LAKE MICHIGAN STUDIES

Special Report Number LM1

TRENDS IN WATER QUALITY-SOUTHERN BASIN

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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Great Lakes - Illinois River Basins Project

FOREWORD

Special Report Number LM1 is the first in a new series of reports to the Justice Department made by the Great Lakes-Illinois River Basins Project. It deals with long term trends in water quality in Lake Michigan, with particular reference to the Southern Basin. Other aspects of water quality of the lake will be incorporated into a new series of reports which has been recently scheduled. Collectively, these reports will present the results of investigations to date by the Project.

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INTRODUCTION

A proposal has been made to return to Lake Michigan, 750 cubic feet per second (cfs) of treated effluent from the treatment plants of the Metropolitan Sanitary District of Greater Chicago (MSD), 40% of the present average total MSD effluent. The effluent would be introduced through a diffusor into the lake at a point located approximately six miles offshore, as shown in Figure 1.

The effects on lake water chemical quality of returning sewage treatment plant effluent to the lake must be measured in terms of the concentration of various substances at some future time. If the mean concentration of a particular substance is higher in the tributary inflow than in the lake water into which it is discharged, there will be an increase in the concentration of that substance in the lake water. Therefore, the questions which must be answered are these:

1. What substances are present in the MSD plant effluents which would, in sufficient concentrations, be detrimental to the quality of the lake water?

2. What are the maximum permissible or desirable concentrations of these substances?

3. Is it possible that these critical levels will be equalled or exceeded if 750 cfs of MSD effluent are returned to the lake? If so, how long would it take to reach the critical level? If not, what would be the maximum (equilibrium) concentration?

The general approach to answering the questions which have been presented was to find the rate of buildup of each substance, then to find the equilibrium concentration of this substance and/or the time to reach critical levels. The answers given herein should be interpreted in the light of the assumptions made. These assumptions and limitations will be discussed as each chemical constituent is considered.

ELEMENTS OF THE PROBLEM

The Water Balance of Lake Michigan

At first sight, it would appear that Lake Michigan is similar to an oversized tub, with a convenient passage at the upper end which allows ships to ply between Lake Huron and Lake Michigan. However, the apparent similarity is far from true. There are currents in the lake which mix the water and transport water from one part of the lake to another. Even if Lake Michigan had no outlet, currents would exist because of winds, variations in temperature and other forces. Moreover, there is a sizeable average outflow from the lake, partly into Lake Huron through the Straits of Mackinac, and partly into the Illinois River Basin as a result of Chicago's water supply withdrawals and diversion at Chicago. This outflow occurs because the recharge by inflow from tributary streams plus the precipitation on the surface of Lake Michigan exceeds the evaporation from the lake surface. Since the volume of water in the lake is essentially constant over a period of years, instead of rising as a result of an excess of inflow over outflow, there must be a net outward flow from the lake.

At times, there may be reversals of flow, from Lake Huron into Lake Michigan, but this condition is temporary. Over a year's time, the net flow is out of Lake Michigan. The average outflow from the entire lake is about 43,000 cfs. This figure was computed from: streamflow records of the U. S. Geological Survey, which cover about 70% of the tributary land area; precipitation records of the U. S. Lake Survey; and the U. S. Weather Bureau Evaporation Maps of the United States. (1) Estimates of the flow from the ungaged tributary land area were made by comparison with nearby gaged tributaries.

While the estimated outflow of 43,000 cfs is subject to errors in the basic data, the errors in streamflow measurement are less than plus or minus 10% and an error of 1 inch in the difference between annual precipitation and evaporation is equivalent to an error of 1,650 cfs, less than 4% of the total outflow. It is therefore concluded that, for the purposes of this study, this estimate is sufficiently accurate.

There is a ridge in the bottom of Lake Michigan running in an east-west direction between Milwaukee, Wisconsin and Grand Haven, Michigan. The location of this ridge is shown in Figure 2 and will be called henceforth the line of separation. This ridge,

or sill, separates the Lake into two basins, a northern basin and a southern basin, with a comparatively shallow connecting passage. Most of the population and industries around Lake Michigan are concentrated around the southern basin. Besides any mixing which results from lake currents and diffusion, there is a net flow of 7,700 cfs out of the southern basin. Diversion and water supply withdrawals at Chicago account for about 3,300 cfs. The remainder, 4,400 cfs, flows across the sill into the northern basin and ultimately into Lake Huron through the Straits of Mackinac. These figures were derived in the same manner as the comparable figures for the entire lake.

Since there is a net outflow from the southern basin, and in turn from Lake Michigan, dissolved chemicals are perenially removed from the southern basin and the entire lake by the outflowing water. The most conservative approach to studying buildup of chemicals is to consider only the southern basin. If the average concentration of a particular chemical would not build up to critical levels in the southern basin, then it would not become critical for the lake as a whole. This is because the sources of detrimental substances are predominantly tributary to the southern basin.

If the calculations indicate that the concentration of a chemical would reach critical levels in a certain number of years, this time would be the shortest period of time required. Any interchange of water between the northern basin and the southern basin caused by currents, diffusion, or advection would increase the time required to reach critical levels. It is emphasized at this point that the foregoing statements assume complete mixing of the water in the southern basin. It is not necessary that complete mixing occur every day or even every month, but it is necessary over a year's duration that there be complete mixing. This assumption will be discussed more thoroughly as each chemical in turn is considered. Throughout the remainder of this report, only the southern basin will be considered.

In localized areas of the southern basin, concentrations of particular chemicals may be higher than those indicated by the succeeding computations. An evaluation of these localized effects is not presented herein; particular local effects will be considered in subsequent reports.

Waste Loads

Substances Considered

The answer to question No. 1: which substances are likely to be detrimental to lake water quality, is perhaps open to some

debate, but the principal substances seem to be dissolved solids, chlorides, synthetic detergent residue (ABS), the nutrients, nitrogen and phosphorus, and complex organic chemicals as measured by carbon chloroform extracts (CCE).

Wastes Added

At present, all of the substances under consideration are being discharged into the southern basin of Lake Michigan. Natural runoff from rural land is the oldest source of waste loads. Domestic wastes constitute a large source of detrimental substances. The population in the area tributary to the southern basin is approximately 2,300,000 (exclusive of Chicago), and the BOD population equivalent is 790,000. The third major source of additives to the lake is industrial waste.

Under the hypothesis that 750 cfs of MSD effluent would be returned to the lake, this effluent would be the fourth major source of detrimental substances.

The quantities of each substance considered which would be present in the 750 cfs of MSD effluent are shown in Table 1. These quantities are the average loads based on data in Chapter VIII, "Water Quality Conditions, report on the Illinois River System, January, 1963.

The contributions of each substance from domestic waste sources other than MSD were computed by ratio to the loads of the Metropolitan Sanitary District of Greater Chicago. The amounts of dissolved solids, chlorides, nitrogen, and phosphorus were found by the BOD population-equivalent ratio. Synthetic detergent residue (ABS), is almost entirely a function of population. Therefore, the contribution of ABS was found by the population ratio.

The contribution of complex organic chemicals (CCE) is not directly related to either population or population equivalent. Therefore, the total amount of CCE which could be accommodated without exceeding the acceptable critical level of concentration was computed.

Wastes Removed

As mentioned in the discussion of the water balance, a certain quantity of each substance is carried out of the southern basin each year with the outflow. This rate of loss is equal to the amount of water which flows out multiplied by the concentration of each substance at the time of outflow.

Rates of Buildup

Buildup in concentration within the basin does not take place at a constant rate. The rate of buildup equals the rate of input minus the rate of removal. The contribution of waste loads from two principal sources, natural runoff and 750 cfs of MSD effluent, will remain substantially the same in the future - assuming of course, no major changes in the concentrations of the various substances in the effluent. There will be increases in waste loads from other domestic and industrial sources in the areas tributary to the southern basin as growth occurs. The rate of removal of a substance is continually increasing as its concentration in the lake water increases. Thus the difference between rate of input and rate of removal is continually decreasing. Therefore the concentrations of detrimental substances would increase most rapidly at the time when MSD effluent was first introduced into the lake. As the concentration in the lake water approaches the mean concentration of the total inflow to the lake, the rate of buildup would approach zero.

Equilibrium Conditions

For a constant rate of input, an equilibrium or steady-state condition is approached as the rate of removal approaches equality with the rate of input. Thus, equilibrium marks the limit beyond which the average concentration in the basin will not build up. The magnitude of this steady-state concentration for a given substance is equal to the total annual input of the substance divided by the net annual volume of water outflow.

BUILDUP OF DETRIMENTAL SUBSTANCES

Dissolved Solids

The present concentration of dissolved solids in Lake Michigan is about 155 mg/l. Over the past one hundred years, there has been a continual buildup in the concentration of dissolved solids in Lake Michigan. The chemical analyses were made at different places by different people. Most of the analyses were of samples taken near the shores. There is some scatter of points which is at least partly caused by these factors. Despite this scatter, the upward trend is unmistakable and a linear approximation of the trend indicates that its magnitude is about 0.29 mg/l per year (2). This is of course due to the present discharge of dissolved solids from natural runoff, domestic sewage and industrial wastes. If the rate of input is found by adding the rate of removal to the rate of buildup, it is found that the weighted mean concentration of dissolved solids from all sources is 208 mg/l. By estimating the quantity of dissolved solids from sources other than natural runoff on the basis

of ratio of discharged BOD population-equivalent to the MSD discharged BOD population-equivalent, it is found that 5.45×10^{14} mg/yr (600,000 tons/yr) are discharged from sources other than natural runoff. The average concentration of dissolved solids in natural runoff is then computed to be 175 mg/l.

Considering all sources of dissolved solids, including 750 cfs of MSD effluent, the equilibrium concentration would be 285 mg/l.

The USPHS Drinking Water Standards (3) set an upper limit of 500 mg/l for total dissolved solids. This is the critical level which is used as a basis for comparison with the equilibrium concentration of 285 mg/l. Since the equilibrium concentration is below the critical level, it is concluded that this concentration of dissolved solids is within permissible limits of quality.

Chlorides

The present concentration of chlorides in Lake Michigan is about 8 mg/l. The annual rate of buildup is about 0.04 mg/l (2). The present discharge of chlorides into the southern basin was found by adding the rate of removal to the rate of buildup. The amount of input from all sources is about 9.3×10^{12} mg/yr (103,000 tons/yr). This is an average concentration of 14 mg/l in the tributary inflow.

The addition of the MSD contribution to all present sources would result in an equilibrium concentration of about 15 mg/l, only slightly greater than the equilibrium concentration without an MSD contribution. It is noted that the assumption of complete mixing is especially applicable to chlorides.

The USPHS Drinking Water Standards set an upper permissible limit of 250 mg/l for chlorides. It will be seen that the estimated maximum buildup of 15 mg/l is well within this limit. It is pointed out, however, that some industrial processes require water having a much lower chloride content. Furthermore, the PHS standard is nationwide and was set with due consideration for the practicability of obtaining high-quality water in some areas; the spread between expected and tolerable values should not be regarded as an unrestrained license to pollute on the part of any waste producer.

Synthetic Detergent Residue (ABS)

Synthetic detergents have been in use for only a short time. There are no measurements of buildup of the residue, ABS, in the lake water. The quantities of ABS discharged into the southern basin are considered to be entirely a function of the population

which is tributary to the southern basin. ABS is not significantly modified in the sewage treatment process.

The equilibrium concentration considering all sources tributary to the southern basin plus the MSD contribution is 0.585 mg/l. The equilibrium concentrations considering all sources except an MSD contribution is 0.32 mg/l.

The USPHS Drinking Water Standards recommend an upper limit of 0.5 mg/l for ABS concentration. This will be accepted as the critical level for ABS concentration in the lake water.

Comparison of the equilibrium concentrations with the critical level shows that the MSD contribution in addition to the contribution from all other sources would cause the critical level to be exceeded, whereas without the MSD contribution, the critical level would not be reached. A further computation shows that the critical level of 0.5 mg/l would be reached in 350 years at present rates of ABS contribution from all sources including MSD.

These computations must be viewed with some qualifications. The assumption of continuing present rates of ABS contribution may be in error in either direction. If detergent products which can be readily broken down by sewage treatment processes become more generally used, or if treatment processes which will economically reduce the amount of ABS in domestic sewage are developed and generally used, the assumption of present contribution rates errs on the high side. If neither new detergent products nor effective treatment processes come into use, the population increase would be expected to bring about an increase in ABS contribution, and the assumption of present contribution rates would err on the low side. A further important qualifying factor is the fact that ABS does undergo some slow-rate deterioration, even though the computations assumed none.

The small difference between the equilibrium concentration considering all sources and the critical level; the remoteness in time of reaching the critical level; the possibility of technological advancement; and the fact that deterioration occurs; all lead to the conclusion that ABS would not consititute a critical water quality problem in the southern basin if there were a return of MSD effluent to Lake Michigan.

Nitrogen and Phosphorus

Nitrogen and phosphorus are nutrients required by chlorophyll-bearing plants. Although other elements are required in measurable amounts, and certain minerals are required in trace amounts, nitrogen and phosphorus are the more important nutrients that limit planktonic algae growth. Phosphorus is not abundant in natural waters until those waters have received many years of soil runoff and domestic and industrial waste discharges. The levels of nitrogen and phosphorus in a natural lake depend on: the age of the lake; the fertility and types of soils in its drainage basin, and consequent transport of nutrients to the lake; the volume of water in the lake; the outflow of water from the lake; the amount lost by bottom deposition; and, after human habitation in the drainage basin, the amounts contributed by domestic sewage and industrial wastes.

In the early years of a lake only enough nutritive material is supplied to support sparse populations of planktonic algae. These scattered algae afford scant food for the minute animals that feed on them, and each element of the remainder of the food chain is accordingly limited in population growth. The lake is considered biologically unproductive at this early stage.

As nutrients from the land inexorably move into the water, a gradual increase in nutrient concentration is manifested in an increasingly more fertile and biologically productive lake. Lake nutrients from human populations increase at rates proportional to the human population growth. For all practical considerations, the nutrients in the lake do not return to the land mass. Except for those amounts transported by water movement to the sea, and except for that portion lost as insoluble compounds and buried by each year's deposition of dead organisms or inert silt, the nutrients remaining and those being added produce progressively larger standing crops of aquatic plants and animals.

At some stage in the life history of the lake, nutrient concentrations reach a level where the addition of more nutrients produces "blooms" of algae and the water becomes murky. In the beginning the blooms are not particularly dense, but the transparency of the water is reduced and the rooted aquatic weeds are inhibited by diminished light. Dense blooms follow and the algal population changes to the blue-green types that cause noisome odors, and appear as unsightly scums on the surface and windrows on the beaches. Some of these blue-green algae have been implicated in swimmer's itch, eye and ear infections, and deaths of livestock. (4)

The events preceding the dense algae blooms also include subtle changes in the fish populations from the trout and whitefish varieties to the coarser carp and catfish populations. Dissolved oxygen during periods of high algae production levels is reduced in the hypoliminion, and after further aging of lake, becomes depleted. The uses of the water so described become seriously limited and the appearance and odors so unsightly as to cause property values to diminish greatly.

Further manifestations of lake fertilization could be made, but at the present time these conditions do not generally occur in Lake Michigan. It is more important to evaluate the present nutrient concentrations in Lake Michigan, and, from these data and from the classical examples of induced eutrophication throughout the world, to infer the probable effects of additional nutrient input from MSD effluent, on the biological productivity of the lake. (Eutrophication is the process of becoming rich in dissolved nutrients and consequent increased biological productivity.)

The concentrations at which nitrogen and phosphorus become critical are generally accepted as 0.3 mg/l and 0.01 mg/l, respectively, all other conditions being favorable for the growth of algae. Other investigators report different concentrations for certain species or groups of algae. Many of these data are for laboratory situations and none of them is in great disagreement with the figures suggested by Sawyer (5). Therefore, the 0.3 mg/l and 0.01 mg/l values for N and P, respectively, are accepted as critical levels that should not be exceeded in Lake Michigan.

Three sets of computations were made for the nutrients: considering MSD effluent as the sole nutrient source; considering other sources alone; and considering MSD effluent plus other sources.

Considering MSD effluent as the only contribution to the lake and disregarding the present concentrations of nutrients, the equilibrium concentrations of nitrogen and phosphorus are 0.99 mg/l and 0.12 mg/l, respectively. The times required to build up to critical levels are 62 years and 15 years, respectively.

Nitrogen and phosphorus are supplied from soil runoff, domestic sewage, and certain industrial wastes. The contributions from rural runoff vary widely from one agricultural area to another; and the concentrations of these nutrients fluctuate with the weather and farming operations. Concentrations of phosphate phosphorus have

ranged from 0.1 mg/l to 0.4 mg/l in a typical Illinois farming region and from 0.00 mg/l to 0.023 mg/l in forested drainage basins (6,7). However, the overall rural contribution from tributary streams is indeterminate and was therefore disregarded in the computations. The quantities of nitrogen and phosphorus contributed by municipal and industrial sources other than the MSD effluent were estimated by the ratio of the discharged BOD population-equivalent of other sources to that of MSD.

The equilibrium concentrations resulting from present sources of nitrogen and phosphorus alone are 2.5 mg/l and 0.31 mg/l, respectively. The times required to build up to critical levels are 24 years and 5.2 years, respectively.

Considering present sources plus the MSD contribution, the equilibrium concentrations of nitrogen and phosphorus are 3.8 mg/l and 0.47 mg/l, respectively. The times required to build up to critical levels are 15 years and 3.7 years, respectively.

It appears from the foregoing that Lake Michigan should already have concentrations in excess of the critical levels, since there has been a large contribution of nutrients for many years. Further, the contributions of nutrients from rural runoff have not been included in the computations.

The question must be asked: "Does the mathematical model apply to the nutrients?" There is substantial evidence that a considerable fraction of the nutrients is lost permanently to the bottom sediments (8). Sylvester (7) repoerts that "55% of the phosphorus was lost to the sediment (permanently) through deposition of algae and particulate matter, and through the thousands of fish taken from the lake by fishermen." These statements were made about Green Lake in the City of Seattle, Washington. It is assumed that similar processes take place, to a greater or lesser degree, in Lake Michigan, thereby slowing the buildup of nutrients, and possibly explaining why manifestations of critical levels have not been common. Furthermore, preliminary data from the 1962 biological studies made by the Great Lakes-Illinois River Basins Project staff indicate that there is a plankton buildup on all shoreline areas. At the same time, there is a noticeable paucity of plankton in the center of the lake. Therefore, the assumption of complete mixing is not strictly applicable for these two reasons: nutrients are not completely retained in the water mass and the distribution in the water mass is not uniform.

However, critical levels of phosphorus and nitrogen may have been approached already in Lake Michigan. Preliminary results from GLIRBP investigations in 1962 indicate levels for phosphorus from 0.00 up to in excess of 0.01 mg/1 in certain lake areas. Data from the Indiana Water Quality Reports for Michigan City show an average for 1960 and 1961 of 0.3 mg/1 of nitrate nitrogen and a range of 0.0 to 2.4 mg/1 (9).

It is therefore concluded that nitrogen and phosphorus are accumulating at rates which indicate that Lake Michigan is not many years away from nutrient levels that can promote widespread nuisance conditions. These conditions can be reached near shore even if the overall lake concentrations of nutrients are less than critical levels. The possibility of organic overenrichment of Lake Michigan is one of the greatest imminent dangers in returning MSD effluent to the lake. It is apparent that if any of the substances considered in this report are going to reach critical levels, the nutrients will be those substances.

Complex Organic Chemicals

The complex organic chemicals which are measured and known as the carbon chloroform extracts (CCE), are not significantly degraded in ordinary sewage treatment processes. Industrial waste discharges are the principal contributors of these chemicals. Because the quantities of these chemicals bear no direct relation to either population or BOD population equivalent, measurement of the actual quantities discharged is necessary to estimate the total contribution. Pending such measurements, the quantity of CCE which would be required to produce an equilibrium concentration equal to the critical level has been computed.

Knowledge of the effects of CCE is meager, particularly regarding the long term chronic effects. Taste and odor problems as well as interference in water treatment are effects which have already been noticed. A level of 0.2 mg/1 has been recommended as the upper limit for this factor of water quality and is accepted herein as the critical concentration level.

Past data concerning CCE levels are non-existent, except for the work recently undertaken by the National Water Quality Network. This source reveals that the average CCE at Milwaukee has been 0.032 mg/1 during the total period of record October, 1960 through August

1962 and 0.036 mg/l at Gary, Indiana for the total period of record October, 1958 through August, 1962. National Water Quality Network data are available from Peoria, downstream from the discharges of the MSD plants. For the published sampling periods, February through December, 1961, the average concentration was 0.118 mg/l and the average flow was 14800 cfs. Deducting the amount of CCE contained in the water which comes out of Lake Michigan and goes into the Illinois River, assuming that Lake Michigan water has a concentration of 0.035 mg/l, the Chicago area contribution amounts to 4.4 tons/day or 14.56 x 10" mg/year. This would result in a load of 5.75 X 10^{11} mg/year discharged into Lake Michigan if 750 cfs were returned to the lake. The equilibrium concentration considering only this source would be about 0.084 mg/l. From all sources, 2.4 times this amount would be required before the equilibrium concentration would reach the critical level of 0.2 mg/l. It is not deemed desirable, in view of the limited knowledge, to consider that there is any deterioration of CCE.

SUMMARY AND CONCLUSIONS

The long-term increase in concentration of substances which are potentially detrimental to the water quality of Lake Michigan, and more specifically the southern basin of Lake Michigan, has been considered. The effects of flow of water out of Lake Michigan have been included as well as the effects of contributions of waste loads from sources which are now tributary to the southern basin. Table 2 summarizes the computations of chemical buildup. The principal question answered in this report is the effect of discharging 750 cfs of treated effluent from the Metropolitan Sanitary District of Greater Chicago.

It is concluded that the additional increase in the concentration of dissolved solids, chlorides, and synthetic detergent residue (ABS) brought about by the discharge of 750 cfs of MSD effluent into Lake Michigan would not cause the ultimate concentrations to reach critical levels.

Nitrogen and phosphorus are accumulating at rates which indicate that Lake Michigan is not many years away from nutrient levels that can promote widespread nuisance conditions. These conditions can be reached near shore even though the lake-wide average concentrations are less than critical levels. The possibility of organic overenrichment of Lake Michigan is one of the greatest imminent dangers in returning MSD effluent to the lake. It is apparent that if any of the substances considered in this report are going to reach critical levels, the nutrients will be those substances.

The complex organic chemicals, known as carbon chloroform extract, could reach critical concentrations in the lake water if at least 1.4 times the MSD contribution were introduced into the lake in addition to the MSD contribution.

It is appropriate at this point to note a significant difference between the use of a flowing stream and Lake Michigan as the receiver of waste residues. If wastes of unknown effect are discharged to a flowing stream, and corrective action resulting from better knowledge is subsequently taken, the stream will restore itself by flushing action in a short time. Conversely, when a large reservoir--or, be it noted, an underground aquifer---becomes permeated throughout by a pollutant, it may require many years for restoration, <u>even after the source of pollution is removed</u>. For this reason, first preference should be given to the use of a flowing stream to assimilate and transport waste products, whenever a choice is possible.

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Table 1 - Waste Loads in 750 cfs of MSD Effluent

Substance	Annual Waste Load	
	Tons	Milligrams
Dissolved Solids (net)	489,000	4.44×10^{14}
Chlorides (net)	6,610	6.0×10^{12}
ABS	1,900	1.72×10^{12}
Nitrogan (as N)	7,460	6.77×10^{12}
Phosphorus (as P)	918	8.32×10^{11}
Carbon Chloroform Extract	1,600	5.75×10^{11}

Table 2

Buildup of Chemical Factors in the Southern Basin of Lake Michigan

The following substances will not build up to critical levels.

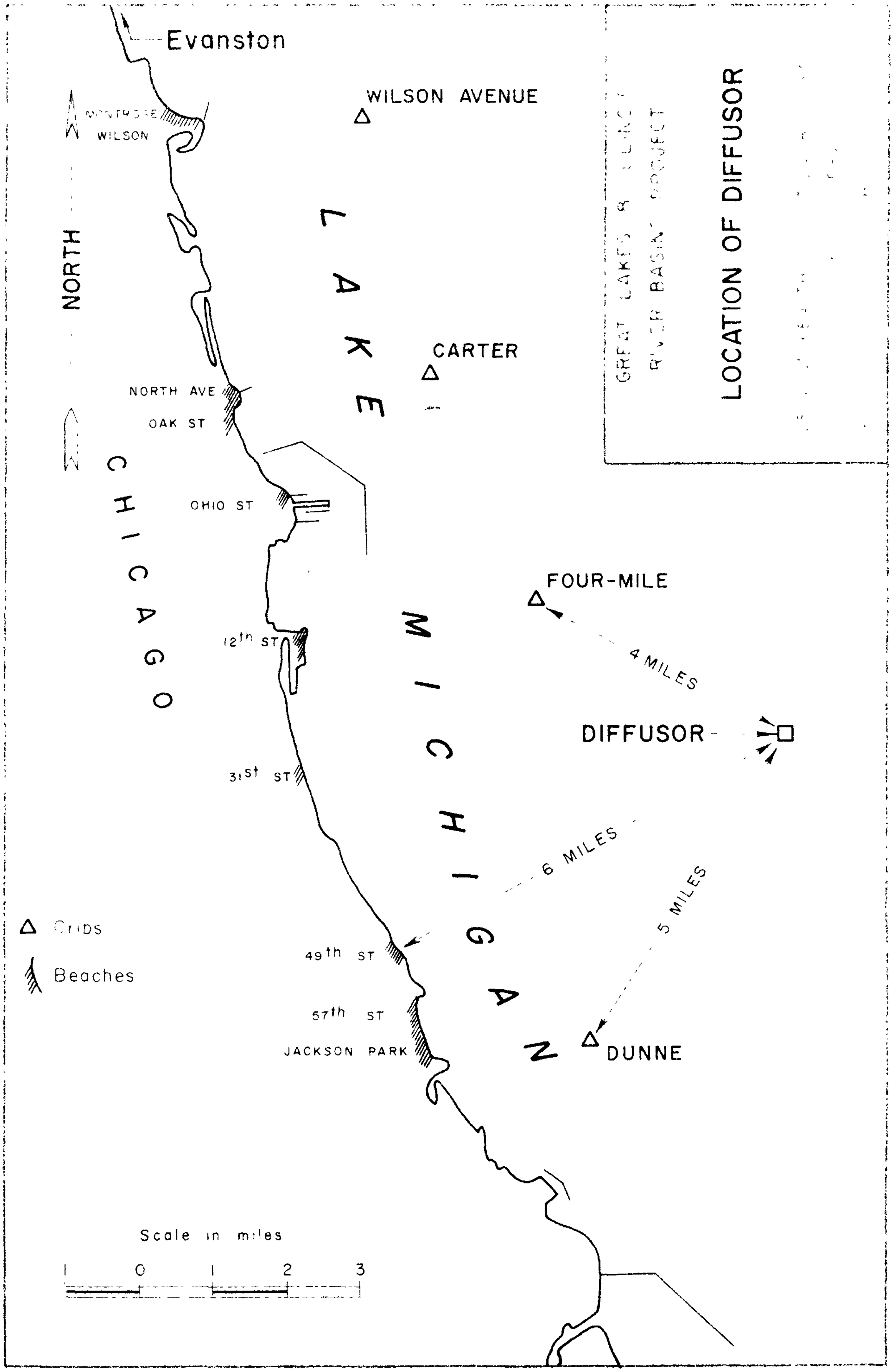
Chemical Constituent	Present Concentration	Present Annual Rate of Increase	Water Quality Objective (Critical Levels)	Equilibrium Concentration All Sources
Dissolved Solids	155 mg/l	0.29 mg/l	500 mg/l	285 mg/l
Chlorides	8 mg/l	0.04 mg/l	250 mg/l	15 mg/l
ABS	-	-	0.5 mg/l	0.585 mg/l*

*Computation assumes present contribution rates and no deterioration of ABS.

The following substances may build up to critical levels. See text for qualifying discussion.

			Equilibrium Concentrations (Time required to reach Critical Level)		
Chemical Constituent	Concentration Present in Lake	Water Quality Objective (Critical Levels)	MSD alone	Other sources alone	MSD plus other sources
Nitrogen (as N)	0-2.4 mg/l (See Text,p.11)	0.3 mg/l	0.99 mg/l (62 yrs.)	2.5 mg/l (24 yrs.)	3.8 mg/l*** (15 yrs.)
Phosphorus (as P)	0-0.01+ mg/l (See Tex,p.11)	0.01 mg/l	0.12 mg/l (15 yrs.)	0.31 mg/l (5.2 yrs.)	0.47 mg/l*** (3.7 yrs.)
Carbon Chloroform Extract	0.035 mg/l	0.2 mg/l	0.084 mg/l*	**	**

*Will not reach critical level.
**At least 1.4 times the MSD contribution must be added from other sources to reach critical levels at equilibrium concentration.
***Exclusive of land-runoff sources.


LOCATION OF DIFFUSOR
Evanston
WILSON AVENUE
MONTROSE
WILSON
NORTH
LAKE
MICHIGAN
CARTER
NORTH AVE
OAK ST
CHICAGO
OHIO ST
FOUR-MILE
4 MILES
12th ST
DIFFUSOR
31st ST
6 MILES
5 MILES
49th ST
57th ST
JACKSON PARK
DUNNE
Beaches
Scale in miles
1 0 1 2 3