COMPREHENSIVE WATER POLLUTION CONTROL PROGRAM

FOR THE

LAKE MICHIGAN BASIN

Milwaukee Area, Wisconsin

June 1966

U. S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Great Lakes-Illinois River Basins Project
Region V

Chicago, Illinois

ENVIRONMENTAL PROTECTION AGENCY

FOREWORD

The Department of the Interior welcomes the opportunity afforded by the Honorable Warren P. Knowles, Governor of the great State of Wisconsin, to present this portion of our comprehensive water pollution control program for the Lake Michigan Basin at Milwaukee, Wisconsin on June 28, 1966.

The action program set forth in this document, when implemented, will protect and enhance the quality of the waters of the Milwaukee area and the adjacent waters of Lake Michigan. It will increase their usefulness for recreational purposes. It will provide a more suitable environment for fish and aquatic life and add to the value of this resource. It will improve the quality and usefulness of the area's waters for municipal and industrial purposes, esthetic enjoyment and many other beneficial uses.

Working together as a team, the agencies concerned with the control of water pollution at all levels of government can, and will bring this program to fruition for the benefit of the people of Wisconsin and the Nation.

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SUMMARY

General

The waters of the Milwaukee area, particularly, the lower Milwaukee River within Milwaukee County, Milwaukee Harbor and the adjacent waters of Lake Michigan are seriously degraded in quality. Swimming, boating, fishing and esthetic enjoyment are among some of the water uses adversly affected by this degradation of water quality. Biological, chemical, microbiological and physical parameters analyzed by the Great Lakes-Illinois River Basins Project indicate this fact. Further evidence of pollution cited in this report included the frequent closing of City beaches due to bacterial contamination, the presence of objectionable algal blooms and the general appearance of the waters of the area.

Sources of Pollution

Municipal waste treatment plants of the Milwaukee area serve a present population of 1,080,000. These plants receive an additional industrial waste load population equivalent (in terms of oxygen consuming capacity) of 1,570,000. The combined effluents from these municipal waste treatment facilities discharge a total of 60,000 pounds per day of BOD_5 to the waters of the area. Municipal waste effluents represent the largest source of pollution in the Milwaukee area.

Other significant waste sources include those industries which discharge wastes directly to the waters of the area (25,000 pounds of BOD_5 per day), intermittant discharges from combined sewer overflows, wastes discharged from commercial and private vessels and urban and rural runoff.

In addition to the organic load imposed by these waste sources other contaminants of significance in the area include phosphates, phenols, ammonia nitrogen and bacterial contamination.

Future Conditions

Growth projections made by GLIRB Project economists indicate that the Milwaukee study area 1960 population of 1,104,000 will increase more than two-fold by 2020. Industrial activity is projected to increase more than six-fold over the same time period. Taking into account these and other related factors it is considered that the untreated waste load handled by all Municipal sewerage systems in the study area will increase to approximately

8 million PE by 2020. Compare this with the present estimated untreated load of 2,700,000 PE.

Need for Comprehensive Program

The present impairment of certain water uses in the area plus the increasing waste loads which will be imposed on the waste treatment facilities point out the need for the development of a comprehensive program for water pollution control in the Milwaukee area. The program of necessity must emphasize construction of new sewerage facilities, proper operation of new and existing facilities, and intensive and continuous monitoring of operation, waste treatment efficiency and water quality.

The following recommendations represent the initial requirements of a comprehensive pollution control program for the Milwaukee Area.

RECOMMENDED ACTIONS

1. All municipal waste treatment facilities should be designed and operated to provide secondary (biological) waste treatment and to achieve an overall reduction in untreated BOD_5 of 90 percent or higher, on a continuous basis.

2. To provide maximum protection to the quality of Milwaukee Harbor waters the Jones Island treatment plant should be continuously operated at maximum efficiency. The Milwaukee Sewerage Commission should also consider the addition of some form or tertiary treatment. The new South Shore plant and the South Milwaukee plant both need improvement so as to provide secondary waste treatment and proper operation to achieve 90 percent BOD_5 removal.

3. Continuous disinfection should be provided for all municipal waste treatment plant effluents in the study area. The Jones Island treatment plant in the Milwaukee Metropolitan Sewerage District has a critical need for disinfection of the plant effluent prior to discharge to Milwaukee Harbor waters.

4. All separately discharging industrial wastes should receive the equivalent of secondary treatment, as described above. Where practicable, industrial wastes should be discharged to municipal sewerage systems so as to receive final treatment at properly designed and operated municipal treatment plants.

5. The Peter Cooper Corporation at Oak Creek, Wisconsin should complete negotiations with the Milwaukee Metropolitan Sewerage District to provide adequate secondary treatment of the industry's waste at the new South Shore treatment plant. The secondary facilities recommended for the South Shore Plant (see 2) should be so designed as to adequately treat this additional industrial waste load.

6. Maximization of phosphate removal, through modification in the operation and/or design of existing and newly constructed secondary waste treatment facilities should be an immediate objective. Records of phosphorus removal at the treatment plants of the study area should be carefully evaluated after one year to determine if significant phosphorus removals have been achieved. If such removals are not achieved, consideration should be given to the possible installation of chemical precipitation facilities at such plants.

7. Combined sewers should be strictly prohibited in all newly developed urban areas and should be separated in coordination with urban renewal projects. Existing combined sewer systems, particularly in the Milwaukee area, should be patrolled and overflow regulating devices should be adjusted to convey the maximum practicable amount of combined flow to treatment facilities.

8. All industries and municipalities and other agencies discharging wastes into the waters of the study area should submit within six months, to the appropriate State agency, a report containing a time schedule for completion of any new construction, modifications to any existing structures, process changes or operating procedures necessary to meet the above recommendations.

9. The Wisconsin State Board of Health should conduct municipal waste treatment plant inspections at least once a year for small and medium-sized plants, and at least twice annually for the larger plants.

10. Monthly reports covering the operation of municipal waste treatment plants should be submitted to the Wisconsin State Board of Health for review and evaluation.

11. The adoption of a mandatory sewage treatment plant operators' certification program in Wisconsin is recommended. Operator training courses should be offered annually.

12. The water quality monitoring program of the Wisconsin Committee on Water Pollution in the study area should be strengthened. The program should be geared to indicate changes or trends in water quality and the need for additional quality improvement measures, such as chemical precipitation for phosphate removal. The monitoring program should be supplemented by monthly reports covering the quantity and quality of all significant municipal and industrial wastes discharged in the study area.

13. It is recommended that the water pollution control activities in Wisconsin be strengthened in terms of staffing and budget. With additional resources and the support available from the Administration the implementation of the program outlined herein and similar programs in other Basins throughout the State can be accelerated to meet the growing need for clean water in Wisconsin.

CHAPTER 1

INTRODUCTION

Purpose

The purpose of this report on the Milwaukee Area, Wisconsin is to present information concerning sources of municipal and industrial wastes, projected future waste loads, present water quality conditions, present and anticipated future water uses and recommended actions to provide the water quality necessary to accommodate those water uses.

Scope

The area within the scope of this report includes the Milwaukee River Basin and all other areas within Milwaukee County. (See Figure 1-1). Water quality conditions in the adjacent waters of Lake Michigan are of particular importance.

Great Lakes-Illinois River Basins Project

This report is one in a series of 7 proposed documents (Table 1-1) being prepared by the Great Lakes-Illinois River Basins (GLIRB Project at Chicago, Illinois. When completed these 7 reports, taken together, will present a comprehensive program for water pollution control in the entire Lake Michigan Basin. In addition to the Lake Michigan Basin, GLIRB Project with program offices currently located at Cleveland, Ohio, Rochester, New York and Detroit, Michigan, is developing similar programs for the watersheds of Lakes Erie, Ontario, Huron and Superior and the Illinois River Basin (Figure 1-2).

Authority

Comprehensive water pollution control studies were authorized by the Federal Water Pollution Control Act of 1956, as subsequently amended. Initiation of the 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) of which the Great Lakes-Illinois

TABLE 1-1

GREAT LAKES-ILLINOIS RIVER BASINS PROJECT

COMPREHENSIVE WATER POLLUTION CONTROL PROGRAM

FOR THE

LAKE MICHIGAN BASIN

Tentative Program Reports

Green Bay Area, Michigan and Wisconsin

Milwaukee Area, Wisconsin

Grand River Basin, Michigan

Kalamazoo River Basin, Michigan

St. Joseph River Basin, Indiana and Michigan

Calumet Area, Illinois and Indiana

Lake Michigan and Tributary Areas (Summary Report)

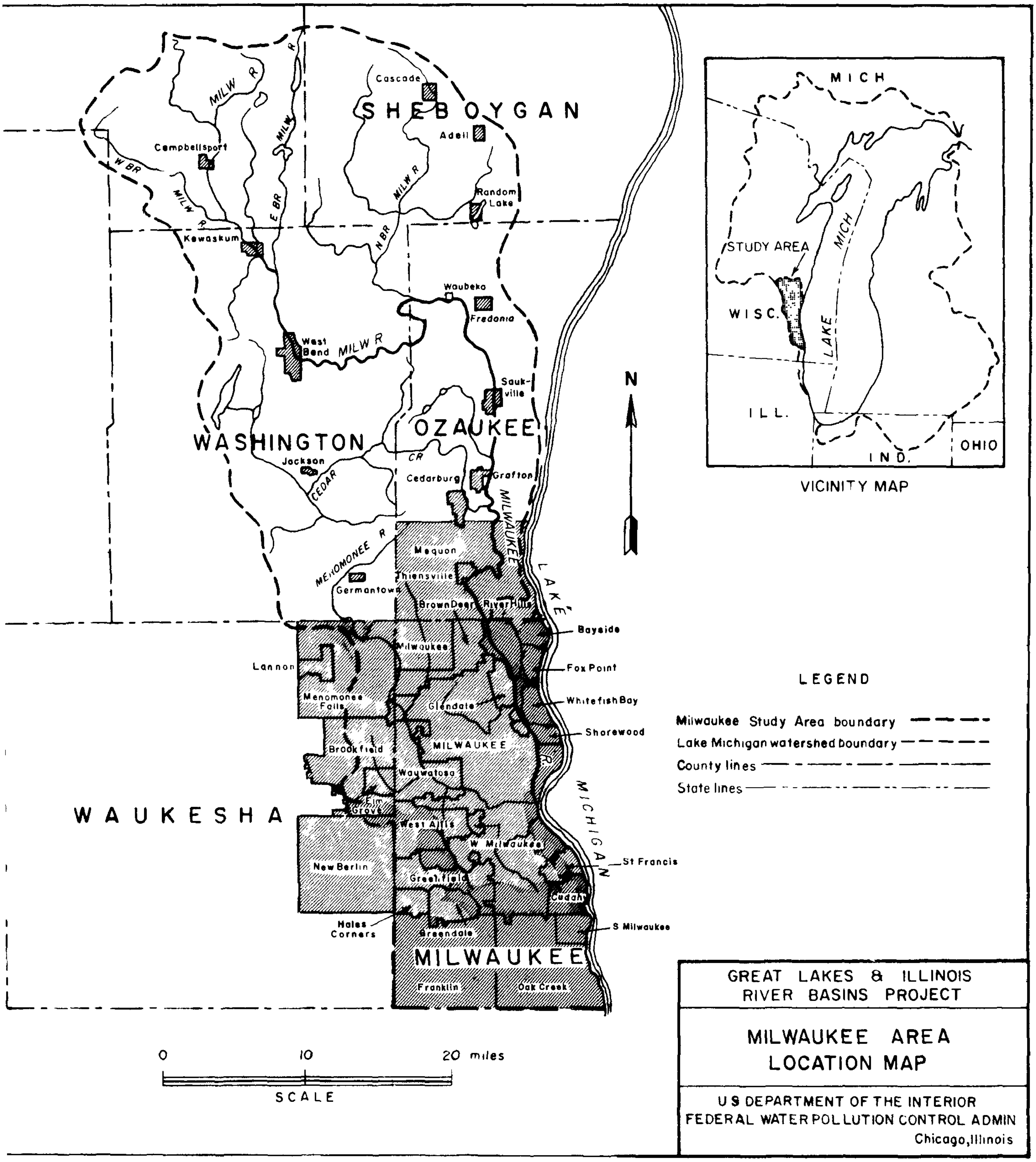
SHEBOYGAN
WASHINGTON
OZAUKEE
WAUKESHA
MILWAUKEE
Cascade
Adell
Campbellsport
Random Lake
Kewaskum
Waubeka
Fredonia
West Bend
Saukville
Jackson
Cedarburg
Grafton
Mequon
Thiensville
Germantown
Brown Deer
River Hills
Bayside
Lannon
Fox Point
Menomonee Falls
Glendale
Whitefish Bay
Shorewood
Brookfield
Wauwatosa
Elm Grove
West Allis
W Milwaukee
New Berlin
St Francis
Greenfield
Cudahy
Hales Corners
Greendale
S Milwaukee
Franklin
Oak Creek
MILW R
W BR
E BR
N BR
CEDAR CR
MENOMONEE R
MILWAUKEE R
LAKE MICHIGAN
N
0
10
20 miles
SCALE
MICH
STUDY AREA
WISC.
LAKE MICH
ILL.
IND.
OHIO
VICINITY MAP
LEGEND
Milwaukee Study Area boundary
Lake Michigan watershed boundary
County lines
State lines
GREAT LAKES & ILLINOIS RIVER BASINS PROJECT
MILWAUKEE AREA LOCATION MAP
U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
Chicago, Illinois

FIGURE 1-1

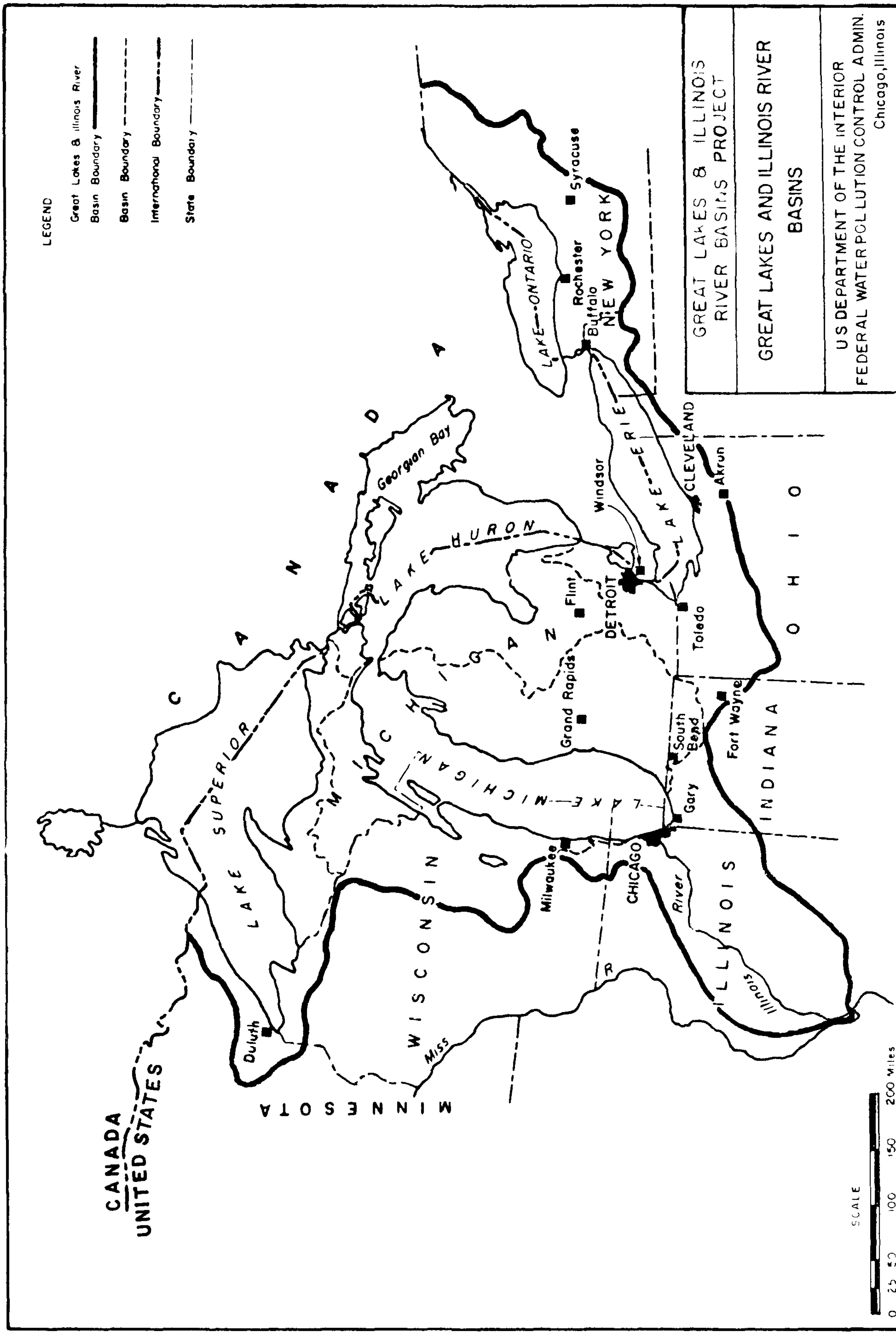
LEGEND
Great Lakes & Illinois River Basin Boundary
Basin Boundary
International Boundary
State Boundary
GREAT LAKES & ILLINOIS RIVER BASINS PROJECT
GREAT LAKES AND ILLINOIS RIVER BASINS
U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Chicago, Illinois
CANADA
UNITED STATES
MINNESOTA
WISCONSIN
MICHIGAN
ILLINOIS
INDIANA
OHIO
NEW YORK
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
Georgian Bay
Duluth
Milwaukee
CHICAGO
Gary
South Bend
Fort Wayne
Grand Rapids
Flint
DETROIT
Windsor
Toledo
CLEVELAND
Akron
Buffalo
Rochester
Syracuse
Illinois River
Miss. R
SCALE
0 25 50 100 150 200 Miles

FIGURE I-2

River Basins Project is now a part. 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.

Organization

Following the initial appropriation of funds by Congress in 1960, a task force designated the GLIRB Project was organized to conduct the comprehensive study. The Project headquarters are located at 1819 West Pershing Road, Chicago, Illinois. Its permanent staff includes specialists covering a broad gamut of professional skills, including sanitary and hydraulic engineers, chemists, biologists, bacteriologists, radiochemists, oceanographers, and economists. The Project has drawn freely on the resources of the Robert A. Taft Sanitary Engineering Center at Cincinnati, Ohio. Valuable counsel and advice have been received from a Technical Committee appointed by the Surgeon General of the Public Health Service. This Committee is composed of men in responsible positions in State water resource and water pollution control agencies, municipal water and sewer departments, private research organizations, conservation groups; industry. Table 1-2 gives the names and positions of the Technical Committee Members.

Cooperative Program

As required by the authorizing legislation the GLIRB Project has worked closely with other Federal, State and local agencies to develop a comprehensive 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:

Illinois

State Sanitary Water Board
Department of Public Health

Indiana

Stream Pollution Control Board
State Board of Health

Michigan

State Water Resources Commission
Department of Health

Wisconsin

State Committee on Water Pollution
State Board of Health

TABLE 1-2

TECHNICAL COMMITTEE TO THE GREAT LAKES-ILLINOIS RIVER BASINS PROJECT

MEMBERS

Norval E. Anderson
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TABLE 1-2 (Cont'd.)

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MEMBERS

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Assistant to the Vice President
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Staff Engineer
Commonwealth Edison Company
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State Sanitary Engineer
The State of Wisconsin
Board of Health
State Office Building
Madison 2, Wisconsin

Loring F. Oeming
Executive Secretary
State of Michigan
Water Resources Commission
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Lansing, Michigan 48912

B. A. Poole
Technical Secretary
Indiana Stream Pollution Control Board
1330 West Michigan Street
Indianapolis 7, Indiana

U. S. Federal Power Commission

U. S. Department of the Army

Corps of Engineers

U. S. Department of the Interior

Bureau of Commercial Fisheries
Bureau of Outdoor Recreation
Bureau of Sport Fisheries and Wildlife
Geological Survey

U. S. Department of Commerce

Weather Bureau
Office of Business Economics

CHAPTER 2

DESCRIPTION OF AREA

Geography

As described in Chapter 1, the study area of this report includes the entire Milwaukee River Basin, all other area within Milwaukee County, and the adjacent waters of Lake Michigan (Figure 1-1).

The Milwaukee River drainage basin has an area of 845 square miles and is located in southeastern Wisconsin. The principal axis of the watershed extends in a north-south direction for approximately 65 miles, roughly parallel to the western shore of Lake Michigan. In the east-west direction the watershed has a maximum dimension of approximately 25 miles in the upper reaches of the stream.

Hydrology

The Milwaukee River originates in the southeast corner of Fond du Lac County approximately 5 miles north of the small community of Campbellsport. The stream flows south to West Bend and then makes a right-angle bend to flow east to the Waubeka area where it is joined by the North Branch of the River, its largest tributary. The stream then flows south through Czaukee County into Milwaukee County and to its outlet to Lake Michigan at Milwaukee.

The major streams in the Milwaukee River Basin are described below in Table 2-1.

TABLE 2-1

Major Streams-Milwaukee River Basin

Stream	Drainage Area (Sq.mi.)	Length of Stream (mi.)	Average Slope (ft./mi.)
Milwaukee River	845	99	5.3
North Branch Milwaukee River	140	24	7.1
Cedar Creek	125	32	11.3
Menomonee River	128	32	8.5

Other minor streams tributary to the Milwaukee River include the West Branch and East Branch of the River, Lincoln Creek and the Kinnickinnic River.

The southwestern corner of Milwaukee County is drained by the Root River which discharges to Lake Michigan at Racine. The southeastern corner of Milwaukee County, including the South Milwaukee Area, is drained by Oak Creek which discharges to Lake Michigan at South Milwaukee.

The U. S. Geological Survey maintains 6 stream gaging stations within the study area. These stations are described below in Table 2-2.

TABLE 2-2

U.S.G.S. Gaging Stations
Milwaukee Area[1]

Stream	Location	Period of Record
Milwaukee River	Milwaukee(Port Washington Rd.Bridge)	1914-Present
Cedar Creek	2 miles North of Cedarburg	1930-Present
Menomonee River	Wauwatosa (70th St. Bridge)	1961-Present
Oak Creek	South Milwaukee (near 15th Ave.Bridge)	1963-Present
Root River	Near Franklin (near Highway 100)	1963-Present
Root River Canal	Near Franklin (3.5 mi.above Root R.)	1963-Present

The mean and pertinent ranges of streamflow as observed at the Milwaukee and Cedar Creek (long-term) stations during the available periods of record are listed in Table 2-3.

TABLE 2-3

Streamflow Records
Milwaukee River Basin(1,2)

Gaging Station	Drainage Area (sq. mi.)	Minimum Flow (cfs)	7-day, 1-in-10 yr. Low Flow (cfs)	Mean Flow (cfs)
Milwaukee R. at Milwaukee	686	0	21	379
Cedar Creek near Cedarburg	121	0.2	1.1	61.5

Topography and Soils

The topography of the area has been largely determined by the various glaciations to which the lands have been subjected. Various advances and recessions of the ice sheets, particularly the last glacial advance during the Wisconsin Ice Age, have endowed the area with numerous ridges, intervening lowlands, and extensive areas where depressions called kettles alternate with kames or small hummocks in lending great diversity to the terrain.

The relative relief of the area is moderate to rolling. The highest elevation is approximately 1200 feet above sea level in Fond du Lac County. Southward, the area becomes flatter and gradually decreases in elevation until it reaches Milwaukee where the elevation is about 580 feet.

The landscape adjacent to Lake Michigan and inland for approximately 4 miles is gently undulating to nearly level, interspersed with swales and depressions. The area west to the "Kettle Moraine" and to the southwest boundary of the watershed is rolling to nearly level. Also to be found are drumlins, kames, and kettles, with some lakes in the area. The area known as the "Kettle Moraine" is rolling to hilly with the depressions occupied by lakes and peat bogs. The remaining area west of the "Kettle Moraine" is rolling to nearly level.

In the Milwaukee River Basin adjacent to Lake Michigan and extending inland to approximately Thiensville, Cedarburg, Fredonia and Random Lake soils of light colored silty clay loam and shallow silt loam surfaces are prevalent. Extending farther inland to West Bend and the "Kettle Moraine" soils are usually of a brownish gray color. In the depressions are peat deposits or dark colored mineral soils. In the "Kettle Moraine" the ridges and hills consist of gravels locally capped by loams having light colored surfaces. The depressions are occupied by lakes, peat bogs and marsh-border soils. In the remaining area to the northwest of the "Kettle Moraine" soils are similar to the ones adjacent to the east of the "Kettle Moraine," as previously described.

Climate

The climate of the area is largely influenced by the waters of Lake Michigan. The area is astride the main cyclonic storm tracks along which a series of high and low pressure centers move across the continent from west to east. The pressure areas provide a varied climate and are the major influence in relation to precipitation. In Table 2-4 the normal temperature range and precipitation distribution are shown for the Milwaukee weather station.

TABLE 2-4

Normal Temperature and Precipitation

Milwaukee (3)

Month		Precipitation (in.)		Temperature (°F)
January		1.83		20.6
February		1.40		22.4
March		2.31		31.0
April		2.53		43.6
May		3.16		53.4
June		3.64		63.3
July		2.95		68.7
August		3.06		67.8
September		2.72		60.3
October		2.10		50.0
November		2.18		35.8
December		1.63		23.6
	TOTAL	29.51	MEAN	45.1

Most of the streams are ice-covered from late November to late March. Snow covers the ground during practically all of the winter months.

Population

The study area had a 1960 population of approximately 1,104,000. It is estimated that 99 percent of the area population is municipal. The total population includes the City of Milwaukee which had a 1960 population of 741,234. Other large cities and centers of industrial activity include West Allis (68,157), Wauwatosa (56,923) and several other communities over 15,000 in population. More than 90 percent of the study area population is located in Milwaukee County.

The 1960 population was distributed over the study area as shown in Table 2-5.

TABLE 2-5

Est. 1960 Population - Milwaukee Study Area

County	Municipal Population	Total Population
Milwaukee	1,036,000	1,036,000
Ozaukee (pt.)	21,800	29,000
Washington (pt.)	14,200	19,000
Sheboygan (pt.)	1,700	5,500
Waukesha (pt.)	10,500	10,500
Fond du Lac (pt.)	1,800	4,200
TOTAL	1,086,000	1,104,000

NOTE: A very minor portion of Dodge County is also in the study area.

The population of the Milwaukee study area has been projected to the year 2020 as shown below in Table 2-6.

TABLE 2-6

Projected Population - Milwaukee Study Area

	1960	1980	2020
Municipal	1,086,000	1,500,000	2,560,000
Total	1,104,000	1,520,000	2,580,000

As shown in the above table, the projected population of the study area remains essentially municipal in the future. A non-municipal population of about 20,000 lives in the upper part of the study area and it is assumed that this non-municipal population will remain approximately the same in the future.

Area Economy

Milwaukee County, Waukesha County and the lower part of Ozaukee County are highly urbanized. The major communities are served by the Chicago and Northwestern Railway and by the Chicago, Milwaukee, St. Paul and Pacific Railroad.

Milwaukee is a leading Lake port. A large part of port activities consists of bringing in raw materials needed in manufacturing and coal needed for fuel and power. A variety of products handled by the port enter into trans-oceanic as well as Great Lakes commerce. In 1963 the net tonnage in Lake and overseas commerce was 7.1 million tons. The transshipment of commodities is an important function of the Milwaukee area and provides linkage between the city and outlying areas.

Manufacturing is the predominant economic activity in the Milwaukee study area. Leading industries include machinery, food and kindred products, fabricated metal products, primary metal industries, transportation equipment and printing and publishing. Generally, total manufacturing activity has not kept pace with the national rate of growth since 1947; also the growth of water-using industries in the study area has not kept pace with the growth of these industries in the East North Central States.

Figures on manufacturing employment and value added by manufacture are presented in Tables 2-7 and 2-8 for the counties which lie entirely or partially within the study area.

TABLE 2-7

Manufacturing Employment in Counties of the (4) Milwaukee River Basin

County	1947	%B	1954	%B	1958	%B	1963	%B
Milwaukee	178,412	83.3	175,802	82.5	171,334	81.0	176,219	78.8
Ozaukee	3,592	1.7	4,114	1.9	4,221	2.0	5,684	2.5
Washington	4,219	2.0	5,218	2.4	5,668	2.7	6,004	2.7
Sheboygan	13,485	6.3	12,071	5.7	12,689	6.0	14,414	6.4
Waukesha	7,280	3.4	8,014	3.8	9,424	4.4	12,853	5.7
Fond du Lac	7,153	3.3	7,784	3.6	8,205	3.9	8,512	3.8
	214,141	100	213,003	100	211,541	100	223,686	100

NOTE: %B = percent county manufacturing employment is of the total of the six counties in the Basin.

TABLE 2-8

Value Added by Manufacture in Counties of the Milwaukee River Basin (4)

(Thousands of Dollars)

County	1947	%B	1954	%B	1958	%B	1963	%B
Milwaukee	1,250,000	83.6	1,580,000	84.7	1,638,000	82.4	2,017,000	79.6
Ozaukee	23,800	1.6	28,000	1.5	42,000	2.1	62,000	2.4
Washington	27,500	1.8	42,400	2.3	56,900	2.9	77,000	3.0
Sheboygan	91,900	6.1	88,400	4.7	104,000	5.2	142,000	5.6
Waukesha	52,700	3.5	59,400	3.2	83,300	4.2	145,000	5.7
Fond du Lac	49,400	3.3	66,100	3.5	63,300	3.2	92,000	3.6
	1,495,300	100	1,864,400	100	1,987,500	100	2,535,000	100

NOTE: %B = percent county value added by manufacture is of the total of the six counties in the basin.

Milwaukee County also ranks ninth among the nation's industrial areas and is one of the largest consumers of steel. Milwaukee County does about 30 percent of Wisconsin's retail trade and about 50 percent of the wholesale trade. Jobs in trade, service, finance, government, and transportation are increasing more rapidly than manufacturing.

Agriculture consists primarily of dairy and livestock farming. In the central and western areas of the Milwaukee River Basin, large areas are used for the production of onions, mint, corn and truck crops. The "Kettle Moraine" land area is used for dairy farming, woodlands and recreation.

Based upon projections of population, manufacturing employment and productivity increases, manufacturing activity in the study area as a whole is expected to increase six-fold by the year 2020.

CHAPTER 3

WATER USES AND WATER QUALITY GOALS

Water Uses

The principal water uses in the Milwaukee study area include:

1. Municipal Water Supply
2. Self-supplied Industrial Water
3. Recreation
4. Irrigation
5. Fish and Aquatic Life
6. Commercial Shipping
7. Waste Assimilation
8. Esthetics

Present and anticipated future water uses have been determined for the main stem of the Milwaukee River, Milwaukee Harbor, and the open waters of Lake Michigan adjacent to Milwaukee County. The major uses are presented below in Table 3-1. The principal water uses in the study area are discussed in detail in the following sections of this chapter.

Municipal Water Supply

As of 1962, twenty-five communities within the study area were served by municipal water supply systems. The total population served is approximately 98 percent of the study area population. Table 3-2 summarizes the available data for the study area.

TABLE 3-2

Total Water Intake
Municipal Water Systems
Milwaukee Area (6,7,8)

Supply	Population Served	Water Intake (mgd)	Per Capita Water Intake (gal/day)
Surface Water	1,033,035	164.7	159
Ground Water	47,625	6.2	130
Totals	1,080,660	170.9	158

Approximately 96 percent of the present municipal water demand in the study area is supplied by surface water from Lake Michigan.

TABLE 3-1

Major Water Uses - Milwaukee Area (5)

Water Use	Lake Michigan	Milwaukee Harbor	Milwaukee River Sectors 1	2	3
Municipal Water Supply	P	-	-	-	-
Industrial Water Supply	P	-	P	P	A
Recreation-Whole Body Contact	P*	-	-	-	P
Recreation-Limited Body Contact	P*	P*	-	P	P
Irrigation	-	-	-	P	P
Fish and Aquatic Life-Tolerant	P	P	P*	P	P
Fish and Aquatic Life-Facultative	P	P	-	P	P
Fish and Aquatic Life-Intolerant	P	-	-	-	P
Wildlife and Livestock Watering	P	P	-	-	P
Hydroelectric Power	-	-	-	-	P
Commercial Shipping	P	P	P	-	-
Cooling	P	P*	P	P	P
Waste Water Assimilation	P	P	P	P	P
Esthetics	P*	P*	P*	P	P

NOTE: Sector 1 - Mouth to North Ave. Dam.
Sector 2 - North Ave. Dam to Milwaukee Co. Line.
Sector 3 - Milwaukee Co. Line to Source.
(-) - Insignificant present and future use.
A - Anticipated future use.
P - Present and anticipated future use.
* - Use presently adversely effected by water pollution

Projections of the municipal water demand for the major water service areas have been made to the years 1980 and 2020 and are presented in Table 3-3. The projections are based upon considerations of population growth, anticipated industrial expansion and industrial water use efficiency factors.

Self-supplied Industrial Water

The major demand for self-supplied industrial water in the study area is confined to Milwaukee County. Based upon County data provided by the U. S. Bureau of the Census in a special tabulation for the GLIRB Project, it is estimated that in 1959 a total of 36 billion gallons of water were used by the industries located in Milwaukee County. Using a 365 day working year, a total of about 100 mgd were used in 1959. Of this total, approximately 44 mgd were supplied by industrial water systems. In Table 3-4 projections of self-supplied industrial water demand are presented for the Milwaukee County industrial service area. Both industrial output and water use efficiency factors have been utilized in developing the projections.

TABLE 3-4

Self-Supplied Industrial
Water Demand (mgd)
Projections, 1980-2020

Service Area	1959	1980	2020
Milwaukee County	44	70	120

Recreation

Moving south from the Kettle Moraine region in the upper part of the study area, stream frontage is highly developed with a large number of small towns bordering the Milwaukee River. In the Kettle Moraine region and in the vicinity of West Bend the River is a popular recreational spot for thousands each summer. Boating, fishing and swimming are the most popular activities. The upper reaches of the River provide spawning ground for small-mouth bass and walleyes.

A recent fishing license sales summary indicates that 90,000 licenses were sold in Milwaukee County. Most of the fishing takes place outside the County since limited fishing opportunities exist in the County and licenses are not required to fish in the Great Lakes. Portions of the Milwaukee River provide the only inland waters with public fishing opportunities in the County. There is a relatively small amount of lake fishing from boats although perch are easily caught and are a desirable fish. (9)

TABLE 3-3

Major Municipal Water Demand(mgd)
Projections, 1980 - 2020

Service Area	1962	1980	2020
Milwaukee Co.	163.1	250	470
Brown Deer	0.7		
Cudahy	3.0		
Fox Point	1.0		
Glendale	-		
Greendale	*		
Greenfield	*		
Milwaukee	152		
Oak Creek	0.5		
St. Francis	*		
Shorewood	*		
South Milwaukee	3.8		
Wauwatosa	*		
West Allis	*		
West Milwaukee	*		
Whitefish Bay	2.1		
Washington Co.			
West Bend	1.5	2.4	5.3
Waukesha Co.			
Menomonee Falls	0.9	5.3	14

*Served by the Milwaukee Water Works.

In the Milwaukee County area few swimming opportunities exist because of poor water quality. Those who want swimming are dependent upon pools and Lake beaches. Even beaches are not an assured opportunity for swimming, primarily because of pollution carried along the shore by Lake currents. Swimming use in Milwaukee County is provided by parks which have 2.25 miles of beach (7.8 percent of the County shore). The Lake front beaches include Doctors Park, Big Bay Park, Bradford Beach, McKinley Beach, South Shore Park, Bay View Park and Grant Park.

It is estimated that 29,000 boats are located in Milwaukee County and about 11.5 percent are moored in yacht basins. Outside of the harbor area, the Milwaukee River, and lagoons having boat liveries, Lake Michigan offers the primary opportunity for boating. Milwaukee Harbor and associated breakwaters now furnish the only protected areas. Sailing has been a favorite activity and it is estimated that about 900 sailboats are located in the County. (9)

The Milwaukee County Park System is considered to be one of the finest systems in the Nation. All the major drainage systems within the County have their immediate floodplains within the park system.

Irrigation

In the 1959 Census of Agriculture data were provided on irrigated land in farms. The data are summarized in Table 3-5 for the principal counties of the study area. Using a straight line projection it is estimated that some 800 acres could possibly be under irrigation by 1980. There is insufficient information to project this data beyond 1980. Because of the proximity of the entire area to metropolitan Milwaukee, however, the number of acres under irrigation is not expected to increase beyond the 1980 figure of 800. It is assumed that some 6 inches of water per acre per year will be required for irrigation purposes. The amount of water necessary, therefore, will reach some 130 million gallons per year. The average water use over a 160 day growing season is now approximately .6 MGD. This could increase to .8 MGD by 1980. Irrigation water use of this magnitude does not represent a significant threat to water quality in the Milwaukee area.

TABLE 3-5

Acreage of Irrigated Land in Farms - Milwaukee Area

County	Acres Reported (10) 1954	1959	Acres Projected 1980
Milwaukee	737	228	230
Ozaukee	27	185	550
Washington	3	7	20
Totals	267	420	800

Fish and Aquatic Life

The waters of Lake Michigan support a wide variety of fish and wildlife. Important fish species include among others the lake perch, walleyed pike, lake trout, smelt, herring and whitefish. Many streams in the upper part of the study area support a fair size fishery consisting of panfish, several species of bass, pike, and walleye. There are a number of trout streams and three lakes, Big Cedar Lake, Silver Lake, and Moldenhauer Lake where the conditions of water temperature, depth, bottom conditions, and public access have warranted trout stocking by the Wisconsin Conservation Department. However, an increasing population orientated toward recreation has begun to put heavy pressures upon the available water areas for other competing uses. (11)

Commercial Shipping

Commercial shipping is confined to the Milwaukee Harbor area. The Milwaukee, Menomonee, and Kinnickinnic Rivers are navigable for deep-draft vessels for 2.9, 1.9 and 1.8 miles above their mouths, respectively. These channels, together with the South Menomonee and Burnham Canals and the Kinnickinnic Mooring Basin, constitute the inner basin of the Milwaukee Harbor, which is one of the principal Great Lakes Harbors. The Harbor is used by vessels moving to and from Great Lakes ports as well as by vessels moving to and from overseas ports via the St. Lawrence Seaway. From 6,000 to 7,000 major cargo ships call at Milwaukee each year, giving it a total vessel movement figure in the range of 12,000 to 14,000 major vessels per year. (12) Harbor vessel traffic has averaged 7.9 million tons for the period 1954-1964. In 1964 the traffic was 6.4 million tons. By 1980 through 2020 this tonnage may be expected to increase somewhat, however, the actual number of ship movements may be expected to remain approximately the same due to an anticipated increase in vessel size.

Waste Assimilation

See Chapters 4 and 6.

Esthetics

The use of water for esthetic enjoyment is an intangible benefit which is directly related to the availability of clean water. The Milwaukee County Park Commission maintains parks and parkway areas along the stream banks of the Milwaukee, Menomonee and Kinnickinnic Rivers in Milwaukee County. The streams thus have esthetic value in relation to those utilizing park and parkway facilities. The proximity of Lake Michigan and the lakefront development which includes numerous parks and beaches also offers many opportunities for esthetic enjoyment of the Lake Michigan waters adjacent to Milwaukee County.

Water Quality Goals

The establishment of water quality criteria for the significant water uses of the Lake Michigan Basin was accomplished through the organization of four water quality work groups chaired by a member of the Technical Committee shown in Table 1-2. These work groups consisted of representatives of the States, municipalities and industries of the Lake Michigan Basin.

These four work groups, The Municipal Work Group; The Industrial Work Group; The Fish, Aquatic Life, and Recreation Work Group; and the General Work Group considered water quality needs to support eleven specific water uses, namely:

- Municipal Water Supply
- Industrial Water Supply
- Recreation - Whole and Partial Body Contact
- Irrigation
- Fish and Aquatic Life
- Wildlife and Stock Watering
- Hydropower
- Commercial Shipping
- Cooling Water Supply
- Waste Assimilation
- Esthetics

The criteria developed by the four work groups give maximum or minimum desirable concentrations of various water quality parameters, above or below which the stated water uses would be adversely affected. Limits were not set for all water quality parameters but rather for those parameters which are generally most significant in the Lake Michigan Basin. The findings of the water quality work groups are summarized in Table 3-6. Minimum dissolved oxygen requirements and maximum coliform, phosphate, phenol, and ammonia nitrogen concentrations are most pertinent to water quality problems within the study area.

In the study area there are certain areas in which specific uses are being jeopardized. The affected uses are indicated on Table 3-1 by means of an asterisk. In these areas, where pollution is adversely affecting water quality to the extent that the established water quality criteria are not met, the criteria become the water quality goals of water quality improvement measures. Further discussion of the water quality problems in the study area is contained in Chapter 6. These areas will be protected through the comprehensive water pollution control action program for the Milwaukee Area outlined in Chapter 9.

TABLE 3-6

LAKE MICHIGAN BASIN - WATER QUALITY CRITERIA FOR SPECIFIC WATER USES (5)

Numerical Values in Columns

WATER USE	WATER QUALITY PARAMETER (Maximum or Minimum Concentrations For Any One Sample																	
	DO (min) mg/1 or % Saturation	pH (Range)	Phenolics (max) mg/1	Chloride (max) mg/1	MBAS (Max) mg/1	Turbidity Units (max)	Temperature °F (max)	Color Units (max)	Coliform Guide (1) (max)	BOD_5 (max) mg/1	NH_3-N (max) mg/1	Dissolved Solids (max) mg/1	Cyanide CN^- (max) mg/1	Iron (Fe^{++}) (max) mg/1	Manganese (max) mg/1	Odors (max) (Threshold No.)	Phos. Soluble (PO_4) (max) mg/1	Sulfate (SO_4) (max) mg/1
Municipal Water Source	80	7.7 9.0	.003	20	0.2			15	C		0.1	186	0.1	0.3		(2)	.03	50
Industrial Process Water	1.0	5 9	1.0	250	1.0	250	80	100	D	10	5	750		0.2	0.1			
Recreational-Whole Body Contact	3.0					50	90	50	A									
Recreational-Limited Body Contact			1.0			250	90		B									
Irrigation																		
Fish and Aquatic Life-Tolerant	3.0	6 9	0.2	500	1.0	50	90											
Fish and Aquatic Life-Facultative	4.0	6 9	0.2	500	1.0	50	87											
Fish and Aquatic Life-Intolerant	6.0	6 9	0.2	500	1.0	50	68											
Wildlife and Live-Stock Watering		5 9		2000		250												
Hydroelectric Power		5 9				250												
Commercial Shipping		5 9				250												
Cooling		5 9		700		250	90											
Esthetics	1.0				1.0													
Waste Water Assimilation	1.0	5 9					110											

(1)
(2) See Following Pages

TABLE 3-6 (Continued)

(1) Coliform Guides

Coliform Guide A - Recreational whole body contact use. The water uses for which this guide is intended are those that entail total and intimate contact of the whole body with the water. Examples of such use are swimming, skin diving, and water skiing, in which the body is totally immersed and some ingestion of the water may be expected. Recommended guide value for coliforms is 1,000 per 100 milliliters (1,000/100 ml). For all waters in which coliform levels are below the guide value of 1,000/100 ml, the water is considered suitable provided there is proper isolation from direct fecal contamination as determined by a sanitary survey. Situations may arise wherein waters having coliform counts somewhat higher than the guide value can be used, provided supplemental techniques are used to determine safe bacterial quality. The analysis for fecal streptococci is more definitive for determining the presence of organisms of intestinal origin, and is suggested as the supplemental technique to be employed. Based on a very limited amount of information, a limit for fecal streptococci of about 20/100 ml is suggested providing there is an accompanying limit on the coliform level. As a provisional limit, it is suggested that a coliform level of 10,000/100 ml be permitted provided the fecal streptococcus count is not more than 20/100 ml, and provided also that there is proper isolation from direct fecal contamination as determined by a sanitary survey.

Coliform Guide B - Recreational, limited body contact use and commercial shipping (barge traffic). The water uses for which this guide is intended are those that entail limited contact between the water user and the water. Examples of such uses are fishing, pleasure boating, and commercial shipping. Recommended guide value for coliforms is 5,000/100 ml. For all waters in which coliform levels are below this guide value, the water is considered suitable for use, provided there is proper isolation from direct fecal contamination as determined by a sanitary survey.

For waters which have coliform levels above the guide value and such levels are evidently caused primarily by organisms of other than fecal origin, the limiting count may be as high as 50,000/100 ml, provided the fecal streptococci count is not more than 100/100 ml. The provisional coliform limit of 50,000/100 ml is based on an examination of reported and measured data for the Illinois River Basin streams. It is believed to be an acceptable limit for taking into consideration, and providing for the occurrence of, background coliform levels. With the accompanying limit on fecal streptococci, it is reasonable to expect that the danger of infection by enteric organisms

TABLE 3-6 (Continued)

will be remote. It is understood that the provisional limit would be subject to modification as more analytical data are accumulated and critically reviewed.

Coliform Guide C - Applies to Municipal Water Source. Where municipal water treatment includes complete rapid-sand filtration or its equivalent, together with continuous postchlorination, source water may be considered acceptable if the coliform concentration (at the intake) averages not more than 5,000 per 100 ml in any one month, and the count exceeds this number in not more than 20 percent of the samples in any one month. Samples should be tested at least once daily.

Coliform Guide D - Applies to Industrial Process Water at the source. Although the requirements of this use will vary widely with the processes of a particular industry, Coliform Guide C, for municipal source, is considered generally applicable. As covered by food and drug acts and other regulations, water incorporated into products for human ingestion should, of course, meet finished drinking water standards.

(2) Odors, Threshold Number

The differences in type of odors makes it difficult to assign numbers for water quality goals with respect to this parameter. For some types of odors the difficulty of removal is greater than for others. To reach acceptable treated levels, experience has shown that it is more difficult to reduce a "hydrocarbon" type odor of 6 threshold units than an algae-type odor of 15 units. It is therefore felt that a maximum limit on hydrocarbon odors be 6, and the average daily odor be less than 4 units.

CHAPTER 4

WASTE SOURCES

Municipal

Based on a 1962 inventory of municipal waste discharges compiled by the GLIRB Project in cooperation with the State of Wisconsin it has been determined that a population of approximately 1,080,000 are served by the municipal sewerage systems within the study area. This population, which includes about 95 percent of the study area population, resides in thirty-four communities which are served by municipal systems. Nineteen of the thirty-four communities, including the major city of Milwaukee, are served by the Milwaukee Metropolitan Sewerage District, hereinafter referred to as the District. Within the District both the Sewerage Commission of the City of Milwaukee and the Metropolitan Sewerage Commission of the County of Milwaukee are responsible for the collection and treatment of sewage.

There are nineteen municipal water pollution control installations in the study area. Primary waste treatment is provided at 2 installations and secondary treatment is provided at 17 installations. It is estimated that an untreated waste Population Equivalent (PE)* of 2,647,000 is discharged to the municipal sewerage systems of the study area. After treatment an estimated PE of 361,000 is discharged to the streams of the study area and Lake Michigan. This amounts to an overall average removal efficiency of about 86 percent.

As of 1963 the District treated the wastes of the following communities in Milwaukee County; Bayside, Brown Deer, Cudahy, Fox Point, Glendale, Greenfield, Milwaukee, River Hills, St. Francis, Shorewood, Wauwatosa, West Allis, West Milwaukee and Whitefish Bay. The District also serves the communities of Brookfield and Elm Grove in Waukesha County and operates separate waste treatment plants in Greendale, Hales Corners and Oak Creek.(13) The City of South Milwaukee constitutes the only area within Milwaukee County remaining outside the limits of the District.

. . . .

*As determined by the 5 day biochemical oxygen demand (BOD_5) analysis, one pound of BOD_5, is equivalent in oxygen-consuming capacity to a Population Equivalent of 6.

The present major municipal waste discharge in the study area originates from the District's Jones Island treatment plant. The plant provides secondary treatment for the wastes originating from an estimated population served of 1,020,000 and discharges the treated effluent to Milwaukee Harbor within the breakwater. During 1963 the plant discharged an average of 162 mgd and an average BOD_5 load of 56,600 pounds per day. The plant BOD_5 removal efficiency was approximately 87 percent.

The District is constructing a new South Shore waste treatment plant. The new plant is located in the City of Oak Creek approximately 1 mile south of the South Milwaukee sewage treatment plant on the shore of Lake Michigan. The plant will discharge treated wastes direct to Lake Michigan by means of an outfall sewer which will discharge at a point approximately 1800 feet offshore. The new plant is designed to provide primary treatment and disinfection and will have a maximum capacity of 320 mgd for periods of heavy storm runoff. The primary plant will not have a by-pass and is rated to handle 60 mgd and an untreated PE of approximately 300,000. The plant is designed for expansion in the future to include activated sludge treatment with a rating of 120 mgd and a maximum capacity of 200 mgd. Waste flows in excess of 200 mgd will receive primary treatment and disinfection only.

The municipal waste discharge from the South Milwaukee Sewage Treatment Plant is also considered to be of significance in the study area. During 1962 the Plant served an estimated population of 20,300 and discharged an average of 2.7 mgd and an average BOD_5 load of 2,300 pounds per day. The Plant BOD_5 removal efficiency was approximately 50 percent. After providing primary waste treatment the plant discharges to Lake Michigan at South Milwaukee via a minor stream.

The GLIRB Project has made projections of the municipal waste loads and flows for the major sewerage service area to the years 1980 and 2020. These are presented in Table 4-1. The projections cover total waste discharges from municipal sewerage systems. It is assumed that 90 percent BOD_5 removal will be provided in 1980 and 95 percent will be provided by 2020. Where existing removal efficiencies are greater than those indicated, it is assumed they will continue to operate at the higher levels.

TABLE 4-1

Major Municipal Waste Load Projections

1980 - 2020

Service Area	1962 Effluent Flow (mgd)	1962 Effluent BOD_5(#/day)	1980 Effluent Flow (mgd)	1980 Effluent BOD_5(#/day)	2020 Effluent Flow (mgd)	2020 Effluent BOD_5(#/day)
Milwaukee Area*	167	59,000	260	68,000	490	63,000

*The Milwaukee Area is defined to include the combined service areas of Milwaukee County, New Berlin, Elm Grove, Brookfield, Menomonee Falls, Butler, Thiensville and Mequon.

Industrial

A 1964 inventory of direct industrial waste discharges in the study area was compiled by the GLIRB Project in cooperation with the State of Wisconsin. A total of 4 significant direct plant discharges have been identified with a total waste flow of about 4 mgd. The total waste load discharged from the 4 plants is estimated to be 25,000 lbs./day. The major industrial waste sources are listed in Table 4-2.

TABLE 4-2

Major Industrial Waste Sources
(Direct Discharge)
1964

Industry (Product)	Location	Treatment	Effluent BOD_5(lbs/day)	Waste Flow (mgd)
Peter Cooper Corp. (Glue & Gelatin)	Oak Creek	Primary	25,000	3.7
Western Condensing Co. (Condensed Milk Prod.)	Adell	Aerated Lagoon	40	0.1
Libby, McNeil & Libby (Canned Veg.)	Jackson	Lagoon, Screening, Spray Irrig.	150	0.2
Krier Preserving Co. (Canned Veg.)	Random Lake	Lagoon, Screening, Spray Irrig.	70	0.1
TOTALS			25,260	4.1

As may be noted above, the major direct industrial waste source in the study area is the Peter Cooper Corporation in Oak Creek. This plant uses rejected tannery hides as raw materials to produce gelatin and glue products. The plant provides primary waste treatment and discharges to Lake Michigan at Oak Creek. The plant has been under orders of the State Committee on Water Pollution for a number of years to provide adequate waste treatment.(14)

Combined Sewers

Of the 34 sewer systems in the study area, 27 are of the separate type. That is, they have been designed to receive only sanitary sewage and industrial wastes. Milwaukee, Cudahy, West Allis, West Milwaukee, South Milwaukee, Whitefish Bay, and Shorewood have both separate and combined sewers.(15,16) It is estimated that approximately 85 percent of the study area population served by sewerage systems is served by systems with both separate and combined sewers. It should be noted that each of the seven communities cited above are within Milwaukee County.

Problems relating to overflows from combined sewer systems are complex and have been adequately documented.(17) The particular problems of combined sewer overflows in the Milwaukee Metropolitan Sewerage District have been described in previous reports.(16,18,19) In summary, there are about 240 overflow devices for storm water and sanitary sewage in the Milwaukee area. Most of these devices are on combined sewers and permit the discharge of combined storm water and sewage to Lake Michigan and tributary streams. The overflow of sewage and industrial wastes together with large amounts of storm water constitutes a major source of pollution in the streams draining Milwaukee County and the adjacent waters of Lake Michigan.

The GLIRB Project has made estimates of the waste loads discharged to Milwaukee Harbor as a result of storm water runoff and overflows from combined sewers.

It is estimated by the GLIRB Project that an average BOD_5 load of 9,800 pounds per day reach the Harbor from combined sewer overflows during periods of overflow. This estimate has been developed on the basis of studies of such overflows in Chicago. Consideration has been given to differences in raw sewage characteristics between Chicago and the Milwaukee area.

For storm water runoff in separate sewer areas, it is also estimated by the GLIRB Project that an additional average BOD_5 load of 8,800 pounds per day are discharged to the Harbor. This estimate is based upon previous studies by the Public Health Service in the Cincinnati area.

In summary approximately 18,600 pounds of BOD_5 per day are discharged to Milwaukee Harbor from combined sewer overflows and storm water runoff during periods of heavy runoff.(19)

Agriculture and Land Runoff

Present estimates of fertilizer use (nitrogen and phosphate) for the Milwaukee River Basin show that approximately 630 tons of nitrogen and 1,600 tons of phosphate have been used annually. The largest total volume of fertilizer is applied to the corn acreage. However, the heaviest applications per acre are applied to fruit and vegetable crops.

During 1963-1964 the GLIRB Project conducted a rural land runoff sampling study to assess the relative amounts of phosphate and other substances transported to streams by rural runoff in the Lake Michigan Watershed. Based upon the results of this study, it is estimated that there is an annual total soluble phosphate runoff from rural land of about 11,000 pounds per year in the Milwaukee River Basin.(20)

Pesticide contamination of streams is a matter of growing concern. Agricultural usage is considered to be the major source of pesticides found in water. In the study area the principal chemicals used are DDT, EPN, Malathion, Parathion and Sevin. There have not been any reports of field evaluations of actual problems resulting from the use of pesticides in the study area. These wastes are particularly difficult to evaluate and control because of their wide distribution over the study area.

Federal Installations

The Federally-owned or Federally-leased installations listed below discharge waterborne wastes in the Milwaukee area. Installations that discharge to municipally-operated sewerage systems have not been listed since the Federal Government does not control the treatment provided.

Milwaukee Breakwater Light Station,
Milwaukee, Wisconsin

This U. S. Coast Guard Station, located in the outer Milwaukee Harbor discharges approximately 150 gallons per day (gpd) of raw sewage to Lake Michigan from a complement of 3 men.

Department of Army Housing

Milwaukee Defense Area housing consists of scattered housing units leased by the Army for use by Defense Area personnel. Most of these housing units are connected to municipal sewer systems. Those units in the Milwaukee area not served by a municipal system are as follows:

1) Milwaukee DA Housing at Brown Deer:

   Five housing units at various locations in Brown Deer, Wisconsin reportedly discharge 1,000 gpd of sanitary wastes. Treatment facilities consist of septic tanks and tile drain fields.

2) Milwaukee DA Housing at S. W. Bay Shore Estates:

   One housing unit located at S. W. Bay Shore Estates, Wisconsin reportedly discharges 200 gpd to a septic tank system.

Phosphates

Each of the waste sources discussed in this Chapter are potential causes of phosphate pollution. Such pollution can result in uncontrollable production of algae followed by decay of this organic matter in lakes and streams. The decay in turn produces oxygen depletion in the waters effected. The algae are also objectionable for many water uses because of unsightly appearance, odors, interference with water treatment processes, and other nuisances.

The major sources of phosphates in the study area are land runoff and municipal waste discharges. Estimates of the quantities of phosphate contributed to Lake Michigan by the above sources have been made by the GLIRB Project and are presented in Table 4-3.

TABLE 4-3

Major Sources of Phosphates
Milwaukee Study Area

Source	Est. Total PO_4 Discharged to Lake Michigan (lbs/day)
Milwaukee Metropolitan Sewerage District (Jones Island Plant)	6600
Milwaukee River and Tributaries	2700
Total	9300

The above figure of 9300 pounds per day represents an estimate of the total amount of phosphate discharged to Lake Michigan at Milwaukee Harbor. This total may be compared with the relatively insignificant total soluble phosphate input to the Milwaukee River and tributaries as a result of rural runoff which amounts to 11,000 pounds per year or about 30 pounds per day.

Ships and Boats

Commercial Ships

The large number of vessels plying Milwaukee Harbor represents a considerable potential for pollution of the Harbor waters. Among the possible sources of pollution are cargo spillage, dunnage, bilge waste, ballast water, fuel spills, garbage and sanitary wastes. Uncontrolled discharges of these wastes can result in serious pollution problems to beaches, shore property, recreational waters, fish and aquatic life, and municipal and industrial water supplies.

Commercial shipping has increased significantly since the opening of the St. Lawrence Seaway in 1959. While all new vessels built since 1952 specifically for use on the Great Lakes have been equipped with waste treatment facilities, ocean-going ships generally have no provision for waste treatment. The majority of these ocean-going vessels are designed to discharge sanitary wastes from multiple outlets making onboard waste collection and treatment an expensive and complex installation.

The U. S. Public Health Service has established regulations governing vessel waste discharges in the Great Lakes based upon their legal responsibility for the interstate control of communicable diseases. Restricted areas have been established in which the discharge of sewage, or ballast or bilge water, from vessels is prohibited. Restricted areas include the water within a three mile radius of domestic water intakes. These restrictions apply to the waters within a three mile radius of the water intakes for the North Shore Water Utility, Milwaukee Water Works, Cudahy, and South Milwaukee.(21)

Recreational Boats

In addition to the commercial traffic, a large number of recreational boats use the Harbor. It is estimated that approximately 700 boats are presently based at the Harbor. The Milwaukee County Park Commission is developing a marina which will ultimately accommodate an additional 1,500 boats. Many of the larger recreational craft are equipped with galley and toilet facilities which may discharge untreated wastes to the Harbor or Lake waters. Oil and gasoline wastes, as well as garbage and sewage from onboard cooking and toilet facilities, are the major potential sources of pollution.

Section 30.71 of the Wisconsin Statutes prohibits the discharge of sewage from boats on inland waters, but does not include the waters of Lake Michigan. The Wisconsin State Board of Health has jurisdiction over all of the area of Lake Michigan within Wisconsin, but has exercised controls over pollution from onshore facilities only. The Board has cooperated with interstate efforts to control vessel pollution.(22)

Dredging. Maintenance dredging is done by the Corps of Engineers to maintain authorized navigation depths in Milwaukee Harbor.

Legislation passed in 1962 provided for increased depths to accommodate deep-draft vessels using the St. Lawrence Seaway. Deepening of the Harbor was started by the Corps last year, and is scheduled to be completed this year. Dredged materials are disposed of in deep waters of Lake Michigan.

Water quality surveys made in 1962 by Great Lakes-Illinois River Basins Project, showed significant evidence of pollution material in the bottom deposits of Milwaukee Harbor. Transfer of this pollutional material to Lake Michigan via the dredging process creates an additional zone of pollution in the Lake.

CHAPTER 5

LAKE CURRENTS

Background

The GLIRB Project studied currents in Lake Michigan adjacent to the Milwaukee area from 1962 through the summer of 1964. Instruments used in this 33 month continuous study included automatic recording current meters, anemometers and thermographs. The objectives of the study were to obtain information relative to the fate and movement of pollutants discharged to Lake Michigan.

Prior to the field effort certain previous Lake Michigan current studies were reviewed. These included the work reported by Harrington in 1895, Johnson in 1955, and Ayers and others in 1955 (23,24,25). Methods used by these workers utilized drift cords and bottles floating at the surface. Unfortunately these earlier efforts dealt with summer currents only.

Findings

It was found that the primary factors which influence Lake Michigan currents adjacent to Milwaukee are the winds and the configuration of the shore line. Winds represent the principal energy source for putting the waters in motion while the shore line maintains the north-south orientation of currents in the area. Generally speaking, water movements tend to parallel the shore as the water depth decreases. Movement patterns of the current flow in Lake Michigan at Milwaukee were typical of this phenomenon.

Density also plays a role in the movement of pollutants entering the Lake. During the summer stratification a pollutant, depending on its initial density, will rise, sink or come to rest on the thermocline. Under winter iso-thermal conditions in the Lake the pollutant, being of lower density than the Lake water, would normally rise toward the surface.

Water motion, such as transport or the net movement of a water mass, can also affect the discharge of a pollutant. If the current is extremely small then a pollutant may build up into a nearly stationary mass. If the existing currents are strong a pollutant will be diluted by the moving water. The initial dilution depends on the rate of discharge of the pollutant and the speed of the current. mixing is another type of water motion which refers to the rate of dilution of a pollutant.

Lake Michigan as a whole has a calculated flow-through time of 100 years. This assumes continual mixing and a constant rate of outflow. However, thermal stratification during both summer and winter and thermal barrier conditions in the spring and fall act to increase the flow-through time two to threefold.

Water transport adjacent to the City of Milwaukee was to the north or the south depending on the wind stress prevailing at the time of study. The net flow or the residual current appears to be variable at Milwaukee. The net flow during 1962-64 in the fall and winter was to the north. In late spring and summer the total net flow was to the south. This is shown on Figures 5-1 and 5-2.

These figures represent in summary nearly 20,000 current meter observations from the station adjacent to the City of Milwaukee. Table 5-1 describes the variability of flow in the area shown from December to April. Figure 5-2 shows that a large percentage of the flow moves toward the north during the summer period. As can be seen, the flow direction during the spring-summer period is highly variable and not as clearly defined as in the fall-winter period.

The prevailing offshore winds at Milwaukee do not produce a strong effect on the currents adjacent to the city. Onshore winds, such as those from the northeast produce a strong influence on the currents. The greatest flow occurred during September 1963 when the dominant wind was from the northeast. The strongest flows during 1962-64 occurred in spring and early fall which coincides with the period of strong winds. Almost without exception, the general flow patterns fit the mean monthly wind regime. It can be shown from the data collected that during any one-day period that the currents flow against the wind in the Milwaukee area. Since water movements depend on long term large-scale forces over a great area, flows against the apparent wind direction are not uncommon.

Summary

The general flow in spring and summer is highly variable with a small residual flow to the south. During fall and winter the flow is definitely to the north with a minimum of variability. Flows occur against the wind frequently in this region because of more dominant forces over other parts of Lake Michigan. The effect of current movements in relation to water quality problems are discussed in Chapter 6.

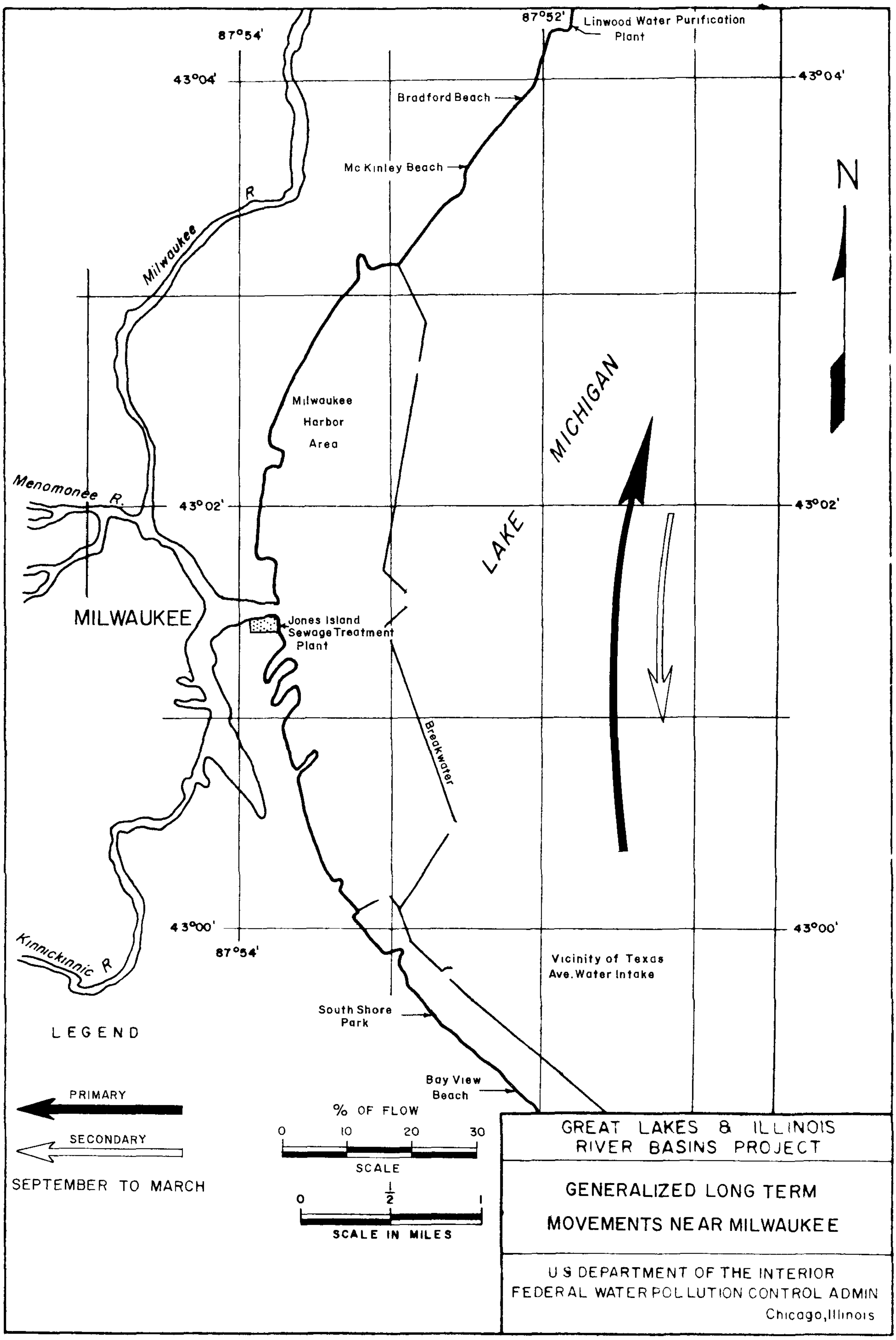
87°54'
87°52'
Linwood Water Purification Plant
43°04'
43°04'
Bradford Beach
Mc Kinley Beach
N
Milwaukee R
Milwaukee Harbor Area
LAKE MICHIGAN
Menomonee R.
43°02'
43°02'
MILWAUKEE
Jones Island Sewage Treatment Plant
Breakwater
43°00'
43°00'
87°54'
Kinnickinnic R
Vicinity of Texas Ave. Water Intake
South Shore Park
Bay View Beach
LEGEND
PRIMARY
SECONDARY
SEPTEMBER TO MARCH
% OF FLOW
0
10
20
30
SCALE
0
½
1
SCALE IN MILES
GREAT LAKES & ILLINOIS RIVER BASINS PROJECT
GENERALIZED LONG TERM MOVEMENTS NEAR MILWAUKEE
U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
Chicago, Illinois

FIGURE 5-1

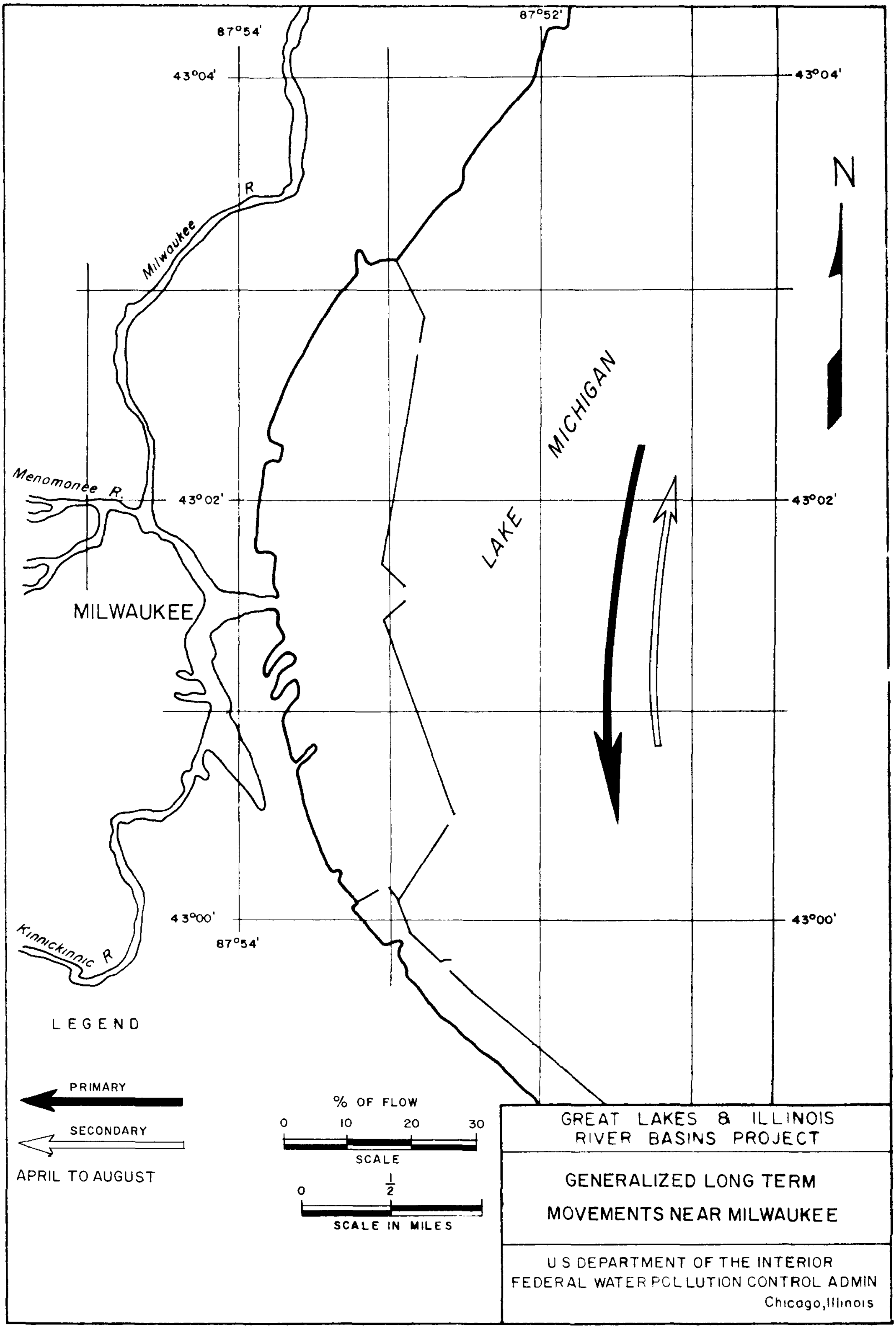

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FIGURE 5-2

TABLE 5-1

HISTOGRAM OF CURRENT DIRECTION
DECEMBER TO APRIL AT MILWAUKEE

1962 - 1964

Direction of Flow (Degrees)		Percent of Time
(North)	0	20.2
	30	13.3
	60	5.8
	90	3.9
	120	3.4
	150	5.2
(South)	180	7.8
	210	7.2
	240	6.0
	270	5.7
	300	8.2
	330	13.3

CHAPTER 6

PRESENT WATER QUALITY AND PROBLEMS

General

The information and interpretations presented in this discussion are based on water quality data collected by the GLIRB Project during its water quality studies of the Lake Michigan Basin (1962-1964). The GLIRB Project studies have been supplemented by data obtained from the State of Wisconsin and regional and local agencies.

Summary

The chemical, biological and bacteriological data presented in subsequent pages are the basis for the following conclusions with respect to water quality effects:

Milwaukee Harbor Area

1. The waters of the Milwaukee Harbor area were found to be polluted from waste discharges of the immediate area.

2. High concentrations of nutrients, phosphate and ammonia, were found in the Harbor area, and in the areas adjacent to the Harbor.

3. Minimum dissolved oxygen levels of 5.3 mg/l, indicated the effects of organic loadings discharged to the Harbor waters.

4. Phenol concentrations, as high as 9.8 micrograms/l, indicated the presence of industrial wastes in the Harbor waters.

5. Other chemical parameters indicated that the waters in the Milwaukee Harbor area vary considerably from the water of the Lake.

6. Biological studies of the bottoms showed heavy organic deposits dominated by high populations of pollution tolerant sludgeworms. Only a few clean water organisms were found in the Harbor area. Degraded benthic conditions extended as far as seven miles into Lake Michigan.

7. Variations in the kinds and numbers of phytoplankton found in Lake waters adjacent to the Harbor indicated that the nutrient-rich waters from the Harbor moved into the Lake.

8. Very high concentrations of coliform and fecal streptococcus bacteria were found in the Harbor area. These organisms are indicators of bacterial contamination and serve to warn that a health hazard may exist for anyone exposed to or consuming these waters.

In general the polluted water conditions in Milwaukee Harbor result from the discharge of wastes from sources described in Chapter 4 and summarized as follows:

1. Treated wastes discharged from the Jones Island sewage treatment plant.

2. Screened sewage which is bypassed by the Jones Island plant during wet weather when flows exceed the plant capacity.

3. Storm water overflow from the Milwaukee area combined sewer systems.

4. Organic material carried into the Harbor as a result of storm water runoff from those sections of the Milwaukee area served by separate sewers.

5. Sanitary waste discharges from vessels plying the Harbor.

Study Area Streams

1. The Milwaukee River within Milwaukee County is polluted. The principal waste source causing pollution is the overflow from combined sewers in the area.

2. High concentrations of coliform bacteria and phosphorous and low dissolved oxygen levels have been observed in the River within Milwaukee County.

3. Relatively high concentrations of coliform bacteria and phosphorous were observed in the Milwaukee River above Milwaukee County. Waste discharges from municipal sewage treatment plants contribute to the high concentrations observed.

Milwaukee Harbor

Physical and Chemical Aspects

Two studies of Milwaukee Harbor were made by the GLIRB Project; one in the fall of 1962 and the second in the summer of 1963. The purpose was to determine the present water quality in Milwaukee Harbor and the effect of these waters on adjacent Lake Michigan. Table 6-1 presents the number of samples, averages and ranges of analytical results for Milwaukee Harbor and waters adjacent to the Harbor. Figures 6-1, 6-2, and 6-3 present sample station locations and concentration variations observed in each area for ammonia nitrogen, soluble phosphate and phenol, three of the more critical water quality parameters.

In Figure 6-1 the highest ammonia nitrogen levels, 1.00-2.20 mg/l, are shown to be in the central area of the harbor and in the Milwaukee River. These concentrations extended about one mile north of the mouth of the Milwaukee River and approximately three miles south along the shore line. Levels of 0.50-0.99 mg/l were found in the southeastern portion of the Harbor and in the northwestern side of the Harbor. The very northern section of the Harbor had concentrations of 0.15-0.49 mg/l. Waters adjacent to the breakwater from the center opening to the southern end and with bands extending out into the Lake, had levels ranging from 0.15 to 0.49 mg/l. North of the breakwall along the shore line, an area outside the Harbor and near the center of the breakwater, and an area south of the Harbor the concentrations were 0.05-0.14 mg/l. All of the remaining waters adjacent to the Harbor had concentrations of 0-0.05 mg/l, which is typical of the background levels found in Lake Michigan proper.

As shown in Figure 6-2 the soluble phosphate values form a similar pattern to that of ammonia nitrogen. Concentrations of 0.49-1.3 mg/l extended generally from about one mile north of the Milwaukee River mouth to the southern end of the Harbor. A section in the southeast portion of the Harbor had levels of 0.15-0.49 mg/l. In the northwestern area of the Harbor the concentrations were 0.15-0.49 mg/l and in the northeastern section, 0.03-0.14 mg/l.

In the waters adjacent to the Harbor at the southern end of the breakwater, phosphate levels were observed ranging from 0.49-1.3 mg/l. A band extending along the entire length of the Harbor with tongues extending out into the Lake had concentrations of 0.03-0.14 mg/l. In all of the remaining waters adjacent to the Harbor the levels ranged from 0-0.03 mg/l, which is the level found throughout the Lake where no local phosphate inputs exist.

Phosphate concentrations found are above the limit of 0.01 mg/l recommended by Sawyer and associated with nuisance algal blooms. (26)

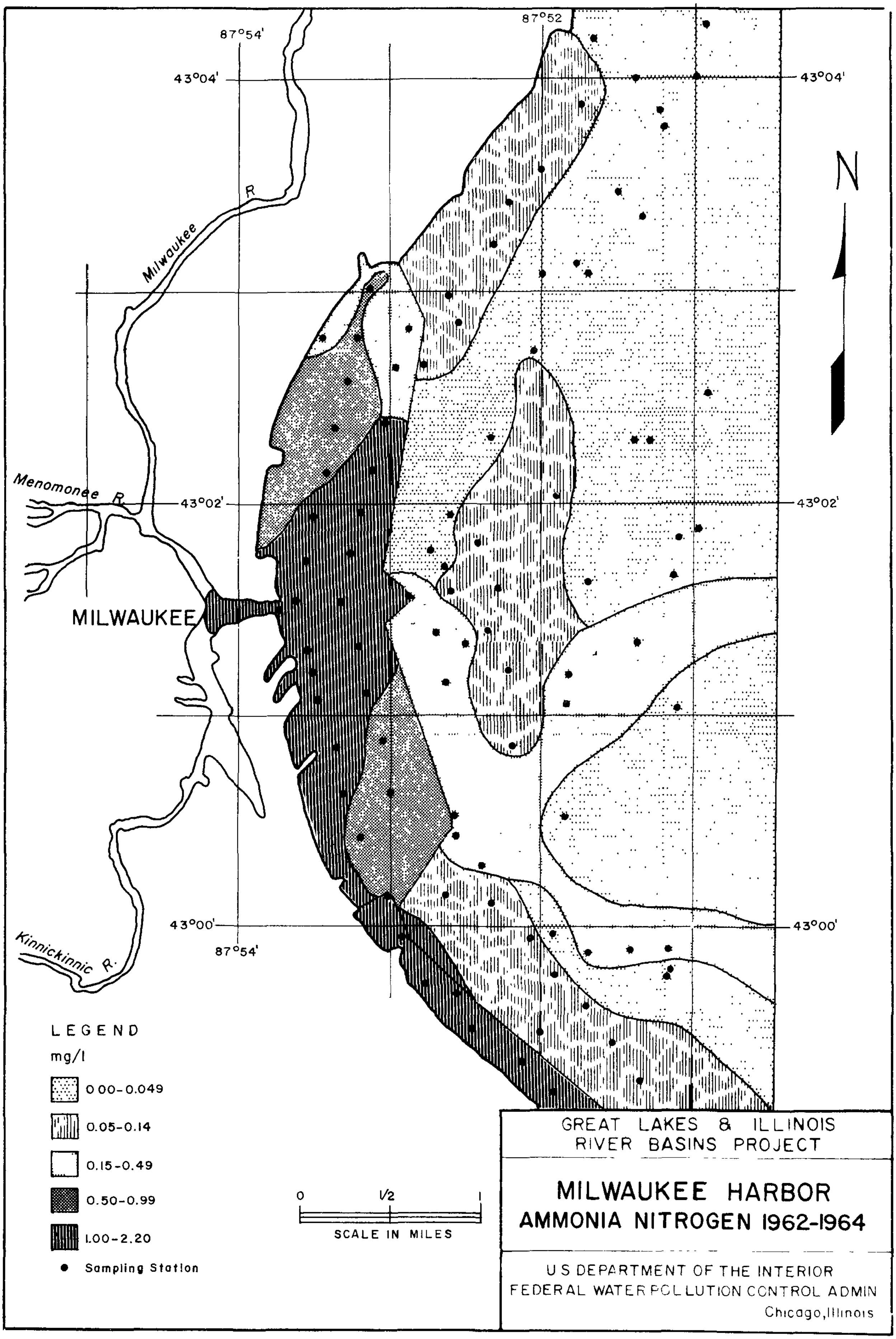
Figure 6-3 presents the phenol concentrations observed in Milwaukee Harbor and the adjacent waters of Lake Michigan. The phenol levels ranged from 4 to 8 micrograms/l at the mouth of the Milwaukee River and for one mile north along the western side of the Harbor, in the very northern end and on the southeastern side of the Harbor. Levels of 2-4 micrograms/l were observed in a large area extending from the eastern side of the Harbor one mile north of the river to three miles south along the western side. A band in the adjacent

TABLE 6-1
WATER QUALITY
MILWAUKEE HARBOR AND ADJACENT WATERS OF LAKE MICHIGAN

October 1962 - June 1963

	Harbor			Water Adjacent to Harbor		
	No. of	Concentration (mg/l)		No. of	Concentration (mg/l)	
Parameter	Samples	Average	Range	Samples	Average	Range
Phenol*	63	3.1	0-9.8	118	1.0	0-7.8
NH_3-N	35	1.12	0.28-2.7	74	0.18	0-1.3
NO_3-N	35	0.15	0.04-0.24	81	0.14	0.03-0.90
Org-N	14	0.37	0.30-0.67	46	0.27	0.01-0.58
Total Soluble PO_4	36	0.44	0.01-1.4	67	0.07	0-0.70
Dissolved Oxygen	48		5.3-15	74		8.7-15
% Saturated	26		77-139	27		108-144
BOD	60	3.4	1.5-8.1	25	2.5	0.3-6.7
Silica	23	1.5	0.98-2.1	46	1.5	1.2-2.8
CL^-	31	19	5.3-36	81	8.3	5.3-23
SO_4	24	29	16-43	50	22	16-53
Dis. Solids	25	214	135-285	38	160	130-225
Spec. Cond.**	48	393	245-585	116	310	220-485
Alk.	37	125	105-155	82	105	100-120
Ca	23	39	32-45	46	33	32-44
Mg	37	15	11-19	82	10	8-19
pH***	38		7.4-8.9	84		7.4-9.1

*Phenol expressed in micrograms/liter.
**Specific Conductance expressed in micromhos/cm
***Logarithm of the reciprocal of the hydrogen-ion concentration.



GREAT LAKES & ILLINOIS
RIVER BASINS PROJECT

MILWAUKEE HARBOR
AMMONIA NITROGEN 1962-1964

U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
Chicago, Illinois

FIGURE 6-1

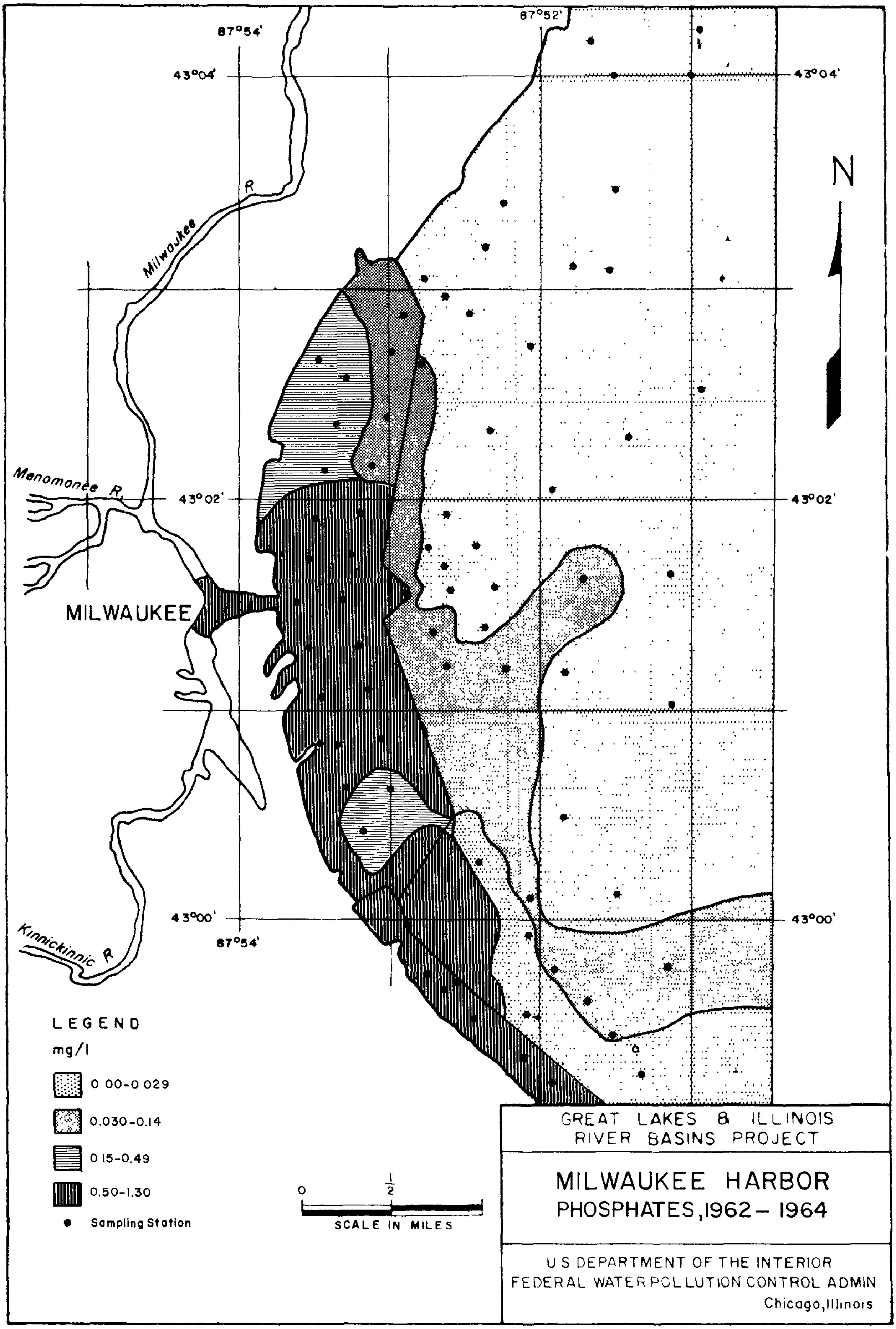


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FIGURE 6-2

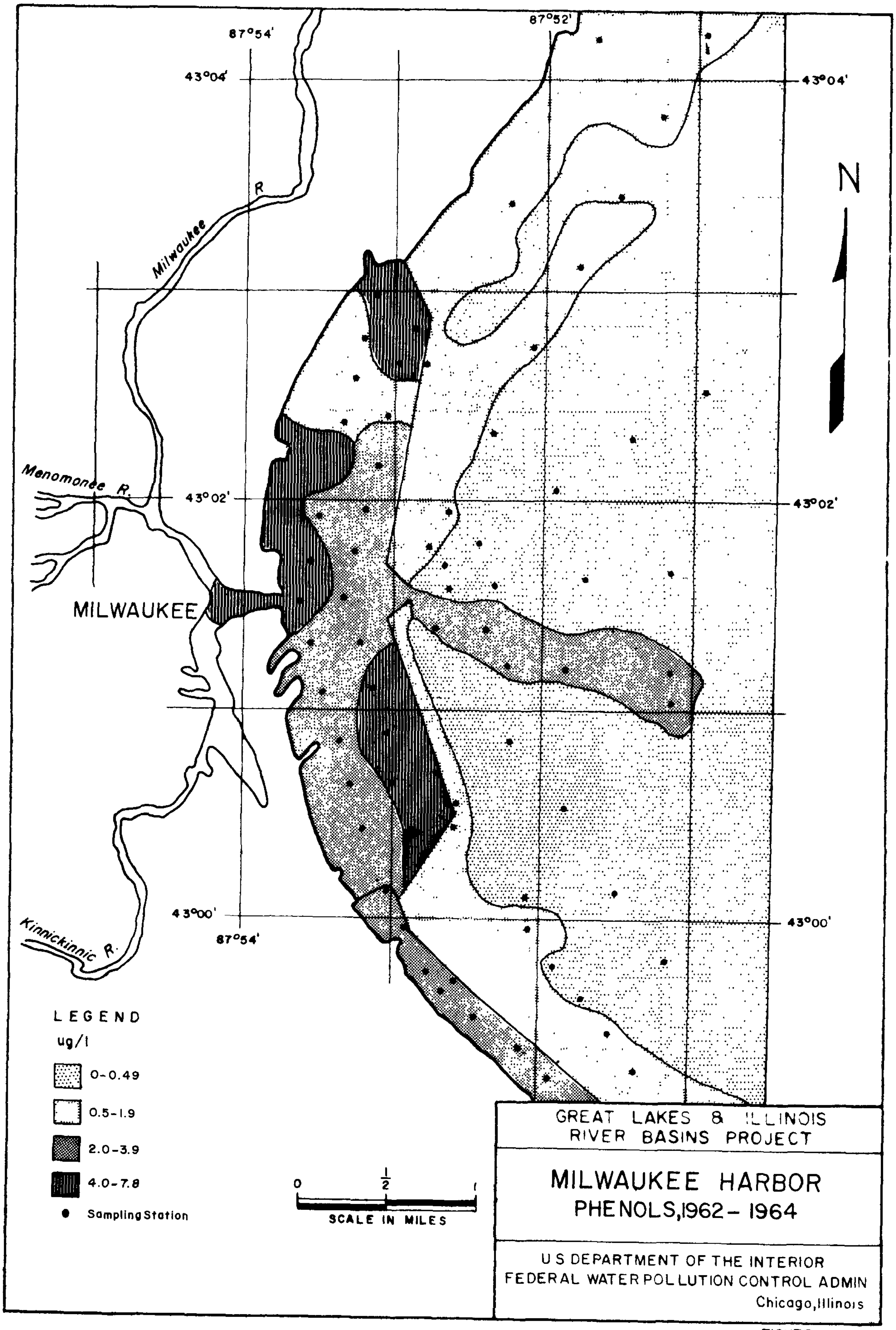
87°54'
87°52'
43°04'
43°04'
N
Milwaukee R
Menomonee R.
43°02'
43°02'
MILWAUKEE
43°00'
87°54'
43°00'
Kinnickinnic R.
LEGEND
ug/l
0-0.49
0.5-1.9
2.0-3.9
4.0-7.8
Sampling Station
0
1/2
1
SCALE IN MILES
GREAT LAKES & ILLINOIS RIVER BASINS PROJECT
MILWAUKEE HARBOR
PHENOLS, 1962 - 1964
U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
Chicago, Illinois

FIGURE 6-3

waters extending from the north to the south along the shore lines and the breakwater had phenol concentrations of 0.5-1.9 micrograms/l. Opposite the center and northern openings in the breakwater, bands extend out into the Lake with the same concentration range. The levels in the remainder of the adjacent waters of Lake Michigan ranged from 0-0.5 micrograms/l.

The other parameters listed in Table 6-1 except for dissolved oxygen, are higher in concentration than in the adjacent Lake waters. The depressed levels of dissolved oxygen that were reported indicate that loadings of organic wastes are entering the Harbor waters.

Biological Findings

The kinds and numbers of aquatic plants and animals, inhabiting a particular body of water, and the stream or lake bottom beneath it, reflect the quality of water that has generally prevailed in the area for an extended period of time. Some plants and animals are capable, by virtue of physiological features or living habits, of withstanding polluted conditions. They multiply rapidly when competition with less tolerant forms is eliminated. Examples of pollution-tolerant animals are the sludgeworms, bloodworms, leeches, and pulmonate snails, that exist in the decaying organic sediment which builds up from the settleable organic solids present in most waste discharges. A benthic (bottom-dwelling) population consisting of many kinds of organisms with low numbers of each species is typical of unpolluted waters. The relative scarcities of pollution-sensitive organisms, such as scuds (crustacea), and the concomitant abundance of pollution-tolerant forms, usually sludgeworms, are considered reasonable indicators of lake areas subjected to organic enrichment if all other conditions are favorable.

Plankton algae are microscopic, chlorophyll-bearing plants suspended in the water. The density of algae in the water is dependent upon several factors, including the concentration of nutrients. All other factors being favorable, the higher the concentration of nutrients, the greater will be the density of algal growth. To a degree, they also indicate the quality of the water in that the kinds and numbers of algae present depend on the chemical and physical composition of the water in which they originated and in which they live.

Biological samples collected in April and September, 1963 in the Milwaukee, Menomonee and Kinnickinnic Rivers all exhibited extreme biological degradation. The predominant bottom animals in the Milwaukee River were sludgeworms - over 1,000,000 per square meter. The Kinnickinnic and Menomonee Rivers had populations of those organisms ranging from 8,000 to 60,000 per square meter. The bottom materials in those areas were composed of ooze with sewage odors.

Degraded biological conditions in the Milwaukee Harbor area in 1962 and 1963 were shown by the analyses of the benthic fauna as shown in Figure 6-4. Populations of sludgeworms as high as 165,000 per square meter were found within the Harbor, and the bottom fauna was composed of 94 to over 99 percent pollution-tolerant forms - mostly sludgeworms. In certain areas of the Lake as far as seven miles from the breakwater outlet, the bottom animal communities continued to be composed of pollution-tolerant forms.

Further evidence of degradation was noted in the analyses of phytoplankton samples collected during sampling operations in June, 1963. In the Harbor area as shown in Figure 6-5, concentrations ranging from 1,000 to 20,000 per ml were found with the dominant forms present being centric diatoms, which are common to enriched waters. Samples collected from the Lake to the south of Milwaukee were predominantly Cyclotella-Stephanodiscus, and Melosira, forms typical of nutrient enriched waters, at levels of over 1,500 per ml. The bulk waters of Lake Michigan remote from nutrient sources or other pollutional discharges were found to contain less than 500 organisms per ml, predominated by forms commonly associated with clean waters, such as Tabelluria.

Microbiological Findings

Coliform concentrations, found during the water quality examination of Milwaukee Harbor and adjacent waters in the fall of 1962, are shown in Table 6-2 and are illustrated in Figure 6-6. The table shows that concentrations exceeded 1,000/100 ml in 38 percent of the samples and 10,000/100 ml in 16 percent. The distribution of these high concentrations are in the immediate Milwaukee River and Harbor area enclosed by the breakwater as shown in Figure 6-6. The results of a repeat study made in June, 1963 are shown in Table 6-3. This table shows that 97% of the samples were found with coliform densities in excess of 1,000 per 100 ml, 35% in excess of 10,000 per 100 ml, and 8% in excess of 100,000 per 100 ml. Fecal streptococci concentrations in excess of 100 per 100 ml were found in 90% of the Samples.

Since the shore line adjacent to Milwaukee contains beach areas that are used for swimming and other water-oriented recreation the high concentrations of bacteria found in the Harbor indicate the possible existence of a health hazard to those using the beaches for this purpose. The Project sampled the beach waters of the Milwaukee area for a brief period and found that at McKinley Beach the coliform concentrations exceeded 1,000 per 100 ml on four of the fourteen days sampled. In the Milwaukee Marina, the concentration exceeded 1,000 per 100 ml on three of the fourteen days sampled. However, the contamination and consequent potential health hazard to bathers of the beach waters in the Milwaukee area has been of serious concern to the Milwaukee Health Department, which prohibited the use of these waters

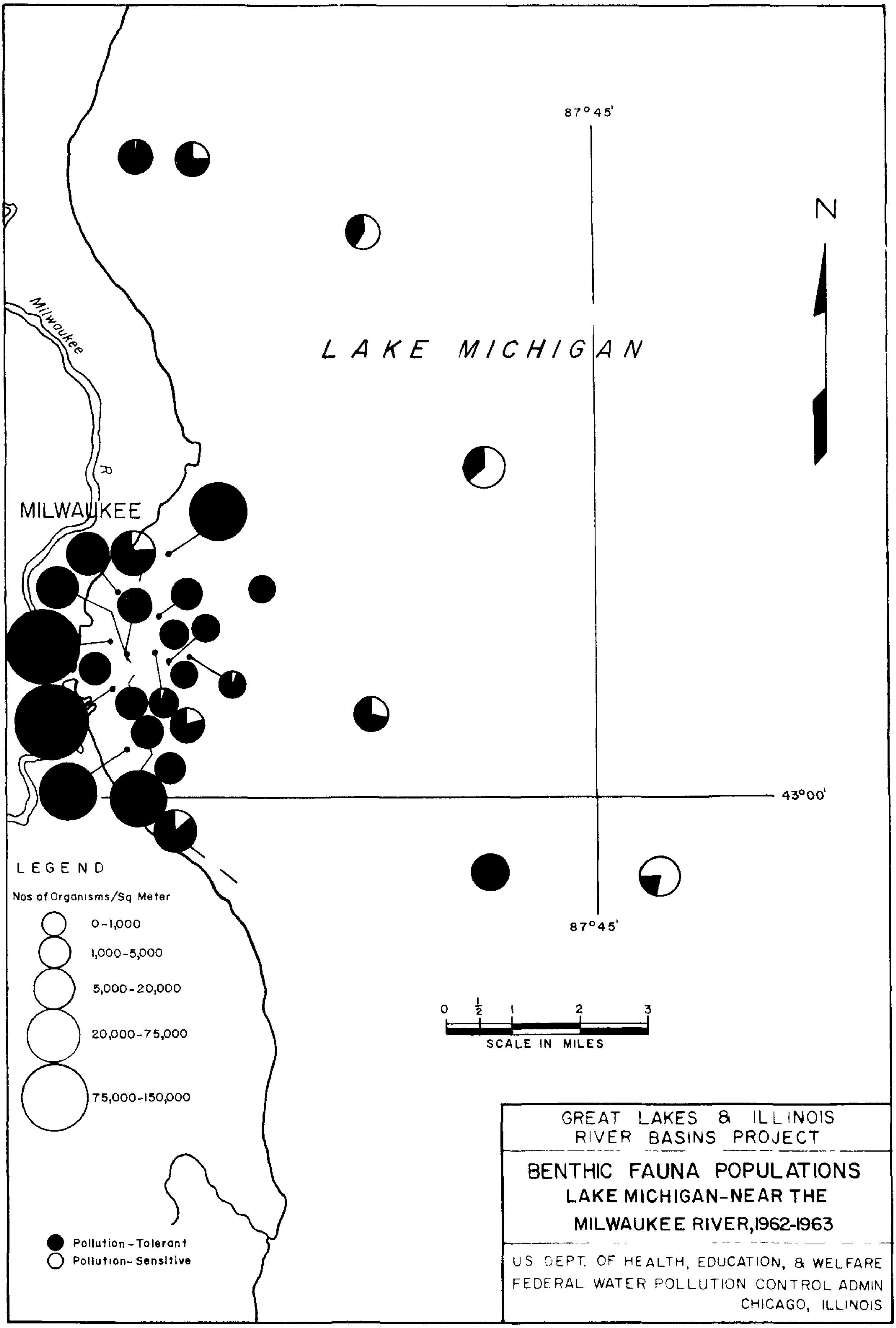
LAKE MICHIGAN
MILWAUKEE
Milwaukee R
87°45'
43°00'
87°45'
N
LEGEND
Nos of Organisms/Sq Meter
0-1,000
1,000-5,000
5,000-20,000
20,000-75,000
75,000-150,000
Pollution-Tolerant
Pollution-Sensitive
0 1/2 1 2 3
SCALE IN MILES
GREAT LAKES & ILLINOIS RIVER BASINS PROJECT
BENTHIC FAUNA POPULATIONS
LAKE MICHIGAN-NEAR THE
MILWAUKEE RIVER, 1962-1963
U.S. DEPT. OF HEALTH, EDUCATION, & WELFARE
FEDERAL WATER POLLUTION CONTROL ADMIN
CHICAGO, ILLINOIS

FIGURE 6-4

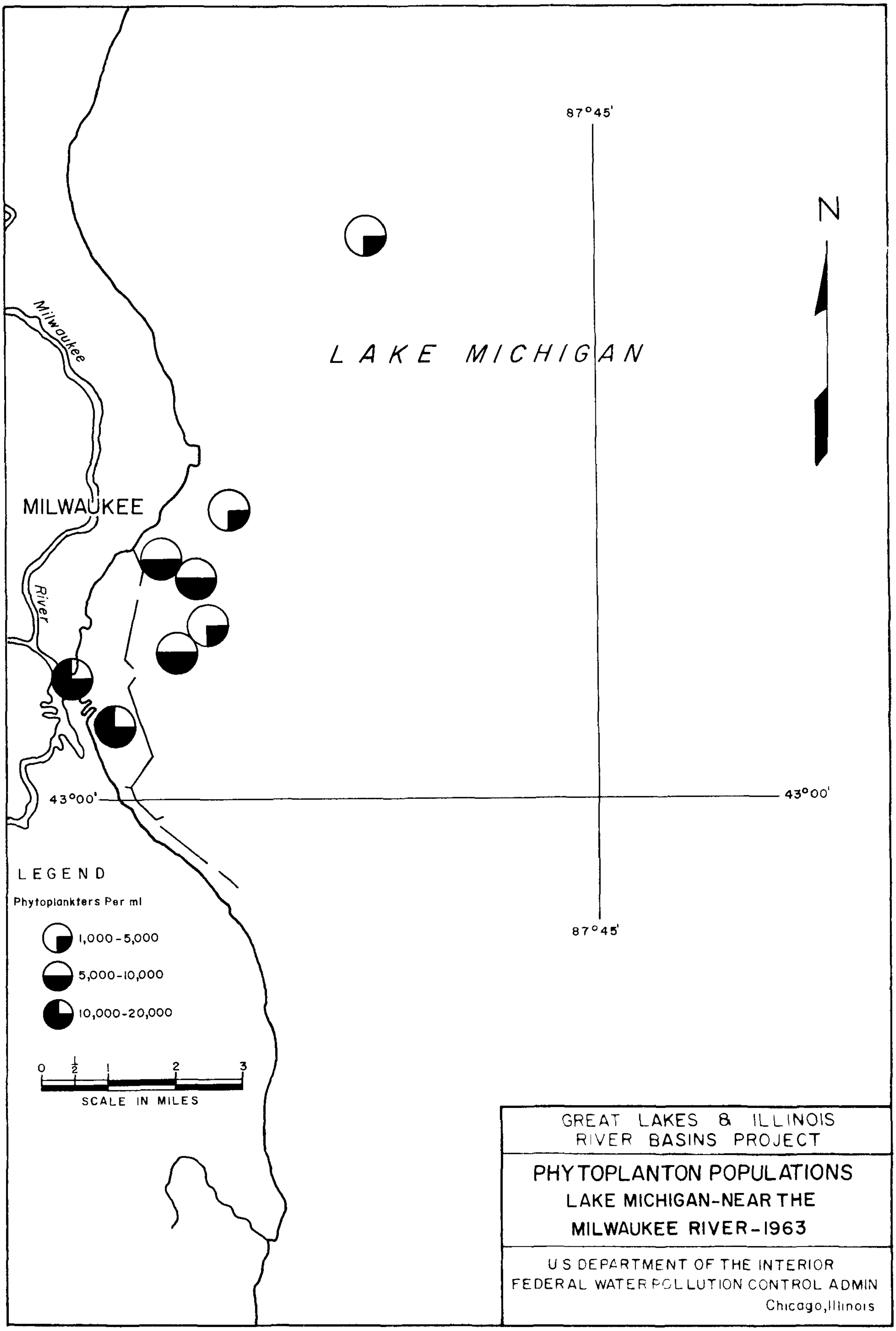
87°45'
N
LAKE MICHIGAN
Milwaukee
River
MILWAUKEE
43°00'
43°00'
87°45'
LEGEND
Phytoplankters Per ml
1,000-5,000
5,000-10,000
10,000-20,000
0 ½ 1 2 3
SCALE IN MILES
GREAT LAKES & ILLINOIS
RIVER BASINS PROJECT
PHYTOPLANTON POPULATIONS
LAKE MICHIGAN-NEAR THE
MILWAUKEE RIVER-1963
U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
Chicago, Illinois

FIGURE 6-5

TABLE 6-2

COLIFORM DENSITIES IN MILWAUKEE HARBOR, 1962

Bacterial density (Range of Coliform Colonies/100 ml.)	No. of Samples Collected	Percent of Samples Collected
1-10	14	18
11-100	12	16
110-1,000	21	28
1,100-10,000	17	22
11,000-39,000	12	16
Total	76	100

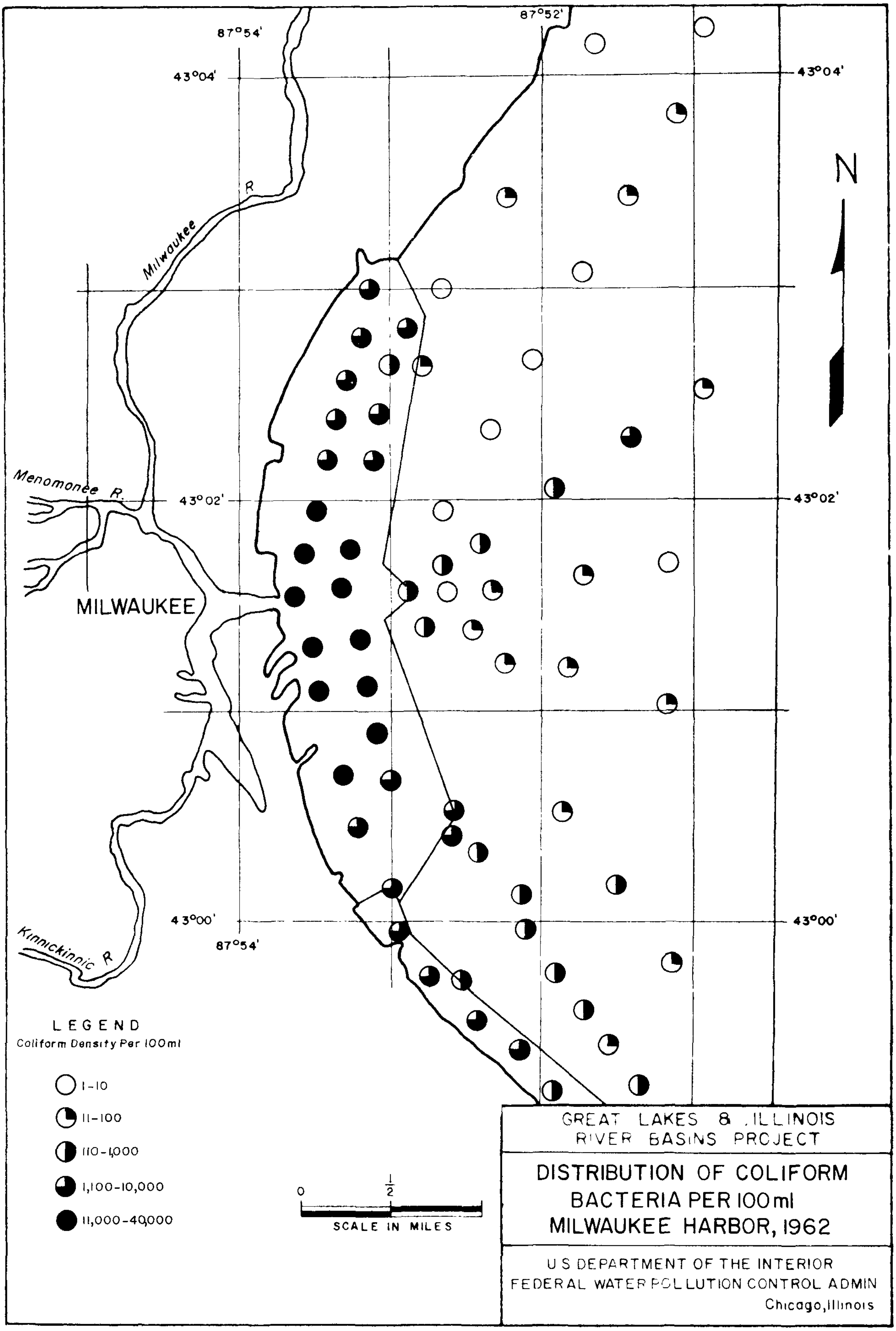
87°54'
87°52'
43°04'
43°04'
N
Milwaukee R
Menomonee R.
43°02'
43°02'
MILWAUKEE
43°00'
43°00'
87°54'
Kinnickinnic R
LEGEND
Coliform Density Per 100ml
1-10
11-100
110-1,000
1,100-10,000
11,000-40,000
0
1/2
SCALE IN MILES
GREAT LAKES & ILLINOIS
RIVER BASINS PROJECT
DISTRIBUTION OF COLIFORM
BACTERIA PER 100ml
MILWAUKEE HARBOR, 1962
U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
Chicago, Illinois

FIGURE 6-6

TABLE 6-3

COLIFORM AND FECAL STREPTOCOCCI DENSITIES
MILWAUKEE HARBOR, 1963

Bacterial Density (per 100 ml)	No. of Samples Collected	Percent of Samples Collected
Coliform:		
110-1,000	1	3
1,100-10,000	23	62
11,000-100,000	10	27
110,000-220,000	3	8
TOTAL	37	100
Fecal Streptococci:		
1-10	1	2
11-100	3	7
110-1,000	20	49
1,100-10,000	15	37
11,000-100,000	2	5
TOTAL	41	100

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for bathing from 1959-1963. The Milwaukee Health Department has recently carried out extensive studies of beach pollution and has concluded that the beaches became affected by combined sewer overflows during and after periods of heavy rainfall. It has also been found that winds from the northeast move polluted Harbor water through the south breakwall opening to the southern beaches, which are also protected by a breakwall. These observations have led to a partial reopening of the beaches for bathing use, geared to the rainfall rate and volume experienced and wind direction and velocity. (27) However, the lack of disinfection for the effluent of the Jones Island sewage treatment plant and overflows from the combined sewers of the area continue to present health hazards as indicated by the high coliform concentrations observed.

Study Area Streams

The Wisconsin State Committee on Water Pollution maintains two monitoring stations on the main stem of the Milwaukee River within Milwaukee County. Data concerning water quality in the River at the 2 stations are presented in Table 6-4.

The above data indicate excessive bacterial pollution with average coliform concentrations in excess of 20,000 per 100 ml at both stations. The water has high color. Phosphorous concentrations are high in relation to the limit 0.01 mg/l of soluble phosphorous as recommended by Sawyer and associated with algal blooms in lakes. (26)

During 1964 and early 1965 the Southeastern Wisconsin Regional Planning Commission (SEWRPC) conducted a water quality study of the Milwaukee River Basin. (28) The results of the SEWRPC study have been discussed in a previous report which was prepared by the GLIRB Project for the U. S. Army Engineer District, Chicago. (29) In general the GLIRB Project report concluded that the present major water quality problems in the Basin are confined to the main stem of the Milwaukee River within Milwaukee County. Problems associated with high concentrations of coliform bacteria, color, and phosphorous were noted in the stream above Milwaukee County, but the critical stream quality problems are associated with combined sewer overflow and storm water runoff in Milwaukee County. High concentrations of coliform bacteria and phosphorous, and low dissolved oxygen levels have been observed resulting primarily from such combined sewer overflows.

During the summer of 1962 the Wisconsin Committee on Water Pollution conducted an investigation of surface water quality in southeastern Wisconsin, including the Milwaukee River. (30) Samples were collected at sixteen (16) stations from Kewaskum to Thiensville during June, July and August. Dissolved oxygen levels were above 6.0 mg/l for each of 61 samples collected, except one sample below Kewaskum which indicated a concentration of 3.8 mg/l.

TABLE 6-4

MILWAUKEE RIVER WATER QUALITY
1961-1964 Averages

Parameter	Machinery Bay near Mouth in Milwaukee	Brown Deer Rd. near Milwaukee Co. Line
Coliform Colonies (per 100 ml)	23,400	20,600
BOD_5 (mg/l)	3.0	3.2
Chlorides (mg/l)	33.4	27.9
Color (S.U.)	27	41
Total Hardness (mg/l)	221	323
Org-N (mg/l)	0.86	1.32
NH_3-N (mg/l)	1.20	0.46
NO_3- N (mg/l)	0.46	0.89
pH	7.6	8.2
Total Phosphorous (mg/l)	0.39	0.52
Soluble Phosphorous (mg/l)	0.25	0.41
Total Solids (mg/l)	348	432
Suspended Solids (mg/l)	16	14
ABS (mg/l)	0.23	0.20
D.O. (mg/l)	5.6	10.0

CHAPTER 7

QUALITY IMPROVEMENT MEASURES

General

The problems of water pollution control in the Milwaukee area are complex. Solutions to these problems will of necessity involve a comprehensive program which includes construction of new sewerage facilities; proper operation of the new and existing facilities; and continuous and intensive monitoring of operating procedures, treatment plant efficiency, and water quality conditions to determine necessary additional construction and operation needs as they arise. These phases of the comprehensive program for pollution control in the Milwaukee area are discussed in the following paragraphs.

Municipal Waste Treatment

The immediate goal in the treatment of municipal wastes is the provision of biological (secondary) treatment at each waste treatment plant. Such treatment is considered adequate in terms of present technology and provides 85-90 percent BOD_5 removal. Adequate effluent disinfection is also considered to be a necessity in the study area, particularly in the immediate Milwaukee area where recreational use of the adjacent waters of Lake Michigan is prevalent. There is also a present need for increased phosphate removal efficiency. See "Reduction of Nutrients" below.

Of the existing waste treatment plants located in the study area all but two provide secondary treatment in the form of activated sludge treatment or trickling filters. The South Milwaukee and Oak Creek plants provide primary treatment only and need improvement to provide secondary waste treatment. The new South Shore plant of the Milwaukee Sewerage Commission is designed to provide primary treatment and disinfection only. This new plant also needs improvement to provide secondary waste treatment. The municipal waste treatment construction needs of the study area are presented in Table 7-1. The needs are based on waste flow and load projections to the year 1980.

It is estimated that the cost of needed municipal plant improvements in the study area, as listed above, but excluding facilities specifically for phosphate removal, is $28,000,000.

TABLE 7-1

MUNICIPAL WASTE TREATMENT NEEDS
MILWAUKEE STUDY AREA

Sewerage Service Area	Present Treatment	Present Pop. Served	Estimated 1980 Pop. Served	Plant Needs
Campbellsport	Secondary, Disinfection**	1,470	1,900	Expansion
Milwaukee Area*	(See Below)	1,050,000	1,440,000	Gen. Expansion
Jones Island	Secondary			Disinfection
South Shore	Primary, Disinfection			Secondary
So. Milwaukee	Primary, Disinfection			Secondary
Menomonee Falls	Secondary			Disinfection
Cedarburg	Secondary	5,190	8,900	Expansion, Disinfection
Fredonia	Secondary	710	1,200	Expansion, Disinfection
Grafton	Secondary	4,000	6,200	Expansion, Disinfection
Saukville	Secondary	1,040	1,800	Expansion, Disinfection
Random Lake	Secondary	860	1,200	Expansion, Disinfection
Germantown	Secondary	620	900	Disinfection
Jackson	Secondary, Disinfection	460	700	Expansion
Kewaskum	Secondary	1,570	2,300	Expansion, Disinfection
West Bend	Secondary, Disinfection	11,740	16,000	Expansion

* Only the major treatment facilities in the Milwaukee Area are listed.

**Cost estimates found in this report assume that chlorination facilities will be used to achieve disinfection of wastes.

Even after the above control measures have been effected, including a high degree of waste treatment, the discharge of waste waters can still result in degradation of receiving waters unless sufficient quantities of higher-quality water are available for dispersal of the effluent. In developing the program for the Milwaukee Area, consideration was given to the desirability of extending the present waste outfall beyond the breakwater and releasing the wastes from the Jones Island Sewage Treatment Plant through a diffuser some two miles from shore. In considering the relative merits of such a proposal, an important factor is the movement of lake waters in this vicinity. Oceanographic studies (Chapter 5) show that during seven months of the year the predominant movement of waters is north toward the Milwaukee and the North Shore Utility water intakes. This raises the possibility that under certain conditions the quality of the lake water in the vicinity of the intakes might be adversely affected. On the other hand, the present breakwater serves as a diffuser by mixing the wastes with the harbor waters before permitting their release through the various openings in the breakwater. The effectiveness of the present arrangement has been demonstrated by the fact that the deterioration of water quality in the vicinity of the water intakes has been minimal. Accordingly, it has been concluded that the present point of discharge provides the best protection for the municipal water supply.

Industrial Wastes

As described in Chapter 4, the Peter Cooper Corporation in Oak Creek is the only significant direct industrial waste source in the study area. Two alternative solutions to the problems of waste treatment at this industry are apparent. Due to the proximity of the new South Shore Treatment Plant of the Milwaukee Metropolitan Sewerage District negotiations could possibly be made whereby the industrial wastes could be discharged to District sewers and treated at the South Shore plant. Some type of pretreatment by the industry might be necessary prior to discharge to the municipal facilities. A second alternative would involve the provision of adequate secondary waste treatment by the Peter Cooper Corporation. The waste waters from the plant are considered to be amenable to biological waste treatment.

Combined Sewers

The need for solutions to the problems caused by overflows from combined sewer systems is pressing and is receiving much current attention.(31) The Water Quality Act of 1965 established a four-year program of grants and contract authority to demonstrate new or improved methods to eradicate the problems of combined sewer overflows.

In 1956 the consulting engineering firm of Alvord, Burdick and Howson submitted a report to the Milwaukee Metropolitan Sewerage District on "Intercepting Sewers and Sewage Treatment in the Milwaukee District Area." The report included the subject of the separation of storm and sanitary sewage in the area. It was concluded that the total cost for separation, including storm sewer construction; roof and foundation drain separation; and interference with the operation of commercial and industrial establishments, would be about $250,000,000. It was also concluded that such an expenditure would be an uneconomic use of the taxpayer's money.

Until economically feasible methods for solving the problems are developed, existing combined sewer systems should be patrolled. Overflow regulating structures should be adjusted to convey the maximum practicable amount of combined flows to and through waste treatment facilities. Combined sewers should be prohibited in all newly developed urban areas and urban renewal projects.

Milwaukee is now constructing an interceptor sewer which should significantly reduce overflows now affecting the southern beaches. It will also convey sanitary sewage to the new South Shore Sewage Treatment Plant.

Reduction of Nutrients

The increasing frequency and severity of algal blooms in Lake Michigan is a clear indication of a rapid acceleration in the concentration of nutrients which stimulate such growths and a clear warning that unless appropriate steps are taken nuisance blooms will become widespread and will interfere with, or inhibit, many important water uses. Studies of this problem in Lake Michigan and also in Lake Erie(32) have led to the conclusion that the best approach to the control of nuisance algal blooms lies in the reduction of phosphorus inputs. The Milwaukee area in general and more significantly the waste effluents from Milwaukee itself are major contributors to the phosphorus content of Lake Michigan (Chapter 4).

The Jones Island Sewage Treatment Plant is accomplishing substantial removals of the phosphorus contained in the raw wastes reaching the Plant. According to recent Plant operating records, approximately 80% of the total phosphorus and 50% of the soluble phosphorus is removed by the activated sludge process. Research now in progress on the mechanism by which phosphorus is removed by the activated sludge process indicates that even higher removals may be achieved.

It is apparent from the conditions in Milwaukee Harbor and the offshore areas (Chapter 6) in the vicinity of Milwaukee that additional phosphorus removal must be achieved if nuisance algal blooms are to be controlled. Complete removal of phosphorus through chemical precipitation can be achieved through the construction of additional plant units with substantial increase in operating costs. It is proposed at this time that all sewage treatment plants of the secondary type located in the area improve the operation of their sewage treatment works to achieve the maximum possible phosphorus removal.

The determination of total and soluble phosphorus should be added to the list of chemical parameters now analyzed in all waste treatment plant laboratories. Such determinations should be made on the raw sewage entering the plant and the plant effluent as well as at other suitable points in the plant process. It is proposed that in one year from this date the records of phosphorus removal be carefully evaluated. If significant improvement in phosphorus removals have not been achieved, consideration should be given to the possible installation of chemical precipitation at all such plants to insure positive continuous phosphorus removal.

Alert Procedures

In 1959 the Milwaukee County Park Commission, based upon the recommendation of the City of Milwaukee Health Department, closed for swimming the public Lake Michigan bathing beaches known as South Shore and Bay View. The beaches were closed due to recurring high coliform bacterial pollution and remained closed until 1963 (Chapter 6). Analyses of past sampling data indicates that a relationship existed between high coliform counts at the beaches and wind direction and rainfall. The relationship was linked to overflows from the combined sewer system serving Milwaukee.(27) In February of 1963 a report was prepared by the Milwaukee Health Department in which periodic opening and closing of the South Shore and Bay View beaches was recommended in accordance with a formula based on rainfall. The development of such alert procedures to cope with the problems of overflows from combined sewers and subsequent beach pollution is commended. However, an overall solution to the problem is the only answer to the constant health hazard posed by these overflows from the combined sewers.

Treatment Plant Operation

A review of the available inventory data relating to the BOD_5 removal efficiencies of the municipal waste treatment plants in the study area indicates that the existing secondary plants at Kewaskum, Fredonia, Saukville and Germantown need operational improvements so as to provide adequate waste treatment. Overloading of the plants at Thiensville, West Bend, Random Lake, Jackson and Butler has contributed to low BOD_5 removal efficiencies at these locations.

Proper plant operation must be coordinated with proper plant design in order to efficiently reach the goals of water pollution control. The importance and value of proper plant operation must be emphasized at all levels of public authority. Effective operation can be encouraged by means of a routine inspection program. The State Board of Health maintains responsibility for the supervision of municipal sewage treatment plant operation in Wisconsin. The State Board of Health should conduct inspections on at least an annual basis for the small and medium-sized plants, and at least, bi-annually for the larger plants such as the Jones Island Plant and the new South Shore Plant.

The Wisconsin Sewage Works Operators Association administers a voluntary sewage treatment plant operators' certification program in Wisconsin. A mandatory certification plan is under consideration. The voluntary program is commendable and can provide definite incentive for the proper operation of waste treatment plants. However, a mandatory program is preferrable to insure the proper qualifications of operators.

State-sponsored operator training programs are also a useful tool for elevating the level of overall plant performance. The existing training program in Wisconsin is a step in the right direction and consists of a 3-day biennial course sponsored by the State Board of Health, University of Wisconsin, and the League of Wisconsin Municipalities. However, the Wisconsin program does not compare favorably with the frequency and duration of such training sponsored by other states. Today, with increasing activity in the field of water pollution control at the Federal, State and local levels, operator training courses should be conducted at least annually.

Annual reports concerning the operation of municipal waste treatment plants are presently submitted to the Wisconsin State Board of Health. Monthly operational reports would provide the

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State with more current information and would enable them to take much quicker action concerning needed improvements.

Monitoring

The maintenance of water quality on a continuing basis calls for a routine monitoring program covering the significant water quality parameters at strategic points. In the Milwaukee area the Wisconsin Committee on Water Pollution maintains two monitoring stations on the Milwaukee River at Brown Deer Road near the Milwaukee County Line and at Machinery Bay in Milwaukee (See Chapter 6). The Milwaukee Metropolitan Sewerage District also monitors water quality in the streams within District boundaries, Milwaukee Harbor and the adjacent waters of Lake Michigan.

The monitoring program of the Wisconsin Committee on Water Pollution should be strengthened and coordinated with other agencies at the Federal, State and Local levels. The Federal Water Pollution Control Administration will cooperate and assist the Committee to the fullest extent of its resources and personnel in expanding its monitoring program. In particular the monitoring program should be expanded to include sampling points at strategic locations on the Milwaukee River and tributaries, Milwaukee Harbor and the adjacent waters of Lake Michigan. In addition to the analyses presently performed, phenol determinations should be made of the samples collected, particularly in Harbor waters and adjacent waters of the Lake.

The industries, municipalities and other agencies, discharging wastes within the study area, should submit monthly reports to the appropriate state agency concerning the quality and quantity of the wastes discharged. These reports could, in many cases, be combined with the monthly operational report which was discussed under "Treatment Plant Operation."

The overall monitoring program should be geared to provide an adequate picture of all wastes being discharged to the waters of the area and serve to indicate changes or trends in water quality or the need for additional water quality improvement measures.

State Water Pollution Control Program

The Federal Water Pollution Control Act recognizes the primary responsibility of the States in the control and prevention of water pollution. The effectiveness of a State program, however, is dependent upon adequate funds and personnel with which to accomplish this mission. The State of Wisconsin has achieved commendable success in the control of water pollution, with the staff and funds available. Recent State legislation which will enable the State to direct efforts toward the prevention of water pollution is an important step toward avoiding water pollution problems in the future.(30)

Although much has been accomplished by the State in controlling pollution, much remains to be done. In 1964, the Public Administration Service prepared a survey report for the Public Health Service concerning the budgeting and staffing of State programs.(31) This report, containing suggested guidelines for use in evaluating the adequacy of State water pollution control programs, may be of assistance to Wisconsin in evaluating its present water pollution control efforts.

In view of the water pollution control problems still existing, consideration should be given by the State to an accelerated program to match the needs of the State for clean water for all legitimate uses. An accelerated State Water Pollution Control program utilizing fully the resources and programs of the Administration will insure the earliest possible accomplishment of our common goal - the elimination of existing pollution and the prevention of pollution in the future, thereby providing more effective use of our water resources.

CHAPTER 8

PROGRAM IMPLEMENTATION

The implementation of the Comprehensive Water Pollution Control Program for the Lake Michigan Basin will involve the combined efforts of the water pollution control agencies at all levels of government. Specific recommendations for implementing the Lake Michigan Comprehensive Water Pollution Control Program, and for coordinating the subbasin programs will be contained in the Summary Report for Lake Michigan, which will be the final report in the Lake Michigan series. The recommendations contained in this report will in no way conflict with recommendations contained in the Milwaukee Area water pollution control program, nor will it interfere in any way with any steps taken to implement those recommendations.

Accordingly it is recommended that the Wisconsin Committee on Water Pollution consider the Comprehensive Water Pollution Control Program contained herein as the basis for improvement of the quality of the waters in the Milwaukee Area. The Federal Water Pollution Control Administration will cooperate with and assist the Committee to the fullest extent of its resources and personnel in each action taken to achieve objectives consistent with the Program.

CHAPTER 9

BENEFITS

Implementation of the recommendations which comprise the above action program will result in substantial improvement in the quality of the waters in the study area. The program objectives, however, are more specific and have been developed to provide water of satisfactory quality for both present and planned uses as shown on Table 3-1. Accomplishment of program objectives will result in both tangible and intangible benefits to the people of the Milwaukee area in particular, and to the people of Wisconsin and the Nation as a whole. As the waters of Lake Michigan serve many States and are of National importance, all will share in the benefits resulting from the enhancement and protection of these waters for both present and future needs.

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

Wisconsin residents and visitors from out-of-state who use the area streams and lakes for swimming, water skiing, boating and other water-oriented sports will be protected against infectious diseases which can be spread as a result of water pollution. The sports fisherman will find additional fishing areas to challenge his skill and improved fishing as a benefit of enhanced water quality.

As a return on their investment in improved water quality, industry will share in the benefits through assurance of consistency in the quality of process water it needs for many of its products and other water needs.

In addition to these immediate and direct benefits resulting from the control of pollution, the preservation and protection of the quality of the waters of Lake Michigan and the Great Lakes is an important benefit and essential to the Nation's continued growth and prosperity. This immense fresh water resource, the greatest in the world, is beginning to show the effects of man's carelessness.

Lake Erie is a clear demonstration that size is no protection against pollution and that man has the capability of destroying the usefulness of even a major water resource.

The Calumet, Milwaukee and Green Bay areas of Lake Michigan are already affected adversely by pollution. Should the Lake as a whole reach critical levels of nutrients or other persistent contaminants, it would require many decades before remedial measures could result in restoration of satisfactory water quality. The beneficial effects of phosphorus removal from wastes originating in the Milwaukee area could result in a very significant benefit in protecting and enhancing the quality of the waters of Lake Michigan.

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