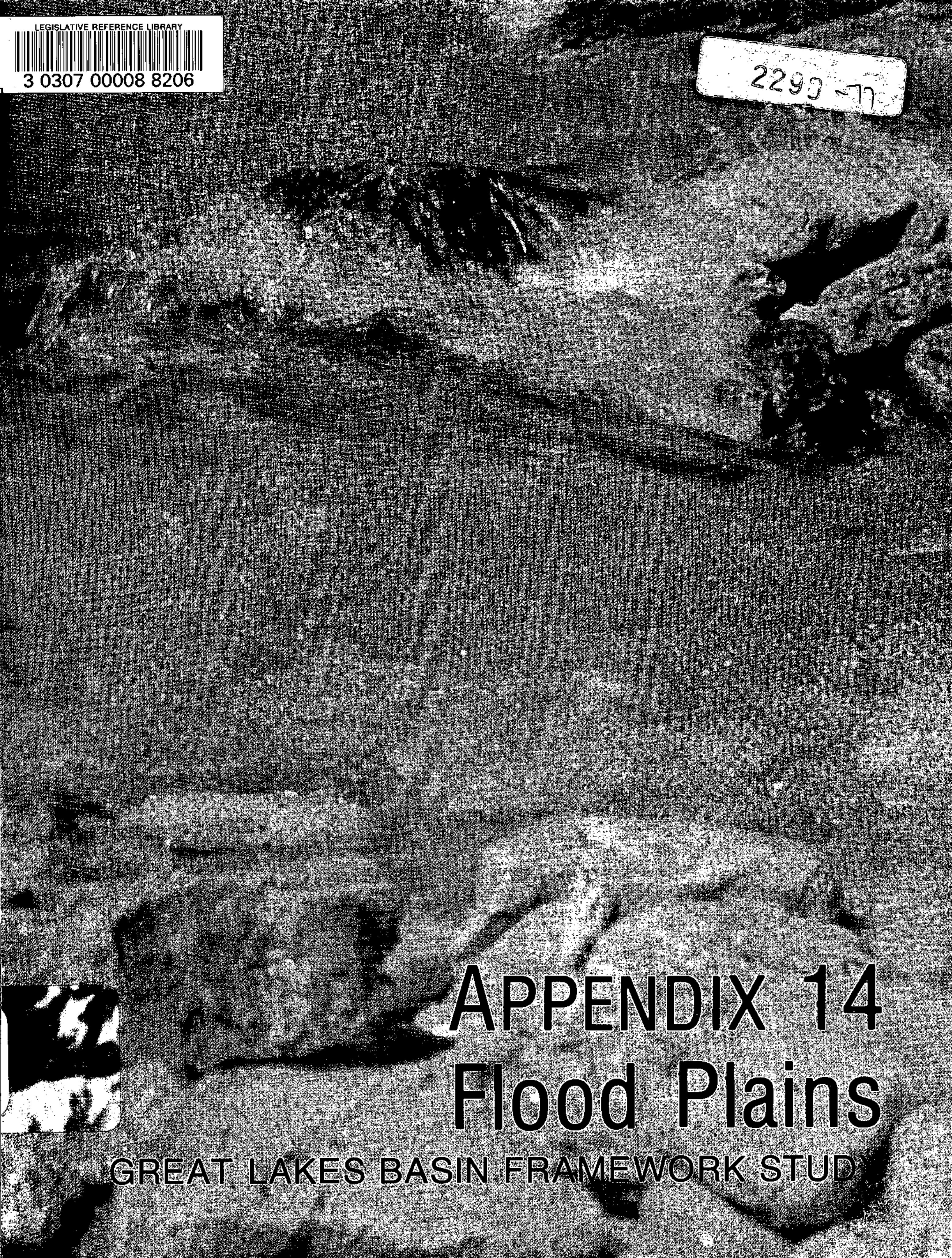

APPENDIX 14
Flood Plains

GREAT LAKES BASIN FRAMEWORK STUD

Great Lakes Basin Framework Study

APPENDIX 14

FLOOD PLAINS

GREAT LAKES BASIN COMMISSION

Prepared by Flood Plains Work Group

Sponsored by Corps of Engineers, U.S. Department of the Army

Soil Conservation Service, U.S. Department of Agriculture

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Cover photo by Kristine Moore Meves.

This appendix to the *Report* of the *Great Lakes Basin Framework Study* was prepared at field level under the auspices of the Great Lakes Basin Commission to provide data for use in the conduct of the Study and preparation of the *Report*. The conclusions and recommendations herein are those of the group preparing the appendix and not necessarily those of the Basin Commission. The recommendations of the Great Lakes Basin Commission are included in the *Report*.

OUTLINE

SYNOPSIS

This appendix is part of a coordinated interagency study to develop the water and related land resources of the Great Lakes Basin. The appendix consists of an assessment of the Basin's flood plains and associated present and future problems.

Associated drainage problems are presented in Appendix 16, *Drainage*. Shoreline flooding problems, which are not considered in this appendix, are included in Appendix 12, *Shore Use and Erosion*.

Most damaging floods in the Basin have occurred in the late winter or early spring as a result of rain and snowmelt on frozen or nearly saturated ground. Ice jams at the mouths of the rivers emptying into the major lakes often aggravate the flood situation. Intense summer storms have also created destructive floods, but these are ordinarily confined to local areas.

Despite gains in flood control measures during the past three decades, major flooding problems are increasing in urban and highly developed agricultural areas throughout the Basin. Much of the damage and personal tragedy caused by Tropical Storm Agnes, the most expensive and destructive natural disaster in the country's recorded history, which hit the Middle Atlantic States in June 1972, was a direct result of expanding development on vulnerable flood plains.

Flood damage reduction may be accomplished through control of rivers or use of flood plains. Strong efforts must be made to limit flood plain development. Where significant encroachment has already occurred, levees, dams, and other man-made devices may be used. Neither method in itself has the total answer to flood damage reduction, but both must be proportioned to reduce the economic and physical hardships inflicted by flood waters.

FOREWORD

The material used in this appendix was obtained predominantly from reports published by Federal and State agencies. The material was compiled through cooperative efforts of the Flood Plains Work Group under leadership of its cochairmen.

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Responsibility for particular river basins was delegated to the district offices of the U.S. Army Corps of Engineers and the Soil Conservation Service. These include Corps of Engineers district offices in Buffalo, Chicago, St. Paul, and Detroit, and Soil Conservation Service State offices in Indiana, Wisconsin, Minnesota, New York, Pennsylvania, Ohio, and Michigan.

Contributions to the study were made by the Division of Water, Indiana Department of Natural Resources; the Wildlife Division, the Hydrologic Survey Division, and the Recreation Resource Planning Division of the Michigan Department of Natural Resources; the Maumee Conservancy District; and the Three Rivers Watershed District of the Ohio Department of Natural Resources.

Cartographic work was prepared by the National Oceanic and Atmospheric Administration, Lake Survey Center, U.S. Department of Commerce.

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INTRODUCTION

Flood damage reduction planning is concerned with the development of comprehensive programs to encourage proper use of flood hazard areas and reduce flood damages. The objective of the work group was to make an assessment of the flood plains and their associated problems. The work includes an inventory of the flood plains to determine the amount and use, the nature and intensity of current flood problems and to predict their direction during the next fifty years.

The study encompasses the five Great Lakes, their connecting channels, the St. Lawrence River to the international boundary, and the land areas of the United States occupying the drainage basin of these waters. The Great Lakes Basin is shown in Figure 14–1.

Most of the floods in the Great Lakes Basin occur in the late winter or early spring from rainfall and snowmelt on frozen or nearly saturated ground. The flood situation at this time is often aggravated by ice jams in the channels or at the mouths of rivers emptying into the major lakes. Severe summer storms have also produced floods in the past, but damages from these floods are usually confined to tributary areas.

Both urban and agricultural damages occur, and in many areas, including the Maumee and Grand River basins, associated damage results from inadequate agricultural drainage. Also, a new type of drainage problem has materialized in recent years. Rapid urbanization in metropolitan areas has intensified storm runoff, thus overloading drainage systems that have not kept pace with growth. This has created severe damages from sewer back-up. Further flood problems could occur as a result of increased storm runoff due to shifts in land use to recreation and to poor logging practices.

The need for flood control is based on the analyses of floods, flood plain areas, and flood plain use to determine the magnitude of flood problems in the Region. Damages are categorized by the land use classifications defined in the Glossary. The physical configuration of the flood plain and its influence on the engineering feasibility of flood protection works were also taken into consideration.

A comprehensive program for flood damage reduction can involve a wide range of alternatives. These can be considered in two broad concepts: protection through control of water and prevention through control of the flood plain. The need for either flood corrective or flood preventive measures is based on the level of existing and projected flood damages. The principal function of corrective measures is to control flood waters and to reduce damages to existing development in the flood plain, while preventive measures are directed at guiding flood plain development compatible with the risk involved. This is generally accomplished by minimizing exposure to flood risk while assuring that development does not obstruct flood flows and thereby increase upstream flood damages. Both systems provide a degree of future flood damage reduction for a given flood magnitude either by reducing the flood stages and frequency, or by controlling flood plain development to minimize damage.

The output of a flood control program is measured in the reduction of flood damages, while the input requirements are defined as local protection schemes such as channel modifications, levees, reservoirs, or as institutional controls such as flood plain regulations and acquisition. A refinement of input requirements would include such items as implementation, enforcement, capital, maintenance and operation.

Many of the flood problems and their associated damages have been aggravated by uncontrolled development in the flood plains. The constant spread of urbanization can only compound a vulnerable situation unless rational planning guidelines are adopted and enforced to control continued high risk development in these natural flood plains.

Methodology

General

The level of analysis of a Type I comprehen-

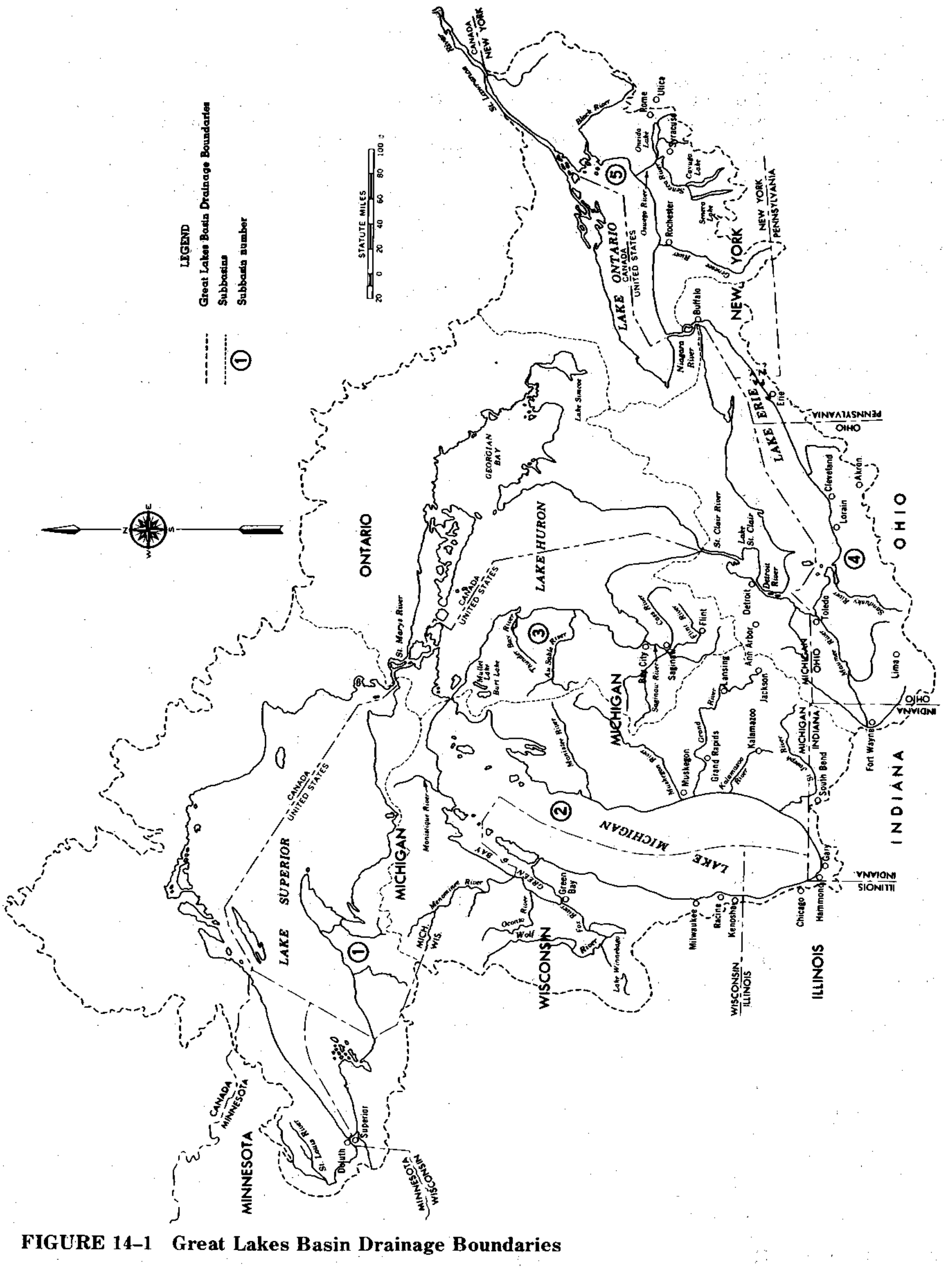


FIGURE 14–1 Great Lakes Basin Drainage Boundaries

sive study precludes a detailed study of the flood plain areas. This study is based on readily available information. Information gathered from personal contacts, as dictated by this type of study, is held to a minimum. In parts of the Basin there is little information, while in other parts a vast amount of information is available. Under these circumstances a methodology had to be developed that would use the available information to the maximum extent possible.

Geographic Study Limits

The Soil Conservation Service and the Army Corps of Engineers were responsible for guiding the efforts of the Flood Plains Work Group. To avoid duplication of work, the flood plains of the river basins within the Great Lakes Basin were divided into two areas. The division of those areas was determined by joint consideration and agreement. The main stem, principal (major) tributaries, and highly urbanized areas were the responsibility of the Corps of Engineers and the upstream watersheds were the responsibility of the Soil Conservation Service. In most instances, these upstream watersheds are about 250,000 acres or less.

Inventory Procedures

The flood plains of the main stems and principal tributaries are divided into workable reaches. A major factor that dictates the limits of a reach is available data. Because these data are usually presented on a county basis, the county line is considered a reach limit unless further defined by the physical characteristics of the flood plain.

The basis for assessing the upstream watersheds is the watershed delineation used in the Conservation Needs Inventory (CNI)—Small Projects. Unless data are available from watershed work plans or other river basin studies, the CNI information is used. This indicates the acres with a flooding problem and gives a breakdown of land use between urban and rural sectors.

Responsibilities of the work group include an investigation to determine the nature of the flood plains' land uses and general locations and intensity of problems in these flood plains. Intensity of the problem is expressed in average annual damages and land use in acres of development. These problems are designated as either urban or rural and existing or projected.

Data related to the main stem and principal tributaries are recorded on worksheets designed specifically for this study. These data have been made a permanent part of the study record for subsequent inspection. For reaches with existing data, the usable portion of this information is recorded on the work sheet. In most instances, the information must be modified in order to be in a form applicable to this study.

For reaches where required basic data are not sufficient, various methods are used to estimate land use and average annual damages. To determine flood plain land use, the natural flood plain is outlined on U.S. Geological Survey topographic maps. Because these maps are not available for all areas, other source maps must be occasionally substituted. Land use is estimated from these maps and from information found in other studies. In some instances the studies may date back twenty years and the topographic maps fifty years. In these cases the data are updated to what is considered as 1970 conditions by using aerial photographs, specific knowledge of the area, and any other data sources. Because this is a Type I framework study, new field work is minimized and maximum use is made of previous studies and surveys.

Average annual damages are computed using stage-damage, stage-discharge, discharge-frequency, and damage-frequency relationships. Total average annual damage is the area under the damage-frequency curve. A typical set of these data is presented in Figure 14–2. In case of ice jams, the stage-frequency curve is used.

In the upstream areas where CNI data are used, it is necessary to estimate a detailed division of land use, frequency of flooding, and damage values to determine average annual damages. This is done by Soil Conservation Service personnel in each of the States in the Basin. All estimates of potential flood damages are prepared for conditions and degree of development for the year 1970.

Projection Procedures

To project future flood damages, growth and development in the flood plains are evaluated on the basis of the general trend in the planning subarea where the flood plain is located. Flood damages are projected to reflect potential damages in future years, assuming exist-

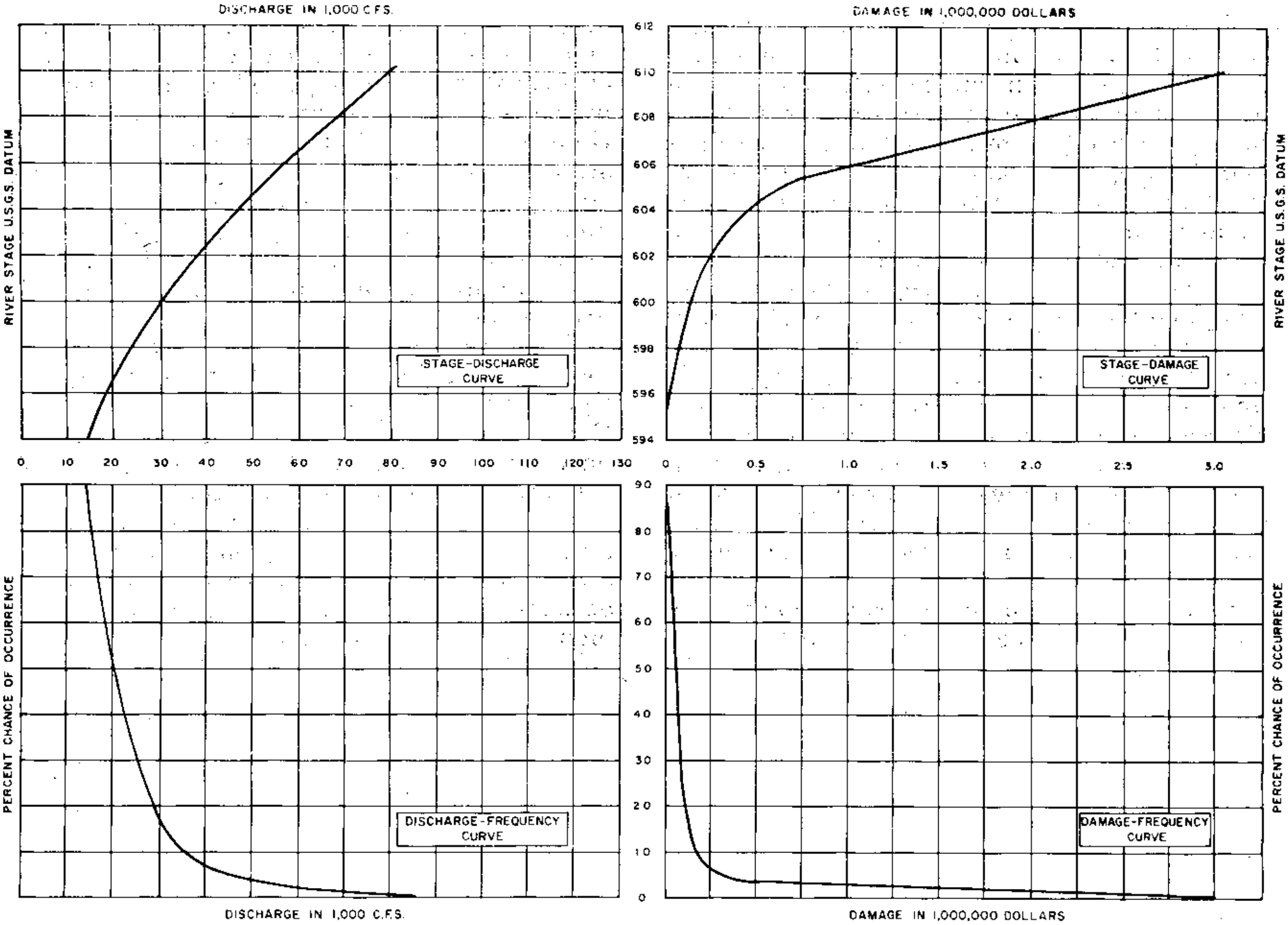


FIGURE 14-2 Stage, Damage, Discharge, and Frequency Relationships

ing flood protection remains the same, and the flood risk factor is unchanged. The historical projection base is the dollar value and conditions existing in 1970.

Indexes of change for total population, total personal income and per capita income provided by the Economic and Demographic Work Group are used to develop a range of indexes for the years 1980, 2000, and 2020. The range of indexes and general knowledge of the study area are used to project future flood damages and the growth and development in the flood plain areas. Effects of flood plain management legislation are not considered in projecting damages from the base year. However, subsequent analysis of flood damage reduction alternatives in the Summary includes estimates of the potential effects of this flood plain management legislation.

Problem Analysis Procedures

Single-purpose flood damage reduction measures for the time periods designated as immediate (before 1980), short term (1980–2000), and long term (after 2000) are evaluated for each region where damages are significant. These reduction measures are considered in two broad concepts: protection through control of water (structural measures), and prevention through control of the flood plain (nonstructural measures). Channel diversion, channel modification levees, floodwalls, and flood control reservoirs are considered structural measures. Some of the nonstructural measures are building codes, public education, flood plain regulation through acquisition and zoning, subdivision regulations, flood insurance, flood warning systems, and evacuation or relocation.

Detailed studies to determine which of the damage reduction measures would best satisfy the conditions of each of the damage centers were not conducted. For the immediate time period damages to existing development in the flood plain can best be reduced by structural measures. Also, it is assumed that for this same time period nonstructural measures cannot be fully implemented except where existing legislation will permit and enforcement is adequate. Therefore, structural measures are recommended to reduce damages for major damage centers. For the short-term and long-term time periods, nonstructural measures are generally recommended. In these instances, it is assumed that there are adequate areas nearby suitable for development as an alternative to flood plain use.

Alternative damage reduction measures are selected on the basis of urgency of the problem, physical characteristics of the stream and surrounding terrain, intensity of existing flood plain development, needs of the area, previous studies, and general knowledge of the damage center locations. From these alternatives, a damage reduction scheme is recommended.

Estimated costs of structural measures are based on experience and cost records of similar projects of comparable size. Cost estimates of nonstructural schemes are considered as costs that would be required to implement the measures. No attempt is made to compute them at this time, but it is recommended that studies be conducted to determine the costs of such programs. Cost estimates for structural measures include appropriate contingencies (engineering and design, supervision costs and administration) and are based on 1970 price levels.

Estimated benefits of nonstructural measures are considered equivalent to the damages resulting if no preventive action is taken. Estimated benefits of structural measures, based on experience and previous reports, are considered to be 95 percent of the urban and 85 percent of the rural damages that would result if no preventive action is taken. Vast additional cost required to fully protect a damage center through the use of structural measures is not justified.

Section 1

FLOOD PLAINS INVENTORY

1.1 General Description of Great Lakes Basin

The Great Lakes Basin poses a wide variety of water and related land problems. The Basin is dominated by the five Great Lakes, relatively small tributary basins, and by the existence of a number of great metropolitan centers which exert primary economic influence and control over the Basin. The Great Lakes are of enormous value as a source of water supply for municipal and industrial consumption.

The Basin is defined as the drainage areas of Lake Superior, Lake Michigan, Lake Huron, Lake Erie, Lake Ontario, and those streams entering the St. Lawrence River within the United States. For the purpose of this study, the five Lake basins have been assigned numbers (Figure 14-1). The system of the Great Lakes extends more than 2,000 miles and has a water surface area of 95,000 square miles, of which 64 percent is in the United States. The United States portion includes a land area of 118,000 square miles and a water area of 61,000 square miles. Drainage areas in the United States portion range from 6,600 square miles for the Maumee River in Ohio and 6,300 square miles for the Saginaw River in Michigan to minor streams of a few square miles flowing directly into the major lakes.

The Great Lakes Basin was scoured and formed by glaciation. Therefore, its physical features and hydrology differ greatly from those of regions not glaciated. Furthermore, its construction was but recently completed in terms of earth history, and the processes of stream and shoreline erosion have made only slight changes in the original postglacial topography. In general the tributary relief varies through a narrow range: major stream profiles are relatively flat, and tributary surface drainage systems are still rudimentary. The few tributary valleys are not well-developed, and they usually follow the lows of the glaciated topography. The divides separating basins are characteristically broad and vary from almost level plains to rolling low hills, except in minor areas at the east and west ends of the Great Lakes Basin. Therefore, overall topography favors infiltration over direct rapid surface runoff. Infiltration is also aided because a great portion of the subsurface material consists of sand and gravel.

Initially, flood plain settlement followed the need for water transportation. The major tributaries provided low-cost water transportation for timber and agricultural products, and so the early rail and road systems paralleled these stream networks. Many of the present urban centers had their beginnings along some type of waterway. Early commercial and industrial sectors were also concentrated along the major waterways. Although the advantages of such locations have faded with technology, the flood hazards they created still persist.

Flooding may occur at any time, but throughout the Great Lakes Region, major floods and most damaging floods are usually the result of rain and snowmelt on frozen or nearly saturated ground. Intense summer storms have created destructive floods, but these are ordinarily confined to local areas. The tributary flood problems in the Basin, while serious, are local problems. The reservoirs, levees, or channel improvements, which reduce flood damages on these tributaries, have little measurable effect on the flow regimen in the Great Lakes system. Many local flood protection schemes have been proposed through the years, but few have reached fruition, and the pressure for flood relief usually diminishes with the passage of time. The only proposals of a Basinwide nature have been the recommendations for controlling the levels of the Great Lakes at the outlets of the connecting channels.

Because flood plains are often agriculturally very productive, there is a continuous program to protect and enhance this resource through the programs of the Soil Conservation Service. Erosion control, improved drainage facilities, and water storage reservoirs are some of the ongoing projects under P.L. 566

being expanded in the upstream watersheds of the Great Lakes.

Solutions to flood problems in the upstream watersheds usually consist of channel improvement in the broader flood plains because discharge control sites are not available due to the topography. Even in the steeper areas, control structures cannot always be justified because the narrow flood plains do not produce sufficient benefits.

For the purpose of data collection, study, and reporting, each of the five major Lake basins is divided into river basin groups or complexes and then into individual river basins within these river basin groups. The river basin groups and complexes are shown in Figures 14–3 through 14–7.

1.2 Lake Superior West, River Basin Group 1.1

1.2.1 Description

River Basin Group 1.1 drains an area of approximately 9,230 square miles. Of this area, 6,142 square miles are in Minnesota, 2,956 square miles are in Wisconsin, and 132 square miles are in Michigan. A basin map and a vicinity map are shown in Figure 14–8. The basin is characterized by numerous swamps and lakes, particularly in the headwater regions. Elevations range from 1,800 feet above sea level in the headwaters section to 600 feet above sea level at Lake Superior. The tributaries and the main stems follow a rocky course, characterized by chutes, falls, and rapids.

1.2.2 Previous Studies

Corps of Engineers studies include the Bad River at Mellen and Odanah, Wisconsin; the Montreal River at Hurley, Wisconsin, and Ironwood, Michigan; the St. Louis River in Minnesota and Wisconsin; and Ball Park Creek at Bayfield, Wisconsin. Of the six studies listed in Table 14–1, three are congressional project documents and three are flood control project reports.

Listed below are additional completed studies:

(1) Nemadji River Erosion and Sedimentation Control Project prepared by the Carlton County, Minnesota, and Douglas County, Wisconsin, Soil and Water Conservation Districts, January 1971

(2) Geological Survey flood-prone area reports for portions of the Nemadji, Black, Amnicon, White, Montreal, Potato, and Bad Rivers and North and South Fish Creeks, 1971

(3) Preliminary Report, Bayfield Cemetery Ravine Watershed, Bayfield County, Wisconsin, prepared by the Soil Conservation Service, August 1970

(4) Feasibility study report, East Branch Montreal River Watershed, Iron County, Wisconsin, and Gogebic County, Michigan, prepared by the Soil Conservation Board, July 1969.

1.2.2 Development in the Flood Plain

The dominant economic factor in the basin is ore mining. Other important industries scattered throughout the area include commercial fishing, fruit growing, and tourist activity. Logging was at one time the major economic activity, but inadequate conservation practices have all but eliminated this activity. Agriculture is practiced only on a limited basis within the region. This is due to the severe climate, the predominance of poorer quality soils, and adverse topographic conditions. Present agricultural practices are generally limited to dairy farming and small grain production.

Although relatively poor industrially and agriculturally, the land is interconnected by an extensive highway and railway network. Towns serviced by this transportation system are small, due to the lack of industry and agriculture. Complementing the road and rail travel network are well developed commercial and recreational harbors on Lake Superior. Navigation upstream on the rivers is hampered by numerous chutes, falls, rapids, and tortuous courses.

Dams have been located on the main stems and tributaries in the basin. These dams are normally very small and are actively used only for the protection of flood plains against excessive floods. Some of the dams produce hydroelectric power. However, the dams have a reduced storage capacity due to the steep slope of the rivers and the deposit of sand and gravel behind the dam structure.

1.2.4 Flood Problems

Most of the floods in the basin occur in the summer, due to intense summer precipitation. Less frequent spring floods develop from early

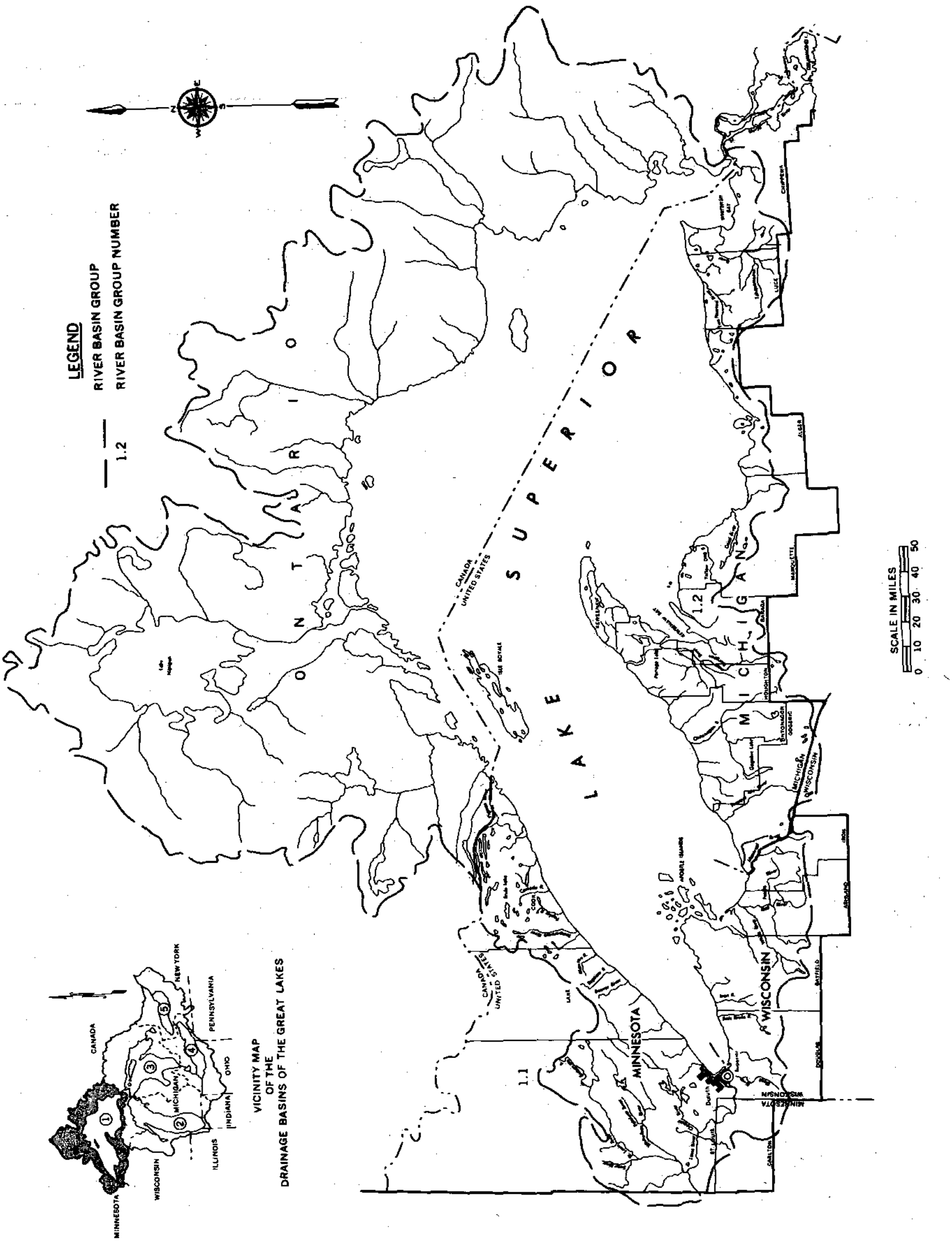


FIGURE 14–3 Lake Superior Basin

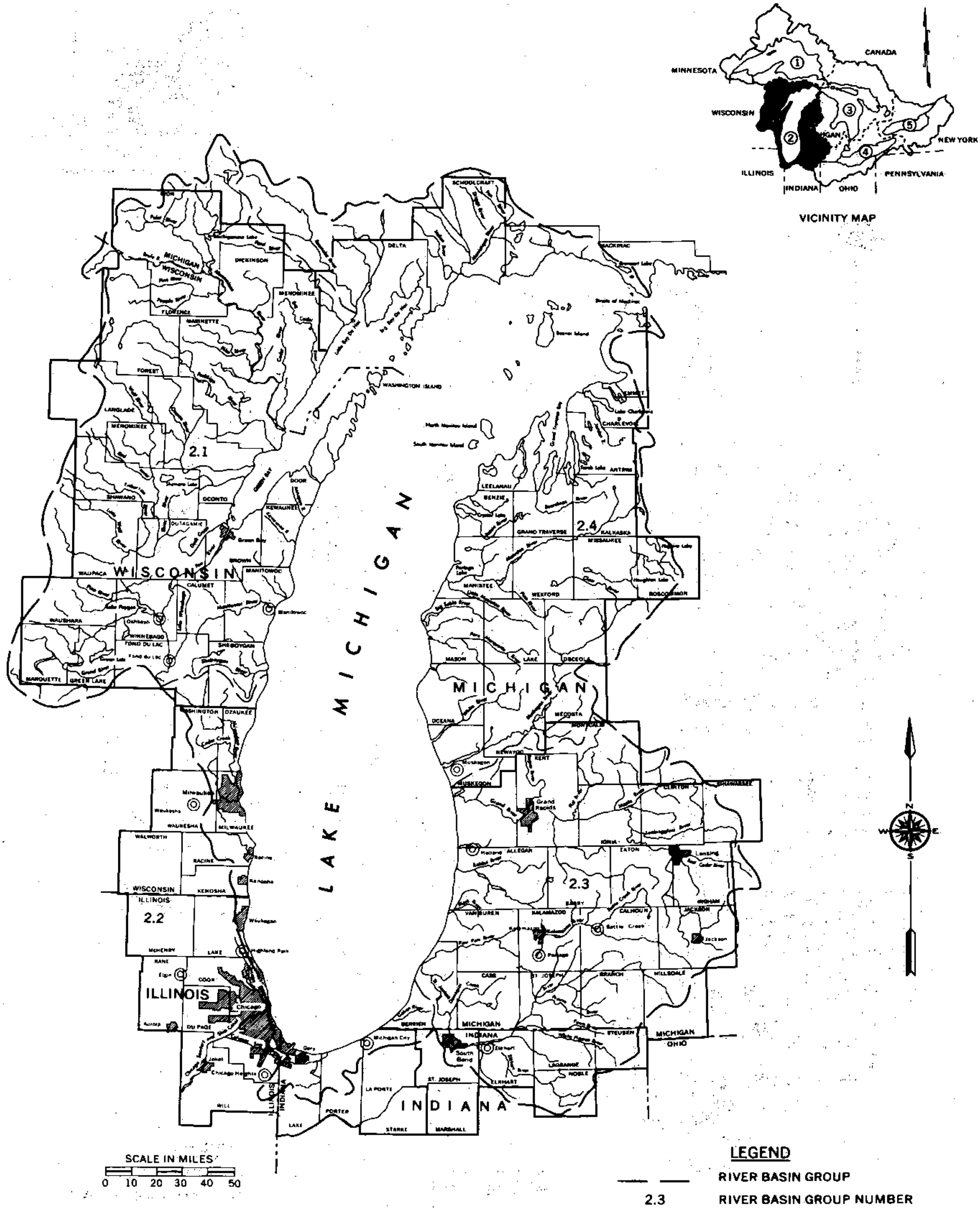


FIGURE 14-4 Lake Michigan Basin

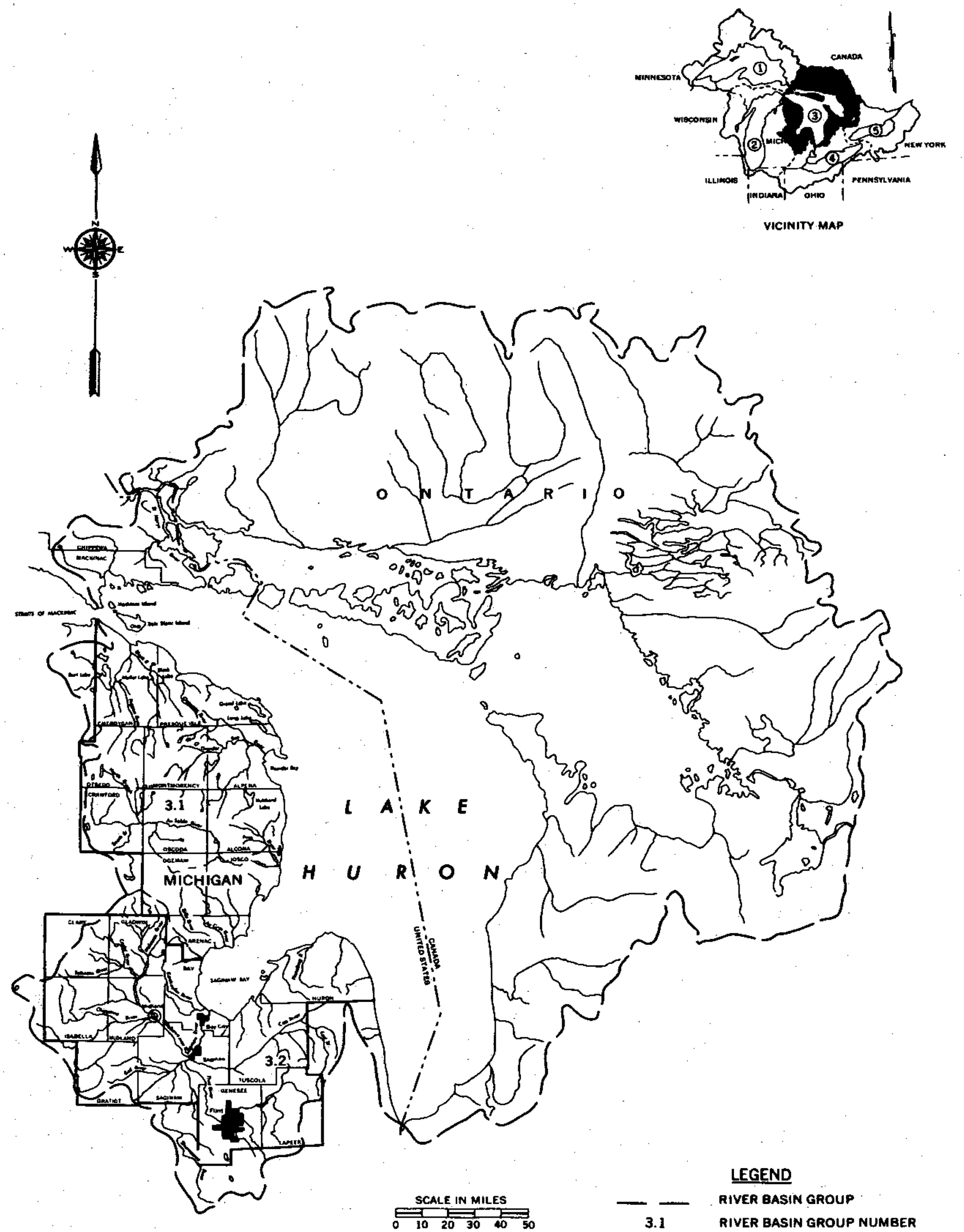
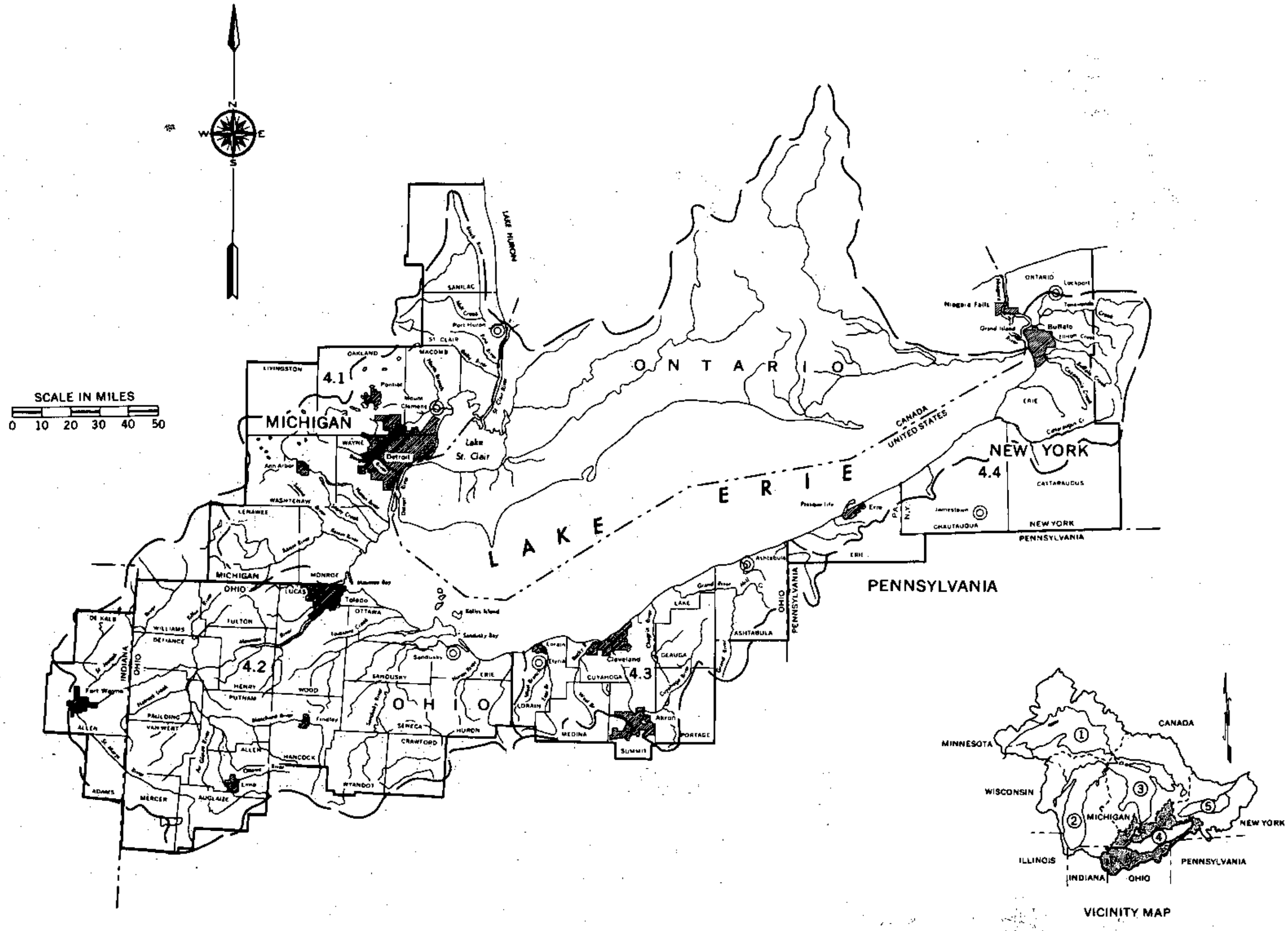


FIGURE 14–5 Lake Huron Basin



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— — RIVER BASIN GROUP

4.2 RIVER BASIN GROUP NUMBER

FIGURE 14–6 Lake Erie Basin

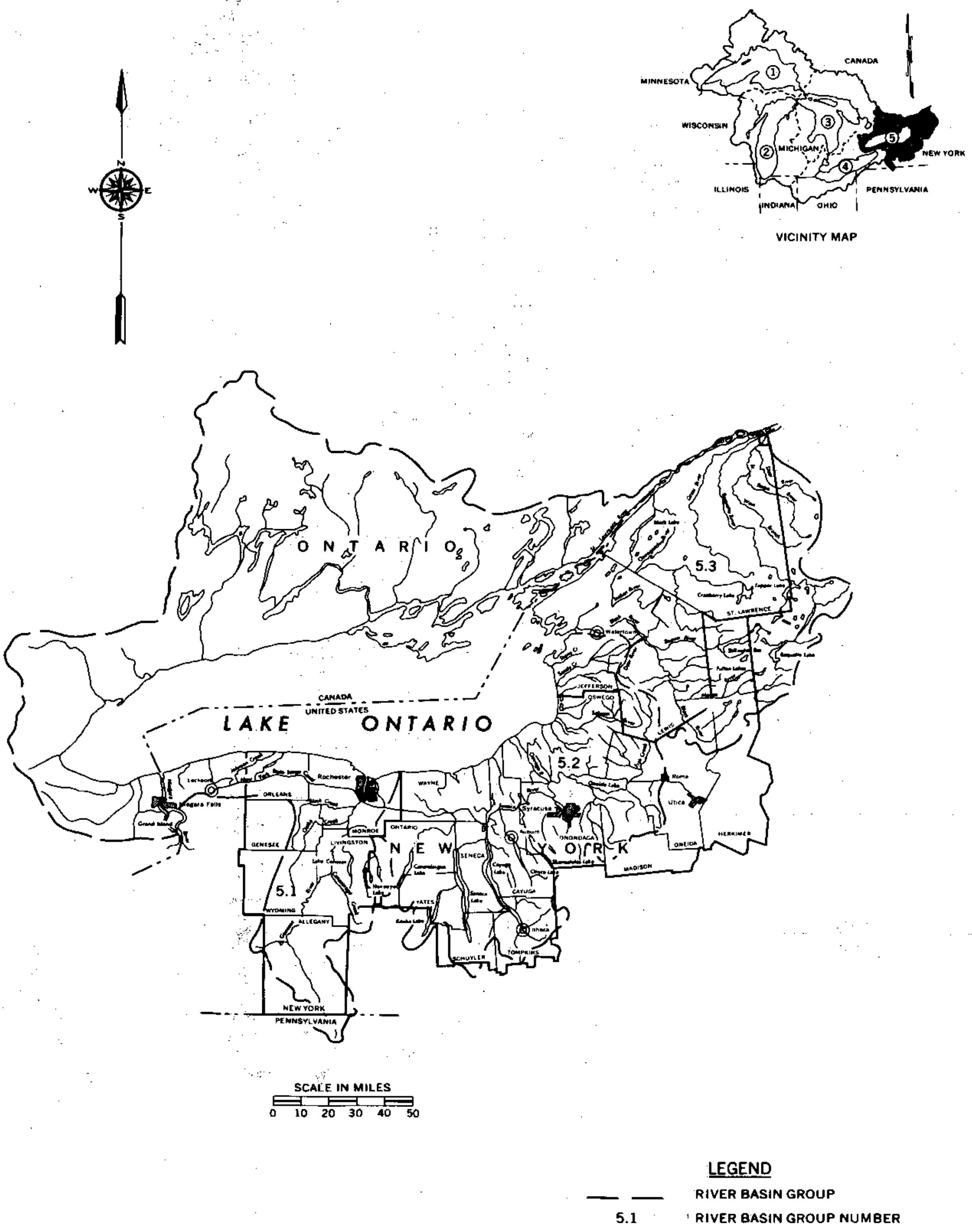

FIGURE 14–7 Lake Ontario Basin

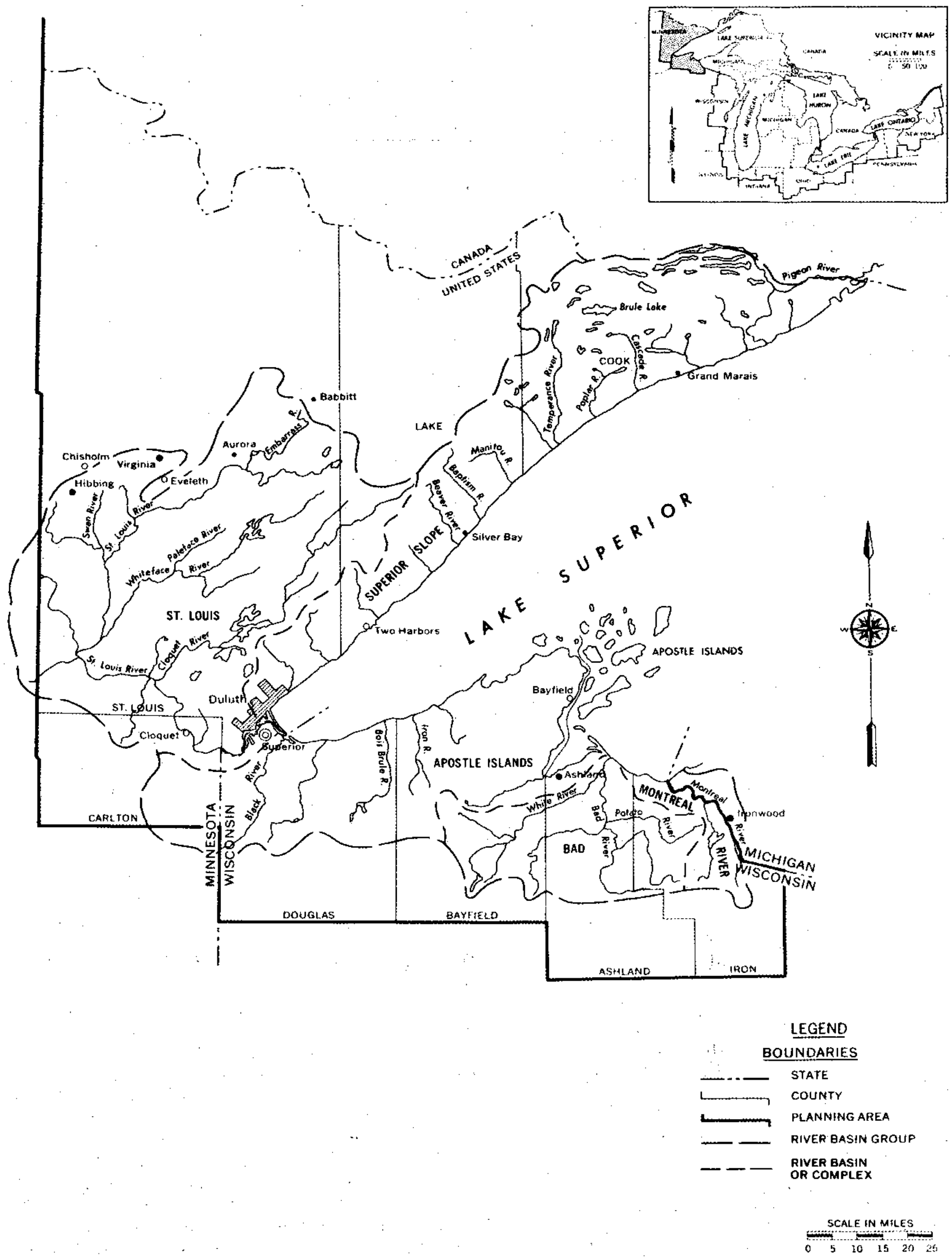

FIGURE 14–8 Lake Superior West—River Basin Group 1.1

TABLE 14–1 Lake Superior West—Previous Studies

Name	River	City	Congress	Date
Report on Economics of Flood Control Project on Bad River at Odanah	Bad River	Odanah, Wis.		12 Feb 60
Report on Economics of Flood Control Project on Bad River at Mellen	Bad River	Mellen, Wis.		5 Feb 60
Bad River at Mellen and Odanah	Bad River	Mellen, Wis. & Odanah, Wis.	H Doc. No. 165 84th Cong.	17 May 55
Small Flood Project	Ball Park Creek	Bayfield, Wis.		22 Jun 53
Report on Montreal River	Montreal River	Wis. & Mich.	H. Doc. No. 89, 73rd Cong	10 Jun 33
Improvement of St. Louis River	St. Louis River	Minn. & Wis.	H. Doc. No. 95, 73rd Cong.	10 Jun 33

spring rains which produce much snowmelt and large ice jams in the main stems. Maximum discharges vary from 3,000 to 10,000 cubic feet per second (cfs) depending upon the size of the drainage area and capacity of the stream. Major floods of record in the basin occurred in July 1942, June 1946, April 1950, June 1958, and August 1960. The major reasons for flooding are the inability of the streams to carry large flows, the relative flatness of the surrounding areas, and the presence of both natural and man-made stream restrictions.

Table 14–2 lists flood damage centers located in the basin. Figure 14–9c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–3 depicts the flood plain damages by reach corresponding to the reaches designated on this figure. Table 14–4 depicts upstream flood damages. These damages are referenced to the watersheds identified in Figure 14–10c. Summations of estimated annual damages and acres in the flood plain are shown by river basin in Table 14–5. County summaries for the main stem and principal tributaries are tabulated in Table 14–6.

1.2.5 Existing Flood Damage Prevention Measures

There are two existing structural flood control projects in the basin. One is a Federal project constructed by the Army Corps of Engineers in 1954 on Ball Park Creek at Bayfield, Wisconsin. It consists of a reinforced concrete inlet structure with retaining walls, cutoff walls, and dikes. Also, there is a multiplate pipe arch steel culvert and a concrete flume with a reinforced concrete outfall structure at the shoreline of Lake Superior. In addition, two debris barriers were constructed upstream from the inlet structure. The second is a project constructed by the State of Minnesota on Mission Creek at Fond du Lac. It consists of a debris catcher approximately one mile upstream from the city bridge. The location of these preventive measures is illustrated in Figure 14–11. No other flood control projects of consequence have been constructed.

TABLE 14-2 Lake Superior West—Flood Damage Centers

Damage Center	Flood Year	Type Damage	River
Hurley Wis. and Ironwood, Mich.	1960	Residential Commercial Agricultural	Montreal River
	1952	Residential Commercial Agricultural	Montreal River
	1946	Residential Commercial Agricultural	Montreal River
	1942	Residential Commercial Agricultural	Montreal River
Mellen, Wis.	1960	Residential Commercial Agricultural	Bad River
	1949	Residential Commercial Agricultural	Bad River
	1946	Residential Commercial Agricultural	Bad River
	1941	Residential Commercial Agricultural	Bad River
Odanah, Wis.	1960	Residential Commercial Agricultural	Bad River
	1949	Residential Commercial Agricultural	Bad River
	1946	Residential Commercial Agricultural	Bad River
	1941	Residential Commercial Agricultural	Bad River
Bayfield, Wis.	1960	Residential Commercial	Ball Park Creek
	1953	Residential Commercial	Ball Park Creek
	1951	Residential Commerical	Ball Park Creek
	1946	Residential Commercial	Ball Park Creek
	1942	Residential Commercial	Ball Park Creek
Fond du Lac, Minn.	1969	Residential	Mission Creek
	1960	Residential	Mission Creek
	1958	Residential	Mission Creek
	1950	Residential	Mission Creek
	1909	Residential	Mission Creek
Floodwood, Minn.	1960	Residential Commercial Agricultural	St. Louis River
	1950	Residential Commercial Agricultural	St. Louis River
	1948	Residential Commercial Agricultural	St. Louis River

Nonstructural preventive measures fall into two basic categories: advanced warning and flood plain regulation. Advanced warning is a responsibility of the National Weather Service and consists of the issuance of a forecast of the possible occurrence of a flood disaster. The extent and severity of floods depend directly on the amount and occurrence of precipitation. Rainfall is forecast for the States of Wisconsin and Michigan by the Weather Service in Chicago and for the State of Minnesota by the Kansas City Weather Service. Characteristics furnished by the forecast include the time of occurrence (24-hour period), area distribution (by sectional classification), and a general statement as to the amount of rainfall expected. Rainfall forecasts are not presently used in flood forecasting. Flood forecasts are presently based on existing conditions. The responsibility to warn or alert the Federal, military, and civilian authorities, State and local officials, and the civilian population of flood forecasts is the duty of the Defense Civil Preparedness Agency.

The second category, flood plain information and regulation, can be used to guide and control developments in flood hazard areas through flood data and sound flood regulations, thereby preventing an increase in flood damage. Such controls have been adopted by many communities and have been accepted as a practical way to assure safe development and to prevent flood disasters. Some State laws provide local governments with the authority to regulate development in flood plain areas. The adoption of local flood plain regulations would permit the use of these areas for facilities having a low flood damage potential and not significantly obstructing flood flows. A more detailed discussion of flood plain legislation is contained in Appendix S20, *State Laws, Policies, and Institutional Arrangements*.

1.3 Lake Superior East, River Basin Group 1.2

1.3.1 Description

River Basin Group 1.2 occupies approximately 7,756 square miles, including 7,664 square miles in Michigan and 92 square miles in Wisconsin. A basin map and a vicinity map are shown in Figure 14-12. The basin is characterized by numerous swamps and lakes and for the most part is covered by forest. Elevations range from 1,980 feet above sea level in the highlands to 600 feet above sea level at Lake Superior. The rivers and streams in passing from the highlands to the Lake are generally characterized by their rocky courses, steep gradients, falls, and rapids.

1.3.2 Previous Studies

Previous Corps of Engineers studies include flood control reconnaissance studies on the Ontonagon River at Ontonagon, Michigan, and on the Presque Isle River at Marenisco, Michigan; a survey scope study of flood problems along the lower 33 miles of the Sturgeon River; and field reconnaissance reports of flood problems on Linden Creek at L'Anse,

TABLE 14–3 Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 1.1

REACH CODE	COUNTY	REACH LOCATION		YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)		ESTIMATED ACRES IN FLOOD PLAIN						REMARKS
		FROM	TO		URBAN	RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	
	ST. LOUIS RIVER												
B1	St. Louis	T48N R15WS8	T49N R15WS5	1970	9,000			25		5	30		Fond Du Lac
				1980	11,000			25		5	30		Same
				2000	16,000			25		5	30		Same
				2020	24,000			25		5	30		Same
B2	St.Louis	T51N R20WS8	T52N R20WS32	1970	70,000		10	40		3440	90	3400	Floodwood
				1980	91,000		10	40		3440	90	3400	Same
				2000	155,000		10	40		3440	90	3400	Same
				2020	260,000		10	40		3440	90	3400	Same
C1	BALL PARK CREEK												
	Bayfield	T50N R4WS11	T50N R4WS13	1970	87,000		10	4		4	18		Bayfield
				1980	113,000		10	4		4	18		Same
				2000	186,000		10	4		4	18		Same
				2020	313,000		10	4		4	18		Same
D1	BAD RIVER												
	Ashland	T48N R3W S26	T48N R3W S36	1970	69,000	2,000	10	130		1430	370	1200	Onadah
				1980	78,000	3,000	10	130		1430	370	1200	Same
				2000	96,000	4,000	10	130		1430	370	1200	Same
				2020	141,000	5,000	10	130		1430	370	1200	Same
D2	Ashland	T45N R2WS32	T44N R2WS6	1970	28,000	3,000	2	14		222	191	47	Mellen
				1980	35,000	3,000	2	14		222	191	47	Same
				2000	55,000	6,000	2	14		222	191	47	Same
				2020	84,000	6,000	2	14		222	191	47	Same
E1	MONTREAL RIVER												
	Iron	T48N R2ES8	T46N R3E S30	1970	35,000		30	60		445	235	300	Hurley, Ironwood
				1980	41,000		30	60		445	235	300	Same
				2000	57,000		30	60		445	235	300	Same
				2020	82,000		30	60		445	235	300	Same

Michigan, and on the Au Train River at Au Train, Michigan. These studies are listed in Table 14–7.

1.3.3 Development in the Flood Plain

The dominant economic factor in the basin is ore mining. Other important industries scattered throughout the area include commercial fishing, fruit growing, and tourist activity. Logging was at one time the major economic activity, but inadequate conservation practices have all but eliminated this activity. Agriculture is practiced only on a limited basis within the region. This is due to the severe climate, the predominance of poorer quality soils, and adverse topographic conditions. Present agricultural practices are generally limited to dairy farming and small grain production.

Although relatively poor industrially and agriculturally, the land is interconnected by an extensive highway and railway network. Towns serviced by this transportation system are small due to the lack of industry and agriculture. Complementing the road and rail travel network are well developed commercial and recreational harbors on Lake Superior. Navigation upstream on the rivers is hampered by numerous chutes, falls, rapids, and tortuous courses.

There are a few dams present on the main stems and tributaries in the basin. These dams are generally of small capacity and are used for hydroelectric power generation and conservation purposes. The dams on the Ontonagon and Sturgeon Rivers have a limited flood storage capacity but are operated during spring flood periods to reduce downstream stages.

1.3.4 Flood Problems

Major floods in the basin have usually oc-

TABLE 14-4 Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 1.1

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)			ESTIMATED ACRES IN FLOOD PLAIN								
		URBAN	RURAL	TOTAL	CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		APOSTLE ISLANDS COMPLEX - MINNESOTA											
627	1970	--	2,100	2,100	250	1,500	3,450	--	--	--	--	--	5,200
628	1970	--	1,100	1,100	175	700	1,725	--	--	--	--	--	2,600
629	1970	--	800	800	100	500	400	--	--	--	--	--	1,000
Total	1970	--	4,000	4,000	525	2,700	5,575	--	--	--	--	--	8,800
	1980	--	5,100	5,100	525	2,700	5,575	--	--	--	--	--	8,800
	2000	--	8,700	8,700	525	2,700	5,575	--	--	--	--	--	8,800
	2020	--	15,300	15,300	525	2,700	5,575	--	--	--	--	--	8,800
		ST. LOUIS RIVER - MINNESOTA											
6D01	1970	--	300	300	--	300	100	200	--	--	--	--	600
6D03	1970	--	300	300	--	300	--	100	--	--	--	--	400
6D04	1970	--	300	300	--	300	--	100	--	--	--	--	400
6D05	1970	--	300	300	--	300	--	100	--	--	--	--	400
6D06	1970	--	7,300	7,300	100	7,000	7,500	400	--	--	--	--	15,000
6D07	1970	--	200	200	--	200	--	--	--	--	--	--	200
6D11	1970	--	500	500	--	500	400	100	--	--	--	--	1,000
6D13	1970	--	10,300	10,300	100	10,000	2,900	2,000	--	--	--	--	15,000
6D14	1970	--	1,000	1,000	45	900	1,700	200	--	--	--	--	2,845
6D15	1970	--	9,300	9,300	915	7,000	12,500	4,500	--	--	--	--	24,915
6D16	1970	--	3,800	3,800	712	2,000	15,400	3,100	--	--	--	--	21,212
6D18	1970	--	5,800	5,800	500	1,800	3,800	--	--	--	--	--	6,100
6D19	1970	--	1,000	1,000	200	550	1,250	150	--	--	--	--	2,150
6D20	1970	--	500	500	--	500	500	200	--	--	--	--	1,200
6D21	1970	--	1,600	1,600	600	410	490	--	--	--	--	--	1,500
6DI01	1970	--	900	900	--	800	600	100	--	--	--	--	1,500
6DI04	1970	--	500	500	--	500	2,000	500	--	--	--	--	3,000
Total	1970	--	43,900	43,900	3,172	33,360	49,140	11,750	--	--	--	--	97,422
	1980	--	56,200	56,200	3,172	33,360	49,140	11,750	--	--	--	--	97,422
	2000	--	95,700	95,700	3,172	33,360	49,140	11,750	--	--	--	--	97,422
	2020	--	167,700	167,700	3,172	33,360	49,140	11,750	--	--	--	--	97,422
		SUPERIOR SLOPE COMPLEX - MINNESOTA											
61	1970	--	100	100	50	100	50	200	--	--	--	--	400
62	1970	--	500	500	100	200	150	50	--	--	--	--	500
63	1970	--	300	300	50	130	100	20	--	--	--	--	300
66	1970	--	300	300	30	200	170	100	--	--	--	--	500
67	1970	--	300	300	50	200	700	50	--	--	--	--	1,000
Total	1970	--	1,500	1,500	280	830	1,170	420	--	--	--	--	2,700
	1980	--	1,900	1,900	280	830	1,170	420	--	--	--	--	2,700
	2000	--	3,300	3,300	280	830	1,170	420	--	--	--	--	2,700
	2020	--	5,700	5,700	280	830	1,170	420	--	--	--	--	2,700
		BAD RIVER - WISCONSIN											
6C1	1970	2,500	--	2,500	200	100	3,700	300	20	20	--	40	4,300
6C5	1970	900	--	900	--	--	--	--	--	8	2	10	--
Total	1970	3,400	--	3,400	200	100	3,700	300	20	28	2	50	4,300
	1980	6,000	--	6,000	200	100	3,700	300	20	28	2	50	4,300
	2000	6,800	--	6,800	200	100	3,700	300	20	28	2	50	4,300
	2020	7,500	--	7,500	200	100	3,700	300	20	28	2	50	4,300
		LAKE SUPERIOR SHORELINE - WISCONSIN											
61A	1970	1,000	--	1,000	300	200	6,450	350	--	3	2	5	7,300
66A	1970	9,500	--	9,500	300	150	4,050	300	2	2	--	4	4,800
67A	1970	2,500	--	2,500	--	--	--	--	5	5	--	10	--
69A	1970	900	--	900	150	50	1,250	150	--	--	5	5	1,600
611A	1970	5,500	--	5,500	--	--	--	--	25	25	--	50	--
Total	1970	19,400	--	19,400	750	400	11,750	800	32	35	7	74	13,700
	1980	34,500	--	34,500	750	400	11,750	800	32	35	7	74	13,700
	2000	38,600	--	38,600	750	400	11,750	800	32	35	7	74	13,700
	2020	43,000	--	43,000	750	400	11,750	800	32	35	7	74	13,700

TABLE 14-5 Data Summary by River Basin, River Basin Group 1.1

River Basin	Year	Estimated Average Annual Damage (Dollars)		Estimated Acres In Flood Plain	
		Urban	Rural	Urban	Rural
St. Louis River	1970	79,000	43,900	120	100,822
	1980	102,000	56,200	120	100,822
	2000	171,000	95,700	120	100,822
	2020	284,000	167,700	120	100,822
Apostle Island Complex	1970	87,000	4,000	18	8,800
	1980	113,000	5,100	18	8,800
	2000	186,000	8,700	18	8,800
	2020	313,000	15,300	18	8,800
Bad River	1970	100,400	5,000	611	5,547
	1980	119,000	6,000	611	5,547
	2000	157,800	10,000	611	5,547
	2020	232,500	11,000	611	5,547
Montreal River Complex	1970	35,000	-	235	300
	1980	41,000	-	235	300
	2000	57,000	-	235	300
	2020	82,000	-	235	300
Superior Slope Complex	1970	19,400	1,500	74	16,400
	1980	34,500	1,900	74	16,400
	2000	38,600	3,300	74	16,400
	2020	43,000	5,700	74	16,400
TOTAL	1970	320,800	54,400	1,058	131,869
	1980	409,500	69,200	1,058	131,869
	2000	610,400	117,700	1,058	131,869
	2020	954,500	199,700	1,058	131,869

curred as a result of early spring rains and snowmelt runoff, complicated by ice jams at the river mouths associated with Lake Superior shore ice accumulation. There is also occasional flooding from intense summer rain storms. Maximum discharges vary from 3,000 to 15,000 cubic feet per second (cfs) depending upon the size of the drainage area and capacity of the stream. Major floods of record in the basin occurred during March 1912, April 1952, April 1960, April 1963, and June 1968. The major reasons for flooding are the inability of the low banks of the flat flood plains in the lowermost river reaches to contain the flood flow, and the windblown ice jams at the mouths of the rivers that enter Lake Superior.

Table 14-8 lists flood damage centers located in the basin. Figure 14-13c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14-9 shows the flood plain damages by reach corresponding to the reaches designated on this figure. Table 14-10 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14-14c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14-11. County summaries for the main stem and principal tributaries are tabulated in Table 14-12.

TABLE 14–6 River Basin Group 1.1, Data Summary by County

County	Estimated Average Annual Damages (Dollars) Urban	Rural	Estimated Acres in Flood Plain Urban	Rural
YEAR 1970				
Minnesota				
St. Louis	79,000	---	120	3,400
Wisconsin				
Bayfield	87,000	---	18	---
Ashland	97,000	5,000	561	1,247
Iron	35,000	---	235	300
TOTALS	298,000	5,000	934	4,947
YEAR 1980				
Minnesota				
St. Louis	102,000	---	120	3,400
Wisconsin				
Bayfield	113,000	---	18	---
Ashland	113,000	6,000	561	1,247
Iron	41,000	---	235	300
TOTALS	369,000	6,000	934	4,947
YEAR 2000				
Minnesota				
St. Louis	171,000	---	120	3,400
Wisconsin				
Bayfield	186,000	---	18	---
Ashland	151,000	10,000	561	1,247
Iron	57,000	---	235	300
TOTALS	565,000	10,000	934	4,947
YEAR 2020				
Minnesota				
St. Louis	284,000	---	120	3,400
Wisconsin				
Bayfield	313,000	---	18	---
Ashland	225,000	11,000	561	1,247
Iron	82,000	---	235	300
TOTALS	904,000	11,000	934	4,947

* On main stem and principal tributaries

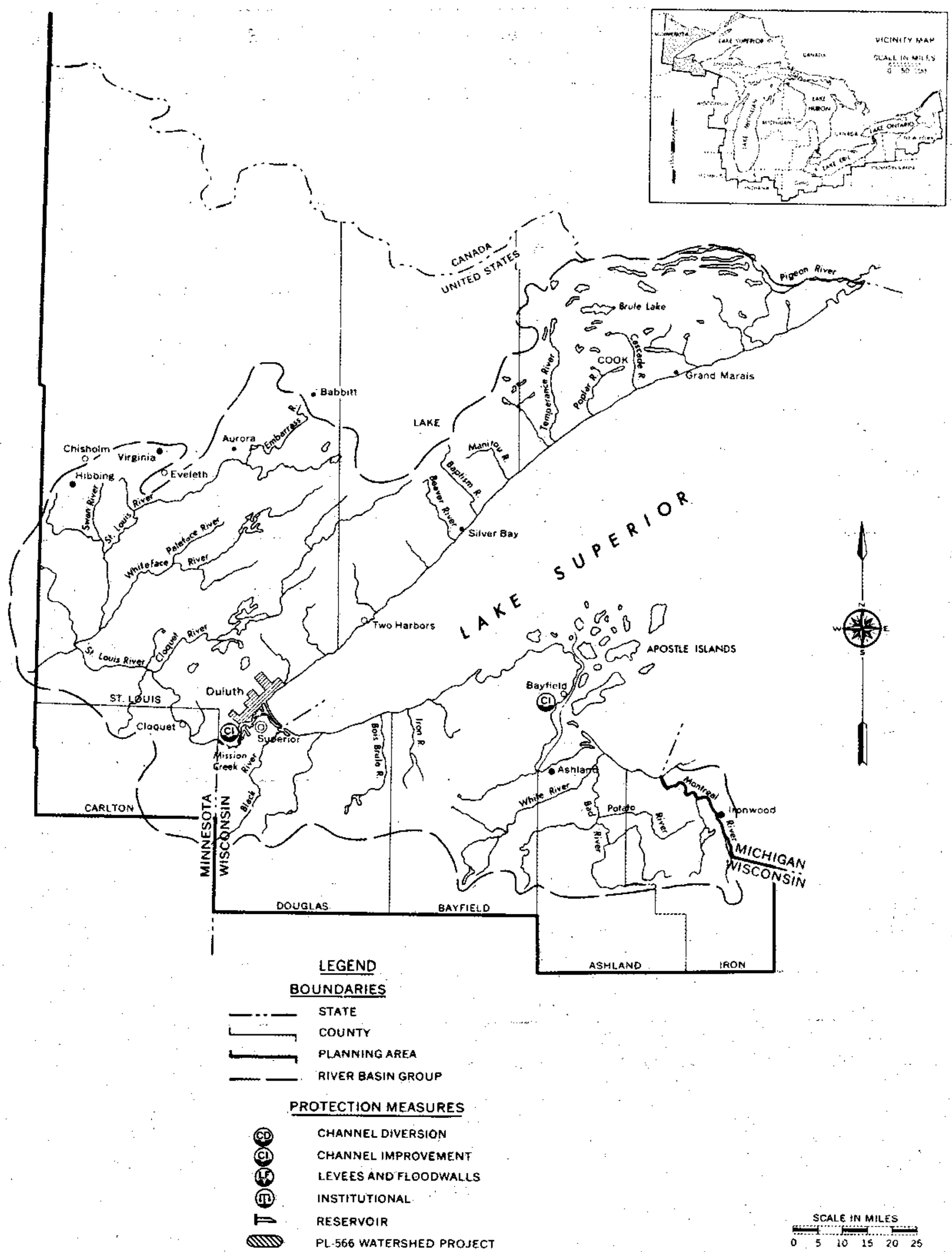

FIGURE 14–11 Existing Flood Damage Protection Measures for River Basin Group 1.1

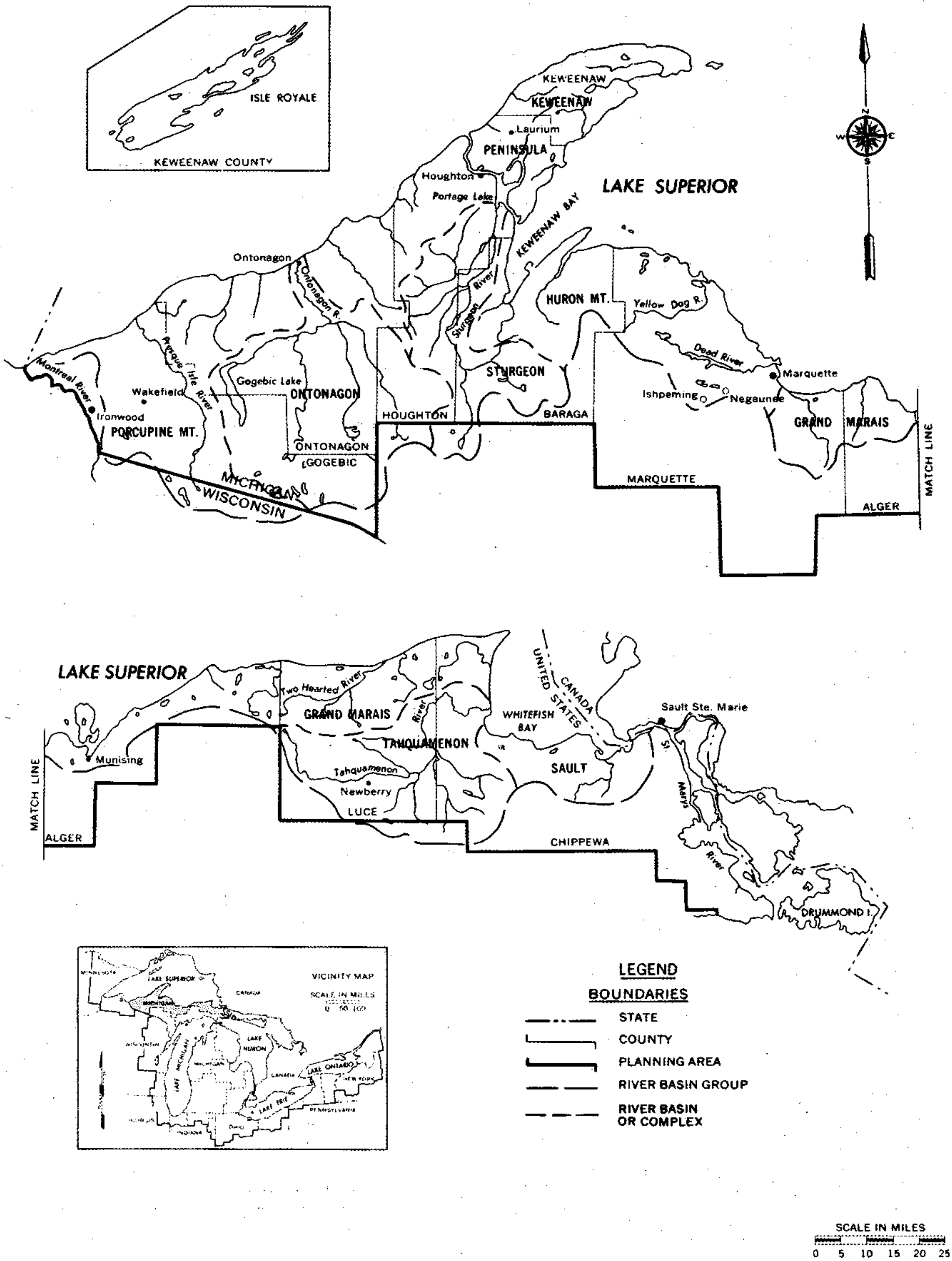

FIGURE 14–12 Lake Superior East—River Basin Group 1.2

TABLE 14–7 Lake Superior East—Previous Studies

Name	River	City	Date
Section 205 Flood Control Recon. Report	Ontonagon	Ontonagon, Mich.	April, 1963
Survey Report	Sturgeon		Not complete
Flood Damage Field Recon. Report	Linden Creek	L'Anse, Mich.	July, 1968
Sect. 205 Flood Control Recon. Report	Presque Isle	Marenisco, Mich.	April, 1960
Flood Damage Field Recon. Report	Au Train	Au Train, Mich.	April, 1969
Flood Plan Infor. Report	Ontonagon	Ontonagon, Mich.	September, 1970

TABLE 14–8 Lake Superior East—Flood Damage Centers

Damage Center	Flood Year	Type Damage	River
Ontonagon, Michigan	1912	Commercial Residential	Ontonagon
	1942	Commercial Residential	Ontonagon
	1963	Commercial Residential	Ontonagon
Arnhiem & Pelkie, Michigan	1952 1960	Agricultural	Sturgeon
L'Anse, Michigan	1968	Commercial Residential Transportation	Linden Creek
Marenisco, Michigan	1960	Commercial Residential Transportation	Presque Isle
Au Train, Michigan	1969	Residential	Au Train

TABLE 14–9 Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 1.2

REACH CODE	COUNTY	REACH LOCATION		YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)		ESTIMATED ACRES IN FLOOD PLAIN						REMARKS
		FROM	TO		URBAN	RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	
F1	PRESQUE ISLE RIVER												
	Gogebic	T46N R43W S21	T47N R43W S33	1970	55,000		10	21		405	186	250	
				1980	56,100		10	21		405	186	250	
				2000	78,000		10	21		405	186	250	
				2020	114,000		10	21		405	186	250	
G1	ONTONAGON RIVER												
	Ontona-gon	T50N R39W S28	T52N R40W S25	1970	34,700		60	20		230	110	200	
				1980	37,300		60	20		230	110	200	
				2000	66,400		60	40		210	110	200	
				2020	119,400		60	40		210	110	200	
I1	STURGEON RIVER												
	Houghton	T51N R34W S16	T52N R33W S6	1970		183,300				20300		20,300	
				1980		219,300				20300		20,300	
	Baraga			2000		325,800				20300		20,300	
				2020		362,000				20300		20,300	
I2	Baraga	Houghton-Baraga Co. Line	Otter Creek	1970	53,000					20	20		
				1980	64,000					20	20		
				2000	95,600					20	20		
				2020	106,200					20	20		
J1	FALLS RIVER												
	Baraga	Mouth	L'Anse	1970	28,000	6,000	20	20		4010	50	4,000	
				1980	34,500	7,300	20	20		4010	50	4,000	
				2000	57,900	11,000	20	20		4010	50	4,000	
				2020	96,000	13,000	20	20		4010	50	4,000	
K1	AU TRAIN RIVER												
	Alger	T45N R21E S24	T47N R20E S32	1970	1,000			20			20		
				1980	1,000			20			20		
				2000	1,200			20			20		
				2020	1,300			20			20		

1.3.5 Existing Flood Damage Prevention Measures

There are no existing Federal flood control projects in this basin.

A discussion of nonstructural preventive measures applicable to this river basin group is included in Subsection 1.2.5.

1.4 Lake Michigan Northwest, River Basin Group 2.1, Manitowoc River Basin

1.4.1 Description

The Manitowoc River, the largest in Manitowoc County, has a total drainage area of 548 square miles. The length of the longest water course is approximately 70 miles. Location within River Basin Group 2.1 is shown in Figure 14–15. The section of the river in Manitowoc County is approximately 34 miles long, the average fall is 6 feet per mile, and the drainage area is 268 square miles. Two significant tributaries, Mud Creek and Branch River, join the Manitowoc River 30 miles and 12 miles respectively above the mouth of the river.

The land surface of Manitowoc County ranges from flat marshland to rough and hilly areas. The more conspicuous features are the sand dunes and marsh and forest area of Point Beach, and the kettle moraine, a belt of irregular hills and depressions crossing the county from southwest to northeast.

1.4.2 Previous Studies

Previous studies are listed below:

(1) 1970—U.S. Army Corps of Engineers, Chicago District, a flood plain information

TABLE 14–10 Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 1.2

Watershed Number	Year	Estimated Average Annual Damages (Dollars)			Estimated Acres in Flood Plain								
		Urban	Rural	Total	Cropland	Pasture	Woodland	Other Rural	Industrial Commercial	Residential	Other Urban	Total Urban	Total Rural
		GRAND MARAIS - MICHIGAN											
641	1970	--	100	100	--	300	--	--	--	--	--	--	300
6N	1970	47,400	100	47,500	--	100	10	90	--	400	--	400	200
6P	1970	--	--	--	--	5	--	--	--	--	--	--	5
Total	1970	47,400	200	47,600	--	405	10	90	--	400	--	400	505
	1980	59,700	400	60,100	--	405	10	90	--	400	--	400	505
	2000	100,500	400	100,900	--	405	10	90	--	400	--	400	505
	2020	180,100	400	180,500	--	405	10	90	--	400	--	400	505
		KEWEENAW PENINSULA - MICHIGAN											
6H	1970	58,500	1,800	59,300	600	400	1,540	510	--	1,400	100	1,500	3,050
6I	1970	800	1,200	2,000	400	100	10	105	10	10	--	20	615
633	1970	--	300	300	100	150	300	--	--	--	--	--	550
634	1970	--	200	200	60	20	--	20	--	--	--	--	100
635	1970	--	200	200	50	20	10	20	--	--	--	--	100
636	1970	--	200	200	60	25	215	215	--	--	--	--	515
637	1970	--	--	--	10	5	--	--	--	--	--	--	15
Total	1970	59,300	3,900	63,200	1,280	720	2,075	870	10	1,410	100	1,520	4,945
	1980	74,700	6,900	81,600	1,280	720	2,075	870	10	1,410	100	1,520	4,945
	2000	125,700	7,800	133,500	1,280	720	2,075	870	10	1,410	100	1,520	4,945
	2020	225,300	8,700	234,000	1,280	720	2,075	870	10	1,410	100	1,520	4,945
		ONTONAGON RIVER - MICHIGAN											
6B1		--	200	200	70	120	160	60	--	--	--	--	410
6B2		--	400	400	130	110	300	10	--	--	--	--	550
6B2A		--	100	100	25	50	175	--	--	--	5	5	250
6B3		1,400	600	2,000	180	200	400	--	15	20	--	35	780
6B3A		23,400	--	23,400	--	--	--	--	--	500	--	500	--
6B4		65,000	--	65,000	--	--	--	--	--	1,055	610	1,665	--
Total	1970	89,800	1,300	91,100	405	480	1,035	70	15	1,575	615	2,205	1,990
	1980	113,200	2,300	115,500	405	480	1,035	70	15	1,575	615	2,205	1,990
	2000	190,400	2,600	193,000	405	480	1,035	70	15	1,575	615	2,205	1,990
	2020	341,200	2,900	344,100	405	480	1,035	70	15	1,575	615	2,205	1,990
		STURGEON RIVER - MICHIGAN											
6I1	1970	13,300	17,600	30,900	1,925	487	6,168	280	--	120	--	120	8,860
6I1(A)	1970	3,100	4,800	7,900	1,540	4,540	6,080	1,370	15	20	45	80	13,530
6I1(A)2	1970	--	100	100	33	40	67	60	--	--	--	--	200
Total	1970	16,400	22,500	38,900	3,498	5,067	12,315	1,710	15	140	45	200	22,590
	1980	20,700	40,000	60,700	3,498	5,067	12,315	1,710	15	140	45	200	22,590
	2000	34,800	44,800	79,600	3,498	5,067	12,315	1,710	15	140	45	200	22,590
	2020	62,300	50,000	112,300	3,498	5,067	12,315	1,710	15	140	45	200	22,590
		PORCUPINE MOUNTAIN - MICHIGAN											
632	1970	--	200	200	60	70	150	--	--	--	--	--	280
	1980	--	400	400	60	70	150	--	--	--	--	--	280
	2000	--	400	400	60	70	150	--	--	--	--	--	280
	2020	--	400	400	60	70	150	--	--	--	--	--	280
		TAHQUAMENON RIVER - MICHIGAN											
6A	1970	400	--	400	--	--	--	--	5	--	5	10	--
6A1	1970	--	200	200	50	50	--	--	--	--	--	--	100
Total	1970	400	200	600	50	50	--	--	5	--	5	10	100
	1980	500	400	900	50	50	--	--	5	--	5	10	100
	2000	800	400	1,200	50	50	--	--	5	--	5	10	100
	2020	1,500	400	1,900	50	50	--	--	5	--	5	10	100

TABLE 14-11 Data Summary by River Basin, River Basin Group 1.2

River Basin	Year	Estimated Average Annual Damage (Dollars)		Estimated Acres In Flood Plain	
		Urban	Rural	Urban	Rural
Porcupine Mountain Complex	1970	55,000	200	186	530
	1980	56,100	400	186	530
	2000	78,000	400	186	530
	2020	114,700	400	186	530
Ontonagon River	1970	124,500	1,300	2,315	2,190
	1980	150,500	2,300	2,315	2,190
	2000	256,800	2,600	2,315	2,190
	2020	460,600	2,900	2,315	2,190
Keweenaw Peninsula Complex	1970	59,300	3,900	1,520	4,945
	1980	74,700	6,900	1,520	4,945
	2000	125,700	7,800	1,520	4,945
	2020	225,300	8,700	1,520	4,945
Sturgeon River	1970	69,400	205,800	220	42,890
	1980	84,700	259,300	220	42,890
	2000	130,400	370,600	220	42,890
	2020	168,500	412,000	220	42,890
Grand Marais Complex	1970	48,400	200	420	505
	1980	60,700	400	420	505
	2000	101,700	400	420	505
	2020	181,400	400	420	505
Tahquamenon River	1970	400	200	10	100
	1980	500	400	10	100
	2000	800	400	10	100
	2020	1,500	400	10	100
Huron Mt. Complex	1970	28,000	6,000	50	4,000
	1980	34,500	7,300	50	4,000
	2000	57,900	11,000	50	4,000
	2020	96,000	13,000	50	4,000
Sault Complex -	Damage is negligible.				
TOTALS	1970	385,000	217,600	4,721	55,160
	1980	461,700	277,000	4,721	55,160
	2000	751,300	393,200	4,721	55,160
	2020	1,248,000	437,800	4,721	55,160

TABLE 14–12 River Basin Group 1.2, Data Summary by County

YEAR 1970

County (Michigan)	Estimated Average Annual Damages (Dollars) Urban	Rural	Estimated Acres in Flood Plain Urban	Rural
Alger	1,000	---	20	---
Baraga (See RBG 2.1)	81,000	6,000	70	4,000
Chippewa	---	---	---	---
Gogebic	55,000	---	186	250
Houghton	---	183,000	---	20,300
Keweenaw	---	---	---	---
Luce	---	---	---	---
Marquette (See RBG 2.1)	---	---	---	---
Ontonagon	34,700	---	110	200
TOTALS	171,700	189,300	386	24,750

YEAR 1980

County (Michigan)	Urban	Rural	Urban	Rural
Alger	1,000	---	20	---
Baraga (See RBG 2.1)	98,500	7,300	70	4,000
Chippewa	---	---	---	---
Gogebic	56,100	---	186	250
Houghton	---	219,300	---	20,300
Keweenaw	---	---	---	---
Luce	---	---	---	---
Marquette (See RBG 2.1)	---	---	---	---
Ontonagon	37,300	---	110	200
TOTALS	192,900	226,600	386	24,750

YEAR 2000

County (Michigan)	Urban	Rural	Urban	Rural
Alger	1,200	---	20	---
Baraga (See RBG 2.1)	153,500	11,000	70	4,000
Chippewa	---	---	---	---
Gogebic	78,000	---	186	250
Houghton	---	325,800	---	20,300
Keweenaw	---	---	---	---
Luce	---	---	---	---
Marquette (See RBG 2.1)	---	---	---	---
Ontonagon	66,400	---	110	200
TOTALS	299,100	336,800	386	24,750

YEAR 2020

County (Michigan)	Urban	Rural	Urban	Rural
Alger	1,300	---	20	---
Baraga (See RBG 2.1)	202,200	13,000	70	4,000
Chippewa	---	---	---	---
Gogebic	114,700	---	186	250
Houghton	---	362,000	---	20,300
Keweenaw	---	---	---	---
Luce	---	---	---	---
Marquette (See RBG 2.1)	---	---	---	---
Ontonagon	119,400	---	110	200
TOTALS	437,600	375,000	386	24,750

* On main stem and principal tributaries

report along limited areas of the five streams in Manitowoc County

(2) 1970—U.S. Geological Survey—flood-prone area reports along numerous reaches of streams in the basin

(3) 1969—U.S. Soil Conservation Service—Preliminary Investigation Report, Brillion Spring Creek Watershed, Calumet and Manitowoc Counties, Wisconsin

(4) 1932—U.S. Army Corps of Engineers—Document No. 481, House of Representatives, 72nd Congress, 2nd Session

(5) 1912—U.S. Army Corps of Engineers—Document No. 136, House of Representatives, 63rd Congress, 1st Session. This report considered extending the navigation channel at Manitowoc Harbor. No work was recommended.

(6) 1906—U.S. Army Corps of Engineers—Document No. 3, House of Representatives, 59th Congress, 2nd Session

1.4.3 Development in the Flood Plain

The greater portion of the population of the Manitowoc River basin is located in Manitowoc, at the mouth of the Manitowoc River. The population of this city is approximately 40,000 and is increasing. The rural population is also increasing due to an increase in nonfarm population. The rural farm population is decreasing.

The character of the county is basically industrially oriented, as reflected by the population trend. Agriculture plays a secondary, although important, role in the economy of the county. Manufacturing of consumer goods is the most important industry.

There is a harbor at the mouth of the Manitowoc River with a channel dredged and maintained to a depth of 21 feet. This channel extends up to the second railway bridge, approximately 1.6 miles from the mouth.

1.4.4 Flood Problems

Major floods occurred in 1912, 1931, 1937, 1959, and 1966. Although floods resulting from heavy thunderstorms during the summer have caused substantial damage, the most serious flooding in this area has occurred in late winter and early spring. Melting snow coincident with a moderate amount of precipitation at this time can cause rivers and creeks to break up, causing ice jams and extensive flooding. The most seriously flooded areas during such a flood are in the vicinity of the three dam sites at Michicot, Shoto, and Manitowoc Rapids.

Figure 14–16c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–13 shows the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–14 depicts upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–17c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–15. County summaries for the main stem and principal tributaries are tabulated in Table 14–16.

1.4.5 Existing Flood Damage Prevention Measures

There are no existing Federal flood control projects in the river basin.

Manitowoc County has adopted flood plain legislation as a means of guiding and controlling development in flood plains. Refer to Appendix S20, *State Laws, Policies and Institutional Arrangements* for a discussion of flood plain legislation.

1.5 Lake Michigan Northwest, River Basin Group 2.1, Sheboygan River Basin

1.5.1 Description

The Sheboygan River rises in Fond du Lac County, Wisconsin, and flows in an easterly direction into Lake Michigan. The stream bed falls approximately 375 feet over the length of the river. The mouth of the Sheboygan River is located approximately 55 miles north of Milwaukee. Location of the river within River Basin Group 2.1 is shown in Figure 14–15. The reach from the point where the Mullet River joins the Sheboygan to the mouth of the Sheboygan is approximately 39 miles long with an average fall of 2.3 feet per mile.

1.5.2 Previous Studies

Sheboygan Harbor has been the subject of a number of studies by the Corps of Engineers, but no study of the river outside of the navigable limits of the harbor has been published.

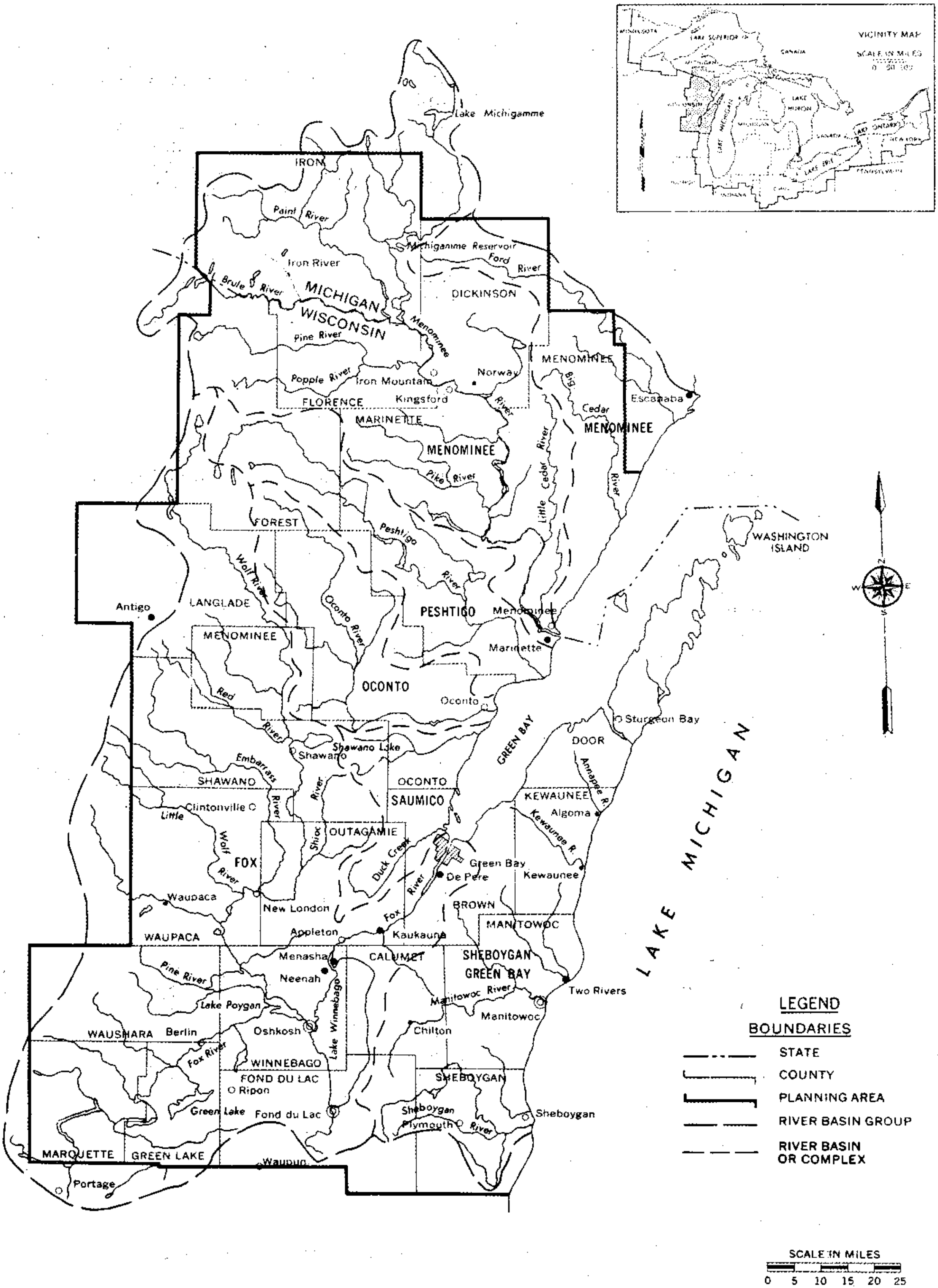

FIGURE 14–15 Lake Michigan Northwest—River Basin Group 2.1

TABLE 14–13 Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 2.1

REACH CODE	COUNTY	REACH LOCATION		YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)		ESTIMATED ACRES IN FLOOD PLAIN						REMARKS
		FROM	TO		URBAN	RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	
01	MENOMINEE RIVER												
	Menominee	T31N	T38N	1970		5,300			25	10980		11,005	
		R27W S1	R29W S2	1980		5,917			25	10980		11,005	
				2000		7,370			25	10980		11,005	
				2020		9,170			25	10980		11,005	
01A	Menominee	Menominee		1970	58,000		70				70		
				1980	91,800		70				70		
				2000	197,000		70				70		
				2020	433,000		70				70		
02	Marinette	T30N	T38N	1970	60,000	16,100	32	73	50	18975	105	19,025	
		R24E S9	R20E S7	1980	61,300	16,410	32	73	50	18975	105	19,025	
				2000	60,600	16,255	32	73	50	18975	105	19,025	
				2020	54,300	14,650	32	73	50	18975	105	19,025	
02A	Marinette	Marinette		1970	100,000		125				125		
				1980	140,000		125				125		
				2000	246,000		125				125		
				2020	391,000		125				125		
03	Dickinson	T39N	T41N	1970		5,066			30	2570		2,600	Includes Kingsford
		R29W S35	R30W S30	1980		5,580			30	2570		2,600	Same
				2000		5,995			30	2570		2,600	Same
				2020		5,608			30	2570		2,600	Same
04	Iron	T14N	T41N	1970		80				436		436	
		R31W S25	R31W S16	1980		84				436		436	
				2000		88				436		436	
				2020		96				436		436	
05	Florence	T38N	T41N	1970	27,800	1,647	12	30	10	1010	42	1,020	
		R13W S12	R18E S12	1980	27,000	1,547	12	30	10	1010	42	1,020	
				2000	26,000	1,439	12	30	10	1010	42	1,020	
				2020	28,000	1,664	12	30	10	1010	42	1,020	
06	BRULE RIVER												
	Florence	T40N	T41N	1970		1,125			6	4247		4,253	
		R18E S12	R15E S19	1980		1,090			6	4247		4,253	
				2000		1,049			6	4247		4,253	
				2020		1,136			6	4247		4,253	
07	Forest	T41N	T41N	1970		4,834			12	5456		5,468	
		R15E S19	R13E S15	1980		3,575			12	5456		5,468	
				2000		3,625			12	5456		5,468	
				2020		4,302			12	5456		5,468	
08	Iron	T41N	T42N	1970		3,138				4761		4,761	
		R31W S16	R36W S18	1980		3,349				4761		4,761	
				2000		3,511				4761		4,761	
				2020		3,834				4761		4,761	
	STURGEON RIVER												
09	Dickinson	T38N	T41N	1970	8,460	2,420	1	3		7415	4	7,415	Includes Loretto
		R29W S23	R28W S27	1980	7,780	2,225	1	3		7415	4	7,415	Same
				2000	8,300	2,370	1	3		7415	4	7,415	Same
				2020	7,820	2,238	1	3		7409	10	7,409	Same
	MICHIGAMME RIVER												
010	Iron	T41N	T44N	1970		2,270			20	6765		6,785	
		R31W S16	R31W S25	1980		2,388			20	6765		6,785	
				2000		2,498			20	6765		6,785	
				2020		2,726			20	6765		6,785	

TABLE 14–13(continued) Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 2.1

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	RURAL	ESTIMATED ACRES IN FLOOD PLAIN INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
011	Dickinson	T44N	T44N	1970		158				2151		2,151	
		R31W S25	R30W S1	1980		145				2151		2,151	
				2000		155				2151		2,151	
				2020		159				2151		2,151	
012	Marquette	T44N	T48N	1970	16,900	8,100	2	6	40	6262	168	6,142	
		R30W S1	R31W S25	1980	16,300	7,810	2	6	40	6262	168	6,142	
				2000	16,100	7,650	2	6	40	6262	168	6,142	
				2020	16,600	7,590	2	6	40	6262	168	6,142	
013	Baraga	T48N	T48N	1970		45				133		133	
		R31W S25	R31W S 25	1980		47				133		133	
				2000		49				133		133	
				2020		54				133		133	
	PAINT RIVER												
014	Iron	T41N	T44N	1970	21,100	1,574	18	42	15	4395	61	4,409	Includes Gibbs City, Crystal
		R32W S12	R35W S9	1980	22,100	1,650	18	42	15	4395	60	4,410	Falls, Same
				2000	23,200	1,930	18	42	15	4395	65	4,405	Same
				2020	25,300	1,887	18	42	15	4395	70	4,400	Same
	IRON RIVER												
015	Iron	T42N	T43N	1970	51,000		110	257		1225	367	1,225	
		R34W S29	R36W S1	1980	53,500		110	257		1225	367	1,225	
				2000	59,000		110	257		1225	367	1,225	
				2020	70,800		110	257		1225	367	1,225	
	PINE RIVER												
016	Florence	T39N	T39N	1970		40				2624		2,624	
		R19E S26	R17E S23	1980		39				2624		2,624	
				2000		37				2624		2,624	
				2020		41				2624		2,624	
	PESHTIGO RIVER												
P1	Marinette	Mouth	Rat River	1970	22,000	58,440	120	280		44560	400	44,560	
				1980	22,400	59,560	130	280		44550	400	44,550	
				2000	22,200	59,100	120	285		44558	405	44,555	
				2020	19,990	52,920	160	200		44600	360	44,600	
P1A	Marinette	Peshtigo		1970	44,100		90	210		20	320		
				1980	61,740		90	210		20	320		
				2000	108,170		90	210		20	320		
				2020	172,200		90	210		20	320		
	OCONTO RIVER												
R1	Oconto	T28N	T29N	1970	46,500	9,160	60	140	50	9610	200	9,660	Includes Oconto, Oconto Falls,
		R21E S20	R7E S13	1980	46,000	9,062	60	138	52	9610	198	9,662	Gillet, Stiles, & Underhill
				2000	45,200	8,881	54	140	56	9610	194	9,668	Same
				2020	39,600	7,782	50	120	80	9610	170	9,690	Same
	FOX RIVER												
T1	Brown	T23N	T21N	1970	140,000	2,960	18	42		1230	60	1,230	Includes Greenbay, West Depere,
		R20E S25	R18E S4	1980	238,000	5,024	20	50		1220	70	1,220	Wrightstown, Depere
				2000	595,000	12,610	40	70		1180	110	1,180	Same
				2020	1,520,000	32,100	50	100		1140	130	1,140	Same
T2	Outagamie	T21N	T19N	1970	140,000	3,320	18	42		1230	60	1,230	Includes Kaukana, Kimberly,
		R18E S4	R17E S27	1980	220,000	5,218	24	48		1288	72	1,288	Little Chute, Appleton, Menasha
				2000	546,000	12,970	38	70		1252	108	1,282	Same
				2020	1,300,000	30,920	37	75		1248	112	1,248	Same
T3	Winnebago	T18N	T17N	1970	212,000	23,800	20	50		13180	70	13,230	Includes Oshkosh, Winnegone,
		R16E S26	R13E S31	1980	244,000	27,400	10	30		13180	80	13,220	Butte, Omro, Eureka, Desmore
				2000	330,000	36,940	20	70		13155	90	13,210	Same
				2020	456,000	51,210	30	90		13110	120	13,180	Same
T4	Waushara	T17N	T17N	1970		8,610			10	4210		4,220	
		R13E S31	R13E S34	1980		9,520			10	4210		4,220	
				2000		11,031			10	4210		4,220	
				2020		11,867			10	4210		4,220	

TABLE 14-13(continued) Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 2.1

REACH CODE	COUNTY	REACH LOCATION		YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)		ESTIMATED ACRES IN FLOOD PLAIN						REMARKS
		FROM	TO		URBAN	RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	
T5	Green	T17N	T16N	1970	140,000	52,350	25	35	10	26930	60	28,940	Includes Berlin, Princeton
	Lake	R13E S34	R11E S24	1980	160,000	59,725	35	35	10	28920	70	28,930	Same
				2000	185,000	69,226	40	40	10	28910	80	28,920	Same
				2020	211,000	79,130	30	60	10	28900	90	28,910	Same
	WAUPACA RIVER												
T6	Waupaca	Mouth	Waupaca	1970	53,600	26,400	292	680		10423	972	10,423	
			Co. Line	1980	51,400	25,340	292	680		10423	972	10,423	
				2000	51,900	25,560	292	680		10423	972	10,423	
				2020	48,600	24,040	292	680		10423	972	10,423	
	EMBARRASS RIVER												
T7	Waupaca	New London	New London	1970	88,000	160	190	445		14	635	14	Includes New London
		City Limit	City Limit	1980	84,500	150	190	445		14	635	14	Same
				2000	85,500	155	190	445		14	635	14	Same
				2020	80,000	145	190	445		14	635	14	Same
T8	Outagamie	New London	Outagamie	1970	25,400	34,300	56	128		10824	184	10,824	
			Waupaca	1980	40,500	55,000	100	172		10736	272	10,736	
			Co. Line	2000	47,000	63,500	110	180		10718	290	10,718	
				2020	54,800	73,700	116	200		10692	316	10,692	
T9	Waupaca	Outagamie	Shawano	1970	18,200	10,740	22	51		1674	73	1,674	
		Waupaca	Waupaca	1980	17,500	10,330	22	51		1674	73	1,674	
		Co. Line	Co. Line	2000	17,650	10,435	22	51		1674	73	1,674	
				2020	16,600	9,800	22	51		1674	73	1,674	
	WOLF RIVER												
T10	Shawano	Shawano	Menominee	1970	29,800	11,260	80	188		11864	268	11,864	
			Shawano	1980	28,000	10,590	80	188		11864	268	11,864	
			Co. Line	2000	27,400	10,360	80	188		11864	268	11,864	
				2020	24,800	9,360	80	188		11864	268	11,864	
T10A	Shawano	Shawano		1970	179,250		486	1134		118	1738		
				1980	168,175		486	1134		118	1738		
				2000	164,650		486	1134		118	1738		
				2020	148,640		486	1134		118	1738		
	WOLF RIVER												
T11	Langlade	Menominee	Post Lakes	1970	65,800	31,100	178	415		16313	593	16,313	
		Langlade	Dam	1980	61,400	29,087	178	415		16313	593	16,313	
		Co. Line		2000	65,800	31,110	178	415		16313	593	16,313	
				2020	75,000	36,200	200	430		16276	630	16,276	
	FOND DU LAC RIVER												
T12	Fond Du	T15N	T15N	1970	159,000		704	1646		750	3100		Fond Du Lac City
	Lac	R17E S15	R17E S3	1980	246,000		704	1646		750	3100		Same
				2000	553,000		704	1646		750	3100		Same
				2020	1,230,000		704	1646		750	3100		Same
	MANITOWOC RIVER												
U1	Manitowoc	T19N	T19N	1970	21,150	26,350	47	95		7281	142	7,281	Includes Manitowac Rapids,
		R24E S29	R21E S31	1980	23,500	29,210	53	108		7270	153	7,270	Collins
				2000	30,000	37,490	73	120		7230	193	7,230	Same
				2020	37,800	47,240	133	200		7190	233	7,190	Same
U1A	Manitowoc	Manitowoc		1970	152,350		186			12	198		
				1980	232,456		186			12	198		
				2000	528,215		186			12	198		
				2020	1,182,710		186			12	198		
	SHEBOYGAN RIVER												
U2	Sheboygan	T15N	T15N	1970	220,000	2,900	28	66		854	94	854	Includes Sheboygan,
		R23E S23	R22E S35	1980	330,000	4,350	28	66		854	94	854	Sheboygan Falls
				2000	715,000	9,425	28	66		854	94	854	Same
				2020	1,550,000	20,400	28	66		854	94	854	Same

TABLE 14–14 Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 2.1

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)			ESTIMATED ACRES IN FLOOD PLAIN								
		URBAN	RURAL	TOTAL	CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		FOX COMPLEX - WISCONSIN											
5H22	1970	--	700	700	200	100	4,650	4,350	--	--	--	--	9,300
5H23	1970	--	2,500	2,500	600	600	4,100	700	--	--	--	--	6,000
5H24	1970	--	1,000	1,000	200	600	4,150	1,150	--	--	--	--	6,100
5H25	1970	--	700	700	240	300	4,500	960	--	--	--	--	6,000
5H27	1970	2,200	32,000	34,200	4,850	1,100	1,800	2,850	5	5	--	10	10,600
5H28	1970	2,500	9,300	11,800	875	150	225	250	--	100	--	100	1,500
5H29	1970	1,400	15,500	16,900	2,150	900	8,500	1,850	6	6	--	12	13,400
5H210	1970	18,000	4,500	22,500	1,000	650	2,250	300	35	50	15	100	4,200
5H211	1970	--	12,800	12,800	1,625	575	2,950	1,100	--	--	--	--	6,250
5H212	1970	--	21,000	21,000	2,400	1,000	1,900	1,300	--	--	--	--	6,600
5H213	1970	--	11,500	11,500	1,250	1,250	6,000	4,000	--	--	--	--	12,500
5H214	1970	5,500	19,500	25,000	2,000	700	800	2,100	25	25	--	50	5,600
5H215	1970	800	21,000	21,800	3,800	2,550	3,550	1,600	--	3	3	6	11,500
5H216	1970	--	9,500	9,500	1,350	400	600	550	--	--	--	--	2,900
5H217	1970	--	10,500	10,500	1,750	850	1,000	1,600	--	--	--	--	5,200
5H218	1970	8,500	9,500	18,000	1,500	1,450	2,400	5,650	25	85	45	155	11,000
5H219	1970	2,200	13,500	15,700	2,100	1,050	1,150	1,400	--	20	--	20	5,700
5H11A	1970	--	28,600	28,600	2,800	1,500	300	900	--	--	--	--	5,500
5H12A	1970	--	19,800	19,800	2,000	1,000	200	1,700	--	--	--	--	4,900
5H13A	1970	--	9,400	9,400	1,100	800	1,200	1,300	--	--	--	---	4,400
5H14A	1970	--	12,100	12,100	1,150	250	450	850	--	--	--	--	2,700
5H1	1970	--	4,900	4,900	700	600	350	350	--	--	--	--	2,000
5H2	1970	--	5,000	5,000	1,100	1,800	1,550	950	--	--	--	--	5,400
5H3	1970	38,500	27,000	65,500	3,000	2,200	2,100	1,400	50	280	50	380	8,700
5H4	1970	15,000	9,300	24,300	1,150	1,450	1,000	2,900	--	600	--	600	6,500
5H5	1970	--	14,300	14,300	1,650	1,000	200	450	--	--	--	--	3,300
5H6	1970	--	1,300	1,300	250	350	100	300	--	--	--	--	1,000
5H7	1970	--	1,700	1,700	250	100	400	250	--	--	--	--	1,000
5H8	1970	--	4,400	4,400	750	600	500	550	--	--	--	--	2,400
5H9	1970	--	19,800	19,800	2,300	1,600	950	3,450	--	--	--	--	8,300
5H10	1970	--	2,200	2,200	315	850	585	2,750	--	--	--	--	4,500
5H11	1970	--	3,100	3,100	400	550	500	650	--	--	--	--	2,100
5H12	1970	3,500	6,100	9,600	1,300	1,850	5,000	4,850	5	35	10	50	13,000
5H13	1970	--	20,300	20,300	2,450	800	400	1,150	--	--	40	40	4,800
5H14	1970	--	14,000	14,000	1,500	550	1,050	1,900	--	--	--	--	5,000
5H15	1970	1,500	3,300	4,800	400	650	550	600	--	--	20	20	2,200
5H17	1970	--	3,600	3,600	550	150	300	--	--	--	--	--	1,000
5H18	1970	2,300	39,600	41,900	8,350	1,100	800	3,050	--	10	10	20	13,300
5H19	1970	--	9,900	9,900	1,200	1,300	500	1,300	--	--	--	--	4,300
Total	1970	101,900	454,700	556,600	62,555	35,275	69,510	63,310	151	1,219	193	1,563	230,650
	1980	135,500	650,200	785,700	62,555	35,275	69,510	63,310	151	1,219	193	1,563	230,650
	2000	244,600	827,600	1,072,200	62,555	35,275	69,510	63,310	151	1,219	193	1,563	230,650
	2020	463,600	859,400	1,323,000	62,555	35,275	69,510	63,310	151	1,219	193	1,563	230,650
		GREEN BAY - WISCONSIN											
59	1970	--	40,500	40,500	3,700	2,400	1,000	1,300	--	--	--	--	8,400
510	1970	--	23,000	23,000	4,100	1,800	3,000	6,900	--	--	--	--	15,800
511	1970	--	16,000	16,000	2,000	700	650	950	--	--	--	--	4,300
512	1970	--	13,500	13,500	1,550	1,050	1,400	1,200	--	--	--	--	5,200
513	1970	--	42,000	42,000	5,000	1,100	1,600	2,300	--	--	--	--	10,000
514	1970	35,000	18,000	53,000	3,100	400	500	1,000	25	60	15	100	5,000
515	1970	--	15,500	15,500	2,000	650	900	650	--	--	--	--	4,200
517	1970	3,000	23,500	26,500	3,000	1,250	2,100	2,050	--	15	10	25	8,400
518	1970	1,300	26,500	27,800	3,200	500	1,650	1,550	--	8	4	12	6,900
519	1970	--	7,500	7,500	900	300	500	300	--	--	--	--	2,000
520	1970	6,500	25,000	31,500	3,000	600	1,500	1,900	10	35	30	75	7,000
521	1970	--	--	--	250	50	150	250	--	--	--	--	700
522	1970	1,500	9,300	10,800	1,020	550	3,700	1,530	--	50	75	125	6,800
523	1970	8,500	13,000	21,500	1,000	250	200	650	--	50	50	100	2,100
524	1970	11,000	36,500	47,500	4,300	1,800	1,600	2,800	50	200	50	300	10,500
525	1970	--	15,500	15,500	2,050	950	850	750	--	--	--	--	4,600
526	1970	13,500	23,500	37,000	4,350	1,600	2,600	750	--	70	20	90	9,300
527	1970	--	9,000	9,000	1,150	1,350	2,500	1,000	--	--	--	--	6,000
528	1970	--	14,500	14,500	1,850	2,050	4,100	1,300	--	--	--	--	9,300
Total	1970	80,300	372,300	452,600	47,520	19,350	30,500	29,130	85	488	254	827	126,500
	1980	106,800	532,400	639,200	47,520	19,350	30,500	29,130	85	488	254	827	126,500
	2000	192,700	677,600	870,300	47,520	19,350	30,500	29,130	85	488	254	827	126,500
	2020	365,400	703,600	1,069,000	47,520	19,350	30,500	29,130	85	488	254	827	126,500

TABLE 14–14(continued) Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 2.1

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)			ESTIMATED ACRES IN FLOOD PLAIN								
		URBAN	RURAL	TOTAL	CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		MENOMINEE RIVER - WISCONSIN											
5K10	1970	2,800	1,400	4,200	350	700	7,200	750	--	40	--	40	9,000
5K12	1970	--	2,800	2,800	600	1,250	9,300	1,050	--	--	--	--	12,200
Total	1970	2,800	4,200	7,000	950	1,950	16,500	1,800	--	40	--	40	21,200
	1980	3,600	6,000	9,600	950	1,950	16,500	1,800	--	40	--	40	21,200
	2000	6,700	7,600	14,300	950	1,950	16,500	1,800	--	40	--	40	21,200
	2020	12,800	8,000	20,800	950	1,950	16,500	1,800	--	40	--	40	21,200
		OCONTO COMPLEX - WISCONSIN											
5I1	1970	13,500	3,100	16,600	550	550	11,500	--	--	150	50	200	12,600
	1980	18,000	4,400	22,400	550	550	11,500	--	--	150	50	200	12,600
	2000	32,400	5,600	38,000	550	550	11,500	--	--	150	50	200	12,600
	2020	61,400	5,900	67,300	550	550	11,500	--	--	150	50	200	12,600
		PESHTIGO COMPLEX - WISCONSIN											
5I6	1970	--	7,500	7,500	1,470	1,190	2,660	1,680	--	--	--	--	7,000
	1980	--	10,700	10,700	1,470	1,190	2,660	1,680	--	--	--	--	7,000
	2000	--	13,700	13,700	1,470	1,190	2,660	1,680	--	--	--	--	7,000
	2020	--	14,200	14,200	1,470	1,190	2,660	1,680	--	--	--	--	7,000
		MENOMINEE RIVER - MICHIGAN											
533	1970	4,000	--	4,000	--	--	--	--	--	100	--	100	--
5N	1970	--	400	400	220	200	500	50	--	--	--	--	970
5N1	1970	--	100	100	40	120	300	200	--	--	--	--	660
5P1	1970	--	300	300	160	20	--	30	--	--	--	--	210
5K1	1970	16,000	800	16,800	500	150	--	100	--	100	300	400	750
5K1(A)	1970	1,200	--	1,200	--	100	--	--	5	20	5	30	100
5K3(A)	1970	--	100	100	50	30	--	20	--	--	--	--	100
5K4	1970	800	--	800	20	30	--	200	--	20	--	20	250
5K5	1970	--	400	400	250	300	800	--	--	--	--	--	1,350
5K7	1970	1,200	300	1,500	200	500	--	--	10	20	--	30	700
5K30	1970	2,400	100	2,500	80	40	--	60	--	60	--	60	180
5K31	1970	--	100	100	80	120	100	160	--	--	--	--	460
5K33	1970	4,000	400	4,400	220	50	640	330	--	75	25	100	1,240
5K34	1970	4,000	300	4,300	200	200	150	50	50	50	--	100	600
530	1970	1,600	200	1,800	120	40	100	260	--	--	40	40	520
531	1970	900	100	1,000	53	22	--	--	--	22	--	22	75
Total	1970	36,100	3,600	39,700	2,193	1,922	2,590	1,460	65	467	370	902	8,165
	1980	48,100	5,100	53,200	2,193	1,922	2,590	1,460	65	467	370	902	8,165
	2000	86,600	6,500	93,100	2,193	1,922	2,590	1,460	65	467	370	902	8,165
	2020	164,200	6,800	171,000	2,193	1,922	2,590	1,460	65	467	370	902	8,165

The U.S. Geological Survey has published flood-prone area reports for numerous reaches of the streams in the basin.

1.5.3 Development in the Flood Plain

The Sheboygan River basin below the junction of the Mullet River is a highly populated area containing the Cities of Sheboygan, Kohler, and Sheboygan Falls. These cities contain light industry and are served by railway and improved highways. The surrounding tributary area is a well developed agricultural community devoted mainly to dairy farming and the manufacturing of cheese.

There is a well-developed, deep-draft harbor serving Sheboygan at the mouth of the river. The river is navigable to commercial traffic for a distance of approximately 1.5 miles above its mouth and is navigable to small craft for a distance of 2.4 miles above its mouth. Project depth of the main harbor is 21 feet.

1.5.4 Flood Problems

Flood problems along the Sheboygan River

TABLE 14–15 Data Summary by River Basin, River Basin Group 2.1

River Basin	Year	Estimated Average Annual Damage (Dollars) Urban	Rural	Estimated Acres In Flood Plain Urban	Rural
Fox River	1970	1,352,950	659,710	9,376	330,682
	1980	1,694,975	887,584	9,453	330,605
	2000	2,913,500	1,111,487	9,620	330,438
	2020	5,628,940	1,217,872	9,767	330,291
Sheboygan-Green Bay Complex	1970	473,800	401,550	1,261	134,635
	1980	692,756	565,960	1,272	134,624
	2000	1,465,915	724,515	1,312	134,584
	2020	3,135,910	771,240	1,352	134,544
Oconto River	1970	60,000	12,260	400	22,260
	1980	64,000	13,462	398	22,262
	2000	77,600	14,481	394	22,266
	2020	101,000	13,682	370	22,290
Peshtigo River	1970	66,100	65,940	720	51,560
	1980	84,140	70,260	730	51,550
	2000	130,370	72,800	725	51,555
	2020	192,100	67,120	680	51,600
Menominee River	1970	382,160	59,747	1,883	108,818
	1980	471,480	63,006	1,895	108,806
	2000	729,500	67,921	1,907	108,794
	2020	1,203,820	70,315	1,928	108,773
Menominee Complex	- Damage is negligible.				
Suamico Complex	- Damage is negligible.				
Pensaukee Complex	- Damage is negligible.				
TOTAL	1970	2,335,010	1,199,207	13,640	647,955
	1980	3,007,351	1,600,272	13,748	647,847
	2000	5,316,885	1,991,204	13,958	647,637
	2020	10,261,770	2,140,229	14,097	647,498

are defined by the Corps' Flood Plain Information Study. The river flows between high banks for much of its length. The fluctuations of water level at Sheboygan Harbor result from seasonal variations in the level of Lake Michigan. Overbank flooding is caused by ice jams.

Figure 14–16c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–13 shows the flood plain damages by reach corresponding to the reaches designated on this figure. Table 14–14 depicts upstream flood damages. Location of these damages within

TABLE 14-16 River Basin Group 2.1, Data Summary by County

YEAR 1970

County	Estimated Average Annual Damages (Dollars) Urban	Rural	Estimated Acres in Flood Plain Urban	Rural
Michigan				
Dickinson	8,460	7,644	4	12,166
Iron	72,100	7,112	427	17,617
Menominee	58,000	5,300	70	11,005
Baraga (PSA 1.2)	---	45	---	133
Marquette (PSA 1.2)	16,900	8,100	168	6,142
Wisconsin				
Brown	140,000	2,960	60	1,230
Calumet	---	---	---	---
Door	---	---	---	---
Florence	27,800	2,812	42	7,897
Fond du Lac	159,000	---	3,100	---
Forest	---	4,834	---	5,468
Green Lake	140,000	52,350	60	28,940
Kewaunee	---	---	---	---
Langlade	65,800	31,110	593	16,313
Manitowoc	173,500	26,350	340	7,281
Marinette	226,100	74,540	950	63,585
Menominee	---	---	---	---
Oconto	46,500	9,160	200	9,660
Outagamie	165,400	37,620	244	12,124
Shawano	209,050	11,260	2,006	11,864
Sheboygan	220,000	2,900	94	854
Waupaca	159,800	37,300	1,680	12,111
Waushara	---	8,610	---	4,220
Winnebago	212,000	23,800	70	13,230
TOTALS	2,100,410	353,807	10,108	241,840

YEAR 1980

County	Urban	Rural	Urban	Rural
Michigan				
Dickinson	7,780	7,950	4	12,166
Iron	75,600	7,471	439	17,605
Menominee	91,800	5,917	70	11,005
Baraga (PSA 1.2)	---	47	---	133
Marquette (PSA 1.2)	16,300	7,810	168	6,142
Wisconsin				
Brown	238,000	5,024	70	1,220
Calumet	---	---	---	---
Door	---	---	---	---
Florence	27,000	2,726	42	7,897
Fond du Lac	246,000	---	3,100	---
Forest	---	3,575	---	5,468
Green Lake	160,000	59,725	70	28,930
Kewaunee	---	---	---	---
Langlade	61,400	29,087	540	16,366
Manitowoc	255,956	29,210	351	7,270
Marinette	285,440	75,970	960	63,573
Menominee	---	---	---	---
Oconto	46,000	9,062	198	9,662
Outagamie	260,500	60,218	344	12,024
Shawano	196,175	10,590	2,006	11,864
Sheboygan	330,000	4,350	94	854
Waupaca	153,400	35,820	1,680	12,111
Waushara	---	9,520	---	4,220
Winnebago	244,000	27,400	80	13,220
TOTALS	2,695,351	391,472	10,216	241,732

*On main stem and principal tributaries

TABLE 14–16(continued) River Basin Group 2.1, Data Summary by County

YEAR 2000

County	Estimated Average Annual Damages (Dollars)		Estimated Acres in Flood Plain	
	Urban	Rural	Urban	Rural
Michigan				
Dickinson	8,300	8,520	4	12,166
Iron	82,200	7,827	451	17,593
Menominee	197,000	7,370	70	11,005
Baraga (PSA 1.2	---	49	---	133
Marquette (PSA 1.2)	16,100	7,650	168	6,142
Wisconsin				
Brown	595,000	12,610	110	1,180
Calumet	---	---	---	---
Door	---	---	---	---
Florence	26,000	2,525	42	7,897
Fond du Lac	553,000	---	3,100	---
Forest	---	3,625	---	5,468
Green Lake	185,000	69,226	80	28,920
Kewaunee	---	---	---	---
Langlade	65,800	31,110	593	16,313
Manitowoc	538,215	37,490	391	7,230
Marinette	436,970	75,355	955	63,580
Menominee	---	---	---	---
Oconto	45,200	8,881	194	9,666
Outagamie	593,000	76,470	398	11,970
Shawano	192,050	10,360	2,006	11,864
Sheboygan	715,000	9,425	94	854
Waupaca	155,050	36,140	1,680	12,111
Waushara	---	11,031	---	4,220
Winnebago	330,000	36,940	90	13,210
TOTALS	4,753,885	452,604	10,426	241,522

YEAR 2020

County	Urban	Rural	Urban	Rural
Michigan				
Dickinson	7,820	8,005	10	12,610
Iron	96,100	8,543	466	17,578
Menominee	433,000	9,170	70	11,005
Baraga (PSA 1.2)	---	54	---	133
Marquette (PSA 1.2)	16,600	7,950	168	6,142
Wisconsin				
Brown	1,520,000	32,100	150	1,140
Calumet	---	---	---	---
Door	---	---	---	---
Florence	28,000	2,841	42	7,897
Fond du Lac	1,230,000	---	3,100	---
Forest	---	4,302	---	5,468
Green Lake	211,000	79,130	90	28,910
Kewaunee	---	---	---	---
Langlade	75,000	36,200	630	16,276
Manitowoc	1,220,510	47,240	431	7,190
Marinette	637,400	67,570	910	63,625
Menominee	---	---	---	---
Oconto	39,600	7,782	170	9,690
Outagamie	1,354,800	104,620	428	11,940
Shawano	173,340	9,360	2,006	11,864
Sheboygan	1,550,000	20,400	94	854
Waupaca	145,200	33,985	1,680	12,111
Waushara	---	11,867	---	4,220
Winnebago	456,000	51,210	120	13,180
TOTALS	9,194,370	542,329	10,565	241,383

*On main stem and principal tributaries

particular watersheds may be seen in Figure 14–17c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–15. County summaries for the main stem and principal tributaries are tabulated in Table 14–16.

1.5.5 Existing Flood Damage Prevention Measures

There are no existing Federal flood control projects in the river basin. Refer to Appendix S20, *State Laws, Policies, and Institutional Arrangements*, for a discussion of flood plain legislation.

1.6 Lake Michigan Northwest, River Basin Group 2.1, Fox River Basin

1.6.1 Description

The Fox River rises in Columbia County, Wisconsin, and flows in a northerly direction into Green Bay, an arm of Lake Michigan. Location within River Basin Group 2.1 is shown in Figure 14–15. Lake Winnebago divides the Fox into two distinct regions. The upper section, from Portage to Lake Winnebago, is 107 miles long with a fall of 40 feet. The lower section, from Lake Winnebago to Green Bay, is 37 miles long and has a fall of 168 feet. The total area drained by the upper and lower Fox is approximately 2,000 square miles (upper, 1680, and lower, 320). The main tributaries of the Fox are the White River and the Puchyan River, both on the upper Fox, and the Wolf River, which enters Lake Winnebago. Much of the area along the upper Fox basin is marshy, whereas along the lower Fox the river banks are relatively high and the surrounding area well drained.

1.6.2 Previous Studies

Previous studies are listed below:

(1) 1970—Soil Conservation Board, Feasibility Study Report, Neenah Slough Watershed, Winnebago County, Wisconsin

(2) 1969—U.S. Geological Survey—flood-prone area reports along numerous reaches of the streams in the basin

(3) 1968—Soil Conservation Board, Feasibility Study Report, Fast River Watershed, Brown and Calumet Counties, Wisconsin

(4) 1967—U.S. Soil Conservation Service—Preliminary Report, Fond du Lac Area Watershed, Fond du Lac County, Wisconsin

(5) 1966—Technical Study Group, State Soil and Water Conservation Committee of Wisconsin, Study of an East Central Wisconsin Watershed, Fond du Lac County, Wisconsin

(6) 1963—U.S. Army Corps of Engineers, Review Report on Upper Fox River Navigation Project, Wisconsin. A project was not recommended.

(7) 1949—Preliminary Examination Report on Fox River and Tributaries, Wisconsin, for Flood Control and Other Purposes, prepared by the U.S. Army Corps of Engineers (not published)

(8) 1931—U.S. Army Corps of Engineers, House Document 212, 72nd Congress, 1st Session. This report was a preliminary report on navigation, flooding, and power throughout the Fox River basin. This study recommended further study of a flood control plan.

(9) 1922—U.S. Army Corps of Engineers, Document No. 146, House of Representatives, 67th Congress, 2nd Session. This is a general study of the Fox River. The report recommends that the Federal government participate in land reclamation by local interests. It also recommends abandonment of the Federal navigation project in the upper Fox River.

1.6.3 Development in the Flood Plain

The Fox River basin contains numerous towns and cities along the river, the largest being Green Bay, Oshkosh, Appleton, Neenah, Fond du Lac, and Menasha. Although there is some agriculture in the plain, it is not significant. Numerous dams and locks are located on the upper and lower Fox. At present, the lower waterway is used mainly for recreational boating. The locks on the upper Fox River have been sealed since 1958.

1.6.4 Flood Problems

In extreme high water periods, some farmland is inundated long enough to prevent crops from being grown that year. Under normal high water conditions the land usually drains early enough so that a crop can be planted. Fond du Lac River, a tributary of the Fox River, is subject to ice jams causing flooding in Fond du Lac.

Figure 14–16c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–13 shows the flood plain damages by reach corresponding to the reaches designated on this figure. Table 14–14 depicts upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–17c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–15. County summaries for the main stem and principal tributaries are tabulated in Table 14–16.

1.6.5 Existing Flood Damage Prevention Measures

There are no existing Federal flood control projects in the river basin. However, there is some flood storage available in Lake Winnebago, especially during winter and spring. The Federal government regulates the outflow of Lake Winnebago through the Menasha dam for navigation purposes. The legal limits of regulation are from 21¼ inches above the crest down to the crest of Menasha dam during the navigation season, and an additional drawdown of 18 to 24 inches during winter. The flood storage thus provided is incidental to operation of the dam in the interest of navigation and power.

The Cities of Berlin, Kimberly, Menasha, and Neenah have adopted flood plain legislation as a means of guiding and controlling development in flood plains. A discussion of flood plain legislation is contained in Appendix S20, *State Laws, Policies, and Institutional Arrangements*.

1.7 Lake Michigan Northwest, River Basin Group 2.1, Wolf River Basin

1.7.1 Description

The Wolf River lies wholly within Wisconsin. Location within River Basin Group 2.1 is shown in Figure 14–15. It rises in small lakes in the central part of Forest County 25 miles south of the Michigan boundary, flows nearly due south to near Stephensville where it turns sharply west and continues westward to beyond New London, then turns south and southeast and, after flowing through Lakes Poygan and Winneconne, joins the Fox River approximately 10 miles above Oshkosh. Below New London it connects directly with three lakes, Partridge Crop, Cincee, and Partridge, which rise and fall with the river. Although the Wolf River is designated as a tributary of the Fox River, the Wolf is physically the main river. The Wolf River drainage basin, which is quite regular in outline, extends 110 miles along its north-south dimension. Its width is 30 miles at the southerly end, 57 miles at a point midway between New London and Shawano, and 5 miles near the source. All the major tributaries of the stream enter from the west and relatively near the mouth. These include the Waupaca and Little Wolf Rivers below New London, the Embarrass at New London, the Red River a few miles above Shawano, and the West Branch a few miles above Keshena. The Shioc River, the principal branch on the east bank, joins the Wolf River at Shiocton. In the upper half of its course the Wolf River flows through a bed of crystalline rocks lying near the surface. Here the river descends rapidly. In the 99-mile distance from the railroad crossing, 4½ miles north of Post Lake, to Semples Bridge, 10 miles below Shawano, the river descends 786 feet or 7.94 feet per mile. The river flows over many falls and rapids in this section. Near Shawano the river passes from the crystalline rock region to sandstone strata. A few more miles downstream it enters a region of red clay. Below Semples Bridge the river becomes sluggish. From the bridge to Lake Winnebago, 117 miles downstream, the river descends only 39.2 feet or 0.335 foot per mile. From the vicinity of Shiocton to the mouth the banks are low, and in high water the river covers the surrounding flats. During flooding conditions the river expands at various points to several miles in width. Practically all the original forest growth in the drainage area has been cut. Above Shawano the basin is thinly settled and second-growth timber covers much of the area.

1.7.2 Previous Studies

Previous studies are listed below:

(1) 1969—U.S. Army Corps of Engineers, Chicago District, Flood Plain Information Report on the Wolf River from Lake Poygan to Shawano, Wisconsin

(2) 1969—U.S. Geological Survey—flood-prone area reports along numerous reaches of the streams in the basin

(3) 1969—U.S. Soil Conservation Service—Preliminary Investigation Report, Bear Creek Watershed, Outagamie County, Wisconsin

(4) 1949—Preliminary Examination Report on Fox River and Tributaries, Wisconsin, for Flood Control and Other Purposes prepared by the U.S. Army Corps of Engineers (not published)

(5) 1932—U.S. Army Corps of Engineers, report from the Chief of Engineers on Wolf River, Wisconsin (House Document No. 276, 72nd Congress, 1st Session) covering navigation, flood control, power development, and irrigation under the provisions of House Document No. 308, 69th Congress, 1st Session. This study recommended no action by the government.

(6) 1925—U.S. Army Corps of Engineers, House Document 257, 69th Congress, 1st Session. This report recommended a study of the Wolf River above New London for the purpose of flood control.

1.7.3 Development in the Flood Plain

The Wolf River above Shawano has a flood plain area consisting primarily of forest and cropland. Several small communities located on the river banks constitute a small portion of the land use. Included in these communities is Shawano, the principal and largest metropolitan area in the study. Smaller communities between Shawano and Post Lake include Keshena, Markton, Langlade, Hollister, Lily, and Pearson.

Railroads passing through Shawano are the Soo Line and the Chicago and Northwestern, both crossing the Wolf River. Further upstream, and running parallel to the river at times, is the Soo Line. State Route 55 is adjacent to the river for most of the flood plain under consideration. State Highways 52, 47, 22, 64 are also in the flood plain.

1.7.4 Flood Problems

A major flood occured in 1888. Since then the river has experienced more than two floods per year. Major floods have occurred in 1912, 1922, 1950, and 1960. Flood damages have been minimal, because almost the entire flood plain is uninhabited and there is little urban land use.

Figure 14–16c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–13 depicts the flood plain damages by reach corresponding to the reaches designated on this figure. Table 14–14 depicts upstream flood damages. Locations of these damages within particular watersheds may be seen in Figure 14–17c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–15. County summaries for the main stem and principal tributaries are tabulated in Table 14–16.

1.7.5 Existing Flood Damage Prevention Measures

There are no existing Federal flood control projects in the river basin. Winnebago, Waupaca, Outagamie, and Shawano Counties have adopted flood plain legislation as a means of guiding and controlling development on flood plains. A discussion of flood plain legislation appears in Appendix S20, *State Laws, Policies, and Institutional Arrangements.*

1.8 Lake Michigan Northwest, River Basin Group 2.1, Oconto River Basin

1.8.1 Description

The Oconto River lies wholly within Wisconsin. Location within River Basin Group 2.1 is shown on Figure 14–15. It rises in the plateau region of northeastern Wisconsin in a number of small lakes and swamps in the southern part of Forest County, and flows in a direction slightly east of south across Oconto County until it passes the southern boundary of that county, then turns abruptly to the east and flows into Green Bay, an arm of Lake Michigan. The mouth of the river is 2½ miles below the City of Oconto, Wisconsin, approximately 29 miles northeast of Green Bay Harbor and 20 miles southwest of Menominee Harbor. Its drainage basin, which is somewhat irregular in outline, is approximately 70 miles long, following the general course of the river, and has an average width of approximately 14 miles. The total area above the mouth is approximately 990 square miles. Its principal tributaries are the South Branch of the Oconto River and McCaslin Brook on the west, and Peshtigo Brook and Little River on the left or east bank. In the upper 35 miles of its course the river flows over crystalline rocks, and approximately two-thirds of the total fall is found in this stretch.

On leaving the crystalline rocks, the river flows nearly due south for 20 miles over sandstone, and in its eastward stretch, it crosses limestone. The total fall is approximately 950 feet, or an average fall of about 8¾ feet per mile. Practically all of the original forest growth has been cut, but there are extensive areas of second growth timber and brush along the river. A small part of the drainage area is improved farmland. The winter conditions are severe. The snowfall is comparatively heavy and ordinarily remains on the ground for long periods. Ice forms from one foot to 2 feet in thickness and lasts for approximately three months. The runoff is approximately 43 percent of the annual rainfall, which averages 31.3 inches.

1.8.2 Previous Studies

Previous studies are listed below:

(1) 1969—U.S. Geological Survey—flood-prone area reports along various reaches of the streams in the basin

(2) 1930—U.S. Army Corps of Engineers, Document No. 489, House of Representatives, 71st Congress, 2nd Session. This study considered flood problems, navigation, power, and irrigation. No need for improvement was found.

1.8.3 Development in the Flood Plain

The Oconto River flood plain is relatively narrow with little cropland or pastureland. There are several small, privately owned dams for power production.

1.8.4 Flood Problems

There is no general flood problem on this river because the large floods overflow only a relatively small amount of low-value land, incurring practically no loss. The Cities of Oconto and Oconto Falls are not damaged by floods.

Figure 14–16c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–13 depicts the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–14 depicts upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–17c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–15. County summaries for the main stem and principal tributaries are tabulated in Table 14–16.

1.8.5 Existing Flood Damage Prevention Measures

A Federal project was completed in 1956 to alleviate flooding in Oconto. This project consists of channel enlargement for approximately two miles of the Oconto River through Oconto. Flooding in this area was caused by frequent ice jams. The total estimated damages prevented by this flood control project are $2,857,000 through 1970. The location of this protection measure is illustrated in Figure 14–18.

Appendix F20, *Federal Laws, Policies, and Institutional Arrangements*, contains a discussion of flood plain legislation.

1.9 Lake Michigan Northwest, River Basin Group 2.1, Peshtigo River Basin

1.9.1 Description

The Peshtigo River lies wholly within Wisconsin. Location of the river within River Basin Group 2.1 is shown in Figure 14–15. It rises in the western part of Forest County in the northern part of the State and flows in a southeasterly direction for approximately 140 miles with total fall of approximately 1,040 feet. The river empties into Green Bay approximately 8 miles south of the mouth of the Menominee River. The drainage basin, comprising approximately 1,100 square miles, is 80 miles long and averages approximately 14 miles in width. Its principal tributaries are the Rat, Thunder, and Little Peshtigo Rivers on the right or west bank and the Big Eagle and Noque Bay Rivers on the left bank. In the upper two-thirds of its course the river flows through an area of crystalline rocks and in the lower third it crosses successive beds of sandstone and limestone. Severe winters result in the formation of fairly heavy ice on the various pools of the river which sometimes causes trouble in the spring breakup.

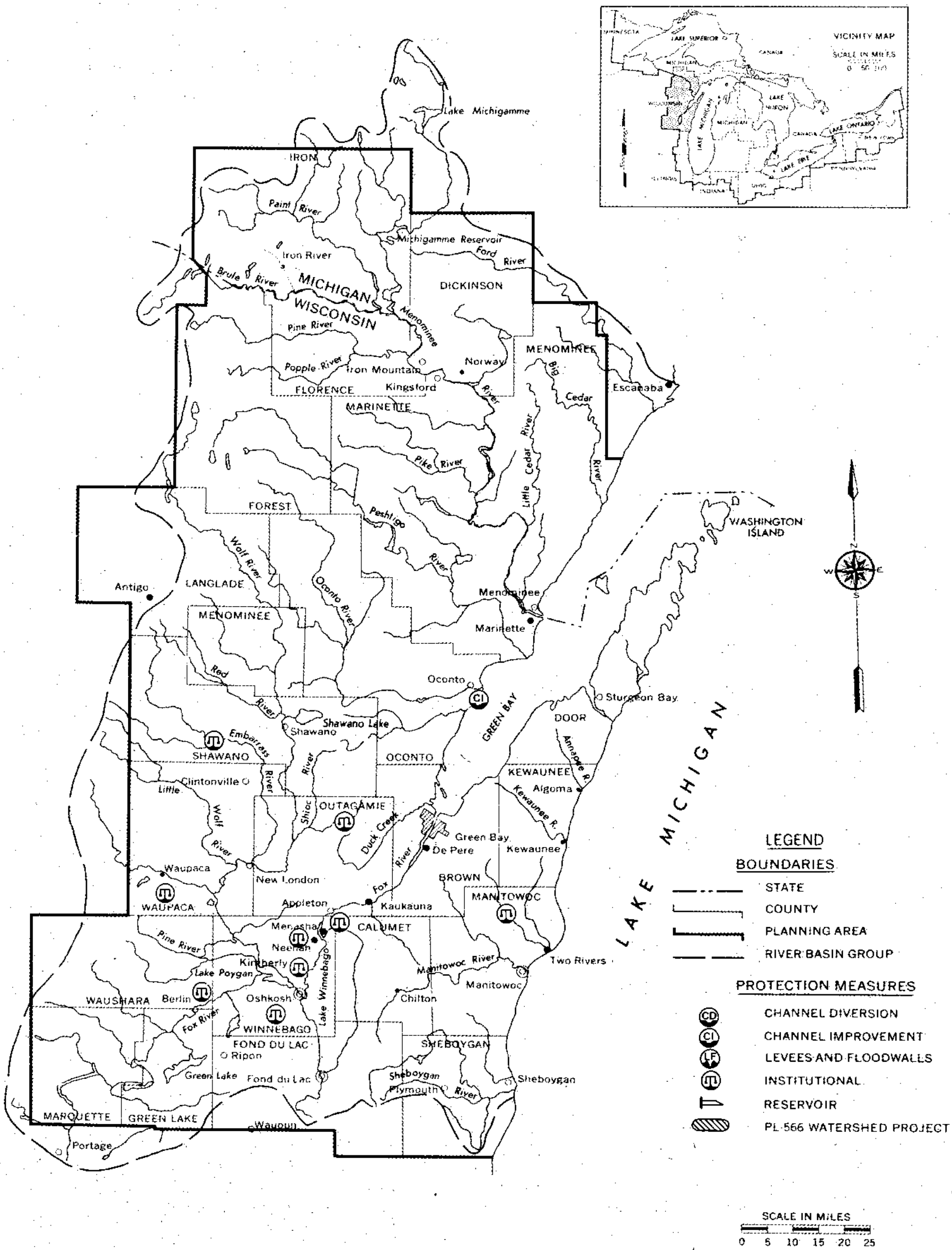

FIGURE 14–18 Existing Flood Damage Protection Measures for River Basin Group 2.1

1.9.2 Previous Studies

Previous studies are listed below:
(1) 1969—U.S. Geological Survey—flood-prone area reports along various reaches of the streams in the basin
(2) 1930—U.S. Army Corps of Engineers, Document No. 491, House of Representatives, 71st Congress, 2nd Session. This survey included flood control, navigation, irrigation, and hydroelectric power. No improvement of the river for any of these purposes was recommended.

1.9.3 Development in the Flood Plain

There has been little development in the Peshtigo River flood plain except for the City of Peshtigo. A number of dams have been constructed for power production. In the vicinity of Peshtigo there have been numerous farm developments. Otherwise most of the flood plain is woodland or swampland.

1.9.4 Flood Problems

There is no major flood problem in this river basin. Figure 14–16c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–13 shows the flood plain damages by reach corresponding to the reach designated in this figure. Table 14–14 indicates upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–17c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–15. County summaries for the main stem and principal tributaries are tabulated in Table 14–16.

1.9.5 Existing Flood Damage Prevention Measures

There are no existing Federal flood control projects in the river basin. Appendix S20, *State Laws, Policies, and Institutional Arrangements*, contains a discussion of flood plain legislation.

1.10 Lake Michigan Northwest, River Basin Group 2.1, Menominee River Basin

1.10.1 Description

The Menominee River is formed by the junction of the Brule and Michigamme Rivers and flows generally in a southeasterly direction into Green Bay, an arm of Lake Michigan. Location within River Basin Group 2.1 is shown in Figure 14–15. The river is 118 miles long and has a drainage area of 4,070 square miles. The average fall is approximately 4.7 feet per mile. Principal tributaries and their drainage areas, in addition to those mentioned, are the Sturgeon River, 427 square miles; the Pine River, 574 square miles; and the Pike River, 249 square miles. The Menominee and the Brule Rivers form part of the boundary between Wisconsin and the Upper Peninsula of Michigan.

The Brule River rises near Brule Lake in western Iron County. It flows in an easterly and southerly direction and drains an area of 1,052 square miles over a length of 42 miles. From Brule Lake to the junction with the Michigamme, the streambed falls 400 feet. Major tributaries of the Brule are the Iron and Paint Rivers, both draining areas entirely in Michigan. The Iron River drains 96.3 square miles and the Paint River, 648 square miles.

The Michigamme River begins at Lake Michigamme and flows almost due south to the nominal head of the Menominee River. Its drainage area is 726 square miles. The fall in the 69-mile length of the stream is approximately 420 feet. The two main tributaries of Lake Michigamme are the Peshekee and the Spurr Rivers.

The Menominee watershed is in a glaciated area characterized by varied topography, including rugged rocky outcrops and rolling uplands made up of moraines, outwash, and glacial channels. The river and its branches flow over hard crystalline rocks for two-thirds of its length and over sandstone and limestone for the remaining one-third. In many places the bed of the river is worn down to these underlying rocks, developing numerous rapids and falls. Because of these rapids and the river's steep slope, it is not adapted for boat or barge navigation above Menominee Harbor. However it is an important source of water power, and many of the falls are now occupied by hydroelectric plants.

Practically all the original forest growth in the drainage basin has been cut, but there are extensive areas of second-growth timber and brush along the river. Only a small part of the basin is improved farm land, and most of the cultivated area lies along the lower one-third of the river. Winter conditions are severe with heavy snowfalls remaining on the ground for long periods. Ice forms one to two feet thick and lasts for approximately three months. The runoff is approximately 41 percent of the annual rainfall, which averages 30.2 inches.

1.10.2 Previous Studies

Previous studies are listed below:

(1) 1969—Soil Conservation Board, Feasibility Study Report, South Branch Little Popple River Watershed, Florence and Marinette Counties, Wisconsin

(2) 1969—U.S. Geological Survey—flood-prone area reports along numerous reaches of streams in the basin

(3) 1966—U.S. Soil Conservation Service—East Branch Sturgeon River Watershed Work Plan, Dickinson County, Michigan

(4) 1966—Michigan Department of Conservation, Report on Outdoor Recreational Potential Related to Hydroelectric Developments in the Michigan Portion of the Menominee River Basin

(5) 1962—U.S. Soil Conservation Service, Little River Watershed Work Plan, Menominee County, Michigan

(6) 1959—U.S. Army Corps of Engineers, Document No. 113, House of Representatives, 86th Congress, 1st Session; Menominee River and Harbor, Michigan and Wisconsin. Recommends existing project be modified.

(7) 1930—U.S. Army Corps of Engineers, published Document No. 141, House of Representatives, 72nd Congress, 1st Session. This report covers navigation, flood control, power development, and irrigation problems in the Menominee Basin. This study considered problems of flooding, navigation, irrigation, and power. The study recommended that no action be taken.

(8) 1899—U.S. Army Corps of Engineers, Document No. 419, House of Representatives, 56th Congress, 1st Session. This report considered channel dredging through Menominee Harbor for navigation.

(9) 1888—U.S. Army Corps of Engineers, Document No. 34, House of Representatives, 51st Congress, 1st Session. This report considered channel enlargement through Menominee in the interest of navigation. Recommended no dredging.

1.10.3 Development in the Flood Plain

The major population centers of the Menominee River basin are generally limited to the vicinity of Iron Mountain in the central portion and the Menominee-Marinette complex at the river mouth. There are a few other small communities on the Menominee River and its branches which contain little industry. There are also a number of residential developments, scattered farms, and private hunting and fishing camps adjacent to the river. However, the river, as a whole, remains in a seminatural state.

Agriculture is not a significant factor in the economy of the basin except near the river mouth, adjacent to the Cities of Menominee and Marinette. Rainfall in the area is plentiful, and there is little need for irrigation projects. The principal industries of the basin are the mining of iron ore and the manufacturing of paper and pulp.

A deep-draft harbor is maintained at the mouth of the Menominee River. An abrupt fall occurs in the river approximately 2½ miles from its mouth, and the length of stream below this point constitutes the navigable portion of the river. Above this point the stream contains numerous falls and rapids. The cost of extending the present navigation project would far exceed the benefits.

Because of its steep slope, the Menominee River and its tributaries are important water power streams on which there are 20 hydroelectric plants. In addition to providing adequate power for the surrounding area, these plants have created extensive backwater areas which provide excellent recreational opportunities. At present adequate recreational facilities are lacking in the river basin. There are extensive, relatively unused wilderness resources in the basin. The potential use of these resources to meet public recreational needs is of paramount importance.

1.10.4 Flood Problems

Except for Marinette and Menominee, there are no large cities located directly on the banks of the Menominee River to be damaged by floods. The water level at Marinette and Menominee is controlled by sluices in dams, and there is no serious flood damage. The river flows between high banks for most of its length. Its flow is regulated by numerous hydroelectric plants and two reservoirs.

Figure 14–16c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–13 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–14 shows upstream flood damages. These damages are referenced to the watersheds identified in Figure 14–17c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–15. County summaries for the main stem and principal tributaries are tabulated in Table 14–16.

1.10.5 Existing Flood Damage Prevention Measures

There are no existing Federal flood control projects in the river basin. Appendix S20, *State Laws, Policies, and Institutional Arrangements*, contains a discussion of flood plain legislation.

1.11 Lake Michigan Southwest, River Basin Group 2.2, Milwaukee River Basin

1.11.1 Description

The Milwaukee River rises in Fond du Lac County and flows generally south through Washington, Ozaukee, and Milwaukee Counties. Location within River Basin Group 2.2 is shown in Figure 14–19. The stream has a total drainage area of 699 square miles and a total length of 99 miles. The section from Fredonia, Wisconsin, to the river mouth at Milwaukee is 43 miles long with a fall of approximately 200 feet. Much of the drainage basin in this section is either highly developed or rapidly urbanizing. The agriculture in the basin consists primarily of dairying and truck gardening.

1.11.2 Previous Studies

Previous studies are listed below:

(1) 1971—a comprehensive plan for the Milwaukee River watershed by the Southeastern Wisconsin Regional Planning Commission

(2) 1970—U.S. Geological Survey—flood-prone area reports along various reaches of the Milwaukee River and its tributaries and the Menominee, Little Menominee, and Kinnickinnic Rivers

(3) 1964—U.S. Army Corps of Engineers, Survey Report for Flood Control on Milwaukee River and Tributaries, Wisconsin (not published). This study considered levees, reservoirs, and channel improvements and concluded channel diversion to be the most feasible alternative.

(4) 1943—U.S. Army Corps of Engineers, a preliminary examination report (not published). This study considered reservoirs, channel improvements, and diversion channels. None were found to be economically feasible. No recommendation was given.

1.11.3 Development in the Flood Plain

Land use in the flood plain varies from the highly developed metropolitan area in and around Milwaukee to the forest area in the northern section. The principal economic activity in the lower section is manufacturing. A large harbor is maintained at the mouth of the Milwaukee River. The river upstream is navigable by deep-draft vessels for a distance of 2.9 miles. Due to shallow channels above this reach, navigation is limited to small recreational craft.

1.11.4 Flood Problems

Flooding occurs along the Milwaukee River between Saukville and Milwaukee whenever runoff exceeds 5,000 cfs at the stream-gaging station in Milwaukee. This has occurred 23 times in the last 50 years. Above Saukville agriculture is the major flood plain activity. Because most previous floods have occurred in early spring prior to planting, little damage has resulted. Below Saukville the flood plain is completely urbanized and includes portions of eight different urban communities. These communities contain approximately 1,100 residences and 100 commercial buildings. To date there have been no Corps of Engineers flood control projects authorized or completed on the Milwaukee River.

Figure 14–20c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–17 shows the flood plain damages by reach

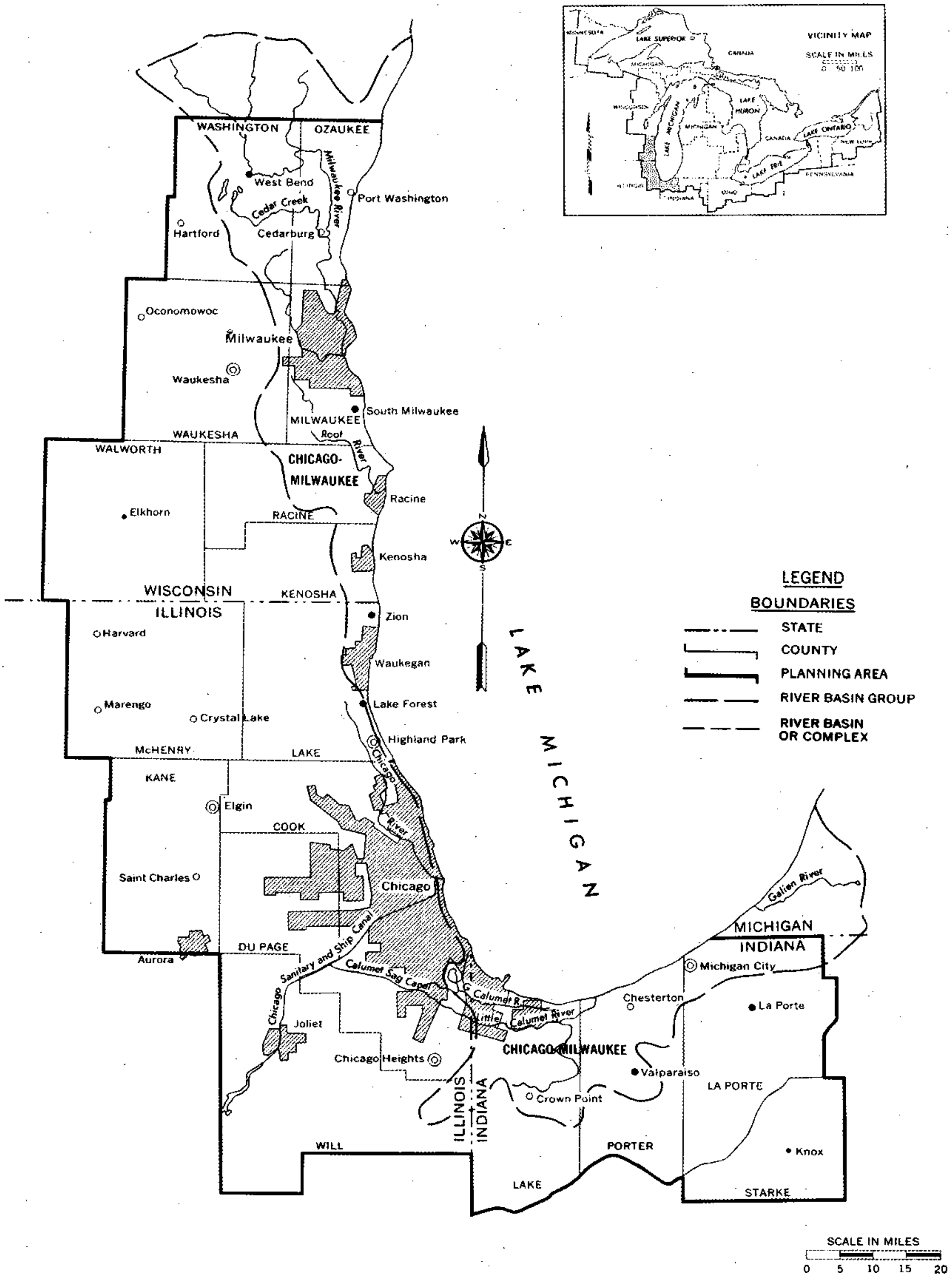

FIGURE 14-19 Lake Michigan Southwest—River Basin Group 2.2

TABLE 14–17 Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 2.2

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN: INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	MILWAUKEE RIVER												
V1	Milwaukee	T7N	T9N	1970	104,600	2,400	194	456		630	650	630	Includes Brown Deer, Glendale
		R22E S28	R21E S36	1980	154,000	3,560	220	500		560	720	560	River Mills
				2000	282,000	6,500	250	600		430	850	430	Same
				2020	494,000	11,130	290	700		290	990	290	Same
V1A	Milwaukee	Milwaukee		1970	32,200		40	140		20	200		
				1980	47,500		40	140		20	200		
				2000	87,000		40	140		20	200		
				2020	151,000		40	140		20	200		
V2	Ozaukee	T9N	T12N	1970	103,250	24,750	250	1110		3165	775	3,750	Includes Grafton, Saukville,
		R21E S36	R21E S27	1980	201,500	29,370	400	1200		2725	1,840	2,885	Mequon, Fredonia
				2000	620,000	90,300	550	1950		2025	2,500	2,025	Same
				2020	1,675,000	143,400	750	2750		1025	3,500	1,025	Same
	ROOT RIVER												
V3	Racine	T3N	T4N	1970	10,950	1,000	38	54		1612	338	1,366	
		R23E S9	R21E S2	1980	17,600	2,018	48	69		1587	430	1,274	
				2000	46,600	5,350	74	106		1524	660	1,044	
				2020	112,500	12,920	104	148		1452	930	774	
	LITTLE CALUMET RIVER												
V4	Lake	T36N	T36N	1970	8,418,000	32,000	100	900		4160	1,990	3,170	Includes Munster, Hammond,
		R10W S12	R7W S9	1980	12,600,000	48,000	110	960		4090	2,130	3,030	Highland, Gary, East Gary
				2000	26,000,000	98,700	140	1300		3720	2,800	2,360	Same
				2020	53,500,000	204,000	190	1700		3270	3,720	1,440	Same
V5	Porter	T37N	T37N	1970	1,180	6,700		210		695	210	695	Includes Chesterton, Portage
		R5W S29	R7W S36	1980	1,640	9,300		210		695	210	695	Same
				2000	3,280	18,600		210		695	210	695	Same
				2020	5,270	29,800		210		695	210	695	Same

TABLE 14–18 Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 2.2

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	RURAL	TOTAL	ESTIMATED ACRES IN FLOOD PLAIN: CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		CHICAGO - MILWAUKEE RIVER - WISCONSIN											
51	1970	--	4,400	4,400	500	250	200	220	--	--	--	--	1,170
52	1970	--	10,500	10,500	850	200	200	1,350	--	--	--	--	2,600
53	1970	--	28,000	28,000	2,700	500	250	1,600	--	--	--	--	5,050
5G1	1970	500	7,200	7,700	650	500	200	550	--	--	50	50	1,900
5G2	1970	21,000	34,100	55,100	3,400	2,150	2,400	3,250	20	80	20	120	11,200
5G3	1970	--	--	--	400	300	800	1,300	--	--	--	--	2,800
5G4	1970	--	15,000	15,000	1,400	1,800	2,100	2,100	--	--	--	--	7,400
5G5	1970	8,000	41,800	49,800	3,800	1,350	400	3,150	10	35	20	65	8,700
5G6	1970	--	14,300	14,300	2,200	100	300	2,800	--	--	--	--	5,400
5G7	1970	--	3,800	3,800	600	450	100	450	--	--	--	--	1,600
5G8	1970	--	4,400	4,400	450	100	150	120	--	--	--	--	820
Total	1970	29,500	163,500	193,000	16,950	7,700	7,100	16,890	30	115	90	235	48,640
	1980	38,400	204,400	242,800	16,950	7,700	7,100	16,890	30	115	90	235	48,640
	2000	64,900	237,100	302,000	16,950	7,700	7,100	16,890	30	115	90	235	48,640
	2020	115,000	278,000	393,000	16,950	7,700	7,100	16,890	30	115	90	235	48,640

TABLE 14–19 Data Summary by River Basin, River Basin Group 2.2

River Basin	Year	Estimated Average Annual Damage (Dollars) Urban	Rural	Estimated Acres In Flood Plain Urban	Rural
Chicago Milwaukee Complex	1970	8,699,680	230,350	4,398	58,251
	1980	13,060,640	296,648	5,765	56,884
	2000	27,103,780	456,550	7,455	55,194
	2020	56,052,770	679,250	9,785	52,864

corresponding to the reaches designated in this figure. Table 14–18 depicts upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–21c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–19. County summaries for the main stem and principal tributaries are tabulated in Table 14–20.

1.11.5 Existing Flood Damage Prevention Measures

There are no existing Federal flood control projects in the river basin. The City of West Allis has adopted flood plain legislation as a means of guiding and controlling development in flood plains. Appendix S20, *State Laws, Policies, and Institutional Arrangements,* contains a discussion of flood plain legislation.

1.12 Lake Michigan Southwest, River Basin Group 2.2, Root River Basin

1.12.1 Description

The Root River rises in Milwaukee County, Wisconsin, and flows in a southeasterly direction into Lake Michigan. Location of this basin within River Basin Group 2.2 is shown in Figure 14–19. The stream has a total drainage area of 197 square miles. The section of the river within Racine County is approximately 22 miles long with a fall of 85 feet. The highly urbanized area of the City of Racine is located at the mouth of the river. Outside this urbanized area, in the southwestern portion of the watershed, is a singular expanse of rich agricultural land.

1.12.2 Previous Studies

Previous studies are listed below:

(1) 1969—U.S. Geological Survey—flood-prone area reports along various reaches of the Root River

(2) 1965—Southeastern Wisconsin Regional Planning Commission, Root River Watershed Study. This study inventoried needs of the watershed and studied alternative plans of development. The recommended plan proposes several actions related to water resource planning, including construction of a multiple-purpose reservoir; restoration of Horlick Dam; replacement of restrictive bridges; channel clearing and maintenance; protection of floodway and flood plains by acquisition and zoning; acquisition and removal of residences subject to severe flooding; and flood proofing of others.

1.12.3 Development in the Flood Plain

At present approximately 90 percent of the residents of the watershed live in incorporated cities and villages, the combined area of which comprises approximately 40 percent of the watershed. These figures emphasize the fact that the Root River watershed is highly urbanized in the headwater and outlet areas, but is predominantly rural elsewhere.

Economic activity within the region and within commuting distance of the Root River watershed is heavily concentrated in the manufacture of durable goods. Many of the jobs that provide primary support to the population of the watershed are located outside the watershed within easy commuting distance. Economic activity in the Root River watershed has been the type that supports the needs of a community that resides within the

TABLE 14-20 River Basin Group 2.2, Data Summary by County*

County	Estimated Average Annual Damages (Dollars) Urban	Estimated Average Annual Damages (Dollars) Rural	Estimated Acres in Flood Plain Urban	Estimated Acres in Flood Plain Rural
YEAR 1970				
Wisconsin				
Milwaukee	136,800	2,400	850	630
Ozaukee	103,250	24,750	775	3,750
Racine	10,950	1,000	338	1,366
Indiana				
Lake	8,418,000	32,000	1,990	3,170
Porter	1,180	6,700	210	695
TOTAL	8,670,180	66,850	4,163	9,611
YEAR 1980				
Wisconsin				
Milwaukee	201,500	3,560	920	560
Ozaukee	201,500	29,370	1,840	2,685
Racine	17,600	2,018	430	1,274
Indiana				
Lake	12,600,000	48,000	2,130	3,030
Porter	1,640	9,300	210	695
TOTAL	13,022,240	92,248	5,530	8,244
YEAR 2000				
Wisconsin				
Milwaukee	369,000	6,500	1,050	430
Ozaukee	620,000	90,300	2,500	2,025
Racine	46,600	5,350	660	1,044
Indiana				
Lake	26,000,000	98,700	2,800	2,360
Porter	3,280	18,600	210	695
Total	27,038,880	219,450	7,220	6,554
YEAR 2020				
Wisconsin				
Milwaukee	645,000	11,130	1,190	290
Ozaukee	1,675,000	143,400	3,500	1,025
Racine	112,500	12,920	930	774
Indiana				
Lake	53,500,000	204,000	3,720	1,440
Porter	5,270	29,800	210	695
TOTAL	55,937,770	401,250	9,550	4,224

*On main stem and principal tributaries

watershed but works elsewhere. This includes such service activities as supermarkets, chain stores, local construction, and light manufacturing.

A well developed deep-draft harbor serves the City of Racine at the mouth of the Root River. It consists of a protected outer harbor and an inner harbor in the lower 3,600 feet of the river. Above this point the river is navigable only by small craft for a distance of 2.9 miles, with depths varying from one to five feet.

1.12.4 Flood Problems

In recent decades flood-damage potential and flood risk have risen from a nuisance level to substantial proportions, due to increased land use of the flood plains in the watershed. Approximately 95 percent of the potential damages are urban, most of which occur to residences. The floods causing the most damage to urban areas have been due to snowmelt and rainfall occurring in the spring, while practically all damages to agriculture have been caused by summer rainfall. Most of the flood plain is as yet unoccupied by flood-vulnerable uses and the opportunity still exists for limiting flood risk by means of land use controls.

Figure 14–20c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–17 shows the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–18 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–21c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–19. County summaries for the main stem and principal tributaries are tabulated in Table 14–20.

1.12.5 Existing Flood Damage Prevention Measures

There are no existing Federal flood control projects in the river basin. Racine has adopted flood plain legislation to guide and control development in flood plains, Appendix S20, *State Laws, Policies, and Institutional Arrangements*, contains a discussion of flood plain legislation.

1.13 Lake Michigan Southwest, River Basin Group 2.2, Little Calumet River Basin

1.13.1 Description

The Little Calumet River rises in the northwestern part of LaPorte County, six miles south of Michigan City, Indiana. Location within River Basin Group 2.2 is illustrated in Figure 14–19. Before construction of Burns Ditch and Burns Waterway in 1926, the stream flowed westerly approximately parallel to the south shore of Lake Michigan and only a few miles from it. It flowed through Porter and Lake Counties in Indiana, and northwesterly through Cook County in Illinois to its junction with the Calumet-Sag Channel. Since the completion of Burns Ditch and Burns Waterway, the flow of that part of the stream lying east of Burns Waterway is diverted through an eastern arm of Burns Ditch to Burns Waterway, and thence into Lake Michigan. In Gary, Indiana, the Little Calumet River has been reversed to flow in an easterly direction through the Gary arm of the Burns Ditch to Burns Waterway. Actually, a flow in this reach of the river may be in either direction, as outlets are provided by both the Burns Waterway and by the Little Calumet River westward into Illinois. For all practical purposes, the stream bottom is flat from Hart Ditch through Deep River. The total watershed contains 587 square miles, of which 205 are in Illinois and 382 are in Indiana. This study will concern itself only with the portion of the watershed that drains into Lake Michigan through Burns Waterway.

1.13.2 Previous Studies

Previous studies are listed below:

(1) 1965—U.S. Army Corps of Engineers, Flood Plain Information Report, Little Calumet River and Tributaries

(2) A series of hydrologic atlases published by the U.S. Geological Survey for the streams in the State of Illinois draining into Lake Michigan. These atlases include topographic maps showing inundated areas by the highest flood known, flood profiles, probable frequencies of floods, and datum and drainage areas of gaging stations.

(3) Reports published concerning the Illinois Waterway which include some mention of the Little Calumet River

1.13.3 Development in the Flood Plain

West of Burns Waterway the flood plain is mainly in residential development. This is particularly true of the section that flows through Gary. East of Burns Waterway the flood plain is generally developed for agriculture. There is also an unusual concentration of highway and railroad crossings which create channel constrictions with insufficient flood-way area.

1.13.4 Flood Problems

Due to urban development in the flood plains, a major flood problem now exists in the flood plains of the Little Calumet River. In the past floods have caused extensive damage to agriculture, commercial and manufacturing properties, public buildings, utilities, railroads, and streets and highways, as well as residential property. In addition a health hazard exists during floods in areas where contamination of wells is possible from flooded residential sewage disposal systems, treatment plant bypass, or sanitary sewer backup and overflow. Past floods indicate the hazard to life is not great because flood waters do not rise rapidly. However, many of the local levees, formed from spoil banks, are constructed of inadequate cross-section and side slopes. When waters become modestly to extremely high, there is a strong possibility that these levees could fail, catching many people off-guard and causing a disaster.

Flood problems in the Little Calumet River basin arise from both stream overflow and inadequate storm drainage systems. The problem is complicated by the extreme flatness of much of the basin and the resulting sluggish character of most streams.

In recent years there has been a tendency for rain storms to produce higher flood stages than similar storms in the past due to the continuing development in the flood plain. Continued development, which results in further encroachment of the flood plain, can only aggravate the situation.

Figure 14–20c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–17 shows the flood plain damages by reach corresponding to the reaches designated on this figure. Table 14–18 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–21c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–19. County summaries for the main stem and principal tributaries are tabulated in Table 14–20.

1.13.5 Existing Flood Damage Prevention Measures

There are no existing Federal flood control projects in the Little Calumet River basin. The Burns Ditch-Burns Waterway System is regarded as a locally constructed flood control project. The location of this project is illustrated in Figure 14–22. Without this project the flooding situation on the river would be much worse than it is today.

The Cities of Riverdale, Dolton, and Calumet City, Illinois; the Cities of Gary and East Gary, Indiana; and the Indiana Counties of Lake and Porter have adopted flood plain legislation as a means of guiding and controlling development in flood plains. A discussion of flood plain legislation appears in Appendix S20, *State Laws, Policies, and Institutional Arrangements.*

1.14 Lake Michigan Southeast, River Basin Group 2.3, St. Joseph River Basin

1.14.1 Description

The St. Joseph River rises in Hillsdale County, Michigan, tracing a wandering course, first northwesterly and then southwesterly to Mishawaka, Indiana. The river then turns northward and discharges into Lake Michigan at St. Joseph, Michigan. The descent from its origin is gradual but constant, being approximately 570 feet in a length of 210 miles. The river is fed by springs and small lakes and is not subject to rapid and excessive rises, nor to extremely low stages of water. Location of this basin within River Basin Group 2.3 is shown in Figure 14–23.

The basin of the St. Joseph River comprises approximately 4,600 square miles (2,944,000 acres). The drainage basin is approximately 100 miles long with an average width of 47 miles and a maximum width of approximately 67 miles at midlength. There are some 400 small lakes in the basin including 300 in Michigan and 100 in Indiana. The proportion of undrained lakes is smaller in Indiana and swamp lands are more extensive. Most of the

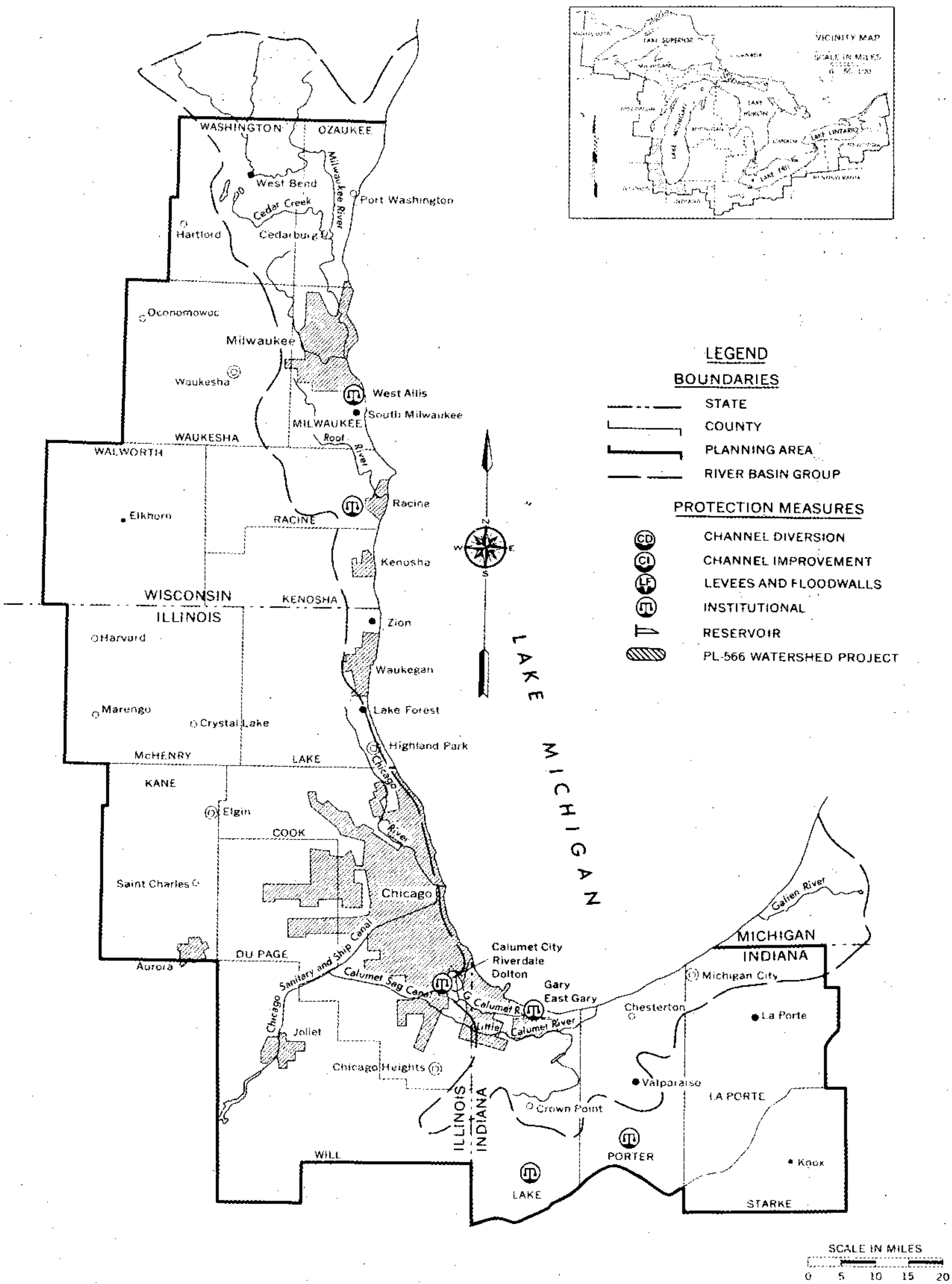

FIGURE 14–22 Existing Flood Damage Protection Measures for River Basin Group 2.2

basin has glacial features such as moraines, till plains, glacial lake plains, and sand dunes. The developed land soils are either well or intermittently drained.

1.14.2 Previous Studies

Previous studies are listed below:

(1) 1972, 1971—U.S. Geological Survey—flood-prone area reports for portions of the St. Joseph River, Elkhart River, Little Elkhart River, Christiana Creek, and Cedar Creek

(2) 1969—U.S. Army Corps of Engineers, Detroit District, a preliminary comprehensive basin study of the St. Joseph River and its tributaries

(3) 1957—U.S. Army Corps of Engineers, an unpublished report on flood control for the Prairie River at Burr Oak, Michigan. A snagging and clearing project was carried out in 1958.

(4) 1955—Michigan Water Resources Commission, a "Report on Water Resource Conditions and Uses in the Paw Paw River Basin." The report points out a growing conflict between uses of water for irrigation and industry.

(5) 1951—E. S. Brewer and Sons, Consulting Engineers, a preliminary engineering report, "Paw Paw Lake Flood Control Project"

(6) 1948—Michigan Department of Conservation, report on the flooding in Paw Paw Lake due to backwater from the Paw Paw River because of insufficient channel capacity

(7) 1933—U.S. Army Corps of Engineers, Report 308, discussion of the problems of water resources and development in the St. Joseph River basin. These reports received unfavorable recommendations because they lacked economic justification under Federal standards.

1.14.3 Development in the Flood Plain

The St. Joseph River basin has many communities that are supported by industry. Many of these industrial units are located along the rivers where ample supplies of water continue to be available. Most of the water used in the basin is obtained from wells, and the river is used primarily for diluting and transporting sewage and waste effluents from these industrial units. In the not too distant future when the well supplies are no longer adequate and the polluted conditions still prevail in the rivers, other sources of water will be required to serve the basin needs.

Agriculture is a significant economic factor in the basin. Of the 2.9 million acres in the basin, approximately 70 percent are farmland, and of this, 1.5 million acres are cropland. Investment in land and buildings is twice the national average. Fruits are extensively grown and include apples, peaches, pears, grapes, strawberries, and raspberries. Truck and dairy farming are important to this area.

A deep-draft harbor is maintained at the mouth of the St. Joseph River, and terminal facilities serve the movement of 50,000 tons of products annually through the St. Joseph-Benton Harbor complex. The basin has main transportation arteries running throughout its length linking the Detroit-Toledo area with Chicago. The Indiana toll road runs along the southern edge of the basin and Interstate 94 follows the northern border. Improved State and Federal highways exist throughout the region. There is also an intensive network of railroads passing through the various communities to metropolitan areas outside the basin.

1.14.4 Flood Problems

Major floods occurred in 1908, 1937, 1943, 1947, and 1950. Urban flooding was experienced during the 1950 flood in major communities throughout the basin. The 1947 flood caused minor damages at the communities of Hartford, Watervliet, and Berrien Springs, Michigan, in addition to those cities damaged during the 1950 flood. Substantial damage occurred during the 1947 flood at Paw Paw Lake and Benton Harbor, Michigan.

Table 14–21 lists flood damage centers located in the basin. Figure 14–24c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–23 shows the flood plain damages by reach corresponding to the reaches designated in this figure, and Table 14–24 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–25c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–25. County summaries for the main stem and principal tributaries are tabulated in Table 14–26.

(continued on page 63)

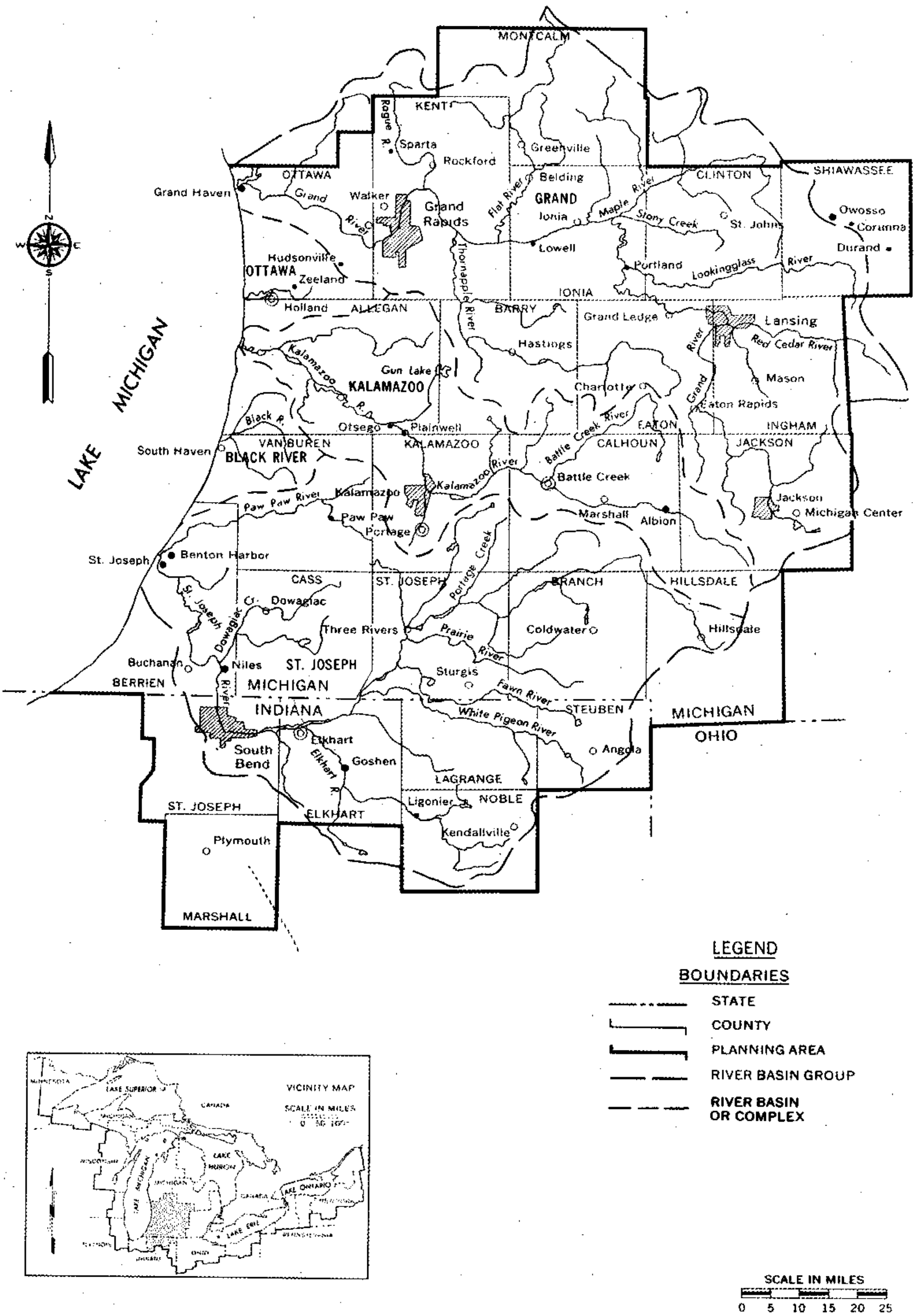

FIGURE 14-23 Lake Michigan Southeast—River Basin Group 2.3

TABLE 14–21 Lake Michigan Southeast, St. Joseph River Basin—Flood Damage Centers

Damage Center	Flood Year	Damage Type	River
Benton Harbor, Mich.	1947	Residential	Ox Creek
		Commercial	(St. Joseph River)
	1950	Industrial	
		Residential	
Niles	1943	Commercial	St. Joseph River
	1950	Industrial	
Three Rivers	1908	Residential	St. Joseph River
		Commercial	
	1950	Industrial	Portage River
Union City	1908		
	1947	Residential	St. Joseph River
	1950	Commercial	Coldwater River
Coldwater	1950	Minor	Coldwater River
Dowagiac	1950	Minor	Dowagiac Creek
Constantine	1908	Residential	St. Joseph River
	1947	Commercial	Fawn River
	1950		
South Bend, Ind.	1908		
	1943	Residential	St. Joseph River
	1950	Commercial	
Mishawaka	1908		
	1943	Residential	St. Joseph River
	1950	Industrial	
Elkhart, Ind.	1908	Residential	
	1950	Commercial	St. Joseph River
		Industrial	Elkhart River
Goshen	1950		
	1951	Residential	Elkhart River
	1954	Other (Parks)	
Paw Paw Lake, Michigan	1908	Residential	Paw Paw Lake
	1947	Industrial	

TABLE 14-22 Lake Michigan Southeast, Grand River Basin—Flood Damage Centers

Damage Center	Flood Year	Damage Type	River
Grandville, Michigan	1904	Residential	Grand River
	1948	Commercial	
	1950	Industrial	
		Agricultural	
Grand Rapids	1904	Residential	Grand River
	1947		
	1948		
Plainfield Township	1907	Residential	Grand River
	1947		
	1948		
Ada	1904	Residential	Grand River
		Commercial	
	1948	Industrial	
	1950	Agricultural	
Lowell	1904	Residential	Grand River
	1948	Commercial	
	1950	Industrial	Flat River
		Agricultural	
Ionia	1904	Residential	Grand River
	1948	Commercial	
	1950	Industrial	
		Agricultural	
Lyons	1904		Grand River
	1947	Residential	
		Commercial	
		Agricultural	
Mason	1918	Residential	Sycamore Creek
	1947	Transportation	
Lansing	1904	Residential	Grand River
		Commercial	
	1918	Industrial	Red Cedar River
	1947	Agricultural	
East Lansing	1947	Residential	Red Cedar River
		Commercial	
		Agricultural	
Eaton Rapids	1943	Residential	Grand River
	1947	Commercial	
	1956	Agricultural	
Hastings	occasional	Minor	Thornapple River
Muir	occasional	Minor	Maple River
Maple Rapids	occasional	Minor	Maple River
Ovid	occasional	Minor	Maple River
Okemos	occasional	Minor	Red Cedar River
Williamston	occasional	Minor	Red Cedar River
Fowlerville	occasional	Minor	Red Cedar River

TABLE 14-23 Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 2.3

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	ST. JOSEPH RIVER												
W1	Berrien	T4S R19W S23	T8S R17W S22	1970		5,500	5	13		4985	53	4,950	Includes Berrien Springs
				1980		6,000	5	17		4981	53	4,950	Same
				2000		7,500	7	24		4972	53	4,950	Same
				2020		9,000	9	35		4959	53	4,950	Same
W1A	Berrien	Benton Harbor		1970	30,000		333			149	482		
				1980	45,000		343			139	482		
				2000	80,000		370			112	482		
				2020	165,000		400			82	482		
W1B	Berrien	Niles		1970	26,500		109	51		269	429		
				1980	37,000		120	50		259	429		
				2000	70,000		150	40		239	429		
				2020	145,000		185	30		214	429		
	INDIANA												
W2	St.Joseph	T38N R2E S11	T37N R4E S10	1970		1,000	6	130		296		432	
				1980		2,000	6	140		286		432	
				2000		3,000	10	170		252		432	
				2020		4,000	10	195		227		432	
W2A	St.Joseph	South Bend		1970	103,000		47	364		251	662		
				1980	155,000		47	370		245	662		
				2000	335,000		45	382		235	662		
				2020	725,000		40	387		235	662		
W2B	St.Joseph	Mishawaka		1970	119,500		62	40		159	261		
				1980	180,000		62	40		159	261		
				2000	380,000		62	44		155	261		
				2020	830,000		60	46		155	261		
	INDIANA												
W3	Elkhart	T37N R4E S10	T38N R6E S12	1970		7,500	24	239		1254		1,517	
				1980		9,500	21	250		1246		1,517	
				2000		17,000	30	300		1187		1,517	
				2020		30,000	40	340		1137		1,517	
W3A	Elkhart	Elkhart		1970	131,000		115	640		250	1,004		
				1980	190,000		115	650		240	1,004		
				2000	420,000		104	670		230	1,004		
				2020	950,000		105	680		219	1,004		
W3B	Elkhart	Bristol		1970	500		6	3		93	102		
				1980	1,000		6	5		91	102		
				2000	1,500		5	10		87	102		
				2020	2,500		5	25		72	102		
	MICHIGAN												
W4	St.Joseph	T8S R13N S23	T6S R8W S6	1970	1,000	7,000	13	125		5734	83	6,491	Includes Mottville, & Mendon
				1980	1,000	8,000	13	122		5728	83	6,491	Same
				2000	2,000	12,000	10	155		5703	83	6,491	Same
				2020	4,000	17,500	10	180		5673	83	6,491	Same
W4A	St.Joseph	Constantine		1970	6,500		10			45	55		
				1980	8,500		10			45	55		
				2000	15,000		10	5		40	55		
				2020	27,000		10	5		40	55		
W4B	St.Joseph	Three Rivers		1970	10,000		130	96		19	245		
				1980	14,000		130	100		15	245		
				2000	29,000		130	100		15	245		
				2020	60,000		130	100		15	245		
W5	Branch	T6S R8W S6	T4S R7W S33	1970	500			64		2320	256	2,128	Includes Union City
				1980	500			65		2319	256	2.128	Same
				2000	1,000			75		2309	256	2,128	Same
				2020	2,000			85		2299	256	2,128	Same
W6	Calhoun	T4S R7W S33	T4S R6W S26	1970	3,000		6	70		2110	377	1,809	Includes Tekonsha
				1980	4,000		6	75		2105	377	1,809	Same
				2000	7,000		6	85		2095	377	1,809	Same
				2020	12,000		10	100		2076	377	1,809	Same

TABLE 14–23(continued) Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 2.3

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	PAW PAW RIVER												
W7	Berrien	T4S R19W S23	T4S R18W S13	1970			14	13		1656	103	1,580	
				1980			14	13		1656	103	1,580	
				2000			14	15		1654	103	1,580	
				2020			15	15		1653	103	1,580	
W7A	Berrien	Benton Harbor		1970	*		57	32		268	357		
				1980	*		57	32		268	357		
				2000	*		60	30		267	357		
				2020	*		60	30		267	357		
W7B	Berrien	Paw Paw Lake		1970	35,000				140	450	230	360	
				1980	45,000				140	450	230	360	
				2000	80,000				145	445	230	360	
				2020	140,000				155	435	230	360	
	DOWAGIAC RIVER												
W8	Berrien	T7S R17W S22	T7S R16W S6	1970						320		320	
				1980						320		320	
				2000						320		320	
				2020				5		315		320	
W9	Cass	T7S R16W S6	T6S R15W S6	1970				77		1502	339	1,240	Includes Dowagiac
				1980				77		1502	339	1,240	Same
				2000				80		1499	339	1,240	Same
				2020				85		1494	339	1,240	Same
	ELKHART RIVER												
W10	Elkhart	T37N R5E S5	T36N R6E S21	1970		1,000		39		790		829	
				1980		1,500		50		779		829	
				2000		2,500		75		754		829	
				2020		4,000		100		729		829	
W10A	Elkhart	Elkhart		1970	*		47	191		214	452		
				1980	*		47	191		214	452		
				2000	*		50	190		212	452		
				2020	*		50	190		212	452		
W10B	Elkhart	Goshen		1970	1,500		20	39		351	410		
				1980	2,000		20	50		340	410		
				2000	4,000		25	70		315	410		
				2020	8,500		30	90		290	410		
	CHRISTIANA CREEK												
W11	Elkhart	T37N R5E S5 Elkhart	T38N R5E S32	1970	*		36	41			77		
				1980	*		36	41			77		
				2000	*		36	41			77		
				2020	*		36	41			77		
	PRAIRIE RIVER												
W12	St. Joseph	T6S R11W S24 Centerville	T6S R10W S9	1970						154	154		
				1980						154	154		
				2000				2		152	154		
				2020				4		150	154		
W13	St. Joseph	T7S R9W S15 Burr Oak	T7S R9W S23	1970						88	88		
				1980						88	88		
				2000				2		86	88		
				2020				4		84	88		
	E. COLDWATER RIVER												
W14	Branch	T6S R6W S20 Coldwater	T6S R6W S22	1970	500					65	65		
				1980	500					65	65		
				2000	1,000					65	65		
				2020	2,000					65	65		

* Damages accounted for in reach on St. Joseph River in Elkhart

TABLE 14–23(continued) Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 2.3

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN: INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	GRAND RIVER												
AA2C	Kent	Comstock		1970	81,000			415		1388	1803		
		Park	Belmont	1980	93,000			480		1323	1803		
				2000	122,000			620		1183	1803		
				2020	158,000			810		993	1803		
AA2D	Kent	Ada		1970	5,700		20	70		210	100	200	
				1980	8,000		70	90		140	175	125	
				2000	13,800		80	100		120	200	100	
				2020	23,900		80	100		120	210	90	
AA2E	Kent	Lowell		1970	8,400		60	210		561	831		
				1980	10,100		75	230		526	831		
				2000	12,600		90	250		491	831		
				2020	16,800		105	270		456	831		
AA3	Ionia	T7N	T5N	1970		15,210				9721		9,721	
		R9W S1	R5W S24	1980		15,210				9721		9,721	
				2000		16,740				9721		9,721	
				2020		19,030				9721		9,721	
AA3A	Ionia	Saranac		1970	3,400		12	44		298	354		
				1980	4,250		16	58		280	354		
				2000	7,800		20	72		262	354		
				2020	13,600		30	82		242	354		
AA3B	Ionia	Ionia		1970	83,500		102	370		301	773		
				1980	108,500		112	380		281	773		
				2000	125,200		112	380		281	773		
				2020	142,000		122	390		161	773		
AA3C	Ionia	Lyons		1970	4,560		24	88		415	124	403	
				1980	5,230		24	98		405	134	393	
				2000	6,840		34	103		390	149	378	
				2020	7,750		34	113		380	162	365	
AA3D	Ionia	Portland		1970	5,000		26	92		147	265		
				1980	7,500		26	97		142	265		
				2000	10,000		26	102		137	265		
				2020	12,500		28	105		132	265		
AA4	Clinton	T5N	T5N	1970		80				650		650	
		R4W S19	R4W S34	1980		90				650		650	
				2000		140				650		650	
				2020		190				650		650	
AA5	Eaton	T4N	T N	1970		1,910		143		3448		3,631	
		R4W S3	R3W S2	1980		2,460		150		3481		3,631	
				2000		3,720		157		3474		3,631	
				2020		5,860		184		3447		3,631	
AA5A	Eaton	Grand		1970			22	74		52	148		
		Ledge		1980	1,400		29	74		45	148		
				2000	2,400		36	74		38	148		
				2020	4,100		40	77		31	148		
AA5B	Eaton	Diamondale		1970			3	22		107	132		
				1980	1,400		25	22		85	132		
				2000	2,400		35	22		75	132		
				2020	4,200		45	27		60	132		
AA5C	Eaton	Eaton		1970	23,800		54	104		93	251		
		Rapids		1980	33,300		59	110		82	251		
				2000	57,100		64	120		77	251		
				2020	99,900		69	130		52	251		

TABLE 14–23(continued) Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 2.3

REACH CODE	COUNTY	REACH LOCATION		YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)		ESTIMATED ACRES IN FLOOD PLAIN						REMARKS
		FROM	TO		URBAN	RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	
	GRAND RIVER												
AA6	Ingham	T1N R2W S7	T1N R2W S33	1970						948	29	919	
				1980		620				948	25	923	
				2000		880				948	25	923	
				2020		1,140				948	25	923	
AA7	Jackson	T1N R2W S33	T3S R1W S12	1970		1,600				5867		5,867	
				1980		1,900				5857		5,857	
				2000		2,700				5857		5,857	
				2020		3,500				5857		5,857	
AA7A	Jackson	Jackson		1970			134	102		237	473		
				1980	1,200		144	112		217	473		
				2000	1,700		154	122		197	473		
				2020	2,200		164	132		177	473		
	SYCAMORE CREEK												
AA8	Ingham	T3N R2W S2	T3N R1W S18	1970				4		592		596	
				1980	1,000	400		20		576	20	576	
				2000	1,600	800		35		651	35	561	
				2020									
	RED CEDAR RIVER												
AA9	Ingham	T4N R2W S7	T4N R2E S31	1970		2,000				1953		1,953	
				1980		2,800				1953		1,953	
				2000	300	4,500	5	20		1928	25	1,928	
				2020	1,400	7,000	15	40		1898	55	1,898	
AA9A	Ingham	Lansing		1970	90,500		471	1008		1005	2484		
				1980	108,600		491	968		1025	2484		
				2000	153,800		511	938		1035	2484		
				2020	199,100		526	908		1050	2484		
AA9B	Ingham	E. Lansing		1970	405,000		1254			290	1554		
				1980	650,000		813	491		240	1544		
				2000	1,580,000		843	511		190	1544		
				2020	3,720,000		873	531		140	1544		
AA9C	Ingham	Okemos		1970	5,000		222			1447	222	1,447	
				1980	8,000		70	332		1267	422	1,247	
				2000	19,500		120	412		1137	572	1,097	
				2020	46,000		200	492		977	752	917	
AA9D	Ingham	William-ston		1970			221			550	771		
				1980	1,400		16	220		535	771		
				2000	2,400		21	230		520	771		
				2020	4,100		26	240		505	771		
	LOOKINGGLASS RIVER												
AA10	Ionia	T6N R5W S34	T5N R5W S1	1970						243		243	
				1980		100				243		243	
				2000		110				243		243	
				2020		130				243		243	
AA11	Clinton	T5N R4W S6	T6N R1W S25	1970		12,000		15		6680		6,695	
				1980	2,800	16,300	30	50		6615	95	6,600	
				2000	4,600	27,400	50	80		6563	155	6,540	
				2020	6,400	48,100	70	110		6515	215	6,480	
AA11A	Clinton	DeWitt		1970				19		83	102		
				1980	400			29		73	102		
				2000	1,000		5	34		63	102		
				2020	2,400		10	39		53	102		

TABLE 14–23(continued) Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 2.3

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	KALAMAZOO RIVER												
Y1	Allegan	T3N R16W S16	T1N R11W S33	1970		1,890				10919		10,919	
				1980	3,140	540	60	80	80	10699	220	10,699	
				2000	4,750	1,850	95	140	140	10544	390	10,529	
				2020	7,990	2,370	165	200	180	10374	485	10,434	
Y1A	Allegan	Allegan		1970	37,200		15	79		40	134		
				1980	46,200		18	84		32	134		
				2000	56,500		21	89		24	134		
				2020	74,400		24	94		16	134		
Y1B	Allegan	Otsego		1970	14,300		304	33		1526	382	1,481	
				1980	19,300		354	113		1396	507	1,356	
				2000	23,300		380	163		1320	583	1,280	
				2020	59,400		380	163		1320	583	1,280	
Y1C	Allegan	Plainwell		1970	9,650		8	103		697	143	665	
				1980	13,000		20	140		648	185	623	
				2000	22,300		30	180		598	260	548	
				2020	40,200		90	280		438	460	348	
Y2	Kalamazoo	T1N R11W S33	T1S R9W S25	1970	2,400	5,300	77	128		3201	340	3,066	Includes Galesburg and Augusta
				1980	3,600	6,300	137	228		3039	500	2,904	Same
				2000	6,500	8,800	187	328		2889	654	2,750	Same
				2020	11,800	11,000	260	430		2714	832	2,572	Same
Y2A	Kalamazoo	Kalamazoo		1970	618,300		925	1412		4119	6456		
				1980	960,000		1,010	1800		3646	6456		
				2000	2,160,000		1,070	2200		3186	6456		
				2020	5,132,000		1,140	2600		2716	6456		
Y3	Calhoun	T1S R9W S25	T3S R4W S1	1970	1,060	1,700		87		3414	207	3,294	
				1980	1,890	1,700	120	180		3201	380	3,121	
				2000	3,510	1,700	230	230		3041	550	2,961	
				2020	5,950	1,700	320	270		2911	720	2,781	
Y3A	Calhoun	Battle Creek		1970	13,500		330	321		1456	907	1,200	
				1980	21,800		402	334		1371	1007	1,100	
				2000	47,600		460	360		1287	1107	1,000	
				2020	108,000		520	367		1220	1207	900	
Y3B	Calhoun	Albion		1970	320		27	6		637	670		
				1980	450		66	27		577	670		
				2000	800		86	47		537	670		
				2020	1,440		100	67		503	670		
	GRAND RIVER												
AA1	Ottawa	T8N R16W S21	T6N R13W S13	1970	6,000	2,800		745		13208	745	13,213	
				1980	8,400	3,900		200	120	12798	1220	12,738	
				2000	14,400	6,700	330	1040		12588	1690	12,268	
				2020	25,200	11,800	430	1360	220	11948	2170	11,788	
AA2	Kent	T6N R13W S13	T7N R8W S10	1970		6,150				4482		4,482	
				1980		7,520				4482		4,482	
				2000		12,150				4482		4,482	
				2020		12,195				4482		4,482	
AA2A	Kent	Grandville		1970	175,000		232	500		1378	1220	890	
				1980	262,000		232	620		1258	1420	690	
				2000	610,000		412	740		968	1620	490	
				2020	1,400,000		512	860		738	1980	130	
AA2B	Kent	Grand Rapids		1970	650,000		1141	2833		1149	5123		
				1980	747,000		1261	2813		1049	5123		
				2000	975,000		1371	2783		969	5123		
				2020	1,270,000		1491	2723		909	5123		

TABLE 14-23(continued) Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 2.3

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN: INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	MAPLE RIVER												
AA12	Ionia	T7N	T8N	1970				15		1257	15	1,257	
		R5W S18	R4W S30	1980		100		10		1262	10	1,262	
				2000		110		5		1267	5	1,267	
				2020		125				1272		1,272	
AA13	Clinton	T8N	T8N	1970						3789	42	3,747	
		R4W S30	R3W S5	1980						3789	42	3,747	
				2000						3789	42	3,747	
				2020						3789	42	3,747	
	FLAT RIVER												
AA14	Kent	T7N	T7N	1970						1000		1,000	
		R9W S35	R9W S13	1980						1000		1,000	
				2000						1000		1,000	
				2020						1000		1,000	
AA15	Ionia	T7N	T8N	1970			36	127		1557	181	1,539	Includes Belding
		R9W S13	R8W S2	1980	1,000	100	38	132		1550	181	1,539	Same
				2000	1,100	110	43	135		1542	181	1,539	Same
				2020	1,300	130	43	138		1539	181	1,539	Same
AA16	Montcalm	T9N	T9N	1970			18	60		506	87	497	Includes Greenville
		R8W S35	R8W S4	1980	1,400	104	18	60		506	87	497	Same
				2000	2,400	110	18	60		506	87	497	Same
				2020	4,200	120	18	60		506	87	497	Same
	ROGUE RIVER												
AA17	Kent	T8N	T9N	1970		5,750	17	17		3385	61	3,358	
		R11W S23	R12W	1980	2,000	5,800	48	37		3334	110	3,309	
				2000	4,200	6,050	80	47		3292	155	3,264	
				2020	7,500	6,200	90	67		3229	210	3,209	
	THORNAPPLE RIVER												
AA18	Kent	T6N	T5N	1970	1,400	4,600	4	41		3362	45	3,362	Includes Alaska, Cascade,
		R10W S34	R10W S35	1980	1,600	5,800	6	44			50	3,357	and Lebarge
				2000	2,100	6,900	8	47		3352	55	3,352	Same
				2020	2,720	9,000	10	50		3347	60	3,347	Same
AA19	Barry	T4N	T3N	1970	640	13,000		32		4594	106	4,520	Includes Middleville and
		R10W S2	R8W S16	1980	770	15,600		37		4589	106	4,520	Irving
				2000	830	16,900	2	40		4584	106	4,520	Same
				2020	1,400	28,600	5	42		4579	106	4,520	Same
AA19A	Barry	Hastings		1970	2,700		34	115		414	563		
				1980	3,800		44	135		384	563		
				2000	6,500		54	155		354	563		
				2020	11,100		64	175		324	563		

TABLE 14-24 Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 2.3

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)			ESTIMATED ACRES IN FLOOD PLAIN								
		URBAN	RURAL	TOTAL	CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		ST. JOSEPH RIVER - MICHIGAN											
5A2B	1970	2,500	--	2,500	--	--	--	--	--	15	--	15	--
5A1C	1970	--	13,600	13,600	2,850	50	50	50	--	--	--	--	3,000
5A2A	1970	14,900	22,000	36,900	1,900	100	--	--	--	115	--	115	2,000
5A4C	1970	2,500	1,100	3,600	125	50	25	50	--	15	--	15	250
5A5C	1970	--	700	700	30	20	70	30	--	--	--	--	150
5A8C	1970	3,300	2,400	5,700	250	50	100	130	--	20	--	20	530
5A8A	1970	8,200	4,600	12,800	275	300	125	310	--	50	--	50	1,010
5A10	1970	--	100	100	50	50	80	80	--	--	--	--	260
5A11	1970	--	4,900	4,900	640	450	--	--	--	--	--	--	1,090
5A12	1970	10,400	1,800	12,200	400	150	200	250	--	100	--	100	1,000
5A12A	1970	--	6,100	6,100	315	365	240	420	--	--	--	--	1,340
5A13	1970	30,000	7,100	37,100	200	300	500	560	50	--	150	200	1,560
5A14B	1970	35,500	8,300	43,800	2,000	400	--	--	--	200	--	200	2,400
5A30	1970	--	2,900	2,900	200	100	105	225	--	--	--	--	630
5A30A	1970	16,400	1,600	18,000	400	200	345	205	--	100	--	100	1,150
Total	1970	123,700	77,200	200,900	9,635	2,585	1,840	2,310	50	615	150	815	16,370
	1980	167,000	97,300	264,300	9,635	2,585	1,840	2,310	50	615	150	815	16,370
	2000	301,800	115,000	416,800	9,635	2,585	1,840	2,310	50	615	150	815	16,370
	2020	573,900	131,200	705,100	9,635	2,585	1,840	2,310	50	615	150	815	16,370
		ST. JOSEPH RIVER - INDIANA											
5A3	1970	9,800	6,600	16,400	986	835	829	1,169	3	27	--	30	3,819
5A4	1970	--	2,600	2,600	455	260	692	106	--	--	--	--	1,513
5A6	1970	--	1,400	1,400	475	155	62	27	--	--	--	--	719
5A7	1970	--	5,200	5,200	663	1,254	2,080	780	--	--	--	--	4,777
5A8	1970	24,800	2,100	26,900	530	195	245	180	--	150	--	150	1,150
5A9	1970	7,700	600	8,300	160	--	40	--	43	222	--	265	200
Total	1970	42,300	18,500	60,800	3,269	2,699	3,948	2,262	46	399	--	445	12,178
	1980	57,100	23,300	80,400	3,269	2,699	3,948	2,262	46	399	--	445	12,178
	2000	103,200	27,600	130,800	3,269	2,699	3,948	2,262	46	399	--	445	12,178
	2020	196,300	31,500	227,800	3,269	2,699	3,948	2,262	46	399	--	445	12,178
		BLACK RIVER COMPLEX - MICHIGAN											
5LL2	1970	13,900	7,500	21,400	1,550	15	5	--	200	--	--	200	1,570
5LL	1970	1,600	2,400	4,000	200	50	50	--	50	--	--	50	300
	1970	15,500	9,900	25,400	1,750	65	55	--	250	--	--	250	1,870
	1980	20,900	12,500	33,400	1,750	65	55	--	250	--	--	250	1,870
	2000	37,800	14,800	52,600	1,750	65	55	--	250	--	--	250	1,870
	2020	71,900	16,800	88,700	1,750	65	55	--	250	--	--	250	1,870
		KALAMAZOO RIVER - MICHIGAN											
5C1	1970	--	19,800	19,800	2,300	300	50	60	--	--	--	--	2,710
5C1A	1970	--	5,100	5,100	590	--	--	--	--	--	--	--	590
5C2	1970	--	1,600	1,600	120	60	30	10	--	--	--	--	220
5C4	1970	--	2,600	2,600	300	50	--	--	--	--	--	--	350
5C530	1970	8,700	1,400	10,100	25	45	45	25	10	15	--	25	140
5C6B	1970	--	56,100	56,100	1,600	260	400	350	--	--	--	--	2,610
5C6C	1970	--	100	100	60	70	50	20	--	--	--	--	200
5C6D	1970	--	18,300	18,300	600	300	1,200	400	--	--	--	--	2,500
Total	1970	8,700	105,000	113,700	5,595	1,085	1,775	865	10	15	--	25	9,320
	1980	11,700	132,300	144,000	5,595	1,085	1,775	865	10	15	--	25	9,320
	2000	21,200	156,500	177,700	5,595	1,085	1,775	865	10	15	--	25	9,320
	2020	40,400	178,500	218,900	5,595	1,085	1,775	865	10	15	--	25	9,320
		OTTAWA COMPLEX - MICHIGAN											
5KK	1970	700	51,400	52,100	2,340	485	160	80	20	80	--	100	3,065
	1980	900	64,800	65,700	2,340	485	160	80	20	80	--	100	3,065
	2000	1,700	76,600	78,300	2,340	485	160	80	20	80	--	100	3,065
	2020	3,200	87,400	90,600	2,340	485	160	80	20	80	--	100	3,065

TABLE 14-24(continued) Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 2.3

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)			ESTIMATED ACRES IN FLOOD PLAIN								
		URBAN	RURAL	TOTAL	CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		GRAND RIVER - MICHIGAN											
5P1 to 5P4	1970	--	143,900	143,900	3,000	500	500	1,016	--	--	--	--	5,016
5P6	1970	--	6,100	6,100	237	141	67	97	--	--	--	--	542
5F4	1970	--	25,800	25,800	1,000	2,150	60	200	--	--	--	--	3,410
5F2	1970	--	--	--	--	20	120	30	--	--	--	--	170
5F1	1970	--	900	900	35	10	5	--	--	--	--	--	50
5R123	1970	--	50,800	50,800	1,767	--	--	--	--	--	--	--	1,767
5M12	1970	--	105,300	105,300	2,028	240	80	177	--	--	--	--	2,525
5LG3	1970	6,100	--	6,100	--	--	--	--	450	2,000	50	2,500	--
5R4	1970	700	16,700	17,400	650	520	65	65	50	250	--	300	1,300
5R5	1970	200	23,600	23,800	916	918	916	306	--	--	100	100	3,056
5R6	1970	600	25,800	26,400	1,000	600	200	200	38	200	--	238	2,000
5LG1	1970	1,200	7,700	8,900	300	400	100	200	100	400	--	500	1,000
5M14	1970	--	4,100	4,100	160	278	740	100	--	--	--	--	1,278
5M15	1970	200	10,000	10,200	390	730	1,580	370	--	5	80	85	3,070
5MG1	1970	1,300	12,900	14,200	500	220	150	450	100	450	--	550	1,320
5L6	1970	5,000	11,300	16,300	440	260	1,320	229	300	1,300	435	2,035	2,249
5L4	1970	400	4,100	4,500	160	160	180	1,100	30	120	--	150	1,600
5MG3	1970	1,600	51,500	53,100	2,000	330	710	130	--	640	--	640	3,170
5UG1	1970	--	1,800	1,800	70	40	10	40	--	--	--	--	160
5UG5	1970	--	21,500	21,500	1,820	362	186	236	--	--	--	--	2,604
5UG7	1970	500	25,800	26,300	1,000	475	450	1,075	50	130	25	205	3,000
5RC14	1970	5,100	92,800	97,900	3,600	900	1,350	3,150	100	2,000	--	2,100	9,000
5MG6	1970	--	10,600	10,600	1,280	170	260	--	--	--	--	--	1,710
5MG7	1970	--	6,800	6,800	723	96	96	40	--	--	--	--	955
5M1 to 5M11	1970	--	272,200	272,200	12,020	1,650	1,700	1,130	--	--	--	--	16,500
5UG8	1970	--	14,300	14,300	1,816	331	255	152	--	--	--	--	2,554
5RC9	1970	--	45,100	45,100	1,750	1,500	500	1,250	--	--	--	--	5,000
5RC7	1970	100	38,600	38,700	1,500	600	450	450	--	20	20	40	3,000
5RC3	1970	--	200	200	8	10	20	22	--	--	--	--	60
5RC4	1970	--	2,700	2,700	106	70	51	64	--	--	--	--	291
5RC5	1970	100	19,700	19,800	765	382	418	485	--	15	5	20	2,050
5RC10	1970	200	9,000	9,200	350	200	200	250	5	40	40	85	1,000
5RC8	1970	--	11,300	11,300	440	220	165	275	--	--	--	--	1,100
5MG2 A	1970	4,600	5,800	10,400	225	165	295	110	420	1,460	20	1,900	795
5MG4 A	1970	--	2,600	2,600	100	--	300	--	--	--	--	--	400
5S1 to 5S6	1970	--	41,600	41,600	1,602	62	200	363	--	--	--	--	2,227
5S6	1970	--	4,100	4,100	160	250	130	21	--	--	--	--	561
5T1	1970	--	154,200	154,200	7,500	750	500	250	--	--	--	--	9,000
5T3	1970	100	53,100	53,200	2,060	620	320	100	10	15	--	25	3,100
5T4	1970	100	14,200	14,300	550	215	185	150	35	5	--	40	1,100
5T5	1970	200	25,800	26,000	1,000	1,000	800	500	--	100	--	100	3,300
5T6	1970	--	1,300	1,300	25	50	25	--	--	--	--	--	100
5T11	1970	--	38,500	38,500	1,493	993	293	746	--	--	--	--	3,525
5MG5	1970	--	14,400	14,400	560	150	10	100	--	--	--	--	820
5MG8	1970	--	24,700	24,700	960	--	480	--	--	--	160	160	1,440
5LG5	1970	2,300	96,600	98,900	3,748	302	470	30	125	800	25	950	4,550
5LG6	1970	200	33,500	33,700	1,300	600	2,000	--	40	40	--	80	3,900
5LG8	1970	200	23,400	23,600	910	595	845	330	--	80	20	100	2,680
5LG10	1970	1,200	1,300	2,500	50	--	320	2,300	60	420	--	480	2,670
5LL	1970	--	3,900	3,900	150	--	350	--	--	--	--	--	500
5UG9	1970	--	7,700	7,703	1,271	80	50	50	--	--	--	--	1,451
5UG10	1970	1,200	11,400	12,600	442	218	218	242	200	300	--	500	1,120
RC1	1970	--	700	700	28	56	42	154	--	--	--	--	280
Total	1970	33,400	1,631,700	1,665,100	65,965	20,589	20,737	18,735	2,113	10,790	980	13,883	126,026
	1980	45,100	2,050,800	2,095,900	65,965	20,589	20,737	18,735	2,113	10,790	980	13,883	126,026
	2000	81,500	2,425,100	2,506,600	65,965	20,589	20,737	18,735	2,113	10,790	980	13,883	126,026
	2020	155,000	2,766,900	2,921,900	65,965	20,589	20,757	18,735	2,113	10,790	980	13,883	126,026

TABLE 14–25 Data Summary by River Basin, River Basin Group 2.3

River Basin	Year	Estimated Average Annual Damage (Dollars)		Estimated Acres In Flood Plain	
		Urban	Rural	Urban	Rural
St. Joseph River	1970	634,000	117,700	7,544	50,204
	1980	907,100	147,600	7,544	50,204
	2000	1,829,500	184,600	7,544	50,204
	2020	3,841,200	227,200	7,544	50,204
Black River Complex	1970	15,500	9,900	250	1,870
	1980	20,900	12,500	250	1,870
	2000	37,800	14,800	250	1,870
	2020	71,900	16,800	250	1,870
Kalamazoo River	1970	705,430	113,890	9,264	29,943
	1980	1,081,080	141,990	10,084	29,123
	2000	2,346,460	168,850	10,829	28,378
	2020	5,481,590	193,570	11,572	27,635
Ottawa Complex	1970	700	51,400	100	3,065
	1980	900	64,800	100	3,065
	2000	1,700	76,600	100	3,065
	2020	3,200	87,400	100	3,065
Grand River	1970	1,585,000	1,696,800	32,477	196,206
	1980	2,119,850	2,129,104	33,597	195,086
	2000	3,822,970	2,531,120	34,602	194,081
	2020	7,345,270	2,921,620	35,805	192,878
TOTAL	1970	2,940,630	1,989,690	49,635	281,288
	1980	4,129,830	2,495,994	51,575	279,348
	2000	8,038,430	2,975,970	53,325	277,598
	2020	16,743,160	3,446,590	55,271	275,652

TABLE 14-26 River Basin Group 2.3, Data Summary by County

St. Joseph River Basin County	Estimated Average Annual Damages (Dollars) Urban	Estimated Average Annual Damages (Dollars) Rural	Estimated Acres in Flood Plain Urban	Estimated Acres in Flood Plain Rural
YEAR 1970				
Michigan				
Berrien	91,500	5,500	1,654	7,210
St. Joseph	17,500	7,000	625	6,491
Branch	500	---	321	2,128
Calhoun	3,000	---	377	1,809
Cass	---	---	339	1,240
Shiawassee (See RBG 3.2)	---	---	---	---
Indiana				
St. Joseph	222,500	1,000	923	432
Elkhart	133,000	8,500	2,045	2,346
TOTALS	468,000	22,000	6,284	21,656
YEAR 1980				
Michigan				
Berrien	127,000	6,000	1,654	7,210
St. Joseph	23,500	8,000	625	6,491
Branch	500	---	321	2,128
Calhoun	4,000	---	377	1,809
Cass	---	---	339	1,240
Shiawassee (See RBG 3.2)	---	---	---	---
Indiana				
St. Joseph	335,000	2,000	923	432
Elkhart	193,000	11,000	2,045	2,346
TOTALS	683,000	27,000	6,284	21,656
YEAR 2000				
Michigan				
Berrien	230,000	7,500	1,654	7,210
St. Joseph	46,000	12,000	625	6,491
Branch	1,000	---	321	2,128
Calhoun	7,000	---	377	1,809
Cass	---	---	339	1,240
Shiawassee (See RBG 3.2)	---	---	---	---
Indiana				
St. Joseph	715,000	3,000	923	432
Elkhart	425,500	19,500	2,045	2,346
TOTALS	1,424,500	42,000	6,284	21,656
YEAR 2020				
Michigan				
Berrien	450,000	9,000	1,654	7,210
St. Joseph	91,000	17,500	625	6,491
Branch	2,000	---	321	2,128
Calhoun	12,000	---	377	1,809
Cass	---	---	339	1,240
Shiawassee (See RBG 3.2)	---	---	---	---
Indiana				
St. Joseph	1,555,000	4,000	923	432
Elkhart	961,000	34,000	2,045	2,346
TOTALS	3,071,000	64,500	6,284	21,656

*On main stem and principal tributaries

TABLE 14-26(continued) River Basin Group 2.3, Data Summary by County

Grand River Basin County (Michigan)	Estimated Average Annual Damages (Dollars)		Estimated Acres in Flood Plain	
	Urban	Rural	Urban	Rural
YEAR 1970				
Ottawa	6,000	2,800	745	13,213
Kent	921,500	16,500	9,183	13,292
Ionia	96,460	15,210	1,712	13,163
Clinton	---	12,080	144	11,092
Eaton	23,800	1,910	531	3,631
Ingham	500,500	2,000	5,050	4,915
Jackson	---	1,600	473	5,857
Barry	3,340	13,000	669	4,520
Montcalm	---	---	87	497
TOTALS	1,551,600	65,100	18,594	70,180
YEAR 1980				
Ottawa	8,400	3,900	1,220	12,738
Kent	1,123,700	18,620	9,512	12,963
Ionia	127,180	15,510	1,717	13,158
Clinton	3,200	16,390	239	10,997
Eaton	36,100	2,460	531	3,631
Ingham	769,000	3,820	5,266	4,699
Jackson	1,200	1,900	473	5,857
Barry	4,570	15,600	669	4,520
Montcalm	1,400	104	87	497
TOTALS	2,074,750	78,304	19,714	69,060
YEAR 2000				
Ottawa	14,400	6,700	1,690	12,268
Kent	1,739,600	25,100	9,787	12,688
Ionia	150,940	17,070	1,727	13,148
Clinton	5,600	27,540	299	10,937
Eaton	61,900	3,720	531	3,631
Ingham	1,757,600	6,180	5,456	4,509
Jackson	1,700	2,700	473	5,857
Barry	7,330	16,900	669	4,520
Montcalm	2,400	110	87	497
TOTALS	3,741,470	106,020	20,719	68,055
YEAR 2020				
Ottawa	25,200	11,800	2,170	11,788
Kent	2,878,920	27,395	10,217	12,258
Ionia	177,150	19,415	1,735	13,140
Clinton	8,800	48,290	359	10,877
Eaton	108,200	5,860	531	3,631
Ingham	3,973,100	9,740	5,681	4,284
Jackson	2,200	3,500	473	5,857
Barry	12,500	28,600	669	4,520
Montcalm	4,200	120	87	497
TOTALS	7,190,270	154,720	21,922	66,852

*On main stem and principal tributaries

TABLE 14-26(continued) River Basin Group 2.3, Data Summary by County

Kalamazoo River Basin County (Michigan)	Estimated Average Annual Damages (Dollars)		Estimated Acres in Flood Plain	
	Urban	Rural	Urban	Rural
YEAR 1970				
Allegan	61,150	1,890	659	13,065
Kalamazoo	620,700	5,300	6,796	3,064
Calhoun	14,880	1,700	1,784	4,494
TOTALS	696,730	8,890	9,239	20,623
YEAR 1980				
Allegan	81,640	1,690	1,046	12,678
Kalamazoo	963,600	6,300	6,956	2,904
Calhoun	24,140	1,700	2,057	4,221
TOTALS	1,069,380	9,690	10,059	19,803
YEAR 2000				
Allegan	106,850	1,850	1,367	12,357
Kalamazoo	2,166,500	8,800	7,110	2,750
Calhoun	51,910	1,700	2,327	3,951
TOTALS	2,325,260	12,350	10,804	19,058
YEAR 2020				
Allegan	181,990	2,370	1,662	12,062
Kalamazoo	5,143,800	11,000	7,288	2,572
Calhoun	115,400	1,700	2,597	3,681
TOTALS	5,441,190	15,070	11,547	18,315

*On main stem and principal tributaries

1.14.5 Existing Flood Damage Prevention Measures

The only Federal flood prevention measure undertaken in the area was a local snagging and clearing project in 1958 on the Prairie River at Burr Oak, Michigan. This was done under the Flood Control Act of 1937 and supervised by the U.S. Army Corps of Engineers. Location of this project is illustrated in Figure 14–26. To date no flood control measures have been initiated by non-Federal agencies. There are many small dams and millraces erected by local public and private interests to serve strictly local purposes. They do little to alleviate possible flood damages, and in many cases actually contribute to the raising of flood stages.

In Indiana and Michigan local authorities are responsible for defining the flood plain and specifying or establishing its limits. However, few if any communities within the St. Joseph River basin have effective land use regulations for proper flood plain development. Both States have taken steps to provide some Statewide regulations on a broad basis to fill in the gap not provided or considered by local governments. Some of these laws and their features pertinent to flood plain regulation are listed below:

(1) Michigan Act No. 288 (Public Acts of 1967) of August 1, 1967. This Act regulates the subdivision of land to control residential building development within the flood plain areas.

(2) Michigan Act No. 245 of 1929, Amended by Act 167 (Public Act of 1968) of June 17, 1968. This Act provides the Michigan State Water Resources Commission with the powers to implement the portion of the Act dealing with flood plain lands, and grants the Commission the authority to make regulations and orders to prevent harmful interference with the discharge and stage characteristics of streams.

(3) The Indiana Flood Control Act, Chapter 318, (Acts of 1945). This Act directs that the flood plains of rivers and streams should not be inhabited and should be kept free and clear of interference or obstructions that will cause any undue restrictions of the capacity of the floodways. It also directs that the Department of Natural Resources shall consider flood plain regulation in preventing and controlling floods.

(4) Indiana Planning Act of 1947. This Act provides for the establishment of planning commissions and the zoning of land.

(5) Area Planning Act of 1957. This Act provides for area planning departments.

For a more detailed discussion of flood plain legislation see Appendix S20, *State Laws, Policies, and Institutional Arrangements.*

1.15 Lake Michigan Southeast, River Basin Group 2.3, Kalamazoo River Basin

1.15.1 Description

The Kalamazoo River rises in the southern part of the Lower Peninsula of Michigan (Hillsdale County), flows northwesterly for 185 miles, and empties into Lake Michigan 2 miles downstream from the village of Saugatuck. The Kalamazoo River basin is approximately 100 miles long with extremes of width ranging from 6 to 30 miles, and containing 1,980 square miles. All of the principal tributaries except Portage Creek enter the main river from the north bank. Only Battle Creek, which joins the river in downtown Battle Creek, and Portage Creek at Kalamazoo have any appreciable effect on the flood problems in the basin. Location of this basin within River Basin Group 2.3 is shown in Figure 14–23.

The entire watershed is generally undulating with prairie, swamps, and hilly sections alternating at frequent intervals. Numerous small lakes and spring hollows are scattered throughout the watershed, holding ponded water part or all of the time. Kalamazoo Lake near the river mouth is the largest lake in the basin. The river is approximately 1,200 feet above sea level at the eastern end of the basin and drops to 700 feet near Lake Michigan. The general elevation of the headwater terrain along the basin edges is 150 to 200 feet above the river channel. Battle Creek and most of the smaller tributaries flow through extensive swamplands as they approach the main channel. The streams of the river basin are not characterized by rapid erosion, and their sediment content is generally low. The soils of the basin are commonly porous which increases the infiltration, thus materially reducing runoff peaks and equalizing the ground water supply reaching the stream.

1.15.2 Previous Studies

Previous studies are listed below:

(1) U.S. Geological Survey—flood-prone area report for a portion of Battle Creek, 1972

(2) a final report covering the local flood problem at Battle Creek and vicinity, dated February 1950

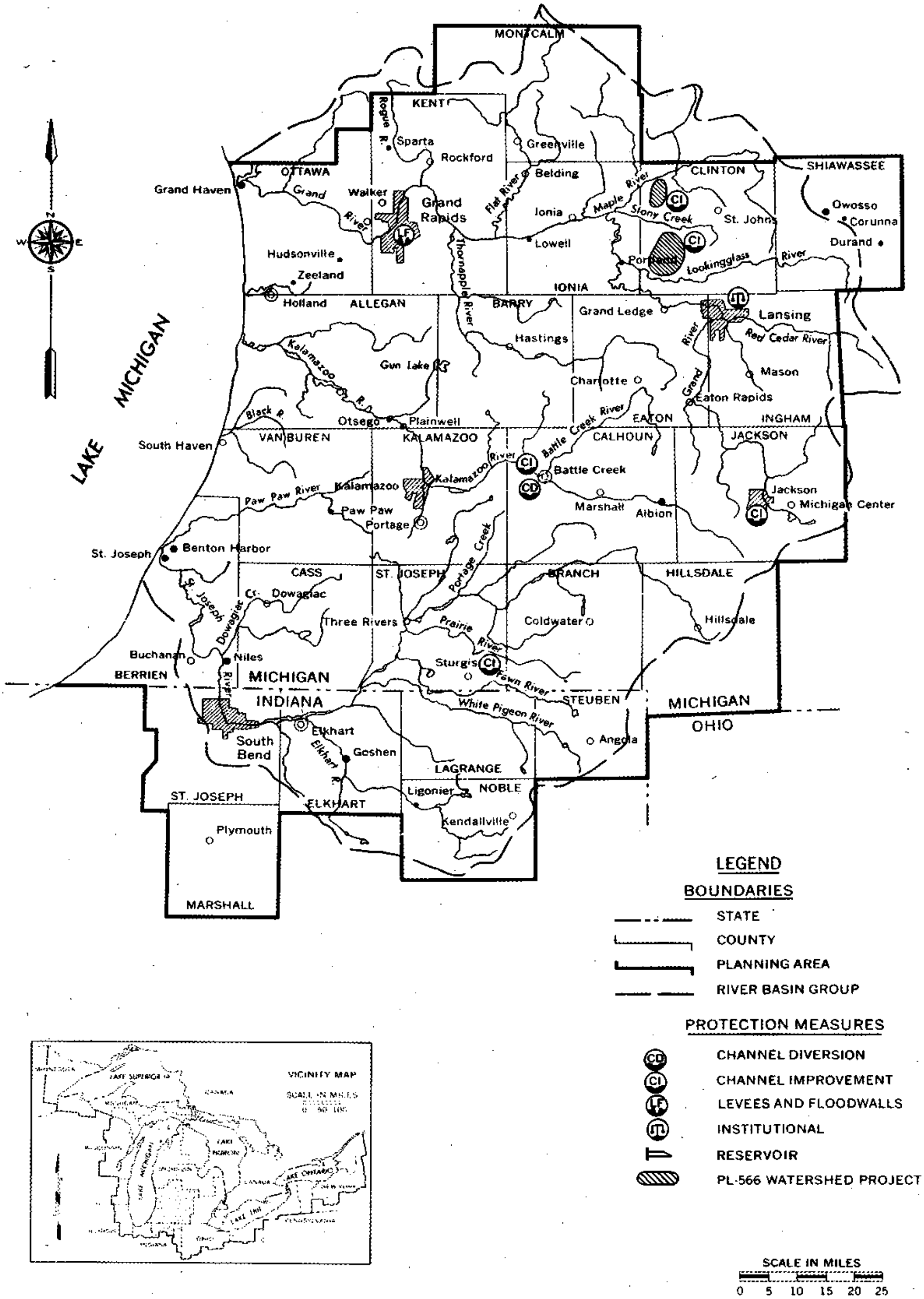

FIGURE 14-26 Existing Flood Damage Protection Measures for River Basin Group 2.3

(3) an interim report, dated July 22, 1949, covering the local flood problems at Kalamazoo and vicinity

(4) survey scope report of the entire Kalamazoo River basin, made under the provisions of House Document No. 308, 69th Congress, submitted to Congress in January 1932

(5) a consulting engineering firm's report for Battle Creek in 1927

1.15.3 Development in the Flood Plain

The Kalamazoo River basin supports a wide variety of industries located in many municipalities. Most of the major industries are concentrated in the population centers of Kalamazoo and Battle Creek. Other major centers are at Allegan, Otsego, Plainwell, Marshall, and Albion. The transportation network is extensive. The terrain does not confine the roads and railways to the river valleys. There are many north-south routes (highway and rail) cutting across the east-west trend of the basin.

Agricultural land in the Kalamazoo River basin is devoted chiefly to small dairy farms averaging 100 acres each. Fruits, grains, and vegetables are raised to a limited extent. The rich river bottom lands near Kalamazoo are famous as celery beds. Much of the land is good for agricultural purposes. However, large areas are swampy or poorly drained, and in the lower reaches of the basin and the soil is too sandy for successful farming. The flood plain of the main river from Plainwell through Kalamazoo and Battle Creek to Marshall consists of fairly level sand and gravel deposits free from large stones and normally covered with loam or clayey loam. These flat areas comprise the richest farmlands in the basin.

Most of the sites on the Kalamazoo River and its tributaries suitable for water power plants have been developed. In the steepest portion of the main river from Allegan to above Plainwell there are seven dams developing a total head of 98 feet.

1.15.4 Flood Problems

With rare exception, major floods in the Kalamazoo River basin have occurred as a result of heavy spring rains or snow, covering ground already partly saturated, at times when stream stages were already rising. The worst flood, which had a peak flow of 10,266 cfs, took place at Allegan, Michigan, in 1904. Slightly lesser floods occurred in 1887, 1908, 1918, 1947, and 1948. The floods of 1854, 1864, 1868, and 1869 are reported to have been greater than those of 1904 and 1908, but there are no records of actual stages for these earlier floods. Lesser floods have occurred at more frequent intervals, and minor floods almost annually. Since the majority of the recorded floods have occurred during the spring runoff periods, agricultural losses have been minimal. However, high intensity summer storms cause appreciable truck garden and other agricultural loss.

Kalamazoo is built on the lowlands adjacent to the Kalamazoo River and its tributary, Portage Creek. At the present time many of the major industries of the city are located in these areas, and the remaining undeveloped lowlands along the river, both upstream and downstream from the center of the city, are attractive locations for future industrial expansion. The flooding of these lowlands is due entirely to the inability of the natural river channel to carry the flood flow at a higher stage. The existing bridges have not materially restricted the flow during past floods because these bridges have passages equal to or greater than the adjacent channel.

The development at Battle Creek is similar, with the added detriment of having many buildings and bridges encroaching on the river floodway. Other urban areas experiencing minor flood damages are Allegan, Otsego, Plainwell, Marshall, and Albion. Problems in these places are due mainly to encroachment on the flood plain.

Figure 14–24c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–23 depicts the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–24 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–25c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–25. County summaries for the main stem and principal tributaries are tabulated in Table 14–26.

1.15.5 Existing Flood Damage Prevention Measures

The "Kalamazoo River Flood Control Project at Battle Creek, Michigan, and Vicinnty," was authorized by the Flood Control Act of

1954, approved September 3, 1954. The following sections of the plan have been completed under supervision of the U.S. Army Corps of Engineers:

(1) Kalamazoo River cutoff channel from Monroe Street dam to below confluence of Battle Creek and old Kalamazoo River channel

(2) widening and straightening of Kalamazoo River channel from confluence with Battle Creek to below Water Works Park downstream, stations 0+00 to 263+30

(3) portion of Battle Creek, upstream Jackson St. Bridge, stations 0+00 to 19+50. The remainder from stations 19+50 to 90+43 has been deferred at request of city.

(4) increased stream capacity to 11,000 cfs below confluence; 1,000 cfs diverted from Kalamazoo River to headrace. Upon completion of Battle Creek portion, 84 percent of damages will be eliminated. Location of this project is shown in Figure 14–26.

There are no other improvements by Federal agencies at this time. There are no State flood control projects in the basin. Kalamazoo has performed some dredging to deepen the channel through the city.

After the 1947 flood Battle Creek established a flood warning station with a permanent chief observer. Battle Creek has attempted to coordinate its planning and development along a course that would aid flood control, but no definite plan has been adopted. Kalamazoo has reclaimed adjacent lowlands for park purposes. Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to this river basin.

1.16 Lake Michigan Southeast, River Basin Group 2.3, Grand River Basin

1.16.1 Description

The Grand River basin has a drainage area of 5,572 square miles. Oval in shape, it is 135 miles long and has a maximum width of 70 miles. The Grand River itself is 260 miles long and drops 460 feet over its length. Location within River Basin Group 2.3 is shown in Figure 14–23. The river basin has a steep slope over half its length from its source to Ionia, but has a very flat slope for the remainder of its course to Lake Michigan. Most flood plains of the Grand River and the major tributaries are broad with only a few feet of water flowing in the channels. The stream banks retain the normal maximum annual flow, but the river valley has flooded to widths of 4,000 feet below Grand Rapids and Ionia when the banks have been overtopped.

The surface deposits in the Grand River basin are permeable glacial drift of great depth, so that the major part of precipitation runoff ordinarily reaches the stream by percolation. Therefore, low flows are high and well sustained in comparison with streams in other sections of the country.

The Grand River basin has six major tributaries. The Rogue, Flat, and Maple Rivers enter from the north, the Thornapple enters from the south, and the Lookingglass and Red Cedar Rivers enter from the east. The drainage area of these tributaries comprises 60 percent of the total drainage area of the basin.

1.16.2 Previous Studies

One of the main studies and sources of information for the Grand River basin is the "Comprehensive Water Resources Study, Grand River Basin, Appendix H," prepared by the U.S. Army Corps of Engineers, Detroit District, under supervision of the Grand River Basin Coordinating Committee. Other studies are listed below:

(1) 1971—Flood Hazard Analysis for Plaster Creek, Kent County, Michigan, prepared by the U.S. Soil Conservation Service

(2) 1971—Draft Watershed Work Plan for the Lower Maple River Watershed (Hayworth Creek), Gratiot and Clinton Counties, Michigan—prepared by the U.S. Soil Conservation Service

(3) 1970—Flood Plain Information Report, Grand River (at Lansing), Michigan—prepared by the Corps of Engineers

(4) 1970—Rogue River Watershed Investigation, Newaygo and Kent Counties, Michigan—prepared by the U.S. Soil Conservation Service

(5) 1969—Flood Plain Information Report, Grand River (Ingham and Eaton Counties), Michigan—prepared by the Corps of Engineers

(6) 1969—Flood Plain Information Report, Grand River (Lookingglass River, Clinton City), Michigan—prepared by the Corps of Engineers

(7) 1969—Watershed Work Plans for the Upper Maple River East and West Watersheds, Clinton and Shiawassee Counties,

Michigan—prepared by the U.S. Soil Conservation Service

(8) 1968—Flood Plain Information Report, Grand River (Red Cedar River, Ingham City), Michigan—prepared by the Corps of Engineers

(9) 1962—Interim Survey Report on Flood Control at Grandville—prepared by the Corps of Engineers

(10) 1961—Basin Plan for Great Lakes-St. Lawrence River Basin—prepared by the Corps of Engineers

(11) 1959—Interim Survey Report on Major Drainage and Flood Control for Portage River, Michigan—prepared by the Corps of Engineers and Soil Conservation Service, U.S. Department of Agriculture

(12) 1955—Flood Control Review Report (Survey Scope) Grand River, Michigan, with particular reference to Lansing, Michigan, and vicinity—prepared by the Corps of Engineers

(13) 1933—U.S. Army Corps of Engineers, 308 report, discussion of problems of water resources and development in the Grand River basin

1.16.3 Development in the Flood Plain

The dominant economic factors in the Grand River basin are industry, agriculture, and extraction and production of mineral resources. The sources of water supply for industry, municipalities, and agriculture are mostly wells, the Grand River itself, and Lake Michigan. Some of the industries use considerable quantities of water and because the Grand River serves as a major drainage outlet for all cities in the basin, further urban and industrial development will increase pollution in the river and limit its use as a major source of water supply. The Grand River basin includes three large metropolitan centers, Jackson, Lansing, and Grand Rapids, which all have flood plain areas.

Extensive deposits of sand and gravel are located throughout the basin, particularly along the lower reaches of the Grand River in Kent and Ottawa Counties. A large portion of the sand and gravel is transported by barge on the Grand River below Grand Rapids. A deep-draft harbor is maintained at Grand Haven for a distance of approximately 3 miles upriver. This area averaged more than 3 million tons of cargo, mostly sand and gravel, during the past five years.

Although many highway and rail routes cross the Grand River flood plain, the transportation paths are not confined to the flood plain by reason of topography. The roads and rail lines crisscross the basin mainly to link the many urban centers located along the main stem of the Grand River. The routes stretch cross-country on the shortest line between towns. There are more than 100 major road, highway, and railway bridges crossing the Grand River and its tributaries. The larger communities, Grand Rapids, Lansing, Jackson, have a significant number of road bridges linking the bisected urban districts. The bridges located in areas where flood problems occur have been well cataloged. Except for the new expressway bridges, the vast majority of road bridges create a head loss and impede the flow of flood waters. The cost for mass removal and replacement of all these bridges would be prohibitive, but definite flood capacity standards should be designed into all new bridge construction and modernization.

More than one-half of the Grand River basin area is cropland, but the agricultural use of the flood plain lands is minimal. This pattern has developed for several reasons:

(1) On the river above Portland and on the upper reaches of the tributaries, the flood plain is narrow in width and seldom flat. Abrupt changes in grade away from the river are common.

(2) The soils are not especially fertile, and therefore, usually not cultivated.

(3) Crop damages have been minor because most floods usually occur in the late winter or early spring before the crops are planted. There are a few farm houses or other rural structures in the flood plain.

Many dams and reservoirs are present on the Grand River and its tributaries. These dams are normally very small, and most have not been used actively for the protection of the flood plains against excessive river flows. Reservoirs are small and are formed behind power and water control dams. Most of the reservoirs have large growths of vegetation which have increased organic materials and thus greatly reduced the storage capacity and recreational area of the reservoirs. Appendix 2, *Surface Water Hydrology*, contains a complete listing of existing dam sites in the Grand River basin.

1.16.4 Flood Problems

Most of the floods in the Grand River basin occur in the spring as warm rains fall on frozen snow-covered ground or on saturated ground. Frequently temperatures rise rapidly before the ice is out of the channel so that the river's capacity to handle the flow is reduced. Ice jams often form and aggravate the situation. Maximum unit discharges in the Grand River basin reach 11 to 20 cfs per square mile of drainage area, which is higher than the peaks for adjacent drainage areas in southern Michigan. Spring floods and high intensity summer floods are normal in the basin, and localized thunder showers create flood conditions in upriver communities. These local peak flows usually do not produce flood conditions at communities located further downstream. The major flood of record on the Grand River in March 1904 was caused by moderate rainfall in conjunction with runoff of snow melt due to high temperatures. Maximum discharges of 54,000 cfs at Grand Rapids and 24,500 at Lansing were recorded in 1904. Other major floods of slightly less intensity occurred along the main river channel in March 1948, April 1947, March 1918, March 1908, and June 1905. Water surface elevations above flood stage were reached twice in the spring of 1949 and three times in the spring of 1950, due to separate snow melts and high intensity rainfalls. The urban areas subject to flooding in the basin are located primarily along the main stem of the Grand River and along the lower reaches of the major tributaries.

Table 14–22 lists flood damage centers located in the basin. Figure 14–24c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–23 depicts the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–24 depicts upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–25c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–25. County summaries for the main stem and principal tributaries are tabulated in Table 14–26.

1.16.5 Existing Flood Damage Prevention Measures

Following the March 1904 flood, Grand Rapids spent approximately $1,000,000 for the construction of flood retaining walls and levees with accompanying interior drainage. These walls were designed with a 2-foot freeboard allowance over the stages reached during the 1904 flood. Their effectiveness is indicated by the fact that flood damage since their construction has been confined to the southwestern section of the city which is not protected by the walls. The 1948 flood crested within 2 feet of the top of these walls. Because of channel sedimentation and encroachment of the walls into the natural flood plain, a flood of the 1904 magnitude would probably overflow the floodwalls. The streets on both sides of the Grand River in this section are several feet below the floodwall and contain the downtown area of Grand Rapids on the left bank and numerous small service businesses, large and small industries, and residential areas along the right bank.

The City of Jackson modified the Grand River channel by encasing the river in a concrete conduit placed on the existing riverbed through the central business district and by widening and straightening the river channel from Jackson Road to Berry Road, approximately 8 miles north of Jackson. Most of the concrete conduit is exposed, except for a small section buried under buildings along both sides of Michigan Avenue.

The U.S. Soil Conservation Service, the Clinton County Soil Conservation District, and the Clinton County Drain Commission constructed the Catlin Waters Watershed Project and the Muskrat Creek Watershed Project.

Location of these flood damage prevention measures is illustrated in Figure 14–26.

No other flood control projects of consequence have been constructed by the Grand River basin communities. Low-head power dams have been constructed and maintained, but the storage capacity of these structures is so limited that they have little effect on flood conditions downstream.

Nonstructural preventive measures fall mainly into two categories: advance warning and flood plain regulation.

The issuance of forecasts of the possible occurrence of a natural disaster is the responsibility of the National Weather Service. The extent and severity of floods depend directly on the amount and occurrence of precipitation. The occurrences of rainfall are forecast for the State of Michigan by the Weather Service in Chicago. Characteristics furnished by the forecast include the time of occurrence (24-hour period), area distribution (by sectional classification), and a general statement of the amount of rainfall expected. The entire Grand River basin has radar coverage from Chicago, Detroit, and Muskegon weather stations. Rainfall forecasts are not presently used in flood forecasting. Flood forecasts are presently based on existing conditions. Whenever measured rainfall amounts exceed 0.5 inches, they are telephoned to the Lansing or Grand Rapids River District Offices. The Lansing District is responsible for flood forecasting on the Grand River from Jackson to Grand Ledge and the Red Cedar River at East Lansing. The Grand Rapids District is responsible for the Grand River downstream from Grand Ledge to Grand Rapids. The responsibility to warn or alert the Federal, military, and civilian authorities, State and local officials, and the civilian population of this forecast is the duty of the Defense Civil Preparedness Agency.

Flood plain information and regulation presents the theory that prevention is worth many millions of dollars in cures. Flood data and reasonable regulations can be used to guide and control developments in flood hazard areas, thereby preventing an increase in flood damage. Such controls have been adopted by many communities and have been accepted as a practical way to assure safe development and to prevent flood disasters. Lansing has adopted flood plain legislation as a means of guiding and controlling development in flood plains. The townships of Meridian, Delhi, Windsor, and Bath have also adopted flood plain legislation. Appendix S20, *State Laws, Policies, and Institutional Arrangements*, includes a more detailed discussion of flood plain legislation.

1.17 Lake Michigan Southeast, River Basin Group 2.3, Ottawa Complex

1.17.1 Description

The Black River rises in the southern part of Michigan's Lower Peninsula in Ottawa County. It flows westerly and empties into Lake Michigan downstream from the Village of Holland. The basin is 24 miles long and 24 miles wide at the extreme point and is shaped like a triangle. Location of the complex within River Basin Group 2.3 is shown in Figure 14–23.

The entire watershed is generally undulating with prairie, swamp, and hilly sections alternating at frequent intervals. Many small lakes and springs are scattered throughout the watershed. Ponded water stands throughout the basin for part of the year.

1.17.2 Previous Studies

A preliminary investigation report on the Black River watershed in Ottawa and Allegan Counties was prepared in 1962.

1.17.3 Development in the Flood Plain

The Black River flood plains are primarily agricultural. Severe agricultural flooding and associated drainage problems have occurred as a result of spring rains and snowmelt on saturated ground. Damages are tabulated in Table 14–24. Location of these damages within particular watersheds may be seen in Figure 14–25c. Summations of estimated average annual damage and acres in the flood plain are shown by river basin in Table 14–25.

1.17.4 Existing Flood Damage Prevention Measures

No Federal flood control projects have been constructed in the complex. Refer to Subsection 1.14.5 for discussion of flood plain legislation applicable to this complex.

1.18 Lake Michigan Northeast, River Basin Group 2.4, Muskegon River Basin

1.18.1 Description

The Muskegon River basin has a drainage area of approximately 2,644 square miles lying in the northwestern part of Michigan's Lower Peninsula. It is an irregularly shaped basin spreading over parts of several counties. Location within River Basin Group 2.4 is shown in Figure 14–27. The basin is 120 miles long and ranges in width from 10 to 40 miles. The main stem of the Muskegon River flows 227 miles in a southwesterly direction from its source at Houghton and Higgins Lakes to its mouth at Lake Michigan. The source of the river is in an upland region at an altitude of more than 1,100 feet, and the river descends 575 feet to Lake Michigan. It descends rather gradually and at a uniform rate over most of its length. There are few rapids or falls, and most of those originally existing have been flooded by backwater from power dams. Average fall is 2½ feet per mile with a slope of 4.4 feet per mile occurring between Hersey and Newaygo. There are no large tributaries. The

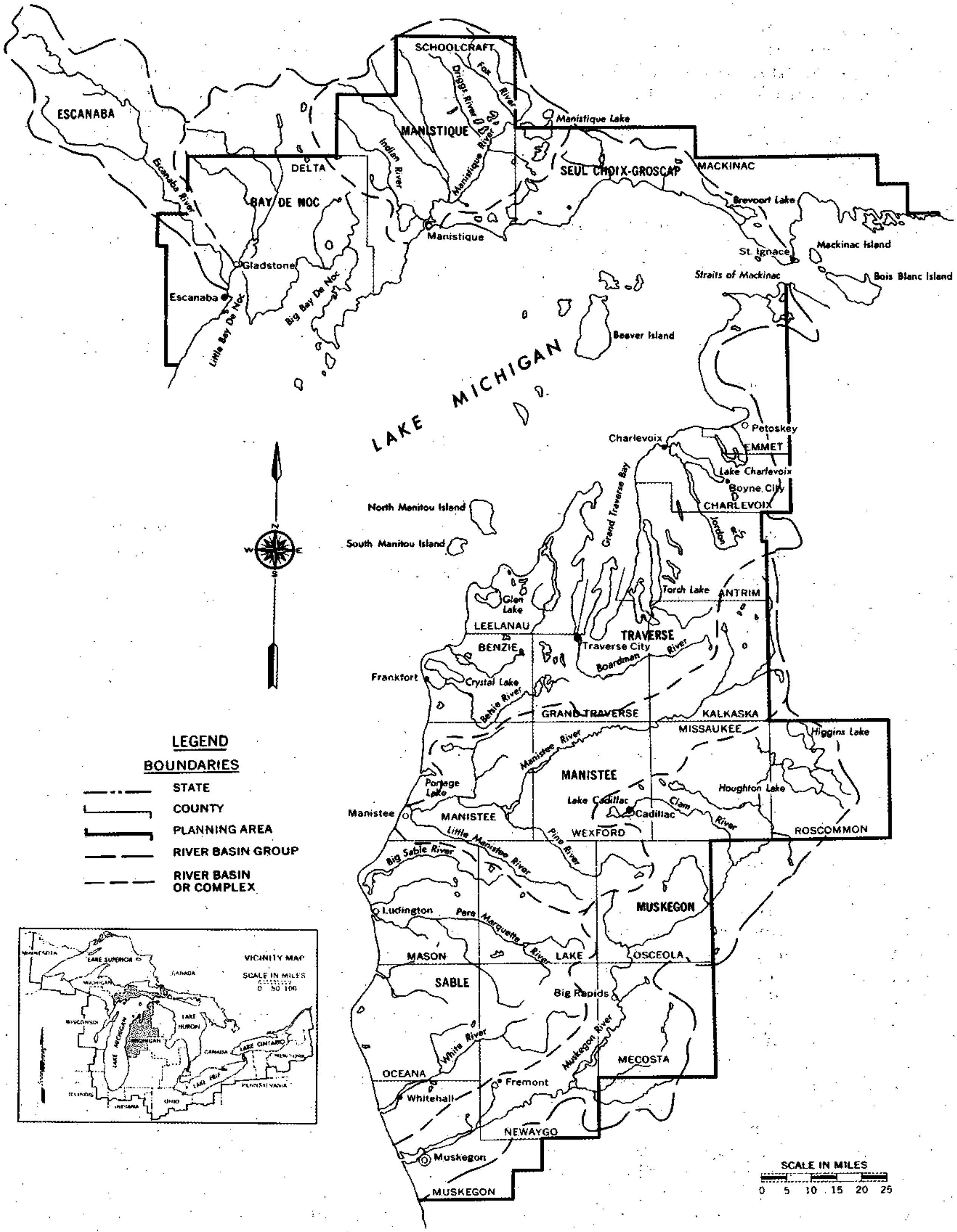

FIGURE 14-27 Lake Michigan Northeast—River Basin Group 2.4

principal small tributaries are the Clam River and Hersey Creek from the right bank and the Little Muskegon River from the left bank. The river expands into Muskegon Lake 5½ miles above the mouth.

The drainage basin consists for the most part of high, gently rolling, sandy plains which are generally thinly populated and covered with second-growth timber. The region is covered with thick glacial drift, and the river has cut a deep channel through these deposits forming valley banks 50 to 150 feet high along the lower 125 miles.

1.18.2 Previous Studies

Previous studies are listed below:

(1) 1960—The Michigan Water Resources Commission report, "Drought Flow of Michigan Streams," gives information on low-flow conditions expected in the basin.

(2) 1931—A 308 report by the Corps of Engineers, published on December 10, 1931, as House Document No. 143, reports on the Muskegon River and covers navigation, flood control, power development, and irrigation. It concluded that flood control was not necessary at the time.

1.18.3 Development in the Flood Plain

The entire Muskegon River below Houghton Lake was extensively used for logging in the latter part of the 19th century. The forests were cut indiscriminately, and the industry declined rapidly after 1900. The lumbering activities of today are confined mainly to harvesting the second-growth timber for pulp uses. Many of the population centers of the logging era were abandoned with the demise of the industry and most of the towns existing today survive on resort and vacation trade. The major cities of the basin include Muskegon, a heavy industry and transportation center surrounding the river mouth at Lake Michigan; Big Rapids, a former furniture center 95 miles upstream, now experiencing rapid growth under the impetus of expanding Ferris State College; and Cadillac, a light industry and vacation center located in the headwater tributary area, currently reaping the benefits of the summer-winter sports boom.

There are five dams across the main river. The one at Big Rapids is an old structure, built in the early lumbering days. Three others are the Croton, Hardy and Rogers Dams which are concrete and earth filled structures used for electric-power development. The fifth is the Reedsburg Dam located in the Deadstream area. The pools behind these dams are becoming increasingly more important as sites for recreation activities. There are also some small dams on the tributaries which have been used for power development. None of the dams are provided with locks for navigation purposes.

Agricultural activity is of minor importance with much of the bottom land in the river valley entirely unsuited for cultivation.

1.18.4 Flood Problems

There have been no general flood problems in the basin. The flow of the main stem is regulated by the impounding reservoirs serving the hydropower dams. The maximum flood flow of 14,950 cfs occurred in 1913. The average flow by the Newaygo gage is approximately 2000 cfs. In the lower half of the Muskegon River the low banks of the river are usually only a few feet above normal water level, with high valley banks a few hundred feet to one mile apart. These bottom lands are subject to frequent overflows, but because they have generally remained unoccupied swamp and brush, damages have been minimal. Through the Cities of Newaygo and Big Rapids the river banks are high, and most flood waters are contained with little damage. The City of Muskegon is not subject to flooding because the level of Muskegon Lake and the connecting channel remain at the approximate level of Lake Michigan.

Figure 14–28c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–27 shows the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–28 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–29c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–29. County summaries for the main stem and principal tributaries are tabulated in Table 14–30.

TABLE 14-27 Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 2.4

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	MUSKEGON RIVER												
AB1	Muskegon	T10N	T10N	1970		3,000	5		20	9900		9,925	
		R17W S28	R15W S4	1980	1,400	2,800	85	60	60	9720	145	9,780	
				2000	2,400	4,800	165	100	100	9560	285	9,640	
				2020	4,400	8,800	200	150	180	9395	410	9,515	
AB2	Newago	T10N	T13N	1970		5,000			40	2010		2,050	
		R15W S4	R11W S1	1980		7,000			80	1970		2,050	
				2000		12,000			100	1930		2,050	
				2020		22,000			120	1950		2,050	
AB3	Mecosta	T13N	T16N	1970		3,000			30	1200		1,230	
		R11W S1	R9W S5	1980		4,000			65	1140		1,205	
				2000		5,200			80	1080		1,160	
				2020		12,200			125	1020		1,145	
AB3A	Mecosta	Big Rapids		1970	4,000			15		30	45		
				1980	5,800			40		30	70		
				2000	11,600			80		35	115		
				2020	18,600			90		40	130		
	WHITE RIVER												
AC1	Muskegon	T11N	T12N	1970		2,500			50	3277		3,327	
		R18W S2	R16W S4	1980		3,250			70	3257		3,327	
				2000		4,250			90	3237		3,327	
				2020		6,000			110	3217		3,327	
	PERE MARQUETTE RIVER												
AC2	Mason	T18N	T18N	1970		3,000			30	8700		8,730	
		R18W S15	R15W S24	1980	500	3,400	40		90	8600	40	8,690	
				2000	1,500	4,800	70	20	130	8510	90	8,640	
				2020	4,500	5,700	100	40	150	8440	140	8,590	
	MANISTEE RIVER												
AD1	Manistee	T21N	T23N	1970	2,000	1,000		15	15	10200	15	10,215	
		R17W S11	R13W S25	1980	2,800	1,400	20	15	45	10150	35	10,195	
				2000	4,800	2,400	40	20	60	10110	60	10,170	
				2020	8,800	4,400	60	30	80	10060	90	10,140	
AD2	Wexford	T23N	T24N	1970		2,000			40	4435		4,475	
		R13W S25	R9W S1	1980		2,400			120	4355		4,475	
				2000		2,800			180	4295		4,475	
				2020		3,600			200	4275		4,475	
	BOARDMAN RIVER												
AE1	Grand Traverse	T27N	T27N	1970		2,000			30	4843		4,843	
		R11W S2	R9W S25	1980		2,300			60	4813		4,873	
				2000		3,000			80	4797		4,873	
				2020		3,800			100	4773		4,873	
	MANISTIQUE RIVER												
AH1	School-craft	T41N	T45N	1970	7,500		5			3000	5	3,000	Includes Manistique
		R16W S13	R13W S36	1980	7,500	300	5		40	2960	5	3,000	Same
				2000	7,500	500	15		80	2910	15	2,990	Same
				2020	7,500	1,500	20		120	2865	20	2,985	Same
AH2	Mackinac	T45N	Manistique Lake	1970		28,200			100	300		400	Includes Manistique Lake
		R13W S36		1980		36,700			120	280		400	Same
				2000		45,100			140	260		400	Same
				2020		59,200			150	250		400	Same
	INDIAN RIVER												
AH3	School-craft	T41N	Indian Lake Inlet	1970		29,700			40	1600		1,640	
		R16W S1		1980		30,900			80	1560		1,640	
				2000		31,800			100	1540		1,640	
				2020		34,700			120	1520		1,640	
	ESCANABA RIVER												
AJ1	Delta	T39N	T41N	1970		2,632			6	3004		3,010	
		R22W S18	R24W S2	1980		2,847			6	3004		3,010	
				2000		3,242			6	3004		3,010	
				2020		3,875			6	3004		3,010	

TABLE 14–28 Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 2.4

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	RURAL	TOTAL	ESTIMATED ACRES IN FLOOD PLAIN CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		MANISTEE RIVER - MICHIGAN											
5F	1970	--	100	100	--	300	950	550	--	--	--	--	1,800
5F2	1970	2,800	--	2,800	--	80	1,030	190	--	65	5	70	1,300
5F3	1970	--	100	100	25	75	300	125	--	--	--	--	525
5F3A	1970	--	--	--	6	64	192	118	--	--	--	--	380
Total	1970	2,800	200	3,000	31	519	2,472	983	--	65	5	70	4,005
	1980	3,700	300	4,000	31	519	2,472	983	--	65	5	70	4,005
	2000	6,600	400	7,000	31	519	2,472	983	--	65	5	70	4,005
	2020	12,500	400	12,900	31	519	2,472	983	--	65	5	70	4,005
		MUSKEGON RIVER - MICHIGAN											
5II	1970	--	4,400	4,400	150	--	350	--	--	--	--	--	500
5E2A	1970	1,000	100	1,100	70	80	200	50	--	2	98	100	400
5E2	1970	--	2,000	2,000	1,520	550	1,770	455	--	--	--	--	4,295
5E3	1970	--	300	300	250	200	550	250	--	--	--	--	1,250
5E6A1	1970	--	400	400	200	600	--	--	--	--	--	--	800
5E	1970	2,000	18,400	20,400	1,000	1,520	3,600	1,000	10	100	--	110	7,120
Total	1970	3,000	25,600	28,600	3,190	2,950	6,470	1,755	10	102	98	210	14,365
	1980	4,000	36,600	40,600	3,190	2,950	6,470	1,755	10	102	98	210	14,365
	2000	7,100	46,600	53,700	3,190	2,950	6,470	1,755	10	102	98	210	14,365
	2020	13,400	48,400	61,800	3,190	2,950	6,470	1,755	10	102	98	210	14,365
		SABLE COMPLEX - MICHIGAN											
5DD	1970	--	100	100	--	200	--	--	--	--	--	--	200
5EE5	1970	--	100	100	50	200	400	150	--	--	--	--	800
5HH	1970	--	--	--	10	10	900	--	--	--	--	--	920
5HH1	1970	--	100	100	--	156	1,324	--	--	--	--	--	1,480
5HH2	1970	--	400	400	--	1,000	4,290	2,000	--	--	--	--	7,290
551	1970	--	1,700	1,700	40	10	--	--	--	--	--	--	50
548A	1970	--	2,100	2,100	1,090	1,000	--	--	--	--	--	--	2,090
563	1970	800	100	900	--	115	200	125	--	--	20	20	440
5CC	1970	4,600	300	4,900	200	500	500	--	--	1,000	--	1,000	1,200
5EE	1970	100	100	200	--	200	500	--	--	--	20	20	700
5EE2	1970	--	300	300	100	1,000	1,720	500	--	--	--	--	3,320
5EE2A	1970	--	17,200	17,200	3,500	236	20	--	--	--	--	--	3,756
Total	1970	5,500	22,500	28,000	4,990	4,627	9,854	2,775	--	1,000	40	1,040	22,246
	1980	7,300	32,200	39,500	4,990	4,627	9,854	2,775	--	1,000	40	1,040	22,246
	2000	13,000	41,000	54,000	4,990	4,627	9,854	2,775	--	1,000	40	1,040	22,246
	2020	24,600	42,500	67,100	4,990	4,627	9,854	2,775	--	1,000	40	1,040	22,246
		SEUL CHOIX GROSCAP - MICHIGAN											
536A	1970	--	300	300	200	100	50	50	--	--	--	--	400
	1980	--	400	400	200	100	50	50	--	--	--	--	400
	2000	--	500	500	200	100	50	50	--	--	--	--	400
	2020	--	600	600	200	100	50	50	--	--	--	--	400
		TRAVERSE COMPLEX - MICHIGAN											
540	1970	4,000	--	4,000	--	--	--	--	--	--	100	100	--
542	1970	1,600	--	1,600	--	--	--	--	--	40	--	40	--
5X	1970	--	100	100	80	300	200	100	--	--	--	--	680
5BB	1970	--	200	200	100	120	375	55	--	--	--	--	650
547	1970	--	--	--	--	150	600	450	--	--	--	--	1,200
550	1970	--	--	--	--	40	546	--	--	--	--	--	586
Total	1970	5,600	300	5,900	180	610	1,721	605	--	40	100	140	3,116
	1980	7,400	400	7,800	180	610	1,721	605	--	40	100	140	3,116
	2000	13,300	500	13,800	180	610	1,721	605	--	40	100	140	3,116
	2020	25,000	600	25,600	180	610	1,721	605	--	40	100	140	3,116
		BAY DE NOC COMPLEX - MICHIGAN											
5T	1970	400	100	500	--	160	--	--	10	--	--	10	160
5T1	1970	--	12,300	12,300	7,500	775	500	250	--	--	--	--	9,025
5T2	1970	--	3,300	3,300	2,000	300	300	400	--	--	--	--	3,000
Total	1970	400	15,700	16,100	9,500	1,235	800	650	10	--	--	10	12,185
	1980	500	22,500	23,000	9,500	1,235	800	650	10	--	--	10	12,185
	2000	900	28,600	29,500	9,500	1,235	800	650	10	--	--	10	12,185
	2020	1,800	29,700	31,500	9,500	1,235	800	650	10	--	--	10	12,185

TABLE 14–28(continued) Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 2.4

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)			ESTIMATED ACRES IN FLOOD PLAIN								
		URBAN	RURAL	TOTAL	CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		ESCANABA RIVER - MICHIGAN											
5L3	1970	--	200	200	100	300	1,200	200	--	--	--	--	1,800
5L4	1970	6,000	300	6,300	160	160	180	1,100	30	120	--	150	1,600
Total	1970	6,000	500	6,500	260	460	1,380	1,300	30	120	--	150	3,400
	1980	8,000	700	8,700	260	460	1,380	1,300	30	120	--	150	3,400
	2000	14,200	900	15,100	260	460	1,380	1,300	30	120	--	150	3,400
	2020	26,800	900	27,700	260	460	1,380	1,300	30	120	--	150	3,400
		MANISTIQUE RIVER - MICHIGAN											
5M	1970	60,000	--	60,000	--	--	--	--	400	1,000	100	1,500	--
5M5	1970	2,000	--	2,000	--	--	--	--	25	25	--	50	--
Total	1970	62,000	--	62,000	--	--	--	--	425	1,025	100	1,550	--
	1980	82,500	--	82,500	--	--	--	--	425	1,025	100	1,550	--
	2000	146,900	--	146,900	--	--	--	--	425	1,025	100	1,550	--
	2020	277,100	--	277,100	--	--	--	--	425	1,025	100	1,550	--

1.18.5 Existing Flood Damage Prevention Measures

There are no structural flood control projects in the Muskegon River basin. Although the dams along the main stem and some tributaries serve to regulate river stages, their primary purpose is the development of hydroelectric power. The Corps of Engineers maintains a navigation channel at 27 feet through Lake Muskegon, but its influence on upstream river stages is negligible.

The Michigan Water Resources Commission has the responsibility and authority to regulate all development in flood plain areas. This authority is of increasing importance as more and more river frontage is occupied for recreational living. Subsection 1.14.5 contains a discussion of flood plain legislation applicable to this river basin.

1.19 Lake Michigan Northeast, River Basin Group 2.4, Sable Complex

1.19.1 Description

The Sable complex is primarily drained by the Pere Marquette River, draining an area of 792 square miles; the White River, draining an area of 492 square miles; and the Big Sable River, draining an area of 164 square miles. The total complex drains an area of approximately 1,941 square miles. Its location within River Basin Group 2.4 is shown in Figure 14–27.

The Pere Marquette basin is approximately 45 miles long and 25 miles wide at its extreme points. The South Branch, the major tributary, joins the main stem 15 miles from the mouth. The terrain is mainly high outwash plains with moraines and till plains. Predominately sandy and gravelly, the soils are extremely well drained.

The Big Sable River basin measures approximately 30 miles long and 8 miles wide at its longest and widest points. There are no major tributaries, and the river flows into Hamlin Lake before entering Lake Michigan. Terrain and soil features are similar to those of the Pere Marquette basin.

Measuring approximately 45 miles long, the White River basin is 15 miles at its widest point. There are no important tributaries, and the river broadens to form White Lake before emptying into Lake Michigan. Terrain and soil features are similar to those of the Pere Marquette basin.

1.19.2 Previous Studies

Previous studies are listed below:

(1) A "Watershed Work Plan for the Black Creek-Mason Watershed" was prepared by

the U.S. Soil Conservation Service in 1963 and supplemented in 1967.

(2) An unfavorable preliminary investigation report dated November 8, 1913, was made by the Corps of Engineers on the Pere Marquette River.

1.19.3 Development in the Flood Plain

The greater portion of the population of the Sable complex is located in the towns near the mouth of the rivers. These localities are largely resort areas with some light industry catering to fruit processing. The hillsides of this region, especially those adjacent to the Lake Michigan shoreline, are cultivated with a variety of orchard crops. The flood plains are narrow and relatively unoccupied.

The marsh area surrounding the mouth of the Pere Marquette River at Ludington is undergoing land-fill operations for industrial expansion. Whether this encroachment will present discharge problems is yet to be seen.

There are also cottages being built along the stream banks for the tourist industry.

1.19.4 Flood Problems

Flooding has not been a serious problem in the Sable complex in past years. Largely because of the thin spread of the population in the area, the narrow extent of flood plain development, the high filtration rates of the soils, and the small expanse of the drainage areas, any flooding is local and extremely limited.

However, the indiscriminate occupation of stream banks by seasonal homes could easily contribute to increased flood damages. Implementation of flood plain regulations is essential to prevent serious losses in the future.

Figure 14–28c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–27 shows the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–28 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–29c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–29. County summaries for the main stem and principal tributaries are tabulated in Table 14–30.

1.19.5 Existing Flood Damage Prevention Measures

There are no existing structural flood control measures in the Pere Marquette basin. Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to this complex.

1.20 Lake Michigan Northeast, River Basin Group 2.4, Manistee River Basin

1.20.1 Description

The Manistee River basin, with a drainage area of approximately 2,006 square miles, has an irregular shape covering several counties in the northwestern part of the Lower Peninsula. Location within River Basin Group 2.4 is shown in Figure 14–27. The main stem of the Manistee River flows southwesterly for 170 miles. Just above its mouth at Lake Michigan it widens to form Manistee Lake with depths from 30 to 45 feet. The basin has a maximum width of 40 miles in the lower half, but contracts in the upper 50 miles into a narrow section only 15 miles wide. The headwaters originate in an area of small lakes, while the principal tributaries, the Little Manistee River and the Pine River, enter the main stem from the south. Total fall is 555 feet for an average drop of 3½ feet per mile.

This watershed is a region of deep glacial drift (up to 800 feet thick) consisting of mostly sandy plains cut in some places by clay ridges. The river has cut a deep channel through this drift deposit, and the valley banks along the lower 100 miles are generally 50 to 200 feet high and ¼ to one mile back from the river bed.

1.20.2 Previous Studies

The report of 1931, made under the provision of House Document 308, 69th Congress, covered all phases of water resources development in the Manistee River basin. It concluded that development of the stream for navigation, water power, flood control, and irrigation was not economically justified at that time.

1.20.3 Development in the Flood Plain

On the whole, the basin and flood plain areas

TABLE 14–29 Data Summary by River Basin, River Basin Group 2.4

River Basin	Year	Estimated Average Annual Damage (Dollars)		Estimated Acres In Flood Plain	
		Urban	Rural	Urban	Rural
Muskegon River	1970	7,000	36,600	255	27,570
	1980	11,200	50,400	425	27,400
	2000	21,100	68,600	610	27,215
	2020	36,400	91,400	750	27,075
Sable Complex	1970	5,500	28,000	1,040	34,303
	1980	7,800	38,850	1,080	34,263
	2000	14,500	50,050	1,130	34,213
	2020	29,100	54,200	1,180	34,163
Manistee River	1970	4,800	3,200	85	18,695
	1980	6,500	4,100	105	18,675
	2000	11,400	5,600	130	18,650
	2020	21,300	8,400	160	18,620
Traverse Complex	1970	5,600	2,300	140	7,989
	1980	7,400	2,700	140	7,989
	2000	13,300	3,500	140	7,989
	2020	25,000	4,400	140	7,989
Seul Choix-Groscap Complex	1970	-	300	-	400
	1980	-	400	-	400
	2000	-	500	-	400
	2020	-	600	-	400
Manistique River	1970	69,500	57,900	1,555	5,040
	1980	90,000	67,900	1,555	5,040
	2000	154,400	77,400	1,565	5,030
	2020	284,600	95,400	1,570	5,025
Bay de Noc Complex	1970	400	15,700	10	12,185
	1980	500	22,500	10	12,185
	2000	900	28,600	10	12,185
	2020	1,800	29,700	10	12,185
Escanaba River	1970	6,000	3,132	150	6,410
	1980	8,000	3,547	150	6,410
	2000	14,200	4,142	150	6,410
	2020	26,800	4,775	150	6,410
TOTAL	1970	98,800	147,132	3,235	112,592
	1980	131,400	190,397	3,465	112,362
	2000	229,800	238,392	3,735	112,092
	2020	425,000	288,875	3,960	111,867

are sparsely settled. The largest city, Manistee, is located at the mouth of Manistee River and has several large industrial operations located along the shores of Manistee Lake. There are at least 25 highway and railway bridges over the lower 162 miles of the Manistee River. Three of the bridges in Manistee are of the bascule type. In the lumber boom days of the latter 19th century, the river was used extensively for floating logs to the sawmills. Agricultural activity is of minor importance in the basin and the flood plains are little used for this purpose. There are four water power developments in the basin, and two dams on the main stem have a total head of 123 feet.

1.20.4 Flood Problems

River flow is unusually regular in this watershed. The streams receive much of their supply from springs along the banks. Ordinarily floods rise only 4 to 5 feet above low water and overflow only swampy, brush-covered lands between the high secondary banks. The towns and villages are located outside these areas and have experienced little if any flood damage. The pressures for recreational land could create some careless use of these flood-prone bottom lands. Local government should exercise enforcement powers to prevent such potentially costly development.

Figure 14–28c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–27 shows the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–28 indicates upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–29c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–29. County summaries for the main stem and principal tributaries are tabulated in Table 14–30.

1.20.5 Existing Flood Damage Prevention Measures

There are no existing structural flood control measures in the basin. Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to this river basin.

1.21 Lake Michigan Northeast, River Basin Group 2.4, Traverse Complex

1.21.1 Description

The Boardman River basin, with a drainage area of approximately 347 square miles, is the largest of this complex. With headwaters in Kalkaska County, the river flows westerly to a point approximately 7 miles south of Traverse City and then northerly to its mouth in the West Arm of Grand Traverse Bay. Location of the complex within River Basin Group 2.4 is shown in Figure 14–27. The basin measures approximately 32 miles long and 12 miles wide. There are no major tributaries.

The only other river of significant size is the Betsie River, draining an area of 260 square miles. This river has its headwaters in Grand Traverse County and flows into Lake Michigan at Frankfort. The main stem is approximately 40 miles long.

The topography of the area is composed of sandy outwash plains interlaced with relatively hilly moraines, also having well drained sandy loam soils. The shoreline in the southern portion of the watershed is bordered by large sand dune formations, notably the Sleeping Bear dune near Empire, Michigan.

1.21.2 Previous Studies

There have been no flood control reports published for the Traverse complex.

1.21.3 Development in the Flood Plain

Much of the population of this relatively sparsely settled region is concentrated in the towns located at the river mouths along the Lake Michigan shoreline. Farming is concentrated in fruit orchards and dairying, neither of which use the flood plains to any extent. The attractions of summer-winter sports activities have created a heavy demand for recreational lands accompanied by the development of river and lake shoreline properties throughout the area.

1.21.4 Flood Problems

Any flood damages reported in the past have been minor. Charlevoix, Boyne City, and Traverse City have experienced flood problems.

TABLE 14–30 River Basin Group 2.4, Data Summary by County

County (Michigan)	Estimated Average Annual Damages (Dollars)		Estimated Acres in Flood Plain	
	Urban	Rural	Urban	Rural
YEAR 1970				
Delta	---	2,632	---	3,010
Grand Traverse	---	2,000	---	4,873
Mackinac	---	28,200	---	400
Manistee	2,000	1,000	15	10,215
Mason	---	3,000	---	8,730
Mecosta	4,000	3,000	45	1,230
Muskegon	---	5,500	---	13,252
Newaygo	---	5,000	---	2,050
Schoolcraft	7,500	29,700	5	4,640
Wexford	---	2,000	---	4,475
TOTALS	13,500	82,032	65	52,875
YEAR 1980				
Delta	---	2,847	---	3,010
Grand Traverse	---	2,300	---	4,873
Mackinac	---	36,700	---	400
Manistee	2,800	1,400	35	10,195
Mason	500	3,400	40	8,690
Mecosta	5,800	4,000	70	1,205
Muskegon	1,400	6,050	145	13,107
Newaygo	---	7,000	---	2,050
Schoolcraft	7,500	31,200	5	4,640
Wexford	---	2,400	---	4,475
TOTALS	18,000	97,297	295	52,645
YEAR 2000				
Delta	---	3,242	---	3,010
Grand Traverse	---	3,000	---	4,873
Mackinac	---	45,100	---	400
Manistee	4,800	2,400	60	10,170
Mason	1,500	4,800	90	8,640
Mecosta	11,600	5,200	115	1,160
Muskegon	2,400	9,050	285	12,967
Newaygo	---	12,000	---	2,050
Schoolcraft	7,500	32,300	15	4,630
Wexford	---	2,800	---	4,475
TOTALS	27,800	119,892	565	52,375
YEAR 2020				
Delta	---	3,875	---	3,010
Grand Traverse	---	3,800	---	4,873
Mackinac	---	59,200	---	400
Manistee	8,800	4,400	90	10,140
Mason	4,500	5,700	140	8,590
Mecosta	18,600	12,200	130	1,145
Muskegon	4,400	14,800	410	12,842
Newaygo	---	22,000	---	2,050
Schoolcraft	7,500	36,200	20	4,625
Wexford	---	3,600	---	4,475
TOTALS	43,800	165,775	790	52,150

*On main stem and principal tributaries

Those at Traverse City were mainly caused by the inadequacies of local drainage. The pervious soils of the basin help to modify the fluctuations in stream flow.

Figure 14–28c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–27 shows the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–29 depicts upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–29c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–29. County summaries for the main stem and principal tributaries are tabulated in Table 14–30.

1.21.5 Existing Flood Damage Prevention Measures

Other than a few dams and reservoirs built primarily for power development purposes, there are no flood damage prevention measures in this basin. The Michigan Water Resources Commission is responsible for regulating all development in the flood plain. Refer to Subsection 1.14.5 for discussion of flood plain legislation applicable to this complex.

1.22 Lake Michigan Northeast, River Basin Group 2.4, Seul Choix-Groscap and Bay de Noc Complexes

1.22.1 Description

The Seul Choix-Groscap basin complex to the east of the Manistique River basin and the Bay de Noc basin complex to the west of the Manistique River basin comprise the greater part of the eastern lowlands in Michigan's upper Peninsula. Their locations within River Basin Group 2.4 are shown in Figure 14–27. The drainage areas of the rivers are small. The largest is the Whitefish River in the Bay de Noc complex with approximately 300 square miles. Most of the region is characterized by flat plains, intermixed with swamplands and low sand ridges. The area is heavily forested, especially with swamp types of cedar, balsam, and spruce.

1.22.2 Previous Studies

There have been no flood control reports published for the area.

1.22.3 Development in the Flood Plain

The area remains sparsely populated. There are no large towns or villages. Agriculture is of minor importance and consists of dairying and hay crops in the upland areas. Forest products and tourism provide the main source of income. Most of the flood plains are occupied by swamp forest.

1.22.4 Flood Problems

Minor flood problems exist for the Seul Choix-Groscap and Bay de Noc basins at present. Areas subjected to annual overflows are unoccupied and undeveloped. Table 14–28 shows estimated damages by watersheds, which are identified in Figure 14–29c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14-29.

1.22.5 Existing Flood Damage Prevention Measures

There are no existing structural flood control measures in the basin. Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to these complexes.

1.23 Lake Michigan Northeast, River Basin Group 2.4, Manistique River Basin

1.23.1 Description

The Manistique River basin drains an area of approximately 1,447 square miles and lies in the eastern part of the Upper Peninsula. With headwaters in northeastern Schoolcraft County, the river flows southwesterly to its mouth in Lake Michigan. Location within River Basin Group 2.4 is shown in Figure 14–27. Fairly regular in shape, the basin measures approximately 42 miles long and 35 miles wide. The primary tributaries come to the main stem from the northwestern part of the basin. A unique feature of this basin is the presence in the headwaters of three large lakes—Manistique, North Manistique, and South Manistique Lakes. Indian Lake is a large lake located in the lower reach of Indian River, a main tributary.

The basin varies from fairly flat plains near Lake Michigan to rolling hills interspersed with occasional outcroppings of bedrock together with large expanses of swampland and marsh. The soil in the basin is composed largely of sand and sand ridges separating the marsh areas.

The Manistique River slopes gradually and is fairly regular along its entire course, except at Manistique, where the river breaks through a limestone escarpment for a fall of 26 feet. Upstream from Manistique, the stream slope averages 1.1 feet per mile. The Manistique River channel is relatively narrow, shallow, and tortuous throughout its entire length. Stream beds of the Manistique River tributaries, especially in their upper reaches, generally have much steeper slopes which provide rapid runoff.

1.23.2 Previous Studies

Since 1873 a total of 10 preliminary examination and survey reports have been written on the subject of improving the Manistique River and its tributaries. Of the 10, only three have dealt with flood control:

(1) 1970—Survey Report Draft on Flood Control in the Manistique River Basin, Michigan. The Survey indicated that flood problems exist at the City of Manistique, Indian Lake, and Manistique Lake. However, solutions to these problems were not economically justified by Corps' standards.

(2) 1966—Small Flood Control Project Study of the flood problem at Indian Lake, originally initiated under the Flood Control Act of 1960. The report concluded that a project to provide a reasonable degree of protection against flooding on Indian Lake would not produce benefits commensurate with costs.

(3) 1929—This study was made under the provision of House Document 308, 69th Congress, and covered all phases of water resources development in the Manistique River basin. It concluded that development of the stream for navigation, water power, flood control, irrigation, or any combination of these items was not economically justified.

Other reports by State agencies follow:

(1) 1960—The Michigan Water Resources Commission report, "Drought Flow of Michigan Streams," gives information on low flow conditions expected in the basin.

(2) 1960—The Michigan Water Resources Commission report concerning the May 1960 flood was prepared from a reconnaissance of the area.

(3) 1955—A Michigan Conservation Department report entitled, "North Manistique Lake Level Control," was subsequently used in 1958 by the court to establish a legal summer and winter lake level.

(4) 1949—The "Report of the Manistique Dam Committee," dated October 15, is on file with Michigan Conservation Department.

(5) 1948—The Michigan Conservation Department lake level report for Manistique Lake was furnished to court hearings on lake levels. A legal level for Manistique Lake was subsequently set at elevation 686.0 (U.S. Geological Survey datum).

(6) 1944—The Michigan Conservation Department report on Indian Lake stabilization provides physical data on the Indian River and structures below Indian Lake. A plan for lake stabilization was presented but was not implemented.

(7) 1943—The Michigan Conservation Department issued a report on the Indian Lake water surface elevations and the outflow from the lake during June 1943. Data were collected to form the basis for control works for Indian Lake.

1.23.3 Development in the Flood Plain

The valleys of the Manistique River and its tributaries are generally spacious, with average widths ranging up to 3 miles in swampland areas. The valleys are not materially encroached upon except for a few bridges and other man-made works at problem areas in the Manistique River basin. Manistique, located on the banks of the Manistique River, is the only city in the river basin. All the other communities have populations well below 1,000 each and have been developed for residential and resort use. The major portions of the flood plains are occupied by swamps and forest land. More than 90 percent of the Manistique River basin is occupied by forest growth, and the manufacturing of forest products constitutes the primary industry. Agriculture plays a very minor role in the basin as evidenced by the fact that only 2.4 percent of the land area in Schoolcraft County was farmed in 1964.

Transportation systems crossing the region consist of one main line railroad crossing east-west, one minor railroad north to the Lake Superior ports, U.S. Highway 2 running east-west through Manistique and the southern sector of the basin, plus a network of State, county, and other secondary routes. An 0.8-mile length of the Manistique River between Manistique and Lake Michigan is used for industrial and commercial navigation. However, the railroad ferries ceased operating into Manistique harbor in 1968, and commerce is continuing to decline.

At present there is one power development within the basin. A local paper company operates a dam situated on the Manistique River at Manistique which supplies water and electric power for company operations. The dam is situated at the tip of the limestone escarpment which separates the greater part of the basin from Lake Michigan and creates a total head of 26 feet.

The Manistique River basin is included among those areas listed as economically depressed. Processing of forest products and increased tourist trade are considered the most significant opportunities for economic recovery and growth.

1.23.4 Flood Problems

Flood have been a problem in the Manistique basin since 1920 when high water caused a washout around the Manistique Dam at Manistique. Flood problems have existed for shorter periods because of later development of these areas. Past floods that have resulted in damage occurred in March 1920, April 1922, June 1943, April 1952, and May 1960. The May 1960 flood caused the most damage throughout the Manistique basin. The storm that produced the flood was a combination of heavy rainfall (5 inches to 7 inches) falling on ground saturated with melting snow, which created heavy runoffs. Although notable rainstorms have been recorded during the summer and fall, rises of the streams above flood stage generally occur in the late winter or early spring. Maximum discharge of record occurred during May 1960 and measured 16,900 cfs at Manistique.

Banks of the rivers within the basin are low and are usually overtopped annually. However, the major portion of flooded land is wooded and undeveloped. The only urban area affected to any degree is the City of Manistique. Other communities have minor flood damage potentials. Germfask, Michigan, located 9 miles downstream from Manistique Lake, has not experienced flooding because it is located on high ground. Seney, located beside the Fox River 8 miles above the confluence with the Manistique River, was found to have surface drainage problems, but no flood problems. Resort areas affected include cottages and homes adjacent to Indian Lake and Manistique Lake. Investigations of North and South Manistique Lakes revealed that, due to adequate lake regulation controls, no flood problems of any major consequence are experienced.

Figure 14–28c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–27 shows the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–28 shows upstream flood damages. These damages are referenced to the watersheds identified in Figure 14–29c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–29. County summaries for the main stem and principal tributaries are tabulated in Table 14–30.

1.23.5 Existing Flood Damage Prevention Measures

There are no Federal structural flood control projects, nor are any authorized for the Manistique River basin. Current navigation improvement programs at the mouth of the Manistique River have no bearing or effect on the flood problems within the basin. The Michigan Water Resources Commission has the authority to regulate all development in flood plain areas. The requirements under the acts of 1967 and 1968 (Act 288 and Act 167) are intended to be minimum requirements only, and local flood plain regulations should be adopted to minimize flood damages.

A discussion of flood plain legislation is included in Appendix S20, *State Laws, Policies, and Institutional Arrangements.*

1.24 Lake Michigan Northeast, River Basin Group 2.4, Escanaba River Basin

1.24.1 Description

The Escanaba River rises in Marquette

County, Michigan, flows generally southeasterly, and empties into Little Bay de Noc near the City of Escanaba. The reach under study is the section of the river within Delta County. It measures approximately 25 miles long and the total fall in this reach is 306 feet. Location within the river basin group is shown in Figure 14–27.

1.24.2 Previous Studies

There have been no reports on this basin published by the Corps of Engineers.

1.24.3 Development in the Flood Plain

The greater portion of the population of the Escanaba basin is located near the mouth of the river in the City of Escanaba. Outside this area the major developments have been dams and hydroelectric plants, for which the river is ideally suited because of its steep slope. Four such installations are located in Delta County. Besides providing adequate power for this surrounding area, these plants have created extensive water areas which provide excellent recreational opportunities.

1.24.4 Flood Problems

Minor flood problems exist in the Escanaba River basin. The river flows between high banks for most of its length, and the hydroelectric plants help regulate the water level. The only large populated region is at the river mouth where the water level varies only with the fluctuations of Lake Michigan.

Figure 14–28c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–27 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–28 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–29c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–29. County summaries for the main stem and principal tributaries are tabulated in Table 14–30.

1.24.5 Existing Flood Damage Prevention Measures

Other than a few dams built primarily for power development purposes, there are no flood damage prevention measures in the basin.

Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to this river basin.

1.25 Lake Huron North, River Basin Group 3.1, St. Marys River Basin

1.25.1 Description

The St. Marys River is the connecting waterway between Lake Superior and Lake Huron. Location within River Basin Group 3.1 is shown in Figure 14–30. The true river section is short, extending only 12 miles downstream from the Sault Falls. Below this section is a series of closely connected lakes and bays. The local basin of the St. Marys drains a small and sparsely populated area.

1.25.2 Previous Studies

There have been no flood control reports published for the basin.

1.25.3 Development in the Flood Plain

The basin is sparsely settled and much of it is in public ownership. The only urbanized areas are the twin cities of Sault Ste. Marie, Michigan, and Sault Ste. Marie, Ontario. Agricultural activity is minimal in the basin. Tourist and vacation trade is increasing.

1.25.4 Flood Problems

There are no flood problems in the St. Marys River basin at this time.

1.25.5 Existing Flood Damage Prevention Measures

The river flow is regulated by the Soo Locks, the hydropower works, and the compensating gates located at the falls. This strict regulation flow (average rate 75,000 cfs) to control the level of Lake Superior diminishes flood hazards downstream.

1.26 Lake Huron North, River Basin Group 3.1, Les Cheneaux Complex

1.26.1 Description

This collection of minor streams occupies the eastern end of the Upper Peninsula. The largest streams are the Carp River, draining 132 square miles, and the Pine River, draining 243 square miles. Location of the complex within River Basin Group 3.1 is shown in Figure 14–30. These streams have their outlets in northern Lake Huron, just east of the Mackinac Straits.

1.26.2 Previous Studies

There have been no flood control reports published for the complex.

1.26.3 Development in the Flood Plain

The complex is very sparsely populated and much of the area is within the Marquette National Forest.

1.26.4 Flood Problems

There are negligible flood problems in the complex at this time.

1.26.5 Existing Flood Damage Prevention Measures

There are no known existing structural flood prevention measures in the complex. Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to this complex.

1.27 Lake Huron North, River Basin Group 3.1, Alcona Complex

1.27.1 Description

This area is situated between the Thunder Bay River basin and the Au Sable River basin. Location of the complex within this river basin group is shown in Figure 14–30. It contains several short streams which flow into Lake Huron. The most noteworthy of these are the Black River with a drainage area of 65 square miles and the Devils River with a basin of 75 square miles. The Black River basin is largely wooded with extensive marsh areas. The lower river channel lies in clay soil, and the river carries little or no sediment. The Devils River drains a region of similar topography. In 1945 the Corps of Engineers performed emergency clearing and snagging at the mouth of the river to remove shoal formation.

1.27.2 Previous Studies

Previous studies are listed below:

(1) 1967—Corps of Engineers, Detroit District, a favorable interim report for a small-boat harbor at Black River

(2) 1967—Channel work on Holcomb Creek (a tributary of the Devils River) for agricultural drainage designed by Soil Conservation Service under authority of P.L. 566

(3) 1962—Corps of Engineers, Detroit District, unfavorable report concerning the establishment of a harbor of refuge at Devils River

(4) 1930—Corps of Engineers, Detroit District, a Preliminary Examination Report on Black River Harbor; survey not recommended

1.27.3 Development in the Flood Plain

The complex is sparsely populated, with little development in the flood plains. There are no large towns in the area. Tourist and vacation trade is increasing.

1.27.4 Flood Problems

Flooding problems of various degrees have occurred in several places in the complex, but details are lacking.

1.27.5 Existing Flood Damage Prevention Measures

There are no known existing structural flood prevention measures in the complex. Refer to Subsection 1.14.5 for a discussion of flood plain legislation.

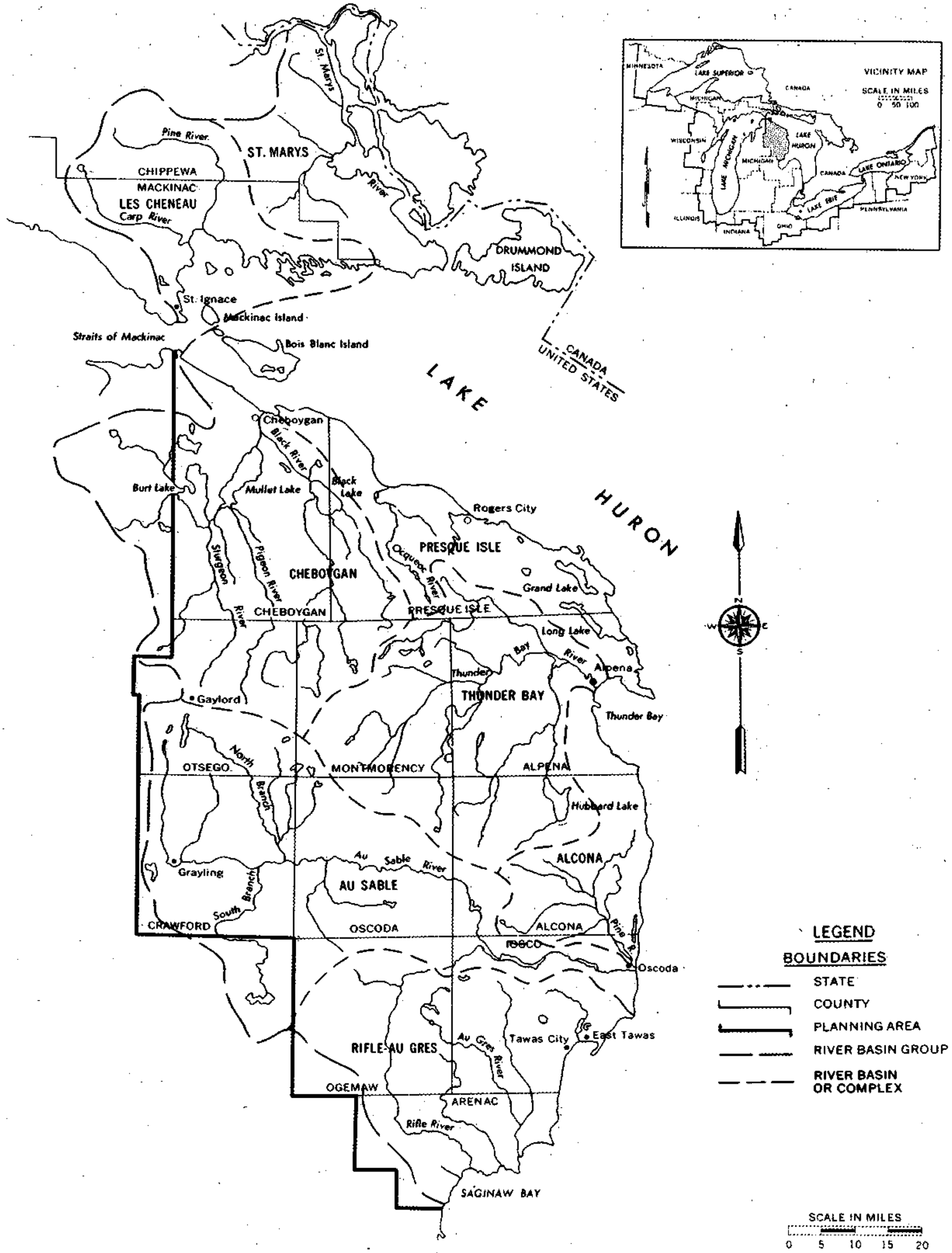

FIGURE 14–30 Lake Huron North—River Basin Group 3.1

1.28 Lake Huron North, River Basin Group 3.1, Cheboygan River Basin

1.28.1 Description

This basin forms an irregular circle with a diameter of approximately 40 miles and a drainage area of 1,328 square miles. Location within River Basin Group 3.1 is shown in Figure 14–30. Twenty-three percent of its surface area is in lakes and swamps. Three of the lakes, Mullett Lake, Burt Lake, and Black Lake, are among the largest inland lakes in the State. The basin is drained primarily by the tributary system including the Maple, Sturgeon, Black, Rainy, and Pigeon Rivers. These all join the main stem through one of the large inland lakes. The main stem is a short stretch of approximately 6 miles between Mullett Lake and Lake Huron. This region has some of the most rugged topography in Lower Michigan. Relief within the basin is several hundred feet in places. Moraine, outwash, and lakebed deposits each account for 30 percent of the basin, and the rest is till plain.

1.28.2 Previous Studies

Previous studies are listed below:

(1) 1965—Corps of Engineers, Detroit District, a Detailed Project Report on Flood Control for Black River, Cheboygan County, Michigan. A favorable recommendation was given for channel improvement to relieve high water conditions on Black Lake.

(2) 1962—Corps of Engineers, Detroit District, a Reconnaissance Report on Flood Control at Black Lake that recommended a detailed Project Report be authorized

(3) 1960—Separate reports concerning the April 1960 high water conditions on Black Lake made by United Associates of Cheboygan, Michigan, and Professor C. O. Wisler of the University of Michigan

(4) 1951—Corps of Engineers, Detroit District, favorable Survey Report on the Indian and Crooked Rivers

(5) 1948—Corps of Engineers, Detroit District, favorable Preliminary Examination Report on the Crooked and Indian Rivers

(6) 1947—Michigan Department of Conservation, a Preliminary Investigation on Black Lake stabilization. This investigation provided physical data on the Black River and Alverno Dam and detailed hydrology studies of Black Lake, and presented two alternative plans of improvement.

(7) 1936, 1938—Corps of Engineers, Detroit District, unfavorable Preliminary Examination Report on the Crooked and Indian Rivers

(8) 1931—Corps of Engineers, unfavorable Preliminary Examination report on the Cheboygan River

1.28.3 Development in the Flood Plain

Most communities in the region exist to provide living essentials for the tourist and vacation trade. The only town of any size in the actual flood plain is Cheboygan, located near the mouth of the Cheboygan River at Lake Huron. The city has experienced little flooding. Most land bordering the streams is forest and swamp with little settlement. However, the lakes of the region are surrounded with seasonal cottages and an increasing number of more expensive year-round homes.

1.28.4 Flood Problems

The most serious flood damage conditions have been caused by high water conditions on the large lakes, especially Black Lake, where serious losses have been experienced. Periods of high lake stage occurred in 1943, 1951, 1952, and 1960. Artificial impoundments for power plants and the large natural lakes have a pronounced stabilizing effect on the stream flow below these lakes. The different geological conditions have also created highly variable runoff conditions in the basin.

Figure 14–31c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–31 indicates the flood plain damages by reach, corresponding to the reaches designated in this figure. Table 14–32 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–32c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–33. County summaries for the main stem and principal tributaries are tabulated in Table 14–34.

1.28.5 Existing Flood Damage Prevention Measures

The only flood damage reduction measure is the Little Black River Watershed Project, Cheboygan County, Michigan, completed in 1962 by the U.S. Soil Conservation Service cooperating with the Cheboygan County Drain Commission and other local sponsors. The location of this flood damage reduction measure is illustrated in Figure 14–33.

The Inland Route Project, completed in 1968, includes a small lock and dam constructed by the Corps of Engineers. It provides a navigation channel for small boats from Crooked, Burt, and Mullet Lakes to Lake Huron. This increased channel capacity had the effect of lowering water levels excessively in Crooked Lake. Therefore the lock and dam structure in the Crooked River outlet was necessary to maintain satisfactory lake water levels.

The Michigan Water Resources Commission has the authority to regulate all development in flood plain areas. Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to this river basin.

TABLE 14–31 Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 3.1

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	CHEBOYGAN RIVER												
AL1	Cheboy-gan	T38N R1W S29	T36N R4W S36	1970									
				1980									
				2000									
				2020									
AL2	Emmet	T36N R4W S36	T35N R5W S24	1970									
				1980									
				2000									
				2020									
	BLACK RIVER												
AL3	Cheboy-gan	T37N R11W S17	T35N R2E S5	1970		57,500			100	1217		1,327	
				1980		74,800			210	1117		1,327	
				2000		103,500			225	1102		1,327	
				2020		132,300			235	1092		1,327	
	THUNDER BAY RIVER												
AN1	Alpena	T31N R6E S25	T31N R5E S19	1970		2,000			10	7500		7,510	
				1980		2,800			200	7310		7,510	
				2000	200	5,000		20	350	7140	20	7,510	
				2020	3,000	6,000	40	40	400	7030	80	7,430	
	AU SABLE RIVER												
AR1	Iosco	T23N R9E S10	T24N R5E S2	1970						2000		2,000	
				1980		1,100			100	1900		2,000	
				2000		1,600			180	1820		2,000	
				2020		2,000			200	1800		2,000	
	AU GRES RIVER												
AQ1	Arenac	T19N R6E S26	T20N R6E S2	1970		148,000				13410		13,410	
				1980		167,000				13410		13,410	
				2000		178,000				13410		13,410	
				2020		222,000				13410		13,410	
	RIFLE RIVER												
AQ2	Arenac	T18N R6E S3	T20N R3E S1	1970						3500		3,500	
				1980		1,400			130	3310		3,500	
				2000		2,600			260	3240		3,500	
				2020		4,500			400	3100		3,500	

TABLE 14–32 Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 3.1

Watershed Number	Year	Estimated Average Annual Damages (Dollars)			Estimated Acres in Flood Plain								
		Urban	Rural	Total	Cropland	Pasture	Woodland	Other Rural	Industrial Commercial	Residential	Other Urban	Total Urban	Total Rural
		AU GRES - RIFLE COMPLEX - MICHIGAN											
4N	1970	--	1,200	1,200	300	400	1,020	150	--	--	--	--	1,870
4P	1970	--	1,200	1,200	310	60	600	--	--	--	--	--	970
4Q	1970	--	800	800	185	330	785	420	--	--	--	--	1,720
4Q1	1970	--	100	100	15	45	20	10	--	--	--	--	90
4R	1970	1,100	100	1,200	--	200	--	--	3	7	10	20	200
Total	1970	1,100	3,400	4,500	810	1,035	2,425	580	3	7	10	20	4,850
	1980	1,500	4,900	6,400	810	1,035	2,425	580	3	7	10	20	4,850
	2000	2,800	6,200	9,000	810	1,035	2,425	580	3	7	10	20	4,850
	2020	5,300	6,400	11,700	810	1,035	2,425	580	3	7	10	20	4,850
		CHEBOYGAN COMPLEX - MICHIGAN											
4E2	1970	--	400	400	100	300	100	--	--	--	--	--	500
4E3A	1970	--	300	300	80	120	--	--	--	--	--	--	200
Total	1970	--	700	700	180	420	100	--	--	--	--	--	700
	1980	--	1,000	1,000	180	420	100	--	--	--	--	--	700
	2000	--	1,300	1,300	180	420	100	--	--	--	--	--	700
	2020	--	1,300	1,300	180	420	100	--	--	--	--	--	700
		LES CHENEAUX - MICHIGAN											
4G1	1970	500	--	500	--	--	--	--	--	--	3	3	--
4H	1970	--	--	--	--	25	--	--	--	--	5	5	25
431	1970	--	--	--	--	7	--	--	--	--	5	5	7
Total	1970	500	--	500	--	32	--	--	--	--	13	13	32
	1980	700	--	700	--	32	--	--	--	--	13	13	32
	2000	1,300	--	1,300	--	32	--	--	--	--	13	13	32
	2020	2,400	--	2,400	--	32	--	--	--	--	13	13	32
		PRESQUE ISLE COMPLEX - MICHIGAN											
4D1C	1970	--	200	200	50	100	50	--	--	--	--	--	200
433	1970	10,000	200	10,200	50	50	--	900	50	200	--	250	1,000
434	1970	8,000	--	8,000	--	--	300	--	--	200	--	200	300
Total	1970	18,000	400	18,400	100	150	350	900	50	400	--	450	1,500
	1980	24,300	600	24,900	100	150	350	900	50	400	--	450	1,500
	2000	45,400	700	46,100	100	150	350	900	50	400	--	450	1,500
	2020	86,800	800	87,600	100	150	350	900	50	400	--	450	1,500
		THUNDER BAY RIVER - MICHIGAN											
4C1	1970	--	800	800	200	1,900	896	200	--	--	--	--	3,196
4C	1970	4,000	400	4,400	100	100	400	--	--	100	--	100	600
4C3B	1970	--	300	300	76	114	--	--	--	--	--	--	190
Total	1970	4,000	1,500	5,500	376	2,114	1,296	200	--	100	--	100	3,986
	1980	5,400	2,100	7,500	376	2,114	1,296	200	--	100	--	100	3,986
	2000	10,100	2,700	12,800	376	2,114	1,296	200	--	100	--	100	3,986
	2020	19,300	2,800	22,100	376	2,114	1,296	200	--	100	--	100	3,986
		ALCONA COMPLEX - MICHIGAN											
4C3	1970	--	600	600	160	180	120	40	--	--	--	--	500
4B1	1970	6,000	--	6,000	--	--	--	--	--	150	--	150	--
Total	1970	6,000	600	6,600	160	180	120	40	--	150	--	150	500
	1980	8,100	900	9,000	160	180	120	40	--	150	--	150	500
	2000	15,100	1,100	16,200	160	180	120	20	--	150	--	150	500
	2020	28,900	1,100	30,000	160	180	120	40	--	150	--	150	500

1.29 Lake Huron North, River Basin Group 3.1, Thunder Bay River Basin

1.29.1 Description

With a drainage area of 1,118 square miles, this basin is irregular in shape, measuring 40 miles long and 34 miles wide at its extremes. It flows easterly into Thunder Bay, an arm of Lake Huron. Location within River Basin Group 3.1 is shown in Figure 14–30. Lakes and swamps make up approximately 25 percent of the drainage area, giving this basin the highest percentage of such terrain of any river basin in the Lower Peninsula. The region is composed of moraines, outwash, and lake and till plains. The higher lands have thick well-

TABLE 14–33 Data Summary by River Basin, River Basin Group 3.1

River Basin	Year	Estimated Average Annual Damage (Dollars)		Estimated Acres In Flood Plain	
		Urban	Rural	Urban	Rural
Les Cheneaux Complex	1970	500	-	13	32
	1980	700	-	13	32
	2000	1,300	-	13	32
	2020	2,400	-	13	32
Cheboygan River	1970	-	58,200	-	2,027
	1980	-	75,800	-	2,027
	2000	-	104,800	-	2,027
	2020	-	133,600	-	2,027
Presque Isle Complex	1970	18,000	400	450	1,500
	1980	24,300	600	450	1,500
	2000	45,400	700	450	1,500
	2020	86,800	800	450	1,500
Thunder Bay	1970	4,000	3,500	100	11,496
	1980	5,400	4,900	100	11,496
	2000	10,300	7,700	120	11,476
	2020	22,300	8,800	180	11,416
Alcona Complex	1970	6,000	600	150	500
	1980	8,100	900	150	500
	2000	15,100	1,100	150	500
	2020	28,900	1,100	150	500
Rifle-Au Gres Complex	1970	1,100	151,400	20	21,760
	1980	1,500	173,300	20	21,760
	2000	2,800	186,800	20	21,760
	2020	5,300	232,900	20	21,760
Au Sable River	1970	-	-	-	2,000
	1980	-	1,100	-	2,000
	2000	-	1,600	-	2,000
	2020	-	2,000	-	2,000
St. Marys Complex	- Damage is negligible				
TOTAL	1970	29,600	214,100	733	39,315
	1980	40,000	256,600	733	39,315
	2000	74,900	302,700	753	39,295
	2020	145,700	379,200	813	39,235

TABLE 14–34 River Basin Group 3.1, Data Summary by County

County (Michigan)	Estimated Average Annual Damages (Dollars) Urban	Estimated Average Annual Damages (Dollars) Rural	Estimated Acres in Flood Plain Urban	Estimated Acres in Flood Plain Rural
YEAR 1970				
Alpena	---	2,000	---	7,510
Arenac	---	148,000	---	16,910
Cheboygan	---	57,500	---	1,327
Iosco	---	---	---	2,000
TOTALS	---	207,500	---	27,747
YEAR 1980				
Alpena	---	2,800	---	7,510
Arenac	---	168,400	---	16,910
Cheboygan	---	74,800	---	1,327
Iosco	---	1,100	---	2,000
TOTALS	---	247,100	---	27,747
YEAR 2000				
Alpena	200	5,000	20	7,490
Arenac	---	180,600	---	16,910
Cheboygan	---	103,500	---	1,327
Iosco	---	1,600	---	2,000
TOTALS	200	290,700	20	27,727
YEAR 2020				
Alpena	3,000	6,000	80	7,430
Arenac	---	226,500	---	16,910
Cheboygan	---	132,300	---	1,327
Iosco	---	2,000	---	2,000
TOTALS	3,000	366,800	80	27,667

*On main stem and principal tributaries

drained sands, and most of the southern part is flat and swampy with areas of peat and muck. In the northeastern part is an area of limestone sinkholes and fissures.

1.29.2 Previous Studies

The only study that has been made is the Truax Creek Watershed Work Plan completed by the U.S. Soil Conservation Service in 1969.

1.29.3 Development in the Flood Plain

There is little development in the flood plains of the basin. The largest city, Alpena, is located at the mouth of the Thunder Bay River and is also the biggest Michigan port on Lake Huron. Streamflow is affected to some degree by the artificial regulation provided by old power dams on the upper tributaries. This, along with the loss of water through evaporation from the large areas of swamps and lakes, accounts for the yields and variations in flows experienced in the watershed.

1.29.4 Flood Problems

Flood problems have been minor and extremely local in nature. Figure 14–31c iden-

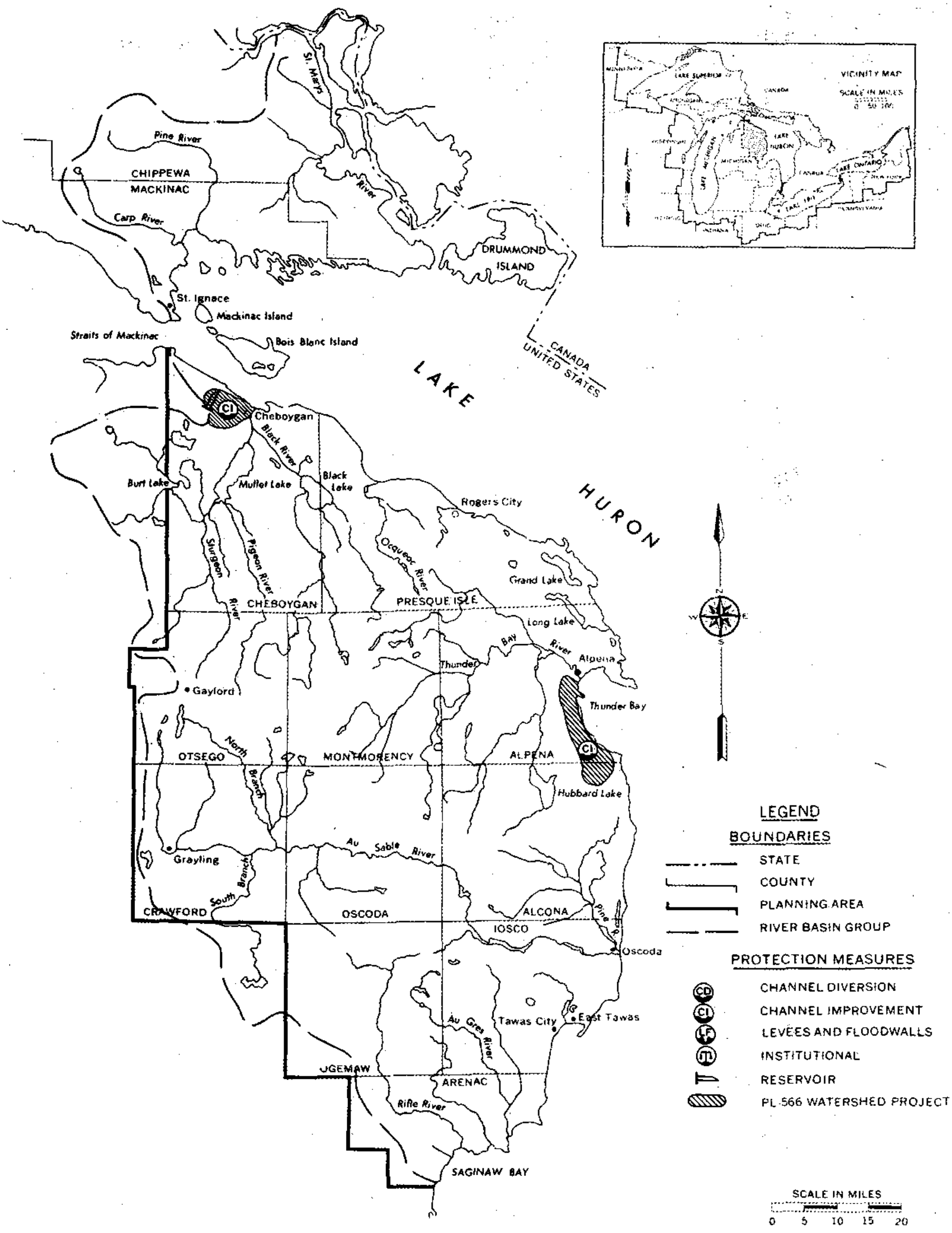

FIGURE 14-33 Existing Flood Damage Protection Measures for River Basin Group 3.1

tifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–31 shows the flood plain damages by reach, corresponding to the reaches designated in this figure. Table 14–32 indicates upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–32c. Summations of estimated average annual damages and acres in flood plain are shown by river basin in Table 14–33. County summaries for the main stem and principal tributaries are tabulated in Table 14–34.

1.29.5 Existing Flood Damage Prevention Measures

One structural flood damage prevention measure has been completed by the U.S. Soil Conservation Service and local sponsors. This is the Sanborn Watershed Project in Alpena County, Michigan. The location of this project is illustrated in Figure 14–33.

Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to this river basin.

1.30 Lake Huron North, River Basin Group 3.1, Au Sable River Basin

1.30.1 Description

The Au Sable River basin drains an area of 2,035 miles. The main stem flows in an easterly direction to its mouth at Oscoda on Lake Huron. Location within River Basin Group 3.1 is shown in Figure 14–30. The Au Sable River basin, irregular in shape, measures approximately 80 miles long and 40 miles wide at its extremes. With headwaters at elevations of 1,500 feet, the overall gradient averages 5 feet per mile, and the main river receives drainage from approximately 60 percent of the total drainage area in 30 percent of its total length. The major tributaries include the North Branch, Middle Branch, South Branch, and the Pine Rivers. The hills, valleys, and plains formed by the retreating glaciers are mostly well-drained sands except in the extreme southwestern portion of the basin where the surface of the land is relatively low and flat with organic soils.

1.30.2 Previous Studies

There have been numerous unfavorable Corps of Engineers Preliminary Examination Reports. The last one was issued in 1963.

1.30.3 Development in the Flood Plain

There is some light industry at Gaylord and Grayling located in the upper reaches of the basin. Tourism provides the main source of income for the area. Agriculture is of minor significance with a total of 31,000 acres under cultivation out of a total 1.15 million acres included in the basin. There are four dams on the main stream between Mio and Oscoda.

1.30.4 Flood Problems

Flood problems have been minor and extremely local in nature. Figure 14–31c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–31 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–32 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14-32c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–33. County summaries for the main stem and principal tributaries are tabulated in Table 14–34.

1.30.5 Existing Flood Damage Prevention Measures

There are no structural flood damage preventive measures in the Au Sable River basin. However, stream flow is regulated to some extent by existing hydropower dams.

Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to this river basin.

1.31 Lake Huron North, River Basin Group 3.1, Rifle River Basin

1.31.1 Description

The Rifle River drains an area of 374 square miles that is irregular in shape. The basin is 40 miles long and varies in width from 5 to 15 miles. Location within River Basin Group 3.1 is shown in Figure 14–30. The river falls some

725 feet from its headwaters in a tableland 1,300 feet above sea level to its mouth in Saginaw Bay, an arm of Lake Huron. The fall is rapid in the upper reaches, while in the lower part of the basin the river traverses slightly rolling terrain with a fairly uniform fall. Lakes and swamps, all in Ogemaw County, cover approximately 5 percent of the basin.

1.31.2 Previous Studies

Previous studies are listed below:
(1) 1972—U.S. Geological Survey—flood-prone area reports for portions of the Rifle River
(2) 1960—U.S. Geological Survey—floods of May 1959 in the Au Gres and Rifle River Basins, Michigan
(3) Corps of Engineers, Preliminary Examination Report, unfavorable conclusions

1.31.3 Development in the Flood Plain

The area is sparsely populated, and there are no large towns in the flood plain. Approximately 30 percent of the area is wooded, and much of the remaining area is marginal land no longer used for farming. Most of the developed farmland in the watershed is around the upper half of the western tributaries, south of Rose City.

1.31.4 Flood Problems

Because the flood area is sparsely populated, damages are largely confined to farmlands and facilities, and to secondary roads and their appurtenant drainage structures. The record floods of May 1959 in the Au Gres and Rifle River basins resulted from heavy rainfall. Peak unit discharges for small drainage areas (less than 15 square miles) were the highest ever measured in the Lower Peninsula of Michigan. For very small areas (approximately one square mile) peak unit discharges were of the same order of magnitude as those for the record Ontonagon River flood of August 1942 in the Upper Peninsula. This storm caused severe damages totaling $108,000 to bridges and culverts maintained by the County Road Commission. Soil loss from cultivated fields was very high, and intermittant drainage channels were severely gullied. Damages to improvement structures also occurred.

Figure 14–31c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–31 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14-32 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–32c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–33. County summaries for the main stem and principal tributaries are tabulated in Table 14–34.

1.31.5 Existing Flood Damage Prevention Measures

There are no known structural flood damage preventive measures in the basin. A discussion of flood plain legislation applicable to this river basin appears in Subsection 1.14.5.

1.32 Lake Huron North, River Basin Group 3.1, Au Gres River Basin

1.32.1 Description

The pear-shaped Au Gres River basin, draining an area of 435 square miles, is 30 miles long with an average width of 15 miles. The Au Gres River flows in a southerly direction into Saginaw Bay, an arm of Lake Huron. Location within River Basin Group 3.1 is shown in Figure 14–30. Major tributaries include the East Branch, Big Creek, Cedar Creek, and Johnstone Creek. The upper portions of the basin are rolling till plains with low relief, while the lower reaches drain a lake plain.

1.32.2 Previous Studies

Previous studies are listed below:
(1) 1959—Corps of Engineers, Detroit District, a Survey Report on Major Drainage and Flood Control of the Au Gres River, Michigan. The report stated that a serious flood problem existed downstream from the Arenac-Iosco County line to U.S. Highway 23 at Au Gres, Michigan. The report recommended a plan for channel improvement to alleviate flooding of farmlands.
(2) 1951—Corps of Engineers, Detroit Dis-

trict, a Preliminary Examination Report on the Au Gres River. The report recommended that a survey for flood control be authorized.

1.32.3 Development in the Flood Plain

The population of the basin is rural. The largest village in the flood plain is Au Gres with less than 1,000 residents. The upper reaches of the basin are mainly forest land, the middle reach is flatter with crop farming and cattle grazing to a considerable degree, and the lower reaches, although having better quality soils, are not fully used for agriculture because of frequent flooding and poor drainage.

The Au Gres River has a much steeper profile in the headwaters area than downstream. The streambed drops 270 feet in the first 27 miles, an average of 10 feet per mile. Below the junction with the East Branch, the river flattens and spreads, the course is crooked, and the flow is sluggish with the drop being slightly more than two feet per mile. The river's width ranges from 100 to 200 feet compared to 40 feet in the middle reach.

1.32.4 Flood Problems

For the 13-year period between 1942 and 1955, 20 separate floods were reported in the Au Gres River basin, several of them reaching two or more peak stages within a week or two. Melting snow and ice coupled with heavy spring rains create the floods which are augmented by ice jams formed in the narrow sharp bends in the river. The severity of the flood is more often determined by the size and duration of the ice jam than by the discharge of the river. The maximum flood flow recorded was 2,300 cfs in April 1952, which corresponds to a frequency of once in 30 years. Approximately 26.5 square miles of bottom land are flooded periodically. A total of 3,631 acres of this flood plain are cultivated as cropland or pasture. The remainder consists of woodlot, idle, or other nonagricultural lands. Floods in the area have damaged roads and bridges. Between the village of Au Gres and the river mouth, the water surface during periods of normal flow fluctuates with the levels of Lake Huron.

Figure 14–31c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–31 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–32 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–32c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–33. County summaries for the main stem and principal tributaries are tabulated in Table 14–34.

1.32.5 Existing Flood Damage Prevention Measures

The principal structural improvements consist of farm ditches, local drains, and the Whitney cut-off drain, all constructed by local interests. The Whitney drain was dug to divert the discharge of the East Branch into Lake Huron. During nonflood periods the entire flow of the East Branch is diverted through this channel. A few small instream ponds are formed by low weirs in the headwater areas but these exert little influence on the flow regimen.

Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to this river basin.

1.33 Lake Huron Central, River Basin Group 3.2, Kawkawlin River Basin

1.33.1 Description

The Kawkawlin River drains an irregularly shaped area of approximately 220 square miles. This area is 18 miles wide and 27 miles long at the extremes. Location within River Basin Group 3.2 is shown in Figure 14–34. The river has two main tributaries, the North and South Branches. These tributaries join to form the main stem of the Kawkawlin River approximately 4½ miles above the mouth of the river in Saginaw Bay.

The topography of the Kawkawlin River basin is typical of central Michigan, ranging from flatlands to low, rolling hills. The area consists mainly of lake-plain features formed during glacial periods. The beaches of former glacial lakes have been flattened out by outwash action to form sand plains in some places, while in other areas the beach ridges remain intact. Overall relief is slight, the terrain rising gradually from 580 feet at the mouth to an elevation of 700 feet in the headwaters.

1.33.2 Previous Studies

Previous studies are listed below:

(1) 1968—U.S. Soil Conservation Service and Bay County Drain Commission in conjunction with local sponsors, Tebo Erickson Watershed Work Plan, Bay County, Michigan

(2) 1966—Corps of Engineers, Detroit District, a Detailed Project Report on Kawkawlin River, Michigan, for Flood Control. The report recommended channel enlargement and elimination of bridge constrictions for improvements in flood control, and included design memoranda (project in progress, 1970).

(3) 1963—Corps of Engineers, Detroit District, a Report of Survey on Kawkawlin River, Michigan, for Flood Control. The report detailed problems experienced by the area and proposed solutions.

(4) 1959—Soil Conservation Service, U.S. Department of Agriculture, a Survey Report on Major and Local Drainage for Kawkawlin River, Michigan

(5) 1953—Spicer Engineering Company, retained by Bay County to study the flood problems in the Kawkawlin River basin. It recommended enlarging the main stem and the lower reaches of the North and South Branches.

(6) 1953—Corps of Engineers, Detroit District, survey to determine remedial measures at the mouth of the Kawkawlin River in the interest of flood control

(7) 1959—Corps of Engineers, Detroit District, a Preliminary Examination Report for the Kawkawlin River. It recommended that survey scope studies should be initiated because flood control improvements could be justified.

(8) 1940—Corps of Engineers, Detroit District, original Preliminary Examination Report on the Kawkawlin River Flood Problems. It recommended no further studies at that time.

1.33.3 Development in Flood Plain

Land on both sides of the Kawkawlin River in the reach between Saginaw Bay and the Village of Kawkawlin is occupied by permanent residences and summer cottages. The village is approximately 3½ miles upstream from the river mouth. From here the lands along the main stem to the confluence of the north and south branches and along these streams are used mostly for agriculture. In 1959, 60 percent of the drainage basin was farmland devoted chiefly to the production of field crops such as corn, beans, wheat, and oats.

1.33.4 Flood Problems

Records indicate that serious flooding occurred during March 1936, February 1938, February 1943, February 1944, February 1945, May 1946, April 1947, March 1948, and March 1960. Flooding is an almost annual occurrence in early spring. The flood of March 1948 was one of the most severe. Peak flow, estimated at 5,300 cfs, was caused by a 24-hour rainfall of 1.22 inches falling on frozen ground.

Areas subject to inundation in the Kawkawlin basin are the residential areas along both banks from Saginaw Bay upstream for a distance of 2.5 miles, and the crop areas located along the upper reach of the main stem and the lower reaches of the two branches. The problem area in the lower reach up to the Village of Kawkawlin contains approximately 335 homes (1966) and other buildings that are vulnerable to flooding. The agricultural study upstream shows that 2,300 acres could benefit from drainage improvements.

Flood conditions have also occurred from high stages due to ice jams even when the Kawkawlin River discharges were low. Water levels near the mouth and extending upriver several miles are influenced by the stage of Saginaw Bay. With a water surface elevation of 582 feet at the mouth, damage along the main stem begins when streamflows exceed 3,000 cfs.

Figure 14–35c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–36 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–37 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–36c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–38. County summaries for the main stem and principal tributaries are tabulated in Table 14–39.

1.33.5 Existing Flood Damage Prevention Measures

Two Corps of Engineers projects have been authorized in the Kawkawlin River basin.

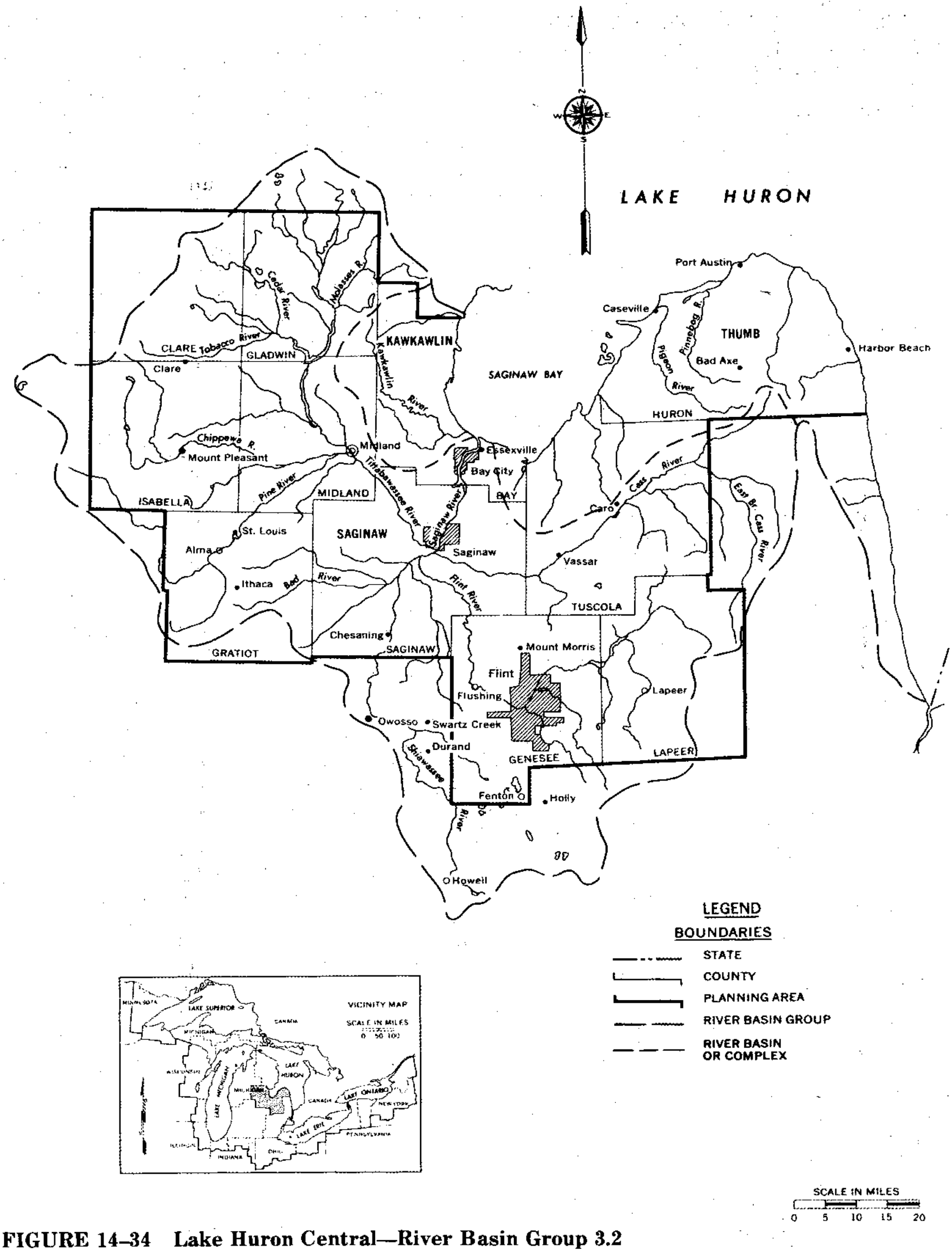

FIGURE 14–34 Lake Huron Central—River Basin Group 3.2

A clearing and snagging project was completed in April 1956, providing a channel 100 feet wide, 2,000 feet long, and 5 feet below low water datum through a bar at the mouth of the Kawkawlin River into Saginaw Bay. This was done to alleviate flooding conditions along the main stem caused by backup from ice jams forming against the bar.

The second, completed in November 1970, provides for channel improvements of approximately 10,000 feet in the lower reach upstream from the first project to Euclid Street. It also increases the flow area through the Detroit and Mackinac Railway Bridge by the addition of extra spans. With the flood control improvements, virtually all damage potential along the lower reach of the main stem of the Kawkawlin River is eliminated. However, it is possible that flooding and subsequent damage could still be caused by ice jams forming at the river mouth. It is considered that the improvements will reduce the severity of ice jam formations. The location of each of these preventive measures are depicted in Figure 14–37.

There have been no flood control improvements by other Federal agencies in the basin. However, Bay County has improved several agricultural land drains which flow into both the north and south branches, and many property owners have constructed retaining walls along the main stem.

A steady demand in land development for residential purposes has taken place near the mouth of the Kawkawlin River. This trend shows no signs of abating, even though the flood threat is recognized. Zoning restrictions against further development would be of value in preventing an increase in flood damages. Such zoning controls are the prerogative of the Michigan Water Resources Commission and local enforcement agencies. Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to this river basin.

1.34 Lake Huron Central, River Basin Group 3.2, Saginaw River Basin

1.34.1 Description

The watershed of the Saginaw River and its tributaries resembles the shape of a butterfly. The river's mouth at Saginaw corresponds to its head and the areas drained by the principal tributaries form the butterfly wings. Location within River Basin Group 3.2 is shown in Figure 14–34. The total drainage area of the Saginaw River basin is 6,260 square miles or approximately 2 percent of the Great Lakes Basin. The total drainage area tributary to the Saginaw River at Saginaw reaches 125 miles east and west and 125 miles north and south. The drainage area and runoff of the basin is distributed between the major tributaries as follows: Flint River, 1,168 square-mile drainage area and 580 cfs average runoff; Shiawassee River, 1,398 square-mile drainage area and 680 cfs average runoff; Cass River, 920 square-mile drainage area and 460 cfs average runoff; Tittabawassee River, 2,562 square-mile drainage area and 1,760 cfs average runoff.

In the uplands of the basin the topography is gently rolling. Some areas reach an elevation of 1,300 feet, whereas the elevation of land adjacent to the Saginaw River varies from 585 to 590 feet. Throughout the basin there are numerous low-lying areas along the streams. These areas provide natural water storage which are effective in reducing flood peaks. The upper portions of the Flint and Shiawassee River basins have large numbers of small inland lakes.

1.34.2 Previous Studies

Previous studies are listed below:

(1) 1972—U.S. Geological Survey—flood-prone area reports for portions of Farmers Creek

(2) 1971—U.S. Soil Conservation Service, Draft Watershed Work Plan for State Road Drain, Shiawassee County, Michigan

(3) 1971—U.S. Soil Conservation Service, Preliminary Information Report, Indian Creek Watershed, Lapeer County, Michigan

(4) 1963—Corps of Engineers, General Design Memorandum for Flood Control on the Cass River at Frankenmuth, Michigan. This develops the project plan for flood protection measures at this locality.

(5) 1962—Corps of Engineers, General Design Memorandum for Flood Control on the Flint River at Flint, Michigan. This develops the project plan for flood protection measures at this locality.

(6) 1960—Corps of Engineers, General Design Memorandum for Flood Control on the Saginaw River, Michigan, and tributaries. This develops the current project plan for the areas included in the Saginaw River Flood Control Project.

(7) 1958—Flood Control Act (P.L. 85–500), approved July 3, authorizing a project sub-

TABLE 14-35 Lake Huron North, Saginaw River Basin—Flood Damage Centers

Damage Center		Flood Year	Damage Type	River
Sanilac Flats	*	1948	Agricultural	Cass River
		1950	Highways	East, Middle &
		1951	"	South Branches
		1954	"	
		1958	"	
Vassar	*	1942	Commercial	Cass River &
		1943	Residential	Moore Drain
		1946	"	
		1948	"	
Frankenmuth	*	1942	Commercial	Cass River
		1943	"	
		1948	"	
		1950	"	
Flint	*	1943	Industrial	Flint River,
		1947	Commercial	Swartz & Thread
		1948	Residential	Creek
		1956		
Corunna &	*	1947	Commercial	Shiawassee River
Owosso		1948	Residential	
		1950		
		1956		
Midland	*	1919	Industrial	Tittabawassee
		1942	Residential	River & Chippewa
		1948		River
		1950		
		1959		
City of Saginaw	*	1904	Commercial	Saginaw River
		1912	Industrial	confluence of tribu-
		1916	Residential	taries
Shiawassee Flats		1942	Agricultural	Cass, Flint,
		1948		Shiawassee &
		1950		Tittabawassee Rivers

* Flood of Record; flood year represents partial list.

TABLE 14–36 Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 3.2

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN: INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	SAGINAW RIVER												
AS1	Bay	T14N R5E S2	T13N R5E S16	1970	1,000		10	10		2500	120	2,400	Includes Bay City
				1980	1,400		100	20		2400	220	2,300	Same
				2000	2,400		200	20		2300	320	2,200	Same
				2020	4,200		300	20		2200	520	2,000	Same
AS2	Saginaw	T13N R5E S16	T11N R4E S2	1970	10,000		500	300		5800	1800	4,800	Includes Saginaw, Milwaukee and Carrollton
				1980	14,000		650	330		5620	2000	4,600	
				2000	24,000		800	200	350	5450	2200	4,400	Same
				2020	42,000		1000	400		5200	2400	4,200	Same
AS3	Saginaw	Shiawassee	Flats	1970		472,000				58200		58,200	
				1980	76,400	490,000		200		58000	200	58,000	
				2000	158,000	550,000	200	300		57700	500	57,700	
				2020	252,800	624,000	400	400		57400	800	57,400	
	TITTABAWASSEE RIVER												
AS4	Saginaw	T10N R3E S22	T8N R3E S6	1970		2,000				3050		3,050	
				1980	400	2,400	50	20		2980	70	2,980	
				2000	1,600	3,200	80	40		2930	130	2,920	
				2020	4,000	4,400	100	60		2890	170	2,880	
AS5	Midland	T13N R3E S7	T14N R2E S8	1970		1,000				1100		1,100	
				1980		2,000				980		980	
				2000		3,000				880		880	
				2020		4,000				780		780	
AS5A	Midland	Midland		1970	174,000		25	150		200	375		
				1980	259,000		120	190		186	495		
				2000	415,000		200	230		165	595		
				2020	918,000		280	270		145	695		
	SHIAWASSEE RIVER												
AS6	Saginaw	T10N R3E S22	T8N R3E S6	1970						2910		2,810	
				1980		1,200				2810		2,810	
				2000		1,500				2810		2,810	
				2020		1,900				2810		2,810	
AS7	Shiawassee	T8N R3E S6	T7N R3E S22	1970						500		500	
				1980						500		500	
				2000						500		500	
				2020						500		500	
AS7A	Shiawassee	Owosso	Corunna	1970	59,000		30	90		100	220		
				1980	65,000		50	100		70	220		
				2000	89,000		80	100		40	220		
				2020	118,000		110	110			220		
	FLINT RIVER												
AS8	Saginaw	T10N R4E S6	T9N R5E S4	1970						510		510	
				1980		1,200				510		510	
				2000		1,500				510		510	
				2020		1,900				510		510	
AS9	Genesee	T9N T5E S4	T8N R7E S28	1970	2,000		1	4		2700	55	2,650	Includes Flushing
				1980	2,400		5	15		2685	55	2,650	Same
				2000	3,200		30	20		2655	75	2,630	Same
				2020	4,100		50	30		2625	95	2,610	Same
AS9A	Genesee	Flint		1970	55,000		60	100		300	460		
				1980	77,000		100	90		270	460		
				2000	132,000		160	80		220	460		
				2020	231,000		220	60		180	460		

TABLE 14-36(continued) Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 3.2

REACH CODE	COUNTY	REACH LOCATION		YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)		ESTIMATED ACRES IN FLOOD PLAIN						REMARKS
		FROM	TO		URBAN	RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	
	CASS RIVER												
AS10	Saginaw	T11N R4E S3	T11N R6E S26	1970	2,000		20	10		3740	150	3,620	Includes Frankenmuth
				1980	2,600	200	70	20		3680	210	3,650	Same
				2000	4,000	400	100	50		3620	280	3,490	Same
				2020	7,800	600	120	70		3580	330	3,440	Same
AS11	Tuscola	T11N R6E S25	T13N R11E S12	1970		2,000				5825		5,825	
				1980		3,000				5825		5,825	
				2000		4,000				5810		5,810	
				2020		6,000				5770		5,770	
AS11A	Tuscola	Vassar		1970	155,000		30	95		50	175		
				1980	138,000		20	70		85	175		
				2000	153,000		70	70		50	190		
				2020	198,000		120	90		20	230		
	KAWKAWLIN RIVER												
AR1	Bay	T15N R5E S33	T15N R3E S26	1970	3,800	5,000	10	50		2000	60	2,000	Includes Kawkawlin
				1980	4,600	6,000	10	70		1980	80	1,980	Same
				2000	5,700	7,500	20	80	40	1920	100	1,960	Same
				2020	7,600	9,000	20	100	60	1880	120	1,940	Same
	SEBEWAING RIVER												
AT1	Huron	T15N R9E S7	T15N R9E S8	1970	4,000		40	100		150	290		
				1980	4,100		40	110		140	290		
				2000	4,500		40	120		130	290		
				2020	5,800		50	120		120	290		

stantially in accordance with the recommendations of the Chief of Engineers in House Document 346, at an estimated cost of $16 million

(8) 1955—House Document No. 346, 84th Congress, containing the recommendations of the Chief of Engineers, U.S. Army Corps of Engineers, for flood control measures in the Saginaw River basin at the following localities: Middle and South Branches of the Cass River, at Vassar on the Cass River, at Frankenmuth on the Cass River, at Flint on the Flint River, at Corunna on the Shiawassee River, at Owosso on the Shiawassee River, at Midland on the Tittabawassee River, at the Shiawassee Flats on the lower reaches of the four principal tributaries

(9) 1950—Corps of Engineers, Preliminary Examination Report for the Saganing River, Michigan, with a view to determining the advisability of providing flood protection. Flood control projects were not justified at that time and further surveys were not recommended.

(10) 1948—Corps of Engineers, a Preliminary Examination Report Review favoring a project survey and indicating that serious flood problems exist at Frankenmuth, Vassar, the Sanilac Flats area, Flint, Midland, Shiawassee Flats, and the Saginaw River near Saginaw. It determined that flood control measures were economically feasible and that a survey for flood control and allied purposes be made for the Saginaw basin.

(11) 1946—House of Representatives, Committee on Flood Control, requesting that all previous reports be reviewed to determine the feasibility of improving the Saginaw River or its tributaries for flood control and other purposes

(12) 1945—Corps of Engineers, Preliminary Examination Report for the Pinconning River, Michigan, in relation to flood control and small-craft navigation. It concluded that further surveys were not justified.

(13) 1941—Corps of Engineers, a Survey Report of the Saginaw River with a view to control floods. The report recommended that such a project could not be economically justified at that time.

(14) 1936—Flood Control Act approved June 22 authorizing the Preliminary Examination of the Saginaw River for possible flood control measures. The report recognized the flood problems at Saginaw, Midland, and the

TABLE 14–37 Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 3.2

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)			ESTIMATED ACRES IN FLOOD PLAIN								
		URBAN	RURAL	TOTAL	CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		KAWKAWLIN COMPLEX - MICHIGAN											
440	1970	--	2,700	2,700	500	100	300	100	--	--	--	--	1,000
4T1	1970	--	10,200	10,200	1,366	14	500	200	--	--	--	--	2,080
4T1A	1970	--	1,700	1,700	300	260	1,200	400	--	--	--	--	2,160
Total	1970	--	14,600	14,600	2,166	374	2,000	700	--	--	--	--	5,240
	1980	--	19,100	19,100	2,166	374	2,000	700	--	--	--	--	5,240
	2000	--	22,800	22,800	2,166	374	2,000	700	--	--	--	--	5,240
	2020	--	26,100	26,100	2,166	374	2,000	700	--	--	--	--	5,240
		SAGINAW COMPLEX - MICHIGAN											
4A4C	1970	4,000	--	4,000	--	--	--	--	--	100	--	100	--
4A1A	1970	--	3,700	3,700	500	250	250	--	--	--	--	--	1,000
4A1B	1970	--	1,400	1,400	140	350	240	70	--	--	--	--	800
4A1C	1970	--	100	100	5	110	2,640	1,625	--	--	--	--	4,380
4A1C1	1970	100	100	200	19	12	6	88	--	3	--	3	125
4A1E	1970	400	11,900	12,300	2,160	555	190	735	5	5	--	10	3,640
4A1E1	1970	200	6,500	6,700	870	30	35	15	5	--	--	5	950
4A1E2	1970	1,500	16,100	17,600	2,540	150	350	--	25	15	--	40	3,040
4A1E3	1970	--	3,200	3,200	425	25	75	25	--	--	--	--	550
4A1E4	1970	--	3,200	3,200	425	10	50	15	--	--	--	--	500
4A2B	1970	16,000	7,000	23,000	2,100	1,075	700	2,170	100	200	100	400	6,045
4A2C	1970	4,500	2,000	6,500	500	480	1,100	1,200	25	50	300	375	3,280
4A2D	1970	1,200	100	1,300	14	310	210	502	--	--	30	30	1,036
4A2E	1970	800	3,000	3,800	400	250	250	150	--	20	--	20	1,050
4A2F	1970	--	10,100	10,100	1,350	90	6,300	450	--	--	--	--	8,190
4A2F2	1970	400	3,300	3,700	430	205	215	5	--	10	--	10	855
4A2G	1970	300	4,900	5,200	650	850	2,787	230	4	--	4	8	4,517
4A2G1	1970	700	6,900	7,600	924	462	1,782	939	2	1	15	18	4,107
4A3A	1970	--	23,400	23,400	3,120	2,220	2,220	360	--	--	--	--	7,920
4A3B	1970	--	100	100	20	20	100	70	--	--	--	--	210
4A3C	1970	--	2,000	2,000	270	40	85	25	--	--	--	--	420
4A3C1	1970	--	2,000	2,000	260	50	75	25	--	--	--	--	410
4A3D	1970	800	100	900	--	100	60	100	--	--	20	20	260
4A4A	1970	2,900	3,600	6,500	1,045	475	670	110	80	260	80	420	2,300
4A4A1	1970	100	3,800	3,900	500	960	726	994	--	--	2	2	3,180
4A4A1A	1970	8,000	27,700	35,700	3,700	1,850	2,135	410	60	115	25	200	8,095
4A4A3	1970	--	100	100	--	75	50	--	--	--	--	--	125
4A4A3A	1970	--	10,100	10,100	1,350	150	300	50	--	--	--	--	1,850
4A4A4	1970	--	25,800	25,800	3,550	500	700	200	--	--	--	--	4,950
4A4A5	1970	--	5,400	5,400	720	576	690	300	--	--	--	--	2,286
4A4A5A	1970	6,400	4,500	10,900	600	900	900	100	--	--	160	160	2,500
4A4D	1970	36,000	200	36,200	100	60	20	20	--	900	--	900	200
4A4E	1970	2,000	2,100	4,100	280	260	120	40	--	50	--	50	700
4A4E1	1970	--	5,300	5,300	700	300	200	30	--	--	--	--	1,230
4A4E2	1970	--	15,500	15,500	2,720	640	2,000	160	--	--	--	--	5,520
4A4F	1970	1,000	1,400	2,400	214	108	387	91	--	20	5	25	800
4A4F2	1970	--	--	--	--	40	75	--	--	--	--	--	115
4A4F4	1970	--	1,900	1,900	250	250	--	--	--	--	--	--	500
4A230	1970	8,000	7,200	15,200	1,100	475	800	1,125	--	--	200	200	3,500
4A5	1970	20,000	1,000	21,000	375	25	30	170	100	380	20	500	600
4A6	1970	6,400	17,100	23,500	2,325	115	205	95	20	40	100	160	2,740
4A7A	1970	--	100	100	20	5	80	--	--	--	--	--	105
4A9	1970	--	38,300	38,300	8,520	110	315	145	--	--	--	--	9,090
Total	1970	121,700	282,200	403,900	45,191	15,518	30,123	12,839	426	2,169	1,061	3,656	103,671
	1980	165,500	369,700	535,200	45,191	15,518	30,123	12,839	426	2,169	1,061	3,656	103,671
	2000	303,000	440,200	743,200	45,191	15,518	30,123	12,839	426	2,169	1,061	3,656	103,671
	2020	572,000	505,100	1,077,100	45,191	15,518	30,123	12,839	426	2,169	1,061	3,656	103,671
		THUMB COMPLEX - MICHIGAN											
4U	1970	--	3,000	3,000	745	50	100	5	--	--	--	--	900
4V	1970	1,600	6,800	8,400	1,700	300	500	130	25	15	--	40	2,630
4W	1970	--	15,000	15,000	2,410	830	745	210	--	--	--	--	4,195
442	1970	2,300	28,300	30,600	1,200	--	--	--	--	10	--	10	1,200
443	1970	--	11,500	11,500	680	740	2,013	607	--	--	--	--	4,040
444	1970	--	4,400	4,400	1,117	4,101	15,000	2,000	--	--	--	--	22,218
445	1970	500	44,000	44,500	7,449	11,142	1,464	732	20	5	5	30	20,787
446	1970	--	400	400	--	800	600	300	--	--	--	--	1,700
452	1970	--	400	400	50	5	20	5	--	--	--	--	80
	1970	4,400	113,800	118,200	15,351	17,968	20,442	3,989	45	30	5	80	57,750
	1980	6,000	149,100	155,100	15,351	17,968	20,442	3,989	45	30	5	80	57,750
	2000	11,000	177,500	188,500	15,351	17,968	20,442	3,989	45	30	5	80	57,750
	2020	20,700	203,700	224,400	15,351	17,968	20,442	3,989	45	30	5	80	57,750

Shiawassee Flats. The report did not recommend a survey, but concluded that the cost of any flood measures necessary to provide complete protection from extreme floods could not be justified.

(15) 1931—Corps of Engineers, a Preliminary Examination Report for Flood Control on the Tittabawassee River and the Chippewa River at Midland, Michigan, and downstream. The report concluded that complete control of floods would be impractical and uneconomical without prior improvements to the Saginaw River.

1.34.3 Development in the Flood Plain

The Saginaw River basin presents a unique combination of highly industrialized urban centers and highly developed agricultural production. Major production centers include Bay City and Saginaw on the Saginaw River, Flint on the Flint River, and Midland on the Tittabawassee River. Medium-sized urban centers located on the main streams include Owosso and Corunna on the Shiawassee River, Frankenmuth and Vassar on the Cass River, Mt. Pleasant on the Chippewa River, Clare on the Tobacco River, and Alma on the Pine River. In Flint the river banks are occupied by the assembly plants of a large automobile manufacturer. Commercial and residential development has also encroached into the river floodway here and in the other urban centers mentioned previously. On the farmlands between these communities the basin produces a dry bean and sugar beet crop that ranks high in national output. Many other field crops are produced in the region, one of the richest agricultural areas in Michigan.

The headwater areas of the Saginaw River's tributaries are readily adaptable to the construction of small reservoirs, and public and private agencies have constructed more than 70 dams on some of the more favorable sites. The purposes of these dams vary from hydroelectric power to regulation of inland lake levels.

The main stem of the Saginaw River has only a very slight slope. However, the natural channel is wide and has been improved through most of its length for navigation by ships of the Great Lakes fleet.

1.34.4 Flood Problems

The four main tributaries, the Tittabawassee, Cass, Shiawassee, and Flint Rivers, are streams with watersheds of different sizes, shapes, intensities of precipitation, patterns of interior drainage, channel slopes, and corresponding flow habits. The records show that damaging floods in the Saginaw basin nearly always occur in the spring and most commonly in the last half of March or the early part of April. Major floods are for the most part caused by the melting of snow on the watershed, reinforced and accelerated by warm spring rains. Many summer and fall rain storms, although heavy, have produced only moderate rises in the streams. The record flood on the Saginaw River at Saginaw occurred in March 1904, and was estimated at 68,000 cfs. Records of flooding in the Saginaw area date back to 1873. During ordinary low water seasons, the river levels respond to the water levels in Saginaw Bay.

The floods in the Saginaw River basin may be classified in two categories: those which are general throughout the entire basin, and those which are local and limited to one or two tributaries without serious rises in the others. The general floods seem to recur with an average frequency of once in six or seven years. However, on any given tributary, the frequency may be once in every two or three years.

Table 14–35 lists flood damage centers in the basin. Figure 14–35c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–36 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–37 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–36c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–38. County summaries for the main stem and principal tributaries are tabulated in Table 14–39.

1.34.5 Existing Flood Damage Prevention Measures

The flood control structures proposed for the Cass River at Frankenmuth, Michigan, in

TABLE 14–38 Data Summary by River Basin, River Basin Group 3.2

		Estimated Average Annual Damage (Dollars)		Estimated Acres In Flood Plain	
River Basin	Year	Urban	Rural	Urban	Rural
Kawkawlin Complex	1970	3,800	19,600	60	7,240
	1980	4,600	25,100	80	7,220
	2000	5,700	30,300	100	7,200
	2020	7,600	35,100	120	7,180
Saginaw River	1970	579,700	759,200	7,011	189,136
	1980	801,700	869,700	7,761	188,386
	2000	1,285,200	1,003,800	8,626	187,521
	2020	2,351,900	1,147,900	9,576	186,571
Thumb Complex	1970	8,400	113,800	370	57,750
	1980	10,100	149,100	370	57,750
	2000	15,500	177,500	370	57,750
	2020	26,500	203,700	370	57,750
TOTAL	1970	591,900	892,600	7,441	254,126
	1980	816,400	1,043,900	8,211	253,356
	2000	1,306,400	1,211,600	9,096	252,471
	2020	2,386,000	1,386,700	10,066	251,501

the Corps of Engineers, Detroit District, General Design Memorandum No. 2, dated November 1963, were initiated and construction was completed in 1968. The protection now afforded allows for a flood flow approximately 50 percent greater than any past recorded flood.

Work on the flood control measures for the Flint River at Flint, Michigan, are currently under way. Section A was completed in 1968, and section B was completed in the fall of 1970. These provide protection from floods greater than any experienced in the past. This protection results in an exceedence frequency of less than two percent. Construction on the remaining sections of the project, sections C and D, was scheduled for completion in 1974.

The Soil Conservation Service has two projects completed under authority of P.L. 566. These projects are the Farm Creek-Lee Drain Watershed, Gladwin County, Michigan, and the Jo Drain Watershed, Midland County, Michigan.

The Soil Conservation Service has three flood control and major drainage works projects under construction. These projects are the Middle Branch of the Cass River Watershed, Sanilac County, Michigan, the South Branch of the Cass River Watershed, Sanilac and Lapeer Counties, Michigan, and the Misteguay Creek Watershed, Saginaw, Shiawassee, and Genesee Counties, Michigan.

The location of completed preventive measures is depicted in Figure 14–37.

The U.S. Weather Bureau has established a flood plain warning system on the main tributaries of the Saginaw River. Key observers report river gage data and rainfall amounts to a central office in Lansing, Michigan. Here the data are analyzed, flood stages are predicted, and the information is disseminated to the public through communication media.

Refer to Subsection 1.14.5 for discussion of flood plain legislation which is applicable to this river basin.

TABLE 14-39 River Basin Group 3.2, Data Summary by County

	Estimated Average Annual Damages (Dollars)		Estimated Acres in Flood Plain	
	Urban	Rural	Urban	Rural
YEAR 1970				
Bay	4,800	5,000	180	4,400
Genesee	57,000	---	515	2,650
Huron	4,000	---	290	---
Midland	174,000	1,000	375	1,100
Saginaw	12,000	474,000	1,950	72,990
Shiawassee (Planning Subarea 2.3)	59,000	---	220	500
Tuscola	155,000	2,000	175	5,825
Clare	---	---	---	---
Gladwin	---	---	---	---
Gratiot	---	---	---	---
Isabella	---	---	---	---
Lapeer	---	---	---	---
TOTALS	465,800	482,000	3,705	87,465
YEAR 1980				
Bay	6,000	6,000	300	4,280
Genesee	79,400	---	515	2,650
Huron	4,100	---	290	---
Midland	259,000	2,000	495	980
Saginaw	93,400	495,000	2,480	72,460
Shiawassee (Planning Subarea 2.3)	65,000	---	220	500
Tuscola	138,000	3,000	175	5,825
Clare	---	---	---	---
Gladwin	---	---	---	---
Gratiot	---	---	---	---
Isabella	---	---	---	---
Lapeer	---	---	---	---
TOTALS	644,900	506,000	4,475	86,695
YEAR 2000				
Bay	8,100	7,500	420	4,160
Genesee	135,200	---	535	2,630
Huron	4,500	---	290	---
Midland	415,000	3,000	595	880
Saginaw	187,600	556,600	3,110	71,830
Shiawassee (Planning Subarea 2.3)	89,000	---	220	500
Tuscola	153,000	4,000	190	5,810
Clare	---	---	---	---
Gladwin	---	---	---	---
Gratiot	---	---	---	---
Isabella	---	---	---	---
Lapeer	---	---	---	---
TOTALS	992,400	571,100	5,360	85,810
YEAR 2020				
Bay	11,800	9,000	640	3,940
Genesee	235,100	---	555	2,610
Huron	5,800	---	290	---
Midland	918,000	4,000	695	780
Saginaw	306,600	632,800	3,700	71,240
Shiawassee (Planning Subarea 2.3)	118,000	---	220	500
Tuscola	198,000	6,000	230	5,770
Clare	---	---	---	---
Gladwin	---	---	---	---
Gratiot	---	---	---	---
Isabella	---	---	---	---
Lapeer	---	---	---	---
TOTALS	1,793,300	651,800	6,330	84,840

* On main stem and principal tributaries

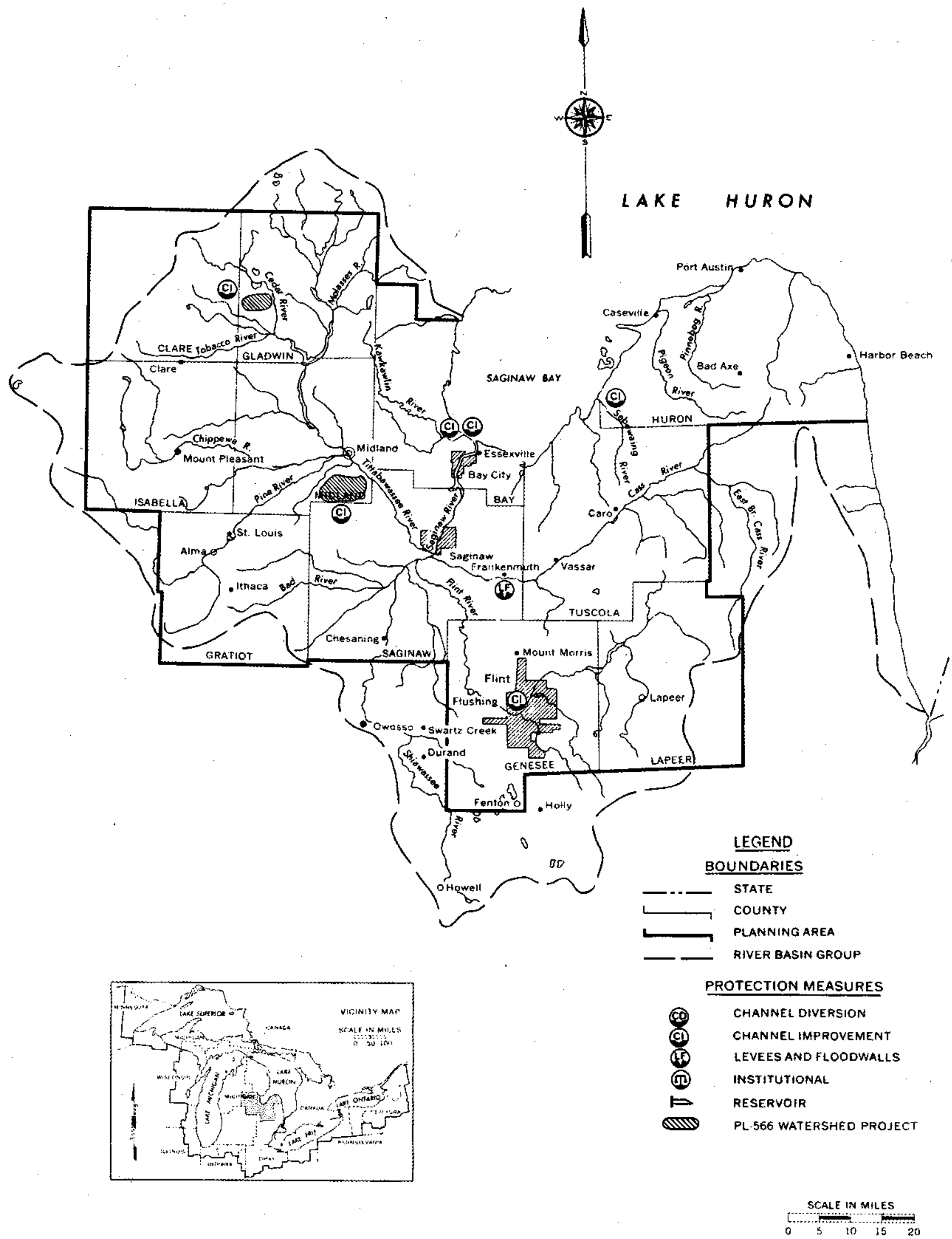

FIGURE 14-37 Existing Flood Damage Protection Measures for River Basin Group 3.2

1.35 Lake Huron Central, River Basin Group 3.2, Thumb Complex

1.35.1 Description

This region is not influenced by any single river basin but is made up of several small rivers and streams which drain the section of land outlining the shores of the Thumb of the Lower Peninsula. Location of this complex within River Basin Group 3.2 is shown in Figure 14–34. This complex occupies an area of approximately 1,400 square miles, but the largest drainage area of any one stream is that of the Pinnebog River draining 171 square miles. Other major streams of the region are: Willow Creek, draining 100 square miles; the Pigeon River, draining 156 square miles; the Sebewaing River, draining 110 square miles; and Wiscoggin Creek.

This area is typical of the lands draining into the southern portion of Lake Huron. In general, ground surfaces do not have a uniform relief, but are broken by occasional low ridges interspaced by level areas. The maximum elevation in the area is 850 feet above sea level, and stream slopes average 11.5 feet per mile until their egress into Lake Huron at approximately 577 feet (L.W.D.).

1.35.2 Previous Studies

Previous studies are listed below:

(1) 1945—Corps of Engineers, Definite Project Report for Sebewaing River at Sebewaing, Michigan

(2) 1939—a Survey for Flood Control with a favorable comment

(3) 1936—a Preliminary Examination which produced an unfavorable recommendation

1.35.3 Development in the Flood Plain

The drainage areas discussed here are a part of the portion of Michigan commonly referred to as the Thumb area. This portion of the State is under the influence of the Detroit metropolitan area directly to the south. It is still primarily a rural agricultural area and also serves as a recreational outlet, especially along the shoreline of Lake Huron, for the neighboring population centers. Because of the water supply available from Saginaw Bay and Lake Huron, many of the main towns and industries of the basin are situated near the shores.

The small size of the individual basins and the relatively flat topography precludes the development of reservoir sites. In fact, during the summer months some of the streams have had no flow. However, at other seasons some streams have overflowed their banks on several occasions.

1.35.4 Flood Problems

Even though the rivers and drainage areas are small, this region is not without flood problems. Flood damages have occurred at Sebewaing, Michigan, in 1935, 1942, and 1948. The flood overflows in 1935 and 1948 were intensified by ice jams and the flood of June 1948 was created by a severe rainstorm. However, other flooding has been extremely local and has caused only minor damages to cropland in most cases.

Figure 14–35c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–36 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–37 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–36c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–38. County summaries for the main stem and principal tributaries are tabulated in Table 14–39.

1.35.5 Existing Flood Damage Prevention Measures

A flood control project of limited scope was completed in 1948 along the Sebewaing River

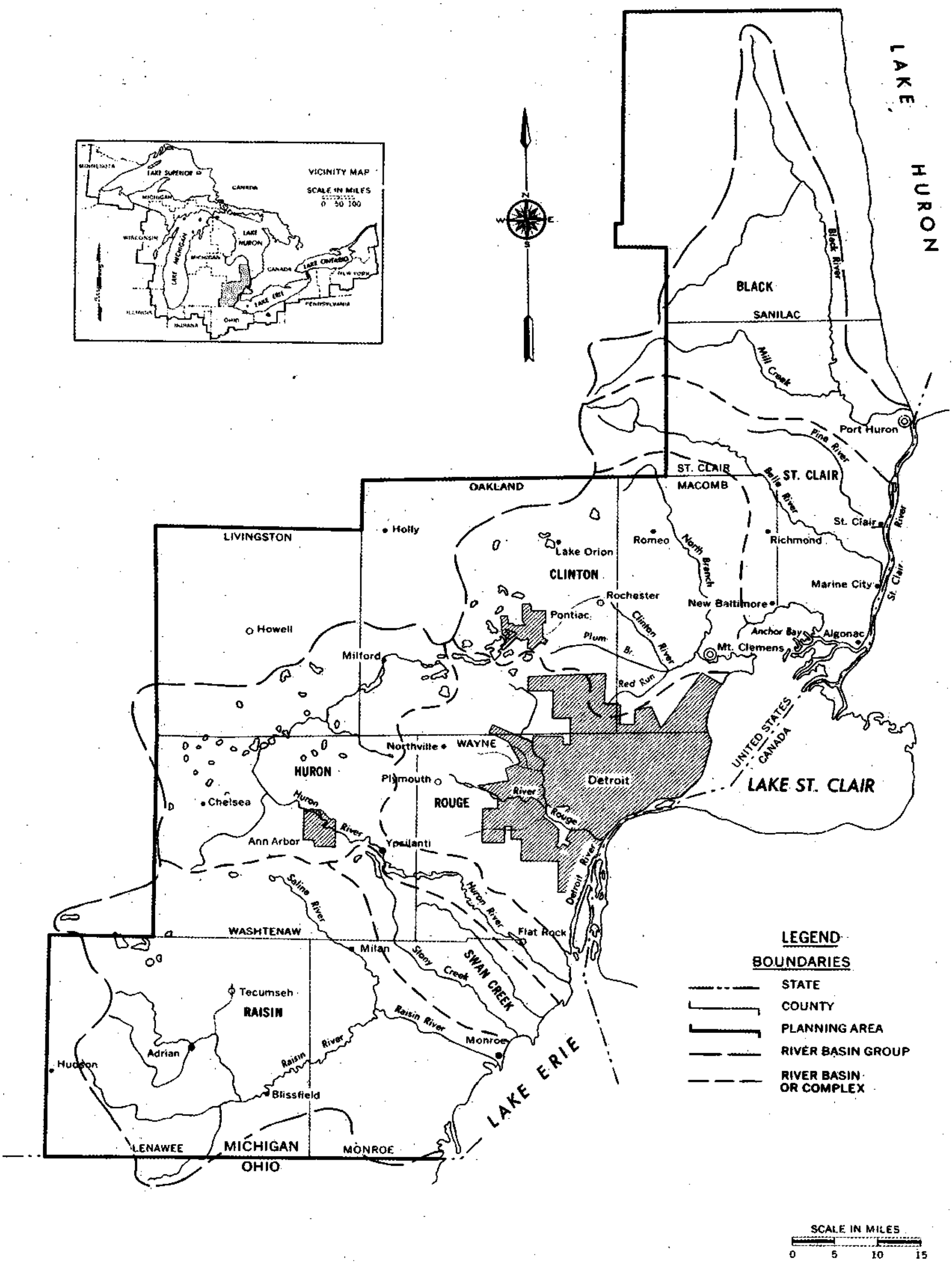

FIGURE 14–38 Lake Erie Northwest—River Basin Group 4.1

in the Village of Sebewaing, Michigan, by the Corps of Engineers. Channel enlargement of approximately two miles with a capacity of 7,500 cfs was provided from the confluence of State and Columbia Drains to the breakwaters in Saginaw Bay. This provided protection for a flood frequency of 15 years.

Caseville, Michigan, at the mouth of the Pigeon River, has a small-boat harbor constructed in 1964 by the Corps of Engineers. Among other features, it provides a channel 8 feet deep and 60 feet wide extending 1,000 feet upstream in the Pigeon River. This increased channel capacity undoubtedly helps to alleviate overflow conditions.

There are no other structural projects for flood control by other governmental or local agencies at this time. The Michigan Water Resources Commission has the authority to regulate all development in the flood plain areas. The need is steadily increasing for well-developed regulations to prevent a buildup of flood damages in the flood plains. Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to this complex.

1.36 Lake Erie Northwest, River Basin Group 4.1, Black River Basin

1.36.1 Description

The Black River basin is the northernmost basin in this river basin group and in the southeastern Michigan study area. This roughly triangular-shaped basin drains an area of 711 square miles in Sanilac, St. Clair, Lapeer, and Huron Counties. Location within River Basin Group 4.1 is shown in Figure 14–38.

The land surface in this area is principally a broad, flat plain nestled between morainal hills which form its boundaries and dictate its drainage patterns. These hills, although not pronounced, provide local topographic contrast. Old beach lines, formed during successive stages of ancestral glacial lakes, are marked by local steepening of the land surface and also provide contrast in the topographic setting. Elevations in the basin range from 579 feet at the mouth of the Black River to slightly more than 1,000 feet in the vicinity of Brown City at the western edge.

In its downstream course the Black River is joined by a number of streams, almost all of which enter from the west. Those streams entering from the east are generally small and most are unnamed. Major tributaries entering from the west include Elk Creek, which joins the Black near Sandusky, and Mill Creek, which joins the river closer to its mouth. Both of these streams rise in the southwestern corner of the basin.

1.36.2 Previous Studies

Previous studies are listed below:

(1) 1972—U.S. Geological Survey—flood-prone area reports for portions of Black River

(2) 1971—Soil Conservation Service, Preliminary Investigation Report for Elk Creek Watershed, Lapeer and Sanilac Counties, Michigan

(3) 1970—Corps of Engineers, Detailed Project Report on the Black River at Port Huron. It concerns an improved navigation channel for approximately 2½ miles above the existing project limits.

(4) 1969—Corps of Engineers, Flood Damage Survey of the Black River at Port Huron (unpublished)

(5) 1951—Corps of Engineers, Review Survey Report (unpublished) considering two separate recreational boating improvements requested by local interest. One of these was for the extension of a navigable channel 10 feet deep from the end of existing project to the confluence with the Black River drainage canal.

1.36.3 Development in the Flood Plain

The Black River has cut well below the adjacent plain in its upper reaches, and this stream erosion has created a gorge more than 100 feet deep at the confluence with Mill Creek. Mill Creek and the smaller tributary streams in the lower reaches of the Black River have also become deeply incised. Elk Creek and other tributaries in the upper reaches of the basin have not cut substantially into the plain. Most major stream channels are well developed, but to drain much of the flat areas between, ditches and drains have been constructed to convey overland runoff. Construction of many of these drains was completed around 1900 to reclaim the land for agricultural use.

Little effort has been made to use streams in the Black River basin for water supply or other resource development. Minor dams have been constructed for mill ponds and related uses, but most have been abandoned. Because

Black River and Mill Creek are deeply incised in their lower reaches, favorable sites for the construction of dams are attainable but undeveloped because of the extended low flows in the streams. There are 48 lakes and ponds within the basin, ranging in size from the 120 acres in Elk Lake to less than 5 acres. Most of the lakes and ponds are small, more than half being less than 5 acres in size. The natural lakes lie in the morainal areas to the southwest. Elsewhere, lakes are primarily ponded gravel pits or areas flooded for wildlife.

Settlement in the Black River basin can still be generally classified as rural. Villages and cities are small and owe a large part of their economic life to agriculture. Port Huron, the largest city, has a population approaching 40,000. The other communities have populations generally less than 2,000. Some light industrial development has occurred in various towns, but 80 percent of the basin area is used for farming, with dairying providing most of the agricultural income. The area is well served by the Michigan State Highway network, including Interstate 94 which terminates at Port Huron, as well as three rail lines providing freight service across the basin.

1.36.4 Flood Problems

For the most part, flood damage in the Black River basin is concentrated at the City of Port Huron and immediate vicinity. Upstream and tributary urban areas have had few overland flooding problems, and floods that have occurred have been caused mainly by deficient drainage. Damage to farmlands has been local, and for the most part, minor in degree.

In recent years floods occurred at Port Huron in 1943, 1947, and 1949. Ice jams are the major causes of the stream overflows in this area. At that time the districts affected by these floods were mostly unsettled river bottomlands. Today, under the pressure of urban expansion and encroachment, these districts are the sites of new home developments, and the toll in property damage could be extensive.

Figure 14–39c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–40 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–41 depicts upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–40c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–42. County summaries for the main stem and principal tributaries are tabulated in Table 14–43.

1.36.5 Existing Flood Damage Prevention Measures

There have been no structural projects on the main stem of the Black River for flood control purposes. The Corps of Engineers completed a navigation channel in 1931 which provided a 16-foot channel including a settling basin approximately 2 miles upstream. Because of the lack of commercial water transportation, this channel has not been maintained in recent years.

Five dams have been inventoried in the basin, and only one was constructed as a flood retarding structure. This dam on the North Branch of Mill Creek is part of the North Branch Watershed Protection and Flood Prevention Project under the supervision of the Soil Conservation Service. Included in this scheme are 12.5 miles of multiple-purpose improvement work below the dam and 3 miles of channel improvement on Brant Lake Drain beginning approximately 2 miles above the dam. Location of this preventive measure is illustrated in Figure 14–41.

The Michigan Water Resources Commission has the authority to regulate all development in the flood plain areas. Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to this river basin.

1.37 Lake Erie Northwest, River Basin Group 4.1, St. Clair Complex

1.37.1 Description

This complex consists of the basins of the Pine River, Belle River, and several small creeks flowing independently into Anchor Bay, an arm of Lake St. Clair. Location of the complex within River Basin Group 4.1 is illustrated in Figure 14–38. The Pine River drains an area of 194 square miles. This river rises in morainal hills and flows in a generally southeasterly direction to the St. Clair River. Its tributaries are all relatively small and many have intermittent flow. The basin area is a level-to-gently-undulating glacial plain interrupted by stream valleys and by a series of

TABLE 14–40 Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 4.1

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	BLACK RIVER												
AU1	St. Clair	T6N R16E S11	T6N R16E S2	1970	127,500		400	2100		3000	5500		
				1980	165,800		440	2160		2900	5500		
				2000	216,800		480	2220		2800	5500		
				2020	306,000		520	2280		2700	5500		
	PINE RIVER												
AV1	St. Clair	T4N R17E S304	T7N R13E S22	1970						5420		5,420	
				1980		1,300				5420		5,420	
				2000	200	1,500	60	40		5320	100	5,320	
				2020	700	1,700	120	80		5220	240	5,180	
	BELLE RIVER												
AV2	St.Clair	T3N R16E S12	T5N R15E S7	1970	800	200	50	50		3600	200	3,500	
				1980	1,000	300	70	70		3560	220	3,480	
				2000	1,200	500	90	90		3520	240	3,460	
				2020	1,600	800	110	120		3370	290	3,410	
	CLINTON RIVER												
AW1	Macomb	River Mouth	Oakland Co Line	1970	2,069,000	125,800		2233		3339	2733	2,839	
				1980	3,215,800	126,400		2453		3119	2913	2,659	
				2000	10,223,400	127,400	40	2673		2859	3173	2,399	
				2020	11,717,000	127,000	200	2893		2319	3653	1,919	
AW2	Oakland	Macomb Co. Line	T3N R10E S27	1970	6,400	1,800	80	480		2160	600	2,120	
				1980	10,900	3,000	100	540		2080	680	2,040	
				2000	24,700	5,600	120	620		1980	800	1,920	
				2020	54,600	14,200	160	740		1820	1000	1,720	
	RED RUN DRAIN												
AW3	Macomb	T2N R13E S19	T1N R11E S14	1970	18,300,000		160	5680		6640	11,840	640	
				1980	27,450,000		320	7560		4600	11,880	600	
				2000	38,400,000		480	9560		2440	11,940	540	
				2020	41,000,000		640	10400		1440	11,940	540	
	RIVER ROUGE												
AX1	Wayne	T2S R11E S45	T1S R10E S5	1970	1,579,000		1700	5220		1060	7980		
				1980	2,039,400		1860	5280		840	7980		
				2000	3,369,900		2040	5320		629	7980		
				2020	5,571,300		2200	5380		400	7980		
AX2	Oakland	T1N R10E S32	T2N R11E S8	1970	140,000		70	80		1550	1550	150	
				1980	224,000		120	130		1450	1600	100	
				2000	518,000		195	180		1325	1650	50	
				2020	1,176,000		270	230		1200	1700		
AX3	Wayne	T2S R10E S665	T2S R9E S29	1970	57,500		500	500		2500	3500		Lower Branch
				1980	69,000		550	550		2400	3500		Same
				2000	80,500		600	600		2300	3500		Same
				2020	92,000		700	700		2100	3500		Same
AX4	Wayne	T2S R10E S10	T2S R9E S3	1970	5,300		520			2000	2520		Middle Branch
				1980	6,400		560			1960	2520		Same
				2000	7,400		600			1920	2520		Same
				2020	8,500		680			1840	2520		Same
AX5	Wayne	T1S R10E S21	T1S R10E S18	1970	55,200			376			376		Upper Branch
				1980	66,200			376			376		Same
				2000	77,300			376			376		Same
				2020	88,300			376			376		Same
	BELL BRANCH												
AX6	Wayne	T1S R10E S21	T1S R10E S13	1970	37,600			845			845		
				1980	48,900			845			845		
				2000	82,700			845			845		
				2020	139,000			845			845		

TABLE 14–40(continued) Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 4.1

REACH CODE	COUNTY	REACH LOCATION		YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)		ESTIMATED ACRES IN FLOOD PLAIN						REMARKS
		FROM	TO		URBAN	RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	
	HURON RIVER												
AY1	Monroe	T5S R10E S25	T5S R10E S6	1970		1,000				400		400	
				1980		1,300				400		400	
				2000		2,200				400		400	
				2020	1,000	2,700		60		340	60	340	
AY2	Wayne	T5S R10E S25	T3S R7E S24	1970	1,000	600		710		10250	1340	9,620	
				1980	2,500	600	30	810		10120	1600	9,360	
				2000	2,200		60	1000		9900	1760	9,200	
				2020	5,300	600	80	1100		9770	1920	9,040	
AY2A	Wayne	Rockwood		1970	80,000		55	400		600	1055		
				1980	104,000		110	440		505	1055		
				2000	176,000		170	470		415	1055		
				2020	296,000		200	530		325	1055		
AY2B	Wayne	Flat Rock		1970	120,000			228		100	328		
				1980	144,000		10	238		80	328		
				2000	168,000		20	248		60	328		
				2020	192,000		30	258		40	328		
AY3	Washtenaw	T3S R7E S24	T1S R5E S31	1970	10,550	800	30	50		1384	554	920	Includes Ann Arbor, Dexter and Delta Mills
				1980	17,260	1030	110	120		1234	654	820	
				2000	40,600	1050	220	200		1044	774	700	Same
				2020	97,100	1570	330	245			879	595	Same
AY3A	Washtenaw	Ypsilanti		1970	150,000		200			75	275		
				1980	187,500		225			50	275		
				2000	285,000		250			25	275		
				2020	412,500		275				275		
	RAISIN RIVER												
BA1	Monroe	T7S R9E S11	T7S R6E S7	1970	5,600	2,000	70	100		5878	250	5,798	
				1980	6,800	3,500	80	110		5858	250	5,798	
				2000	10,400	5,100	100	110		5838	250	5,798	
				2020	16,000	7,500	130	115		5803	250	5,798	
BA1A	Monroe	Dundee		1970	8,500		30			100	130		
				1980	11,000		30	20		80	130		
				2000	18,700		40	30		60	130		
				2020	31,400		40	50		40	130		
BA2	Lenawee	T7S R5E S12	T6S R4E S15	1970	5,800	1,000	20				192	6,570	
				1980	6,400	2,200	30	80		6652	192	6,570	
				2000	8,700	3,000	40	80		6642	192	6,570	
				2020	12,000	4,200	40	100		6622	192	6,570	
BA2A	Lenawee	Blissfield		1970	8,000		30	70		200	300		
				1980	8,800		40	80		180	300		
				2000	12,000		60	100		140	300		
				2020	16,800		60	100		140	300		
BA3	Lenawee	T6S R4E S29	T6S R3E S10	1970			37			380	37	380	Includes Adrian
				1980	800	500	37	20		360	57	360	Same
				2000	1,200	1,000	40	27		350	67	350	Same
				2020	2,200	1,500	40	37		340	77	340	Same

beaches which were formed by glacial lakes. Elevations in the basin range from 578 feet at the mouth of the Pine River to 850 feet in the northwest corner. Stream gradients are small, averaging falls of less than 10 feet per mile. However, in the headwaters of most streams, slopes in excess of 10 feet per mile are common.

The Belle River also rises in morainal hills and flows in a southeasterly direction to the St. Clair River. This basin is long and narrow, 40 miles in length, and generally less than 10 miles in width. Because this is a narrow basin,

TABLE 14–41 Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 4.1

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	RURAL	TOTAL	ESTIMATED ACRES IN FLOOD PLAIN CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		ST. CLAIR COMPLEX - MICHIGAN											
3G2	1970	--	203,500	203,500	2,960	552	1,484	500	--	--	--	--	5,496
3G3	1970	--	6,400	6,400	2,000	1,000	2,000	500	--	--	--	--	5,500
3G30	1970	2,100	10,900	13,000	5,300	5,200	10,500	9,100	150	3,100	250	3,500	30,100
Total	1970	2,100	220,800	222,900	10,260	6,752	13,984	10,100	150	3,100	250	3,500	41,096
	1980	2,800	260,500	263,300	10,260	6,752	13,984	10,100	150	3,100	250	3,500	41,096
	2000	4,900	322,400	327,300	10,260	6,752	13,984	10,100	150	3,100	250	3,500	41,096
	2020	8,800	382,000	390,800	10,260	6,752	13,984	10,100	150	3,100	250	3,500	41,096
		SWAN CREEK - MICHIGAN											
330	1970	89,100	15,400	104,500	9,100	--	--	1,900	--	300	--	300	11,000
333	1970	--	2,700	2,700	900	--	--	--	--	200	--	200	900
3J1	1970	800	12,700	13,500	800	200	20	180	--	260	85	345	1,200
3I	1970	149,700	22,300	172,000	1,860	80	1,330	1,716	600	1,300	--	1,900	4,986
3J	1970	165,300	2,600	167,900	880	100	100	214	600	4,165	--	4,765	1,294
Total	1970	404,900	55,700	460,600	13,540	380	1,450	4,010	1,200	6,225	85	7,510	19,380
	1980	542,600	65,700	608,300	13,540	380	1,450	4,010	1,200	6,225	85	7,510	19,380
	2000	935,300	81,300	1,016,600	13,540	380	1,450	4,010	1,200	6,225	85	7,510	19,380
	2020	1,700,600	96,400	1,797,000	13,540	380	1,450	4,010	1,200	6,225	85	7,510	19,380
		BLACK RIVER - MICHIGAN											
3G4	1970	2,700	7,000	9,700	1,050	100	100	50	30	--	10	40	1,300
3G4D	1970	--	67,800	67,800	6,961	1,035	376	1,035	--	--	--	--	9,407
Total	1970	2,700	74,800	77,500	8,011	1,135	476	1,085	30	--	10	40	10,707
	1980	3,600	88,300	91,900	8,011	1,135	476	1,085	30	--	10	40	10,707
	2000	6,200	109,200	115,400	8,011	1,135	476	1,085	30	--	10	40	10,707
	2020	11,300	129,400	140,700	8,011	1,135	476	1,085	30	--	10	40	10,707
		HURON RIVER - MICHIGAN											
3F1	1970	800	191,800	192,600	10,152	4,500	1,500	2,208	20	205	120	345	18,360
3F2A	1970	500	55,700	56,200	871	625	705	3,729	5	10	1,000	1,015	5,930
3F2C	1970	--	200	200	300	100	200	1,000	--	--	--	--	1,600
3F2	1970	4,000	3,600	7,600	712	180	2,305	7,848	--	521	--	521	11,045
3F2B	1970	--	700	700	200	1,200	320	1,480	--	--	--	--	3,200
Total	1970	5,300	252,000	257,300	12,235	6,605	5,030	16,265	25	736	1,120	1,881	40,135
	1980	7,100	297,400	304,500	12,235	6,605	5,030	16,265	25	736	1,120	1,881	40,135
	2000	12,200	367,900	380,100	12,235	6,605	5,030	16,265	25	736	1,120	1,881	40,135
	2020	22,300	436,000	458,300	12,235	6,605	5,030	16,265	25	736	1,120	1,881	40,135
		RIVER RAISIN COMPLEX - MICHIGAN											
3M	1970	104,500	1,148,000	1,252,500	29,000	--	5,000	1,000	--	200	--	200	35,000
3K	1970	168,300	200	168,500	80	--	80	--	200	700	100	1,000	160
331	1970	376,200	170,300	546,500	3,150	--	100	50	400	400	--	800	3,300
3L	1970	41,600	4,700	46,300	175	--	--	--	--	64	--	64	175
3E1	1970	69,300	6,600	75,900	2,160	--	390	--	15	55	10	80	2,550
3E3	1970	--	12,800	12,800	4,300	320	2,550	530	--	--	--	--	7,700
3E4	1970	--	4,600	4,600	1,500	400	2,500	600	--	--	--	--	5,000
3E6	1970	2,100	300	2,400	90	110	285	130	--	50	--	50	615
3E2	1970	8,300	1,500	9,800	500	--	200	100	160	480	--	640	800
3E5	1970	--	500	500	150	50	200	100	--	--	--	--	500
3DE4	1970	--	18,000	18,000	740	85	100	--	--	--	--	--	925
Total	1970	770,330	1,367,500	2,137,800	41,845	965	11,405	2,510	775	1,949	110	2,834	56,725
	1980	1,032,200	1,613,700	2,645,900	41,845	965	11,405	2,510	775	1,949	110	2,834	56,725
	2000	1,779,400	1,996,600	3,776,000	41,845	965	11,405	2,510	775	1,949	110	2,834	56,725
	2020	3,235,300	2,365,800	5,601,100	41,845	965	11,405	2,510	775	1,949	110	2,834	56,725

tributary streams are small, and many have intermittent flow. The topography of this basin is similar to the area of the Pine River. Elevations in this basin range from 1,100 to 576 feet above sea level.

The Salt River, probably the largest of the other minor streams in the complex, drains an area of approximately 36 square miles, flowing

(continued on page 115)

TABLE 14–42 Data Summary by River Basin, River Basin Group 4.1

River Basin	Year	Estimated Average Annual Damage (Dollars) Urban	Rural	Estimated Acres In Flood Plain Urban	Rural
Black River	1970	130,200	74,800	5,540	10,707
	1980	169,400	88,300	5,540	10,707
	2000	223,000	109,200	5,540	10,707
	2020	317,300	129,400	5,540	10,707
St. Clair Complex	1970	2,900	221,000	3,700	50,016
	1980	3,800	262,100	3,720	49,996
	2000	6,300	324,400	3,840	49,876
	2020	11,100	384,500	4,030	49,686
Huron River	1970	366,850	254,430	5,433	51,075
	1980	462,360	300,330	5,793	50,715
	2000	685,400	371,750	6,073	50,435
	2020	1,026,200	440,870	6,398	50,110
Swan Creek Complex	1970	404,900	55,700	7,510	19,380
	1980	542,600	65,700	7,510	19,380
	2000	935,300	81,300	7,510	19,380
	2020	1,700,600	96,400	7,510	19,380
Raisin River	1970	798,230	1,370,500	3,743	69,473
	1980	1,066,000	1,619,900	3,763	69,453
	2000	1,830,400	2,005,700	3,773	69,443
	2020	3,313,700	2,379,000	3,783	69,433
Rouge Complex	1970	1,874,600	-	16,771	150
	1980	2,453,900	-	16,821	100
	2000	4,135,800	-	16,871	50
	2020	7,075,100	-	16,921	-
Clinton River	1970	20,375,400	127,600	15,173	5,599
	1980	30,676,700	129,400	15,473	5,299
	2000	48,648,100	133,000	15,913	4,859
	2020	52,771,600	141,200	16,593	4,179
TOTAL	1970	23,953,080	2,104,030	57,870	206,400
	1980	35,374,760	2,465,730	58,620	205,650
	2000	56,464,300	3,025,350	59,520	204,750
	2020	66,215,600	3,571,370	60,775	203,495

TABLE 14–43 River Basin Group 4.1, Data Summary by County

County (Michigan)	Estimated Average Annual Damages (Dollars) Urban	Rural	Estimated Acres in Flood Plain Urban	Rural
YEAR 1970				
Lenawee	13,800	1,000	529	6,950
Livingston	---	---	---	---
Macomb	20,369,000	125,800	14,573	3,479
Monroe	14,100	3,000	380	6,198
Oakland	146,400	1,800	2,150	2,270
St. Clair	128,300	200	5,700	8,920
Sanilac	---	---	---	---
Washtenaw	160,550	830	829	920
Wayne	1,935,600	600	17,944	9,620
TOTALS	22,767,750	133,230	42,105	38,357
YEAR 1980				
Lenawee	16,000	2,700	549	6,930
Livingston	---	---	---	---
Macomb	30,665,800	126,400	14,793	3,259
Monroe	17,800	4,800	380	6,198
Oakland	234,900	3,000	2,280	2,140
St. Clair	166,800	1,600	5,720	8,900
Sanilac	---	---	---	---
Washtenaw	204,760	1,030	929	820
Wayne	2,480,400	600	18,204	9,360
TOTALS	33,786,460	140,130	42,130	37,607
YEAR 2000				
Lenawee	21,900	4,000	559	6,920
Livingston	---	---	---	---
Macomb	48,623,400	127,400	15,113	2,939
Monroe	29,100	7,300	380	6,198
Oakland	542,700	5,600	2,450	1,970
St. Clair	218,200	2,000	5,840	8,780
Sanilac	---	---	---	---
Washtenaw	325,600	1,050	1,049	700
Wayne	3,965,400	600	18,364	9,200
TOTALS	53,726,300	147,950	43,755	36,707
YEAR 2020				
Lenawee	31,000	5,700	569	6,910
Livingston	---	---	---	---
Macomb	52,717,000	127,000	15,593	2,459
Monroe	48,400	10,200	440	6,138
Oakland	1,230,600	14,200	2,700	1,720
St. Clair	308,300	2,500	6,030	8,590
Sanilac	---	---	---	---
Washtenaw	509,600	1,570	1,154	595
Wayne	6,392,400	600	18,524	9,040
TOTALS	61,237,300	161,770	45,010	35,452

*On main stem and principal tributaries

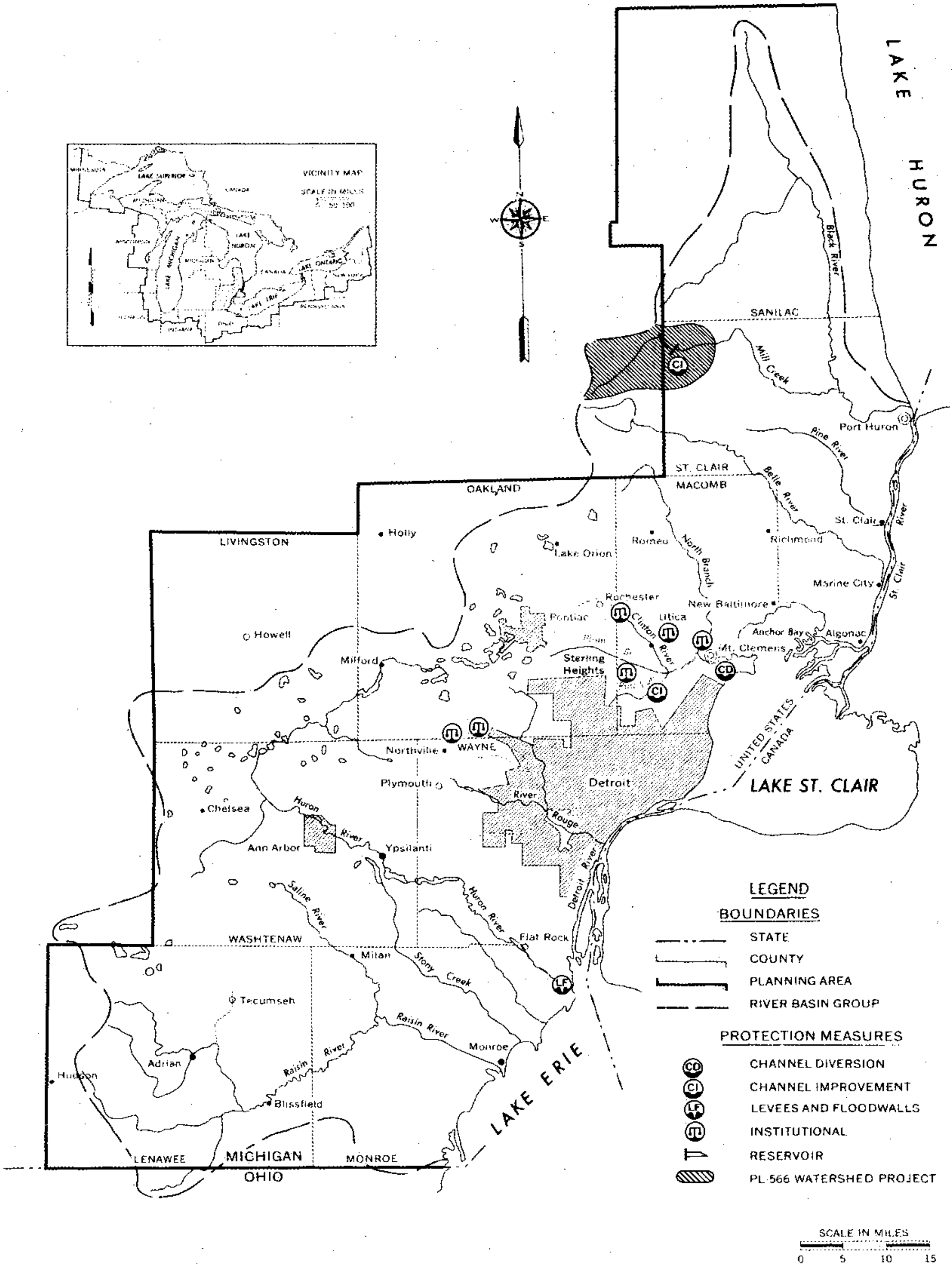

FIGURE 14–41 Existing Flood Damage Protection Measures for River Basin Group 4.1

southerly into Lake St. Clair. It drains an area of old lake plain and has a very slight stream gradient.

1.37.2 Previous Studies

There have been no studies for flood control purposes in the St. Clair complex.

1.37.3 Development in the Flood Plain

The natural drainage network within the various basins is not well developed. For this reason, ditches and drains have been constructed to convey some of the runoff. Most stream channels are cut less than 10 feet below the adjacent land surface, except in the lower reaches where the streams have become incised as deep as 30 feet into the glacial plains.

Because of the small flows for extended periods of time each year, no effort has been made to construct dams to use the flow of streams. Small stream gradients and narrow stream valleys also reduce the potential for development through dam construction.

Population in the complex is principally rural with agriculture constituting the major land use. Towns and cities are small. The largest is St. Clair at the mouth of the Pine River. Except for some seasonal homes along the St. Clair River, expansion of the Detroit metropolitan area has not reached into this complex.

Although the St. Clair River is one of the major connecting channels in the Great Lakes Seaway, no deep water ports have been established in this reach. State and local roads grid the area while Interstate Highway 94 slashes across in a northeasterly direction. The Grand Trunk and Western Railroad provides the necessary transportation for bulk materials in and out of the region.

1.37.4 Flood Problems

The St. Clair complex has not experienced severe flood damage or hardship. Those communities in the upper reaches of the basins have little trouble from overland flooding because the drainage areas are small and the stream gradients adequate. Several of the towns located at the mouths of the major streams where they empty into the St. Clair River have reported flood problems. The Corps of Engineers has compiled survey reports for Algonac, Marine City, and St. Clair at various times. Most of the flood overflows in these cities can be blamed on ice jams and packs in the local stream and the St. Clair River.

Figure 14–39c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–40 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–41 indicates upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–40c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–42. County summaries for the main stem and principal tributaries are tabulated in Table 14–43.

1.37.5 Existing Flood Damage Prevention Measures

No flood control projects have been initiated in the complex. Occasional ice jams in the St. Clair River are cleared by Coast Guard ice breakers. The Michigan Water Resources Commission has the authority to regulate all development in the flood plain areas. Subsection 1.14.5 contains a discussion of flood plain legislation applicable to this river basin.

1.38 Lake Erie Northwest, River Basin Group 4.1, Clinton River Basin

1.38.1 Description

The Clinton River drains 741 square miles in four counties of southeast Michigan. Location within River Basin Group 4.1 is shown in Figure 14–38. A fan-shaped basin, it is approximately 32 miles long and 36 miles wide at its extreme parts. The northeast and south portions of the basin are gently sloping to flat lands facing Lake St. Clair, and the northwest one-third has rolling glacial topography. Lakes are interspersed throughout this section and act as natural reservoirs in the drainage system. Among the several tributaries coming into the main stem from the north are the North Branch with Deer Creek, the Middle Branch, Stoney Creek, and Paint Creek. The main tributary entering from the southern part of the basin is Red

Run. Elevations range from more than 1,000 feet in the hilly western parts to 575 feet at the egress into Lake St. Clair.

1.38.2 Previous Studies

Previous studies are listed below:

(1) 1970—Corps of Engineers, Interim Survey Report on Flood Control, Major Drainage, and Allied Purposes for Red Run Drain and Lower Clinton River, Clinton River Basin, Michigan. It recommended increased channel capacities for Red Run and sections of the Clinton River (House Document No. 91–431, 91st Congress, 2nd Session). This report is part of the Comprehensive Water Resources Study for Southeastern Michigan authorized in 1965 by P.L. 89–298, 89th Congress. A project was authorized by the 1970 Flood Control Act, P.L. 91–611, 91st Congress, H.R. 19877, which was approved on December 31, 1970. Construction of the project is contingent upon the receipt of funds.

(2) 1970—Soil Conservation Service, Preliminary Investigation Report on the North Branch of the Clinton River, Macomb County, Michigan

(3) 1965—Flood Plain Information Report, Clinton River (Middle Branch), Michigan

(4) 1964—Flood Plain Information Report, Clinton River (Main River and Branch), Michigan

(5) 1964—Flood Plain Information Report, Clinton River (North Branch), Michigan

(6) 1948—Corps of Engineers, a review of the survey report on the Clinton River with a view to flood protection on the Red Run, printed as House Document No. 628, 80th Congress (2nd). It recommended an 11-mile long channel improvement.

(7) 1946—Corps of Engineers, a survey report on the flood problems of Mt. Clemens, printed as House Document No. 694, 79th Congress (2nd). It recommended a cut-off channel to reduce flood damages.

(8) 1939—Corps of Engineers, a survey report on flood control initiated following a preliminary examination report that indicated flood problems along the lower reaches of the Clinton River

1.38.3 Development in the Flood Plain

The area occupied by the Clinton River basin is under heavy urbanization pressures. This is especially true in the lower reaches. The upstream area, comprising approximately half the total watershed, contains numerous inland lakes interconnected by marshy lands and small streams. This area is not suited to cultivation and is mainly devoted to pasture and dairy farming. The stream slopes in the central portion are somewhat steeper as a result of the drop from the glacial moraines. Several potential multiple-purpose reservoir sites are located on the Clinton River and its major tributaries in the general vicinity of Rochester and north of Mt. Clemens. These sites have not been developed due to the intense rate of urbanization that has been occurring in the river valleys. The Huron-Clinton Metropolitan Authority, a State of Michigan agency, has been purchasing much of the flood plain of the Clinton River in recent years and developing the lands into park areas. The flood plain area between the Cities of Utica and Rochester has been set aside for recreational use. This agency is also developing a recreational area by impounding Stoney Creek with low-head dams as a portion of the project. Another development is Metropolitan Park on the shores of Lake St. Clair just below the mouth of the Clinton River.

1.38.4 Flood Problems

Major flood problems still persist in the Clinton River basin. The areas around Mt. Clemens and Pontiac, and areas served by the Red Run Drain have experienced considerable damage. Other minor problems exist at Rochester, Yates, and Utica along the main stem, and Fraser on Harrington Drain. Two flood control projects were completed in the early 1950s to help alleviate the conditions around Mt. Clemens and the Red Run Drain. However, the urbanization of the area has increased to such a degree that the capacities of the projects have been overtaxed, and the areas are again plagued by runoff and drainage problems.

Floods have occurred in the Mt. Clemens area for many years. The largest floods were in 1902, 22,800 cfs; 1938, 14,500 cfs; 1943, 14,600 cfs; and 1947, 21,600 cfs. Above Mt. Clemens, from the junction of the branches, mostly agricultural lands are flooded. Although considerable amounts of water have overflowed these plains, little damage has been done. At Mt. Clemens the flooding is limited to 700 acres, mostly in residential sections. Much of the property along the river banks is in parks, gardens, or unoccupied parcels of land. Below

Mt. Clemens the flood plain is not well defined, being generally low and flat. The stage of Lake St. Clair has considerable effect on the magnitude of the acreage flooded. During high stages as much as 1,000 acres may be inundated, while at low lake stages the flooded area is much restricted. In this area there are approximately 200 houses and cottages. There is little cultivation, and vacant property is undergoing real estate development.

The Pontiac area has experienced floods over a similar period of time. Serious damages occurred in the floods of 1938, 1943, and 1947. Records indicate that flood peaks are primarily the result of flash runoff of storm rainfall from within the city, and this condition can be expected to intensify with urban growth. The lakes and marshes upstream of Pontiac serve as natural regulating basins, and thus save the city from more serious flood loss.

The Red Run drains 70 square miles of fairly level ground in the most southern section of the Clinton River basin. Investigations made by the Corps of Engineers indicate that flood damages due to heavy storm runoff have not been due to the Red Run overflowing its banks, but rather by backwater effect in the sewers due to high water in Red Run. The channel improvement project of 1951 relieved this situation temporarily, but the concentrated growth in the region has once more overtaxed the drainage facilities of Red Run.

Figure 14–39c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–40 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–41 lists upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–40c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–42. County summaries for the main stem and principal tributaries are tabulated in Table 14–43.

1.38.5 Existing Flood Damage Prevention Measures

To assist flood runoff in the Mt. Clemens vicinity, the Corps of Engineers completed construction of a large cutoff channel in 1951. The channel runs from Mt. Clemens to Lake St. Clair and has a capacity together with the lower reach of the Clinton River of 15,000 cfs. A weir at the upstream end of the canal maintains normal flow in the natural channel through Mt. Clemens and also prevents erosive velocities resulting from low lake level or moderate flood flows.

The Corps of Engineers Red Run Project was approved by the Flood Control Act of 1948. This project consisted of widening and deepening the existing channel from Royal Oak to its confluence with the Clinton River, a distance of approximately 12 miles. The project, completed in 1954, provided for a maximum capacity of 7,000 cfs at its downstream end.

Communities and townships in the Clinton River basin known to have adopted flood plain legislation as a means of guiding and controlling development in flood plains are the Cities of Mt. Clemens, Sterling Heights, and Utica and the Townships of Shelby and Clinton. Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to this river basin.

1.39 Lake Erie Northwest, River Basin Group 4.1, Rouge Complex

1.39.1 Description

The Rouge complex is a fan-shaped basin that drains an area of 467 square miles in Oakland, Washtenaw, and Wayne Counties. Location within River Basin Group 4.1 is shown in Figure 14–38. The land surface of the River Rouge basin ranges from hilly or moderately undulating topography in the west and north to relatively flat terrain to the southeast. Elevations in the headwater area to the northwest generally range between 900 and 1,000 feet above mean sea level. In the flatter lands of the southeast sector elevations are approximately 600 feet. Dividing these two topographically different areas are a series of beach lines which traverse the River Rouge basin in a southwest to northwest direction. These beaches, formed by glacial lakes, are marked by a local steepening of land surface.

In its downstream course the Rouge is joined by a number of tributaries, most of which enter from the west or northwest. The major tributaries include the Upper, Middle, and Lower Rivers Rouge. The largest stream entering from the east is Evans Ditch with a drainage area of 11.1 square miles. From an elevation of 735 feet at the inner margin of the old glacial beach, the ground surface descends at a slope of approximately 8 feet to the mile and meets the Detroit River at an elevation of 573 feet.

1.39.2 Previous Studies

Previous studies are listed below:

(1) 1970—Flood Plain Information Report, River Rouge (Lower Rouge at Wayne), Michigan

(2) 1969—Corps of Engineers, a reconnaissance study, under Section 205 of the 1948 Flood Control Act, initiated to determine the feasibility of a small flood control project on the Main Branch of River Rouge near Birmingham, Michigan.

(3) 1969—Corps of Engineers, Post Flood Report of Southeast Michigan Flood, June 25–27, 1968, concerned with the flooding along the Clinton, Saline, Raisin, and Huron Rivers, and the River Rouge and its tributaries during this period

(4) 1966—Flood Plain Information Report, River Rouge (Main Branch), Michigan

(5) 1966—Corps of Engineers, a snagging and clearing project for flood control on the Upper Rouge authorized under Section 208 of the 1954 Flood Control Act. However, work was indefinitely suspended as a result of no local cooperation.

(6) 1965—Corps of Engineers, Design Memorandum (No. 1) for River Rouge Flood Control Project, Michigan

(7) 1963—Flood Plain Information Report, River Rouge (Upper River Rouge at Farmington), Michigan

(8) 1959—Corps of Engineers, Survey Report on Flood Control of River Rouge, Michigan, submitted. The study was concerned with the flood and related water-use problems of the entire basin area. It concluded that a serious flood problem existed in areas along the main stem between the navigation turning basin and Michigan Avenue. It recommended a channel improvement project for this problem area.

(9) 1957—Wayne County Road Commission, "Flood of the River Rouge," prepared by consulting engineers, studying hydrological effects on the Rouge basin and recommended various channel improvements

(10) 1957—City of Detroit, as Supplement I to County report, recommending channel improvement on the main stem from the turning basin to the Eight Mile Road

(11) 1951—Corps of Engineers, a Preliminary Examination Report completed as authorized by the Flood Control Act of 1948. It favorably recommended an investigation of survey scope on flood control in the River Rouge and its tributaries.

(12) 1949—U.S. Geological Survey, "Flood and Stream-Flow Characteristics on the River Rouge Basin," dealing with discharge hydrographs, stream-flow data, the magnitude and frequency of floods, and the magnitude of the April 1947 flood if the storm center were placed over the River Rouge basin

1.39.3 Development in the Flood Plain

The River Rouge complex drains the highly urbanized area of Detroit and its immediate environs. Throughout the basin major river channels are well developed with stream beds ranging from 20 to 30 feet below the adjacent land surface. Although their courses are well developed, smaller streams have not cut substantially into the supporting plain. Where urbanization is extensive, drainage patterns have been altered, and ditches and drains are used to convey runoff. In Detroit and adjacent areas storm sewers are used to transport surface flow.

In much of the basin, flood plains have been used to good advantage through the development of parks, golf courses, and other recreation facilities. However, encroachment onto the flood plains, the filling in of flood plain valleys, and the addition of bridges and other obstruction to free flow have resulted from urban development. The lower reach of the Rouge is lined with heavy industrial developments. Other reaches usually influence nearby residential areas or commercial business communities where main arteries cross the Rouge or its tributaries. The upper reaches are beset by the intrusions of residential subdivisions and shopping plazas. Areas that were once devoted to agriculture are fast disappearing.

Because of low flows in the basin for extended periods of time each year, little effort has been made to construct dams to use stream flow. Dams have been erected and stream flow used for mill ponds, lake impoundments, or small ponds from which water may be withdrawn for municipal supply, irrigation, or fire protection. At one time the Middle River Rouge had a structure used for power generation, but this has been discontinued. The only remaining use for the low-head dams is for maintaining a head over intakes for irrigation supplies and lake impoundment.

1.39.4 Flood Problems

The River Rouge tributary system follows a radiating pattern throughout the fan-shaped basin. Flood stages of the Lower, Middle, and Upper Rouge tend to be coincidental with the flood stage of the main stem of the River Rouge at the respective junction points. As a consequence, the downstream reach of the main channel is subjected to hazardous flood discharges. Channel capacities of the main stem and the major tributaries are small and overbank flooding occurs frequently. Throughout most of the basin, notably upstream from Michigan Avenue, bottomland flooding is confined within sharply defined valleys associated with the streams. Highway crossings of the River Rouge streams are high enough to avoid inundation during minor flooding. However, the flood of record, which occurred in April 1947, covered all highway bridges up to 5½ miles upstream from the river mouth. Railroad bridges located at higher elevations suffered only minor service disruptions and bridge scouring during the 1947 flood.

Downstream from Michigan Avenue the marked valley associated with the upper reaches of the River Rouge is no longer evident. Natural ground levels extending for great distances on each side of the stream are only 15 to 20 feet higher than low water profile. High flood stages inundate large areas of land in that reach of the river between the turning basin and Michigan Avenue. Additional areas are subject to basement flooding in this reach.

In many cases local flooding is due to causes not related to stages of the River Rouge. Inadequate sewers or drainage ditches were discovered to be the primary cause of isolated problem areas. Studies have indicated that high river stages occur several hours after local storm outlet discharges. It was determined that basement damages occurring during high stages of the River Rouge are caused by basement floor elevations lower than the river high water elevation at the storm outlet.

The highest flood discharge in the basin during the period of record occurred in April 1947. Heavy rains falling on relatively impervious ground produced a peak stage almost four feet greater than any previously recorded. Of the 2.95 inches of rainfall measured during this storm, the equivalent of 2.5 inches was measured as surface runoff. Approximately 4,300 acres were inundated by this flood. Another serious flood occurred during June 25 to 27, 1968, following 2.6 inches of rainfall over the immediate area. Four lives were lost as a result of high turbulent waters. This flood peaked at 21.7 feet, and the flood of 1947 reached a peak of 23.0 feet at the Plymouth Road gage of the River Rouge.

Figure 14–39c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–40 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–41 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–40c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–42. County summaries for the main stem and principal tributaries are tabulated in Table 14–43.

1.39.5 Existing Flood Damage Prevention Measures

Construction of the River Rouge Flood Control Project in Wayne County, Michigan, began in the summer of 1970. This project essentially provides the improvements recommended in the survey report submitted by the Detroit District Corps of Engineers in 1959. This scheme will enlarge and straighten the main river channel from Michigan Avenue to the turning basin and will provide a design flood flow of 24,000 cfs compared to an estimated 1980 discharge of 19,000 cfs. With these improvements there is a one percent chance of flooding, and should flooding occur, the improvements will eliminate 96 percent of the average annual damages.

There are no other existing flood control projects in the River Rouge basin. The Corps of Engineers maintains an improved deepwater navigation channel from the mouth to 2.9 miles upstream. The Ford Motor Company has constructed several small power dams across the River Rouge, but these dams have been long abandoned and contribute only a minor amount of storage capacity during flood periods.

Non-Federal local agencies have taken steps to help alleviate the flood problem. These measures consist primarily of discouraging private development of the flood plains, public purchasing of river valley lands for development into parks and recreational sites, and enlarging of restrictive bridges along the valley parkways by allowing the highway paralleling the stream to pass under the highway crossing the stream. In high flood flows the overbank flood waters use the parkway bridge openings. It is expected that the communities in Oakland and western Wayne Counties that are undergoing rapid transformation from rural to urban development will recognize the annual flooding that occurs in the valleys and will follow the pattern initiated by Detroit and Wayne County of restricting development in the flood plains by municipal purchase.

Farmington and Beverly Hills have adopted flood plain legislation as a means of guiding and controlling development in flood plains. Redford Township has also adopted flood plain legislation. Subsection 1.14.5 contains a discussion of flood plain legislation applicable to this river basin.

1.40 Lake Erie Northwest, River Basin Group 4.1, Huron River Basin

1.40.1 Description

The Huron River basin drains parts of seven counties in southeastern Michigan and has a drainage area of 923 square miles. The Huron River discharges into Lake Erie at Pointe Mouillee, which is located 5 miles below the mouth of the Detroit River. Location within River Basin Group 4.1 is shown in Figure 14–38. The main stem is 125 miles long and has a total fall of 430 feet of which 70 percent occurs in the upper basin above the City of Ann Arbor. From the mouth of the Huron to Ann Arbor the basin is narrow, averaging 5 miles in width. Above Ann Arbor the basin fans out irregularly to form the upper basin which covers 80 percent of the total area. This upper basin contains approximately 340 lakes and impoundments.

The upper basin topography is formed from glacial moraines consisting of rolling hills, flatlands, and lakes. There are extensive deposits of sand and gravel in this area. The terrain below Ann Arbor is relatively flat, containing primarily clay and silt deposits.

There are two primary tributaries of the Huron River: Portage Creek and Mill Creek. Portage Creek drains a 79-square-mile area and joins the Huron 76 miles upstream. The Mill Creek watershed is approximately 135 square miles in area and joins the Huron at the City of Dexter, 58 miles upstream.

1.40.2 Previous Studies

Previous studies are listed below:

(1) 1972, 1971—U.S. Geological Survey—flood-prone area reports for much of Huron River and Mill Creek

(2) 1967—Corps of Engineers, Interim Survey Report on the Lower Huron River for Flood Control, considering channel improvement downstream of Telegraph Road. Investigations were not completed.

(3) 1966—Corps of Engineers, Interim Survey Report on Mill Creek. This report recommended an impounding reservoir on this major tributary to provide storage for flood control, water supply, and recreation. The report is being reevaluated in light of the Southeastern Michigan Water Resources Study.

(4) 1963—U.S. Department of Health, Education, and Welfare, Public Health Service; Report on Water Resources Study, Huron River Basin, Michigan; a study of potential needs and value of water for municipal, industrial, and water quality control purposes

(5) 1958—Corps of Engineers, Preliminary Review of Report on Huron River and Tributaries, Michigan, for Flood Control. It concluded flood control schemes are economically unfeasible.

(6) 1957—Michigan Water Resources Commission, "Water Resource Conditions and Uses in the Huron River Basin;" a comprehensive study including hydrology, water use, resource improvement, floods, and flood control

(7) 1956—Michigan Department of Conservation, "Huron River—Seven Lakes Level Control" to develop means of controlling lake levels to reduce flooding

(8) 1948—Michigan Department of Conservation, "Portage Lake Level Control and Hi-Land Lakes Control" to develop means of controlling lake level to reduce flooding

(9) 1931—Corps of Engineers, Preliminary Examination Report on the Huron River. This report considered improvement of the river for navigation, water power, land reclamation, and flood control. It concluded potentials are unfavorable and no further study was recommended.

1.40.3 Development in the Flood Plain

Presently land is being converted from agricultural to urbanized uses in many parts of the basin, especially downstream from Ann Arbor. In addition to the Ann Arbor-Ypsilanti complex, other communities located along the river are Belleville, New Boston, Flat Rock, and Rockwood. Deposits of silica sand and limestone are quarried and sold commercially in the Rockwood-Flat Rock area. The Silica Sand Corporation has erected dikes around its quarry along the lower Huron to prevent river overflows from drowning its operation. Industrial corridors have developed in the basin along major rail lines and traffic arteries which lead from Detroit. Some portions of the lower Huron River have attained growth well ahead of previous predictions.

Upstream from Ann Arbor, the Huron-Clinton Metropolitan Park Authority has reserved much of the flood plain for "Metro Park" recreation areas. There are also large tracts in the lower Huron River valley for this purpose. The agricultural land still in production is changing toward truck farming with increased acreage devoted to high value crops. The largest towns in the upper reach are Dexter and Milford in the headwater area.

There are seven small hydroelectric dams and associated impoundments on the lower Huron River and two in the upper portions of the basin. Most of these dams were built before 1920 by the Detroit Edison Company and the Ford Motor Company. The maximum head at any one plant is 33 feet. As a source power production, these plants are obsolete, and those of the Detroit Edison Company are no longer in use. New developments of hydroelectric plants are unlikely due to the lack of suitable sites that could produce significant amounts of power.

1.40.4 Flood Problems

Flooding has occurred in scattered localities throughout the basin, particularly in the low areas adjacent to the river from Flat Rock to its mouth as well as along the the shores of some upland lakes through which the river flows. The communities of Ann Arbor, Ypsilanti, Flat Rock, and South Rockwood have suffered flood damages in the past.

Huron River floods occur most often in the spring. However, the largest floods are more likely to occur in the summer. Both types of floods are generally caused by storms that cover the entire basin. The maximum flood of record occurred in 1918 when the flow recorded at Ann Arbor was 5,840 cfs. Although the Ann Arbor gage was not in operation at the time, it appears that the flood of 1947 was the same or slightly greater than the 1918 flood. Another serious flood that caused widespread damage in the Huron River basin occurred from the heavy rains of June 25 to 27, 1968. During that time the Huron reached a flow of 4,600 cfs at Ann Arbor. The 1918 flow was estimated to have a 1.5 percent chance of occurrence in one year. Nine other floods have been recorded which have from 5 to 20 percent chance of occurrence in one year.

The two main tributaries of the Huron River contribute differently to the flood flows experienced on the main stem. The headwaters of Portage Creek flow through a chain of inland lakes which produce a natural ponding area for this stream flow; thus leveling off peak flows into the Huron River. The other large tributary, Mill Creek, has very fast runoff with virtually no natural ponding areas, thereby producing high instantaneous peak flows into the Huron River just north of Dexter. The high peaks from Mill Creek are felt in Ann Arbor the same day as the runoff occurs in this tributary, while the peaks from the areas upstream from Hudson Mills are not observed in Ann Arbor until three of four days later. This first peak from Mill Creek is apparently the most damaging single force in flooding Ann Arbor and downstream areas.

Figure 14–39c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–40 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–41 indicates upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–40c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–42. County summaries for the main stem and principal tributaries are tabulated in Table 14–43.

1.40.5 Existing Flood Damage Prevention Measures

A dike was constructed around the Silver Creek subdivision, located just upstream from the mouth of the Huron River, to prevent flooding due to high water in Silver Creek and the Huron River. The project, completed in April 1953, consisted of raising existing dikes and earthfill.

The Corps of Engineers has initiated surveys for a tentative plan of channel rectification between Flat Rock and Rockwood. Local government agencies and private citizen groups have undertaken several projects to lessen flood damage potentials.

Several years ago local interests completed a snagging and clearing project between Flat Rock and Rockwood for the dual purposes of recreational boating and flood damage reduction. It is doubtful if any benefits from the action are still being realized.

The Washtenaw County Drain Commission has built a new Huron River dam to maintain legal water surface elevations at Portage and Base Line Lakes. Operation of such a dam would alter the regimen of the Huron River both for low flows and flood hydrographs. Studies are being conducted for the Drain Commission to establish a regulating plan.

Most of the former hydroelectric facilities have been sold to local municipalities. The Huron River Watershed Council has initiated a coordinated effort among various dam owners and operations in the lower Huron River basin in an attempt to improve control of high and low river flows. The study of the water problems in this basin has been expanded from concentration on a flood control problem to multiple-purpose water resource problems.

The Michigan Water Resources Commission has the authority to regulate all development in the flood plain areas. Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to this river basin.

1.41 Lake Erie Northwest, River Basin Group 4.1, River Raisin Basin

1.41.1 Description

The River Raisin basin is roughly circular in shape with the overall diameter being approximately 37 miles. The basin is connected to Lake Erie by the main stem. Location within River Basin Group 4.1 is shown in Figure 14–38. Of the total watershed area of 1,050 square miles, only 22.7 miles are in Ohio. The basin is similar to the others in southeastern Michigan because the soil was deposited and topography formed by the ancient ice sheets and glacial lakes which covered the area. The eastern portion, which occupies slightly less than half the basin, is lake plain, while the western section is primarily moraines and till plain with a small area of outwash in the northwest.

The basin headwaters originate 530 feet above the Lake Erie lake level, but the decline is rather rapid, so the stream gradients in the downstream reaches are nearly flat. The upstream area of the watershed is dotted with 85 small lakes which are often interconnected with marsh. The tributary system of the River Raisin is well distributed throughout the basin. The principal tributaries are the Saline River, Black Creek, Wolf Creek, and North and South Macon Creeks.

1.41.2 Previous Studies

Emergency flood damage surveys have been conducted as needed at localized areas:

(1) In 1972 the U.S. Geological Survey published flood-prone area reports for portions of the River Raisin and Saline River.

(2) A negative Preliminary Investigation Report was prepared for the Saline River in 1970 by the Soil Conservation Service.

1.41.3 Development in the Flood Plain

The River Raisin basin is largely rural with medium-sized towns well dispersed throughout the area. Monroe at the mouth of the river is the only Michigan deep-draft harbor on Lake Erie. Adrian, a city of similar size, is an industrial and college community located in the upper tributary sector. Approximately 50 percent of the basin's population is centered in and around these two towns. Other population centers within the flood plain are Dundee and Tecumseh on the main stem and Milan and Saline on the Saline River. Several limestone quarries are in operation in the eastern portion of the basin, and a large cement manufacturing plant is located at Dundee, Michigan. Major industrial expansion of both the automotive and chemical industries is under way in the Tecumseh-Adrian area.

The earliest dams on the River Raisin were constructed to furnish water power for the operation of grist mills and lumber mills. In the early 1900s several dams were built to produce hydroelectric power for small shops manufacturing automobile parts for the Ford Motor Company. During the past half century many dams and mills have been allowed to deteriorate. The only unit supplying commercial quantities of electrical power is the Southeast Michigan Electrical Cooperative plant at Tecumseh which operates on a 24-foot head. There are other small dams in the basin built by individuals or companies for lake level control, farm ponds, or other purposes. Their value for flood control is inconsequential.

This area of Michigan includes much agricultural wealth. More than 70 percent of Lenawee and Monroe counties is cropland. These counties rank in the top 100 of the nation in the production of certain field and truck crops. Agricultural lands not in use are found in the areas of less productive soils or rough topography, such as the Irish Hills district in northwest sector of the basin. Although once covered with extensive stands of hardwoods, the remaining forest growth is now concentrated in the river bottoms and farm woodlots.

Even though the transportation network of the basin was one of the first developed in Michigan, urban growth has not been particularly influenced by these pioneer road and rail routes. New residential development is concentrated in the Adrian-Tecumseh district and near Monroe.

1.41.4 Flood Problems

Although the River Raisin basin is not considered a major flood area of the State, many acres of agricultural land are flooded annually. The problem is actually a combination of flooding and poor land drainage. There are two general areas in the basin where this problem exists. One is upstream from the City of Saline on the Saline River, and the other is between Adrian and Dundee on the main stem and lower reaches of Black Creek near Blissfield, where it joins the Raisin River. Some cropland is also flooded along the South Branch in the vicinity of Adrian. Communities that have experienced flood damages are Monroe, Milan, Saline, and Tecumseh. The regional flood that hit Southeast Michigan in June 1968 caused heavy damage at Saline where a small dam was washed out, creating municipal and bridge damage. There was also a small dam failure at Tecumseh, and damages to buildings and the municipal water system at Milan. Monroe has suffered minor flooding problems created by ice jams in the restricted channels during winter thaws or spring runoffs. A 20-square-block area was flooded by such an occurrence in late January 1969.

Figure 14–39c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–40 shows the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–41 indicates upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–40c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–42. County summaries for the main stem and principal tributaries are tabulated in Table 14–43.

1.41.5 Existing Flood Damage Prevention Measures

Coast Guard ice breakers are used to alleviate occasional flood-causing ice jams.

Applications have been filed for assistance under provisions of the Watershed Protection and Flood Prevention Act (P.L. 566), administered by the U.S. Soil Conservation Service. That agency has divided the basin into five watersheds for examination to determine possible improvements. However, no structural flood control schemes have been effected by governmental agencies to date. Preliminary investigations revealed that the sites for flood control reservoirs lacked sufficient capacity to be effective, but there is a possibility that flood control could be provided by channel improvements in some tributaries.

The River Raisin Watershed Association, formed in 1963, endorsed the general goal of eliminating the basin problems through construction of a chain of dams. However, no projects have actually been started by this organization.

The River Raisin is one of Michigan's more intensely used streams. Municipal, commercial, and industrial uses of the waters limit its potential for increased use and demand close regulation to prevent disintegration of this valuable water resource. Refer to Subsection 1.14.5 for a discussion of flood plain legislation applicable to this river basin.

1.42 Lake Erie Northwest, River Basin Group 4.1, Swan Creek Complex

1.42.1 Description

The streams in this area, notably Swan Creek and Stony Creek, are small and not of major importance. These streams lie within 30 miles of Lake Erie, with the basin headwaters 100 feet above the lake. The individual basins are parallel, narrow strips which penetrate directly into the drainage area. Location within River Basin Group 4.1 is shown in Figure 14–38. The coastal land along the Lake is often marsh or land only slightly above lake levels. High water of Lake Erie often inundates these areas, and they are generally undeveloped. However, much of the shore area has been developed for fish and wildlife purposes.

1.42.2 Previous Studies

In 1962 the Corps of Engineers took a reconnaissance survey of flood conditions in the vicinity of Newport, Michigan.

1.42.3 Development in the Flood Plain

Because the areas in the lower reaches of these streams are subject to frequent inundation from either overland flooding or high water levels in Lake Erie, they have remained relatively undeveloped except for pasture land and wildlife refuge developments. There are several beachside communities along the shores and embayments of Lake Erie.

1.42.4 Flood Problems

The lower reaches of these minor streams are subject to almost annual flooding to some degree. The community of Newport, Michigan, on Swan Creek suffered some flood damages in 1949 and again in 1956. The Corps of Engineers conducted a reconnaissance survey at the request of local citizens, but efforts have not continued because of the lack of local cooperation. Flood problems seem to be compounded by restricting drains. Several beach communities suffered heavy damages in the Lake Erie storm of 1966 which lashed the west shore with high winds and waves.

Table 14–41 indicates estimated damages by watersheds which are identified in Figure 14–40c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–42.

1.42.5 Existing Flood Damage Prevention Measures

There are no existing structural flood prevention measures in the complex. Refer to Subsection 1.14.5 for a discussion of flood plain legislation.

1.43 Lake Erie Southwest, River Basin Group 4.2, Maumee River Basin

1.43.1 Description

The Maumee River basin drains a fan-shaped area of approximately 6,586 square miles (4,215,040 acres). This includes 1,260 square miles in Indiana, 470 square miles in Michigan, and 4,856 square miles in northwestern Ohio. Location within River Basin Group 4.2 is shown in Figure 14–42. The basin is one of the largest and most important tributaries of the Great Lakes-St. Lawrence system. The Maumee River originates at Fort Wayne, Indiana, at the confluence of the St. Marys and St. Joseph Rivers and flows northeast for a distance of approximately 130 miles to Lake Erie at Toledo, Ohio.

The Maumee River has four principal tributaries: The St. Joseph, St. Marys, Tiffin, and Auglaize Rivers. The St. Joseph and Tiffin Rivers rise in the hills of southern Michigan and flow southerly to join the main stream. The St. Marys and Auglaize Rivers head up in the morainal divide near Wapakoneta, Ohio, and flow northerly to join the Maumee River.

The topography of the Maumee River basin varies from gently rolling plains to hilly areas. The topographic relief of the basin roughly resembles a huge saucer, relatively flat at the center and higher around the rim except for the northeast portion toward Lake Erie. Elevations range from 1,100 feet on the northern rim in Michigan and 970 feet on the southern edge in Ohio to 650 feet at the center of the basin and 570 feet above sea level at the Maumee River mouth. Although the basin has relatively little topographic relief, except in the upper reaches of the main tributaries, the stream slopes are sufficiently steep to facilitate fairly rapid runoff.

1.43.2 Previous Studies

There is a long list of studies and reports on the Maumee River basin for flood control extending from 1871 to recent years. The latest authorization is a letter from the Chief of Engineers dated January 16, 1947, directing that a flood control survey be undertaken for the Maumee basin in compliance with the Flood Control Act of 1944 and the River and Harbor Act of 1945. Two urban area reports have received favorable recommendations. These are the Interim Survey Report on Flood Control at

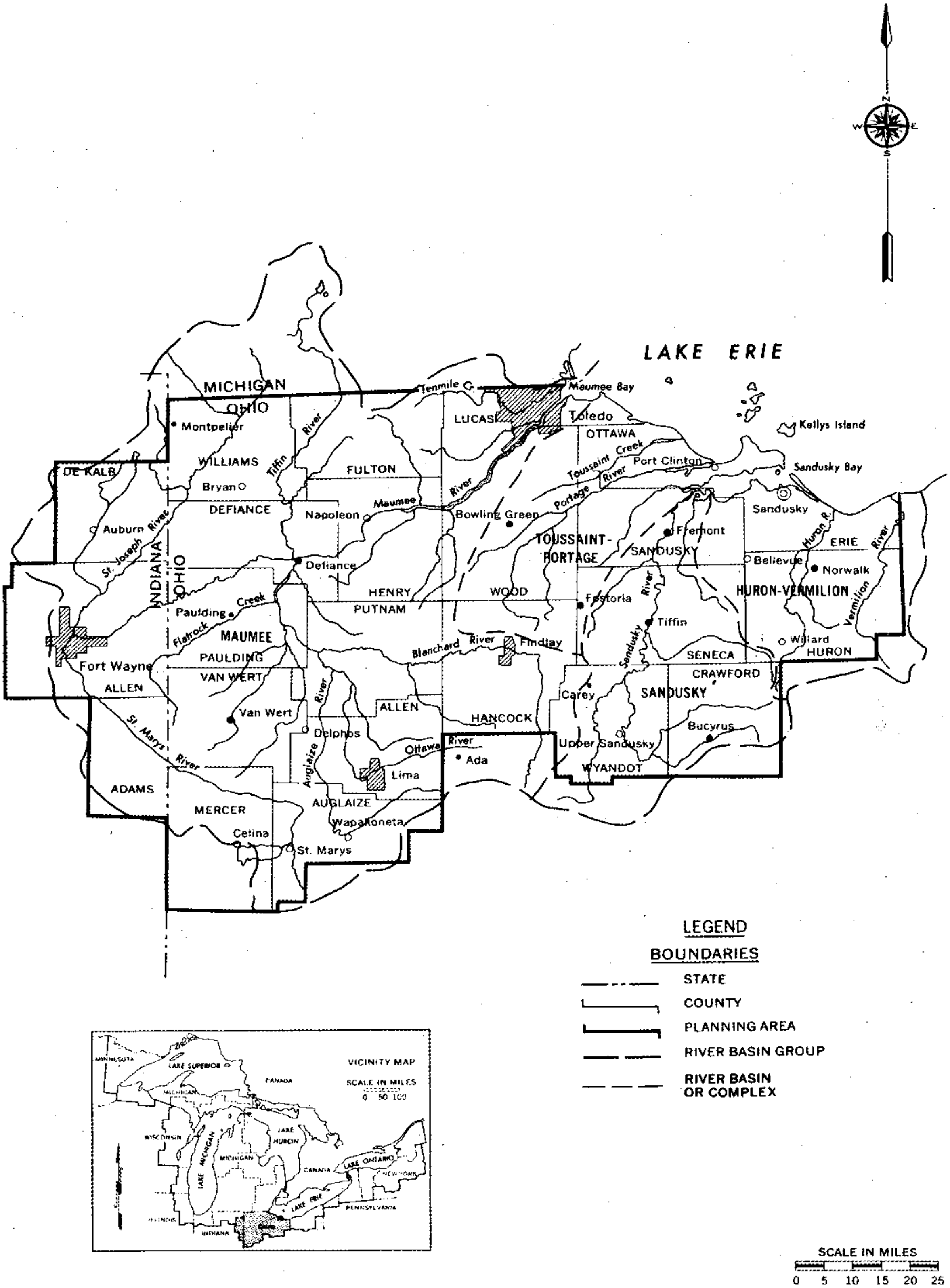

FIGURE 14–42 Lake Erie Southwest—River Basin Group 4.2

Findlay, Ohio, dated April 1962, and the Interim Survey Report on Flood Control on the Blanchard River at Ottawa, Ohio, dated November 1964. The proposed project at Ottawa has been authorized but not funded. Due to the lack of local interest, the proposed project at Findlay has not been authorized.

As of 1971, the Soil Conservation Service has completed the following studies:

(1) Work Plans for the Little Auglaize River Watershed—Van Wert, Paulding, Putnam and Mercer Counties, Ohio; the Middle Branch of the Little Auglaize River Watershed—Paulding and Van Wert Counties, Ohio; the Prairie-Hoaglin Branch of the Little Auglaize Watershed—Paulding and Van Wert Counties, Ohio; and a draft work plan for Upper Tiffin (Bean Creek)—Fulton and Williams Counties, Ohio, and Hillsdale and Lenawee Counties, Michigan

(2) Preliminary Investigation and Work Plan in progress on Flat Rock Creek, Paulding and Van Wert Counties, Ohio, and Adams and Allen Counties, Indiana

(3) Preliminary Investigation on Swan Creek, Fulton, Henry, and Lucas Counties, Ohio

(4) Beaver Creek (Maumee) Preliminary Investigation—Henry, Wood, Putnam, and Hancock Counties, Ohio

(5) Lower Tiffin Preliminary Investigation—Fulton, Williams, Defiance, and Henry Counties, Ohio

Flood Plain Information Reports completed in the Basin are as follows:

(1) November 1970—Maumee River at Napoleon, Ohio

(2) October 1970—Maumee River and Auglaize River at Defiance, Ohio

(3) May 1968—Auglaize River at Wapakoneta, Ohio

(4) June 1967—Ottawa River at Lima, Ohio.

As of 1971 the U.S. Geological Survey published flood-prone area reports for portions of the Maumee River and portions of its following tributaries: Blanchard, St. Joseph, St. Marys, Wolf Creek, Swan Creek, Towner Creek, Fairfield Ditch, Halfway Creek, Ten Mile Creek, Ottawa River, and Cedar Creek.

1.43.3 Development in the Flood Plain

The basin was developed early because of its rich farmlands. In later years a considerable part of the population in this area had concentrated in small communities for the purpose of handling the business of a prosperous farming industry. In recent years considerable manufacturing has been developed in most of the communities, which in turn has been a factor for increasing population. The flood plains are crossed by numerous railroads and highways linking the area to the large industrial centers to the east and west.

A large portion of the land within the flood area of the Maumee River basin has been improved by years of scientific farming. Most of this land has been tiled and drained. Improvements along both the St. Marys and Auglaize Rivers have been built to reduce flooding and improve drainage.

1.43.4 Flood Problems

The major floods of record in the Maumee basin have been caused by warm rains falling on snow-covered and frozen ground. Occasional flooding is caused by intense summer thunderstorms. Floods overflow agricultural lands during the growing season in the upper reaches of the tributaries and urban property along those rivers from the headwaters to Napoleon, Ohio. Periodic floods have resulted in the inundation of lowlands along the St. Marys River and a considerable portion of the urban area in the City of Fort Wayne. It has been estimated that along the St. Marys River more than 16,000 acres of productive farmland are flooded on an average of once every two years. Flooding along the St. Joseph River bottomlands is not as extensive.

The flood of March 1913, caused by a heavy spring rainfall, produced the greatest runoff and peak flow throughout the entire Maumee River basin. The peak discharge of the Maumee River near Toledo was estimated at 222,000 cfs. This rate, which occurred on March 27, 1913, is approximately three times the maximum reported for any other flood. Other serious flooding was experienced in 1943 and 1944 over most of the basin, while areas along the tributaries have suffered localized floods during other years.

Table 14–44 lists flood damage centers located in the basin. Figure 14–43c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–46 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–47 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–44c. Summations of

TABLE 14-44 Lake Erie Southwest, Maumee River Basin—Flood Damage Centers

Damage Center	Flood Year	Damage Type	River
Defiance, Ohio	1913	Residential	Auglaize River
	1930	Commercial	Tiffin River
	1943	Industrial	Maumee River
	1950		
Findlay, Ohio	1913	Residential	
	1927	Commercial	Blanchard River
	1937 (2)	Industrial	
	1943		
	1944	Agricultural	
Ottawa, Ohio	1903	Residential	
	1913	Commercial	Blanchard River
	1950	Industrial	
	1959	Agricultural	
Fort Wayne, Indiana	1913	Residential	St. Joseph River
	1943	Commercial	Maumee River
	1944	Industrial	
		Agricultural	St. Marys River
	1959	Residential	St. Marys R. (Fairfield Ditch)
Toledo, Ohio	1907	Residential	
	1913		Maumee River
Auburn, Indiana	1913	Commercial	Cedar Creek
	1943	Residential	
	Annual	Agricultural	(St. Joseph River)
Rural Areas	1937	Agricultural	Auglaize River
Fulton County, Ohio	1937	Agricultural	Bean Creek (Tiffin River)
Napoleon, Ohio	1913	Residential	
	1943	Commercial	Maumee River
	1936	Agricultural	
		Other	
Florida, Ohio	1913	Commercial	Grassy Creek
	1943	Residential	(Maumee River)
Grand Rapids, Ohio	1913	Residential	
	1943	Commercial	Maumee River
	1950	Other	
	1959		

TABLE 14-44(continued) Lake Erie Southwest, Maumee River Basin—Flood Damage Centers

Damage Center	Flood Year	Damage Type	River
Perrysburg, Ohio	Frequent	Residential	Grassy Creek (Maumee River)
Swan Creek (Toledo)	1945 1947 1950	Residential	Swan Creek (Maumee River)
Oakwood, Ohio	1913 1943 1950	Residential Commercial	Auglaize River
Wapakoneta, Ohio	1913 1950 1959 1963	Residential Commercial Industrial Agricultural Residential	Auglaize River
Van Wert, Ohio	1959	Commercial Agricultural	Town Creek (Auglaize River)
Gordon Creek	Annually	Agricultural	(Maumee River
Flat Rock Creek	Annually	Agricultural	(Auglaize River)
Grassy Creek	Annually	Agricultural	(Maumee River)
Little Auglaize River	Annually	Agricultural	(Auglaize River)
Blanchard River	Annually	Agricultural	(Auglaize River)
Outlet Ditch	Annually	Agricultural	(Blanchard River)
Ottawa River	Annually	Agricultural	(Auglaize River)
Hog Creek	Annually	Agricultural	(Ottawa River)
St. Marys River	Annually	Agricultural	(Maumee River)

TABLE 14–45 Minor Channel Improvements

Agency	Year	Location	Project	Cost
Wood County	1883	Jackson Cut-off between Yellow Creek and Maumee River	Diversion Channel	Not Known
Wood County	1910	Same	Clean-Up Jackson Cut-off	Not Known
Wood-Hancock	1926-27	Middle Branch from Hoytsville to New Rochester	Channel Improvement	$ 258,344
Civilian Conservation Corps	1936-37	Portions of Bull Creek	Clean-up and Deepening	$ 6,000
Wood County	1939	North Branch from Jackson Cut-off to near Portage	Clean-up and Deepening	$ 32,000

estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–48. County summaries for the main stem and principal tributaries are tabulated in Table 14–49.

In most cases major rural drainage and flood control problems on tributaries of the Maumee River are limited to the flood plains of the stream. The flood problems of the urban areas are the result of constricted reaches of the river, inadequate channel capacities, encroachment on the natural flood plain, or combinations of these causes.

1.43.5 Existing Flood Damage Prevention Measures

No Federal projects for flood control exist on the Maumee River or any of its tributaries. There is a navigation project currently maintained for the lower 7 miles of the Maumee River which extends for 18 miles through Maumee Bay into Lake Erie.

The Soil Conservation Service has two projects under construction: the Little Auglaize Watershed—Van Wert, Paulding, Putnam and Mercer Counties, Ohio; and the Middle Branch (Little Auglaize) Watershed—Paulding and Van Wert Counties, Ohio. They also have a project authorized for construction, the Prairie-Hoaglin Branch (Little Auglaize)—Paulding and Van Wert Counties, Ohio.

There have been some improvements of a limited nature instituted by local authorities:

(1) The City of Fort Wayne has constructed two water supply dams on the St. Joseph River.

(2) The City of Fort Wayne has built dikes to protect limited areas.

(3) Local dredging and dike building to control spring floods have been performed in Bean Creek in the Tiffin River basin.

(4) Numerous drainage ditches have been constructed throughout the basin area to facilitate runoff.

Nonstructural prevention measures arise mainly through flood plain regulation and zoning laws. The Indiana Flood Control Act, Chapter 318 (Acts of 1945), directs that the flood plains of rivers and streams should not be inhabited and should be kept free and clear of interference or obstructions that will cause undue restrictions of the capacity of the floodways. The Act also states that the Department of Natural Resources shall consider flood plain regulation in preventing and controlling floods. The Indiana Planning Act of 1947 provides for the establishment of planning commissions and the zoning of land. The Area Planning Act of 1957 provides for area planning departments. It was not until 1965 that regulatory authority was consolidated and invested in the Department of Natural Resources. Permits or approval must be obtained from this department before any channel encroachment or development in the flood plain can occur.

TABLE 14–46 Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 4.2

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	MAUMEE RIVER												
BB1	Lucas	T9S R8E S21	T5N R9E S7	1970	160		15	56	6	2078	299	1,856	
				1980	210	1,450	20	66	8	2061	299	1,856	
				2000	870	2,500	30	91	10	2024	319	1,836	
				2020	2,340	5,000	35	111	12	1999	324	1,826	
BB1A	Lucas	Toledo Perrysburg	Maumee Rossard	1970						1294	1294		
				1980	1,400					1294	1294		
				2000	2,900					1294	1294		
				2020	6,200					1294	1294		
BB1B	Lucas	Grand Rapids		1970	22,500		9	101		626	736		
				1980	24,750		15	140		581	736		
				2000	31,500		22	160		559	736		
				2020	40,500		29	180		527	736		
BB2	Henry	T5N R9E S7	T4N R6E S18	1970		15,500		6	30	5223	6	5,253	
				1980		17,000		8	40	5211	8	5,251	
				2000	500	20,200		18	50	5191	18	5,241	
				2020	1,000	24,800		28	60	5171	28	5,231	
BB2A	Henry	Napoleon		1970	11,800		137	281		751	1175		
				1980	15,340		140	312		723	1175		
				2000	27,140		155	337		683	1175		
				2020	47,200		180	362		633	1175		
BB2B	Henry	Florida		1970	14,000			51		84	135		
				1980	15,400			51		78	135		
				2000	18,200			61		74	135		
				2020	22,400			69		66	135		
BB3	Defiance	T4N R5E S13	T4N R3E S31	1970		15,000		32		4152		4,181	
				1980	1,500	19,400	9	46		4132	25	4,163	
				2000	4,000	20,100	15	60		4112	45	4,148	
				2020	7,000	23,400	25	70		4092	65	4,122	
BB3A	Defiance	Defiance		1970	21,500		148	516		712	1376		
				1980	28,200		160	550		660	1376		
				2000	49,700		180	560		630	1376		
				2020	86,000		200	570		600	1376		
BB4	Paulding	T3N R1E S27	T2N R1E S31	1970		9,450		3		2737	20	2,720	
				1980		9,500		3		2737	20	2,720	
				2000		11,300		3		2737	20	2,720	
				2020		14,200		3		2737	20	2,720	
BB5	Allen	T2N R1E S31	T30N R12E S1	1970		16,000		20		3760		3,780	
				1980	2,400	18,400	10	20		3750	30	3,750	
				2000	9,200	27,600	35	30		3715	65	3,715	
				2020	18,200	45,800	60	35		3680	95	3,685	
BB5A	Allen	Fort Wayne		1970	1,774,000		50	180		530	760		
				1980	2,306,200		70	190		500	760		
				2000	4,080,200		95	195		470	760		
				2020	7,096,000		120	200		440	760		
	ST. JOSEPH RIVER												
BB6	Allen	T30N R13E S5	T32N R14E S5	1970		25,000				3840		3,840	
				1980		35,000				3840		3,840	
				2000	2,000	65,000		30		3810	30	3,810	
				2020	10,000	115,000	10	50		3780	60	3,780	
BB6A	Allen	Fort Wayne		1970	*		140	65		330	535		
				1980	*		155	70		310	535		
				2000	*		165	80		290	535		
				2020	*		165	100		270	535		
BB6B	Allen	Cedarville and Leo		1970	15,000			330		100	460		
				1980	24,000		15	370		75	460		
				2000	60,000		30	380		50	460		
				2020	143,000		35	400		25	460		
BB7	DeKalb	T31N R14E S5	T34N R15E S28	1970	10,000	7,500		10		4066		4,076	
				1980	11,000	8,300		10		4066	10	4,066	
				2000	14,000	10,500		26		4050	26	4,050	
				2020	17,000	12,800		40		4036	40	4,036	

* Damages accounted for in Fort Wayne on Reach in Maumee River.

TABLE 14–46(continued) Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 4.2

REACH CODE	COUNTY	REACH LOCATION		YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)		ESTIMATED ACRES IN FLOOD PLAIN						REMARKS
		FROM	TO		URBAN	RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	
	ST. MARY'S RIVER												
BB8	Allen	T30N	T29N	1970		9,750				2810		2,810	
		R12E S1	R13E S34	1980		11,700				2810		2,810	
				2000		16,580				2810		2,810	
				2020		23,400				2810		2,810	
BB8A	Allen	Fort Wayne		1970	*		2760	3320		2950	9030		
				1980	*		2800	3430		2800	9030		
				2000	*		2900	3480		2650	9030		
				2020	*		2960	3570		2500	9030		
BB9	Adams	T29N	T27N	1970		16,400				5088		5,088	
		R13E S34	R15E S26	1980		18,000				5088		5,088	
				2000		22,900				5088		5,088	
				2020	1,000	26,800		20		5068	20	5,068	
BB9A	Adams	Decatur		1970	22,000		64	72		781	917		
				1980	28.600		70	80		767	917		
				2000	50,600		80	90		747	917		
				2020	88,000		100	110		707	917		
BB10	AuGlaize	T6S	T6S	1970	81,000		38	162		424	624		
		R4E S3	R4E S10	1980	105,300		44	186		394	624		
		St. Mary's		2000	186,300		70	210		344	624		
				2020	324,000		105	235		284	624		
	AUGLAIZE RIVER												
BB11	Paulding	T3N	T1N	1970	500	4,500		15		2880	15	2,880	
		R4E S17	R4E S12	1980	1,500	5,000		20	10	2865	30	2,865	
				2000	5,500	6,000		20	30	2845	50	2,845	
				2020	12,500	7,500		25	50	2820	75	2,820	
BB11A	Paulding	Oakwood		1970	7,600		18	58		9	85		
				1980	7,600		18	58		9	85		
				2000	9,120		20	60		5	85		
				2020	11,400		22	61		2	85		
BB11B	Defiance	Defiance											Accounted for in Reach on Maumee River
BB12	Putnam	T1N	T2S	1970		20,000		82		7045		7,127	
		R4E S12	R5E S16	1980		20,000		82		7045		7,127	
				2000		24,000		82		7045		7,127	
				2020		30,000		82		7045		7,127	
BB13	Allen	T2S	T4S	1970		7,400				2935		2,935	
		R5E S16	R5E S15	1980		8,140				2935		2,935	
				2000		10,360				2935		2,935	
				2020		12,580				2935		2,935	
BB14	AuGlaize	T4S	T5S	1970		18,750		11		2449		2,460	
		R5E S15	R6E S28	1980		22,500		13		2447		2,460	
				2000		26,250		15		2445		2,460	
				2020		31,880		20		2440		2,460	
BB14A	AuGlaize	Wapakoneta		1970	4,060		148	12		22	182		
				1980	5,300		154	12		16	182		
				2000	9,300		158	12		12	182		
				2020	16,240		163	12		7	182		
	OTTAWA RIVER												
BB15	Allen	T4S	T3S	1970			34	126		194	354		
		R6E S2	R7E S30	1980			34	126		194	354		
		Lima		2000			34	126		194	354		
				2020			34	126		194	354		
	BLANCHARD RIVER												
BB16	Putnam	T1N	T1N	1970		50,000				14667		14,667	
		R4E S12	R7E S26	1980		50,000				14667		14,667	
				2000	5,000	55,000	20	30		14647	50	14,617	
				2020	12,000	63,000	60	60		14547	120	14,547	

*Damages accounted for in Fort Wayne on Reach in Maumee River.

TABLE 14-46(continued) Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 4.2

REACH CODE	COUNTY	REACH LOCATION		YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)		ESTIMATED ACRES IN FLOOD PLAIN						REMARKS
		FROM	TO		URBAN	RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	
BB16A	Putnam	Ottawa		1970	279,000		158	550		79	787		
				1980	362,700		160	555		72	787		
				2000	641,700		162	565		60	787		
				2020	1,116,000		170	575		42	787		
	BLANCHARD RIVER												
BB17	Hancock	T1N	T1N	1970		40,000				9050		9,050	
		R8E S24	R11E S17	1980		44,000				9050		9,050	
				2000	7,000	57,000	50	50		8950	100	8,950	
				2020	14,000	66,000	100	100		8850	200	8,850	
BB17A	Hancock	Findlay		1970	1,110,000		408	1428		204	2040		
				1980	1,443,000		468	1428		144	2040		
				2000	2,553,000		488	1448		104	2040		
				2020	4,440,000		508	1458		74	2040		
	TIFFIN RIVER												
BB18	Defiance	T4N	T5N	1970		7,000				2531		2,531	
		R4E S27	R4E S3	1980		7,700				2531		2,531	
				2000		9,100				2531		2,531	
				2020		11,200				2531		2,531	
BB18A	Defiance	Brunersburg		1970	32,000			66			66		
		and		1980	35,000			66			66		
		Evansport		2000	41,600			66			66		Channel Diversion
				2020	51,200			66			66		not practical.
BB19	Williams	T5N	T7N	1970		8,000				2902		2,902	
		R4E S3	R4E S22	1980		8,800				2902		2,902	
				2000		10,400				2902		2,902	
				2020		12,800				2902		2,902	
	PORTAGE RIVER												
BC1	Ottawa	T6N	T6N	1970				15		1110	15	1,110	
		R17E S6	R13E S27	1980				20		1105	20	1,105	
				2000				25		1100	25	1,100	
				2020				30		1095	30	1,095	
BC2	Sandusky	T6N	T5N	1970		11,700		38		625	38	625	Includes Woodville
		R13E S27	R12E S1	1980	2,000	13,200		40		623	40	623	Same
				2000	4,000	22,900		43		620	43	620	Same
				2020	6,000	40,800		45		618	45	618	Same
BC3	Wood	T5N	T5N	1970		5,800		11		266	70	207	Includes Pemberville
		R12E S1	R12E S10	1980	1,000	5,400		15		262	70	207	Same
				2000	1,500	7,200		20		257	70	207	Same
				2020	2,700	7,700		25		252	70	207	Same
	SANDUSKY RIVER												
BD1	Sandusky	T6N	T4N	1970		97,300			250	9016		9,266	
		R16E S28	R15E S32	1980	9,800	152,700		35	278	8953	35	9,231	
				2000	21,700	340,600		41	322		41	9,225	
				2020	46,000	723,000		48	370	8848	48	9,218	
BD1A	Sandusky	Fremont		1970	433,500		135	565		400	1100		
				1980	680,600		150	627		322	1100		
				1980	1,517,300		174	729		197	1100		
				2000	3,194,900		182	798		120	1100		
BD2	Seneca	T3N	T1N	1970	4,000	88,200		20		4724	20	4,724	
		R15E S5	R14E S36	1980	10,500	123,300		42		4702	42	4,702	
				2000	21,500	203,100		49		4695	49	4,695	
				2020	45,500	534,400		57		4687	57	4,687	
BD2A	Seneca	Tiffin		1970	43,800		25	367		133	529		
				1980	65,500		27	407		41	525		
				2000	134.900		32	443		50	525		
				2020	278,900		35	440		39	525		

TABLE 14–46(continued) Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 4.2

REACH CODE	COUNTY	REACH LOCATION		YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)		ESTIMATED ACRES IN FLOOD PLAIN						REMARKS
		FROM	TO		URBAN	RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	
	SANDUSKY RIVER												
BD3	Wyandot	T15	T15	1970		52,100				2730		2,730	
		R14E S1	R14E S17	1980	4,400	76,500		15		2715	15	2,715	
				2000	8,900	154,200		17		2713	17	2,713	
				2020	18,800	326,100		20		2710	20	2,710	
BD4	Crawford	T3S	T3S	1970	61,500		12	86		101	205		
		R16E S11	R16E S1	1980	90,300		13	96		96	205		
		(Bucyrus)		2000	193,600		15	111		79	205		
				2020	404,100		18	127		60	205		
	HURON RIVER												
BE1	Erie	T6N	T4N	1970		30,900			170	2540		2,710	
		R22W S1	R23W S1	1980		47,200			181	2517		2,704	
				2000		107,500			224	2470		2,694	
				2020		229,300			258	2425		2,683	
BE1A	Erie	Huron		1970	5,500		5		5	5	15		
				1980	8,800		6		6	9	15		
				2000	17,600			7	6	2	15		
				2020	37,100			8		7	15		
BE1B	Erie	Milan		1970	89,000		55				55		
				1980	136,200		61				61		
				2000	307,700		71				71		
				2020	660,400		75	7			82		
BE2	Huron	T4N	T4N	1970	7,200		2	5		183	190		
		R23W S4	R23W S4	1980	10,800		2	6		182	190		
		Monroeville		2000	22,900		3	6		181	190		
				2020	48,800		3	7		180	190		
	NORWALK CREEK												
BE3	Huron	T4N	T4N	1970	39,600		14	7		245	151	115	
		R23W S1	R23W S4	1980	59,500		16	8		242	156	110	
				2000	126,400		18	9		239	161	105	
				2020	269,000		21	10		225	168	98	
	VERMILION RIVER												
BE4	Erie	T6N	T5N	1970		3,600				570		570	
		R20W S1	R20W S2	1980	1,600	5,700		5		565	5	565	
				2000	3,800	13,600		6		564	6	564	
				2020	8,000	26,900		7		563	7	563	
BE4A	Erie	Vermilion		1970	100,500		60	70	5	20	155		
				1980	157,300		60	70	5	20	155		
				2000	378,500		60	80	5	10	155		
				2020	807,200		60	80	5	10	155		
BE5	Lorain	T6N	T5N	1970		6,200			20	495		515	
		R19W	R19W	1980	1,500	9,600		5	22	488	5	610	
				2000	3,900	23,800		6	26	483	6	509	
				2020	8,300	61,600		7	30	478	7	508	

Three Indiana counties within the Maumee River basin, De Kalb, Allen, and Adams, have adopted flood plain legislation to guide and control development in the flood plain. Garret and New Haven, Indiana, have adopted flood plain legislation.

In Ohio the power to adopt and enforce zoning regulations is delegated to political subdivisions. The enabling statutes are Sections 303.02, 519.02, and 713.07 of the Revised Code. The General Assembly of the State of Ohio has passed an amendment to House Bill No. 314 which states that all departments and agencies of the State shall notify and furnish information to the Division of Water on State facilities that may be affected by flooding. This information is required to avoid the uneconomical, hazardous, or unnecessary use of flood plains in connection with State facilities. The amendment further reads that where economically feasible, departments and agencies of the State and political subdivisions responsible for existing publicly owned facilities shall apply flood proofing measures to reduce potential flood damage.

Watershed authorities have been given the

TABLE 14-47 Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 4.2

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)			ESTIMATED ACRES IN FLOOD PLAIN								
		URBAN	RURAL	TOTAL	CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		TOUSSAINT - PORTAGE RIVER - OHIO											
30	1970	100	100	200	10	--	--	--	--	--	10	10	10
30	1970	2,200	8,300	10,500	440	62	103	5	20	5	--	25	610
33	1970	--	4,100	4,100	210	100	70	--	--	--	--	--	380
37	1970	--	14,100	14,100	60	60	30	--	--	--	--	--	150
35	1970	--	56,800	56,800	2,641	515	100	--	--	--	--	--	3,256
361	1970	6,700	562,000	568,700	31,655	50	--	--	20	405	--	425	31,705
31	1970	--	168,600	168,600	7,983	400	400	200	--	--	--	--	8,983
32	1970	1,300	15,300	16,600	725	--	50	--	--	185	--	185	775
34	1970	--	500	500	30	--	--	--	--	--	--	--	30
Total	1970	10,300	829,800	840,100	43,754	1,187	753	205	40	595	10	645	45,899
	1980	13,600	1,029,000	1,042,600	43,754	1,187	753	205	40	595	10	645	45,899
	2000	24,100	1,311,100	1,335,200	43,754	1,187	753	205	40	595	10	645	45,899
	2020	44,600	1,518,500	1,563,100	43,754	1,187	753	205	40	595	10	645	45,899
		SANDUSKY RIVER - OHIO											
3C3	1970	--	72,100	72,100	4,192	400	800	--	--	--	--	--	5,392
3C2	1970	1,000	35,200	36,200	1,500	240	300	--	--	--	50	50	2,040
3C7	1970	--	203,900	203,900	8,700	525	1,025	--	--	--	--	--	10,250
3C11	1970	63,000	83,600	146,600	4,600	500	650	--	20	20	60	100	5,750
3C10	1970	10,000	103,600	113,600	5,660	1,050	1,000	390	--	50	--	50	8,100
3C9	1970	500	50,200	50,700	2,900	650	600	350	--	20	--	20	4,500
3C4	1970	--	28,000	28,000	1,500	240	300	--	--	--	--	--	2,040
3C6	1970	--	56,000	56,000	3,000	500	500	--	--	--	--	--	4,000
3C8	1970	1,700	37,300	39,000	2,150	650	650	--	--	30	45	75	3,450
3C5	1970	--	28,000	28,000	1,500	200	300	--	--	--	--	--	2,000
Total	1970	76,200	697,900	774,100	35,702	4,955	6,125	740	20	120	155	295	47,522
	1980	100,600	865,400	966,000	35,702	4,955	6,125	740	20	120	155	295	47,522
	2000	178,300	1,102,700	1,281,000	35,702	4,955	6,125	740	20	120	155	295	47,522
	2020	329,900	1,277,200	1,607,100	35,702	4,955	6,125	740	20	120	155	295	47,522
		MAUMEE RIVER - OHIO											
3D292	1970	--	7,400	7,400	380	--	20	--	--	--	--	--	400
3D44	1970	--	8,500	8,500	550	--	50	--	--	--	--	--	600
3D49	1970	--	43,500	43,500	2,000	500	550	--	--	--	--	--	3,050
3D42	1970	--	32,000	32,000	550	275	195	400	--	--	--	--	1,420
3D452	1970	76,200	123,500	199,700	5,134	425	553	237	--	--	200	200	6,349
3D451	1970	--	123,100	123,100	4,176	1,035	1,306	755	--	--	--	--	7,270
3D3	1970	--	43,200	43,200	1,780	--	500	280	--	--	--	--	2,560
3D45	1970	--	228,900	228,900	6,532	954	1,856	2,100	--	--	--	--	11,442
3D5	1970	--	59,000	59,000	2,000	--	--	230	--	--	--	--	2,230
3D43	1970	16,500	11,000	27,500	210	--	1,775	975	--	--	380	380	2,960
3D32	1970	--	104,600	104,600	11,890	145	1,160	1,305	--	--	--	--	14,500
3D1	1970	54,600	15,400	70,000	3,200	700	1,500	300	200	400	200	800	5,700
3D17	1970	--	4,400	4,400	200	--	75	25	--	--	--	--	300
3D41	1970	--	55,800	55,800	3,508	498	661	253	--	--	--	--	4,920
3D46	1970	--	72,100	72,100	3,655	345	330	170	--	--	--	--	4,500
3D47	1970	--	428,900	428,900	24,556	2,881	2,400	1,294	--	--	--	--	31,131
3D05	1970	35,000	123,000	158,000	5,000	200	800	500	1	149	400	550	6,500
3D2	1970	--	56,300	56,300	1,885	100	200	680	--	--	--	--	2,865
3D4	1970	14,500	199,600	214,100	7,230	--	--	600	15	50	--	65	7,830
3D10	1970	--	73,800	73,800	3,350	250	540	--	--	--	--	--	4,140
3D18	1970	--	99,000	99,000	4,500	--	300	200	--	--	--	--	5,000
3D290	1970	--	378,300	378,300	19,378	700	1,600	800	--	--	--	--	22,478
3D291	1970	--	38,800	38,800	2,066	376	354	136	--	--	--	--	2,932
Total	1970	196,800	2,330,100	2,526,900	113,730	9,384	16,725	11,240	216	599	1,180	1,995	151,079
	1980	259,800	2,889,300	3,149,100	113,730	9,384	16,725	11,240	216	599	1,180	1,995	151,079
	2000	460,500	3,681,500	4,142,000	113,730	9,384	16,725	11,240	216	599	1,180	1,995	151,079
	2020	852,100	4,264,100	5,116,200	113,730	9,384	16,725	11,240	216	599	1,180	1,995	151,079

TABLE 14–47(continued) Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 4.2

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)			ESTIMATED ACRES IN FLOOD PLAIN								
		URBAN	RURAL	TOTAL	CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		MAUMEE RIVER - INDIANA											
3D2B	1970	--	11,200	11,200	1,031	66	253	--	--	--	--	--	1,350
3D1B	1970	--	10,900	10,900	1,953	855	785	356	--	--	--	--	3,949
3D1D	1970	--	20,200	20,200	2,708	1,661	1,593	1,402	--	--	--	--	7,364
3D2A	1970	--	4,600	4,600	363	27	35	18	--	--	--	--	443
3D4A	1970	--	13,500	13,500	1,116	70	63	65	--	--	--	--	1,314
Total	1970	--	60,400	60,400	7,171	2,679	2,729	1,841	--	--	--	--	14,420
	1980	--	74,900	74,900	7,171	2,679	2,729	1,841	--	--	--	--	14,420
	2000	--	95,400	95,400	7,171	2,679	2,729	1,841	--	--	--	--	14,420
	2020	--	110,500	110,500	7,171	2,679	2,729	1,841	--	--	--	--	14,420
		MAUMEE RIVER - MICHIGAN											
3D1B	1970	--	1,900	1,900	168	56	112	224	--	--	--	--	560
3D1A	1970	--	600	600	71	18	80	9	--	--	--	--	178
3D130	1970	--	100	100	18	6	5	1	--	--	--	--	30
3D1C	1970	--	7,700	7,700	1,500	200	500	50	--	--	--	--	2,250
3D1C1	1970	--	2,300	2,300	445	67	128	35	--	--	--	--	675
3D3A	1970	--	7,500	7,500	1,450	220	420	110	--	--	--	--	2,200
Total	1970	--	20,100	20,100	3,652	567	1,245	429	--	--	--	--	5,893
	1980	--	24,900	24,900	3,652	567	1,245	429	--	--	--	--	5,893
	2000	--	31,800	31,800	3,652	567	1,245	429	--	--	--	--	5,893
	2020	--	36,800	36,800	3,652	567	1,245	429	--	--	--	--	5,893
		HURON - VERMILION - OHIO											
384	1970	--	600	600	30	10	10	--	--	--	--	--	50
382	1970	--	100	100	--	70	--	--	--	--	--	--	70
39	1970	--	1,300	1,300	70	20	--	20	--	--	--	--	110
385	1970	--	100	100	--	60	--	--	--	--	--	--	60
383	1970	1,100	3,000	4,100	150	50	50	--	4	6	--	10	250
381	1970	--	71,600	71,600	1,300	--	25	--	--	--	--	--	1,325
310	1970	34,700	32,600	67,300	1,770	375	1,605	--	60	50	--	110	3,750
Total	1970	35,800	109,300	145,100	3,320	585	1,690	20	64	56	--	120	5,615
	1980	47,300	135,500	182,800	3,320	585	1,690	20	64	56	--	120	5,615
	2000	83,800	172,700	256,500	3,320	585	1,690	20	64	56	--	120	5,615
	2020	155,000	200,000	355,000	3,320	585	1,690	20	64	56	--	120	5,615

authority to designate specific channel reaches of any watercourse within the district as a restricted channel, and thereafter a permit is required for any change within this area.

The Ohio townships of American, Bath, Shawnee, and Perry within the Maumee River basin have adopted flood plain legislation as has Lima, Ohio.

In Michigan the State Water Resources Commission has been empowered to establish regulations governing flood plain development. Recent Michigan laws (1968) authorized the Commission to control the alteration and occupation of the watercourses and flood plains of all the rivers and streams in the State to assure that the channels and floodways are kept free of obstructions. The Michigan Water Resources commission has established rules and regulations for this purpose.

For a more detailed description of flood plain legislation, refer to Appendix S20, *State Laws, Policies, and Institutional Arrangements.*

1.44 Lake Erie Southwest, River Basin Group 4.2, Portage River Basin

1.44.1 Description

The Portage River basin is in the general shape of a curved wedge. The basin measures approximately 60 miles long, and the width at the headwaters is 25 miles. The watershed lies entirely within Ohio and has little topographic relief. Location within River Basin Group 4.2 is shown in Figure 14–42. The basin headwaters originate from the Defiance Moraine, immediately north of Findlay, Ohio. The top of this ridge lies 260 feet above the level of Lake Erie, but the river decline is rapid in the headwaters, which results in rather flat

TABLE 14–48 Data Summary by River Basin, River Basin Group 4.2

		Estimated Average Annual Damage (Dollars)		Estimated Acres In Flood Plain	
River Basin	Year	Urban	Rural	Urban	Rural
Maumee River	1970	3,601,920	2,680,850	22,891	249,554
	1980	4,679,200	3,293,990	22,973	249,472
	2000	8,269,830	4,204,590	23,274	249,171
	2020	14,435,280	4,937,560	23,603	248,842
Toussaint-Portage Complex	1970	10,300	847,300	768	47,841
	1980	16,600	1,047,600	775	47,834
	2000	29,600	1,341,200	783	47,826
	2020	53,300	1,567,000	790	47,819
Sandusky River	1970	619,000	929,500	2,145	64,242
	1980	962,000	1,217,900	2,217	64,170
	2000	2,076,200	1,850,600	2,232	64,155
	2020	4,318,100	2,860,700	2,250	64,137
Huron-Vermilion Complex	1970	277,600	150,000	686	9,525
	1980	423,000	198,000	707	9,504
	2000	946,600	317,600	724	9,487
	2020	1,993,000	509,800	744	9,467
TOTALS	1970	4,508,820	4,607,650	26,490	371,162
	1980	6,080,800	5,757,490	26,672	370,980
	2000	11,322,230	7,713,990	27,013	370,639
	2020	20,799,680	9,875,060	27,387	370,265

stream slopes throughout the central and lower reaches of the river. There are no known impoundments on the Portage River and its tributaries, and there are no potential sites available. Small quantities of water are obtained from the river channels for agricultural use by small low-head structures which have been placed across the river bottom.

The stream pattern of the basin consists of a single channel threading throughout the lower 30 miles of the basin. Three major tributaries, the North Branch, Middle Branch, and East Branch, meet at the same general confluence. Basin soils are clays and mucks in the downstream reaches, and sands, gravels, and admixtures of clays in the headwater regions. Total drainage area is approximately 575 square miles. The Wolf, Crane, Turtle, and Toussaint Creeks and other smaller streams are included in the Portage River basin.

1.44.2 Previous Studies

In 1972 the U.S. Geological Survey published a flood-prone area report for portions of Rocky Fork Creek.

The U.S. Army Corps of Engineers, Detroit District, issued a "Report of Preliminary Examination of the Portage River and Its Tributaries with Particular Reference to the Middle Branch in Ohio" in August 1940. A channel improvement project of 33 miles was recommended, and a channel cleaning program of 20 miles from Pemberville to Oak Harbor, Ohio, was also included.

1.44.3 Development in the Flood Plain

Because most areas are suitable for farming, a large portion of the acreage in the Portage River basin is under cultivation, except

TABLE 14–49 River Basin Group 4.2, Data Summary by County

YEAR 1970

County	Estimated Average Annual Damages (Dollars)		Estimated Acres in Flood Plain	
	Urban	Rural	Urban	Rural
Indiana				
Adams	22,000	16,400	917	5,088
Allen	1,789,000	50,750	10,785	10,430
De Kalb	10,000	7,500	---	4,076
Ohio				
Allen	---	7,400	354	2,935
Auglaize	85,060	18,750	806	2,460
Crawford	61,500	---	205	---
Defiance	53,500	22,000	1,442	6,718
Erie	195,000	34,500	225	3,280
Fulton	---	---	---	---
Hancock	1,110,000	40,000	2,040	9,050
Henry	25,800	15,000	1,316	5,253
Huron	46,800	---	341	115
Lorain (PSA 4.3)	---	6,200	---	515
Lucas	22,660	---	2,329	1,856
Mercer	---	---	---	---
Ottawa	---	---	15	1,110
Paulding	8,100	13,950	120	5,600
Putnam	279,000	70,000	787	21,794
Sandusky	433,500	109,000	1,138	9,891
Seneca	47,800	82,200	545	4,724
Van Wert	---	---	---	---
Williams	---	8,000	---	2,902
Wood	---	5,800	70	207
Wyandot	---	52,100	---	2,730
TOTALS	4,189,720	560,050	23,435	100,734

YEAR 1980

County	Urban	Rural	Urban	Rural
Indiana				
Adams	28,600	18,000	917	5,088
Allen	2,332,600	65,100	10,815	10,400
De Kalb	11,000	8,300	10	4,066
Ohio				
Allen	---	8,140	354	2,935
Auglaize	110,600	22,500	806	2,460
Crawford	90,300	---	205	---
Defiance	64,700	27,100	1,467	6,693
Erie	303,900	52,900	236	3,269
Fulton	---	---	---	---
Hancock	1,443,000	44,000	2,040	9,050
Henry	30,740	17,000	1,318	5,251
Huron	70,300	---	346	110
Lorain (PSA 4.3)	1,500	9,600	5	510
Lucas	26,360	1,450	2,320	1,856
Mercer	---	---	---	---
Ottawa	---	---	20	1,105
Paulding	9,100	14,500	135	5,585
Putnam	362,700	70,000	787	21,704
Sandusky	692,400	165,900	1,175	9,854
Seneca	76,300	123,300	567	4,702
Van Wert	---	---	---	---
Williams	---	8,800	---	2,902
Wood	1,000	5,400	70	207
Wyandot	4,400	76,500	15	2,715
TOTALS	5,659,500	738,490	23,617	100,552

*On main stem and principal tributaries

TABLE 14-49(continued). River Basin Group 4.2, Data Summary by County

YEAR 2000

County	Estimated Average Annual Damages (Dollars) Urban	Rural	Estimated Acres in Flood Plain Urban	Rural
Indiana				
Adams	50,600	22,900	917	5,088
Allen	4,151,400	109,680	10,880	10,335
De Kalb	14,000	10,500	26	4,050
Ohio				
Allen	---	10,360	354	2,935
Auglaize	195,600	26,250	806	2,460
Crawford	193,600	---	205	---
Defiance	95,300	28,800	1,487	6,673
Erie	709,600	121,100	247	3,258
Fulton	---	---	---	---
Hancock	2,560,000	57,000	2,140	8,950
Henry	45,840	20,200	1,328	5,241
Huron	149,300	---	351	105
Lorain (PSA 4.3)	3,900	23,800	6	509
Lucas	35,270	2,500	2,349	1,836
Mercer	---	---	---	---
Ottawa	---	---	25	1,100
Paulding	14,620	17,300	155	5,565
Putnam	646,700	79,000	837	21,744
Sandusky	1,543,000	363,500	1,184	9,845
Seneca	156,400	253,100	574	4,695
Van Wert	---	---	---	---
Williams	---	10,400	---	2,902
Wood	1,500	7,200	70	207
Wyandot	8,900	154,200	17	2,713
TOTALS	10,575,530	1,318,790	23,958	100,211

YEAR 2020

County	Urban	Rural	Urban	Rural
Indiana				
Adams	89,000	26,800	937	5,068
Allen	7,267,200	184,200	10,940	10,275
De Kalb	17,000	12,800	40	4,036
Ohio				
Allen	---	12,580	354	2,935
Auglaize	340,240	31,880	806	2,460
Crawford	404,100	---	205	---
Defiance	144,200	34,600	1,507	6,653
Erie	1,512,700	258,200	259	3,246
Fulton	---	---	---	---
Hancock	4,454,000	66,000	2,240	8,850
Henry	70,600	24,800	1,338	5,231
Huron	317,800	---	358	98
Lorain (PSA 4.3)	8,300	51,600	7	508
Lucas	49,040	5,000	2,359	1,826
Mercer	---	---	---	---
Ottawa	---	---	30	1,095
Paulding	23,900	21,700	180	5,540
Putnam	1,128,000	93,000	907	21,674
Sandusky	3,246,900	763,800	1,193	9,836
Seneca	324,400	534,400	582	4,687
Van Wert	---	---	---	---
Williams	---	12,800	---	2,902
Wood	2,700	7,700	70	207
Wyandot	18,000	326,100	20	2,710
TOTALS	19,418,080	2,467,960	24,332	99,837

*On main stem and principal tributaries

at the mouth of the river where there are patches of swampland. Before settlement the land was almost completely covered with timber, and land drainage was so slow that swamps were abundant even in the rolling country to the south. The land was cleared and later drained with extensive systems of tile drains. The land has been worked and developed by good farming methods which have not seriously depleted the fertility of the soil. Agriculture is general but large tomato crops are concentrated around Bowling Green, a canning center, and soy beans have also become a major cash crop.

Some depleted oil fields are scattered throughout the southern portion of the basin. The only other natural resources consist of gravel and limestone quarries and some peat bogs worked by local inhabitants.

The area is crossed by four major railroads and is served by a network of highways and roads which connect the principal cities and communities. The Portage River is navigable for light-draft vessels from Port Clinton at Lake Erie to Oak Harbor, a distance of 12 miles above the mouth. This section of the river has not been subject to flood damage.

1.44.4 Flood Problems

Northern Ohio is not subject to the storms of intense precipitation that occur south of the Lake Erie-Ohio River divide. Flood-producing storms in the Ohio Valley may extend northward and encompass the Portage River basin, but past records indicate that the intensity of precipitation is less than that which occurs in southern Ohio. The average annual precipitation for northern Ohio is slightly more than 35 inches, but due to topographic or other reasons, there is a considerable variation in average precipitation between the various localities within this section of the State. The Portage River basin, being comparatively low, receives less precipitation than does most of northern Ohio. However, the runoff factor for the basin appears rather large. The comparatively low rate of infiltration appears to be caused by the proximity of the rock to the ground surface and the character of the overlying topsoils. Under the worst meteorological and ground conditions it is estimated that a runoff of 10 inches might occur from a 24-hour rainfall. Runoff gages are located at Woodville, Pemberville, and Bowling Green, Ohio. The Woodville gage records the drainage from 433 square miles or 72 percent of the basin. The average discharge is 311 cfs with a maximum of 11,500 cfs. Average yearly runoff for the period 1928 to 1950 equaled 9.1 inches compared to an average precipitation of 30 inches.

The report of 1940 makes no estimate of flood stages for a maximum storm condition because damages would be confined principally to the inundation of farmlands. This report also indicates that under such conditions an interchange of water between the Middle and North Branches would occur. The flood plain slopes very gradually from the channel banks. Above Rudolph the flood plain is nearly flat so that a considerable amount of valley storage would result.

According to residents, the most severe flood occurred in July 1929. Some residents along the Portage River state that periodic flooding occurs every two or three years. Examination of discharge records discloses that the flow at the Woodville gage in 1929 (6,000 cfs) was not large compared with that which frequently occurs during the spring or late winter break-up. Those floods which are called the most severe are the most damaging but not necessarily the greatest from the standpoint of flood discharge or river stage. Other important floods in the Portage River basin occurred in May 1933, June 1937, and July 1969. These floods were all caused by high intensity storms. The principal damage resulting from floods in the Portage River basin is the loss of crops during the growing season.

Figure 14–43c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–46 depicts the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–47 depicts upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–44c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–48. County summaries for the main stem and principal tributaries are tabulated in Table 14–49.

1.44.5 Existing Flood Damage Prevention Measures

At the present time the Corps of Engineers has no flood control projects in the Portage River or its tributaries. Minor channel improvements which have been initiated by other Federal and non-Federal agencies are listed in Table 14–45.

Aside from the current State and conservancy district programs there are no known nonstructural flood control projects. The farming community has shown foresight; very few worthwhile farm buildings are located within the area subject to inundation.

Refer to Subsection 1.43.5 for discussion of flood plain legislation which is applicable to this river basin.

1.45 Lake Erie Southwest, River Basin Group 4.2, Sandusky River Basin

1.45.1 Description

The Sandusky River drains the second largest area in northwestern Ohio, 1,420 square miles. This river and its tributaries drain all or part of eight Ohio counties. Location within River Basin Group 4.2 is shown in Figure 14–42. The basin has maximum dimensions of 50 miles east-west and 60 miles north-south. The main stem of the river has a total length of 130 miles. There are no large lakes or other prominent topographic features in the basin. The elevation at the river source is 1,093 feet, and at its mouth, 573 feet. Streams flow in shallow valleys following the general surface slope. Bottomlands along the river and its tributaries vary in width from ¼ to ¾ mile. The average fall of the Sandusky River equals 3.9 feet per mile, and the channel slopes of tributaries equals 12 feet per mile.

1.45.2 Previous Studies

Previous studies are listed below:

(1) 1972—U.S. Geological Survey, flood-prone area reports for portions of the Sandusky River and Little Sandusky River

(2) 1971—U.S. Geological Survey, flood-prone area reports for Pipe Creek, Mills Creek and Plum Brook

(3) 1971—Soil Conservation Service, preliminary investigation report on upper Honey Creek, Crawford, Huron, and Seneca Counties, Ohio

(4) 1969—U.S. Geological Survey, flood-prone area reports for portions of the Sandusky River and Tymochtee Creek

(5) 1964—Flood Plains Information Report, Sandusky River, Ohio

(6) 1961—Corps of Engineers, Buffalo District, initiated Flood Plain Information Studies in the basin

(7) 1961—Department of Natural Resources, comprehensive flood control report on the Sandusky River basin

(8) 1959—Ohio State Division of Water, plan for formation of a dam and lake on Spicer Creek; reduction in flood flow limited to immediate downstream area

(9) 1959—Corps of Engineers, Buffalo District, review report of previous studies including flood control by means of reservoirs, levees, and channel improvements. The report concluded that channel improvement projects at Fremont and Bucyrus with alterations to sewers and drainage systems were economically justified. Other conclusions were that the project at Tiffin, Ohio, was not justified, that the reservoir site at Mexico, limited in capacity, would aid flood control but was not economically justified, and that the reservoir upstream of Bucyrus was justified for multi-purpose use.

(10) 1950—Scioto, Sandusky Conservancy District, report recognized need for basinwide plan. Recommendations included water supply and flood control reservoirs and local flood protection systems.

(11) 1949—Scioto, Sandusky Conservancy District, preliminary investigation of flood problems on Tymochtee Creek between Marseilles and mouth. It investigated reservoir, channel improvement, and levees.

(12) 1947—Corps of Engineers, study of canal from Lake Erie to Ohio River. The study showed flood control benefits to be small for the Sandusky River basin.

(13) 1941—U.S. Army Corps of Engineers, survey report for flood control. This report included studies of reservoirs, levees, and channel improvement.

1.45.3 Development in the Flood Plain

The Sandusky River basin is identified by no single outstanding resource or raw material. Approximately 90 percent of the land is devoted to agriculture. In spite of flood hazards, the areas along the river and its tributaries are used as cropland.

The Sandusky basin has a well-developed network of highways and improved connecting roads. Several railroads serve the area, running generally across the basin rather than along the valleys and so remain relatively unimpaired by flooding except within the immediate Fremont area. Gradual urbanization is taking place, especially around the cities, with the construction of shopping plazas and other retail outlets on the periphery of the towns.

1.45.4 Flood Problems

Historical records show that serious flooding occurred in February 1833, January 1847, February 1883, and January, February, and March 1904. However, no reliable data are available regarding discharges, stages, or damages for floods prior to 1913. Major floods of record occurred in March 1913, and January and February of 1959. Less significant flooding also occurred in January 1930, June 1937, and March 1963.

Between Sandusky Bay and Fremont, residences on or near the river bank, some of which are occupied all year, often incur heavy flood damages. In many cases these residences have been constructed in spite of flood hazard, because other features make sites attractive. Minor damages to agricultural and highway units also occur in this reach.

In the City of Fremont the right bank of the Sandusky is a commercial and residential district. The commercial units are located along East State Street and the remainder of the flooded area is a concentrated middle-class residential development of two-story, single-family units. The left bank is composed of industrial, commercial, and two-story residential units. Also located on the left bank is the downtown business district centered along Front Street. The sewage treatment plant and water filtration plant and a large city park (Rodger Young Memorial Park) are also located on this bank.

The City of Tiffin has remained relatively free from major flood damage since the completion of a local protection project shortly after the 1913 flood. Damages as a result of flooding are now confined primarily to the low areas upstream and downstream of the flood walls. The inundated area upstream of the walls consists almost entirely of the low-lying, partially developed residential area known locally as Mechanicsburg. The inundated area downstream from the flood walls lies along the left bank of the river and consists of older, middle-class residential units.

Between Fremont and Tiffin the flood plain is confined to a relatively narrow strip through the area known as Ballville. From Ballville southward to the northern boundary of Tiffin, the flood plain is occupied almost entirely by farms, with occasional flooding relatively near nonfarm homes.

The flooded area of the City of Bucyrus is confined by the topography to a relatively narrow strip through the city, almost wholly on the right bank of the river, containing a combination of long established residential areas with a number of commercial and small industrial units. A large portion of the flooded area is either completely undeveloped or is being used for park and athletic purposes.

Figure 14–43c identifies the time period in which major damages, as defined in this study, are first noted within a given reach of the main stem and principal tributaries. Table 14–46 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–47 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–44c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–48. County summaries for the main stem and principal tributaries are tabulated in Table 14–49.

1.45.5 Existing Flood Damage Prevention Measures

The only Federal measure undertaken in the area was a navigation project adopted March 3, 1867, for the Sandusky River from its mouth to Fremont. In 1903 the Board of Engineers for Rivers and Harbors reported that further improvement of this reach of the river was inadvisable. Abandonment of the project was recommended in House Document No. 467, 69th Congress, 1st Session, but no action has been taken on the recommendation. Therefore, it is subject to Section 10 of the Rivers and Harbors Act of March 3, 1899, which requires that all work in navigable waters of the United States must be authorized by the Department of the Army prior to its commencement. Permits must be obtained for all structures which are proposed within the Sandusky River channel.

After the 1913 flood, the City of Tiffin and Seneca County enlarged the river channel through the central part of the city and built concrete walls on both banks. The channel of the lower part of Rock Creek was similarly improved to prevent damage by backwater from the river.

A flood control project now under construction for Fremont is designed to eleminate the damage in the city from a discharge of 50,000 cfs which under ice-free conditions occurs on the average of once every 133 years. It would also eliminate damage from high stages resulting from ice jams up to a stage that would occur on the average of once every 80 years. As far as practicable, stages will be lowered by enlarging and realigning the channel, and levees or walls will be provided to contain the reduced stages. Pressure conduits will be constructed to provide for runoff from areas above the design flow line. Pumping will be provided for runoff from areas below the design flow line. Ponding areas will be used where possible to reduce peak pumping loads.

Major features are:

(1) channel enlargement and partial realignment in a 10,450-foot reach of the Sandusky River, including a 2,000-foot-long control channel to provide the transition to natural levels at the upstream end

(2) construction of 18,300 feet of levees and 3,500 feet of flood walls

(3) construction of three pumping stations along the west bank at Minnow Creek, Birchard Street, and Liberty Street, and one pumping station on the east bank at Pine Street

With the exception of the City of Fremont, there is no zoning at present within Sandusky County. In 1962 a proposal was submitted in Sandusky County for zoning on a countywide basis. The referendum was defeated by the people of the county. Fremont has a zoning ordinance but it is in no way related to regulation or use of the flood plain. Within Seneca County, the situation is essentially the same. The City of Tiffin and Pleasant and Clinton Townships have zoning ordinances, but in all cases the ordinances have no reference to regulation or use of the flood plain. Refer to Subsection 1.43.5 for a discussion of flood plain legislation applicable to this river basin.

The National Weather Service in Columbus, Ohio, predicts peak flood stages along the Sandusky River.

1.46 Lake Erie Southwest, River Basin Group 4.2, Vermilion River Basin

1.46.1 Description

The Vermilion River has its source in the Savannah Lakes of Ashland County and flows generally north for a distance of nearly 59 miles into Lake Erie. The watershed has a maximum width of a little more than 16 miles and a maximum length of 34 miles. Location within River Basin Group 4.2 is shown in Figure 14–42. The Vermilion River picks up the tributaries of Clear Creek from the west and Buck Creek from the east in Ashland County. In Huron County the Southwest Branch and Indian Creek enter from the west and the East Branch enters the river from the east. The East Fork enters the river from the east in Erie County. No major tributaries enter the river in Lorain County. The river has a relatively flat slope throughout its length, averaging less than 8 feet per mile. All of the tributaries except the East Fork are characterized by relatively broad but well-defined valleys. The Vermilion River itself flows through a relatively wide valley section throughout most of its length. In the upper 15 miles within Ashland County the valley is defined by moderately sloping sides up to 100 feet or more above the stream bed. The central 23 miles of the river within Huron County are less well defined and the adjacent high ground averages only 50 feet above the stream bed. Near the Village of Wakeman, 21 miles upstream from the mouth, the river starts a meandering course to the Lake through a gorge averaging 100 feet in depth and ranging from 200 feet to 2,000 feet in width. The valley walls broaden out and disappear approximately one mile upstream from the river mouth at a point just upstream from the principal development of the City of Vermilion.

1.46.2 Previous Studies

Previous studies are listed below:

(1) 1971—flood-prone area report for portions of Vermilion River

(2) 1970—flood-prone area reports for portions of the Huron River, east and west branches of the Huron River, and Norwalk Creek

(3) 1970—Flood Plain Information Report, Huron River, Ohio

(4) 1970—Flood Plain Information Report, Vermilion River (Erie, Lorain, and Huron Counties, Ohio)

(5) 1965—Flood Plain Information Report, Vermilion River, Ohio, from Lake Erie to Mill Hollow

1.46.3 Development in the Flood Plain

The City of Vermilion in Erie County has an excellent small boat harbor, one of the largest on the Great Lakes. A maintained channel 100 feet wide and 12 feet deep extends to deep water in the Lake and upstream approximately 1,200 feet from the Vermilion River mouth. These facilities not only provide access for the large number of recreation craft but also provide access and mooring for a number of Lake Erie fishing boats. Vermilion is well known as a summer resort, and the flood-prone area within Erie County is part of the large water-oriented development of the city. The low-lying shore areas adjacent to the river have been dredged out to form lagoons to increase the amount of shoreline available. This makes it possible for the individual property owner to have boat and dock facilities at his home. The area downstream from Liberty Avenue (U.S. Route 6 and Ohio Route 2) has been developed for some time and contains a large development of fine residential homes. In the area immediately upstream from Liberty Avenue similar development has begun recently. The lagoons and boat facilities have been constructed, but residential development has taken place more slowly, partly because of recent flooding. The commercial units in the flooded area are fisheries, boat marinas, and one restaurant, which line the river's edge. The city water plant and sewage treatment plant are also situated close to the river bank downstream from Liberty Avenue and are affected during high water periods. Immediately downstream from the Erie County boundary on the right bank is a development of summer cottages known as Vermilion River Park. The development contains nearly 50 cottages, most of which are not occupied during the cold weather months.

Portions of the City of Vermilion in Lorain County lie along the right bank of the Vermilion River upstream to the Mill Hollow Park Reservation. The portion of the city within the flood plain is relatively undeveloped. Although there are several camping and recreation sites in the area, there are few permanent structures. In spite of the steep slopes, some of the area is cultivated and crops of hay, winter wheat, and corn are normally grown.

Brownhelm Township in Lorain County extends along the left bank of the Vermilion River from the county line to the upstream limit of the study area. The only major development within the flooded area in the township is the Olympic Club area just upstream of the Erie County line. This is a summer residential area containing approximately 25 summer cottages along with concession buildings and playground areas. The remainder of the flooded area has no significant development. Some of the more accessible areas are cultivated, but much of the flood plain is in woodland. The Mill Hollow Reservation of the Lorain County Metropolitan Park system is on both banks of the river at the upstream limit of the study area.

1.46.4 Flood Problems

The greatest flood of record along the Vermilion River occurred in July 1969, and other serious flooding occurred in March 1913, February 1951, May 1956, January and February 1959, and March 1963. The March 1913 flood is regarded as a historical flood because it occurred before formal record keeping of flood stages began with the establishment of the U.S. Geological Survey gage in March 1950. There have undoubtedly been other floods that occurred before 1913 and between 1913 and 1950, but no factual data are available. The 1913 flood was great enough so that some high water marks are still noticeable and newspaper accounts are still available. Floods on the Vermilion River are often accompanied by ice jams so that resulting flood stages are higher than they would be from river discharge alone.

Figure 14–43c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–46 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–47 shows upstream flood damages. These damages are referenced to the watersheds identified in Figure 14–44c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–48. County summaries for the main stem and principal tributaries are tabulated in Table 14–49.

1.46.5 Existing Flood Damage Prevention Measures

The Coast Guard is called upon almost annually to break ice in the Vermilion River to alleviate floods caused by ice jams or the threat of flooding due to ice jams.

There are zoning resolutions in the City of Vermilion and in Brownhelm Township, and there are subdivision regulations and building codes within the City of Vermilion. Refer to

Subsection 1.43.5 for a discussion of flood plain legislation applicable to this river basin.

A P.L. 566 project has been constructed on the Huron River in the March Run Watershed, Crawford, Richland and Huron Counties, Ohio. Location of this project is illustrated in Figure 14–45. A harbor improvement at the mouth of the Vermilion River, a Federal project, is still subject to periodic dredging to maintain the project depth. A new entrance and the extension of the dredged channel to the Liberty Avenue bridge with a depth of 8 feet were authorized in 1958. These proposed improvements are classified as inactive at present by the Corps of Engineers.

1.47 Lake Erie Central, River Basin Group 4.3, Black River Basin

1.47.1 Description

The watershed has a maximum width of approximately 22 miles and a maximum length of 34 miles. From the City of Elyria southward the Black River consists of two branches: the east branch which drains approximately 217 square miles, and the west branch which drains approximately 175 square miles. The east branch measures 56 miles, including a section at the upper end known as the West Fork. The flow on this branch originates in Ashland and Medina Counties, flows eastward for a distance of 13 miles, then turns northward picking up the tributaries of East Fork, Coon, Crow, Salt, and Willow Creeks. It finally joins the flow from the west branch within the City of Elyria. The west branch of the Black River has a total length of 43 miles. Originating in Ashland County, it flows generally northeasterly to its confluence with the east branch in Elyria. Tributaries of the west branch are considerably larger than those of the east branch, the most notable being Charlemont, Plum, and Wellington Creeks. From the confluence of the east and west branches the Black River flows northward, then westward, for a total distance of approximately 15 miles, finally terminating at Lake Erie in the City of Lorain. The only major tributary in this reach is French Creek which flows westerly and enters the Black River 5 miles from its mouth. Location within River Basin Group 4.3 is shown in Figure 14–46.

From the mouth of the Black River to approximately 3 miles upstream, the river channel has a width of from 200 to 400 feet and a maintained depth of 27 feet. This reach lies within the Federal navigation project of Lorain Harbor. From this point southward, the river channel gradually narrows until its average width at the confluence is approximately 150 feet. The banks of the channel are relatively low in this reach, but the river flows in a meandering course to the Lake through a deep gorge which varies from 40 to 90 feet in depth and from 300 to 2,000 feet in width. The Black River channel bottom is below mean lake level for approximately 6 miles from its mouth. From this point to the confluence, the thalweg rises approximately 60 feet resulting in an average slope of 5 to 6 feet per mile.

The east and west branches of the Black River merge in Elyria in the area known as Cascade Park. Less than one-half mile above the confluence there is a waterfall on each branch of the river. Flows from the watersheds of the east and west branch fall 40 to 50 feet at these waterfalls before combining to form the main stem running to Lake Erie. Because of this difference in elevation, flood stages upstream of the waterfalls are not affected by ice jams, lake stage, or other hydraulic conditions which affect flood stages in the river below the cascades. The average slopes of the thalwegs of the east and west branches are approximately 8 feet and 5 feet per mile, respectively.

1.47.2 Previous Studies

As of 1972 the U.S. Geological Survey had published flood-prone area reports for portions of the following tributaries of the Black River: east and west branches, East Fork, Plum Creek, Willow Creek, and Wellington Creek.

The Flood Plain Information Report, Black River, Ohio, from Lake Erie to Carlisle Township, dated June 1964, was reprinted July 1968 and May 1970.

1.47.3 Development in the Flood Plain

Because the Black River is confined to a relatively deep gorge throughout much of its length, and because those areas where wide overland flow does occur have had relatively light development, the floods of 1913 and 1959 caused little damage in comparison with many of the river basins in Ohio. The City of Lorain is endowed with an excellent harbor. The Corps of Engineers maintains a minimum

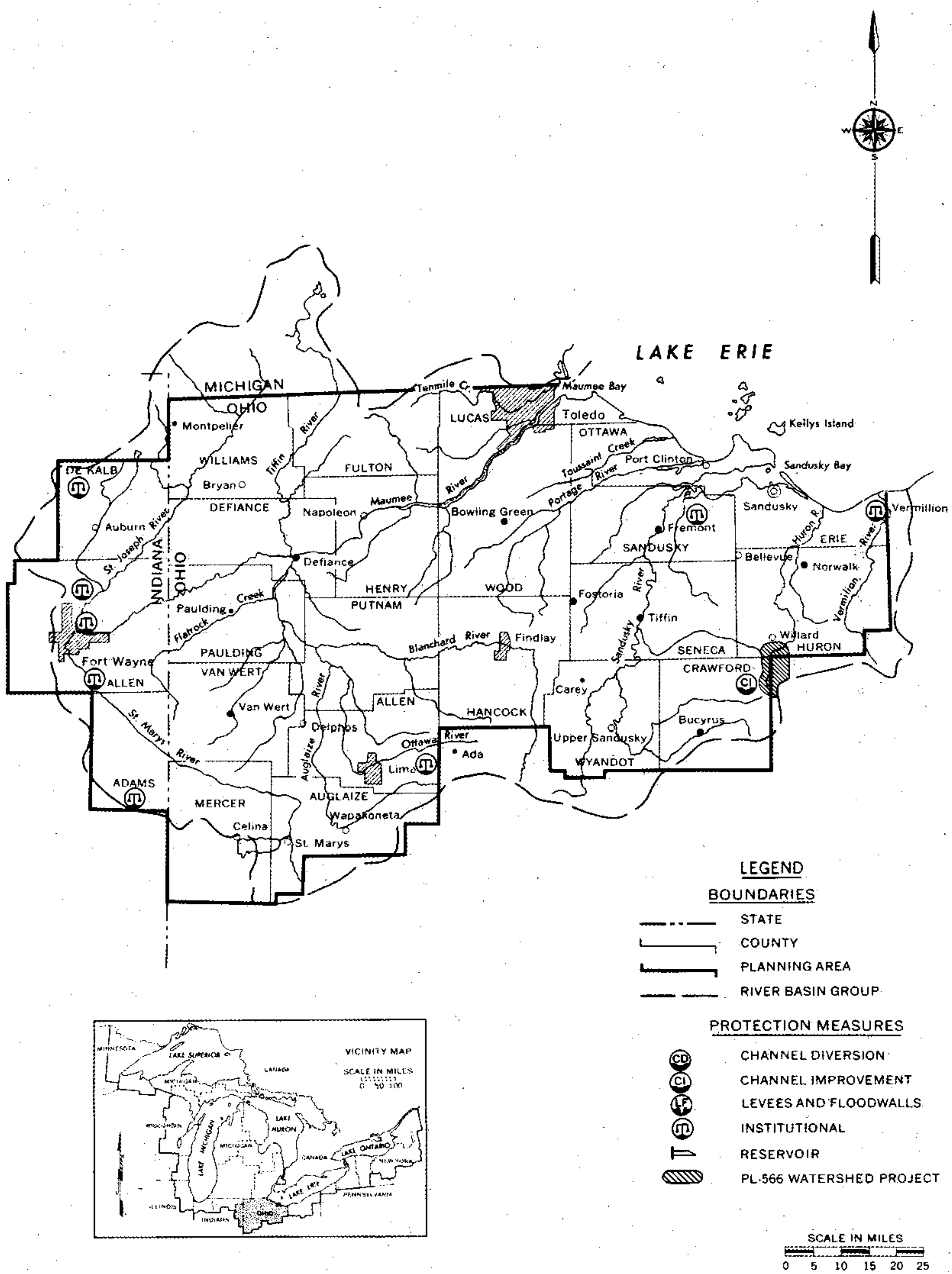

FIGURE 14-45 Existing Flood Damage Protection Measures for River Basin Group 4.2

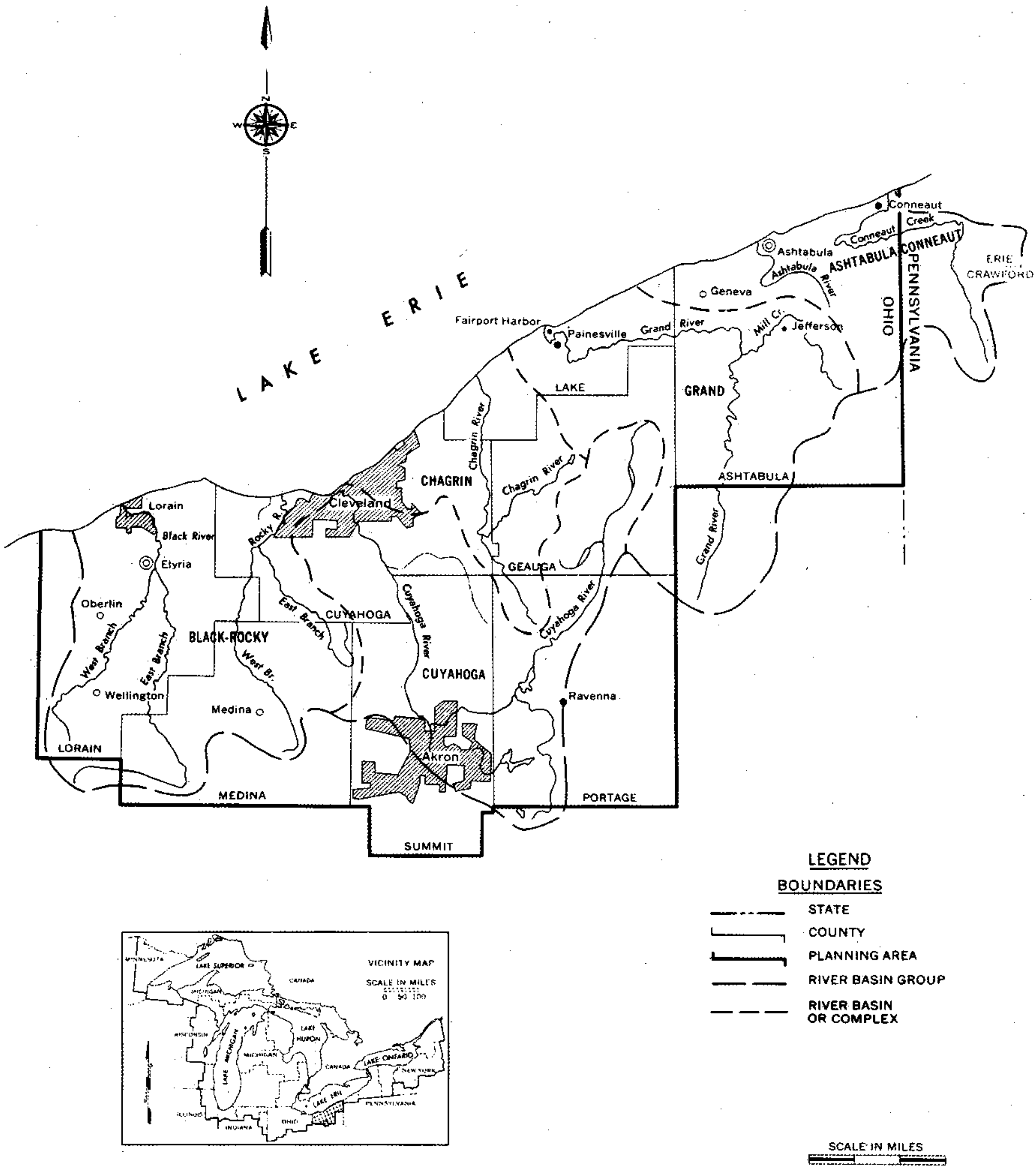

FIGURE 14–46 Lake Erie Central—River Basin Group 4.3

dredged depth of 27 feet for a distance of approximately 3 miles from the mouth of the Black River. Both banks of the river have become heavily industrialized, and at the present time Lorain has the largest freshwater shipyard in the world. The river is well confined within the channel in this area during high discharges. Consequently, the only major damage from high water during the floods of July 1969 and January 1959 was the result of debris being drawn into the water intakes at U.S. Steel.

In the reach through Sheffield Township the flood plain of the Black River is confined to a deep gorge which is completely undeveloped and quite inaccessible at present. A few farm roads extend to the bottomland, and some land has been cultivated. However, the major portion of the area appears to be unused at present.

In the northern portion of the City of Elyria land use in the bottom land is primarily agricultural and recreational. The Elyria sewage treatment plant is located approximately 10.5 river miles from the mouth. From this point southward to the waterfalls on the east and west branches, the flood plain is used almost entirely for recreation. One obvious exception is the Ford Road dump, located slightly upstream from the sewage treatment plant. From this point southward the flood plain is occupied successively by Spring Valley Golf Club, Cherry Ridge Golf Club, and Cascade and Elywood Parks in Elyria. These parks offer the residents of the area a playground and athletic field, and facilities for hiking, picnicking, and swimming. From the confluence the east and west branches course through the heart of downtown Elyria. The flood plain is bordered by commercial and residential land uses, but for the most part the developed land lies above the flood level of 1959. Moving to the south boundary of the City of Elyria, flood plain land use is primarily residential.

In the northern part of Carlisle Township land use is again essentially residential in nature. In this area many homeowners have beautifully landscaped the rear portion of their property which lies within the flood plain. In most cases the builders constructed the houses well above previous flood levels. Further south on the branches of the Black River there is a general decrease in residential use and an increase in agricultural use. Some flood plain land in this township is also used for recreational purposes. On the west branch two private golf courses are located just upstream from the Route 20 bridge and a private hunting club occupies a portion of the flood plain just north of Parsons Road. The Metropolitan Park System has acquired a small tract near Parsons Road in the flood plain of the east branch. However, on both branches there still exist large tracts of unused land, much of which is heavily wooded.

1.47.4 Flood Problems

The six largest floods on the Black River in decreasing order of magnitude occurred in July 1969, March 1913, January 1959, May 1956, February 1959, and June 1937. Of these, only the 1969, 1959, and 1965 floods were recorded at the U.S. Geological Survey gage in Cascade Park.

In general the March 1963 flood was moderate. Floods equaling or exceeding its discharge occur about every other year. However, because of a severe ice jam on the east branch above the East Bridge Street dam, the river stage upstream approached the flood level of 1959.

The most severe floods in the history of the Black River have produced relatively light damages, mostly to residential property. There is no record of loss of life during these floods.

Figure 14–47c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–50 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–51 indicates upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–48c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–52. County summaries for the main stem and principal tributaries are tabulated in Table 14–53.

1.47.5 Existing Flood Damage Prevention Measures

There have been no structural Federal flood control or allied projects constructed nor are any anticipated at this time within the Black River basin, except for the harbor development at the river mouth. There are three dams on the east branch and four on the west branch. The Mussey Avenue Dam (west branch) is used in connection with the intake of water for the Republic Steel plant. A small dam is located just upstream of Parsons Road Bridge (west branch). Water is pumped from this point to the New Oberlin reservoir lying approximately one-half mile to the west. The remaining dams have been erected by local public and private interests to serve strictly local purposes. All the dams contribute to the raising of flood stages.

The City of Elyria has an ordinance which prohibits dumping in or obstructing water courses. The ordinance was in effect at the time revetment for the Medical Arts Building was constructed on the east branch. Although the encroachment became a local issue, the ordinance was not enforced.

There are zoning restrictions in nearly all of the townships and incorporated villages and cities of Lorain County at the present time. However, it appears that there are no subdivision regulations, building codes or zoning ordinances with provisions that affect or regulate the use of land with respect of flood risk.

Refer to Subsection 1.43.5 for a discussion of flood plain legislation applicable to this river basin.

1.48 Lake Erie Central, River Basin Group 4.3, Rocky River Basin

1.48.1 Description

Rocky River flows into Lake Erie between the Cities of Lakewood and Rocky River, 6.5 miles west of the main entrance to Cleveland Harbor and 21.5 miles east of Lorain Harbor. Location within River Basin Group 4.3 is shown in Figure 14–46. The river has two principal branches. The east branch rises in North Royalton in southern Cuyahoga County, flowing southerly then northwesterly. The west branch rises in Medina County and flows northerly to join the east branch to form the Rocky River 12 miles above the mouth. In their upper reaches the two branches flow with moderate slopes in broad valleys. As they approach they drop in a series of cascades into deep narrow gorges. The west branch has a number of falls and rapids in the vicinity of Olmsted Falls. Below the confluence the main river flows through a narrow, winding, rock-walled valley, 100 to 120 feet below the level of the adjacent ground. The width of the valley floor is approximately 300 feet, and access is difficult. The Rocky River slopes in Olmsted Falls are relatively steep, averaging 60 feet per mile. Upstream from Olmsted Falls the river slope averages 2 feet per mile.

1.48.2 Previous Studies

Previous studies are listed below:

(1) Flood Plain Information Report, West Branch, Rocky River, Ohio, Cuyahoga and Lorain Counties, dated 1970

(2) Flood Plain Information Report, Rocky River, Ohio, in the Cities of Rocky River and Lakewood, dated 1968

(3) a report on the harbor submitted to Congress on November 10, 1936, recommending an east pier 900 feet in length and an entrance channel 100 feet wide with a depth of 10 feet. The recommended improvements were authorized by the River and Harbor Act, approved August 26, 1937.

(4) an interim Report on Rocky River Harbor submitted to Congress, and approved March 2, 1945. This report recommended the modification to the existing project previously discussed.

(5) a preliminary examination of the south shores of Lake Erie with a view to the establishment of harbors and harbors of refuge for light-draft commercial fishing vessels and for recreational craft submitted on July 19, 1946. Rocky River was one of 33 locations recommended for further studies of survey scope.

(6) because of the severity of the January 1959 flood, a reconnaissance report on Rocky River in 1962 at the request of the County Commissioners, Cuyahoga County, Ohio, to determine the feasibility of improving Rocky River for flood control. The report recommended that no further study for flood control in the vicinity of the mouth of Rocky River be made at that time due to the lack of economic justfication, but that alleviation of flood damages be considered as a project in the authorized navigation study.

1.48.3 Development in the Flood Plain

In recent years suburban development has occurred in the Rocky River basin as a result of the westward expansion of the Cleveland metropolitan area. Rocky River Harbor is a desirable basing point for recreational craft in the populous Cleveland area. The only other existing small boat facilities of any magnitude are at Cleveland Harbor itself. However, boating activity at Rocky River is free of interfer-

TABLE 14–50 Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 4.3

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN: INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	BLACK RIVER												
BF1	Lorain	T7N	T5N	1970						196		196	
		R18W	R17W	1980	6,100			12		184	16	180	
				2000	15,300			40		156	47	149	
				2020	32,900			55		141	70	126	
BF1A	Lorain	Lorain		1970	900		5	5		302	302		
				1980	12,600		10	10		292	302		
				2000	33,600		15	15		282	302		
				2020	68,200					272	302		
BF1B	Lorain	Elyria		1970	38,300		15	10		368	393		
				1980	59,000		18	12		363	393		
				2000	147,500		25	17		351	393		
				2020	318,700		30	20		343	393		
	SPERRY CREEK												
BF2	Cuyahoga	T7N	T7N	1970	9,600		17	62		65	144		
		R15W	R15W	1980	13,300		21	76		47	144		
				2000	24,600		28	103		13	144		
				2020	52,600		28	103		13	144		
	ROCKY RIVER												
BF3	Cuyahoga	T7N	T5N	1970	24,000	26,000	10			4125	2315	1,870	
		R14W	R13W	1980	44,600	36,200	10	20		4105	2335	1,850	
				2000	83,600	67,800	10	27		4098	2342	1,843	
				2020	179,200	145,300	10	32		4093	2347	1,838	
BF3A	Cuyahoga	Rocky	S.Lakewood	1970	21,000		12	15		3	30		
		River		1980	29,200		12	15		3	30		
				2000	54,900		12	15		3	30		
				2020	117,600		12	15		3	30		
BF4	Cuyahoga	T6N	T6N	1970		6,500				650		650	
		R15W	R15W	1980	2,500	9,100		6		644	6	644	
				2000	4,700	16,900		8		642	8	642	
				2020	10,100	36,300		10		640	10	640	
BF5	Lorain	T5N	T5N	1970		14,300				1610		1,610	
		R15W	R15W	1980	4,600	22,000		25		1585	210	1,400	
				2000	11,500	55,100		33		1577	282	1,327	
				2020	25,000	119,000		40		1570	343	1,267	
	CUYAHOGA RIVER												
BG1	Cuyahoga	T17N	T5N	1970	131,700	17,900	76	40		1930	371	1,675	
		R12W	R11W	1980	192,100	24,900	93	61		1892	467	1,579	
				2000	360,700	46,600	126	83		1837	632	1,414	
				2020	772,500	100,100	153	101		1792	769	1,277	
BG1A	Cuyahoga	Cleveland		1970	194,400		400			880	1280		
				1980	269,600		491			789	1280		
				2000	506,400		665			615	1280		
				2020	1,084,500		808			472	1280		
BG2	Summit	T5N	T2N	1970	190,700	14,600	199	105		2770	589	2,485	
		R12W	R10W	1980	275,500	21,200	245	129		2700	724	2,330	
		Akron &	Peninsola	2000	564,400	43,200	330	174		2570	977	2,097	
				2020	1,216,600	93,600	401	212		2461	1189	1,885	
	TINKER'S CREEK												
BG3	Cuyahoga	T6N	T6N	1970	9,200	4,000		27		1116	137	1,006	
		R12W	R10W	1980	12,800	5,600		33		1110	168	975	
				2000	24,000	10,500		45		1098	228	915	
				2020	51,400	22,400		54		1089	276	867	
BG4	Summit	T5N	T5N	1970	27,900	6,400	8	73		954	81	954	
		R10W	R10W	1980	40,500	9,200	10	90		935	100	935	
				2000	82,600	19,000	13	121		901	134	901	
				2020	178,800	40,500	16	148		871	164	871	

TABLE 14–50(continued) Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 4.3

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	CHAGRIN RIVER												
BH1	Lake	T10N	T9N	1970	15,100	7,700	15	45		1315	115	1,260	
		R10W	R10W	1980	25,500	12,900	18	55		1302	141	1,234	
				2000	64,200	32,800	25	75		1275	191	1,184	
				2020	138,200	70,500	30	91		1254	233	1,142	
BH1A	Lake	Eastlake		1970	143,400		25	110		785	920		
				1980	242,300		31	135		754	920		
				2000	608,660		42	183		695	920		
				2020	1,310,300		50	222		648	920		
BH2	Cuyahoga	T8N	T7N	1970	20,900	4,200	55	35		1335	370	1,055	
		R10W	R9W	1980	29,100	5,700	68	43		1314	426	999	
				2000	54,500	10,400	91	58		1276	529	896	
				2020	116,900	22,500	111	71		1243	615	810	
	GRAND RIVER												
BI1	Lake	T11N	T11N	1970	2,800	2,500		14		1280	14	1,280	
		R8W	R6W	1980	4,800	4,300		18		1276	18	1,276	
				2000	13,400	11,100		23		1271	23	1,271	
				2020	28,800	23,900		28		1266	28	1,266	
BI1A	Lake	Painesville		1970	10,200	2,200		20		1050	260	810	
				1980	20,700	3,700	5	25		1040	275	795	
				2000	51,900	9,400	10	33		1027	296	774	
				2020	111,600	20,100	20	40		1010	320	750	
BI2	Ashtabula	T11N	T10N	1970	18,000	8,100	2	90		1491	90	1,493	
		R5W	R4W	1980	28,100	11,900	2	117		1464	117	1,466	
				2000	54,900	23,500	3	157		1423	157	1,426	
				2020	119,000	50,600	4	192		1387	192	1,391	
	CONNEAUT CREEK												
BJ1	Ashtabula	T14N	T13N	1970		12,400				1850		1,850	
		R1W	R1W	1980	3,600	18,300		12		1838	12	1,838	
				2000	7,200	36,900		17			17	1,833	
				2020	15,600	77,600		20			20	1,830	
BJ1A	Ashtabula	Conneaut		1970	5,600		10			210	220		
				1980	8,300		12			208	220		
				2000	16,200		17			203	220		
				2020	35,100		20			200	220		
BJ2	Erie	T13N	Erie-Crawford County Line	1970		19,700	5			3905		3,900	
		R1W		1980	3,700	29,000	6	12		3892	12	3,898	
				2000	7,800	61,800	8	17		3885	17	3,893	
				2020	16,700	131,700	10	20		3880	20	3,890	
BJ3	Crawford	Erie-Crawford Co. Line	Conneaut Lake	1970		9,300				2140		2,140	
				1980	4,200	13,700		10	10	2120	20	2,120	
				2000	9,100	29,100		13	13	2114	26	2,114	
				2020	19,400	62,100		16	20	2104	36	2,104	
BJ3A	Crawford	Conneautville		1970	3,000			5		65	70		
				1980	4,400			6		64	70		
				2000	9,400			8		62	70		
				2020	20,100			10		60	70		

ence from commercial navigation and the damages of polluted water. There are no commercial terminals at the harbor. The public dock constructed by the City of Lakewood for landing small boats is on the east bank of the river just upstream from the Detroit Avenue bridge. The Cleveland Metropolitan Park District has provided a launching ramp and parking facilities on park property a short distance above the public dock. There are no other public facilities, such as boat hoists, repair shops, or onshore storage. These are provided by local marina operators. Private docks and commercial marinas have been built along the banks of the river and along the shores of the Yacht Club Island and Clifton Park Lagoon to provide facilities for recreational craft. These generally consist of walkways supported on

TABLE 14-51 Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 4.3

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)			ESTIMATED ACRES IN FLOOD PLAIN								
		URBAN	RURAL	TOTAL	CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		ASHTABULA - CONNEAUT COMPLEX - OHIO											
30D	1970	1,700	200	1,900	10	10	10	20	--	200	--	200	50
317	1970	600	12,400	13,000	100	300	500	300	--	200	--	200	1,200
318	1970	--	700	700	50	150	200	200	--	--	--	--	600
Total	1970	2,300	13,300	15,600	160	460	710	520	--	400	--	400	1,850
	1980	2,700	17,000	19,700	160	460	710	520	--	400	--	400	1,850
	2000	4,700	19,900	24,600	160	460	710	520	--	400	--	400	1,850
	2020	8,500	22,700	31,200	160	460	710	520	--	400	--	400	1,850
		GRAND RIVER - OHIO											
3152	1970	6,100	1,700	7,800	100	--	125	--	15	55	5	75	225
3153	1970	3,900	1,100	5,000	75	25	75	--	15	35	--	50	175
3154	1970	--	27,500	27,500	1,300	1,775	6,700	2,025	--	--	--	--	11,800
3155	1970	--	100	100	--	50	100	50	--	--	--	--	200
31555	1970	--	7,300	7,300	335	150	500	480	--	--	--	--	1,465
3156	1970	--	2,400	2,400	120	530	550	365	--	--	--	--	1,565
3157	1970	300	900	1,200	100	400	600	400	--	50	--	50	1,500
316	1970	97,600	119,000	216,600	1,815	110	115	1,060	500	1,300	500	2,300	3,100
Total	1970	107,900	160,000	267,900	3,845	3,040	8,765	4,380	530	1,440	505	2,475	20,030
	1980	140,300	206,400	346,700	3,845	3,040	8,765	4,380	530	1,440	505	2,475	20,030
	2000	239,500	241,600	481,100	3,845	3,040	8,765	4,380	530	1,440	505	2,475	20,030
	2020	437,000	275,200	712,200	3,845	3,040	8,765	4,380	530	1,440	505	2,475	20,030
		BLACK - ROCKY COMPLEX - OHIO											
311	1970	2,700	16,600	19,300	1,000	500	500	1,000	--	200	--	200	3,000
3121	1970	2,500	75,200	77,700	390	410	300	--	300	--	--	300	1,100
3122	1970	600	27,500	28,100	1,285	1,200	1,400	--	10	45	--	55	3,885
313	1970	185,200	31,500	216,700	1,600	750	1,350	500	965	2,110	100	3,175	4,200
Total	1970	191,000	150,800	341,800	4,275	2,860	3,550	1,500	1,275	2,355	100	3,730	12,185
	1980	248,300	194,500	442,800	4,275	2,860	3,550	1,500	1,275	2,355	100	3,730	12,185
	2000	424,000	227,700	651,700	4,275	2,860	3,550	1,500	1,275	2,355	100	3,730	12,185
	2020	773,600	259,400	1,033,000	4,275	2,860	3,550	1,500	1,275	2,355	100	3,730	12,185
		CHAGRIN RIVER - OHIO											
314	1970	--	9,300	9,300	550	50	400	150	--	--	--	--	1,150
	1980	--	12,000	12,000	550	50	400	150	--	--	--	--	1,150
	2000	--	14,000	14,000	550	50	400	150	--	--	--	--	1,150
	2020	--	16,000	16,000	550	50	400	150	--	--	--	--	1,150
		CUYAHOGA RIVER - OHIO											
3B1	1970	--	37,000	37,000	850	--	--	--	--	--	--	--	850
3B2	1970	--	21,700	21,700	1,078	152	660	210	--	--	--	--	2,100
3B21	1970	53,500	5,700	59,200	240	10	50	50	--	50	--	50	350
3B22	1970	--	69,900	69,900	800	--	300	100	--	--	--	--	1,200
Total	1970	53,500	134,300	187,800	2,968	162	1,010	360	--	50	--	50	4,500
	1980	69,600	173,200	242,800	2,968	162	1,010	360	--	50	--	50	4,500
	2000	118,800	202,800	321,600	2,968	162	1,010	360	--	50	--	50	4,500
	2020	216,700	231,000	447,700	2,968	162	1,010	360	--	50	--	50	4,500

timber piling and are of temporary construction, being placed and removed every season. These facilities occupy the entire river frontage that is suitable for economical development.

There is little likelihood of any future commercial development in Rocky River within the study area. All available dock space and river frontage is owned or controlled by organizations or individuals interested primarily in its development for recreational boating.

1.48.4 Flood Problems

Most of the units that are susceptible to flood damage are located in the lower reach of the basin. Damage to these units can be either caused by high stages resulting from ice jamming conditions accompanied by a moderate amount of runoff or by excessive runoff alone. Historical documents indicate that the maximum stage of record occurred in March 1913 and was caused by excessive runoff. The

TABLE 14–52 Data Summary by River Basin, River Basin Group 4.3

River Basin	Year	Estimated Average Annual Damage (Dollars)		Estimated Acres In Flood Plain	
		Urban	Rural	Urban	Rural
Black-Rocky Complex	1970	284,800	197,600	6,914	16,511
	1980	420,200	261,800	7,166	16,259
	2000	799,700	367,500	7,279	16,146
	2020	1,577,900	560,000	7,369	16,056
Cuyahoga River	1970	607,400	177,200	2,508	10,620
	1980	861,100	234,100	2,789	10,339
	2000	1,656,900	322,100	3,301	9,827
	2020	3,519,700	487,900	3,728	9,400
Chagrin Complex	1970	179,400	21,200	1,405	3,465
	1980	296,900	30,600	1,487	3,383
	2000	727,300	57,200	1,640	3,230
	2020	1,565,400	108,900	1,768	3,102
Grand River	1970	138,900	172,800	2,839	23,613
	1980	193,900	226,300	2,885	23,577
	2000	359,700	285,600	2,951	23,501
	2020	696,400	369,800	3,015	23,437
Ashtabula-Conneaut Complex	1970	10,900	54,700	690	9,750
	1980	26,900	78,000	734	9,706
	2000	54,400	146,700	750	9,690
	2020	115,400	294,100	766	9,674
TOTALS	1970	1,221,400	623,500	14,356	63,959
	1980	1,799,000	830,800	15,061	63,254
	2000	3,598,000	1,179,100	15,921	62,394
	2020	7,474,800	1,820,700	16,646	61,669

second highest stage of record occurred on June 29, 1924, and was the result of a tornado. The greatest flood known to have occurred in recent years was on January 22, 1959. It was caused by an ice jam at the Norfolk and Western Railway bridge. Other damaging floods have occurred in January 1952, June 1947, August 1935, March 1933, January 1929, March and December 1927, and February 1926.

Figure 14–47c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–50 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–51 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–48c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–52. County summaries for the main stem and principal tributaries are tabulated in Table 14–53.

1.48.5 Existing Flood Damage Prevention Measures

There are no structural flood control projects in the basin. However, in the period 1904 to 1907, rock was dredged from the Rocky

TABLE 14–53 River Basin Group 4.3, Data Summary by County

County	Estimated Average Annual Damages (Dollars) Urban	Estimated Average Annual Damages (Dollars) Rural	Estimated Acres in Flood Plain Urban	Estimated Acres in Flood Plain Rural
YEAR 1970				
Ohio				
Ashtabula	23,600	20,500	310	3,343
Cuyahoga	410,800	58,600	4,647	6,256
Lake	171,500	12,400	1,309	3,350
Lorain (See RBG 4.2)	39,200	14,300	695	1,806
Summit	218,600	21,000	670	3,439
Pennsylvania				
Crawford	3,000	9,300	70	2,140
Erie (PSA 4.4)	---	19,700	---	3,910
TOTALS	866,700	155,800	7,701	24,244
YEAR 1980				
Ohio				
Ashtabula	40,000	30,200	349	3,304
Cuyahoga	593,200	81,500	4,856	6,047
Lake	293,300	20,900	1,354	3,305
Lorain (See RBG 4.2)	82,300	22,000	921	1,580
Summit	317,000	30,400	824	3,285
Pennsylvania				
Crawford	8,600	13,700	90	2,120
Erie (PSA 4.4)	3,700	29,000	12	3,898
TOTALS	1,338,100	227,700	8,406	23,539
YEAR 2000				
Ohio				
Ashtabula	73,300	59,400	394	3,259
Cuyahoga	1,113,400	152,200	5,193	5,710
Lake	738,100	53,300	1,430	3,224
Lorain (See RBG 4.2)	207,900	55,100	1,025	1,476
Summit	647,000	62,200	1,111	2,998
Pennsylvania				
Crawford	18,500	29,100	96	2,114
Erie (PSA 4.4)	7,800	61,800	17	3,893
TOTALS	2,811,000	473,100	9,266	22,679
YEAR 2020				
Ohio				
Ashtabula	169,700	128,200	432	3,221
Cuyahoga	2,384,800	326,500	5,471	5,432
Lake	1,588,900	114,500	1,501	3,158
Lorain (See RBG 4.2)	444,800	119,000	1,108	1,393
Summit	1,394,600	134,400	1,353	2,756
Pennsylvania				
Crawford	39,500	62,100	106	2,104
Erie (PSA 4.4)	16,700	131,700	20	3,890
TOTALS	6,039,000	1,016,400	9,991	21,954

*On main stem and principal tributaries

River for use as core stone in the construction of breakwaters at Cleveland Harbor, Ohio. A depth of 12 feet was generally secured upstream from the Detroit Avenue highway bridge. The Cleveland Yacht Club from time to time has dredged alongside their bulkhead to provide adequate depths for mooring of members' vessels. The Clifton Park Lagoon Association has dredged its lagoons to 9 feet. Other organizations and individuals have done minor amounts of dredging in the vicinity of their docks.

When ice jams in the river entrance cause a flooding threat, they are broken by a Coast Guard ice breaker.

At present only the Township of Columbia has flood plain regulations. In 1967 the township established a flood plain district to protect the public and encourage the establishment of recreational facilities in the flood plain. It was created for the areas along Rocky River that were flooded in January 1959.

Refer to Subsection 1.43.5 for a discussion of flood plain legislation applicable to this river basin.

1.49 Lake Erie Central, River Basin Group 4.3, Cuyahoga River Basin

1.49.1 Description

The Cuyahoga River basin comprises an area of approximately 810 square miles in northeastern Ohio. Parts of the Counties of Cuyahoga, Geauga, Medina, Portage, Stark, and Summit are within the basin. Location within River Basin Group 4.3 is shown in Figure 14–46. The Cuyahoga River rises 10 miles northeast of Burton in Geauga County. It flows in a southerly direction to near the village of Hiram Rapids, then southwesterly and westerly, passing through Mantua, Kent, and Cuyahoga Falls to its confluence with the Little Cuyahoga River at Akron. From there it flows generally north to Lake Erie at Cleveland. The main tributaries of the river are Big, Mill, Tinkers, and Chippewa Creeks, Mud Brook, the Little Cuyahoga River, Congress Lake Outlet, and the Cuyahoga River west branch.

The watershed, except for the gently sloping area approximately 3 miles wide bordering on Lake Erie, consists of rolling hills and contains some natural small lakes and ponds. The Cuyahoga River rises at an elevation of 1,300 feet. From Cuyahoga Falls to its mouth, the river valley is approximately ½-mile wide and is bordered by hills rising from 100 to 500 feet above the valley floor. Numerous small streams and runs indent these side hills. A relatively distinct escarpment divides the basin between an upland plateau and the lake plain. The upland soils in the area have developed from glacial till. These soils have silt or clay loam textures with slow internal drainage. Along the flood plains of the streams, on glacial outwash areas, and in areas that were occupied in prehistoric times by Lake Erie, the soils are partly of lacustrine and partly of alluvial origin. These soils have loam, sandy loam, or gravelly loam textures. There are small, scattered areas of poor drainage where peats and mucks have developed.

The Cuyahoga River watershed is roughly "U" shaped with a long eastern arm, as the result of drainage changes during glaciation. In the upper reaches of the Cuyahoga River, above Cuyahoga Falls, the channel is shallow and cuts through glacial drift with a fall of 4 feet per mile. At Cuyahoga Falls, where the river cuts through the Pennsylvania sandstone, the drop is 200 feet in 1½ miles. In the lower northward course, the river flows in a preglacial valley, with a fall of approximately 5 feet per mile.

Relatively steep stream slopes characterize Tinkers Creek below the City of Bedford. On the average the stream drops 40 feet per mile. Above Bedford the slope is flatter, dropping an average of 5 feet per mile. The stream slope on Big Creek is generally steep, varying from 25 feet per mile near the mouth to 80 feet per mile near the source.

1.49.2 Previous Studies

The Buffalo District of the Corps of Engineers initiated a flood control study for a portion of the Cuyahoga River, as authorized by the Flood Control Act of 1968. The scope of the study was expanded by the River and Harbor Act of 1970 into the Cuyahoga River Basin Restoration Study which authorized the investigation, study, and undertaking of measures in the interests of water quality, environmental quality, recreation, fish and wildlife, and flood control for the entire Cuyahoga basin. The First Interim Report of the Cuyahoga River Restoration Study was published in September 1971. The projects proposed by the report include a pilot sediment removal program, harbor debris removal, recreational improvements at two locations on the river, and flood control improvements for Big Creek in the vicinity of the Cleveland Zoo.

In 1971 the Geological Survey published flood-prone area reports for portions of the Cuyahoga River and portions of its tributaries including Tinkers, Indiana, Mud, Yellow, and Brandywine Creeks.

A special report, "Dredging and Water Quality Problems in the Great Lakes," was prepared by the Buffalo District of the Corps of Engineers. Dated March 1969, the report was submitted to the Office of the Chief of Engineers on June 20, 1969. Preparation was authorized by the Chief of Engineers on November 22, 1966, to comply with Executive Order No. 11288 issued in furtherance of the purpose and policy of the Federal Water Pollution Control Act as amended (33 USC 466). The plan presented in the special report provided the most feasible alternative means for disposing of materials dredged from the Cleveland Harbor navigation channels during maintenance. Historically, dredged materials have been dumped in deep water in Lake Erie. The plan includes construction of a settling basin in the Cuyahoga River upstream from the channels.

The Buffalo District of the Corps of Engineers, published in July 1968 a flood plain information report on Cuyahoga River, Big Creek, and Tinkers Creek, all within Cuyahoga County. It was prepared in response to a request from the Cuyahoga County Regional Planning Commission through the Ohio Department of Natural Resources. Its purposes were to aid in the understanding of local flood problems and to provide guidance in selection of the best uses for lands subject to overflow. Among other things, it defines and illustrates the areal extent and profile of flooding that would be associated with recurrence of an intermediate regional flood (defined as one of 100-year frequency—equal to the January 1959 flood), recurrence of the maximum flood of record (March 1913), and an occurrence of the standard project flood.

The Board of County Commissioners, Cuyahoga County, Ohio, acting with the commissioners of six other counties in 1959, retained the Stanley Engineering Company to prepare a report on "Flood Control Studies, Cuyahoga, Chagrin, and Rocky Rivers, Ohio." The consulting engineers' report of August 15, 1960, recommended construction of a dam and reservoir on Tinkers Creek. Channel improvement below Route 21 was also considered feasible. The consultants concluded that other flood detention reservoirs on the Cuyahoga would not be feasible, but that a reservoir site on Furnace Run in Summit County possesses good potential for recreational use.

A report on sedimentation in the Cuyahoga River basin, prepared by the Soil Conservation Service, Department of Agriculture, in 1952, contains some data pertinent to this present study. The report discusses sediment sources and loads in tributaries and the main stream.

Reports were submitted to Congress on November 13, 1942, and May 21, 1946. The first report was an unfavorable preliminary examination concerned with flood control for Cuyahoga River and tributaries. The report submitted May 21, 1946, was printed as House Document No. 629, 79th Congress, 2nd Session, and recommended against construction of a settling basin at that time.

1.49.3 Development in the Flood Plain

The Cuyahoga basin is highly developed. Cleveland, one of the major industrial centers of the United States, is located in Cuyahoga County and lies partly within the basin. The remainder of that part of the flood plain in Cuyahoga County is predominantly industrial and commercial in character. The flood plain has developed rapidly in recent years, due to the accessibility of highway and railroad transportation and its close proximity to Cleveland. In the vicinity of Rockside Road there is a scattering of residential units. The small manufacturing cities of Ravenna, Kent, and Cuyahoga Falls, and the major part of Akron, an important industrial city, are located in the southern part of the Cuyahoga basin. The area adjacent to Akron contains many small suburban residential communities. Other small villages scattered throughout the basin serve primarily as trading centers for the rural areas of the watershed. Some commercial development has recently occurred at Mantua, one of the small villages in the upper Cuyahoga River. The Cleveland and the Akron Metropolitan Park Districts have large holdings devoted to park and recreational purposes within the watershed limits in Cuyahoga and Summit Counties respectively. The development of the remainder of the basin is agricultural.

The development in the flood plain along Tinkers Creek is predominantly residential in character. There is also a sprinkling of commercial buildings and a large undeveloped area on the left bank of the creek. A small portion of the land has been cleared for agricultural purposes.

The development along Big Creek near the confluence with the Cuyahoga River is commercial and industrial in character. The land is almost completely developed with buildings very close to the creek banks. From a point approximately one-half mile above the mouth, extending upstream to West 25th Street bridge, the flood plain is predominantly vacant and inaccessible. A large industrial plant and the Cleveland Zoo cover a large portion of the flood plain above the West 25th Street bridge.

Dairy farming is the principal agricultural activity of the Cuyahoga basin. General farm crops produced include timothy and clover hay, oats, corn, wheat, and potatoes. Fruit and nursery stock are produced in the northerly part of the basin.

Improved Federal, State, and county highways traverse the area. The watershed is served by one or more lines of four railroads: the Baltimore and Ohio; Erie-Lackawanna; Norfolk and Western; and Penn Central railroads. Three local lines at Cleveland handle freight between industrial plants and trunk lines: Cuyahoga Valley Railway; Newburgh and South Shore Railway; and River Terminal Railway. At Akron the Akron and Barberton Belt Railroad serves the industrial plants. Commercial airfields regularly served by the large transportation lines are the Cleveland Hopkins Airport, 12 miles southwest of Cleveland; the Cleveland Lakefront Airport, near the mouth of the Cuyahoga; and the Akron-Canton Airport, 10 miles south of Akron.

1.49.4 Flood Problems

Storms, causing serious flooding in the Cuyahoga River basin, occurred in March 1913, June 1947, January 1952, October 1954, and January 1959. The maximum flood recorded by the Independence gage on the Cuyahoga River occurred in January 1959. Heavy rain augmented by snowmelt caused extensive damage in the lower Cuyahoga River basin. The peak discharge at the gage is calculated to have been 23,000 cfs. The maximum flood of historical record occurred in March 1913. The peak discharge for that flood is estimated to have been 30,000 cfs at the gage site.

Figure 14–47c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–50 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–51 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–48c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–52. County summaries for the main stem and principal tributaries are tabulated in Table 14–53.

1.49.5 Existing Flood Damage Prevention Measures

There are no existing or authorized structural flood control projects within the study area. Federal funds have been used to construct, improve, and maintain as a deep-draft navigation channel the lower 5.8 miles of the Cuyahoga River in Cleveland. Although that project is not considered a flood control project, hydraulic studies indicate that as a result of the navigation improvements, a recurrence of the 1913 flood in the lower 5.8 miles of the river would be confined within the channel.

Runoff from the upper Cuyahoga River basin is modified to some extent by existing reservoirs, the effects of which are felt somewhat downstream in the study area. These reservoirs provide domestic and industrial water supply and some flood control, and have been partially financed with Federal funds. They are briefly described as follows:

(1) The Mogadore Reservoir, which controls 12 square miles of the headwaters of Little Cuyahoga River, was constructed by the Works Project Administration and the City of Akron. The Federal share of total costs was $900,000. The reservoir supplies raw water to industries in Akron via the channel of the Little Cuyahoga River.

(2) The East Branch Reservoir, located north of Burton on the Cuyahoga River, regulates river flow to Lake Rockwell Reservoir, the principal water supply reservoir of the City of Akron. The Federal share of total costs was $258,000. The reservoir impounds approximately 4,600 acre-feet of water from a drainage area of approximately 18 square miles.

(3) The Lake Rockwell Reservoir on the Cuyahoga River is located approximately 2

miles northeast of Kent and was constructed by the City of Akron for water supply. It controls 205 square miles of drainage area and has a considerable modifying effect on floods in the upper basin.

(4) The La Due Reservoir is located just north of Hiram Rapids and controls approximately 30 square miles of drainage area. The reservoir was also constructed by the City of Akron for water supply.

A project has been authorized for construction under P. L. 566 on the Black Brook watershed in Portage County, Ohio.

Refer to Subsection 1.43.5 for a discussion of flood plain legislation applicable to this river basin. At present, Independence and Twinsburg, Ohio, are known to have flood plain legislation as does the Township of Ravenna. Although the remaining communities within the study area do not have specific provisions to regulate building within the flood plain or to regulate the use of land with respect to flood risk, development within known flooded areas is usually discouraged by local governments unless construction is above known flood levels.

1.50 Lake Erie Central, River Basin Group 4.3, Chagrin River Basin

1.50.1 Description

The Chagrin River drains an area of 268 square miles in northeastern Ohio and flows into Lake Erie 15 miles east of Cleveland. The watershed is elliptical in shape, approximately 30 miles long north-to-south, and 17 miles wide east-to-west. Location within River Basin Group 4.3 is shown in Figure 14–46. The main stream rises one-half mile west of Chardon, Ohio, at an elevation of 1,340 feet above mean sea level, flows southeasterly approximately 2 miles and then southwesterly approximately 2 miles to Bass Lake. From there it flows 18 miles sourhwesterly to the confluence with the Aurora Branch and then north 26 miles to Lake Erie.

The Aurora Branch, draining 57 square miles in the southern part of the basin, rises 3 miles southeast of Aurora Station at an elevation of 1,150 feet, and flows north-north westerly 16 miles to the junction with the main stream. The east branch, draining 51 square miles in the northeastern part of the basin, rises 2 miles west of Chardon at an elevation of 1,290 feet, and flows southwesterly 5 miles, then north-northeasterly 5 miles, and then westerly 9 miles to its junction with the main stem 5 miles upstream from Lake Erie. Other tributaries are of short length and drain small areas.

The watershed, except for a gently sloping plain four miles wide bordering on Lake Erie, consists of rolling hills separated by deep valleys. The valleys, except near the headwaters, vary from 100 to 300 feet deep and up to one-half mile in width. Hilltop elevations vary from 1,100 to 1,350 feet above mean sea level. The slopes of the hills and the abrupt shale cliffs of the valleys are cut by numerous streams and gullies. A few small natural lakes, ponds, and marshy areas are located in the headwaters. Bass Lake, the largest of the lakes, approximately 3 miles southwest of Chardon, has a surface area of 0.2 square miles. A small dam has been built on its outlet to control the outflow. In the flood flats near the mouth, the stream divides into several channels, two of which extend to the lake shore. During normal flows only one of these channels is open. The smaller, more eastern one is closed by a sand bar. At times the sand bar also tends to close the main channel.

The rocks underlying the Chagrin River watershed are of sedimentary origin. There are outcrops of sandstone or shale formations at many points along the main stem and tributaries. Outcroppings of the Berea Grit (sandstone) form the upper and lower cataracts at Chagrin Falls. Overburden of the watershed derives from glacial till. Alluvial deposits, derived from erosion of the till and exposed rock formations, are present along the stream bottoms and comprise the flood flats near the mouth of the main stem.

The main stream has a number of falls and rapids in the vicinity of Chagrin Falls, but from there to Lake Erie, it has a relatively regular slope.

The Aurora Branch has abrupt breaks in slope near its source and near its junction with the main stem. The east branch has a generally regular and moderately steep slope throughout.

1.50.2 Previous Studies

The Buffalo District of the Corps of Engineers published a flood plain information report on Chagrin River in Lake and Cuyahoga Counties in July 1968. It was prepared in response to a request of the Cuyahoga County Regional Planning Commission through the Ohio Department of Natural Resources. Its purposes were to aid in the understanding of local flood problems and to provide guidance in selection of the best uses for lands subject to overflow. Among other things it defines and illustrates the areal extent and profile of flooding that would be associated with occurrence of an intermediate regional flood (defined as one of 100-year frequency), occurrence of a flood of the magnitude of the January 1959 flood, and an occurrence of the standard project flood.

In May 1963 the Buffalo District completed a "Review of Reports for Flood Control and Allied Purposes, Chagrin River, Ohio."

The Board of County Commissioners, Cuyahoga County, Ohio, acting with the commissioners of six other counties in 1959, retained a consulting engineering firm to prepare a report on "Flood Control Studies, Cuyahoga, Chagrin and Rocky Rivers, Ohio." The consulting engineers' report, dated August 15, 1960, recommended improvement of the lower 2 miles of river channel and construction of a pair of jetties to protect the mouth of the river. The consultants concluded that flood detention reservoirs on the Chagrin would not be feasible but that a reservoir site on the Aurora Branch possesses good potential for a water supply reservoir.

Reports were submitted to Congress May 7, 1942, and April 24, 1947. Both were unfavorable survey reports concerned with flood control for the Chagrin River. In each case only the area near the mouth was studied in detail, and considered improvements consisted of channel enlargement and straightening in the lower mile of the river, and construction of parallel piers at the mouth.

One other report, the Preliminary Examination of the Shores of Lake Erie for Harbors and Harbors of Refuge for Light-Draft Vessels, dated July 18, 1946, is also pertinent to the present study. The mouth of the Chagrin River, one of the localities studied in that report, was recommended for further study in a survey report on the proposed shallow navigation improvements. The considered improvement for the locality was similar to that considered in the flood control studies under review, consisting of deepening and straightening in the lower reach of the river and construction of parallel piers at the mouth.

1.50.3 Development in the Flood Plain

The flood-prone areas along the Chagrin River are almost completely residential. One major exception is the area downstream from Lake Shore Boulevard in the City of Eastlake where several small-boat marinas and a yacht club are located. Another is the area of light industries just upstream from the Lakeland Freeway bridges in the City of Willoughby. Eastlake began to develop in 1922 as a recreation and resort area. However, the summer cottages soon were converted to year-round homes, and the area now contains primarily small residential units of frame construction. The area has expanded greatly. New construction in the area has also gradually increased in size and value. Homes with basements are not common so that damage is not serious at shallow overflow depths. A large trailer court is located on the downstream side of Lake Shore Boulevard. The sewage treatment plant located in the flood plain in Eastlake does not serve the homes in the flood-prone area. The outfall for this plant extends several thousand feet into Lake Erie from the end of Erie Road. The residences near the Chagrin River have individual septic tanks. Almost all local streets in the area are closed during flooding as is Lake Shore Boulevard which crosses the channel.

The Chagrin River valley from upstream of Willoughby to Chagrin Falls is relatively narrow and contains only scattered development. Most of the area has been agricultural with the flood-prone area either actively cultivated or used as pasture and grazing land. Except in Willoughby Hills and Gates Mills, residential development is scattered with the majority of buildings above the valley floor. In Willoughby Hills approximately 50 homes in the vicinity of Trailard Drive and 20 homes along Milan Drive are located within the flood plain. Agricultural damage is not extensive and residential damage, outside of Willoughby Hills, is largely a matter of inconvenience. In the areas of scattered development only a few of the lowest-lying homes are affected. However, when the lowlands become flooded the connecting roads are closed in several places.

There are no large industries in the Chagrin River basin. There are, however, several small manufacturing companies in Chagrin Falls and Willoughby which produce paper bags, chairs, road machinery, commercial laundry equipment, and machinery parts.

Agricultural activities in the watershed include production of nursery stock, truck crops, fruits and berries, and general farm crops in support of dairying. General farm crops include timothy and clover hay, oats, corn, wheat, and potatoes.

Improved Federal, State and county highways traverse the area. The Penn Central Railroad and the Norfolk and Western Railway cross the basin in Willoughby.

Willoughby obtains some of its domestic water supply from the Chagrin River. Other communities obtain their water from wells or from Lake Erie via the Ohio Water Service Company of the City of Cleveland. The river is used by all adjacent communities for disposal of sewage effluent. Pollution has not been reported as an impediment to other uses of water. There are several small developments for power on the river, only two of which are presently operated for that purpose. The greater part of the power demand in the region is supplied by the Cleveland Electric Illuminating Company, which has facilities fully adequate for present and prospective needs.

The area from the Chagrin River mouth to Lake Shore Boulevard in Eastlake has been extensively developed for basing of small boats and is subject to heavy recreational traffic. There are three boating clubs and four commercial marine establishments. A private airport is located in Hunting Valley and a polo club is in Moreland Hills.

1.50.4 Flood Problems

Records of stream flows and newspaper records for periods when flows were not recorded indicate that major floods occurred in the Chagrin River basin in March 1913, January 1929, June 1931, March 1948, October 1954, and January 1959. Floods have caused minor basinwide damage or damage in parts of the basin, particularly in the lowermost reaches, at more frequent intervals. Most of the major floods have been due to rain on snow-covered or frozen ground, resulting in rapid runoff equal to or greater than the rainfall. The maximum recorded discharge, 28,000 cfs, occurred during the March 1948 flood as a result of intense rainfall concentrated over the lower portion of the basin after prolonged cold weather.

In the lowermost reaches of the Chagrin River, flooding is aggravated by the sand bar in Lake Erie across the river mouth. The bar affects river stages during high discharges, hampers small boat operation, and in the spring restricts passage of river ice. River ice jammed on the bar, often combined with windrowed ice piled up by the Lake, impounds water behind the jam and causes flooding of low areas in Willoughby and Eastlake. Jams may also form at sharp bends or at shoals in the river. Thus flooding often occurs in these areas even when river discharges are low.

Figure 14–47c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–50 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–51 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–48c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–52. County summaries for the main stem and principal tributaries are tabulated in Table 14–53.

1.50.5 Existing Flood Damage Prevention Measures

There are no existing Federal structural flood control projects in this basin. In October 1960 residents of a flood area in the Village of Willoughby Hills completed a local channel improvement consisting of straightening a short reach of existing channel and excavating a section of a new channel across a meander. Most of the necessary equipment and labor was donated. The effectiveness of their work is not yet known, because no high discharges have occurred since it was completed.

During the summer local interests in Eastlake attempt to keep a minimum navigation channel open through the sand bar at the mouth of the Chagrin River. Usually this is accomplished by issuance of a permit to a commercial dredging concern to which the sand has utilitarian value, so the material has been removed without charge. The life of each channel is short, and its effectiveness is generally lost in the next major storm.

Present regulations for the communities in the basins, with the exception of Willoughby and Eastlake, do not have specific provisions to regulate building within the flood plain, or to regulate the use of land with respect to flood risk. However, such regulations are possible through counties, municipalities, and townships under their regular zoning and building code statutes. Refer to Subsection 1.43.5 for a discussion of flood plain legislation applicable to this river basin.

1.51 Lake Erie Central, River Basin Group 4.3, Grand River Basin

1.51.1 Description

The Grand River originates northwest of Warren, Ohio. It flows generally in a north direction for 25 miles from its source, then west another 20 miles to Painesville, Ohio. It enters Lake Erie at Fairport Harbor. Location within River Basin Group 4.3 is shown in Figure 14–46. There are numerous small tributaries, but no major ones. The river is largely in its natural state except for the development of Fairport Harbor at its mouth, a mill dam at Painesville, and a water supply dam at Harpersfield.

1.51.2 Previous Studies

Previous studies are listed below:

(1) 1972—flood-prone area report for portions of the Grand River and Cowles Creek

(2) 1969—flood-prone area report for portions of the Grand River and Ashtabula River

(3) 1965—Review of Reports on Lake Erie—Ohio River Canal, Pittsburgh-Ashtabula Route via Beaver-Mahoning-Grand River Valleys. Although this report concluded that the canal was economically feasible, approval of the report by higher authority was not received.

(4) 1959—Great Lakes Harbors Study, Interim Report on Fairport Harbor, Ohio. The report recommended modification of the existing project for Fairport Harbor to provide depths of 29 feet in the approach channel, 28 feet in the outer harbor, 27 and 28 feet in the Grand River except in the 8-foot section of the existing project, and 21 feet in an enlarged turning basin.

(5) 1947—Review of Reports on Lake and Ohio River Canal, Pittsburgh-Ashtabula Route. The report concluded that the construction of a canal to connect Lake Erie with the Ohio River is practicable from engineering and navigation viewpoints and that the benefits that would result would be sufficient to justify construction of the canal.

1.51.3 Development in the Flood Plain

The Grand River valley contains practically no industrial development except for Fairport Harbor at the mouth of the river on Lake Erie. It is also a commercial lake fishing center. Painesville is a manufacturing, commercial, and transportation center. The upper or southern end of the Grand River valley has large areas of swamp and brush land. Agriculture has developed in the valley bottom to only a moderate degree. Dairy farming, the principal agricultural pursuit, and truck gardening are developed in the middle and lower reaches of the valley. Vineyards and orchards thrive in the lower valley where the length of the growing season is increased by proximity to Lake Erie.

1.51.4 Flood Problems

Flood events at Painesville have been reported as early as 1823, with fairly continuous newspaper accounts since 1849. During this period prior to records the highest flood probably occurred in 1887 and the second highest in March 1913. The discharges at Painesville for these two floods are estimated to be 22,500 and 20,500 cfs, respectively, as compared with a discharge of approximately 10,000 cfs at flood stage. Other high floods occurred in 1878 and 1893. The maximum flood of record occurred on January 22, 1959, and had a discharge of 21,100 cfs at the gaging station near Madison.

Figure 14–47c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–50 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–51 indicates upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–48c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–52. County summaries for the main stem and principal tributaries are tabulated in Table 14–53.

1.51.5 Existing Flood Damage Prevention Measures

There have been no Federal structural flood control or allied projects constructed, and none are anticipated at this time within the Grand River basin, except for the harbor development at the river mouth.

Refer to Subsection 1.43.5 for a discussion of flood plain legislation applicable to this river basin.

1.52 Lake Erie Central, River Basin Group 4.3, Conneaut Creek Basin

1.52.1 Description

Conneaut Creek rises in Crawford County, Pennsylvania, near Conneautville and flows northerly for 28 miles where it turns west for 22 miles, crossing the Ohio-Pennsylvania border. The creek then turns east-northeast and flows 13 miles to Conneaut, Ohio, where it empties in Lake Erie. It drains approximately 100,000 acres in Pennsylvania and 24,000 acres in Ohio. Location within River Basin Group 4.3 is shown in Figure 14–46.

1.52.2 Previous Studies

Previous studies are listed below:

(1) a flood-prone area report on portions of Conneaut Creek, published in 1970

(2) a Survey Report for Flood Control on Conneaut Creek in the vicinity of Conneautville, Pennsylvania, dated 1966

1.52.3 Development in the Flood Plain

There is a furniture factory in the Borough of Conneautville where wood is glued into sheets and shipped to another location. There are two grocery stores, a lumber yard, a bank, and other assorted small commercial establishments in the community. Many of these establishments are in the center of the town where they receive some damage from flooding.

1.52.4 Flood Problems

The Borough of Conneautville is subject to flooding from Conneaut Creek and from a small tributary, Thatcher Run. Flooding occurs biennially to some degree and is usually caused by intense warm weather storms. On July 24, 1967, a flash flood on Thatcher Run causes relatively high damages in Conneautville. On August 3, 1967, a flood on Conneaut Creek in Conneautville caused severe flooding. Severe flooding also occurred in October 1954, June 1947, July 1941, and June 1937. The 1954 highwater occurrence was caused by high flows in Conneaut Creek alone, while other highwater occurrences were caused by high flows in Thatcher Run and probably some high water in Conneaut Creek.

Figure 14–47c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–50 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–51 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–48c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–52. County summaries for the main stem and principal tributaries are tabulated in Table 14–53.

1.52.5 Existing Flood Damage Prevention Measures

There are no Federal flood control or allied projects constructed nor are any anticipated at this time within the Conneaut Creek basin. A clearing and snagging project in the Borough of Conneautville was completed in 1949 at a Federal cost of $13,500. In 1962 the Borough of Conneautville began replacement of the 600-foot culvert which carries Thatcher Run under the business district. Work was started on the upstream end and approximately 210 feet of 7-foot diameter corrugated metal pipe was installed. The project was stopped after available funds were expended and no further work has been done. The location of this project is illustrated in Figure 14–49.

Refer to Subsection 1.43.5 for a discussion of flood plain legislation applicable to this basin.

1.53 Lake Erie East, River Basin Group 4.4, Erie County, Pennsylvania

Erie and Crawford Counties are the only counties in Pennsylvania that are within the Great Lakes Basin. The portion of Erie County draining into Conneaut Creek and Crawford County as it relates to Conneaut Creek are discussed with River Basin Group 4.3 in Subsection 1.52.

Tributaries in Erie County include Elk, Walnut, Crooked, Turkey, and Raccoon Creeks. Elk Creek and Walnut Creek are the largest of these, draining areas of approximately 99 square miles and 38 square miles, respectively. Crooked Creek drains 20 square

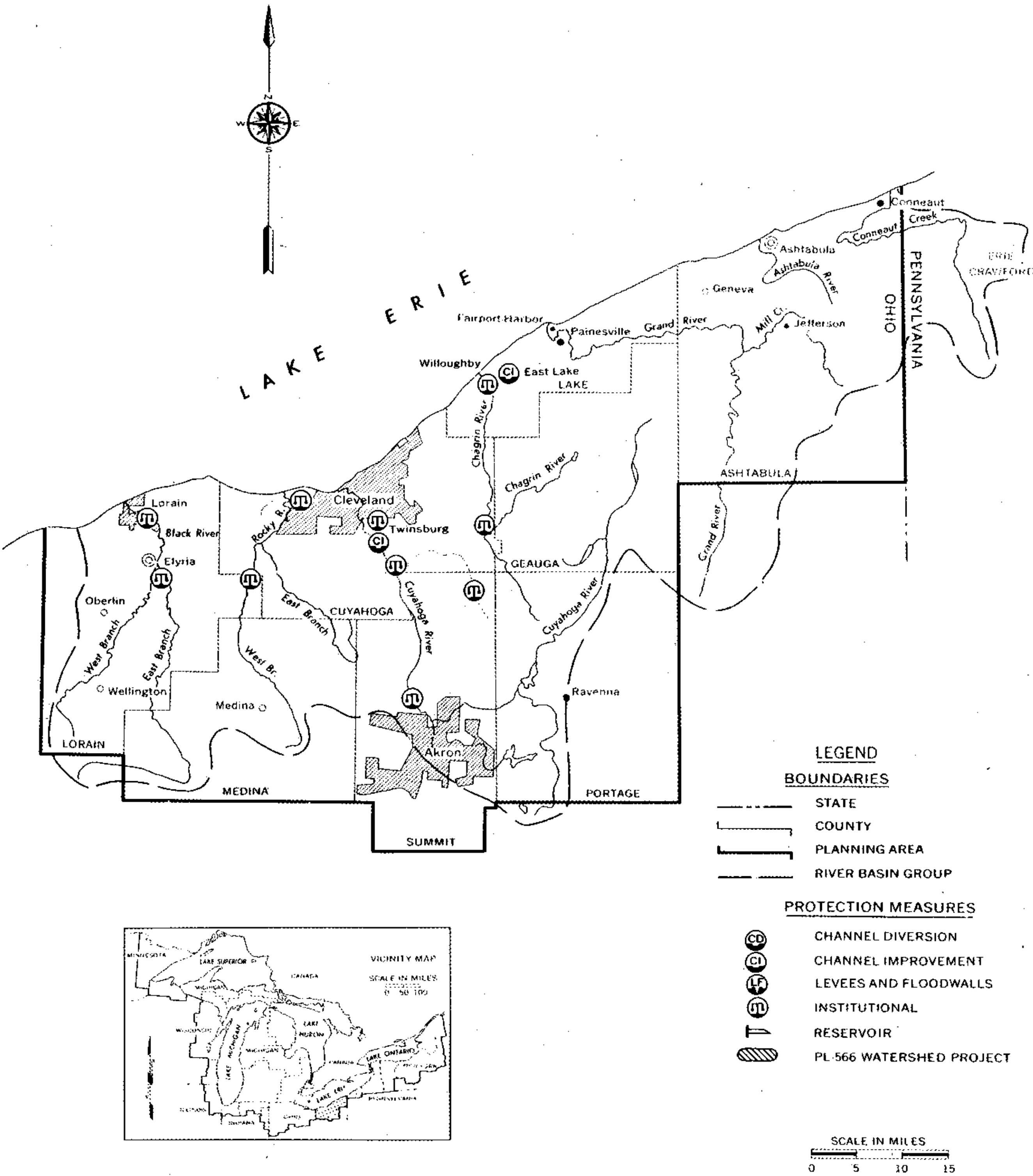

FIGURE 14-49 Existing Flood Damage Protection Measures for River Basin Group 4.3

miles, Turkey Creek 8 square miles, and Raccoon Creek 9 square miles. All are direct tributaries to Lake Erie. Location within River Basin Group 4.4 is shown in Figure 14–50.

There are no known published flood control reports for the Great Lakes Basin within Erie County.

There are no major flood problems existing in the area at this time. Table 14–55 indicates estimated damages by watersheds which are identified in Figure 14–52c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–56.

There are no existing structural flood control measures in the area. Refer to Appendix S20, *State Laws, Policies, and Institutional Arrangements*, for a discussion of flood plain legislation.

1.54 Lake Erie East, River Basin Group 4.4, Smokes Creek Basin

1.54.1 Description

The Smokes Creek basin, located entirely within Erie County, New York, includes the Village of Orchard Park, parts of the City of Lackawanna, the Village of Blasdell, and the Towns of Aurora, Elma, Hamburg, Orchard Park, and West Seneca. Location within River Basin Group 4.4 is shown in Figure 14–50.

The two branches of the creek rise on the north slope of the Allegheny Plateau and flow in a generally northwesterly direction across the Lake Erie plain to their junction in the City of Lackawanna. The main stem then flows westward 1.7 miles to enter Lake Erie 6 miles south of the point where the Lake empties into the Niagara River at Buffalo. Stream slopes in this basin follow the general topography closely and the flood plain is very poorly defined. Smokes Creek drains 31 square miles at the confluence, divided nearly equally between the north and south branches.

1.54.2 Previous Studies

Three reports concerning local flood protection on Smokes Creek have been submitted and are included in the listing below:

(1) 1970—The Erie-Niagara Basin Planning Board published its basin plan in 1970 for development and management of water and related land resources in the Erie-Niagara basin.

(2) 1965—A flood plain information report on Smokes Creek within the City of Lackawanna was completed by the Corps of Engineers in February 1965. It was prepared in response to a request of the Erie-Niagara Basin Regional Water Resources Planning Board. Its purposes were to aid in the understanding of local flood problems and to provide guidance in selection of the best uses for lands subject to overflow.

(3) 1959—A review report on Smokes Creek for flood control in the vicinity of Lackawanna, New York, was submitted by the District Engineer to the Division Engineer in compliance with resolutions of the Committee on Public Works of the House of Representatives and the Committee on Public Works of the United States Senate, adopted on March 16, 1954, and May 16, 1955, respectively. This review report was submitted to Congress on July 8, 1959, and published in House Document No. 200, 86th Congress, 1st Session. It recommended that a Federal project be authorized for flood protection at Smokes Creek, New York.

(4) 1956—The report of the New England-New York Inter-Agency Committee was submitted to Congress June 18, 1956, and printed as Senate Document No. 14, 85th Congress, 1st Session. It recommended study of Smokes Creek but did not discuss plans of improvement.

(5) 1942—A preliminary examination, which considered channel improvements and reservoirs for the protection of the City of Lackawanna, was submitted to Congress March 18, 1942. No plan was found to be feasible, and no project was recommended. The report was not printed.

1.54.3 Development in the Flood Plain

The Lackawanna plant of the Bethlehem Steel Company occupies both banks of the lower 1.1 miles of Smokes Creek. The company has raised the general level of the area and is continuing to fill offshore areas in the Lake. None of the Bethlehem property was damaged during past floods because the buildings were situated on fills above the maximum flood elevations. For its manufacturing operations the company pumps large quantities (up to 400 cfs) of water from Lake Erie. Much of this is discharged through an open ditch and pipes to Smokes Creek. The steel company provides

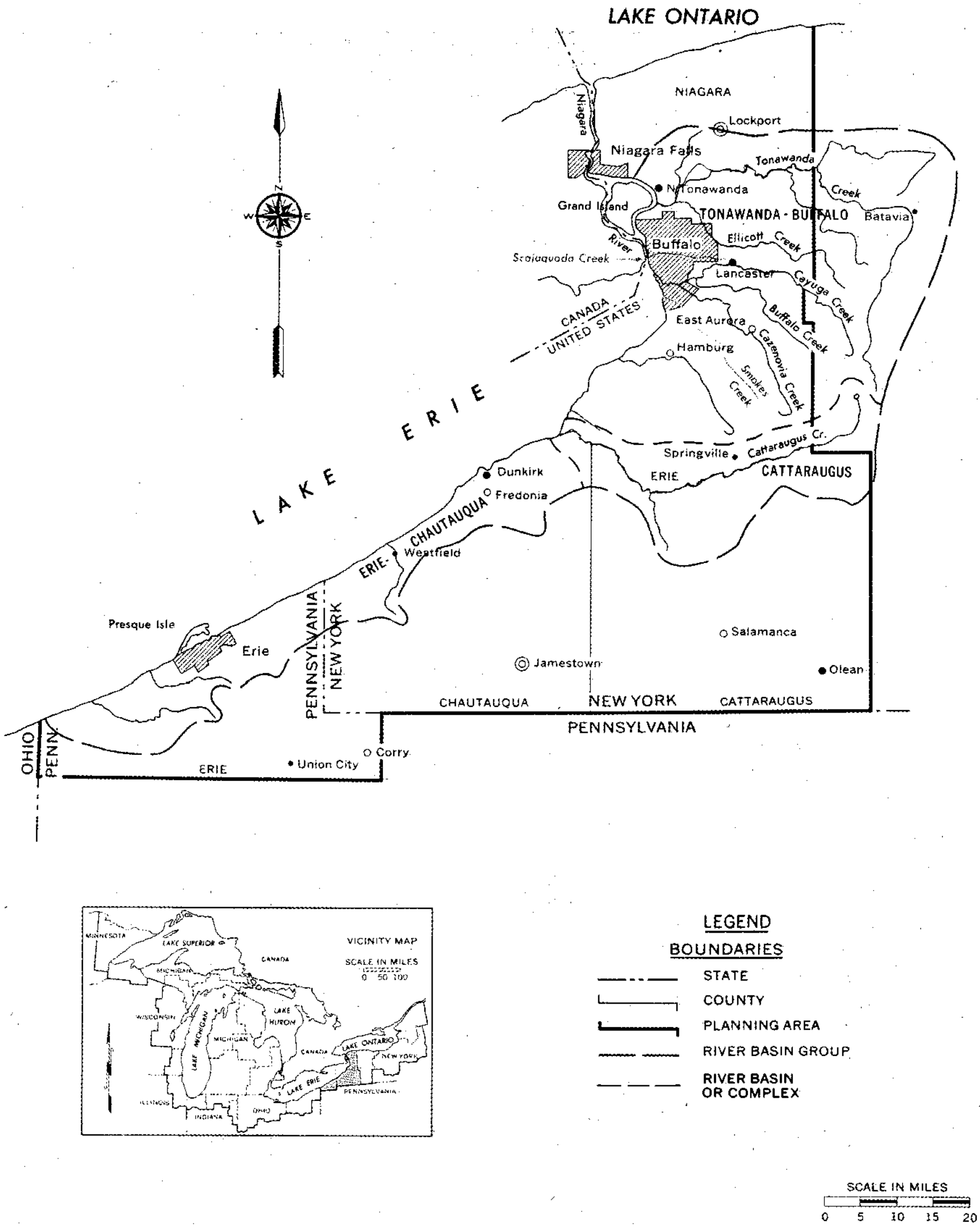

FIGURE 14–50 Lake Erie East—River Basin Group 4.4

TABLE 14–54 Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 4.4

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN: INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	CATTARAUGUS CREEK												
BL1	Erie	Mouth	Erie-Wyo-	1970	14,400	18,600	3		30	4648	39	4,642	
			ming Co.	1980	20,100	28,800	3		33	4645	43	4,638	
			Line	2000	38,700	59,300	4		39	4638	51	4,630	
				2020	73,500	121,200	4	44		4633	57	4,624	
BL1a	Erie	Gowanda		1970	2,800		11	42		68	121		
				1980	4,100		12	47		62	121		
				2000	8,500		14	56		52	121		
				2020	17,700		16	62		43	121		
BL2	Chautauqua	Mouth	Chautauqua	1970	23,400	5,000	7	45	182	833	322	745	
			Catt Co.	1980	33,300	7,100	8	50		1009	342	725	
			Line	2000	64,600	14,000	9	58		1000	380	637	
				2020	124,200	26,700	10	67		990	406	661	
BL3	Cattarau-	Chautaqua-	Cattarau-	1970		3,800				2056		2,056	
	gus	Cattaragus	gus-Wyo-	1980		6,700				2056		2,056	
		Co. Line	ming Co.	2000		12,800				2056		2,056	
			Line	2020		24,500				2056		2,056	
BL3A	Cattarau-	Gowanda		1970	32,000		60	90		103	253		
	gus			1980	44,500		61	100		92	253		
				2000	86,100		63	117		73	253		
				2020	163,600		64	133		56	253		
BL4	Wyoming	Catt-Wyo-	Arcade	1970	5,500		24	77		387	161	337	
		ming Co.	City	1980	7,500		26	85		387	178	320	
		Line	Limit	2000	15,300		31	100		367	209	289	
				2020	28,400		36	114		348	239	259	
	BIG SISTER CREEK												
BM1	Erie	Mouth	Interstate	1970		5,300		10		390		400	
			90	1980		7,700		11		389		400	
				2000		16,100		13		387		400	
				2020		33,400		15		385		400	
	SMOKES CREEK												
BM2	Erie	Mouth	Orchard	1970		12,800		23		812		835	
			Park	1980		18,700		26		809		835	
				2000		39,300		30		805		835	
				2020		80,300		34		801		835	
BM2A	Erie	Lackawanna		1970	16,000		120	200		135	455		
				1980	23,500		120	200		135	455		
				2000	49,100		120	200		135	455		
				2020	100,600		120	200		135	455		
	CAZENOVIA CREEK												
BM3	Erie	Confluence	Holland	1970	88,300	22,900	55	135		2705	480	2,415	
		with Buffa-		1980	129,800	36,600	61	172		2662	532	2,363	
		lo River		2000	270,200	76,400	71	202		2622	624	2,271	
				2020	555,400	156,700	81	230		2584	711	2,184	
BM3A	Erie	Buffalo		1970	66,000		20	250		290	560		
				1980	97,000		20	250		290	560		
				2000	202,000		20	250		290	560		
				2020-	415,000		20	250		290	560		
	BUFFALO CREEK												
BM4	Erie	Confluence	Erie-Wyo-	1970	16,200	12,300	30	170		1450	400	1,250	
		with Buffa-	ming Co.	1980	23,800	18,100	33	189		1428	444	1,206	
		lo River	Line	2000	49,500	37,600	39	221		1390	520	1,130	
				2020	101,900	77,300	44	252		1358	592	1,058	

TABLE 14–54(continued) Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 4.4

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	CAYUGA CREEK												
BM5	Erie	Confluence	Erie-Wyo-	1970	47,000	7,000	56	187		2718	1776	1,184	
		with Buffa-	ming Co.	1980	69,100	10,300	62	207		2641	1776	1,184	
		lo River	Line	2000	143,900	21,500	73	243		2644	1776	1,184	
				2020	295,600	44,100	83	277		2600	1776	1,184	
	ELLICOTT CREEK												
BM6	Erie	Confluence	Erie-Gene-	1970	217,000	5,800	262	3670		10588	9588	4,832	
		with Tona-	see Co.	1980	319,000	8,500	291	4073		10056	10641	3,779	
		wanda Crk	Line	2000	664,100	17,700	341	4771		11308	12464	1,956	
				2020	1,365,000	14,500	388	5432		8600	14190	230	
	TONAWANDA CREEK												
BM7	Erie	Mouth	Erie-Gene-	1970	34,300	109,200	125	562		21450	687	21,450	
			see Co.	1980	50,500	160,500	139	624		21374	763	21,374	
			Line	2000	105,100	333,900	162	731		21244	893	21,244	
				2020	272,700	686,400	185	832		21120	1017	21,120	
BM8	Niagara	Mouth	Niagara-	1970	45,800	85,400	65	852		21037	917	21,037	
			Genesee Co	1980	66,900	124,700	73	945		20937	1017	20,937	
			Line	2000	155,000	288,800	85	1101		20762	1192	20,762	
				2020	360,300	671,500	96	1261		20597	1397	20,597	
BM9	Genesee	Erie -	Genesee-	1970	7,300	45,500	14	133		12888	147	12,888	
		Niagara	Wyoming	1980	10,300	63,900	15	148		12872	163	12,872	
		Co. Line	Co. Line	2000	21,800	135,100	18	173		12844	191	12,844	
				2020	43,300	268,600	21	197		12817	118	12,817	
	SCAJAQUADA CREEK												
BM10	Erie	Confluence	Lancaster	1970	228,200		260	2772		500	3532		
		with		1980	335,500		260	2872		400	3532		
		Niagara		2000	698,300		260	2972		300	3532		
		River		2020	1,435,400		260	2972		300	3532		

sedimentation basins for its effluent. However, the natural creek sediment, plus a certain amount of sediment which escapes the sedimentation basins, creates shoal areas near the mouth of the creek which must be removed from time to time. Littoral drift from the west along the shore of Lake Erie also forms an obstructive bar across the mouth of the creek.

Upstream from Hamburg Turnpike, the main stem is bordered on the south bank by a residential area known as Bethlehem Park, and on the north by industrial development. From Bethlehem Park to 0.1 mile beyond the confluence (a distance of approximately 1,600 feet), the flood plain lies completely within railroad property. Except for the Holy Cross Cemetery, owned by the Diocese of Buffalo and lying east of South Park Avenue, the remaining development in the flood plain is residential or commerical in nature. Commercial establishments make up a small percentage of the total development and are centered principally along Electric and South Park Avenues. Between the north and south branches just east of South Park Avenue lies a large, relatively undeveloped tract also belonging to the Diocese of Buffalo. The Diocese plans to develop a large portion of this land as a cemetery sometime in the future.

1.54.4 Flood Problems

Since industrial development of the basin was begun in aproximately 1900, major flooding has been reported in 1903, 1936, 1937, 1953, 1955, 1956, and 1957, with minor flooding at more frequent intervals. The greatest flood, according to available information, was that of March 1, 1955, when 2.3 inches of rainfall in eight hours on frozen ground produced a peak inflow of 4,900 cfs into the flood area at Lackawanna. A rainfall of slightly more than 2 inches in six hours fell on saturated ground May 25, 1953, and produced a peak inflow of

TABLE 14–55 Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 4.4

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)			ESTIMATED ACRES IN FLOOD PLAIN								
		URBAN	RURAL	TOTAL	CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		ERIE CHAUTAUQUA COMPLEX - PENNSYLVANIA											
31	1970	1,200	2,400	3,600	300	240	120	--	30	20	10	60	660
32	1970	100	700	800	--	45	135	--	--	--	8	8	180
33	1970	200	1,800	2,000	100	250	100	--	--	--	15	15	450
34	1970	5,000	2,800	7,800	550	100	50	--	50	175	25	250	700
Total	1970	6,500	7,700	14,200	950	635	405	--	80	195	58	333	1,990
	1980	8,500	10,700	19,200	950	635	405	--	80	195	58	333	1,990
	2000	14,600	13,700	28,300	950	635	405	--	80	195	58	333	1,990
	2020	26,000	15,000	41,000	950	635	405	--	80	195	58	333	1,990
		CATTARAUGUS CREEK - NEW YORK											
44	1970	25,000	13,300	38,300	2,655	1,630	400	525	10	160	10	180	5,210
55	1970	200	1,000	1,200	105	456	120	80	--	6	--	6	761
Total	1970	25,200	14,300	39,500	2,760	2,086	520	605	10	166	10	186	5,971
	1980	32,800	20,000	52,800	2,760	2,086	520	605	10	166	10	186	5,971
	2000	56,400	25,500	81,900	2,760	2,086	520	605	10	166	10	186	5,971
	2020	100,800	27,900	128,700	2,760	2,086	520	605	10	166	10	186	5,971
		ERIE - CHAUTAUQUA COMPLEX - NEW YORK											
114	1970	1,000	500	1,500	1,230	160	123	50	450	950	100	1,500	1,563
114A	1970	1,000	--	1,000	30	10	--	--	5	5	5	15	40
38	1970	500	900	1,400	225	50	--	25	100	50	50	200	300
197	1970	--	500	500	100	40	15	10	--	--	--	--	165
Total	1970	2,500	1,900	4,400	1,585	260	138	85	555	1,005	155	1,715	2,068
	1980	3,200	2,700	5,900	1,585	260	138	85	555	1,005	155	1,715	2,068
	2000	5,600	3,400	9,000	1,585	260	138	85	555	1,005	155	1,715	2,068
	2020	10,000	3,700	13,700	1,585	260	138	85	555	1,005	155	1,715	2,068
		TONAWANDA COMPLEX - NEW YORK											
56	1970	--	400	400	90	90	--	--	--	--	--	--	180
1	1970	38,000	400	38,400	40	40	10	10	10	30	--	40	100
203	1970	--	500	500	200	150	--	30	--	--	--	--	380
57	1970	--	800	800	240	20	75	90	--	--	--	--	425
148	1970	4,700	300	5,000	50	40	5	5	10	35	5	50	100
240	1970	2,000	7,000	9,000	515	275	180	360	--	10	--	10	1,330
241	1970	--	2,700	2,700	540	650	--	130	--	--	--	--	1,320
241A	1970	--	33,600	33,600	1,200	660	610	2,230	--	--	--	--	4,700
242	1970	--	100	100	5	--	--	25	--	--	--	--	30
243	1970	3,000	100	3,100	40	5	5	--	10	20	20	50	50
245	1970	2,000	2,000	4,000	400	50	100	330	5	5	15	25	880
Total	1970	49,700	47,900	97,600	3,320	1,980	985	3,210	35	100	40	175	9,495
	1980	64,600	67,100	131,700	3,320	1,980	985	3,210	35	100	40	175	9,495
	2000	111,300	85,300	196,600	3,320	1,980	985	3,210	35	100	40	175	9,495
	2020	198,800	93,400	292,200	3,320	1,980	985	3,210	35	100	40	175	9,495

4,150 cfs. In March 1957 a rainfall of 2.2 inches on partially frozen ground resulted in a peak inflow of 3,700 cfs. As a result of clearing and snagging operations in 1954, stages in the 1955 flood were approximately the same as in 1953, although the flows were greater in 1955.

Figure 14–51c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–54 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–55 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–52c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–56. County summaries for the main stem and principal tributaries are tabulated in Table 14–57.

1.54.5 Existing Flood Damage Prevention Measures

A structural flood control project was completed on Smokes Creek in August 1970. The improvements consisted principally of channel enlargement on the entire main stem and

TABLE 14–56 Data Summary by River Basin, River Basin Group 4.4

River Basin	Year	Estimated Average Annual Damage (Dollars) Urban	Rural	Estimated Acres In Flood Plain Urban	Rural
Erie-Chautauqua Complex	1970	9,000	9,600	2,048	4,058
	1980	11,700	13,400	2,048	4,058
	2000	20,200	17,100	2,048	4,058
	2020	36,000	18,700	2,048	4,058
Cattaraugus Creek	1970	103,300	41,700	1,082	13,751
	1980	142,300	62,600	1,123	13,710
	2000	269,600	111,600	1,200	13,633
	2020	508,200	200,300	1,262	13,571
Tonawanda-Buffalo Complex	1970	587,600	354,100	15,185	75,786
	1980	854,500	516,100	16,526	74,445
	2000	1,772,000	1,051,700	18,850	72,121
	2020	3,708,700	2,126,200	21,051	69,920
Scajaquada Creek	1970	228,200	---	3,532	---
	1980	335,500	---	3,532	---
	2000	698,300	---	3,532	---
	2020	1,435,400	---	3,532	---
TOTAL	1970	928,100	405,400	21,847	93,595
	1980	1,344,000	592,100	23,229	92,213
	2000	2,760,100	1,180,400	25,630	89,812
	2020	5,688,300	2,345,200	27,893	87,549

the lower reaches of the north and south branches. Location of the prevention measure is illustrated in Figure 14–53. To obtain the required channel area for flood flows without replacing a large number of bridges, the project plan called for considerable channel deepening as well as widening. At the mouth of the creek, jetties were constructed on each side of the channel to prevent obstruction of the mouth by littoral drift. The project plan was designed to provide a nondamaging channel capacity of 2,500 cfs on each branch and 5,000 cfs on the main stem at the confluence. This provides protection against a 40-year flood on the main stem and a 30-year flood on each branch. The project was limited to this degree of protection by the maximum capacity of many of the existing bridges, particularly at the lower end in Bethlehem Steel Company property. When these bridges are eventually replaced with bridges of greater clearance, the project will be able to carry higher discharges without additional damage. Clearing and snagging was done on the main stem and its two branches between Hamburg Turnpike and South Park Avenue in 1954 at a cost of $49,200. Local interests were not required to provide a guarantee of maintenance. No further work will be done under this authority.

The City of Lackawanna sponsored a Works Project Administration project under which the north branch was straightened between South Park Avenue and the Baltimore and Ohio Railroad. As a result of this improvement, the area flooded by the north branch in 1955 was less than that flooded in 1936, although the rate of discharge was greater in 1955. Two short overflow channels have been constructed, one by the city on the south branch upstream from South Park Avenue and the other by Bethlehem Steel Company near the mouth. Both provide additional capacity for high flows and both are dry at normal flows.

Present regulations for communities do not include specific provisions to regulate building within the flood plain or to regulate the use of land with respect to flood risk, although development within known flood areas is usually discouraged by local governments.

Although zoning regulations have been in

TABLE 14-57 River Basin Group 4.4, Data Summary by County

County	Estimated Average Annual Damages (Dollars) Urban	Estimated Average Annual Damages (Dollars) Rural	Estimated Acres in Flood Plain Urban	Estimated Acres in Flood Plain Rural
YEAR 1970				
New York				
Cattaraugus	32,000	3,800	253	2,056
Chautauqua	23,400	5,000	322	745
Erie	730,200	193,900	17,638	37,008
Genesee (PSA 5.1)	7,300	45,500	147	12,888
Niagara	45,800	85,400	917	21,037
Wyoming (PSA 5.1)	5,500	---	161	337
Pennsylvania				
Erie (See RBG 4.3)	---	---	---	---
TOTALS	844,200	333,600	19,438	74,071
YEAR 1980				
New York				
Cattaraugus	44,500	6,700	253	2,056
Chautauqua	33,300	7,100	342	725
Erie	1,072,400	289,200	18,867	35,779
Genesee (PSA 5.1)	10,300	63,900	163	12,872
Niagara	66,900	124,700	1,017	20,937
Wyoming (PSA 5.1)	7,500	---	178	320
Pennsylvania				
Erie (See RBG 4.3)	---	---	---	---
TOTALS	1,234,900	491,600	20,820	72,689
YEAR 2000				
New York				
Cattaraugus	86,100	12,800	253	2,056
Chautauqua	64,600	14,000	380	687
Erie	2,229,400	601,800	20,996	33,650
Genesee (PSA 5.1)	21,800	135,100	191	12,844
Niagara	155,000	288,800	1,192	20,762
Wyoming (PSA 5.1)	15,300	---	209	289
Pennsylvania				
Erie (See RBG 4.3)	---	---	---	---
TOTALS	2,572,200	1,052,500	23,221	70,288
YEAR 2020				
New York				
Cattaraugus	163,600	24,500	253	2,056
Chautauqua	124,200	26,700	406	661
Erie	4,632,900	1,213,900	23,011	31,635
Genesee (PSA 5.1)	43,300	268,600	218	12,817
Niagara	360,300	671,500	1,357	20,597
Wyoming (PSA 5.1)	28,400	---	239	259
Pennsylvania				
Erie (See RBG 4.3)	---	---	---	---
TOTALS	5,352,700	2,205,200	25,484	68,025

*On main stem and principal tributaries

TABLE 14–57A River Basin Group 4.4, Average Annual Flood Damages (Auxiliary Data)

Stream	1967	1980	2020
Tonawanda Creek	$ 463,400	$ 491,000	$ 521,900
Bull Creek	13,500	18,900	34,100
Ellicott Creek	244,500	761,300	1,640,000
Scajaquada Creek	185,500	200,000	234,000
Cayuga Creek	36,400	213,200	218,800
Buffalo Creek	38,400	78,800	120,200
Cazenovia Creek	181,200	209,600	241,400
Tannery Brook	19,500	19,500	19,500
Smokes Creek	22,700	37,200	50,400
North Branch 18 Mile Creek	2,600	7,100	43,400
Cattaraugus Creek			
At Gowanda	321,000	321,000	321,000
At Mouth	33,400	45,500	71,400
Thatcher Brook	4,400	4,400	4,400
TOTALS	$1,566,500	$2,407,800	$3,520,500

*This table from the Erie-Niagara River Basin Report is supplied by the New York State Department of Environmental Conservation. Differences in this table and those previously presented occur as a consequence of variances in study criteria, principally methodology of damage projection. The Erie-Chautauqua complex is not included in the above totals.

effect for the communities within this study area for a number of years, there are no provisions that regulate the use of land with respect to flood risk. However, the State of New York enabling statutes that permit city zoning specify in Chapter 21, Article 2-A, Section 24, that "such regulations shall be designed to secure safety from fire, floods and other dangers, and to promote the public health and welfare. . . ." The State of New York Town Law, Section 263, states "such regulations shall be made in accordance with comprehensive plan and design to lessen congestion in the street to secure safety from fire, floods, panic and other dangers to promote health and general welfare. . . ." Also, Section 277, concerning planning boards and official maps, states that "land shown on such plats shall be of such a character that it can be used safely for building purposes without danger to health or peril from fire, flood or other menace." The 1965 Legislature of New York State passed amendments adding Part IIIA, Use and Protection of Waters, to Article 5 of the Conservation Law. Although Part IIIA is not meant to regulate the flood plain, it does help prevent encroachment of streams, thereby helping to reduce future flood damages. Part IIIA states, in part, that no person or public corporation shall change, modify, or disturb the course, channel or bed of any stream or shall erect, reconstruct, or repair any dam or impoundment structure without a permit from the Department of Environmental Conservation (formerly from the Water Resources Commission). The full text of the Act can be found in Chapter 955 Sections 429 a-g of the Laws of New York State—1965.

While Federal agencies can prevent unwise Federal and Federally assisted construction in the flood plains and provide information and guidance on flood hazard areas, State and local leadership in flood plain management is essential if flood plain management is to become effective. Regulations of flood plain usage by zoning, subdivision regulations, building codes, and other police power measures can be done only by State or local governments. Legislation should be passed by the State of New York requiring local com-

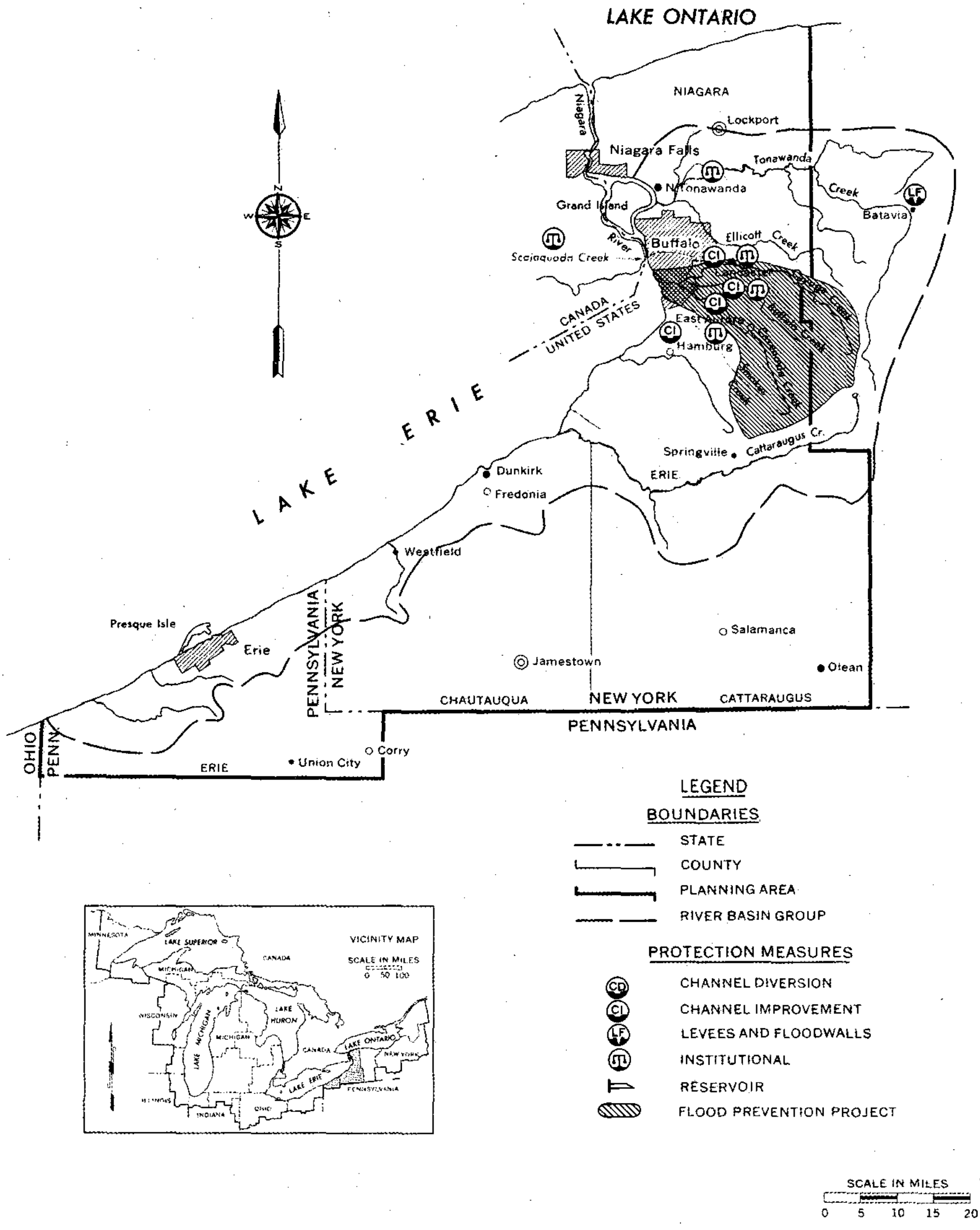

FIGURE 14–53 Existing Flood Damage Protection Measures for River Basin Group 4.4

munities with existing or potential flood problems to establish flood plain regulations. Assistance is available through the Corps of Engineers' Flood Plain Management Services program. Refer to Appendix S20, *State Laws, Policies, and Institutional Arrangements,* for a discussion of flood plain legislation. Current land management and conservation programs should be continued and accelerated by local interests in cooperation with the Department of Agriculture in order to reduce runoff from the rural lands in the basin.

1.55 Lake Erie East, River Basin Group 4.4, Ellicott Creek Basin

1.55.1 Description

Ellicott Creek, the largest tributary of Tonawanda Creek, drains an area of approximately 110 square miles in Erie, Genesee, and Wyoming Counties. Location within River Basin Group 4.4 is shown in Figure 14–50. The source of the principal tributary, Elevenmile Creek, is 22 miles east of Buffalo, at an elevation of 1,300 feet above mean sea level. It joins Crooked Creek to form Ellicott Creek, which flows in a northwesterly direction into the canalized section of Tonawanda Creek at an elevation of 564 feet. There are three named tributaries to Ellicott Creek: Elevenmile Creek, draining 10.4 square miles; Crooked Creek, draining 6.1 square miles; and Spring Creek, also draining 6.1 square miles. The topography of the watershed varies from flat lands near the mouth to steep hills around the headwaters. Near the headwaters the stream flows through steep valleys and is fed by small streams and gullies from hillsides. The slope of the stream varies from 2 feet per mile in the flatlands near its mouth to 70 feet per mile near the headwaters. There is a precipitous drop of 60 feet over a length of approximately 0.2 miles at the Village of Williamsville, just below a small dam constructed in 1929 as a flood control measure. Ellicott Creek pursues a very meandering course and measures approximately 47 miles in a basin roughly 27 miles long.

The Ellicott Creek watershed lies within the western portion of the Erie-Ontario lowland which is bounded on the north by Lake Ontario and on the south by the Allegheny Plateau. The generally flat-to-rolling lowland surface is interrupted by three east-west trending escarpments known as the Niagara, Onondaga, and Portage Escarpments, the latter forming the northern edge of the Allegheny Plateau. The lowland belts delineated by the escarpments are named, from north to south, the Ontario Plain, the Huron Plain, and the Lake Erie Plain. From its headwaters on the Portage Escarpment, Ellicott Creek flows over the Lake Erie Plain for approximately two-thirds of its length before cutting northward across the Onondaga Escarpment onto the Huron Plain, and then joining the Niagara River.

The bedrock underlying the western portion of the lowland consists of sedimentary strata: limestone, dolomite, shale, siltstone, and sandstone. This bedrock surface is covered largely with glacial deposits associated with Wisconsin stage glaciation.

1.55.2 Previous Studies

Previous studies are listed below:

(1) 1970—the Erie-Niagara Basin Planning Board and its basin plan in 1970 for development and management of water and related land resources in the Erie-Niagara basin

(2) 1970—Survey Report for Flood Control and Allied Purposes, Ellicott Creek, New York. The District Engineer recommended that a Federal project be authorized on Ellicott Creek to provide a dam and multiple-purpose reservoir for flood control, water supply, water quality, recreation, and fish and wildlife, in the Towns of Alden and Darien, and channel enlargement and appurtenant work for flood control in the Towns of Tonawanda and Amherst at an estimated cost of $19,810,000.

(3) 1968—a flood plain information report on Ellicott Creek between the mouth of the creek and a point 22 miles upstream near the Village of Bowmansville was completed by the Corps of Engineers in January 1968. It was prepared in response to a request from the Erie-Niagara Basin Regional Water Resources Planning Board. Its purposes were to aid in the understanding of local flood problems and to provide guidance in selection of the best uses for lands subject to overflow.

(4) 1939—a preliminary examination of Ellicott Creek for flood control, submitted in April 1939. No work was recommended, after consideration of a reservoir and local protection. The report was not published.

1.55.3 Development in the Flood Plain

Development in the first mile of Ellicott Creek is commercial and industrial. Then, through the remainder of the City of Tonawanda, the Township of Tonawanda, and the Town of Amherst to the upper limit of Williamsville, development is essentially residential of varying degrees of intensity, interspersed with parks, golf courses, shopping centers, and vacant land. A large sparsely developed area on the left bank in Amherst has been acquired by the State University of New York, which has started construction of a new campus. Upstream from Williamsville, the basin, once entirely agricultural, is gradually changing to suburban residential development whose intensity is greatest near Buffalo. In the interim, many of the farms have either been combined into larger units for dairy and general farming or are dormant, with the buildings in use but the land uncultivated. The upstream portion of the basin is used mainly for agricultural purposes.

1.55.4 Flood Problems

Historical documents state that two floods of approximately equal magnitude occurred in March 1916 and January 1929. The greatest known flood in the study area occurred on March 17, 1936. The maximum recorded flood at the Williamsville gage occurred in March 1960. Other large floods also occurred in June 1937, March 1940, March 1954, March 1956, January 1959, and March 1963. Other floods probably occurred before 1916, but no definite dates or stages could be established because of the lack of development and records in the area at the time.

Figure 14–51c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–54 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–55 depicts upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–52c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–56. County summaries for the main stem and principal tributaries are tabulated in Table 14–57.

1.55.5 Existing Flood Damage Prevention Measures

In 1929 the Village of Williamsville, at a cost of $64,000, executed a flood control project just upstream on Ellicott Creek from Main Street consisting of a new channel 1,100 feet long with a bottom width of 70 feet. The existing channel immediately upstream from the new channel was cleaned, deepened, and widened for a distance of approximately 1,400 feet, and a small gate-controlled dam at the lower end of the new channel was constructed. The gates are normally closed to maintain a pool for scenic purposes and are opened as needed to provide extra channel capacity for flood flows.

In 1932 the Town of Amherst made channel improvements on Ellicott Creek at a cost of $25,000, consisting of cleaning, deepening, and widening the creek upstream from the Williamsville village limit for a distance of 2,800 feet. This project was financed in conjunction with a State-county work relief organization. Later that year the Village of Williamsville, under the Public Works Administration, did some widening and levee work upstream from the town project. The cost of these improvements was $15,000, but the extent of the project is not known. These projects afforded protection to the immediately adjacent land, and increased the efficiency of the flood control project described in the preceding paragraph.

The Federal government expended $75,700 in 1958 and 1959 for clearing and snagging a 7-mile reach of Ellicott Creek between Sheridan Drive and Niagara Falls Boulevard. Maintenance has been performed by local interests. Erie County constructed a diversion channel between Ellicott Creek and Tonawanda Creek in 1965 at a cost of approximately $300,000. Because Ellicott Creek normally reaches peak flood stages earlier than Tonawanda Creek, the channel will divert part of the high flow on Ellicott Creek to Tonawanda Creek. The trapezoidal channel located just downstream from Niagara Falls Boulevard is approximately 2,000 feet long and has a maximum bottom width of 120 feet. One culvert was constructed near the Tonawanda Creek end of the channel to pass the flows under an existing highway.

Present regulations for communities, with the exception of the Town of Royalton in Niagara County and the Village and Town of Cheektowaga, New York, do not have specific provisions to regulate building within the flood plain, or to regulate the use of land with respect to flood risk, although development within known flood areas is usually discouraged by local governments. Refer to Subsection 1.54.5 for discussion of flood plain legislation applicable to this basin.

1.56 Lake Erie East, River Basin Group 4.4, Buffalo River Basin

1.56.1 Description

The watershed of Buffalo River and its tributaries, Buffalo, Cayuga, and Cazenovia Creeks, is located in the west central part of the State of New York. It is roughly triangular in shape with the apex at the mouth of the creek in Buffalo, New York, and the base, approximately 25 miles long, 30 miles to the southeast. The area of the watershed is 446 square miles. Location within River Basin Group 4.4 is shown in Figure 14–50. Buffalo Creek rises near Java, New York, and flows through the center of the watershed in a northwesterly direction. Cayuga Creek rises near North Java Station, flows generally westerly through the northern part of the watershed, joining Buffalo Creek approximately 9 miles upstream from the mouth of the Buffalo River. Little Buffalo Creek, rising approximately midway between Folsomdale and Bennington Corners, flows northwesterly to join Cayuga Creek approximately one mile southeast of Lancaster. Cazenovia Creek is formed by its east and west branches, which rise near the southern corner of the watershed, flow northerly approximately 5 miles apart and join west of East Aurora; then the creek flows generally northwesterly joining Buffalo River approximately 6 miles above its mouth.

The topography of western New York resembles an irregular flight of steps, consisting of a series of nearly level plains separated by steep escarpments rising to the south. The highest of these plains, the Allegheny Plateau, has been eroded deeply at its northern edge by the upper reaches of Cayuga, Buffalo, and Cazenovia Creeks. The steep slopes of this region, which are not heavily wooded, cause rapid runoff and continual erosion. To the north, below the Portage Escarpment, is the Erie Plain which contains the lower reaches of the streams. The eroded material is deposited in the flatter lower reaches of the streams, obstructing the channels and leading to further bank erosion at points where flows are concentrated.

The sources of the streams in the rugged upper part of the watershed are located on the western edge of the Allegheny Plateau, and are separated from the watershed to the south by a terminal glacial moraine. The lower valley lands lie on the eastern edge of the interior lowlands. The rock strata form an outcrop pattern of east-west trending bands. All the rock formations that outcrop in the basin are Middle and Upper Devonian in age. The types of rock are limestone, shale, siltstone, and sandstone. The ridge and valley slopes of the watershed are composed of a heavy-textured soil consisting of silt loam and silty clay loam underlain by heavy plastic or hard compact silty clay loam subsoils. The subsurface drainage of these soils is poor, and their absorptive capacity is limited. The creek bottomlands consist of sandy or gravelly soils or light, easily worked surface soils grading downward into sandy and gravelly friable subsoils.

1.56.2 Previous Studies

Previous studies are listed below:

(1) The Soil Conservation Service in 1970 published a Preliminary Investigation Report on Tannery Brook Watershed in Erie County, New York.

(2) The Erie-Niagara Basin Regional Water Resources Planning Board published its basin plan in 1970 for development and management of water and related land resources in the Erie-Niagara Basin.

(3) The Buffalo District of the Corps of Engineers published flood plain information reports on Buffalo Creek in April 1966, Cazenovia Creek in October 1966, and Cayuga Creek in May 1967. They were prepared in response to a request of the Erie-Niagara Basin Regional Water Resources Planning Board. The purpose of the reports was to aid in the understanding of local flood problems and to provide guidance in selection of the best uses for lands subject to overflow.

(4) A survey scope report was completed by the District Engineer on November 1, 1946 and was submitted to Congress November 7, 1949. The report considered improvements to reduce flood damages along the lower reaches of Cayuga, Buffalo, and Cazenovia Creeks and the possibility of combining water supply for Lockport and other places with flood control storage in a reservoir on the watershed. Although an economically feasible plan could have been developed to supply water from a reservoir on the watershed to the Buffalo

suburban area, it did not appear that the cost of water at Lockport could be reduced by a gravity supply from this watershed, and the probable benefits from flood control would not justify Federal participation. There was no feasible local protection project. Accordingly, no improvement was recommended in this report.

(5) A survey report on Cayuga, Buffalo, and Cazenovia Creeks, submitted to Congress July 23, 1941, was subsequently published in House Document No. 326, 77th Congress, 1st Session, and was the basis for authorization of the existing project at Lancaster on Cayuga Creek. The report was unfavorable with respect to flood protection improvements at other locations. A definite project report dated July 1, 1943, was prepared prior to the construction of the project at Lancaster.

(6) House Document No. 574, 78th Congress, 2nd Session, contains a survey report on the subject watersheds by the Department of Agriculture describing an investigation of programs of water flow retardation and soil erosion prevention in aid of flood control and of stream bank protection. That report recommended a program of farmland treatment, and retirement and reforestation of submarginal land, to be consummated jointly by the Department of Agriculture and appropriate State and local agencies.

1.56.3 Development in the Flood Plain

The Cayuga Creek flood plain is relatively undeveloped at present. However, one small community, Bellevue in the Township of Cheektowaga, has occasionally been affected by flooding. The affected development in this locality is principally residential with a total of approximately 50 homes subjected to damage in the past. Minor damage to farm buildings, equipment, and crops occurs throughout its length.

The Buffalo Creek flood plain is relatively undeveloped at present. However, three small communities are occasionally affected by flooding: Gardenville in the Township of West Seneca, and Blossom and Elma in the Township of Elma. The development in these localities is principally residential with a scattering of commercial units subjected to damage in the past. Minor damage to farm buildings, equipment and crops occurs throughout its length.

The Cazenovia Creek flood plain within the City of Buffalo is completely utilized, including residential areas, a park, and a golf course. The urbanized areas within the city that are occasionally affected by floods are principally residential with a scattering of commercial and public establishments which have been subject to damage in the past. In the Township of West Seneca several residential subdivisions and a large plaza have been affected by floods in the past.

1.56.4 Flood Problems

Records of stream flows and information from previous reports indicate that major floods occurred in February and March 1904, January 1929, June 1937, March 1942, March 1955, March 1956, and January 1959. Most of the major floods have been due to rain on frozen ground augmented by snowmelt. In the January 1959 flood, flow conditions were further aggravated by ice jams. The maximum flood of historical record on Cayuga Creek occurred in June 1937.

Figure 14–51c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–54 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–55 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–52c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–56. County summaries for the main stem and principal tributaries are tabulated in Table 14–57.

1.56.5 Existing Flood Damage Prevention Measures

A Federal structural flood control project at Lancaster, New York, was authorized by the Flood Control Act of 1941. The project consisted of clearing and improving the Cayuga Creek channel from Park Boulevard in the Village of Lancaster downstream to Penora Street in the Village of Depew; constructing earth levees and steel sheet pile flood walls; and altering existing drainage facilities. Location of this project is shown in Figure 14–53. The project was completed by contract in July 1949 except for a flap gate on the head wall of a 60-inch pressure culvert. The gate was installed in 1953. Total Federal cost for the completed project was $797,300, and contributed funds added another $28,000. It was estimated by local interests that they incurred costs of $311,200. The project is maintained by the State of New York. A clearing and snagging operation was performed on Cazenovia Creek in West Seneca from Ridge Road upstream to Mill Road in 1947. The Federal cost was $24,900, and no maintenance of the project by local interests was required.

In 1942 the Town of Lancaster widened Cayuga Creek from the sewage disposal plant in Lancaster, downstream to Transit Road in Depew, a distance of approximately one mile. The channel was enlarged to a 90-foot bottom width and the cost to the town was $58,000.

The Soil Conservation Service has done some bank protection and channel straightening on both Buffalo and Cazenovia Creeks to reduce erosion along the waterways. A by-product of this work was flood reduction in some areas.

The City of Buffalo has employed several means to alleviate flooding from Cazenovia Creek within its boundaries. The most significant work was construction of levees in Cazenovia Park. After the January 1959 flood, a levee was constructed on the left bank of the creek. The top was set at the 1959 flood elevation. In 1962 another flood occurred in the area and while the levee prevented damage to the left bank, flooding on the right bank was almost as severe as in 1959. The left bank levee precluded use of a large portion of the park for an ice storage area and even though the discharge in 1962 was far less than the 1959 flow, the ice collected and jammed in the park area and caused right bank overflow. To protect the right bank another levee was constructed in 1964 along Beyer Street. The second levee also had the top set at the 1959 flood elevation. Previously the right bank of Cazenovia Creek for 900 feet downstream from Union Road in West Seneca was filled, raised, and protected with concrete bag riprap in 1960. A low levee beginning at Sunbriar Drive and extending downstream for 600 feet was begun in 1963 by the builders of a new housing development in the area. At present it is open-ended and affords little protection, but if it were completed it would protect the area from a flood of the magnitude of the January 1959 flood.

Present regulations for the communities, except for Elma on Buffalo Creek and Cheektowaga on Cayuga Creek, do not have specific provisions to regulate building within the flood plain, or to regulate land use with respect to flood risk. However, development within known flooded areas is usually discouraged by local governments.

Refer to Subsection 1.54.5 for a discussion of flood plain legislation applicable to this basin.

1.57 Lake Erie East, River Basin Group 4.4, Tonawanda Creek Basin

1.57.1 Description

Tonawanda Creek is the largest tributary of the Niagara River, joining it 13 miles from Lake Erie and draining an area of 648 square miles in Erie, Niagara, Orleans, Genesee, and Wyoming Counties in western New York. Location within River Basin Group 4.4 is shown in Figure 14–50. It rises in the highlands in Wyoming County near North Java at an elevation of 1,900 feet above mean sea level and flows generally northward between steep hills through Varysburg and Attica to Alexander, from where it meanders through flat land to Batavia at an elevation of 890 feet. It then turns abruptly westward, and then northerly to the Tonawanda Indian Reservation. From that point it forms the boundary between the Niagara and Erie Counties, meandering generally westerly to confluence with Niagara River at elevation 564 feet. The lower 12½ miles west of Pendleton form a part of the New York State Barge Canal and have a navigable depth of 12 feet.

The principal tributary to the mainstream in the upper part of the watershed is Little Tonawanda Creek. This stream rises approximately 3 miles south of Dale and follows a generally northerly course for 18 miles to enter Tonawanda Creek from the east 5 miles above Batavia. Other tributaries are the East Fork which joins the creek downstream from North Java, Stoney Brook which enters from the east at Varysburg, Crow Creek which also enters from the east above Attica, and Bowen Creek which enters from the south just upstream of East Pembroke.

The headwaters of Tonawanda and Little Tonawanda Creeks rise in the steep foothills of the Allegheny Plateau. The lower portions of the two streams and the watershed of Bowen Creek are in the rolling flatlands of the Erie Plain. Hilltop elevations in the headwaters range up to 2,100 feet above mean sea level. The valleys in this region are generally deep and narrow, and their sides are indented by short, steep gullies. Tonawanda and Little Tonawanda Creeks enter the plains region near elevation 940 feet, 8 miles south of Batavia. In this region, which generally comprises the remainder of the watershed, slopes are generally flat. Elevations of the land in the Batavia-East Pembroke area range from 910 feet to 870 feet. Watershed divides on the plains are poorly defined, and swampland occurs in many locations.

Overburden in the Tonawanda Creek watershed consists generally of glacial till in the headwaters, lacustrine deposits in the plains, and recent alluvial formations along stream bottoms and in swamps. The underlying rocks are of sedimentary origin. There are outcrops of sandstone, shale, and limestone at a number of points along the course of the creek. The Onondaga limestone outcropping north and west of Batavia forms a barrier which deflects the creek westward until it reaches Indian Falls.

1.57.2 Previous Studies

Previous studies are listed below:

(1) 1970—The Erie-Niagara Basin Planning Board issued its basin plan in 1970 for development and management of water and related land resources in the Erie-Niagara basin.

(2) 1967—Flood Plain Information Report on Tonawanda Creek and its Affected Tributaries, Erie and Niagara Counties. It was prepared in response to a request of the Erie-Niagara Basin Regional Water Resources Planning Board. Its purposes were to aid in the understanding of local flood problems and to provide guidance in selection of the best uses for lands subject to overflow.

(3) 1961—Favorable survey report for Flood Control, Tonawanda Creek in the vicinity of Batavia, New York. During a 5-year period there were 3 floods greater than or nearly equal to the flow for which the completed project on Tonawanda Creek at Batavia was designed. A plan of improvement consisted of enlarging a 13,330-foot reach of channel, protecting a 1,300-foot length of bank, constructing a levee 3,200 feet long, and other appurtenant works.

(4) 1945—A favorable survey report proposed local protection in the vicinity of the City of Batavia and served as the basis for subsequent authorization by the Flood Contract Act of June 1948.

(5) The U.S. Geological Survey—A flood-prone area report was issued for a portion of Tonawanda Creek.

1.57.3 Development in the Flood Plain

Between the Cities of Tonawanda and North Tonawanda development is primarily confined to boat houses, both private and commercial, and a scattering of residential homes. Upstream from the City of Tonawanda to the confluence of the Barge Canal, much of the area is developed for recreational use such as parks, public boat marinas and golf courses.

The development along Ransom Creek from its mouth to the confluence of Black Creek is rapidly changing from an agricultural to a residential area. Most new construction is of individual homes rather than large subdivisions. Development within the Black Creek basin is still primarily agricultural, although an increase in individual residential units is evident. The largest concentration of flood damage is in the Hamlet of Wolcottsburg.

The majority of development in the Mud Creek basin is agricultural with a scattering of farm homes, farm buildings, and individual residential units throughout the area. The only exceptions are a large trailer court consisting of 75 trailers located on the left bank of Mud Creek, just upstream of Minnick Road, and the Hamlet of Wolcottsville where a number of residential units and a few public and commercial buildings are located. Upstream from Ditch Road the flood plain has been incorporated into the "Tonawanda Game Management Area," operated by the New York State Conservation Department.

1.57.4 Flood Problems

Historical documents indicate that the greatest floods in the basin occurred in March 1865 and were equalled again in March 1904. At the time of these floods a dam existed upstream from the Main Street bridge in the City of Tonawanda, thereby aggravating the flood situation upstream from this point. The dam was originally constructed as part of the Erie Canal in the spring of 1823. It was estimated that the removal of the dam in 1918, along with the modernization of the Barge Canal, lowered Tonawanda Creek approximately 6 feet. Severe floods have also occurred in 1889, 1893, 1894, 1896, 1902, 1916, 1940, and 1960. Other large floods have occurred in 1936, 1942, 1954, 1955, 1956, 1957, and 1959.

Figure 14-51c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table

14–54 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–55 lists upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–52c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–56. County summaries for the main stem and principal tributaries are tabulated in Table 14–57.

1.57.5 Existing Flood Damage Prevention Measures

The only Federal structural measure undertaken on Tonawanda Creek was a flood control project completed in the City of Batavia in 1956. Location of the project is shown in Figure 14–53. The project, completed in 1956, provided for the following: widening the channel of Tonawanda Creek for approximately 2 miles below the municipal dam in Batavia; bank protection, where required, and minor channel clearing above the municipal dam for a distance of approximately 1.5 miles; and structural relocations as required.

Present regulations for communities, with the exception of the Town of Royalton in Niagara County, do not have specific provisions to regulate building within the flood plain or land use with respect to flood risk. However, development within known flood areas is usually discouraged by local governments.

Refer to Subsection 1.54.5 for a discussion of flood plain legislation applicable to this basin.

1.58 Lake Erie East, River Basin Group 4.4, Cattaraugus Creek Basin

1.58.1 Description

The Cattaraugus Creek basin is located in Chautauqua, Cattaraugus, Allegany, Wyoming, and Erie Counties and encompasses a total drainage area of 554 square miles. Location within River Basin Group 4.4 is shown in Figure 14–50.

The creek is approximately 70 miles long, rises at an elevation of 1,900 feet above mean sea level, and flows westerly to enter Lake Erie near Irving 25 miles south of Buffalo. The watershed is irregular in shape, 45 miles long from east to west, and 22 miles wide. The largest tributary, the south branch, joins the main stream 21 miles above the mouth and drains an area of approximately 100 square miles. Cattaraugus Creek falls over 1,200 feet in its upper 54 miles and slightly less than 200 feet in its lower 16 miles. There are numerous tributaries of Cattaraugus Creek.

1.58.2 Previous Studies

Previous studies are listed below:

(1) 1969—Development of Water Resources in Appalachia, Part V, Vol. 13

(2) 1968—Flood plain information reports on Cattaraugus Creek for the areas Irving, Sunset Bay, Gowanda, and Arcade by the Corps of Engineers. They were prepared in response to a request from the Erie-Niagara Basin Regional Water Resources Planning Board.

(3) 1964—Coast of Lake Erie, Interim Report on Cattaraugus Creek Harbor, New York. It has been determined that the plan of improvement that will most economically and effectively serve the purposes involved would provide for the following: breakwaters in Lake Erie aggregating approximately 2,300 feet in length; a berm extending from the inner end of the north breakwater northerly to high ground; a channel generally 100 feet wide with a depth of 8 feet from deep water in the Lake upstream to a maneuvering area; a maneuvering area 300 feet by 600 feet with a depth of 6 feet, and from there a channel upstream 1,600 feet long with a depth of 6 feet, with a riprapped friction section through the New York Central Railroad bridge; and two short levees on the left bank. In addition to the benefits to navigation and flood control, breakwaters (with little additional cost for providing railings), walkways, and related onshore facilities would provide benefits from use for sport fishing.

(4) 1956—Survey report on the Cattaraugus Creek basin authorized by a House Committee resolution of July 23, 1956, and a Senate Committee resolution of June 2, 1956, to provide for study of flood problems in the basin upstream from the mouth of the creek

(5) The U.S. Geological Survey—a flood-prone area report for a portion of Cattaraugus Creek

1.58.3 Development in the Flood Plain

The Cattaraugus Reservation of the Seneca Nation of New York Indians occupies the entire northern side of the creek in the lower two-mile reach. Development in this reach is cottage-type homes. Undeveloped areas near the mouth are used mainly for agricultural purposes. The flood plain in the City of Gowanda is extensively developed with residential, commercial, industrial, and public properties. Sunset Bay and Hanford Bay are summer resort areas with typical seasonal, residential, and commercial developments. The community of Irving is primarily residential, with some commercial establishments. The undeveloped areas in the reach from Gowanda to Arcade are used for agricultural purposes. The Town of Arcade is a large rural area with a small population, located in the foothills of the Allegany Plateau. Residential development in the Village of Arcade is essentially older, single-family homes and is considered primarily low density. Arcade's industrial heritage, which dates back to the early 1800s, is diversified and essentially light industry. Arcade has been the center of a milk processing industry for more than half a century and is the location of the world's largest powdered milk plant.

1.58.4 Flood Problems

Damaging floods along Cattaraugus Creek date back 100 years. The resort areas near the mouth of the creek have been developed primarily in the last 30 years, so good information on flood events prior to that time is not available. Significant flooding occurred at the mouth of the Cattaraugus Creek in March 1942, June 1944, April 1947, March 1955, March 1956, January 1957, January 1959, February 1961, and March 1963; at Gowanda in March 1942, June 1940, September 1939, August 1967, 1861, 1894, 1902, 1904, 1913, 1918, and 1937; and at Arcade in July 1902 and September 1967.

Figure 14–51c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–54 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–55 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–52c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–56. County summaries for the main stem and principal tributaries are tabulated in Table 14–57.

1.58.5 Existing Flood Damage Prevention Measures

There is no existing Federal structural project for improvement of Cattaraugus Creek Harbor, nor is there any existing structural flood control project on Cattaraugus Creek.

At the mouth of Cattaraugus Creek local interests have constructed a dike which alleviates damages due to high water, and local interests periodically dredge the sandbar at the mouth which reduces the chance of ice jamming. The Village of Gowanda has made channel improvements and constructed drop structures on Thatcher Brook which have done much to decrease flooding. Improvements to Cattaraugus Creek by local interests consist of retaining walls and bank protection to prevent erosion and contain high flows.

Present regulations for communities do not have specific provisions to regulate building within the flood plain or regulate land use with respect to flood risk. However, development within known flood areas is usually discouraged by local governments.

Refer to Subsection 1.54.5 for a discussion of flood plain legislation applicable to this basin.

1.59 Lake Erie East, River Basin Group 4.4, Scajaquada Creek Basin

1.59.1 Description

Scajaquada Creek drains to the Black Rock Canal in the Niagara River at Buffalo, New York. It is a small stream, flowing generally from east to west, with a total drainage area of only 24.4 square miles, all in Erie County. The watershed measures 14 miles in overall length east and west, by approximately 3 miles in width north and south. It includes parts of the Town of Lancaster, the Village of Depew, the Town of Cheektowaga, and the City of Buffalo. Location within River Basin Group 4.4 is shown in Figure 14–50.

The topography upstream from the City of Buffalo is gently rolling, varying from 760 feet in elevation near the headwaters in the Town of Lancaster to 630 feet near the Buffalo-Cheektowaga line. Just upstream from the Buffalo-Cheektowaga line at Pine Ridge Road, the creek enters a covered conduit and is carried in the conduit a distance of 3.7 miles under Buffalo to a point just downstream from Main Street. After a short steep fall the open stream enters Delaware Park Lake and then proceeds to the Black Rock Canal at an elevation of 572 feet.

The region of western New York, which includes the Scajaquada Creek watershed, consists of a series of terraces or platforms separated by northwest-facing escarpments. Descending in a direction northward from the Allegheny Plateau of northern Pennsylvania, the terraces are named the Erie, Huron, and Ontario Plains and the escarpments that separate them are named the Portage, Onondaga, and Niagara Escarpments. The headwaters of Scajaquada Creek are in the Erie Plain, and the main stem crosses the Onondaga Escarpment into the Huron Plain near Main Street in Buffalo. All of the strata dip quite uniformly to the south approximately 30 feet to the mile and strike approximately east-west. The rock strata consist of black calcareous shales of the Marcellus formation and resistant Onondaga limestone of Middle Devonian age. The strata have been only slightly disturbed, and no significant faults or folds are known. However, the strata do contain fractures called joints. During the Pleistocene era there were glacial advances and withdrawals during which great ice sheets spread over the area. Therefore, the overburden consists largely of glacial drift.

1.59.2 Previous Studies

Previous studies are listed below:

(1) 1969—a flood plain information report in the Towns of Cheektowaga and Lancaster, Erie County, New York

(2) 1968—Review of Reports for Flood Control, Scajaquada Creek and Tributaries, New York. Corps of Engineers, Buffalo District, recommended that a Federal project be authorized to provide improvements to 9,100 feet of the Scajaquada Creek channel and 16,800 feet of tributary channel, levees totaling 4,000 feet, all within the Town of Cheektowaga at an estimated total cost of $1,915,000, based on 1968 price levels.

(3) 1946—a preliminary examination of Scajaquada Creek for flood control by the Corps of Engineers, Buffalo District, in December. It was concluded at that time that improvements could not be economically justified.

1.59.3 Development in the Flood Plain

The area subject to flooding is adjacent to the creek channel. In total the flood area extends over a distance of 10 miles, but it is generally very narrow in width, lying close to the main stem except in Cheektowaga. In Cheektowaga development is almost entirely residential with a scattering of public and commercial facilities. Downstream from the conduit in the City of Buffalo, development near the creek is primarily industrial, but the facilities most vulnerable to flooding are the Scajaquada Expressway, the Casino Building in Delaware Park, and the Forest Lawn Cemetery.

1.59.4 Flood Problems

Scajaquada Creek has a relatively short history of flood damage. Significant flooding is known to have been experienced on at least five occasions prior to 1957, without appreciable damage, in 1936, 1937, 1942, 1944 and 1947. The upper portion of the watershed was not as developed then, and damages were concentrated downstream from the covered conduit. Major flooding in the watershed occurred in August 1963 and September 1967. These were the only floods in which substantial damages were incurred. The August 1963 flood was the maximum flood known to have occurred on Scajaquada Creek. The 1963 and 1967 floods resulted from intense rainstorms over the watershed and rapid runoff due to its largely urban character. This was true of all other known floods. Although there were instances when snowmelt and ice jams were contributing factors, their significance was limited.

Figure 14–51c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–54 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–55 indicates upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–52c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–56. County summaries for the main stem and principal tributaries are tabulated in Table 14–57.

1.59.5 Existing Flood Damage Prevention Measures

A section of covered conduit enclosing

Scajaquada Creek between Main Street and the Buffalo-Cheektowaga line was constructed by the City of Buffalo from 1921 to 1928.

In 1938 the Town of Cheektowaga, with WPA aid, extended the conduit upstream to Pine Ridge Road, constructed an open concrete approach channel extending 300 feet upstream, and further improved the main stem channel to a point 6,000 feet above Pine Ridge Road.

In 1950 the Corps of Engineers completed a clearing and snagging project 7,700 feet long, entirely within the Village of Depew.

In 1959 the Town of Cheektowaga made improvements throughout the length of the main stem from Pine Ridge Road to the downstream limit of the Village of Depew. A clearing and snagging project was performed in the 6,000-foot section previously improved in 1938. In 1962 the channel improvement was continued upstream into the Village of Depew to a point 6,600 feet above Dick Road.

In 1964 the Village of Depew and the Town of Lancaster, with the financial assistance of the Federal government under the accelerated public works program, improved the 2-mile reach upstream from Transit Road.

Present regulations for the communities, except for the Town of Cheektowaga, do not have specific provisions to regulate building within the flood plain, or to regulate land use with respect to flood risk. However, development within known flooded areas is usually discouraged by local governments. Refer to Subsection 1.54.5 for a discussion of flood plain legislation applicable to this basin.

1.60 Lake Ontario West, River Basin Group 5.1, Genesee River Basin

1.60.1 Description

The Genesee River basin covers 2,479 square miles, mostly in western New York, with a small portion, 96 square miles, in northwestern Pennsylvania. It is roughly elliptical in shape, with a north-south major axis of approximately 100 miles and a maximum width of 40 miles. Location within River Basin Group 5.1 is shown in Figure 14–54. The river rises in the Allegheny highlands in Potter County, Pennsylvania, at an elevation of 2,500 feet and flows approximately 157 river miles in a generally northward direction to its mouth at Rochester Harbor on Lake Ontario at an elevation of 247 feet.

The topography of the southern portion, the upper basin upstream of Mount Morris Dam, is steep and rugged, while in the northern portion the lower basin is gently rolling. If the slope characteristics of the basin are studied, it becomes apparent that there is a great contrast between the upper and lower basins as the Genesee River changes from a flashy, steep stream to a sluggish, meandering river. In Letchworth State Park, just upstream from Mount Morris Dam, the river drops from an elevation of 1,080 feet to 768 feet over three successive falls, flowing through a deep gorge cut in rock. It then enters the broad lower Genesee valley at the Village of Mount Morris. From this point to Rochester, the valleys are flat alluvial plains up to 3 miles wide and were subject to frequent flooding before the construction of Mount Morris Dam. At Rochester the river drops over three falls from elevation 513 to 247 feet, the elevation of Lake Ontario. The headwater stream slopes in Pennsylvania are up to 102 feet per mile, from the New York boundary to Letchworth State Park the average stream slope is 9 feet per mile, and between Rochester and Mount Morris the average stream slope is 0.8 feet per mile.

The largest tributary of the Genesee River is Canaseraga Creek. It has a drainage area of 334 square miles and joins the Genesee River just downstream from Mount Morris. In many respects it is a miniature duplicate of the larger Genesee basin in that its upper reaches above the Village of Dansville are steep and rugged, while its lower valley is a flat alluvial plain which is frequently flooded for several months at a time.

The Genesee basin contains six major lakes and numerous ponds. Four lakes in the lower basin are natural and considered a part of the Finger Lake chain. In the upper basin there are two lakes, one natural and one artificial. The total surface area of these lakes amounts to 13.5 square miles. The New York State Barge Canal crosses the Genesee River at grade just south of Rochester.

The basin is largely agricultural except in the urban Rochester area. The lower basin valleys are devoted to raising truck crops, grain, and cattle. The soils are considered among the most fertile in New York State. The area west of the Genesee Basin and bounded approximately by the Canal, the Niagara River, and Lake Ontario has been included in Planning Subarea 5.1. The land is flat-to-gently-rolling and slopes downward from its southern boundary to bluffs along the lake-

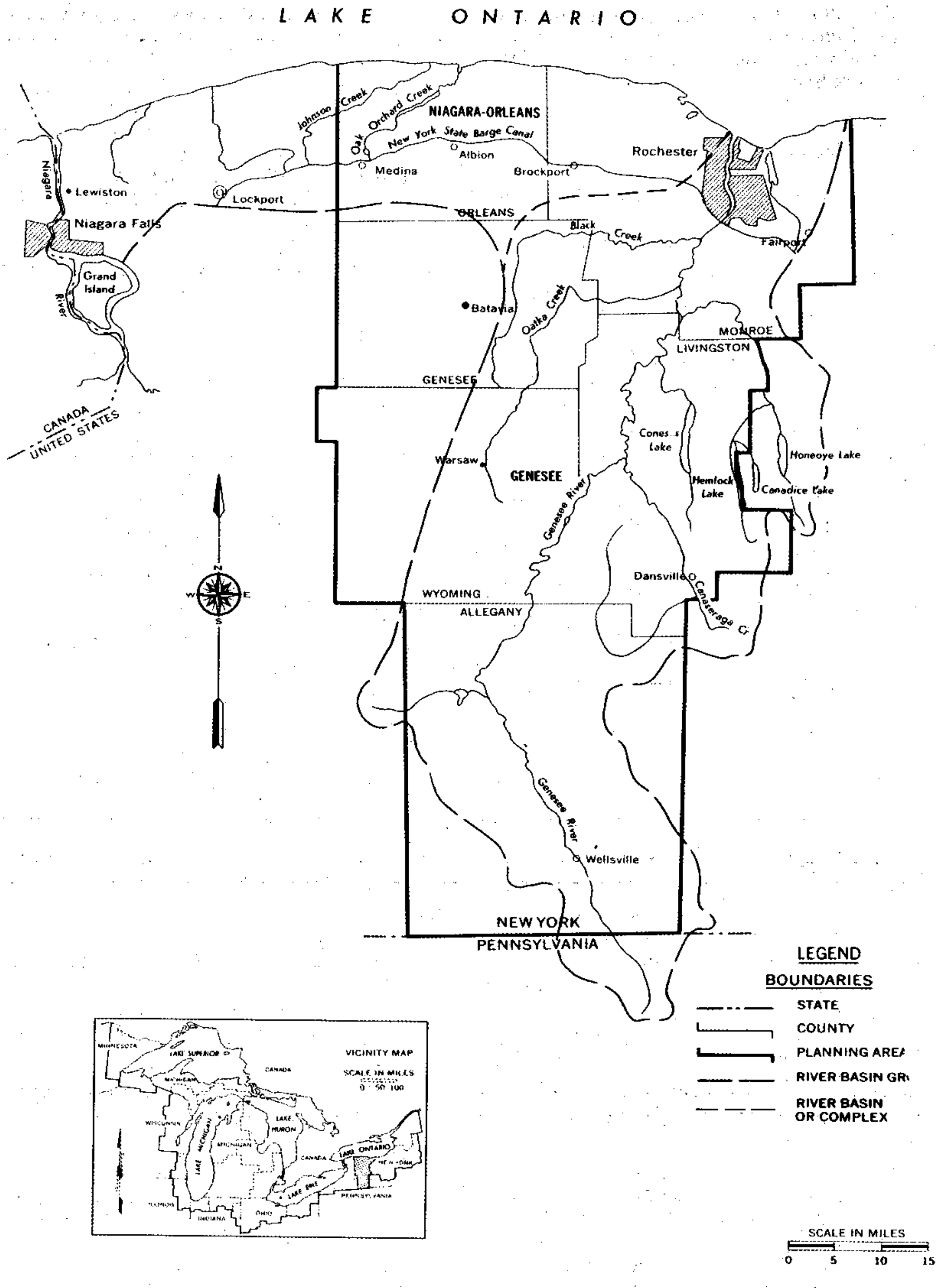

FIGURE 14–54 Lake Ontario West—River Basin Group 5.1

shore. The soils range from moderately to highly productive and comprise one of the major fruit and vegetable crop producing regions in New York State.

1.60.2 Previous Studies

Existing Federal projects and studies in the Genesee River basin (by the Corps of Engineers, unless otherwise noted) are as follows:

(1) 1969—Flood Plain Information Report, Black Creek and Genesee River, New York

(2) 1969—Genesee River Basin Comprehensive Study of Water and Related Land Resources

(3) 1969—Development of Water Resources in Appalachia, Office of Appalachian Studies

(4) 1964—a joint Federal-State pollution study that included the Genesee River basin with the Great Lakes-Illinois River Basins Project. This project began studying the Lake Ontario basin in 1964 under authority of Section 3(a) of Public Law 84–660, as amended. The project report is "Lake Ontario and St. Lawrence River Basins, Water Pollution Problems and Improvements Needs, June 1968."

(5) 1962—a design memorandum for rectification of deficiencies in a completed flood protection project in Wellsville, New York, authorized by the Office of the Chief of Engineers on March 22, 1962. The report was submitted to a higher authority on April 22, 1966.

(6) 1961—flood control project for Red Creek, Monroe County, New York, authorized by the River and Harbor Act of 1966, Public Law 89–789, approved November 7, 1966. This project was initiated by the Soil Conservation Service in 1961 under authority of Public Law 566, 83rd Congress, and the Corps of Engineers was requested to participate in October 1961 under authority of Public Law 685, 84th Congress. As the study developed, the scope of the project exceeded the limitations of Public Law 685, 84th Congress, and the study was transferred by authority of the Office of the Chief of Engineers, March 20, 1963, to the Genesee River Basin Comprehensive Study. An interim report was submitted in August 1965 and published in Senate Document No. 107, 89th Congress, 2nd Session.

(7) 1961—a reconnaissance report on Oatka Creek at Warsaw, New York, for flood control under Public Law 685, 84th Congress, submitted September 27, 1960. Detailed project report was authorized by Chief of Engineers, January 6, 1961. Construction of the project was started in October 1966 and was completed July 24, 1968.

(8) 1959—a review of reports on the Genesee River, in the vicinity of Dansville, New York, with respect to Canaseraga Creek, authorized by resolution adopted by the Committee on Public Works, House of Representatives, June 3, 1959. This Corps study was concurrent with a study by the Soil Conservation Service under Public Law 566, 83rd Congress. The Canaseraga Creek study by both agencies was combined with the Genesee River Basin Comprehensive Study.

(9) 1958—a study of flood problems at Honeoye Lake and Honeoye Creek, initiated by the Soil Conservation Service in 1958 under Public Law 566, 83rd Congress

(10) 1954—a comprehensive study by the New England-New York Inter-Agency Committee, conducted under the general authority of Section 205 of the Flood Control Act of 1950, Public Law 516, 81st Congress, and other acts. Chapter XXXIII of this report was a detailed study of the Genesee River and was completed in 1954.

(11) 1953—an unfavorable preliminary examination of the Allegheny-Genesee waterway barge navigation, submitted to Congress April 13, 1953

(12) 1953—a snagging and clearing project in Canaseraga Creek from Groveland Station to the Genesee River, completed in 1954

(13) 1953—a snagging and clearing project in Keshequa Creek, in the vicinity of Nunda, New York, completed in 1955

(14) 1951—a snagging and clearing project on the Genesee River and Dyke Creek at Wellsville, New York, completed in 1951

(15) 1950—flood control project at Caledonia, New York, authorized by the Flood Control Act of 1950, Public Law 516, 81st Congress, approved May 17, 1950. This project has been classified as deferred for restudy.

(16) 1950—flood control project at Wellsville, New York, authorized by the Flood Control Act of 1950, Public Law 516, 81st Congress approved May 17, 1950. Construction was initiated July 1956 and substantially completed November 1957.

(17) 1949—a review of reports on the Genesee River with particular reference to Angelica Creek, Allegany County, New York, authorized by resolution adopted by the Committee on Public Works, House of Representatives, May 27, 1949. The report submitted March 18, 1955, found that improve-

ments were not considered justified.

(18) 1948—a survey report dated March 12, 1948, and published in House Document No. 232, 81st Congress, 1st Session, recommending channel improvements for flood control at Wellsville and Caledonia, New York

(19) 1948—flood control project at Dansville and vicinity, New York, authorized by the Flood Control Act of 1948, Public Law 858, 80th Congress, approved June 30, 1948. This project has been placed in an inactive category.

(20) 1945—a survey report dated July 30, 1945, and published in House Document No. 206, 80th Congress, 1st Session, recommending channel improvements in Canaseraga Creek for flood control in the vicinity of Dansville, New York

(21) 1944—Mount Morris Dam and Reservoir, authorized by Section 10 of the Flood Control Act, Public Law 534, 78th Congress, approved December 22, 1944. Construction was initiated in March 1948 and completed in 1952.

(22) 1943—a proposed plan for development of the Genesee River basin by the Federal Power Commission, prepared February 1943

(23) 1941—a preliminary examination and survey for flood control on the Genesee River authorized under Section 6 of the Flood Control Act, Public Law 738, 74th Congress, approved June 22, 1936. This survey report, dated May 16, 1941, and published in House Document No. 615, 78th Congress, 2nd Session, recommended construction of an earth-filled dam in the Genesee River near Mount Morris.

Other studies are listed below:

The State of New York in 1889–1893 investigated the possibility of reservoirs on the Genesee River for water supply for the Erie Canal. The first sites studied included several in the Mount Morris Gorge, but because of the development of other water supply sources for the canal, the State of New York did not proceed with development of reservoirs on the Genesee River.

The Water Supply Commission of the State of New York, between 1907 and 1910, made a study of the Genesee River for flood control and power. Two sites were found for multiple-purpose reservoirs, one near Mount Morris and the other near Portageville.

In 1905 a special committee was appointed by the Mayor of Rochester and another committee was appointed by the Chamber of Commerce to investigate and report on flood conditions. A report was submitted covering the history of previous floods and suggesting remedies. In 1928 the City Manager of Rochester enlarged the scope of an investigation for a Civic Center for the City of Rochester to include the general subject of flood protection. A detailed report referred to as the "Fisher Report" on flood conditions was published in 1937.

The New York State Water Pollution Control Board published Survey Report No. 1 on the Upper Genesee River Drainage Basin in 1955 and Survey Report No. 2 on the Lower Genesee River Drainage Basin in 1961. These reports recommended classification and assigned standards of quality and purity for various reaches of the tributaries and main stem of the Genesee River.

The U.S. Geological Survey has published a flood-prone area report for a portion of Canaseraga Creek.

1.60.3 Development in the Flood Plain

The Genesee River basin has one major urban center, Rochester, spread along both of its banks for the last 11 miles before it enters Lake Ontario. Many of the major industries of Rochester are along these banks and the river is presently heavily polluted in this reach. The river passes through the business district, residential areas, and a rapidly growing suburban area. To the south of Rochester the river flows through mainly agricultural lands. Small communities, dating from the days when water was needed to run the mills, dot its banks. Wellsville is the only large village in the upper basin that sustains industrial, commercial, and residential damage from river overflow.

Agriculture is the main factor in the economy of the basin upstream from Rochester. Approximately 55 percent of the land is classified as cropland and pasture, while 35 percent is classified as forested. The majority of the cropland is rich bottomland which is subject to overflow from the river.

In the past several railroads followed the valley and crossed it, but today most of these railroads have abandoned their tracks and improved State and county highways have replaced them. The New York State Thruway crosses the valley, but well above any flood profile.

There are numerous artificial controls in the Genesee River basin. The major one is the Federal Mount Morris Dam and Reservoir on which construction was begun in March 1948 and completed in June 1952. It is a concrete gravity dam with an ungated ogee spillway 550 feet long with the crest 175 feet above the streambed and is operated solely for flood control. Other artificial controls in the Genesee basin include the following:

(1) a series of run-of-river structures for hydroelectric power, developed in the falls reaches at Rochester by the Rochester Gas and Electric Company

(2) a State-operated gated dam in Rochester for regulation of the elevation of the New York State Barge Canal, which crosses the Genesee River at grade just upstream from Rochester. Its elevation is maintained at approximately 513 feet during the navigation season, and it is provided with guard gates on either side of the river to prevent high flows from entering the canal.

(3) a dam and reservoir, operated by the Rochester Gas and Electric Company, on Caneadea Creek, an upper basin tributary which enters the Genesee at river mile 108 on the main stem. Power is not produced at this dam, its purpose being to augment low flows downstream.

(4) a dam on Hemlock Lake in the Honeoye Creek basin, operated by the City of Rochester, to provide water supply to that city

(5) a dam on Conesus Lake outlet to maintain adequate lake levels for recreation on that lake

(6) a dam on the Genesee River just below Mount Morris, operated by the Rochester Gas and Electric Company for power. The plant is basically run-of-river, and releases from the Corps' Mount Morris Dam are held at or above 300 cfs when natural flows permit to provide flow for the R. G. & E. Dam.

(7) a concrete arch-type dam on Wiscoy Creek 3 miles upstream from the Genesee River. This dam provides storage and part of the head for a Rochester Gas and Electric Power development at Wiscoy.

(8) a concrete and sheet pile drop-structure across the Genesee River at Wellsville. It was constructed by the Corps as part of a local flood protection project.

(9) a low dam just upstream from Wellsville for public water supply to the village

1.60.4 Flood Problems

Damaging floods on the Genesee River basin have occurred in all months of the year except August. Summer floods are in general localized in a part of the watershed and are usually the result of convectively unstable air conditions. Winter and spring floods are usually the result of frontal precipitation on saturated or frozen ground or on melting snow cover. However, floods have occurred from melting snow cover alone.

On Canaseraga Creek, the largest of the Genesee River tributaries, agricultural flooding occurs in the lower 15 miles every spring and whenever there is a heavy rain. The agricultural lands drain slowly and have had ponded water on them up to 100 days. This agricultural area under flood conditions is an excellent waterfowl habitat area. Table 14–58 lists the largest floods of record, types of flood, and general damage areas.

Figure 14–55c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–59 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–60 depicts upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–56c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–61. County summaries for the main stem and principal tributaries are tabulated in Table 14–62.

1.60.5 Existing Flood Damage Prevention Measures

There are several Corps structural projects completed in the Genesee River basin. The major project is the single-purpose Mount Morris Dam and Reservoir. Location of this preventive measure is shown in Figure 14–57. This dam controls 44 percent of the Genesee River basin. It controls mainstem flows from the upper basin as they flow into the broad flood plain of the lower basin. It also protects Rochester. The reservoir has a capacity of 337,400 acre-feet of water and cost $23,400,000 to build. It has eliminated approximately $1,000,000 in average annual damage each year since its completion in 1952.

A local flood protection project for the Village of Wellsville was completed in 1957. The project consisted mainly of channel enlargement on the Genesee River and Dyke Creek and the construction of three control structures. Since its completion, the flow for the flood of record has been revised and presently advanced engineering for rectification of deficiencies in the completed project is under way.

Another small Corps project for local flood protection was completed in 1968 on Oatka Creek at Warsaw, New York. This project consists of channel enlargement, several high velocity sections, and a control structure.

Several clearing and snagging projects have been completed as listed previously in Subsection 1.60.2. The benefits from these projects have been minor.

There is also one major flood control project by a local government in the basin. The City of Rochester built protective flood walls, around 1915, through the commercial and business sections of the city. These flood walls were built to protect against the flood of record. They have eliminated most of the damage in downtown Rochester.

In use since 1954 in the Genesee River basin is a river flood forecasting system developed by the Hydrologic Services Division of the Weather Service and put into use by the personnel of the Rochester Weather Service office. At the same time, a system for dissemination of the flood forecast information was developed through the cooperation of commercial radio and television news departments,

TABLE 14–58 Lake Ontario West, Genesee River Basin—Record Floods and Damage Area

Flood Date	Type	Damage Type	Major Location
1865 - March	Snowmelt & Rain	Commercial	Rochester
		Agricultural	Mt. Morris to Rochester
1875 - March	Rain	Commercial	Rochester
1889 - June	Rain	Commercial	Upper Basin and Dansville
		Agricultural	Upper Basin and Canaseraga Cr.
1894 - May	Rain	Agricultural	Upper and Lower Basin
1896 - April	Snowmelt	Agricultural	Lower Basin
1902 - March	Snowmelt	Commercial	Rochester
		Commercial	Upper Basin
		Agricultural	Upper and Lower Basin
1902 - July	Rain	Agricultural	Lower Basin and Canaseraga Cr.
1913 - March	Snowmelt & Rain	Commercial	Rochester
		Residential	Rochester
		Agricultural	Upper and Lower Basin
1916 - March	Snowmelt	Agricultural	Upper and Lower Basin
1916 - May	Rain	Agricultural	Upper and Lower Basin
1927 - December	Rain	Agricultural	Lower Basin & Canaseraga Cr.
1935 - July	Rain	Commercial	Upper Basin
		Agricultural	Upper Basin & Canaseraga Cr.
1936 - March	Snowmelt & Rain	Agricultural	Upper Basin & Canaseraga Cr.
1942 - July	Rain	Commercial	Upper Basin
		Agricultural	Upper Basin
1950 - March	Snowmelt & Rain	Residential	Rochester
		Agricultural	Upper and Lower Basin
1950 - November	Rain	Residential	Upper Basin
		Commercial	Upper Basin
1960 - April	Snowmelt	Agricultural	Upper Basin & Canaseraga Cr.

TABLE 14–59 Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 5.1

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	GENESEE RIVER												
B01	Monroe	Mouth	Monroe – Livingston Co. Line	1970		28,200				5150		5,150	
				1980		40,900				5114		5,114	
				2000		88,800				5065		5,065	
				2020		191,800				5003		5,003	
B01A	Monroe	Rochester		1970	46,400		65	150		115	325		
				1980	67,400		72	167		122	361		
				2000	146,500		83	189		139	410		
				2020	316,600		94	218		160	472		
B02	Livingston	Monroe-Livingston Co. Line	Livingston Allegany Co. Line	1970		4,100				1430		1,430	
				1980	700	5,500		12		1416	12	1,418	
				2000	1,400	11,400		34		1396	34	1,396	
				2020	2,800	23,000		68		1362	68	1,362	
B03	Wyoming	R.R. Bridge at Portage	Wyoming-Allegany Co. Line	1970		1,000				300		300	
				1980		1,300				300		300	
				2000		2,800				300		300	
				2020		5,200				300		300	
B04	Allegany	Wyoming Allegany Co. Line	Penn.-New York State Line	1970	1,000	18,100					20	2,491	
				1980	1,400	24,600	3	25		2483	22	2,489	
				2000	2,500	45,900	4	29		2478	25	2,486	
				2020	4,400	80,100	4	33		2474	29	2,482	
B04A	Allegany	Wellsville		1970	34,500								
				1980	46,900		50	90			480		
				2000	87,200		63	113		304	480		
				2020	152,700		72	130		278	480		
	BLACK CREEK												
B05	Monroe	Mouth	Monroe-Genesee Co. Line	1970	19,500	38,400	17	135		9542	674	9,020	
				1980	28,400	55,800	19	150		9525	746	8,946	
				2000	61,600	120,800	21	170		9503	849	8,845	
				2020	133,200	261,100	25	196		9473	978	8,716	
	RED CREEK												
B06	Monroe	Mouth	Lehigh-Station Bridge	1970	65,800		200	353		1447	2000		
				1980	95,400		222	392		1386	2000		
				2000	207,200		252	445		1303	2000		
				2020	448,000		290	512		1198	2000		
	CONESUS LAKE												
B07	Livingston	Northend	Southend	1970	2,200				149	964	149	964	
				1980	3,000				164	948	165	948	
				2000	6,200				188	925	188	925	
				2020	12,500				216	897	216	897	
	CANASERAGA CREEK												
B08	Livingston	Mouth	Steuben Co. Line	1970		71,100				10000		10,000	
				1980		95,300				10000		10,000	
				2000		196,300				10000		10,000	
				2020		399,700				10000		10,000	
	HONEOYE LAKE												
B09	Ontario	Northend	Southend	1970	1,300				65	1159	65	1,159	
				1980	1,900				72	1152	72	1,152	
				2000	4,300				82	1142	82	1,142	
				2020	9,200				94	1130	94	1,130	

TABLE 14–60 Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 5.1

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)			ESTIMATED ACRES IN FLOOD PLAIN								
		URBAN	RURAL	TOTAL	CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		GENESEE RIVER - NEW YORK											
10	1970	--	700	700	200	200	400	200	--	--	--	--	1,000
17	1970	12,000	300	12,300	100	--	200	200	400	400	200	1,000	500
23	1970	--	100	100	25	65	10	8	--	--	--	--	108
32	1970	--	2,400	2,400	300	650	100	150	--	--	--	--	1,200
33	1970	100	55,500	55,600	2,110	225	110	130	--	10	--	10	2,575
51	1970	600	500	1,100	100	234	150	10	8	45	2	55	494
73	1970	200	3,200	3,400	300	100	75	25	--	20	5	25	500
94	1970	11,300	14,500	25,800	1,685	2,145	325	545	205	715	105	1,025	4,700
255	1970	300	10,800	11,100	1,300	500	100	100	--	25	25	50	2,000
256	1970	600	7,100	7,700	820	430	210	455	15	25	11	51	1,915
257	1970	300	3,000	3,300	300	170	225	5	--	25	--	25	700
258	1970	--	2,200	2,200	245	500	100	40	--	--	--	--	885
259	1970	--	1,500	1,500	175	1,000	300	25	--	--	--	--	1,500
260	1970	--	100	100	20	60	50	175	--	--	--	--	305
261	1970	900	400	1,300	76	220	30	30	10	65	5	80	356
262	1970	--	300	300	50	204	30	20	--	--	--	--	304
263	1970	300	700	1,000	160	390	84	80	1	24	--	25	714
264	1970	--	200	200	30	164	60	30	--	--	--	--	284
138	1970	400	5,300	5,700	887	300	800	550	6	28	37	71	2,537
128	1970	400	600	1,000	55	302	50	5	7	21	2	30	412
Total	1970	27,400	109,400	136,800	8,938	7,859	3,409	2,783	652	1,403	392	2,447	22,989
	1980	35,900	161,900	197,800	8,938	7,859	3,409	2,783	652	1,403	392	2,447	22,989
	2000	62,200	191,500	253,700	8,938	7,859	3,409	2,783	652	1,403	392	2,447	22,989
	2020	112,300	215,500	327,800	8,938	7,859	3,409	2,783	652	1,403	392	2,447	22,989
		NIAGARA - ORLEANS COMPLEX - NEW YORK											
94	1970	11,300	14,500	25,800	1,685	2,145	325	545	205	715	105	1,025	4,700
246	1970	--	800	800	60	15	15	10	--	--	--	--	100
247	1970	--	600	600	155	30	45	70	--	--	--	--	300
248	1970	--	800	800	170	50	60	20	--	--	--	--	300
249	1970	--	1,800	1,800	200	100	150	150	--	--	--	--	600
250	1970	--	2,100	2,100	170	50	80	100	--	--	--	--	400
251	1970	1,000	1,700	2,700	200	50	50	100	--	100	--	100	400
252	1970	3,000	200	3,200	50	--	--	200	100	100	50	250	250
69	1970	--	2,600	2,600	190	50	50	10	--	--	--	--	300
143	1970	--	185,600	185,600	8,300	200	300	300	--	--	--	--	9,100
36	1970	--	15,600	15,600	1,500	100	300	300	--	--	--	--	2,200
Total	1970	15,300	226,300	241,600	12,680	2,790	1,375	1,805	305	915	155	1,375	18,650
	1980	20,000	334,900	354,900	12,680	2,790	1,375	1,805	305	915	155	1,375	18,650
	2000	34,700	396,000	430,700	12,680	2,790	1,375	1,805	305	915	155	1,375	18,650
	2020	62,700	445,800	508,500	12,680	2,790	1,375	1,805	305	915	155	1,375	18,650

city-county radio networks, Civil Defense communications facilities, fire bureau networks, and newspapers.

Refer to Subsection 1.54.5 for a discussion of flood plain legislation applicable to this basin.

1.61 Lake Ontario Central, River Basin Group 5.2, Oswego River Basin

1.61.1 Description

The Oswego River basin is situated in west-central New York State and is bounded by the basins of small streams which empty into Lake Ontario, the Genesee River basin, the Mohawk River basin, and the Black River basin. It has a total drainage area of 5,099 square miles. Location within River Basin Group 5.2 is shown in Figure 14–58. The Oswego River is formed by the junction of the Seneca and Oneida Rivers at Three Rivers. From this junction it flows 23 miles northwest to Lake Ontario at Oswego. The river has been canalized and has a fall of 188 feet concentrated at seven sites by dams and locks having lifts which vary from 10 to 27 feet. The direct drainage area of the Oswego River is 150 square miles.

The largest tributary of the Oswego River is Seneca River. This river, which is 62 miles long, flows in a northeasterly direction between Seneca Lake and Three Rivers and drains an area of 3,467 square miles. The river has been canalized throughout, with its fall of 82 feet having been concentrated at dams equipped with locks. Three of these locks, whose combined lift equals 63.5 feet, are in the 11 miles between Seneca Lake and Seneca Falls. Above Seneca Falls the dam at Waterloo controls the levels of Seneca Lake, and below Seneca Falls the dam at Mud Lock controls Cayuga Lake. Major tributaries to Seneca River are listed below.

(1) The Clyde River, largest of the Seneca tributaries, is formed by the junction of Canandaigua Outlet and Ganargua Creek at Lyons 19 miles above Seneca River. The total drainage area is 895 square miles, of which 309 are drained by Ganargua Creek and 445 by Canandaigua Outlet.

(2) Cayuga Lake, one of the two largest of the Finger Lake group, is 37 miles long and varies in width from one to three miles. The lake has a surface area of 66.9 square miles and is 431 feet deep at its deepest point northwest of Heddens Point. It drains an area of 780 square miles. Seneca Lake drains into this lake.

(3) Seneca Lake, one of the two largest and deepest of the Finger Lakes, is 35 miles long and varies in width from one to three miles. The lake has a surface area of 66.6 square miles and is 633 feet deep at its deepest point. It drains an area of 714 square miles. Keuka Lake drains into Seneca Lake.

(4) Onondaga Lake enters the Seneca River 8 miles above Three Rivers, draining a total of 301 square miles.

(5) Owasco Lake Outlet has its source in Owasco Lake and drains an area of 225 square miles, entering Seneca River from the south, 9 miles above Cross Lake.

(6) Oneida River, which combines with the Seneca River to form the Oswego River, has a drainage area of 1,504 square miles. It is 18 miles long and meanders in a westerly direction from Oneida Lake to Three Rivers. Parts of the Oneida River have been canalized and combined with land cuts across bends to form a 9-mile-long canal between the same points. Of the total drainage area of 1,504 square miles, 151 square miles drain directly into Oneida River. Oneida Lake, the largest in the basin, has a surface area of 80 square miles. It is 21 miles long and from 2 to 5 miles wide. Major tributaries to Oneida Lake are listed below.

(a) Fish Creek with its east and west branches comprises the largest stream system tributary to Oneida Lake. The Fish Creek system drains an area of 423 square miles north and northeast of Oneida Lake and enters the lake at the eastern end. Its two branches drain nearly equal areas above their junction at Blossvale.

TABLE 14-61 Data Summary by River Basin, River Basin Group 5.1

River Basin	Year	Estimated Average Annual Damage (Dollars)		Estimated Acres In Flood Plain	
		Urban	Rural	Urban	Rural
Niagara-Orleans Complex	1970	15,300	226,300	1,375	18,650
	1980	20,000	334,900	1,375	18,650
	2000	34,700	396,000	1,375	18,650
	2020	62,700	445,800	1,375	18,650
Genesee River	1970	198,200	270,300	6,160	53,503
	1980	281,000	385,300	6,307	53,356
	2000	579,100	657,500	6,515	53,148
	2020	1,191,700	1,176,400	6,784	52,879
TOTAL	1970	213,500	496,600	7,535	72,153
	1980	301,000	720,200	7,682	72,006
	2000	613,800	1,053,500	7,890	71,798
	2020	1,254,400	1,622,200	8,159	71,529

TABLE 14–62 River Basin Group 5.1, Data Summary by County

County (New York)	Estimated Average Annual Damages (Dollars) Urban	Estimated Average Annual Damages (Dollars) Rural	Estimated Acres in Flood Plain Urban	Estimated Acres in Flood Plain Rural
YEAR 1970				
Allegany	35,500	18,100	500	2,491
Livingston	2,200	75,200	149	12,394
Monroe	131,800	66,600	2,999	14,170
Ontario (PSA 5.2)	1,300	---	65	1,159
Genesee (See RBG 4.4)	---	---	---	---
Wyoming (See RBG 4.4)	---	1,000	---	300
TOTALS	170,800	160,900	3,713	30,514
YEAR 1980				
Allegany	48,300	24,600	502	2,489
Livingston	3,700	100,800	177	12,366
Monroe	191,200	96,700	3,109	14,060
Ontario (PSA 5.2)	1,900	---	72	1,152
Genesee (See RBG 4.4)	---	---	---	---
Wyoming (See RBG 4.4)	---	1,300	---	300
TOTALS	245,100	223,400	3,860	30,367
YEAR 2000				
Allegany	89,700	45,900	505	2,486
Livingston	7,600	207,700	222	12,321
Monroe	415,300	209,600	3,259	13,910
Ontario (PSA 5.2)	4,300	---	82	1,142
Genesee (See RBG 4.4)	---	---	---	---
Wyoming (See RBG 4.4)	---	2,800	---	300
TOTALS	516,900	466,000	4,068	30,159
YEAR 2020				
Allegany	157,100	80,100	509	2,482
Livingston	15,300	422,700	284	12,259
Monroe	897,800	452,900	3,450	13,719
Ontario (PSA 5.2)	9,200	---	94	1,130
Genesee (See RBG 4.4)	---	---	---	---
Wyoming (See RBG 4.4)	---	5,200	---	300
TOTALS	1,079,400	960,900	4,337	29,890

*On main stem and principal tributaries

TABLE 14–62A River Basin Group 5.1, Average Annual Flood Damages[1] (Auxiliary Data)

	Main Stem Reach	Tributary Reach	Avg. Annual Damage	Remarks
1.	Rochester		$ 5,000	(2)
2.	Chili		---	
		Black Cr.	16,850	
		Red Cr.	26,300	(3)
3.	Avon		5,750	
		Oatka Cr.	4,500	
		Oatka Cr. (Warsaw)	39,200	(4)
		Honeoye Cr.	3,000	
4.	Genesee		450	
		Conesus Lake	2,500	
		Keshequa Cr.	3,000	
		Canaseraga Cr.	64,650	(5)
5.	Mt. Morris		---	(6)
6.	Portageville		1,650	
		Wiscoy Cr.	3,000	
7.	Fillmore		2,250	
8.	Belfast		500	
		Angelica Cr.	7,800	
9.	Belvidere		350	
		Van Campen Cr.	1,230	
10.	Belmont		700	
11.	Scio		5,300	
12.	Wellsville		23,800	(7)
13.	Stannards Cor.		2,400	
14.	Shongo		2,450	
		Cryder Cr.	3,990	
15.	Pennsylvania		---	(6)

(1) This table, from the Genesee River Basin Coordinating Committee Report, is supplied by the New York State Department of Environmental Conservation

(2) Left bank Genesee River only

(3) Local protection project authorized 1966--Senate Document No. 107, 89th Congress, 2nd Session

(4) Construction local protection project initiated October 1966

(5) Only existing flood damages are shown

(6) No significant damages

(7) Modification existing project--Design Memorandum for Rectification of Deficiencies in Completed Local Protection Project Wellsville, N. Y., April 1966

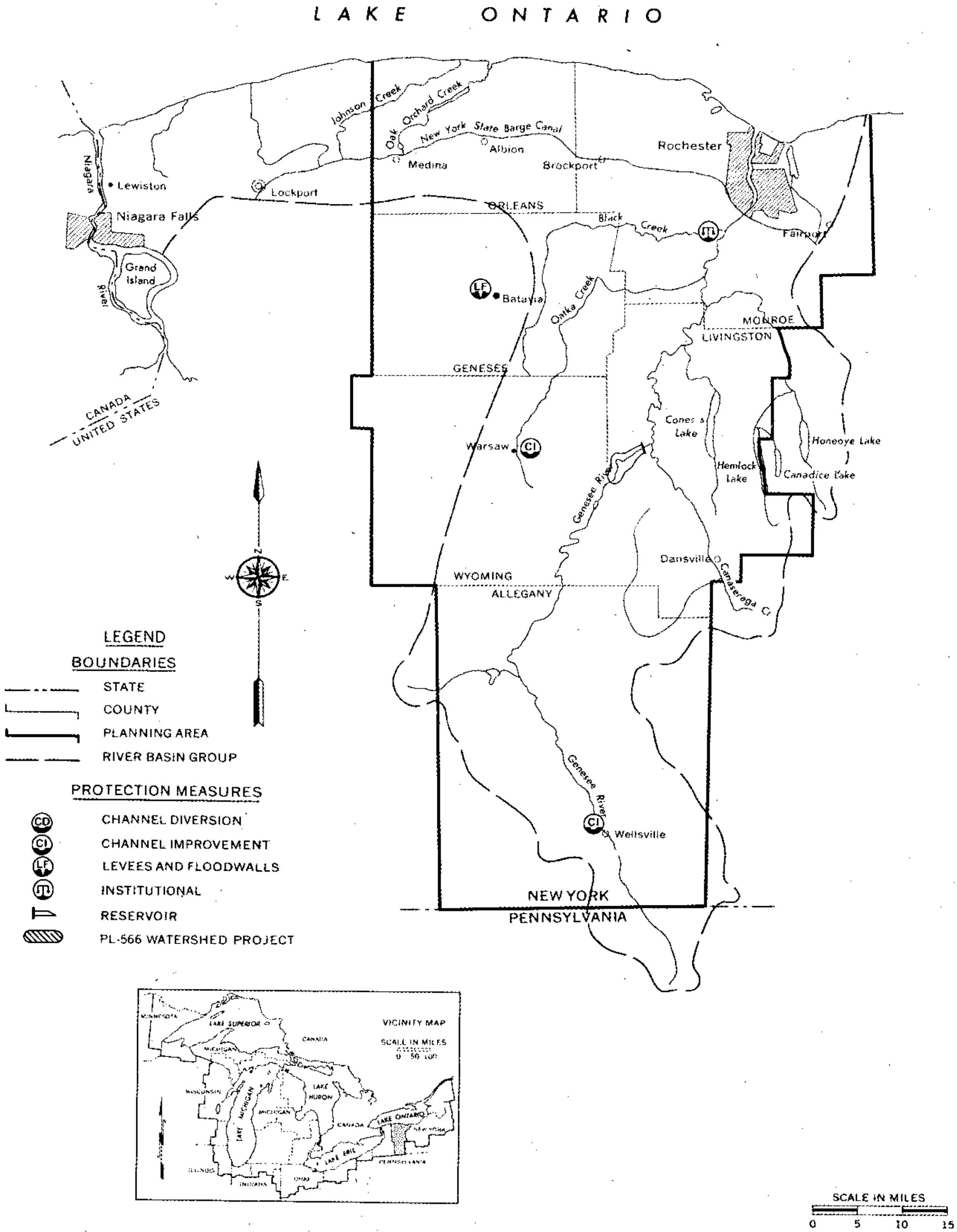

FIGURE 14–57 Existing Flood Damage Protection Measures for River Basin Group 5.1

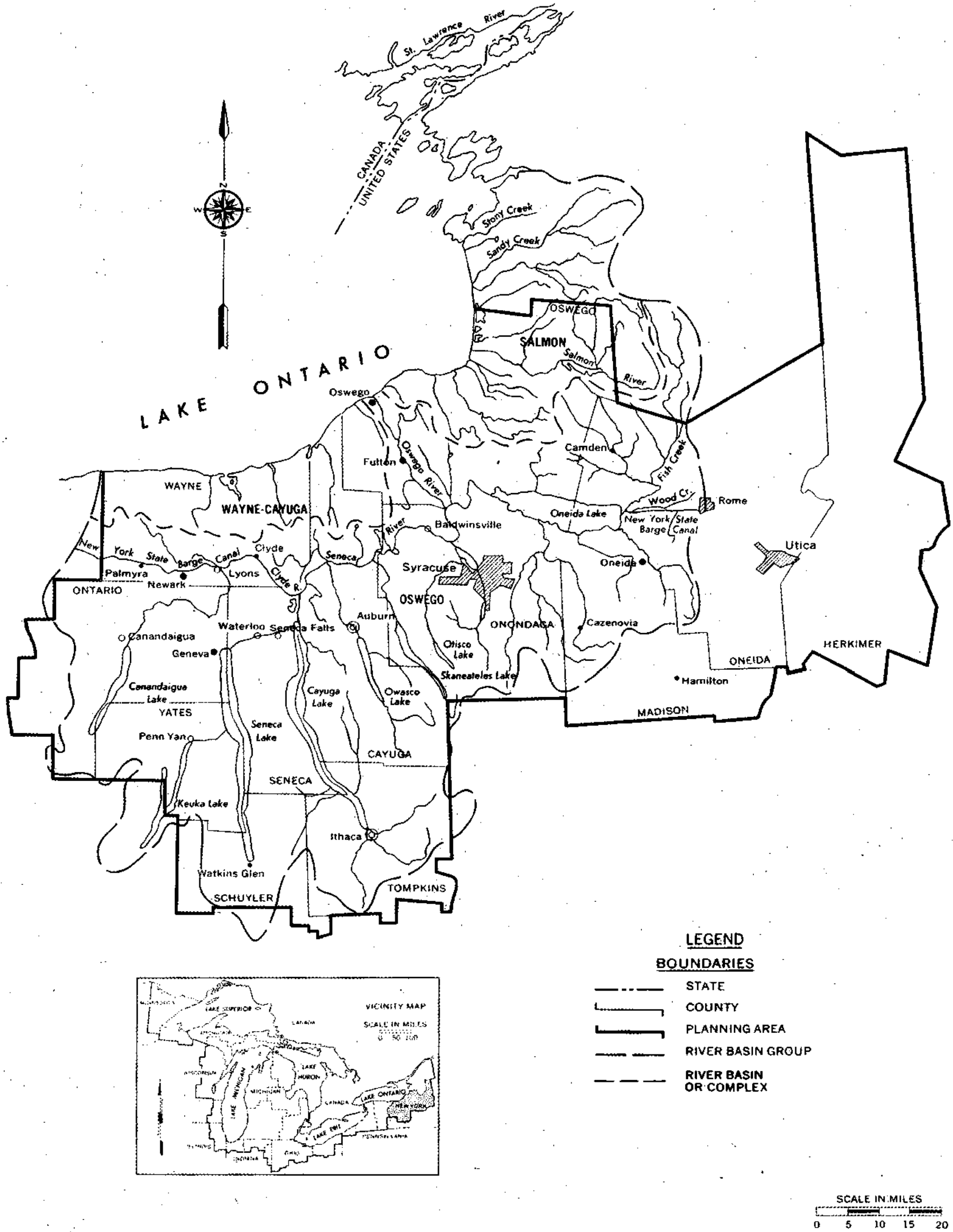

FIGURE 14–58 Lake Ontario Central—River Basin Group 5.2

(b) Chittenango Creek drains 326 square miles and enters Oneida Lake near Bridgeport. The watershed is triangular in shape with its apex at Oneida Lake and its base 20 miles wide located 27 miles south of the lake.

(c) Oneida Creek drains a hook-shaped area of 147 square miles to the south of Oneida Lake.

(7) The New York State Barge Canal was completed about 1918 and provides for a 12-foot draft. It follows a land line, locking down to Oneida Lake, crosses the lake, and goes down the Oneida River to Three Rivers. The canal then goes up the Seneca and Clyde Rivers to Lyons. From Lyons it goes west on a land line, leaving the basin near Macedon and continuing to lock up (seven locks in all) to the Genesee River at the south edge of Rochester. The Oswego Branch of the canal uses the Oswego River between Three Rivers and Oswego.

1.61.2 Previous Studies

Previous studies are listed below:

(1) 1970—Soil Conservation Service Preliminary Investigation Report on the Rome Muck Watershed, Oneida County, New York; Flint Creek Watershed, Ontario and Yates Counties, New York

(2) 1968—Flood Plain Information Report, Canandaigua Outlet, Ontario and Wayne Counties, New York

(3) 1967—Flood Plain Information Report, Canandaigua Lake, New York

(4) 1967—Flood Plain Information Report, Seneca Lake, New York

(5) 1967—A Review of Reports for Flood Control, "Chittenango Creek, New York," dated 1967, authorized by resolution adopted by the Committee on Public Works, House of Representatives, August 24, 1961. The report, submitted March 27, 1967, recommended that improvements were not considered economically justifiable. Local improvements were considered on Limestone and Butternut Creeks, tributaries of Chittenango Creek. Retention reservoirs were considered on all three creeks.

(6) 1967—Flood Plain Information Report, Cayuga Lake, New York

(7) 1960—A Review Report on Cayuga Inlet for flood control in the vicinity of Ithaca, New York, submitted and published in House Document No. 204, 86th Congress. It recommended that a project be authorized for flood protection on Cayuga Inlet. The project, which was completed in 1969, consisted of a concrete drop structure and included facilities for a fish passage at the head of an improved channel and a closure structure, channel widening and realigning for approximately 5,000 feet downstream from the drop structure, and replacement of a railroad bridge just below the drop structure. The project is designed for discharge that has a recurrence interval in the order of one in 100 years.

(8) Design Memorandum for Local Flood Protection at Auburn, New York (completed project, 1962)

(9) Detailed Project Report for Flood Control, "Onondaga Creek at Nedrow, New York" (completed project, 1963)

(10) 1959—A Reconnaissance Report on Keuka Outlet at Penn Yan, New York, for improvement for flood control submitted by the District Engineer June 10, 1959. This was followed by a detailed project report. The project, although economically feasible, was not constructed because of lack of local cooperation. A plan of operation recommended that Keuka Lake be controlled as nearly as may be possible to remain between a maximum elevation of 713.5 and a minimum elevation of 712.0.

(11) 1956—Review of Report for Flood Control, "Marsh Creek at and in the Vicinity of Geneva, New York." The report was authorized by the Committee on Public Works, House of Representatives, October 16, 1951. The report, submitted December 14, 1956, recommended the following improvements: widening and deepening the existing channel, realigning a portion of it, and installing closure structures on storm sewers entering the creek.

(12) 1947—In response to the request of local interests, an investigation into the possibility of cleaning and enlarging the outlet channel between Owasco Lake and State Dam under the general authority of Section 2 of the Flood Control Act approved August 1937, as amended (completed project, 1949)

(13) Definite Project Report on Local Flood Protection on Onondaga Creek at Syracuse, New York (completed project, 1951)

(14) 1941—The Flood Control Act of 1941 authorizing construction of a local improvement project at Ithaca, consisting of channel enlargements, levees, and related works on Cascadilla and Fall Creeks. Construction has not been started.

(15) 1940—A Survey Report on the Oswego River Watershed, prepared by a Special Board

of Officers, submitted to Congress June 17, 1940, and published as House Document No. 846, 76th Congress, 3rd Session. The report recommended construction of local improvements for flood control at eight localities, including a project on Cascadilla and Falls Creeks at Ithaca. The Board found that improvement of Cayuga Inlet was not warranted at that time.

(16) 1939—The Survey Report for Flood Control in the Oswego River Watershed submitted by the Board of Officers, February 1939 (revised October 1939). The Board recommended that a project be undertaken subject to certain conditions of local cooperation.

(17) 1937—Report of Preliminary Examination, dated April 17, 1937, authorized by the Flood Control Acts of April and June 1936, and submitted by a Special Board of Officers. It recommended that surveys be made for the purpose of planning flood control improvements at Montour Falls and was followed by a Definite Project Report on Local Flood Protection at Montour Falls, New York (completed project, 1953).

(18) Definite Project Report on Local Flood Protection at Watkins Glen, New York. The authorized project consisted of enlarging the channel of Glenn Creek through the village, protecting the banks, constructing flood walls, replacing one highway bridge, and adding spans to one highway and one railroad bridge. A review of the economics of the local improvement project at Watkins Glen, New York, was authorized by the Chief of Engineers on October 2, 1957. Based on this study, the plan of improvement was not economically justified, and it was recommended that the authorized project be classified as inactive.

(19) 1937—The Report of the Preliminary Examination, authorized by the Flood Control Acts of April and June 1936, submitted by the Special Board of Officers, April 1937. It recommended that surveys be made to determine flood control plans for Syracuse and other localities.

(20) 1927—Report of Onondaga Creek Flood Prevention submitted to the Mayor and Council of Syracuse by the Syracuse Intercepting Sewer Board in 1927. The work recommended in that report was essentially the same as that in the authorized project.

(21) The U.S. Geological Survey—flood-prone area reports for portions of Seneca and Oneida Rivers and Lerg, Butternut, and Limestone Creeks

1.61.3 Development in the Flood Plain

The Finger Lakes area has been the destination of vacationists for many years, and considerable recreational activity takes place around these lakes (Skaneateles, Owasco, Cayuga, Seneca, Keuka, and Canandaigua) each summer. The principal recreation activities include swimming, boating, picnicking, camping, touring, hunting, hiking, and winter sports. Recreation in general is a major influence in the economy of the basin and expenditures in connection with recreation by vacationists, tourists, and sportsmen constitute the principal source of revenue for a number of towns and communities. State and county parks contain nearly 10,000 acres of the land in the basin.

There are a variety of establishments and accommodations for the tourist and vacationist. Private summer homes and camps dot the shores of most lakes, and hotels, motels, cabins, cottages, tourist homes, and related establishments are distributed generally throughout the basin. Roseland Park at the foot of Canandaigua Lake is perhaps the largest commercial amusement park in the Finger Lakes area. At Watkins Glen the annual Grand Prix sports car race is an event which attracts many visitors from far and near.

The Erie Canal, constructed between 1817 and 1825, led to rapid development of the basin and to a demand for branch canals. The Oneida Lake Canal was built in 1835 from New London to the lake. The Oswego Canal, from Syracuse to Oswego, was built between 1825 and 1829. The Cayuga and Seneca Canal, following the Seneca River from near Montezuma to Geneva with a short branch to Cayuga Lake, was built between 1826 and 1829. An extension at Ithaca was built in 1869. The Crooked Lake Canal between Dresden and Penn Yan, parallel to Keuka Outlet, was built between 1831 and 1833, and abandoned in 1877. The Erie Canal was enlarged twice before 1890 and was abandoned for navigation in 1918 when the New York State Barge Canal was completed. It provides for a draft of 12 feet, whereas the Erie Canal only provided a draft of approximately 4 feet.

Except in the Tug Hill area, agriculture is well developed. Dairying is carried on throughout the entire basin. General farm crops and some dairy products are produced along the Oswego River. In the central lowland, particularly in drained swamp areas, vegetables are intensively cultivated. Along the northern fringe of the basin and the Finger Lakes fruit growing predominates. Grapes are grown along Canandaigua and Keuka Lakes. At Hammondsport, Penn Yan, and Naples, the specialty is wine. Nursery stock is grown at Geneva and Newark.

Industry is highly developed in the basin. A great variety of articles is produced in the villages, nearly all of which have one or more small industry. The principal industrial center is Syracuse where chemicals, electrical equipment, steel, typewriters, pottery, and machinery are manufactured.

1.61.4 Flood Problems

Flooding occurs in the Oswego River basin at any time of the year and there is usually some flooding every year. High flows occur nearly every spring from a combination of melting snow and rainfall. Summer storms usually affect only small areas. Although the basin comprises a total of 5,099 square miles, its principal flood problems occur at points where the tributary drainage area is 200 square miles or less. Due to regulation provided by the basin's lakes, damages along the main stream are relatively low.

The flood during July 7 and 8, 1935, caused the greatest damage of any single flood. Damage occurred principally in the headwaters of the western part of the basin. The levels of Seneca and Cayuga Lakes reached record heights and some damage was reported along the Seneca River. Flooding was widespread in June 1922, November 1927, June 1930, August 1937, August 1938, April 1940, July 1942, May and June 1947, and March 1950.

Figure 14–59c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–63 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–64 indicates upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–60c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–65. County summaries for the main stem and principal tributaries are tabulated in Table 14–66.

1.61.5 Existing Flood Damage Prevention Measures

There are several Corps structural projects completed in the Oswego River basin. A brief summary of these projects is as follows:

(1) Syracuse—This project, on Onondaga Creek, consists of two sections. Onondaga Reservoir, located 4 miles south of Syracuse, provides 18,200 acre-feet of storage. The earth dam is 1,780 feet long with a maximum height of 67 feet. A side channel spillway in the east abutment has a crest length of 200 feet. Outflow from the reservoir is limited by the capacity of a 6.5-foot diameter ungated conduit to a maximum of 1,270 cubic feet per second with a full reservoir. The other portion of the project is 2.1 miles of channel widening, deepening, and straightening of the creek in the southern part of Syracuse. Location of the preventive measure is shown in Figure 14–61.

(2) Montour Falls—This project consists of works on Catharine Creek and a tributary, Shequaga Creek. It is designed to protect the Village of Montour Falls against a repetition of the maximum flood of record. Catharine Creek was diverted into a new channel, 7,200 feet long. A levee 8,200 feet long was constructed along the west side of the new channel with a gated culvert to provide flow in the old channel for sanitation. Improvements on Shequaga Creek include a stilling basin (at the foot of the fall where the stream enters the village), a concrete conduit with two barrels, each 14.5 feet square and 560 feet long, and enlargement of 1,800 feet of channel with a levee on the south bank 140 feet long.

(3) Moravia—The project at Moravia consists of improvements along Owasco Inlet, Mill Creek, and Dry Creek. The channel of Mill Creek was enlarged for a length of 4,500 feet. A levee 2,200 feet long was constructed along the north bank of Dry Creek, short sections of the channel were enlarged, and a span was added to a railroad bridge. The channel of Owasco Inlet was cleared for 5.4 miles to provide a getaway channel and improve the carrying capacity of the other two streams, thereby reducing flood stages locally between Moravia and Owasco Lake.

(4) Geneva—The project consists of widening and deepening the channel from Seneca Lake to about 800 feet upstream of the Lehigh Valley Railroad. Abutments of three bridges were underpinned and short sections of concrete walls were constructed.

(5) Auburn—The project consists of improving the outlet between Owasco Lake and

TABLE 14–63 Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 5.2

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	OSWEGO RIVER												
BQ1	Oswego	Mouth	Seneca	1970		2,800		10	10	141		161	
			Oneida R.	1980		3,900		13	13	135		161	
			Junction	2000		8,400		16	16	129		161	
				2020		17,300		20	20	121		161	
BQ2	Onondaga	Onondaga-	Seneca-	1970						40		40	
		Oswego Co.	Oneida R.	1980	500			3		37	3	37	
		Line	Junction	2000	1,100			4		36	4	36	
				2020	2,600			5		35	5	35	
	SENECA RIVER												
BQ3	Onondaga	Junction	Onondaga-	1970		59,500	15	75	157	2924		3,171	
		Oswego-	Cayuga	1980		93,500	19	97	202	2853		3,171	
		Oneida	Co. Line	2000		220,800	25	124	259	2763		3,171	
		Rivers		2020		506,300	31	153	320	2667		3,171	
BQ4	Cayuga	Cayuga-	Cayuga-	1970		4,400		29	15	8142		8,186	
		Onondaga	Seneca	1980		6,300		37	19	8130		8,186	
		Co. Line	Co. Line	2000		12,800		48	25	8113		8,186	
				2020		25,900		59	31	8096		8,186	
BQ5	Wayne	Wayne-	Seneca-	1970		1,900				2985		2,985	
		Cayuga	Wayne	1980		3,500		5		2980		2,985	
		Co. Line	Co. Line	2000		8,000		15		2970		2,985	
				2020		18,200		26		2959		2,985	
BQ6	Seneca	Seneca-	Seneca-	1970	400	7,000	8		37	6204	8	6,241	
		Cayuga-	Ontario	1980	600	11,400	10		51	6188	10	6,239	
		Wayne	Co. Line	2000	1,300	24,200	13		80	6156	13	6,235	
		Co. Lines		2020	2,700	50,900	16		109	6124	16	6,233	
	SENECA LAKE												
BQ7	Seneca	Seneca-	Seneca-	1970	1,200	600	16	55	85	620	536	240	
		Yates	Schuyler	1980	1,900	1,000	21	71	110	574	544	232	
		Co. Line	Co. Line	2000	3,900	2,000	26	91	140	519	545	231	
				2020	8,100	4,000	32	112	173	459	491	285	
BQ8	Schuyler	Seneca-	Yates-	1970	700	300	10	30	25	790	1030	25	
		Schuyler	Schuyler	1980	1,100	500	13	39	32	971	1023	32	
		Co. Line	Co. Line	2000	2,100	900	16	49	41	949	1014	41	
				2020	4,600	2,000	20	61	51	923	1004	51	
BQ9	Yates	Seneca-	Yates-	1970		1,200	5	20	70	120		215	
		Yates	Schuyler	1980		1,700	6	26	90	93		215	
		Co. Line	Co. Line	2000		4,400	8	33	116	58		215	
				2020		8,600	10	41	123	41		215	
	KEUKA LAKE												
BQ10	Yates	Seneca-	Yates-	1970		12,600	20	118	162	380		680	
		Lake	Steuben	1980		14,100	26	152	187	315		680	
		Inlet	Co. Line	2000		35,600	30	152	187	311		680	
				2020		69,400	33	152	187	308		680	
BQ11	Steuben	Yates-	Yates -	1970		9,700	11	100	100	189		400	
		Steuben	Steuben	1980		14,200	14	129	129	128		400	
		Co. Line	Co. Line	2000		24,900	18	150	129	103		400	
				2020		48,600	18	150	129	103		400	
	CANANDAIGUA LAKE & OUTLET												
BQ12	Wayne	Wayne-	Wayne-	1970	6,400	10,100	59	35		9996	218	9,812	
		Seneca-	Ontario	1980	9,800	19,900	76	45	54	9915	281	9,809	
		Cayuga	Co. Line	2000	22,200	45,100	98	57	172	9763	360	9,730	
		Co. Line		2020	50,500	102,600	120	71	288	9611	444	9,646	
BQ13	Ontario	Wayne-	Ontario-	1970	1,700	9,200	114	175	70	3211	410	3,160	
		Ontario	Yates	1980	2,500	13,500	147	226	90	3101	529	3,041	
		Co. Line	Co. Line	2000	5,600	30,400	188	288	115	2979	677	2,893	
				2020	12,100	65,500	232	357	143	2836	836	2,734	
BQ14	Yates	Ontario-	Ontario-	1970		1,400	3	10		45		58	
		Yates	Yates	1980		2,000	4	13	19	22		58	
		Co. Line	Co. Line	2000		5,100	5	16	25	12		58	
				2020		10,100	6	20	31	1		58	

TABLE 14-63(continued) Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 5.2

REACH CODE	COUNTY	REACH LOCATION FROM	REACH LOCATION TO	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) URBAN	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS) RURAL	ESTIMATED ACRES IN FLOOD PLAIN: INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	REMARKS
	CAYUGA LAKE												
BQ15	Cayuga	Cayuga-	Cayuga-	1970		8,700	4	34	143	160		341	
		Seneca	Tompkins	1980		12,800	5	44	184	108		341	
		Co. Line	Co. Line	2000		24,900	7	56	181	91		341	
				2020		50,000	8	69	152	112		341	
BQ16	Seneca	Seneca-	Seneca-	1970		8,700	2	42	164	379		587	
		Cayuga	Tompkins	1980		13,100	2	54	212	319		587	
		Co. Line	Co. Line	2000		28,000	3	69	271	244		587	
				2020		59,100	4	86	334	163		587	
BQ17	Tompkins	Tompkins-	Tompkins-	1970		4,400	4	30	56	250		340	
		Seneca	Cayuga	1980		7,000	4	39	72	225		340	
		Co. Line	Co. Line	2000		18,100	6	50	92	192		340	
				2020		44,900	8	61	114	157		340	
	OWASCO LAKE AND OUTLET												
BQ18	Cayuga	Seneca	South end	1970		2,700	7	75	20	1453		1,555	
		River		1980		3,700	9	96	26	1424		1,555	
				2000		8,000	11	124	33	1357		1,555	
				2020		16,000	14	153	41	1347		1,555	
	SKANEATELES LAKE AND OUTLET												
BQ19	Onondaga	Onandaga-	Onondaga-	1970	9,200	2,500	17	51	15	1535	54	1,564	
		Cayuga	Cortland	1980	14,500	4,100	21	66	19	1512	70	1,548	
		Co. Line	Co. Line	2000	34,000	9,400	28	84	25	1481	89	1,529	
				2020	78,200	21,000	34	104	31	1449	110	1,508	
BQ20	Cayuga	Onondaga-	Cortland-	1970		200		6	10	100		116	
		Cayuga	Cayuga	1980		200		8	13	95		116	
		Co. Line	Co. Line	2000		600		10	16	90		116	
				2020		1,200		12	20	84		116	
BQ21	Cortland	Onondaga-	Cortland-	1970			2	1	3	50		56	
		Cortland	Cayuga	1980		300	2	1	4	49		56	
		Co. Line	Co. Line	2000		600	3	2	5	46		56	
				2020		1,500	4	2	6	44		56	
	OTISCO LAKE AND OUTLET												
BQ22	Onondaga	Mouth at	South end	1970	2,000	2,400	18	86	11	1139	66	1,254	
		Onondaga	of Lake	1980	3,100	3,800	24	111	14	1171	86	1,234	
		Lake		2000	7,300	8,900	29	142	18	1131	109	1,211	
				2020	16,900	20,700	37	175	14	1094	135	1,185	
	ONONDAGA LAKE												
BQ23	Onondaga	North end	South end	1970	3,100		90			467	557		
				1980	4,800		90			467	557		
				2000	11,500		90			467	557		
				2020	26,400		90			467	557		
	ONEIDA RIVER AND LAKE												
BQ24	Oswego	Oswego	Oswego-	1970		35,500	13	33	196	4002		4,244	
		River	Oneida	1980		50,800	17	42	253	3932		4,244	
			Co. Line	2000		105,400	21	55	323	3845		2,244	
				2020		220,800	26	61	400	3751		2,244	
BQ25	Onondaga	Oswego	Roudell	1970		43,100	14	25	213	2243		2,495	
		River		1980		67,600	17	32	274	2172		2,495	
				2000		159,800	23	42	305	2125		2,495	
				2020		366,500	26	49	338	2082		2,495	
BQ26	Oneida	Oneida-	Oneida	1970	1,600	23,800	18	27	150	935	32	1,098	
		Oswego	City	1980	2,400	34,700	23	35	174	895	41	1,089	
		Co. Line	Boundary	2000	4,800	71,700	29	45	156	900	53	1,077	
				2020	9,700	144,000	36	55	137	902	66	1,064	
BQ27	Madison	Onondaga-	Oneida	1970	800	17,600	10	20	90	1241	14	1,347	
		Madison	City	1980	1,300	27,800	12	26	116	1209	18	1,343	
		Co. Line	Boundary	2000	2,900	64,800	16	35	148	1164	23	1,338	
				2020	6,900	151,000	20	40	184	1117	28	1,333	
	CHITTENANGO CREEK												
BQ28	Onondaga	Mouth at	18 Mile	1970		4,400				828		828	
		Oneida	Creek	1980		7,100		10		818		828	
		Lake		2000		16,300		13		815		828	
				2020		37,600		16		812		828	
BQ29	Madison	Mouth at	18 Mile	1970		4,300		7		825		832	
		Oneida	Creek	1980		6,900		9		823		832	
		Lake		2000		15,900		12		820		832	
				2020		37,200		14		818		832	

TABLE 14–64 Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 5.2

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)			ESTIMATED ACRES IN FLOOD PLAIN								
		URBAN	RURAL	TOTAL	CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		OSWEGO RIVER - NEW YORK											
462	1970	200	--	200	--	--	--	--	--	20	--	20	--
433	1970	--	49,700	49,700	785	--	--	--	--	--	--	--	785
5	1970	600	46,100	46,700	4,600	800	200	400	10	40	--	50	6,000
12	1970	16,000	--	16,000	--	20	--	10	--	175	75	250	30
71	1970	26,000	2,500	28,500	550	1,300	1,050	100	800	1,000	200	2,000	3,000
122	1970	1,200	18,900	20,100	850	1,500	700	700	30	60	10	100	3,750
127	1970	--	86,500	86,500	790	--	640	445	--	--	--	--	1,875
142	1970	--	2,300	2,300	200	200	100	200	--	--	--	--	700
419	1970	2,500	2,800	5,300	450	550	75	25	75	100	25	200	1,100
423	1970	--	300	300	100	20	20	10	--	--	--	--	150
424	1970	--	2,000	2,000	300	50	100	50	--	--	--	--	500
425	1970	800	1,600	2,400	400	600	1,500	500	30	20	--	50	3,000
426	1970	--	36,300	36,300	600	100	100	--	--	--	--	--	800
11	1970	300	130,000	130,300	2,550	450	1,500	288	2	22	47	71	4,788
29	1970	--	200	200	50	50	200	100	--	--	--	--	400
30	1970	--	26,000	26,000	325	175	--	--	--	--	--	--	500
52	1970	700	600	1,300	150	220	80	50	5	60	85	150	500
68	1970	18,000	1,400	19,400	443	74	221	512	200	221	--	421	1,250
137	1970	2,300	1,800	4,100	410	500	500	4,590	30	120	10	160	6,000
140	1970	4,100	1,000	5,100	428	72	158	--	1	54	--	55	658
150	1970	300	4,300	4,600	250	315	225	1,125	4	15	40	59	1,915
434	1970	--	3,000	3,000	874	1,750	550	650	--	--	--	--	3,824
435	1970	--	6,000	6,000	451	415	1,510	215	--	--	--	--	2,591
436	1970	--	200	200	70	50	200	100	--	--	--	--	420
439	1970	--	2,200	2,200	175	50	75	12	--	--	--	--	312
441	1970	200	200	400	20	20	435	2	--	21	1	22	477
442	1970	100	400	500	80	320	400	20	--	10	--	10	820
443	1970	100	600	700	60	40	60	115	1	7	2	10	275
446	1970	--	700	700	122	165	218	70	--	--	--	--	575
447	1970	--	1,000	1,000	290	89	112	60	--	--	--	--	551
448	1970	--	100	100	10	10	--	--	--	--	--	--	20
450	1970	2,000	2,600	4,600	750	610	340	40	5	195	--	200	1,740
451	1970	--	1,100	1,100	289	178	342	70	--	--	--	--	879
453	1970	--	10,200	10,200	850	100	--	50	--	--	--	--	1,000
454	1970	300	31,900	32,200	1,700	600	1,800	1,550	10	5	5	20	5,650
455	1970	--	9,400	9,400	800	600	750	1,000	--	--	--	--	3,150
456	1970	400	2,300	2,700	350	200	600	850	8	22	--	30	2,000
458	1970	--	2,700	2,700	789	454	734	2,402	--	--	--	--	4,379
459	1970	--	1,000	1,000	300	90	250	100	--	--	--	--	740
461	1970	--	1,000	1,000	125	75	100	--	--	--	--	--	300
Total	1970	76,100	490,900	567,000	22,336	12,812	15,845	16,411	1,211	2,167	500	3,878	67,404
	1980	102,000	687,300	789,300	22,336	12,812	15,845	16,411	1,211	2,167	500	3,878	67,404
	2000	184,200	824,700	1,008,900	22,336	12,812	15,845	16,411	1,211	2,167	500	3,878	67,404
	2020	342,500	937,600	1,280,100	22,336	12,812	15,845	16,411	1,211	2,167	500	3,878	67,404
		SALMON - PERCH - NEW YORK											
92	1970	600	1,700	2,300	400	800	580	20	10	40	50	100	1,800
393	1970	--	100	100	25	75	40	10	--	--	--	--	150
Total	1970	600	1,800	2,400	425	875	620	30	10	40	50	100	1,950
	1980	800	2,500	3,300	425	875	620	30	10	40	50	100	1,950
	2000	1,500	3,000	4,500	425	875	620	30	10	40	50	100	1,950
	2020	2,700	3,400	6,100	425	875	620	30	10	40	50	100	1,950
		WAYNE - CAYUGA COMPLEX - NEW YORK											
20	1970	4,000	--	4,000	--	--	--	--	150	100	50	300	--
253	1970	8,000	3,700	11,700	1,060	400	1,000	1,115	300	202	101	603	3,575
116	1970	100	7,000	7,100	350	--	450	--	--	4	--	4	800
427	1970	200	1,400	1,600	540	20	110	47	5	5	40	50	717
428	1970	--	23,700	23,700	1,300	50	500	150	--	--	200	200	2,000
429	1970	--	4,300	4,300	700	50	200	50	--	--	--	--	1,000
430	1970	--	6,300	6,300	250	--	50	--	--	--	--	--	300
431	1970	--	2,100	2,100	310	100	130	160	--	--	--	--	700
432	1970	--	2,600	2,600	100	--	200	--	--	--	--	--	300
Total	1970	12,300	51,100	63,400	4,610	620	2,640	1,522	455	311	391	1,157	9,392
	1980	16,500	71,500	88,000	4,610	620	2,640	1,522	455	311	391	1,157	9,392
	2000	29,800	85,800	115,600	4,610	620	2,640	1,522	455	311	391	1,157	9,392
	2020	55,400	97,600	153,000	4,610	620	2,640	1,522	455	311	391	1,157	9,392

TABLE 14–65 Data Summary by River Basin, River Basin Group 5.2

River Basin	Year	Estimated Average Annual Damage (Dollars) Urban	Rural	Estimated Acres In Flood Plain Urban	Rural
Wayne-Cayuga Complex	1970	12,300	51,100	1,157	9,392
	1980	16,500	71,500	1,157	9,392
	2000	29,800	85,800	1,157	9,392
	2020	55,400	97,600	1,157	9,392
Oswego River	1970	103,200	769,900	6,803	119,495
	1980	144,500	1,112,700	7,040	119,258
	2000	280,900	1,779,700	7,322	118,976
	2020	561,200	3,038,500	7,570	118,728
Salmon River Complex	1970	600	1,800	100	1,950
	1980	800	2,500	100	1,950
	2000	1,500	3,000	100	1,950
	2020	2,700	3,400	100	1,950
TOTALS	1970	116,100	822,800	8,060	130,837
	1980	161,800	1,186,700	8,297	130,600
	2000	312,200	1,868,500	8,579	130,318
	2020	619,300	3,139,500	8,827	130,070

the State Dam, rehabilitation of the State Dam, and adoption of an operation schedule under which maximum use would be made of these improvements to hold lake stages and outlet discharges within nondamaging limits.

(6) Ithaca—The project consists of a concrete drop structure at the head of the improved channel and wing levees from the ends of the drop structure to high ground; a closure structure where the left bank crosses a railroad; widening and realigning the channel for about 4,800 feet downstream of the drop structure; and widening on its present alignment for approximately 4,300 feet at its downstream end, the latter reach extending into Cayuga Lake. Between these two widened reaches flows will be divided between two channels, the existing channel which will be maintained at its present capacity, and a new channel 6,000 feet long. Two new highway bridges and a railroad bridge near the drop structure were replaced. In addition, the project includes facilities at the drop structure for fish passage and fish trappings to provide for research and lamprey control. The channel between the drop structure and Taber Street is wide enough for a three-lane crew-racing course.

(7) After a flood in 1905 the City of Ithaca enlarged the channel of Sixmile Creek and constructed walls and levees along the banks. These improvements have practically eliminated flood damage from Sixmile Creek.

(8) About 1870, in connection with an enlargement of the Erie Canal, the State constructed reservoirs on Chittenango Creek at Erieville, on Limestone Creek near DeRuyter, and on Butternut Creek near Jamesville, and regulating works for Cazenovia Lake on a tributary of Chittenango Creek.

(9) In Fayetteville a levee was constructed along the west bank of Limestone Creek from the West Genesee Street bridge to a point 1,600 feet upstream. This levee was completed in 1918.

(10) In 1935 improvements partially financed with Federal aid in the Village of Chittenango on Chittenango Creek consisted of deepening, widening, and realigning the creek channel for 4,200 feet through the village. The New York State Department of Public Works, in 1938, extended the improved channel an additional 1,000 feet.

(11) A P.L.–566 watershed project has been constructed by the Soil Conservation Service on Cowaselon Creek in Madison County, New York.

Refer to Subsection 1.54.5 for a discussion of flood plain legislation applicable to this basin.

TABLE 14-66 River Basin Group 5.2, Data Summary by County

County (New York)	Estimated Average Annual Damages (Dollars) Urban	Rural	Estimated Acres in Flood Plain Urban	Rural
YEAR 1970				
Cayuga	---	16,000	---	10,198
Cortland	---	---	---	56
Madison	800	21,900	14	2,179
Oneida	1,600	23,800	32	1,098
Onondaga	14,300	111,900	677	9,352
Ontario (See RBG 5.1)	1,700	9,200	410	3,160
Oswego	---	38,300	---	4,405
Schuyler	700	300	1,030	25
Seneca	1,600	16,300	544	7,068
Steuben	---	9,700	---	400
Tompkins	---	4,400	---	340
Wayne	6,400	12,000	218	12,857
Yates	---	15,200	---	953
TOTALS	27,100	279,000	2,925	52,091
YEAR 1980				
Cayuga	---	23,000	---	10,198
Cortland	---	300	---	56
Madison	1,300	34,700	18	2,175
Oneida	2,400	34,700	41	1,089
Onondaga	22,900	176,100	716	9,313
Ontario (See RBG 5.1)	2,500	13,500	529	3,041
Oswego	---	54,700	---	4,405
Schuyler	1,100	500	1,023	32
Seneca	2,500	25,500	554	7,058
Steuben	---	14,200	---	400
Tompkins	---	7,000	---	340
Wayne	9,800	23,400	281	12,794
Yates	---	17,800	---	953
TOTALS	42,500	425,400	3,162	51,854
YEAR 2000				
Cayuga	---	46,300	---	10,198
Cortland	---	600	---	56
Madison	2,900	80,700	23	2,170
Oneida	4,800	71,700	53	1,077
Onondaga	53,900	415,200	759	9,270
Ontario (See RBG 5.1)	5,600	30,400	677	2,893
Oswego	---	113,800	---	4,405
Schuyler	2,100	900	1,014	41
Seneca	5,200	54,200	558	7,054
Steuben	---	24,900	---	400
Tompkins	---	18,100	---	340
Wayne	22,200	53,100	360	12,715
Yates	---	45,100	---	953
TOTALS	96,700	955,000	3,444	51,572
YEAR 2020				
Cayuga	---	93,100	---	10,198
Cortland	---	1,500	---	56
Madison	6,900	188,200	28	2,165
Oneida	9,700	144,000	66	1,064
Onondaga	124,100	952,100	807	9,222
Ontario (See RBG 5.1)	12,100	65,500	836	2,734
Oswego	---	283,100	---	4,405
Schuyler	4,600	15,600	1,004	51
Seneca	10,800	114,000	507	7,105
Steuben	---	48,600	---	400
Tompkins	---	44,900	---	340
Wayne	50,500	120,800	444	12,631
Yates	---	88,100	---	953
TOTALS	218,700	2,100,900	3,692	51,324

*On main stem and principal tributaries

TABLE 14-66A River Basin Group 5.2, Nonagricultural Average Annual Flood Damages* (Auxiliary Data)

	Existing	1980	2020
Basin	284,000	433,200	2,141,500
Lakes			
Canandaigua	9,400	13,700	67,000
Cayuga	21,800	32,900	153,800
Seneca	4,000	6,200	27,300
Keuka	21,800	27,700	114,400
Owasco	1,700	2,400	10,100
Skaneateles	600	1,300	5,900
Otisco	1,700	2,700	14,700
Oneida	75,100	112,800	539,400
Lake Outlets			
Canandaigua	10,400	15,800	79,900
Owasco	1,000	1,300	5,900
Skaneateles	11,300	17,800	96,000
Otisco (Ninemile Cr.)	2,700	4,200	22,900
Barge Canal (Erie Div.)	119,800	190,300	985,900
Cayuga-Seneca Canal	2,700	4,100	18,300

* This table, from the draft of the tentative Oswego River Basin Report, is supplied by the New York State Department of Environmental Conservation. Differences in this table and those previously presented occur as a consequence of variances in study criteria, principally methodology of damage projection.

1.62 Lake Ontario East, River Basin Group 5.3, Black River Basin

1.62.1 Description

The Black River drains an area of 1,916 square miles in the southwestern part of the Adirondack region of northern New York. Its basin is located east of Lake Ontario. The basin adjoins the St. Lawrence drainage basin on the north and east, the Hudson River basin on the east and south, and the Oswego River basin and the drainage basins of small streams that empty into Lake Ontario on the south and west. Location within River Basin Group 5.3 is shown in Figure 14-62. It is approximately 75 miles wide in an east-west direction and 40 miles from north to south at the widest point. The river rises in North Lake, flows southwesterly 15 miles to a point near its confluence with Little Black Creek, then northwesterly 73 miles to Deferiet, and then westerly 24 miles to Dexter where it enters Black River Bay, an arm of Lake Ontario. Its principal tributaries are Moose River, draining 212 square miles; Beaver River, draining 334 square miles; Deer River, draining 102 square miles; and Woodhull Creek, draining 98 square miles.

1.62.2 Previous Studies

Previous studies are listed below:

(1) 1954—the Resources of the New England-New York Region, Part II, Chapter XXXI, Black River Basin, New York

(2) 1949—a report considering local improvements in the Carthage-Lyons Falls reach.

(3) 1944—the Panther Mountain reservoir project, approved by Congress under P.L.

TABLE 14-66B River Basin Group 5.2, Agricultural Average Annual Flood Damages[1] (Auxiliary Data)

	Existing[2]
Basin	434,100
Barge Canal	
Wa-Ont-Ya Area	115,200
Eastern Oswego Area	8,000
Local Areas	
Wa-Ont-Ya	281,200
Chemung[3]	6,600
Cayuga Lake	---
Eastern Oswego	146,300

[1]This table, from the draft of the tentative Oswego River Basin Report, is supplied by the New York State Department of Environmental Conservation.

[2]Less acreage or intensity in agriculture in the future would tend to lower these figures; higher acreage or intensity might increase them.

[3]Oswego basin portion of Board area only.

534, 78th Congress, enacted December 22, 1944. The authorization expired in 1951, because assurances of local cooperation had not been furnished.

(4) the U.S. Geological Survey—a flood-prone area report for a portion of the Black River

1.62.3 Development in the Flood Plain

Flooding in the Black River basin affects the flatlands between Lyons Falls and Carthage. The land is used almost entirely for agricultural purposes. Dairying is the principal activity and the land is devoted to pasture or raising hay, corn, and some grain for feed. Land, subject to frequent flooding, is largely wild grass, pasture, or meadow.

The principal industry is the manufacture of paper and paper products. There are mills at Dexter, Brownville, Watertown, Deferiet, Herrings, Carthage, West Carthage, Beaver Falls, Lyons Falls, and Lyondale. Watertown also manufactures paper-mill machinery, air brakes, and textiles, and is the principal business and commercial center of northern New York State.

1.62.4 Flood Problems

Flooding in the Black River basin occurs at any time of the year and has been more frequent in the middle reaches of the river between Carthage and Lyons Falls. The combination of heavy spring rainfall and melting snow with the breaking up of river ice often causes flood conditions in this reach of the basin. Although flooding in the reach between Carthage and Lake Ontario is less frequent, the damage is serious because it affects industrial and residential areas. The maximum recorded flood occurred in April 1928, but the flood of December 1901 was estimated to be greater.

Failure of a dam at McKeever in 1947 caused damage along the Moose River but ordinarily there is little flood damage in the basin.

Figure 14-63c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14-67 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14-68 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14-64c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14-69. County summaries for the main stem and principal tributaries are tabulated in Table 14-70.

1.62.5 Existing Flood Damage Prevention Measures

There are no structural flood control projects in the basin.

Refer to Subsection 1.54.5 for a discussion of flood plain legislation applicable to this river basin.

1.63 Lake Ontario East, River Basin Group 5.3, Oswegatchie River Basin

1.63.1 Description

The Oswegatchie River drains an area of

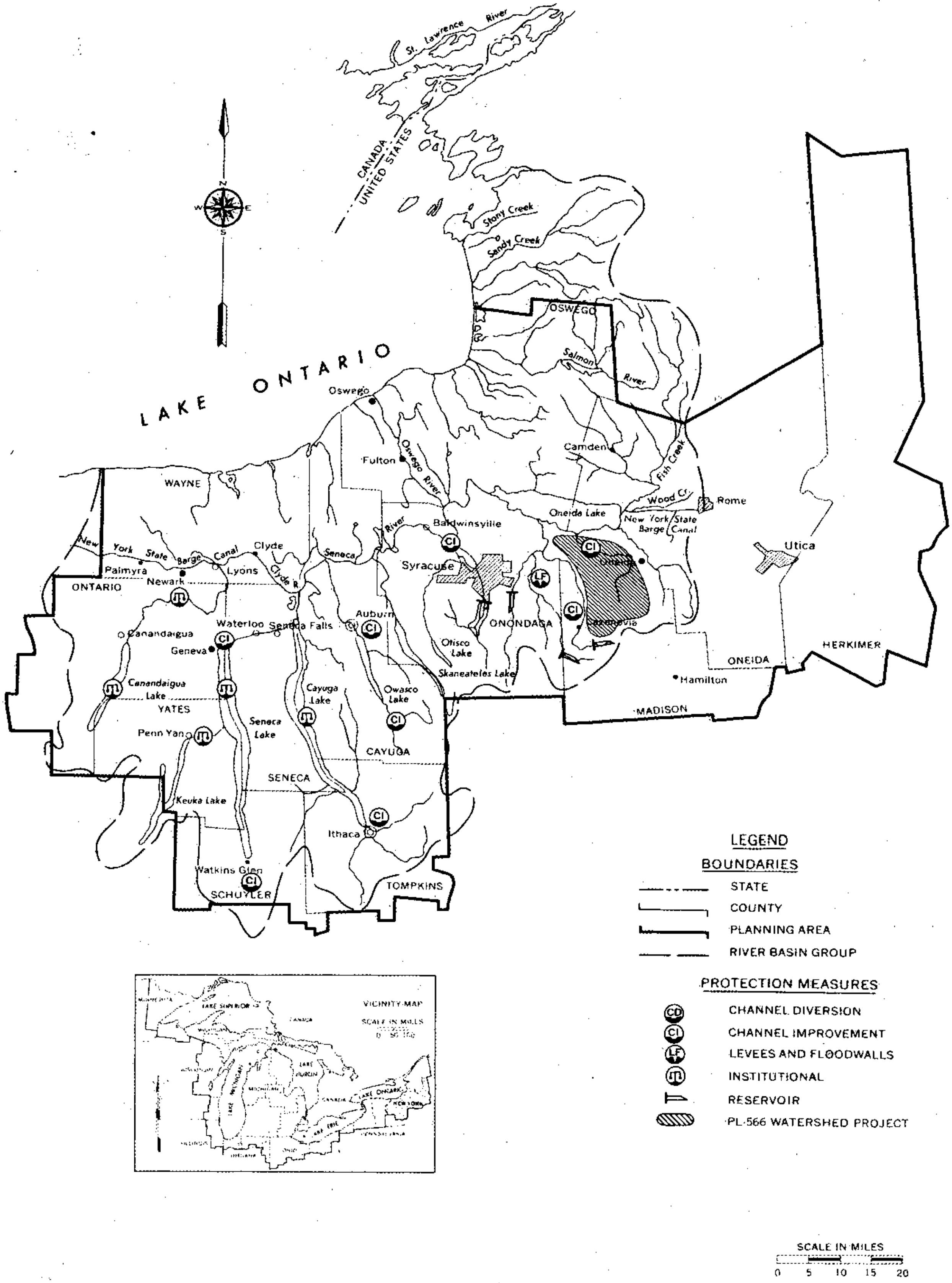

FIGURE 14–61 Existing Flood Damage Protection Measures for River Basin Group 5.2

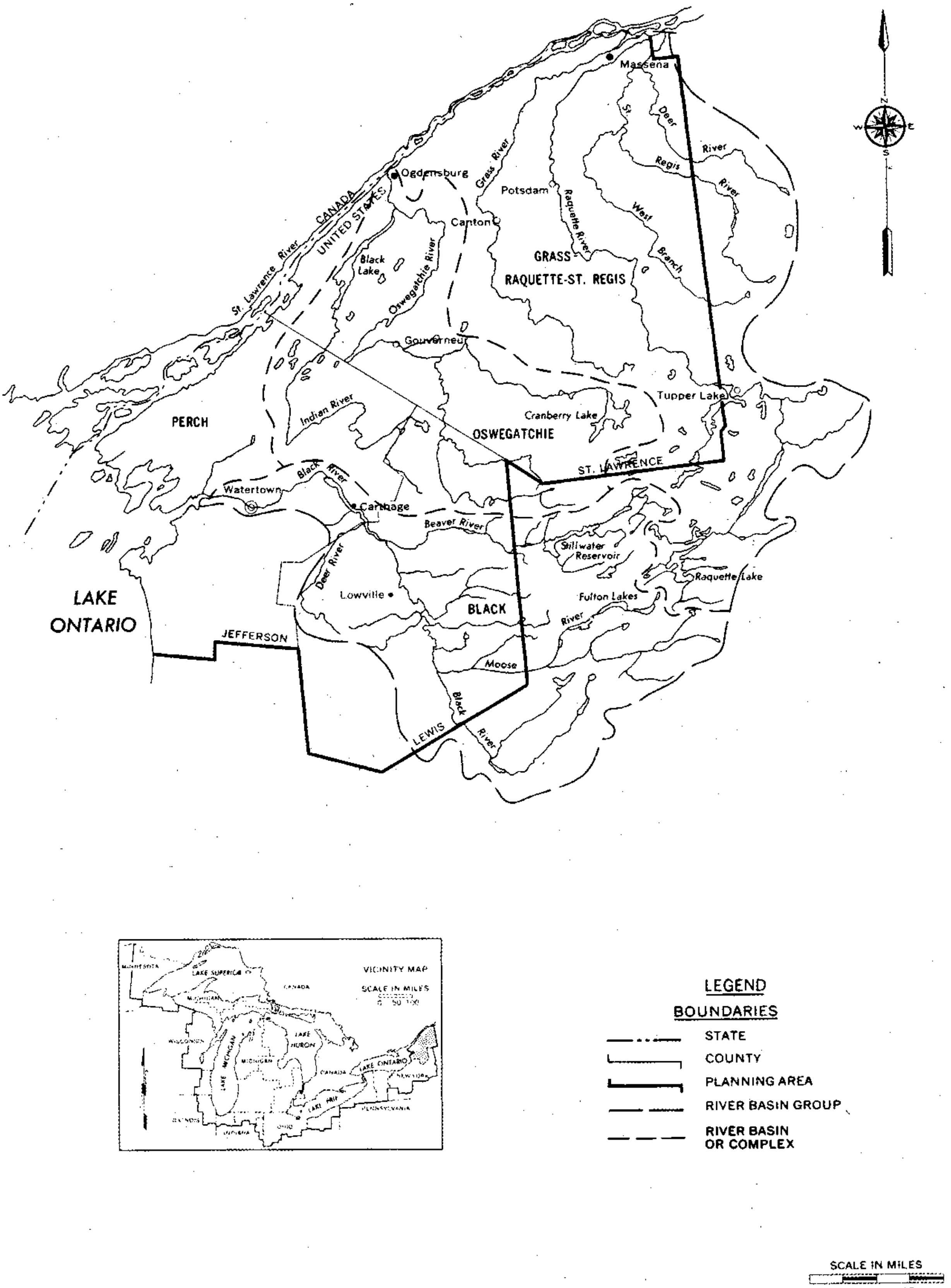

FIGURE 14–62 Lake Ontario East—River Basin Group 5.3

TABLE 14–67 Flood Plain Damage Summary, Main Stem and Principal Tributaries, River Basin Group 5.3

REACH CODE	COUNTY	REACH LOCATION		YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)		ESTIMATED ACRES IN FLOOD PLAIN						REMARKS
		FROM	TO		URBAN	RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	RESIDENTIAL RECREATION	OTHER	TOTAL URBAN	TOTAL RURAL	
	BLACK RIVER												
BS1	Jefferson	Mouth	Jefferson-	1970		6,000		25	10	1900		1,935	
			Lewis	1980		8,200		25	10	1900		1,935	
			Co. Line	2000		16,800		26	10	1899		1,935	
				2020		34,800		28	11	1896		1,935	
BS2	Lewis	Jefferson-	Moose	1970		147,600				18000		18,000	
		Lewis	River	1980		187,800				18000		18,000	
		Co. Line	Lyons and	2000		379,300				18000		18,000	
			Falls	2020		815,700				18000		18,000	
	OSWEGATCHIE RIVER												
BT1	St. Law-	Mouth	Governeur	1970	800	9,700	7		6	3957	17	3,953	
	rence			1980	1,000	13,000	7		6	3957	17	3,953	
				2000	2,300	27,400	7		6	3957	18	3,952	
				2020	4,700	56,800	7		6	3957	19	3,951	
	GRASS RIVER												
BU1	St. Law-	Mouth	Middle	1970		11,100		20	5	3355		3,380	
	rence		Branch	1980		15,000		20	5	3355		3,380	
				2000		31,200		20	5	3355		3,380	
				2020		66,700		21	6	3353		3,380	
	RAQUETTE RIVER												
BU2	Franklin	Mouth	St. Law-	1970						30		30	
			rence -	1980						30		30	
			Franklin	2000						30		30	
			Co. Line	2020						30		30	
BU3	St. Law-	St. Law-	Carry	1970		10,500			55	1400		1,455	
	rence	rence	Falls	1980		14,200			55	1400		1,455	
		Franklin	Reservoir	2000		29,600			58	1397		1,455	
		Co. Line		2020		61,500			61	1394		1,455	
	ST. REGIS RIVER												
BU4	Franklin	U.S./	St. Law-	1970	300	1,000		5		1406	11	1,400	
		Canada	rence -	1980	300	1,400		5		1406	11	1,400	
		Border	Franklin	2000	900	1,800		5		1406	11	1,400	
			Co. Line	2020	1,800	5,800		6		1405	12	1,400	
BU5	St. Law-	St. Law-	Confluence	1970		300				390		390	
	rence	rence-	with West	1980		300				390		390	
		Franklin	Branch	2000		900				390		390	
		Co. Line		2020		1,800				390		390	

1,603 square miles. Location within River Basin Group 5.3 is shown in Figure 14–62. The upstream half of the watershed lies on the northwestern slopes of the Adirondack Mountains between elevations of 600 and 2,200 feet, with small areas in the extreme southeast portion of the watershed approaching 3,000 feet. Small lakes, ponds, and swampy areas occur throughout the area. The lower half of the basin lies almost entirely between elevations of 200 and 600 feet and is relatively flat. The largest tributary is Indian River, draining 559 square miles in the southwestern and western part of the watershed.

1.63.2 Previous Studies

The Resources of the New England-New York Region, Part II, Chapter XXVIII, St. Lawrence Drainage Basin, New York, dated 1955, is the only previous study.

1.63.3 Development in the Flood Plain

The principal industries in the basin are mining and paper making. There are paper mills at Newton Falls, Harrisville, Natural Dam, and Ogdensburg. The principal agricul-

TABLE 14–68 Flood Plain Damage Summary, Upstream Watersheds, River Basin Group 5.3

WATERSHED NUMBER	YEAR	ESTIMATED AVERAGE ANNUAL DAMAGES (DOLLARS)			ESTIMATED ACRES IN FLOOD PLAIN								
		URBAN	RURAL	TOTAL	CROPLAND	PASTURE	WOODLAND	OTHER RURAL	INDUSTRIAL COMMERCIAL	RESIDENTIAL	OTHER URBAN	TOTAL URBAN	TOTAL RURAL
		BLACK RIVER - NEW YORK											
34	1970	200	3,500	3,700	1,080	435	140	40	5	10	5	20	1,695
405	1970	--	200	200	60	100	840	--	--	--	--	--	1,000
407	1970	--	1,700	1,700	520	248	100	--	--	--	--	--	868
408	1970	--	1,700	1,700	480	320	25	20	--	--	--	--	845
409	1970	--	100	100	30	20	100	25	--	--	--	--	175
410	1970	--	100	100	20	--	80	700	--	--	--	--	800
411	1970	--	200	200	75	100	25	--	--	--	--	--	200
412	1970	--	1,400	1,400	300	700	200	300	--	--	--	--	1,500
413	1970	100	2,500	2,600	700	590	10	9	2	8	--	10	1,309
414	1970	100	900	1,000	145	700	770	130	4	4	2	10	1,745
416	1970	--	2,200	2,200	500	1,020	50	45	--	--	--	--	1,615
417	1970	3,000	1,400	4,400	400	300	200	100	75	75	50	200	1,000
Total	1970	3,400	15,900	19,300	4,310	4,533	2,540	1,369	86	97	57	240	12,752
	1980	4,300	21,900	26,200	4,310	4,533	2,540	1,369	86	97	57	240	12,752
	2000	7,400	27,000	34,400	4,310	4,533	2,540	1,369	86	97	57	240	12,752
	2020	13,500	30,400	43,900	4,310	4,533	2,540	1,369	86	97	57	240	12,752
		GRASS-RAQUETTE - ST. REGIS COMPLEX - NEW YORK											
351	1970	5,000	--	5,000	--	--	--	--	--	500	--	500	--
358	1970	--	600	600	100	500	--	--	--	--	--	--	600
362	1970	--	2,000	2,000	500	800	400	--	--	--	--	--	1,700
310	1970	--	100	100	--	75	125	--	--	--	--	--	200
Total	1970	5,000	2,700	7,700	600	1,375	525	--	--	500	--	500	2,500
	1980	6,400	3,700	10,100	600	1,375	525	--	--	500	--	500	2,500
	2000	11,000	4,600	15,600	600	1,375	525	--	--	500	--	500	2,500
	2020	19,900	5,200	15,100	600	1,375	525	--	--	500	--	500	2,500
		OSWEGATCHIE RIVER - NEW YORK											
381	1970	--	300	300	50	150	180	20	--	--	--	--	400
	1980	--	400	400	50	150	180	20	--	--	--	--	400
	2000	--	500	500	50	150	180	20	--	--	--	--	400
	2020	--	600	600	50	150	180	20	--	--	--	--	400

tural areas are west of Edwards and Natural Bridge. Tourists, hunters, and fishermen are important sources of income in many parts of the watershed, particularly at Black, Bonaparte, and Cranberry Lakes. Camp Drum Military Reservation occupies a large area in the southwestern part of the watershed.

1.63.4 Flood Problems

Floods are not a serious problem in the St. Lawrence drainage basin. High flows occur nearly every spring from a combination of melting snow and rainfall. Records of flood damage in the Oswegatchie Watershed are sparse. Recent records indicate that reported damages have generally occurred at the time of the spring runoff, but not always at the time of the peak runoff, because many overflows are due to ice jams. At Gouveneur approximately 25 residential units suffer damage.

Figure 14–63c identifies the time period in which major damages, as defined in this study, are first noted within a given reach on the main stem and principal tributaries. Table 14–67 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–68 indicates upstream flood damges. Location of these damages within particular watersheds may be seen in Figure 14–64c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–69. County summaries for the main stem and principal tributaries are tabulated in Table 14–70.

1.63.5 Existing Flood Damage Prevention Measures

The only structural measure is a deep draft harbor maintained at Ogdensburg at the mouth of the Oswegatchie River.

Refer to Subsection 1.54.5 for a discussion of flood plain legislation applicable to this river basin.

TABLE 14–69 Data Summary by River Basin, River Basin Group 5.3

River Basin	Year	Estimated Average Annual Damage (Dollars)		Estimated Acres In Flood Plain	
		Urban	Rural	Urban	Rural
Black River	1970	3,400	169,500	240	32,687
	1980	4,300	217,900	240	32,687
	2000	7,400	423,100	240	32,687
	2020	13,500	880,900	240	32,687
Oswegatchie River	1970	800	10,000	17	4,353
	1980	1,000	13,400	17	4,353
	2000	2,300	27,900	18	4,352
	2020	4,700	57,400	19	4,351
Grass-Raquette-St. Regis Complex	1970	5,300	25,600	511	9,155
	1980	6,700	34,600	511	9,155
	2000	11,900	69,100	511	9,155
	2020	21,700	141,000	512	9,154
Perch River Complex	1970	-	-	-	-
	1980	-	-	-	-
	2000	-	-	-	-
	2020	-	-	-	-
TOTAL	1970	9,500	205,100	768	46,195
	1980	12,000	265,900	768	46,195
	2000	21,600	520,100	769	46,194
	2020	39,900	1,079,300	771	46,192

1.64 Lake Ontario East, River Basin Group 5.3, Grass, Raquette, and St. Regis River Basins

1.64.1 Description

Location of these river basins are shown in Figure 14–62. The Grass River drains an area of 676 square miles in St. Lawrence County. The south branch, largest of the three branches, rises on the slopes of Long Tom Mountain in the southeastern part of the county and is the outlet for Lake Massawepie at an elevation of 1,500 feet, the largest body of water in the watershed. The total length from the sources of the south branch to the mouth is 110 miles, and the total fall is 1,600 feet. The principal tributaries are Little River, draining 136 square miles, and Harrison Creek, draining 84 square miles.

The Raquette River drains an area of 1,256 square miles. The source of the river is Blue Mountain Lake, situated in the central part of the Adirondack Plateau at an elevation of 1,790 feet above mean sea level. The largest tributary is Bog River which drains 133 square miles west of the main stream. Cold River enters from the east, draining 84 square miles. Jordan River drains 49 square miles of swampy area on the east side of the basin.

The St. Regis River drains an area of 852 square miles. The basin is generally rectangular in shape, 42 miles long in a northwesterly direction, and 20 miles wide. The southern portion of the basin lies on the northern slopes of the Adirondack Mountains. The largest tributary, Deer River, enters at Helena, 7 miles above the mouth, and drains 193 square miles on the east side of the basin.

1.64.2 Previous Studies

The Resources of the New England-New

TABLE 14-70 River Basin Group 5.3, Data Summary by County

County (New York)	Estimated Average Annual Damages (Dollars)		Estimated Acres in Flood Plain	
	Urban	Rural	Urban	Rural
YEAR 1970				
Franklin	300	1,000	11	1,430
Jefferson	---	6,000	---	1,935
Lewis	---	147,600	---	18,000
St. Lawrence	800	31,600	17	9,178
TOTALS	1,100	186,200	28	30,543
YEAR 1980				
Franklin	300	1,400	11	1,430
Jefferson	---	8,200	---	1,935
Lewis	---	187,800	---	18,000
St. Lawrence	1,000	42,500	17	9,178
TOTALS	1,300	239,900	28	30,543
YEAR 2000				
Franklin	900	2,800	11	1,430
Jefferson	---	16,800	---	1,935
Lewis	---	379,300	---	18,000
St. Lawrence	2,300	89,100	18	9,177
TOTALS	3,200	488,000	29	30,542
YEAR 2020				
Franklin	1,800	5,800	12	1,429
Jefferson	---	34,800	---	1,935
Lewis	---	815,700	---	18,000
St. Lawrence	4,700	186,800	19	9,176
TOTALS	6,500	1,043,100	31	30,540

* On main stem and principal tributaries

York Region, Part II, Chapter XXVIII, St. Lawrence Drainage Basin, New York, dated 1955, is the only previous study.

1.64.3 Development in the Flood Plain

Outside of the Massena area there are few industries located in the watershed. Agriculture is confined to the northern part of the watershed and consists of dairying and related activities. The southern part is not suited to agriculture and is covered with second-growth timber. A considerable growth of hardwood remains standing above Sylvan Falls on the west branch due to its inaccessibility. Tourists, hunters, and fishermen are important sources of income in the southern part of the watershed.

1.64.4 Flood Problems

Floods are not a serious problem in the St. Lawrence drainage basin. High flows occur nearly every spring from a combination of melting snow and rainfall. Floods that have occurred appear to be due to ice jams rather than to high discharges.

Figure 14-63c identifies the time period in which major damages as defined in this study are first noted within a given reach on the main stem and principal tributaries. Table 14-67 indicates the flood plain damages by reach corresponding to the reaches designated in this figure. Table 14–68 shows upstream flood damages. Location of these damages within particular watersheds may be seen in Figure 14–64c. Summations of estimated average annual damages and acres in the flood plain are shown by river basin in Table 14–69. County summaries for the main stem and principal tributaries are tabulated in Table 14–70.

1.64.5 Existing Flood Damage Prevention Measures

At the present time there are no structural flood control projects in the basin.

Subsection 1.54.5 contains a discussion of flood plain legislation applicable to these basins.

1.65 Lake Ontario East, River Basin Group 5.3, Perch River Complex

1.65.1 Description

The Perch River complex is 486 square miles in size and is composed of several relatively small streams. The largest is the Perch River which has a drainage area of 98 square miles. Location within River Basin Group 5.3 is shown in Figure 14–62.

1.65.2 Previous Studies

The Resources of the New England-New York Region, Part II, dated 1955, is the only previous study.

1.65.3 Development in the Flood Plain

The complex is sparsely populated and has little development in the flood plains.

1.65.4 Flood Problems

There are negligible flood problems in the complex at this time.

1.65.5 Existing Flood Damage Prevention Measures

There are no known existing structural flood prevention measures in the complex. Refer to Subsection 1.54.5 for a discussion of flood plain legislation applicable to this complex.

Section 2

FLOOD PROBLEM ANALYSIS

2.1 Introduction

Because the nature and extent of flood problems vary appreciably among the river basins of a region, comprehensive plans are needed to guide the development, use, and conservation of the resources of major drainage basins.

There has been a tendency among land-use planners in the United States to think that flood plain regulation would provide the whole answer, just as in the past engineers tended to think that flood protection works provided the solution. If future flood control efforts are confined only to the construction of engineering works, while the nation's citizens continue to develop its flood plains without regard for flood losses, expenditures of Federal funds alone will nationally have to exceed $510 million annually to keep flood losses from increasing. It has been shown in urban areas that protection leads to continued invasion of the flood plain, and unless catastrophic losses occur, there tends to be a progressive crowding into the lowlands to enjoy the benefits of cheaper accessibility, transportation, and waste disposal.

Therefore, it should be recognized that preventative methods of containing future flood damages may necessarily go hand in hand with the methods for reducing existing flood damages. Thus, an engineering project for controlling floods in one portion of the flood plain may be accompanied by local regulations preventing further encroachment into other sections of the flood plain. Neither method provides the total answer. Prevention and protection must be proportioned in a manner best suited to reduce the economic and physical hardships inflicted by flood waters.

This section consists of two parts. The first part reviews the two methods of flood damage reduction measures that are available for consideration: protection through control of flood waters (structural measures) and prevention through control of the flood plain (nonstructural measures). The second part examines each river basin group for significant damage totals and recommends flood damage reduction measures for the special time periods designated as immediate (before 1980), short term (1980 to 2000), and long term (after 2000). The subsequent tables denote these alternative flood damage reduction measures. Multipurpose consideration of reservoirs may result in their use at a time period earlier than indicated.

2.2 Flood Damage Reduction Measures

2.2.1 Preventive Measures

An institutional alternative, legislative regulation of uses in flood plain areas for flood loss control, may be undertaken at the State or local levels through the adoption of one or more regulatory tools. Flood plain zoning is a legal tool that is widely used by local and State agencies to control and direct the development of land within the flood plain. Such zoning attempts to insure the safekeeping of these lands for the public health and welfare. Flood plain zoning should be a part of a comprehensive zoning program for the entire area. Local authorities should take into account flood limitations in plans for public facilities such as roads, sewers, parks, water supply, and other public and private installations. Designated floodways may be zoned for the purpose of passing flood waters and other limited uses that do not conflict with that primary purpose. The ordinances may also establish regulations for the flood plain areas outside the floodway. These include designating elevations below which certain types of development cannot be constructed. Zoning needs should be anticipated and regulations initiated beforehand, even in land presently rural or undeveloped.

Another institutional alternative, building codes, are legislative regulations for flood reduction control that may be adopted by a local governing body. These codes can set forth standards for the construction of buildings and other structures for the purpose of protecting the health, safety, and general welfare of the public. Well written and properly enforced building codes can effectively reduce damages in the flood plain. Existing codes are generally more related to fire and health protection than to flood prevention. Some requirements that should be specified in a building code to reduce flood damages are listed below.

(1) Prevent flotation of buildings from their foundations by requiring proper anchorage.

(2) Establish basement elevations and minimum first floor elevations consistent with potential floods.

(3) Require structural strength sufficient to withstand water pressure and high velocity water flows.

(4) Restrict use of materials that deteriorate rapidly when exposed to water.

(5) Prohibit equipment that might be hazardous to life when submerged, such as chemical storage, boilers, or electrical equipment.

A third legislative flood loss reduction measure is the institutional alternative of subdivision regulation. Subdivision regulations are used by local governments to specify the manner in which land may be divided. These may state the required width of streets, requirements for curbs and gutters, size of lots, elevation of building floors, size of floodways, and other points pertinent to the community welfare. Not only can personal welfare benefit, but various municipal costs such as maintenance of streets and utilities can be reduced during flood periods. Subdivision regulations provide an effective means for controlling construction in presently undeveloped flood plain areas. The following typical provisions which could be added to regulations would be helpful in preventing flood damage:

(1) Show the extent of flood plains on subdivision maps.

(2) Show floodway limits or encroachment lines.

(3) Prohibit fill in channels and floodways that would restrict flow.

(4) Require that subdivision roads be above the elevation of a selected flood level.

(5) Require that each lot contain a building site with an elevation above a selected flood level.

Another legislative flood loss reduction measure is the institutional alternative of tax incentives. Tax adjustments for land dedicated to agriculture, recreation, conservation, or other open space uses may be effective in preserving existing flood plains from damage-prone development. Unless such concessions are made, open land adjacent to communities tends to be assessed in a manner reflecting potential development values. This increasing tax burden soon rises to the point where the land can no longer be used profitably for farming or other open-space use. Zoning changes to match the tax levy soon lead to more intensive use of the flood plain. However, one problem in devising a preferential tax scheme is in defining an acceptable method for recapture of unassessable tax value if open-space lands are ultimately developed. A number of political, administrative, constitutional, and other legal barriers may also stand in the way of its use.

A large portion of past flood damages could have been averted if the public had had a better understanding of the risks involved by building in a flood hazard area. To prevent further encroachment into the flood plain, planning agencies at all levels as well as the general public need to be made more aware of the hazards and extent of flooding. The U.S. Army Corps of Engineers, in an attempt to aid local planning agencies and to inform the people, has been publishing Flood Plain Information Reports since 1960. A flood plain information study is an engineering analysis of a basin's hydrology and the stream's hydraulics. Based upon currently accepted criteria and guidelines, this information is applied in establishing depths and frequency of flooding for selected design floods including the highest flood recorded.

The objectives of a Flood Plain Information Report are listed below.

(1) The report should compile and present in clear and useful form all pertinent information relative to past and potential flood hazards including identification of areas subject to inundation by floods of various magnitudes.

(2) It should encourage wise use of river valleys by providing a basis for State or local regulation of flood plain uses, promoting the preparation of land use plans that preserve an adequate channel to accommodate flood flows.

(3) It should publicize in an understandable form information to guide interests in either local or general areas of concern.

(4) It should minimize the need for flood control projects to protect future development that would have otherwise have been built in the flood plain, thereby perpetuating the concepts of environmental preservation.

In addition to the Corps' flood plain information studies, flood hazard analysis studies are conducted by the U.S. Soil Conservation Service, and the U.S. Geological Survey prepares maps delineating flood-prone areas.

The effectiveness of State and local flood plain management programs will largely depend on data like that presented in flood plain information studies, the flood hazard analysis studies, and on the flood-prone area maps. It is therefore important that programs such as these be properly funded and expanded to meet the rapidly increasing needs.

Public education is necessary both to obtain pertinent legislation and to alert the public to the inherent dangers associated with encroachment into a flood plain. A program of public education should be designed to familiarize the general populace with the various means that can be used to reduce flood hazards. Other methods besides the protective approach for reducing flood damages must be presented to the public. Most citizens understand engineering projects for flood protection, but much remains to be done in the way of public education before the ordinary person is equally familiar with such an alternative as regulating the use of flood plains so that high hazard areas are in parks rather than expensive homes, or with the use of flood proofing techniques so that damage can be minimized.

Newspapers and periodicals can acquaint the public with such alternatives and can remind the community of its flood history, the extent of previous floods, and the magnitude of possible extraordinary floods. Civic organizations can initiate flood plain information programs and can place warning signs marking flood-prone areas and high water marks. Motion pictures produced by governmental water resource agencies can be forceful in depicting flood disasters and their remedies. These should be made readily available to student groups, civic organizations, and legislators concerned with the general welfare.

If established on a sound and equitable basis, flood insurance, an institutional alternative, could provide still another supplement to the many programs for reducing flood damage. However, insurance rates should realistically reflect the flood risk in order to avoid encouragement of improper development of flood plains. There are cases of damage caused by floods whose intensity has been influenced by upstream changes in the watershed. For such situations modest levels of flood insurance are appropriate.

Indeed, under the National Flood Insurance Program (Act of 1968), flood insurance has been made available to a limited number of communities and will be extended to others with flood problems. This program provides existing structures with a lower than actuarial rate made possible through government subsidy, while structures erected later will pay the full-risk premium. The Secretary of Housing and Urban Development (HUD) is authorized to carry out studies to determine where insurance will be made available and to establish premium risk rates once the eligibility for insurance has been established. Since December 31, 1971, no flood insurance coverage has been provided or renewed under the program unless the community has adopted land-use and control measures for flood hazard areas which meet HUD requirements.

Weather modification is another area offering possibilities for preventing the occurrence of floods and their resulting damage. The state of this science is such that no definite predictions can be made as to the definite reduction or increases in flood damages that might be caused by modifications in weather conditions. Such phenomena as inadvertent increases in average and intense precipitation have been noted over metropolitan areas with air pollution problems. As more information becomes available, this factor must be considered in the planning effort.

The institutional alternative, alternative land use and restrictions, forms an integral part of any flood plain management program by providing for low damage usage, e.g., recreation or agriculture. When such a program is part of a broader land use control program, the needs of the entire area must be considered by restricting floodways and flood plain fringe lands to particular use. The particulars of such a program will depend upon the availability of alternative sites and the suitability of flood-prone land for special applications. This interest in and control of flood hazard areas may encourage an integrated approach in managing the flood plain and provide for broader community land use.

Regulatory programs for land use in flood-prone areas should take into account the most desirable service from the viewpoint of the general welfare and the needs and rights of the property owner. In comparing the application of protective measures to regulatory programs, one must define the environmental objective to determine what the public wants and expects as well as what is needed. It is not at all impracticable to think of rather intensive use of flood plains in circumstances that would lead to very slight flood losses. The problem is not one of prohibiting any kind of use of the flood plain, but of finding maximum utility, taking into account not only the flood losses that would result, but also the benefits accrued from such usage. Land use regulation can be developed to foster the wise choice of flood plain use.

All the preventative measures previously enumerated will have little impact without the establishment of methods for effective implementation and enforcement of ongoing programs. Many States and some localities have regulations governing flood plain use. But lax enforcement has largely nullified their influence and voluntary measures have proven ineffective.

Most authorities agree that the State has the key role in any widespread exercise of the various legal methods of regulating flood plain development because police powers rest basically with the State and not with the Federal government or municipalities. A technically staffed State agency may be in a better position than a local unit to consider regulations and other uses which have extra-municipal effects and require special expertise usually not available at the local level. However, effective enforcement and implementation of ongoing programs at the State level can be obtained only through adequate funding of these programs.

The most direct form of controlling future flood losses is by setting encroachment lines. Several States actively regulate the building of structures or the filling of channels with a view to prevent any encroachment that would increase flood stages. The Corps of Engineers and the Soil Conservation Service are requiring that communities agree to regulate flood plain use as a condition of building protection works. Other direct methods of regulation are: restricting loans for construction in flood-prone areas; prohibiting construction unless plans are first approved by the appropriate agency; establishing zoning ordinances that specify the kind of use that can be made of a particular area; and creating subdivision regulations that indicate the conditions in which new urban development can take place. The realignment of exercising authority by constitutional changes in some States may even be required.

The Federal Housing Authority housing program, water and sewer constructions grants, loans and guarantees, the FHA flood insurance program, and Department of Transportation highway and airport funds could be used as an instrument for remedial and preventative actions by prohibiting applications for projects in any flood plains identified by the Corps of Engineers or Soil Conservation Service unless measures for protection from flooding are assured and will not cause any adverse effects downstream. Also the A–95 State and Regional Clearinghouse process and the comments they generate could be used to identify problem projects.

2.2.2 Corrective Measures

A comprehensive program of flood damage control for a particular river basin may include any or all of the known methods for flood damage reduction or prevention. A sound and economically efficient flood damage reduction program for a river basin with extensive urban and rural flood-prone areas should normally include a balanced combination of most known damage reduction measures. Such a combination of measures could logically be viewed as a unified and comprehensive flood plain management program. This program might include the traditional structural means of controlling or regulating the river. Engineering works are still the standard and most reliable methods of reducing flood losses at present. The chief methods which technology provides are listed below.

(1) Flood runoff can be reduced by land treatment, although this alone is effective only to a limited degree and in very rare situations.

(2) Peak rates can be reduced by storage of the flood runoff in reservoirs.

(3) Peak stages can be decreased by increasing the channel capacity.

(4) The flow of water can be confined through the construction of levees and walls.

Reliance should not be placed solely upon any one measure because it is a rare situation in which flood protection, or flood warning, or any of the other methods will be completely effective if used alone.

Flood protection can be achieved by providing reservoirs with control structures to collect and delay excessive runoff to reduce flood stages. Appendix 2, *Surface Water Hydrology,* lists potential reservoir sites for each of the river basin groups in this study. The function of reservoirs is to store water when streamflow is excessive and to release it gradually after the threat of flooding has passed.

Various degrees of protection through reservoir storage may be obtained through development of either tributary or main stem reservoirs or combinations of these. If properly designed, dams are not subject to failure. However, they do not necessarily protect against the maximum probable flood. It has been demonstrated in the Tennessee valley that a system of large multipurpose reservoirs may not succeed in preventing all losses at a nearby damage center, but it may reduce the frequency of great floods.

Levees and floodwalls protect the populace and exposed property by acting as a barrier and confining floodwater to a floodway where it would cause little damage. Levees are earth embankments, whereas floodwalls are generally concrete or steel walls. They are built in the flood plain near the normal stream and should be located to provide maximum protection while encroaching as little as possible on natural floodways.

Flood stages can be reduced by improving flow conditions within the channel and by increasing the stream's carrying capacity. Methods generally used to obtain channel improvements are:

(1) straightening and removing bends, thus increasing flow velocities

(2) deepening and widening to increase capacity of waterway

(3) clearing to remove brush, trees, and other obstructions to permit unrestricted flow

(4) lining with concrete to increase efficiency of flow by decreasing flow friction

(5) diverting floodwater through bypass channel construction

Flood proofing through structural changes offers a more direct means of reducing losses to individual establishments in the flood plain. Flood proofing has merit in one or more of the following situations:

(1) where the traditional type of flood protection is not feasible

(2) where individuals desire to solve their flood problems without collective action, or where collective action is not possible

(3) where activities dependent on riverside locations require flood protection

A common type of adjustment is in the design of roads, bridges, and earthworks so they will not be damaged at times of high water by the greater velocities and high saturations that result from floods. Without adequate waterway openings, the embankments for the bridge approaches tend to impound water, thus increasing flood heights upstream. Accordingly, future stream crossings, particularly in urban areas, should be designed to provide adequate waterway openings, adequate bridge clearance above estimated flood levels, and adequate roadway height above projected flood levels.

Flood proofing can be provided most effectively and economically in the design of new construction, and it can be applied successfully to existing facilities under certain circumstances. Usually flood proofing is suitable only where moderate flooding with low stage, low velocity, and short duration is experienced. The following are common methods for flood proofing:

(1) seepage control
(2) sewer adjustment
(3) permanent closure
(4) openings protected
(5) interiors protected
(6) protective coverings
(7) fire protection
(8) appliance protection
(9) utility adjustments
(10) roadbed protection
(11) elevation or raising
(12) temporary removal
(13) proper salvage
(14) watertight caps
(15) proper anchorage
(16) underpinning
(17) timber treatment
(18) deliberate flooding
(19) structural design
(20) reorganized use

Flood warning and evacuation systems provide means of reducing a substantial part of the ordinary flood loss. If a flood peak can be forecast in sufficient time to permit occupants to take emergency measures, it is possible to reduce losses in urban areas from 10 to 30 percent and by a substantial amount in agricultural areas. Structural changes combined with warning systems make it possible to carry out an efficient flood proofing program. In fact, some structural changes such as emergency bulkheads can be put into operation only with sufficient warning time. Experience has shown that a combination of adequate flood warning with structural measures may render a very complex urban area largely free from flood losses.

The National Weather Service (NWS) of the National Oceanic and Atmospheric Administration (NOAA) provides river and flood forecasts for selected portions of the Great Lakes Basin. This service is confined to flood crest forecasts for these areas. There are still several river basins with flood hazards that are not currently served by flood forecast programs.

River district office locations and the river basin area they serve are in Lansing, Michigan (the Grand River above Grand Ledge, Michigan and the Saginaw River basin); Grand Rapids, Michigan (the Grand River below Grand Ledge, Michigan); Fort Wayne, Indiana (the Maumee River basin); Akron, Ohio (the Vermilion, Cuyahoga, and Chagrin River basins); and Rochester, New York (the Genesee River basin).

These river and flood forecast services are supported by weather surveillance radar located at Weather Service Offices in Minneapolis, Minnesota; Chicago, Illinois; Detroit, Michigan; Pittsburgh, Pennsylvania; and Buffalo, New York. These facilities are operated on a continuous basis and have the capability for detection and evaluation of precipitation within a radius of 125 nautical miles. These continuous radar observations are an effective source of information for the issuance of flash flood warnings. The radar can also be used to record photographically precipitation patterns which provide recorded data over areas where rain gage installations are impractical or nonexistent. Other local-use radar is at Cleveland, Ohio; Flint, Michigan; Fort Wayne, Indiana; and Muskegon, Michigan. At certain locations weather information and warnings are broadcast continuously 24 hours a day. Messages include weather and radar summaries together with detailed local and area forecasts.

Future requirements for the Great Lakes hydrologic forecast program include:

(1) expansion of the river and flood forecast program to provide service to the remaining areas that have flood hazards

(2) development of continuous flow forecasts for selected rivers for water quality and quantity management

(3) Great Lakes inflow-outflow forecasts, both monthly and annually, to aid in operational decisions and management of the hydrologic resources of the Basin

(4) expansion of the river and rainfall data network to more clearly define and document the water resources of the Basin and to provide more definitive data for future studies

(5) expansion of the VHF continuous weather broadcast program

When a flood emergency exists the National Weather Service usually has primary responsibility for flood forecasts. The local Defense Civil Preparedness Agency office establishes evacuation procedures and the U.S. Army Corps of Engineers contributes technical assistance in constructing temporary floodworks. However, the key to effective response is community action. It is essential that communities establish an appropriate local organization that can receive and disseminate flood warnings swiftly to the public. Every member of the community should know what a forecast river height means in terms of his own situation. Community preparedness means that everyone can take positive emergency steps in the face of imminent disaster. Evacuation routes can be established, an emergency coordination can be manned, Red Cross shelters can be designated, and municipal and enforcement officials can be fully mobilized in advance of a destructive flood.

Permanent evacuation of developed areas subject to periodic inundation involves the acquisition of lands by purchase (through exercise of the powers of eminent domain, if necessary), removal of damageable property, and relocation of the population from such areas. Lands acquired in this manner could be used for agriculture, parks, or other purposes that would not interfere with flood flows or result in material damage from floods.

Such a system may be applied in conjunction with urban renewal programs and used to restore the economic welfare of flood-blighted community areas that do not lend themselves to other methods of control. The Federal Urban Renewal Program provides substantial assistance to municipalities burdened with such conditions. Such a redevelopment program should include flood control works where necessary as well as setting aside the lower flood plain areas for parks, open spaces, athletic fields, and other uses not subject to substantial damages by flooding. To maximize the employment of these lands, the outer fringes of the flood plain can be used by new floodproofed structures.

Proper watershed land treatment is a basic element in a comprehensive flood prevention program. The concept of land treatment is to improve land and water management on each individual ownership in such a way that surface water runoff is reduced.

Land treatment includes water control measures, such as terraces and waterways; measures to protect the soil from erosion and to increase infiltration rates, e.g., strip cropping, contouring, and the planting of grass and cover crops; and the hydrologic improvement of forest lands.

In addition to increasing infiltration rates and reducing water surface runoff, land treatment measures reduce erosion and sedimentation, and thus maintain the capacity of streams and reservoirs to carry flood flows. Studies by the Soil Conservation Service in the Midwest indicate that a watershed land treatment program can reduce flows from 7 to 10 percent.

Disaster relief is the most direct means of dealing with flood losses. This is administered by the American Red Cross and a wide range of government agencies that assist with rescue, public health, transport, and financial aid. However, a problem lies in the policy of extending assistance without assurances that the sufferer will not return to his old place in the flood plain.

Minor measures that would contribute to the control of flood waters are periodic stream maintenance and ice formation control.

A maintenance program for removing the collection of debris and accumulation of jams, especially around bridge piers, would aid stream velocities and remove the dangers of artificially created high water stages due to such damming action. Such a program would require regular funding to maintain its effectiveness.

Another method, although still in the research and investigative stages, would be a system for the control of ice formations. Many communities at the mouths of the rivers entering the Great Lakes suffer from water overflows created by the damming action of ice packs. This damage often occurs even though the stream stages are at their lowest. An air-bubbling system has proved successful under limited conditions but has not yet received wide-spread use or acceptance.

2.3 Potential Solutions

Estimated potential flood damages indicated in Section 1 were based on the premise that use and further development of flood plains would continue to take place. Local, State, and Federal governments are aware of the tremendously high damage potential inherent in the unrestrained occupation of flood plain lands. They also recognize that much of the flood plains will be used in one form or another. Therefore, adequate management is essential to maintain efficient land use and minimize undesirable effects. Wherever possible, the use of flood-prone areas by developments that would suffer little or no damage from flood waters would contribute to an attractive high quality environment.

It is also assumed that the benefits from flood plain management programs will increase in the future. This is because of the time lag between the adoption of legislative tools and their general acceptance and enforcement. Therefore, it is necessary to modify the potential flood damages indicated in Section 1 to reflect the preventive measures effected by management measures. It was estimated that only 10 percent of the nonagriculture flood damage, as the result of growth between 1970 and 1980, would be reduced. Between 1980 and 2000, the reduction would be 40 percent, and between 2000 and 2020, 75 percent of the damage would be prevented.

The dimensionless curves shown in Figure 14–65 depict the shape of the unrestricted damage growth curve and the increasing effectiveness of flood plain legislation in reducing damage increments due to growth. The third line depicts a theoretical zero growth line or 100 percent effectiveness in preventing additional construction within the flood plain. In reality this line would not be straight because increased personal property would be added to existing structures while depreciation would tend to lower valuation and subsequent damage totals. For simplicity the line was drawn straight.

For urban areas several factors must be viewed concurrently when considering flood damage reduction measures:

(1) the trend to develop damageable property in the flood plain

(2) the retarding effect of flood plain legislation and other nonstructural damage reducing programs

(3) the social pressures for permanent protection against lost economic opportunities, health hazards, and the danger to human life and other related demands

While it is idealistic to program flood damage reduction via nonstructural means, the realistic fact is that some flood plain development will take place. For such developed areas, corrective measures are desirable for flood damage reduction. When this approach is applied, it will have to withstand the rigorous principles of economic and design analysis.

In the rural areas along the main stem and principal tributaries, some significant damages occur, but in most instances these are not serious enough to warrant the consideration of alternative corrective measures for damage reduction purposes. Recommendations in these areas are for preventative measures to preserve the flood plains with low potential damage uses such as permanent pasture, selective crops, parks, and valley preserves.

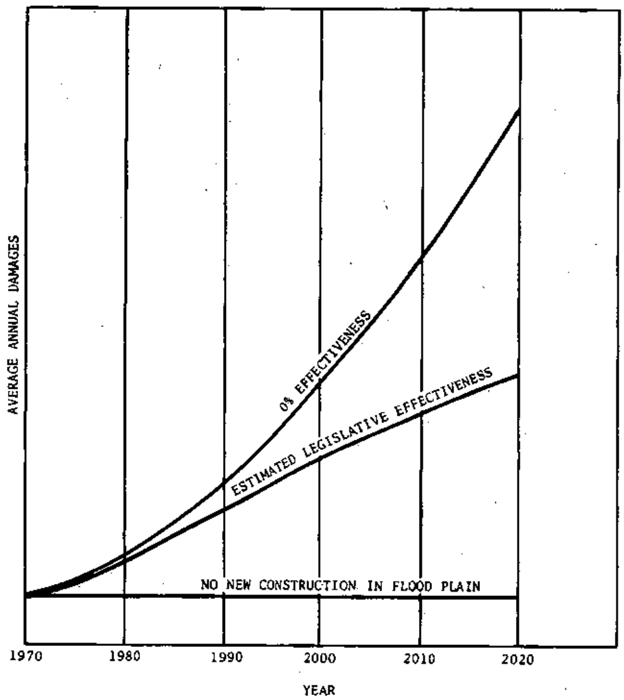

FIGURE 14-65 Estimated Effectiveness of Flood Plain Legislation and Minor Structural Measures

The damage data for the upstream watershed have been computed by using the Conservation Needs Inventory of problem areas, estimated frequency of flooding, and damageable values for crops determined in Public Law 566. Rural and urban damages for upstream areas are presented by a watershed number. The information listed in Tables 14-71 through 14-85 indicates the watersheds with significant flood damages that appear favorable for project action. Projects were selected on a priority basis with those having the most intense problems recommended in the earlier time periods.

Although a major corrective measure is recommended and ultimately constructed, there is no guarantee that this will prevent all future flood damages. Too often in the past, construction of a flood control scheme has only served to intensify the problem by creating a false sense of security, and thus encouraging increased development in the "protected" flood plain. A corrective measure should be a component of a comprehensive flood plain management program that can control the type and extent of development. The impact on the environment of all stages of development must be determined and plans to preserve and enhance environmental qualities must be formulated. Individual rights versus those of the public welfare must be clarified and codified if a management program is to be successful.

Tables 14-71 through 14-115 indicate alternatives that could be implemented during designated time periods to arrest the predicted growth of potential flood damages. Although requirement figures do not reflect reduction in potential damage growth due to the effects of existing and future flood plain legislation, this amount is taken into account and is reflected in the estimated damage reduction figures of feasible structural alternatives for all the main stems and principal tributaries in the Great Lakes Basin. The amount is in the proportion discussed earlier (see the example). The estimated damage reduction figures for upstream watersheds do not include effects of flood plain legislation, due to the rural nature of upstream areas. Other than the damage reduction included in the alternative structural measures for the main stems and principal tributaries, estimated damage reduction and related costs, as the result of proposed nonstructural measures, have not been computed due to insufficient data. For a rationale of selection of reduction measures see the subsection Problem Analysis Procedures in the Introduction and the earlier discussion in this section.

EXAMPLE

Niles, Michigan

Year	Estimated Average Annual Damages ($1000)*	1 Difference	2 Percent Effective	3 Column 1 times Column 2	4 Column 1 minus Column 3	5 Revised Damage Estimate
1970	26.5					
1980	37.0	10.5	10	1.1	9.4	35.9
2000	70.0	33.0	40	13.2	19.8	55.7
2020	145.0	75.0	75	56.3	18.7	74.4

*Taken from Table 14-23

Referring to the short term time period of Table 14-84 the estimated damage reduction is $67,300 for Niles, Michigan. This figure includes the following:

Item	Estimated Damage Reduction
Reduction due to effects of flood plain legislation on growth	
1970 to 1980 (taken from Column 3, above table)	$ 1,100
1980 to 2000 (taken from Column 3, above table)	13,200
Reduction due to effects of structural measures	
(Revised damage estimate from above calculation times estimated effectiveness of structural measures)	
55.7 x 0.95	53,000
Total	$67,300

TABLE 14–71 Flood Damage Reduction Measures, River Basin Group 1.1, Before 1980

PROBLEM AREA	REDUCTION MEASURES										ESTIMATED DAMAGE REDUCTION				ESTIMATED COST (1970 PRICE LEVEL)			
											URBAN		RURAL					
	Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	1000 Acres	$1000	1000 Acres	$1000	Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)											1.1	409.5	131.9	69.2				
SUPPLY (1970)											-	-	-	-				
NEED (1980)											1.1	409.5	131.9	69.2				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
ST. LOUIS RIVER																		
FOND DU LAC	*	*	*	*	*	*												
FLOODWOOD	*							*			0.1	86.6			320	300	20	
BALL PARK CREEK																		
BAYFIELD	*	*	*	*	*	*												
BAD RIVER																		
ODANAH	*									*	0.4	74.2			180	170	10	
MELLEN	*	*	*	*	*	*												
MONTREAL RIVER																		
HURLEY, IRONWOOD	*	*	*	*	*	*												
UPSTREAM WATERSHEDS																		
6D13	*																	
66A	*	*	*	*	*	*												
6D15	*							*					24.9	14.0	400	260	140	
6D06	*							*					15.0	11.0	750	490	260	
6D18	*							*					6.1	8.7	400	260	140	
611A	*	*	*	*														
6D16	*																	
67A	*	*	*															
6C1	*	*	*															
627	*							*					5.2	2.5	1,300	845	455	
6D21	*																	
628	*																	
TOTAL											0.5	160.8	51.2	36.2	3,350	2,325	1,025	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–72 Flood Damage Reduction Measures, River Basin Group 1.1, 1980–2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION — URBAN: 1000 Acres	URBAN: $1000	RURAL: 1000 Acres	RURAL: $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2000)											1.1	610.4	131.9	117.7				
SUPPLY (1980)											0.5	160.8	51.2	36.2				
NEED (2000)											0.6	449.6	80.7	81.5				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
ST. LOUIS RIVER																		
FOND DU LAC	*	*	*	*	*	*												
FLOODWOOD												62.0						
BALL PARK CREEK																		
BAYFIELD	*							*				178.3			1,800	1,620	180	
BAD RIVER																		
ODANAH	*											17.5						
MELLEN	*									*	0.2	52.4			600	540	60	
MONTREAL RIVER																		
HURLEY, IRONWOOD	*	*	*	*	*	*												
UPSTREAM WATERSHEDS																		
6D15	*													2.0				
6D06	*													1.0				
6D18	*													1.0				
627	*													1.1				
61A	*	*	*															
6D19	*																	
6D14	*							*					2.8	1.7	135	88	47	
6DI01	*																	
6C5	*	*	*															
69A	*	*	*															
629	*							*					1.0	1.3	380	247	133	
6D11	*																	
6DI04	*																	
TOTAL											0.2	310.2	3.8	8.1	2,915	2,495	420	

*ALTERNATIVE
(1) Structural Cost

TABLE 14-73 Flood Damage Reduction Measures, River Basin Group 1.1, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2020)											1.1	954.5	131.9	199.7				
SUPPLY (2000)											0.7	471.0	55.0	44.3				
NEED (2020)											0.4	483.5	76.9	155.4				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
ST. LOUIS RIVER																		
FOND DU LAC	*																	
FLOODWOOD												103.7						
BALL PARK CREEK																		
BAYFIELD	*											125.4						
BAD RIVER																		
ODANAH	*											44.4						
MELLEN	*											28.6						
MONTREAL RIVER																		
HURLEY, IRONWOOD	*																	
UPSTREAM WATERSHEDS																		
6D15	*													1.0				
6D06	*													2.0				
6D18	*													1.3				
627	*													0.4				
628	*							*					2.6	2.1	1,000	650	350	
6D19	*							*					2.1	2.0	260	170	90	
6D14	*													0.2				
629	*													0.1				
62	*																	
6D20	*																	
63	*																	
66	*																	
67	*																	
6D01	*																	
6D03	*																	
6D04	*							*					4	.6	158	103	55	
6D05	*																	
6D06	*																	
61	*																	
TOTAL											0	302.1	5.1	9.7	1,418	923	495	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–74 Flood Damage Reduction Measures, River Basin Group 1.2, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)											4.7	461.7	55.2	277.0				
SUPPLY (1970)											-	-	-	-				
NEED (1980)											4.7	461.7	55.2	277.0				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
PRESQUE ISLE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
ONTONAGON RIVER																		
RURAL FLOOD PLAINS	*	*		*														
STURGEON RIVER																		
RURAL FLOOD PLAINS	*	*		*														
FALLS RIVER																		
L'ANSE	*							*			0.1	32.8			320	300	20	
AUTRAIN RIVER																		
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
6B4	*	*	*	*	*	*												
6H	*	*	*	*	*	*												
6N	*							*			0.4	57.0	0.2		265	172	93	
6I1	*							*			0.1	21.0	8.8	20.	680	442	238	
6B3A	*							*			0.5	28.0			159	103	56	
6I1(A)	*	*	*															
6B3	*	*	*															
TOTAL											1.1	138.8	9.0	20.0	1,424	1,017	407	

*ALTERNATIVE
(1) Structural Cost

TABLE 14-75 Flood Damage Reduction Measures, River Basin Group 1.2, 1980–2000

PROBLEM AREA	REDUCTION MEASURES										ESTIMATED DAMAGE REDUCTION URBAN		ESTIMATED DAMAGE REDUCTION RURAL		ESTIMATED COST (1970 PRICE LEVEL)			REMARKS
	Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	1000 Acres	$1000	1000 Acres	$1000	Total ($1000)	Federal ($1000)	Non-Federal ($1000)	
REQUIREMENTS (2000)											4.7	751.3	55.2	393.2				
SUPPLY (1980)											1.1	138.8	9.0	20.0				
NEED (2000)											3.6	612.5	46.2	373.2				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
PRESQUE ISLE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
ONTONAGON RIVER																		
RURAL FLOOD PLAINS	*	*		*														
STURGEON RIVER																		
RURAL FLOOD PLAINS	*	*		*														
FALLS RIVER																		
L'ANSE	*											21.7						
AUTRAIN RIVER																		
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
6N	*											38.0						
6I1	*											14.0		2.0				
6B3A	*											19.0						
6I	*	*	*															
6B2	*																	
6A	*	*	*															
633	*																	
634	*																	
635	*																	
636	*										-							
TOTAL											0	92.7	0	2.0	0	0	0	

*ALTERNATIVE

TABLE 14-76 Flood Damage Reduction Measures, River Basin Group 1.2, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2020)											4.7	1,248.0	55.2	437.8				
SUPPLY (2000)											1.1	231.5	9.0	22.0				
NEED (2020)											3.6	1,016.5	46.2	415.8				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
PRESQUE ISLE RIVER																		
RURAL FLOOD PLAINS	*																	
ONTONAGON RIVER																		
RURAL FLOOD PLAINS	*																	
STURGEON RIVER																		
RURAL FLOOD PLAINS	*																	
FALLS RIVER																		
L'ANSE	*											37.6						
AUTRAIN RIVER																		
RURAL FLOOD PLAINS	*																	
UPSTREAM WATERSHEDS																		
6N	*											75.0		0.1				
6I1	*											29.0		3.0				
6B3A	*											37.0						
6B1	*																	
632	*																	
6A1	*																	
641	*																	
6B2A	*																	
6I1(A)2	*																	
6P	*																	
637	*																	
TOTAL											0	178.6	0	3.1	0	0	0	

*ALTERNATIVE

TABLE 14–77 Flood Damage Reduction Measures, River Basin Group 2.1, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)											13.7	3,007.4	647.8	1,600.3				
SUPPLY (1970)											-	-	-	-				
NEED (1980)											13.7	3,007.4	647.8	1,600.3				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
MENOMINEE RIVER																		
MENOMINEE	*	*	*	*	*	*												
MARINETTE	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
BRULE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
STURGEON RIVER																		
RURAL FLOOD PLAINS	*	*		*														
MICHIGAMME RIVER																		
RURAL FLOOD PLAINS	*	*		*														
PAINT RIVER																		
RURAL FLOOD PLAINS	*	*		*														
IRON RIVER																		
RURAL FLOOD PLAINS	*	*		*														
PINE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
PESHTIGO RIVER																		
PESHTIGO	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
OCONTO RIVER																		
RURAL FLOOD PLAINS	*	*		*														
FOX RIVER																		
GREEN BAY	*	*	*	*	*	*												
DE PERE	*	*	*	*	*	*												
APPLETON	*	*	*	*	*	*												
OSHKOSH	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
WAUPACA RIVER																		
RURAL FLOOD PLAINS	*	*		*														
EMBARRASS RIVER																		
NEW LONDON	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
WOLF RIVER																		WOLF RIVER DESIGNATED AS COMPONENT OF NATIONAL WILD & SCENIC RIVER SYSTEM
SHAWANO	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														

*ALTERNATIVE

TABLE 14–77(continued) Flood Damage Reduction Measures, River Basin Group 2.1, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)																		
SUPPLY (1970)																		
NEED (1980)																		
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
FOND DU LAC RIVER																		
FOND DU LAC	*	*	*	*	*	*												
MANITOWOC RIVER																		
MANITOWOC	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
SHEBOYGAN RIVER																		
SHEBOYGAN	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
SH3	*							*					8.7	33.0	620	403	217	WOLF RIVER DESIGNATED AS COMPONENT OF NATIONAL WILD & SCENIC RIVER SYSTEM
514	*							*	*		0.1	44.0	5.0	22.0	188	122	66	
524	*							*	*		0.3	14.0	11.0	45.0	2,124	1,381	743	
513	*							*	*				10.0	51.0	936	608	328	
SH18	*							*			0.1	2.9	13.0	48.0	279	181	98	
59	*							*					8.4	49.0	600	390	210	
526	*							*	*		0.1	17.0	9.3	29.0	2,372	1,542	830	
SH27	*	*	*															
520	*	*	*	*														
SH11A	*																	
518	*							*			0.1	1.6	6.9	32.0	124	81	43	
517	*	*	*															
SH214	*	*	*															
SH4	*	*	*	*														
510	*																	
TOTAL											0.7	79.5	72.3	309.0	7,243	4,708	2,535	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–78 Flood Damage Reduction Measures, River Basin Group 2.1, 1980–2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN: 1000 Acres	URBAN: $1000	RURAL: 1000 Acres	RURAL: $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2000)											14.0	5,316.9	647.6	1,991.2				
SUPPLY (1980)											0.7	79.5	72.3	309.0				
NEED (2000)											13.3	5,237.4	575.3	1,682.2				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
MENOMINEE RIVER																		
MENOMINEE	*	*	*	*	*	*												
MARINETTE	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
BRULE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
STURGEON RIVER																		
RURAL FLOOD PLAINS	*	*		*														
MICHIGAMME RIVER																		
RURAL FLOOD PLAINS	*	*		*														
PAINT RIVER																		
RURAL FLOOD PLAINS	*	*		*														
IRON RIVER																		
RURAL FLOOD PLAINS	*	*		*														
PINE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
PESHTIGO RIVER																		
PESHTIGO	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
OCONTO RIVER																		
RURAL FLOOD PLAINS	*	*		*														
FOX RIVER																		
GREEN BAY	*	*	*	*	*	*												
DE PERE	*	*	*	*	*	*												
APPLETON	*	*	*	*	*	*												
OSHKOSH	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
WAUPACA RIVER																		
RURAL FLOOD PLAINS	*	*		*														
EMBARRASS RIVER																		
NEW LONDON	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
WOLF RIVER																		WOLF RIVER DESIGNATED AS COMPONENT OF NATIONAL WILD & SCENIC RIVER SYSTEM
SHAWANO	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														

*ALTERNATIVE

TABLE 14–78(continued) Flood Damage Reduction Measures, River Basin Group 2.1, 1980–2000

PROBLEM AREA	REDUCTION MEASURES										ESTIMATED DAMAGE REDUCTION URBAN		ESTIMATED DAMAGE REDUCTION RURAL		ESTIMATED COST (1970 PRICE LEVEL)			REMARKS
	Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	1000 Acres	$1000	1000 Acres	$1000	Total ($1000)	Federal ($1000)	Non-Federal ($1000)	
REQUIREMENTS (2000)																		
SUPPLY (1980)																		
NEED (2000)																		
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
FOND DU LAC RIVER																		
FOND DU LAC	*	*	*	*	*	*												
MANITOWOC RIVER																		
MANITOWOC	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
SHEBOYGAN RIVER																		
SHEBOYGAN	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		WOLF RIVER DESIGNATED AS COMPONENT OF NATIONAL WILD & SCENIC RIVER SYSTEM
5H3														9.0				
514												36.0		6.0				
524												11.0		11.0				
513														14.0				
5H18														13.0				
59														14.0				
526												14.0		6.0				
518												1.4		9.0				
5H210	*							*			0.1	41.0	4.2	6.9	344	224	120	
5H215	*	*																
523	*	*	*	*	*													
5H212	*																	
5H13	*							*			0.1		4.8	31.0	160	104	56	
5H12 A	*							*			0.1	8.0	13.0	9.4	248	161	87	
5H9	*							*					8.3	31.0	270	176	94	
5H218	*																	
5H29	*							*			0.1	3.2	13.0	24.0	110	72	38	
5K1	*	*	*	*														
5I1	*	*	*	*														
511	*																	
5H219	*							*			0.1	5.0	5.7	21.0	140	91.0	49.0	
515	*							*					4.2	24.0	174	113	61	
525	*																	
528	*																	
5H5	*																	
5H14 A	*							*	*				5.0	22.0	630	410	220	
512	*																	
5H211	*																	
5H14	*																	
5H28	*	*	*															
5H213	*																	
522	*	*	*															
5H217	*							*					5.2	16.0	245	159	86	
5H19	*							*					4.3	15.0	186	121	65	
5H12	*							*	*				4.9	31.0	1,390	904	486	
5H216	*							*					2.9	15.0	82	53	29	
5H13 A	*																	
527	*																	
519	*																	
516	*																	
5H2	*																	
5H1	*																	
5H15	*	*	*															
5H8	*																	
5K33	*	*	*															
5K34	*	*	*															
5K10	*	*	*															
533	*	*	*	*														
5H17	*																	
5H11	*							*					2.1	4.6	84	55	29	
5K12	*																	
5K30	*	*	*															
5H23	*																	
TOTAL											0.5	119.6	77.6	288.1	4,063	2,643	1,420	

*ALTERNATIVE

TABLE 14–79 Flood Damage Reduction Measures, River Basin Group 2.1, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS(2020)											14.1	10,261.8	647.5	2,140.2				
SUPPLY (2000)											1.2	199.1	149.9	597.1				
NEED (2020)											12.9	10,062.7	497.6	1,543.1				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
MENOMINEE RIVER																		
MENOMINEE	*																	
MARINETTE	*																	
RURAL FLOOD PLAINS	*																	
BRULE RIVER																		
RURAL FLOOD PLAINS	*																	
STURGEON RIVER																		
RURAL FLOOD PLAINS	*																	
MICHIGAMME RIVER																		
RURAL FLOOD PLAINS	*																	
PAINT RIVER																		
RURAL FLOOD PLAINS	*																	
IRON RIVER																		
RURAL FLOOD PLAINS	*																	
PINE RIVER																		
RURAL FLOOD PLAINS	*																	
PESHTIGO RIVER																		
PESHTIGO	*																	
RURAL FLOOD PLAINS	*																	
OCONTO RIVER																		
RURAL FLOOD PLAINS	*																	
FOX RIVER																		
GREEN BAY	*																	
DE PERE	*																	
APPLETON	*																	
OSHKOSH	*																	
RURAL FLOOD PLAINS	*																	
EMBARRASS RIVER																		
NEW LONDON	*																	
RURAL FLOOD PLAINS	*																	
FOND DU LAC RIVER																		
FOND DU LAC	*																	
MANITOWOC RIVER																		
MANITOWOC	*									*	0.2	1152.1			7,800	7,500	300	
RURAL FLOOD PLAINS	*																	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–79(continued) Flood Damage Reduction Measures, River Basin Group 2.1, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2020)																		
SUPPLY (2000)																		
NEED (2020)																		
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
SHEBOYGAN RIVER																		
SHEBOYGAN	*									*	0.1	1512.6			10,400	10,000	400	
RURAL FLOOD PLAINS	*																	
WAUPACA RIVER																		
RURAL FLOOD PLAINS	*																	
WOLF RIVER																		WOLF RIVER DESIGNATED AS COMPONENT OF NATIONAL WILD & SCENIC RIVER SYSTEM
SHAWANO	*																	
RURAL FLOOD PLAINS	*																	
UPSTREAM WATERSHEDS																		
5H3	*													1.0				WOLF RIVER DESIGNATED AS COMPONENT OF NATIONAL WILD & SCENIC RIVER SYSTEM
514	*											71.0		1.0				
524	*											13.0		3.0				
513	*													2.0				
5H18	*											4.8		3.0				
59	*													2.0				
526	*											27.0		3.0				
518	*											2.6		1.0				
5H210	*											37.0		0.3				
5H13	*													2.0				
5H12A	*											7.0		0.6				
5H9	*													1.0				
5H218	*							*			0.1	11.0	1.5	15.0	751	488	263	
5H29	*											2.8		1.0				
5H219	*											4.5		1.0				
515	*													1.0				
5H14 A	*													1.0				
5H217	*													1.0				
5H19	*													1.0				
5H12	*													1.0				
5H216	*													0.1				
5H11	*													0.2				
5H10	*							*					4.5	3.5	505	328	177	
530	*	*	*															
5H7	*																	
5K7	*	*	*															
5H6	*																	
5K1(A)	*	*	*															
531	*	*	*															
5H24	*																	
5K4	*	*	*															
5H22	*																	
5H25	*																	
5N	*																	
5K5	*																	
5P1	*																	
5N1	*																	
5K3(A)	*																	
5K31	*																	
521	*																	
TOTAL											0.3	2,844.4	6.0	40.7	19,456.0	18,316	1,140	

*ALTERNATIVE
(1) Structural Cost

TABLE 14-80 Flood Damage Reduction Measures, River Basin Group 2.2, Before 1980

PROBLEM AREA	REDUCTION MEASURES										ESTIMATED DAMAGE REDUCTION				ESTIMATED COST (1970 PRICE LEVEL)			
											URBAN		RURAL					
	Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	1000 Acres	$1000	1000 Acres	$1000	Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)											5.8	13,060.7	56.9	296.7				
SUPPLY (1970)											-	-	-	-				
NEED (1980)											5.8	13,060.7	56.9	296.7				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
MILWAUKEE RIVER																		
MILWAUKEE	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
ROOT RIVER																		
RURAL FLOOD PLAINS	*	*		*														
LITTLE CALUMET RIVER																		
MUNSTER, HAMMOND, HIGHLAND, GARY, & EAST GARY	*							*		*	2.0	11,990.9	2.9	45.7	100,000	80,000	20,000	
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
5G2	*							*			0.1	26.0	11.0	36.0	103	67	36	
5G5	*							*			0.1	10.0	8.7	44.0	396	257	139	
53	*							*	*				5.0	30.0	1,245	809	335	
TOTAL											2.2	12,026.9	27.6	155.7	101,744	81,133	20,510	

*ALTERNATIVE
(1) Structural Cost

TABLE 14-81 Flood Damage Reduction Measures, River Basin Group 2.2, 1980–2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION URBAN: 1000 Acres	URBAN: $1000	RURAL: 1000 Acres	RURAL: $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2000)											7.5	27,103.8	55.2	456.6				
SUPPLY (1980)											2.2	12,026.9	27.6	155.7				
NEED (2000)											5.3	15,076.9	27.6	300.9				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
MILWAUKEE RIVER																		
MILWAUKEE	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
ROOT RIVER																		
RURAL FLOOD PLAINS	*	*		*														
LITTLE CALUMET RIVER																		
MUNSTER, HAMMOND, HIGHLAND, GARY & EAST GARY	*											12,998.0		49.2				
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
5G2	*											18.0		6.0				
5G5	*											7.0		8.0				
53	*													5.0				
5G4	*							*					7.4	18.0	212	138	74	
5G6	*							*					5.4	18.0	166	108	58	
52	*							*					2.6	13.0	206	134	72	
TOTAL											0	13,023.7	15.4	117.2	584	380	204	

*ALTERNATIVE
(1) Structural Cost

TABLE 14-82 Flood Damage Reduction Measures, River Basin Group 2.2, After 2000

PROBLEM AREA	REDUCTION MEASURES										ESTIMATED DAMAGE REDUCTION				ESTIMATED COST (1970 PRICE LEVEL)			REMARKS
											URBAN		RURAL					
	Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	1000 Acres	$1000	1000 Acres	$1000	Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	
REQUIREMENTS (2020)											9.8	56,052.8	52.9	679.3				
SUPPLY (2000)											2.2	25,050.6	43.0	272.9				
NEED (2020)											7.6	31,002.2	9.9	406.4				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
MILWAUKEE RIVER																		
MILWAUKEE	*																	
RURAL FLOOD PLAINS	*									*	1.5	1,663.4			7,500	7,000	500	
ROOT RIVER																		
RURAL FLOOD PLAINS	*																	
LITTLE CALUMET RIVER																		
HAMMOND, MUNSTER, HIGHLAND, GARY, & EAST GARY	*											27,156.3		123.9				
RURAL FLOOD PLAINS	*																	
UPSTREAM WATERSHEDS																		
5G2	*											34.0		7.0				
5G5	*											13.0		8.0				
53	*													6.0				
5G4	*													4.0				
5G6	*													3.0				
52	*													2.0				
5G1	*	*	*															
51	*																	
5G8	*																	
5G7	*							*					1.6	5.5	207			
5G3	*																	
TOTAL											1.5	28,866.7	1.6	159.4	7,707	7,000	500	

*ALTERNATIVE

(1) Structural Cost

TABLE 14–83 Flood Damage Reduction Measures, River Basin Group 2.3, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)											51.6	4,129.8	278.8	2,496.0				
SUPPLY (1970)											-	-	-	-				
NEED (1980)											51.6	4,129.8	278.8	2,496.0				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
ST. JOSEPH RIVER																		
BENTON HARBOR	*	*	*	*	*	*	*											
NILES	*	*	*	*	*	*												
SOUTH BEND	*	*	*	*	*	*	*											
MISHAWAKA	*									*	0.3	172.3			1,800	1,650	150	
ELKHART	*	*	*	*	*	*	*											
BRISTOL	*	*	*	*	*	*												
CONSTANTINE	*	*	*	*	*	*												
THREE RIVERS	*									*	0.2	13.3			170	155	15	
RURAL FLOOD PLAINS	*	*		*														
PAW PAW RIVER																		
PAW PAW LAKE	*							*			0.2	42.8			580	530	50	
RURAL FLOOD PLAINS	*	*		*														
DOWAGIAC RIVER																		
RURAL FLOOD PLAINS	*	*		*														
ELKHART RIVER																		
GOSHEN	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
PRAIRE RIVER																		
CENTERVILLE	*	*	*	*	*	*												
BURR OAK	*	*	*	*	*	*												
EAST COLDWATER RIVER																		
COLDWATER	*	*	*	*	*	*												
KALAMAZOO RIVER																		
ALLEGAN	*	*	*	*	*	*												
OTSEGO	*	*	*	*	*	*												
PLAINWELL	*	*	*	*	*	*												
KALAMAZOO	*							*			6.1	913.7			15,115	13,395	1,720	
BATTLE CREEK	*																	
ALBION	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
GRAND RIVER																		
GRANDVILLE	*									*	2.0	249.3			2,469	2,372	97	
GRAND RAPIDS	*	*	*	*	*	*	*											
COMSTOCK PARK & BELOW	*	*	*	*	*	*												
ADA	*	*	*	*	*	*												
LOWELL	*	*	*	*	*	*												
SARANAC	*	*	*	*	*	*												
IONIA	*	*	*	*	*	*												
LYONS	*	*	*	*	*	*												
PORTLAND	*	*	*	*	*	*												
GRAND LEDGE	*	*	*	*	*	*												
DIAMONDALE	*	*	*	*	*	*												
EATON RAPIDS	*							*			3.1	76.3			1,120.5	1,120.5		
JACKSON	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
SYCAMORE CREEK																		
RURAL FLOOD PLAINS	*	*		*														

*ALTERNATIVE
(1) Structural Cost

TABLE 14-83(continued) Flood Damage Reduction Measures, River Basin Group 2.3, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)																		
SUPPLY (1970)																		
NEED (1980)																		
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
RED CEDAR RIVER																		
LANSING, E. LANSING	*								*		3.5	688.3			7,294	7,294		
OKEMOS	*	*	*	*	*	*												
WILLIAMSTON	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
LOOKINGGLASS RIVER																		
DEWITT	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
MAPLE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
FLAT RIVER																		
RURAL FLOOD PLAINS	*	*		*														
ROUGE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
THORNAPPLE RIVER																		
HASTINGS	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
5M1 to 5M11	*							*	*				16.0	282	6,574	4,273	2,301	
5T1	*																	
5P1 to 5P4	*							*					5.0	154	3,736	2,428	1,308	
5M12	*							*					2.5	112	921	599	322	
5LG5	*	*	*															
5RC14	*	*	*															
5C6B	*							*	*				6.1	60.0	6,148	3,996	2,152	
5T3	*																	
5MG3	*	*	*															
5KK	*							*			0.3	1.0	3.0	55.0	2,300	1,495	805	
5R123	*							*					1.8	54.0	1,076	699	377	
5RC9	*																	
5A14B	*																	
5S1 to 5S6	*							*					2.2	44.0	801	521	280	
5RC7	*																	
5T11	*																	
5A13	*	*	*	*														
5A2A	*							*			0.1	10.0	3.5	24.0	936	608	328	
5LG6	*																	
TOTAL											15.8	2,176.0	40.1	795.0	51,040.5	41,135.5	9,905	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–84 Flood Damage Reduction Measures, River Basin Group 2.3, 1980–2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2000)											53.3	8,038.4	277.0	2,976.0				
SUPPLY (1980)											15.8	2,176.0	40.1	795.0				
NEED (2000)											37.5	5,862.4	236.9	2,181.0				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
ST. JOSEPH RIVER																		
BENTON HARBOR	*	*	*	*	*	*	*											
NILES	*									*	0.4	67.3			1,000	950	50	
SOUTH BEND	*									*	0.6	322.5			2,600	2,400	200	
MISHAWAKA	*											194.0						
ELKHART	*							*		*	1.4	403.9			5,000	4,600	400	
BRISTOL	*	*	*	*	*	*												
CONSTANTINE	*	*	*	*	*	*												
THREE RIVERS	*											14.6						
RURAL FLOOD PLAINS	*	*		*														
PAW PAW RIVER																		
PAW PAW LAKE	*											43.7						
RURAL FLOOD PLAINS	*	*		*														
DOWAGIAC RIVER																		
RURAL FLOOD PLAINS	*	*		*														
ELKHART RIVER																		
GOSHEN	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
PRAIRIE RIVER																		
CENTERVILLE	*	*	*	*	*	*												
BURR OAK	*	*	*	*	*	*												
E. COLDWATER RIVER																		
COLDWATER	*	*	*	*	*	*												
KALAMAZOO RIVER																		
ALLEGAN	*	*	*	*	*	*												
OTSEGO	*	*	*	*	*	*												
PLAINWELL	*	*	*	*	*	*												
KALAMAZOO	*											1,164.0						
BATTLE CREEK	*																	
ALBION	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
GRAND RIVER																		
GRANDVILLE												337.6						
GRAND RAPIDS	*	*	*	*	*	*	*											
COMSTOCK PARK & BELOW	*	*	*	*	*	*	*											
ADA	*	*	*	*	*	*	*											
HOWELL	*	*	*	*	*	*	*											
SARANAC	*	*	*	*	*	*	*											
IONIA	*	*	*	*	*	*	*											
LYONS	*	*	*	*	*	*	*											
PORTLAND	*	*	*	*	*	*	*											
GRAND LEDGE	*	*	*	*	*	*	*											
DIAMONDALE	*	*	*	*	*	*	*											
EATON RAPIDS	*											30.8						
JACKSON	*	*	*	*	*	*	*											
RURAL FLOOD PLAINS	*	*		*														
SYCAMORE CREEK																		
RURAL FLOOD PLAINS	*	*		*														

*ALTERNATIVE
(1) Structural Cost

TABLE 14–84(continued) Flood Damage Reduction Measures, River Basin Group 2.3, 1980–2000

PROBLEM AREA	REDUCTION MEASURES										ESTIMATED DAMAGE REDUCTION				ESTIMATED COST (1970 PRICE LEVEL)			REMARKS
											URBAN		RURAL					
	Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	1000 Acres	$1000	1000 Acres	$1000	Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	
RED CEDAR RIVER																		
LANSING, E. LANSING	*											869.8						
OKEMOS	*	*	*	*	*	*												
WILLIAMSTON	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
LOOKINGGLASS RIVER																		
DEWITT	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
MAPLE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
FLAT RIVER																		
RURAL FLOOD PLAINS	*	*		*														
ROGUE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
THORNAPPLE RIVER																		
HASTINGS	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
5M1 to 5M11	*													54.0				
5P1 to 5P4	*													29.0				
5M12	*													21.0				
5C6B	*													11.0				
5KK												0.7		10.0				
5R123														10.0				
5A14B	*							*			0.2	53.0	2.4	9.3	1,375	894	481	
5S1 to 5S6	*													9.0				
5A2A	*											15.0		4.0				
5A8	*							*	*		0.2	58.0	1.1	2.7	608	395	213	
5R6	*	*	*															
5UG7	*	*	*															
5T5	*																	
5F4	*																	
5MG8	*																	
5R5	*																	
5LG8	*																	
5UG5	*							*					2.6	27.0	427	278	149	
5LL2	*							*			0.2	32.0	1.6	10.0	1,560	1,014	546	
5RC5	*																	
5C1	*							*			0.1	4.9	2.7	8.1	6,600	4,290	2,310	
5C6D	*																	
5A30A	*							*			0.1	18.0	1.1	1.8	432	281	151	
5R4	*	*	*															
5A3	*	*	*	*														
5L6	*	*	*	*														
5MG5	*																	
5T4	*																	
5UG8	*							*					2.6	18.0	290	189	101	
5MG1	*	*	*															
5A1C	*																	
5A8A	*	*	*	*														
5UG10	*	*	*															
5A12	*							*			0.1	24.0	1.2	2.3	364	237	127	
5RC8	*																	
5MG6	*							*					1.7	13.0	231	150	81	
5MG2A	*	*	*	*														
5M15	*																	
5C530	*	*	*	*														

*ALTERNATIVE
(1) Structural Cost

TABLE 14-84(continued) Flood Damage Reduction Measures, River Basin Group 2.3, 1980–2000

PROBLEM AREA	REDUCTION MEASURES										ESTIMATED DAMAGE REDUCTION				ESTIMATED COST (1970 PRICE LEVEL)			REMARKS
											URBAN		RURAL					
	Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	1000 Acres	$1000	1000 Acres	$1000	Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	
UPSTREAM WATERSHEDS																		
5RC10	*																	
5LG1	*	*	*															
TOTAL											3.3	3,653.8	17.0	240.2	20,487	15,678	4,809	

*ALTERNATIVE

(1) Structural Cost

TABLE 14-85 Flood Damage Reduction Measures, River Basin Group 2.3, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2020)											55.3	16,743.2	275.1	3,446.6				
SUPPLY (2000)											19.1	5,829.8	57.1	1,035.2				
NEED (2020)											35.2	10,913.4	218.0	2,411.4				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
ST. JOSEPH RIVER																		
BENTON HARBOR	*																	
NILES	*											74.0						
SOUTH BEND	*											394.6						
MISHAWAKA	*											425.4						
ELKHART	*											524.3						
BRISTOL	*																	
CONSTANTINE	*																	
THREE RIVERS	*											30.6						
RURAL FLOOD PLAINS	*																	
PAW PAW RIVER																		
PAW PAW LAKE	*											59.3						
RURAL FLOOD PLAINS	*																	
DOWAGIAC RIVER																		
RURAL FLOOD PLAINS	*																	
ELKHART RIVER																		
GOSHEN	*																	
RURAL FLOOD PLAINS	*																	
PRAIRIE RIVER																		
CENTERVILLE	*																	
BURR OAK	*																	
E. COLDWATER RIVER																		
COLDWATER	*																	
KALAMAZOO RIVER																		
ALLEGAN	*																	
OTSEGO	*																	
PLAINWELL	*																	
KALAMAZOO	*											2,929.9						
BATTLE CREEK	*																	
ALBION	*																	
RURAL FLOOD PLAINS	*																	
GRAND RIVER																		
GRANDVILLE	*											780.1						
GRAND RAPIDS	*																	
COMSTOCK PARK & BELOW	*																	
ADA	*																	
LOWELL	*																	
SARANAC	*																	
IONIA	*																	
LYONS	*																	
PORTLAND	*																	
GRAND LEDGE	*																	
DIAMONDALE	*																	
EATON RAPIDS	*											42.7						
JACKSON	*																	
RURAL FLOOD PLAINS	*																	
SYCAMORE CREEK																		
RURAL FLOOD PLAINS	*																	

*ALTERNATIVE

TABLE 14-85(continued) Flood Damage Reduction Measures, River Basin Group 2.3, After 2000

PROBLEM AREA	REDUCTION MEASURES										ESTIMATED DAMAGE REDUCTION URBAN		ESTIMATED DAMAGE REDUCTION RURAL		ESTIMATED COST (1970 PRICE LEVEL)			REMARKS
	Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	1000 Acres	$1000	1000 Acres	$1000	Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	
RED CEDAR RIVER																		
LANSING, E. LANSING	*											2,128.3						
OKEMOS	*																	
WILLIAMSTON	*																	
RURAL FLOOD PLAINS	*																	
LOOKINGGLASS RIVER																		
DEWITT	*																	
RURAL FLOOD PLAINS	*																	
MAPLE RIVER																		
RURAL FLOOD PLAINS	*																	
FLAT RIVER																		
RURAL FLOOD PLAINS	*																	
ROGUE RIVER																		
RURAL FLOOD PLAINS	*																	
THORNAPPLE RIVER																		
HASTINGS	*																	
RURAL FLOOD PLAINS	*																	
UPSTREAM WATERSHEDS																		
5M1 to 5M11	*													48.0				
5P1 to 5P4	*													27.0				
5M12	*													19.0				
5C6B	*													10.0				
5KK	*											1.6		9.0				
5R123	*													9.0				
5A14B	*											47.0		0.7				
5S1 to 5S6	*													7.0				
5A2A	*											31.0		4.0				
5A8	*											41.0		0.4				
5UG5	*													4.0				
5LL2	*											29.0		1.0				
5C1	*											4.4		1.1				
5A30A	*											16.0		0.3				
5UG8	*													3.0				
5A12	*											22.0		0.2				
5MG6	*													2.0				
5A9	*							*			0.3	34.0	0.2	0.9	448	291	157	
5UG9	*							*					1.5	11.0	119	77	42	
5MG7	*							*					1.0	10.0	128	83	45	
5LG3	*	*	*	*														
5F6	*																	
5A12A	*																	
5A8 C	*	*	*															
5A7	*																	
5C1A	*							*	*				0.5	7.4	300	195	105	
5A11	*																	
5L4	*																	
5S6	*																	
5M14	*																	
5LL	*							*			0.1	7.0	0.3	3.5	2,240	1,456	784	
5LL	*																	
5A4	*	*	*															
5A30	*																	
5RC4	*																	
5MG4A	*																	
5C4	*																	
5A4 C	*	*	*															

*ALTERNATIVE
(1) Structural Cost

TABLE 14–85(continued) Flood Damage Reduction Measures, River Basin Group 2.3, After 2000

PROBLEM AREA	REDUCTION MEASURES										ESTIMATED DAMAGE REDUCTION				ESTIMATED COST (1970 PRICE LEVEL)			
											URBAN		RURAL					
	Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	1000 Acres	$1000	1000 Acres	$1000	Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
UPSTREAM WATERSHEDS																		
5A2B	*	*	*															
5LG10	*	*	*															
5UG1	*																	
5C2	*																	
5A6	*																	
5T6	*																	
5F1	*																	
5A5 C	*																	
RC1	*																	
5RC3	*																	
5C6C	*																	
5A10	*							*					0.3	0.1	525	341	184	
5F2	*																	
TOTAL											0.4	7,622.2	3.8	178.5	3,760	2,443	1,317	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–86 Flood Damage Reduction Measures, River Basin Group 2.4, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)											3.5	131.4	112.4	190.4				
SUPPLY (1970)											-	-	-	-				
NEED (1980)											3.5	131.4	112.4	190.4				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
MUSKEGON RIVER																		
BIG RAPIDS	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
WHITE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
PERE MARQUETTE RIVER																		PERE MARQUETTE RIVER BEING STUDIED FOR INCLUSION IN NATIONAL WILD & SCENIC RIVER SYSTEM
RURAL FLOOD PLAINS	*	*		*														
MANISTEE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
BOARDMAN RIVER																		
RURAL FLOOD PLAINS	*	*		*														
MANISTIQUE RIVER																		
MANISTIQUE	*	*	*	*	*	*												
MANISTIQUE LAKE	*																	
RURAL FLOOD PLAINS	*	*		*														
INDIAN RIVER																		
INDIAN LAKE	*																	
RURAL FLOOD PLAINS	*	*		*														
ESCANABA RIVER																		
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		PERE MARQUETTE RIVER BEING STUDIED FOR INCLUSION IN NATIONAL WILD & SCENIC RIVER SYSTEM
5E	*																	
5EE2A	*							*					3.8	21	296	192	104	
5T1	*	*	*															
5CC	*							*			1.0	5.8	1.2	0.4	204	133	71	
5II	*							*					0.5	5.4	276	180	96	
540	*	*	*															
5T2	*																	
5F2	*							*			0.1	3.5	1.3		680	442	238	
548A	*							*					2.1	2.5	156	101	55	
5E2	*																	
551	*							*					0.1	2.1	156	101	55	
542	*	*	*															
TOTAL											1.1	9.3	9.0	31.4	1,768	1,149	619	

*ALTERNATIVE

(1) Structural Cost

TABLE 14-87 Flood Damage Reduction Measures, River Basin Group 2.4, 1980–2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2000)											3.7	229.8	112.1	238.4				
SUPPLY (1980)											1.1	9.3	9.0	31.4				
NEED (2000)											2.6	220.5	103.1	207.0				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
MUSKEGON RIVER																		
BIG RAPIDS	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
WHITE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
PERE MARQUETTE RIVER																		PERE MARQUETTE RIVER BEING STUDIED FOR INCLUSION IN NATIONAL WILD & SCENIC RIVER SYSTEM
RURAL FLOOD PLAINS	*	*		*														
MANISTEE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
MANISTIQUE RIVER																		
MANISTIQUE	*	*	*	*	*	*												
MANISTIQUE LAKE	*																	
RURAL FLOOD PLAINS	*	*		*														
INDIAN RIVER																		
INDIAN LAKE	*																	
RURAL FLOOD PLAINS	*	*		*														
ESCANABA RIVER																		
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		PERE MARQUETTE RIVER BEING STUDIED FOR INCLUSION IN NATIONAL WILD & SCENIC RIVER SYSTEM.
5E	*							*	*		0.1	4.5	7.1	28.0	2,996	1,947	1,049	
5EE2A	*													6.0				
5CC	*											4.2		0.1				
511	*													1.4				
5F2	*											2.7		0.1				
548A	*													0.6				
551	*													0.6				
5E2A	*	*	*															
563	*	*	*															
5T	*	*	*															
5HH2	*																	
5E6A1	*							*					0.8	5.4	730	475	255	
5E3	*																	
5EE2	*							*					3.3	0.5	816	530	286	
536A	*							*					0.4	0.4	120	78	42	
5BB	*																	
5EE	*							*					0.7	0.1	340	221	119	
TOTAL											0.1	11.4	12.3	43.2	5,002	3,251	1,751	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–88 Flood Damage Reduction Measures, River Basin Group 2.4, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION URBAN: 1000 Acres	URBAN: $1000	RURAL: 1000 Acres	RURAL: $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2020)											4.0	425.0	111.9	288.9				
SUPPLY (2000)											1.2	20.7	21.3	74.6				
NEED (2020)											2.8	404.3	90.6	214.3				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
MUSKEGON RIVER																		
BIG RAPIDS	*																	
RURAL FLOOD PLAINS	*																	
WHITE RIVER																		
RURAL FLOOD PLAINS	*																	
PERE MARQUETTE RIVER																		PERE MARQUETTE RIVER BEING STUDIED FOR INCLUSION IN NATIONAL WILD & SCENIC RIVER SYSTEM
RURAL FLOOD PLAINS	*																	
MANISTEE RIVER																		
RURAL FLOOD PLAINS	*																	
BOARDMAN RIVER																		
RURAL FLOOD PLAINS	*																	
MANISTIQUE RIVER																		
MANISTIQUE	*																	
MANISTIQUE LAKE	*																	
RURAL FLOOD PLAINS	*																	
INDIAN RIVER																		
INDIAN LAKE	*																	
RURAL FLOOD PLAINS	*																	
ESCANABA RIVER																		
RURAL FLOOD PLAINS	*																	
UPSTREAM WATERSHEDS																		PERE MARQUETTE RIVER BEING STUDIED FOR INCLUSION IN NATIONAL WILD & SCENIC RIVER SYSTEM
5E	*													2.0				
5EE2A	*													1.0				
5CC	*											9.2		<0.1				
5II	*													0.3				
5F2	*											5.8						
548A	*													0.2				
551	*													0.1				
5HH2	*																	
5E6A1	*													0.6				
5EE2	*													<0.1				
536A	*													0.1				
5EE	*													0.1				
5F	*																	
5F3	*																	
5DD	*																	
5EE5	*																	
5HH1	*																	
5X	*																	
5F3A	*																	
5HH	*																	
547	*																	
550	*																	
TOTAL											0	15.0	0	4.4	0	0	0	

*ALTERNATIVE

TABLE 14–89 Flood Damage Reduction Measures, River Basin Group 3.1, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)											0.7	40.0	39.3	256.6				
SUPPLY (1970)											-	-	-	-				
NEED (1980)											0.7	40.0	39.3	256.6				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
CHEBOYGAN RIVER																		
RURAL FLOOD PLAINS	*	*		*														
BLACK RIVER																		
RURAL FLOOD PLAINS	*							*					1.3	71.1	510	460	50	
THUNDER BAY RIVER																		
RURAL FLOOD PLAINS	*	*		*														
AU SABLE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
AU GRES RIVER																		
RURAL FLOOD PLAINS	*							*					12.7	158.7 #	3,900	2,400	1,500	# ADDITIONAL BENEFITS TO BE GAINED FROM LAND ENHANCEMENT FROM IMPROVED DRAINAGE.
RIFLE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
433	*	*	*	*	*													
434	*	*	*	*	*													
4B1	*	*	*	*	*													
4C	*	*	*															
4N	*																	
4P	*																	
TOTAL											0	0	14.0	229.8	4,410	2,860	1,550	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–90 Flood Damage Reduction Measures, River Basin Group 3.1, 1980–2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2000)											0.8	74.9	39.3	302.7				
SUPPLY (1980)											-	-	14.0	229.8				
NEED (2000)											0.8	74.9	25.3	72.9				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
CHEBOYGAN RIVER																		
RURAL FLOOD PLAINS	*	*		*														
BLACK RIVER																		
RURAL FLOOD PLAINS	*													27.9				
THUNDER BAY RIVER																		
RURAL FLOOD PLAINS	*	*		*														
AU SABLE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
AU GRES RIVER																		
RURAL FLOOD PLAINS	*													10.7				
RIFLE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
4R	*																	
4Q	*																	
4C1	*							*					3.2	1.2	1,700	1,110	590	
4C3	*																	
4G1	*	*	*															
4E2	*																	
TOTAL											0	0	3.2	39.8	1,700	1,110	590	

*ALTERNATIVE
(1)Structural Cost

TABLE 14–91 Flood Damage Reduction Measures, River Basin Group 3.1, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN: 1000 Acres	URBAN: $1000	RURAL: 1000 Acres	RURAL: $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2020)											0.8	145.7	39.2	379.2				
SUPPLY (2000)											-	-	17.2	269.6				
NEED (2020)											0.8	145.7	22.0	109.6				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
CHEBOYGAN RIVER																		
RURAL FLOOD PLAINS	*																	
BLACK RIVER																		
RURAL FLOOD PLAINS	*													48.9				
THUNDER BAY RIVER																		
RURAL FLOOD PLAINS	*																	
AU SABLE RIVER																		
RURAL FLOOD PLAINS	*																	
AU GRES RIVER																		
RURAL FLOOD PLAINS	*													43.5				
RIFLE RIVER																		
RURAL FLOOD PLAINS	*																	
UPSTREAM WATERSHEDS																		
4R	*							*			0.1	5.3	0.2	0.1	1,525	990	535	
4Q	*																	
4C1	*													0.6				
4C3	*																	
4G1	*	*	*															
4E2	*																	
4C3B	*																	
4E3A	*																	
4D1C	*																	
4Q1	*																	
4H	*																	
431	*																	
TOTAL											0.1	5.3	0.2	93.1	1,525	990	535	

*ALTERNATIVE
(1) Structural Cost

TABLE 14-92 Flood Damage Reduction Measures, River Basin Group 3.2, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)											8.2	816.4	253.4	1,043.9				
SUPPLY (1970)											-	-	-	-				
NEED (1980)											8.2	816.4	253.4	1,043.9				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
SAGINAW RIVER																		
SAGINAW	*	*	*	*	*	*												
SHIAWASSEE FLATS	*	*		*														
RURAL FLOOD PLAINS	*	*		*														
TITTABAWASSEE RIVER																		
MIDLAND	*							*		*	0.6	246.5			2,900	2,725	175	
RURAL FLOOD PLAINS	*	*		*														
SHIAWASSEE RIVER																		
OWOSSO & CORUNNA	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
FLINT RIVER																		
FLINT	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
CASS RIVER																		
VASSAR	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
KAWKAWLIN RIVER																		
RURAL FLOOD PLAINS	*	*		*														
SEBEWAING RIVER																		
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
445	*							*			0.1	0.7	21.0	49.0	4,680	3,042	1,638	
4A9	*							*					9.0	43.0	2,460	1,599	861	
4A4D	*							*				23.0	0.2	0.2	1,380	892	483	
4A4A1A	*	*	*	*														
442	*							*			0.1	3.0	1.2	32.0	375	244	131	
4A4A4	*							*					5.0	29.0	528	343	185	
4A6	*	*	*	*														
4A3A	*																	
4A2B	*							*			0.4	11.0	6.0	7.8	1,775	1,154	621	
4A5	*							*			0.5	0.6	0.5	1.1	1,590	1,034	556	
4A1E2	*																	
4A4E2	*							*					5.5	17.0	924	601	323	
4A230	*							*	*		0.2	0.5	3.5	8.0	4,472	2,907	1,565	
4W	*							*					4.2	17.0	2,100	1,365	735	
4A1E	*																	
TOTAL											1.9	285.3	56.1	204.1	23,184	15,906	7,273	

*ALTERNATIVE
(1) Structural Cost

TABLE 14-93 Flood Damage Reduction Measures, River Basin Group 3.2, 1980–2000

PROBLEM AREA	REDUCTION MEASURES										ESTIMATED DAMAGE REDUCTION				ESTIMATED COST (1970 PRICE LEVEL)			REMARKS
											URBAN		RURAL					
	Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	1000 Acres	$1000	1000 Acres	$1000	Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	
REQUIREMENTS (2000)											9.1	1,306.4	252.5	1,211.6				
SUPPLY (1980)											1.9	285.3	56.1	204.1				
NEED (2000)											7.2	1,021.1	196.4	1,007.5				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
SAGINAW RIVER																		
SAGINAW	*	*	*	*	*	*												
SHIAWASSEE FLATS	*	*		*														
RURAL FLOOD PLAINS	*	*		*														
TITTABAWASSEE RIVER																		
MIDLAND	*											151.3						
RURAL FLOOD PLAINS	*	*		*														
SHIAWASSEE RIVER																		
OWOSSO & CORUNNA	*							*		*	0.2	85.1			1,050	820	230	
RURAL FLOOD PLAINS	*																	
FLINT RIVER																		
FLINT	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
CASS RIVER																		
VASSAR	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
KAWKAWLIN RIVER																		
RURAL FLOOD PLAINS	*	*		*														
SEBEWAING RIVER																		
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
445	*											0.6		9.0				
4A9	*													8.0				
4A4D	*											19.0						
442	*											2.4		6.0				
4A4A4	*													5.0				
4A2B	*											9.0		1.6				
4A5	*											0.4		0.2				
4A1E2	*																	
4A4E2	*													4.0				
4A230	*											0.4		1.5				
4W	*													3.0				
4A1E	*							*			0.1	0.9	3.6	16.0	1,850	1,203	647	
443	*							*					4.0	15.0	530	345	185	
4A4A5A	*	*	*	*														
4T1	*							*					2.1	10.0	3,869	2,515	1,354	
4A2F	*																	
4A4A3A	*																	
4V	*																	
4A2G1	*	*	*															
4A1E1	*																	
4A2C	*							*	*		0.4	11.0	3.3	2.6	2,293	1,491	802	
4A4A	*																	
4A4A5	*																	
4A4E1	*																	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–93(continued) Flood Damage Reduction Measures, River Basin Group 3.2, 1980–2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
UPSTREAM WATERSHEDS																		
4A2G	*												22.0	5.9	6,800	4,420	2,380	
444	*																	
4A4E	*	*	*															
4A4C	*	*	*															
4A4A1	*							*			0.1	3.3	3.2	6.1	3,198	2,079	1,119	
TOTAL											0.8	283.4	38.2	93.9	19,590	12,873	6,717	

*ALTERNATIVE
(1) Structural Cost

TABLE 14-94 Flood Damage Reduction Measures, River Basin Group 3.2, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2020)											10.1	2,386.0	251.5	1,386.7				
SUPPLY (2000)											2.7	568.7	94.3	298.0				
NEED (2020)											7.4	1,817.3	157.2	1,088.7				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
SAGINAW RIVER																		
SAGINAW	*																	
SHIAWASSEE FLATS	*							*		*	0.5	252.3	54.8	569.3	18,000	14,400	3,600	
RURAL FLOOD PLAINS	*																	
TITTABAWASSEE RIVER																		
MIDLAND	*											496.7						
RURAL FLOOD PLAINS	*																	
SHIAWASSEE RIVER																		
OWOSSO & CORUNNA	*											28.6						
RURAL FLOOD PLAINS	*																	
FLINT RIVER																		
FLINT	*																	
RURAL FLOOD PLAINS	*																	
CASS RIVER																		
VASSAR	*																	
RURAL FLOOD PLAINS	*																	
KAWKAWLIN RIVER																		
RURAL FLOOD PLAINS	*																	
SEBEWAING RIVER																		
RURAL FLOOD PLAINS	*																	
UPSTREAM WATERSHEDS																		
445	*											1.1		9.0				
4A9	*													7.0				
4A4D	*											38.0						
442	*											4.6		5.0				
4A4A4	*													5.0				
4A2B	*											18.0		1.6				
4A5	*											1.0		0.2				
4A1E2	*							*			0.1	6.6	3.4	24.0	4,389	2,853	1,536	
4A4E2	*													3.0				
4A230	*											0.8		1.5				
4W	*													3.0				
4A1E	*											0.9		2.0				
443	*													3.0				
4T1	*													1.0				
4A2C	*											9.0		0.4				
4A4A	*							*			0.2	13.0	2.3	5.4	1,050	683	367	
444	*													0.8				
4A4A1	*											3.0		0.9				
4A2E	*	*	*															
4A1A	*							*					1.0	5.5	1,247	811	436	
4A2F2	*	*	*															
4A1E3	*																	
4A1E4	*																	
4U	*																	
440	*							*					1.0	4.1	1,378	896	482	
4A4F	*							*			0.1	8.1	2.0	2.1	2,360	1,547	833	
4A3C	*																	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–94(continued) Flood Damage Reduction Measures, River Basin Group 3.2, After 2000

PROBLEM AREA	REDUCTION MEASURES										ESTIMATED DAMAGE REDUCTION				ESTIMATED COST (1970 PRICE LEVEL)			REMARKS
											URBAN		RURAL					
	Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	1000 Acres	$1000	1000 Acres	$1000	Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	
UPSTREAM WATERSHEDS																		
4A3C1	*																	
4A4F4	*							*					0.5	2.9	920	600	320	
4T1A	*							*					2.2	2.6	210	137	73	
4A1B	*							*					0.6	2.1	2,176	1,414	762	
4A2D	*	*	*	*														
4A3D	*	*	*															
446	*																	
452	*																	
4A1C1	*																	
4A1C	*							*					4.3	0.1	2,320	1,508	812	
4A3B	*																	
4A4A3	*																	
4A7A	*																	
4A4F2	*																	
TOTAL											0.9	881.7	72.1	681.6	34,070	24,849	9,221	

*ALTERNATIVE
(1) Structural Cost

TABLE 14-95 Flood Damage Reduction Measures, River Basin Group 4.1, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN: 1000 Acres	URBAN: $1000	RURAL: 1000 Acres	RURAL: $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)											58.6	35,374.8	205.7	2,465.7				
SUPPLY (1970)											-	-	-	-				
NEED (1980)											58.6	35,374.8	205.7	2,465.7				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
BLACK RIVER																		
PORT HURON	*							*			5.0	157.7			2,100	1,950	150	
RURAL FLOOD PLAINS	*	*		*														
PINE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
BELLE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
CLINTON RIVER & RED RUN DRAIN																		
RURAL, URBAN FLOOD PLAINS	*							*			3.4	29,170.0			167,000	121,000	46,000	
RIVER ROUGE																		
DEARBORN	*							*			5.0	1,793.0			35,000	26,000	9,000	PROJECT UNDER CONSTRUCTION
BIRMINGHAM	*							*			0.2	89.9			810	450	360	
URBAN FLOOD PLAINS	*	*	*	*	*	*												
BELL BRANCH URBAN FLOOD PLAINS	*	*	*	*	*	*												
HURON RIVER																		
ROCKWOOD	*	*	*	*	*	*												
FLAT ROCK	*	*	*	*	*	*												
YPSILANTI	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
RAISIN RIVER																		
DUNDEE	*	*	*	*	*	*												
BLISSFIELD	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
3M	*							*			0.2	133.0	35.0	1,150.0	3,900	2,535	1,365	
331	*							*			0.8	478.0	3.3	171.0	4,320	2,808	1,512	
3G2	*							*					5.5	204.0	5,540	3,601	1,939	
3F1	*							*	*		0.3	1.0	18.0	193.0	6,634	4,312	2,322	
3I	*							*			1.9	191.0	6.0	21.0	5,830	3,790	2,040	
3K	*							*			1.0	214.0	0.2	0.2	1,290	839	451	
3J	*							*			4.8	211.0	1.3	2.6	6,660	4,329	2,331	
330	*							*			0.3	113.0	11.0	15.0	1,025	666	359	
TOTAL											22.9	32,551.6	80.3	1,756.8	240,109	172,280	67,829	

*ALTERNATIVE

(1) Structural Cost

TABLE 14-96 Flood Damage Reduction Measures, River Basin Group 4.1, 1980-2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2000)											59.5	56,464.3	204.8	3,025.4				
SUPPLY (1980)											22.9	32,551.6	80.3	1,756.8				
NEED (2000)											36.6	23,912.7	124.5	1,268.6				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
BLACK RIVER																		
PORT HURON	*											49.5						
RURAL FLOOD PLAINS	*	*		*														
PINE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
BELLE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
CLINTON RIVER & RED RUN DRAIN																		
RURAL, URBAN FLOOD PLAINS	*											18,369.0						
RIVER ROUGE																		
DEARBORN	*											1,266.0						
BIRMINGHAM	*											121.8						
URBAN FLOOD PLAINS	*	*	*	*	*	*												
BELL BRANCH URBAN FLOOD PLAINS	*	*	*	*	*	*												
HURON RIVER																		
ROCKWOOD	*	*	*	*	*	*												
FLAT ROCK	*	*	*	*	*	*												
YPSILANTI	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
RAISIN RIVER																		
DUNDEE	*	*	*	*	*	*												
BLISSFIELD	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
3M	*											96.0		275.0				
331	*											348.0		40.0				
3G2	*													49.0				
3F1	*											0.7		45.0				
3I	*											138.0		7.0				
3K	*											156.0		0.1				
3J	*											151.0		0.6				
330	*											82.0		4.0				
3E1	*							*			0.1	152.0	2.6	8.2	600	390	210	
3G4D	*							*					9.4	84.0	7,120	4,628	2,492	
3F2A	*							*			1.0	1.0	5.9	69.0	2,070	1,350	720	
3L	*							*			0.1	91.0	0.2	5.8	1,125	731	394	
3DE4	*							*					0.9	22.0	360	234	126	
3J1	*							*			0.3	1.7	1.2	16.0	760	494	266	
3G30	*							*			3.5	4.6	28.0	12.0	2,700	1,755	945	
3E2	*							*			0.6	18.0	0.8	1.8	5,850	3,803	2,047	
TOTAL											5.6	21,047.3	49.0	639.5	20,585	13,385	7,200	

*ALTERNATIVE
(1)Structural Cost

TABLE 14-97 Flood Damage Reduction Measures, River Basin Group 4.1, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION URBAN: 1000 Acres	URBAN: $1000	RURAL: 1000 Acres	RURAL: $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2020)											60.8	66,215.6	203.5	3,571.4				
SUPPLY (2000)											28.5	53,598.9	129.3	2,396.3				
NEED (2020)											32.3	12,616.7	74.2	1,175.1				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
BLACK RIVER																		
PORT HURON	*											88.9						
RURAL FLOOD PLAINS	*																	
PINE RIVER																		
RURAL FLOOD PLAINS	*																	
BELLE RIVER																		
RURAL FLOOD PLAINS	*																	
CLINTON RIVER & RED RUN DRAIN																		
RURAL, URBAN FLOOD PLAINS	*											3,992.0						
RIVER ROUGE																		
DEARBORN	*											2,147.0						
BIRMINGHAM	*											286.1						
URBAN FLOOD PLAINS	*																	
BELL BRANCH URBAN FLOOD PLAINS	*																	
HURON RIVER																		
ROCKWOOD	*																	
FLAT ROCK	*																	
YPSILANTI	*																	
RURAL FLOOD PLAINS	*																	
RAISIN RIVER																		
DUNDEE	*																	
BLISSFIELD	*																	
RURAL FLOOD PLAINS	*																	
UPSTREAM WATERSHEDS																		
3M	*											188.0		265.0				
331	*											674.0		40.0				
3G2	*													46.0				
3F1	*											1.4		44.0				
3I	*											264.0		5.0				
3K	*											302.0						
3J	*											297.0		0.7				
330	*											160.0		4.0				
3E1	*											125.0		1.8				
3G4D	*													16.0				
3F2A	*											0.8		13.0				
3L	*											75.0		1.2				
3DE4	*													4.0				
3J1	*											1.4		3.0				
3G30	*											3.7		2.0				
3E3	*							*					7.7	19.0	7,208	4,685	2,523	
3E2	*							*			0.6	332.0	0.8	2.2	5,850	3,803	2,047	
3G4	*							*			0.1	10.0	1.3	10.0	660	429	231	
3F2	*							*			2.5	16.0	11.0	5.3	6,900	4,485	2,415	
3G3	*																	
3E4	*							*					5.0	6.8	7,200	4,680	2,520	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–97(continued) Flood Damage Reduction Measures, River Basin Group 4.1, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
UPSTREAM WATERSHEDS																		
333	*							*			0.2		0.9	3.9	380	247	133	
3E6	*							*			0.1	8.3	0.6	0.5	2,652	1,724	928	
3F2B	*																	
3E5	*							*					0.5	0.7	8,160	5,304	2,856	
3F2C	*							*					1.6	0.3	750	488	262	
TOTAL											3.5	8,673.8	24.4	494.4	39,760	25,845	13,915	

*ALTERNATIVE

(1) Structural Cost

TABLE 14–98 Flood Damage Reduction Measures, River Basin Group 4.2, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)											26.7	6,080.8	371.0	5,757.5				
SUPPLY (1970)											-	-	-	-				
NEED (1980)											26.7	6,080.8	371.0	5,757.5				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
MAUMEE RIVER																		MAUMEE RIVER BEING STUDIED FOR INCLUSION IN NATIONAL WILD & SCENIC RIVER SYSTEM
TOLEDO	*	*	*	*	*	*	*											
PERRYSBURG	*	*	*	*	*	*												
ROSSFORD	*	*	*	*	*	*												
MAUMEE	*	*	*	*	*	*	*											
GRAND RAPIDS	*	*	*	*	*	*												
NAPOLEON	*	*	*	*	*	*												
FLORIDA	*	*	*	*	*	*												
DEFIANCE	*	*	*	*	*	*												
FORT WAYNE	*	*	*	*	*	*	*											
RURAL FLOOD PLAINS	*	*		*														
ST. JOSEPH RIVER																		
CEDARVILLE & LEO	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
ST. MARYS RIVER																		
DECATUR	*	*	*	*	*	*	*											
ST. MARYS	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
AUGLAIZE RIVER																		
OAKWOOD	*	*	*	*	*	*												
WAPAKONETA	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
BLANCHARD RIVER																		
OTTAWA	*							*		*	0.7	345.0			5,900	5,015	885	
FINDLAY	*							*		*	1.9	1,372.5			20,000	15,000	5,000	
RURAL FLOOD PLAINS	*	*		*														
TIFFIN RIVER																		
BRUNERSBURG	*	*	*	*	*	*												
EVANS PORT	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
PORTAGE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
SANDUSKY RIVER																		
FREMONT	*							*		*	1.0	647.8			8,820	8,100		PROJECT UNDER CONSTRUCTION. TO BE COMPLETED BY 1980.
TIFFIN	*	*	*	*	*	*												
BUCYRUS	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
HURON RIVER																		
HURON	*	*	*	*	*	*												
MILAN	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
VERMILION RIVER																		
VERMILION	*	*	*	*	*	*	*											
RURAL FLOOD PLAINS	*	*		*														

*ALTERNATIVE
(1) Structural Cost

TABLE 14–98(continued) Flood Damage Reduction Measures, River Basin Group 4.2, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
UPSTREAM WATERSHEDS																		MAUMEE RIVER BEING STUDIED FOR INCLUSION IN NATIONAL WILD & SCENIC RIVER SYSTEM
361	*							*			0.4	8.4	32.0	593	2,573	1,672	901	
3D47	*																	
3D290	*																	
3D45	*							*					11.0	241.0	4,020	2,613	1,407	
3D4	*	*	*															
3C7	*							*	*				10.0	215.0	2,139	1,426	713	
3D452	*							*			0.2	95.0	7.0	130.0	2,500	1,625	875	
31	*							*					9.0	178.0	818	532	286	
3D05	*	*	*	*														
3C11	*							*	*		0.1	79.0	5.8	88.0	3,721	2,480	1,241	
3D451	*							*					7.3	130.0	1,733	1,126	607	
3C10	*							*	*		0.1	13.0	8.1	109.0	4,808	3,205	1,603	
3B32	*																	
3D18	*																	
3D10	*																	
3D46	*																	
3C3	*							*					5.4	76.0	106	69	37	
381	*							*					1.3	75.0	900	585	315	
3D1	*	*	*	*	*	*												
TOTAL											4.4	2,560.7	96.9	1,835.0	58,038	43,448	13,870	

*ALTERNATIVE
(1) Structural Cost

TABLE 14-99 Flood Damage Reduction Measures, River Basin Group 4.2, 1980–2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2000)											27.0	11,322.2	370.6	7,714.0				
SUPPLY (1980)											4.4	2,560.7	96.9	1,835.0				
NEED (2000)											22.6	8,761.5	273.7	5,879.0				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
MAUMEE RIVER																		MAUMEE RIVER BEING STUDIED FOR INCLUSION IN NATIONAL WILD & SCENIC RIVER SYSTEM
TOLEDO	*	*	*	*	*	*	*											
PERRYSBURG	*	*	*	*	*	*												
ROSSFORD	*	*	*	*	*	*												
MAUMEE	*	*	*	*	*	*	*											
GRAND RAPIDS	*	*	*	*	*	*												
NAPOLEON	*	*	*	*	*	*												
FLORIDA	*	*	*	*	*	*												
DEFIANCE	*	*	*	*	*	*												
FORT WAYNE	*							*		*	9.3	3,914.2			49,100	44,200	4,900	
RURAL FLOOD PLAINS	*	*		*														
ST. JOSEPH RIVER																		
CEDARVILLE & LEO	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
ST. MARYS RIVER																		
DECATUR	*	*	*	*	*	*	*											
ST. MARYS	*							*			0.6	178.0			2,300	2,070	230	
RURAL FLOOD PLAINS	*	*		*														
BLANCHARD RIVER																		
OTTAWA	*											270.6						
FINDLAY	*											1,076.7						
RURAL FLOOD PLAINS	*	*		*														
TIFFIN RIVER																		
BRUNERSBURG	*	*	*	*	*	*												
EVANS PORT	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
PORTAGE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
SANDUSKY RIVER																		
FREMONT	*											802.4						
TIFFIN	*							*		*	0.5	129.7			1,700	1,550	150	
BUCYRUS	*							*	*	*	0.2	188.0			15,000	12,000	3,000	
RURAL FLOOD PLAINS	*	*		*														
HURON RIVER																		
HURON	*	*	*	*	*	*												
MILAN	*									*	0.2	295.3			3,000	2,800	200	
RURAL FLOOD PLAINS	*	*		*														
VERMILION RIVER																		
VERMILION	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
AUGLAIZE RIVER																		
OAKWOOD	*	*	*	*	*	*												
WAPAKONETA	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														

*ALTERNATIVE
(1) Structural Cost

TABLE 14–99(continued) Flood Damage Reduction Measures, River Basin Group 4.2, 1980–2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION URBAN: 1000 Acres	URBAN: $1000	RURAL: 1000 Acres	RURAL: $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
UPSTREAM WATERSHEDS																		
361	*											6.6		162.0				MAUMEE RIVER BEING STUDIED FOR INCLUSION IN NATIONAL WILD & SCENIC RIVER SYSTEM
3D45	*													67.0				
3C7	*													59.0				
3D452	*											74.0		36.0				
31	*													48.0				
3C11	*											61.0		24.0				
3D451	*													35.0				
3C10	*											9.0		30.0				
3C3	*													21.0				
381	*													21.0				
310	*							*	*		0.1	7.7	3.8	44.0	7,133	4,636	2,497	
3D5	*							*					2.2	79.0	2,050	1,333	717	
35	*							*					3.3	76.0	380	247	133	
3D2	*																	
3C6	*							*					4.0	75.0	1,168	779	389	
3D41	*																	
3C9	*							*	*		0.1	1.1	4.5	67.0	1,658	1,105	553	
3D49	*							*					3.0	58.0	660	429	231	
3D3	*																	
3C8	*							*	*		0.1	3.8	3.5	52.0	2,578	1,670	908	
3D291	*																	
3C2	*							*			0.1	2.2	2.0	47.0	468	312	156	
3D42	*							*					1.4	43.0	1,515	1,010	505	
3C5	*							*					2.0	37.0	1,673	1,115	558	
3C4	*							*					2.0	37.0	1,713	1,142	571	
3D43	*							*			0.4	37.0	3.0	14.0	4,125	2,750	1,375	
3D1D	*																	
TOTAL											11.6	7,057.3	34.7	1,132.0	96,221	79,148	17,073	

*ALTERNATIVE

(1) Structural Cost

TABLE 14–100 Flood Damage Reduction Measures, River Basin Group 4.2, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2020)											27.4	20,799.7	370.2	9,875.1				
SUPPLY (2000)											16.0	9,618.0	131.6	2,967.0				
NEED (2020)											11.4	11,181.7	238.6	6,908.1				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
MAUMEE RIVER																		MAUMEE RIVER BEING STUDIED FOR INCLUSION IN NATIONAL WILD & SCENIC RIVER SYSTEM
TOLEDO	*																	
PERRYSBURG	*																	
ROSSFORD	*																	
MAUMEE	*																	
GRAND RAPIDS	*																	
NAPOLEON	*																	
FLORIDA	*																	
DEFIANCE	*																	
FORT WAYNE	*											2,978.3						
RURAL FLOOD PLAINS	*																	
ST. JOSEPH RIVER																		
CEDARVILLE & LEO	*																	
RURAL FLOOD PLAINS	*																	
ST. MARYS RIVER																		
DECATUR	*																	
ST. MARYS	*											137.0						
RURAL FLOOD PLAINS	*																	
AUGLAIZE RIVER																		
OAKWOOD	*																	
WAPAKONETA	*																	
RURAL FLOOD PLAINS	*																	
BLANCHARD RIVER																		
OTTAWA	*											468.4						
FINDLAY	*											1,862.9						
RURAL FLOOD PLAINS	*																	
TIFFIN RIVER																		
BRUNERSBURG	*																	
EVANS PORT	*																	
RURAL FLOOD PLAINS	*																	
PORTAGE RIVER																		
RURAL FLOOD PLAINS	*																	
SANDUSKY RIVER																		
FREMONT	*											1,656.7						
TIFFIN	*											142.2						
BUCYRUS	*											207.8						
RURAL FLOOD PLAINS	*																	
HURON RIVER																		
HURON	*																	
MILAN	*											345.9						
RURAL FLOOD PLAINS	*																	
VERMILION RIVER																		
VERMILION	*																	
RURAL FLOOD PLAINS	*																	

*ALTERNATIVE

TABLE 14-100(continued) Flood Damage Reduction Measures, River Basin Group 4.2, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
UPSTREAM WATERSHEDS																		MAUMEE RIVER BEING STUDIED FOR INCLUSION IN NATIONAL WILD & SCENIC RIVER SYSTEM
361	*											12.0		119.0				
3D45	*													48.0				
3C7	*													43.0				
3D452	*											144.0		26.0				
31	*													36.0				
3C11	*											119.0		18.0				
3D451	*													26.0				
3C10	*											19.0		22.0				
3C3	*													15.0				
381	*													15.0				
310	*											65.0		7.0				
3D5	*													13.0				
35	*													12.0				
3C6	*													12.0				
3C9	*											0.9		11.0				
3D49	*													10.0				
3C8	*											3.2		6.0				
3C2	*											1.9		8.0				
3D42	*													7.0				
3C5	*													6.0				
3C4	*													6.0				
3D43	*											31.0		3.0				
32	*							*			0.2	5.4	0.8	24.0	608	405	303	
37	*							*					0.2	22.0	240	160	80	
3D4A	*																	
3D2B	*							*					1.4	17.0	168	109	59	
3D1B	*							*	*				3.9	17.0	339	220	119	
30	*							*			0.1	9.0	0.6	13.0	425	276	149	
3D44	*							*					0.6	13.0	1,040	676	364	
3D1C	*																	
3D3A	*																	
3D292	*							*					0.4	11.0	21	14	7	
3D2A	*																	
3D17	*																	
33	*							*					0.4	6.3	100	65	35	
383	*							*			0.1	4.3	0.3	4.7	314	204	110	
3D1C1	*																	
3D1B	*																	
39	*							*					0.1	2.1	111	72	39	
3D1A	*																	
384	*							*					0.1	9.3	6	4	2	
34	*							*					0.1	0.7	280	197	93	
30	*							*			0.1	0.4	0.1	0.2	202	131	71	
3D130	*																	
382	*							*					0.1	0.1	33	22	11	
385	*							*					0.1	0.1	35	23	12	
TOTAL											0.5	8,214.3	9.2	609.5	3,922	2,578	1,454	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–101 Flood Damage Reduction Measures, River Basin Group 4.3, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)											15.1	1,799.0	63.3	830.8				
SUPPLY (1970)											-	-	-	-				
NEED (1980)											15.1	1,799.0	63.3	830.8				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
BLACK RIVER																		
LORAIN	*	*	*	*	*													
ELYRIA	*	*	*	*	*	*	*											
RURAL FLOOD PLAINS	*	*		*														
SPERRY CREEK																		
RURAL FLOOD PLAINS	*	*		*														
ROCKY RIVER																		
ROCKY RIVER	*	*	*	*	*	*												
LAKEWOOD	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
CUYAHOGA RIVER																		
BROOKLYN HGTS. & VALLEY VIEW & INDEPENDENCE	*							*		*	1.6	426.2			8,080	5,584	2,496	
AKRON	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
TINKERS CREEK																		
RURAL FLOOD PLAINS	*	*		*														
CHAGRIN RIVER																		
EASTLAKE	*							*		*	.9	230.7			3,500	2,800	700	
RURAL FLOOD PLAINS	*	*		*														
GRAND RIVER																		
PAINESVILLE	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
CONNEAUT CREEK																		
CONNEAUT	*							*			.2	7.9			500	400	100	
CONNEAUTVILLE	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
313	*							*	*		3.2	229.0	4.2	35.0	1,067	693	374	
316	*							*			2.3	120.0	3.1	131.0	1,068	694	374	
3121	*							*	*		0.3	3.1	1.1	82.0	2,681	1,743	938	
3B22	*							*					1.2	76.0	438	285	153	
3B21	*							*			0.1	66.0	0.4	6.2	640	416	224	
3B1	*							*					0.9	40.0	900	585	315	
TOTAL											8.6	1,082.9	10.9	370.2	18,874	13,200	5,674	

*ALTERNATIVE
(1) Structural Cost

TABLE 14-102 Flood Damage Reduction Measures, River Basin Group 4.3, 1980–2000

PROBLEM AREA	REDUCTION MEASURES										ESTIMATED DAMAGE REDUCTION				ESTIMATED COST (1970 PRICE LEVEL)			REMARKS
											URBAN		RURAL					
	Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	1000 Acres	$1000	1000 Acres	$1000	Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	
REQUIREMENTS (2000)											15.9	3,598.0	62.4	1,179.1				
SUPPLY (1980)											8.6	1,082.9	10.9	370.2				
NEED (2000)											7.3	2,515.1	51.5	808.9				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
BLACK RIVER																		
LORAIN	*	*	*	*	*	*												
ELYRIA	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
SPERRY CREEK																		
RURAL FLOOD PLAINS	*	*		*														
ROCKY RIVER																		
ROCKY RIVER	*	*	*	*	*	*												
LAKEWOOD	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
CUYAHOGA RIVER																		
INDEPENDENCE & VALLEY VIEW & BROOKLYN HGTS.	*											381.2						
AKRON	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
TINKERS CREEK																		
RURAL FLOOD PLAINS	*	*		*														
CHAGRIN RIVER																		
EASTLAKE	*											355.3						
RURAL FLOOD PLAINS	*	*		*														
GRAND RIVER																		
PAINESVILLE	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
CONNEAUT CREEK																		
CONNEAUT	*																	
CONNEAUTVILLE	*	*	*	*	*	*						7.7						
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
313	*											161.0		5.0				
316	*											86.0		22.0				
3121	*											2.2		14.0				
3B22	*													14.0				
3B21	*											46.0		1.1				
3B1	*													8.0				
3122	*							*	*		0.1	1.1	3.9	35.0	2,341	1,522	819	
3154	*							*					12.0	35.0	1,895	1,232	663	
3B2	*																	
311	*							*					3.0	21.0	180	117	63	
317	*							*	*		0.2	1.2	1.2	16.0	932	606	326	
314	*							*					1.1	12.0	1,366	888	478	
3152	*	*	*	*														
31555	*							*					1.5	9.3	448	291	157	
TOTAL											0.3	1,041.7	22.7	192.4	7,162	4,656	2,506	

* ALTERNATIVE
(1) Structural Cost

TABLE 14-103 Flood Damage Reduction Measures, River Basin Group 4.3, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2020)											16.6	7,474.8	61.7	1,820.7				
SUPPLY (2000)											8.9	2,124.6	33.6	562.6				
NEED (2020)											7.7	5,350.2	28.1	1,258.1				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
BLACK RIVER																		
LORAIN	*																	
ELYRIA	*																	
RURAL FLOOD PLAINS	*																	
SPERRY CREEK																		
RURAL FLOOD PLAINS	*																	
ROCKY RIVER																		
ROCKY RIVER	*																	
LAKEWOOD	*																	
RURAL FLOOD PLAINS	*																	
CUYAHOGA RIVER																		
INDEPENDENCE &																		
VALLEY VIEW &																		
BROOKLYN HGTS.	*											948.0						
AKRON	*																	
RURAL FLOOD PLAINS	*																	
TINKERS CREEK																		
RURAL FLOOD PLAINS	*																	
CHAGRIN RIVER																		
EASTLAKE	*											693.4						
RURAL FLOOD PLAINS	*																	
GRAND RIVER																		
PAINESVILLE	*																	
RURAL FLOOD PLAINS	*																	
CONNEAUT CREEK																		
CONNEAUT	*																	
CONNEAUTVILLE	*											18.6						
RURAL FLOOD PLAINS	*																	
UPSTREAM WATERSHEDS																		
313	*											322.0		6.0				
316	*											169.0		21.0				
3121	*											4.3		14.0				
3B22	*													14.0				
3B21	*											94.0		1.0				
3B1	*													6.0				
3122	*											1.0		5.0				
3154	*													5.0				
311	*													3.0				
317	*											0.9		2.0				
314	*													2.0				
31556	*													1.7				
3153	*							*			0.1	15.0	0.2	1.6	259	168	91	
3156	*																	
30D	*	*	*															
3157	*							*			0.1	1.0	1.5	1.3	410	267	143	
318	*							*	*				0.6	1.0	178	116	62	
3155	*							*					0.2	0.1	280	182	98	
TOTAL											0.2	2,267.2	2.5	84.7	1,127	733	394	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–104 Flood Damage Reduction Measures, River Basin Group 4.4, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)											23.2	1,344.0	92.2	592.1				
SUPPLY (1970)											-	-	-	-				
NEED (1980)											23.2	1,344.0	92.2	592.1				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
CATTARAUGUS RIVER																		
GOWANDA	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
BIG SISTER CREEK																		
RURAL FLOOD PLAINS	*	*		*														
SMOKES CREEK																		
LACKAWANDA	*	*	*	*	*	*												NUMEROUS RAILROAD ALTERATIONS REQUIRED FOR INCREASED PROTECTION MAKE PROJECT NON-FEASIBLE
RURAL FLOOD PLAINS	*	*		*														
CAZENOVIA CREEK																		
BUFFALO & RURAL FLOOD PLAINS	*	*	*	*	*	*												
BUFFALO RIVER																		
RURAL FLOOD PLAINS	*	*	*	*	*	*												
CAYUGA CREEK																		
RURAL FLOOD PLAINS	*									*	1.7	65.7			1,120	1,000	120	
ELLICOTT CREEK																		
RURAL FLOOD PLAINS	*							*	*	*	11.8	415.3	3.6	8.1	7,700	7,300	400	TOTAL COST $19.8 MILLION 39% CHARGEABLE TO FLOOD CONTROL.
TONAWANDA CREEK																		
RURAL FLOOD PLAINS	*																	
SCAJAQUADA CREEK																		
RURAL FLOOD PLAINS	*							*			3.3	319.3			1,915	1,800	115	
UPSTREAM WATERSHEDS																		
1	*							*	*		0.1	47.0	0.1	0.5	862	560	302	
44	*								*		0.2	31.0	5.2	16.0	102	66	36	
241A	*							*					4.7	40.0	285	185	100	
240	*							*			0.1	2.5	1.3	8.3	110	72	38	
34	*	*	*															
148	*	*	*	*	*									-				
TOTAL											17.2	880.8	14.9	72.9	12,094	10,983	1,111	

*ALTERNATIVE

(1) Structural Cost

TABLE 14-105 Flood Damage Reduction Measures, River Basin Group 4.4, 1980–2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2000)											25.6	2,760.1	89.8	1,180.4				
SUPPLY (1980)											17.2	880.8	14.9	72.9				
NEED (2000)											8.4	1,879.3	74.9	1,107.5				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
CATTARAUGUS RIVER																		
GOWANDA	*								*		.3	90.9			25,000	20,000	5,000	
RURAL FLOOD PLAINS	*	*		*														
BIG SISTER CREEK																		
RURAL FLOOD PLAINS	*	*		*														
SMOKES CREEK																		
LACKAWANDA	*	*	*	*	*	*												
RURAL FLOOD PLAINS	*	*		*														
CAZENOVIA CREEK																		
BUFFALO & RURAL FLOOD PLAINS	*								*		1.2	454.1	2.1	69.5	27,000	21,600	5,400	
BUFFALO RIVER																		
RURAL FLOOD PLAINS	*	*	*	*	*	*												
CAYUGA CREEK																		
RURAL FLOOD PLAINS	*											73.6						
ELLICOTT CREEK																		
RURAL FLOOD PLAINS	*											474.0		8.9				
TONAWANDA CREEK																		
RURAL FLOOD PLAINS	*								*		2.2	271.1	52.1	728.6	27,000	21,600	5,400	
SCAJAQUADA CREEK																		
RURAL FLOOD PLAINS	*											351.9						
UPSTREAM WATERSHEDS																		
1	*											34.0		0.1				
44	*											22.0		4.0				
241A	*													11.0				
240	*											1.8		2.7				
245	*							*			0.1	4.3	0.9	3.0	800	520	280	
31	*	*	*															
243	*	*	*	*														
241	*							*					1.3	4.1	450	293	157	
33	*	*	*															
114	*	*	*	*														
TOTAL											3.8	1,777.7	56.4	831.9	80,250	64,013	16,237	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–106 Flood Damage Reduction Measures, River Basin Group 4.4, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2020)											27.9	5,688.3	87.5	2,345.2				
SUPPLY (2000)											21.0	2,658.5	71.3	994.8				
NEED (2020)											6.9	3,029.8	16.2	1,440.4				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
CATTARAUGUS RIVER																		
GOWANDA	*											85.0						
RURAL FLOOD PLAINS	*																	
BIG SISTER CREEK																		
RURAL FLOOD PLAINS	*																	
SMOKES CREEK																		
LACKAWANDA	*																	
RURAL FLOOD PLAINS	*																	
CAZENOVIA CREEK																		
BUFFALO & RURAL FLOOD PLAINS	*											492.1		82.3				
BUFFALO RIVER																		
RURAL FLOOD PLAINS	*																	
CAYUGA CREEK																		
RURAL FLOOD PLAINS	*											149.8						
ELLICOTT CREEK																		
RURAL FLOOD PLAINS	*											1,059.5						
TONAWANDA CREEK																		
RURAL FLOOD PLAINS	*											389.5		857.9				
SCAJAQUADA CREEK																		
RURAL FLOOD PLAINS	*											727.9						
UPSTREAM WATERSHEDS																		
1	*											64.0		0.1				
44	*											42.0		2.0				
241A	*													5.0				
240	*											3.3		1.0				
245	*											3.3		0.3				
241	*													0.4				
38	*	*	*															
55	*	*	*															
114A	*	*	*	*														
32	*																	
57	*																	
197	*																	
203	*																	
56	*																	
242	*																	
TOTAL												3,016.4		866.7				

*ALTERNATIVE

TABLE 14-107 Flood Damage Reduction Measures, River Basin Group 5.1, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)											7.7	301.0	72.0	657.7				
SUPPLY (1970)											-	-	-	-				
NEED (1980)											7.7	301.0	72.0	657.7				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
GENESEE RIVER																		
ROCHESTER	*	*	*	*	*	*												
WELLSVILLE	*							*		*	0.1	44.6			780	730	50	
RURAL FLOOD PLAINS	*	*		*														
BLACK CREEK																		
RURAL FLOOD PLAINS	*	*	*	*	*	*												
RED CREEK																		
RURAL FLOOD PLAINS	*							*			0.7	90.8			4,070	3,800	270	
CONESUS LAKE																		
RURAL FLOOD PLAINS	*	*		*														
CANASERAGA CREEK																		
RURAL FLOOD PLAINS	*							*	*				9.5	90.7	8,000	6,400	1,600	
HONEOYE LAKE																		
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
143	*							*	*				9.1	234	5,225	3,396	1,829	
33	*	*	*															
94	*							*			1.0	14.0	4.7	18.0	1,850	1,202	648	
36	*																	
17	*	*	*	*														
255	*	*	*															
256	*	*	*															
138	*	*	*															
73	*																	
257	*	*	*															
TOTAL											1.8	149.4	23.3	342.7	19,925	15,528	4,397	

* ALTERNATIVE
(1) Structural Cost

TABLE 14-108 Flood Damage Reduction Measures, River Basin Group 5.1, 1980–2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2000)											7.9	613.8	71.8	1,053.5				
SUPPLY (1980)											1.8	149.4	23.3	342.7				
NEED (2000)											6.1	464.4	48.5	710.8				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
GENESEE RIVER																		
ROCHESTER	*	*	*	*	*	*												
WELLSVILLE	*											39.1						
RURAL FLOOD PLAINS	*							*					8.8	143.1	137,000	109,600	27,400	
BLACK CREEK																		
RURAL FLOOD PLAINS	*	*	*	*	*	*												
RED CREEK																		
RURAL FLOOD PLAINS	*											108.5						
CONESUS LAKE																		
RURAL FLOOD PLAINS	*	*		*														
CANASERAGA CREEK																		
RURAL FLOOD PLAINS	*													97.9				
HONEOYE LAKE																		
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
143	*													42.0				
94	*											10.0		3.0				
252	*	*	*	*														
251	*	*	*															
69	*																	
32	*																	
258	*																	
250	*																	
249	*																	
259	*																	
261	*	*	*															
51	*	*	*															
TOTAL											0	157.6	8.8	286.0	137,000	109,600	27,400	

*ALTERNATIVE
(1) Structural Cost

TABLE 14-109 Flood Damage Reduction Measures, River Basin Group 5.1, After 2000

PROBLEM AREA	REDUCTION MEASURES										ESTIMATED DAMAGE REDUCTION				ESTIMATED COST (1970 PRICE LEVEL)			
											URBAN		RURAL					
	Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	1000 Acres	$1000	1000 Acres	$1000	Total ($1000)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2020)											8.2	1,254.4	71.5	1,622.2				
SUPPLY (2000)											1.8	307.0	32.1	628.7				
NEED (2020)											6.4	947.4	38.4	993.5				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
GENESEE RIVER																		
ROCHESTER	*																	
WELLSVILLE	*											64.7						
RURAL FLOOD PLAINS	*													149.3				
BLACK CREEK																		
RURAL FLOOD PLAINS	*																	
RED CREEK																		
RURAL FLOOD PLAINS	*											237.8						
CONESUS LAKE																		
RURAL FLOOD PLAINS	*																	
CANASERAGA CREEK																		
RURAL FLOOD PLAINS	*													200.9				
HONEOYE LAKE																		
RURAL FLOOD PLAINS	*																	
UPSTREAM WATERSHEDS																		
128	*	*	*															
263	*	*	*															
246	*																	
248	*																	
10	*																	
247	*																	
262	*																	
264	*																	
260	*																	
23	*																	
143	*													35.0				
94	*											19.6		2.7				
TOTAL											0	322.1	0	387.9	0	0	0	

*ALTERNATIVE

TABLE 14–110 Flood Damage Reduction Measures, River Basin Group 5.2, Before 1980

PROBLEM AREA	Reduction Measures: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	Estimated Damage Reduction, Urban: 1000 Acres	Urban: $1000	Rural: 1000 Acres	Rural: $1000	Estimated Cost (1970 Price Level): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)											8.3	161.8	130.6	1,186.7				
SUPPLY (1970)											-	-	-	-				
NEED (1980)											8.3	161.8	130.6	1,186.7				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
OSWEGO RIVER																		
RURAL FLOOD PLAINS	*	*		*														
SENECA RIVER																		
RURAL FLOOD PLAINS	*	*		*														
SENECA LAKE																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
KEUKA LAKE																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
CANANDAIGUA LAKE & OUTLET																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
CAYUGA LAKE																		
RURAL FLOOD PLAINS																		LAKE REGULATION
OWASCO LAKE & OUTLET																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
SKANEATELES LAKE & OUTLET																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
OTISCO LAKE & OUTLET																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
ONONDAGA LAKE																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
ONEIDA LAKE & RIVER																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
CHITTENANGO CREEK																		
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
11	*	*	*					*	*		0.1	0.4	4.8	155.0	3,157	2,052	1,105	
127	*							*	*				0.7	54.0	545	354	191	
433	*							*	*				0.8	59.0	558	363	195	
5	*	*	*															
426	*							*	*				0.4	41.0	450	293	157	
454	*							*					3.0	24.0	248	161	87	
71	*	*	*	*	*	*												
30	*																	
428	*																	

*ALTERNATIVE

(1) Structural Cost

TABLE 14-110(continued) Flood Damage Reduction Measures, River Basin Group 5.2, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)																		
SUPPLY (1970)																		
NEED (1980)																		
UPSTREAM WATERSHEDS																		
122	*	*	*	*														
68	*	*	*	*	*	*												
12	*								*		0.3	20.0	0.1		153	99	54	
253	*	*	*	*	*	*												
453	*																	
TOTAL											0.4	20.4	9.8	333.0	5,111	3,322	1,789	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–111 Flood Damage Reduction Measures, River Basin Group 5.2, 1980–2000

PROBLEM AREA	Reduction Measures: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	Estimated Damage Reduction, Urban: 1000 Acres	Urban: $1000	Rural: 1000 Acres	Rural: $1000	Estimated Cost (1970 Price Level): Total ($1000)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2000)											8.6	312.2	130.3	1,868.5				
SUPPLY (1980)											0.4	20.4	9.8	333.0				
NEED (2000)											8.2	291.8	120.5	1,535.5				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
OSWEGO RIVER																		
RURAL FLOOD PLAINS	*	*		*														
SENECA RIVER																		
RURAL FLOOD PLAINS	*	*		*														
SENECA LAKE																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
KEUKA LAKE																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
CANANDAIGUA LAKE & OUTLET																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
CAYUGA LAKE																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
OWASCO LAKE & OUTLET																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
SKANEATELES LAKE & OUTLET																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
OTISCO LAKE & OUTLET																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
ONONDAGA LAKE																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
ONEIDA LAKE & RIVER																		
RURAL FLOOD PLAINS	*	*																LAKE REGULATION
CHITTENANGO LAKE																		
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
11	*											0.3		31.0				
127	*													11.0				
433	*													12.0				
426	*													8.0				
454	*													5.0				
12	*											17.0						
455	*																	
116	*	*	*															
430	*																	
435	*																	
419	*	*	*	*	*													

*ALTERNATIVE

TABLE 14–111(continued) Flood Damage Reduction Measures, River Basin Group 5.2, 1980–2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
UPSTREAM WATERSHEDS																		
140	*							*			0.1	9.4	0.7	1.5	532	346	186	
150	*	*	*															
450	*	*	*	*														
429	*																	
137	*	*	*	*														
20	*	*	*	*														
434	*																	
456	*	*	*															
458	*																	
432	*																	
425	*	*	*															
92	*	*	*															
TOTAL											0.1	26.7	0.7	68.5	532	346	186	

*ALTERNATIVE

(1) Structural Cost

TABLE 14-112 Flood Damage Reduction Measures, River Basin Group 5.2, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION: URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2020)											8.8	619.3	130.1	3,139.5				
SUPPLY (2000)											0.5	47.1	10.5	401.5				
NEED (2020)											8.3	572.2	119.6	2,738.0				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
OSWEGO RIVER																		
RURAL FLOOD PLAINS	*																	
SENECA RIVER																		
RURAL FLOOD PLAINS	*																	
SENECA LAKE																		
RURAL FLOOD PLAINS	*																	LAKE REGULATION
KEUKA LAKE																		
RURAL FLOOD PLAINS	*																	LAKE REGULATION
CANANDAIGUA LAKE & OUTLET																		
RURAL FLOOD PLAINS	*																	LAKE REGULATION
CAYUGA LAKE																		
RURAL FLOOD PLAINS	*																	LAKE REGULATION
OWASCO LAKE & OUTLET																		
RURAL FLOOD PLAINS	*																	LAKE REGULATION
SKANEATELES LAKE & OUTLET																		
RURAL FLOOD PLAINS	*																	LAKE REGULATION
OTISCO LAKE & OUTLET																		
RURAL FLOOD PLAINS	*																	LAKE REGULATION
ONONDAGO LAKE																		
RURAL FLOOD PLAINS	*																	LAKE REGULATION
ONEIDA LAKE & RIVER																		
RURAL FLOOD PLAINS	*																	LAKE REGULATION
CHITTENANGO LAKE																		
RURAL FLOOD PLAINS	*																	LAKE REGULATION
UPSTREAM WATERSHEDS																		
11	*											0.5		25.0				
127	*													8.0				
433	*													10.0				
426	*													6.0				
454	*													5.0				
12	*											31.0		0.1				
140	*											8.6		0.3				
142	*																	
439	*																	
431	*																	
424	*																	
427	*	*	*															

*ALTERNATIVE

TABLE 14–112(continued) Flood Damage Reduction Measures, River Basin Group 5.2, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL) Total ($1000)	Federal ($1000)	Non-Federal ($1000)	REMARKS
UPSTREAM WATERSHEDS																		
52	*	*	*	*														
451	*																	
447	*																	
459	*																	
461	*																	
443	*	*	*															
446	*																	
442	*	*	*															
441	*	*	*															
423	*																	
29	*																	
436	*																	
462	*	*	*															
393	*																	
448	*																	
TOTAL											0	40.1	0	54.4	0	0	0	

*ALTERNATIVE

TABLE 14–113 Flood Damage Reduction Measures, River Basin Group 5.3, Before 1980

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION URBAN 1000 Acres	URBAN $1000	RURAL 1000 Acres	RURAL $1000	ESTIMATED COST (1970 PRICE LEVEL) Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (1980)											0.1	12.0	46.2	265.9				
SUPPLY (1970)											-	-	-	-				
NEEDS (1980)											0.1	12.0	46.2	265.9				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
BLACK RIVER																		
RURAL FLOOD PLAINS	*	*		*														
OSWEGATCHIE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
GRASS RIVER																		
RURAL FLOOD PLAINS	*	*		*														
RAQUETTE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
ST. REGIS RIVER																		
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
351	*	*	*	*	*	*												
417	*	*	*	*	*	*												
34	*																	
413	*																	
416	*																	
362	*							*					1.7	2.4	1,200	780	420	
TOTAL											0	0	1.7	2.4	1,200	780	420	

*ALTERNATIVE
(1) Structural Cost

TABLE 14–114 Flood Damage Reduction Measures, River Basin Group 5.3, 1980–2000

PROBLEM AREA	REDUCTION MEASURES										ESTIMATED DAMAGE REDUCTION				ESTIMATED COST (1970 PRICE LEVEL)			REMARKS
											URBAN		RURAL					
	Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	1000 Acres	$1000	1000 Acres	$1000	Total ($1000)	Federal ($1000)	Non-Federal ($1000)	
REQUIREMENTS (2000)											0.1	21.6	46.2	520.1				
SUPPLY (1980)											-	-	1.7	2.4				
NEED (2000)											0.1	21.6	44.5	517.7				
MAIN STEM AND PRINCIPAL TRIBUTARIES*																		
BLACK RIVER																		
RURAL FLOOD PLAINS	*	*		*														
OSWEGATCHIE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
GRASS RIVER																		
RURAL FLOOD PLAINS	*	*		*														
RAQUETTE RIVER																		
RURAL FLOOD PLAINS	*	*		*														
ST. REGIS RIVER																		
RURAL FLOOD PLAINS	*	*		*														
UPSTREAM WATERSHEDS																		
362	*													0.5				
407	*																	
408	*																	
412	*																	
414	*	*	*															
358	*																	
TOTAL												0	0	0.5	0	0	0	

*ALTERNATIVE

TABLE 14–115 Flood Damage Reduction Measures, River Basin Group 5.3, After 2000

PROBLEM AREA	REDUCTION MEASURES: Institutional	Flood Proofing	Modification of Existing Building Use	Relocation of Damageable Property	Emergency Measures	Flood Warning and Evacuation Systems	Urban Redevelopment	Channel Modification	Reservoirs	Levees, Floodwalls and Other Local Protective Works	ESTIMATED DAMAGE REDUCTION URBAN: 1000 Acres	URBAN: $1000	RURAL: 1000 Acres	RURAL: $1000	ESTIMATED COST (1970 PRICE LEVEL): Total ($1000) (1)	Federal ($1000)	Non-Federal ($1000)	REMARKS
REQUIREMENTS (2020)											0.1	39.9	46.2	1,079.3				
SUPPLY (2000)											-	-	2.2	2.4				
NEED (2020)											0.1	39.9	44.0	1,076.9				
MAIN STEM AND PRINCIPAL TRIBUTARIES																		
BLACK RIVER																		
RURAL FLOOD PLAINS	*																	
OSWEGATCHIE RIVER																		
RURAL FLOOD PLAINS	*																	
GRASS RIVER																		
RURAL FLOOD PLAINS	*																	
RAQUETTE RIVER																		
RURAL FLOOD PLAINS	*																	
ST. REGIS RIVER																		
RURAL FLOOD PLAINS	*																	
UPSTREAM WATERSHEDS																		
362	*													0.3				
405	*																	
411	*																	
310	*							*					0.2	0.2	400	260	140	
409	*																	
410	*																	
TOTAL											0	0	0.2	0.5	400	260	140	

*ALTERNATIVE

(1) Structural Cost

SUMMARY

It is the purpose of this appendix to complete an overall appraisal of present and future flood problems involving the flood plains of the river basins and complexes within the Great Lakes Basin. Its content and accuracy are consistent with a framework study. The principal sources of data used were prior studies and reports. These data have been updated to reflect prices and conditions of development for the base year 1970. Where data were either incomplete or missing, they were developed using methods discussed in this appendix. Associated drainage problems are presented in Appendix 16, *Drainage*. Flooding problems along the shoreline have not been considered in this appendix, but are included in Appendix 12, *Shore Use and Erosion*.

Despite the gains earned by flood protection works, flood damages are increasing at a rate faster than encountered in previous years. Encroachment of the flood plains continues without significant change. Major flood problems exist in urban and highly developed agricultural areas throughout the Great Lakes Basin. Property has been damaged and destroyed and lives have been lost. Interruption of services and impairment of productive capacity have resulted in irreparable losses. Agricultural production has been reduced through deposition of infertile overwash on fertile crop- and pastureland and irrigation installations such as pumping stations or distribution channels have been damaged.

Projections on future conditions in the Basin indicate that without flood control or preventive measures, and with continued use and development of the flood plains, average annual damages could be as high as $222,720,000 given the economic conditions and development expected by the year 2020. These suppositions were used in order to have a standard base throughout the Basin for the assessment of its flood plains and their associated flooding problems. This is not to say that there will be little regulation of the flood plains in the future. On the contrary, many States are accelerating their flood plain management programs. A summation of estimated average annual damages and estimated acres in the flood plain are tabulated by State and by Lake basin in Tables 14–116 and 14–117. The Great Lakes Basin totals are also noted in these same tables. To point out the potential and extent of major floods, the term average annual damages was used. Future damages were determined by projecting estimated 1970 damages, using indexes of change. These indexes were based upon growth factors provided by the Economic and Demographic Work Group as well as present and historical factors. Detailed information on economic growth projections is contained in Appendix 19, *Economic and Demographic Studies*.

The study of upstream watershed problems included analysis of drainage problems as well as flood problems. Areas indicated as subject to flooding may also have a drainage problem. There is a possible overlap of problem areas with the Appendix 16, *Drainage*. Damages listed are those due to flooding only.

During the final phases of these investigations, Tropical Storm Agnes hit the Middle Atlantic States in June 1972. The storm accounted for 122 dead, and it was the most expensive and destructive natural disaster in the country's recorded history. Damages caused by flooding reached a record total of approximately 3.1 billions of dollars. Extensive flooding occurred in hundreds of communities. Farms were destroyed and homes were demolished. Highway and railroad bridges were ripped out. Business and industries as well as highways and utilities were damaged and destroyed. Damages would have been higher were it not for the flood control capacities of existing projects.

Although the areas hardest hit by Agnes were in the States of Pennsylvania and New York and outside the Great Lakes Basin, the storm did play havoc with some of the Basin's streams, particularly in the State of New York. However, data in this appendix were not reanalyzed to reflect the effects of Agnes due to the late stage that the study was in at the time the storm occurred.

Adequate flood plain management is essential to maintain proper land use so that flood hazards may be kept to a minimum. Much of

the damage and personal tragedy caused by Tropical Storm Agnes was the direct result of overdevelopment in the flood plains. Flood plain management combines proper use with reduced risk, thus achieving optimum use of the flood plains with consideration for both private and public benefits and related costs. The wise use of flood plains, in areas where there is little demand for development, is in the form of parks and open space or agricultural crops that would help to maintain an attractive and high quality environment. Where the pressure for land for development is high, structural flood control measures may be necessary, with full consideration to social and environmental factors as well as material output. However, first consideration should be the nonstructural approach.

Flood damage reduction may be accomplished through control of water (corrective measures) or through control of the use of the flood plain (preventive measures). The need for flood corrective or flood preventive measures is based on the level of existing and projected flood damages. It should be recognized that neither method provides the total answer. Prevention and correction must be proportioned in a manner best suited to reduce the economic and physical hardships inflicted by flood waters.

In the selection of the flood damage reduction measures indicated in Tables 14–71 through 14–115, attention was given to various preventive and corrective measures that appeared to be the most practical and economical, including estimated effectiveness of existing and future flood plain legislation. It should be noted that multipurpose considerations of reservoirs may result in their use at a time period earlier than indicated in these tables. A primary consideration in the selection of future damage reduction measures is their environmental and social effects on the Great Lakes Basin. Potential structural measures are estimated to cost approximately $1,059 million by the year 2020, which would include $550 million in the immediate time period (before 1980), $396 million in the short-term period (1980 to 2020), and $113 million in the long-term period (after 2020). Costs for upstream watersheds (noted in the tables) are for measures to alleviate both the flood and drainage problems and are duplicated in Appendix 16, *Drainage*. Estimated costs are based on experience and cost records of previous studies and projects.

Proposed structural measures, which include the anticipated effects of existing and future flood plain legislation, would reduce the potential average annual flood damages in the immediate time period from approximately $85,179,000 to $26,562,000; in the short-term period from approximately $142,752,000 to $31,549,000; and in the long-term period from approximately $222,720,000 to $44,598,000. Damage reduction as the result of proposed nonstructural measures, other than that for flood plain legislation which is included in the above figures, has not been computed in this appendix due to insufficient available data and the nature of a framework study. It is recommended that studies be conducted in the future to determine flood damage reduction and related costs for nonstructural measures.

As a result of Tropical Storm Agnes, the New York State Department of Environmental Conservation recommended additional alternatives (Table 14–118).

It is unrealistic to expect to prevent all flood damages because of the cost of protection when compared to the losses prevented and other uses that may preclude complete flood protection. However, an economically justifiable degree of flood protection can be achieved through flood plain legislation, consistent with environmental and social considerations and other resources used.

Current flood plain land use practices fall short of future needs. It is therefore recommended that an accelerated effort be initiated to expand and enforce flood plain management programs through political and legal means. To be fully effective, adequate funding to carry out plans and to enforce regulations must be provided.

TABLE 14–116 Summary by State

State	River Basin Group	Year	Estimated Average Annual Damage (Dollars) Urban	Rural	Estimated Acres In Flood Plain Urban	Rural
Minnesota	1.1	1970	79,000	49,400	120	112,322
	1.1	1980	102,000	63,200	120	112,322
	1.1	2000	171,000	107,700	120	112,322
	1.1	2020	284,000	188,700	120	112,322
Wisconsin	1.1	1970	241,800	5,000	938	19,547
	1.1	1980	307,500	6,000	938	19,547
	1.1	2000	439,400	10,000	938	19,547
	1.1	2020	670,500	11,000	938	19,547
	2.1	1970	2,143,450	1,167,406	12,069	592,727
	2.1	1980	2,767,771	1,565,977	12,165	592,631
	2.1	2000	4,926,685	1,953,288	12,363	592,433
	2.1	2020	9,544,050	2,099,707	12,481	591,865
	2.2	1970	280,500	191,650	2,198	54,386
	2.2	1980	459,000	239,348	3,425	53,159
	2.2	2000	1,100,500	339,250	4,445	52,139
	2.2	2020	2,547,500	445,450	5,855	50,729
	TOTALS	1970	2,665,750	1,364,056	15,205	666,660
		1980	3,534,271	1,811,325	16,528	665,337
		2000	6,466,585	2,302,538	17,746	664,119
		2020	12,762,050	2,556,157	19,274	662,141
Michigan	1.2	1970	385,000	217,400	4,721	55,160
	1.2	1980	461,700	277,000	4,721	55,160
	1.2	2000	751,300	393,200	4,721	55,160
	1.2	2020	1,248,000	437,800	4,721	55,160
	2.1	1970	191,560	31,801	1,571	55,228
	2.1	1980	239,580	34,295	1,583	55,216
	2.1	2000	390,200	37,916	1,595	55,204
	2.1	2020	717,720	40,522	1,616	55,633
	2.3	1970	2,542,830	1,961,690	46,222	266,332
	2.3	1980	3,544,730	2,459,694	48,162	264,392
	2.3	2000	6,794,730	2,925,870	49,912	262,642
	2.3	2020	14,030,860	3,377,090	51,858	260,696
	2.4	1970	98,800	147,132	3,235	112,592
	2.4	1980	131,400	190,397	3,465	112,362
	2.4	2000	229,800	238,392	3,735	112,092
	2.4	2020	425,000	288,875	3,960	111,867
	3.1	1970	29,600	214,100	733	39,315
	3.1	1980	40,000	256,600	733	39,315
	3.1	2000	74,900	302,700	753	39,295
	3.1	2020	145,700	379,200	813	39,235
	3.2	1970	591,900	892,600	7,441	254,126
	3.2	1980	816,400	1,043,900	8,211	253,356
	3.2	2000	1,306,400	1,211,600	9,096	252,471
	3.2	2020	2,386,000	1,386,700	10,066	251,501
	4.1	1970	23,953,080	2,104,030	57,870	206,400
	4.1	1980	35,374,760	2,465,730	58,620	205,650
	4.1	2000	56,464,300	3,025,350	59,520	204,750
	4.1	2020	66,215,600	3,571,370	60,775	203,495
	4.2	1970	-	20,100	-	5,893
	4.2	1980	-	24,900	-	5,893
	4.2	2000	-	31,800	-	5,893
	4.2	2020	-	36,800	-	5,893
	TOTALS	1970	27,792,770	5,589,053	121,793	995,046
		1980	40,608,750	6,752,516	125,495	991,344
		2000	66,011,630	8,166,828	129,332	987,507
		2020	85,168,880	9,518,357	133,809	983,480

TABLE 14–116(continued) Summary by State

State	River Basin Group	Year	Estimated Average Annual Damage (Dollars) Urban	Rural	Estimated Acres In Flood Plain Urban	Rural
Indiana	2.2	1970	8,419,180	38,700	2,200	3,865
	2.2	1980	12,601,640	57,300	2,340	3,725
	2.2	2000	26,003,280	117,300	3,010	3,055
	2.2	2020	53,505,270	233,800	3,930	2,135
	2.3	1970	397,800	28,000	3,413	14,956
	2.3	1980	585,100	36,300	3,413	14,956
	2.3	2000	1,243,700	50,100	3,413	14,956
	2.3	2020	2,712,300	69,500	3,413	14,956
	4.2	1970	1,821,000	135,050	11,702	34,014
	4.2	1980	2,372,200	166,300	11,742	33,974
	4.2	2000	4,216,000	238,480	11,823	33,893
	4.2	2020	7,373,200	334,300	11,917	33,799
TOTALS		1970	2,219,980	169,750	15,325	49,665
		1980	2,958,940	211,900	15,365	49,625
		2000	5,462,980	307,180	15,446	49,544
		2020	10,090,770	433,600	15,540	49,450
Ohio	4.2	1970	2,687,820	4,452,500	14,788	331,255
	4.2	1980	3,708,600	5,566,290	14,930	331,113
	4.2	2000	7,106,230	7,443,710	15,190	330,853
	4.2	2020	13,426,480	9,503,960	15,470	330,573
	4.3	1970	1,218,400	594,500	14,286	57,909
	4.3	1980	1,786,700	788,100	14,959	47,236
	4.3	2000	3,571,700	1,088,200	15,808	56,387
	4.3	2020	7,418,600	1,626,900	16,520	55,675
TOTALS		1970	3,906,220	5,047,000	29,074	389,164
		1980	5,495,300	6,354,390	29,889	388,339
		2000	10,677,930	8,531,910	30,998	387,240
		2020	20,845,080	11,130,860	31,990	386,248
New York	4.4	1970	921,600	397,700	21,514	91,605
	4.4	1980	1,335,500	581,400	22,896	90,223
	4.4	2000	2,745,500	1,166,700	25,297	87,822
	4.4	2020	5,662,300	2,330,200	27,560	85,559
	5.1	1970	213,500	496,600	7,535	72,153
	5.1	1980	301,000	720,200	7,682	72,006
	5.1	2000	613,800	1,053,500	7,890	71,798
	5.1	2020	1,254,400	1,622,200	8,159	71,529
	5.2	1970	116,100	822,800	8,060	130,837
	5.2	1980	161,800	1,186,700	8,297	130,600
	5.2	2000	312,200	1,868,500	8,579	130,318
	5.2	2020	619,300	3,139,500	8,827	130,070
	5.3	1970	9,500	205,100	768	46,195
	5.3	1980	12,000	265,900	768	46,195
	5.3	2000	21,600	520,100	769	46,194
	5.3	2020	39,900	1,079,300	771	46,192
TOTALS		1970	1,260,700	1,922,200	37,877	340,790
		1980	1,810,300	2,764,200	39,643	339,024
		2000	3,693,100	4,608,800	42,535	336,132
		2020	7,575,900	8,171,200	45,317	333,350

TABLE 14–116(continued) Summary by State

State	River Basin Group	Year	Estimated Average Annual Damage (Dollars) Urban	Rural	Estimated Acres In Flood Plain Urban	Rural
Pennsylvania	4.3	1970	3,000	29,000	70	6,050
	4.3	1980	12,300	42,700	102	6,018
	4.3	2000	26,300	90,900	113	6,007
	4.3	2020	56,200	193,800	126	5,994
	4.4	1970	6,500	7,700	333	1,990
	4.4	1980	8,500	10,700	333	1,990
	4.4	2000	14,600	13,700	333	1,990
	4.4	2020	26,000	15,000	333	1,990
TOTALS		1970	9,500	36,700	403	8,040
		1980	20,800	53,400	435	8,008
		2000	40,900	104,600	446	7,997
		2020	82,200	208,800	459	7,984
Great Lakes		1970	46,351,920	14,210,159	221,787	2,564,857
Basin Totals		1980	67,130,181	18,048,931	229,605	2,557,029
		2000	118,524,125	24,228,256	239,423	2,547,221
		2020	190,308,880	32,411,674	250,229	2,536,415

TABLE 14-117 Summary by Lake Basin

Lake Basin	River Basin Group	Year	Estimated Average Annual Damage (Dollars)		Estimated Acres In Flood Plain	
			Urban	Rural	Urban	Rural
Superior	1.1	1970	320,800		1,058	131,869
	1.1	1980	409,500	69,200	1,058	131,869
	1.1	2000	610,400	117,700	1,058	131,869
	1.1	2020	954,500	199,700	1,058	131,869
	1.2	1970	385,000	217,600	4,721	55,160
	1.2	1980	461,700	277,000	4,721	55,160
	1.2	2000	751,300	393,200	4,721	55,160
	1.2	2020	1,248,000	437,800	4,721	55,160
TOTALS		1970	705,800	272,000	5,779	187,029
		1980	871,200	346,200	5,779	187,029
		2000	1,361,700	510,900	5,779	187,029
		2020	2,202,500	637,500	5,779	187,029
Michigan						
	2.1	1970	2,335,010	1,199,207	13,640	647,955
	2.1	1980	3,007,351	1,600,272	13,748	647,847
	2.1	2000	5,316,885	1,991,204	13,958	647,637
	2.1	2020	10,261,770	2,140,229	14,097	647,498
	2.2	1970	8,699,680	230,350	4,398	58,251
	2.2	1980	13,060,640	296,648	5,765	56,884
	2.2	2000	27,103,780	456,550	7,455	55,194
	2.2	2020	56,052,770	679,250	9,785	52,864
	2.3	1970	2,940,630	1,989,690	49,635	281,288
	2.3	1980	4,129,830	2,495,994	51,575	279,348
	2.3	2000	8,038,430	2,975,970	53,325	277,598
	2.3	2020	16,743,160	3,446,590	55,271	275,652
	2.4	1970	98,800	147,132	3,235	112,592
	2.4	1980	131,400	190,397	3,465	112,362
	2.4	2000	229,800	238,392	3,735	112,092
	2.4	2020	425,000	288,875	3,960	111,867
TOTALS		1970	14,074,120	3,566,379	70,908	1,100,086
		1980	20,329,221	4,583,311	74,553	1,096,441
		2000	40,688,895	5,662,116	78,473	1,092,521
		2020	83,482,700	6,554,944	83,113	1,087,881
Huron	3.1	1970	29,600	214,100	733	39,315
	3.1	1980	40,000	256,600	733	39,315
	3.1	2000	74,900	302,700	753	39,295
	3.1	2020	145,700	379,200	813	39,235
	3.2	1970	591,900	892,600	7,441	254,126
	3.2	1980	816,400	1,043,900	8,211	253,356
	3.2	2000	1,306,400	1,211,600	9,096	252,471
	3.2	2020	2,386,000	1,386,700	10,066	251,501
TOTALS		1970	621,500	1,106,700	8,174	293,441
		1980	856,400	1,300,500	8,944	292,671
		2000	1,381,300	1,514,300	9,849	291,766
		2020	2,531,700	1,765,900	10,879	290,736
Erie	4.1	1970	23,953,080	2,104,030	57,870	206,400
	4.1	1980	35,374,760	2,465,730	58,620	205,650
	4.1	2000	56,464,300	3,025,350	59,520	204,750
	4.1	2020	66,215,600	3,571,370	60,775	203,495
	4.2	1970	4,508,820	4,607,650	26,490	371,162
	4.2	1980	6,080,800	5,757,490	26,672	370,970
	4.2	2000	11,322,230	7,713,990	27,013	370,639
	4.2	2020	20,799,680	9,875,060	27,387	370,265

TABLE 14–117(continued) Summary by Lake Basin

Lake Basin	River Basin Group	Year	Estimated Average Annual Damage (Dollars)		Estimated Acres in Flood Plain	
			Urban	Rural	Urban	Rural
Erie (Continued)	4 3	1970	1,221,400	623,500	14,356	63,959
	4.3	1980	1,799,000	830,800	15,061	63,254
	4.3	2000	3,598,000	1,179,100	15,921	62,394
	4.3	2020	7,474,800	1,820,700	16,646	61,669
	4.4	1970	928,100	405,400	21,847	93,595
	4.4	1980	1,344,000	592,100	23,229	92,213
	4.4	2000	2,760,100	1,180,400	25,630	89,812
	4.4	2020	5,688,300	2,345,200	27,893	87,549
TOTALS		1970	30,611,400	7,740,580	120,563	735,116
		1980	44,598,560	9,646,120	123,582	732,087
		2000	74,144,630	13,098,840	128,084	727,595
		2020	100,178,380	17,612,330	132,701	722,978
Ontario	5.1	1970	213,500	496,600	7,535	72,153
	5.1	1980	301,000	720,200	7,682	72,006
	5.1	2000	613,800	1,053,500	7,890	71,798
	5.1	2020	1,254,400	1,622,200	8,159	71,529
	5.2	1970	116,100	822,800	8,060	130,837
	5.2	1980	161,800	1,186,700	8,297	130,600
	5.2	2000	312,200	1,868,500	8,579	130,318
	5.2	2020	619,300	3,139,500	8,827	130,070
	5.3	1970	9,500	205,100	768	46,195
	5.3	1980	12,000	265,900	768	46,195
	5.3	2000	21,600	520,100	769	46,194
	5.3	2020	39,900	1,079,300	771	46,192
TOTALS		1970	339,100	1,524,500	16,363	249,185
		1980	474,800	2,172,800	16,747	248,801
		2000	947,600	3,442,100	17,238	248,310
		2020	1,913,600	5,841,000	17,757	247,791
Great Lakes Basin Totals		1970	46,351,920	14,210,159	221,787	2,564,857
		1980	67,130,181	18,048,931	229,605	2,557,029
		2000	118,524,125	24,228,256	239,423	2,547,221
		2020	190,308,880	32,411,674	250,229	2,536,415

TABLE 14–118 Additional Alternatives

River Basin Group	Location	Reduction Measure
5.1	Wellsville	Reservoir (Stannard)
	Conesus Lake	Lake Regulation
	Silver Lake	Lake Regulation and Institutional
	Honedge Lake	Lake Regulation
5.2	Ley Creek	Institutional and Local Protection
	Chittenango Creek	Reservoir
	Oneida Lake and River	Channel Modification
	Owasco Lake and Outlet	Reservoir
	Cayuga Lake	Reservoir
	Canandaigua Lake and Outlet	Reservoir
	Seneca River	Channel Modification
	Oswego River	Channel Modification

GLOSSARY

average annual damages—the weighted yearly average of all flood damages that would be expected to occur under specified economic conditions and development. Such damages are computed on the basis of the expectancy in any one year of the amounts of damage that would result from events throughout the full range of potential magnitude.

design flood—the peak discharge value adopted as the basis for design and operation of a particular project.

flood—the temporary overflowing of a river or stream inundating lands not normally covered by water. A flood is usually caused by torrential rainfalls or snowmelt, sometimes aggravated by ice jams.

flood damage—the loss resulting from floods within the flood plains of rivers and streams and excluding the Great Lakes shoreline. The damages are caused by inundation, ponding, velocity of water, and deposition of sediment. In this appendix damages have been classified according to land use. These are direct physical losses. Floods may also create indirect losses (loss of time, disruption of production, and emergency activities) and intangible damages, including loss of human life and human suffering.

flood damage prevention measures—
(1) structural—a program for reducing flood damages by means of controlling the water through engineering works such as levees, channel improvements, and reservoirs.
(2) nonstructural—a program for reducing or preventing flood damages by means of controlling the use of the flood plain. Examples of these measures are flood plain regulation through acquisition and zoning, flood warning and evacuation systems, and flood insurance protection.

flood of record—any flood for which there is reasonably reliable data useful in technical analyses. The term is often used to refer to the maximum flood of known record.

flood plain—that portion of a river valley, adjacent to the river channel, which is built of sediments during the present regimen of the stream and which is covered with water when the river overflows its banks at maximum flood stages.

flood plain zoning—an ordinance adopted by local or State governments that recognizes the hazards inherent in flood plains and restricts the allowable uses of the flood plains to uses which are compatible with these flood hazards.

floodway—those portions of a stream channel and its adjacent flood plains that are necessary to carry floodwaters. Any decrease in the cross-sectional area of a floodway usually results in higher flood stages.

highly urbanized area—a city, town, or other area occupied by residences, public or commercial buildings, and industrial structures. The occupied area is essentially continuous.

land use classifications—
(1) industrial—includes all industrial buildings, parking areas, adjacent yards, and landscaped grounds. Included are research and clerical office facilities, warehouses, mining and other extractive industries, steel mills, and private utilities.
(2) commercial—includes buildings, parking areas, and other land directly related to retail and wholesale trade, personal, business and professional services. This category includes small industrial or public buildings that occur in predominantly commercial areas, residences over commercial uses, and recreational boat marinas. It includes most buildings and related grounds belonging to public or quasi-public agencies, governments, or organizations that 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, airports, and railroad facilities.
(3) residential—all forms of residential use are included (single family and multifamily houses, town houses, apartment buildings, mobile home parks, etc.) with the exception of farmsteads, residential recreation, and other noncontiguous residences. In general a residential area will consist of four or more residential buildings adjacent to each other. 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.
(4) transportation—includes railroad rights-of-way, highways, roads, and bridges. Does not include buildings at a railroad terminal.
(5) open urban—includes all vacant and undeveloped urban and recreation lands. Privately owned outdoor recreation lands such as golf courses or tennis clubs are also included, as are parks, amusement parks, and cemeteries.
(6) residential recreation—includes all residential facilities such as cottages and lodges located along rivers and lakes used for recreational activities.
(7) cropland—includes land currently tilled, land with harvested crops, failed crops, summer fallow, idle cropland, cropland in cover crops or soil improvement crops not harvested or pastured, rotation pasture, and cropland being prepared for crops, or newly seeded crops. Cropland also includes land in vegetables, fruits and nuts, and all hayland including tame and wild hay.
(8) pasture-range—land in grass or other long-term forage growth used primarily for grazing, does not include rotation hayland pasture and hayland. The land may contain shade or timber trees if the canopy is less than 10 percent, but the principal plant cover must be such as to identify its use as permanent grazing land.
(9) woodland—land at least 10 percent stocked by forest trees of any size, or formerly having had such tree cover, and not currently developed for nonforest use. The minimum area for classification of forest land is one acre. Roadside, streamside, and shelterbelt strips of timber must have a crown width at least 120 feet wide to qualify as forest land. Unimproved roads and trails, streams, or other bodies of water or clearings in forest areas shall be classed as forest, if less than 120 feet in width.
(10) other rural—all land in the Great Lakes Basin not classified as cropland, pasture and range, forest land, urban built-up areas, and water area. It includes farmsteads, farm lanes, idle land, wildlife areas, built-up urban areas of less than 10 acres, farm roads, filling stations, rural nonfarm residences, country churches, cemeteries, school grounds, feed lots, ditch banks, fence and hedge rows, coastal dunes, unused marshes, and strip mines, borrow and gravel pits.

major damage (map designation)—damage that exceeds an average annual damage of $20,000, within a given study reach.

minor damage (map designation)—damage that has an average annual damage, within a given study reach, of $20,000 or less.

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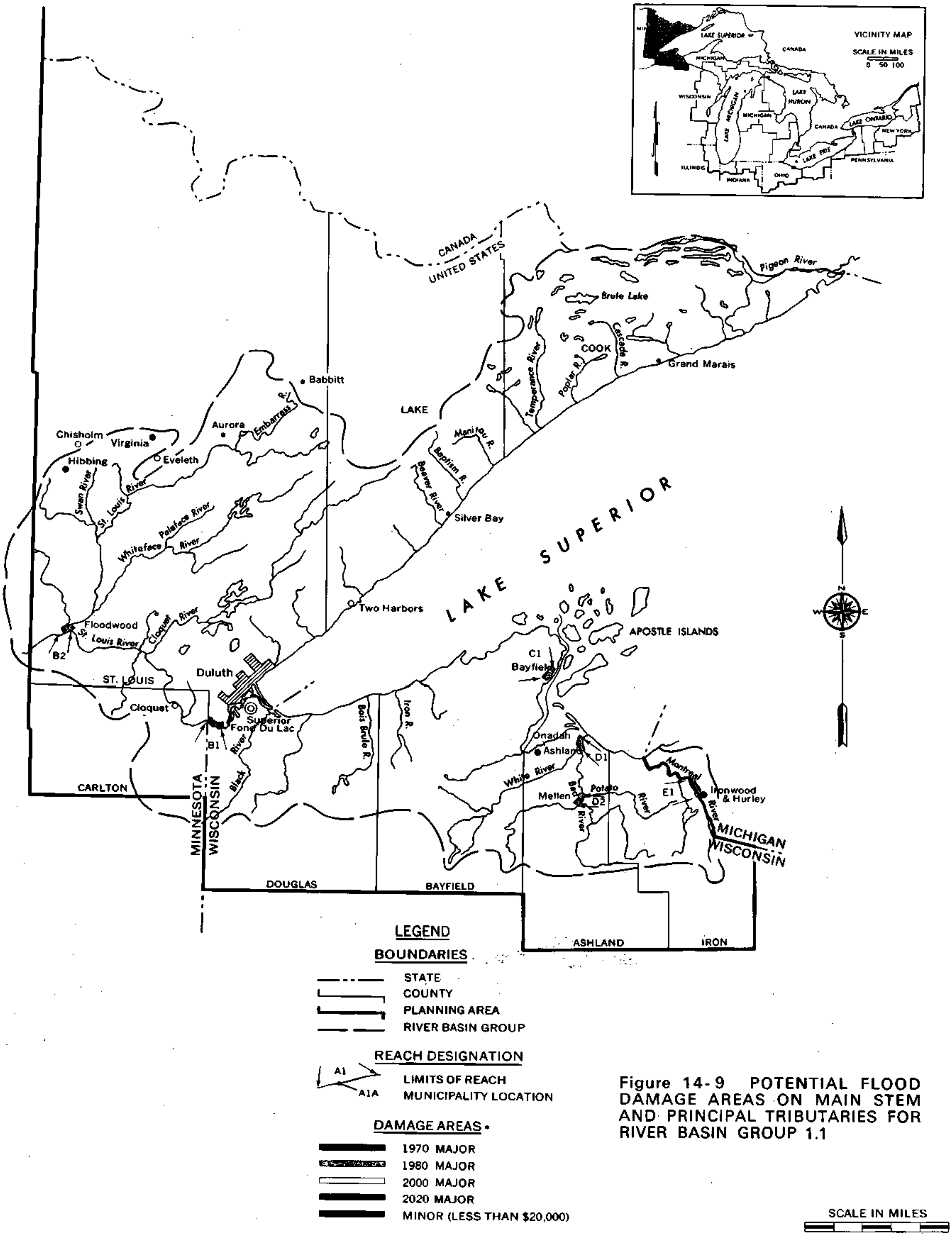


FIGURE 14-9c Potential Flood Damage Areas on Main Stem and Principal Tributaries for River Basin Group 1.1

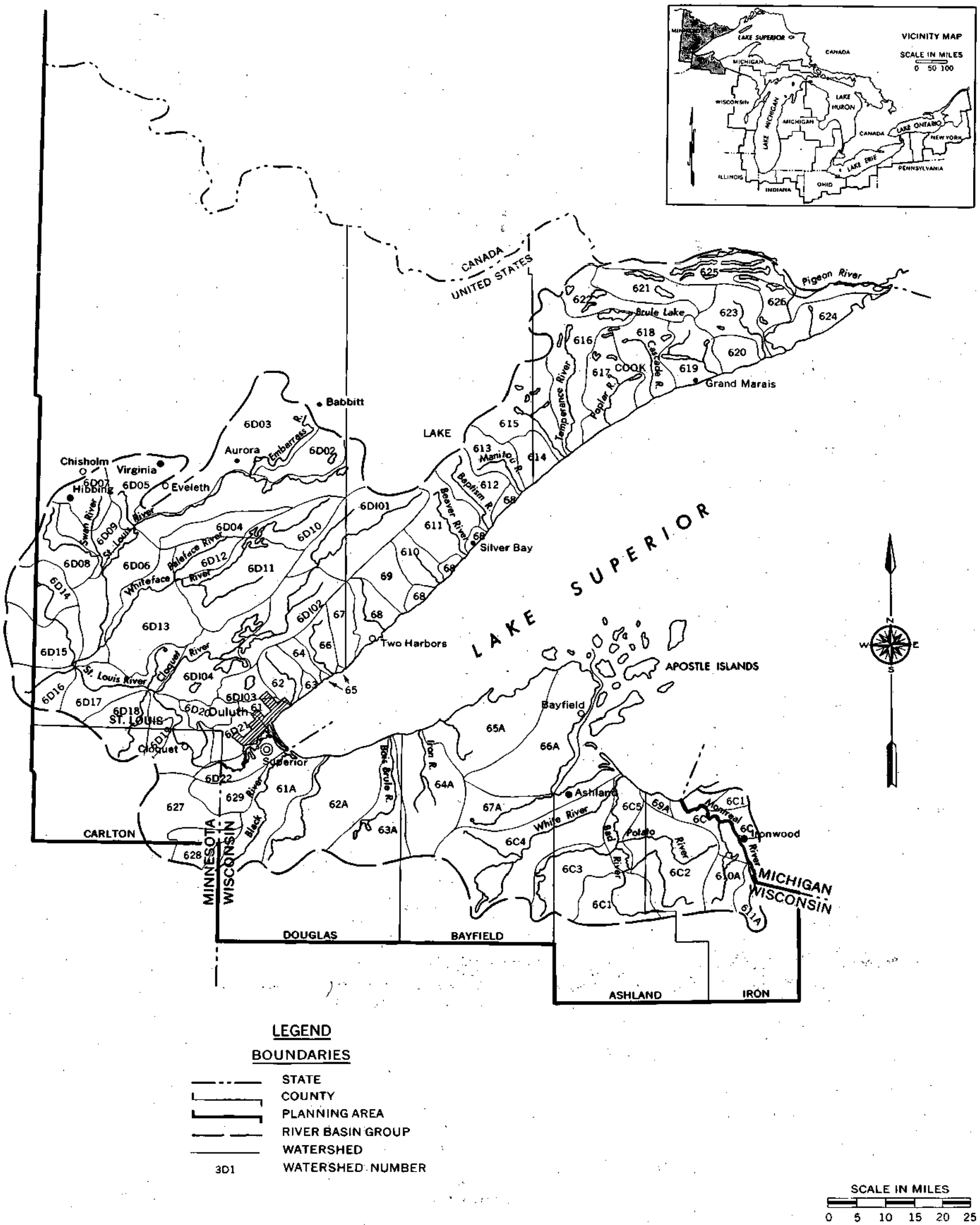


FIGURE 14–10c Watershed Designation—River Basin Group 1.1

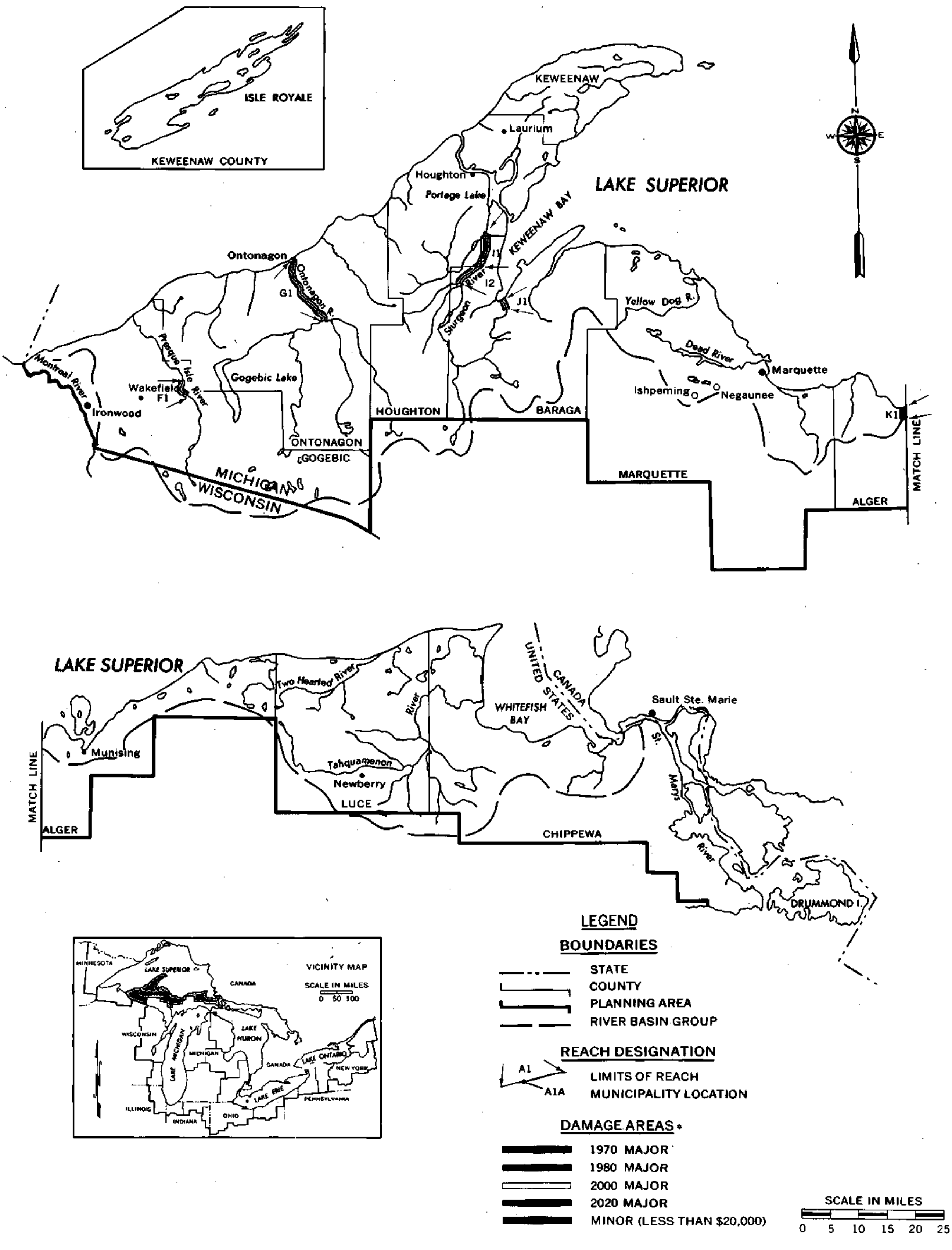


FIGURE 14–13c Potential Flood Damage Areas on Main Stem and Principal Tributaries for River Basin Group 1.2

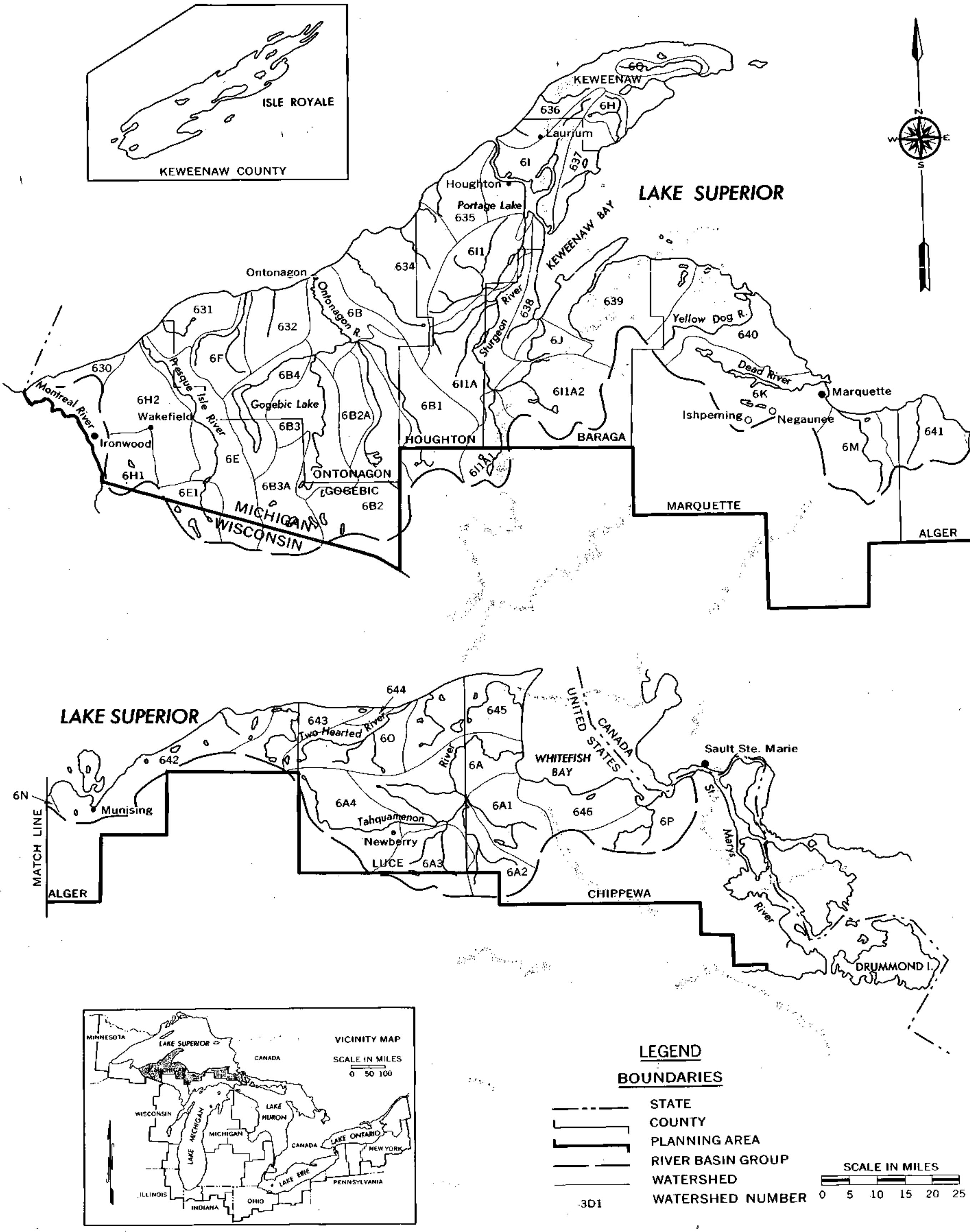


FIGURE 14–14c Watershed Designation—River Basin Group 1.2

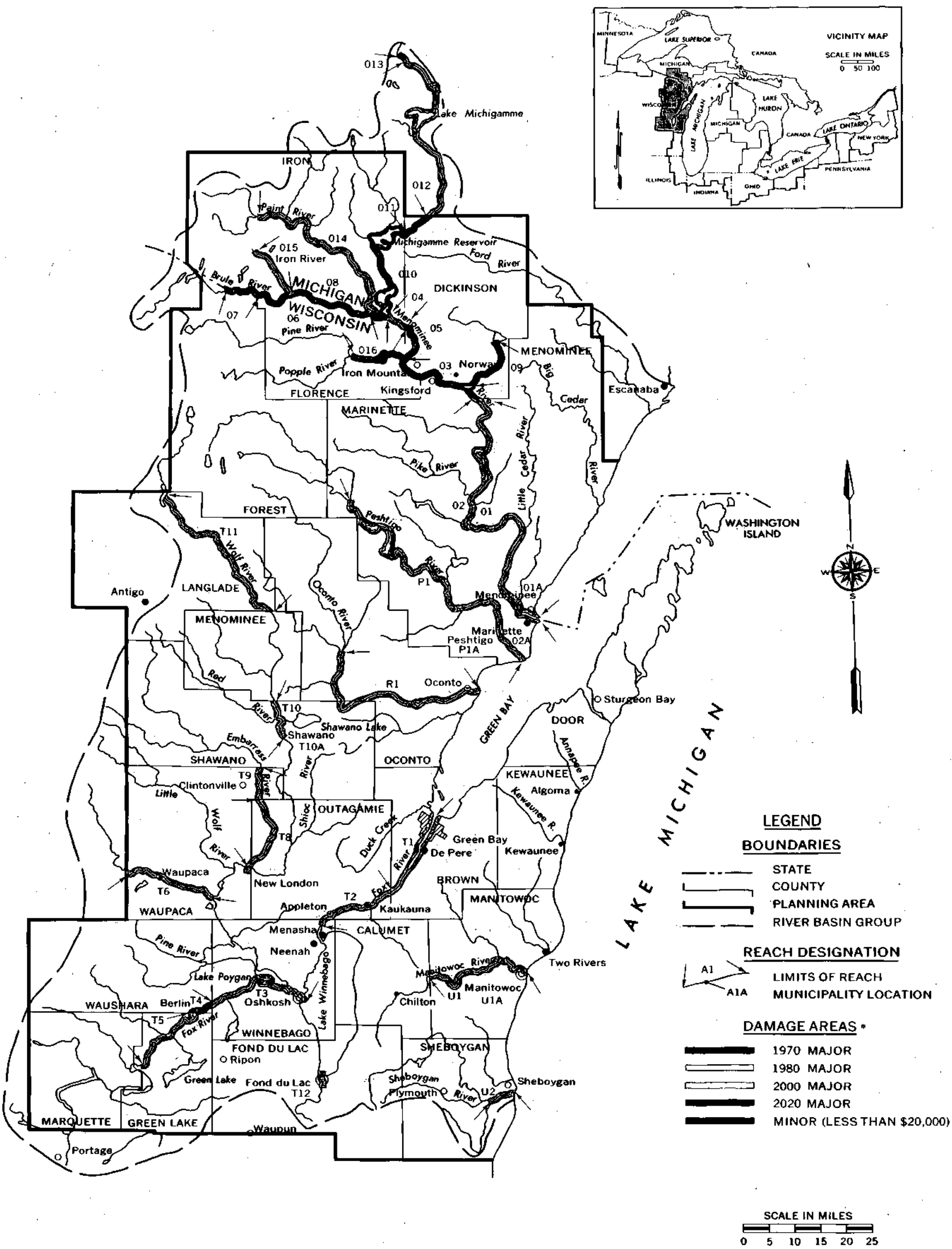


FIGURE 14–16c Potential Flood Damage Areas on Main Stem and Principal Tributaries for River Basin Group 2.1

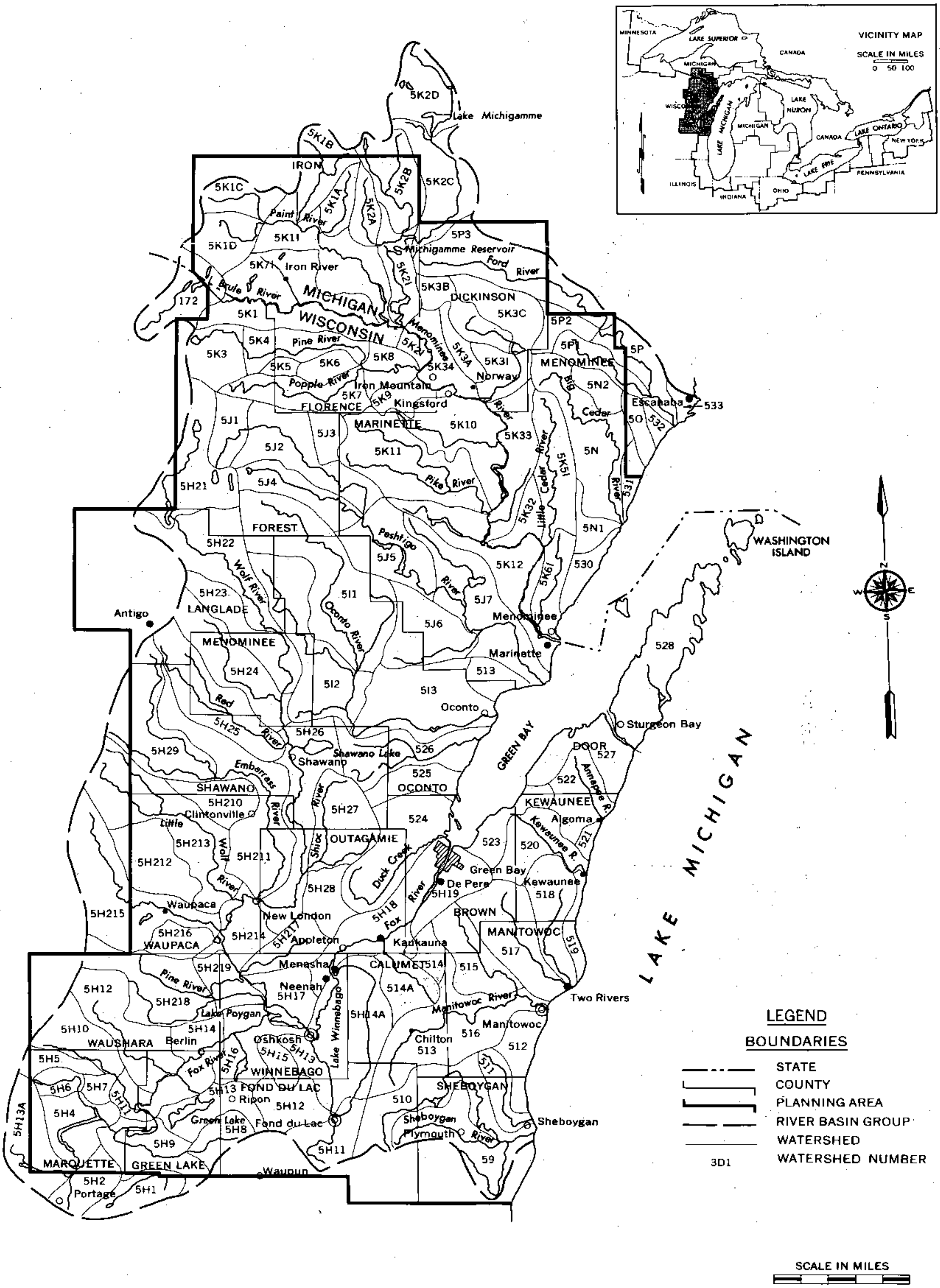


FIGURE 14–17c Watershed Designation—River Basin Group 2.1

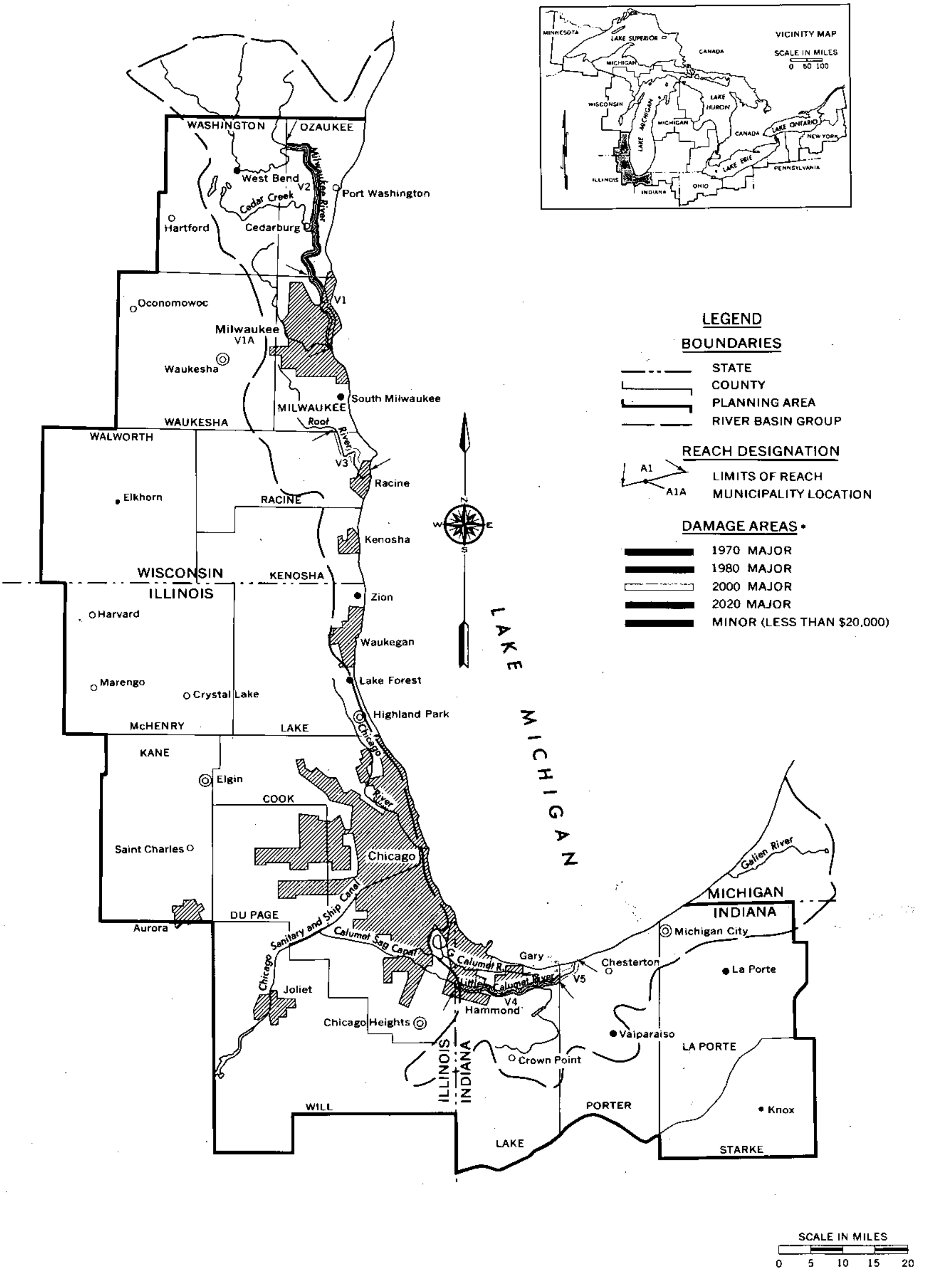


FIGURE 14–20c Potential Flood Damage Areas on Main Stem and Principal Tributaries for River Basin Group 2.2

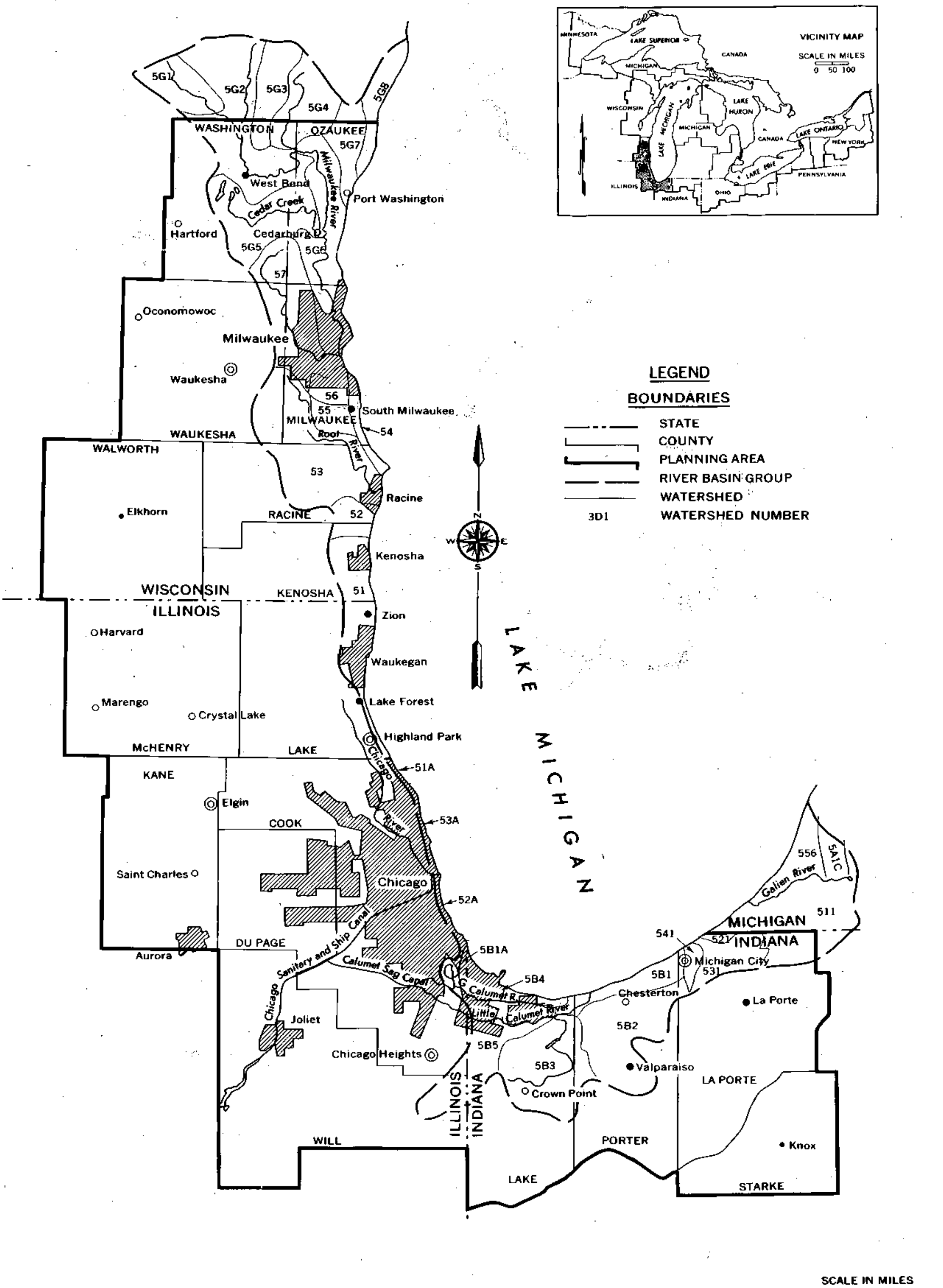


FIGURE 14-21c Watershed Designation—River Basin Group 2.2

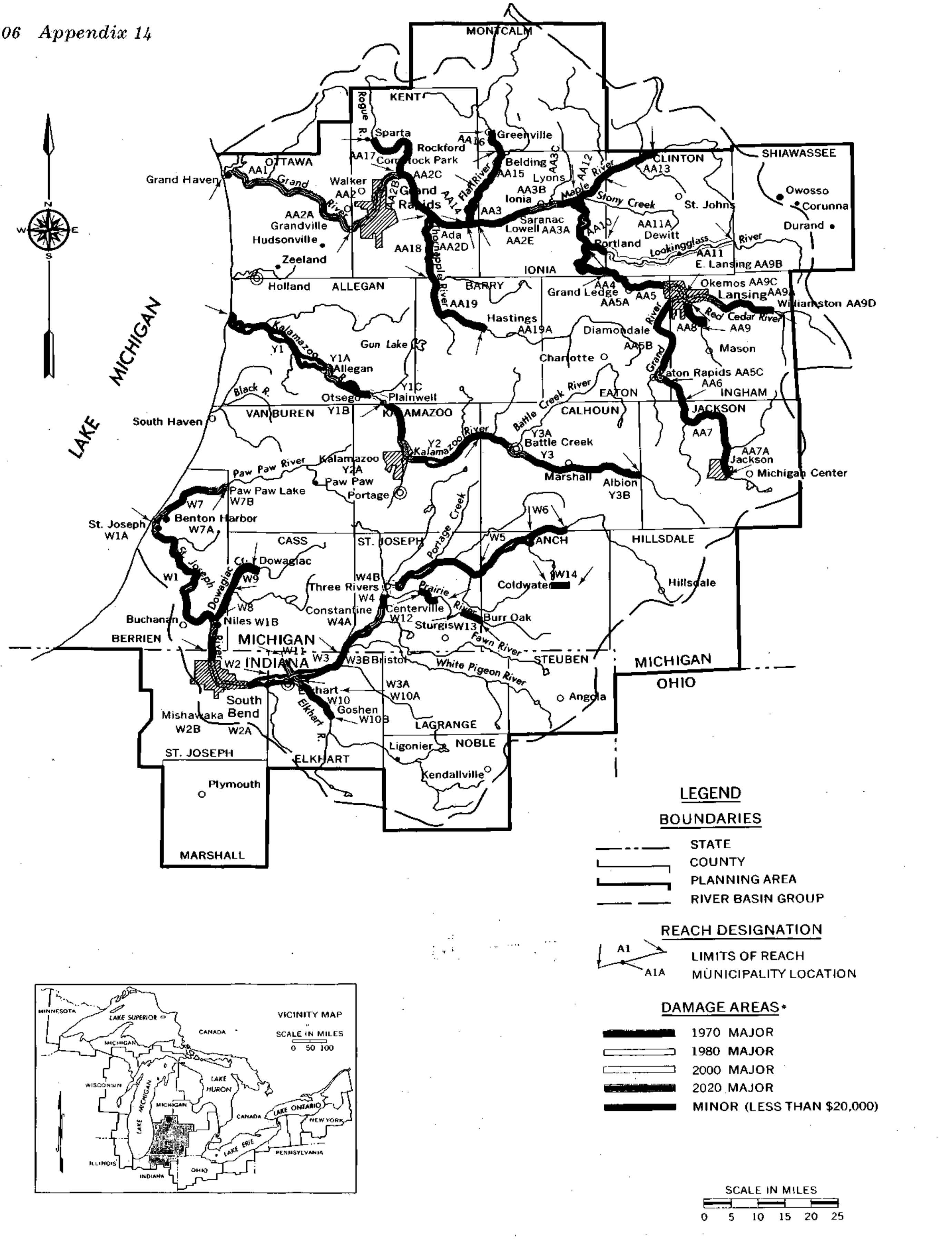


FIGURE 14–24c Potential Flood Damage Areas on Main Stem and Principal Tributaries for River Basin Group 2.3

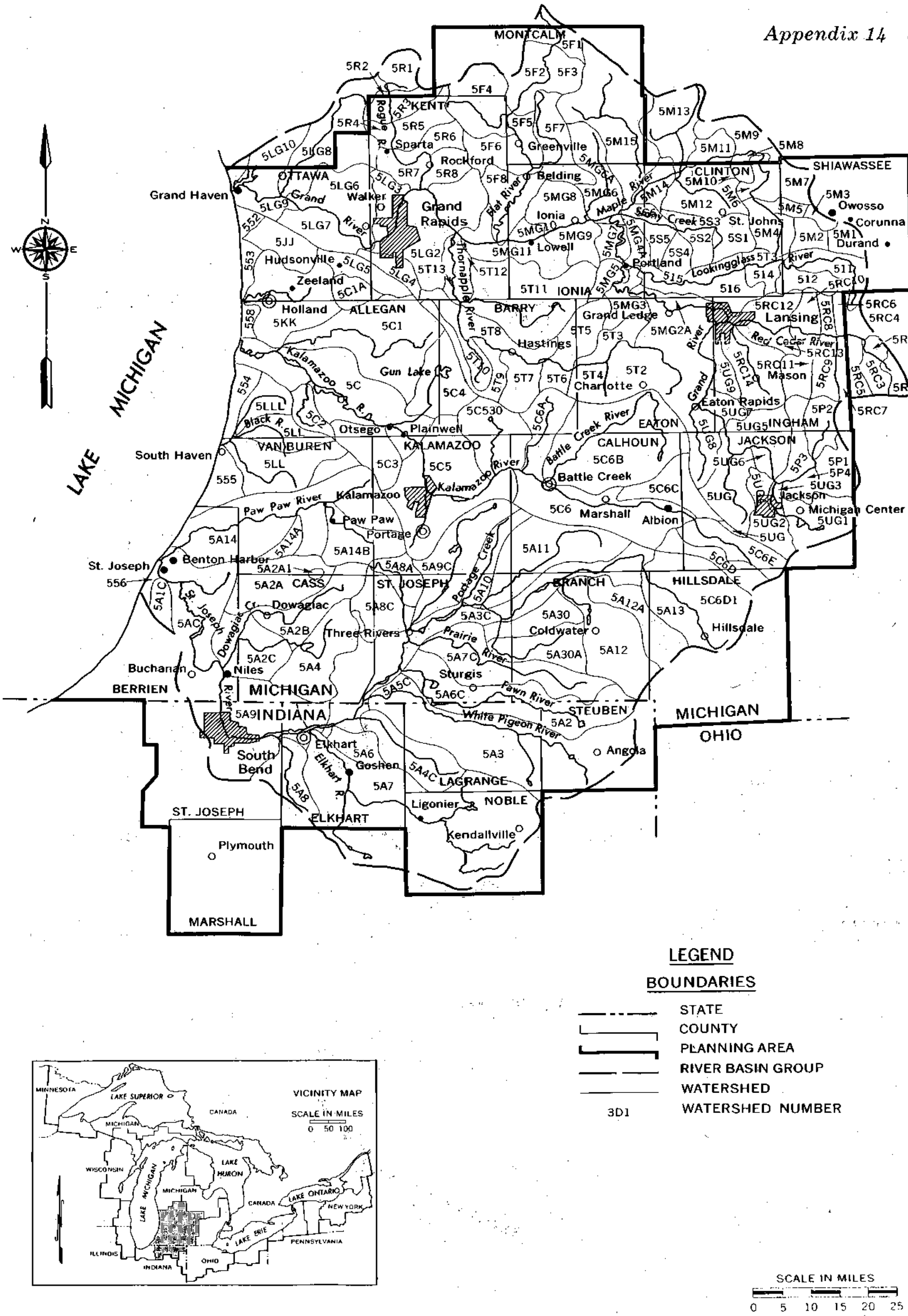


FIGURE 14–25c Watershed Designation—River Basin Group 2.3

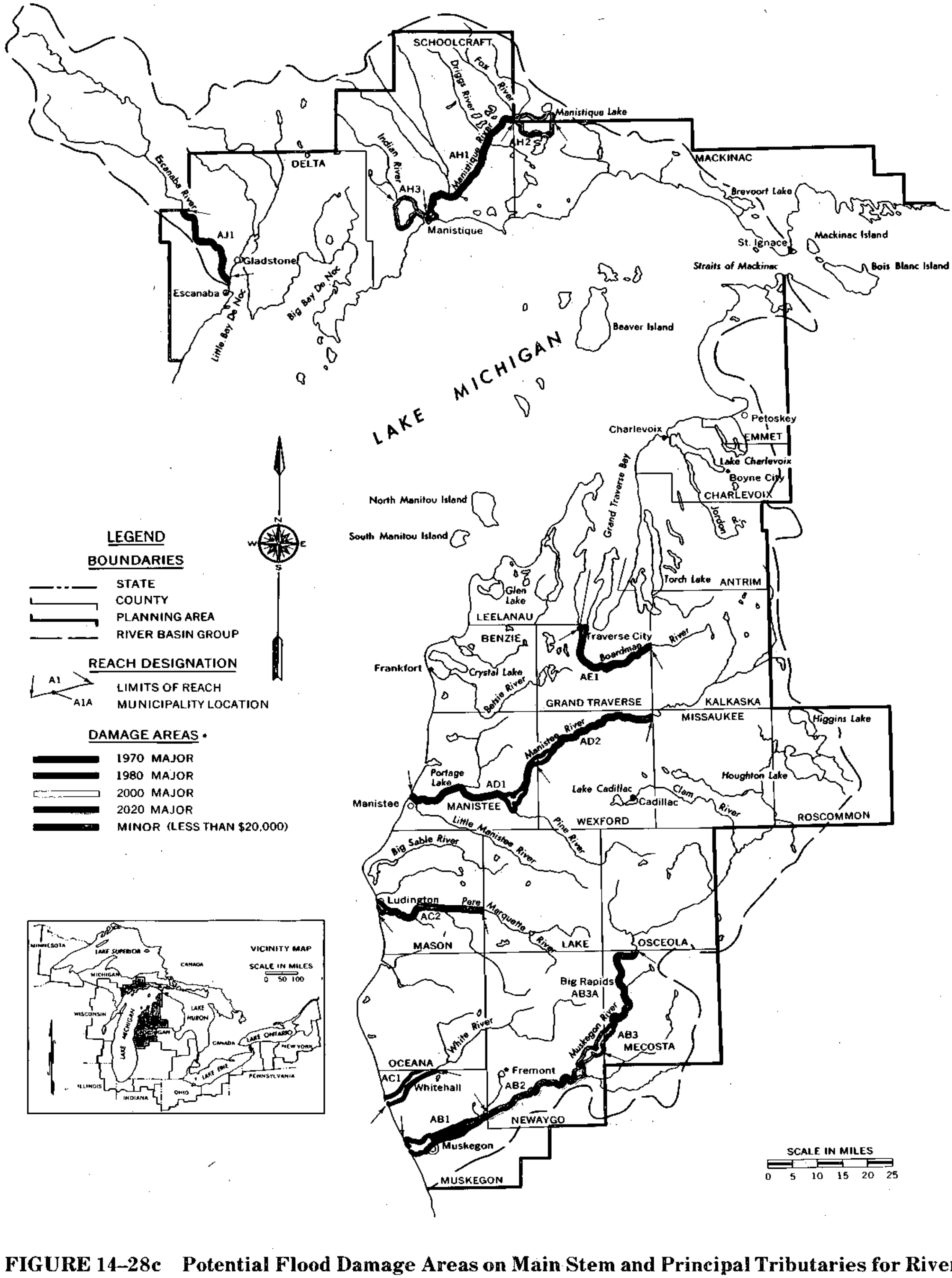


FIGURE 14–28c Potential Flood Damage Areas on Main Stem and Principal Tributaries for River Basin Group 2.4

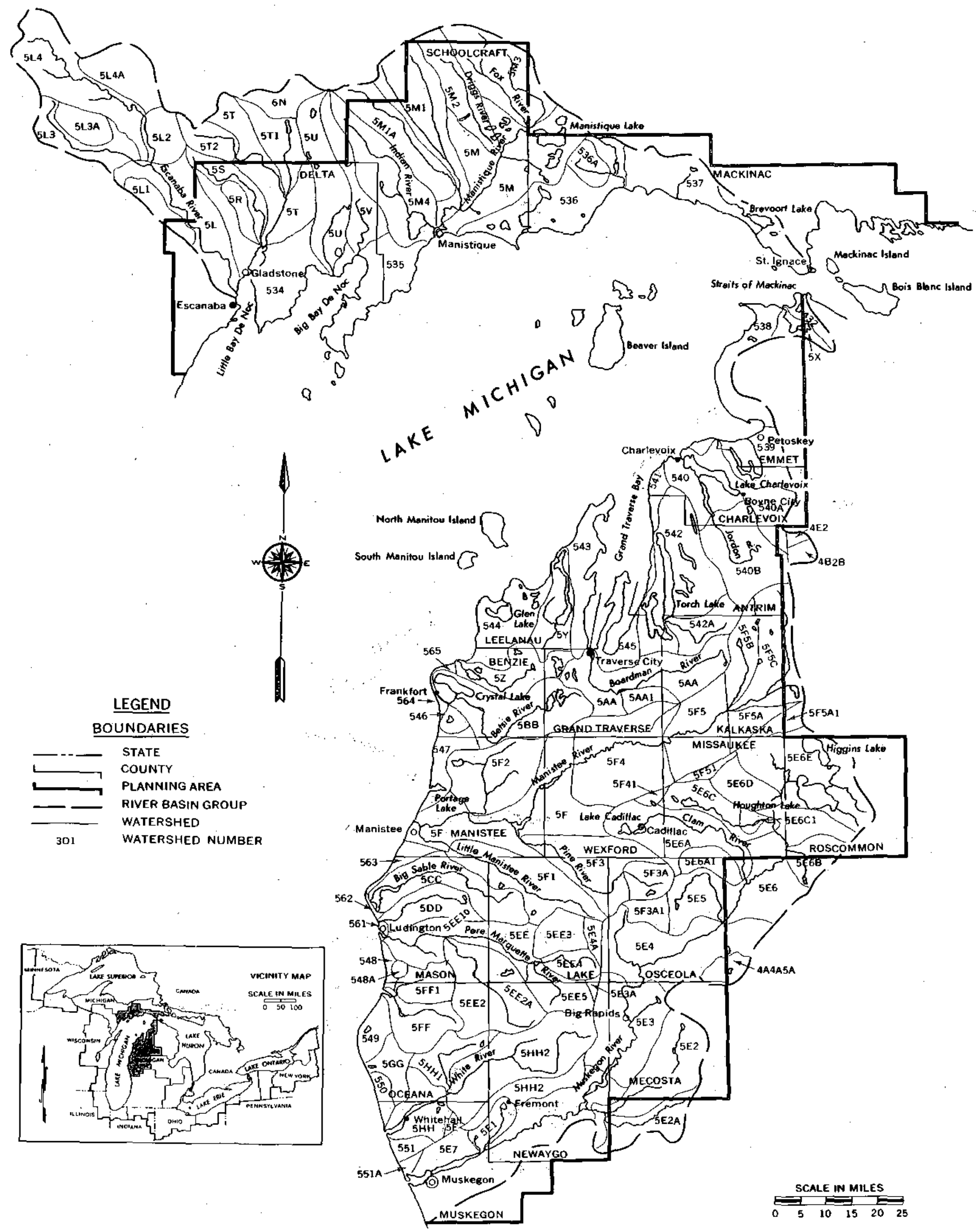


FIGURE 14–29c Watershed Designation—River Basin Group 2.4

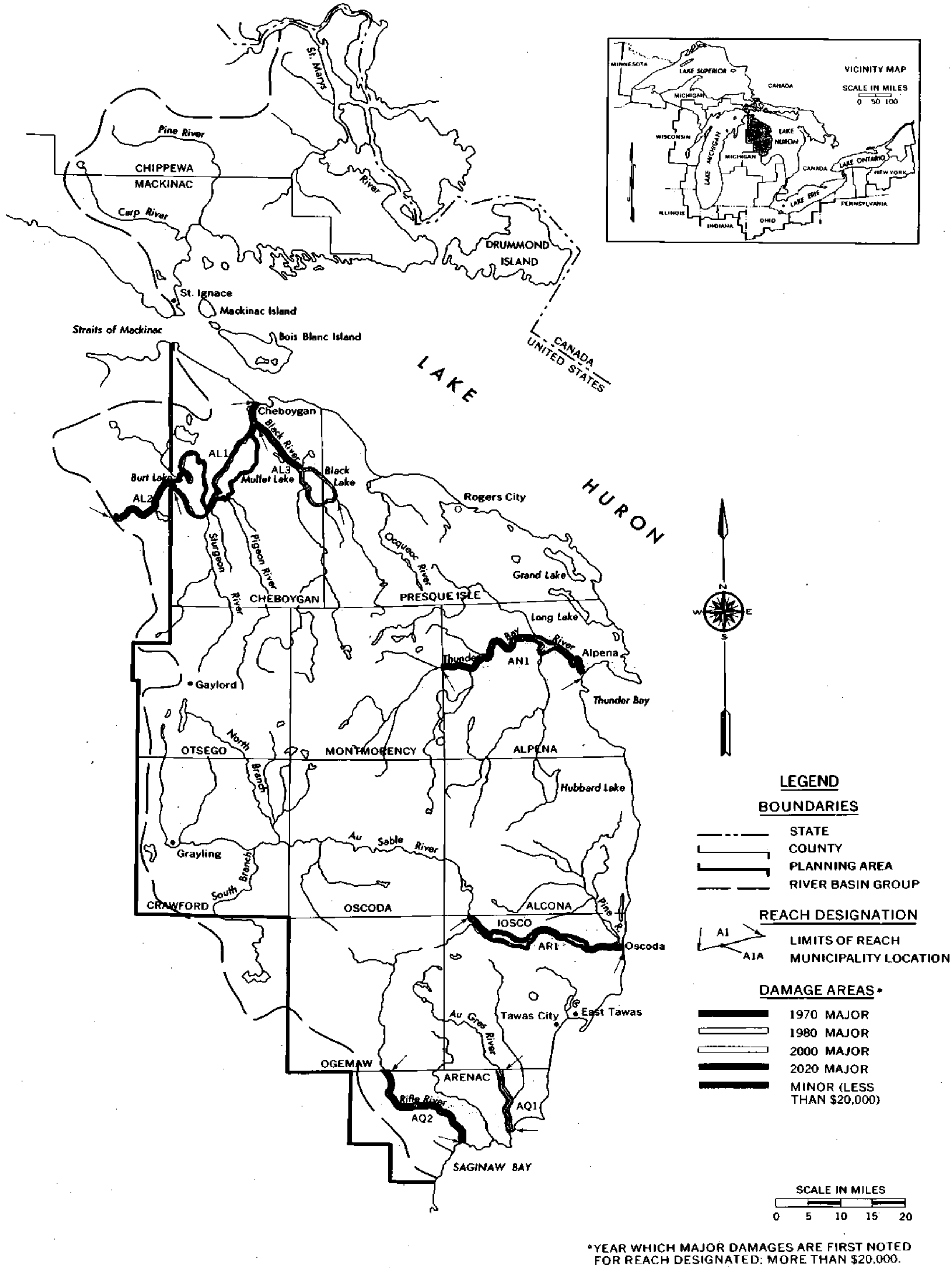


FIGURE 14–31c Potential Flood Damage Areas on Main Stem and Principal Tributaries for River Basin Group 3.1

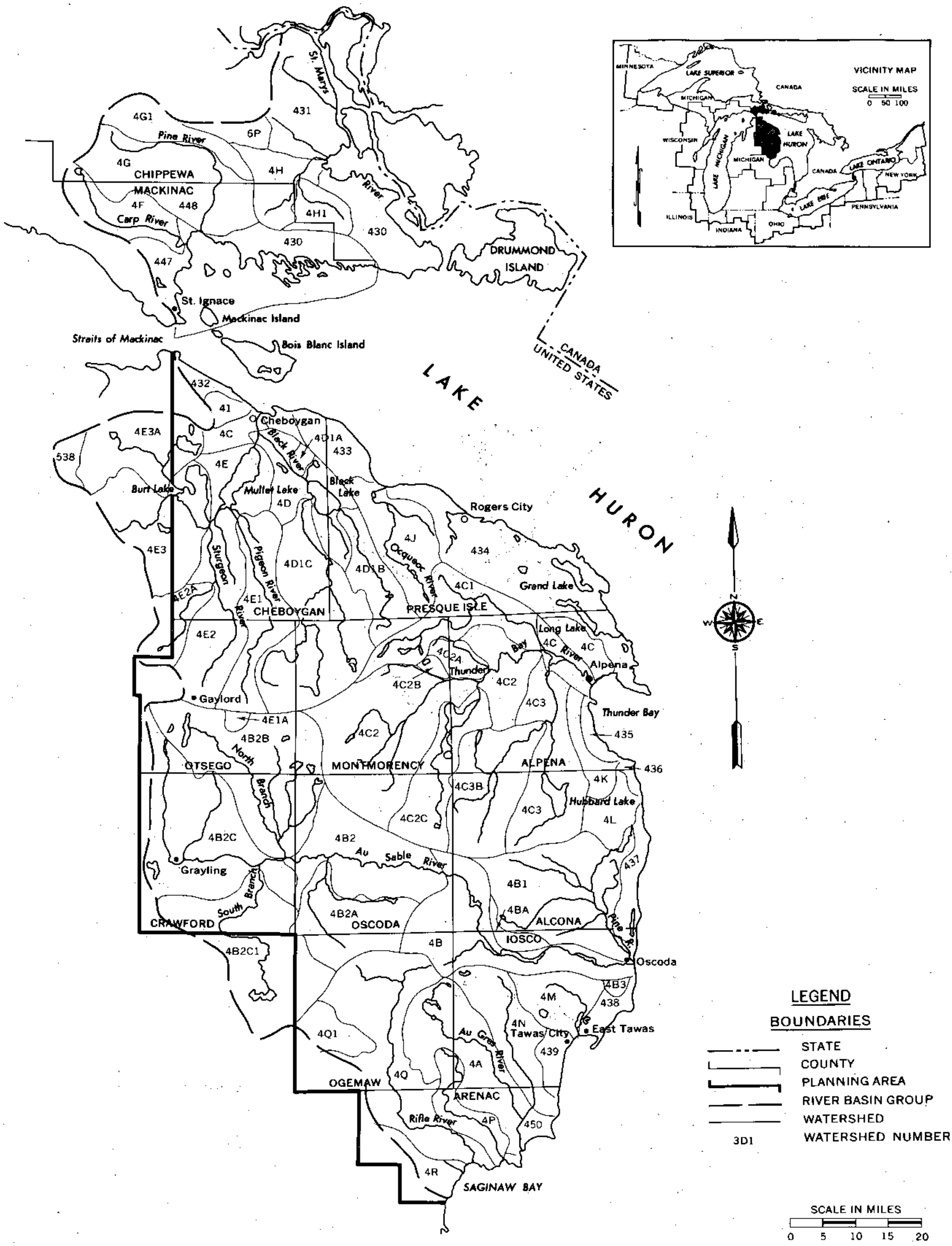


FIGURE 14–32c Watershed Designation—River Basin Group 3.1

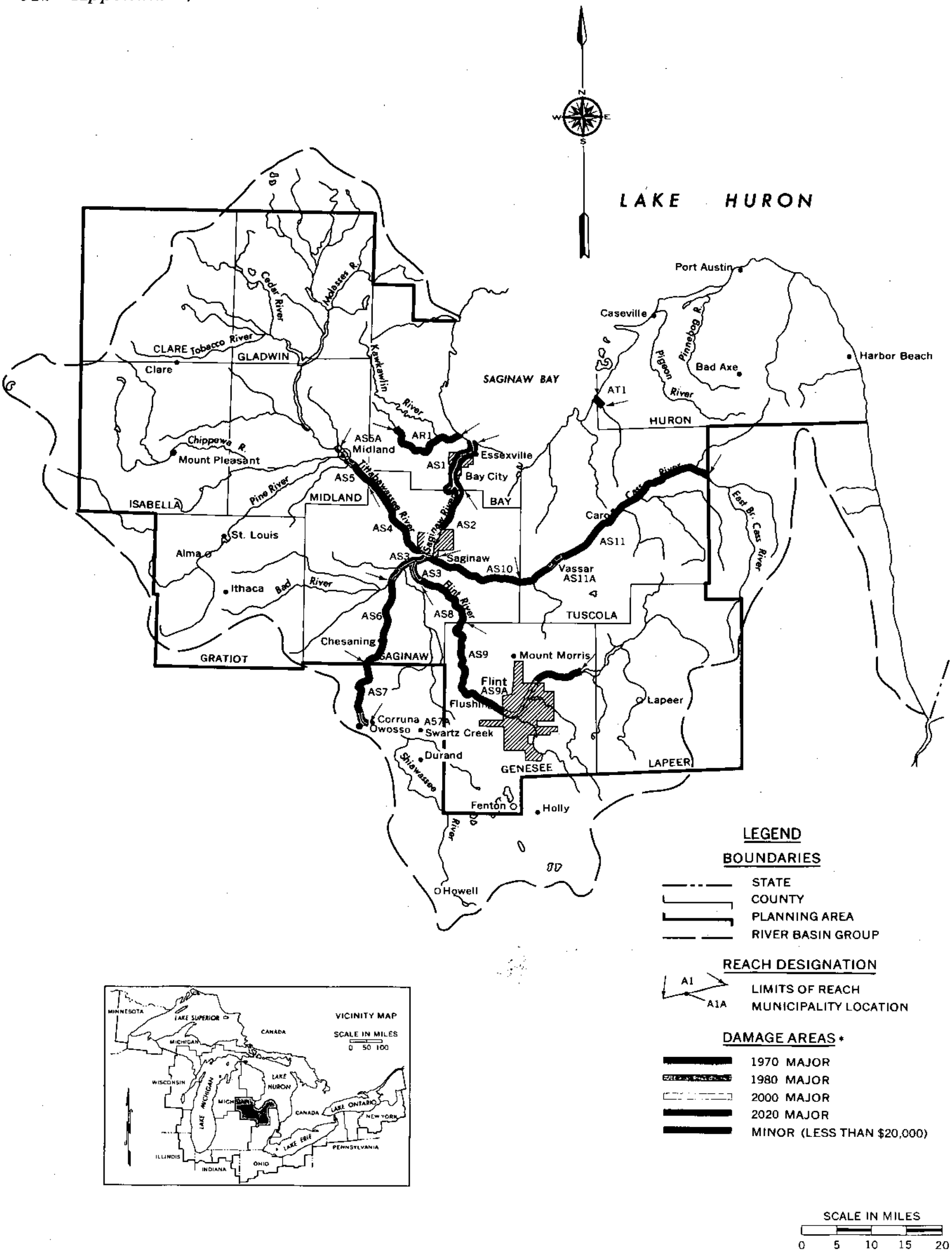


FIGURE 14–35c Potential Flood Damage Areas on Main Stem and Principal Tributaries for River Basin Group 3.2

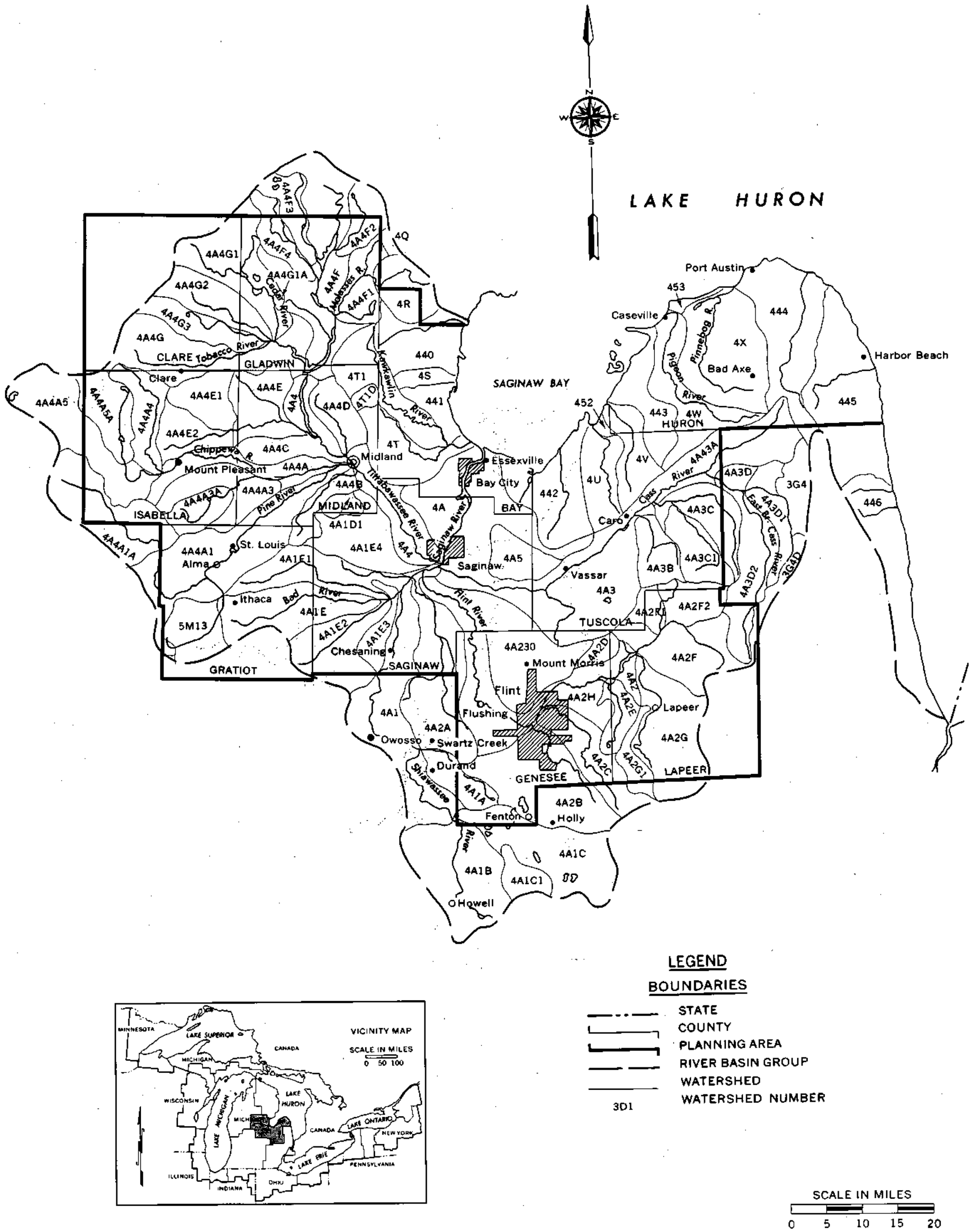


FIGURE 14–36c Watershed Designation—River Basin Group 3.2

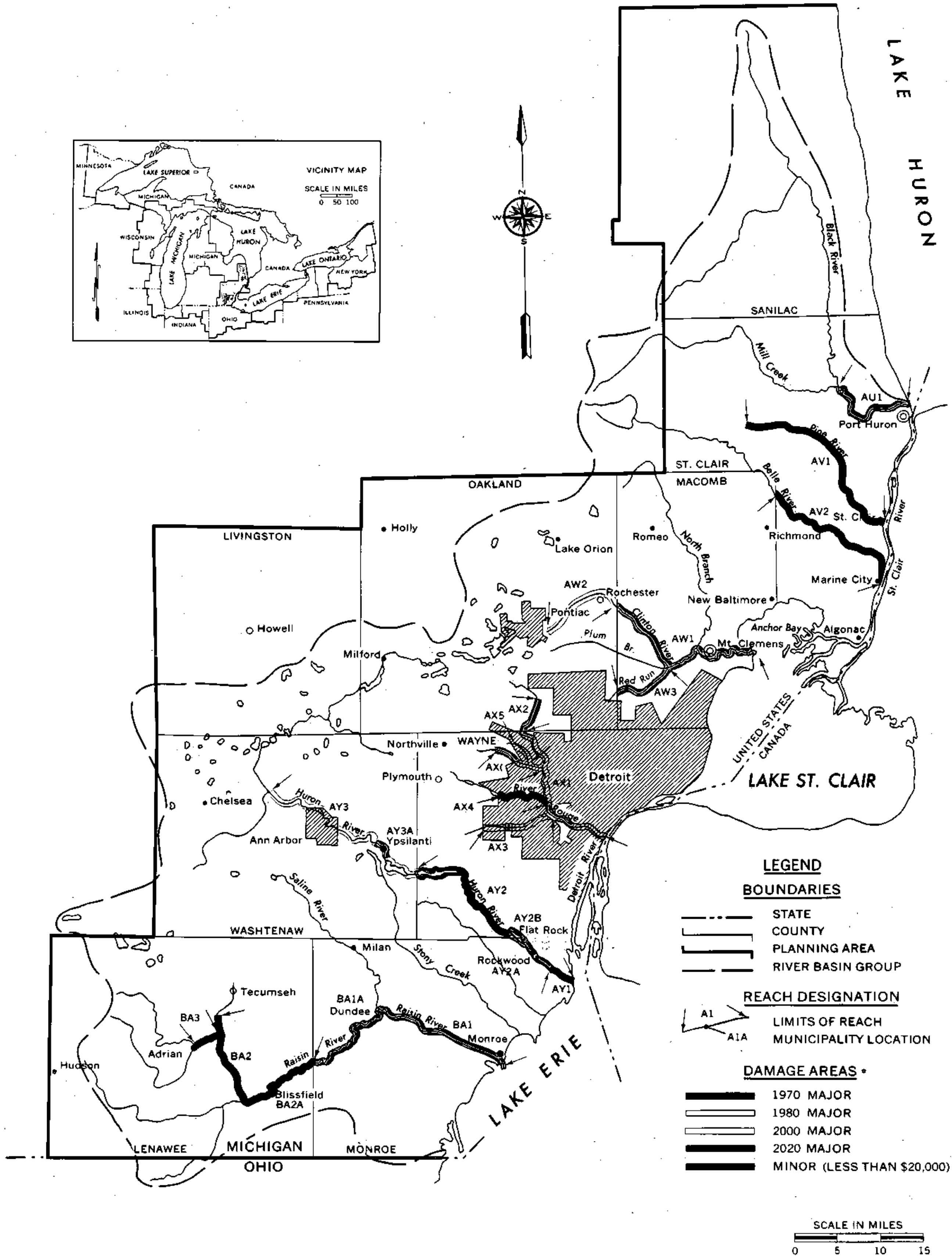


FIGURE 14-39c Potential Flood Damage Areas on Main Stem and Principal Tributaries for River Basin Group 4.1

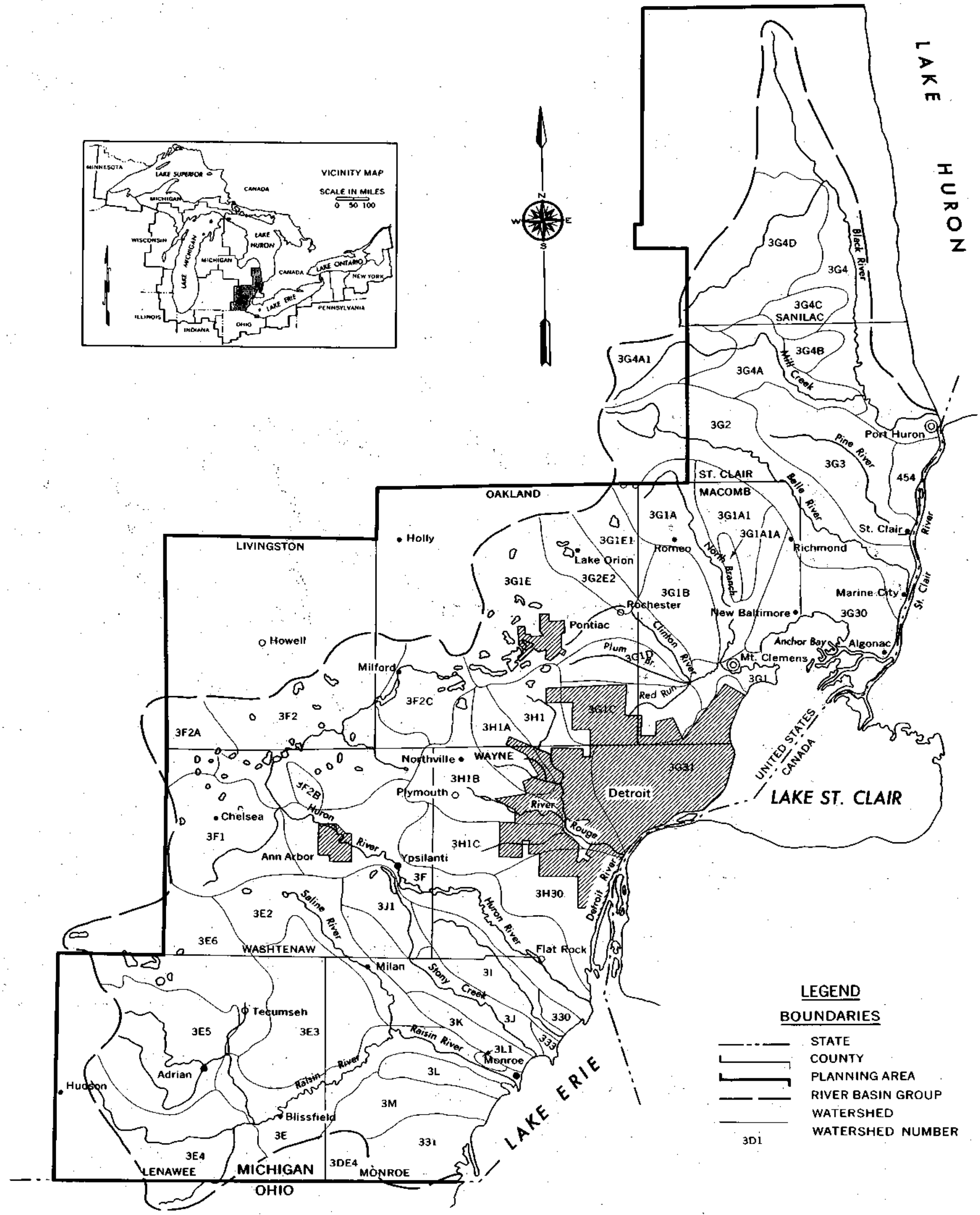


FIGURE 14–40c Watershed Designation—River Basin Group 4.1

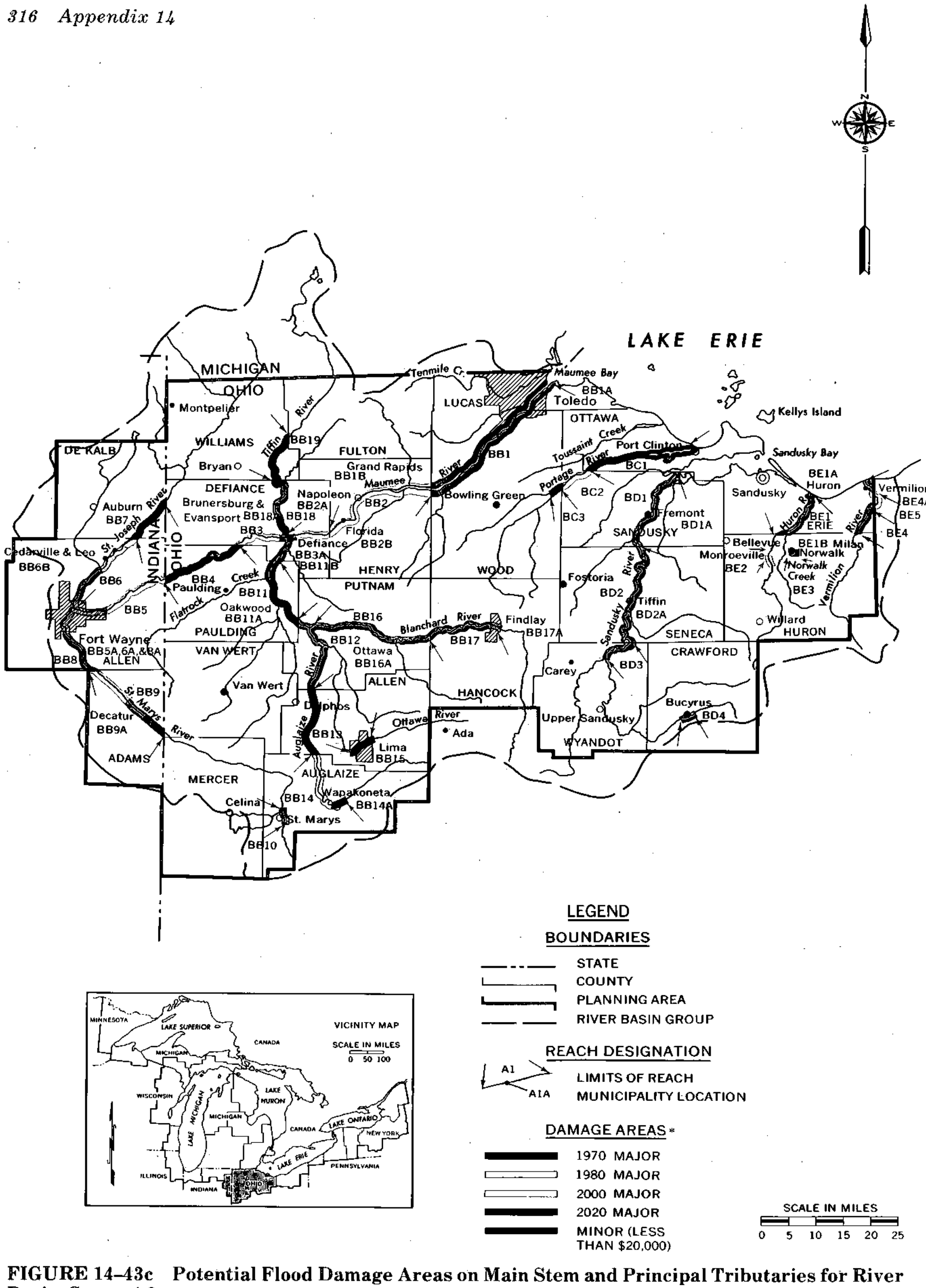


FIGURE 14-43c Potential Flood Damage Areas on Main Stem and Principal Tributaries for River Basin Group 4.2

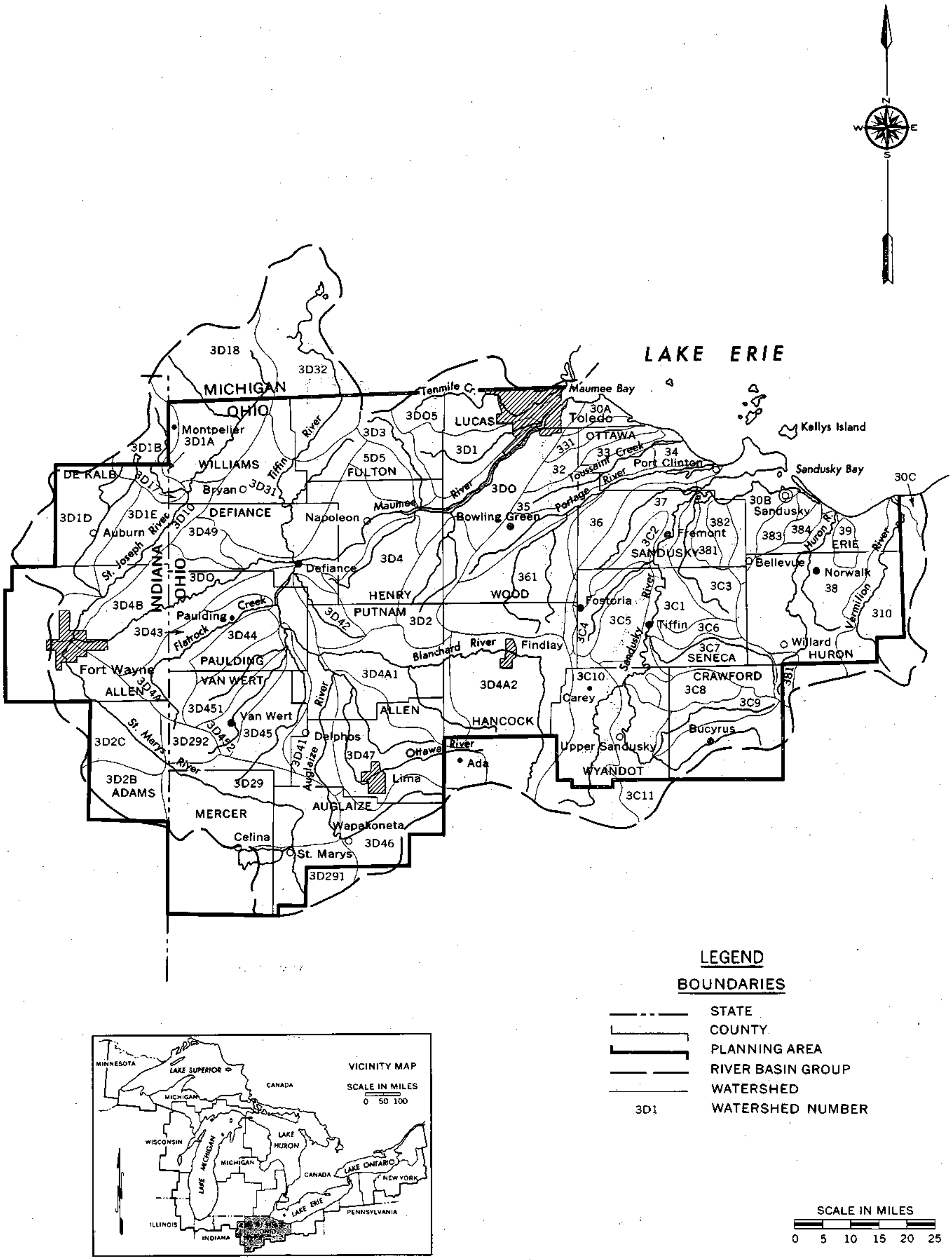


FIGURE 14–44c Watershed Designation—River Basin Group 4.2

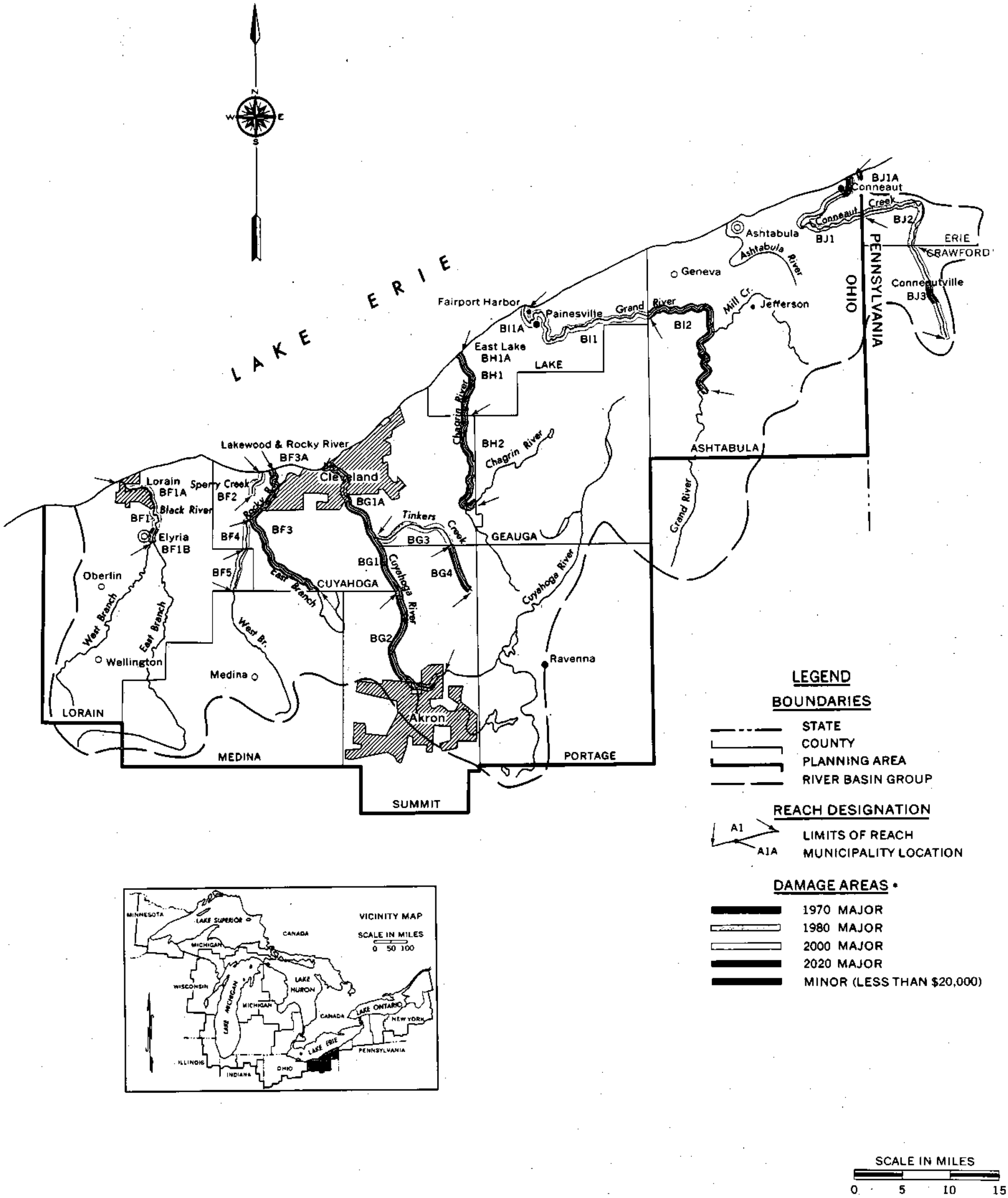


FIGURE 14–47c Potential Flood Damage Areas on Main Stem and Principal Tributaries for River Basin Group 4.3

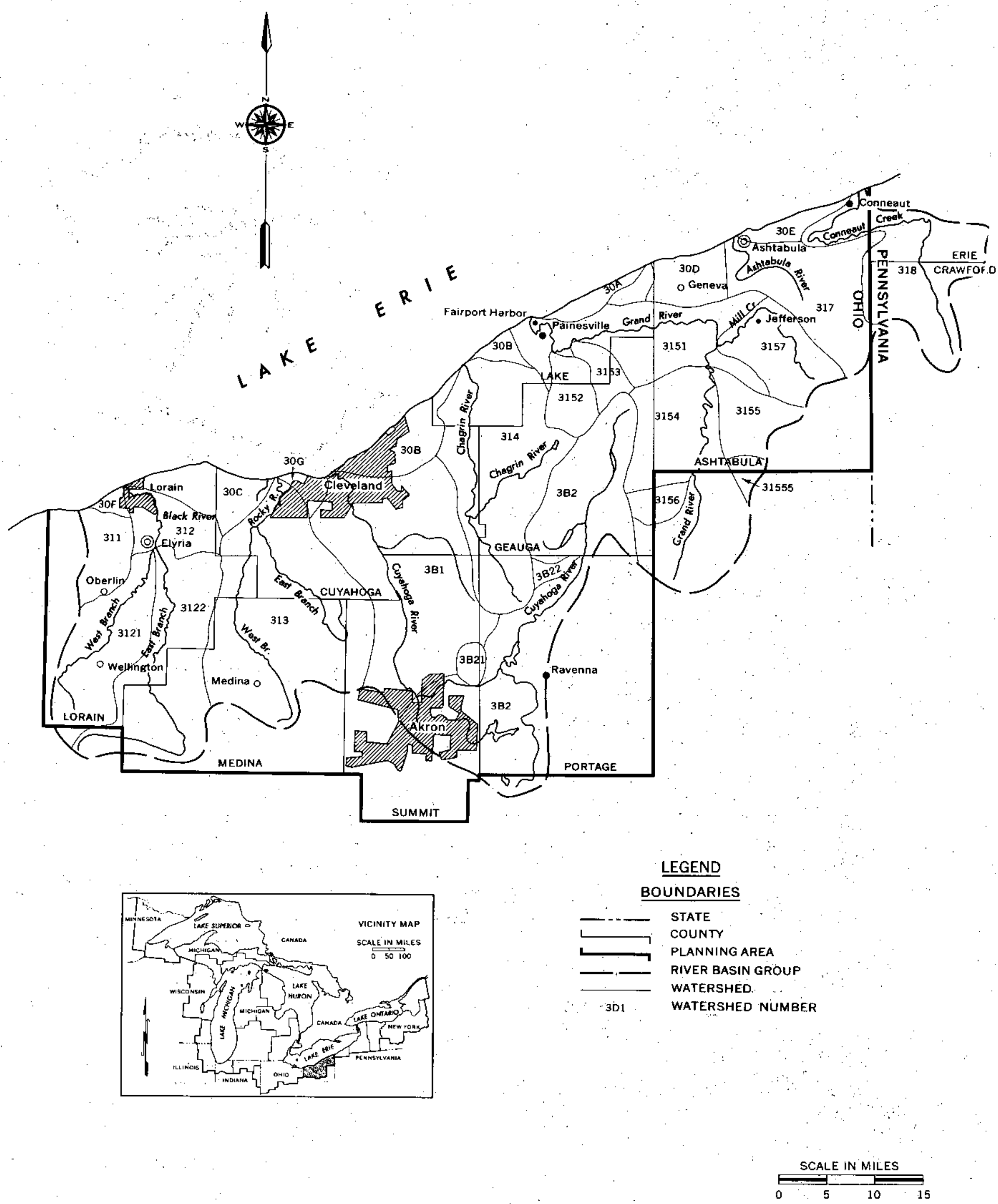


FIGURE 14–48c Watershed Designation—River Basin Group 4.3

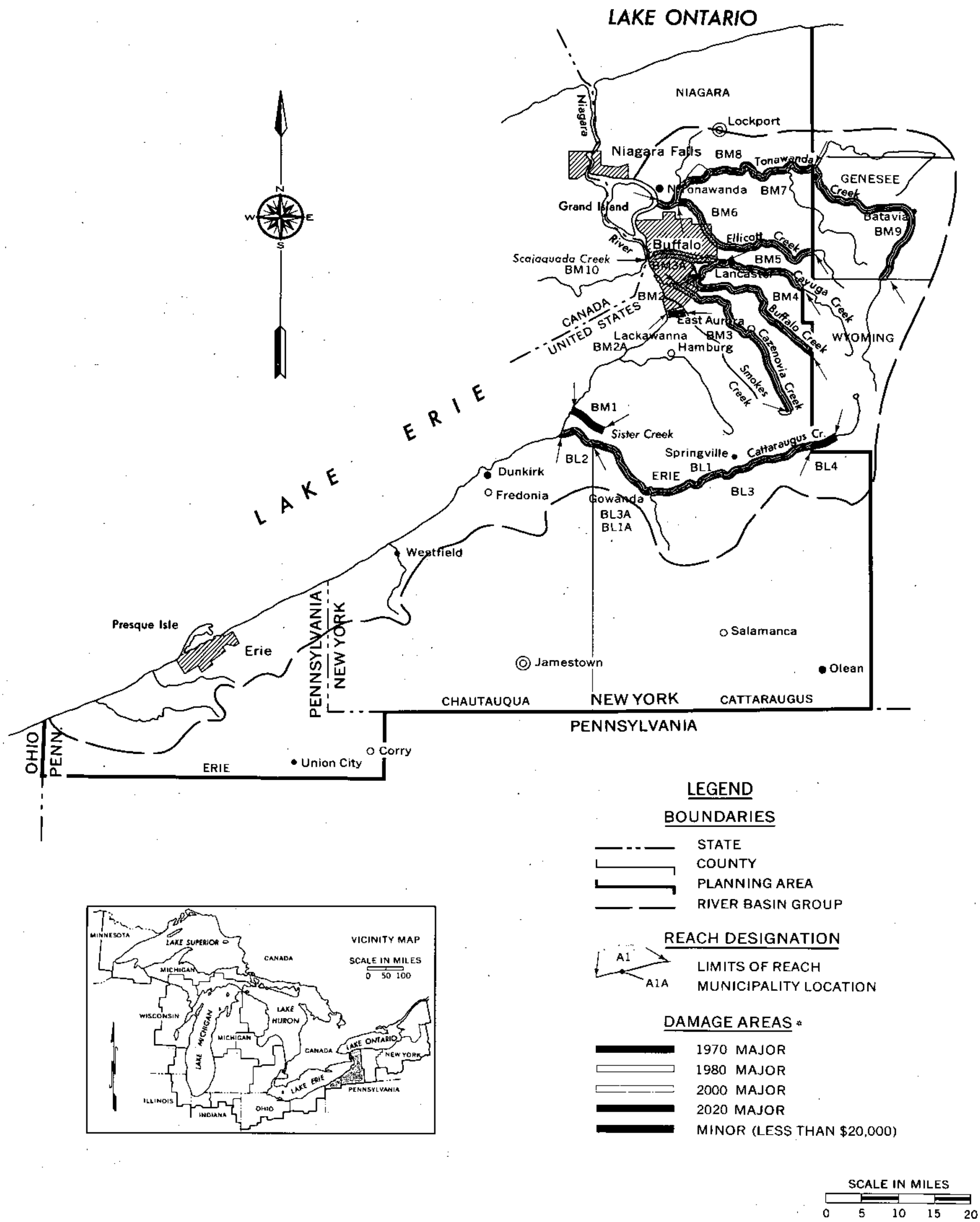


FIGURE 14–51c Potential Flood Damage Areas on Main Stem and Principal Tributaries for River Basin Group 4.4

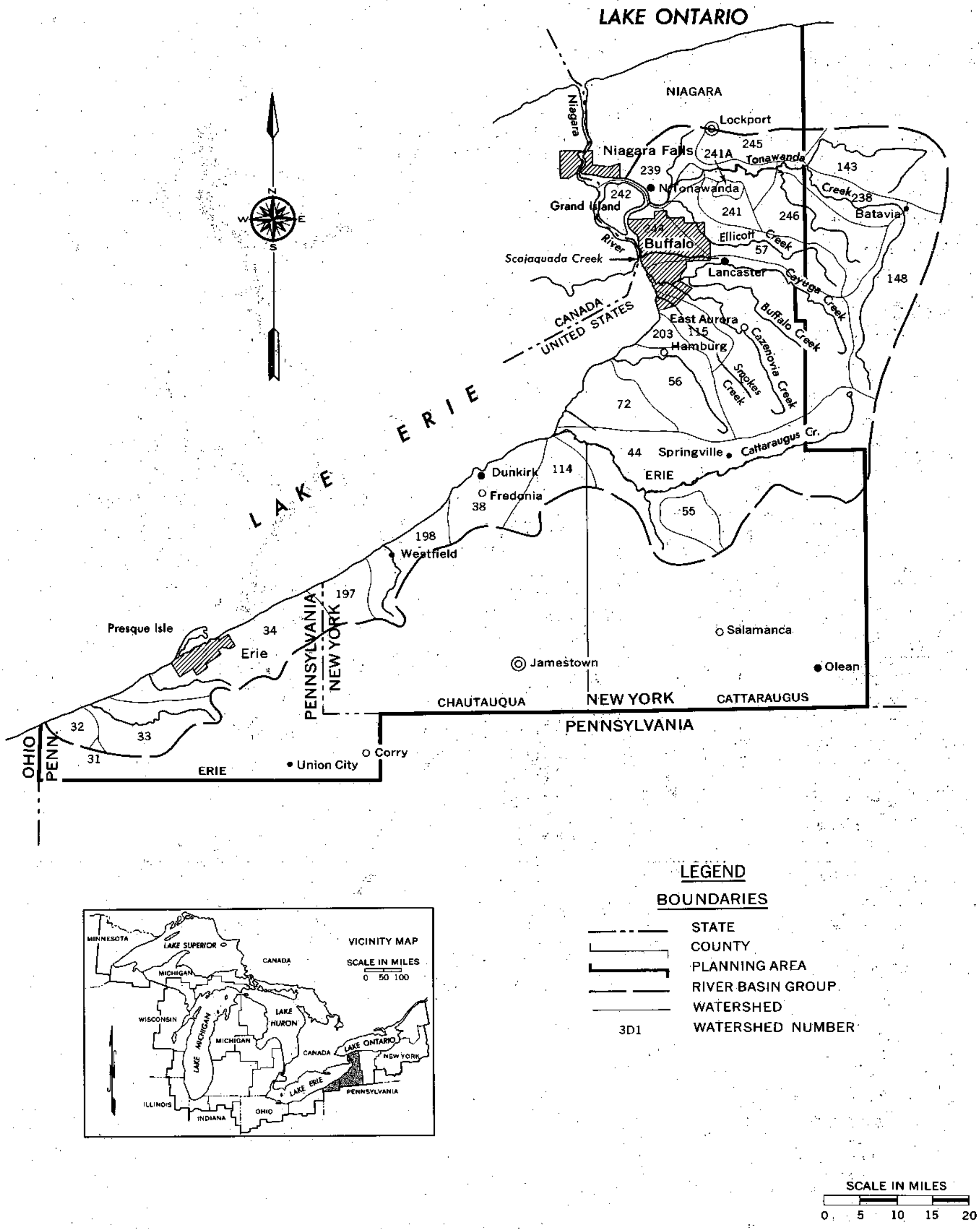


FIGURE 14–52c Watershed Designation—River Basin Group 4.4

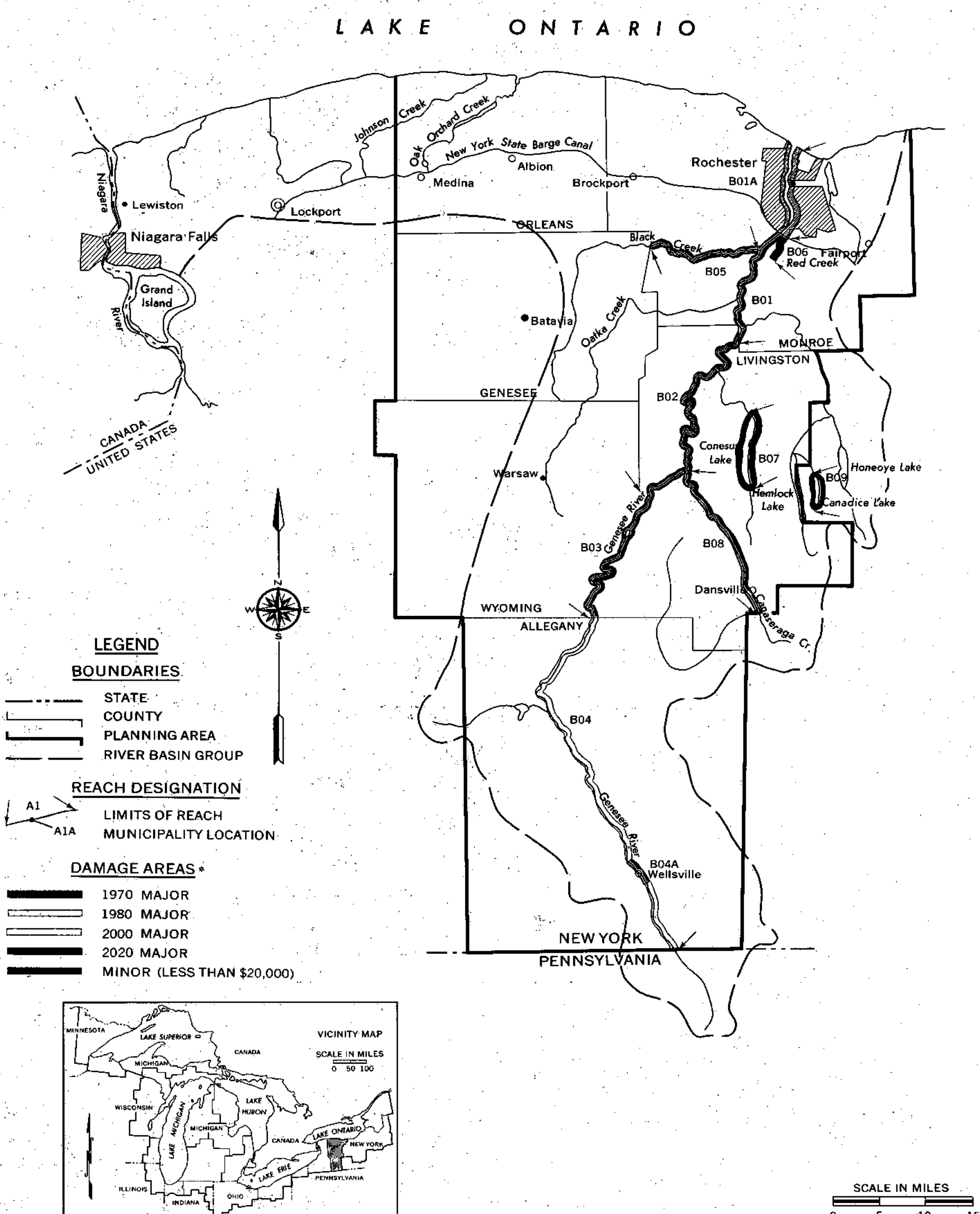


FIGURE 14-55c Potential Flood Damage Areas on Main Stem and Principal Tributaries for River Basin Group 5.1

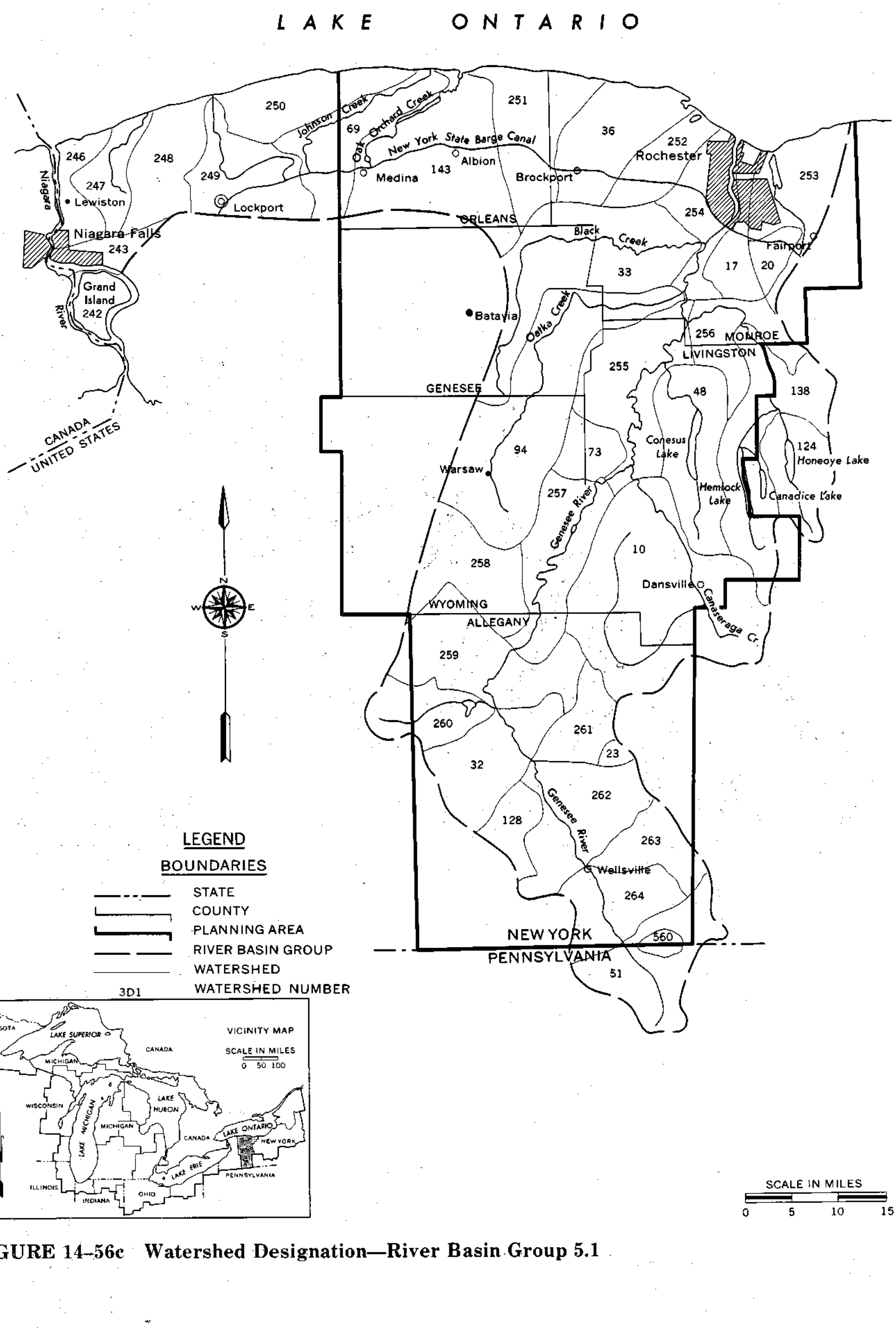


FIGURE 14-56c Watershed Designation—River Basin Group 5.1

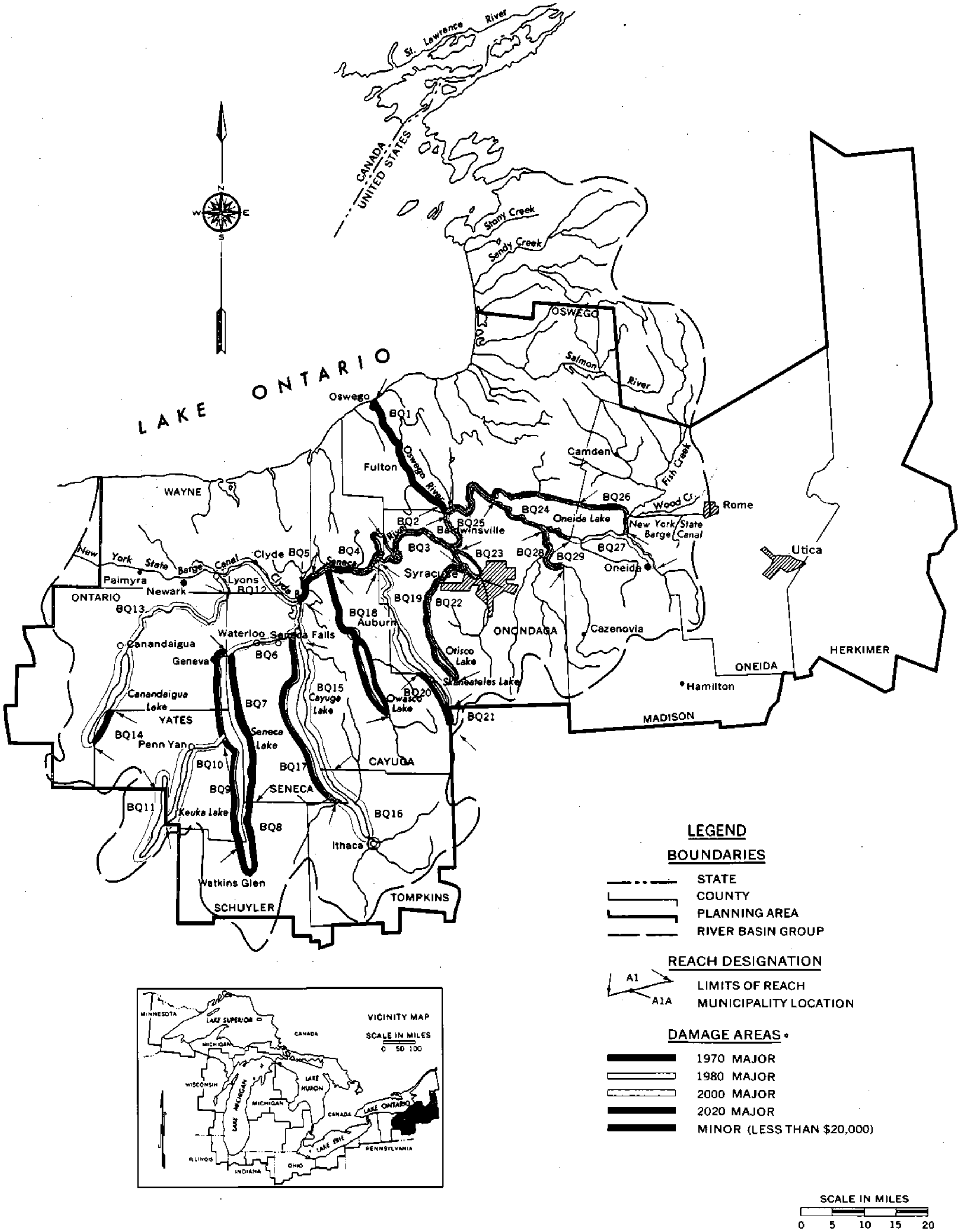
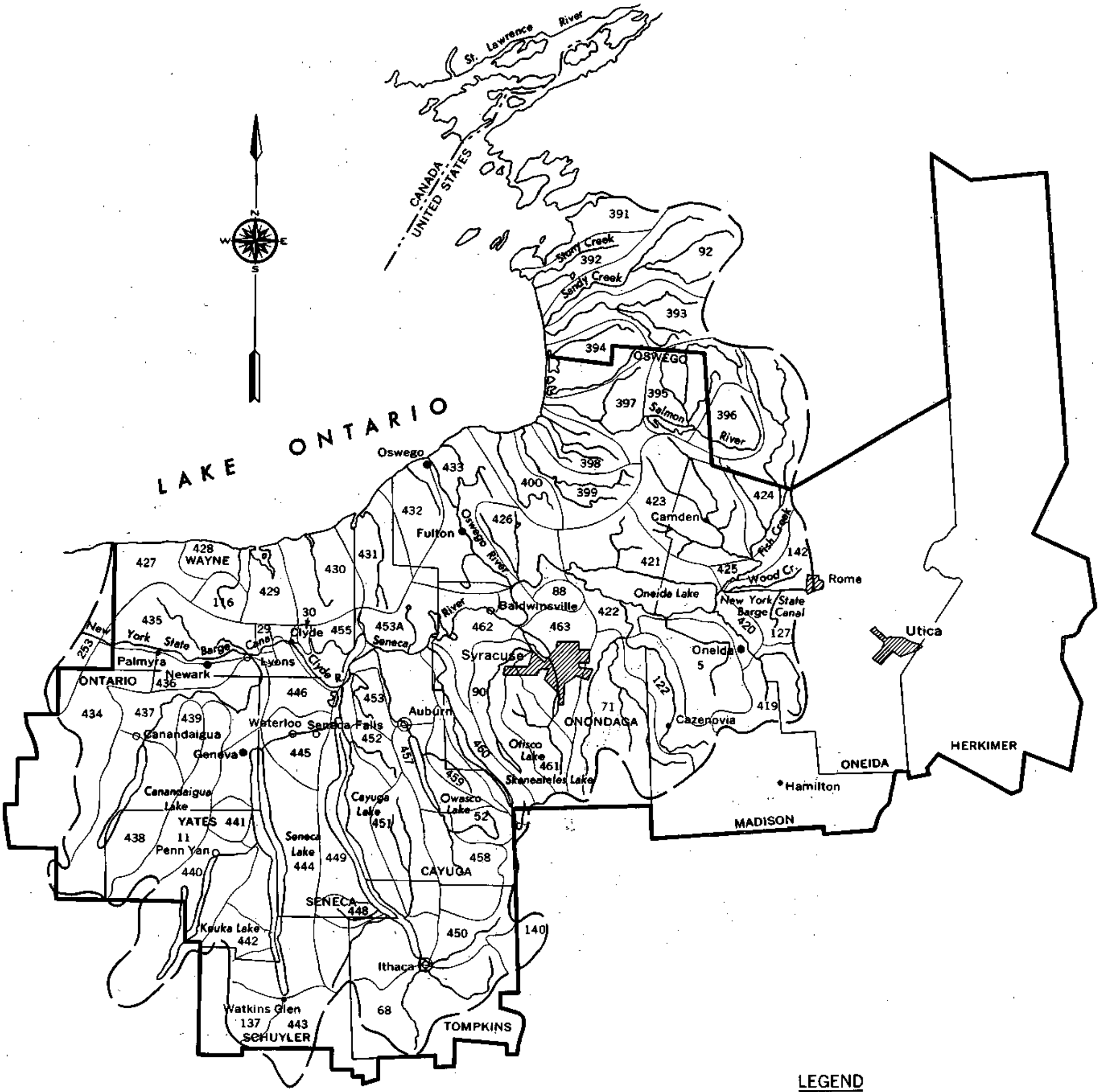


FIGURE 14–59c Potential Flood Damage Areas on Main Stem and Principal Tributaries for River Basin Group 5.2



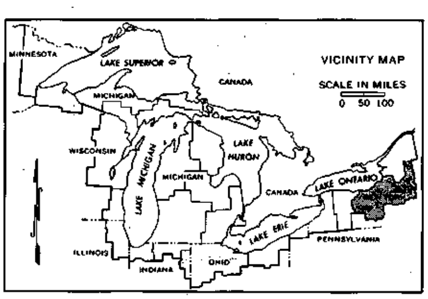


FIGURE 14-60c Watershed Designation—River Basin Group 5.2

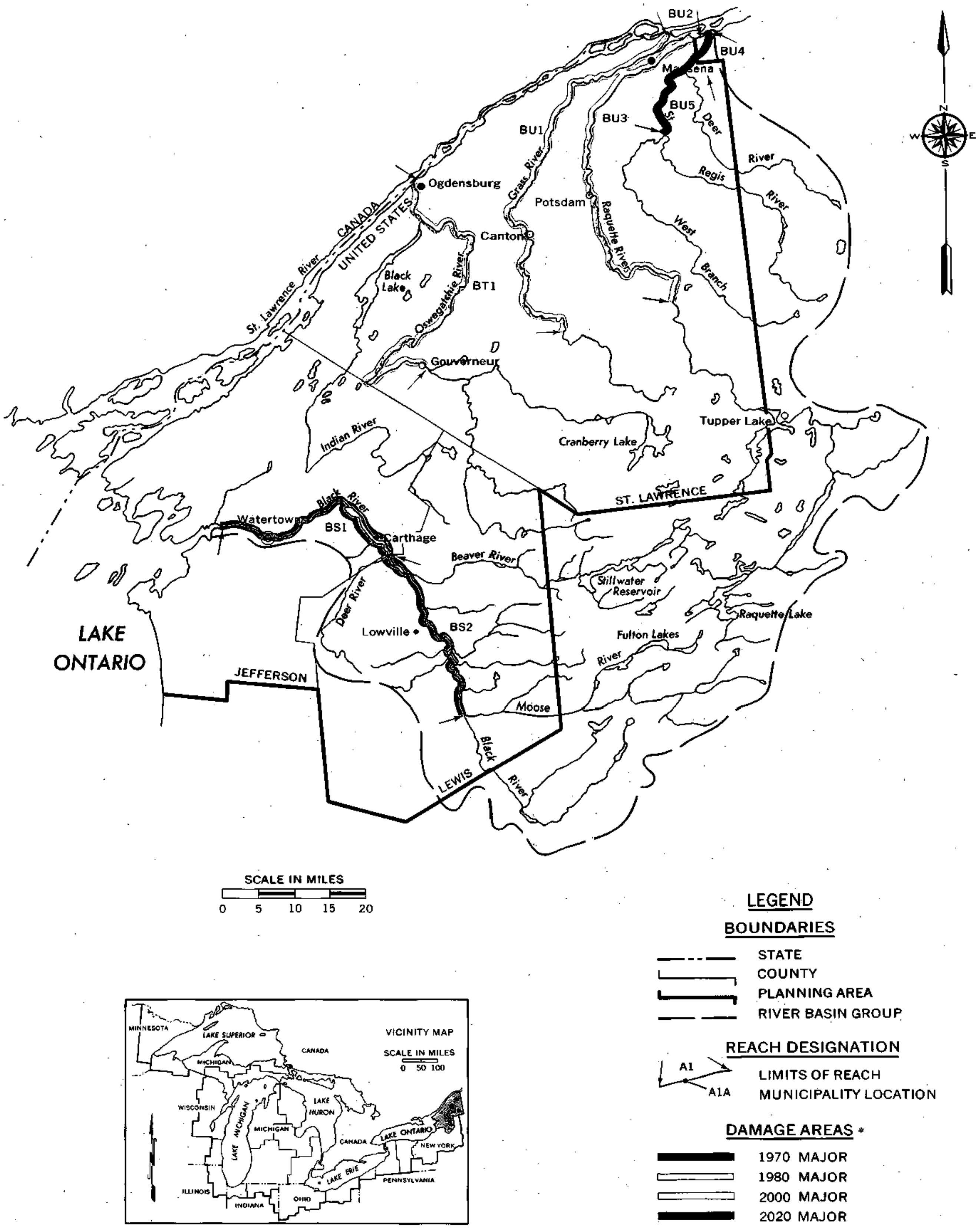


FIGURE 14-63c Potential Flood Damage Areas on Main Stem and Principal Tributaries for River Basin Group 5.3

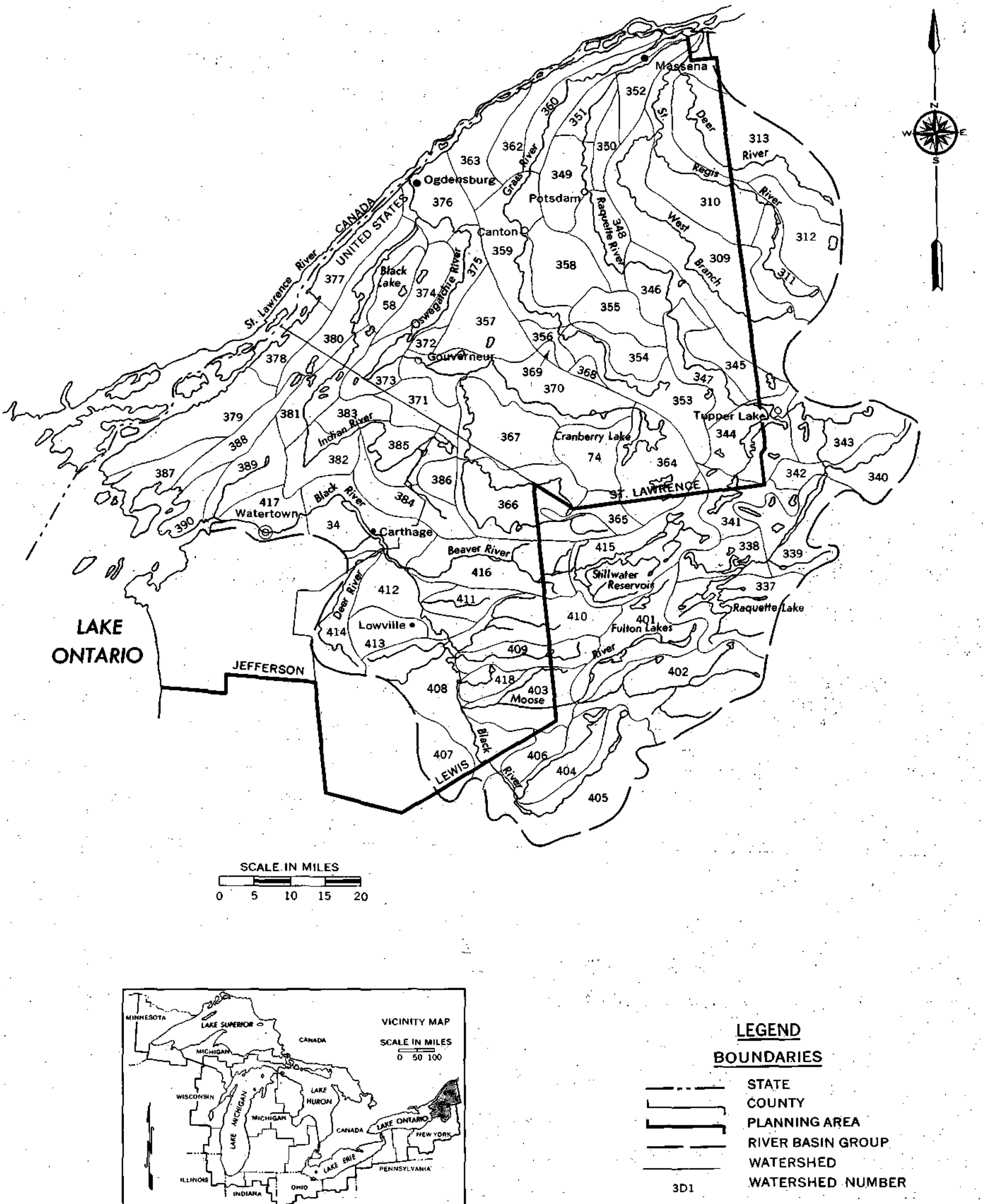
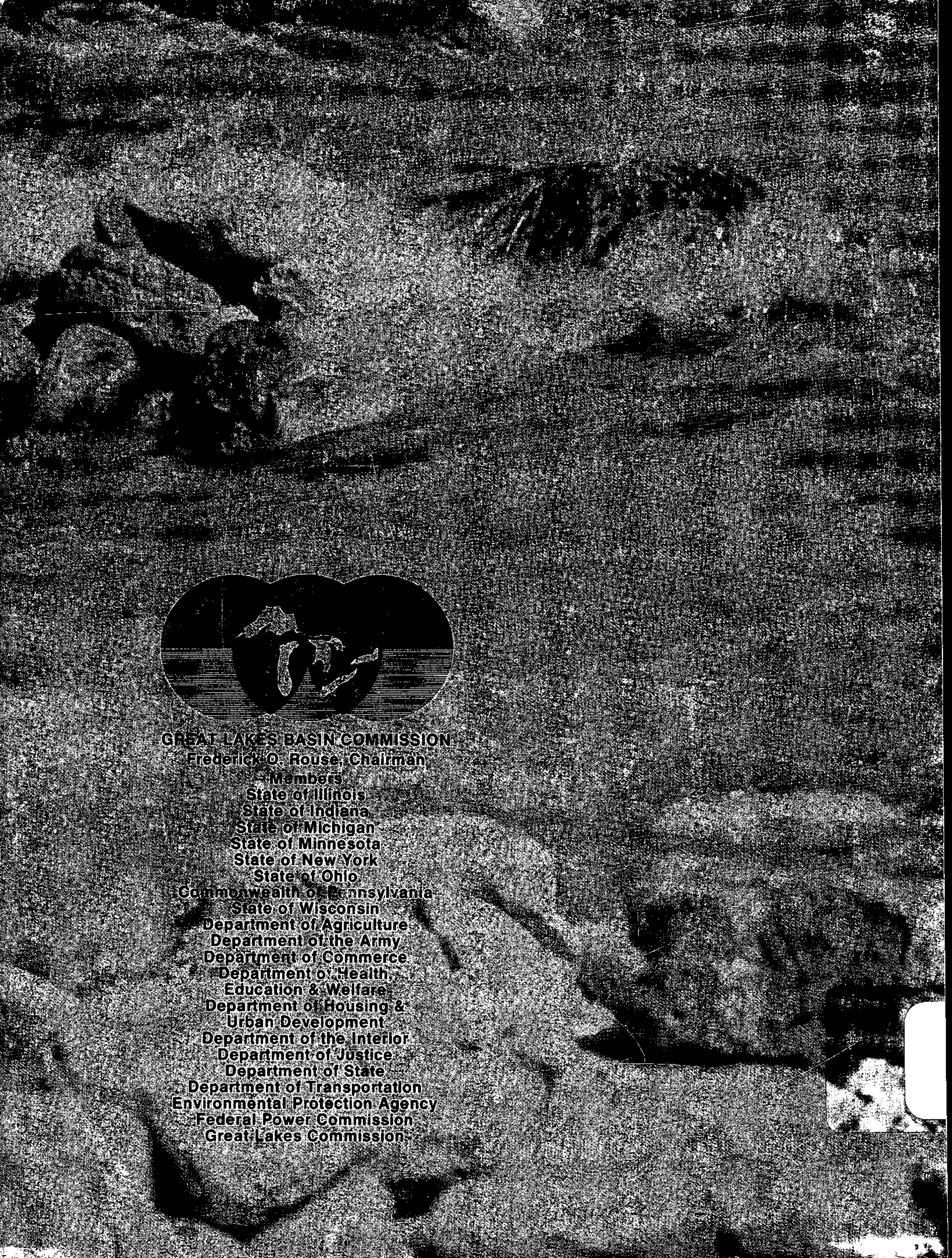


FIGURE 14–64c Watershed Designation—River Basin Group 5.3



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