AIR POLLUTANT EMISSION INVENTORY OF NORTHWEST INDIANA

A PRELIMINARY SURVEY

1966

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

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by

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CONDUCTED FOR NORTHWEST INDIANA
AIR RESOURCE MANAGEMENT PROGRAM

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Bureau of Disease Prevention and Environmental Control
Durham, North Carolina

April 1968

National Center for Air Pollution Control Publication APTD-68-4

FOREWORD

The Northwest Indiana Air Resource Management Program is a cooperative effort initiated in March, 1965, by the cities of Gary and East Chicago, the State of Indiana, and the U. S. Public Health Service. The primary purpose of this program is to assist and strengthen local agencies in developing and implementing an area-wide air resource management plan. This study was prepared at the request of the Program Executive Committee. Its purpose is threefold: (1) to provide a preliminary but comprehensive inventory of the air pollutant emissions from the entire area; (2) to help initiate the air resource management programs in Hammond and Whiting, Indiana; and (3) to provide guidelines for future, more detailed surveys, similar to those presently conducted by the cities of Gary and East Chicago.

This report is the result of a joint effort by the air pollution control agencies and health departments of East Chicago, Gary, Hammond, Whiting, and the National Center for Air Pollution Control. As in all emission surveys, the data presented here are estimates and should not be interpreted as actual values. They are, however, of sufficient accuracy and validity to allow their use in developing and improving an air resource management program.

ABSTRACT

Sources of air pollutant emissions were surveyed to quantify the total pollution load emitted to the air over the Northwest Indiana communities of East Chicago, Gary, Hammond, and Whiting. The emissions are reported on an annual basis and subdivided into the five major pollutants: particulates, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide. The four major source categories that were utilized in reporting emissions from area and point sources are: fuel combustion in stationary sources, fuel combustion in mobile sources, combustion of refuse, and industrial process losses. The results of this survey are reported by city and illustrated on the grid system established by the Northwest Indiana Air Resource Management Program.

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INTRODUCTION

This report presents the results of a rapid emissions inventory of air pollutant sources in Northwest Indiana. The objectives of this study are to determine the total quantities of the various air pollutants emitted and to estimate, as accurately as possible, the geographical variation in air pollutant emissions. To accomplish this, the study area was divided into a grid system and the emission quantities are reported in terms of tons of pollutant per grid on an annual basis.

The pollutants considered in this survey carbon monoxide, hydrocarbons, nitrogen oxides, sulfur oxides and particulates - are those emitted in large quantities from the variety and multitude of sources dispersed throughout the area. The emissions of pollutants not considered herein are generally associated with a specific process or operation and, in general, are not distributed throughout the community.

The sources of air pollution, as used in this report, are subdivided into the following four categories:

1. Fuel combustion in stationary sources.
2. Fuel combustion in transportation vehicles.
3. Combustion of refuse material.
4. Industrial process emissions.

STUDY AREA

The study area, shown on Figure 1, includes the Northwest Indiana communities of East Chicago, Gary, Hammond, and Whiting. The total land area involved in the study is approximately 85 square miles. The 1960 population was 355,824.

According to census figures the population in the study area has increased by 24.6 percent from 1950 to 1960, and in the Gary-Hammond-East Chicago Standard Metropolitan Statistical Area, which includes Lake and Porter Counties, the population has increased by 40.5 percent. The population of the area outside the central cities has increased by 70.5 percent. Of the four cities, Gary has had the largest increase in population, 33 percent, and Whiting has the only decrease in population, 15.8 percent. Figure 2 shows the distribution of the population of the study area by grids.

The area included in this study has a variety of industries, but three large steel mills and four large petroleum refineries located near or on the shores of Lake Michigan dominate the industrial complex. Other industries in the area tend to be support activities for the steel and petroleum industries. Foundries, steel fabricators, and chemical plants are the largest group of support industries while two large power utilities and a large cement manufacturing plant make up the large single industries not directly supported by these two major industries.

The study area also includes some industry that is divorced from the petroleum and steel industries. The printing and publishing, grain, soap, textile, and building material industries are well represented. Various types of small manufacturing plants are also located in the four communities.

Almost 200 of the 400 industrial plants in the area employ more than 20 employees. The total number of employees in the study area is approximately 100,000; approximately 60 percent of them are in the primary metals industry, and 9 percent are employed in both the petroleum and metal fabrication industries.

The automobile traffic in the study area is handled by a number of major arteries. The Indiana toll road and the Tri-State Highway, which bound the study area on the north and south, handle most of the east-west traffic, Indianapolis Boulevard, Calumet Avenue, Kennedy Avenue, Grant, and Broadway handle a large portion of the north-south traffic.

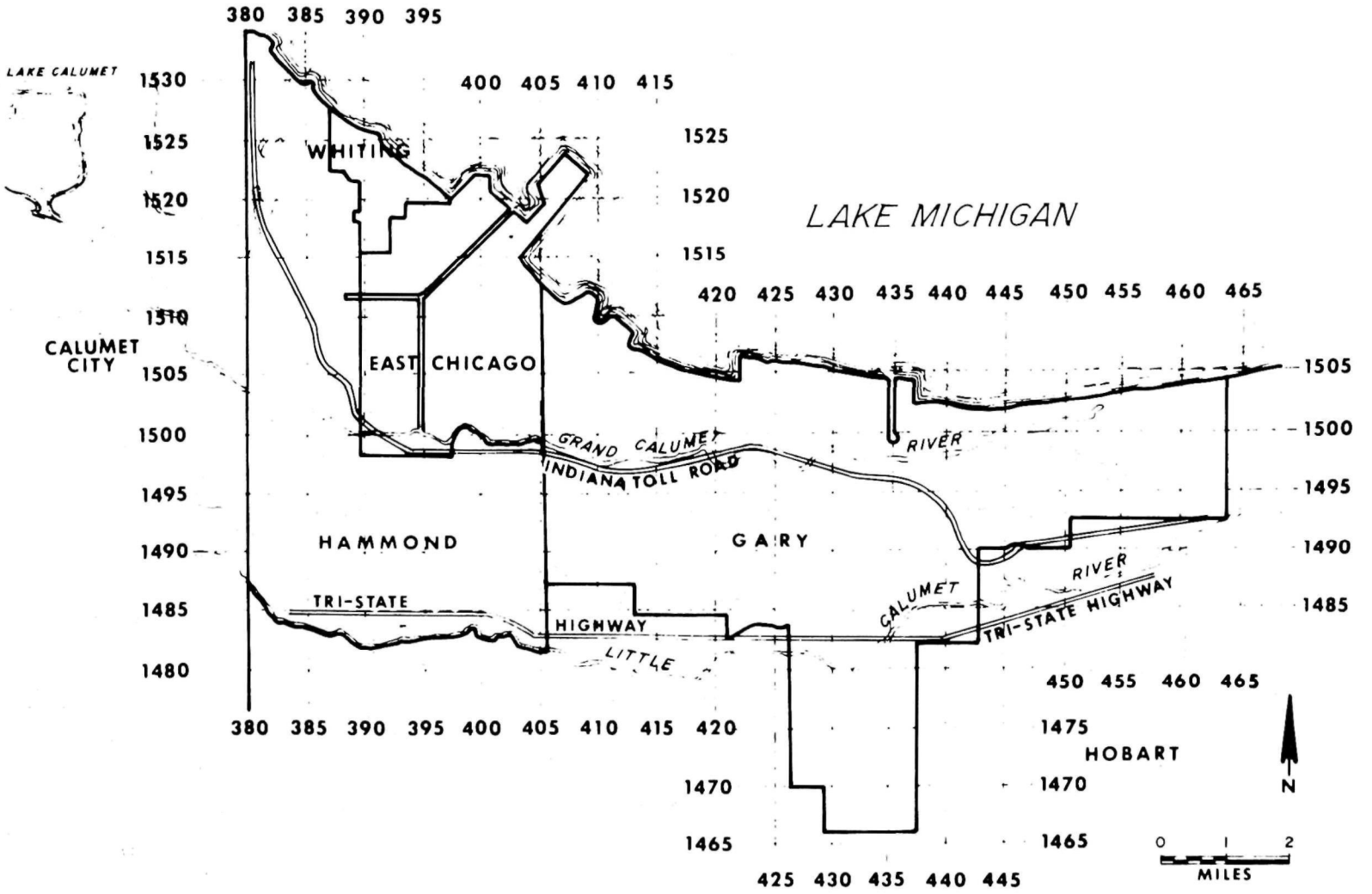

Figure 1. Location map of study area.

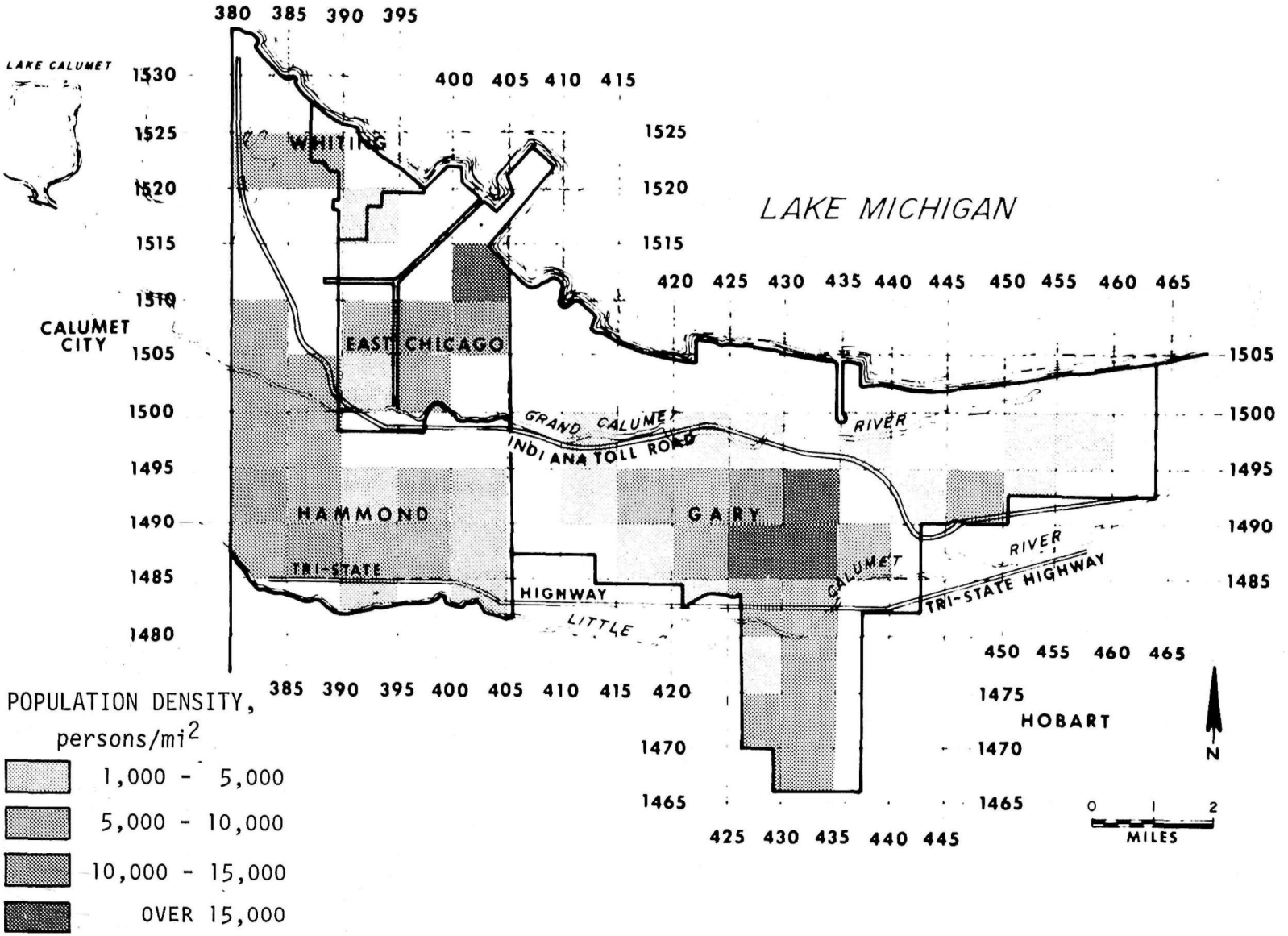

Figure 2. Population densities in Northwestern Indiana communities.

In the development of the Northwest Indiana Air Resource Management Program, the Executive Committee adopted a grid system encompassing the entire study area covered in this report. The grid system consists of 10,000-foot squares designated on the United States Coast and Geodetic Survey maps of the Northwest Indiana Area. The grid system used throughout this report is the same grid system as that adopted by the Northwest Indiana Air Resource Management Program except that this grid system is subdivided into 5,000-foot squares.

SUMMARY OF RESULTS

The following is a brief summary of pollutant emissions and sources in the study area:

1. Particulate matter is emitted primarily from industrial processes, coal combustion, and refuse disposal. Particulate emissions from industrial processes contribute 76 percent, from coal combustion contributes 20 percent, and from refuse disposal contributes 1 percent of the total emissions.

2. The burning of fossil fuels contributes approximately 86 percent of the total amount of sulfur oxides emitted in the study area. The combustion of coal accounts for 66 percent, and the combustion of fuel oils contributes 19 percent to the total amount of sulfur oxides emitted. Industrial process emissions account for 14 percent of the total amount of sulfur oxide emissions, but lack of data on certain industrial processes does not give a complete picture of this source.

3. Oxides of nitrogen are emitted primarily from two sources, combustion of fuels and transportation. The combustion of coal accounts for 38 percent of the total emissions and the combustion of fuel oils accounts for 40 percent of the total. The combustion of natural gas accounts for 13 percent, and the combustion of gasoline in automobiles accounts for 8 percent of the total amount of nitrogen oxides emitted.

4. The emission of hydrocarbons is accounted for in three major sources industrial processes, transportation, and refuse disposal. Industrial processes account for 58 percent of the total emissions, the motor vehicle accounts for 24 percent, and the disposal of refuse contributes 15 percent to the total emission of hydrocarbons.

5. Industrial process emissions account for 24 percent of the total amount of carbon monoxide emitted, and motor vehicles account for 72 percent of the total.

The emissions of pollutants discharged in the study area are listed in Table 1. The accuracy of the results depends on the accuracy and applicability of the available emission factors and the information available concerning the specific processes in which large quantities of pollutants are emitted. The emission factors, for the most part, represent the average emission rates for a particular

Table 1. SUMMARY OF AIR POLLUTANT EMISSIONS IN NORTHWEST INDIANA

(tons/year)

Source category	Particulates	Sulfur oxides	Nitrogen oxides	Hydrocarbons	Carbon monoxide
Transportation	780	630	7,910	27,700	204,000
Combustion of fuels					
Stationary sources					
Industry	39,260	138,960	58,930	1,080	2,000
Steam-electric utilities	18,390	149,500	25,330	230	570
Residential	1,520	10,180	2,920	610	2,840
Other	1,170	2,320	430	230	1,120
Subtotal	60,340	300,960	87,610	2,150	6,530
Refuse disposal					
City dumps	280	10	--	1,680	500
On-site burning	2,680	50	30	15,960	4,785
Subtotal	2,960	60	30	17,640	5,285
Industrial process emissions	208,800	49,000[a]	840	66,800	66,800
Totals	272,880	350,650[a]	96,390	114,290	282,615

[a]Does not include sulfur oxide emissions from 3 refineries.

industry or fuel group. Because of the differences in emissions rates among the plants or fuel users within a given category, the application of the emission factors, as applied to an individual plant, could result in a considerable discrepancy between the actual and calculated emissions.

The incompleteness of data relating to pollutant emissions from some processes and fuel uses has resulted in the omission of some air pollutants and air pollution sources in the area. These omissions have primarily been confined to area sources or to sources contributing a relatively small amount of pollutants. The emissions inventory should therefore be fairly representative of total area emissions of the principal pollutants.

EMISSIONS BY CATEGORY

For purposes of compiling basic data and calculating emission quantities, the air pollution sources are grouped into four categories:

1. Fuel combustion in stationary sources.
2. Fuel combustion in transportation vehicles.
3. Combustion of refuse material.
4. Industrial process emissions.

Each of these categories is, in turn, subdivided in a number of subgroups some according to type or size to allow estimates of the geographical variation in pollutant emissions. In the following discussion the various information sources are documented, assumptions made are cited, and the resulting emission quantities are summarized.

Fuel Combustion in Stationary Sources

The combustion of fuels is one of the principal sources of air pollutant emissions in urban areas. The combustion of fuels releases various products that deteriorate the quality of the urban air.

The major fuels used in the study area are coal, fuel oil, natural gas, and process gas. The primary consumers of the three major fuels are: industry, steam-electric utilities, and residential dwellings.*

Table 2 summarizes the annual fuel consumption for the study area, and Table 3 subdivides the annual fuel consumption into use category and political subdivisions. The fuel consumption data for the study area were obtained through the use of a variety of techniques and from numerous information sources. Where possible, data have been cross-checked by using different techniques and other sources of information. The annual consumption of natural gas was furnished by the local utility, and Bureau of Census data for 1962 were used for annual consumption of coal and fuel oil.

*To more accurately define the sources of pollution and provide better estimates of emissions, a fourth category, Other Consumers, was used. Included in this category are commercial sources that primarily use fuel for space heating.

Table 2. ANNUAL FUEL CONSUMPTION IN NORTHWEST INDIANA

Fuel	Consumer category	Annual consumption	Percent of total
Coal, tons /yr	Industry[a]	1,306,000	34.8
	Steam-electric utilities	2,290,000	61.0
	Residential	111,000	3.0
	Other	45,000	1.2
	Total	3,752,000	100.0
Fuel oil, gal/yr	Industry	271,656,000	83.3
	Steam-electric utilities	---	--
	Residential	54,600,000	16.7
	Other	na[b]	na[b]
	Total	326,256,000	100.0
Gas, million ft^3/yr	Industry	79,445	75.0
	Steam-electric utilities	12,461	11.8
	Residential	9,534	9.0
	Other	4,487	4.2
	Total	105,927	100.0

[a] An additional 12,488,000 tons is used in the production of coke.

[b] na - Information not available or not reported.

Table 4 specifically locates the major fuel consumer categories in the study area and gives total consumption of each of the specific fuels used in both process heating and area or space heating. The steam - electric utilities, the major users of coal, consume 61 percent of the area total annually. Industry consumes 83 percent of the fuel oil and 75 percent of the natural gas. Industry, consuming 35 percent annually, is also the second largest user of coal.

The Mid-West Coal Producers Institute provided the quantities of coal of Midwestern origin that was shipped into this area. Table 5 shows the distribution, usage, and chemical composition of this coal. This information was not made available until after the calculations were completed. The sulfur and ash

Table 3. ANNUAL FUEL CONSUMPTION BY POLITICAL SUBDIVISIONS OF NORTHWEST INDIANA, 1966

Fuel	Jurisdiction	User category				
		Industry	Steam-electric plants	Residential	Other	Totals
Coal, tons/yr	Hammond	115,870	1,161,000	33,520	15,000	
	East Chicago	726,060	--	25,900	7,000	
	Gary	308,850	1,129,000	47,630	22,000	
	Whiting	125,000	--	3,950	1,000	
	Totals	1,275,780	2,290,000	111,000	45,000	3,752,000
Fuel oil, gal/yr	Hammond	3,798,700	--	15,558,000		
	East Chicago	308,247,400	--	8,030,000		
	Gary	96,886,300	--	30,070,000		
	Whiting	9,430,000	--	942,000		
	Totals	418,862,400	--	54,600,000	na	326,256,000
Gas, million ft^3/yr	Hammond	4,334	11,561	3,273	1,311	
	East Chicago	48,178	--	1,103	775	
	Gary	22,407	900	4,963	2,288	
	Whiting	4,526	--	195	113	
	Totals	79,445	12,461	9,534	4,487	105,929

na - Information not available or not reported.

Table 4. MAJOR FUEL CONSUMERS IN STUDY AREA
BY INDUSTRIAL CATEGORY

City	Category	Annual fuel consumption				
		Coal, tons	Fuel oil, gallons		Gas, $10^6 ft^3$	
			Residual	Distillate	Natural	Process
East Chicago	Chemical and allied products	92,500	211,800	31,700	1,307	--
	Stone, clay, glass products	5,561	63,900	--	412	--
	Primary metals industries	628,000	242,270,000	1,306,000	36,617	43,000
	Petroleum and coal products	--	64,364,000	--	--	26,460
	Totals	726,061	306,909,700	1,337,700	38,336	69,460
Gary	Chemical and allied products	--	520,000	--	3	--
	Stone, clay, glass products	280,000	2,000,000	--	921	--
	Primary metals industries	34,856	91,389,700	4,585,000	22,557	382,931
	Transportation equipment	--	392,000	--	--	--
	Power utilities	1,129,000	--	--	900	--
	Totals	1,443,856	94,301,700	4,585,000	24,381	382,931
Hammond	Chemical and allied products	--	389,200	--	1,585	--
	Stone, clay, glass products	--	--	--	264	--
	Primary metals industries	5,876	1,725,000	388,000	912	--
	Power utilities	1,161,000	--	--	11,561	--
	Food and kindred products	110,000	854,000	42,500	170	--
	Printing and publishing	--	400,000	--	--	--
	Paper and allied products	--	--	--	310	--
	Totals	1,276,876	3,368,200	430,500	14,802	--
Whiting	Petroleum and coal products	--	9,500,000	--	4	16,000
	Chemical and allied products	125,000	430,000	--	2,500	2,000
	Totals	125,000	9,930,000	--	2,504	18,000
	Area totals	3,571,793	414,509,600	6,353,200	80,023	470,391

Table 5. MIDWEST COAL ASSOCIATION SUMMARY OF MIDWESTERN COAL SHIPPED TO NORTHWEST INDIANA AREA

	Use[a]	Coal shipped, tons	Moisture, %	Ash, %	Sulfur, %
To Whiting from:					
Western Kentucky	RT	101	10.10	6.00	2.95
Southern Illinois	IN	86,900	7.90	7.84	1.88
Western Kentucky	IN	165,814	8.34	6.36	2.91
Total and Averages		252,815	8.19	6.87	2.56
To Hammond from:					
Southern Illinois	RT	108	7.22	7.90	1.86
Indiana	RT	1,453	13.00	7.50	2.72
Fulton County	IN	6,234	14.78	7.03	2.77
DuQuoin	IN	371	10.00	8.60	2.72
Indiana	IN	2,098	13.77	6.47	2.29
Western Kentucky	IN	1,469	8.34	6.36	2.91
Belleville and South Illinois	UT	1,673,944	13.66	10.26	3.38
Total and Averages		1,685,677	13.66	10.24	3.38
To Gary from:					
Central Illinois	RT	54	12.00	8.10	3.44
Southern Illinois	RT	306	7.22	7.90	1.86
Indiana	RT	576	13.00	7.50	2.72
Western Kentucky	RT	584	10.10	6.00	2.95
Danville	IN	13,619	13.35	7.51	2.67
Belleville	IN	52,864	10.68	9.71	3.27
Southern Illinois	IN	32,117	7.90	7.84	1.88
Indiana	IN	79,236	13.77	6.47	2.29
Western Kentucky	IN	121,821	8.34	6.36	2.91
Belleville	UT	996,987	10.60	9.93	2.87
DuQuoin	UT	249,424	9.80	15.10	2.60
Total and Averages		1,547,588	10.43	10.23	2.79
To East Chicago from:					
Fulton County	IN	101,570	14.74	7.18	2.52
Central Illinois	IN	6,146	13.40	8.60	3.40
Belleville	IN	633	10.68	9.71	3.27
Southern Illinois	IN	44,175	7.90	7.84	1.88
Indiana	IN	5,834	13.77	6.47	2.29
Western Kentucky	IN	18,078	8.34	6.36	2.91
Southern Illinois	MT	351,632	9.20	5.90	1.03
Total and Averages		528,068	10.23	6.37	1.50

[a]RT coal used for retail purposes; IN - coal used for industrial purposes; UT - coal used for electric utility purposes; MT coal used for metallurgical purposes.

contents of the coal were assumed when they were not made available by the particular consumers of coal, and the sulfur contents of the residual and distillate fuel oil were also assumed and used under the same circumstances. A sulfur content of 2.7 percent and an ash content of 10 percent for coal, and a sulfur content of 0.4 percent for distillate (number 1 and 2 oil) and a sulfur content of 1.5 percent for residual (numbers 4 and 5 oil) fuel oil were assumed for the fuels that did not have their composition reported. A weighted average of all the reported fuels with their respective compositions was calculated to estimate the assumed composition of the other fuels. Pollutants should be recalculated to be comparable with the analysis as stated in Table 5.

Air pollutant emissions from fuel combustion in stationary sources are summarized in Table 6 by user category. The combustion of coal accounts for over 70 percent by weight of all the pollutants emitted from this source category. Coal combustion accounts for 99 percent of the carbon monoxide, 93 percent of the particulates, 77 percent of the sulfur oxides, 42 percent of the nitrogen oxides, and 77 percent of the hydrocarbons emitted from fuel combustion. Fuel oil accounts for 23 percent of the sulfur oxides and 44 percent of the nitrogen oxides emitted. Gas accounts for only 14 percent of the nitrogen oxides emitted from fuel combustion.

Industry - Industry consumes 1,306,000 tons of coal, 271,656,000 gallons of fuel oil (mostly residual), and 79,445 million cubic feet of gas for process heat, power generation, and space heating and 12,488,000 tons of coal for coking annually. The emissions from the combustion of fuel amount to 39,260 tons of particulates, 138,965 tons of sulfur oxides, 58,930 tons of nitrogen oxides, 2,000 tons of carbon monoxide, and 1,080 tons of hydrocarbons annually. The following percentages of the total amount of pollutants emitted from fuel combustion in the study area are attributed to industrial fuel combustion:

particulate	65 percent
sulfur oxides	46 percent
nitrogen oxides	67 percent
hydrocarbons	50 percent
carbon monoxides	30 percent

Steam-Electric Utilities Utilities are the major user of coal; they consume 2,290,000 tons annually. They also consume 12,460 million cubic feet of gas

Table 6. AIR POLLUTANT EMISSIONS FROM COMBUSTION OF FUELS IN STATIONARY SOURCES IN NORTHWEST INDIANA

(tons/year)

Fuel	User category	Carbon monoxide	Hydro-carbons	Nitrogen oxides	Sulfur oxides	Particulates
Coal	Industrial	2,000	650	13,060	74,150	35,625
	Steam-electric	570	230	22,900	149,500	18,300
	Residential	2,780	560	400	6,750	1,100
	Others	1,120	225	180	2,320	1,125
	Totals	6,470	1,665	36,540	232,720	56,150
Fuel oil	Industrial	5	430	36,490	64,800	2,920
	Steam-electric	--	--	--	--	--
	Residential	55	55	1,970	3,430	330
	Others	--	--	--	--	--
	Totals	60	485	38,460	68,230	3,250
Gas	Industrial	n	n	9,380	15	715
	Steam-electric	n	n	2,430	2	90
	Residential	2	n	550	2	90
	Others	n	--	245	n	40
	Totals	2	n	12,605	19	935
	Total emissions	6,532	2,150	87,605	300,970	60,335

n Negligible.

annually as a secondary fuel. The use of electrostatic precipitators in both of the power plants reduces the emission of particulates to 18,390 tons annually. Steam generating plants are one of the major sources of sulfur oxides, however, with annual emissions of 149,500 tons. The amounts of nitrogen oxides, carbon monoxides, and hydrocarbons emitted annually from fuel combustion for power generation are, respectively, 25,330 tons, 570 tons, and 230 tons.

Residential - The combustion of fuels in residential dwellings accounts for 111,000 tons of coal, 54,600,000 gallons of fuel oil (mostly distillate), and 9,500 million cubic feet of gas. Annual emissions from the combustion of this

fuel are: 1,545 tons of particulates, 10,180 tons of sulfur oxides, 2,610 tons of nitrogen oxides, 620 tons of hydrocarbons, and 2,840 tons of carbon monoxide.

Others The commercial establishments use 45,000 tons of coal and 4,500 million cubic feet of gas primarily for space heating. The quantity of fuel oil consumed by commercial establishments is not available from the sources contacted. This quantity of fuel should be defined to complete the fuel balance for the study area. The amount of pollution from this source is not as great in quantity as from residential fuel combustion; but the concentration of the commercial sources is confined to specific areas within the four cities and their contribution is, therefore, significant. Pollutants from commercial sources amount to 1,170 tons of particulates, 2,320 tons of sulfur oxides, 425 tons of nitrogen oxides, 225 tons of hydrocarbons, and 1,120 tons of carbon monoxide emitted annually.

Fuel Combustion in Transportation Vehicles

The transportation sources of air pollution include any vehicles that are powered by the combustion of fuels. The lack of traffic surveys and the lack of data on gasoline and diesel fuel consumption limited this category to automobile emissions in the total study area.

The total emissions from automobiles were estimated by using gasoline sales in the area and converting this figure to gallons of gasoline. Although only an estimate, the results correlated well with similar surveys conducted in other areas.

Automotive exhaust is estimated to contribute 204,000 tons of carbon monoxide, 27,700 tons of hydrocarbons, 7,910 tons of nitrogen oxides, 630 tons of sulfur oxides, and 780 tons of particulates. This amounts to 72 percent of the total emission of carbon monoxide and 24 percent of the total emission of hydrocarbons from all sources in the study area.

Since traffic flow maps were not available for the entire area, no attempt was made to distribute the emissions from transportation throughout the study area.

Combustion of Refuse Material

Most of the refuse generated in the study area is disposed of in three ways: city-controlled landfills, industrial dumps, and on-site burning. On-site means

that the refuse is disposed of on the premises on which it is produced. Certain industries, large apartments, and some commercial establishments are equipped with incineration facilities; but this factor was not considered because of the lack of specific data.

Municipal landfills are subject to intermittent burning, which along with on-site burning, constitutes a substantial source of pollution. Estimating air pollutants emitted annually from open burning and incineration of refuse was difficult because accurate data on the quantities of refuse burned was unknown.

To estimate air pollutants from solid wastes, information from local sanitation and health agencies was gathered to determine the amount of wastes generated. This total amount was subdivided among the different modes of disposal.

Certain assumptions and estimates had to be made in order to determine the quantity of refuse generated and disposed in the area. National averages of 1.0 pound per capita per day for noncombustible and 3.5 pounds per capita per day for combustible were used to determine the quantity of refuse generated in the four communities. As shown in Table 7, the total quantity was estimated to be 290,500 tons of refuse per year. The refuse is composed of 227,000 tons of combustible refuse and 63,500 tons of noncombustible refuse.

The location of this refuse in the communities was accomplished by using information received from the local sanitation agencies. From this information the amount of refuse disposed of by on-site burning was estimated by taking the difference between the amount of refuse generated in the area and the amount of refuse taken to the city dumps. On-site disposal was assumed to be exclusively by burning.

The amount of refuse burned openly in the city landfills is unknown. Calculation of the pollutants emitted from the city landfills was based on burning of an estimated 10 percent of the combustible material received. This estimate is an arbitrary assumption and should be interpreted as such.

Table 8 shows the amounts of pollutants emitted from the burning of refuse from the different modes of disposal. Disposal by on-site burning accounts for approximately 40 percent of the total refuse generated in the study area. This method of disposal accounts for over 80 percent of the pollutants emitted in each

Table 7. REFUSE DISPOSAL IN NORTHWEST INDIANA

Location	Population	Types and quantities of refuse generated[a]		Mode of disposal		
		Type	Quantity, tons/yr	City dump[b]		On-site[c]
				Landfill	Burned	
Hammond	111,648	Combustible	71,000	28,000	3,000	40,000
		Noncombustible	20,000	20,000	--	--
E. Chicago	57,669	Combustible	37,000	27,000	3,000	7,000
		Noncombustible	10,000	10,000	--	--
Gary	178,320	Combustible	114,000	43,000	5,000	66,000
		Noncombustible	32,000	32,000	--	--
Whiting	8,137	Combustible	5,000	3,000	1,000	1,000
		Noncombustible	1,500	1,500	--	--
Total Refuse			290,500	164,500	12,000	114,000

[a] Quantities of refuse generated were based on observed national averages of 3.5 pounds per capita per day for combustibles and 1.0 pound per capita per day for noncombustible.

[b] Quantities of refuse taken to city dumps are based on estimates from local sanitation agencies.

[c] On-site quantity was taken as the difference between refuse generated and deposited at city dumps.

Table 8. AIR POLLUTANT EMISSIONS FROM REFUSE BURNING

Location	Source	Pollutants, tons/yr				
		Particulates	Sulfur oxides	Nitrogen oxides	Hydrocarbons	Carbon monoxide
Hammond	City dump	70	2	n	420	125
	On-site	940	16	10	5,600	1,680
E. Chicago	City dump	70	2	n	420	125
	On-site	20	3	1	980	295
Gary	City dump	120	3	1	700	210
	On-site	1,550	26	16	9,240	2,770
Whiting	City dump	20	n	n	140	40
	On-site	20	n	n	140	40
Totals		2,810	52	28	17,640	5,285

n Negligible.

category from refuse burning. The amounts of each pollutant from on-site burning were distributed by population densities throughout the study area. Since these totals were obtained by differences, any error in the assumed per capita generation or in the quantities handled at the collective disposal sites will be reflected in these figures.

Although 60 percent of the total refuse is estimated to be disposed at the city landfills, only approximately 10 percent of the total pollutants are ascribed to this method of disposal. The amounts burned at these locations is only an estimate, and the air pollution estimates are, therefore, thought to be conservative.

Additional information on amounts of refuse burned at the landfills at specific industrial dumps, and at commercial and domestic incinerators is needed to refine the emission quantities from refuse disposal. Emissions from refuse disposal are small in comparison with most of the other types of sources, but the proximity of these sources (on-site disposal) to the individual citizen can cause irritation and concern.

Industrial Process Emissions

The quantities of the various pollutants discharged to the atmosphere from industrial and commercial establishments are generally attributable to two types of operations, the combustion of fuels and industrial processes. Unfortunately, emission factors are available for only a small number of processes and industries.

Data relating to the industrial processes and the materials handled in these processes were collected through questionnaires distributed by local air pollution agencies and by personal contact with a number of industrial groups. Several smaller sources did not have the necessary information, and these exceptions are noted where applicable.

In the Northwest Indiana area the two predominant types of industry are petroleum refining and steel manufacturing. Allied industries in the area are chemical plants, foundries, and metal fabricators. As stated previously, the petroleum and steel industries employ approximately 60 percent of the 100,000 workers in the study area. A summary of the emissions from the industrial processes in the study area is shown in Table 9. Because of insufficient data, not all existing industrial processes are listed in this table. The data on this table are subject to change when more specific process information is available.

Table 9. SUMMARY OF INDUSTRIAL PROCESS EMISSIONS IN NORTHWEST INDIANA, 1966

(tons/yr)

Pollutant and sources	E.Chicago	Gary	Hammond	Whiting	Study area
Particulates					
Refineries	900	--	--	1,500	2,400
Cement plants	--	26,600	--	--	26,600
Chemical plants	na	182	--	--	182
Foundries					
Steel	--	1,420	--	--	1,420
Grey iron	na	--	10	--	10
Other	na	--	20	--	20
Other sources	--	na	20	--	17
Steel mills					
Blast furnace	3,380	3,800	--	--	7,180
Open hearth	40,600	26,900	--	--	67,500
Basic oxygen furnace	--	450	--	--	450
Sintering plant	36,400	53,100	--	--	88,500
Coke plant	6,050	7,500	--	--	13,550
Total	87,300	120,000	50	1,500	208,800
Sulfur oxides					
Refineries	na	--	na	13,000	13,000
Sulfuric acid manufacturing	18,000[a]	--	18,000	--	36,000
Other sources	--	--	--	--	--
Total	18,000	--	18,000	13,000	49,000
Hydrocarbons					
Refineries	--	--	--	16,400	16,400
Storage	20,075	--	--	--	20,075
Blowdown system	8,400	--	--	--	8,400
Wastewater separator	9,860	--	--	--	9,860
Leakage	2,560	--	--	--	2,560
Catalytic cracking	2,190	--	--	--	2,190
Vacuum distillation	1,095	--	--	--	1,095
Other sources	6,220	--	--	--	6,220
Total	50,400	--	--	16,400	66,800
Carbon monoxide					
Refineries	60,200	--	--	6,600	66,800
Total	60,200	--	--	6,600	66,800

[a]Estimated figure.

na - Information not available or reported.

Steel Manufacturing Three major steel plants within the boundaries of the study area operate a full line of equipment including: blast furnaces, oxygen-lanced and nonoxygen-lanced open hearths, sintering plants, coke plants, basic oxygen furnaces, and individual power plants. As shown in Table 10, the steel manufacturing industry emits 186,780 tons of particulates per year, which amounts to 89.4 percent of the total particulates from industrial processes and 68.5 percent of the total particulates emitted in the study area.

Oil Refineries The study area has four complete oil refineries and a number of storage and distribution centers. The most important air pollution considerations with respect to refinery emissions are crude oil processing capacity, the processing techniques employed, types of fuels used and their composition, maintenance and housekeeping, and the air pollution control measures used. Hydrocarbons, oxides of sulfur and nitrogen, carbon monoxide, and odors are the primary pollutants emitted from these operations.

Table 11 shows the different sources and amounts of pollutants emitted from the petroleum refineries. Of the hydrocarbons emitted in the study area, 62 percent are from the industrial processes of the refineries.

Chemical Industry - A number of large chemical plants are located in the study area, but lack of emission factors and production data for most of the plants make it impossible to estimate emissions from the chemical industry's operations. Sulfuric acid is produced at two of the chemical plants. Information for one plant permitted an emission estimate of 18,000 tons of sulfur dioxide per year.

Cement Manufacturing - A large cement manufacturing plant in the area has an annual capacity of 8.3 million barrels. By the nature of this process, particulate material is the pollutant of prime concern. The amount of particulate matter emitted from the cement kilns was estimated by applying emission factors and control efficiency information from the local air pollution agency. An estimated 26,600 tons of particulate is discharged annually from this plant.

Foundries - The lack of process information on area foundries makes it virtually impossible to estimate their total emission contribution. Data were available for two foundries; one, a steel foundry, emitted approximately 1,420 tons of particulates annually, and the second, a grey iron foundry with a capacity of

Table 10. AIR POLLUTANT EMISSIONS FROM STEEL INDUSTRY IN NORTHWEST INDIANA (tons/yr)

Operation	Number of units	Pollutants				
		Particulates	Sulfur oxides	Nitrogen oxides	Hydrocarbons	Carbon monoxide
Blast furnaces	23	7,180	--	--	--	--
Open hearths	101	67,500	--	--	--	--
Basic oxygen furnaces	3	450	--	--	--	--
Sintering plants	5	88,500	--	--	--	--
Coking plants	3	13,550	--	--	--	--
Combustion of fuel	--	9,600	77,850	54,000	820	920
Total		186,780	77,850	54,000	820	920

Table 11. POLLUTANT EMISSIONS FROM PETROLEUM REFINERIES IN NORTHWEST INDIANA (tons/yr)

Pollutant source	Particulates	Sulfur oxides	Nitrogen oxides	Hydrocarbons	Carbon monoxides
Storage	--	--	--	20,070	--
General Processes[a]	--	13,000	--	23,720	--
Catalytic cracking	2,240	--	840	2,200	66,825
Auxiliary equipment[b]	--	--	--	20,840	--
Fuel combustion	1,050	51,990	14,860	--	--
Total	3,290	64,990	15,700	66,830	66,825

[a]General processes include vacuum distillation, loading, cooling towers, etc.
[b]Auxiliary equipment includes blowdown systems, waste water separators, leakage, etc.

12,500 tons of material per year, emits only 10 tons per year because of control equipment. More data should be collected because of the significant nature of this process in the quantities of pollutants emitted.

EMISSIONS BY GEOGRAPHICAL AREA

The Northwest Indiana communities of East Chicago, Gary, Hammond, and Whiting are geographically interrelated to the extent that each community borders two or more of the other communities. This factor adds to the complexity of the air resource management program because air pollution does not respect municipal boundaries.

Figures 3 through 13 indicate the geographical locations of point and area source emissions. Point sources are those specific industries with total emissions above a particular figure, and area sources are domestic, commercial, manufacturing, and refuse burning sources that are below a specified amount of emissions and are reported in tons per year per grid. Not all sources that could be listed in the point source category are included on these maps because of the lack of specific data, mostly on process capacities, that would make it possible to calculate their emissions.

The location of the point sources in the study area are illustrated on Figures 3, 4, and 5. Figure 3 shows the location of point sources that annually emit 250 tons or more of particulates. This map locates 20 such sources with a range of emissions from 250 tons per year to 92,000 tons per year. Because of the location of these point sources, all but three of them could influence the air pollution problem in all of the four communities located in the study area.

Sulfur oxide emissions from point sources are located in Figure 4. This map shows 17 point sources with a range of 250 to 75,000 tons per year.

Figure 5 shows the point sources that emit more than 250 tons of nitrogen oxides per year. The map locates 13 such sources; these emissions are in the range of 250 to 23,000 tons per year.

The Northwest Indiana study area includes over 400 manufacturing plants, over 102,000 domestic dwelling units, and numerous commercial establishments. Figures 6 through 12 illustrate the estimated geographical location of the pollutant emissions from these sources. The area manufacturing sources include

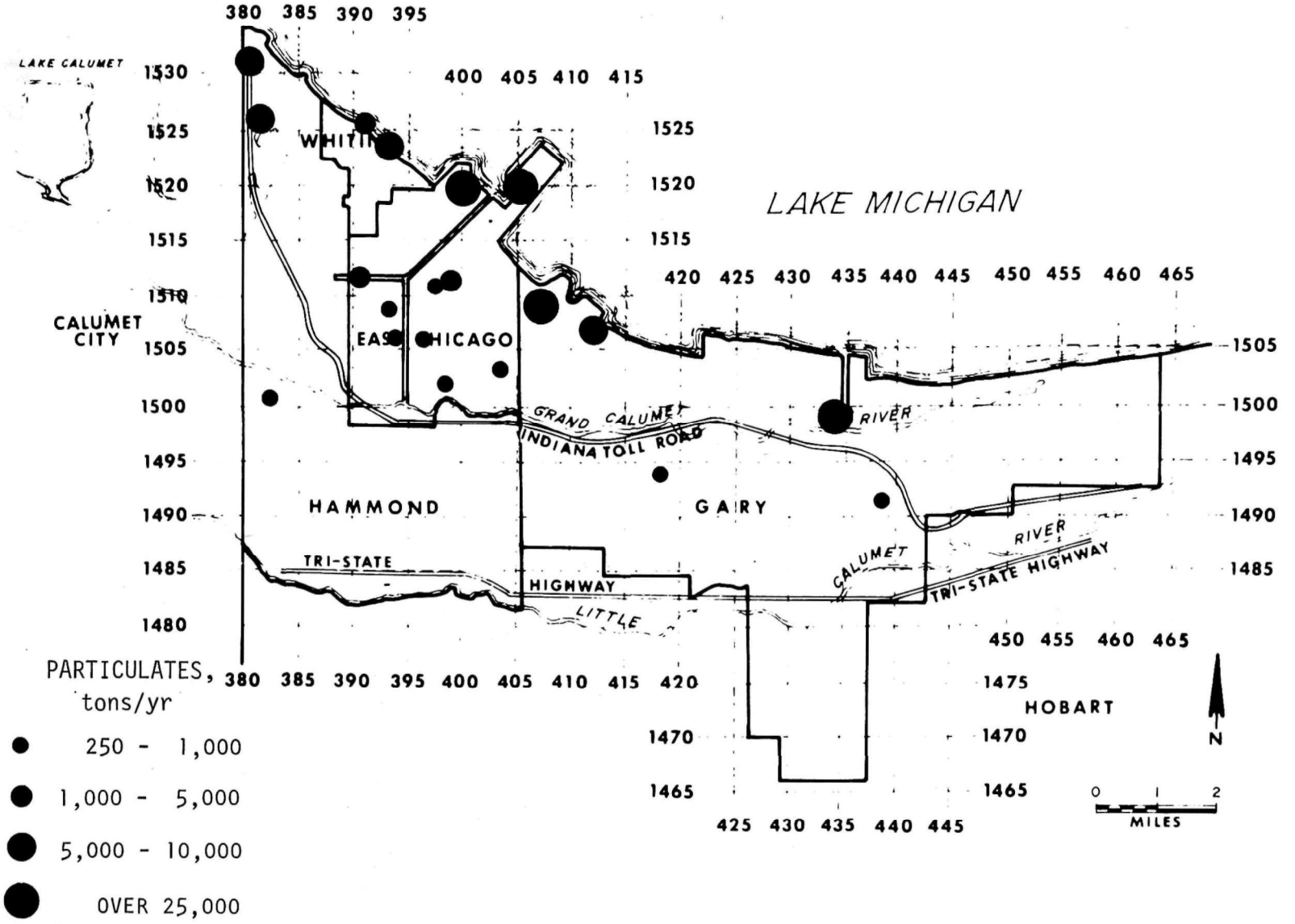

Figure 3. Particulate emissions from point sources.

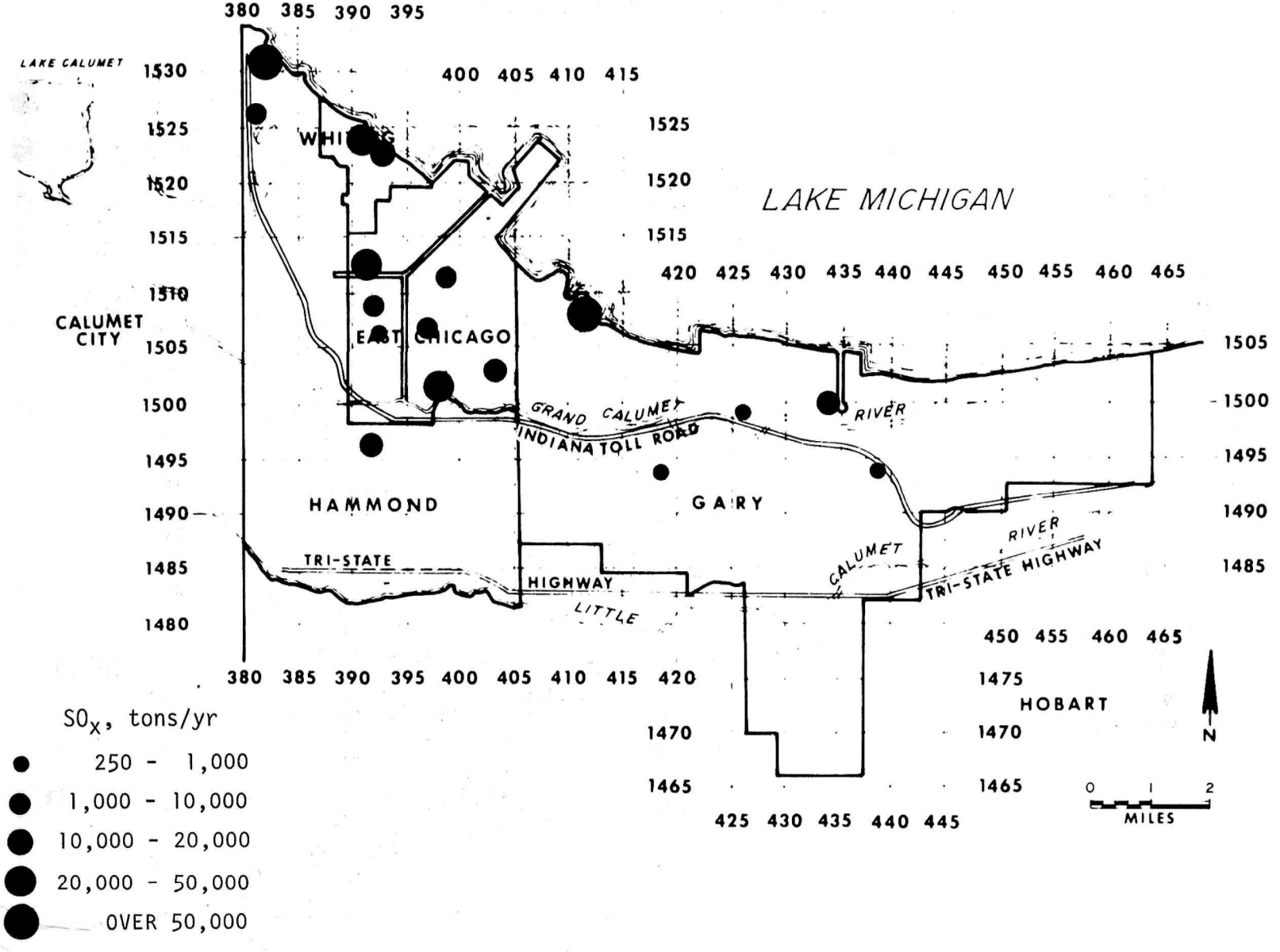

Figure 4. Sulfur oxide emissions from point sources.

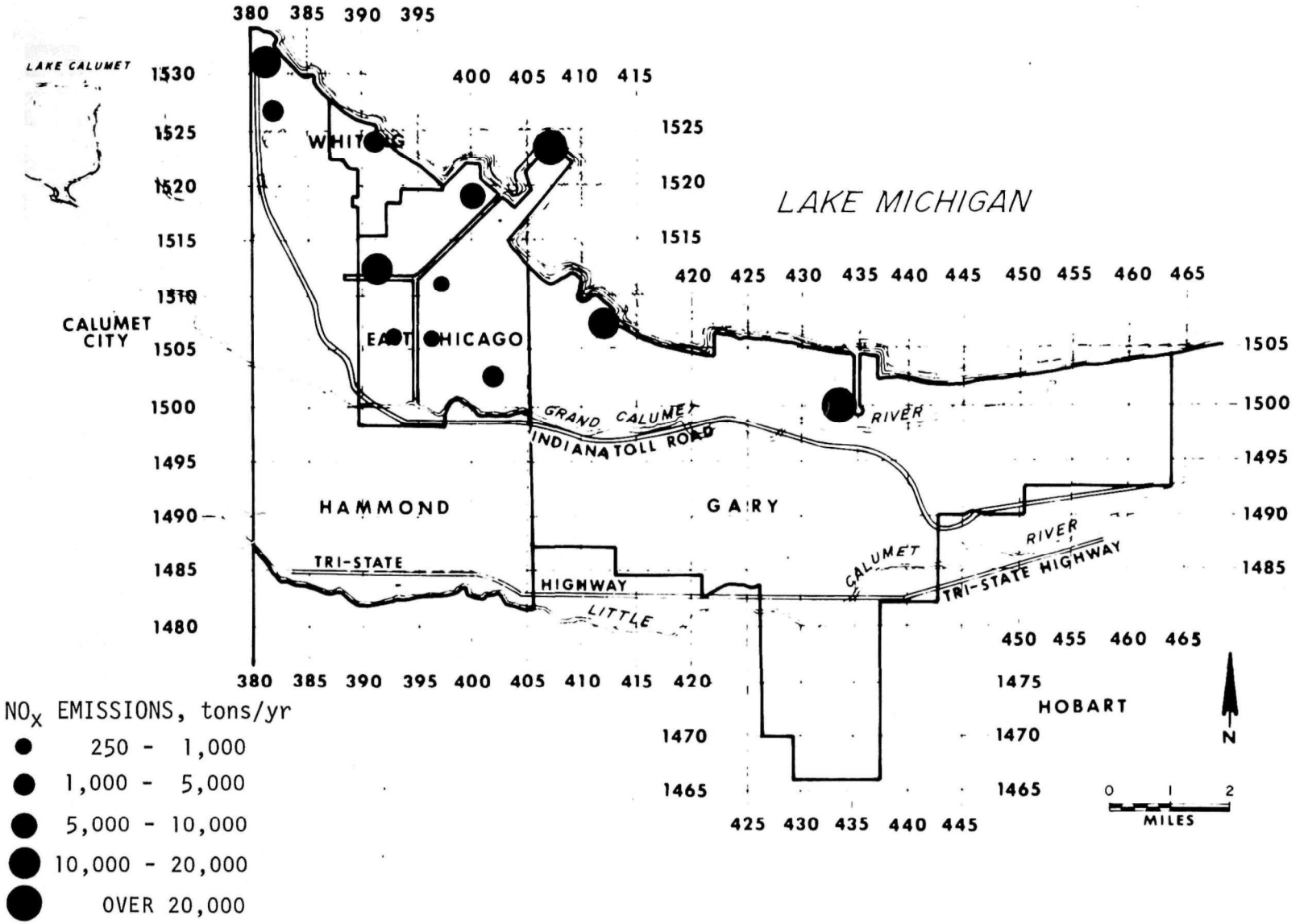

Figure 5. Nitrogen oxide emissions from point sources.

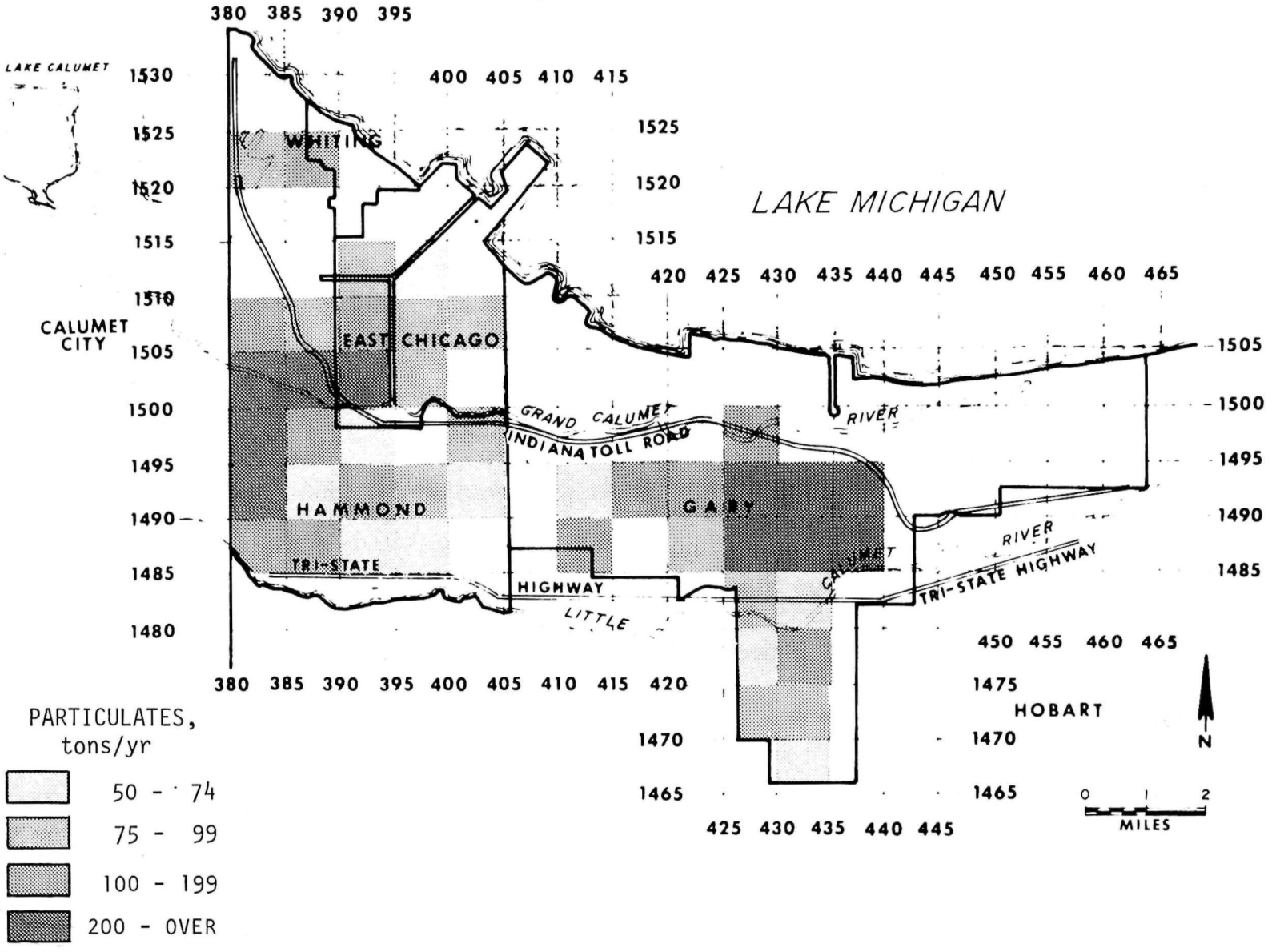

Figure 6. Particulate emissions from area sources.

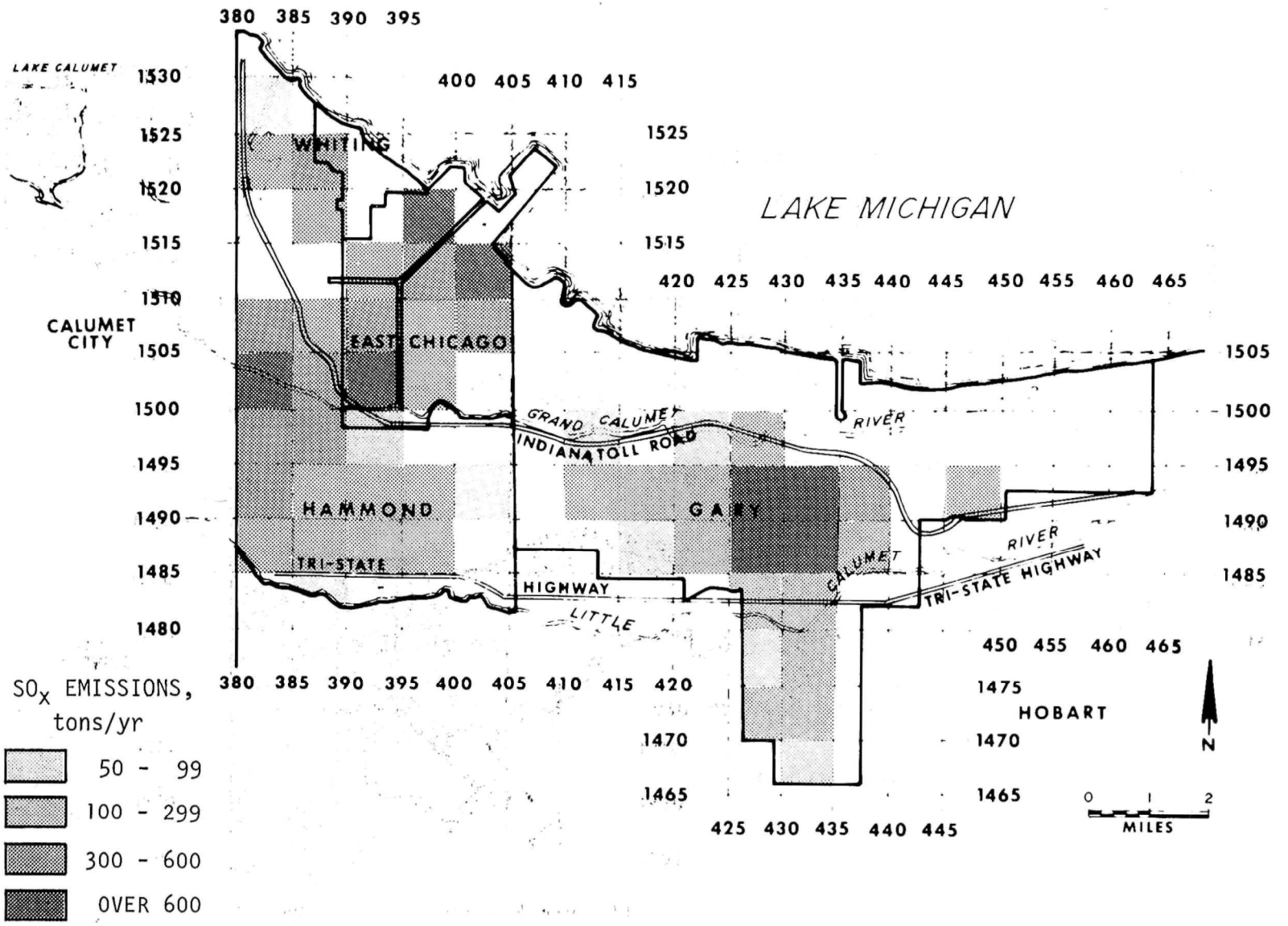

Figure 7. Sulfur oxide emissions from area sources.

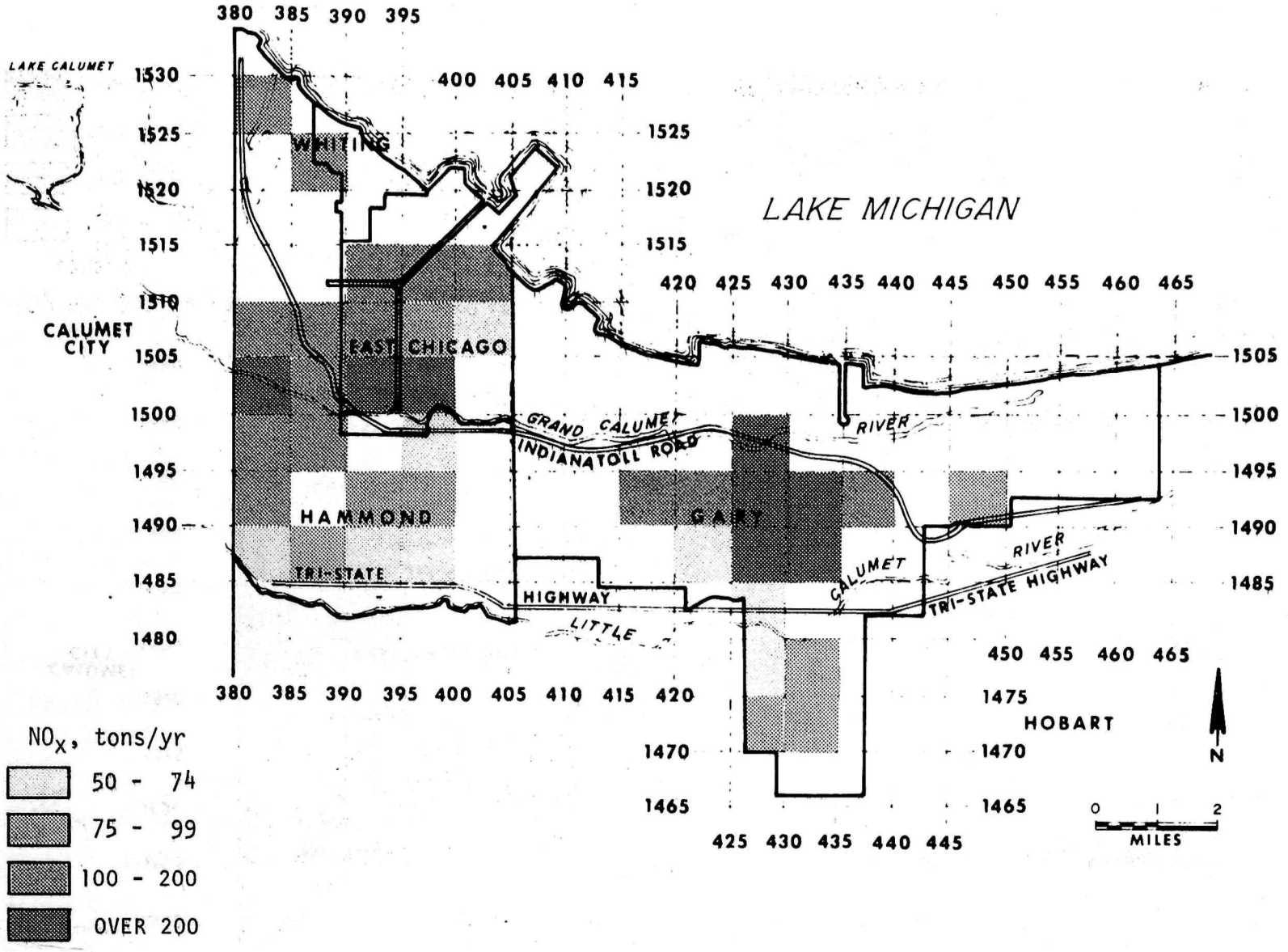

Figure 8. Nitrogen oxide emissions from area sources.

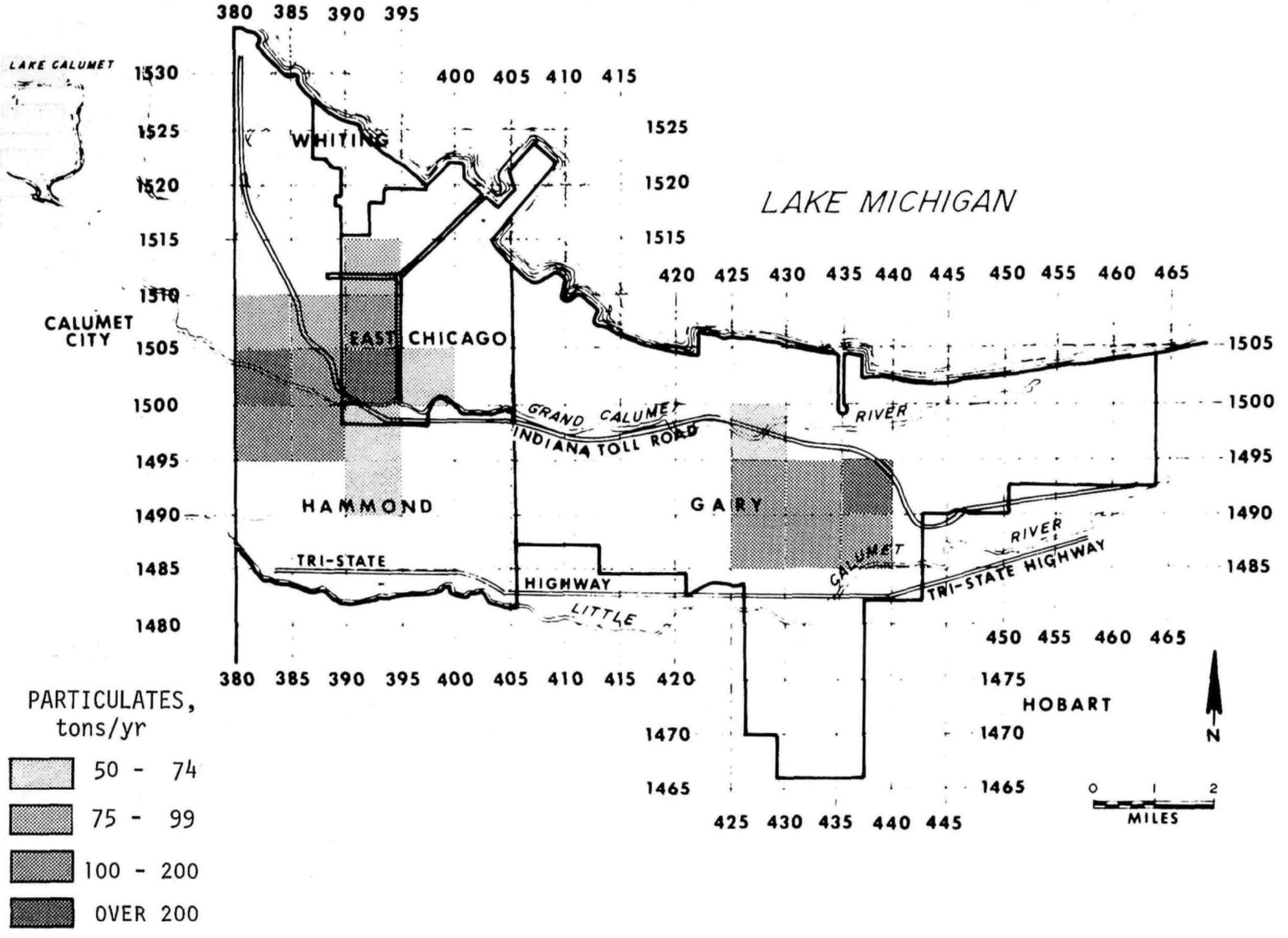

Figure 9. Particulate emissions from commercial and area manufacturing sources.

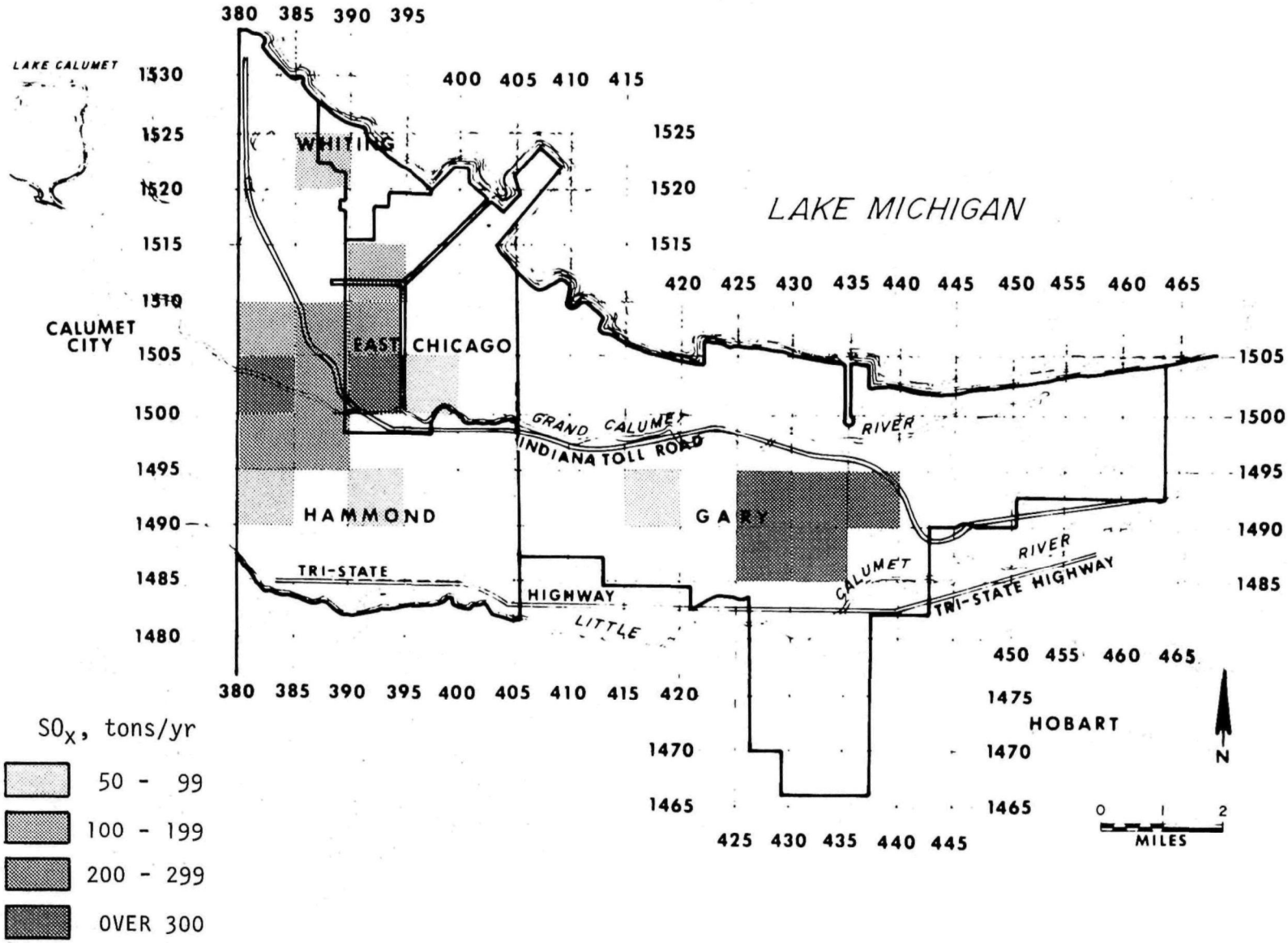

Figure 10. Sulfur oxide emissions from commercial and area manufacturing.

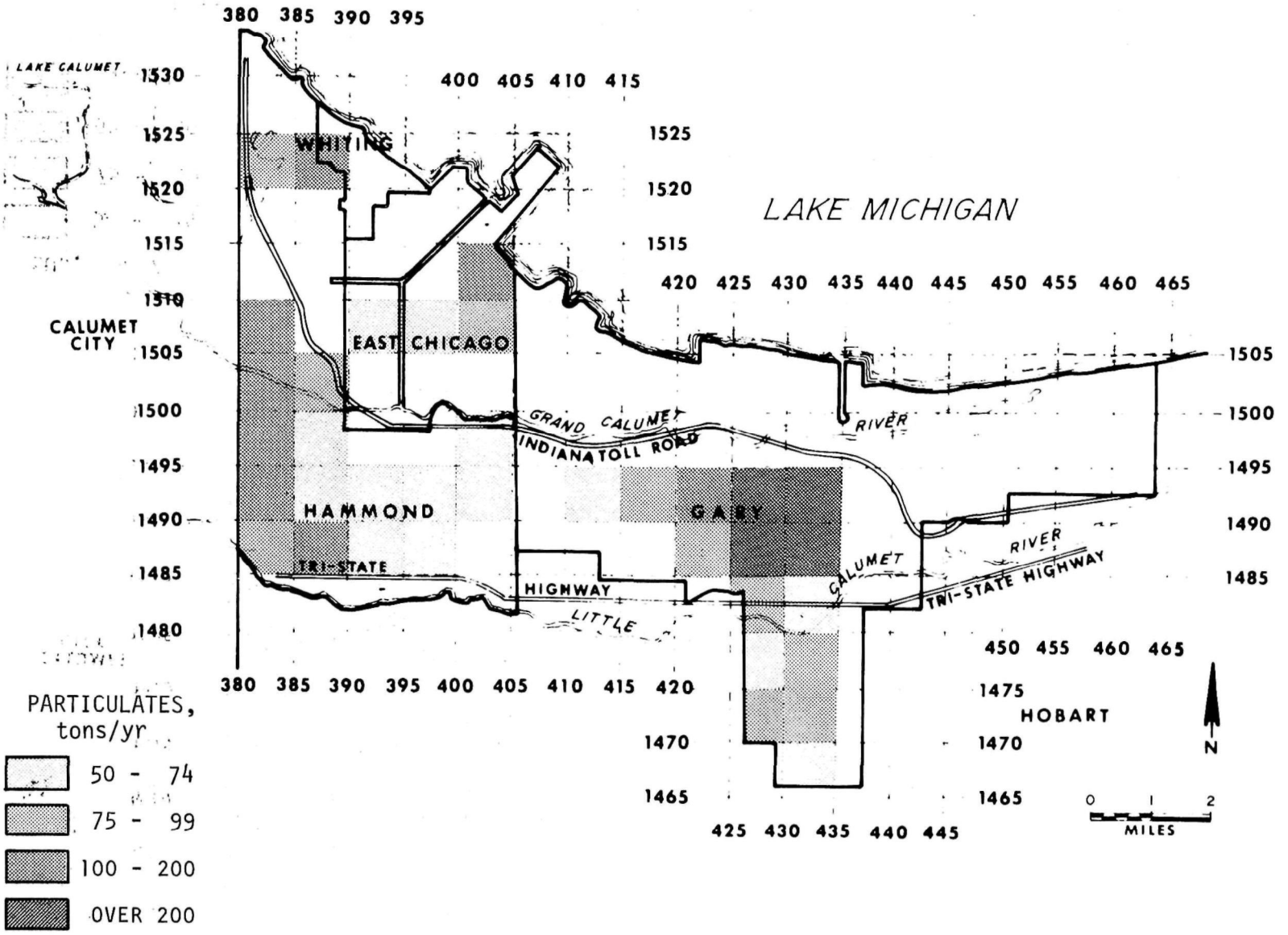

Figure 11. Particulate emissions from domestic heating and on-site burning.

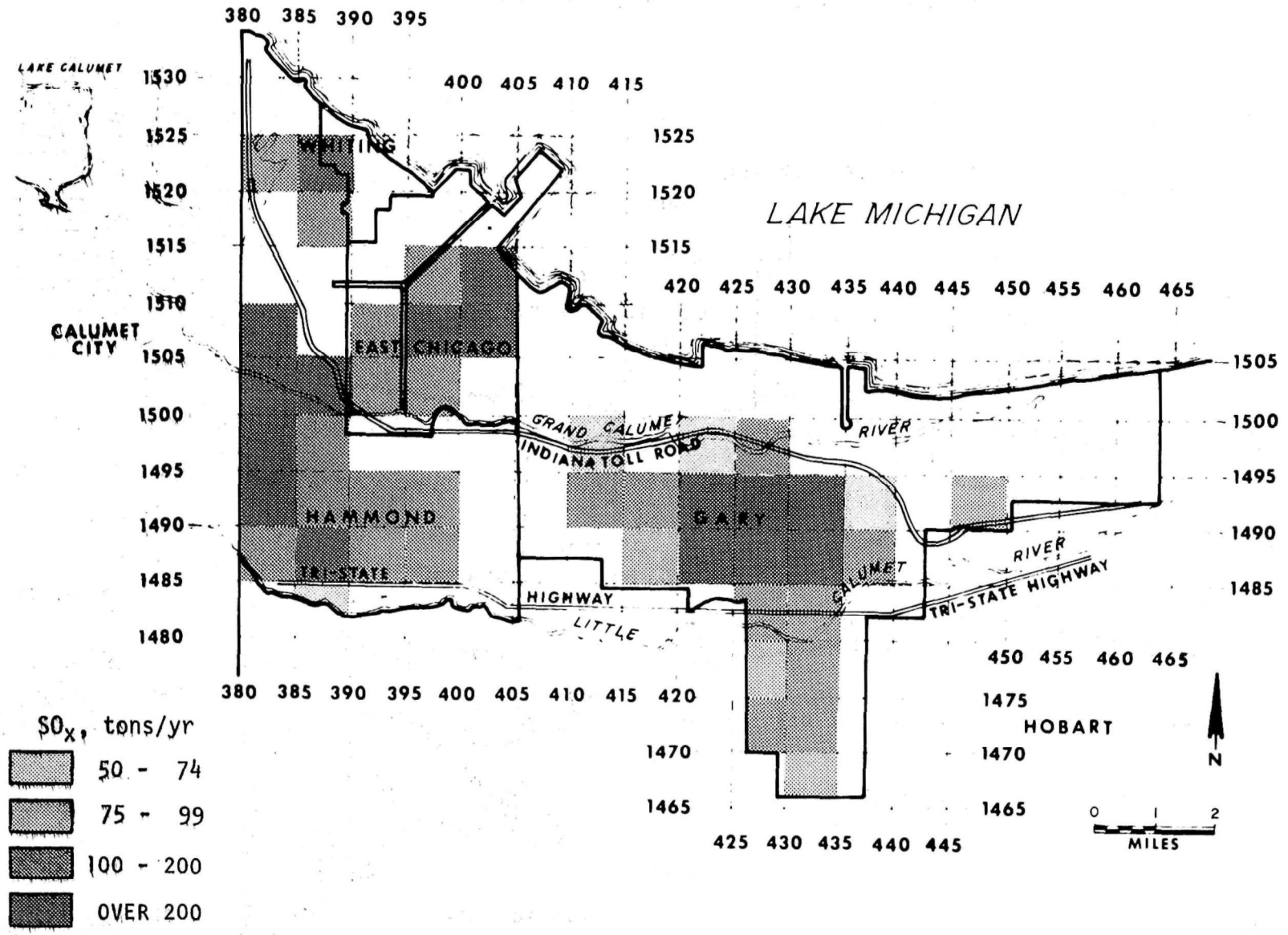

Figure 12. Sulfur oxide emissions from domestic heating and on-site burning.

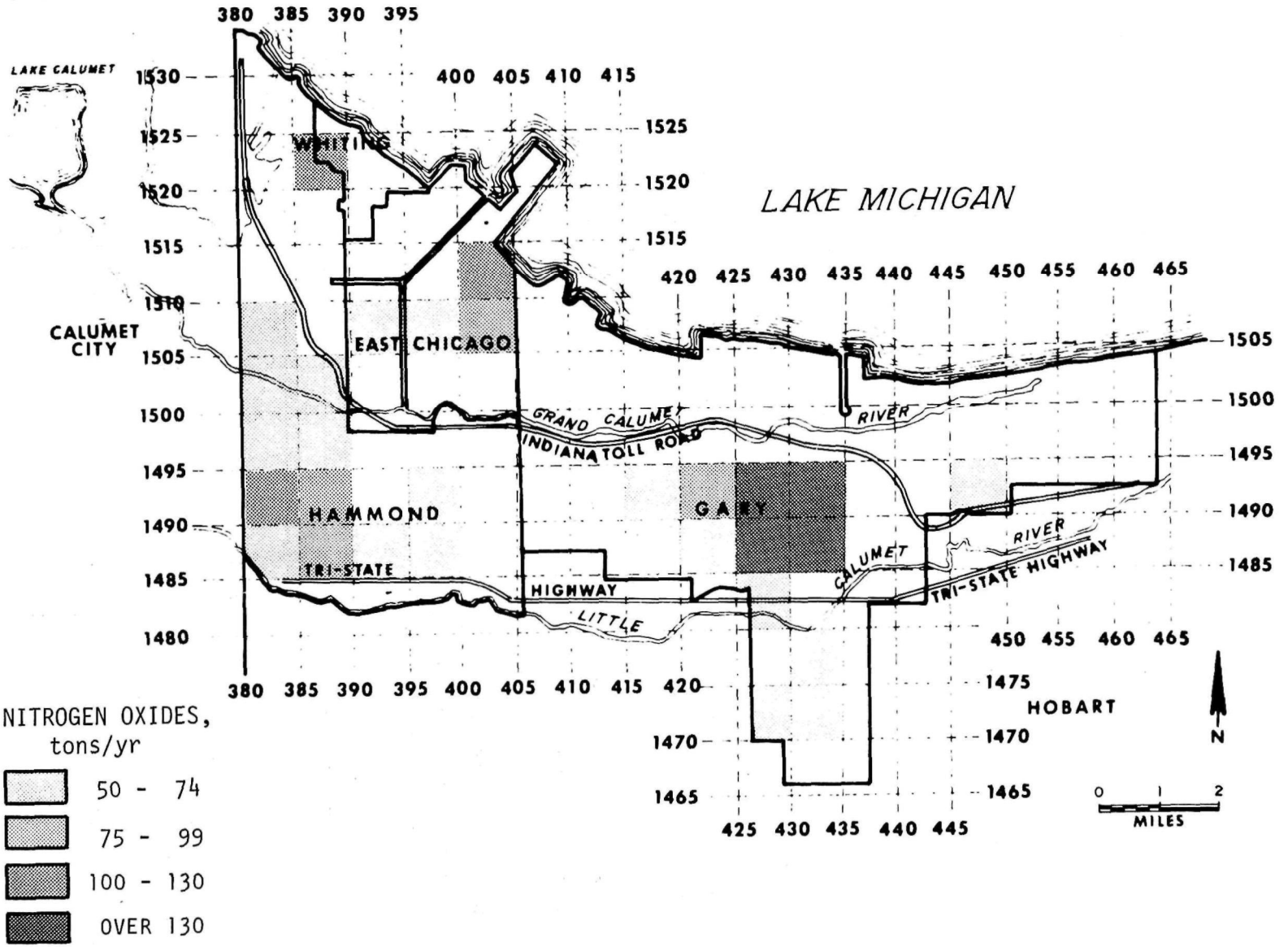

Figure 13. Nitrogen oxide emissions from domestic heating and on-site burning.

those plants that were not considered as point sources, and the pollutants ascribed to these sources were distributed by finding a percentage of the employees in the particular grids and assigning that particular percentage of the total pollutant load from area manufacturing to that grid or by actual location of the particular plant. The emissions from commercial sources were calculated, and this amount was distributed to the downtown sections of each of the four communities. There is probably notable error in this distribution; but since detailed data on commercial sources were not available, this method of distribution was used to incorporate this source of pollutant emissions.

The domestic source of pollutant emission was distributed in the following manner. The census tracts in this Standard Statistical Metropolitan Area were available with information on the number of dwellings using specific fuels (see Table 12). These numbers were distributed into the grid system, and a percentage of the total amount of dwellings for each fuel was taken. This percentage was then applied to the total emissions from this source and added to the particular grid in question. Another source of pollution, on-site burning of refuse, was also distributed in a like manner.

Table 12. SUMMARY OF DOMESTIC HEATING BY NUMBER OF DWELLING UNITS IN NORTHWEST INDIANA, 1960

	East Chicago	Gary	Hammond	Whiting	Study area	Percent of total
All occupied units	16,837	50,283	32,997	2,569	102,686	100.0
Heating fuel						
Utility gas	4,855	12,692	12,271	1,035	30,853	30.1
Fuel oil, kerosene, etc.	7,839	29,283	15,272	929	53,323	52.0
Coal or coke	3,772	6,935	4,881	575	16,163	15.7
Electricity	59	296	59	--	414	0.4
Bottled, tank, or LP gas	100	780	470	30	1,380	1.3
Other fuel	173	251	20	--	444	0.4
None	39	46	24	--	109	0.1

Figures 6, 7, and 8 show the geographical variation of particulates, sulfur oxides, and nitrogen oxides, respectively, for area sources. Included in these area sources are area manufacturing and commercial, domestic and on-site burning.

A breakdown of the geographical area source emissions is given in Figures 9 through 13. The commercial and area manufacturing sources in Figures 9 and 10 show emissions of particulates and sulfur oxides, respectively. Figures 11, 12, and 13 locate the emissions from domestic fuel combustion and on-site burning throughout the study region. These figures show the amounts of particulates, sulfur oxides, and nitrogen oxides and their distribution throughout the study region. It should be noted that 1960 census figures were used in the calculation of the domestic emissions and that the amounts of fuels used for domestic heating were up-dated to 1965 when the figures were available.

SUMMARY

The results of the emission inventory show the need for further study in certain areas. The fuel consumption by industries has been defined well in some areas and poorly in others. The consumption of coal and of natural gas have been defined to a fairly accurate degree from figures provided by area-wide associations. The lack of such an organization to provide fuel oil data has left an emission category that still must be evaluated. Also, as stated in the report, recalculation of some of the coal figures could be performed when more information on the chemical composition of the coal is received. This would help to increase the accuracy of the inventory.

An inventory should be made to determine the locations of commercial establishments and the exact quantity of fuel burned at each. This information would complete the fuel combustion inventory.

Comprehensive traffic flow maps of the four-city area are needed to compute the emissions from transportation on a vehicle-mile basis. Since emissions from transportation are approximately 25 percent of the total emission in this area, geographical distribution of these emissions is important and should be studied further.

A detailed study is also needed to determine industrial process emissions. The lack of process information that can be used to estimate the emissions re-

sulting from these sources impaired establishing an accurate inventory. Foundries, chemical plants, sulfuric acid manufacturing, and refineries are a few of the processes requiring collection of more detailed information.

The last area of concern is refuse disposal. The quantities of refuse burned at the city dumps should be more accurately defined because of the size of this source of pollution. An inventory of the industrial and commercial incinerators should be made to define the on-site burning more precisely.