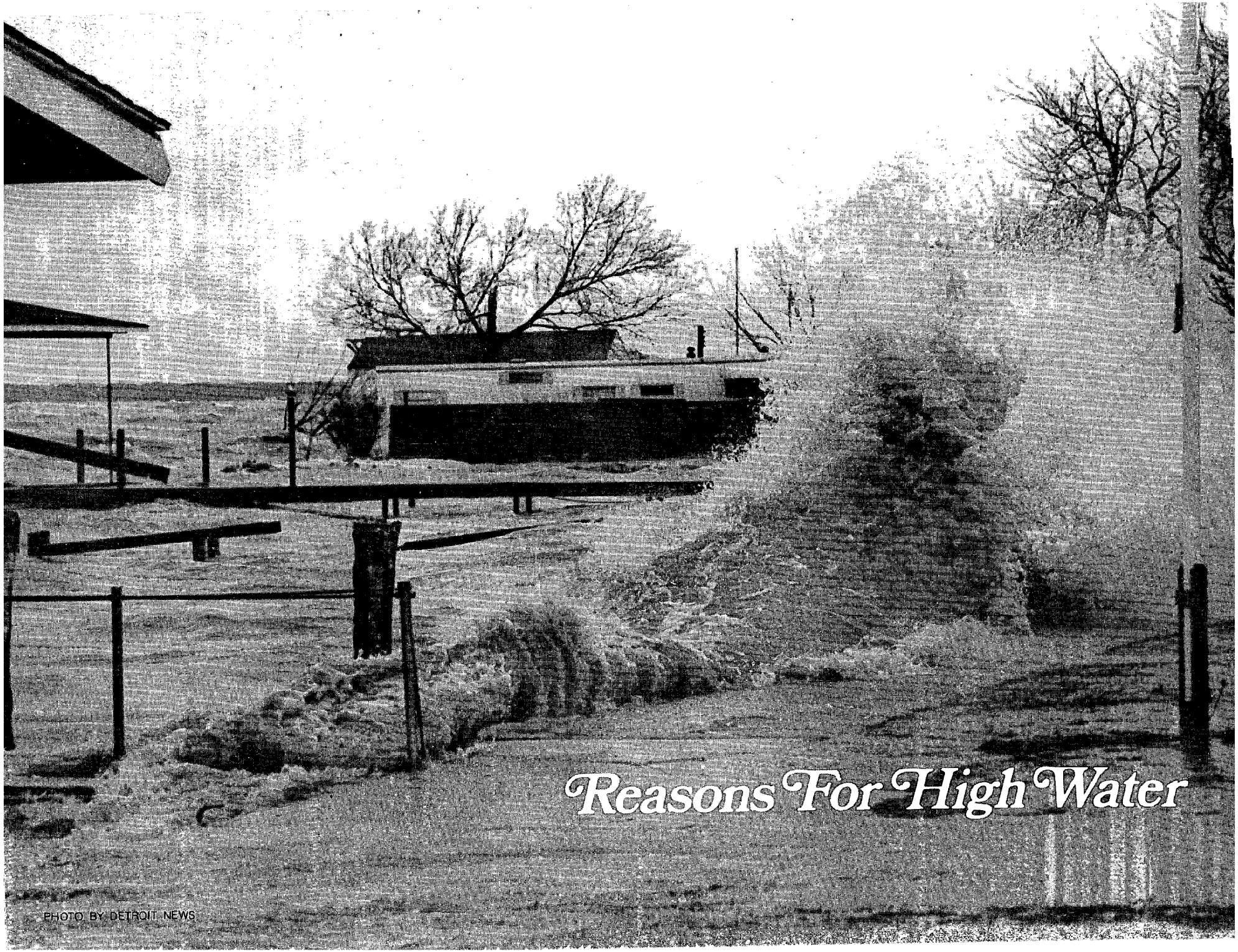
MAP 4

Areas on Saginaw Bay Where Flooding Occurred
During March, 1973 Storm



Flooding of homes in the Bay City area on the south shore of Saginaw Bay, March 1973. Photo by Detroit News.

As late as August, 1973, many roads on Harsens Island were impassable due to standing water.


Reasons For High Water
PHOTO BY DETROIT NEWS

REASONS FOR HIGH WATER LEVELS

Precipitation supplies the water in the Great Lakes, either falling directly into the Lakes or on the drainage basins which surround them. A great deal of rain and snowfall is lost from the basin by evaporation. In normal years, evaporation from the lakes is very nearly the same as the precipitation that falls on them and about 1/3 of the total that falls on the drainage basin. In years of excess rain and snow, with attendant increases in coldness and humidity, evaporation loss declines.

The hydraulic characteristics of the outlets and connecting channels of the Great Lakes are such that they do not provide sufficient capacity to discharge above-normal amounts of precipitation nor do they produce sufficient control to hold back water when below normal precipitation occurs. The result is that the lake levels rise or fall depending upon whether or not surpluses or deficiencies in rain and snow occur (a more detailed discussion is provided in the Appendix).

Precipitation in the Great Lakes basin has been well above normal during three of the last four years and is reflected in the current high lake levels (Figure 1).

In 1970, departures from normal precipitation ranged from 1% on Lake Erie to 14% on Lake Superior. The basinwide annual precipitation was 34.25 inches, 2.69 inches or 9% above the normal.

In 1971, some individual lakes had below normal precipitation, while Lake Superior experienced 33.45 inches, 13% above normal. Considering the Great Lakes basin as a whole, precipitation in 1971 was very close to the normal (long term average) of 31.56 inches.

1972 brought above-normal precipitation to all of the Great Lakes. The greatest deviation from normal was recorded in the Lake Ontario sub-basin where 43.67 inches fell, 31% more than the average. Precipitation on the entire basin was 14% above normal.

FIGURE 1

Great Lakes Levels - August, 1973
(Normal is average level 1860-1973)

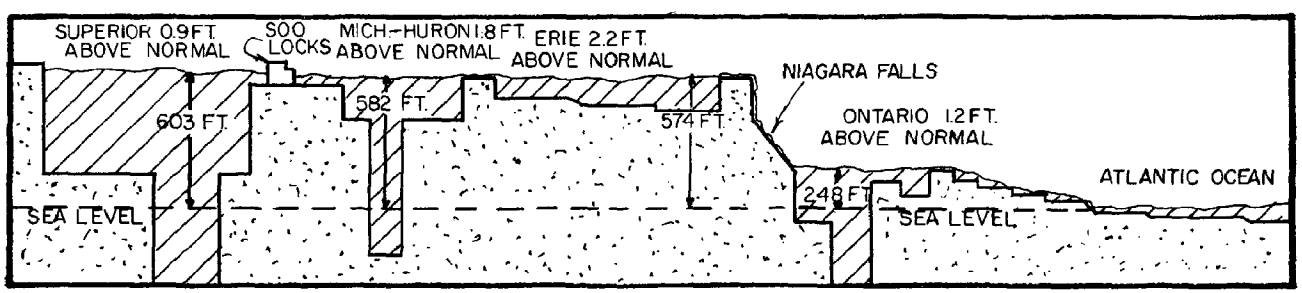


TABLE 3

Great Lakes Annual Precipitation in Inches

LAKE	NORMAL	1970 ACTUAL	Departure	Percent	1971 ACTUAL	Departure	Percent	1972 ACTUAL	Departure	Percent	1973 (1st 7 months) ACTUAL	Departure	Percent
Superior	29.70	33.84	4.14	14	33.45	3.75	13	32.21	2.51	8	17.99	1.87	12
Michigan	31.24	32.86	1.62	5	30.1	-1.14	4	34.97	3.73	12	20.44	2.71	15
Huron	31.38	34.94	3.56	11	31.25	-0.13	0.4	35.32	3.94	12	19.33	2.18	13
Erie	33.80	34.23	0.43	1	28.97	-4.83	14	39.70	5.90	17	22.54	2.50	12
Ontario	34.29	36.42	2.13	7	32.66	1.63	5	43.67	9.38	31	21.21	1.52	8
Entire Basin	31.56	34.25	2.69	9	31.43	0.13	0.4	35.97	4.41	14	19.87	2.19	12

The above-normal precipitation experienced by all of the Great Lakes during 1972-73, coupled with the limiting hydraulic characteristics of the outlets and connecting channels resulted in serious flooding of over 300 miles of Michigan shoreline. These flooded conditions have necessitated the use of watercraft to reach places of business and employment in many areas as exemplified in the photo at right of Gibraltar during the April 1973 storm. Photo by Detroit News.

Figures for the first seven months of 1973 again show above-average precipitation on all the Great Lakes. The 19.87 inches which have fallen thus far, exceed the norm by 22%. Great Lakes annual precipitation over the last 3 years is shown in Table 3.

The day-to-day or hour-to-hour water level of the Great Lakes is influenced by several factors, any or all of which can come into force at any particular point in time. The primary factor which determines the undisturbed or still water, lake level over time is precipitation. Imposed on the undisturbed lake level are the effects of storms, i.e., waves, pressure changes, etc. Figure 2 illustrates how the various storm factors combine to effect ultimate water levels.

During the twelve months from September 1972 to August 1973, Lake Erie's average water level for each month was higher than the highest average monthly level that had occurred since 1860. In fact, the water levels averaged about half a foot above the previous record highs for each month. Figure 3 illustrates the accumulative effect of excess precipitation on Lake Erie over recent years. In Figure 3 the monthly mean levels for the lake are indicated for 1972 and for 1973 through August by the middle line (---). Since last November, the new record highs have all exceeded the average monthly levels (_ _) by over two feet. During each month the levels vary considerably about the mean, and the upper line (__) indicates the highest hourly levels recorded at the west end of Lake Erie at the Toledo, Ohio gage. Major flooding and storm damage along the shore zone in that area occured at the time of the peaks reached in November, April and June.

The instantaneous high water level of record at the Toledo gauge is elevation 576.67 International Great Lakes Datum. It occurred on April 9, 1973 and includes approximately a 3.2 foot increase in water level due to the wind tide at that time. The high level which occurred on April 9th of this year at the Gibralter gauge was 575.82 IGLD. This is not the high level of record. The high level of record at the Gibralter gauge is 576.08 IGLD.

FIGURE 2

Storm Effects on Water Levels

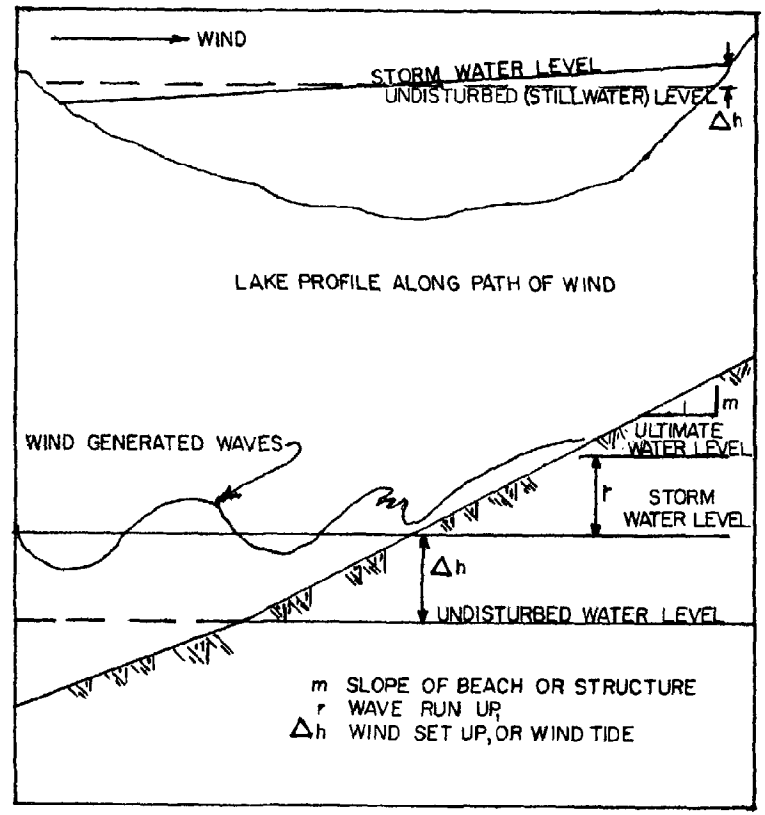
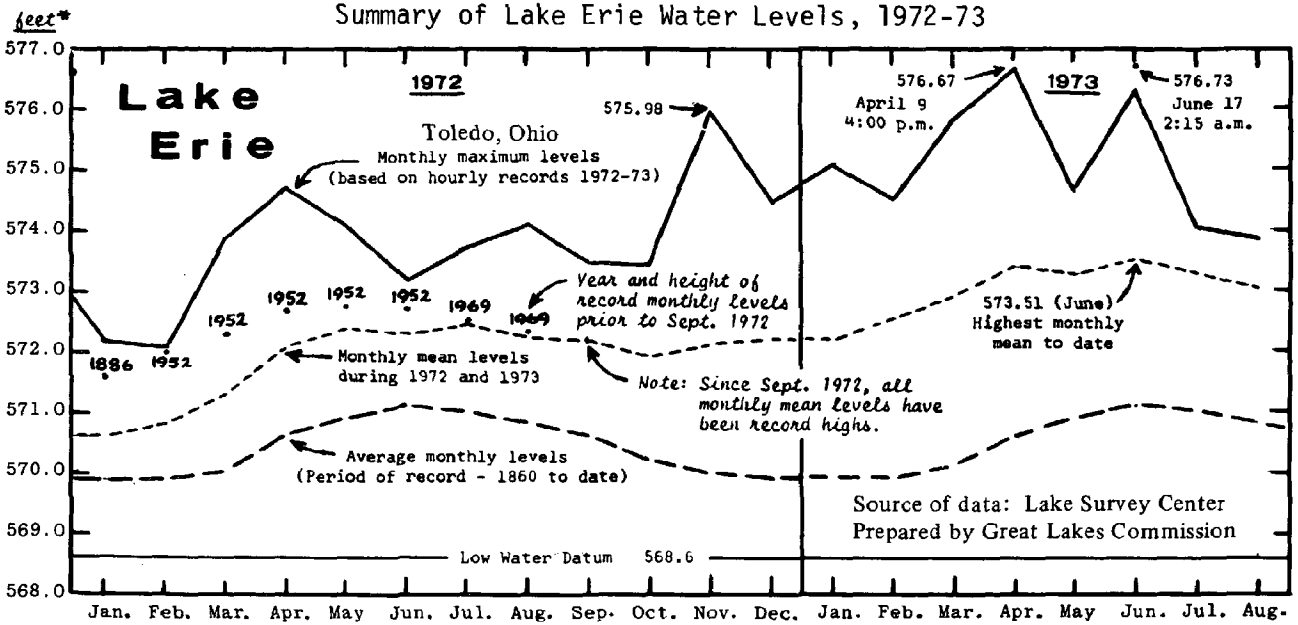


FIGURE 3

Summary of Lake Erie Water Levels, 1972-73



* Elevations are in feet above sea level at Father Point, Que., on the lower St. Lawrence River.

TABLE 4

Selected Lake Level Fluctuations Within the Last 20 Years for Lake Erie

Number of Occurrences	Lake Level Increase (above monthly mean)
43	2.5'
23	3.0'
13	3.5'
6	4.0'
1	5.5'

Source of data: Ohio - Michigan Disaster Housing Office, U.S. Department of Housing and Urban Development.

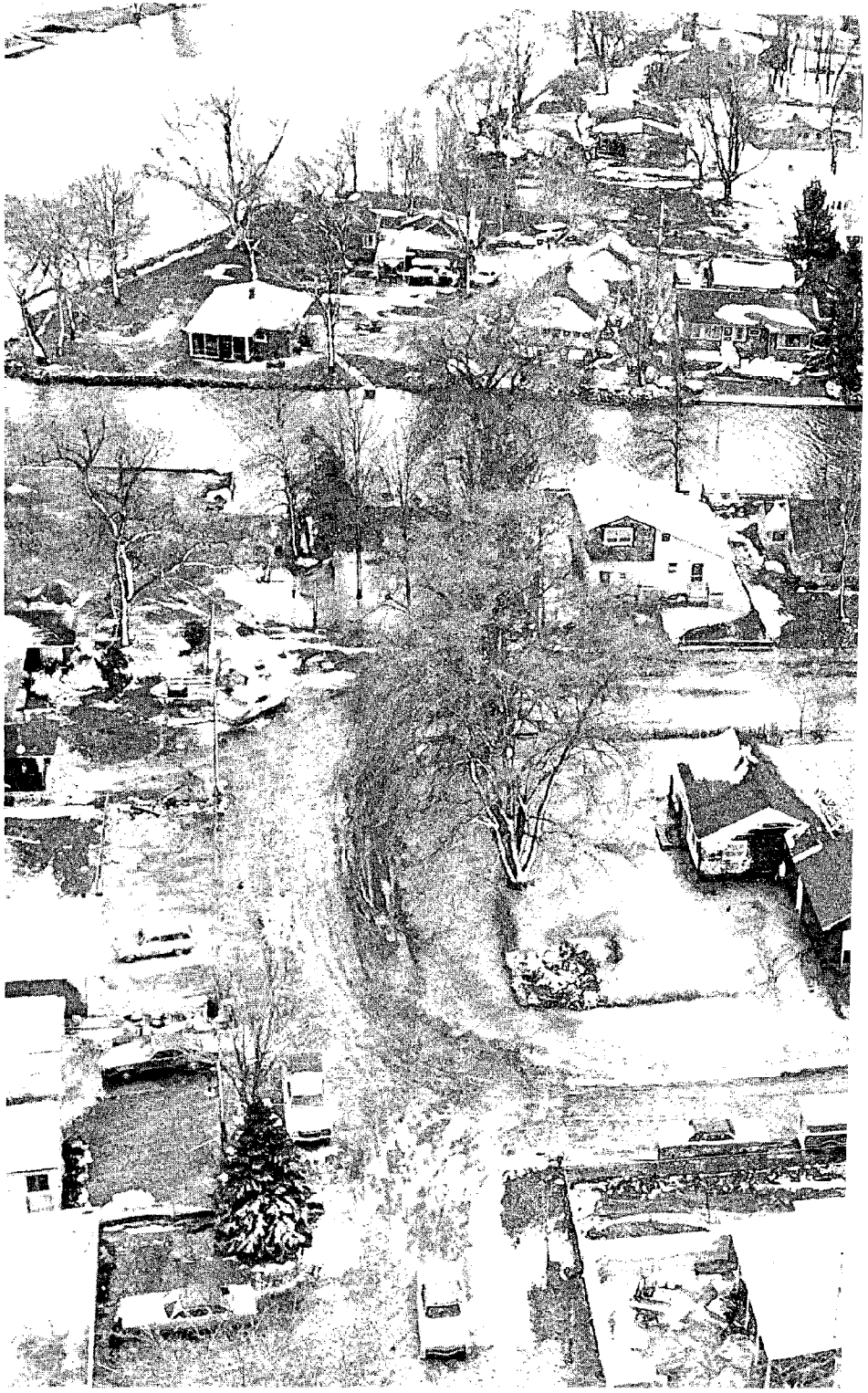
It occurred on the 17th of June, 1973. This level included about 2.6 feet of set-up (see Figure 2). Unlike the April 9, 1973, high, this set-up was due to differences in barometric pressure. These effects were not as significant in the Toledo area.

The mean level for the month of June, 1973, was 573.5 IGLD. The average June level for the 10 years preceeding 1973 was 571.1. The June, 1973, elevation was approximately 2.4 feet higher than the average for the past 10 years of record. It is also approximately 2.4 feet higher than the average June level for the entire period of record from 1860 to 1972. Note that in the annual fluctuation of the lake level, June is the month at which the peak normally occurs. Therefore the 2.4 foot increase above the average of all Junes of record is an indication of how much higher monthly average lake levels are at this time over the long term average.

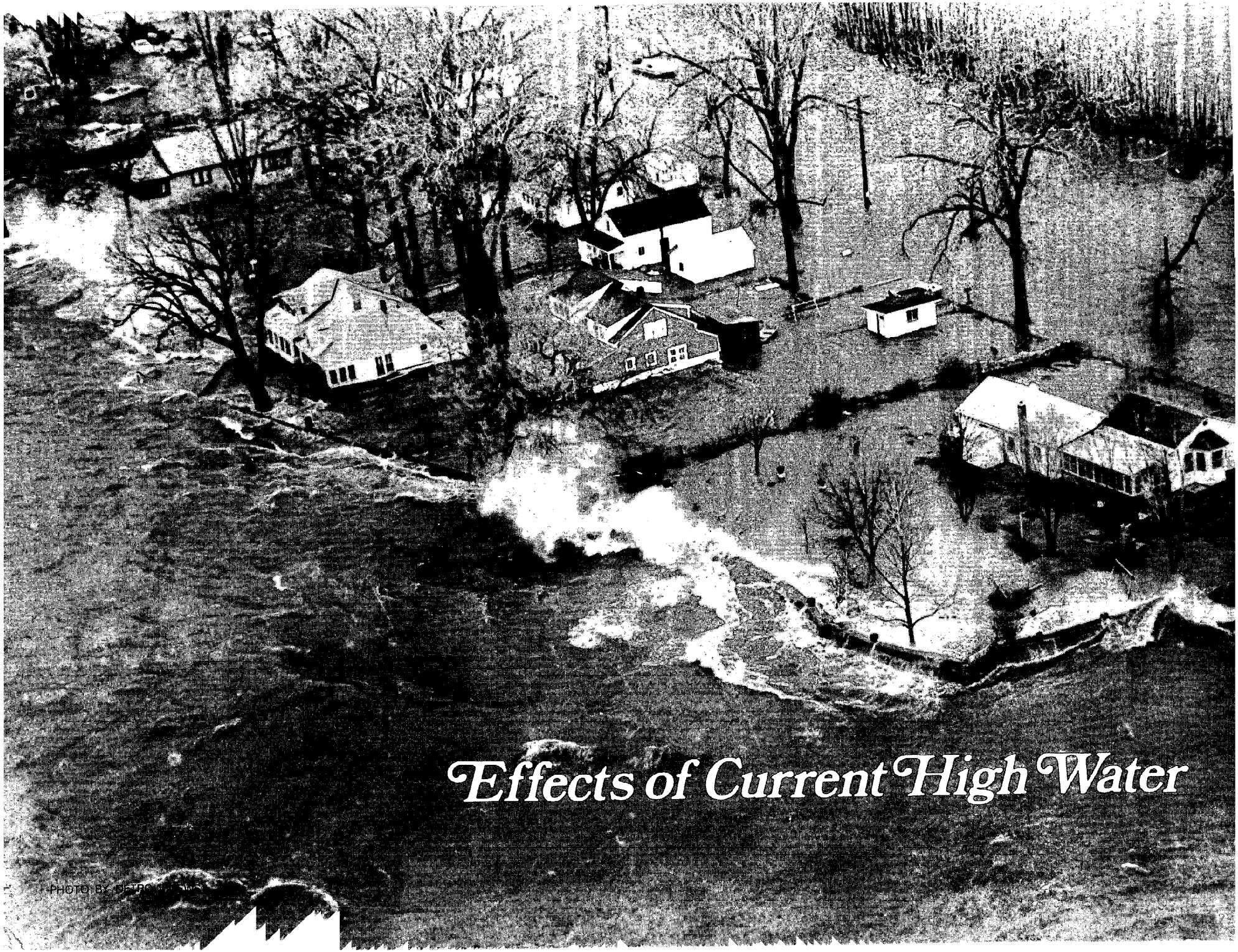
Selected lake level fluctuations in Lake Erie over the past 20 years, as recorded at the Toledo gauge, are shown in Table 4.

No detailed statistical analysis of the lake levels on Lake St. Clair is available. In June, July and August, 1973 lake levels were at record highs. The mean monthly values for the summer of 1973 were about 2.4 feet above the monthly means for the period of record (1898-1972), and about .4 foot above the previous monthly high of record.

As shown in the photo at right, serious flooding was not confined to Michigan's Great Lakes shores, but often extended miles inland along main tributaries. Flooding in the Bay City vicinity along the Saginaw River on March 18, 1973. Photo by Detroit News.



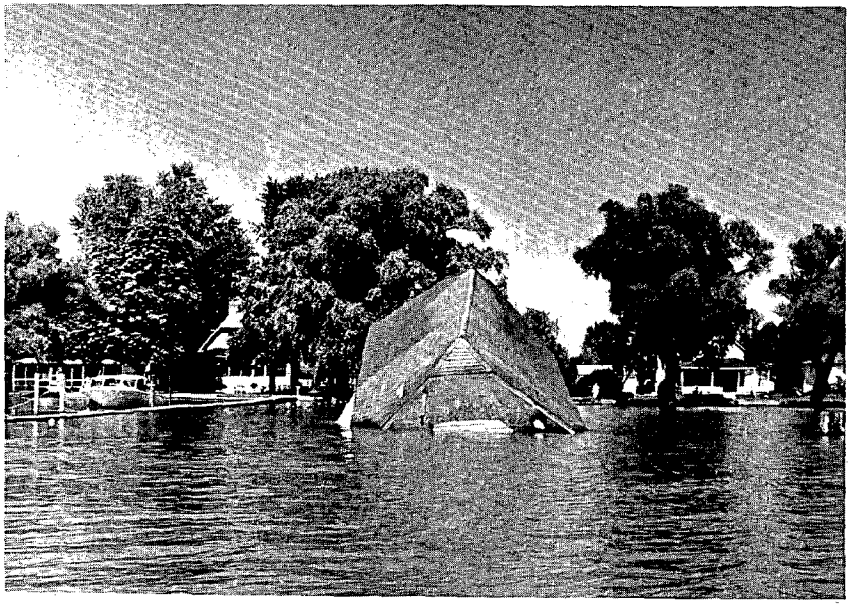
Effects of Current High Water
PHOTO BY DETROIT NEWS


Effects of Current High Water
PHOTO BY DETROIT

EFFECTS OF CURRENT HIGH WATER

The effects of high water along the Great Lakes range from nuisance conditions to major destruction of property. The problem and damage can be grouped into primary and secondary categories. Primary damage results from combining high water with storm waves; causing physical damage to docks, sea walls, boat houses, homes and cottages. Roads and highways are eroded away or closed by inundation. Increased amounts of sediment impair water quality. Sedimentation damages are most significant in areas where shore materials are not sandy, i.e., clays, heavier textured soils and organic soils. Lake Erie is particularly vulnerable as are Saginaw Bay and Lake St. Clair. There also occurs an increased potential of ice push along flat shorelines, especially during spring ice breakup on Saginaw Bay and Lake St. Clair.

Secondary effects of high water include increased



costs and inconvenience of use of shore and lake facilities. The flooding of docks, boat houses and marinas is a particularly costly problem. Not only do the facilities become impossible or inconvenient to use but they become increasingly subject to wave and ice action and associated damage.

Navigation hazards are created by floating debris such as trees, stumps and timber from wrecked structures. Reduction of clearance below fixed bridges, overhead pipe lines, and transmission lines impairs the use of tributary waters for recreational boating and increases the opportunity for logs and debris to jam against structures.

Another subject of concern involves the impact of flooding on the biological resources adjacent to the Great Lakes. It is nearly impossible to place a dollar value on the loss of habitat and the corresponding repercussions on fish and wildlife populations that use these areas for breeding, feeding and cover.

Saginaw Bay, Lake St. Clair and Lake Erie all have large expanses of coastal marshlands of superb quality as biological habitat (see Appendix). Substantial amounts of valuable marshlands were severely damaged during the fall 1972 and spring 1973 storms. Many more marshland environments succumbed months later due to long-term inundation. The gravity of the problem is demonstrated by the fact that the Michigan Department of Natural Resources received over $167,000 in Federal aid for physical damages to established wildlife areas.

In addition to the major economic losses suffered by the citizens, are the many other hardships also endured. It is difficult to quantify these, though some can be qualified. People have been forced to leave their homes time and again; school aged children have experienced a loss of school time. Work losses have occurred because people were unable to reach their places of employment or because of actual closings of commercial and industrial establishments. Loss of business opportunity occurred at restaurants, bait shops, marinas, boat rentals, etc.

Approximately 300 miles of Michigan Great Lakes shoreland are currently subject to flooding by the high levels of the Great Lakes. In Michigan on two separate storm occurences over 12,000 people were evacuated because of flood conditions, (Table 5). Upwards of 10,000 homes were subject to the effects of flooding, (Table 6). More than 50,000 acres of land were flooded in 1973, (Table 2). Operations of several manufacturing establishments were interrupted. Damage to private property from November, 1972 through June, 1973 was over $8,000,000, (Table 7). Public costs have nearly reached $47,000,000, (Table 8).

In summary, the current high water levels of the Great Lakes, as depicted in Figure 1, have caused suffering, hardship and substantial economic loss to both the private residents-owners and the public.

TABLE 5

Evacuations Due to Flooding, 1972 - 1973

County	Number of People Evacuated		
	November 1972	March-April 1973	June 1973
Bay	100	600	0
Macomb	100	0	0
Monroe	11,000 (500 sheltered)	11,000 (500 sheltered)	500 (100 sheltered)
St. Clair	150	100	0
Tuscola	0	70	0
Wayne	500	700	500
Total	11,850	12,470	1,000

From information estimated by County Office of Civil Defense

TABLE 6

OPERATION FORESIGHT SUMMARY DATA FROM U.S. ARMY CORPS OF ENGINEERS*

Lake or River	Potential Projects	Homes that would be protected	Estimated Cost
Lake Michigan (Western Half)	3	32	44,200
Lake Michigan (Eastern Half)	13	230	359,500
Lake Huron	2	0	200,000
Lake St. Clair	9	5,370	5,185,000
St. Clair River	3	380	830,000
Lake Erie (Western Basin)	10	2,875	9,120,000
Total	40	8,889	$15,738,700

*Preliminary estimates, March 21, 1973

TABLE 7

PRIVATE EXPENDITURES DUE TO FLOODING, FALL, 1972 and SPRING, 1973

Source	Amount
1. Small Business Administration loans, November, 1972 flood (15% of $5,034,000 repaid)	$ 755,000
2. S.B.A. loans, March 16 - April 10, 1973 flood (15% of $6,736,000 repaid)	$1,010,000
3. Monroe County, June, 1973 flood	$1,500,000
4. Farmers Home Administration Emergency loans (amount to be repaid)	$4,000,000
5. National Flood Insurer's Association, March 16 - April 10, 1973 flood (10% of $9,452,000 paid by issuing insurance companies)	$ 945,000
Total	$8,210,000

TABLE 8

Public Expenditures Due to Flooding, Fall, 1972 and Spring, 1973

	Source	Amount
1.	Federal Disaster Assistance Administration (formerly Office of Emergency Preparedness) November, 1972 flood disaster; declaration no. OEP-363-DR	$ 584,000
	Federal Disaster Assistance Administration, March 16 - April 10, 1973, flood and storm disaster; declaration no. OEP-371-DR	1,312,000
2.	Farmers Home Administration Emergency loans. Over $16,000,000 in loans; $12,000,000 considered grants	12,000,000
3.	Housing and Urban Development	200,000
4.	Small Business Administration loans, November, 1972 flood - $5,034,000 (85% not to be repaid)	4,279,000
	March 16 - April 10, 1973 storm and flood $6,736,000 (85% not to be repaid)	5,726,000
5.	National Flood Insurer's Association, March 16 - April 10, 1973 flood - $9,452,000 in claims (90% subsidized by HUD)	8,507,000
6.	Bureau of Social Services, March 16 - April 10, 1973 storm and flood	9,000
7.	American Red Cross: November, 1972 flood	6,000
	March, 1973 flood	117,000
	June, 1973 flood	16,000
8.	Michigan National Guard	75,000
9.	Operation Foresight	13,000,000
10.	Contingency Fund	109,000
11.	State Department of Highways, $1,574,000 requested for damages to Federal Aid System	900,000
12.	Corps of Engineers - Emergency Bank, Protection for Cities of Charlevoix and Grand Haven	100,000
	TOTAL	$46,940,000

TABLE 9

Property Damages (Private and Public) Due to Great Lakes High Waters, 1951 and 1952

LAKE	INUNDATION	EROSION	TOTAL	TOTAL/mi
Superior (incl. upper St. Mary's River)	$1,506,000	$2,853,000	$4,359,000	$3,100
Michigan	1,560,000	29,083,500	30,643,800	18,700
Huron (incl. lower St. Mary's River)	274,700	2,461,500	2,736,200	2,700
St. Clair (incl. St. Clair & Detroit Rivers)	1,921,700	2,317,850	4,239,550	21,100
Erie (incl. Niagara River above falls)	4,753,200	7,167,000	11,920,200	22,100
Ontario (inc. lower Niagara River & St. Lawrence River)	1,266,250	6,087,900	7,354,050	11,800
	11,281,850	49,970,750	61,252,800	------

If the calamitous events of the Fall of 1972 and the Spring of 1973 were to be one-time historical circumstances it would be troublesome enough to all concerned. Unfortunately, both the record of natural events and that of the response of our society is such that it seems nearly a "sure bet" that without some positive action now, the next period of high water will see an enormous increase in the number of people involved and economic losses.

It is difficult to develop a direct comparison of the damages and public costs between the high water period of 1951-52 and that of 1972-73. The damage to public property for those counties included in Presidential Disaster Declarations (see Table D in Appendix) for March 16 to April 10, 1973 was $1.3 million, while the entire flood damage to public property for all of Michigan's shoreline from the Spring of 1951 to the Spring of 1952 was $555,200 (Table E in Appendix).

Public damage for the June 26, 1973 storm was $88,700 in Monroe County alone with private damage of $1.5 million. The immensity of the high water problem is demonstrated by the $61 million in property damage incurred along all United States shore of the Great Lakes during the early 1950's (Table 9), as compared with the current expenditure of over $46 million in public funds for flood relief measures in Michigan alone. Nearly all of the current flood relief programs such as temporary diking, flood insurance, small business assistance, Farmers Home Administration loans, etc. were either nonexistant or not utilized during the flood period of the early 1950's. If the public costs of these programs is added to public and private flood damages for Michigan, the cost of the present high water to Michigan is some 10 times what it was in the 1950's.

What Can Be Done Under Existing Programs

PHOTO BY DETROIT NEWS

WHAT CAN BE DONE UNDER EXISTING PROGRAMS

What then can be done about the flooding problem? Following is a brief discussion of existing courses of action and some of the apparent limitations to such actions.

Federal Level -

Lake level regulations - On first thought, engineering works to control the levels of the various Great Lakes seems to be a very logical means of alleviating both low and high water problems; and there are at least partial controls in existence for Lake Superior and Lake Ontario, (Map 5). These existing controls do provide a means for controlling the levels of Lake Superior and Lakes Michigan-Huron but only within limits. During prolonged periods of excess precipitation when all the Lakes get "full" the relief available is at the expense of one lake or another, i.e., in order to keep Lake Michigan at a lower level, the level of Lake Superior must be raised. Because of the great difference in elevation between Lake Erie and Lake Ontario at Niagara Falls, the control of Lake Ontario has no effect on the upper Lakes.

To achieve major relief from high water problems on the Great Lakes, a series of controls would have to be built that could pass excess water through the entire system - down to the lower St. Lawrence River - the factor which is the most complicating is that the largest lakes are at the "top" and the surplus water from Lake Superior must be passed through not only Lake Huron, but Lake Erie and Lake Ontario - a foot of water from Lake Superior would raise Lake Erie 3.2 feet.

The cost of a control would be enormous, hundreds of millions of dollars. Not only would connecting waterways, St. Marys, St. Clair, Detroit and Niagara rivers have to be widened and deepened to pass excess waters, but moveable dams or gates would have to be installed in some locations to control low water levels. Even if works were built, they could only control the extremes of the fluctuation, that is, lower the extreme highs, raise the extreme lows, but some fluctuation would remain. This is particularly true of Lake Erie, which fluctuates significantly from the effects of wind and barometric changes - up to 4 feet at Toledo.

In addition to the cost factor, a further consideration which must be recognized to achieve lake level control, is that of International Agreement. The Canadian Government would necessarily have to be a party to any regulation plan. This presents a host of other international questions which would require solutions and place the reality of level control, with the possible exception of Lake Erie, decades into the future. Illustrative of this forecast is that 10 years have been required for a study of the Great Lakes water levels. Even control for Lake Erie, the least expensive, is not likely to be accomplished in the immediate foreseeable future.

Protection -

Flood protection for the property subject to damage from high lake levels is within the realm of engineering feasibility, but only from an engineering point of view. The cost would probably greatly exceed the value of what is to be protected. The desirability of living behind the kind of structures that would be required would be marginal at best.

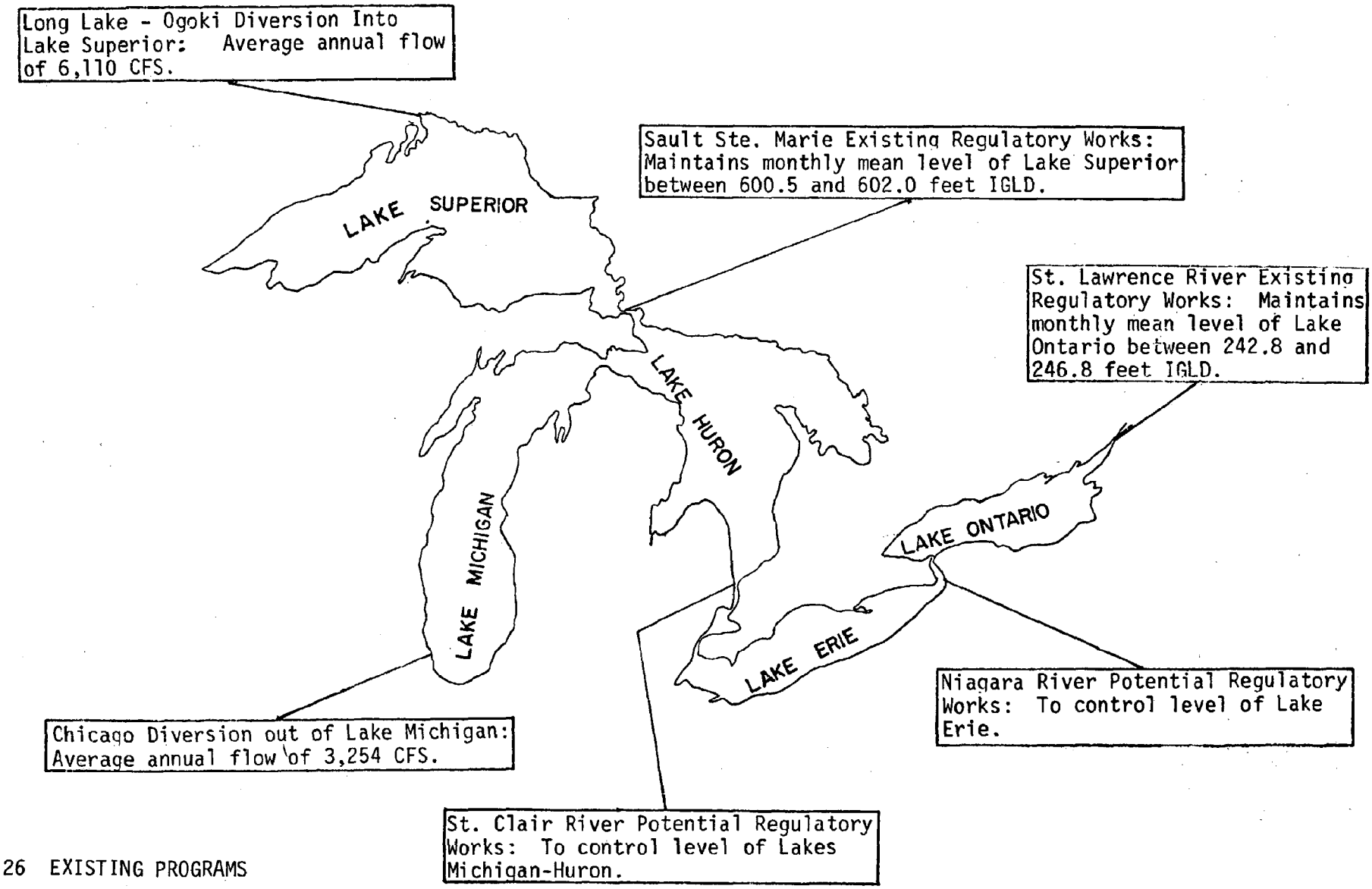
Some concept of the funds which would be involved can be illustrated by the cost of the temporary protection afforded by Operation Foresight, $13 million in Michigan alone.

Other Programs -

There are a number of other measures that the Federal government has made available. The 1968 National Flood Insurance Act provides a program of flood insurance

MAP 5

Locations of Existing and Potential Regulatory Works for the Great Lakes



normally unavailable from private insurers for property subject to flood damage. In return for the provision of subsidized insurance to existing properties, there is a requirement that local governments adopt and enforce land use control measures that will guide land development in flood-prone areas in order to avoid or reduce future flood damage. The U.S. Department of Housing and Urban Development administers the program.

In order to qualify, a community must request to participate in the program for the entire area within its jurisdiction. In addition, the community must show evidence that decisions concerning the location, design, and construction of new structures will take known flood hazards into account . Generally, building permits or subdivision regulations are accepted for this minimum requirement. However, the Act requires that HUD provide technical data to the community precisely defining the flood hazard area. Once such information is made available a community has six months to adopt zoning in compliance with Federal requirements.

The thrust of the program is to provide flood insurance for existing structures and prevent new construction or substantial improvements of property located in the flood hazard area unless adequately flood proofed.

The program operates through an insurance industry pool under the auspices of the National Flood Insurer's Association, by means of a Federal subsidy to make up the difference between actuarial rates and the rates actually charged to consumers for the protection provided. In many cases, the Federal subsidy amounts to more than 90 percent of the insurance cost. 10 percent is assumed by the issuing insurance companies. To avoid duplication of benefits, Federal disaster assistance is not available to reimburse property losses to the extent that the losses are covered under flood insurance policies. Many of Michigan's communities bordering the Great Lakes are included in the National Flood Insurance Program, (Table F in Appendix).

At this point in time, some of the merits of this program are negated to a degree by the lack of staffing assurance at the Federal level (no personnel permanently stationed in Michigan). Technical studies to delineate flood hazard areas are done by contracting with other Federal agencies or consulting engineers and there is a considerable backlog of needed studies.

The Michigan Department of Natural Resources has been designated by the Governor to serve as the State coordinating agency to assist communities in qualifying for the flood insurance program and in the development of acceptable land use control measures. Major responsibility is to coordinate technical flood delineation studies to assure adoption of standard criteria for the development of flood plain ordinances. At present, the State's involvement is regulated by the level of Federal spending for technical studies.

Congress has recently passed the Flood Disaster Protection Act of 1973 which substantially increases the limits of coverage authorized under the National Flood Insurance Program. The new limits of coverage are: $35,000 aggregate liability for any single family dwelling; $100,000 for any residential structure containing more than one unit; and $10,000 for any contents related to the dwelling unit. In the Virgin Islands, Guam, and the states of Alaska and Hawaii, the amounts are $50,000 and $150,000 for single and multiple family dwelling units, respectively.

Since future demand for flood insurance is undetermined, there is no monetary limit on the amount of insurance coverage which can be written under this act, but rather a program expiration date of June 30, 1977.

The new act also requires that local communities participate in flood insurance program and adopt adequate flood plain ordinances as a condition of federal financial assistance. Flood prone communities identified by the Secretary of Housing and Urban Development must qualify for the flood insurance program within one year after notification or by July 1, 1975 (whichever

is later) in order to receive federal financial assistance.

The Farmers Home Administration operates an emergency loan program for victims of natural disasters which cause property damage or severe agricultural production losses. In order to be eligible for this type of assistance, the area must be declared a major disaster area by the President or designated as a natural disaster area by the Secretary of Agriculture. In addition, individual applicants must be 1) U.S. Citizens, 2) farmers or ranchers managing their own operations, 3) of good character, and 4) unable to obtain credit from other sources at reasonable rates and terms. The primary purpose of these emergency loans is to enable farmers to meet annual operating expenses and continue their normal farming or ranching programs. The terms are very flexible and can be adjusted to the needs and circumstances of each individual.

In contrast to the FHA program the Small Business Administration offers disaster loans for property damages without regard to whether the required financial assistance is available from private sources. This disaster loan program is also applicable to personal as well as real property. However, the area must be declared a disaster area by the SBA. Under SBA provisions for home loans the maximum assistance available for real property is $50,000 and $10,000 for personal property, such as household goods, etc. For SBA declared disasters occurring on or after April 20, 1973, all loans must be repaid with no forgiveness benefits at an annual interest rate of 5% over a period of up to 30 years, depending on the applicant's ability to repay. For disasters occurring on or after January 1, 1972, but prior to April 20, 1973, up to $5,000 of a loan was forgiven with the remainder of the loan to be repaid at a 1 percent annual interest rate. These loans may be used to repair, rehabilitate, or replace property which has been damaged or destroyed as a result of a natural disaster. If it is necessary to construct a new home, new business, or institutional facilities on a different site -- for example, on higher ground because of being located in a flood-prone area -- these loans may be used for that purpose.

SBA disaster loans are also available to businesses, under slightly different conditions. Business loans may cover machinery and equipment, fixtures, and inventory as well as real property. Loans made directly by SBA can be as much as $500,000. In addition to these direct loans, SBA may approve a guarantee of up to 90 percent of a commercial bank loan to repair disaster damage. Small businesses, as defined by SBA, can receive economic injury assistance as well as physical disaster assistance, but these are combined in the $500,000 maximum. Terms are the same as for home loans. However, under section 237 of the 1970 Disaster Relief Act, SBA may make loans of unlimited size at interest rates not in excess of 6% per year to enterprises which are major sources of employment in stricken areas and have substantially ceased operation as a result of the disaster.

The National Flood Insurer's Association has expended approximately $9,500,000 for flood relief in Michigan.

Over $16,000,000 has been spent by Farmer's Home Administration for Michigan flood relief programs.

The Small Business Administration has granted nearly $12,000,000 in loans to Michigan residents and businesses for flood damage.

Lack of adequate identification of flood hazard areas has led to developments such as this mobile home park adjacent to Lake St. Clair.

After each flooding occurs, the home owner is left little choice but to move back into the flood prone area. He has no solution of permanent value and the taxpayers are faced with continuing future costs.

There are certain areas of development which will warrant protection or modification rather than abandonment. Flood proofing, improved transportation facilities, or protection may be well warranted particularly in low risk areas. Such determinations need high priority.

In addition to lack of permanent solutions at the Federal level, is the question of when temporary measures are applicable. Certain assistance programs are dependent upon the requisite of a disaster declaration; substantial damage and problems can occur in flood situations which do not meet the criteria for such a declaration.

State Level -

What is the State's role? Under existing statutes it is limited. The major responsibility is in the area of disaster relief and emergency procedures. The Departments of Agriculture, Commerce, Public Health, Department of Natural Resources, State Highways and Transportation, Social Services as well as other Departments provide technical and energy services to citizens and communities in flood emergency. By and large such involvement is part of the general responsibilities of the agencies and not as a result of specific programs.

Under the authority of the Governor the National Guard can be utilized to supply manpower and equipment in emergency situations. Under certain circumstances National Guard equipment can be utilized to assist communities through a training schedule. The Department of Corrections has cooperated in supplying volunteer inmates for labor to assist in emergency situations associated with Great Lakes flooding.

The Department of State Police has responsibility for coordinating disaster relief efforts including obtaining assistance from other State Departments and for recommending to the Governor action to be taken in declaration of disasters. It is beyond the scope of this report to discuss the procedures of State and Federal Disaster Declaration.

The State programs not associated with emergency and disaster flood problems are limited. Mostly, the responsibility is under the authority of the Department of Natural Resources primarily to assure that new plats of land are not in flood prone areas or that certain criteria are met as condition of platting (fill above flood line, flood proofing, diking). The other major state program, control of development in the riverine flood plains, is not applicable to flood areas adjacent to the Great Lakes. The premise for that program is that no development take place in the flood plain which would cause increased elevation of flood stage (by backing water up, etc.). Development along the Great Lakes has no appreciable effect on lake levels.

Local Level -

The problems facing community governments in regulating lands are discussed in the U.S. Senate Report on the pending land use legislation (930 Congress 1st session, Report No. 93-197 Report of Committee on Interior and Insular Affairs, U.S. Senate to accompany S.268).

"The varied and complex land use controls in use today by some 10,000 local governments are, to a large extent, merely refinements upon the land use controls developed and validated in the first third of this century. These controls enabled local governments for the first time to place significant restrictions on private land use to protect the larger public interest.

Despite current high water levels, development of flood-hazard shoreline areas continues.

Yet, in keeping with the traditional concept of land, for the larger public interest was and is interpreted to be protection of property values and the economic value of land. The dependency of most cities upon property taxes, which in turn are dependent on property values, serves to reinforce this prevailing purpose of land use controls.

In the absence of State concern or guidance, the cities (and, for that matter, the courts) came to treat the decidedly negative local land use regulations as though they embodied whatever planning was considered necessary. Thus, rather than guiding planned development, land use controls have lent protection to virtually unplanned development. As a result, whether land use decisions have been left entirely to the market place or to local regulations absent a planning base, inefficient, unsightly, and often costly land use patterns have developed."

For a variety of understandable reasons management of flood hazard lands by community government has achieved only limited success in preventing the increase of flood damages along the Great Lakes. The major factors appear to be:

1. relatively long time periods between high water levels;

2. great economic value of land adjacent to water;

3. dependency of community government services on property tax revenues;

4. limited State responsibility.

The failure of either State or community governments to establish program goals to control development subject to damage in flood hazard lands has resulted in dramatic consequences. Table 10 illustrates the development that has occurred along Lake St. Clair and Lake Erie since 1952.

TABLE 10

DEVELOPMENT COMPARISON
1952 vs. 1967

Location	Number of Homes 1952	Number of Homes 1967	Percent Increase
Lake Erie			
Milleville and Maple Beach	55	110	100
Gibralter	424	883	108
Luna Pier	338	378	---
Lake St. Clair			
Harsens Island	649	843	32
Algonac	661	794	20
New Baltimore	62	97	56
Lakeside	190	250	32
Metropolitan Beach	167	470	181
St. Clair Haven	224	455	105
Belvidere Bay	120	282	135

2

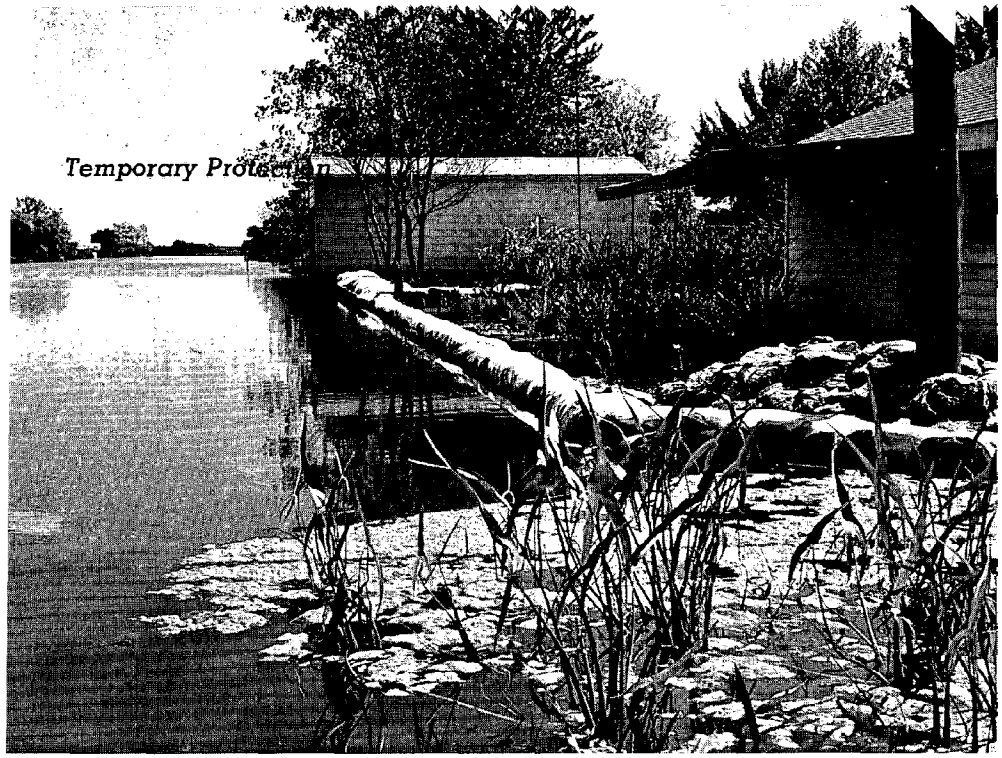
One of the most nagging aspects of the flood problem along the Great Lakes is that most existing Federal programs (as well as other levels of government) are aimed at providing temporary solutions, i.e., protection, temporary housing, emergency funding, etc. Very few are designed to provide permanent solutions to the damage or destruction of existing property.

Because of the lack of knowledge on the part of builders, absence of land use controls, and in some cases a substantial loss of land, a number of buildings are located along Lake Erie, the Detroit River, Lake St. Clair, the St. Clair River and Saginaw Bay, which at times, are unfit for human

occupancy. This can be for safety, sanitary reasons, lack of communication or transportation. Serious consideration needs to be given to abandonment of such structures as the most realistic long-term solution. If not, the situation will continue where the expenditure of funds for temporary measures may exceed the value of the property as was the case with Estral Beach, Detroit Free Press, October 8, 1973.

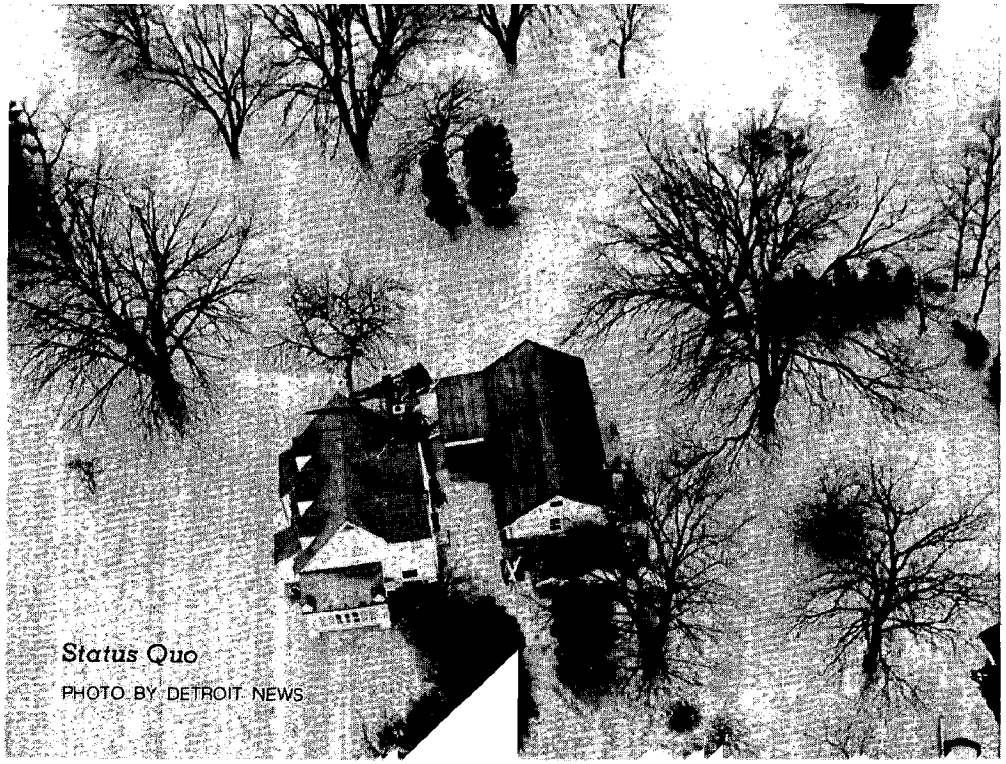
> "Ambitious programs; including at least $500,000 in Small Business Administration "excused" or non-repayable loans and HUD gifts of free housing to an estimated 50 families, have come in and attempted to prop the village back on its feet. Many families who received up to $5,000 in SBA repair money after the November 14 flood, received SBA money again after the April 9 flood to repair their earlier repairs, only to have them destroyed again in the June 17 flood. But the biggest project of all, a $714,000 Corps of Engineers dike-building plan to bolster the defenses along the town's fringe, has been indefinitely held-up by a strike. Since November, Estral Beach has been declared a national disaster area three times - in November, April and again in June. After each declaration, government agents from the Office of Emergency Preparedness (OEP) (now the Federal Disaster Assistance Administration), Small Business Administration (SBA) Housing and Urban Development (HUD), Farmers Home Administration (FHA) and the Army Corps descend on the town like a conquering army making reparations. By conservative estimate the village has already received $1.4 million in federal disaster aid, $100,000 more than its assessed land valuation and an average of more than $6,000 per household."

Alternatives



Temporary Protection

Permanent Protection



Status Quo

PHOTO BY DETROIT NEWS

Public A

ALTERNATIVES FOR FUTURE ACTION

Through the field investigation, discussions with officials of the various levels of Government and shoreland residents, it seems very evident that long-term permanent solutions to recurring damages to developed property do not exist. There are undoubtedly several alternatives which could be developed to provide such solutions. It is much beyond the scope of this summary report to fully explore such alternatives.

Since all levels of government are involved with the Great Lakes flooding problems, and since all will be a part of developing solutions, it is difficult to suggest in precise detail the relationships between one level of government and another. Following are some concepts which could be a part of a number of alternatives.

Community governments have the major responsibility for guiding the orderly growth and development within their jurisdiction by the exercise of various regulatory powers based on the protection and enhancement of public health, safety and welfare. Community government, therefore, has a major role to fulfill in the implementation of flood damage control programs. The use of zoning ordinances, subdivision regulations, building and sanitation codes and related measures will be primary tools in containing the damage problem.

To this end, Federal-State programs should be so designed and operated as to provide maximum assistance to community governments in executing their responsibilities.

In order to provide that assistance, the following measures could be undertaken:

1. Amend the Shorelands Protection Act (Act 245 of 1970) to add a category of flood hazard to the requirements of the Act. In essence, such an amendment would require the identification of flood hazard areas along the Great Lakes, and the notification of community government and those State agencies who have land use regulatory responsibility, i.e., (1) Department of Labor - State Building Code (2) Department of Licensing and Regulation - land sales (3) Department of Treasury - Plat regulations.*

   *Through the identification and notification process, community and state agencies are able to regulate future land uses in flood hazard areas.

2. Work out arrangements whereby Water Resources Commission would assume H.U.D. responsibilities for technical flood hazard area identification. Such a course of action would assure uniformity in technical studies along the Michigan shoreline and would expedite Federal Plan.

3. A State program of technical assistance aimed at providing service to community government be developed. The main purpose would be to provide technical data, consultation, and legal guidelines in preparation of local land use programs. It would be a costly and difficult proposition for each governmental unit to establish a data collection program and research legal approaches to land management. A state program would be consistent with the emerging coastal management concepts.

While controlling land use is properly a community responsibility, reducing the magnitude of the existing damage problem may require a joint state-federal approach. If reduction can not be achieved there will be a continuing escalation of private and public costs due to Great Lakes flooding. Given the physical nature of the flooding and high water damages; the unlikely construction of level controls and the great cost of providing permanent protection - reduction of the amount

of improved property subject to damage provides an alternative to prevent added future costs. At present, there is no systematic, fully operative program to acquire and convert flood prone real property to uses compatible with the physical risks involved along the flood area of the Great Lakes.

There are many uses both private and public which can be made of these areas, but such uses require either the physical alteration by filling, diking, etc., to make structures secure, or not constructing facilities which would be subject to repeated risks.

Shoreland use regulations could be promoted by public purchase (Federal-State program) of the most critical flood areas, particularly those where permanent protection is not economically feasible. Such property or parcels of property could either be retained in public ownership or resold with appropriate deed restrictions. Deed restrictions could for example limit the permissible type and extent of development. A deed restriction program could be financed by a revolving fund with possible annual supplements to cover reduction of the fund. This potential technique has not been considered in adequate detail.

Should the State of Michigan take the initiative in the development of such a procedure there is at least some potential that Federal programs could be altered to provide a partnership approach.

There are a number of potential land regulatory techniques available for consideration by State government which could be utilized in managing flood hazard areas.

The question of property tax becomes key to the applicability of a number of such techniques and especially so because of the general high value of even marginal shoreline property. Proposals to encourage preservation of land in natural state (conversely to discourage building) through tax relief, suggest a reduction in taxes to compensate for a reduction in land value resulting from a decision to make the land unavailable for development.

Although property tax is assessed on the basis of market value of the land, if property values are lowered by governmental action the assessment should be correspondingly adjusted. If flood hazard lands are declared not suitable for building in their natural state would property taxes automatically be reduced? One of the problems with the self-adjusting process can be the time lag in establishing new market values, and perhaps an undue burden on the property owner to rely on the appeal process.

An alternative to the dependence on the establishment of new market values would be an exemption for flood hazard property to be granted by the Legislature. The ability of local government to tax is granted and limited by the State; however, the state could authorize such exemptions by amending Act No. 206 P.A. of 1893, as amended. Exemptions which may be granted by the state would not conceivably violate the requirement of uniformity in Art.9 section 3 of the Michigan Constitution, if the exemption applied statewide to all property that met eligibility requirements.

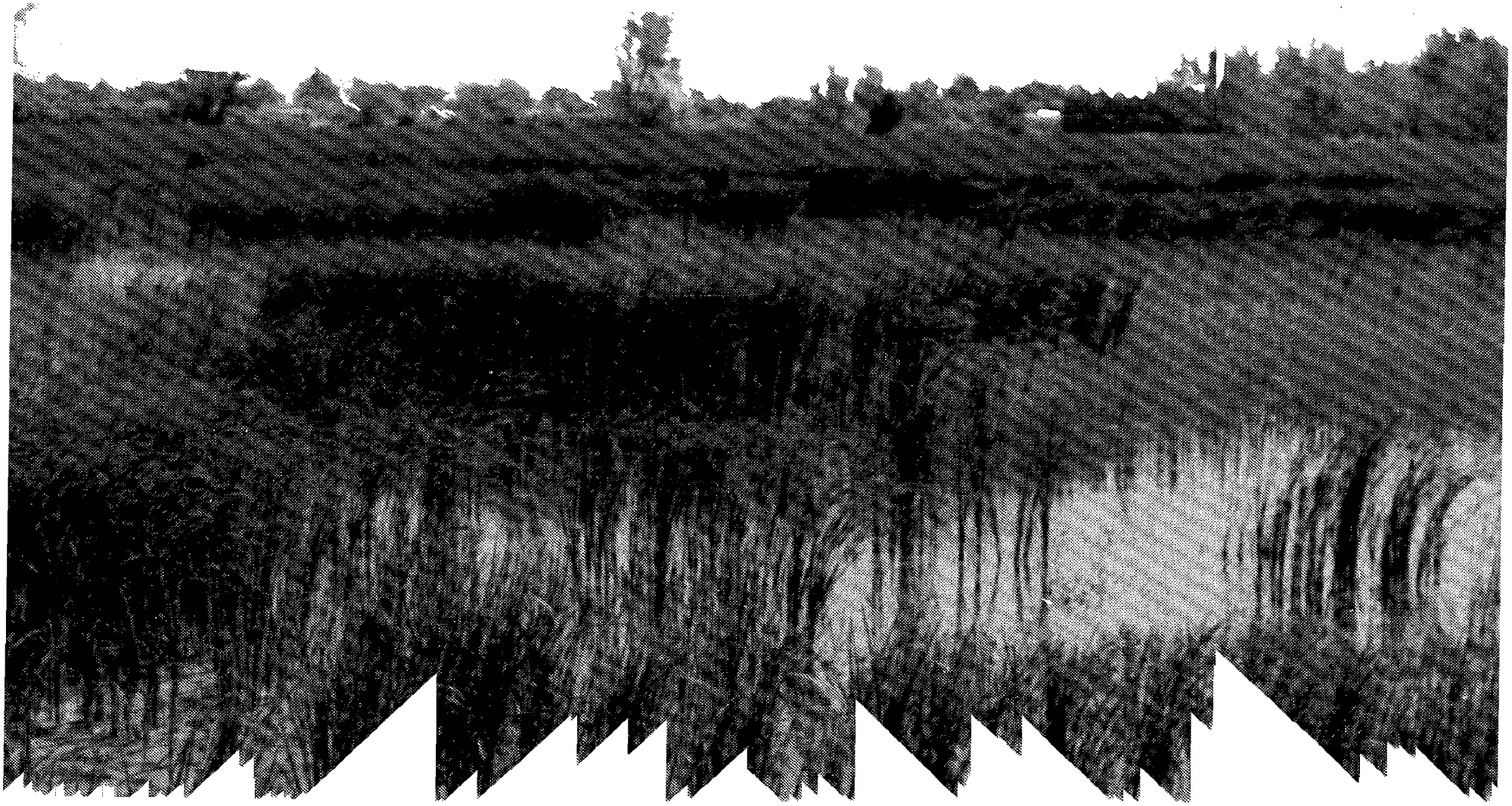
Numerous vacant parcels have been rendered unbuildable due to current high water (as well as shoreland erosion, seasonal inundation, transportation facility, construction, etc.). Many remain assessed at the evaluation imposed prior to the physical loss or impairment of the property. Thus, sale to any unwary buyer emerges as the most practical option available for the present owner. Two courses of action are open at the state level. First, due to the reduced value of such parcels for development, purchase, at low cost, by the State or other governmental units for public open space benefits invites consideration. Second, there should be identification of such parcels for protection of the private purchaser. Subsequent to identification,

assembly of such parsels to form an area capable of future development with modification - again at fair cost - may be fostered. In either case, a public service is rendered.

To be more specific in the case of property subject to flooding, consideration could be given to requiring that such property have a flood hazard declaration recorded on the property deed. At least subsequent owners would then be aware of the potential risk involved with such property.

* * *

It has been the aim of this reconnaissance level report to provide a brief overview of a problem of serious magnitude and to suggest some alternatives that might be considered for solutions.



Appendix

SHORELAND DEVELOPMENT, OWNERSHIP AND SHORE TYPE

LAKE HURON
Use and Development

The United States shorelands of Lake Huron are located entirely within the State of Michigan and have a total mainland length of about 634 miles. The majority of the lake's shore, however, is under the jurisdiction of the province of Ontario, Canada.

Lake Huron contains significant fishery and wildlife values, especially in the Saginaw Bay area, the Les Cheneaux Island groups, and the Potagannissing Bay and Munuscong Lake Area. Saginaw Bay is one of the most significant fish and wildlife habitat areas on the Great Lakes.

Use and development of the Lake Huron shorelands is light in the Upper Peninsula and in the northeastern portion of the Lower Peninsula (from the Straits of Mackinac to the Oscoda area). Predominant use of this shore is for seasonal and permanent residential housing, some agricultural use, and forest lands, particularly in the more northern areas. The southern Lake Huron shore is developed to a greater degree. Residential and agricultural development predominates in rural areas, while commercial and industrial complexes are founded at Bay City and Port Huron. Because of the marshy shore type of Saginaw Bay, large tracts of shorelands in Tuscola and Huron counties are almost completely undeveloped except for agricultural use landward of the marshes.

Overall, only 3.1 percent of the Michigan Lake Huron shore is developed for commercial and industrial purposes. Residential development accounts for 42 percent of the total shorelands. Nearly one-half of the Lake Huron shorelands is forest lands and in agricultural or undeveloped use.

Some 4.5 percent of the Lake Huron mainland shore is within designated recreation areas. This category includes fifteen Michigan state parks and numerous county, township, and municipal parks, and other recreation areas.

Ownership

The Michigan mainland shore of Lake Huron is an estimated 634 miles in length. About 107 miles of this total shore are in public ownership representing nearly 17 percent of the total shoreland.

The island shoreland of Lake Huron within Michigan is an additional 347 miles. Some 108 miles or 31 percent of the total is in public ownership. The state of Michigan accounts for the bulk of the public island shoreland with 25.8 percent of the total; the federal government owns 4.4 percent, and local governmental units hold 0.8 percent.

Shore Types

The shore of Lake Huron is quite different from Lake Michigan and Lake Superior. In the north, the shore is mainly rocky with some high banked beaches extending landward into a rolling upland area. Saginaw Bay is characterized by wetlands. The lower lakeshore is largely characterized by sandy beaches backed by low bluffs. One reach along the eastern shore of Huron County, consists of exposed bedrock and very rocky shorelands contributing to the picturesque nature of that area.

Of the 10 shore types used in this report to characterize shorelands, seven are found in the Michigan Lake Huron shorelands. In contrast to Lakes Michigan and Superior, low sand dunes occupy only 3.3 percent of the shore. Wetlands, on the other hand, make up about 29 percent of the total shore, primarily around Saginaw Bay. (see Table A).

TABLE A

Shoretypes of the Mainland
Michigan Shore of Lake Huron

Shore Type	Percent of Shore
Artificial fill area	------
Erodible high bluff	6.1
Non-erodible high bluff	------
Erodible low bluff	10.6
Non-erodible low bluff	10.6
High sand dune	------
Low sand dune	3.3
Erodible low plain	32.5
Non-erodible low plain	8.0
Wetlands	28.9
	100.0

LAKE ERIE, LAKE ST. CLAIR, ST. CLAIR AND DETROIT RIVERS
Use and Development

The United States shorelands of the St. Clair River, Lake St. Clair and the Detroit River are all under the jurisdiction of the state of Michigan. Lake Erie's shore is administered by four states - Michigan, Ohio, Pennsylvania, and New York. From Port Huron at the head of the St. Clair River to the Michigan - Ohio state line near Toledo, the mainland Michigan shore amounts to 147 miles.

Abutting the heavily populated Southeast Michigan urban-industrial complex, these shorelands are the most intensively developed within the state. The Detroit River, Lake St. Clair, and the St. Clair River form a busy waterway bridging the upper lakes (Superior, Michigan, and Huron) and the lower lakes (Erie and Ontario).

The city of Detroit is the major metropolitan area in this shoreland region. Many other suburban communities are also found in the shorelands from Port Huron in the north to Monroe in the south. Shoreland use and development in this area is largely urban-oriented with residential, commercial, and industrial uses predominating. Because of the intensive shoreland development, a great deal of the original shore has been artificially altered.

Residential users occupy 58.3 percent of the shorelands of Lake St. Clair, the St. Clair River, and the Detroit River and 46.2 percent of the Michigan Lake Erie shorelands. Much of the residential development is permanent and of high quality.

In total, commercial and industrial development accounts for 25.7 percent of the shorelands of Lake St. Clair, the St. Clair River, and the Detroit River. In Lake Erie, this category accounts for only 2.5 percent of the shorelands due to the character of the shoreland and the significant portion in state-owned recreational and wildlife areas.

As would be expected, agricultural and undeveloped lands are very limited along the St. Clair River, Lake St. Clair, and the Detroit River, accounting for only 8.1 percent of the total shoreland. Along Lake Erie, however, this category accounts for 17.8 percent of the shorelands, but these lands are under pressure to convert to residential use. Virtually no forest lands other than small, isolated woodlots are found along the entire length of the shorelands in this heavily developed region.

Along the St. Clair River, Lake St. Clair, and the Detroit River, recreational developments occupy only 4 percent of the shorelands, and the area is deficient in recreational public water frontage. Many of the existing recreational areas are small parks and access sites.

The Michigan shore of Lake Erie has 8.6 percent of the total area devoted to recreational development. Sterling State Park is located in this shore reach, and it receives heavy use during the summer months.

The western end of Lake Erie consists largely of low-lying silt and clay materials with marshlands that are of special significance to wildlife, particularly migratory waterfowl. Along the Michigan shore of Lake Erie, 24.9 percent of the total shore is found in three state-owned wildlife areas - Pointe Mouillee State Game Area, Plum Creek Wildlife Area, and Erie State Game Area. All three areas are very popular for duck hunting.

Along Lake St. Clair and the St. Clair and Detroit Rivers, wildlife areas account for only 1.8 percent of total shoreland use and development. One large, high quality wildlife area, the St. Clair Flats Wildlife Area, is located in Lake St. Clair near the mouth of the St. Clair River. These marshlands are state-owned and provide excellent waterfowl hunting. Parts of Dickinson Island and Harsen's Island are located within this wildlife area.

In addition to the mainland shore, an estimated 116.8 miles of island shoreline are located in the Michigan portion of Lake Erie, the Detroit and St. Clair Rivers, and Lake St. Clair. A group of islands are found near the mouth of the St. Clair River in Lake St. Clair on both sides of the international boundary. Harsen's Island is the largest of this group. This island shoreland is generally marshy and is known for its extensive waterfowl habitat. Portions of Harsen's Island and nearby Dickinson Island make up the bulk of the state-owned St. Clair Flats Wildlife Area.

Ownership

The Michigan mainland shore of Lake Erie, the Detroit and St. Clair Rivers, and Lake St. Clair has an estimated total length of 147 miles. The amount of shoreland in this region in public ownership is 42.5 miles, which represents 28.4 percent of the total shoreline. The State of Michigan accounts for the bulk of the public shoreland with 19.4 percent of the total; the federal governmental units hold 7.3 percent.

In addition to the mainland shore, Michigan embraces some 117 miles of island shore in its portion of Lake Erie, the Detroit and St. Clair Rivers, and Lake St. Clair. About 64 miles of island shore, 55 percent of the total, is in public ownership. State lands account for 46.2 percent of the total island shore, federally-owned lands for 3.4 percent, and local government ownership for 5.3 percent. Overall, including both mainland and island shore, 40 percent of the Michigan shorelands of Lake Erie, the Detroit and St. Clair Rivers, and Lake St. Clair are in public ownership.

Shore Types

The Michigan shore of Lake Erie consists of low-lying, silt and clay materials supporting extensive marshlands. Only two shore types are found in this shore reach. About 56 percent of the shoreline has been altered by artificial fill, and the remaining 44 percent of the shoreline is classified as wetlands.

Only a little more diversity is present in the shores of the Detroit and St. Clair Rivers and Lake St. Clair. Artificial fill accounts for nearly one-half of this shoreland, and two other shore types - wetlands and erodible low plains - account for 46 percent of the shorelands (see Table B).

TABLE B

Shore Types of the Michigan Mainland Shore
of Lake Erie, Lake St. Clair and the Detroit
and St. Clair Rivers

Shore Type	Percent of Shore	
	Lake St. Clair and St. Clair and Detroit Rivers	Lake Erie
artificial fill area	56.0	49.1
erodible high bluff	----	----
non-erodible high bluff	----	----
erodible low bluff	----	4.9
non-erodible low bluff	----	----
high sand dune	----	----
low sand dune	----	----
erodible low plain	----	30.3
non-erodible low plain	----	----
wetlands	44.0	15.7
	100%	100%

[From Interim Report on Lakes Superior and Ontario Regulation by the International Great Lakes Levels Board to the International Joint Commission]

"1. THERE ARE THREE CATEGORIES OF WATER LEVEL FLUCTUATIONS ON THE GREAT LAKES: SHORT PERIOD, SEASONAL, AND LONG-TERM.

Short period fluctuations, lasting from a few hours to several days, are caused by meteorological disturbances. Wind and differences in barometric pressure over the surface of a lake create temporary imbalances in the water levels at various locations in the lake. Although the level of the lakes at a particular location may change as much as 8 feet from such causes, there is no change in the volume of water in the lake. Short-term fluctuations cannot be reduced by operation of a regulatory structure at the outlet of the lake, and they are superimposed on the seasonal and long-term fluctuations of the water levels.

Seasonal fluctuations of Great Lakes levels result from the annual hydrologic cycle. This cycle is characterized by higher supplies during the spring and early summer and lower supplies during the remainder of the year. The magnitude of seasonal fluctuations is quite small, averaging about one foot on Lake Superior and Lakes Michigan-Huron, 1.5 feet on Lake Erie, and 1.8 feet on Lake Ontario. Ontario has the largest average seasonal fluctuations because it is the lowest in the chain of lakes. Such seasonal fluctuations are only about one-quarter of the long-term fluctuations and are superimposed on the latter.

Long-term fluctuations are the result of persistent low or high water supply conditions within the basin which climinate in extreme low levels such as were recorded in 1964-65 or in extreme high levels recorded in 1972-73. A century of record in the Great Lakes Basin indicates that there are no regular, predictable cycles such as one might expect. The intervals between periods of high and low levels and the length of such periods vary widely and erratically over a number of years. Maximum recorded ranges of levels, from extreme high to extreme low, have varied from 3.8 feet on Lake Superior to 6.6 feet on Lakes Michigan-Huron and Ontario.

Superimposed upon all three categories of water level fluctuations are wind induced waves which attack the shoreline.

Climatic change which would influence both the amounts of precipitation received by the lakes and their basins and the amounts withdrawn through evaporation has been receiving more attention from scientists. Although there have been fluctuations in climate, the data have not permitted the identification of any long-term climatic trend in the Great Lakes region.

2. THE LARGE STORAGE CAPACITIES AND RESTRICTED OUTFLOW CHARACTERISTICS OF THE GREAT LAKES ARE HIGHLY EFFECTIVE IN PROVIDING A NATURALLY-REGULATED SYSTEM.

The vast surface areas of the Great Lakes, which are equal to about half the land areas contributing runoff to them constitute a unique feature of this waterway. Small differences in lake level, therefore, represent enormous quantities of water. Both seasonal and long-term fluctuations in the lake levels are the result of changes in lake volume.

The level of each of the Great Lakes depends on the balance between the quantity of water supplied to the lake and quantity of water removed from it. The source of supply is precipitation on any part of the basin above a lake's outlet. This reaches the lake as inflow from the lake next upstream in the series, runoff from the precipitation falling on the drainage area directly contributing to the lake, and precipitation falling

directly on the lake. Water leaves the lake by evaporation and by flow through its outlet river to the next lake in the chain or, in the case of Lake Ontario, through the St. Lawrence River to the ocean. If the quantity of water received by a lake is larger than the quantity removed, the volume of water in the lake increases, the lake level rises, and its outflow increases. The more limited the outflow capacity, the greater will be the rise in water level for a given volume of total inflow to the lake. The supply to a lake in one month has been as much as three times the volume of water that could be discharged through its outlet river during the month. The magnitudes of the lake level and outflow fluctuations which will occur in the system depend upon the magnitude of water supply change and the timing of the passage of water supply through the Great Lakes system. The variation in the supply, which is primarily the difference between precipitation on the Great Lakes and their basins and evaporation from them, is the primary cause of seasonal and long-term fluctuations. Net monthly water supplies to Lakes Michigan-Huron, for example, range from a maximum of 680,000 cfs-months to a minimum of -86,000 cfs-months. The negative value indicating that losses from evaporation and outflow exceed the supply from precipitation and inflow. However, large variations in supplies to the lakes are absorbed and modulated to such an extent that their outflows are remarkably steady in comparison with the variations in flows exhibited by other large rivers of the world.

Because of the size of the Great Lakes and the limited discharge capacities of their outflow rivers, extreme high or low levels and flows persist for some considerable time after the factors which caused them have changed or ceased. Some measure of the importance of this may be gaged from the fact that it takes three and one-half years for only 60% of the full effect of a supply change to Lakes Michigan-Huron to be realized in the outflow from Lake Ontario.

3. THE MEAN LEVELS OF THE UNREGULATED LAKES WILL CHANGE PROGRESSIVELY WITH TIME AS A RESULT OF:

   (a) THE STEADILY INCREASING CONSUMPTIVE USE OF WATER IN THE BASIN, AND
   (b) THE NEARLY IMPERCEPTIBLE MOVEMENT OF THE EARTH'S CRUST IN THE REGION OF THE GREAT LAKES BASIN.

(a) The increasing economic activity in the basin and the concomitant increase in consumptive use of the water for industrial, municipal and like uses, will gradually decrease the net supply to the lakes. Based on projected land uses, industry and power growths, and population increases, the rates of consumptive use could increase from a main total of 2,300 cfs in 1965, to 6,000 cfs in 2000 and to 13,500 cfs by 2030. The effect of this will be to decrease the mean water elevation of an unregulated lake. In the case of a regulated lake, the mean level can be maintained even with the reduced supply by changing the regulation rules. However, the effect of the reduced supply would be transmitted downstream in the form of reduced outflows from the regulated lake.

(b) The "tilting" of the earth's crust in the region is gradually raising the northeastern limits of the Great Lakes basin relative to its southwestern limits. This effect is apparent on individual lakes; for example, on Lakes Michigan-Huron, land at Milwaukee, on the southwestern shore, is subsiding with respect to land at Thessalon, on the northeastern shore, at a rate of about 1.2 feet per century. This relative movement, which is probably the rebounding of the earth's crust from the weight of ice-age glaciers, is continuing. Although it is imperceptible in a year, its cumulative effect is measurable over several decades. The net effect of the "tilting" is to gradually increase the mean water elevation of unregulated lakes. For regulated lakes, the effect can be ameliorated by adjustment of the regulation regime. Ultimately the limiting factor of such compensating adjustment is the regulation capability, including the capacity of the outflow works and channels. Crustal movement does not change the supply of water to the lakes."

TABLE C

U.S.G.S. Topographic Quadrangle Maps Used in Field Survey
(South to North)

Lake Erie

1. Oregon - 1965
2. Erie - 1967
3. Stoney Point - 1967
4. Monroe - 1967
5. Estral Beach - 1967
6. Rockwood - 1967

Detroit River

1. Rockwood - 1967
2. Wyandotte - 1967
3. Detroit - 1968
4. Belle Isle - 1968

Lake St. Clair

1. Belle Isle - 1968
2. Grosse Pointe - 1968
3. Mt. Clemens West - 1968
4. Mt. Clemens East - 1968
5. New Haven - 1968
6. New Baltimore - 1968
7. Algonac - 1968
8. St. Clair Flats - 1968
9. Marine City - 1968

St. Clair River

1. Marine City - 1968
2. St. Clair - 1968
3. Port Huron - 1968
4. Lakeport - 1961

Lake Huron - Saginaw Bay

1. Rush Lake - 1970
2. Caseville - 1970
3. Bay Port West - 1970
4. Sebewaing - 1963
5. Fish Point - 1963
6. Quanicassee - 1963
7. Essexville - 1967
8. Bay City N.E. - 1967
9. KawKawlin - 1967
10. Pinconning - 1967
11. Standish - 1967
12. Standish N.E. - 1967
13. Omer - 1968
14. AuGres - 1966

TABLE D

Counties Included in the Presidential Disaster Declarations

FLOOD
November, 1972

Arenac, Bay, Berrien, Iosco, Macomb, Monroe, St. Clair, Tuscola, Wayne.

FLOOD
March 16 to April 10, 1973

Arenac, Bay, Berrien, Huron, Iosco, Macomb, Menominee, Monroe, Saginaw, St. Clair, Sanilac, Tuscola, Van Buren, Wayne.

FLOOD
June, 1973
DENIED July 26, 1973

Monroe County — Public loss - $88,700
Private loss - $1,500,000

TABLE E

MICHIGAN FLOOD DAMAGES (Spring 1951 - Spring 1952)

Lake-River	Private Property Damage Direct	Private Property Damage Indirect		Public Property Damage Direct	Public Property Damage Indirect
Lake Erie	$2,232,080	$132,000		$ 22,000	$ 1,100
Detroit River	15,000				
Lake St. Clair	995,700	135,500		279,500	15,000
St. Clair River	460,000	7,500		13,000	5000
Lake Huron	228,500	15,100		29,400	1,700
Lake Michigan	455,000	32,000		20,000	18,000
Lake Superior			Public	150,000	
Private Sub-Totals	$4,386,380	$322,100	Sub-Totals	$513,900	$36,300

Private Total $4,708,380 Public Total $555,200 Grand Total $5,258,580

TABLE F

MICHIGAN COMMUNITIES PARTICIPATING IN THE
NATIONAL FLOOD INSURANCE PROGRAM, AUGUST 31, 1973

Redford Township
Southfield, City of
Meridian, Charter Township
Birmingham, City of
Chesterfield Township
St. Clair Shores, City of
Grosse Point Park, City of
Harrison Township
Ira Township
Algonac, City of
Farmington, City of
Clay Township
Grosse Pointe Shores, City
Monroe, City of
Dearborn Heights, City of
New Baltimore, City of
Port Huron, City of
Sterling Heights, City of
Benton Harbor, City of
Frenchtown Township
Erie Township
Luna Pier, City of
Marine City
Detroit, City of
Monroe Township
Clinton Township
East China Township
LaSalle Township
Gibralter, City of
Grosse Pointe Farms, City
Fraser, City of
Grosse Pointe, City of
Livonia, City of
Cottrellville Township
Grosse Ile Township
Inkster, City of
Troy, City of
Bridgeman, City of
Wyandotte, City of
Chikaming Township
Grand Beach, Village of
Lansing, City of
Shelby Township
Berlin Township
St. Clair Township
Dearborn, City of
Lincoln Township
Brownstown Township
Fort Gratiot Township
Allen Park, City of
Bay County, Uninc. areas
Fraser, Garfield, Gibson, Kawkawlin
Bangor Township
Bay City, City of
Essexville, City of
Frankenlust Township
Hampton Township
Merritt Township
Pinconning Township
Grandville, City of
Kentwood, City of
Estral Beach, Village of
Farmington Township
West Bloomfield Township
Grosse Pointe Woods, City
Trenton, City of
Mount Clemens, City of
Walker, City of
Warren, City of
Norton Shores, City of
St. Joseph, City of
Baldwin Township
New Buffalo, City of
Wyoming, City of
Grand Rapids, City of
Madison Heights, City of
Michiana, Village of
Shoreham, Village of
Benton Township
Hagar Township
Plainfield Township
Ann Arbor, City of
Portsmouth Township
Ferrysburg, City of
East Tawas, City of
Menominee, City of
Rockwood, City of
Sims Township
Waterford Township
Genesee Township
Southgate, City of
AuGres Township
Oscoda Township
Royalton Township
River Rouge, City of
Wisner Township
Bloomfield Township
Standish Township
Whitney Township
AuSable Township
Muskegon, City of
Spring Lake, Village of
Coloma Township
Park Township
Marysville, City of
St. Clair, City of
Genessee County, Uninc. areas
Holland, City of
Royal Oak, City of
Taketon Township
Menominee County, Uninc. areas
Saginaw Township
Delta County, Uninc. areas
Tawas, City of
Pentwater Township
Lake Township
AuGres, City of
Gladstone, City of
China Township
Ecorse, City of
Pontiac, City of
Pontiac Township
Stephenson, City of
Muskegon Township
Montague, City of
Alpena, City of
Flint, City of
Grand Haven, City of

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