FOREWORD

James M. Quigley, Commissioner
Federal Water Pollution Control Administration
U. S. Department of the Interior

Lake Erie, for the volume of water it contains, is one of the most polluted bodies of water in the Nation. A priceless national heritage and lifeblood of eleven million persons, this lake suffers from the continual outpourings of industrial and domestic wastes and silt pollution. The effect of this pollution on the water quality of Lake Erie is devastating. Pollution plagues the fisherman, limits the recreational value of the lake, and poses a major impediment to commerce.

Lake Erie's use as a fishing resource for commercial and sport fishermen is declining. Once rich with such prize fish as sauger, sturgeon, pike, cisco, whitefish, and walleye, the catch now usually contains yellow perch, smelt, sheepshead, whitebass, and carp.

Water pollution has caused many lakeshore areas to be posted against bathing. Other areas are littered continuously with rotting masses of algae and dead fish. In fact, where the recreational needs around the lake are the greatest, the water quality is the poorest.

Industrial and domestic wastes and silt pollution block the harbors and navigational channels. Each year six million tons of ugly sediment must be removed from the harbors to maintain navigation. This foul material is in turn carried to the lake and dumped.

Although Lake Erie remains the best source of water supply for its citizens, occasional problems do occur from unpleasant tastes and odors in drinking water. In addition to these problems, Lake Erie is aging faster than natural processes would exhibit, hastened by the spoils of society.

In spite of the fact that the states bordering Lake Erie have long fought for pollution control in the watershed, the conditions in Lake Erie have continued to worsen. Recognizing this, in 1961 Gov. John Swainson of Michigan requested a federal enforcement conference on the Detroit River and Michigan waters of Lake Erie. In 1965, Gov. James A. Rhodes of Ohio expanded the scope of enforcement powers by requesting a conference on all of Lake Erie. I am pleased to report that accelerated action programs have been instituted to finally stem the tide of pollution in Lake Erie.

This is not all that has been done. In 1961, the Water Supply and Pollution Control Division of the Public Health Service began an exhaustive study of water quality in the Great Lakes. The study, continued under the Federal Water Pollution Control Administration, early focused attention on Lake Erie, since it contained the most obvious and most serious instances of water pollution found in the Great Lakes.

The results of these studies are covered in this report, which contains (1) a detailed analysis of the nature and extent of pollution in Lake Erie, (2) its causes, (3) what must be done to abate it and prevent its recurrence, and (4) what it will cost to control it. This report covers the major drainage areas of Lake Erie. These are: Southeast Michigan area; Maumee River and North Central Ohio basin; Greater Cleveland-Akron area; Northeast Ohio basin; Pennsylvania and New York area.

The course of action recommended in this report is based largely upon the decision of the people of Michigan, Ohio, Indiana, Pennsylvania, and New York, who live in the basin--a decision manifested by the repeated pronouncements of their public officials and many interested clean water groups--that the waters of Lake Erie are to be fit habitats for desirable species of fish, suitable sources for all forms of recreation, and excellent source of water supply. They must be esthetically pleasing in appearance, and generally clean, refreshing, and sparkling.

These are demanding goals in terms of water quality, but no lesser goals have ever been publicly advanced. Secretary of the Interior, Stewart Udall, has said that "the Great Lakes represent the finest fresh water resource that the Nation has. The lakes are in trouble and the one that is in the most trouble is Lake Erie." Senator Robert Kennedy of New York repeated this concern when he said, "Lake Erie is polluted and now it's a question of doing something about it."

Much speculation exists in the minds of many on the ultimate outcome of Lake Erie. Can we merely retard its aging process? Can we call a complete halt to old age? Or most of all, can we make it young and fresh as it once was many years ago? These provoking questions need not plague us into doing little or nothing, but should make us unite in a giant effort to do all we can with the hope that the best will come true. As more information unfolds, more must be done but the tools are at hand now to begin and make better.

This report sets forth a plan to do something about it and to make the goals a reality. Whether this plan will achieve its purpose is also a decision which rests largely with the citizens of the Lake Erie basin.

TABLE OF CONTENTS

INTRODUCTION

Authority

The Federal Water Pollution Control Act (33 U.S.C. 466 et seq.) contains among its provisions a directive to the Secretary of the Interior to develop comprehensive programs for controlling pollution of interstate waters and their tributaries. The following document presents such a program for Lake Erie. It is the result of a painstaking study of the water quality of Lake Erie and its surrounding watershed, the use of the lake system, the factors that affect water quality, the probable nature of the economic development of the basin and its impact on water quality, and the nature of measures that must be taken both to abate pollution in the watershed and to prevent recurrence of pollution.

While the Federal Water Pollution Control Administration prepared this report and bore the major responsibility for developing the study, a number of federal,state, local and private agencies provided important assistance in collecting and analyzing data. In particular, the water pollution control agencies of the States of Michigan, Ohio, Indiana, Pennsylvania, and New York accepted a large role in developing both information and concepts.

An enforcement action on the Michigan waters of the Detroit River and Lake Erie, called at the request of former Governor Swainson of Michigan in 1961 under the provisions of the Federal Water Pollution Control Act, provided an early start toward achieving many of the desired water quality improvement measures. A timely enforcement action on all of Lake Erie, called at the request of Governor Rhodes of Ohio in 1965 under the provisions of the Federal Water Pollution Control Act, added further impetus to the early achievement of many of the requirements for pollution abatement.

Purpose

This report presents an action program of water pollution control, designed to provide high quality waters in Lake Erie through abatement of existing pollution, and to provide continuing control of pollution through preventive actions scheduled in anticipation of future problems. The report and resulting program have been developed from both extensive and intensive information on present water quality, water uses, and trends in water usage; present and anticipated future waste loads from existing and projected population and economic growth, and other relevant facts gathered by the Lake Erie Program Office (LEPO), Federal Water Pollution Control Administration, Department of the Interior, during its study of the Lake Erie Basin.

Acknowledgments

As required by the authorizing legislation, the Lake Erie Program Office has worked closely with State, local, and other Federal agencies

to develop a water pollution control program. A list of the principal agencies which have participated through preparation of special reports or through their release of supporting information is as follows:

Michigan:

Water Resources Commission
Department of Public Health

Indiana:

Board of Health
Stream Pollution Control Board

Ohio:

Water Pollution Control Board
Department of Health
Department of Natural Resources

Pennsylvania:

Department of Health
Sanitary Water Board
Department of Forests and Waters

New York:

Department of Health
Division of Pure Water

U. S. Department of the Army:
Corps of Engineers

U. S. Department of Commerce:
Weather Bureau
Office of Business Economics

U. S. Department of the Interior:
Bureau of Commercial Fisheries
Bureau of Outdoor Recreation
Bureau of Sport Fisheries and Wildlife
Geological Survey

Canada:

Ontario Water Resources Commission
Department of National Health and Welfare
Department of Lands and Forests
Department of Mines and Technology

International Joint Commission

of the following:

Grover Cook, past Chairman
FWPCA
Chicago, Illinois

George Harlow, present Chairman
FWPCA
Cleveland, Ohio

Carlos Fetterolf
Michigan Water Resources Comm.
Lansing, Michigan

Walter A. Lyon
Pa. Sanitary Water Board
Harrisburg, Pa.

Perry E. Miller
Indiana Board of Health
Indianapolis, Indiana

Earl Richards
Ohio Department of Health
Columbus, Ohio

Donald B. Stevens
New York Dept. of Health
Albany, N.Y.

Recognition is also made to municipalities, industries, universities, civic groups, the press, and the various authors who, through their writings, have added to the science of Lake Erie.

Dr. LaVerne Curry of Central Michigan University entered into the study through research into the biology of Lake Erie. Dr. Donald O'Connor of Manhattan College consulted on the mathematics of stream deoxygenation and reaeration.

Without the combined effort of these participating agencies and organizations, both public and private, this study would not have been possible.

SUMMARY--A GENERAL VIEW

WATER USES

The waters of Lake Erie are used for many important purposes, each critical in its own right. One major use, of course, is that of a water supply--as a source of water for such things as drinking, washing, and bathing; industrial processes and cooling; for hydroelectric power generation; and irrigation and stock watering. Other important uses include shipping, commercial fishing, a habitat for fish and waterfowl, recreation and scenic beauty, and finally waste assimilation.

Water Supply

Lake Erie holds 125 trillion gallons of water, enough water to serve municipal and industrial water supply needs in the Erie basin for 34 years without replenishment, or to serve these needs nationwide for approximately one year.

To serve the 11 million citizens of the Lake Erie region, municipalities use 1.3 billion gallons per day with 41 per cent being taken directly from the lake, 42 percent from the Detroit River, and 17 per cent from inland sources. The Detroit area alone withdraws 0.55 billion gallons per day.

Industries use 10 billion gallons per day, withdrawing 48 per cent of this from the lake and 32 percent from the Detroit River. Of the total withdrawal, 38 per cent is used for industrial cooling and processing, the rest goes for hydroelectric power production. Detroit area industry heads the list by using 3.4 billion gallons per day.

Lake Erie water is not directly withdrawn in significant quantities for either irrigation or stock watering. However, several million gallons per day are withdrawn from inland surface streams and groundwaters for nurseries, truck crops, golf courses, lawns, and livestock.

Commercial Shipping

Industries in the Lake Erie basin account for approximately 10 per cent of the country's manufacturing output, a factor enhanced by the rich natural resources of the area and the availability of both interlake and international waterborne commerce. In 1962, eleven major U. S. harbors around the perimeter of the lake handled 125 million tons of cargo. Lake Erie waters carried 13 billion ton-miles of shipping in 1963.

Commercial Fishing

For almost 50 years, Lake Erie has led the Great Lakes in fish production. However, in recent years, the commercial fishing industry has suffered tremendously. For example, the catch reported in 1963 was the lowest since 1879, and the 1964 catch was even lower with a dollar value of only 1.2 million. This compares with the value of the 1951 catch of $44 million. This figure was even higher in earlier years when higher dollar value species of fish were plentiful.

In earlier decades fisherman relied heavily on such select species as sturgeon, pike, cisco, sauger, and whitefish to sustain the industry. Now these fish are gone or are rare, and perch, smelt, sheepshead, whitebass, and carp make up the bulk of the commercial catch today.

Even though the value is declining, total poundage of fish caught has remained relatively steady, averaging approximately 50 million pounds annually through 1964. In the past five years, the Canadian catch has doubled that of the U.S.

Recreation

Tourism in the Lake Erie basin is a major industry and the lake itself is the main attraction. The basin does not have an abundance of scenic beauty or other factors to make it especially attractive to tourists. Therefore, tourism is confined to activities in which the lake plays a part such as boating, water skiing, swimming, and sport fishing. During 1963, 75 million visits were made to the 170 federal, state, and local parks in the basin. Five parks, Middle Rouge County and Belle Isle in Detroit, Rocky River in Cleveland, Presque Isle in Pennsylvania, and Niagara River Reservation in New York, accounted for almost 50 per cent of the visits.

Summer water temperature makes Lake Erie well-suited to water contact sports. Available beaches are heavily used because of dense population and the relative scarcity of good beaches. The most notable beaches are Metropolitan Beach, Belle Isle Beach, and Sterling State Park in Michigan; Crane Creek, East Harbor, and Headlands State Parks. Cedar Point, and Mentor, Geneva, Walnut, and Conneaut Townships in Ohio; Presque Isle in Pennsylvania, and Evangola and Lake Erie State Park in New York. In 1963 approximately 15 million visits were made to these beaches.

Inland lakes in the Lake Erie watershed basin also provide excellent opportunities for swimming, boating, sport fishing, and water skiing. The great majority of these lakes are located in southeast Michigan. Six million outdoor enthusiasts visited these inland lakes in 1963.

Sport fishing is a major recreational attraction in Lake Erie, and at times the catch in Ohio waters exceeds the commercial catch, especially in yellow perch fishing. During winter the fishermen venture onto the ice in large numbers to continue their fishing. The heaviest sport fishing activity occurs in the western basin and particularly in the island area.

During a warm summer day, pleasure boats navigate Lake Erie in large numbers. Over 200,000 pleasure boats are registered in the Lake Erie basin.

Waste Disposal

About 10 million people in the U.S. portion of the Lake Erie basin are served by sewers and sewage treatment discharging wastes amounting to 1.3 billion gallons per day. Fifty-five per cent of these are served by primary treatment only. Another half million people live in areas which are unsewered.

Approximately 270 industrial waste producers utilize the streams and lakes within the basin for disposal purposes. Their discharges total 10 billion gallons per day. The hydroelectric generating plants contribute 62 per cent of this amount. Known industrial wastes account for another 2 million population equivalents.

In addition to the above contributors, there are several hundred combined storm and sanitary sewer outfalls. These outfalls discharge an estimated 40 billion gallons per year and approximately 50 per cent of this is untreated municipal wastes; i.e., sewage entering sewer systems that were bypassed during a rainstorm. The estimated population equivalent for these wastes is 1/2 million.

WATER QUALITY PROBLEMS

The population of the Lake Erie basin is expected to more than double by the year 2020 (see Fig. 1) and along with this there is expected to be a five-fold increase in industrial activity. This increase, of course, will bring attendant waste discharges. Unless steps are taken now to halt the growing tide of pollution and the more than doubling of the load by the year 2020, the pollution problems in Lake Erie will increase accordingly.

Lake Enrichment

The greatest pollution problem in the lake is also the one with the most awesome potential--over-enrichment of the lake's waters with nutrients. Over-enrichment fosters excessive plant productivity (algae growth) and rapidly accelerates the natural aging process of the lake.

Even without the presence of man, the lake would be in a more advanced state of enrichment (eutrophication) than the other Great Lakes because of its relative warmth, shallowness, and soil fertility. Add the population factor, however, and the rate of enrichment accelerates rapidly. Within the last two generations, man has dumped enough refuse into Lake Erie not only to make the aging rate measurable, but to make it glaringly obvious. Since 1900, this aging rate has shown a marked increase, and, in fact, during the last 10 years, has exhibited an even sharper upturn.

Much evidence exists to show both directly and indirectly the state of eutrophication of Lake Erie. Profuse algal growths occur in

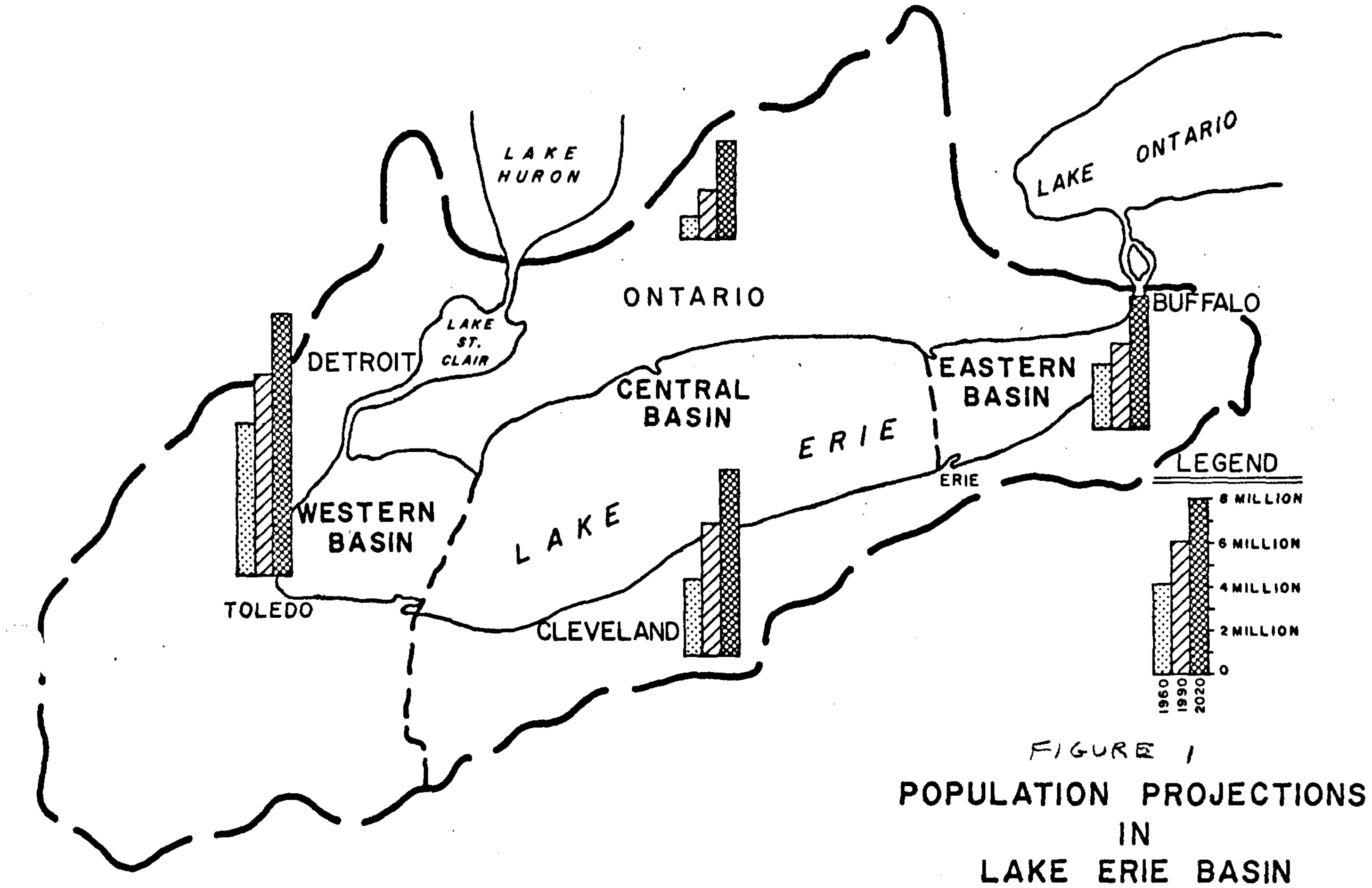


FIGURE 1

POPULATION PROJECTIONS
IN
LAKE ERIE BASIN

Figure 1 -- Population trends for the Lake Erie basin.

the Western basin and along the southern shoreline where nutrient levels are highest. For its size, Lake Erie's algae-producing capacity is among the highest in the world and its rate of algae production is presently at its highest peak. The varieties of algae are changing to those which are more suitable to highly enriched environments.

When these organisms die and sink to the bottom, they decompose, thereby utilizing the water's life-giving oxygen. During summer temperature stratification periods in Lake Erie, the oxygen is consumed at a rate faster than it is replenished, leading to the annual occurrence of low dissolved oxygen (DO) in bottom waters. The length of time of existence of low oxygen levels is also increasing.

Low DO in turn has changed the aquatic food chain by killing off certain bottom dwelling organisms, such as the mayfly, which were an important food for the desirable carnivorous fishes. Thus, these fishes are suffering for lack of food, and scavenger type fishes are replacing them. Low DO and undesirable habitat are also killing young fish and fish eggs. Stated simply, select fishes are vanishing from the lake because of undesirable alteration of their environment by water pollution.

Other evidences of over-enrichment are the increasing problems of surface algal scums, algal littering of beaches (with a subsequent decrease in shoreline property values), algae-produced bad taste and odor in drinking water supplies, and the clogging of intakes by algae. In spite of this, Lake Erie, even though it contains the lowest quality water of the five Great Lakes, remains a highly satisfactory source of raw water supply when compared with inland and groundwater supplies.

Phosphorus is the key element in the over-enrichment problem in Lake Erie. Because it is an essential and most vital nutrient, it accelerates the process of over-enrichment, when present in excess. The excess begins in Lake Erie when the daily phosphorus input exceeds a total of 23,000 lbs/day from municipal, industrial, and rural and urban runoff sources. These sources are now adding 147,000 lbs/day of phosphorus. The phosphorus contribution from within the Lake Erie basin is composed of 68 per cent from municipal wastes, 16 per cent from rural runoff, 9 per cent from industrial wastes and 7 per cent from urban runoff. In municipal wastes, 66 per cent of the phosphates come from detergents. This one source, detergents, accounts for ~~45~~ approx 50 per cent of the total phosphorus load going to the lake from all major sources. The Detroit and Maumee Rivers contribute 55 per cent of the total load to Lake Erie, Table 1.

Assuming that the Lake Huron input and other runoff sources are not easily controllable, the enrichment process can be retarded by limiting the discharge of total phosphorus from municipal and industrial sources to no more than 9,000 lbs/day within the entire basin. This would include 1,000 lbs/day from Canadian sources. This requires 92 per cent removal of the present municipal and industrial phosphorus load and 100 per cent removal by the year 2020.

TABLE 1

SOURCE AND AMOUNT OF PHOSPHORUS DISCHARGES TO LAKE ERIE, lbs/day

(exclusive of Lake Huron input and shore erosion)

Basin	Municipal Waste	Industrial Waste	Urban Runoff	Rural Runoff	Total
Western Basin	56,900	8,000	4,800	14,300	84,000
Central Basin	27,400	3,200	3,410	2,970	35,980
Eastern Basin	3,000	2,100	650	1,000	6,750
Ontario	11,900	unknown	450	5,500	17,850
TOTAL	98,200	13,300	9,310	23,770	144,580

Nearshore Bacterial and Blight Problems

Many bathing beaches in Lake Erie are plagued by pollution problems. A danger to health is caused in the nearshore water by bacterial loading derived primarily from sewage discharges and combined sewer overflows. The greatest bacterial problems are found nearest the metropolitan centers where many beaches are unsafe for water contact recreation because of these problems, Table 2. In fact, even though there is a high demand for water contact recreation on Lake Erie from its 11,000,000 residents, much of this goes unsatisfied because water pollution limits the use.

The nearshore waters of Lake Erie are generally unattractive, being polluted by debris, silt, and dead and decaying aquatic life and occasionally oily wastes. Nearshore waters are ordinarily very turbid in all of Lake Erie and in the western basin turbidity may extend from shore to shore. Turbidity in Lake Erie is high compared to the other Great Lakes. The turbidity is caused by silt washing in from the land, suspended solids from municipal and industrial wastes, plant life suspended in the waters, and lake shallowness which lets wave action stir up bottom muds. Total silt load to the lake is estimated at 134 million lbs/day.

Harbors in Lake Erie are now characteristically and continuously foul, unpleasant, and odorous because of waste discharges. Industrial and municipal discharges at Detroit and Monroe, Michigan; Cleveland, Ohio; Erie, Pennsylvania; Buffalo, New York, are particularly obnoxious in this respect. So much waste is added to major harbors that annual dredging is required to maintain them. Up to this time, dredged material has been dumped into the lake, further adding to the polluted condition.

TABLE 2

BATHING BEACHES ON LAKE ERIE THAT ARE UNSAFE FOR SWIMMING

DUE PRIMARILY TO BACTERIAL POLLUTION FROM SEWAGE DISCHARGES

MICHIGAN	OHIO
Estral Beach	Little Cedar Point, Toledo
Maple & Milleville Beach	Lakeview Park, Lorain
Sterling State Park	Century Park, Lorain
NEW YORK	Rocky River Park
Hamburg	All Cleveland Beaches
Silver Creek	Euclid Beach
Westfield	

Removal of nearshore blights will require bacteria control in waste discharges, control of silt and suspended solids from land runoff and municipal and industrial wastes, control of nutrients to limit algae growth, oil control from industries and passing ships, and control of debris and trash dumped on the land and in the waters. Control of harbor fouling requires treatment for siltation and suspended solids from municipalities and industries, and discontinuation of the practice of dumping the dredged material in the lake.

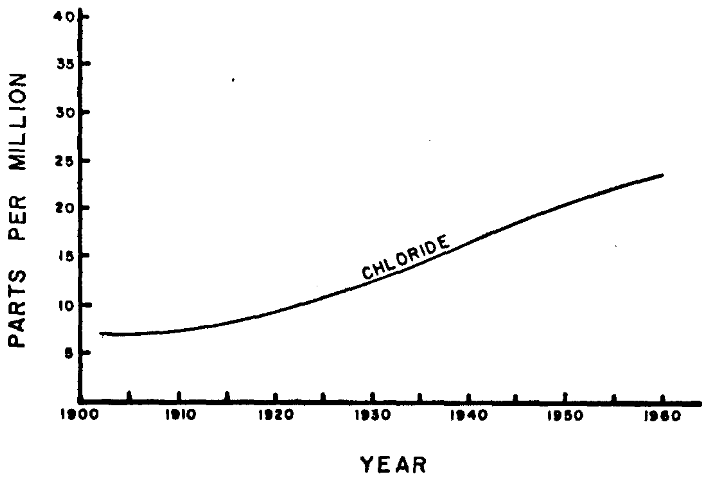
Dissolved Solids

The dissolved solids content of Lake Erie has increased rapidly in the past 30 years. A major factor is the increase in chlorides which have doubled during this time interval (see Figure 2). Presently 16 million pounds of chlorides are discharged to Lake Erie daily from sources within the basin. Of this amount, approximately 17 per cent comes from de-icing streets in winter, 58 per cent from industrial wastes, and 10 per cent from municipal wastes. One chemical industry in the Painesville, Ohio area contributes 21 per cent of the total chloride load to Lake Erie.

These inputs of chlorides to Lake Erie must be controlled in order to maintain a high quality water supply. The chloride concentration in Lake Erie should be maintained at a level not above that which presently exists.

Biochemical Oxygen Demanding Substance

The discharge of wastes to streams and tributaries within the Lake Erie basin as measured by the 5-day biochemical oxygen demand test



CHANGES IN CHLORIDE CONCENTRATIONS OF LAKE ERIE

Figure 2 -- Trends in ~~dissolved solids loading to~~ chloride concentrations in Lake Erie.

is 2.3 million pounds per day. Of this amount sources within the U.S. portion of the basin contribute 1.4 million pounds and the Lake Huron input is equivalent to 0.9 million pounds. (see figure 3)

The oxygen demand of these substances is critical in tributary waters; many reaches have virtually continuous depressed dissolved oxygen levels. The effect is not serious in Lake Erie proper because most of the demand is satisfied before the wastes reach Lake Erie and also because the lake has tremendous oxidative capacity.

The discharge of BOD_5 substances should be reduced to a basin total of 320,000 pounds per day from the present total of 1.4 million pounds. This requires at least a 90 per cent reduction of the raw BOD load now being discharged and at least 98 per cent by the year 2020.

RECOMMENDATIONS

The five Lake Erie basin states have agreed to the recommendations arising from the Detroit and Lake Erie Enforcement conferences and have instituted programs designed to achieve the aims of the conferees. The information contained herein amplifies the Enforcement recommendations and projects water pollution control needs to the year 2020. For current needs, it follows closely the program outlined by the conferees; it also points out remedial measures that were beyond the scope of the conferees.

Present Needs

1. Each of the states of Michigan, Indiana, Ohio, Pennsylvania and New York should control municipal and industrial waste discharge to the extent that when discharged to the waters of the Lake Erie basin, they will not contain more than 320,000 lbs/day of oxygen-consuming substances as measured by the 5-day biochemical oxygen demand test. This discharge,amounting to secondary treatment or 90% reduction, should be allocated among the 5 states in the following manner:

Michigan	150,000 lbs/day
Indiana	10,000 lbs/day
Ohio	140,000 lbs/day
Pennsylvania	16,000 lbs/day
New York	4,000 lbs/day

No cities or industries in the Lake Erie watershed that discharge oxygen consuming substances presently treat to this degree of removal on a continuous basis. It is recognized, however, that the state water pollution control agencies of Indiana, Ohio, and Pennsylvania are committed to complete such facilities in their respective states by 1971. Michigan and New York, although endorsing secondary treatment, have adopted a lesser

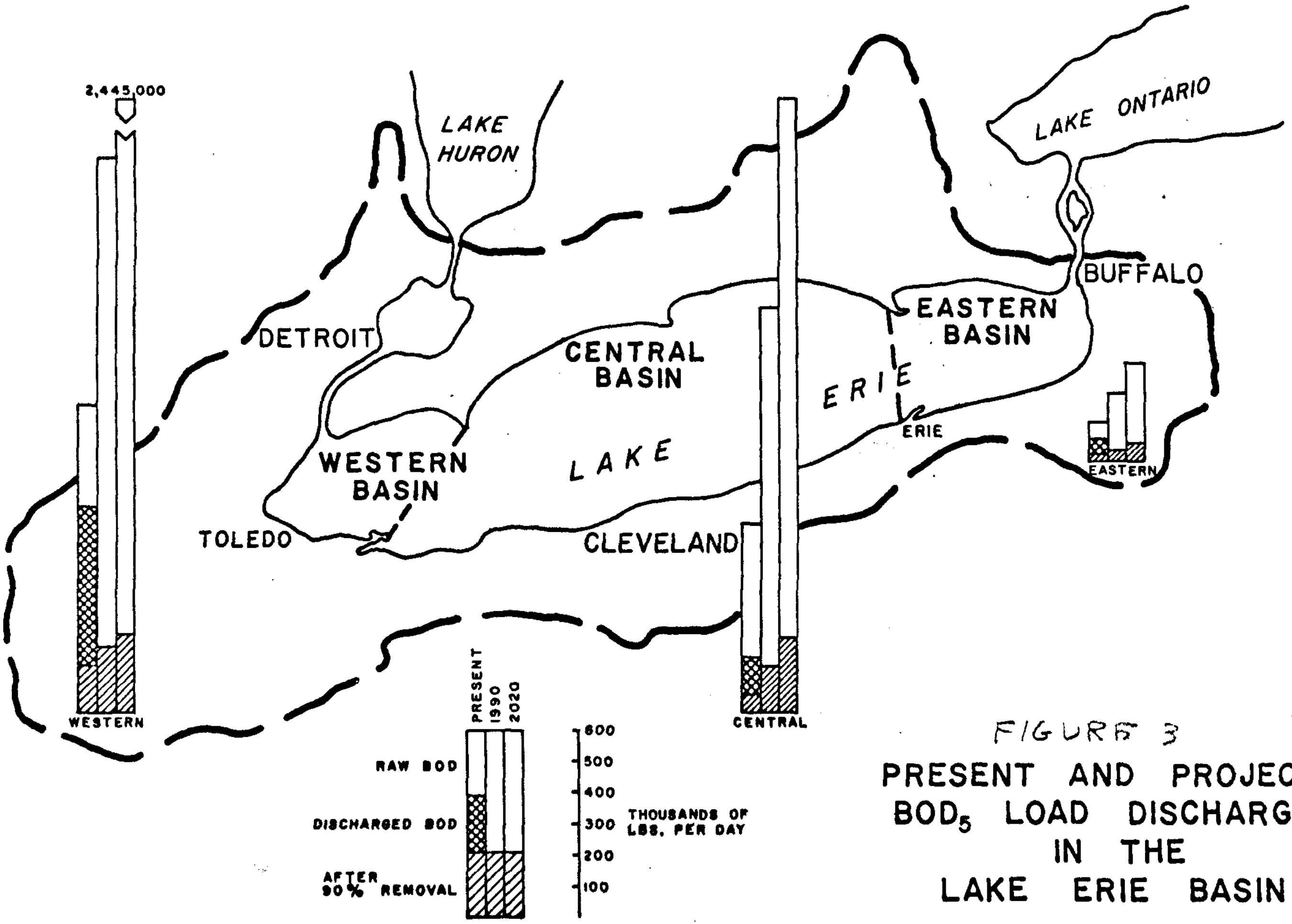


FIGURE 3

PRESENT AND PROJECTED BOD_5 LOAD DISCHARGED IN THE LAKE ERIE BASIN degree of removal and are also asking to have the remedial facilities completed by 1971. These two states should upgrade their requirements to 90% efficiency of treatment. In some inland areas, even higher removal rates will be required to maintain desired water quality.

2. Each of the states of Michigan, Indiana, Ohio, Pennsylvania and New York should control its municipal and industrial waste discharges to the extent that when discharged to the waters of the Lake Erie basin, they will not contain more than 8,000 lbs/day of phosphorus. The discharges from agricultural and urban runoff should be limited to 15,000 pounds per day. This discharge should be allocated among the five states in the following manner:

Michigan	11,600 lbs/day
Indiana	850 lbs/day
Ohio	9,600 lbs/day
Pennsylvania	700 lbs/day
New York	250 lbs/day

No cities or industries that discharge phosphorus presently treat to this level in the Lake Erie watershed although it is recognized that the states are embarking on a program of treatment. Therefore, the Lake Erie states should order their cities and industries to have such facilities in operation by 1971 in accordance with the above allocation, with each state being responsible for apportioning the amounts among their respective producers of phosphorus waste.

3. In order to protect inland streams in portions of the Lake Erie watershed, the following municipalities need advanced waste treatment to effect a 98 per cent reduction of oxygen consuming substances as measured by the BOD_5 test:

Indiana

Auburn
Decatur
Fort Wayne
Garrett

Ohio

Akron	Brookpark	Delphos
Amherst	Bryan	Delta
Archbold	Bucyrus	Elyria
Attica	Carey	Findlay
Bellevue	Cleveland Southerly	Fostoria
Berea	Clyde	Fremont
Bloomdale	Columbus Grove	Genoa
Bloomville	Crestline	Gibsonburg
Bowling Green	Cuyahoga Falls	Grafton

Ohio continued

Greenwich
Kent
LaGrange
Lakewood
Lima
Lodi
McComb
Medina
Middleburg Hts.
New London
New Washington
North Baltimore
North Royalton
Norwalk
Oberlin
Olmsted Falls
St. Marys
Spencer
Stow
Strongsville
Tiffin
Toledo
Upper Sandusky
Van Wert
Wapakoneta
Wauseon
Welland
Wellington

New York

Arcade
Cattaraugus
East Aurora
Eden Twp.
Gowanda
Hamburg Village
Holland
North Collins

4. Emergency measures must be instituted by the states of Michigan and Ohio to protect the health of bathers using the beaches in western Lake Erie and the Cleveland metropolitan area (from Lorain, Ohio to Painesville, Ohio). Since the major cause of the public health problem at bathing beaches is the discharge of fecal matter from combined storm and sanitary sewers and inadequately treated sewage, the emergency measures should take the form of disinfection at the outlets in the vicinity of bathing areas and diversion of troublesome outlets to remote areas away from beaches. Existing public beaches should be opened for bathing as soon as adequate emergency control measures are taken; this should be no later than the 1969 bathing season. Crews should be assigned by the state water pollution control agencies to carefully patrol the sewer outlets that have been designated as affecting bathing beach areas to see that all discharges are adequately disinfected. In addition the beaches themselves should be continuously monitored to assure maximum protection to public health.

5. Each of the five Lake Erie states should enact the necessary legislation to enable metropolitan areas to develop area-wide sanitary districts. Such master planning and area-wide control is currently needed in the metropolitan areas of Detroit, Michigan; Toledo, Akron, and Cleveland, Ohio; and Buffalo, New York. It is recognized that Detroit is already embarking on an area-wide master sewer program and this program is encouraged. Those communities in Ohio within the metropolitan areas of Cleveland and Akron that are listed in Recommendation No. 3 as needing advanced waste treatment should, as the best approach, join the metropolitan plan recommended for development by Cleveland and Akron.

6. The iron and steel industry should install and operate or otherwise increase its waste reduction facilities to effectively reduce taste and odor producing substances, suspended solids, substances that cause discoloration in receiving streams, acids, oils and cyanides.

The iron and steel industry should be required by state water pollution control agencies to abide by the following list of general requirements for waste constituents in order to best protect and enhance water quality. Furthermore, no outfall discharging to public waters should exceed these levels at any time, nor should it be construed that the industry should be permitted to redesign sewer systems in order to meet these levels without reducing the overall flow of waste materials.

Suspended solids	35 mg/l
Oil	5 mg/l or to the extent that no visible oil film appears on the surface of the receiving stream.
Iron	17 mg/l
Cyanides	0.025 mg/l
Phenol	0.050 mg/l
pH	between 5.5 and 10.6

The industries to which these requirements ~~are~~ appl~~icable~~ are ~~as follows~~:

Ford Motor Co. Rouge Plant	Detroit, Michigan
Great Lakes Steel Corp.	Detroit, Michigan
McLouth Steel Corp.	Detroit, Michigan
Interlake Iron Corp.	Toledo, Ohio
U. S. Steel Corp.	Lorain, Ohio
Republic Steel	Elyria, Ohio
U.S. Steel Corp.	Cleveland, Ohio
Jones & Laughlin Steel Corp.	Cleveland, Ohio
Republic Steel Corp.	Cleveland, Ohio
Bethlehem Steel Corp.	Lackawanna, N.Y.
Republic Steel	Buffalo, N.Y.
Donner Hanna Coke	Buffalo, N.Y.

7. The petroleum industry should install and operate or otherwise increase waste reduction facilities to effectively reduce phenolic discharges to the extent that taste and odors are eliminated; oil wastes should be reduced to the extent that no oil films are visible in the receiving stream.
The following effluent limitations are recommended as the maximum:

Phenols	0.050 mg/l
Oils	5 mg/l

The industries to which the requirements ~~are~~ applicable are ~~as follows~~:

Mobil Oil	Detroit, Michigan
Gulf Oil	Toledo, Ohio
Sun Oil	Toledo, Ohio
Pure Oil	Toledo, Ohio

Standard Oil	Toledo, Ohio
Ashland Oil	Findlay, Ohio
Standard Oil	Lima, Ohio
Mobil Oil	Buffalo, N.Y.

8. The heavy chemical industry should install and operate waste reduction measures or otherwise control its discharge of chlorides to Lake Erie so that the combined flow from all such plants does not contain more than 9 million lbs/day. The industries and their respective allocations to which this recommendation refers are as follows.

	Lbs/day
Allied Chemical Corp. Solvay Div., Detroit, Michigan	2,800,000
Pennsalt Chemical Corp., Detroit, Michigan	508,800
Wyandotte Chemical Corp., Detroit, Michigan	1,850,000
Diamond Alkali Corp., Painesville, Ohio	3,900,000
Midland Ross Corp., Painesville, Ohio	40,000
Reactive Metals, Inc., Ashtabula, Ohio	308,000
Olin Mathieson Corp., Ashtabula, Ohio	15,000
Cabot Titanium Corp., Ashtabula, Ohio	21,000

9. The paper industry should install and operate waste reduction measures or otherwise control the discharge of BOD and suspended solids to Lake Erie so that the flow from such plants meets the state requirements for the total allocated BOD load to the lake. The industries to which this recommendation refers are as follows
add list of paper industries

Long Range Needs

1. By the year 1990 most cities should have installed tertiary treatment of sewage with removal of BOD_5 equal to 98%. Exceptions to this are towns in the remote reaches of the watershed where sustained stream flows are sufficient and smaller communities on the lake shore and towns not under the influence of metropolitan growth or where population is not expected to increase. By the year 2020 all communities should be served by tertiary treatment.

2. By the year 1990 most cities should be connected to metropolitan sewage plants located at Algonac, Detroit, and Rockwood, Michigan; Toledo, Lorain, Avon Lake, Rocky River, Cleveland, Akron, Eastlake, and Fairport, Ohio; Erie, Pennsylvania; and Dunkirk, Hamburg, and Buffalo, New York. Exceptions would be cities located in remote reaches of the watershed where population is not expected to increase.

3. By the year 1990, removal of almost 97 per cent of the phosphorus from municipal and industrial waste is required to maintain satisfactory lake conditions. By the year 2020, 100% removal will be required.

4. The Department of Agriculture should institute programs to control wastes from barnyards, animal feed lots, and farmland runoff. By 1975 this program should be in full effect to control sediment, BOD_5, and phosphates going to the streams and lakes in the watershed from these

The US Dep't of Agr? Do we want them to do this? Would not State regulations be better?

farm sources.

5. The states of the Lake Erie basin should encourage and provide assistance in development of institutional arrangements that bring appropriate communities, industries, and metropolitan areas together for the purpose of planning and financing pollution control measures within the framework provided by drainage areas.

6. Municipal and industrial plant inspection, data gathering, and monitoring activities of the Lake Erie states and the FWPCA should be coordinated and expanded to maintain intimate knowledge of waste loadings, bypasses, treatment plant efficiencies and illegal discharges in order that such information may be used in day-to-day water quality management.

7. By 2020 all cities in the Lake Erie watershed should have complete separate sewer systems. The storm water outlets should then be disinfected and directed away from recreational areas.

ADMINISTRATIVE AND FINANCIAL NEEDS

Over the next 50 years, it will be necessary to spend approximately $8 billion on construction of sewers and treatment systems in the Lake Erie Basin. The area to be serviced by this construction will encompass most of the 23,000 square miles of land in the drainage basin.

The estimated costs to implement the recommendations in this report are itemized as follows:

<u>Current Needs</u>

Municipal[1]	$850,000,000
Industrial	$255,000,000

[1]Expansion to secondary treatment with phosphate control and improvements to existing secondary plants, plus tertiary treatment in some cases.

<u>Long Term Needs</u>

Municipal[2]	$2,200,000,000
Industrial	1,000,000,000
Sewer Separation	3,000,000,000
Rural Runoff	400,000,000

[2]Includes expansion to tertiary treatment by 2020, improvements, new sewer construction, and operation and maintenance of existing plants.

The most complex water pollution control problem facing the citizens of the Lake Erie basin is the potential political difficulty of integrating and managing the engineering requirements. Inadequate machinery presently exists for doing this with any amount of organization or efficiency beyond the state water pollution control agencies and the federal enforcement procedures.

The engineering solutions, complex in themselves, are relatively well known and are also relatively easy to apply, but large sums of money are required to see them through. Solutions to the engineering problems must, by their nature, be solved along the lines of the natural drainage basins.

At certain stages in the process toward development of the lake-wide engineering solutions, entire new sewer systems will have to be built. In some instances, existing treatment facilities will have to be abandoned and new plants will have to be built, either at existing sites or on completely new locations. Existing treatment plants will also have to consolidate into large centrally managed plants.

The enforcement conferences and other programs of the FWPCA such as enforcement of interstate standards, grants to municipalities for the construction of sewage treatment plants, state and interstate programs and planning grants, demonstration grants, and research, provide assistance for carrying out the recommendations of this report.

Since Lake Erie is an international body of water, the International Joint Commission, by treaty, has responsibility for pollution control. Since some of the wastes, roughly 10%, entering Lake Erie come from Ontario sources, a basin wide control program must necessarily consider Canadian waste disposal, and cannot be limited to only states in the U.S. Cleanup on either side of the border, without a corresponding effort from the adjacent nation, would not result in total pollution control for the Lake Erie basin. Therefore, IJC must play a major, if not the lead role, in implementing the pollution control program for Lake Erie.

To guide and plan lake-wide pollution control above the state level, the Great Lakes River Basin Commission, recently organized and constituted, should set up as its first priority the implementation of this Lake Erie comprehensive report. This commission was called for under the Water Resource Planning Act of 1965 and agreed upon by the governments of the Lake Erie states and the Secretary of the Interior. It will serve to integrate all governmental organizations and activities to see that the best purposes are being served in achieving high quality water in Lake Erie and its tributaries.

Below the state level, drainage basin organizations should develop and integrate plans for pollution control. The closest approach to the ideal is that recommended by the National Sanitation Foundation for southeast Michigan. Another approach, called the Northwest Ohio Water Redevelopment Council, is being used in northwest Ohio. This council is in its infancy and if it would give the attention to water pollution that it is giving to water supply, it could develop into an effective tool for pollution control in northwest Ohio. Such a scheme, if proven effective, should also be developed in northeast Ohio. In the Pennsylvania and western New York portions of Lake Erie, where population densities are light, existing local governments will be able to manage pollution problems effectively for a long period of time.

In New York State, the Erie-Niagara basin is being actively studied by the Erie-Niagara Water Resources Regional Planning and Development Board. This board was set up under article 5 of the New York State Conservation Law. Its purpose is to facilitate water resources planning on a basin basis. Also, county-wide comprehensive sewerage studies are under way in the New York counties of Erie and Niagara. These studies are being conducted under Section 1263-a of the New York State Public Health Law and are supported by 100% state grants.

In spite of the above considerations, local units of government are ultimately the best suited and equipped for the financial, engineering and operational aspects of water pollution control. However, they must be answerable to the basin organizations.

When local units of government become concentrated and contiguous, problems arise from overlap, "spillover," duplication and disorganization. It is then necessary for a metropolitan authority for water supply and pollution control to step in. Such a need presently exists in the metropolitan areas of Detroit, Michigan; Toledo, Cleveland, and Akron, Ohio; and Buffalo, New York. The need is pressing also in Ft. Wayne, Indiana; Lima, Lorain, Elyria, and Painesville, Ohio, and Erie, Pa. The local units of government in these metropolitan areas should band together to form a workable metropolitan authority for water supply and pollution control. (It is recognized that the Detroit area is currently working on arrangements for metropolitan control.) Other cities in the Lake Erie basin do not need such an arrangement at this time.

Insert a
see pg 1-1

The first phase of the comprehensive program for the Lake Erie basin is contained in the recommendations and conclusions agreed to by the Lake Erie Federal Enforcement Conference. The significant point in those recommendations and conclusions is an agreement, or commitment, by the conferees to initiate an action program to effect certain improvements on a scheduled basis. This program calls for improvements in (1) the collection, treatment and disposal of various wastes, (2) the sampling and reporting of waste outputs and (3) in surveillance programs in receiving waters.

The key point here is that the Lake Erie Enforcement Conference, which now has come into being as a continuing entity for an indefinite period, in effect constitutes the organization to implement the initial phase of a comprehensive program for Lake Erie and its tributaries. It does this by attaching a degree of formality to the agreements and commitments of the conferees. Adding to its effectiveness as an organizational approach are various other features, including the chairman's authority to reconvene the conferees; their authority to review progress, to alter schedules, and to establish further agreements; and the ultimate possibility, should this prove necessary, of applying the sanctions of a Federal court to compel needed remedial measures.

However, the subsequent phases of a comprehensive program for Lake Erie require organization and authority which the enforcement conference approach is unable to provide. In this regard there is a need for a control authority with jurisdiction over an entire drainage basin, and with the capacity to administer programs now in the developmental stage. New arrangements could be initiated to finance water pollution control on a basin-wide basis, rather than the present local community by community approach. Thus it is recommended that the Lake Erie Basin Commission be officially constituted.

Some conclusions related there to are presented in the following discussion and depicted in figure a.

1. The basic organizational components of the outlined approach are two: a central Lake Erie Basin Commission for the entire basin, including the Detroit river, and a series of local control authorities for individual tributary streams and areas. ("Area" is used to denote the possible selection in special cases of a metropolitan area, contiguous counties, etc., as an authority's geographical area of jurisdiction.)

Insert a

2. The nature of each local authority would depend on a variety of factors. These include the nature of any additional water quality management plan developed by the comprehensive study, the extent of its acceptance locally, other water resource problems and programs in the basin or area, whether the basin or area is intrastate or interstate, pertinent local and State statutes, local attitudes, etc.

Thus in Michigan's waters of the basin, as an example, the local authority for the Detroit river and metropolitan area, might be the Detroit Board of Water Commissioners, perhaps modified as proposed by the National Sanitation Foundation. On rivers such as the Huron and Raisin in Michigan, in contrast, the river management district concept, which already has been proposed for the Huron under a new Michigan statute, might be used to create the control authority. Inclusion of the Huron river basin -- and perhaps other basins ~~as well~~, as Southeastern Michigan becomes even more urbanized -- in the Detroit system, a proposal now also under consideration, is still another alternative.

In the case of Ohio, the conservancy district approach has a long history, and its organic law specifically includes the collection and disposal of sewage and other wastes among its authorized functions. Thus the existing Maumee Watershed Conservancy District, modified to deal with the interstate situation, might serve as the control authority in that basin. Again there are alternatives, among these an interstate compact being a distinct possibility. The Northwest Ohio Water Development Council could be the local control authority for Northwest Ohio but it should be expanded to include the Indiana and Michigan portions of the Maumee.

3. Functionally too, of course, there could be significant differences among the local authorities. Some of the tributary basins and areas might confine the authority's role to water quality management, while others might include water supply, flood control, etc. Other important differences could pertain to independent financing powers, and the authority to abate pollution, construct and operate waste collection and treatment facilities, etc.

Insert a

4. Key structural and functional details of the proposed central authority for the entire basin, are shown in figure a.

Functionally, the proposed Lake Erie Basin Commission closely resembles the river basin planning commissions authorized in the Federal Water Resources Planning Act. However, it is recognized that the role proposed for the commission goes somewhat beyond that of a planning agency. Hence the suggestion that it be established by a Federal-State compact or by other special Federal legislation. In that event, however, it is suggested that the entity so created also be given the powers of a river basin planning commission.

5. This proposes minimum disturbance of the complex of powers and operating responsibilities under present Federal and State laws.. This is consistent with a basic principle of the Federal system.

Three related points need emphasis. The first is that the proposed system would leave intact enforcement authority under the Federal Water Pollution Control Act. This is an important essential. The second point: Formal Federal-State cooperation under a Federal-State compact or other comparable stututory authoriztion is proposed only at the level of the Lake Erie Basin Commission, but it is not suggested at the level of the local control authorities.

The third point provides a necessary balance to the previous one. In lieu of the Federal-State compact or comparable approach as the basis for Federal-State or Federal-local cooperation, an administrative agreement--in particular agreements between the various Federal agencies or the Lake Erie Basin Commission, on the one hand, and State agencies or local control authorities, on the other could be used.

Less formal than the intergovernmental compact and less rigid in its requirements for specific legislative (Federal and State) authorization and/or approval, the administrative agreement would seem to have an especially useful potential in implementing the comprehensive programs.

Insert a

Although it must have a statutory basis, the administrative agreement normally can be formulated and adopted by water pollution control authorities at various levels of government and others without any action by any legislative body on the specific agreement reached. It thus avoids the time-consuming legislative ratification frequently encountered by compacts in the Congress and in the State legislatures. Carefully prepared, it can become not only a statement of long-rangs objectives and procedures but also a working guide setting forth the Federal, State, or other participant's obligations in achieving those objectives, a time-table for that purpose, etc. Because of its non-legislative character, the administrative agreement also offers flexibility; as conditions change and new needs suggest new obligations on the part of any participant, the agreement can easily be revised. (An excellent example, of course, are the agreements and commitments resulting from an enforcement conference.)

6. On the matter of timing, establishment of new local control authorities in most instances is not the immediate need. It would, however, not be premature even now to initiate appropriate studies and discussions with the States and others, looking toward developing agreements and tentative conclusions on organizational needs, objectives, and procedures.

As to the timing on the creation of a Lake Erie Basin Commission, if there is agreement on its desirability, a number of reasons support early action. One is the momentum going on Lake Erie as a result of the Enforcement Conference. A second is the recent enactment of the Water Resources Planning Act. Another reason is the issuance of this comprehensive plan for the development of the water and related land resources of the Lake Erie basin and for imroving inter-agency coordination in water resource programs in the basin. And the fourth reason is the promulgating of interstate water quality standards in the Lake Erie water shed.

water pollution control

out

7. Referring to the upward-pointing arrows in the organizational sketch, several explanatory comments are in order. First, there will be a need to relate the Lake Erie comprehensive program and the Lake Erie Basin Commission to the Great Lakes Basin Commission. An important role of the Lake Erie Basin Commission, therefore, would be to to effect the necessary liaison with comparable authorities on the other Great Lakes and the Great Lakes Basin Commission.

Second, there will remain the need to coordinate United States and Canadian programs in the Lake Erie Basin. Other organizations on the Great Lakes -- the International Joint Commission, the Great Lakes Fishery Commission, and the construction and operation of the St. Lawrence Seaway -- have utilized some form of dual or parallel authority. The necessary coordination in any new water resource programs of the two countries could be achieved under a similar arrangement, and probably to continue under the supervision of the IJC. In the Lake Erie Basin Commission, the United States section of the IJC would gain a new and valuable source of advice and aid.

The other arrow denotes a somewhat similar relationship between the Lake Erie Basin Commission and the Federal Water Resources Council.

8. Nothing has been said thus far about the possible role of the Great Lakes Commission. Its special contribution in the past has been to provide a forum for focusing attention on Great Lakes water resource problems and needs and for obtaining discussion, and hopefully agreement, among the States on these problems and needs. Among its limitations in the immediate context are its present orientation toward problems of the Great Lakes system as a whole rather than those of each lake basin, its lack of regulatory and management authority, and the exclusion of the Federal Government.

In the present situation its special usefulness would seem to lie in two areas. One is to serve as a forum in which proposals such as this and others can be discussed, and the viewpoints of all of the Great Lakes States elicited. The Commission also can render important service in educating and informing the public. A specific role which might be strengthened is its part in stimulating the organization of viable and effective citizen groups with interest in water resource programs.

Proposed Organization To Implement Lake Erie Comprehensive Program

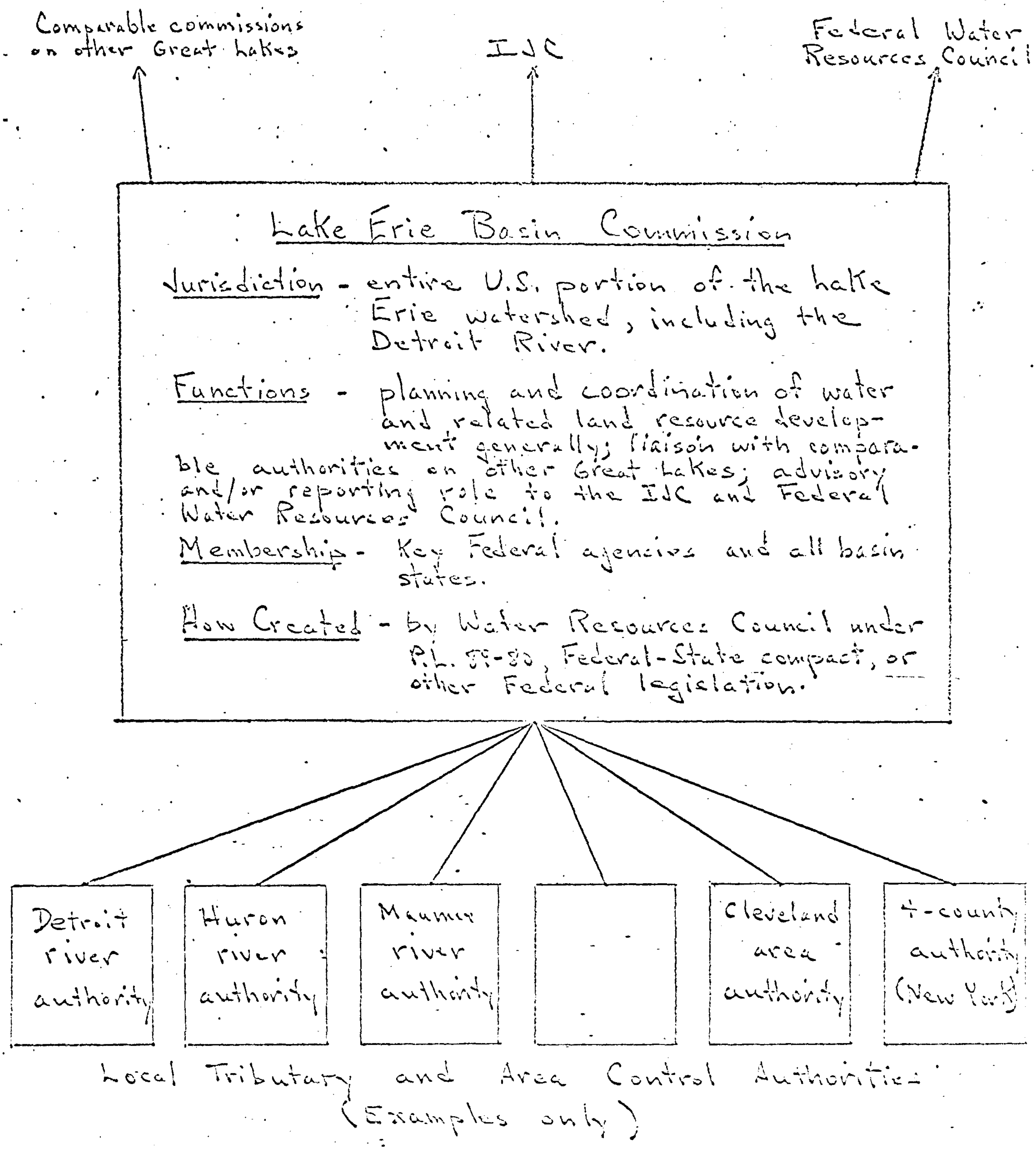


Figure a

CHAPTER I

IMPLEMENTATION

This chapter summarizes the measures necessary to restore and preserve water quality in the Lake Erie watershed. It states specifically what should be done, and by whom; it includes an estimate of the financial needs to sustain the recommended programs; finally, it discusses the benefits to be derived.

Controlling pollution and restoring satisfactory water quality in the Lake Erie basin will require international cooperation, the concerted efforts of the five Lake Erie states, many Federal agencies and local governments. The broad principles underlying such a program have been presented as recommendations.

Specific water pollution control measures should include: secondary treatment in 85 communities; plant improvements in 46 communities; tertiary treatment in 45 locales; emergency disinfection measures to abate pollution from combined storm and sanitary sewer overflows in 7 cities; vast improvements in industrial waste abatement, especially from such industries as iron and steel, chemical, petroleum, and pulp and paper; and area-wide master water pollution control plans in four areas. Waste abatement measures must also include removing phosphorus and preventing it from reaching Lake Erie. The requirements listed above are needed now and will cost approximately $1.1 billion to achieve.

Needed by 1990, at a cost of $2.7 billion, will be tertiary treatment almost without exception throughout the basin; control of pollution (including phosphorus from barnyards and cultivated farmlands; control of sediment loss from bank erosion, highway construction, urban redevelopment and farming; final solution to the storm water overflow problem; area-wide master planning in 5 more metropolitan areas; and continuing industrial waste treatment.

INTERNATIONAL AGENCIES AND PROGRAMS

Article IV of the Boundary Waters Treaty of January 11, 1909, states that boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health and property on the other side. The Governments of Canada and the United States have agreed that all such boundary pollution problems should be referred to the International Joint Commission (IJC) for control.

On October 7, 1964 the Secretary of State for External Affairs for the Government of Canada and the Secretary of State for the Government of the United States requested the IJC to investigate and report upon the extent, causes, locations, and effects of pollution in the waters of Lake Erie and to recommend the most practicable remedial measures. The Commission was requested to inquire into and to report upon the following questions:

1. Are the waters of Lake Erie, Lake Ontario and the international section of the St. Lawrence River being polluted on either side of the boundary to an extent that is causing or is likely to cause injury to health or property on the other side of the boundary?

If the foregoing question is answered in the affirmative, to what extent, by what causes, and in what localities is such pollution taking place?

3. If the Commission should find that pollution of the character just referred to is taking place, what remedial measures, in its judgment, would be most practicable from economic, sanitary, and other points of view and what would be the probable cost thereof?

The Commission is conducting its technical investigations through boards composed of federal, provincial and state officials. Because of the magnitude and complexity of the problems involved, it will be some time before these investigations can be completed. The Commission has now been apprised by its boards of relevant and important information deriving from various studies (notably those of the FWPCA) which have already been made. This information reveals that the situation in Lake Erie is serious and the water quality is deteriorating. For this reason, the Commission has concluded that the facts should be brought to the attention of the two governments.

The report of the IJC to the two governments on boundary water pollution problems of Lake Erie is scheduled for completion in 1969. The comprehensive water pollution control program described in this report will form a major share of the U. S. input to the IJC report.

The IJC report when accepted by the two governments, will establish the means for control of Lake Erie pollution on an international scale.

FWPCA recommends that IJC accept this report in its entirety and that the Commission assume the responsibility for seeing that the recommendations of FWPCA are carried out in full. Further, it is suggested the IJC Advisory Board meet every six months to receive a progress report from each state and provincial government stating what is being done to comply with the report. If control is not forthcoming in accordance with the report, the Advisory Board should refer the problem to the IJC for necessary action.

It is hoped that in the future IJC will exercise more authority in controlling pollution. This agency will be strengthened, and abatement action steps taken, only if the Advisory Boards consistently bring to the attention of the Commission recommendations for control whenever a polluter is lagging.

Because the states and provincial agencies are heavily represented on the board, they exert a major voice in making certain that appropriate action is taken through the IJC. The problem of pollution of Lake Erie cannot be minimized, and it is up to the state and provincial agencies to use the powers of the IJC immediately to achieve pollution control. With this strong backing, the IJC would be in a position to act as a regulatory agency or "Compact" for controlling pollution in Lake Erie.

FEDERAL AGENCIES AND PROGRAMS

Federal agencies which have responsibilities in water pollution control are the Federal Water Pollution Control Administration of the Department of the Interior, the Corps of Engineers, the Department of Agriculture, the Bureau of Public Roads, and the Department of Housing and Urban Development.

FWPCA – spell out

The Federal Water Pollution Control Administration obtains, analyzes, and disseminates information regarding water quality; advises all Federal agencies on water quality control; administers grants for basin planning, training, research, demonstration projects, and construction of sewage plants, and for state and interstate water pollution control programs; provides modifications to the comprehensive plan for pollution oontrol so that the plan will maintain its utility in the face of changing conditions; conducts research; and enforces water pollution control in interstate streams and lakes. All activities of the FWPCA should be geared to implementing the comprehensive program on Lake Erie.

Because of the need to obtain more knowledge of the dynamics of water quality in Lake Erie, the FWPCA should continue its surveillance program of the lake and expand the program to include interstate tributaries. This program will serve the following purposes:

1) Reflect water quality responses upon completion of remedial works.

2) Unfold new problem areas which may require comprehensive program adjustments.

3) Provide emergency service in case of serious and sudden spills.

4) Assess compliance with water quality standards established pursuant to the Water Quality Act of 1965.

5) Judge whether the intent and purpose of the comprehensive program is being carried out.

The FWPCA along with other Federal agencies and the soap and detergent industry must step up research to find a suitable substitute for phosphorus in detergents. Approximately one-half of all phosphorus entering Lake Erie originates from detergents and it will be difficult if not impossible to sufficiently reduce the level of phosphorus discharge to the lake without finding a replacement for phosphorus in detergents. This is an urgent need and should be an immediate goal.

In its program to find new and improved methods to control pollution from combined sanitary and storm sewers, the FWPCA must concentrate its efforts on Lake Erie. Means of abating this pollution are being explored and some should find application in the Lake. Some of the engineering proposals and solutions to the problem of combined sewers are discussed later in this chapter in the section on "Alternatives."

Finally, the FWPCA should enforce compliance with the comprehensive program where it has jurisdiction, and all grants administered by the FWPCA should be in accordance with the recommended program. This authority will necessarily be tied in with enforcing compliance with interstate stream standards.

Bureau of Public Roads and Department of Housing and Urban Development

The FWPCA has the responsibility, through Executive Order 11288, to control pollution from Federal installations and in projects where Federal monies are expended. Two areas where this applies are the Bureau of Public Roads (BPR) in highway construction, and the Department of Housing and Urban Development in urban renewal.

Sediment load entering the watercourses from highway construction and urban development causes unnecessary pollution in the watershed. Highway contractors currently do not reseed the graded areas until a particular job is completed. It would be of great benefit to pollution control if the areas were immediately reseeded after grading, and basins were provided during construction to catch the sediment that washed away in the interim. The same applies to area development. Often entire areas are left bare for long periods of time before construction begins.

The FWPCA should establish policies and guidelines in respect to these problems, and see that recommended control procedures are strictly adhered to. In connection with the highway projects that are financed by the Bureau of Public Roads, the FWPCA should set policy directing the BPR to install separate sewers during highway construction.

The Department of Housing and Urban Development should utilize its means of reducing water pollution. It administers a grant program for construction of sewers; these grants should be given to implement the comprehensive program of this report. Furthermore in the urban renewal program, the Department should establish a policy of prohibiting the installation of combined sewers, another means deemed advisable to control pollution.

Corps of Engineers

The U. S. Army Corps of Engineers has a variety of responsibilities related to pollution control. The Rivers and Harbors Act of 1899 (administered by the Corps) specified that it is unlawful to deposit refuse into waterways that interferes with navigation. Refuse has been interpreted to include oil and suspended solids from municipal and industrial wastes. Oil pollution is a problem, at a number of locations in Lake Erie especially in thé harbor areas of Detroit, Toledo, Cleveland, and Buffalo. The Corps of Engineers should enforce the law to the fullest extent and prosecute violators who allow oil to be deposited in navigable waterways.

Much of the sediment deposited in the streams of the Lake Erie watershed finds its way to the harbors and blocks navigational channels. The Corps of Engineers dredges these harbors annually and deposits the polluted spoils into the lake. Each year, six million cubic yards of sediment are removed from the lake's harbors.

The Corps of Engineers currently charges certain industries that add sediment to the navigational channels in the Rouge and Raisin Rivers in Michigan a portion of the cost required to remove the sediment. This system of charges by the Corps should be extended to all ports in Lake Erie where dredging is required.

Furthermore, where it is determined that spoils contain contaminants that will pollute the lake, places of disposal other than in the lake should be found. Toward this end, the Corps of Engineers is presently conducting a study in cooperation with FWPCA to seek alternate methods of disposal.

In certain harbors on the seacoast the Corps of Engineers is authorized to operate scavenger vessels to remove floating debris and oil from navigation channels. A proposal is now being considered for a scavenger crew and boat in Lake Erie only for the purpose of removing floating debris, not oil. This proposal should be extended to include oil removal.

The Corps of Engineers, as the principal construction agency of the Federal Government, constructs multipurpose reservoirs, in accordance with Congressional approval, in areas where they are needed. Three such reservoirs are in various stages of development in the Lake Erie watershed: One on Mill Creek in the Huron River, (Michigan) one in the Sandusky River, and one on Cattaraugus Creek in New York. For the first two reservoirs, the Federal Water Pollution Control Administration has made studies to determine the amount of storage necessary to provide flow augmentation for water quality control. Reports of these studies have been given to the Corps of Engineers. The study on Cattaraugus Creek Reservoir has just begun and it will be some time before an analysis is completed.

Department of Agriculture:

The Department of Agriculture administers a sewer grant program to rural communities. These grants should be awarded in accordance with the plan outlined in this report.

The Agriculture Department -- specifically the Soil Conservation Service-- should accelerate the construction of small watershed improvement projects to implement recommendations for reducing the solids load to Lake Erie. In the Maumee River Basin the Department of Agriculture has under consideration the construction of 27 of these projects. To date, however, only one of these watershed improvement projects has been funded by Congress even though the Maumee River contributes a heavy nutrient and silt load to Lake Erie.

Another area in which the Department of Agriculture should assume greater responsibility is in control of pollution from barnyards and animal feed lots. Animals excrete approximately 10 times more pollutants than humans, based on a nation-wide average. It is not known how much of the animals' wastes reach the streams in the Lake Erie basin (much is absorbed by the soil), but it is undoubtedly a significant amount. To reduce this pollution, the Department of Agriculture should initiate a program to control contamination from animal wastes. In cooperation with FWPCA, ways for accomplishing this reduction might include technical assistance, research, grants, and enforcement. This is an area that has been relatively untouched and should receive immediate attention.

State Programs

FWPCA recommends that state water pollution control agencies integrate the program set forth in this report with their ongoing programs. State groups should become the agencies for implementation of this report in the areas where they have principal authority. In most cases, the state agencies already have sufficient laws to carry out the recommendations, but they lack authority or compulsion in the areas of sediment pollution, pollution from agricultural lands and animal feed lots, and areas where extreme financial burdens would become overwhelming (such as sewer separation) and in master planning. The states should enact laws or direct activities to adequately cope with these problems.

In Ohio and Michigan, the state water pollution control programs are vested in more than one agency. A more efficient program would result if all functions in water pollution control were delegated to one agency.

All the states excepting Pennsylvania have authority to impose sewer construction bans where pollution is occurring and abatement not forthcoming. This authority should be used in many more instances than it is in the Lake Erie watershed. It should be extended to include methods whereby area-wide master sewerage schemes can be ordered. It is recommended that this authority be extended to Pennsylvania.

State agencies, especially in Ohio, lack sufficient manpower to carry out all their responsibilities. Because of these manpower shortages, the states have been delinquent in municipal and industrial plant inspections, planning for long-term needs, and pollution surveillance.

Thorough municipal and industrial waste treatment plant inspections should be conducted at least annually and plants causing any significant problems in water quality of the receiving streams should be inspected as frequently as the situation requires. Status of sewage plant operators should be upgraded and the states should continue and expand annual training programs and certify all operators.

All tributaries to Lake Erie should be patrolled and surveyed by means of visual and analytical measurements to locate new sources of wastes and spills, to determine additional needs, and to provide data for enforcement.

Provisions should be made by the states for onshore disposal of vessel wastes at major ports. Provision for control of waste disposal from all classes of vessels, including pleasure craft, should be instituted.

The state water pollution control agencies should prepare and enact enforceable water quality standards for all water courses of the state. Furthermore, each state should enact programs of financial aid to cities to gain the maximum benefit from Federal aid programs.

In northeast Ohio and the New York portions of the Lake Erie basin* the states should develop basin-wide, long-range plans for water supply and waste disposal. Such plans have been prepared for southeast Michigan and northwest Ohio and these two plans should be used as guides. There is a matching Federal grant of 50 percent available to state agencies to assist in the preparation of Master plans.

A major obstacle facing pollution control by state agencies is lack of power to enforce the necessary requirements until <u>after</u> a water quality problem has occurred. Once a pollution problem has occurred it is almost too late, because of the difficulty of tracing the source of pollution. Many sources could have been at fault and water bodies, being what they are, are subject to a wide variety of influences. Because of this fact, states are often reluctant to press charges, even for the most flagrant violations.

To correct such occurrences the states often rely on the power of persuasion, using the threat of court action as a final measure to be taken. The irony of this approach is that polluters know the problems involved in reaching a decision in court and therefore often evade responsibility for gross abuse of water.

There is a need to strengthen the states' position in these matters and to extend their programs by law, if necessary, to include limits on waste discharge levels in their system of permits. In this way, enforcement authority could be initiated more effectively and as soon as waste discharge levels are exceeded regardless of whether the stream has yet been harmed. Thus, pollution would be prevented before it occurred.

Michigan has adopted this approach in the Detroit River area. Other states have been less anxious to go this way; New York and Ohio have been

---

* It would be advantageous to the whole program to include all the Niagara Frontier as well

the most vague in the adoption of waste abatement orders.

States also need strong, enforceable legislation in the area of trash and garbage dumps along watercourses. Traditionally, these have been the areas where dumps are located and little or no control has been exercised over the material entering the waterway. Strict enforcement of the law would be necessary to apprehend violators. Garbage and trash dumps are particularly prevalent in Ohio.

Local Governments

The local governmental agencies take many forms. Some are county operated, some are run by city control boards, and some are a city staff function. These local government agencies have the responsibility in most cases for design, financing, and operation of waste treatment works and sewer systems. Local governments should continue to exercise this responsibility subject to state approval and FWPCA approval when Federal grant monies are allocated. The approval should be based on the recommended plan.

Each city tends to operate independently and as a result there is little coordination, and a large number of small, poorly operated plants and sewer systems abound. This is especially true in the large metropolitan areas of Detroit, Toledo, Akron, Cleveland, and Buffalo.

The barriers of city limits and jurisdictional responsibility must be broken down in the Lake Erie basin if effective and efficient control on an area-wide or basin approach is to be achieved. This type of approach will be cheaper in the long run and result in better water quality.

Where metropolitan control of sewage treatment is needed (Detroit, Cleveland, Toledo, Akron, and Buffalo) the functions of water supply, sewage treatment and sewer construction should be vested in one central local agency responsible to a local board or commission with representation on the board (on an equitable basis) of the various cities and communities involved. The Detroit Water Board and its system of operation is one example of this. The system of financing the agency and the board through revenue on water and sewers should be subject to approval by the state.

All local governments should have strictly enforced sewer codes. Many have adopted codes in the past, but have paid no attention to them. Any establishment discharging waste to the system should be required to conform to the code. In almost all cities the sewer codes need revising and strengthening.

Many local governments have provided substandard operation and maintenance of sewers and treatment plants. Personnel have been poorly paid, some plants are not even operated, and many have been bypassed without the knowledge of local officials. Sewer breaks have been a major problem especially in the older metropolitan areas such as Cleveland and Detroit. Often damage to the sewer systems has resulted in extended bypass periods while the system was under repair.

Many sewage plants bypass daily because of overload, poor design or poor operation. A glaring example of this is the Toledo plant. Treatment plants have also been designed without built-in safety factors, and minimum criteria have been applied in the design.

Cities should strive to overcome these problems by strengthening the local water pollution control agency. Sewers should be inspected continually and replaced (without the necessity of bypassing) where obsolescence occurs. Each agency should have a staff on industrial wastes to see that industries tied to the sewer system are providing proper pretreatment and proper payment for use of the sewer system. Status of the sewage plant operator should be substantially upgraded. Sewage plants should be designed with built-in safety features and bilateral design criteria and finally, cities should verify that the plants are operated with high degree of removal efficiency and without need for bypassing.

One of the major problems that plague metropolitan areas (especially Cleveland) is the tremendous amount of litter, junk, logs, and debris that find their way into Lake Erie. This problem is especially acute in the late spring after the ice melts. The cities of Detroit, Toledo, Cleveland, Erie and Buffalo should continue and strengthen programs to clean up this mess. Programs should be extended upstream to remove material at its source. Furthermore, the cities should pursue aggressive programs to apprehend and prosecute anyone found deliberately littering the lake and its tributaries.

Private Interests

Many private organizations are involved in water pollution control activities in the Lake Erie watershed. They include Kiwanis, Isaac Walton League, League of Women Voters, Rotary, Citizens for Land Water Use, United Auto Workers, Clean Water, Inc., Lake Erie Cleanup Committee, Knights of Columbus, the newspapers and others. These service, conservation, and other organizations, although without legal responsibility for pollution control, have shown an active interest by promoting public awareness of water pollution problems and by supporting pollution control measures taken at all levels of government. The services provided by these organizations are vital and indispensable in the implementation of this or any water pollution control program. Several private individuals have also been extremely prominent in the water pollution field and have devoted much time to focusing public attention on the problem.

It is hoped that these groups will continue to support Lake Erie cleanup programs, and nationwide programs too, doing their part through meetings, forums, publicity, and lobbying to see that the recommendations of this report are carried out.

MUNICIPAL WASTE TREATMENT NEEDS

The population of the Lake Erie basin is expected to more than double by the year 2020, with most of the growth occurring in the metropolitan areas. To cope with this growth, many new, enlarged and consolidated treatment schemes will have to be devised.

At the present time, the area should be served by treatment resulting in at least 90% removal of BOD and suspended solids and 92% removal of phosphorus. By the year 1990 in many cases treatment should be increased to at least 98 percent removal of BOD and suspended solids, and 97 percent removal of phosphorus, and by the year 2020, 100 percent of phosphorus.

The balance of this section will be devoted to a discussion of the municipal waste treatment needs for various areas around the Lake Erie Basin.

Southeast Michigan

Maintenance of water quality in southeast Michigan is largely dependent on the development and implementation of a comprehensive program for the entire basin. The complex nature of the metroplitan area, which crosses natural watershed boundaries, together with the relatively flat, natural terrain has led to development of interceptor drainage systems for both stormwater and sanitary wastes that are regional in extent. The relatively small size of the tributary streams in comparison to the heavy waste loads resulting from urbanization has caused a serious deficiency in the water quality even with secondary treatment by the communities throughout the basins.

Several studies have been made for regional water systems and regional sewage interceptor systems. These systems would have the effect of removing the waste products from the major communities and industries throughout the southeast Michigan area and transporting them to the downstream ends of the small streams where discharge of the highly treated effluent into the Detroit or St. Clair Rivers would have a minimal effect on those large streams. The Clinton River is a prime example of the action necessary to restore and enhance the water quality. Waste assimilation studies by the Michigan Water Resources Commission and the Federal Water Pollution Control Administration (FWPCA) have shown that during summer low flow periods, the stream is unable to cope with the secondary effluents presently discharged to it.

A plan is now being implemented to carry the waste from the large communities in the basin, as well as Selfridge Air Force Base, through an interceptor system to the City of Detroit for treatment. This action resulted from a sewer construction ban imposed by the Michigan Department of Public Health, in which they declared that further development of the area would not be approved until a satisfactory waste treatment system was established. Major cities and townships having treatment facilities in Macomb County have agreed to connect to the Detroit Water Board regional interceptors. Two remaining cities, Warren and Mt. Clemens, should also connect to this system, but as of this date have not agreed to do so because of the many millions of dollars they have presently invested in treatment facilities for which bonding commitments have not as yet been satisfied.

The Rouge River urbanizing area has for the most part been served by interceptors which transport the waste material to the downstream area. The Raisin and Huron River areas are faced with similar problems, but as yet have not taken definite steps to implement an area-wide interceptor system. To maintain water quality in these areas the existing treatment plants must be operated to provide maximum removal of nutrients and organic loadings until regional interceptors are available.

Programs for development of low flow augmentation systems through storage reservoirs might have the effect of delaying the need for regional interceptors, but long-range projections indicate that eventually interceptors will provide the best solution to the water quality problems in the basin.

The individual septic tank systems in the basin, especially those located near lakes, reservoirs, and tributary streams, must be considered as temporary measures and provision made for collection and discharge to the central system as it becomes available. The nearness to the watercourse, the poor soil characteristics, and the unauthorized connections to water courses or drains permit the accumulation of pollutants, especially nutrients, in these small lakes and streams.

In providing connections to the regional interceptor, particular attention must be given to the problem of combined sewers which exist in the basin, especially in sections of long-established communities. Although present policy of the Michigan regulatory agencies is not to approve future construction of combined systems, a careful evaluation of older systems must be made in order to benefit from the regional system of interceptors. Where only part of the system is combined and where the area is scheduled for eventual redevelopment, separation of sewers should be considered as an immediate need. Where combined systems are extensive in sections of a municipal area, these sections should be isolated from the remainder of the system and enter the interceptor as an entity with provision for separate handling of overflows. Treatment of overflows would then be limited to combined overflows, and the ever-increasing quantity of separate sanitary sewage could be handled by the treatment plant.

In order to maintain acceptable water quality in the southeastern Michigan basin, even with removal of the major waste sources, low flow augmentation must be available to remedy the effects of "natural" pollution and storm runoff both from urban and agricultural sources. The construction of additional recreational areas in the upper reaches of the main stem and tributaries should include the provision for water storage for low flow augmentation. Site selection must be made with this multi-purpose use in mind as recreational use requirements include minimum change in water levels and minimum depths to be suitable for boating. The provision of access ramps at different levels, bank modification and stabilization, and control of shoreline vegetation would make a small reservoir suitable for these multiple purposes. These areas will be needed to supply the recreational needs of the expanding basin population.

To implement the overall program necessary to achieve water quality and objectives for the basin, a watershed management system must exist. The function of this group must include total resource planning. For many functions extra basin authorities will also exist. These functions include water supply and wastewater disposal which would efficiently be administrated by the regional authority or Detroit Water Services. For large-scale park and recreation site development, both the state and the Huron-Clinton Metropolitan Authority already have a vested interest. The watershed management system would coordinate the planning and zoning activities of the various regional local and county units affecting the water resources of the basin. Such activities as flood plain zoning, bankside development, and the creation of river parkways are proper functions of this group. A prime function would be that of education of the citizens of the basin in matters which affect the water resources of the basin.

The Detroit River-Lake Erie Project, an enforcement action by the Public Health Service under Section 8 of Public Law 660, recommended improvements throughout the Detroit River and Michigan portion of Lake Erie. The Michigan Water Resources Commission has obtained agreements with all industrial and municipal units in this area to provide the recommended levels of treatment by 1970. The State of Michigan, in compliance with the Water Quality Act of 1965 has established water quality standards for the waters of Lake Erie, Detroit River, Lake St. Clair, and St. Clair River.

As each industry and municipality expands, its treatment facilities must keep pace so as not to violate the interstate standards established for these waters.

The stormwater overflows throughout the Detroit system are presently being studied and control measures are being developed by the City of Detroit in an attempt to reduce the number of overflows to controls of levels within the interceptor system.

In Southeast Michigan, especially in the Detroit metropolitan area, the primary need is for expanding the interceptor sewer system and integrating and consolidating sewage treatment plants. Such a plan has been recommended by the National Sanitation Foundation (NSF) and is depicted in Figure 1-1. This master plan, endorsed by FWPCA, calls for:

1. Intercepting the wastes originating primarily along the St. Clair River and in the Counties of St. Clair, Sanilac, and Lapeer, with waste treatment being provided near the City of Algonac on the St. Clair River.

This area is presently served by 5 primary and 6 secondary sewage treatment plants which have a connected population estimated at 63,000. This portion of the plan should be constructed by 1990 with treatment level providing 90% removal, or waste discharge not to exceed 7000 lbs/day BOD. The cost of this portion of the plan is estimated at $40 million.

2. Expansion of the present service area of Detroit to intercept the wastes originating in Macomb and Oakland Counties and draining to the Clinton River and Lake St. Clair, with treatment at the site of the now-existing Detroit sewage treatment plant.

Nineteen secondary and nine primary sewage treatment plants with an

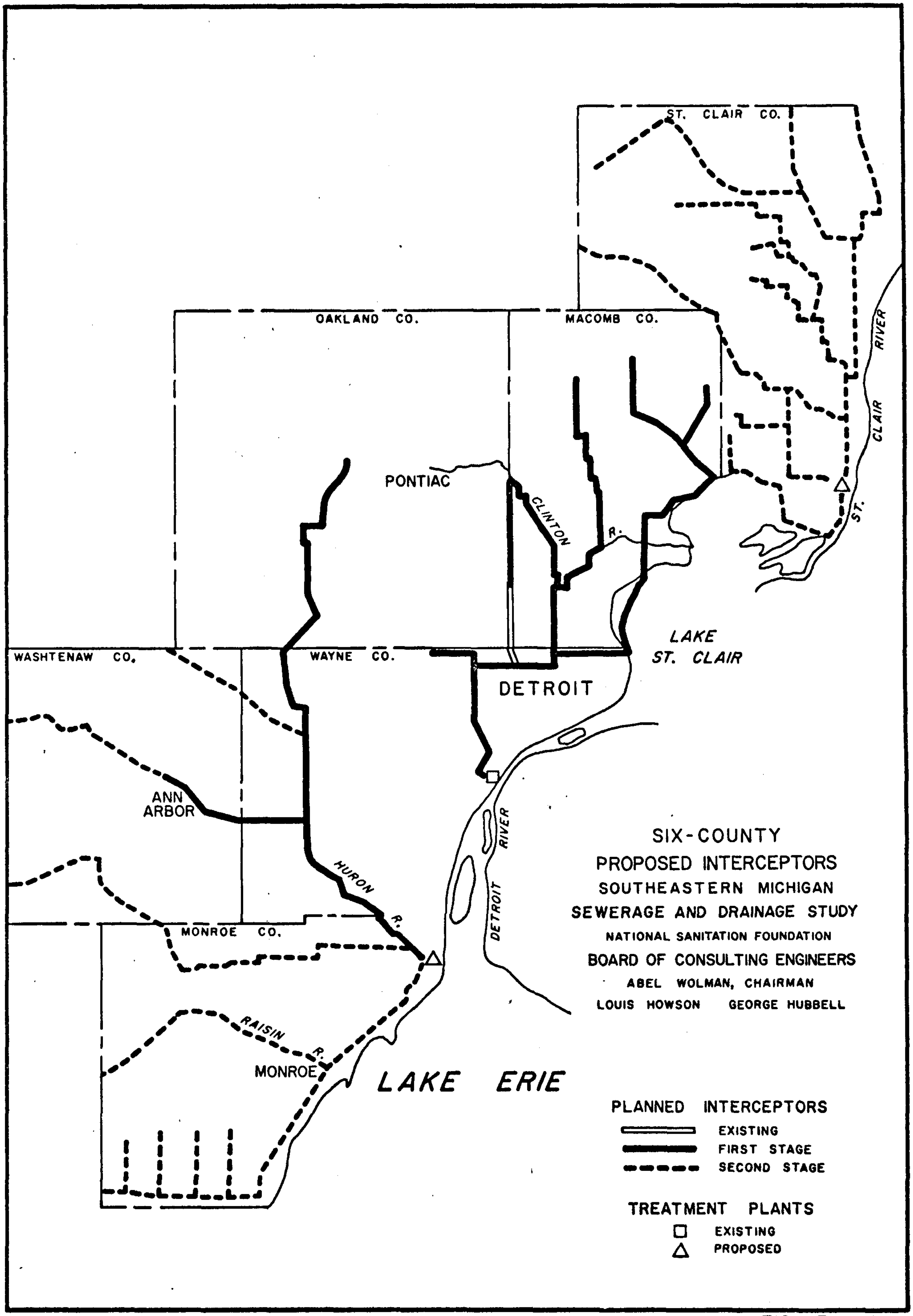

ST. CLAIR CO.
OAKLAND CO.
MACOMB CO.
PONTIAC
CLINTON
R.
ST. CLAIR RIVER
LAKE ST. CLAIR
WASHTENAW CO.
WAYNE CO.
DETROIT
ANN ARBOR
DETROIT RIVER
HURON R.
MONROE CO.
RAISIN R.
MONROE
LAKE ERIE
SIX-COUNTY
PROPOSED INTERCEPTORS
SOUTHEASTERN MICHIGAN
SEWERAGE AND DRAINAGE STUDY
NATIONAL SANITATION FOUNDATION
BOARD OF CONSULTING ENGINEERS
ABEL WOLMAN, CHAIRMAN
LOUIS HOWSON GEORGE HUBBELL
PLANNED INTERCEPTORS
EXISTING
FIRST STAGE
SECOND STAGE
TREATMENT PLANTS
EXISTING
PROPOSED

FIGURE ~~8-2~~ 1-1

estimated connected population of 3,000,000 presently serve this area. This portion of the plan should be constructed in the next ten years with treatment level providing 90% removal or waste discharge not to exceed 100,000 lbs/day BOD. The cost of this portion of the plan is estimated at $380 million.

3. Interception of waste drainage of the Huron River and much of the Raisin River and Monroe County drainage, including the western shoreline of Lake Erie down to the Ohio border and the city of Monroe, with centralized treatment on Lake Erie at the mouth of the Huron River.

This area is now served by 15 secondary plants and 7 primary plants with a connected population estimated at 180,000. The first stage of the Huron River system should be constructed in the next ten years with treatment providing 90% removal or waste discharge not to exceed 43,000 lbs/day BOD. The cost of this portion of the plan is estimated at $165 million. The second stage, which should be constructed by 1990, will increase the treat ment requirements at this plant to 95% removal of BOD. The cost of this portion of the plan would be an additional $140 million.

The proposal of the NSF with modifications by FWPCA represents the long-range master plan for pollution control in southeast Michigan. For immediate pollution control, the needs are summarized in Table 1-1. The estimated cost of the immediate needs is $433 million. Figure 1-2 graphically illustrates the short and long term pollution control requirements. Some communities in the Detroit River-Lake Erie Project Enforcement area are bound by stipulations set forth by the Michigan Water Resources Commission in 1966 The communities involved and their immediate treatment needs are listed in Table 1-2.

<u>Maumee River Basin and Northcentral Ohio Area</u>

The major need for this portion of the Lake Erie watershed is expansion of waste treatment facilities to secondary treatment, and installation of tertiary treatment at 47 locations.

With the exception of a few population centers, the area is predominantly rural. The present population stands at approximately 1.7 million. By 1990 it is expected to grow to 2.6 million and by 2020 to 4.0 million.

Immediate treatment needs are listed in Table 1-3. The cost of these needs is estimated at $85 million. For long range requirements it is felt that by the year 2000, tertiary treatment will be needed at almost all locations at a cost of $300 million.

The Northwest Ohio Water Development Plan of the State of Ohio covers Ohio's portion of this drainage basin. The plan contains excellent pollution control requirements which in many ways are commensurate with those recommended in this report. The Northwest Ohio Water Development Plan and this report should be used as the guide for implementing all water resource developments in the area.

Figure 1-3 shows the short and long range treatment needs for this area.

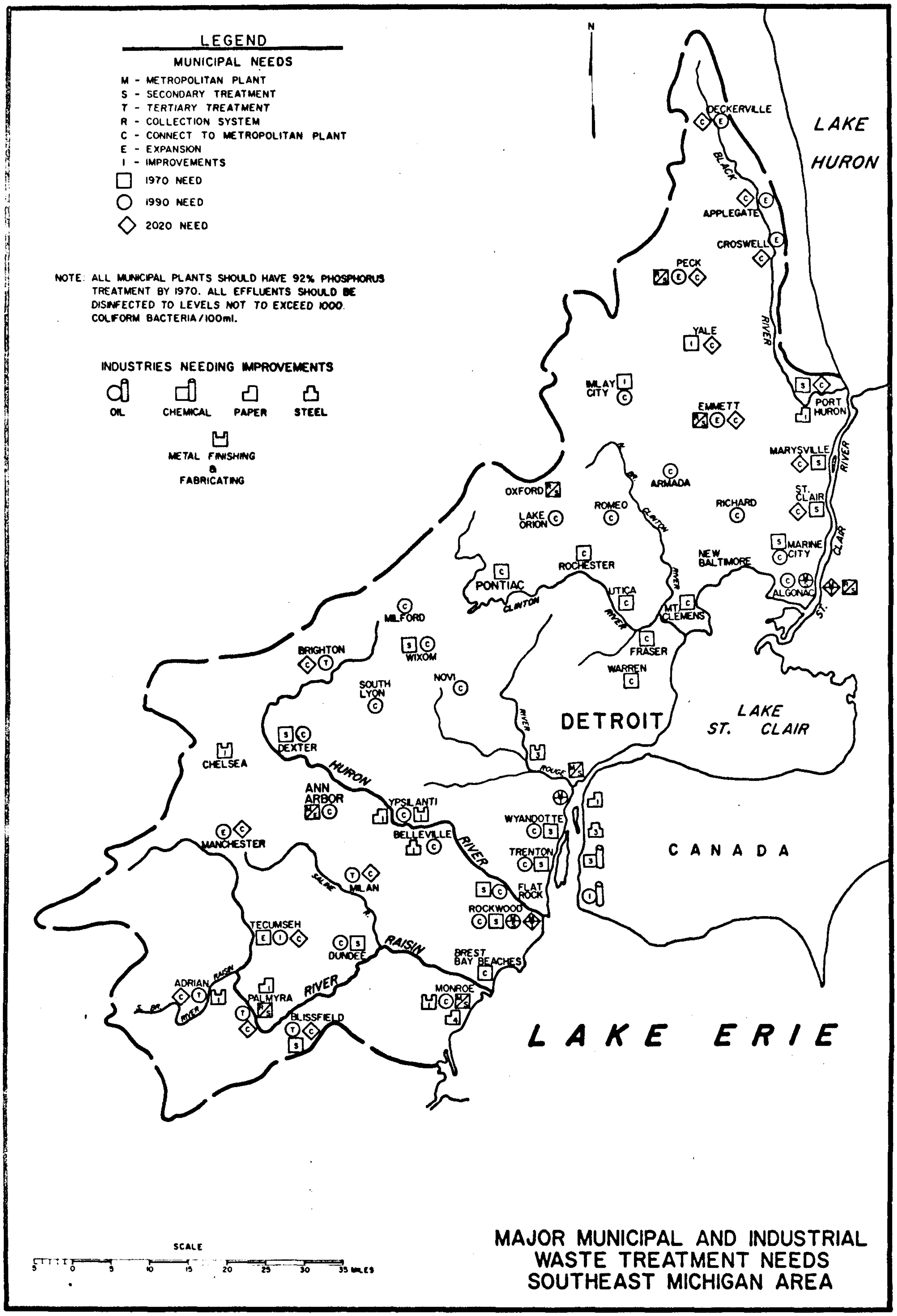
TABLE 1-1

IMMEDIATE MUNICIPAL WASTE TREATMENT NEEDS for SOUTHEAST MICHIGAN

Location	Needs
ST. CLAIR RIVER BASIN	
St. Clair River	
Port Huron	Expand to secondary
Marysville	Expand to secondary
St. Clair	Expand to secondary
Marine City	Expand to secondary
Cottrelville T.	Collection system & secondary
Kimball T.	Collection system & secondary
St. Clair T.	Expand to secondary
Clay T.	Collection system & secondary
Algonac	Collection system & secondary
East China T.	Expand to secondary
Black River	
Deckerville	Collection system & lagoon
Yale	Lagoon modifications'
Fort Gratiot T.	Collection system & secondary
Peck	Collection system & lagoon
Pine River	
Emmett	Collection system & lagoon
Belle River	
Imlay City	Improve collection system
Clinton River	
Clinton T.	Connect to Detroit Metro
Mt. Clemens	Connect to Detroit Metro
Sterling T.	Connect to Detroit Metro
Utica	Connect to Detroit Metro
Warren	Connect to Detroit Metro
Pontiac	Connect to Detroit Metro
Rochester	Connect to Detroit Metro
Oxford Village	Collection system & secondary
Harrison T.	Connect to Detroit Metro
Fraser	Connect to Detroit Metro
Shelby T. (Part)	Connect to Detroit Metro
Leonard	Collection system & lagoon
Washington	Collection system & secondary

TABLE 1-1 (cont.)

Location	Needs
LAKE ERIE BASIN	
Lake Erie (Minor tributaries)	
Maybee	Collection system & lagoon
Bedford T.	Collection system & lagoon
Erie T.	Collection system & lagoon
Huron River	
Ann Arbor T.	Connect to Ann Arbor Metro
Ypsilanti T.	Connect to Ann Arbor Metro
Pittsfield T.	Connect to Ann Arbor Metro
Superior T.	Connect to Ann Arbor Metro
Dexter	Expand to Secondary
Pinckey	Collection system & lagoon
South Lyon	Collection system & secondary
South Rockwood	Collection system & lagoon
Stockbridge	Collection system & lagoon
Wixom	Collection system & secondary
Flat Rock	Improve collection system; secondary
Rockwood	Improve collection system; secondary
Ann Arbor Metro	Collection system & expand secondary
Raisin River	
Blissfield	Expand to secondary
Britton	Collection system & lagoon
Brooklyn	Collection system & lagoon
Cement City	Collection system & lagoon
Clayton	Collection system & lagoon
Clinton	Expand to secondary
Deerfield	Collection system & lagoon
Dundee	Expand to secondary
Madison T.	Collection system & secondary
Ash T.	Connect to Monroe Metro
Onstead	Collection system & lagoon
Palmyra T.	Collection system & secondary
Petersburg	Collection system & lagoon
Tecumseh	Expand collection system & treatment
Monroe Metro	Expand to secondary & increase collection



MAJOR MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS SOUTHEAST MICHIGAN AREA

FIGURE 1-2

qualify title, see p. 1-13, RH

TABLE 1-2

WASTE TREATMENT NEEDS FOR SOUTHEAST

MICHIGAN COMMUNITIES

Location	Needs
Detroit Metro	Expand collections: secondary (to serve 18 additional communities by 1970)
Grosse Ile	Improve collection; secondary
Riverview	Expand to secondary
Wayne County System*	
Wyandotte	Expand to secondary
Trenton	Expand to secondary
Trenton	Expand to secondary
Estral Beach	Collection system and secondary
Berlin T.	Collection system and secondary
Luna Pier	Collection system and secondary
Frenchtown T.	Connect to Monroe Metro
Monroe T.	Connect to Monroe Metro

*Wayne County System also serves Rockwood and Flat Rock

TABLE 1-3

IMMEDIATE POLLUTION ABATEMENT NEEDS FOR MUNICIPALITIES

IN MAUMEE RIVER BASIN AND NORTH-CENTRAL OHIO AREA

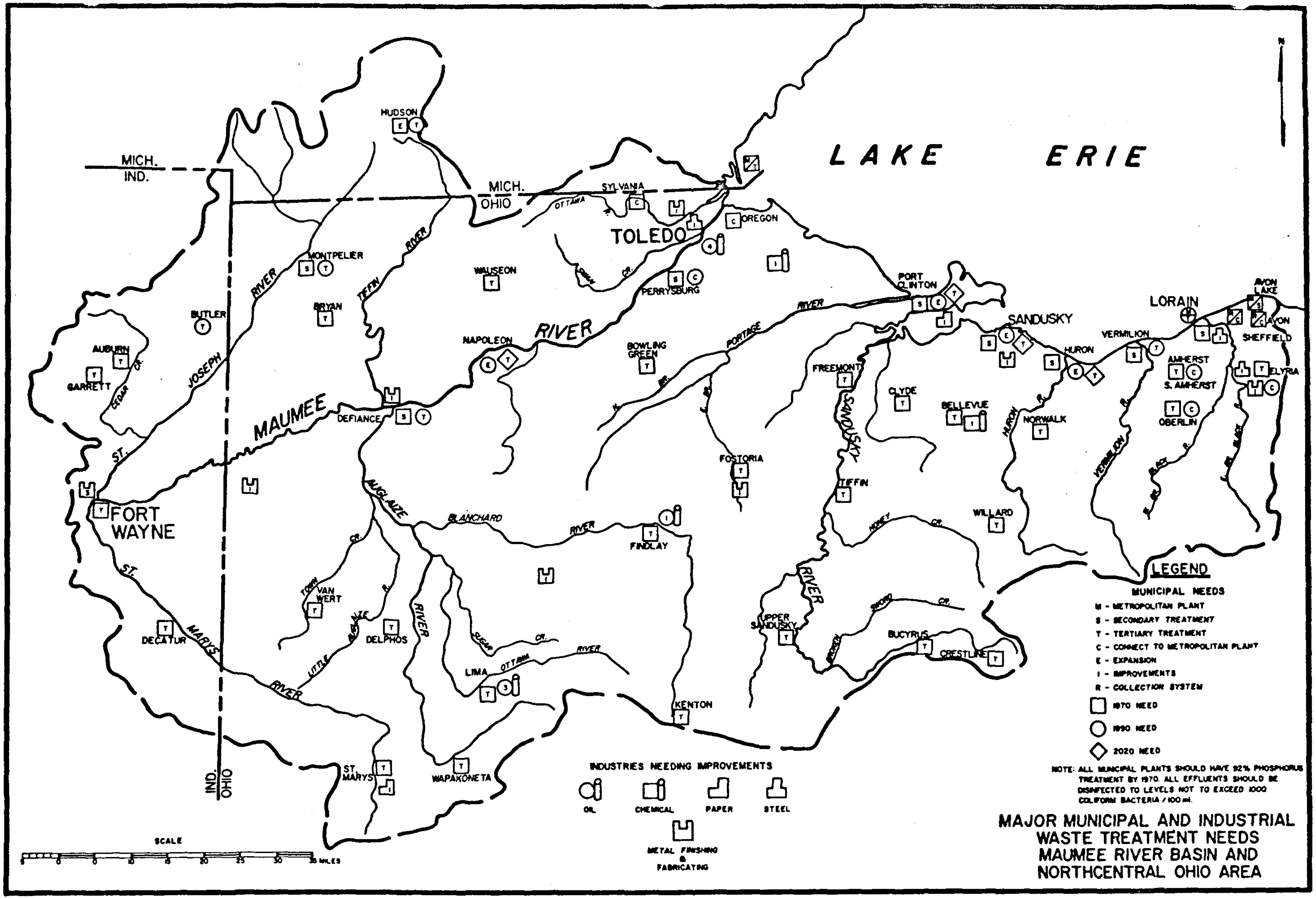
Community	Subbasin Location	Present Treatment	Needs
Michigan			
Reading	St. Joseph R.	Minor	Secondary & disinfection
Hudson	Tiffin River	Sec.	Expansion
Indiana			
Auburn	St. Joseph	Sec.	Advanced Waste Treatment
Butler	St. Joseph	Sec.	Disinfection
Garrett	St. Joseph	Sec.	Advanced Waste Treatment
Waterloo	St. Joseph	Sec.	Disinfection
Berne	St. Marys	Lagoon	Disinfection
Decatur	St. Marys	Sec.	Advanced Waste Treatment
Diversified Utilities, Inc.	Maumee	Sec.	Expansion
Ft. Wayne	Maumee	Sec.	Advanced Waste Treatment
Ohio			
Edgerton	St. Joseph	Minor	Secondary & disinfection
Montpelier	St. Joseph	Prim.	Secondary & disinfection
New Bremen	St. Marys	Sec.	Expansion & disinfection
Rockford	St. Marys	Prim.	Secondary & disinfection
St. Marys	St. Marys	Sec.	Advanced waste treatment
Ada	Auglaize	Sec.	Expansion & disinfection
Bluffton	Auglaize	Sec.	Disinfection
Columbus Grove	Auglaize	Sec.	Advanced waste treatment
Continental	Auglaize	Sec.	Disinfection
Cridersville	Auglaize	Sec.	Disinfection
Delphos	Auglaize	Sec.	Advanced waste treatment
Dunkirk	Auglaize	Minor	Secondary & disinfection
Elida	Auglaize	Minor	Secondary & disinfection
Findlay	Auglaize	Sec.	Advanced waste treatment
Forest	Auglaize	Minor	Secondary & disinfection
Lima	Auglaize	Sec.	Advanced waste treatment
Paulding	Auglaize	Lagoon	Disinfection
Payne	Auglaize	Minor	Secondary & disinfection
Spencerville	Auglaize	Sec.	Disinfection
Van Wert	Auglaize	Sec.	Advanced waste treatment
Wapakoneta	Auglaize	Sec.	Advanced waste treatment
Archbald	Tiffin	Sec.	Advanced waste treatment
Bryon	Tiffin	Sec.	Advanced waste treatment
Fayette	Tiffin	Lagoon	Disinfection
Stryker	Tiffin	Lagoon	Disinfection
West Unity	Tiffin	Minor	Secondary & disinfection
Antwerp	Maumee	Minor	Secondary & disinfection
Defiance	Maumee	Intermediate	Expansion
Hicksville	Maumee	Sec.	Expansion
Delta	Maumee	Sec.	Advanced waste treatment

Immediate Pollution Abatement Needs (cont.)

Community	Subbasin Location	Present Treatment	Needs
Ohio (cont.)			
Deshler	Maumee	Lagoon	Disinfection
Holgate	Maumee	Minor	Secondary & disinfection
Leipsic	Maumee	Sec.	Disinfection
Perrysburg	Maumee	Intermediate	Secondary
Swanton	Maumee	Sec.	Disinfection
Toledo	Maumee	Sec.	Advanced waste treatment
Waterville	Maumee	Sec.	Expansion & disinfection
Wauseon	Maumee	Sec.	Advanced waste treatment
Weston	Maumee	Sec.	Disinfection
Whitehorse	Maumee	Sec.	Expansion
Sylvania	10-mile Creek	Sec.	Expansion
Trilby	Silver Creek	Minor	Secondary & disinfection
Bloomdale	Portage	Minor	Secondary & advanced waste treatment
Bowling Green	Portage	Sec.	Advanced waste treatment
Elmore	Portage	Minor	Secondary
Fostoria	Portage	Sec.	Advanced waste treatment
Genoa	Portage	Lagoon	Advanced waste treatment
Gibsonburg	Portage	Minor	Secondary and advanced waste treatment
Lakeside	Portage	Primary	Secondary
McComb	Portage	Primary	Secondary & AWT
N. Baltimore	Portage	Sec.	Advanced waste treatment
Oak Harbor	Portage	Primary	Secondary
Oregon	Portage	Minor	Connect to Toledo Metro
Pemberville	Portage	Minor	Secondary
Port Clinton	Portage	Intermediate	Secondary & diffuse outfall
Woodville	Portage	Minor	Secondary
Attica	Sandusky	Minor	Secondary & AWT
Bloomville	Sandusky	Minor	Secondary & AWT
Bucyrus	Sandusky	Secondary	Advanced waste treatment
Carey	Sandusky	Secondary	Advanced waste treatment
Clyde	Sandusky	Secondary	Advanced waste treatment
Crestline	Sandusky	Secondary	Advanced waste treatment
Fremont	Sandusky	Secondary	Advanced waste treatment
Green Springs	Sandusky	Primary	Secondary
Nevada	Sandusky	Minor	Secondary
New Washington	Sandusky	Minor	Secondary & AWT
Sandusky	Sandusky	Primary	Secondary & diffuse outfall
Tiffin	Sandusky	Primary	Secondary & AWT
Upper Sandusky	Sandusky	Secondary	Advanced waste treatment
Bellevue	Huron	Minor	Secondary & AWT
Huron	Huron	Intermediate	Secondary & diffuse outfall
Milan	Huron	Primary	Secondary
Monroeville	Huron	Primary	Secondary
Norwalk	Huron	Secondary	Advanced waste treatment
Willard	Huron	Secondary	Advanced waste treatment
Greenwich	Vermilion	Lagoon	Advanced waste treatment
New London	Vermilion	Secondary	Advanced waste treatment
Vermilion	Vermilion	Primary	Secondary & diffuse outfall
Amherst	Black	Secondary	Advanced waste treatment

Immediate Pollution Abatement Needs (cont.)

Community	Subbasin Location	Present Treatment	Needs
Ohio (cont.)			
South Amherst	Black		Combine with Amherst
Avon	Black	Secondary	Combine into one
Avon Lake	Black	Primary	secondary plant and
Sheffield Lake	Black	Minor	diffuse outfall
Elyria	Black	Secondary	Advanced waste treatment
Grafton	Black	Secondary	Advanced waste treatment
La Grange	Black	Secondary	Advanced waste treatment
Lodi	Black	Secondary	Advanced waste treatment
Lorain	Black	Primary	Secondary & diffuse outfall
Oberlin	Black	Secondary	Advanced waste treatment
Spencer	Black	Minor	Secondary & AWT
Wellington	Black	Secondary	Advanced waste treatment



MAJOR MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS MAUMEE RIVER BASIN AND NORTHCENTRAL OHIO AREA

FIGURE 1-3

Greater Cleveland-Akron Area

In this area of Ohio, three streams drain to the lake: Cuyahoga, Rocky, and Chagrin Rivers. Each river travels through heavily populated areas and becomes progressively polluted as it nears the lake.

The Rocky River and, to a degree the Chagrin River, form the core of the Cleveland Metropolitan Park system even though these streams are polluted to the extent that recreational and water supply uses are impaired.

In both the Cleveland and Akron areas, metropolitan master planning for water pollution control is needed. Both cities should form metropolitan sanitary districts and by the year 1990, when the areas will grow together, an amalgamation of the two sanitary districts will be necessary.

The metropolitan plan calls for halting the practice of proliferous construction of small sewage plants. With this in mind, all sewage plants in the Rocky and Chagrin Rivers should be phased out and the communities should be ordered to connect to the metropolitan system.

As an alternate but less desirable approach, the cities on the Rocky and Chagrin Rivers could expand to tertiary treatment (98% BOD removal).

Table 1-4 shows the individual immediate needs in the Cleveland-Akron area. The cost of an immediate program to meet these needs is estimated at $260 million, with a following annual expenditure of $12 million to keep pace with population growth. The short and long term treatment needs for the Greater Cleveland-Akron area as well as the Northeast Ohio area, are graphically shown in Figure 1-4.

Northeast Ohio Area

Major pollution in Northeast Ohio occurs at the mouths of the tributaries where industry and municipalities are located. There are also small isolated problems upstream.

In the Painesville, Ohio area, the cities of Fairport, Painesville, Painesville East, Orwell, and Grand River should integrate and consolidate their sewer systems and treatment plants into one collection system with secondary treatment on the lake. In the Conneaut area the cities of Conneaut and Lakeville should do likewise. Additional treatment needs primarily include expanding to secondary treatment, providing collection systems, and disinfecting municipal plant effluents.

By 1990 the recommended treatment works will have to be expanded to meet an expected doubling of the population. In the Grand River Basin, tertiary treatment will be necessary by 1990.

The cost of municipal waste treatment is estimated to be $28 million for the immediate needs. An annual expenditure thereafter of $1 million will be needed to keep pace with population growth and to provide expanded and advanced treatment where needed.

The immediate pollution control needs are given in Table 1-5.

TABLE 1-4

MUNICIPAL WASTE TREATMENT NEEDS

GREATER CLEVELAND-AKRON AREA

Municipality	Present Treatment	Plant Needs
Rocky River Basin		
Berea	Secondary	Connect to metro system
Broadview Heights	Minor	Sewers & connect to metro system
Brook Park	Secondary	Connect to metro system
Lakewood	Secondary	Discharge outfall to Lake Erie
Medina	Secondary	Connect to metro system
North Olmsted	Secondary*	Connect to metro system
North Royalton	Secondary	Connect to metro system
North Royalton	Minor*	Sewers & connect to metro system
Olmsted Falls	Minor	Sewers package plant & connect to metro system
Strongsville	Minor*	Sewers & connect to metro system
Westlake	Minor	Sewers package plant & connect to metro system
Westview	Minor	Sewers package plant & connect to metro system
County Districts		
Breezewood	Secondary	Connect to metro system
Brunswick SD 100	Secondary	Connect to metro system
Beverly Hills SD 8	Secondary	Connect to metro system
Medina Co. SD 5	Secondary	Connect to metro system
Middleburg Hts.	Secondary*	Connect to metro system
Cuyahoga River Basin		
Akron	Secondary*	Advanced waste treatment
Bedford	Secondary	Connect to metro system
Bedford Hts.	Secondary	Connect to metro system
Cleveland Southerly	Secondary	Advanced waste treatment
Cuyahoga Falls	Secondary	Connect to metro system
Independence	Minor	Sewers & connect to metro system
Kent	Secondary*	Expansion
Mantua	Secondary*	Expansion
Maple Hts.	Secondary*	Connect to metro system
Middlefield	Primary	Expansion
Munroe Falls	Minor*	Sewers & connect to metro system
Northfield	Secondary	Connect to metro system
Oakwood	Primary*	Connect to metro system
Oakwood	Minor*	Sewers & connect to metro system
Ravenna	Secondary	Advanced waste treatment
Sagamore Hills	Minor	Sewers package plant & connect to metro system

*Works under construction, but may not meet criteria proposed

JUN 28 1967

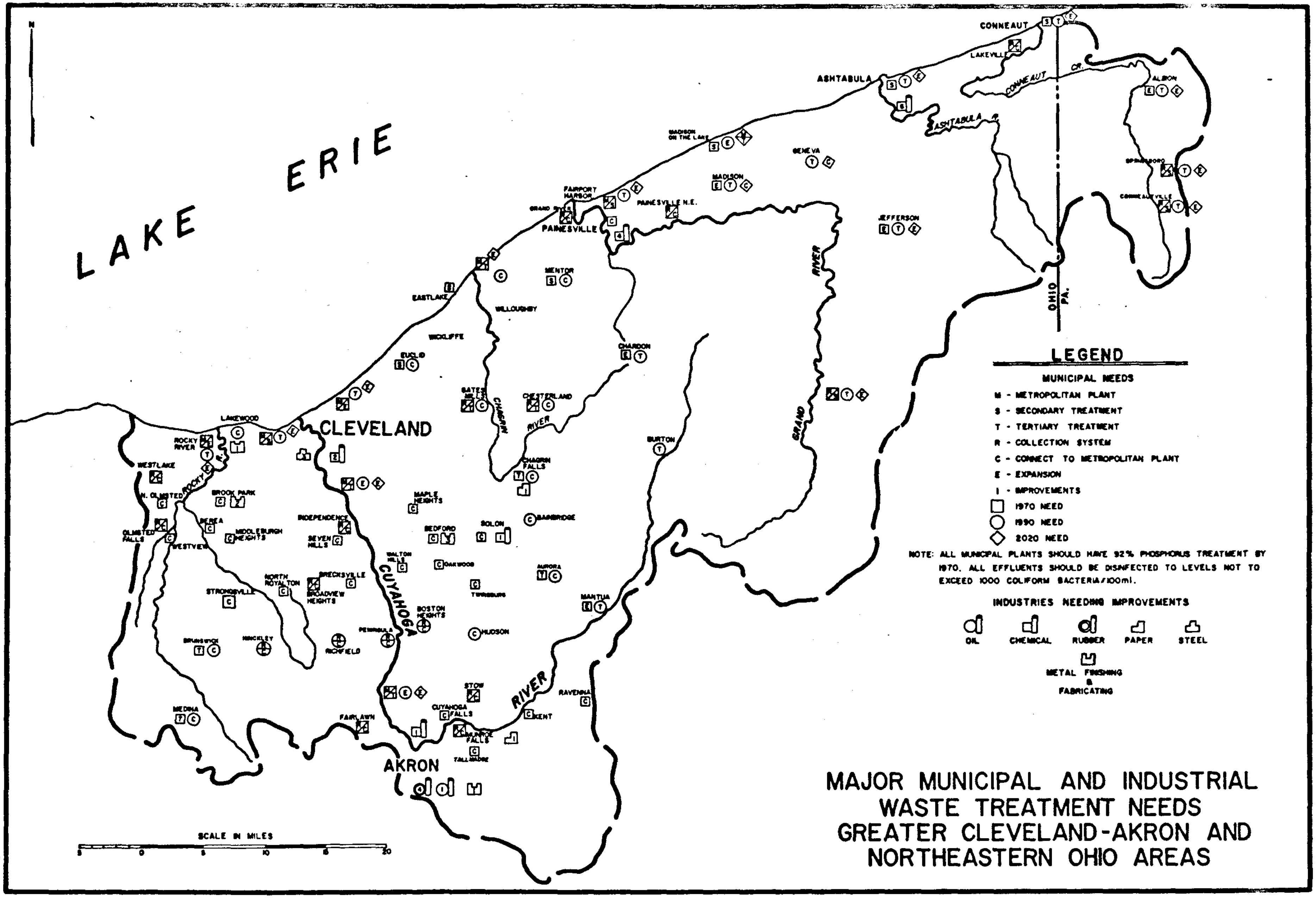
TABLE 1-4 (concluded)

MUNICIPAL WASTE TREATMENT NEEDS

GREATER CLEVELAND-AKRON AREA

Municipality	Present Treatment	Plant Needs
Cuyahoga River Basin		
Sawyerwood	Minor	Sewers & connect to metro system
Solon	Secondary	Connect to metro system
Tallmadge	Secondary	Connect to metro system
Twinsburg	Secondary	Connect to metro system
Valley View	Minor	Sewers & connect to metro system
County Districts		
Brecksville SD 13	Secondary	Connect to metro system
Northeast SD 1	Secondary	Connect to metro system
Northeast SD 6	Secondary	Connect to metro system
Northeast SD 15	Secondary	Connect to metro system
Seven Hills SD 2	Secondary	Connect to metro system
Stow Twp SD 4	Primary*	Sewers & connect to metro system
Walton Hills SD 20	Secondary	Connect to metro system
Chagrin River Basin		
Aurora	Secondary	Connect to metro system
Chagrin Falls	Secondary	Connect to metro system
Pepper Pike	Secondary	Connect to metro system
County Districts		
Chester Twp. SD 1 & 2	Secondary	Connect to metro system
Richmond Heights		Connect to metro system
Direct to Lake Erie		
Cleveland Easterly	Secondary	Expansion & extend outfall
Cleveland Westerly	Primary	Secondary & disinfection
Euclid	Intermediate	Secondary & disinfection
Willoughby-Eastlake	Intermediate	Secondary & disinfection
County Districts		
Rocky River SD 6	Intermediate	Secondary & disinfection

*Works under construction, but may not meet criteria proposed



MAJOR MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS GREATER CLEVELAND-AKRON AND NORTHEASTERN OHIO AREAS

FIGURE 1-4

TABLE 1-5

MUNICIPAL WASTE TREATMENT NEEDS FOR NORTHEASTERN OHIO

Sewerage Service Area	Present Treatment	1960 Population Served	Plant Needs
Grand River			
Fairport	Intermediate	4,267	Secondary (Metropolitan system 1)
Painesville	Primary	16,116	Secondary (Metropolitan system 1)
Chardon	Secondary	3,154	Expansion and Disinfection
Jefferson	Secondary	2,116	Expansion and Disinfection
Painesville - Northeast	Septic Tanks	1,265	Collection system and Secondary
Grand River	Septic Tanks	477	Collection system and Secondary (Metropolitan system 1)
Orwell	Septic Tanks	819	Collection system and Secondary
Conneaut Creek			
Conneaut	Primary	10,557	Secondary (Metropolitan system 2)
Lakeville	Septic Tanks	4,180	Collection system and Secondary (Metropolitan system 2)
Albion	Secondary	1,630	Expansion
Springboro	Septic Tanks	583	Collection system and Secondary
Conneautville	Septic Tanks	1,200	Collection system and Secondary
Small Tributaries			
Madison	Secondary	1,347	Expansion and Disinfection*
North Kingsville	Septic Tanks	1,854	Collection system and Secondary
Direct-to-Lake			
Ashtabula	Intermediate	28,738	Secondary
Lake County SD #1 Madison	Primary	6,000	Secondary
Lake County SD Willoughby-Mentor	Intermediate		Secondary

* - New plant to be in operation summer 1967.

Pennsylvania and New York Areas

The area of coverage for this Lake Erie comprehensive report includes the Buffalo River.

In New York State, the Erie-Niagara Basin is being actively studied by the Erie-Niagara Water Resources Regional Planning and Development Board. This board was set up under article 5 of the New York State Conservation Law. Its purpose is to facilitate water resources planning on a basin basis. Also, county-wide comprehensive sewerage studies are under way in the New York counties of Erie and Niagara. These studies are being conducted under Section 1263-a of the New York State Public Health Law and are supported by 100% state grants.

At Erie, Pa. the greatest need is for large scale expansion of the existing secondary treatment facilities to accept the pretreated waste from the Hammermill Paper Company and achieve an overall BOD and phosphorus removal of 90%.

A metropolitan system should be established for the Dunkirk-Fredonia area. This will require a secondary treatment plant in Dunkirk with discharge to Lake Erie.

At Gowanda, N. Y. there is need for a tertiary treatment plant of sufficient capacity to accept the pretreated waste discharged by the Moench Tannery and the Peter Cooper Glue Works.

The greatest need in the Buffalo area is for a long-range, area-wide master sewer and treatment plan. This plan would cover the entire Niagara Frontier area as well as the drainage to the Buffalo River and other tributaries to Lake Erie.

Many small treatment plants dot the area, especially in the suburbs surrounding the large cities. Any long range plan should call for phasing out these small plants and connecting to a large municipal system. Also, the plan should consider intercepting of most of the municipal waste drainage in the Buffalo River watershed, including the area as far down the lake as the city of Blasdell. Centralized treatment should be provided at an expanded secondary treatment plant at Buffalo. The plan should also consider intercepting the municipal waste drainage of Eighteenmile Creek with centralized treatment at the mouth of the creek on the lake. An entirely new secondary treatment plant would have to be built here.

There are approximately 14 major municipal sewerage facilities that discharge to the Lake Erie watershed from the Greater Buffalo area. Of these, six provide some form of secondary waste treatment. Fifteen major municipal sewage plants discharge partially treated effluents to the watershed in the rest of the basin. Four of these plants provide some form of secondary treatment.

The immediate goal in the treatment of municipal wastes is the provision for at least secondary treatment. Such treatment provides 90 percent BOD_5 removal and is considered adequate in the lakefront communities. To regain the desired water quality, tertiary or advanced treatment must be

TABLE 1-6

MUNICIPAL WASTE TREATMENT NEEDS FOR NEW YORK AND PENNSYLVANIA AREAS

Municipality	Present Treatment	Plant Needs
Blasdell (V)	Secondary	Connect to Buffalo metro
Cheektowage SD3 (T)	Secondary	Connect to Buffalo metro
Depew (V)	Primary	Connect to Buffalo metro
Eden (T)	Septic Tanks	Sewers and Advanced Waste Treatment
Hamburg (V)	Secondary	Advanced Waste Treatment
Hamburg (Woodlawn)	Secondary	Ex pansion
Hamburg (Mt. Vernon)	Primary	Secondary
Hamburg (Wanakah)	Primary	Secondary
Hamburg (Master)	Primary	Secondary
Holland (T)	Septic Tanks	Sewers & Advanced Waste Treatment
Lackawanna (C)	Primary	Connect to Buffalo metro
Lancaster (V)	Secondary	Connect to Buffalo metro
West Seneca SD 6 (T)	Primary	Connect to Buffalo metro
Erie County SD 2	Secondary	Expansion
East Aurora	Secondary	Advanced Waste Treatment
Arcade	Secondary	Advanced Waste Treatment
Gowanda	Primary	Advanced Waste Treatment
Gowanda State Hosp.	Primary	Secondary
Dunkirk	Primary	Integrate into one secondary plant
Fredonia	Secondary	
Springville	Primary	Secondary
Angola	Septic Tanks	Sewers and Advanced Waste Treatment
North Collins	Secondary	Advanced Waste Treatment*
Westfield	Secondary	Advanced Waste Treatment*
Brocton	Septic Tanks	Sewers and Advanced Waste Treatment*
Ripley	Primary	Advanced Waste Treatment*
Derby	Septic Tanks	Sewers and Advanced Waste Treatment*
Cattaraugus	Septic Tanks	Sewers and Advanced Waste Treatment*
Erie, Pa.	Secondary	Expansion and Collection for Un-sewered Areas
Girard, Pa.	Intermediate	Secondary
Lake City, Pa.	Secondary	Secondary Improvements

* Secondary if discharged to the lake

constructed in most inland areas. Adequate effluent disinfection is considered to be a necessity in the study area--particularly where recreational use of the receiving waters is prevalent or desired. There is also a major present need for increased phosphorus removal. Municipal waste treatment construction needs for the major communities of the area are given in Table 1-6, and illustrated in Figure 1-5. The construction cost of the recommended immediate municipal needs for Pennsylvania and New York is $45 million, with an annual expenditure after 1971 of $3.5 million needed to maintain high quality water in the face of population growth.

INDUSTRIAL WASTE TREATMENT NEEDS

Industries in the Lake Erie basin insist that, for the most part, fierce competition with similar industries elsewhere in the nation prevent them from voluntarily installing additional waste abatement facilities. In general, only through regulatory agency action have industries installed present treatment facilities. In many cases industry is unwilling to provide facilities because it is entirely unprofitable, and since there is no outside source of finance to offset this loss, they continue to pollute. There is a pressing need for nationwide regulation to make pollution requirements uniform throughout the United States, so that industry cannot use less rigid requirements in some other location as an excuse to move. Establishing water quality standards for interstate streams will improve this situation.

Industry is also often reluctant to install abatement equipment because of the lack of assurance that the planned program will solve the problem. If the operations do not work satisfactorily (as is often the case because of their frequently experimental nature) the industry has lost a great deal of money. Demonstration grants for control of industrial wastes will partially help to solve this problem.

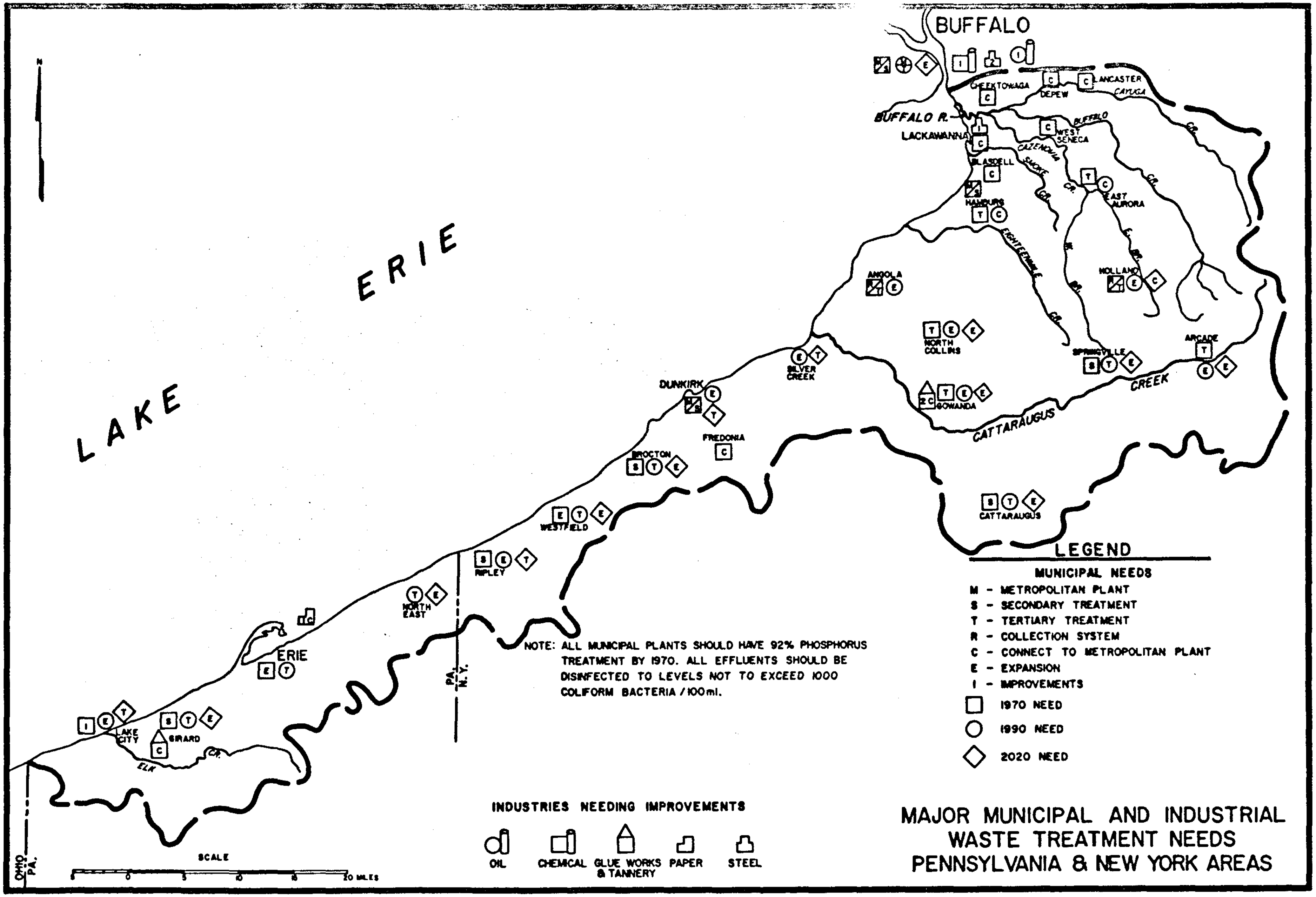
Wherever feasible, industries are encouraged to connect to municipal plants after they have provided suitable pretreatment of waste. In this way, overall waste treatment can be improved and financial gains will result because the city could qualify for an increased federal construction grant.

Perhaps the best way to control industrial discharges is by in-plant process changes to prevent or lessen the original waste products. Industrial incentives are needed to encourage this type of abatement.

The industries that discharge significant waste products into the Lake Erie basin are the heavy chemical, steel, paper, and oil ~~industries~~.

All industries should abide by the following general effluent requirements for waste constituents to protect and enhance Lake Erie water quality. Furthermore, no outfall discharging to public waters should exceed these levels at any time, nor should it be construed that industry will be permitted to redesign sewer systems in order to meet these levels without reducing its overall flow of waste constituents.

Suspended Solids	35 mg/1
Biochemical Oxygen Demand	30 mg/1



MAJOR MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS PENNSYLVANIA & NEW YORK AREAS

FIGURE 1-6

Oil	5 mg/l
Iron	17 mg/l
Phenol	0.050 mg/l
Heavy metals and CN (toxic)	0.03 mg/l each
Coliform bacteria	1000 MPN/100 ml
pH	Between 5.5 and 10.6

Industries which are already below these levels should not be permitted to increase their waste discharges to the maximum values, but should be required to maintain their concentrations at existing levels, or, if possible, to decrease their discharges.

Dissolved solids are not covered in the preceding recommendations because information is scarce on practical methods to control them. Their concentrations are increasing in Lake Erie, however, and unless something is done to halt their increase, the levels will continue to rise as cities and industries expand. With this in mind, industries should be required to maintain the flow of dissolved solids from their factories at the present level of discharge, or to decrease this discharge. Industry itself is in the best position to arrive at a solution whereby this may be achieved.

In regard to oil, it is recognized that often the allowable effluent level of 5 mg/l will not prevent an oil film from appearing on the surface of the water. Where a film is noticeable, the oil discharged should be reduced below the level of 5 mg/l to the extent that the oil film does not appear.

Specific industrial waste treatment needs will be discussed separately for each basin draining to the lake.

Southeast Michigan Area

More than 90 individual industries in this area discharge in excess of one billion gallons of wastewater each day. Some effluents contain no significant concentrations of contaminants, while some are grossly polluted with waste material.

The following is a summary of the adequacy of these treatment facilities rated by the Michigan Water Resources Commission:

Adequate treatment - 42
Inadequate treatment - 22
Unreliable treatment - 9
Adequacy not established - 18
Need not established - 1

Most of the industries with inadequate treatment in the Detroit federal-state enforcement conference area are currently under stipulations for improvements in treatment. These industries and the pollution requirements are shown in Table 1-7. This table also includes the municipal waste requirements covered in the stipulations.

Table 1-8 is a summary of the industrial waste treatment needs for Southeast Michigan. The cost of construction of these facilities is estimated at $85 million.

Maumee River Basin and North-Central Ohio Areas

Ninety-five industries have been placed under the permit system in the Maumee River Basin and North-Central Ohio areas. According to the State of Ohio, 58 have adequate treatment facilities and the remaining 37 are causing pollution problems. Also, an industry in Indiana is listed as causing problems.

As with domestic wastes, industrial wastes require a very high degree of treatment in this region in order to provide suitable stream conditions. Most industries in the basin are aware of the acute problems caused by their wastes and have programs which, when put into effect, will all but eliminate their waste problems. (For example, Sohio at Lima is spending more than a million dollars a year for operating costs of its treatment facilities.)

Besides BOD, the main industrial problems are caused by oils, phenols, ammonia, and solids. The waste discharge loadings from several of the industries listed are small, but due to the extremely low flows in many areas of the basin, these loadings are quite important. The cost of industrial waste abatement is estimated at $30 million. Table 1-9 lists the immediate industrial waste treatment needs for the Northwest Ohio area.

Greater Cleveland-Akron Area

Table 1-10 lists the immediate industrial waste treatment needs for this area. The cost of construction of these facilities is estimated to be $90 million. The waste discharge from several of the industries listed are small, but are important due to the extremely low flows in several parts of the area, The major industrial pollution materials which enter the area's waters are: solids, toxic materials, complex organic compounds, iron, acid, oil, heat, and color.

More efficient in-plant controls for reducing the volume of wastes to be treated should be instituted. Waste storage facilities and standby treatment units should be installed to permit normal maintenance work on treatment facilities; to prevent by-passing; and to prevent accidental spills and leakages from entering the area's waterways. Industrial wastes should be discharged to municipal sewage systems whenever adequate treatment can be provided by the sewage plant.

Northeast Ohio Area

TABLE 1

SUMMARY OF MICHIGAN RESOURCES COMMISSION STIPULATION FOR INDUSTRIAL POLLUTERS

Municipalities and Industries	Susp. mg/l	Solids lb/day	Sol. Phos. (as PO_4) lb/day	Phenols g/l	Phenols lb/day	Oil mg/l	BOD mg/l	BOD lb/day	Tot. Coli. MPN	Constr. Comple. Date
Allied Chem. Corp. Semet-Solvay Div.	-	-	-	-	-	(1)	-	-	--	4/1/67
Solvay Process	30	-	-	-	-	-	-	-	-	4/1/68
E. I. duPont de Nemours & Co. (2)	-	-	-	-	-	-	-	-	-	4/1/67
Time Container Corp. Monroe Paper Prod.	35	650	-	-	-	-	-	300	1000	1/1/69
Scott Paper Co.	30	-	-	-	-	-	-	31,000	-	11/1/68
Consolidated Packaging Coi. No. Plant	35	2,200	-	-	-	-	-	2,400	1000	1/1/69
So. Plant	35	2,100	-	-	-	-	-	1,500	1000	1/1/69
Ford Motor Co. Monroe Plant	-	-	200	-	-	15	-	-	1000	1/1/68
Union-Bag-Camp Co.	35	1,350	-	-	-	-	-	2,500	1000	1/1/69

(1) The effluent should not contain oil in amounts sufficient to create a visible film on the surface waters of the State.

(2) pH control

TABLE 1-7 contd.

Municipalities and Industries	Susp. mg/l	Solids lb/day	Sol. Phos. (as PO_4) lb/day	Phenols g/l	Phenols lb/day	Oil mg/l	BOD mg/l	BOD lb/day	Tot. Coli. MPN	Constr. Comple. Date
American Cement Corp.	50	-	-	-	-	-	-	-	-	5/1/67
Darling & Co.	-	-	-	-	-	-	-	600	1000	11/1/67
Wyandotte Chem. Corp.	50	-	-	-	-	15	-	-	-	4/1/68
Pennsalt Chem. Corp.	50	-	-	-	-	-	-	-	-	4/1/68
McLouth Steel Corp. Trenton Plant	50	-	-	-	-	15	-	-	-	4/1/68
Revere Copper & Brass, Inc.	50	-	-	-	-	15	-	-	-	11/1/67
Firestone Tire & Rubber Co.	-	-	-	-	-	-	-	-	-	11/1/67
Mobil Oil Co.	50	-	-	-	-	15	-	-	-	11/1/67
Monsanto Chem.Corp.										
Inorganic Chem.Div.	-	-	2000	-	-	-	-	-	-	5/1/68
Trenton Resins Plt.	-	-						2800		4/1/68
City of Detroit (present area)	50	324,000	21,000	-	93	15	-	206,000	1000	11/1/70
Wayne County (Wyandotte & Trenton)	50	19,000	3,000	-	10	15	-	28,900	1000	11/1/70

TABLE 1-7 contd.

Municipalities and Industries	Susp. mg/l	Solids lb/day	Sol.Phos. (as PO_4) lb/day	Phenols g/l	Phenols lb/day	Oil mg/l	BOD mg/l	BOD lb/day	Tot. Coli. MPN	Constr. Comple. Date
City of Riverview	50	470	35	-	0.2	15	-	920	1000	11/1/70
City of Trenton	50	935	138	-	5	15	-	1840	1000	11/1/70
Grosse Isle Twp. (formerly Wayne Co.)	50	500	20	-	1	15	-	980	1000	11/1/70
City of Monroe	50	1200	128	-	-	-	-	350	1000	5/1/69
Great Lakes Steel										
Blast FurnaceDiv.	50	-	-	-	180	15	-	-	-	4/1/68
Strip Mill	50	-	-	-	-	15	-	-	-	4/1/68
Ecorse Plant	50	-	-	-	-	15	-	-	-	4/1/68
Ford Motor Co.(Rouge)	50	-	-	-	70	15	-	-	-	4/1/69

TABLE 1-8

INDUSTRIAL WASTE TREATMENT NEEDS FOR SOUTHEASTERN MICHIGAN AREA

Industry	Location	Needs
ST. CLAIR RIVER BASIN		
Black River		
Michigan Milk Producers Assn.	Peck	Establish treatment needs
Port Huron Paper Co.	Port Huron	Establish adequacy of treatment
Belle River		
Michigan Milk Producers Assn.	Inlay City	Establish adequacy of treatment (Irrigation)
Vlasic Food Products Co.	Inlay City	Establish adequacy of treatment (holding ponds)
LAKE ST.CLAIR BASIN		
Clinton River		
Briggs Manufacturing Co.	Sterling T.	Establish adequacy of treatment (lagoon)
Chrysler Corp. Michigan Missile Plant	Sterling T.	Establish adequacy of treatment (lagoons)
Ford Motor Co. Chassis Parts	Sterling T.	Establish adequacy of treatment for oil and sanitary wastes
TRW, Inc. Thompson Products,Mich.Div.	Sterling T.	Improve reliability of treatment of oil wastes Establish adequacy of treatment of sanitary wastes
LAKE ERIE BASIN		
Huron River		
General Motors Corp. Fisher Body Div.	Willow Run	Establish adequacy of treatment (coagulation & lagoon)
Huron Valley Steel Corp.	Belleville	Improve treatment (solids in wastewater)
Longworth Plating Co.	Chelsea	Establish adequacy of treatment
Peninsular Paper Co.	Ypsilanti	Improve treatment
River Raisin		
Buckeye Products Corp.	Adrian	Establish adequacy of treatment
Dundee Cement Co.	Dundee	Improve treatment reliability
Simplex Paper Corp.	Palmyra	Establish adequacy of treatment

TABLE 1-9

INDUSTRIAL WASTE TREATMENT NEEDS FOR THE MAUMEE RIVER BASIN AND NORTH-CENTRAL OHIO AREAS

Industry	Location	Control Measures Needed
	Lower Maumee	
Toledo Edison	Toledo, Ohio	General Control Measures & Improvements
Gulf Oil Company	Toledo, Ohio	COD, Oil
Sun Oil Company	Toledo, Ohio	Solids
Pure Oil Company	Toledo, Ohio	Oil, COD, and Phenols
Standard Oil Company	Toledo, Ohio	Phenols, Oil, COD
Libbey-Owens-Ford	Toledo, Ohio	Oil, Solids, Color
Interlake Iron	Toledo, Ohio	Phenols, Solids
Johns-Manville Company	Waterville, Ohio	Solids, BOD, Phenol
Campbell Soup Company	Napoleon, Ohio	BOD
Central Foundry (Div. GM)	Defiance, Ohio	Solids, BOD
S.K. Wayne Tool Co.	Defiance, Ohio	General Control Measures
	Upper Maumee	
Weatherhead Corporation	Antwerp, Ohio	Oils and Solids
International Harvester	Ft. Wayne, Indiana	Oils, solids, heavy metals
Franke Plating Works	Ft. Wayne, Indiana	Cyanides, heavy metals
General Plating	Ft. Wayne, Indiana	Chrome and acid treatment
Parrot Packing Co.	Ft. Wayne, Indiana	BOD
	Auglaize	
Hayes Industry - Decorative Division	Spencerville, Ohio	Solids
Ohio Decorative Products	Spencerville, Ohio	Solids, Housekeeping
	Blanchard	
Buckeye Sugar	Ottawa, Ohio	BOD
National Refinery (Ashland Oil)	Findlay, Ohio	Oil, General Housekeeping
Rusco Inc.	Pandora, Ohio	Oil, Solids, Secondary Treatment of sewage
	Ottawa	
Excello Corporation	Lima, Ohio	General Housekeeping
Ford Motor Company	Lima, Ohio	Oil
Republic Creosote	Lima, Ohio	Phenol
Standard Oil Company		
Refinery	Lima, Ohio	Evaluate completed improvements
Chemical	Lima, Ohio	Ammonia
Petrochemical	Lima, Ohio	Evaluate completed improvements

TABLE 1-9 (cont)

Industry	Location	Control Measures Needed
	St. Joseph	
Edgerton Metal Products	Edgerton, Ohio	Chrome treatment, acid neutralization
Kitchen Quip, Inc.	Waterloo, Indiana	Chrome treatment, acid neutralization
Borg-Warner, Inc.	Auburn, Indiana	Chrome treatment, acid neutralization
	St. Marys	
Weston Paper	St. Marys, Ohio	BOD
Goodyear Tire & Rubber Co.	St. Marys, Ohio	General Housekeeping
Beatrice Foods Co.	St. Marys, Ohio	General Housekeeping
Essex Wire Company	Fort Wayne, Ind.	Phenol
	Tenmile Creek	
Dana Corporation	Toledo, Ohio	Oil
	Portage River	
Foster Duck Farm		BOD
Agrico Chemical Co.	Allen Township	
Hirzel Canning Co.	Pemberville, Ohio	BOD
	Sandusky River	
G. E. Lamp Plant #242	Bellevue, Ohio	BOD
Central Soya	Bellevue, Ohio	Oil
Bechtel-McLaughlin, Inc.	Sandusky, Ohio	Acids, chrome, solids
Lake Erie Cannery Co.	Sandusky, Ohio	BOD
Muskalonge View Dairy	Fremont, Ohio	BOD
Northern Ohio Sugar Co.	Fremont, Ohio	BOD
Seneca Wire & Mfg. Co.	Fostoria, Ohio	Metals, solids
Swift & Co.	Fostoria, Ohio	BOD, oil, color
Pioneer Rubber Co.	Attica, Ohio	BOD, rubber
Pa. R.R.	Crestline, Ohio	Oil
NASA Plum Brook	Sandusky, Ohio	BOD
U. S. Gypsum Co.	Gypsum, Ohio	BOD
	Huron River	
Clevite Corp.	Milan, Ohio	Acids, metals, solids
B & O R.R.	Willard, Ohio	Oil
	Black River	
U. S. Steel Corp.	Lorain, Ohio	Solids, Oil, phenols, Fe
CEI	Avon Lake, Ohio	Solids
Republic Steel	Elyria, Ohio	Solids, Oil, phenols, Fe
Ternstedt Div. GM Corp.	Elyria, Ohio	CN, chrome
Buckeye Pipeline		Oil

TABLE 1-10

INDUSTRIAL WASTE NEEDS FOR GREATER CLEVELAND-AKRON AREA

Industry	Location	Control Measure Needed
Cuyahoga River		
Republic Steel	Cleveland	Solids, Iron, Oil, Ammonia, Acids
U. S. Steel	Cleveland	Solids, Iron, Oil, Acids
E. I. DuPont	Cleveland	Solids, Zinc
Jones & Laughlin	Cleveland	Solids, Iron, Oil, Acids
Harshaw Chemical	Cleveland	Solids, Fluorides, Heavy Metals, Acids
Ford Motor Co.	Brook Park	Oil
E. W. Ferry Screw	Brook Park	Heavy Metals, Oil, Others*
Cuyahoga Meat	Cleveland	BOD, Others*
Bailey Wall Paper	Cleveland	Color, BOD, Others*
Burdett Oxygen	Cleveland	Others*
Master Anodizers	Bedford	Heavy Metals, Cyanide
Owens-Illinois Glass Co., Mill Div.	Northfield	Others* --
Cornwell Tools	Mogadore	Heavy Metals, Cyanide
S. K. Wellman, Division American Brake Shoe Co.	Bedford	Heavy Metals, Cyanide
Ferro Chemical, Division Ferro Corp.	Bedford	Heavy Metals
Zirconium Corp. of America	Solon	Solids, Chlorides
Diamond Crystal Salt Co.	Akron	Solids, Chlorides
Firestone Tire & Rubber	Akron	Solids, Others*, Oil
General Tire & Rubber	Akron	Solids, Others*, Oil
B. F. Goodrich Co.	Akron	Solids, Others*, Oil
Goodyear Tire & Rubber	Akron	Heavy Metals, Solids, Cyanides, Others*, Oil
Sunoco	Munroe Falls	BOD
Lamson & Sessions Co.	Kent	Solids, Oil
Smallwood Packing Co.	Middlefield	BOD, Oil, Others*
Rocky River		
Astoria Plating Corp.	Cleveland	Heavy Metals, Color, Cyanide
Allison Division General Motors Corp., Testing Area	Hinckley	Solids
Chagrin River		
Chase Bag Co.	Chagrin Falls	Color, Solids, BOD
Lakefront		
Cleveland Municipal Light Plant	Cleveland	Bottom & Fly Ash, Heat
Cleveland Electric Illuminating Co.		
Eastlake Plant	Eastlake	Bottom & Fly Ash, Heat
Lakeshore Plant	Cleveland	Bottom & Fly Ash, Heat

* Presently do not report materials in waste outfall.

JUN 29 1967

The principal industrial waste problem of Northeast Ohio is related to the disposition of soluble chemicals. These chemicals are not removed by the usual biological waste treatment methods. The most logical possible solutions for their removal include evaporation, recovery and utilization in the form of some marketable product, deep-well disposal, and in-plant control through process change, conservation of materials, good housekeeping, and source control. Other industrial waste problems involve settleable materials and organic waste loads, and are amenable to treatment by established methods using equipment and procedures that are readily available.

Expenditures necessary to abate industrial pollution in this area will depend upon control measures adopted by the industries involved. An estimated cost of $15 million is based on the experiences of other industries which have utilized deep-well injection into sub-surface strata containing highly mineralized waters, unsuitable for water supplies and unlikely to be used for any purpose except the extraction of useful minerals.

Industrial waste treatment needs for Northeast Ohio are given in Table 1-11.

Pennsylvania-New York Area

The principal industrial waste treatment needs for this area are control of steel, chemical and oil wastes in the Buffalo River, control of wastes from a glue works and tannery at Gowanda, New York, and treatment or control of pulp and paper wastes at Erie, Pennsylvania.

In this area, even though the industries are few in number, their waste volumes are large. Bethlehem Steel at Lackawanna, New York discharges the largest volume of waste products of any industry in the Lake Erie watershed and Hammermill Paper Company at Erie, Pennsylvania is the largest waste producer of the paper companies in the Lake Erie basin. The answer to Hammermill's problem is to discharge pretreated wastes to the Erie, Pennsylvania sewage treatment plant.

At the Bethlehem plant, a special problem results from the disposal of refuse slag in Lake Erie. As a long-range solution, it is recommended that Bethlehem Steel use the slag to build a dike along the entire waterfront area of the plant, enclosing the area around Smokes Creek and South Ditch for a large final treatment lagoon. This lagoon should not replace treatment facilities planned or under construction within the plant, but should serve as an effluent polishing device and as emergency treatment in case of spills or equipment breakdown. The outer wall of the dike should be reinforced with riprap to prevent erosion.

The most obvious pollution problem in this area and perhaps one of the most well-known and appalling in the nation occurs in the Buffalo River. It is partly caused by industrial wastes. The river, already heavily polluted and stagnant from upstream sewage discharges, receives massive outfalls of

TABLE 1-11

INDUSTRIAL WASTE TREATMENT NEEDS FOR NORTHEAST OHIO

Industry by Subbasin	Location	Control Measures Needed
GRAND RIVER BASIN		
Calhio Chemical, Inc.	Perry	Solids, chlorides
Diamond Alkali Co.	Painesville	Solids, chlorides, ammonia, phenol, color
U. S. Rubber Co. - Uniroyal	Painesville	Solids
A. E. Staley Manufacturing Co.	Grand River	BOD, oils, solids, & connect to city sewers
ASHTABULA RIVER BASIN		
Cabot Titania Corp. Titanium Dioxide Plant	Ashtabula	Solids, chlorides, color, pH
Cabot Titania Corp. Titanium Tetrachloride Plt.	Ashtabula	Solids, chlorides, pH
Detrex Chemical Industries, Inc. Chlorinated Solvents	Ashtabula	COD, solids, chlorides, pH
Diamond Alkali Co. Semi-Works	Ashtabula	COD, solids, chlorides
General Tire & Rubber Co. Chemical Division	Ashtabula	Solids
Olin Mathieson Chemical Corp. TDI Facility	Ashtabula	Solids
Reactive Metals, Inc. Metals Reduction Plant	Ashtabula	Solids, chlorides, pH
Reactive Metals, Inc. Sodium & Chlorine Plant	Ashtabula	Solids, pH
CONNEAUT CREEK BASIN		
Albro Packing Co.	Springboro	BOD, solids, and connect to city sewers
SMALL TRIBUTARIES		
True Temper	Geneva	Oils, solids
DIRECT TO LAKE		
Midland Ross Corp. IRC Fibers Division	Painesville	Color, oils, solids, chlorides, zinc, BOD
Cleveland Electric Illuminating Co.	Ashtabula	Fly and bottom ash
Detrex Chemical Ind. Inc. Chlorine-Alkali Plant	Ashtabula	Solids, chlorides

TABLE 1-11 (cont.)

INDUSTRIAL WASTE TREATMENT NEEDS FOR NORTHEAST OHIO

Industry by Subbasin	Location	Control Measures Needed
Union Carbide Corp. Linde Division	Ashtabula	Solids
Union Carbide Corp. Metals Division	Ashtabula	Solids

industrial waste from Republic Steel, Donner Hanna Coke, Mobil Oil, and Allied Chemical just before emptying into Lake Erie.

Expenditures necessary to abate industrial pollution in this area are estimated at $35 million. Industrial waste treatment needs for Pennsylvania and New York are given in Table 1-12.

ALTERNATIVES

The pollution abatement program presented in this report represents the best solutions to the water quality problems of the Lake Erie Basin based on present known technology. It is not, however, either a final nor a maximum solution. Other pollution control possibilities exist and more will become evident as technology and knowledge of the lake advance.

The most obvious alternative is simply to allow quality to deteriorate, with only enough waste treatment provided to avert a public nuisance. The next most obvious solution is to maintain the status quo--let water quality get no worse and no better.

More acceptable alternatives that deserve mention, although they do not fit into the desired plan of this report, include:

1. Instream reaeration in reaches suffering from lack of DO.

2. Mid-lake reaeration within the period of summer thermocline formation to break up the thermocline and allow the lake waters to mix.

3. Provisions for flow augmentation at many locations.

4. Diversion of water from the Hudson Bay drainage system into the Great Lakes.

5. Dredging of the entire bottom of Lake Erie.

6. Building a pipeline around Lake Erie and treating municipal and industrial wastes at the outlet of the lake.

Each of the possibilities will be discussed separately in this section. In addition, methods for abating pollution from combined sewer overflow which have been proposed, or are being studied, will be discussed here.

Instream reaeration is obvious where dissolved oxygen concentrations in the stream are less than those demanded by uses. By reaerating the water, it is possible to maintain a higher DO level under circumstances where the process of waste assimilation is continuing and would otherwise result in oxygen depletion. Unlike flow augmentation and waste treatment, reaeration is specific in its operation. Its benefits extend only to dissolved oxygen, whereas waste treatment and flow augmentation provide multiple benefits.

TABLE 1-12

INDUSTRIAL WASTE TREATMENT NEEDS FOR PENNSYLVANIA AND NEW YORK

Industry	Location	Control Measures Needed
Allied Chemical, Buffalo Dye	Buffalo	Color, solids, BOD, acid, phenol
Bethlehem Steel	Lackawanna	Oil, CN, phenol, solids color, ammonia, acid, iron
Donner Hanna Coke	Buffalo	Oil, phenol, BOD
General Mills	Buffalo	Sewage & connect to Buffalo metro
Mobil Oil	Buffalo	Oil, phenol
Lehigh Cement	Buffalo	Solids
Pennsylvania Railroad	West Seneca	Oil
Pillsbury	Buffalo	Sewage & connect to Buffalo metro
Republic Steel	Buffalo	Oil, solids, color, acid, iron
Silver Creek Preserving Co.	Cattaraugus Indian Reservation	Solids, color, oil
Moench Tannery Co.	Gowanda	BOD, solids, connect to Gowanda STP
Peter Cooper Glue Works	Gowanda	BOD, solids, connect to Gowanda STP
Gunnison Brothers	Girard Township,Pa.	Tertiary treatment for removal of BOD and solids
Hammermill Paper Company	Erie, Pa.	Secondary treatment for removal of BOD, color, foam, and taste and odor, connect to Erie, Pa. STP
Welch Grape Juice	Westfield, N.Y.	Connect to city sewers
Seneca Westfield Maid	Westfield, N.Y.	Connect to city sewers
Growers Coop Grape Juice	Westfield, N.Y.	Connect to city sewers
Welch Grape Juice	Brocton, N.Y.	Connect to city sewers
Pro-Canners Coop	North Collins	Connect to city sewers
Gro-Packers Coop	North Collims	Connect to city sewers
Allegheny-Ludlum Steel	Dunkirk, N.Y.	Solids, oil, acids
Niagara Mohawk	Dunkirk, N.Y.	Solids
Hanna Furnace	Buffalo, N.Y.	Solids
Symington Wayne	Depew, N.Y.	Oil, BOD & Color

Except for a few local areas, serious DO depletions occur most frequently at the mouths of major tributaries where navigational channels have been built. Reaeration could be accomplished at these locations by installation of mechanical devices to induce turbulence and force oxygen into solution with the water. The stream reaches requiring this extend for several miles. Because of the sluggishness of these reaches, it would be necessary to reaerate practically the entire stretch of stream. Attempts to employ this method of stream pollution control have met with only limited success in other parts of the country. At best, instream reaeration should follow high-level waste treatment as an emergency measure or last step and should never be used to take the place of treatment at the source.

The only location in the watershed where a possibility exists for using this alternative with success is the Ottawa River below Lima, Ohio. After waste treatment facilities have been installed by the city and the Standard Oil Company, reaeration should be employed if the DO in the river still falls below desired levels

Because of the limited success and disappointing results of instream reaeration elsewhere, its narrow benefits, and its questionable application to the Lake Erie watershed, it is not considered generally in the overall recommendations of this report.

Mid-Lake reaeration is being used experimentally in a few locations in this country not so much to increase the DO of the hypolimnion but as a means of breaking up the thermocline. In the summer months, mid-Lake Erie suffers from lack of DO in the hypolimnion; this leads to many of the lake's problems. If the lake waters could be mixed in such a way to prevent formation of the thermocline, overall water quality conditions would improve. This idea is strictly experimental, but is worthy of an attempt in Lake Erie. Even this method, if it works, should in no way take the place of the best waste treatment tributaries.

Flow augmentation through construction of multipurpose reservoirs appears beneficial to water quality control at three locations in the Lake Erie watershed; namely, the Huron River in Michigan,Sandusky River in Ohio, and Cattaraugus Creek in New York. Primarily because of the geologic nature of the basin, other areas are not suitable for this alternative. The watersheds of the western end of the lake are extremely flat, and the watersheds at the eastern end are small, Low flow augmentation would prove beneficial only to tributary waters; it would not benefit the lake.

The areas of worst pollution are at the mouths of tributaries. Sustained flows during dry periods would not be sufficient to benefit the water quality in these areas. One possibility does exist, however, for using low flow augmentation to improve water quality at the tributary mouths. Once all treatment has been provided by industries and municipalities, it would be possible to pump lake water to the uppermost end of the navigational channel, or further, if economics and the pollution nature of the stream warrant such extensions. This would provide a means to keep the sluggish waters moving during dry weather to prevent a buildup of pollutants.

Areas where this approach appears feasible are the lower reaches of the Rouge, Raisin, Cuyahoga, and Buffalo Rivers. It is already being practiced in the Buffalo River with recirculation of 100 cfs of lake water through the river. But improvement will not be noticed in the Buffalo River until waste treatment, as recommended in this report, is installed. This method, like others included here as alternates, should be considered only as an additional step after adequate waste treatment has been installed.

The Cuyahoga River basin is a special case, where additional flow provisions should be considered. The Cuyahoga is used extensively from headwaters to mouth and, beginning a few miles above Akron, becomes so degraded in quality that it is fit only for waste disposal. In fact, during low flow periods, the city of Akron uses the entire flow of the river for its water supply. The only practical means for augmenting flow above Akron (because of the limited size of the watershed) is to pump water out of Lake Erie and recirculate it rhough the entire Cuyahoga River. This would require elevating the water 480 feet and pumping it a distance of 20 miles from Lake Erie to the headwaters of the Cuyahoga River. It is not an urgent need at present because impounded waters above Akron will be sufficient for water supply for approximately 30 years. After that, this alternate approach should be strongly considered both for water supply and quality control benefits.

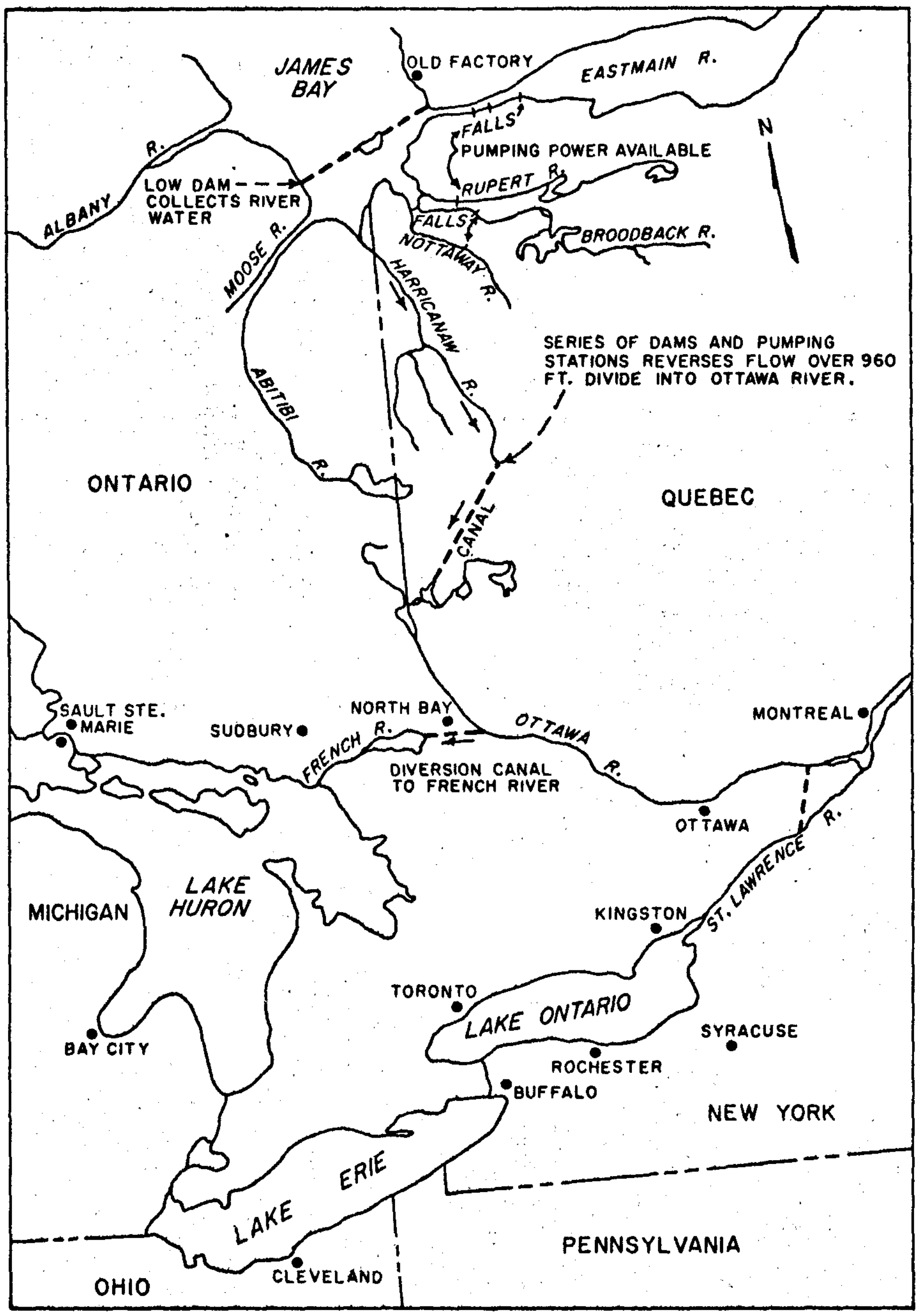
Diversion of water into the Great Lakes from the James Bay Drainage has been proposed by T. W. Kierans, Consulting Engineer from Sudbury, Ontario. He calls it the "Grand Canal Concept." He claims that a system delivering 25,000 cfs could be built for $2 billion to deliver water to the Great Lakes at less than 1.5¢ per 1,000 gallons. He also states that the diverted water would help to regulate lake levels and reap sizable benefits to water quality. The starting point of this proposal would be a low-level barrier across James Bay which would keep the water of several rivers that flow into the bay from mingling with salt waters. The fresh water would be pumped over the divide at its lowest elevation--about 969 feet--through a canal and into the Ottawa River, Ontario. From there, it would be pumped through another canal into the Great Lakes at Georgian Bay (see Fig. 1-6).

The FWPCA has evaluated the benefits to water quality in Lake Erie from such an approach and considers the improvement to be minor and not worth the expense for pollution control purposes alone. Therefore it is not a satisfactory alternate to the water pollution abatement program recommended, nor is it deemed advisable even as an adjunct to the recommended program.

Dredging Lake Erie to remove the polluted sediments has been proposed. One theory states that long after necessary pollution abatement projects are completed, the lake bottom will continue to exude pollutants into the waters, and the continued recycling of contaminants will cause the lake to remain polluted for many years.

To remove the top 3 feet of sediments would require $14 billion and many years to accomplish. Also to be considered is the question of where to dump the material after removal from the lake.

Because of the complete absence of knowledge about actual benefits of such



GRAND CANAL CONCEPT

FIGURE 8-1-6

an undertaking and the questionable nature and great expense, this proposal is considered impractical. The FWPCA does not believe that it will be necessary to remove bottom sediments in order to restore Lake Erie water quality.

Building a pipeline around Lake Erie and treating the municipal and industrial wastes at the mouth of the lake has been proposed. This would require a pipeline approximately 400 miles long, ending in a giant 5,000 mgd secondary treatment plant in the Niagara Falls area. The proposed pipeline would rest on the lake bottom just offshore. Estimating the cost of the pipeline and connections at $2 million per mile and cost of the treatment plant at $500 million, an expenditure of $1.3 billion would be required. This fantastic idea is considered impractical. It is more costly than the recommended plan, extremely difficult to implement and ignores the ability of waters to absorb a certain amount of chemicals without causing problems. Furthermore, overcoming the problems in Lake Erie with this approach might create similar problems in Lake Ontario.

Combined Sewer Overflow

Combined sewer overflows are responsible for a large pollutional load to Lake Erie. In the Detroit area, for example, as much as 10 per cent of the sanitary and industrial waste generated and discharged to city sewers periodically escapes directly to the river without ever reaching the treatment plant. These wastes enter the river during overflows and are considered to be simply bypassed raw sewage. Studies made in the Detroit area have shown that, in a general way, the pollution effect from separate storm sewers on a watercourse is approximately 10 percent that of combined sewers, as shown in Table 1-13. Several proposals have been made for solving this overflow problem which exists nationwide--not just in Lake Erie.

The solutions listed for the combined sewer problem are those which present technology has made available. Undoubtedly, the future will present many new approaches to the problem. But, regardless of the methods used, the cities in the Lake Erie Basin should begin today to consider an effective course of action to eliminate combined sewer discharges. The citizens of the basin must realize and accept the fact that, in the changeover of individual household or building connections, considerable expense will be involved. Clean water costs money.

Sewer Separation would require that the sanitary and industrial wastes would receive treatment at all times. During periods of rain, however, the urban runoff would go directly to the lake, and since runoff does carry a slight waste load, some pollution would still occur.

Separating sewers in the Lake Erie Basin would cost approximately $3 billion. If this figure were extended over a 50-year period to the year 2020, it would cost $5/capita/year.

In new construction and in redevelopment areas, separate storm and sanitary sewers should be laid. In the course of redeveloping cities, it costs relatively little to lay separate sewers when the streets are repaved, buildings are rebuilt,

TABLE 1-13

COMPARISON OF DISCHARGE FROM COMBINED AND SEPARATED SEWER SYSTEMS

Analysis	DETROIT Combined Sewer Overflow Pounds per acre	ANN ARBOR Separate Sewer System Pounds per acre
Phenols	0.042	0.002
BOD	90	31
NH_3-N	6.2	0.7
Organic Nitrogen	1.6	0.4
Soluble phosphorus	1.9	0.3
Total phosphorus	3.7	0.9
NO_3-N	0.15	0.8
Total Coli*	17,000,000	1,700,000
Fecal Coli*	3,100,000	78,000

* Densities per 100 ml and data from studies conducted in 1964. Results are median densities of monthly geometric means.

or sewer and water lines wear out. Over a period of 50 to 100 years, a city is mostly redeveloped anyway, so that sewer separation, if considered in this light, would be practical.

The $3 billion figure cited above for sewer separation does not include connections to individual buildings, separation of house laterals, roofdrains, etc.--this cost might be an additional $3 billion.

Underground Storage has been proposed by the City of Chicago to serve a 21 square mile area in the southern suburbs at a cost of approximately $85 million. Excess storm and sanitary runoff collected during and shortly after a rain would be stored in underground caverns and then bleed through the sewage plant for treatment during dry weather. This idea might be applicable to some communities on Lake Erie.

Sedimentation Basins have been used on a small scale in a few places and have been considered by such cities as Toledo and Cleveland on a grand scale. The process involves treating the combined sanitary and storm runoff by settling in gigantic catch basins built either of concrete or made by diking in large portions of lake waterfront. It would be necessary to have sludge draw-off facilities in these basins. The supernatant overflow could be treated by chlorination or piped to the centralized treatment plant of the city.

The City of Toledo has calculated that this plan would cost approximately $29 million to store a 1-inch rain.

Express Sanitary Sewers are presently being utilized by Cleveland to bring the sanitary wastes from the suburbs, where separated sewers exist, directly to the city's three large treatment plants. This plan is fine for the suburbs and does help the sewer system of the inner city by relieving the combined sewers of the load from the suburbs. It does not, however, totally solve the sewer problem of the inner city, and long-range plans should consider alternate solutions for the combined sewer area.

The cost of installing three major trunk sewers to carry sanitary wastes from the suburbs to the Cleveland treatment plants has been estimated at $20 million.

Storage in Existing Sewer System has been used in a number of large cities--for example, Detroit, Michigan and Washington, D.C. It involves building the combined sewers much larger than would be necessary to handle dry weather flow. When rain occurs, the excess runoff can be stored in the sewer system and drawn off to the treatment plant during dry weather. This plan has been of limited effectiveness in Detroit because the sewers were not originally built big enough.

This alternative is not considered to be applicable to cities in the Lake Erie Basin. To make the sewers big enough to achieve the desired result of eliminating overflows would require a giant sewer construction program which would cost almost as much as separating the sewers.

Detroit and a few other large cities in the country are attempting to make more effective use of their existing system by automation, through use of a series of centrally controlled gates, pumps, and rain gages. Instead of merely storing the excess runoff in the portion of the system where a rainstorm occurs, they will be able to store an isolated rain in the entire city sewer system. This plan, however, should only be considered temporary, since it will reduce the number and duration of overflows but will not eliminate them.

Sanitary Force Mains Inside Existing Combined Sewers is an idea being put to test by a few cities which involves constructing a pipeline for carrying the sanitary sewage inside the existing combined sewer. Actually, this is a form of sewer separation, but does not involve the major street and sewer rehabilitation construction that separate sewers require. Cost for such a system is not known at this time, but the idea, as proposed, seems feasible and practical.

SUMMARY OF FINANCIAL NEEDS

The costs over the next five years to meet present needs for the Lake Erie watershed are estimated at $850 million for municipal treatment and $225 million for industrial waste treatment. Afterwards, the annual cost needed to maintain and operate facilities and meet the future demands is estimated at $44.5 million for municipal wastes. An additional $3 billion will be needed for complete sewer separation by the year 2020, $1.0 billion for industrial waste treatment and $400 million to control rural runoff of soil, phosphorus, and farm animal wastes. These figures are summarized in Table 1-14 and Figure 1-17 shows this by subdrainage basins.

TABLE 1-14

PRESENT AND FUTURE FINANCIAL NEEDS FOR POLLUTION CONTROL

IN THE LAKE ERIE WATERSHED

State	PRESENT NEEDS[1] (millions of dollars) Municipal[2]	Industrial[3]	LONG RANGE NEEDS (billions of dollars)	
Michigan	432	85	Municipal[5]	2.2
Indiana	8	3	Industrial	1.0
Ohio	365	132	Sewer Separation	3.0
Pennsylvania	10	5	Rural Runoff	0.4
New York[4]	35	30		
TOTAL	850	255		6.6

[1]Present financial needs are those that exist now and for the next 5 years during which proposed construction of remedial works will be completed.

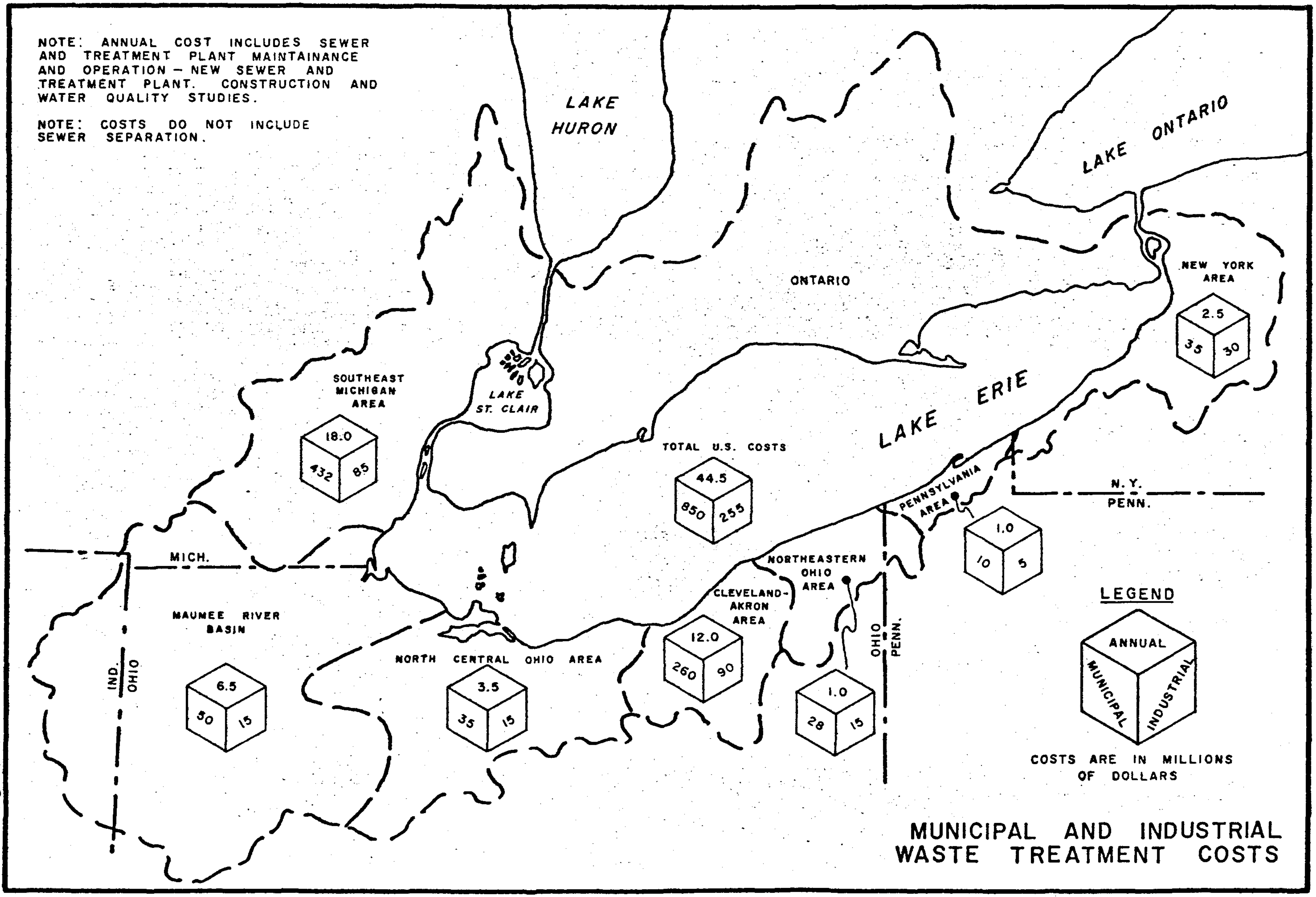
[2]Municipal costs are divided almost evenly between treatment plant and sewer construction. Municipal costs assume secondary treatment for all cities; tertiary treatment in 45 cases (most of these are in the flat, primarily rural area of northwest Ohio where tertiary lagoons would be adequate, and this is the type of treatment for which the cost figures were calculated) and development of master sewage collection and treatment systems in Cleveland, Detroit, Akron, Toledo, and Buffalo.

[3]Industrial costs are those for industries that drain to the watershed.

[4]The cost figures for the New York area includes the Buffalo River watershed, and only that portion of the western New York watershed that drains into Lake Erie.

[5]Long range municipal cost estimates include expansion of all treatment to tertiary by the year 2020, plant operation and maintenance, improvements and new sewer construction.

There is no direct financial aid to industries for construction of waste control facilities. Indirect aid in the form of tax relief is available from both state and Federal Governments. An industry can deduct



MUNICIPAL AND INDUSTRIAL WASTE TREATMENT COSTS

FIGURE 1-7

from its Federal income tax liability up to seven per cent of the construction cost of waste treatment facilities.

Industries are also financially aided indirectly to the extent that some industrial wastes are treated by municipal waste treatment plants which receive construction grants from non-local sources. It is therefore in industry's best interest to discharge its waste to a municipal sewerage system if the local plant provides adequate treatment.

Financial arrangements among municipal, state, and Federal apportionments depend on the state's water pollution control program. The following financial aids are currently available.

1. If a municipality's plans have been approved by the appropriate state water pollution control agency and the Secretary of the Interior, the Federal Government will contribute up to 30% of the cost if the municipality agrees to pay the remaining 70%.

2. If the state has a matching grant program, that is one in which they will match the municipal expenditures, the Federal Government will contribute 40% of the cost, leaving 30% each for the state and municipolity. The Federal Government grant program is operating for a period through June, 1971.

The states in the Lake Erie basin are considering legislation for a matching grant-bond program. The State of New York already has a matching grant program and along with Pennsylvania, financial assistance for plant operation.

3. If the state has a matching grant program, and in addition, has established enforceable water quality standards for the waters into which the proposed plant will discharge, the Federal Government will contribute up to 50% of the cost, with the state and municipality each contributing 25%.

An additional 10% of the amount of Federal grant can be contributed if the grant is to be applied to a metropolitan area which conforms to comprehensive plans that have been developed or are being developed for that area.

Through 1971, approximately $160 million in Federal monies will be available for Lake Erie if the full Federal share is granted.

BENEFITS FROM WATER QUALITY CONTROL IN THE

LAKE ERIE WATERSHED

The water quality control programs recommended for the subbasins of the Lake Erie watershed will, in many instances, contribute to a greatly improved living environment in future years; in others, it will assure the continuance of existing high quality water resources. The improvement or maintenance of water quality for municipal and industrial use, the enhancement of recreational opportunities including the overall betterment of the esthetic aspects of lake shores and tributaries, will result not only in dollar savings but also in greater personal enjoyment for millions of people. The projected population and industrial growth stated previously indicates not only the magnitude of future benefits, but also emphasizes the need for adequate water quality and quantity if such growth is to take place.

The benefits from water quality control measures are not always apparent to the public because such measures frequently constitute insurance for future usefulness of a vital resource or result in benefits which are indirect or intangible. Some benefits, however, such as improved fishing or swimming, or the reduction of health hazards are somewhat more apparent. Also, for many industrial uses, the quality of water supply as determined by its physical, chemical, and ~~of~~ biological characteristics is of great importance. Suitable water quality is frequently either an enhancing factor or a necessity to new industry or expanding existing industry. Substantial benefits may accrue to communities when the costs of extensive treatment of water supply can be avoided.

Accomplishment of the program objectives will result in benefits to the people of the area in particular, and to the people who reside along the shores of Lake Ontario, our Canadian neighbors to the north, and to the Nation as a whole. As the waters of Lake Erie serve many states and are of national importance, all will share in the benefits resulting from the enhancement and protection of thesewaters for both present and future needs. Let it be emphasized again that all recommendations must be carried out to the fullest extent if Lake Erie is to be saved. Any one omitted due to indifference of the people may seal the fate of Lake Erie and doom it for posterity.

The 13 million people who will reside in the area by 1980 will benefit from the assurance of a safer, more palatable water supplied to their homes, business establishments, industries, schools, and public buildings. Owners of property adjacent to and near bodies of water will derive increased esthetic enjoyment and enhanced property values from the elimination of ugliness and unsightly conditions resulting from water pollution, including nuisance algal blooms stimulated by over-fertilization.

Residents and visitors from outside the basin who use the lake for swimming, water skiing, boating and other water-oriented sports will be protected against infectious diseases which can be spread as a result of water pollution.

The need for water-oriented recreational activity in the Lake Erie basin underscores the importance of its water resources. At present, there are nearly 250 million activity days of demand within its boundaries. Of these, over 100 million are water-dependent; the remainder consist mainly of water-enhanced activities such as camping, picnicking, sightseeing and hiking. Estimates of the value of one day of recreation activity vary somewhat, but one dollar per person per activity day is considered reasonable--perhaps conservative. At one dollar per person, the annual value of such recreation presently would be a minimum of 100 million dollars. By the year 2020, it is likely to be at least 4 times this amount. These benefits are direct benefits to participants and do not include the millions of dollars of income accruing to motels, restaurants, and suppliers of boats, fishing tackle and other water-oriented equipment.

Although not all of the future dollar benefits would result from water quality control programs, some approximations of such benefits to participants are possible. The Bureau of Outdoor Recreation, in its report "Water Oriented Outdoor Recreation--Lake Erie Basin," projects that the number of occasions of participation in water-dependent activities during summer activity days will approximate 315 million in the year 2020, with present quantity and quality of facilities and almost 370 million with improvements in quantity and quality of such facilities. Even an average difference of 20 million activity days per year between the present and 2020 would result in a loss of direct benefits of at least a billion dollars--and many more millions due to loss in sales of water-oriented services and equipment. The value of protecting the benefits from current participation rates and expenditures must also be considered.

The chances are more than good that the once-prevalent sport fish, such as whitefish, cisco, sugar and blue pike may once again return to Lake Erie to challenge the skill of the sport fisherman. This will not come about without considerable effort and careful planning because even after all remedial measures have been employed, water quality needed to support these highly prized fish will not arrive overnight. Furthermore, the agency responsible for restocking the lake will have to apply utmost care and use the most advanced techniques of fishery management to restore the sport fish and maintain its delicate ecological balance.

During 1964, the average price received for the commercial catch sold was 9.4 cents per pound. This average price includes the price received for the total pounds caught and sold of all species, e.g. the

51 cents per pound received for lake whitefish and the 1.7 cents per pound for sheepshead.

Total amount of fish caught and sold by the U.S. fishing industry on Lake Erie was approximately 13.4 million pounds with a resultant value of about $1,250,000. The total demand for fishery products from the Great Lakes is likely to increase four-fold by the year 2020--the portion of the total demand which could be met from Lake Erie is more likely to increase six-fold due to Lake Erie's inherent productivity. If the average of pounds caught and sold by U.S. industry were to approximate 50 million pounds per year at 10 cents per pound, the value of fish caught and sold during a fifty year period, such as 1970 to 2020 would total about a quarter of a billion dollars. Substantial values or benefits would also result from the increased purchases of boats and equipment and from increased employment of fishermen.

To achieve such widespread benefits would necessitate not only the attainment and preservation of suitable water quality but also development of an effective management program including regulatory, biological, and marketing aspects. Considerable research effort would be necessary and justified to achieve these benefits.

In addition to these immediate and direct benefits resulting from the control of pollution, the preservation and protection of the quality of the waters of Lake Erie are essential to the Nation's growth and prosperity. This immense fresh water resource, among the greatest in the world, is showing the effects of man's carelessness and abuse. Lake Erie is a clear demonstration that size is no protection against pollution and that man has the capability of destroying the usefulness of even a major water resource. As this lake is serving as an example of what will happen to the other Great Lakes if pollution remains unchecked, it may also serve as an example of what man can do to restore the quality of his environment and provide more useful benefits to the total population.

Of all the Great Lakes, Lake Erie shows the greatest deterioration of water quality, in spite of the fact that 80% of the input to the lake is high quality water from Lake Huron. Of all the Great Lakes, Lake Erie is most amenable to a significant degree of restoration of water quality, because the principal sources of pollution are essentially within its own drainage basin and because Lake Erie has a large flowthrough in relation to volume.

The benefits derived from improved Lake Erie water quality will not accrue overnight. It will take years and much of it will depend on the long-term effect of residual pollution remaining in the lake after all objectionable wastes have been removed. The flowthrough time in Lake Erie is 2-1/2 years and this is another factor which prevents the water quality from improving rapidly.

Seeing what the future offers, it is believed that the people of this Great Lake will rise to the occasion, fulfilling their obligations of stewardship for the benefit of mankind and for those generations yet unborn.

CHAPTER 2

DESCRIPTION OF THE LAKE ERIE BASIN

PHYSICAL CHARACTERISTICS

General

The area of the Lake Erie basin is about 32,500 square miles--about 40,000 square miles if the Lake St. Clair drainage area is included. Nearly one third (9,940 square miles) of the Lake Erie Basin is covered by the lake itself, a ratio which is approximated in each of the other Great Lakes basins. However, Lake Erie receives the drainage of the four lake basins above it, so that the total watershed supplying Lake Erie is in reality 260,000 square miles.

In terms of surface area, Lake Erie ranks fourth of the five Great Lakes. Only twelve fresh-water lakes in the world are larger. The depth of Lake Erie, however, is remarkably shallow, averaging only 60 feet and reaching a maximum of 216 feet. Its total storage is 125 trillion gallons, the smallest of the Great Lakes (see Fig. 2-1 and Table 2-1).

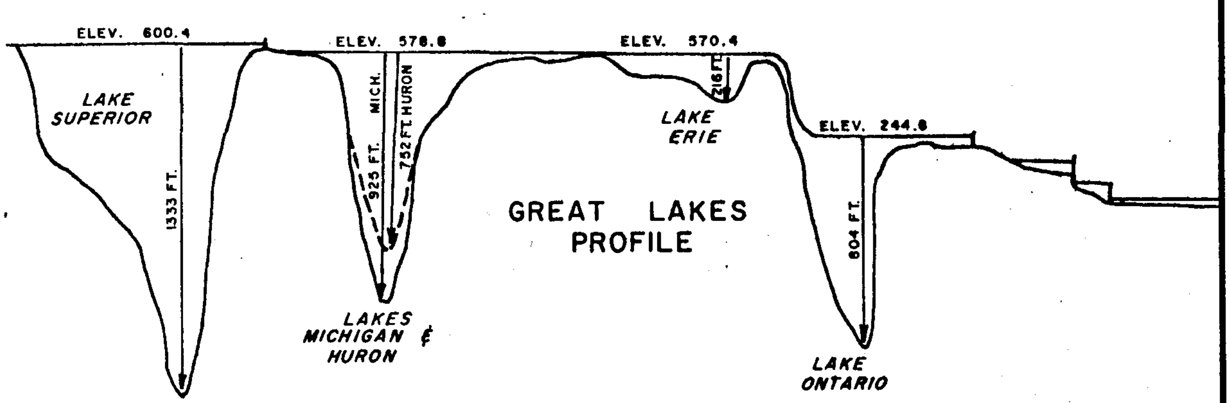
The water of Lake Erie lies entirely above the surface level of Lake Ontario, into which it drains. Lake Erie owes its existence both to the Niagara bedrock sill, which acts as a dam, and to glacial scouring during the Ice Age. The form of Lake Erie reflects the bedrock structure of the area, Fig. 2-2.

The landscape of the Lake Erie basin is characterized by thousands of square miles of flat terrain, broken only by occasional ancient beach ridges and relatively steep valley walls in many of the major tributaries. Even these features are subdued in the western part of the lake. The terrain is less monotonous from Cleveland eastward, along the south shore, where the basin reaches into the northwestern perimeter of the Appalachian uplands with their rolling hills. However the basin there is relatively narrow between the lake and the drainage divide.

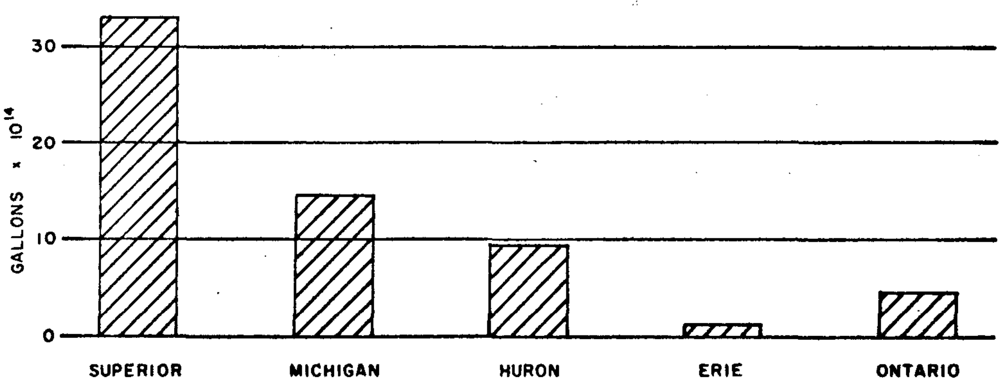
Soils in the extensive flatlands of the Lake Erie basin are characteristically dominated by poorly drained and relatively impervious clays, derived from old lake and glacial sediments, Fig. 2-3. These soils are fertile and, because of this, have been artificially drained to a great extent. The uplands along the southeast edge of the basin are well-drained, rock-derived, and less fertile. Old beach ridges throughout the basin are extensively used for highways and farming.

Streams entering Lake Erie are generally low-gradient and winding but with steep-walled valleys. They carry large silt loads where they traverse easily eroded clay flatlands and smaller loads in the rocky hilly areas. Excluding the Detroit River input, only two streams, the Maumee River in Ohio and the Grand River in Ontario, supply significant quantities of water to the lake.

THE GREAT LAKES



GREAT LAKES PROFILE



GREAT LAKES STORAGE

Fig. 2-1

TABLE 2-1

PHYSICAL FEATURES OF GREAT LAKES SYSTEM

Lake	Length (miles)	Breadth (miles)	Water Area (sq. miles) U.S.	Water Area (sq. miles) Canada	Total	Mean Depth (feet)	Drainage area (sq. miles)
Superior	350	160	20,700	11,200	31,820	487	80,000
Michigan	307	118	22,400	-	22,400	276	67,860
Huron	206	183	9,110	13,900	23,010	195	72,620
St. Clair	26	24	200	290	490	10	7,430
Erie	241	57	4,990	4,940	9,930	60	32,490
Ontario	193	53	3,600	3,920	7,520	283	34,800
Totals			61,000	34,170	95,170		295,200

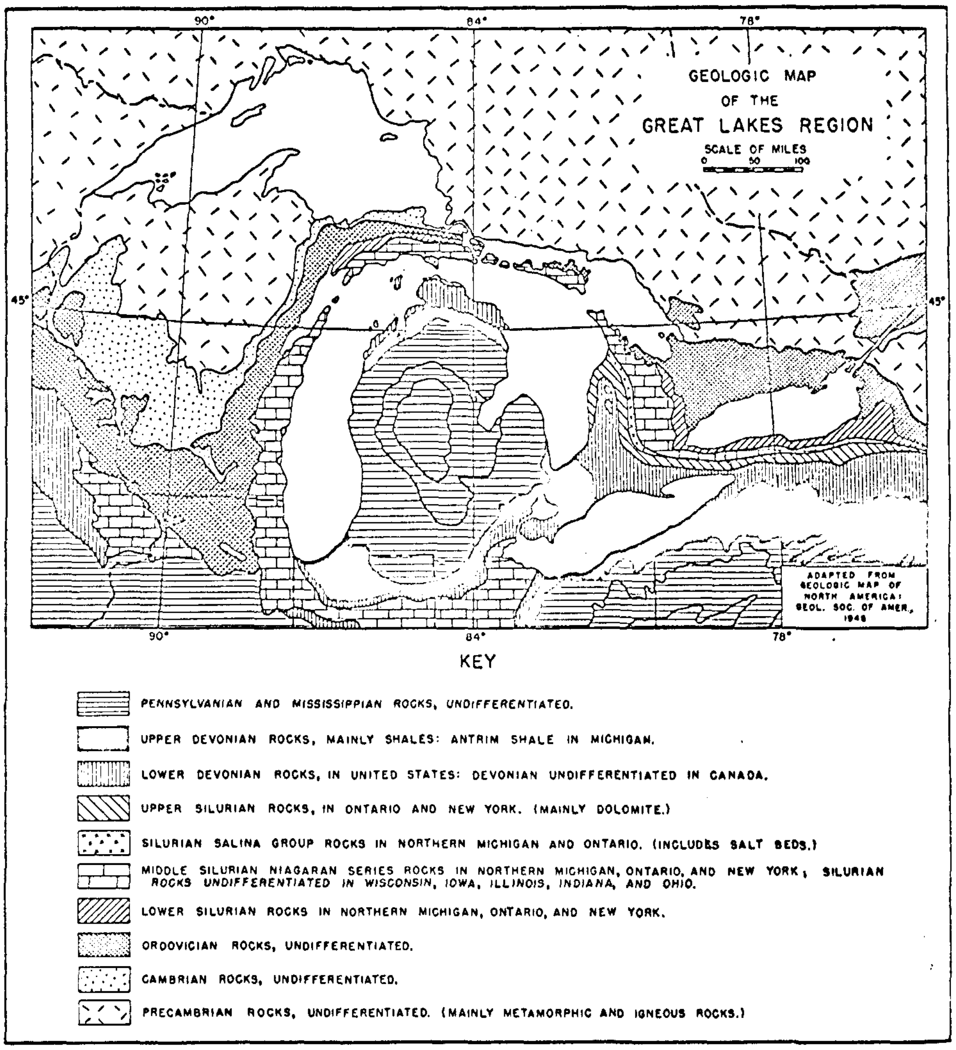
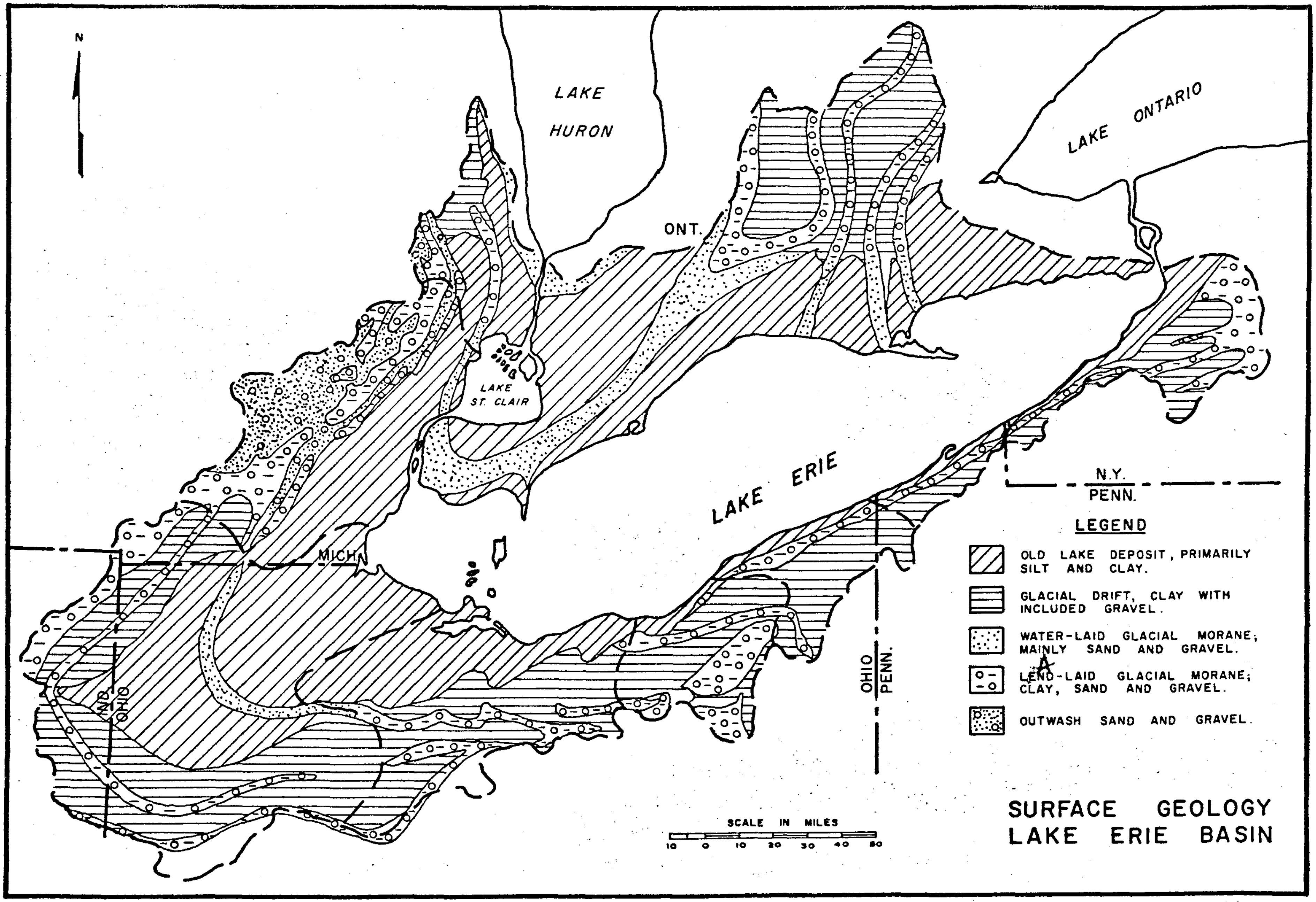


Fig. 8. Geologic map of the Great Lakes region.

were formed more than a half-billion years ago. Some of them were laid down in extensive seas of either salty or fresh water, but they have been metamorphosed into slates, quartzites, phyllites, gneisses, or other types, depending on their composition and degree of metamorphism. Large areas of the shield contain granite and other igneous rocks, cooled from the molten state. Earth forces

have folded the
have been worn
The details o
the history of th
distribution of t
form a framew
Superior.
Lapping onto
proximately 18
which were de
the sea flooded
a tendency for
was most mark
the Lower Penin
geosyncline, wh
Pennsylvania, a
Paleozoic rocks
the region the
out on the flan
in this part of t
and sandstones.
are not strongly
As with the
history are of s
The sea water
Paleozoic era,
tion of the reg
present Great L
Paleozoic seas.
tilted slightly,
processes in a
which later de
A brief exa
there is a defin
tions of the la
exerted by the
Chap. 4, for a l
shore of Lake

Fig. 2-2 -- Geologic map of the Great Lakes region.



SURFACE GEOLOGY
LAKE ERIE BASIN

Fig. 2-2

Lake Erie proper is unique among the Great Lakes in several of its natural characteristics, each of which has a direct bearing on its condition with respect to pollution. Lake Erie is by far the shallowest of the Great Lakes and the only one with its entire water mass above sea level. It has the smallest volume, 113 cubic miles, and its flow-through time of 988 days is the shortest. It is the most biologically productive and the most turbid. It has the flattest bottom; it is subject to the widest fluctuations in water level (13 feet maximum); and its seasonal average surface levels are the most unpredictable. It is the only one of the Great Lakes with its long axis paralleling the prevailing wind direction and is subject to violent storms. Lake Erie is also the southernmost, warmest, (averaging 51° F) and the oldest (12,000 years) of the Great Lakes. Although it has been studied the most, its phenomena are probably the least understood.

Geology and Topography

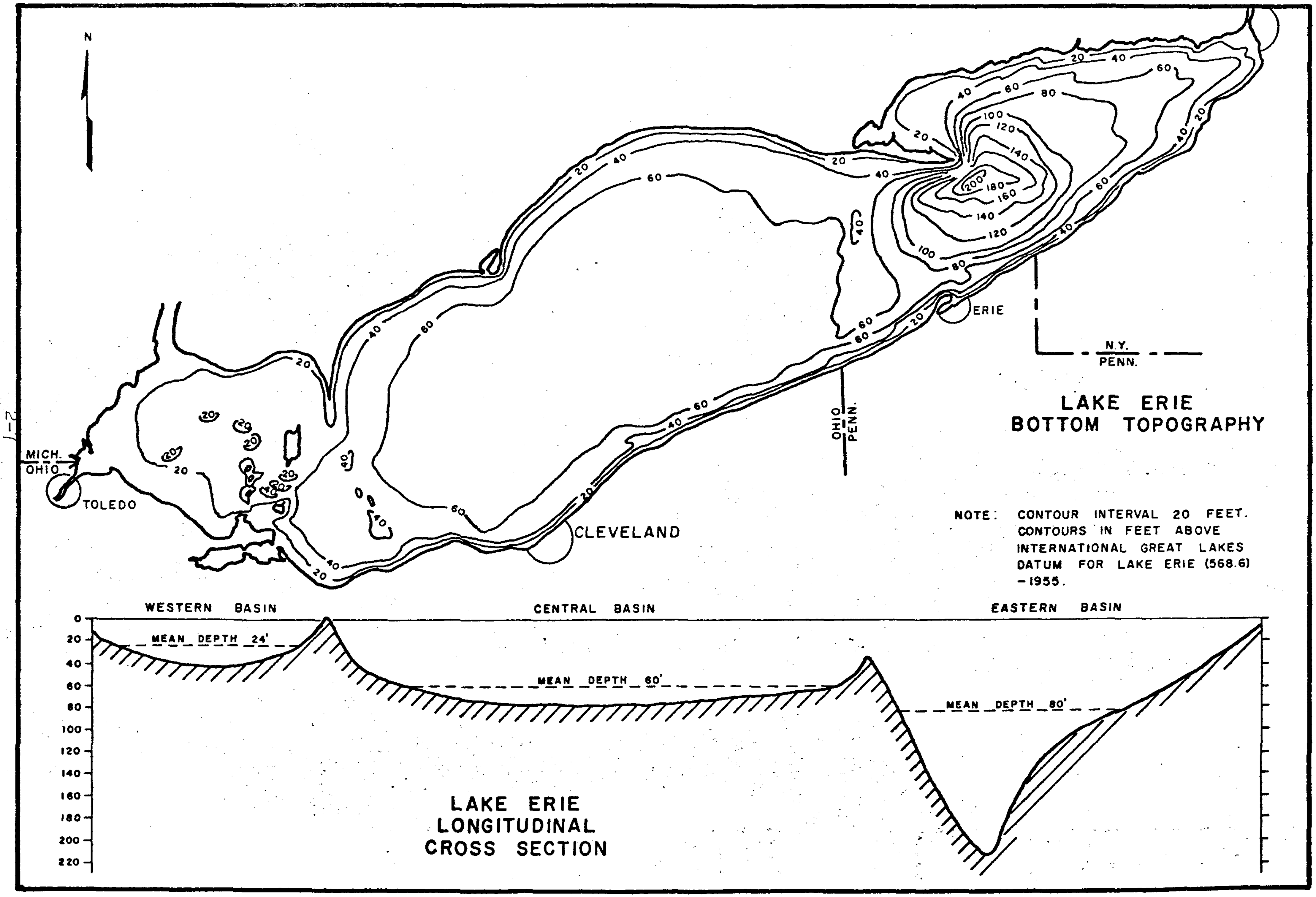
Lake Erie's shores are characterized by easily eroded banks of glacial till and not much sand. Bluffs of limestone or shale bedrock exist in the islands area, between Vermilion and Cleveland, Ohio, and around the eastern end of the lake. Good sand beaches are few in number, but where developed, are built to the extreme. Examples are Long Point, Pointe aux Pins, and Point Pelee, Ontario; Cedar Point, Ohio; and Presque Isle, Pennsylvania. The till and lake clay bluffs recede by erosion at rates up to 5 or more feet per year, contributing an average of 16 million tons of sediment annually to the lake.

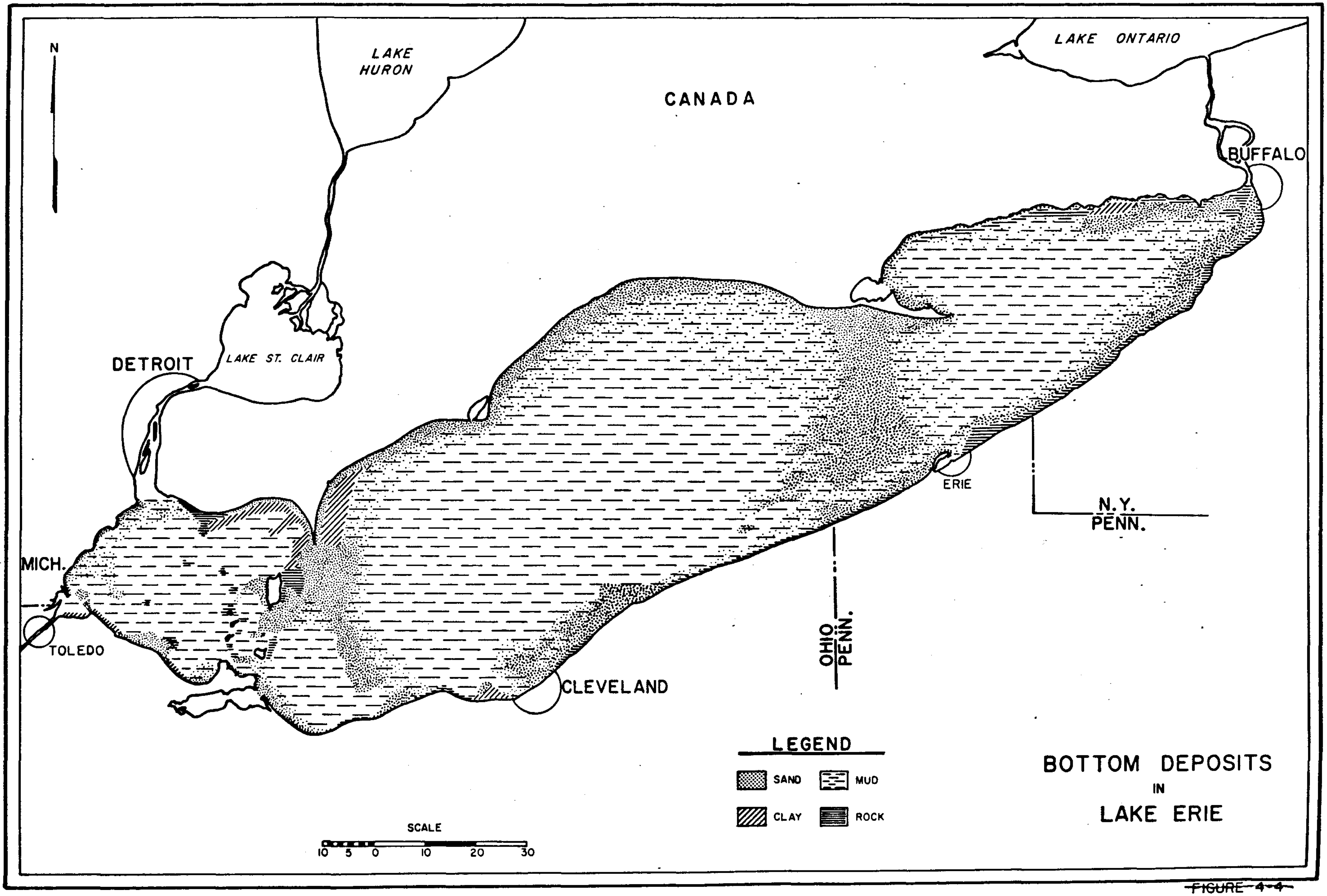
Topographically, Lake Erie is separated into three basins, Figure 2-4. The relatively small shallow western basin is separated from the large, somewhat deeper, flat-bottomed central basin by the rocky island chain. The deep, bowl-shaped eastern basin is separated from the central basin by a low, wide sand and gravel ridge near Erie, Pennsylvania. The western basin averages 24 feet deep with a maximum of 63 feet in South Passage; the central basin averages 60 feet with a maximum of 80 feet; the eastern basin averages 80 feet with a maximum of 216 feet. The areas of the western, central, and eastern basins are approximately 1,200, 6,300, and 2,400 square miles, respectively.

The bottom sediments of Lake Erie show patterns closely related to topography and relief, Fig. 2-5. In general the broad, remarkably flat areas of the western and central basins and the deeper, smoother part of the eastern basin have mud bottoms and are the recipients of nearly all of the sedimentation in Lake Erie. Ridges and shoreward-rising slopes are generally comprised of sand and gravel and are characterized by either erosion or the deposition of coarse sediments. Rock is exposed in the western basin and in strips along shores in the central and eastern basins.

Climate

The climate of the Lake Erie basin is temperate, humid-continental


LAKE ERIE
BOTTOM TOPOGRAPHY
N
MICH.
OHIO
TOLEDO
CLEVELAND
ERIE
N.Y.
PENN.
OHIO
PENN.
NOTE: CONTOUR INTERVAL 20 FEET. CONTOURS IN FEET ABOVE INTERNATIONAL GREAT LAKES DATUM FOR LAKE ERIE (568.6) - 1955.
WESTERN BASIN
CENTRAL BASIN
EASTERN BASIN
MEAN DEPTH 24'
MEAN DEPTH 60'
MEAN DEPTH 80'
LAKE ERIE
LONGITUDINAL
CROSS SECTION



BOTTOM DEPOSITS IN LAKE ERIE

~~FIGURE 4-4~~ 2-5

with the chief characteristic of rapidly changing weather.

The annual average temperatures for land stations in the Erie basin range between 47°F and 50°F. Temperatures generally decrease northeastward from the southwestern end of the basin. The highest average temperature at recording stations is at Put-in-Bay on South Bass Island with an annual average of 51.2°F.

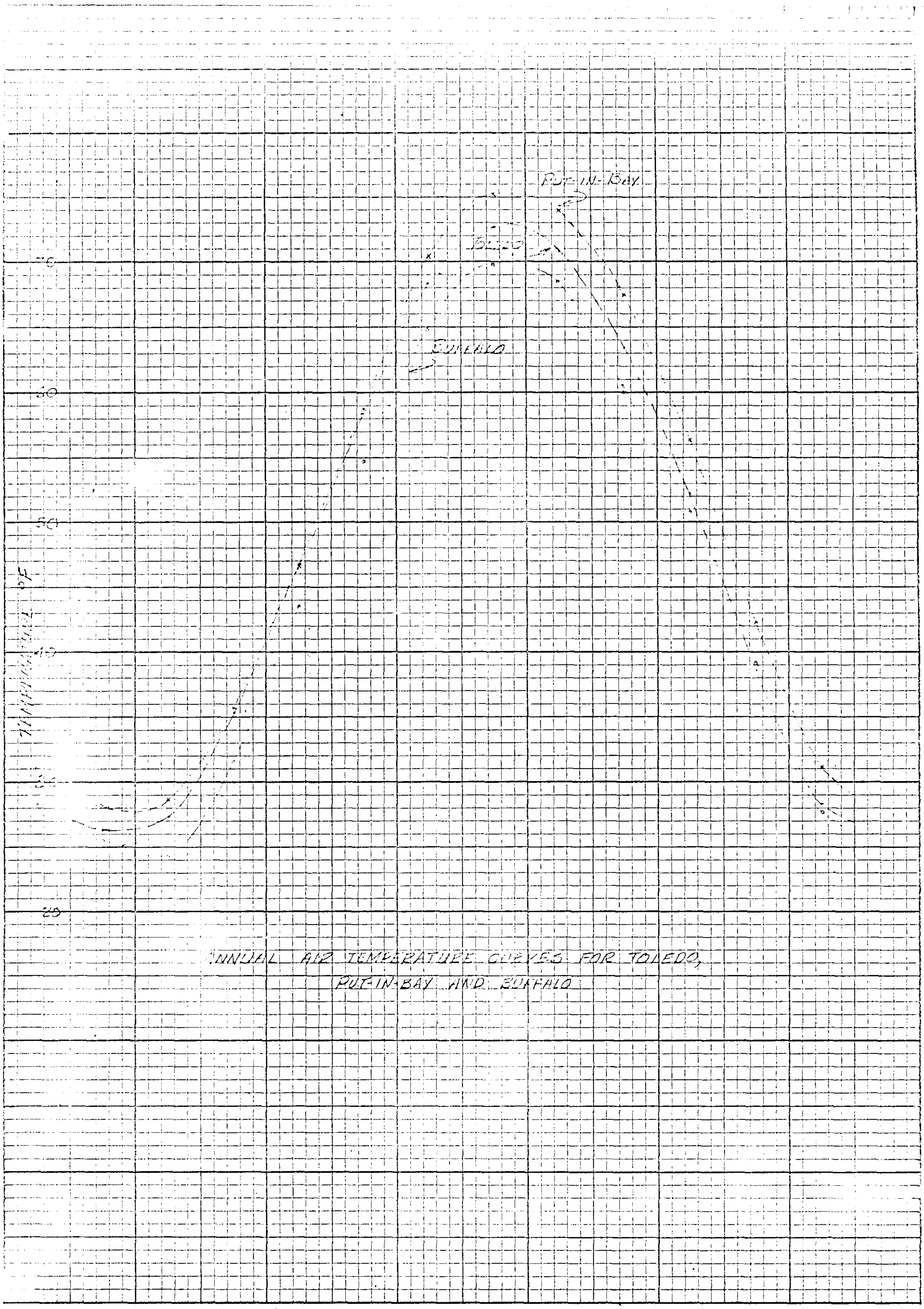
The highest average monthly temperatures occur in July, ranging from 70°F to 74°F at land stations. These also generally decrease northeastward across the basin, Fig. 2-6. Put-in-Bay again is highest at 75.1°F. The lowest average monthly temperatures occur in January at the west end of the basin and February at the east end, and range from 24°F to 28°F. The extremes of temperature in the Lake Erie basin are about -20°F and 100°F.

Average annual precipitation at land stations in the basin is well-distributed throughout the year, Fig. 2-7, and ranges from about 30.5 inches to more than 40 inches with an overall basin average of about 34 inches. Yearly precipitation has varied between the extremes of 24 and 43 inches. Precipitation shows a striking correlation to land elevation and topography, Fig. 2-8. Low-lying flat areas of the basin have the lowest precipitation. Highest precipitation occurs in the southeastern part of the basin.

Most of the precipitation in the Lake Erie basin is derived from the flow northeastward of warm, moisture-laden air of low pressure systems from the Gulf of Mexico. Precipitation results when this clashes with colder, northern air of high pressure systems, moving in from the west and northwest. This kind of weather is characteristic of spring, summer, and early fall, and usually occurs in cycles of a few days. Humidity is high along with high temperatures, and south to southwest winds persist for long periods.

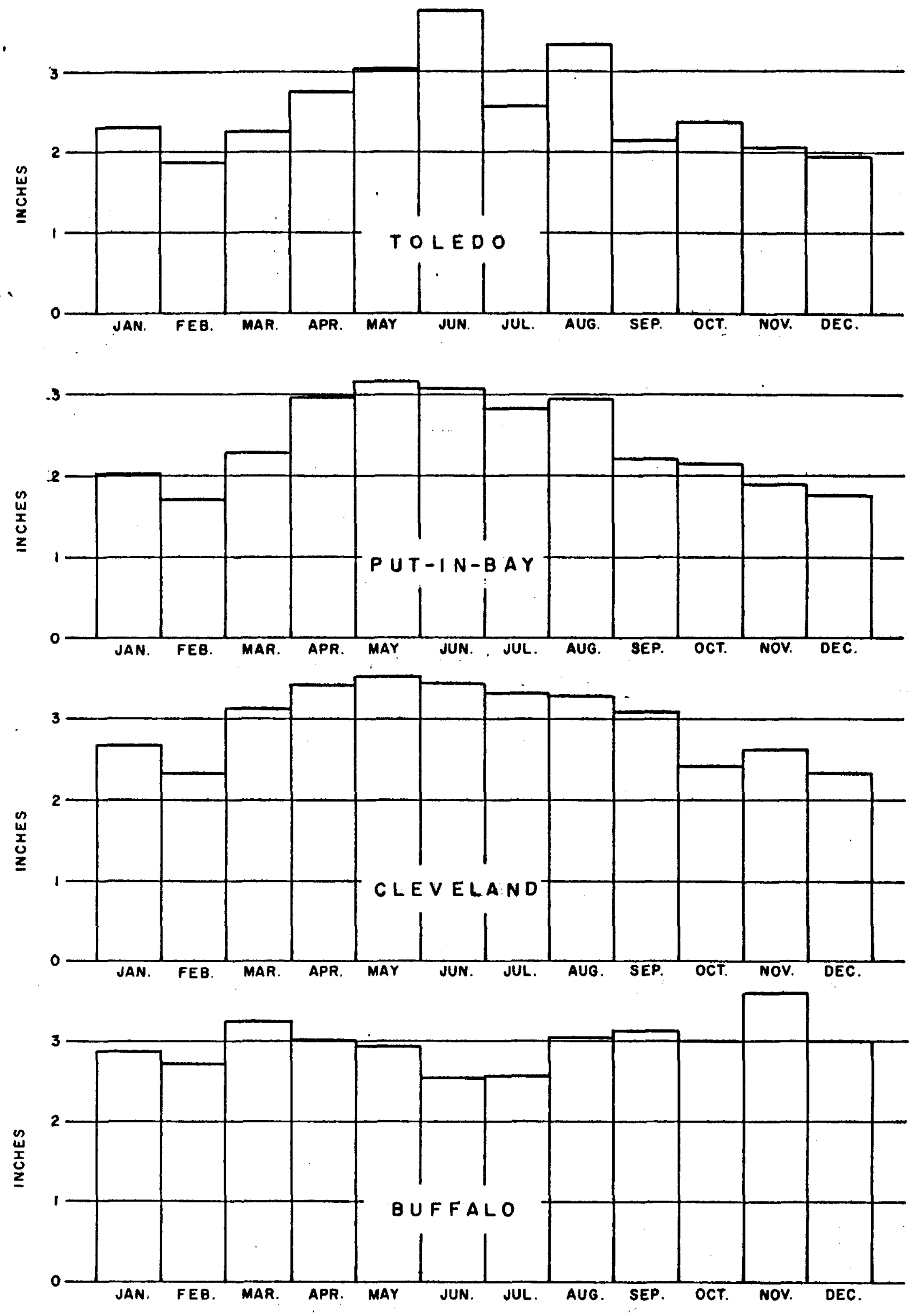
In winter, however, the colder Canadian air masses push southeastward and dominate the weather, resulting in less precipitation and less humidity. However, heavier precipitation (usually snow) is experienced in the southeastern part of the basin, explaining the shift in the annual precipitation pattern in that area. This phenomenon is largely local, caused by air moving across Lake Erie, picking up moisture enroute, and precipitating it when the air rises along the front of the hills on the southeastern shore. Snowfall is greater in the eastern part of the basin with Buffalo having an annual average snowfall of 72 inches, as compared to less than 36 inches for Toledo.

Southwesterly winds prevail in the Erie basin in all months of the year, a characteristic common to the northern hemisphere temperate region. However, in fall and winter, northwesterly winds occur frequently, reaching high velocities (40-50 mph) in storms. In spring the same is true of northeasterly winds except that velocities (30-40 mph) are usually lower.



ANNUAL AIR TEMPERATURE CURVES FOR TOLEDO, PUT-IN-BAY AND BUFFALO

Fig 2-6



AVERAGE MONTHLY PRECIPITATION AT LAND STATIONS
LAKE ERIE BASIN

Fig. 2-7

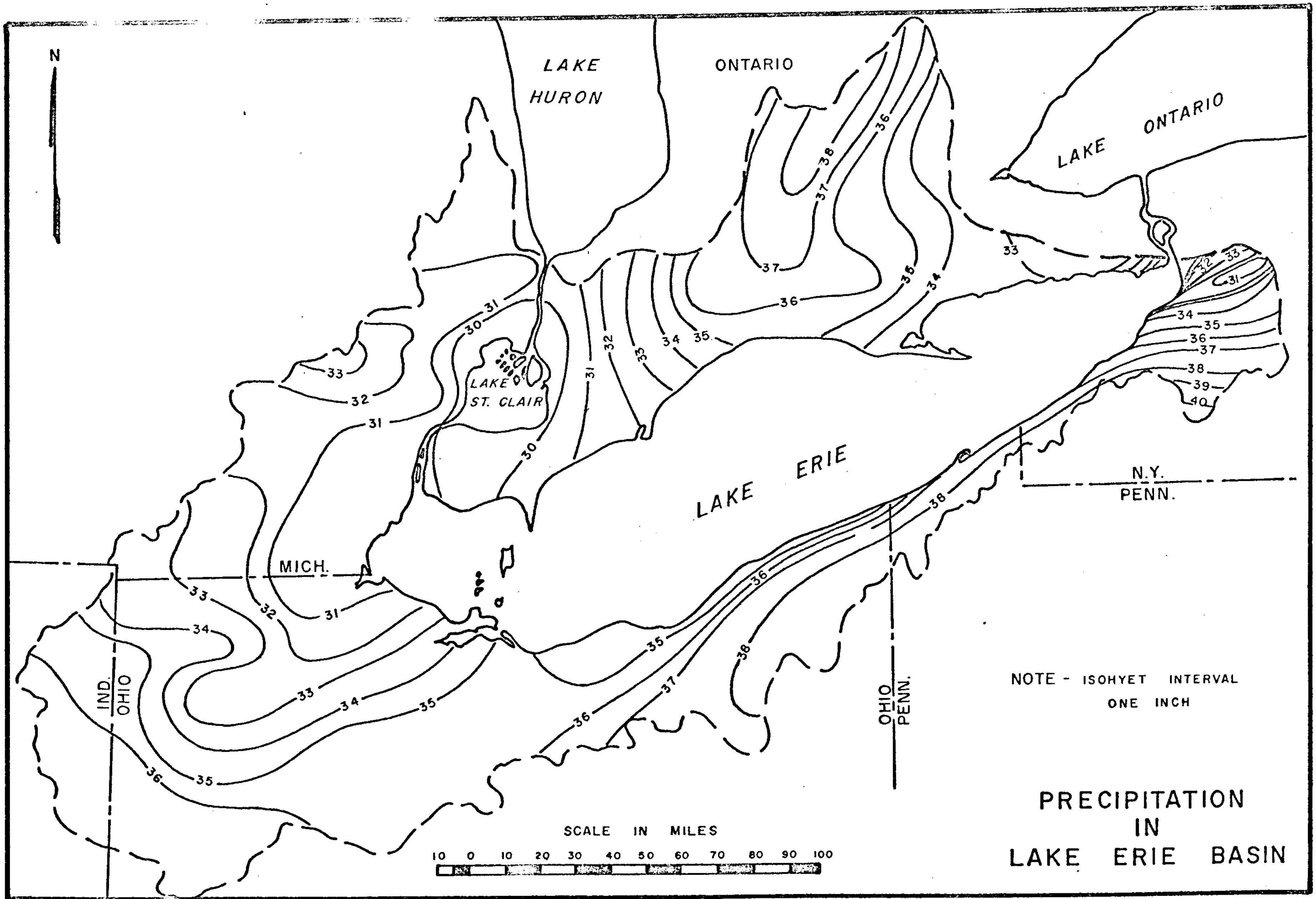

N
LAKE HURON
ONTARIO
LAKE ONTARIO
LAKE ST. CLAIR
LAKE ERIE
MICH.
IND.
OHIO
N.Y.
PENN.
OHIO
PENN.
NOTE - ISOHYET INTERVAL ONE INCH
SCALE IN MILES
10 0 10 20 30 40 50 60 70 80 90 100
PRECIPITATION IN LAKE ERIE BASIN

Fig 2-8

The percent of possible sunshine is greatest in midsummer and least in winter, Fig. 2-9, although precipitation might indicate otherwise. Less sunshine in winter is due to the cloud-producing effects of the lake. December and January ordinarily have less than 40 percent of possible sunshine, while June and July average more than 70 percent at most stations. The percentage over the lake proper in summer is even greater.

Lake Erie has a marked moderating effect on the climate of the basin, especially for a few miles inland from the shore. This is demonstrated by the length of the frost-free season--near shore it is greater than 200 days, while only a few miles inland it is as much as 30 days less. This longer frost-free season is due to a warming effect from the lake water. During the late fall and early winter the lake water is still relatively warm and delays the first killing frost.

Land Use

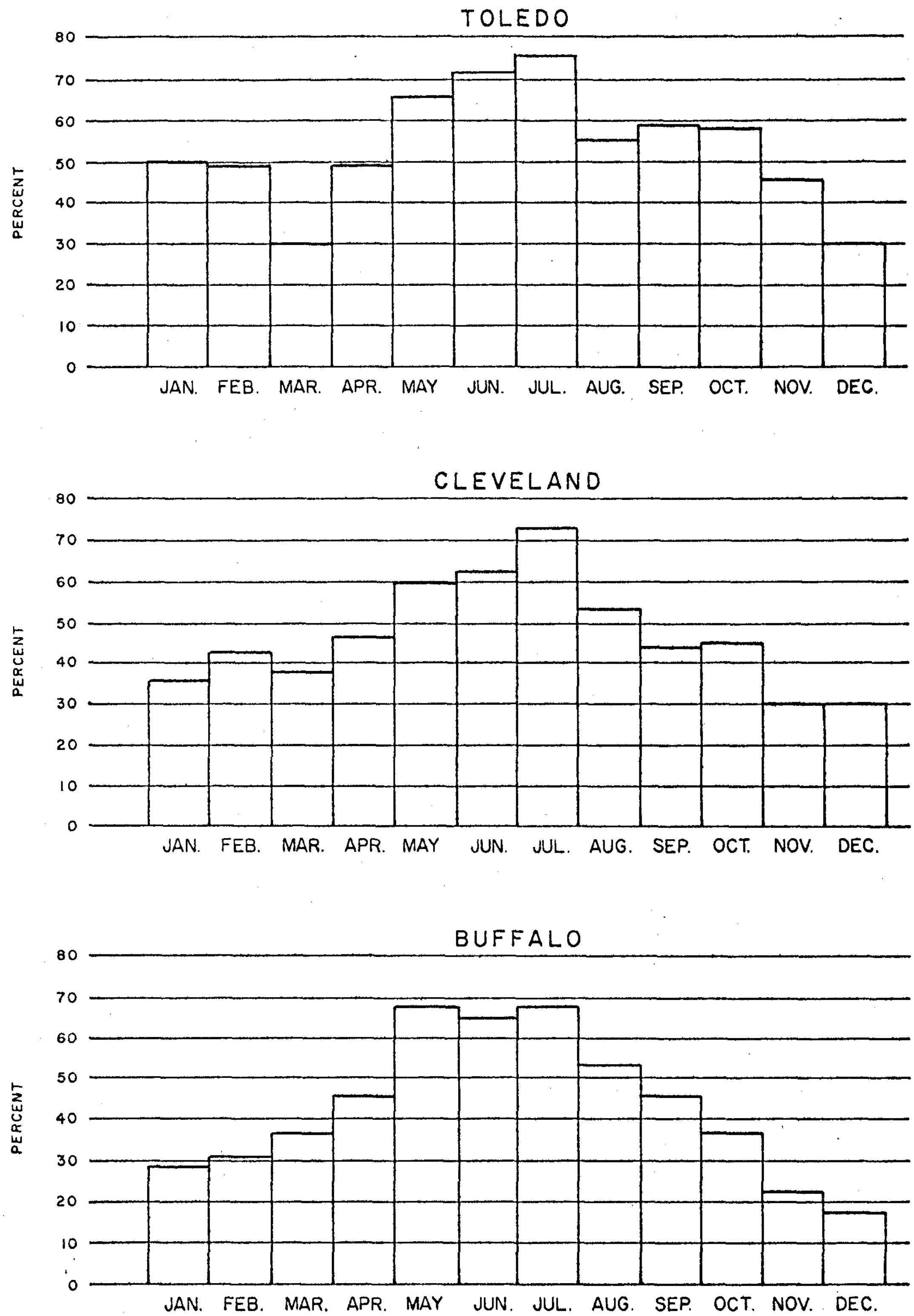
General land use for the Lake Erie basin is shown in Fig. 2-10 as compiled by the U. S. Bureau of Outdoor Recreation. The uses shown thereon are predominant, but a wide variety of uses can, of course, be found within each section.

Urban Development: In the Lake Erie basin urban development is concentrated largely along the U. S. lake shore, primarily in the metropolitan areas of Detroit, Toledo, Cleveland, and Buffalo. These areas are growing rapidly as are many smaller intervening cities. The Canadian shore, in contrast, is characterized by widely spaced small fishing ports, except in the Windsor area adjacent to Detroit and in the Niagara Falls area near Buffalo.

The urbanized area of the Lake Erie basin is estimated at about 10 percent of the total land area, and about 90 percent of this is on the American side of the lake.

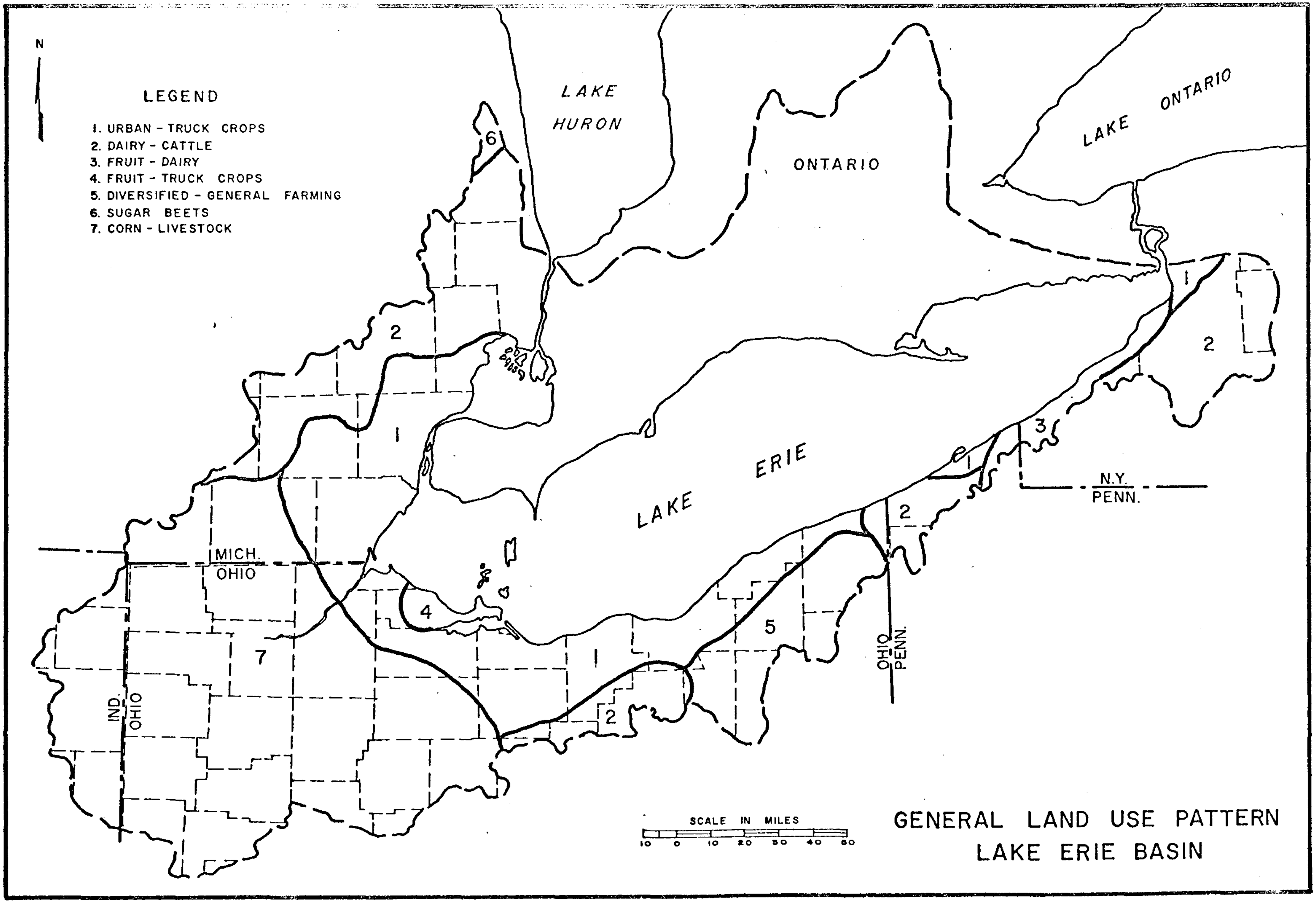
Rural Development: At least 90 percent of the Lake Erie watershed land area is rural in character. Very little of it is truly forested, although there are significant areas (about five percent of the total basin) of cut-over scrub land, especially in the hills of the southeastern part, between Cleveland and Buffalo.

Rural land in the Lake Erie basin is fertile and much of it is cultivated. The rich lands of the Raisin, Maumee, Portage, and Sandusky river basins, and the western part of the Canadian portion of the basin support a large production of cash grain crops and associated livestock. In the eastern half of the basin, much land is also devoted to farming, with greater emphasis on dairying and the production of fruit. In areas near the lake, truck farming, fruit-growing, and nursery production are prevalent. Tobacco raising is important on the Canadian side in the eastern half of the basin.



MONTHLY PERCENT OF POSSIBLE SUNSHINE 1965

Fig. 2-1



GENERAL LAND USE PATTERN
LAKE ERIE BASIN

Fig 2-10

Land capable of agricultural production, but standing idle, is not in abundance, although many small areas can be found between Cleveland and Buffalo, especially within a mile or so of the lake shore. Some of this land is apparently held in speculation of urban or suburban development.

WATER RESOURCES AND HYDROLOGY

Since the recommended water pollution control program allows for the discharge of wastes to a stream system, the program design must consider hydrologic characteristics of the system. Surface flow features--primarily volume, velocity, distribution, and temperature, and changes in each--directly affect waste assimilation capacity and, therefore, program requirements. Hydrologically then, a pollution control program should be designed according to some low flow or drought flow of the stream to which wastes are discharged. The lowest average seven-day flow which can be expected to recur not more than once in ten years is herein considered adequate for design purposes.

For descriptive purposes, Lake Erie tributaries can be conveniently divided into three types: (1) Lake Huron outflow, (2) major tributaries with average flows greater than 1,000 cubic feet per second (cfs), and (3) minor tributaries with average flows less than 1,000 cfs. Flow data are given in Table 2-2. Average tributary flows at gaging stations are shown in Figure 2-11.

Lake Huron Outflow

Lake Erie receives 80 percent of its water supply from upper lake drainage. The large volume and high quality of this inflow has a great dilutional effect on Lake Erie, and any significant decrease in either the volume or quality could be disastrous.

The Lake Huron outflow is the only source of water to Lake Erie which is not controlled by precipitation over the Erie basin, being controlled instead by precipitation in the basins of Lakes Superior, Michigan, and Huron. Diversion out of Lake Michigan at Chicago, diversion into Lake Superior, and flow regulation from Lake Superior affect to a minor degree the Lake Huron discharge.

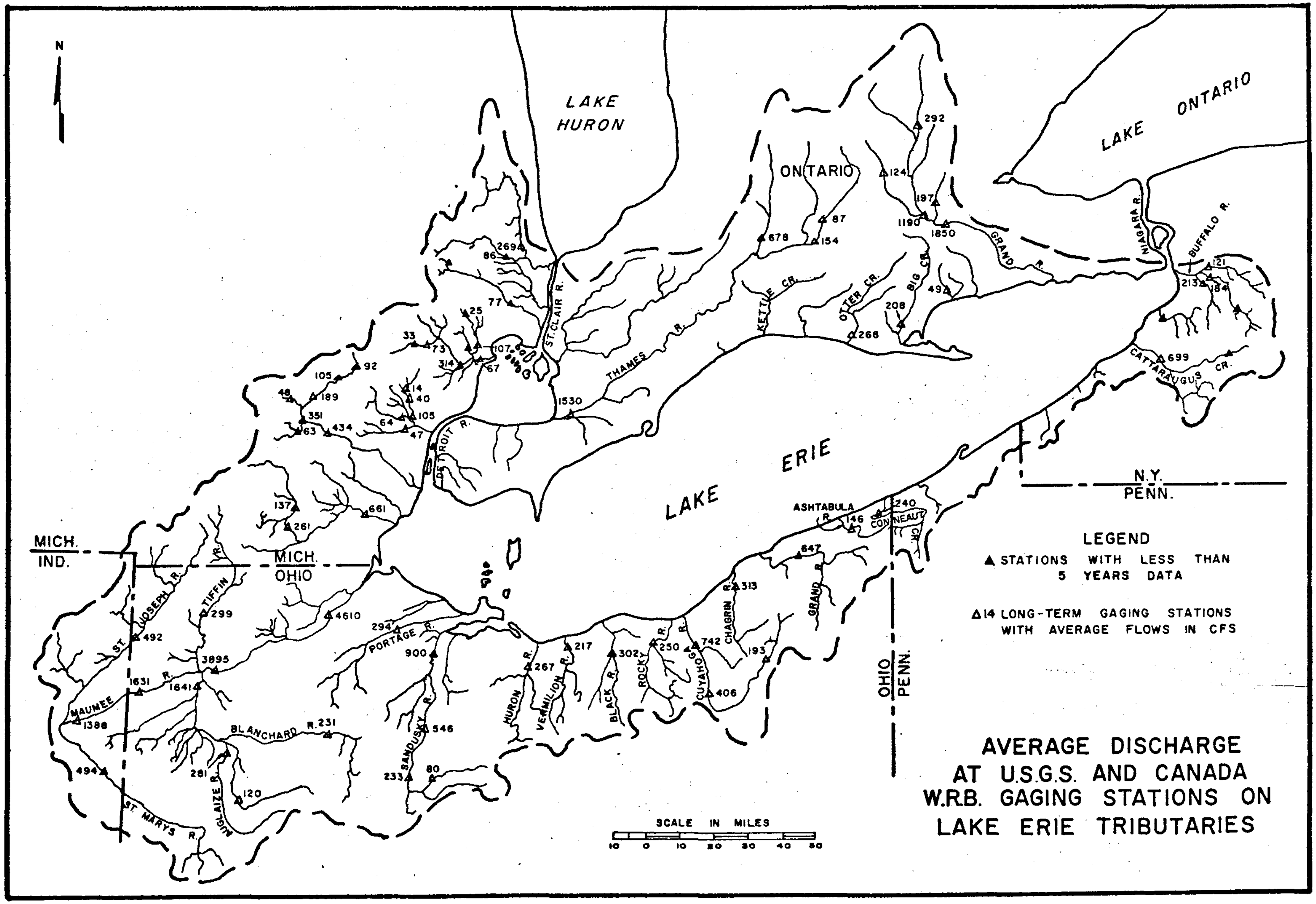
According to U. S. Lake Survey measurements, the Lake Huron outflow has averaged 187,450 cfs between 1860 and the present. The monthly averages have ranged from a high of 242,000 cfs in June 1896 to a low of 99,000 cfs in February 1942. Lowest flows ordinarily occur in February (average 159,000 cfs) and the highest in July or August (average 199,000 cfs), Fig. 2-12. Other tributary runoff to Lake Erie is generally at a minimum during periods of high Lake Huron outflow.

Though the variation in flow volume from Lake Huron is great, it is still the most uniform of the tributary drainages to Lake Erie. This

TABLE 2-2

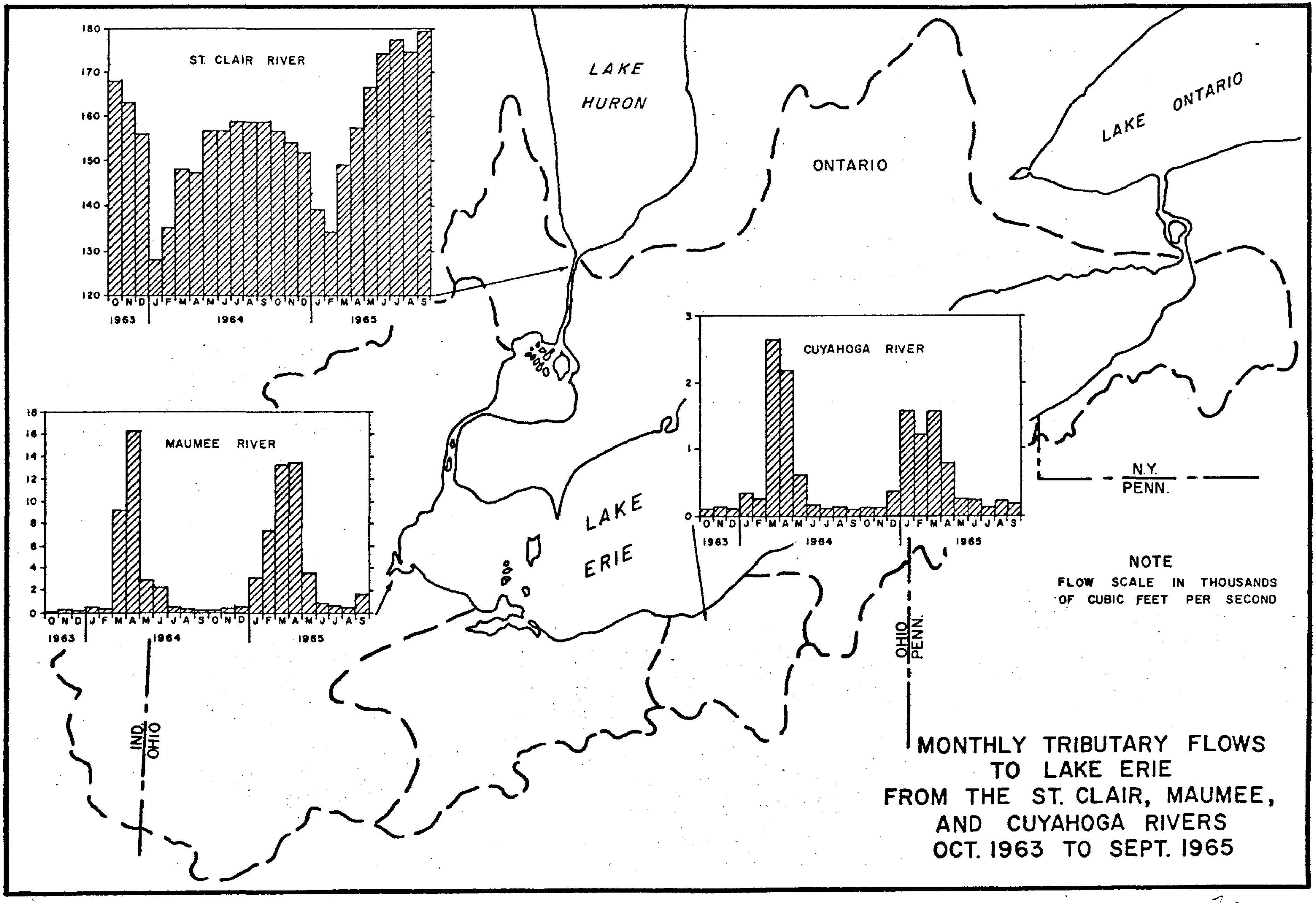
RUNOFF STATISTICS FOR TRIBUTARIES OF THE LAKE ERIE BASIN

Stream	Drainage Area ($mi.^2$)	Period of Record (years)	Max. Flow (cfs)	Min. Flow (cfs)	Average Flow (cfs)	Average Yield ($cfs/mi.^2$)	7-Day Low Flow, 10 yr. Recurrence ($cfs/mi.^2$)	7-Day Low Flow, 10 yr. Recurrence (cfs at mouth)	Runoff Precip. (percent)
St. Clair River (Lake Huron outflow)		106			187,450				
Clinton River	740	31	21,200	---	470	.635	.052	24	28
Rouge River	467	35	13,000	1.8	235	.503	.033	7.8	22
Huron River (Mich.)	890	19	5,840	4.0	556	.625	.044	24	27
Raisin River	1,125	28	12,900	2.0	714	.635	.027	19.3	28
Maumee River	6,586	40	94,000	20.0	4,794	.728	.013	86	29
Portage River	587	33	11,500	0.3	403	.687	.001	0.6	28
Sandusky River	1,421	39	28,000	4.4	1,021	.719	.010	14.0	28
Huron River (Ohio)	403	15	25,800	2.2	296	.732	---	5.1 est.	28
Vermilion River	272	15	20,500	0.0	228	.840	---	0.6 est.	33
Black River	467	21	24,000	0.0	302	.647	---	0.5 est.	29
Rocky River	294	34	21,400	0.2	273	.929	.004	1.0	35
Cuyahoga River	813	34	24,800	14.0	850	1.045	---	112	39
Chagrin River	267	36	28,000	3.0	333	1.247	.051	4.0	46
Grand River (Ohio)	712	40	21,100	0.0	784	1.101	.003	2.2	40
Ashtabula River	137	34	11,600	0.0	169	1.234	.000	0.0	45
Conneaut Creek	191	28	17,000	0.2	257	1.346	.006	1.2	49
Cattaraugus Creek	436	25	35,900	6.0	705	1.617	.129	55	58
Buffalo River	565	25	35,000	2.8	784	1.388			55
Grand River (Ontario)	2,614	24	47,800	65.0	2,405	.920			36
Big Creek	281	7	3,060	54.0	256	.911			35
Otter Creek	316	13	4,140	10.8	312	.987			37
Kettle Creek	200 est.	-	2,400 est.	7 est.	185est.	.902			34
Thames River	2,000 est.	7	38,500 est.	58	1,840	.902			36



AVERAGE DISCHARGE AT U.S.G.S. AND CANADA W.R.B. GAGING STATIONS ON LAKE ERIE TRIBUTARIES

Fig. 2-11



MONTHLY TRIBUTARY FLOWS TO LAKE ERIE FROM THE ST. CLAIR, MAUMEE, AND CUYAHOGA RIVERS OCT. 1963 TO SEPT. 1965

Fig. 2-12

is because of the regulating effect of the upper lakes storage.

Major Tributaries

Only four Lake Erie tributaries beside the Lake Huron outflow, exceed an average discharge of 1,000 cfs to Lake Erie. These are the Maumee and Sandusky Rivers in Ohio and the Grand and Thames Rivers in Ontario, Table 2-2. The Thames discharges to Lake St. Clair. These rivers supply a total flow of approximately 10,000 cfs--the Maumee River accounting for about one-half of this.

All four major tributaries drain land which is largely agricultural and rather intensively cultivated. Precipitation on the Grand and Thames basins is slightly higher than on the Maumee and Sandusky basins, Fig. 2-7. However, the percentage of precipitation appearing as runoff is considerably greater in the Canadian basins, 36 percent compared to 28 percent, the difference being accounted for in topography and soil characteristics. The average water yield per square mile is just over 0.7 cfs in the Maumee and Sandusky River basins, and over 0.9 cfs for the Grand and Thames River basins.

Drought flow volumes are very low for the Maumee and Sandusky Rivers. Seven-day, 10-year recurrence low flows are estimated at 86 cfs and 14 cfs, respectively, at the mouths of these streams. Drought flows of the Grand and Thames Rivers appear to be much higher per unit area, indicating that ground water is significant in contributing to those flows. The low ground water contribution in the Maumee and Sandusky basins can be attributed to the relatively flat topography and to the dense and relatively impermeable clay soils.

In many upstream locations there is virtually no flow during the critical low flows, high temperature, high evaporation months of July through October, thus compounding waste assimilation problems. Low flow is even more of a problem on tributaries to the main streams; and flow related to time of travel is a problem, especially in the lower reaches of the major tributaries where pollution load is greatest.

For example; in the lower several miles of the Maumee River the flow volume is low, the cross-sectional area of the river is large, and the gradient is virtually nil. This results in a very long time for water to travel through the Toledo area--frequently a month or more. A similar situation, but less severe, exists in the lower several miles of the Sandusky River.

At other localities in both basins, time of travel is lengthened by pooling effects of both natural and artificial features. Long time of travel is not only detrimental to stream quality in the presence of wastes, but is detrimental to lake quality near the stream mouths, primarily because of the cumulative storage of nutrients as the water moves downstream. The building of navigational channels and harbor enlargement projects at the mouths of tributaries have compounded the pollution problem by increasing the time-of-travel of the stream water.

Minor Tributaries

All other tributaries to Lake Erie contribute only minor water flow to the lake. Although their flows are relatively low, their contribution to the pollution of Lake Erie is relatively high. The more important of the minor tributaries, with pertinent hydrologic data, are listed in Table 2-2. These streams have average flows between 200 and 900 cfs.

The Portage and Raisin Rivers are similar in most characteristics to the Sandusky and Maumee Rivers except for much lower average and drought flows. The minor tributaries in Ontario are also similar to the Grand and Thames Rivers.

The Huron River in Ohio is similar to the Sandusky in flow characteristics except that it has a higher base flow per unit area and its basin is partly in higher land, approaching the hilly section of the lake watershed. Ground water appears to be more important as a part of this stream supply.

From the Huron (Ohio) basin eastward along the Ohio shore, precipitation generally increases (Fig. 2-8) and a greater share of the precipitation reaches the lake as runoff (Table 2-2). Drought flows are, however, widely variable and again reflect the ability of ground water to support stream flow. In addition, these streams have higher gradients and runoff is much faster. The upstream reaches of most of these streams may be completely dry during much of the summer-fall low flow period.

All of the streams along the south shore become sluggish in the lower few miles, a characteristic accentuated by the harbor enlargement of stream cross-section. This is a particularly important problem where waste inputs are very high, such as in the navigation channels of the Black, Cuyahoga, and Grand Rivers in Ohio, and the Buffalo River in New York. The problem is most critical in the Cuyahoga and Buffalo Rivers where the pollution load is the heaviest and the time-of-travel in the dredged channels is often a week or more. The 7-day low flow volume for the Cuyahoga River (Table 2-2) is relatively high, due to impoundments and large waste water discharges to the river, rather than ground water supply.

The important minor tributaries in Michigan are the Clinton, Rouge, Huron, and Raisin Rivers. The Clinton discharges into Lake St. Clair, the Rouge into the Detroit River, and the Huron and Raisin directly into Lake Erie. All are highly polluted streams, passing through the urbanized and industrialized area of southeast Michigan. They all drain relatively flat land, and not only is precipitation the lowest, but the proportion of runoff to precipitation is also the lowest in the Lake Erie basin. However, their drought flows are higher than average per unit area, indicating that perhaps there is significant release of ground water or surface storage. The Clinton and Huron are fed by several small natural lakes, but the Rouge and Raisin are not. There are several low-head dams near the mouth of the Raisin River.

The lower few miles of Michigan tributaries are dredged, sluggish, and lake-affected. Time of travel is long and especially long in summer and fall. The streams are similar to the south shore minor tributaries mentioned above in having long time-of-travel characterisitcs in the zones of the heaviest pollution loads. The Raisin and Rouge Rivers rank with the Cuyahoga and Buffalo in degree of severity.

Ground Water

Ground water in the soil and rocks surrounding Lake Erie varies widely in both quantity and quality, Figs. 2-13 and 2-14. Quantity alone is not a good indicator of supply capacity because of differences in retention characteristics of the soil. For example, glacial clays may contain much water, with the water table very near the surface, but their low permeability makes them a poor source of water supply.

Although characteristics vary, the basin as a whole is a rather poor producer of ground water. Tills, lake clays, and shales which are prevalent over much of the basin are not good aquifers--producers of water. Where they do produce significant quantities, it is not uncommon for the water to have a high sulfur content. Locally high quantities of water may be available where deep sandy soils occur as the result of beach-building or glacial outwash, or in old valleys filled with gravelly soils. Porous limestones are also locally good aquifers as are sandstones, but all of these sources, except for sandstones, may contain sulfur.

Lake Hydrology

The first consideration in the hydrology of Lake Erie proper is that of the water balance, or balancing the water inputs to the lake with losses. The factors can be formulated, for a given period, in the equation;

$$P + R + U + I - O \pm D - E = \Delta S$$

where:

P = precipitation directly on the lake's surface
R = runoff from the lake's land drainage area
U = ground water - considered plus in the aggregate
I = inflow from lake above
O = outflow from lake
D = diversion; plus if into lake, minus if out of lake

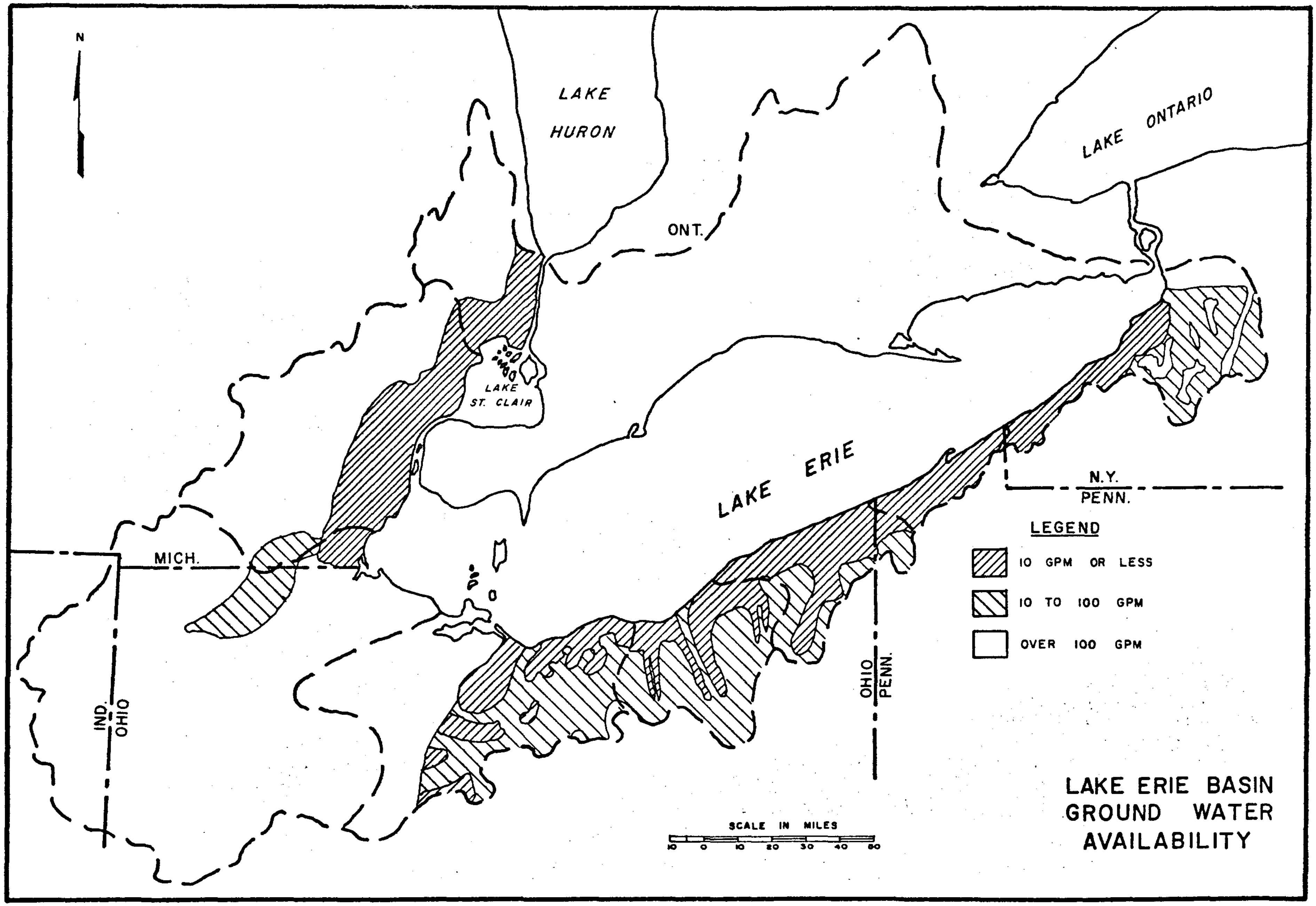

N
LAKE HURON
LAKE ONTARIO
ONT.
LAKE ST. CLAIR
LAKE ERIE
MICH.
N.Y.
PENN.
IND.
OHIO
OHIO
PENN.
LEGEND
10 GPM OR LESS
10 TO 100 GPM
OVER 100 GPM
SCALE IN MILES
10 0 10 20 30 40 50
LAKE ERIE BASIN
GROUND WATER
AVAILABILITY

Fig. 2-13

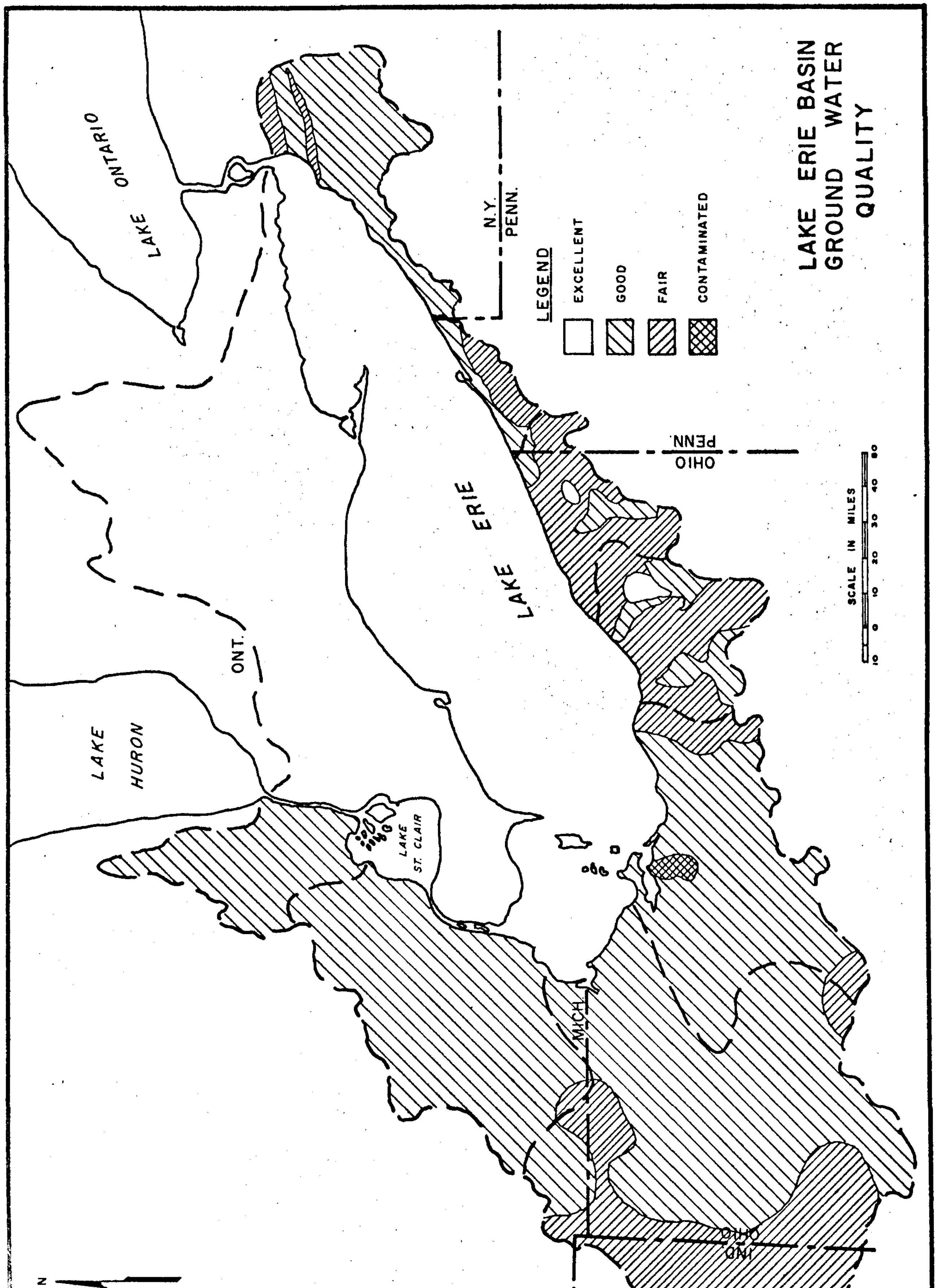

LAKE ERIE BASIN
GROUND WATER
QUALITY
LEGEND
EXCELLENT
GOOD
FAIR
CONTAMINATED
SCALE IN MILES
10 0 10 20 30 40 50
LAKE ONTARIO
LAKE ERIE
LAKE HURON
LAKE ST. CLAIR
ONT.
N.Y.
PENN.
OHIO
PENN
MICH.
IND
OHIO
N

Fig. 2-14

E = evaporation from the lake's surface

ΔS = change in amount of water stored in the lake; plus if supplies exceed removal, minus if removals exceed supplies

Precipitation (P) on the lake's surface is difficult to measure and must be interpolated from perimeter land precipitation measurements. It is generally considered that over-lake precipitation is less than that over land and precipitation on the lake's surface approximately equals evaporation in the long run. In the balance shown here, the precipitation (29 inches annually) at Put-in-Bay has been used.

Runoff (R) is measurable to a degree by stream gaging but is highly variable due to areal differences in precipitation, topography, soil type, and vegetation. Runoff is estimated by applying factors, derived from stream gaging, to stream drainage basin areas.

The ground-water contribution (U) is virtually unknown, is not directly measurable, and is usually considered negligible in lake water budget computations. It is regarded as positive in the equation, meaning that it is actually a negative factor. ?

Inflow (I) from the lake above and natural outflow (O) are not difficult to measure, and the U. S. Lake Survey has done this for more than 100 years. The measurements are considered reliable and adequate for balance calculations.

Diversion (D) in Lake Erie is of two kinds, diversion out of the basin and consumptive, or transient, use within the basin. Water is diverted out of the basin as a supply for the Welland Ship Canal. In the balance, the U. S. Lake Survey estimate of 7,000 cfs annually has been used. Within the basin, water is diverted for man's use out of and back into the lake. A small portion is consumed and not returned in this process. The total consumption is measurable, but in the total lake water balance it is considered negligible. The diversion factor in Lake Erie is always minus. Diversion to the lake from outside the basin is non-existent.

Evaporation (E) is a net loss from the lake. Its measurement with unquestioned accuracy is not possible with present methods. It is usually calculated by solving the water budget equation for E. This calculation obviously depends upon the accuracy of the other factors. In the balance presented here it has been calculated to be 34.3 inches per year.

Changes in storage (ΔS) are easily measured by recording water levels over the period. Changes in water levels at a particular site induced by factors other than those in the equation; i. e., wind set-up, seiches, and tides, are not considered as changes in storage. The long term change in storage is assumed to be nil for Lake Erie.

A Lake Erie water budget study by Derecki (1964) has been used to determine monthly percentages of precipitation and runoff. Annual runoff was calculated from U. S. Geological Survey and Canadian Water Resources Branch surface water gaging data. Inflow and outflow were calculated from U. S. Lake Survey reported measurements. Changes in storage were calculated from average monthly water levels as reported by the U. S. Lake Survey. Evaporation was obtained by solving the equation for it.

The annual supply sources for the Lake Erie water balance are detailed in Table 2-3. The relative importance of each of the tributaries to the Lake Erie water supply is graphically shown in Fig. 2-15.

In the water balance table, Table 2-4, cubic feet per second (cfs) has been used for the unit of volume. The values shown can be converted to inches of water in Lake Erie by dividing by 735.

A study of the water balance indicates the following significant factors: (1) annual evaporation nearly equals runoff to the lake, (2) evaporation exceeds precipitation, (3) change in storage over a long period is significant, and (4) evaporation is greatest in late winter and in autumn.

Calculations show that 80 percent of the net basin supply is derived from Lake Huron inflow via the Detroit River, 9 percent is precipitation upon the lake's surface, and only 11 percent is contributed by basin runoff. Loss of water from Lake Erie consists of 86 percent outflow, 3 percent diversion, and 11 percent evaporation.

Lake Levels

Lake levels vary over short periods of time due to such phenomena as wind set-up, seiches, and lunar and solar tides. But, lake levels show changes in storage only when averaged over long periods of time. Changes in storage for Lake Erie reflect precipitation fluctuations over it and the upper Great Lakes. From 1860 (the beginning of U. S. Lake Survey records) to the present, change between minimum and maximum levels for Lake Erie has been 5.3 feet--almost nine percent of the lake's average depth.

Short-period fluctuations mentioned above are manifested, not by changes in volume, but by changes in the shape of the water mass. Tidal effects are negligible, but wind set-up and seiches may be quite pronounced, especially at the ends of the lake.

A wind set-up is the result of wind drag across the lake. Water is pushed toward the leeward shore in greater quantity than can be

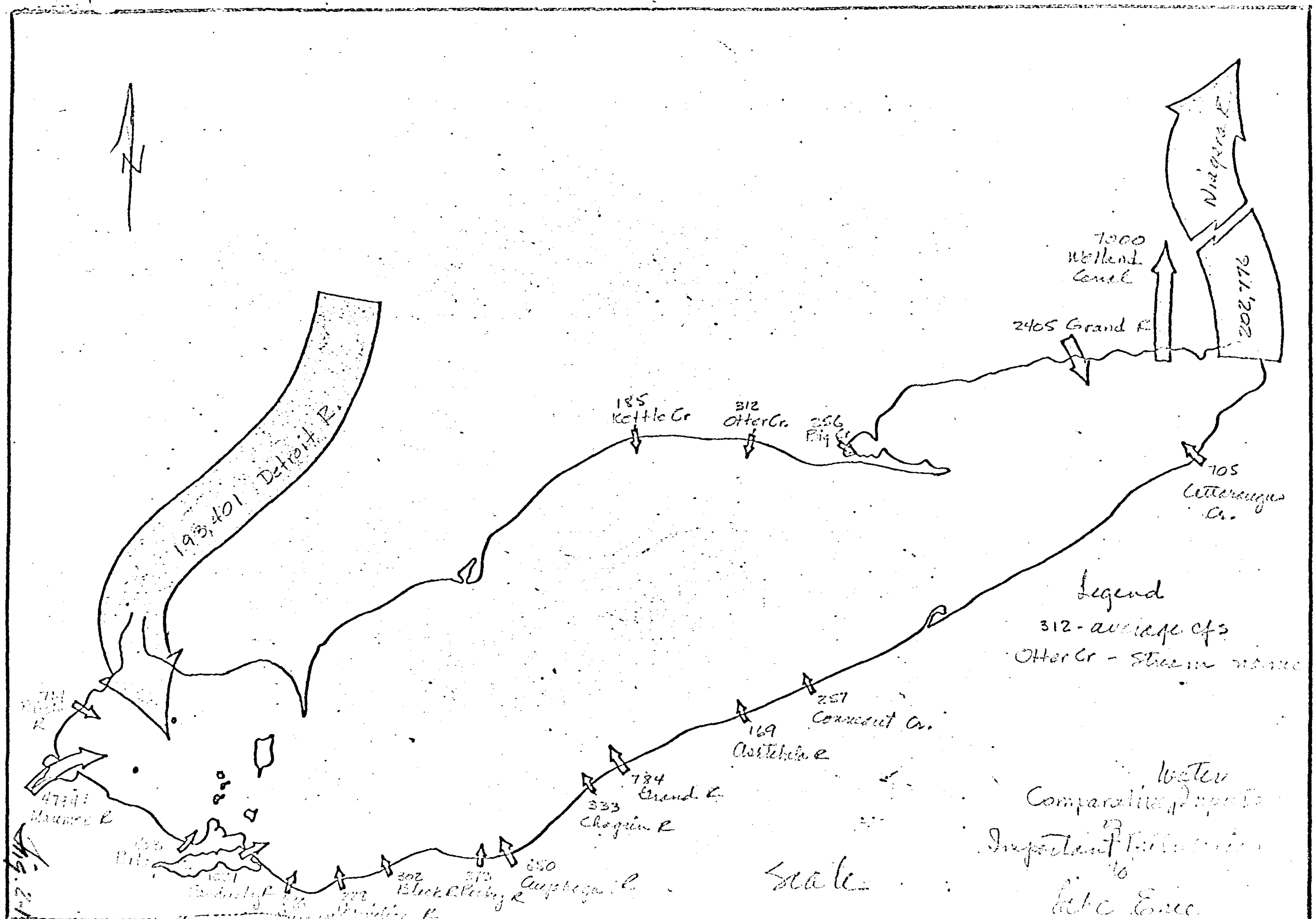
TABLE 2-3

WATER SUPPLY TO LAKE ERIE

Source	Supply (cfs)	Percent of Total Lake Supply	Percent of Basin Supply
Western Basin			
St.Clair River (Lake Huron, outflow)	187,450	79.774	92.921
Black, Pine, Belle Rivers	688	.293	.338
Clinton River	470	.200	.231
Rouge River	235	.100	.115
Thames River	1,840	.783	.903
Miscellaneous Runoff	1,799	.766	.883
Precipitation (Lake St.Clair)	919	.391	.451
Subtotal (Detroit River)	193,401	82.307	94.943
Huron River (Michigan)	556	.237	.273
Raisin River	714	.304	.351
Maumee River	4,794	2.040	2.353
Portage River	403	.172	.198
Miscellaneous Runoff	1,271	.541	.624
Precipitation (Western Basin)	2,564	1.091	1.259
Subtotal	10,302	4.384	5.057
Total Western Basin	203,703	86.691	100.000
Evaporation	-3,042	-1.295	-1.493
Central Basin			
Western Basin	200,661	85.396	90.966
Sandusky River	1,021	.435	.463
Huron River (Ohio)	296	.126	.134
Vermilion River	228	.097	.103
Black River	302	.129	.137
Rocky River	273	.116	.124
Cuyahoga River	850	.362	.385
Chagrin River	333	.142	.151
Grand River (Ohio)	784	.334	.355
Ashtabula River	169	.072	.077
Conneaut Creek	257	.109	.117
Otter Creek	312	.133	.141
Kettle Creek	185	.079	.084
Miscellaneous Runoff	1,410	.600	.639
Precipitation (Central Basin)	13,508	5.749	6.124
Total Central Basin	220,589	93.877	100.000
Evaporation	-16,023	-6.819	-7.264

WATER SUPPLY TO LAKE ERIE (continued)

Source	Supply (cfs)	Percent of Total Lake Supply	Percent of Basin Supply
Eastern Basin			
Central Basin	204,566	87.058	94.746
Cattaraugus Creek	705	.300	.327
Buffalo River	784	.334	.363
Grand River (Ontario)	2,405	1.024	1.114
Big Creek	256	.108	.119
Miscellaneous Runoff	2,023	.861	.937
Precipitation (Eastern Basin)	5,172	2.201	2.395
Total Eastern Basin	215,911	91.886	100.000
Evaporation	-6,135	-2.611	-2.841
Lake Outflow	209,776	89.275	



N
193,401 Detroit R.
7000 Welland Canal
202,776
Niagara R.
2405 Grand R.
185 Kettle Cr
312 Otter Cr.
256 Big Cr.
705 Cattaraugus Cr.
Legend
312 - average cfs
Otter Cr - Stream name
257 Conneaut Cr.
169 Ashtabula R
784 Grand R
333 Chagrin R
850 Cuyahoga R
302 Black R
Maumee R
Scale

Fig. 2-15

TABLE 2-4

WATER BALANCE IN LAKE ERIE
(cfs)

	P +	R +	I -	O -	D -	E =	ΔS
January	18,000	32,000	168,700	193,400	--	27,400	-2,100
February	18,200	44,300	159,600	187,300	--	39,400	-4,600
March	22,500	56,400	172,500	192,100	--	38,600	20,700
April	27,200	54,000	185,600	201,400	5,250	-4,050	64,200
May	26,900	32,000	191,900	213,300	10,500	-4,000	31,000
June	24,000	21,300	196,400	216,200	10,500	2,200	12,800
July	24,000	8,100	199,600	212,800	10,500	10,500	-2,100
August	24,000	8,100	199,800	209,900	10,500	30,100	-18,600
September	21,600	8,300	198,400	204,800	10,500	45,100	-32,100
October	18,800	8,100	196,500	200,800	10,500	45,200	-33,100
November	21,600	12,700	193,900	200,800	10,500	44,700	-27,800
December	18,800	20,600	186,500	200,100	5,250	28,850	8,300
Annual Average	22,000	25,000	187,000	203,000	7,000	25,000	--

simultaneously returned in subsurface flow. The water rises at the leeward side and is depressed at the windward side. Lake Erie is particularly susceptible to high amplitude wind set-ups because of its shallowness and the orientation of its long axis parallel to predominant southwest and northeast winds. Amplitudes in excess of 13 feet have been recorded simultaneously between the ends of the lake during storms.

In general the highest amplitude wind set-ups occur in spring and fall with northeasterly and westerly winds, respectively. Flooding and erosion are severe when high amplitude wind set-ups occur during periods of high lake levels (times of increased storage).

A wind set-up, which generally lasts less than 24 hours, forms a standing wave which will persist when the wind subsides. The standing wave, called a seiche, will persist and gradually diminish until another wind set-up. A typical example of wind set-ups and following seiches is shown in Figure 2-16 for simultaneous lake level readings at five different stations. Influencing winds and barometric pressure are also shown.

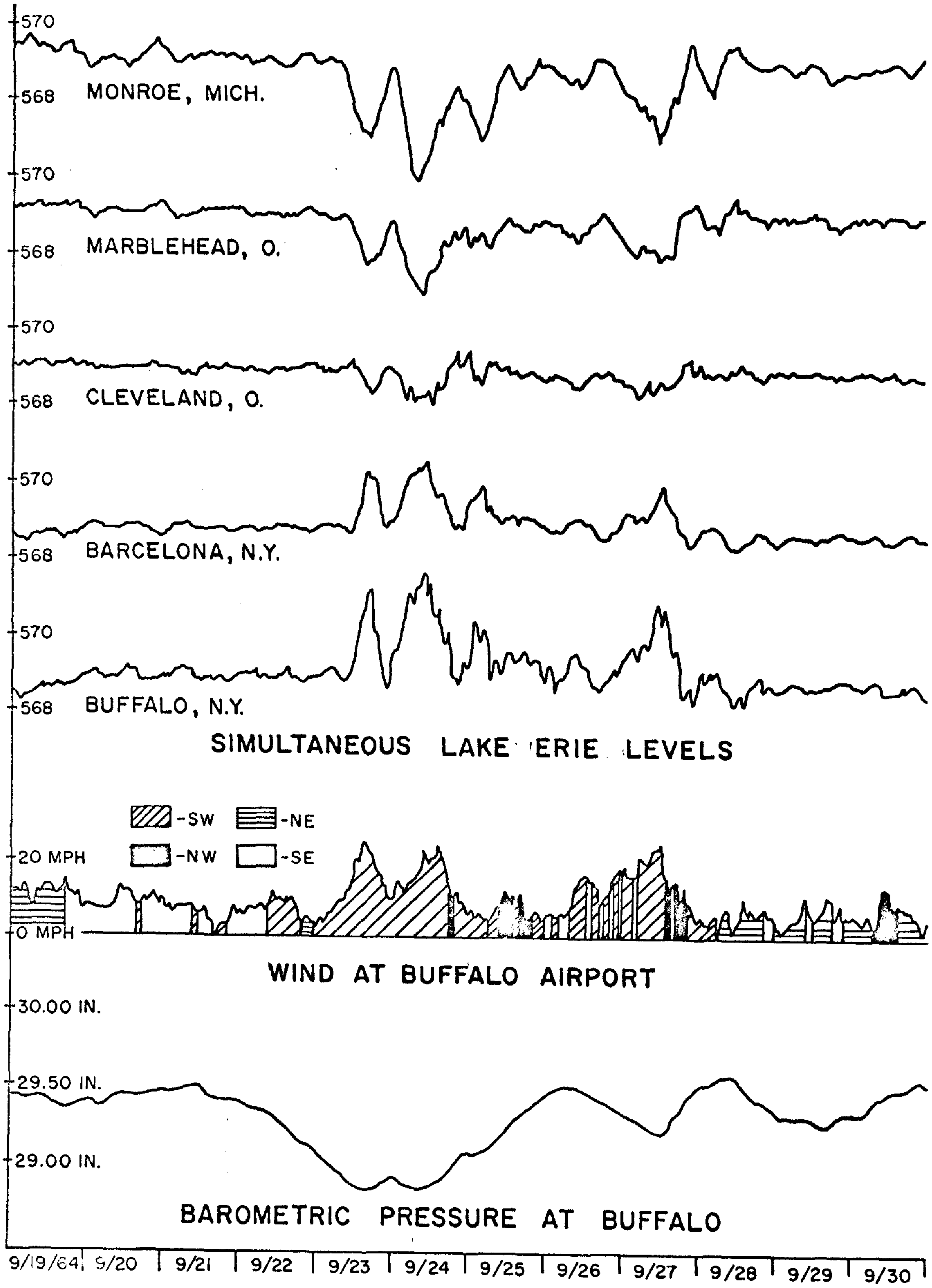
The primary seiche period of Lake Erie is 14.2 hours, that of the uninodal oscillation between the ends of the lake. This seiche period is nearly always apparent on water level records from west of Cleveland and east of Ashtabula, Ohio. Any number of seiches can exist together and each can have several nodes, giving rise to seemingly unintelligible water level records. Even the harbors, where most recorders are located, can have short-period seiches called surges or harbor resonance.

The shortest period oscillations of water level are simple surface waves caused by wind. In Lake Erie these waves ordinarily have periods of less than six seconds. Wave heights are limited by lake depths and fetch or length of water surface over which the wind blows. In general, maximum possible wave heights increase from west to east in Lake Erie. Waves over six feet in height are rare in the western basin, while similar conditions may produce wave heights of 15 or 20 feet in the eastern basin. Violence of waves in Lake Erie is caused by short wave lengths and the resulting wave steepness.

Waves are destructive to shore property in Lake Erie. The shoreline of Ohio is particularly susceptible because beaches are narrow and most banks are clay. Waves, of course, are more destructive during high lake stages and in areas of simultaneous wind set-up. In the western basin, wave action is believed to be the principal agent in maintaining the relatively high turbidity of the shallow water by stirring up bottom sediments.

Lake Water Temperatures

Lake Erie is the warmest of the Great Lakes. Mid-lake surface



LAKE LEVELS AND WINDS

SEPTEMBER, 1964

FIGURE 4-6

water reaches an average maximum of about 75°F usually in the first half of August (Figure 2-17). Occasionally the summer temperature in mid-lake surface water rises above 80°F. Nearshore water normally reaches a maximum along the south shore of 80°F or more.

The most important characteristic of lake temperatures in summer is temperature stratification. Upper warm water (epilimnion) becomes separated from bottom cold water (hypolimnion), Figure 2-18. The transition zone between these layers is called the thermocline.

Surface water temperatures throughout much of the ice-free seasons reflect water depth with temperature decreasing toward deep water. This inverse relationship changes to a direct relationship in the fall and early winter.

Water temperature is, of course, changed by variations in air temperature, and the relationship is direct. Slight modifications to the relationship are caused by the amount of sunshine, strength and duration of winds, and by humidity.

Temperature phenomena in Lake Erie vary between the basins quite significantly, and these phenomena are important in the lake's processes. Under average conditions the western basin freezes over completely in winter. The freeze usually occurs in January and the ice breaks up in early March. The remainder of the lake freezes over only under the most severe conditions. Normally it freezes only along the shores with a varying cover of floe ice in mid-lake. Ice normally disappears in Lake Erie by May 1.

Warming of the lake water usually begins immediately after the ice break-up. The rate of warming is remarkably uniform until about the first of July when the maximum temperature is being approached and the rate flattens out.

A comparison of surface water temperature curves and air temperature curves (Figure 2-17) shows that during the ice-free season there is a definite and expected parallelism. The water temperature curve lags the air temperature by 9 to 12 days in spring and by 12 to 15 days in fall. The greatest departure is in midsummer when the air temperature decline begins about three weeks before the water temperature decline.

Temperature of the surface water of Lake Erie is of less significance than the three-dimensional temperature structure. This structure influences circulation of the water and its dissolved and suspended substances, and also has a marked influence on the chemical and biochemical activity at the bottom sediment-water interface.

Western Basin: Figures 2-19a, b, and c diagrammatically show the development of seasonal temperature structure in each of Lake Erie's three basins. Figure 2-19a for the western basin shows the simplest

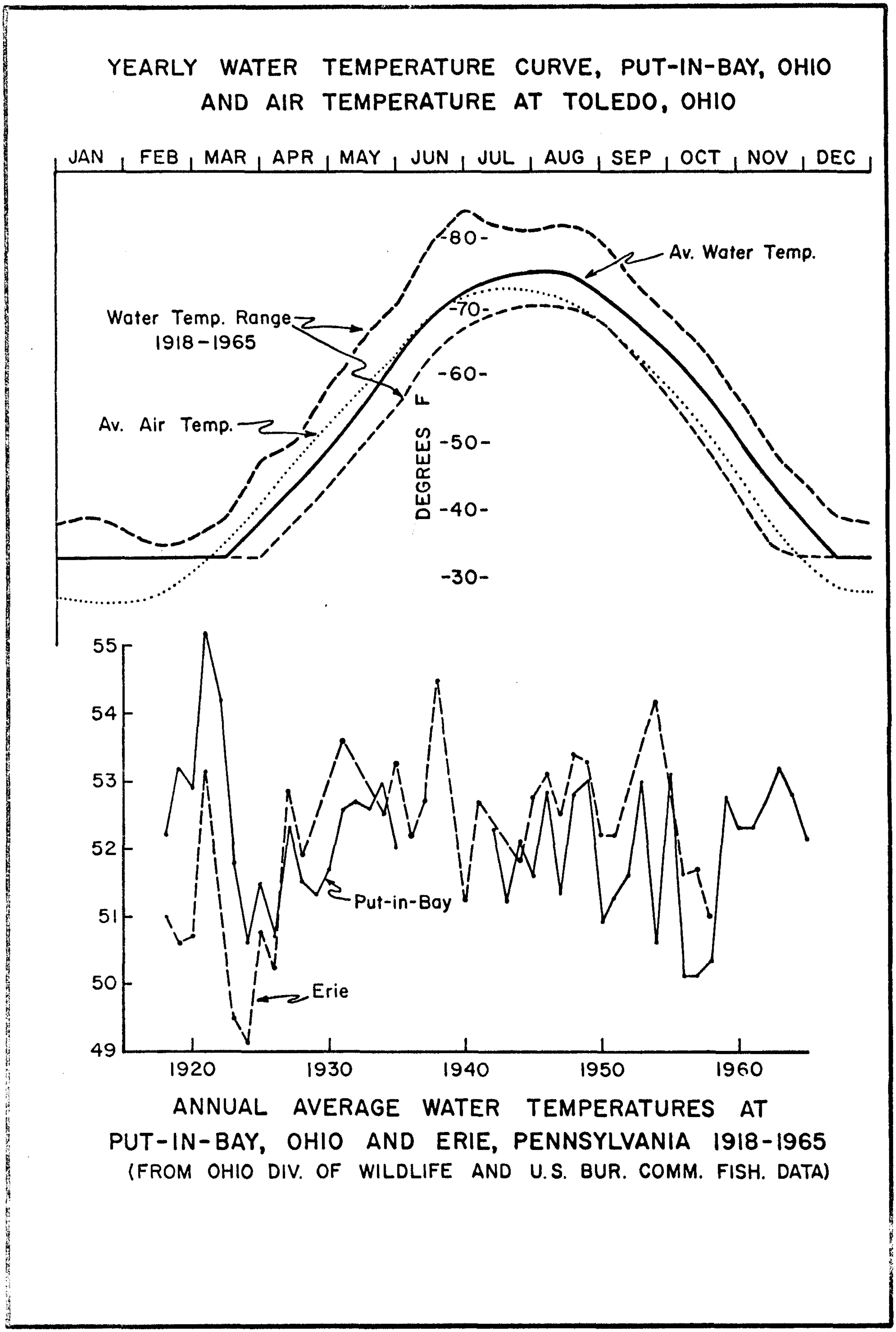
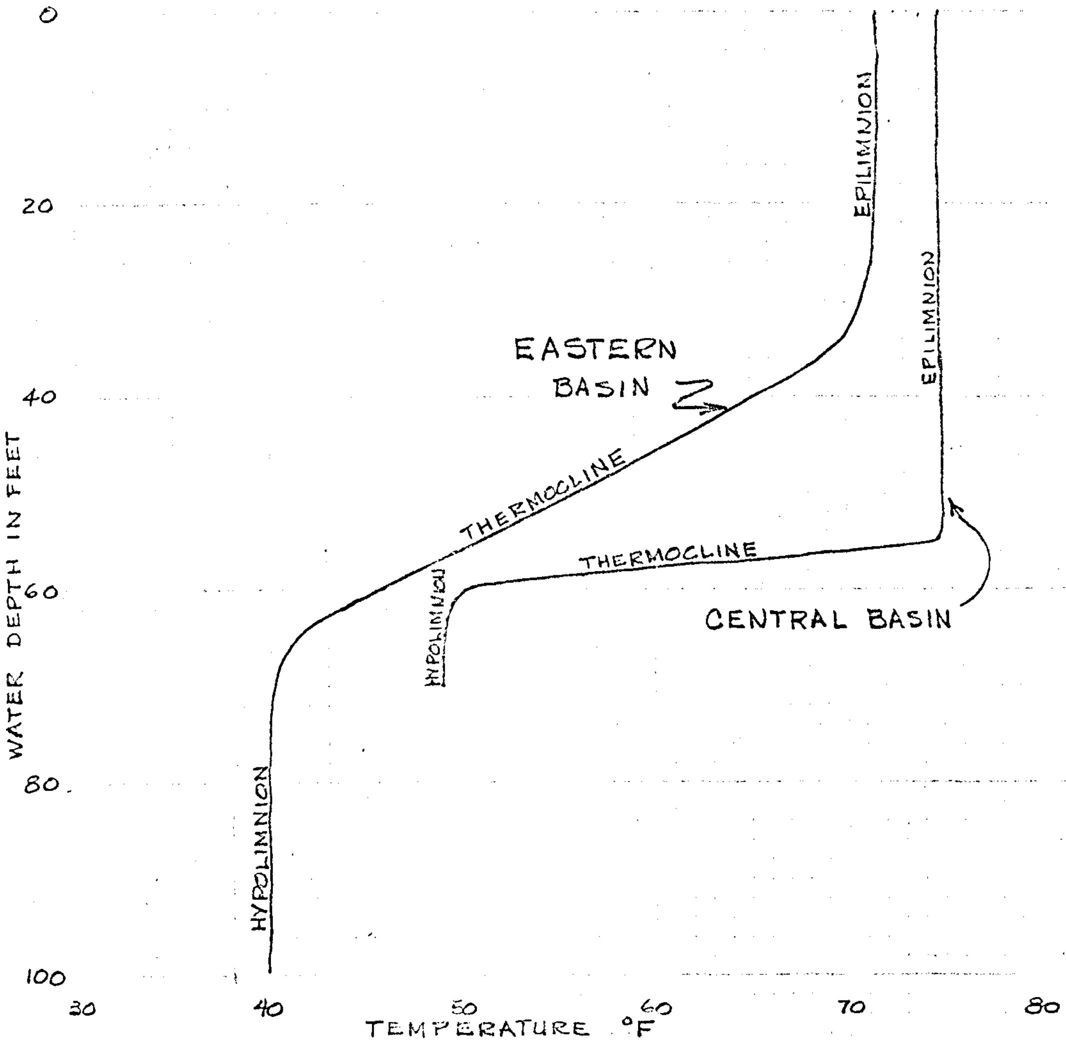
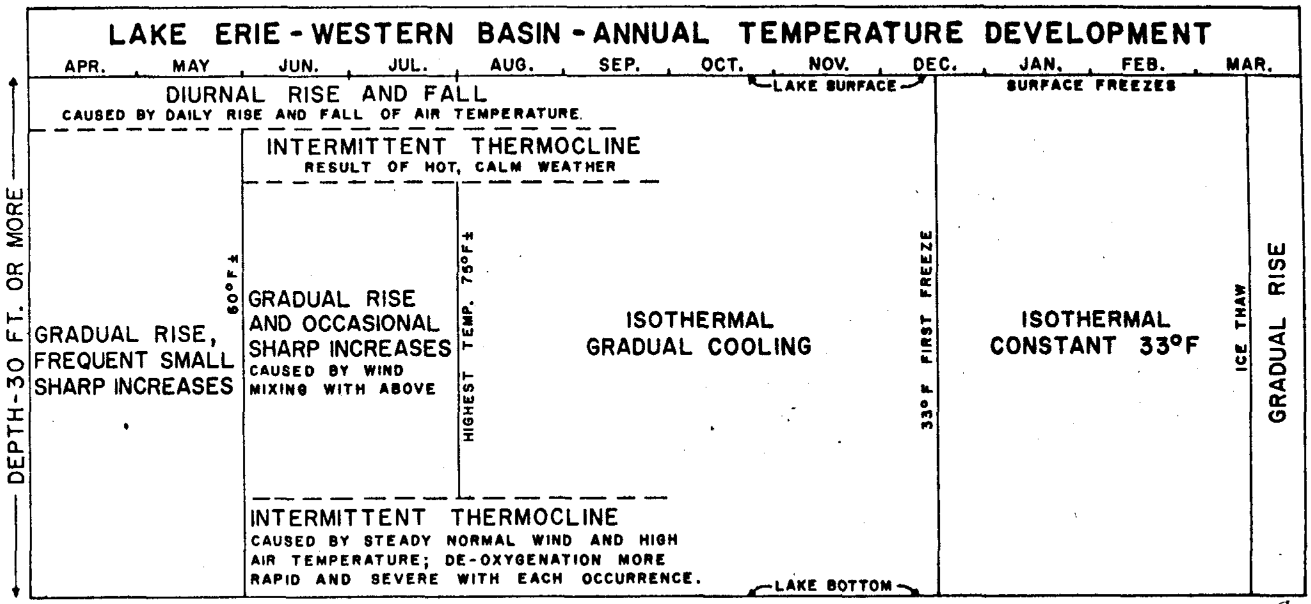

YEARLY WATER TEMPERATURE CURVE, PUT-IN-BAY, OHIO AND AIR TEMPERATURE AT TOLEDO, OHIO
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Av. Water Temp.
Water Temp. Range 1918-1965
Av. Air Temp.
DEGREES F
-80-
-70-
-60-
-50-
-40-
-30-
55
54
53
52
51
50
49
1920
1930
1940
1950
1960
Put-in-Bay
Erie
ANNUAL AVERAGE WATER TEMPERATURES AT PUT-IN-BAY, OHIO AND ERIE, PENNSYLVANIA 1918-1965
(FROM OHIO DIV. OF WILDLIFE AND U.S. BUR. COMM. FISH. DATA)

FIGURE 4-19

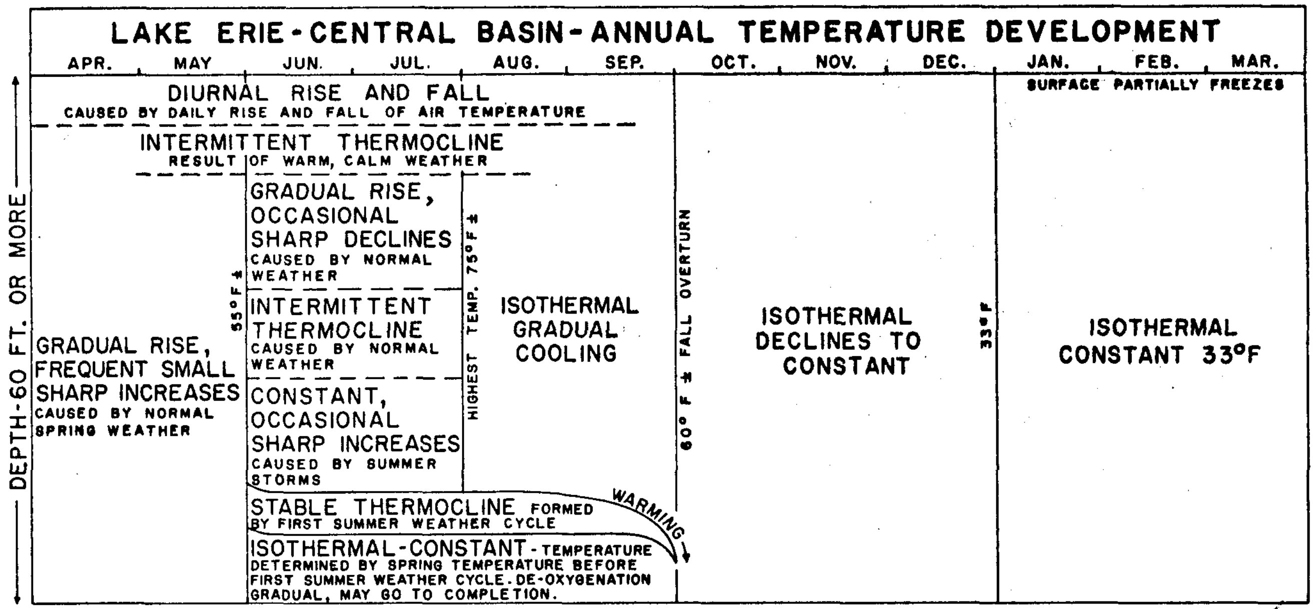


TYPICAL SUMMER DEPTH VS. TEMPERATUEE
IN LAKE ERIE

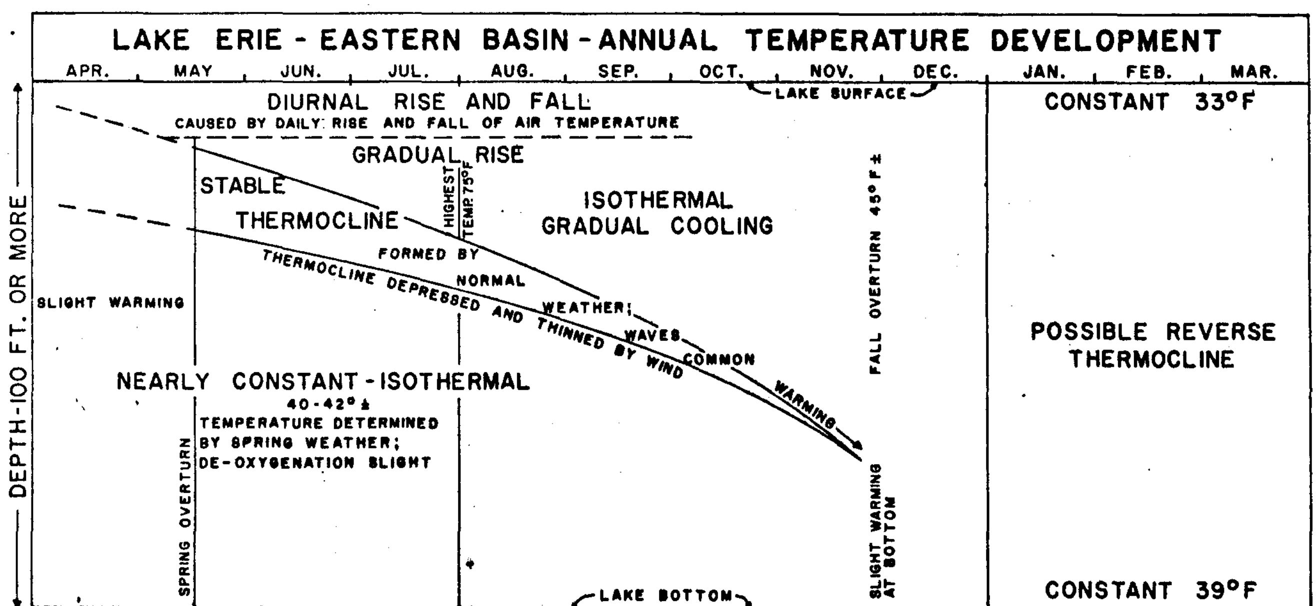
Fig 2-18



LAKE ERIE - WESTERN BASIN - ANNUAL TEMPERATURE DEVELOPMENT
APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC. JAN. FEB. MAR.
LAKE SURFACE
SURFACE FREEZES
DIURNAL RISE AND FALL
CAUSED BY DAILY RISE AND FALL OF AIR TEMPERATURE.
INTERMITTENT THERMOCLINE
RESULT OF HOT, CALM WEATHER
DEPTH-30 FT. OR MORE
GRADUAL RISE, FREQUENT SMALL SHARP INCREASES
60°F ±
GRADUAL RISE AND OCCASIONAL SHARP INCREASES
CAUSED BY WIND MIXING WITH ABOVE
HIGHEST TEMP. 75°F ±
ISOTHERMAL GRADUAL COOLING
33°F FIRST FREEZE
ISOTHERMAL CONSTANT 33°F
ICE THAW
GRADUAL RISE
INTERMITTENT THERMOCLINE
CAUSED BY STEADY NORMAL WIND AND HIGH AIR TEMPERATURE; DE-OXYGENATION MORE RAPID AND SEVERE WITH EACH OCCURRENCE.
LAKE BOTTOM
a



LAKE ERIE - CENTRAL BASIN - ANNUAL TEMPERATURE DEVELOPMENT
APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC. JAN. FEB. MAR.
SURFACE PARTIALLY FREEZES
DIURNAL RISE AND FALL
CAUSED BY DAILY RISE AND FALL OF AIR TEMPERATURE
INTERMITTENT THERMOCLINE
RESULT OF WARM, CALM WEATHER
DEPTH-60 FT. OR MORE
GRADUAL RISE, OCCASIONAL SHARP DECLINES
CAUSED BY NORMAL WEATHER
55°F ±
INTERMITTENT THERMOCLINE
CAUSED BY NORMAL WEATHER
CONSTANT, OCCASIONAL SHARP INCREASES
CAUSED BY SUMMER STORMS
HIGHEST TEMP. 75°F ±
ISOTHERMAL GRADUAL COOLING
60°F ± FALL OVERTURN
ISOTHERMAL DECLINES TO CONSTANT
33°F
ISOTHERMAL CONSTANT 33°F
GRADUAL RISE, FREQUENT SMALL SHARP INCREASES
CAUSED BY NORMAL SPRING WEATHER
STABLE THERMOCLINE FORMED BY FIRST SUMMER WEATHER CYCLE
WARMING
ISOTHERMAL-CONSTANT - TEMPERATURE DETERMINED BY SPRING TEMPERATURE BEFORE FIRST SUMMER WEATHER CYCLE. DE-OXYGENATION GRADUAL, MAY GO TO COMPLETION.
b



LAKE ERIE - EASTERN BASIN - ANNUAL TEMPERATURE DEVELOPMENT
APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC. JAN. FEB. MAR.
LAKE SURFACE
DIURNAL RISE AND FALL
CAUSED BY DAILY RISE AND FALL OF AIR TEMPERATURE
CONSTANT 33°F
GRADUAL RISE
STABLE THERMOCLINE
HIGHEST TEMP 75°F
ISOTHERMAL GRADUAL COOLING
FORMED BY NORMAL WEATHER; WAVES COMMON
THERMOCLINE DEPRESSED AND THINNED BY WIND
WARMING
FALL OVERTURN 45°F ±
DEPTH-100 FT. OR MORE
SLIGHT WARMING
POSSIBLE REVERSE THERMOCLINE
NEARLY CONSTANT - ISOTHERMAL
40-42° ±
TEMPERATURE DETERMINED BY SPRING WEATHER; DE-OXYGENATION SLIGHT
SPRING OVERTURN
SLIGHT WARMING AT BOTTOM
LAKE BOTTOM
CONSTANT 39°F

c

Fig. 2-19

thermal structure. In spring the temperature of the entire water column rises gradually. In summer the water is usually nearly isothermal vertically. A transient secondary thermocline of little importance can be formed near the surface during hot calm periods. During periods of normal winds and above average air temperatures, a thermocline can be formed near the bottom, simultaneously with the development of a secondary thermocline in the central basin. This thermocline is accompanied by rapid de-oxygenation of the bottom water due to oxygen consuming material and the inability of oxygen to penetrate the thermocline.

Storms equalize temperatures in the western basin top to bottom. In August when cooling begins, the western basin water is vertically isothermal and remains so as it cools in fall and winter.

Central Basin: The central basin water, Figure 2-19b, has a simple fall, winter, and spring thermal structure. In summer the structure is more complex than in the western basin. The temperature at the beginning of the first summer weather cycle in early June is approximately the temperature of the following hypolimnion.

The stable thermocline and hypolimnion are formed relatively suddenly during the first storm ending this weather cycle. The intensity of this storm determines the depth of the thermocline, and the thermocline remains at approximately its initial elevation until the lake begins to cool in August. During this time the hypolimnion loses oxygen and may lose it all because it does not mix with the water above, and it contains oxidizing organic matter.

Summer storms cause upwelling, downwelling, and amplify internal waves in the central basin, especially during northwesters. The hypolimnion slides around in the basin. This water movement probably brings bottom sediments into suspension and this may increase oxygen consumption, bringing about relatively sudden oxygen depletion in the hypolimnion.

Summer weather cycles cause the epilimnion to alternate in structure between one layer and three layers. Storms equalize the temperature of the epilimnion. Figure 2-20 shows the summer cyclic development at a station in the central basin for the month of June. In August the epilimnion begins to cool uniformly. The density gradient at the thermocline decreases and the thermocline deepens, disappearing entirely by October.

Eastern Basin: The temperature structure of the eastern basin is probably like that of the deeper Great Lakes, Figure 2-19c. In winter it is nearly isothermal and may have reverse stratification. In spring it mixes top to bottom and is vertically isothermal. The upper waters warm gradually and a shallow thick thermocline forms early, thinning and deepening as summer progresses. The epilimnion is mixed more often or more constantly than in the central basin. Figure 2-21 shows a typical summer thermal development at a station in the eastern basin.

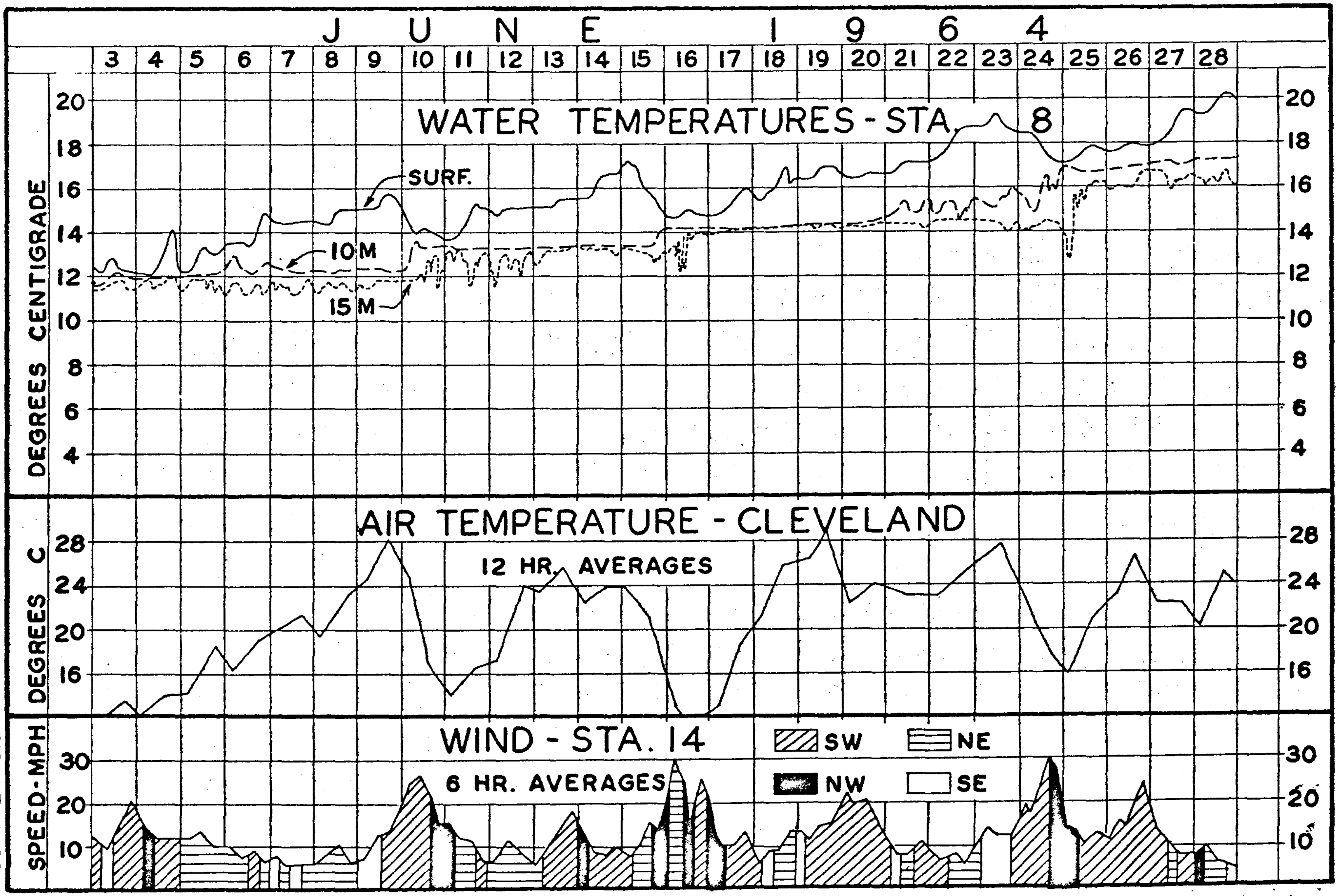

J U N E 1 9 6 4
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
WATER TEMPERATURES - STA. 8
DEGREES CENTIGRADE
20 18 16 14 12 10 8 6 4
SURF.
10 M
15 M
AIR TEMPERATURE - CLEVELAND
12 HR. AVERAGES
DEGREES C
28 24 20 16
WIND - STA. 14
6 HR. AVERAGES
SW
NE
NW
SE
SPEED-MPH
30 20 10

FIGURE 4-23

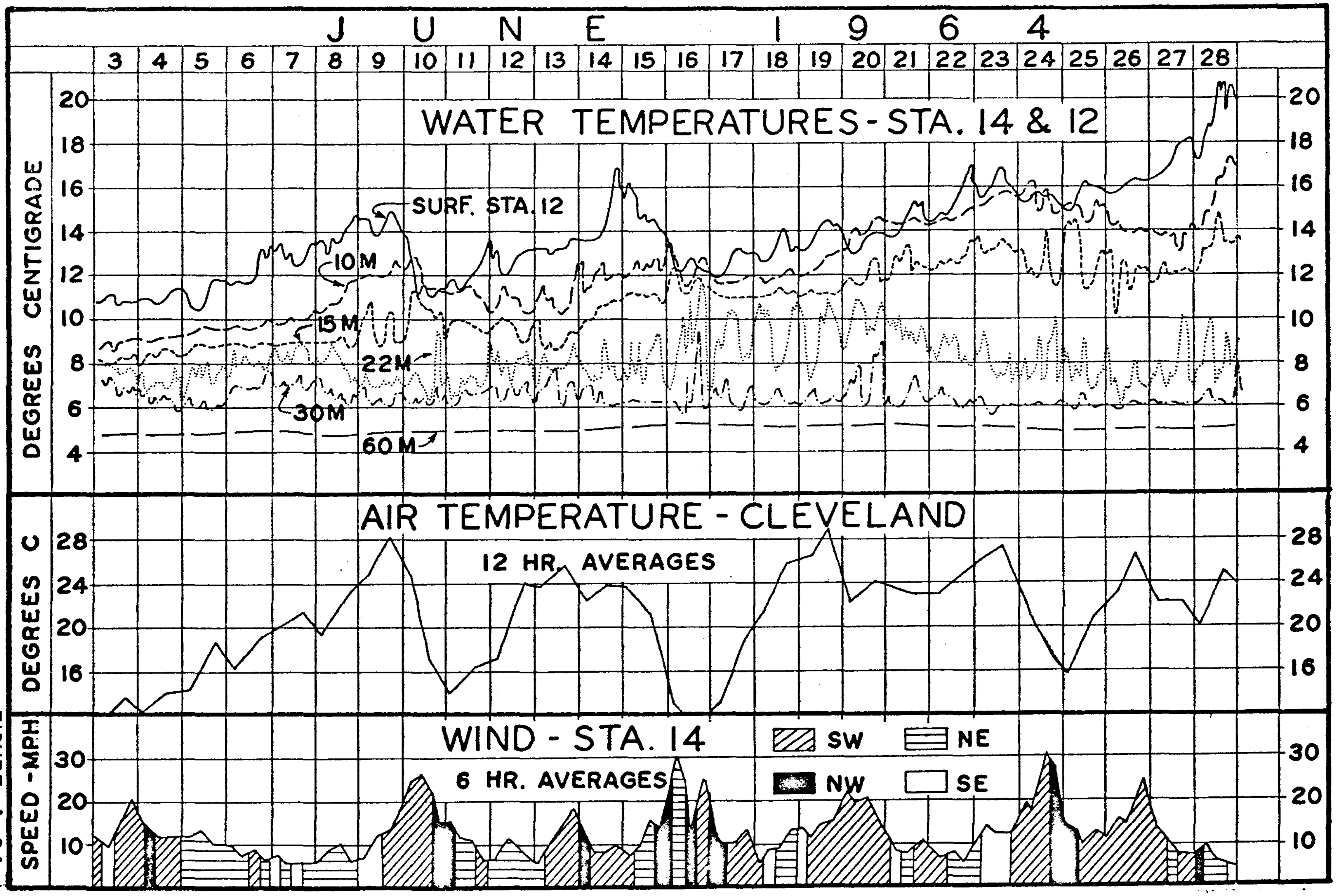

J U N E 1 9 6 4
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
WATER TEMPERATURES - STA. 14 & 12
DEGREES CENTIGRADE
20 18 16 14 12 10 8 6 4
SURF. STA. 12
10M
15M
22M
30M
60M
AIR TEMPERATURE - CLEVELAND
12 HR. AVERAGES
DEGREES C
28 24 20 16
WIND - STA. 14
6 HR. AVERAGES
SW
NE
NW
SE
SPEED - MPH.
30 20 10

FIGURE 4-24

Mixing in the epilimnion of the eastern basin may be aided greatly or perpetuated by relatively high amplitude thermoclinal waves. Significant internal wave motion is virtually constant throughout the summer with an inertial 17 to 18-hour period dominant. The thermocline thins and deepens rapidly after the epilimnion begins to cool. Just before the thermocline disappears, usually in November, it has reached a depth of 100 feet or more. With its disappearance the hypolimnion zone warms somewhat, due to mixing, and then begins to cool to winter temperatures.

Effects of Temperature Phenomena: Temperature plays a most important role in the pollution of Lake Erie, as does the temperature-related density stratification. Some of the more important effects are:

1. Actual temperature controls plant and animal productivity of the lake to some degree; in general the higher the temperature, the greater the productivity.

2. Intermittent thermal stratification near the bottom of the western basin leads to rapid de-oxygenation of the water in the hypolimnion, when and where it occurs. The warmer the hypolimnion the more rapid the de-oxygenation will be.

3. Stable summer thermal stratification in the central basin leads to the annual de-oxygenation of hypolimnetic water.

4. Thermal stratification in the eastern basin does not have serious consequences because of the much greater thickness and less rapid circulation of the hypolimnion.

5. Temperature is important in controlling water movements in nearshore areas. Density barriers may confine warmer waters and pollution substances to the nearshore zones, especially along the south shore, in spring and summer.

6. Temperature rises in general limit top to bottom mixing; temperature declines favor it.

Lake Currents

Water movements in Lake Erie appear to be complex, and at any one time the circulation pattern may differ markedly from that of another time.

Horizontal currents generally have more energy than vertical currents, but all currents tend to relocate and disperse suspended or dissolved constituents. Water movement is quite different between offshore and nearshore waters because of the effects of bottom topography, temperature differences, and other density variations.

It is very difficult to describe Lake Erie's predominant flows three-dimensionally as such directions vary with both depth and location in each basin. Therefore, the discussion of Lake Erie's currents will deal mainly with surface and bottom currents.

Western Basin Circulation - A pattern of most probable dominant surface currents has been compiled, Figure 2-22, using the data from all of these studies.

The surface currents in the western half of the basin are dominated by the Detroit River inflow. In the eastern half of the basin the surface flow is greatly influenced by the prevailing southwesterly winds, and this effect produces a clockwise flow around the islands. Eddy current effects along the sides of the Detroit River inflow lead to sluggish movement of surface water west of Colchester, Ontario and between Stony Point, Michigan and Toledo. These eddies tend to retain waters contained within them, leading to higher concentrations of pollutants commonly found in these areas.

The surface flow of the western basin water is often altered by changes in wind direction and intensity. The effect of strong winds on surface circulation is essentially to skim the surface water and move it in the direction of the wind. A sufficiently strong wind will move most of the surface water in the same direction.

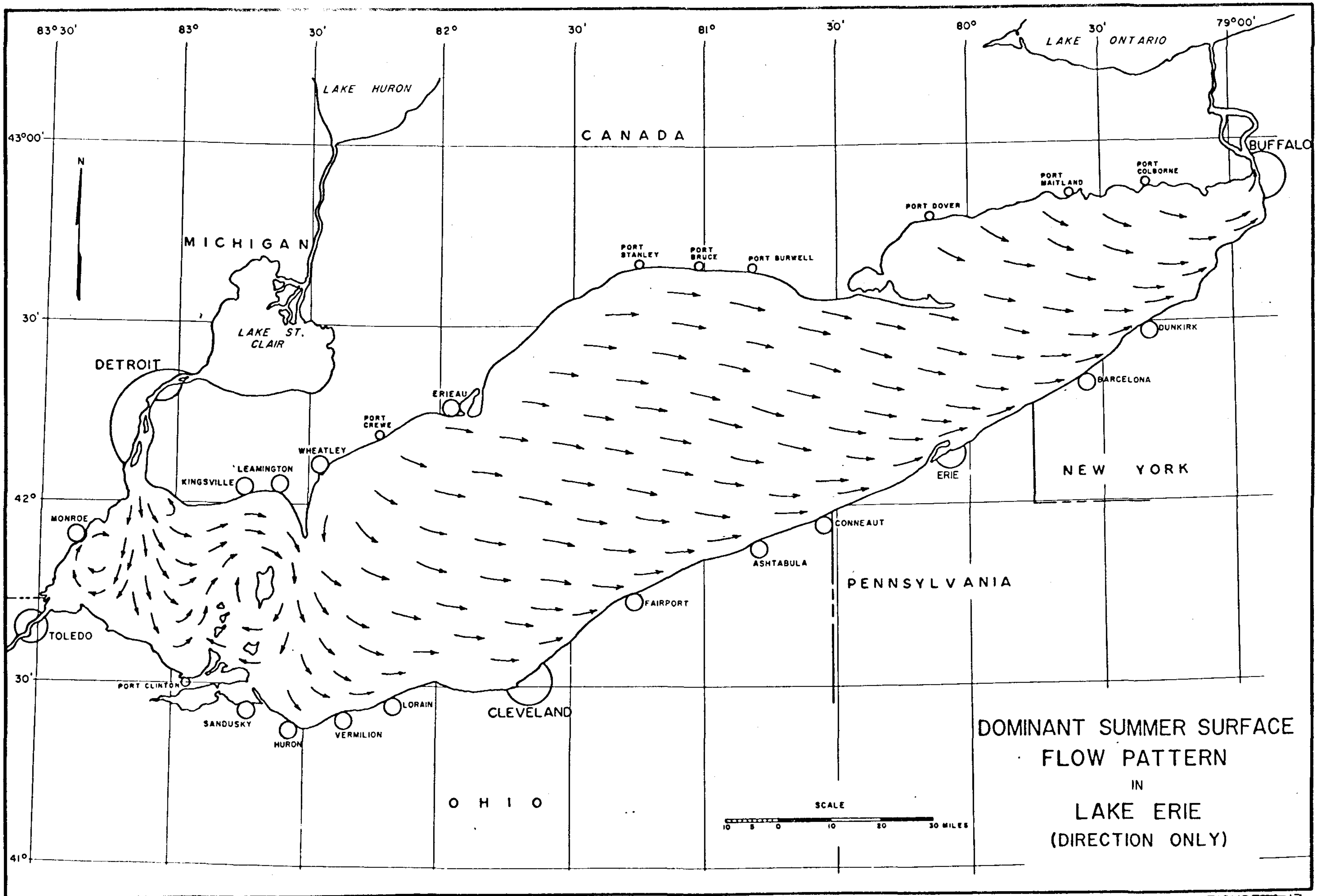
Surface flow tells nothing about bottom circulation. It has been found that, in summer, bottom currents in the western part of the basin are similar to surface currents, being dominated by the Detroit River inflow (Figure 2-23). However, in the island area, the bottom currents are apparently the reverse of the surface currents with a counter-clockwise flow around the islands.

Like the surface movement, bottom currents can also be changed by the wind, although it probably takes a stronger wind to create a major change of pattern. With very strong winds, which cause major changes of water level, the bottom currents are essentially the reverse of surface currents. This means, for example, that a strong westerly wind will cause bottom currents toward the west and a strong easterly wind will cause bottom currents to shift toward the east.

Seiches and changing winds complicate the patterns which occur at any particular time. An ice cover will enable the existence of a more or less stable pattern which should be similar to the dominant pattern of summer surface flow.

The most significant effects of current patterns in the western basin are:

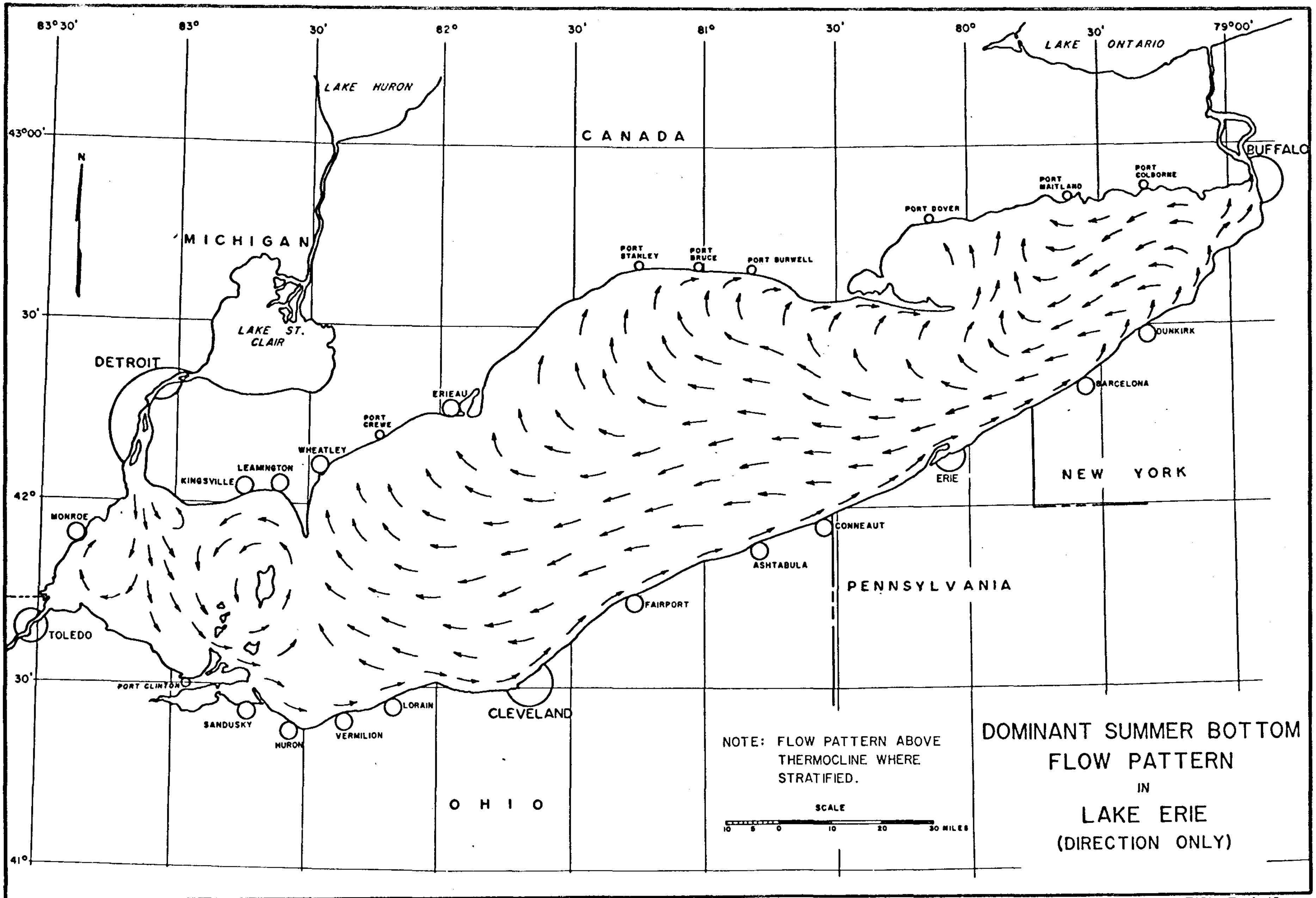
1. Concentrations of contaminants from the Detroit, Raisin, and Maumee Rivers may build up along the west shore under the conditions of dominant flows, both surface and bottom.



DOMINANT SUMMER SURFACE FLOW PATTERN IN LAKE ERIE (DIRECTION ONLY)

~~FIGURE 4-17~~

Fig 2-22



DOMINANT SUMMER BOTTOM FLOW PATTERN IN LAKE ERIE (DIRECTION ONLY)

FIGURE 4-18

Fig 2-23

2. Concentrations of contaminants may similarly build up to even higher values under ice cover since wind then has less effect.

3. Winds cause mixing and redistribution of contaminants over the entire basin in ice-free periods.

4. A portion of central Lake Erie water may recirculate in and around the island area of the western basin.

Central Basin Circulation - The wind exerts a dominating effect on the water circulation of the central basin of Lake Erie. The orientation of the basin, with its long axis essentially parallel to the prevailing southwesterly winds, makes this effect especially important.

The predominant surface water movement in central Lake Erie is also illustrated in Figure 2-22. The pattern is for summer but should be similar for winter months except for a decided shift in movement toward the southeast and south as a result of the more frequent occurrence of northwesterly winds.

Surface currents do not exactly parallel the wind direction but move to the right of it because of the Coriolis effect. The predominant pattern is essentially that of resultant movement over an extended period, at any one time, surface movement may be greatly different or even reversed.

Because surface currents are generally moving water in much greater quantity than can be removed from the basin, the balancing movement must be subsurface and essentially a return flow over most of the basin. The predominant bottom flow pattern for summer is shown in Figure 2-23. In this case, bottom flow means the motion at the lake bottom in unstratified water, but where the lake is thermally stratified it means the predominant movement at the bottom of the epilimnion. It is generally westward and more or less opposite to the surface flow.

High velocity currents (up to 2 ft/sec.) have been measured in the hypolimnion during storms. These are brought about during upwelling and downwelling when the hypolimnion water is forced to slide around in the basin. This phenomenon results in higher velocity currents at the bottom in late summer and early fall when the hypolimnion is thin and sharply divided from the epilimnion.

Bottom currents near shore are pronounced in summer and are quite different from bottom currents off shore, indicating a separate system of water movement. There is a distinct eastward movement of nearshore water, top to bottom. Water temperature structure supports this conclusion with a spring and summer band of warmer water near the south shore.

Transport of sediments near the water line along the south shore of the central basin is not necessarily indicative of prevalent flow of water. For example, from Avon Point westward, beach sediment accretion patterns indicate a general drift toward the west. This results from wave action in the nearshore zone which is stronger from the northeast. Sediments are moved toward the west during the intermittent periods of northeasters. The slower but more prevalent water circulation toward the east is unable to transport the sediments. From Avon Point eastward, the nearshore sediment drifts toward the east, the same as prevailing water flow, because increased westerly fetch makes waves from that direction more effective.

A different type of situation exists along the north shore of the central basin. In summer, the zone of separate nearshore flow, if it exists at all, is limited. Temperature measurements indicate that the near-shore water is cooler throughout the summer than along the south shore. This implies removal of warm upper water and replenishment by lower cooler water.

The Canadian shore of the central basin is more irregular than the south shore, and the irregularity has a pronounced effect on wave action and beach drift along the shore. On the east side of Pelee Point the drift is toward the south-southwest, moving sediment to the tip of Pelee Point. Between Wheatley and Erieau, Ontario, the drift reverses and at Erieau it is toward the east. Along the eastern side of Pointe-aux-Pins, the drift is toward the south. Eastward, the drift reverses again and at Port Stanley and eastward the drift is strongly toward the east. All of these drift phenomena are functions of wind, fetch, and resulting wave force in the nearshore zone, and do not necessarily reflect prevailing nearshore water movement.

The most significant change in circulation in the central basin water, in fall and winter, is the disruption of the confining influence of temperature differences. Usually in September the surface waters of Lake Erie become nearly uniform in temperature , and by the first of October, the thermocline has disappeared from the central basin. The higher temperatures which previously existed along the south shore disappear, and there is no longer a density restriction to water movement. In effect then, the nearshore flow is more free to move water lakeward, and cooler tributary water can flow under the lake water. The bottom flow return circulation in mid-lake reaches to the lake bottom where the thermal barrier (thermocline) previously blocked it from the lake bottom.

In spring when the shore water warms to several degrees above the temperature of mid-lake water, the south shore nearshore flow zone is re-established. Warmer tributary discharges may be even more confined to the nearshore zone.

Conclusions which can be made regarding the pollutional effects of currents in central Lake Erie are as follows:

1. In spring and summer, tributary and lake outfall discharges along the south shore tend to stay near shore and move eastward primarily as a result of the prevailing southwesterly winds.

2. In fall and early winter, the same kinds of discharges can flow under the lake water and can be distributed over the basin.

3. Contaminants reaching more than three miles off shore are likely to be distributed over the entire basin.

4. A vertical circulation in mid-lake exists year-round with easterly moving surface flow and westerly moving bottom flow.

5. The hypolimnion of mid-summer may not have a net circulation flow but does have occasional high-velocity flow with up and downwelling. This flow is capable of resuspending uncompacted bottom sediments.

6. Surface waters in summer move toward the south shore and away from the north shore.

7. Velocities at any level can be up to 2 feet per second during storms.

8. Vertical turbulent mixing is very effective in storms in the epilimnion in summer and throughout in unstratified water.

9. Dispersion of suspended materials is slow and limited.

Eastern Basin Circulation - Water circulation in the eastern basin is primarily wind-controlled. Flow-through currents become important near the headwaters of the Niagara River but are otherwise insignificant.

The surface water movement in the eastern basin appears to be similar to that of the central basin in that the dominant flow is eastward and toward the south shore (Figure 2-23). The predominant surface flow over most of the eastern basin is probably similar throughout the year, but with a shift more toward the south in fall and winter.

The surface flow in the nearshore zone along the south shore is predominantly to the east, but an essentially independent summer zone is much narrower than in the central basin and is probably most important in spring and early summer.

Net subsurface flow in summer is somewhat confused in the lower layers of the epilimnion. The resulting areal pattern is as shown in Figure 2-23 for the lake bottom in unstratified water and the lower layers of the epilimnion in stratified water. Short term patterns often seem disrupted and confused by commonly occurring internal thermoclinal waves, leading to difficulties in determining net flows. Just below the thermocline the predominant motion is apparently similar to that just above the thermocline. It appears that a vertical circulation may be important in the hypolimnion. The horizontal lake bottom currents are nearly the reverse of currents just below the thermocline. Velocities at the bottom are ordinarily very slow however, increasing upward. When upwelling occurs, high velocity currents are not associated as in the central basin.

The thermocline disappears in the eastern basin ordinarily in November. The circulation changes to one system, with a predominant southeastward moving surface flow and a westward moving current at the lake bottom. Velocities decrease with depth and are probably insignificant at the bottom except within a few miles of shore in shallower waters.

In summary the eastern basin circulation is similar to the central basin and in general is as follows:

1. A vertical circulation exists above the thermocline in summer. The dominant flow is eastward at the surface and westward in the lower part of the epilimnion.

2. A vertical circulation, similar to above, exists, top and bottom in early winter, and perhaps all winter, with a slower but greater volume of movement at the bottom in deeper water.

3. Internal waves on the thermocline lead to turbulent mixing in the epilimnion.

4. Discharges from tributaries are carried to deep water quickly at nearly all times of the year. A somewhat broader near-shore current, which restricts dispersion, is limited to spring and early summer.

5. Discharges not caught in the Niagara outflow can be distributed over the entire basin.

6. Surface water moves toward the south shore and away from the north shore and vice versa at depth.

7. Discharges into upper waters of either the central or eastern basins may at one time or another be found nearly anywhere in either of these basins.

8. Water below the level reached by the summer thermocline may be trapped there due to incomplete overturns for long periods, on the order of a year or more.

General Observations - During periods of quiet weather in summer, rotational currents, due to internal waves with an inertial period, are created in the central and eastern basins with no net transport involved.

It appears that, at least in summer, the bulk of the drainage from Lake Erie is from surface water, much of which has been moved to, and is moving along the south shore of the central and eastern basins. This tends to create two retention systems, one of which is much shorter than the theoretical retention time, and one which is much longer.

Present Management of Water Resources

Water resources in the Lake Erie basin are for the most part not managed for flow regulation and flood control. Supply storage reservoirs have been constructed, i. e., at several places on the Maumee River, on the Cuyahoga River by the city of Akron, and on the Rocky River by the city of Berea. There are several upground reservoirs in the Maumee River basin. Some of these reservoirs (i. e. at Lima) impound almost the total flow of the stream. Other than those just mentioned, dams are few in number and of little consequence to the purposes of this report.

The stream basins in the Lake Erie watershed are not generally adaptable to large storage reservoirs because of flat land and narrow valleys. An exception is the Grand River valley in Ohio where a large reservoir is being contemplated as part of a proposed Lake Erie-Ohio River canal system.

At this time flow regulation for waste assimilation is being considered in a number of river sections, particularly in the lower reaches, such as the Buffalo, Cuyahoga, Maumee, and Raisin Rivers.

Flow of the upper Niagara River is controlled by diversionary works for power production. These works are capable of greatly affecting the flow of the river above the Falls, and minimum seasonal and daily flows have been established by international agreement. The control works do not appreciably affect Lake Erie proper and the discharge rate from it. They are not of concern to pollution within the Lake Erie basin as considered in this report.

POPULATION AND ECONOMIC PROJECTIONS

A water quality program must be based not only upon present but also upon future needs, which of course, are dependent upon the economic and population growth of the area. This section describes the factors in general terms for the Lake Erie basin and for economic subregions of the basin. The basin has been divided into thirteen subregions on the basis of similar economic characteristics.

Population

In 1960 more than 10 million persons lived in the United States portion of the Erie basin and 1.2 million lived in the Canadian portion. This is almost a three-fold increase over the 1910 population, Figure 2-24. About 80 percent of the basin population is shared evenly by Michigan and Ohio. Figure 2-25 shows the 1960 population and projections for 1990 and 2020 for various economic subregions. It is anticipated that the population will double in the next 50 years, and the population in the U. S. part of the basin may exceed 23 million by 2020. Although the rate of future overall growth is comparable to the national growth rate (Figure 2-24), past and estimated future growth rates show great differences within the watershed.

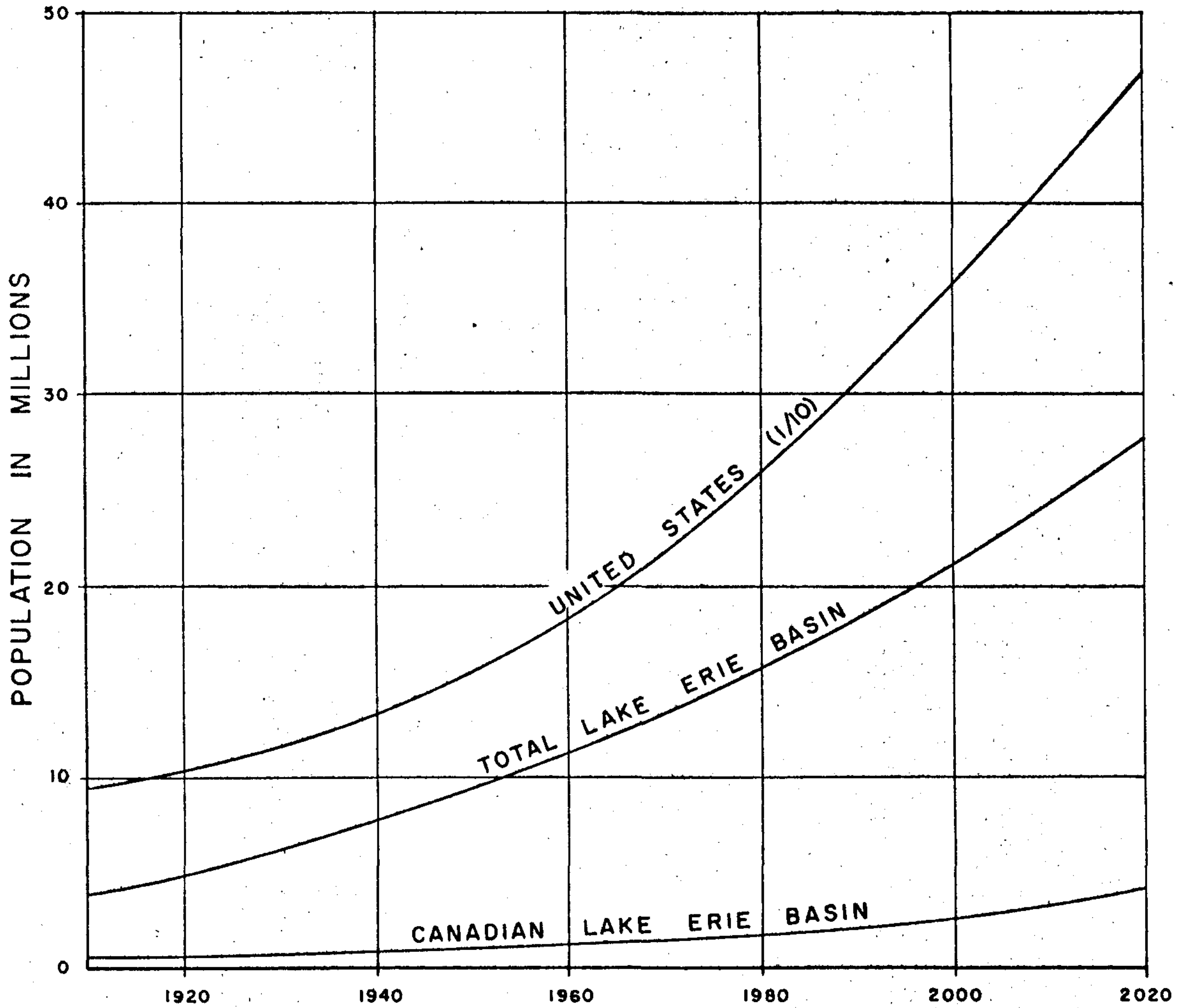
Counties which have shown the most rapid growth rates in terms of percent during the 1950-1960 decade are Macomb and Oakland counties (northern Detroit area) in Michigan and Lake and Geauga counties (eastern Cleveland area) in Ohio. In terms of numbers, however, the largest increases were in Oakland, Macomb, and Wayne counties (Detroit area) in Michigan; Allen County (Fort Wayne area) in Indiana; Erie County (Buffalo area) in New York; and Cuyahoga County (Cleveland area), Summit County (Akron area), Lorain County (Lorain and Elyria areas), and Lucas County (Toledo area) in Ohio. These nine counties out of a total of 45 in the basin, accounted for 50 percent of the 1950-1960 population increase. Present indications are that these large metropolitan counties will account for an even greater share of the total population growth in the future. Already the population in the Erie basin is more than 85 percent urban.

Economy

The Lake Erie basin population enjoys a thriving economy. It is diversified although heavily weighted in favor of manufacturing.

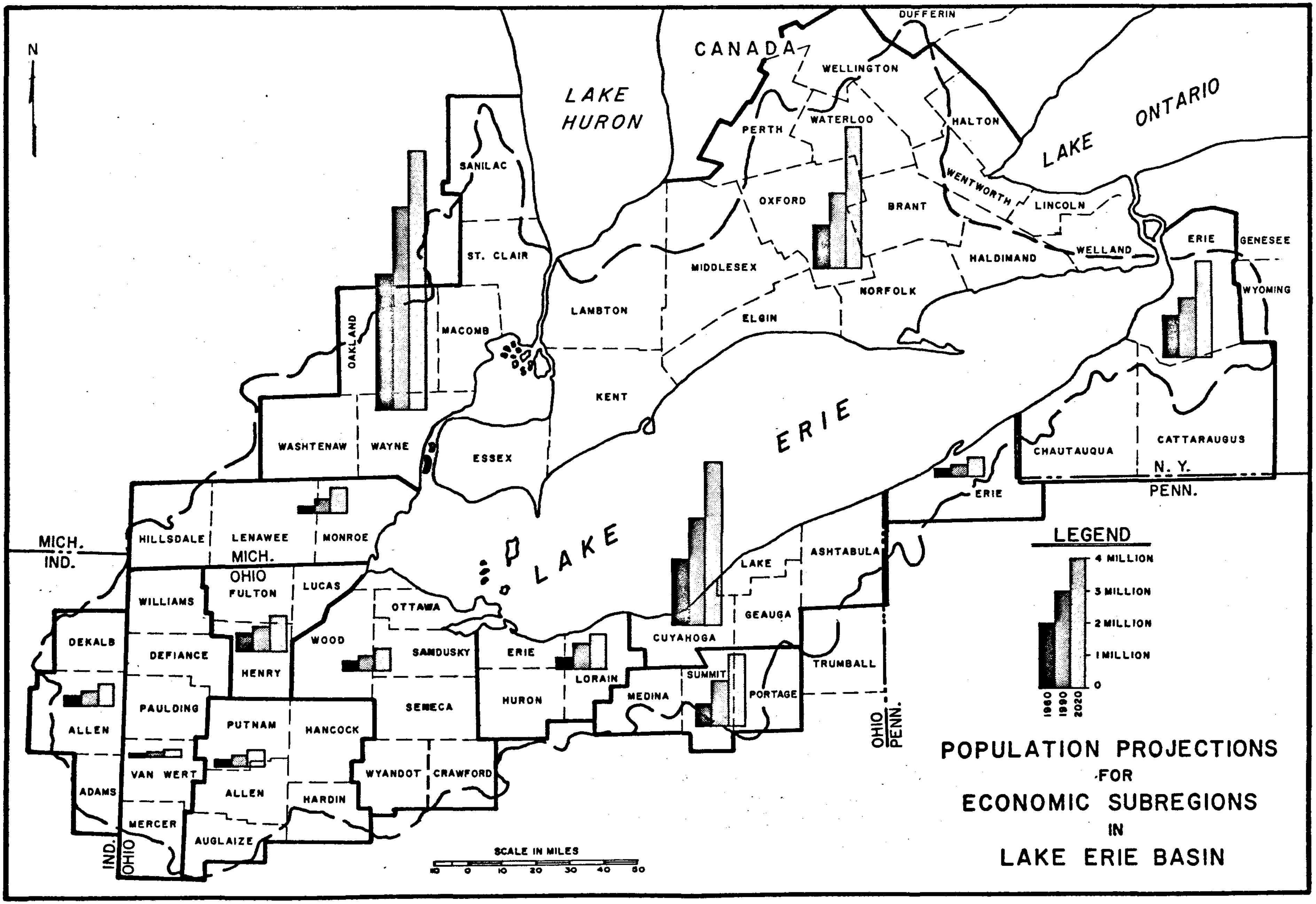
Manufacturing: Industrial growth in the Lake Erie basin appears to be paralleling the growth of the states. About 25 percent of the total production of the five Lake Erie states is within the basin.

Industrial activity as measured by value added by manufacture, is for the most part concentrated in a few highly populated metropolitan areas, and most manufacturing is near the lakeshore because it relies on a plentiful water supply as well as waterborne commerce. The leading counties in 1963, listed in descending order, were: Wayne, Michigan; Cuyahoga, Ohio; Erie, New York; Summit, Ohio; Lucas, Ohio; and Oakland and Macomb, Michigan. These seven counties accounted for 75 percent of



POPULATION PROJECTIONS

Fig. 2-24



POPULATION PROJECTIONS FOR ECONOMIC SUBREGIONS IN LAKE ERIE BASIN
LEGEND
4 MILLION
3 MILLION
2 MILLION
1 MILLION
0
1960
1990
2020
SCALE IN MILES
10 0 10 20 30 40 50
N
CANADA
LAKE HURON
LAKE ONTARIO
LAKE ERIE
DUFFERIN
WELLINGTON
PERTH
WATERLOO
HALTON
OXFORD
BRANT
WENTWORTH
LINCOLN
WELLAND
MIDDLESEX
NORFOLK
HALDIMAND
ELGIN
LAMBTON
KENT
ESSEX
SANILAC
ST. CLAIR
MACOMB
OAKLAND
WASHTENAW
WAYNE
HILLSDALE
LENAWEE
MONROE
MICH.
IND.
OHIO
WILLIAMS
FULTON
LUCAS
DEKALB
DEFIANCE
HENRY
WOOD
OTTAWA
SANDUSKY
ERIE
LORAIN
CUYAHOGA
LAKE
GEAUGA
ASHTABULA
TRUMBULL
PORTAGE
SUMMIT
MEDINA
HURON
SENECA
ALLEN
PAULDING
PUTNAM
HANCOCK
VAN WERT
WYANDOT
CRAWFORD
HARDIN
ADAMS
MERCER
AUGLAIZE
PENN.
N. Y.
CHAUTAUQUA
CATTARAUGUS
GENESEE
WYOMING

Fig. 2-25

the total Value Added by Manufacture in the entire watershed (Figure 2-26).

Figure 2-27 lists the chief types of manufacturing for each of the economic subregions of the U. S. part of the basin. Chemical industry activity is projected to quadruple in the Lake Erie basin by the year 2020, primarily in the subregions in which it is now significant. All other industrial activity is expected to approximately double. However industrial water use, although expected to increase somewhat, will not increase by the same proportions, because the demand will be less per unit of activity due to increased inplant efficiency.

Agriculture: Agricultural activity decreases with expanding urbanization but remains a vital part of the Lake Erie basin economy. Its importance is due to the high fertility and tilth of the old lake bed and beach soils, the large area and flatness of the region, and the moderating influence of the Great Lakes upon the climate of the area. Because of the predominance of some factors over others, specialized farming predominates in some areas, i. e. truck crops, nursery products, fruits, etc.

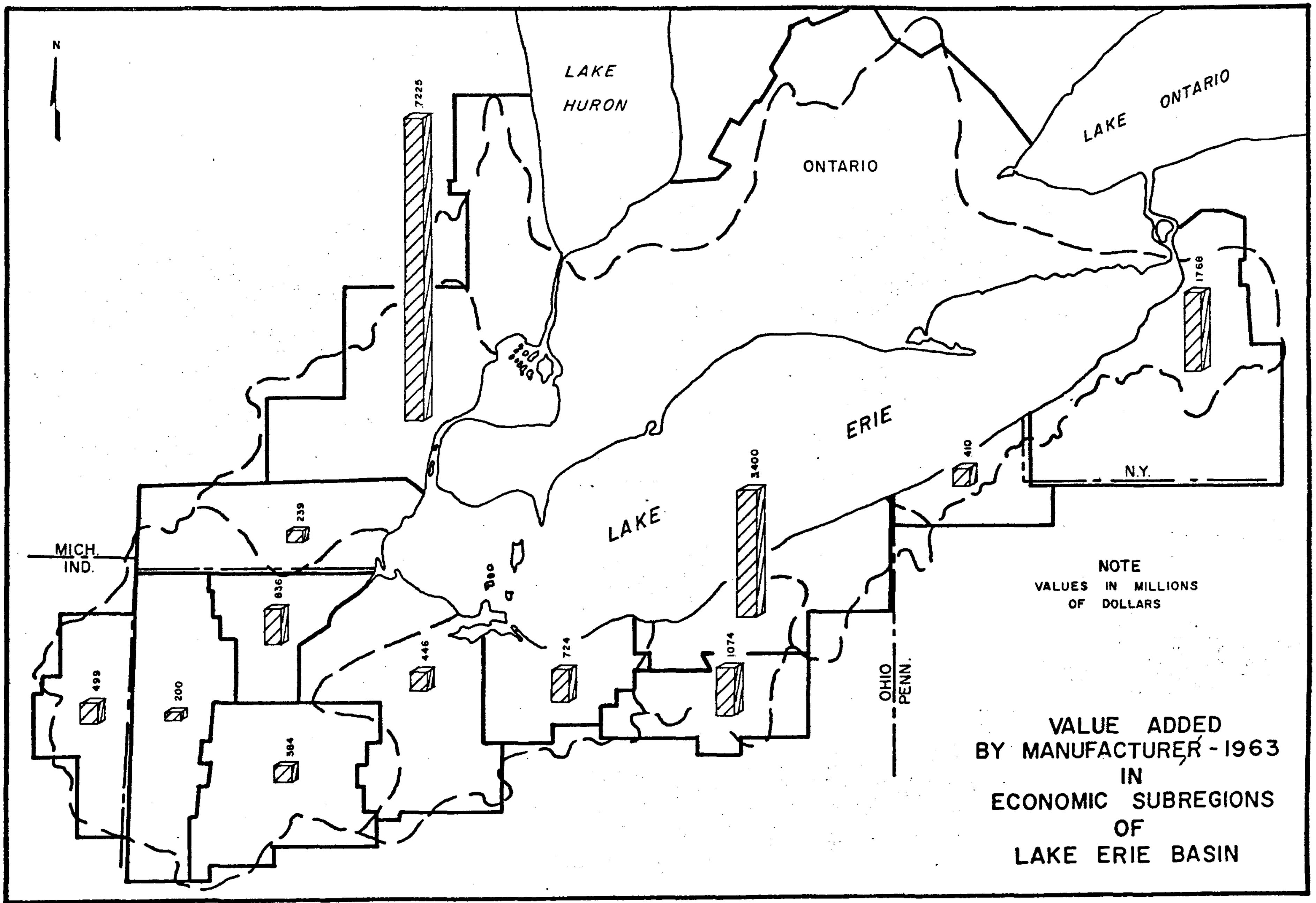
Figure 2-28 illustrates for the economic subregions, the value of agricultural sales in the U. S. portion of the Erie basin for the year 1959. As this figure indicates, the most intensively cultivated land is in and around the Maumee and Sandusky River basins.

In general the kind of agricultural crop activity changes from west to east in the basin, from general farming to truck crops to nursery products to fruit crops at the east end, Figure 2-10, Land Use. Also, in general, agricultural activity increases inland from the lake shore.

Agricultural production in the Erie basin is expected to double by the year 2020, paralleling the population growth, even though areas under cultivation will probably decrease.

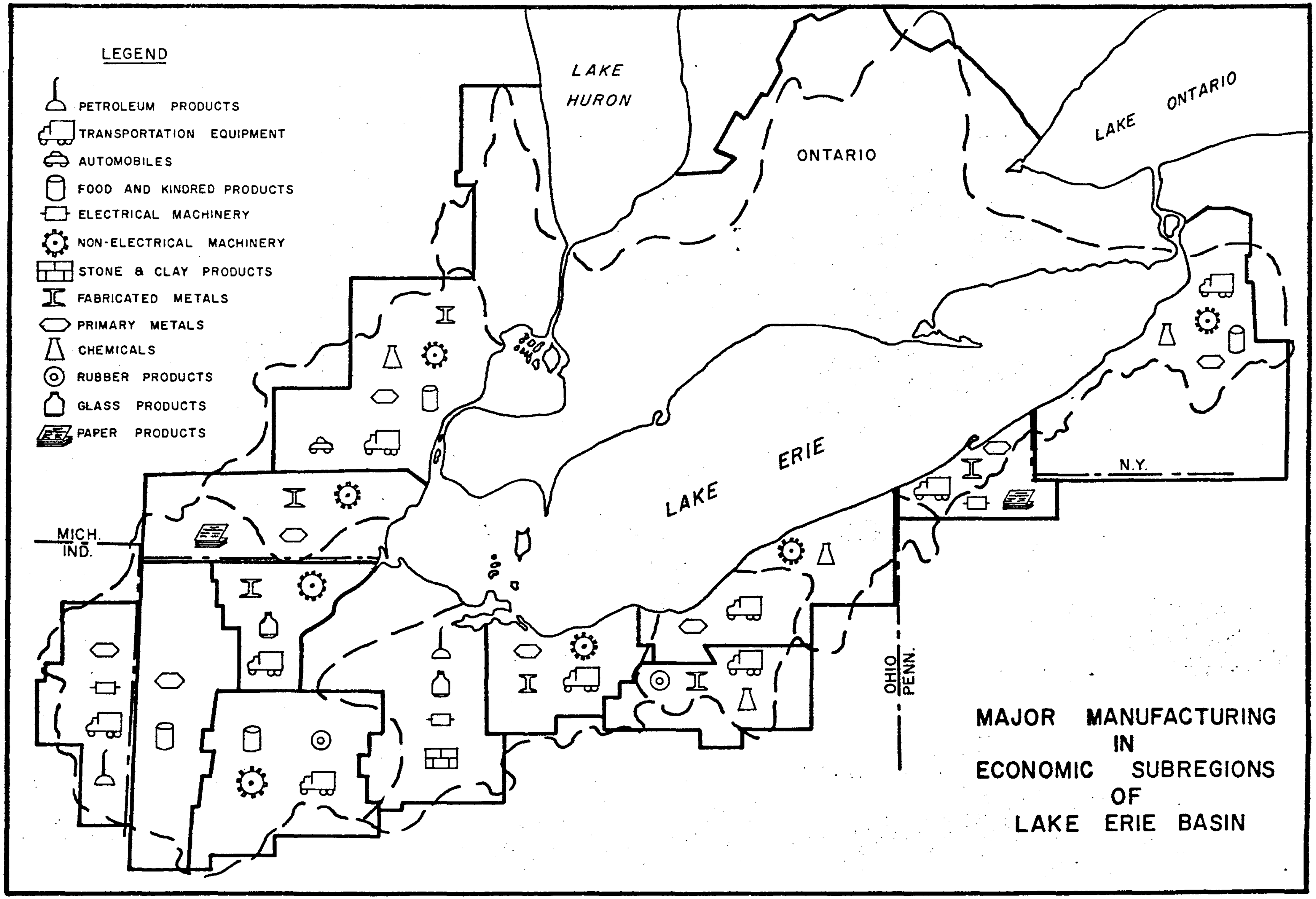
Commerce: The Lake Erie basin is near the commercial center of one of the most industrially productive areas in the world. The five states of the basin contribute more than 36 percent of the nation's manufacturing output. In addition, these states contain or are near the nation's largest coal reserves and the richest agricultural lands. These factors, combined with the availability of the Great Lakes and the St. Lawrence Seaway for waterborne commerce and the restrictive effect of Lake Erie on the convergence of land routes, have made the basin a major distribution area for both raw materials and finished products.

The basin is traversed by an excellent network of state, federal, and interstate highways and railroads. It has eleven major U. S. ports: Detroit, Toledo, Sandusky, Huron, Lorain, Cleveland, Fairport, Ashtabula, Conneaut, Erie, and Buffalo. Table 2-5 lists the major Lake Erie ports and their total export and import tonnages. Also listed is the largest



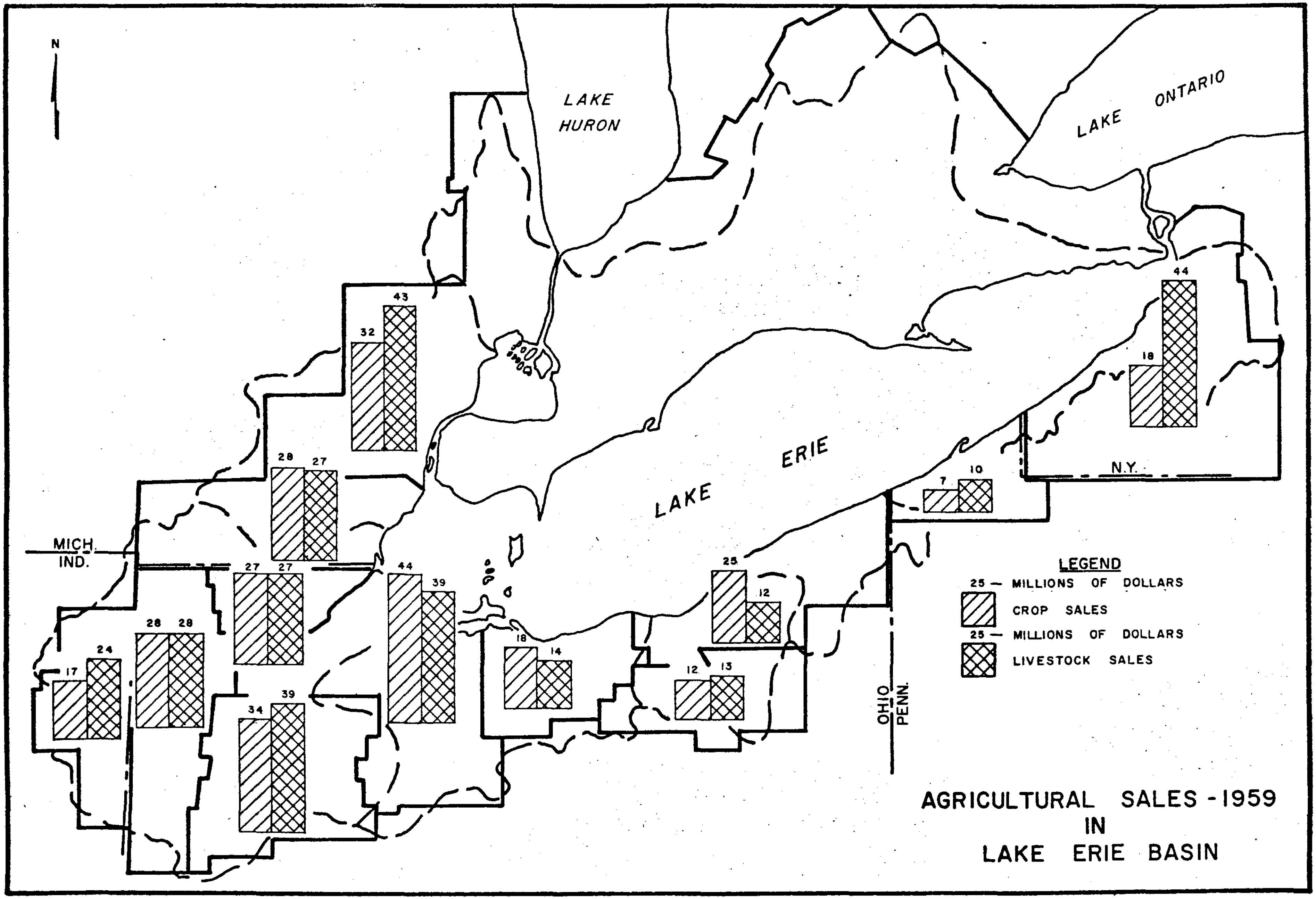
VALUE ADDED BY MANUFACTURER - 1963 IN ECONOMIC SUBREGIONS OF LAKE ERIE BASIN

Fig. 2-26



MAJOR MANUFACTURING IN ECONOMIC SUBREGIONS OF LAKE ERIE BASIN

Fig. 2-27



AGRICULTURAL SALES - 1959
IN
LAKE ERIE BASIN

Fig. 2-28

TABLE 2-5

TRADE AT LAKE ERIE PORTS
(thousands of tons)

Port	Total tonnage in 1962	Largest Commodity
Detroit	27,023	Coal and iron ore import
Toledo	36,536	Coal export
Sandusky	4,154	Coal export
Huron	1,546	Iron ore import
Lorain	5,800	Iron ore import
Cleveland	16,900	Iron ore import
Fairport	3,051	Limestone import
Ashtabula	9,051	Iron ore import
Conneaut	3,063	Iron ore import
Erie	2,550	Iron ore import
Buffalo	15,587	Iron ore import

commodity handled at each port.

In 1963 Lake Erie accounted for 13 billion ton-miles of shipping out of a total of 95 billion on the Great Lakes. The Detroit River must accommodate all water-borne traffic between Lake Erie and the upper lakes. In 1962 this amounted to more than 100 million tons of cargo.

Mining and Lumbering: Mining is not an important part of the overall economy of the Lake Erie basin, although in certain areas it is significant. Wherever mining occurs, it is confined to non-metallics, and is not expected to increase significantly except for salt production.

Sand and gravel are stripped from open pits at many places in the basin, usually in old beach ridges and glacial end moraines. Sand and gravel are also removed from the lake bed in Maumee Bay, Pelee Passage, between Vermilion and Pelee Point, off Fairport, and northwest of Erie, Pennsylvania. This yield amounts to about one million tons annually, valued at about three million dollars.

Salt is mined at Detroit, Cleveland, and at Fairport, Ohio. The latter two mines are beneath Lake Erie. All are deep and mined by shaft and room-and-pillar method. In 1964 some eight million tons were mined with a value of nearly 50 million dollars.

Gypsum is mined both by the drift room-and-pillar method and by the open-pit method at Port Clinton, Ohio. Total production is on the order of one-half million tons annually.

Limestone and dolomite are quarried in the western part of the basin, the main activity concentrated near Sandusky, Ohio. Some limestone quarrying is also done in the east end of the basin. Total production is estimated at 30 million tons annually with a value of 45 million dollars.

Sandstone quarrying is an important operation at Amherst, near Lorain, Ohio. It is not significant elsewhere.

Oil and gas production, formerly significant in the economy of the U. S. portion of the basin, especially at Lima and near Cleveland, is no longer of consequence. However, the states of Ohio, Pennsylvania, and New York are now considering leasing portions of the lake bottom for drilling. The bottom of Lake Erie is now producing significant quantities of gas in Canadian waters northeast of Point Pelee and in the vicinity of Long Point Bay. There are some producing wells on Pelee Island and along the Canadian shore. Drilling for oil in the lake can add to pollution problems and could have a serious bearing on water quality unless careful controls are maintained.

A minor amount of fire clay is produced near Cleveland, and marl has been quarried near Sandusky.

Lumbering is not important in the Lake Erie basin although it has been to some extent in the past.

Tourism: In the Lake Erie basin tourism is a major industry, adding hundreds of millions of dollars annually to the basin's economy. The lake itself is the main attraction. In general the basin does not have an abundance of scenic beauty or other factors to make it especially attractive. Therefore tourism is largely confined to activities in which the lake plays a part, such as boating, swimming, and fishing.

The largest and fastest growing tourist enterprises are the Presque Isle State Park at Erie, Pennsylvania, and Cedar Point beach and amusement park at Sandusky, Ohio. The remainder of the tourism industry can be classified as group endeavors, or many clusters of small enterprises such as in the island area, along the shore from Huron to Cleveland, and inshore suburbs of larger towns. The economy of the larger islands and some towns, such as Geneva-on-the-Lake, Ohio, are largely dependent upon summer residents, vacationers, and visitors.

State and provincial parks such as East Harbor and Headlands in Ohio, Presque Isle in Pennsylvania, and Long Point in Ontario are responsible for attracting large numbers of visitors, and they are becoming increasingly important for bolstering the tourism industry.

In winter, providing accommodations for ice fishermen has also become important. In previous years this was mainly confined to the islands, but it is now increasing at many places along the shores.

Excursion trips, once of importance on Lake Erie, are no longer significant.

Tourism can be expected to increase in parallel with the development of recreational facilities on which it largely depends. The development of facilities is not rapidly expanding except in a few local areas where state governments or large private enterprises are developing facilities. The total tourism industry should double its present activity by the year 2020. However, certain facets of the industry, especially those centered around small boating activities, are now expanding rapidly and should increase at a significantly greater rate than population growth.

Commercial Fishing: In the past, fishing in Lake Erie was an important segment of the economy, and particularly at many of the smaller port cities along the lake, especially in the western half of the basin. For example, only a few years ago Sandusky, Ohio laid claim to being one of the largest freshwater fishing ports in the world.

Within the last 20 years the fishing industry on the United States side of Lake Erie has suffered an almost disastrous decline because of the disappearance of prized species, such as walleye, blue pike, and whitefish, upon which the industry depended so heavily. Reluctance of the industry to adapt to less desirable types of fish also contributed to this decline. There is still about 20 million dollars of capital investment in the Ohio commercial fishing industry, but this is only about one-third of the investment in sport fishing.

The Canadian fishing industry has offset the decline, in volume, of the U. S. fisheries. It has maintained the industry through improved efficiency and flexibility in adapting its efforts to the less desirable species, primarily smelt and yellow perch. It has made large capital investments since 1950, with governmental assistance.

Total catch in Lake Erie, in pounds, appears to be tenuously holding its own; but dollar value is decreasing. For example, in the 1950-59 decade, an average annual catch of 53 million pounds of fish brought 7.5 million dollars, while between 1960 and 1964, a catch of 52 million pounds brought only 3.9 million dollars, Table 2-6.

Projecting the economic future of commercial fishing is virtually impossible. The market demand for desirable fish will probably parallel population growth, but this will have little effect on production if the proper kinds and quantity of fish are not available. Attempts at fish management have had little effect up to now on production. It is not known with complete assurance whether pollution control alone can re-establish the Lake Erie fishery, and the effects of attempts to utilize less desirable species are also unknown. The economic future of commercial fishing does not appear bright. Other reasons for the probable future decline are changes in church attitude toward meat fasting, reluctance toward eating other than the traditional species, and public concern for possible pollution effects on fish quality.

TABLE 2-6

AVERAGE ANNUAL LAKE ERIE COMMERCIAL FISHING PRODUCTION AND VALUE
BY STATES AND PROVINCE

(Thousands of Pounds; Thousands of Dollars)

Period	Ohio		Michigan		Pennsylvania		New York		Ontario		Total	
	lbs.	Value	lbs.	Value	lbs.	Value	lbs.	Value	lbs.	Value	lbs.	Value
1934-1939	24,882	1,430	1,083	50	3,183	259	1,213	105	13,552	771	43,913	2,615
1940-1949	21,233	2,825	1,211	109	2,715	416	1,182	168	14,272	2,220	40,613	5,738
1950-1959	21,793	3,719	1,473	122	1,827	409	726	147	24,415	3,677	53,234	7,534
1960-1964	14,900	1,266	1,624	123	1,336	121	355	56	33,799	2,365	52,014	3,931

U. S. Bureau of Commercial Fisheries data, 1966.

CHAPTER 3

WATER USES

Since water quality requirements vary with the uses demanded, the goals of an adequate water pollution control program are determined by the uses of the water supply. Upon improvement of the water quality, the variety of practical uses should be expanded whenever possible. Otherwise, the pollution control program would offer no greater benefits than maintaining current conditions of use.

Two basic kinds of water uses must be satisfied: (1) consumptive transient uses and (2) non-consumptive water environment uses. Consumptive uses include drinking and household supply, industrial supply, power supply, irrigation, and stock watering. Non-consumptive uses include commercial shipping, recreation, fish and wildlife propagation, and waste water assimilation. The effect of pollution on these uses is discussed in Chapter 5.

Municipal Water Use

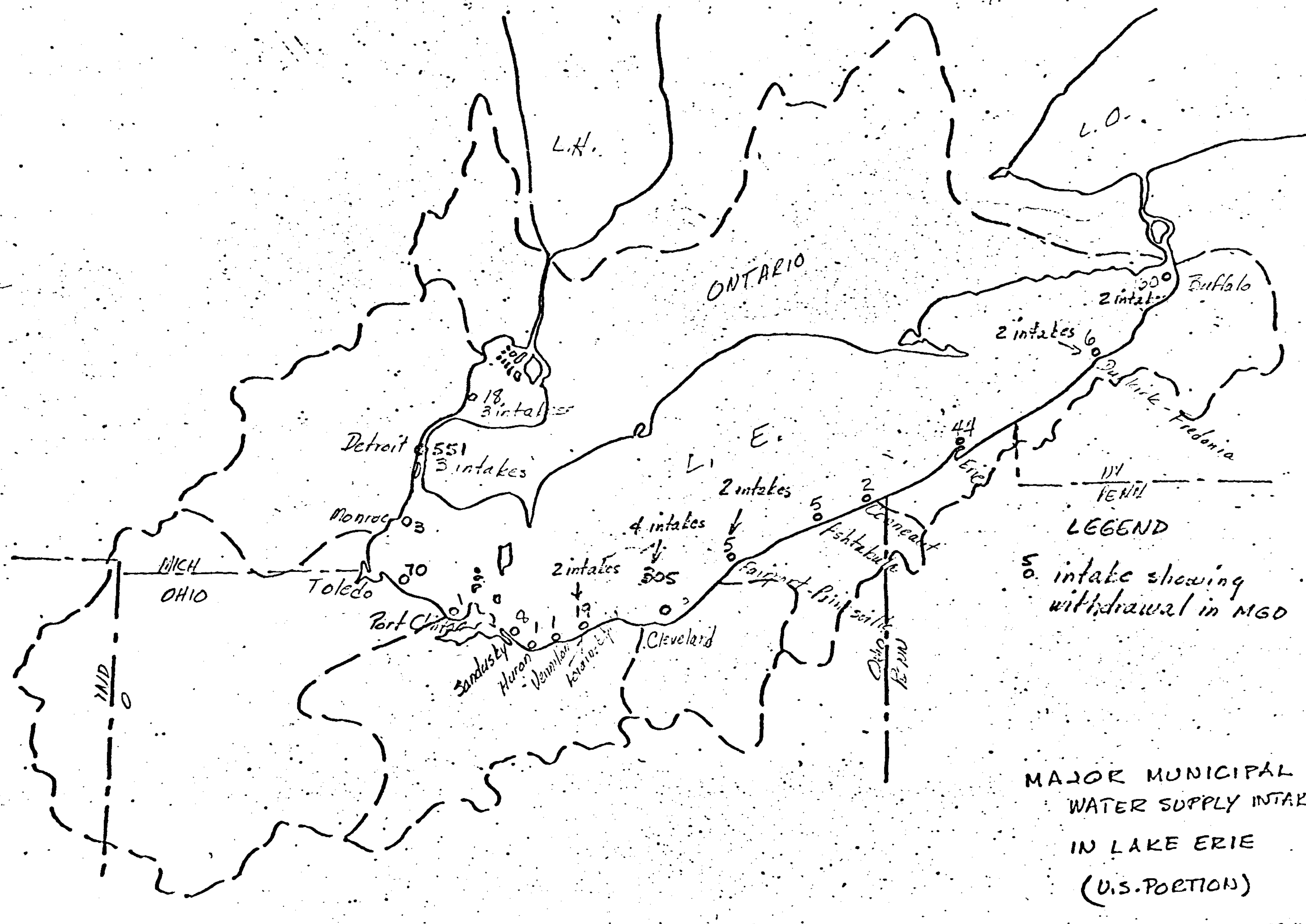
Lake Erie is presently a good raw water source in both quantity and quality for domestic supply, although tastes and odors in drinking water occasionally occur and bacterial problems have been observed at water intakes. Municipal supplies often provide some water for industrial uses. Major water intakes are shown in Figure 3-1.

Lake Erie now supplies about 48 percent or 638 MGD (million gallons per day) of the municipal water needs of the basin. Another 41 percent or 551 MGD is supplied by the Detroit River. Other surface and underground sources supply the remainder of 158 MGD or 11 percent. This ratio will undoubtedly change because inland sources in many cases have almost reached their productive capacity while the demand continues to increase. Thus it is projected that Lake Erie will be supplying over 57 percent of the 2020 demand of nearly 4,100 MGD, the Detroit River and Lake Huron another 34 percent, and the remaining 19 percent will be supplied by inland surface and ground water. In the future, Detroit intends to take its municipal water supply from Lake Huron. This supply will be used to provide the water needs of all of Southeast Michigan. The locations of present surface municipal water sources in the Lake Erie basin are shown in Figure 3-2.

It is expected that municipal water use will increase at a rate greater than the population increase, meaning that the per capita consumption will increase. The per capita consumption is projected to be 25 percent greater in 1990 and 33 percent greater in 2020 than it is today.

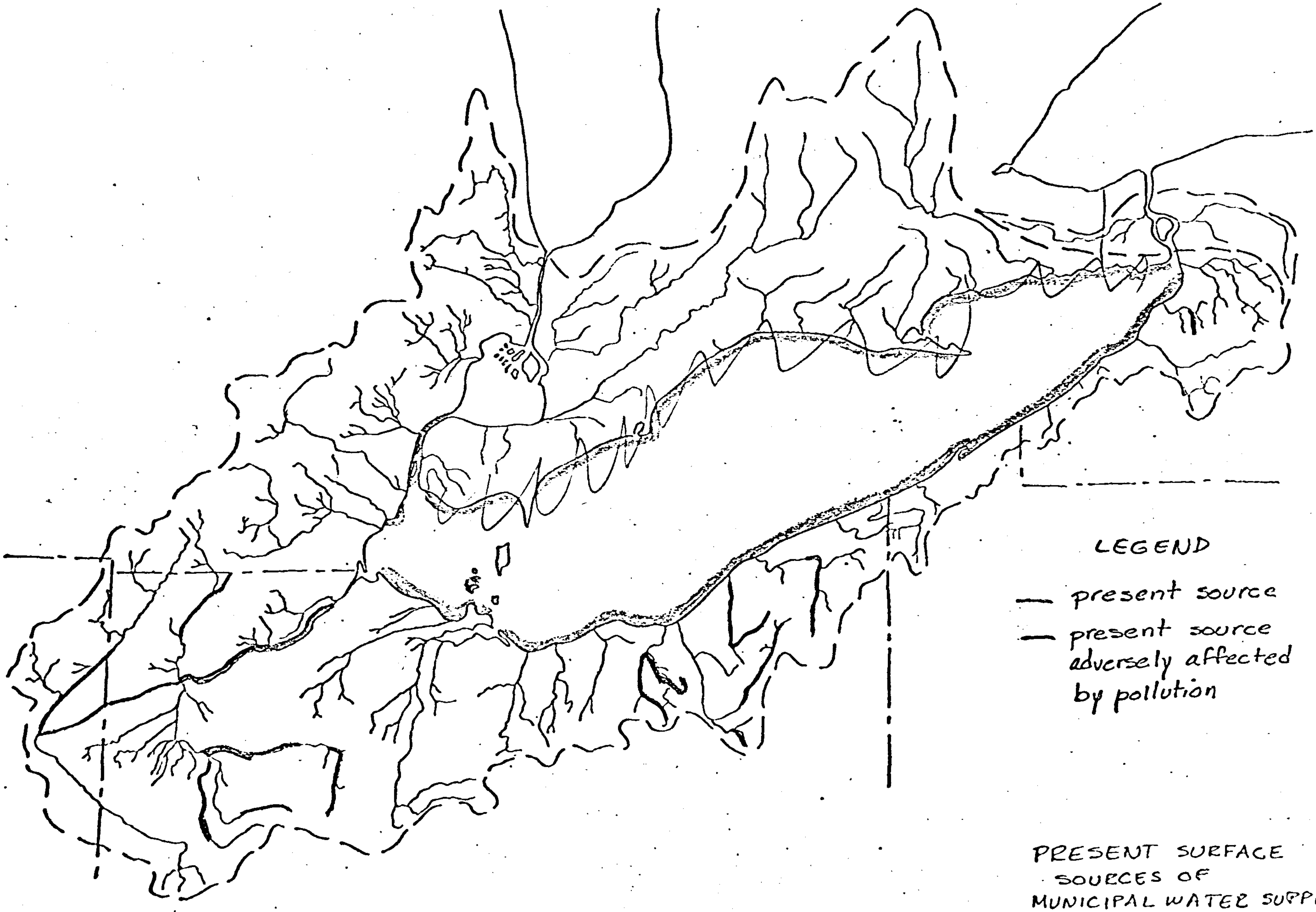
Municipal water use, present and projected, for the United States portion of the basin, by subbasin, is shown in Figure 3-3. The total present and projected use is shown graphically in Figure 3-4.

FIGURE 3-1



MAJOR MUNICIPAL WATER SUPPLY INTAKES IN LAKE ERIE (U.S. PORTION)

FIGURE 3-2



PRESENT SURFACE SOURCES OF MUNICIPAL WATER SUPPLY IN LAKE ERIE BASIN (US PORTION)

In general, the quality of municipal water supplies taken from Lake Erie is good. In the lower Detroit River quality is affected by upstream sewage discharge and taste and odor producing substances. In the upper Detroit River (the main source of water for Detroit) the quality is excellent, being primarily uncontaminated water from Lake Huron. Groundwater contamination caused by underground sewage disposal occurs in the Bellevue, Ohio area. Tastes and odors, not particularly harmful, are occasional nuisances and the most difficult to overcome. These problems are increasing in the central and eastern basins and they have occurred for many years in the western basin supplies. The Lake Erie water supply generally improves from west to east in the basin. Inland sources of supply are greatly inferior to lake supplies, many lacking quantity and most suffering from quality problems.

Industrial Water Use

Industries in the Lake Erie basin use tremendous quantities of water from both the lake proper and its tributaries for product processing (1 percent), power generation (62 percent), and cooling (37 percent). Industrial water use, for purposes of this report, is considered to be that which is self-supplied. Some is obtained from municipal systems. Several of the largest self-supplied lake intakes are shown in Figure 3-5. Figure 3-6 shows present industrial process surface water sources in the Lake Erie basin.

Present and projected industrial water use quantities are shown in Figure 3-3 and total basin-wide projections in Figure 3-4. The total basin-wide projected industrial water use for the year 2020 is more than 21,000 MGD. As with municipal supply, Lake Erie will become the prime source of water as inland supplies become inadequate. At that time the industrial usage will be equivalent to nearly 17 percent of the total input to Lake Erie.

Industrial water supply is contaminated by both municipal and industrial wastes and industry is often the victim of its own waste discharges. Particularly obnoxious streams used for industrial water are the Rouge River, Raisin River, Cuyahoga River, and the Buffalo River.

Rural Use

Rural water use includes household supply, irrigation, and livestock watering. Included in irrigation is general crop, nursery, and golf course watering. Surface water sources for irrigation and stock watering are shown in Figure 3-7.

Total rural water use in the United States portion of the Lake Erie basin is estimated at 124 MGD. This will probably rise to about 250 MGD by the year 2020. Much of the water for rural use is lost by evaporation and transpiration. An ever-increasing amount of rural water will come from Lake Erie as inland supplies become inadequate. Quality has not been a serious problem except for taste in many groundwater supplies.

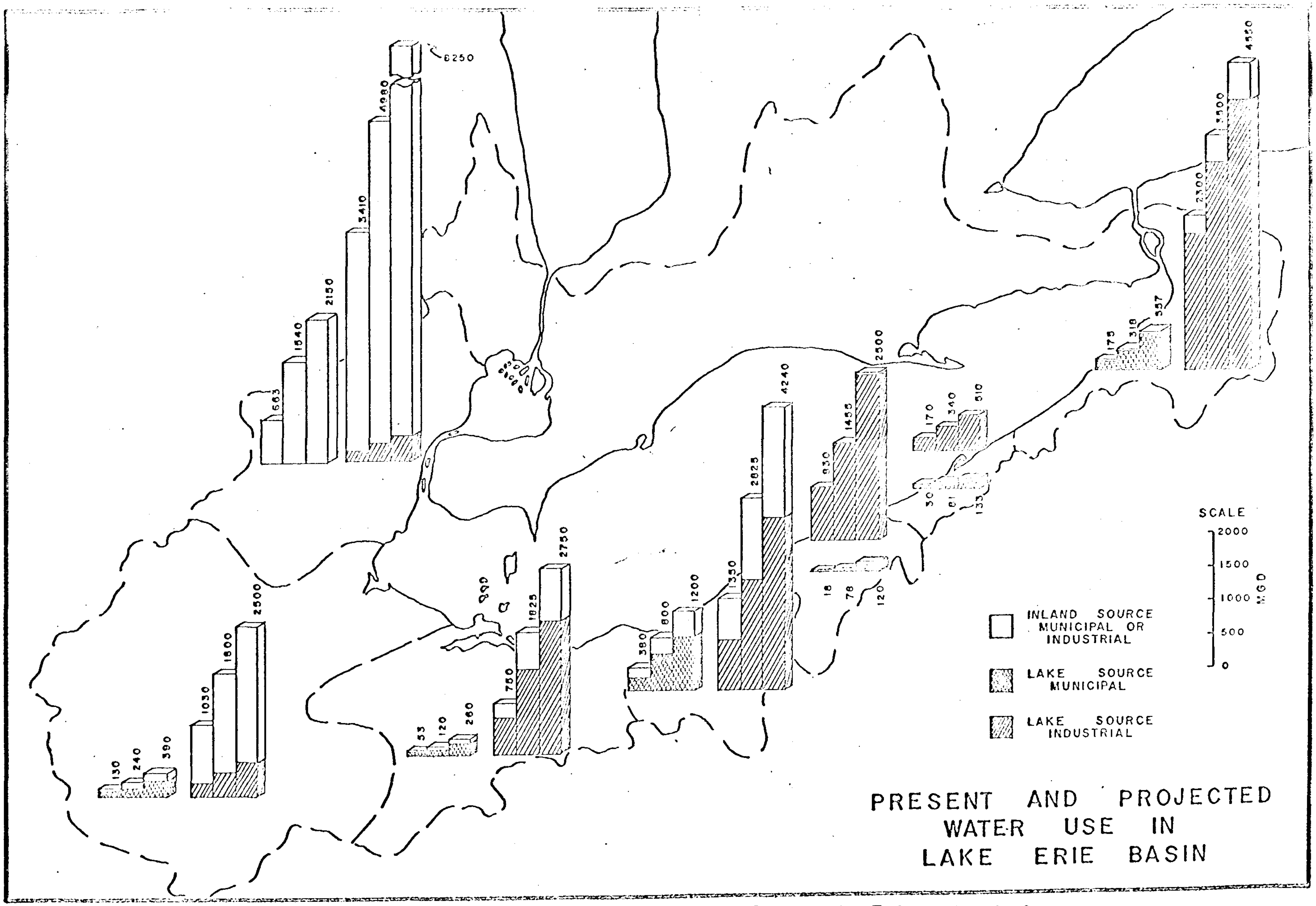
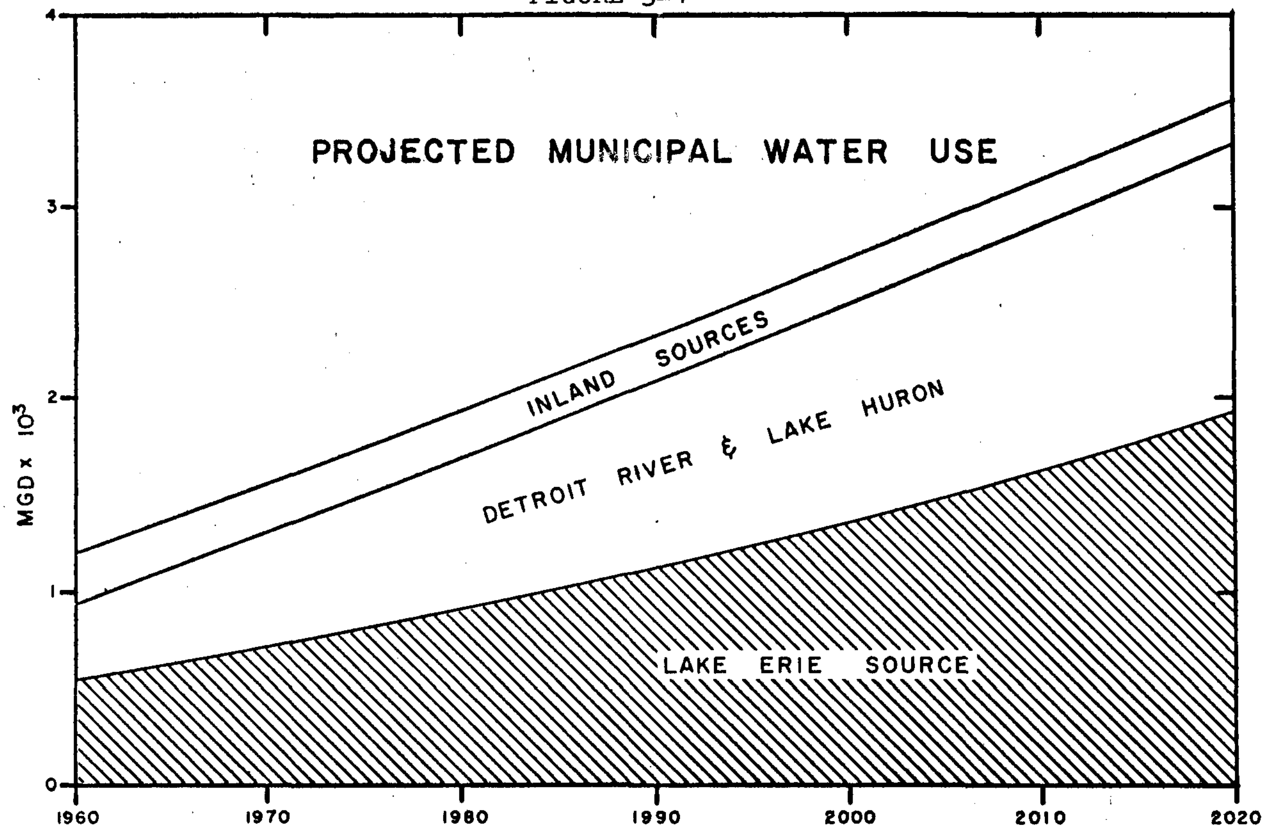


Fig. 3-3 -- Present and projected water use in the subbasins of the Lake Erie watershed

FIGURE 3-4



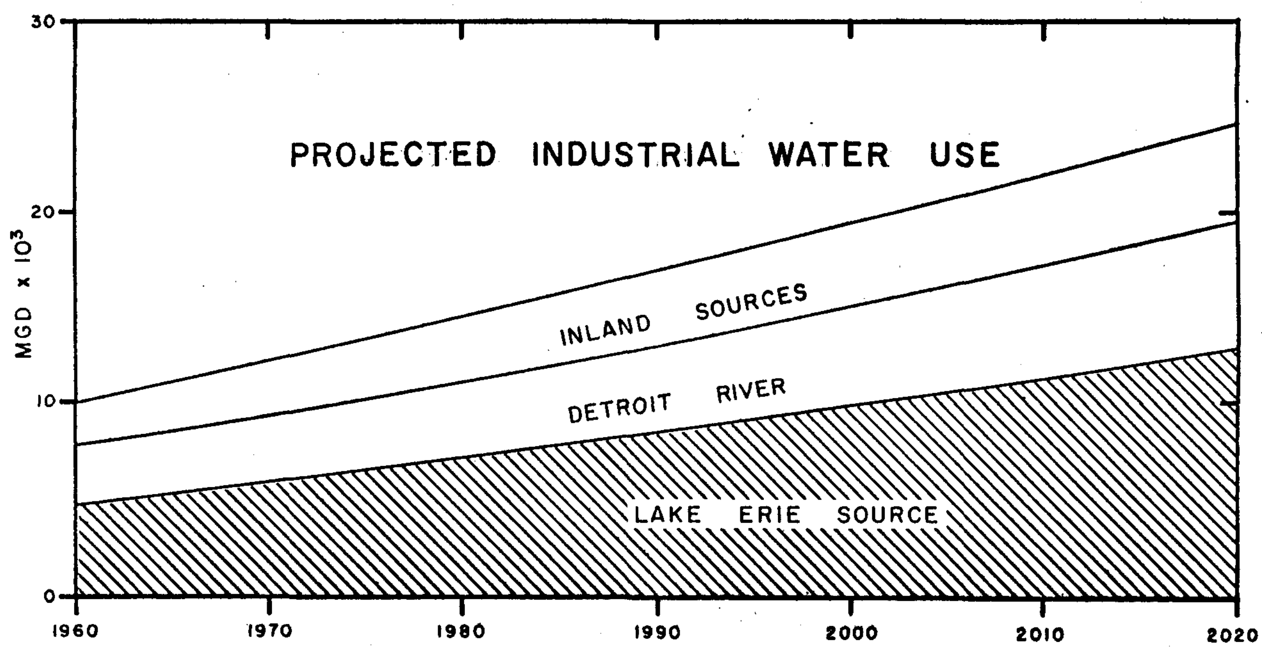


Fig. 3-4

Fig 3-5

Not drawn yet

FIGURE 3-6

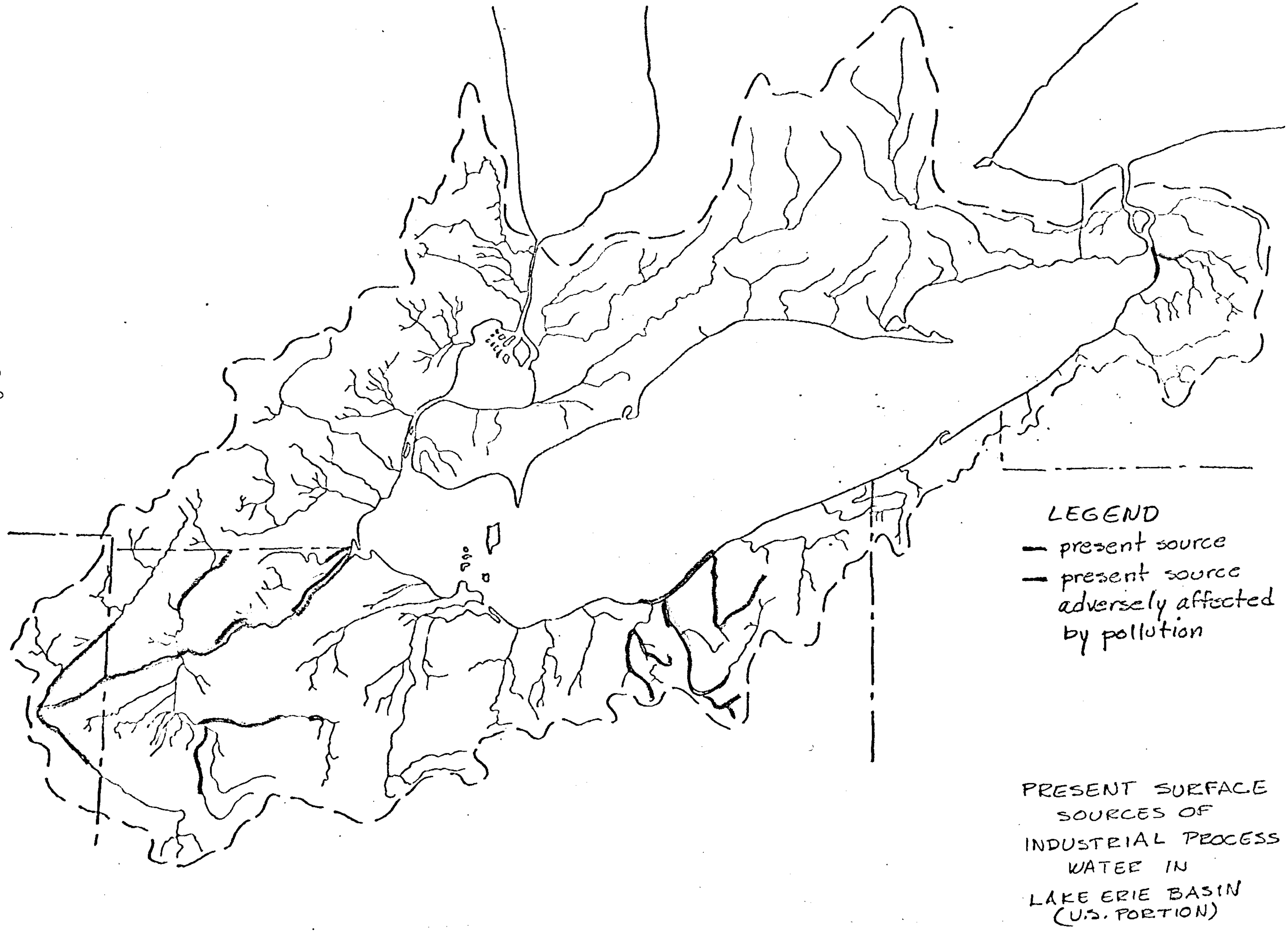
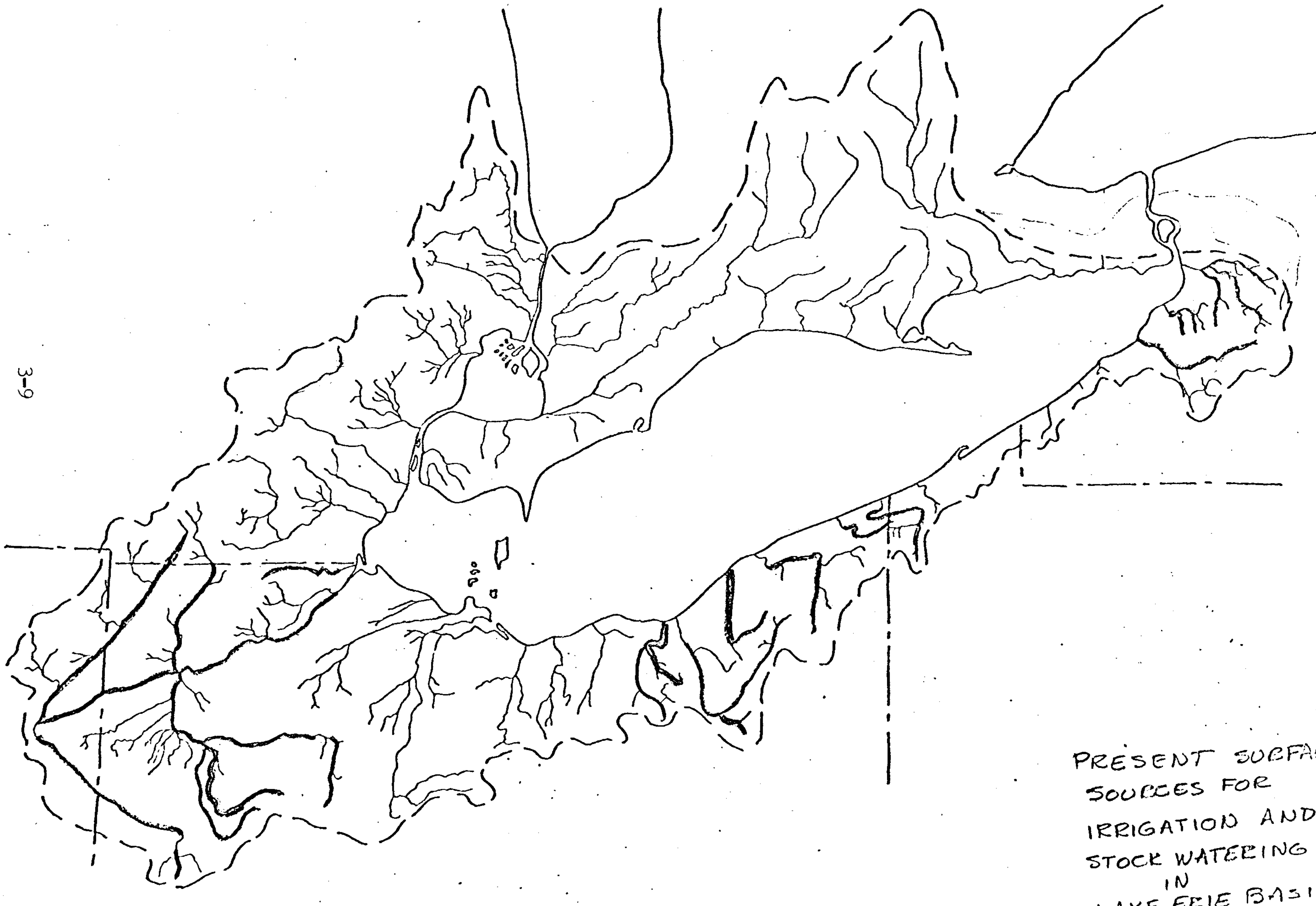


Fig 3-6

FIGURE 3-



PRESENT SURFACE SOURCES FOR IRRIGATION AND STOCK WATERING IN LAKE ERIE BASIN (U.S. PORTION)

Fig 3-1

Commercial Shipping

Shipping is a use not so much dependent upon quality as upon quantity in the Lake Erie basin. Lake levels and corresponding water depths have an economic impact upon bulk carriers by reducing or increasing load limits as much as a thousand tons per foot of vessel draft. The loss or gain may be significant over the length of a shipping season.

Tributaries, except for the St. Clair and Detroit Rivers, are used for shipping only in their lake-affected portions at and near their mouths. Navigation routes are controlled by the water depths in the western basin of the lake (Figure 3-8). Because of the natural shallowness of the lake, most harbors have long dredged channels which extend far into the lake, especially in the western basin. Large amplitude, short-period changes in lake level are occasionally limiting.

Commercial cargo carriers use lake water transiently for engine cooling, ballast, and potable water supply. The last of these obviously requires high quality water since sometimes it receives no treatment. The potable water use is equivalent to that of 1,200 persons for eight months of the year. This use may be expected to more than double by the year 2020.

Fish and Wildlife Propagation

Fish populations depend upon the adequacy of water and its quality in regard to their specific needs. Quantity is not ordinarily a problem in the Lake Erie basin but deteriorating quality caused by inadequately treated municipal and industrial wastes has upset the fishery, so much so that fish can no longer exist in parts of most major tributaries. Also great changes for the worst have taken place in the lake because of its declining water quality. Water areas presently supporting a variety of fish are shown in Figure 3-9.

Lake Erie proper is capable of supporting and does support a tremendous fish population although the type of fish found has changed to less desirable fish. Pollution of the lake is the main reason for this change. The fish are extensively exploited by both commercial and sports fishermen (Figures 3-10). It appears now that commercial fishing will continue to decline but that sports fishing will increase in proportion to the population increase. Fish populations, in total, will probably remain essentially constant. Detailed information on the fish problem is contained in Chapter 5.

Wildlife, especially waterfowl, is water dependent. The marshes along the shore of western Lake Erie are important parts of flyways. Most of the marshes are somewhat dependent upon the water level of Lake Erie. Although the water quality has not been a serious problem in the marshes, it has been in some of the tributaries where pollution has been known to be deadly to waterfowl.

FIGURE 3-8

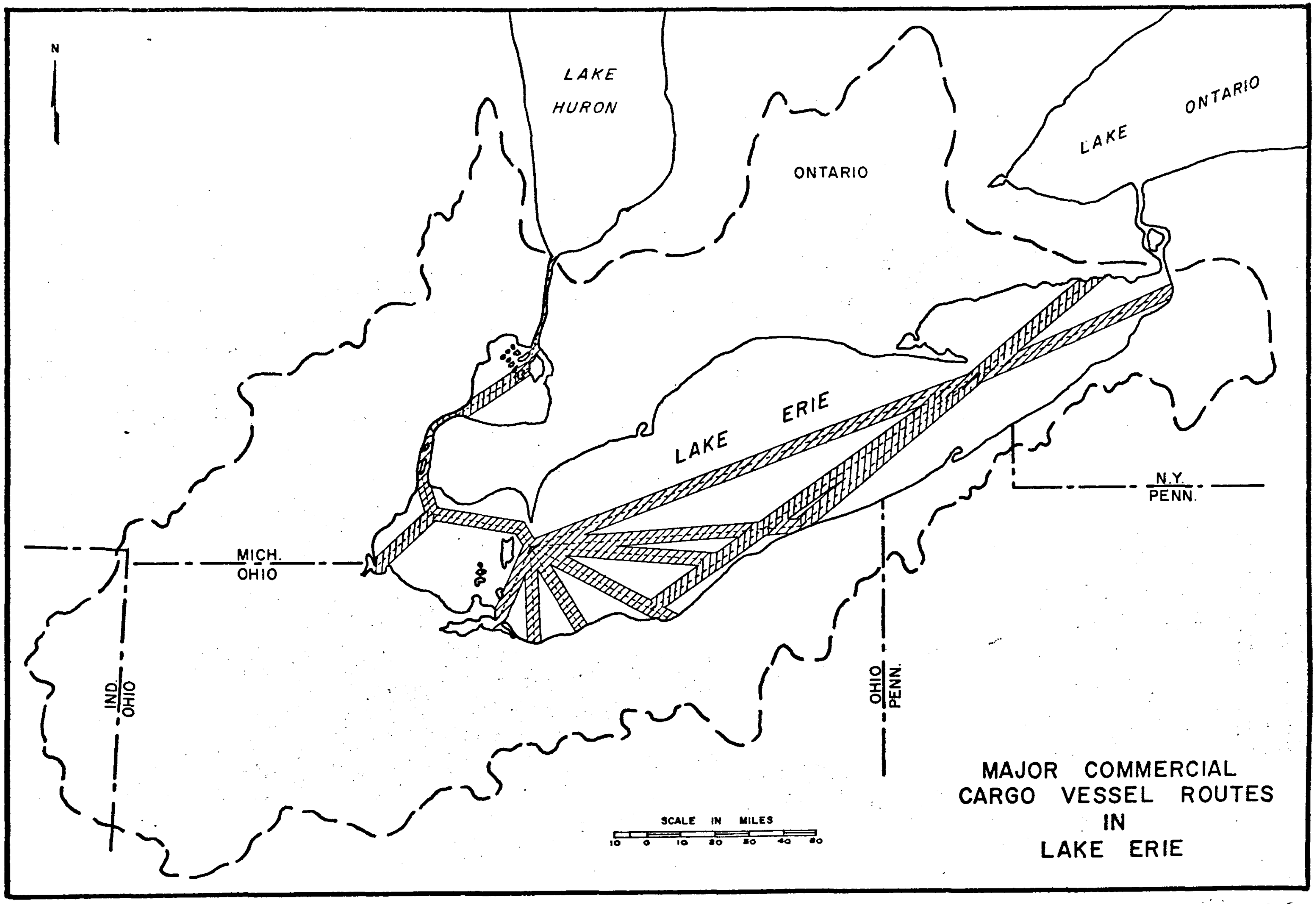
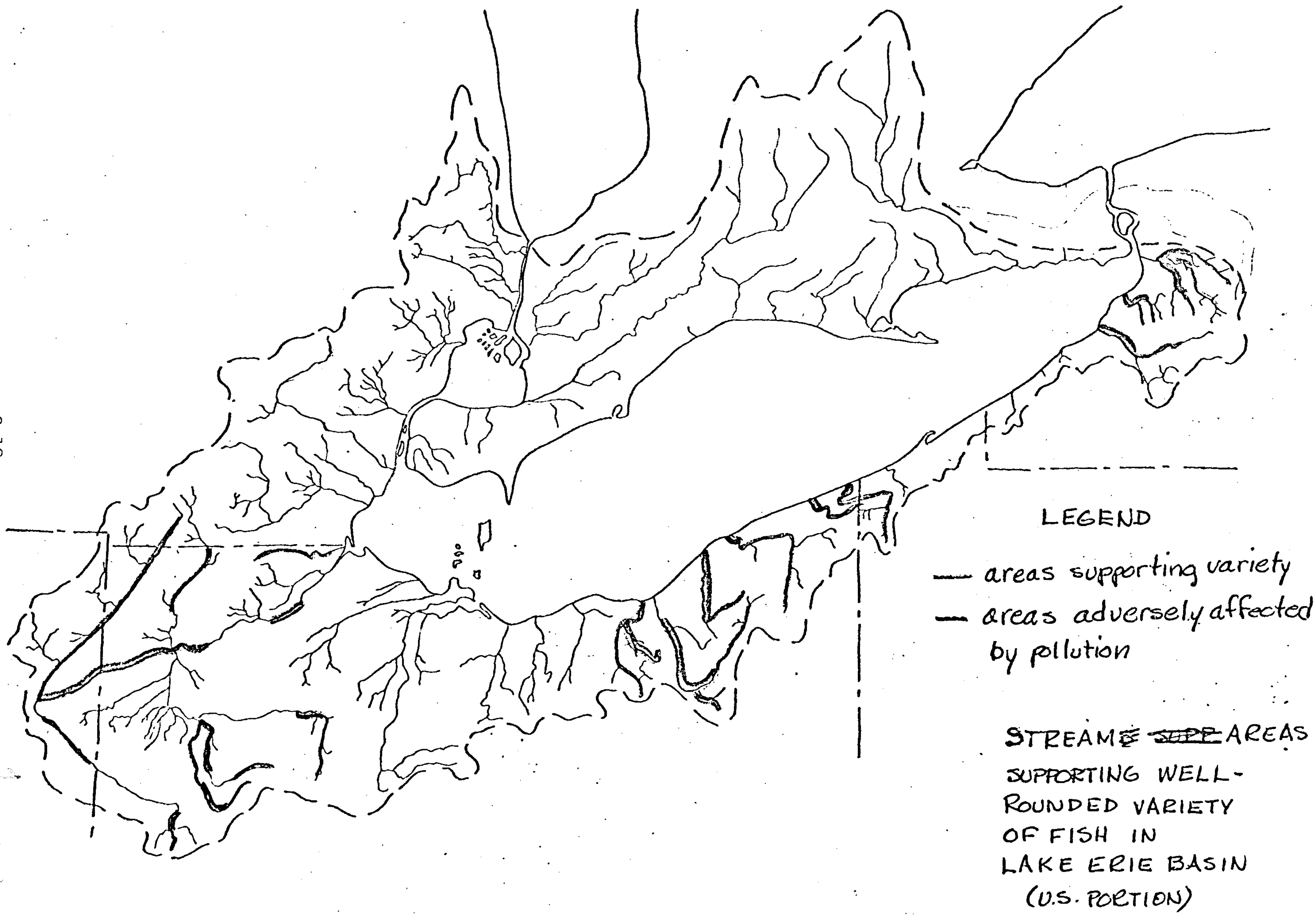

N
LAKE HURON
ONTARIO
LAKE ONTARIO
LAKE ERIE
MICH.
OHIO
IND.
OHIO
OHIO
PENN.
N.Y.
PENN.
SCALE IN MILES
10 0 10 20 30 40 50
MAJOR COMMERCIAL CARGO VESSEL ROUTES IN LAKE ERIE

FIGURE 3-9


LEGEND
— areas supporting variety
— areas adversely affected by pollution
STREAMS AREAS
SUPPORTING WELL-
ROUNDED VARIETY
OF FISH IN
LAKE ERIE BASIN
(U.S. PORTION)

Waterfowl and other wildlife are not expected to increase significantly in the Lake Erie basin except locally as a result of management. Pollution control will not materially increase populations. However, unabated pollution will decrease the populations of waterfowl still further.

Recreation

While water-dependent and water-enhanced outdoor recreation is not critical to man's survival, it is the use commanding the most attention. In the Lake Erie basin the lake itself is the prime attraction, although many inland areas are also popular. Figure 3-11 shows water areas of the basin with present or anticipated use for whole- and partial-body contact recreation. Figure 3-12, showing public park areas and attendance at major beaches, illustrates the importance of recreation, as does Table 3-1 showing present and projected summer activity days for water-oriented activities in the basin.

Summer water temperature and climatic conditions make Lake Erie well suited to swimming, the single most popular form of water-oriented recreation, and to water skiing. These two forms are whole-body contact and water quality is most critical to them.

Most of the lake shore is in private ownership and much of it is naturally unsuitable for heavy recreational use because of steepness and lack of sand. Available beaches, because of their relative scarcity and dense population are heavily used, even though some are frequently contaminated and unsafe. The more notable of public beach areas are Sterling State Park in Michigan; Crane Creek, East Harbor, and Headlands State Parks, Cedar Point, Mentor Township, Geneva Township, Walnut (Ashtabula), and Conneaut Township Parks in Ohio; Presque Isle State Park in Pennsylvania; and Evangola Beaver Island and Lake Erie State Parks in New York. Ontario also has several excellent beaches including those at Pelee Point, Rondeau, Long Point, Crystal Beach, and at several small ports. All of these beaches together attract millions of persons annually although several are affected by fecal contamination and most by decomposing algae. Several other beaches, which are less suitable because of physical or pollution problems, also attract large numbers of persons.

Sport fishing is a major recreational attraction in Lake Erie, so much so that in Ohio waters for example the sport fishing catch frequently exceeds the commercial catch, especially in yellow perch fishing. It is not uncommon on summer weekends to find forty thousand or more sport fishermen fishing from boats in Ohio waters alone and similar numbers from structures which offer access to lake waters. The heaviest sport fishing activity occurs in the western basin and particularly in the island area (Figure 3-10).

FIGURE 3-10

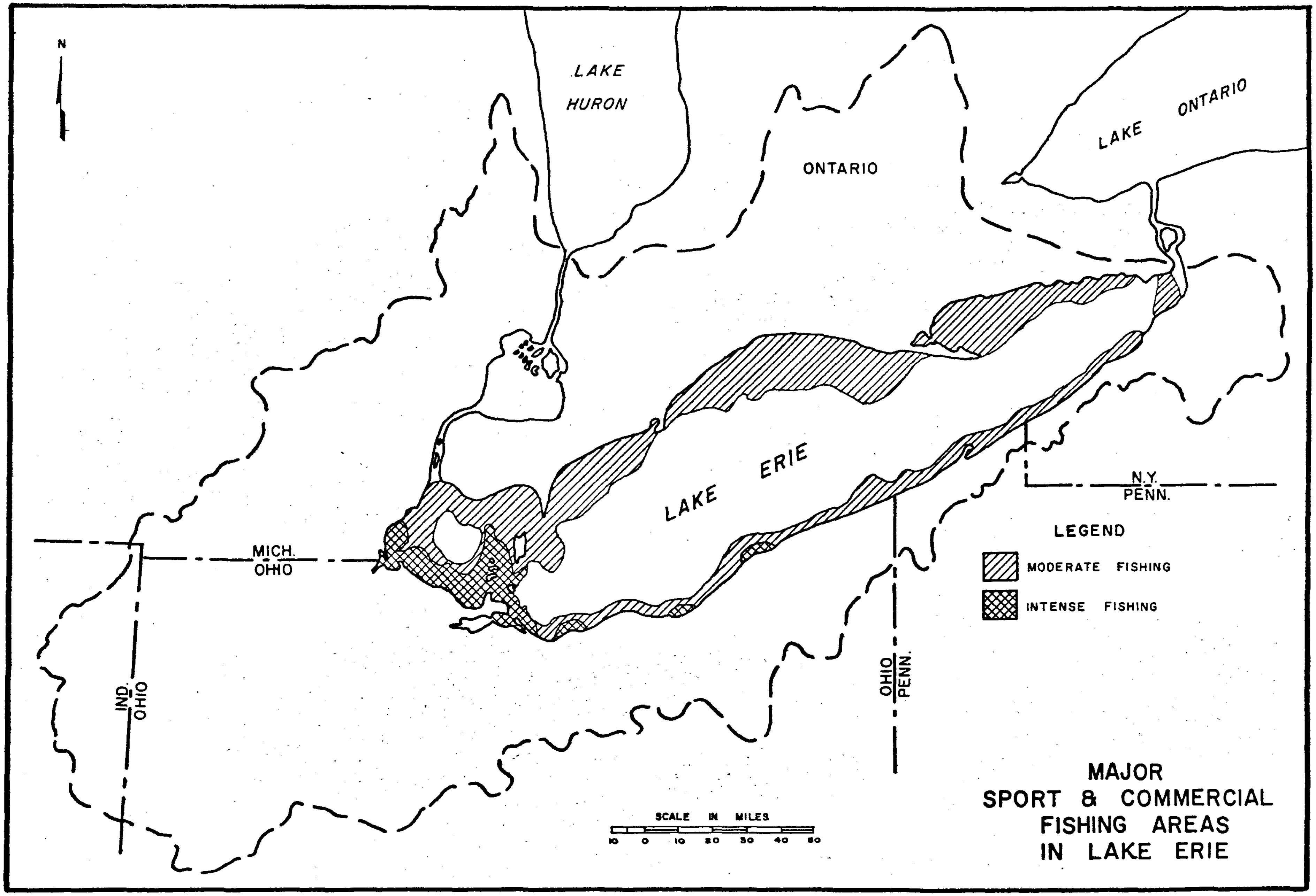
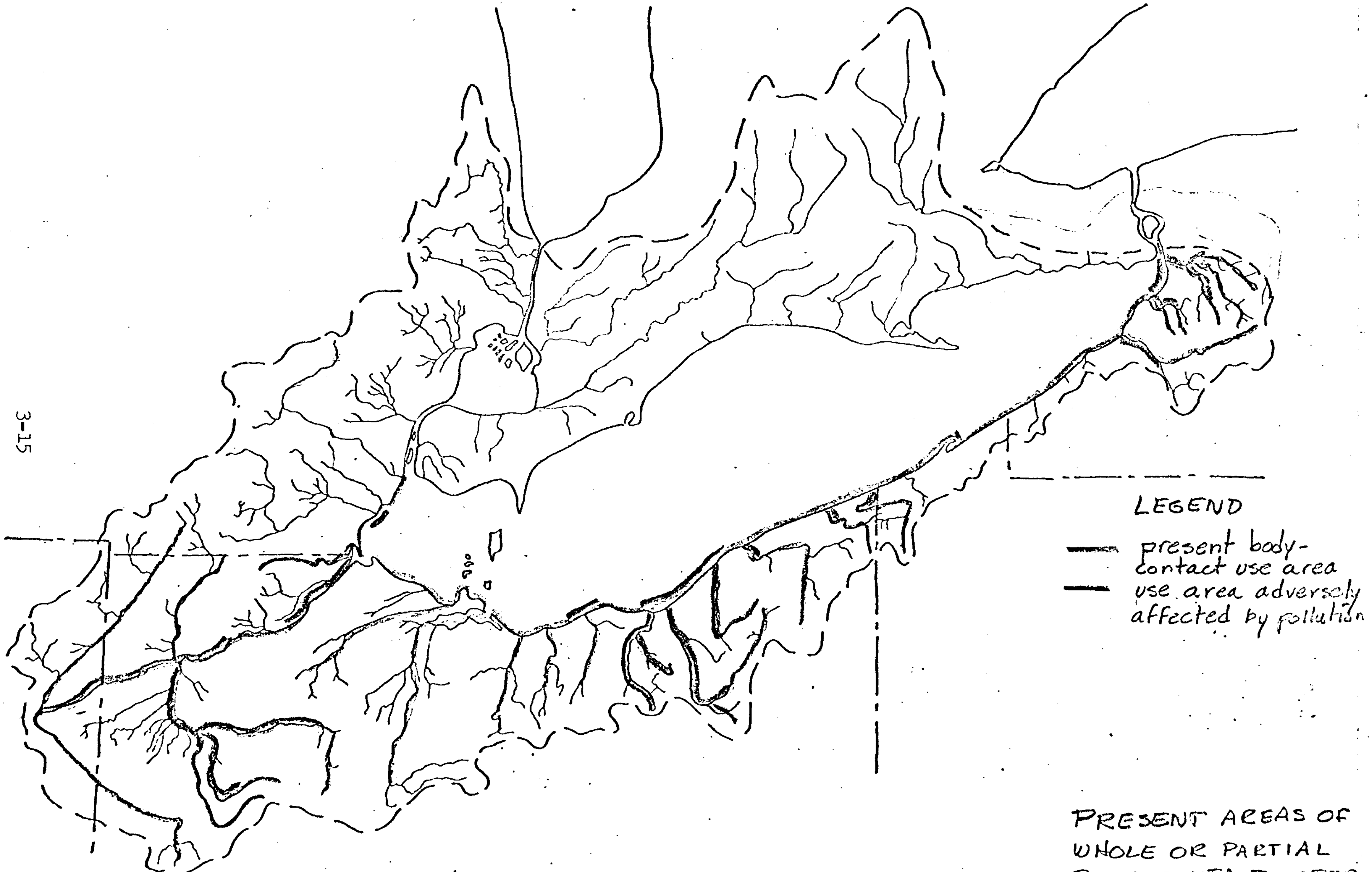


Fig. 3-10

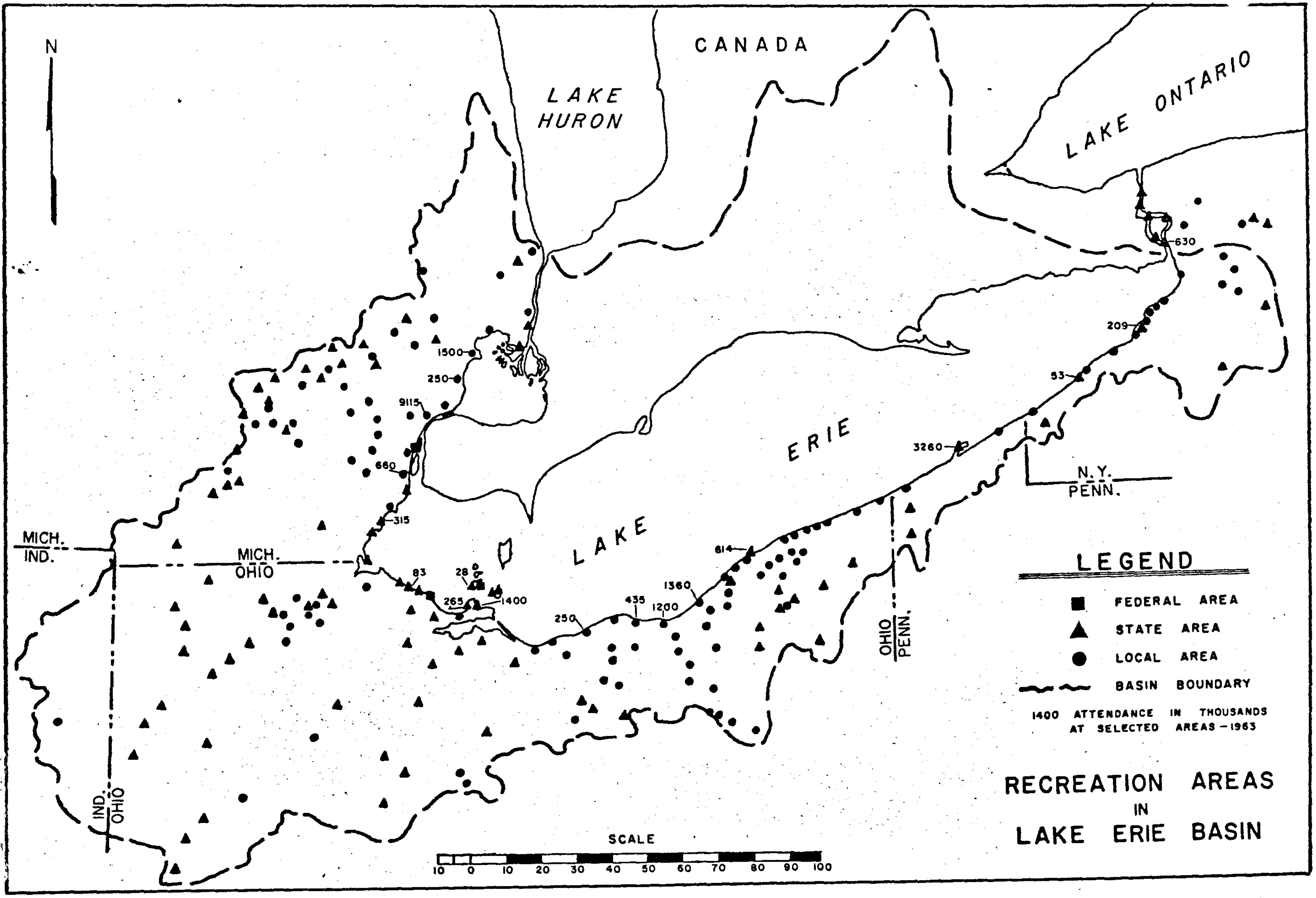
FIGURE 3-11



PRESENT AREAS OF WHOLE OR PARTIAL BODY-CONTACT WATER RECREATION IN LAKE ERIE BASIN (U.S. PORTION)

Fig 3-11

FIGURE 12



RECREATION AREAS IN LAKE ERIE BASIN

TABLE 3-1

EXPECTED SUMMER (JUNE, JULY, AUGUST) PARTICIPATION IN SELECTED WATER-ORIENTED ACTIVITIES IN 2000 AND 2020, LAKE ERIE BASIN

Activity	1960 Summer Activity Days (thousands)	2000 Summer Activity Days (thousands) Without Opportunity[1]	2000 Summer Activity Days (thousands) With Opportunity[2]	2020 Summer Activity Days (thousands) Without Opportunity[1]	2020 Summer Activity Days (thousands) With Opportunity[2]
Water-Dependent					
Swimming	41,718	143,093	166,872	193,781	229,449
Fishing	18,379	36,758	36,758	40,800	40,800
Boating	13,370	46,795	55,753	63,508	76,944
Water Skiing	1,862	9,012	10,725	12,587	15,157
Canoeing	592	2,072	2,469	2,812	3,408
Sailing	423	1,480	1,764	2,009	2,435
Subtotal	76,344	239,210	274,341	315,497	368,193
Water-Enhanced					
Camping	3,639	14,301	23,472	19,632	33,389
Picknicking	21,071	52,678	65,109	68,482	87,128
Sightseeing	24,455	70,186	115,917	93,052	161,648
Nature Walks	5,416	14,569	14,569	19,146	19,146
Hiking	1,862	6,871	11,377	9,376	16,135
Subtotal	56,443	158,605	230,444	209,688	317,466
TOTAL (Water-Oriented)	132,787	397,815	504,785	525,185	685,639
Winter Sports	13,623	47,303	47,303	64,143	64,143

1. Without opportunity - based on 1960 per capita quality and quantity of facilities.

2. With opportunity - assumes improvement in 1960 per capita quality and quantity.

Sport fishing in winter (ice fishing) has become an increasingly popular form of recreation. Catches during ice fishing season are frequently phenomenal. In fact, fishermen refer to catches in summer as numbers of fish, while in winter they commonly refer to catches in pounds of fish.

Boating activity has increased greatly in the past few years as a result of affluence. Boats, of course, furnish a "base of operations" for swimming and fishing, in addition to providing enjoyment in their own right.

Table 3-2 lists the number of pleasure boats using Lake Erie as estimated from the number of boat licenses issued in the bordering states. Large numbers of boats are trailered to Lake Erie on summer weekends, many from 100 or more miles away. According to the Ohio Division of Wildlife, twenty thousand boats have been counted in the Ohio waters of Lake Erie on a warm summer weekend in 1963. This number may be equaled or exceeded in Lake St. Clair and the Detroit River. Major small boating areas are shown in Figure 3-13.

Waste Water Assimilation

Lake Erie is the eventual recipient of nearly all waste water in the Erie basin. The lake, being such a large body of water, has generally been thought capable of assimilating the tremendous quantities of wastes that flow into it. This has not been the case, however, as the lake is suffering from the throes of pollution caused by man's unwise control of his waste products.

Waste assimilation is an unfortunate use for Lake Erie's water. However, it is one which must be accepted, and it is a use which will undoubtedly continue. The problem is to change the wastes to forms which are not seriously detrimental to water quality.

The quantity of wastes which Lake Erie and its tributaries must accommodate is roughly equivalent to the quantity of municipal and industrial water used since this water is essentially returned to the system. The present input is approximately 11,000 MGD and will increase to 19,000 MGD by 1990 and 28,000 MGD by 2020. Approximately 34 percent of the total wastewater is now discharged directly to the Detroit River and 40 percent directly to Lake Erie. The remainder (26 percent) is discharged above lake-affected protions of tributaries.

Areas of major waste water sources are the Detroit-Maumee region, the Cleveland-Akron region, and the Buffalo region. A detailed breakdown of the important waste input constituents is given in the chapter on "Waste Sources."

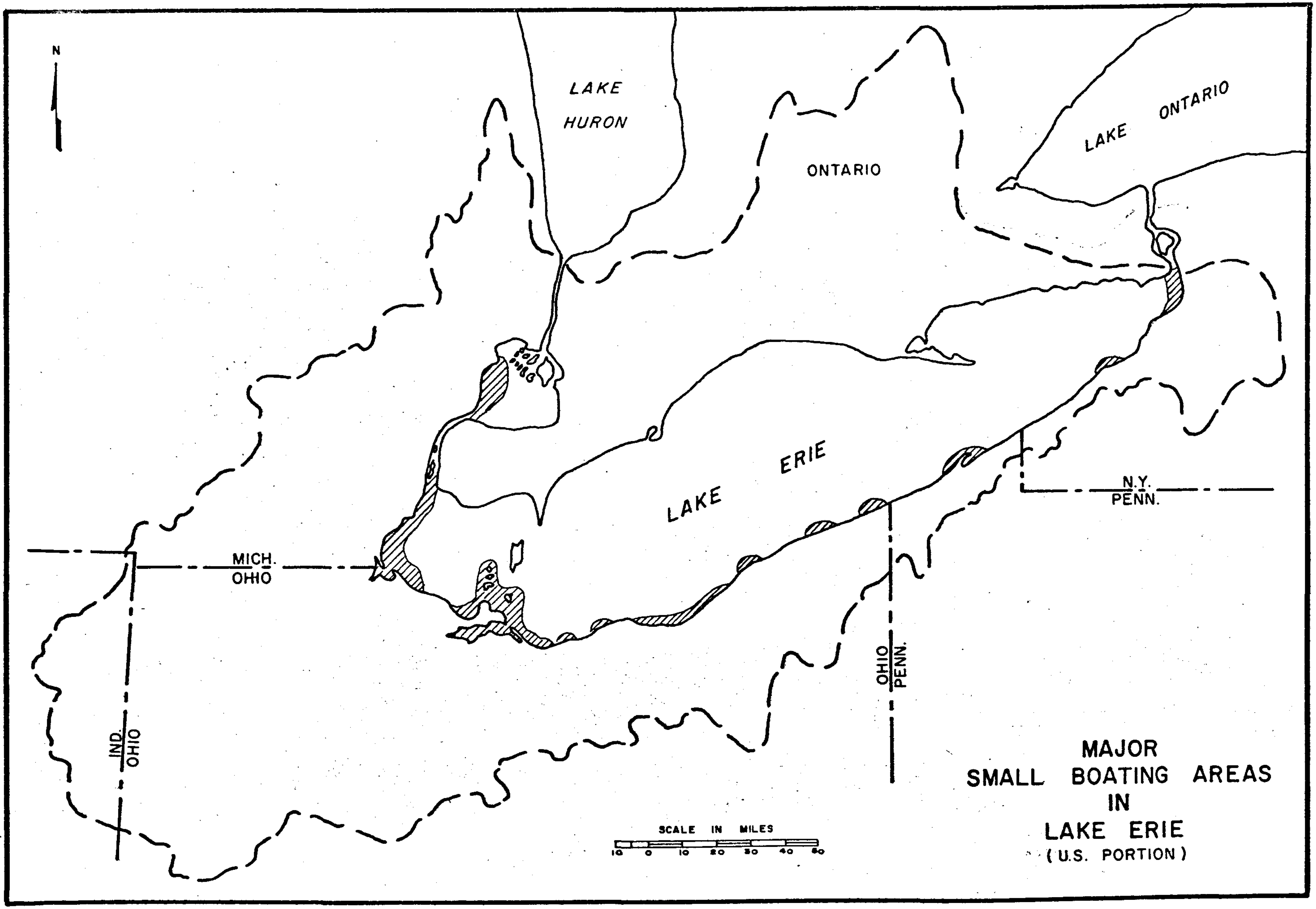
TABLE 3-2

PLEASURE BOATS REGISTERED IN LAKE ERIE

State	Number
Ohio	73,000
Michigan	101,000*
Pennsylvania	6,000
New York	34,000
Total	214,000

*Includes Lake St. Clair

FIGURE 3-13



MAJOR
SMALL BOATING AREAS
IN
LAKE ERIE
(U.S. PORTION)

Water Quality Objectives

The goal of the water pollution control program in the Erie basin is clean water. Because clean water is not necessarily pure water, the program must have definable use-directed objectives for various constituents. Those objectives should not be determined by present uses--instead, they should be determined by potential uses.

Uses vary from place to place within the basin, but few, if any, places can now be found where water quality is consistently adequate for all uses. However, many places can be found where water quality is not adequate for any legitimate use.

Objectives must be high and relentlessly pursued. Prohibitive cost, as an excuse for inaction, is no longer valid. Technological ignorance in treatment methods is also no reason for delay.

Objectives will not be presented here for all uses. Because water supply, recreation, and aquatic life have the most rigorous requirements, a pollution control program serving these needs will more than meet the requirements of other important uses. Objectives are therefore given for these three uses in Table 3-3 for both triburaty and lake waters. In some cases, the lake objectives have been listed as those values which now exist, i.e., dissolved solids and chlorides, because these values are now fully adequate for all major uses. If the objectives, in these cases, were relaxed, it would in effect be permitting lake water quality to deteriorate and this, by law, is not permissible.

TABLE 3-3

SUMMARY OF WATER QUALITY OBJECTIVES BY USAGE

PARAMETER	WATER SUPPLY Tributary	WATER SUPPLY Lake	RECREATION Tributary	RECREATION Lake	FISHERY Tributary	FISHERY Lake
Dissolved Oxygen	>75% saturation	>90% and <110% saturation	>85% saturation	>85% saturation	>90% saturation	>90% saturation
BOD	<3 mg/l at all times-av.<1.5 mg/l	<1 mg/l	<2 mg/l	<1 mg/l	<3 mg/l	<1 mg/l
pH	>6.5 and<9	>7.5 and<8.5	>6.5 and<8.5	>7.5 and<8.5	>6.5 and<9	>7.5 and<8.5
Temperature*	<85°F	<70°F	<90°F	<85°F	<85°F	<80°F
Turbidity**	<5 JCU	<5 JCU	<50 JCU	<25 JCU	<100 JCU	<25 JCU
Dissolved Solids	<500 mg/l	<185 mg/l	<775 mg/l	<200 mg/l	<775 mg/l	<185 mg/l
Chlorides	<250 mg/l	<25 mg/l	<150 mg/l	<40 mg/l	<150 mg/l	<25 mg/l
Toxic Metals	None	None	None	None	None	None
Phenols	<.005 mg/l	<.001 mg/l	<.005 mg/l	<.005 mg/l	<.005 mg/l	<.001 mg/l
Total Phosphorus	<.10 mg/l	<.025 mg/l	<.050 mg/l	<.025 mg/l	<.050 mg/l	<.025 mg/l
Total Coliform Bacteria	<5000 MPN/ 100 ml	<1000 MPN/ 100 ml	<1000 MPN/ 100 ml	<1000 MPN/ 100 ml	<5000 MPN/ 100 ml	<1000 MPN/ 100 ml

*Controllable only to the extent of artificially adding heat.
**Controllable only to the extent of restricting solids input; wave-stirring uncontrollable.

CHAPTER 4

WASTE SOURCES

CHAPTER 4

WASTE SOURCES

The principal pollution materials discharged into Lake Erie and its tributaries are municipal and industrial wastes. It is difficult to state which source is the greater contributor to pollution problems. These major wastes consist not only of continuous, direct discharges, but also of combined sewer overflows and those of treatment plants which are seldom adequate.

Other significant sources of pollution are wastes from agricultural runoff, wastes from commercial and pleasure craft, and those from harbor dredging operations. Urban runoff and shore erosion are also important contributors. All of these combined are now potentially disastrous to Lake Erie water quality.

Three geographical areas are primarily responsible for the present condition of Lake Erie (Table 4-1). These areas in order of decreasing effect on the overall quality of Lake Erie water are (1) Detroit, Mich. and its surrounding municipalities (2) the Cleveland-Cuyahoga River basin, and (3) the Maumee River basin. The Buffalo area has high waste inputs but these wastes affect the Niagara River more than Lake Erie. Many other areas have problems which are primarily local, but cumulatively, they also have a profound effect on the general water quality.

The remarkably degrading effect which the Detroit and Maumee areas have on Lake Erie can be shown by subtracting their discharges of almost any constituent from the total input of that constituent to the lake. If all the wastes from these two areas were somehow to be removed from Lake Erie, the lake water quality would be better overall than that of Lake Michigan and not much behind Lake Huron. If only wastes from the Detroit area were removed, Lake Erie would still rival Lake Michigan in most respects.

TABLE 4-1

PERCENT IN-BASIN WASTE CONTRIBUTION OF MAJOR SOURCE AREAS IN LAKE ERIE BASIN

	Detroit and Southeast Michigan	Toledo-Maumee River	Cleveland-Akron-Cuyahoga
Phosphorus	38.0	16.6	18.5
BOD_5	60.3	15.5	11.0
Chloride	51.0	4.7	10.6

Municipal Wastes

Municipal waste or sewage is defined as the water-carried waste from residential, public, commercial, and industrial sources discharged into a collection system for transport to a central treatment and/or discharge point. Approximately 10 million people inhabit communities throughout the U.S. portion of the Lake Erie basin, discharging their wastes directly into Lake Erie or into its tributaries. The total volume of municipal waste water is and will continue to be approximately equal to the amount of municipal water used (refer to Figure 3-4).

In the southeast Michigan area almost the entire population is in and around Detroit. The Detroit primary sewage treatment plant serves about 3.1 million people. While 94 percent of the southeastern Michigan population discharges wastes to sewers, the wastes from only 11 percent of the total population receive secondary treatment.

About 79 percent of the total municipal waste in the Ohio portion of the Lake Erie basin receives secondary treatment. About 3.5 percent of the population is not served by sewer systems.

The wastes from almost 100 percent of the sewered population in Pennsylvania receive secondary treatment. The city of Erie is the largest city in Pennsylvania whose discharge reaches Lake Erie.

In New York the wastes from 78 percent of the total population receive primary treatment. The cities of Buffalo, Niagara Falls, and part of Tonawanda have sewage treatment plants that give only primary treatment but these wastes are discharged to the Niagara River and flow into Lake Ontario. These three cities include over a million of the 1.2 million people served by primary treatment.

Biochemical oxygen demand (BOD) is the main municipal degradant to tributary waters. It is not especially harmful to the lake proper. The most harmful municipal contribution to the lake is in the form of nutrients, primarily nitrogen and phosphorus although locally bacteria are causing serious problems.

Industrial Wastes

Industrial wastes are those spent process waters associated with industrial operations which are discharged separately and not in combination with municipal wastes. Lake Erie and its tributaries receive industrial wastes from 271 known sources. A summary of these, by states, is given in Table 4-2, along with their treatment adequacy, according to classification by state control agencies. About 23 percent of the industries are classified as having inadequate treatment facilities and 10 percent are listed as adequacy unknown.

Industries are responsible for 86 percent of total waste flow discharged to Lake Erie and its tributaries. If power production is not included in waste flows, the total drops to 75 percent. In general, waste flows are essentially equal to water use, Figure 3-3.

About 44 percent of the total industrial waste discharges in the basin flows directly to the lake or to lake-affected portions of the tributaries; another 40 percent is discharged to the Detroit River. Twenty-two of the industries with direct discharges to Lake Erie and the Detroit River were reported, by the state agencies in 1965, to have inadequate treatment facilities.

Industries discharge millions of tons daily of dissolved solids to Lake Erie; for example, they discharge 11 million tons of chlorides daily and a similar quantity of sulfates. The chloride input is expected to double by 1990 and quadruple by 2020 unless restrictions are placed upon inputs. Industries have a major pollutional effect, especially in tributaries, by adding a variety of substances such as phenols, iron, cyanides, toxic heavy metals, acids, and alkalis. They also add heat.

Agricultural Runoff

Agricultural land is a major source of nutrient and silt pollution in Lake Erie resulting largely from surface erosion of intensively cultivated, fine-grained soils with sparse crop cover. While silt covers the bottom of the lake and may be influential in the fisheries problem, the nutrient input is of greater immediate concern. Large quantities of nitrogen compounds and phosphates are used in fertilizers and these substances find their way to the lake during runoff.

TABLE 4-2

INDUSTRIAL WASTE SOURCES

STATE CLASSIFICATION (1965)

State	TREATMENT Adequate	Inadequate	Unknown
Ohio	116	36	9
Indiana	9	2	-
Michigan	42	31	19
Pennsylvania	5	2	2
New York	3	4	7
Total	175	75	37

In the Ohio portion of the basin alone, during the last half of 1966, more than 21,000,000 pounds of phosphorus were sold in commercial fertilizers, most of it in the Maumee basin - and the use rate is increasing. The percentage of commercial fertilizer nutrients reaching Lake Erie is unknown. It is known that much of the phosphorus used in fertilizers becomes tightly bound in the soil, and reaching the waterways mainly in this form and not as leached compounds.

Nutrients are also contributed by runoff from animal wastes. Some studies indicate that animal wastes, when used as fertilizer, may be a significant source of nutrients to a drainage system.

If an estimated rate of 365 pounds of total phosphorus per square mile per year (in the Maumee basin the rate is higher, other areas lower) is used to calculate the agricultural contribution, more than eight million pounds is supplied to Lake Erie per year from this source. The nitrogen input from runoff is at least ten times this amount.

An estimated eight million tons of silt are discharged to Lake Erie from agricultural runoff each year. Nearly half of this is discharged to the western basin.

The Maumee River is the greatest contributor to rural runoff pollution, in both nutrients and silt, in the Erie basin. About two million tons per year of silt enter the lake from this drainage basin.

It is not likely that the rate of silt input from rural runoff will increase by any significant amount in the future because of improved soil conservation practices. In fact it appears that the present rate is considerably less than it has been in the past and will continue to decrease.

The inputs of nutrients from rural runoff are likely to increase by a small amount because of efficiency of utilization, soil conservation practices, and decreasing agricultural area.

Urban Runoff

Urban runoff, like rural runoff, is variable and difficult to study. It is known however, that it contributes significant quantities of suspended solids, chlorides, BOD, debris, nutrients, and bacteria. This is because of the general untidiness of cities, the use of salt in street deicing, and the use of fertilizers in lawn and garden care. Here again nutrients are the most significant factors. It is estimated that an average of 530 pounds of phosphorus per square mile per year is derived from urban runoff. This is about 50 percent greater per unit area than that from rural runoff. The rate of nitrogen runoff is again about 10 times that of phosphorus. The present phosphorus contribution is now in the vicinity of one million pounds annually. It is expected to rise, by 2020, to more than three million pounds annually.

Combined Sewer Overflows

Many large cities in the Lake Erie basin have combined sewer systems which carry both sewage and surface drainage water. During dry weather the sewer systems supposedly direct all flow to a sewage treatment plant. During periods of precipitation the excess flow by-passes the treatment plant and goes directly to the drainage system. Many of the systems are in such poor condition that sewage is continuously by-passed.

Combined sewer systems are recognized as very significant sources of pollutants both to tributaries and to Lake Erie. The more important materials contributed, as far as Lake Erie is concerned, are BOD, bacteria, and the nutrients, nitrogen and phosphorus. Beaches are closed in many places because of the bacterial loadings.

At present the largest contributors to Lake Erie pollution from combined sewers are the cities of Detroit and Cleveland. These have an immediate detrimental effect, particularly at bathing beaches in the vicinity.

Approximately 40 billion gallons per year flow from combined sewers directly to the basin's waterways. About half of this flow is untreated municipal waste; i.e. sewage by-passed to the overflow during rainstorms.

Construction of combined sewers is no longer permitted in Ohio, but is still continued in Michigan. The load due to existing combined systems will increase somewhat with the increase in population in areas served by them. The present flow of 40 billion gallons per year may increase to 50 billion gallons per year by 2020 with 60 percent of this flow being due to municipal wastes if combined sewer systems continue to exist.

Vessel Waste

The contribution of vessels to the pollution of Lake Erie is not a significant factor in the overall water quality of the lake, but it can be locally damaging especially in the harbor areas. Possible sources of pollution from vessels include cargo spillage, dunnage, ballast and bilge waters, fuel spills, garbage, and sanitary wastes. Uncontrolled discharge of these wastes can result in serious pollution problems for beaches, shore property, recreational waters, fish and aquatic life, and municipal and industrial water supplies.

It is estimated that the bacterial and nutrient pollution load from commercial vessels on Lake Erie is equivalent to the raw sewage of 1,200 persons for eight months of the year, or a permanent population of 800. By the year 2020 this waste source may increase by 50 percent.

The pollution contribution from pleasure craft is much greater, and is estimated to be equivalent to the raw sewage of a permanent population of 5,500. This pollution load is locally damaging in harbors and marinas. By 1990 this load will double, and by 2020, will triple.

The U.S. Public Health Service has established regulations governing vessel waste discharges in the Great Lakes based upon its legal responsibility for the interstate control of communicable diseases. Restricted areas have been established in which the discharge of sewage, ballast, or bilge water from vessels is prohibited. Restricted areas include the water within a three-mile radius of domestic water intakes.

Vessel wastes are sources of pollution in all harbors and marinas. Areas of particular concern are around Detroit, Toledo, Sandusky, Vermilion, Rocky River, Cleveland, Erie, and Buffalo.

Stream Bank and Shore Erosion

Erosion of the lakeshore contributes an est imated 16 million tons of silt to Lake Erie per year. The rate is much higher during higher lake stages. Shore erosion is responsible for most of the near shore turbidity during storms. Silting and nutrient contribution are the major pollution factors. Phosphorus is the major nutrient, being contributed to the lake at a rate of approximately 11 million pounds annually. More than 80 percent of the annual loss of shore materials occurs in the central basin.

Stream bank erosion has the same effect as shore erosion during times of high precipitation. Its nutrient content has been considered a part of rural runoff. Both stream and shore bank erosion cause debris such as trees, stumps, and dumped materials to be carried into the lake. Various kinds of trash are used as bank protection in many places and this also contributes debris to Lake Erie, Debris without control may increase, but nutrients and silting should remain essentially constant in the future.

Dredging Dumps

All harbors along the United States shore are dredged periodically to maintain navigation channel depths. In most harbors the removed material is a combination of silt and municipal and industrial wastes, amounting to some six million tons (Table 4-3) annually in the Erie basin, almost one-fourth of the total silt load to Lake Erie. In many cases the wastes harm water quality by the addition of BOD and nutrients. It has been the policy to dump the dredged materials in the lake within a few ,iles of the dredging sites, which may be transferring highly polluted substances to relatively unpolluted areas.

TABLE 4-3

1967 ESTIMATED HARBOR DREDGING SPOIL TO BE DUMPED
IN LAKE ERIE

Harbor	Volume cu. yds.	Principal sludge source
Monroe (Raisin River)	250,000	industrial
Bolles Harbor	186,000	rural
Toledo (Maumee River)	1,000,000	rural
Sandusky	600,000	rural
Huron	180,000	rural
Lorain (Black River)	500,000	industrial
Rocky River	60,000	municipal
Cleveland (Cuyahoga River)	1,300,000	industrial, municipal
Fairport (Grand River)	360,000	industrial, rural
Ashtabula	350,000	industrial, rural
Conneaut	400,000	rural
Erie	200,000	municipal
Dunkirk	26,000	industrial
Buffalo	620,000	industrial
TOTAL	6,032,000	

It is difficult to show a lasting effect of these wastes upon the general quality of Lake Erie, but the immediate effect is apparent in turbidity. A study is now underway by FWPCA and the Corps of Engineers to determine precise effects. One of the effects is ordinarily for dredged materials to cover the natural sediments over a wide area. The dredged materials are often of low density and can be moved easily over large areas. For example a large area around the Cleveland offshore dumping grounds is covered with oily mud. In this area the phosphate content is up to three times the concentration of other mid-lake bottom muds.

If harbor dredging continues, it is not likely that the total annual volume dredged will increase significantly.

Construction Runoff - Highway and Urban Development

Pollution from construction sites is mainly silt and is similar to agricultural runoff. The quantity per unit area is much greater, however. For a given area, sheet wash may have 100 times the load of agricultural runoff. The problem is becoming increasingly serious because of the recent intensification of highway and housing programs in the Erie basin covering large areas of land. There is apparently no adequate program of reseeding, catch-basins, etc., and the land is left barren for long periods, especially over winter.

Potential Sources of Pollution

Drilling for oil and gas is now being contemplated by several companies under land to be leased from the states of Ohio, Pennsylvania, and New York. This is a potential source of pollution, mainly from oil spillage and drilling muds. However, drilling in Ontario waters has shown an excellent record in regard to control of harmful wastes for many years.

Reactor plants for power sources seem to be inevitable. These represent remotely potential sources of radioactive pollution substances. Their main contribution to the degradation of Lake Erie is and will be thermal pollution because of the necessarily great amount of cooling water used.

Very important potential sources of pollution are the ultimate disposal sites of the residue from waste treatment plants. This is especially important with regard to nutrients. Nutrients removed at a treatment plant can have little effect on improving Lake Erie water quality if the nutrients still get back into the drainage system.

Constituents in Waste

The waste substances that are discharged to the lake from municipal and industrial outfalls, tributaries, and land drainage are many, and their effects on water uses are varied. Many substances such as acid, oil, cyanide, iron, coliform bacteria, phenol, and oxygen-consuming materials have severe effects on water uses in the localities of the discharge.

Those substances that have damaging effects on the total waters of the lake are suspended solids (sediment), carbonaceous oxygen-consuming materials, nitrogen compounds, and phosphorus. A discussion of chlorides and dissolved solids is included, not because they have reached damaging concentrations, but because their dramatic increases are indicative of the rate at which water quality has been degraded. Table 4-4 presents summaries of the major known sources and loads to Lake Erie of suspended solids, chlorides, biochemical oxygen demand $(BOD)_5$ substances, and phosphorus.

Suspended Solids - Damages to Lake Erie resulting from suspended matter entering from waste discharges and tributaries are dependent on the nature of the material. Suspended matter from municipal discharges is primarily organic and its deposition results in enriched bottom muds or sludge banks whose effects are largely local and can be corrected by proper treatment for removal of these wastes. Suspended matter from certain industries and the material from tributaries originating as land runoff are largely inorganic and serve to fill harbors, embayments, ship channels and the lake.

The principal sources of suspended solids discharged to Lake Erie are the Detroit, Maumee, Cuyahoga, and Grand Rivers which represent a total of 12,700,000 pounds per day of known discharges. The Detroit River, because of its large volume, constitutes the major source or 68 percent of this total, the Maumee 19 percent, the Grand 9 percent, and the Cuyahoga 4 percent.

About 1.5 million pounds of the suspended solids of the Detroit River discharges are from industrial and municipal sources. The Maumee discharges are largely silt from land runoff. The greatest quantities are released during periods of heavy rain and high runoff; therefore, control must be instituted through improvements in land use practices on the watershed. The Cuyahoga discharges are believed to be largely of industrial origin with some contribution from municipal wastes and land runoff. This load on the Cleveland harbor and channels results in severe discoloration and the need for frequent dredging. The Grand River (Ohio) sources are believed to be similar to the Cuyahoga.

Carbonaceous Oxygen-Consuming Materials - Carbonaceous oxygen-consuming materials, usually measured by the 5-day biochemical oxygen demand (BOD_5), are generally considered direct pollutants to streams in that they depress dissolved oxygen levels. This immediate effect is not evident in lakes such as Lake Erie because of its tremendous oxidative capacity and satisfaction of the BOD before the lake is reached.

TABLE 4-4

WASTE LOADS TO LAKE ERIE BASIN WATERS - 1966
Pounds/Day

	BOD_5	Chlorides	Total Phosphorus	Suspended Solids
Western Basin				
Industrial	261,000	6,200,000	7,000	
Municipal	632,000	1,060,000	55,000	
Rural Runoff		} 1,600,000	13,000	
Urban Runoff			4,000	
Lake Huron outflow	950,000	6,500,000	20,000	3,800,000
U. S. (undifferentiated)				27,000,000
Canada (undifferentiated)		1,400,000	5,000	1,100,000
Subtotal	1,843,000	16,760,000	102,000	31,900,000
Central Basin				
Industrial	110,700	4,500,000	4,000	
Municipal	149,300	646,000	27,000	
Rural Runoff		} 1,220,000	4,000	
Urban Runoff			4,000	
U. S. (undifferentiated)				45,000,000
Canada (undifferentiated)		1,000,000	8,000	50,000,000
Subtotal	260,000	7,366,000	45,000	95,000,000
Eastern Basin				
Industrial	160,000	280,000	2,200	
Municipal	72,1000	128,000	4,400	
Rural Runoff		} 294,000	1,220	
Urban Runoff			760	
U. S. (undifferentiated)				1,000,000
Canada (undifferentiated)		500,000	5,000	6,000,000
Subtotal	232,100	1,202,000	11,580	7,000,000
GRAND TOTAL	2,335,100	25,328,000	164,580	133,900,000

However, BOD_5 is a measure of wastes that are used by bacteria in cell growth and reproduction, thereby creating sludge which settles to the lake bottom. Thus BOD_5 is a measure of wastes which produce the same end effect as nutrients. Carbonaceous BOD_5 of wastes is most effectively removed by secondary treatment.

The present and projected daily BOD_5 loading for the entire basin is shown in Figure 4-1 along with the loading after various degrees of reduction. Figure 4-2 shows projected loadings for each of the subbasins; as this figure indicates. The Detroit area contributes more BOD_5 to Lake Erie than all other known sources combined.

Chlorides - The concentration of chloride in the headwaters of the Detroit River averages 7 mg/l, 18 mg/l at the Detroit River mouth, and 24 mg/l at Buffalo. The increase within the length of the Detroit River overshadows the increase within Lake Erie. Major known sources of chloride input are municipal and industrial contributors at Detroit, about 10 million pounds per day; the Grand River, industrial contribution, 3.9 million pounds per day; and the Maumee and Cuyahoga Rivers, 1.2 million pounds per day. Here again the tremendous influence of Detroit is shown. Figure 4-3 shows the projected chloride loadings by subbasin, and Figure 4-4 shows projected total lake loading and the effects of various degrees of reduction.

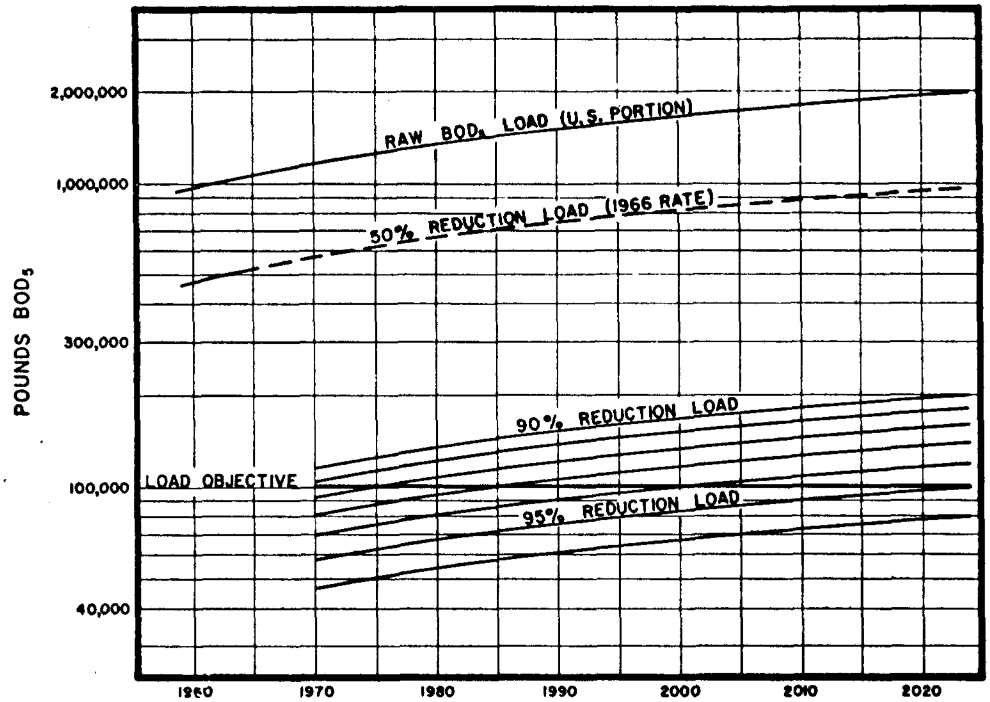
A large input of chloride, from street and highway salting for ice control during winter, drains to the lake through municipal sewers and tributaries. Salt used for this purpose in the basin in 1964 was at least 800,000 tons. This could represent an increase of at least 2.4 mg/l to the chloride level of Lake Erie. Chlorides contributed from street and highway salting represent approximately 10 percent of the total chloride in Lake Erie. Industrial sources contribute about 44 percent and the Lake Huron input 40 percent.

Historical data indicate that the concentration of chloride in Lake Erie was 7 mg/l at the beginning of this century. At that time, a noticeable increase began. In about 60 years the concentration has tripled.

Dissolved Solids - Dissolved solids concentrations at the head of the St. Clair River average 110 mg/l, at the head of the Detroit River 126 mg/l, and at Buffalo 180 mg/l. These levels represent daily inputs of 116 million pounds per day from the watershed above Detroit and a discharge of almost 200 million pounds per day to the Niagara River from Lake Erie. Most of the increase within Lake Erie actually is derived from the Detroit area.

The concentration of dissolved solids in Lake Huron has remained fairly constant at 110 to 115 mg/l since 1900, whereas the increase in Lake Erie at Buffalo in the same period was from 115 to 180 mg/l (Figure 4-5). If unchecked, the dissolved solids level will reach 230 mg/l by 2020.

LAKE ERIE BASIN
(U.S. PORTION)
TOTAL PROJECTED DAILY BOD_5 LOAD AND EFFECT OF REDUCTION
INDUSTRIAL SOURCES



LAKE ERIE BASIN
(U.S. PORTION)
TOTAL PROJECTED DAILY BOD_5 LOAD AND EFFECT OF REDUCTION
MUNICIPAL SOURCES

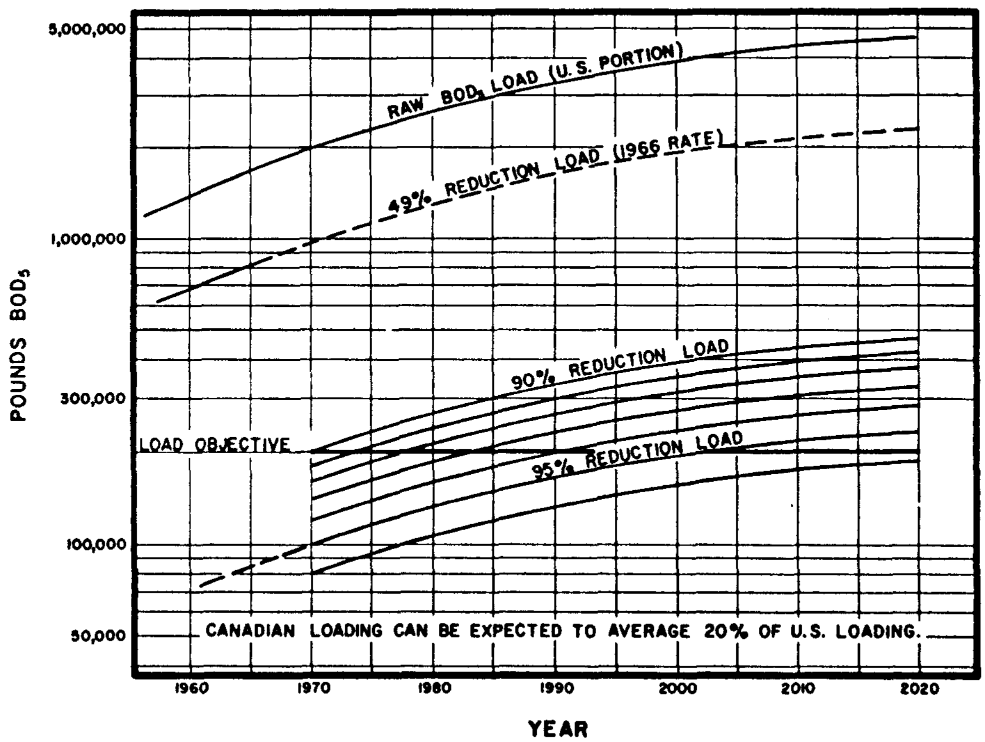
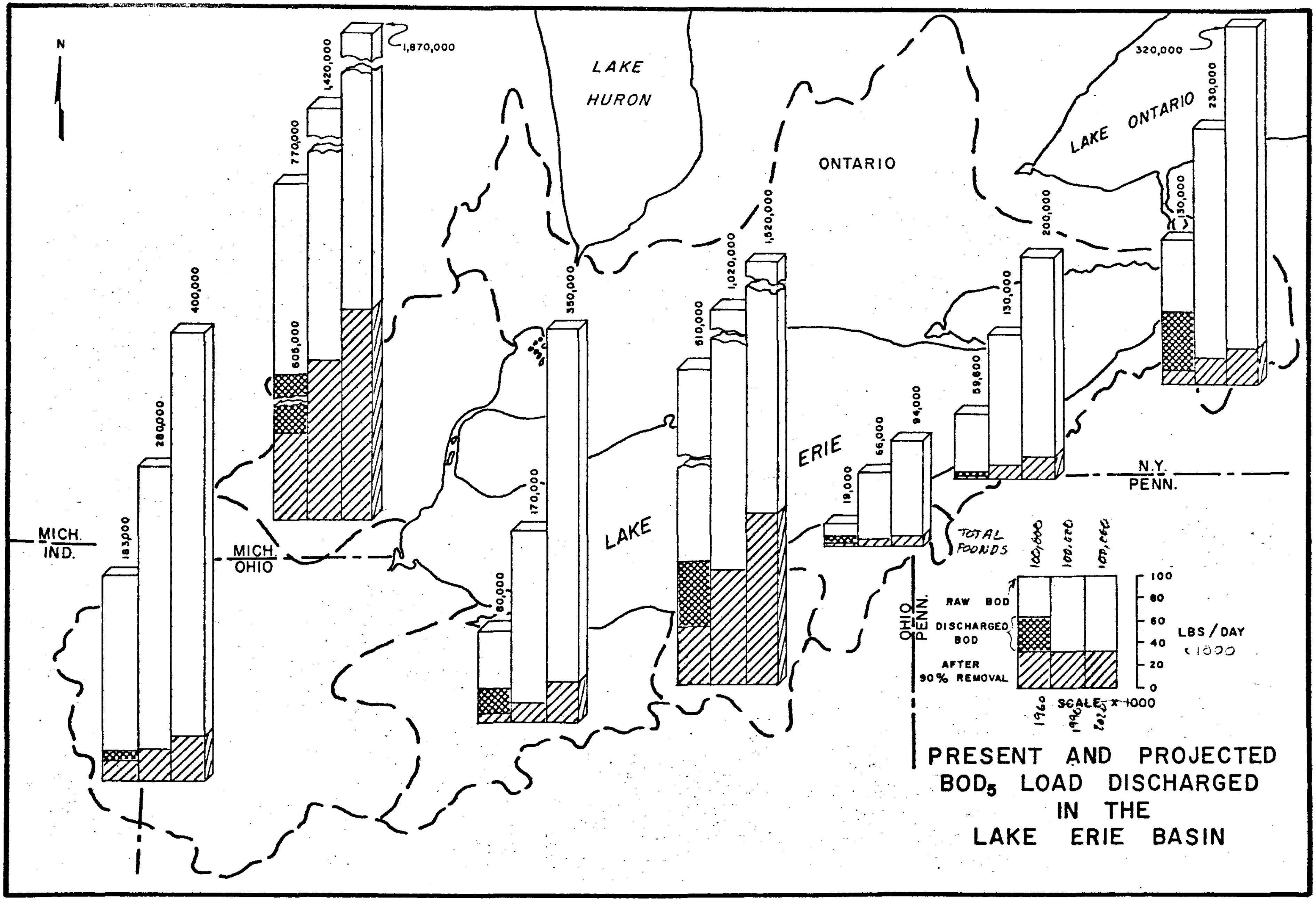
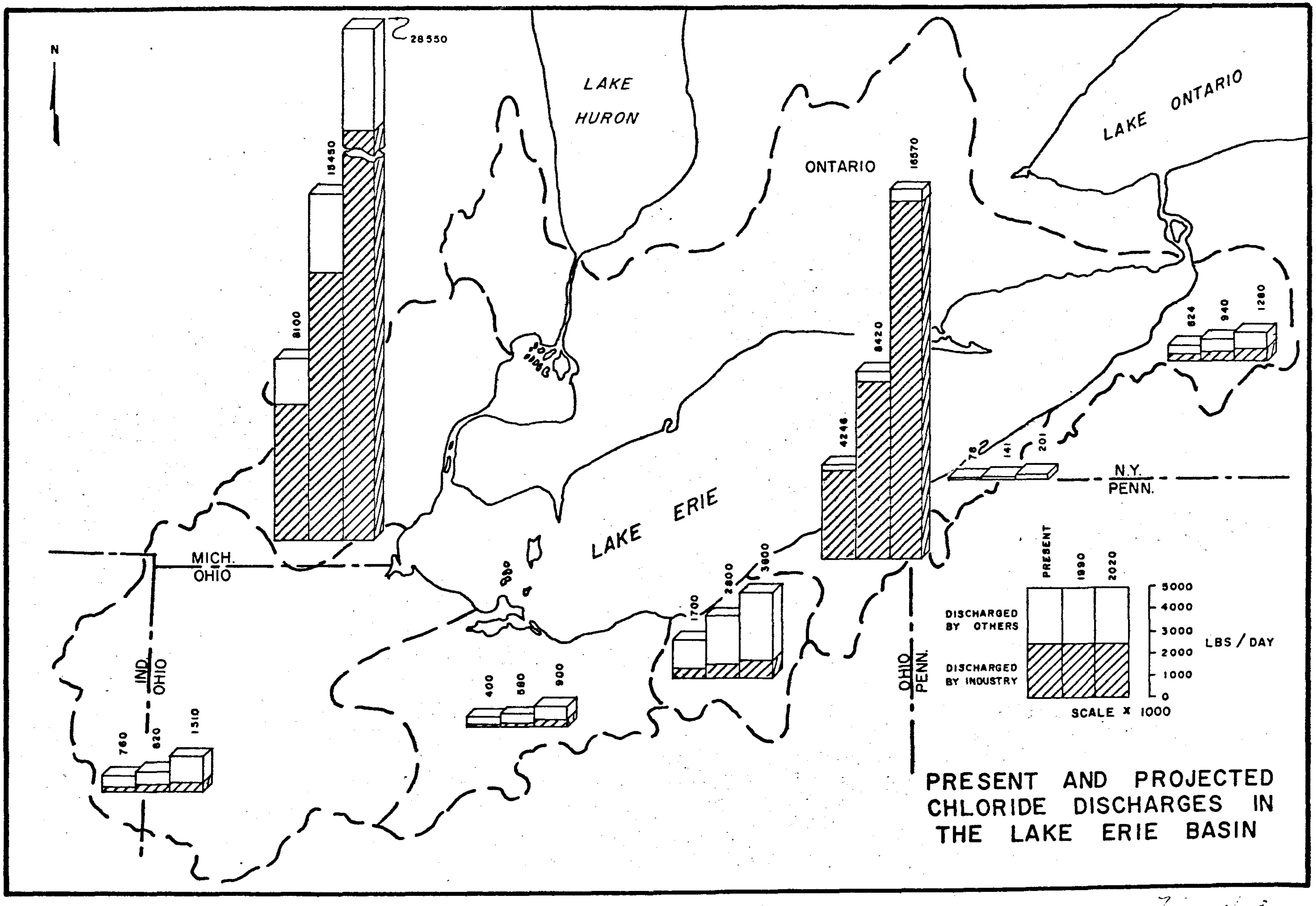


Fig. 4-1



PRESENT AND PROJECTED
BOD_5 LOAD DISCHARGED
IN THE
LAKE ERIE BASIN

Fig. 4-2



PRESENT AND PROJECTED CHLORIDE DISCHARGES IN THE LAKE ERIE BASIN

Fig. 4-3

Nitrogen Compounds - The largest input of this constituent is from the Detroit River which consists of the nitrogen residual from the upper Great Lakes and the major contributions from the Detroit metropolitan area. Other important sources are the Maumee and Cuyahoga Rivers discharging at Toledo and Cleveland, respectively.

The origin of these materials in waste discharges is largely from organic wastes, with sizable contributions from agricultural runoff and from specific manufacturers of ammonia and nitrogen salts. Except for local effects of discharges of these materials, the principal effect on Lake Erie is that of overenrichment.

Phosphorus - Phosphorus, in its inorganic form of orthophosphate (PO_4) is essential to life. Because of this it is used extensively as an agricultural fertilizer. A multitude of phosphorus compounds are used in the manufacture of many products with an overwhelming amount used in household and industrial detergents. Even though phosphorus has so many beneficial properties, it is easily implicated as the most damaging pollution substance being discharged into Lake Erie. As discussed in other sections of this report, phosphorus stimulates productivity of algae and other aquatic plant life with a multitude of serious ramifications.

The principal sources of phosphorus are municipal wastes, agricultural runoff, urban runoff, and industrial wastes (Table 4-5). In municipal wastes about one pound per capita per year is contributed by human excreta and 2.5 pounds per capita per year by detergents. Phosphorus from agricultural runoff amounts to about 250 pounds per square mile per year except in the Maumee basin where the rate is about 580 pounds per square mile per year. Urban runoff contributes phosphorus at the rate of about 530 pounds per square mile per year. There is no useful constant in calculating industrial contribution since this depends upon the type of industry.

Figure 4-6 shows the contributions of phosphorus for each of the subbasins and the projected contributions for the years 1990 and 2020. Phosphorus loading to Lake Erie will increase nearly 2.5 times by 2020 if the present rates continue unchecked. Figure 4-7 shows total projected phosphorus inputs from various sources over a 60-year period for no removal and for various degrees of removal of municipal and industrial waste phosphorus.

The Detroit area contributes by far the largest amount of phosphorus to Lake Erie, more than twice as much as the Cleveland area, the second largest source.

TABLE 4 -5

PRESENT AND PROJECTED PHOSPHORUS DISCHARGES TO LAKE ERIE, lbs/day
(exclusive of Lake Huron input and shore erosion)

Subbasins	Municipal Waste	Industrial Waste	Urban Runoff	Rural Runoff	Total
Present Loading					
Southeast Michigan	46,000	3,000	3,000	3,000	55,000
Maumee River Basin	9,000	4,000	1,000	10,000	24,000
North-Central Ohio	3,800	2,000	1,600	2,600	10,000
Greater-Cleveland-Akron area	22,000	2,000	2,000	700	26,700
Northeast Ohio	1,100	100	500	750	2,450
Pennsylvania	1,400	100	110	220	1,830
Western New York	3,000	2,100	650	1,000	6,750
Ontario	11,900	unknown	450	5,500	17,850
	98,200	13,300	9,310	23,770	144,580
Projected 1990 Loading					
Southest Michigan	85,000	4,500	4,500	3,000	97,000
Maumee River Basin	12,000	6,000	2,000	10,000	30,000
North-central Ohio	8,000	3,000	2,400	2,600	16,000
Greater Cleveland-Akron area	40,000	3,000	3,000	700	46,700
Northeast Ohio	3,700	200	700	700	5,300
Pennsylvania	3,100	180	160	210	3,650
Western New York	6,100	3,100	1,000	1,000	11,200
Ontario	21,400	-----	810	6,500	28,710
	179,300	19,980	14,570	24,710	238,560
Projected 2020 Loading					
Southeast Michigan	111,000	6,000	6,000	3,000	126,000
Maumee River Basin	19,000	8,000	3,000	10,000	40,000
North-central Ohio	17,000	4,000	3,400	2,600	27,000
Greater Cleveland-Akron area	58,000	4,000	4,000	700	66,700
Northeast Ohio	5,400	400	1,000	700	7,500
Pennsylvania	4,700	270	220	200	5,390
Western New York	8,600	4,200	1,300	1,000	15,100
Ontario	40,500	-----	1,200	8,000	49,700
	264,200	26,870	20,120	26,200	337,390

JUL 10 1967

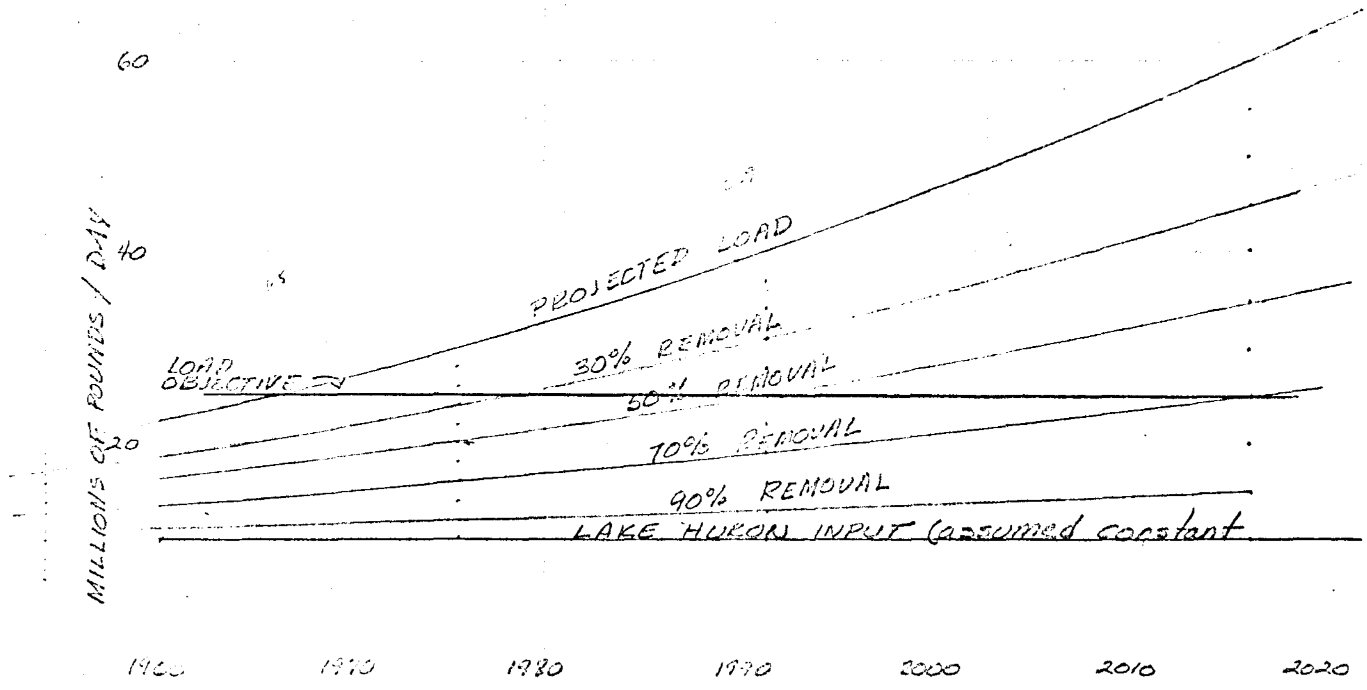


Fig 4.4 PROJECTED CHLORIDE LOAD TO LAKE ERIE AND LOADS WITH VARIOUS IN-BASIN LOAD REDUCTIONS

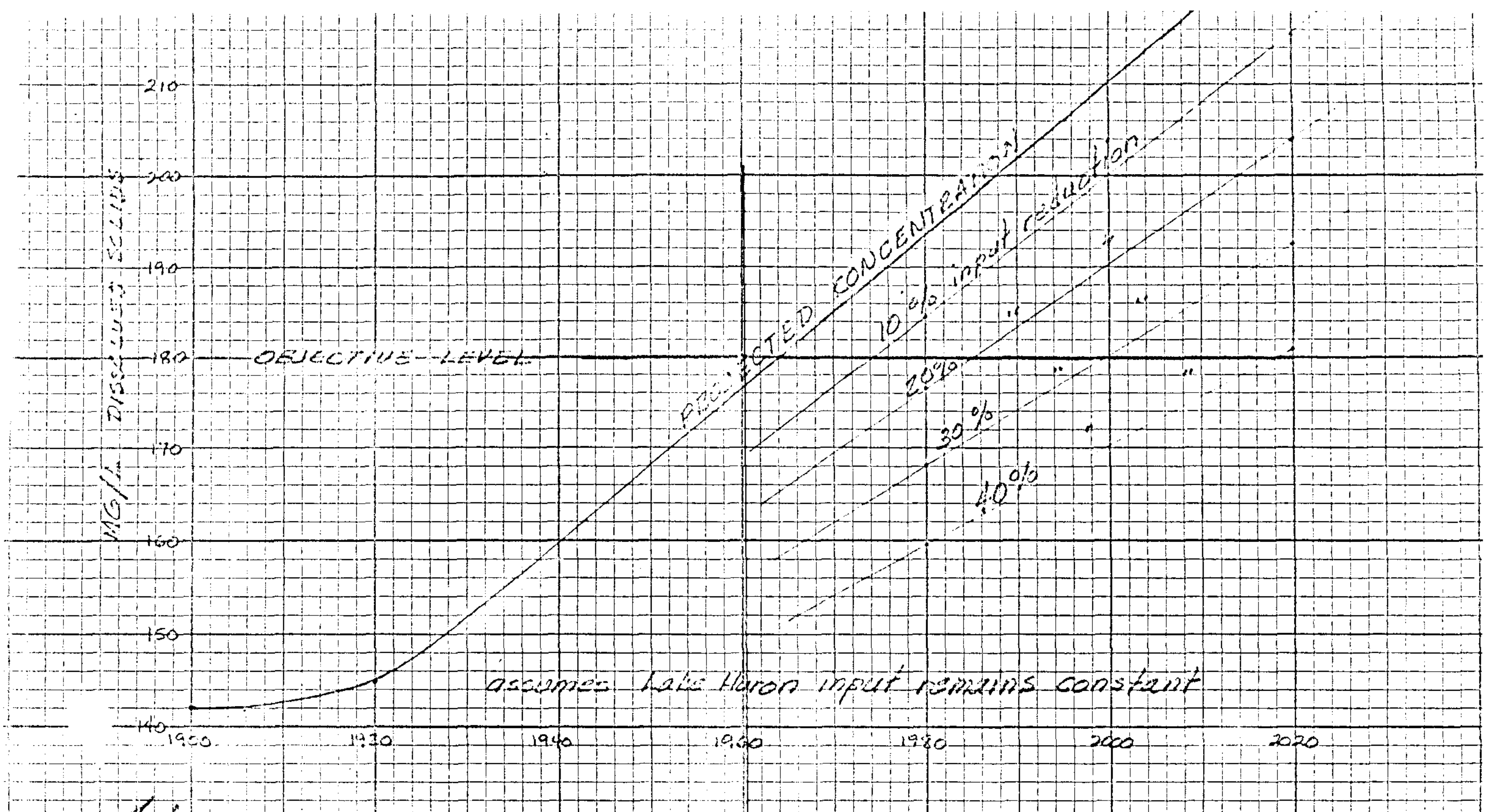
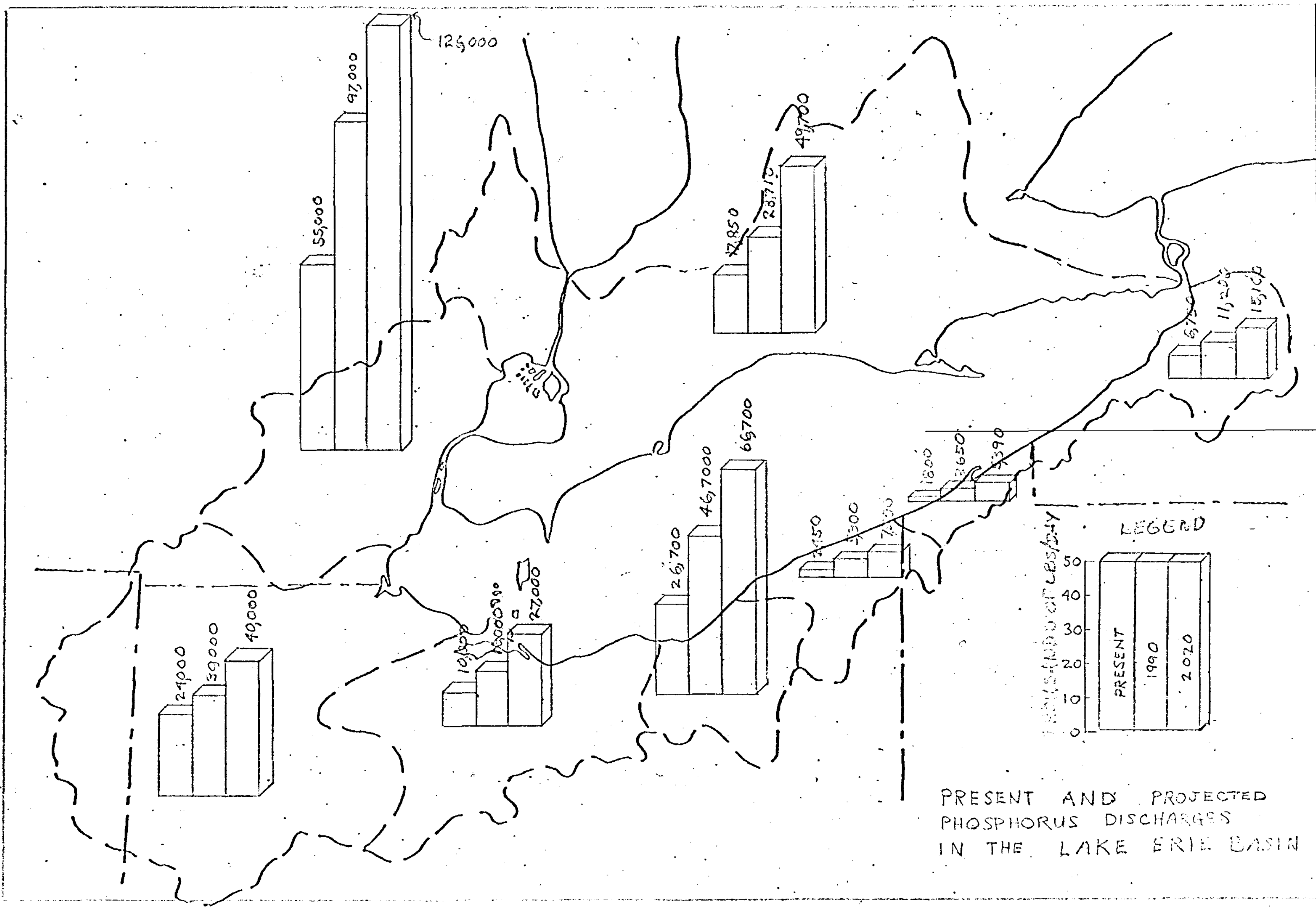
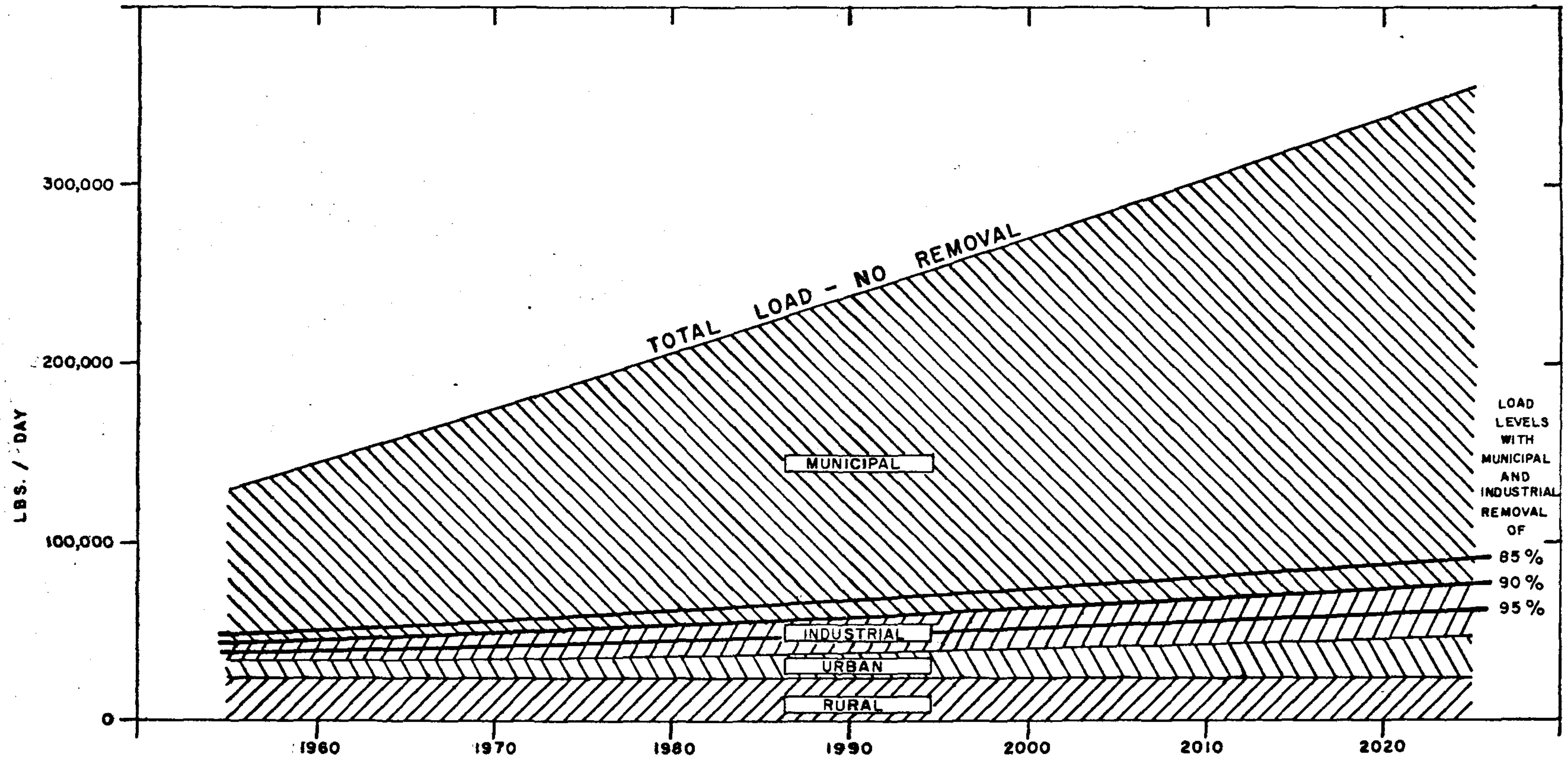


Fig 4-5 PROJECTED DISSOLVED SOLIDS CONCENTRATION IN LAKE ERIE AND EFFECT OF VARIOUS IN-BASIN INPUT REDUCTIONS



PRESENT AND PROJECTED PHOSPHORUS DISCHARGES IN THE LAKE ERIE BASIN

Fig. 4-6



PROJECTED PHOSPHORUS LOAD TO LAKE ERIE BY SOURCE - CUMULATIVE

EVALUATION OF WASTE SOURCES BY SUBAREAS

SOUTHEASTERN MICHIGAN

The subareas of the Southeastern Michigan Basin are discussed in this section of the report. It covers municipal and industrial waste sources, waste effects on receiving streams, water quality of the rivers and lakes, and the loadings from the tributaries to the Great Lakes system.

Municipal Waste

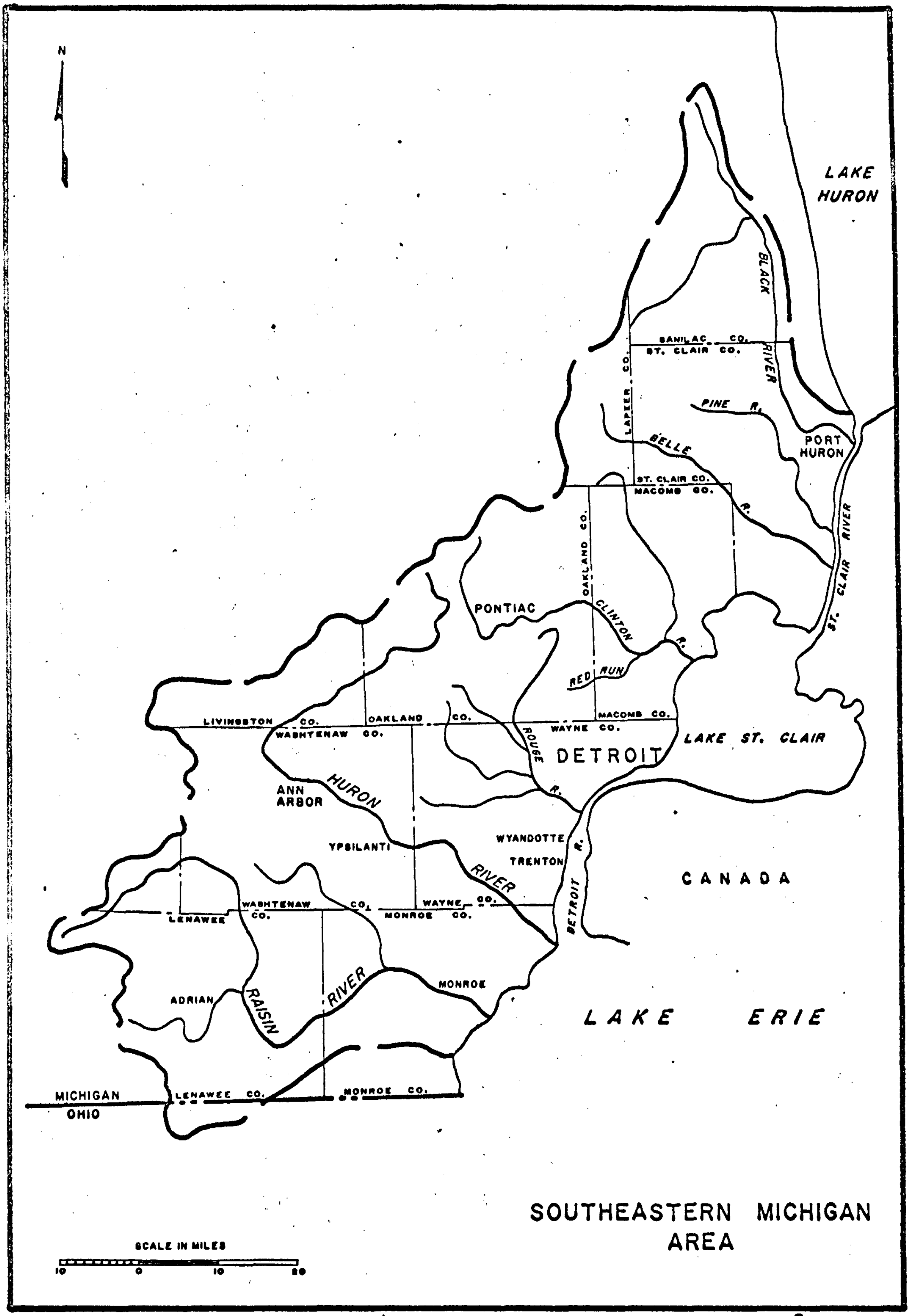
Within the basin, see Figure 4-8, there are 54 municipal waste treatment plants operating of which 19 provide primary treatment and serve 3.1 million people, 30 provide secondary treatment and serve 420,000 persons, and 5 are sewage lagoons. Another 630,000 persons are served by septic tanks. The municipal waste treatment plants discharge 650 mgd (million gallons per day), with the Detroit plant alone discharging 550 mgd to the Detroit River. Table 4-6 lists, for each major river, the municipal waste treatment plant, type of treatment, flow, and BOD loadings. Figures 4-9, 4-10, 4-12, and 4-13 show the sources of municipal and industrial wastes for each of the river basins in Southeast Michigan.

As of January 1, 1967, the Michigan Department of Public Health has ordered all municipal treatment plants to disinfect effluent discharge all year-round. Twenty-five communities or areas not currently providing adequate collection and treatment are under orders to discharge their wastes to adequate treatment facilities. Many of the communities in the basin currently provide treatment for their wastes at plants not in the community. Both the Detroit system and the Wayne County system serve numerous areas. Industrial wastes for many industries are presently treated with the municipal waste.

Combined Sewers - Stormwater Overflow

The majority of the people in the basin live in communities that have all or part of their sewage collection system as combined storm-sanitary sewers. Approximately 80 percent of the people are served by combined systems. This is especially true of the older, more urban sections of these communities. Stormwater overflows are estimated to discharge directly to the Detroit River 2 percent to 5 percent of the yearly total raw sewage contributed to the Detroit sewage treatment plant. This overflow, although a small proportion of the total flow, constitutes a much higher proportion of suspended organic material, and an extremely high proportion of the total bacterial load discharged to the river.

In suburban areas with separate sewer systems, the illegal practice of connecting roof, patio, or driveway drains to the sanitary sewer,



SOUTHEASTERN MICHIGAN AREA

FIG 4-8

TABLE 4-6

MAJOR MUNICIPAL WASTES
SOUTHEASTERN MICHIGAN AREA

Municipality or Institution	Receiving Stream	Type Sewage System	Flow (mgd)	BOD (lbs/day) Raw	Final
St. Clair River(1)					
Sandusky	Dwight Creek Black River	Secondary	0.37	x	x
Brown City	Elk Creek Elk River	Lagoons	0.20	x	x
Crosell	Black River	Secondary	0.34	x	x
Yale	Mill Cr. Black River	Lagoons	0.24	x	x
Port Huron	St. Clair River	Primary	11.70	x	x
Marysville	St. Clair River	Primary	1.14	x	x
St. Clair	St. Clair River	Primary	0.48	x	x
East China Twp.	St. Clair River	Primary	0.07	x	x
Imlay City	Belle River	Secondary	0.14	x	x
Capac	Belle River	Lagoon	0.01	x	x
Memphis	Belle River	Lagoon	0.03	x	x
Marine City	St. Clair River	Primary	0.65	x	x
Lake St. Clair(1)					
New Baltimore	Lake St. Clair	Secondary	0.20	x	x
Richmond	Lake St. Clair	Secondary	0.35	x	x
New Haven	Lake St. Clair	Secondary	0.14	x	x

x = Sufficient data not available for evaluation.
(1) See Figure 4-11 for location.

TABLE 4-6 (continued)

MAJOR MUNICIPAL WASTES
SOUTHEASTERN MICHIGAN AREA

Municipality or Institution	Receiving Stream	Type Sewage System	Flow (mgd)	BOD (lbs/day) Raw	BOD (lbs/day) Final
Clinton River(1)					
Pontiac #1	Clinton River	Secondary	9.8	x	x
Pontiac #2	Clinton River	Secondary	11.4	x	x
Rochester	Clinton River	Secondary	0.97	x	x
Utica	Clinton River	Secondary	0.39	x	x
Sterling Twp.#1	Clinton River	Secondary	2.20	x	x
Warren	Red Run	Secondary	23.70	x	x
Clinton Twp.#2	Clinton River	Secondary	2.03	x	x
Almont	N.Br.Clinton R.	Secondary	0.14	x	x
Romeo	East.Pond Creek	Secondary	0.37	x	x
Armanda	E.Br.Coon Creek	Secondary	0.12	x	x
Clinton Twp.#1	Clinton River	Secondary	2.34	x	x
Mt. Clemens	Clinton River	Secondary	3.72	x	x
Selfridge AFB	Clinton River	Secondary	x	x	x
Selfridge Nike Sites	Clinton River	Septic Tanks	x	x	x
Detroit River(2)					
Detroit	Detroit River	Primary	516	603,600	501,000
Wyandotte	Trenton Channel Detroit River	Primary	21.1	34,000	22,100
Riverview	Mongaugon Creek	Primary	1.0	x	x
Grosse Ile Twp.	Detroit River	Primary	0.15	150	100

x = Sufficient data not available for evaluation.
(1) See Figure 4-12 for location.
(2) See Figure 4-13 for location.

TABLE 4.6 (continued)

MAJOR MUNICIPAL WASTES
SOUTHEASTERN MICHIGAN AREA

Municipality or Institution	Receiving Stream	Type Sewage System	Flow (mgd)	BOD (lbs/day) Raw	BOD (lbs/day) Final
Detroit River (cont'd)					
Trenton (new)	Eliz. Park Canal	Primary	2.25	x	x
Wayne Co. STP (Trenton)	Eliz. Park Canal	Primary	2.42	2,660	1,780
Huron River(1)					
Milford	Huron River	Secondary	0.53	x	x
South Lyon	Novi-Lyon Drain	Secondary	0.18	x	x
Brighton	Ore Creek	Secondary	0.49	x	x
Stockbridge	Portage Creek	Lagoons	0.13	x	x
Chelsea	Letts Creek	Secondary	0.27	x	x
Dexter	Mill Creek	Primary	0.12	x	x
Ann Arbor	Huron River	Secondary	10.31	x	x
Ypsilanti	Huron River	Secondary	2.28	x	x
Ypsilanti Twp.	Huron River	Secondary	3.65	x	x
Flat Rock	Huron River	Primary	0.34	x	x
Rockwood	Huron River	Primary	0.32	x	x
River Raisin(2)					
Manchester	River Raisin	Secondary	0.53	x	x
Clinton	River Raisin	Primary	0.08	x	x
Tecumseh	River Raisin	Secondary	0.71	x	x
Adrian	S.Br.River Raisin	Secondary	2.83	x	x

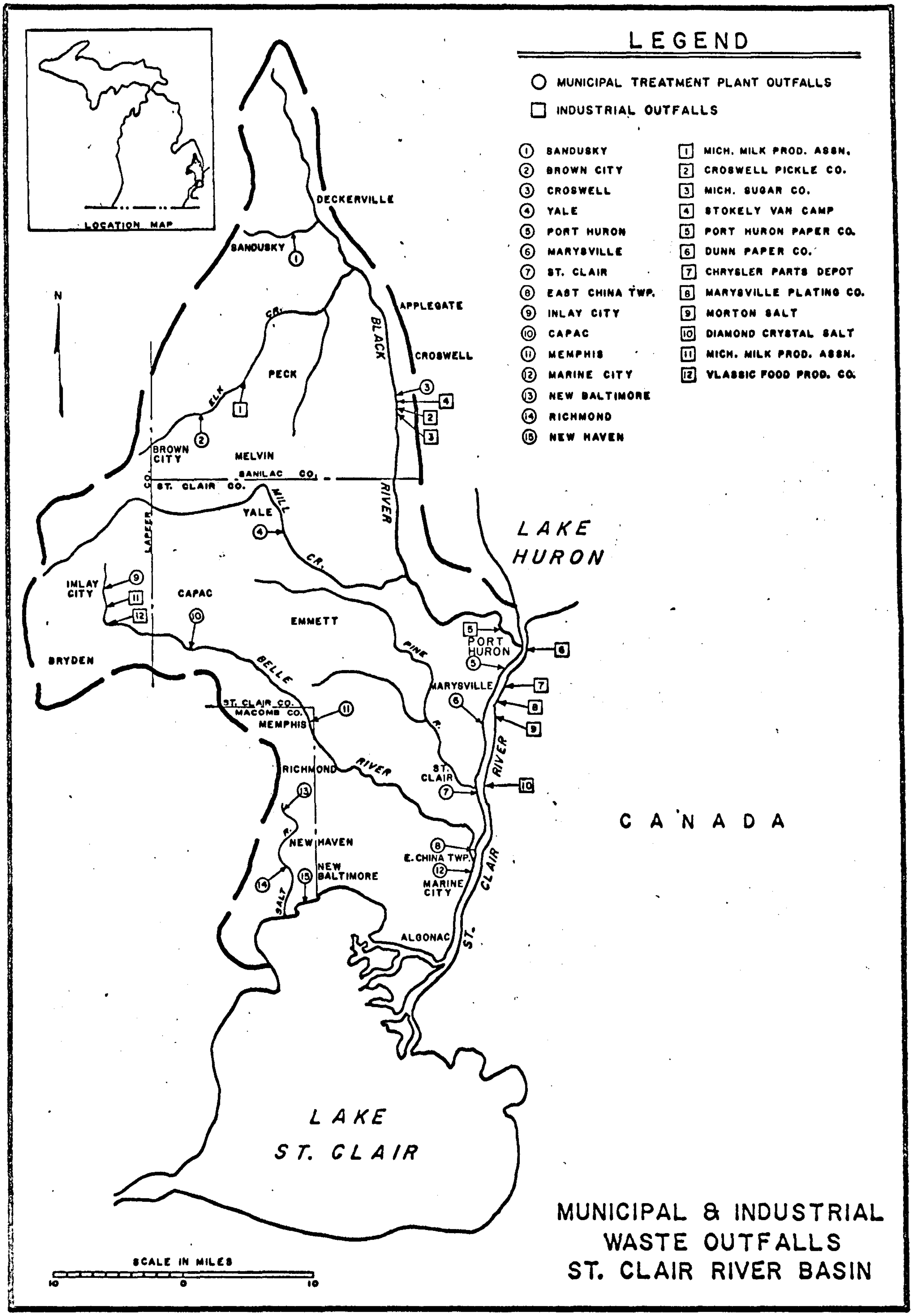
x = Sufficient data not available for evaluation.
(1) See Figure 4-14 for location.
(2) See Figure 4-15 for location.

TABLE 4-6 (concluded)

MAJOR MUNICIPAL WASTES
SOUTHEASTERN MICHIGAN AREA

Municipality or Institution	Receiving Stream	Type Sewage System	Flow (mgd)	BOD (lbs/day) Raw	Final
River Raisin (cont'd)					
Blissfield	River Raisin	Primary	0.49	x	x
Dundee	River Raisin	Primary	0.20	x	x
Saline	Saline River	Secondary	0.32	x	x
Milan	Saline River	Secondary	0.80	x	x
Monroe	River Raisin	Primary	2.93	3,365	1,380

x = Sufficient data not available for evaluation.



MUNICIPAL & INDUSTRIAL WASTE OUTFALLS ST. CLAIR RIVER BASIN

FIG 4-9

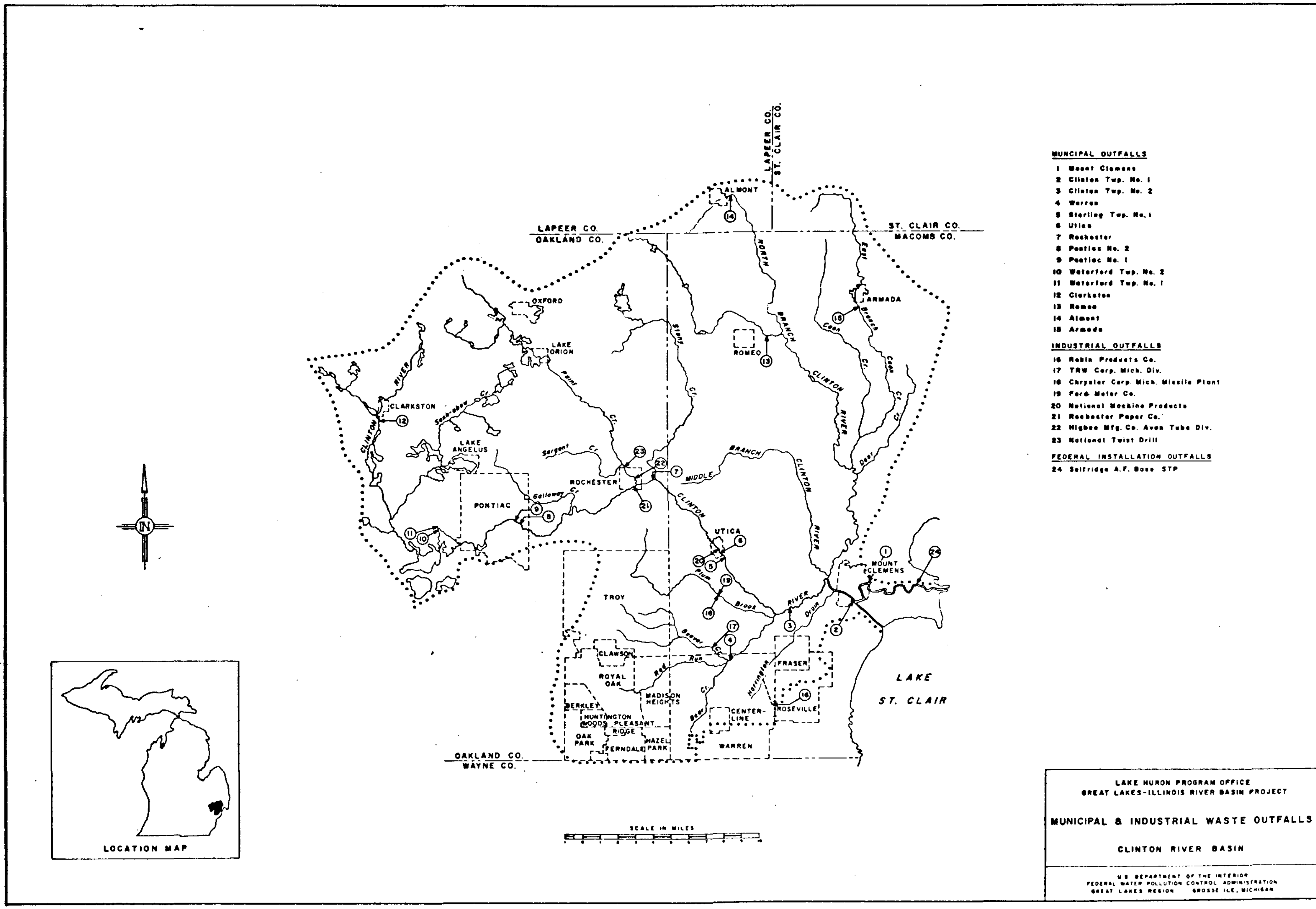
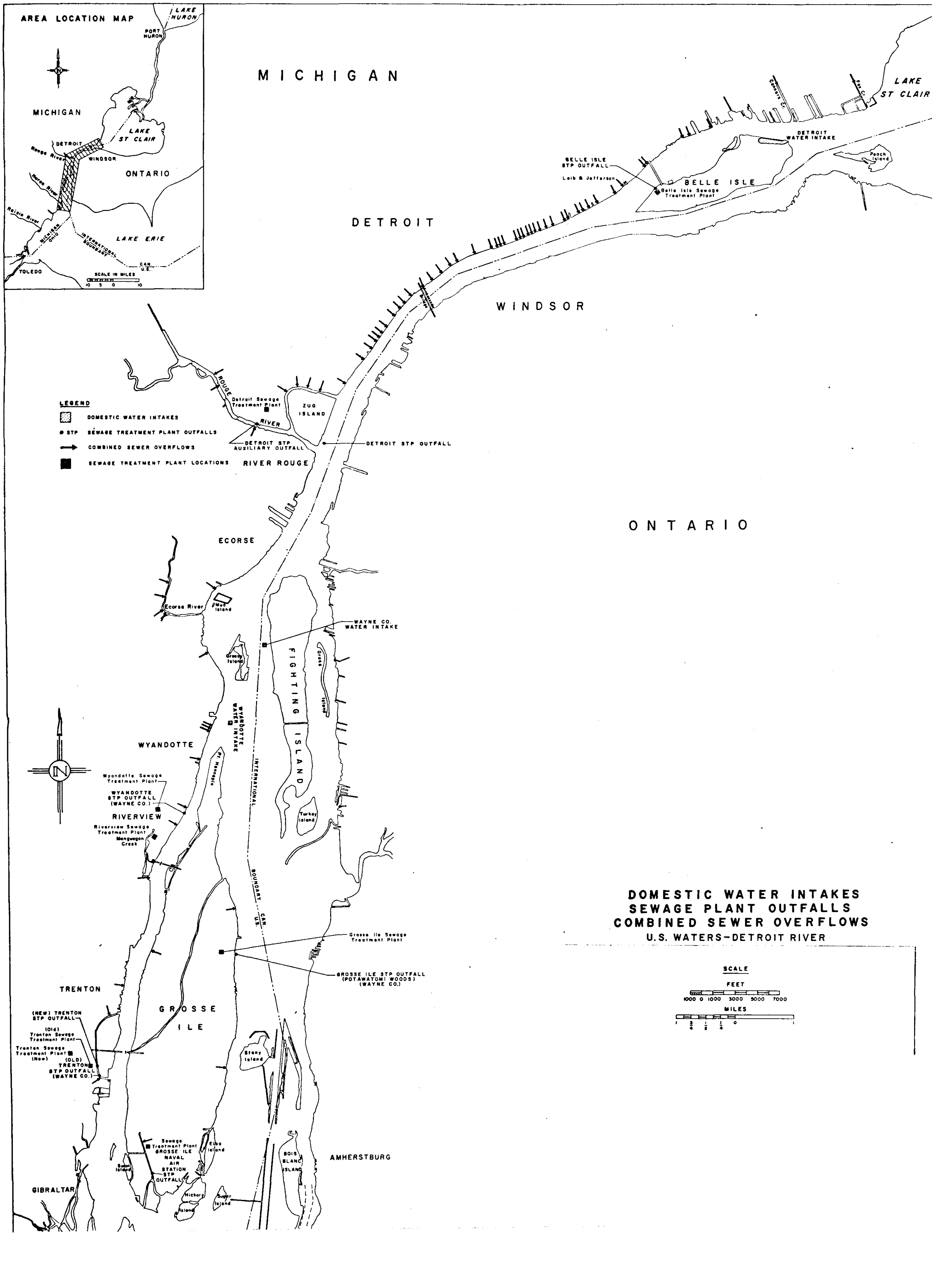

MUNCIPAL OUTFALLS
1 Mount Clemens
2 Clinton Twp. No. 1
3 Clinton Twp. No. 2
4 Warren
5 Sterling Twp. No. 1
6 Utica
7 Rochester
8 Pontiac No. 2
9 Pontiac No. 1
10 Waterford Twp. No. 2
11 Waterford Twp. No. 1
12 Clarkston
13 Romeo
14 Almont
15 Armada
INDUSTRIAL OUTFALLS
16 Robin Products Co.
17 TRW Corp. Mich. Div.
18 Chrysler Corp. Mich. Missile Plant
19 Ford Motor Co.
20 National Machine Products
21 Rochester Paper Co.
22 Higbee Mfg. Co. Avon Tube Div.
23 National Twist Drill
FEDERAL INSTALLATION OUTFALLS
24 Selfridge A.F. Base STP
LAPEER CO.
OAKLAND CO.
LAPEER CO.
ST. CLAIR CO.
ST. CLAIR CO.
MACOMB CO.
OAKLAND CO.
WAYNE CO.
ALMONT
OXFORD
LAKE ORION
ARMADA
ROMEO
CLARKSTON
LAKE ANGELUS
PONTIAC
ROCHESTER
UTICA
MOUNT CLEMENS
TROY
CLAWSON
ROYAL OAK
MADISON HEIGHTS
BERKLEY
HUNTINGTON WOODS
PLEASANT RIDGE
OAK PARK
FERNDALE
HAZEL PARK
CENTER-LINE
WARREN
FRASER
ROSEVILLE
LAKE ST. CLAIR
NORTH BRANCH CLINTON RIVER
MIDDLE BRANCH CLINTON RIVER
CLINTON RIVER
Paint Cr.
Stony Cr.
Sargent Cr.
Galloway Cr.
Red Run
Beaver Cr.
Bear Cr.
Plum Brook
Coon Cr.
Deer Cr.
East Branch
N
LOCATION MAP
SCALE IN MILES
LAKE HURON PROGRAM OFFICE
GREAT LAKES-ILLINOIS RIVER BASIN PROJECT
MUNICIPAL & INDUSTRIAL WASTE OUTFALLS
CLINTON RIVER BASIN
U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION GROSSE ILE, MICHIGAN

FIGURE 3



AREA LOCATION MAP
LAKE HURON
PORT HURON
MICHIGAN
LAKE ST CLAIR
DETROIT
WINDSOR
ONTARIO
Rouge River
Huron River
Raisin River
MICHIGAN OHIO
INTERNATIONAL BOUNDARY
LAKE ERIE
CAN. U.S.
TOLEDO
SCALE IN MILES
M I C H I G A N
LAKE ST CLAIR
DETROIT WATER INTAKE
Peach Island
BELLE ISLE STP OUTFALL
Leib & Jefferson
BELLE ISLE
Belle Isle Sewage Treatment Plant
D E T R O I T
W I N D S O R
LEGEND
DOMESTIC WATER INTAKES
STP SEWAGE TREATMENT PLANT OUTFALLS
COMBINED SEWER OVERFLOWS
SEWAGE TREATMENT PLANT LOCATIONS
ROUGE
RIVER
Detroit Sewage Treatment Plant
ZUG ISLAND
DETROIT STP AUXILIARY OUTFALL
DETROIT STP OUTFALL
RIVER ROUGE
O N T A R I O
ECORSE
Ecorse River
Mud Island
WAYNE CO. WATER INTAKE
Grassy Island
FIGHTING ISLAND
Grass Island
WYANDOTTE WATER INTAKE
WYANDOTTE
Pt. Hennepin
INTERNATIONAL BOUNDARY
CAN. U.S.
Wyandotte Sewage Treatment Plant
WYANDOTTE STP OUTFALL (WAYNE CO.)
RIVERVIEW
Riverview Sewage Treatment Plant
Monguagon Creek
Turkey Island
DOMESTIC WATER INTAKES
SEWAGE PLANT OUTFALLS
COMBINED SEWER OVERFLOWS
U.S. WATERS–DETROIT RIVER
Grosse Ile Sewage Treatment Plant
GROSSE ILE STP OUTFALL (POTAWATOMI WOODS) (WAYNE CO.)
SCALE
FEET
1000 0 1000 3000 5000 7000
MILES
TRENTON
GROSSE ILE
(NEW) TRENTON STP OUTFALL
(Old) Trenton Sewage Treatment Plant
Trenton Sewage Treatment Plant (New)
(OLD) TRENTON STP OUTFALL (WAYNE CO.)
Stony Island
Sewage Treatment Plant GROSSE ILE NAVAL AIR STATION STP OUTFALL
Elba Island
Swan Island
BOIS BLANC ISLAND
AMHERSTBURG
GIBRALTAR
Hickory Island
Sugar Island

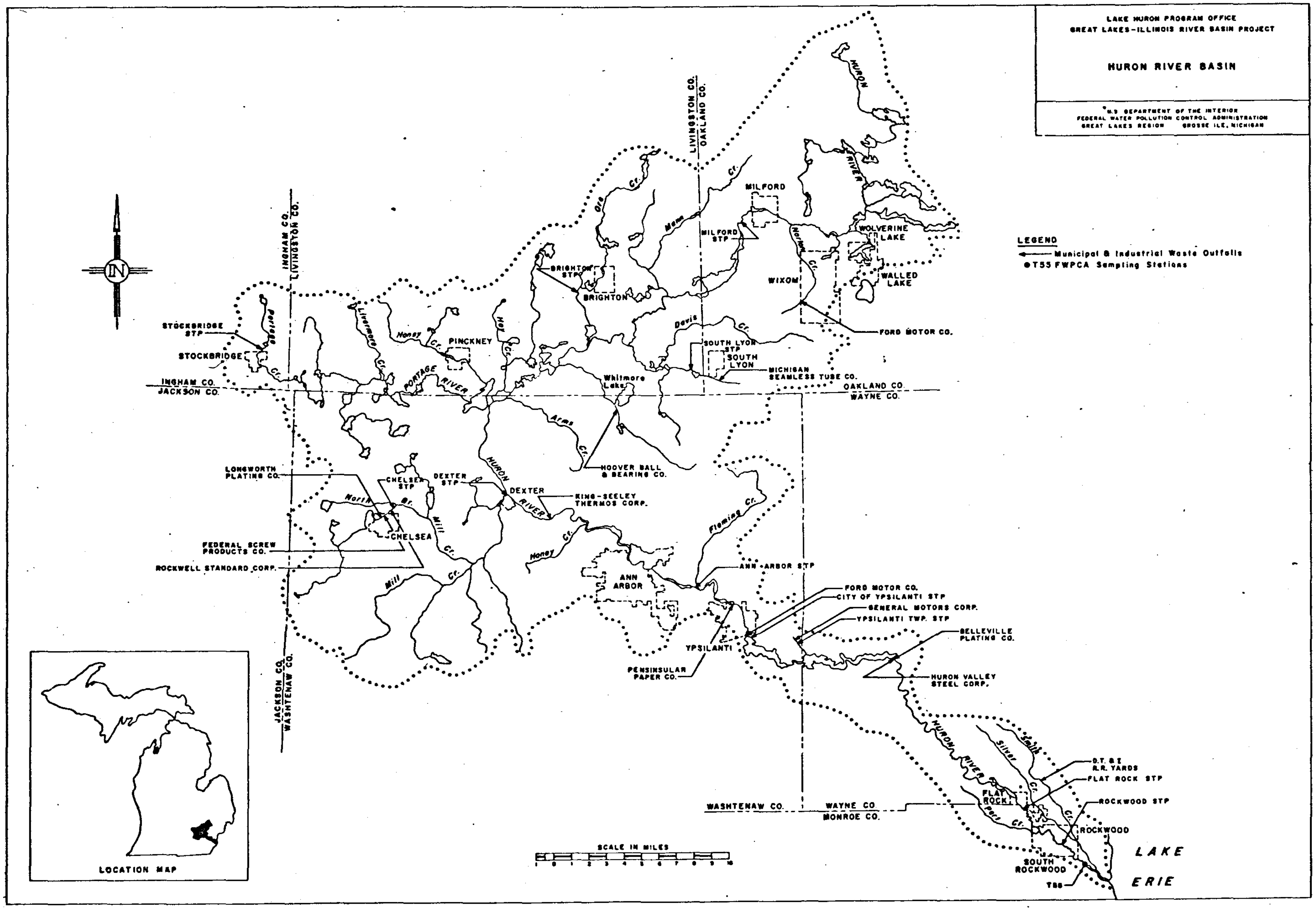
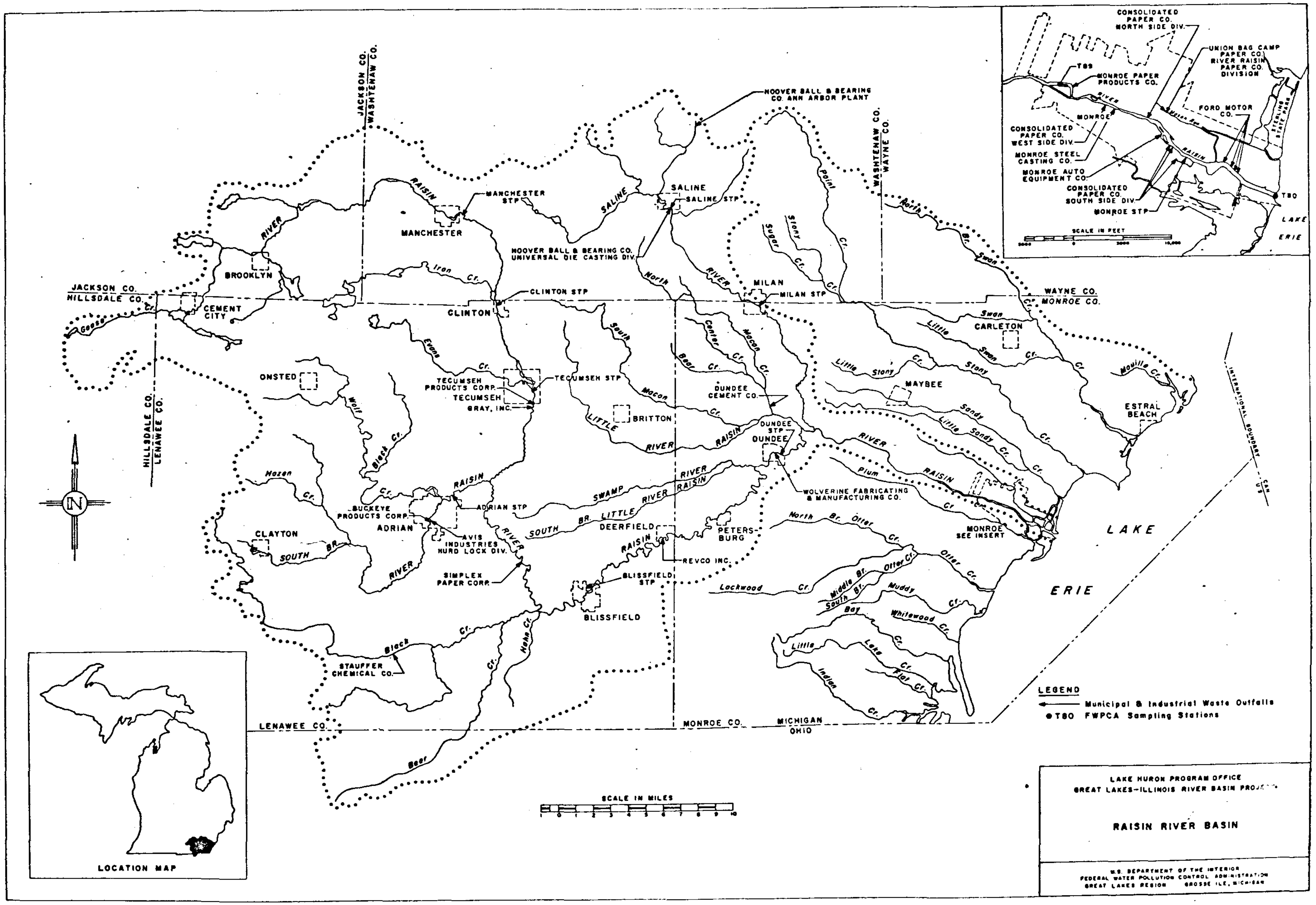

LAKE HURON PROGRAM OFFICE
GREAT LAKES-ILLINOIS RIVER BASIN PROJECT
HURON RIVER BASIN
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION GROSSE ILE, MICHIGAN
LEGEND
Municipal & Industrial Waste Outfalls
T55 FWPCA Sampling Stations
INGHAM CO.
LIVINGSTON CO.
OAKLAND CO.
JACKSON CO.
WASHTENAW CO.
WAYNE CO.
MONROE CO.
STOCKBRIDGE STP
STOCKBRIDGE
PINCKNEY
BRIGHTON STP
BRIGHTON
MILFORD
MILFORD STP
WOLVERINE LAKE
WALLED LAKE
WIXOM
FORD MOTOR CO.
SOUTH LYON STP
SOUTH LYON
MICHIGAN SEAMLESS TUBE CO.
Whitmore Lake
HOOVER BALL & BEARING CO.
LONGWORTH PLATING CO.
CHELSEA STP
DEXTER STP
DEXTER
KING-SEELEY THERMOS CORP.
CHELSEA
FEDERAL SCREW PRODUCTS CO.
ROCKWELL STANDARD CORP.
ANN ARBOR
ANN ARBOR STP
FORD MOTOR CO.
CITY OF YPSILANTI STP
GENERAL MOTORS CORP.
YPSILANTI TWP. STP
BELLEVILLE PLATING CO.
HURON VALLEY STEEL CORP.
YPSILANTI
PENINSULAR PAPER CO.
D.T. & I. R.R. YARDS
FLAT ROCK STP
ROCKWOOD STP
FLAT ROCK
ROCKWOOD
SOUTH ROCKWOOD
T58
LAKE ERIE
HURON RIVER
PORTAGE RIVER
SCALE IN MILES
LOCATION MAP

FIGURE #4-12

#31



LAKE HURON PROGRAM OFFICE
GREAT LAKES–ILLINOIS RIVER BASIN PROJECT
RAISIN RIVER BASIN
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION GROSSE ILE, MICHIGAN
LEGEND
Municipal & Industrial Waste Outfalls
T80 FWPCA Sampling Stations
SCALE IN MILES
LOCATION MAP
CONSOLIDATED PAPER CO. NORTH SIDE DIV.
UNION BAG CAMP PAPER CO. RIVER RAISIN PAPER CO. DIVISION
MONROE PAPER PRODUCTS CO.
FORD MOTOR CO.
MONROE
CONSOLIDATED PAPER CO. WEST SIDE DIV.
MONROE STEEL CASTING CO.
MONROE AUTO EQUIPMENT CO.
CONSOLIDATED PAPER CO. SOUTH SIDE DIV.
MONROE STP
SCALE IN FEET
LAKE ERIE
HOOVER BALL & BEARING CO. ANN ARBOR PLANT
JACKSON CO.
WASHTENAW CO.
WAYNE CO.
HILLSDALE CO.
LENAWEE CO.
MONROE CO.
MICHIGAN
OHIO
MANCHESTER STP
MANCHESTER
SALINE
SALINE STP
HOOVER BALL & BEARING CO. UNIVERSAL DIE CASTING DIV.
BROOKLYN
CEMENT CITY
CLINTON STP
CLINTON
MILAN
MILAN STP
CARLETON
ONSTED
TECUMSEH STP
TECUMSEH PRODUCTS CORP.
TECUMSEH
GRAY, INC.
BRITTON
DUNDEE CEMENT CO.
MAYBEE
ESTRAL BEACH
DUNDEE STP
DUNDEE
WOLVERINE FABRICATING & MANUFACTURING CO.
BUCKEYE PRODUCTS CORP.
ADRIAN STP
ADRIAN
CLAYTON
AVIS INDUSTRIES HURD LOCK DIV.
DEERFIELD
PETERSBURG
REVCO INC.
MONROE SEE INSERT
SIMPLEX PAPER CORP.
BLISSFIELD STP
BLISSFIELD
STAUFFER CHEMICAL CO.
INTERNATIONAL BOUNDARY
RAISIN RIVER
SALINE RIVER
North Br.
Iron Cr.
Goose Cr.
Evans Cr.
Wolf Cr.
Black Cr.
Hazen Cr.
SOUTH BR.
South Br.
Macon Cr.
Little River
Swamp River
South Br. Little River
Sugar Cr.
Stony Cr.
Paint Cr.
North Br. Swan Cr.
Little Swan Cr.
Little Stony Cr.
Sandy Cr.
Little Sandy Cr.
Plum Cr.
Mouille Cr.
North Br. Otter Cr.
Otter Cr.
Middle Br. Otter Cr.
Lockwood Cr.
Muddy Cr.
Whitewood Cr.
Bay Cr.
Little Lake Cr.
Flat Cr.
Indian Cr.
Hahn Cr.
Bear Cr.

FIGURE

results in an overload and subsequent noneffective treatment during storm periods, with an effect similar to stormwater overflow on the receiving stream.

Federal Installations

The Selfridge Air Force Base operates a secondary wastewater treatment plant which discharges a chlorinated effluent into the Clinton River. There are some base facilities served by septic tanks that occasionally overflow to the river without disinfection. Plans are underway to connect the base's system to the Detroit Metro System.

The U. S. Coast Guard operates a manned lighthouse at the mouth of the Detroit River. Untreated sanitary wastes are directly discharged into the water. This unit will become an unmanned lighthouse.

The Naval Air Station at Grosse Ile is responsible for significant quantities of oil in Frenchmen's Creek attributable to aircraft washings and dumps of engine oil. This can affect problems with wildlife and boating recreation. The Navy plans to move its air facility to Selfridge AFB in 1968.

Industrial Waste

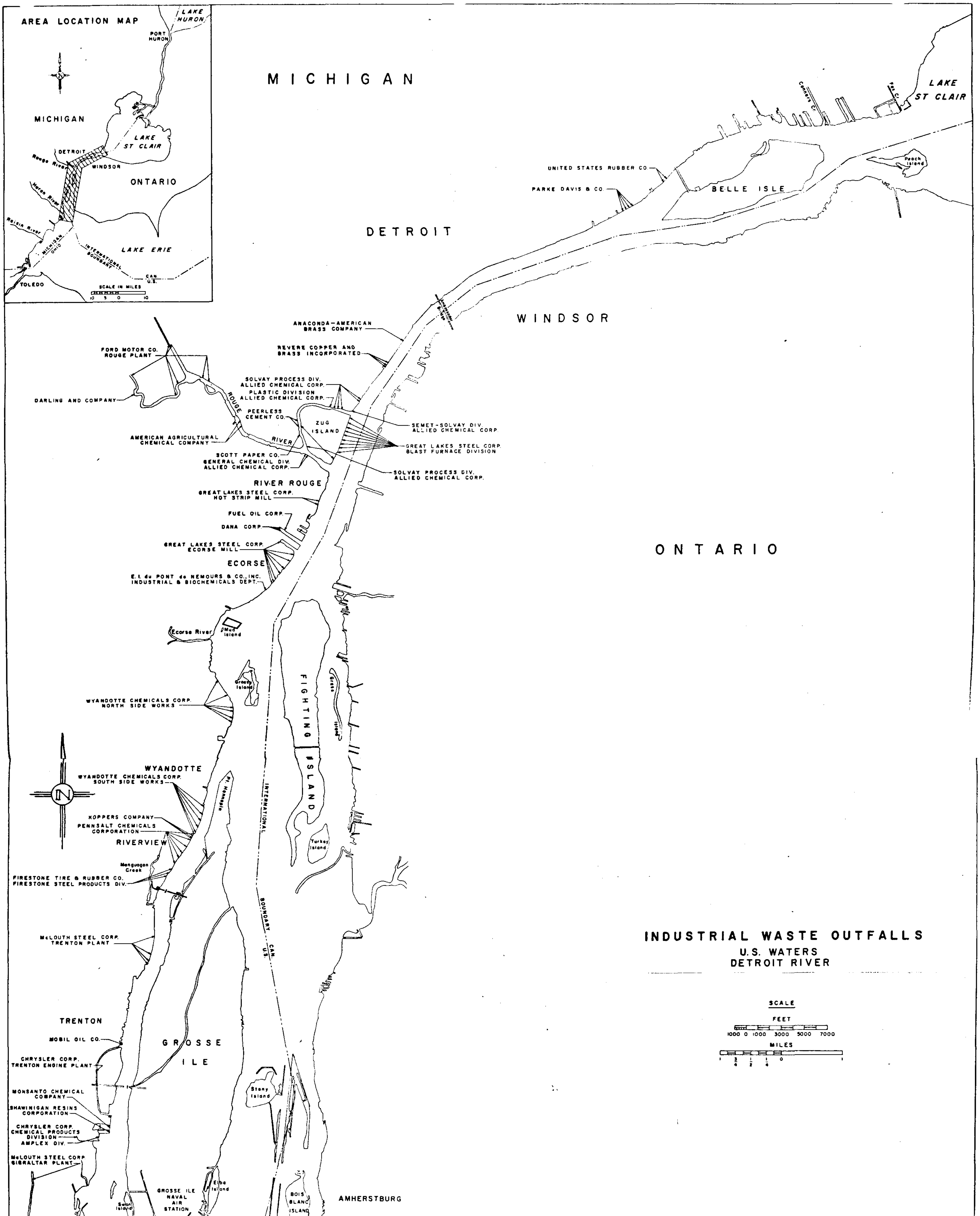
More than 90 individual industries exclusive of the hydroelectric generating plants discharge approximately 1.4 billion gallons of wastewater each day. About a billion of this goes to the Detroit River. These effluents contain suspended solids, dissolved solids, oils, grease, cyanide, toxic metals, acids, alkalis, bacteria, phenols, oxygen-demanding wastes, nutrients, and heat. Industrial wastes are those spent process waters associated with industrial operations which are discharged separately and not in combination with municipal wastes. Some effluents contain no significant concentration of contaminants, while some are grossly polluted with waste material. Figure 4-14 shows the geographical location of industrial waste outfalls in the Detroit River. For other river basins the location of the sources of industrial wastes were shown in the figures in the municipal waste section.

The following is a summary of the adequacy of the industries' treatment facilities rated by the Michigan Water Resources Commission:

Adequate treatment	-	42
Inadequate treatment	-	22
Unreliable treatment	-	9
Adequacy not established	-	18
Need not established	-	1

A number of industries include more than one type of discharge with different ratings for the separate discharges. The majority of the industries with inadequate treatment in the Detroit River-Lake Erie conference

4-33


AREA LOCATION MAP
LAKE HURON
PORT HURON
MICHIGAN
LAKE ST CLAIR
DETROIT
Rouge River
WINDSOR
ONTARIO
Huron River
Raisin River
MICHIGAN OHIO
INTERNATIONAL BOUNDARY
LAKE ERIE
CAN. U.S.
TOLEDO
SCALE IN MILES
MICHIGAN
LAKE ST CLAIR
UNITED STATES RUBBER CO.
PARKE DAVIS & CO.
BELLE ISLE
Peach Island
DETROIT
WINDSOR
ANACONDA-AMERICAN BRASS COMPANY
REVERE COPPER AND BRASS INCORPORATED
FORD MOTOR CO. ROUGE PLANT
DARLING AND COMPANY
SOLVAY PROCESS DIV. ALLIED CHEMICAL CORP.
PLASTIC DIVISION ALLIED CHEMICAL CORP.
PEERLESS CEMENT CO.
ROUGE
ZUG ISLAND
SEMET-SOLVAY DIV. ALLIED CHEMICAL CORP.
AMERICAN AGRICULTURAL CHEMICAL COMPANY
RIVER
GREAT LAKES STEEL CORP. BLAST FURNACE DIVISION
SCOTT PAPER CO.
GENERAL CHEMICAL DIV. ALLIED CHEMICAL CORP.
SOLVAY PROCESS DIV. ALLIED CHEMICAL CORP.
RIVER ROUGE
GREAT LAKES STEEL CORP. HOT STRIP MILL
FUEL OIL CORP.
DANA CORP.
GREAT LAKES STEEL CORP. ECORSE MILL
ECORSE
E.I. du PONT de NEMOURS & CO., INC. INDUSTRIAL & BIOCHEMICALS DEPT.
ONTARIO
Ecorse River
Mud Island
Grassy Island
FIGHTING ISLAND
Grass Island
WYANDOTTE CHEMICALS CORP. NORTH SIDE WORKS
WYANDOTTE
WYANDOTTE CHEMICALS CORP. SOUTH SIDE WORKS
Pt. Hennepin
INTERNATIONAL BOUNDARY
KOPPERS COMPANY
PENNSALT CHEMICALS CORPORATION
RIVERVIEW
Turkey Island
Monguagon Creek
FIRESTONE TIRE & RUBBER CO. FIRESTONE STEEL PRODUCTS DIV.
CAN. U.S.
McLOUTH STEEL CORP. TRENTON PLANT
INDUSTRIAL WASTE OUTFALLS
U.S. WATERS
DETROIT RIVER
SCALE
FEET
1000 0 1000 3000 5000 7000
MILES
TRENTON
MOBIL OIL CO.
GROSSE ILE
CHRYSLER CORP. TRENTON ENGINE PLANT
MONSANTO CHEMICAL COMPANY
SHAWINIGAN RESINS CORPORATION
CHRYSLER CORP. CHEMICAL PRODUCTS DIVISION AMPLEX DIV.
Stony Island
McLOUTH STEEL CORP. GIBRALTAR PLANT
GROSSE ILE NAVAL AIR STATION
Elba Island
Swan Island
BOIS BLANC ISLAND
AMHERSTBURG

area are currently under stipulations for improvements in treatment. Table 4-7 lists industries, locations, treatment, wastes, flow, receiving waters and ratings by the Michigan Water Resources Commission.

Maintenance Dredging Operations, Corps of Engineers

Rouge River

The dredging of the channels of the Main Rouge, Old Rouge and Short Cut Canal commencing at the Ford Motor Company turning basin and extending to the Detroit River is classified as maintenance work. Dredging operations are annual and commence about the middle of September and continue until just before Christmas. In 1962 approximately 174,000 cubic yards of silt, industrial waste and clay were removed and hauled by the U. S. Hopper Dredge Hains to Grassy Island and pumped within the diked area. In 1963, 255,000 cubic yards were removed.

The costs of maintenance dredging by the Corps of Engineers in the Rouge were $206,288 in 1962 and $258,524 in 1963. To help defray the cost of dredging various industries were charged an amount (see Table 4-8) commensurate with the cost of removing that portion of the dredged material deposited by industrial waste discharges.

Detroit River

The Corps of Engineers removes some 100,000 cubic yards annually from the Livingstone Channel and 200,000 cubic yards annually from the East Outer Channel. The upper Livingstone Channel annual maintenance dredging is primarily carried out to remove diked material (rocks and boulders) which wave action has caused to topple into the channel. The lower Livingstone Channel and the East Outer Channel operation consists of removal of solids originating upstream and deposited in areas where the velocity decreases as the river approaches and enters Lake Erie.

Raisin River

Monroe Harbor dredging is classified as maintenance work and in 1962 and 1963 consisted of dredging from the Monroe Harbor terminal turning basin to a point about 8,000 feet into Lake Erie. This is an annual operation and usually takes place during the month of October. Two hundred and seventy one thousand cubic yards of excavated material consisting principally of silt, paper pulp and clay were hauled by the U. S. Hopper Dredge Hoffman to a disposal area in Lake Erie in 1962. Similar operations were repeated in 1963 with 390,000 cubic yards of material being removed by the U. S. Hopper Dredge Lyman.

The costs of maintenance dredging by the Corps of Engineers in the Raisin River were $58,774 in 1962 and $128,536 in 1963. To help defray

TABLE 4-7

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
St. Clair River							
1-Michigan Milk Products Assn.	Peck	Elk Creek	Milk products	0.01			BOD x
2-Croswell Pickle	Croswell	Black River	Pickled products	0.20		x	BOD x
3-Michigan Sugar	Croswell	Black River	Sugar processing	1.44			BOD x
4-Stokely-Van Camp	Croswell	Black River	Food products	x			BOD x
5-Port Huron Paper	Port Huron	Black River	Paper mill	7.10			BOD x; Fiber x; Color x
6-Dunn Paper	Port Huron	St. Clair R.	Paper mill	x			Fiber x
7-Midwest Machine Co. of Indiana	Port Huron	Bunce Creek	Machine products	0.0009			Oil x
8-Chrysler Parts Depot	Marysville	St. Clair R.	Motor vehicle parts	0.01			Px; Cr^{+6} x
9-Marysville Plating	Marysville	St. Clair R.	Metal plating	0.006			Ni x; Cr^{+6} x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved
x Sufficient data not available for evaluation.

TABLE 4-7 (continued)

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
St. Clair River (cont'd)							
10-Morton Salt	Marysville	St. Clair R.	Salt processing	8.00		x	$CaSO_4$ x; NaCl x, $CaCl_2$ x
11-Diamond Crystal Salt	St. Clair	St. Clair R.	Salt processing	7.20		x	$CaSO_4$ x; NaCl x; $CaCl_2$ x
12-Michigan Milk Products Assn	Imlay City	Belle River	Milk products	0.10			BOD x
13-Vlasic Food Products	Imlay City	Belle River	Food products	0.10		x	BOD x
Clinton River							
1-Rochester Paper	Rochester	Clinton R.	Paper mill	0.29			Dye x; Fiber x
2-National Twist Drill	Rochester	Clinton R. Paint Cr.	Machine products	0.36			Cr^{+6} x; CN x; Oil x
3-Higbee Mfg. Co. Avon Tube	Rochester	Clinton R. Paint Cr.		0.40			
4-National Machine Products	Utica	Clinton R.	Machine products	0.10			

*Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved
x Sufficient data not available for evaluation.

TABLE 4-7 (continued)

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
Clinton River (cont'd)							
5-TRW Corp. Michigan Div.	Utica	Red Run Beaver Cr.		0.10			Soluble oil x
6-Chrysler-Michigan Missile	Sterling Twp.	Plumb Br.		0.55 0.2(san)			Fe x; Zn x; Oil x; Cu x; CN x; Cd x; Cr^{+6} x;
7-Ford Motor	Sterling Twp.	Clinton R. Plumb Br.	Motor vehicle parts	1.5	xS		Oil x
Detroit River							
1-U. S. Rubber	Detroit	Detroit R.	Rubber goods	42.0		2,500	NH_3 10; Zn 650; P 22.5
2-Parke, Davis & Co.	Detroit	Detroit R.	Pharmaceutical products	8.1	65S	45	BOD 17; Oil 256; Phenol 1; CN 0.13; NH_3 X
3-Anaconda-American Brass	Detroit	Detroit R.	Copper products	5.3	135S		BOD 376; Fe 1.1; Cu 60; Zn 32; Pb 0.25; Chromium 10; NH_3 x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x Sufficient data not available for evaluation.

TABLE 4-7 (continued)

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
Detroit River (cont'd)							
4-Revere Copper & Brass	Detroit	Detroit R.	Brass and copper products	2.9	2,166S		BOD 570; Oil 2,628, Fe 3.5; NH_3 x; CN x; Cu 100; Ni 0.4; Zn 66; Pb 0.9; Chromium 29
5-Great Lakes Steel-Blast Furnace Div.	Detroit	Detroit R.	Pig iron and coke	90.0	100,000S	17,959	BOD 3,700; Oil 2,482; Phenol 370; Fe 5,146; NH_3 2,900; CN 10; Cu 108; Zn 750; Pb 123 P x
6-Great Lakes Steel-Hot Stip Mill	River Rouge	Detroit R.	Sheet steel	72.0	29,000S	1,000	Phenol 1.65; Fe 1,500; Oil 2,738; NH_3 86; Zn 42; BOD 350; Pb 280; PO_4 x

* Except temperature in $^{\circ}$F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x Sufficient data not available for evaluation.

TABLE 4-7 (continued)

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day*		
					Solids**	Chlorides	Other
Detroit River (cont'd)							
7-Dana Corp	Ecorse	Detroit R.	Auto, truck and railroad frames	0.4			BOD 588; Oil 60; Phenol 0.26; Fe 20; NH_3 x; CN x; Acid x; Cu 1.2; Zn 11; Pb 0.5; Chromium 1.3; P x
8-Fuel Oil Corp.	River Rouge	Detroit R.	Ship washing		70S***	20***	BOD 221***; Oil 124***
9-Great Lakes Steel Ecorse Mill	Ecorse	Detroit R.	Steel	72.0	8,400S	1,800	BOD x; Oil 7,884; Phenol 1.67; Fe 49,000; NH_3 x; CN x; Acid 158,000; Cu 137; Ni 4; Zn 12; Pb 34; Chromium 8

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved
*** Pounds per ship.
x Sufficient data not available for evaluation.

TABLE 4-7 (continued)

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
Detroit River (cont'd)							
10-E.I.DuPont de Nemours	Ecorse	Detroit R.	Chemical products	1.4		1,500	Fe 23, NH_3 x; Acid x; Cu 0.3; Zn 6; Pb 0.4; P x
11-Wyandotte Chemicals, North Side Works	Wyandotte	Detroit R.	Chemical products	57.0	300,000S	1,300,000	BOD 2,200; Oil x; Phenol 34.13; Fe x; NH_3 x; CN x; Cu 59; Zn 7; P 14
12-Wyandotte Chemicals, South Side Works	Wyandotte	Trenton Channel	Chemical products	54.7	69,745S	550,000	BOD 3,000' Oil x; Fe x; NH_3 x; CN x; Cu 35; Ni 1; Zn 10; Pb 7; Chromium 6; P x
13-Pennsalt Chemical East Plant	Wyandotte	Trenton Channel	Chemical products	97.0	93,370	500,000	BOD x; Oil x; NH_3 x; CN x; P x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, D=Total Dissolved.
x Sufficient data not available for evaluation.

TABLE 4-7 (continued)

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
Detroit River (cont'd)							
14-Koppers Co.	Wyahdotte	Trenton Channel	Chemical products	0.8	25S	158	BOD 112; Oil 17.5; Phenol 0.6; Fe 13; NH_3 x; Cu 2.7; Zn 2.8; Pb 1.2; P x
15-Firestone Tire and Rubber	Riverview	Trenton Channel	Wheel rims	1.0	296S	16	BOD 70; Phenol 0.19; Fe 5,407; NH_3 x; CN x; Acid 2,700; Cu 13, Zn 9; P x
16-McLouth Steel	Trenton	Trenton Channel	Stainless steel products	65.7	15,588S	24,267	BOD 5,000; Oil 270; Phenol 9.04; Fe 1,990; NH_3 250; CN 119; Cu 63; Ni 9; Zn 300, Pb 325; Chromium 3; P x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved; S=Total Suspended, and D=Total Dissolved.
x Sufficient data not available for evaluation.

TABLE 4-7 (continued)

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
Detroit River (cont'd)							
17-Mobile Oil	Woodhaven	Trenton Channel	Fuels and Solvents	1.1	1,588S	12,989	BOD 1,000; Oil 719; Phenol 117; Fe 2; NH_3 x; CN x; Cu 0.7; Zn 0.5; Pb 3; Chromium 0.8; P x
18-Chrysler Corp. Engine Plant	Trenton	Eliz. Park Channel	Motor vehicle machines	1.1		268	BOD 85; Phenol 0.78; Fe 2; NH_3 x; Cu 0.4; Ni 0.1; Zn 0.7; Pb 2; P x
19-Monsanto Chemical	Trenton	Trenton Channel	Phosphates & detergents	18.0	6,500S		BOD x; Oil x; Fe 6; NH_3 x; Cn x; Acid x; Cu 3.5; Ni 0.8; Zn 0.4; P 10,000
20-Shawinigan Resins	Trenton	Trenton Channel	Chemical products	0.4	1,313S		BOD 6,970; Oil x; NH_3 x; CN x; Acid 7,190; P x Phenol 0.01

* Except temperature in °F and pH
** Solids: T=Total Suspended and Dissolved, S=Total suspended, and D=Total Dissolved.
x Sufficient data not available for evaluation.

TABLE 4-7 (continued)

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
Detroit River (cont'd)							
21-Chrysler-Chemical Div.	Trenton	Trenton Channel	Chemical products	0.3			NH_3 x; CN x; P x
22-Chrysler-Amplex Div.	Trenton	Trenton Channel	Gears	0.3	168S		NH_3 x; CN x; P x
23-McLouth Steel	Gibraltar	Trenton Channel	Steel	1.6	xS	25,600	Oil 241; Fe 210; NH_3 x; CN x; Acid 15,400; Cu x; Cd x; Ni x; Zn x; Pb x; Chromium x; P x
Rouge River							
1-Ford Motor-Rouge	Dearborn	Rouge R.	Automobiles and auto parts	400.0	62,000S	32,000	BOD 2,930; Oil 6,570; Phenol 750; Fe 19,000' NH_3 5,000; CN 900; Acid 50,000; Cu 1,500; Ni 36; Zn 275; Pb 50; Chromium 260; P x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, D=Total Dissolved
x Sufficient data not available for evaluation.

TABLE 4-7 (continued)

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
Rouge River (cont'd)							
2-Darling & Co.	Melvindale	Rouge R.		1.1	168S	14	BOD 7,100; Oil 158; Phenol 0.24; Fe x; NH_3 135; CN x; Pb 1.0; P 5.5
3-American Agric. Chemicals	Detroit	Rouge R.	Fertilizers and chemicals	1.2	19S		Phenols 0.03; Fe x; NH_3 x; Cu 6.5; Zn 2.0; Pb 0.9; Chromium x; P x
4-Allied Chemical General Chem.Div.	River Rouge	Route R.	Industrial chemicals	9.1	1,135S	456	BOD x; Oil x; Phenol 0.1; Fe x; NH_3 x; CN x; Cu 5; Cd 4.1; Zn 11; Pb 1; P x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x Sufficient data not available for evaluation.

TABLE 4-7 (continued)

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
Rouge River (cont'd)							
5-Solvay Process Div.	Detroit	Rouge R.	Industrial chemicals	15.2	10,000S	2,800,000	Phenol 17.6; Fe x; NH_3 x; Cu 3.6; Zn 2.8; Pb 1.5; Chromium 0.4; P x
6-Plastics Div.	Detroit	Rouge R.	Industrial chemicals	0.5		12	BOD 60; Oil 9.5; Phenol 9; NH_3 140; CN 0.6; P x
7-Semet Solvay Div.	Detroit	Rouge R.	Industrial chemicals	5.9	100S	150	BOD 50; Oil x; Phenol 7.3; NH_3 x; CN 0.35; Cu 2; P x
8-Scott Paper	Detroit	Rouge R.	Paper mill	43.8	31,300S	33,600	BOD 135,000; Oil x; Phenol 26; Fe x; NH_3 x; Cu 114; Zn 230; P x
9-American Cement Peerless Cement Div.	Detroit	Rouge R.	Cement	8.1	3,000S	367	BOD 25; Oil 70.3; Phenol 0.27, Fe 6; P x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.

TABLE 4-7 (continued)

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
Huron River (cont'd)							
9-Ford Motor	Ypsilanti	Huron R.	Motor vehicle parts	0.1			Temp. x
10-General Motors	Willow Run	Willow Run Cr.	Motor vehicle parts	0.7	x		Paint sludge x; BOD x; CrO_4 x
11-Huron Valley Steel	Belleville	Huron R.	Steel products	1.1	x		
12-Belleville Plating	Belleville	Huron R.	Metal plating	0.1			Acids x; alkali x, toxic metals x
13-DT & I RR Yards	Flat Rock	Silver Cr.	Railroad yards	0.01			Oil x
River Raisin							
1-Tecumseh Products	Tecumseh	River Raisin		1.44			Temp. x
2-Gray	Tecumseh	River Raisin		0.01			Toxic Metals x
3-Buckeye Products	Adrian	S.Br. River Raisin		0.20			Acid x; alkali x; toxic metals x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x Sufficient data not available for evaluation.

TABLE 4-7 (continued)

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
River Raisin (cont'd)							
4-Avis Industries	Adrian	S.Br.River Raisin		0.28			Chrome x
5-Simplex Paper	Palmura	River Raisin	Paper products	0.25			Fiber x; BOD X
6-Stauffer Chemical	Weston	Black Creek	Chemicals	0.23			Acid x; alkali x
7-Revco	Deerfield	River Raisin		0.03			Washer water bonderite x
8-Wolverine Co.	Dundee	River Raisin	Paper products	0.03			Paper x; fiber x
9-Dundee Cement	Dundee	Macon Creek	Cement	1.40	x		H_2S x; caustic materials x
10-Hoover Ball & Bearing	Saline	Saline R.	Bearing parts	0.57			Acids x; alkali x; CN x; toxic metals x
11-Hoover Ball & Bearing	Pittsfield Twp.	Wood Outter Drain	Bearing parts	0.03			Temp. x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x Sufficient data not available for evaluation.

TABLE 4-7 (continued)

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
River Raisin (cont'd)							
12-Monroe Paper	Monroe	River Raisin	Liner board	2.21	1,475S	120	BOD 1,900; oil 36.5; phenol 0.6; Fe 15; NH_3 3; Acid x; Cu 3; Zn 93
13-Consolidated Paper North Side Div.	Monroe	River Raisin	Liner board and cardboard	7.50	7,823S		BOD 17,204; Oil 898; phenol 11.0 acid x; P x
14-Consolidated Paper South Side Div.	Monroe	River Raisin	Automotive black-board, boxboard	7.0	10,600S		BOD 7,000; oil 263; phenol 0.5; NH_3 2; acid x; Zn 15; P 9
15-Monroe Steel Casting	Monroe	River Raisin	Steel casting	x			
16-Monroe Auto Equipment	Monroe	River Raisin	Shock absorbers	0.02			

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved
x Sufficient data not available for evaluation.

TABLE 4-7 (concluded)

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
River Raisin (cont'd)							
17-Union Bag-Camp Paper	Monroe	Mason Run	Liner board	4.57	3,587S		BOD 11,770; Oil 672; phenol 5.9; Fe 20; NH_3 12; acid x
18-Ford Motor Co.	Monroe	River Raisin	Automotive accessories	130	8S	16,000	BOD 48; oil 6,351; phenol 3.8; NH_3 160; CN 1,075; acid x; Cu 700; Ni 120; Zn 125; Chromium 136; P 1,046

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x Sufficient data not available for evaluation.

the cost of dredging in the Raisin River, the Consolidated Paper Co. is charged a fixed annual fee of $5,000.

TABLE 4-8

PARTICIPATING COSTS
ROUGE RIVER MAINTENANCE DREDGING

Industry	Year	Amount
Ford Motor Company	1962	17,051.11
	1963	35,671,83
Scott Paper Company	1962	1,836.54
	1963	8,701.66
Allied Chemical Corporation- Solvay Process Division	1962	4,469.49
	1963	5,379.53
American Cement Corporation- Peerless Cement Division	Fixed Annual Charge	3,500.00

Population and Waste Load Projections

Demographic studies conducted by the Great Lakes-Illinois River Basins Project, Chicago, for the Southeastern Michigan portion of the Lake Erie Basin have developed population trends on a national, regional, and county basis. These studies, plus the projected populations in the National Sanitation Report, Sewerage and Drainage Problems, Six-county Metropolitan Area, Southeastern Michigan, were used to project populations for the year 1990 and 2020.

The population centers of the area are Detroit and the surrounding communities of Pontiac, Ann Arbor, Port Huron, Monroe, and Adrian. Each area (including several not mentioned above) was analyzed, assuming that by 2020 the areas will be urbanized and served by water and sewer systems. The results from each individual area were added to yield the total population served.

The waste loading of communities in the Clinton River Basin served by the City of Detroit have been included in the Detroit area. In projecting the populations, the possibility that some of the communities may in the future transport their wastes out of their individual basins was not taken into account.

Since the principal degradant from municipal waste sources is oxygen demanding material (BOD), the 5-day biochemical oxygen demand test (BOD_5) is used as an indicator. Results are based upon populations and upon present-day inventory information obtained from the Michigan Water Resources Commission, the Michigan Department of Public Health, and the Federal Water Pollution Control Administration. The resulting untreated and treated BOD loading projections are shown in Table 4-9. They are summarized in Table 4-10. Table 4-8 also shows the present and projected BOD load from storm and sanitary sewers.

TABLE 4-9

BOD_5 PROJECTIONS BY RIVER BASINS
SOUTHEASTERN MICHIGAN AREA

St. Clair River-Lake St. Clair	1965	1990	2020
Untreated BOD_5			
Municipal			
Residential	12,000	27,000	50,000
Industrial	2,400	4,300	5,800
Subtotal	14,400	31,300	55,800
Industrial			
(Direct to river)	32,000	57,500	77,000
Total Untreated BOD_5	46,400	88,800	132,800
Treated BOD_5			
Municipal			
With present 57% removal	6,200	13,500	24,000
With 90% removal	1,440	3,130	5,580
With 95% removal	720	1,570	2,790
With 99% removal	144	313	558
Industrial (direct to river)			
With present 77% removal	7,300	13,200	17,700
With 90% removal	3,200	5,750	7,700
With 95% removal	1,600	2,880	3,850
With 99% removal	320	575	770
Total BOD			
With present removal	13,500	26,700	41,700
With 90% removal	4,640	8,880	13,280
With 95% removal	2,320	4,440	6,640
With 99% removal	464	888	1,328

TABLE 4-9 (continued)

BOD$_5$ PROJECTIONS BY RIVER BASINS
SOUTHEASTERN MICHIGAN AREA

Clinton River	1965	1990	2020
Untreated BOD$_5$			
Municipal			
Residential	53,975	198,000	325,400
Industrial	12,350	20,375	29,644
Subtotal	66,325	218,375	355,044
Industrial (direct to river)	143	235	341
Total Untreated BOD$_5$	66,468	218,610	355,385
Treated BOD$_5$			
Total BOD			
With present 84% removal	11,179	35,447	57,234
With 90% removal	6,648	21,861	35,518
With 95% removal	3,324	10,930	17,759
With 99% removal	665	2,186	3,552

TABLE 4-9 (continued)

DETROIT METROPOLITAN AREA

BOD_5 PROJECTIONS (#/day)

DETROIT METRO	1962	1990	2020
Untreated BOD_5			
Municipal			
Residential	533,000	910,000	1,100,000
Industrial	134,000	240,000	320,000
Subtotal	667,000	1,150,000	1,420,000
Industrial* (direct to river)	226,000	405,000	538,000
Total Untreated BOD_5	893,000	1,555,000	1,958,000
Treated BOD_5			
Municipal			
With present 20% removal	533,000	920,000	1,140,000
With 90% removal	66,700	115,000	142,000
With 95% removal	33,000	57,500	71,000
With 99% removal	6,670	11,500	14,200
Industrial (direct to river)			
With present 25% removal*	170,000	304,000	404,000
With 90% removal	22,600	40,500	53,800
With 95% removal	11,300	20,250	26,900
With 99% removal	2,260	4,050	5,380
Total BOD_5 to Detroit River			
With present removal	703,000	1,224,000	1,544,000
With 90% removal	89,300	155,500	195,800
With 95% removal	44,650	77,750	97,900
With 99% removal	8,930	15,550	19,580

*Estimated

TABLE 4-9 (continued)

HURON RIVER

Untreated BOD	1965	1990	2020
Municipal			
Residential	25,000	65,000	102,000
Industrial	10,000	17,000	24,000
Subtotal	35,000	82,000	126,000
Industrial (direct to river)	4,000	6,800	9,600
Total Untreated BOD	39,000	88,800	135,600

Treated BOD to Huron River	1965	1990	2020
Municipal			
With present 90% removal	3,500	8,200	12,600
With 95% removal	1,750	4,100	6,300
With 99% removal	350	820	1,260
Industrial (direct to river)			
With present 50% removal	2,000	3,400	4,800
With 90% removal	400	680	960
With 95% removal	200	340	480
With 99% removal	40	68	96
Total BOD to Huron River			
With present removal	5,500	11,600	17,400
With 90% removal	3,900	8,880	13,560
With 95% removal	1,950	4,440	6,780
With 99% removal	390	888	1,356

TABLE 4-9 (continued)

RIVER RAISIN	1965	1990	2020
Untreated BOD_5			
Municipal			
Residential	11,500	37,800	118,000
Industrial	2,060	4,500	10,800
Subtotal	13,560	42,300	128,800
Industrial (direct to river)	86,200	190,000	450,000
Total Untreated BOD_5	99,760	232,300	578,800
Treated BOD_5 to Raisin River			
Municipal			
With present 68% removal	4,290	13,500	41,200
With 90% removal	1,356	4,230	1,290
With 95% removal	678	2,100	640
With 99% removal	136	420	130
Industrial (direct to river)			
With present 43% removal	48,900	108,000	256,000
With 90% removal	8,620	19,000	45,000
With 95% removal	4,300	9,500	22,500
With 99% removal	860	1,900	4,500
Total BOD_5 to River Raisin			
With present removal	53,190	121,500	297,000
With 90% removal	9,980	23,230	57,900
With 95% removal	4,990	11,600	29,000
With 99% removal	970	2,320	5,800

TABLE 4-7 (continued)

MAJOR INDUSTRIAL WASTES
SOUTHEASTERN MICHIGAN AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day*		
					Solids**	Chlorides	Other
Huron River							
1-Ford Motor	Wixom	Norton Cr.	Motor vehicle parts	1.2	x		Paint sludge x; chromate x
2-Michigan Seamless Tube	So. Lyon	Novi-Lyon Dr.		0.9			Pickle liquor x; Temp. x
3-Hoover Ball and Bearing	Whitmore Lake	O'Conner Dr.	Bearing parts	0.1			Temp. x
4-Longworth Plating	Chelsea	Letts Cr.	Metal plating	0.1			Acids x; alkali x; toxic metals x; oil x
5-Federal Screw Products	Chelsea	Letts Cr.	Screws, bolts, etc.	0.1			Temp. x
6-Rockwell-Standard	Chelsea	Letts Cr.		0.1			Temp. x
7-King-Seely Thermos	Scio	Huron R.		0.3			Acids x; alkalis x; toxic metals x
8-Peninsular Paper	Ypsilanti	Huron R.	Paper mill	1.6			Fiber x; dye x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x Sufficient data not available for evaluation.

TABLE 4-10

SOUTHEASTERN MICHIGAN AREA

SUMMARY OF BOD_5 PROJECTIONS (lbs//day)

	1962-1965	1990	2020
Untreated BOD_5			
Municipal			
Residential	635,475	1,237,800	1,695,400
Industrial	160,810	286,175	390,244
Subtotal	796,285	1,523,975	2,085,644
Industrial			
(Direct to river)	348,343	659,535	1,074,941
Total Untreated BOD_5	1,144,628	2,183,510	3,160,585
Treated BOD_5			
Total BOD_5			
With present 36% removal	786,368	1,419,247	1,957,334
With 90% removal	114,463	218,351	316,059
With 95% removal	57,230	109,175	158,030
With 99% removal	11,446	21,835	31,606

BOD load from Storm Water Overflow

Estimated present load = 43,000 lbs/day from combined sewers
4,000 lbs/day from separate sewers.

Assuming straight line projection with population growth
1990 combined sewer load without treatment = 70,000 lbs/day
2020 combined sewer load without treatment = 90,000 lbs/day
of all combined sewers are replaced by separate sewers and no new combined sewers are built, the projected BOD load from storm water overflow would be:

1990 - 29,000 lbs/day
2020 - 38,000 lbs/day

The total untreated BOD for the Southeastern Michigan area of the Lake Erie Basin is expected to nearly double by 1990 and almost triple by 2020. Removal of the projected BOD loadings at present efficiencies would allow over 60% of total untreated BOD to reach the rivers and lakes of the area.

Projections have been made for phosphorus and chlorides from waste sources in Southeastern Michigan. These projections are shown in Table 4-11 and 4-12.

TABLE 4-11

PROJECTIONS OF PHOSPHORUS INPUTS
SOUTHEASTERN MICHIGAN

Phosphorus

Present discharge (Raw)	1960 lbs/day	1990 lbs/day	2020 lbs/day
Rural runoff[1]	3,000	3,000	3,000
Urban runoff[2]	3,000	4,500	6,000
Ind. waste[3]	3,000	4,500	6,000
Mun. waste[4]	46,000	85,000	111,000

[1]Based on 4,300 mi.^{2} of rural area and constant of 250 lbs/yr/mi^2 phosphorus for rural runoff.

[2]Using 2.5 lbs/acre/yr phosphorus contribution for urban areas.

[3]Direct discharge industries.

[4]Includes industries connected to city sewers.

Projected discharges

Year	Treatment[1]	Phosphorus lbs/day
1990	0	97,000
1990	90%	9,750
1990	95%	4,880
2020	0	126,000
2020	95%	6,300
2020	98%	2,500

[1]All sources

TABLE 4-12

CHLORIDE PROJECTIONS
SOUTHEASTERN MICHIGAN

Chlorides	1964 lbs/day	1990 lbs/day	2020 lbs/day
Municipal wastes	800,000	1,500,000[1]	1,950,000
Industrial wastes	6,000,000	9,000,000	12,000,000
Streets	1,300,000	1,950,000	2,600,000
TOTAL	8,100,000	12,450,000	16,550,000

[1]Using 0.23 lbs/cap/day

To maintain discharge at 8.1×10^6 lbs/day (present load) will require the following treatment:

	Municipal%	Industrial%	Streets%
1990	46.5	33	33
2020	60	50	50

Maumee River Basin

The principal waste sources in the Maumee River Basin are municipal, industrial, and agricultural. Presently, strong headway is being made in the control of the municipal and particularly the industrial wastes, but agricultural wastes appear to remain as the major long-term pollution problem yet to be controlled. Due to the low flow in the basin's waterways, some form of tertiary or advanced waste treatment of all wastes is presently, or will be, required. All wastes should be treated to the point that no effluent BOD_5 concentrations exceed 6-10 mg/l, depending on stream slope.

Municipal Wastes

Approximately 705,000 people are served by sewage plants in the Maumee Basin. The location of these plants is given in Figure 4-16. Over 400,000 people are served by individual septic tank systems. These people have a raw BOD_5 of approximately 183,000 lbs. per day. If these wastes received either secondary or tertiary treatment, the discharges would total 18,000 and 5,500 lbs. per day respectively, as compared to present estimated discharge of 27,000 lbs. per day. This is a net removal of 85 percent, neglecting bypassing of untreated sewage. Of the total 45 municipal treatment plants 36 provide secondary treatment, 5 provide oxidation lagoons, 2 provide intermediate treatment, 2 provide primary treatment, and 11 provide minor treatment. Table 4-13 lists the major Maumee River Basin municipal wastes for the present, and the years 1990 and 2020 with complete secondary or tertiary treatment provided. The individual subbasins are summarized in Figure 4-17.

The present total phosphorus discharged by municipalities is estimated to be 9,000 lbs. per day. This is expected to rise to 12,000 and 19,000 lbs. per day by 1990 and 2020 respectively.

Industrial Wastes

Industrial wastes have a great effect on receiving waters in the basin. Table 4-14, listing the major industrial waste producers of the Maumee Basin, is based mainly on information obtained from State water pollution control agencies. The location of these industries is shown in Figure 4-16.

The major materials in industrial wastes which have caused the most persistent water quality problems in the area's waters are: BOD, phenol, oil, nitrogen compounds, and toxic materials. Some industries, such as Excello in Lima, have relatively small waste discharges, but at the place their outfall reaches the stream, the stream flow is quite small or nonexistent for most of the year. Other industries, such as Standard Oil of Ohio in Lima, have in the past affected the quality of not only the immediate receiving stream, but also at the Maumee River from its point of junction down to its mouth.

Figure 4-16 - Municipal and Industrial Waste Discharges in the Maumee River Basin.

TABLE 4 -13

MAUMEE RIVER BASIN - MAJOR MUNICIPAL WASTES
(BOD_5 in pounds per day)

City	1960 Population	1960 Raw	1960 Sec. Eff.[2]	1960 Tert. Eff.[3]	1980 Sec. Eff.[2]	1980 Tert. Eff.[3]	2020 Sec. Eff.[2]	2020 Tert. Eff.[3]
St. Joseph River								
Montpelier, O.	4,131	1,050	105	31	160	48	300	90
Butler, Ind.	2,176	370	37	11	50	15	80	24
Auburn, Ind.	6,350	1,080	108	32	140	42	230	69
Garrett, Ind.	4,364	740	74	22	100	30	160	48
St. Marys River								
St. Marys, O.	7,737	1,330	133	40	230	70	533	160
Berne, Ind.	2,644	450	45	13	70	21	150	45
Decatur, Ind.	8,327	1,420	142	43	210	63	460	138
Upper Maumee River								
Fort Wayne, Ind.	168,376[4]	46,100	4,610	1,380	8,200	2,460	21,890	6,570
New Haven, Ind.	3,396	580	58	17	100	30	220	66
Hicksville, O.	3,116	530	53	16	80	24	200	60
Defiance, O.	14,553	2,470	247	74	390	118	920	276
Tiffin River								
Hudson, Mich.	2,550	430	43	13	80	24	240	72
Morenci, Mich.	2,055	350	35	10	60	18	200	60
Archbold, O.	2,348	5,090	509	150	810	243	1,900	570
Bryan, O.	7,361	1,930	193	58	290	78	560	168

[2]Secondary treatment (90% removal)

[3]Tertiary treatment (97% removal)

[4]Includes population of Waynedale

TABLE 4-13 (continued)

City	1960 Population	1960 Raw	1960 Sec. Eff.[2]	1960 Tert. Eff.[3]	1980 Sec. Eff.[2]	1980 Tert. Eff.[3]	2020 Sec. Eff.[2]	2020 Tert.Eff.
Auglaize River								
Wapakoneta, O.	6,756	2,580	258	77	407	122	970	290
Spencerville, O.	2,061	280	28	8	50	15	130	39
Delphos, O.	6,961	1,320	132	40	230	69	630	189
Ada, O.	3,918	670	67	20	90	27	90	27
Lima, O.	53,537[5]	11,200	1,120	340	2,000	600	5,200	1,560
Columbus Grove, O.	2,104	1,470	147	44	220	66	420	126
Findlay, O.	30,344	7,700	770	230	1,270	380	3,000	900
Bluffton, O.	2,591	340	34	10	60	18	160	48
Ottawa, O.	3,245	550	55	16	79	24	155	46
Van Wert, O.	11,323	3,400	340	100	490	147	830	249
Paulding, O.	2,936	500	50	15	70	21	120	36
Lower Maumee River								
Napoleon, O.	6,739	1,150	115	34	170	51	330	99
Wauseon, O.	4,311	730	73	22	110	33	270	81
Delta, O.	2,376	560	56	17	90	27	210	63
Perrysburg, O.	5,519	790	79	24	140	42	380	114
Swanton, O.	2,306	440	44	13	70	21	160	48
Toledo, O.	318,003	85,060	8,510	2,550	14,600	4,380	30,300	9,090

[5] Includes population of Westwood

Figure 4-17. Future Municipal Waste Loadings in the Maumee River Basin.

TABLE 4-14

MAJOR INDUSTRIAL WASTES
MAUMEE RIVER BASIN

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Other
Tenmile Creek						
1-Dana Corporation	Toledo	Tenmile Cr.	Motor vehicle parts	x		Oil x
Driftmeyer Ditch						
1-E. I. DuPont	Toledo	Driftmeyer Ditch	Paints, varnishes, lacquers	x	x	BOD x, COD x, Oil x
Otter Creek						
1-Standard Oil Co.***	Toledo	Otter Cr.	Petroleum refining	39.8	184,000T 151,000D	pH 6.9-9.1, BOD 8,810, COD x, Phenol 670, Oil 11,800, Temp. 78°F
2-Gulf Oil Co.	Toledo	Otter Cr.	Petroleum refining	68.4		BOD 4,600, COD 8,200, Phenol 110, Oil 1,260, Temp. x
3-Sun Oil Co.	Toledo	Otter Cr.	Petroleum refining	1.81	1,620S	pH 6.6-9.1, BOD 1,060, COD 4,400, Phenol 3, Oil 440, Temp. x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S-Total Suspended, and D=Total Dissolved.
*** Contains Pure Oil Company's effluent.
x Sufficient data not available for evaluation.

TABLE 4-14 (continued)

MAJOR INDUSTRIAL WASTES
MAUMEE RIVER BASIN

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Other
<u>Lower Maumee River</u>						
1-Interlake Steel Corp.	Toledo	Lower Maumee River	Blast furnaces	44.0	x	pH x, BOD x, COD x, phenol x; oil x, temp.x
2-Toledo Edison	Toledo	Lower Maumee River	Power Plant	x	x	Temp. x
3-Libby-Owens-Ford (East Toledo)	Defiance	Lower Maumee River	Flat, glass products	0.25	x	Oil 76; Color x
4-Allied Chemical	Toledo	Lower Maumee River				COD 60
5-Johns-Manville	Defiance	Lower Maumee River	Fiberglas products	0.3	6,900S	BOD 380, Oil x
6-Campbell Soups***	Napoleon	Lower Maumee River	Canned soups	3.2		BOD 5,900, Oil x, Temp. x
7-Central Foundry GMC	Defiance	Lower Maumee River	Gray iron foundry	4.0		BOD 960, COD 8,700, Phenol 4, Oil x, Temp. x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved
*** Discharged in winter months only
x Sufficient data not available for evaluation.

TABLE 414 (continued)

MAJOR INDUSTRIAL WASTES
MAUMEE RIVER BASIN

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Other
<u>Lower Maumee River</u> (cont'd)						
8-Johns-Manville***	Defiance	Lower Maumee River	Fiberglas products			
9-S. K. Wayne Tools	Maria Stein	Lower Maumee River	Tools			Oil x
10-Weatherhead Corp.	Antwerp	Upper Maumee River	Screw machine products	0.28		BOD 33, COD 31, Phenol x CN 2.6
11-B. F. Goodrich	Ft. Wayne	Maumee R.	Rubber products	0.25		BOD 27, COD x, Oil 1, Temp. x
12-Parrot Packing	Ft. Wayne	Maumee R.		0.09		BOD 884, COD 730, Oil 136, Temp. x
13-International Harvestor	Ft. Wayne	Maumee R.	Motor vehicles	x		Oil x, CN x
14-Magnavox Co.	Ft. Wayne	Maumee R.				Phenol x
15-Phelps Dodge	Ft. Wayne	Maumee R.		0.16		BOD 17.3, Phenol x, COD x

*Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
*** Unknown amount discharged to Defiance sewage treatment plant.
x Sufficient data not available for evaluation.

TABLE 4-4 (continued)

MAJOR INDUSTRIAL WASTES
MAUMEE RIVER BASIN

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Other
Lower Maumee River (cont'd)						
16-Franke Plating	Ft. Wayne	Maumee R.	Metal plating	0.12		BOD 7.1; phenol x, Oil x; CN 38.0; COD 117; Zn 0.7; Cu 1.7; Ni 2.0; Cd 4.6
17-General Elec.***	Ft. Wayne	Maumee R.				
Auglaize River						
1-Ohio Decorative Products	Spencerville	Auglaize R.	Metal finishing	0.04		BOD 8.9, Oil x, COD 28.2
2-Hayes Industries Decorative Div.	Spencerville	Auglaize R.	Hardware	.11		BOD 6.4, Oil x, COD 35.9
Blanchard River						
1-Buckeye Sugars Inc.	Ottawa	Blanchard R.	Beet sugar	2.59		BOD 2,160, Oil x, COD x
2-Rusco, Inc.	Pandora	Blanchard R.	Metal doors and trim	.06		BOD 92, Phenol x, Oil 16.8, CN x COD 30.9; Mg 13.5, Si 36.8
3-Contris Packing	Findlay	Blanchard R.	Meat packing	0.01		Phenol x, BOD 9, COD 5.8, CN x
4-Ashland Oil	Canton	Blanchard R.	Petroleum refining	0.64		BOD 35, Phenol 1.1, Oil 480, CN x, COD 1,780

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
*** Unknown amount discharged to Fort Wayne sewage treatment plant.
x Sufficient data not available for evaluation.

TABLE 4-14 (continued)

MAJOR INDUSTRIAL WASTES
MAUMEE RIVER BASIN

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	WASTE CONSTITUENTS-lbs/day* Other
Ottawa River						
1-Ford Motor Co.	Lima	Ottawa R.	Motor vehicle engines	0.45		BOD 51, Oil 67, COD 259
2-Sohio Nitrogen	Lima	Ottawa R.	Chemicals	1.93	33,600T	BOD 140, NH_3 5,640, COD 2,960, Cu 21
3-Sohio Acrylonitrile	Lima	Ottawa R.	Chemicals	0.85	13,400T	BOD x, NH_3 500, COD 1,970, CN 75
4-Standard Oil Co.	Lima	Ottawa R.	Petroleum refining	3.15	1.0T	BOD 1,900, NH_3 x, Phenol 80, Oil 881, COD x
5-Ex-Cell-O-Corp.	Lima	Ottawa R.	Aircraft engines	0.12		BOD 16, CN x, COD 34.2
6-Republic Creosote	Lima	Ottawa R.	Wood preserving	0.01		BOD 26, Phenol 7.7, Oil 19, CN x, COD 12.7
Tiffin River						
1-Defiance Fertilizer Co.	Defiance	Tiffin R.	Fertilizer			NH_3 x, COD 0.2, PO_4 x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved
x Sufficient data not available for evaluation.

TABLE 4-14 (continued)

MAJOR INDUSTRIAL WASTES
MAUMEE RIVER BASIN

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Other
St. Marys River						
1-Dana Corp. Sal Axle Works	Ft. Wayne	St. Marys R.	Motor vehicle parts	1.05		BOD 42, Oil 3.5, CN x, COD x
2-Essex Wire	Ft. Wayne	St. Marys R.	Wire	.09		BOD 2.1, Phenol x
3-Central Soya	Decatur	St. Marys R.	Soybean products	.05		BOD 4.3, Phenol x, CN x, COD x
4-Weston Paper	St. Marys	St. Marys R.	Paperboard	x		Oil x, COD x, BOD x
5-Goodyear Tire & Rubber	St. Marys	St. Marys R.	Rubber products	1.10		BOD 344, CN x, COD 448
6-Beatrice Foods	New Breman	St. Marys R.	Fluid milk	0.08		BOD 15, Oil x, COD 59
St. Joseph River						
1-Warner Automotive	Auburn	St. Joseph R.		0.39		BOD 4.7, Phenol x, Oil x, CN x, COD x
2-Kitchen Quip	Waterloo	St. Joseph R.		0.14		BOD 12.1, Phenol x, Oil x, CN 0.01, Zn 1.5, Cu 0.9 Ni 7.2

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x Sufficient data not available for evaluation.

TABLE 4-14 (concluded)

MAJOR INDUSTRIAL WASTES
MAUMEE RIVER BASIN

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day*	
					Solids**	Other
St. Joseph River (cont'd)						
3-Crane-Edmund	Butler	St. Joseph R.		0.06		BOD 3.9, Phenol x, Oil 17.1, CN 1.30, COD 49.5, Zn 3.9
4-Universal Tool***	Butler	St. Joseph R.		0.03		BOD 4.4, Phenol x, Oil 19.2, CN 3.3, COD 7.9, Zn 4.0
5-Edgerton Metal Products	Edgerton	St. Joseph R.	Metal finishing	0.14		BOD 14.5, CN 2.0, COD 42.2, Cr 0.1
6-Bundy Foods	Blakeslee	St. Joseph R.	Canned Foods	0.11		BOD 5.5, Oil x, COD 15.8

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
*** Unknown amount discharged to Butler sewage treatment plant.

It is estimated that industries in this area presently provide an average removal of BOD_5 of 86 percent, neglecting bypassing. As with domestic wastes, a much higher degree of industrial waste treatment is required in the future to produce acceptable conditions. Table 4-15 gives the industrial BOD_5 for 3 degrees of removal and 1990 and 2020 projections.

Combined Sewers and Storm Water Overflow

Most of the sewer systems within the Maumee Basin are either partially or totally of the combined type. These systems contribute appreciable quantities of oxygen demanding wastes and bacterial pollution to the waterways. Storm water overflow from separate systems which have become overloaded from infiltration or illegal drain connections, also contribute measurable quantities of pollutants to the waters. The extimated oxygen demand exerted by these wastes was 11,000 lbs. per day in 1960. If all combined sewers are separated by 1990, the discharge from storm water overflows alone will be 6,000 lbs. per day. This will increase to 9,000 lbs. per day by 2020.

Agriculture and Land Runoff

Probably the major long-term pollutional problem in the Maumee Basin is from agricultural sources. Even if all domestic and industrial wastes were given 100 percent treatment, there would still be significant water pollution problems from agricultural sources. The primary pollutants are nutrients, sediment and dissolved solids, with secondary materials of herbicides, fungicides, pesticides, and algicides.

An example of nutrient pollution from agriculture is Burr Lake on the Little Auglaize River where secci disc (transparency) readings of 3 inches were commonly obtained. Another example is Van Buren Lake in which, when the temperature is above 55 percent, the secci disc readings average around 6 inches due to the colloidal material present.

Trautman has described how particular agricultural practices have

TABLE 4-15

FUTURE INDUSTRIAL BOD_5 DISCHARGES
pounds per day

Year	Raw	86%	90%	97%
1960	220,000	31,000	22,000	6,600
1990	300,000	42,000	30,000	9,000
2020	380,000	53,000	38,000	11,400

degraded the water quality in the Maumee Basin. The only soil conservation practices instituted in the basin seem to be drainage works - water is moved off the land as quickly as possible, regardless of other considerations.

The Maumee River has the highest sediment concentration of any river in the Lake Erie Basin even with its extremely flat stream and ground slopes. It discharges an average suspended sediment load of two million tons per year to Lake Erie. Biologists believe that these heavy silt loads from the Maumee River have smothered the spawning beds of the white fish in Western Lake Erie and hastened the decline of the Lake Erie fishery.

The difficulty with much of the sediment from this area is its extremely small particle size, in many cases approaching a colloidal diameter. During low flows, over 80 percent of the sediment has a particle diameter less than 2 microns and over 90 percent has a diameter less than 4 microns. (A micron is about 1/25,000th of an inch.) Thus, besides having the greatest total amount of sediment load, the Maumee River also contains the finest grained sediment.

To make a preliminary estimate of the chemical constituents in the rural runoff in the Maumee River watershed, results of data obtained in the Lake Michigan small rural watershed sampling program were used. This information with knowledge obtained from field observations in the Maumee Basin was utilized to make the final determination. Table 4-16 is a listing of the preliminary estimates of the chemical constituents for the runoff expressed in 100 tons per year for the various subbasins of the Maumee Basin.

To solve the problem of rural runoff, land should be drained through subsurface tile drains in combination with contour farming. The crops of some parts of the basin should be changed since beans and corn leave the land denuded in the wintertime. Strips of hay and grasses are needed to help prevent erosion. Strip or contour farming is needed in some almost flat areas to help prevent sheet erosion.

After oxygen deficits and sediment, algae are probably the next major problem in the basin's waterways. In many areas of the basin, the expression "too thick to drink, too thin to plow" is quite applicable in relation to algae. Algae of the green or blue-green types are present the year around throughout almost all of the basin. Besides the taste and odor problems they cause in domestic drinking waters and commercial canning, they interfere with the recreation and esthetic uses of the waters.

<u>Solid Wastes</u>

In several areas, the basin's waterways are used for the disposal of solid wastes. An example is Willshire, Ohio which has a large dump

TABLE 4-16

ESTIMATED CHEMICAL CONSTITUENTS OF RURAL RUNOFF*
(in 100 tons per year)

	Auglaize	Upper Maumee	Lower Maumee	St. Joseph	St. Marys	Tiffin
Ammonia	.9	.1	.4	1.2	.3	.5
Organic Nitrogen	1.6	.4	.6	1.2	.3	.9
Nitrate	1.5	.3	.7	1.7	.5	1.0
Total Nitrogen	3.6	.6	1.5	5	1.1	2.1
Sodium	18	3.8	6	41	3.9	15
Silicate	34	9	10	37	4.9	20
Potassium	7	.8	3.4	8	2.8	29
Sulfate	65	4.4	37	200	32	55
Chloride	20	2.1	11	65	9	18
Magnesium	70	9	35	90	29	34
Calcium	145	27	55	300	39	105

* Runoff Quality by Soil Groups and General Land Use--A preliminary estimate--made by extrapolation of data from the Lake Michigan Watershed (GLIRBP Rural Runoff Studies) and field observations made of the Maumee River Basin. Values for solids are omitted since no correlation has been established.

along the St. Marys River just above the Indiana line. Disposal of garbage, trash, and other deleterious refuse in the Maumee River and its tributaries should be prohibited and existing dumps along the river banks should be removed.

Federal Installations

There are 43 Federal installations in the basin. Of these 37 discharge their wastes to municipalities providing secondary treatment and 4 discharge to municipalities providing primary treatment. The other two Federally-owned or Federally-leased installations listed below discharge waterborne wastes in the Maumee River Basin area. Installations that discharge to municipally-operated sewerage systems have not been listed since the Federal Government does not control the treatment provided.

1. The New Haven Defense Materials Supply Depot discharg 2,000 gpd to the ground. The waste treatment facilities operate satisfactorily and appear adequate at this installation.

2. The U. S. Coast Guard's Toledo Harbor Light Station presently discharge some 350 gpd of sewage to the harbor. The station will be completely automated, thus ending the discharge of raw sewage.

Dredging

Legislation passed in 1962 provided for the present maintained depth of 25 feet in Toledo Harbor to accommodate deep draft vessels using the St. Lawrence Seaway.

All maintenance dredging of the harbor is done b y the Corps of Engineers with th eir own boats. In 1965 they dredged almost one million cubic yards of materials from the Maumee River channel. This material, as a whole, was composed of about 80 percent silt and 20 percent sand, with a higher content of silt in the river and sand off-shore. Only a small percentage of the materials appears to be from industrial sources. The majority of the sediment is from river bank and land sheet erosion and off-shore transport.

All materials dredged in the river and out to channel buoy 30 (about four miles into the bay from the mouth) are discharged either to a large diked area just north of the mouth, or to two temporary private areas at Riverside Park. The materials dredged from buoy 30 out are discharged to an area off the Erie Ordnance Depot and Proving Grounds.

North Central Ohio Area

The major water pollution problems in the North Central Ohio Area are caused by municipal, agricultural, and industrial pollutants. As in the Maumee River Basin, the major long-term problem, particularly in the western part of this basin, is from agricultural sources.

Municipal

Approximately 75 percent of the North Central Ohio population of 600,000 live in organized communities. This population of 442,000 is served by 43 municipalities that discharge treated waste to the waters of the basin. Approximately 85 percent of the population of the organized communities (368,000) people) have central sewage treatment facilities. Fifty-five percent of the total sewered population is served by secondary treatment.

Most of the primary treatment plants are located on Lake Erie; or, as at Lorain, at the mouth of the Black River. Inland from Lake Erie, 185,000 are served by secondary sewage treatment. The population and type of municipal waste treatment in each of the subbasins of the North Central Ohio area is summarized in Table 4-17. The locations of the major municipal waste sources are shown in Figure 4-18.

These major communities and numerous smaller ones (population under 1,000) discharge a waste load of 29,000 pounds of BOD_5 per day to the basin. The population equivalent (PE) of this waste load, based on 0.167 pounds of BOD_5 per capita per day is 171,000 people. In addition to the wastes from municipal treatment systems, organized communities with a total population of 74,000 discharge domestic sewage from individual home treatment units (septic tanks) with a waste load of 12,000 pounds of BOD_5 per day. Sometimes, however, this waste is discharged directly underground or to a receiving stream without the treatment provided by a leach field. The community of Bellevue, population 8,285, discharges raw untreated sewage from a municipal collection system to an underground limestone cavern, which affects ground water supplies in the area.

Despite the widespread inland use of secondary sewage treatment, the waste load often exceeds the assimilative capacity of the basin's streams. This is especially true in the headwater reaches and below the larger municipalities. The average BOD_5 reduction by secondary treatment is approximately 80 percent, but the remaining load of 7,000 pounds of BOD_5 per day is still equivalent to the raw sewage of 42,000 people. Including primary treatment, the total BOD_5 load to inland waters is 17,000 pounds per day. There is a present need for almost all inland municipalities to provide tertiary treatment to remove this excessive loading. Another 11,600 pounds is discharged directly into the lake (See Table 4-18.)

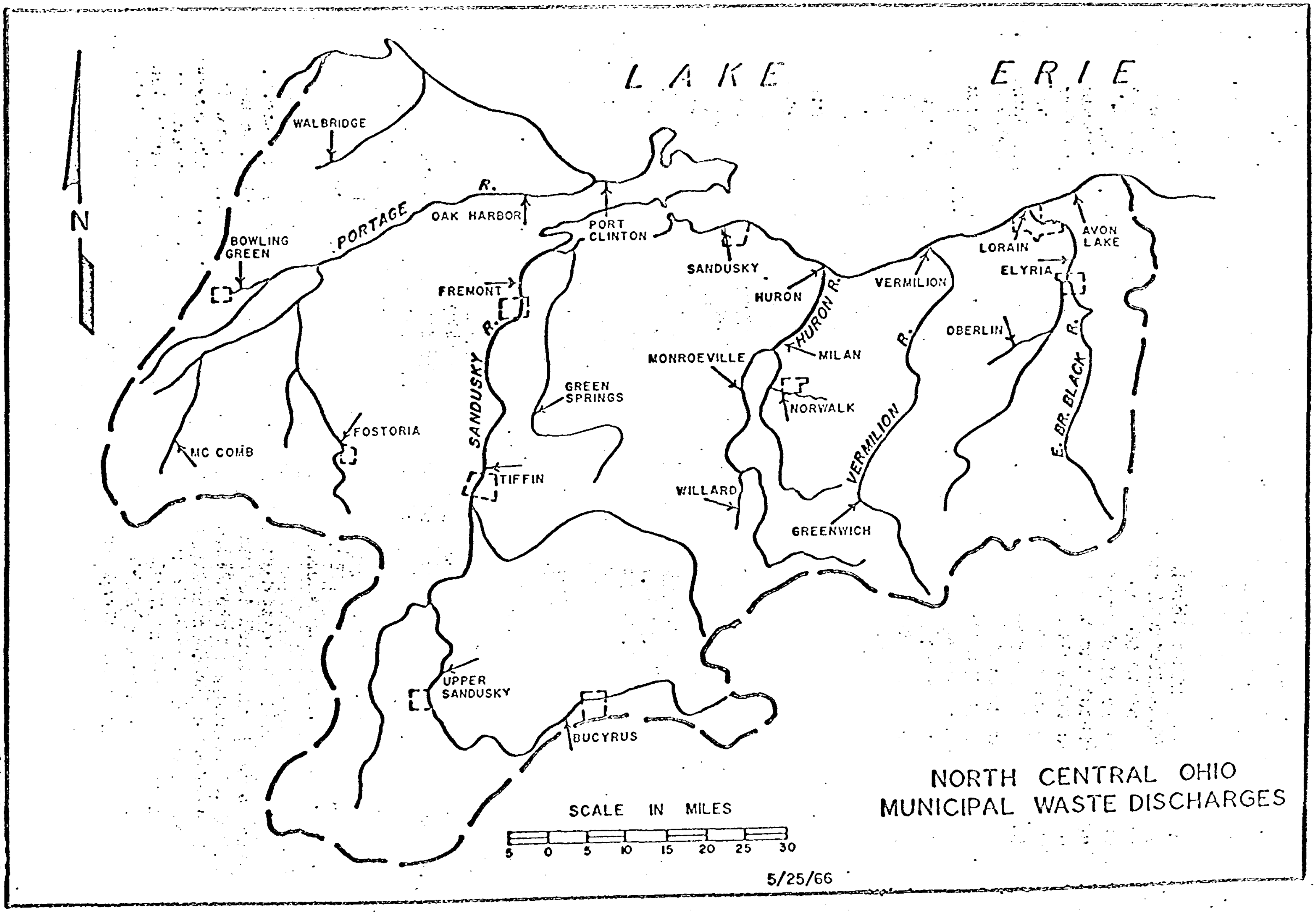
The 11 major municipalities discharging treated wastes to Lake Erie (including Lorain) serve 40 percent of the basin's population and contribute almost two-thirds of the total municipal waste discharge. The reason for this is that the average reduction of BOD_5 from the

TABLE 4-17

Populations and Municipal Sewage Treatment
in the Subbasins of the North Central Ohio Area

River Basin	Secondary		Primary		Septic tanks or
	Plants	Population	Plants	Population	no treatment
Portage	3	32,000	2	4,000	15,000
Sandusky	5	44,000	2	23,000	15,000
Huron	3	23,000	2	3,000	3,000
Vermilion	2	5,000	0	0	3,000
Black	7	64,000	1	76,000	9,000
Minor Tributaries	5	17,000	1	2,000	13,000
Lake Erie	2	16,000	8	59,000	8,000
Totals	27	201,000	16	167,000	74,000

FIGURE 4-18



NORTH CENTRAL OHIO
MUNICIPAL WASTE DISCHARGES

TABLE 4 - 8

MUNICIPAL WASTE LOAD IN TERMS OF
POPULATION EQUIVALENTS AND BOD_5 for NORTH CENTRAL OHIO

River Basin	Population Equivalents* From Sewage Treatment Plants		Pounds per day BOD_5 From Sewage Treatment Plants	
	Raw	Discharged	Raw	Discharged
Portage	60,650	9,205	10,100	1,540
Sandusky	87,690	36,795	14,600	6,140
Huron	32,555	6,500	5,440	1,090
Vermilion	4,710	1,815	787	303
Black	150,125	47,060	25,100	7,860
Minor Tributaries	12,655	2,845	2,110	475
Lake Erie	115,865	66,965	19,300	11,200
Totals	464,250	171,185	77,500	28,600#

* PE = 0.167# BOD_5/day
# Based on 63% reduction

JUL 10 1967

primary treatment plants on Lake Erie is only 55 percent. This efficiency, however, is good for primary treatment and indicates well-operated plants. Basin-wide, the efficiency of primary treatment plants for BOD_5 removal is 43 percent, but includes very poor results from Tiffin (20 percent removal.) These municipalities are presently being required to provide a minimum of secondary treatment.

As the population of this area increased, even higher degrees of treatment will be required. Table 4-19 lists the future loadings of BOD_5 to the area's waters.

Industrial

Industrial wastes from 41 industries are discharged to the waters of the North Central Ohio basin. The greatest waste loads in the basin are discharged to the Black River by an automotive and two steel industries. The largest volumes of waste water are discharged to Lake Erie by two power-generating stations in Lorain County. Aside from the large industries concentrated along the Black River, the remainder of the industrial waste discharges are scattered through the basin.

Food processors and metal finishing operations are the most numerous industries. The food processors are located in the agricultural western subbasins. Many are small seasonal operations which employ spray irrigation or holding lagoons for waste treatment. The metal finishing industries discharge a small volume of waste containing heavy metals and toxic compounds. These industries quite often discharge to small streams.

The other industrial waste sources include another steel industry, paper mills, chemical and rubber plants, railroad yards, and oil producers. The locations of the industrial waste discharges are shown in Figure 4-20 and data on the industrial waste discharges are listed in Table 4-20.

Federal Installations

Of the 49 Federal installations in this area, all but 8 of these discharge to municipal systems which provide the following treatment: Secondary-26, primary-14, and none-1.

The Federally-owned or Federally-leased installations listed below discharge waterborne wastes to the area's waters. Installations that discharge to municipally operated systems are not included in this listing since the Federal Government has no control over the treatment provided.

1. Ottawa Job Corps Center (formerly Erie Army Depot), Port Clinton, has a secondary treatment (activated sludge) and chlorination unit which provides adequate treatment for 100 persons.

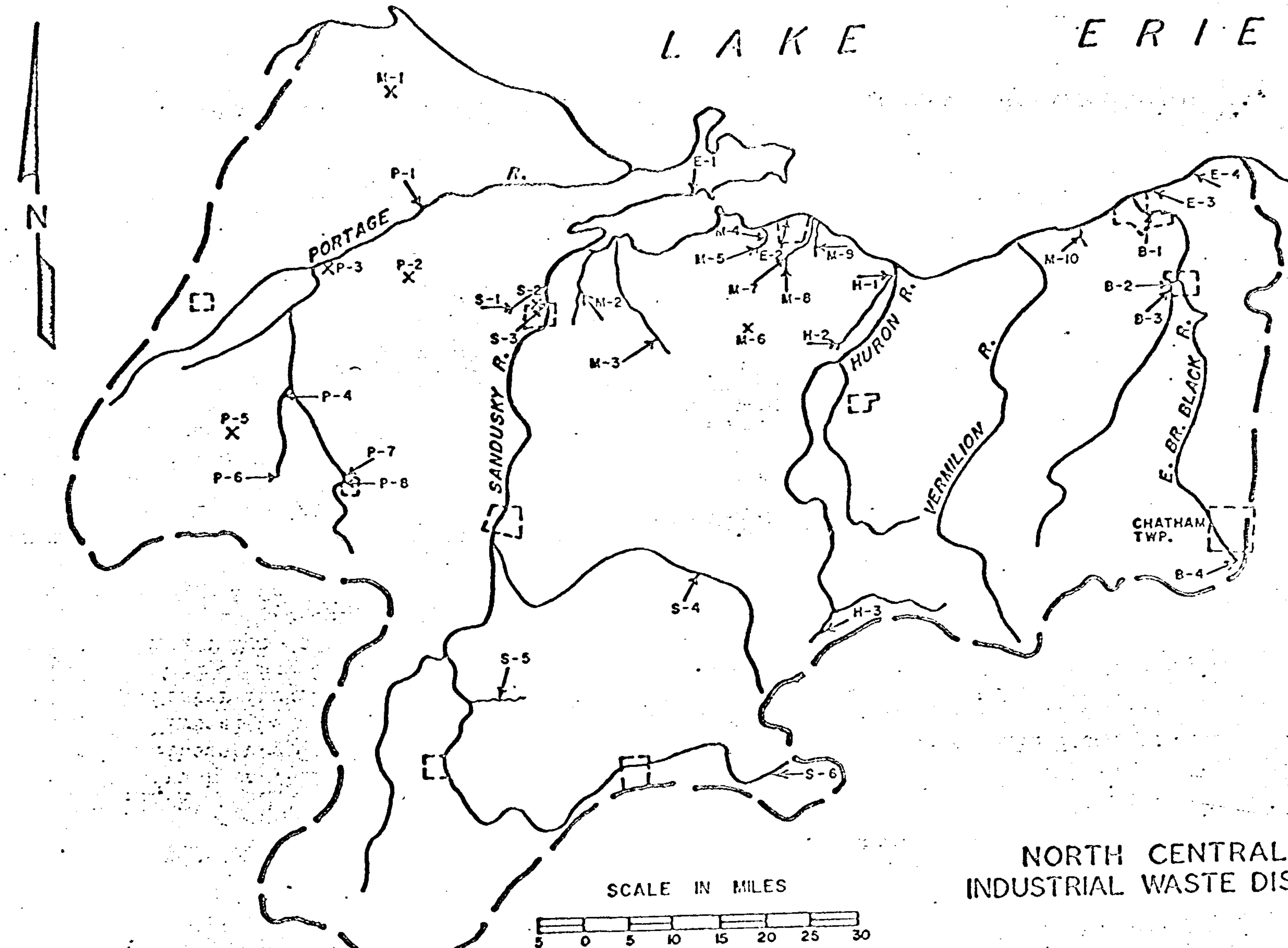
TABLE 4 - 19

PROJECTED FUTURE MUNICIPAL WASTE LOADS for NORTH CENTRAL OHIO

Year	Population	Flow of Sewered Population (mgd)	Pounds per day of BOD_5 Raw	90%	97%
1960	620,000	53	80,000	8,000	2,400
1990	1,000,000	120	170,000	17,000	5,100
2020	1,800,000	260	350,000	35,000	10,500

JUL 10 1967

Figure 4-19. Future Municipal Waste Loadings in the North Central Ohio Area.



NORTH CENTRAL OHIO
INDUSTRIAL WASTE DISCHARGES

5/25/66

FIGURE 4-20

FIGURE 4-20 Continued

LEGEND FOR NORTH CENTRAL OHIO INDUSTRIAL WASTE DISCHARGES

Code	Industry
Portage River	
P-1	Brush Beryllium Co.
P-2	Gibsonburg Canning Co.
P-3	Hirtzel Canning Co., Pemberville
P-4	Foster Duck Farm, Inc.
P-5	Wood County Canning Co.
P-6	A & P Tea Co.
P-7	Seneca Wire Co.
P-8	Swift & Co.
Sandusky River	
S-1	Hewitt Robins, Inc.
S-2	H. J. Heinz Co.
S-3	Northern Ohio Sugar Co.
S-4	Pioneer Rubber Co.
S-5	Corfman Gravel Co.
S-6	Pennsylvania RR
Black River	
B-1	U. S. Steel, Tubular Operation, Lorain
B-2	GMC, Ternstedt Div.
B-3	Republic Steel, Steel & Tubes Div.
B-4	United Dairy
Chatham Twp.	Baldwin Producing Corp.
	Berea Oil Corp.
	Chatham Operating Co.
	Dymo Oil Corp.
	Carter M. Hanna Co.
	The Preston Oil Co.

Code	Industry
Huron River	
H-1	E. I. duPont deNemours & Co.
H-2	Johns-Manville Products Co.
H-3	B & O RR
Minor Tributaries	
M-1	Stokely-Van Camp, Inc.
M-2	Silver Fleece Canning Co.
M-3	Whirlpool Corp.
M-4	GMC, New Departure Div.
M-5	Ford, Sandusky Hardware Plant
M-6	G.E., Bellevue Lamp Plant #242
M-7	Bechtel-McLaughlin Co.
M-8	Lake Erie Canning Co.
M-9	NASA, Plum Brook Facilities
M-10	Ford, Lorain Assembly Plant
Direct to Lake Erie	
E-1	U. S. Gypsum Co.
E-2	Aluminum & Magnesium Co.
E-3	Ohio Edison Co. - Edgewater
E-4	Cleveland Electric Illuminating Co. - Avon Lake

Table 4-20. Major Industrial Wastes, North Central Ohio Area.

2. Perry's Victory and International Peace Memorial National Monument, South Bass Island has the following treatment: Sewage from the public comfort station located below the monument is treated by a septic tank and drain field. The superintendent's home and the National Park Service Office at the Monument are each served by two septic tanks, and the effluent is discharged to the Put-In-Bay sewer system which discharges to Lake Erie without further treatment.

3. The Put-In-Bay Light Station facility consists of a houseboat which is unmanned at this time. The houseboat is served by a retention tank with chlorination.

4. The Marblehead Lifeboat Station facility has a complement of 15 and is served by two septic tanks and a subsurface disposal field. This system is operating satisfactorily. One house trailer at the installation is served by a cesspool consisting of a 50 gallon punched oil drum.

5. The Sandusky Bay Lifeboat Station has a complement of 25 and is served by three septic tanks and a subsurface disposal field. The sewerage system appears to be operating adequately.

6. The Bellevue Post Office has 27 employees. Sewage (250 gpd) and some storm water flow to a concrete-block-lined cesspool on the installation's property. The system appears hydraulically adequate to handle the flow. The City of Bellevue is under orders from the State of Ohio to construct a municipal sewerage system.

7. The Lewis Research Center (NASA) Plum Brook Facility, located near Sandusky has a complement of approximately 700. A primary treatment plant with chlorination treats wastes from 400 employees; two smaller secondary package treatment plants serve the rest. Septic tanks with disposal fields serve isolated buildings on the property. Small amounts of chemical and acid wastes are collected in underground holding tanks for disposal by a contract firm. A contract was let June 30, 1967 for construction by May 1968 of a trickling filter and final coagulation unit which will provide tertiary treatment for all Plum Brook wastes.

8. The Lorain Lifeboat Station has a complement of 12 and is served by a septic rank which discharges directly to the Black River. This facility is located less than 400 yards from the Lorain Sewage Treatment Plant. The outer harbor light station has a complement of two to three persons and discharges raw sewage into Lake Erie. The

The facilities at Camp Perry are presently owned and operated by the Ohio Militia and are no longer considered a Federal installation. Part of the land has been converted into the Erie Industrial Park and is operated by the Ottawa Improvement Corp. (U.S.Rubber Co. is leasee.)

Land Runoff

Rural land runoff is the source of a significant portion of the waste load to North Central Ohio streams. The runoff carries silt, nutrients, organic matter, and microorganisms into the streams. Silt and nutrients are the greatest pollutants. The sediment transport amounts to over 100,000 tons per month during the spring runoffs in the Sandusky River alone. Table 4-2 lists the yearly estimates of sediment loading from the rivers in the North Central Ohio basin.

Estimated nutrient loads of nitrogen and phosphate in rural land runoff are tabulated below:

Nutrient	NH_3	Organic N	NO_3	Total N	PO_4
Tons per yr.	250	360	520	1,090	160

The extent of urban land runoff has not been fully defined in North Central Ohio. Most of the communities in the basin have combined or partially combined sewer systems. This permits the discharge of untreated raw sewage to the lake or nearest water course. The overflow from combined sewers and runoff from developed septic tank areas contain organic matter, nutrients, and microorganisms. Microbiological pollution is the most serious result of these discharges. It jeopardizes the use of bathing beaches and other recreational areas. Organic discharges cause septic conditions which result in severe local nuisance conditions.

Greater Cleveland-Akron ARea

Municipal and industrial wastes which are discharged to the area's waterways are the major cause of pollution in this basin. Sediment from highway and subdivision construction also are important sources of pollution.

Municipal Wastes

Approximately 2.2 million people are served by sewage plants in this area. This population has a raw BOD_5 of over 500,000 pounds per day. If these wastes received either complete secondary (90 percent removal) or tertiary (97 percent removal) treatment, the discharges would total 40,000 and 11,000 pounds per day, respectively.

Of the 57 municipal sewage facilities in this area, 50 provide some form of secondary treatment, 4 provide intermediate treatment, and 3 provide primary treatment. There are twelve municipalities which do not have central collection systems and provide no treatment.

Over 40 percent of the treatment facilities are deemed inadequate by the Ohio Water Pollution Control Board and have been ordered to

TABLE 4 - 21

SEDIMENT LOADINGS TO LAKE ERIE for the NORTH CENTRAL OHIO BASIN

River	Tons per year
Black	180,000
Huron	150,000
Portage	200,000
Sandusky	410,000
Vermilion	130,000

JUL 10 1967

improve their systems to provide adequate treatment. Table 4-22 lists the principal municipal waste treatment plants located in the Greater Cleveland-Akron area. Raw load of BOD_5 is projected to increase to 1.0 million pounds per day by 1990 and 1.5 million by 2020. Tertiary treatment is presently being required of most inland cities with secondary treatment required for lakefront areas.

Industrial Wastes

Industrial wastes have a great effect on receiving waters in the Greater Cleveland-Akron area. Table 4-23 lists the major industries which discharge wastes to the area's waters. This table is based mainly on information obtained from Ohio water pollution control agencies, and has been reviewed by these agencies.

Some of the industries listed in the table have relatively small waste discharges, but where their outfall reaches the stream, the flow is quite small or nonexistent for most of the year. A number of industries discharge their wastes to municipal storm sewers without adequate treatment. Presently these industries are neither under permit to the State, nor are they being properly controlled by the cities involved. There are over 20 of these industries in the City of Euclid alone.

It should be recognized that many of the area's industries have spent vast sums of money in removing the pollutional materials discharged to the streams, and that they expect to continue this program by removing as high or higher percentages of their wastes in the future.

Federal Installations

There are 181 Federal installations in the Greater Cleveland-Akron area. Of those discharging to municipal systems, 144 discharge to systems providing secondary treatment, and 22 discharge to systems providing intermediate or primary treatment. In the Berea, Olmsted Falls, and Westlake areas 8 army-leased housing units discharge to septic tanks since municipal systems are not available. The Federally-owned or Federally-leased installations listed below discharge waterborne wastes to the area's waters. Installations that discharge to municipally-operated sewerage systems have not been listed since the Federal Government does not control the treatment provided.

1. The Cleveland Lifeboat Station has installed an aerobic digester treatment unit with chlorination. This unit became operational in the fall of 1966 and is considered adequate.

Combined Sewers

Of the 32 major community sewer systems in the area, 7 are of the combined or combined-separated type, and 2 are not sewered. Among those cities with a combined-separated system are the two largest cities in the area, Cleveland and Akron.

Figure 4-21. Municipal Waste Discharges in the Greater Cleveland-Akron Area.

TABLE 4-22

PRINCIPAL MUNICIPAL WASTES - GREATER CLEVELAND-AKRON AREA

Municipality	Sewer System	Type of Treatment	Data Year	Discharge in mgd*	Effluent BOD mg/l*	Effluent BOD lbs/day*
Rocky River Basin						
Berea	Separate	Secondary	1966	2.08	10	173
Broadview Heights	Separate	Septic Tanks	1966	--	--	--
Brookpark	Separate	Secondary				
Lakewood	Sep-Comb.	Secondary	1966	14.14	33	220
Medina	Separate	Secondary	1966	1.11	42	388
North Olmsted	Separate	Secondary	1966	1.84	13	199
North Royalton	Separate	Secondary	1967	**	**	**
Olmsted Falls	Separate	Septic Tanks	1966	--	--	--
Strongsville	Separate	Secondary	1967	**	**	**
Westlake	Separate	Septic Tanks	1966	--	--	--
Westview	Separate	Septic Tanks	1966	—	—	—
County Districts						
Brunswick	Separate	Secondary	1966	.80	8	53
Middleburg Hts.	Separate	Secondary	1966/67	.49	75/**	306/**
Cuyahoga River Basin						
Akron	Sep.-Comb.	Secondary	1966/67	63 .75	/**	/**
Bedford	Sep.-Comb.	Secondary	1966	2.29	30	572
Bedford Heights	Sept.-Comb.	Secondary	1965	.85	56	397
Cleveland Southerly	Sept.-Comb.	Secondary	1966			
Cuyahoga Falls	Separate	Secondary	1966	.04	.11	4
Hudson	Separate	Secondary	1966	.42	40	140
Independence	Separate	Septic Tanks	1966	--	--	--

Data are yearly averages based on material supplied by the Ohio Department of Health.

* Does not include by-passing.

** New plant presently completed and no data available, or plant to be completed by June 1, 1967.

TABLE 4 -22

PRINCIPAL MUNICIPAL WASTES - GREATER CLEVELAND-AKRON AREA

Municipality	Sewer System	Type of Treatment	Data Year	Discharge in mgd*	Effluent BOD mg/l*	Effluent BOD lbs/day*
Cuyahoga River Basin (cont'd)						
Kent	Separate	Secondary	1967	**	**	**
Mantua	Separate	Secondary	1967	**	**	**
Maple Heights	Separate	Secondary	1966/67	.70/**	149/**	869/**
Middlefield	Combined	Primary	1966	.30	72	180
Munroe Falls	Separate	Septic Tanks	1966		33	
Northfield	Separate	Secondary	1966	.32	41	109
Oakwood	Separate	Secondary	1967	**	**	**
Ravenna	Separate	Secondary	1966	.80	24	160
Sagamore Hills	Separate	Septic Tanks	1966	--	--	--
Sawyerwood	Separate	Septic Tanks	1966	--	--	--
Solon	Separate	Secondary	1966	.56	15	70
Tallmadge	Separate	Secondary	1965	.13	13	14
Twinsburg	Separate	Secondary	1965	11.81	15	1480
Valley View	Separate	Septic Tanks	1966	--	--	--
County Districts						
Brecksville SD 13	Sep-Comb.	Secondary	1966	.83	14	97
Northeast SD 1	Separate	Secondary				
Northeast SD 6	Separate	Secondary				
Northeast SD 15	Separate	Secondary				
Shalersville SD 1	Separate	Secondary	1965	.06	6	3
Shalersville SD 2	Separate	Secondary	1965	.11	7	6
Stow Twp. SD 4	Separate	Primary	1966/67	1.10/**	164/**	1500/**
Walton Hills SD 20	Separate	Secondary	1966	.21	23	40

Data are yearly averages based on material supplied by the Ohio Department of Health.

* Does not include by-passing

** New plant presently completed and no data available, or plant to be completed by June 1, 1967.

Figure 4-22. Future Municipal Waste Loadings in the Greater Cleveland-Akron Area.

Figure 4-23. Industrial Waste Discharges in the Greater Cleveland-Akron Area.

TABLE 4-23

MAJOR INDUSTRIAL WASTES
GREATER CLEVELAND-AKRON AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Other
Cuyahoga River Basin						
1-Republic Steel	Cleveland	Cuyahoga R.	Steel	290	xT 180,000S	SO_4 120,000, Cl 32,000, Phenol 280, CN 400, NH_3 4,100, Mg 1,100, Fe 12,000, Temp. 10°F, pH x, COD x, Oil x
2-Sherwin Williams	Cleveland	Cuyahoga R.	Organic chemicals	x	xT	Temp. x
3-Standard Oil***						
4-U. S. Steel	Cleveland	Cuyahoga R.	Steel	23.5	84,000T 30,000S	Oil 510, Temp. x, SO_4 50,000, Cl 1,000 Fe 15,000
5-E. I. DuPont	Cleveland	Cuyahoga R.	Inorganic chemicals	1.4	16,900T 15,400D	pH 4.9-6.2, Temp. x SO_4 4,600, NH_3 175, Zn 970, Cl 3,900
6-Jones & Laughlin	Cleveland	Cuyahoga R.	Steel	130	xT 10,400S	pH x, COD x, Oil 1,200, Temp. x, SO_4 12,200, Fe 6,600, Cl 4,900

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
*** Plant operation discontinued except for asphalt plant which now discharges to Cleveland's sewage system.
x Sufficient data not available for evaluation.

TABLE4-23 (continued)

MAJOR INDUSTRIAL WASTES
GREATER CLEVELAND-AKRON AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Other
Cuyahoga River Basin (cont'd)						
7-Elco Lube	Cleveland	Cuyahoga R.	Lubricating oils and greases	Oil		pH x, Oil 1, Temp. x
8-Harshaw Chemical	Cleveland	Cuyahoga R.	Chemicals	1.4		pH 1.0-8.7, COD x, Temp. x, 550 F Ni 160, Co 20, ***(Pb 45, SO_4 x, Cu 75, Cl 3,100, Mn 30)
9-Ford Motor Engine Plant	Cleveland Brook Park	Cuyahoga R.	Motor vehicle parts	0.9	xT 62S	pH 6.5-10.5, Oil 62, Temp. x
10-E.W.Ferry Screw	Cleveland	Cuyahoga R.	Fabricated metal products	x	xT	COD x, Oil x, Temp. x
11-Cuyahoga Meat	Cleveland	Cuyahoga R.	Meat products	x	xT	BOD x, Temp. x
12-Bailey Wallpaper	Cleveland	Cuyahoga R.	Wallpaper	x	xT	BOD x, Temp. x
13-Burdett Oxygen	Cleveland	Cuyahoga R.	Industrial gases	x	xT	COD x, Temp. x
14-Allied Chemical	Cleveland	Cuyahoga R.		.02	xT 65S	pH 4.6-7.0, SO_4 9, Cl 21

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
*** Plant operation discontinued except for asphalt plant which now discharges to Cleveland's sewage system.
x Sufficient data not available for evaluation.

TABLE 4-23 (continued)

MAJOR INDUSTRIAL WASTES
GREATER CLEVELAND-AKRON AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Other
Cuyahoga River Basin (cont'd)						
15-Republic Steel Research Center	Cleveland	Cuyahoga R.	Research	x		COD x, Temp. x
16-Master Anodizers	Bedford	Cuyahoga R.	Metal Anodizing	.09	xT	Temp. x, SO_4 150, Cr 0.3, CN x, Cu x
17-Chrysler	Twinsburg	Cuyahoga R.	Metal stamping	x	xT	pH x, Temp. x
18-Cornwell Tools	Mogadore	Cuyahoga R.	Tools	.01	xT	Temp. x, Cr x, CN x, Cu x, SO_4 x, Cd x, Zn x
19-Ohio Edison		Cuyahoga R.	Power Plant	95		Temp. x
20-S.K.Wellman, Div. American Brake Shoe	Bedford	Cuyahoga R.	Motor vehicle parts	.17	xT	Temp. x, Cu 16, CN 1.6, SO_4 190
21-Ferro Chemical	Bedford	Cuyahoga R.	Chemicals	.23	xT	pH 4.7-9.4, COD x, Temp. x, Cd 0.5, Co 1, Ba 0.2
22-Zirconium Corp. of America	Solon	Cuyahoga R.	Inorganic chemicals	.04	4,700T 4,000D	pH 3.4-4.5, Oil 2,600, ZrO_2 43, Cl 2,600, SiO_2 410, SO_4 x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved
x Sufficient data not available for evaluation.

TABLE 4-23 (continued)

MAJOR INDUSTRIAL WASTES
GREATER CLEVELAND-AKRON AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Other
Cuyahoga River Basin (cont'd)						
23-Diamond Crystal Salt	Akron	Cuyahoga R.	Salt	x	xT	pH x, Temp. x, Cl x
24-Firestone Tire & Rubber	Akron	Cuyahoga R.	Rubber products	x	xT	pH x, COD x, Temp. x
25-General Tire	Akron	Cuyahoga R.	Rubber products	x	xT	pH x, COD x, Temp. x
26-B.F.Goodrich	Akron	Cuyahoga R.	Rubber products	x	xT	pH x, COD x, Temp. x
27-Goodyear Tire & Rubber	Akron	Cuyahoga R.	Rubber products	x	xT	pH x, COD x, Oil x, Temp. x CN x, Cr x, Cu x, Zn x, SO_4 x, Cd x
28-Sonoco Products	Munroe Falls	Cuyahoga R.	Paperboard	.57	300S	BOD 782, Temp. 64°F
29-Lamson & Sessions	Kent	Cuyahoga R.	Hardware	.03	8.5 ft^3/day	Oil x, SO_4 x
30-Smallwood Packing	Middlefield	Cuyahoga R.	Meat packing	x	xT	pH x, BOD x, Oil x, Temp. x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x Sufficient data not available for evaluation.

TABLE 4-23 (concluded)

MAJOR INDUSTRIAL WASTES
GREATER CLEVELAND-AKRON AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Other
Rocky River Basin						
1-Astoria Plating	Cleveland	Rocky R.	Plating	x	xT	pH x, COD x, Temp. x, CN x, Cu x, Cr x, Color x
2-Allison Division General Motors	Brook Park	Rocky R.	Testing track	x	xT	pH x, Oil x, Temp. x
Chagrin River Basin						
1-Chase Bag	Chagrin Falls	Chagrin R.	Paper mill	1	xT 770S	pH 5.9-7.6, BOD x, COD x, Temp. x, Color x
2-General Biochemicals	Chagrin Falls	Chagrin R.	Chemicals	.003		pH 7.1-10.6, Temp. 60°F
3-Moss Farm Dairy	Chester-land	Chagrin R.	Dairy products	x		pH x, BOD x, Temp. x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x Sufficient data not available for evaluation.

A substantial portion of the cities of Cleveland and Akron are served by a combined sewer system. This system collects both sanitary and storm waters, and was originally designed before the development of treatment plants to discharge overflows to the nearest water course. With the development of treatment plants, combined sewers were tied together with interceptor sewers to intercept the dry weather sewage flow. Some allowance was made for increases due to storm waters. Overflow structures were provided at most junctures between the combined sewers and the interceptor sewer so that heavy storm water flow would continue to pass directly to the nearest water course.

The city of Cleveland has approximately 380 combined sewer overflow structures. During periods of storm runoff they discharge raw sewage and industrial wastes, mixed with storm water, to the streams passing through Cleveland and to Lake Erie. There are 21 storm water outfalls that discharge directly to the lake, and 40 outfalls that discharge to 6 small streams flowing through eastern Cleveland to Lake Erie. The outfalls constitute a major intermittent source of pollution, but plugged and defective overflow structures which discharge continuously are also responsible for a large portion of the area's pollution. The city of Akron also has numerous overflow structures which discharge into almost all water courses in the Akron area.

Solid Wastes

There are some locations where the area's waterways are being used for the disposal of solid wastes. Whenever the rivers meander close to an access, illegal dumps, as shown in Figure 4- , are often found. Dumps range from the small one-family size to large municipally operated areas. Municipal dumps presently exist along the river banks and flood plains at such places as Willoughby, Independence, Jaite, Boston Mills, and Bay Village. Besides being an esthetic eyesore, these dumps contribute oils, oxygen demand, trash, and other wastes. There are also industrial dumps at such places as Eastlake and Cleveland.

Another problem along the area's waterways, particularly on the Cuyahoga River between Akron and Cleveland, are the fallen trees which choke the rivers and streams. The Cuyahoga River is cluttered in several areas with fallen trees, tree stumps, trash, and floating debris. Many sawed-off tree stumps with their expansive root systems block the river's flow and collect floating material (Figure 4-). Much of this debris find its way down the river to the harbor area and along the lakefront where it interferes with both commercial navigation and pleasure boating.

Agricultural and Land Runoff

Soil erosion causes the addition of silt, nutrients, and other deleterious substances to the area's waterways. The principal sources of these materials are from unstable river banks; from highway and subdivision construction and from agricultural lands.

Northeastern Ohio Area

Municipal Wastes

Approximately 110,000 people are served by eleven sewage treatment plants in the Northeastern Ohio area. Figure 4-24 shows the location of these treatment plants, and Table 4-24 describes them. Five of these plants provide secondary treatment, four provide intermediate treatment, and two provide primary treatment. The five secondary treatment plants receive a population equivalent (PE) of approximately 19,000, while the six plants that provide only primary or intermediate treatment receive a PE of approximately 94,000. The total BOD discharged to the area's waters is 9,300 pounds per day or a PE or 56,000. This indicates an overall removal of only 50 percent. Projected BOD loads for each river basin are shown in Figure 4-25.

Sewage treatment plants for Ashtabula and Conneaut provide intermediate treatment, while Painesville's plant provides primary treatment. These three plants serve approximately 65 percent of the total population served in Northeastern Ohio. These three plants receive approximately 12,000 pounds of BOD per day and discharge 7,100 pounds per day, which indicates a total average removal of only 40 percent. If ashtabula, Painesville, and Conneaut provide secondary treatment (90% BOD removal) the combined load discharged would be only 1,200 pounds of BOD per day.

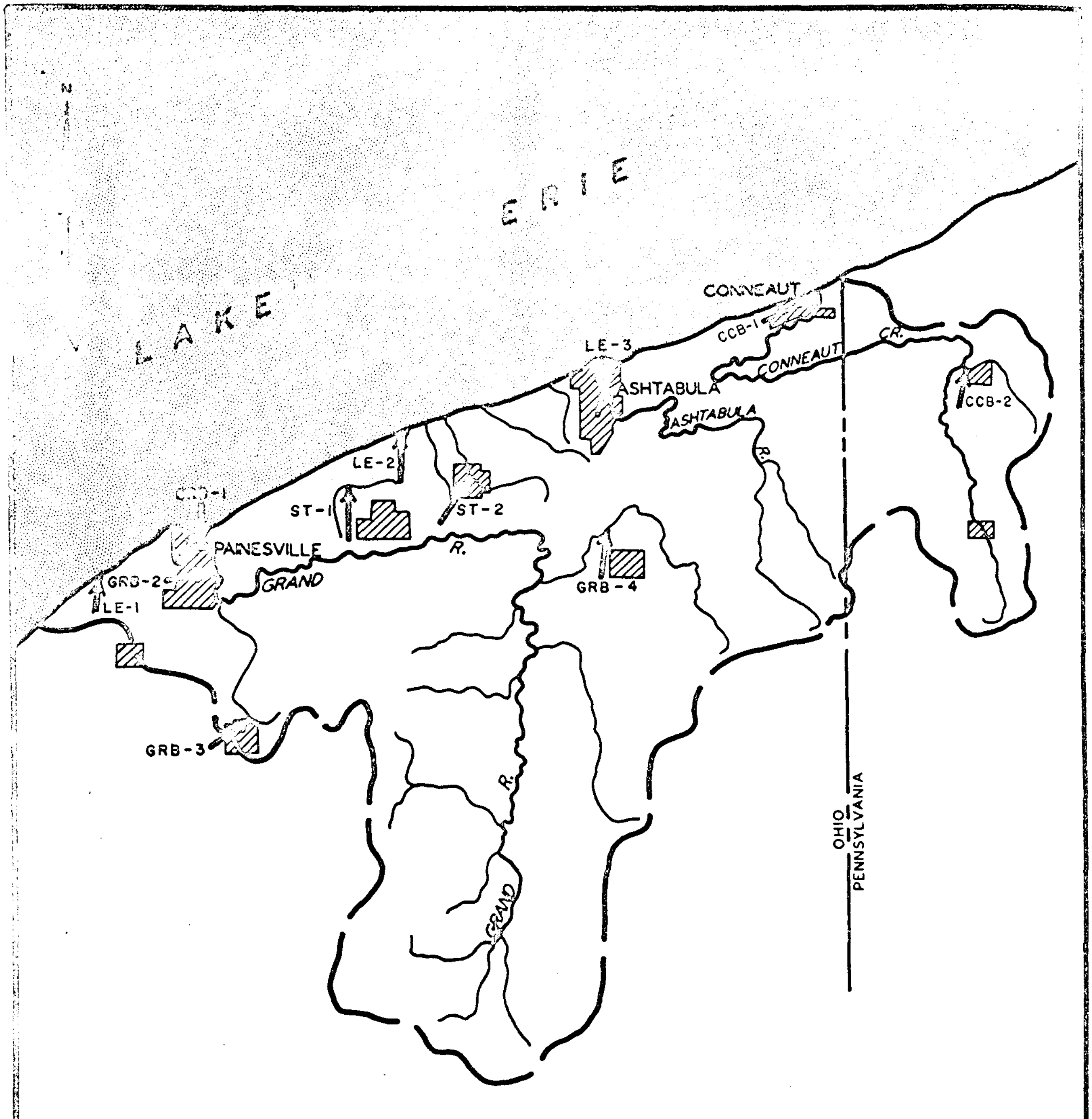
The total phosphorus load discharged by municipalities in the Northeastern Ohio area is approximately 1,100 pounds per day. The present and projected phosphorus loads from municipal treatment plants are shown in Figure 4-25.

In addition to the treated wastes from the eleven treatment plants, the streams receive wastes with little or no treatment from seven municipalities and many small communities (less than 1,000 population). The seven municipalities that provide no treatment other than septic tanks are: Lakeville, Ohio (1960 population of 4,190), North Kingsville, Ohio (1960 population of 1,854), Painesville Northeast, Ohio (population of 1,265), Orwell, Ohio (1960 population of 819), Grand River, Ohio (1960 population of 477), Conneautville, Pennsylvania (1960 population of 1,200) and Springboro, Pennsylvania (1960 population of 583).

Industrial Waste

Figure 4-26 shows the location of the industries that discharge their wastes to Northeastern Ohio waters. The majority of industries are located near Lake Erie and discharge their wastes directly to the lake, to the lower reach of the Grand River, or to a small tributary which flows into the Ashtabula River.

A large industrial complex consisting of eleven industries is located just outside the City of Ashtabula. Eight of these industries discharge wastes to Fields Brook either directly or to a storm sewer which empties into it. Fields Brook is a small tributary which flows into the lake-affected portion of the Ashtabula River.



LEGEND

GRB = DISCHARGE TO GRAND RIVER BASIN (SEE TABLE 6-1)

CCB = DISCHARGE TO CONNEAUT CREEK BASIN (SEE TABLE 6-1)

ST = DISCHARGE TO SMALL TRIBUTARY (SEE TABLE 6-1)

LE = DISCHARGE DIRECT TO LAKE ERIE (SEE TABLE 6-1)

SCALE IN MILES

5 0 5 10 15 20

NORTHEASTERN OHIO AREA
MUNICIPAL WASTE DISCHARGES

FIGURE

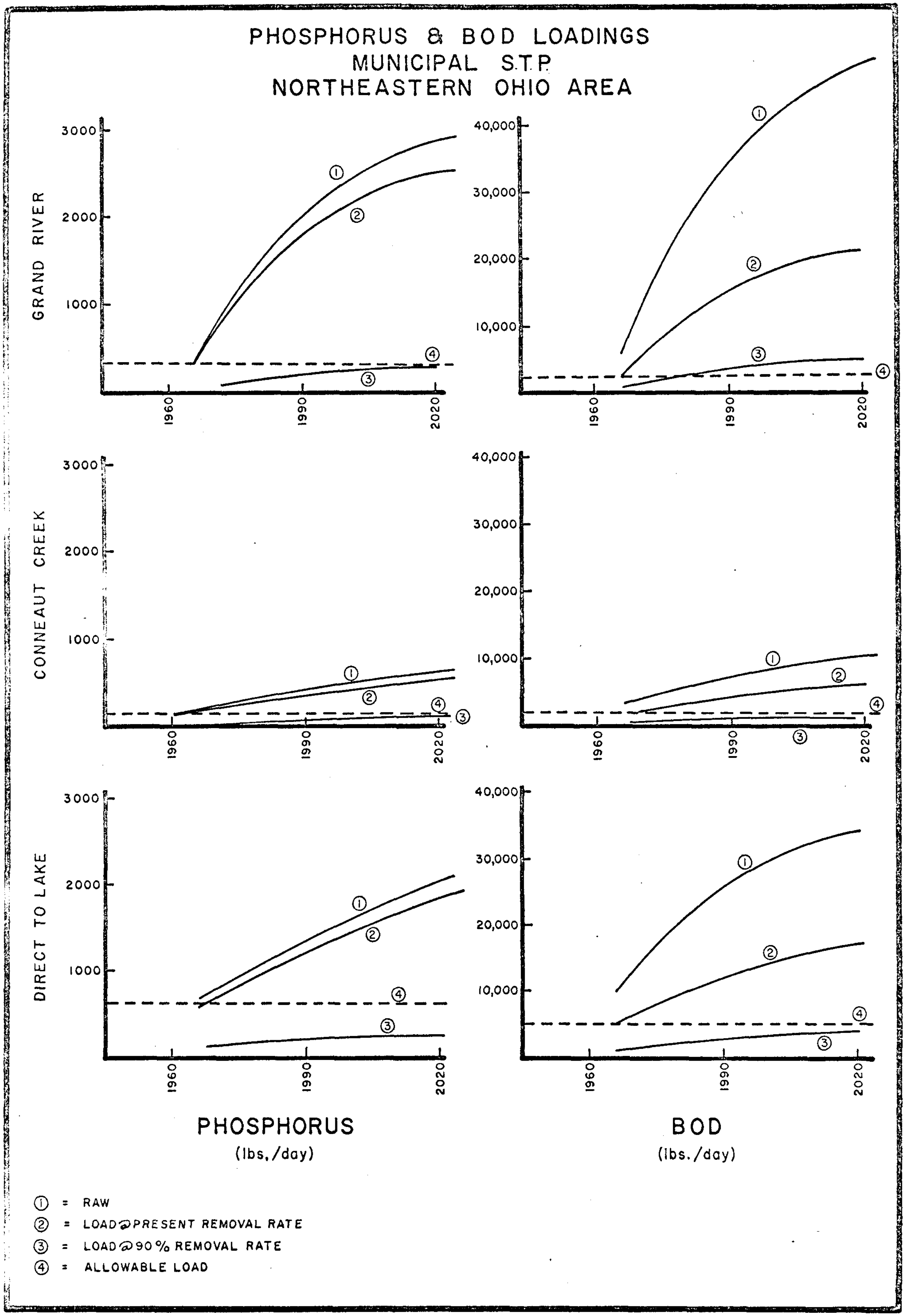
TABLE 4-24

MAJOR MUNICIPAL WASTES

NORTHEASTERN OHIO AREA

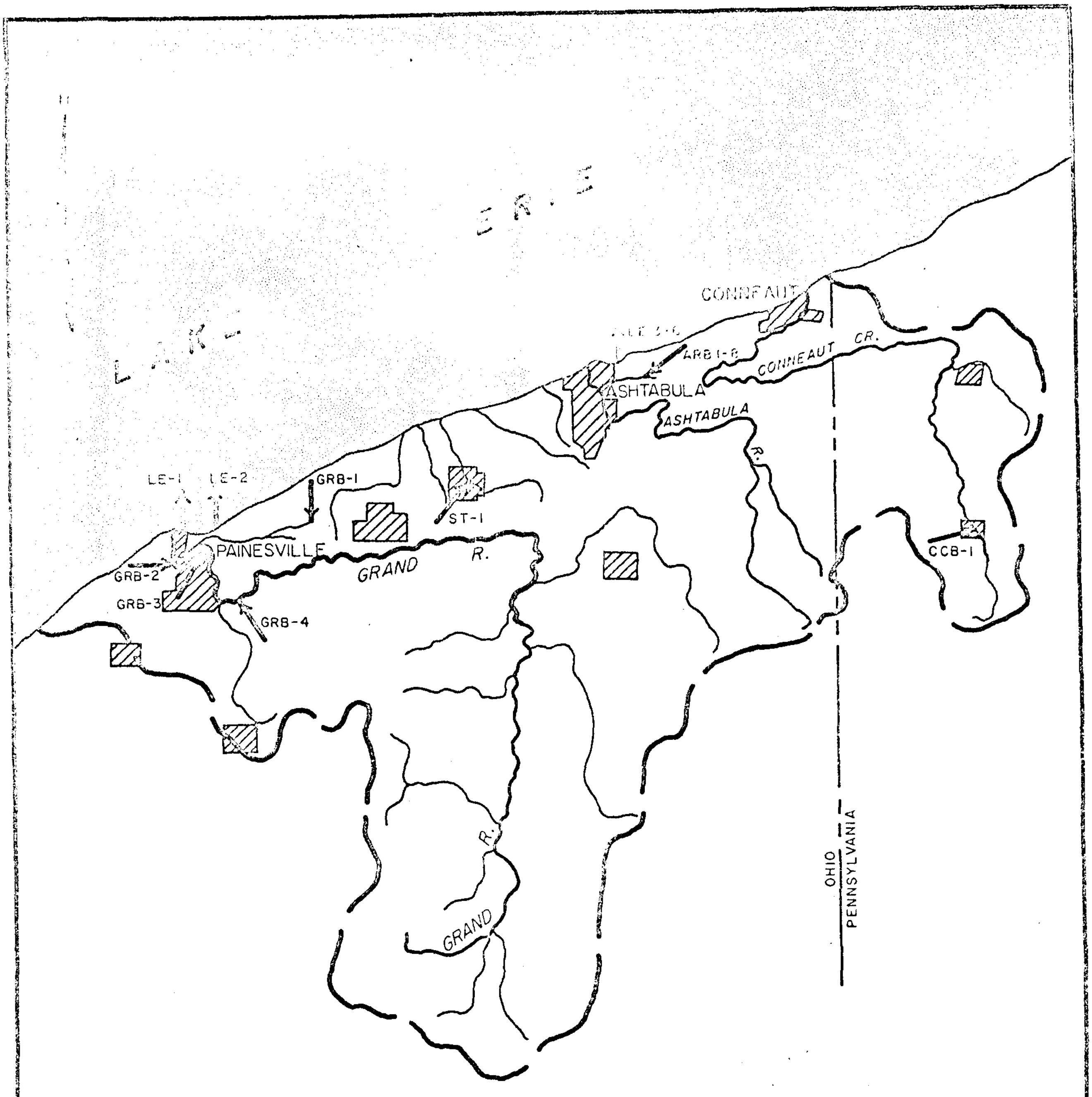
Municipality or Institution	Receiving Stream	Type Sewerage System*	Flow (mgd)	BOD (lbs/day) Raw	Final
Grand River Basin					
Fairport	Grand River	Intermediate-S		517	357
Painesville	Grand River	Primary-S		4,230	2,000
Chardon	Big Creek	Secondary-S		408	98
Jefferson	Mill Creek	Secondary-S		505	61
Ashtabula River Basin					
Conneaut Creek Basin					
Conneaut	Conneaut Creek	Intermediate-S		2,370	1,630
Albion	E.Br.Conneaut Cr.	Secondary-S		370	55
Small Tributaries					
Madison	Arcola Creek	Secondary-S		265	58
Geneva	Cowles Creek	Secondary-S		1,610	232
Direct to Lake Erie					
Lake County SD # Willoughby-Mentor	Lake Erie	Intermediate-S		2,520	810
Lake County SD#1 Madison	Lake Erie	Primary-S		540	540
Ashtabula	Lake Erie	Intermediate-S		5,485	3,435

*S = Separate Sewer System, C = Combined Sewer System, S-C = Separate and Combined Sewer Systems



PHOSPHORUS & BOD LOADINGS
MUNICIPAL S.T.P.
NORTHEASTERN OHIO AREA
GRAND RIVER
CONNEAUT CREEK
DIRECT TO LAKE
3000
2000
1000
40,000
30,000
20,000
10,000
1960
1990
2020
PHOSPHORUS
(lbs./day)
BOD
(lbs./day)
① = RAW
② = LOAD @ PRESENT REMOVAL RATE
③ = LOAD @ 90% REMOVAL RATE
④ = ALLOWABLE LOAD

Figure 4-25



LEGEND

GRB = DISCHARGE TO GRAND RIVER BASIN (SEE TABLE 6-2)

ARB = DISCHARGE TO ASHTABULA RIVER BASIN (SEE TABLE 6-2)

CCB = DISCHARGE TO CONNEAUT CREEK BASIN (SEE TABLE 6-2)

ST = DISCHARGE TO SMALL TRIBUTARY (SEE TABLE 6-2)

LE = DISCHARGE DIRECT TO LAKE ERIE (SEE TABLE 6-2)

SCALE

5 0 5 10 15 MILES

NORTHEASTERN OHIO AREA INDUSTRIAL WASTE DISCHARGES

FIGURE

Another area of large industrial activity is the lower reaches of the Grand River near Painesville and Fairport. Here five industries discharge to Lake Erie or the Grand River.

Table 4-25 summarizes the waste loads for each of the major industries in Northeastern Ohio. This table is based on data obtained from the Ohio Department of Health and has been reviewed by them. The main problem stemming from industrial wastes in this area is that of solids. Most of these solids are dissolved in the water and are predominantly chlorides. The Grand River receives an average of over 6.6 million pounds of total solids daily from the Diamond Alkali Company, 3.9 million pounds of which are chlorides. This represents the highest chloride discharge from one industry anywhere within the Lake Erie Basin.

If the present control measures are not improved, the solids load will be phenomenal. Figure 4-27 graphically shows the waste loads expected if control measures are not improved.

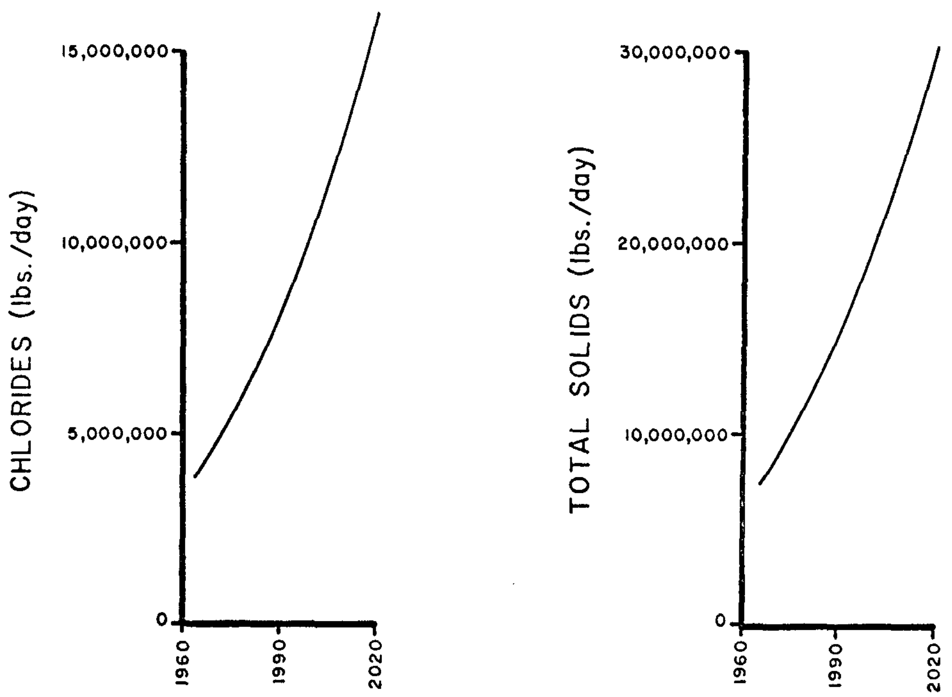


Figure 4-27

TABLE 4-25

MAJOR INDUSTRIAL WASTES
NORTHEASTERN OHIO AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day*		
					Solids**	Chlorides	Other
<u>Grand River Basin</u> (GR)							
1-Calhio Chemical	Perry	Red Cr.	Organic chemicals	0.2	36,000T xD	11,000	
2-A.E.Staley	Grand River	Grand R.	Soybean oil	x	xT xD		pH x, BOD x
3-Diamond Alkali	Painesville	Grand R.	Inorganic chemicals	5.3	6,500,000D 160,000S	3,900,000	Ammonia 17,000 Phenol 21
4-U.S.Rubber - Uniroyal	Painesville	Grand R.	Plastics, synthetic resins	0.3	1,880T 518S		
<u>Ashtabula River Basin</u> (AR)							
1-Cabot Titania Titania Dioxide Plant	Ashtabula	Fields Br.	Inorganic chemicals	3	xT 1,930S	5,880	TiO_2 x
2-Cabot Titania Titania Tetrachloride Plant	Ashtabula	Fields Br.	Inorganic chemicals	3	xT 11,000S	15,000	pH 2.5-11.9

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x = Sufficient data not available for evaluation.

TABLE 4-25 (cont'd)

MAJOR INDUSTRIAL WASTES
NORTHEASTERN OHIO AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day*		
					Solids**	Chlorides	Other
Ashtabula River Basin (cont'd)							
3-Detrex Chemical Ind.-Chlorinated Solvents Div.	Ashtabula	Fields Br.	Inorganic chemicals	0.1	1,800T 1,700D	2,400	pH 0.4-8.3, Fe 41
4-General Tire & Rubber-Chemical Division	Ashtabula	Fields Br.	Plastics, synthetic resins				
5-Olin Mathieson Chemical-TDI Facilities	Ashtabula	Fields Br.	Inorganic chemicals	0.4		15,000	pH 1.2-11.4
6-Diamond Alkali Semi-Works	Ashtabula	Fields Br.	Inorganic chemicals	0.6	xT xD		COD 425 pH 1.6-9.6
7-Reactive Metals Metals Reduction Plant	Ashtabula	Fields Br.	Non-ferrous metals	1.3	430,000T 2,300S	270,000	pH 1.0-2.3
8-Reactive Metals Sodium & Chlorine Plant	Ashtabula	Fields Br.	Inorganic chemicals	0.04	8,800T 326S		pH x

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x = Sufficient data not available for evaluation.

TABLE 4-25 (cont'd)

MAJOR INDUSTRIAL WASTES
NORTHEASTERN OHIO AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
Conneaut Creek Basin (CC)							
1-Albro Packing	Springboro		Pickles & Sauerkraut	x	xT xS		pH x, BOD x
Small Tributaries (ST)							
1-True Temper	Geneva	Cowles Cr.	Sporting Goods	0.7	380S		Oil x, Fe 66, Chrome 10
Direct to Lake Erie (LE)							
1-Diamond Alkali	Painesville	Lake Erie	Inorganic chemicals	10	37,000D 6,200S	26,000	Ammonia 1,000 Phenol 17
2-Midland Ross IRC Fibers Div.	Painesville	Lake Erie	Tire cord & fabric	29	274,000T 254,000D	40,000	pH 2.8-3.8, BOD 8,700, Oil 4,300, Zn 6,700
3-Cleveland Electric Ill. Co.	Ashtabula	Lake Erie	Power plant	x	x		Temp. x
4-Detrex Chemical Ind.-Chlorine & Alkali Plant	Ashtabula	Lake Erie	Industrial inorganic chemicals	4.6	xD 651S	10,000	

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x = Sufficient data not available for evaluation.

TABLE 4-25 (concluded)

MAJOR INDUSTRIAL WASTES
NORTHEASTERN OHIO AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	Chlorides	Other
Direct to Lake Erie (cont'd)							
5-Union Carbide, Linde Div. Welding Materials Plant	Ashtabula	Lake Erie	Industrial gases	1.3	16,000T 740S		pH 9.0-11.0 Copper 2
6-Union Carbide Metals Div.	Ashtabula	Lake Erie	Electrometallurgical products	5.6	36,000T		pH 8.2-12.6

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.

Agricultural and Land Runoff

The upper portion of the Northeastern Ohio area is rural and runoff from this area carries nutrients and sediment into the streams. Organic and bacterial pollution of streams is also caused by agricultural runoff from pastures. Other pollutants from agricultural lands include pesticides, herbicides, fungicides, and algicides. Due to the limited agricultural uses of land in Northeastern Ohio, the nutrient runoff to streams is not as great as in areas in the western basin. Sediment loading to the streams is caused by land runoff and bank erosion. Approximately 500 tons of suspended solids are carried daily by the Grand River to Lake Erie. During the spring thaw and intense rain storms, this sediment load is increased tremendously. Sediment pollution, which occurs in all streams, is a minimal problem in Northeastern Ohio. There is a silt problem in the Grand River, but this is not a major problem and does not affect any water uses.

The rural areas in Northeastern Ohio will decrease with increase in urban areas. Because of the relatively unproductive soils within this area, agricultural uses will not increase significantly. However, with increased uses of fertilizers and other nutriments, the pollution loads to Lake Erie from these rural lands are expected to stay relatively constant.

Solid Wastes

Northeastern Ohio waterways, in some areas are being used for the disposal of solid wastes. Dumping of garbage, trash, and other deleterious refuse into streams should be prohibited and existing dumps along river banks should be removed.

A dump is located in Conneaut within the flood plain of Conneaut Creek. Although there is apparently no refuse entering the creek during low flow, refuse and drainage from this dumping area may adversely affect water quality of Conneaut Creek during the high flow season.

Dredging

Dredging in the Northeastern Ohio area is done by the Corps of Engineers at Conneaut, Fairport, and Ashtabula Harbors. The amounts dredged in 1967 are shown in Table 4-26.

Dumping areas for the dredged material for each harbor are located in Lake Erie approximately three miles from the mouths of the rivers. The dump area for Fairport Harbor is for all material; whereas there are two dump areas each for Conneaut and Ashtabula Harbors: one for earth and the other for rock. The minimum depth requirement at all these areas is 35 feet.

Studies are presently being carried out by the Corps of Engineers and the Federal Water Pollution Control Administration to determine the effects of the dumped dredged materials on the lake.

TABLE 4-26

ESTIMATED DREDGED MATERIAL FROM HARBORS

in NORTHEAST OHIO--1967

Harbor	Maintained Depth (ft)	Volume dredge (yd^3)
Conneaut	25	400,000
Fairport	24-18	360,000
Ashtabula	27-16	350,000

Federal Installations

Two Federal installations discharge waterborne wastes to the Northeastern Ohio area. These are:

1. U. S. Coast Guard, Fairport Harbor Light Station. A new tile field was completed in May, 1966. The septic tank system is now adequate.

2. U. S. Coast Guard, Ashtabula Light Station. The sewage from two persons was discharged directly to Lake Erie without treatment. A gas-fired incinerator unit was installed in August, 1966.

Pennslyvania Area

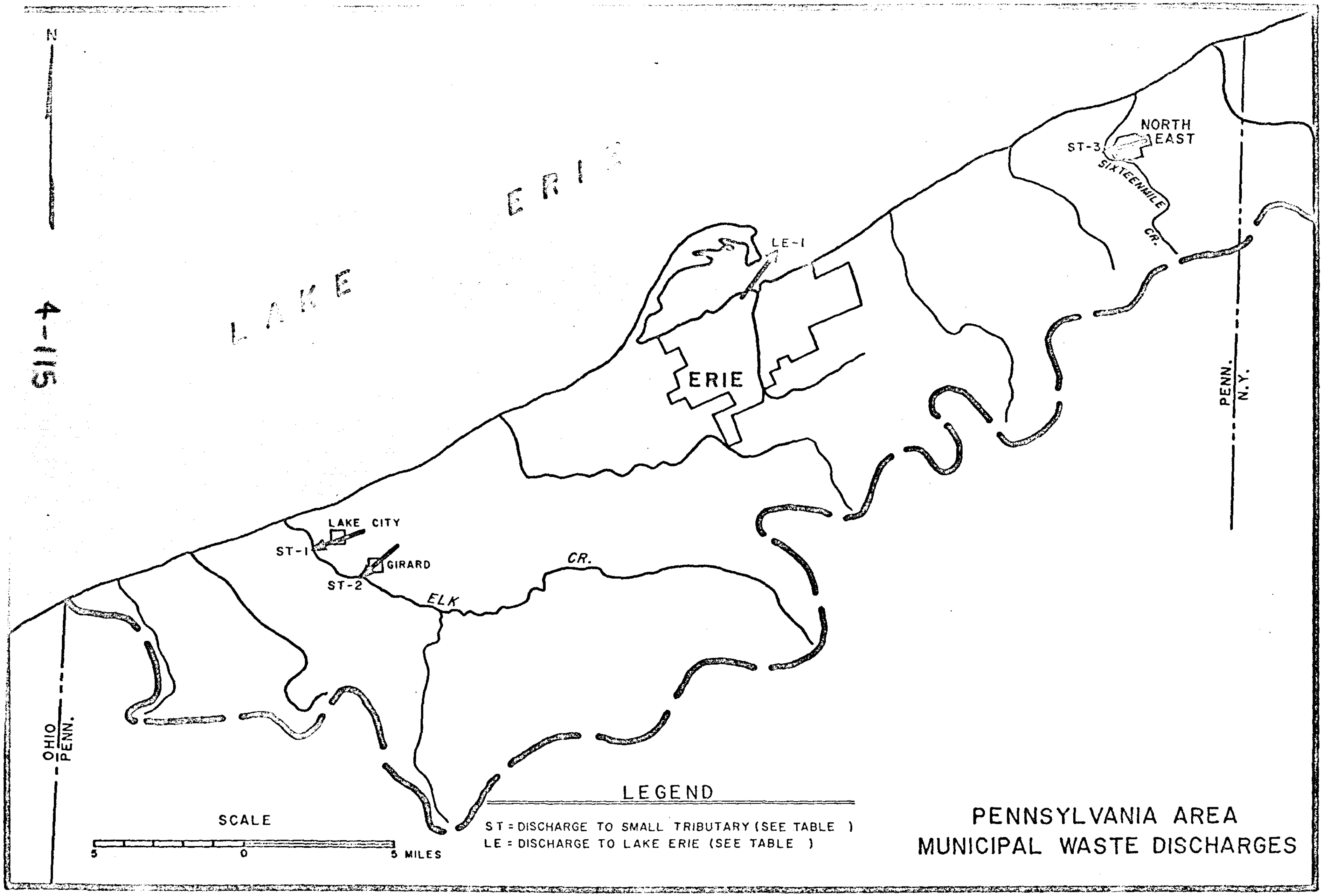
Municipal Wastes

Approximately 150,000 people are served by four sewage treatment plants in the Pennsylvania area. They are shown in Figure 4-28 and described in Table 4-27. Three of the plants provide secondary treatment and one plant provides intermediate treatment. The intermediate treatment plant at Girard removes an average of 64 percent of the BOD load it receives and is presently under orders by the Pennsylvania Health Department to improve treatment. The secondary treatment plants at Erie and North East remove an average of approximately 85 percent of their influent BOD. The plant at Lake City has facilities for secondary treatment; however, they are not removing equivalent loads. Samples taken by the Pennsylvania Health Department indicate that the Lake City plant is removing only 75 percent of the raw BOD.

The Erie sewage treatment plant, by far the largest in the Pennsylvania area, serves approximately 94 percent of the population connected to treatment plants in this area. Some 140,000 residents of Erie and suburban communities are connected to the plant which discharges 6,700 pounds of BOD_5 daily to Lake Erie.

The total phosphorus discharge from the four sewage treatment plants is approximately 1400 pounds daily. The projected phosphorus and BOD loads from these plants are shown graphically below in Figure 4-29.

The plants at Erie, Lake City and North East all presently provide continuous chlorination to the effluent all year around. Girard does not provide any chlorination; but improvements required by the Pennsylvania Health Department include disinfection facilities operated on a continuous, year around basis.



PENNSYLVANIA AREA
MUNICIPAL WASTE DISCHARGES

TABLE 4-27

MAJOR MUNICIPAL WASTES

PENNSYLVANIA AREA

Municipality or Institution	Receiving Streams	Type Sewerage System*	Flow (mgd)	BOD (lbs/day) Raw	BOD (lbs/day) Final
Small Tributaries					
Lake City	Elk Creek	Secondary-S	0.4	868	227
Girard	Elk Creek	Intermediate-S	0.2	230	84
North East	Sixteenmile Creek	Secondary-S	0.5	1,135	138
Direct to Lake Erie					
Erie**	Lake Erie	Secondary-S-C	40	57,450	6,680

*S = Separate Sewer System, C = Combined Sewer System, S-C = Separate and Combined Sewer Systems

** Also serves portions of Lawrence Park, Wesleyville, Harbor Creek Township and Mill Creek Township

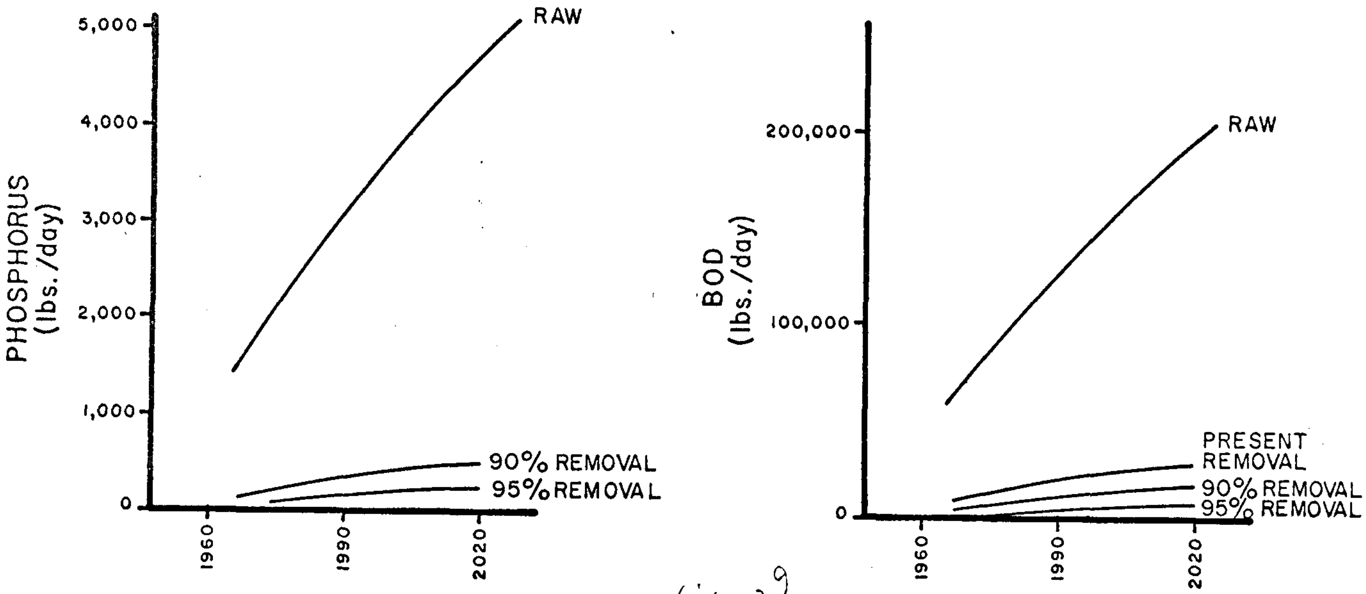


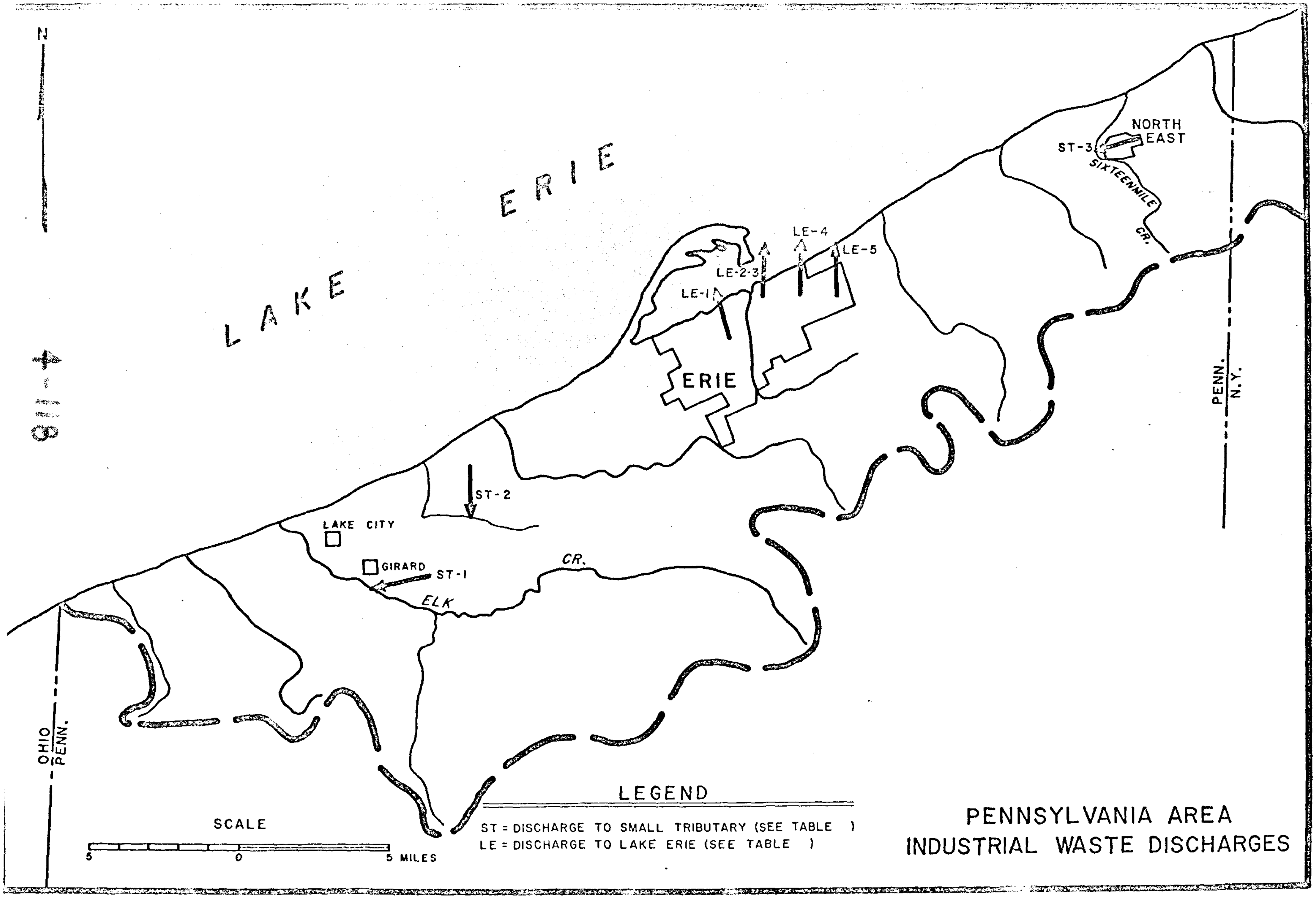
fig 4-29

Some of the suburbs of Erie and many of the motels and houses along the lakefront near and in Erie are not sewered and should be connected to the Erie Metropolitan sewerage system. Two projects are in the planning stage for the collection of wastes from the lakefront residents. The Kelso Beach Area Project and the Bayshore Sanitary Sewer Improvement Project will collect wastes from the area and pump these to the sewage treatment plant.

Industrial Wastes

Figure 4-30 shows the locations of the major industries in Pennsylvania discharging their wastes to Lake Erie or its tributaries. These industrial waste sources are summarized in Table 4-28.

The Hammermill Paper Company is the largest polluter of Lake Erie waters within the Commonwealth of Pennsylvania. The Hammermill Paper Company discharge has a BOD_5 population equivalent of 370,000. The quantity of suspended solids, coliform, color, and foam are also very high. The effects of this waste on Lake Erie are discussed in the Pennsylvania Area section of Chapter 5. Hammermill Paper Company has



PENNSYLVANIA AREA
INDUSTRIAL WASTE DISCHARGES

TABLE 4-28

MAJOR INDUSTRIAL WASTES
PENNSYLVANIA AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	BOD	Other
Small Tributaries (ST)							
1-Gunnison Bros.	Girard	Trib. of Elk Cr.	Tannery	0.002	100T 20S	6	
2-Parker White Metals	Fairview Twp.	Trout Run	Metal production	0.02	x	x	COD 22, Oil 90
3-Welch Grape Juice	North East	Sixteenmile Cr.	Food processing				
Direct to Lake Erie (LE)							
1-Pennsylvania Electric	Erie	Lake Erie	Power plant	0.1	34S		Temp.
2-Erie Reduction	Erie	Lake Erie	Rendering	0.02	x	10	
3-Interlake Iron	Erie	Lake Erie	Steel	a	a	a	a
4-Hammermill	Erie	Lake Erie	Pulp & Paper	20	530,000T 84,000S	62,000	Color, SO_4 51,000
5-General Electric	Lawrence Park Twp.	Lake Erie	Machine manufacturing	0.3	x		pH 4.8, Iron 200

a = Presently not in operation.
* = Except temperature in °F and pH.
** = Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x = Sufficient data not available for evaluation.

done much work in improving its waste discharge. Approximately 78 percent of this total spent pulping liquor (population equivalent of 487,000) is injected to deep underground wells; however, total BOD removal from all effluents is only 60 percent. Other methods of further reducing the waste discharge are presently being studied. One such study, discussed in this report, is the feasibility of connecting to the Erie sewage treatment plant.

Figure 4-31 shows the present and projected loadings from industries discharging to Lake Erie. If Hammermill connects to the Erie sewage treatment plant, almost the entire industrial BOD load will become part of the municipal loadings. This additional loading will more than triple the present BOD load to the Erie Plant (see Figure [illegible]).

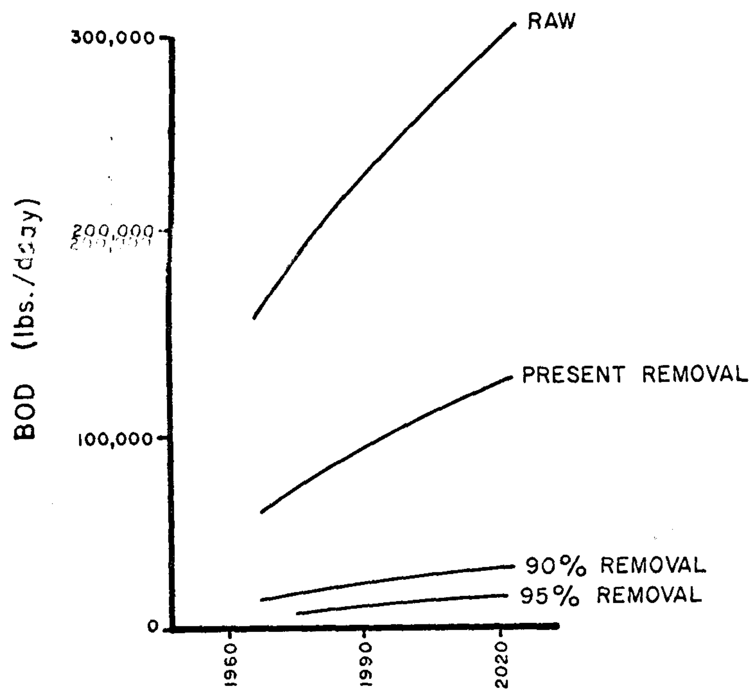
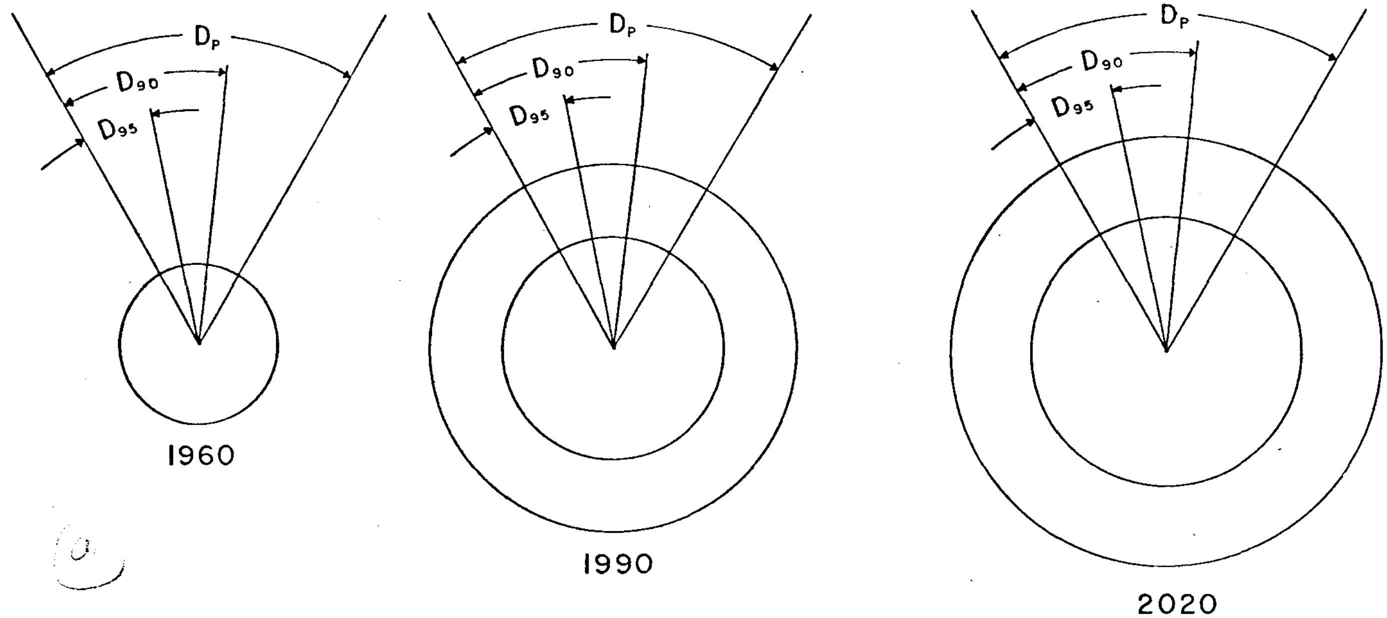


Fig 4-31

Combined Sewers

Of the four sewer systems listed in Table 4-27, one is partially a combined system. During storms, the sewage treatment plant cannot handle the additional loads and much of the untreated sewage is, therefore, discharged through overflow structures into the nearest watercourse.



RADIUS = 1" AREA = 100,000 lbs./day (RAW BOD)
RADIUS = 2" AREA = 400,000 lbs./day

D_P = DISCHARGED @ PRESENT REMOVAL RATE
D_{90} = DISCHARGED @ 90% REMOVAL RATE
D_{95} = DISCHARGED @ 95% REMOVAL RATE

INNER CIRCLE REPRESENTS RAW MUNICIPAL LOAD
OUTER CIRCLE REPRESENTS RAW MUNICIPAL LOAD IF HAMMERMILL CONNECTS TO ERIE S.T.P.

B.O.D. LOADS
HAMMERMILL & ERIE STP

The City of Erie has approximately 43 storm water outfalls which discharge to Mill Creek, Garrison Run, Cascade Creek, and Lake Erie. As discussed in the water quality problems chapter, the streams have become heavily polluted from the wastes discharged from these overflows. The main area served by combined sewers is the older portion of Erie consisting of the downtown area and the adjacent residential areas. Approximately 50 percent of Erie's population is served with these sewers. The estimated BOD discharged from the overflows is approximately 2,000 pounds per day. Erie has a program where they are separating storm and sanitary sewers in redevelopment areas. Assuming conversion of combined sewers, the BOD load from storm water overflow will increase slightly to 2,100 pounds daily in 1990 and to 2,900 pounds per day by 2020.

Agricultural and Land Runoff

Agricultural and rural land runoff is not a major problem in the Pennsylvania area. Approximately 80 tons of sediment per day are discharged into Lake Erie and Presque Isle Bay from Pennsylvania waters.

One major problem from soil erosion is that of Presque Isle peninsula. This sand and gravel spit extends into Lake Erie from a rocky bluff. Littoral currents pick up sand from the base of the peninsula and deposit it at the eastern end. This process moves the peninsula in an eastward direction. If allowed to continue, the thin base would soon erode away, forming an island. The island would eventually reconnect to the mainland, filling in what is now Erie Harbor. To prevent this, sand is pumped from the bay side of the peninsula to the lake side, replacing the eroding sand. A series of groins has been constructed to help retain the sand and slow its eastward drift.

Dredging

Legislation passed in 1962 provided for the present maintained depth of 29 feet in Erie Harbor to accommodate deep draft vessels using the St. Lawrence Seaway.

All maintenance dredging of the harbors is done by the U. S. Corps of Engineers with their own boats. In 1967 an estimated 200,000 cubic yards of material will be dredged from Erie Harobr, which ranks ninth of fourteen harbors in estimated volume to be dredged.

The dumping area for the dredged material from Erie Harbor is located in Lake Erie approximately one and a half miles north of Presque Isle. The dumping area has a minimum depth requirement of 35 feet.

Federal Installations

There is only one Federal installation not connected to a municipal sewerage system. It is the Erie Coast Guard Station and has subsurface disposal through septic tanks. The population using the facilities varies from six to eight.

New York Area

Industries and municipalities are the principal sources of waste discharges in the New York area. Other sources of waste also contributing pollution to the streams in this area are accidental spills from vessels or industries, combined sewer overflows, land runoff, material from dredging operations, and wastes from lake vessels and pleasure craft. In Chapter 5 the consequences of these waste discharges are further described.

Municipal Wastes

Approximately 220,000 people are served by 21 sewage treatment plants in the New York area. Ten of these plants provide secondary treatment and eleven provide only primary treatment. In addition, seven municipalities with a total population of approximately 12,200 have no treatment facilities other than spetic tanks. Figure 4-33 shows the location of the municipal sewage treatment plants and Table 4-29 summarizes their waste discharges.

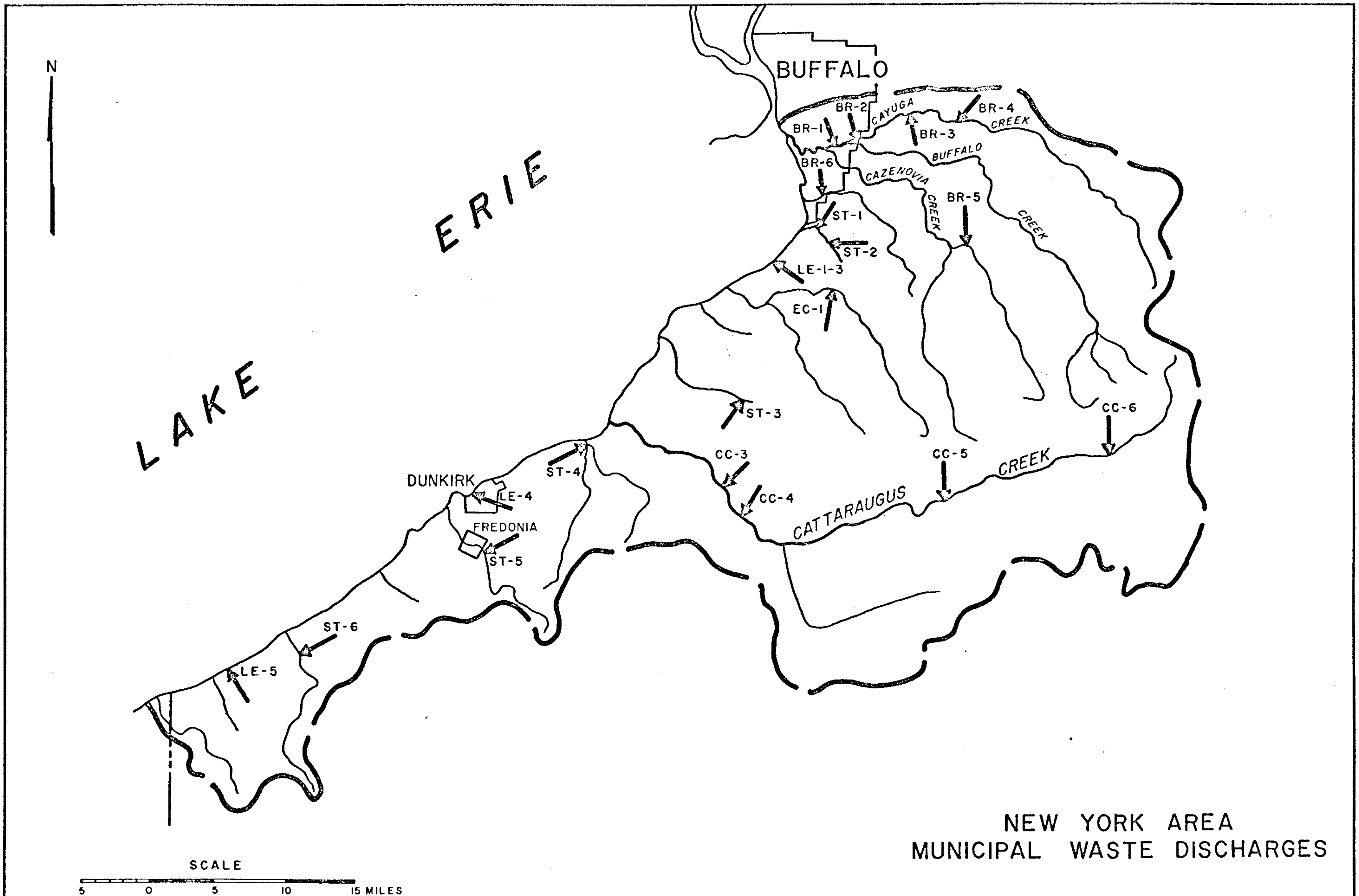
The total phosphorus load discharged by the sewage treatment plants is approximately 3,000 pounds per day and the total BOD load discharged is 29,000 pounds per day. This represents an overall BOD removal rate of only 60 percent. The projected phosphorus and BOD loads from the municipal treatment plants in the New York area through 2020 are shown in Figure 4-34. These projections assume all municipalities presently providing only septic tanks will have treatment facilities by 1971 and all populations in municipalities having treatment plants will be connected to them.

Industrial Wastes

Table 4-30 lists the major industries which discharge wastes to the area's waters. The location of the industrial waste discharges is shown in Figure 4-35. The information presented in the table has been obtained from several sources such as studies conducted by official pollution control agencies, data provided by industries through the New York State Health Department, and other available information of New York pollution control agencies. It has been reviewed by these agencies.

A few of the industries listed in the table have relatively small discharges, but significantly degrade the water quality because the flow in the receiving stream is also very small. Some very large industrial waste discharges enter streams with very small flows during much of the year. This has been the situation in the Buffalo River where the river water consists essentially of a concentrated mixture of industrial and other wastes during extended periods of time.

The pollutant materials discharged by industry are diverse; they include oil, solids, phenols, acid, color, BOD, odor, alkali, cyanide, ammonia, COD and heavy metals and other toxic constituents. The Bethlehem Steel Company discharges the largest volume of waste in the entire Lake Erie basin. Other major contributors of pollution to the New York



NEW YORK AREA
MUNICIPAL WASTE DISCHARGES

4-124

Fig. 4-33

TABLE 4-29

MAJOR MUNICIPAL WASTES

NEW YORK AREA

Municipality or Institution	Receiving Stream	Type Sewerage System*	Flow (mgd)	BOD (lbs/day)	
				Raw	Final
Buffalo River Basin (BR)					
1-West Seneca SD 6	Buffalo River	Primary-S	x	x	x
2-Cheektowaga SD 3	Buffalo River	Secondary-S	2.1	4,100	1,300
3-Depew	Cayuga Creek	Primary-S	1.1	1,760	500
4-Lancaster SD 1	Cayuga Creek	Secondary-S	0.9	x	x
5-East Aurora (V)	E. Br. Cazenovia Creek	Secondary-S	0.8	1,600	560
6-Lackawanna	Smoke Creek	Primary-S	3.1	4,500	x
Eighteenmile Creek (EC) and Cattaraugus Creek (CC) Basins					
1-Hamburg (V)	Eighteenmile Creek	Secondary-S	x	x	x
2-Gowanda State Hospital	Cattaraugus Creek	Primary-S	x	x	x
3-Gowanda	Cattaraugus Creek	Primary-S	0.8	x	x
4-Springville	Cattaraugus Creek	Primary-S	0.4	x	380
5-Arcade	Cattaraugus Creek	Secondary-S	x	x	x

*S = Separate Sewer System, C = Combined Sewer System, S-C = Separate and Combined Sewer Systems.
x = Not available.

TABLE 4-29 (concluded)

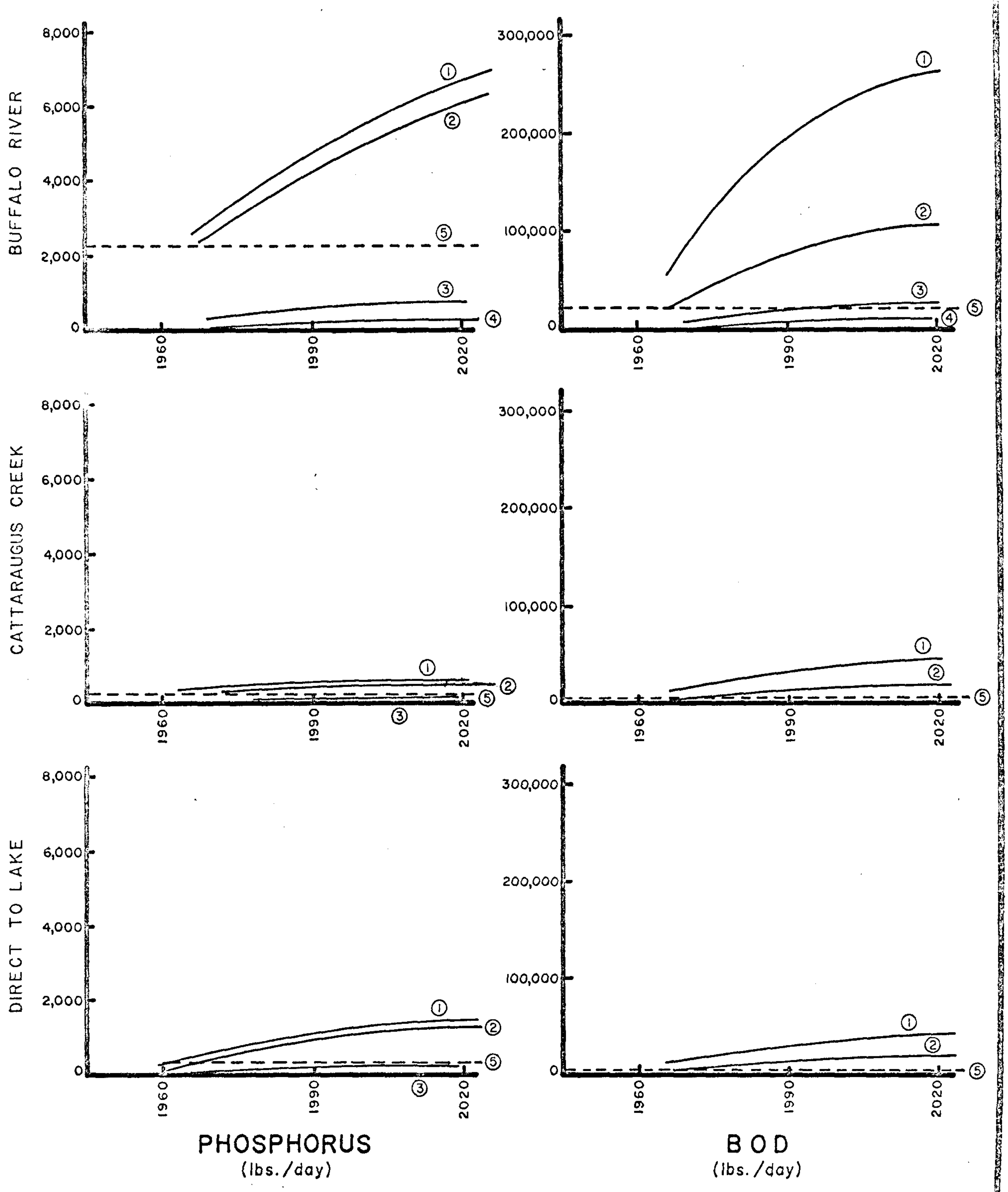
MAJOR MUNICIPAL WASTES

NEW YORK AREA

Municipality or Institution	Receiving Stream	Type Sewerage System*	Flow (mgd)	BOD (lbs/day)	
				Raw	Final
Small Tributaries (ST)					
1-Blasdell	Rush Creek	Secondary-S	0.8	1,900	260
2-Hamburg SD 1 (Woodlawn)	Rush Creek	Secondary-S	x	x	x
3-North Collins	Big Sister Creek	Secondary-S	x	x	x
4-Silver Creek	Silver Creek	Secondary-S**	x	x	x
5-Fredonia	Canadaway Cr.	Secondary-S-C	1.7	x	1,100
6-Westfield	Chautauqua Cr.	Secondary-S	0.9	x	300
Direct to Lake Erie (LE)					
1-Hamburg SD 2 (Mt. Vernon)	Lake Erie	Primary-S	x	x	x
2-Hamburg (Wanakah)	Lake Erie	Primary-S	x	x	x
3-Hamburg (Master)	Lake Erie	Primary-S	1.1	820	x
4-Dunkirk	Lake Erie	Primary-S-C	4.1	x	4,300
5-Ripley	Lake Erie	Primary-S	0.1	x	850

*S = Separate Sewer System, C = Combined Sewer System, S-C = Separate and Combined Sewer Systems.
x = Not available.
** = These facilities are approximately 85 percent completed.

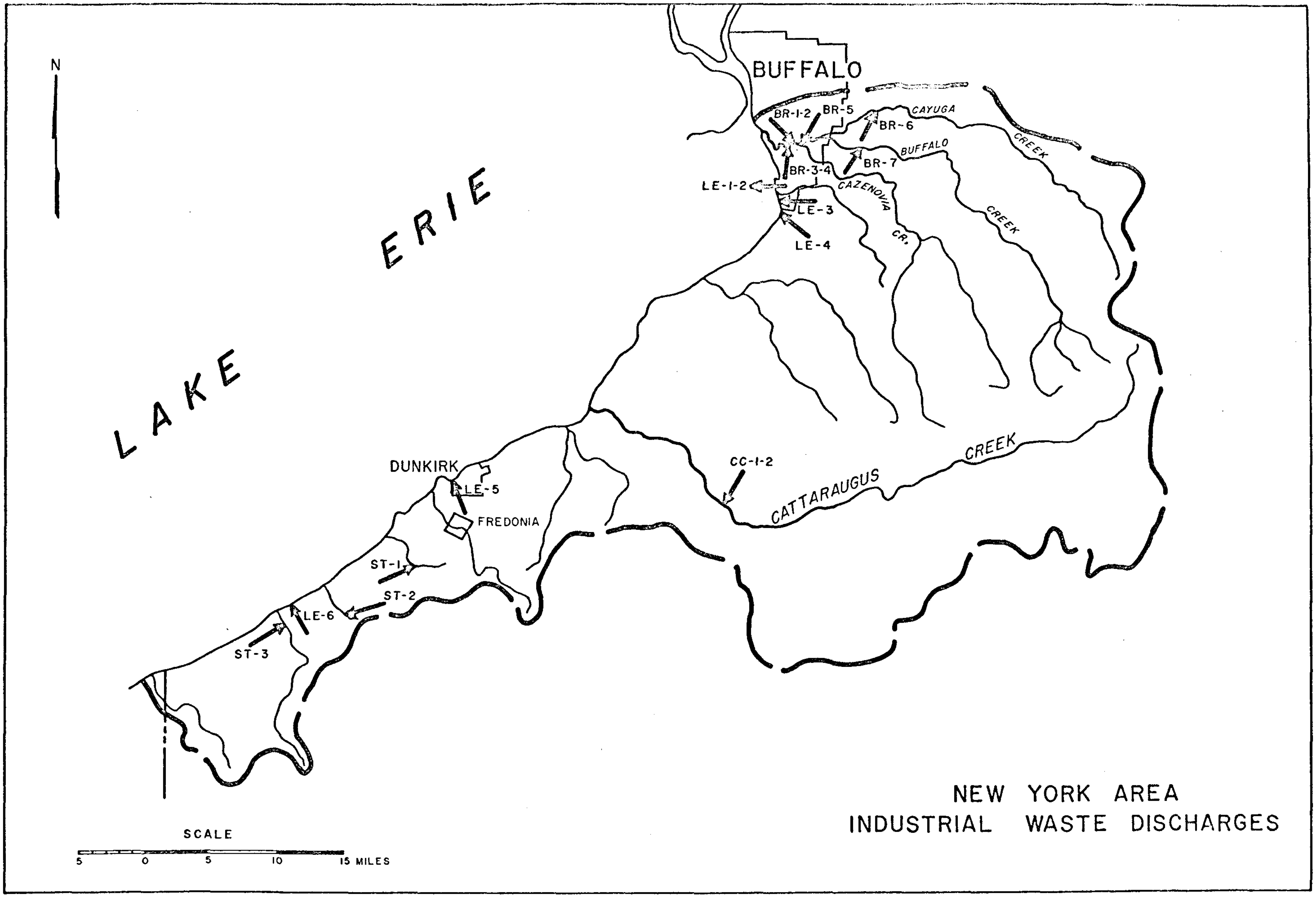
PHOSPHORUS & BOD LOADINGS
MUNICIPAL S.T.P.
NEW YORK AREA



① = RAW
② = LOAD @ PRESENT REMOVAL RATE
③ = LOAD @ 90% REMOVAL RATE
④ = LOAD @ 95% REMOVAL RATE
⑤ = ALLOWABLE LOAD

4-128

Fig 4-35



NEW YORK AREA
INDUSTRIAL WASTE DISCHARGES

TABLE 4-30

MAJOR INDUSTRIAL WASTES
NEW YORK AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	BOD	Other
Buffalo River Basin (BR)							
1-Allied Chemical Buffalo Chemical Division	Buffalo	Buffalo R.	Inorganic chemical		0		pH 5.7-7.0
2-Allied Chemical Buffalo Dye	Buffalo	Buffalo R.	Organic chemicals	14.8	40,000S	45,000	pH 2.5-4.0 COD 80,000 Cl 26,000 Cyanide 12 Iron 7,400 Phenol 145 Color
3-Republic Steel	Buffalo	Buffalo R.	Steel	26.5	15,800x	x	pH 3.7-9.5 COD x, Oil x, Color, Iron 16,300
4-Donner Hanna Coke	Buffalo	Buffalo R.	Coke	6.0	0	x	COD x, Oil <775; Phenols 115
5-Mobil Oil (a)	Buffalo	Buffalo R.	Refinery	22.5	25,000T 2,600S	3,700	pH 7.4-8.0; COD 4,700, Oil 1,500, Cl 2,500, Phenol 379

(a) Plant is discontinuing operations in 1968.
* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x Sufficient data not available for evaluation.

TABLE 4-30 (continued)

MAJOR INDUSTRIAL WASTES
NEW YORK AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day* Solids**	BOD	Other
Buffalo River Basin (cont'd)							
6-Symington Wayne	Depew	Cayuga Cr.	Machining	x		x	pH x, Oil x, Color
7-Pennsylvania Railroad Shops	Gardenville	Buffalo Cr.	Repair Yards	x			Oils x
Cattaraugus Creek Basin (CC)							
1-Peter Cooper Eastern Tanners and Glue	Gowanda	Cattaraugus Creek		3.6	131,000T 9,600S	26,000	
2-Moench Tannery	Gowanda	Cattaraugus Creek		1.7	90,000T 7,600S	8,700	
Small Tributaries (ST)							
1-Welch Grape Juice	Brocton	Slippery Rock Creek	Food processing	x	xS	x	Color
2-Growers Coop Grape	Westfield	Chautauqua Creek	Food processing	x	xS	x	Color
3-Welch Grape Juice	Westfield	Chautauqua Cr. & Lake Erie	Food processing	x	xS	x	Color

* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x Sufficient data not available for evaluation.

TABLE 4-30 (concluded)

MAJOR INDUSTRIAL WASTES
NEW YORK AREA

Industry	Location	Receiving Stream	Type	Flow (mgd)	WASTE CONSTITUENTS-lbs/day*		
					Solids**	BOD	Other
<u>Direct to Lake Erie</u> (LE)							
1-Lehigh Portland Cement	Buffalo	Lake Erie	Cement	x	xS		
2-Hanna Furnace	Buffalo	Lake Erie	Foundry	x	xS		Oil x
3-Bethlehem Steel	Lackawanna	Lake Erie	Steel	350	350,000S	x	pH 4.0-7.0 COD x, Oil 31,000, phenols 680, cyanide 950
4-Penn Dixie Cement (b)	Buffalo	Lake Erie	Cement	x	xS		
5-Allegheny-Ludlum Steel	Dunkirk	Lake Erie	Steel	x	xS		Color, pH x, Oil x, Temp. x, Iron x
6-Seneca Westfield Maid	Westfield	Lake Erie	Food processing	x	xS	x	Color

(b) Plant is currently not in operation.
* Except temperature in °F and pH.
** Solids: T=Total Suspended and Dissolved, S=Total Suspended, and D=Total Dissolved.
x Sufficient data not available for evaluation.

portion of Lake Erie waters are Allied Chemical-Buffalo Dye, Donner Hanna Coke, Hanna Furnace, Mobil Oil, Moench Tannery, Peter Cooper-Eastern Tanners Glue Division, and Republic Steel.

Waste production from industries is expected to double throughout the Lake Erie basin. The industries in the New York area are expected to follow this pattern; however, some of these industries will connect to municipal sewage treatment plants. Figure 4-36 shows the expected raw and discharged BOD from industries which will not connect to city sewerage systems.

Combined Sewers

Of the 21 sewered communities only two are served with a combined system. The municipalities of Dunkirk and Fredonia are both sewered with a combination of separate and combined sewers. Less than 10 percent of the sewered population is served by combined sewers. The City of Buffalo (not included in this report) is served with a combined-separate system. Approximately 100,000 residents of Buffalo are served by combined sewers with overflows discharging to the Buffalo River. There are over 30 overflows on the Buffalo River from the City of Buffalo. During periods of storm runoff these plants with combined sewer systems discharge raw sewage and industrial wastes, mixed with storm water, to the streams. These outfalls constitute a major intermittent source of pollution. The estimated BOD load from the storm water overflow in the New York area is 12,000 pounds per day. With the conversion of all combined

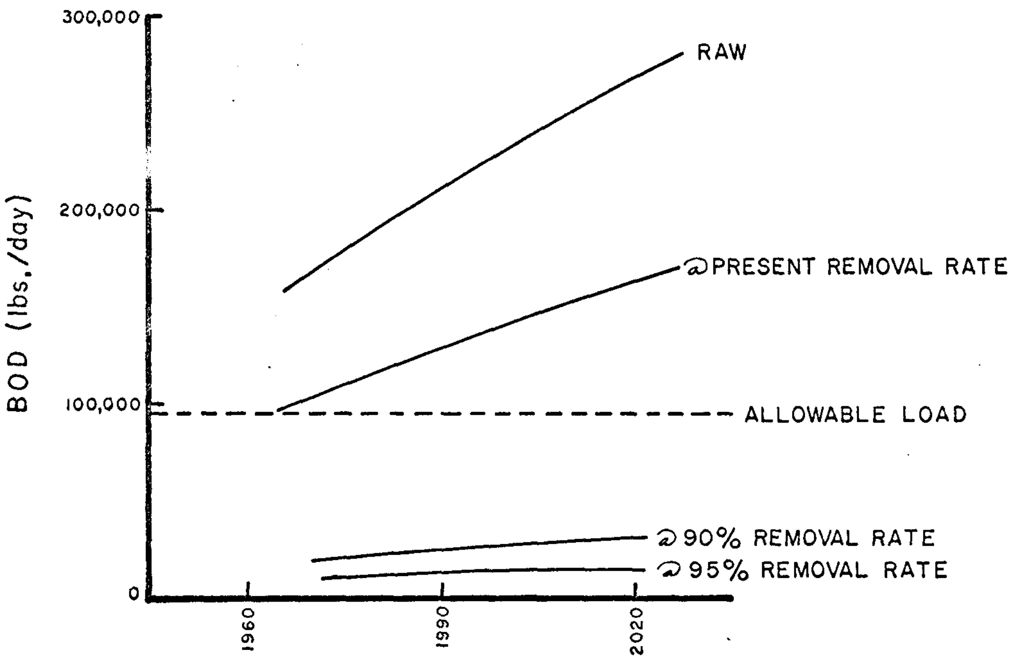

300,000
200,000
100,000
0
BOD (lbs./day)
RAW
@PRESENT REMOVAL RATE
ALLOWABLE LOAD
@90% REMOVAL RATE
@95% REMOVAL RATE
1960
1990
2020

Fig 4-36

sewers to separate sewers the BOD load in 1990 will be 8,000 pounds daily and will be back to 12,000 pounds per day in 2020.

Solid Wastes

There are some locations near the area's waterways which are being used for the disposal of solid wastes. There are dumps in the area ranging from the small one-family size to the large, municipally-operated areas. Presently dumps exist along stream banks in the communities of Cheektowaga, Depew, Gowanda, Lancaster, etc. Dumps never add to the esthetic value of a stream and they may contribute oils, oxygen demand, trash, debris and other wastes.

Disposal of garbage, trash, and other deleterious refuse in the New York area along the streams should be prohibited and existing dumps along the river banks or in the flood plains should be removed.

Agriculture and Land Runoff

Soil erosion causes the addition of silt, nutrients, and other deleterious substances to the area's waterways. The principal sources of these materials are from unstable river banks, highway and subdivision construction and agricultural lands.

In the New York area, sediment loads during high flow are very high due to the steepness of the streams. The sediment loads for the major streams, as computed by the U. S. Geological Survey, are listed below in Table 4-31.

TABLE 4-31

SEDIMENT LOADS - TONS/YEAR

Buffalo River	
Cayuga Creek	110,000
Cazenovia Creek	200,000
Buffalo Creek	150,000
Cattaraugus Creek	610,000

Dredging

There are two harbors in the New York area that are dredged by the Corps of Engineers: Dunkirk Harbor and Buffalo Harbor-Buffalo River and Ship Canal.

Over 600,000 cubic yards of material is dredged yearly from the Buffalo Harbor area. The harbor is maintained at a depth of 23 to 28 feet while the river and ship canal is maintained to a depth of 22 feet.

Presently all dredged materials are deposited in a dumping area adjacent to Bethlehem Steel Company north of Smoke Creek. A new diked dumping area is being constructed for materials dredged from the Buffalo River by the Corps of Engineers. The dike will be extended west from the small boat harbor adjacent to the Niagara Frontier Prot Authority.

The materials from Hanna Furnace's Union Canal and particularly from Bethlehem Steel's Lackawanna Canal, which are dredged by private contract, should also be discharged behind diked areas. The material from the Union Canal contains high concentrations of iron and the material from the Lackawanna Canal and/or Buffalo River contain high concentrations of oil and tars, phenols, organics, etc.

Dunkirk Harbor is dredged primarily for small boat traffic and is maintained at a 16 foot depth. Additional dredging will be done by the Corps of Engineers in order to widen the harbor area for a boat marina. The estimated volume of material dredged by the Corps of Engineers from Dunkirk Harbor is 26,000 cubic yards. The dredged material is dumped into Lake Erie in an area approximately one mile north of the harbor.

Chapter 5

Water Quality Problems

CHAPTER 5

WATER QUALITY PROBLEMS

Sewage, industrial waste, and silt pour into the Lake Erie watershed in incessent amounts. This chapter presents the effects of these wastes on water quality and also on water use in the Lake Erie basin.

Every type of waste discharged in the basin takes its toll in some form or other. The most obvious signs of pollution occur in the tributaries and around the lake shoreline where recreational and water supply uses are greatest. An enigma as menacing as a cancerous growth is also taking its toll in the entire lake, and that is the seemingly inexorable onslaught of premature aging.

The process of lake aging, its ramifications, and limits on the recreational use of the lake are discussed first, followed by a discussion of pollutional effects and use limitations in each of the tributaries. It will be shown that the major pollution problems in the tributaries occur below the large municipal and industrial complexes and that the water quality becomes the poorest as these streams enter the lake.

Lake Erie

Lake Erie is the recipient of most of the wastes dumped into its tributaries; but, because of tremendous dilution and the lake's natural purification capacity, the wastes cause problems of lesser degrees. The lake has two problems which are now critical, not because of incurability, but because of inattention to them. These problems are (1) over-fertilization of the entire lake which is most serious throughout the western basin and along shore and (2) bacterial contamination near shore which is most serious in the vicinity of metropolitan centers where the need for clean water is the greatest.

Lake Erie is naturally the most productive of the Great Lakes, meaning that, without the presence of man, it would be in a more advanced state of fertilization or enrichment (eutrophication). Proof of this lies in the quantity and variety of fishes which inhabited the lake at the turn of the century. see table 5-1. They were the result of the high productive capacity of the waters. At that time Lake Erie had probably reached the ideal in its ability to support a prolific, varied, and balanced aquatic life, while at the same time providing for all the uses which man might make of it. Unfortunately the ideal level in natural lake aging spans a relatively short time in the total aging process. It is near the stage when a lake can become rapidly less satisfactory, when explosive production of a few species of relatively undesirable life forms crowds out many other species which are characteristic of clean water.

Still the ideal level in a lake the size of Lake Erie should hold sufficiently that a change would be practically immeasurable in a man's lifetime. Such is not the case in Lake Erie. Within two generations man has dumped enough fertilizing refuse into the lake to not only make the change measurable but to make it glaringly obvious. The refuse contains excessive quantities of every nutrient known to be necessary to biological production, but the crucial ones are nitrogen and phosphorus. These two nutrients are the prime catalysts for a biological and chemical chain reaction which, if unchecked, can lead to the greatly premature destruction of Lake Erie as a water resource. The inputs of these nutrients are not now being effectively controlled and are increasing at an alarming rate (Figures 4-6 and 4-7). Control can and must be instituted at the earliest possible time for Lake Erie to return to its normal rate of aging.

Bacterial contamination of nearshore waters ranks in severity along with over-fertilization. Mid-lake waters, beyond a mile or so from shore, are generally very acceptable in this respect. However, upon approaching the shore in many locations, the waters are unfit a great deal of the time for body-contact uses. In general, the most severe contamination fronts metropolitan areas, and the larger the metropolitan area, the more severe the condition (Figure 5-7).

Sources of bacterial contamination are treated or untreated sewage discharges, industrial wastes, combined sewer overflows, storm sewer discharges, and general land runoff. Usually, however, the most severe contamination is associated with storm sewer overflow and sewage discharges, although at Sterling State Park in Mich paper mill wastes are a significant cause

Other less harmful substances have been found in Lake Erie which for the most part indicate general deterioration although they may or may not cause special harm, in themselves, for many uses. Such problems are turbidity, siltation, total dissolved solids, chlorides, manganese, iron, and general refuse.

The following description attempts to show the specific interferences or problems in various water uses in Lake Erie. It should be noted that many problems result from another problem, the change in aquatic biology; therefore, the causes for this change will be dealt with in some detail.

Aquatic Biology

An explanation of changes in aquatic biology begins at the bottom of the food chain in primary productivity or the conversion of inorganic to organic compounds. This is the event which initiates the most awesome problems in Lake Erie.

Many elements plus sunlight are necessary for the conversion of inorganic substances to organic matter and energy. The bulk of primary organic matter is comprised of carbon, hydrogen, and oxygen (carbohydrates). However many other substances act as catalysts controlling the conversion. The two prime ones in Lake Erie, as mentioned previously, are nitrogen and phosphorus.

Nitrogen is believed to be an abundant element in Lake Erie with or without the presence of man; therefore, its abundance is difficult to control in adequate amounts. However, phosphorus is abundantly introduced by man; it limits productivity in the central and eastern basins; it facilitates high productivity in the western basin and nearshore everywhere; and it can be controlled. Therefore it offers the possibility of limiting productivity at all places in Lake Erie.

High primary productivity in western Lake Erie and along the entire lake shore can be directly correlated to phosphorus levels in these areas. These levels average above 0.010 mg/l soluble inorganic phosphorus and 0.030 as total phosphorus (organic plus inorganic), which are considered as limiting levels (Figure 5-1). These levels approximate the average levels of the mid-lake central and eastern basins where excessive productivity is not now a normal problem.

Excessive primary productivity, resulting from over-enrichment, leads quickly to a change in the primary (algae) balance from a wide variety of forms with relatively few numbers of each to a narrow variety with superabundance of each. This has been demonstrated in Lake Erie (Figure 5-2). Unfortunately, ~~also~~ accompanying this change is also a change from clean-water forms to undesirable pollution-tolerant forms, and this characteristic extends farther up the food chain.

Large numbers of algae of course produce large numbers of dead organisms. While living, algae reproduce in the trophic (sunlit) zone near the surface, often releasing oxygen in quantities sufficient to raise the dissolved oxygen concentration to 130 percent of saturation or more in their zone of existence. However upon dying they sink to the bottom. This leads directly to the next change in the food chain.

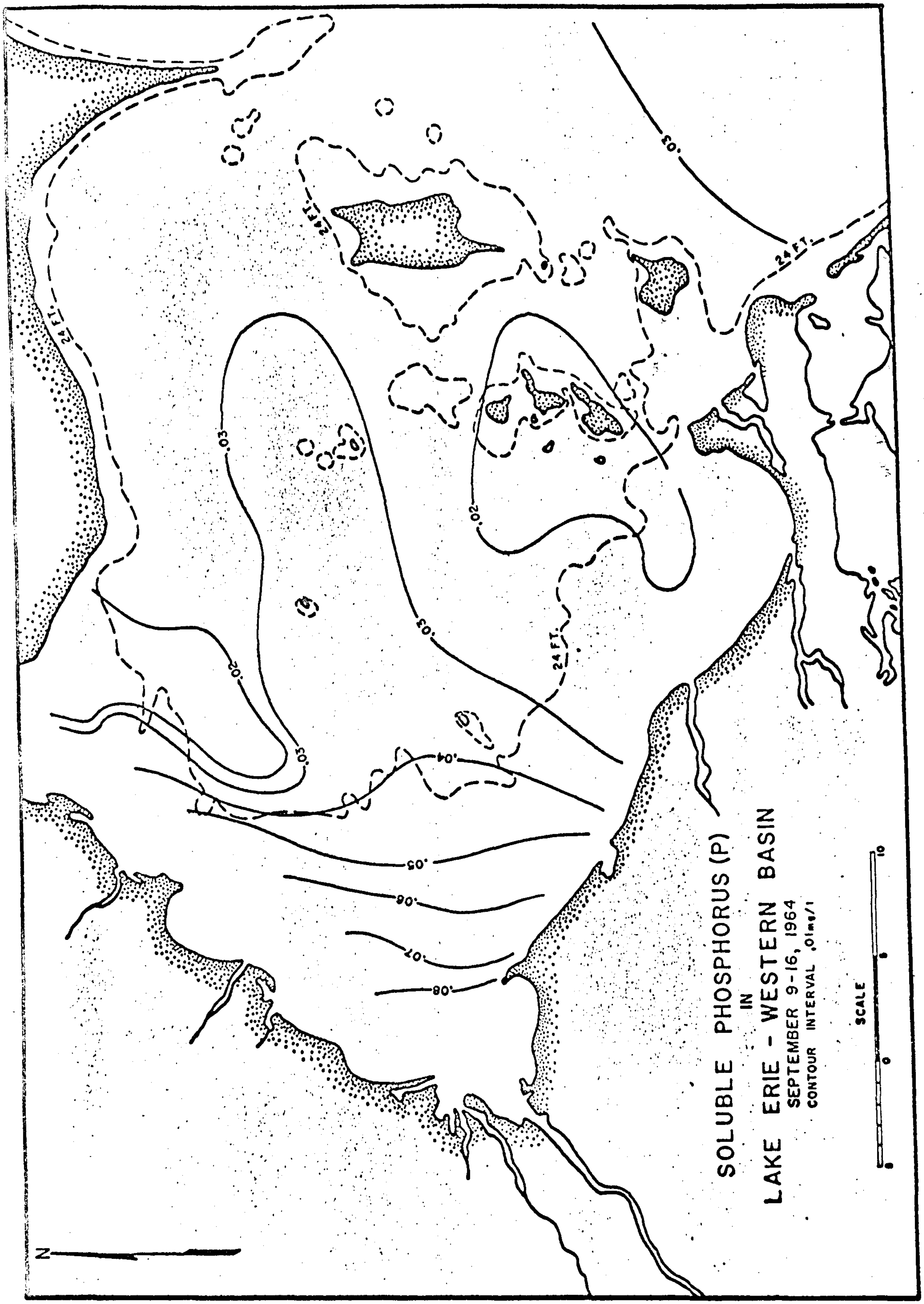
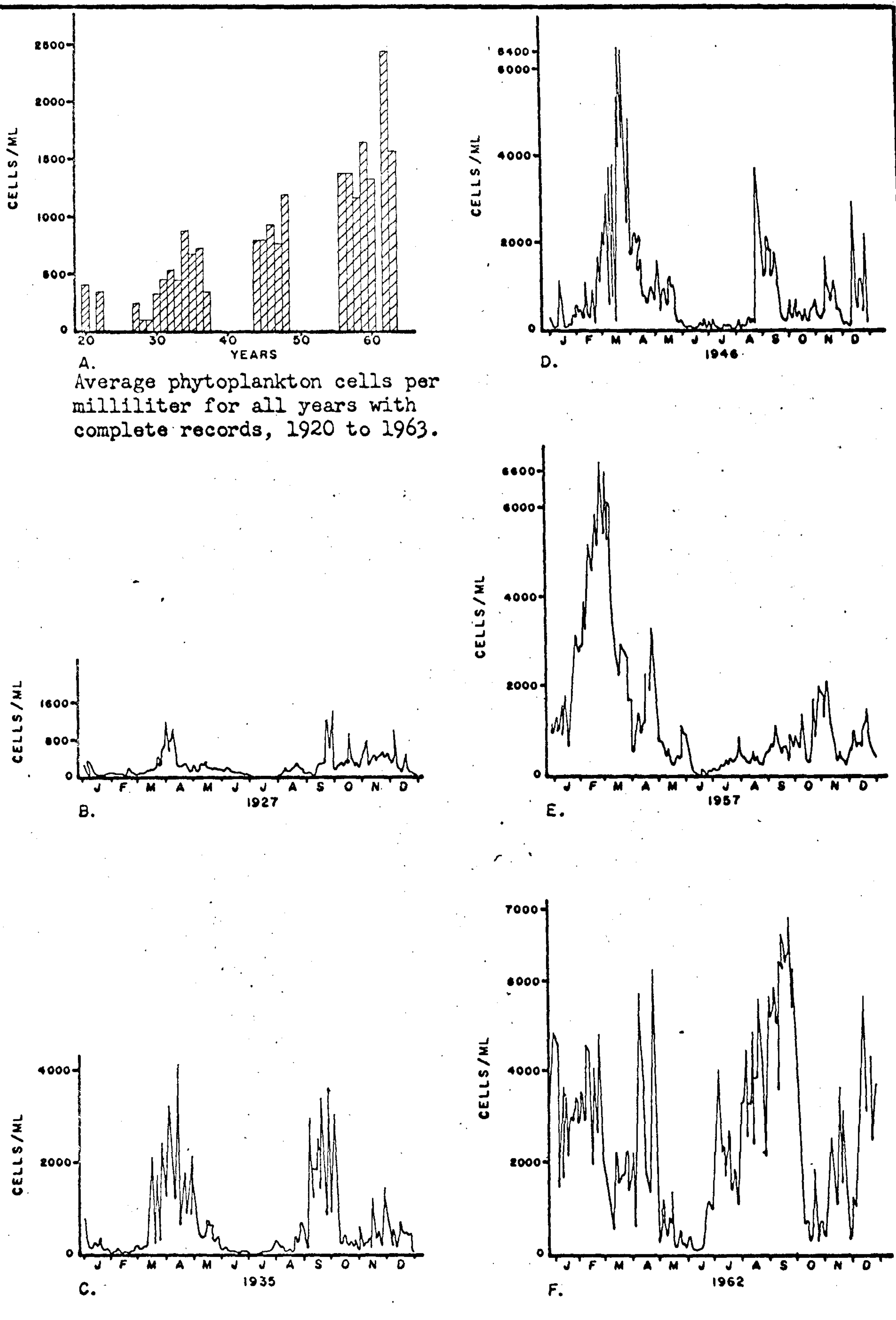

SOLUBLE PHOSPHORUS (P)
IN
LAKE ERIE - WESTERN BASIN
SEPTEMBER 9-16, 1964
CONTOUR INTERVAL .01 mg/l
SCALE
0
5
10
N
24 FT.
.02
.03
.04
.05
.06
.07
.08

FIGURE ~~6-4~~ 5-1



PHYTOPLANKTON ABUNDANCE

LAKE ERIE (CLEVELAND WATER INTAKE RECORDS)

FIGURE ~~6-16~~ 5-2

Dead organisms, while sinking through the water, consume oxygen in decomposition. Some numbers of these organisms reach the bottom and the waters just above the bottom. If the water is thermally stratified, the hypolimnion is not mixed with the water above and it contains a definitive amount of dissolved oxygen with no source of replenishment. If a large amount of dead organic matter is present, oxygen is consumed very rapidly and may entirely disappear from the hypolimnion water. Movement of the hypolimnion, caused by wind (Refer to Chapter 2 - Lake Temperature Section), can re-suspend bottom materials, increasing the rate of depletion.

Hypolimnion oxygen depletion now commonly occurs in summer in the western basin intermittently and in the central basin for a continuous period of a month or more (Figure 5-3). ~~It is quite possible that~~ The depletion in the central basin results in part from the transport of algae, dead or alive, from the western basin and from nearshore areas in the central basin.

Oxygen depletion should, in quiet water, occur at the sediment-water interface, without thermal stratification if the organic content of the sediment is high. This may be important in the western basin.

If the bottom water oxygen content is high and the bottom sediments are ideal, significant numbers of many types of organisms, including large numbers of so-called pollution-sensitive organisms such as Hexagenia (mayflies) and Tricoptera (caddisflies) may be found. When oxygen is depleted significantly and consistently the benthos changes to a preponderance of pollution-tolerant organisms (Figure 5-4), but in less numbers (Figure 5-5), which are able to withstand

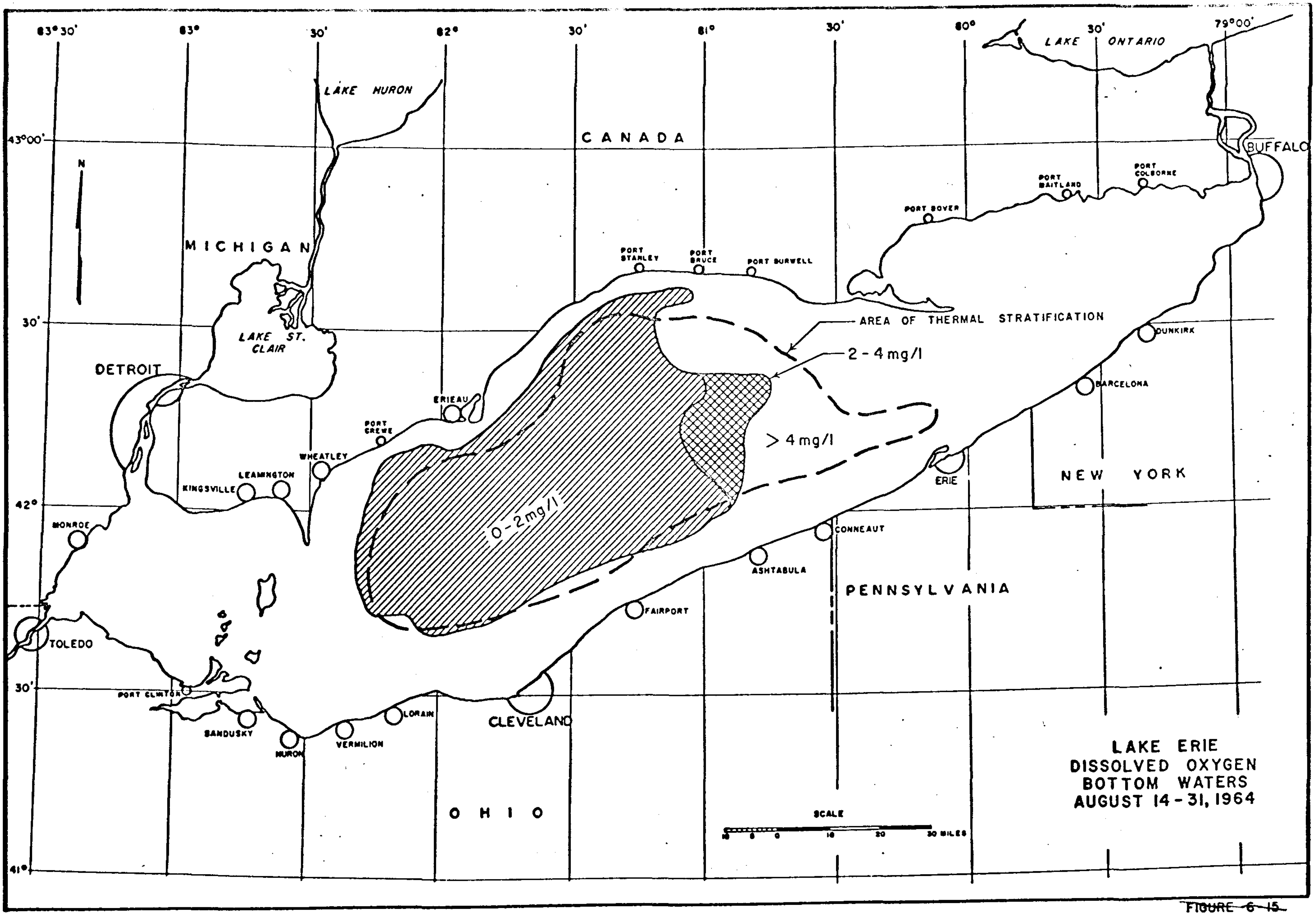


FIGURE 6-15

Fig 6-3

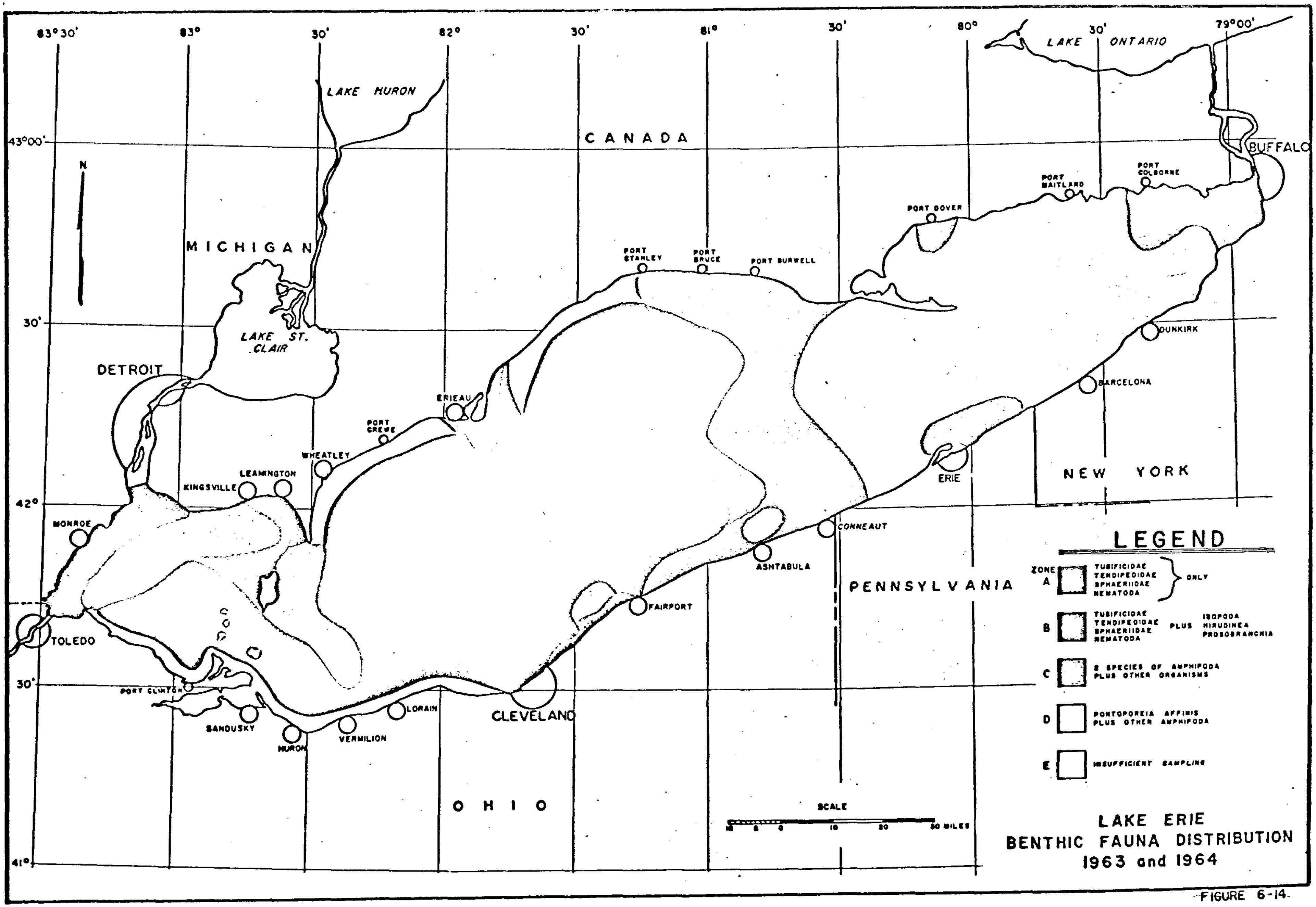
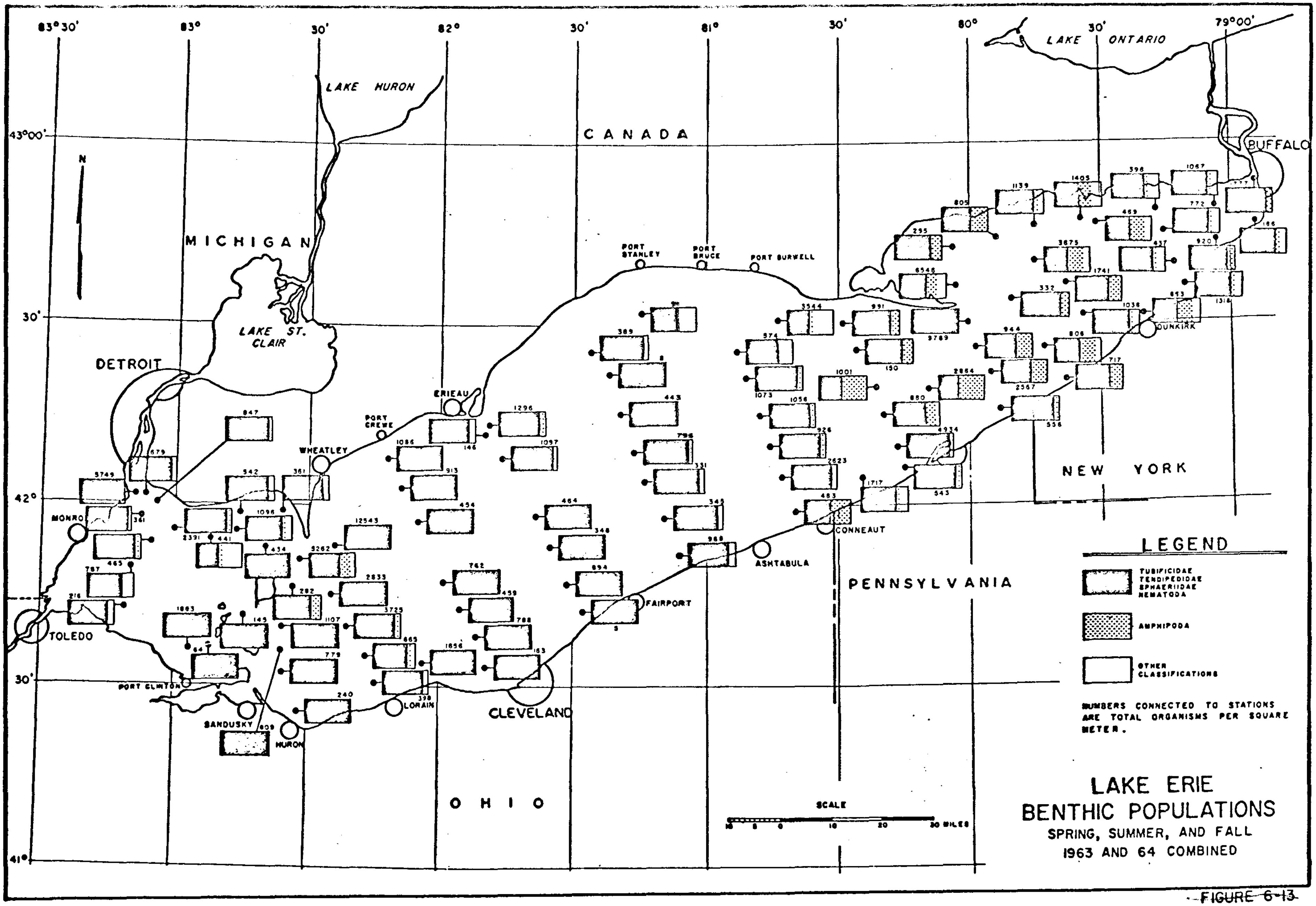

83°30'
83°
30'
82°
30'
81°
30'
80°
30'
79°00'
43°00'
30'
42°
30'
41°
LAKE HURON
LAKE ONTARIO
CANADA
MICHIGAN
LAKE ST. CLAIR
DETROIT
BUFFALO
PORT COLBORNE
PORT MAITLAND
PORT DOVER
PORT STANLEY
PORT BRUCE
PORT BURWELL
DUNKIRK
BARCELONA
ERIEAU
PORT CREWE
WHEATLEY
LEAMINGTON
KINGSVILLE
MONROE
ERIE
NEW YORK
CONNEAUT
ASHTABULA
PENNSYLVANIA
FAIRPORT
TOLEDO
PORT CLINTON
SANDUSKY
HURON
VERMILION
LORAIN
CLEVELAND
OHIO
N
LEGEND
ZONE A TUBIFICIDAE TENDIPEDIDAE SPHAERIIDAE NEMATODA ONLY
B TUBIFICIDAE TENDIPEDIDAE SPHAERIIDAE NEMATODA PLUS ISOPODA HIRUDINEA PROSOBRANCHIA
C 2 SPECIES OF AMPHIPODA PLUS OTHER ORGANISMS
D PONTOPOREIA AFFINIS PLUS OTHER AMPHIPODA
E INSUFFICIENT SAMPLING
SCALE
10 5 0 10 20 30 MILES
LAKE ERIE
BENTHIC FAUNA DISTRIBUTION
1963 and 1964

FIGURE 6-14.



LAKE ERIE
BENTHIC POPULATIONS
SPRING, SUMMER, AND FALL
1963 AND 64 COMBINED

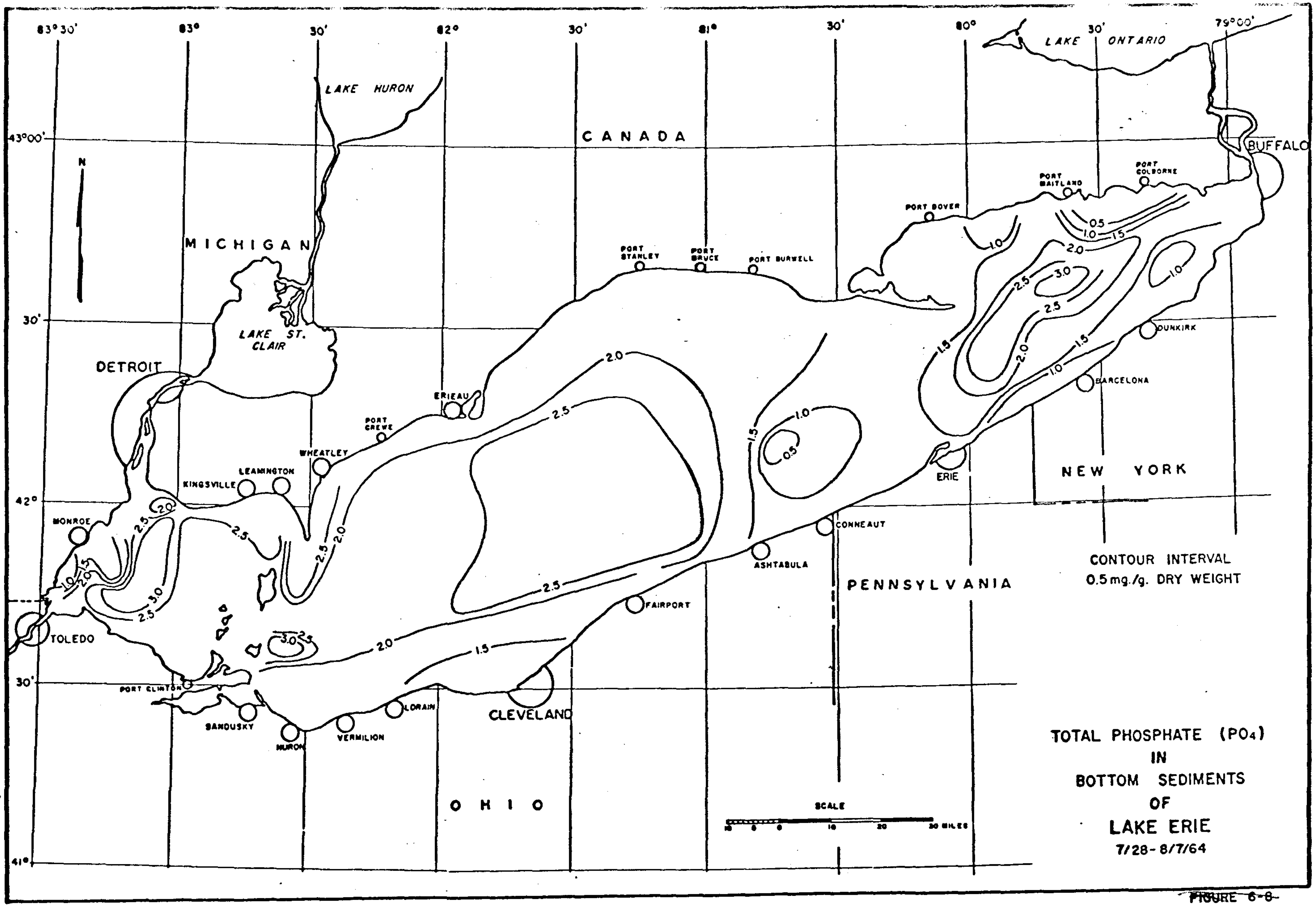
FIGURE 6-13

low oxygen levels. Tubificidae (sludgeworms) and Tendipedidae (bloodworms) are such organisms. Pollution-sensitive organisms may disappear. This has happened to Hexagenia in Lake Erie which formerly was the most abundant benthic organism in the western basin. It virtually disappeared in the mid-1950's.

The pollution-sensitive benthic organisms are apparently preferred by the more desirable carnivorous fishes as food. Thus a change to pollution-tolerant forms, characteristic of oxygen-deficient zones has interfered with their food supply and has had some effect in reducing the numbers of the more desirable species and increasing the relative abundance of scrub fish whose food supply has not been interrupted but perhaps increased by the same phenomena.

Fish are not only affected by a change in their food supply but they are directly affected by their inability to even survive in low oxygen waters. Thus even though the benthic food supply might be sufficient, it is essentially not available at many places during times of oxygen deficiency in bottom waters.

A further complication of low oxygen levels in bottom waters is that they lead to the re-cycling of nutrients from the bottom sediments back into the water, thus tending toward a self-perpetuating nutrient system. A plentiful supply of phosphorus exists in the bottom sediments of the lake (Figure 5-6). ~~The phosphorus content of the bottom sediments is two or three times the content of older lake sediments on land.~~



TOTAL PHOSPHATE (PO_4)
IN
BOTTOM SEDIMENTS
OF
LAKE ERIE
7/28-8/7/64

FIGURE 6-8

Fig 6.6

The Phosphorus Problem - The phosphorus problem is not all so simple in Lake Erie. As stated previously phosphorus is now the limiting nutrient in the mid-lake waters of the central and eastern basins. It is so plentiful in the western basin and along the shore that it is probably not limiting.

A phosphorus balance for Lake Erie shows that at least two-thirds of the phosphorus discharged to the lake is retained in the lake, being stored mainly in bottom sediments. The phosphorus content of the bottom sediments is two or three times the content of older lake sediments on shore. The mechanisms of the phosphorus retention and phosphorus cycle are not well understood in any lake, being problems of both biochemistry and geochemistry. It is known that sediments will normally accumulate phosphorus much faster than they will release it.

Soluble inorganic phosphorus is available for algal nutrition. The remainder of the phosphorus content in the water is tied up chemically in inorganic sediments and organic matter, mainly in the latter. Measurements made in tributary discharges and in Lake Erie indicate the following average ratios of soluble to total phosphorus:

Tributaries	1:1.7
Western Lake Erie	1:2
Central Lake Erie	1:3
Eastern Lake Erie	1:4

A study of the phosphorus distribution in Lake Erie indicates that (1) a rapid reduction of phosphorus concentration occurs within the western basin water before this water reaches the central basin (Figure 5-1), (2) phosphorus levels average fairly constant in the central basin water, and (3) total phosphorus levels increase slightly in the eastern basin water.

The natural reduction of phosphorus levels in the western basin of Lake Erie apparently results from chemical and mechanical precipitation and from the productivity uptake and subsequent organic deposition. Almost two-thirds of the phosphorus contribution to Lake Erie, nearly 100,000 pounds daily, is discharged into the western basin, yet only some 30,000 pounds daily can be accounted for in the discharge from the western basin. About the same amount or a little more is transferred daily from the central to the eastern basin and about 40,000 pounds daily is discharged via the Niagara River.

The fairly constant average level of phosphorus concentration in the central and eastern basin water indicates that some sort of balance system is in operation in these basins, and the balance system must involve sediment-water phosphorus exchange. It is likely that the average phosphorus level in the water of these two basins will maintain itself as long as there is phosphorus available in the bottom sediments in adequate amounts. However this will not cause serious problems because serious problems do not currently exist in mid-lake surface waters of these two basins.

The immediately desirable objective in phosphorus control should be to bring the concentrations in the lake into areal uniformity. The high levels of the western basin and nearshore waters should be reduced to the average level of the mid-lake waters of the central and eastern basins. This should reduce productivity accordingly. Because of lake nutrient re-cycling the reduction would likely be gradual instead of sudden and immediate.

It is very likely that in the western basin that a reduction of lake input from the present in-basin loading of 80,000 pounds per day of phosphorus to 22,000 pounds would solve the immediate problem of over-enrichment. This would require a 92 percent reduction of phosphorus from municipal and industrial wastes in the area. Maintenance of this level of input would require 96 percent removal in 1990 and 100 percent in 2020 from municipal and industrial wastes. These recommendations assume that at least 20 percent of the remaining discharge of phosphorus, primarily from urban and rural runoff, will be chemically or mechanically bound in bottom sediments and will not be available as a nutrient except in the balance exchange process.

Essentially the same degree of treatment of municipal and industrial wastes will be required in the remainder of the basin to prevent excessive productivity in nearshore waters. Because a 100 percent degree of treatment in 2020 will be difficult to attain, other sources of phosphorus, such as runoff, must be limited.

Fishing

The above description indicates the water quality problems which may be most detrimental to fishing in Lake Erie, both sport and commercial. Other pollution factors, such as silting of spawning beds which may smother fish eggs, suffocation of hatching fish by lack of oxygen due to organic deposition, toxicity and flesh tainting of tributary waters from raw wastes, turbidity, and release of intolerable substances from bottom sediments such as sulfides, all contribute to the decline of various fishes. In addition, over-exploitation of certain prized species, while leaving rough fish to proliferate, has assuredly contributed to the shift in species abundance. And still further, man has caused the introduction of undesirable species to compete for food. The relative effects of each of these factors have not yet been ascertained, much less the effects of natural evolution. Clearly and unfortunately all factors related to man's activities have been detrimental.

Commercial fish catch statistics, gathered by the U. S. Bureau of Commercial Fisheries, have provided a long record of the relative abundance of desirable fish species in Lake Erie (Tables 5-1 and 5-2). In recent years, continuing surveys have been introduced by federal and state agencies on the reproduction phase of the life cycles of fishes and limited predictions of near-future populations are now possible.

The sturgeon almost disappeared from catch statistics at about the turn of the century. The cisco, once the dominant species of the commercial catch, experienced a sudden decline in 1926, showed a slight recovery, and declined to insignificance in 1957. Whitefish declined drastically in the commercial catch in 1955. The walleye began a drastic decline in 1957 and is still in great distress. The blue pike, which formerly produced several million pounds per year, became nearly extinct in 1958.

The yellow perch has managed to hold its own, but it also shows signs of weakening in the commercial catch. It is the only plentiful fish remaining of the former many prized varieties. The smelt is now commercially exploitable and it, along with yellow perch, is sustaining the fishing industry in Lake Erie.

The capacity of Lake Erie to support fish, considered as a total population of all species, has apparently been maintained and may be increasing. This means that the habitat is changing in favor of such fish as carp, alewife, shad, sheepshead, etc. These are generally considered as indicators of general water quality degradation.

Massive adult and near-adult fish kills occur in Lake Erie and have occurred on various occasions for many years. These kills are not associated with the decline of desirable species. Species which have been susceptible to kills have commonly been perch, white bass, alewife, smelt, gizzard shad, and carp. Kills seem to be more common in the months of June and August and may be associated with some sort of algal poisoning. Occasionally during times of large commercial catches, the appearance of a local kill may be given by the discarding of fish from commercial fishing operations. Sometimes fish kills have been called natural die-off, but this does not appear to be a good explanation. At any rate, it does not appear that massive fish kills have had a measurable effect on any species in Lake Erie.

Commercial fishing is suffering economically because of the decline of desirable fishes. It does have another problem which is minor by comparison and this is the fouling of nets and lines by algae, primarily Cladophora. This again is caused by the excessive stimulation of nutrients.

Recreation and Tourism

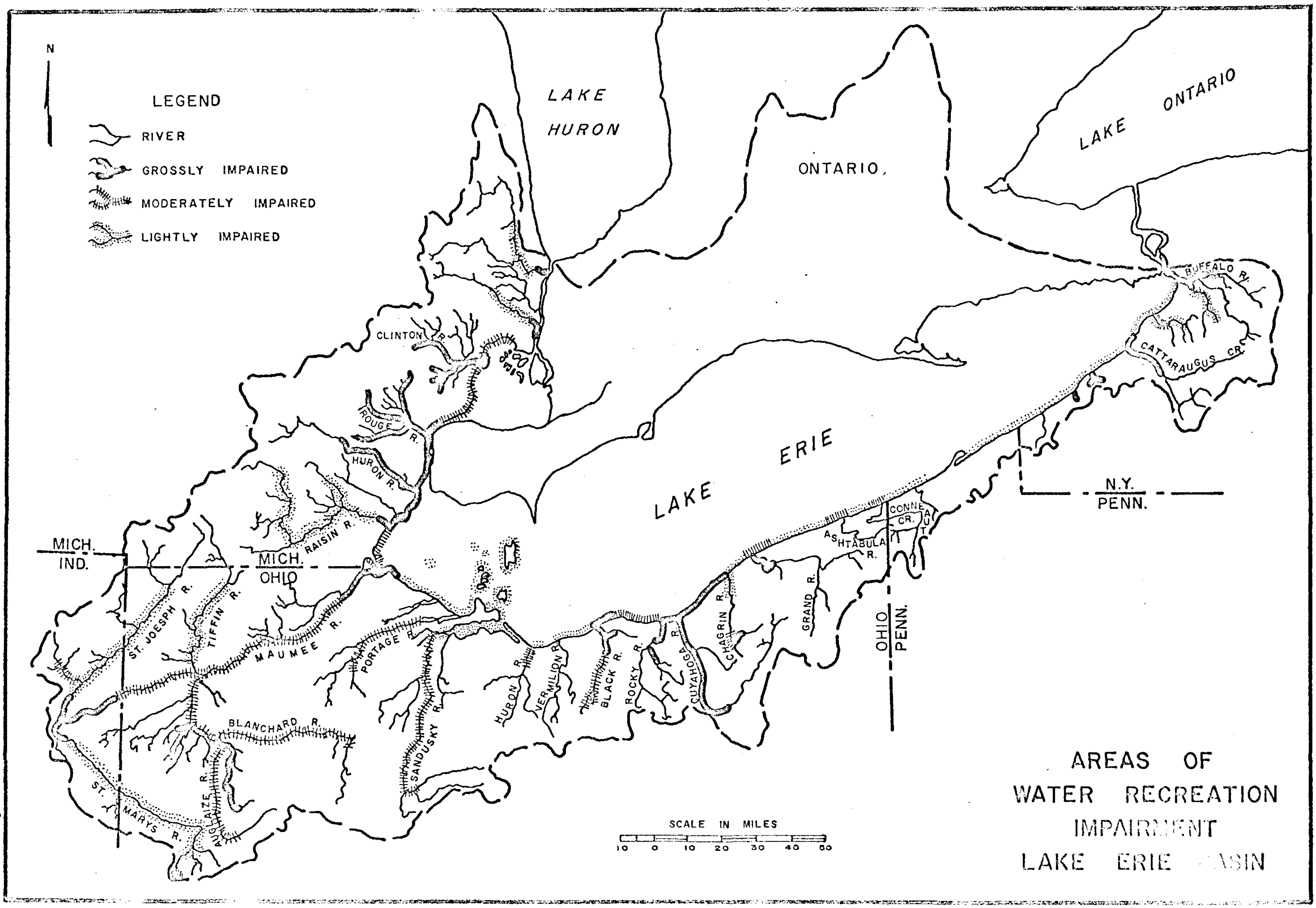
Water quality problems of recreation and tourism receive the most attention because most of them are so obvious to so many people when they come into direct contact with the lake water.

Figure 5-7 depicts the relative pollution impairment to recreational activities in the Lake Erie basin as compiled by the Bureau of Outdoor Recreation and revised by the Federal Water Pollution Control Administration. This figure in general is not intended to be precise, but it serves to show the differences from one area to another. Degrees of impairment have been divided into light, moderate, and gross with the following definitions by the Bureau of Outdoor Recreation:

Waters lightly impaired were considered to be those on and in which recreational activities involving body contact with the water could be freely engaged in. Such waters, however, are not aesthetically pleasing at least part of the recreational season due to man's activities in the area. These activities would include mining, gravel washing, canning, sewage treatment and similar activities.

Waters moderately impaired were considered to be those on which recreational activities not involving body contact with the water could be freely engaged in. Some persons may engage in water activities involving body contact, but most people shy away from such activity.

Waters grossly impaired were considered to be those on and in which most people would not engage in activities requiring body contact with the water, and many would not engage in activities on the water. Much of the time such waters would be aesthetically displeasing due to such conditions as algae growth, dead fish, oil slicks, floating debris, and raw sewage.



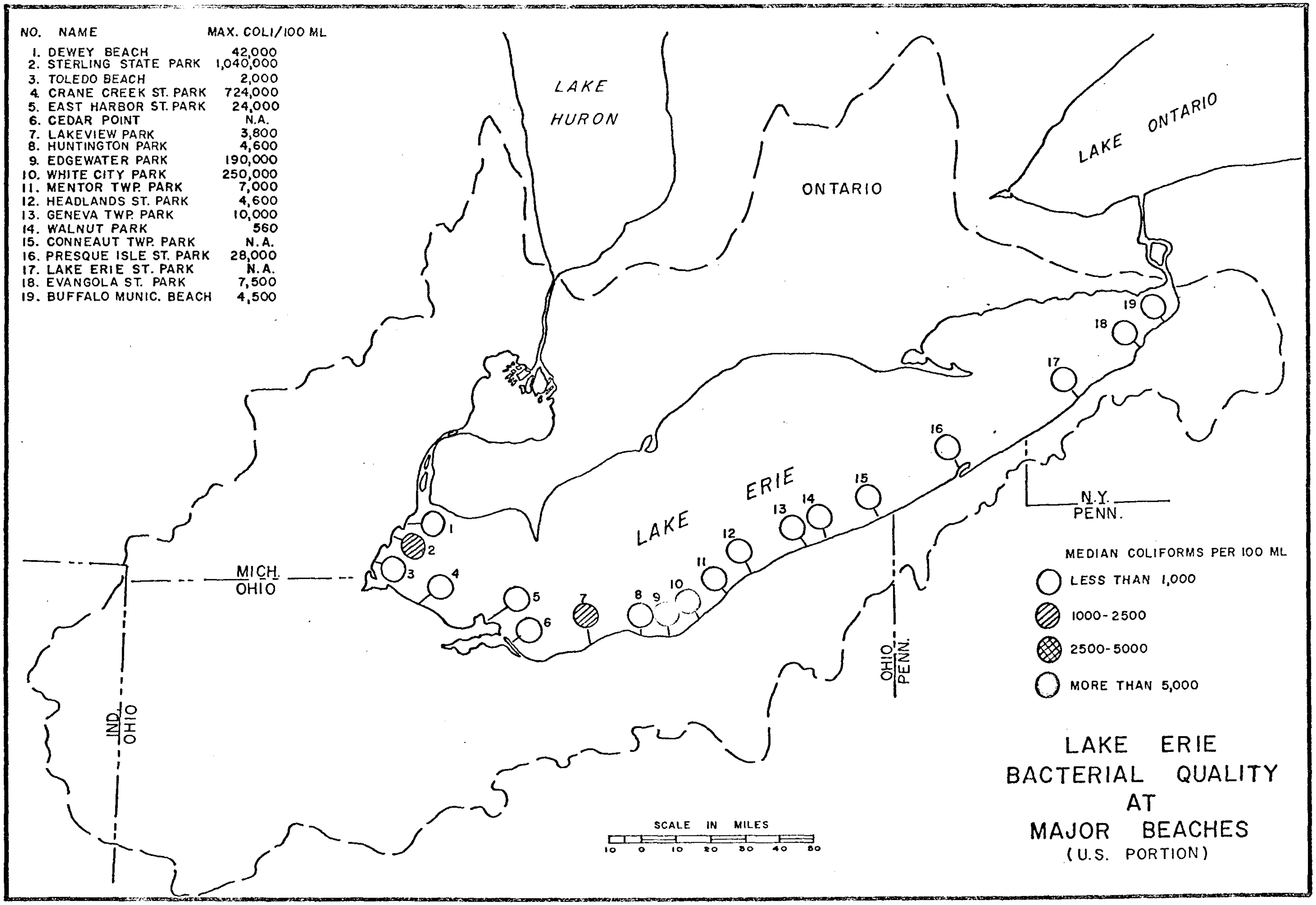
AREAS OF
WATER RECREATION
IMPAIRMENT
LAKE ERIE BASIN

Among the factors taken into consideration were the past records and reports of such agencies as the Michigan Water Resources Commission, the New York State Department of Health, and the Ohio Department of Natural Resources. When available, records of coliform counts were used.

Nearshore waters support the greatest recreational use concentration in Lake Erie in such activities as swimming, water skiing, small boating, and sport fishing. At many, if not most, places along the shore these activities are interfered with in some degree by one or more of the following factors: bacterial contamination, dead and dying algae masses, dead fish, turbidity, and general refuse or solid wastes.

Beaches open to the public receive the largest numbers of visitors, especially on warm summer weekends. Many of the beaches' waters are either continuously or intermittently contaminated with large numbers of bacteria as measured by total coliforms (Figure 5-8), fecal coliforms, fecal streptococci, and total bacterial plate counts. In general the worst conditions are near metropolitan centers. The Cleveland lakefront, for example, is the most grossly contaminated area along the Lake Erie shore as a result of sewage and storm water discharges. Yet the demand is so intense that many areas are heavily used regardless of contamination.

Bacterial and/or chemical contamination is generally very great in all major harbors and most smaller ones. These waters in most cases are so heavily contaminated that they are completely unfit for any kind of



LAKE ERIE
BACTERIAL QUALITY
AT
MAJOR BEACHES
(U.S. PORTION)

Fig. 5-8

body contact use including fishing. Swimmers usually recognize the danger but many harbor areas are used extensively for water skiing and fishing. The most severely contaminated harbor areas are at Detroit, Monroe, Toledo, Lorain, Rocky River, Cleveland, Ashtabula, and Buffalo. Coliform counts in the hundreds of thousands per 100 ml are common. However they persist for only a short distance into the lake, generally less than one mile. Background lake concentrations average less than 100 organisms per 100 ml.

In nearly all areas where total coliform counts are high, fecal coliform and fecal streptococci counts are also high, indicating contamination from sewage. Enteroviruses, such as Salmonella, have been found in harbor waters but not at lake beaches.

Less dangerous but far more widespread is the problem of littering of beaches and nearshore waters by growing, dead, dying, and decaying algae, primarily Cladophora. Masses of algae can be found at nearly all places along the shore in summer causing unpleasant sights and odors. These algae problems decrease shore property values, decrease tourism, and present clean-up problems. Esthetic values are greatly reduced.

Activities with which algae physically interfere are swimming, boating, and fishing. Swimming or wading through masses of algae, although perhaps not particularly harmful, is an unpleasant experience to say the least. Algae foul engine propellers and engine cooling systems of small boats and also foul fishing lines.

Dead fish present problems similar to algae on beaches and during massive fish kills they may become highly offensive at any place along the shore.

Turbidity is mainly an esthetic problem in nearshore waters throughout the lake and interferes with underwater visibility. It is not generally a nuisance otherwise.

Solid wastes (trash) are dumped in the tributaries and along shore. These cause esthetic problems and swimming and boating safety problems. The safety problems from this cause, resulting from such things as broken glass, logs, and scrap metal, are serious at all times but especially dangerous at night. Again these problems are most serious near centers of large population.

Municipal Water Supply

Lake Erie is an outstanding source of municipal water supply in both quantity and quality. It has no especially deleterious chemical constituents as indicated in Table 5-[illegible], listing intake water quality at various intakes and in Table 5-4, summarizing the FWPCA lake-wide surveys of 1963 and 1964.

Municipal water supply from Lake Erie does have problems of filter clogging, tastes and odors, and in some places suspended solids. All of these problems frequently are caused by algae, and large algae populations are the main causative factor in lake supply problems. In general the problems are worst in the western basin, and decrease eastward.

Some blue-green algae produce offensive tastes and odors in their biochemical structure. Over-abundance of these leads to shorter filter runs and the need for carbon filtration, thus increasing costs.

Some algae also concentrate coloring substances, such as manganese, TABLE ~~6-21~~ 5-3

RAW WATER QUALITY AT SELECTED WATER INTAKES

	Total Solids mg/l		Alkalinity mg/l $CaCO_3$		pH		Chlorides mg/l		Turbidity units		NO_3 mg/l		Hardness mg/l $CaCO_3$	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Monroe	--	--	75	122	7.9	8.9	12	81	5	1,350	--	--	116	240
Toledo	167	282	72	140	7.6	8.9	15	36	5	148	0.5	1.0	103	234
Sandusky	193	265	91	113	7.7	8.5	11	21	5	1,560	0.0	1.5	138	166
Lorain	178	286	80	99	7.8	8.7	16	27	1	140	0.1	2.5	116	138
Cleveland (Crown)	170	220	83	104	7.4	8.6	19	28	2	190	0.0	0.5	118	133
Ashtabula	192	217	87	110	7.7	8.2	21	30	5	260	0.0	1.0	130	148
Erie														
Buffalo	156	254	80	92	7.9	8.6	18	23	4	40	--	--	120	142

TABLE 5-4

LAKE ERIE WATER CHEMISTRY SUMMARY - 1964
(mg/l unless otherwise noted)

Parameter	Western Basin			Central Basin			Eastern Basin		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
COD	29.0	1.1	10.4	16.0	3.1	7.1	27.0	4.7	7.4
Conductivity 25°C (μmhos/cm)	364	196	272	353	254	300	328	284	301
Dissolved Solids	220	110	162	239	137	178	233	150	179
Total Solids	250	140	181	218	159	185	240	167	188
Alkalinity	114	81	94	103	81	95	112	83	97
Chlorides	34	10	21.3	46	19	24.5	31	21	24.5
Sulfates	35	9	17.7	43	15	22.4	29	17	23.4
Calcium	43	28	33.9	49	32	39.5	49	36	40.5
Magnesium	11	7	8.7	14	7	10.0	14	7	10.0
Potassium	4.5	1.0	1.5	1.6	1.1	1.3	1.9	1.1	1.3
Sodium	19.0	5.5	9.9	17.0	8.3	11.0	15.0	8.6	10.9
Silica	5.0	0.3	1.20	9.6	0.2	0.68	3.5	0.2	0.47
ABS	0.14	0.01	0.067	0.20	0.02	0.065	0.15	0.03	0.065
Soluble Phosphate	0.333	0.003	0.032	0.040	0.000	0.010	0.037	0.000	0.010
Total Phosphate	----	----	0.065	----	----	0.030	----	----	0.040
Ammonia Nitrogen	0.77	0.01	0.159	0.39	0.01	0.086	0.32	0.00	0.086
Nitrate Nitrogen	1.50	0.02	0.124	0.84	0.00	0.090	0.85	0.01	0.090
Organic Nitrogen			0.36			0.25			0.24

in their cellular structure. These may cause coloring of tap water and staining of fixtures. They are sometimes difficult to control.

Excessive turbidity or suspended solids occur in the western basin at times, thus again raising the cost of treatment.

Until now water treatment plants have been discharging their treatment sludge back into Lake Erie. Thus they are creating or prolonging a pollution problem on their own.

Industrial Water Supply

Industries which independently withdraw water from Lake Erie generally obtain water of lower overall quality than that of municipal supply because their intakes are closer to shore. Industry in general does not require water of such high quality although some uses require elaborate pre-treatment.

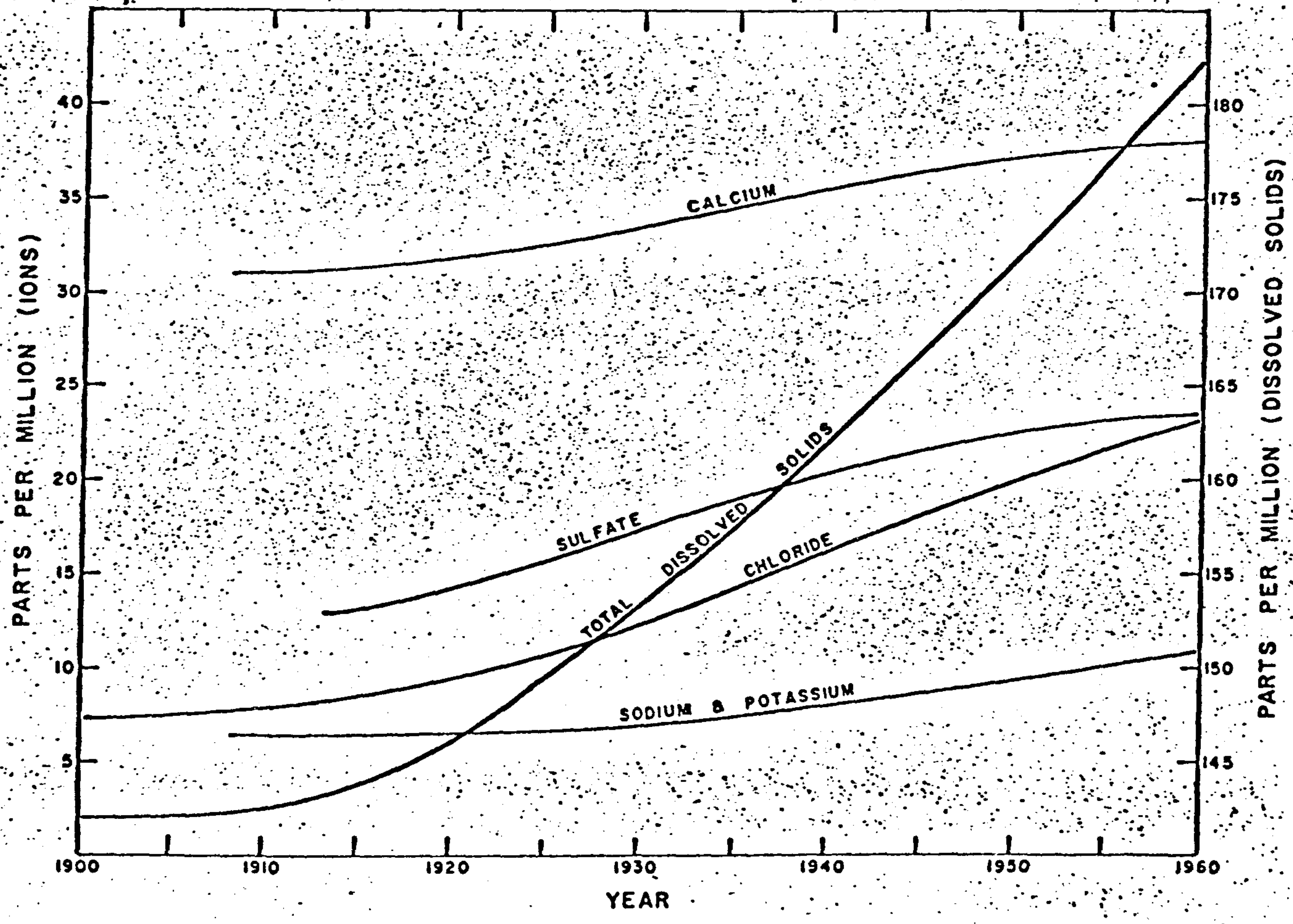
Industrial intakes are clogged occasionally by algae and by dead fish and debris. Turbidity and dissolved solids cause scale to form, especially in cooling and heating uses.

Industries, especially along tributaries, cause severe problems to themselves and others by using water to flush wastes back to the tributaries. Depending upon the industry a variety of obnoxious substances, some of which may be toxic, are released. Fortunately many industrial uses can withstand economically their own quality degradation.

General Lake Erie Water Quality

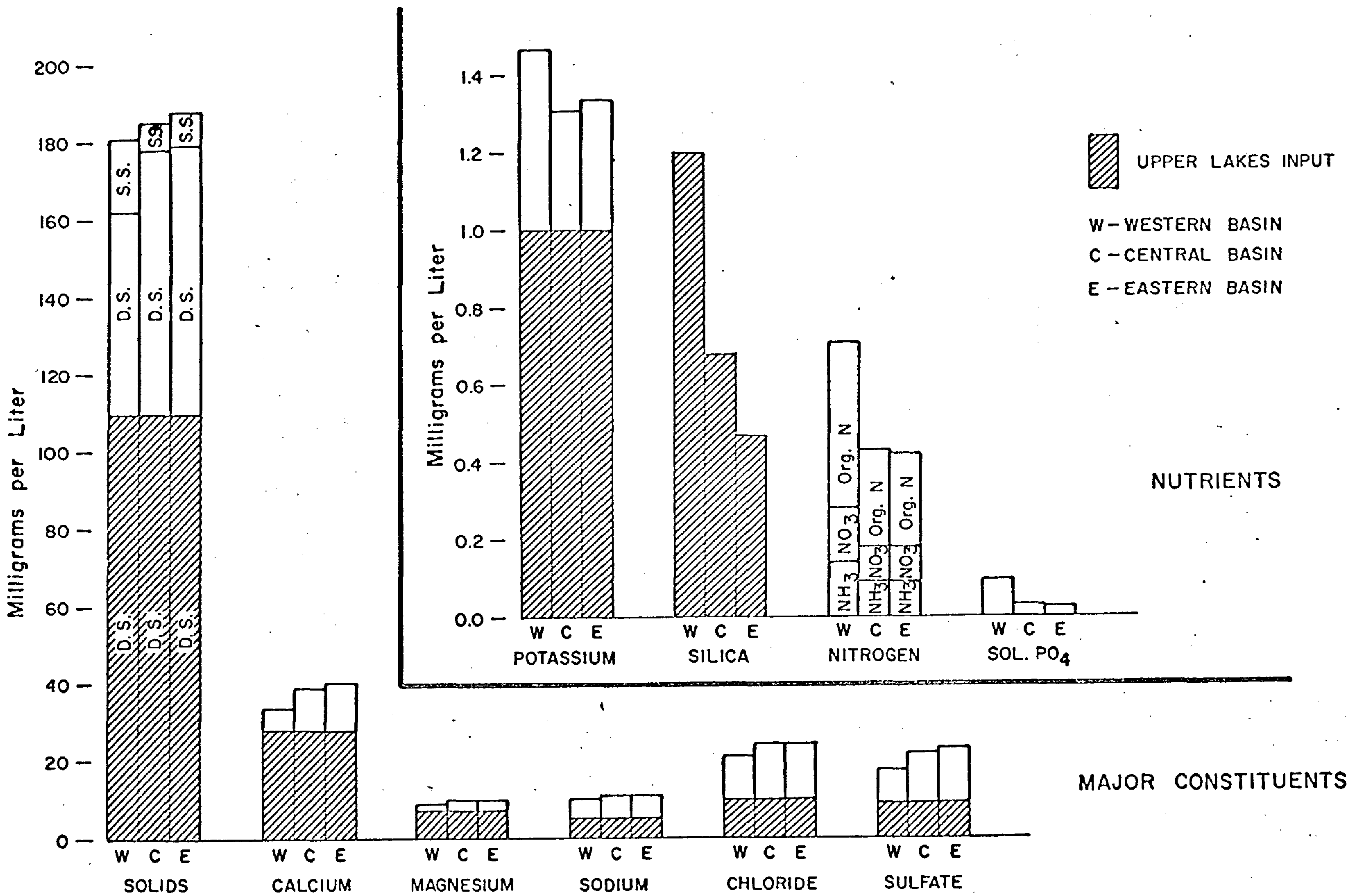
Many substances, although not of immediate concern, show signs of increasing to the point of impairing many water uses. In addition, they indicate the progressively increasing rate of waste input. Figure 5-9 , as compiled by the U. S. Bureau of Commercial Fisheries, shows several constituents in Lake Erie and how they have increased since 1900. Dissolved solids show an alarming increase to the present level of 180 mg/l. If this rate continues the concentration in the lake will be greater than 225 mg/l. Most of the increases in constituents have been derived from sources within the basin. The average concentration of in-basin tributary inputs of dissolved solids is 775 mg/l, considerably above recommended levels for many uses. The Lake Huron input dilutes this concentration to 180 mg/l, however it is clear that in-basin sources must be controlled to maintain a high quality water supply.

Siltation of Lake Erie is locally a problem, especially in the western basin where it tends to at least occasionally cover coarser sediments and rock which are the spawning areas for many fishes. Quantity-wise, sedimentation is about 24 million tons annually, two-thirds of which comes from shore erosion. Lake Erie can accommodate this rate for many centuries without measurable effect in shallowing the lake.



CHANGES IN CHEMICAL CHARACTERISTICS OF LAKE ERIE
(ADAPTED FROM BEETON, 1965)

~~FIGURE 6-3~~ Fig. 5-9



CHEMISTRY OF LAKE ERIE WATER IN WESTERN, CENTRAL AND EASTERN BASINS

One of the most displeasing problems in Lake Erie is the use of the lake as a refuse dump. Like most other water quality characteristics, concentrations of debris are also related to the amount of human activity in the vicinity. The water and beaches along the Michigan shore, in Maumee Bay, in and around Cleveland Harbor, and several other parts, are often so cluttered with debris that a very real danger to small boating is created. Floating lumber, trees, bottles, cans, tires, boat cushions, life preservers, fish net floats, balls, boats, piling, power poles, barrels, boxes, shoes, gloves, balls of grease, raw sewage, and many other types of debris, even including television picture tubes, have been observed in quantity in these areas. Often many of these things have been observed in mid-lake. On a quiet day, from any location in Lake Erie, an observer can see some kind of debris attributable directly to man. For example, in early spring, it is common to find Christmas trees scattered throughout the lake.

Excessive suspended solids and colored wastes, while they may or may not be harmful, create objectionable conditions at one time or another, at all places along the Lake Erie shore. Here again some areas are worse than others. All tributaries carry occasional large loads of silt from runoff, the Maumee and Portage Rivers carrying great amounts. Maumee Bay, Sandusky Bay, and Cleveland Harbor are clouded with silt and/or industrial wash virtually constantly. Silt from shore erosion causes turbid nearshore water throughout the lake and is worst during storms.

Odors and colors are associated with wastes, mainly industrial, particularly in Maumee Bay, Cleveland Harbor, and Erie Harbor.

SOUTHEASTERN MICHIGAN BASIN

Water Quality

Water quality is both a measure of the usefulness of a stream and a consequence of the nature and degree of existing use. Man's activities modify ~~the~~ water quality. The municipal and industrial waste discharges have the most significant effect on ~~the~~ water quality throughout the southeastern Michigan basin.

The wastes ~~to be~~ causing the most concerns ~~with~~ are those from the municipalities, industries, Federal installations, stormwater overflow, and in some areas navigation and dredging. These wastes include organic material, suspended solids, nutrients and bacteria. All these cause water quality deterioration by depressing oxygen, solids settling and causing sludge beds, bacterial contamination, and nutrient stimulated slime and algal growths. A map of S.E. Mich is shown in fig—.

Water Quality Problems

St. Clair River Basin

The St. Clair River receives the outwash from Lake Huron at an average flow of 186,000 cfs. Water quality leaving Lake Huron is exceptionally high and remains satisfactory in the pasaage down the St. Clair River. The following table of average data for the St. Clair River shows this high quality.

Feet from West Shore	100'	800'	1500'
Coliform bacteria MF/100 ml	20	<10	<10
Chlorides mg/l	6	6	6
Phenols µg/l	2	3	3
Total N mg/l →	0.4	0.4	0.4
Total p mg/l	<0.008	<0.008	<0.008
Dissolved Solids mg/l	110	110	110

The obly indication of degradation occurs from occassional excessive coliform and phenol values. The cause of the high phenols is the petroleum complex in Canada at Sarnia, Ontario, ~~and~~ the high coliforms are caused by polluted water entering the St. Clair River from the tributaries. The values however are not at levels that cause much concern.

The American tributaries to the St. Clair River, Black, Pine, and Belle Rivers (see Figure 1) are not as well off. The following data derived from samples taken at the mouth of each of these small rivers shows ~~this~~ the water quality degradation.

	Black	Pine	Belle
DO mg/l	4.2		2.9
Coliform Bact. MF/100 ml	1,400	1,800	29,000

Sewage odors ~~were noted~~ occur on the Black, Pine, and Belle Rivers. A navigation channel is maintained on the Black River through Port Huron, Michigan and this channel, throughout its entire length, is polluted. The cause of pollution in these tributaries is inadequately treated wastes from paper mills, food processing plants, and municipalities. Controls should be initiated to remove organic wastes and provide disinfection.

To achieve high quality water and maintain it where it now exists, within the St. Clair River system, the industrial and municipal recommendations are shown in the following table:

MUNICIPAL WASTE TREATMENT NEEDS
(by basin)

Location	Needs
ST. CLAIR RIVER BASIN	
St. Clair River	
Port Huron	Expand to secondary
Marysville	Expand to secondary
St. Clair	Expand to secondary

MUNICIPAL WASTE TREATMENT NEEDS (Cont'd)

Marine City	Expand to secondary
Cottrelville Twp.	Collection system add secondary
Kimball Twp.	Collection system and secondary
St. Clair Twp.	Expand to secondary
Clay Twp.	Collection system and secondary
Algonac	Collection system & secondary
East China T.	Expand to secondary
Black River	
Deckerville	Collection system & lagoon
Yale	Lagoon modifications
Fort Gratiot T.	Collection system & secondary
Peck	Collection system & lagoon
Pine River	
Emmett	Collection system & lagoon
Belle River	
Imlay City	Improve collection system

INDUSTRIAL WASTE TREATMENT NEEDS (by basin)

ST. CLAIR RIVER BASIN

Industry	Location	Needs
Black River		
Michigan Milk Producers Assn.	Peck	Establish treatment needs
Port Huron Paper Co.	Port Huron	Establish adequacy of treatment
Belle River		
Michigan Milk Producers Assn.	Imlay City	Establish adequacy of treatment (irrigation
Vlasic Food Products Co. →	Imlay City	Establish adequacy of treatment (holding ponds)

Lake St. Clair

Water quality of Lake St. Clair is good (see Table___) although isolated problems occur around the shoreline.

LAKE ST. CLAIR - SUMMARY OF 1964 SURVEY

	DO	BOD_5	NH_3	NO_2	NO_3	Tot.Sol.	Phenols ug/l	Coliforma org/100ml
Average	9.1	2	.22	.007	0.34	151	2	62
Maximum	10.2	7	.69	.019	1.80	204	12	250,000
Minimum	6.7	1	.07	.002	0.08	120	0	1

All results in mg/l unless otherwise noted.

The Milk River which carries stormwater overflow discharges a coliform load of 250,000 orgamisms/100 ml into Lake St. Clair at St. Clair Shores, Michigan. Stormwater overflow occurs all along the heavily populated Michigan shoreline endangering swimmers in the area. Overflows from these sewers should be disinfected to a level not to exceed 1,000 coliform organisms/100 ml to protect users of the water.

Metropolitan Beach, a recreational area ~~for swimming~~ is located on the west shore of Lake St. Clair near Mt. Clemens, Michigan. Recorded coliform densities as high as 8600 organisms/100 ml present an occasional health problem to users of the beach. The beach is affected by the pollution output of the Clinton River. To protect Lake St. Clair amd maintain its high quality water, removal of all municipal wastes from the Clinton River is recommended. Also, stormwater overflow should be disinfected.

Clinton River

The Clinton River (see Figure ___) is one of the major sources of pollution in Lake St. Clair. The downstream reach of the river, extending approximately 17 miles from Red Run to the mouth of the Clinton River, reflects the quality of the water entering the lake. The results of recent surveys on this section of the Clinton River are shown in the table below:

CLINTON RIVER (Red Run to Mouth)
Summer Survey (mg/l)

	Temp. °C	DO	BOD_5	Cl	NH_3-N	NO_3-N	Totl P	Totl Solids	Susp. Solids
Avg.	24	2.7	9	81	4.58	2.6	3.1	544	35
Max.	26	6.1	14	103	6.00	4.9	4.8	670	169
Min	22	0.6	3	67	3.20	1.3	2.2	500	5

All the sewage treatment plants on the Clinton River are secondary, but some are inadequately operated or overloaded and a few small areas have no treatment. Most of the major industries on the river have treatment rated as adequate by the Michigan Water Resources Commission. The long-term average flow at Mt. Clemens is 468 cfs. In 1964, the minimum flow was 83 cfs. The total municipal and industrial waste effluent discharged into the river is estimated at more than 71 cfs.

Surveys of the Clinton River in the summer of 1964 and 1966 found two sections of the Clinton River which had severe oxygen deficiencies. A definite oxygen sag existed downstream from the City of Pontiac, a result of the organic and nitrogenous loading from the two sewage treatment plants serving Pontiac. The dissolved oxygen concentration in the Clinton River recovered upstream from the Rochester sewage treatment plant. Below the Rochester sewage treatment plant, the dissolved oxygen concentration in the lower Clinton River averaged 2.7 mg/l with a range of 0.6 to 6.1 mg/l for the 1966 survey. During the 1964 survey, the dissolved oxygen level in the reach of the river between heavily polluted Red Run and Clinton Township sewage treatment plant #1 averaged 4.0 mg/l with a range of 1.6 to 6.1 mg/l.

Dissolved oxygen concentrations in Paint Creek And Stony Creek, tributaries of the Clinton River, were approximately 9.0 mg/l. Red Run had an average concentration of 10.2 mg/l during the 1966 survey, well above the 4.3 mg/l average for the 1964 survey. This is due to photosynthetic action by algae causing supersaturation of Red Run. The Middle Branch of the Clinton River had an average concentration of 5.0 mg/l during the 1966 survey, much lower than the 9.5 mg/l average during the 1964 summer survey.

The 5-day biochemical oxygen demand (BOD) in the Clinton River in the reach above the Pontiac sewage treatment plants had an average of 4 mg/l. This increased steadily to an average 9 mg/l at the lower section of the Clinton River during the 1966 survey. The BOD resulss were similar for the 1964 survey. The tributaries of Paint Creek, Stony Creek, and Middle Branch had low average BOD of 2 mg/l, 3 mg/l, and 4 mg/l respectively.

Ammonia, as nitrogen, in the reach below the two Pontiac sewage treatment plants, averaged 9.33 mg/l, with a range of 3.12 to 18.12 mg/l during the 1966 summer survey. This reach had an average ammonia concentration 25 times greater than the section above Pontiac. The river from the confluence of Red Run to Lake St. Clair had an average concentration of 4.58 mg/l of ammonia.

Nitrate, as nitrogen during the 1966 summer survey averaged 0.4 mg/l above Pontiac, 1.4 mg/l below Pontiac, 5.2 mg/l from Rochester to a point above the confluence of Red Run, and 2.6 mg/l in the lower Clinton River. Nitrate-nitrogen concentrations in all of the tributaries had average concentrations less than 0.8 mg/l.

Total phosphorus above Pontiac's sewage treatment plant outfalls averaged 0.3 mg/l during the 1966 summer survey. Below the Pontiac outfalls,the average concentration increased to 2.3 mg/l. The reach below Rochester had an average of 1.5 mg/l and the reach below the confluence of Red Run had an average total phosphorus concentration of 3.1 mg/l.

The total soluble phosphorus averaged about 82% of the total phosphorus in the Clinton River. The total phosphorus concentrations in the tributaries averaged less than 0.2 mg/l with the exception of Red Run. Red Run had an average concentration of 16.3 mg/l during the 1966 survey, or twice that of the averabe concentration in the lower Clinton River. Red Run transverses a heavily populated area of suburban Detroit and receives large quantities of raw sewage through discharges from overloaded sewer systems. Phosphorus found in the Clinton River is almost all from municipal wastes.

Total coliform densities in the Clinton River above Pontiac sewage treatment plant #1 at 2 stations were 690,000 and 39,000 organsisms/100 ml respectively during a survey conducted in 1966.

Total coliform densities varied from 1600 to 22,000 organisms/100 ml in the reach of the river from below Pontiac sewage treatment plant #2 to Rochester, Michigan during the same survey.

The 1966 survey in the lower Clinton River (below Red Run to the mouth of the Clinton River) had total coliform densities which ranged from 1100 to 4400 organisms/100 ml. The coliform density in the June 30 survey ranged from 5200 to 450,000 organisms/100 ml.

The heavy pollutional load of the Clinton River has created serious problems with water use. The Clinton River functions almost exclusively as an open sewer with little other uses possible because of the heavy pollution. All municipal waste treatment plants on the Clinton have secondary treatment. Industrial plants are treating wastes, but not all eight industries are rated adequate by the Michigan Water Resources Commission. To abate municipal pollution in the Clinton River, plans are b eing implemented that will connect all municipal waste discharges to an interceptor system and carry them away to a central treatment and discharge point of the Detroit system. The following table shows the municipal and industrial treatment needs for the Clinton River.

MUNICIAPL WASTE TREATMENT NEEDS

Location	Needs
LAKE ST. CLAIR BASIN	
Clinton River	
Clinton Twp.	Connect to Detroit Metro
Mt. Clemens	Connect to Detroit Metro
Sterling T.	Connect to Detroit Metro
Utica	Connect to Detroit Metro
Warren	Connect to Detroit Metro
Pontiac	Connect to Detroit Metro
Rochester	Connect to Detroit Metro
Oxford Village	Collection system and secondary
Harrison T.	Connect to Detroit Metro
Fraser	Connect to Detroit Metro
Shelby T. (part)	Connect to Detroit Metro
Leonard	Collection system & lagoon
Washington	Collection system & secondary
Avon T.	Connect to Detroit Metro
Bingham Farms	Connect to Detroit Metro
Franklin	Connect to Detroit Metro
Independence T.	Connect to Detroit Metro
Lake Angelus	Connect to Detroit Metro
Lake Orion	Connect to Detroit Metro
Novi	Connect to Detroit Metro
Orchard Lake	Connect to Detroit Metro
Orion T.	Connect to Detroit Metro
Quakertown	Connect to Detroit Metro
Waterford	Connect to Detroit Metro
Wood Creek Farms	Connect to Detroit Metro

INDUSTRIAL WASTE TREATMENT NEEDS

LAKE ST. CLAIR BASIN

Industry	Location	Needs
Clinton River		
Briggs Manufacturing Co.	Sterling T.	Establish adequacy of treatmant (lagoon)
Chrysler Corp. Michigan MOssile Plant	Sterling T.	Establish adequacy of treatmant (lagoons)
Ford Motor Co. Chassis Parts	Sterling T.	Establish adequacy of treatment for oil and sanitary wastes
TRW, Inc. Thompson Products, Mich. Division	Sterling T.	Improve reliability of treatment of oil wastes Establish adequacy of treatment of sanitary wastes

Detroit River (See Fig. ___)

In December of 1961 the Honorable John B. Swainson, Governor of Michigan, requested the Department of Health, Education, and Welfare to call a conference on water pollution problems in the Michigan waters of the Detroit River and Lake Erie.

At the first session of the conference in March, 1962 at Detroit, Michigan, it was unanimously agreed that a study should be made of pollution problems in the area.

The Detroit River-Lake Erie Project, under the direction of the U. S. Public Health Service and in cooperation with State agencies, conducted a two-year study of the condition of the waters and sources of waste. In June 1965, the findings and recommendations of the study were presented to the second session of the conference. Conferees agreed that the Michigan Water Resources Commission would implement the recommendations under State law.

The water quality of the Detroit River has been discussed in detail in the "Report on Pollution of the Detroit River, Michigan Water of Lake Erie, and Their Tributaries," by the Federal Water Pollution Control Administration. Action has been taken by the Michigan Water Resources Commission against the major polluters in accordance with the Federal Water Pollution Control Administration's recommendation. This has been discussed in Section V of the Detroit River-Lake Erie report. Water quality remains relatively unchanged since the report was published.

The following is a summary of the water quality problems of the Detroit River from that report.

Every day more than 1.6 billion gallons of waste water flow into the Detroit River--1.1 billion gallons from industry and 540 million gallons from municipal sewage. Huge quantities of waste products contained in this discharge change the Detroit River from a basically clean body of water at its head to a polluted one in its lower reaches. These waters are polluted bacteriologically, chemically, physically, and biologically, and contain excessive coliform densities as well as excessive quantities of phenols, iron, oil, ammonia, suspended solids, settleable solids, chlorides, nitrogen compounds, and phosphorus. Pollution of the Detroit River will become progressively worse unless effective action is taken immediately.

The City of Detroit's main sewage treatment plant, serving more than 90 percent of the people in the Detroit area contributes 95 percent of the municipal waste to the Detroit River and is also the major source of suspended solids, phenols, oil, inorganic nitrogen, phosphorus, and biochemical oxygen demand in the river. In fact, the Detroit primary sewage plant is the largest single source of pollution in ~~all of~~ the entire Lake Erie watershed. Overflow from combined sewers in Detroit and its suburbs, carrying both stormwater and raw sewage contributes greatly to the degradation of the river.

In the upper Detroit River, the Great Lakes Steel Company and the Allied Chemical Corporation are the major sources of industrial wastes. The Ford Motor Company is the principal contributor of inorganic wastes to the Rouge River, and the Scott Paper Company is the principal contributor of organic wastes. Downriver industries contributing significant quantities of wastes are the Great Lakes Steel Corporation, the McLouth Steel Corporation, Pennsalt Chemical Corpration, and Wyandotte Chemical Corporation.

Other significant sources of pollution in the area are overflows from combined sewers, municipal and industrial waste spills, and wastes from shorefront homes.

Pollution of the Detroit River causes interference with municipal water supply, recreation, fish and wildlife propagation, and navigation. Two municipal water intakes, particularly that of Wyandotte, are endangered by the high bacterial counts of the river, and the rising chloride levels indicate potential future problems for industrial water usage. In addition, high concentrations of phenols and ammonia at the Wyandotte water intake have interfered with municipal water treatment by causing taste and odor problems and reducing the effectiveness of chlorination. Excessive quantities of chlorine are needed to reduce bacteria to a safe level.

All forms of water contact sports in the lower Detroit River ~~are hazardous~~. Declining levels of dissolved oxygen in the lower Detroit River as it enters Lake Erie are approaching the danger point, indicating trouble in the future unless appropriate remedial action is taken. Together with bottom sludge deposits, oils, and toxic materials, ~~they~~ threaten fish, migratory birds, and other wildlife. In order to maintain navigation, extensive annual dredging is required in the Rouge River and at the mouth of the Detroit River to remove deposits of suspended solids in large part originating in municipal and industrial waste discharges.

The following table shows the quantities of various materials at the beginning of the Detroit River and those that empty into Lake Frie from the Detroit River.

	Lbs/day	
	Mouth	Headwaters
Total phosphorus	86,000	41,000
Chlorides	18,560,000	7,000,000
Phenols	3,800	--
Total N	590,000	445,000
Suspended Solids (est)	14,000,000	6,000,000

The following table shows summary statistics for bacterial water quality at headwaters and mouth of the Detroit River. The data are divided into conditions during and immediately after a rain and those essentially ~~un~~ affected by rain.

TABLE ____

TOTAL COLIFORM DENSITIES SUMMARY STATISTICS
WET AND DRY CONDITIONS

	DRY		WET
Headwaters	Maximum Value	Geo. Mean	Geo. Mean
100'	710	110	130
300'	700	68	87
500'	300	42	37
1,000'	200	24	22
2,500'	130	15	19
3,000'*	100	15	67
3,350'*	1,100	40	58
3,480'*	86,000	1,300	1,200

*Canadian stations

TABLE____

TOTAL COLIFORM DENSITIES SUMMARY STATISTICS
WET AND DRY CONDITIONS

Mouth[1]	DRY Maximum Value	Geo. Mean	WET Geo. Mean
2,500'	94,000	4,100	13,000
3,500'	410,000	3,600	18,000
4,500'	330,000	5,900	20,000
5,500'	200,000	5,900	16,000
6,500'	320,000	3,800	8,900
7,500'	300,000	3,000	9,500
9,500'	110,000	2,000	2,700
11,500'*	80,000	1,200	3,300
13,500'*	47,000	920	3,600
15,000'*	73,000	1,100	2,300
16,500'*	58,000	2,800	3,700
17,500'*	42,000	11,000	12,000
19,000'*	51,000	11,000	15,000
19,300'*	39,000	11,000	12,000

[1]distances are feet from American shore
*Canadian waters

Since the study of the Detroit River, the Michigan Water Resources Commission has obtained stipulations or agreements with 23 individual polluters, municipal and industrial, to facilitate control of their effluents to recommend levels by 1970. The following table contains a summary of the state stipulations.

SUMMARY OF MICHIGAN WATER RESOURCES COMMISSION STIPULATIONS

Municipalities and Industries	Susp. Solids mg/l	Susp. Solids lb/day	Sol. Phos. (as PO_4) lb/day	Phenols µg/l	Phenols lb/day	Oil mg/l	BOD mg/l	BOD lb/day	Tot. Coli. MPN	Constr. Comple. Date	Remarks (1)
Allied Chem. Corp. Semet-Solvay Div.	-	-	-	-	-	(2)	-	-	-	4/1/67	
Solvay Process	50	-	-	-	-	-	-	-	-	4/1/68	Cl
E. I. duPont de Nemours & Co.	-	-	-	-	-	-	-	-	-	4/1/67	pH
Scott Paper Co.	50	-	-	-	-	-	-	31,000	-	11/1/68	

(1) For "Remarks" see page

(2) The effluent should not contain oil in amounts sufficient to create a visible film on the surface waters of the State.

SUMMARY OF MICHIGAN WATER RESOURCES COMMISSION STIPULATIONS (cont.)

Municipalities and Industries	Susp. Solids mg/l	Susp. Solids lb/day	Sol. Phos. (as PO_4) lb/day	Phenols mg/l	Phenols lb/day	Oil mg/l	BOD mg/l	BOD lb/day	Tot. Coli. MPN	Constr. Comple. Date	Remarks(1)
American Cement Corp.	50	-	-	-	-	-	-	-	-	5/1/67	
Darling & Co.	-	-	-	-	-	-	-	600	1000	11/1/67	
Wyandotte Chem.Corp.	50	-	-	-	-	15	-	-	-	4/1/68	Cl
Pennsalt Chem.Corp.	50	-	-	-	-	-	-	-	-	4/1/68	Cl
McLouth Steel Corp. Trenton Plant	50	-	-	-	-	15	-	-	-	4/1/68	Fe
Revere Copper & Brass, Inc.	50	-	-	-	-	15	-	-	-	11/1/67	
Firestone Tire & Rubber Co.	-	-	-	-	-	-	-	-	-	11/1/67	Fe
Mobil Oil Co.	50	-	-	-	-	15	-	-	-	11/1/67	
Monsanto Chem.Corp. Inorganic Chem.Div.	-	-	2000	-	-	-	-	-	-	5/1/68	
Trenton Resins Plt.	-	-						2800		4/1/68	
City of Detroit (present area)	50	324,000	21,000	-	93	15	-	206,000	1000	11/1/70	
Wayne County (Wyandotte & Trenton)	50	19,000	3,000	-	10	15	-	28,900	1000	11/1/70	

(1) For "Remarks" see page 23.

SUMMARY OF MICHIGAN WATER RESOURCES COMMISSION STIPULATIONS (cont.)

Municipalities and Industries	Susp. Solids mg/l	Susp. Solids lb/day	Sol. Phos. (as PO_4) lb/day	Phenols ug/l	Phenols lb/day	Oil mg/l	BOD mg/l	BOD lb/day	Tot. Coli. MPN	Constr. Complt. Date	Remarks (1)
City of Riverview	50	470	35	-	0.2	15	-	920	1000	11/1/70	
City of Trenton	50	935	138	-	5	15	-	1840	1000	11/1/70	
Grosse Ile Twp. (formerly Wayne Co.)	50	500	20	-	1	15	-	980	1000	11/1/70	
Great Lakes Steel											
Blast Furnace Div.	50	-	-	-	180	15	-	-	-	4/1/68	
Strip Mill	50	-	-	-	-	15	-	-	-	4/1/68	
Ecorse Plant	50	-	-	-	-	15	-	-	-	4/1/68	Fe, pH
Ford Motor Co. (Rouge)	50	-	-	-	70	15	-	-	-	4/1/69	Fe

(1) For "Remarks" see page 23.

Remarks:

Fe: Iron was found to be a major constituent in the effluent of industries and the limit of 17 mg/l was recommended by both the Public Health Service and the Michigan Water Resources Commission. The following loading limitations were also included in the Michigan Water Resources Commission stipulations:

Ford Motor Company	-	2500 lbs/day
Firestone Tire and Rubber Co.	-	330 lbs/day
Great Lakes Steel Corp. - Ecorse Plant	-	4000 lbs/day
McLouth Steel Corp. - Trenton Plant	-	2500 lbs/day

pH: The recommended limit on the pH range for Great Lakes Steel (Ecorse Plant) effluent was set at 5.5-10.6 by both the Public Health Service and the Michigan Water Resources Commission. Public Health Service recommended that E. I. duPont de Nemours and Company comply with the State order that the effluent of this industry have pH in the range of 5.8-10.3.

Cl: Chlorides were found to be a significant waste constituent in the effluent of the several industries and limits of chlorides loading were set by the Michigan Water Resources Commission as follows:

Allied Chemical Corporation -		
Solvay Process	-	2,800,000 lb/day
Wyandotte Chemical Corporation -		
North Plant	-	1,300,000 lb/day
South Plant	-	64,000 lb/day
Pennsalt Chemicals Corp.		
East Plant		550,000 lb/day
West Plant		8,800 lb/day

Huron River

The Huron River (see Figure ___) in Michigan empties into Lake Erie south of Detroit. It rises in a series of recreational lakes in southeast Michigan and because of this and ground water storage, flows during drought periods are sustained. The average discharge of record approximates 445 cfs. The once in 10 year, 7 day low flow is 30 cfs.

The Cities of Ann Arbor and Flat Rock use the Huron River for water supply. The 132,000 people in the watershed are served by eight secondary sewage plants and 3 primary plants. The primary plants are located at Dexter, Flat Rock and Rockwood. Most of the area has separate sewer systems. The total population of the watershed is 247,000.

Water quality in the Huron River ~~downstream to~~ upstream from Dexter is reasonably good. ~~All~~ Most of the recreational lakes which support numerous bathers in the summer and ice fishermen in the winter are above this point. Below the primary sewage plant of Dexter the river begins to show signs of degradation and remains ~~in an~~ unsatisfactory ~~condition~~ all the rest of the way to Lake Erie. Below Dexter even though the river falls quite rapidly, DO dips to values around 5.0 mg/l. Below the secondary sewage treatment plant of Ann Arbor the DO falls below 5.0 mg/l and the concentration of phosphorus in the river increases 5 times. The effects of this are noticed in a series of man-made impoundments farther downstream where the lakes are continually choked with algae being fed by the nutrients from the Ann Arbor sewage treatment plants and others. At Ypsilanti three secondary sewage treatment plants, Ypsilanti, Ypsilanti Township and Willow Run discharge treated wastes to the Huron River further depressing the DO levels and adding to the phosphorus load in the stream.

Bacteriological problems exist in most of the Huron River from Ann Arbor to the mouth during periods of heavy storm runoff and non-chlorination of sewage effluents. The areas of greatest severity are below Ann Arobr, the Ypsilanti area and Flat Rock-Rockwood area.

The following table shows the quality of various waste materials discharged to Lake Erie from the Huron River. Values are in lbs/day.

Suspended Sol.	Chlorides	Total Phosphorus	Total N.
10,000	75,000	700	3,000

To relieve the polluted conditions of the Huron River there is need for upgrading sewage plants to secondary and in some locations integrating and centralizing sewerage systems.

Four industries in the watershed are rated as having unsatisfactory treatment and the effect of their wastes can be observed in the river. Longworth Plating Company at Chelsea discharges toxic compounds. The General Motors Corporation, Fisher Body Division discharges a variety of waste materials (oils, toxic compounds, and sewage) to Willow Run, a small tributary of the Huron River. Peninsula Paper Company in Ypsilanti discharges large quantities of oxygen consuming wastes and Huron Valley Steel Corporation at Belleville has unsatisfactory control of suspended solids.

The following table shows the municipal and industrial waste treatment needs for the Huron River.

MUNICIPAL WASTE TREATMENT NEEDS

Location	Needs
Ann Arbor T.	Connect to Ann Arbor Metro
Ypsilanti T.	Connect to AnnArbor Metro
Pittsfield T.	Connect to Ann Arbor Metro
Superior T.	Connect to Ann Arbor Metro
Dexter	Expand to secondary
Pinckney	Collection system & lagoon
South Lyon	Collection system & secondary
South Rockwood	Collection system & lagoon
Stockbridge	Collection system & lagoon
Wixom	Collection system & secondary
Flat Rock	Improve collecbion system; secondary
Rockwood	Improve collection system; secondary
Ann Arbor Metro	Collection system & expand secondary

INDUSTRIAL WASTE TREATMENT NEEDS

Industry	Location	Needs
General Motors Corp. Fisher Body Div.	Willow Run	Establish adequacy of treatment (coagulation & lagoon)
Huron Valley Steel Corp.	Belleville	Improve treatment (solids in wastewater)
Longworth Plating Co.	Chelsea	Establish adequacy of treatment
Peninsular Paper Co.	Ypsilanti	Improve treatment

River Raisin

The River Raisin watershed (see Fig ___) had a 1960 population of 131,000. Primary sewage treatment plant served 29,479, secondary sewage treatment plant served 32,563, and 68,958 persons were without public sewerage systems. Four of the sewage plants are primary and five are secondary.

The River Raisin discharges an average of 714 cfs to Lake Erie. It rises in a series of small recreational lakes which partly sustain its flow in drought periods. The one in 10 year 7 day low flow is 27 cfs.

The water quality in the river upstream from Manchester is generally good ~~with~~ the recreational lakes safe for bathing. Below Manchester varying degrees of water quality occur and the most severe are ~~noticed~~ directly downstream of the sewered communities. However the river above Monroe, Michigan is able to absorb most of the wastes dumped into it without creating serious impairment with existing water uses. Concentrations of phosphorus in excess of levels sufficient to cause algae blooms are noticed throughout the river below Manchester.

In the Monroe area the river becomes grossly polluted. This area was included in the Detroit River-Lake Erie enforcement conferences because of the severe effect the lower few miles of the River Raisin has on recreational uses of the Lake Erie shoreline. In the last three miles ~~of~~ the River the primary sewage plant of Monroe serving 22,000 persons, the effluents from five paper mills with a population equivalent of 225,000 and cyanides ~~discharge to the river~~.

Waste constituents discharged to the river are high in coliform, suspended solids, cyanide concentrations, and BOD. The lower Raisin River is frequently completely devoid of dissolved oxygen, resulting in a continuous state of putrefaction during the summer months. All uses of theRiasin River except waste disposal and navigation have been eliminated by pollution, and deposits of settleable solids at the mouth interfere with these uses to the extent that annual dredging is required to remove bottom material and keep the channels open for ship movement. Bacterial counts in the lower river are excessively high and represent prohibition of any possible recreational use of the water. The effect of the Raisin River upon Lake Erie is seen in the enrichment of the waters of the western basin and in high coliform levels at bathing beaches near ~~its~~ mouth (including Sterling State Park).

The Brest Bay beach area, a series of unsewered communities, population of 4,000 just north of the River Raisin mouth, discharges septic tank wastes to Brest Bay and the effect of those wastes is intensified when heavy rains fall.

The combined effect of the city of Monroe municipal wastes, paper mill wastes (containing coliform bacteria in the 100,000 level) and the Brest Bay beach area have resulted in the unsafe bathing conditions at Sterling State Park on Lake Erie.

Pollution-stimulated algae growths have forced Monroe to move its water intake point to avoid unpleasant tastes and odors in the water, and algae blooms near the new intake again threaten to degrade Monroe's drinking water. Discharges of nutrients and organic wastes into the Michigan part of Lake Erie have ~~speeded~~ the enrichment ~~of~~ that portion of the Lake.

Water at Sterling State Park is erratically polluted, and this area occasionally had coliform counts exceeding 100,000 organisms per 100 ml. A standard frequently accepted as safe for recreation is 1,000 per 100 ml, ~~and the recommendations in this report are based on that standard.~~ The Raisin River was discovered to be the primary cause of this pollution; when lake currents are northerly (40 to 45% of the time) polluted Raisin River water is carried directly to the beaches. When currents are southerly, polluted drainage from septic tanks reaches the park. To improve water quality at Sterling State Park, these sources of pollution must be controlled.

The following table shows the loadings of various substances to Lake Erie from the River Raisin. Values are in lbs/day.

Chlorides	Suspended Solids	Phosphorus	Nitrogen
45,000	50,000	300	6,000

The following table shows the municipal and industrial waste treatment needs for the Raisin River area.

MUNICIPAL WASTE TREATMENT NEEDS

Location	Needs
Blissfield	Expand to secondary
Britton	Collection system & lagoon
Brooklyn	Collection system & lagoon
Cement City	Collection system & lagoon
Clayton	Collection system & lagoon
Clinton	Expand to secondary
Deerfield	Collection system & lagoon
Dundee	Expand to secondary
Madison T.	Collection system & secondary
Ash T.	Connect to Monroe Metro
Onsted	Collection system & lagoon
Palmyra T.	Collection system & secondary
Petersburg	Collection system & lagoon
Tecumseh	Expand collection system & treatment
Monroe Metro	Expand to secondary & increase collection
Estral Beach	Collection system & secondary
Berlin T.	Collection system & secondary
Luna Pier	Collection system & secondary
Frenchtown T.	Connect to Monroe Metro
Monroe T.	Connect to Monroe Metro
Maybee	Collection system & lagoon
Bedford T.	Collection system & lagoon
Erie T.	Collection system & lagoon

INDUSTRIAL WASTE TREATMENT NEEDS

INdustry	Location	Needs
Buckeye Products Corp.	Adrian	Establish adequacy of treatment
Dundee Cement Co.	Dundee	Improve treatment reliability
Simplex Paper Corp.	Palmyra	Establish adequacy of treatment

The Ford plating factory and the paper mills in the Monroe area are under orders from the Michigan Water Resources Commission, as a result of the Detroit-Lake Erie enforcement conferences, to clean up their wastes. The following requirements are in force for these industries:

Industries	Susp. mg/l	Solids lb/day	Sol. Phos (as PO_4) lb/day	Oil mg/l	BOD lb/day	Tot. Coli MPN	Constr. Comple. Date	Remarks
Time Container Corp Monroe Paper Prod.	35	650	-	-	500	1000	1/1/69	
Consolidated Packaging Co. North Plant	35	2200	-	-	2400	1000	1/1/69	
South Plant	35	2100	-	-	1500	1000	1/1/69	
Ford Motor Co. Monroe Plant	-	-	200	15	-	1000	1/1/68	CN
Union-Bag-Camp Co.	35	1350	-	-	2500	1000	1/1/69	

CN: Cyanide concentration of .025 mg/l was recommended as the limit by both the Public Health Service and the Michigan Water Resources Commission. In addition, the state agency stipulationset a maximum loading of 25 lb/day CN for Ford Motor Company (Monroe).

Maumee River Basin

The waters of the Maumee River Basin are seriously degraded in quality. The effects of pollution are particularly evident in the Ottawa River, the Upper Maumee River, and the Lower Maumee River at Toledo. All water uses, actual and potential, are influenced by this pollution.

From waters that were once useful and generally free of harmful materials, this River Basin has been degraded in quality to the point where, in several stretches, few legitimate uses may be made of the waters. Not only are activities such as swimming, boating, and fishing no longer available in a number of these locations, but in several areas the water is not even of sufficient quality to be used for waste assimilation. The excellent sport fishery which formerly existed throughout the Maumee Basin is now virtually non-existent.

Biological, chemical, microbiological, and physical parameters analyzed by the Lake Erie Program Office confirm the pollution found in the Basin. Further evidence of pollution cited in this report include the abandonment of the beaches along the Toledo area, the numerous cities and industries which experience tastes and odors in their water supplies, the presence of objectionable algal blooms, and the esthetically disagreeable appearance of many of the waters in the area.

Industry, cities, and agriculture are all major sources of wastes which pollute many of the area's streams. The effluents from the cities' sewage treatment plants seriously depress the receiving waters of oxygen and contribute to the algal growth in many areas. Industrial

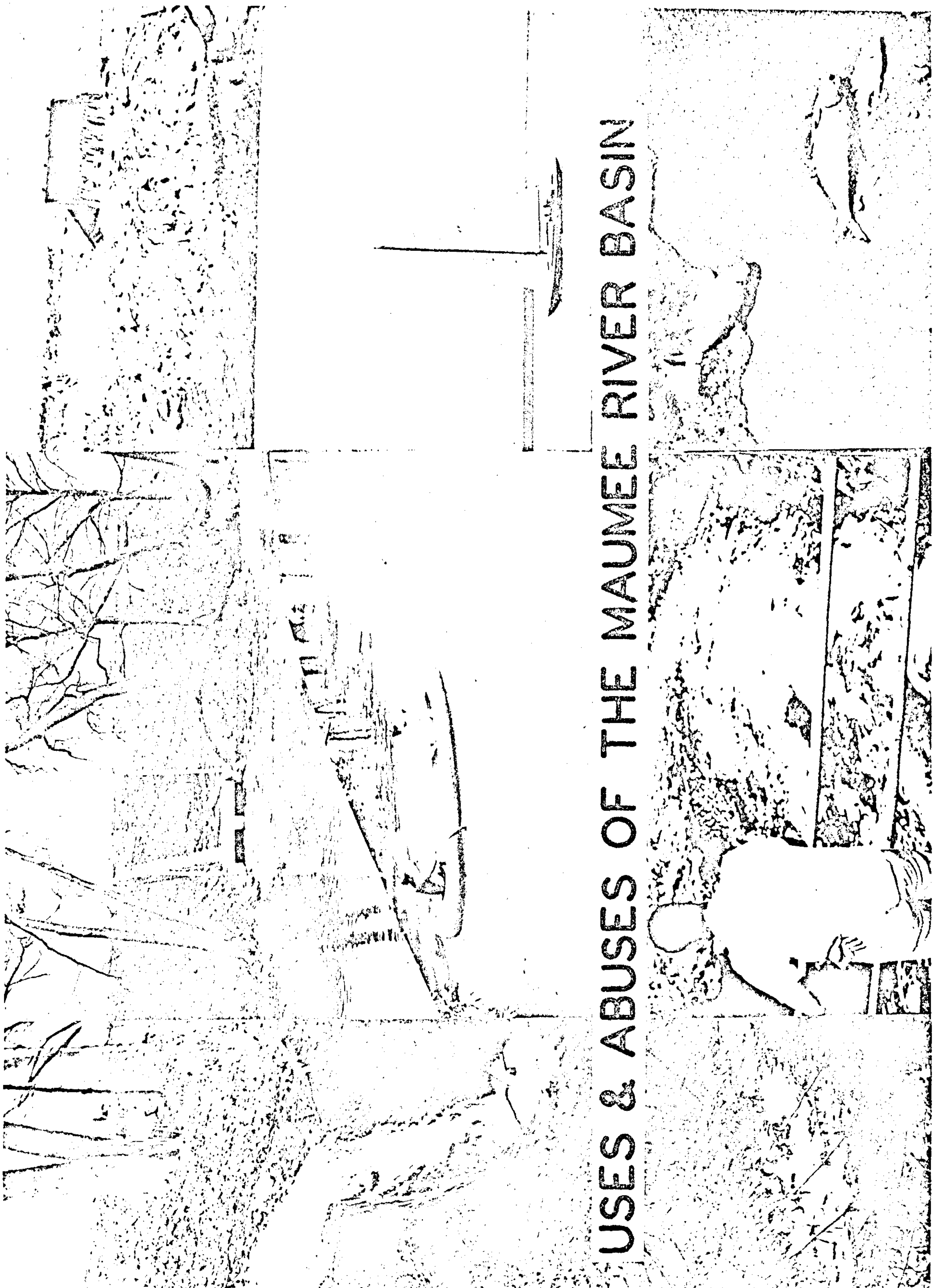


FIGURE 1-2

waste discharges also depress the Basin's rivers of oxygen, cause taste and odor problems in domestic water supplies, and interfere with the esthetic enjoyment of the Basin's water in a number of areas. The runoff from agricultural areas causes turbidity in waters of the area, requires extensive dredging of the shipping channel, and helps to produce the abundant algal growths.

A population growth projection made by Project economists indicates that the Maumee Basin's population will increase from 1,140,000 to 1,600,000 in 1980 and 2,700,000 by 2020. Industrial activity is also projected to increase by a substantial quantity in the Basin over the same period. Taking into account these and other related factors, it is apparent that the existing degraded conditions will become much worse unless extensive control measures are taken now and continued into the future.

Water Quality Evolution

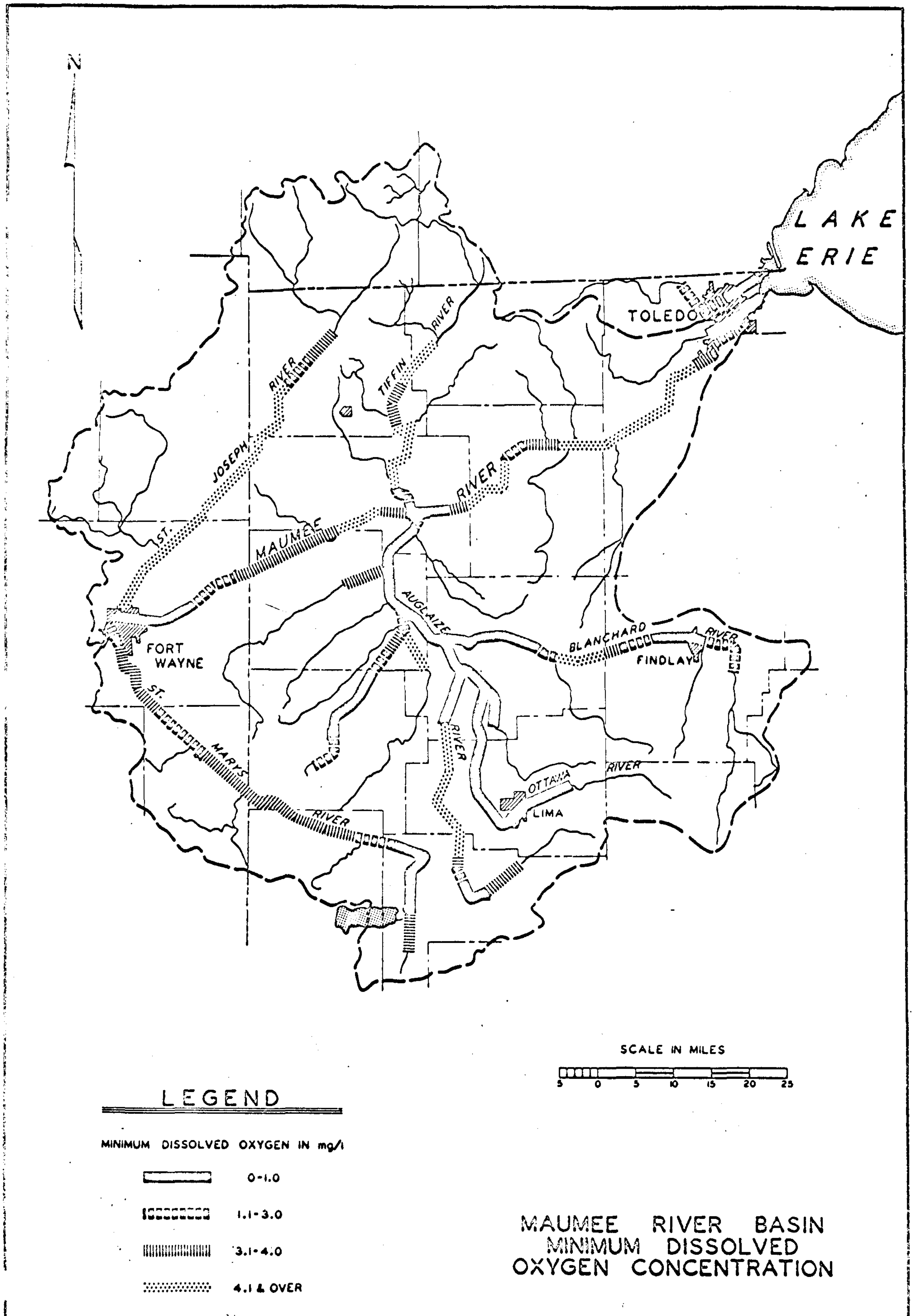
Prior to 1800, historical references regarding conditions of streams in the Maumee River Basin indicate that the waters were normally clear; soil erosion was slight; and stream bottoms were composed of sand, gravel, boulders, bedrock, and organic silt. Aquatic vegetation flourished in unshaded areas of the waters, but where trees or foliage covered a stream, little aquatic vegetation prevailed.

References regarding enormous fish populations, both larger food fishes as well as the smaller fine fishes, indicate that the waters and sediments of these streams were conducive to excellent clean water aquatic life.

Since 1800, the increasing population, with its industry, farming, dams, mills, slaughter houses, breweries, and cities, was the major factor which influenced the accelerated degradation of the water quality in the Maumee River Basin. Ditching, dredging, and tilling of the marshlands surrounding this area allowed accelerated erosion of the soils. Soil, dams, and pollutants adversely affected the aquatic vegetation. Troutman (1957) observed a decrease in the amount or elimination of rooted aquatic vegetation between 1901-1930. (12) Consequently, desirable fish disappeared and a more pollution tolerant species became prevalent. Continuing sedimentation from the Maumee and other southwestern tributaries has affecred the western end of Lake Erie drastically. The gravel and bedrock reefs of western Lake Erie that were spawning grounds for Whitefish and Cisco are now silted over. It is quite likely that sedimentation from eroding soils was the most detrimental and the most universal of all pollutants.

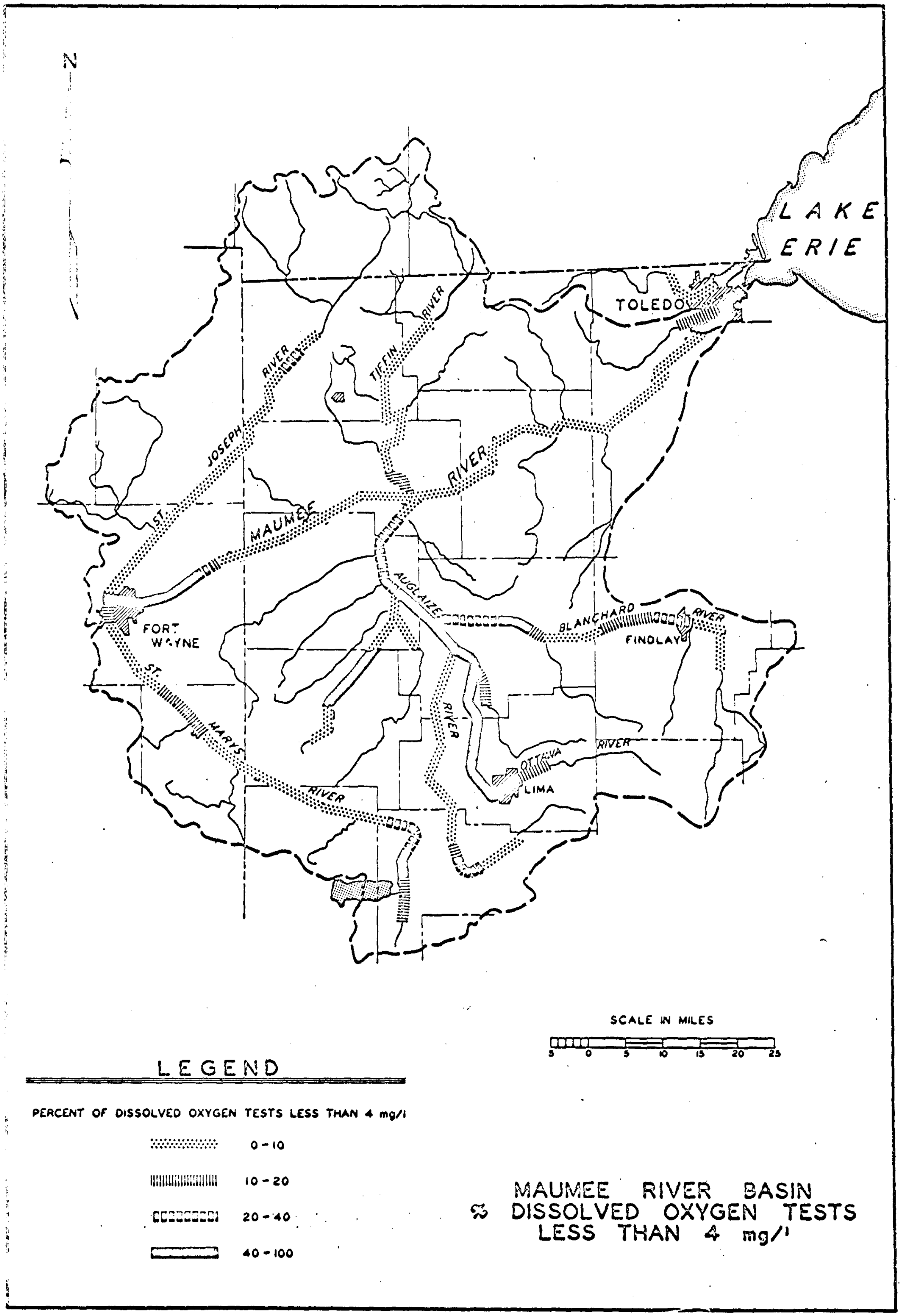
Present Water Quality

Figures 7-2 through 7-9 graphically depict a number of the significant chemical and microbiological parameters. These figures indicate many of the water quality problem areas and should be referred to while reading this chapter. The fold out map at the back of this section should be used to locate a specific city or area in reference to these figures.



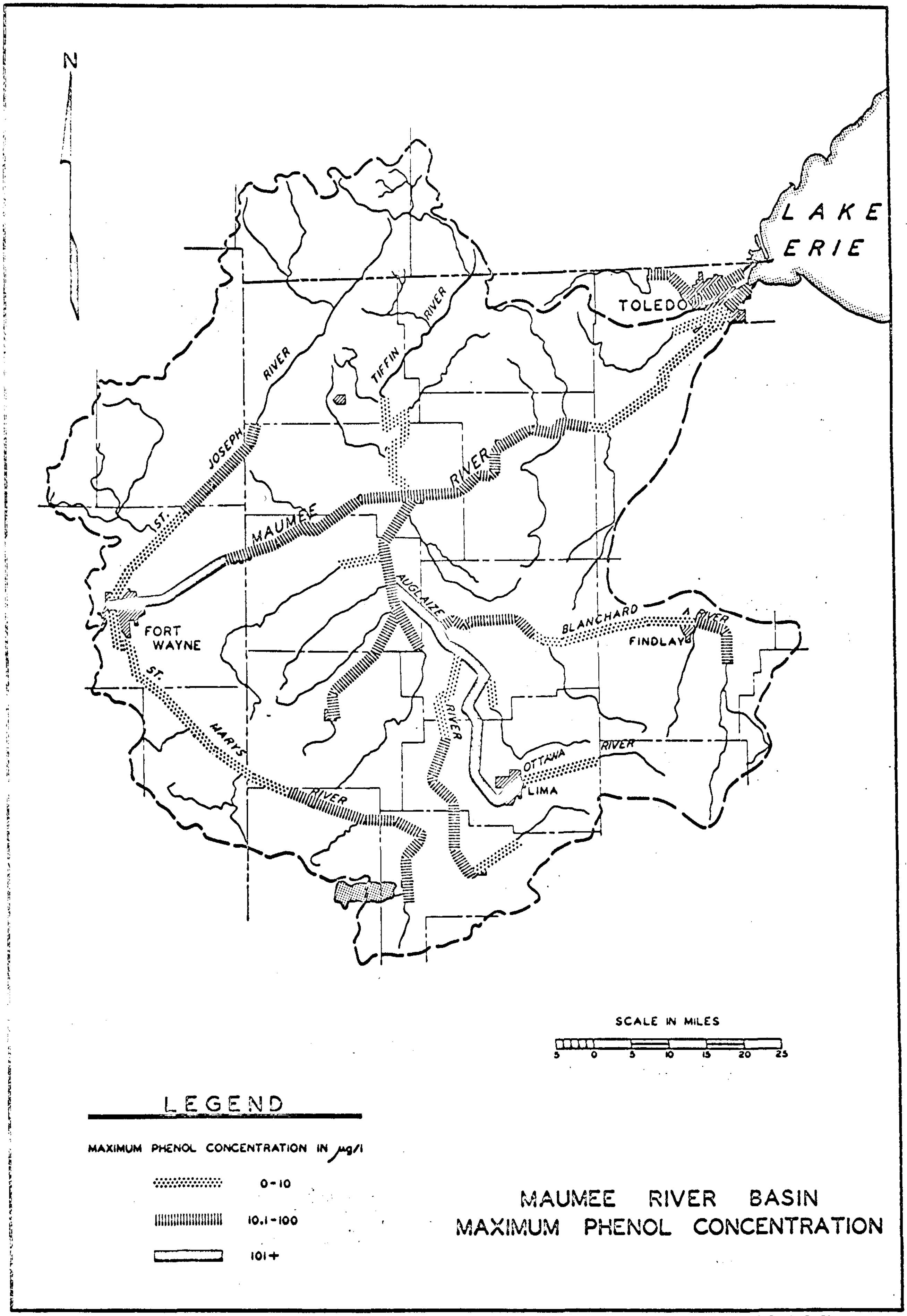
MAUMEE RIVER BASIN
MINIMUM DISSOLVED
OXYGEN CONCENTRATION

FIGURE 7-2



MAUMEE RIVER BASIN
% DISSOLVED OXYGEN TESTS
LESS THAN 4 mg/l

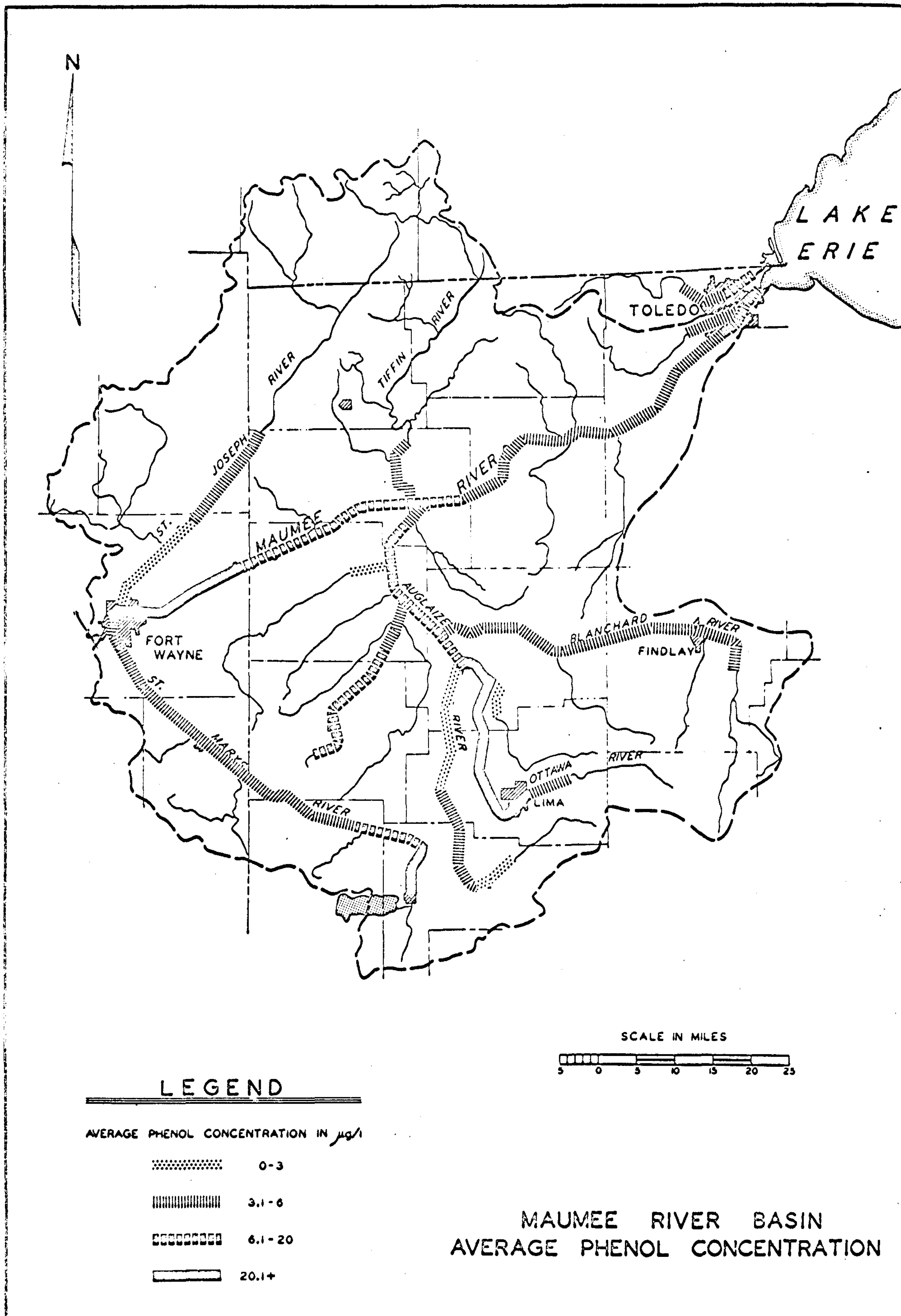
FIGURE 7-3



MAUMEE RIVER BASIN
MAXIMUM PHENOL CONCENTRATION

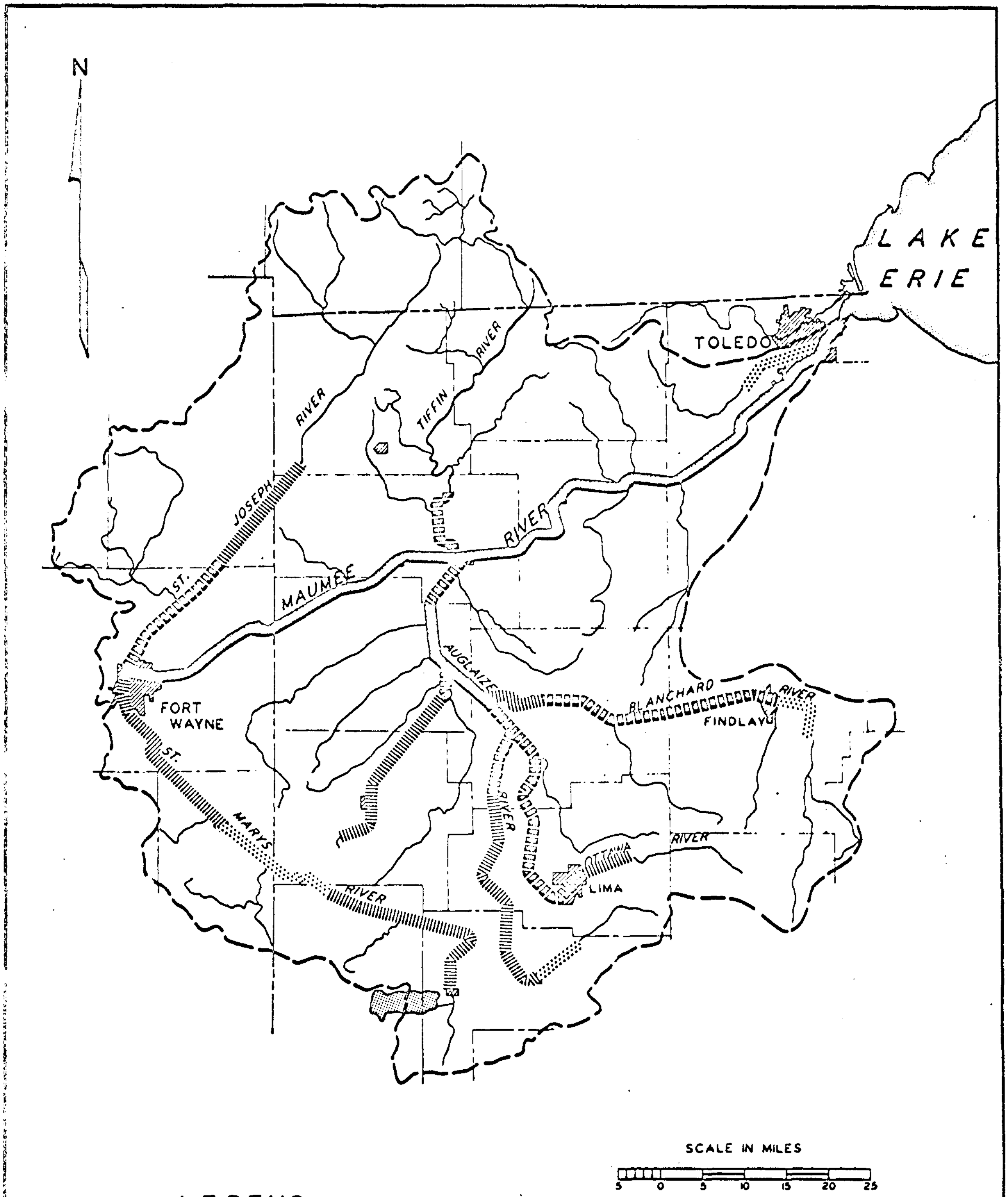
GPO 827-431-7

FIGURE 7-4



MAUMEE RIVER BASIN
AVERAGE PHENOL CONCENTRATION

FIGURE 7-5



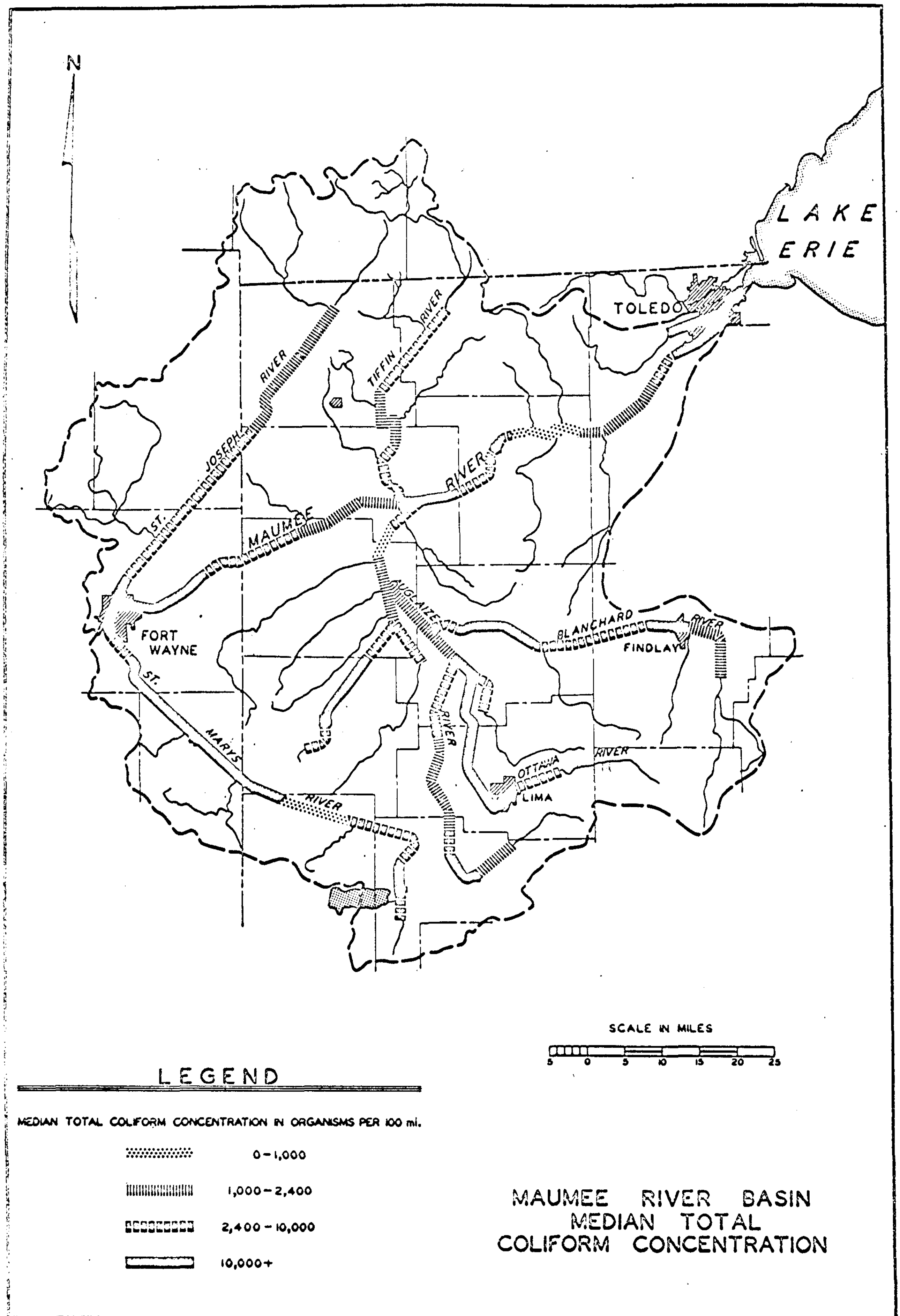
LEGEND

AVERAGE SOLUBLE PHOSPHATE LOAD IN POUNDS PER DAY

(dotted)	0 – 400
(hatched)	400 – 1,000
(segmented)	1,000 – 10,000
(open)	10,000 +

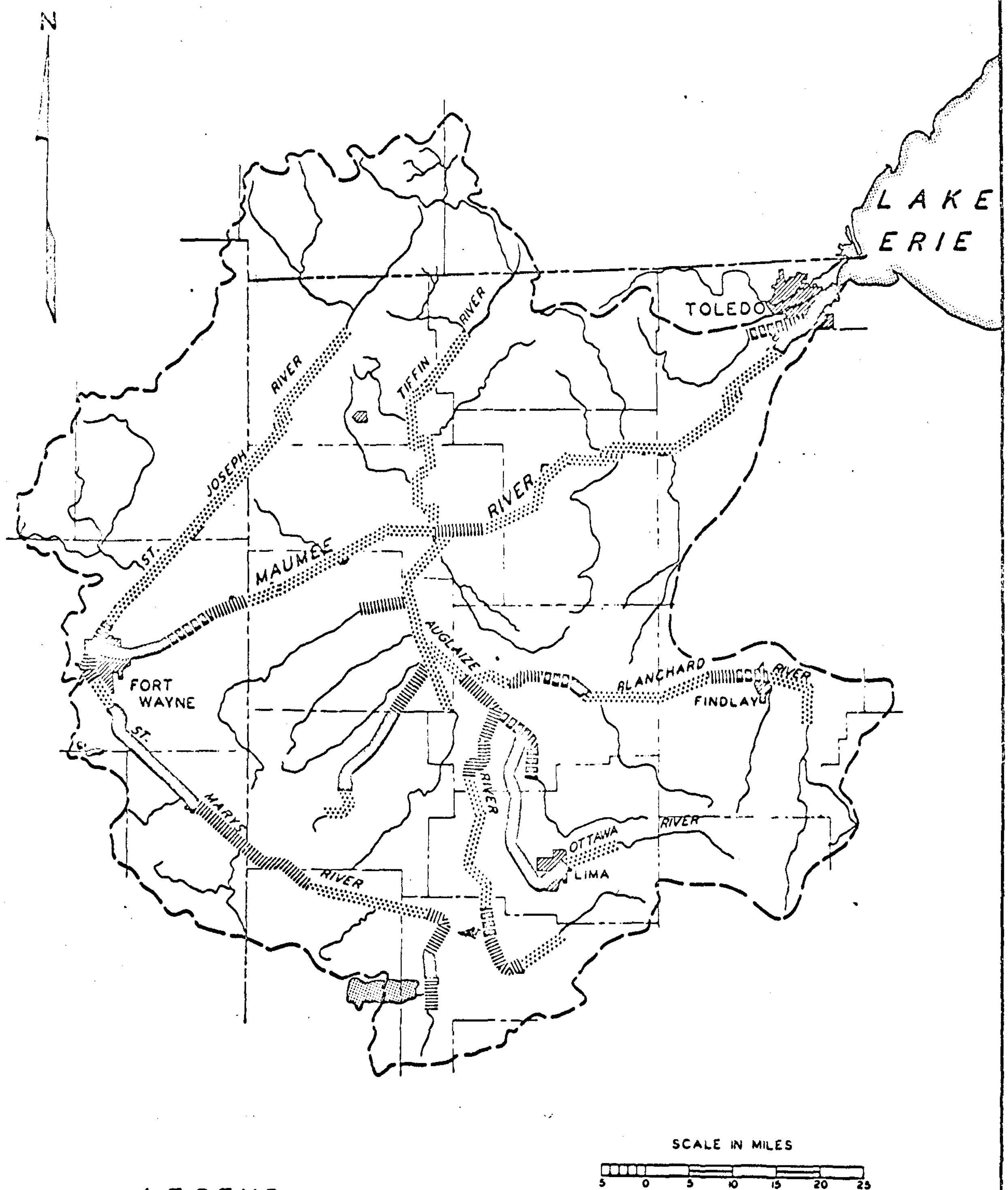
MAUMEE RIVER BASIN
AVERAGE SOLUBLE PHOSPHATE LOAD

FIGURE 7-6



MAUMEE RIVER BASIN
MEDIAN TOTAL
COLIFORM CONCENTRATION

FIGURE 7-7



LEGEND

MEDIAN FECAL COLIFORM CONCENTRATION IN ORGANISMS PER 100 ml.

0 – 500

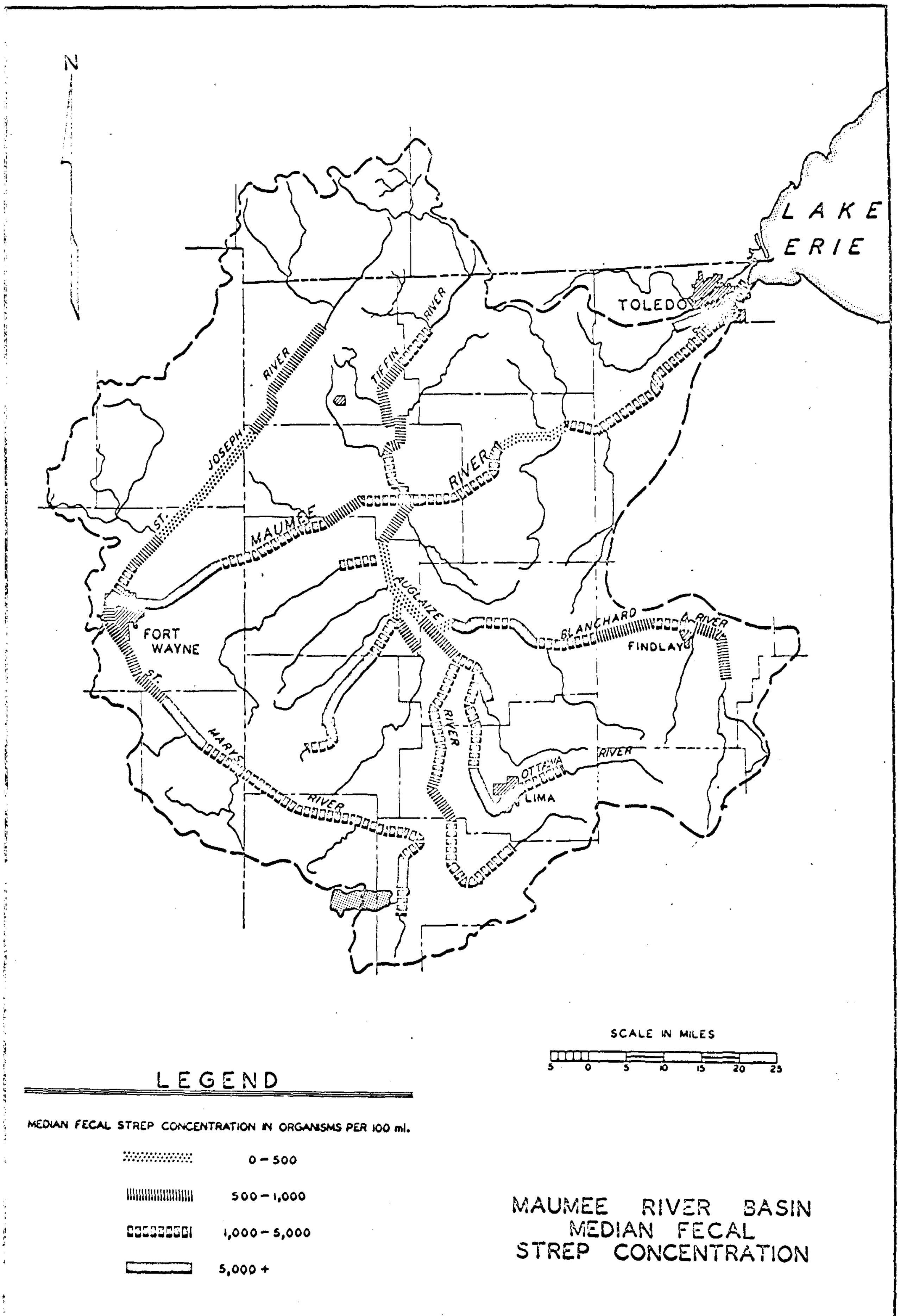
500 – 1,000

1,000 – 10,000

10,000 +

MAUMEE RIVER BASIN
MEDIAN FECAL
COLIFORM CONCENTRATION

FIGURE 7-8



MAUMEE RIVER BASIN
MEDIAN FECAL
STREP CONCENTRATION

FIGURE 7-9

St. Joseph River

The overall water quality of the St. Joseph River above Montpelier, Ohio is good. The Montpelier sewage treatment plant discharges an effluent with an oxygen demand of 800 pounds per day. Below this point, the concentration of dissolved oxygen (DO) falls to an average of 4 mg/l during low flow. A minimum DO concentration of 2 mg/l was recorded several times during late summer. Biological conditions typical of gross pollution existed during these low flows, and an oily sludge was observed.

St. Marys River

The overall water quality of the St. Marys River is fair. Abundant growth of algae occur throughout the entire year. The main sources of pollution in this subbasin are agricultural and domestic.

A dissolved oxygen sag occurs on the St. Marys River below the City of St. Marys. This sag is caused by the discharges of the St. Marys sewage treatment plant, Goodyear Tire and Rubber Company, Beatrice Foods Company, and Weston Paper Manufacturing Company. The DO at this point was below 1 mg/l over fifty percent of the time sampled.

During the period October-December, 1964, the median coliform densities in this area were 540,000 organisms per 100 ml with a range of 10,000-2,900,000. The maximum fecal streptococci density recorded was 155,000 organisms per 100 ml.

Biological sampling in the early spring discloses a sparse population of pollution-tolerant midge larvae and sludgeworms. The stream bottom is sand, rubble, and rock, and no sludge deposits are found. By July, a black septic sludge accumulates over the stream bottom and emits a strong septic odor. Because of severe environmental conditions, no bottom-dwelling organisms are found during the summer or fall.

An example of interstate pollution by solid wastes occurs at Willshire, Ohio where the city has a large dump along the St. Marys River just above the Indiana line. This dump, as can be seen in Figure 2-2D, spills garbage, trash, and other deleterious refuse into the St. Marys River.

Another dissolved oxygen sag occurs downstream from Decatur, Indiana. For several miles below Decatur the dissolved oxygen was below 4 mg/l for 20 percent of the samples. The majority of the oxygen demand load in this area is from Decatur's secondary treatment plant. Although the BOD loading from the plant is relatively low, the river cannot accommodate these loads during the low flow months. The principal industry, Central Soya, may well serve as a model for many industries and cities in the Maumee Basin, in that at this time they provide the equivalent of tertiary treatment through the use of oxidation ponds. The only additional treatment that might be required of Central Soya would be some form of phosphate removal.

Upper Maumee River

The Upper Maumee River varies in water quality from extensively polluted in the upper reaches below Fort Wayne to nutriently enriched above the Defiance area. In the upper reaches the biological conditions are seriously degraded. The stream bottom has heavy deposits of oily organic sludge and supports only a sparse population of pollution-tolerant sludgeworms and midge larva.

High concentrations of phenols occur below Fort Wayne, with a maximum concentration of 137 micrograms per liter (mg/l) recorded at a station 12.6 miles below the Fort Wayne sewage treatment plant. The average phenol concentration at this station was 24 mg/l for the year sampled. In warm weather the phenols in the Upper Maumee are readily broken down by the self-purification processes in the receiving stream. But in winter months, when the water temperature is reduced to near freezing, phenols may persist for many miles downstream. Under these conditions the phenols discharged in the Fort Wayne area may help cause the extensive taste and odor problems in the City of Defiance's water supply. Phenol concentrations in excess of 50 mg/l have been recorded in the winter time above Defiance. There are no known sources except the Fort Wayne area to account for these high readings before its junction with the Auglaize River.

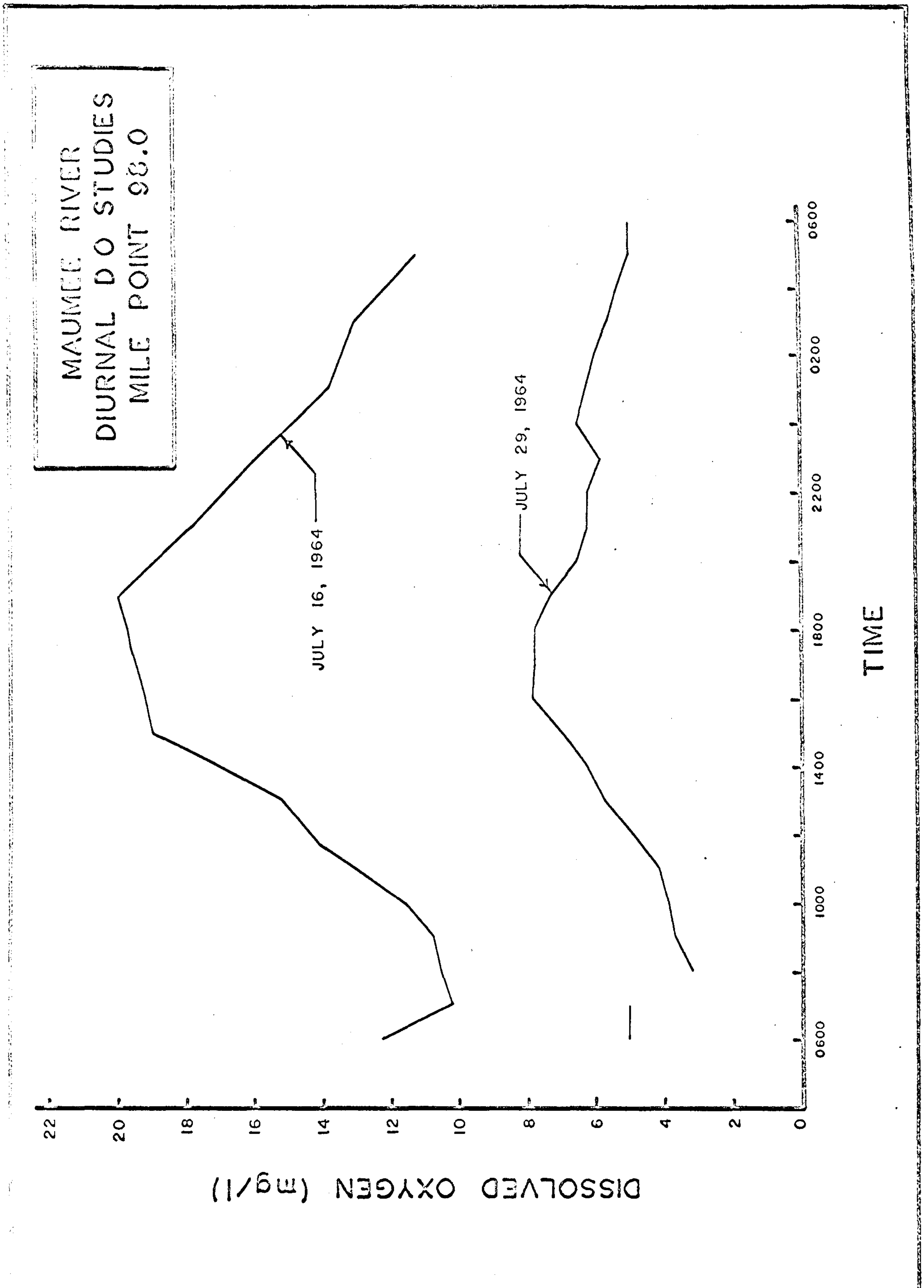
In an area below Fort Wayne the geometric mean values of total coliform, fecal coliform, and fecal streptococci were 210,000, 12,000, and 8,000 respectively. These high values result from a combination of Fort Wayne's treatment plant effluent and the discharge from the numerous suburban septic tanks in and above the Fort Wayne area.

A dissolved oxygen (DO) sag occurs in this area below Fort Wayne. At mile point 129.1 (7.0 miles below the confluence of the St. Marys and St. Joseph Rivers) the DO was below 4 mg/l over 60 percent of the times sampled. Seven miles farther downstream the DO was still below 4 mg/l over 50 percent of the times sampled throughout the year. From mile point 113.6 downstream the stream had recovered and the DO was below 4 mg/l less than 10 percent of the time.

In the nutrient-rich waters of the Upper Maumee extensive phytoplankton populations occur, with counts in excess of 30,000 per ml. In this area algal photosynthesis is the most important factor affecting the DO. At Antwerp, diurnal DO studies showed ranges of 3.8 to 8.2 mg/l and 10.3 to 20.0 mg/l on two 24-hour studies in July (Figure 7-10). Palmer (1963) indicates that there are certain genera of planktons that persist in polluted streams. According to his table of genera, 95 percent of the genera found in the Maumee River are of the pollution tolerant type (63). Increasing numbers of blue-green and green planktons which are associated with taste and odor problems, have been recorded in the Basin. These or related planktons also exist in the wintertime even under an ice cover. The average soluble phosphate content in the river dropped from over 3.6 mg/l near Fort Wayne to just over 0.5 mg/l above Defiance indicating that it had been incorporated in the organic chain. The presence of relatively intolerant bottom-dwelling animals in the Antwerp area indicates that prolonged periods of low DO do not occur in this vicinity.

Tiffin River

The overall water quality in the Tiffin River is generally quite good throughout its entire length except in several of the lower parts where it is mildly polluted. The high3st coliform densities recorded



MAUMEE RIVER
DIURNAL D O STUDIES
MILE POINT 98.0
JULY 16, 1964
JULY 29, 1964
DISSOLVED OXYGEN (mg/l)
0
2
4
6
8
10
12
14
16
18
20
22
0600
1000
1400
1800
2200
0200
0600
TIME

FIGURE 7-10

rarely exceeded 5,000 per 100 ml, and these occurred in the Stryker and Defiance areas. Excluding the last four miles of the Tiffin River, the DO never went below 3.5 during the time the river was sampled.

Auglaize River Basin

The water quality in the Auglaize River Basin, and particularly in its tributary, the Ottawa River, is the lowest in the Maumee River Basin. Above the cities and industries the water is relatively good quality, but below many of them, the water is presently unfit for many uses.

Ottawa River

The Ottawa River is grossly polluted. The stream degenerates rapidly at Lima, Ohio, and during low flow never recovers. Thirty-three miles below Lima the water is still highly colored, ranging at times from red-orange to black. Oil is normally in evidence along the banks.

As the Ottawa River nears Lima its water quality is degraded by the effluent from septic tanks and agricultural runoff. The DO was below 4 mg/l 16 percent of the time and the minimum DO was zero. What flow there is in this stretch of the river during low flow months is utilized by Lima to augment its water supply. The small amount of water that flows through Lima is further impaired by the discharge of phenols from Republic Creosote.

Below Lima, the flow in the Ottawa River is composed entirely of the effluent from Lima's secondary sewage treatment plant and the

FIGURE 2-1. A. Lake Saint Marys near Saint Marys, Ohio. B. Outfall of the Standard Oil Co. of Ohio on the Ottawa River below Lima, Ohio (note oil in waste and on rocks and bank).

effluent from Sohio's chemical and petrochemical plants and refinery.

In the past the heavy chemical pollution from this area affected water supplies not only on the Ottawa, Blanchard, and Auglaize Rivers, but at times all the way along the Lower Maumee River. Phenolic concentrations directly below Lima ranged from 40 μg/l to 19,000 μg/l and at the mouth from 13 μg/l to 1,400 μg/l. Chemical oxygen demand (COD) values ranged from 30 mg/l to 540 mg/l below Lima and from 35 mg/l to 515 mg/l at the mouth. Concentrations of ammonia ranged from 22 mg/l to 127 mg/l below Lima with a median value of 63 mg/l. One mile above the mouth of the Ottawa River, ammonia concentrations ranging from 12 mg/l to 136 mg/l were detected with a median value of 60 mg/l. Below Lima the DO was less than 4 mg/l 80 percent of the time with many zero values recorded.

Severe bacterial pollution exists at all points sampled along the Ottawa River. Four miles below Lima the median concentration per 100 ml of Total Coliform, Fecal Coliform, and Fecal Streptococci was 350,000; 165,000; and 5,500 respectively.

Below Lima, rooted aquatic plants, attached algae, and bottom-dwelling animals were completely absent in all seasons. The stream bottom is rock and shale which in the spring is scoured clean of any silt or sludge. During low flow in the summer and fall, a black, oily sludge with a strong petrochemical odor accumulates over the stream's bottom. Between Lima and the confluence with the Auglaize River, the Ottawa River showed no signs of biological recovery. The only aquatic life observed in this reach was a very sparse population of sludgeworms and midge larvae near the mouth. The complete absence of attached algae and bottom-dwelling animals indicated not only severe oxygen deficits, but the presence of highly toxic chemicals.

Sohio is presently incinerating the wastes from their acrylo-nitrile plant at a cost of one million dollars a year, and has recently completed construction of aerated ponds to provide additional treatment for their refinery wastes. This installation should markedly improve the water quality in the river, but until the City of Lima provides tertiary treatment, full recovery will not be achieved.

Blanchard River

The water quality in the Blanchard River varies from good to excessively polluted. Samples collected from the Blanchard River reveal two critical areas. The first is immediately below the City of Findlay's sewage treatment plant. Dissolved oxygen values below 4 mg/l occurred about 35 percent of the time. The water quality is severely degraded as indicated by the presence of only the pollution-tolerant sludgeworms, midge larvae, and air breathing snails. The stream bottom is silt and gravel with sludge banks along the edge. Sewage solids have been observed floating in the water.

The other critical area occurs below Ottawa, Ohio. In addition to the municipal effluent from the city, the Buckeye Sugar Co. Inc. has in the past discharged a waste containing a BOD of 2,160 pounds per day. The high oxygen demand of these wastes caused the dissolved oxygen in the Blanchard River to fall to zero for a stretch of some 20 miles downstream to the point of confluence with the Auglaize River.

This occurred in the fall of 1964.

On the Blanchard River below Ottawa, the average dissolved oxygen was 4.8 mg/l during June-September, and zero in October and November. These conditions were the same at every sampling station to the confluence with the Auglaize River. The median total coliform densities increased from 290,000 organisms per 100 ml during the June-September period to 3,400,000 during the October-December period. The highest value recorded during this period was 114,000,000 coliform organisms per 100 ml. Biological surveys confirmed these findings of gross pollu tion. In October, conditions typical of a grossly polluted stream were observed. A strong odor of hydrogen sulfide permeated the area. The water was black, and the rocks in the stream were covered with black scum. Only the most tolerant forms of biological life were found throughout the length of the river to its mouth.

Auglaize River

The main stem of the Auglaize River above the confluence with the Ottawa River is of good quality except in a stretch below Wapakoneta. In the lower areas, the Auglaize is severely degraded by wastes entering from the Ottawa and Blanchard Rivers. At Wapakoneta the Auglaize receives the effluent from the sewage treatment plant, two packing companies, a Pepsi-Cola bottling plant, and the Monarch Battery Company. No records on the effluents from these industries have been made available. The dissolved oxygen below Wapakoneta falls to zero during low flow periods. The dissolved oxygen downstream was below 4 mg/l approximately 31 percent of the time. During the period October-December 1964, the median coliform density was 140,000 organisms per 100 ml, with a range of 1,200 to 11,000,000.

Below the town, the water quality is severely degraded. Although bottom fauna of pollution-sensitive mayflies, caddis flies, and dragon flies were found to be fairly numerous in the spring, by July all pollution-sensitive organisms are eliminated and only sludgeworms and midge larvae remain. The stream bottom which had been scoured clean of silt and organic deposits during the spring is covered with black, septic, malodorous sludge by July. Below this point, the Auglaize River quickly recovers and for over 50 miles, dissolved oxygen, biochemical oxygen demand, microbiological and biological data gave little evidence of organic pollution.

Below the confluences with the Ottawa and Blanchard Rivers, another dissolved oxygen sag occurred. This is the most critical area of water quality on the Auglaize River. During the summer, dissolved oxygen concentrations averaged 2 to 3 mg/l; during low flow in the fall season, it frequently dropped to below 1 mg/l. At mile point 25.6, located directly below the confluence of the Blanchard River, the biochemical oxygen demand ranged from 4 to 40 mg/l while phenol concentrations averaged about 28 μg/l (micrograms per liter). The maximum value of phenol was about 140 μg/l.

During the summer, extensive algal growths were observed on the Auglaize River. Stream sampling indicated that, during the warm months, such compounds as phenols and organics were rapidly assimilated. During the winter months, the colder stream temperatures allow greater concentrations of these organic compounds to reach the Maumee

River. Ammonia concentrations which averaged less than 2 mg/l during July and August 1964 in this area rose to a median concentration of 42 mg/l, and as high as 84 mg/l during October to December. These results reveal that the Auglaize is severely affected by the Ottawa and Blanchard Rivers during periods of low flow and low stream temperatures.

Substantial winter fish mortalities of shad and other rough fish have been observed in the lower reaches of the Auglaize during the past four years. Since low dissolved oxygen was not a problem at that time of year the kills most likely resulted from the large ammonia concentrations mentioned previously. (Table 7-1)

TABLE 7-1

FISH KILLS - MAUMEE RIVER BASIN (OHIO)*

1964-1965

River	County	Fish Killed	Pollutant
Blanchard	Hancock	6,839	Sewage, Municipal
Blanchard	Hancock	720	Sewage, Municipal
Blanchard	Hancock	1,245,374	Sewage, Municipal
Blanchard Trib.	Putnam	1,627	Silo Drainage
Blanchard	Putnam	494,499	Sugar Beet Waste
Riley Creek	Putnam	11,163	Unknown
Auglaize	Auglaize	43,836	Sewage & Industrial
Jennings Creek	Van Wert	76	Industrial
Little Auglaize	Van Wert	14,533	Pipeline Break
Auglaize	Defiance	769,606	Unknown
West Branch Deer Cr.	Fulton	2,004	Manure
Jackson Ditch	Wood	62,607	Oil & Liquid Fertilizer
Maumee	Lucas	361,418	Sewage, Municipal
Tenmile Creek	Lucas	4,855	Unknown

* From Ohio Department of Natural Resources, Division of Wildlife Pollution Investigation, 1964-1965.

The Little Auglaize River, Flatrock Creek, and Sugar Creek exert little, if any, effect on the main stem of the Auglaize from sources other than agricultural pollution.

Town Creek is a tributary to the Little Auglaize River. Samples from this stream collected at a point below Van Wert, Ohio, revealed gross pollution during low flow. The dissolved oxygen dropped to zero in the summer. Samples collected were septic and foul smelling. Coliform densities exceeding 50,000,000 organisms per 100 ml were found.

Lower Maumee River

The water quality of the Lower Maumee River (confluence of the Tiffin River to mile point 15) is fair to severely polluted. Cities situated on or near the Maumee River draw their raw water supply from the highly polluted waters of this stream. Taste and odor problems are prevalent throughout most of the year in the water supplies at Defiance, Napoleon, Bowling Green, and other cities. At Defiance, during periods of low temperatures and ice cover, problems are encountered with phenolic compounds. The finished water imparts a medicinal taste and odor enhanced by chlorination. During the period of Spring runoff, the water has an intense earthly or musty taste. During late Spring in 1963, 1964 and 1965, there were periods of exceptionally severe taste and odor problems. The water during these periods was described variously as musty, moldy, earthy, fishy, and "rotten".

The taste and odor problems at Napoleon are similar to those in Defiance with the exception of additional interference from ammonia compounds from the Auglaize River. Campbell Soup Company has reported excessive taste and odor problems at times in their raw water supply, but they are able to remove it in their extensive treatment plant. Large concentrations of ammonia at the plant have created peak chlorine demands as high as 150 mg/l. The company reports that the quality of its raw water supply has continued to deteriorate in recent years.

The main sources of ammonia, nitrates and phenols to the waters in this area are: surface runoff from agricultural sources, and the discharges of: the Fort Wayne area, Sohio industrial plants and Johns-Manville Fiberglass Company through the Defiance Sewage Treatment Plant.

Above the City of Defiance, Ohio a dissolved oxygen deficit occurs. This point is above the confluence with the highly polluted Auglaize River and the Defiance Sewage Treatment Plant. This deficit is attributed to the large number of unsewered or faulty sewered residences in this area discharging raw sewage into the Maumee River. Also, the sewage collection system is faulty in that the sewage treatment plant is closed 30 to 60 days each year. As the river stage rises 5 feet above normal, water is backed up in the main lift station closing the main interceptor and sewage is bypassed directly to the river 2 miles above the plant.

The sewage treatment plant at Defiance provides only primary treatment facilities. An industrial and municipal waste survey by the State of Ohio indicated 1,770 lbs/day BOD and 6,750 lbs/day total solids in the final effluent. Phenol concentrations in the range of 14,000 - 22,000 µg/l were recorded, which averaged about 100 lbs. of

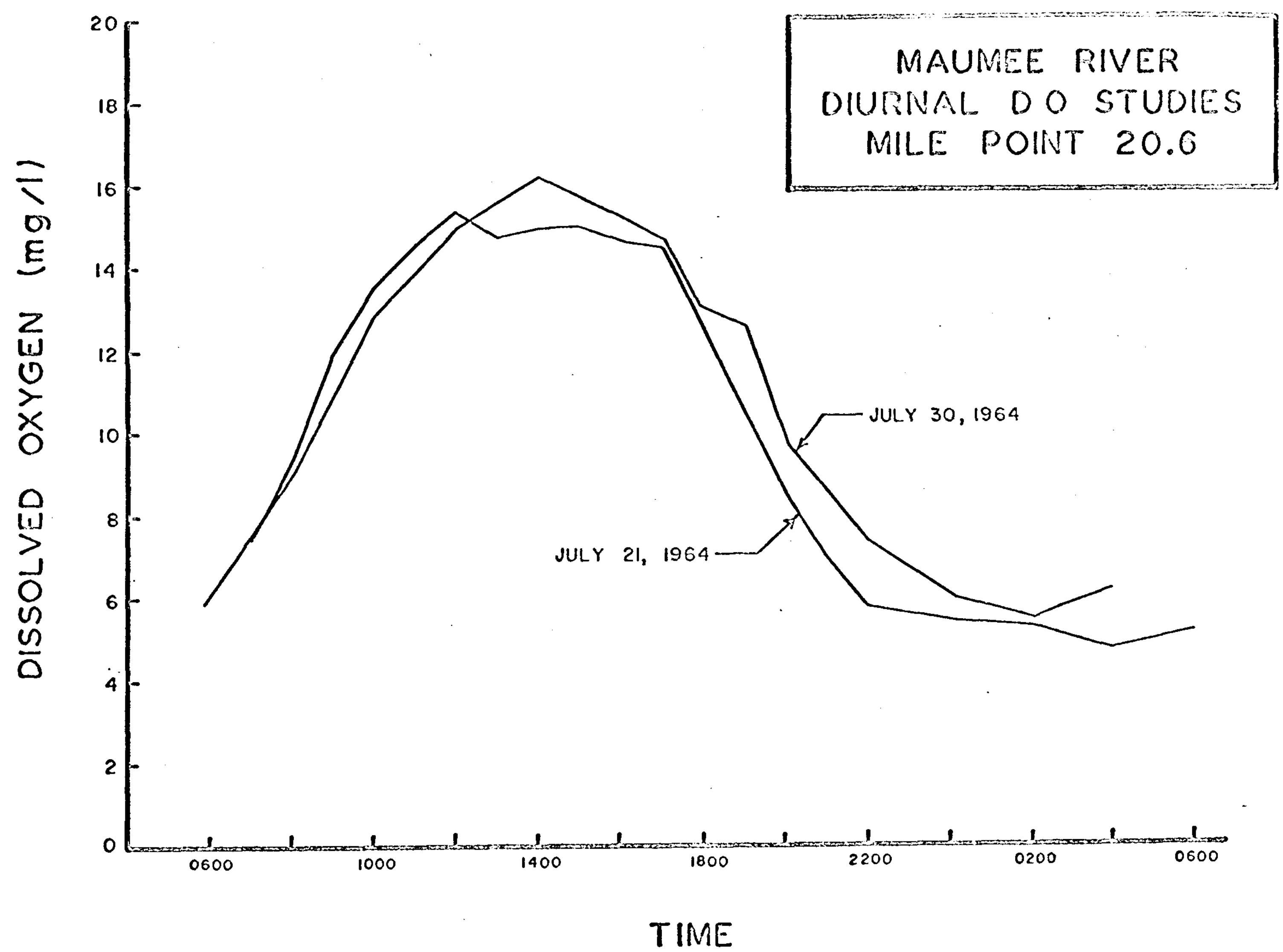


FIGURE 7-11

GPO 827-431-5

phenol discharged per day. Most of the industry in Defiance is sewered. However, primary treatment cannot assimilate the heavy loading of phenolic compounds from the Johns-Manville Fiberglass Company.

Municipal wastes are also discharged to the Lower Maumee by the communities of Perrysburg and Waterville. The sewage treatment plant at Perrysburg has only primary treatment while Waterville has a secondary plant.

The extensive growth of blue-green and green algae throughout this entire stretch also helps produce taste and odor problems. Phytoplankton counts in excess of 100,000 per ml were found in the summer of 1964. Table 7-2 is a tabulation of the plankton counts at mile point 65 from October 1964 to June 1965.

TABLE 7-2

PLANKTON COUNTS AT MILE POINT 65.0 ON THE MAUMEE RIVER

AT DEFIANCE, OHIO
(Numbers per ml)

Date	Diatoms		Green		Blue-green		Total
	Centric	pennate	coccoid	flag-ellate	coccoid	fila-mentous	
10-29-64	35,952	17,136	61,488	448	11,200		126,224
12-23-64	5,670	1,755	1,755	1,305		900	11,385
12-28-64	4,888	585	630			45	5,948
1-12-65	900	4,185	540	315	270	180	6,363
1-23-65	45	607	67	22	22	22	785
3-8-65	Too turbid to count						
4-4-65	360	505	315	135	450	270	2,035
4-21-65	360	90	135	45	45	45	720
4-23-65	270	405	90	180	45	135	1,125
5-4-65	1,688	1,123	741	88	112	742	4,498
5-18-65	1,710	1,845	1,395	315	450	315	6,030
5-27-65	12,960	3,115	9,945	675	3,375	1,080	30,096

During the same period (October 1964-June 1965) diurnal DO studies showed considerable vertical and diurnal variations. Values as high as 10 mg/l were often found at the surface while the bottom waters contained only 0.5 mg/l. Diurnal variations gave early morning concentrations of 8.0 mg/l at the surface and 25 mg/l in the afternoon. The low DO values at the bottom confirmed the absences of any intolerant animals on the stream bottom. Figure 7-11 shows the diurnal curve for mile point 20.6 on two dates in 1964.

Toledo Channel, Harbor, and Lakefront

Lake level fluctuations have been found to affect the Maumee River as far as 15 miles upstream; therefore, pollution which enters the Maumee at one point in this lake affected area may degrade the water quality several miles upstream.

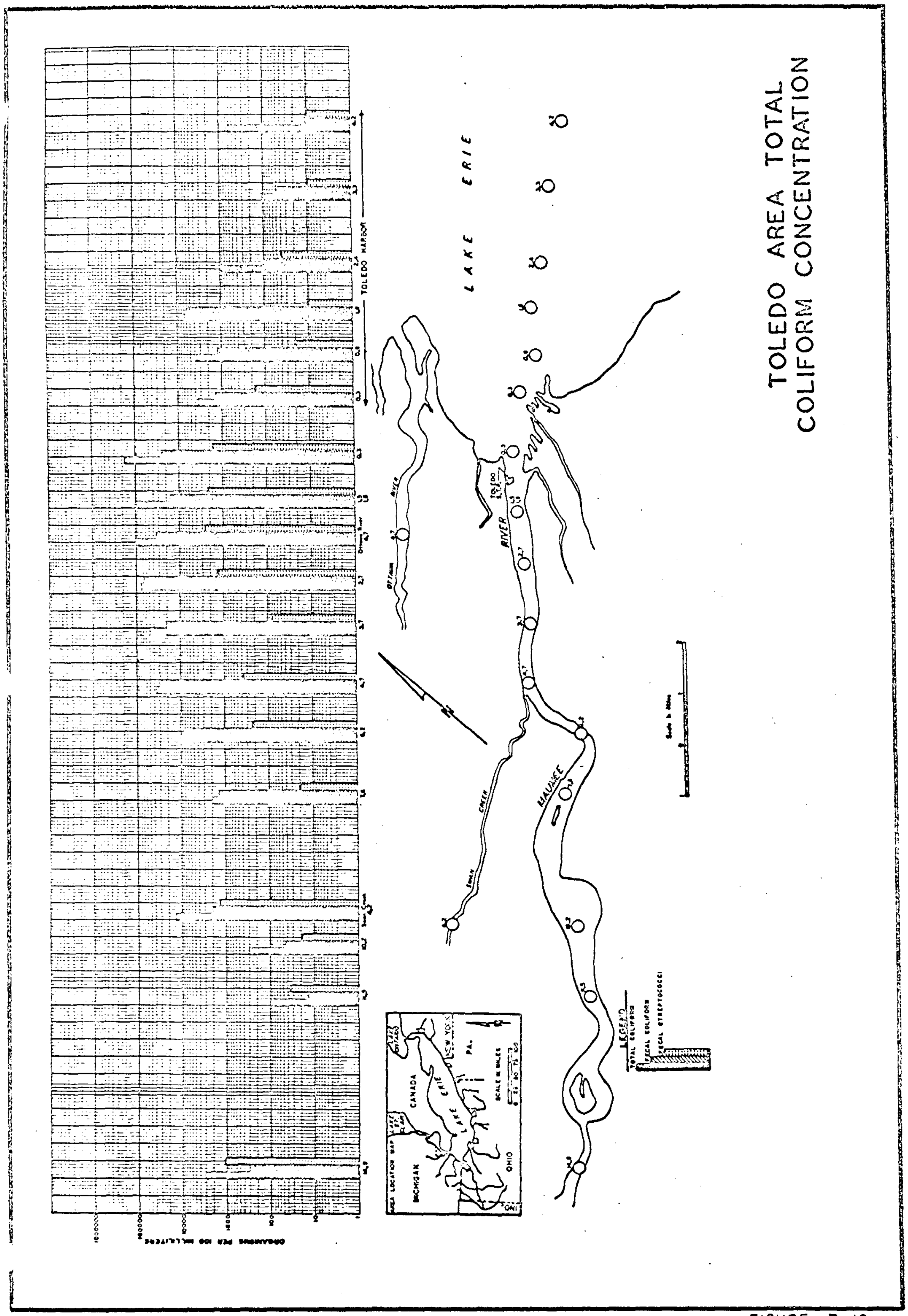
Sediment is a problem in the navigation channel, which extends approximately seven miles upstream from the mouth of the river and must be continuously dredged. The suspended sediment is extremely fine and stays in suspension for long periods of time. The Maumee discharges about 2 million tons of sediment a year to Lake Erie.

The waters in the navigation channel and lake front areas are severely polluted. Very high bacterial densities were found in these waters, with median densities of total coliform, fecal coliform, and fecal strep in excess of 100,000; 11,000; and 1,100 organisms per 100 ml respectively. As can be noted in Figure 7-12, fecal coliform was the prime coliform present in the lower eight miles of the Maumee River. The existence of human enteric pathogenic microorganisms were also revealed. *Salmonella* was detected 40 percent of the times sampled, confirming the health hazard to persons exposed to these waters. A partial listing of Salmonella serotypes isolated is given in Table 7-3.

TABLE 7-3

ISOLATIONS OF SALMONELLAE-LOWER MAUMEE
January 15 - April 1, 1964

Sampling Site	Date of Collection	Salmonella Serotypes (isolates)
Tenmile Creek 004.7	1-21-64	Salmonella cubana (1)
	1-28-64	--
	2-18-64	Salmonella infantis (1), chester (1)
	3-31-64	Salmonella tennessee (4), thompson(2)
Tenmile Creek 010.2	1-28-64	--
	2-18-64	Salmonella worthington (1)
	3-10-64	--
Maumee River 001.6	2-18-64	Salmonella infantis (1)
	3-10-64	Salmonella tennessee(2), oranienburg(1)
Maumee River 014.9	1-21-64	--
	2-5-64	--
	3-10-64	--



TOLEDO AREA TOTAL
COLIFORM CONCENTRATION
LAKE ERIE
RIVER
MAUMEE
TOLEDO HARBOR
LEGEND
TOTAL COLIFORM
FECAL COLIFORM
FECAL STREPTOCOCCI
AREA LOCATION MAP
CANADA
LAKE ERIE
MICHIGAN
OHIO
PA.
NEW YORK
ORGANISMS PER 100 MILLILITERS

FIGURE 7-12

IMMEDIATE NEEDS
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
MAUMEE RIVER BASIN

MUNICIPAL

Sewerage Service Area	Present Treatment	1960 Population	Plant Needs
	MICHIGAN		
	St. Joseph River		
Reading	Septic Tanks	1,130	Secondary & Disinfection
	Tiffin River		
Hudson	Secondary	2,550	Expansion
Morenci	Stabilization Lagoons	2,055	None
	INDIANA		
	St. Joseph River		
Auburn	Secondary	6,350	Tertiary
Butler	Secondary	2,170	Disinfection
Garrett	Secondary	4,364	Tertiary
Waterloo	Secondary	1,432	Disinfection
	St. Marys River		
Berne	Stabilization Lagoons	2,644	Disinfection
Decatur	Secondary	8,327	Tertiary
	Upper Maumee River		
Diversified Utilities, Inc.	Secondary	4,200	Expansion
*Fort Wayne	Secondary	171,780	Tertiary
New Haven	Secondary	3,396	Disinfection
	OHIO		
	St. Joseph River		
Edgerton	Septic Tanks	1,566	Secondary & Disinfection
*Montpelier	Primary	4,131	Secondary & Disinfection

* Indicates sewage treatment plants receiving significant industrial loads.

MUNICIPAL (Cont'd)

Sewerage Service Area	Present Treatment	1960 Population	Plant Needs
	St. Marys River		
New Bremen	Secondary	1,972	Tertiary
Rockford	Primary	1,155	Secondary & Disinfection
*St. Marys	Secondary	7,737	Tertiary
	Auglaize River		
Ada	Secondary	3,918	Tertiary
Bluffton	Secondary	2,591	Tertiary
*Columbus Grove	Secondary	2,104	Tertiary
Continental	Secondary	1,147	Tertiary
Cridersville	Secondary	1,053	Tertiary
*Delphos	Secondary	6,961	Tertiary
Dunkirk	Septic Tanks	1,006	Secondary & Disinfection
Elida	Secondary	1,215	None
*Findlay	Secondary	30,344	Tertiary
Forest	Secondary	1,314	Tertiary
*Lima	Secondary	51,037	Tertiary
Ottawa	Secondary	3,245	None
Paulding	Stabilization Lagoons	2,936	Disinfection
Payne	Septic Tanks	1,287	Secondary & Disinfection
Spencerville	Secondary	2,061	Expansion & Disinfection
*Van Wert	Secondary	11,323	Tertiary
*Wapakoneta	Secondary	6,756	Tertiary
	Tiffin River		
*Archbold	Secondary	2,348	Tertiary
*Bryan	Secondary	7,361	Tertiary
Fayette	Stabilization Lagoons	1,090	Disinfection
Stryker	Stabilization Lagoons	1,205	Disinfection
West Unity	Septic Tanks	1,192	Tertiary
	Upper Maumee River		
Antwerp	Septic Tanks	1,465	Secondary & Disinfection
Defiance	Intermediate	14,553	Expansion
Hicksville	Secondary	3,116	Expansion
	Lower Maumee River		
*Delta	Secondary	2,376	Tertiary
*Deshler	Stabilization Lagoons	1,824	Tertiary

* Indicates sewage treatment plant receiving significant industrial loads.

MUNICIPAL (Cont'd)

Sewerage Service Area	Present Treatment	1960 Population	Plant Needs
	Lower Maumee River (continued)		
Holgate	Septic Tanks	1,374	Tertiary
Leipsic	Secondary	1,802	Tertiary
Napoleon	Secondary	6,739	None
Perrysburg	Intermediate	5,519	Secondary
Swanton	Secondary	2,306	Tertiary
*Toledo	Secondary	318,000	Tertiary
Waterville	Secondary	1,856	Expansion & Disinfection
Wauseon	Secondary	4,311	Tertiary
Weston	Secondary	1,075	Tertiary
*Whitehouse	Secondary	1,135	Expansion
Oregon	Septic Tanks	14,830	Connect to Toledo
Walbridge	Primary	2,850	Connect to Toledo
	Minor Tributaries		
	Tenmile Creek (Ottawa River)		
Sylvania	Secondary	5,187	Connect to Toledo
	Silver Creek		
Trilby	Septic Tanks	5,000	Secondary & Disinfection

INDUSTRIAL

Industry	Location	Control Measures
	Lower Maumee River	
Toledo Edison	Toledo, Ohio	General Control Measures & Improvements
Gulf Oil Company	Toledo, Ohio	COD, Oil
Sun Oil Company	Toledo, Ohio	Solids
Pure Oil	Toledo, Ohio	Oil, COD, and Phenols
Standard Oil Company	Toledo, Ohio	Phenols, Oil, COD
Libbey-Owens-Ford	Toledo, Ohio	Oil, Solids, Color
Interlake Iron	Toledo, Ohio	Phenols, Solids
Johns-Manville Company	Waterville, Ohio	Solids, BOD, Phenol
Campbell Soup Company	Napoleon, Ohio	BOD
Central Foundry(Div.GM)	Defiance, Ohio	Solids, BOD
S. K. Wayne Tool Co.	Defiance, Ohio	General Control Measures

* Indicates sewage treatment plants receiving significant industrial loads.

INDUSTRIAL (Cont'd)

Industry	Location	Control Measures
	Upper Maumee River	
Weatherhead Corporation	Antwerp, Ohio	Oils and Solids
	Auglaize River	
Hayes Industry - Decorative Division	Spencerville, Ohio	Solids
Ohio Decorative Products	Spencerville, Ohio	Solids, Housekeeping
	Blanchard River	
Buckeye Sugars	Ottawa, Ohio	BOD
National Refinery (Ashland Oil)	Findlay, Ohio	Oil, General Housekeeping
Rusco Inc.	Pandora, Ohio	Oil, Solids, Secondary Treatment of Sewage
	Ottawa River	
Excello Corporation	Lima, Ohio	General Housekeeping
Ford Motor Company	Lima, Ohio	Oil
Republic Creosote	Lima, Ohio	Phenol
Standard Oil Company		
Refinery	Lima, Ohio	Phenol, Oil, COD
Chemical	Lima, Ohio	Amonia
Petrochemical	Lima, Ohio	Evaluate Completed Improvements
	St. Joseph River	
Edgerton Metal Products	Edgerton, Ohio	Chrome Treatment, Acid Neutralization
	St. Marys River	
Weston Paper	St. Marys, Ohio	BOD
Goodyear Tire & Rubber Company	St. Marys, Ohio	General Housekeeping
Beatrice Foods Company	St. Marys, Ohio	General Housekeeping
Essex Wire Company	Fort Wayne, Ind.	Phenol
	Tenmile Creek	
Dana Corporation	Toledo, Ohio	Oil

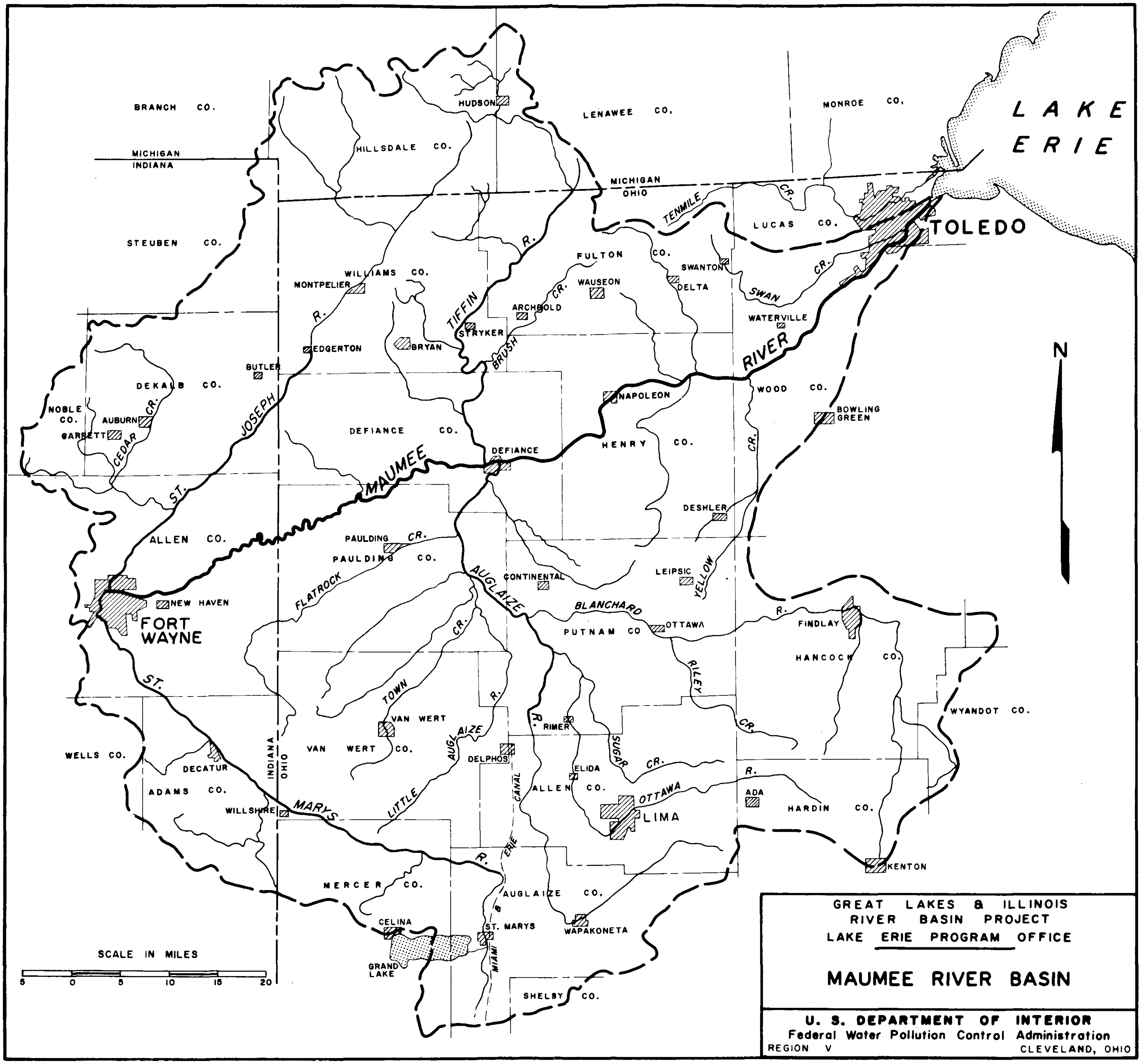

LAKE ERIE
BRANCH CO.
LENAWEE CO.
MONROE CO.
HILLSDALE CO.
HUDSON
MICHIGAN
INDIANA
MICHIGAN
OHIO
STEUBEN CO.
TENMILE CR.
LUCAS CO.
TOLEDO
FULTON CO.
SWANTON
DELTA
SWAN CR.
WILLIAMS CO.
MONTPELIER
TIFFIN R.
WAUSEON
ARCHBOLD
WATERVILLE
STRYKER
BRUSH CR.
EDGERTON
BRYAN
BUTLER
RIVER
DEKALB CO.
NOBLE CO.
AUBURN
GARRETT
CEDAR CR.
ST. JOSEPH R.
NAPOLEON
WOOD CO.
BOWLING GREEN
DEFIANCE CO.
DEFIANCE
HENRY CO.
MAUMEE
ALLEN CO.
DESHLER
PAULDING CR.
PAULDING CO.
AUGLAIZE
CONTINENTAL
LEIPSIC
YELLOW CR.
FLATROCK
NEW HAVEN
FORT WAYNE
BLANCHARD R.
OTTAWA
PUTNAM CO
FINDLAY
HANCOCK CO.
TOWN CR.
RILEY CR.
ST. MARYS R.
VAN WERT
RIMER
WYANDOT CO.
WELLS CO.
INDIANA
OHIO
VAN WERT CO.
LITTLE AUGLAIZE R.
DELPHOS
SUGAR CR.
DECATUR
ELIDA
ALLEN CO.
OTTAWA R.
ADAMS CO.
MIAMI & ERIE CANAL
ADA
HARDIN CO.
WILLSHIRE
LIMA
KENTON
MERCER CO.
AUGLAIZE CO.
GREAT LAKES & ILLINOIS
RIVER BASIN PROJECT
LAKE ERIE PROGRAM OFFICE
CELINA
ST. MARYS
WAPAKONETA
MAUMEE RIVER BASIN
SCALE IN MILES
5 0 5 10 15 20
GRAND LAKE
SHELBY CO.
U. S. DEPARTMENT OF INTERIOR
Federal Water Pollution Control Administration
REGION V
CLEVELAND, OHIO
N

FIGURE I-3

NORTH CENTRAL OHIO AREA

The major Ohio tributaries to Lake Erie in North Central Ohio are the Portage, Sandusky, Huron, Vermilion, and Black Rivers (Fig. 5-1). They drain an area of 4,109 square miles, with a population of 600,000. The principal cities are Lorain, Elyria, and Sandusky.

Present Water Quality

The majority of streams in this area suffer from either direct pollution or enrichment. Dissolved oxygen deficites occur in numerous locations, as do excessive algal growths. Windrows of decomposing algae are commonly found along the lakefront during summer months.

The upstream reaches of these rivers flow through predominantly farm lands, where water quality is slowly degraded by silt and aquatic growths. However, as the streams flow toward the Lake through urban areas and industrial complexes, the rivers rapidly become more degraded and in places grossly polluted. Their color ch anges to unnatural hues, and repulsive sights and noxious odors develop by the time they reach the Lake. This is not true for all streams in North Central Ohio, and some recover from their pollution before flowing into Lake Erie.

The Portage River is often septic and black below Bowling Green, and turbid-white and rust-colored within Fostoria. The Black River is multicolored from industrial wastes in Elyria and the city's Cascade Park. In Lorain, the navigation channel of the Black River is sometimes covered by oil slicks. Upstream the rivers are green-colored by algae and often covered with the scum of aquatic growths. River bank trash dumps are found on all rivers, and the streams are clogged in places with logs and debris.

During periods of low flow the dissolved oxygen (DO) drops to less than 4.0 mg/l below Upper Sandusky, Tiffin, and Fremont on the Sandusky River. Forty percent of the samples collected at the critical point below Upper Sandusky showed oxygen concentrations of less than 4.0 mg/l. On three occasions there was no measurable oxygen, and accompanying BOD's reached 39.0 mg/l. Intensive sampling programs below Tiffin and Fremont revealed that during the low flow period under normal loadings from the treatment plants, the dissolved oxygen concentrations were near 1.0 mg/l. Below Upper Sandusky the oxygen sag extends approximately four miles below the treatment plant.

There are similar problems on the West Branch of the Black River and Plum Creek from Oberlin to the lake-affected area in Lorain. The

July 1964 average of dissolved oxygen for this reach was 2 mg/l. The highest average seasonal BOD_5 in North Central Ohio was 20 mg/l below Elyria. Even at mile point 0.6 in the mouth of the river where lake dilution is high, the dissolved oxygen averaged only 3.4 mg/l during the fall of 1964.

The most serious problems from low dissolved oxygen on the Portage River occur below Bowling Green and Fostoria. Septic conditions have been reported in the stream at both locations.

Microbiology

Domestic pollution, as indicated by total coliform densities, is prevalent throughout most of the basin. Because the waters of the basin are used for recreation and water supply, the microbial pollution presents a potential health hazard. On the Portage River at mile point 0.4, median densities during the summer and fall of 1964 were 130,000 organisms per 100 ml. During the summer, the median fecal coliform density was 21,000 organisms per 100 ml.

The Sandusky River had median total coliform densities of 190,000 organisms per 100 ml below Fremont at mile point 13.6 during the fall, 1964. In Sandusky Bay at the mouth of the river, the median total coliform density was less than 1,000 organisms per 100 ml with a maximum of 1,300 organisms per 100 ml.

The median total coliform density in the Black River at mile point 10.2 below the Elyria treatment plant was 300,000 organisms per 100 ml during the first three months of 1964. The maximum density reached 15,300,000 per 100 ml. During April and May 1964 the median

TABLE 7-1

FISH KILLS - NORTH CENTRAL OHIO AREA*

1964-1965

River	County	Fish Killed	Pollutant
Kiser Run	Wyandot	15	Livestock sewage
Sandusky	Seneca	20,320	Tiffin, sewage
Camel Creek	Medina	2,437	Oil-gas well
Bear Run	Richland	103	Silo drainage
Sandusky	Wyandot	2,054	Unknown
Black	Lorain	65	Grafton, sewage
Sandusky	Seneca	4,833	Tiffin, sewage
Sandusky	Wyandot	3,529	Upper Sandusky, sewage
Sandusky	Seneca	4,883	Tiffin, sewage
Sandusky	Wyandot	65	Upper Sandusky, sewage
Crone Creek	Ottawa	278,968	Tomato processing waste
Sandusky	Sandusky	105,552	Fremont, sewage
Pipe Creek	Erie	394	Canning waste
Kelly Marsh	Erie	19	Industrial waste
Pettie Ditch	Seneca	2,940	Unknown

* From Ohio Department of Natural Resources, Division of Wildlife Pollution Investigation, 1964-1965.

of metals and cyanide in the river at mile point 10.2. Maximum concentrations in mg/l during 1964 were: copper, 0.31; cadmium, 0.08; nickel, 0.42; sinc, 0.28; chromium, 1.32; and lead, 0.04.

In the navigation channel of the Black River phenol concentrations averaged 15.1 micrograms per liter during the first three months of 1964. At this location, mile point 0.6, a maximum phenol concentration of 65.9 micrograms per liter was found. The steel industry is a significant source of phenol wastes, and with the reactivations of coke operations, these waste discharges could increase greatly. These industrial wastes are significant because density was 140,000 organisms per 100 ml. At this same station, the median fecal coliform density was 57,000 organisms per 100 ml during April and May.

Biology

Biological conditions in the Portage, Huron, and Vermilion Rivers are generally good except for the areas near the Lake which are degraded by siltation and local waste sources. The effect upon the Lake by these rivers could be detected more than 1,000 feet into the Lake. The Sandusky River below Upper Sandusky, Tiffin, and Fremont shows evidences of biological degradation. All pollution sensitive bottom-dwelling animals are absent below each area, and full recovery does not occur until the next water source. Between Tiffin and Fremont, the nutrient-rich waters support a dense growth of attached algae which completely cover the bottom in summer. Between Oberlin and the mouth of the Black River, biological conditions typical of a polluted stream are found. Numerous fish kills have occurred in this area. Those occurring in 1964-1965 are summarized below.

Chemistry

Oil slicks from floating oil are found on the Sandusky, Huron, and Black Rivers. Emulsified oil has turned the Portage River turbid at Fostoria. The major problems from industrial wastes occur in the industrialized Black River. The steel, automotive (metal-plating), and chemical industries in Elyria, some of whose wastes are treated by the municipal sewage treatment plant, are the sources two major municipal water intakes are located near the mouth of the Black River.

IMMEDIATE NEEDS
MUNICIPALITIES AND INDUSTRIES IN THE
PORTAGE RIVER BASIN

MUNICIPALITIES

Sewerage Service Area	Present Treatment	1965 Population	Plant Needs
Bloomdale	Septic Tanks	700	
Bowling Green	Secondary	14,100	Tertiary
Elmore	None	1,360	Secondary
Fostoria	Secondary	16,100	Tertiary
Gibsonburg	Septic Tanks	2,700	Tertiary
McComb	Primary	1,270	Tertiary
North Baltimore	Secondary	3,200	Tertiary
Oak Harbor	Primary	3,130	Secondary
Pemberville	None	1,280	Secondary
Woodville	None	1,880	Secondary

INDUSTRIES

Industry	Location	Control Measures
Brush Beryllium	Elmore	None
Foster Duck Farm		BOD
Gibsonburg Canning Co.	Gibsonburg	None
✓ Hirzel Canning Co.	Pemberville	BOD
Seneca Wire & Manufacturing	Fostoria	Metals, Solids
Swift & Co.	Fostoria	Oil, Color, BOD
Wood Co. Canning Co.	North Baltimore	None

IMMEDIATE NEEDS
MUNICIPALITIES AND INDUSTRIES IN THE
SANDUSKY RIVER BASIN

MUNICIPALITIES

Sewerage Service Area	Present Treatment	1965 Population	Plant Needs
Attica	None	1,020	Tertiary
Ballville	Septic Tanks	1,470	Tertiary
Bloomville	None	870	Tertiary
Bucyrus	Secondary	13,200	Tertiary
Carey	Secondary	4,100	Tertiary
Clinton Township	Septic Tanks		Tertiary
Crestline	Secondary	6,100	Tertiary
Fremont	Secondary	20,060	Tertiary
Nevada	Septic Tanks	1,010	Tertiary
New Washington	Septic Tanks	1,300	Tertiary
Sandusky Co.S.D. #1	Septic Tanks		Secondary
Sycamore	Septic Tanks	1,090	Tertiary
Tiffin	Primary	22,480	Tertiary
Upper Sandusky	Secondary	5,290	Tertiary

INDUSTRIES

Industry	Location	Control Measures
H. J. Heinz	Fremont	None
Northern Ohio Sugar	Fremont	BOD
Pennsylvania R.R.	Crestline	Oil
Pioneer Rubber	Willard	BOD, Rubber

IMMEDIATE NEEDS
MUNICIPALITIES AND INDUSTRIES IN THE
HURON RIVER BASIN

MUNICIPALITIES

Sewerage Service Area	Present Treatment	1965 Population	Plant Needs
Huron	Secondary, Intermediate	6,470	Tertiary
Milan	Primary	1,570	Secondary
Monroeville	Primary	1,420	Secondary
Norwalk	Secondary	14,200	Tertiary
Plymouth	Secondary	1,960	Tertiary
Willard	Secondary	5,900	Tertiary

INDUSTRIES

Industry	Location	Control Measures
Baltimore & Ohio RR	Willard	Oil
Clevite Corp.	Milan	Acid, Metals, Solids

IMMEDIATE NEEDS
MUNICIPALITIES AND INDUSTRIES IN THE
VERMILION RIVER BASIN

MUNICIPALITIES

Sewerage Service Area	Present Treatment	1965 Population	Plant Needs
Greenwich	Secondary	1,500	Tertiary
New London	Secondary	2,620	Tertiary
Vermilion	Primary	7,730	Tertiary

IMMEDIATE NEEDS
MUNICIPALITIES AND INDUSTRIES IN THE
BLACK RIVER BASIN

MUNICIPALITIES

Sewerage Service Area	Present Treatment	1965 Population	Plant Needs
Elyria	Secondary	47,000	Tertiary
Grafton	Septic Tanks	1,840	Tertiary
LaGrange	Septic Tanks	1,110	Tertiary
Lodi	Secondary	2,430	Tertiary
Oberlin	Secondary	8,900	Tertiary
North Ridgeville	Secondary	8,600	Tertiary
Vincent	Septic Tanks	4,000	Connect to Lorain
Wellington	Secondary	3,860	Tertiary

INDUSTRIES

Industry	Location	Control Measures
Buckeye Pipeline		Oil
GMC, Turnstedt Div.	Elyria	Cyanide, Chrome
Locke Manufacturing	Lodi	None
Republic Steel, Steel & Tube Div.	Elyria	Acid
U.S. Steel, Tubular Operations	Lorain	Solids
United Dairy	Lodi	None

IMMEDIATE NEEDS
MUNICIPALITIES AND INDUSTRIES IN THE
NORTH CENTRAL OHIO AREA
SMALL TRIBUTARIES

MUNICIPALITIES

Sewerage Service Area	Present Treatment	1965 Population	Plant Needs
Amherst	Secondary	8,620	Tertiary
Bellevue	None	8,900	Tertiary
Brownhelm Township	Secondary	1,890	Tertiary
Castalia	Septic Tanks	1,040	Tertiary
Clyde	Secondary	5,300	Tertiary
Genoa	Septic Tanks	2,100	Tertiary
Green Springs	Primary	1,010	Tertiary
Perkins-Margaretta S.D.	Septic Tanks		Connect to Sandusky
Sandusky Soldiers & Sailors Home	Secondary	1,500	Tertiary
South Amherst	Septic Tanks	1,790	Connect to Amherst
Trilby	Septic Tanks	5,500	Tertiary

INDUSTRIES

Industry	Location	Control Measures
Bechtel-McLaughlin	Sandusky	Acid, Chrome, Solids
Central Soya	Bellevue	Oil
Ford, Assembly Plant	Lorain	None
Ford, Hardware Plant	Sandusky	None
G. E. Lamp Plant #242	Bellevue	BOD
GMC, New Departure Div.	Sandusky	None
Hirzel Canning		BOD, Solids
Lake Erie Canning	Sandusky	BOD
NASA, Plumb Brook Facilities	Sandusky	BOD
Norfolk & Western RR		Oil
Silver Fleece Canning	Port Clinton	None
Stokely-Van Camp	Norwalk	None
Whirlpool Corp.	Clyde	None

IMMEDIATE NEEDS
MUNICIPALITIES AND INDUSTRIES IN THE
NORTH CENTRAL OHIO AREA
DIRECT TO LAKE

MUNICIPALITIES

Sewerage Service Area	Present Treatment	1965 Population	Plant Needs
Avon	Septic Tanks	7,660	Connect to County Plant
Avon Lake	Septic Tanks	12,100	Secondary
Bay View		1,020	Secondary
Camp Perry	Secondary	15,000	None
E Erie Sewer & Water Dist.	Intermediate	1,300	Secondary
Lakeside		4,000	Connect to County Plant
Lorain	Primary	76,920	Secondary
Marblehead		950	Connect to County Plant
Port Clinton	Intermediate	7,350	Secondary
Put-In-Bay		400	Secondary
Sandusky	Primary	33,850	Secondary
Sheffield	Septic Tanks	1,800	Connect to County Plant
Sheffield Lake		7,580	Connect to County Plant
Vermilion-On-The-Lake		1,450	Connect to Vermilion
Westlake		15,000	Connect to County Plant

INDUSTRIES

Industry	Location	Control Measures
Aluminum & Magnesium	Sandusky	None
Cleveland Electric Illuminating	Avon Lake	Solids
Ohio Edison	Lorain	None
U. S. Gypsum Co.	Gypsum	BOD

GREATER CLEVELAND-AKRON AREA

The Greater Cleveland-Akron Area consists of the Rocky, Cuyahoga, and Chagrin Rivers and several minor streams with an area of 1,490 square miles. The population of Cleveland and Akron is 876,000 and 290,000 respectively, and the total population in the area is presently 2,270,000. It is projected to increase to 4,200,000 by 1990 and to 6,000,000 by 2020. Cleveland is one of the great steel producing and fabricating areas in the country and Akron is the country's main supplier of rubber. The water quality of the area's streams vary from excellent to extensively degraded or polluted.

Figures 7-1 through 7-3 depict the present water quality of the Rocky, Cuyahoga, and Chagrin Rivers. These figures indicate the location of water quality problem areas. The fold out map at the back of this section should be used to locate a specific city or area.

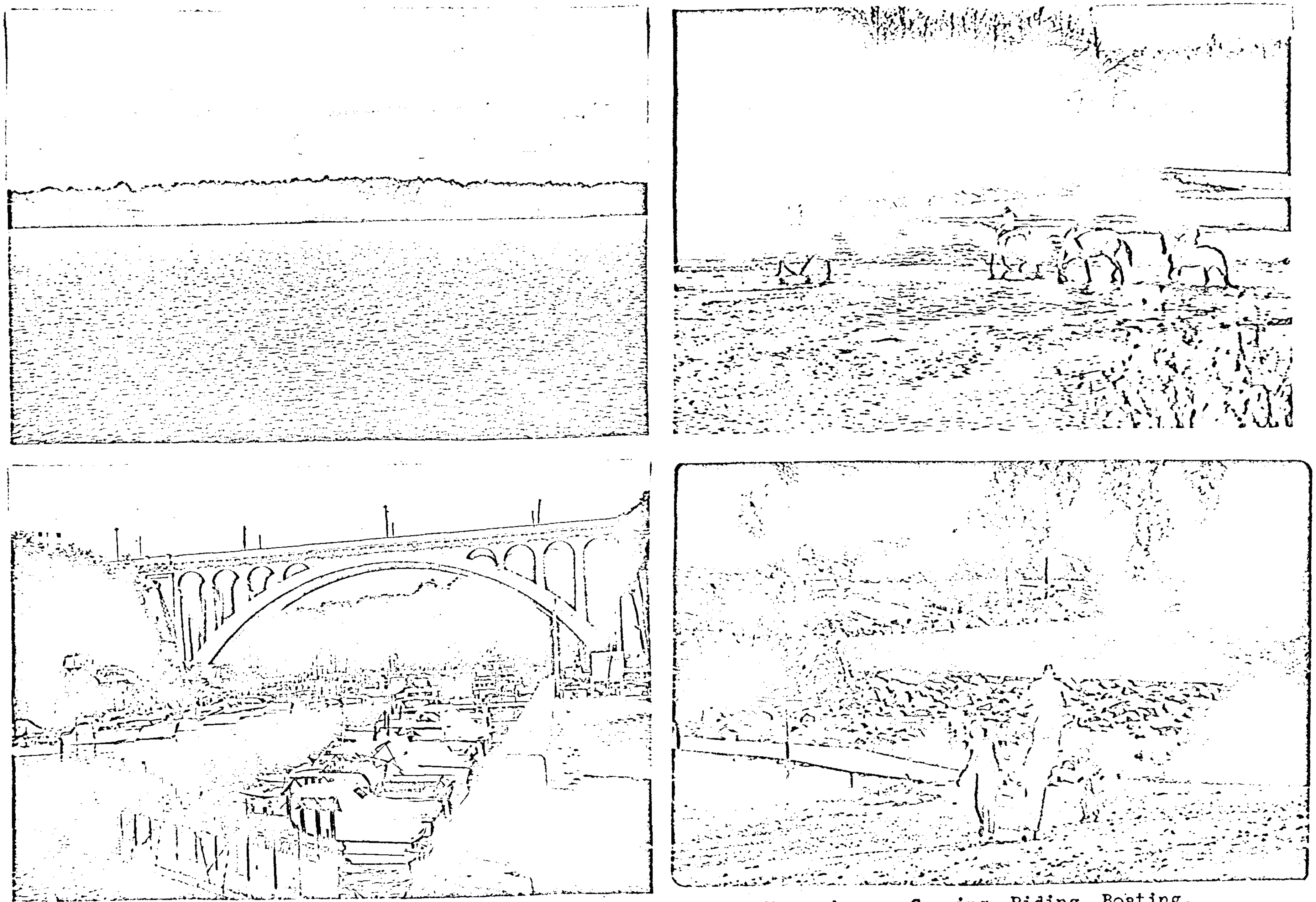


Figure 5-1. Recreational Water Uses in the Greater Cleveland-Akron Area - Camping, Riding, Boating, Picnicking and Esthetics

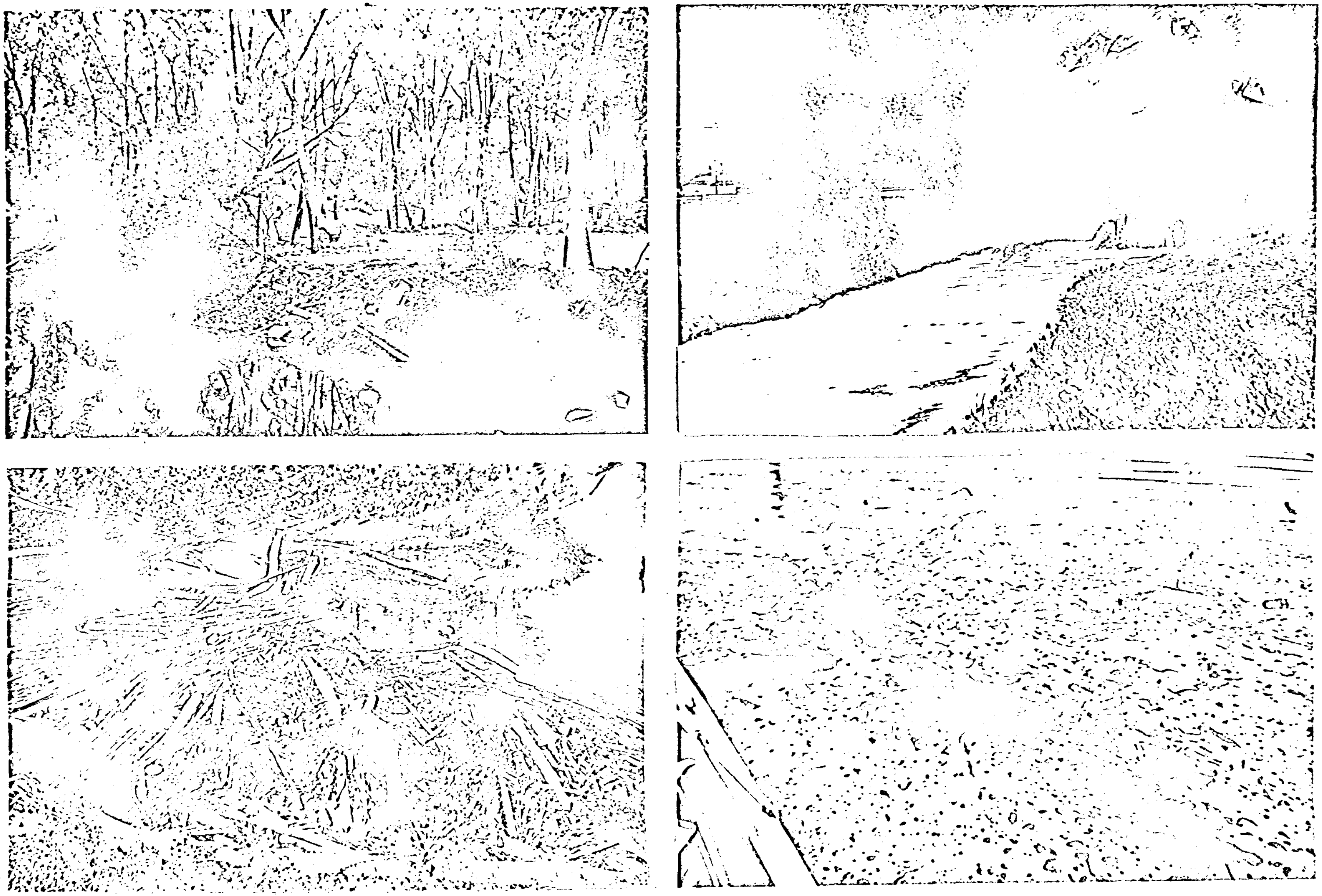
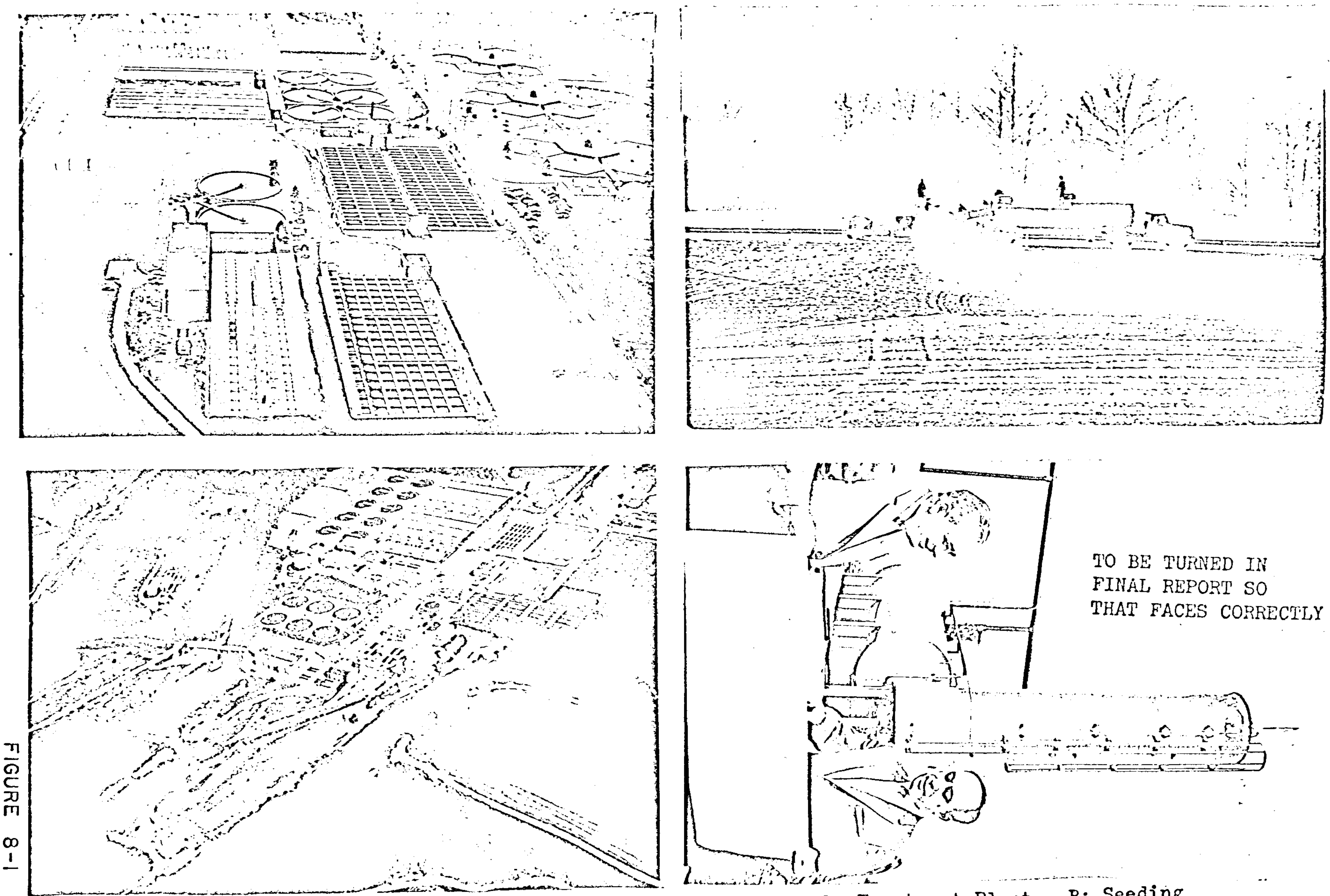


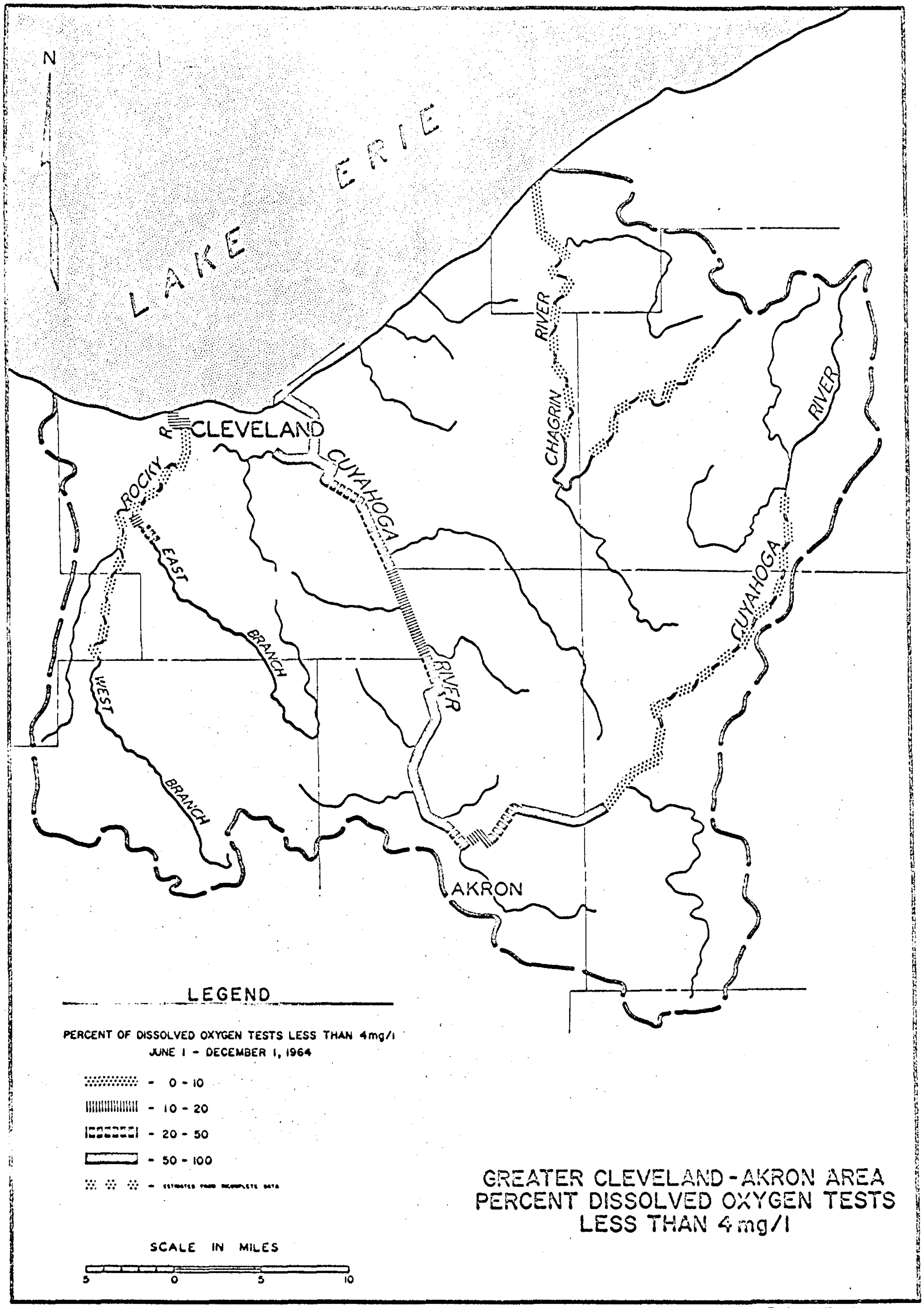
FIGURE 5-6. Esthetic Water Abuses in the Greater Cleveland-Akron Area - Garbage and Trash Dumps, Sewage and Detergent Foam, Debris, and Oils.



TO BE TURNED IN FINAL REPORT SO THAT FACES CORRECTLY

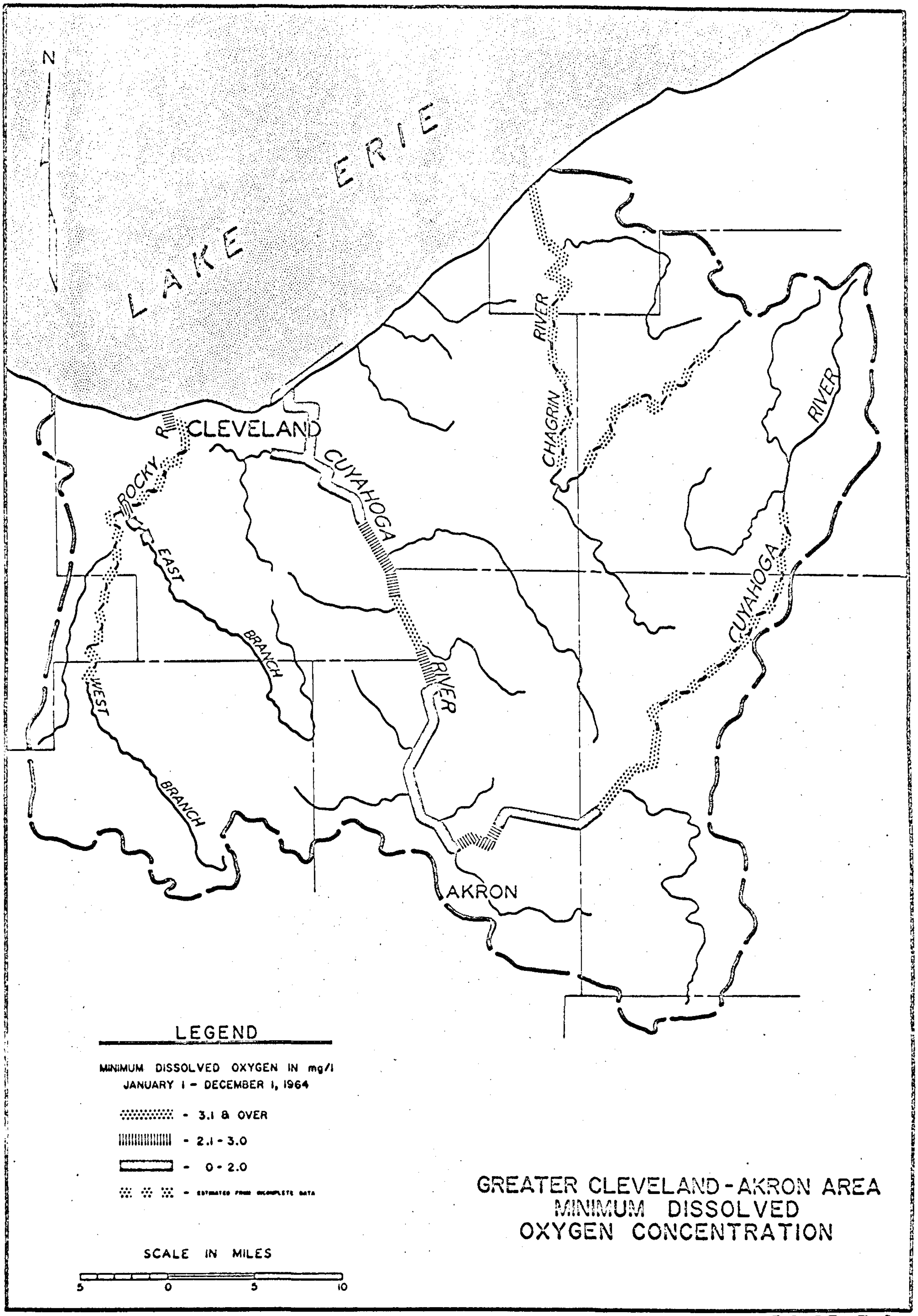
FIGURE 8-1

FIGURE 8-1. Quality Improvement Measures - A: Cleveland Easterly Treatment Plant. B: Seeding of embankments by Ohio Department of Highways. C: Akron Water Pollution Control Station. D: Complete waste removal at Chrysler Corporation's Twinsburg Stamping Plant. (Photo C courtesy City of Akron, and photo D courtesy Chrysler Corp.)



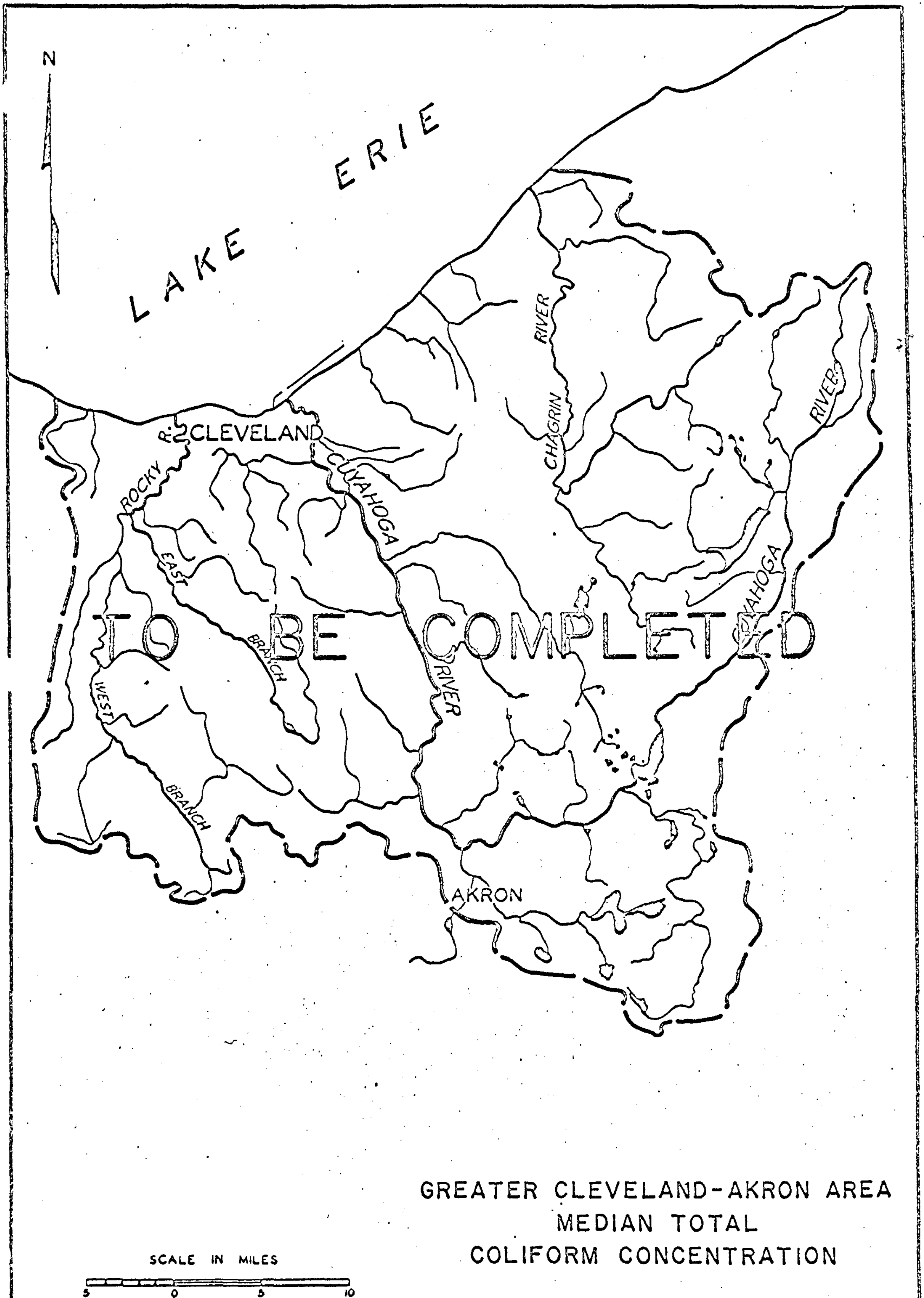
GREATER CLEVELAND - AKRON AREA
PERCENT DISSOLVED OXYGEN TESTS
LESS THAN 4 mg/l

FIGURE 7-1



GREATER CLEVELAND-AKRON AREA
MINIMUM DISSOLVED
OXYGEN CONCENTRATION

FIGURE 7-2



GREATER CLEVELAND-AKRON AREA
MEDIAN TOTAL
COLIFORM CONCENTRATION

FIGURE 7-3

Rocky River

The present water quality in most parts of the Rocky River system is degraded. The reason there are not more major problem areas in this basin is because of the steep slope and therefore high reaeration rate. The major sources of pollution to Rocky River are from the many small municipalities which dot its course. The river contains high BOD and total coliform concentrations below most outfalls, and is extensively enriched throughout its course. Excessive algal growths occur wherever the waters are pooled and high turbidity and sediment problems exist in many locations.

West Branch

The West Branch of Rocky River receives the discharge from the five significant treatment plants and from a number of small package plants. There are several dumps along the stream banks and flood plains in the Columbia Station area and numerous septic tanks and misused storm drains which pollute the waters in Olmsted Falls. The City of Olmsted Falls has been under orders from the Ohio Water Pollution Control Board for several years to remove their wastes, but has recently moved to remedy this situation. The surrounding township should also provide adequate treatment for its wastes.

East Branch

The City of Berea depends upon Baldwin Reservoir on the East Branch for its municipal water supply. The reservoir and nearby Wallace Lake are also used for swimming, boating, and fishing. The East Branch flows through Cleveland's Metropolitan Park from near the Cuyahoga County line to its confluence with the West Branch. Extensive recreational use is made of this scenic area.

Six municipal waste treatment plants discharge treated sewage to the river within this reach. These discharges contribute micro-organisms and nutrients to the river. Coliform counts show that a potential health hazard exists for visitors to the park. Extensive algae blooms in the past have been reported to cause taste and odor problems in Berea's water supply. Such algae growths are also offensive to the recreational use made of the river.

Hinckley Lake is also extensively used for swimming, boating, and fishing, but it is polluted to a degree from nutrients and sediments. The Cleveland Metropolitan Park Board has had to perform extensive dredging on this lake to maintain depth. The source of this sediment is mainly from highway construction and subdivision development, and in the past from the testing grounds of the Cleveland Tank Plant. The Ohio Department of Highways now includes provisions in new contracts being let which require the prevention, control, and active abatement of pollution during construction. Measures to be instituted in future construction include the construction of check dams and early seeding of individual slopes as they are completed. They presently have an adequate maintenance erosion control program.

This past summer, the discharge from the Berea sewage treatment plant reduced the oxygen content of the receiving waters to zero. These anaerobic conditions produced foul odors which made this part of the park unusable. This problem has also occurred below Middleburg Heights.

Main Stem

The main stem of the Rocky River flows through Cleveland's Metropolitan Park for its entire length. Extensive recreational use is made of the park. Three municipalities and one industry discharge to this area of the stream. Near the mouth of Rocky River, several small boat harbors, yacht clubs, marinas, and boat launching facilities exist. The water quality in this area is at times seriously degraded as far as low dissolved oxygen concentrations and high coliform concentrations. The measured maximum and median total coliform, fecal coliform, and fecal strep concentrations at mile point 0.2 were: 560,000 and 31,000; 180,000 and 3,000; and 49,000 and 900 organisms per 100 ml respectively. Table 7-1 is a listing of Salmonella isolations from this same station. These are all direct disease causing organisms and are pathogenic to man.

To restore the Rocky River Basin to its desired state so that full use may be made of its waters, all wastes, domestic, industrial, or from farming or construction should be removed from its waters or tertiary treatment which provides at least 97 percent BOD_5 should be provided. To actuate this program, an area-wide disposal system should be constructed which would discharge fully treated effluents directly to the lake. Plants such as at Lakewood should construct an outfall system which extends one-quarter to one-half mile off shore from nearby bathing beach areas. Also, all storm water outfalls in the vicinity of beach areas which cannot be eliminated should be extended to one-half mile off shore and the treated waters discharged through a diffusion system.

Due to the shortage of water to maintain low flows, the use of Rocky River as a water source by Berea and Medina should be discontinued. Both of these cities can very easily be served by the Cleveland system.

TABLE 7-1

ISOLATIONS OF SALMONELLA - LOWER ROCKY RIVER MILE POINT 0.2

January 16 - August 31, 1964

Date of Collection	Salmonella Serotypes (isolates)
January 16, 1964	Salmonella newport (1)
" 22, "	Salmonella hartford (1)
" 30, "	Salmonella worthington (1)
February 20, 1964	Salmonella thompson (1) Salmonella infantis (1)
March 17, 1964	Salmonella tennessee (6) Salmonella infantis (1) Salmonella thompson (1)
May 5, 1964	Salmonella anatum (3)
" 12, "	--
" 22, "	--
" 28, "	--
June 2, 1964	--
" 15, "	--
" 19, "	Salmonella anatum (1) Salmonella enteritidis (10)
" 22, "	Salmonella derby (2)
July 1, 1964	--
" 15, "	--
" 29 "	Salmonella thompson (1) Salmonella typhimurium (1)
August 31, 1964	--

IMMEDIATE NEEDS
MUNICIPALITIES AND INDUSTRIES IN THE
ROCKY RIVER BASIN

MUNICIPALITIES

Sewerage Service Area	Present Treatment	1965 Population	Plant Needs
Berea	Secondary	19,650	Connect to metro system**
Broadview Heights	Septic Tanks	8,590	Sewers & connect to metro system**
Brook Park	Secondary	14,200	Connect to metro system**
Lakewood	Secondary	70,210	Discharge outfall to Lake Erie
Medina	Secondary	9,100	Connect to metro system**
North Olmsted	Secondary*	17,800	Connect to metro system**
North Royalton	Secondary	11,110	Connect to metro system**
Olmsted Falls	Septic Tanks	2,290	Sewers & connect to metro system**
Strongsville	Secondary	11,510	Connect to metro system**
Westlake	Septic Tanks	15,000	Sewers & connect to metro system**
Westview	Septic Tanks	1,500	Sewers & connect to metro system**
County Districts			
Breezewood	Secondary		Connect to metro system**
Brunswick SD 100	Secondary	6,500	Connect to metro system**
Beverly Hills SD 8	Secondary	1,000	Connect to metro system**
Medina Co. SD 5	Secondary	1,000	Connect to metro system**
Middleburg Hts.	Secondary*	11,920	Connect to metro system**

* Works under construction, but may not meet criteria proposed
** Where "Connect to metropolitan system" is listed, tertiary treatment may be substituted.

INDUSTRIES

Industry	Location	Control Measures
Astoria Plating Corp.	Cleveland	Heavy Metals, Color, Cyanide
Allison Division, GMC, Testing Area	Hinckley	Solids

Cuyahoga River

The waters of the Cuyahoga River Basin are seriously degraded in quality in many sections. The effects of pollution are particularly evident below Kent, Stow, and Akron, and in Cleveland. All water uses, actual and potential, are influenced by this pollution.

Changes in water quality occur in the Cuyahoga and its tributaries as man and nature add wastes to it. The dissolved oxygen content fluctuates as BOD and oxygen inputs vary. Phenols, total solids, and specific conductance increase as waste loads are added.

Above Lake Rockwell

Two towns, Mantua and Burton, with a total population of 2,300 are the only known significant sources of wastes above Lake Rockwell. The 207 square mile watershed above Lake Rockwell provides the water supply for the City of Akron. Three reservoirs in this area give a maximum storage capacity of over 10 billion gallons. Coliform counts average less than 200 per 100/mls. The water is considered to be of excellent quality.

Lake Rockwell to Akron

Three creeks, seven towns, and two industries contribute wastes to this section. Municipal wastes contribute approximately 4,000 lbs. BOD per day into the streams between Lake Rockwell and Akron while industrial contribution is insignificant.

Starting at Lake Rockwell Dam, mile point 60.1, and proceeding downstream, one can visibly detect the changes in water quality. Immediately below Rockwell Dam three seasonal biological observations were made and 25 genera of benthic organisms were found. Attached algae were sparse, and the water quality of this reach was excellent.

The first major source of pollution entering the Cuyahoga River is from Breakneck Creek (Congress Lake Outlet). This creek is degraded by the discharge or by-passing of Ravenna's sewage treatment plant and the numerous businesses, motels, and homes in this area. Below Breakneck Creek, during low flow, the river was gray-brown in color with a great abundance of aquatic plants along the shoreline and much floating algae on the surface. These are indicative of the nutrients added by Ravenna's discharge and the inadequately treated wastes from the other sources.

Above the Kent treatment plant, the discharge from Lamson & Sessions Electrical Co. enters the river. This discharge was reddish and appeared to have a high oil content at the time of the field survey. A bridge abutment at this point was stained red from the wastes and the stream bank was oily. Just below this point the effluent from the Kent sewage treatment plant enters the Cuyahoga. The aquatic plant life which was so abundant above these outfalls does not exist for up to 2 miles downstream. The river is grayish and produces an oily odor. Below Kent, the river has deteriorated to such an extent that only pollution tolerant sludgeworms, midge larvae, leeches, and pulmonate snails could be found. Even though the river bottom was cobble, sand, and silt, only moderate growths of pollution tolerant blue-green algae were found on the rocks, and a strong septic odor was noted. Between Kent and the mouth of the Cuyahoga, a biota typical of gross pollution existed at all seasons of the year.

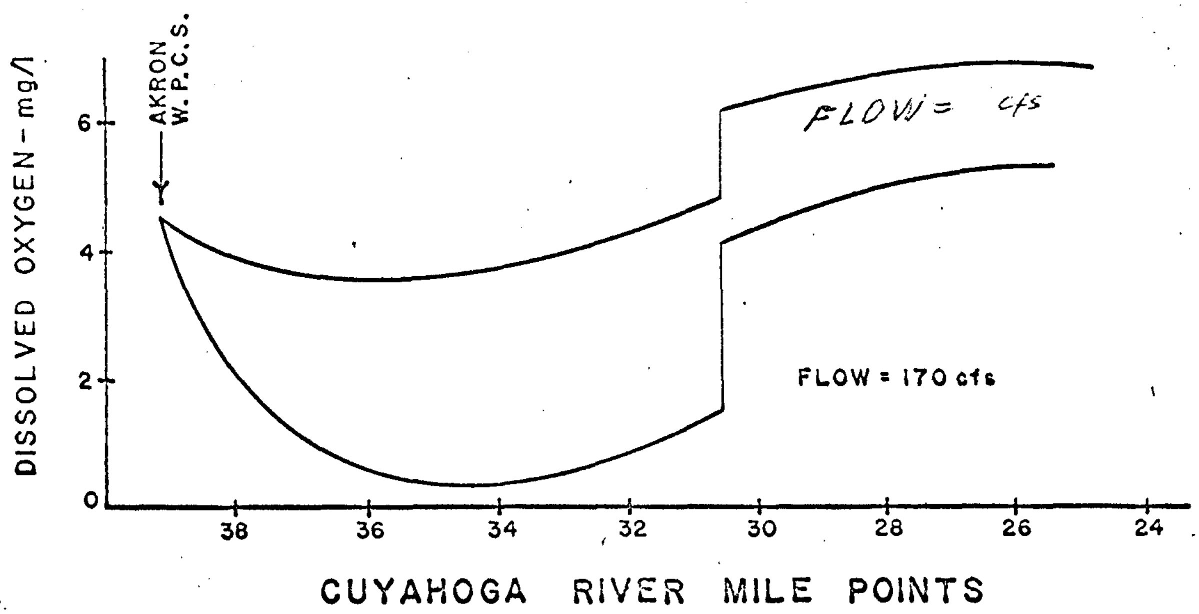
Akron

Firestone Tire and Rubber Co., General Tire Co., B. F. Goodrich Co., Goodyear Tire and Rubber Co., Tire Division, Goodyear Tire and Rubber Co., Aerospace Division, and Diamond Salt Co. all discharge wastes to the Little Cuyahoga River which interfere with its water quality. Two of these firms, Firestone and Goodyear, have recently made data as to their waste effluents available to the State of Ohio. The other two industries, General and Goodrich, have not made data as to the quality or quantity of their waste discharges known to the State of Ohio or to the Federal Water Pollution Control Administration. Biological surveys of the streams which receive the wastes from these industries indicate that gross pollution exists. During low flow, as far downstream on the Cuyahoga as at Peninsula, the odor imparted to the receiving waters can be detected. The wastes from the four rubber plants contain temperature, oxygen demanding materials, color, odor, oils, solids, and complex organics. The discharge from the Aerospace Division of Goodyear contains heavy metals, cyanides, and other toxic materials. Diamond Salt Co. discharges wastes containing chlorides to the Ohio Canal. They also discharge large concentrations of chlorides to the Akron waste treatment plant which is not able to treat them.

Akron to Cleveland

The wastes mentioned in the previous section enter the Cuyahoga at mile 44.0. The effect of those wastes can be seen in Figures 7-1 through 7-3. At mile 39.0 the effluent from Akron's Water Pollution

Control Station enters the river. At low flow, this effluent comprises over 60 percent of the river's flow. Figure 7- depicts the



effect that this waste has on depressing the oxygen content in the river and shows the river's gradual recovery. When the flow is above 170 cfs, the minimum median dissolved oxygen is raised, and conversely when the flow is less than this amount. The reason that the dissolved oxygen is not depressed below that indicated is due to the extremely high natural reaeration rate. The river may be considered to be acting as a trickling filter in a sewage treatment plant. As the wastes flow over the rock and cobble bottom the bacteria (such as Sphaerotilius) and fungi which grow on the rocks' surface feed on the wastes and reduce them. Extensive growths of pollution tolerant blue-green alga such as Oscillatoria and Phormidium, and the green filamentous alga Cladophora. At many locations, particularly below the sewage treatment plant, the filamentous bacterium Sphaerotilius sp., which is an indicator of recent organic pollution, was abundant. A strong volatile odor from the outfall persists several miles downstream.

Below this area, as in many areas above Akron, the river is often blocked with trees, brush, and junk. There are dumps along the river at Independence, Boston Mills, Jaite, Akron, etc.

The waste materials discharged from the Akron area are noticeable even in the lower sections of the Cuyahoga above the navigation canal. Numerous anaerobic sludgebanks exist along the river banks throughout this reach. Whenever any appreciable fall occurs in the river, detergent foam is produced which gives the river the appearance of "white water".

Cleveland

The first major waste entering the Cuyahoga in the Cleveland area is from Tinkers Creek. This stream contains the wastes of the Cities of Streetsboro, Twinsburg, Solon, Bedford Heights, Bedford, and Walton Hills. Master Anodizer, Weathertite, etc. also discharge to this creek. Tinkers Creek is degraded throughout most of its course by these wastes.

Big Creek discharges wastes with the following concentrations: phenol 46 μg/l; Chemical Oxygen Demand (COD) of 120 mg/l; Biochemical Oxygen Demand (BOD) of 40 mg/l; and total solids of 600 mg/l. The pH varied between 3.2 and 8.7. The median concentrations of total coliform, fecal coliform, and fecal strep were 1,100,000; 440,000; and 5,800 organisms per 100 ml respectively. These wastes were discharged by the Bailey Wallpaper Co., Cuyahoga Meat Co., E. W. Ferry Screew Co., and Ford Motor Co.

The oil content of the bottom muds increases within the Cleveland industrial complex. The extremely high concentrations in the muds near the mouth of Big Creek indicate it as a major source of oil pollution.

The major source of microbial pollution to the Lower Cuyahoga is the Cleveland Southerly Sewage Treatment Plant. This plant discharges an average of 80 mgd per day of wastes to this reach. Besides the microbial materials, this plant discharges wastes with a population equivalent oxygen demand of 48,000. Five times in the last five years there has been a break in the main interceptor sewer to this plant. This break has resulted in the discharge of billions of gallons of raw sewage to the Cuyahoga.

At mile point 6.6 the first station in the Cleveland industrial complex, the water quality is very poor and remains so until the river disperses into the lake. Sixteen industries, an undetermined number of storm water overflows, and three creeks discharge into this section of the river.

Oil scum and lack of turbulence compound the effects of BOD in the navigation channel. Within this reach the DO often drops to zero and the phenol concentration reaches a maximum of 175 μg/l. The major wastes discharged in this section are solids, acid, phenol, oil, iron, sulfates, and heavy metals. The only life found in the lower navigation channel were bacteria. No higher forms of life were found, not even such pollution tolerant forms such as sludge or bloodworms. Enteric pathogen studies conducted in this reach revealed 14 different species of Salmonella organisms (see table below).

ISOLATIONS OF SALMONELLAE - LOWER CUYAHOGA MILE POINT 1.0

January 22 - August 31, 1964

Date of Collection	Salmonella Serotypes (Isolates)
January 22, 1964	Salmonella anatum (4)
	Salmonella 6,7;y monophasic (4)
	Salmonella tennessee (3)
	Salmonella bareilly (1)
" 30, "	Salmonella anatum (2)
February 20, 1964	" typhimurium var. copenhagen (1)
March 17, 1964	Salmonella tennessee (2)
May 12, 1964	Salmonella tennessee (1)
" 17, "	--
" 22, "	--
" 28, "	Salmonella java (1)
	Salmonella panama (1)
	Salmonella worthington (1)
June 2, 1964	Salmonella heidelberg (1)
" 11, "	--
" 15, "	--
" 19, "	Salmonella enteritidis (3)
" 22, "	--
July 1, 1964	--
" 14, "	Salmonella java (1)
	Salmonella montevideo (1)
	Salmonella 6,7;y monophasic (3)
	Salmonella bareilly (1)
" 29, "	Salmonella bareilly (2)
	Salmonella thompson (1)
	Salmonella oranienburg (1)
	Salmonella typhimurium (1)
	Salmonella enteritidis (1)
August 31, 1964	Salmonella typhimurium (1)

The major industries discharge the above listed wastes to this river stretch are Republic Steel, U. S. Steel, E. I. Dupont, Jones & Laughlin Steel, and Harshaw Chemical. Besides these industrial wastes, there are numerous storm water and sewage overflow structures which contribute significant wastes to this area. Since the construction by Cleveland of the low level sewer, a large source of organic pollution has been removed. Prior to this, industries in this area discharge their sanitary sewage to the river without adequate treatment.

The immediate pollution control needs of the industries and municipalities discharging to the Cuyahoga River system are listed in the following table:

IMMEDIATE NEEDS
MUNICIPALITIES AND INDUSTRIES IN THE
CUYAHOGA RIVER BASIN

MUNICIPALITIES

Sewerage Service Area	Present Treatment	1965 Population	Plant Needs
Akron	Secondary*	298,000	Advanced waste treatment
Bedford	Secondary	16,700	Connect to metro system**
Bedford Hts.	Secondary	5,800	Connect to metro system**
~~Burton~~	~~Secondary~~	~~1,200~~	~~None~~
Cleveland Southerly	Secondary	525,000	Tertiary
Cuyahoga Falls	Secondary	54,000	Connect to metro system**
~~Hudson~~	~~Secondary~~	~~2,690~~	~~None~~
Independence	Septic Tanks	7,770	Sewers & connect to metro system**
Kent	Secondary	23,290	Expansion
Mantua	Secondary*	1,240	Expansion
Maple Hts.	Secondary*	34,620	Connect to metro system**
Middlefield	Primary	1,570	Secondary & disinfection
Monroe Falls	Septic Tanks	2,850	Sewers & connect to metro system
Northfield	Secondary	3,160	Connect to metro system**
Oakwood	Primary*	2,290	Connect to metro system
Oakwood	Septic Tanks	2,500	Sewers & connect to metro system
Ravenna	Secondary	12,000	Connect to metro system**
Sagamore Hills	Septic Tanks	4,230	Sewers & connect to metro system**
Sawyerwood	Septic Tanks	5,940	Sewers & connect to metro system**
Solon	Secondary	8,040	Connect to metro system**
Tallmadge	Secondary	11,200	Connect to metro system**
Twinsburg	Secondary	4,500	Connect to metro system**
Valley View	Septic Tanks	1,340	Sewers & connect to metro system**
County Districts			
Brecksville SD 13	Secondary	3,300	Connect to metro system**
~~Brimfield SD 1~~	~~Secondary~~		~~None~~
Northeast SD 1	Secondary		Connect to metro system**
Northeast SD 6	Secondary		Connect to metro system**
Northeast SD 15	Secondary		Connect to metro system**

* Works under construction, but may not meet criteria proposed

** Where "Connect to metropolitan system" is listed, tertiary treatment may be substituted.

MUNICIPALITIES (Cont'd)

Sewerage Service Area	Present Treatment	1965 Population	Plant Needs
County Districts (Cont'd)			
Seven Hills SD 2	Secondary		Connect to metro system**
~~Shalersville SD 1~~	~~Secondary~~		~~None~~
~~Shalersville SD 2~~	~~Secondary~~		~~None~~
Stow Twp SD 4	Primary*	13,400	Sewers & connect to metro system**
Walton Hills SD 20	Secondary		Connect to metro system**

* Works under construction, but may not meet criteria proposed.
** Where "Connect to metropolitan system" is listed, tertiary treatment may be substituted.

INDUSTRIES

Industry	Location	Control Measures
Cuyahoga River		
Republic Steel	Cleveland	Solids, Iron, Oil, Ammonia, Acids
U. S. Steel	Cleveland	Solids, Iron, Oil, Acids
E. I. DuPont	Cleveland	Solids, Zinc
Jones & Laughlin	Cleveland	Solids, Iron, Oil, Acids
Harshaw Chemical	Cleveland	Solids, Fluorides, Heavy Metals, Acids
Ford Motor Co.	Brook Park	Oil
E. W. Ferry Screw	Brook Park	Heavy Metals, Oil, Others*
Cuyahoga Meat	Cleveland	BOD, Others*
Bailey Wall Paper	Cleveland	Color, BOD, Others*
Burdett Oxygen	Cleveland	Others*
Master Anodizers	Bedford	Heavy Metals, Cyanide
Owens-Illinois Glass Co., Mill Div.	Northfield	Others*
Cornwell Tools	Mogadore	Heavy Metals, Cyanide
S. K. Wellman, Division American Brake Shoe Co.	Bedford	Heavy Metals, Cyanide
Ferro Chemical, Division Ferro Corp.	Bedford	Heavy Metals
Zirconium Corp. of America	Solon	Solids, Chlorides

* Presently do not report materials in waste outfall.

INDUSTRIES (Cont'd)

Industry	Location	Control Measures
Cuyahoga River (Cont'd)		
Diamond Crystal Salt Co.	Akron	Solids, Chlorides
Firestone Tire & Rubber	Akron	Solids, Others*, Oil
General Tire & Rubber	Akron	Solids, Others*, Oil
B. F. Goodrich Co.	Akron	Solids, Others*, Oil
Goodyear Tire & Rubber	Akron	Heavy Metals, Solids, Cyanides, Others*, Oil
Sonoco Products	Munroe Falls	BOD
Lamson & Sessions Co.	Kent	Solids, Oil
Smallwood Packing Co.	Middlefield	BOD, Oil, Others*

* Presently do not report materials in waste outfall.

Chagrin River

Except for reaches in the cities of Chagrin Falls, Willoughby, and Eastlake, the water quality of the Chagrin River is presently good to excellent. A well balanced biological population is normally present even during periods of low flow. Good fish populations exist except in areas which are overfished or affected by pollution. The stream bottoms are generally rocky except in several pooled areas. A very high natural reaeration rate occurs due to the turbulent conditions and steep slope (16-35 foot fall per mile). Thus, pollution which enters the streams is quickly degraded and low dissolved oxygen levels seldom occur throughout this basin.

There are six major sewage treatment plants in the Chagrin River Basin which discharge wastes containing a population equivalent of 30,000.

Below the waste discharges from the sewage treatment plants in Chester townships and from the Cities of Aurora and Pepper Pike, an enriched biological condition exists. Moderate growths of the filamentous alga, Cladophora sp. occur, and a population of pollution sensitive bottom species such as snails, mayflies, caddis flies, and other immature aquatic insects are found.

During periods of low flow, the Chagrin River above Chagrin Falls is completely degraded by waste materials discharged by the Chase Bag Co. The waters below Chase's effluent is highly colored and contain an oxygen deficit. Sediment and sludge banks are also prevalent. The pooled water behind the low head dam above the falls presently acts as a treatment lagoon for these wastes. This pooled area has a severely degraded biological community with no fish present, and produces excessive odors in the late summer.

In the fall of 1966 when the effect upon the river of the City of Chagrin Falls' treatment plant effluent was most recently studied, the effluent was found to degrade the receiving waters. After thorough mixing occurred, only pollution tolerant pulmonate snails, sludgeworms, and bloodworms were found. This condition was prevalent for 1-2 miles downstream. The main reason complete anaerobic conditions were not found was attributed to the high reaeration of the river through riffled areas. The city dump along the river at Chagrin Falls does not seem to appreciably affect the water quality of the river. From 2 miles below Chagrin Falls until the river enters the Willoughby area, the river's water quality is generally excellent.

The City of Willoughby's dump along the east and west banks of the Chagrin River has in the past been extended out into the river itself. Recently, Willoughby has removed the material immediately adjacent to the river to higher ground. But, the dump is still located within the flood plain of the river. (Figure 7-x)

In the past, the Chagrin River from Willoughby to the lake has been extensively polluted by domestic and industrial wastes. When a biological survey was conducted in the summer of 1963 by the Lake Erie Program Office, only pollution tolerant bottom organisms and blue-green algae were found. Some dead rough fish, shad and gar, were observed. At the mouth of the river a transition zone occurs between the lake and river water in which the level of degradation was reduced. The major bottom organisms were bloodworms, leeches, and scuds.

Over the past 5 years, the Cities of Eastlake, Willoughby, Lakeline, and Timberlake have instituted a program for installing sewers in what were largely unsewered areas. When this program is completed within this next year, the remaining loadings of oxygen demanding and bacterial wastes will be removed from the lower Chagrin River. In the past much raw or poorly treated sewage was discharged in this area. A program has also been instituted by Willoughby to check each household and industry to insure that no downspouts are connected to the sewer system, and that no household sewage enters the storm water system.

In a study by the Lake Erie Program Office in the early part of 1964, three types of salmonella were isolated in the lower reach of the river. These isolates are tabulated below:

TABLE 7-

ISOLATIONS OF SALMONELLA - LOWER CHAGRIN RIVER

February 19 - March 24, 1964

Sampling Site	Date of Collection	Salmonella Sterotypes (isolates)
Chagrin River 000.8	February 19, 1964	--
	March 10, "	--
	" 24, "	Salmonella oranienburg(1)
Chagrin River 003.1	February 19, 1964	--
	March 3, "	Salmonella tennessee (8)
		Salmonella worthington (1)

An area wide plan for the development of sewerage systems throughout the Chagrin River Basin is an immediate goal. All domestic and industrial wastes discharged within the basin should receive tertiary treatment with a minimum BOD_5 removal of 97 percent within 2-3 years. The waste loadings from the Chase Bag Co. and Chagrin Falls should be reduced immediately through modification in plant operation. As this area builds up in the expansion of the Cleveland metropolitan area, the use of the river as a water supply should be discontinued.

IMMEDIATE NEEDS
MUNICIPALITIES AND INDUSTRIES IN THE
CHAGRIN RIVER BASIN

MUNICIPALITIES

Sewerage Service Area	Present Treatment	1965 Population	Plant Needs
Aurora	Secondary	4,730	Connect to metro system**
Chagrin Falls	Secondary	4,100	Connect to metro system**
Pepper Pike	Secondary	3,900	Connect to metro system**
County Districts			
Chester Twp. SD 1 & 2	Secondary		Connect to metro system**
Richmond Heights		6,000	Connect to metro system**

** Where "Connect to metropolitan system" is listed, tertiary treatment may be substituted.

INDUSTRIES

Industry	Location	Control Measures
Chase Bag Co.	Chagrin Falls	Color, Solids, BOD

Lakefront

The major type of pollutant in the Greater Cleveland Area Lakefront with an immediate effect on the area's water quality is microbiological. Other significant pollutants are debris, oxygen consuming materials, color, settleable and suspended solids, oil, nutrients, and odor. Unlike many cities which are able to rid themselves of their wastes by discharging them to a nearby river which carries them out of the area, Cleveland's wastes are discharged at its own front door. In their order of importance, the sources of pollution to the lakefront are: 1. municipal sewage treatment plants, 2. storm water overflows, 3. industries, 4. erosion, and 5. dredging.

Microbiological Water Quality

Microbiological contamination is the number one water quality problem on the lakefront. Figure 7- is a contour map of the median total coliform concentration along the area's shoreline. Table 7- is a summary of the median total and fecal coliform and fecal streptococcus concentrations for the various tributaries to the lakefront and bathing areas along the lakefront.

As can be seen from the table and figure, (and from Tables 7- , 7- , and 7- , which show enteric pathogens isolated in the tributary waters) the waters immediately along the lakefront are heavily polluted. In the summers of 1964 through 1966 only Huntington Park at the extreme western limits of the study area, was generally within the accepted limits for full body contact recreation. Even though all

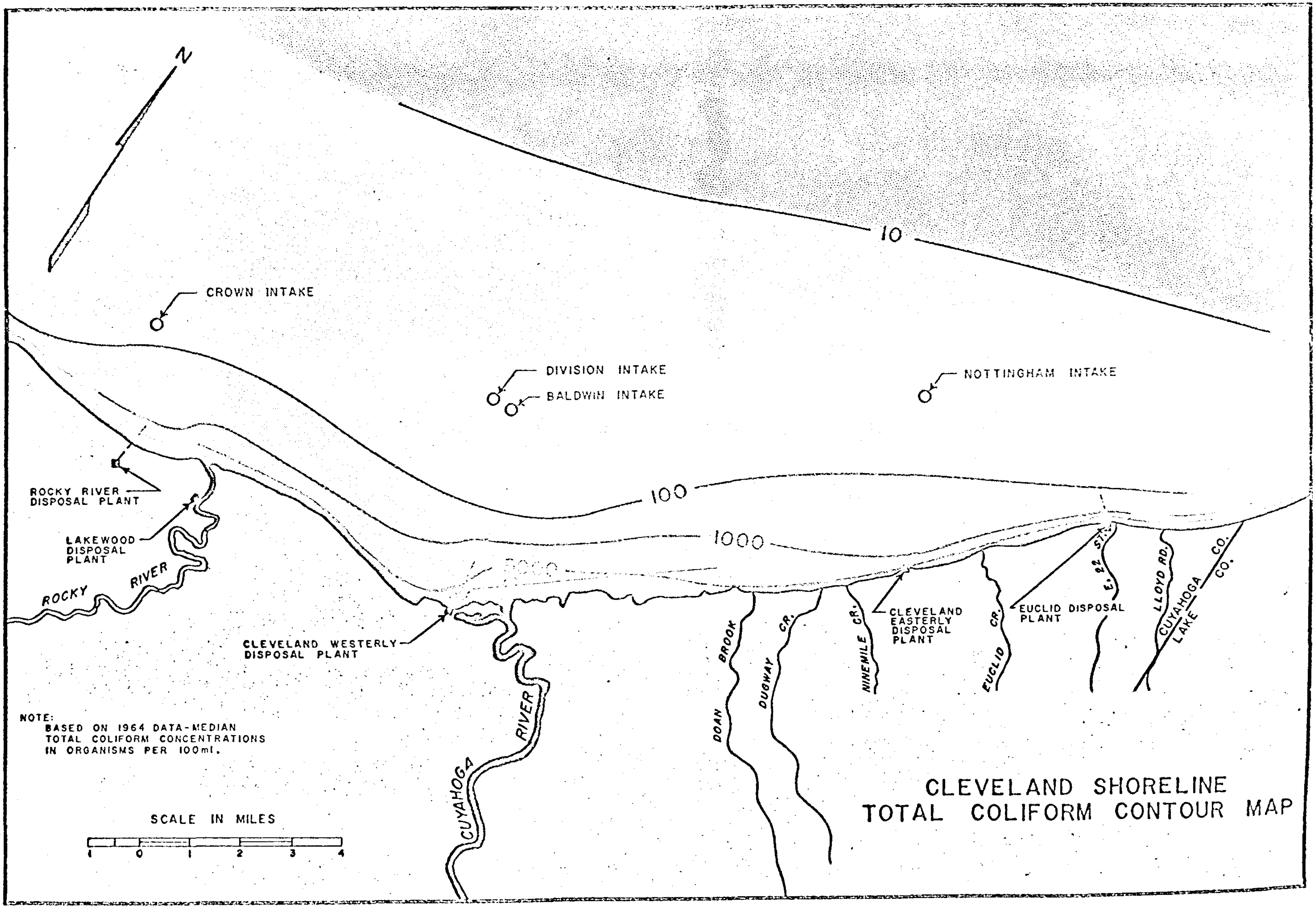

N
CROWN INTAKE
DIVISION INTAKE
BALDWIN INTAKE
NOTTINGHAM INTAKE
10
100
1000
5000
ROCKY RIVER DISPOSAL PLANT
LAKEWOOD DISPOSAL PLANT
ROCKY RIVER
CLEVELAND WESTERLY DISPOSAL PLANT
CUYAHOGA RIVER
DOAN BROOK
DUGWAY CR.
NINEMILE CR.
CLEVELAND EASTERLY DISPOSAL PLANT
EUCLID CR.
EUCLID DISPOSAL PLANT
E. 22 ST.
LLOYD RD.
CUYAHOGA CO.
LAKE CO.
NOTE:
BASED ON 1964 DATA-MEDIAN
TOTAL COLIFORM CONCENTRATIONS
IN ORGANISMS PER 100ml.
SCALE IN MILES
1 0 1 2 3 4
CLEVELAND SHORELINE
TOTAL COLIFORM CONTOUR MAP

FIGURE 7-

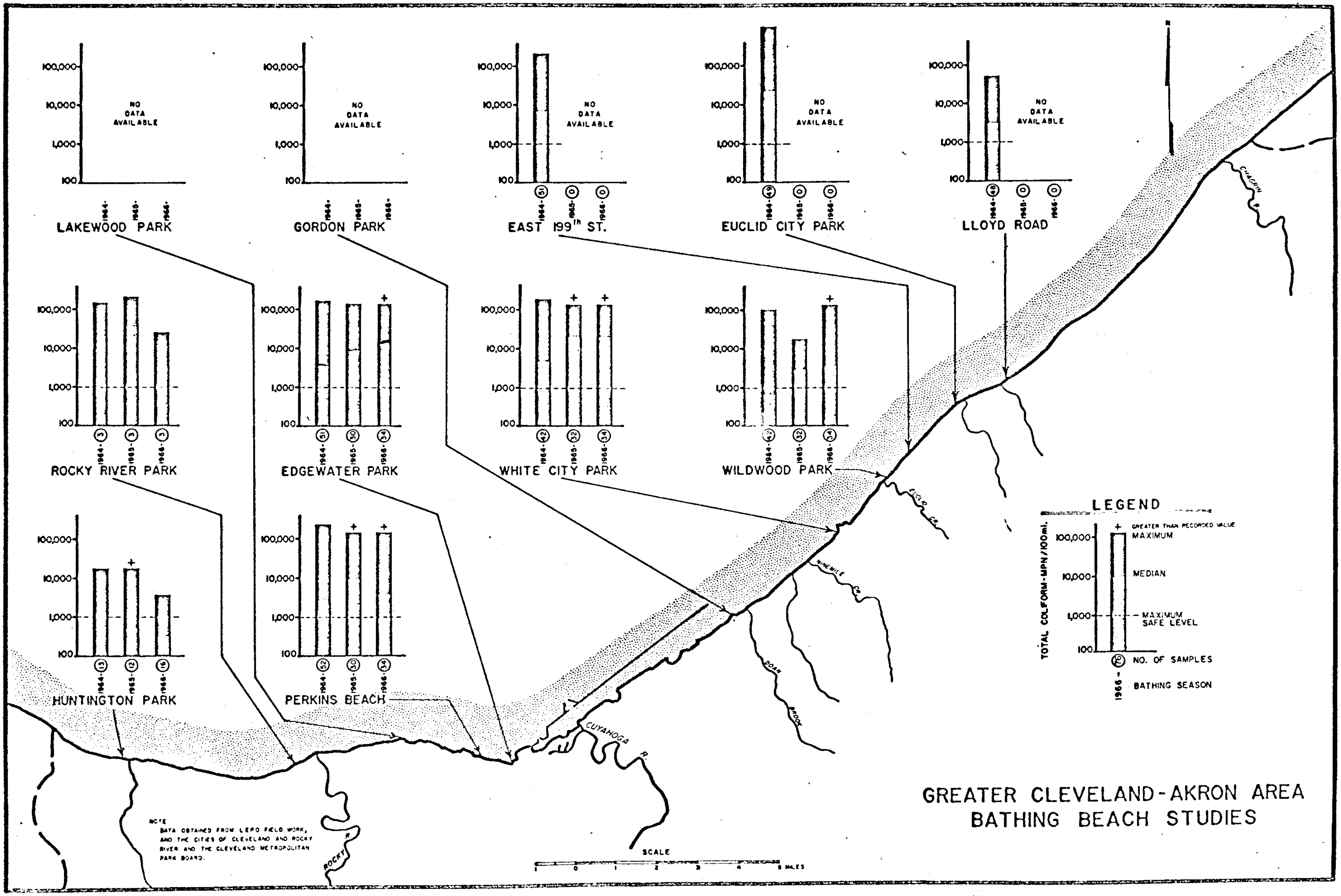

LAKEWOOD PARK
GORDON PARK
EAST 199th ST.
EUCLID CITY PARK
LLOYD ROAD
NO DATA AVAILABLE
ROCKY RIVER PARK
EDGEWATER PARK
WHITE CITY PARK
WILDWOOD PARK
HUNTINGTON PARK
PERKINS BEACH
100,000
10,000
1,000
100
LEGEND
+ GREATER THAN RECORDED VALUE
MAXIMUM
MEDIAN
MAXIMUM SAFE LEVEL
NO. OF SAMPLES
BATHING SEASON
TOTAL COLIFORM-MPN/100ml.
CUYAHOGA R.
ROCKY R.
EUCLID CR.
NINEMILE CR.
DOAN BROOK
CHAGRIN
NOTE
DATA OBTAINED FROM L.E.P.O FIELD WORK, AND THE CITIES OF CLEVELAND AND ROCKY RIVER AND THE CLEVELAND METROPOLITAN PARK BOARD.
SCALE
MILES
GREATER CLEVELAND-AKRON AREA
BATHING BEACH STUDIES

FIGURE 7-

TABLE 7-

GREATER CLEVELAND LAKEFRONT 1964 MICROBIOLOGICAL DATA

Station	Fecal Coliform (median*)	Fecal Strep (median*)	Total Coliform (median*)	Total Coliform % Greater than 1000
Huntington Park (1)	--	--	100	25
Rocky River Park (2)	--	--	10,000	100
Rocky R 0.2 mi	5,200	960	33,000	100
Rocky R 2.9 mi	750	1,900	13,000	87
Perkins	350	570	3,000	69
Edgewater	850	560	7,200	78
Cuyahoga R 0.3 mi	2,700	3,500	29,000	98
Cuyahoga R 1.0 mi	3,100	1,400	37,000	100
Cuyahoga R 3.4 mi	3,000	1,000	17,000	100
Doan Brook (3)	--	--	200,000	50
Dugway Brook (3)	--	--	900,000	100
White City	900	480	8,700	91
Euclid Cr	--	--	800,000	100
Wildwood	100	160	740	41
E. 199 St	1,000	220	8,600	90
E. 215 St	1,300	290	9,200	90
E. 222 St	1,200	200	12,000	88
E. 225 St	1,000	200	12,000	86
E. 252 St	1,000	200	6,100	84
Lloyd Rd	1,000	590	4,700	81
Chagrin R 0.8 mi	1,700	610	7,300	95
Chagrin R 3.1 mi	5,400	1,600	19,000	96

* Organisms per 100 ml
(1) Data from 1964 by the Cleveland Metropolitan Park Board
(2) Data from 1964 by the City of Rocky River
(3) Data from 1962 report by the Ohio Department of Health

bathing beaches within the Cleveland city limits are microbiologically polluted far in excess of the recommended limits for full body contact recreation, the Cities of Cleveland and Rocky River still do not prohibit swimming in these areas, and have only in recent years started to institute a serious program to remove these wastes.

The effluent from the following sewage treatment plants contribute significant amounts of microbial pollution to the shoreline region:

Rocky River, Lakewood, Cleveland Westerly, Cleveland Southerly, Cleveland Easterly, Euclid, and Willoughby-Eastlake. Besides their microbiological content, the wastes from these 7 plants contain a BOD loading with a population equivalent of over 500,000. Even with secondary treatment (advanced waste treatment for Cleveland Southerly) and disinfection, to maintain a safe water quality in bathing areas, all outfall lines should need to be extended one-half to one mile offshore and discharged through a diffusion system.

The second major source of pollution is the numerous storm water overflows along the lakefront and tributaries which during period of rainfall discharge raw sewage to the area. But, even during periods in which no rainfall has occurred for several weeks, raw sewage is observed along the shoreline between the Cuyahoga and Chagrin Rivers. These dry weather discharges are caused mainly by the overloading of sewers in the central area by increased flows from the expanding suburbs. There is a need to construct trunk sewers to intercept the flows from these outlying areas. Storm water outfalls from built-up areas which are in the vicinity of beach area should be eliminated. Where this is not possible they should be extended to one-half mile offshore and the treated waters discharged through a diffusion system.

The total water quality problems are more severe to the east of the Cuyahoga then to the west. If the cities involved so desired, the bacteriological quality of all western beaches could be improved significantly for a nominal cost and these areas could then be available for safe public use. Much higher, but not prohibitive costs will be involved in resurrecting the eastern beaches and allowing them to be once again useful.

Esthetic Nuisances and Navigation Hazards

Debris, color, settleable and suspended solids, oil, odor, and nutrients cause problems along the lakefront. The discolored water and floating debris which hang along the shoreline, and particularly behind the Federal Breakwater, have reduced the esthetic value that is normally associated with shoreline property. The visual esthetic nuisances to property owners, boaters, and visitors consist of discarded lumber, tree limbs, sewage, metal cans, paper products, condoms, dead fish, old car bodies, oil slicks, grease, and scum. The lumber and tree limbs are also a navigation hazard to boaters who ply the area's waters. These materials tend to collect in the small boat harbors as well as behind the Federal Breakwater. The source of these materials is from dumps, industries, municipal treatment plants, storm water overflows, stream bank erosion, and dredging.

A program to remove debris from the area's waterways before they reach the navigable sections and lakefront is an immediate need in the Cleveland-Akron area. It would be a never ending job to attempt to remove debris from the navigable waters without establishing a meaningful control and removal program in the upstream areas.

Aquatic and Benthic Life

All bottom stations examined inside the Federal Breakwater exhibited a very limited variety of pollution tolerant organisms. Only sludgeworms, fingernail clams, nematods, and bloodworms were found in this area. Outside the breakwater a slightly more diverse fauna was found which included the less tolerant leeches, pulmonate and gill-breathing snails, and aquatic sowbugs in addition to the forms found inside the breakwater.

Inspection of the benthic data showed a wide variation in total numbers. Conditions in the Cuyahoga River were so severe that no bottom-dwelling animals could survive in the navigable portion upstream from mile point 0.2. In the river mouth which is considerably diluted by lake water over 400,000 organisms per m^2 (all sludgeworms) were found. Stations in the harbor and harbor mouth, except in areas with hard clay or rock bottom, yielded between 14,000 and 60,000 organisms per m^2. Farther from shore numbers dropped to 200 - 3,000 organisms per m^2. No correlation between distance from shore and total number can be demonstrated beyond the two mile contour.

The predominant attached algae in the Cuyahoga River was Oscillatoria sp. and Phormidium sp. These are both genera which are known to be common in organically enriched areas ( ). Growing on the breakwall, on buoys in the harbor, and th e water intake crib were luxurious growths of the filamentous green alga Cladophora sp. This is the most common attached alga in Lake Erie and is known to increase in abundance as concentration of nutrients increase. However, this form cannot tolerate the severe pollutional conditions found in the river and is only found where sufficiently diluted with lake water.

Extensive dissolved oxygen data collected during the sampling period showed no severe oxygen depletion in the study area except at the Cuyahoga River mouth. Although variety is somewhat greater outside the harbor and greater still beyond the two mile contour, some of the pollution intolerant mayfly nymphs, caddis fly larvae, scuds and unionid clams were found at any of the stations sampled. Since the bottom type, depth, and temperature here are suitable for all of these intolerant groups, and they occur under similar conditions in other parts of Lake Erie, it must be assumed that some other factor is responsible for th eir absence. The probable explanation lies with composition of bottom sediments and resulting biological and chemical activity at the mud water interface. In sediments containing high concentrations of organic matter bacterial activity can produce a microzonal deficit in oxygen at the mud water interface. This zone may be only a few centimeters thick, and the dissolved oxygen sampling procedures used in this study could not detect such a condition. As a result of this microzonal oxygen deficit a decrease in redox potential would be expected which could allow formation of hydrogen sulfide and ammonia in sufficient concentrations to be toxic to many less tolerant species. In areas which are used as dumping areas by the U. S. Corps of Engineers, the toxicity of the sediments would prevent the existence of higher level benthic fauna.

IMMEDIATE NEEDS
MUNICIPALITIES AND INDUSTRIES IN THE
GREATER CLEVELAND-AKRON AREA
DIRECT TO LAKE

MUNICIPALITIES

Sewerage Service Area	Present Treatment	1965 Population	Plant Needs
Cleveland Easterly	Secondary	660,000	Expansion & extend outfall
Cleveland Westerly	Primary	240,000	Secondary, Disinfection & extend outfall
Euclid	Intermediate	114,000	Secondary, Disinfection & extend outfall
Willoughby-Eastlake	Intermediate	62,050	Secondary, Disinfection & extend outfall
County Districts			
Rocky River SD 6	Intermediate	50,000	Secondary, Disinfection & extend outfall

INDUSTRIES

Industry	Location	Control Measures
Lakefront		
Cleveland Municipal Light Plant	Cleveland	Bottom & Fly Ash, Heat
Cleveland Electric Illuminating Co.		
Eastlake Plant	Eastlake	Bottom & Fly Ash, Heat
Lakeshore Plant	Cleveland	Bottom & Fly Ash, Heat

Loading to Lake Erie

Besides the Rocky, Cuyahoga, and Chagrin Rivers, there are 5 municipal sewage treatment plants, 5 industries, and a number of small streams which discharge waste materials to Lake Erie from the Greater Cleveland-Akron Area. Over 2,300 tons per day of solids, both dissolved and suspended, are discharged every day to the lake. Included in this load are phosphates, nitrates, and trace minerals which help produce the prolific growths of algae in the lake and along the shoreline. Also included are materials which exert a biochemical or chemical oxygen demand on the lake and materials which interfere with the natural biological processes within the lake waters and on the lake bottom. Table 7- is a summary of materials discharged to Lake Erie in 1964 for the rivers, and in 1966 for th e municipal sewage treatment plants and industries.

TABLE 7-

LOADING TO LAKE ERIE FROM THE GREATER CLEVELAND-AKRON AREA
(in pounds per day)

	Rocky River	Cuyahoga River	Chagrin River	Municipal Wastes	Industrial Wastes
Total Solids	880,000	2,800,000	680,000	190,000	210,000
Suspended Solids	160,000	490,000	190,000	69,000	200,000
Dissolved Solids	720,000	2,300,000	490,000	120,000	10,000
Chlorides	120,000	430,000	27,000		2,000
BOD	7,500	49,000	2,900	80,000	4,000
COD	52,000	250,000	42,000	100,000	6,000
Soluble Phosphate	3,400	2,400	300		100
Nitrates	3,100	30,000	700		
Flow (mgd)	194	454	197	177	977

Northeastern Ohio Area

The Northeastern Ohio area drains 1,040 square miles in Ohio and 170 square miles in Pennsylvania. It extends 53 miles along the Lake Erie shoreline and includes the Grand River, Ashtabula River, and Conneaut Creek Basins.

The Grand River drains 712 square miles, is 104 miles long, and has an average fall of 11.3 ft/mile. The Ashtabula River drains approximately 10 square miles in Pennsylvania and 127 square miles in Ohio. It is approximately 40 miles long with an average fall of 11.6 ft/mile. Conneaut Creek drains 153 square miles in Pennsylvania and 38 square miles in Ohio. The average slope is 11.3 ft/mile.

The streams flow through rural areas except near Lake Erie where the larger urban areas are located such as Ashtabula (1960 pop. of 25,449), Painesville (1960 pop. of 16,116) and Conneaut (1960 pop. of 10,557). The population along Lake Erie represents approximately seventy percent of the total population of the Northeastern Ohio subarea. The population density near the shore increases westward which is influenced by nearby Cleveland. The lower part of the Grand River basin now has the largest population density and is expected to be the major growth area in Northeastern Ohio. Present and projected populations for each of the basins are shown in the following table.

NORTHEASTERN OHIO

PRESENT & PROJECTED POPULATIONS

River Basin	Population 1960	1990	2020
Grand	118,000	262,000	372,000
Ashtabula	49,100	84,000	127,000
Conneaut	24,000	44,000	60,400
	191,000	390,000	559,000

Northeastern Ohio is also a major industrial area. Two large industrial centers are Painesville-Fairport and Ashtabula. Two of Ohio's seven salt plants are located in the subarea accounting for half of the state's salt production. The large salt deposit also has attracted many chemical industries which are now predominant in Northeastern Ohio.

The economy of the area has shown its effects on the water quality of Northeastern Ohio streams. The municipal and industrial complexes near the lake have degraded the water quality in the lower reaches of the three major streams.

Grand River

The water quality of the Grand River varies from good in the upper reaches to grossly polluted in the lower reaches. Although the Grand River above Painesville generally has good water quality, there is a silt problem which adversely affects some water uses such as esthetics and possibly fish and their spawning grounds. The turbidity in the river was clearly evident while investigating the river in October 1966. A biological investigation of this area did reveal a balanced variety of pollution intolerant benthic fauna at all locations examined above the City of Painesville.

The Grand River in the lower stretch is one of the most chemically polluted rivers in the Lake Erie Basin due to the extremely high solids load discharged by the Diamond Alkali Co. Occasionally the river is brightly colored with hues ranging from bright green and yellow to black. The green and yellow colors are the result of the chemical discharges while the black color is attributed to fly ash discharges.

Biological investigation of these three miles revealed the upper mile to be devoid of benthic fauna, indicating that even the most pollution tolerant organisms could not survive in waters receiving such high pollution loads. The attached algae were pollution tolerant Ulothrix, Stigeodonium and Oscillatoria.

Maximum total solids recorded were 10,400 mg/l occurring 2.3 miles upstream from the mouth just below the location where Diamond Alkali discharges the majority of their wastes. The average concentration of total solids at this location for the period January to November 1964 was 4,470 mg/l, while just upstream of Diamond Alkali at mile point 5.5 the average concentration of total solids for the same period was only 300 mg/l. The majority of total solids were in the form of dissolved solids, mainly chlorides. The average concentrations of dissolved solids and chlorides at mile point 2.3 were 10,300 mg/l and 2,500 mg/l, respectively. The average concentration at mile point 5.5 for dissolved solids was 272 mg/l and for chlorides, 33 mg/l.

The Diamond Alkali Co., which has several outfalls to the Grand River, discharges approximately 6.5 million pounds of dissolved solids per day. The Chloride load discharged is approximately 3.9 million pounds per day. This extremely large dissolved solids load and corresponding chloride load are, for all practical purposes, being discharged entirely from the overflow of Diamond Alkali's waste settling basin located just above the sampling station at mile point 2.3.

Using mile point 2.3 as a tributary load station, the Grand River discharges an average of 4 million pounds of chlorides per day, or 15 percent of the total average daily chloride input into Lake Erie. However, excluding the Detroit River, the Grand River contributes 60 percent of all remaining chlorides discharged to Lake Erie while contributing less than four percent of runoff to the lake.

Assuming the chemical industries in Northeastern Ohio will double in waste production by 1990 and quadruple by 2020, and assuming no additional steps are taken to control chloride discharges, then the following chloride loads can be expected:

	Loads (lbs/day)	
1965	1990	2020
4.2×10^6	8.4×10^6	16.6×10^6

By 2020 there will be over 8,000 tons of chlorides discharged to Northeastern Ohio waters every day. The chlorides discharged during 2020 would be large enough in quantity to salt the roads throughout the entire Lake Erie Basin for the next four winters. This tremendously high load cannot continue without some eventual effect on municipal and industrial water uses. The chemical industries, especially Diamond Alkali Co., must employ some method for removal of chlorides. Evaporation, recovery, and utilization in some form of marketable product or deep well disposal are possible solutions.

In addition to the large chemical waste discharges, the lower reach of the Grand River receives the inadequately treated effluent of two sewage treatment plants. The Painesville sewage treatment plant discharges approximately 2,000 pounds of BOD per day, and the Fairport sewage treatment plant adds another 360 pounds of BOD to the sewer daily. These plants receive a BOD load of 4,200 pounds per day and 520 pounds per day respectively. This indicates the low percentage of organic material that is removed by the sewage treatment plants. Both municipalities of Fairport and Painesville have been ordered by the Ohio Water Pollution Control Board to provide at least secondary treatment.

The Grand River also receives waste discharges from two more sewage treatment plants. These plants located at Chardon and Jefferson both provide secondary treatment and both discharge to tributaries of the Grand River. Presently there are no effects on the river from these two plants; however, the additional population growth will necessitate additional treatment. The graph below shows the present and projected raw BOD loads received by the four treatment plants in the Grand River Basin. The present and projected BOD loads discharged to the Grand River system are also shown.

As can be seen from the graph, additional treatment is an immediate need. If the present BOD load is established as the maximum allowable load to the Grand River, it is apparent that at least secondary treatment, that removes 90% of the BOD must be immediately provided. By 1990, secondary treatment will no longer be satisfactory and some form of advanced treatment must be provided. As indicated by the graph, an even higher percentage of removal will be required sometime around 2010.

In addition the Grand River also receives effluents from septic tanks. Two communities have been ordered by the Ohio Water Pollution Control Board to provide sewerage systems. These communities are Orwell and Grand River. Orwell is located in the southern part of the basin, while Grand River is located in the Painesville-Fairport area.

Since this area around Painesville and Fairport will be one of the fastest growing population centers in Ohio, and since the present treatment plants are inadequate and require major additions, it is recommended that one large treatment plant providing 90 percent BOD removal be constructed to serve Painesville, Fairport, Grand River, and the surrounding areas. It is also recommended that with the proximity of this area to Lake Erie, a regional treatment plant could easily discharge its effluent directly to Lake Erie and thereby remove all major municipal waste sources from the lower reach of the Grand River. One large regional treatment plant instead of several smaller ones would increase the operating efficiency, would decrease the demand for qualified sewage treatment plant operators, and would be less expensive on a per capita basis to maintain and operate.

The A. E. Staley Manufacturing Co. located in the municipality of Grand River had been discharging soybean processing wastes directly to the Grand River. In 1965, they were reported to be negotiating to discharge their waste to a municipal sewer system. However, Lake County officials have attributed some of the present water quality problems in the Grand River to a discharge from the A. E. Staley Manufacturing Co. A discharge from such a manufacqurer could include a large BOD load. Concentrations and flow of this discharge should be reported by the industry to the Ohio Department of Health on a monthly basis.

Microbiological problems are also prevalent in the lower reaches of the Grand River. Total coliform counts below Fairport and Painesville's sewage treatment plants had a median value of 15,000 organisms/100 ml with a maximum count of 340,000 organisms/100 ml occurred during a moderate rainfall. The corresponding fecal coliform concentration was 60,000 org/100 ml. This indicates that the source of pollution was animal wastes. Since this area is served by separate systems, it is concluded that this load must have been discharged from the storm sewers. During rainfall much organic matter is carried into the storm sewers by the rainwater. This waste is discharged to the streams without any treatment, creating health hazards. In order to eliminate this condition, all storm water from built-up municipal areas should be treated and disinfected before discharge.

It is apparent from the high median total coliform concentrations and high fecal coliform concentrations (median fecal coliform concentrations at mile point 2.3 was 6,000 organisms/100 ml) that bacterial pollution is also in the stream during dry weather. This can be attributed to the unsewered areas of Grand River and Painesville. Northeast as well as inadequate disinfection procedures at the Painesville and Fairport sewage treatment plants. All municipal sewage treatment plants in the Northeastern Ohio Area should provide continuous year around chlorination. An enteric pathogen study at mile point 2.3 found 34 isolates of two Salmonella serotypes. Since this stretch of the river could be used for recreational purposes, the bacterial pollution presents a definite health hazard.

Near the mouth of the Grand River the biological conditions improve due to dilution by lake water. However, even in this transitional zone of dilution, pollution tolerant sludgeworms and bloodworms are predominant.

Being in a lake-affected area, a cross-section of the Grand River at mile point 0.1 would contain lake water as well as river water.

Dispersion studies in Fairport Harbor reveal a stratification between the river and lake water. Conductivity readings, which measure the ion (dissolved solids) concentration in the water, averages 300 umhos in the central and eastern portions of Lake Erie. These data near the mouth of the river range from 500 umhos near the surface to approximately 4,000 umhos near the bottom.

Approximately a mile and a half from the river mouth, conductivities are considerably less with only minor indications of stratification. Two miles from the mouth the stratification is nonexistent.

IMMEDIATE NEEDS

MUNICIPALITIES & INDUSTRIES
in
GRAND RIVER BASIN

Municipalities

Sewerage Service Area	Present Treatment	1960 Population Served	Plant Needs
Fairport	Intermediate	4,267	Secondary (Metropolitan system) and year-around disinfection
Painesville	Primary	16,116	Secondary (Metropolitan system) and year-around disinfection
Chardon	Secondary	3,154	Expansion and year-around disinfection
Jefferson	Secondary	2,116	Expansion and year-around disinfection
Painesville-Northeast	Septic Tanks	1,265	Collection system and Secondary (Metropolitan system) and year-around disinfection
Grand River	Septic Tanks	477	Collection system and Secondary (Metropolitan system) and year-around disinfection
Orwell	Septic Tanks	819	Collection system and Secondary with year-around disinfection

Industries

Name	Location	Control Measures Needed
GRAND RIVER BASIN		
Calhio Chemical, Inc.	Perry	Solids, Chlorides
Diamond Alkali Co.	Painesville	Solids, Chlorides, Ammonia. Phenols and Color
U. S. Rubber Co.-Uniroyal	"	Solids
A. E. Staley Manufacturing Co	Grand River	BOD, Oils, Solids

Ashtabula River

The Ashtabula water quality varies from polluted in the lower reaches to very good in the upper reaches. The water quality in the harbor area and navigational portion of the river is degraded by pollution from vessels and corresponding dock activities. A portion of the Ashtabula River is adversely affected by Fields Brook, a small tributary which is heavily polluted with industrial wastes.

The water quality of the upper reaches of the Ashtabula River is generally very good. Many types of pollution intolerant organisms can be found at all locations above the City of Ashtabula.

The lower reach of the river is in a lake-affected area. Even with dilution from the lake water, biological investigations reveal polluted conditions. Clean-water bottom organisms are absent at all locations in this section of the river. Sludgeworms are the only bottom organism found at some locations in the lower reach while at the mouth conditions are somewhat improved, but only to the extent that pollution tolerant bloodworms and fingernail clams are found in addition to the sludgeworms.

In the harbor the predominant bottom fauna are still sludgeworms and bloodworms. The attached algae Cladophora are abundant on both sides of the river and the aquatic weeds arrowhead and water lilies are found in a few locations.

Coliform concentrations at mile point 0.7 are as high as 540,000 organisms/100 ml with a median value of 89,000 organisms/100 ml.

Median fecal coliform concentrations are 11,000 organisms/100 ml, while median fecal streptococci are 1,700 organisms/100 ml. The bacterial pollution is caused by vessel wastes and from personnel employed at the various docking activities. None of these activities on either side of the Ashtabula River or any part of the lakeshore are connected to the collection system of the City of Ashtabula and there are no modern facilities. This area is served with nothing but pit privies which discharge to the river or lake. This situation is a definite health hazard to the people of Ashtabula and should be remedied as soon as possible. A collection system should be provided for oils, garbage, refuse, and other deleterious materials and a system should be installed to pump the sanitary sewage to the Ashtabula sewage treatment plant.

At mile point 3.3 median coliform counts are 2,100 organisms/100 ml with median fecal streptococci values of 390 organisms/100 ml and fecal coliform of 520 organisms/100 ml. This indicates organic pollution from septic tanks or from storm water sewers with illegal household sanitary connections as well as other animal wastes carried by storm water. In order to remove this health hazard, the Ashtabula Health Department should see that all septic tanks in this area are abandoned and the sources connected on to the municipal system. The Ashtabula Health Department should also conduct an intensive study to locate and remove all illegal connections to storm and sanitary sewers.

Between the two stations at mile points 0.7 and 3.3 a small tributary, Fields Brook, discharges to the Ashtabula River. Fields Brook carries wastes from a large industrial complex outside Ashtabula into the lake-affected portion of the Ashtabula River. The industries in the complex are primarily chemical industries whose effluents contain both organic and inorganic wastes. The effect of Fields Brook on the Ashtabula River is reduced because lake waters dilute the constituents which are discharged into the river. However, biological conditions indicate this lower reach of river to be polluted. Concentrations of several chemical constituents show large increases between the magnitudes above and below Fields Brook. Average dissolved solids concentrations increased from 295 mg/l to 507 mg/l. Phenol concentrations tripled in value jumping from an average of 1.8 ug/l upstream to 5.9 ug/l downstream. Other increases include suspended solids, chlorides and ammonia. The degradation of the Ashtabula River can be attributed to the industrial waste discharges to Fields Brook and the municipal wastes previously discussed. The effects of the industrial waste discharge can be more readily seen by inspection of Fields Brook.

The waters of Fields Brook are normally milky white. The color, according to the Ohio Department of Health, is caused by small amounts of titanium dioxide. One use of titanium dioxide is as a white color base for paint and paper. The Cabot Titania Corp., Titanium Dioxide Plant as its name implies, manufactures titanium dioxide which is used as a base material by the Cabot Titania Corp.-Titanium Tetrachloride Plant. The suspended solids load from this plant includes 10,900 pounds per day from the Titanium Tetrachloride Plant and 1,900 pounds per day from the Titanium Dioxide Plant. Another contributor of high suspended solids loads is the Reactive Metals, Inc. - Metals Reduction Plant which discharges 2,300 pounds daily. A storm sewer, which discharges the wastes of several industries into Fields Brook, receives 3,800 pounds of suspended solids daily from Detrex Chemical Industries, Inc. - Chlorinated Solvents Plants, and another 2,900 pounds of suspended solids per day from Reactive Metals, Inc. - Sodium and Chlorine Plant.

The dissolved solids being discharged to Fields Brook are also extremely high. The Reactive Metals, Inc. - Metals Reduction Plant discharges 430,000 pounds of dissolved solids daily. Detrex Chemical Industries, Inc. - Chlorinated Solvents Plant discharges 1,700 pounds of dissolved solids per day to Fields Brook, and 18,000 pounds per day to the storm sewer. Reactive Metals, Inc. - Sodium and Chlorine Plant discharges an additional 52,000 pounds of dissolved solids daily to the storm sewer. Other industries that do not report dissolved solids are Cabot Titania - Titanium Dioxide Plant; Cabot Titania - Titanium Tetrachloride; Olin Mathieson Chemical Corp. - TDI Plant and the Diamond Alkali Company - Semi-Works.

Analyses of samples from Fields Brook indicate that sediment is present in Fields Brook from below the industrial complex to the Ashtabula River. The sediment is very light weight and stays in suspension as long as the waters move rapidly. Fields Brook has sufficient velocity to keep this sediment in suspension until it flows to the quiescent waters of the lake-affected portion of the Ashtabula River; here the sediment settles out. During an investigation of Fields Brook, the waters were found to be very acidic with pH ranging between 2 and 3. As these waters flow into the relatively neutral waters of the

Ashtabula River (pH between 6 and 7) precipitation probably takes place, producing more settleable solids.

Pollution entering a lake-affected portion of a river can adversely affect the water quality upstream from the source. This is evident by the sediment problem in the Ashtabula River just upstream from Fields Brook. An inspection of the area in October of 1966 very markedly showed that sediment in this area of the Ashtabula River is coming from Fields Brook. The sediment not only covers the bottom and adversely affects bottom fauna, but it also adversely affects recreational uses in this section of the river. Fields Brook is also esthetically unpleasing. In addition to the white, turbid appearance of the waters, there is a strong chemical or medicinal odor that is almost continuously present.

It is apparent by the degraded conditions of the Ashtabula River and Fields Brook that the waste discharges of the industries in this area must be improved. The solution is one of immediate action. Table _____ shows the control measures needed by the various industries. The waste loads produced by these industries will be increasing with increased production. New industries will be moving into the complex. Sherwin-Williams Co. was constructing facilities when the area was last investigated. Volumes of discharge are expected to increase two to four times, and the pollutional load will increase at nearly the same rate if these control measures are not instituted.

IMMEDIATE NEEDS

MUNICIPALITIES & INDUSTRIES
in
ASHTABULA RIVER BASIN

Municipalities

Sewerage Service Area	Present Treatment	1960 Population Served	Plant Needs
Ashtabula Lakeshore and harbor area	Unsewered		Collection system and connect to Ashtabula STP

Industries

Name	Location	Control Measures Needed
Cabot Titania Corp. Titanium Dioxide Plant	Ashtabula	Solids, Chlorides, Color, pH
Cabot Titania Corp. Titanium Tetrachloride Plant	Ashtabula	Solids, Chlorides, pH
Detrex Chemical Industries Inc. Chlorinated Solvents	Ashtabula	COD, Solids, Chlorides, pH
Diamond Alkali Co. Semi-Works	Ashtabula	COD, Solids, Chlorides
General Tire & Rubber Co. Chemical Division	Ashtabula	Solids
Olin Mathieson Chemical Corp. TDI Facility	Ashtabula	Solids, Chlorides, COD, pH
Reactive Metals, Inc. Metals Reduction Plant	Ashtabula	Solids, Chlorides, pH
Reactive Metals, Inc. Sodium & Chlorine Plant	Ashtabula	Solids, pH

Conneaut Creek

The quality of water in Conneaut Creek varies from polluted to very good.

The water quality of the upper reaches of Conneaut Creek above Springboro, Pennsylvania is good. A variety of pollution intolerant bottom fauna are found at all locations between Springboro and Conneautville, Pennsylvania. Conneautville, a municipality of 1,200 (1960 population) is contributing nutrients as well as bacterial pollution to Conneaut Creek. Although this municipality has several storm sewers it does not have a sewage treatment plant. The Corps of Engineers in a recent study reported the discharge of raw sewage into Conneaut Creek from three sewer pipes in Conneautville. (10). This adversely affects water quality and presents a serious health hazard to both local inhabitants and downstream neighbors. These raw sewage discharges should be removed immediately and the three sewer pipes should be connected to a sewerage system. Most of the sewage from Conneautville receives minimal treatment in septic tanks. The septic tanks should be abandoned and the wastes sources should be connected to the sewerage system. The treatment plant should provide at least secondary treatment. Conneautville is located in the upper reaches of Conneaut Creek; during the dry weather season this creek has very little flow for dilution of waste discharges. Because of this low dependable yield, small waste loads may have a degrading effect on the stream in this location. Although the population is not expected to grow appreciably in the Conneautville area, the sewage treatment plant will have to convert to tertiary treatment by 2020 and possibly before if there is a significant industrial build-up in the area.

Presently the Pennsylvania Sanitary Water Board does not have the authority to place under orders municipalities that do not have collection systems. Since Conneautville and several other locations within the Lake Erie Basin do not have collection systems it is recommended that legislation be adopted giving the Pennsylvania Sanitary Water Board the authority to order a municipality to construct and properly operate and maintain a collection system and a sewage treatment plant.

At Springboro, the water quality of Conneaut Creek is seriously degraded. An unnamed tributary which flows into Conneaut Creek receives wastes from the Albro Packing Company and from the effluents of many septic tanks. At the confluence, Conneaut Creek becomes very turbid. Sludge deposits are found on the bank and beds of Conneaut Creek and throughout the entire length of the unnamed tributary. A biological investigation of Conneaut Creek downstream from the confluence revealed an absence of all bottom organisms.

This is another instance where the Pennsylvania Sanitary Water Board cannot order the municipality to provide adequate treatment. A sewerage system should be constructed to provide secondary treatment of all sanitary sewage. The Albro Packing Co. should connect to this municipal sewerage system. Sealtest Foods, Inc. and other industries whose waste discharge will not upset the biological process of the sewage treatment plant should eventually connect on to the municipal system.

Below Springboro, Conneaut Creek recovers rapidly and within a half mile the biological conditions are typical of those found in a recovery zone.

The water quality of Conneaut Creek is very good as it flows across the Pennsylvania-Ohio line. (See Interstate Waters). A well balanced variety of pollution intolerant bottom fauna are found.

Above the City of Conneaut the water quality is still very good. Pollution intolerant mayflies, caddis flies, and scuds were common at all locations investigated. However, sparse growths of attached algae were again apparent at all locations. The nutrients are most likely from agricultural runoff and septic tank effluents from a fairly large population. Septic tanks are the only means of treatment for sewage in Lakeville, a municipality with a 1960 population of 4,100 and North Kingsville, a municipality with a 1960 population of 1,800. Septic tanks in municipalities with populations as large as these cannot be accepted as adequate, especially in this area where soils generally have poor drainage characteristics.

Both these municipalities should construct sewer systems and provide treatment facilities. Lakeville should connect to the Conneaut sewerage system.

Conneaut Creek becomes turbid as it flows through the City of Conneaut, a condition apparently caused by dredging operations just upstream from the navigation channel. Dredged materials have been deposited along the east bank of Conneaut Creek for about 100 feet.

Behind these deposits is a dumping area. An inspection of this area in September 1966 indicated that refuse from the dump did not appear to be falling into the creek, at least under low or normal flow conditions; some of the refuse, however, was in the Conneaut flood plain. Refuse and drainage from this dumping area may adversely affect water quality in Conneaut Creek during the high flow season.

Across the creek from the dump and dredging deposits is a large storage area for the Pittsburgh-Conneaut Docking Co. It has been reported that large slugs of coal from this storage area have spilled into Conneaut Creek on at least one occasion. According to the Ohio Division of Wildlife, there could be an adverse effect on fish if this spill-over occurs with any frequency. Drainage through the stored coal may also have a degrading effect on the water quality of Conneaut Creek.

Near the mouth of Conneaut Creek in the lake affected portion of the stream, the Conneaut sewage treatment plant discharges its inadequately treated wastes which contain a BOD load of 2,400 pounds per day. The present plant removes only 30 percent of the BOD_5 load it receives. Conneaut Creek in this stretch is overenriched as evidenced by the abundant growths of algae. A biological investigation indicated that the lower stretch of Conneaut Creek is substantially polluted. Only pollution tolerant sludgeworms, bloodworms, leeches and fingernail clams could be found in this area. Attached algae in the creek were predominantly pollution tolerant Oscillatoria, Ulothrix, and Cladophora, while in the harbor, Cladophora was dominant and abundant.

The Conneaut sewage treatment plant should be immediately expanded to provide secondary treatment. Due to the proximity of the plant to the lake, the effluent should not be discharged to Conneaut Creek but should be discharged through a diffusion system extended a half mile into Lake Erie. Secondary treatment will be adequate for the Conneaut area through 2020. If secondary treatment is employed, the BOD loading from the plant in 2020 will be less th an the present loading to Conneaut Creek. This 2020 loading includes the addition of Lakeville to the system as well as the increase in population from the Conneaut-Lakeville Area.

IMMEDIATE NEEDS

MUNICIPALITIES & INDUSTRIES
in
CONNEAUT CREEK

Municipalities

Sewerage Service Area	Present Treatment	1960 Population Served	Plant Needs
Conneaut	Primary	10,557	Secondary (Metropolitan system) and year around disinfection
Lakeville	Septic Tanks	4,180	Collection system and Secondary (Metropolitan system) with year around disinfection
Albion	Secondary	1,630	Expansion
Springboro	Septic Tanks	583	Collection system and Secondary with year around disinfection
Conneautville	Septic Tanks	1,200	Collection system and Secondary with year around disinfection

Industries

Name	Location	Control Measures Needed
Albro Packing Co.	Springboro	BOD, Solids

Interstate Waters

Three streams in the Northeastern Ohio area are classified as interstate streams. Conneaut Creek, Ashtabula Creek, and Turkey Creek all originate in Pennsylvania and flow into Ohio.

Conneaut Creek, the largest of the interstate streams, drains 153 square miles in 34 miles in Pennsylvania and 38 square miles in 23 miles in Ohio. The creek crosses the interstate boundary approximately five miles south of Lake Erie. As discussed earlier, waste loads which degrade the water quality are discharged to Conneaut Creek in Pennsylvania, but the creek rapidly recovers and there is no evidence of pollution as it flows into Ohio. Biological investigation at the Pennsylvania-Ohio line revealed a well-balanced variety of pollution intolerant bottom fauna. Chemical analyses also indicate the water to be of very good quality. Table 7-2 summarizes the chemical and microbiological data obtained from the samples taken at the interstate boundary.

WATER QUALITY OF

INTERSTATE WATERS

	Conneaut Creek	Ashtabula Creek	Turkey Creek
Mile Point	23.3	5.5	1.6
Drainage Area (sq. miles)	x	x	x
Flow (cfs)	x	x	x
BOD (mg/l)	1.3	1.2	0.8
DO (mg/l)	14.0	13.0	13.0
Nitrogen (mg/l)	1.1	0.8	1.3
Soluble Phosphate (mg/l)	0.08	0.05	0.03
Total Solids (mg/l)	200	191	317
Dissolved Solids (mg/l)	194	190	315
Chlorides (mg/l)	34	28	72
Conductivity (umhos/cm)	285	235	470
Total Coliform(org/100 ml)	130 x	310 x	x
Fecal Coliform(org/100 ml)	20 x	110 x	50 x
Fecal Strep.(org/100 ml)	28 x	22 x	47 x

Ashtabula Creek, a tributary of the Ashtabula River, flows for only three miles in Pennsylvania draining eight square miles. It flows into Ohio approximately six miles south of Lake Erie. There are no wastes discharged into Ashtabula Creek and, as can be seen in the above table, does not have any water quality problems as it crosses the Pennsylvania-Ohio border.

Turkey Creek is a small tributary flowing to Lake Erie midway between the Pennsylvania-Ohio line and Conneaut, Ohio. The creek is only seven miles long, six of which are in Pennsylvania, and drain ten square miles, nine of which are in Pennsylvania. Turkey Creek, like Ashtabula Creek, receives no significant waste loads and has very good water quality as it flows into Ohio.

Interstate stream water quality standards are being proposed by all states in accordance with the Clean Waters Restoration Act of 1966. The Act requires that the standards be submitted by June 30, 1967.

The Ohio Water Pollution Control Board and the Pennsylvania Sanitary Water Board have both submitted standards for the three above-mentioned streams. These proposed standards should help to maintain the existing water quality of these streams and should keep any additional sources of wastes from entering these waters.

Bathing Beaches

The quality of water of the bathing beaches in Northeastern Ohio is fair. Data on coliform concentrations from bathing beach studies performed by county or municipal health departments are shown in Figure 7-2. Although some data are available for bathing beaches in Ashtabula County, the sampling was infrequent and no definite conclusions can be made. The data obtained from the Lake County Department of Health indicate that beaches within Lake County have geometric mean coliform concentrations between 100 and 1,000 organisms/100 ml. This indicates that there is some organic pollution from sources which should be investigated. The abatement of this organic pollution will greatly improve the quality of water of these bathing beaches.

The State of Ohio recommends that for bathing beach waters, the monthly arithmetical mean coliform concentration should not exceed 1,000 organisms/100 ml; nor should this number be exceeded in more than 20 percent of samples examined during the month; nor should any one sample exceed 2,400 organisms/100 ml. It should be pointed out that arithmetical averages are considerably higher than geometrical averages, especially with large variances in coliform concentrations.

Although the geometric average coliform concentrations are under 1,000 organisms/100 ml, the individual samples frequently exceed this value. Below is a tabulation of the percentage of samples that were over 1,000 organisms/100 ml at the various beaches in Lake County:

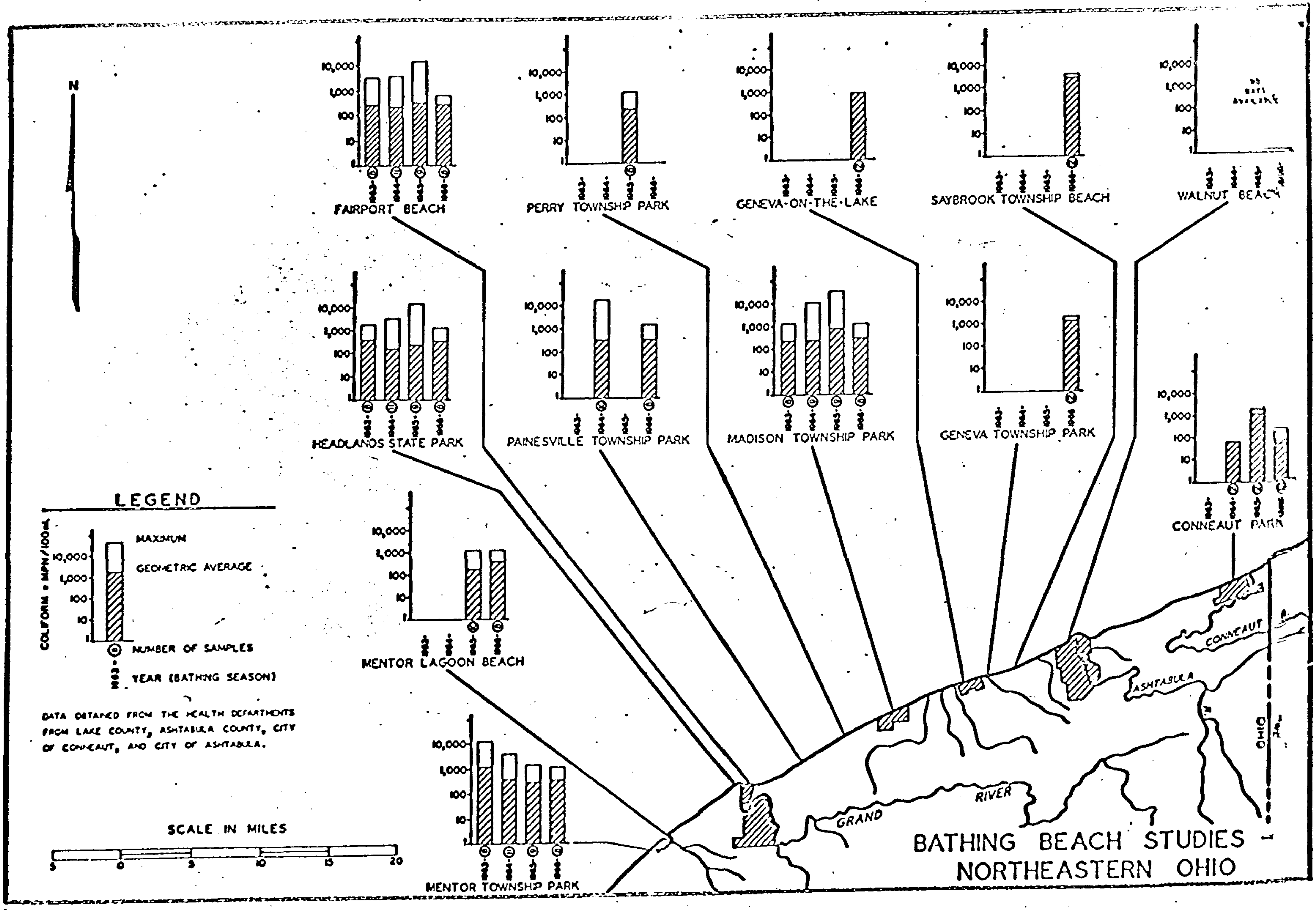

N
FAIRPORT BEACH
PERRY TOWNSHIP PARK
GENEVA-ON-THE-LAKE
SAYBROOK TOWNSHIP BEACH
WALNUT BEACH
HEADLANDS STATE PARK
PAINESVILLE TOWNSHIP PARK
MADISON TOWNSHIP PARK
GENEVA TOWNSHIP PARK
CONNEAUT PARK
MENTOR LAGOON BEACH
MENTOR TOWNSHIP PARK
LEGEND
MAXIMUM
GEOMETRIC AVERAGE
COLIFORM - MPN/100 ml
NUMBER OF SAMPLES
YEAR (BATHING SEASON)
DATA OBTAINED FROM THE HEALTH DEPARTMENTS FROM LAKE COUNTY, ASHTABULA COUNTY, CITY OF CONNEAUT, AND CITY OF ASHTABULA.
SCALE IN MILES
5 0 5 10 15 20
GRAND RIVER
ASHTABULA
CONNEAUT
OHIO
BATHING BEACH STUDIES
NORTHEASTERN OHIO

TABLE 7-1
Percentages of Samples
with Coliform Concentrations over 1,000/100 ml

	% of samples which had coliform concentrations greater than 1,000 org./100 ml
Mentor Township Park	30
Headlands State Park	20
Fairport Beach	20
Madison Township Park	35
Painesville Township Park	39
Mentor Lagoons	28
Perry Township Park	25

Coliform concentrations for the four years represented ranged from a minimum of 10 org./100 ml recorded at Perry Township Park in 1965 to a maximum of 54,200 organisms/100 ml at Madison Township Park in 1965. The range in 1966 was from 200 to 1,400 organisms/100 ml. This range was equaled or nearly equaled at all beaches in Lake County in 1966.

No data are available on the causes of the high coliform concentrations, but studies in other bathing beaches have indicated a definite correlation between high coliform concentrations and meteorological conditions as well as storm runoffs and overflows. Intensive studies should be made to determine the effects on bathing beaches of surface runoff and all municipal and industrial wastes that are discharged directly to Lake Erie. The effects of the streams on the beaches should also be studied. Correlation of high coliform concentrations with meteorological conditions should be ascertained in order to determine the feasibility of temporarily closing the beaches during and immediately after unfavorable weather conditions. Routine sampling programs should be set up for all bathing beaches. Samples should be taken at least every other day, and possibly every day during the bathing season.

Loadings to Lake Erie

In addition to the loadings from the Grand and Ashtabula Rivers, and Conneaut Creek, three municipal treatment plants, six industries, and several small tributaries discharge wastes to Lake Erie. Table 7-3 summarizes the loads to Lake Erie. Individual discharges of municipal treatment plants and industries are shown in Table 6-1 and 6-3.

The three sewage treatment plants discharging directly to Lake Erie are the Ashtabula plant and the two Lake County sewer districts; one at Willoughby-Mentor and the other at Madison.

The Ashtabula plant is the largest plant in the Northeastern Ohio Area and provides intermediate treatment. The plant removes only 37 percent of the BOD_5 and discharges 3,400 pounds per day to Lake Erie. Total coliform concentrations in 1964 within the breakwall near the sewage treatment plant were as high as 64,000 organisms/100 ml with a median of 1,950 organisms/100 ml.

The Willoughby-Mentor plant also provides intermediate treatment and removes 68 percent of the BOD_5 it receives. It discharges approximately 810 pounds of BOD_5 daily to Lake Erie.

The Lake County plant at Madison is nothing more than an Imhoff tank and removes essentially nothing but large solids. It removes no BOD_5 and discharges approximately 540 pounds of BOD_5 daily.

The projected BOD loads from the three sewage treatment plants are shown in Table 7-3.

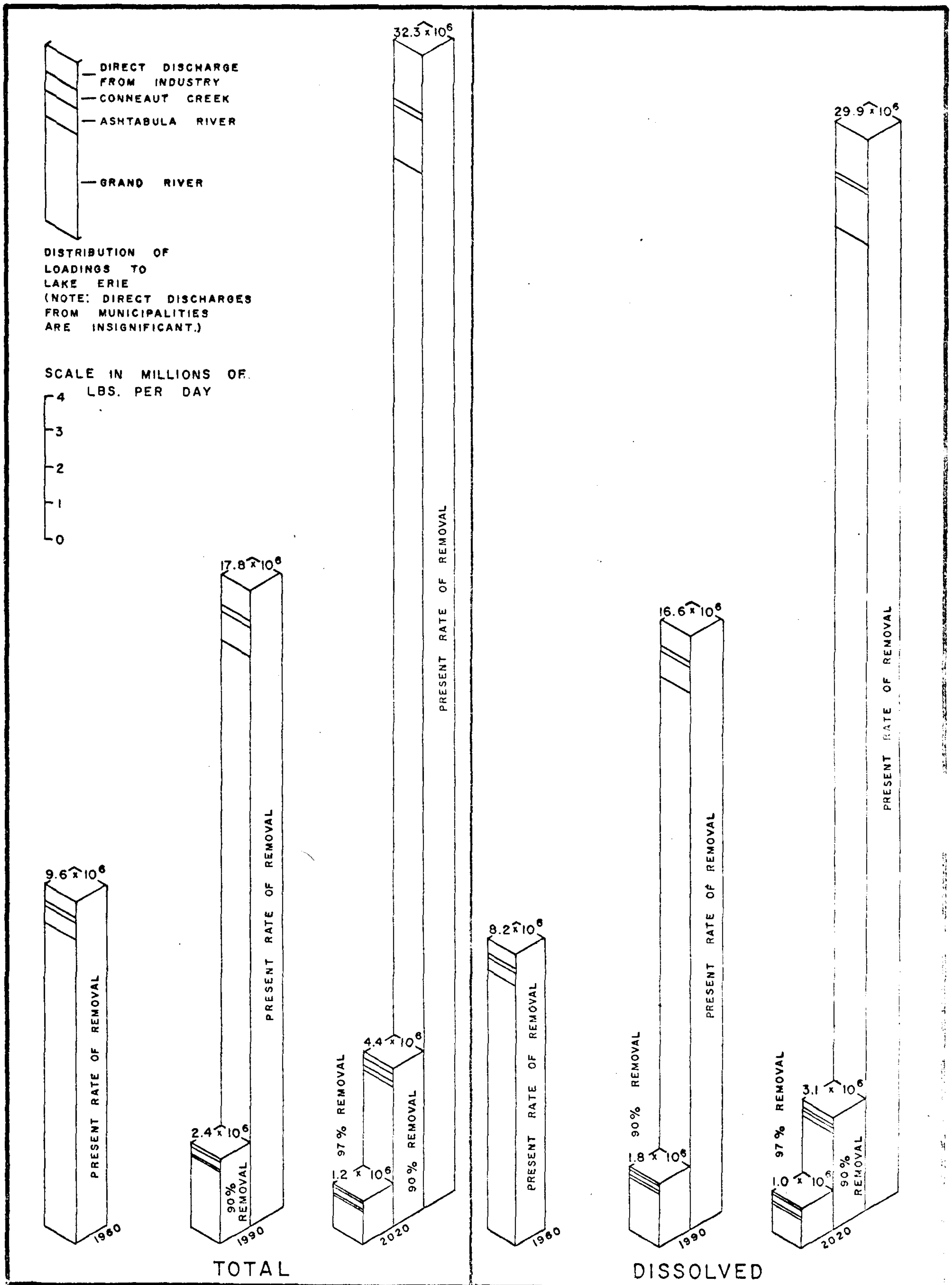
These plants should provide secondary waste treatment and should chlorinate their wastes all year around.

Of the six industries discharging directly to Lake Erie, two are located in Painesville. They are Midland Ross Corp. - IRC Fibers Division, and Diamond Alkali Co. The Midland Ross Corp. - IRC Fibers Division discharges some 274,000 pounds per day of solids, 250,000 pounds per day of which are dissolved. The dissolved solids include 40,000 pounds of chlorides and 6,700 pounds of zinc. The waste also includes 4,300 pounds per day of grease and 8,700 pounds per day of BOD. The Diamond Alkali Company, in addition to its outfalls to the Grand River has an outfall discharging directly to Lake Erie. This discharge includes 43,000 pounds per day of solids, 37,000 pounds per day of which are dissolved. The dissolved solids are primarily chlorides which account for 26,000 pounds daily. Diamond Alkali also discharges 1,000 pounds of ammonia daily.

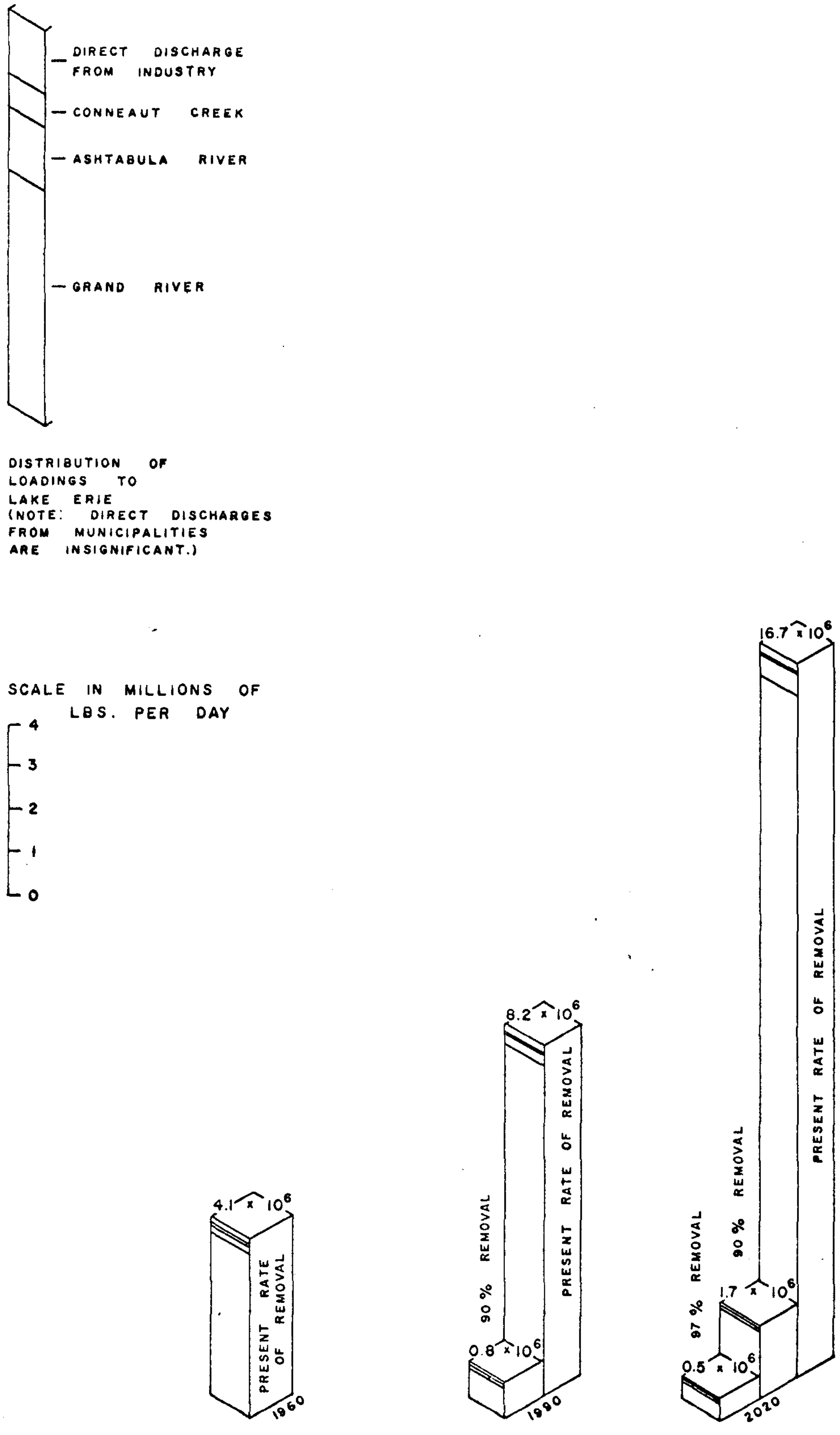
The remaining industries that discharge directly to Lake Erie are all located in the Ashtabula industrial complex. Russell Road Ditch is a small tributary of Lake Erie with a flow comprised almost entirely from waste discharges from Detrex Chemical Industries Inc. - Chlorine and Alkali Plant, and Union Carbide Corp. - Linde Division and Metals Division. The total solids load to Russell Ditch from Union Carbide Corp. - Metals Division is 18,000 pounds per day and 16,000 pounds per day from the Linde Division.

In addition to Russell Ditch, Union Carbide Corp. - Metals Division discharges 18,000 pounds of total solids daily to the Union Carbide sewer which discharges directly to Lake Erie.

As discussed earlier the industrial waste production is expected to double by 1990 and quadruple by 2020. Table 7-3 shows the loads that will be discharged to the lake if the present level of treatment is not improved.

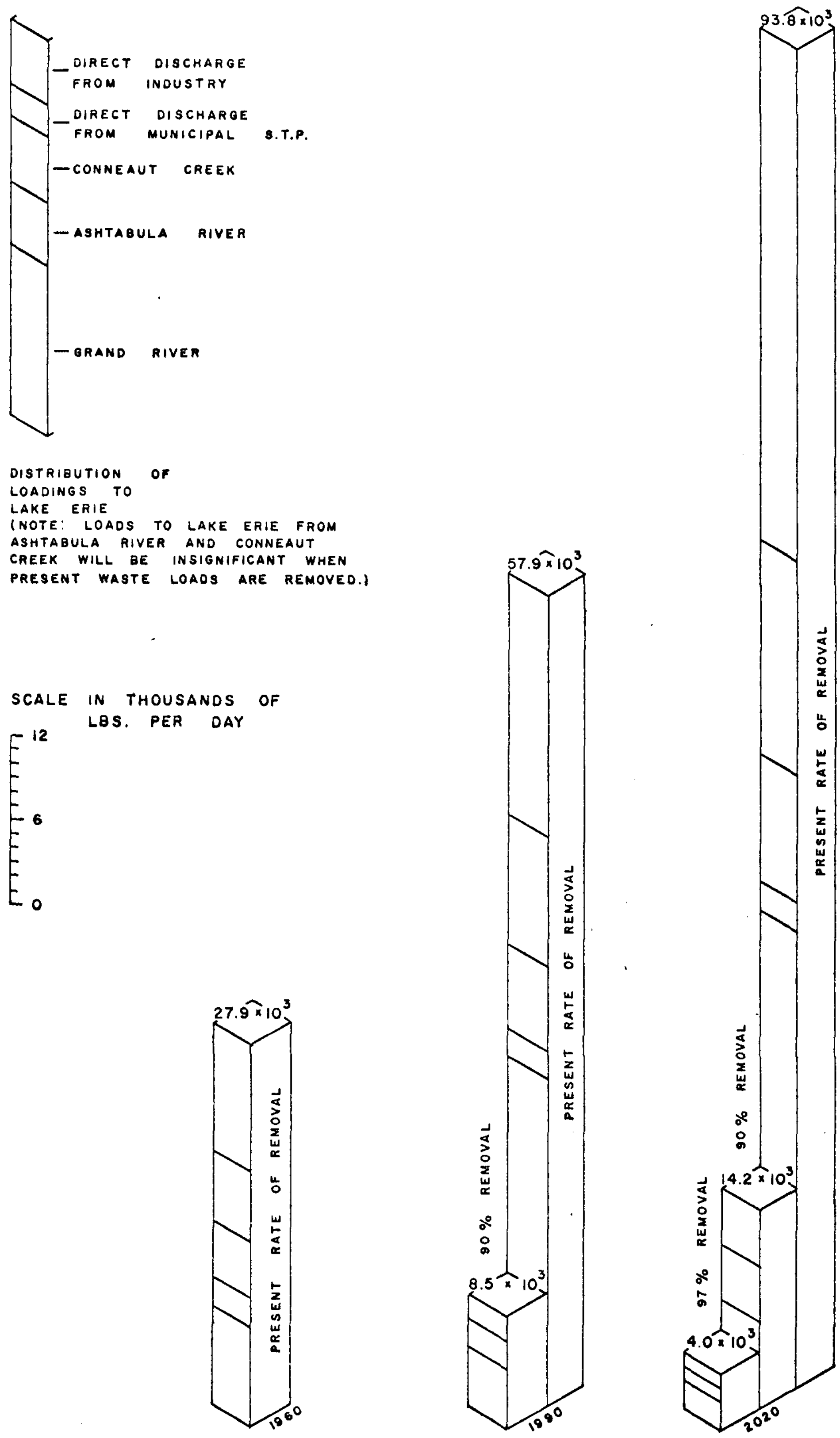


LOADINGS TO LAKE ERIE
(SOLIDS)



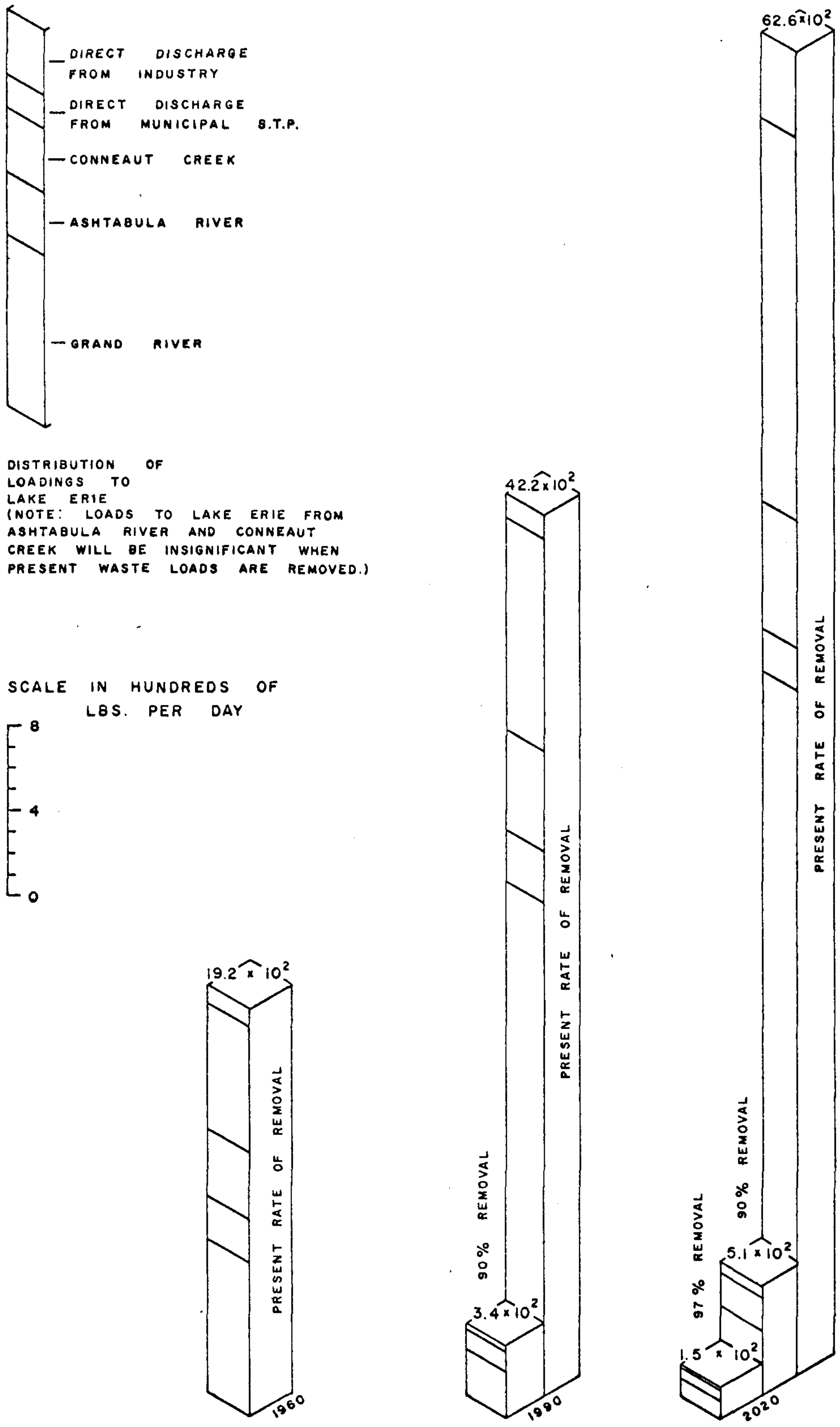
LOADINGS TO LAKE ERIE

(CHLORIDES)



LOADINGS TO LAKE ERIE

(BOD)



LOADINGS TO LAKE ERIE

(SOLUBLE PO_4)

TABLE 7-3

LOADINGS TO LAKE ERIE
(lbs/day)

	Grand River	Ashtabula River	Conneaut Creek	Munic-ipal*	Industrial
			Present Loadings		
Total Solids	8,500,000	460,000	190,000	16,000	400,000
Dissolved Solids	7,300,000	370,000	110,000	10,000	360,000
Chlorides	3,900,000	130,000	17,000	2,800	76,000
BOD	7,200	1,700	4,400	5,000	9,000
Soluble PO_4	720	200	310	590	100
			1990 Loadings		
Total Solids					
A	16,000,000	800,000	193,000	28,000	790,000
B	2,000,000	72,000	--	9,500	79,000
Dissolved Solids					
A	15,000,000	720,000	110,000	18,000	710,000
B	1,500,000	61,000	--	6,200	71,000
Chlorides					
A	7,800,000	260,000	17,000	5,000	150,000
B	780,000	26,000	--	5,000	15,000
BOD					
A	23,000	2,000	6,800	9,100	17,000
B	4,000	**	***	2,800	1,700
Soluble PO_4					
A	~~23,000~~ 2300	240	480	1,000	200
B	220	**	***	100	20
			2020 Loadings		
Total Solids					
A	29,000,000	1,500,000	193,000	48,000	1,600,000
B	3,900,000	140,000	--	11,000	160,000
C	900,000	43,000	--	8,900	48,000
Dissolved Solids					
A	27,000,000	1,400,000	100,000	30,000	1,400,000
B	2,700,000	150,000	--	7,000	140,000
C	800,000	70,000	--	1,800	40,000

TABLE 7-3 (Cont'd)

LOADINGS TO LAKE ERIE
(lbs/day)

	Grand River	Ashtabula River	Conneaut Creek	Municipal*	Industrial
			2020 Loadings		
Chlorides					
A	16,000,000	500,000	17,000	8,400	150,000
B	1,600,000	50,000	--	8,400	15,000
C	480,000	15,000	--	8,400	4,500
BOD					
A	32,000	2,200	8,600	15,000	36,000
B	6,000	**	***	3,600	3,600
C	2,000	**	***	1,000	1,000
Soluble PO_4					
A	3,200	260	600	1,800	400
B	300	**	***	170	40
C	90	**	***	50	10

A = Loadings @ present level of treatment
B = Loadings @ 90% removal (secondary treatment)
C = Loadings @ 97% removal (tertiary treatment)
* Does not include storm water
** Loading from unsewered area. If connected to Ashtabula STP the load would be discharged to Lake Erie.
*** If Conneaut STP discharged to Lake Erie and unsewered areas of Lakeville connected to it, the loadings would be discharged directly to Lake Erie.

Pennsylvania Area

The streams of Pennsylvania that flow to Lake Erie are very small and, except for those in Greater Erie, pass through relatively unpopulated areas.

Elk Creek, the largest of the Lake Erie Tributaries draining 100 square miles, receives discharges from two sewage treatment plants, Lake City and Girard. Elk Creek is classified by the Pennsylvania Health Department as a "complete treatment stream," which means that all municipal and industrial waste discharges to the stream must have adequate secondary treatment. The Girard sewage treatment plant does not meet this requirement and has been placed under orders by the Pennsylvania Sanitary Water Board. This plant presently removes only 65 percent of the BOD load it receives. Girard should immediately provide secondary treatment. Removing 90 percent of the raw BOD will lower the effluent BOD concentration to under 15 mg/l. In a small stream such as Elk Creek the BOD concentration must be kept low because of the lack of sufficient quantity of water for dilution. In order to maintain a low concentration of BOD in Elk Creek the sewage treatment plants in Girard and Lake City should provide tertiary treatment by 2020. Although the population growth in this area will not be great, it will be large enough by 2020 to cause degrading conditions in Elk Creek if only secondary treatment is provided.

Another water quality problem in Elk Creek is caused by the discharges from the Gunnison Bros. Tannery located in Girard Township and discharging to Brandy Run, a tributary of Elk Creek. A recent grab sample taken by the Pennsylvania Health Department indicated high concentrations of BOD and solids. The BOD concentration was 320 mg/l and concentrations were 4,850 mg/l for total solids and 900 mg/l for suspended solids. The volume of waste discharged is only 2,500 gallons per day. Although this discharge is quite small, it should be noted that the flow in the receiving stream is also small, especially in the late summer months. The water quality of Elk Creek and Brandy Run is at times degraded from the waste discharged from Gunnison Bros.

The concentrations of BOD and solids produced by tanner are extremely large. The secondary treatment presently employed at Gunnison Bros. cannot remove large enough concentrations of these constituents to meet standards that should be required for discharge to a small stream such as Brandy Run. Tertiary treatment or at least 98 percent removal of BOD and suspended solids should be an immediate objective of Gunnison Bros.

The largest pollution problem in the Pennsylvania streams is in Cascade Creek, Garrison Run, and Mill Creek. These streams flow through Erie and receive the combined sewers overflow from the Erie collection system. Mill Creek, flows under the City of Erie through a large tube. In the past, this creek was used as a sewer for industrial waste discharges. Erie Brewing Co. was the principal industry that discharged to Mill Creek. This industry has since connected to the municipal sewer system and their wastes are now treated by the Erie Sewage Treatment

Plant.

Large BOD loads are discharged from the combined sewer overflows. A combined system carries storm water and sewage in one sewer. With small or moderate rainfall the volume of waste to the sewage treatment plant becomes too large for the plant to handle. Combined systems are designed to bypass through the overflow structures all wastes that cannot be handled by the sewage treatment plant. During storms approximately half the discharge from the overflows is raw municipal sewage. The larger the storm, the larger the discharge of raw sewage to the streams. These overflow discharges not only aid in degradation of water quality of the streams but create a definite health hazard. Coliform concentration in the three streams were over 1,000,000 organisms/100 ml. Cascade Creek, Garrison Run, and Mill Creek all discharge in Presque Isle Bay, and all three of these streams have a degrading effect on the waters of the bay.

Enteric pathogen studies in Mill Creek and Erie Harbor revealed that several Salmonella isolations were present. These are all direct disease causing organisms and are pathogenic to man. Table 7- is a tabulation of the findings.

Since combined sewers present a health hazard, they should be removed wherever possible. Erie is presently converting portions of its combined sewer to separate sewers. In separate systems storm water is separated from municipal and industrial waste and therefore, will not overload the sewage treatment plant. The storm water is discharged without treatment to the nearest open water course. However, storm water

TABLE 7-

ISOLATIONS OF SALMONELLAE
ERIE, PA.
March - July, 1965

Sampling Site	Date of Collection	Salmonella	Serotypes (isolates)
Trunk sewer (Wallace and Front manhole)	3-8-65	S. san diego S. cubana S. muenchen S. enteritidis	(1) (2) (1) (1)
Mill Creek (West of STP)	3-8-65	S. schwarzengrund	(1)
Coast Guard (Boathouse)	3-8-65	S. san diego	(1)
Trunk Sewer (Wallace and Front manhole	4-12-65	S. derby S. newport S. alachua	(2) (1) (1)
Mill Creek (West of STP)	4-12-65	S. alachua S. newport	(1) (1)
Mill Creek (Wallace and Front manhole	4-12-65	S. derby S. newport S. cubana S. alachua	(1) (12) (2) (1)
Coast Guard (Boathouse)	4-12-65	negative	
Trunk Sewer (Wallace and Front manhole)	5-3-65	S. cubana	(2)
Mill Creek (West of STP)	5-3-65	S. cubana	(3)
Mill Creek (Wallace and Front manhole)	5-3-65	S. cubana	(7)
Coast Guard (Boathouse)	5-3-65	S. cubana	(4)

TABLE 7- (concluded)

ISOLATIONS OF SALMONELLAE
ERIE, PA.
March - July, 1965

Sampling Site	Date of Collection	Salmonella	Serotypes (isolates)
Trunk Sewer (Wallace and Front manhole)	6-2-65	S. heidelberg S. bredeney S. bareilly	(8) (1) (1)
Mill Creek (West of STP)	6-2-65	S. heidelberg	(1)
Coast Guard (1,000 feet east)	6-2-65	negative	
Presque Isle State Park (E. Gull Point)	6-2-65	negative	
Presque Isle State Park, Beach 11 N. bathing area	6-2-65	negative	
Mill Creek (West of STP)	7-12-65	S. newport S. enteritidis	(1) (1)
Trunk Sewer (Wallace and Front Manhole)	7-12-65	S. cubana S. heidelberg S. enteritidis	(1) (1) (5)
Beach Comber Hotel	7-12-65	negative	
Presque Isle State Park, Beach 11 (South Ski area)	7-12-65	negative	
Coast Guard (1,000 ft E)	7-21-65	negative	
Coast Guard (Boathouse)	7-12-65	S. panama	(2)
Presque Isle State Park, Beach 11 (N. bathing area)	7-12-65	negative	
Presque Isle State Park, Beach 1	7-12-65	negative	
Presque Isle State Park, Beach 11 (E. Gull Point)	7-12-65	negative	

picks up large quantities of organic material from street and land washing. This organic material should be removed before discharge to open waters. All storm water from built-up municipal areas with combined sewers or separate sewers should be treated and disinfected before discharge. Plans for treatment are an immediate need and the operation should be going full scale by 1971.

Direct to Lake Erie

The largest industrial and municipal waste discharges in the Pennsylvania area are located in Erie. The Hammermill Paper Company and the Erie Sewage Treatment Plant both discharge their wastes directly to Lake Erie east of Erie Harbor.

The effects of the wastes from Hammermill Paper Company on the waters of Lake Erie can be seen for miles. Wastes from the bleaching process imparts foam and color to the waters which, with westerly winds, have been detected along the shoreline for 20 to 30 miles. With winds from the east, some of the waste discharged by Hammermill gets into the Erie water supply. Taste problems have occurred in Erie's drinking water when such winds prevail. The taste is attributed to the lignins and/or tannins which are a waste product of the pulping process from the Hammermill Plant. The lignins and tannins were supposed to be removed from the discharge to Lake Erie by deep well injection of the spent liquors wastes; however, there are still some present. This taste of odor-producing constituents should be immediately removed along with the color and foam.

The wastes from Hammermill's effluent is also tremendously high in oxygen consuming material. Previous discharges from the paper company had a BOD_5 of approximately 144,000 lbs/day or a population equivalent of 860,000. Much of this BOD_5 load has been removed by Hammermill Paper Company by injecting its spent liquor wastes into deep wells. However, the discharge to Lake Erie still contains approximately 62,000 pounds of BOD_5 per day (PE of 370,000). Even with the removal of the spent liquor wastes, the percent removal of BOD_5 is only 60 percent.

A survey conducted by the Pennsylvania Health Department in September 1966 indicated that the BOD_5 concentrations in Lake Erie in the vicinity of Hammermill's discharge ranged from 8 to 32 ppm as compared to 0.5 to 2.8 ppm found at other locations in the lake.

In order to remove the BOD_5 load to Lake Erie, the Hammermill Paper Company is applying to the Federal Government for a research grant to determine the feasibility of having its wastes treated by the Erie sewage treatment plant.

The Pennsylvania Health Department has Hammermill under orders to improve their treatment and are requiring greater removal of BOD_5 and suspended solids and to alleviate the foaming and color problem.

The color and foaming creates esthetically undesirable conditions especially for swimmers, boaters, fishermen. The water is a brownish-black color in the bay and along the shore as far east as the Pennsylvania-New York line. The foam can also be seen for many miles. There is no definite division between the black waters of the inshore area with the clear offshore waters. The color seems to blend into the clear water with no distinct division between the two; however, there is a definite contrast between the waste affected water and the clear unaffected waters about one-quarter mile offshore.

Just west of Hammermill Paper Company's outfalls is the Erie Sewage Treatment Plant outfall. The treatment plant discharges 6,700 pounds of BOD_5 per day to the lake. The Erie plant provides secondary treatment and removes on an average approximately 85 percent of the BOD_5 load to the plant. The plant is operating near capacity, however, and frequently by-passes raw sewage to Mill Creek near Erie Bay. Expansion of the Erie Sewage treatment plant will be necessary in the near future in order to provide adequate treatment for the increase in waste loads that will accompany this population growth of Erie and the connection of presently unsewered areas.

One such unsewered area is along the lake and bay front. Houses, cabins, motels, restaurants, etc. are located at the foot of the bluff atop of which the City of Erie and the sewage treatment plant are located. Presently the sanitary wastes from this area have been discharged directly to Lake Erie or Presque Isle Bay. At times during the summer when the resorts are in full operation, the pollution affects the water quality of the nearby beaches of Presque Isle State Park. Although these beaches are presently well within the safe range for swimming, it is apparent that with the increase in population and the increase of tourist attraction to the park, this potential health hazard should be immediately removed. Not only will the waste loads increase but the number of swimmers using these waters will increase. Two projects have been proposed by the City of Erie to collect the waste from this area and pump it up to the Erie sewage treatment plant . The plans for the Kelso Beach Area Project and the Bay Front Project have been drawn and are awaiting a method of finance. These projects should not be delayed and construction should start immediately.

Large fish kills occur yearly in Presque Isle Bay due to temperature changes from the discharge of the Pennsylvania Electric Co. in Erie. Gizzard shad which enter Presque Isle Bay from the open lake waters are highly sensitive to temperature changes and are killed from this increase in water temperature. This fish is considered not to be a sport fish and these kills are not reported by the Pennsylvania Fish Commission.

Biological investigation in the Presque Isle Bay area indicated an abundance of filamentous green alga Cladophora in most areas where depth was less than six feet. Serious nuisance conditions have developed affecting home owners and boating.

Bottom deposits in the harbor were a brownish-black combination of mud, silt, and detritus with numerous clam and snail relics. Sewage chemical odors were present from some bottom deposits inside and outside the harbor.

A wide variety of bottom fauna was found in Erie Harbor. Snails were abundant and comprised the largest part of the biomass. The most common were Amnicola sp. Valvata sincera, V. tricarinata, Bithinia tentaculata, and Pomacea sp. all of which are sensitive to low dissolved oxygen and excessive organic pollution. Other pollution sensitive bottom dwellers were Gammarus fasciatus and Hyalella azteca (scuds) and *Psychomvia* sp. (caddis larvae). The moderately tolerant *Asellus militaris* (sowbug) and several low dissolved oxygen sensitive species of leeches were found.

The results indicate that Erie Harbor is in fairly good biological condition. Comparison of Erie Harbor with other Lake Erie harbors shows it to have a far greater variety of bottom organisms than any of the others. However, coliform concentrations around Mill Creek and Cascade Creek ranged from 6,000 to 500,000 organisms per 100 ml. This as discussed earlier is probably due to pollution entering the bay from Mill Creek, Garrison Run, and Cascade Creek.

TABLE

FISH KILLS*

Date	Location	Number - Type	Cause - Source
		Pennsylvania	
4/30-5/1/64	Presque Isle Bay	336,000-northern pike, bluegills, bass	Cyanide - metal plating
7/11/64	Lake Erie - South pier	2,000 - perch, bass, walleye, catfish, sheepshead	Oxygen depletion - paper mill waste
7/24/64	Lake Erie - south pier	4-5 ton - perch, catfish, walleye, sheepshead	Oxygen depletion - paper mill waste
8/4/64	Presque Isle Bay - public dock	2000 fingerlings - various species	Oxygen depletion - rainfall scoured storm sewer - silt & BOD shock load
7/19/65	Lake Erie & Presque Isle Bay	number not determined - perch and catfish	Oxygen depletion - paper mill waste
6/11/65	Lake Erie	20 walleye	Oxygen depletion - source not determined
8/9/66	Elk Creek	10,000 - trout, bass, suckers, bullheads	Dieldrin - sewage treatment plant

* Data obtained from Pennsylvania Department of Health

IMMEDIATE NEEDS
MUNICIPALITIES & INDUSTRIES
IN THE
PENNSYLVANIA AREA

Municipalities

Sewerage Service Area	Present Treatment	1966 Population Served	Plant Needs
Lake City	Secondary	1,720	None
Girard	Secondary	2,500	Additions and Improvements
Erie	Secondary	140,000	Expansion and collection system for unsewered areas.
North East	Secondary	5,000	None

Industries

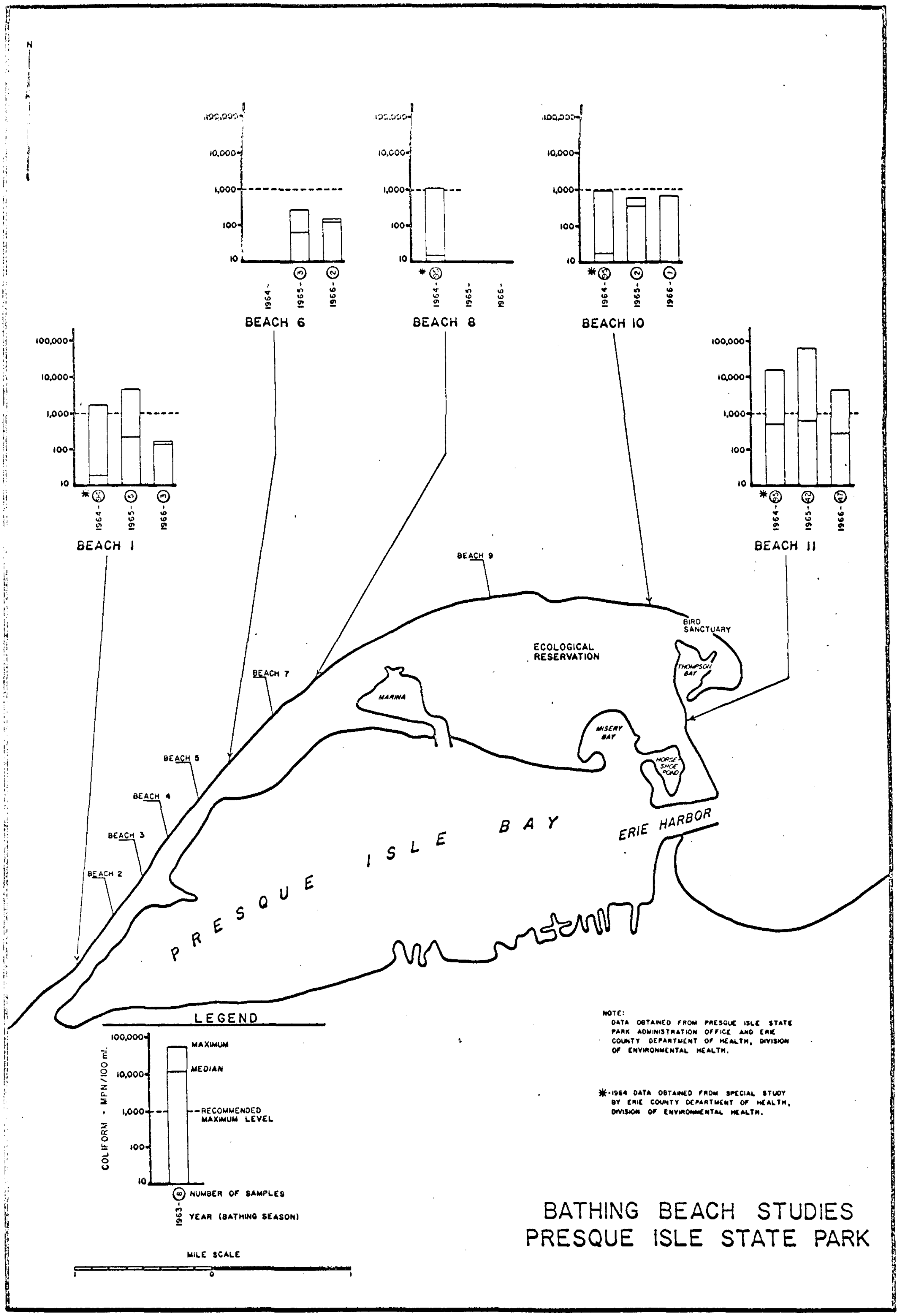
Name	Location	Control Measures Needed
Gunnison Bros.	Girard Township	Tertiary
Hammermill	Erie	Secondary and color, foam, taste and odor producers.
Welch Grape Juice	North East	Color, BOD
Parker White Metal	Fairview	Evaluate improvements
Pennsylvania Electric	Erie	None
Interlake Steel	Erie	Phenols & Solids*
Erie Reduction	Erie	Evaluate improvements
General Electric	Lawrence Park	Evaluate improvements

* = Presently closed, requirement before start of operations

Bathing Beaches

Although there are several small beaches along the Lake Erie shoreline in Pennsylvania, the only major area is Presque Isle State Park, located on the peninsula separating Lake Erie from Presque Isle Bay. There are eleven main beaches on Presque Isle all located on the Lake Erie side of the peninsula. The water quality of these beaches is generally good except for beach 11. Data on coliform concentrations at each beach area obtained from the park administration is shown in Figure . As indicated, beach 11 has very high maximum concentrations and quite high median concentrations. This is caused by pollution from several sources. With correct wind direction, the effluent from the Erie sewage treatment plant effects the water quality at the beach. Previously the plant only disinfected its effluent during the summer months; however, for the past four years, the Erie plant has been chlorinating its discharge continuously all year around.

Another pollution source is the combined sewers overflow from the Erie area which discharges in the bay by way of several streams passing through the Greater Erie Area. During rains these overflows discharge raw sewage which can eventually effect the water quality at beach 11. Other raw sewage discharges from residences and tourists in motels and cabins along the bay front and lakeshore also aid in degrading the water quality. Still another source of pollution to beach 11 is the bird sanctuary located to the north. A large total coliform concentration can be contributed from this area in the form of animal wastes. All these sources have adversely effected the water quality which has re-



BATHING BEACH STUDIES
PRESQUE ISLE STATE PARK

quired that beach 11 be closed approximately percent last summer.

The other beaches of Presque Isle, although they occasionally have high maximum concentrations, are generally of good water quality. Beach 1 occasionally is effected by the raw sewage from homes and motels west of the peninsula. The problem of raw sewage discharges to Lake Erie and Presque Isle Bay will be alleviated with the construction of two bay front and lakefront sewer projects which have been planned by the City of Erie.

New York Area

The New York Area comprises the eastern end of the Lake Erie Drainage Basin. The area drains approximately 2,900 square miles and extends 67 miles along Lake Erie from the Pennsylvania-New York line to and including the Buffalo River.

The major streams are the Buffalo River, Eighteenmile Creek, and Cattaraugus Creek. The Buffalo River is formed by three tributaries namely Buffalo Creek, Cayuga Creek, and Cazenovia Creek. The Buffalo River drains 436 square miles as it flows to Lake Erie through the City of Buffalo. This river is an extreme example of the degradation of once clean waters to a virtual cesspool. During low flow, the river is composed of concentrated industrial and municipal wastes and is probably the most grossly polluted river in the Lake Erie Basin. Cattaraugus Creek is another example of gross pollution; however, it flows through a much less populated area.

Except for the Greater Buffalo Metropolitan Area, the New York Area is predominately rural. The present and projected populations are shown below. The majority of the population is from the rapidly developing southern and eastern suburbs of Buffalo. The City of Buffalo itself is not included in this report since the Buffalo sewage treatment plant discharges to the Niagara River rather than Lake Erie. However, it should be noted that the City of Buffalo does contribute a large share of the pollution loads to the Buffalo River through storm water and combined sewer overflows.

PRESENT & PROJECTED POPULATIONS

NEW YORK AREA

1960	1980	2020
504,000	790,000	1,100,000

Buffalo River

The Buffalo River system of Buffalo River, Cazenovia Creek, Cayuga Creek, and Buffalo Creek varies from very good quality waters at the headwaters to extremely poor. At its mouth the navigation channel waters are essentially concentrated municipal and other wastes in which no biological organisms exist.

Cazenovia Creek

Waste materials discharged by the Village of East Aurora, septic tank effluents, and misused storm drains seriously affect the water quality of Cazenovia Creek. The West Branch of the creek and the East Branch above East Aurora generally maintain good water quality with only several areas of limited enrichment from septic tank effluents.

The waste discharge from the secondary treatment plant at East Aurora contained over 80 mg/l of BOD_5 during 1966. This concentration is much higher than can be adequately assimilated by the stream, and thus the waters are severely degraded. Only pollution tolerant sludgeworms, bloodworms, and air-breathing snails are found for several miles downstream.

This stream is excessively productive even after it is diluted by the West Branch. Dense growths of Cladophora and Hydrodictyon cover the stream bottom. Four miles below the junction of these streams excessive enrichment is still found and Cladophora form a solid mat over much of the stream. Throughout this area, diurnal dissolved oxygen variations are quite pronounced. These variations produce short periods of low concentrations of dissolved oxygen with minimum values being observed just before dawn. In the next eight miles the stream recovers almost completely from the upstream waste source. The excessive nutrient concentrations have been removed by the dense Cladophora growths. In this sector only sparse growths occur and a wide variety of organisms are found. However, effects of the upstream pollution can still be found in pooled areas where algae and other organic matter collects and decomposes after being washed down from upstream. During the summer and fall this decomposing material may act to produce serious oxygen depletions in the stream.

The effluent from septic tanks and misused storm drains in the West Seneca area contribute to the pollution of the lower 2.5 miles of Cazenovia Creek. The lower 0.7 miles are affected by backwater pollution from the Buffalo River industries during low flow. All sources of pollution in this area should be connected to a metropolitan sewerage system.

Cayuga Creek

The Villages of Depew and Lancaster, and the Symington Wayne Corporation are the major polluters of Cayuga Creek. Of the three major tributaries to the Buffalo River, Cayuga Creek has by far the lowest minimum flow. This plays a large part in its inability to handle even moderate wastes, not to mention the relatively large loadings it presently receives.

Above Lancaster only a relatively low level of nutrients are found along with a population of pollution sensitive bottom organisms in both Cayuga Creek and its tributary Little Buffalo Creek. This sector contains water of excellent quality, and only the relatively low flows prevent the development of a balanced fishery.

In the lower nine miles of its length, Cayuga Creek receives the poorly treated plant effluents from Depew and Lancaster, septic tank effluents, storm water overflows, untreated industrial wastes from the Symington Wayne Corporation, garbage and drainings from the village of Depew's dump, and garbage and debris from various other sources. Conditions typical of severe pollution exist throughout this lower nine miles. The water varies from grey to brown to black and normally is turbid and has a strong sewer odor during low flow periods. The two predominant bottom fauna are the pollution tolerant sludgeworms and bloodworms. In many slow moving areas the stream bottom is covered with a black, oily, septic sludge; and fecal matter has been observed floating in the water.

This area is typical of many locations where a lack of planning and foresight have resulted in what is for all practical purposes a running sewer during low flow periods. An area-wide development plan should be set up and put into action which would combine these two plants and other nearby expanding areas into one effective plant operation.

Buffalo Creek

Except for the lower two miles, Buffalo Creek is of excellent water quality with only a minimal amount of nutrients from wastes present. In the early spring trout are taken from the upper reaches of Buffalo Creek and its first tributaries. Slight nutrients are added by small hamlets such as Strykerville, Porterville, and Java Village, but these in the past have had little effect on the stream. Pollution sensitive species of aquatic insect larva are found throughout this reach.

It is only when Buffalo Creek enters the Gardenville area at mile 2.2 that the first noticeable signs of organic pollution are in evidence. The effluent from septic tanks in this area has upset the normal biota of the stream, and slight septic odors are detectible. The water becomes moderately turbid and the bottom fauna consist predominately of leeches and air-breathing snails. Below this point, additional waste inputs continue to degrade the water quality of Buffalo Creek. Oil wastes from the Pennsylvania Railroad shops enter Buffalo Creek at the New York Central Railroad bridge (mile point 1.7). These wastes accumulate in a swamp during dry periods. Fires have occurred in the swamp. The large quantities of accumulated oils discharge rapidly to Buffalo Creek during heavy rainfalls which are contributed to the oil films present on Niagara River during high flow in the Buffalo River. A program should be instituted by the Pennsylvania Railroad to completely remove all oils which may get into the stream and to prevent all future discharges of oils to the area's waters.

Buffalo River

The portion of this drainage system extending downstream from the confluence of Buffalo and Cayuga Creeks is designated as the

Buffalo River.

The flow in the Buffalo River is negligible during dry periods. The sum of the minimum 7 day 10-year return flow in the tributaries is 9.2 second feet. It takes more than 70 days of this flow to equal the volume of water in the dredged portion of the river. At low flow both the rate and direction of movement of water in the dredged channel is primarily influenced by the rise and fall of Lake Erie levels at the river mouth.

The effect of Lake Erie levels on the level and flow in the river extends upstream to mile point 6.6. Cazenovia Creek is similarly affected up to the dam at Stevenson Street or 0.7 miles above its mouth. During periods of low flow, wastes discharged to this pseudo tidal sector of the river may travel both upstream and downstream from the point of discharge.

The waters entering the Buffalo River at the confluence of Buffalo and Cayuga Creeks is poor in quality. One tenth mile downstream of the junction the effluent from the Cheektowaga sewage treatment plant No. 3 causes additional degradation.

The West Seneca treatment plant discharges its effluent at mile point 7.7. Tests performed by the New York Health Department in December of 1966 indicated that at that time the effluent from this primary plant contained over 80 mg/l of BOD_5, and showed a net plant efficiency of only 30 percent BOD_5 removal. The river continues to deteriorate from this point to its confluence with Lake Erie.

Several storm water overflows of the combined sewer system discharge to the river. About one mile above the mouth, raw sanitary sewage from the area between the Buffalo River and West Canal discharges to the river. Industrial wastes from chemical, coke, steel, refinery and grain malting plants discharge to the river.

Prior to March 1967 five major industries on the Buffalo River pumped 100 mgd (155 second ft) from the river for process and cooling water. During low flow periods they were literally recirculating their waste waters and increasing the concentration of many polluting constituents.

Extremely heavy films of heavy oil accumulate and are present on the Buffalo River at all times except during flood flows. Although the refinery has reduced the concentration of oil in its effluent below 10 mg/l they discharge about 1,500 lbs per day. Oil discharges from the Republic Steel Plant, Donner Hanna Coke Plant, the Pennsylvania Railroad shops entering upstream to Buffalo Creek, sanitary wastes and combined sewer overflows also are significant contributions. The heavy oil films on the river and the oil coated shores effectively prevent boating or any recreational activity on the river.

Because of the prevailing winds these oils tend to move upstream rather than downstream during periods of low flow. A large increase in river flow moves most of these oils out into the Niagara River during a period of two to four days. This results in noticeable oil films along the United States shore of the Niagara River down to the Falls and at times are obviously apparent from Lewiston to the mouth of the Niagara.

The industrial plants have reduced the total quantity of industrial waste ph enol entering the river by more than 70 percent in the last twenty-five years. In spite of this reduction, maximum concentrations over 1,000 μg/l are usually present some time each year in the section extending from mile point 3 to mile point 5. Average concentration present in the sector usually less than 500 μg/l. Fortunately, the reduction that has been accomplished has reduced the effect on the Niagara River such that the formerly frequent reported occurrences of phenolic tastes and odors in the finished water of the downstream municipal water plants have almost if not completely been eliminated. However, the present concentrations are high enough to be a potential hazard to the municipal supplies and need to be further reduced.

Biological, microbiological, and other chemical data further demonstrate the degraded condition of the river water. There are no bottom dwelling biological organisms except for a very short distance above the mouth where the cooler Lake Erie water intrudes up along the bottom. The annual maximum coliform MPN in most of the river is usually about 230,000. The median count has ranged from 10,000 to 90,000 at various locations in the river.

During warm water and low flow periods BOD_5 values as high as 61 mg/l have been found in the middle sector of the river with the average less than 15 in all sectors. During above normal flow and lower water temperatures the river water contains up to 10 or more

IMMEDIATE NEEDS

MUNICIPALITIES & INDUSTRIES
IN
BUFFALO RIVER BASIN

Municipalities

Sewerage Service Area	Present Treatment	1960 Population Served	Plant Needs
East Aurora	Secondary	25,000	Tertiary
Holland	Septic Tanks	950	Collection system & tertiary
Lackawanna	Primary	26,100	Secondary (outfall to Lake Erie
West Seneca SD 6	Primary	6,320	Tertiary (connect to metro system
Cheektowaga SD 3	Secondary	15,200	Tertiary (connect to metro system)
Depew	Primary	13,700	Tertiary (connect to metro system)
Lancaster SD 1	Secondary	3,160	Tertiary (connect to metro system)

Industries

Name	Location	Control Measures Needed
General Mills	Buffalo	Connect to city sewers
Pillsbury	Buffalo	Connect to city sewers
Republic Steel	Buffalo	Oils, solids, color, acid, iron
Donner Hanna Coke	Buffalo	Oil, phenol, BOD
Allied Chemical-Buffalo Chemical Div.	Buffalo	None

IMMEDIATE NEEDS

MUNICIPALITIES & INDUSTRIES
IN
BUFFALO RIVER BASIN
(continued)

Industries

Name	Location	Control Measures Needed
Allied Chemical-Buffalo Dye	Buffalo	Color, solids, BOD, acid, phenol
Mobile Oil	Buffalo	Oils, phenols
Pennsylvania Railroad	West Seneca	Oil
Symington Wayne	Depew	Oil, BOD, color
Malting	Buffalo	Connect to city sewers

Eighteenmile Creek

Eighteenmile Creek generally maintains fair to good water quality except below the Village of Hamburg. The South Branch and the upper main stem above Boston are normally of excellent quality. Moderate to heavy enrichment is apparent throughout the remainder of the main stem.

Above Hamburg moderate enrichment was evidenced by the abundance of attached algae, moderately sensitive species of bottom organisms, and scavengers which indicate a large supply of organic material. The source of this enrichment is most probably from land runoff, the several small treatment plants and the numerous septic tanks in the towns of Boston, Evans, and Hamburg.

Below the point where the Village of Hamburg's treatment plant effluent enters Eighteenmile Creek, the stream is degraded and becomes anaerobic at times during low flow. This plant discharges significant loadings of organic matter and nutrients. Due to the high natural reaeration of the stream as it flows to Lake Erie, it recovers from this loading in about three to four miles, although enrichment is still present at this point. As it enters the lake affected area, the stream appears well recovered from the effects of Hamburg's pollution.

As this area is growing with the expansion of Buffalo, there is a present need for an area-wide plan for the orderly development of treatment facilities. Because of the low flow in these streams, all areas should be combined to treatment works discharging to Lake Erie by 1980.

Cattaraugus Creek

Cattaraugus Creek varies in water quality from excellent to grossly polluted. Figure shows the relative degree of pollution of the various sections along the creek.

As indicated by Figure , the first sources of pollution are near the headwaters. Several industries and the municipal sewage treatment plant, all located in the village of Arcade, discharge their wastes to Cattaraugus Creek. The principal problem is from the Arcade sewage treatment plant which receives domestic wastes from approximately 1,900 people and sewage and industrial wastes from industries, employing approximately 1,000 people. The plant provides secondary treatment; however, the process is affected by the industrial wastes containing cyanides, zinc, copper, and cadmium ions.

Floating solids are present in Cattaraugus Creek in the immediate vicinity of the sewage treatment plant's outfall. Cyanides, cadmium, and copper are present in the creek just below the outfall according to the New York State Health Department. These constituents are toxic to fish and other aquatic life and should be removed by industries before discharging to the municipal sewer system. The Arcade sewage treatment plant is under orders by the New York Health Department to improve their treatment. Being near the headwaters of Cattaraugus Creek creates an additional problem. During the low flow season, there is very little flow in the creek above the sewage treatment plant outfall to dilute the waste discharged. Small loads can, therefore, degrade the water quality of the stream. Due to this condition the Arcade sewage treatment plant should provide advanced waste treatment (tertiary treatment) which should remove 98 percent of the BOD_5 load.

Cattaraugus Creek in its upper reach has an extremely high reaeration rate due to the steep slope and swift flow. This aids in the natural self-purification of the waters. The waters recover to a natural condition as it flows through the Zoar Valley.

Upstream from Gowanda, Cattaraugus Creek is in excellent biological condition. The water is clear with the stream bottom consisting of boulder, cobble, gravel, and sand, except in pooled areas where a little fine silt was deposited. Through the Zoar Valley the stream supported a wide variety of pollution sensitive bottom-dwelling animals. Pollution sensitive species of mayfly nymphs and caddis fly larvae were predominant. Very sparse growths of *Cladophora* were found on rocks, and equally sparse growths of *Elodea*, an aquatic plant, were found in a few locations where a little silt had collected. This portion of the stream is typical of a nutrient-poor, relatively unpolluted stream with a minimum of dissolved and suspended organic material.

As Cattaraugus Creek flows through Gowanda, the water quality changes from the relatively clean natural waters with scenic beauty to a grossly polluted open sewer. Oils, toxic wastes, organic loadings, suspended and dissolved solids, and inadequately treated domestic wastes are poured into the creek in the vicinity of Gowanda.

The Peter Cooper Corporation, and Moench Tanning Co. are the principal sources of these wastes. The Eastern Tanners Division of the Peter Cooper Corporation, manufacturers of glue, discharge a BOD_5 load equivalent to the untreated sewage from 150,000 people. In addition some 65 tons of total solids are discharged daily to Cattaraugus Creek. The Moench Tannery Company discharges a BOD_5 load equivalent to the untreated sewage from 50,000 people. Wastes from both Peter Cooper Corp. and Moench Tannery Co. contain ammonia, grease, and chromium constituents. These two industries provide no more than primary treatment to their wastes. The Moench Tannery Co. does not have sludge removal facilities and periodically dumps the sludge into Cattaraugus Creek. This load is probably equivalent to the untreated wastes of another 30,000 people. These plants should immediately provide advanced treatment to all their wastes and should remove at least 98 percent of the BOD and solids loads. There should be additional facilities for removing the chrome from the discharge to Cattaraugus Creek.

In addition, the sewage treatment plants, the Gowanda State Hospital, and the Village of Gowanda discharge inadequately treated sewage to Cattaraugus Creek. Both plants provide only primary treatment for the 7,200 people served. The plant at the state hospital also receives cannery wastes which increase the organic solids load during the canning season.

Secondary treatment should be an immediate objective of both plants. The estimated population growth for Gowanda is not great, so adequately operated secondary treatment for these two sewage treatment plants should be sufficient through 2020.

Biological investigation of Cattaraugus Creek below all waste discharges from Gowanda indicated that aquatic life was limited to only pollution-tolerant sludgeworms and bloodworms with luxuriant growths of Sphaerotilis (sewage fungus) and the blue-green alga Oscillitoria. The water was cloudy and had a dirty gray color. The odor was septic. Black anaerobic sludge deposits were found and all of the rocks were blackened from the effects of hydrogen sulfide. These septic conditions are caused by the extremely high oxygen demand wastes from the above-mentioned sources.

To add still further to the unsightly conditions, a dumping area is located along the banks of the creek in the village of Gowanda. As can be seen in Figure , everything from garbage to refrigerators are dumped in this area. The dump not only is an eyesore but adds organic and bacterial pollution to the waters as garbage is thrown into the creek. Dumps along stream banks are prohibited by the recommendations set forth by the conferees of the Lake Erie Enforcement Conference,and this dump should be removed immediately.

In the six miles from Gowanda to Versailles, the creek shows only a slight improvement. At Versailles, the biological conditions were typical of an early recovery zone with sludgeworms, bloodworms, and blackfly larvae leeches, the predominant bottom fauna. Sphaerotilis and sludge deposits were still present, although not as abundant as they were downstream from Gowanda.

As Cattaraugus Creek flows through the Cattaraugus Indian Reservation and the community of Irving, the water quality becomes once again degraded.

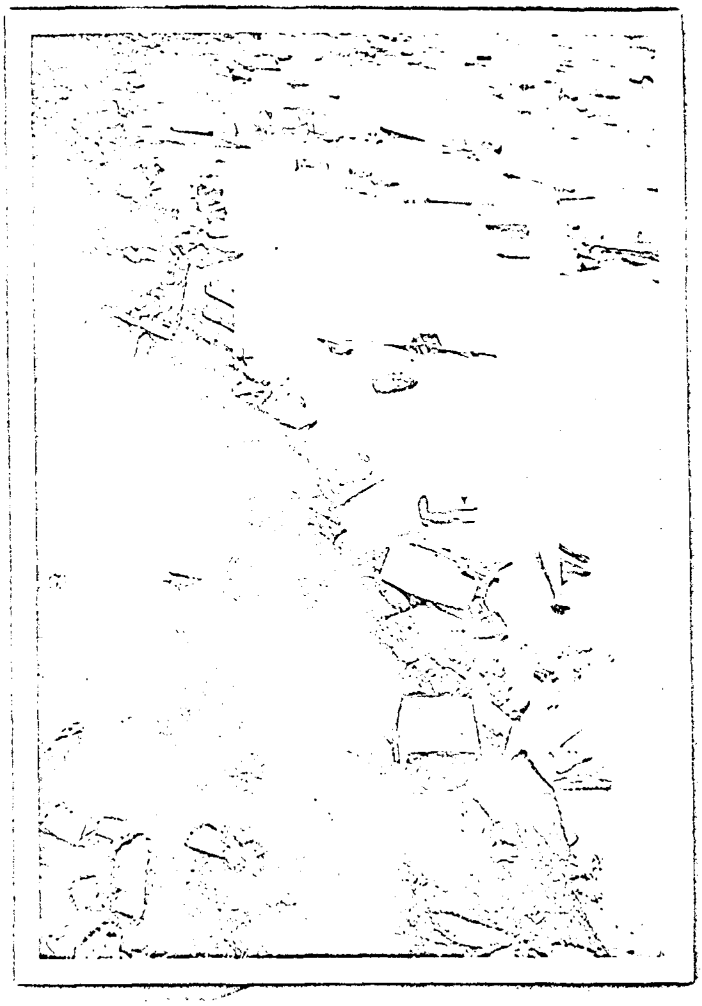
The slope of the stream in this area is much reduced and the velocity is lower. Due to the reduction in velocity, the algae that are carried downstream settle out and start to decompose.

The stream bottom near Irving was sand and gravel where stream flow was moderate; however, in pooled areas extensive sludge deposits were found. Figure shows typical conditions found in this area. The sludge was about two feet deep and anaerobic conditions existed beneath the surface. Methane bubbles were constantly breaking the surface of the overlying water. Stirring the sludge bank released a strong hydrogen sulfide odor.

The Silver Creek Preserving Corp., located in the Cattaraugus Indian Reservation, discharge wastes from its canning process to Cattaraugus Creek. The waste contains string bean particles, some oil slicks, and some discoloration during beet canning season. All this adds further to the obnoxious conditions of Cattaraugus Creek and should be eliminated immediately.

Other Tributaries

Several smaller streams have also been affected by municipal and industrial waste discharges. Due to lower flows, smaller streams are more susceptible to pollutional loads than larger bodies of water. For this reason, no wastes should be discharged to small tributaries, or for that matter to any stream that cannot adequately handle this waste input.



IMMEDIATE NEEDS

MUNICIPALITIES & INDUSTRIES
in
EIGHTEENMILE CREEK & CATTARAUGUS CREEK BASINS

Municipalities

Sewerage Service Area	Present Treatment	1960 Population Served	Plant Needs
Hamburg (V)	Secondary	6,280	Tertiary or connect to metro system
Eden	Septic Tanks	2,370	Collection system & tertiary
Gowanda State Hospital	Primary	3,900	Secondary
Gowanda	Primary	3,352	Secondary
Cattaraugus	Septic Tanks	1,000	Collection system, secondary treatment
Springville	Primary	3,200	Secondary & cyanides, cadmium, copper, zinc
Arcade	Secondary	1,900	Tertiary or [illegible]

Industries

Name	Location	Control Measures Needed
Silver Creek Preserving	Cattaraugus Indian Reservation	Solids, colors, oils
Moench Tannery	Gowanda	Tertiary & ammonia, grease, chrome
Peter Cooper-Eastern Tanners Div.	Gowanda	Tertiary & ammonia, grease, chrome

Blasdell and Smoke Creeks

Blasdell Creek, also known as South Ditch, is a small stream which would normally be dry most of the year. Bethlehem Steel plant wastes entering at various points of the section, extending about one mile upstream of its mouth, maintains a considerable flow in this sector. At its mouth it is essentially a Bethlehem Steel waste outfall entering Lake Erie. In addition to other materials it continually discharges much oil to the lake. During winter periods the ice holds much of the oil near the mouth. The oil is suddenly released when the ice moves out and is most probably one of the major causes of the slug discharges of oil down the Niagara River which occurs each spring.

Smoke Creek extends through an urban type area throughout most of its length. Visual and other evidence show that the water in the south branch at its junction with the north branch is markedly degraded by organic wastes entering upstream. It contains considerable fatty matter of the type normally present in sanitary wastes, indicating the probability that septic tank effluent or other sanitary wastes are entering upstream of the junction. The north branch appears to be somewhat polluted. The one mile length of the stream from the junction of the branches to the mouth on Lake Erie receives industrial waste discharges. The South Buffalo Railway shops may contribute some oil, but this has not been definitely established. The Buffalo Brake Beam Company discharges a very small quantity of oil and sanitary wastes to the stream. They have been requested to connect their discharge to the sanitary sewers.

The principal flow at the mouth of Smoke Creek is Bethlehem Steel's wastes. It also contains approximately 1.1 mgd of Lackawanna sewage treatment plant effluent. In addition to other materials the Bethlehem Steel plant contributes considerable quantities of heavy oil to these waters.

The combined effect of the Blasdell and Smoke Creek discharges create an oil film and red discoloration of approximately two square miles of Lake Erie. The continuing oil discharge from Bethlehem is believed to be one of the principal if not the major source of oils causing damage to certain water uses of the Niagara River. The 350 mgd of Bethlehem Steel wastes entering these waters contain 380,000 pounds of suspended solids, 280,000 pounds of iron, 31,000 pounds of oil, 680 pounds of phenol, and 950 pounds of cyanide. Quantities of this magnitude would be expected to create the conditions described above.

The Bethleh em Steel Company is presently under orders from the New York State Health Department to remove an appreciable amount of their waste products. The most significant constituant in their outfalls is the large qu antity of oil and a major effort should be exerted to removing this material so that no problem remains. A continuing program will need to be extended into the future by Bethlehem to alleviate the problems caused by their waste discharges.

Rush Creek

Coliform counts exceeding 150,000 per 100 milliliters are present in the water approximately one mile upstream from the mouth and above the Basdell sewage treatment plant show the effect of septic tank or other sanitary waste discharges above that point. These wastes do not normally depress the dissolved oxygen content below 5.0 mg/l at this point. A storm water by-pass of a Hamburg sewage pumping station discharges to an upstream point of the stream. It is reported that unnecessary by-passing in the past has crested serious pollution of the creek, but more carefully controlled operation now limits by-passing to periods of very heavy rainfall and resultant higher creek flow.

In additon to the Blasdell sewage treatment plant one mile above the mouth the Woodlawn treatment plant effluent enters the stream about one fourth mile above the mouth. Some relatively old data (1952) showed no dissolved oxygen present near the mouth. Although more recent data are not available it is probable that dissolved oxygen may be completely absent at times. Although this is a very small stream it is reported that water for irrigation is being taken from upstream sectors of the creek. This significantly depletes the already limited flow in the stream.

Present treatment on this stream should be expanded so that all wastes receive 90-95 percent BOD_5 removal. By 1980 all wastes should be connected to treatment works discharging directly to the lake.

Canadaway Creek

Another example of overload of a small stream is Canadaway Creek which receives the effluent of the Fredonia sewage treatment plant which provides treatment for approximately 8,500 people. A cannery is also connected to the sewage treatment plant. During the low flow season, the flow in the creek near Fredonia is comprised almost entirely of the effluent from the Fredonia plant. Secondary treatment is provided but it is not sufficient during the canning season to maintain desirable water quality in Canadaway Creek. Biological investigation in August 1966 indicated the effluent from the Fredonia plant is grossly polluting the creek which never completely recovers as it flows to Lake Erie

Luxuriant growths of Sphaerotilis, sewage fungus, was observed for one mile downstream from the outfall and Oscillatoria, a pollution tolerant algae appeared as a blue-green mat covering the stream bottom (see Figure). No benthic fauna could be found in the creek at the outfall and approximately a half-mile downstream the only bottom organisms present were pollution tolerant sludgeworms and Physa (air-breathing snails). Phytoplankton counts increased tremendously in this area and the type definitely indicated an increase in nutrients. The average count above the STP was about 1,000 organisms per ml while the counts below were approximately 10,000 per ml.

In order to maintain a desirable water quality in Canadaway Creek the Fredonia sewage treatment plant should either provide tertiary treatment (98 percent BOD_5 removal) or preferably remove their waste discharge from Canadaway Creek and discharge directly to Lake Erie through a combined metropolitan plant serving both Fredonia and Dunkirk.

Direct Discharge to Lake Erie

The Dunkirk sewage treatment plant discharges approximately pounds of BOD_5 daily directly into the lake. Dunkirk provides only primary treatment which removes only percent of the BOD_5 load it receives.

Dunkirk has had great difficulty with algae in the past. Storms break algae loose and they are washed onto the beaches of the area where they decompose, producing a foul odor. Since the harbor is shallow and turbidity is quite low, rooted aquatic weeds and algae grow abundantly in the littoral zone. Even in depths of fifteen feet or more outside the breakwater Cladophora grows quite well. In the shallow areas rooted aquatic weeds reach the surface in two to four feet of water and make boating almost impossible.

Another problem encountered in Dunkirk is that of flyash from the Niagara-Mohawk plant. In the past The flyash ~~is~~ was spread as a landfill behind the plant and is washed into the harbor during winds and rains. In sections of the harbor, flyash deposits were found to be at least two feet deep. This is an inorganic sediment and exerts little BOD. The main objection is that the flyash fills the harbor and reduces its depth for navigation. **This problem has been reported to be alleviated.**

As mentioned earlier, grape orchards are a large land use in the the Western New York area. Associated with the grape orchards are grape processing industries located in Westfield and Brocton. The discharges of these wastes have caused water quality problems in Chautauqua Creek as it flows through Westfield and Slippery Rock Creek, as it flows through Brocton.

Welch Grape Juice Co. Inc., discharges pressing and process wastes and storage tank wash waters at Brocton and Westfield. Seneca Westfield Maid, Inc. and Growers Cooperative Grape Juice Co. discharge similar wastes in Westfield. These wastes contain high oxygen demanding solids which cause turbidity and sludge deposits in their receiving waters.

A survey of the New York State Health Department in 19___ revealed a large increase in coliform concentration in Chautauqua Creek as it flows through Westfield. Their samples show that the most probable number (MPN) is parts per million (ppm) increased from 700 at the South Gale Street Bridge (approximately three stream miles from Lake Erie) to 100,000 at the Hawley Street Bridge (approximately one stream mile from Lake Erie). They stated this high coliform concentration was due possibly to the waste discharged from Welch Grape Juice Co. and Growers

Cooperative Grape Juice Co. Inc. in Westfield.

Welch Grape Juice Co. also creates esthetic problems in Slippery Rock Creek. The creek is turned a purple to black color and produces odors. The effects of this discharge can be seen for more than a mile.

Walnut Creek and Silver Creek are polluted by raw sewage discharged from Forestville and Silver Creek and by wastes discharged by the Silver Creek Preserving Company. This pollution renders the area unsuitable for any water contact sports. As conditions stand, this area is a virtual septic tank.

The village of Silver Creek is presently building a secondary treatment plant which should be in operation by the summer of 1967.

Interstate Waters

There is only one stream, Twentymile Creek, that is classified as an interstate stream. The stream originates in Chautauqua County, New York and flows for approximately 8 miles draining 35 square miles in New York. It crosses into Pennsylvania approximately 3 miles south of Lake Erie and drains another two square miles in Pennsylvania as it flows to Lake Erie.

Twentymile Creek doesn't receive any major pollution loads in New York or Pennsylvania and creates no interstate water quality problems. Chemical data show the stream to be of excellent water quality as it crosses the Pennsylvania-New York line ($BOD_5 < 1$ and D.O. at saturation, total solids < 100).

IMMEDIATE NEEDS
FOR
MUNICIPALITIES & INDUSTRIES
DIRECT TO LAKE ERIE & SMALL TRIBUTARIES

Municipalities

Sewerage Service Area	Present Treatment	1960 Population Served	Plant Needs
Ripley	Primary	1,250	Tertiary*
Westfield	Secondary	3,800	Tertiary*
Brocton	Septic Tanks	1,420	Collection system & Tertiary*
Dunkirk	Primary	18,800	Secondary (connect to metropolitan system)
Fredonia	Secondary	8,500	Tertiary or connect to metro system
Silver Creek	Septic Tanks	3,000	Collection system & Secondary**
Angola	Septic Tanks	1,000	Collection system & Tertiary
North Collins	Secondary	2,000	Tertiary
Derby	Septic Tanks	2,500	Collection system & Tertiary*
Hamburg SD 1 (Woodlawn)	Secondary	1,900	Tertiary or connect to metropolitan system
Hamburg SD 2 (Mt. Vernon)	Primary	1,750	Secondary (connect to metropolitan system)
Hamburg (Wanakah)	Primary	1,400	Secondary (connect to metropolitan system)
Hamburg (Master)	Primary	2,500	Secondary (connect to metropolitan system)
Blasdell	Secondary	23,000	Tertiary or connect to metropolitan system

IMMEDIATE NEEDS
FOR
MUNICIPALITIES & INDUSTRIES
DIRECT TO LAKE ERIE & SMALL TRIBUTARIES
(Continued)

Industries

Name	Location	Control Measures Needed
Welch Grape Juice	Westfield	Connect to city sewer system
Seneca Westfield Maid	Westfield	Connect to city sewer system
Growers Coop. Grape Juice	Westfield	Connect to city sewer system
Welch Grape Juice	Brocton	Connect to city sewer system
Allegheny Ludlum Steel	Dunkirk	Solids, oils, acids
Niagara-Mohawk Power	Dunkirk	Solids
Pro-Canner's Coop.	North Collins	Connect to city sewer system
Gro-Packer's Coop.	North Collins	Connect to city sewer system
Bethlehem Steel	Lackawanna	Oil, phenol, solids, color, cyanides, ammonia, acid, iron
Hanna Furnace	Buffalo	Solids

* = or secondary treatment with discharge to Lake Erie
** = secondary treatment plant construction near completion, should be placed into operation summer 1967.

Bathing Beaches

The beaches along the Lake Erie shoreline in New York are of good water quality during dry weather. Figure   is a summary of coliform concentrations found in tests run by the Erie County Health Department. Individual data showed that generally the concentrations were under 500 organisms/100 ml; however, concentrations over 1,000 organisms/100 ml were quite frequent. These high concentrations were found to be associated with the meteorological conditions.

During and immediately after summer storms these beaches become unsafe for swimming due to the health hazard indicated by the increase of coliform concentrations. Rains and winds bring high pollution loads to the beaches from nearby streams and storm water overflows.

In the findings of its beach survey, the Erie County Health Department has attributed wind as the probable major meteorological factor in pollution of Miller's Beach, Evangola State Park, and Evans Town Park. The winds help keep the pollution from Cattaraugus Creek near the shore. Evans Town Park also receives pollution from the large unsewered population in the immediate area.

The beach with the most serious problem is that of Hamburg Town Park. Several storm sewer overflows are located near this beach with one overflow immediately adjacent to it. This beach has been closed by the Erie County Health Department.

Other beaches in Chautauqua County also have serious problems but a lack of data prohibits any comparison of the problems. A study conducted by the Federal government in 1964 indicated polluted conditions on the two beaches in Dunkirk. Pollution entered these beaches from raw sewage discharges from some small rural towns, inadequately treated sewage discharged to Canadaway Creek from the Fredonia sewage treatment plant, inadequately treated sewage from the Dunkirk sewage treatment plant, and combined sewer overflows from both Dunkirk and Fredonia, both of which are partially served by combined sewers.

Loadings to Lake Erie

Most waste discharges in the New York Area are to tributaries rather than direct to Lake Erie. Table shows the total present and projected loads discharged by municipalities and industries in the New York Area.

TABLE

LOADINGS TO LAKE ERIE
(lbs/day)

	1965	1990	2020
Total Solids			
A	1,500,000	2,300,000	3,000,000
B		340,000	450,000
C		100,000	140,000
Dissolved Solids			
A	1,000,000	1,600,000	2,100,000
B		200,000	270,000
C		60,000	90,000
Chlorides			
A	624,000	900,000	1,300,000
B		90,000	130,000
C		27,000	39,000
BOD			
A	127,000	240,000	320,000
B		40,000	60,000
C		12,000	18,000
Soluble Phosphate			
A	6,100	10,000	14,000
B		1,100	1,500
C		600	800

A = Loadings @ present level of treatment
B = Loadings @ 90% removal (secondary treatment)
C = Loadings @ 97% removal (tertiary treatment)

mg/l of dissolved oxygen, but it is completely devoid of oxygen during low flow and warm water temperatures. Except during flood flow it contains relatively little suspended solids as most of the considerable amount of these solids from land erosion and municipal and industrial wastes settle rather rapidly to the bottom of the dredged section. The following data collected by an automatic monitor at the Ohio Street Bridge location are fairly typical of much of the chemical analytical data that have been collected on the stream. During a low flow period from October 4 to November 1, 1965, the dissolved oxygen concentration ranged from a minimum of 0 to a maximum of 2.9 mg/l, pH from 5.3 to 7.6, conductivity from 1,900 to 2,400, chlorides from 150 to 345 and temperature from 15.0 to 19.8 degrees centigrade. During a period of higher flow from March 10 to April 27, 1966, the dissolved oxygen ranged from 9.4 to 12.4 mg/l, pH from 5.5 to 7.6, conductivity from 240 to 650, chlorides from 7 to 76 and temperature from 2.6 to 16 degrees centigrade.

The Buffalo River also markedly harms the residential area on each side of that sector of Cazenovia Creek extending 0.7 miles upstream of its mouth which is affected by Buffalo River backwater. Residents of this area complain vociferously each summer about the disagreeable odors emanating from the stream and the heavy oil films present.

It is apparent from the information presented above that during the six month or more period of lower flows each year the Buffalo River water is concentrated industrial and other wastes. It is not surprising that the quality is extremely poor even though all the major industries have and are spending considerable monies to provide waste treatment or otherwise reduce the polluting constituents in their discharges. They have generally made a conscientious effort to comply with the requirements of the Pollution Control agencies. An example, at one time it was believed that reduction of the oil concentration in the industrial effluents to 15 mg/l would be adequate. The Mobil Refinery has reduced theirs to below 10, but these oils as they accumulate create a major problem. Restoring the river to a reasonably satisfactory condition will require extreme measures.

One forward step has just recently been accomplished. The five major industries on the Buffalo River have recently placed in operation a water supply system which has cost over $9,000,000. This system pumps Lake Erie water to the industries for their use and eventual discharge to the Buffalo River which will provide greater flow in the lower sector. The industries have committed themselves to discharge a minimum of 100,000,000 gallons of water per day to the stream during low natural flow whether or not they require the total quantity for their operations.

Many other corrective measures are needed. The oil films will be eliminated only if essentially no oil, fats or grease are permitted to reach the stream. This will require practically complete removal of these constituents from any industrial, sanitary, storm water overflows permitted to enter the river or its tributaries. This includes such small discharges as septic tank effluents. Probably the most easily accomplished would be the removal from municipal wastes as effective secondary treatment may adequately reduce the oils and fats in the effluent. Storm water overflows will need to be eliminated or otherwise effectively treated. The maximum reduction, almost to the point of elimination, of other polluting constituents in wastes in any water entering the river are needed.

The need for these extreme measures are obvious wh en one recognizes that much of the time the wastes constitute more than 90 percent of the water in the river and its quality is no better than the quality of the mixed wastes. A goal of water quality suitable for boating and fishing in the dredged section and swimming in the upstream portions may be difficult to attain, but our sights should be set this high.