STATEMENT ON

WATER POLLUTION IN THE LAKE ERIE BASIN

Prepared for the Natural Resources and Power Subcommittee of the House Committee on Government Operations.

U. S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Great Lakes-Illinois River Basins Project
Lake Erie Program Office

Cleveland, Ohio

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PREFACE

This statement by the Department of the Interior on water pollution in the Lake Erie Basin summarizes the principal problems within the Lake proper and the contributions to those problems by the various tributaries and direct discharges to the Lake.

Recommendations for remedial action, as agreed upon by the various states concerned and the Federal Government are contained herein. The recommendations, when fully implemented, should improve and maintain the quality of Lake Erie water at a level adequate for all legitimate uses. Implementation requires the full cooperation and coordination of water pollution control agencies at all levels of government.

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CHAPTER 1 - INTRODUCTION

AUTHORITY

Comprehensive water pollution control studies were authorized by the Federal Water Pollution Control Act of 1956, as amended (33 USC 466 et seq.). Initiation of the Great Lakes-Illinois River Comprehensive Program Activity followed an appropriation of funds by the 86th Congress late in 1960. In accordance with the provisions of the Act, the Secretary of Health, Education, and Welfare delegated the responsibility for the study to the Division of Water Supply and Pollution Control of the Public Health Service. Passage of the "Water Quality Act of 1965" gave the responsibility for these studies to the Federal Water Pollution Control Administration (FWPCA). As a result of Reorganization Plan No. 2 of 1966, the FWPCA was transferred from the Department of Health, Education, and Welfare to the Department of the Interior effective May 10, 1966.

PURPOSE

This document discusses the quality characteristics of the waters of Lake Erie and its tributaries as they exist today and some of the trends in recent years. It evaluates the effect of waste discharges on water uses, summarizing the principal problems and recommended corrections.

SCOPE

The area covered by this report includes the waters of Lake Erie proper and the tributary basins in Indiana, Ohio, and Pennsylvania. Detailed descriptions of Michigan and New York tributaries have been the subjects of separate reports and are not discussed except in very general terms.

ORGANIZATION

After initial funds for the Great Lakes study were appropriated by Congress in 1960, the overall Great Lakes-Illinois River Basin Project, and eventually separate Basin Program Offices were established. The Lake Erie Program Office at Cleveland, Ohio was opened in October 1962 to begin the Lake Erie portion of the Great Lakes study. The Lake Erie Program Office is now located at 21929 Lorain Road, Cleveland, Ohio. Its permanent staff includes specialists in several professional skills, including sanitary and hydraulic engineers, chemists, biologists, bacteriologists, and oceanographers. The Program has drawn freely on the resources of the Robert A. Taft Sanitary Engineering Center at Cincinnati, Ohio and the Communicable Disease Center at Atlanta, Georgia. Additional assistance and guidance in many fields have been obtained from the Great Lakes-Illinois River Basin Project in Chicago.

ACKNOWLEDGMENTS

The statement is based on studies made over the past three years by the Lake Erie Program Office. 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:
- State Water Resources Commission
- Department of Health

Indiana:
- State Board of Health
- Stream Pollution Control Board

Ohio:
- Water Pollution Control Board
- Department of Health
- Department of Natural Resources

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

CHAPTER 2 - SUMMARY

Lake Erie and its tributaries are polluted. The main body of the Lake is deteriorating in quality at a rate greater than that of normal aging due to inputs of pollution resulting from the activities of man.

Pollutants which damage water uses in Lake Erie are sewage and industrial wastes, oils, silts, sediments, floating solids, and nutrients (phosphates and nitrates). They cause significant damage to recreation, commercial fishing, sport fishing, navigation, water supply, and esthetic values.

Eutrophication, or over-fertilization, of Lake Erie and the Maumee River is of major concern. Problems from algal growths stimulated by nutrients are occurring along the Lake shoreline and at some water intakes. Algal growths can be controlled. Eutrophication of Lake Erie may be retarded and perhaps even reversed by reducing one or more nutrients to below the level required for extensive growth.

Soluble phosphate is the one nutrient most amenable to reduction or exclusion from Lake Erie and its tributaries. Present technology is capable of removing a high percentage of soluble phosphates from sewage at a reasonable cost.

More than three-fourths of the soluble phosphates reaching Lake Erie are from municipal waste discharges. (Municipal discharges include some industrial wastes which are routed through municipal facilities.) Secondary sewage treatment plants, if properly designed and operated, will remove a significantly greater amount of phosphorus compounds that primary treatment plants can remove.

Discharges of municipal and industrial wastes originating in Michigan, Indiana, Ohio, Pennsylvania, and New York are endangering the health or welfare of persons in states other than those in which such discharges originate. This pollution is subject to abatement under the Federal Water Pollution Control Act.

The Maumee, Sandusky, Black, Rocky, and Cuyahoga Rivers and their tributaries, all of which are tributary to Lake Erie in Ohio, are grossly polluted. This pollution is caused by refuse, sewage, and sludge which result in low dissolved oxygen, algal growths, bacterial contamination, and odors. Other pollutants found in significant areas of Lake Erie tributaries are oil, silt, and sediment. Specifically, phenols and nitrogenous compounds cause taste and odor problems in municipal water supplies. Pollution interferes with water uses for municipal and industrial supply, recreation, fishing, and esthetic enjoyment.

Lake Erie and its tributary streams in the Pennsylvania Basin are polluted by discharges of municipal and industrial wastes, combined sewer overflows, accidental spills from vessels and industries, wastes from Lake vessels, and land drainage. This pollution has caused taste and odor problems in domestic water supplies, bacterial contamination of bathing beaches, fish kills, and algal growths. In addition, wastes which cause the receiving waters to foam, turn blackish-brown, and have a foul odor have interfered with recreation and esthetic enjoyment.

Lake Erie and its tributary streams in the western New York Basin and the Erie-Niagara Basin in New York are polluted by municipal and industrial wastes. Discharges of these wastes cause interferences with municipal and industrial supplies, recreation, fish and aquatic life. In addition, these wastes cause discoloration of the receiving waters, foul odors, and algal growths.

CHAPTER 3 - LAKE ERIE

DESCRIPTION OF AREA

General Description

Lake Erie is the oldest, southernmost, and warmest of the Great Lakes. It is by far the shallowest, and the only one with its entire water mass lying above sea level. Lake Erie contains the smallest volume of water; it is the most turbid; it is subject to the widest fluctuations in water level; it has the flattest bottom; and it undergoes the most violent wave activity. It is also the most studied and probably the least understood. At least in recent years, it apparently has changed the most rapidly in its chemistry and biology.

Lake Erie (Figure 3-1) is approximately 240 miles long with its long axis oriented at about N 70° E. It is more than 50 miles wide near the mid-point of its long axis. The lake covers an area of 9,940 square miles, and contains a total water volume of approximately 113 cubic miles.

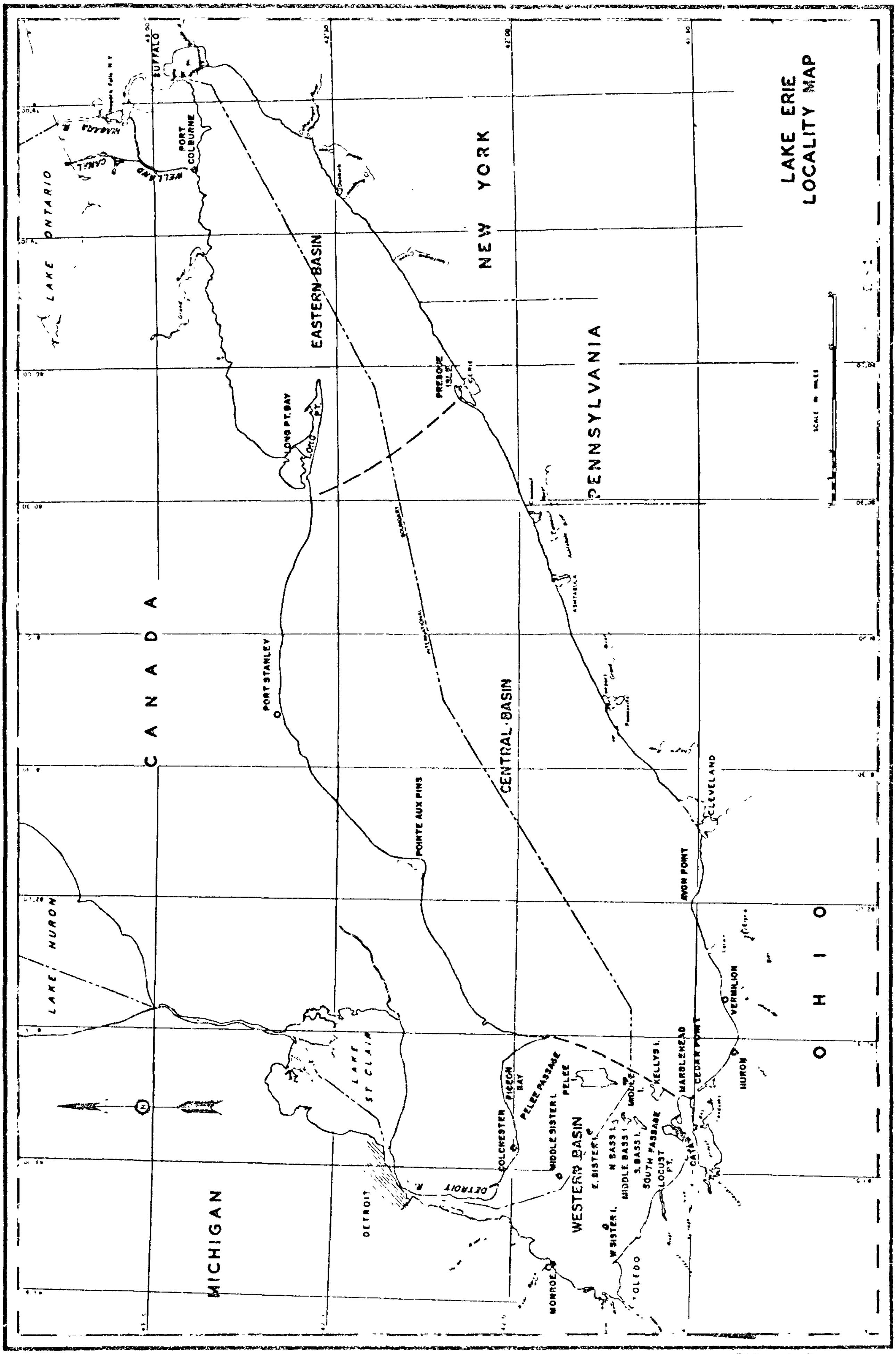
Figure 3-2 shows the topography of the Lake Erie bottom, with a 20-foot contour interval, as interpreted from U. S. Lake Survey charts and soundings made by the Ohio Division of Geological Survey.

Topographically, Lake Erie is separated into three basins. The relatively small shallow western basin is separated from the large, somewhat deeper, flat-bottomed central basin by a rocky island chain. The relatively deep, bowl-shaped eastern basin is separated from the central basin by a low, wide sand and gravel ridge near Erie,Pennsylvania. The average depth of the western basin is 24 feet, the central basin, 60 feet, and the eastern basin, 80 feet.

In general, the water in the western basin is the most turbid. It is much less turbid in the central basin and is usually very clear in the eastern basin.

Hydrology

Precipitation on the lake surface is a direct contribution to its water supply and the lake level is affected immediately. Overwater precipitation measurements are lacking; thus perimeter weather station data must be transposed to the lake area. Average annual precipitation over the lake has been estimated at 34.6 inches.



LAKE ERIE
LOCALITY MAP
CANADA
NEW YORK
PENNSYLVANIA
OHIO
MICHIGAN
LAKE ONTARIO
LAKE HURON
LAKE ST CLAIR
EASTERN BASIN
CENTRAL BASIN
WESTERN BASIN
BUFFALO
PORT COLBURNE
WELLAND CANAL
NIAGARA R
LONG PT. BAY
LONG PT.
PRESQUE ISLE
ERIE
ASHTABULA
PORT STANLEY
POINTE AUX PINS
INTERNATIONAL BOUNDARY
CLEVELAND
AVON POINT
VERMILION
HURON
CEDAR POINT
MARBLEHEAD
KELLYS I.
PELEE I.
MIDDLE I.
PIGEON BAY
PELEE PASSAGE
COLCHESTER
MIDDLE SISTER I.
E. SISTER I.
N BASS I.
MIDDLE BASS I.
S. BASS I.
SOUTH PASSAGE
LOCUST PT.
W SISTER I.
DETROIT R.
DETROIT
MONROE
TOLEDO
SCALE IN MILES

FIGURE 3-1

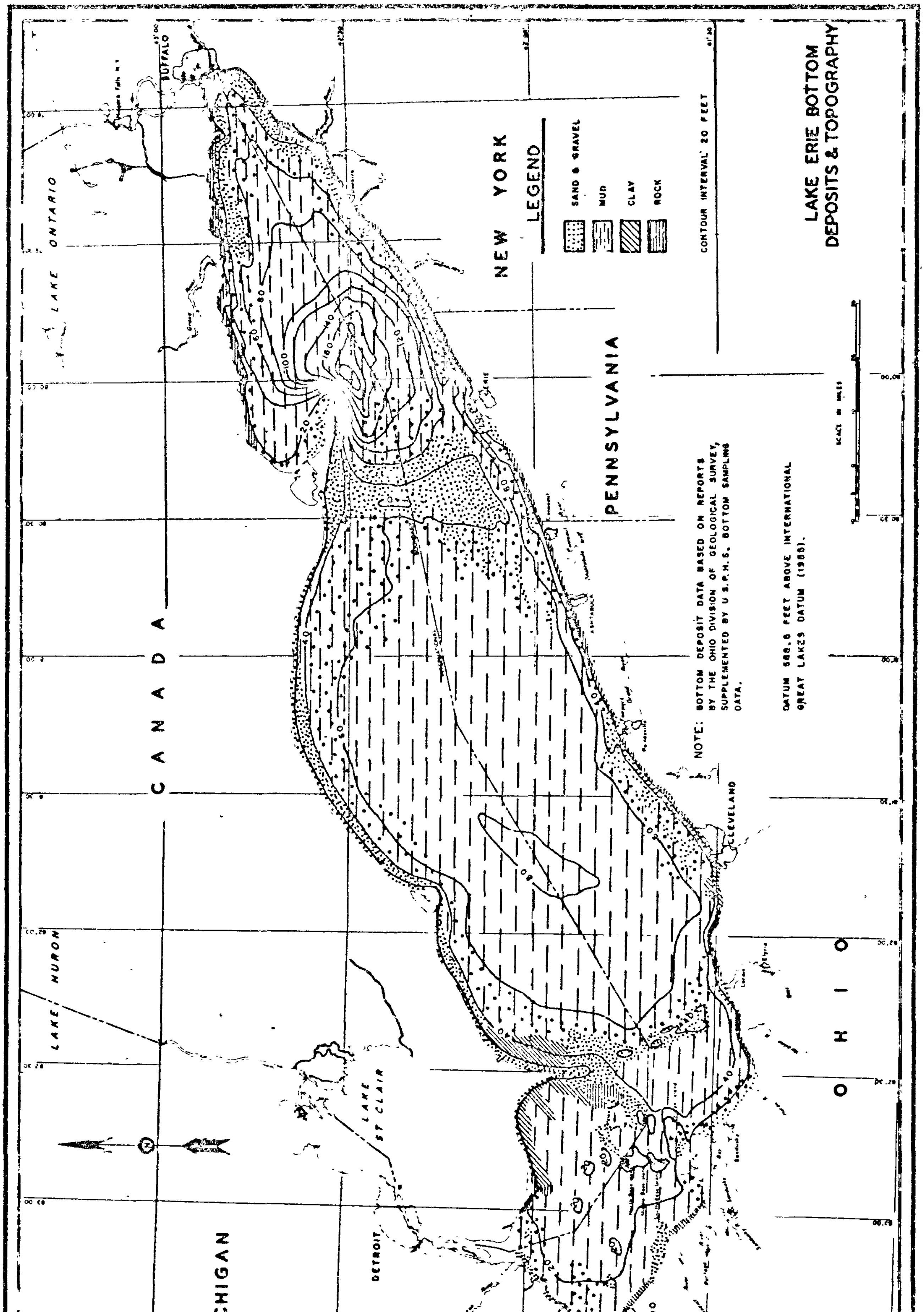

LAKE ERIE BOTTOM
DEPOSITS & TOPOGRAPHY
LEGEND
SAND & GRAVEL
MUD
CLAY
ROCK
CONTOUR INTERVAL 20 FEET
NOTE: BOTTOM DEPOSIT DATA BASED ON REPORTS BY THE OHIO DIVISION OF GEOLOGICAL SURVEY, SUPPLEMENTED BY U.S.P.H.S. BOTTOM SAMPLING DATA.
DATUM 568.6 FEET ABOVE INTERNATIONAL GREAT LAKES DATUM (1955).
NEW YORK
PENNSYLVANIA
OHIO
CANADA
MICHIGAN
LAKE ONTARIO
LAKE HURON
LAKE ST CLAIR
BUFFALO
ERIE
CLEVELAND
TOLEDO
DETROIT

FIGURE 3-2

Surface runoff from the drainage area enters the lake via the many tributary rivers or by direct runoff from the shore areas. Average annual runoff since 1937 has been estimated at 21,000 cubic feet per second (cfs), equivalent to 29.1 inches of water over the lake's surface, and corresponding to 35 percent of the overland precipitation.

About 90 percent of the total inflow to Lake Erie comes from the Detroit River, the drainage outlet for Lake Huron. The average annual inflow, as measured by the U. S. Lake Survey near the head of the Detroit River is 182,000 cfs, equivalent to 251.1 inches of water on Lake Erie.

The outflow from Lake Erie is through the Niagara River at Buffalo and the Welland Canal diversion at Port Colborne. Combined outflow averages about 202,000 cfs annually. Seasonally, both inflow and outflow are generally higher in the early summer and lower in the winter.

Evaporation from the lake surface is controlled by climatological conditions, and it is difficult to assess with confidence. According to one estimate, it averages annually 33.5 inches. The minimum average monthly evaporation occurs in April when the air-water temperature difference is small and the water temperature rises sharply, absorbing heat from the atmosphere. In September, when the water temperature decreases sharply, dissipating heat into the atmosphere, the maximum average monthly evaporation occurs. The low evaporation season extends from January through June, and the high evaporation season is from July through December.

The variations of lake level on an annual basis are small, though on a monthly basis they may be relatively large. The average annual change in lake storage in the period 1937-1959 has been insignificant and it is therefore unimportant in the computations of an average annual water budget.

<u>Lake Currents</u>

The net movement of water in Lake Erie is from west to east, draining into Lake Ontario via the Niagara River. Figure 3-3 shows the generalized flow pattern within the upper 30 feet.

About 90 percent of the input to Lake Erie is from the Detroit River. Most of this flow comes down the center of the river, fanning out and continuing far southward into the western basin. The flow along the west side of the river continues along the Michigan shore to mix with the Maumee River discharge. This flow then continues eastward along the Ohio shore. The flow along the east side of the Detroit River appears to move eastward along the Canadian shore, The western basin water mixes in the island area, and most of it then drains into the central basin via Pelee Passage. Apparently, a dominant flow toward the west exists in the southern channels, creating a rotary movement in the island area.

The drainage from Pelee Passage appears to reach as far south as the Ohio shore, at least at the surface. Much of the flow must, however, turn eastward before reaching that far south, as shown in Figure 3-3.

The predominant eastward flow in the central and eastern basin is reinforced by prevailing winds from the southwest. However, wind studies for a 10-year period for Lake Erie indicate that the reversed pattern of flow may occur nearly 25 percent of the time.

Discharges from tributary streams along the south shore such as the Huron, Vermilion, Black, and Cuyahoga Rivers, and other streams to the east in Ohio, Pennsylvania, and New York tend to stay along the south shore and move normally eastward with an alternate, but smaller secondary flow to the west. General dispersal of the flows from the south shore streams with the deeper off-shore waters is limited.

The discharge of wastes and the tributary streams along the south shore of the lake will contribute to the pollution of beaches and other water uses as it moves along the shore, both from Ohio waters into Pennsylvania and to a lesser extent from Pennsylvania to Ohio. This along-shore flow will also apply to the movement of tributary streams and wastes from Pennsylvania to New York and to a lesser degree from New York to Pennsylvania.

Deep water or mid-lake circulation is complex in the central and eastern basins, being controlled to a great degree by the wind. The wind induces surface flow in its general direction accompanied by an opposing subsurface flow into the wind. Since south-west winds prevail, the surface flow is dominantly toward the east and the subsurface flow is dominantly toward the west over most of the central and eastern basins. A wide band along the Canadian shore, as wide as about 1/3 of the lake's width, moves predominantly eastward from top to bottom.

It is apparent that discharges anywhere along the shores of Lake Erie can affect water quality in Lake Erie, with the dominant effect occurring from west to east.

Population

The 1960 census shows that approximately 10 million persons live in the U. S. portion and 1.2 million persons live in the

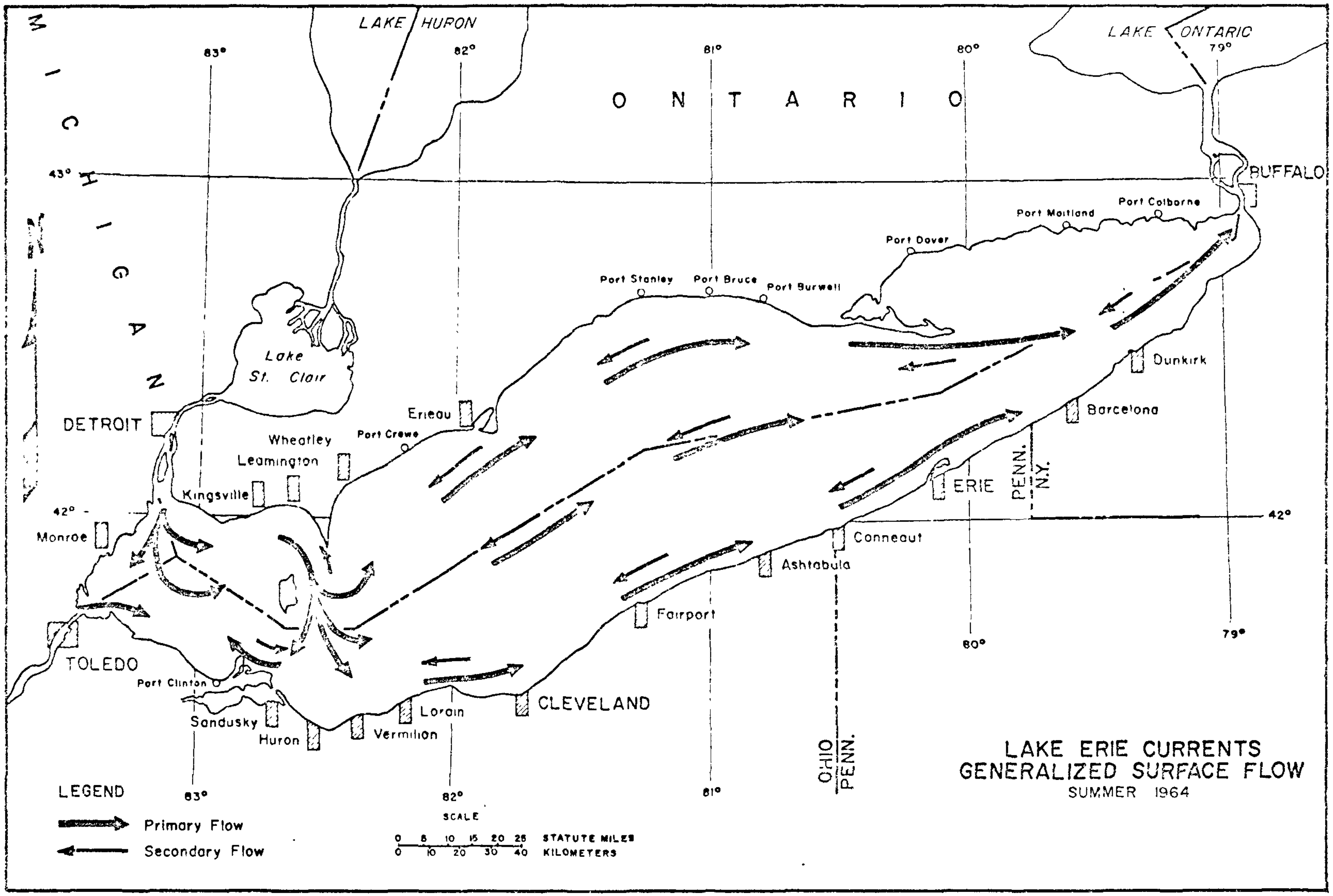

LAKE ERIE CURRENTS
GENERALIZED SURFACE FLOW
SUMMER 1964
LEGEND
Primary Flow
Secondary Flow
SCALE
0 5 10 15 20 25 STATUTE MILES
0 10 20 30 40 KILOMETERS
LAKE HURON
LAKE ONTARIO
ONTARIO
MICHIGAN
Lake St. Clair
DETROIT
Monroe
TOLEDO
Port Clinton
Sandusky
Huron
Vermilion
Lorain
CLEVELAND
Fairport
Ashtabula
Conneaut
ERIE
Barcelona
Dunkirk
BUFFALO
Kingsville
Leamington
Wheatley
Port Crewe
Erieau
Port Stanley
Port Bruce
Port Burwell
Port Dover
Port Maitland
Port Colborne
OHIO
PENN.
N.Y.
83°
82°
81°
80°
79°
43°
42°

FIGURE 3-3

Canadian portion of the Lake Erie Basin. This is almost three times the 1910 population. Population of the U. S. Portion of the Basin is expected to double within the next 50 years. By the year 2020, the total population of the U. S. portion of the Basin is expected to exceed 23 million. Although this overall rate of growth is comparable to the estimated national growth rate, past and estimated future growth rates show great differences within the watershed. Between 1940 and 1960 many economic subregions and the counties which comprise them have shown rapid growth rates. Almost 80 percent of the population is evenly divided between Michigan and Ohio.

Counties which have shown the most rapid growth rates during the 1950-1960 decade include Macomb and Oakland Counties in Michigan, and Lake and Geauga Counties in Ohio. In terms of actual numbers, however, the largest increases were in Oakland, Macomb, and Wayne Counties in Michigan; Allen County in Indiana; Erie County in New York; and Cuyahoga, Summit, Lorain, and Lucas Counties in Ohio. These nine counties of the total of 45 in the Basin accounted for 50 percent of the 1950-1960 increase in population. Present indications are that these large metropolitan counties will account for an even greater share of the total population of the Basin in the future.

Economics

Industrial activity as measured by Value Added by Manufacture, although occurring in substantial volume in most counties, is for the most part highly concentrated in a few metropolitan areas. The leading counties in 1958 were: Wayne, Michigan; Cuyahoga, Ohio; Erie, New York; Summit, Ohio; Lucas, Ohio; and Oakland and Macomb in Michigan, in the order listed. These seven counties in 1958 accounted for 75 percent of the total Value Added by Manfacture in the entire watershed. Manufacturing is even more concentrated in a small group of counties than is the population. Whereas the total population of the watershed will more than double by the year 2020, industrial activity may increase six- or seven-fold.

The dominant industries in the largest metropolitan areas in this highly industrialized region are as follows:

Detroit
Automotive and related industry, steel, chemicals, pulp and paper, petroleum refining, and rubber.

Toledo
Automotive, glass, petroleum refining, and steel.

Cleveland
Steel, steel fabricating, automotive, and chemical.

Erie
Pulp and paper, and general manufacturing.

Buffalo
Steel, chemical, automotive, pulp and paper, Portland cement, flour milling, and electrical equipment.

IMPORTANCE OF LAKE ERIE AS A WATER RESOURCE

Municipal Water Supply

Lake Erie is used as a source of municipal water supply by 27 waterworks serving many municipalities. These municipal systems serve more than 3.2 million people, and a number of industrial firms, with some 619 million gallons per day.

A summary by states showing the number of municipalities, population served, and estimated water usage is given below. The Ohio portion of the Basin accounts for about two-thirds of the use.

State	Number of Municipal Systems	Estimated Population Served	Estimated Water Usage mgd
Ohio	16	2,239,000	409
Michigan	2	23,000	3
Pennsylvania	1	160,000	44
New York	8	835,000	163
	27	3,257,000	619

Industrial Water Supply

Industries use an estimated 4.7 billion gallons of water daily from Lake Erie. As the tabulation below shows, power production (cooling water) accounts for some 80 percent of the industrial withdrawals. Water used for other industrial cooling accounts for approximately 15 percent. Approximately 100 million gallons per day (mgd) is withdrawn directly by industries as process water. In addition, an unknown amount of industrial process water is obtained from municipal supplies.

State	Total Industrial Withdrawal (mgd)	Amount Used for Power (mgd)	Amount Used for Cooling (mgd)
Ohio	2,210	1,920	270
Michigan	337	190	2
Pennsylvania	170	140	20
New York	2,020	1,600	350
	4,717	3,850	642

Lake Erie Commerce

Lake Erie is fourth in size of the five Great Lakes, but its total freight tonnage of 107.5 million tons was second only to that of Lake Huron in 1962.

The domestic shipping in 1962 on Lake Erie was 74.7 million tons, or 70 percent of the total tonnage. Domestic shipping included all commercial movements between points in the continental United States. The foreign shipping (93 percent Canadian) was 32.8 million tons, 30 percent of the total. In ton-mileage, Lake Erie accounted for 12.6 billion ton-miles.

Lake Erie has eleven major U. S. ports: Toledo, Detroit, Cleveland, Buffalo, Ashtabula, Lorain, Sandusky, Conneaut, Fairport, Erie, and Huron. During the period from 1953 to 1962, eight of these ports have shown a decline in total tonnage. In 1964, the Corps of Engineers dredged about 3.3 million cubic yards from Lake Erie ports at a cost of about $1.2 million for routine maintenance of navigation channels.

Recreation

Lake Erie has few long wide sand beaches. The best beaches are at Catawba Island; Cedar Point at Sandusky; and Erie, Pennsylvania. These highly developed recreational areas attract thousands of people each year. The beaches in most other areas are relatively narrow. Some cities, such as Cleveland, have developed artificial beaches in order to serve the people in the area.

Lake Erie is used extensively for other recreational purposes such as fishing and boating. There are many boat launching ramps along the lake shore; and therefore, it is possible for people from a wide area to use the resource. A large number of boats are trailered to various sites each weekend, many from outside the area. Due to this fact, it is difficult to determine exactly how many boats are actually using the Lake. However, an estimate can be made by totaling the boats registered in the counties near the Lake. This is the basis for the second column in the tabulation below.

State	Total State Boat Registration (1964)	Estimated Number Using Lake Erie
Ohio	142,922	73,000
Michigan	362,112	79,000
Pennsylvania	78,359	6,000
New York	335,000*	34,000
	918,393	192,000

*Estimate made by State of New York, Department of Conservation

Fishing

Commercial fishing has been practiced in Lake Erie for more than a century and a half. It has always produced more fish and a greater variety of fish than the other Great Lakes. However, dramatic changes have occurred during the past 30 to 60 years. The species composition has varied greatly, and the annual harvest has diminished. Lake herring practically vanished around 1890, and whitefish have declined greatly since about 1920. Lake trout, which never reached great numbers, are practically non-existent today. The blue pike, a highly desirable species, declined from a peak annual U. S. catch of 20 million pounds in 1936 to a meager 7,400 pounds in 1960. Sauger also declined sharply from a U. S. catch of about 6 million pounds in 1916 to almost none in 1960.

The importance of sport fishing in Lake Erie is reflected in the numbers of fishermen and in the annual harvest of sport fishes. In the counties bordering Lake Erie, more than one-half million fishing licenses were issued in 1964. Presumably, a good many of those people fish in Lake Erie. According to a 1964 report by the Ohio Department of Natural Resources, boat anglers in 1960 harvested 1,300,000 pounds of fish. During that year, the Ohio commercial catch was 1,290,000 pounds. Species that predominated the sport harvest were yellow perch, sheepshead, white bass, small-mouth bass, channel catfish, and walleyes. The highest intensity of sport fishing was in the island area. Fishing pressure is also heavy in the Michigan and Pennsylvania waters.

LAKE EUTROPHICATION

Lake Enrichment

Eutrophication is a term that is increasingly used to mean enrichment of waters through either man-created or natural means. Natural enrichment produces a rate of lake aging that may be measured only by the clock of geologic time. Additional fertilization will accelerate the rate of lake aging, making noticeable changes in water quality within a decade or even less. For example, growing cities and expanding industries are pouring nutrients into the nation's waterways at an ever-increasing rate, and aquatic weed and algae nuisances are occurring in areas where they did not exist before.

To the layman, the most perceptible characteristics are nuisance growths of small suspended plants or algal scums, developing areas of attached algae, and odors associated with decaying vegetation. More subtle changes can be found by the investigator as indicated by decreased light penetration; decreased dissolved oxygen in bottom waters; increased nitrogen and phosphorus concentrations in the bottom sediments in the deeper waters; significant increases and changes in the algal population; and increases in the kinds and numbers of bottom dwelling organisms.

There are many elements that are essential to life processes. Among these are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, sulfur, and several trace minerals. Nitrogen, phosphorus, and potassium are the elements most often applied as fertilizer in agricultural practice. Of the above elements, the ones most amenable to artificial control as inputs to lakes are nitrogen and phosphorus--particularly phosphorus. Phosphorus in the form of phosphate is usually present only in small amounts in unpolluted water. The discharges of domestic sewage and certain industrial wastes increase the concentration of phosphate. Organic phosphate in sewage and simple and complex phosphates from synthetic detergents are the principal sources. Decomposition of the organic material, along with soluble phosphates, results in phosphate concentrations in the Lake higher than the requirement for plant growth.

It is well documented that many lakes throughout the country have been fertile reservoirs for algal development for many years and have been labeled eutrophic. Included among these are Lake Zoar in Connecticut, Lake Sebasticook in Maine, the Madison Lakes in Wisconsin, Lake Erie, the Detroit Lakes in Minnesota, Green Lake and Lake Washington in Washington, and Klamath Lake in Oregon. Of these, Lake Erie is the largest.

When the concentrations of inorganic nitrogen and soluble phosphate exceed 0.3 mg/l and 0.03 mg/l, respecitvely, prior to the algal growing season and when other growth conditions such as light, temperature, turbulence, and turbidity are favorable, algal blooms develop. Those algae that would usually occur in small numbers in infertile lakes become supplanted by larger populations of more troublesome kinds.

As nutrient concentrations increase, the numbers of algal cells increase. Nuisance conditions occur, such as surface scums and foul-smelling water. Filter-clogging problems may occur at municipal water supplies. Filamentous algae, especially Cladophora, grow profusely on suitable subsurfaces. They, too, cause nuisance conditions when they break loose and wash ashore at bathing beaches to form windrows of stinking vegetation. Growths of filamentous algae and slimes hamper commercial fishing by adhering to nets, and interfere with municipal and industrial water supplies by clogging intake screens.

At this stage of eutrophication, other changes occur in the Lake. The bottom changes by increased deposition of organic material; this habitat then changes from one suitable for mayfly nymphs, scuds, and other small organisms favored as food by desirable fish to one where only sludgeworms and bloodworms can exist. Fish populations change to the coarser species because the habitat is more favorable to them.

Nutrient concentrations in Lake Erie indicate that soluble phosphate values in the western basin consistently exceed the stated critical value during studies in 1963 and 1964 with average concentrations ranging from 0.05 to 0.15 mg/l. The central and eastern basins now have phosphate concentrations at the critical threshold value and any increase in present levels will produce a corresponding increase in algal populations.

Water clarity as demonstrated by Secchi disc readings indicates that visibility of the white and black disc extends through 4 feet in the western basin, and through 13 feet in both the central and eastern basins. Because this test measures relative turbidity caused by a combination of algae and other suspended material, it indicates undesirable changes in the western basin.

The biology of the western Lake Erie basin has changed drastically during the past 35 years, especially the past 15 years. In the Bass Island area, samples collected in September, 1964 showed suspended algal populations of 3,500 organisms per milliliter (about 3.5 million per quart) compared to a maximum 1,000 per milliliter found in a study conducted between 1938 and 1942. Species composition has also changed from one predominantly of diatoms to one presently dominated by blue-green algae which are common to enriched waters.

A long-term progressive increase in suspended algal populations is also apparent from data published for the area adjacent to Cleveland in the central basin of Lake Erie. Annual averages have increased from 200 to 400 cells per milliliter between 1920 and 1930 to between 1,500 and 2,300 cells at the present time. Also, there have been significant changes in dominant organisms with blue-green algal forms becoming increasingly present even in this area.

Although historical data are not available for the suspended algae of the eastern basin, Public Health Service studies in 1963 and 1964 revealed that the kinds are similar to those that occurred in the central basin, and that the number of cells per milliliter ranged from 100 to 1,300 with an average of about 400 during the sampling period.

The filamentous green alga Cladophora is encouraged by enriched waters to grow on any suitable attachment site. When it matures, it characteristically breaks loose, floats to the water surface, and creates an odorous nuisance when deposited on beaches by wind and waves. An estimated 340 square miles of Lake Erie has shoal waters with a subsurface suitable for Cladophora growth. Nuisance conditions have become so serious that restricted swimming and sunbathing have occurred in the island area and at the beaches in the eastern basin, especially east of Erie, Pennsylvania and near Dunkirk, New York.

The four groups of bottom-dwelling animals that occur abundantly in Lake Erie include sludgeworms, bloodworms, and fingernail clams, all of which are found in a lake bed covered by decaying organic ooze; and scuds which prefer a relatively clean lake bed. Of the four groups, scuds are preferred as food by the more desirable fish species. Although all of these organisms were found in all three basins of Lake Erie, there was a difference in the relative abundance of each.

In the western basin, sludgeworms and bloodworms were predominant in three large areas. One area extended from the Detroit River mouth southward for more than ten miles. Another fan-shaped area extended from the mouth of the Maumee River for a distance of ten miles. The third area extended about 4 miles lakeward from the mouth of the River Raisin.

Sludgeworms, bloodworms, and fingernail clams predominated in the bottom populations in almost the entire western two-thirds of the central basin. In the eastern third of the central basin, as in the eastern basin, scuds were the predominant animals.

The present biological conditions are in sharp contrast to the kinds of bottom-dwelling organisms that lived in the western basin in past years. Prior to 1953, burrowing mayfly nymphs were the predominant bottom organisms. In September 1953 the western basin became thermally stratified and dissolved oxygen was depleted in the deeper waters. Great numbers of mayflies were killed. Although some areas were repopulated by mayflies in 1954, the overall distribution of these important fish food organisms declined year by year, and by 1959 only a few organisms could be found. During this same period, the caddisfly, another desirable fish food organism, virtually disappeared from the deeper waters surrounding the islands. Sludgeworms and bloodworms have supplanted the mayflies and caddisflies as the predominant bottom-dwelling animals. Restoration of mayfly and caddisfly populations will not be possible as long as periodic depletion of dissolved oxygen occurs.

The above biological evidence indicates a general degradation of Lake Erie from east to west, reflecting the major influence of the large sources of waste at the west end of the Lake.

Dissolved Oxygen Deficit in the Bottom Waters

Low dissolved oxygen concentrations were detected in the bottom waters of the central basin as early as August 1929 when DO values of 4.4 and 4.8 mg/l were recorded at two stations in the central basin. A low value of 0.8 mg/l was measured at one station near Marblehead, Ohio in August 1930.

Low DO values from 1948 through 1951 of 2 to 4 mg/l were recorded, and in September 1959 the DO was found to be less than 3 mg/l in a large area of the central basin bottom water. A survey in August 1960 revealed a similarly large area where the DO was less than 3 mg/l. One zero DO was recorded in August 1959 near the south shore.

In August 1964, an area of about the same magnitude was found where the DO concentrations were even lower (Figure 3-4). Most of the affected area had DO values of 2 mg/l or less. This area was about 2,600 square miles, or about 25 percent of the entire Lake.

In summary, late summer dissolved oxygen values in the bottom (hypolimnion) waters of the central basin of Lake Erie appear to have decreased during the past 35 years from about 5 mg/l to less than 2 mg/l, with many parts near zero.

This change is caused largely by lake enrichment and thermal stratification of water. As explained earlier, the Lake is enriched by the introduction of such materials as nitrogen and phosphorus, which encourage plant growth. Thermal stratification occurs when the upper layer of the lake water becomes one temperature, a lower layer of water becomes a different temperature, and a third layer of water called the thermocline is sandwiched between them. The thermocline is the layer where a sharp temperature differential exists.

During summer stratification, the upper water layer is as much as 16°C higher than the bottom layer. A density barrier is thus created between the upper and lower water and no mixing occurs between

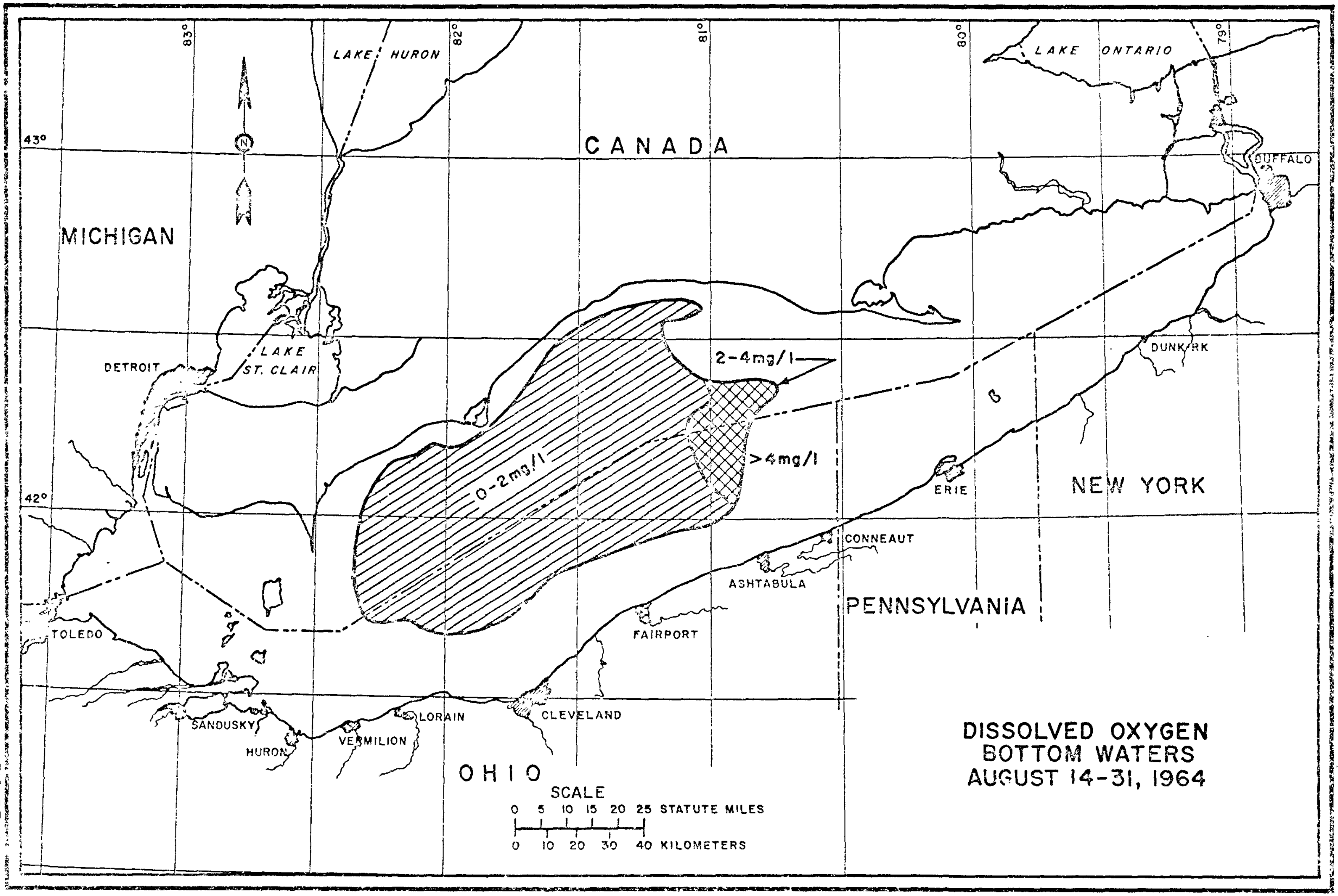

DISSOLVED OXYGEN
BOTTOM WATERS
AUGUST 14-31, 1964
CANADA
MICHIGAN
NEW YORK
PENNSYLVANIA
OHIO
LAKE HURON
LAKE ONTARIO
LAKE ST. CLAIR
DETROIT
TOLEDO
SANDUSKY
HURON
VERMILION
LORAIN
CLEVELAND
FAIRPORT
ASHTABULA
CONNEAUT
ERIE
DUNKIRK
BUFFALO
0-2mg/l
2-4mg/l
>4mg/l
43°
42°
83°
82°
81°
80°
79°
N
SCALE
0 5 10 15 20 25 STATUTE MILES
0 10 20 30 40 KILOMETERS

FIGURE 3-4

the two zones. Plant material sinks to the bottom and decays, using oxygen which cannot be replenished from above and oxygen depletion occurs.

The western basin does not become stratified except during periods of calm because it is so shallow that wind-induced turbulence creates thorough mixing from surface to bottom.

Both the central and eastern basins do become stratified, usually from June to October. A serious dissolved oxygen deficit does not develop in the eastern basin because it is much deeper than the central basin. The thermocline, or middle layer of water, lowers quickly in the central basin as stratification is established until it is about 50 feet below the surface. The lower layer of water in the central basin becomes thin, sometimes only 8 to 10 feet thick. At the same time, the eastern basin, which is about 150 feet deep, may have a cold bottom layer 100 feet thick. The oxygen supply in the central basin is obviously much less than in the eastern basin and is depleted much more rapidly.

The central basin is adjacent to the western basin where there are large inputs of wastes and where the heaviest growths of suspended algae occur. The overall easterly movement of water may carry some of this material to the quieter waters of the central basin where it settles to the bottom.

Changes in the Fishery

There are several opinions as to the decline of commercial fishing in Lake Erie. Ohio commercial fishermen tend to blame Ohio fishing regulations that have required them to use larger mesh nets than the Canadians use. They also believe that sport fishermen and pollution have contributed to their problems.

Some fishery biologists agree in part with the Ohio commercial fishermen, but take a more cautious view. They recognize that the dynamics of fishery biology allows for population and species composition fluctuations, and are well aware that natural changes occur even in remote wilderness lakes. The fishery biologist is also cognizant of the changes in water quality and species composition that have resulted from man's activities. Studies of Lake Erie water quality date back to Civil War times, and reliable records are available for the past 50 years. Those records show a sharp rise in certain mineral constituents such as chlorides and sulfates during this period, and particularly in the past 30 years. Presumably, other materials such as nitrogen, phosphorus, and organic suspended solids have increased comparably. Marked changes in the bottom fauna of western Lake Erie occurred about 20 years ago. Many biologists believe these changes were caused by organic sedimentation and sometimes by dissolved oxygen deficits. If this is so, the Detroit, Monroe, and Toledo areas are the likely pollution sources.

Fish species composition has also been affected by the introduction of carp and smelt; and by the introduction of alewife and lamprey, which gained entry to the Great Lakes through the Welland Canal and the New York State Barge Canal.

Smelt and alewife populations have increased greatly within the past 10 years. Unfortunately their market value is less than the former predominant species. Perch have also increased and are now the principal Lake Erie commercial species. Whether perch will remain so is problematical.

WASTE INPUTS TO LAKE ERIE

Introduction

Municipal sewage and industrial wastes are the principal pollution materials discharged continuously into the waters of Lake Erie. These waste sources, along with other sources such as land runoff; combined sewer overflow; wastes from lake vessels, barge tows and pleasure craft; and materials from dredging operations are all adding to the pollution of the Lake by direct discharge or by increasing the tributary loadings of rivers draining into the Lake.

Municipal Wastes

Approximately 10 million people inhabit communities throughout the Lake Erie Basin. These communities discharge their waste directly into Lake Erie or into rivers tributary to it. Table 3-1 shows the approximate unsewered and sewered populations discharging into the various rivers from each state bordering the Lake. The table also shows the degree of treatment, primary and/or secondary, received by the sewered population. Population equivalents are given of the sewered industrial loads as well as the municipal loads.

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

TABLE 3-1
LAKE ERIE MUNICIPAL WASTE TREATMENT FACILITIES

River Subbasin	Drainage Area (sq. miles)	Estimated Population Equivalent				
		Total	Unsewered		Sewered	
			1	2	Primary	Secondary
MICHIGAN						
St. Clair River-Lake						
St. Clair Basin						
Black River	690	20,800	---	4,100	---	16,700
Belle River	210	9,000	---	600	---	8,400
St. Clair River		63,100	---	3,200	59,900	---
Clinton River	760	288,500	---	66,500	---	222,000
Lake St. Clair		9,000	---	2,500	---	6,500
Totals for Basin		390,400**		76,900	59,900	253,600
Detroit River		3,457,400	---	135,800	3,321,600	---
Huron River	892	171,600	---	17,000	8,900	145,700
Raisin River	1070	60,000	---	7,000	25,600	27,400
Maumee River Basin	6586.3*					
St. Joseph River	1060.4*	2,700	---	2,700	---	---
Tiffin River	804.5*	6,645	2,055	2,040	---	2,550
Direct to Lake		9,400	---	9,400	---	---
		4,098,145	2,055	250,840	3,416,000	429,250
INDIANA						
Maumee River	6586.3*					
St. Joseph River	1060.4*	20,020	---	5,105	---	14,915
St. Marys River	816.7*	16,940	---	10,050	---	6,890
Upper Maumee River		212,925	---	985	---	211,940
		249,885		16,140		233,745

TABLE 3-1 (Continued)
LAKE ERIE MUNICIPAL WASTE TREATMENT FACILITIES

River Subbasin	Drainage Area (sq. miles)	Estimated Population Equivalent				
		Total	Unsewered		Sewered	
			1	2	Primary	Secondary
OHIO						
Maumee River	6586.3*					
Auglaize River	2448.2*	190,995	7,240	16,600	---	167,155
Lower Maumee River		623,910	5,035	5,815	3,660	609,400
St. Joseph River	1060.4*	11,780	---	3,330	8,450	---
St. Marys River	816.7*	22,560	---	2,600	440	19,520
Tiffin River	804.5*	44,915	2,395	2,045	---	40,475
Upper Maumee River		13,735	1,465	1,020	9,650	1,600
Totals for Maumee River		907,895	16,135	31,410	22,200	838,150
Ward Canal		450	---	450	---	---
Halfway Creek	18.81	5,000	---	5,000	---	---
Ottawa River	178.51	10,525	---	1,325	---	9,200
Cedar Creek	49.91	3,150	---	950	2,200	---
Crane Creek	54.04	1,565	---	1,565	---	---
Turtle Creek	28.66	665	---	665	---	---
Toussaint Creek	142.29	4,610	---	2,325	---	2,285
Portage River	587.2	75,270	4,905	9,715	4,075	56,575
Muddy Creek	105.59	1,210	---	630	---	580
Raccoon Creek	30.09	2,500	---	---	---	2,500
Strong Creek	30.56	830	---	285	---	545
Sandusky River	1420.7	102,240	2,720	11,830	21,160	66,530
Mills Creek	36.44	8,445	8,285	160	---	---
Pipe Creek	26.73	1,500	---	---	---	1,500
Cold Creek	8.17	955	---	955	--	---
Old Woman Creek	30.37	970	---	970	---	---
Huron River	403.4	35,870	1,820	1,495	2,205	30,350
Vermillion River	271.7	7,875	730	2,435	---	4,710

TABLE 3-1 (Continued)
LAKE ERIE MUNICIPAL WASTE TREATMENT FACILITIES

River Subbasin	Drainage Area (sq. miles)	Estimated Population Equivalent				
		Total	Unsewered		Sewered	
			1	2	Primary	Secondary
Quarry Creek	6.51	2,480	---	---	---	2,480
Beaver Creek	43.93	4,505	---	1,655	---	2,850
Martin Run	4.26	3,000	---	3,000	---	---
Black River	466.8	65,600	1,005	7,570	---	57,025
Cahoon Creek	5.44	12,905	12,905	---	---	---
Rocky River	293.8	67,883	1,940	10,393	430	55,120
Cuyahoga River	813.3	1,186,098	14,798	20,155	28,725	1,122,420
Euclid Creek	23.15	1,200	---	---	---	1,200
Chagrin River	267.0	24,480	---	12,325	7,950	4,205
Mentor Marsh		3,640	---	---	3,640	---
Arcola Creek	10.15	1,970	---	500	---	1,470
Grand River	712.1	32,225	---	6,840	19,460	5,925
Wheeler Creek		500	---	500	---	---
Cowles Creek	22.18	5,380	---	---	---	5,380
Indian Creek	16.84	350	---	350	---	---
Ashtabula River	137.1	1,095	---	1,095	---	---
Conneaut Creek	191.2***	5,130	---	5,130	---	---
Direct to Lake Erie		1,770,085	1,635	7,455	652,900	1,108,095
		4,360,051	66,878	149,133	764,945	3,379,095
PENNSYLVANIA						
Conneaut Creek	191.2***	4,440	---	2,060	---	2,380
Raccoon Creek	8.95	500	---	---	---	500
Crooked Creek	21.2	760	---	760	---	---
Elk Creek	101	5,660	---	915	25	4,720
Trout Run	5.88	1,640	---	---	---	1,640
Walnut Creek	36.1	2,000	---	---	---	2,000

TABLE 3-1 (Continued)
LAKE ERIE MUNICIPAL WASTE TREATMENT FACILITIES

River Subbasin	Drainage Area (sq. miles)	Estimated Population Equivalent				
		Total	Unsewered		Sewered	
			1	2	Primary	Secondary
Sevenmile Creek	8.70	255	---	---	---	255
Sixteenmile Creek	18.4	13,145	---	---	---	13,145
Direct to Lake Erie		173,500	---	500	---	173,000
		201,900	---	4,235	25	197,640
NEW YORK						
Chautaqua Creek	36	3,800	---	---	---	3,800
Cornell Creek		500	---	500	---	---
Slippery Rock Creek		1,415	1,415	---	---	---
Beaver Creek		130	130	---	---	---
Canadaway Creek	40	37,640	140	---	---	37,500
Silver Creek	52	4,215	---	4,215	---	---
Cattaraugus Creek	565	18,035	130	8,150	7,825	1,930
Big Sister Creek		5,240	---	3,665	---	1,575
Muddy Creek		422	---	422	---	---
Pike Creek		2,500	---	2,500	---	---
Eighteenmile Creek	110	17,155	300	1,400	5,920	9,535
Rush Creek		25,300	---	600	---	24,700
Smoke Creek		42,035	---	5,855	290	35,890
Buffalo River	842					
Buffalo River		22,110	---	590	6,320	15,200
Buffalo Creek		4,785	4,000	785	---	---
Cayuga Creek		17,160	---	300	13,700	3,160
Cazenovia Creek		27,895	---	2,925	---	24,970
Totals for Buffalo River		71,950	4,000	4,600	20,020	43,330
Niagara River U. S. Subbasin						
Niagara River		1,163,174	---	2,400	1,099,174	61,600

TABLE 3-1 (Concluded)
LAKE ERIE MUNICIPAL WASTE TREATMENT FACILITIES

River Subbasin	Drainage Area (sq. miles)	Estimated Population Equivalent				
		Total	Unsewered		Sewered	
			1	2	Primary	Secondary
Tonawanda Creek	768	71,055	---	960	4,945	65,150
Totals for basin		1,234,229	---	3,360	1,104,119	126,750
Direct to Lake Erie		31,320	700	8,015	22,605	---
		1,495,886	6,815	43,282	1,160,779	285,010

1 Unsewered, presently under state order to provide waste collection and treatment facilities
2 Remaining unsewered population

* Drainage area for Maumee River includes 4,856.2 sq. miles in Ohio, 1,260.0 sq. miles in Indiana, 470.1 sq. miles in Michigan
Drainage area for Auglaize River includes 2,341.6 sq. miles in Ohio, 106.6 sq. miles in Indiana
Drainage area for St. Joseph River includes 238.0 sq. miles in Ohio, 603.2 sq. miles in Indiana, 219.2 sq. miles in Michigan
Drainage area for St. Marys River includes 457.7 sq. miles in Ohio, 359.0 sq. miles in Indiana
Drainage area for Tiffin River includes 553.5 sq. miles in Ohio, 251.0 sq. miles in Michigan

** Population does not include communities discharging to inceptor systems connected to Detroit Sewage Treatment Plant

*** Drainage area for Conneaut Creek includes 37.7 sq. miles in Ohio and 153.5 sq. miles in Pennsylvania

In the Michigan Basin, 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 is sewered, only 11 percent of the total population receives secondary treatment.

In New York, the wastes from 78 percent of the total population receives primary treatment. The Cities of Buffalo, Niagara Falls, and part of Tonawanda have sewage treatment plants that give only primary treatment. These three cities serve over a million of the 1.2 million people receiving primary treatment.

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. Its sewage treatment plant discharges directly into the Lake and it provides treatment for 173,000 population equivalent (PE) or about 90 percent of the total.

Industrial Pollution

Industrial waste information in this report was obtained from records of the Michigan Water Resources Commission, Indiana Stream Pollution Control Board, Ohio Department of Health, Pennsylvania Sanitary Water Board and New York Water Pollution Control Board.

Industrial Waste Sources
State Classification (1965)

State	Adequate	Inadequate	Unknown
Ohio	116	36	9
Indiana	9	2	-
Michigan	49	19	8
Pennsylvania	5	2	2
New York	3	4	7
Total	182	63	26

The above tabulation shows that there are 271 known sources of industrial wastes that discharge to the Lake and tributaries. The states have classified about 23 percent of these industries as having inadequate treatment facilities. The adequacy of an additional 10 percent of the industries has not been determined. Table 3-2 lists the total number of industries in each major subbasin in 1965. The individual industries are listed in the following chapters.

TABLE 3-2
INDUSTRIES IN LAKE ERIE BASIN

River Subbasin	Drainage Area (sq. miles)	Industries with adequate Treatment [1]	Industries with inadequate Treatment [1]	Industries with Treatment Status Unknown
MICHIGAN				
Detroit River		18	5	3
Rouge River	464.	13	5	1
Total for Basin		31	10	4
Huron River	892.	10	1	2
Raisin River	1070.	7	6	2
Direct to Lake		1	--	--
Total for Basin		49	17	8
INDIANA				
Maumee River				
St. Joseph River	1060.4*	4	--	--
St. Marys River	816.7*	2	1	--
Upper Maumee River		7	1	--
		13	2	--
OHIO				
Maumee River	6586.3*			
Auglaize River	2448.2*	8	2	3
Lower Maumee River		8	1	1
St. Joseph River	1060.4*	2	--	--
St. Marys River	816.7*	3	--	--
Tiffin River	804.5*	1	--	--
Upper Maumee River		3	1	--
Total for Maumee		25	4	4

TABLE 3-2 (continued)
INDUSTRIES IN LAKE ERIE BASIN

River Subbasin	Drainage Area (sq. miles)	Industries with adequate Treatment[1]	Industries with inadequate Treatment[1]	Industries with Treatment Status Unknown
Portage River	587.2	7	1	--
Sandusky River	1420.7	5	--	--
Huron River	403.4	2	1	--
Black River	466.8	13	1	--
Rocky River	293.8	2	--	--
Cuyahoga River	813.3	24	16	--
Chagrin River	267.0	5	--	--
Grand River	712.1	5	1	--
Ashtabula River	131.1	1	3	5
Minor Tributaries to Lake		10	2	--
Direct to Lake		8	1	2
		107	30	11
PENNSYLVANIA				
Conneaut Creek	191.2**	--	--	1
Tributaries to Lake		4	--	1
Direct to Lake		1	2	--
		5	2	2
NEW YORK				
Buffalo River	842	1	4	1
Cattaraugus Creek	565	--	--	2
Tributaries to Lake		2	--	4
		3	4	7

TABLE 3-2 (Concluded)
INDUSTRIES IN LAKE ERIE BASIN

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1 Status of Waste Treatment Facilities by State

* Drainage area for Maumee River includes 4,856.2 sq. miles in Ohio, 1260.0 sq. miles in Indiana and 470 sq. miles in Michigan.
Drainage area for Auglaize River includes 2,341.6 sq. miles in Ohio, and 106.6 sq. miles in Indiana.
Drainage area for St. Joseph River includes 238.0 sq. miles in Ohio, 603.2 sq. miles in Indiana and 219.2 sq. miles in Michigan.
Drainage area for St. Marys River includes 457.7 sq. miles in Ohio, and 359.0 sq. miles in Indiana.
Drainage area for Tiffin River includes 553.5 sq. miles in Ohio and 251.0 sq. miles in Michigan.

** Drainage area for Conneaut Creek includes 37.7 sq. miles in Ohio and 153.5 sq. miles in Pennsylvania.

Table 3-3 lists the industrial establishments that discharge directly to the Lake or to the lower rivers in the lake-affected areas. This represents about 20 percent of total industrial discharges in the Basin. Of these 53 industries, 22 were reported to have inadequate treatment facilities by the state agencies in 1965.

Inputs of Constituents

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. These will be dealt with in discussions of local water use problems and damages.

Those substances that have damaging effects on the water use of the total waters of the Lake are suspended solids (sediment), carbonaceous oxygen consuming materials, nitrogen compounds and soluble phosphate. A discussion of chlorides and dissolved solids is also included here, not because they have reached damaging concentrations, but because their dramatic increases are indicative of the rate at which water quality has been degraded. Tables 3-4 through 3-7 present summaries of the major known inputs to Lake Erie of suspended solids, chlorides, nitrogen compounds, and soluble phosphates.

Suspended Solids

Damage 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 is largely inorganic and its effects on settling result in the filling of 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 11,000,000 pounds per day of known discharges. The Detroit River, because of its large volume, constitutes the major source or 73 percent of this total, the Maumee 13.5 percent, the Cuyahoga 4.0 percent, and the Grand 3 percent. Table 3-4 lists the known sources of suspended solids.

TABLE 3-3
LAKE ERIE
INDUSTRIAL WASTE DISCHARGES

Industry	Type of Waste	State Classification: Status	State Classification: Required Improvements
MICHIGAN	Direct to Lake Erie		
Detroit Edison Enrico-Fermi Station	Power		
OHIO			
	Maumee River (0 - 14.9 Miles)		
Standard Oil Co.	Oil Refinery		
Gulf Oil Co.	Oil Refinery		
Interlake Iron	Steel		Solids
Sun Oil Co.	Oil Refinery		
Toledo Edison	Power		
Libbey-Owens Fords	Glass Manufacture		
Allied Chemical	Plastics		
	Black River (0 - 10.2 Miles)		
U. S. Steel Corp.	Steel		
	Cuyahoga River (0 - 6.6 Miles)		
Republic Steel	Steel		
Bolt & Nut Div.	Acid Iron	I	Pickling Liquor
Mill Scale			
Standard Oil Corp.	Oil Refinery		
#1		I	Oil and phenol
#2			
U. S. Steel Corp.	Steel		
Blast Furnace		I	Solids
Pickling		I	Pickling Liquor
Mill Scale		I	Solids
E. I. DuPont	Chemical	I	Metals
Republic Steel			
Coke Plant			
Blast Furnace		I	Solids - Increase Efficiency
Rolling Mill		I	Oil & Solids - Increase Efficiency
Pickling			
J. L Steel Corp.	Steel	I	Pickling Liquor
Pickling		I	Pickling Liquor
Blast Furnace			
Mill Scale			

TABLE 3-3 (Continued)
LAKE ERIE
INDUSTRIAL WASTE DISCHARGES

Industry	Type of Waste	State Classification: Status	State Classification: Required Improvements
Harshaw Chemical Co.	Chemicals	I	Reduction of metallic salts
Sherwin-Williams	Chemical	I	Acids & Alkaline Sludges
Elco Lubricant Corp	Oil		Acids & Alkaline Sludges
Grand River (0 - 2.3 Miles)			
Diamond Alkali Co.	Chemical		
U. S. Rubber Co.	Chemical		
Ashtabula River (0 - 3.3 Miles)			
Olin Mathieson	Chemical	I	Solids - pH
Cabot Titania Corp.	Chemical		Solids
Titania Dioxide Plant	Chemical	.	Solids
Titania Tetrachloride	Chemical		Solids - Chloride
Detrex Chemical Ind.	Chemical	I	Iron Hydrocarbon
Reactive Metals	Chemical		
Sodium & Chlorine Plant			Solids
Metal Reduction Plant		I	Solids and pH
Extrusion Plant			
Diamond Alkali Co.	Chemical		Solids
General Tire & Rubber Co.	Chemical		Solids
Direct to Lake Erie			
Aluminum & Magnesium Co., Sandusky, Ohio	Metals		
United States Gypsum Gypsum	Paper		Solids
Cleveland Electric Illuminating Co.	Power		
Avon Lake			
Eastlake		I	Solids
Ashtabula			
Ohio Edison Co. Lorain	Power		
The Lubrizol Corp. Wickliffe	Chemical		
Thompson Ramo Woolridge Euclid	Metal Finishing		Metals Reduction

TABLE 3-3 (Concluded)
LAKE ERIE
INDUSTRIAL WASTE DISCHARGES

Industry	Type of Waste	State Classification Status	State Classification Required Improvements
Industrial Rayon Co. Painesville	Textile	I	Metals Reduction
Union Carbide Corp. Metals Division Ashtabula	Steel Acid-iron		
Detrex Chemical Ind. Chloro-Alkali Plant Ashtabula	Chemical		
PENNSYLVANIA			
	Direct to Lake Erie		
Hammermill Paper Co. Erie, Pa.	Paper	I	
Interlake Iron Corp. Erie, Pa.	Metal	I	
Pennsylvania Electric Erie, Pa.	Flyash		
NEW YORK			
	Direct to Lake Erie		
Bethlehem Steel Co. Lackawanna	Steel		
Penn-Dixie Cement Co. Lackawanna	Inorganic Solids	I	

I - Inadequate Treatment

TABLE 3-4
SUSPENDED SOLIDS INPUTS TO LAKE ERIE

Source	Pounds/Day
MICHIGAN	
Discharge by	
Detroit River	8,600,000
Huron River	10,000
Raisin River	48,000
OHIO	
Maumee River	1,600,000
Portage River	130,000
Sandusky River	130,000
Black River	73,000
Rocky River	84,000
Cuyahoga River	490,000
Chagrin River	70,000
Grand River	360,000
Ashtabula River	15,000
NEW YORK	
Buffalo River	100,000
TOTALS -- Major Known Sources	11,710,000

About 1.5 million pounds of the Detroit River discharges are from industrial and municipal sources. The Maumee discharges are largely silt originating from land runoff. The greatest quantity is 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 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. 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, as discussed below. Carbonaceous BOD_5 of wastes is most effectively removed by secondary treatment.

Chloride

The concentration of chloride in the headwaters of the Detroit River averaged 7 mg/1, 22 mg/1 at the Detroit River mouth, and 23 mg/1 at Buffalo. A threefold increase within the length of the Detroit River completely overshadows the small increase within Lake Erie. Major known sources of input are the municipal and industrial contributaions at Detroit, about 3 million pounds per day, the Grand River, 2.2 million pounds per day, and the Maumee and Cuyahoga, 1 million pounds per day. Table 3-5 lists the known chloride inputs to Lake Erie.

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 use for this purpose in 1964 in the Basin was at least 800,000 tons, which could represent an increase of at least 2.4 mg/1 to the chloride level of Lake Erie.

Historical data indicate that concentration of chloride in Lake Erie was 7 mg/1 at the beginning of this century. At that

TABLE 3-5
CHLORIDE INPUTS TO LAKE ERIE

Source	Pounds/Day
MICHIGAN	
Head of Detroit River	6,500,000
Additions to Detroit River (incl. Canada)	11,500,000
Discharges by	
Huron River	90,000
Raisin River	140,000
OHIO	
Discharges by	
Maumee River	440,000
Portage River	100,000
Sandusky River	170,000
Black River	170,000
Rocky River	110,000
Cuyahoga River	660,000
Chagrin River	60,000
Grand River	2,200,000
Ashtabula River	20,000
Municipalities	
Toledo	80,000
Sandusky	7,000
Lorain-Avon	17,000
Lakewood	10,000
Cleveland-Westerly	37,000
Cleveland-Easterly	140,000
Euclid	14,000
Industrial --Direct to Lake--Ohio	unknown
PENNSYLVANIA	
Municipalities	
Erie	12,000
Small sources	---
Industrial	unknown
NEW YORK	
Buffalo River	70,000
Other sources	4,000
CANADA (other than Detroit River)	unknown
Sum of Known Sources	22,551,000
Discharged at Niagra River	25,100,000

time, a noticeable increase was observed. Concentrations have doubled in each successive twenty-year period, resulting in the present-day level of 23 mg/l.

Dissolved Solids

Dissolved solids concentrations at the head of the Detroit River average 126 mg/l and at Buffalo 192 mg/l. These levels represent daily inputs of 116 million pounds per day from the watershed above Detroit and a discharge of 210 million pounds per day to the Niagara River from Lake Erie.

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 192 mg/l.

Nitrogen Compounds

The major known sources of nitrogen compounds entering Lake Erie are listed in Table 3-6. The largest input is the Detroit River, which consists of the nitrogen residual from the upper Great Lakes and the contributions from the Detroit metropolitan area. Other important sources are the Maumee and Cuyahoga Rivers and the discharges at Toledo and Cleveland.

The origin of these materials in waste discharges is largely from organic wastes, with sizeable contributions 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 fertilization. However, the institution of secondary treatment will significantly reduce nitrogen inputs and thereby aid in the control of local problems as well as reduction in total inputs to the Lake.

Soluble Phosphate

Phosphorus, in its inorganic form of orthophosphate (PO_4) is an essential element of life. As such, it is used extensively as an agricultural fertilizer. Therefore, it is difficult to implicate this substance as a pollutant since it has so many beneficial qualities, but it is recognized seriously for its effect on the biology of lakes and streams.

TABLE 3-6
TOTAL NITROGEN INPUTS TO LAKE ERIE

Source	Pounds/Day
MICHIGAN	
Discharge by	
Detroit River	500,000
Huron River	1,600
Raisin River	3,800
OHIO	
Tributaries	
Maumee River	65,000
Portage River	19,600
Sandusky River	*
Black River	13,200
Rocky River	*
Cuyahoga River	52,100
Chagrin River	*
Grand River	4,000
Ashtabula River	*
Municipalities	
Toledo	40,000
Sandusky	3,500
Lorain-Avon	8,700
Lakewood	5,200
Cleveland-Westerly	19,000
Cleveland-Easterly	71,000
Euclid	6,900
Industrial--Direct to Lake	*
PENNSYLVANIA	
Erie	12,000
NEW YORK	
Buffalo River	*
Other Sources	2,100
CANADA (Other than Detroit River)	*
Sum of Known Inputs	821,700

*Unknown

Because phosphate is so important to life, it can become a controlling factor in the rate of growth or size of crop, and under conditions of limited abundance as prevail in Lake Erie, it is the one factor most easily controlled.

Excessive phosphate in Lake Erie results in high production of algae followed by decay of this organic matter. The decay, in turn, produces zones of oxygen depletion in bottom waters in summer.

Phosphate inputs from principal sources are presented in Table 3-7. Of the total of 174,000 pounds of soluble phosphate discharged from known sources daily, 67 percent is from municipal and industrial sources discharging directly to the Lake, and 33 percent from tributaries (including the St. Clair River) and other small sources. The St. Clair River input is 6.8 percent of this total.

A 65 percent reduction of phosphate input can be achieved through secondary sewage treatment, operated to effect optimum phosphate removal. The major controllable sources and the amount of reduction that can be achieved by the secondary treatment described above are listed below:

Detroit	45,500 pounds per day
Toledo	2,900
Sandusky	700
Lorain-Avon	1,700
Lakewood	600
Westerly	3,500
Easterly	6,800
Euclid	1,300
Erie	1,300
	64,300
80% reduction Michigan Industry	8,000
Total Reduction	72,300 pounds per day

Thus, at least 40 percent of present PO_4 input (174,000 pounds per day) can be removed by secondary treatment at the principal waste sources. The reduction rate, based on present-day factors, must be constantly improved in order to overcome increases in phosphate loadings resulting from population, industrial, and agricultural growth.

TABLE 3-7
SOLUBLE PHOSPHATE INPUTS TO LAKE ERIE

Source	Pounds/Day
MICHIGAN	
Discharge from Lake Huron	11,800
Municipal	70,000
Industrial	10,000
Tributaries	
Huron River	2,000
Raisin River	900
OHIO	
Municipalities	
Toledo	8,400
Sandusky	1,000
Lorain-Avon	2,600
Lakewood	1,100
Cleveland Westerly	5,400
Cleveland Easterly	14,900
Euclid	2,100
Industrial--Direct Discharge	unknown
Tributaries	
Maumee River	11,000
Portage River	1,100
Sandusky River	6,000
Black River	3,100
Rocky River	3,400
Cuyahoga River	3,500
Chagrin River	300
Grand River	---
Ashtabula	100
PENNSYLVANIA	
Erie	2,600
Other sources	2,900
NEW YORK	
Buffalo River	2,300
Other sources	2,500
CANADA (est.-Municipal)	5,000
Sum of Major Known Sources	174,000
Discharge at Niagra River	24,000

CHAPTER 4 - MAUMEE RIVER BASIN

A detailed statement on the Maumee River Basin has been prepared for release at this hearing. The following is a summary of this statement.

The effects of pollution in the Maumee River Basin are particularly evident in the Ottawa River, the Upper Maumee River, and at Toledo. Biological, chemical, microbiological, and physical investigations have affirmed this pollution. The once clear waters of this river Basin have been degraded so that few legitimate uses may be made of them. In some areas, the water quality is too poor for even waste assimilation. The once-prevalent fishery is now virtually nonexistent. Further evidence of pollution includes the abandonment of the beaches in the Toledo area, taste and odor problems in water sources, objectionable algal blooms and the generally esthetically unpleasing appearance of the waters.

Industry, cities, and agriculture are all major waste sources in the Maumee Basin. The effluents from municipal sewage treatment plants deplete the receiving waters of oxygen and cause algal growths. Industrial waste discharges deplete oxygen, cause taste and odor problems and interfere with esthetic enjoyment. The wastes from agricultural sources cause extreme turbidity, result in a need for channel dredging, and help produce the abundant algal growths.

The Maumee Basin's population will increase from 1,140,000 to 2,700,000 by 2020. Industrial activity will also increase considerably. Unless extensive measures are taken now and continue into the future, the present problems will be greatly compounded.

The need for implementation of a program for water pollution control in the Maumee River Basin is immediate. The program must emphasize new and enlarged sewage facilities with tertiary treatment in some areas; proper operation of facilities; and continuous monitoring of operation, waste treatment efficiency, and water quality.

CHAPTER 5 - NORTH CENTRAL OHIO

DESCRIPTION OF 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.

Hydrology

The rivers within this area are not hydraulically controlled to any great extent except for an occasional run-of-the-river dam. Low flows (those exceeded 90% of the time) are estimated at the U. S. Geological Survey gage nearest to the Lake as follows: Portage, 5 cfs; Sandusky, 31 cfs; Huron, 14 cfs; Vermilion, 4 cfs; and Black, 2 cfs.

Economy

The economy of the area is diversified. Farm lands occupy 91 percent of the Basin. In 1962 cash receipts from agriculture in nine counties of the Basin totaled 144 million dollars. Industry is found in communities throughout the Basin, but heavy industry is concentrated in the Elyria-Lorain area on the Black River. Manufacture and production of clay, glass, and stone products predominate in the western portion of the Basin, while heavy metals, transportation, and electrical industries are important in Sandusky and Lorain County. The Value Added by Manufacture in nine counties of the Basin in 1962 was 720 million dollars. The Basin is a leading producer of the mineral products from lime, limestone, and sandstone.

WATER USES

Municipal

The average amount of water used by all municipalities in North Central Ohio was 53 mgd in 1960. Lake Erie is the most significant source of municipal water, supplying 35 mgd. Not only do lakefront municipalities draw water from Lake Erie, but Elyria, located 10 miles inland, depends on the Lake for its municipal supply. Although inland surface waters of the Basin supplied 13 mgd, Bowling Green

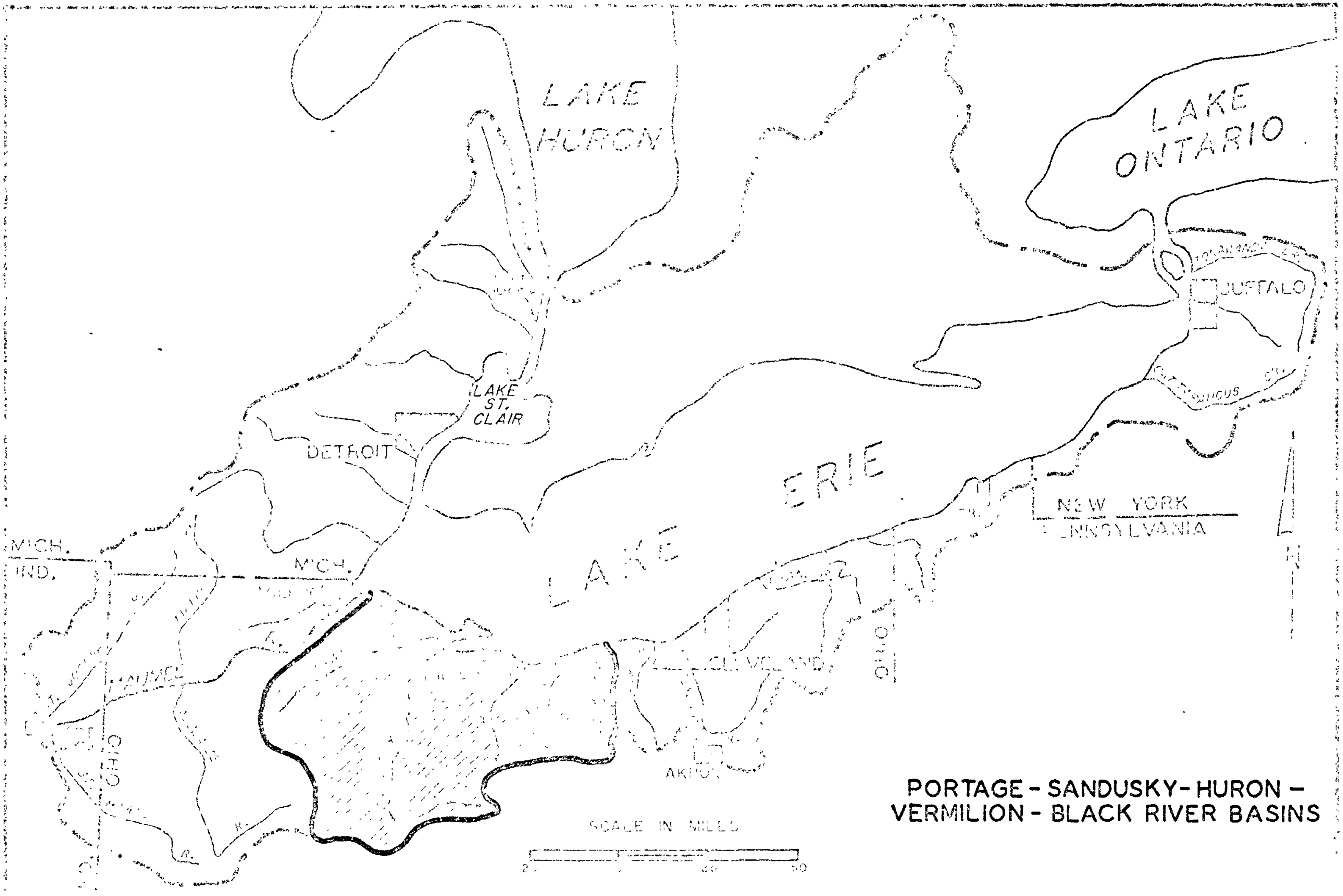

PORTAGE - SANDUSKY-HURON -
VERMILION - BLACK RIVER BASINS
LAKE ONTARIO
LAKE HURON
LAKE ERIE
LAKE ST. CLAIR
BUFFALO
DETROIT
CLEVELAND
NEW YORK
PENNSYLVANIA
OHIO
MICH.
IND.
N
SCALE IN MILES

FIGURE 5-1

imported its municipal water from the Maumee River, 10 miles away. The lack of dependable ground water is illustrated by the fact that only 5 mgd was supplied by this source.

Rural

The total water use in rural areas of North Central Ohio in 1955 was estimated at 24 mgd. Water uses were fairly evenly divided between suburban and farm domestic uses, livestock watering, and irrigation. The greatest concentration of farm irrigation in Ohio occurs in Lorain County, and, surprisingly, golf course watering exerts a significant demand.

Industrial

Industrial water use in North Central Ohio in 1955 was 228 mgd, and water used in thermal power generation was 521 mgd. Of the total industrial water use, 7 mgd was used in each of the Portage and Sandusky River Basins, and 214 mgd was used in the Huron to Black River Basins. The greatest industrial water use (over 200 mgd) was by the steel industries in Lorain and Elyria, where approximately 85 percent of the water was used for cooling.

Waterborne Commerce

Waterborne commerce in North Central Ohio is served by the port facilities of Lorain, Huron, and Sandusky. These three ports handle only 9 percent of the tonnage moved through all Lake Erie ports. This cargo still amounted to 11.5 million tons in 1962. No commercial navigation exists above the Lake-affected portions of the Basin's rivers.

Recreation

Water-oriented recreation is popular throughout North Central Ohio. Lake Erie and its shoreline are the most prominent features the area has to offer. The islands of Lake Erie (offshore of Sandusky and Port Clinton) are one of Ohio's principal recreational areas. In this area, including Catawba Peninsula and Sandusky Bay, are found a national monument and wildlife refuge. State facilities include a fish hatchery, a beach, five wildlife refuges, four parks, and two memorials. There are also numerous private and local recreation facilities. Cedar Point has one of the finest amusement parks and bathing beaches in the country.

Transportation between the mainland and islands is provided by ferry service and "the world's shortest airline". Nine recreational harbors and other private marinas serve the area. Winter ice fishing is popular around the islands. East Harbor State Park's bathing beaches attracted almost 1-1/2 million people in 1963.

Outside of the island area, recreational harbors are found near the mouths of the Huron, Vermilion, and Black Rivers, and several creeks; and bathing beaches are found in many locations between Huron and Avon Point.

Upstream on the Sandusky, Huron, and Black Rivers are located State memorials and parks, wildlife areas, and local recreational developments. Canoeing is popular on these three streams as well as on the Vermilion River.

Esthetics

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 changes 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.

SOURCES OF WASTES

Municipal

Forty-three municipalities with a total population of 442,000 discharge treated municipal wastes to the waters of North Central Ohio. 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. 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 is suspected of affecting some ground water supplies. The population and type of municipal waste treatment in each of the subbasins of North Central Ohio is summarized below. The locations of the major municipal waste sources are shown in Figure 5-2. A tabulation of the load and treatment facilities of the major municipal waste sources is presented as follows:

MUNICIPAL WASTE TREATMENT

River Basin	Secondary		Primary		Minor
	Plants	Population	Plants	Population	Population
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	13,000-8,000*
Lake Erie	2	16,000	8	59,000	8,000
Totals	27	201,000	16	167,000	74,000

* Collection system but no treatment

Approximately 75% of the 600,000 population of North Central Ohio live in organized communities. Of this 442,000 population, 85 percent (368,000 people) are served by central sewage treatment plants. 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, 85 percent of the population (185,000 people) are served by secondary sewage treatment.

Despite the widespread inland use of secondary sewage treatment, the waste load, which is summarized below, 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.

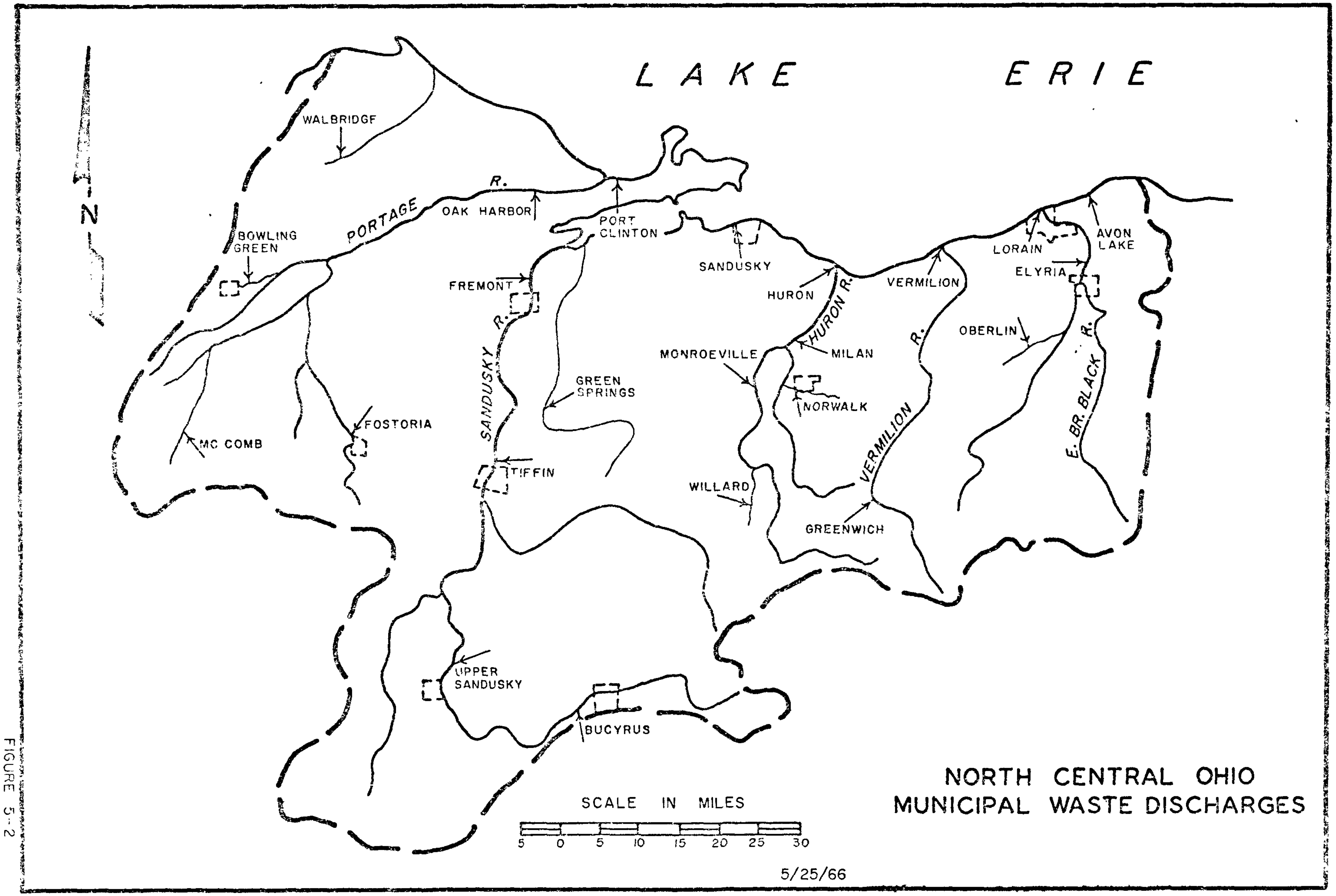

LAKE ERIE
NORTH CENTRAL OHIO
MUNICIPAL WASTE DISCHARGES
N
WALBRIDGF
PORTAGE R.
OAK HARBOR
PORT CLINTON
BOWLING GREEN
MC COMB
FOSTORIA
FREMONT
SANDUSKY R.
TIFFIN
GREEN SPRINGS
SANDUSKY
HURON
HURON R.
MILAN
MONROEVILLE
NORWALK
WILLARD
VERMILION
VERMILION R.
GREENWICH
OBERLIN
LORAIN
ELYRIA
AVON LAKE
E. BR. BLACK R.
UPPER SANDUSKY
BUCYRUS
SCALE IN MILES
5 0 5 10 15 20 25 30
5/25/66

FIGURE 5-2

MUNICIPAL WASTE LOAD

River Basin	Population Equivalents* Raw	Population Equivalents* Discharged	Pounds per day BOD_5 Raw	Pounds per day BOD_5 Discharged
	From Sewage Treatment Plants			
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
			63% reduction	

*P.E. = 0.167#BOD_5/day

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 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).

Industrial

Industrial wastes from 41 industries are discharged to the waters of North Central Ohio. 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 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 throughout 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 5-3. Data on the industrial waste discharges are now being obtained and evaluated.

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.

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. These permit 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.

EFFECTS OF WASTES ON WATER QUALITY AND WATER USES

DO - BOD relationships

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. The Sandusky River, however, is

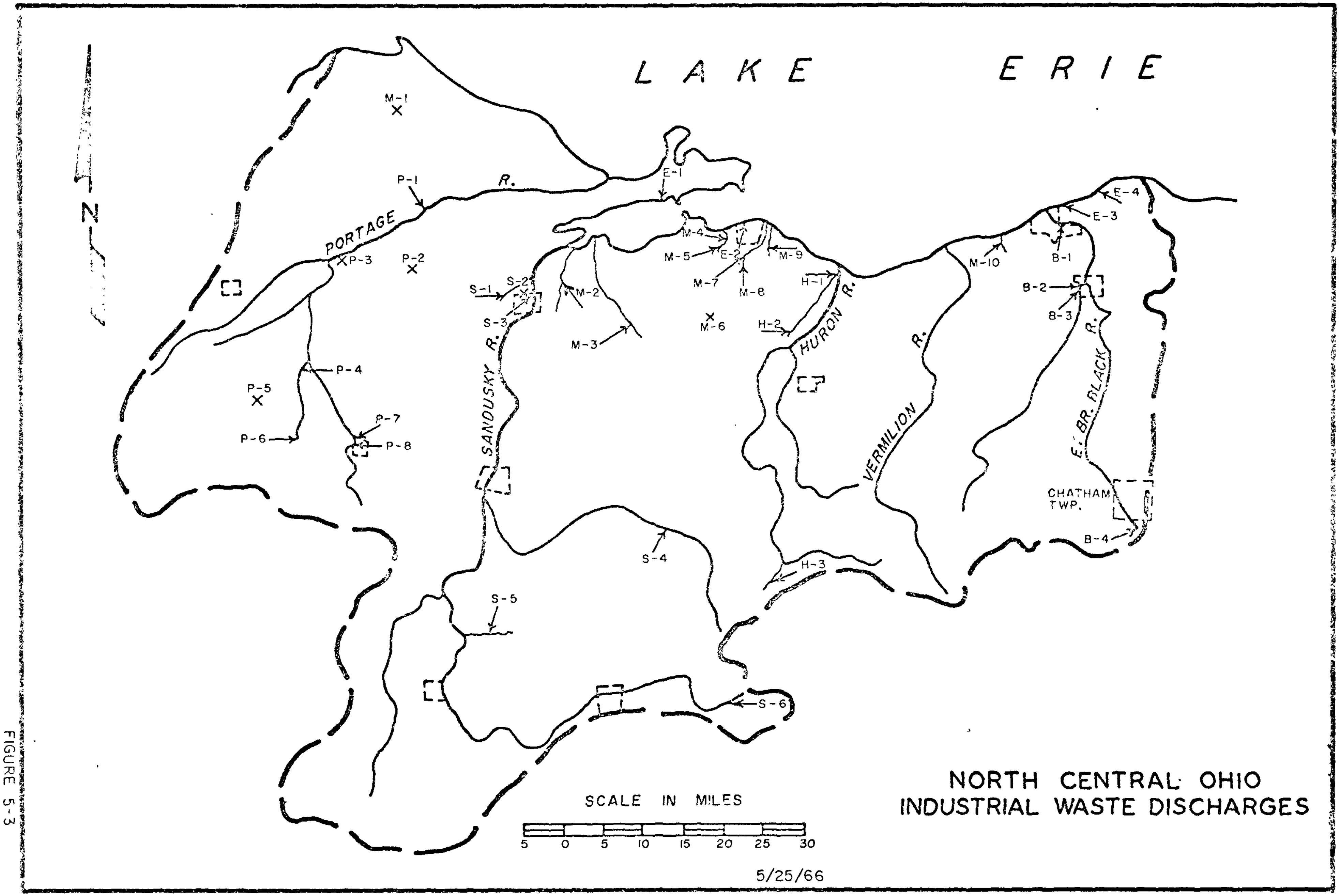

LAKE ERIE
N
PORTAGE R.
SANDUSKY R.
HURON R.
VERMILION R.
E. BR. BLACK R.
CHATHAM TWP.
M-1
P-1
P-2
P-3
P-4
P-5
P-6
P-7
P-8
E-1
E-2
E-3
E-4
M-2
M-3
M-4
M-5
M-6
M-7
M-8
M-9
M-10
S-1
S-2
S-3
S-4
S-5
S-6
H-1
H-2
H-3
B-1
B-2
B-3
B-4
SCALE IN MILES
5 0 5 10 15 20 25 30
NORTH CENTRAL OHIO
INDUSTRIAL WASTE DISCHARGES
5/25/66

FIGURE 5-3

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	Cort'man Gravel Co
S-6	Pennsylvania RR
Black River	
B-1	U. S. Steel, Tubular Operation, Lorain
B-2	GMC, Turnstedt 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

FIGURE 5-3 Cont'd.

able to assimilate the waste loads it receives and recovers rapidly from these dissolved oxygen deficits. 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 above the area of study 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 fecal coliform to fecal streptococci ratio for this period was 21:1, which indicates pollution from human wastes.

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. Below Fremont's treatment plant was the only station where the fecal coliform to fecal streptococci ratio (3:1) indicated pollution from human wastes.

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 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. No 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.

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 of metals and cyanide in the river at mile point 10.2. Maximum concentrations in mg/l during 1964 were: copper, 0.31; cadmium, 0.03; nickel, 0.42; zinc, 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 two major municipal water intakes are located near the mouth of the Black River.

EFFECTS ON THE LAKE

All the wastes emanating from the rivers in North Central Ohio are diluted to the background concentration of the Lake within a mile of the shoreline. The Sandusky River flows through the 15 mile long Sandusky Bay before reaching Lake Erie. Any effects which the Sandusky River might have on Lake Erie are exerted in Sandusky Bay. Microbial pollution is found near the mouth of the Black River. The 1964 median total coliform density at the east entrance to Lorain Harbor was 27,000 organisms per 100 ml.

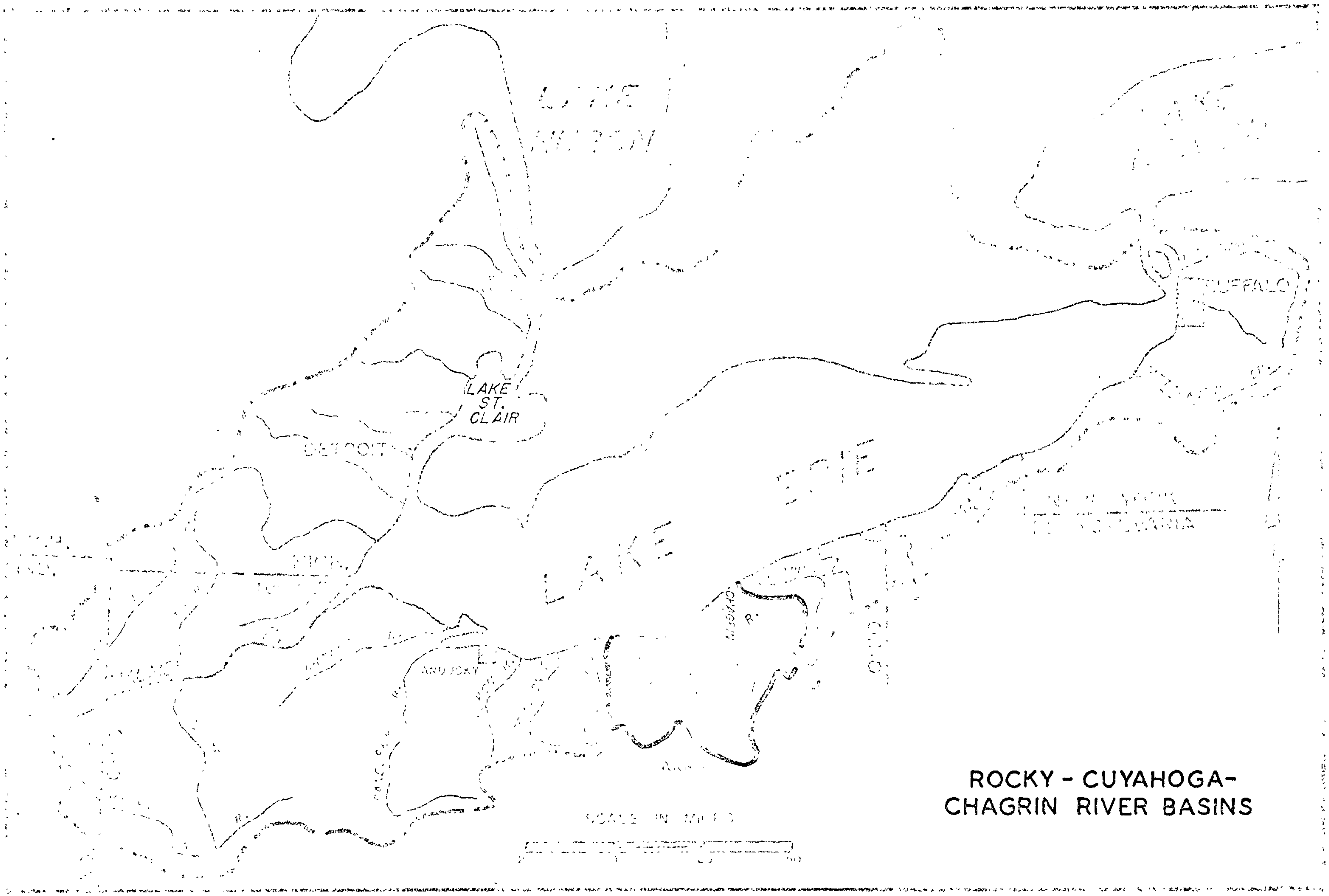

ROCKY - CUYAHOGA-
CHAGRIN RIVER BASINS
LAKE ERIE
LAKE ST. CLAIR
BUFFALO
SCALE IN MILES

FIGURE 6-1

CHAPTER 6 - GREATER CLEVELAND-CUYAHOGA

AREA DESCRIPTION

The Greater Cleveland-Cuyahoga River Basin consists of the Rocky, Cuyahoga, and Chagrin Rivers. These three rivers drain an area of 1,492 square miles in and around the Greater Cleveland and Akron areas. The 1960 populations of these two cities were 876,000 and 290,000 respectively and the total population in the Basin was 2,270,000.

Except for its upper reaches, much of the Greater Cleveland-Cuyahoga Basin is highly urbanized. Cleveland and Akron with their expanding suburban communities occupy large sections of the Basin.

The Cuyahoga River rises in the farm lands of Geauga County and meanders for 103 miles through gorges and flat lands into the central basin of Lake Erie. Its network of tributaries drains an area of 813 square miles. The fall of the upper Cuyahoga River is 9 feet per mile in a shallow channel cut through glacial drift. At Cuyahoga Falls, the river falls 220 feet in 1.5 miles through a sandstone gorge. The lower Cuyahoga River flows through a wide preglacial valley with a fall of 6 feet per mile until it reaches the navigation channel in Cleveland.

The Rocky River forms as two branches in rural Medina County and drains an area of 294 square miles. The East Branch forms near Hinckley and the West Branch near Medina. The two branches converge below Berea and flow 12 miles through the western edge of metropolitan Cleveland to Lake Erie. Approximately 30 miles of this river system flow through the Cleveland Metropolitan Park.

The Chagrin River drains an area of 267 square miles with a population of 158,000. Its headwaters rise in rural Geauga County near Chardon. The river flows southwesterly to Chagrin Falls where it is joined by the Aurora Branch. In Chagrin Falls the river crosses an escarpment and falls over 100 feet before flowing north to Lake Erie through the eastern fringe of the suburban Cleveland area.

Hydrology

Precipitation averages 34 inches a year with a fairly uniform distribution throughout the year. The Cuyahoga River provides the highest safe yield of runoff per square mile of any Ohio stream flowing into Lake Erie. Low flow (flow equaled or exceeded 90 percent of the time) in the upper Cuyahoga is fairly high; 18.9 cfs at Hiram Rapids, 30.5 cfs at Kent, 71.0 cfs at Old Portage below Akron, and 90.0 cfs at Independence above Cleveland. Streams tributary to the Cuyahoga below Akron have little sustained flow during dry weather and some go dry part of the year. Tinkers Creek, Brandywine Creek, Mud Brook, and Big Creek are exceptions.

Three reservoirs above Kent with a total capacity of 10 billion gallons furnish Akron with water from the Cuyahoga. Six mgd are available from the 2.3 billion gallon Mogadore Reservoir on the Little Cuyahoga River in Akron. Through maximum development of reservoir sites in the Basin, the present safe yield at Independence could be tripled.

Ground water yields of over 100 gpm are found only in isolated areas of the Basin. Ground water use is significant in the Akron and Cuyahoga Falls area.

Although run-of-the-river dams are located on both branches of the Rocky River, the discharge of wastes from 15 sources supply the greatest part of the dry weather flow. The low flow at the United States Geological Survey gage at Berea is 6.4 cfs.

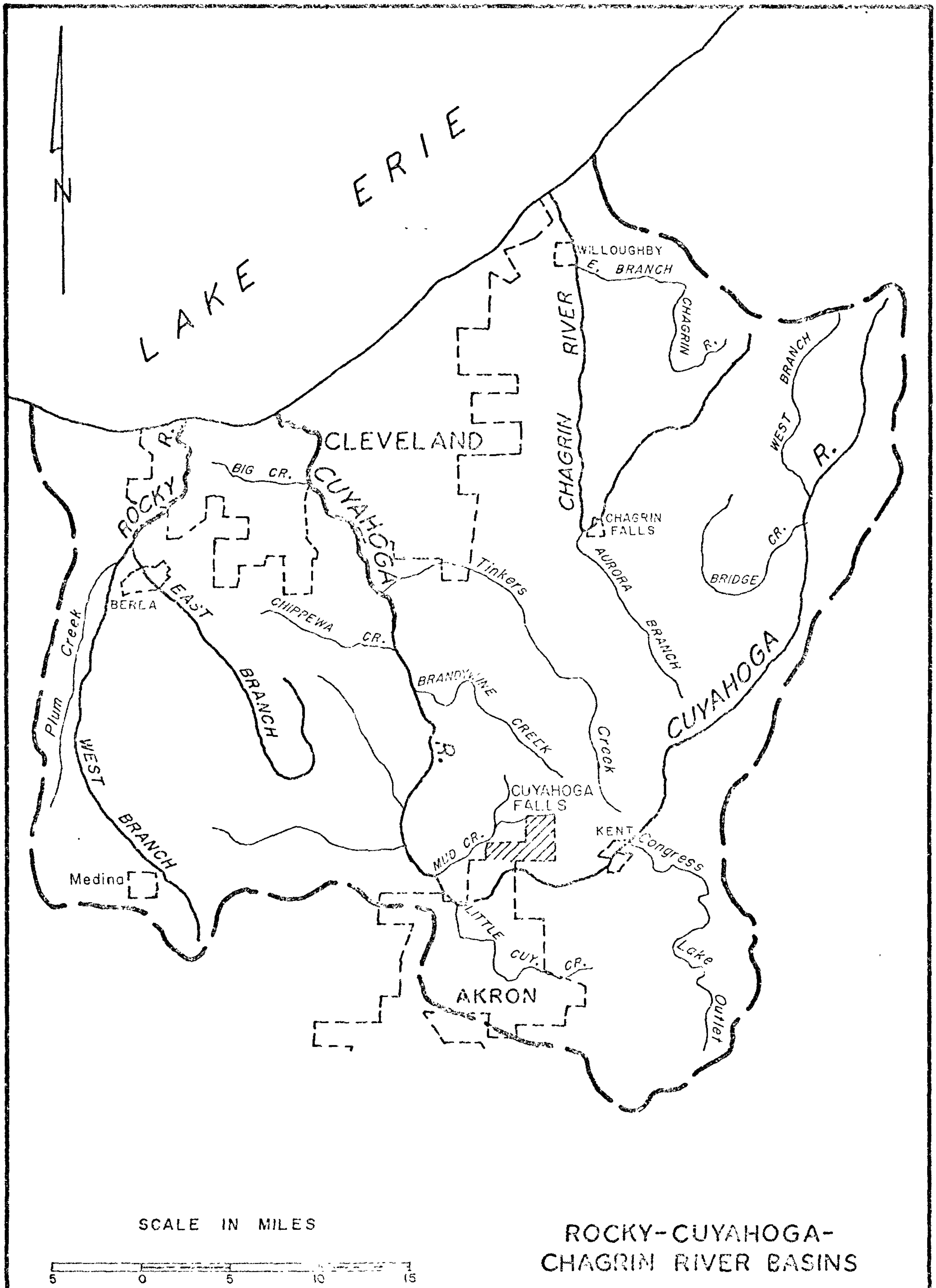
There are no major water developments on the Chagrin River. The river has a relatively high dry weather flow of 0.110 cfs/sq. mi. or 27.7 cfs which results in part from ground water discharge from sandstone outcrops throughout the Basin.

Economy

Although the Greater Cleveland-Cuyahoga Basin contains only 5 percent of the land in the Lake Erie Basin, its 2.3 million people represent 20 percent of the total population. Twelve municipalities within the Basin each have populations of 50,000 or greater. A steady growth pattern since 1900 indicates that by the year 2020 the population of the Basin will have climbed to six million.

The economic growth expected within the Basin should follow the increasing population. The Cleveland area is one of the great steel producing and fabricating areas in the country, and Akron supplies 75 percent of the world's rubber needs. In addition to these two industries, automotive manufacturing and chemical industries play a large role in the economy of the Basin. These industries and others account for over 600,000 jobs. The Value Added by Manufacture in the Basin is over three billion dollars.

Besides industry's contribution to the economy of the Basin,



ROCKY-CUYAHOGA-
CHAGRIN RIVER BASINS

FIGURE 6-2

agriculture is still important. Dairy products are important in Geauga County, and Cuyahoga County is a leading county in Ohio for vegetable, nursery, and greenhouse products. The cash receipts from the sale of agricultural products in the Basin is estimated at 30 million dollars annually.

WATER USES

Municipal

From its headwaters, downstream to Lake Rockwell, the Cuyahoga River supplies 50 mgd to the City of Akron's municipal water supply system. At Cuyahoga Falls, the river recharges that city's well water supply during periods of high flow. Wells supply 8 mgd of the municipal water supply in the Cuyahoga subbasin. Medina and Berea are the only municipalities using the Rocky River for water supplies. They each use an average of 1.7 mgd. The City of Cleveland, which obtains its water from Lake Erie, supplies 22 mgd to municipalities within the Rocky River subbasin. Only one municipality, Willoughby, depends upon the Chagrin River for its municipal water supply. It uses an average of 1.9 mgd. The City of Cleveland supplies 7.9 mgd of the 10.4 mgd municipal water demand in this subbasin. Wells supply only 0.6 mgd in the Chagrin River subbasin.

Lake Erie is the most significant source of municipal water supplies in the Greater Cleveland-Cuyahoga Basin. Cleveland's four water filtration plants supply an average of 204 mgd from Lake Erie to most communities in Cuyahoga County and some outlying ones.

Rural

Rural water use in the Greater Cleveland-Cuyahoga Basin amounted to 17 mgd in 1955. Golf course watering accounted for over 9 mgd of the total.

Industrial

In the upstream portion of the Cuyahoga subbasin, industrial well fields tap underground supplies for 18 mgd in Akron. Surface water meets an additional 180 mgd industrial demand in this portion of the subbasin. Between Akron and the navigation channel in Cleveland, 120 mgd are withdrawn for industrial use. Water supplied from the navigation channel of the Cuyahoga River is 300 mgd. This cannot be directly attributed to river yield since the water levels in this section are determined by lake elevations. The Chagrin River supplies 1.6 mgd of industrial water at Chagrin Falls.

Municipal water supplies are ample for industrial water needs in the remainder of the Basin. Cooling water for power generation is withdrawn from Lake Erie at Cleveland and Eastlake. The withdrawal is estimated at 723 mgd. Approximately 10 mgd of industrial water for other uses is also withdrawn directly from Lake Erie.

Waterborne Commerce

The Corps of Engineers, U. S. Army, reported that in 1962 over 16 million tons of cargo moved through the port of Cleveland. Iron ore and related materials for the steel industry, petroleum products, and materials for the chemical industry were the major types of cargo. The Cuyahoga River is dredged to a depth of 23 feet for a distance of 5.4 miles above its mouth to provide for navigation. There is no commercial navigation on the Rocky or Chagrin Rivers.

Recreation

The upstream sections of the Cuyahoga River are used for fishing and boating. This area supports many species of fish. Below Lake Rockwell, the species of fish become less desirable and the quantities decrease. Below Akron, to Lake Erie, the river is nearly devoid of aquatic life. Reaches of the river below Akron are unsuitable for any type of water recreation.

Along the Cleveland metropolitan lakefront there are 10 public beaches and several boat marinas. Because of the high microbiological densities in the nearshore zone, the city has adopted a "swim if you must" bathing beach program. Cuyahoga County has closed beaches in Rocky River because of pollution.

The Rocky River flows through Cleveland Metropolitan Park from near the Cuyahoga County line (on the East Branch) to Lake Erie where extensive recreational use is made of the river. Two marinas are located near the mouth of the river. Hinckley and Lester Lakes afford good recreational sites upstream.

Recreation in the Chagrin River is limited to fishing and boating. Three boat clubs and four marinas are located in the mouth of the river. Facilities are at present rather poor but anticipated construction by the U. S. Army Corps of Engineers will improve navigation conditions for pleasure boating. Fishing is good throughout the length of the river and its tributaries.

Esthetics

Debris-filled, oil-slicked, dirty-looking waterways are not pleasant. One or more of these terms defines the Cuyahoga River at any place along its course. Some reaches are blocked completely by dead trees and stumps, while the banks are dotted with many small dumps. Trash, ranging from tin cans to refrigerators, is a common sight in the river. In the navigation channel, where the Cuyahoga flows through Cleveland, even more debris exists, and the water surface often becomes black with oil or sulfides from the industrial outfalls. As long as these situations remain, the Cuyahoga will be a liability to the cities and adjacent property owners which it serves.

Debris is the biggest esthetic problem on the Cleveland lakefront. It is also a navigation hazard. The discolored water and floating debris, particularly behind the Federal Breakwater, have reduced the esthetic value of the lakefront. The visual nuisances consist of discarded lumber, tree limbs, metal cans, paper products, dead fish, oil-slicks, grease, and scum. Debris-littered beaches are also found near the mouth of the Chagrin and Rocky Rivers.

Since much of the lower Rocky River flows through a well-used Metropolitan Park, the poor esthetic character of the stream reduces the park's value as a recreational area. Debris and floating fecal solids have been observed at numerous locations. During the summer, the water is a deep green color due to blue-green algal blooms. When flow is low, the lower 15 miles of the stream often reek with the characteristic odor of septic sewage. The problem is particularly severe below the Berea municipal sewage treatment plant.

The esthetic value of the Chagrin River is impaired by multi-colored dye discharges in Chagrin Falls and municipal refuse dumps along the river banks in Willoughby and Eastlake.

SOURCES OF WASTES

Municipal

There are 892,000 people served by 18 secondary treatment plants and 31,000 people served by 6 primary plants which are tributary to the Cuyahoga River. Thirty-five thousand people in organized communities are not served by any central treatment plant. Cleveland's Southerly Sewage Treatment Plant and Akron's Water Pollution Control Station together treat the wastes from 826,000 people. The waste load discharged by the 18 secondary treatment plants is 24,000 pounds of BOD_5 per day. This is equivalent to a raw sewage load from 142,000 people. The discharge from the six primary plants is 3,300 pounds of BOD_5 per day.

There are 12 secondary treatment plants serving 63,000 people and one small primary plant tributary to the Rocky River. Twenty-six thousand people in organized communities are not served by any central treatment plant. The waste load discharged to the Rocky River is 1,400 pounds of BOD_5 per day. This is equivalent to the raw sewage of 8,000 people.

There are 8,000 people served by two secondary treatment plants and 28,000 people served by one primary (intermediate) plant which are tributary to the Chagrin River. The waste load discharged to the Chagrin River is 2,900 pounds of BOD_5 per day. This is equivalent to the raw sewage of 17,000 people.

Lake Erie, which is the most important source of water supply in the Basin, is also the most used for a municipal waste disposal. Cleveland Easterly Sewage Treatment Plant is the only lakeshore secondary treatment plant in this Basin. It serves 604,000 people and discharges 19,000 pounds of BOD_5 per day to Lake Erie. Four primary sewage treatment plants serve 406,000 people and discharge 49,000 pounds of BOD_5 per day to Lake Erie. This is equivalent to the raw sewage of 288,000 people.

Industrial

There are 41 industrial operations of 30 industries under permit to discharge wastes to the Cuyahoga River. These industries range from small packing houses with overflowing septic tanks to three "giants" of the steel industry, which each discharge an estimated 20 mgd of waste water to the navigation channel.

Only two metal plating industries are under permit by the Ohio Department of Health to discharge directly to the Rocky River. Five industries discharge to the Chagrin River, and three industries (one is a power plant) discharge directly to Lake Erie.

In addition to the 40 industries under permit to discharge wastes directly to the waters of the Basin, there are 20 industries discharging to storm sewers in Cleveland's eastern suburbs. Also, not one of the industries in Akron is under permit by the Ohio Department of Health for their direct discharges to the Cuyahoga River and its tributaries.

Data on industrial waste discharges in the Greater Cleveland-Cuyahoga Basin is now being collected and evaluated. To this date only one industry, Republic Steel's Bolt and Nut Division and Cleveland District Plants, has made its waste discharge data available to the Federal Water Pollution Control Administration for study.

Land Runoff

A substantial portion of the City of Cleveland is served by a combined sewer system. This system collects both sanitary and storm waters, and is designed to discharge overflows to the nearest watercourse. Combined sewers are tied together with interceptor sewers to collect the dry weather sewage flow and transport it to sewage treatment plants. Some allowance is made for increased flow due to storm waters. Overflow structures are provided at most junctures between the combined sewers and the interceptor sewer so that heavy storm water flow may continue to pass directly to the nearest watercourse.

The City of Cleveland has approximately 383 combined sewer overflow structures. During periods of storm runoff, they discharge raw sewage and industrial wastes, mixed with storm water, directly to Lake Erie and to streams which flow through Cleveland. 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. Plugged and defective overflow structures or sewers continuously discharge wastes which are not diluted by storm water. These malfunctioning devices are responsible for a large portion of the pollution from combined sewers.

EFFECTS OF WASTES ON WATER QUALITY AND WATER USES

DO-BOD Relationships

There are large dissolved oxygen deficits below Kent, Stow and Akron, and in the navigation channel in Cleveland. During 1964, oxygen concentrations downstream from Kent's treatment plant ranged from a high of 9.2 mg/l in the winter to a low of 0 mg/l in the summer with a yearly average of 2.4 mg/l. The average dissolved oxygen below Akron's Water Pollution Control Station was 3.3 mg/l and the range was from 7.6 to 0.4 mg/l. In the navigation channel, which is below Cleveland's Southerly Treatment Plant and amid the industrial complex, values ranged between 0.0 mg/l and 1.2 mg/l with a yearly average of 0.2 mg/l. The usually accepted minimum dissolved oxygen range for most water uses is between 3.0 and 5.0 mg/l. Accompanying the oxygen concentrations in these areas are BOD_5 concentrations that average 10.2 mg/l, 11.3 mg/l and 8.9 mg/l respectively. Because of these conditions, the water cannot support most forms of aquatic life.

Dugway Brook and Ninemile Creek on Cleveland's east side were sampled several times in 1963 and 1964 and showed indications of gross pollution. The dissolved oxygen concentrations in both creeks were generally zero and the BOD_5 concentrations varied from 9 to 30 mg/l. The stream was septic when sampled in 1963 following precipitation, but not in 1964 when no precipitation occurred before sampling.

From municipal sewage, the organic load to the Rocky River had depleted the oxygen concentration at mile point 2.9 to below 4 mg/l 50 percent of the time during the summer. Waste discharges above the confluence of the branches created only local areas of pollution. Average BOD_5 concentrations remained above 4 mg/l below Berea's sewage treatment plant.

No dissolved oxygen depletions were found in the lower Chagrin River. Except for esthetic complaints, the water quality is little impaired.

Microbiology

Bacterial pollution of the Cuyahoga River exists from Rockwell Dam to its mouth. Median total coliform values per 100 ml range from a low of 9,200 organisms per 100 ml at Rockwell Dam to a high of 470,000 organisms per 100 ml at the head of the navigation channel. The fecal coliform to fecal streptococcus ratio is greater than 1:1 at all sampling stations and reaches a maximum of 10:1, indicating a human origin of the microbes. The enteric pathogen study conducted in the Cleveland reach of the river revealed 14 different species of *Salmonella* organisms. *Salmonella* was detected 65 percent of the times sampled. These human pathogens are transmitted almost exclusively by fecal contamination of water, food, or milk.

In order to determine the effect of storm water overflows, sampling stations were established above and below an overflow on Euclid Creek. The total coliform density was 770,000/100 ml above and 5,000,000/100 ml below the outfall. Comparing these counts to the 2,200/100 ml obtained in the 1963 survey during dry weather gives an indication of the effect storm water overflows have on streams such as Euclid Creek.

Discharges from sewage treatment plants, storm water overflows, and ditches carrying septic tank drainage are causing high densities of bacterial organisms in the Rocky River. The routine and special studies on the main stem of the Rocky River above the lake-affected area showed fecal pollution which impairs the water use for recreation. Maximum total coliform densities ranged from 55,000 to 1,000,000 organisms per 100 ml at the stations sampled.

Biology

In the impounded waters of the Cuyahoga River above Kent, and between Kent and Akron, there is a prolific growth of algae and aquatic weeds which create a nuisance condition and degrade the esthetic value of the river. Decomposition of these growths which are nourished by the effluents from the sewage treatment plants of Ravenna, Kent, and Stow exert an oxygen demand on the river.

The waters flowing from Lake Rockwell support clean water communities of bottom-dwelling animals, but are rapidly degraded below this point. Between Kent and the river mouth only pollution tolerant forms of bottom organisms were found. In the lower Cuyahoga, conditions were so severe that even the most tolerant forms were totally absent.

The nutrients from the upstream sewage treatment plants on the Rocky River fertilize the impounded areas of the stream to such an extent that large algal blooms develop during the summer months. The rooted aquatics increase correspondingly. This plant life causes nuisance problems in the Metropolitan Park, as well as taste and color problems in the Berea water supply. Show-flowing and stagnant pools in the river provide ideal breeding areas for mosquitoes which create a serious nuisance condition in the park and surrounding areas.

Phenols

Results of phenol determinations on the Cuyahoga River for 1964 illustrate a continual concentration increase from Rockwell Dam to Lake Erie. The average summer concentrations at Lake Rockwell were 1.8 µg/l, increasing to 7.2 µg/l above Akron, and 20.8 µg/l above Cleveland. In the navigation channel, the average was 58.0 µg/l and reached a maximum of 175 µg/l. Besides creating odor problems, phenols are toxic to many forms of aquatic life.

EFFECTS ON LAKE

At the Cuyahoga River-Lake Erie interface, dispersion or dilution of river water takes place. The dissolved oxygen values approach saturation, and other substances approach background concentrations of the Lake. Conductivity values at 30 harbor stations show no appreciable concentration gradients one-half mile beyond the breakwall.

Because of the large sewage treatment plants located along the Cleveland shoreline, it is difficult to trace bacterial pollution from the Cuyahoga into the Lake. Nevertheless, the fecal coliform to fecal streptococcus ratios in the harbor area range up to 30:1. This ratio decreases to below 1:1 at stations further from the shore.

The population of bottom-dwelling animals shows that the Lake is affected by Cleveland area pollution. Sludgeworms, which thrive on organic materials averaged 400,000 per square meter in the harbor. Numbers of organisms decreased between the harbor mouth and the two-mile contour, and no significant variation could be detected beyond this line.

The effect the Rocky and Chagrin Rivers have on Lake Erie is less significant than that of the Cuyahoga River.

CHAPTER 7 - NORTHEASTERN OHIO

AREA DESCRIPTION

The Northeastern Ohio Basin covers an area 1,208 square miles, of which 86 percent is in Ohio, the remainder in Pennsylvania. The principal tributaries to the Lake in this area are the Grand River, the Ashtabula River, and Conneaut Creek (Figure 7-1).

The Grand River is the largest stream draining an area of 712 square miles. Its headwaters are in Geauga County and it flows for 98 miles to Lake Erie at Fairport Harbor. The average fall of the river is 5.6 feet per mile through gently rolling terrain.

The Ashtabula River, draining 137 square miles, originates in Ashtabula County as two branches. The East and West Branches flow for 12 miles where they join to form the main stem. The river continues, at an average fall of 11.6 feet per mile for another 28 miles, flowing into Lake Erie at the City of Ashtabula.

Conneaut Creek, draining 191 square miles, originates in Crawford County, Pennsylvania. It flows north through Pennsylvania for 25 miles, then west for 20 miles through Pennsylvania and Ohio. Here it makes a sharp bend and flows in a northeasterly direction for 13 miles to Lake Erie at Conneaut, Ohio. The average fall of Conneaut Creek is 11.3 feet per mile.

These Northeastern Ohio streams rise in the glaciated Allegheny Plateau province and flow across a narrow band of Lake Plains sub-province into the Lake. The two provinces are divided by an escarpment through which the Ashtabula River and Conneaut Creek have cut deep, steep-walled gorges. The Grand River, however, flows across the escarpment through a broad valley. The terrain is undulating throughout the Northeastern Ohio Basin.

The soils of the glaciated plateau are heavy till soils of the Mahoning Trumbull family. In the Lake Plain, the soils are generally clay and relatively heavy. The soils and overburden of glacial till are of low permeability and contain little ground water to supplement dry weather flow. Sustained flow in these streams is very low as shown by the flows tabulated as follows:

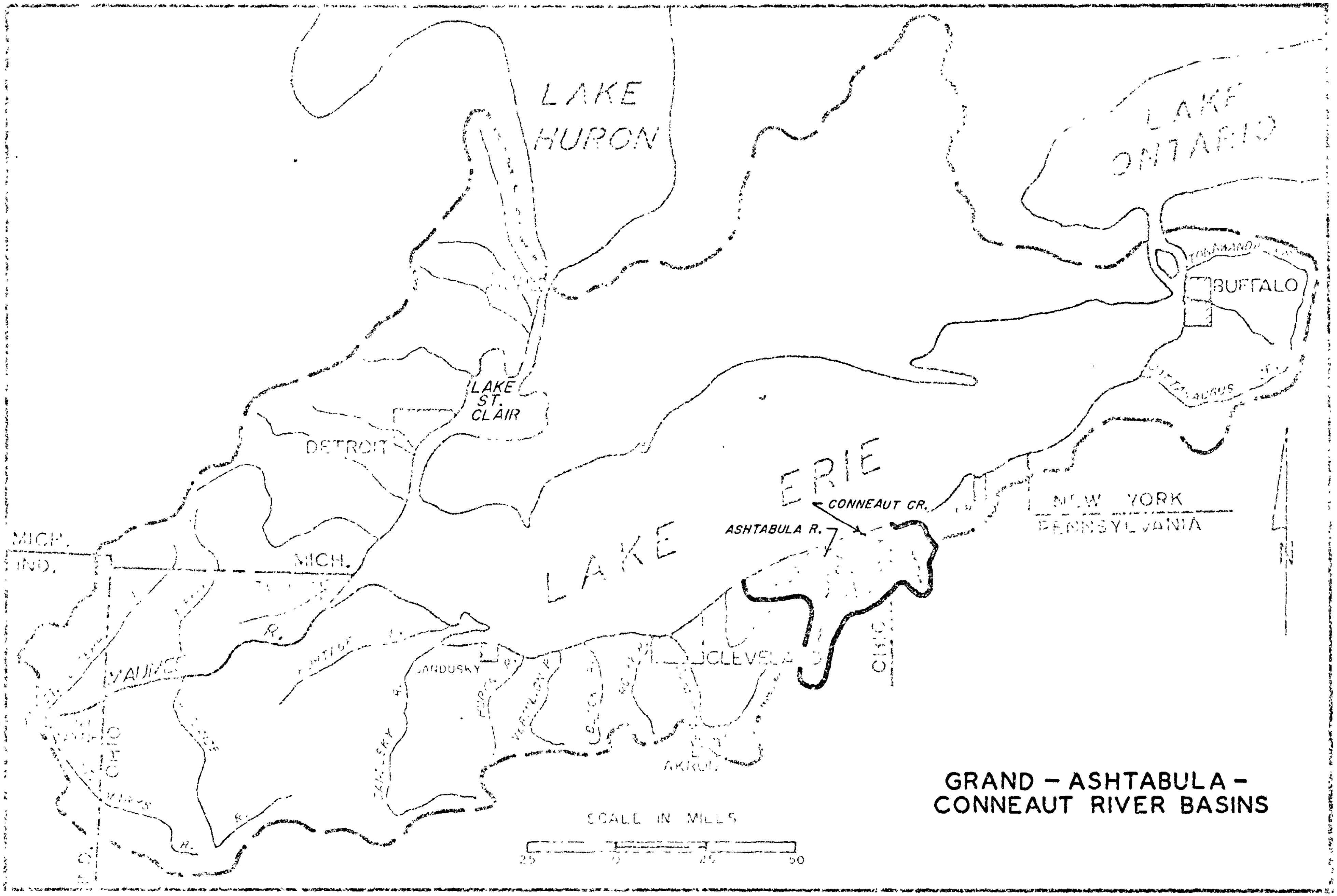

LAKE HURON
LAKE ONTARIO
BUFFALO
LAKE ST. CLAIR
DETROIT
LAKE ERIE
CONNEAUT CR.
ASHTABULA R.
NEW YORK
PENNSYLVANIA
OHIO
MICH.
IND.
MAUMEE
SANDUSKY
CLEVELAND
AKRON
SCALE IN MILES
25
0
25
50
N
GRAND – ASHTABULA –
CONNEAUT RIVER BASINS

FIGURE 7-1

NORTHEASTERN OHIO STREAM FLOWS

Stream	Location	Drainage Area (Sq. Miles)	Period of Record (Yrs.)	Yield* (cfs)
Grand River	Madison	587	30	9.50
Ashtabula	Ashtabula	118	27	0.21
Conneaut	Amboy	178	18	5.60

*Flow equaled or exceeded 90 percent of the time

Economy

The area in the Basin is 86 percent rural. The population of approximately 180,000 is concentrated in Lake County or along the lakeshore. The largest population centers in the Basin are Painesville, Ashtabula, and Conneaut (Figure 7-2) with populations of 16,000, 25,000, and 11,000 respectively.

Painesville, Ashtabula, Conneaut, and Fairport Harbor are all areas of large industrial activity. The production of chemicals and allied products is the principal industry. The Value Added by Manufacture (VAM) in 1962 was 264 million dollars for Lake and Ashtabula Counties combined.

Agriculture in the Northeastern Ohio Basin is quite diversified. In 1962, cash receipts from agriculture totaled as estimated 24 million dollars. Dairy, greenhouse, and nursery products accounted for half of this total. Ashtabula County in 1962 ranked second among Ohio counties in cash receipts from sale of dairy products. Lake County ranked first among Ohio counties in cash receipts from the sale of greenhouse and nursery products.

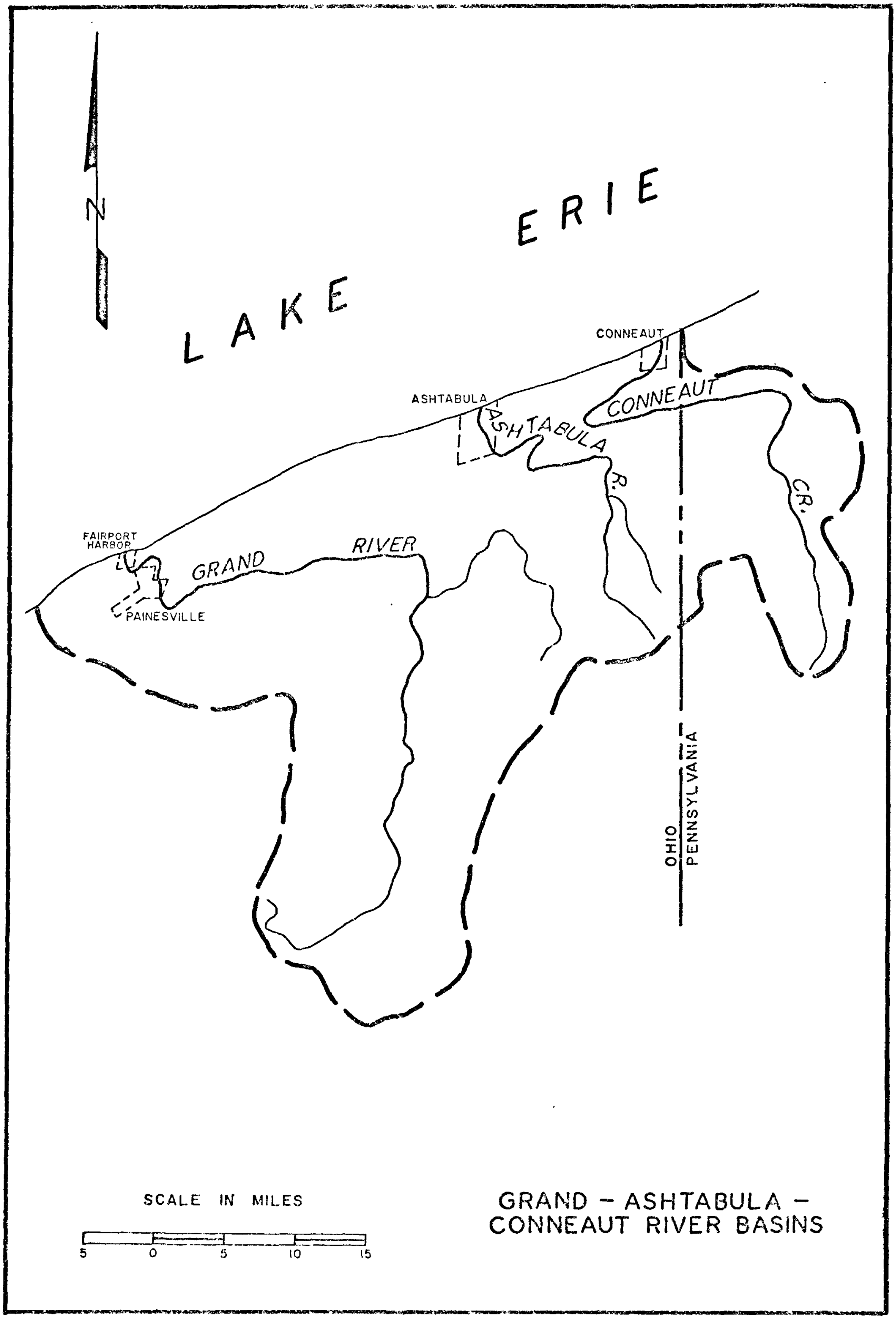
The commercial centers of Northeastern Ohio are Fairport Harbor, Ashtabula, and Conneaut. In 1962, these ports handled 11 percent of the total Lake Erie tonnage.

The Port of Conneaut, at the mouth of Conneaut Creek, and Fairport Harbor, at the mouth of the Grand River, each handled 3.1 million tons of cargo in 1962, and ranked eighth and ninth respectively in tonnage handled on Lake Erie. The Port of Ashtabula, at the mouth of the Ashtabula River, handled 9.0 million tons of cargo, ranking fifth among Lake Erie ports.

WATER USES

Municipal

Lake Erie provides 12.7 mgd or 83 percent of the municipal water



GRAND – ASHTABULA – CONNEAUT RIVER BASINS

FIGURE 7-2

supply in the Basin. Only two communities, Geneva and Jefferson, withdraw municipal water from inland surface streams. These communities, located in the Grand River Basin, withdraw 0.9 mgd from the Grand River and 0.25 mgd from Mill Creek respectively. Only 1.43 mgd of municipal water supplies are taken from wells.

Industrial

Industrial water use in the Northeastern Ohio Basin totaled 290 mgd in 1955 and water used in thermal power generation totaled 540 mgd. Primary metals industries used 180 mgd; chemical and allied products industries used 110 mgd. Lake Erie furnished 98 percent of the industrial water in the Basin. Sixty-six percent was used by industries in Fairport Harbor. Cooling water accounted for 93 percent of industrial water usage.

Shoreline Recreation

There are five main shoreline recreation areas in Lake County and four in Ashtabula County: Mentor Twp. Park, Headlands State Park, Fairport Beach, Painesville Twp. Park, Madison Twp. Park, Geneva-on-the-Lake, Geneva Twp. Park, Walnut Park, and Conneaut Twp. Park. These beach areas are used for swimming, boating, water skiing, and fishing, and serve the people of Greater-Cleveland as well as local residents. The beaches have replaced the Cleveland lakefront as recreation centers owing to the latter's heavy pollution.

PRINCIPAL SOURCES OF WASTE

Municipal

Nine municipalities with a total population of 71,000 (1960 census) treat their wastes. These major communities and the smaller ones (under 1,000 population) discharge 8,000 pounds of BOD_5 per day. The population equivalent (PE) of this discharged waste load based on 0.167 pounds of BOD5 per person per day is 46,000. A tabulation of loads and types of treatment is presented in Table 7-1. All nine of these communities are served by sewer systems that keep separate sanitary wastes from storm waters.

In addition to the load discharged by these treatment plants, a population of approximately 20,000 discharge domestic sewage (3,000 pounds of BOD_5 per day) into septic tanks.

TABLE 7-1

NORTHEASTERN OHIO
PRINCIPAL MUNICIPAL WASTE DISCHARGES

Community	Treatment	Estimated Sewered Population	Population Equivalent*		Loads per day BOD_5	
			Raw	Discharged	Raw	Discharged
Grand River						
Fairport Harbor, Ohio	Primary	4,267	3,110	2,090	519	349
Painesville, Ohio	Primary	16,115	16,300	10,700	2,720	1,790
Chardon, Ohio	Secondary	3,155	3,630	755	606	126
Jefferson, Ohio	Secondary	2,115	1,980	250	331	42
Ashtabula River						
Conneaut Creek						
Albion, Pa.	Secondary	2,200	2,200	330	367	55
Minor Lake Tributaries						
Madison, Ohio	Secondary	1,345	1,470	285	245	48
Geneva, Ohio	Secondary	5,675	5,380	2,160	90	36
Direct to Lake						
Ashtabula, Ohio	Primary	28,738	32,000	19,800	5,340	3,310
Conneaut, Ohio	Primary	10,557	14,500	9,250	2,420	1,540

* Population equivalent based on 0.167 pounds of BOD_5 per day per capita

Industrial

There are 26 industries located in Northeastern Ohio. Three of these industries discharge their wastes directly into Lake Erie. The remainder discharge wastes to inland surface streams. For example, Fields Brook, a tributary of the Ashtabula River, receives wastes from nine of the industries in the Ashtabula area. Other major industrial areas are near Painesville and Fairport Harbor.

Chemical and allied products are the principal industries of Northeastern Ohio. The wastes from these industries are mainly inorganic solids, predominantly chlorides.

Discharges from the metal finishing operations in the Basin are small compared to those of the chemical industries, but the wastes are extremely toxic. They consist of acid and alkaline, phenolic or other solvents, cyanide, chrome, and other heavy metals which are being treated or used for plating.

EFFECTS OF WASTES ON WATER QUALITY & WATER USE

Grand River

The lower three miles of the river are brightly colored, with hues ranging from bright green or yellow to black. The green and yellow colors result from chemical discharges, but the black color has been attributed to boiler fly ash discharges. The banks of the river in this section are covered with white sediment from chemical discharges.

Chloride concentrations of 3,620 mg/l and 5,260 mg/l were found during the summer and fall of 1964 respectively at mile point 2.3. This station is below the discharges of several chemical industries. Above the station, chloride concentrations during the same seasons were 40 mg/l and 44 mg/l respectively.

Total solid concentrations in the Grand River also increased below the chemical industries. The average concentration during the summer increased from 314 mg/l at mile point 5.3 to 5,280 mg/l at mile point 2.3. Total dissolved solids averaged 4,710 mg/l during this period.

Median total coliform densities within the river were always below 10,000 organisms per 100 ml except below the Fairport Harbor and Painesville sewage treatment plants. At these locations, the median values were 67,000 organisms per 100 ml during the summer, 1964 and 150,000 organisms per 100 ml during the fall. Total coliform densities were less than 1,000 organisms per 100 ml at the mouth of the river and did not indicate a great health hazard. There were no dissolved oxygen problems in the chemically polluted Grand River; the highest seasonal BOD was only 5.0 mg/l.

Between Painesville and the river mouth, bottom-dwelling organisms were limited to pollution tolerant sludgeworms and bloodworms.

Ashtabula River

At mile point 3.3 and above, the water is of excellent quality. The lowest dissolved oxygen concentration found was 6.6 mg/l. Seasonal BOD_5 averages were below 2.9 mg/l during 1964. The highest total dissolved solids' seasonal average was 332 mg/l and the highest seasonal average chloride concentration was 42 mg/l. Even though mile point 3.3 is within the center of Ashtabula, the seasonal median total coliform densities were always under 7,900 organisms per 100 ml and under 750 organisms per 100 ml in the winter and spring.

Median total coliform densities of 43,000 and 250,000 organisms per 100 ml were found at mile point 0.7 during the summer and fall, 1964. Since Ashtabula has a separate sewer system, these values may represent vessel pollution.

An enteric pathogen study at mile point 0.7 during the first three months of 1964 revealed only one organism. No enteric pathogens were found at mile point 5.5.

Industrial pollution, which is so significant in the Grand River, is only minor in the Ashtabula River. The chemical and allied products industries at Ashtabula discharge their wastes into a large marshy area of Fields Brook. The marsh acts as a treatment lagoon for the wastes, but creates a severe local problem.

BOD_5 and dissolved oxygen were not major problems in the lower portion of the Ashtabula River. The dissolved oxygen concentration at mile point 2.3 was below 4 mg/l 25 percent of the time during the summer. The lowest concentration recorded was 1.2 mg/l. The BOD_5 average was 10 mg/l during October and November, 1964. Both of these conditions existed during the extremely low flows of 7 cfs during the summer and 3 cfs during October and November of the same year.

Conneaut Creek

Biological investigations made in 1963 revealed bottom sediments of rock, sand, and silt in the harbor and outside the breakwall; the river bottom consisted of gravel, rubble, and silt. Benthic organisms in the harbor were fingernail clams, snails, bloodworms, and sludgeworms; in the river, there were only sludgeworms. Outside the breakwall, pollution intolerant scud and snails were found.

Two secondary treatment plants in Pennsylvania constitute the only municipal waste discharges to Conneaut Creek. Their combined discharge is 60 pounds of BOD_5 per day.

A meat packing operation at Springboro, Pennsylvania, discharges approximately 140 pounds of BOD_5 per day to Conneaut Creek from a secondary treatment plant. Even though streamflow is low, the stream gradient near the headwaters of Conneaut Creek seem sufficient to prevent problems of low dissolved oxygen from developing in this reach of the stream.

EFFECTS ON LAKE

The total loading to Lake Erie from the Grand River was measured 2.3 miles above the mouth. The results showed that the following average pounds per day were being contributed during 1964.

Chlorides	2,200,000
Chemical Oxygen Demand	140,000
Biochemical Oxygen Demand	7,000
Total Solids	9,500,000
Phenols	75
NH_3 - N	1,358
NO_3 - N	2,610

The actual load was greater because an undetermined quantity of industrial wastes were being discharged to the river below this tributary loading station. The principal contributions of the Grand River to the Lake, however, consisted of total solids and chlorides.

Loads of the Ashtabula River to Lake Erie in pounds per day at the tributary loading station 3.3 miles from the mouth were as follows:

Chlorides	17,000
Chemical Oxygen Demand	14,000
Biochemical Oxygen Demand	13,000
Total Solids	170,000
Phenols	1
PO_4	55
NH_3 - N	78
NO_3 - N	230

Chemical data show that the Grand River exerts an influence on Lake Erie as far as two miles from the river mouth. Conductivity and COD data show that most of the river flow is out into Lake Erie through the entrance of the harbor. The conductivity and COD averaged 1,5[illegible]0 µmhos and 14.0 mg/l respectively at the mouth of the Grand River. At the entrance to the harbor, the respective averages were 594 µmhos and 12.2 mg/l. As far in the Lake as two miles from the river mouth, conductivity remained at about 360 µmhos, which is above the average of 290 µmhos for the Central Basin of Lake Erie. The COD at all stations except in the entrance to the harbor averaged between 10.2 mg/l and 11.5 mg/l. This is also above the average of 8.6 mg/l for the Central Basin of Lake Erie.

Chloride concentrations which were very high in the river averaged between 40 and 50 mg/l outside the breakwall and 107 mg/l at the entrance to the harbor.

Microbiological data show that median total coliform densities were below 660 per 100 ml in Fairport Harbor. Two miles into the Lake, the median total coliform density was 10 per 100 ml, which is the same concentration of total coliforms found offshore in this section of the Lake.

Two diffusion studies in Fairport Harbor revealed that, while the river water was approximately 6°C warmer than the Lake water, the density from the solids load carried by the river caused it to flow along the bottom of the Lake. This fact explains the sudden decrease in solids and chlorides concentration between sampling stations on the Grand River between mile points 2.3 and 0.7. It also explains the low total coliform densities which were found in surface samples of Fairport Harbor.

The Ashtabula River exerts an influence on the Lake as far as 1.5 miles from the river mouth, according to the chemical data. The average conductivity decreased from 440 µmhos at the river mouth to 315 µmhos at 1.5 miles from the mouth. This is somewhat above the average conductivity in the Central Basin of Lake Erie. COD showed the same decrease. The average COD at the river mouth was 10.9 mg/l; at 1.5 miles from the river mouth, the average COD was 9.3 mg/l, about equal to the average for the Central Basin.

The median total coliform densities decreased from 41,000 at Mile Point 0.7 to 150 organisms per 100 ml 1.5 miles into the Lake. Offshore from Ashtabula, total coliform values in Lake Erie were less than 1 organism per 100 ml 60 percent of the time. Within the harbor, median total coliform densities were below 1,500.

A median total coliform value of 2,800 organisms per 100 ml was found at the station offshore from the Ashtabula sewage treatment plant. The average COD concentration was 10.9 mg/l.

Generally, the shoreline of Lake Erie in eastern Ohio is of good bacterial quality.

CHAPTER 8 - PENNSYLVANIA

DESCRIPTION OF AREA

The Pennsylvania Basin (Figure 8-1) of Lake Erie includes the area from Twentymile Creek on the east to, but not including, Conneaut Creek on the west. The area comprises 384 square miles and is located within Erie County, Pennsylvania and Chautauqua County, New York. The Basin is 46 miles long and varies in width from 6 to 13 miles. The land rises from the lake in a steep bluff 100 to 200 feet high. This makes it generally inaccessible and unusable for recreation, with the notable exception of Presque Isle State Park, a seven-mile long sand and gravel peninsula at Erie. This peninsula encloses Erie Harbor, thus protecting it and making it an important lakeport.

The streams in this area have steep gradients as they descend from the uplands. Flow is considerably slower through the lake plain. Several streams drop over a steep bluff as they flow into Lake Erie, making fish migration impossible. Streams of importance are Crooked, Elk, Mill, Sixteenmile, Twentymile, and Walnut Creeks. In Sixteenmile Creek, flow has varied from 0.2 cfs (1951) to 9,710 cfs (1942). Average stream flow varied from 3 cfs on Ellicott Creek to 130 cfs on Elk Creek.

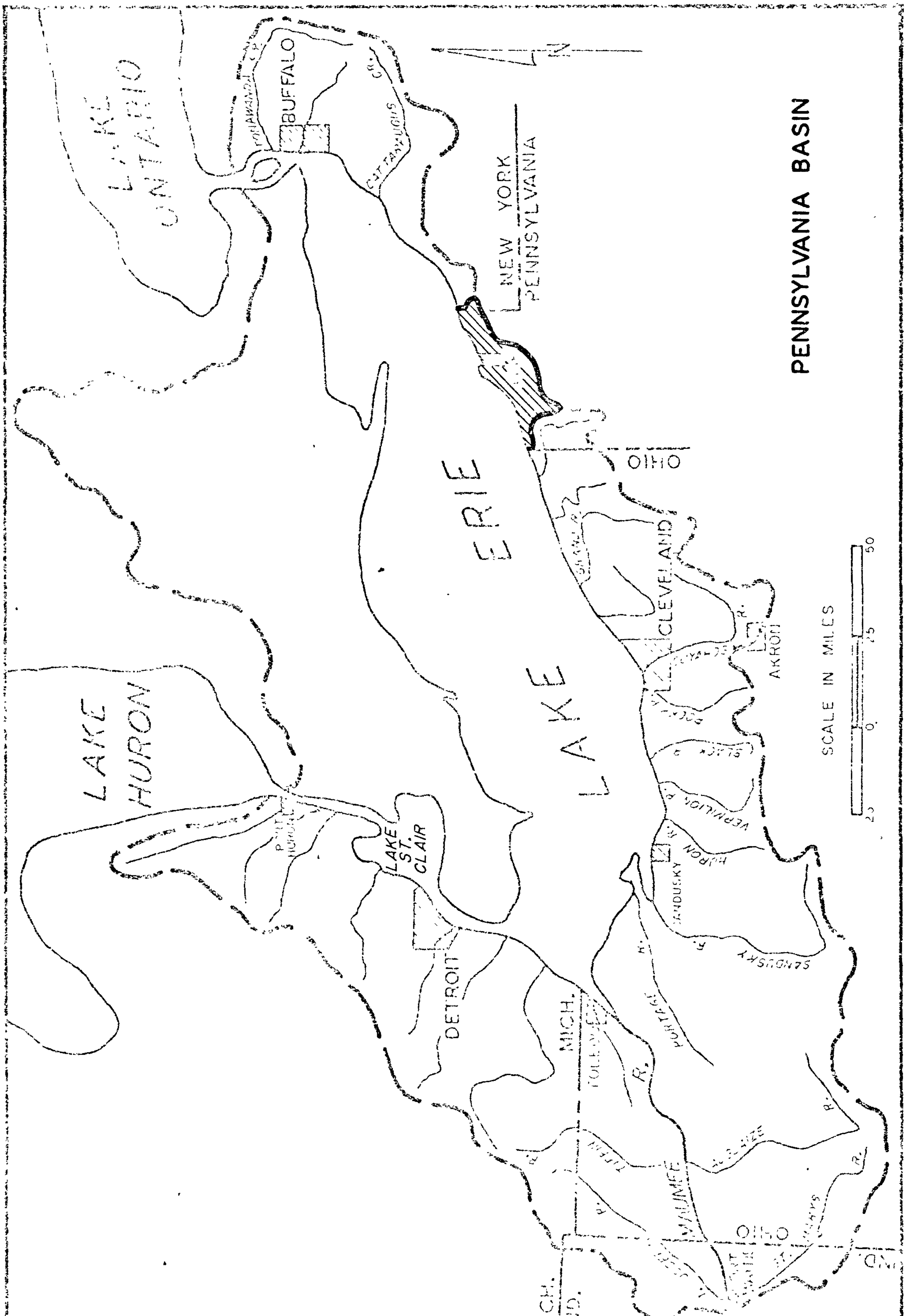
Erie (Figure 8-2), with a 1960 population of 138,000, is the third largest city in Pennsylvania. The Erie Metropolitan complex is Pennsylvania's fifth largest, with 219,000 people.

There is a variety of industrial production in this area. Over 200 manufacturers produce machinery, steel, paper, plastics, and other products. Erie's port facilities annually handle over six million tons of Lake shipping. Tourism is a rapidly developing industry. The lakefront, particularly Presque Isle State Park, attracts people from as far as Cleveland, Pittsburgh, and Buffalo.

WATER USES

Municipal and Industrial

The predominant source of water for both municipal and industrial usage is Lake Erie. The Lake supplies over 90 percent of domestic water supplies. The other 10 percent is supplied from reservoirs and shallow wells. Three major industries and a power plant maintain their own supply systems from the Lake. The City of North East has



PENNSYLVANIA BASIN
LAKE ONTARIO
BUFFALO
NEW YORK
PENNSYLVANIA
LAKE ERIE
OHIO
CLEVELAND
AKRON
SCALE IN MILES
25
0
25
50
LAKE HURON
LAKE ST. CLAIR
DETROIT
MICH.
IND.
MAUMEE
SANDUSKY

FIGURE 8-1

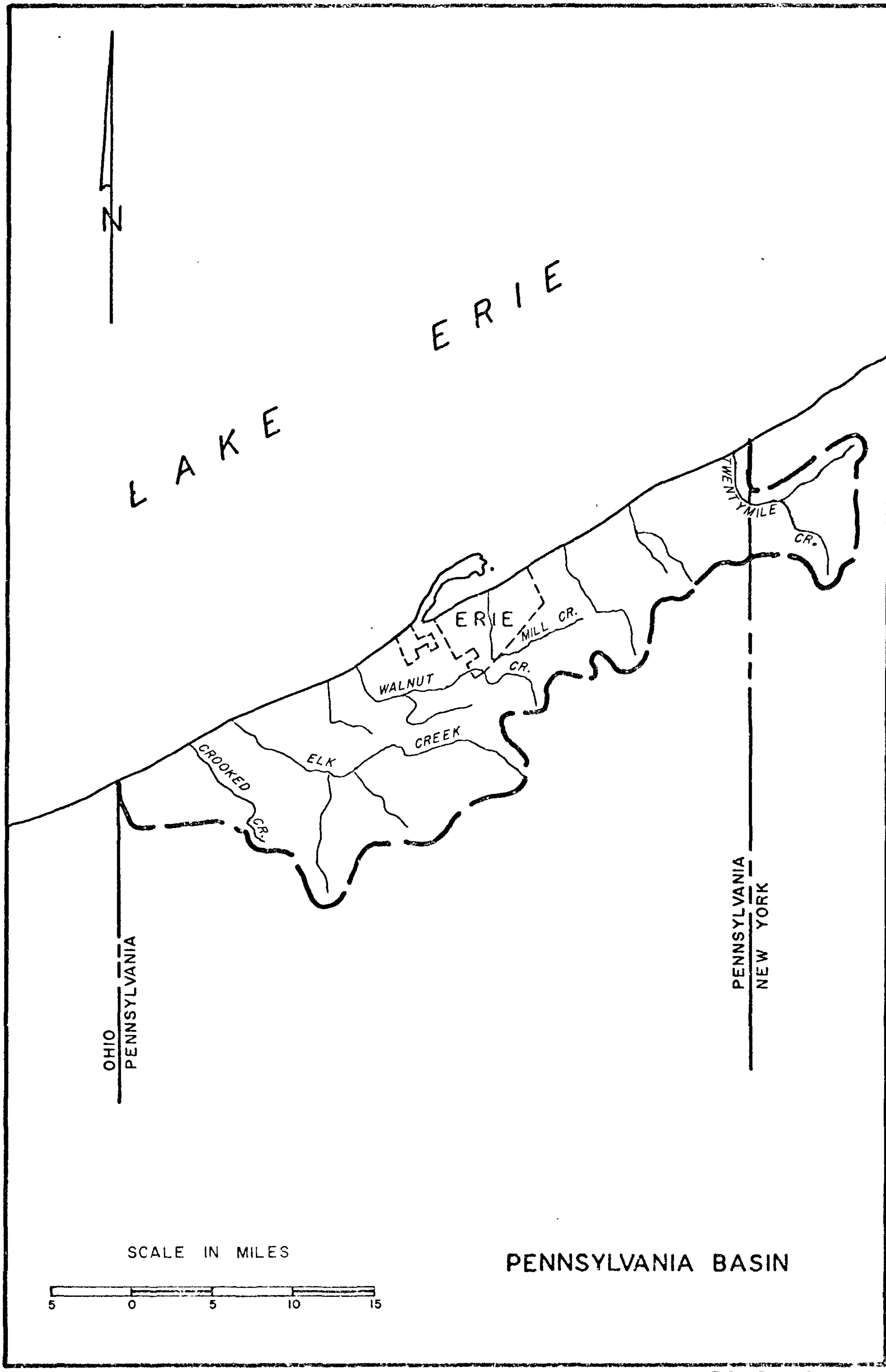

N
LAKE ERIE
ERIE
MILL CR.
WALNUT CR.
ELK CREEK
CROOKED CR.
TWENTYMILE CR.
OHIO
PENNSYLVANIA
PENNSYLVANIA
NEW YORK
SCALE IN MILES
5 0 5 10 15
PENNSYLVANIA BASIN

FIGURE 8-2

developed Sixteenmile Creek and French Creek (in the Allegheny River Watershed) for its water supply. Only 7,000 people in urban areas use ground water as their domestic water source.

Recreation

Other than water supply, the largest water use in the Basin is recreation. Swimming, boating, water skiing, fishing, and the esthetic enjoyment of clean water are available throughout most of the Basin. The nucleus of this development is Presque Isle State Park and Bay. Park attendance on a warm summer weekend is over 100,000 people. Between three and four million people visit the park annually. The recent completion of new roadways and other facilities will further stimulate this important water use. Higher development of adjacent beach areas to the east and west is expected.

Although there are only 4,400 boat registered in Erie County, the area is used extensively for pleasure boating. On a weekend in the mid-summer of 1962, the Pennsylvania Department of Fish and Game counted 12,000 boats in the lakefront area.

Fish and Aquatic Life

Excellent year-round fishing exists in many of the area's streams. Twentymile Creek, Trout Run, and Godfrey's Run are good trout streams. All other streams support fish life (from trout to suckers) except Sixteenmile Creek from Route 89 to Route 5, Cascade Creek, Mill Creek below West Thirtieth Street, and Garrison Run. Many fish of various types are taken from Presque Isle Harbor and all along the shore and into the Lake.

SOURCES OF WASTES

Municipal wastes, combined sewer overflows, and industrial waste are principal sources of discharge into the shore region. Other wastes, discharged intermittently, also have severe, though temporary effects. Among these are accidental spills from vessels or industries, wastes from lake vessels and pleasure crafts, and material from dredging operations.

Municipal

The major sources of municipal wastes are Erie, Girard, Lake City, and North East. All major treatment plants in this basin provide secondary treatment and remove an average of 85 percent of the organic loading. North East and Erie chlorinate their sewage treatment plant effluents. Lake City and Girard are enlarging their treatment plants and plan to include chlorination, as required by the State of Pennsylvania.

Bacterial tests of Mill Creek and Garrison Run indicate that they are receiving domestic wastes. Samples collected in the harbor off Mill Creek in 1964 revealed high coliform counts.

Combined Sewer Overflows

Lake City and North East have separate sewers for domestic wastes and stormwater runoff. Girard and Erie each have a combination of separate and combined systems. Erie's combined system exists mainly in the downtown area.

Industrial

One industry, Hammermill Paper Company, contributes 90 percent of the total oxygen demand loading to this area's water. This part of Hammermill's waste will soon be largely removed with the installation of deep well disposal. However, this will not alleviate the problem caused by the industry's discharge of tannins and lignins from spent pulping liquors. These wastes cause the water to foam, turn brownish black in appearance, and produce a strong stench.

Other industries having discharges with a more localized effect are Gunnison Brothers, Interlake Iron Corporation, General Electric, and Parker-White Metal. Noticeable quantities of oil and iron have been observed on Fourmile Creek.

EFFECTS OF WASTES ON WATER QUALITY AND WATER USES

Various communities along the lakefront have individual pollution problems. Generally, beaches to the west of Presque Isle have maintained good quality, while those to the east, including Beach 11 on Presque Isle, have at times been severely polluted. The pollution problems at the beaches have been both bacterial and esthetic.

Fish kills have occurred sporadically in the history of the lakeshore area and the various tributaries. The majority of the fish kills were caused by industrial waste discharges. Others have been caused by water temperature fluctuations. A combined effort by state and local officials, and wildlife organizations has helped to curb illegal industrial discharges.

Erie Harbor

As Erie Harbor is enclosed by Presque Isle and has only a small opening into Lake Erie, it is well protected and flow in and out is restricted. Water color in the harbor and well up the east shore is a deep brownish-tan, caused by pulp and paper wastes. Turbidity is relatively low in the harbor and is further reduced outside the harbor. Filamentous green algae (Cladaphora and Chara) can be found in most areas of the harbor where the depth is less than six feet.

Bottom deposits in the harbor are a brownish black combination of mud, silt, and detritus (including wood fiber). The harbor shows a wide variety of pollution intolerant benthic organisms, indicating that the paper mill wastes in the concentrations that normally enter the harbor are not toxic to bottom organisms. Much sport fishing takes place in the harbor which contains an adequate fish population.

Studies have shown that the part of Erie Harbor immediately along the downtown marina facilities and docks, and off Mill Creek, contains high coliform densities. They range from 1,000 to 500,000 organisms per 100 ml near Mill Creek and in the ship channel. The source of this pollution is probably Mill Creek, where coliform densities of over 1,000,000 organisms per 100 ml have been found and from other local sources of pollution. Enteric pathogen studies revealed Salmonella were isolated in both of these locations 80 percent of the times sampled. This same organism was found in Erie's sewage.

Lake Erie Shoreline

In many areas outside the harbor the Lake bottom is composed of coarse sand and rock. This, along with relatively fast offshore currents, prevents the accumulation of detritus or other materials on the bottom to the east of Hammermill. This habitat reduces the variety of bottom organisms that can be supported, but an assortment of clean water associated organisms have been found.

The Hammermill Paper Company's waste outfall is located just east of the mouth of Erie Harbor. With the prevailing winds in the area from the west, Hammermill's effluent affects the esthetic conditions of beaches and boating areas for 10 to 20 miles eastward. This line of foam and foul smelling colored water is commonly visible at Sixteenmile and Twentymile Creeks. This effluent hinders the development of the eastern portion of the Basin as a water supply and as a recreational area. Also, it reduces the usefulness of potentially valuable lakefront property. When the wind is from the east, these wastes make parts or all the beaches on Presque Isle unusable for water contact sports.

In addition to their adverse esthetic effects, these discharges cause severe problems with tastes and odors in domestic water supplies. In the spring of 1964, for a period of 5 to 10 days, when the prevailing wind was from the east, the City of Erie had high tannin concentrations in its water intakes. They caused severe taste and odor problems and required extensive extra treatment. Periodically, Erie closes its eastern intake to avoid such high tannin concentrations.

In the summer of 1964, the Erie County Health Department carried out an intensive microbiological examination of the beaches at Presque Isle State Park. Presque Isle State Park officials, the U. S. Public Health Service, the Pennsylvania Department of Health, and the City of Erie cooperated in this study. A summary of the data collected in the summer of 1964 from over 4,000 separate tests appears below:

MICROBIOLOGICAL RESULTS FROM PRESQUE ISLE STATE PARK
SUMMER 1964

Beach	Total Coliform Density* Median	Total Coliform Density* % Greater Than 1,000	Fecal Streptococcus Density* Median
Presque Isle - 1	36	4%	10
Presque Isle - 8	23	0%	7
Presque Isle - 10	20	0%	4
Presque Isle - 11	700	38%	5

*Count per 100 ml - preliminary evaluation, 1964 data, Millipore Filter Technique.

The data in the above table indicate that Beach 1 on the west end of the park has an occasional source of pollution which diminishes as it progresses down the beach, whereas Beach 11 on the eastern tip is affected by larger and more constant sources of pollution.

Preliminary analyses indicate that, except for short periods, all of the beaches except Beach 11 are relatively free from pollution. All beaches, but particularly Beach 11, appear to be influenced by heavy rainfall, strong wind from any direction which causes turbulence in the water, and winds of any velocity but long duration from the east. Beach 11 was closed as a precautionary measure several times during the summer of 1965 by Park officials while all western beaches remained open at all times.

CHAPTER 9 - NEW YORK BASINS

A report on the New York basins tributary to Lake Erie was submitted at the Rochester meeting of the subcommittee and is therefore not included in this report.

CHAPTER 10 - DETROIT RIVER AND MICHIGAN TRIBUTARIES

The Detroit River and Michigan tributaries draining into Lake Erie have been described in the Federal Water Pollution Control Administration's "Report on Pollution of the Detroit River, Michigan Waters of Lake Erie, and their Tributaries", April, 1965, available from the Lake Huron Program Office, FWPCA, Grosse Ile, Michigan.

11 - FEDERAL ENFORCEMENT ACTIVITIES

The Federal Water Pollution Control Administration has proceeded in compliance with all the recommendations of the conference in the matter of pollution of the navigable waters of the Detroit River and Lake Erie and their tributaries (Michigan) and the conference in the matter of pollution of Lake Erie and its tributaries (Michigan - Indiana - Ohio - Pennsylvania - New York) for which it has responsibility. The progress and accomplishments noted below are provided only in regard to the Detroit River and the western and central portions of Lake Erie. That is, that portion bordered by the States of Michigan, Indiana and Ohio.

Detroit River

Recommendations

The summary of the second session of the conference in the matter of pollution of Detroit River and Lake Erie and their tributaries held June 15-18, 1965 and issued by the Secretary of Health, Education, and Welfare contained the following conclusions and recommendations unanimously agreed upon by the conferees:

1. The Detroit River and Lake Erie within the State of Michigan, and their tributaries within the State of Michigan, are navigable waters within the meaning of section 8 of the Federal Water Pollution Control Act.

2. Pollution of navigable waters subject to abatement under the Federal Water Pollution Control Act is occurring in the Detroit River, the Michigan waters of Lake Erie, and their tributaries within the State of Michigan. The discharges causing and contributing to the pollution come from various industrial and municipal sources.

3. While many sources of waste discharge in the area have adequate facilities, many sources still have inadequate waste treatment facilities. The delays in controlling the pollution problem of the area covered by the conference are caused by the lack of such adequate facilities and the complex municipal-industrial nature of the problem.

4. Cognizance is taken of the excellent work and programming of the Michigan State authorities. Most wastes in the area receive a measure of treatment or control.

5. The "Report on Pollution of the Detroit River and the Michigan Waters of Lake Erie and Their Tributaries," prepared by the U. S. Department of Health, Education, and Welfare, dated April 1965, will be submitted to the Michigan Water Resources Commission for implementa-

tion under State and local law. Action taken by the Michigan Water Resources Commission will be reported to the conferees at six-month intervals at public meetings to be called by the Chairman of the conference. The conferees expect that a time schedule for the control of pollution in the area covered by the conference will be established by the Michigan Water Resources Commission regarding all sources of pollution within one year from the date of the issuance of this summary.

6. The Department of Health, Education, and Welfare will consult with the Michigan Water Resources Commission on action taken under State law by that Commission relating to specific problems of the Detroit River and Michigan waters of Lake Erie. Staff members of the Department of Health, Education, and Welfare will be available for presentation of evidence and testimony at conferences and hearings before the Michigan Water Resources Commission.

7. All municipalities and industries be required to provide a degree of treatment sufficient to protect all legitimate uses. Where the effluent contains significant bacterial loadings deleteriously affecting legitimate water uses, disinfection of the effluent will be required.

8. Sewerage systems with collection sewers terminating in adequate treatment facilities be provided in those areas along the Michigan shore of Lake Erie and the Detroit River where sewers do not now exist and homes discharge either raw wastes or septic tank effluent to the watercourse.

9. Waste treatment facilities be designed to prevent the necessity of bypassing untreated wastes during maintenance and renovation operations. Cognizance is taken of the fact that many installations provide this protection at the present time.

10. Programs to reduce the likelihood of accidental spills of waste material to the river be continued and strengthened.

11. All municipal waste water treatment plants and industries discharging wastes analyze regularly significant waste constituents contributing to pollution, and furnish such reports and records to the Michigan Water Resources Commission as specified by it.

12. A Department of Health, Education, and Welfare water pollution control surveillance station be established in the lower section of the Detroit River. This will be in addition to the Department station now in operation at the head of the Detroit River so as to indicate changes in water quality after improvements are made.

13. Surveillance will be the primary responsibility of the State of Michigan. The Department of Health, Education, and Welfare will assist the State at such times as requested. Surveillance will include regular sampling of waste effluents and overflows from combined sewers as well as aerial and power boat reconnaissance as practiced by the Michigan Water Resources Commission. Expansion of this activity is encouraged and recommended.

14. The conference may be reconvened on the call of the Chairman.

Accomplishments

In compliance with recommendation 6 of this conference, a Federal representative was invited and did consult with the Michigan Water Resources Commission on action taken under State law by that Commission relating to specific problems of the Detroit River and Michigan Waters of Lake Erie. The Federal representative attended all the meetings of the Michigan Water Resources Commission in which the Detroit River pollution problems were discussed and presented testimony on the occasions where requested.

The Federal scientists provided the Michigan Water Resources Commission with current information on the removal of phosphates by sewage treatment processes.

A water pollution control surveillance station has been established in the lower section of the Detroit River by the FWPCA as required by recommendation 12 of the Detroit River-Lake Erie conference summary. Automatic and continuous measurements will be made on temperature, dissolved oxygen, conductivity and turbidity. This station has been established as one of the national water pollution surveillance stations of the FWPCA, which means that samples will be collected weekly for the entire spectra of water quality measurements, including radiochemistry and chlorinated hydrocarbons (pesticides). In addition, the station includes a low-flow rate carbon filter for organic analysis.

Finally, in compliance with recommendation 13, the ongoing surveillance of the FWPCA which includes regular sampling of waste effluents and overflows as well as aerial and power boat reconnaissance as practiced by the Michigan Water Resources Commission was reinforced with State personnel and control of the operations gradually shifted to the State which now has taken the major role in surveillance of the Detroit River, tributaries, and waste sources. The Detroit field unit of the International Joint Commission continues to monitor the water quality in the Detroit River, and the Ontario Water Resources Commission also collects additional samples. Communication between all agencies is maintained to prevent overlap or conflict.

Lake Erie

Recommendations

The summary of the second session of the conference in the matter of pollution of Lake Erie and its tributaries held August 10-12, 1965 and issued by the Secretary of Health, Education, and Welfare contained the following conclusions and recommendations unanimously agreed upon by the conferees:

1. The waters of Lake Erie within the United States are interstate waters within the meaning of section 8 of the Federal Water Pollution Control Act. The waters of Lake Erie and its tributaries within the United States are navigable waters within the meaning of section 8 of the Federal Water Pollution Control Act.

2. Lake Erie and many of its tributaries are polluted. The main body of the Lake has deteriorated in quality at a rate many times greater than its normal aging processes, due to the inputs of wastes resulting from the activities of man.

3. Identified pollutants contributing to damages to water uses in Lake Erie are sewage and industrial wastes, oils, silts, sediment, floating solids and nutrients (phosphates and nitrates). Enrichment of Lake Erie, caused by man-made contributions of nutrient materials, is proceeding at an alarming rate. Pollution in Lake Erie and many of its tributaries causes significant damage to recreation, commercial fishing, sport fishing, navigation, water supply, and esthetic values.

4. Eutrophication or over-fertilization of Lake Erie is of major concern. Problems are occurring along the Lake shoreline at some water intakes and throughout the Lake from algal growths stimulated by nutrients. Reduction of one or more of such nutrients will be beneficial in controlling algal growths and eutrophication.

5. Many sources of waste discharge reaching Lake Erie have inadequate waste treatment facilities. The delays in controlling this pollution are caused by the lack of such adequate facilities and the complex municipal, industrial and biological nature of the problem.

6. Interstate pollution of Lake Erie exists. Discharges into Lake Erie and its tributaries from various sources are endangering the health or welfare of persons in States other than those in which such discharges originate. In large measure this pollution is caused by nutrients which over-fertilize the Lake. This pollution is subject to abatement under the Federal Water Pollution Control Act.

7. Municipal wastes are to be given secondary treatment or treatment of such nature as to effectuate the maximum reduction of BOD and phosphates as well as other deleterious substances.

8. Secondary treatment plants are to be so designed and operated as to maximize the removal of phosphates.

9. Disinfection of municipal waste effluents is to be practiced in a manner that will maintain coliform densities not in excess of 5,000 organisms per 100 ml. at water supply intakes, and not in excess of 1,000 organisms per 100 ml. where and when the receiving waters in proximity to the discharge point are used for recreational purposes involving bodily contact. It is recognized that bathing water quality standards are established by statute in New York State.

10. All new sewerage facilities are to be designed to prevent the necessity of bypassing untreated waters.

11. Combined storm and sanitary sewers are to be prohibited in all newly developed urban areas, and eliminated in existing areas wherever feasible. Existing combined systems are to be patrolled and flow-regulating structures adjusted to convey the maximum practicable amount of combined flows to and through treatment plants.

12. Programs are to be developed to prevent accidental spills of waste materials to Lake Erie and its tributaries. In-plant surveys with the purpose of preventing accidents are recommended.

13. Unusual increases in waste output and accidental spills are to be reported immediately to the appropriate State agency.

14. Disposal of garbage, trash, and other deleterious refuse in Lake Erie or its tributaries is to be prohibited and existing dumps along river banks and shores of the Lake are to be removed.

15. The conferees are to meet with representatives of Federal, State and local officials responsible for agricultural, highway and community development programs for the purpose of supporting satisfactory programs for the control of runoff which deleteriously affects water quality in Lake Erie.

16. Industrial plants are to improve practices for the segregation and treatment of waste to effect the maximum reductions of the following:

a. Acids and alkalies

b. Oil and tarry substances

c. Phenolic compounds and organic chemicals that contribute to taste and odor problems

d. Ammonia and other nitrogenous compounds

e. Phosphorous compounds

f. Suspended material

g. Toxic and highly-colored wastes

h. Oxygen-demanding substances

i. Excessive heat

j. Foam-producing discharges

k. Other wastes which detract from recreational uses, esthetic enjoyment, or other beneficial uses of the waters.

17. The Michigan, Indiana, Ohio, Pennsylvania and New York water pollution control agencies are to undertake action to insure that industrial plants discharging wastes into the waters of Lake Erie and its tributaries within their respective jurisdictions institute programs of sampling their effluents to provide necessary information about waste outputs. Such sampling shall be conducted at such locations and with such frequency as to yield statistically reliable values of all waste outputs and to show their variations. Analyses to be so reported are to include, where applicable: pH, oil, tarry residues, phenolics, ammonia, total nitrogen, cyanide, toxic materials, total biochemical oxygen demand, and all other substances listed in the preceding paragraph.

18. Waste results are to be reported in terms of both concentrations and load rates. Such information will be maintained in open files by the State agencies for all those having a legitimate interest in the information.

19. The U. S. Department of Health, Education, and Welfare is to establish water pollution surveillance stations at appropriate locations on Lake Erie. Surveillance of the tributaries will be the primary responsibility of the States. The Department of Health, Education, and Welfare will assist the States at such times as requested.

20. The U. S. Department of Health, Education, and Welfare will be responsible for developing up-to-date information and experience concerning effective phosphate removal and the control of combined sewer systems. This information will be reported to the conferees regularly.

21. Regional planning is often the most logical and economical approach toward meeting pollution problems. The water pollution control agencies of Michigan, Indiana, Ohio, Pennsylvania and New York, and the Department of Health, Education, and Welfare will encourage such regional planning activities.

22. Within six months after the issuance of this Summary, the State water pollution control agencies concerned are to present a schedule of remedial action to the Conferees for their consideration and evaluation.

23. The Federal Conferee recommends the following for the consideration of the State agencies:

a. Recommended municipal treatment: Completion of plans and specifications, August, 1966; completion of financing, February, 1967; construction started, August, 1967; construction completed, January 1, 1969; chlorination of effluents, May 15, 1966; provision of stand-by and emergency equipment to prevent interruptions in operation of municipal treatment plants, August, 1966; patrolling of combined sewer systems, immediately.

b. Discontinuance of garbage and trash dumping into waters; immediately.

c. Industrial waste treatment facilities: Completed and in operation by January 1, 1969.

24. Federal installations: Waste treatment facilities are to be completed and in operation by August of 1966.

25. Representatives of the U. S. Army Corps of Engineers are to meet with the Conferees, develop and put into action a program for disposal of dredged material in Lake Erie and its tributaries which will satisfactorily protect water quality. Such a program is to be developed with six months after the issuance of this Summary and effectuated as soon as possible thereafter.

26. The conferees will establish a Technical Committee as soon as possible which will evaluate water quality problems in Lake Erie relating to nutrients and make recommendations to the conferees within six months after the issuance of this Summary.

27. The conference may be reconvened on the call of the Chairman.

Accomplishments

The FWPCA, in compliance with recommendation 11, has established and will continue the process of reviewing urban renewal projects for proper separation of storm and sanitary sewers. The FWPCA recommendation for the construction of separate storm and sanitary sewers will be complied with at the University-Euclid Urban Renewal Project in Cleveland, Ohio, the Vistula Meadows Urban Renewal Project in Toledo, Ohio, and the Cascade Urban Renewal Project in Akron, Ohio.

In keeping with recommendation 15 of the Lake Erie conference summary a meeting has been held with the Bureau of Public Roads and state highway officials in pursuit of programs to control runoff which deleteriously effects Lake Erie. The Federal and State highway officials indicated great interest in minimizing pollution, and have received an Instructional Memorandum from the Federal Highway Administrator to conduct the Federal highway program in such a way as to be in compliance with President Johnson's Executive Order No. 11288.

In compliance with recommendation 19 a Federal surveillance program has been established in the western portion of Lake Erie covering Michigan and Ohio waters. Plans are presently being prepared which will provide a more complete surveillance program on Lake Erie to evaluate the effectiveness of pollution control practices in local and lake-wide situations, to determine needs in local and lake-wide pollution situations, and to determine cause and effect relationships among chemical, biological, and physical factors in lake eutrophication.

The ongoing responsibilities established by recommendation 20 are being fulfilled. Information has been made available by the Federal Water Pollution Control Administration to the States and municipalities on both phosphate removal and on control of combined sewer systems. The Technical Committee, appointed by the Conferees, heard from Federal Water Pollution Control Administration scientists and engineers and private consultants were made available. The Chief of the Technical Services Branch, Federal Water Pollution Control Administration, met with the Michigan Water Resources Commission to relate recent experiences in phosphate removal. Several sites are now being surveyed in the Lake Erie area for a field demonstration of phosphate removal at one or more operating sewage treatment plants.

Regional planning on pollution problems required by recommendation 21 was furthered by the provision of the Water Quality Act of 1965 that permits construction grant increases of 10 percent where a sewage treatment plant project is certified as conforming with a comprehensive metropolitan area plan. Such increased grants have been made to: Detroit, \$60,000; Oakland County, Michigan, \$18,624; the 8½ Mile Relief

Drain in Macomb County, Michigan, $110,715; and Sylvania, Ohio, $20,340. The total 10 percent grant increases amount to $209,679. Meetings have also been held with some Conference Area regional planning agencies.

In addition to the 10 percent construction grant increases, a total of 14 regular construction grants, amounting to $3,927,790, in support of eligible construction of $13,583,147, have been made to communities in the western and central portions of the Lake Erie Basin since last summer.

In compliance with recommendation 25 a meeting was held with representatives of the Chief of the Corps of Engineers to discuss the problem of dredged material disposal. The Corps of Engineers has proceeded diligently in the development of plans for disposal that would minimize pollutional effects.

Recommendation 26 of the Lake Erie conference summary calling for the establishment of a Technical Committee has been fulfilled. The conferees appointed a Technical Committee which met, heard testimony from a number of Federal, State and private consultants, prepared an interim report, and presented their preliminary recommendations to the conferees. This Technical Committee continues to function and will provide a more detailed report to the conferees.

In a continuing effort to carry out the recommendations of the Lake Erie Conferences and to stimulate necessary action on the part of all concerned, the conferees met again on June 22, 1966. At that time the States of Michigan, Indiana and Ohio reported their own progress and accomplishments in the western and central portions of the Lake Erie Basin since the previous conference; and all the conferees agreed that to assure continued progress they would meet again in six months. At that time, when municipalities have proceeded with their plans for the construction of adequate waste facilities, a detailed abatement schedule may be drawn up which will include both municipalities and industries.

Federal Installations

In support of Executive Order 11288 concerning the waste treatment practices of Federal installations and recommendation 24 of the Lake Erie conference summary all such installations in the western and central portions of the Lake Erie Basin are providing adequate treatment or have initiated satisfactory abatement programs.

In the Detroit River Conference Area the Naval Air Station at Grosse Ile has improved its primary treatment plant and provided continuous chlorination. Further treatment facilities were not required because the Station is scheduled for closing by September 1, 1967.

A package aeration plant with chlorination was put into operation at the boat dock and the airplane washing wastes are now being treated by the Grosse Ile Sewage treatment plant. The U. S. Coast Guard Detroit River Lighthouse is to be converted to an automatic operation within the next 12 months. The Corps of Engineers in response to FWPCA recommendations has ordered that the practice of dumping ship's garbage and trash at the dredged material disposal area be stopped; that closer control be maintained in order to prevent the spillage of dredged material outside of the disposal areas; and that treatment units be provided on board dredging vessels for sanitary wastes. All other Federal installations in the Detroit Conference Area discharge to municipal systems.

In the western and central portions of the Lake Erie Conference Area involving the States of Michigan, Indiana and Ohio the following installations have adequate treatment facilities and are in compliance with the conference summary:

U. S. Coast Guard installations, Lake Erie
- Marblehead Lifeboat Station, Ottawa Co., Ohio
- Sandusky Bay Light Station, Ohio
- Cleveland Reserve Training Unit, Ohio
- Chesterland Radio Station, Gates Mills, Ohio
- Fairport Harbor Light Station, Ohio

Perry's Victory and International Peace Memorial National Monument, South Bass Island, Ohio
Erie Army Depot, Port Clinton, Ohio
Locust Point Firing Range
Post Office, Bellevue, Ohio
Cleveland Army Tank Automotive Plant, Cleveland, Ohio
The Lewis Research Center, NASA, Cleveland, Ohio
Army NIKE Sites, Cleveland Area (Sites 29C and 34L)
GSA Materials Depot, New Haven, Indiana
Post Office, Berne, Indiana

The following installations (all U. S. Coast Guard facilities) are not in compliance with the recommendations and conclusions of the conferees at present, but are expected to be in August 1966:

Toledo Harbor Light Station, Ohio
Put-In-Bay Light Station, Ohio
Lorain Lifeboat Station, Ohio
Cleveland Lifeboat Station, Ohio
Ashtabula Light Station, Ohio

One installation, the Lewis Research Center, NASA, Plum Brook, Facility, Sandusky, Ohio, has been notified that the primary treatment plant is inadequate. Plans are underway to place this installation in compliance by next year.

Although Selfridge Air Force Base is not included within an enforcement conference area, the discharges to the Clinton River have been the subject of both State and Federal concern; and the accomplishments with regard to this problem are noteworthy. FWPCA recommendations called for the Air Force to install sewage treatment facilities capable of producing an effluent having very low biochemical oxygen demand, suspended solids, total phosphates, coliforms and oil and to initiate a vigorous program of sampling and analysis for these parameters. The FWPCA recommended that the sewage from the Army NIKE Sites and the Missile Maintenance Area at Selfridge be pumped to the Air Force sewage plant for treatment or that the effluent from the septic tanks either (1) be pumped out of the basin, (2) be contained in evaporation lagoons, or (3) if discharged to the Clinton River, shall not exceed strict requirements for biochemical oxygen demand, suspended solids, total phosphates and coliforms. If the last alternative is implemented, an active, ongoing testing program is to be conducted. On July 18, 1966 representatives of the FWPCA, the Air Force and the Army met, the recommendations of the FWPCA were accepted, and the following time schedules set:

U. S. Army NIKE Sites and Missle Maintenance Area

1.	Plans completed for abatement program	December 31, 1966
2.	Final plans and specifications and contract award	July 1, 1967
3.	Construction completed	December 31, 1967

Selfridge Air Force Base Sewage Treatment Plant

1.	Final plans and specifications and contract award	October 1, 1967
2.	Construction completed	October 1, 1968