REPORT FOR CONSULTATION ON THE METROPOLITAN HOUSTON-GALVESTON INTRASTATE AIR QUALITY CONTROL REGION (TEXAS)

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service

REPORT FOR CONSULTATION ON THE

HOUSTON-GAVELSTON

INTRASTATE AIR QUALITY CONTROL REGION

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National Air Pollution Control Administration
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SECTION I

THE REGIONAL APPROACH TO AIR QUALITY CONTROL AND A FEDERAL PROPOSAL FOR THE HOUSTON-GALVESTON REGION

PREFACE

The Secretary, Department of Health, Education, and Welfare, is directed by the Clean Air Act, as amended, to designate "air quality control regions" prior to the adoption by the State(s) of air quality standards and plans for the implementation of the standards. In addition to listing the major factors to be considered in the development of region boundaries, the Act stipulates that the designation of a region shall be preceded by consultation with appropriate State and local authorities.

The National Air Pollution Control Administration (NAPCA) recently established a new policy by which States may propose to the Federal Government boundaries for air quality control regions. The Texas Air Control Board is the first state agency to initiate proposals for region boundaries under the new policy. The Air Control Board, with assistance from NAPCA, has conducted a study of the Houston-Galveston metropolitan area, the results of which are presented in the body of this report. The Region boundaries proposed in the report reflect consideration of available and pertinent data; however, the boundaries remain subject to revision suggested by consultation between Federal, State, and local authorities. Formal designation will be withheld pending the outcome of the meeting. This report is intended to serve as the starting point for the consultation.

THE REGIONAL APPROACH

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 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), Air Quality Act of 1967

Air Pollution, because of its direct relationship to people and their activities, is an urban problem. Urban sprawls often cover thousands of square miles; they quite often include parts of more than one state and almost always are made up of several counties and an even greater number of cities. Air pollution, therefore, also becomes a regional problem, and the collaboration of several governmental jurisdictions is prerequisite to the solution of the problem in any given area. Air quality control regions called for in the above-quoted section of the Air Quality Act of 1967 are meant to define the geographical extent of air pollution problems in different urban areas and the combination of jurisdictions that must contribute to the solution in each.

The regional approach set up by the Air Quality Act is illustrated in Figure 1. The approach involves a series of steps to be taken by Federal, State, and local governments, beginning with the designation of regions, the publication of air quality criteria, and the publication of information on available control techniques by the Federal Government. Following the completion of these three steps, the Governors of the States affected by a region must file with the Secretary within 90 days a letter of intent, indicating that the States will adopt within 180 days ambient air quality standards for the pollutants covered by the published criteria and control technology documents and adopt within another 180 days plans for the implementation, maintenance, and enforcement of those standards in the designated air quality control regions.

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 reserves approval authority, the States involved in a designated region assume the responsibility for developing standards and an implementation plan which includes administrative procedures for abatement and control.

Criteria for Determining Region Size

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 as well as most of the people and property affected by those sources.

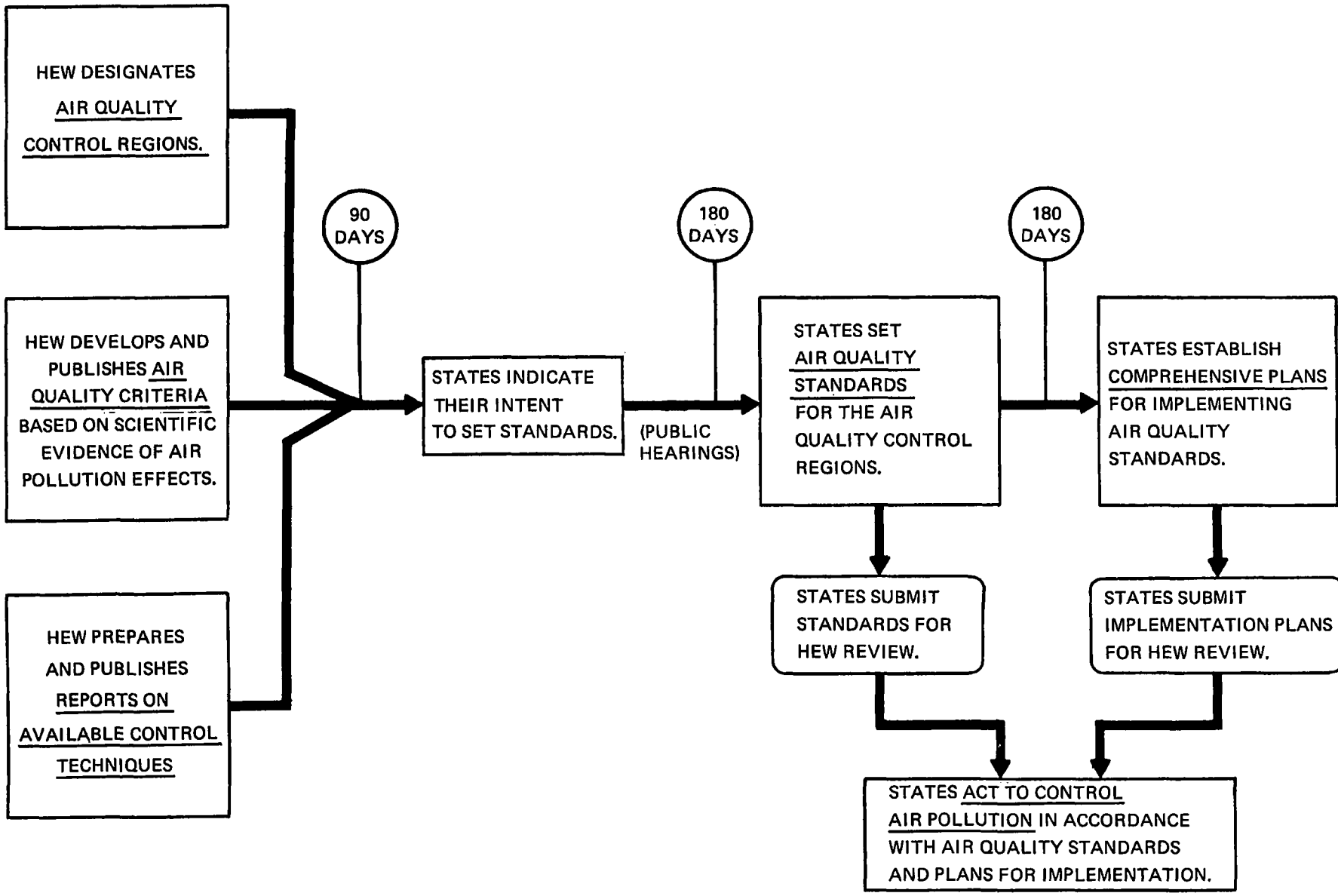

Figure 1 FLOW DIAGRAM FOR ACTION TO CONTROL AIR POLLUTION ON A REGIONAL BASIS,

In this way, all the major elements of the regional problem will be 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 judgment. The judgment 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 better measures 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, and provide a way of maintaining areas now favored by clean air. 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. The pattern of cooperation among existing air pollution control programs is a relevant factor. The existing boundaries of regional planning agencies or councils of government may also become an important consideration. 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 is 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.

Procedures for Designating Region Boundaries

Figure 2 summarizes the procedure used by the National Air Pollution Control Administration for designating air quality control regions whose boundaries are proposed by the State.

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 study of "Engineering Factors" indicates the location of pollution sources and the geographic extent of serious pollutant concentrations in the ambient air. Pollution sources are located by an inventory of emissions from automobiles, industrial activities, space heating, waste disposal, and other pollution generators. Pollution concentrations in the ambient air are estimated from air quality sampling data and from a theoretical diffusion model. When it exists, air quality sampling data is more reliable than the theoretical diffusion model results since the data is directly recorded by pollution measuring instruments. Unfortunately, in many cases extensive air quality sampling data is unavailable in the rural areas surrounding an urban complex.

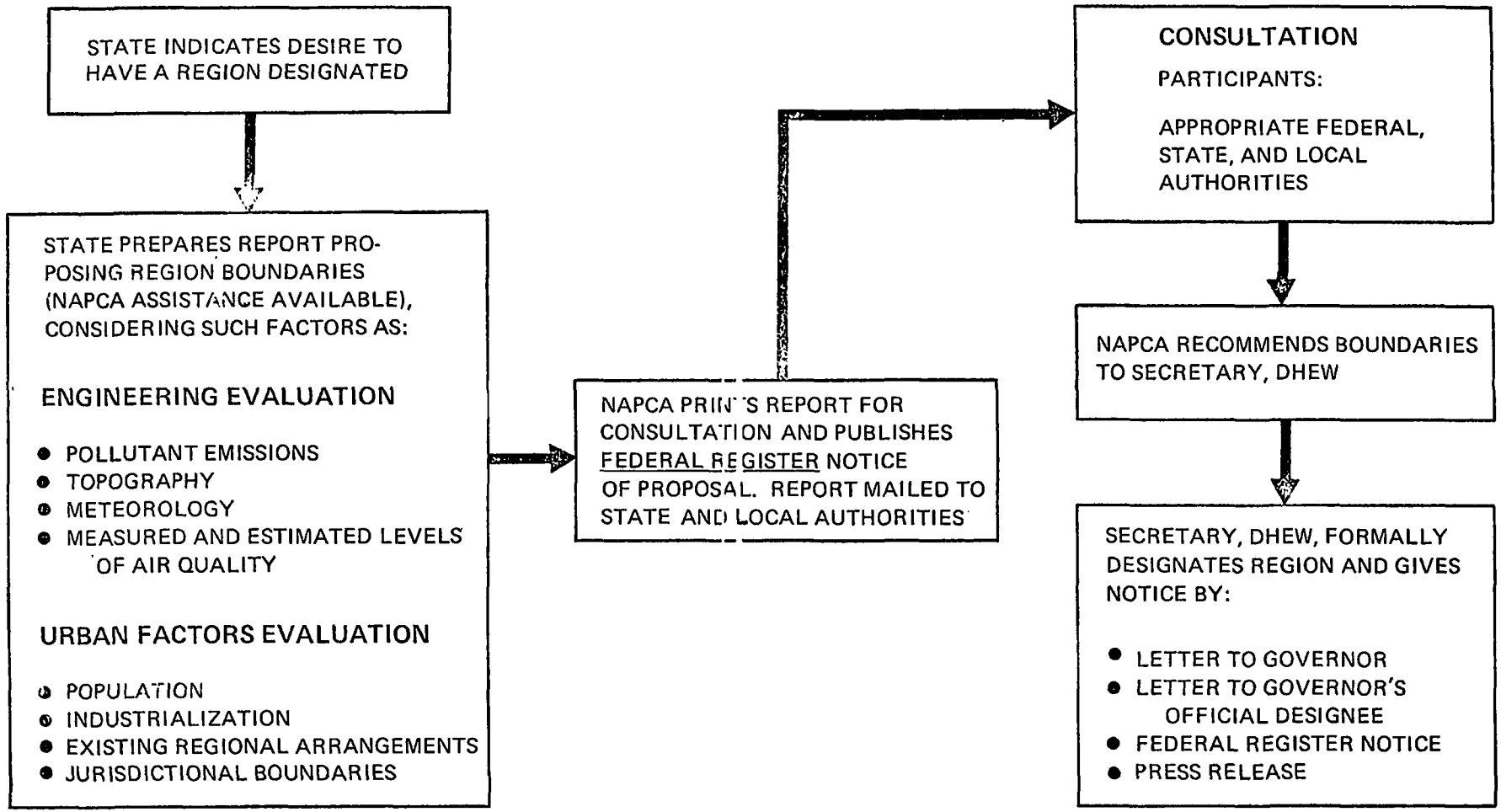

Figure 2. FLOW DIAGRAM FOR STATE-INITIATED AIR QUALITY CONTROL REGIONS.

The study of "Urban Factors" encompasses non-engineering considerations. It reviews existing governmental jurisdictions, current air pollution control programs, present concentrations of population and industry, and expected patterns of urban growth. Other non-engineering factors are discussed when they are relevant. As a whole, the study of urban factors indicates how large an air quality control region must be in order to encompass expected growth of pollution sources in the future. It also considers which group of governmental jurisdictions will most effectively administer a strong regional air quality control region program.

The conclusions of the engineering study are combined with the results of the urban factors study to form the basis of an initial proposal for an air quality control region. As shown in Figure 2, the proposal is then submitted to NAPCA for review and printing.

The report is mailed to State and local authorities in preparation for the consultation between appropriate Federal, State, and local officials. After reviewing the suggestions raised during the consultation, the Secretary formally designates the region with a notice in the Federal Register and notifies the Governor(s) of the State(s) affected by the designation.

Section II of this report and the proposal therein were prepared by the Texas Air Control Board. The report itself is intended to serve as the background document for the formal consultation.

THE FEDERAL PROPOSAL

The National Air Pollution Control Administration has reviewed the proposal and supportive discussion prepared by the Texas Air Control Board. NAPCA concurs with the findings of the Board and proposes to include Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties in the Metropolitan Houston-Galveston Intrastate Air Quality Control Region.

The three objectives outlined in the subsection entitled "Criteria for Determining Region Size" are met by the proposed delineation. Most pollution sources and receptors are located in four of the eight counties--Brazoria, Fort Bend, Galveston, and Harris. However, all eight counties have population and industrial growth potential.

The National Air Pollution Control Administration encourages the establishment of air quality control regions which correspond to, or are compatible with, State or locally defined planning regions. Such designation may be realized in those instances where the air pollution problem area lies within the bounds of the planning agency; this is the case in the Houston-Galveston area. The Region as proposed is coterminous with the jurisdictional boundaries of the Houston-Galveston Area Council of Governments. The Council of Governments may be capable of providing assistance in the development of air quality standards and implementation plans which recognize the close relationship

between air resource management, transportation, land-use patterns, solid-waste disposal, and other urban activities.

The proposed eight-county Region is considered to be one which will be capable of abating air pollution in the metropolitan Houston-Galveston area.

SECTION II

ANAYLSIS AND PROPOSAL FOR THE HOUSTON-GALVESTON METROPOLITAN INTRASTATE REGION

BY THE TEXAS AIR CONTROL BOARD

EVALUATION OF ENGINEERING FACTORS

INTRODUCTION

The engineering evaluation for the Houston-Galveston area was based on a study of topography, air pollutant emissions, meteorology, estimated air quality levels, and available air quality data. The emission inventory indicated the location of point and area sources and the quantity of pollutants emitted from these sources. Emission densities were calculated from the emission quantities and grid areas. Emissions and average meteorological data were used in a diffusion model to estimate air quality levels. Figure 1 shows the Houston-Galveston metropolitan area in relation to other metropolitan areas. Figure 2 is a more detailed map of the eight county study area.

TOPOGRAPHY

The topography of the eight counties within the study area is basically the same. The area is a relatively flat coastal plain with many small streams, bayous and marsh areas. Surface elevation varies from sea-level to approximately 400 feet.

METEOROLOGY

The climate of the study area is predominately marine. The many small streams, bays and marsh areas favor the development of both ground fog and advective fog. Prevailing winds are from the southeast, except during the winter months when frequent passages of high pressure systems bring invasions of polar air. Daytime thermal inversions of at least one hour duration do occur about 50% of the

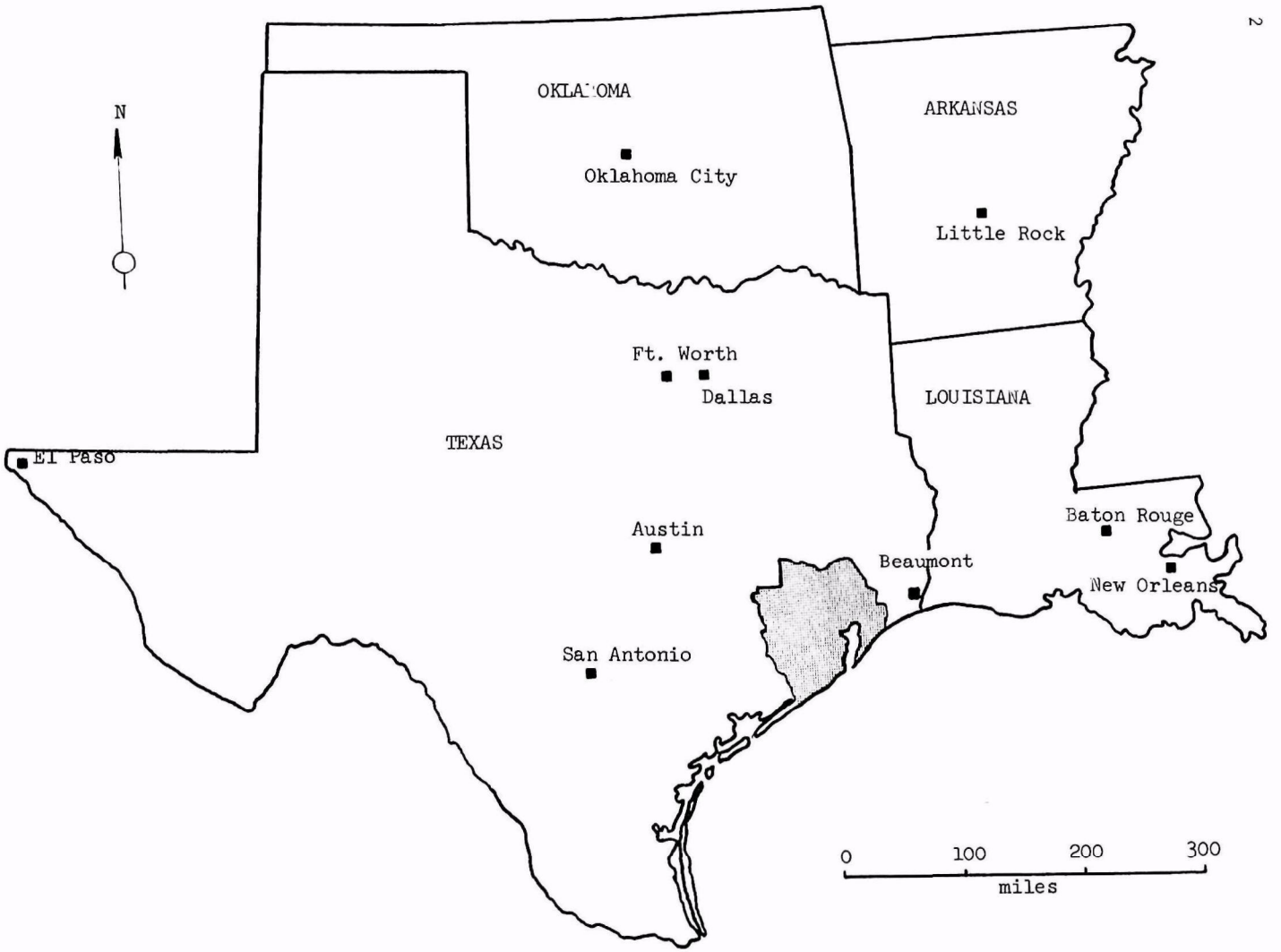

Figure 1. Map of Houston-Galveston Study Area and Surrounding States

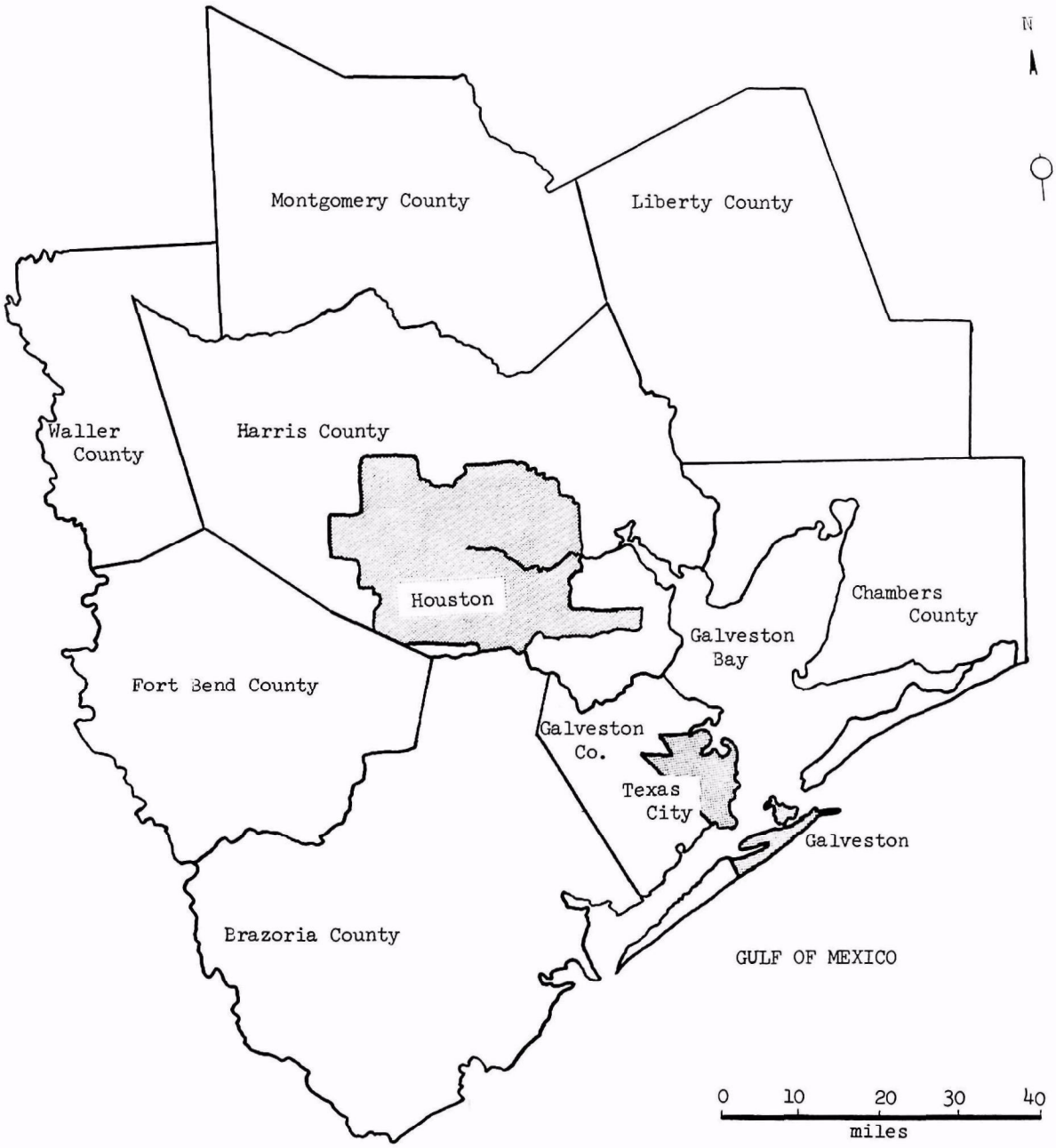

Figure 2. Houston-Galveston Eight County Study Area

time. Low level inversion layers occur much more frequently during nighttime. Annual and seasonal wind roses for the Houston-Galveston area are shown in Figure 3.

Average morning and afternoon mixing depths in meters for the Houston-Galveston area are shown below in Table I.

Table I

	Winter	Spring	Summer	Autumn	Average
Morning	350	565	605	400	856
Afternoon	880	1190	1430	1340	

The wind rose data and mixing depth information were utilized in the simulation model for the eight county study area.

EMISSION INVENTORY

The National Air Pollution Control Administration in cooperation with the State and local control programs conducted an inventory of air pollutant emissions for the eight county Houston-Galveston study area. The method employed was the Rapid Survey Technique for Estimating Community Air Pollutant Emissions.[1] This technique provided estimates of the total emissions for the following five pollutants: sulfur oxides; nitrogen oxides; hydrocarbons; carbon monoxide; and particulate matter. Sulfur oxides, total particulates and carbon monoxide are considered in this report. No attempt was made to account for the effects of reactive pollutants combining following their release into the atmosphere.

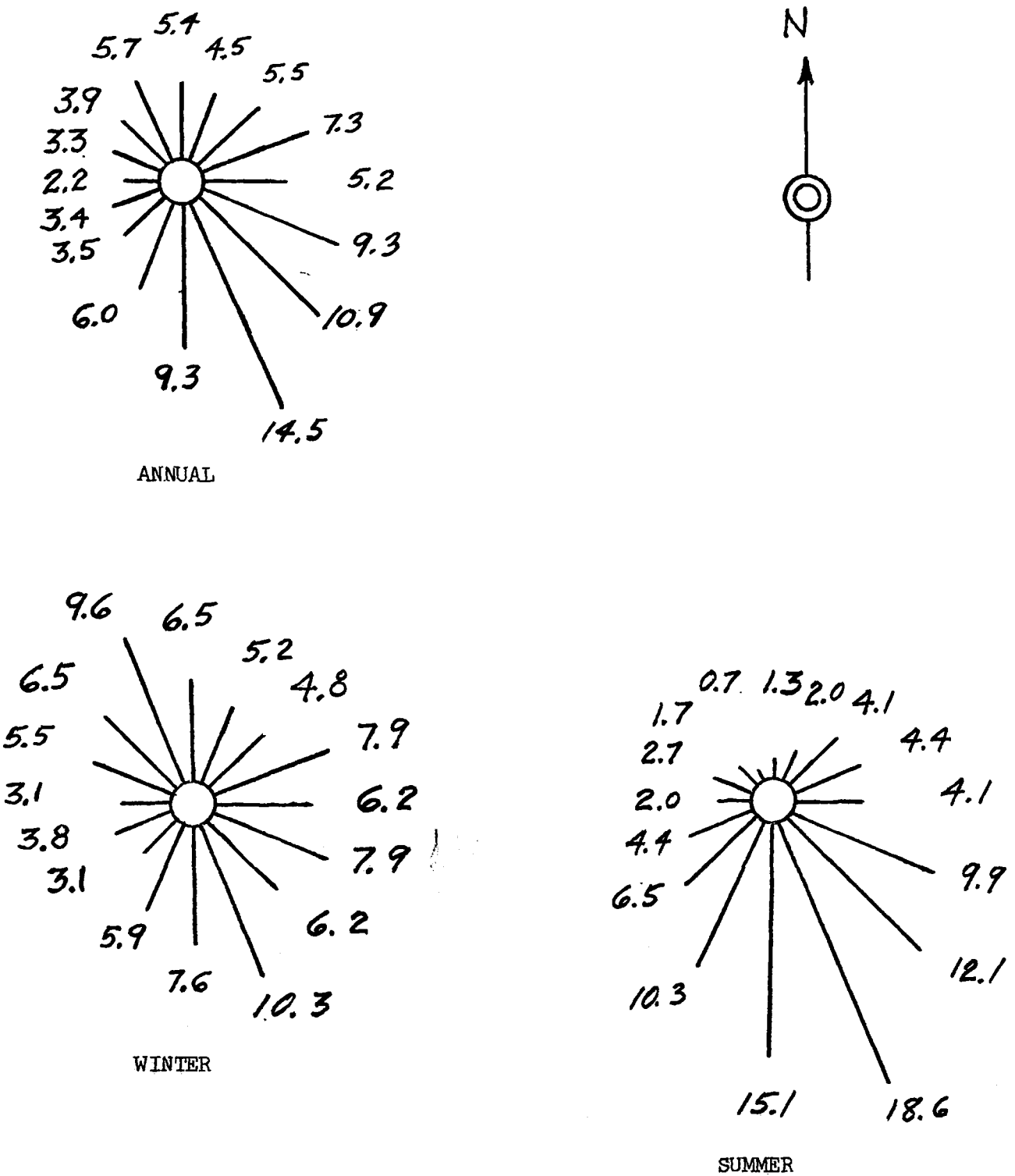

Figure 3. Wind Roses for Houston-Galveston Area
(numbers indicate % of time)

Sulfur oxide levels and total particulate emissions illustrate the impact of industrial processing activities from stationary sources. Levels of carbon monoxide provide the best indication of the impact of gasoline powered motor vehicles.

The eight county study area was divided into grid zones which served as the basis for locating sources and reporting emissions. Figure 4 shows the grid coordinate system for the Houston-Galveston study area. Major point source locations are shown in Figure 5. Most of the major point sources are located in Harris, Galveston, and Brazoria counties. Fort Bend county contains one major power plant.

Figure 6 illustrates sulfur oxide emission densities for the eight county study area. Major sulfur emissions are shown for Harris, Galveston, and Brazoria counties. Figure 7 shows the particulate emission density for the study area. Portions of Harris, Galveston, Brazoria, and Fort Bend counties show relatively high emissions of particulates. Carbon monoxide emission density is shown in Figure 8. Again portions of Harris, Galveston, Brazoria, and Fort Bend counties show the majority of the carbon monoxide emissions.

A summary of the emissions by source category is shown in Figure 9.

AIR QUALITY ANALYSIS

The geographical distribution of pollutant sources illustrate the core of the problem area. However, this does not elucidate the extent of the influence of the pollution sources on the people and the property located outside of the highly urbanized portions of the Houston-Galveston area. A study of air quality levels known to occur

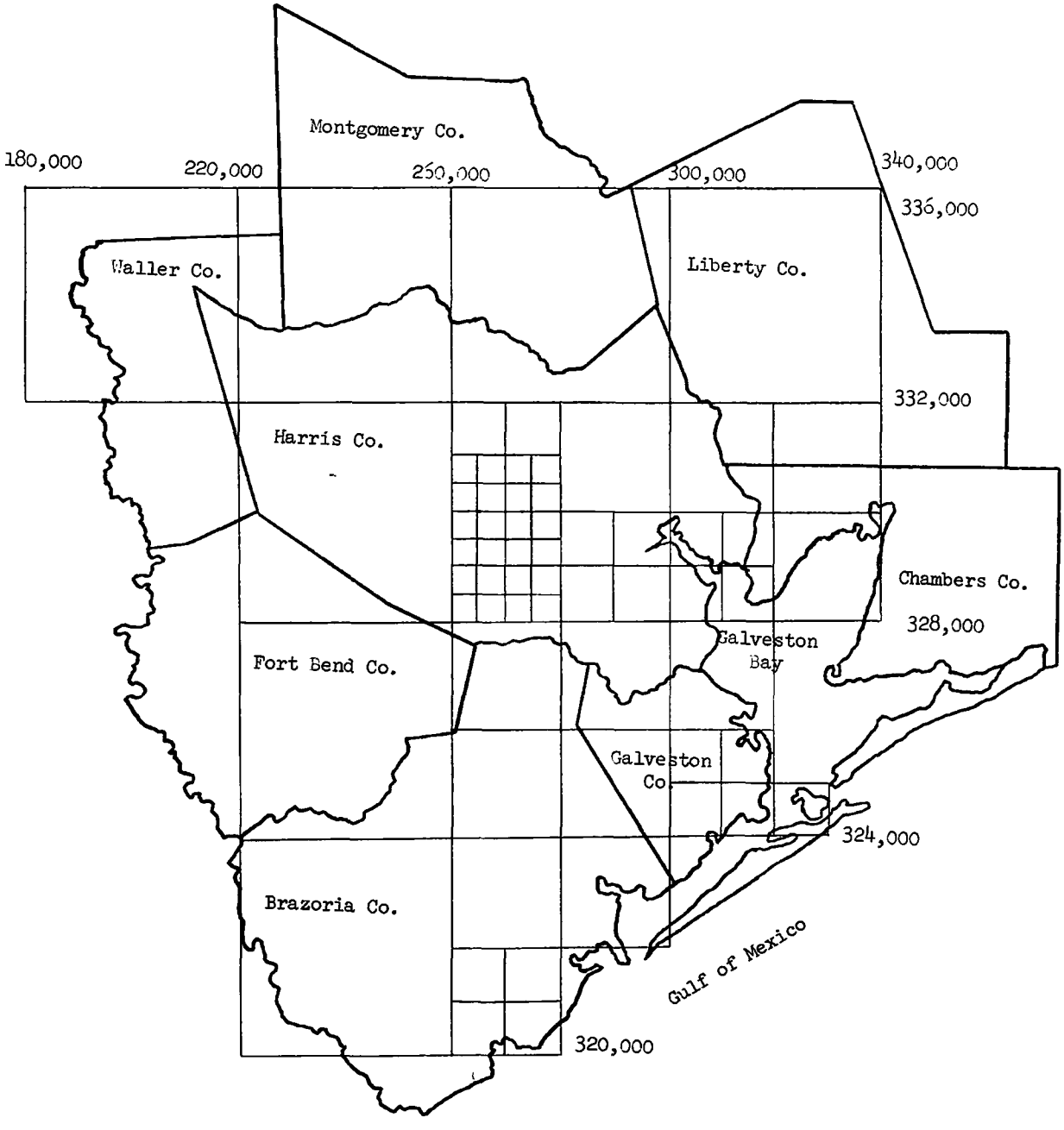

Figure 4. Grid Coordinate System

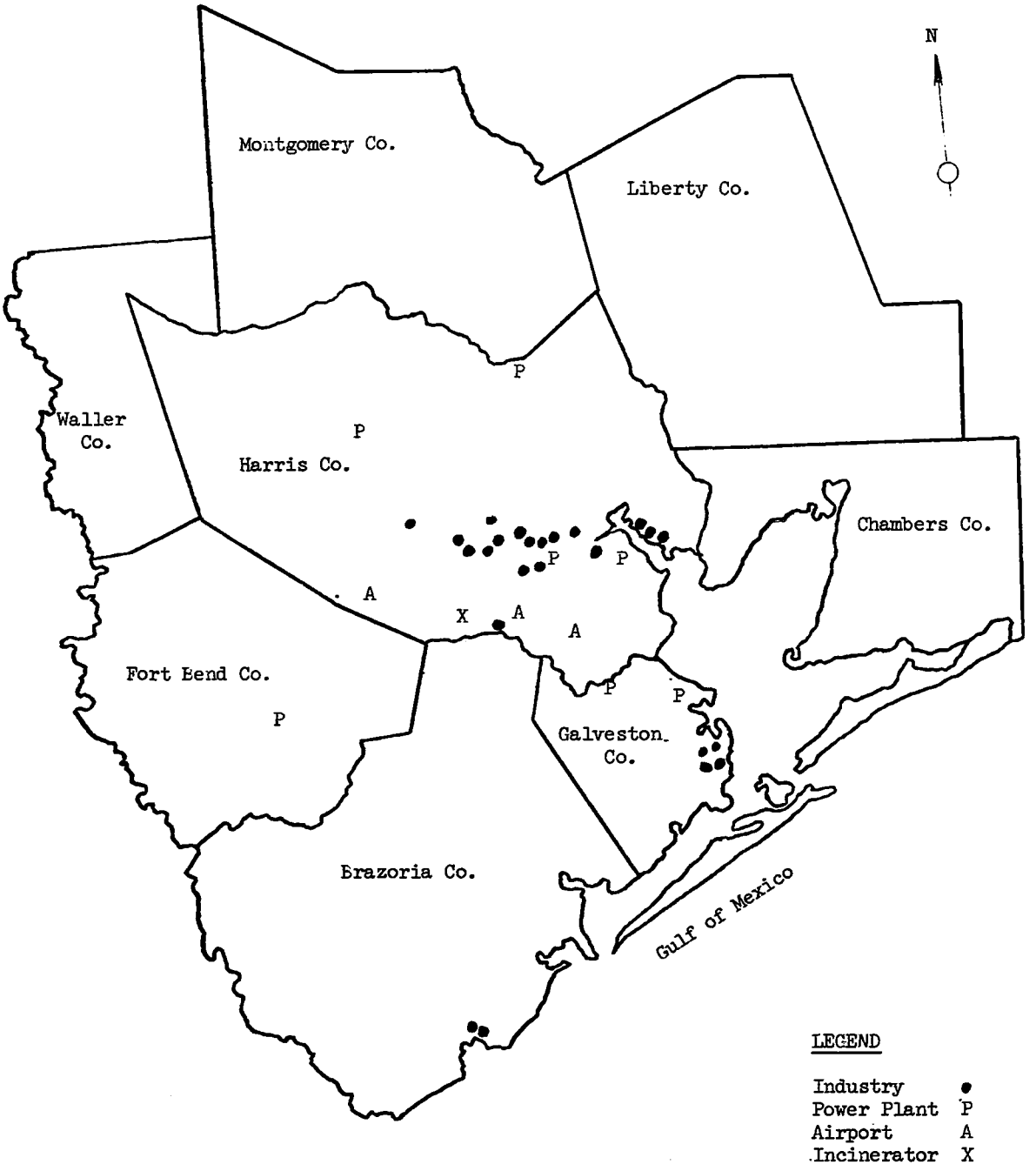

Figure 5. Major Point Source Locations for Houston-Galveston Area

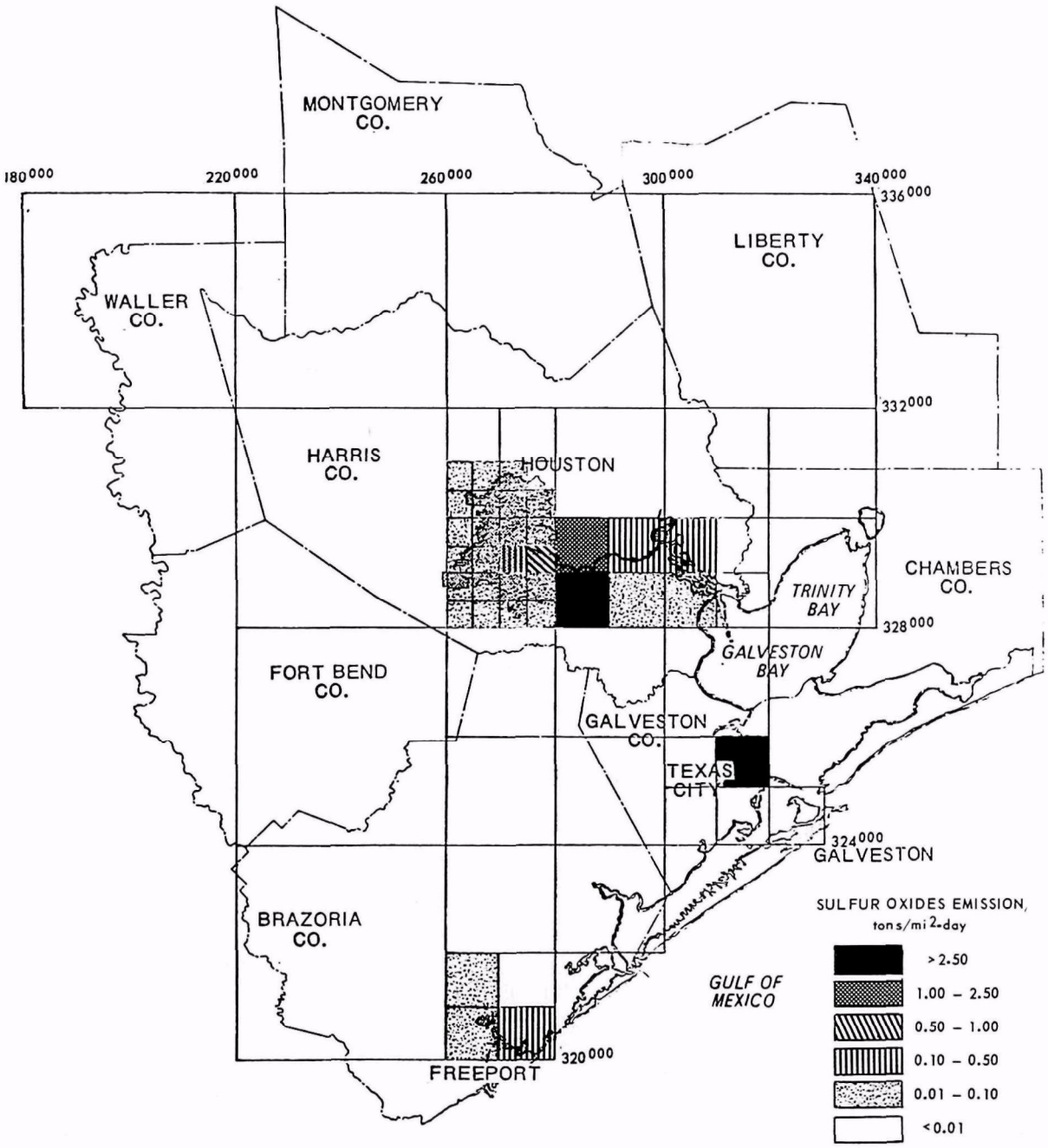

Figure 6. Sulfur oxides emission density from all sources for Houston-Galveston study area.

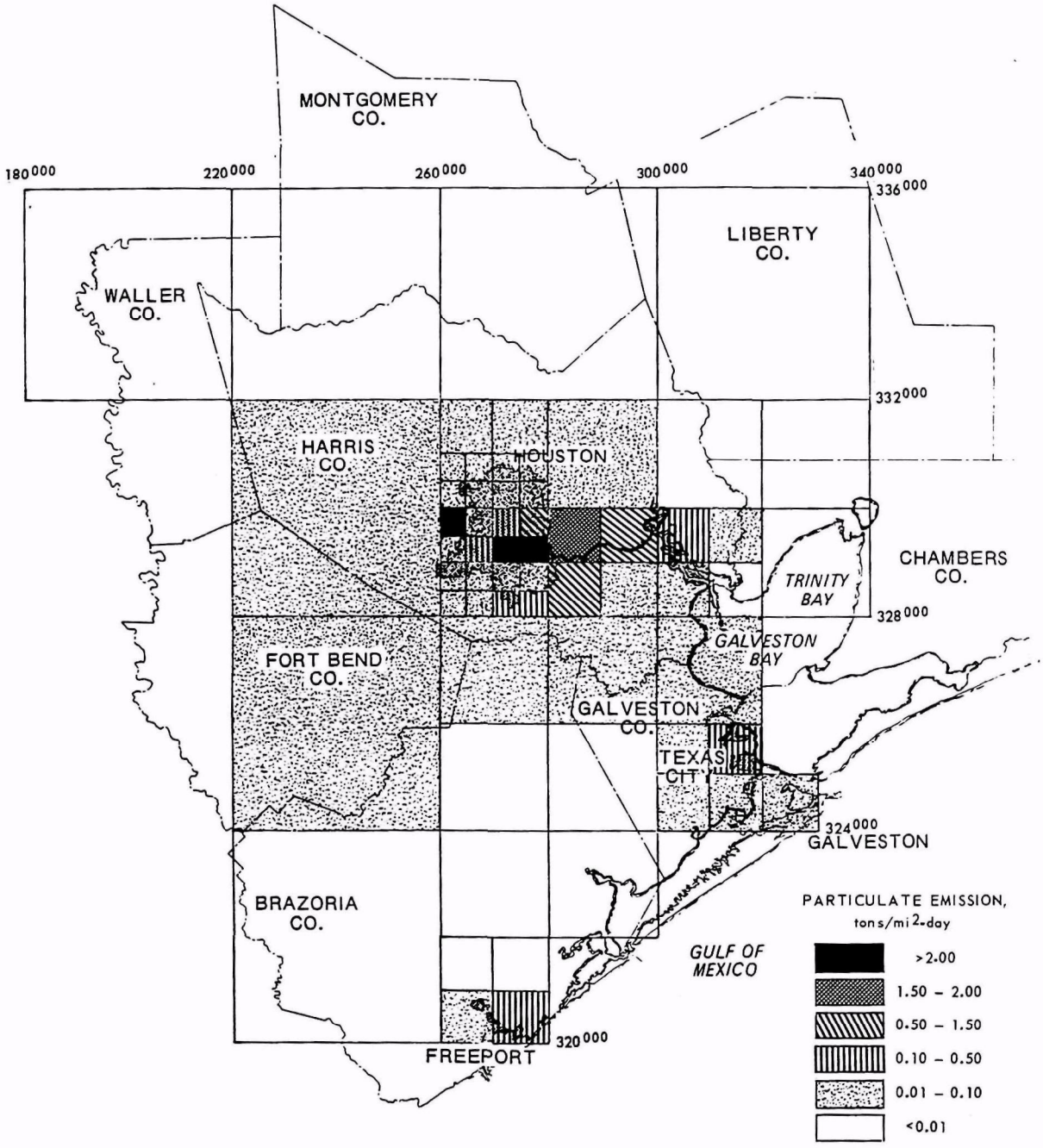

Figure 7. Particulate emission density from all sources for Houston-Galveston study area.

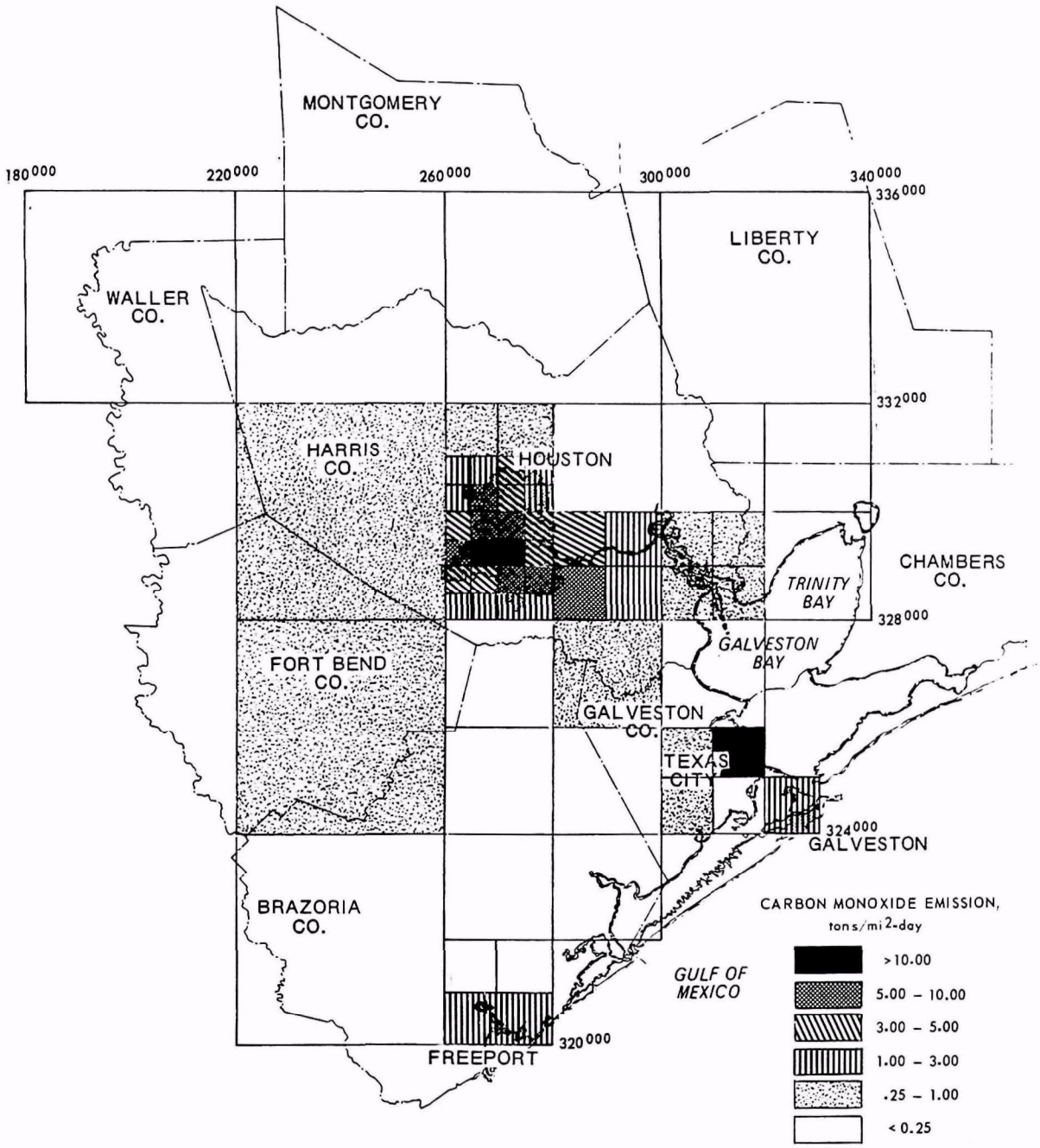

Figure 8. Carbon monoxide emission density from all sources for Houston-Galveston study area.

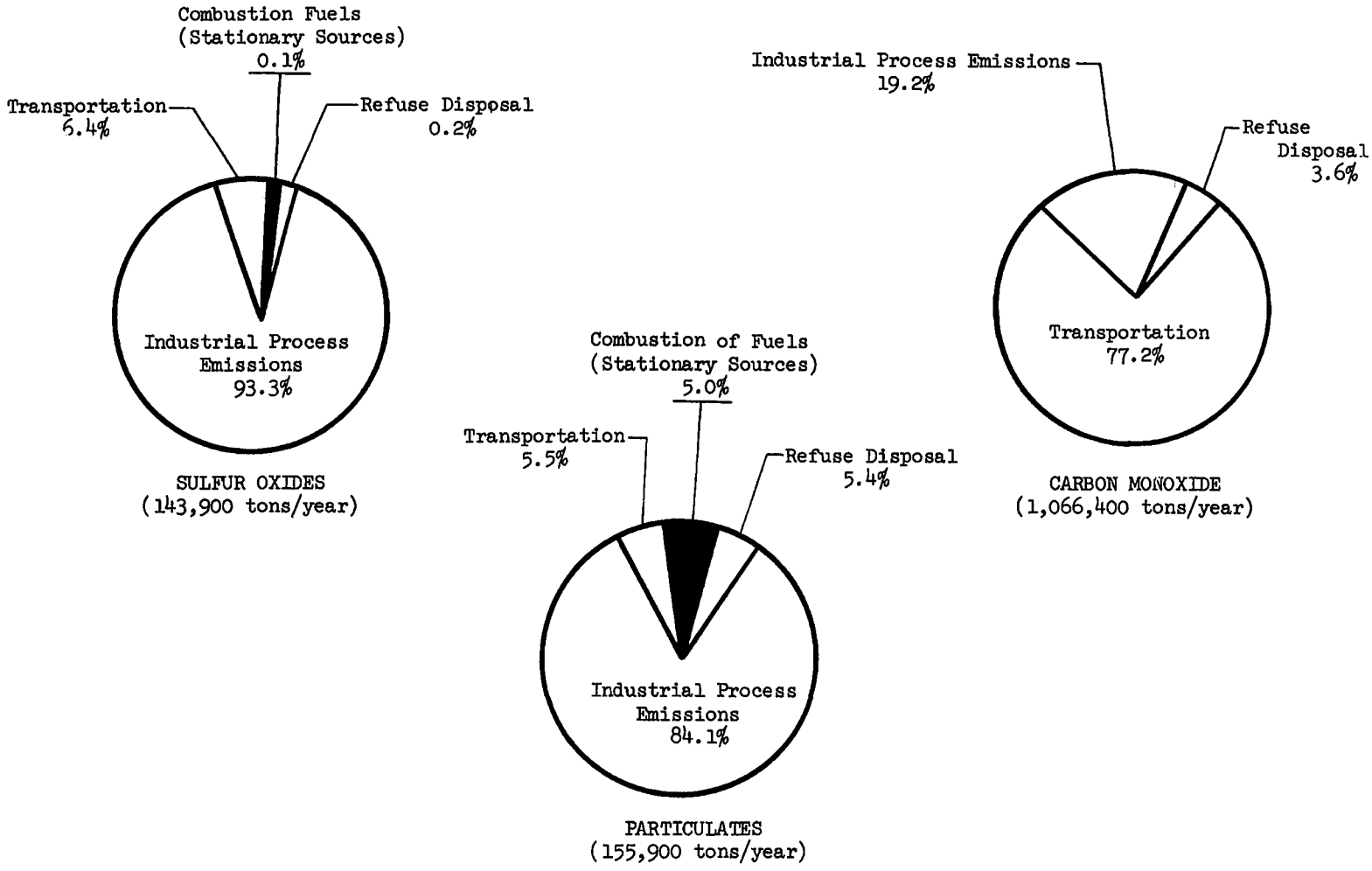

Figure 9. Summary of Air Pollutant Emissions - 1967

NOTE: This information represents data on specific air pollutant emissions gathered during the rapid survey for the major point sources shown in Figure 5 and the area sources. It should not be interpreted as representative of air pollutant emissions for any specific location within the study area.

is useful in determining the area affected by the pollution sources and thus subject to inclusion in the Air Quality Control Region. Such an analysis can be based directly on air sampling data in those instances where the monitoring program covers a large enough area and has been in existence long enough to provide a reliable pattern of air quality throughout the region under study. Since such comprehensive air quality data rarely exists, it becomes necessary to develop estimates of prevailing air quality. Diffusion modeling is a technique by which such estimates can be made based on the location and quantity of the pollutant emissions and on meteorological conditions. Topography is reflected in the results of the model, but only to the extent that it influences general meteorological conditions.

The diffusion model was applied for each of the three pollutants for an average summer day, winter day and annual day. Since the Martin-Tikvart model[2] used in this study attempts to show long-term rather than episodic air quality conditions, only average emissions and long-term meteorology are considered. The results of the diffusion model are theoretical in nature and are not meant to show exact concentrations. The relative magnitudes and general shape of the contours, however, should be valid. The outputs from the computer model have been adjusted to reflect measured air quality data. Figures 10, 11, and 12 show these adjusted values for particulates, sulfur oxides and carbon monoxide, respectively.

SUSPENDED PARTICULATE AIR LEVELS

The levels predicted by the diffusion model were generally lower than the actual measured air quality data. The theoretical

levels aid in delineating the affected area. Figure 10 shows the annual average distribution of particulate pollution. Portions of Harris, Galveston, Brazoria, and Fort Bend counties are shown to be affected.

SULFUR OXIDE LEVELS

Figure 11 shows the distribution of sulfur oxides over the eight county study area. The absence of high sulfur content fuels eliminates the area-wide sulfur oxide problems encountered in many other metropolitan areas. Sulfur oxides are present in Harris, Galveston, and Brazoria counties.

CARBON MONOXIDE LEVELS

Since the primary source of carbon monoxide is the internal combustion engine, the distribution of this pollutant tends to correlate with major traffic patterns. The influences of the interstate freeway system are obvious. Portions of Harris, Galveston, Brazoria, and Fort Bend counties are shown in Figure 12 to be experiencing carbon monoxide pollution.

SUMMARY

The engineering evaluation of the eight county study area shows that at the present time the major point sources are located in Harris, Galveston, Brazoria, and Fort Bend counties. Receptors in these four counties are also shown to be experiencing the major air pollution problems.

Figure 10. Annual Particulate Concentrations
(micrograms per cubic meter $\mu g/m^3$)

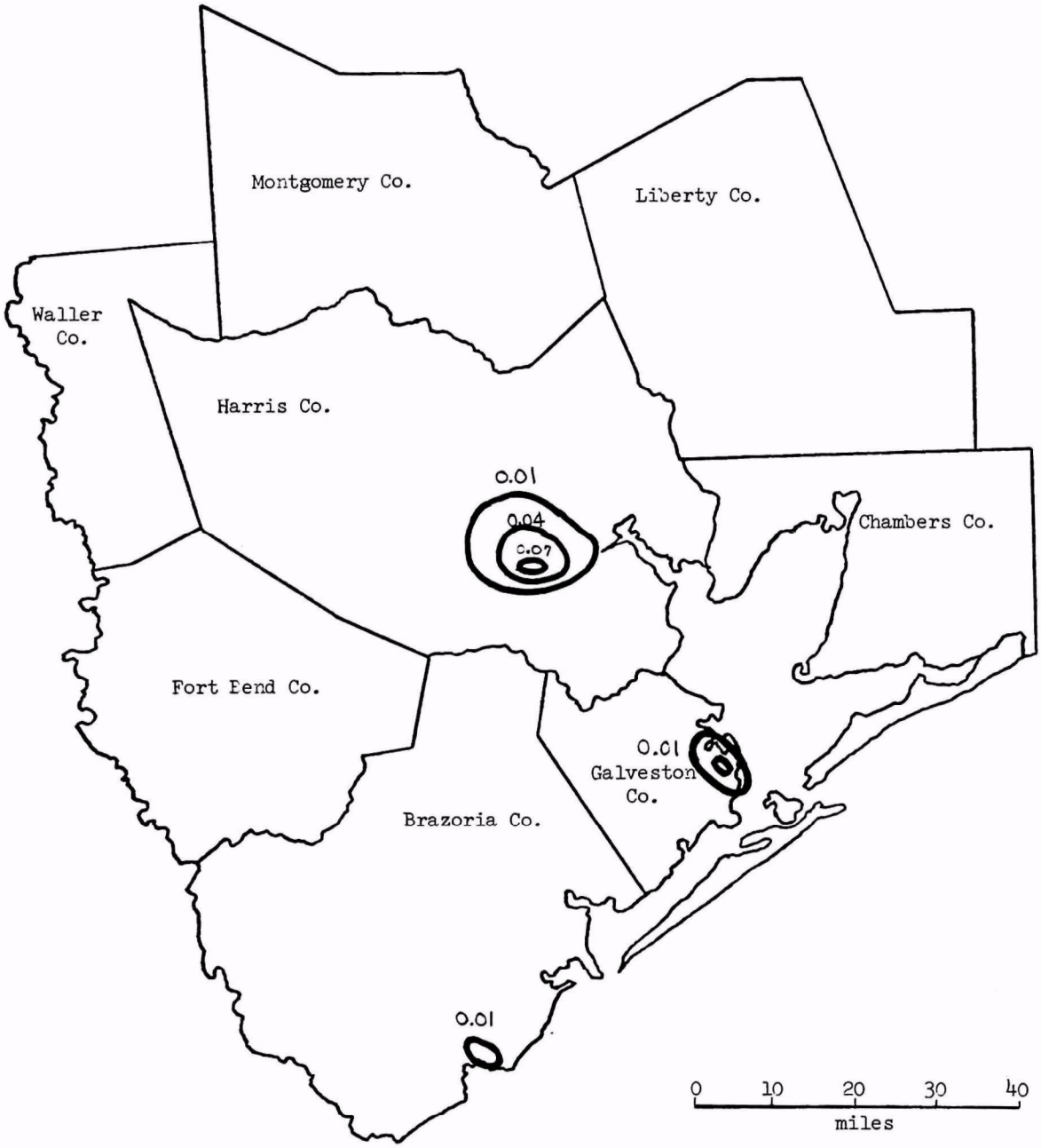

Figure 11. Annual Sulfur Oxide Concentrations
(parts per million by volume)

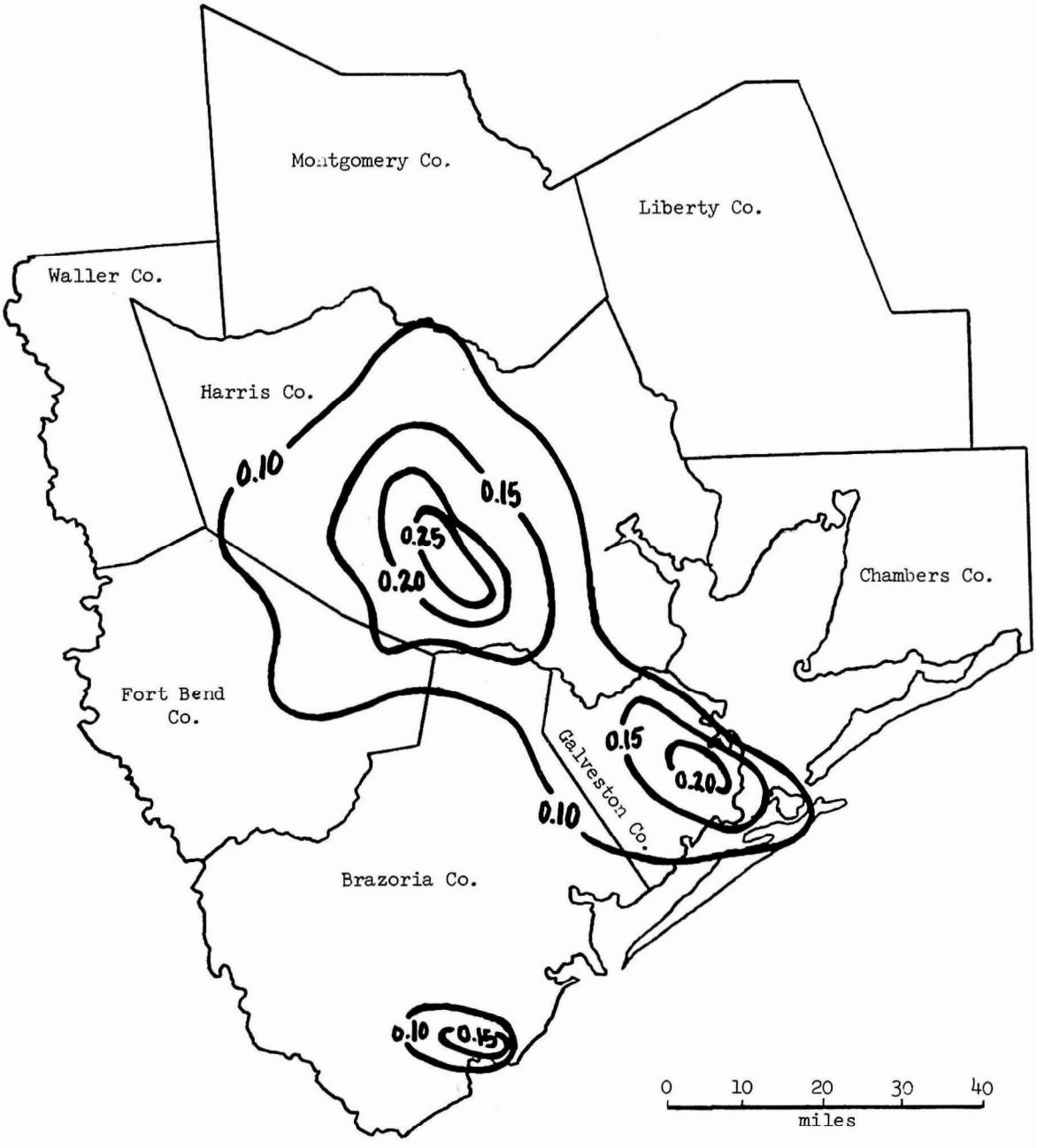

Figure 12. Annual Carbon Monoxide Concentrations
(parts per million by volume)

EVALUATION OF URBAN FACTORS

INTRODUCTION

A number of urban factors are relevant to the problems of defining the boundaries of air quality control regions. These factors include the location of population and industry, the population density, projected growth of both population and industry, and jurisdictional considerations. These are all important considerations since human activity is the initial cause of most air pollution. Humans are also the receptors affected by the pollution. The projected growth patterns are most important for future planning purposes.

POPULATION

Table II shows the population growth for the study area from 1960 to 1967 with an overall growth of 27%. Estimates of future population show that there will be 5 million people in the eight county area by the year 1990.[4] Currently more than 87% of the population for the study area reside in Harris and Galveston counties. The remaining 13% is spread among the other six counties which are primarily rural. Waller and Chambers are the only two counties in the study area which are not included in either the Houston or Galveston Standard Metropolitan Area.

INDUSTRY

Table III indicates the high degree of diversification of the industries in the area. In addition to the major oil refineries, there are petrochemical plants, cement manufacture, metal processing,

Table II Population Figures for the Houston-Galveston Study Area[3]

	1960	1967	Percent Increase
Brazoria County	76,200	97,800	28
Chambers County	10,400	12,000	15
Fort Bend County	40,500	50,700	25
Galveston County (Balance	73,200	96,700	32
City of Galveston	67,200	70,600	5
Harris County (Balance)	305,000	430,900	41
City of Houston	938,200	1,159,800	24
Liberty County	31,600	33,000	6
Montgomery County	26,800	35,700	33
Waller County	12,100	14,800	22
Grand Total	1,581,200	2,002,600	27

Table III Types of Manufacturing Establishments in the Houston and Galveston Standard Metropolitan Statistical Areas[5] (1960)

	Houston	Galveston Texas City
Food and Tobacco	81	8
Textile Products	18	-
Paper and Printing	62	3
Chemical Products	113	8
Lumber & Wood Products	47	-
Stone & Gravel Products	53	
Primary & Intermediate Metal Products	152	4
Electrical Machinery	126	-
Transportation and Ordinance	20	2
Instruments and Miscellaneous	17	-

Table IV Manufacturing Data Houston-Galveston Study Area[3] (1963)

County	Number of Establishments	Number of Employees	Value Added $1000
Brazoria	73	7,807	277,125
Chambers	4	39	Unavailable
Galveston	96	9,504	342,101
Harris	2,048	97,517	1,590,567
Liberty	42	597	2,843
Montgomery	66	1,017	19,652
Fort Bend	32	1,647	28,243
Waller	6	17	78

coffee roasting, grain processing and aerospace facilities. Additional manufacturing data is shown in Table IV. The industrial growth potential for the Houston-Galveston area is certainly high. The counties which are now primarily rural today will surely be sharing in the expected growth. As an example Chambers County is scheduled to receive a large industrial park development in the very near future. The planned canalization of the Trinity River from the Gulf of Mexico to the Dallas-Fort Worth area is certain to enhance the industrial expansion potential of Chambers and Liberty counties. The navigation project proposed by the Army Corps of Engineers is in the planning stages; however, a completion date in the 1980's is possible.

REGIONAL PLANNING

The Houston-Galveston Area Council of Governments is the regional planning agency for the area. The eight counties of the study area including 48 cities and 22 school districts make up the council which was formed in 1966. Projects relating to transportation, land use surveys, base map preparation and environmental health planning have been undertaken some of which have been completed. Planning relative to the air quality control region may best be coordinated by this agency.

AIR POLLUTION CONTROL AGENCIES

The Texas Air Control Board is the State agency responsible for air pollution control activities. The Texas Clean Air Act provides for equal enforcement of State Rules and Regulations by local governments (cities, counties, and health districts). The

State Board has adopted regulations relating to smoke and suspended particulate matter, outdoor burning, sulfur compounds and toxic materials. Enforcement provisions allow both injunctive relief and civil and criminal penalty of up to $1000 per day. Within the eight-county study area organized local control programs are presently functional in the City of Houston, Harris County and Galveston County. The City of Pasadena is currently organizing an air control program.

THE PROPOSED REGION

Subject to the scheduled consultation, The Texas Air Control Board recommends that the Secretary, Department of Health, Education, and Welfare, designate an air quality control region for the Houston-Galveston area, consisting of the following jurisdictions in Texas:

Harris County
Galveston County
Brazoria County
Fort Bend County
Waller County
Montgomery County
Chambers County
Liberty County

As so proposed, the Houston-Galveston Air Quality Control Region would consist of the territorial area encompassed by the outermost boundaries of the proposed jurisdictions. The proposed Region is shown in Figure 13.

DISCUSSION OF PROPOSAL

The proposed Region boundaries coincide with the boundaries of the Houston-Galveston Area Council of Governments. In general, state or locally defined planning regions do not automatically qualify as air quality control regions. However, the Air Quality Act of 1967 requires region boundaries to take into account existing jurisdictions, among other factors. Clearly, a council of governments created under a state enabling act is an important jurisdictional consideration. Therefore, this study of the geographic extent of the air pollution problem indirectly evaluates the suitability of the eight county area as a geographic basis of attack on the air pollution problem. As discussed below, the eight counties in the council of governments area satisfy the three requirements for air quality control region boundaries.

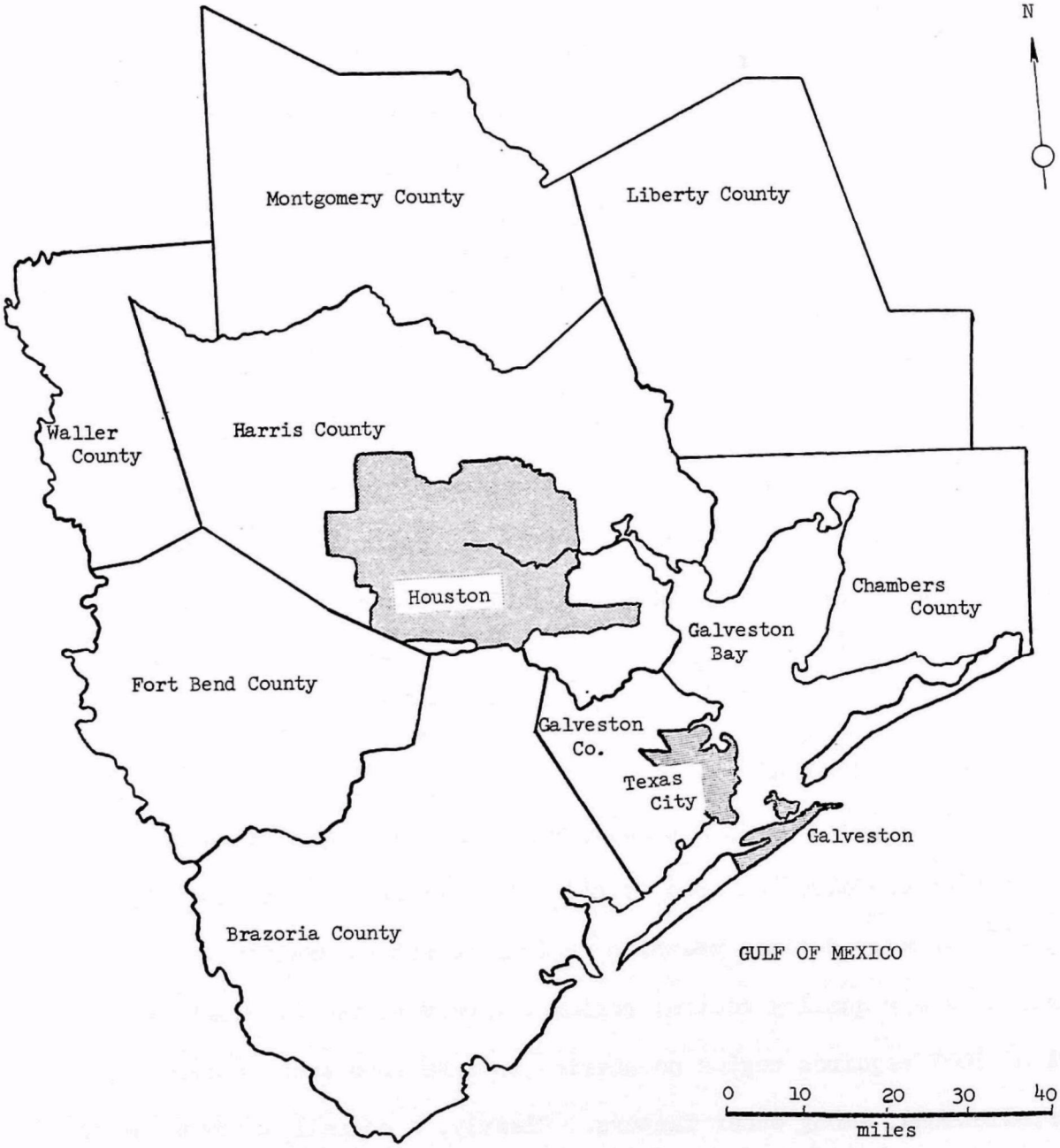

Figure 13. Proposed Houston-Galveston Air Quality Control Region

To be successful, an air quality control region should meet three basic conditions. First, its boundaries should encompass most pollution sources as well as most people and property affected by those sources. Second, the boundaries should encompass those locations where industrial and residential development will create significant air pollution problems in the future. Third, the boundaries should be chosen in a way which is compatible with and even fosters unified and cooperative governmental administration of the air resources throughout the region. The "Evaluation of Engineering Factors" (discussion beginning with page 1) discussed the first of these conditions, and the "Evaluation of Urban Factors" (page 18), the second and third.

The first consideration--that most air pollution sources and receptors be within the Region boundaries--is satisfied by the proposed Region. Major point sources are located in four counties--Harris, Galveston, Brazoria, and Fort Bend. Emission densities of particulates, carbon monoxide, and sulfur oxides are greatest in these four jurisdictions.

The second consideration is directed towards future population and industrial expansion. Approximately 2,000,000 people live in the proposed Region, which represents about 20% of the population of the State. Estimates for the year 1990 show 5,000,000 people in the eight county area. Industrial expansion is certain to include the counties which today are primarily rural. The proposed canalization of the Trinity River is certain to have an impact on the industrial development of the entire area.

The third objective relates to governmental administration in the area. Regional planning is coordinated by the Houston-Galveston Area Council of Governments, whose jurisdiction includes all eight of the counties. The Council was established in 1966 and consists of representatives of 48 cities and 22 school districts.

Based on the technical data presented on air pollutant emissions and resultant ambient air concentrations, only four counties need be part of the Region to attack the air pollution problem. Waller, Montgomery, Liberty, and Chambers are mostly rural at present and may remain so through 1990. However, since these four counties have joined with the other counties in the administration of the Council of Governments, it is logical to include them in the Air Quality Control Region for administrative purposes, despite their present low air pollution potential.

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 Houston-Galveston Metropolitan Area.

REFERENCES

1. "Rapid Survey Technique for Estimating Community Air Pollution Emissions," PHS Publication No. 999-AP-29, Environmental Health Series, USDEW, NCAPC, Cincinnati, Ohio, October, 1966.

2. "General Atmospheric Diffusion Model for Estimating the Effects on Air Quality of One or More Sources," Martin, D. and Tikvart, Minnesota, June, 1968.

3. "Texas Almanac" 1968-1969, published by A.H. Belo Corporation.

4. Population projections provided by the Houston-Galveston Area Council of Governments.

5. "Commercial Atlas and Marketing Guide", 100th Edition, 1969, Rand McNally and Company.

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