MERRIMACK VALLEY METROPOLITAN AREA
AIR POLLUTANT EMISSION INVENTORY

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PREFACE

This report, which presents the emission inventory for the Merrimack Valley Metropolitan Area, is another in a series of surveys outlining the sources and emissions of air pollutants for major metropolitan areas in the country. These surveys, conducted by the National Inventory of Air Pollutant Emissions and Control Branch of the National Air Pollution Control Administration, provide estimates of the present levels of air pollutant emissions and status of their control. The pollutants, which include sulfur oxides, particulates, carbon monoxide, hydrocarbons and nitrogen oxides, are delineated with respect to source type, season of the year and geographical distribution within the area. The general procedure for the surveys is based upon the rapid survey technique for estimating air pollutant emissions.[1] These reports are intended to serve as aids in the proposing of boundaries of Air Quality Control Regions, as directed by the Air Quality Act of 1967.

INTRODUCTION

This report is a summary of the Merrimack Valley air pollutant emission inventory conducted in December 1969. Since all inventories are based upon a calendar year, the data and emission estimates presented are representative of 1968 and should be considered as indicating the conditions as existed during that year.

The Study Area, which was chosen on the basis of the distribution of population and air pollution sources, consists of six counties in Southern New Hampshire and 28 cities and towns in northeast Massachusetts. This area covers approximately 4,690 square miles and had a 1968 population of 1,045,000.

A grid coordinate system was used to show the geographical distribution of emissions within counties. The Study Area was subdivided into 68 grid zones ranging in size from 25 square kilometers in the heavily populated and industrialized areas to 400 square kilometers in the rural areas.

All sources of emissions were classified into five categories--transportation, stationary fuel combustion, solid-waste disposal, industrial processes and evaporative losses. Each of these source categories was divided into two subgroups--point sources and area sources. Facilities, which emit large quantities of air pollutants, were considered individually as point sources, while the many remaining contributors such as motor vehicles, residential fuel users, small commercial and industrial facilities and on-site refuse burning equipment, were considered collectively as area sources. For this report, individual sources, which had emissions greater than 0.50 tons per average annual day for any pollutant, were classified as point sources.

Emissions were estimated by using various indicators such as fuel consumption, refuse burning rates, vehicle-miles, production data, and control efficiencies and emission factors relating these indicators to emission rates.[2] These factors represent average emission rates for a particular source category. Since individual sources have inherent differences that cannot always be taken into consideration, discrepancies between the actual and estimated emissions are more likely in individual sources than in the total emissions for a source category.

As in all emission surveys, the data presented are estimates and should not be interpreted as absolute values. The estimates are, in some cases, partial totals due to the lack of emission factors and production or consumption data. Despite these limitations, the estimates are of sufficient accuracy and validity in defining the extent and distribution of air pollutant emissions within the Study Area.

SUMMARY OF RESULTS

The estimated annual emissions of the five surveyed pollutants in the Merrimack Valley Metropolitan Area are presented in Table 1. The following is a brief summary of pollutant emissions and sources.

Sulfur Oxides	The predominant sources of the 100,700 tons of sulfur oxides emitted annually are the combustion of fuels. The largest collective source is steam-electric power plants, which emit over 65 percent.
Particulate Matter	The annual emissions of 29,090 tons are distributed between the various source types. The largest source is stationary fuel combustion with solid waste disposal the second largest.
Carbon Monoxide	Motor vehicles contribute 89 percent of the 452,200 tons of carbon monoxide emitted within the Study Area in 1968. Other important sources include solid waste disposal and aircraft.
Hydrocarbons	The two largest sources of the yearly 71,900 tons of hydrocarbons are motor vehicles and evaporative losses. They contribute 44 and 31 percent respectively.
Oxides of Nitrogen	Motor vehicles and stationary fuel combustion are the important sources of the 52,900 tons of oxides of nitrogen. The five steam-electric utilities alone account for 29 percent of the total emitted.

TABLE 1 SUMMARY OF AIR POLLUTANT EMISSIONS FOR THE MERRIMACK VALLEY STUDY AREA, 1968 (Tons/Year)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Transportation	1,840	2,930	411,800	33,240	22,770
Motor Vehicles	1,730	2,730	402,060	31,260	22,060
Other	110	200	9,740	1,980	710
Stationary Fuel Combustion	100,720	11,590	950	930	25,380
Industrial	11,590	2,470	100	80	2,990
Steam-Electric	67,380	6,250	280	230	14,880
Residential	4,930	1,350	310	460	2,550
Commercial-Institutional	16,820	1,520	260	160	4,960
Solid Waste Disposal	920	9,440	38,780	11,210	4,780
Incineration	550	3,540	7,460	160	720
Open Burning	370	5,900	31,320	11,050	4,060
Industrial Processes	80	5,130	700	4,220	0
Evaporative Losses	--	--	--	22,300	--
TOTAL	103,560	29,090	452,230	71,900	52,930

TABLE 1A SUMMARY OF AIR POLLUTANT EMISSIONS FOR THE MERRIMACK VALLEY STUDY AREA, 1968 (10^3 Kg/Year)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Transportation	1,670	2,660	373,580	30,160	20,660
Motor Vehicles	1,570	2,480	367,750	28,360	20,010
Other	100	180	8,830	1,800	650
Stationary Fuel Combustion	91,370	10,510	860	840	23,020
Industrial	10,510	2,240	90	70	2,710
Steam-Electric	61,130	5,670	250	210	13,500
Residential	4,470	1,220	280	420	2,310
Commercial-Institutional	15,260	1,380	240	140	4,500
Solid Waste Disposal	830	8,560	35,180	10,170	4,340
Incineration	500	3,210	6,770	150	650
Open Burning	330	5,350	27,510	10,020	3,690
Industrial Processes	70	4,650	640	3,830	0
Evaporative Losses	--	--	--	20,230	--
TOTAL	93,940	26,380	410,260	65,230	48,020

STUDY AREA

The Study Area for the Merrimack Valley Metropolitan Area Air Pollutant Emission Inventory consists of six counties in southern New Hampshire and twenty-eight cities and towns in Massachusetts. The New Hampshire portion of the Study Area contains 80 percent of the State's population. Figure 1 presents the Study Area in relation to other large metropolitan areas.

The six counties in New Hampshire consist of Cheshire, Hillsborough, Merrimack, Rockingham, Strafford and Sullivan (Figure 2). The Massachusetts portion contains 28 cities and towns in portions of Essex and Middlesex counties. Table 3 is a listing of the Massachusetts portion of the Study Area. Part of the Study Area is in two Standard Metropolitan Statistical Areas (SMSA) as defined by the Bureau of the Budget. These SMSA's contain cities and towns in New Hampshire and Massachusetts. The other counties and towns were added in the study to insure that all areas which may have a high rate of growth in future years were included.

The approximate 1968 population for the Study Area was 1,045,000 which covers an area of 4,693 square miles. Table 2, which gives population by county and Figure 3, which shows the population density, indicate that most of the population is in the urbanized portions of southern New Hampshire and most of Massachusetts. The population in this area has increased at a quicker pace than the nation as a whole. Between 1960 and 1968, the nation's population increased over 11 percent while the Merrimack Valley Study Area increased 17 percent.

The Study Area lies in the prevailing westerlies so that major systems affecting the area are cold, dry air from the North and warm, moist air traveling overland from the Gulf of Mexico. Since the flow of air is generally offshore, the adjacent ocean consitutes a modifying factor on the immediate coast, but its effect is felt less and less farther inland. The temperatures are generally cooler in summer and

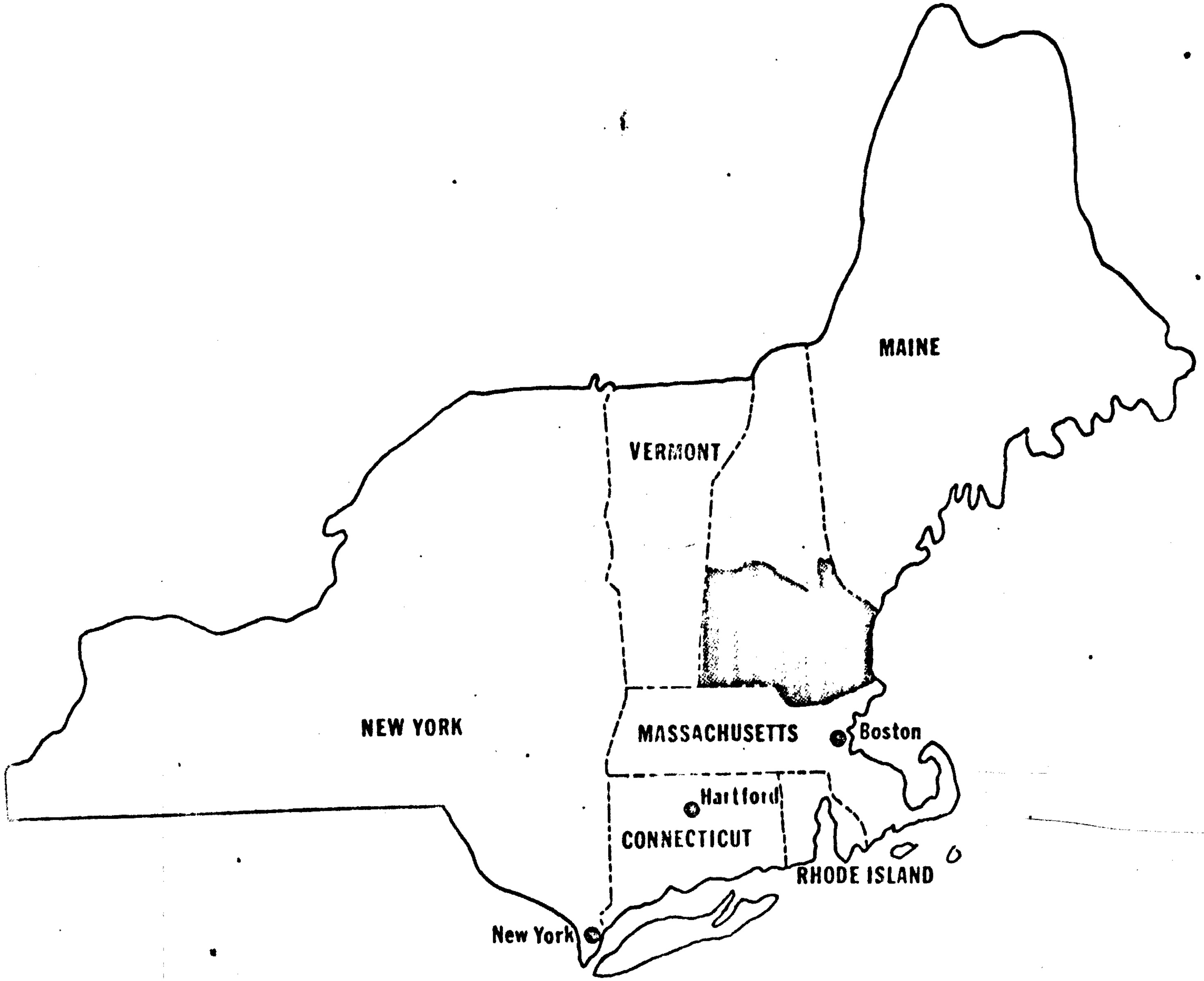

Figure 1. Map of Northeastern U. S. showing Merrimack Valley study area.

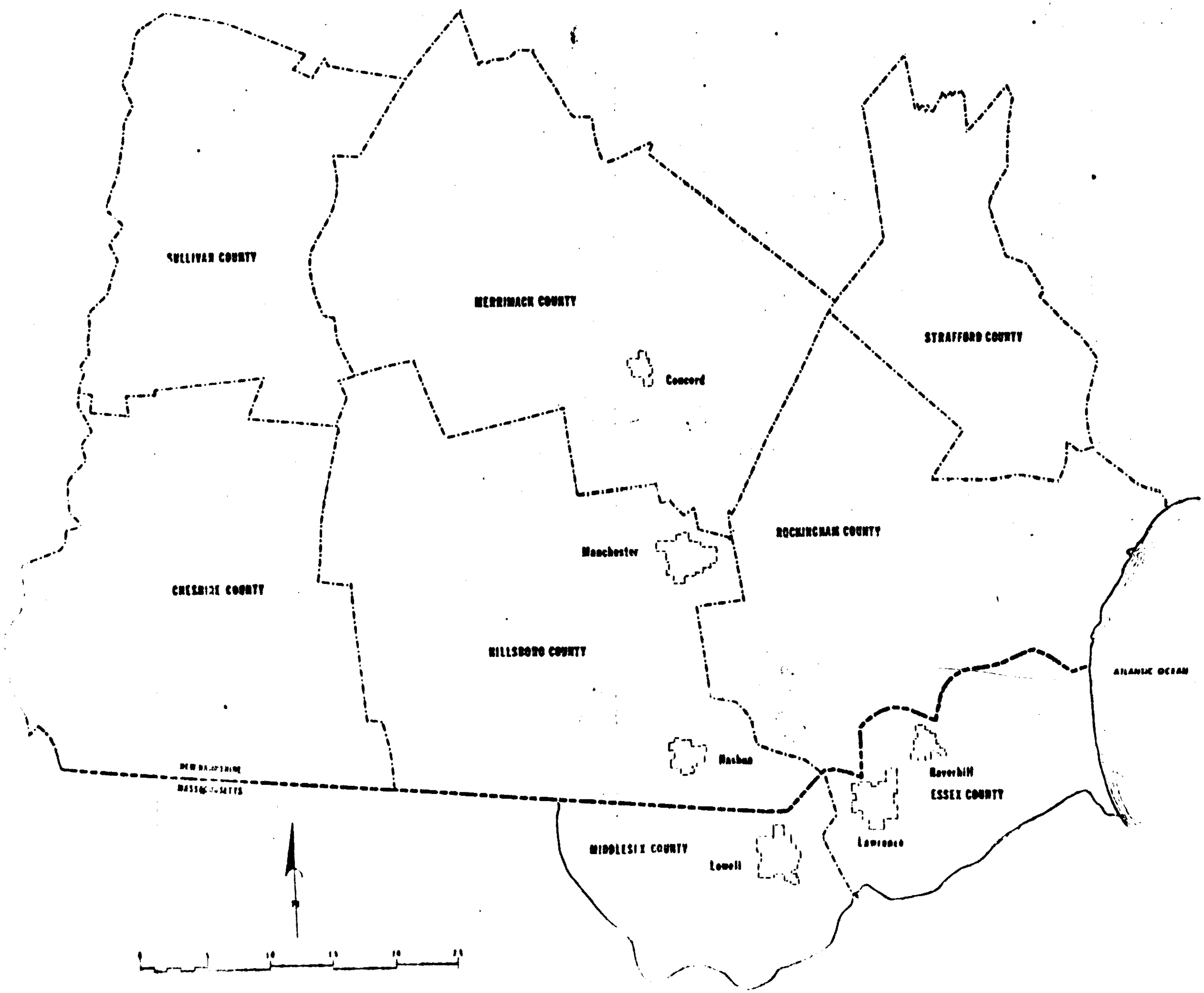

Figure 2. Merrimack Valley study area.

TABLE 2 POPULATION AND AREA CHARACTERISTICS FOR THE MERRIMACK VALLEY STUDY AREA, 1968

Jurisdiction	Population 1960	Population 1968	Area Mi.[2]	Population Density 1968
Massachusetts Portion*				
TOTAL	415,680	458,340	549	835.0
New Hampshire				
Cheshire	43,340	49,640	715	69.4
Hillsborough	178,160	219,700	893	246.0
Merrimack	67,790	75,520	930	81.2
Rockingham	99,030	140,610	691	203.5
Strafford	59,800	69,050	376	183.6
Sullivan	28,070	32,500	539	60.3
TOTAL	478,660	587,020	4,144	141.7
GRAND TOTAL	894,340	1,045,360	4,693	223.0

* See Table 3 for definition of Massachusetts Portion

TABLE 3 JURISDICTIONS IN MASSACHUSETTS PORTION OF THE STUDY AREA

Cities	Townships
1. Haverhill	1. Amesbury
2. Lawrence	2. Andover
3. Lowell	3. Ayer
4. Newburyport	4. Billerica
	5. Boxford
	6. Carlisle
	7. Chelmsford
	8. Dracut
	9. Dunstable
	10. Georgetown
	11. Groton
	12. Groveland
	13. Littleton
	14. Methuen
	15. Merrimac
	16. Newbury
	17. North Andover
	18. Pepperell
	19. Rowley
	20. Salisbury
	21. Tewksbury
	22. Tyngsborough
	23. Westford
	24. West Newbury

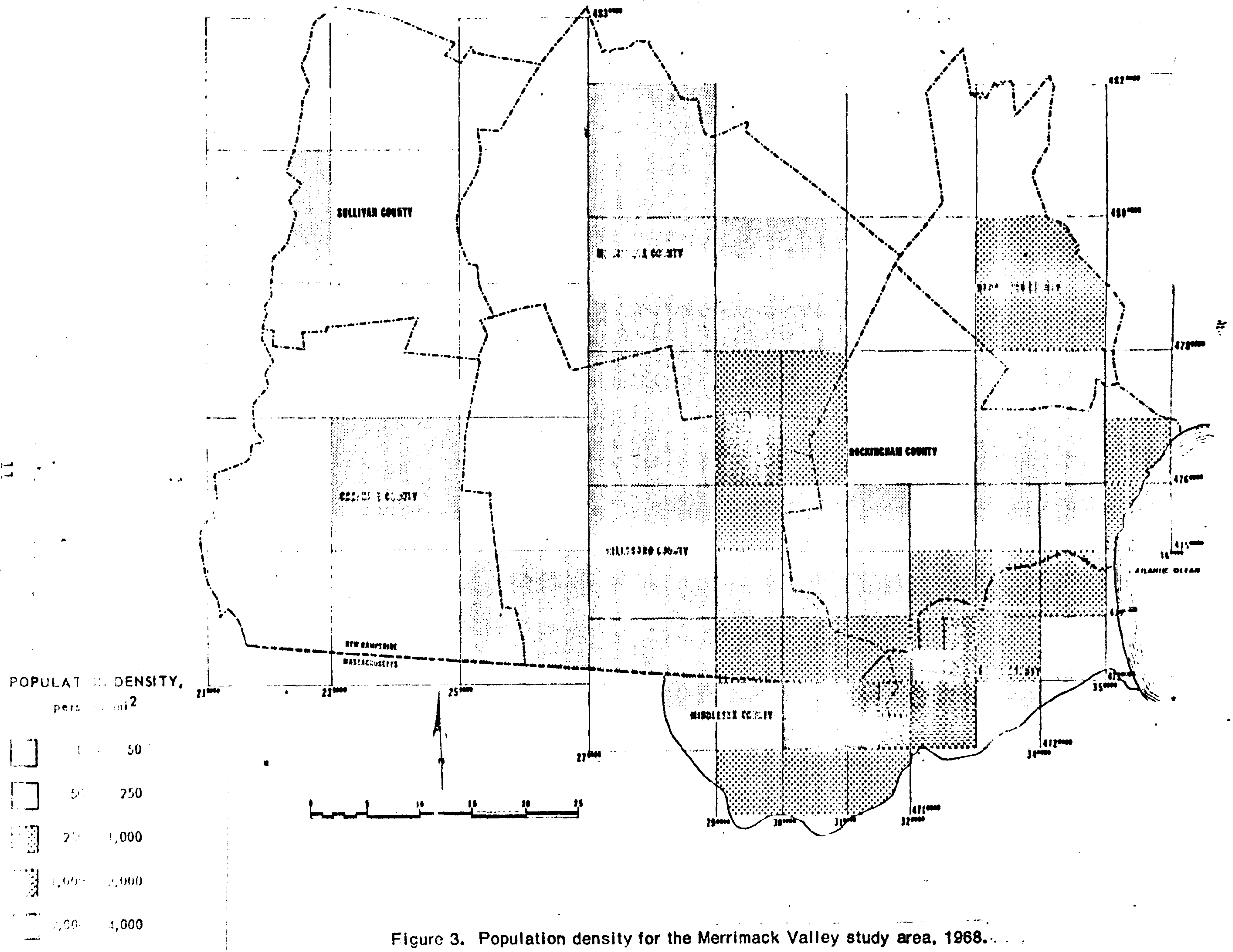

Figure 3. Population density for the Merrimack Valley study area, 1968.

warmer in winter near the coast.

Precipitation is fairly constant throughout the year. Prevailing winds are westerly. During the summer, winds normally come from the southwest, while during the winter the northwest direction predominates.

GRID COORDINATE SYSTEM

A grid coordinate system, based on the Universal Transverse Mercator Projection (UTM), was used in the Merrimack Valley Study Area to indicate the geographical distribution of emissions. A map showing the grid coordinate system is presented in Figure 4.

An evaluation of all the available coordinate systems was completed before the UTM system was chosen to present emissions. The most convenient systems evaluated were the State Plane, Longitude-Latitude, and UTM. Although each of the systems had valuable qualities, the use of the UTM coordinate system was felt to be necessary to meet the requirements of these emission inventories.

The two primary requisites of the grid coordinate systems were used to evaluate each system. The first requirement was that the grid coordinate system had to have square grid zones, since the data were to be used in meteorological dispersion models. The grid zones, which the UTM system and most of the State Plane systems project, are always square, but the longitude-latitude system projects grid zones that become skewed as the zones become further from the equator. The other quality the grid coordinate system had to possess was consistency. Each emission inventory should be conducted on a grid coordinate system which used the same reference point throughout the Study Area. Since some air pollutant inventories would include areas in two or more states, the State Plane systems could not be used. However, since the UTM system, as well as the longitude-latitude system, is not referenced to points in individual states, it is not influenced by jurisdiction boundaries. The UTM system was chosen since it was the only prevalent coordinate system which can project square grid zones over any Study Area using a common reference point.

The Universe Transverse Mercator Projection is based upon the metric system. Each north-south and east-west grid line, as illustrated in Figure 4, is identified by a coordinate number expressed in meters. Each point source and grid, using its geographical center, is identified by a horizontal and vertical coordinate to the nearest 100 meters.

Grid zones of different sizes are used in the grid coordinate system to allow a satisfactory definition of the geographical gradation of emissions and to limit the number of grid zones. The majority of the emissions is usually concentrated in the populated and industrialized portions of a Study Area. Smaller grids are placed over these areas to allow the grid coordinate system to reflect the changes of emissions over short distances. Grid zones smaller than the 25 kilometer grid zones used in this report are not usually warranted because of the inherent inaccuracies in the data. Larger grid zones are used in the rural portions, because a smaller percentage of the total emissions usually occurs in lightly populated areas.

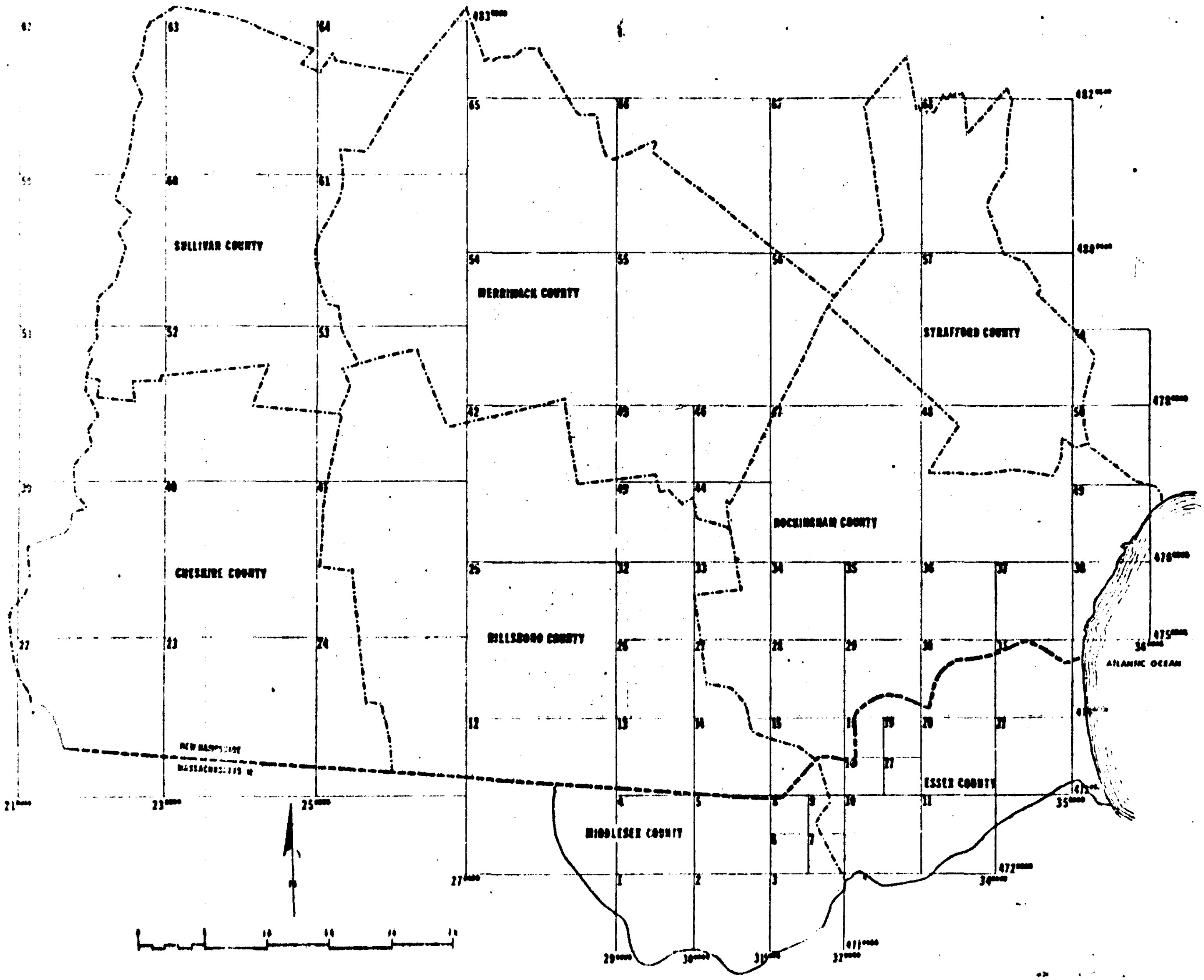

Figure 4. Merrimack Valley grid coordinate system.

EMISSIONS BY CATEGORY

TRANSPORTATION

Transportation is the source category concerned with mobile sources of air pollutants. The sources in this category include: road vehicles (both gasoline and diesel powered), aircraft, vessels, and railroads. With the exception of aircraft, all the sources are presented as area sources. Since most of the aircraft emissions are attributable to the immediate vicinity of the airports, aircraft are presented as point sources.

Road Vehicles

METHODOLOGY: Vehicle miles of travel were obtained from gasoline consumption. Total vehicle miles of travel for 1968 were obtained from Highway Statistics using an average factor of fuel consumed per vehicle mile.[3]

The vehicle miles of travel which included both gasoline and diesel vehicles were apportionned onto the grid system by motor vehicle registration in Massachusetts and population in New Hampshire.

Approximately 1.5 to 2.0 percent of gasoline is lost through evaporation from the gasoline tanks and carburetor losses. (This is exclusive of hydrocarbon losses from exhaust.) It was assumed that no diesel fuel was lost by evaporation. Since 1963 most new automobiles were equipped with positive crankcase ventilation (PCV) valves that reduce hydrocarbon emissions from the crankcase by about 90 percent. Due to a lag time in the automobile replacement rate, it was assumed that only 20 percent of the automobiles were not equipped with PCV valves.

RESULTS: More than 4.88 billion miles were traveled by motor vehicles in 1968. In the process, 398 million gallons of gasoline and 15 million gallons of diesel fuel were consumed for highway purposes.

Table 4 indicates that about 61 percent of all motor vehicle travel occurs in the Massachusetts portion and Hillsborough County in New Hampshire.

The resulting emissions from motor vehicles are shown in Table 5. Motor vehicles are by far the most significant transportation source, accounting for89 percent of the carbon monoxide and 68 percent of the hydrocarbons.

Aircraft

METHODOLOGY: The total number of flights by type was obtained from the Federal Aviation administration and the 1968/1969 Transportation Facts.[4,5] A flight is defined as the combination of a take-off and landing. Estimates were made as to the kind and number of engines in each type category. Table 6 presents the results of these estimates at the six airports in the Study Area.

Emissions were obtained by applying the appropriate emission factors to the total number of flights in each engine and type category.

RESULTS: Table 7 presents the resulting air pollutant emissions from the six airports in the Study Area. As can be seen, the piston engines are the largest source of emissions among aircraft, accounting for 99 percent of the carbon monoxide and 99 percent of the hydrocarbons.

Trains

METHODOLOGY: The total fuel consumed by railroads in any State is given by the Bureau of Mines' Mineral Industry Surveys.[6] The proportion consumed in the Study Area was found by taking the ratio of population of the Study Area to that of the State (in both Massachusetts and New Hampshire) times the total state fuel consumption. This fuel usage was apportionned to the individual grids by locating train routes and rail-road yards.

RESULTS: The Summary of Air Pollutant Emissions from Transportation Sources (Table 4) shows that trains are not a significant source of any

TABLE 4 VEHICLE MILES OF TRAVEL AND FUEL CONSUMPTION IN THE STUDY AREA, 1968

Jurisdiction	Total Vehicle-Miles 10^3/Day	Gasoline 10^3 Gal./Year	Diesel 10^3 Gal./Day
Massachusetts Portion	5,410	160,000	8,300
Cheshire	730	21,800	590
Hillsborough	2,810	83,900	2,260
Merrimack	1,193	35,600	960
Rockingham	1,780	53,300	1,440
Strafford	1,052	31,400	850
Sullivan	395	11,700	320
TOTAL	13,370	397,700	14,700

TABLE 5 AIR POLLUTANT EMISSIONS FROM TRANSPORTATION SOURCES FOR THE MERRIMACK VALLEY STUDY AREA, 1968 (Tons/Year)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Motor Vehicles	1,730	2,730	402,040	31,260	22,060
Gasoline					
Exhaust	1,440	1,930	401,600	30,270	20,440
Evaporation*	--	--	--	20,200	--
Diesel	290	800	440	990	1,620
Aircraft	N	90	9,680	1,840	480
Jet	N	40	30	20	30
Turboprop	N	N	N	N	N
Piston	N	50	9,650	1,820	450
Railroads	40	110	60	140	220
Vessels	70	N	N	N	N
TOTAL	1,840	2,930	411,780	33,240	22,776

N = Negligible

* = Included under evaporative losses

TABLE 6 AIRCRAFT FLIGHTS FOR THE STUDY AREA, 1968

Airport and Engine Type	Number of Flights 1 Engine	2 Engines	3 Engines
Haverhill			
Piston	3,500	3,500	
Lawrence			
Piston	24,000	24,100	
Plum Island			
Piston	600	600	
Tew-Mac			
Piston	3,000	3,000	
Methuen			
Piston	200	200	
Manchester			
Conventional Jet		1,500	2,000
Fan Jet		1,000	
Piston	27,000	24,000	
TOTAL	58,300	57,900	2,000

TABLE 7 AIR POLLUTANT EMISSIONS FROM AIRCRAFT, 1968 (Tons/Year)

Airport	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Haverhill	N	N	600	110	30
Lawrence	N	30	4,140	780	200
Plum Island	N	N	110	20	N
Tew-Mac	N	N	520	100	20
Methuen	N	N	40	10	N
Manchester	N	60	4,270	820	230
TOTAL	N	90	9,680	1,840	480

N = Negligible

of the five pollutants.

Vessels

METHODOLOGY: The amount of fuel consumed by vessels was estimated by the Bureau of Mines.[6] It was assumed the quantity of fuel burned in Massachusetts was negligible.

RESULTS: Air pollutant emissions are shown in Table 5. Emissions from this category are small when compared to the total from the other transportation sources.

FUEL COMBUSTION IN STATIONARY SOURCES

All three of the major fuels (Coal, oil, natural gas) are consumed within the Study Area, with fuel oil being the most important. In 1968 fuel oil accounted for 92 x 10^{12} BTU's of energy or about 68 percent of the total. As shown in Tables 8 and 9, 15.5 billion cubic feet of natural gas, 146.2 million gallons of distillate fuel oil, 414.5 million gallons of residual fuel oil were consumed in the Study Area. In addition, 1.1 million tons of coal were burned in power plants and 30,000 tons in commercial and industrial sources. Commercial and institutional buildings consume the largest amount of residual fuel with steam-electric utilities consuming almost as much. Distillate fuel oil is consumed predominantly for residential home heating and commercial-institutional buildings. Natural gas is burned primarily for residential heating and by some industrial consumers. Coal only finds usage in one power plant and a few other sources.

There are five steam-electric power plants in the Study Area. Table 10 presents the fuels consumed, and Table 11 presents their sulfur and ash contents. The coal fired plant is equipped with cyclones and electrostatic precipitators. They use pulverized coal boilers.

METHODOLOGY: Natural gas consumption and fuels consumed by power plants were obtained from the utility companies and are considered accurate. However, the fuel oil figures were based on state totals published by the [illegible]

TABLE 8 NATURAL GAS CONSUMPTION BY CONSUMER CATEGORY, 1968
(10^6 Feet^3)

Jurisdiction	Residential	Commercial-Institutional	Industrial
Massachusetts Portion	6,630	1,290	1,410
Cheshire	510	N	N
Hillsborough	2,350	50	200
Merrimack	580	N	N
Rockingham	1,150	100	1,600
Strafford	270	N	N
Sullivan	290	N	N
TOTAL	11,780	1,440	3,210

TABLE 9 FUEL OIL CONSUMPTION BY CONSUMER CATEGORY, 1968
(10^3 Gallons)

Jurisdiction	Residual Oil Commercial	Residual Oil Industrial	Distillate Oil Residential	Distillate Oil Commercial	Distillate Oil Industrial
Massachusetts Portion	70,000	36,100	121,800	25,000	3,200
Cheshire	1,200	2,000	15,500	2,000	530
Hillsborough	5,600	13,000	71,300	6,000	1,500
Merrimack	4,000	3,100	23,900	2,000	570
Rockingham	2,000	2,000	43,600	4,000	540
Strafford	3,000	1,200	23,500	2,000	420
Sullivan	860	2,200	9,900	1,000	40
TOTAL	86,600	59,600	309,500	42,000	6,800

TABLE 10 FUEL CONSUMPTION IN STEAM-ELECTRIC POWER PLANTS, 1968

Plant	County	Residual Oil (10^6 Gallons)	Coal (10^3 Tons)
Schiller	Rockingham	58.8	--
Daniel Street	Rockingham	6.3	--
Manchester	Hillsborough	5.3	--
Kelleys	Hillsborough	4.2	--
Merrimack	Hillsborough	--	1,100
TOTAL	Hillsborough	74.6	1,100

TABLE 11 SULFUR AND ASH CONTENTS OF FUELS IN ALL STATIONARY SOURCES (By Weight)

Fuel	Ash	Sulfur
Coal	7.1 - 10.0	2.6
Residual Oil[a]	--	1.6 - 2.3
Distillate Oil[b]	--	0.2 - 1.5

a = Grades 4,5,6

b = Grades 1,2,3

The emissions from fuel combustion in area sources were apportionned to the individual grids by population.

RESULTS: The resulting emissions are presented in Table 12. The combustion of coal, although providing 21 percent of the energy input, produces the majority of emissions from combustion of stationary fuels.

SOLID WASTE

METHODOLOGY: The total solid waste generated within the Study Area was found by applying the national average per capita generation rate of 10 pounds of refuse per day to the total Study Area resident population.[7] This generation rate includes both collected and uncollected waste. On the average 5.5 lb/day of waste is collected by municipalities for disposal. This figure includes household, commercial and industrial refuse. The remaining 4.5 lb/day includes industrial (3.0 lb/day), and commercial and other household (1.5 lb/day).

The disposal methods were determined from the State Air Pollution Agencies. Then, the national averages of disposal method quantities were applied to the known disposal methods of the jurisdiction involved.

The emissions from large municipal and private disposal facilities were calculated individually and located within the Study Area. The remaining waste (on-site incineration, on-site open burning, and small open burning dumps) were treated as area sources and were apportionned onto the grid system by population.

RESULTS: Table 13 which is a solid waste balance for the Study Area shows the results of the above methodology. The predominant disposal practices within the Study Area are sanitary landfills (26%) and open burning dumps (22%). There are three municipal incinerators. The majority of emissions in this category (Table 14) comes from open burning.

TABLE 12 AIR POLLUTANT EMISSIONS FROM STATIONARY FUEL COMBUSTION 1968 (Tons/Year)

Fuel	User Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Coal	Steam-Electric	54,340	5,880	280	110	11,000
	Industrial	1,000	1,700	40	10	250
	Commercial	190	120	120	20	20
	Total	55,530	7,700	440	140	11,270
Distillate Fuel Oil	Residential	4,930	1,240	310	460	1,860
	Commercial-Institutional	1,480	390	40	40	1,580
	Industrial	170	40	10	10	250
	Total	6,580	1,670	360	510	3,690
Residual Fuel Oil	Steam-Electric	13,040	370	N	120	3,880
	Industrial	10,420	700	60	60	2,150
	Commercial	15,150	1,000	90	100	3,280
	Total	38,610	2,070	150	280	9,310
Natural Gas	Residential	N	110	N	N	690
	Commercial	N	10	N	N	80
	Industrial	N	30	N	N	340
	Total	N	150	N	N	1,110
TOTAL	All Users	100,720	11,590	950	930	25,380

TABLE 13 SOLID WASTE DISPOSAL PRACTICES FOR THE MERRIMACK STUDY AREA, 1968. (TONS/YEAR)

Ju diction	Waste Generated	Open Burning		Incineration		Sanitary Landfills	Hauled Out
		Dumps	On-Site	Municipal	On-Site		
M chusetts Portion							
AL	830,000	218,000	142,000	150,000	160,000	160,000	0
N mpshire							
shire	63,000	9,000	15,000	0	13,000	26,000	0
lsborough	400,000	40,000	65,000	70,000	80,000	145,000	0
rimack	96,000	15,000	31,000	0	15,000	35,000	0
kingham	260,000	90,000	70,000	0	44,000	56,000	0
afford	88,000	15,000	17,000	0	17,000	39,000	0
llivan	42,000	5,000	5,000	0	5,000	0	27,000
AL	949,000	174,000	203,000	70,000	174,000	301,000	27,000
T STUDY AREA	1,779,000	392,000	345,000	220,000	334,000	461,000	27,000

TABLE 14 AIR POLLUTANT EMISSIONS FROM SOLID WASTE DISPOSAL PRACTICES IN THE MERRIMACK VALLEY STUDY AREA 1968, (Tons/Year)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Incineration					
Municipal	220	1,870	110	30	220
On-site	330	1,670	7,350	130	500
Total	550	3,540	7,460	160	720
Open Burning					
On-site	170	2,760	14,660	5,170	1,900
Dumps	200	3,140	16,660	5,880	2,160
Total	370	5,900	31,320	11,050	4,060
GRAND TOTAL	920	9,440	38,780	11,210	4,780

INDUSTRIAL PROCESSES

The area is notably void of the heavy industrial areas or the chemical process industries. Table 15 shows that a majority of industrial establishments are in food, textiles, clothing, leather and machinery. There are, however, several foundries, asphalt and concrete batching plants and one paper mill.

Table 1 presents emissions from industrial processes. As can be seen, this category represents a small percentage of the Area's emissions.

TABLE 15 SELECTED MANUFACTURING ESTABLISHMENTS FOR THE MERRIMACK VALLEY STUDY AREA, 1963

Jurisdiction	Food	Textiles & Apparel	Lumber & Wood	Leather	Machinery	Total All Establishments
Mass. Portion	98	68	28	125	180	900
Cheshire	6	14	44	5	23	157
Hillsborough	55	54	58	39	67	449
Merrimack	10	19	43	7	22	169
Rockingham	23	11	28	31	16	161
Strafford	15	7	18	22	15	126
Sullivan	11	8	21	1	9	70
Total Mass.	98	68	28	125	180	900
Total N.H.	120	113	212	105	152	1,132
TOTAL	218	181	240	230	332	2,032

EVAPORATIVE LOSSES

The sources of solvent evaporation considered in this survey were industry, dry cleaning and motor vehicles.

METHODOLOGY: Industrial solvent evaporation was found from individual source information. Dry cleaning emissions were calculated using a per capita rate of 4.0 lb/year.[8] This was apportionned to the grid system by population. Motor vehicle emissions were determined from the vehicle miles, age of vehicle and extent of control equipment (see transportation - motor vehicles). This was broken down on a grid basis in a manner similar to that used for exhaust emissions from motor vehicles.

RESULTS: There was over 22,300 tons of hydrocarbons emitted, of which none was industrial, 2,100 was from dry cleaning operations, and 21,200 were from automobiles.

EMISSIONS BY JURISDICTION

The previous section of this report presents emissions primarily by source category. The emissions by county and source are summarized here in Tables 16 through 23.

As is expected due to a higher degree of urbanization than the other counties. The Massachusetts portion and parts of Hillsborough and Merrimack contribute to the majority of air pollutants.

TABLE 16 SUMMARY OF AIR POLLUTANT EMISSIONS IN MASS PORTION COUNTY TONS/YEAR

SOURCE CATEGORY	SOX	PART	CO	HC	NOX
TRANSPORTATION					
ROAD VEHICLES	735.	1202.	162137.	12727.	9099.
OTHER	37.	129.	5466.	1151.	464.
SUB-TOTAL	773.	1332.	167603.	13878.	9563.
COMBUSTION OF FUELS					
INDUSTRY	7615.	2154.	77.	51.	1817.
STEAM-ELEC	0.	0.	0.	0.	0.
RESIDENTIAL	1939.	550.	123.	182.	1116.
COMM AND INST.	13189.	1004.	95.	94.	3494.
SUB-TOTAL	22745.	3709.	295.	329.	6428.
[illegible]USE DISPOSAL					
INCINERATION	309.	2075.	3594.	86.	389.
OPEN BURNING	179.	2879.	15299.	5399.	1979.
SUB-TOTAL	489.	4954.	18894.	5486.	2369.
[illegible]ESS	80.	2832.	700.	0.	0.
[illegible] LOSSES				9062.	

TABLE 17 SUMMARY OF AIR POLLUTANT EMISSIONS
IN CHESHIRE COUNTY
TONS/YEAR.

SOURCE CATEGORY	SOX	PART	CO	HC	NOX
TRANSPORTATION					
ROAD VEHICLES	91.	139.	22004.	1699.	1188.
OTHER	0.	0.	0.	0.	0.
SUB-TOTAL	91.	139.	22004.	1699.	1188.
COMBUSTION OF FUELS					
INDUSTRY	278.	26.	2.	2.	91.
STEAM-ELEC	0.	0.	0.	0.	0.
RESIDENTIAL	246.	66.	15.	23.	122.
COMM AND INST.	251.	28.	3.	3.	115.
SUB-TOTAL	776.	122.	21.	28.	328.
REFUSE DISPOSAL					
INCINERATION	13.	65.	285.	5.	19.
OPEN BURNING	12.	192.	1019.	359.	132.
SUB-TOTAL	25.	257.	1305.	365.	151.
PROCESS	0.	0.	0.	0.	0.
EVAP LOSSES				1205.	

TABLE 18 SUMMARY OF AIR POLLUTANT EMISSIONS IN HILLSBOROUGH COUNTY TONS/YEAR

SOURCE CATEGORY	SOX	PART	CO	HC	NOX
TRANSPORTATION					
ROAD VEHICLES	352.	538.	84700.	6541.	4574.
OTHER	0.	60.	4274.	818.	226.
SUB-TOTAL	352.	599.	88975.	7360.	4800.
COMBUSTION OF FUELS					
INDUSTRY	2231.	162.	14.	14.	543.
STEAM-ELEC	1652.	47.	0.	15.	491.
RESIDENTIAL	1134.	307.	71.	107.	564.
COMM AND INST.	1076.	109.	11.	11.	420.
SUB-TOTAL	6096.	627.	98.	148.	2020.
REFUSE DISPOSAL					
INCINERATION	150.	994.	1794.	42.	190.
OPEN BURNING	52.	839.	4462.	1574.	577.
SUB-TOTAL	202.	1834.	6257.	1617.	767.
PROCESS	0.	2297.	0.	4215.	0.
EVAP LOSSES				4697.	

TABLE 19 SUMMARY OF AIR POLLUTANT EMISSIONS IN MERRIMACK COUNTY TONS/YEAR

SOURCE CATEGORY	SOX	PART	CO	HC	NOX
TRANSPORTATION					
ROAD VEHICLES	149.	228.	35960.	2777.	1942.
OTHER	0.	2.	1.	3.	5.
SUB-TOTAL	150.	231.	35961.	2780.	1947.
COMBUSTION OF FUELS					
INDUSTRY	471.	39.	3.	3.	132.
STEAM-ELEC	54340.	5873.	275.	110.	11000.
RESIDENTIAL	379.	100.	23.	35.	176.
COMM AND INST.	1122.	256.	137.	37.	457.
SUB-TOTAL	56314.	6270.	439.	186.	11766.
REFUSE DISPOSAL					
INCINERATION	15.	75.	330.	6.	22.
OPEN BURNING	22.	367.	1954.	689.	252.
SUB-TOTAL	37.	442.	2284.	695.	275.
PROCESS	0.	0.	0.	0.	0.
EVAP LOSSES				1957.	

TABLE 20 SUMMARY OF AIR POLLUTANT EMISSIONS
IN ROCKINGHAM COUNTY
TONS/YEAR

SOURCE CATEGORY	SOX	PART	CO	HC	NOX
TRANSPORTATION					
ROAD VEHICLES	222.	340.	53653.	4143.	2897.
OTHER	66.	5.	1.	2.	16.
SUB-TOTAL	289.	346.	53655.	4146.	2913.
COMBUSTION OF FUELS					
INDUSTRY	374.	41.	2.	2.	262.
STEAM-ELEC	11385.	325.	1.	104.	3385.
RESIDENTIAL	693.	185.	43.	65.	328.
COMM AND INST.	427.	53.	6.	5.	221.
SUB-TOTAL	12881.	606.	54.	178.	4198.
REFUSE DISPOSAL					
INCINERATION	44.	219.	967.	17.	66.
OPEN BURNING	80.	1280.	6799.	2400.	879.
SUB-TOTAL	123.	1499.	7767.	2417.	945.
PROCESS	0.	0.	0.	0.	0.
EVAP LOSSES				2975.	

TABLE 21 SUMMARY OF AIR POLLUTANT EMISSIONS
IN STRAFFORD COUNTY
TONS/YEAR

SOURCE CATEGORY	SOX	PART	CO	HC	NOX
TRANSPORTATION					
ROAD VEHICLES	131.	201.	31710.	2448.	1712.
OTHER	0.	0.	0.	0.	0.
SUB-TOTAL	131.	201.	31710.	2448.	1712.
COMBUSTION OF FUELS					
INDUSTRY	223.	16.	1.	1.	58.
STEAM-ELEC	0.	0.	0.	0.	0.
RESIDENTIAL	374.	96.	23.	35.	156.
COMM AND INST.	580.	49.	4.	4.	179.
SUB-TOTAL	1178.	163.	30.	41.	395.
REFUSE DISPOSAL					
INCINERATION	17.	85.	373.	6.	25.
OPEN BURNING	15.	255.	1359.	479.	175.
SUB-TOTAL	33.	340.	1733.	486.	201.
PROCESS	0.	0.	0.	0.	0.
EVAP LOSSES				1733.	

TABLE 22 SUMMARY OF AIR POLLUTANT EMISSIONS IN SULLIVAN COUNTY TONS/YEAR

SOURCE CATEGORY	SOX	PART	CO	HC	NOX
TRANSPORTATION					
ROAD VEHICLES	49.	75.	11906.	919.	643.
OTHER	0.	0.	0.	0.	0.
SUB-TOTAL	49.	75.	11905.	919.	643.
COMBUSTION OF FUELS					
INDUSTRY	396.	25.	2.	2.	80.
STEAM-ELEC	0.	0.	0.	0.	0.
RESIDENTIAL	157.	43.	9.	14.	82.
COMM AND INST.	173.	17.	1.	1.	66.
SUB-TOTAL	727.	86.	14.	18.	229.
REFUSE DISPOSAL					
INCINERATION	5.	25.	110.	1.	7.
OPEN BURNING	5.	80.	425.	150.	55.
SUB-TOTAL	10.	104.	535.	151.	62.
PROCESS	0.	0.	0.	0.	0.
EVAP LOSSES				668.	

TABLE 23 RELATIVE CONTRIBUTION OF EACH COUNTY TO TOTAL AIR POLLUTANT EMISSIONS

Jurisdiction	Sulfer Oxides	Partic-ulates	Carbon Monoxide	Hydor-carbons	Nitrogen Oxide
Massachusetts Portion	23.2	44.2	41.5	40.0	34.7
Chesire	0.9	1.8	5.2	4.6	3.2
Hillsborough	6.4	18.4	21.0	25.1	14.3
Merrimack	54.5	23.9	8.6	7.8	26.1
Rockingham	12.8	8.4	13.6	13.5	15.2
Strafford	1.3	2.4	7.4	6.5	4.4
Sullivan	0.8	0.9	2.7	2.5	1.8
TOTAL	100	100	100	100	100

EMISSIONS BY GRID

For the purpose of defining the geographical variation of air pollutant emissions in the Study Area, the resulting emissions were apportionned on the grid coordinate system. The emissions were divided into two source groups--point and area sources. Thirty-eight point sources are identified individually with respect to location and emissions. Each of these point sources emit more than 0.5 ton per day of any pollutant.

Figure 5 shows the location of most of the point sources in the area. Collectively the 38 point sources account for 75 percent of the sulfur oxides, 58 percent of particulates, 4 percent of carbon monoxide, 13 percent of hydrocarbons and 34 percent of nitrogen oxides. The percent contribution to carbon monoxide emissions is low because motor vehicles, which are area sources account for most of the total carbon monoxide emissions. Similarly, the contribution to total hydrocarbon emissions is low since two groups of area sources, motor vehicles and evaporative losses are major contributors. Table 24 presents the emissions of point sources. It has been assumed that seasonal variations in point sources are negligible.

Area sources are sources of emissions that are insignificant by themselves, but as a group emit a significant amount. Examples are motor vehicles, residential houses, light commercial and industrial establishments and backyard burning. The emissions from area sources have been added to that for point sources to obtain total emissions by grid as given in Table 25.

The emissions are presented for an annual average day, and average winter day (December, January, February), and an average summer day (June, July, August). Tha annual average daily emission rates were obtained by dividing yearly totals by 365. Seasonal averages were calculated by the use of space heating variations in fuel consumption and variations in motor vehicle traffic activity. This method is described in detail in the appendix. Other sources were assumed to be constant throughout the year.

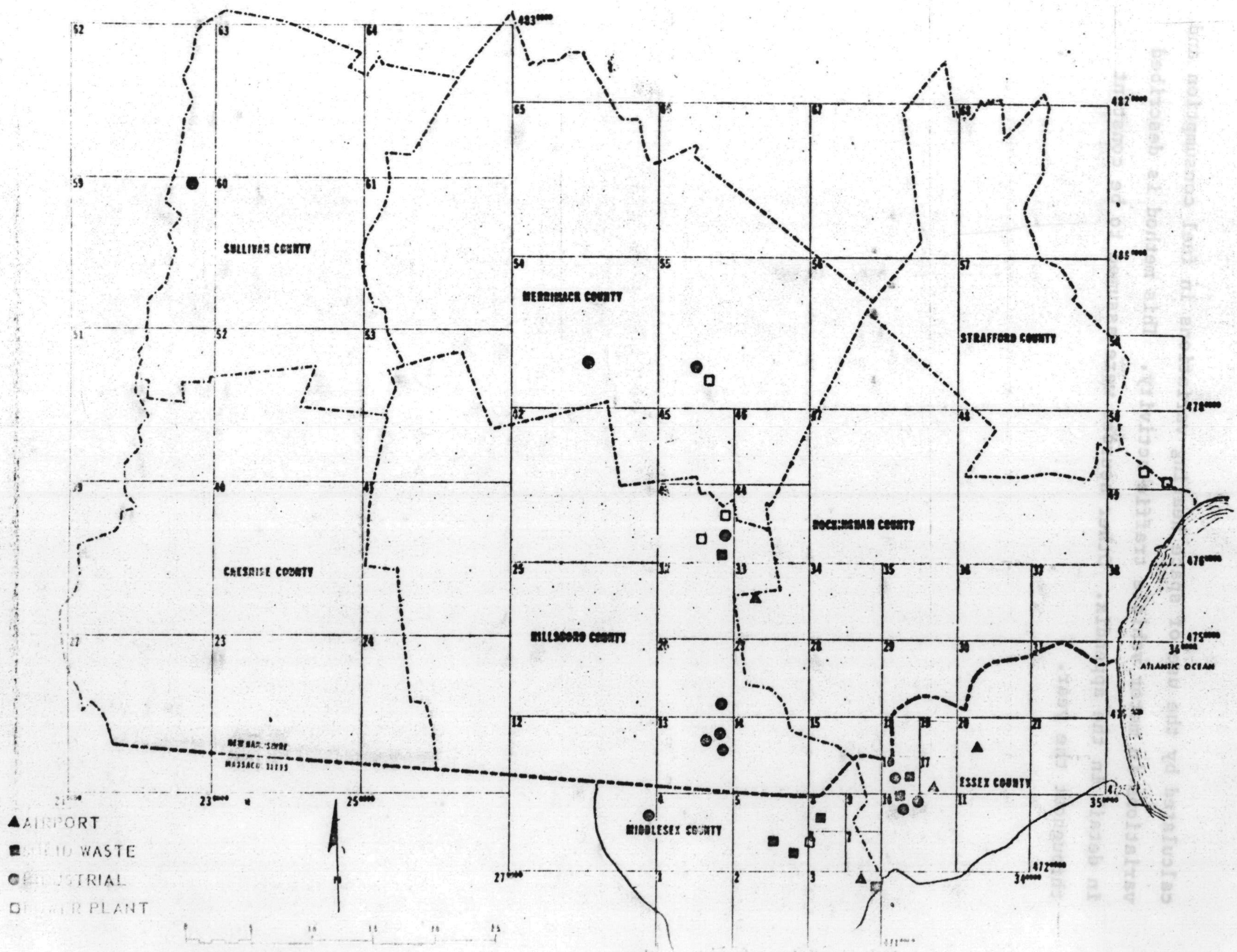
SULLIVAN COUNTY
MERRIMACK COUNTY
STRAFFORD COUNTY
CHESHIRE COUNTY
HILLSBORO COUNTY
ROCKINGHAM COUNTY
MIDDLESEX COUNTY
ESSEX COUNTY
ATLANTIC OCEAN
AIRPORT
WASTE
STRIAL
PLANT

TABLE 24 SUMMARY OF AIR POLLUTANT EMISSIONS FROM POINT SOURCES
TONS/DAY

ID	GR	HC	VC	SOX S	SOX W	SOX A	PART S	PART W	PART A	CO S	CO W	CO A	HC S	HC W	HC A	NOX S	NOX W	NOX A
5	3	3190	47170	0.0	0.0	0.0	0.54	0.54	0.54	2.91	2.91	2.91	1.02	1.02	1.02	0.37	0.37	0.37
7	3	3195	47175	0.0	0.0	0.0	0.00	0.00	0.00	1.41	1.41	1.41	0.26	0.26	0.26	0.06	0.06	0.06
2	5	3096	47233	0.5	0.9	0.7	0.03	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.18	0.14
5	5	3070	47225	0.0	0.0	0.0	0.65	0.65	0.65	3.49	3.49	3.49	1.23	1.23	1.23	0.45	0.45	0.45
5	5	3045	47235	0.0	0.0	0.0	0.87	0.87	0.87	4.65	4.65	4.65	1.64	1.64	1.64	0.60	0.60	0.60
6	5	3070	47225	0.1	0.1	0.1	1.63	1.63	1.63	0.09	0.09	0.09	0.02	0.02	0.02	0.19	0.19	0.19
5	8	3115	47270	0.0	0.0	0.0	0.39	0.39	0.39	2.09	2.09	2.09	0.73	0.73	0.73	0.27	0.27	0.27
2	10	3234	47285	1.1	1.9	1.5	0.07	0.12	0.09	0.00	0.01	0.00	0.00	0.01	0.00	0.22	0.38	0.29
2	10	3237	47294	2.3	3.8	2.9	8.07	8.29	8.17	1.94	1.95	1.94	0.01	0.02	0.01	0.41	0.71	0.55
5	10	3220	47290	0.0	0.0	0.0	0.43	0.43	0.43	2.32	2.32	2.32	0.82	0.82	0.82	0.30	0.30	0.30
6	10	3220	47290	0.2	0.2	0.2	1.86	1.86	1.86	0.10	0.10	0.10	0.03	0.03	0.03	0.21	0.21	0.21
2	12	2890	47260	1.5	2.6	2.0	3.20	5.52	4.27	0.06	0.10	0.08	0.02	0.03	0.02	0.40	0.69	0.53
2	13	2995	47375	0.0	0.1	0.1	0.70	0.71	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.03
2	13	2992	47362	0.9	1.6	1.2	0.06	0.10	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.33	0.25
2	13	2980	47376	0.1	0.2	0.2	0.01	0.01	0.01	0.00	0.00	0.00	11.00	11.00	11.00	0.03	0.05	0.04
2	13	2989	47366	0.0	0.0	0.0	0.77	0.78	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01
2	13	2970	47370	0.0	0.0	0.0	4.09	4.09	4.09	0.00	0.00	0.00	0.55	0.55	0.55	0.00	0.00	0.00
7	15	3160	47330	0.0	0.0	0.0	0.00	0.00	0.00	0.11	0.11	0.11	0.02	0.02	0.02	0.00	0.00	0.00
2	16	3235	473 2	1.3	2.3	1.8	0.08	0.15	0.11	0.00	0.01	0.01	0.00	0.01	0.01	0.27	0.47	0.36
2	16	3215	47312	2.0	3.5	2.7	0.12	0.22	0.17	0.01	0.01	0.01	0.01	0.01	0.01	0.40	0.70	0.54
2	16	3234	473 0	2.1	3.7	2.8	0.13	0.23	0.18	0.01	0.02	0.01	0.01	0.02	0.01	0.42	0.73	0.56
5	16	3240	47340	0.0	0.0	0.0	0.98	0.98	0.98	5.23	5.23	5.23	1.84	1.84	1.84	0.67	0.67	0.67
7	17	3260	47315	0.0	0.0	0.0	0.05	0.05	0.05	11.34	11.34	11.34	2.14	2.14	2.14	0.53	0.53	0.53
7	20	3323	47350	0.0	0.0	0.0	0.00	0.00	0.00	1.64	1.64	1.64	0.31	0.31	0.31	0.07	0.07	0.07
2	26	2981	474 5	0.5	0.9	0.7	0.03	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.19	0.14
7	31	3485	474 0	0.0	0.0	0.0	0.00	0.00	0.00	0.29	0.29	0.29	0.05	0.05	0.05	0.01	0.01	0.01
7	33	3018	47560	0.0	0.0	0.0	0.16	0.16	0.16	11.70	11.70	11.70	2.23	2.23	2.23	0.61	0.61	0.61

[illegible]	45	[illegible]	47610	0.1	0.1	0.1	1.63	1.63	1.63	0.09	0.09	0.09	0.02	0.02	0.02	0.19	0.19	0.19
2	45	2985	476 3	0.1	1.0	0.5	0.00	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.21	0.10
4	45	2965	47624	2.0	2.0	2.0	0.05	0.05	0.05	0.00	0.00	0.00	0.01	0.01	0.01	0.60	0.60	0.59
4	45	2987	47640	2.5	2.5	2.5	0.07	0.07	0.07	0.00	)0.00	0.00	0.02	0.02	0.02	0.75	0.75	0.74
4	50	3546	47730	28.5	28.5	28.1	0.81	0.81	0.80	0.00	0.00	0.00	0.26	0.26	0.25	8.49	8.49	8.37
4	50	3570	477 7	3.0	3.0	3.0	0.08	0.08	0.08	0.00	0.00	0.00	0.02	0.02	0.02	0.90	0.90	0.89
2	54	2790	47850	0.6	1.1	0.8	0.04	0.07	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.23	0.18
2	55	2950	47860	0.5	0.9	0.7	0.03	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.19	0.14
3	55	2930	4786(	1.0	1.7	1.3	0.06	0.11	0.09	0.00	0.01	0.00	0.00	0.01	0.00	0.21	0.36	0.28
4	55	2964	47840	150.9	150.9	148.8	16.31	16.31	16.09	0.76	0.76	0.75	0.30	0.30	0.30	30.55	30.55	30.13
2	59	2260	48020	0.4	0.8	0.6	0.03	0.05	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.16	0.12

TABLE 25 SUMMARY OF AIR POLLUTANT EMISSIONS TONS/DAY

GRID	AREA	SOX S	SOX W	SOX A	PART S	PART W	PART A	CO S	CO W	CO A	HC S	HC W	HC A	NOX S	NOX W	NOX A
1	38.6	0.4	3.0	1.6	0.3	0.6	0.4	17.7	16.1	16.9	2.4	2.3	2.4	1.1	1.8	1.4
2	38.6	0.2	4.0	1.9	0.4	0.8	0.6	23.0	21.0	22.0	3.2	3.0	3.1	1.4	2.5	1.9
3	38.6	0.3	6.2	3.0	1.2	1.8	1.4	36.8	33.9	35.3	5.9	5.6	5.7	2.4	4.0	3.2
4	38.6	0.1	1.6	0.8	0.2	0.3	0.2	10.2	9.3	9.8	1.4	1.3	1.4	0.6	1.0	0.8
5	38.6	2.2	20.8	10.8	5.1	6.9	5.9	94.5	87.1	90.8	15.2	14.6	14.9	6.8	12.0	9.2
6	9.6	0.2	5.8	2.8	0.6	1.2	0.9	27.2	24.9	26.0	3.9	3.7	3.8	1.8	3.3	2.5
7	9.6	0.1	2.2	1.0	0.3	0.5	0.3	11.7	10.7	11.2	1.7	1.6	1.6	0.8	1.3	1.0
8	9.6	0.1	2.7	1.3	0.7	0.9	0.8	15.0	13.9	14.4	2.6	2.5	2.5	1.1	1.8	1.4
9	9.6	0.1	1.7	0.8	0.2	0.3	0.3	9.4	8.5	8.9	1.3	1.2	1.3	0.6	1.0	0.8
10	38.6	6.7	21.2	13.4	11.7	13.2	12.4	56.3	51.9	54.1	8.3	7.9	8.1	5.0	8.8	6.7
11	38.6	0.1	2.0	0.9	0.2	0.4	0.3	11.7	10.7	11.2	1.6	1.5	1.6	0.7	1.2	0.9
12	154.4	2.0	5.6	3.7	3.6	6.1	4.8	19.7	18.0	18.8	2.7	2.6	2.7	1.6	2.6	2.1
13	38.6	2.9	7.2	4.9	6.6	7.1	6.8	41.2	37.6	39.4	17.4	17.0	17.2	3.0	4.2	3.6
14	38.6	0.7	3.1	1.8	0.7	1.1	0.9	36.1	32.9	34.5	5.1	4.8	4.9	2.2	3.0	2.6
15	38.6	0.3	4.1	2.1	1.1	1.6	1.3	42.5	38.9	40.7	6.4	6.0	6.2	2.7	3.9	3.2
16	9.6	6.6	18.8	12.2	2.2	3.2	2.6	40.4	37.4	38.9	6.9	6.7	6.8	4.1	7.2	5.5
17	9.6	0.4	3.2	1.7	0.4	0.6	0.5	24.6	23.5	24.1	4.0	3.9	4.0	1.4	2.2	1.8
18	9.6	0.1	1.5	0.7	0.2	0.3	0.2	7.6	7.0	7.3	1.1	1.0	1.0	0.5	0.9	0.6
19	9.6	0.1	3.0	1.5	0.3	0.6	0.5	15.6	14.2	14.9	2.2	2.1	2.1	1.0	1.8	1.3
20	38.6	0.2	5.6	2.7	0.6	1.1	0.8	31.4	28.8	30.1	4.5	4.2	4.4	1.9	3.4	2.6
21	38.6	0.1	1.9	0.9	0.3	0.4	0.3	12.3	11.2	11.8	1.8	1.7	1.7	0.8	1.3	1.1
22	154.4	0.8	1.7	1.2	0.2	0.3	0.3	7.8	7.1	7.5	1.1	1.0	1.1	0.7	1.0	0.8
23	154.4	0.0	0.2	0.1	0.1	0.1	0.1	4.1	3.8	4.0	0.6	0.5	0.6	0.2	0.3	0.3
24	154.4	0.1	0.7	0.4	0.2	0.3	0.3	11.7	10.7	11.2	1.6	1.5	1.6	0.7	0.9	0.8
25	154.4	0.1	1.0	0.5	0.3	0.5	0.4	16.7	15.3	16.0	2.4	2.2	2.3	1.0	1.3	1.1

26	38.6	0.8	1.9	1.3	0.2	0.4	0.3	10.1	9.2	9.7	1.4	1.3	1.4	0.7	1.0	0.9
27	38.6	0.1	0.7	0.4	0.4	0.5	0.4	13.1	12.1	12.6	2.0	1.9	2.0	0.8	1.1	1.0
28	38.6	0.1	0.4	0.2	0.2	0.3	0.2	6.9	6.4	6.6	1.1	1.0	1.0	0.4	0.6	0.5
29	38.6	0.2	3.2	1.6	0.6	0.9	0.8	24.4	22.3	23.3	3.6	3.4	3.5	1.5	2.4	1.9
30	38.6	0.2	3.3	1.6	0.4	0.7	0.6	19.9	18.2	19.0	2.8	2.7	2.8	1.2	2.1	1.6
31	38.6	0.7	6.6	3.4	0.7	1.3	1.0	31.4	28.7	30.0	4.5	4.2	4.4	2.1	3.8	2.9
32	38.6	0.1	1.1	0.6	0.4	0.5	0.4	18.3	16.7	17.5	2.6	2.4	2.5	1.1	1.4	1.2
33	38.6	0.2	0.4	0.3	0.3	0.3	0.3	15.0	14.7	14.8	2.7	2.7	2.7	0.9	1.0	0.9
34	38.6	0.0	0.3	0.1	0.2	0.2	0.2	5.2	4.7	4.9	0.8	0.8	0.8	0.3	0.4	0.4
35	38.6	0.0	0.1	0.1	0.1	0.1	0.1	1.9	1.8	1.9	0.3	0.3	0.3	0.1	0.2	0.1
36	38.6	0.0	0.2	0.1	0.1	0.2	0.2	4.6	4.3	4.4	0.7	0.7	0.7	0.3	0.4	0.3
37	38.6	0.0	0.3	0.2	0.2	0.2	0.2	6.3	5.8	6.0	1.0	0.9	0.9	0.4	0.5	0.5
38	38.6	0.3	0.9	0.6	0.4	0.6	0.5	14.9	13.6	14.3	2.3	2.2	2.2	1.0	1.3	1.1
39	154.4	0.0	0.2	0.1	0.1	0.1	0.1	4.3	3.9	4.1	0.6	0.6	0.6	0.2	0.3	0.3
40	154.4	0.2	2.0	1.1	0.6	0.9	0.7	36.0	32.8	34.4	5.0	4.7	4.9	2.1	2.7	2.4
41	154.4	0.1	0.6	0.3	0.2	0.3	0.2	9.6	8.8	9.2	1.4	1.3	1.3	0.6	0.7	0.6
42	154.4	0.1	1.0	0.5	0.3	0.5	0.4	16.9	15.5	16.2	2.4	2.2	2.3	1.0	1.3	1.1
43	38.6	0.7	4.7	2.6	3.0	3.7	3.3	72.6	66.3	69.4	10.2	9.6	9.9	4.5	5.8	5.1
44	38.6	0.6	2.5	1.4	0.6	0.9	0.8	30.3	27.7	29.0	4.3	4.0	4.2	1.9	2.5	2.2
45	38.6	5.0	7.6	6.1	0.4	0.7	0.5	13.0	11.9	12.5	1.9	1.8	1.8	2.2	2.8	2.4
46	38.6	0.1	0.5	0.3	0.2	0.4	0.3	12.8	11.8	12.3	1.8	1.7	1.8	0.8	0.9	0.8
47	154.4	0.1	0.5	0.3	0.3	0.4	0.3	9.8	9.0	9.4	1.5	1.4	1.5	0.6	0.8	0.7
48	154.4	0.2	1.9	1.0	0.8	1.1	0.9	32.6	29.9	31.2	4.9	4.6	4.7	2.0	2.6	2.3
49	38.6	0.3	1.7	1.0	1.0	1.2	1.1	32.6	29.9	31.3	5.0	4.8	4.9	2.1	2.7	2.4
50	38.6	31.8	32.3	31.6	1.1	1.2	1.1	6.8	6.2	6.5	1.3	1.3	1.3	9.9	10.0	9.8
51	154.4	0.0	0.3	0.2	0.1	0.1	0.1	5.7	5.2	5.5	0.8	0.7	0.8	0.3	0.4	0.4
52	154.4	0.0	0.1	0.1	0.0	0.1	0.0	2.4	2.2	2.3	0.3	0.3	0.3	0.1	0.2	0.2
53	154.4	0.0	0.2	0.1	0.1	0.1	0.1	3.8	3.5	3.6	0.5	0.5	0.5	0.2	0.3	0.3
54	154.4	1.0	2.4	1.6	0.3	0.5	0.4	12.2	11.2	11.7	1.7	1.6	1.7	0.9	1.2	1.1

55	154.4	153.1	156.2	152.5	17.4	18.3	17.6	43.2	39.8	41.5	6.3	6.0	6.2	34.2	35.7	34.4
56	154.4	0.2	0.7	0.4	0.2	0.3	0.2	8.4	7.7	8.1	1.2	1.1	1.2	0.5	0.7	0.6
57	154.4	0.7	5.7	3.0	1.2	1.9	1.5	74.0	67.5	70.7	10.3	9.6	10.0	4.3	5.6	4.9
58	38.6	0.0	0.2	0.1	0.0	0.1	0.1	2.9	2.7	2.8	0.4	0.4	0.4	0.2	0.2	0.2
59	154.4	1.2	3.0	2.0	0.3	0.6	0.4	18.8	17.1	17.9	2.6	2.5	2.5	1.3	1.8	1.5
60	154.4	0.1	0.7	0.3	0.2	0.3	0.2	10.8	9.9	10.4	1.5	1.4	1.5	0.6	0.8	0.7
61	154.4	0.0	0.2	0.1	0.1	0.2	0.1	5.6	5.1	5.3	0.8	0.7	0.8	0.3	0.4	0.4
62	154.4	0.0	0.2	0.1	0.0	0.1	0.1	2.9	2.6	2.7	0.4	0.4	0.4	0.2	0.2	0.2
63	154.4	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.8	0.1	0.1	0.1	0.0	0.1	0.1
64	154.4	0.0	0.1	0.0	0.0	0.0	0.0	1.6	1.5	1.5	0.2	0.2	0.2	0.1	0.1	0.1
65	154.4	0.1	0.5	0.3	0.3	0.4	0.3	14.5	13.3	13.9	2.0	1.9	2.0	0.8	1.0	0.9
66	154.4	0.7	1.3	1.0	0.1	0.2	0.1	2.5	2.3	2.4	0.4	0.3	0.4	0.3	0.4	0.3
67	154.4	0.0	0.1	0.0	0.0	0.0	0.0	0.8	0.7	0.8	0.1	0.1	0.1	0.0	0.1	0.1
68	154.4	0.0	0.5	0.3	0.1	0.2	0.1	7.1	6.4	6.7	1.0	0.9	0.9	0.4	0.5	0.5

EMISSION DENSITIES

In order to provide a visual representation of the emissions of pollutants by grid, emission density maps have been provided. Figures 6 through 10 show variation in emission densities for the respective grids throughout the Study Area. As expected the emissions generally follow the pattern and degree of urbanization. Emission densities are higher in grids with high populations and correspondingly high vehicular and industrial activity.

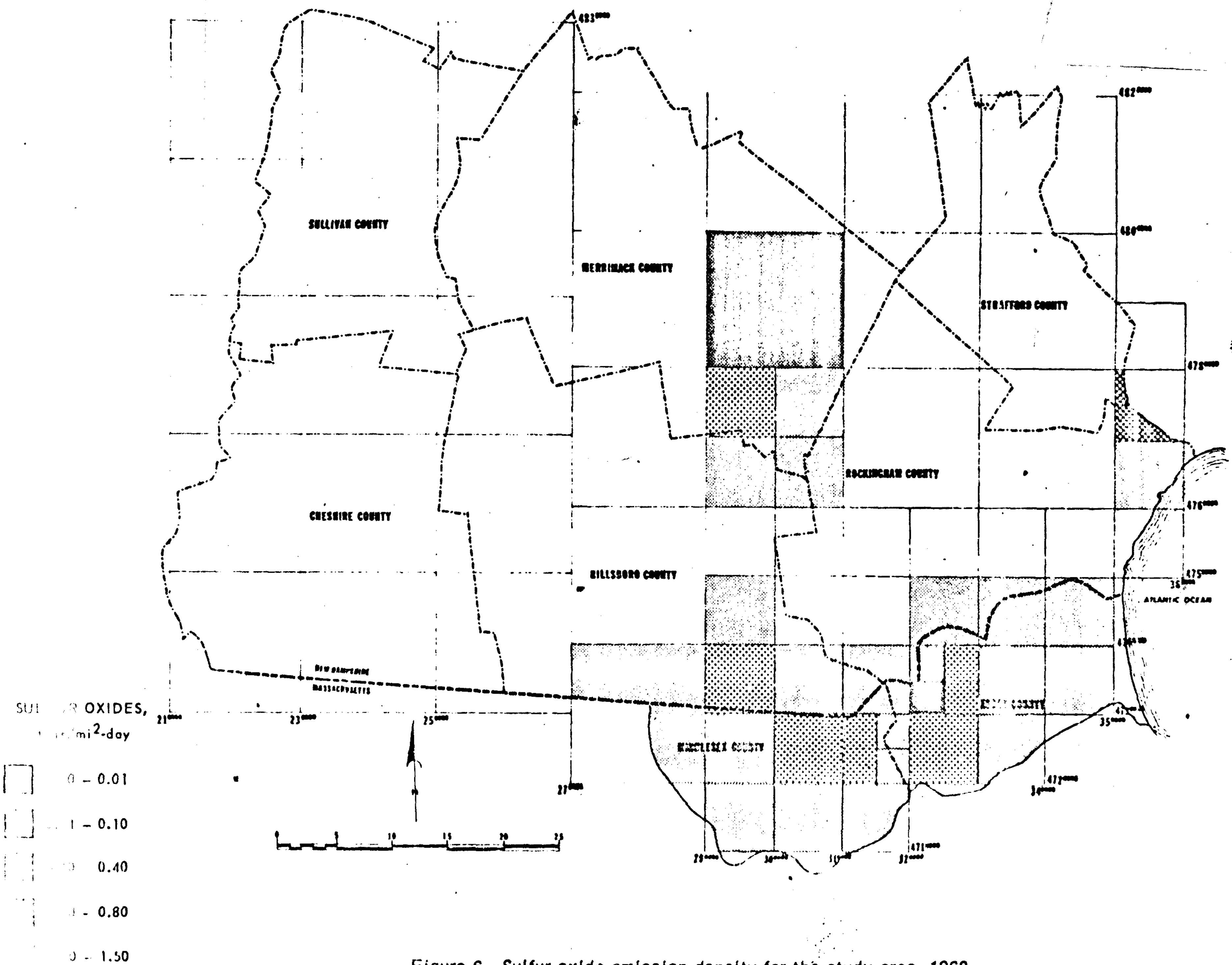

Figure 6. Sulfur oxide emission density for the study area, 1968.

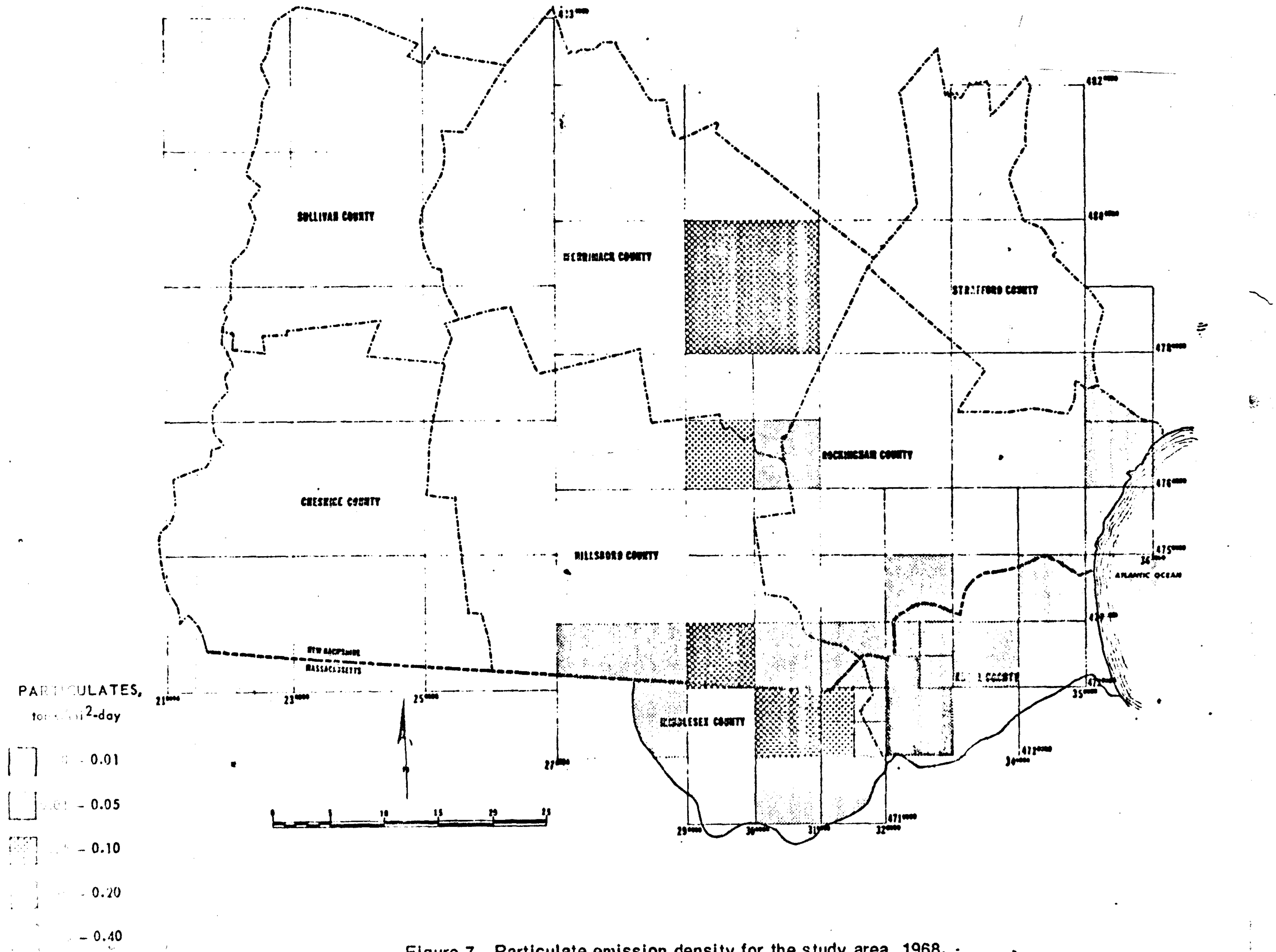

Figure 7. Particulate emission density for the study area, 1968.

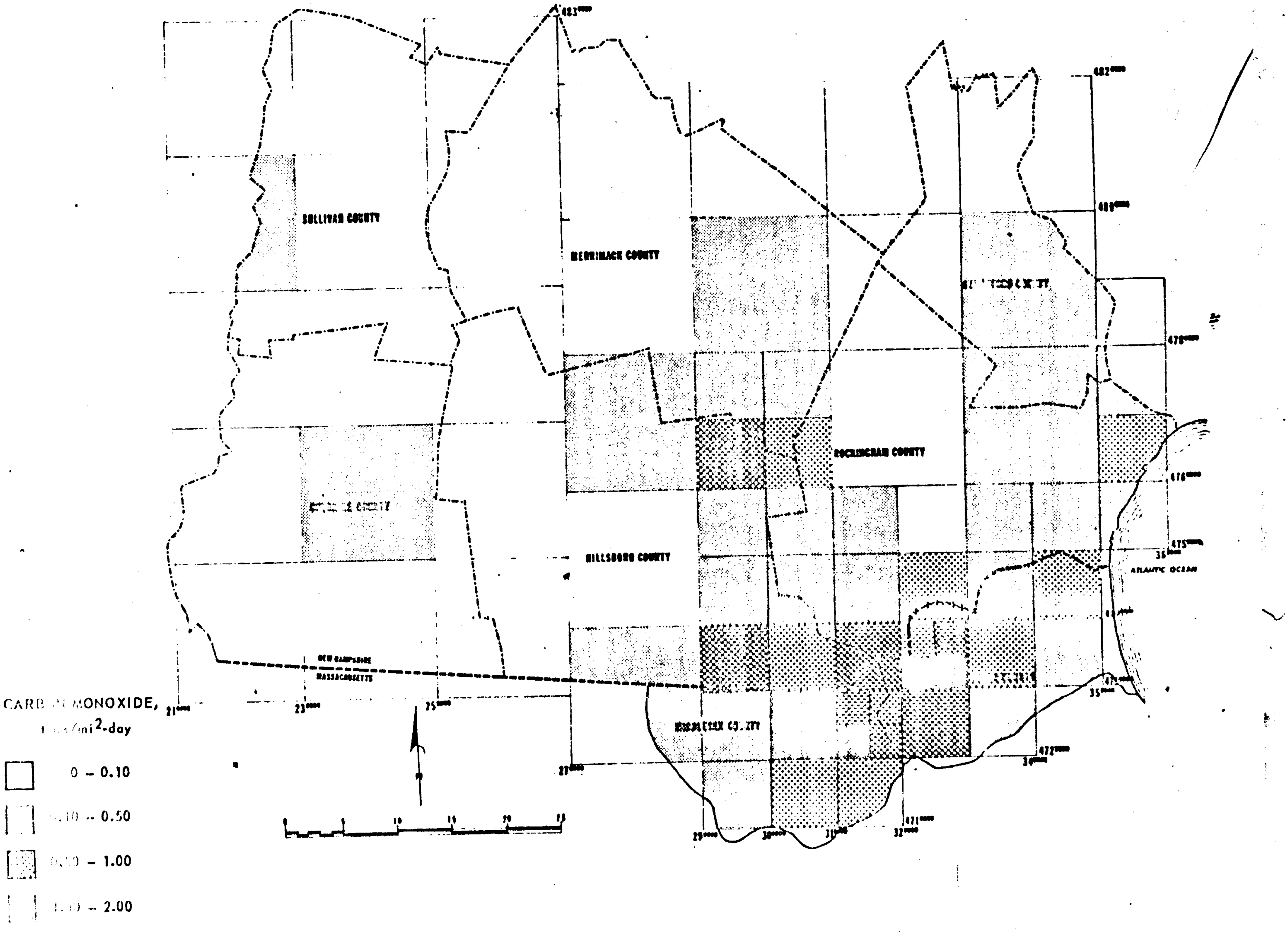

Figure 8. Carbon monoxide emission density for the study area, 1968.

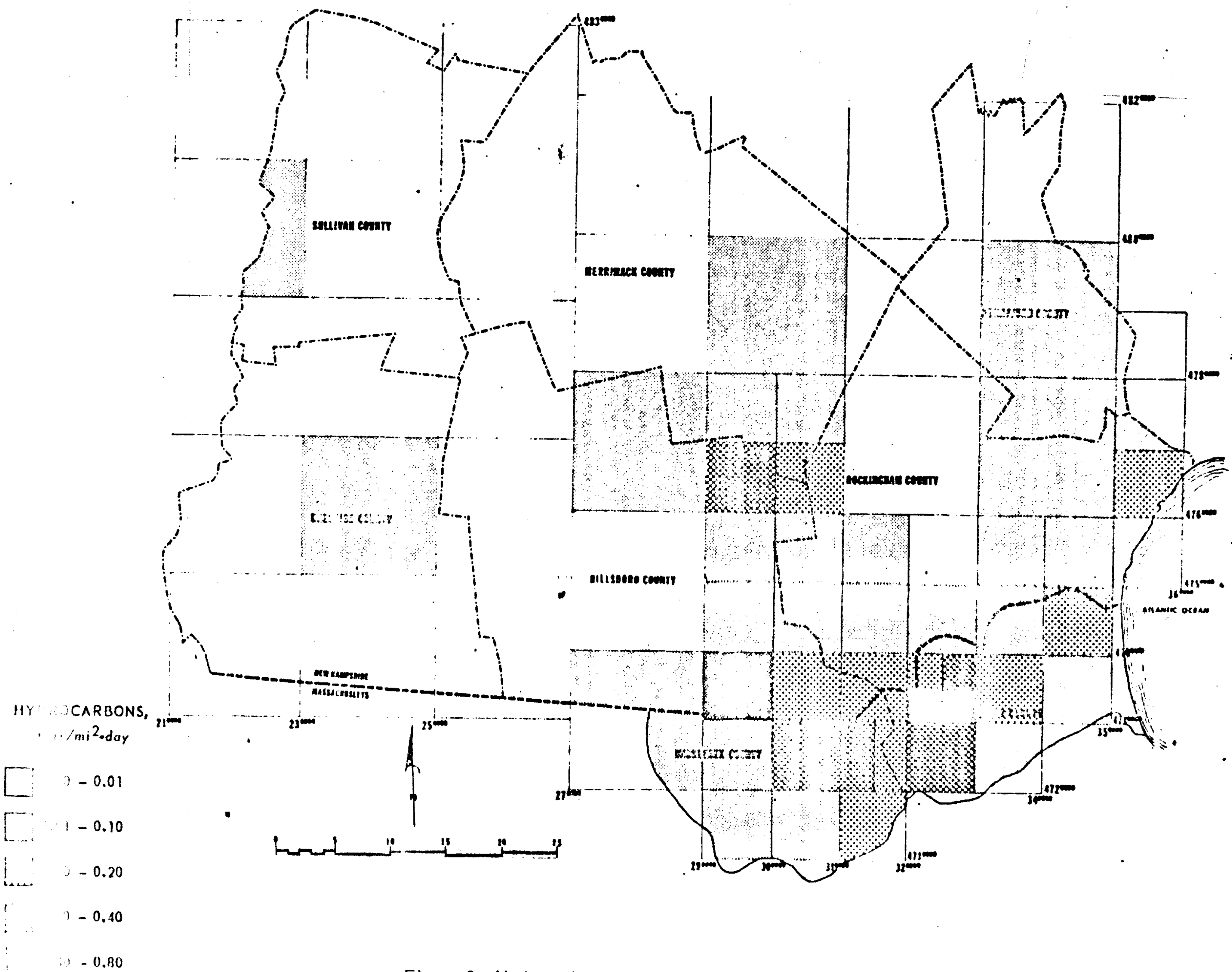

Figure 9. Hydrocarbon emission density for the study area, 1968.

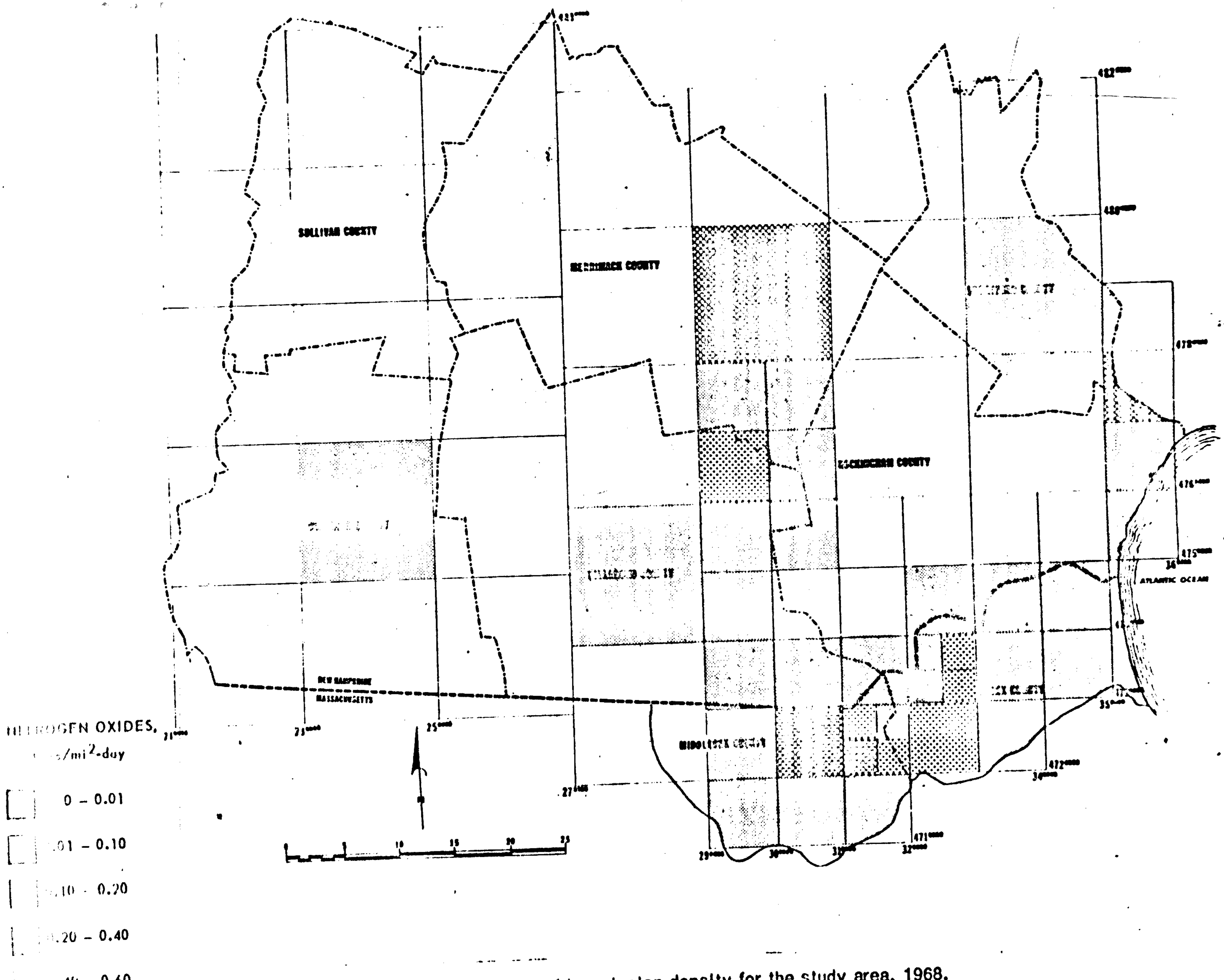

Figure 10. Nitrogen oxide emission density for the study area, 1968.

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APPENDIX

METHOD FOR CALCULATING SUMMER, WINTER AND ANNUAL AVERAGE EMISSIONS FOR FUEL CONSUMPTION IN STATIONARY SOURCES

YEARLY AVERAGE (A)

$$A = \frac{\text{Fuel Consumed} \times \text{Emission Factor (E. F.)}}{\text{Days of Operation}}$$

e.g. A plant consumed 100,000 tons of coal in 1967 while operating 365 days. The total degree days for the area was 4,800 and 2,800 for the three winter months. The plant was estimated to use 15 percent of the fuel for space heating and 85 percent for process heating. From this information, the annual average emission for carbon monoxide would be the following:

$$A = \frac{100{,}000 \text{ Tons/year} \times 3 \text{ lbs. CO/Ton coal}}{365 \text{ Days/year} \times 2{,}000 \text{ lb./Ton}}$$

$$A = 0.41 \text{ Ton/Day}$$

WINTER AVERAGE (W)

$$W = \frac{\text{Fuel Consumed} \times \text{E.F.}}{\text{Days of Winter Operation}} \times \frac{\text{Winter Degree Days}}{\text{Total Degree Days}} \times \begin{matrix}\text{\% Fuel Used} \\ \text{for space heating}\end{matrix}$$

$$+ \frac{\text{Fuel Consumed} \times \text{E.F.}}{365} \times \text{\% Fuel used for process heating}$$

$$W = \left[\frac{100{,}000 \times 2{,}800}{90 \times 4{,}800} \times 0.15 + \frac{100{,}000}{365} \times 0.85\right] \frac{3}{2{,}000}$$

$$W = 0.49 \text{ Ton/Day}$$

SUMMER AVERAGE (S)

$$S = \frac{\text{Fuel Consumed} \times \text{E.F.}}{\text{Days of Summer Operation}} \times \frac{\text{Summer Degree Days}}{\text{Total Degree Days}} \times \begin{matrix}\text{\% Fuel Used} \\ \text{for space heating}\end{matrix}$$

$$+ \frac{\text{Fuel Consumed} \times \text{E.F.}}{365} \times \text{\% Fuel used for process heating}$$

$$S = \left[\frac{100{,}000}{90} \times \frac{0}{4{,}800} \times 0.15 + \frac{100{,}000}{365} \times 0.85\right] \frac{3}{2{,}000}$$

$$S = 0.35 \text{ Ton/Day}$$

APPENDIX B

METRIC CONVERSION FACTORS

Multiply	By.	To Obtain
Feet	0.3048	Meters
Miles	1609	Meters
Square Feet	0.0929	Square meters
Square Miles	2.59	Square kilometers
Pounds	453.6	Grams
Pounds	$453.6/10^4$	Tons (metric)
Tons (metric)	1.103	Tons (short)
Tons (short)	907.2	Kilograms
Tons (short)	.9072	Tons (metric)
To Obtain	By	Divide