REPORT FOR CONSULTATION ON THE METROPOLITAN INDIANAPOLIS INTRASTATE AIR QUALITY CONTROL REGION

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service
National Air Pollution Control Administration

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CONSUMER PROTECTION AND ENVIRONMENTAL HEALTH SERVICE
NATIONAL AIR POLLUTION CONTROL ADMINISTRATION
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PREFACE

The Secretary, Department of Health, Education, and Welfare is directed by the Air Quality Act of 1967 to designate "air quality control regions" as an initial step toward the establishment of regional air quality standards. In addition to listing the major factors to be considered in the designation of region boundaries, the Act stipulates that the designation of a region shall be preceded by a consultation with appropriate State and local authorities.

The National Air Pollution Control Administration, DHEW, has conducted a study of the Metropolitan Indianapolis urban area, the results of which are presented in this report. The boundaries of the Region*, as proposed in this report, reflect consideration of all available and pertinent data; however, the boundaries remain subject to revision suggested by consultation with State and local authorities. Formal designation will be withheld pending the outcome of that consultation.

The Administration is appreciative of assistance received either directly during the course of this study or during previous activities in the Metropolitan Indianapolis area from the Indiana Air Pollution Control Board and the Indianapolis Bureau of Air Pollution Control.

*For the purposes of this report, the word region, when capitalized, will refer to the Metropolitan Indianapolis Intrastate Air Quality Control Region. When not capitalized, unless otherwise noted, it will refer to air quality control regions in general.

Useful data was also supplied by the Indiana Department of Commerce, the Indiana Employment Security Division, the Metropolitan Planning Department of Marion County, the Hendricks, Shelby, Boone, Johnson, Hancock and Morgan County Plan Commissions, the Delaware-Muncie Metropolitan Planning Commission, the Anderson City Plan Commission, and the Carmel City Plan Commission.

INTRODUCTION

> "For the purpose of establishing ambient air quality standards pursuant to section 108, and for administrative and other purposes, the Secretary, after consultation with appropriate State and local authorities shall, to the extent feasible, within 18 months after the date of enactment of the Air Quality Act of 1967 designate air quality control regions based on jurisdictional boundaries, urban-industrial concentrations, and other factors including atmospheric areas necessary to provide adequate implementation of air quality standards. The Secretary may from time to time thereafter, as he determines necessary to protect the public health and welfare and after consultation with appropriate State and local authorities, revise the designation of such regions and designate additional air quality control regions. The Secretary shall immediately notify the Governor or Governors of the affected State or States of such designation."
>
> Section 107(a)(2), Air Quality Act of 1967

THE AIR QUALITY ACT

Air Pollution in most of the Nation's urban areas is a regional problem. This regional problem demands a regional solution, consisting of coordinated planning, data gathering, standard setting and enforcement. Yet, with few exceptions, such coordinated efforts are notably absent among the Nation's urban complexes.

Beginning with the Section quoted above, in which the Secretary is required to designate air quality control regions, the Air Quality Act presents an approach to air pollution control involving coordinated efforts by Federal, State, and local governments, as shown in Figure 1. After the Secretary has (1) designated regions, (2) published air quality criteria, and (3) published corresponding documents on control

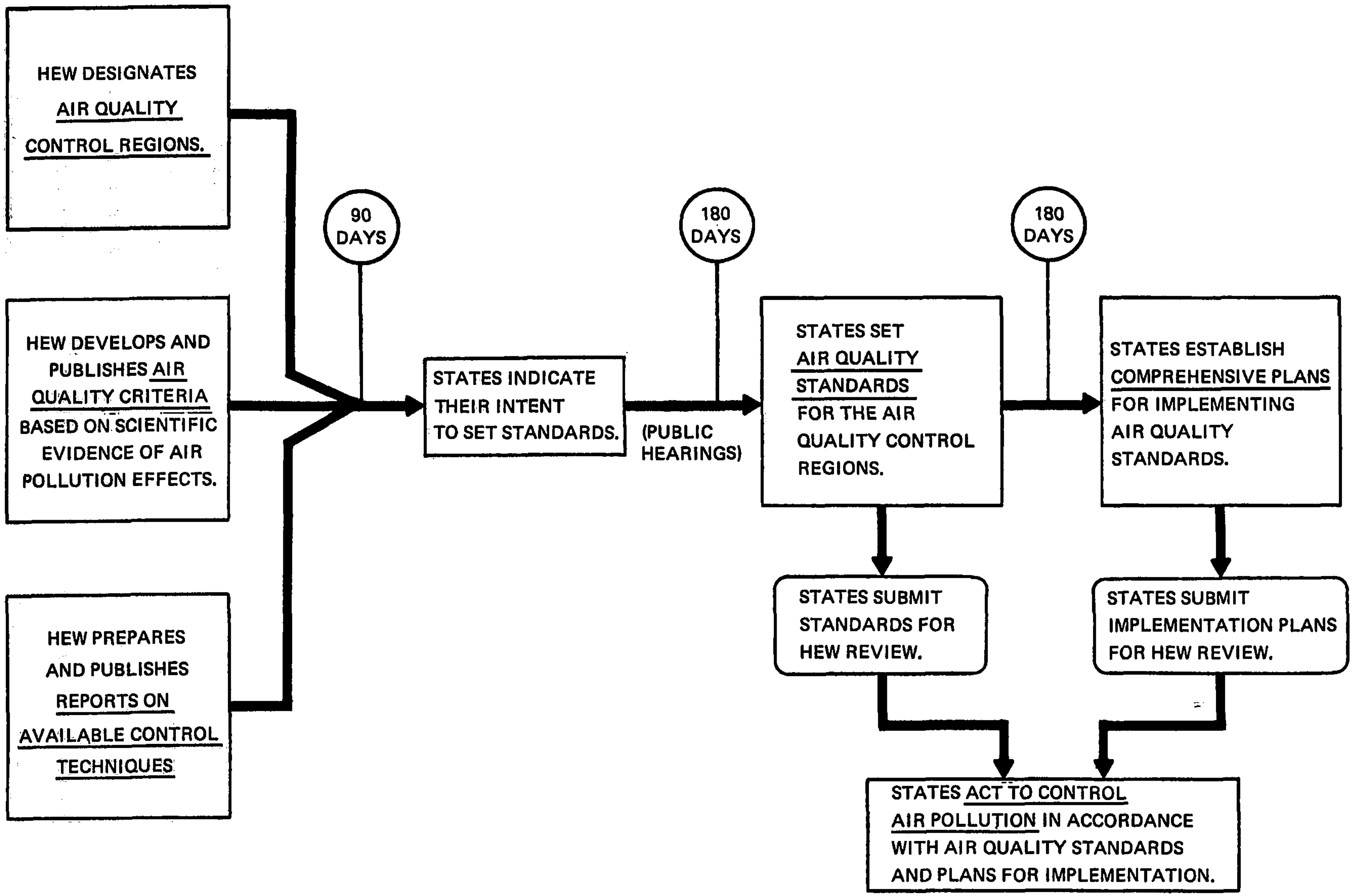

Figure 1 FLOW DIAGRAM FOR ACTION TO CONTROL AIR POLLUTION ON A REGIONAL BASIS, UNDER THE AIR QUALITY ACT.

technology and associated costs, the Governor(s) of the States(s) must file with the Secretary within 90 days a letter of intent, indicating that the States(s) will adopt within 180 days ambient air quality standards for the pollutants covered by the published criteria and control technology documents and adopt within an additional 180 days plans for the implementation, maintenance, and enforcement of those standards in the designated air quality control region.

The new Federal legislation provides for a regional attack on air pollution and, at the same time, allows latitude in the form which regional efforts may take. While the Secretary retains approval authority, the States(s) involved in a designated region assumes the responsibility for developing standards and an implementation plan which includes administrative procedures for abatement and control. Informal cooperative arrangements with proper safeguards may be adequate in some regions, whereas in others, more formal arrangements, such as interstate compacts, may be selected. The objective in each instance will be to provide effective mechanisms for control on a regional basis.

THE SIZE OF A REGION

Several objectives are important in determining how large an air quality control region should be. Basically, these objectives can be divided into three separate categories. First a region should be self-contained with respect to air pollution sources and receptors. In other words, a region should include most of the important sources in the area as well as most of the people and property affected by those sources.

In this way, all the major elements of the regional problem will lie within one unified administrative jurisdiction. Unfortunately, since air pollutants can travel long distances, it is impractical if not impossible to delineate regions which are completely self-contained. The air over a region will usually have at least trace amounts of pollutants from external sources. During episodic conditions, such contributions from external sources may even reach significant levels. Conversely, air pollution generated within a region and transported out of it can affect external receptors to some degree. It would be impractical and inefficient to make all air quality control regions large enough to encompass these low-level effects. The geographic extent of trace effects overestimates the true problem area which should be the focus of air pollution control efforts. Thus, the first objective, that a region be self-contained, becomes a question of relative magnitude and frequency. The dividing line between "important influence" and "trace effect" will be a matter of judgement. The judgement should be based on estimates of the impact a source has upon a region, and the level of pollution to which receptors are subjected. In this respect, annual and seasonal data on pollutant emissions and ambient air concentrations are a better measure of relative influence than short term data on episodic conditions.

The second general objective requires that region boundaries be designed to meet not only present conditions but also future conditions. In other words, the region should include areas where industrial and residential expansion are likely to create air pollution problems in the foreseeable future. This objective requires careful consideration of existing metropolitan development plans, expected population growth, and projected industrial expansion. Such considerations should result in the designation of regions which will contain the sources and receptors of regional air pollution for a number of years to come. Of course, region boundaries need not be permanently fixed, once designated. Boundaries should be reviewed periodically and altered when changing conditions warrant readjustment.

The third objective is that region boundaries should be compatible with and even foster unified and cooperative governmental administration of the air resource throughout the region. Air pollution is a regional problem which often extends across several municipal, county, and even state boundaries. Clearly, the collaboration of several governmental jurisdictions is prerequisite to the solution of the problem. Therefore, the region should be delineated in a way which encourages regional cooperation among the various governmental bodies involved in air pollution control. In this regard, the existing pattern of governmental cooperation on the whole range of urban problems may become an important consideration. Certainly the pattern of cooperation among existing air pollution control programs is a relevant factor. In general, administrative considerations dictate that governmental jurisdictions should not be divided. Although it would be impractical to preserve State jurisdictions undivided, usually it is possible to preserve the unity of county governments by including or excluding them in their entirety. Occasionally, even this would be impractical due to a county's large size, wide variation in level of development, or striking topographical features.

To the extent that any two of the above three objectives lead to incompatible conclusions concerning region boundaries, the region must represent a reasonable compromise. A region should represent the best way of satisfying the three objectives simultaneously.

PROCEDURE FOR DESIGNATION OF REGIONS

Figure 2 illustrates the procedures used by the National Air Pollution Control Administration for designating air quality control regions.

A preliminary delineation of the region is developed by bringing together two essentially separate studies - the "Evaluation of Engineering Factors", and the "Evaluation of Urban Factors".

The "Evaluation of Engineering Factors" considers pollutant source locations and the geographic extent of significant pollutant concentrations in the ambient air. An inventory of air pollutant emissions determines the geographic location and quantities of the various pollutants emitted from the sources in a region. Major quantities of pollution are emitted by automobiles and industry, and from refuse disposal operations, power generation, and space heating. The subsequent effect of the pollution emitted into the atmosphere is determined by measuring ambient air quality. The air quality analysis presented in this report is divided into two major parts. The first part deals with the topography and meteorology of the area and measured air quality. The second part of the analysis describes the results of the diffusion model applied to the Indianapolis area in

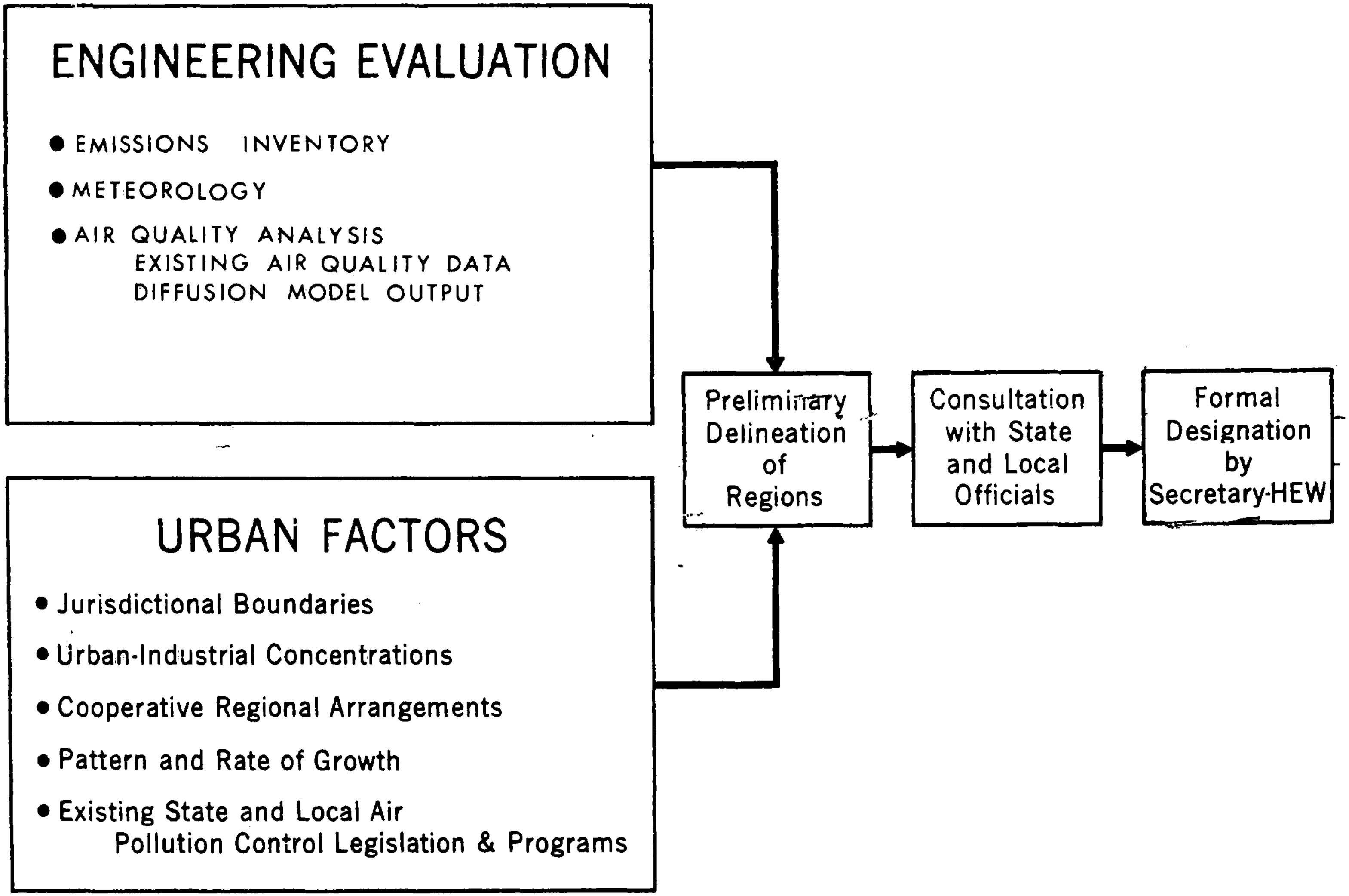

Figure 2. Flow diagram for the designation of air quality control regions.

order to predict air quality levels. Some of the basic conclusions drawn from the model results, as they relate to the size of the proposed Region, are outlined.

The "Evaluation of Urban Factors" encompasses all considerations of a non-engineering nature. This evaluation consists of a review of existing governmental jurisdictions, current air pollution programs and legislation, demographic data, current urbanization, and projected patterns of urbanization.

The findings of the engineering evaluation are combined with the results of the urban factors evaluation, and an initial proposal for the air quality control region is made. As indicated in Figure 2, the proposal is submitted for consultation with State and Local officials. The report itself is intended to serve as a background document for the formal consultation. After reviewing the official transcript of the consultation proceedings which provides the viewpoints of the State and local officials toward the proposal, the Secretary formally designates the region. Formal designation includes a notice in the Federal Register and a notification to the Governor(s) of the State(s) affected by the designation.

EVALUATION OF ENGINEERING FACTORS

EMISSION INVENTORY

A quantitative evaluation of air pollutant emissions provides the basic framework for air conservation activities. The compilation of an emissions inventory makes possible the correlation of pollutant emissions with specific geographic locations. This procedure generally results in the identification of the "core" of an air quality control region----that is, the area where the bulk of the pollutant emissions occur. In this study, the emissions inventory results are further utilized as input data to a meteorological diffusion model. In this manner the spatial and temporal distribution of the pollution emitted into the atmosphere can be systematically predicted. For these reasons, a presentation of the emissions inventory results serves as a logical starting point in the engineering evaluation.

The emission inventory for the Indianapolis area was conducted by the Division of Air Quality and Emission Data of the National Air Pollution Control Administration. Emissions were surveyed over the eight county Indianapolis Standard Metropolitan Statistical Area (SMSA). The counties involved are Boone, Hamilton, Hancock, Hendricks, Johnson, Marion, Morgan and Shelby. This 3,080 square mile area contains 1,043,000 persons (estimated 1967), 72% of whom reside in Marion County.

The Public Health Service rapid survey technique was used, with some modification, for the estimation of pollutant emissions.[1] The emissions were calculated from data representative of the year 1967 using Public Health Service emission factors.[2] Table I provides a breakdown of

TABLE I. SUMMARY OF AIR POLLUTANT EMISSIONS IN THE METROPOLITAN INDIANAPOLIS STUDY AREA, 1967. (Tons/Year).

		TRANSPORTATION		COMBUSTION OF FUEL, STATIONARY SOURCES					
	COUNTY	MOTOR VEHICLES	AIRCRAFT	INDUSTRIAL	RESIDENTIAL	COMMERCIAL & INSTITUTIONAL	STEAM-ELECT.	REFUSE DISPOSAL	INDUSTRIAL PROCESS EMISSIONS
Sulfur Dioxide	Boone	60	Neg.*	30	340	30	0	0	Neg.
	Hamilton	110	Neg.	40	630	40	3,480	0	Neg.
	Hancock	60	Neg.	10	360	10	0	0	Neg.
	Hendricks	80	Neg.	Neg.	500	20	0	0	Neg.
	Johnson	130	Neg.	50	450	10	0	0	Neg.
	Marion	1,700	Neg.	32,880	6,750	6,200	57,920	0	4,500
	Morgan	70	Neg.	20	500	40	46,300	0	Neg.
	Shelby	70	Neg.	60	410	80	0	0	Neg.
	TOTAL	2,350	Neg.	33,090	9,940	6,430	107,700	0	4,500
Total Particulates	Boone	100	Neg.	10	160	10	0	145	Neg.
	Hamilton	180	Neg.	10	220	20	2,100	235	Neg.
	Hancock	110	Neg.	Neg.	140	Neg.	0	160	Neg.
	Hendricks	140	Neg.	Neg.	180	10	0	245	Neg.
	Johnson	230	Neg.	10	160	Neg.	0	255	Neg.
	Marion	2,960	400	7,700	2,340	3,370	24,040	3,760	10,000
	Morgan	130	Neg.	Neg.	200	20	17,960	200	Neg.
	Shelby	110	Neg.	20	160	30	0	180	Neg.
	TOTAL	3,960	400	7,750	3,560	3,460	44,100	5,180	10,000
Carbon Monoxide	Boone	9,000	Neg.	Neg.	210	Neg.	0	780	Neg.
	Hamilton	18,500	Neg.	Neg.	290	Neg.	20	1,270	Neg.
	Hancock	11,630	Neg.	Neg.	180	Neg.	0	860	Neg.
	Hendricks	15,320	Neg.	Neg.	220	Neg.	0	1,300	Neg.
	Johnson	25,200	Neg.	Neg.	210	Neg.	210	1,380	Neg.
	Marion	513,500	5,260	1,450	2,730	3,300	220	20,000	97,000
	Morgan	12,600	Neg.	Neg.	290	Neg.	200	1,100	Neg.
	Shelby	11,500	Neg.	Neg.	220	Neg.	0	970	Neg.
	TOTAL	617,250	5,260	1,450	4,350	3,300	650	27,660	97,000

*Negligible

sulfur dioxide*, total particulate and carbon monoxide emissions by county according to source type in four general categories. These categories are transportation, fuel combustion in stationary sources, refuse disposal and industrial process emissions. The data presented in this table indicates that the major portion of SO_2, CO and total particulate emissions are attributable to sources located within Marion County. It is also evident from this table that power plants located in Hamilton and Morgan Counties emit significant quantities of SO_2 and total particulates. Figures for the entire survey area reveal that power plants are responsible for 66% of the total SO_2 emissions and 57% of the total particulate emissions while 82% of CO emissions are attributable to road vehicles.

The geographic location of sources within the survey area are defined by the use of grid coordinates based on the Universal Transverse Mercator (UTM) System. The numbered grid system is shown in Figure 3, superimposed over a map of the study area. Grid squares 5 kilometers on a side are used in the areas of most dense population and industrialization. Grid squares 10 kilometers and 20 kilometers on a side are used in areas of less dense urbanization.

Figures 4, 5, and 6 are maps representing yearly average daily emission densities for SO_2, CO, and total particulates respectively, based on the grid system. The densities are computed on the basis of emissions from both point sources and area sources within each grid

* Estimates are based on all oxides of sulfur, of which the vast majority is composed of SO_2.

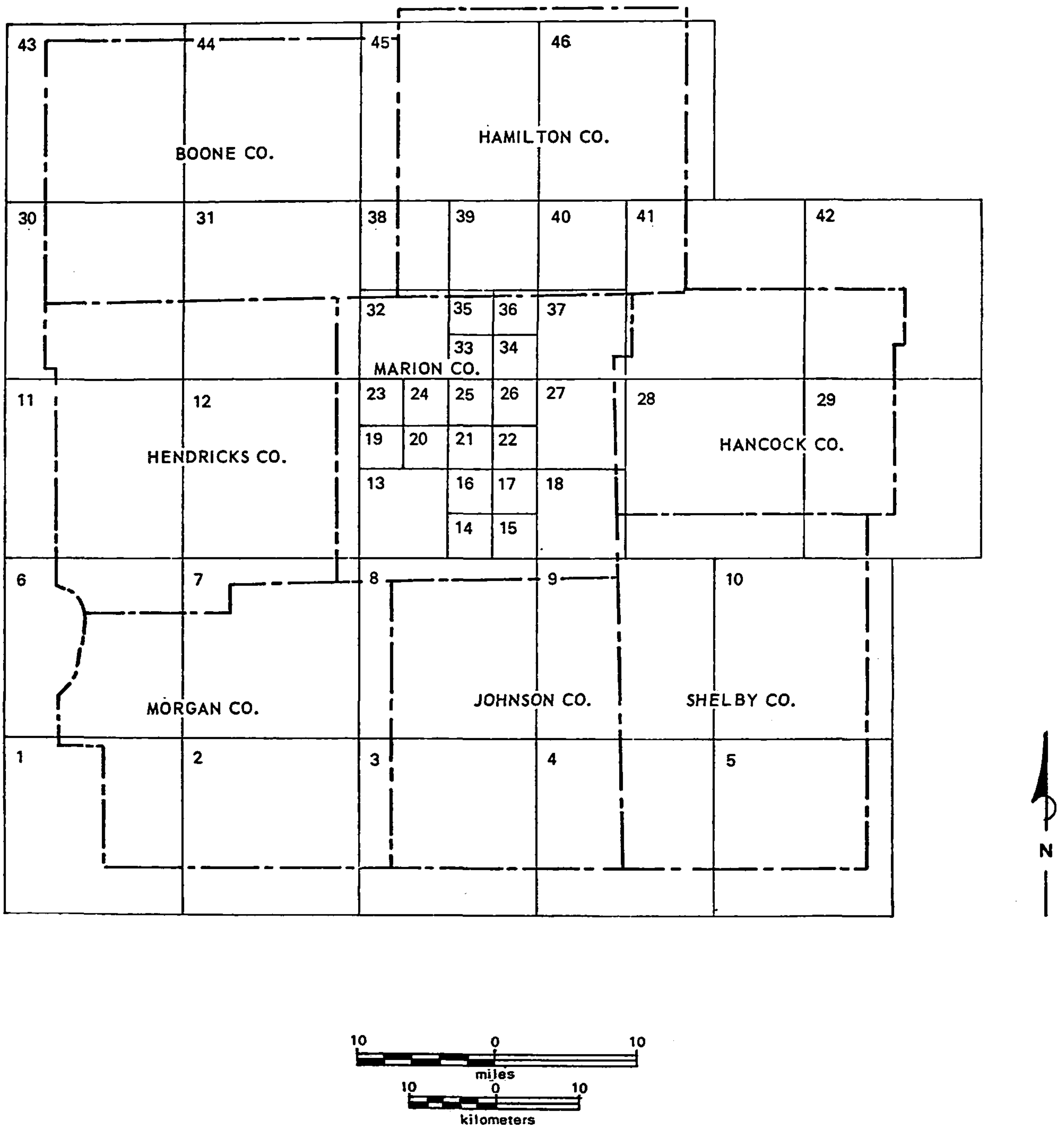

Figure 3. Indianapolis grid coordinate map.

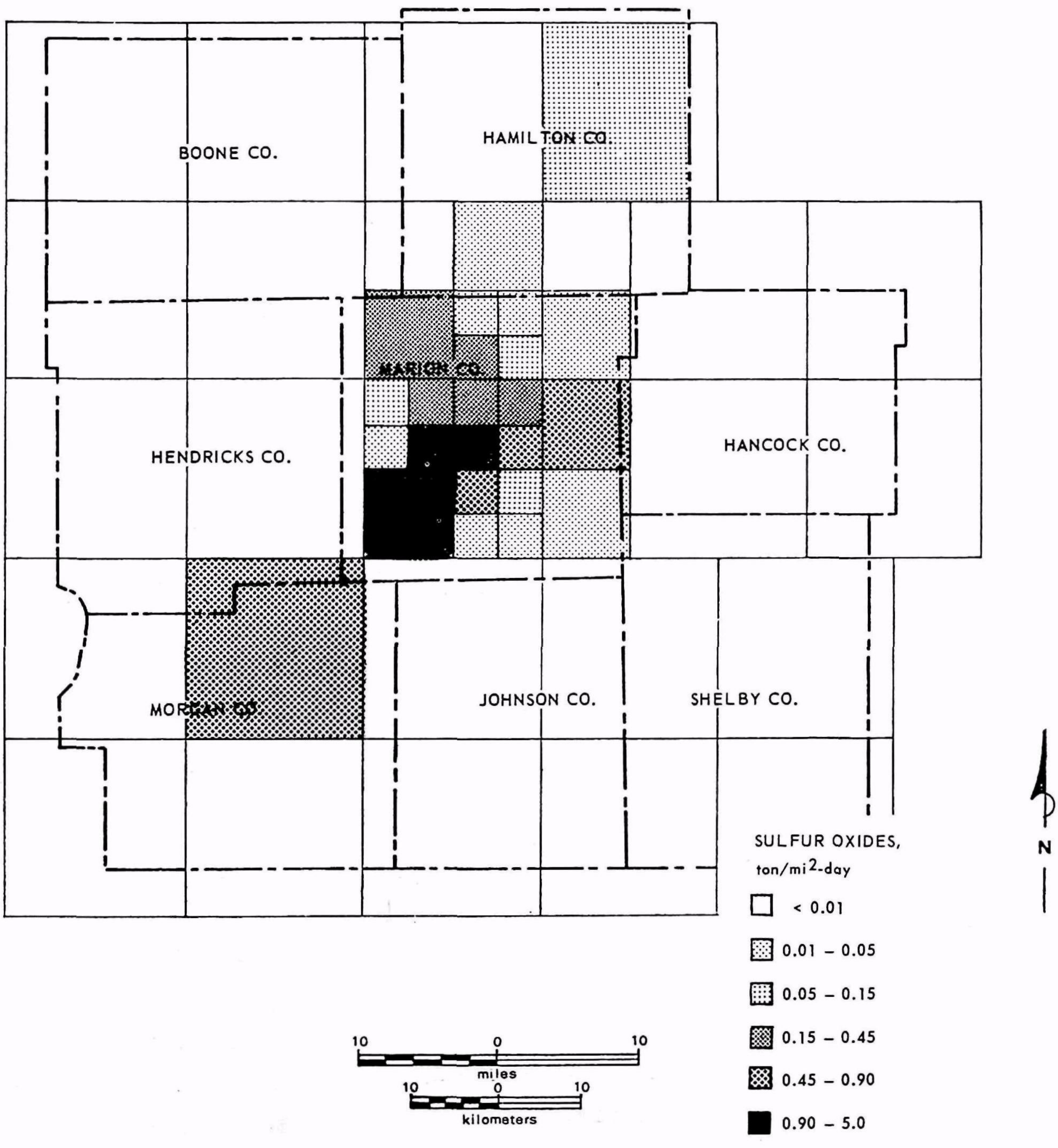

Figure 4. Sulfur oxide emission density from all sources in the Indianapolis study area, 1967.

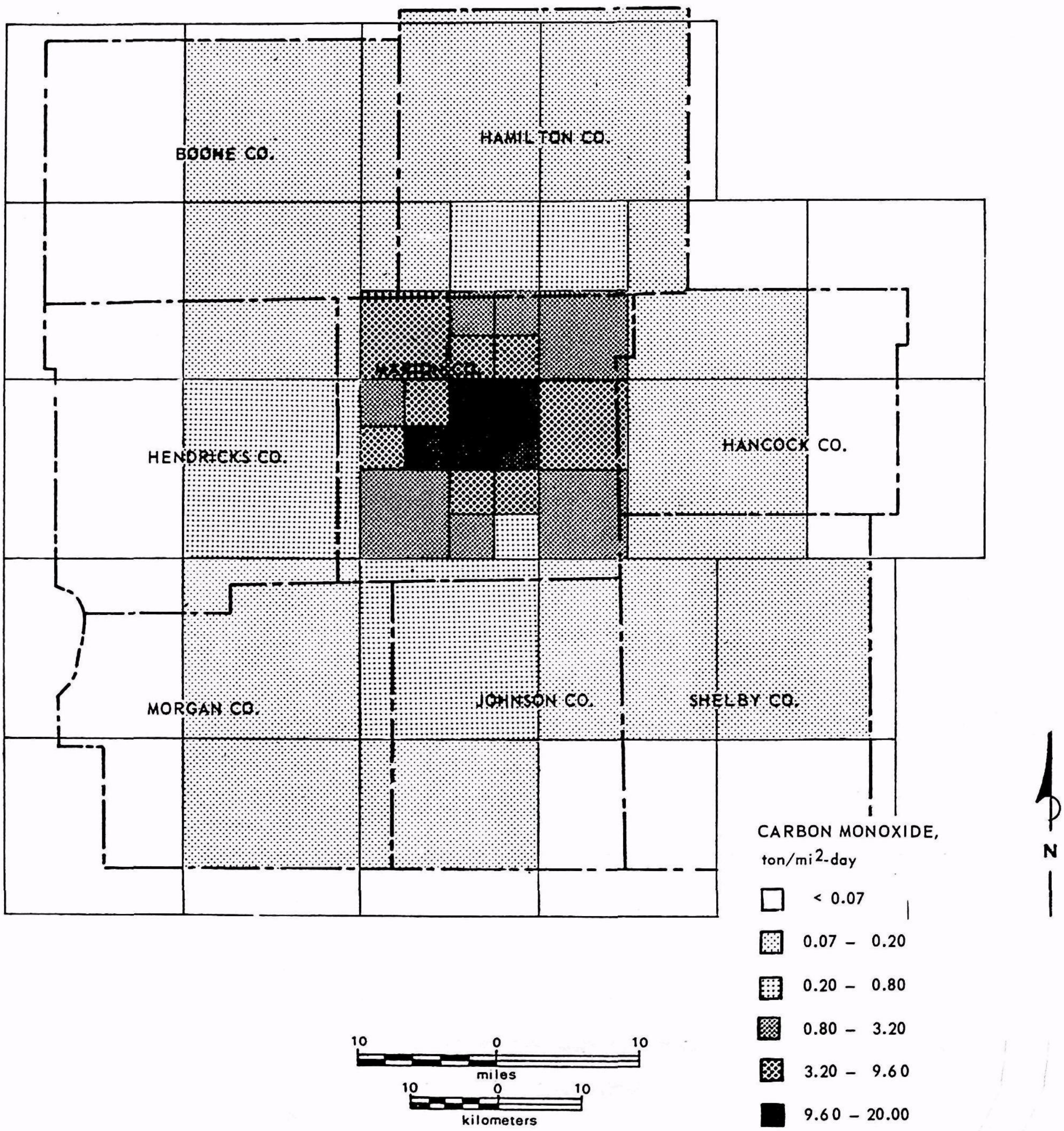

Figure 5. Carbon monoxide emission density from all sources in the Indianapolis study area, 1967.

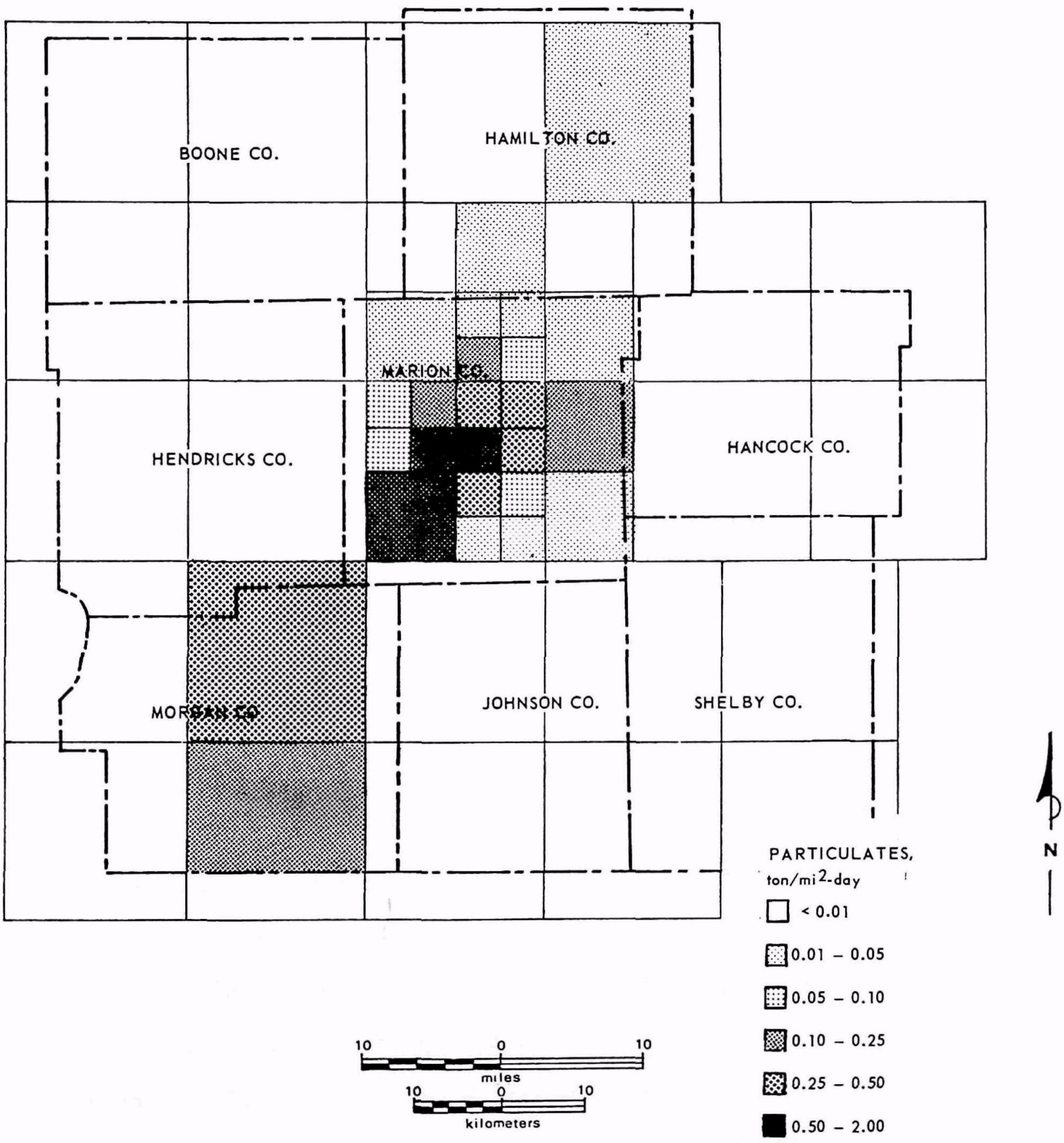

Figure 6. Particulate emission density from all sources in the Indianapolis study area, 1967.

zone. The areas of greatest pollutant emissions are located within and immediately surrounding the city of Indianapolis. The majority of the SO_2 and total particulate emissions occur within Marion County. Also, significant quantities of these two pollutants are emitted from Morgan and Hamilton Counties. The source complexes of other peripheral counties emit smaller quantities of SO_2 and total particulates. Total carbon monoxide emissions are also greatest in Marion County and are particularly dense within the city of Indianapolis. These emissions are closely related to the vehicular traffic intensity and geographic distribution. Lesser CO emissions occur in a somewhat uniform ring around Marion County. Figure 7 indicates that most major pollutant point sources (SO_2, CO and/or total particulate emissions) are located within Marion County.

AIR QUALITY ANALYSIS

Introduction

To facilitate the administration of an air resource management program, an air quality control region should include those jurisdictions containing the majority of air pollutant sources in a region as well as the majority of people and property adversely affected by the source emissions. The core area of a region can be roughly defined on the basis of pollutant point source locations and relative emission densities. However, a determination of ambient air quality is necessary in order that the peripheral pollutant receptor areas may be identified and considered for inclusion in the region. This procedure results in an essentially self-contained region,

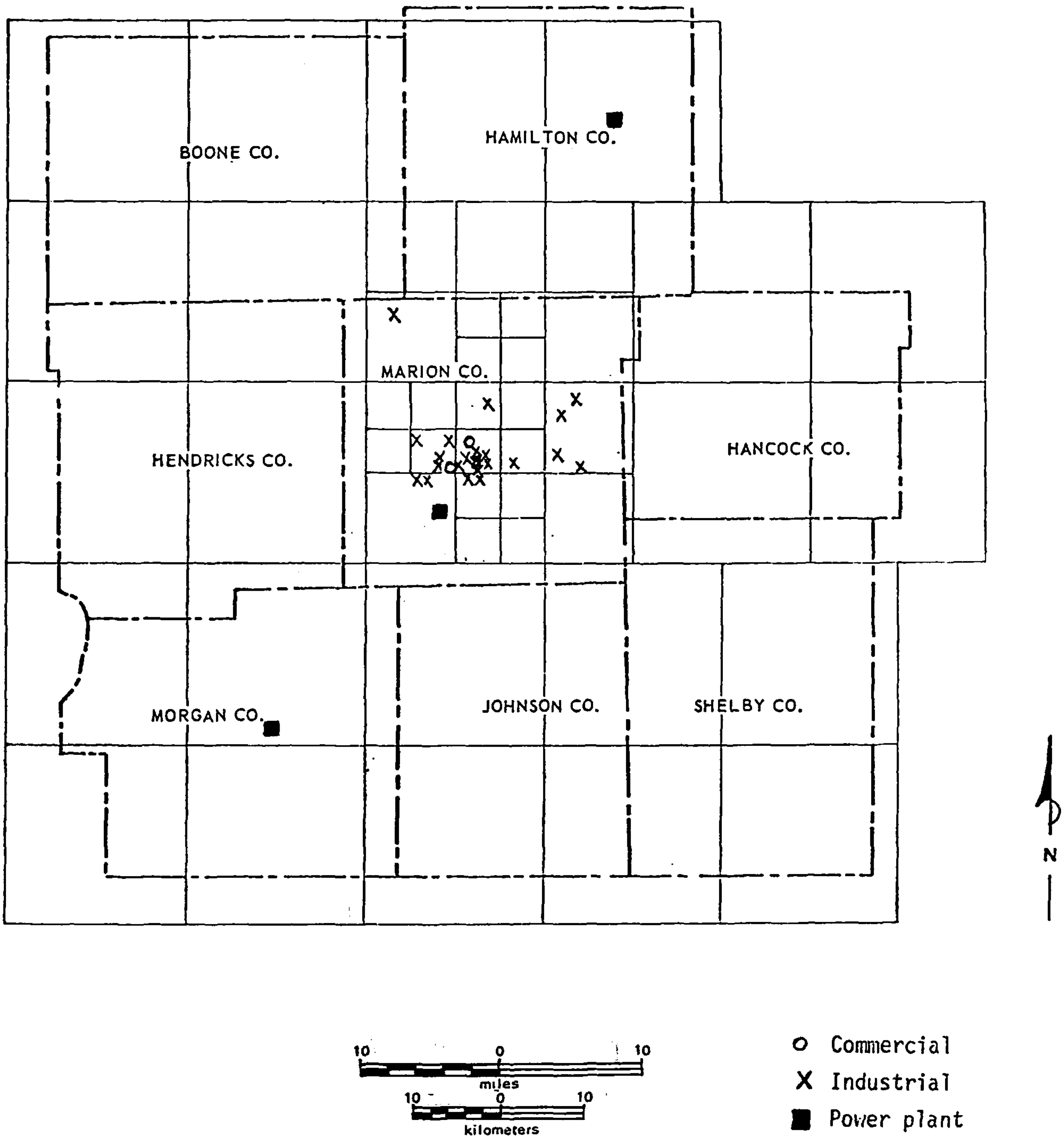

FIGURE 7. MAJOR POINT SOURCE LOCATIONS.

one which includes within its bounds virtually the entire pollutant source-receptor system for a particular area. In this way too, the possibility of pollutant transport across boundaries will be minimized. Two alternate approaches exist for the determination of air quality in metropolitan Indianapolis.

The first and most logical approach is to measure quantitatively pollutant concentrations in the ambient air. A review and evaluation of such measured data will be presented in the following section.

The second approach consists of predicting air quality, in terms of concentrations of individual pollutants, by the use of a meteorological diffusion model. This technique is particularly desirable in the Indianapolis area since existing air-sampling networks do not encompass large enough areas to be useful as guides for the establishment of the Region boundaries.

Topography, Meteorology, and Measured Air Quality

Indianapolis is located in the central part of the State of Indiana and is situated on mostly level or slightly rolling terrain. The majority of the City lies east of the White River, which flows in a generally north-south direction through Marion County. It is not likely that meteorological conditions which would create localized air pollution or air pollution of great severity would be caused directly by topographical influences.

The climate in Indianapolis is continental, with warm summers, moderately cold winters, and occasional wide variations in temperature, particularly during the colder seasons. Hot, humid weather caused by warm air masses occurs occasionally during the summer, though these air masses are soon replaced by cooler, drier air from the north. Precipitation is generally evenly distributed throughout the year. Prevailing winter winds are from the northwest (see Figure A-1, Appendix A), while prevailing summer and annual winds are from the southwest. The greatest dilution potential for pollutants in the atmosphere occurs during summer afternoons, while pollutant dilution is most restricted during summer mornings.

Air sampling in Indianapolis is conducted by the Indianapolis Bureau of Air Pollution Control and by the Indiana Air Pollution Control Board. Public Health Service stations measuring gaseous pollutants are located in the city of Indianapolis and in Monroe County (located to the south of Morgan County). The majority of the sampling has been for particulate pollution. A ten-station 1967 yearly average concentration of suspended particulates in Indianapolis was 116 $\mu g/m^3$. The PHS station located within that city recorded an average concentration of 132 $\mu g/m^3$ for the same time period. The maximum concentration of suspended particulates recorded at one station in Indianapolis in 1967 was 570 $\mu g/m^3$, based on a 24-hour average. During the same year suspended particulate concentrations exceeding 200 $\mu g/m^3$ at individual stations (24-hour average values) were not unusual. Measurements taken in the city of Anderson in Madison County produced a 1967 yearly average concentration of 93 $\mu g/m^3$. In contrast to these values, measurements at the non-urban sampling site in Monroe County produced a yearly average concentration of 51 $\mu g/m^3$. This value can be regarded as a representative background concentration for the Indianapolis area.

Thus, measurements within the cities of Indianpolis and Anderson indicate that relatively high suspended particulate concentrations exist. Diffusion model results (see Figure 8) indicate that above-background suspended particulate concentrations are not confined solely to the city of Indianapolis but affect, to some degree, the remainder of Marion County and portions of Morgan, Johnson, and Hendricks Counties.

Monitoring of sulfur dioxide concentrations in the ambient air has been limited. Stations exist in the city of Indianapolis and at the Monroe County non-urban site. The 1965 average of biweekly 24-hour average SO_2 concentrations within the city of Indianapolis was approximately .018 ppm. The comparable value for 1966 was .015 ppm, and was approximately .020 ppm for 1967. These concentrations are similar to those measurements for other major cities of approximately the same size as Indianapolis and are, as expected, lower in value than similar average SO_2 concentrations for larger cities such as Chicago and Philadelphia.[3] The 1966 mean concentration of SO_2 at the Monroe County non-urban site was .004 ppm. This represents a rough measure of the SO_2 background level in the Indianapolis area. It is clear that SO_2 measurements within the city of Indianapolis are significantly above this level.

No 1967 sampling data are available for carbon monoxide concentrations in the Indianapolis area. As a result, no validation of diffusion model results by comparison with measured CO concentrations is possible. Previous applications of the diffusion model to other urban areas considered in consultation reports have shown that the model generally tends to underestimate measured CO concentrations.

Diffusion Model Results

The meteorological diffusion model has been used to compute suspended particulate, sulfur dioxide and carbon monoxide concentrations in the ambient air at specified receptor points. The model predicts these concentrations from the mathematical treatment of pollutant emission and meteorological data.* While the model contains inherent limitations, it still has merit in providing reasonable <u>spatial distributions</u> of long term (seasonal and annual)** average pollutant concentrations.

Figure 8 shows theoretical suspended particulate concentrations in $\mu g/m^3$ for the summer averaging time. It is during this season that the greatest suspended particulate concentrations occur according to the model. The model does not consider concentrations of particulate matter from natural sources or from nearby urban areas which combined to make up the background level in the area. For this reason, the predicted concentration values shown in Figure 8 are not considered absolute. The model results are, however, considered representative of suspended particulate dispersion patterns created by emissions from the Indianapolis area source complex. Figure 8 indicates the existence of a uniform pollutant diffusion pattern centered on Indianapolis. Significantly high concentrations of particulates occur in Morgan County (south of Marion County) in the vicinity of a major point source. Source emissions are the

*See Appendix A for a more detailed discussion.
**Averaging times are as follows:

Winter: December, January, and February.
Summer: June, July, and August.
Annual: All 12 months of the year

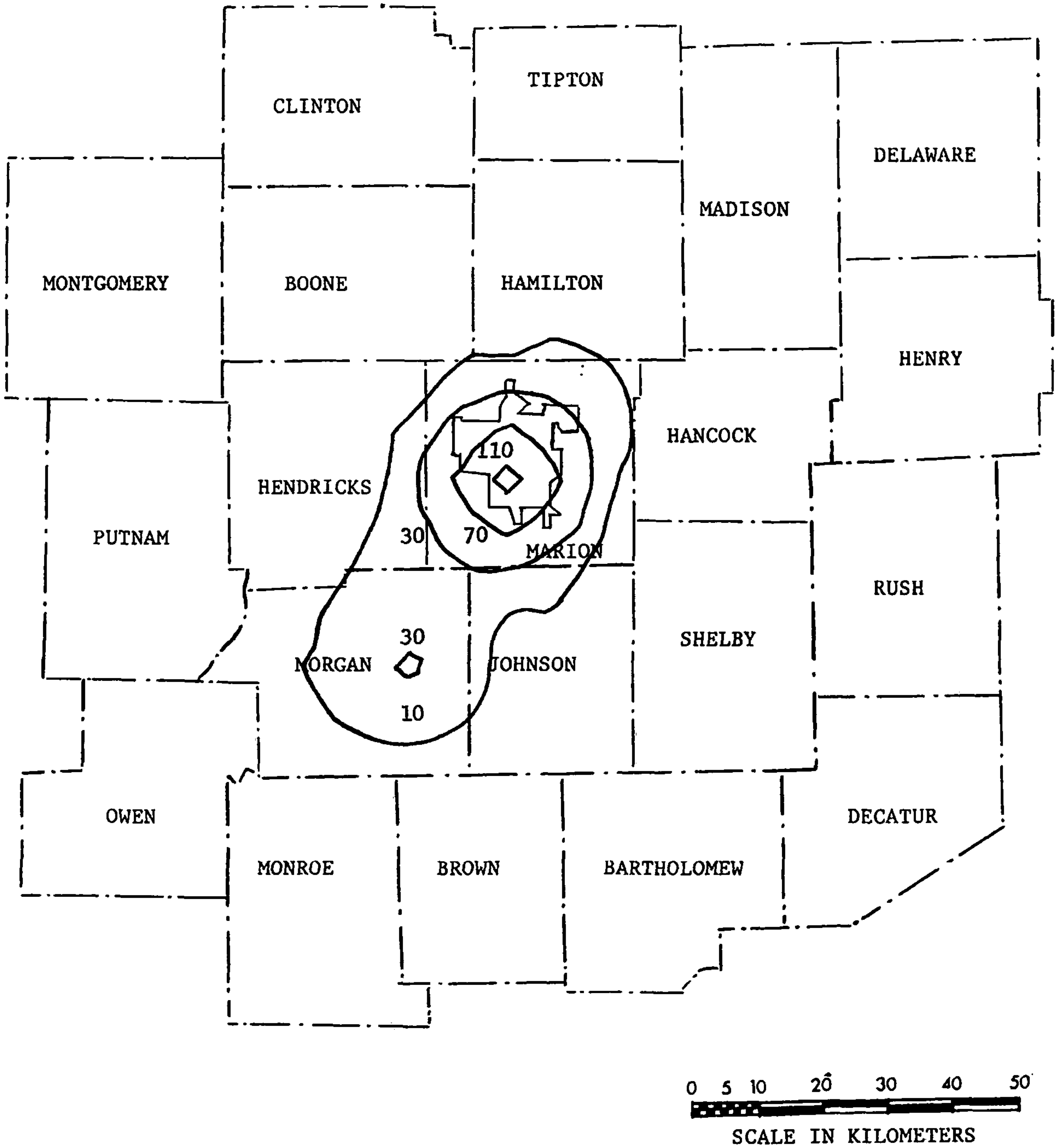

FIGURE 8. THEORETICAL SUSPENDED PARTICULATE CONCENTRATIONS IN $\mu G/M^3$, SUMMER AVERAGE.

greatest for Morgan and Marion Counties (see Table I) and ultimately affect the air quality over sizable portions of Johnson and Hendricks Counties.

Theoretical sulfur dioxide concentrations are shown in Figure 9. Results for the winter season are presented since SO_2 emissions are greatest during that season and help to create the greatest build-up of SO_2 concentrations in the ambient air. A 3-hour half-life for sulfur dioxide is used in the model as the assumed rate of decay of SO_2. This produces values which correlate best with measured concentrations. The sulfur dioxide concentrations predicted by the model appear to be overestimated on the basis of comparison with limited air quality data. The dispersion pattern of above-background levels of SO_2 is similar to that for suspended particulates. A symmetrical pattern of SO_2 equal concentration contours is predicted for Indianapolis and immediately outlying areas. A secondary peak of SO_2 concentrations occurs in Morgan County at and near the site of the large point source referred to above. As a result, a corridor of relatively high concentrations occurs from Indianapolis south to include a large portion of Morgan County and part of Johnson County.

Figure 10 shows predicted carbon monoxide concentrations based on the summer averaging time. It is suring this averaging time that greatest CO emissions occur. Partly as a result of this, greatest CO levels are predicted to occur during the summer period. As anticipated, concentrations are predicted to be highest in the city of Indianapolis where vehicular traffic density is greatest.

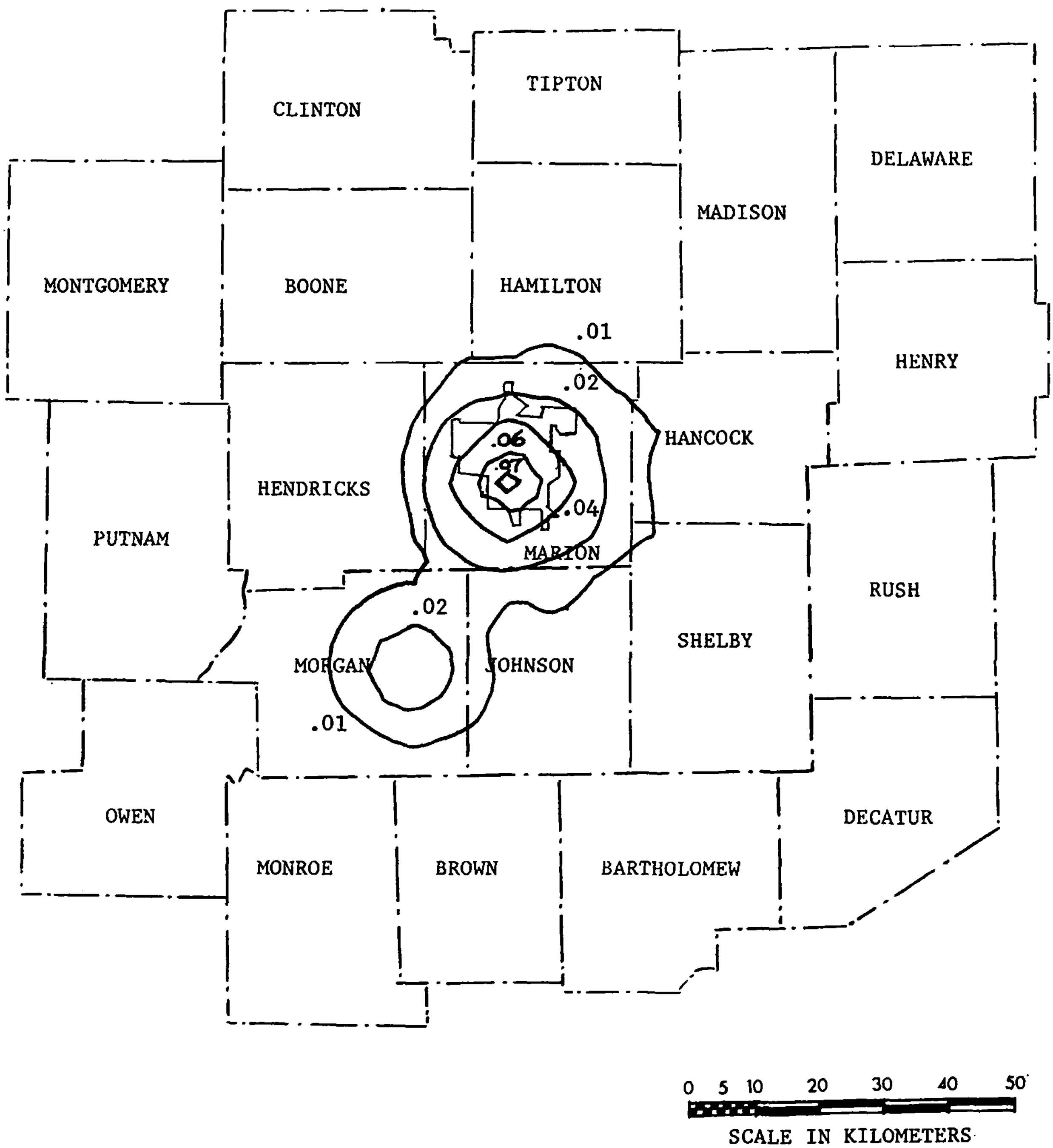

FIGURE 9. THEORETICAL SO_2 CONCENTRATIONS IN PPM, WINTER AVERAGE (ASSUMED 3 HOUR HALF-LIFE).

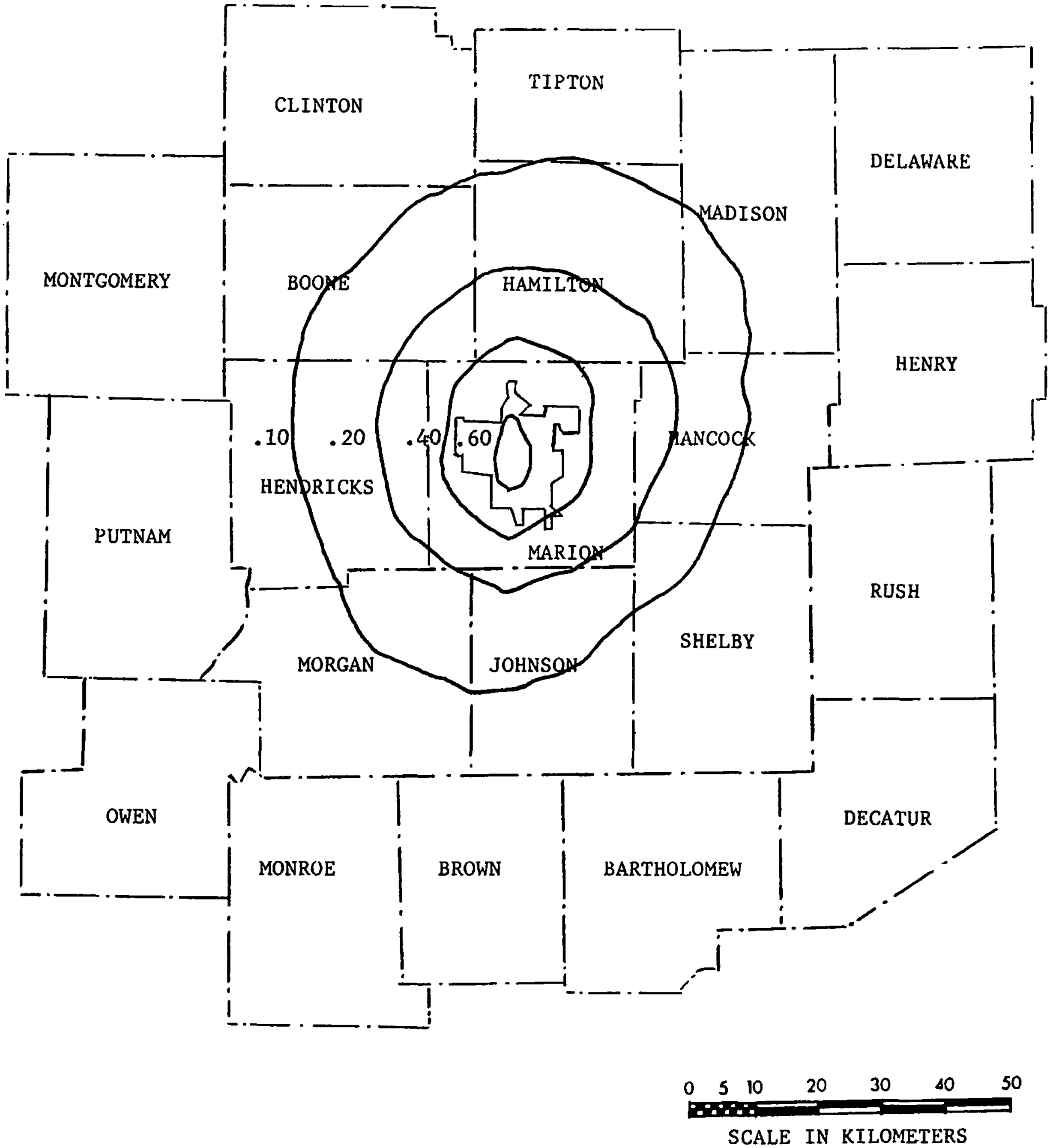

FIGURE 10. THEORETICAL CARBON MONOXIDE CONCENTRATIONS IN PPM, SUMMER AVERAGE.

Diffusion of carbon monoxide outward from the city of Indianapolis appears to be uniform in all directions. The concentration gradient decreases significantly at the 0.20 ppm isopleth. Portions of Boone, Hamilton, Madison, Hancock, Shelby, Johnson, Morgan, and Hendricks Counties are encompassed by the 0.10 ppm isopleth. Pollutant transport does appear to be slightly greater toward the northeast (Hamilton and Madison Counties) of the Indianapolis core however, as reflected by the slight elongation of the isopleths in that direction. This is logical since prevailing summer winds are from the southwest.

SUMMARY

Specific conclusions can be reached with regard to the size of the Indianapolis Region based on the consideration of pollutant emissions and measured and predicted pollutant concentrations in the ambient air. Total particulate and SO_2 emissions are greatest in Marion, Morgan and Hamilton Counties. Significant quantities of particulate matter and SO_2 are emitted from a variety of source types of Marion County. However, the primary sources of these pollutants in Morgan and Hamilton Counties are power plants. Carbon monoxide emissions are greatest in Marion County, and occur at diminished levels in those counties contiguous to Marion County (i.e., Boone, Hendricks, Hamilton, Hancock, Johnson, Morgan, and Shelby Counties).

Available air-sampling data are not extensive enough to be of much aid in determining the size of the Region. A diffusion model has been used to predict pollutant concentrations in the ambient air as an alternative to this lack of real air quality data. Equal-concentration contours for SO_2 and total particulates indicate that peak concentrations occur in Marion and Morgan Counties while sizeable portions of Johnson and Hendricks Counties are affected by lesser pollutant concentrations. Peak carbon monoxide concentrations occur in Marion County. Diffusion of CO appears to be uniform around Marion County so that large areas of Boone, Hamilton, Hancock, Shelby, Johnson, Morgan, Hendricks, and Madison Counties are affected by carbon monoxide emanating primarily from the urban core.

In general, the air pollution problem in Indianapolis is not confined solely to Marion County. Instead, this problem appears to be common to Marion County and, with varying degrees of intensity, to the counties of Boone, Hendricks, Morgan, Johnson, Shelby, Hamilton, Hancock, and Madison.

EVALUATION OF URBAN FACTORS

INTRODUCTION

The Air Quality Act of 1967 calls for the designation of air quality control regions based on "jurisdictional boundaries, urban-industrial concentrations, and other factors" in order to provide for the adequate implementation of air quality standards. The designation of air quality control regions must also be based on a consideration of existing cooperative regional arrangements, State and local air pollution control programs and enabling legislation, and patterns and rates of urban growth.

POPULATION DISTRIBUTION

Existing and potential air pollution problems can be related geographically to areas harbouring present or anticipated residential and industrial development. Similarly, air pollution problem areas can generally be identified by studying population statistics since human activity is the basic cause of air pollution. Figure 11 shows 1968 population densities by county in metropolitan Indianapolis. These population density figures (persons/square mile) are based upon county land areas and total population, as listed in Table II. At the present time, Indianapolis is the largest city in Indiana, while Marion County is the States' largest county. Present population in Marion County is approximately 762,000 persons, 515,000 of whom reside in the city of Indianapolis. The population of the 8-county Indianapolis SMSA (see Figure 14) is about 1,043,000 persons. Thus, close to three-fourths of the total population in the 8 counties

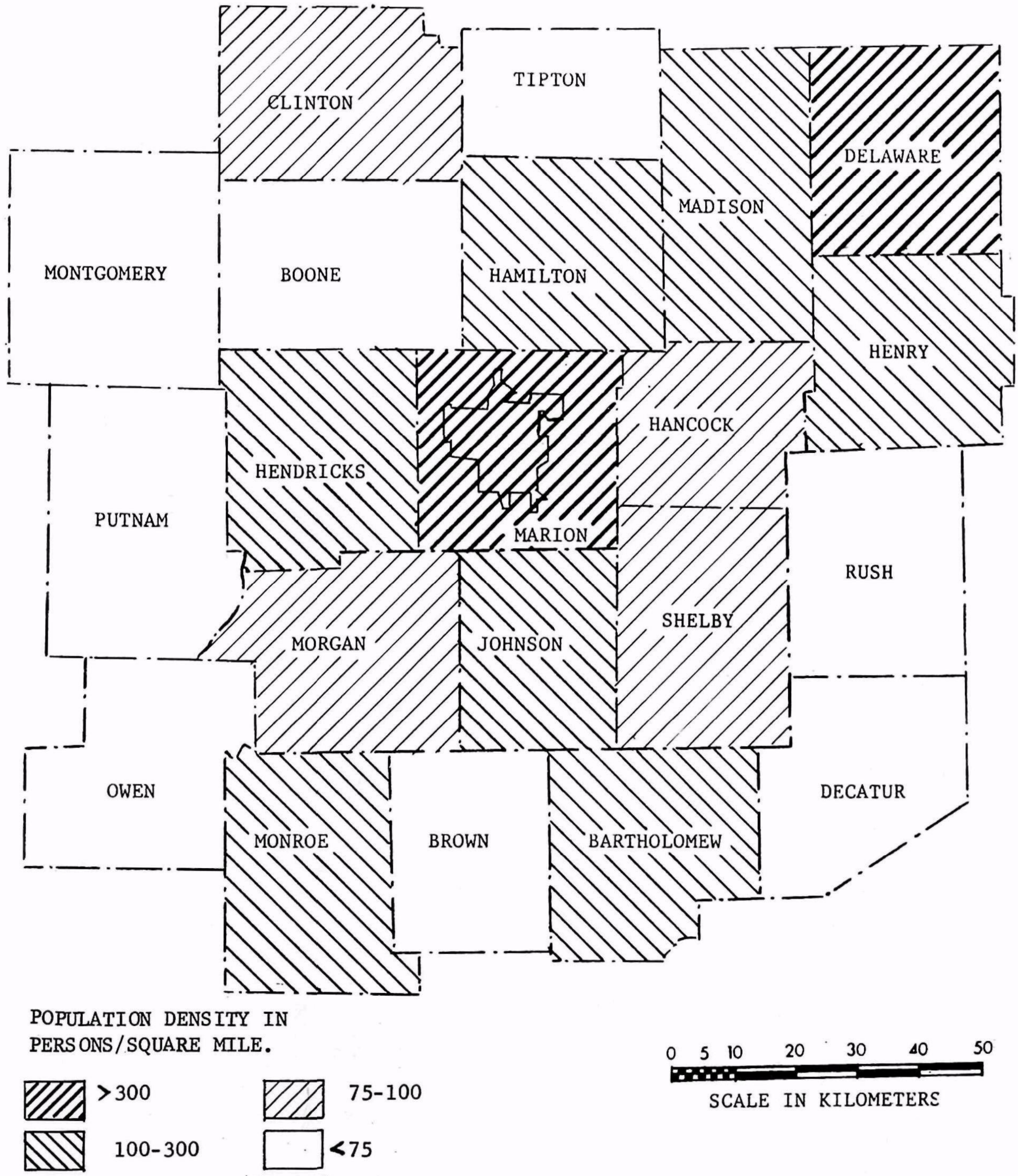

FIGURE 11. 1965 POPULATION DENSITIES.

TABLE II. PRESENT AND PROJECTED POPULATION DATA AND

MANUFACTURING EMPLOYMENT BY JURISDICTION

JURISDICTION (County)	AREA (Mi.^{2})	1968 ESTIMATED POPULATION[4]	1980 PROJECTED POPULATION[5]	1968 POPULATION DENSITY (Persons/Mi.^{2})	1980 PROJECTED POPULATION DENSITY (Persons/Mi.^{2})	ADDITIONAL RESIDENTS PER SQUARE MILE 1968-1980	1963 MANUFACTURING EMPLOYMENT	1963 MANUFACTURING EMPLOYMENT DENSITY (Persons/Mi.^{2})
Bartholomew	402	56,000	83,991	140	209	71	12,420	31
Boone	427	29,000	33,592	68	79	11	1,652	4
Brown	324	7,500	8,343	23	26	3	18	*
Clinton	407	31,800	30,041	78	74	-1	2,274	6
Decatur	370	21,500	23,787	58	64	8	1,291	3
Delaware	398	118,000	149,750	296	376	64	16,658	42
Hamilton	401	46,000	67,000	115	167	54	2,768	7
Hancock	305	31,500	46,014	99	151	52	1,198	4
Hendricks	417	48,000	90,250	115	217	110	221	*
Henry	400	53,000	53,371	133	133	8	4,641	12
Johnson	315	50,000	96,250	159	306	140	2,573	8
Madison	453	134,000	165,500	296	365	67	26,201	58
Marion	400	762,000	1,001,500	1,905	2,500	580	104,714	260
Monroe	410	69,600	86,348	170	210	51	8,233	20
Montgomery	507	32,200	39,122	64	77	11	3,856	8
Morgan	406	39,500	58,000	97	143	48	988	2
Owen	390	11,900	9,946	31	25	-4	197	*
Putnam	490	25,800	28,750	53	59	6	1,563	3
Rush	409	21,200	20,372	52	60	0	1,229	3
Shelby	409	37,000	45,750	90	112	22	3,355	8
Tipton	261	17,300	14,790	66	57	-3	875	3

*Negligible

resides in Marion County, while one-half resides in Indianapolis. Within the SMSA, and among those counties peripheral to Marion County, total population and population densities are progressively smaller in Johnson, Hendricks, and Hamilton Counties. Delaware and Madison Counties, located northeast of the Indianapolis SMSA, contain greater populations and population densities than counties within the SMSA with the exception of Marion County. Over one-half of the total population in each of these counties resides in the cities of Muncie and Anderson, respectively. All other counties on the periphery of the Indianapolis SMSA contain significantly less total populations and population densities than either Madison or Delaware Counties.

Nineteen-eighty projected population densities by county are shown in Figure 12. Population projections from which these densities were derived are shown in Table II. In addition, Table II expresses population growth by county, in terms of additional residents per square mile, for the years 1968 to 1980. Marion County is expected to undergo the greatest growth in population, followed by Johnson and Hendricks Counties. Growth for these counties is projected to be 580, 140, and 110 additional residents per square mile, respectively. Bartholomew, Madison, Delaware, Hamilton, Hancock, Monroe, and Morgan Counties, in that order, are projected to experience lesser though significant increases in population. Shelby and Boone Counties, which border Marion County, are expected to undergo relatively small increases in population. Other outlying counties at present possess relatively low population densities, and are projected to experience only small population increases, or in some instances, population decreases.

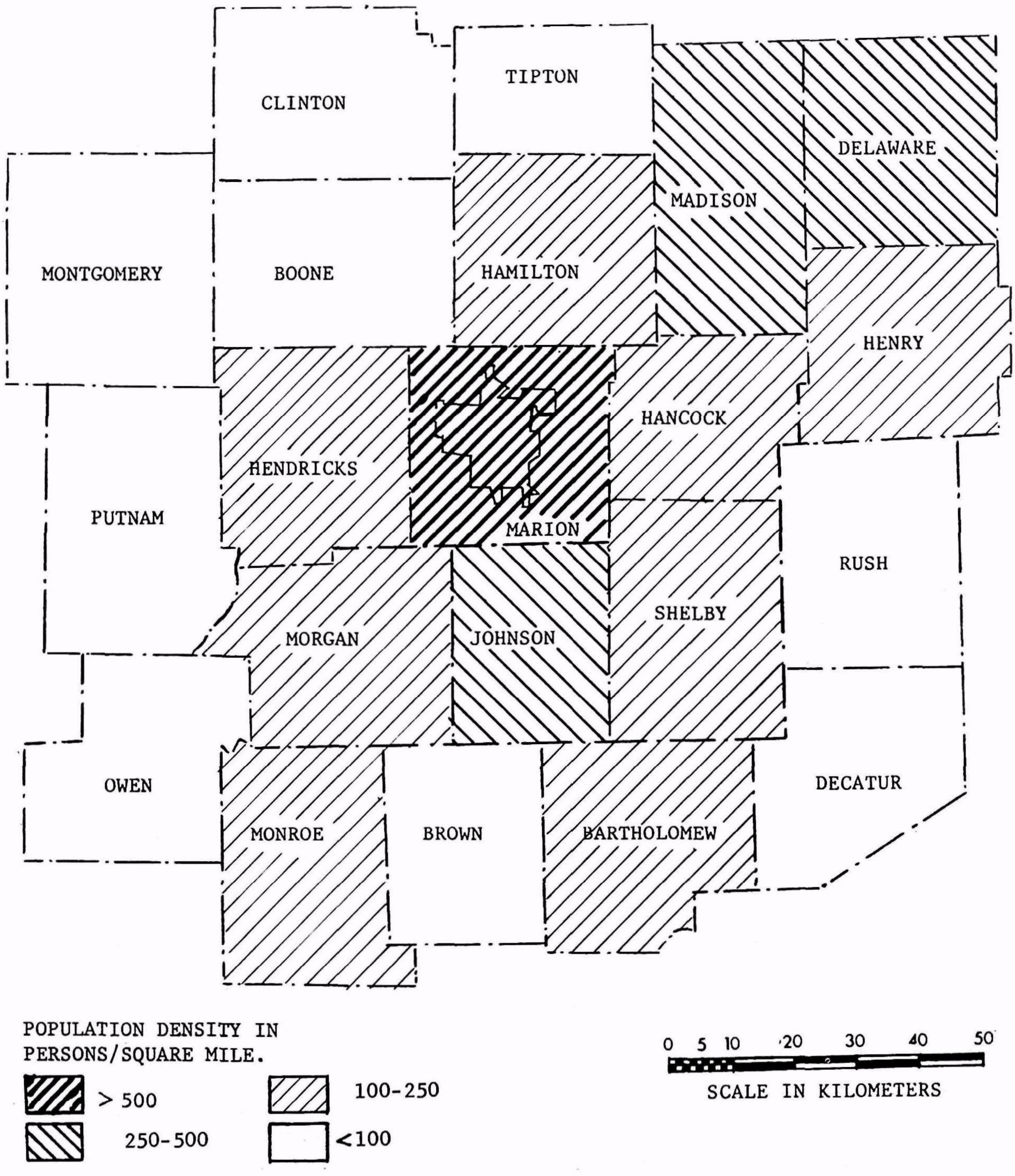

FIGURE 12. 1980 PROJECTED POPULATION DENSITIES.

Generally, the Indianapolis area will show considerable growth in the next 50 years, though it is difficult to predict exactly where this growth will occur. It is expected, however, that much of the growth will be in the counties bordering Marion County. During the early 1960's Marion County experienced slight out-migration. This is consistent with the trend showing that as commuting time is decreased by better roads, people move to surrounding areas. This will serve to increase the interdependency between the Indianapolis core and outlying counties.

INDUSTRY

The location of industrial activity is helpful in determining the size of an air quality control region since industrial sources are major contributors of air pollutant emissions. Manufacturing employment statistics have been used to determine the location of industrial activity in the Indianapolis area. Figure 13 shows 1963 manufacturing employment densities by county drawn from the total manufacturing employment statistics presented in Table II. The statistics indicate that approximately 105,000 persons are employed by manufacturing firms in Marion County; 70,000 of these are employed in Indianapolis. Within Marion County, industrial development has been closely associated with the transportation network. Industry has developed along railroad lines and along major highways. Also, a significant amount of industrial development has occurred along the White River Valley where quantities of water are available for industrial purposes. Madison County follows

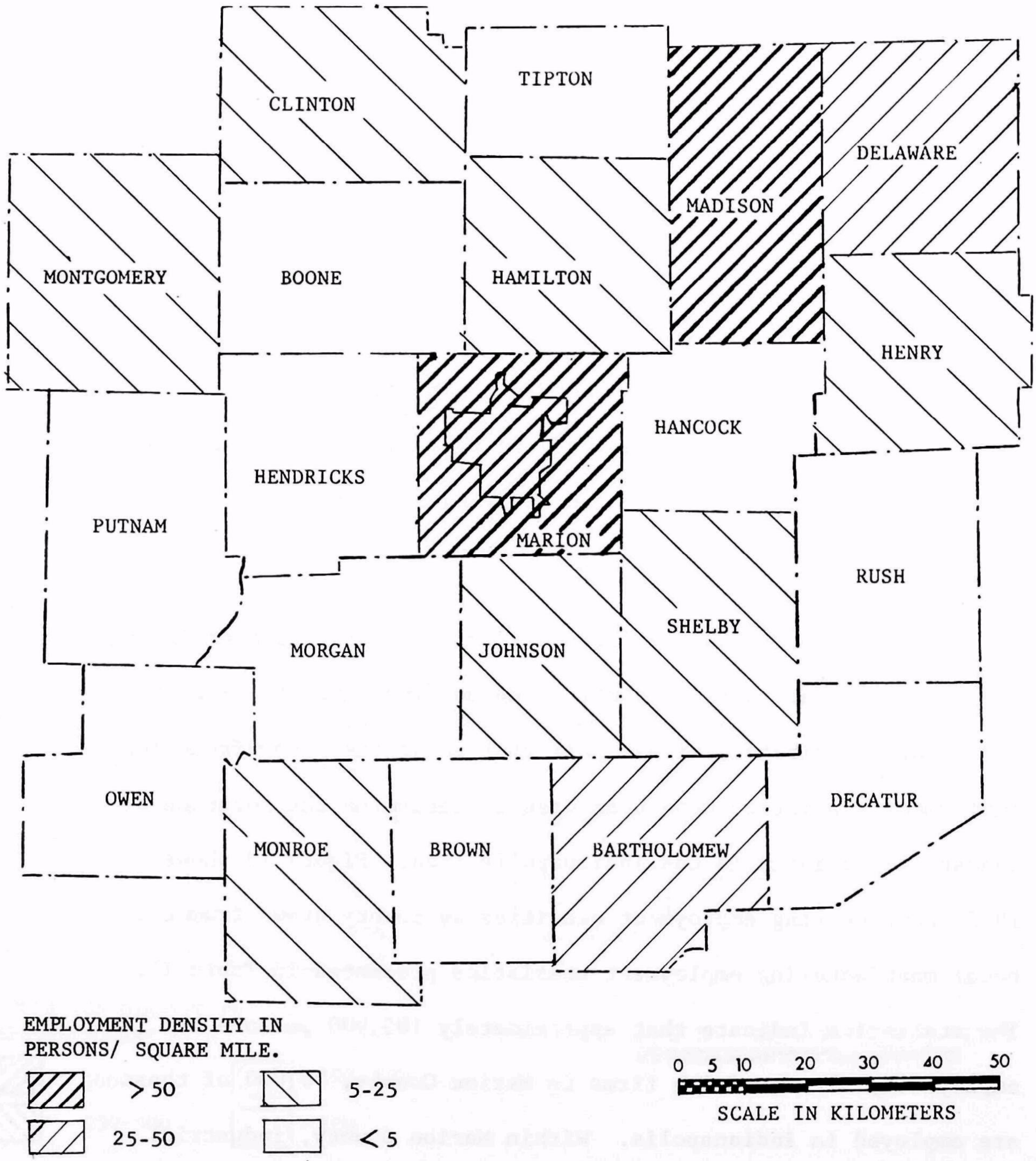

FIGURE 13. 1963 MANUFACTURING EMPLOYMENT BY COUNTY.

Marion County in size as far as the number of manufacturing employees is concerned. Delaware and Bartholomew Counties also harbour significant numbers of manufacturing employees. All other counties in the Indianapolis area, including those immediately surrounding Marion County, contain relatively few manufacturing employees.

EXISTING REGIONAL ARRANGEMENTS

The prerequisite for Standard Metropolitan Statistical Areas (SMSA's) is that they contain a core city of at least 50,000 persons and the county of that core city, as well as adjacent counties which are found to be metropolitan in character and are economically and socially integrated with the county of the central city. The boundaries of the Indianapolis, Anderson, and Muncie SMSA's are shown in Figure 14. The 1968 estimated populations of these three SMSA's are 1,043,000, 134,000, and 118,000 persons respectively. The Indianapolis SMSA includes Marion County as well as seven surrounding counties (Boone, Hamilton, Hancock, Hendricks, Johnson, Morgan, and Shelby). The Anderson and Muncie SMSA's include only the county in which those cities lie (Madison and Delaware Counties respectively). It appears that the social and economic influence exerted by Indianapolis extends beyond the borders of Marion County. At the same time, the Anderson and Muncie metropolitan areas are distinct from metropolitan Indianapolis and from each other.

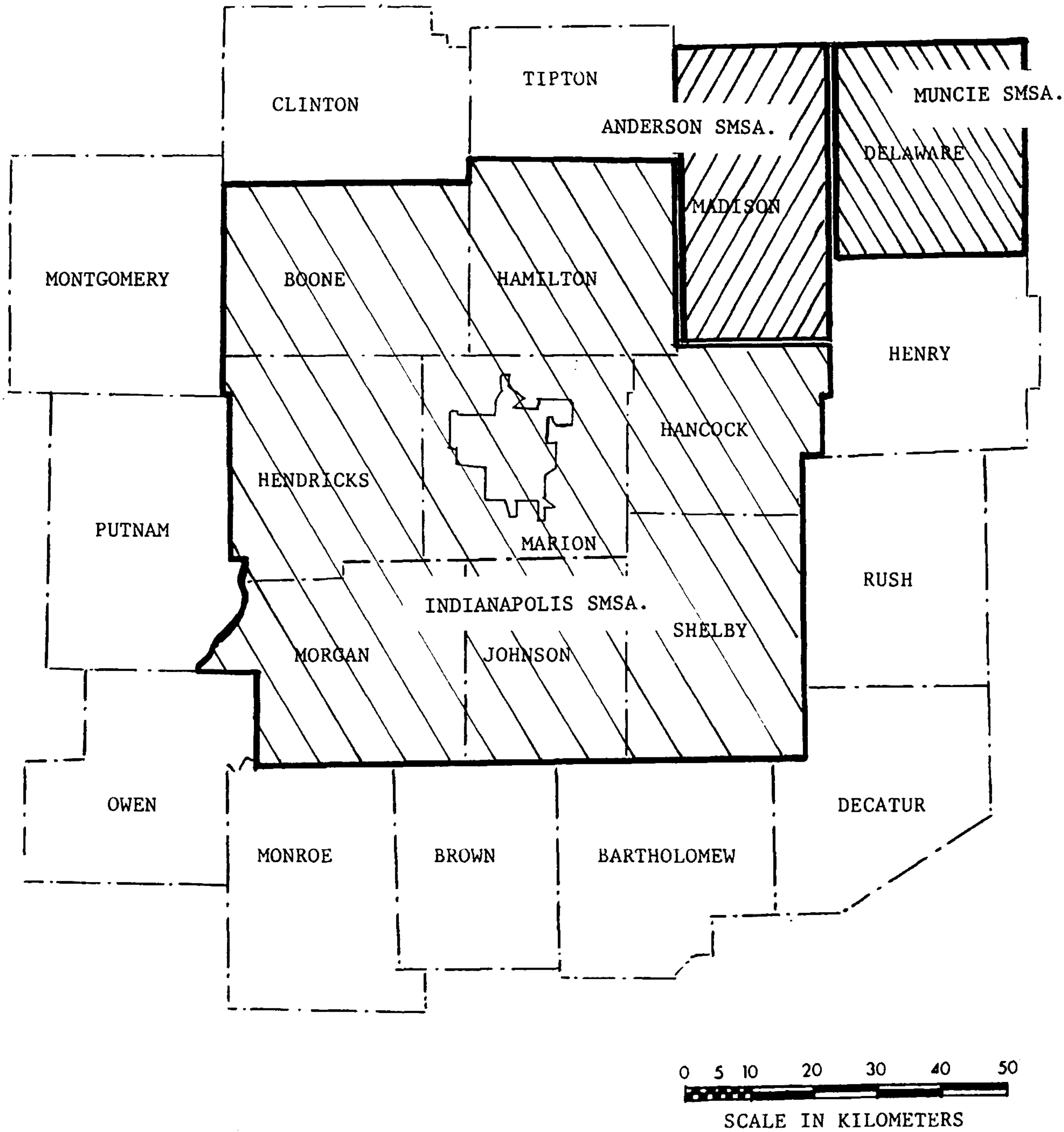

FIGURE 14. STANDARD METROPOLITAN STATISTICAL AREAS IN THE INDIANAPOLIS AREA.

Official State planning and development regions have been established by the Governor of Indiana through Executive Order No. 18-68. Fourteen such regions have been established throughout the State of Indiana. These regions were defined by the Division of Planning of the Indiana Department of Commerce on the basis of physical contiguity, commuting patterns, newspaper circulation, economic data such as income, employment and industry, as well as upon a consideration of existing regional arrangements within the State. These planning and development regions were established in order to satisfy several objectives. First, they serve as an organizational basis for data collection and analysis, and projection of population, economic and social factors related to comprehensive planning. Second, these regions serve to relate Federal programs requiring regional coordination with appropriate plans and programs. Also the planning regions will facilitate program coordination among agencies at the State level. Finally, the planning and development regions will provide a framework for regional planning and development programs. In establishing these regions it was felt that a common set of regions would provide a basis for coordination and cooperation among Federal, State, and local agencies. The planning and development region centered on Indianapolis is shown in Figure 15. This region consists of Marion County and seven additional counties, and is coextensive with the Indianapolis SMSA. Madison and Delaware Counties are included along with five additional counties in a separate planning and development region.

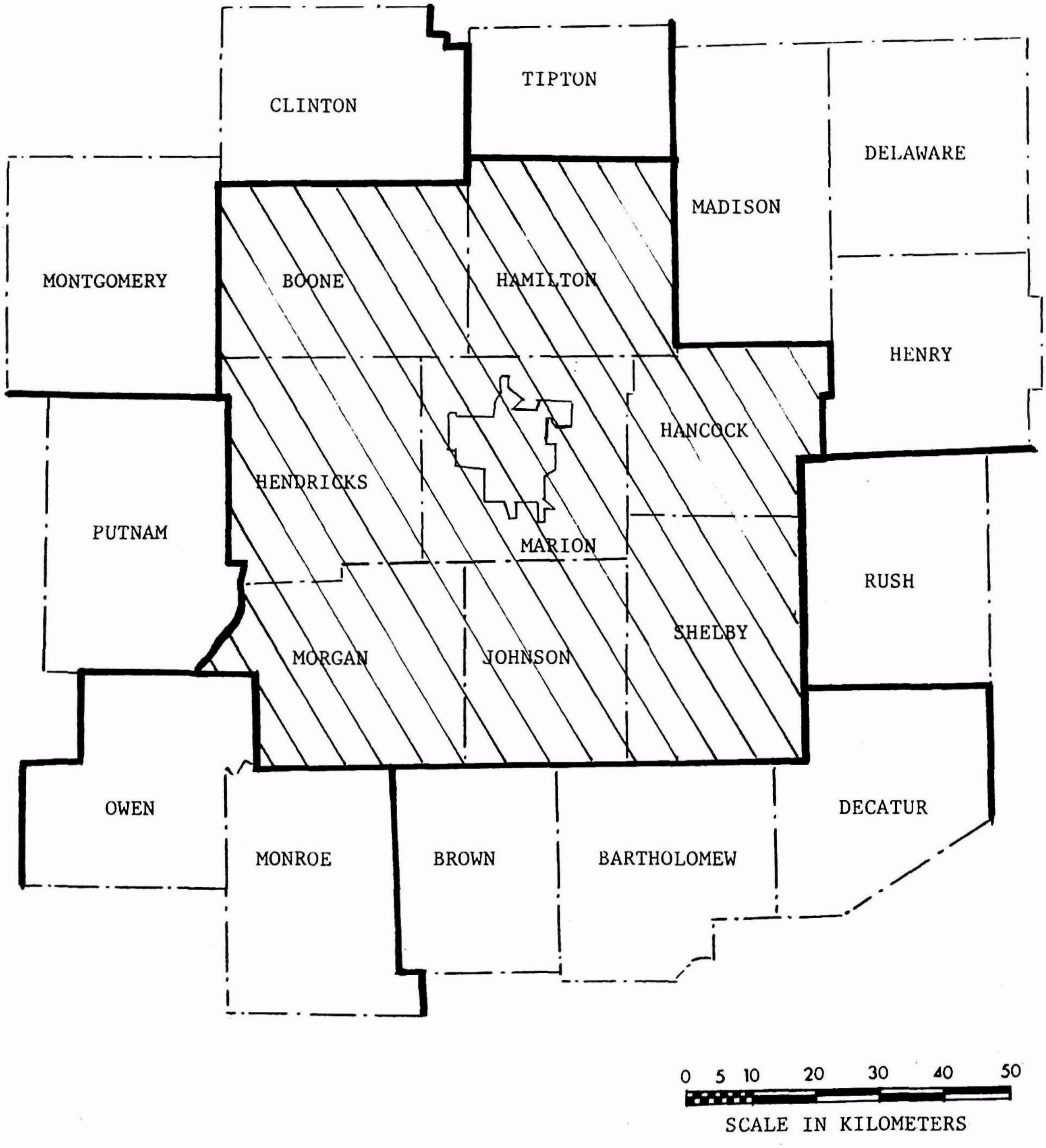

FIGURE 15. INDIANAPOLIS PLANNING AND DEVELOPMENT REGION.

EXISTING AIR POLLUTION CONTROL PROGRAMS AND LEGISLATION

In the process of defining the bounds of an air quality control region it becomes important to consider the role of existing State and local air pollution control programs. It is also important to review pertinent legislation which allows for the promulgation of air pollutant control regulations and which grants enforcement powers to agencies at the State and local levels. Such consideration of existing programs is necessary since it is upon them that the ultimate responsibility for implementing region-wide air quality standards rests.

The 1961 Indiana Air Pollution Control Law (Chapter 171, Acts of 1961) established an Air Pollution Control Board as an independent enforcement agency, and authorized the State Board of Health to consult with public and private groups, other States, and the Federal Government to prevent air pollution. The original Act has been amended by the Indiana General Assembly as set forth in Chapter 357 of the Acts of 1969. The declared intention of the Act is that primary responsibility for the control of air pollution rests with local and air quality basin control programs. The Act declares that this can be done most successfully by focusing on goals to be achieved by a maximum of cooperation among all parties concerned.

The Air Pollution Control Board is empowered to administer and carry out the adjudicatory provisions of the Act and to make investigations, consider complaints and hold hearings, and to make such determinations as are necessary to carry out the purposes of the Act. The Board may adopt rules and regulations consistent with the general intent and purposes of the Act. Rules and regulations may be adopted which would create air quality basins based upon scientific study of geographical, topographical, and meteorological data. The Board may adopt and promulgate ambient air quality standards for these air quality basins.

The State Board of Health is empowered to advise, consult, and cooperate with other agencies of the State, towns, cities, and counties, industries, other States, and the Federal government in the prevention and control of new and existing air contamination sources within the State. The Board of Health is also empowered to encourage authorized air pollution agencies of towns, cities, and counties to handle air pollution problems within their respective jurisdictions to the greatest extent possible. It is also empowered to render technical assistance to these local agencies to further air pollution control.

The Act maintains provisions for towns, cities, and counties to enforce local air pollution ordinances consistent with the provisions of the Act, and permits them to enact and enforce more restrictive ordinances to further the purposes of the Act. It allows the board of commissioners of any county to enact and enforce ordinances controlling air pollution, and further allows any city or county within an air quality basin to administer its own air pollution control program in cooperation with one or more towns, cities, or counties. The failure of an air quality jurisdiction to enforce local ordinances may prompt action by the Control Board to enforce applicable provisions of the State law.

In the city of Indianapolis responsibility for the control of air pollution rests with the Bureau of Air Pollution Control. The Bureau was established according to Air Pollution Control Ordinance No. 140, dated 1951. The jurisdiction of the Bureau encompasses the city of Indianapolis and that area within Marion County four miles from the corporate boundaries of the city. General Ordinance No. 115 (1952) prohibited the emission from any stack of pollutants which might cause injury or nuisance to any person or property at the risk of being enjoined by the courts or abated by the Bureau. A new General Ordinance No. 109 dated 1967 was enacted to provide further provisions for the control of the atmosphere in the Indianapolis area. According to this ordinance, the duties of the Director of the Bureau are to receive and institute complaints, institute enforcement actions, and cooperate with Federal, State, county, and other agencies concerned with air pollution. This Ordinance establishes the Indianapolis Air Pollution Control Board which is empowered to establish air quality objectives and to determine the need for specific controls to achieve and maintain the desired air quality. The Board may make and amend rules and regulations and set standards based on the need, technical feasibility, and economic practicability. It also is empowered to achieve compliance with the rules and regulations outlined in the Ordinance.

In summary, it appears that air pollution control legislation enacted by both the State of Indiana and the city of Indianapolis is based on a recognition of the value of cooperation between control agencies at the various levels of government. Provisions in the State Act allow for the creation of basins over which air quality standards may be established. Thus, there is an awareness at the State level of the value of controlling air pollution on a regional basis. This concept is entirely compatible with the efforts of the Federal government to establish regions over which the air resource may be administered.

SUMMARY

The evaluation of urban factors indicates that an Indianpolis Air Quality Control Region composed of the eight counties which are members of a common State planning and development region (Boone, Hamilton, Hancock, Hendricks, Johnson, Marion, Morgan, and Shelby Counties) would satisfy the objectives for air quality control region boundaries previously outlined. This eight county area has been defined as a Standard Metropolitan Statistical Area, indicating that these counties are economically and socially integrated with the core city and county (Indianapolis and Marion) and with each other. This eight county area has been established by the Governor as a State planning and development region to provide a common basis for cooperation and coordination among Federal, State, and local agencies. Existing State air pollution control legislation promotes and endorses such cooperation between control agencies at the various levels of government and between neighboring agencies at the same governmental levels. It appears logical to designate this entire eight county area for purposes of conducting a regional effort toward air pollution control since the interdependence of these counties has been established.

THE PROPOSED REGION

Subject to the scheduled consultation, the Secretary, Department of Health, Education, and Welfare, proposes to designate an air quality control region for the metropolitan Indianapolis area, consisting of the following jurisdictions in the State of Indiana:

Boone County
Hamilton County
Hancock County
Hendricks County
Johnson County
Marion County
Morgan County
Shelby County.

As so proposed, the Metropolitan Indianapolis Intrastate Air Quality Control Region would consist of the territorial area encompassed by the outermost boundaries of the above jurisdictions and the territorial area of all municipalities located therein and as defined in Section 302(f) of the Clean Air Act, 42 U.S.C. 1857h(f). Figure 16 shows the boundaries of the proposed Region while Figure 17 indicates the geographic relationship of the Region to surrounding areas.

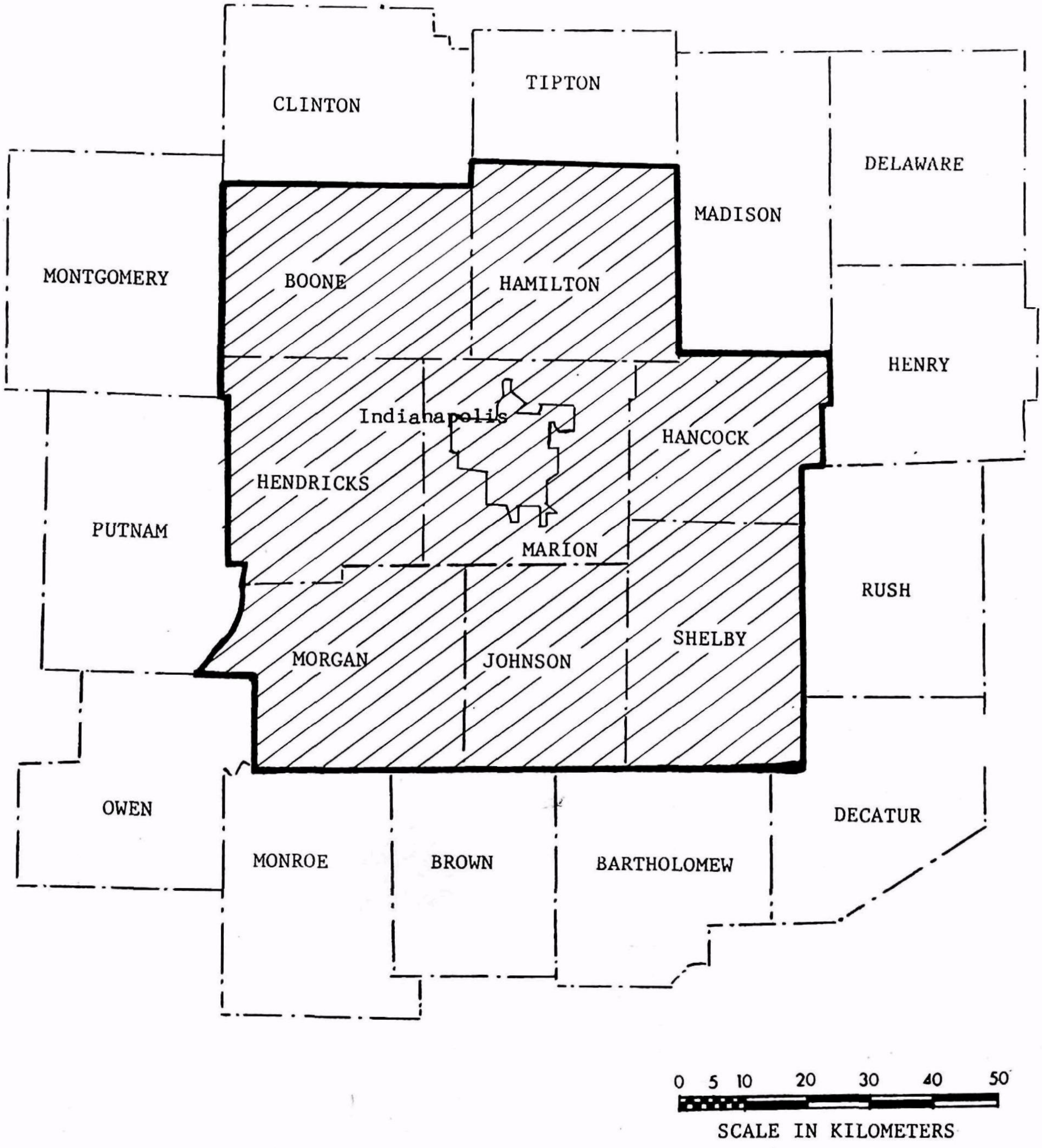

FIGURE 16. PROPOSED METROPOLITAN INDIANAPOLIS INTRASTATE AIR QUALITY CONTROL REGION.

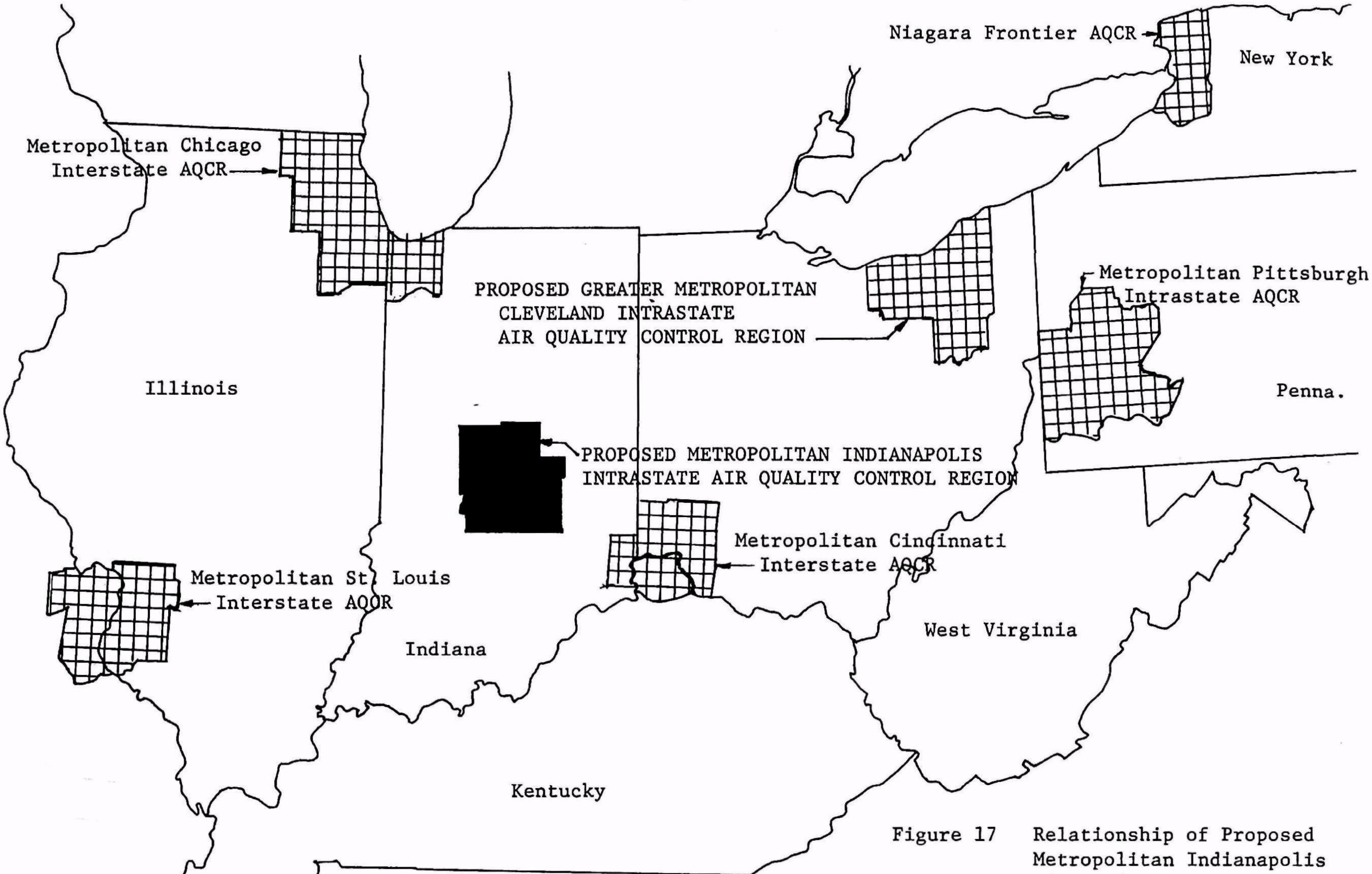

Figure 17 Relationship of Proposed Metropolitan Indianapolis Air Quality Control Region to Surrounding Areas.

DISCUSSION OF PROPOSAL

To implement a successful air resource management program, an air quality control region should be sufficiently large so as to encompass most pollution sources as well as most people and property affected by those sources. The boundaries should also encompass those locations where present and projected urbanization and industrialization will create significant future air pollution problems. Finally, the boundaries chosen should be compatible with and foster unified and cooperative regional governmental administration of the air resource. The proposed Metropolitan Indianapolis Region was designed to best satisfy these requirements.

Designation of the eight county Indianapolis Region, as proposed, will satisfy the objective that most pollutant sources and receptors in a metropolitan area be included in the same air quality control region. Greatest quantities of sulfur dioxide, total particulate and carbon monoxide pollution are emitted from Marion County. Significant quantities of SO_2 and total particulates are emitted from Morgan and Hamilton Counties. Carbon monoxide emissions are evenly distributed among those counties contiguous to Marion County (i.e., Boone, Hamilton, Hancock, Hendricks, Johnson, Morgan, and Shelby Counties). Outlying areas of these peripheral counties contribute relatively low levels of pollutant emissions. Diffusion model results reveal that the counties contiguous to Marion County are receptors of pollutants of various concentrations in the ambient air. Much of this pollution emanates from the city of Indianapolis and from the remainder of Marion County.

A review of population statistics and industrial activity indicates that the proposed region is sufficient to accommodate future expansion of both population and industry. As expected, much of the population is and will continue to be concentrated in Indianapolis and Marion County. Surrounding counties, and in particular the areas of those counties furthest from Indianapolis, have much lower population densities and industrial activity.

The eight-county Region proposed in this report coincides with the Indianapolis Standard Metropolitan Statistical Area. It also coincides with one of the States' fourteen planning and development regions. Designation of this eight-county area as an SMSA and planning region provides some indication of the interdependence of these counties to one another and to the Indianapolis core. This multi-county region should not be sub-divided insofar as regional effort toward air pollution control is concerned.

Madison and Delaware Counties, to the northeast of Marion County, contain two large cities (Anderson and Muncie respectively) and a significant amount of population and industry. There is some relation of these areas (especially Madison County) to the Indianapolis area both from the economic and social point of view. These counties are not, however, closely enough related to metropolitan Indianapolis either through "urban" factors or through a common link based on the air pollution problem, to be included in the Indianapolis Air Quality Control Region.

As is true of most efforts to draw boundaries around an area to differentiate it from its surroundings, there is always a likelihood of boundary conditions existing or developing. In the case of air quality control regions, such a boundary condition would exist where sources of pollution on one side of the region boundary affect in some real way air quality on the other side of the boundary. Relocating the boundary would only rarely provide relief from this condition. The solution is to be found in the way in which control efforts are implemented following the designation of an air quality control region. Consonant with the basic objective of providing desirable air quality within the problem area being designated as an air quality control region, the implementation plan that follows the designation should have provisions for the control of sources located close to but beyond the region boundaries. The level of control for such sources should be a function of, among other factors, the degree to which emissions from sources cause air quality levels to exceed the standards chosen for application within the air quality control region. The boundaries of the Indianapolis Region were selected so as to minimize the pollutant transport boundary problems mentioned above.

In summary, the Region proposed is considered on the whole to be the most cohesive and yet inclusive area within which an effective regional effort can be mounted to prevent and control air pollution in the Indianapolis metropolitan area.

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APPENDIX A. DESCRIPTION OF DIFFUSION MODEL.

The diffusion model is based on the Gaussian diffusion equation, described by Pasquill[1,2] and modified for long-term averages[3,4] for application to the multiple-source situation typical of an urban complex. The basic equation assumed that the concentration of a pollutant within a plume has a Gaussian distribution about the plume centerline in the vertical and horizontal directions. The dispersion of the plume is a function of the emission rate, effective source and receptor heights, atmospheric stablility and the distance from the source. The plume is assumed to move downwind according to the mean wind.

The model was used to predict concentrations of SO_2, and CO, and total suspended particulates. The averaging times were the summer and winter seasons and the year. In order that the theoretical pollutant levels could be determined, it was necessary to evaluate certain meteorological input parameters. These parameters are wind direction and frequency of occurrence in each direction, effective wind speeds for each direction, and mixing depths for various averaging times.

Figure I-A shows the wind roses for the summer, winter, and year for the Indianapolis area*. They represent graphically the frequency of occurrence of the wind from the various compass directions. This data, along with effective wind speeds for the respective compas directions

*U.S. Weather Bureau Data for Weir Cook Airport, 1951 through 1960.

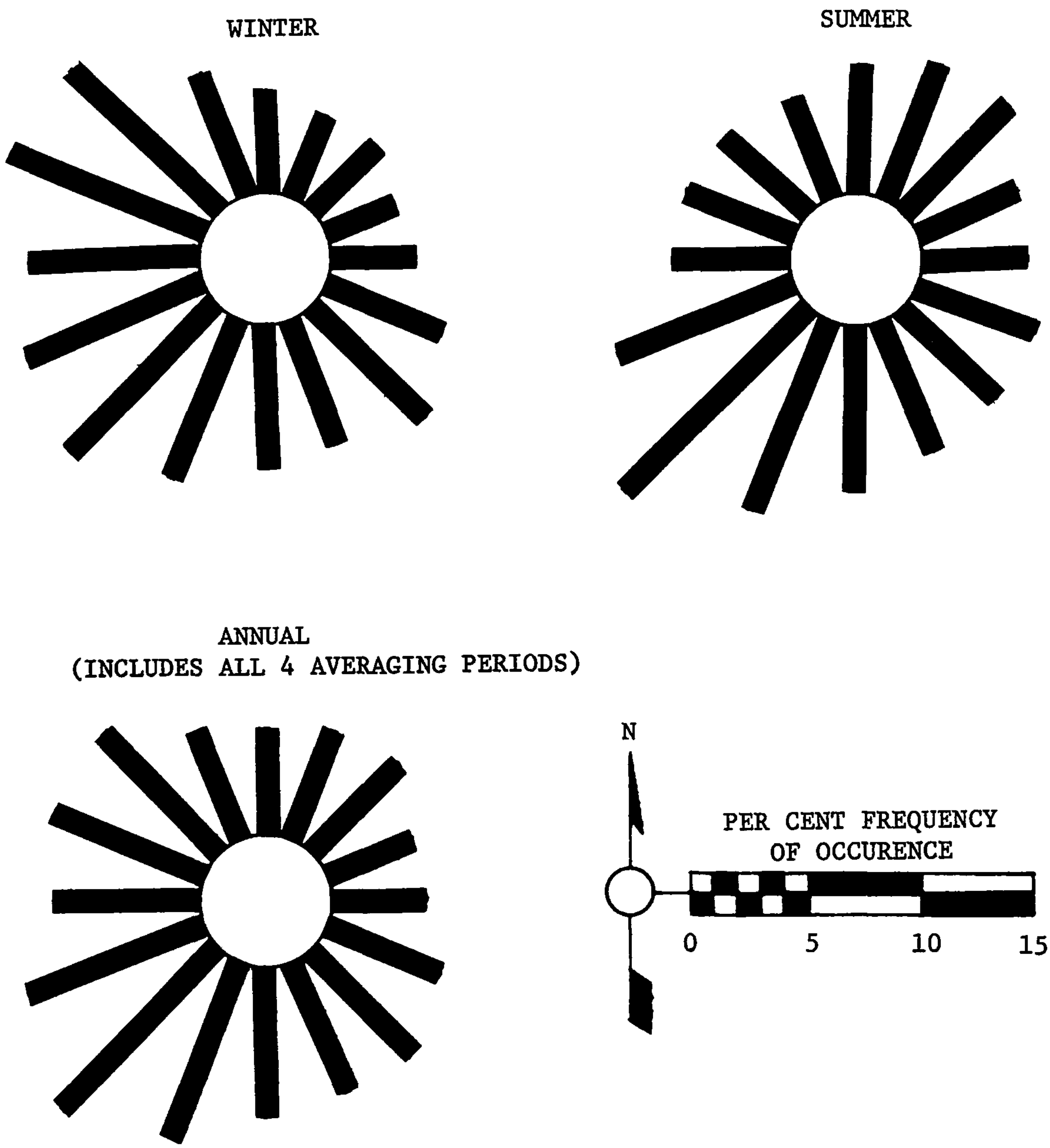

FIGURE 1-A. WIND DIRECTION PER CENT FREQUENCY OF OCCURENCE FOR VARIOUS AVERAGING TIMES.

was used as input data to the computerized model. The characteristic prevailing wind directions for each of the averaging times as depicted by the length of the wind rose radials, produce a direct influence over the dispersion of pollutants.

Table I-A shows average mixing depths for the winter, summer, and annual averaging periods*. A significant diurnal variation in the mixing depth is indicated. These mixing depths define the volume of air above the surface through which pollutants are allowed to mix, and are assumed to have no spatial variation (i.e., mixing depth is constant) over the receptor grid system.

Table I-A.

Average Mixing Depths for Metropolitan Indianapolis by Season and Time of Day (meters).

Season	Morning Average	Afternoon Average	Average, Morning and Afternoon
Winter	430	700	565
Summer	320	1590	955
Annual (four seasons)	390	1262	826

*Computed mixing depths documented by Holzworth[5,6] and by recent tabulations furnished to the Meteorological Program, NAPCA, by the National Weather Record Center, ESSA.

The diffusion model was used to compute the ground level concentrations of pollutants at 225 receptor points. Their locations were defined by an orthogonal grid system with mesh points 15 kilometers apart. This grid, 210 km. on a side, was centered in the city of Indianapolis. An effective source height of 75 meters was assumed for all pollutant point sources, while topographical features were neglected for area-source emissions and for the 225 receptor points.

APPENDIX A. REFERENCES

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