Report on Water Pollution in the

LAKE HURON BASIN

FLINT RIVER

UNITED STATES DEPARTMENT OF THE INTERIOR

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

GREAT LAKES REGION

DECEMBER 1966

REPORT ON

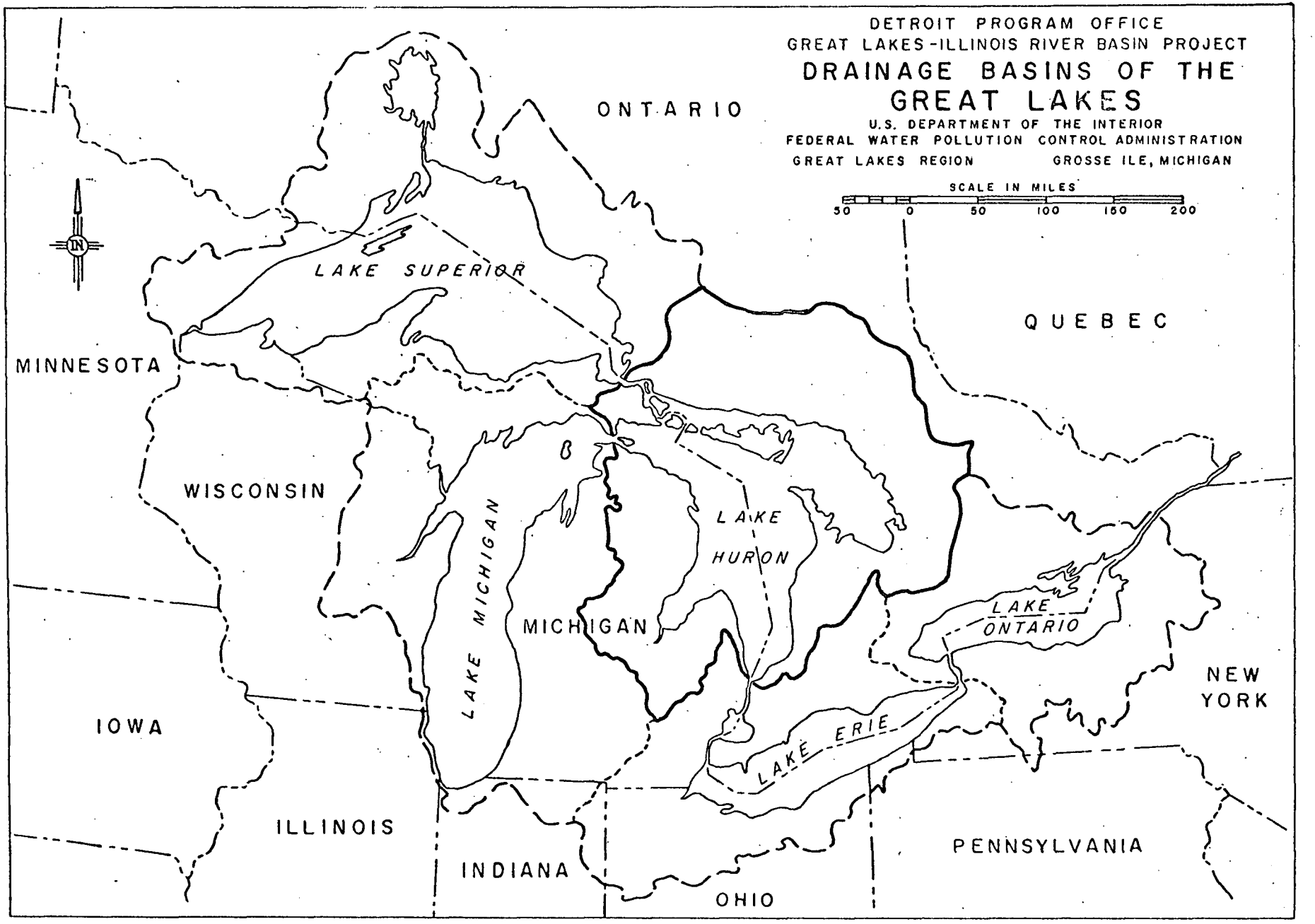
WATER POLLUTION IN THE LAKE HURON BASIN
FLINT RIVER

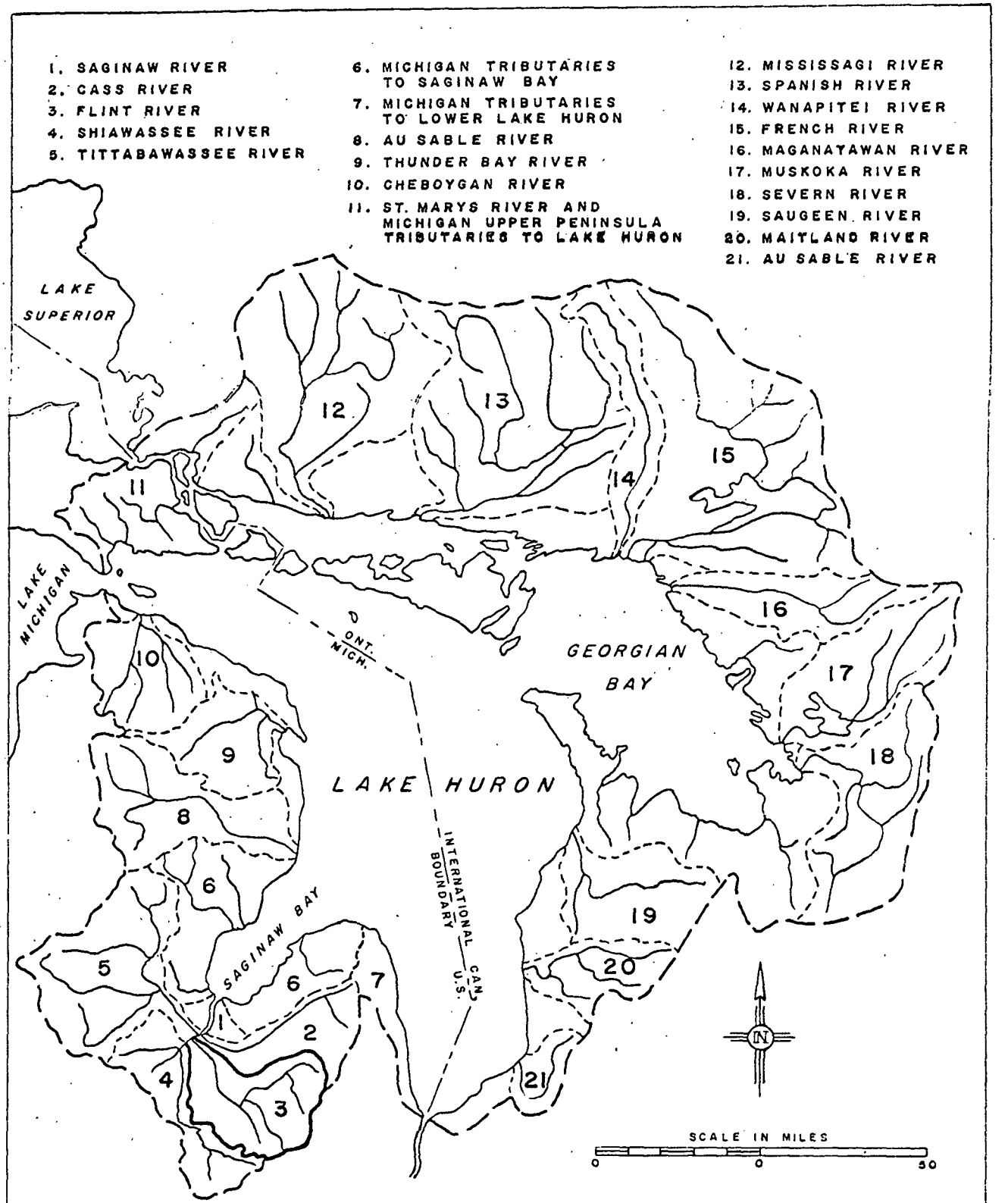
DECEMBER 1966

U.S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Great Lakes Region
Detroit Program Office
U.S. Naval Air Station
Grosse Ile, Michigan

PREFACE

This document was assembled by the Detroit Program Office, Federal Water Pollution Control Administration, with the intention that it be used together with information from other sources to develop a comprehensive plan for water pollution control in the tributaries of the Lake Huron Basin. The intended purpose of the plan would be to restore the usefulness of these waters for recreational purposes, provide a more suitable environment for fish and aquatic life, and enhance the value of this resource. It would improve the quality of the area's waters for municipal and industrial purposes, aesthetic enjoyment, and other beneficial uses.


DETROIT PROGRAM OFFICE
GREAT LAKES-ILLINOIS RIVER BASIN PROJECT
DRAINAGE BASINS OF THE GREAT LAKES
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION
GROSSE ILE, MICHIGAN
SCALE IN MILES
50 0 50 100 150 200
N
ONTARIO
QUEBEC
LAKE SUPERIOR
MINNESOTA
WISCONSIN
LAKE MICHIGAN
MICHIGAN
LAKE HURON
LAKE ONTARIO
NEW YORK
IOWA
LAKE ERIE
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA



DETROIT PROGRAM OFFICE
GREAT LAKES ILLINOIS RIVER BASIN PROJECT

LAKE HURON BASIN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION GROSSE ILE, MICHIGAN

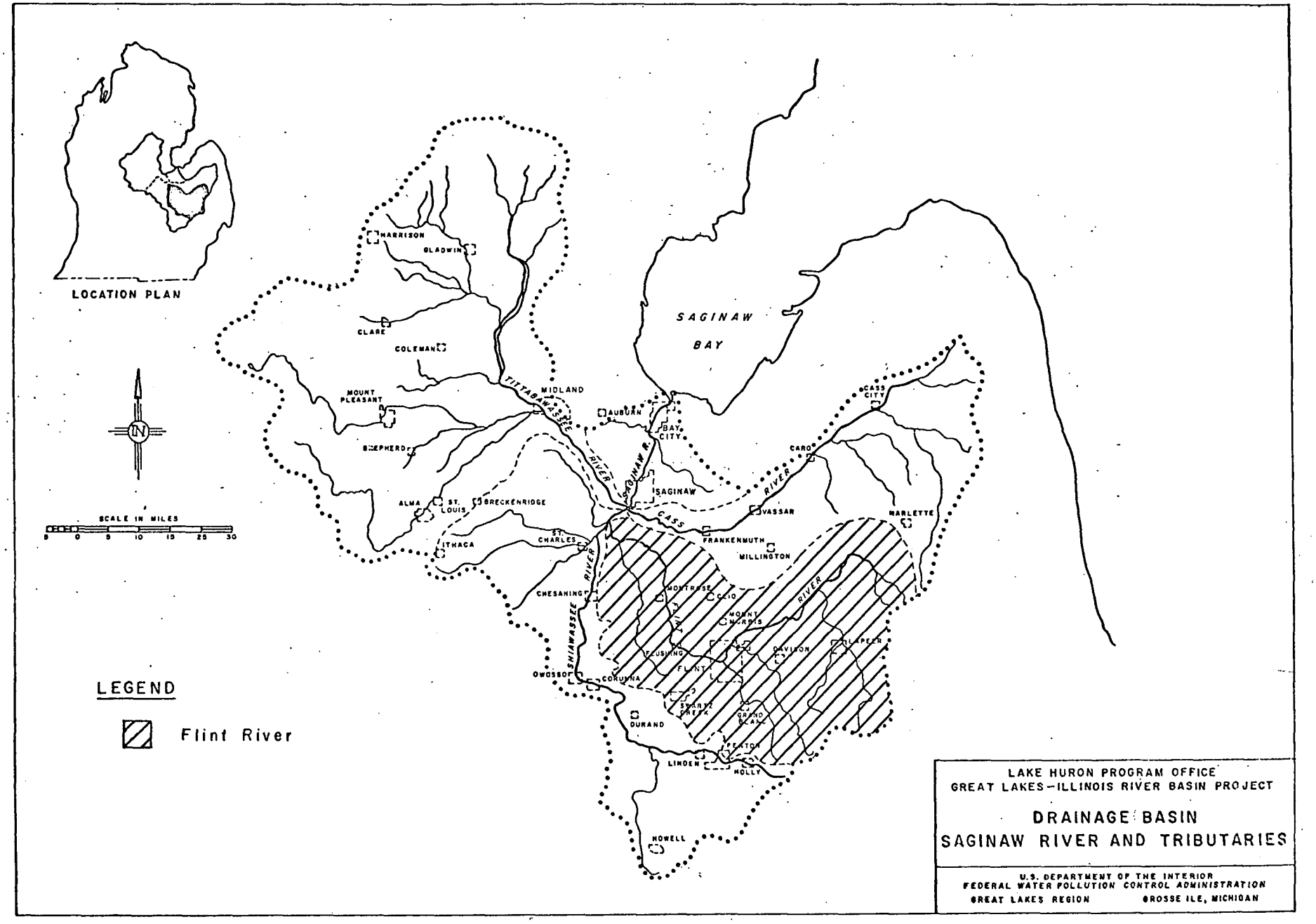

LOCATION PLAN
SCALE IN MILES
5 0 5 10 15 25 30
LEGEND
Flint River
SAGINAW BAY
HARRISON
GLADWIN
CLARE
COLEMAN
MOUNT PLEASANT
SHEPHERD
ALMA
ST. LOUIS
BRECKENRIDGE
ITHACA
ST. CHARLES
CHESANING
OWOSSO
CORUNNA
DURAND
LINDEN
HOLLY
HOWELL
MIDLAND
AUBURN
BAY CITY
SAGINAW
TITTABAWASSEE RIVER
SAGINAW R.
CASS RIVER
SHIAWASSEE RIVER
FLINT RIVER
FRANKENMUTH
MILLINGTON
VASSAR
CARO
CASS CITY
MARLETTE
MONTROSE
OLIO
MOUNT MORRIS
FLUSHING
FLINT
DAVISON
LAPEER
SWARTZ CREEK
GRAND BLANC
PENTON
LAKE HURON PROGRAM OFFICE
GREAT LAKES–ILLINOIS RIVER BASIN PROJECT
DRAINAGE BASIN
SAGINAW RIVER AND TRIBUTARIES
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION
GROSSE ILE, MICHIGAN

TABLE OF CONTENTS

	Page No.
INTRODUCTION	1
GENERAL DESCRIPTION	5
Description of Area Climate Hydrology	
WATER USE	18
Municipal Water Supply Industrial Water Supply Water-related Recreation	
SOURCES AND CHARACTERISTICS OF WASTES	25
Municipal Industrial	
POPULATIONS AND WASTE LOAD PROJECTIONS	35
DESCRIPTION OF WATER QUALITY	41
Physical and Chemical Microbiological Biological	
DISSOLVED OXYGEN PROJECTIONS	59
SUMMARY AND WATER QUALITY PROBLEMS	69

LIST OF TABLES

Table No.		Page No.
1	Flint River Drought Flows	10, 11
2	Flint River Sampling Stations	12
3	Municipal Water Supplies	20, 21
	Owner and Treatment Code (for Table 3)	22
4	Industrial Water Use	23
5	Municipal Water Use Projections	24
6	Flint River Municipal Waste	31
7	Flint River Industrial Waste Inventory	32, 33
8	Waste Flow Projections	37
9	BOD_5 Projections	38
10	Flint River Water Quality - 1965 Average Concentrations	47
11	Dissolved Oxygen Fluctuation - Station X240	48
12	Flint River - Seasonal Nitrate-N Concentration	49
13	Flint River - 1965 Total and Soluble Phosphate Concentrations	50
14	Flint River Water Quality - 1965 Average Concentrations	51
15	Flint River - Total and Fecal Coliform Densities	52
16	Flint River - 1965 Total and Fecal Coliform Density Statistics	53
17	Flint River - Loadings for Match Run - 1965 Model	62
18	Flint River - Water Quality	77-80
	Notes for Water Quality Tables	81

LIST OF FIGURES

Figure No.		Page No.
1	Flint River Basin	4
2	Time of Passage	13
3	Flow Duration Curve - Flint River near Flint	14
4	Flow Duration Curve - Flint River near Fosters	15
5	Drainage Area vs River Miles	16
6	Location of Sampling Stations	17
7	Municipal and Industrial Waste Outfalls	34
8	Municipal and Industrial Waste Flow Projection Area	39
9	Population and Municipal Waste Flow Projections	40
10	Dissolved Oxygen and BOD	54
11	Nitrate Concentrations	55
12	Total Phosphate	56
13	Total Solids and Chlorides	57
14	Total Coliform Densities	58
15	Dissolved Oxygen - Computed Profile	63
16	Kjeldahl Nitrogen and Ultimate BOD - Computed Profile	64
17	Computed Dissolved Oxygen Profiles - Effect of Temperature and Loadings - 1965 Summer Survey Flow	65
18	Computed Dissolved Oxygen Profiles - Effect of Temperature and Loadings - 7 Day Once-in-Ten Year Flow	66
19	Computed Dissolved Oxygen Profiles - Effect of Temperature and Loadings - 1 Day Once-in-Ten Year Flow	67

LIST OF FIGURES
(cont'd)

Figure No.		Page No.
20	Computed Dissolved Oxygen Profiles - Effect of Temperature and Loadings - Augmented Flow	68

INTRODUCTION

AUTHORITY

Comprehensive water pollution control studies were authorized by the Federal Water Pollution Control Act of 1956, as amended (33 USC 466 et seq.).

> Sec. 3.(a) "The Secretary shall, after careful investigation, and in cooperation with other Federal agencies, with State water pollution control agencies and interstate agencies, and with the municipalities and industries involved, prepare or develop comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof and improving the sanitary condition of surface and underground waters. In the development of such comprehensive programs due regard shall be given to the improvements which are necessary to conserve such waters for public water supplies, propagation of fish and aquatic life and wildlife, recreational purposes, and agricultural, industrial, and other legitimate uses. For the purpose of this section, the Secretary is authorized to make joint investigations with any such agencies of the condition of any waters in any State or States, and of the discharges of any sewage, industrial wastes, or substance which may adversely affect such waters."

> Sec. 5.(f) "The Secretary shall conduct research and technical development work, and make studies, with respect to the quality of the waters of the Great Lakes, including an analysis of the present and projected future water quality of the Great Lakes under varying conditions of waste treatment and disposal, an evaluation of the water quality needs of those to be served by such waters, an evaluation of municipal, industrial, and vessel waste treatment and disposal practices with respect to such waters, and a study of alternate means of solving water pollution problems (including additional waste treatment measures) with respect to such waters."

Initiation of the Great Lakes-Illinois River Comprehensive Program Activity followed an appropriation of funds by the 86th Congress late in 1960. In accordance with the provisions of the Act, the Secretary of Health, Education, and Welfare delegated the responsibility for the study to the Division of Water Supply and Pollution Control of the Public Health Service. Passage of the "Water Quality Act of 1965" gave the

responsibility for these studies to the Federal Water Pollution Control Administration (FWPCA). As a result of Reorganization Plan No. 2 of 1966, the FWPCA was transferred from the Department of Health, Education, and Welfare to the Department of the Interior effective May 10, 1966.

PURPOSE

This report presents the water quality of the Flint River, Michigan as it exists today, and includes predictions of population, water use, and waste load trends for future years. Its purpose is to present information that can be used as a basis for developing a basin wide water pollution control program.

The objectives of the FWPCA are to enhance the quality and value of the Nation's water resources, and to prevent, control, and abate water pollution through cooperative local, State, and Federal pollution control plans.

SCOPE

The area covered by this report is the Flint River, Michigan. The study of the Flint River was conducted by FWPCA on the 60 miles between the City of Flint and the confluence of the Flint and Shiawassee Rivers. These two rivers, together with the Tittabawassee and Cass Rivers, form the Saginaw River which flows 22 miles to Saginaw Bay. Similar reports are being prepared for each of these rivers.

ORGANIZATION

The Detroit Program Office, located at the Naval Air Station, Grosse Ile, Michigan, began collecting water quality data on the Flint River in 1965. Its staff include specialists in several professional skills,

including sanitary engineers, hydrologists, chemists, biologists, and bacteriologists. The resources of the Robert A. Taft Sanitary Engineering Center at Cincinnati, Ohio have been utilized, and assistance and guidance have been obtained from the Great Lakes-Illinois River Basins Project, Chicago.

ACKNOWLEDGMENTS

The Detroit Program Office has received the cooperation and assistance of local, State, and Federal agencies, as well as interested individuals. The principal agencies taking an active part in providing assistance in the preparation of the report are as follows:

State Agencies -

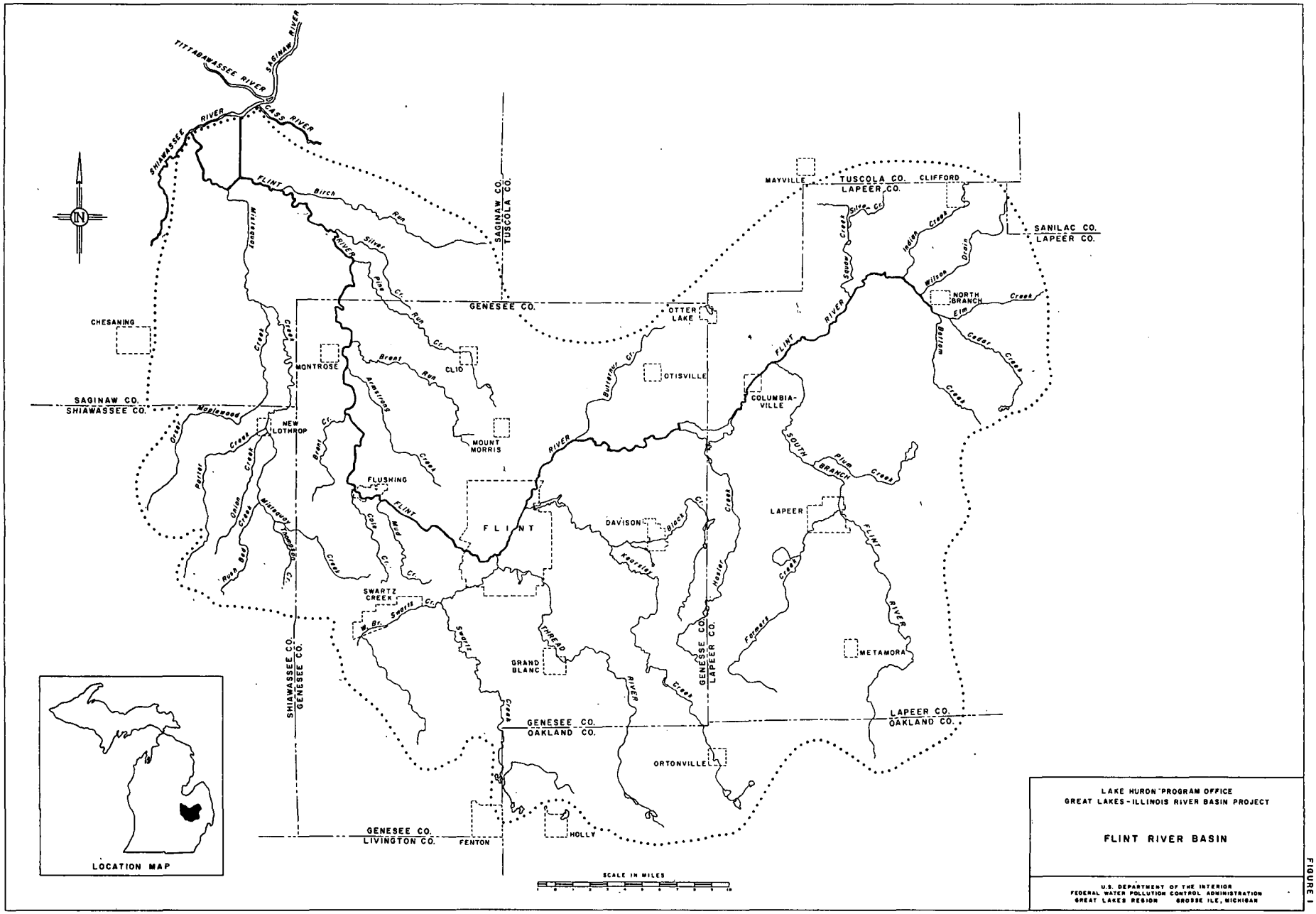
Michigan Water Resources Commission
Michigan Department of Public Health

Federal Agencies -

U.S. Department of Commerce
- Weather Bureau
- Office of Business Economics
- Bureau of Census

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

U.S. Department of Defense
- Detroit District, Corps of Engineers
- Lake Survey, Corps of Engineers



LAKE HURON PROGRAM OFFICE
GREAT LAKES-ILLINOIS RIVER BASIN PROJECT

FLINT RIVER BASIN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION GROSSE ILE, MICHIGAN

FIGURE 1

GENERAL DESCRIPTION

Description of Area

The Flint River Basin occupies most of Genessee and Lapeer Counties and portions of Shiawassee, Saginaw, Tuscola, and Oakland Counties. The Flint River is one of the four main tributaries of the Saginaw River drainage system which drains an area of 6,260 square miles. The Flint River drains an area of approximately 1,454 square miles.

The basin is irregular in shape, with the greatest length approximately 55 miles, and the greatest width approximately 35 miles, narrowing to about 5 miles near the mouth. It is bounded on the north by the Cass River Basin; on the east by the Black, Belle, and Pine Basins; on the south by the Clinton and Shiawassee Basins; and on the west by the Shiawassee River Basin. Major tributaries include the North Branch and the South Branch along with Kearsley Creek, Thread River, and Misteguay Creek.

The North and South Branches of the Flint River originate in Lapeer County and join to form the main stem. The river then flows generally southwesterly about 35 miles to the City of Flint, at which point it flows northwesterly to the Saginaw River. The last five miles flow through a cutoff canal.

The portion of the basin upstream from the City of Flint consists of rolling morainic features interspersed with ancient lake beds. Numerous small lakes in this area drain into the Flint River system. Downstream from Flint the river flows through the bed of glacial Lake Saginaw, which extends to Saginaw Bay.

Flint, the largest city in the basin, and third largest in Michigan, is a large automobile manufacturing center. Lapeer, the second largest city in the Flint River Basin is an agricultural and dairy center, and home of light industry.

Climate

The climate of the Flint River Basin conforms to the general weather pattern that exists in the entire lower Great Lakes area. There are wide seasonal variations in temperature, many storms, and the yearly precipitation distribution remains fairly constant. In the winter this precipitation is usually in the form of snow. The air masses moving toward Michigan are heated in the winter and cooled in the summer by the waters of the Great Lakes, which nearly surround the State. This results in a more moderate climate than is experienced to the west and southwest of Michigan.

The mean yearly temperature is about 45°F, while the mean summer and winter temperatures are about 68°F and 23°F, respectively. There is an average yearly precipitation of 30 inches on the basin, of which 60 percent can be expected to fall during the six month period of May through October.

Hydrology

Above Columbiaville, the slope of the stream averages about six feet per mile, and below that point, about two feet per mile as far as Flint. From Flint to Flushing, the slope is about four feet per mile. Across the Shiawassee Flats, the slope of the Flint River is less than one foot per mile. The tributaries to the Flint River follow the same pattern.

In the upper reaches, the slopes of the tributaries are steep and flatten out as they approach the main stream.

Location of U.S. Geological Survey Gages

There are seven U.S. Geological Survey gaging stations in the Flint River Basin. Of these seven, one records the contents of Holloway Dam, and another, the stages in the Shiawassee Flats area. Three of the remaining five gaging stations were utilized by the FWPCA in this report.

The first of these is Flint River near Otisville. It has a drainage area of 547 square miles, and is located 20 feet downstream from the State Highway 15 bridge (1-1/2 miles downstream from the Holloway Reservoir). It has been in operation from October 1952 to the present.

The second U.S. Geological Survey gaging station is Flint River near Flint. It is located on the grounds of the Flint sewage treatment plant, two miles downstream from Flint. It has been in continuous operation since August 1932, and has a drainage area of 927 square miles.

The third U.S. Geological Survey gaging station is Flint River near Fosters. It is located on the downstream side of the bridge of Sheridan Road, one mile west of Fosters. The drainage area for this gage is approximately 1,120 square miles, and it has been in service since October 1939.

The range of observed discharges of these gaging stations are as follows:

Flint River near Otisville	-	Maximum	- 6,150 cfs
		Average	- 255 cfs
		Minimum	- 4.3 cfs
Flint River near Flint	-	Maximum	- 14,900 cfs
		Average	- 536 cfs
		Minimum	- 9.0 cfs
Flint River near Fosters	-	Maximum	- 19,000 cfs
		Average	- 684 cfs
		Minimum	- 27 cfs

Time of Passage

It is necessary to know the stream travel time of a river in order to determine its waste decay rate. On the Flint River these times of passage have been determined for various flows at the station Flint River near Flint, and are for the stretch of river between mile points 46.1 and 9.7.

Time of passage studies on the Flint River were made by the Detroit Program Office during 1965 and 1966. These studies used multiple releases of Rhodamine B dye and measured the time of occurrence and concentration of the dye at downstream points. In the reach between Flint and Flushing, times of passage were also determined by use of a computer program utilizing cross-sectional measurements made by Michigan Water Resources Commission personnel. The stretch of river between mile points 46.1 and 9.7 coincides with the intensive sampling areas below Flint.

Drought Flow

The one-day and seven-day low flows (once in 10 years) have been calculated for the Flint River at two of the U.S. Geological Survey stations by use of Gumbel Extremal Probability Paper. The stations used

were Flint River near Flint, and Flint River near Fosters. The flow at the remaining points along the river was arrived at by comparison of their drainage areas with that of the U.S. Geological Survey stations.

Because the Flint gage has a longer period of record than the Fosters gage, only those flows occurring in the period 1940-1963 were used in this analysis. This results in a slightly higher flow at Flint than would have been expected had the entire period of recrod been used.

This analysis does not take into account the effect of the operation of Holloway Dam on the Flint River drought flows. This dam should tend to raise the flow in the river during periods of extended drought. The Michigan Water Resources Commission stated in their "1956 Report on Water Resource Conditions and Uses in the Flint River Basin" that the reservoir would sustain a flow of 100 cfs in the river during drought years. Use of that figure would add roughly 50 cfs to the flow at each of the remaining points on the river below the dam.

Also, no consideration was made for the reduction in flow between the intake for the Flint water treatment plant and the Flint sewage treatment plant.

TABLE 1. FLINT RIVER DROUGHT FLOWS

(See Figure 6) Location	Drainage Area (square miles)	1-Day Flow (cfs)	7-Day Flow (cfs)
X290	453.0	18.6	23.0
X288	466.0	19.1	23.7
X286	494.8	20.3	25.1
X284	543.5	22.3	27.6
X282	547.0	22.4	27.8
X280	553.7	22.7	28.1
X270	598.9	24.6	30.4
X260	605.3	24.8	30.7
Kearsley Creek*	608.3	24.9	30.9
Kearsley Creek	721.4	29.6	36.6
X258	737.4	30.2	37.4
Swartz Creek*	737.9	30.3	37.5
Swartz Creek	915.4	37.5	46.5
X256	925.7	38.0	47.0
X254	939.5	38.5	47.5
X250	949.1	38.9	47.9
X246	960.6	39.4	48.4
X242	967.7	39.7	48.7
X240	981.8	40.2	49.2
Brent Run*	983.8	40.3	49.3
Brent Run	1035.1	41.9	50.9
X236	1045.5	42.3	51.3

*Up to, but not including named stream.

TABLE 1. FLINT RIVER DROUGHT FLOWS (cont.)

Location	Drainage Area (square miles)	1-Day Flow (cfs)	7-Day Flow (cfs)
Pine Run Creek*	1046.6	42.4	51.4
Pine Run Creek	1102.5	44.1	53.1
X234	1106.0	44.2	53.2
X232	1116.7	44.7	53.7
X230	1118.9	45.0	54.0
X220	1178.2	47.1	56.9

*Up to, but not including named stream.

TABLE 2. FLINT RIVER SAMPLING STATIONS

Mainstream Stations

Station	Mile Point	Location
X220	9.7	Bridge on Tom Creswell Rd., 2 mi. W of M-13
X230	14.7	Bridge on Sheridan Rd., 1 mi. W. of Fosters (USGS* Gage)
X236	22.1	Bridge on E. Burt Rd. in Morseville
X237	28.5	Montrose outfall, 50' N. of M-57 bridge near Montrose
X240	28.5	Bridge on M-57 near Montrose
X246	33.9	End of Mt. Morris Rd., 3 mi. N. of Flushing
X248	39.0	Flushing sewage treatment plant
X250	39.6	Bridge on W. Main St. in Flushing
X255	45.6	Flint sewage treatment plant (USGS Gage)
X256	46.1	Bridge on Mill Rd., 1 mi. W. of Flint
X260	55.9	Bridge on Carpenter Rd. in Flint

Tributary Stations

Station	Mile Point	On Tributary	Confluence Mile Point	Location
X239	0.2	Brent Run	27.6	Bridge on McKinley
X295	1.6	Farmers Creek-South Branch	76.6/14.4	Lapeer State Hospital (USGS Gage)
X296	25.5	Swartz Creek	50.5	Bridge on Elliott Rd. 1-1/2 mi. N. of Holly (USGS Gage)

* U.S. Geological Survey

FIGURE 2

TIME OF PASSAGE OF THE FLINT RIVER

FLOW AT FLINT GAGE

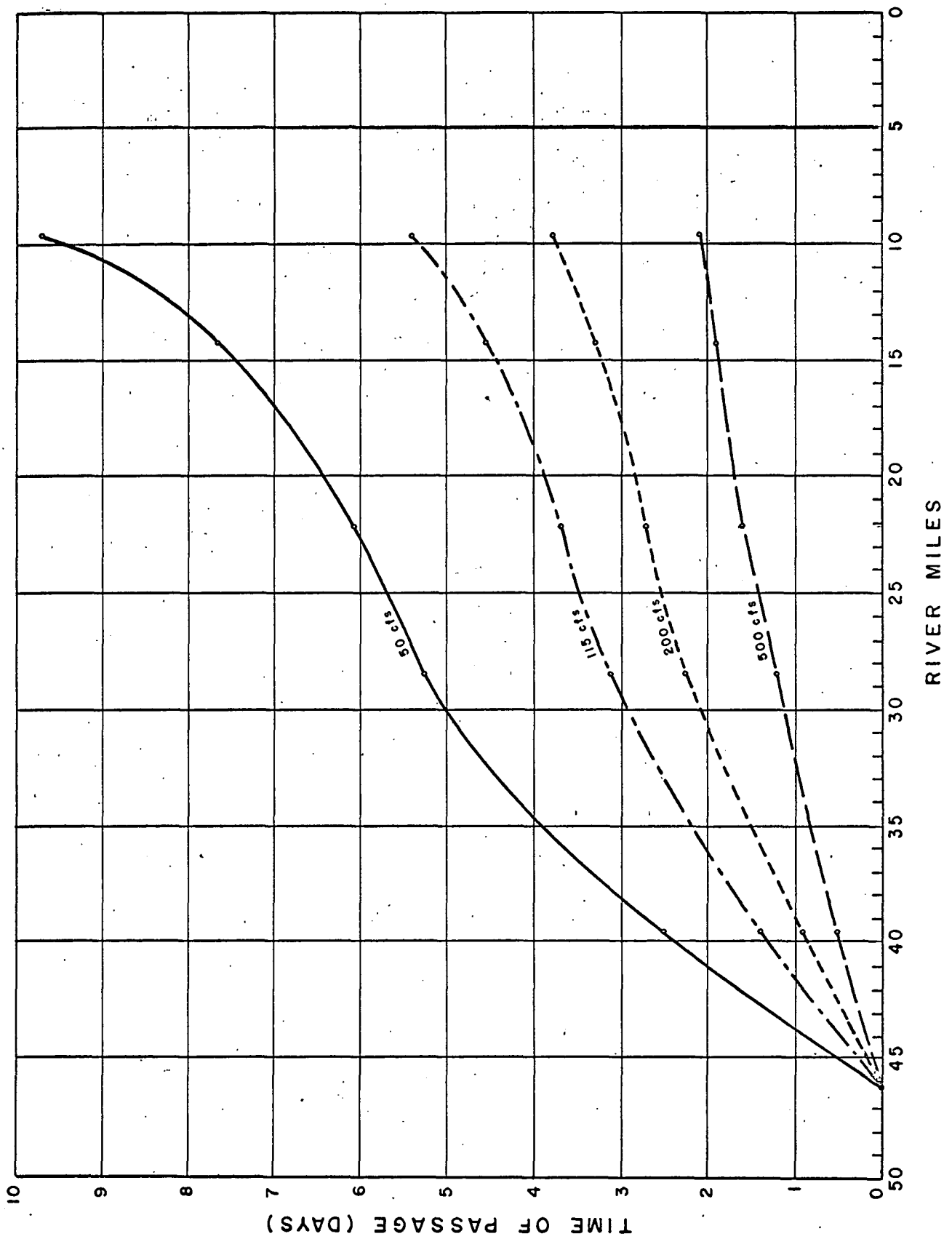


FIGURE 3

FLOW DURATION CURVE
FLINT RIVER NEAR FLINT
1933 - 1964

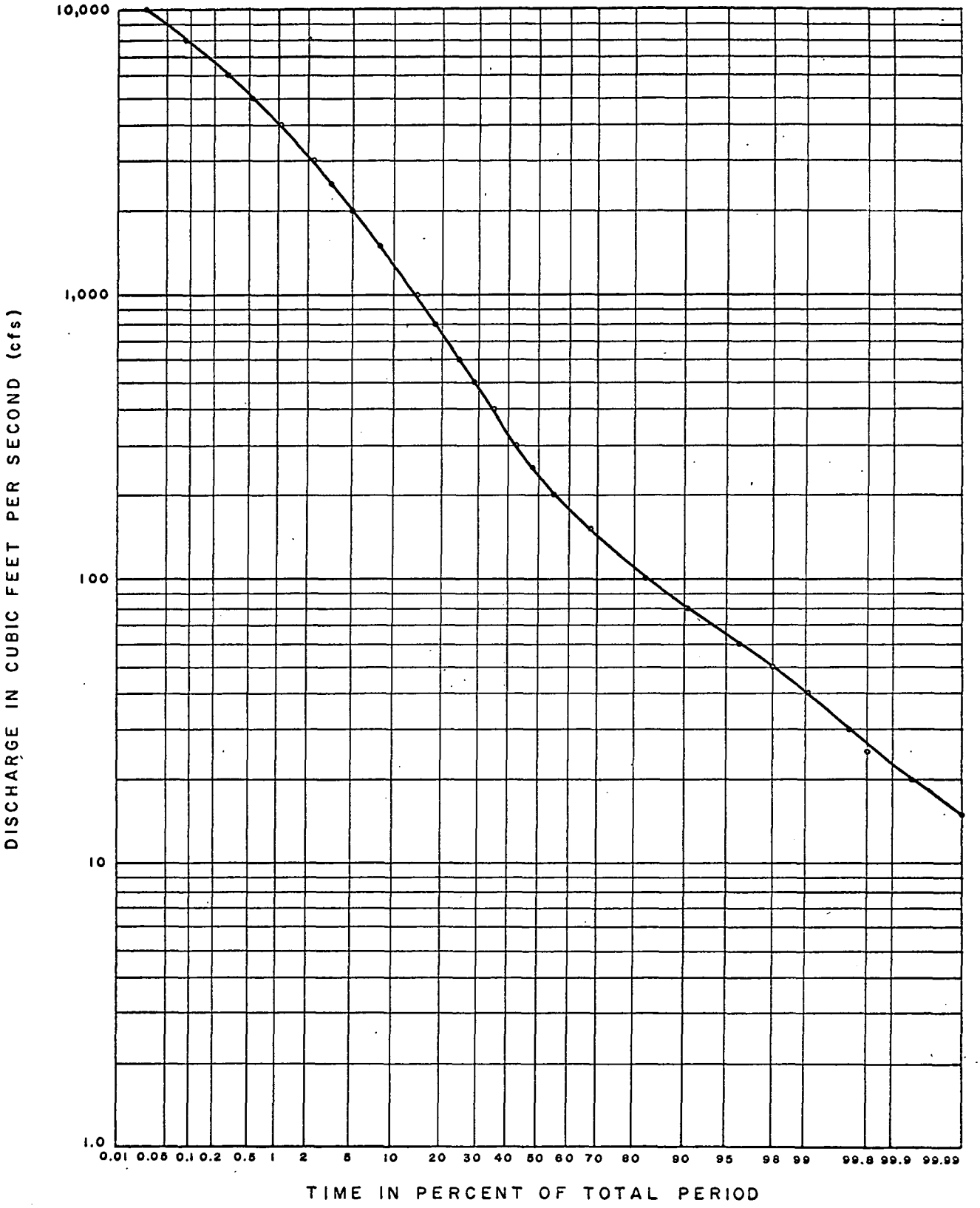


FIGURE 4

FLOW DURATION CURVE
FLINT RIVER NEAR FOSTERS
1940 - 1964

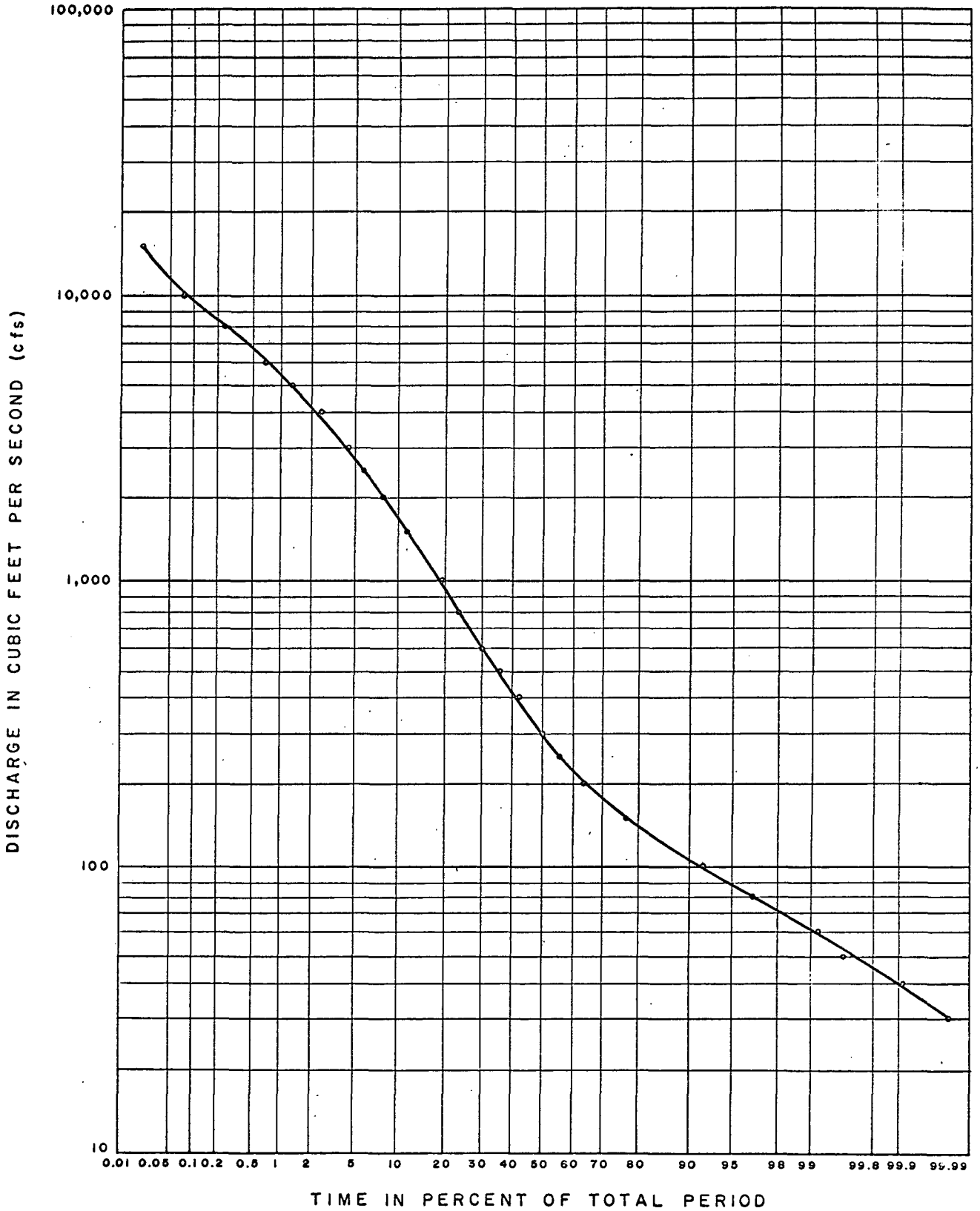
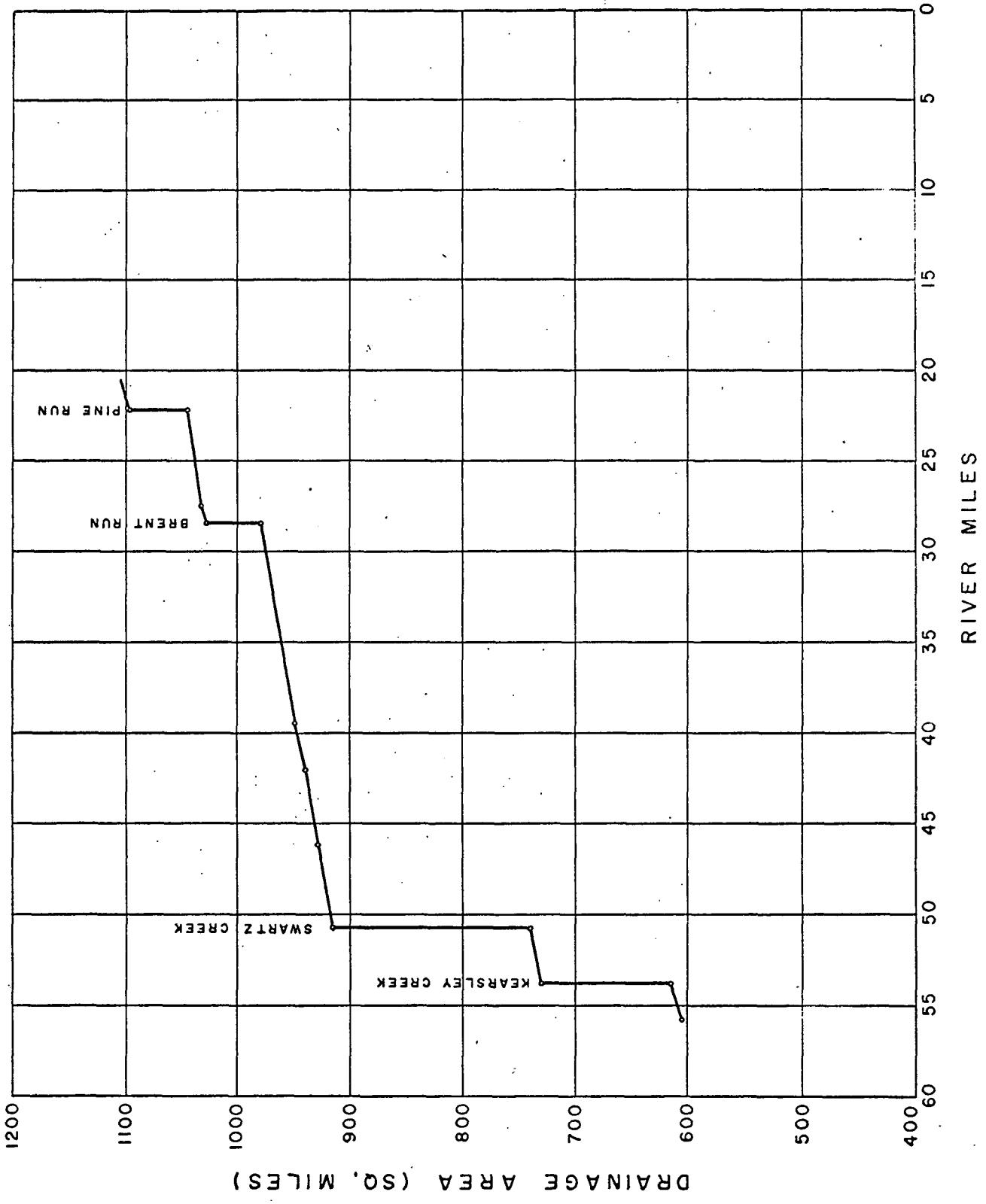
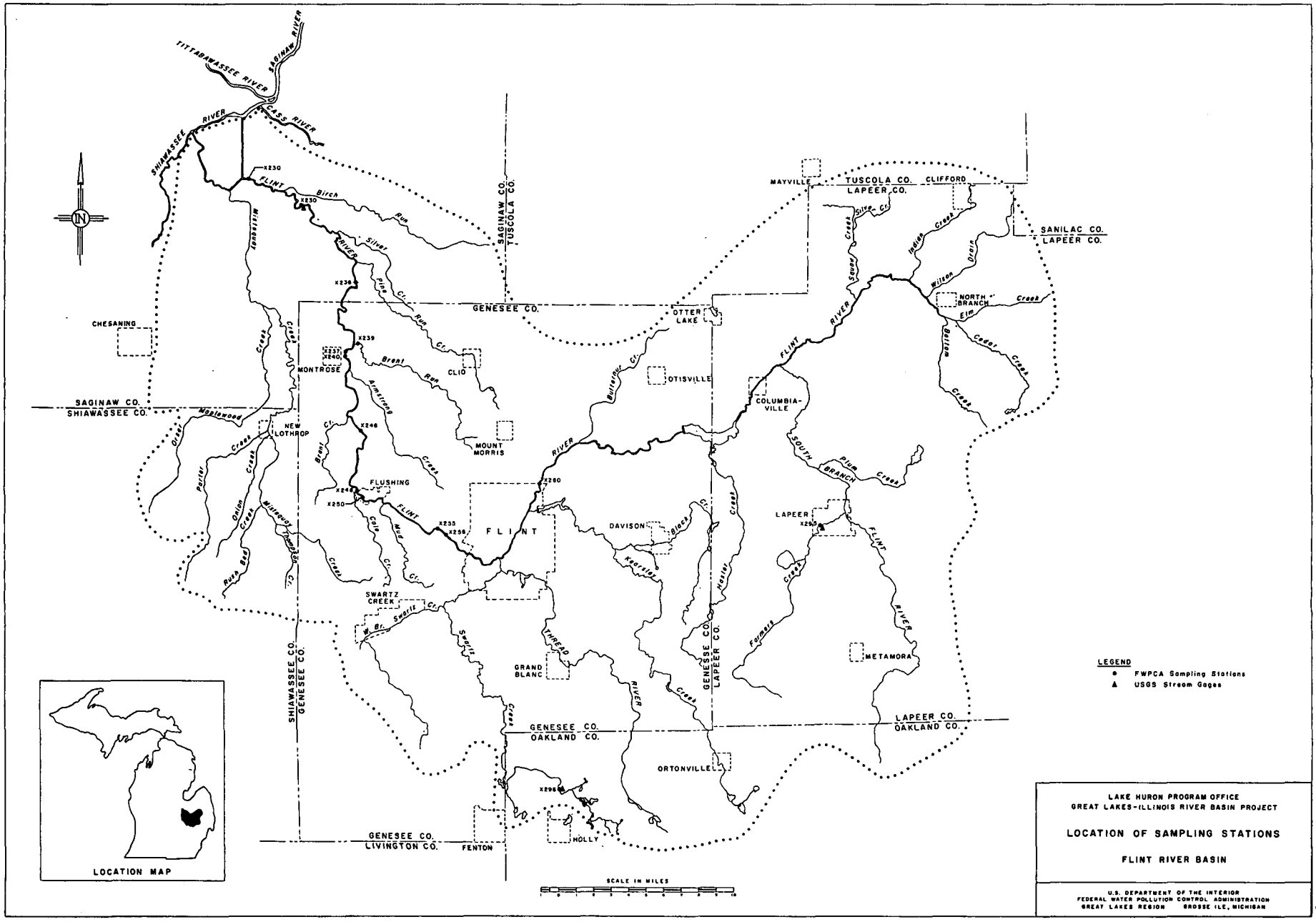


FIGURE 5

DRAINAGE AREA VS. RIVER MILES
FLINT RIVER





LAKE HURON PROGRAM OFFICE
GREAT LAKES-ILLINOIS RIVER BASIN PROJECT

LOCATION OF SAMPLING STATIONS

FLINT RIVER BASIN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION BROSSE ILE, MICHIGAN

FIGURE 6

WATER USE

Municipal Water Supply

The Flint River Basin has a population served by public water supplies of approximately 280,000 people. This number is expected to increase to 620,000 by 1990, and 1,300,000 by 2020. The City of Flint is the largest user, serving about 235,000 people and numerous industries. Flint obtains its water from the Flint River at the present time, but since this source of supply is limited, Flint is planning to tie in with the City of Detroit water line from Lake Huron. Holloway reservoir controls the flow of the Flint River for water supply, and the reach between the dam and the city serves as an aqueduct. All other public water supplies in the basin come from local wells.

Table 3 lists the individual water users and gives the source of the supply. Projected use for the basin in 1990 and 2020 is shown on Table 5.

Industrial Water Supply

Most of the industries in the Flint River Basin obtain their water from municipal supplies. The only exception is the Vogt Packing Company in Grand Blanc which has its own well system for its 0.06 million gallons per day (MGD) use.

Table 4 lists the industrial users and the use. Projections of 1990 and 2020 use are included in the municipal water in Table 5.

Water-related Recreation

The Flint River Basin in 1965 had approximately 22,000 boats registered by its residents.

The Flint River is generally too small for boat traffic, but there are several reservoirs on the river that are suitable for boating. The basin has over forty lakes with sizes varying from several acres to over 400 acres. These lakes offer fishing, boating, swimming, and most of them are fully developed for summer and year round residence. Commercial boat liveries are located on a number of these lakes.

TABLE 3. MUNICIPAL WATER SUPPLIES*
Flint River Basin

Town	1960 Pop.	Owner**	Source	Treatment**
New Lothrop	510	M	Wells in drift 62' to 69' deep	5
Fenton Twp.	280	T	Wells in rock 73' deep	
Burton Twp.	29,700	T	Wells in rock 257' deep, wells in drift 168' to 196' deep	-
Clio	2,212	M	Wells in rock 145' to 317' deep; well in drift 141' deep	-
Davison	3,761	M	Wells in rock 210' to 260' deep	5
Flint	196,940	M	Flint River	2, 6
Flint Twp. (Genesee Cty. Drain Commission)	300	C	Water from City of Flint and wells in rock 160' to 167' deep	-
Flushing	3,761	M	Water from City of Flint	
Beecher Metropolitan District		D	Wells in rock 350' to 431' deep; wells in drift 98' to 124' deep	5
Grand Blanc	1,565	M	Wells in rock 287' to 306' deep	-
Grand Blanc Twp.	640	T	Wells in rock 267' to 300' deep	-
Southhampton Subdivision	120	P	Wells 200' deep	-
Wildwood Subdivision	320	P	Wells in rock 230' deep	-

*Taken from "Data on Public Water Supplies in Michigan," Engineering Bulletin No. 4 by the Michigan Department of Public Health.

**See Owner and Treatment Code page 22

TABLE 3. MUNICIPAL WATER SUPPLIES* (cont'd)
Flint River Basin

Town	1960 Pop.	Owner**	Source	Treatment**
Montrose	1,466	M	Wells in drift 67' to 77' deep	-
Mt. Morris	3,484	M	Wells in drift 60' to 82' deep	3, 4
Otisville	701	M	Wells in rock 415' deep	-
Clifford	330	M	Wells in rock 400' deep	-
Columbiaville	789	M	Wells in rock 280' to 300' deep	5
Lapeer	8,020	M	Wells in rock 200' deep	5
Lapeer Home Training School		S	Wells in rock	-
North Branch	832	M	Wells in rock 250' & 276' deep	-

*Taken from "Data on Public Water Supplies in Michigan," Engineering Bulletin No. 4 by the Michigan Department of Public Health.

**See Owner and Treatment Code page 22

OWNER AND TREATMENT CODE

Owner Code:

M = City or Village

T = Township

P = Private

D = District

C = County

S = State

U.S. = Federal

Treatment Code:

1. Std. Filtration*
2. Lime softening**
3. Zeolite softening
4. Iron removal
5. Chlorination
6. Fluoridation

* Implies at least chlorination, chemical coagulation, and rapid sand filtration.

** Lime softening includes filtration.

TABLE 4. INDUSTRIAL WATER USE
Flint River Basin

Name of User	Quantity Used (MGD)	Source	Use
GMC-AC Spark Plug	1.5	City of Flint	Process & Cooling
GMC-Buick Division	2.2	City of Flint	Process & Cooling
GMC-Chev. Flint Div.	2.0	City of Flint	General Mfg.
GMC-Fisher Body Div.	0.08	City of Flint	General Mfg.
GMC-Ternstedt	1.5	City of Flint	Process
GMC-Parts Division	0.36	City of Flint	Process
GMC-Chevrolet Assembly	1.4	City of Flint	Process
GMC-Chev. Engine & Stamping Plant	0.72	City of Flint	Process
Vogt Packing Co.	0.06	Private wells	Process

TABLE 5. MUNICIPAL WATER USE PROJECTIONS (MGD)
Flint River Basin

	1965	1990	2020
Municipal*	40	96	220

*Includes industrial water use.

SOURCES AND CHARACTERISTICS OF WASTES

Municipal

The Flint River Basin population served by municipal waste treatment systems is approximately 210,000 people, of which all but about 5,000 are in Genesee County.

The county has a metropolitan sewerage plan which will serve the City of Flint's suburbs with sewer connections and treat the waste at the Flint sewage treatment plant. This sytem should be operable by 1967 and serve the communities of Montrose, Linden, Swartz Creek, Birch Run, Clio, Grand Blanc, and Davidson. Swartz Creek, Clio, and Davidson have sewage treatment plants now that will be abandoned when the metro system is completed. The others have no facilities.

The Village of Columbiaville in Lapeer County has a small separate sewer system but has no treatment facilities. The Michigan Water Resources Commission has requested that they provide treatment, and the village is studying the problem.

North Branch has a sewage collection system with treatment in municipally owned and operated septic tanks. Upgrading of the system is scheduled for 1967.

The following information is based on 1965 monthly average figures reported to the Michigan Department of Public Health by the individual plants. Prior to January 1967, minimum chlorination period required by the Michigan Department of Public Health was from May 15 to September 15. After January 1967, all municipal plants are required to disinfect their effluents continuously.

Plant outfall locations are shown in Figure 7, and a summary of

results listed in Table 6.

Davidson Sewage Treatment Plant - 1965

This plant is a trickling filter unit which serves about 3,000 people. The flow averaged 0.40 million gallons per day (MGD) during 1965, with variations between 0.29 and 0.69 MGD. The 5-day biochemical oxygen demand (BOD_5) removal by this plant was about 70 percent, which left an average effluent BOD_5 of 62 milligrams per liter (mg/l). The effluent was chlorinated from May 15 to September 15 as required by the Michigan Department of Public Health.

Flint Sewage Treatment Plant - 1965

This plant is the largest in the Flint Basin and serves a population of approximately 200,000 people. Part of the average flow of 26.5 MGD is treated by a trickling filter unit and the rest by a new activated sludge unit. The plant, which usually operates with a BOD_5 removal efficiency in excess of 90 percent, has an average effluent BOD_5 value of 14 mg/l. The BOD_5 during 1965 varied from 5 to 21 mg/l. The effluent was chlorinated from May 15 through September 15.

During the Federal Water Pollution Control Administration survey of the Flint River on August 11, 1965, the BOD_5 of the effluent was in the 5 mg/l range. The plant used about 1,100 pounds of chlorine on this date, which is about average.

Flushing Sewage Treatment Plant - 1965

The Flushing sewage treatment plant is a small trickling filter unit which serves about 2,500 people. The average flow is 0.48 MGD, with variations in 1965 between 0.35 and 0.67 MGD. BOD_5 during the same

period varied from 26 to 45 mg/l, with an average of 33 mg/l. The effluent was chlorinated from May 15 through September 15.

The plant operation during the Federal Water Pollution Control Administration Flint River survey of August 11, 1966 was normal for August.

Lapeer Sewage Treatment Plant - 1965

This trickling filter plant serves about 6,000 people. The average flow and BOD_5 for 1965 were 0.73 MGD and 22 mg/l, respectively. The plant removes about 90 percent of the BOD_5 from the influent. Flow fluctuated during 1965 between 0.57 and 0.87 MGD, and BOD_5 varied between 11 and 40 mg/l. The effluent was chlorinated from May 15 through September 15.

Lapeer State Home and Training School Sewage Treatment Plant - 1965

This trickling filter plant serves the residents of the State School. Average flow for 1965 was 0.37 MGD with very little variation. The average effluent BOD_5 for the year was 21 mg/l, with variations between 14 and 39 mg/l. The plant chlorinates its effluent continuously throughout the year.

Swartz Creek Sewage Treatment Plant - 1965

This activated sludge plant serves a population of about 3,000. The flow for 1965 averaged 0.31 MGD with variations between 0.20 to 0.48 MGD. Effluent BOD_5 values ranged between 11 and 25 mg/l, with an average of 18 mg/l. The plant effluent was chlorinated from May 15 to September 15.

Industrial - 1966

Industries in the Flint River Basin are mainly located in and around the City of Flint; the rest of the basin is primarily rural farming land. The industries include eight General Motors plants, and one small rendering

plant. Generally, water is purchased from the Flint municipal system. Most of these plants discharge their process waste to the Flint River after treatment. The eight General Motors plants have been rated as "providing adequate control" by the Michigan Water Resources Commission. The Vogt Packing Company, which operated a small rendering plant, has been rated as "providing control - but adequacy not established." This plant has been asked to improve treatment by the Michigan Water Resources Commission, and municipal sewers should be available within a year.

Outfall locations for the above plants are shown on Figure 7, and results of sampling are shown in Table 7. All of this information was obtained from the Michigan Water Resources Commission in April 1966.

General Motors Corporation (GMC)
AC Spark Plug Division

This plant is located on Dort Highway in the City of Flint. The plant, which produces spark plugs, has a waste flow of approximately 1.5 million gallons per day (MGD). This flow is discharged to Gilkey Creek, a tributary of the Flint River. Waste constituents include cyanide, hexavalent chromium, nickel, oil, and suspended solids. Treatment facilities consist of settling, and chrome and cyanide separation.

GMC - Buick Division

The Buick Plant, located on Industrial Avenue in Flint, discharges approximately 2.2 MGD of general manufacturing and plating wastes to the Flint River. Treatment facilities are settling and a Utah skimmer.

GMC - Chevrolet Flint Division

Located on Chevrolet Avenue in Flint, this plant discharges about 2

MGD directly to the Flint River. Waste constituents include suspended solids and oil. Treatment facilities consist of settling tanks and oil removal equipment.

GMC - Fisher Body Division

The plant is located in Grand Blanc and discharges its flow of 0.08 MGD to Thread Creek, which is a tributary to Swartz Creek which in turn empties into the Flint River. Wastes include oil and suspended solids. Treatment is by a secondary unit and a lagoon.

GMC - Ternstedt Division

This plant, located on Coldwater Road in Flint, discharges its waste flow of 1.5 MGD to Brent Run, a tributary of the Flint River. A secondary unit and lagoons treat the wastes which contain oil, suspended solids, cyanide, hexavalent chromium, and copper.

GMC - Parts Division

Located in the town of Swartz Creek, the plant discharges 0.4 MGD of treated wastes to Swartz Creek, a tributary of the Flint River. Waste constituents include oil and suspended solids, and are treated by settling tanks, oil removal equipment, and lagoons.

GMC - Chevrolet Assembly Plant

This plant is located on Van Slyke Road in Flint and discharges its flow of 1.4 MGD to Swartz Creek, a tributary of the Flint River. Waste constituents include oil, and suspended solids. The waste flow is treated by settling tanks and oil removal equipment.

GMC - Chevrolet Engine and Stamping Plant

This plant is located on Van Slyke Road in Flint and discharges its flow of 0.72 MGD to Carment Creek, a tributary of Swartz Creek, which drains into the Flint River. Wastes include oil and suspended solids, which are treated by settling tanks and oil removal equipment.

Vogt Packing Company

This plant is located in Grand Blanc and discharges a flow of 0.06 MGD to Thread Creek, a tributary of Swartz Creek which drains into the Flint River. This rendering plant's waste constituents include BOD, suspended solids, and suspended volatile solids. Treatment consists of settling.

TABLE 6. FLINT RIVER MUNICIPAL WASTE

(Yearly average for 1965 in mg/l, unless otherwise noted)
All plants are secondary units.

Plant Name	Flow (MGD)	Temp. °F (Raw)	5-Day BOD	Susp. Solids	Susp. Vol. Solids	pH	Cl_2* Applied #/day	Avg.* Cl_2 Res.
Davidson	0.40	60	62	57	53	7.7	37	1.5
Flint	26.5	61	14	30	19	7.4	1280	-
Flushing	0.48	50	33	30	20	-	39	0.9
Lapeer	0.73	59	22	32	22	7.6	24	-
Lapeer State Home	0.37	70	21	16	13	8.4	26	1.0
Swartz Creek	0.31	52	18	31	27	-	11	1.0

*During chlorination period, from May 15 through September 15, except for Lapeer State Home which chlorinates continuously all year.

TABLE 7. FLINT RIVER INDUSTRIAL WASTE INVENTORY

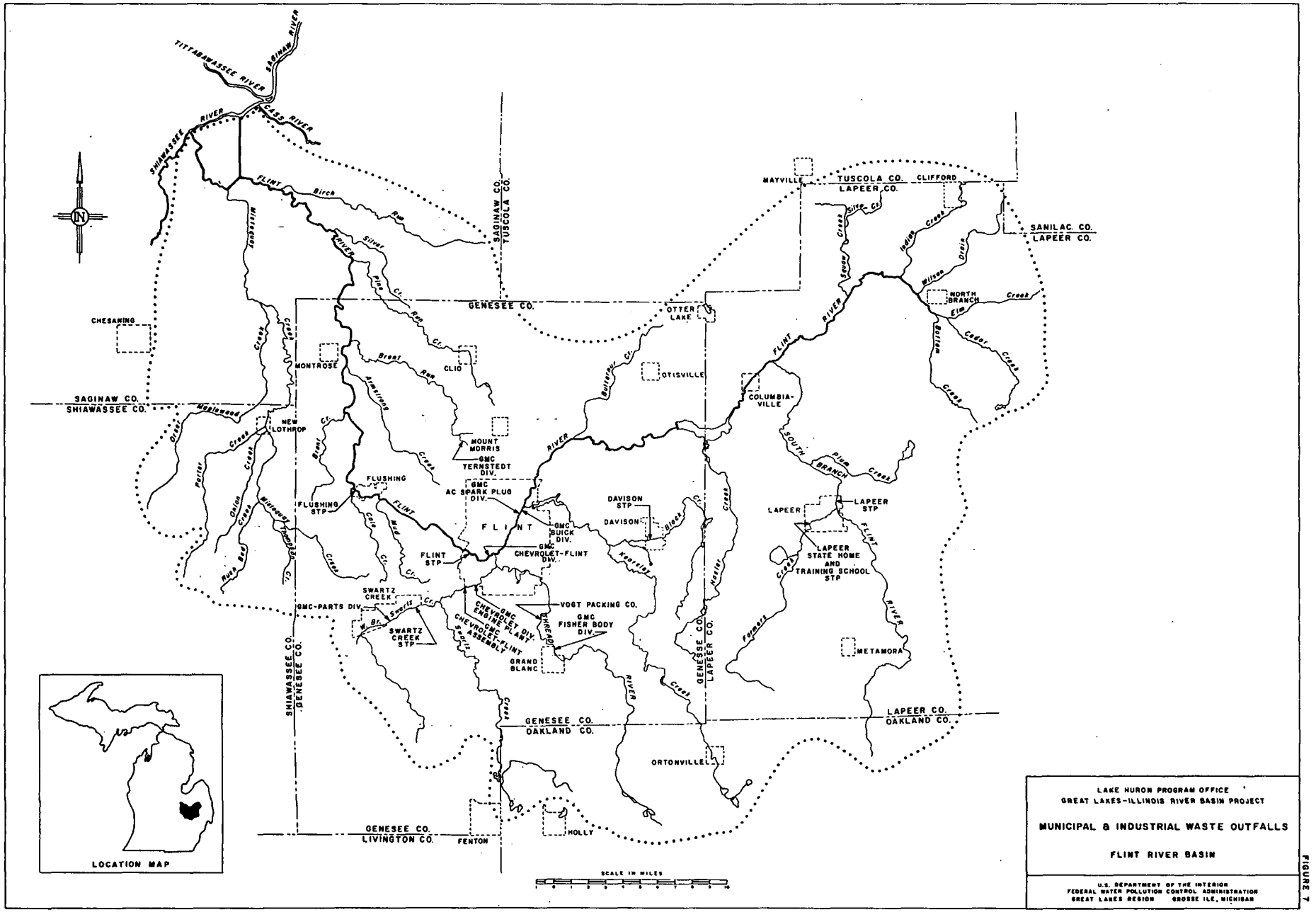
Industry	Location	Receiving Stream	Waste Constituents	Waste Flow (MGD)	Treatment Provided	MWRC Rating April 1966*
GMC-AC Spark Plug Div.	Dort Hwy Flint	Gilkey Creek Flint River	CN, Cr^6, Ni, Oil, Susp. Sol.	1.5	Cr^6 & CN separation Settling	A
GMC-Buick Div.	Industrial Ave.-Flint	Flint River	Gen. Mfg. & Plating Waste	2.2	Settling Utah Skimmer	A
GMC-Chev. Flint Div.	Chevrolet Ave.-Flint	Flint River	Susp.Sol., Oil, Gen. Mfg.	2.0	Oil Removal-Settling	A
GMC-Fisher Body Div.	Grand Blanc	Thread Creek Swartz Creek Flint River	Oil, SS, Gen. Mfg. Wastes	0.08	Lagoon & Secondary	A
GMC-Ternstedt Div.	Coldwater Rd.-Flint	Brent Run Flint River	Oil, SS, CN, Cr^6, Cu	1.5	Secondary & Lagoons	A
GMC-Parts Div.	M-78 Swartz Cr.	Swartz Creek Flint River	Oil, Susp.Sol.	0.4	Settling, Oil removal, Lagoons	A
GMC-Chev. Assembly	Van Slyke Flint	Swartz Creek Flint River	Oil, Susp.Sol.	1.4	Settling, Oil removal	A

* A - Adequate control.

TABLE 7. FLINT RIVER INDUSTRIAL WASTE INVENTORY
(CONT.)

Industry	Location	Receiving Stream	Waste Constituents	Waste Flow (MGD)	Treatment Provided	MWRC Rating April 1966*
GMC-Chev. Engine & Stamping Plant	Van Slyke Flint	Carmen Creek Swartz Creek Flint River	Oil, Susp. Sol.	0.72	Settling, Oil removal, Lagoons	A
Vogt Packing Co.	Grand Blanc	Thread Creek Swartz Creek Flint River	BOD, Susp. Sol., Susp.Vol.Sol.	0.06	Settling	B

* A - Adequate Control.
B - Control provided - adequacy not established (additional treatment requested).



LAKE HURON PROGRAM OFFICE
GREAT LAKES-ILLINOIS RIVER BASIN PROJECT

MUNICIPAL & INDUSTRIAL WASTE OUTFALLS

FLINT RIVER BASIN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION GROSSE ILE, MICHIGAN

FIGURE 7

POPULATION AND WASTE LOAD PROJECTIONS

Demographic studies were conducted by the Great Lakes-Illinois River Basins Project, Chicago, for the Lake Huron Basin. Population trends on a national, regional, and county basis were analyzed, and population projections were developed for the various areas of the Lake Huron Basin. In 1960, approximately 1.2 million persons lived in the Lake Huron Watershed - about double the 1920 population. By the year 2020 it is estimated that the population of the watershed will be approximately 3.2 million.

The one major city on the Flint River is Flint (196,940) according to the 1960 census figures. For this report, the Flint area and surrounding communities were analyzed as a unit, assuming that by 2020 the entire area will be urbanized and served by water and sewer systems. For this area, the 1965 population served by sewerage systems was estimated to be 210,000, and projected to be 620,000 by 1990, and 1,300,000 by the year 2020.

Table 8 shows the estimated waste flow in MGD for the Flint Basin.

BOD_5 projections were based on present day inventory information obtained from the Michigan Water Resources Commission, the Michigan Department of Public Health, and the U.S. Public Health Service. Municipal and industrial water use growth rates and BOD_5 production in terms of population equivalents were determined from studies on the Lake Michigan Basin and applied to the inventory data obtained for the Flint area.

The results of these projections are shown on Table 9. For example, in 1965, a total of 42,930 pounds per day of BOD_5 was produced in the area of which 90 percent was removed, leaving 4,300 pounds of BOD_5 being discharged to the river. By the year 2020, with the same percentage of

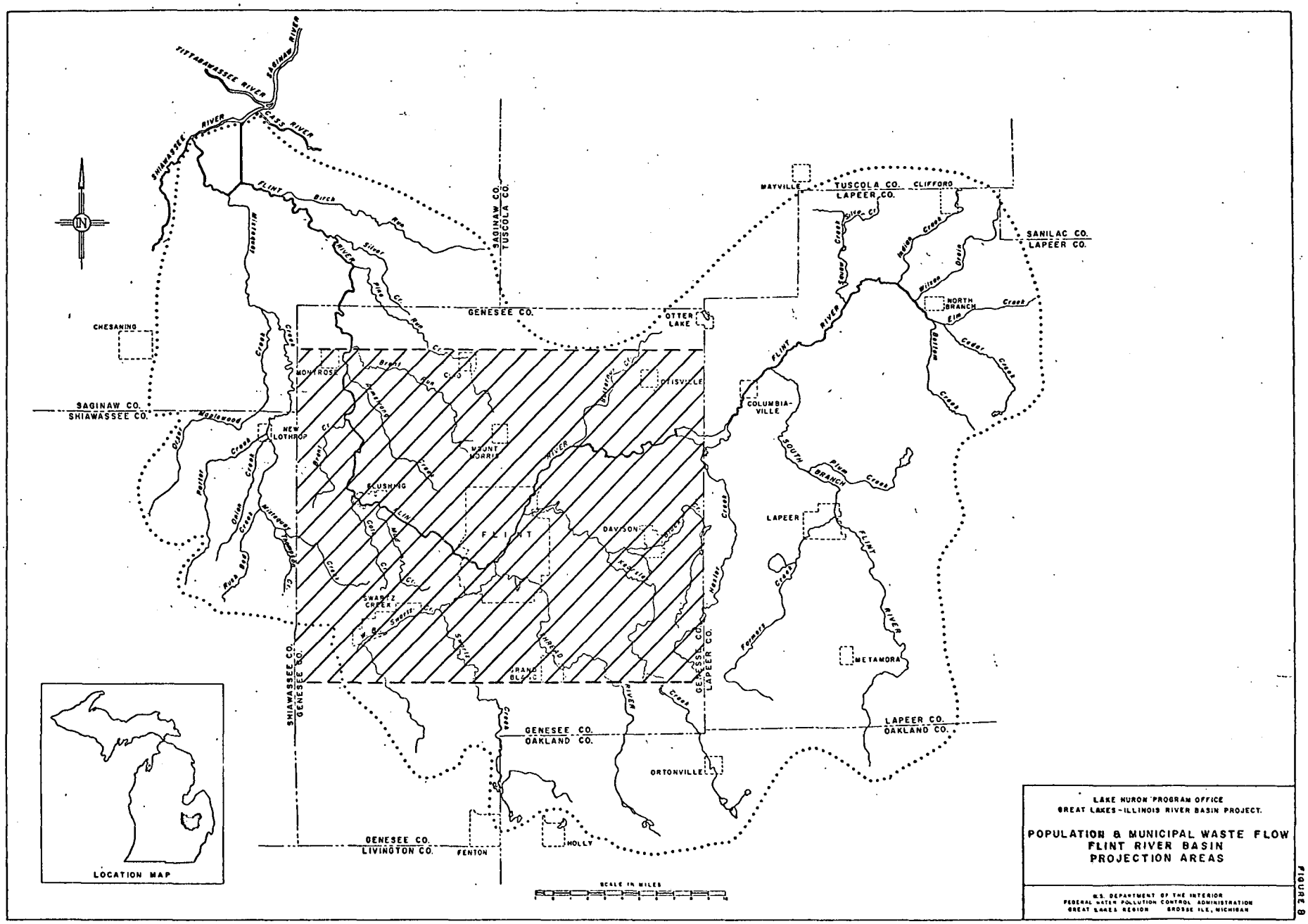
treatment, 27,850 pounds would reach the river. In order to show an improvement over present water quality, 99 percent or more removal will be necessary at that time.

TABLE 8. WASTE FLOW PROJECTIONS

	1965	1990	2020
Municipal (MGD)			
Residential	18.8	75	182
Industrial	8.7	20	44
Total	27.5	95	226
Industrial (direct to river)	9.5	22	48
Total to River	37.0	117	274

TABLE 9. BOD_5 PROJECTIONS

	1965 #/day	1990 #/day	2020 #/day
Municipal			
Residential	35,600	111,500	260,000
Industrial	6,020	13,600	30,500
Total Municipal	41,620	125,100	290,500
Present 92% removal	3,380	10,000	23,200
With 90% removal	4,162	12,510	29,050
With 95% removal	2,080	6,255	14,525
With 99% removal	416	1,251	2,905
Industrial (direct to river)	1,310	2,960	6,640
Present 30% removal	917	2,070	4,650
With 90% removal	131	296	664
With 95% removal	65	148	332
With 99% removal	13	30	66
Total load before treatment	42,930	128,060	297,140
Present 90% removal	4,297	12,070	27,850
With 90% removal	4,293	12,806	29,714
With 95% removal	2,146	6,403	14,857
With 99% removal	829	1,281	2,971



LAKE HURON PROGRAM OFFICE
GREAT LAKES-ILLINOIS RIVER BASIN PROJECT.

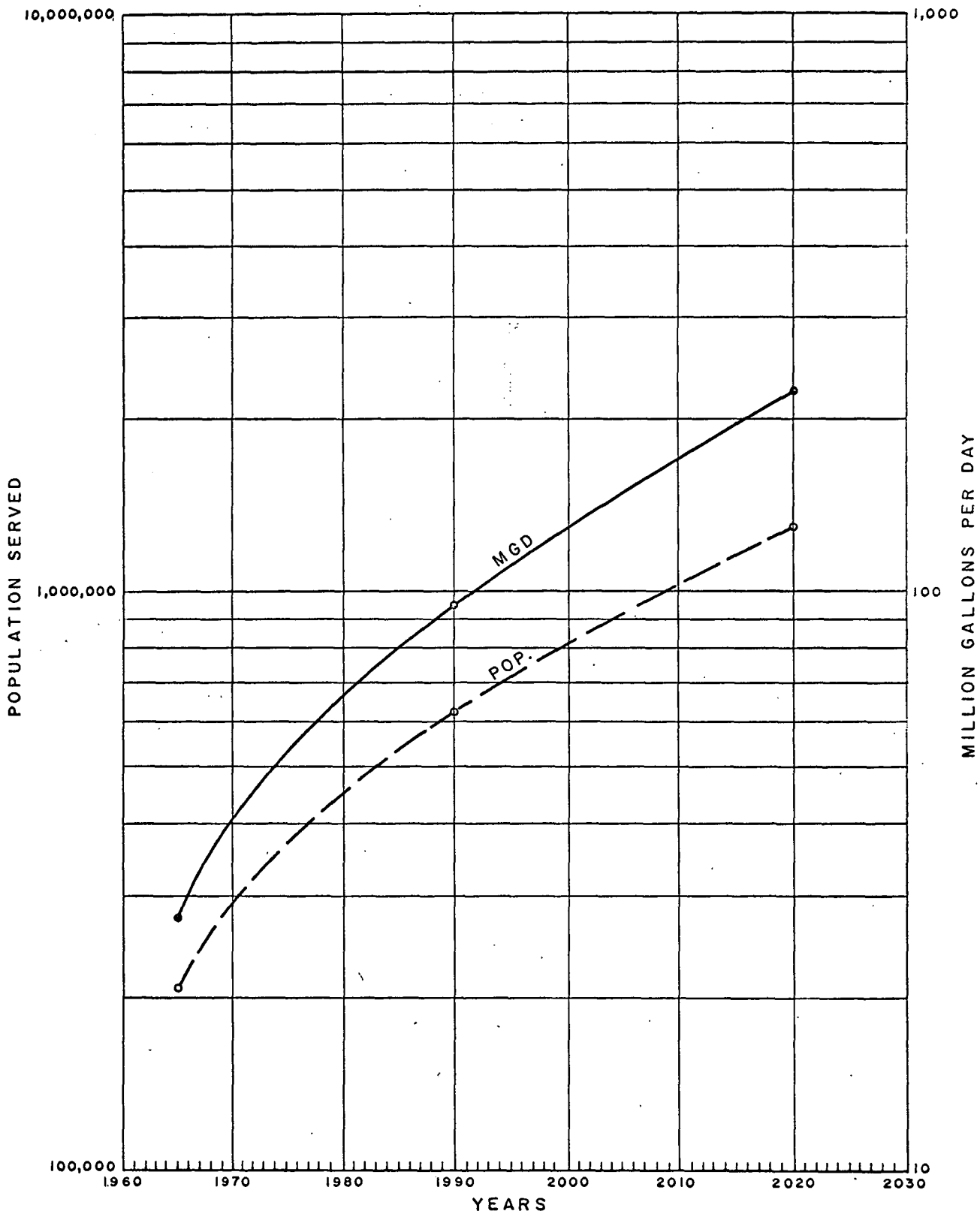
POPULATION & MUNICIPAL WASTE FLOW
FLINT RIVER BASIN
PROJECTION AREAS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION GROSSE ILE, MICHIGAN

FIGURE 8

FIGURE 9

POPULATION AND MUNICIPAL WASTE FLOW PROJECTIONS FOR THE FLINT RIVER BASIN



DESCRIPTION OF WATER QUALITY

The Detroit Program Office conducted surveys of the Flint River during 1965 to determine the quality of this watercourse. Figure 6 shows the general locations of sampling stations X260 and X240, sampled approximately twice a month, and several municipal sewage treatment plant sampling stations. The remaining stations shown on Figure 6 were OXSAG stations which were sampled approximately once every 4 hours over a 24-hour period on the August 11-12, 1965 survey.

Chemical

The following water quality measurements were made during 1965 with respect to chemical criteria: dissolved oxygen, BOD_5, nitrogen (ammonia, organic, and nitrate), phosphates (total and total soluble), solids (total, suspended, and volatile suspended), chlorides, iron, and phenols.

Table 10 shows the seasonal average and range of dissolved oxygen levels for the regular Flint River sampling stations, X240 and X260. This table also lists the average seasonal and yearly results of the nitrogens, phosphates, solids, chlorides, phenols, and BOD_5.

The yearly average dissolved oxygen at the upstream station X260, located above the City of Flint, was 9.8 milligrams per liter (mg/l) - 91 percent saturated, with a range of 6.4 to 13.2 mg/l (68 to 111 percent saturated).

In the lower Flint River, at Station X240, the yearly average dissolved oxygen was 9.4 mg/l, with a range of 3.7 to 13.6 mg/l. Dissolved oxygen saturation at Station X240 averaged 90 percent during 1965, with a range of 35 to 170 percent saturation.

Maximum dissolved oxygen saturations of 100 to 170 percent at both of these stations were noted in measurements made during May, June, August, September, and October.

The entire reach of the Flint River was sampled at 7 sampling stations over a 24-hour period on August 11-12, 1965. Dissolved oxygen and temperature determinations were made every four hours. A composite sample was prepared and analyzed for BOD and other chemical determinations. Samples for bacteriological analysis were collected on two of the six runs.

Table 11 shows the daily dissolved oxygen fluctuation during this survey for Station X240.

The percent saturation increased during the daylight hours to a high of 170 percent in mid-afternoon, and declined during the hours of darkness. This increased percent saturation is due mainly to the presence of significant phytoplankton populations and/or photosynthetic production in the river.

Figure 10 shows the results of the August 11-12, 1965 survey and lists the observed individual dissolved oxygen average values and their ranges for each station.

The lowest dissolved oxygen levels were recorded at Station X250, located downstream from the City of Flint's sewage treatment plant. The 24-hour dissolved oxygen average was 3.4 mg/l with respective maximum and minimum values of 5.7 and 0.6 mg/l. The average dissolved oxygen saturation was low with 45 percent, and a range of 7 to 68 percent saturation. The effect of the City of Flint's municipal wastes on the Flint River is apparent from the low dissolved oxygen levels encountered downstream of the City of Flint's sewage treatment plant.

The average dissolved oxygen increased from 9.0 mg/l at Station X240 to a high of 11.5 mg/l at Station X220 downstream. The increase in the average dissolved oxygen and percent saturation is associated with excessive algal growth and subsequent production of oxygen.

The average BOD_5 results at Stations X260 and X240, from measurements made during summer and fall of 1965, were 4 and 6 mg/l, respectively.

Five-day BOD results of composite samples taken during the special OXSAG survey on August 11-12, 1965 on the entire reach of the Flint River are illustrated in Figure 10.

High BOD_5 levels of 6 to 11 mg/l were recorded downstream at Stations X240, X236, X230, and X220. These high BOD_5 results were found at the same locations as the high dissolved oxygen and coincided with high phytoplankton populations as evidenced by biological sampling.

The Flint River had a definite seasonal variation in the nitrate concentration during the 1965 sampling period at Stations X240 and X260. The nitrate concentration at Station X240 increased from an average of 1.41 mg/l in January to April to an average of 1.96 mg/l in the May through September period. In the October to December period, the nitrate concentration reached an average level of 3.10 mg/l. The average annual nitrate concentration at Station X240 was 1.93 mg/l. Station X260 had an average annual nitrate concentration of 0.83 mg/l, with lower values in the summer and fall, as shown in Table 12.

Figure 11 depicts the increase of nitrate concentrations during the special OXSAG survey conducted on August 11-12, 1965, and the average annual nitrate concentrations for the two regular sampling stations. The nitrate concentration increased from 0.90 mg/l at Station X260, above the City of Flint, to an average of 3.20 mg/l at Station X236, downstream

from Montrose. Stations X230 and X220 had nitrate concentrations of 2.50 to 2.30 mg/l.

The average annual ammonia nitrogen concentration in the Flint River at Station X260, above Flint, was 0.56 mg/l; and at Station X240, downstream from Flint, was 1.09 mg/l. Average annual organic nitrogen concentrations for Stations X260 and X240 were 0.25 and 0.27 mg/l, respectively.

The average seasonal variation and annual total and soluble phosphate concentrations found in the Flint River during 1965 at the regular sampling stations, X260 and X240, are shown in Table 13.

The average annual total phosphate concentration was 0.21 mg/l at Station X260 and 4.36 mg/l at Station X240. Soluble phosphate, as a percent of total phosphate, at Stations X260 and X240 ranged from 61 to 76 percent.

Figure 12 illustrates the average and range of total phosphate concentrations for the two regular sampling stations, and also the results of the special survey conducted on August 11-12, 1965.

Total solids and chlorides were significantly high in the Flint River as shown in Table 10. The average annual total solids concentration at Stations X260 and X240 were 395 mg/l and 505 mg/l, respectively. Chloride levels made up 9 and 16 percent of the total solids.

Figure 13 depicts the increase in total solids and chlorides in the Flint River below Flint's sewage treatment plant during the special survey conducted on August 11-12, 1965. Chloride concentration of 27 mg/l at Station X260 increased to 100 mg/l at Station X250. Chloride levels accounted for 17 percent of total solids below Flint's sewage treatment

plant.

Average annual phenol concentration in the Flint River at Station X260 was 4 micrograms per liter (ug/l), with a range of 0 to 9 ug/l. At Station X240, the annual average phenol concentration was 5 ug/l, with a range of 0 to 15 ug/l.

Table 14 summarizes average iron, sodium, potassium, calcium, magnesium, sulfate, and total hardness values found during the 1965 survey in the Flint River for the two regular sampling stations. Average annual iron concentration for Station X260 was 1,350 ug/l, with seasonal averages of 2,080, 1,000, and 230 ug/l. At Station X240, average annual iron concentration was 1,430 ug/l, with seasonal average values of 2,640, 540, and 100 ug/l.

Sodium and potassium levels were noticeably increased in the Flint River from Station X260 to X240. Calcium, magnesium, and sulfate concentrations were typical of concentrations in other tributaries in the Saginaw River Basin. Hardness averaged 241 to 256 mg/l upstream, and 231 to 233 mg/l downstream of Flint.

Microbiological

The microbiological findings for the Flint River are from the 1965 sampling period. This sampling period was separated into three intervals - January 11 to May 15, May 15 to September 15, and September 15 to November 30 - to coincide with the municipal waste chlorination period beginning May 15 and ending September 15. Representative median, low, and high total, and fecal coliform results for the regular sampling stations are shown in Table 15.

Total coliform densities at Station X260, above the City of Flint,

ranged from 360 to 18,000 organisms/100 ml, with a median annual value of 1,400 organisms/100 ml. Station X240, located below the City of Flint's sewage treatment plant, exhibited a median annual total coliform count of 24,000 organisms/100 ml, with a range of 200 to 370,000 organisms/100 ml. Percent fecal coliform remained fairly constant in the reaches above and below Flint's sewage treatment plant, these values being 16 and 22 percent, respectively.

Chlorination had a definite effect on the total and fecal coliform densities at Station X240 during the 1965 chlorination period. The median total coliform count at Station X240 declined from 150,000 organisms/100 ml in the January 11-May 15 period to a median value of 4,000 organisms/100 ml in the May 15-September 15 sampling period.

A comparison of the average, median, and geometric mean values of annual total and fecal coliform results for Stations X240 and X260 is shown in Table 16.

Figure 14 depicts the variation in total coliform distributions at various sampling points in the Flint River during surveys conducted on August 11 and 12, 1965. The median annual total coliform densities for the two regular sampling stations are also shown in Figure 14. On August 11, the total coliform densities increased from 700 organisms/100 ml at Station X260 above Flint to a high of 29,000 organisms/100 ml at Station X256, then declined to a low of 500 organisms/100 ml at Station X220. On August 12, the total coliform density of 800 organisms/100 ml at Station X260 increased to a high of 15,000 organisms/100 ml at Station X256. Station X250 had a total coliform count of 3,000 organisms/100 ml, which increased downstream to a value of 12,000 organisms/100 ml at Station X220.

TABLE 10. FLINT RIVER WATER QUALITY
1965 AVERAGE CONCENTRATIONS
Seasonal

River	Dissolved Oxygen Avg	Max	Min	5-Day BOD	NH_3-N	Org-N	NO_3-N	Tot.** PO_4	Tot.*** Sol. PO_4	Tot. Sol.	Susp. Sol.	Vol.* S.S.	Cl	Phenols
January - April 1965														
Flint				-										
X240	10.2	12.9	5.2	-	1.56	0.22	1.41	2.20	1.77	464	37	11	77	5
X260	11.7	12.3	10.9	-	0.51	0.16	1.18	0.31	0.19	369	22	4	29	4
May - September 1965														
Flint														
X240	9.1	13.6	3.7	6	0.50	0.35	1.96	4.46	3.26	533	18	4	83	4
X260	8.3	10.1	6.4	4	0.81	0.38	0.44	0.16	0.11	422	18	3	23	5
October - December 1965														
Flint														
X240	9.1	10.9	5.6	5	0.97	0.23	3.10	9.23	6.90	554	9	6	100	8
X260	11.6	13.2	10.5	4	0.28	0.27	0.70	0.06	0.04	414	14	8	33	2
January - December 1965														
Flint														
X240	9.4	13.6	3.7	6	1.09	0.27	1.93	4.36	3.29	505	25	7	83	5
X260	9.8	13.2	6.4	4	0.56	0.25	0.83	0.21	0.13	395	19	4	28	4

Note: All results in mg/l except phenols - µg/l.
Phosphates reported as PO_4.
Nitrogens (NH_3, NO_3, Organic) reported as Nitrogen.

*Volatile Suspended Solids

**Total phosphate includes: ortho, poly, biological, and organic phosphate

***Total soluble phosphate (performed on filtered sample) includes: soluble ortho, soluble poly and soluble organic phosphate

TABLE 11. DISSOLVED OXYGEN FLUCTUATION - FLINT RIVER
Station X240

Date	Time	Temp. °C	DO (mg/l)	% Saturation
8/11/65	0930	18.0	7.0	74
	1325	22.0	13.1	151
	1710	26.0	13.6	170
	2100	24.0	10.3	124
8/12/65	0125	22.0	6.2	71
	0535	20.5	3.7	42

TABLE 12. FLINT RIVER
Seasonal Nitrate-N Concentration
(mg/l)

Station	Jan-April	May-Sept.	Oct.-Dec.	Annual
X240				
Average	1.41	1.96	3.10	1.93
Range	0.89-1.60	0.70-2.80	1.90-4.60	0.70-4.60
X260				
Average	1.18	0.44	0.70	0.83
Range	0.90-1.60	0.20-0.90	0.30-1.20	0.20-1.60

TABLE 13. FLINT RIVER
1965 TOTAL AND SOLUBLE PHOSPHATE CONCENTRATIONS
Seasonal

	Total Phosphate mg/l			Soluble Phosphate mg/l		
Station #	Average	Minimum	Maximum	Average	Minimum	Maximum
Jan.-April						
X240	2.20	0.50	4.70	1.77	0.10	4.60
X260	0.31	0.10	0.60	0.19	0.00	0.40
May-Sept.						
X240	4.46	0.60	8.70	3.26	0.10	5.10
X260	0.16	0.08	0.30	0.11	0.06	0.20
Oct.-Dec.						
X240	9.23	5.40	12.80	6.90	4.00	8.80
X260	0.06	0.04	0.10	0.04	0.04	0.04
Annual						
X240	4.36	0.50	12.80	3.29	0.10	8.80
X260	0.21	0.04	0.60	0.13	0.00	0.40

TABLE 14. FLINT RIVER WATER QUALITY
1965 AVERAGE CONCENTRATIONS
Seasonal

River	Total Iron	Sodium	Potassium	Calcium	Magnesium	Sulfate	Total Hardness
Jan-April							
Flint							
X240	2640	68	14	62	23	84	233
X260	2080	31	9	64	23	80	241
May-Sept							
Flint							
X240	540	58	13	66	27	105	254
X260	1000	15	5	69	30	86	267
Oct-Dec							
Flint							
X240	100	77	17	59	19	76	231
X260	230	24	7	63	27	70	256
Jan-Dec							
Flint							
X240	1430	68	15	62	23	89	238
X260	1350	26	8	65	26	80	253

Note: All results in mg/l, except Iron - µg/l
Total Hardness as $CaCO_3$

TABLE 15. FLINT RIVER
1965 TOTAL AND FECAL COLIFORM DENSITIES
Seasonal

Season and Station No.	Total Coliform Organisms/100 ml Median	Low	High	Fecal Coliform Organisms/100 ml Median	Low	High
Jan. 11-May 15						
X240	150,000	7,000	370,000	11,000	3,700	30,000
X260	1,700	360	18,000	520	60	1,700
May 15-Sept. 15						
X240	4,000	200	21,000	100	20	1,700
X260	1,100	600	9,900	250	140	900
Sept. 15-Nov. 30						
X240	3,400	1,000	5,800	360	10	700
X260	1,200	800	1,500	190	180	200
Annual						
X240	24,000	200	370,000	5,300	10	30,000
X260	1,400	360	18,000	220	60	1,700

TABLE 16. FLINT RIVER
1965 TOTAL AND FECAL COLIFORM DENSITY STATISTICS
(organisms/100 ml)

Station	Average	Median	Geometric Mean	Low	High
Total Coliform					
X240	94,000	24,000	20,000	200	370,000
X260	3,600	1,400	1,800	360	18,000
Fecal Coliform					
X240	8,300	5,300	1,900	10	30,000
X260	490	220	320	60	1,700

FLINT RIVER
DISSOLVED OXYGEN AND 5-DAY BOD
AUGUST 11-12, 1965 SURVEY

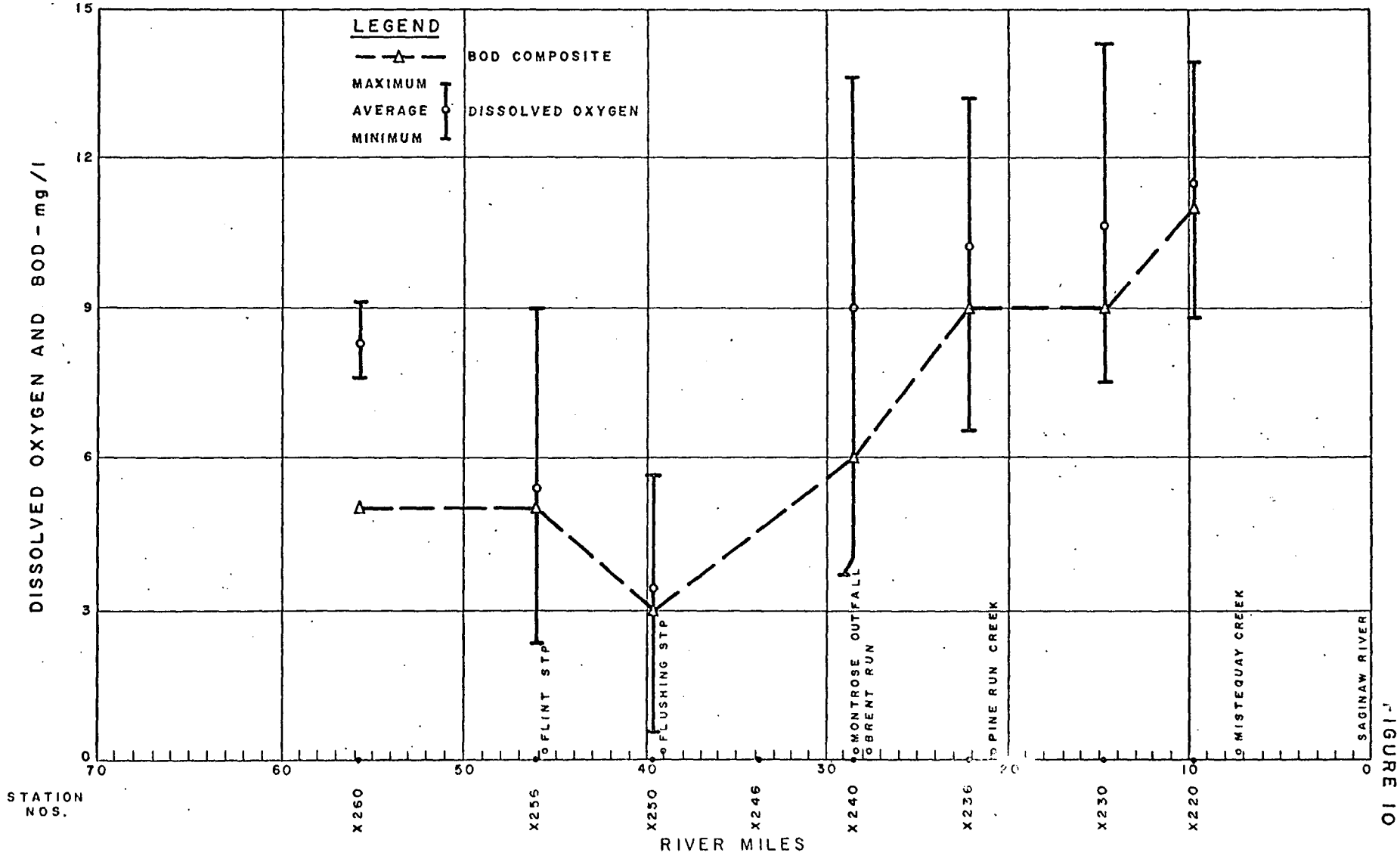


FIGURE 10

FLINT RIVER
NITRATE CONCENTRATION
AUGUST 11-12, 1965 SURVEY

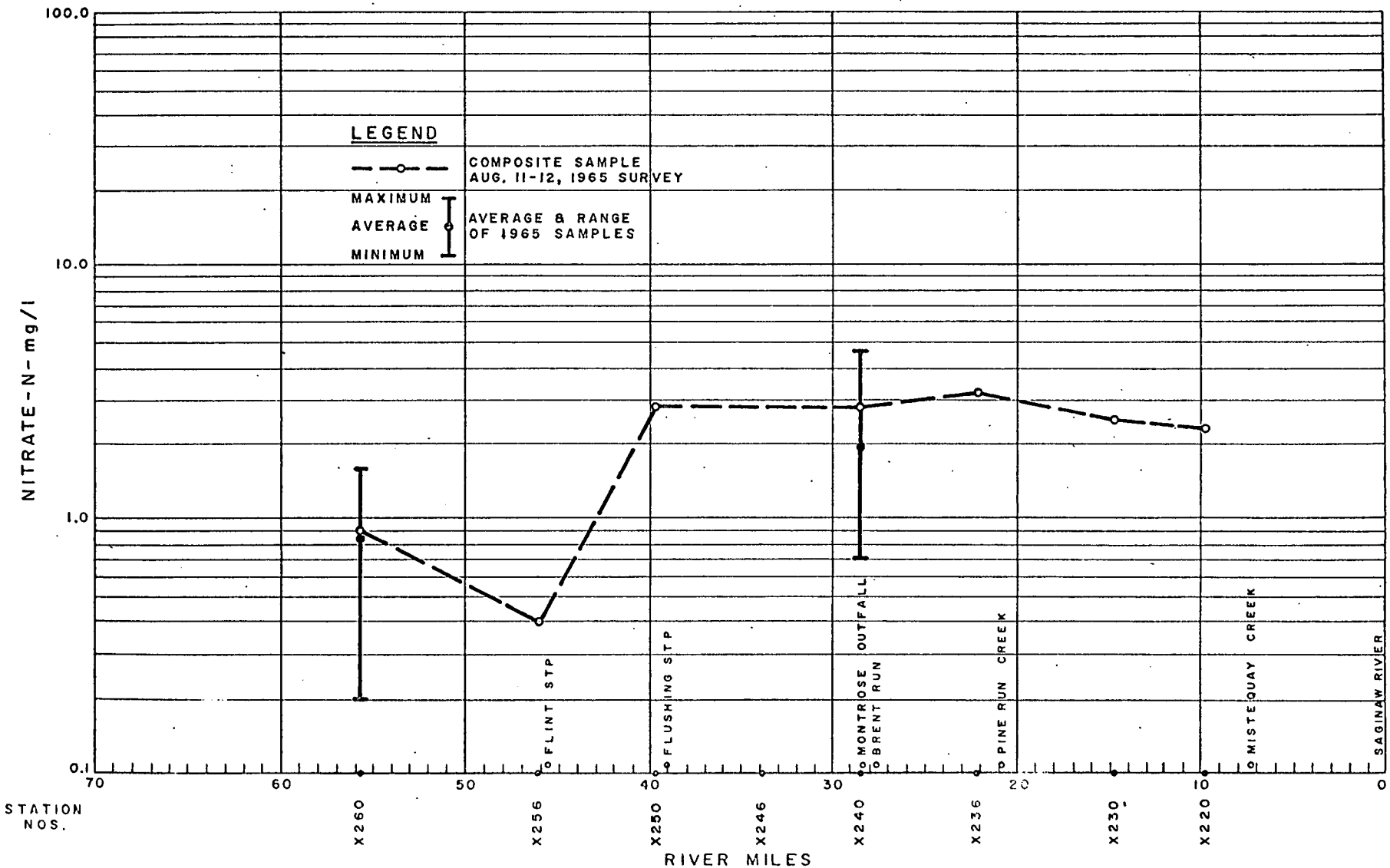


FIGURE 11

FLINT RIVER
TOTAL PHOSPHATE
AUGUST 11-12, 1965 SURVEY

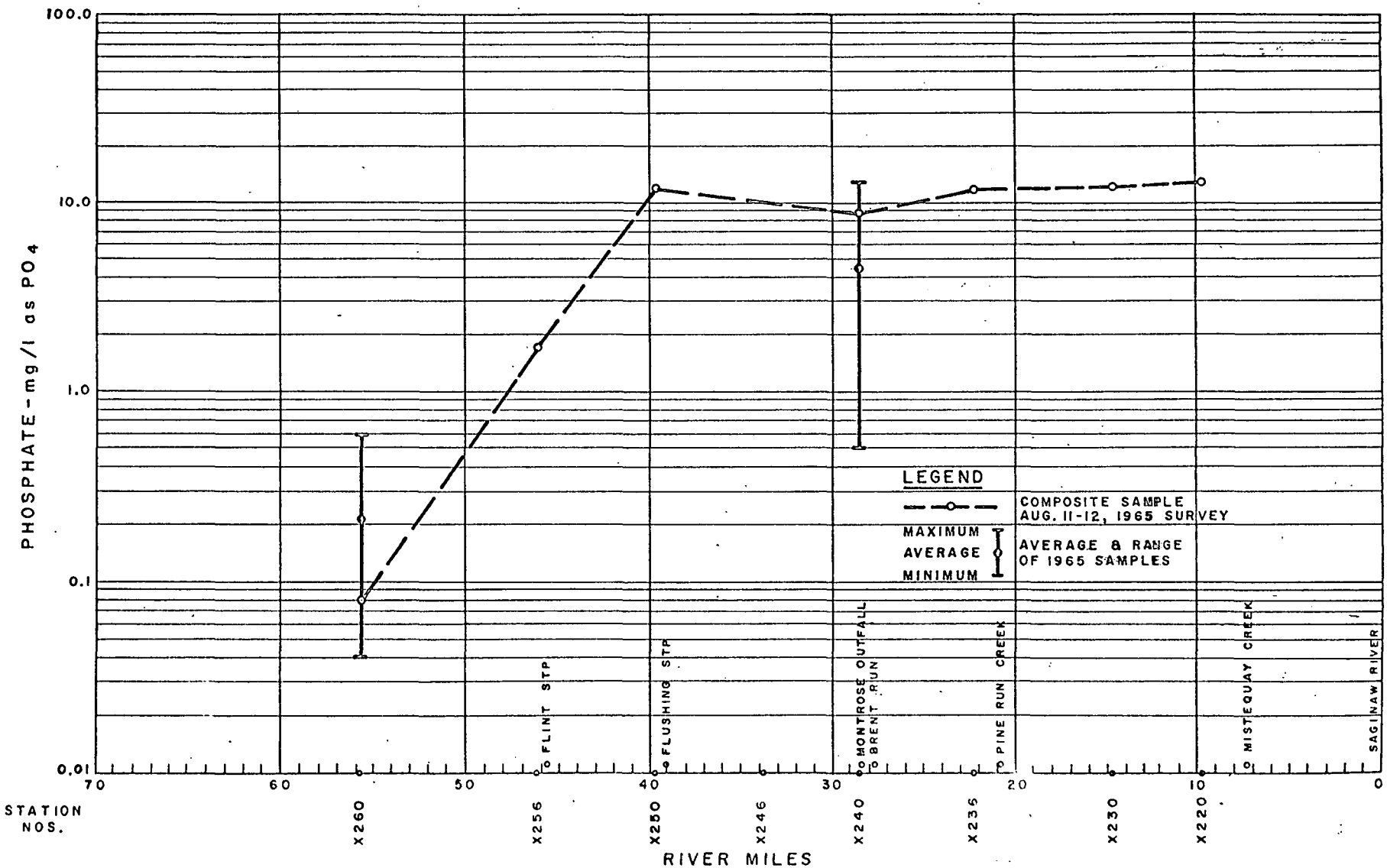


FIGURE 12

FLINT RIVER
TOTAL SOLIDS AND CHLORIDES
AUGUST 11-12, 1965 SURVEY

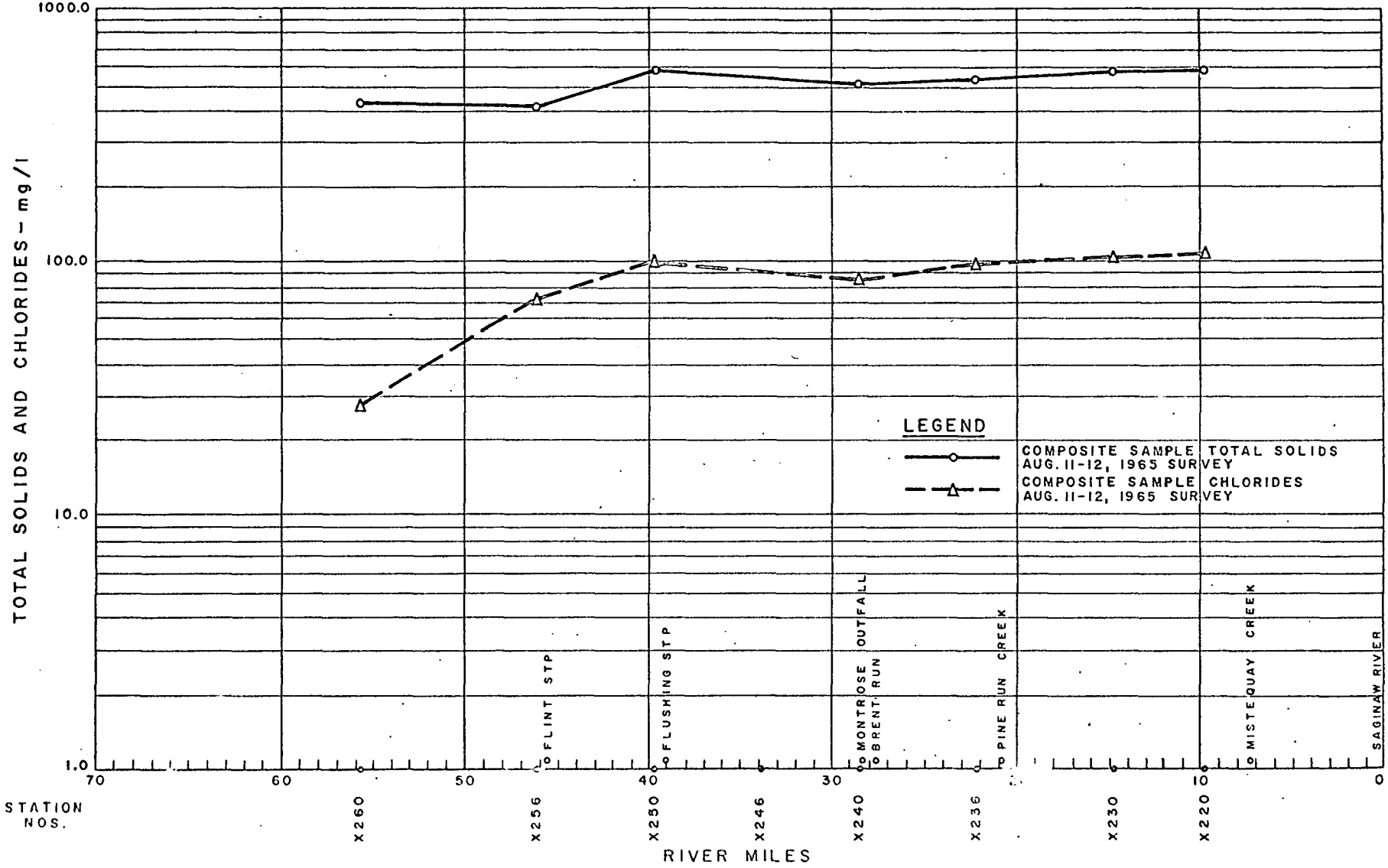


FIGURE 13

FLINT RIVER
TOTAL COLIFORM DENSITIES
AUGUST 11-12, 1965 SURVEY

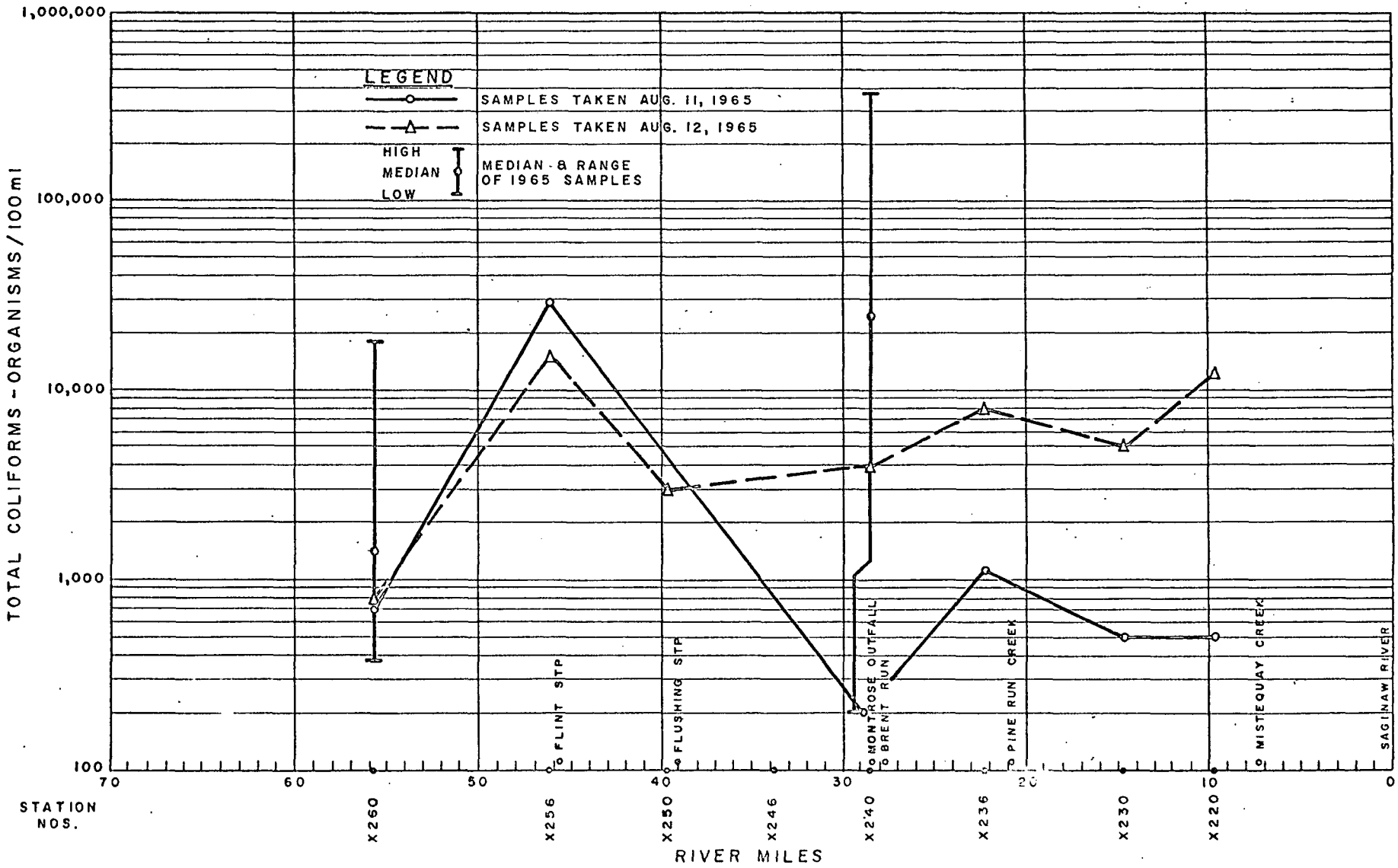


FIGURE 14

DISSOLVED OXYGEN PROJECTIONS

The water quality data described in previous sections of this report were submitted to analyses in a mathematical model depicting oxygen balance in streams. This particular model is a modification of the classical Streeter-Phelps formulation for oxygen balance in a stream. This equation includes an additional non-conservative oxygen demand (Kjeldahl nitrogen), which acts in a similar fashion to the BOD factor in the original formulation.

Long-term oxygen demand and nitrogen balance determinations were made on stream and waste source samples to determine a laboratory K-rate in order to calculate the ultimate carbonaceous oxygen demand. The ultimate carbonaceous oxygen demand stream profile was constructed, and the stream BOD decay rate determined. A similar profile of the Kjeldahl nitrogen yielded the nitrogenous demand decay rate. These profiles were checked by a wastes loadings profile. All rates were converted from the stream temperature to 20°C.

Reaeration rates were initially calculated based on the O'Connor-Dobbins formulation for natural streams using computed reach velocities and depths. These values were used for initial match runs, but were then modified somewhat in the final match run for simplicity in the projection runs. The photosynthetic production of algae is not a factor in the model. No attempt was made to match the dissolved oxygen profile to observed data above or near the saturation value.

Survey data indicated an apparent high decay rate for the Kjeldahl nitrogen portion of the total oxygen demand in the stream reach below

the main municipal waste source. This high demand rate was indicated also by the observed dissolved oxygen profile. (Previous work by others indicated an intensified rate of oxygen demand in this reach.) The Kjeldahl nitrogen level in this reach had the potential for an abnormal decay rate. With the exception of this reach, a uniform decay rate was used throughout the stream. A uniform decay rate was used for the carbonaceous portion of the total oxygen demand. The presence of significant algae concentrations as evidenced by diurnal dissolved oxygen fluctuations, and visual observations of the stream, is believed reponsible for the anomalous BOD data found during the 1965 survey. Resurveys during 1966 indicated a somewhat different decay rate which more closely resembled the nitrogen decay rate. This rate was used for the final match run. The computed match run profiles are shown superimposed on the survey data (Figures 15 and 16). Loadings for the final match run are included in Table 17.

The parameters determined for the match run were used to project the expected dissolved oxygen profiled for a number of flow and loading conditions. Minor modifications were made for ease in projection changes. All additional augmentation was assumed to have the same yield for all low flow conditions due to the minor increase in flow below the initial reach. All waste sources were combined on a flow basis with the major municipal source. The concentrations used were those determined during the 1965 survey. For all projection runs, the initial stream parameters, with the exception of flow, remained constant.

Figures 17 through 20 show computed dissolved oxygen profiles for the following situations:

Figure 17 - 1965 Summer Survey Flow (75 cfs)
Temperature ranges - 15°C to 30°C at 5°C increments
Stream loadings - 1965 - 100%; 1990 - 316%; and 2020 - 741%

Figure 18 - 7 Day Once in 10 Year Flow (47 cfs)
Temperature ranges - 15°C to 30°C at 5°C increments
Stream loadings - 1965 - 100%; 1990 - 316%; and 2020 - 741%

Figure 19 - 1 Day Once in 10 Year Flow (38 cfs)
Temperature ranges - 15°C to 30°C at 5°C increments
Stream loadings - 1965 - 100%; 1990 - 316%; and 2020 - 741%

Figure 20 - Augmented Flow (100 cfs)
Temperature ranges - 15°C to 30°C at 5°C increments
Stream loadings - 1965 - 100%; 1990 - 316%; and 2020 - 741%

TABLE 17. FLINT RIVER - LOADINGS FOR MATCH RUN - 1965 MODEL

	Flow		5-Day BOD		Ultimate BOD		Kjeldahl N.		Dissolved Oxygen	
	MGD	cfs	mg/l	#/day	mg/l	#/day	mg/l	#/day	mg/l	#/day
Municipal Wastes										
Flint	25.9	40.1	12	2590	15	3240	12.7	2690	4.0	847
Flushing	.4	0.6	41	137	53	177	11.2	37	2.0	7
Montrose	1.3	2.0	101	1090	147	1590	11.8	128	0.0	0
Industrial Wastes										
Brent Run	2.6	4.0	3	88	3.5	102	2.3	50	5.0	108
Tributary Flow										
Flint (Initial)	48.5	75.0	5	2040	5.6	2270	.9	364	4.9	1980

FLINT RIVER
DISSOLVED OXYGEN
SUMMER 1965 SURVEY

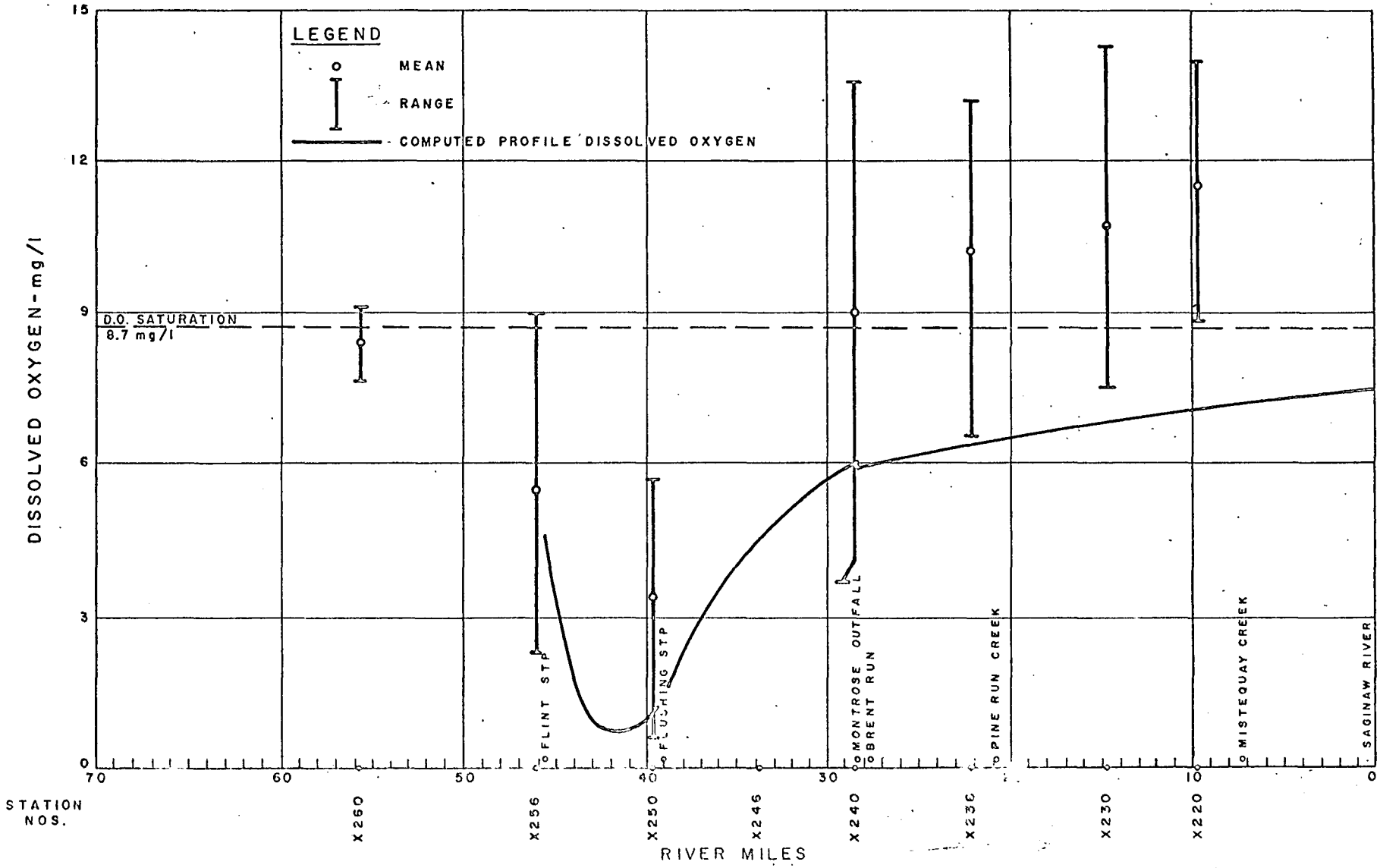


FIGURE 15

FLINT RIVER
KJELDAHL NITROGEN as N AND 5-DAY BOD
SUMMER 1965 SURVEY

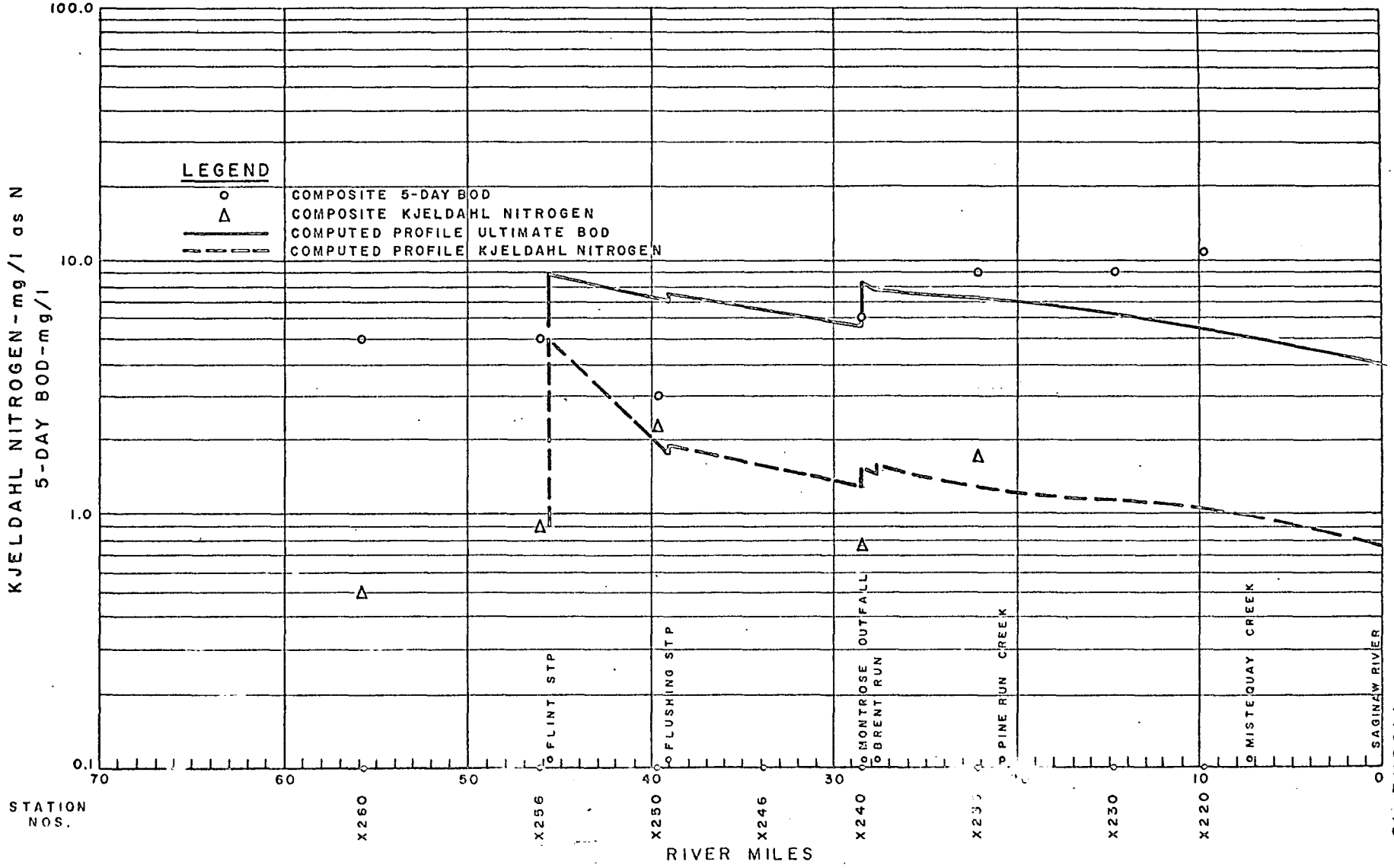


FIGURE 16

FIGURE 17

FLINT RIVER
COMPUTED DISSOLVED OXYGEN PROFILES
EFFECT OF TEMPERATURE AND LOADINGS
1965 SUMMER SURVEY FLOW

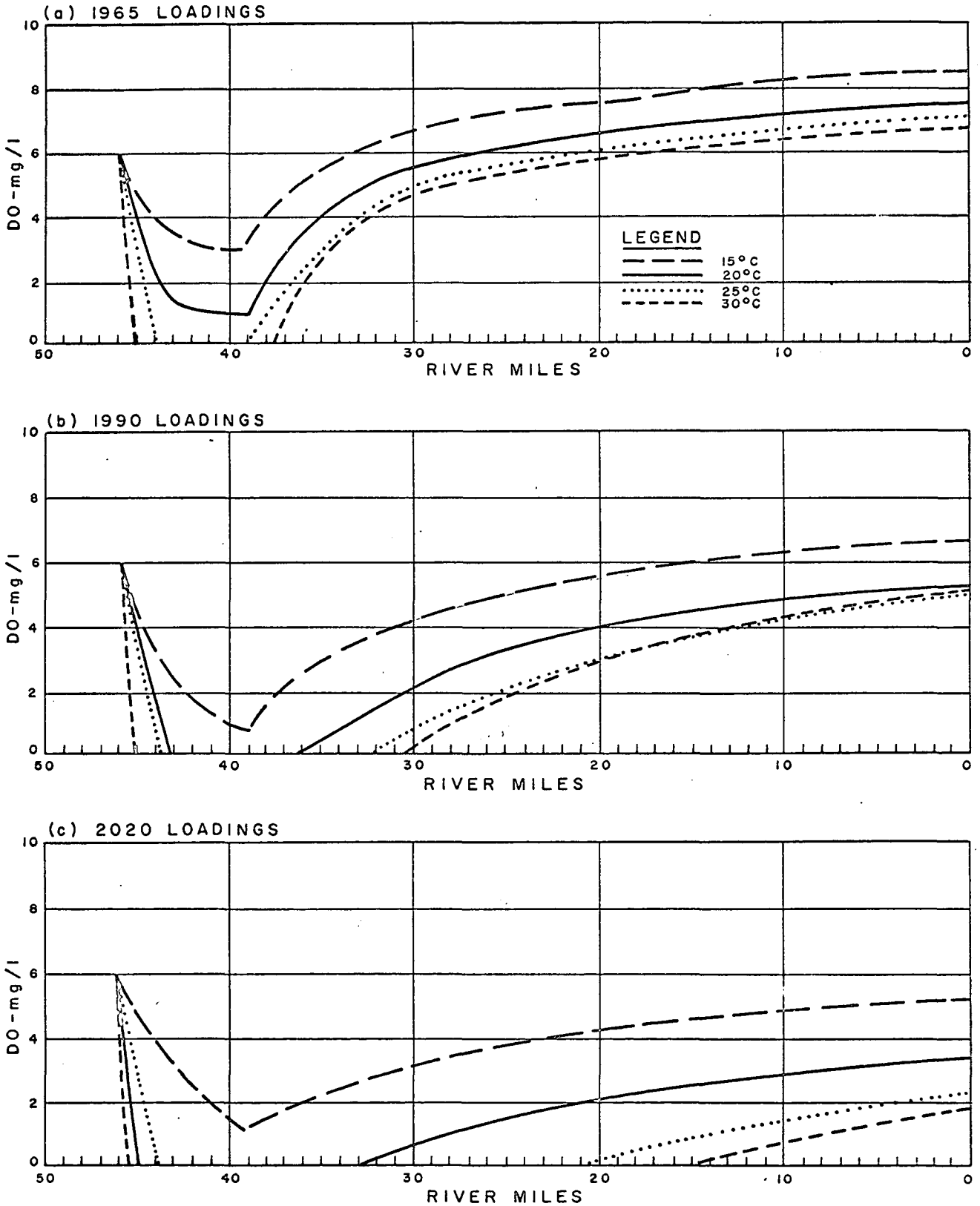


FIGURE 18

FLINT RIVER
COMPUTED DISSOLVED OXYGEN PROFILES
EFFECT OF TEMPERATURE AND LOADINGS
7 DAY ONCE IN 10 YEAR FLOW

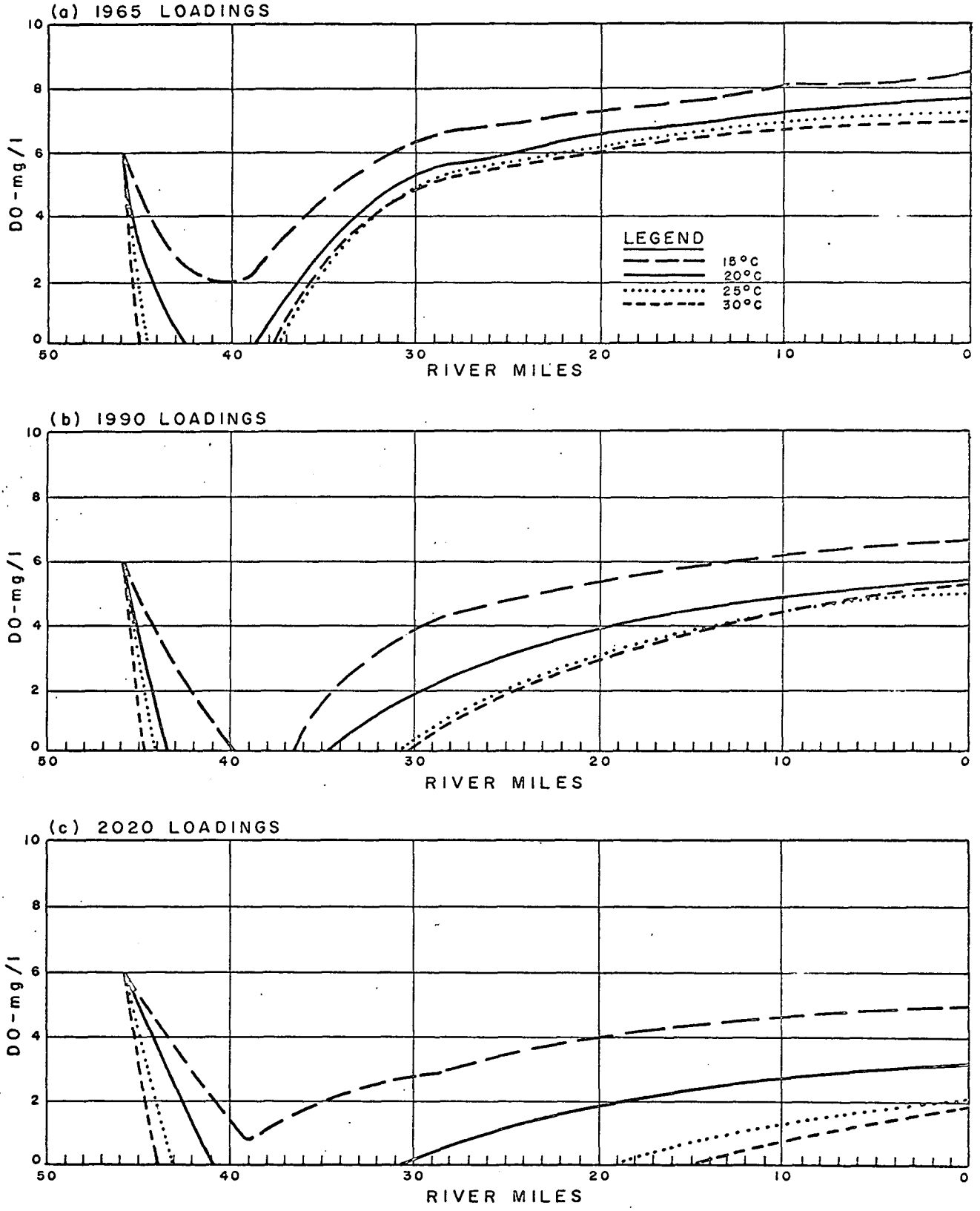


FIGURE 19

FLINT RIVER
COMPUTED DISSOLVED OXYGEN PROFILES
EFFECT OF TEMPERATURE AND LOADINGS
1 DAY ONCE IN 10 YEAR FLOW

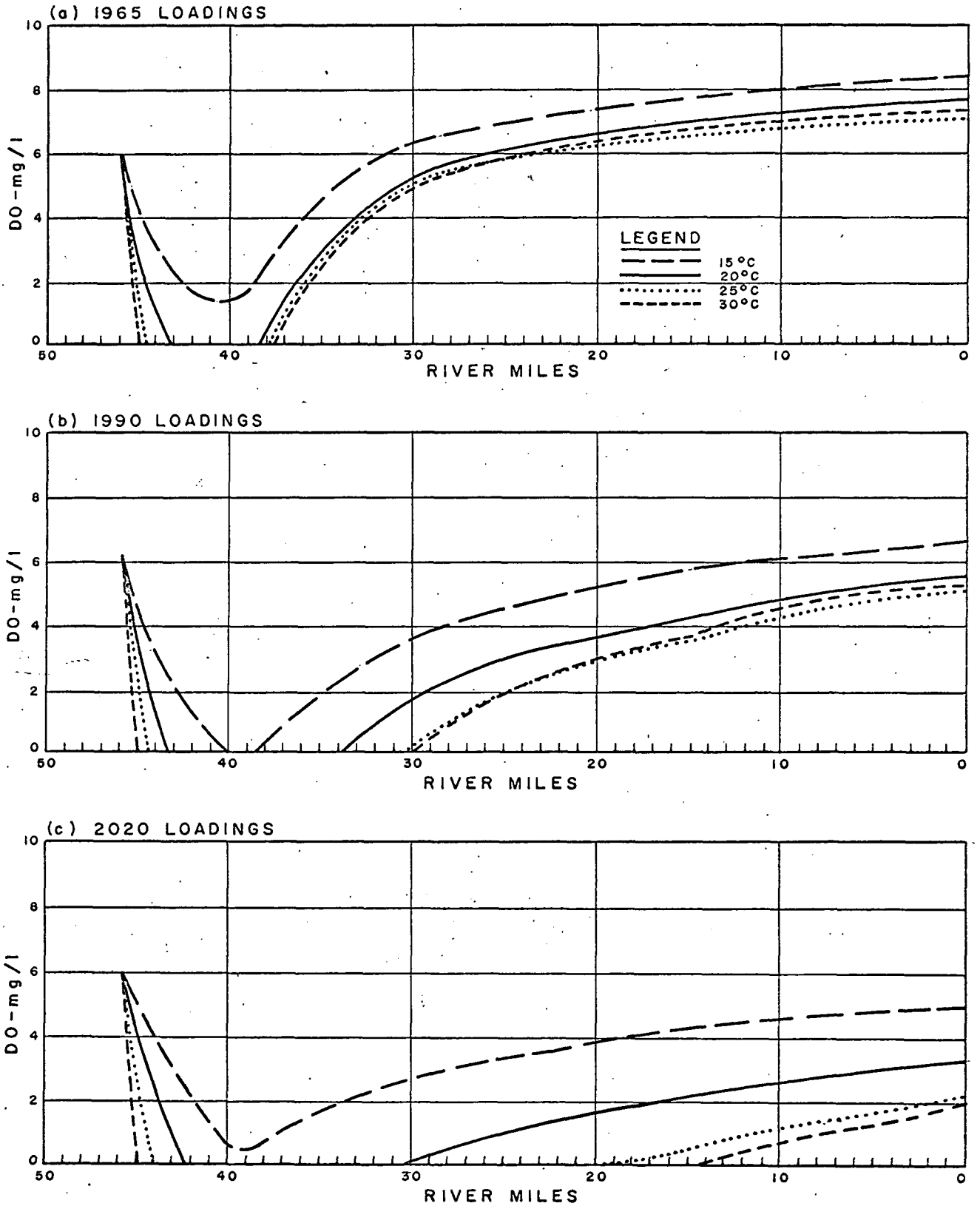
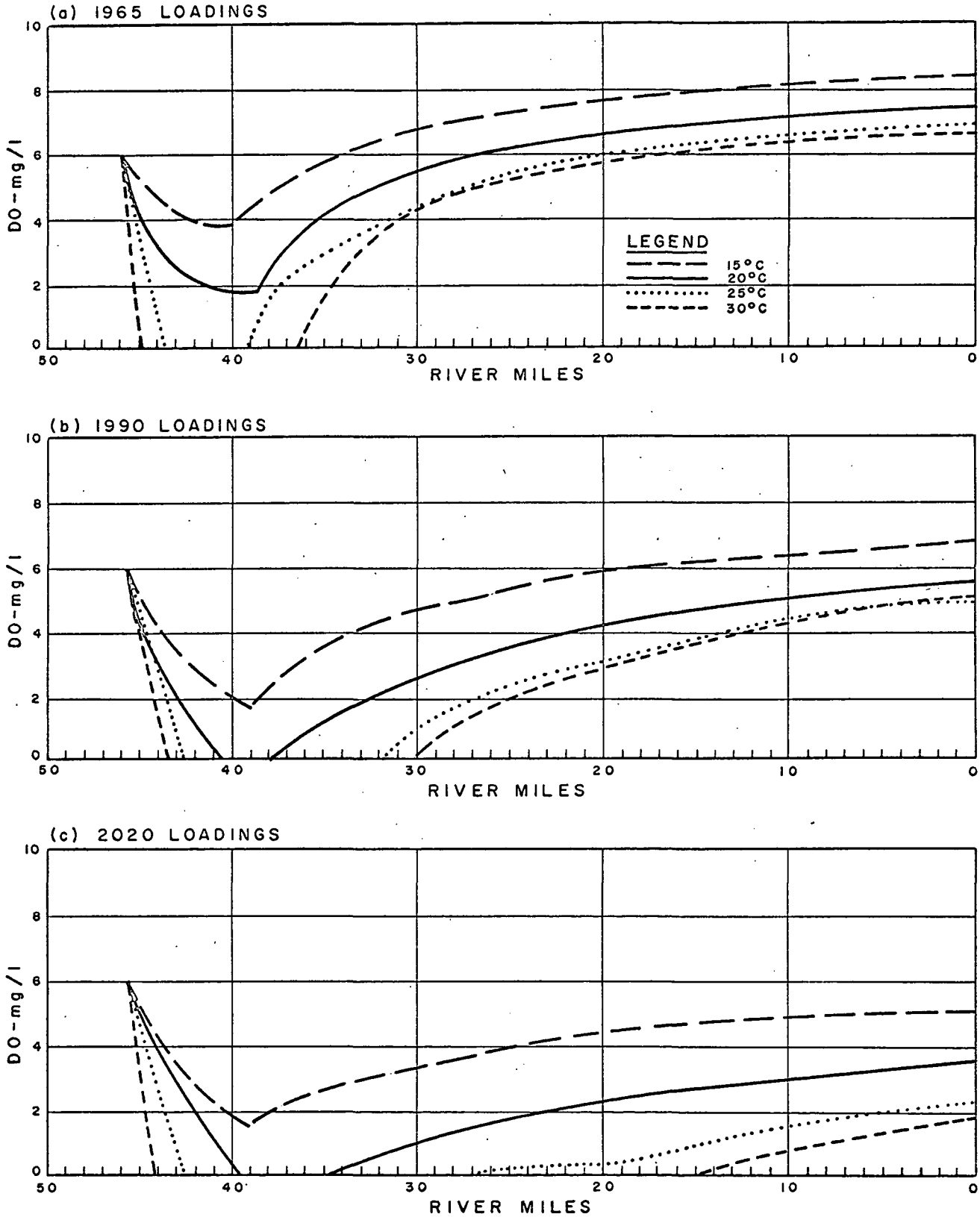


FIGURE 20

FLINT RIVER
COMPUTED DISSOLVED OXYGEN PROFILES
EFFECT OF TEMPERATURE AND LOADINGS
AUGMENTED FLOW



SUMMARY AND WATER QUALITY PROBLEMS

Water quality of the Flint River Basin is, in general, good above and degraded below the City of Flint. The upper portion of Kearsley Creek is managed as a trout stream. The Flint River provides water supply for the City of Flint, with storage in the Holloway Reservoir located 20 miles upstream. The stream reaches below the municipalities have moderate levels of coliform bacteria. Below the City of Flint, however, these levels are excessive during the non-chlorination period. The Flint River below Flint has extremely high levels of nutrients - levels of nitrate were 2 mg/l and phosphate about 4.4 mg/l in 1965. Chloride levels were in excess of 80 mg/l in this area. A severe dissolved oxygen depression appears below the Flint sewage treatment plant.

The Flint River Basin above the confluence of the South Branch Flint River is sparsely populated, having only two communities - North Branch (832), and Clifford (330). Lapeer (8,020) is located midway up the South Branch Flint River. Also located in this area is the Lapeer State and Home Training School. The only other community in this part of the basin is Metamora (390). The community of Columbiaville (789) is located on the Flint River about 10 miles above the headwaters of the Holloway Reservoir. Otisville (701) and Otter Lake (523) are two communities in the Flint River drainage below Holloway Reservoir. Kearsley Creek joins with the Flint River at the City of Flint. Ortonville (702) is at its headwaters, and Davison (1,745) is on Black Creek near its confluence with Kearsley Creek. Both communities are upstream of Kearsley Creek Reservoir, which is a 2,000 acre-feet emergency water supply for the City

of Flint. The City of Flint, in 1960, had a population of 196,940 and is the third largest city in Michigan. There are numerous suburbs located in the immediate area: Burton Township (29,700), Flint Township (300), City of Flushing (3,761), Mt. Morris Township (17,000), Grand Blanc (1,565), Grand Blanc Township (640). Further downstream, other communities are: Montrose (1,466), and on the tributaries Mt. Morris (3,484), and Clio (2,212). The community of New Lothrop (510) is located on Mistequay Creek, a tributary to the Flint River near its confluence with the Shiawassee River. Mistequay Creek joins the natural channel of the Flint River downstream of the Cutoff Canal which diverts excess flows to the Shiawassee River.

The following communities provide secondary waste treatment: Flint, Flushing, Davison, Lapeer, Lapeer State Home and Training School, and Swartz Creek. The communities of Columbiaville and North Branch have no formal treatment system, although there are some sewers which discharge raw or semi-treated sewage to the Flint River. There are a number of industrial sources in the City of Flint which discharge directly to various points along the Flint River. These include the following divisions of the General Motors Corporation: AC Spark Plug, Buick, Chevrolet-Flint, Ternstedt, Chevrolet Assembly Plant, and Chevrolet Engine and Stamping Plant. The Fisher Body Division of General Motors Corporation is located in the community of Grand Blanc, and the Parts Division - General Motors Corporation is located in the community of Swartz Creek. All of these industrial sources are rated adequate by the Michigan Water Resources Commission. The Vogt Packing Company at Grand Blanc is rated as "providing control," although the adequacy of control has not been

established. Many communities in the basin have joined the Genesee County-Metropolitan System which has six districts for sanitary sewers and sewage treatment plants.

In February 1965, a reconnaissance survey of the Flint River from above Columbiaville to its confluence with the Shiawassee River was conducted. Twenty-one locations on 61 miles of stream were sampled. Moderately high bacterial levels were found from Columbiaville to the Holloway Reservoir, where a decrease in bacterial concentration was noted. High bacterial levels were found below the outfall of the Flint sewage treatment plant. The bacterial level below Flint declined in the area of Montrose. A moderate increase in concentration was noted in the lower ten miles of stream, although there was an abrupt decrease in the last two miles below the Flint River Cutoff Canal. Chloride concentrations increased moderately from above Columbiaville to the City of Flint, and more than doubled at the City of Flint to remain at a high level throughout the remainder of the stream. A severe dissolved oxygen depletion was noted below the City of Flint. A moderate depression was noted in the area from above Columbiaville to the Holloway Reservoir. An increase in dissolved oxygen occurred in passage through the reservoir.

Two locations on the Flint River were sampled routinely by the FWPCA in 1965. These were above the City of Flint and at the community of Montrose. The results are indicated on Table 18.

The data indicate that a substantial increase occurs in the pollutional level of the river from Flint and the other sources. Chloride level tripled, the nitrogen levels - nitrate, nitrite, and ammonia - doubled. The phosphate levels, however, increased 20 times (2,000 percent) from a

level of 0.2 mg/l above Flint to a level of 4.0 mg/l at Montrose. The increase was even more spectacular during the lower flow periods (summer). There was not as great a difference in the dissolved oxygen and BOD levels of the two locations due to the recovery zone of fifteen miles of stream passage. Bacterial densities increased substantially in the stream, although this increase was predominantly during non-disinfection period of September to May.

An additional location on the Flint River at Flushing, downstream from the Flint sewage treatment plant, was sampled from September to December 1965. The results are indicated on Table 18.

The degraded quality of the river is evident from the data. Organic demand is indicated by both the BOD_5 and ammonia nitrogen levels. Nutrient levels - nitrate and phosphate - increased considerably in the river's passage through the Flint area, with a fiftyfold increase (5,000 percent) in the phosphate concentration. Chlorides increased fourfold; dissolved oxygen levels were low even though the sampling period did not include the high temperature low flow midsummer period. Bacterial densities were high, although the disinfection period was not included in the survey.

Samples were collected on a monthly basis from May to November at two locations in the Basin. These were Farmers Creek at Lapeer and the headwaters of Swartz Creek near Holly. The results of those analyses are listed on Table 18.

The data indicate that there is considerably more pollution entering Farmers Creek than Swartz Creek, as evidenced by the higher chloride and phosphate levels. The Farmers Creek sampling station was located on the

grounds of the Lapeer State Home and Training School, a short distance upstream from the sewage treatment plant. The headwaters of Swartz Creek are in Holly State Recreation Area, a few miles upstream. The community of Holly is at the headwaters of the Shiawassee River, therefore, there are no significant sources of pollution to the Creek. The data indicate quality which may be expected in an unpolluted stream.

Due to the dissolved oxygen depression noted below the City of Flint in a reconnaissance study, an intensified survey was conducted during the summer of 1965. Seven locations, at about 6-mile intervals along the lower 40 miles of the river from above Flint to below the community of Fosters, were sampled every 4 hours for 24 hours. Dissolved oxygen and temperature determinations were made on these samples. Composites were prepared for other parameters and analyzed. Samples for bacteriological analysis were collected on two of the six runs.

Above the City of Flint, the water quality approximated that of Swartz Creek near Holly and Farmers Creek at Lapeer. Nutrients, BOD, chloride, and bacterial levels were low. The only major sources of wastes are Lapeer and Lapeer State Home and Training School sewage treatment plants on the South Branch Flint River about 10 miles from its confluence with the Flint. In the 20 miles of stream from the confluence point to Flint is the 15,350 acre-feet Holloway Reservoir.

There was a moderate increase in the pollutional level of the Flint River passing through the City of Flint. There are three direct industrial sources on the river, five industrial, and two municipal sources on the tributaries - Kearsley Creek, Thread River, and Swartz Creek, which join the Flint River in the City of Flint. The chloride level

tripled, and the phosphates increased from 0.08 to 1.70 mg/l - a twenty-fold increase. There was a minor decrease in dissolved oxygen level.

Below the Flint sewage treatment plant outfall, at a location above the City of Flushing sewage treatment plant, there were excessive increases in most pollution indicies. Chlorides increased to 100 mg/l and remained at this level downstream. Nitrates increased to 2.8 mg/l as nitrogen. The total phosphate concentration in the river increased to 11.8 mg/l and remained at this level for the remainder of the stream. The oxidizable nitrogen concentration increased to 2.5 mg/l as nitrogen, and accounted for severe oxygen depletion found in the river at this point. Both the BOD and COD (chemical oxygen demand) increased to moderate levels of pollution and continued to increase downstream. Bacterial levels indicated only moderately polluted waters. Brent Run, a tributary which joins the Flint River at Montrose, and which receives the effluent from the Ternstedt Division, General Motors Corporation, had high levels of chlorides, dissolved solids, and conductivity. Both nitrogen and phosphate concentrations in this stream were high, although BOD and COD levels were low. The dissolved oxygen level was at saturation.

There was considerable diurnal variation in dissolved oxygen at all stations. Maximum variation (10 mg/l) was found in the recovery area near Montrose. Average daily concentration at this location and at all downstream locations was above saturation. Minimum observed dissolved oxygen - 0.8 mg/l - was just above the Flushing sewage treatment plant outfall. Average daily concentration at this location was at 3.5 mg/l. The dissolved oxygen sag from above the City of Flint to this location showed an average reduction of 5 mg/l in the stream.

The City of Flint presently (1965) accounts for in excess of 90 percent of the waste flows in the basin. Present removal efficiency is in excess of 90 percent for this plant in terms of 5-day BOD loadings. The City of Flint currently obtains its water supply from the Flint River with return via the Flint sewage treatment plant. During the seven day once-in-ten-year low flow, about 88 percent of the river flow yield below Flint would have passed through the sewage treatment plant unless excess water was released from storage. This area is expected to have a tie-in to the Lake Huron water supply under construction by the City of Detroit. With water supply from Lake Huron, the storage now available in Holloway Reservoir could sustain a flow of 100 cfs in excess of sewage treatment plant flows during drought years.

The present high ratio of sewage treatment plant flow to natural river flow results in high concentrations of nutrients - 10 mg/l of total phosphates and 3 mg/l of nitrate-nitrogen were found during the 1965 survey, which had an average flow of 75 cfs - about 1-1/2 times the 7 day once-in-ten-year flow. The concentrations remained at about the same level throughout the stream to its junction in the Shiawassee Flats area. The effect of these nutrients in the Flint River was readily apparent in both the physical observations of algae and in the supersaturated dissolved oxygen levels caused by photosynthesis. The sewage treatment plant phosphate level of about 30 mg/l represents approximately 50 percent removal. The Flint area discharges increased the phosphate level by about 140 times during the 1965 survey. Phosphate removal of 95 percent (3 mg/l effluent) would have resulted in a river concentration of 1.7 mg/l during the 1965 survey.

The principal quality demanding uses of water in the Flint River Basin are municipal and industrial water supply, aquatic life, recreation and aesthetics.

The use of the Flint River as a source of water for industrial and municipal use is expected to decrease considerably with the completion of the Lake Huron-Flint Project of the Detroit Water Services. A prime consideration for quality objectives is the impact of the Flint River on the Saginaw River. The Flint River, with approximately 24 percent of the flow, contributes about 50 percent of the phosphate loadings to the Saginaw River. The removal of nutrients and organic materials is desirable also to prevent the severe algal blooms which currently degrade even the aesthetic quality of the Flint River below Flint.

Table 18. Water Quality

FLINT RIVER
1965

Parameters	X295 Farmer's Creek				X260 above Flint				X 296 Swartz Creek			
	NS	Avg	Low	High	NS	Avg	Low	High	NS	Avg	Low	High
Dissolved Oxygen	0	-	-	-	12	10.6	6.4	13.2	0	-	-	-
5-day BOD	0	-	-	-	7	5	3	8	0	-	-	-
NH_3-N	4	0.26	0.13	0.33	14	0.59	0.23	2.65	3	0.25	0.17	0.35
Org-N	3	0.12	0.07	0.18	14	0.26	0.10	0.70	3	0.12	0.08	0.16
NO_3-N	5	0.2	0.1	0.4	14	0.8	0.2	1.6	5	0.1	0.1	0.2
NO_2-N	4	0.03	>0.01	0.04	10	0.02	0.01	0.03	4	0.02	0.00	> 0.03
Total PO_4	5	0.3	0.2	0.5	14	-	<0.04	0.60	5	-	<0.04	0.30
Total Sol. PO_4	5	0.3	0.2	0.3	14	-	<0.04	0.40	5	-	<0.04	0.10
Total Solids	4	424	334	481	14	394	314	508	4	399	280	675
Suspended Solids	5	10	1	17	14	20	4	44	5	12	3	29
Vol. Susp. Solids	2	5	0	9	13	5	1	12	2	4	0	7
Cl^-	5	43	24	67	16	28	13	63	5	9	3	11
Phenol	0	-	-	-	15	4	0	9	0	-	-	-
pH	5	8.1	7.7	8.4	16	7.9	7.6	8.5	5	7.9	7.4	8.4

Table 18. Water Quality (cont'd) FLINT RIVER 1965

Parameters	X 295 Farmer's Creek				X260 above Flint				X296 Swartz Creek			
	NS	Avg	Low	High	NS	Avg	Low	High	NS	Avg	Low	High
Total Iron	1	100	-	-	14	1400	100	3600	1	200	-	-
Sodium	2	32	19	44	12	26	4	100	2	9	8	9
Potassium	2	9	6	11	12	8	2	16	2	4	3	4
Calcium	2	72	70	73	14	65	58	77	2	54	46	62
Magnesium	3	28	20	33	14	26	15	40	3	21	15	26
Sulfate	4	50	40	70	14	80	50	120	4	37	<10	66
Total Hardness	0	-	-	-	15	253	190	326	0	-	-	-
Conductivity	5	650	560	740	17	520	330	730	5	420	350	480
Total Coliform	0	-	-	-	15	1,500	360	18,000	0	-	-	-
Fecal Coliform	0	-	-	-	13	220	60	1,700	0	-	-	-
Fecal Strep	0	-	-	-	13	<100	12	>1,500	0	-	-	-

Table 18. Water Quality (cont'd)

FLINT RIVER
1965

Parameters	X250 at Flushing				X240 at Montrose							
	NS	Avg	Low	High	NS	Avg	Low	High	NS	Avg	Low	High
Dissolved Oxygen	6	4.2	1.8	9.2	12	9.7	5.2	12.9				
5-day BOD	6	10	7	15	7	6	3	11				
NH_3-N	5	4.70	3.50	6.20	14	1.15	0.17	3.38				
Org-N	5	0.55	0.35	0.96	14	0.26	0.10	0.50				
NO_3-N	6	1.9	0.8	3.4	14	1.9	0.7	4.6				
NO_2-N	1	0.29	-	-	10	0.06	0.017	0.29				
Total PO_4	6	9.7	5.9	15.2	14	4.1	0.5	12.8				
Total Sol. PO_4	6	7.4	4.8	12.8	14	3.2	0.1	8.8				
Total Solids	6	530	470	582	14	505	358	771				
Suspended Solids	6	11	0	19	14	27	2	122				
Vol. Susp. Solids	6	7	0	12	13	8	1	32				
Cl^-	6	101	92	112	16	83	28	252				
Phenol	6	6	1	9	15	6	0	15				
pH	6	7.4	7.0	7.6	16	7.8	7.4	8.4				

Table 18. Water Quality (cont'd)

FLINT RIVER
1965

Parameters	X250 at Flushing				X240 at Montrose							
	NS	Avg	Low	High	NS	Avg	Low	High	NS	Avg	Low	High
Total Iron	3	-	<100	200	14	-	<100	8300				
Sodium	5	-	6	>100	13	62	12	248				
Potassium	5	16	2	22	13	15	3	39				
Calcium	6	58	51	66	14	62	45	74				
Magnesium	6	17	12	25	14	23	14	45				
Sulfate	6	89	60	110	14	89	49	132				
Total Hardness	6	226	210	268	14	239	176	320				
Conductivity	6	810	740	900	17	700	430	1160				
Total Coliform	3	310,000	17,000	680,000	15	49,000	400	370,000				
Fecal Coliform	3	88,000	3,200	130,000	13	5,300	10	30,000				
Fecal Strep	3	4,200	490	8,300	13	450	10	3,500				

NOTES
for
WATER QUALITY TABLES

NS .... Number of samples

Chemical Parameters

Cl	Chloride	Mg	Magnesium
Fe	Iron	Na	Sodium
SO_4	Sulfate	K	Potassium
Si	Silica	CO_3	Carbonate
Ca	Calcium	HCO_3	Bicarbonate

Total hardness: reported as $CaCO_3$

Nitrogens: ammonia (NH_3), organic, nitrates (NO_3), and nitrites (NO_2) reported as nitrogen equivalent (N)

Phosphates: reported as PO_4

Total phosphates include: ortho, poly, biological, and organic

Total soluble phosphates include: soluble ortho, soluble poly, and soluble organic

pH: reported in standard units

All results recorded in milligrams per liter (mg/l) except:

phenols and iron .... micrograms per liter (ug/l)

conductivity .... micromhos per centimeter (umhos/cm)

Microbiological Parameters

Total Coliform)
Fecal Coliform) reported as organisms(MF)/100 ml
Fecal Streptococcus)

Total Plate Count: number of bacteria/ml

Median value is used for "average" statistic except as noted.

Indeterminate values (less than $<$ or greater than $>$) not used in calculating average