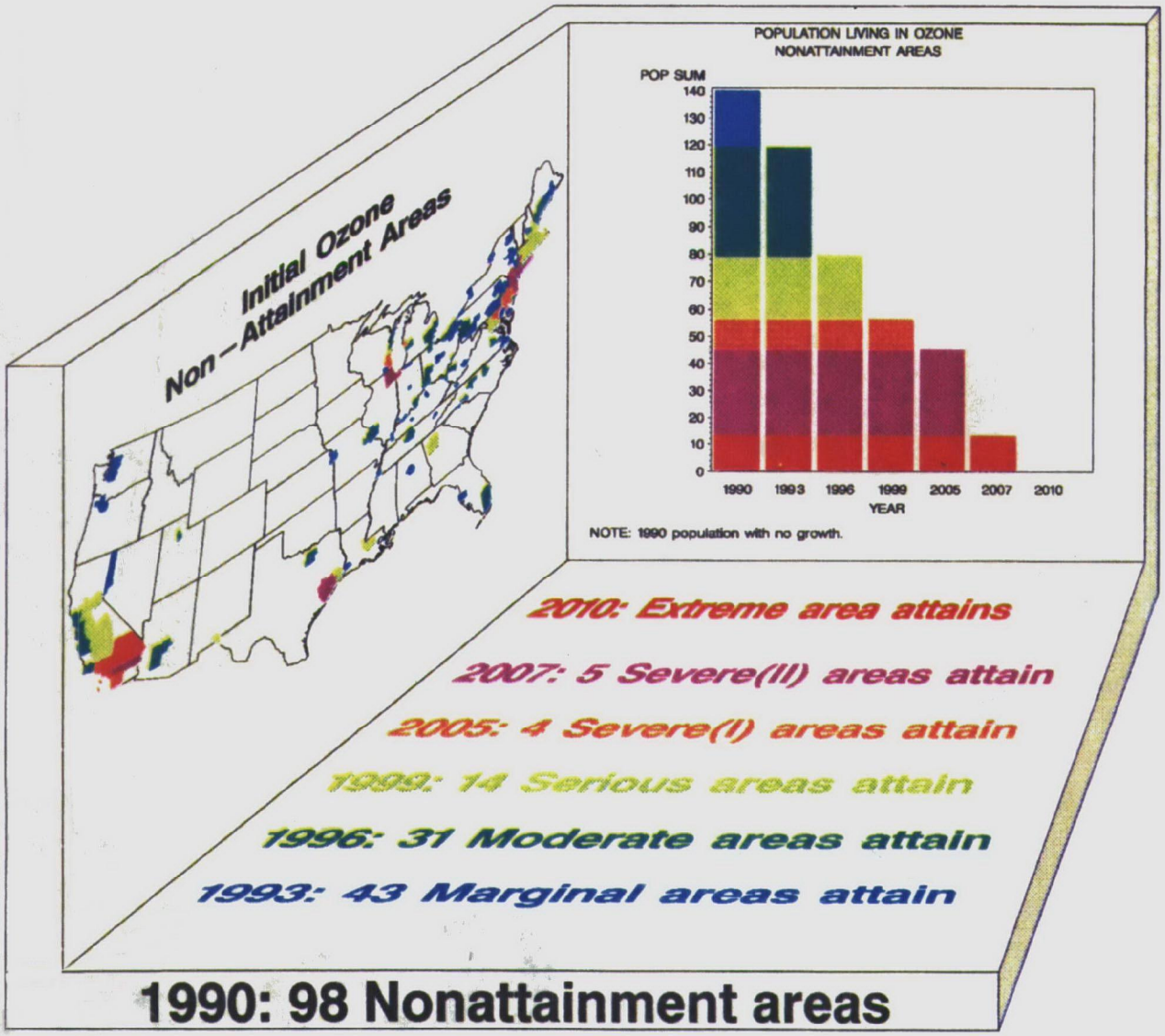
United States Environmental Protection Agency
Office of Air Quality Planning and Standards Research Triangle Park NC 27711
450-R-92-001
Press Release Edition
Air

EPA

National Air Quality and Emissions Trends Report, 1991



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
AIR AND RADIATION

Dear Colleague:

I am pleased to transmit to you the Environmental Protection Agency's (EPA) nineteenth annual National Air Quality and Emissions Trends Report. This document describes one- and ten-year trends in emissions and air quality for the following six important air pollutants. Specifically, for the timeperiod 1982 - 1991 it shows:

Pollutant	Air Quality Improvement	Emission Reduction
Carbon monoxide	30%	31%
Lead	89%	90%
Nitrogen Dioxide	6%	8%
Ozone (Smog)	8%	13%
Particulate Matter	10%	5%
Sulfur Dioxide	20%	2%

While we are pleased with the progress the nation has been able to achieve to date, the report shows that there are still 86.4 million Americans that live in areas with air quality that does not meet one or more of the national ambient air quality standards. Ozone (smog) continues to be the pollutant to which most Americans are exposed.

We are aggressively implementing the Clean Air Act to address these problems, as well as air quality and health problems associated with acid rain, air toxics, and stratospheric ozone depletion.

I hope this report is helpful to you.

Sincerely,

William G. Rosenberg
Assistant Administrator
for Air and Radiation

450-R-92-001

National Air Quality and Emissions Trends Report, 1991

Technical Support Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711
October 1992

DISCLAIMER

This report has been reviewed by the Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, and has been approved for publication. Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use.

About the Cover: The graphical display presents three types of information on ground level ozone in the U.S. The map shows those areas that were not meeting the ozone National Ambient Air Quality Standard when the 1990 Clean Air Act Amendments were passed. The color shading indicates the classification of each area. The text lists the attainment deadlines specified in the Amendments with the same color coding used in the maps. The bar chart shows the reduction in the population living in areas not meeting the ozone standard that should occur as these deadlines are met.

PREFACE

This is the nineteenth annual report of air pollution trends issued by the U. S. Environmental Protection Agency. The report is prepared by the Technical Support Division and is directed toward both the technical air pollution audience and the interested general public. The Division solicits comments on this report and welcomes suggestions on our trend techniques, interpretations, conclusions, and methods of presentation. Please forward any response to Dr. Thomas C. Curran, (MD-14) U. S. Environmental Protection Agency, Technical Support Division, Research Triangle Park, North Carolina 27711.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

NATIONAL AIR QUALITY AND EMISSIONS TRENDS REPORT, 1991

1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

This is the nineteenth annual report[1-18] documenting air pollution trends in the United States for those pollutants for which the U.S. Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards. EPA set these standards to protect public health and welfare. There are two types of National Ambient Air Quality Standards, primary and secondary. Primary standards are designed to protect public health, while secondary standards protect public welfare, such as effects of air pollution on vegetation, materials and visibility.

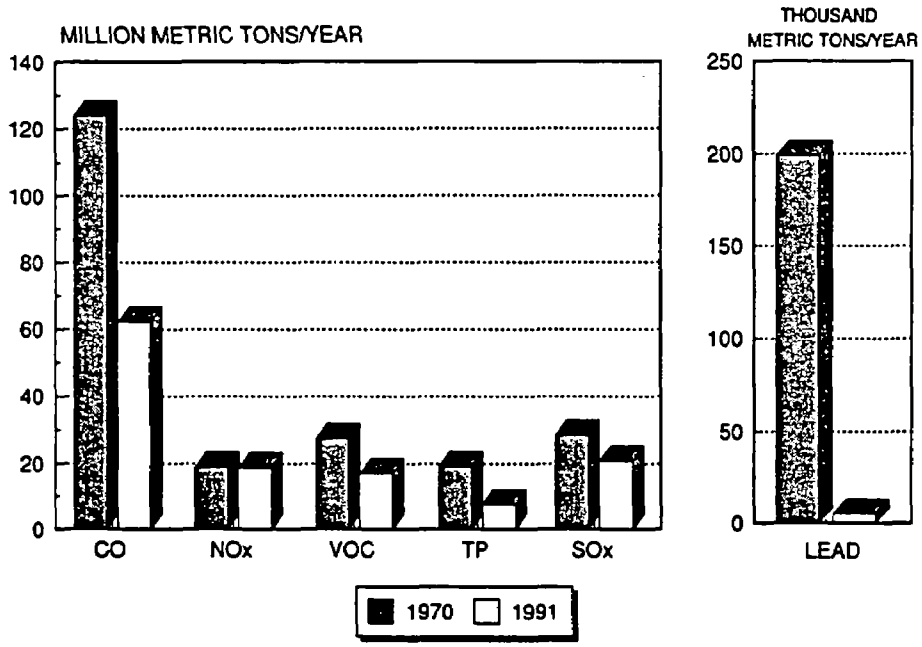
This report focuses on comparisons with the primary standards in effect in 1991 to examine changes in air pollution levels over time, and to summarize current air pollution status. EPA has established national air quality standards for six pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (formerly as total suspended particulate (TSP) and now as PM-10 which emphasizes the smaller particles), and sulfur dioxide (SO_2). It is important to note that the discussions of ozone in this report refer to ground level, or tropospheric, ozone and not to stratospheric ozone. Ozone in the stratosphere, miles above the earth, is a beneficial screen from the sun's ultraviolet rays. Ozone at ground level, in the air we breathe, is a health and environmental concern and is the primary ingredient of what is commonly called smog.

The report tracks two kinds of trends: **air concentrations**, based on actual direct measurements of pollutant concentrations at selected sites throughout the country; and **emissions**, which are based upon the best available engineering calculations. It also provides estimates of the total tonnage of these pollutants released into the air annually. Chapter 4 of this report includes a detailed listing of selected 1991 air quality summary statistics for every metropolitan statistical area (MSA) in the nation and maps highlighting the largest MSAs. Chapter 5 presents 1982-91 trends for 15 cities throughout the U.S. Chapter 6 presents summary air pollution statistics from other countries. This is a new feature of this report and is intended to provide a broader range of air pollution information.

A major event for air pollution control in the United States was the passage of the Clean Air Act Amendments in November 1990, which has initiated a wide range of planning and regulatory activities that will affect future air pollution levels in the U.S. The 1991 data included in this report do not yet show the full effect of this legislation because the implementation process is still underway. This report notes some of these ongoing activities.

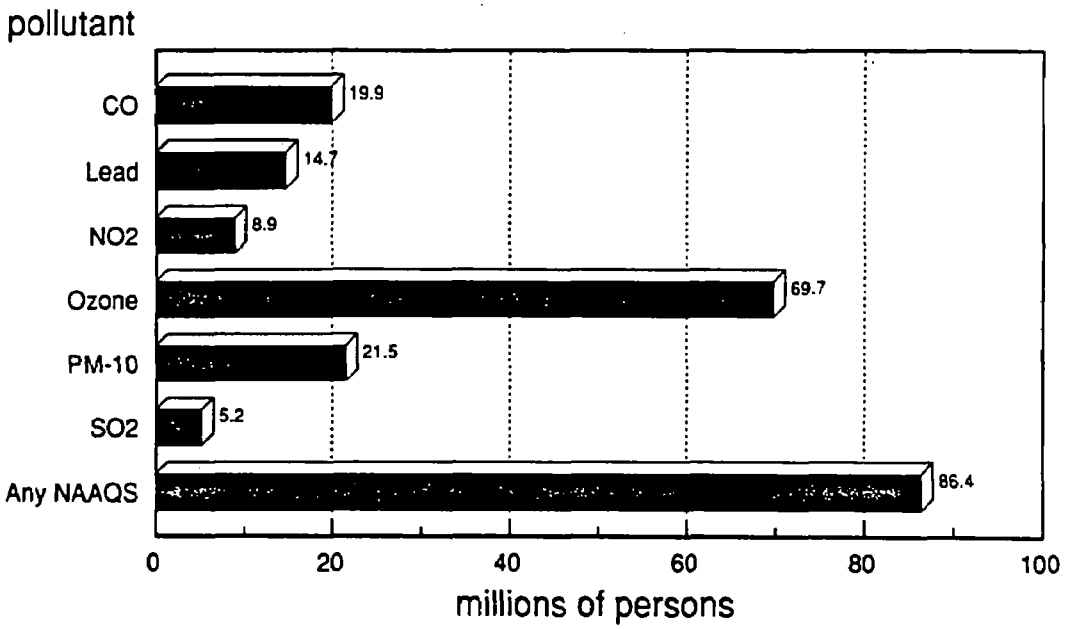
1.2 SOME PERSPECTIVE

A 10-year time period is convenient for considering ambient air pollution trends because monitoring networks underwent many changes around 1980. However, it is important not to overlook some of the earlier control efforts in the air pollution field. Emission estimates are useful in examining longer term trends. Between 1970 and 1991, lead clearly shows the most impressive decrease (-98 percent) but improvements are also seen for carbon monoxide (-50 percent), nitrogen oxides (-1 percent), total particulate (-61 percent), volatile organic compounds, which contribute to ozone formation, (-38 percent) and sulfur oxides (-27 percent). It is also important to realize that many of these reductions occurred even in the face of growth of emissions sources. More detailed information is contained in a companion report.[19]



While progress has been made, it is important not to lose sight of the magnitude of the air pollution problem that still remains. About 86 million people in the U.S. reside in counties which did not meet at least one air quality standard based upon data for the single year 1991. Ozone is the most common contributor with 70 million people living in counties that exceeded the ozone standard in 1991. These statistics, and associated qualifiers and limitations, are discussed in Chapter 4. These population estimates are based only upon a single year of data, 1991, and only consider counties with monitoring data for that pollutant. As noted in Chapter 4, there are other approaches that would yield different numbers. In 1991, EPA issued a rule formally designating areas that did not meet air quality standards.[20] Based upon these designations, EPA estimated that 140 million people live in ozone nonattainment areas. This difference is because the formal designations are based upon three years of data, rather than just one, to reflect a broader range of

meteorological conditions. Also, the boundaries used for nonattainment areas may consider other air quality related information, such as emission inventories and modeling, and may extend beyond those counties with monitoring data to more fully characterize the ozone problem and to facilitate the development of an adequate control strategy. For lead, EPA's aggressive effort to better characterize lead point sources has resulted in new monitors that have documented additional problem areas.



Based on 1990 population data and 1991 air quality data.

Finally, it should be recognized that this report focuses on those six pollutants that have National Ambient Air Quality Standards. There are other pollutants of concern. According to industry estimates, more than 2.4 billion pounds of toxic pollutants were emitted into the atmosphere in 1989.[21] They are chemicals known or suspected of causing cancer or other serious health effects (e.g. reproductive effects). Control programs for the pollutants discussed in this report can be expected to reduce these air toxic emissions by controlling particulates, volatile organic compounds and nitrogen oxides. However, Title III of the Clean Air Act Amendments of 1990 provided specific new tools to address routine and accidental releases of these toxic air pollutants. The statute established an initial list of 189 toxic air pollutants. Using this list, EPA published a list of the industry groups (or "source categories") for which EPA will develop emission standards. EPA will issue standards for each listed source category, requiring the maximum degree of emissions reduction that has been demonstrated to be achievable. These are commonly referred to as maximum achievable control technology (MACT) standards. EPA is also implementing other programs to reduce emissions of chlorofluorocarbons, halons, and other pollutants that are depleting the stratospheric ozone layer.

CARBON MONOXIDE (CO)

AIR CONCENTRATIONS

1982-91: 30 percent decrease (8-hour second high at 313 sites)
90 percent decrease (8-hour exceedances at 313 sites)

1990-91: 5 percent decrease (8-hour second high at 378 sites)

EMISSIONS

1982-91: 31 percent decrease

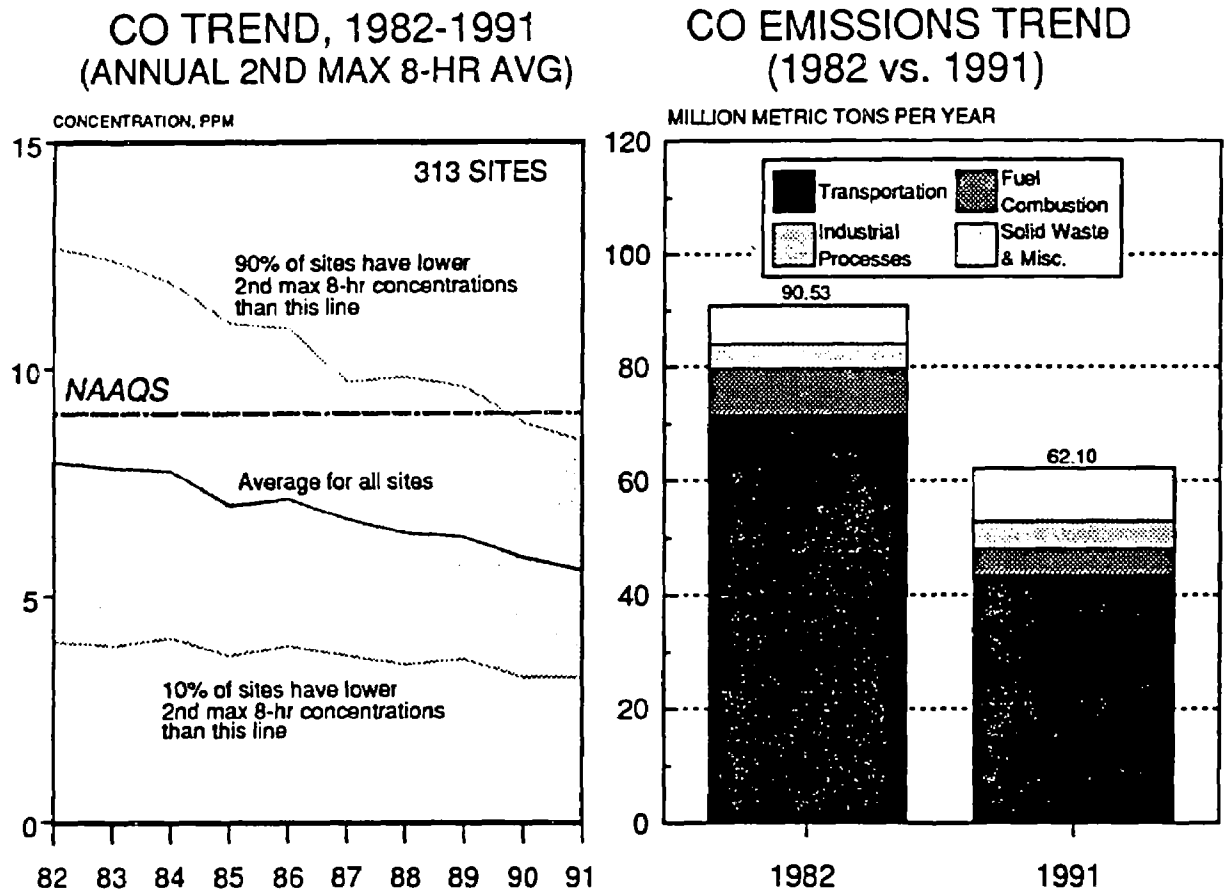
1990-91: 8 percent decrease

OVERVIEW

Trends Carbon monoxide emissions decreased 50 percent since 1970. Progress has continued with the 1982-91 ten year period showing 30 percent improvement in air quality levels and a 31 percent reduction in total emissions. This progress occurred despite continued growth in miles of travel in the U.S. Transportation sources account for approximately 70 percent of the nation's CO emissions. Emissions from highway vehicles decreased 45 percent during the 1982-91 period, despite a 36 percent increase in vehicle miles of travel. Estimated nationwide CO emissions decreased 8 percent between 1990 and 1991.

Status On November 6, 1991, EPA designated 42 areas as nonattainment for CO. Based upon the magnitude of the CO concentrations, 41 of these areas were classified as moderate and 1 (Los Angeles) was classified as serious.

Current Activities The 1990 Clean Air Act Amendments provided a detailed schedule for CO nonattainment areas. States identified their nonattainment areas and are now developing plans to ensure that these areas attain and maintain these standards. Control strategies for these nonattainment areas are due in November 1992. In addition, the provisions of the Act, that deal with mobile sources, include a variety of provisions to help reduce CO levels including a winter time oxygenated fuels program for most CO nonattainment areas, increased application of vehicle inspection and maintenance programs, and a tailpipe standard for CO under cold temperature conditions.



CO EFFECTS

Carbon monoxide enters the bloodstream and reduces the delivery of oxygen to the body's organs and tissues. The health threat from carbon monoxide is most serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease. Healthy individuals also are affected but only at higher levels. Exposure to elevated carbon monoxide levels is associated with impairment of visual perception, work capacity, manual dexterity, learning ability and performance of complex tasks.

LEAD (Pb)

AIR CONCENTRATIONS

1982-91: 89 percent decrease (maximum quarterly average at 209 sites)

1990-91: 18 percent decrease (maximum quarterly average at 239 sites)

EMISSIONS

1982-91: 90 percent decrease in total lead emissions
(97 percent decrease in lead emissions from transportation sources)

1990-91: 3 percent decrease in total lead emissions
(5 percent decrease in lead emissions from transportation sources)

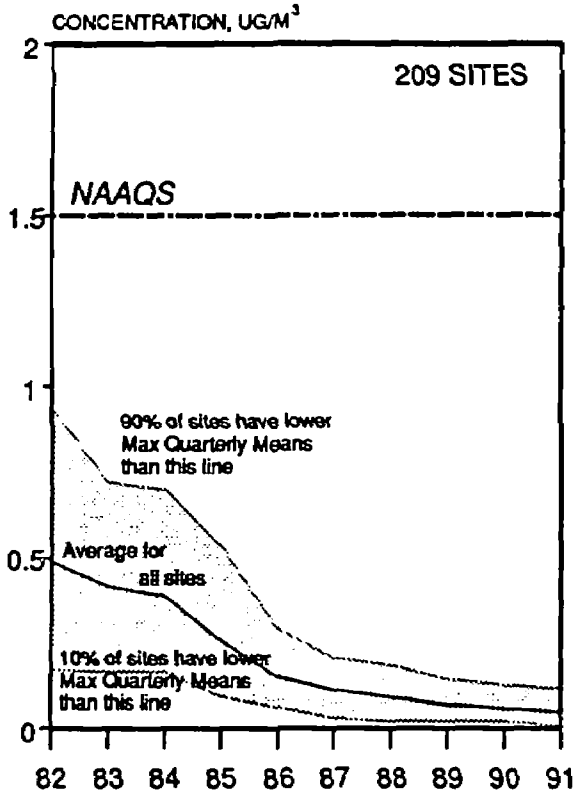
OVERVIEW

Trends Total lead emissions have dropped 98 percent since 1970 due principally to reductions in ambient lead levels from automotive sources. Ambient lead (Pb) concentrations in urban areas throughout the country have decreased 89 percent since 1982 while emissions decreased by 90 percent. The drop in Pb consumption and subsequent Pb emissions was brought about by the increased use of unleaded gasoline in catalyst-equipped cars (97 percent of the total gasoline market in 1991) and the reduced Pb content in leaded gasoline.

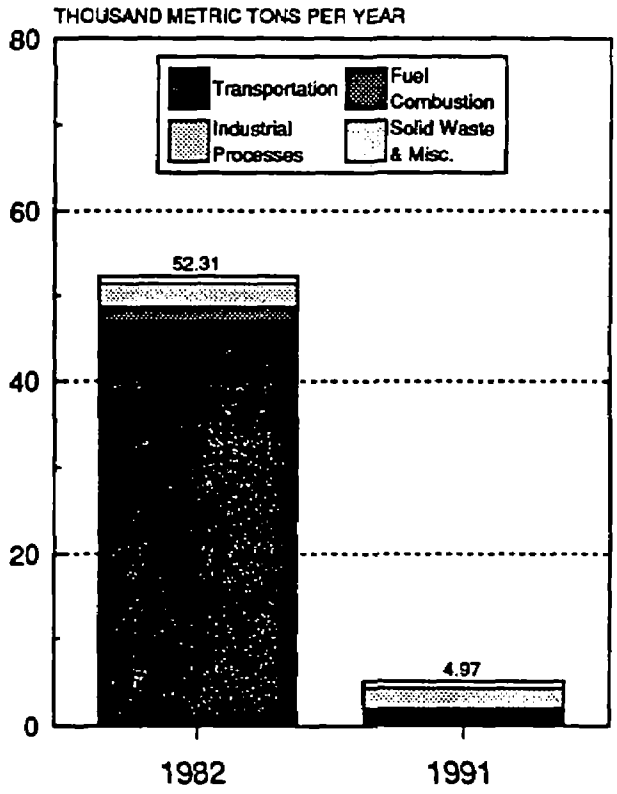
Status In 1991, EPA designated 12 areas as nonattainment because of recorded violations of the National Ambient Air Quality Standard for lead. EPA also designated as "unclassifiable" 9 other areas for which existing air quality data are insufficient at this time to designate as either attainment or nonattainment.

Current Activities The large reduction in lead emissions from transportation sources has changed the nature of the ambient lead problem in the U.S. Current problems are associated with specific point sources and this has become more apparent as the transportation component was dramatically reduced. As a result, EPA's current lead strategy is to better characterize lead levels near these sources, fully enforce existing emission limits, and, if necessary, require new control plans. In some cases, new monitors have been placed in operation and documented ambient levels of concern. This shift in the lead monitoring strategy can initially appear to complicate the interpretation of lead trends as new monitors result in the documentation of new problems. However, the more complete picture is that the successful reduction in lead emissions from transportation sources is now being followed by a more complete characterization of specific industrial sources such as smelters.

PB TREND, 1982-1991
(ANNUAL MAX QRTLY AVG)



PB EMISSIONS TREND
(1982 vs. 1991)



PB EFFECTS

Exposure to lead can occur through multiple pathways, including inhalation of air, diet and ingestion of lead in food, water, soil or dust. Lead accumulates in the body in blood, bone and soft tissue. Because it is not readily excreted, lead also affects the kidneys, liver, nervous system and blood-forming organs. Excessive exposure to lead may cause neurological impairments such as seizures, mental retardation and/or behavioral disorders. Even at low doses, lead exposure is associated with changes in fundamental enzymatic, energy transfer and homeostatic mechanisms in the body. Fetuses, infants and children are especially susceptible to low doses of lead, often suffering central nervous system damage. Recent studies have also shown that lead may be a factor in high blood pressure and subsequent heart disease in middle-aged white males.

NITROGEN DIOXIDE (NO_2)

AIR CONCENTRATIONS

1982-91: 6 percent decrease (annual mean at 172 sites)

1990-91: no change (annual mean at 236 sites)

EMISSIONS : NO_x

1982-91: 8 percent decrease

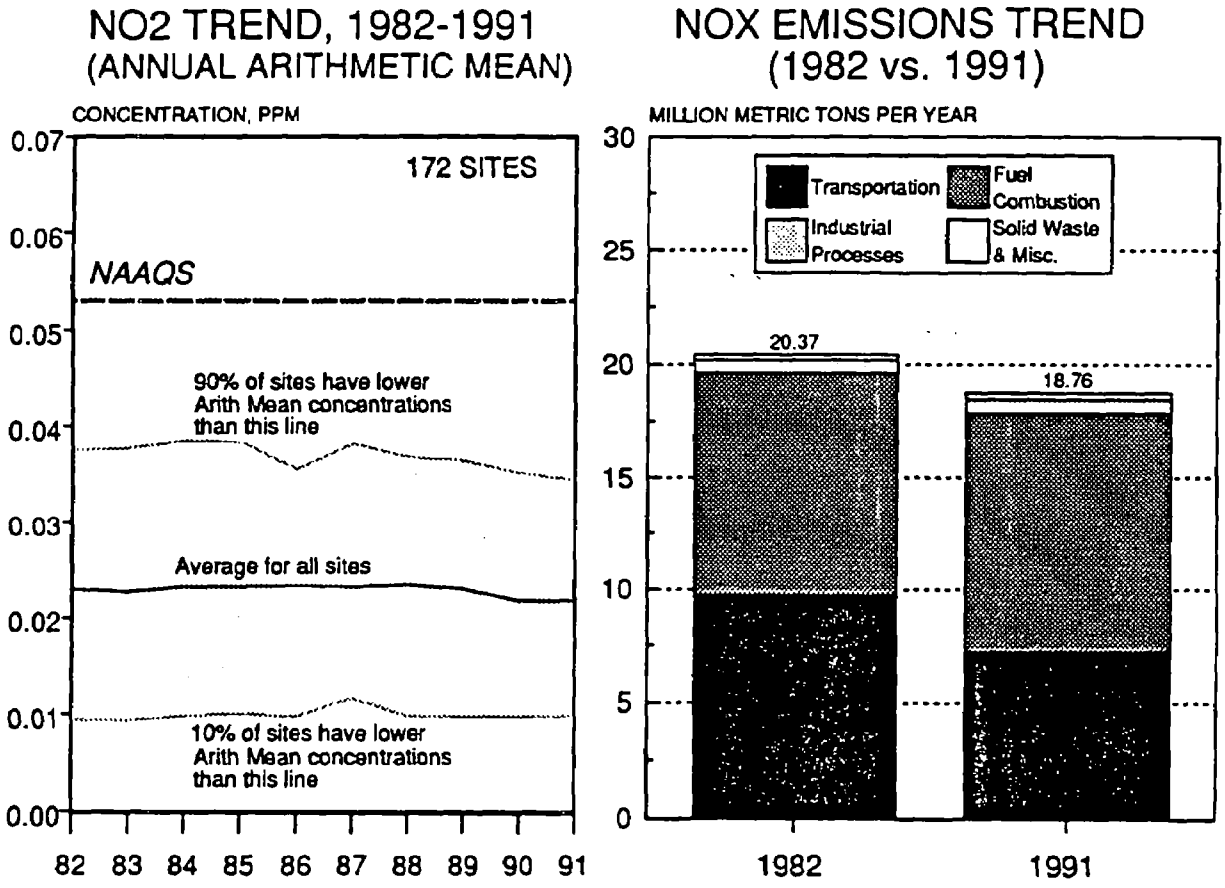
1990-91: 3 percent decrease

OVERVIEW

Trends Nitrogen oxide emissions decreased 1 percent since 1970. Both emissions (-8 percent) and nitrogen dioxide air quality (-6 percent) showed improvement since 1982. The two primary source categories of nitrogen oxide emissions, and their contribution in 1991, are fuel combustion (56 percent) and transportation (39 percent). Since 1982, emissions from the transportation category have decreased 25 percent while fuel combustion emissions are estimated to have increased by 8 percent.

Status On November 6, 1991, EPA designated only one area as nonattainment for NO_2. Los Angeles, CA (which reported an annual mean of 0.055 parts per million (ppm) in 1991 compared to the EPA standard of 0.053 ppm) is the only urban area that has recorded violations of the National Ambient Air Quality Standard for NO_2 during the past 10 years.

Current Activities Although Los Angeles is the only nonattainment area for nitrogen dioxide, the Clean Air Act Amendments of 1990 recognized the need for nitrogen oxide controls due to its contributing role in other problems including ozone (smog), particulate matter, and acid rain. The role of NO_x in ozone nonattainment problems is receiving additional attention from both the scientific and regulatory communities. EPA has already issued final tighter tailpipe standards for NO_x as required under the new amendments and the Acid Rain provisions of the Act calls for a 2 million ton NO_x reduction from affected utilities.



NO_2 EFFECTS

Nitrogen dioxide can irritate the lungs and lower resistance to respiratory infection (such as influenza). The effects of short-term exposure are still unclear but continued or frequent exposure to concentrations higher than those normally found in the ambient air may cause increased incidence of acute respiratory disease in children. Nitrogen oxides are an important precursor both to ozone and to acidic precipitation and may affect both terrestrial and aquatic ecosystems. Atmospheric deposition of NO_x is a potentially significant contributor to ecosystem effects including algal blooms in certain estuaries such as the Chesapeake Bay. In some western areas, NO_x is an important precursor to particulate concentrations.

OZONE (O_3)

AIR CONCENTRATIONS

1982-91: 8 percent decrease (second highest daily max 1-hour at 495 sites)
38 percent decrease (exceedance days at 495 sites)

1990-91: 1 percent increase (second highest daily max 1-hour at 647 sites)

EMISSIONS : VOC

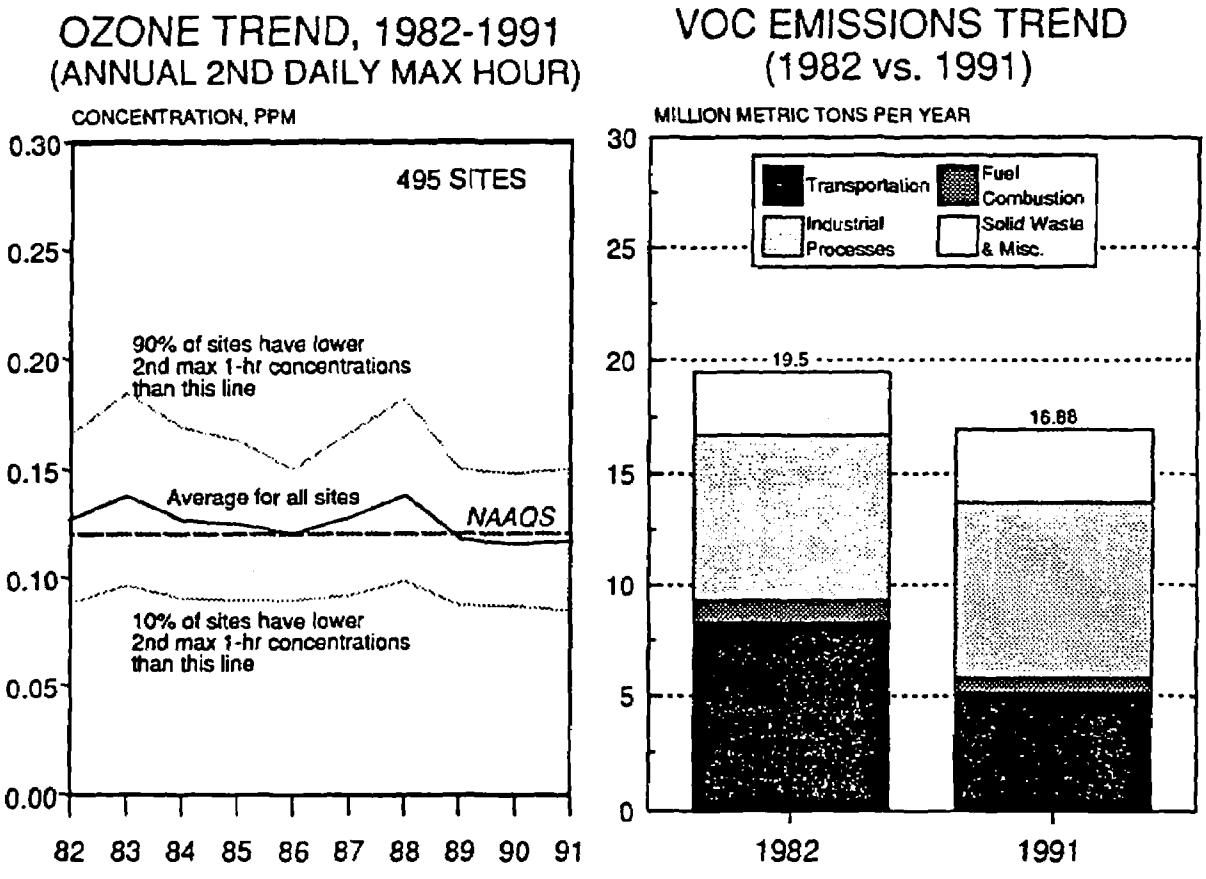
1982-91: 13 percent decrease (-8 percent for NO_x)
1990-91: 4 percent decrease (-3 percent for NO_x)

OVERVIEW

Trends Ground level ozone, the primary constituent of smog, has been a pervasive pollution problem for the U.S. Ambient trends during the 1980's were influenced by varying meteorological conditions. Relatively high 1983 and 1988 ozone levels are likely attributed in part to hot, dry, stagnant conditions in some areas of the country. The 1991 levels were somewhat higher than 1990 but were still 15 percent lower than 1988. There have now been three years with relatively low levels compared to earlier years. While the complexity of the ozone problem and the effects of meteorological conditions warrants caution in interpreting the data, there have been recent control measures, such as lower Reid Vapor Pressure for gasoline resulting in lower fuel volatility and lower NO_x and VOC emissions from tailpipes. Emission estimates for volatile organic compounds (VOCs), which contribute to ozone formation, are estimated to have improved by 38 percent since 1970 and 13 percent since 1982. However, these volatile organic compound (VOC) emission estimates represent annual totals. NO_x emissions, the other major precursor factor in ozone formation, decreased 8 percent between 1982 and 1991. While these annual emission totals are the best national numbers now available, seasonal emission trends would be preferable.

Status In 1991, EPA designated 98 nonattainment areas for O_3. Based upon the O_3 concentrations in these areas, EPA classified 43 areas as marginal, 31 as moderate, 14 as serious, 9 as severe, and 1 (Los Angeles) as extreme.

Current Activities Kansas City became the first of these nonattainment areas to be redesignated as attainment. The other areas classified as marginal under the Clean Air Act have until 1993 to attain. During 1992, all ozone nonattainment areas were required to prepare emission inventories. These inventories identify the sources contributing to the ozone problems in these areas and are a critical first step in developing control strategies to bring these areas into attainment.



O_3 EFFECTS

The reactivity of ozone causes health problems because it damages biological tissues and cells. Recent scientific evidence indicates that ambient levels of ozone not only affect people with impaired respiratory systems, such as asthmatics, but healthy adults and children, as well. Exposure to ozone for 6 - 7 hours at relatively low concentrations has been found to significantly reduce lung function in normal, healthy people during periods of moderate exercise. This decrease in lung function often is accompanied by such symptoms as chest pain, coughing, nausea and pulmonary congestion. Though less well established in humans, animal studies have demonstrated that repeated exposure to ozone for months to years can produce permanent structural damage in the lungs and accelerate the rate of lung function loss and aging of the lungs. Ozone is responsible each year for agricultural crop yield loss in the U.S. of several billion dollars and causes noticeable foliar damage in many crops and species of trees. Forest and ecosystem studies indicate that damage is resulting from current ambient ozone levels.

PARTICULATE MATTER

AIR CONCENTRATIONS : Particulate Matter (PM-10)

1988-91: 10 percent decrease (based on arithmetic mean at 682 sites)

1990-91: 1 percent decrease PM-10 (based on arithmetic mean at 682 sites)

EMISSIONS : Total Particulates (TP) and PM-10

1982-91: 3 percent decrease (TP)

1985-91: 3 percent decrease (PM-10)

1988-91: 5 percent decrease (PM-10)

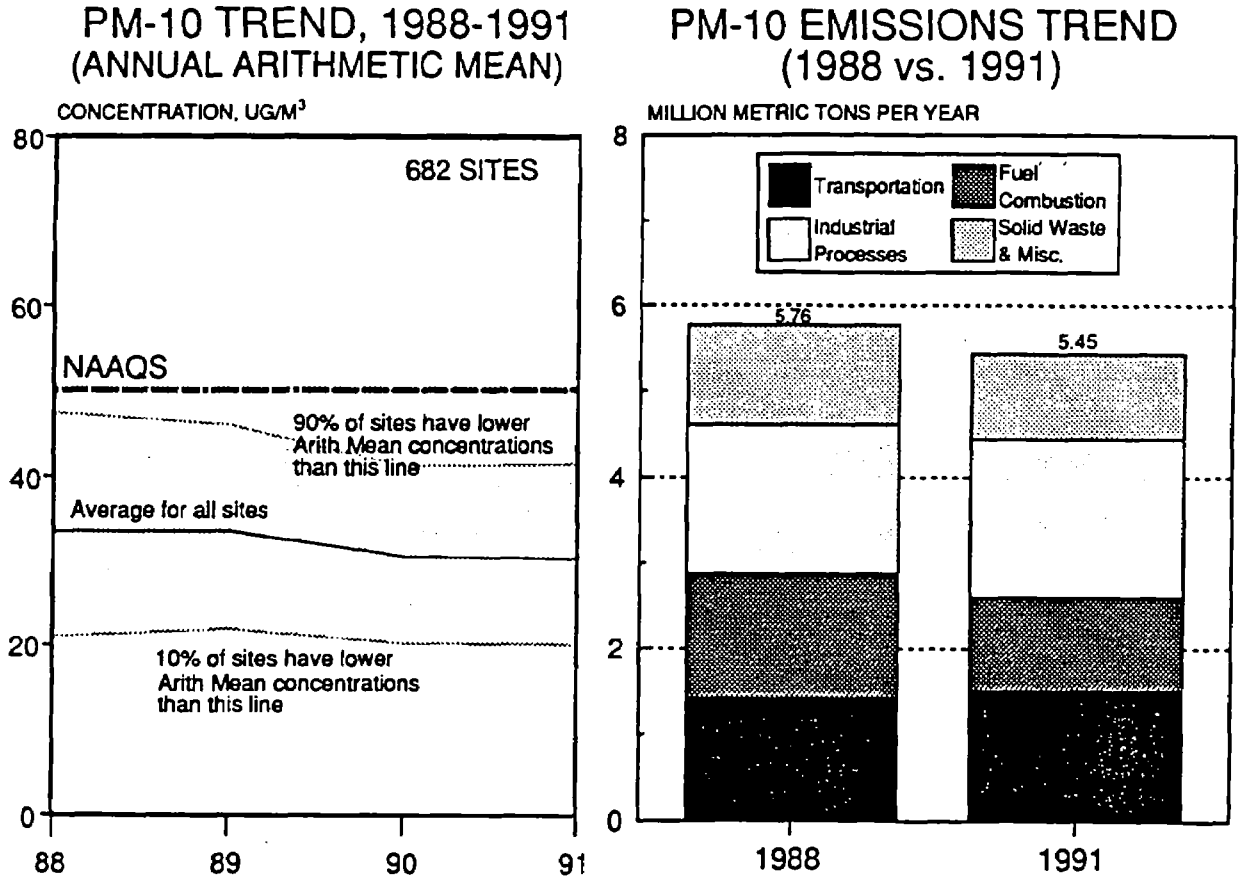
1990-91: no change (TP); 1 percent increase (PM-10)

OVERVIEW

Trends Total Particulate emissions from historically inventoried sources have been reduced 61 percent since 1970. In 1987, EPA replaced the earlier TSP standard with a PM-10 standard. (PM-10 focuses on the smaller particles likely to be responsible for adverse health effects because of their ability to reach the lower regions of the respiratory tract.) Ambient monitoring networks have been revised to measure PM-10 rather than TSP. Although PM-10 trends data are limited, ambient levels decreased 10 percent between 1988 and 1991. The historically inventoried PM-10 portion of TP emissions is estimated to have decreased 3 percent since 1985. Nationally, fugitive sources (such as emissions from agricultural tilling, construction, and unpaved roads) provide 6-8 times more tonnage of PM-10 emissions than sources historically included in emission inventories.

Status On November 15, 1991, EPA designated 70 areas as nonattainment for PM-10.

Current Activities The Act focuses attention on nonattainment of PM-10 health based standards. Because many PM-10 monitoring networks were patterned after existing TSP networks, additional emphasis is now being placed on evaluating current PM-10 monitoring networks to be certain that they adequately characterize problems from these finer particles. The Acid Rain provisions of the Act address visibility impairment caused by fine (<2.5 micrometer) particles.



PM EFFECTS

Based on studies of human populations exposed to high concentrations of particles (often in the presence of sulfur dioxide), and laboratory studies of animals and humans, the major effects of concern for human health include effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, carcinogenesis and premature mortality. The major subgroups of the population that appear likely to be most sensitive to the effects of particulate matter include individuals with chronic obstructive pulmonary or cardiovascular disease, individuals with influenza, asthmatics, the elderly and children. Particulate matter causes damage to materials, soiling and is a major cause of substantial visibility impairment in many parts of the U.S.

SULFUR DIOXIDE (SO_2)

AIR CONCENTRATIONS

1982-91: 20 percent decrease (arithmetic mean at 479 sites)
31 percent decrease (24-hour second high at 479 sites)

1990-91: 4 percent decrease (arithmetic mean at 577 sites)

EMISSIONS : SO_x

1982-91: 2 percent decrease

1990-91: 2 percent decrease

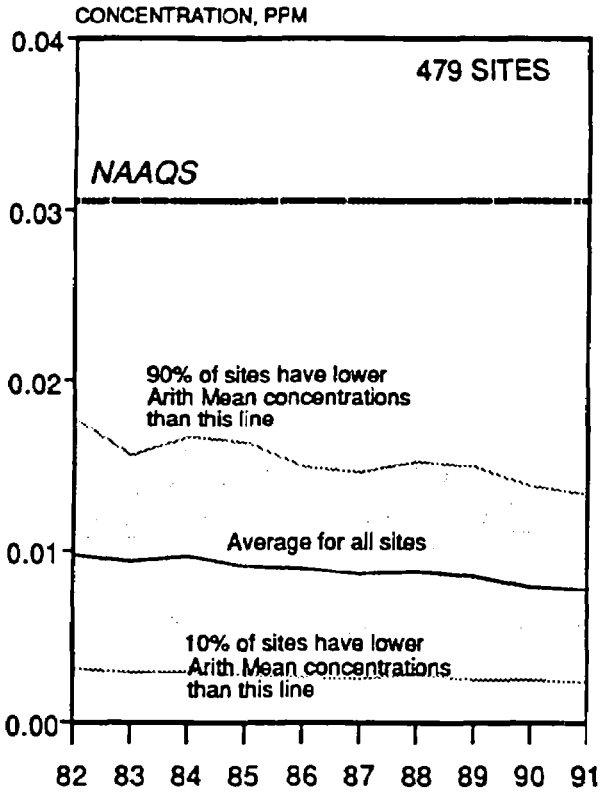
OVERVIEW

Trends SO_x emissions decreased 27 percent since 1970. Since 1982, emissions improved 2 percent while average air quality improved by 20 percent. This difference occurs because the historical ambient monitoring networks were population-oriented while the major emission sources tend to be in less populated areas. The exceedance trend is dominated by source oriented sites. The 1982-91 decrease in emissions reflects reductions at coal-fired power plants.

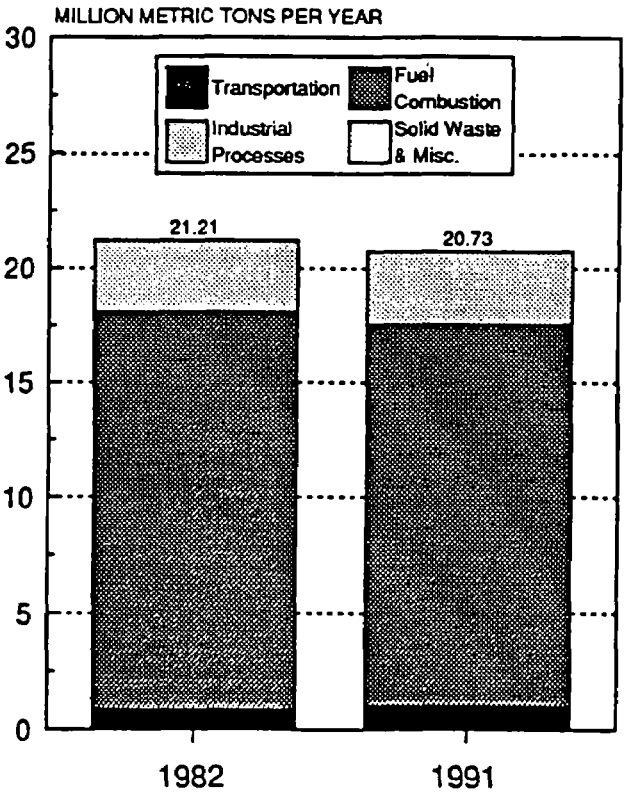
Status Almost all monitors in U.S. urban areas meet EPA's ambient air quality standards for SO_2. Dispersion models are commonly used to assess ambient SO_2 problems around point sources because it is frequently impractical to operate enough monitors to provide a complete air quality assessment. Currently, there are 50 areas designated nonattainment for SO_2. Current concerns focus on major emitters, total atmospheric loadings and the possible need for a shorter-term standard. Sixty-eight percent of all national SO_x emissions are generated by electric utilities (96% of which come from coal fired power plants).

Current Activities The Acid Rain provisions of the 1990 Clean Air Act Amendments include a goal of reducing SO_x emissions by 10 million tons relative to 1980 levels. The focus of this control program is an innovative market-based emission allowances which will provide affected sources flexibility in meeting the mandated emission reductions. This is EPA's first large-scale regulatory use of market-based incentives and the first allowance trade was announced in May 1992. This program is coordinated with the air quality standard program to insure that public health is protected while allowing for cost effective reductions of SO_2.

SO2 TREND, 1982-1991
(ANNUAL ARITHMETIC MEAN)



SOX EMISSIONS TREND
(1982 vs. 1991)



SO_2 EFFECTS

The major health effects of concern associated with high exposures to sulfur dioxide include effects on breathing, respiratory illness and symptoms, alterations in the lung's defenses, aggravation of existing respiratory and cardiovascular disease, and mortality. The major subgroups of the population most sensitive to sulfur dioxide include asthmatics and individuals with chronic lung disease (such as bronchitis or emphysema) or cardiovascular disease. Children and the elderly may also be sensitive. Sulfur dioxide produces foliar damage on trees and agricultural crops. It and nitrogen oxides are major precursors to acidic deposition (acid rain), which is associated with a number of effects including acidification of lakes and streams, accelerated corrosion of buildings and monuments and visibility impairment.

1.4 REFERENCES

1. The National Air Monitoring Program: Air Quality and Emissions Trends - Annual Report, EPA-450/1-73-001a and b, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, July 1973.

2. Monitoring and Air Quality Trends Report, 1972, EPA-450/1-73-004, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, December 1973.

3. Monitoring and Air Quality Trends Report, 1973, EPA-450/1-74-007, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, October 1974.

4. Monitoring and Air Quality Trends Report, 1974, EPA-450/1-76-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, February 1976.

5. National Air Quality and Emissions Trends Report, 1975, EPA-450/1-76-002, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, November 1976.

6. National Air Quality and Emissions Trends Report, 1976, EPA-450/1-77-002, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, December 1977.

7. National Air Quality and Emissions Trends Report, 1977, EPA-450/2-78-052, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, December 1978.

8. 1980 Ambient Assessment - Air Portion, EPA-450/4-81-014, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, February 1981.

9. National Air Quality and Emissions Trends Report, 1981, EPA-450/4-83-011, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, April 1983.

10. National Air Quality and Emissions Trends Report, 1982, EPA-450/4-84-002, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, March 1984.

11. National Air Quality and Emissions Trends Report, 1983, EPA-450/4-84-029, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, April 1985.

12. National Air Quality and Emissions Trends Report, 1984, EPA-450/4-86-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, April 1986.

13. National Air Quality and Emissions Trends Report, 1985, EPA-450/4-87-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, February 1987.

14. National Air Quality and Emissions Trends Report, 1986, EPA-450/4-88-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, February 1988.

15. National Air Quality and Emissions Trends Report, 1987, EPA-450/4-89-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, March 1989.

16. National Air Quality and Emissions Trends Report, 1988, EPA-450/4-90-002, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, March 1990.

17. National Air Quality and Emissions Trends Report, 1989, EPA-450/4-91-003, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, February 1991.

18. National Air Quality and Emissions Trends Report, 1990, EPA-450/4-91-023, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, November 1991.

19. National Air Pollutant Emission Estimates, 1900-1991, EPA-454/R-92-013, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, October 1992.

20. Federal Register, November 6, 1991.

21. Toxics in the Community, EPA-560/4-91-014, U. S. Environmental Protection Agency, Office of Pesticides and Toxic Substances, Washington, D.C. 20460, September 1991.

2. INTRODUCTION

This report focuses on 10-year (1982-91) national air quality trends for each of the major pollutants for which National Ambient Air Quality Standards (NAAQS) have been established. This section presents many of the technical details involved in these analyses; readers familiar with previous reports may prefer initially to proceed directly to the remaining sections. The national analyses are complemented in Chapter 5 with air quality trends in 15 metropolitan areas and in Chapter 6 with an international air pollution perspective.

The air quality trends statistics displayed for a particular pollutant in this report are closely related to the form of the respective air quality standard. Trends in other air quality indicators are also presented for some pollutants. NAAQS are currently in place for six pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter whose aerodynamic size is equal or less than 10 microns (PM-10), and sulfur dioxide (SO_2). There are two types of standards - primary and secondary. Primary standards protect against adverse health effects; whereas, secondary standards protect against welfare effects like damage to farm crops and vegetation, and damage to buildings to mention just a few examples. Table 2-1 lists the NAAQS for each pollutant in terms of the level of the standard and the averaging time that the standard represents. Some pollutants (PM-10 and SO_2) have standards for both long-term (annual average) and short-term (24-hour or less) averaging times. The short-term standards are designed to protect against acute, or short-term, health effects, while the long-term standards were established to protect against chronic health effects.

It is important to note that discussions of ozone in this report refer to ground level, or tropospheric ozone and not stratospheric ozone. Ozone in the stratosphere, miles above the earth, is a beneficial screen from the sun's ultraviolet rays. Ozone at ground level, in the air we breathe, is a health and environmental concern and is the primary ingredient of what is commonly called smog.

Table 2-1. National Ambient Air Quality Standards (NAAQS) in Effect in 1992.

POLLUTANT	PRIMARY (HEALTH RELATED)		SECONDARY (WELFARE RELATED)	
	Type of Average	Standard Level Concentration[a]	Type of Average	Standard Level Concentration
CO	8-hour[b]	9 ppm (10 mg/m³)	No Secondary Standard	
	1-hour[b]	35 ppm (40 mg/m³)	No Secondary Standard	
Pb	Maximum Quarterly Average	1.5 µg/m³	Same as Primary Standard	
NO_2	Annual Arithmetic Mean	0.053 ppm (100 µg/m³)	Same as Primary Standard	
O_3	Maximum Daily 1-hour Average[c]	0.12 ppm (235 µg/m³)	Same as Primary Standard	
PM-10	Annual Arithmetic Mean[d]	50 µg/m³	Same as Primary Standard	
	24-hour[d]	150 µg/m³	Same as Primary Standard	
SO_2	Annual Arithmetic Mean	80 µg/m³ (0.03 ppm)	3-hour[b]	1300 µg/m³ (0.50 ppm)
	24-hour[b]	365 µg/m³ (0.14 ppm)		

[a] Parenthetical value is an approximately equivalent concentration.

[b] Not to be exceeded more than once per year.

[c] The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is equal to or less than 1, as determined according to Appendix H of the Ozone NAAQS.

[d] Particulate standards use PM-10 (particles less than 10µ in diameter) as the indicator pollutant. The annual standard is attained when the expected annual arithmetic mean concentration is less than or equal to 50 µg/m³; the 24-hour standard is attained when the expected number of days per calendar year above 150 µg/m³ is equal to or less than 1; as determined according to Appendix K of the PM NAAQS.

The ambient air quality data presented in this report were obtained from EPA's Aerometric Information Retrieval System (AIRS). These are actual direct measurements of pollutant concentrations at monitoring stations operated by state and local governments throughout the nation. EPA and other federal agencies operate some air quality monitoring sites on a temporary basis as a part of air pollution research studies. In 1991,

more than 4200 monitoring sites reported air quality data for the six NAAQS pollutants to AIRS. The vast majority of these measurements represent the heavily populated urban areas of the nation.

The national monitoring network conforms to uniform criteria for monitor siting, instrumentation, and quality assurance.[1] Each monitoring site is classified into one of three specific categories. National Air Monitoring Stations (NAMS) were established to ensure a long term national network for urban area-oriented ambient monitoring and to provide a systematic, consistent data base for air quality comparisons and trends analysis. The State and Local Air Monitoring Stations (SLAMS) allow state or local governments to develop networks tailored to their immediate monitoring needs. Special purpose monitors (SPM) fulfill very specific or short-term monitoring goals. Often SPMs are used as source-oriented monitors rather than monitors which reflect the overall urban air quality. Data from all three types of monitoring sites are presented in this report.

Trends are also presented for annual nationwide emissions. These are estimates of the amount and kinds of pollution being emitted by automobiles, factories and other sources, based upon best available engineering calculations. The 1991 emission estimates are preliminary and may be revised in the next annual report. Estimates for earlier years have been recomputed using current methodology so that these estimates are comparable over time. The reader is referred to a companion EPA publication, National Air Pollutant Emission Estimates, 1900-1991[2], for more detailed information.

2.1 AIR QUALITY DATA BASE

Monitoring sites are included in the national 10-year trend analysis if they have complete data for at least 8 of the 10 years 1982 to 1991. For the regional comparisons, the site had to report data in each of the last three years to be included in the analysis. Data for each year had to satisfy annual data completeness criteria appropriate to pollutant and measurement methodology. Table 2-2 displays the number of sites meeting the 10-year trend completeness criteria. For PM-10, whose monitoring network has just been initiated over the last few years, analyses are based on sites with data in 1988 through 1991.

Table 2-2. Number of Monitoring Sites

Pollutant	Number of Sites Reporting in 1991	Number of Trend Sites 1982-91
CO	494	313
Pb	450	209
NO_2	322	172
O_3	835	495
PM-10	1363	682*
SO_2	748	479
Total	4212	2350

* Number of Trend Sites in 1988-91

The air quality data are divided into two major groupings -- 24-hour measurements and continuous 1-hour measurements. The 24-hour measurements are obtained from monitoring instruments that produce one measurement per 24-hour period and typically operate on a systematic sampling schedule of once every 6 days, or 61 samples per year. Such instruments are used to measure PM-10 and Pb. For PM-10, more frequent sampling of every other day or everyday is now also common. Only PM-10 sites with weighted annual arithmetic means that met the AIRS annual summary criteria were selected as trends sites. The 24-hour Pb data had to have at least six samples per quarter in at least 3 of the 4 calendar quarters. Monthly composite Pb data were used if at least two monthly samples were available for at least 3 of the 4 calendar quarters.

The 1-hour data are obtained from monitoring instruments that operate continuously, producing a measurement every hour for a possible total of 8760 hourly measurements in a year. For continuous hourly data, a valid annual mean for trends requires at least 4380 hourly observations. The SO_2 standard related daily statistics required 183, or more, daily values. Because of the different

selection criteria, the number of sites used to produce the daily SO_2 statistics may differ slightly from the number of sites used to produce the annual SO_2 statistics. Ozone sites met the annual trends data completeness requirement if they had at least 50 percent of the daily data available for the ozone season, which typically varies by State.[3]

The use of a moving 10-year window for trends yields a data base that is more consistent with the current monitoring network and reflects the period following promulgation of uniform monitoring requirements. In addition, this procedure increases the total number of trend sites for the 10-year period relative to the data bases used in the last annual report.[4]

2.2 TREND STATISTICS

The air quality statistics presented in this report relate to the pollutant-specific NAAQS and comply with the recommendations of the Intra-Agency Task Force on Air Quality Indicators.[5] Although not directly related to the NAAQS, more robust air quality indicators are presented for some pollutants to provide a consistency check.

A composite average of each of the trends statistics is used in the graphical presentations that follow. All sites were weighted equally in calculating the composite average trend statistic. Missing annual summary statistics for the second through ninth years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. This procedure results in a statistically balanced data set to which simple statistical procedures and graphics can be applied. The procedure is also conservative, because end-point rates of change are dampened by the interpolated estimates.

This report presents statistical confidence intervals around composite averages. The confidence intervals can be used to make comparisons between years; if the confidence intervals for any 2 years do not overlap, then the composite averages of the 2 years are significantly different. Ninety-five percent confidence intervals for composite averages of annual means and second maxima were calculated from a two-way analysis of variance followed by an application of the Tukey Studentized Range.[6] The confidence intervals for composite averages of estimated exceedances were calculated by fitting Poisson distributions[7] to the exceedances each year and then applying the Bonferroni multiple comparisons procedure.[8] The utilization of these procedures is explained elsewhere.[9,10]

Boxplots[11] are used to present air quality trends because they have the advantage of displaying, simultaneously, several features of the data. Figure 2-1 illustrates the use of this technique in presenting the percentiles of the data, as well as the composite average. For example, 90 percent of the sites would have concentrations equal to or lower than the 90th percentile.

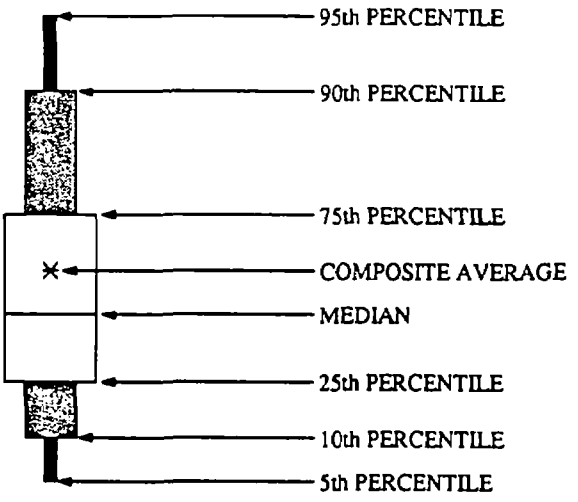


Figure 2-1. Illustration of plotting convention of boxplots.

Bar graphs are introduced for the Regional comparisons with the 3-year trend data base. These comparisons are based on the ten EPA Regions (Figure 2-2). The composite averages of the appropriate air quality statistic of the years 1989, 1990 and 1991 are presented. The approach is simple, and it allows the reader at a glance to compare the short-term changes in all ten EPA Regions.

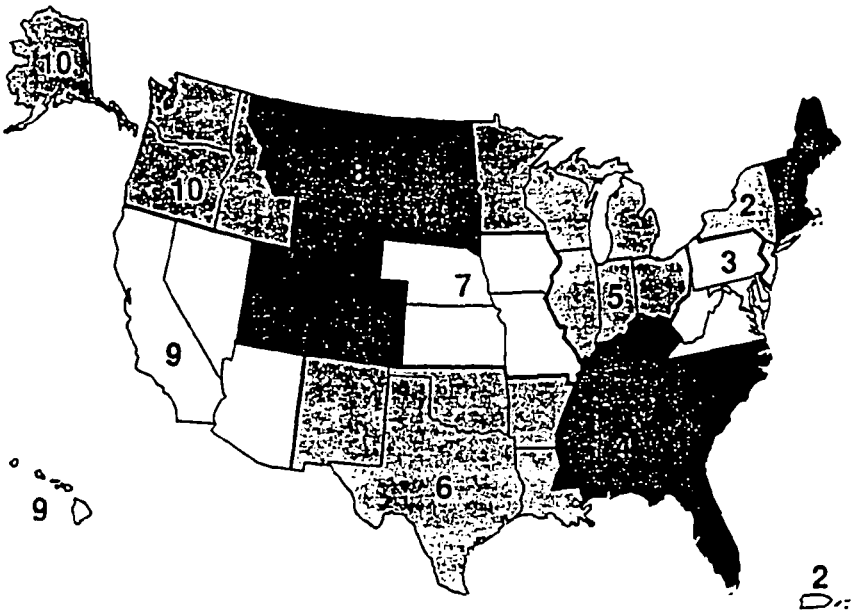


Figure 2-2. Ten Regions of the U.S. Environmental Protection Agency.

2.3 REFERENCES

1. Ambient Air Quality Surveillance, 44 FR 27558, May 10, 1979.

2. National Air Pollutant Emission Estimates, 1900-1991, EPA-454/R-92-013, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, October 1992.

3. Ambient Air Quality Surveillance, 51 FR 9597, March 19, 1986.

4. National Air Quality and Emissions Trends Report, 1990, EPA-450/4-91-023, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, November 1991.

5. U.S. Environmental Protection Agency Intra-Agency Task Force Report on Air Quality Indicators, EPA-450/4-81-015, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1981.

6. B. J. Winer, Statistical Principles in Experimental Design, McGraw-Hill, NY, 1971.

7. N. L. Johnson and S. Kotz, Discrete Distributions, Wiley, NY, 1969.

8. R. G. Miller, Jr., Simultaneous Statistical Inference, Springer-Verlag, NY, 1981.

9. A. Pollack, W. F. Hunt, Jr., and T. C. Curran, "Analysis of Variance Applied to National Ozone Air Quality Trends", presented at the 77th Annual Meeting of the Air Pollution Control Association, San Francisco, CA, June 1984.

10. A. Pollack and W. Hunt, "Analysis of Trends and Variability in Extreme and Annual Average Sulfur Dioxide Concentrations", presented at the Air Pollution Control Association, American Society for Quality Control Specialty Conference on Quality Assurance in Air Pollution Measurements, Boulder, CO, 1985.

11. J. W. Tukey, Exploratory Data Analysis, Addison-Wesley Publishing Company, Reading, MA, 1977.

3. NATIONAL AND REGIONAL TRENDS IN NAAQS POLLUTANTS

EPA has set National Ambient Air Quality Standards (NAAQS) for six pollutants considered harmful to public health: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM-10), and sulfur dioxide (SO_2). This chapter focuses on both 10-year (1982-91) trends and recent changes in air quality and emissions for these six pollutants. Changes since 1990, and comparisons between all the trend sites and the subset of National Air Monitoring Stations (NAMS) are highlighted. Trends are examined for both the nation and the ten EPA Regions.

As in previous reports, the air quality trends are presented using trend lines, confidence intervals, boxplots and bar graphs. The reader is referred to Section 2.2 for a detailed description of the confidence interval and boxplot procedures.

Trends are also presented for annual nationwide emissions of carbon monoxide, lead, nitrogen oxides (NO_x), volatile organic compounds (VOC), particulate matter [both in terms of total particulate (TP), which includes all particles regardless of size, and for PM-10], and sulfur oxides (SO_x). These emissions data are estimated using best available engineering calculations. The reader is referred to a companion report for a detailed description of emission trends, source categories and estimation procedures.[1] While the ambient data trends and the emission trends can be viewed as independent assessments that lend added credence to the results, the emission estimates can also be used to provide information on trends over longer time periods. Because of changes that have occurred in ambient monitoring measurement methodology and the change over time in the geographical distribution of monitors, it is difficult to provide ambient trends going back to 1970, other than for TSP, and yet it is important not to lose sight of some of the earlier progress that was made in air pollution control. Emission estimates can provide some insight in this area. Figure 3-1 depicts long-term change in emission estimates. Lead clearly shows the most impressive decrease of 98 percent but improvements are also seen for TP (-61 percent), SO_x (-27 percent), CO (-50 percent), VOC (-38 percent), and a small improvement for NO_x (-1 percent).

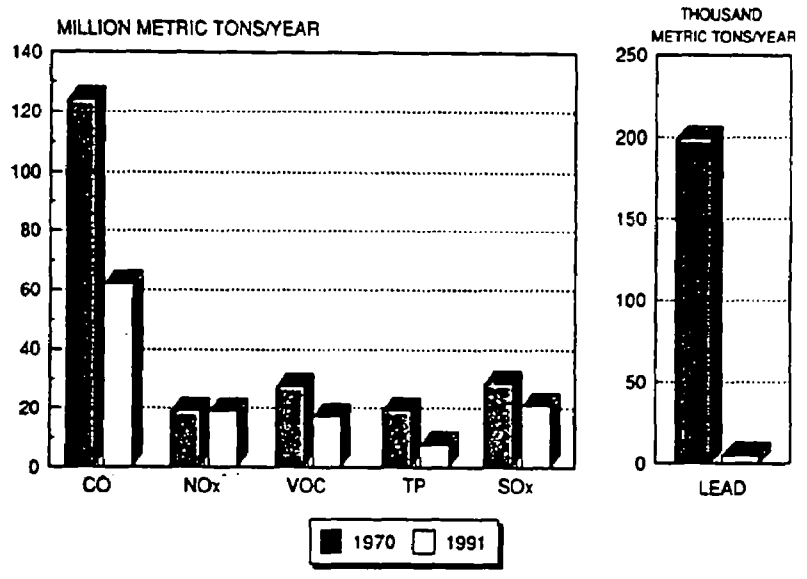


Figure 3-1. Comparison of 1970 and 1991 emissions.

3.1 TRENDS IN CARBON MONOXIDE

Carbon monoxide (CO) is a colorless, odorless and poisonous gas produced by incomplete burning of carbon in fuels. Seventy percent of the nationwide CO emissions are from transportation sources, with the largest contribution coming from highway motor vehicles. The NAAQS for ambient CO specify upper limits for both 1-hour and 8-hour averages that are not to be exceeded more than once per year. The 1-hour level is 35 ppm, and the 8-hour level is 9 ppm. This trends analysis focuses on the 8-hour average results because the 8-hour standard is generally the more restrictive limit. Also, there were no exceedances of the CO 1-hour NAAQS recorded at any site during 1991.

Carbon monoxide enters the bloodstream and reduces the delivery of oxygen to the body's organs and tissues. The health threat is most serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease. Exposure to elevated carbon monoxide levels is associated with impairment of visual perception, manual dexterity, learning ability and performance of complex tasks.

Trends sites were selected using the criteria presented in Section 2.1 which yielded a data base of 313 sites for the 10-year period 1982-91 and a data base of 378 sites for the 3-year 1989-91 period. There were 94 NAMS sites included in the 10-year data base and 108 NAMS sites in the 3-year data base. Most of these sites are located in urban areas where the main source of CO is motor vehicle exhaust; other sources are wood-burning stoves, incinerators, and industrial sources.

3.1.1 Long-term CO Trends: 1982-91

The 1982-91 composite national average trend is shown in Figure 3-2 for the second highest non-overlapping 8-hour CO concentration for the 313 long-term trend sites and the subset of 94 NAMS sites. During this 10-year period, the national composite average of the annual second highest 8-hour concentration decreased by 30 percent and the subset of NAMS decreased by 34 percent. Both curves show similar trends for the NAMS and the larger group of long-term trend sites. Nationally, the median rate of improvement between 1982 and 1991 is 4 percent per year for the 313 trend sites, and for the subset of 94 NAMS. Except for a small upturn between 1985 and 1986, composite average 8-hour CO levels have shown a steady decline throughout this period. All the regional median rates of improvement varied from 3 to 6 percent per year, except for Region 9 which had a median rate of improvement of one percent per year. The 1991 composite average is significantly lower than the composite means for 1989 and earlier years for both the 313 trend sites, and the subset of 94 NAMS. This same trend is shown in Figure 3-3 for the 313 trend sites by a boxplot presentation which provides more information on the year-to-year distribution of ambient CO levels at the long-term trend sites. While there is some year to year fluctuation in certain percentiles, the general long-term improvement in ambient CO levels is clear.

Figure 3-4 displays the 10-year trend in the composite average of the estimated number of exceedances of the 8-hour CO NAAQS. This exceedance rate was adjusted to account for incomplete sampling. The trend in exceedances shows long-term improvement but the rates are much higher than those for the second maximums. The composite average of estimated exceedances decreased 90 percent between 1982 and 1991 for the 313 long-term trend sites, while the subset of 94 NAMS showed an 87 percent decrease. These percentage changes for exceedances are typically much larger than those found for peak concentrations. The trend in annual second maximum 8-hour value is more likely to reflect the change in emission levels, than the trend in exceedances. For both curves, the 1991 composite average of the estimated exceedances is significantly lower than levels for 1989 and earlier years.

Figure 3-2. National trend in the composite average of the second highest non-overlapping 8-hour average carbon monoxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1982-1991.

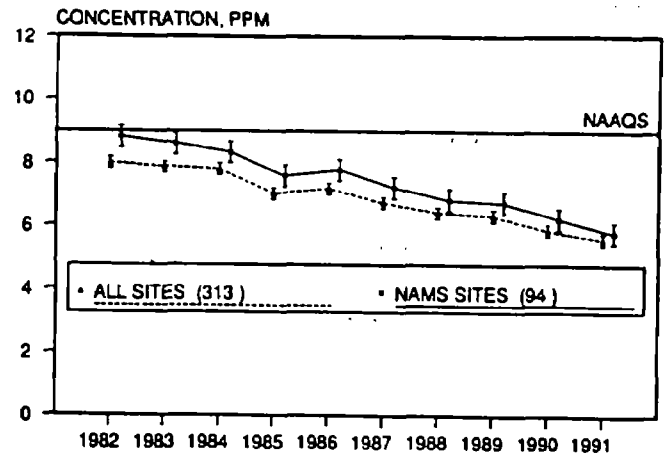


Figure 3-3. Boxplot comparisons of trends in second highest non-overlapping 8-hour average carbon monoxide concentrations at 313 sites, 1982-1991.

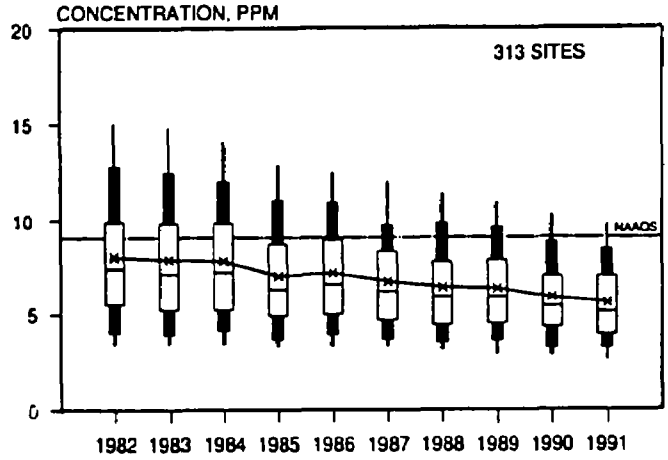
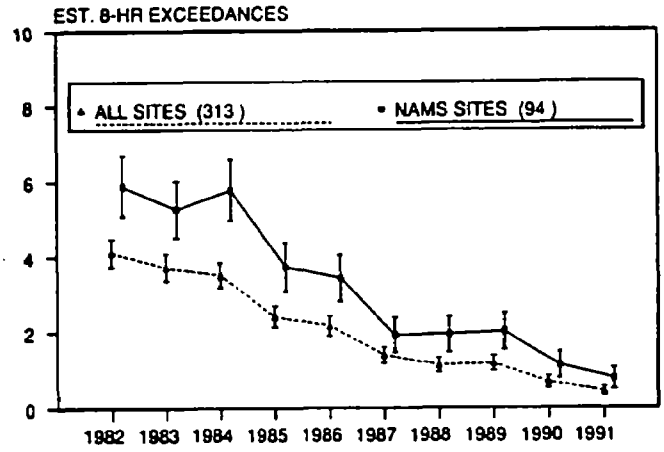


Figure 3-4. National trend in the composite average of the estimated number of exceedances of the 8-hour carbon monoxide NAAQS, at both NAMS and all sites with 95 percent confidence intervals, 1982-1991.



The long-term trends have emphasized air quality statistics that are closely related to the NAAQS. For many pollutants, this tends to place an emphasis on peak values. While these summary statistics may be more readily understood, there is concern that they may be too variable to be used as trend indicators. This issue was raised recently concerning ozone trend indicators in a report[2] by the National Academy of Sciences (NAS). One possible concern is whether trend results using a peak value type of summary statistic, such as the annual second maximum, are overly influenced by data from just a few days and are not necessarily representative of an "overall" trend. Of course, a major reason to look at ambient trends is to make comparisons with the NAAQS and, therefore, it makes sense to use a summary statistic that clearly relates to the standard. Similarly, it can be argued that the peak values are associated with health effects, and thus should be considered in any trends analysis of ambient levels. Nevertheless, it is still useful to look at trends in alternative summary statistics to see if there are sufficient differences among trends for different summary statistics to warrant concern. As an example of alternative trends indicators, the NAS report cited earlier analyses which used a comparison of different percentiles and maximum values.[3,4] The percentiles are statistically robust, in the sense that they are less affected by a few extreme values. The percentiles selected here range from the 50th percentile (or median) to the 95th percentile. The mean of the hourly concentrations is also presented. Figure 3-5 presents the 10-year trends for these various alternative carbon monoxide summary statistics. All of the patterns are somewhat similar among the various summary statistics, with a tendency to become flatter in the lower percentiles. The percent change between 1982 and 1991 for each summary statistic follows: annual maximum 8-hour concentration (-31%), annual second maximum 8-hour concentration (-30%), 95th and 90th percentiles of 8-hour concentrations (-28%), 70th percentile (-27%), median of the 8-hour concentrations (-23%), and the annual mean of the hourly concentrations (-26%).

The 10-year 1982-91 trend in national carbon monoxide emission estimates is shown in Figure 3-6 and in Table 3-1. These estimates show a 31 percent decrease in total emissions between 1982 and 1991. Transportation sources accounted for approximately 80 percent of the total in 1982 and

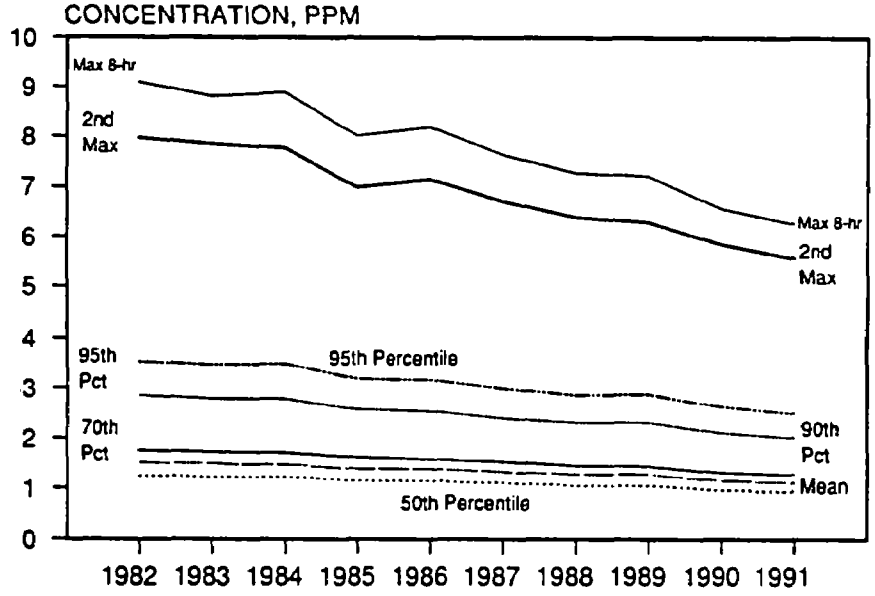


Figure 3-5. Trend in carbon monoxide air quality indicators, 1982-1991.

decreased to 70 percent of total emissions in 1991. The estimates of CO emissions from transportation sources have been recalculated for this report using the MOBILE 4.1 model, rather than the MOBILE 4.0 model used in the last report.[5] Emissions from highway vehicles decreased 45 percent during the 1982-91 period, despite a 36 percent increase in vehicle miles of travel.[1] The 1990 estimate for fuel combustion sources in the last report, which was based on preliminary data, has been revised downward by almost 3 million metric tons (or 38% lower than the preliminary 1990 estimate). Figure 3-7 contrasts the 10-year increasing trend in vehicle miles traveled (VMT) with the declining trend in carbon monoxide emissions from highway vehicles. This indicates that the Federal Motor Vehicle Control Program (FMVCP) has been effective on the national scale, with

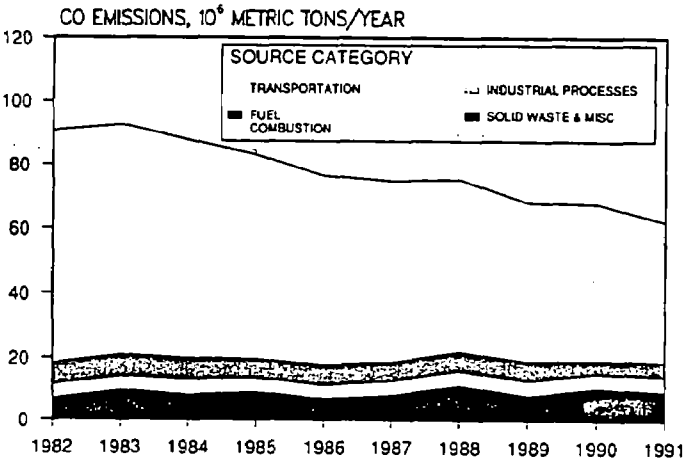


Figure 3-6. National trend in carbon monoxide emissions, 1982-1991.

TABLE 3-1. National Carbon Monoxide Emission Estimates, 1982-1991

(million metric tons/year)										
SOURCE CATEGORY	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**
Transportation	72.26	71.40	67.68	63.52	58.71	56.24	53.45	49.30	48.48	43.49
Fuel Combustion	7.07	6.97	7.05	6.29	6.27	6.34	6.27	6.40	4.30	4.68
Industrial Processes	4.35	4.34	4.66	4.38	4.20	4.33	4.60	4.58	4.64	4.69
Solid Waste Disposal	1.94	1.84	1.84	1.85	1.70	1.70	1.70	1.70	1.70	2.06
Miscellaneous	4.91	7.76	6.36	7.09	5.15	6.44	9.51	6.34	8.62	7.18
TOTAL	90.53	92.31	87.60	83.12	76.03	75.05	75.53	68.32	67.74	62.10
NOTE: The sums of sub-categories may not equal total due to rounding.										

controls more than offsetting growth during this period. While there is general agreement between changes in air quality and emissions over this 10-year period, it is worth noting that the emission changes reflect estimated national totals, while ambient CO monitors are frequently located to identify local problems. The mix of vehicles and the change in vehicle miles of travel in the area around a specific CO monitoring site may differ from the national averages.

3.1.2 Recent CO Trends: 1989-1991

This section examines ambient CO changes during the last 3 years, 1989-91 at sites that recorded data in all three years. Between 1990 and 1991, the composite average of the second highest non-overlapping 8-hour average concentration at 378 sites decreased by 5 percent and by 7 percent at the 108 NAMS sites. The composite average of the estimated number of exceedances of the 8-hour CO NAAQS decreased by 39 percent between 1990 and 1991 at these 378 sites and by 31% for at the NAMS sites. Estimated nationwide CO emissions decreased 8 percent between 1990 and 1991, and CO emissions from highway vehicles decreased by 13 percent.

Figure 3-8 shows the composite Regional averages for the 1989-91 time period. Eight of ten Regions had 1991 composite mean levels less than the corresponding 1989 and 1990 values. Every region had 1991 composite mean CO levels less than the composite means for 1989. These Regional graphs are primarily intended to depict relative change. Because the mix of monitoring sites may vary from one area to another, this graph is not intended to indicate Regional differences in concentration levels.

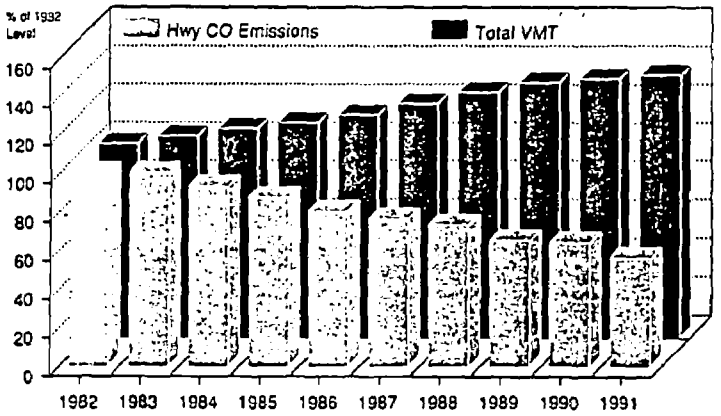


Figure 3-7. Comparison of trends in total national vehicle miles traveled and national highway vehicle emissions, 1982-1991.

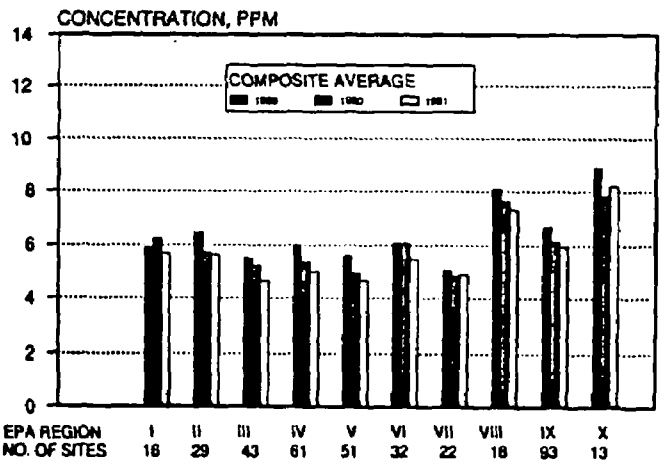


Figure 3-8. Regional comparisons of 1989, 1990, 1991 composite averages of the second highest non-overlapping 8-hour average carbon monoxide concentrations.

3.2 TRENDS IN LEAD

Lead (Pb) gasoline additives, nonferrous smelters and battery plants are the most significant contributors to atmospheric Pb emissions. Transportation sources in 1991 contributed 33 percent of the annual emissions, down substantially from 81 percent in 1985. Total lead emissions from all sources dropped from 18.3×10^3 metric tons in 1985 to 5.1×10^3 and 5.0×10^3 metric tons, respectively in 1990 and 1991. The decrease in lead emissions from highway vehicles accounts for essentially all of this drop. The reasons for this drop are noted below.

Two air pollution control programs implemented by EPA before promulgation of the Pb standard[6] in October 1978 have resulted in lower ambient Pb levels. First, regulations issued in the early 1970s required gradual reduction of the Pb content of all gasoline over a period of many years. The Pb content of the leaded gasoline pool was reduced from an average of 1.0 gram/gallon to 0.5 gram/gallon on July 1, 1985 and still further to 0.1 gram/gallon on January 1, 1986. Second, as part of EPA's overall automotive emission control program, unleaded gasoline was introduced in 1975 for use in automobiles equipped with catalytic control devices. These devices reduce emissions of carbon monoxide, volatile organics and nitrogen oxides. In 1991, unleaded gasoline sales accounted for 97 percent of the total gasoline market. In contrast, the unleaded share of the gasoline market in 1982 was approximately 50 percent. These programs have essentially eliminated violations of the lead standard in urban areas, except in those areas with lead point sources. Programs are also in place to control Pb emissions from stationary point sources. Pb emissions from stationary sources have been substantially reduced by control programs oriented toward attainment of the particulate matter and Pb ambient standards, however, significant ambient problems still remain around some lead point sources, which are the focus of new monitoring initiatives. Lead emissions in 1991 from industrial sources, e.g. primary and secondary lead smelters, dropped by more than 75 percent from levels reported in the mid 70s. Emissions of lead from solid waste disposal are down over 50 percent since the mid 70s. In 1991, emissions from solid waste disposal, industrial processes and transportation were respectively: 0.7, 2.2 and 1.6×10^3 metric tons. The overall effect of these three control programs has been a major reduction in the amount of Pb in the ambient air. In addition to the above Pb pollution reduction activities, additional reductions in Pb are anticipated as a result of the Agency's Multi-media Lead Strategy issued in February, 1991.[7] The goal of the Agency's Lead Strategy is to reduce Pb exposures to the fullest extent practicable.

Exposure to lead can occur through multiple pathways, including inhalation of air and ingestion of lead in food, water, soil or dust. Excessive lead exposure can cause seizures, mental retardation and/or behavioral disorders. Fetuses, infants and children are especially susceptible to low doses of lead, resulting in central nervous system damage. Recent studies have also shown that lead may be a factor in high blood pressure and subsequent heart disease in middle-aged white males.

3.2.1 Long-term Pb Trends: 1982-91

Early trend analyses of ambient Pb data[8,9] were based almost exclusively on National Air Surveillance Network (NASN) sites. These sites were established in the 1960's to monitor ambient air quality levels of TSP and associated trace metals, including Pb. The sites were predominantly located in the central business districts of larger American cities. In September 1981, ambient Pb monitoring regulations were promulgated.[10] The siting criteria in the regulations resulted in finding many of the old historic TSP monitoring sites unsuitable for the measurement of ambient Pb concentrations and many of the earlier sites were moved or discontinued.

As with the other pollutants, the sites selected for the long-term trend analysis had to satisfy annual data completeness criteria of at least 8 out of 10 years of data in the 1982 to 1991 period. A year was included as "valid" if at least 3 of the 4 quarterly averages were available. As in last year's report, composite lead data, i.e., individual 24-hour observations are composited together by month or

quarter and a single analysis made, are being used in the trend analysis. Nineteen sites qualified for the 10-year trend because of the addition of composite data.

A total of 209 urban-oriented sites, from 38 States and Puerto Rico, met the data completeness criteria. Seventy-eight of these sites were NAMS, the largest number of lead NAMS sites to qualify for the 10-year trends. Twenty-six (12 percent) of the 209 trend sites were located in the State of California. However, the lead trend at the California sites was identical to the trend at the non-California sites; so that these sites did not distort the overall trends. Other states with 10 or more trend sites included: Illinois (13), Kansas (16), Pennsylvania (10), Tennessee (12), Texas (13), and West Virginia (12). Again, the Pb trend in each of these states was very similar to the national trend. Sites that were located near lead point sources such as primary and secondary lead smelters were excluded from the urban trend analysis, because the magnitude of the levels at these sources could mask the underlying urban trends. Trends at lead point source oriented sites will be discussed separately in the next section.

The means of the composite maximum quarterly averages and their respective 95 percent confidence intervals are shown in Figure 3-9 for both the 209 urban sites and 78 NAMS sites (1982-1991). There was an 89 percent (1982-91) decrease in the average for the 209 urban sites. Lead emissions over this 10-year period also decreased. There was a 90 percent decrease in total lead emissions and a 97 percent decrease in lead emissions from transportation sources. The confidence intervals for all sites indicate that the 1986-91 averages are significantly less than all averages from preceding years. Because of the smaller number (78) of NAMS sites with at least 8 years of data, the confidence

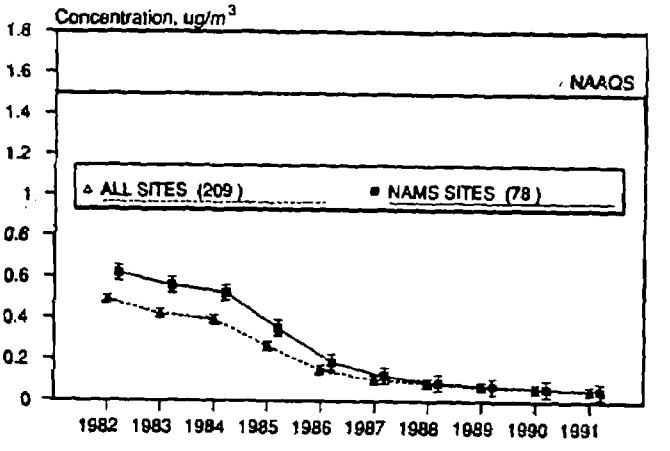


Figure 3-9. National trend in the composite average of the maximum quarterly average lead concentration at both NAMS and all sites with 95 percent confidence intervals, 1982-1991.

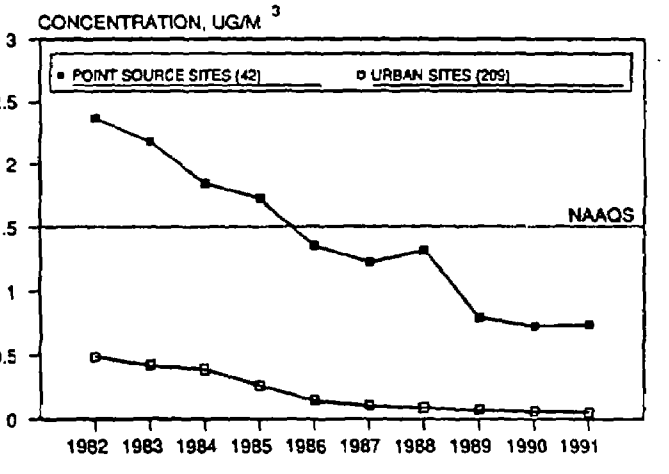


Figure 3-10. Comparison of national trend in the composite average of the maximum quarterly average lead concentrations at urban and point-source oriented sites, 1982-1991.

intervals are wider. However, the 1986-91 NAMS averages are still significantly different from all NAMS averages before 1986. It is interesting to note that the composite average lead concentration at the NAMS sites in 1991 is the same (0.053 $\mu g/m^3$) as the "all sites" average; whereas in the early 1980's the averages of the NAMS sites were significantly higher.

Figure 3-10 shows the trend in average lead concentrations for the urban-oriented sites and for 42 point-source oriented sites which also met the 10-year data completeness criteria. Composite average ambient lead concentrations at the point-source oriented sites, located near industrial sources of lead, e.g. smelters, battery plants, improved 69%, compared to 89% at the urban oriented sites. The average at the point-source oriented sites dropped in magnitude from 2.4 to 0.7 $\mu g/m^3$, a 1.7 $\mu g/m^3$ difference; whereas, the average at the urban sites dropped only from 0.5 to 0.1 $\mu g/m^3$. This improvement at the point-source oriented sites reflects both industrial and automotive lead emission controls, but in some cases, the industrial source reductions are because of plant shutdowns. However, there are still several urban areas where significant Pb problems persist. The 10 MSAs shown in Table 4-5 that are above the lead NAAQS in 1991 are all due to lead point sources. These MSAs are Birmingham, AL; Columbus, GA-AL; Indianapolis, IN; Los Angeles-Long Beach, CA; Memphis, TN-AR-MS; Nashville, TN; Omaha, NE-IA; Philadelphia, PA-NJ; St Louis, MO-IL; and Tampa-St Petersburg-Clearwater, FL. None of the monitoring sites responsible for 1991 lead concentrations above the NAAQS had sufficient historical data to be included in the point-source oriented trends discussed above. The sites in these MSAs which recorded lead concentrations above the NAAQS were sites situated near the lead point sources listed in EPA's Lead Strategy. This strategy targeted 28 primary or secondary lead smelters for more intensive lead monitoring.

Figure 3-11 shows boxplot comparisons of the maximum quarterly average Pb concentrations at the 209 urban-oriented Pb trend sites (1982-91). This figure shows the dramatic improvement in ambient Pb concentrations over the entire distribution of trend sites. As with the composite average concentration since 1982, most of the percentiles also show a monotonically decreasing pattern. The 209 urban-oriented sites that qualified for the 1982-91 period, when compared to the 202 sites for 1981-90 and the 189 sites for 1980-89

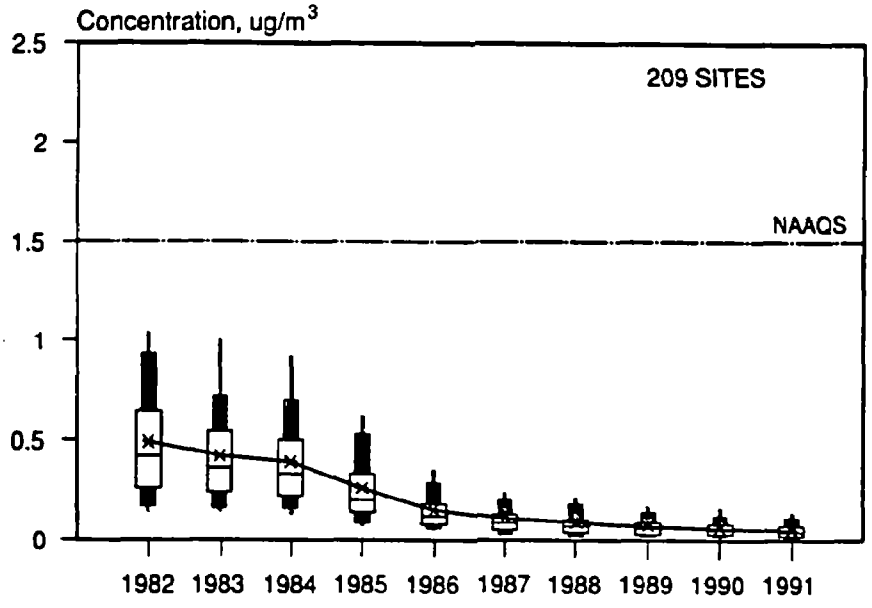


Figure 3-11. Boxplot comparisons of trends in maximum quarterly average lead concentrations at 209 sites, 1982-1991.

period, indicate an expansion of the 10-year trends data base.[5,11]

The trend in total lead emissions is shown in Figure 3-12. Table 3-2 summarizes the Pb emissions data as well. The 1982-91 drop in total Pb emissions was 90 percent. Lead emissions in the transportation category account for most of this drop. The trend in Pb emissions from non-transportation sources is shown in Figure 3-13. This figure shows the trend in three categories: fuel combustion, industrial, and solid waste disposal. Lead emissions from these categories show a drop early in the time period with a leveling off in the case of fuel combustion and solid waste disposal and an increase in the case of industrial. The drop in the non-transportation emissions

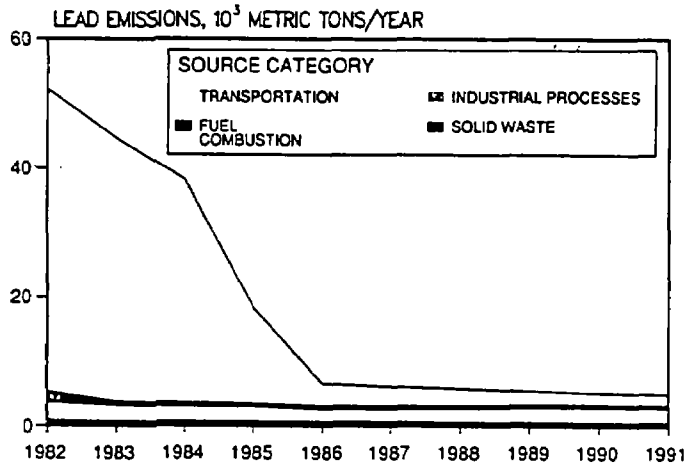


Figure 3-12. National trend in lead emissions, 1982-1991.

TABLE 3-2. National Lead Emission Estimates, 1982-1991

(thousand metric tons/year)										
SOURCE CATEGORY	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**
Transportation	46.96	40.80	34.69	14.70	3.45	3.03	2.64	2.15	1.71	1.62
Fuel Combustion	1.70	0.60	0.49	0.47	0.47	0.46	0.46	0.46	0.46	0.45
Industrial Processes	2.71	2.44	2.30	2.30	1.93	1.94	2.02	2.23	2.23	2.21
Solid Waste Disposal	0.94	0.82	0.82	0.79	0.77	0.77	0.74	0.69	0.73	0.69
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	52.31	44.66	38.30	18.26	6.62	6.21	5.86	5.53	5.13	4.97
NOTE: The sums of sub-categories may not equal total due to rounding.										

is due to decreases in lead from all categories as shown in Table 3-2. This compares with the 89 percent decrease (1982-91) in ambient lead concentrations. The drop in Pb consumption and subsequent Pb emissions since 1982 was brought about by the increased use of unleaded gasoline in catalyst-equipped cars and the reduced Pb content in leaded gasoline. The results of these actions in 1991 amounted to a 73 percent reduction nationwide in total Pb emissions from 1985 levels. As noted previously, unleaded gasoline represented 97 percent of 1991 total gasoline sales. Although the good agreement among the trend in lead consumption, emissions and ambient levels is based upon a limited geographical sample, it does show that ambient urban Pb levels are responding to the drop in lead emissions. The 10-year trend at the 42 point source oriented sites shows a much larger decline in lead concentrations (69%), than did lead emissions from industrial processes (18%). The improvement in lead concentrations at the point source oriented sites reflect improvements at a relatively small number of lead sources unlike the emission figures for industrial processes which represent all industrial sources in the nation. It is interesting to note that the lead emissions from industrial processes are lowest in 1986 ($1.93X10^3$ metric tons) then rise to $2.23X10^3$ metric tons in 1989 and 1990. On the other hand, the trend in lead concentrations shows a decline over this period, although there is a small increase in average lead concentrations in 1988.

In Canada a very similar trend in ambient lead concentrations has been observed. Composite average lead concentrations declined over 95 percent for the 1974-90 time period.[12] Also, average ambient Pb concentrations in Tokyo, Japan[13] have dropped from around 1.0 $\mu g/m^3$ in 1967 to

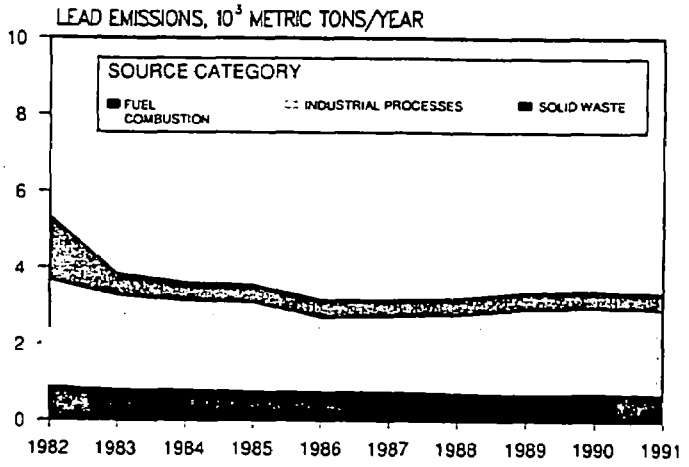


Figure 3-13. National trend in emissions of lead excluding transportation sources, 1982-1991.

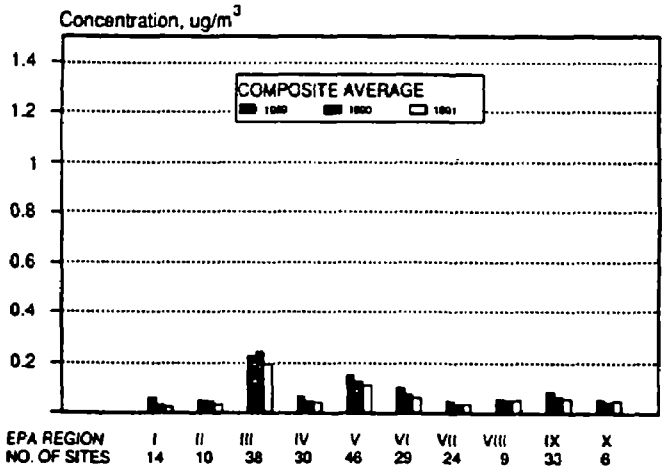


Figure 3-14. Regional comparisons of the 1989, 1990, 1991 composite average of the maximum quarterly average lead concentrations.

approximately 0.1 $\mu g/m^3$ in 1985 - a 90% improvement.

3.2.2 Recent Pb Trends: 1989-91

Ambient Pb trends were also studied over the shorter period 1989-91. A total of 239 urban sites from 38 States and Puerto Rico met the data requirement that a site have all 3 years with data. In recent years, the number of lead sites has dropped because of the elimination of some TSP monitors from state and local air monitoring programs. Lead measurements were obtained from the TSP filters. Some monitors were eliminated due to the change in the particulate matter standard from TSP to PM-10 while others were discontinued because of the very low lead concentrations measured in many urban locations. Although some further attrition may occur, the core network of NAMS lead sites together with supplementary State and local sites should be sufficient to assess national ambient lead trends. The 3-year data base (1989-91) showed an improvement of 27 percent in composite average urban Pb concentrations. The 1989 and 1991 lead averages respectively were 0.113 and 0.082 $\mu g/m^3$. This corresponds to reductions in total Pb emissions of 10 percent and a reduction of 25 percent in lead emissions from transportation sources. Most of this decrease in total nationwide Pb emissions was due once again to the decrease in automotive Pb emissions. Even this larger group of sites was disproportionately weighted by sites in California, Illinois, Kansas, Pennsylvania and Texas. These States had about 42 percent of the 239 sites represented. However, the percent changes in 1989-91 average Pb concentrations for these five States were very similar to the percent change for the remaining sites, thus the contributions of these sites did not distort the national trends. Although urban lead concentrations continue to decline consistently, there are indications that the rate of the decline has slowed down. Clearly in some areas, urban lead levels are so low, that further improvements have become difficult.

Indeed, as will be shown later, all sections of the country are showing declines in average lead concentrations. Sixty-five (65) point source oriented sites did not show any change over the 1989-91 time period. Thus, lead concentrations near lead point sources unlike the urban sites, which showed an 18% decrease, have remained steady over the last 3 years. Lead emissions from industrial processes also did not change over the 1989-91 period. The average lead levels at the point oriented sites are much higher here than at the urban sites. The 1990 and 1991 lead point source averages were 0.78 and 0.74 $\mu g/m^3$ respectively.

The larger sample of sites represented in the 3-year trends (1989-91) will be used to compare the most recent individual yearly averages. However, for the 10-year time period the largest single year drop in average lead concentrations, 44 percent, occurs as expected between 1985 and 1986, because of the shift of the lead content in leaded gasoline. The 1991 composite average lead concentrations show the more modest decline of 18 percent from 1990 levels. The 10-year data base showed a 15 percent decrease in average lead concentrations from 1990 to 1991. There has been a 5 percent improvement in estimated Pb emissions for the transportation category between 1990 and 1991, although, VMT increased 1 percent between 1990 and 1991. The Pb emissions trend is expected to continue downward, but at a slower rate, primarily because the leaded gasoline market will continue to shrink. Between 1990 and 1991, total lead emissions decreased 3 percent, while emissions from transportation sources decreased 5%. Some major petroleum companies have discontinued refining leaded gasoline because of the dwindling market, so that in the future the consumer will find it more difficult to purchase regular leaded gasoline.

Figure 3-14 shows 1989, 1990 and 1991 composite average Pb concentrations, by EPA Region. Once again the larger more representative 3-year data base of 239 sites was used for this comparison. The number of sites varies dramatically by Region from 6 in Region X to 46 in Region V. In all Regions there is a decrease in average Pb urban concentrations between 1989 and 1991. These results confirm that average Pb concentrations in urban areas are continuing to decrease throughout the country, which is exactly what is to be expected because of the national air pollution control program in place for Pb.

3.3 TRENDS IN NITROGEN DIOXIDE

Nitrogen dioxide (NO_2) is a brownish, highly reactive gas which is present in urban atmospheres. The major mechanism for the formation of NO_2 in the atmosphere is the oxidation of the primary air pollutant, nitric oxide (NO). Nitrogen oxides play a major role, together with volatile organic compounds, in the atmospheric reactions that produce ozone. The role of NO_x in ozone formation received attention in the recent NAS study.[2] Nitrogen oxides form when fuel is burned at high temperatures. The two major emissions sources are transportation and stationary fuel combustion sources such as electric utility and industrial boilers.

Nitrogen dioxide can irritate the lungs, cause bronchitis and pneumonia, and lower resistance to respiratory infections. Nitrogen oxides are an important precursor both to ozone and acidic precipitation and may affect both terrestrial and aquatic ecosystems. Los Angeles, CA is the only urban area that has recorded violations of the annual average NO_2 standard of 0.053 ppm during the past 10 years.

NO_2 is measured using a continuous monitoring instrument which can collect as many as 8760 hourly observations per year. Only annual means based on at least 4380 hourly observations were considered in the trends analyses which follow. A total of 172 sites were selected for the 10-year period and 236 sites were selected for the 3-year data base.

3.3.1 Long-term NO_2 Trends: 1982-91

The composite average long-term trend for the nitrogen dioxide mean concentrations at the 172 trend sites and the 42 NAMS sites, is shown in Figure 3-15. The 95 percent confidence intervals about the composite means reveal that the 1982-89 NO_2 levels are statistically indistinguishable. The 1991 composite average NO_2 level is 6 percent lower than the 1982 level, and the difference is statistically significant. The 1990 composite average is also significantly lower than the 1982 composite mean level. A similar trend is seen for the NAMS sites which, for NO_2, are located only in

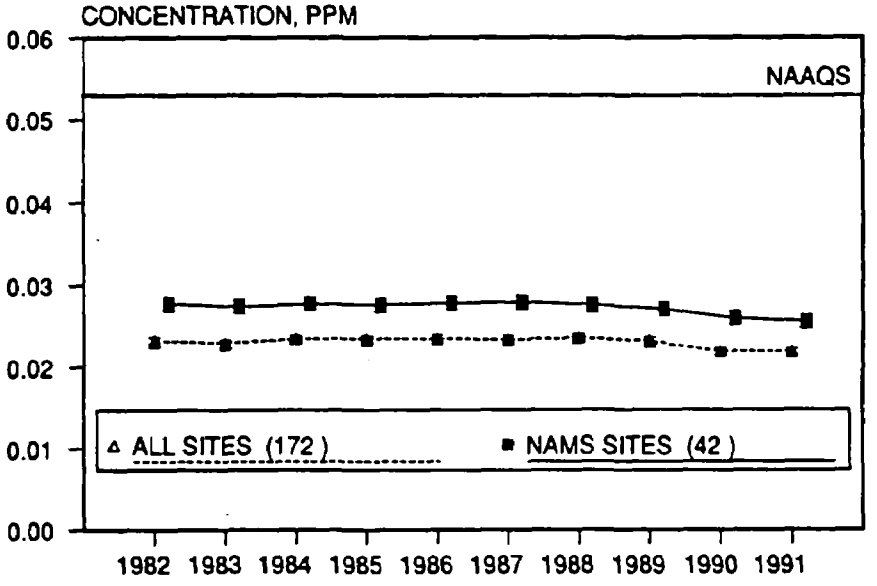


Figure 3-15. National trend in the composite annual average nitrogen dioxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1982-1991.

large urban areas with populations of one million or greater. As expected, the composite averages of the NAMS are higher than those of all sites. The 1991 composite average of the NO_2 annual mean concentration at the 42 NAMS is 8 percent lower than the composite average in 1982. This difference is statistically significant.

Long-term trends in NO_2 annual average concentrations are also displayed in Figure 3-16 with the use of boxplots. The middle quartiles for the years 1982 through 1989 are similar, while a decrease in levels can be seen in 1991. The upper percentiles, which generally reflect NO_2 annual mean levels in the Los Angeles metropolitan area, also show improvement during the last three years. The lower percentiles show little change. Long-term NO_2 annual mean trends vary with population size among metropolitan areas. Previous reports have shown that the level of the NO_2 composite means varied by metropolitan area size, with the larger areas recording the higher concentration levels.[11]

Figure 3-17 presents a comparison of the 10-year trend in the annual arithmetic mean NO_2 concentration with the 10-year trends in various alternative NO_2 air quality indicators. The trends in the peak indicators, both the annual maximum and the second maximum 1-hour concentrations, show a much steeper decline (18 and 17 percent reductions, respectively) than for the annual arithmetic mean concentration, which recorded a 6 percent reduction between 1982-91. The reductions in the various percentiles were similar to that observed in the annual arithmetic mean; 95th percentile of the hourly concentrations (-7%), 90th percentile (-6%), 70th percentile (-5%), and the 50th percentile, or median (-5%).

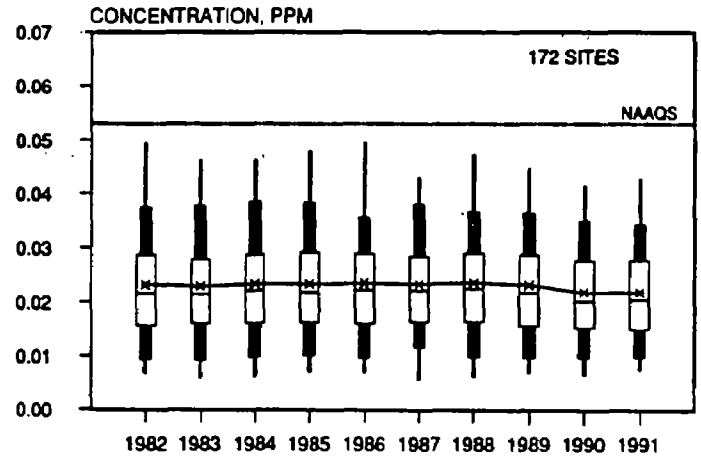


Figure 3-16. Boxplot comparisons of trends in annual mean nitrogen dioxide concentrations at 172 sites, 1982-1991.

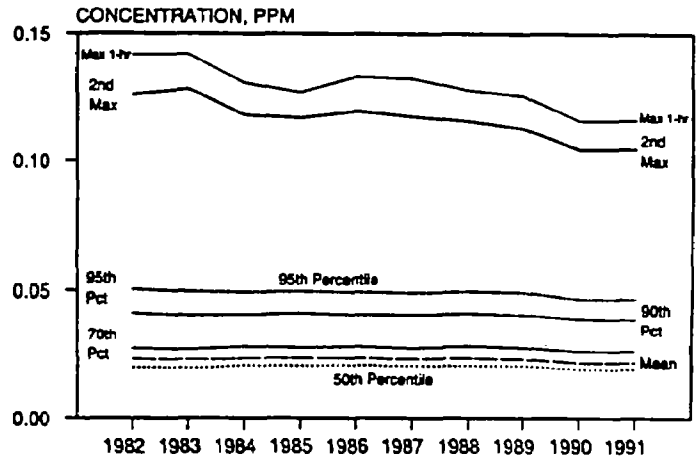


Figure 3-17. Trend in nitrogen dioxide air quality indicators, 1982-1991.

Table 3-3 presents the trend in estimated nationwide emissions of nitrogen oxides (NO_x). Total 1991 nitrogen oxides emissions are 8 percent less than 1982 emissions. Highway vehicle emissions decreased by 32 percent during this period, as estimated using the MOBILE 4.1 model. These estimates differ only slightly (about 4% higher in 1982) from those calculated with MOBILE 4.0 in the last report.[5] Fuel combustion emissions, which are 8 percent higher in 1991 than in 1982, have remained relatively constant during the last 4 years. Most of the decreases in mobile source emissions occurred in urban areas. Figure 3-18 shows that the two primary source categories of nitrogen oxides emissions are fuel combustion and transportation, composing 56 percent and 39 percent, respectively, of total 1991 nitrogen oxides emissions.

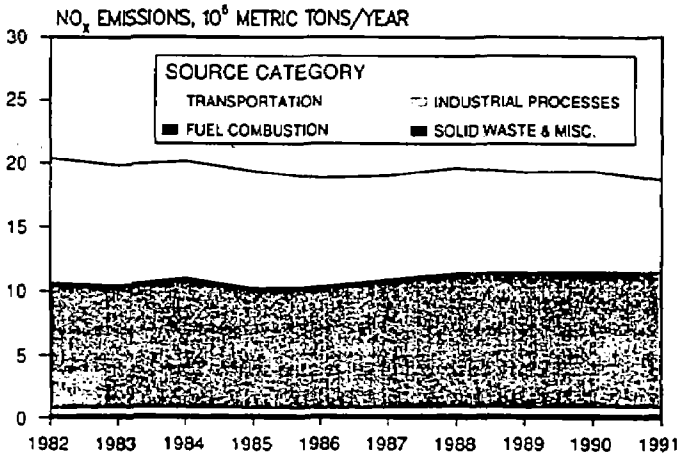


Figure 3-18. National trend in nitrogen oxides emissions, 1982-1991.

TABLE 3-3. National Nitrogen Oxides Emission Estimates, 1982-1991

(million metric tons/year)										
SOURCE CATEGORY	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**
Transportation	9.74	9.35	9.10	9.15	8.49	8.14	8.19	7.85	7.83	7.26
Fuel Combustion	9.84	9.60	10.16	9.38	9.55	10.05	10.52	10.59	10.63	10.59
Industrial Processes	0.55	0.55	0.58	0.56	0.56	0.56	0.58	0.59	0.59	0.60
Solid Waste Disposal	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.10
Miscellaneous	0.15	0.23	0.19	0.21	0.16	0.19	0.28	0.19	0.26	0.21
TOTAL	20.37	19.80	20.11	19.39	18.83	19.03	19.65	19.29	19.38	18.76

NOTE: The sums of sub-categories may not equal total due to rounding.

3.3.2 Recent NO_2 Trends: 1989-1991

Between 1990 and 1991, there was no change in the composite annual mean NO_2 concentration at 236 sites, with complete data during the last three years. This followed a decrease of 6 percent between 1989 and 1990, the largest decrease in the past decade. At the subset of 42 NAMS, the composite mean concentration decreased 2 percent between 1990 and 1991. Nationwide emissions of nitrogen oxides are estimated to have decreased 3 percent between 1990 and 1991, due primarily to the 8 percent reduction in NO_x emissions from transportation sources.

Regional trends in the composite average NO_2 concentrations for the years 1989-91 are displayed in Figure 3-19 with bar graphs. Region X, which did not have any NO_2 sites meeting the 3-year data completeness and continuity criteria, is not shown. All of the remaining nine Regions have 1991 composite average NO_2 annual mean concentrations that are lower than the 1989 composite mean levels. Five of the nine Regions have 1991 composite mean concentrations which are lower than the corresponding 1990 levels. These Regional graphs are primarily intended to depict relative change. Because the mix of monitoring sites may vary from one area to another, this graph is not intended to indicate Regional differences in absolute concentration levels.

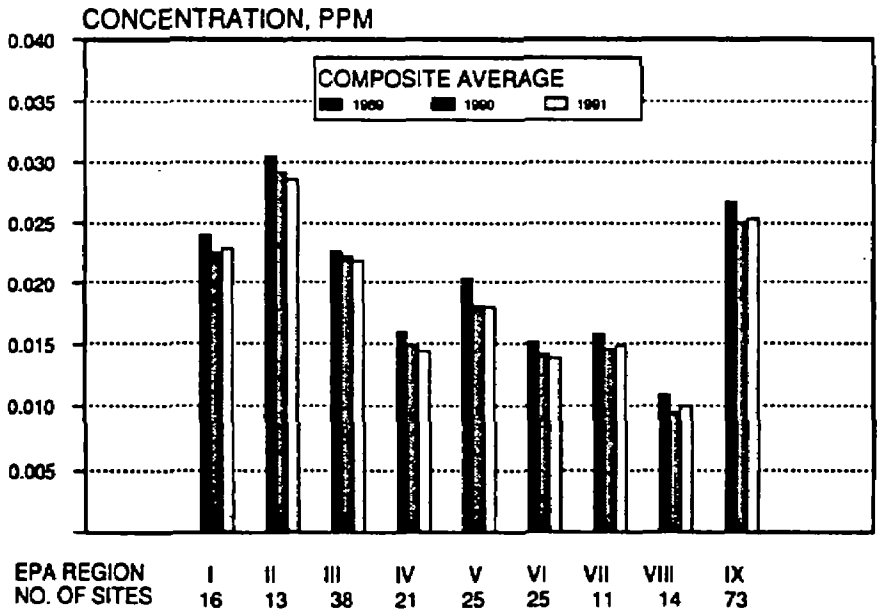


Figure 3-19. Regional comparisons of 1989, 1990, 1991 composite averages of the annual mean nitrogen dioxide concentrations.

3.4 TRENDS IN OZONE

Ozone (O_3) is a photochemical oxidant and the major component of smog. While ozone in the upper atmosphere is beneficial to life by shielding the earth from harmful ultraviolet radiation from the sun, high concentrations of ozone at ground level are a major health and environmental concern. Ozone is not emitted directly into the air but is formed through complex chemical reactions between precursor emissions of volatile organic compounds and nitrogen oxides in the presence of sunlight. These reactions are stimulated by sunlight and temperature so that peak ozone levels occur typically during the warmer times of the year. Both volatile organic compounds and nitrogen oxides are emitted by transportation and industrial sources. Volatile organic compounds are emitted from sources as diverse as autos, chemical manufacturing, and dry cleaners, paint shops and other sources using solvents. Nitrogen oxides emissions were discussed in the previous section.

The reactivity of ozone causes health problems because it tends to break down biological tissues and cells. Recent scientific evidence indicates that ambient levels of ozone not only affect people with impaired respiratory systems, such as asthmatics, but healthy adults and children, as well. Exposure to ozone for several hours at relatively low concentrations has been found to significantly reduce lung function in normal, healthy people during exercise. This decrease in lung function generally is accompanied by symptoms including chest pain, coughing, sneezing and pulmonary congestion.

The O_3 NAAQS is defined in terms of the daily maximum, that is, the highest hourly average for the day, and it specifies that the expected number of days per year with values greater than 0.12 ppm should not be greater than one. Both the annual second highest daily maximum and the number of daily exceedances during the ozone season are considered in this analysis. The strong seasonality of ozone levels makes it possible for areas to limit their ozone monitoring to a certain portion of the year, termed the ozone season. The length of the ozone season varies from one area of the country to another.[14] May through October is typical but States in the south and southwest may monitor the entire year. Northern States would have shorter ozone seasons such as May through September for North Dakota. This analysis uses these ozone seasons to ensure that the data completeness requirements apply to the relevant portions of the year.

The trends site selection process, discussed in Section 2.1, resulted in 495 sites being selected for the 1982-91 period, an increase of 24 sites (or 5%) from the 1981-90 trends data base. A total of 647 sites are included in the 1989-91 data base. The NAMS compose 199 of the long-term trends sites and 216 of the sites in the 3-year data base.

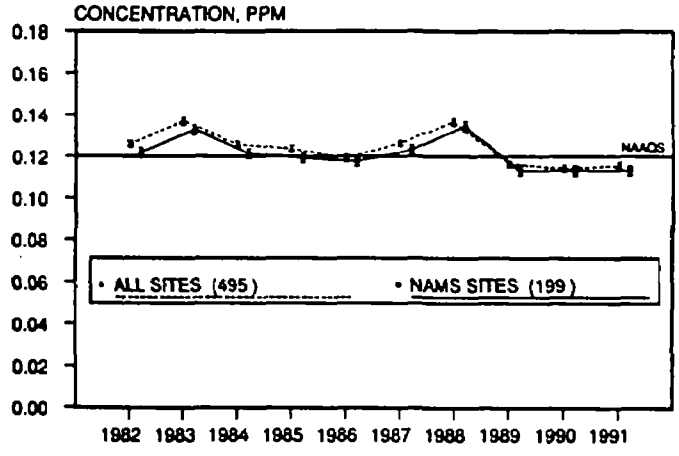


Figure 3-20. National trend in the composite average of the second highest maximum 1-hour ozone concentration at both NAMS and all sites with 95 percent confidence intervals, 1982-1991.

3.4.1 Long-term O_3 Trends: 1982-91

Figure 3-20 displays the 10-year composite average trend for the second highest day during the ozone season for the 495 trends sites and the subset of 199 NAMS sites. The 1991 composite average for the 495 trend sites is 8 percent lower than the 1982 average and 7 percent lower for the subset of 199 NAMS. These 1991 values are slightly higher than the 1990 levels, which were the lowest composite averages of the past ten years. The 1991 composite average is significantly less than the 1988 composite mean, which is the second highest average (1983 was the highest) during this 10-year period. As discussed in previous reports, the relatively high ozone concentrations in both 1983 and 1988 are likely attributed in part to hot, dry, stagnant conditions in some areas of the country that were more conducive to ozone formation than other years. Peak ozone concentrations typically occur during hot, dry, stagnant summertime conditions (high temperature and strong solar insolation).[15,16] Previous reports have compared the regional variability in meteorological parameters such as maximum daily temperature and precipitation with the variability in peak ozone concentrations.[11,17]

The interpretation of recent ozone trends is difficult due to the confounding factors of meteorology and emission changes. Just as the increase in 1988 is attributed in part to meteorological conditions, the 1989 decrease is likely due, in part, to meteorological conditions being less favorable for ozone formation in 1989 than in 1988.[11,17] Nationally, summer 1991 was warmer than the long-term climatological means.[18] Also, precursor emissions of nitrogen oxides and volatile organic compound emissions from highway vehicles have decreased in urban areas. The volatility of gasoline was reduced by new regulations which lowered national average summertime Reid Vapor Pressure (RVP) in regular unleaded gasoline from 10.0 to 8.9 pounds per square inch (psi) between 1988 and 1989.[19,20,21] RVP

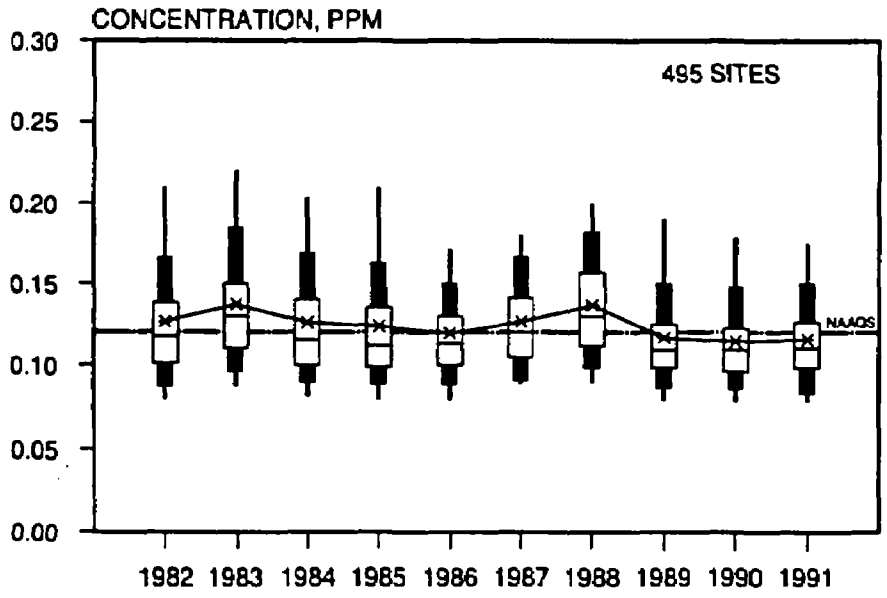


Figure 3-21. Boxplot comparisons of trends in annual second highest daily maximum 1-hour ozone concentration at 495 sites, 1982-1991.

was reduced an additional 3 percent between 1989 and 1990.[22]

The inter-site variability of the annual second highest daily maximum concentrations for the 495 site data base is displayed in Figure 3-21. The years 1983 and 1988 values are similarly high, while the remaining years in the 1982-91 period are generally lower, with 1990 being the lowest, on average. The distribution of second daily maximum 1-hour concentrations in 1991 is similar to that recorded in 1986 and 1990.

Historically, the long-term ozone trends in this annual report have emphasized air quality statistics that are closely related to the NAAQS. A recent report[2] by the National Academy of Sciences (NAS) stated that "the principal measure currently used to assess ozone trends (i.e., the second-highest daily maximum 1-hour concentration in a given year) is highly sensitive to meteorological fluctuations and is not a reliable measure of progress in reducing ozone over several years for a given area." The report recommended that "more statistically robust methods be developed to assist in tracking progress in reducing ozone." The report described "several other potentially robust indicators of ozone trends" and featured indicators described previously by Curran and Frank which used a comparison of different percentiles and maximum values[4]. Of course, the main focus of this report is to track the trends in the quality of air people are breathing when outdoors, therefore, it makes sense to use a summary statistic that clearly relates to the ozone air quality standard. Nevertheless, it is still useful to look at trends in alternative summary statistics to see if there are sufficient differences among trends for different summary statistics to warrant concern. As research continues, it may become possible to quantify the effect of meteorological influences on ozone levels so that meteorologically adjusted trends could be presented. The percentiles are statistically robust, in the sense that they are less affected by a few extreme values. The percentiles selected here range from the 50th percentile (or median) to the 95th percentile. The mean of the hourly concentrations is also presented. Figure 3-22

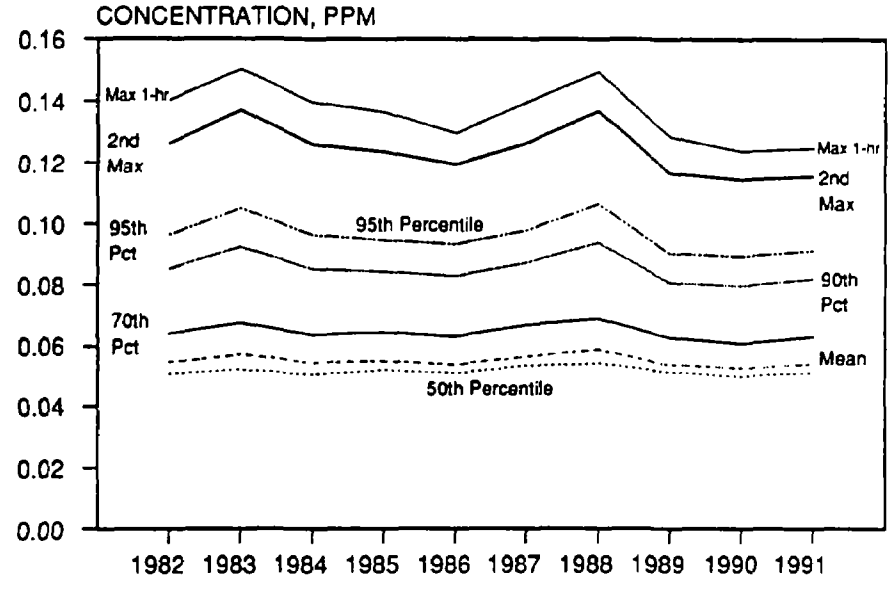


Figure 3-22. Trend in ozone air quality indicators, 1982-1991.

presents the 10-year trends for these various alternative ozone summary statistics. All of the patterns are somewhat similar among the various summary statistics, with a tendency to become flatter in the lower percentiles. The peak years of 1983 and 1988 are still evident in the trend lines for each indicator, however. The increase of 8 percent recorded in the annual second-highest daily maximum 1-hour concentration between 1987 and 1988 was also seen in the 95th and 90th percentile concentrations. The lower percentile indicators had smaller increases of 3 to 4 percent. The percent change between 1982 and 1991 for each of the summary statistics follows: annual daily maximum 1-hour concentration (-11%), annual second daily maximum 1-hour concentration (-8%), 95th percentile of the daily maximum 1-hour concentrations (-5%), 90th percentile (-4%), 70th percentile (-1%), 50th percentile, or median of the daily maximum 1-hour concentrations (+1%), and the annual mean of the daily maximum 1-hourly concentrations (-1%).

Figure 3-23 depicts the 1982-91 trend for the composite average number of ozone exceedances. This statistic is adjusted for missing data, and it reflects the number of days that the ozone standard is exceeded during the ozone season. Since 1982, the expected number of exceedances decreased 38 percent at the 495 long-term trend sites and 42 percent at the subset of 199 NAMS. As with the second maximum, the 1983 and 1988 values are higher than the other years in the 1982-91 period. The 1989 through 1991 levels are significantly lower than all the previous years.

Table 3-4 and Figure 3-24 display the 1982-91 emission trends for volatile organic compounds (VOC) which, along with nitrogen oxides shown earlier in Table 3-3, are involved in the atmospheric chemical and physical processes that result in the formation of O_3. Total VOC emissions are estimated to have decreased 13 percent between 1982 and 1991. During this same period, nitrogen oxides emissions, the other major

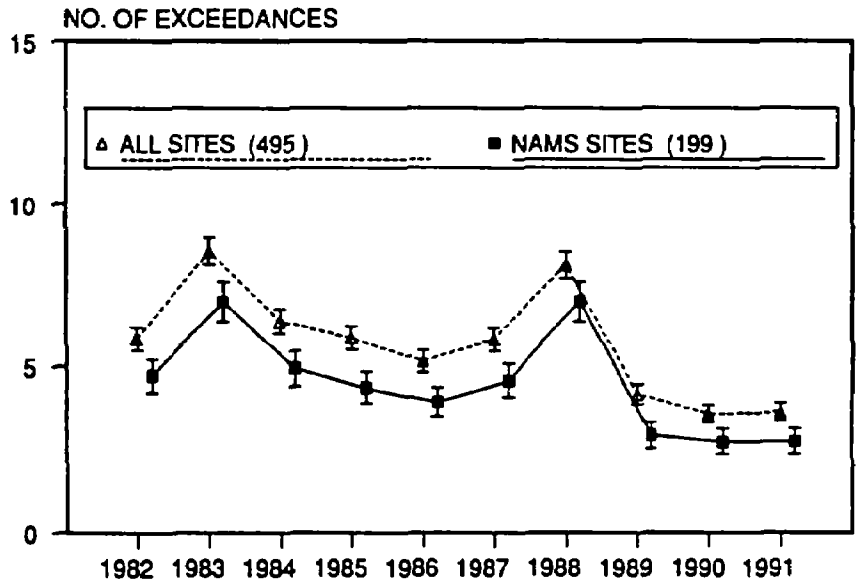


Figure 3-23. National trend in the estimated number of daily exceedances of the ozone NAAQS in the ozone season at both NAMS and all sites with 95 percent confidence intervals, 1982-1991.

precursor of ozone formation, decreased 8 percent. Between 1982 and 1991, VOC emissions from highway vehicles decreased 46 percent, despite a 36 percent increase in vehicle miles of travel during this time period. These VOC estimates are based on statewide average monthly temperatures and statewide average RVP. The highway vehicle emission estimates in this report were recalculated using the MOBILE 4.1 model and revised statewide estimates of RVP 1989 and 1990. In contrast to previous reports, these VOC totals now reflect the reduction in RVP that occurred since 1988. However, these VOC emissions estimates are annual totals. While these are the best national numbers now available, ozone is predominately a warm weather problem and seasonal emission trends would be preferable.

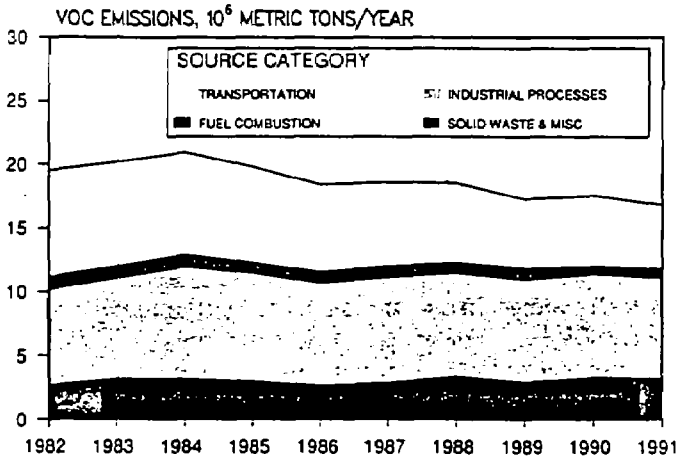


Figure 3-24. National trend in volatile organic compound emissions, 1982-1991.

TABLE 3-4. National Volatile Organic Compound Emission Estimates, 1982-1991

(million metric tons/year)										
SOURCE CATEGORY	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**
Transportation	8.32	8.19	8.07	7.47	6.88	6.59	6.26	5.45	5.54	5.08
Fuel Combustion	1.01	1.00	1.01	0.90	0.89	0.90	0.89	0.91	0.62	0.67
Industrial Processes	7.41	7.80	8.68	8.35	7.92	8.17	8.00	7.97	8.02	7.86
Solid Waste Disposal	0.63	0.60	0.60	0.60	0.58	0.58	0.58	0.58	0.58	0.69
Miscellaneous	2.13	2.65	2.64	2.49	2.19	2.40	2.88	2.44	2.82	2.59
TOTAL	19.50	20.26	20.99	19.80	18.45	18.64	18.61	17.35	17.58	16.88
NOTE: The sums of sub-categories may not equal total due to rounding.										

3.4.2 Recent O_3 Trends: 1989-1991

This section discusses ambient O_3 changes during the 3-year time period 1989-91. Using this 3-year period permits the use of a larger data base of 647 sites, compared to 495 for the 10-year period.

Summer 1991 temperature averaged across the nation was above the long-term mean and ranks as the 19th warmest summer on record since 1895.[18] Spatially averaged 1991 precipitation was slightly below the long-term mean and ranks as the 29th driest summer. Regionally, the northeastern part of the country had summertime temperatures above the long-term mean, ranking Summer 1991 as the 8th warmest summer on record.[18] Also, conditions were relatively dry in the East Northcentral, Northeast, and Central Regions. Also, 1990 average RVP decreased 3 percent from summer 1989 levels, and 1989 was 11 percent lower than 1988 average RVP.[22] A recent modeling analysis of New York City conditions estimated that the impact of this RVP reduction was a 25 percent reduction in VOC emissions.[23]

Between 1990 and 1991, composite mean ozone concentrations increased 1 percent at the 647 sites and were essentially unchanged at the subset of 216 NAMS. Between 1990 and 1991, the composite average of the number of estimated exceedances of the ozone standard increased by 5 percent at the 647 sites, and 8 percent at the 216 NAMS. Nationwide VOC emissions decreased 4 percent between 1990 and 1991, and 3 percent between 1989 and 1991.

The composite average of the second daily maximum concentrations increased in five of the ten Regions between 1990 and 1991. As Figure 3-25 indicates, the largest increases were recorded in the northeastern states, composing EPA Regions I through III. In four Regions, 1991 composite mean levels were the highest of the 3-year period.

These Regional graphs are primarily intended to depict relative change. Because the mix of monitoring sites may vary from one area to another, this graph is not intended to indicate Regional differences in absolute concentration levels.

As with last year's report, the accelerated printing schedule for this year's report precluded an advanced estimate for 1992, because sufficient 1992 data were not available as the report went to press.

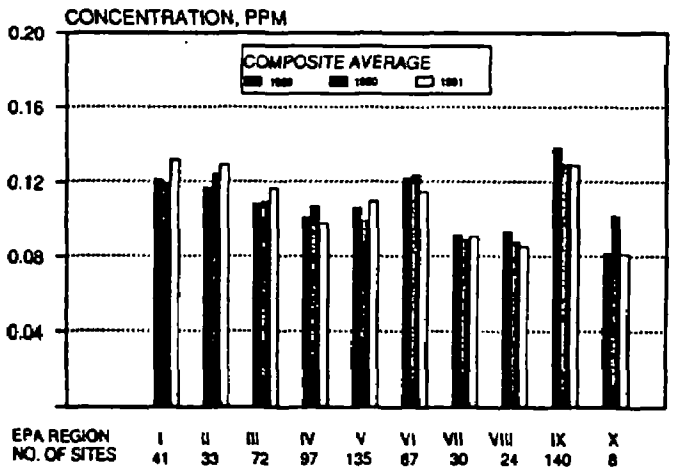


Figure 3-25. Regional comparisons of the 1989, 1990, 1991 composite averages of the second-highest daily 1-hour ozone concentrations.

3.5 TRENDS IN PARTICULATE MATTER

Air pollutants called particulate matter include dust, dirt, soot, smoke and liquid droplets directly emitted into the air by sources such as factories, power plants, cars, construction activity, fires and natural windblown dust as well as particles formed in the atmosphere by condensation or transformation of emitted gases such as sulfur dioxide and volatile organic compounds.

Based on studies of human populations exposed to high concentrations of particles (often in the presence of sulfur dioxide), and laboratory studies of animals and humans, the major effects of concern for human health include effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, carcinogenesis and premature mortality. The major subgroups of the population that appear likely to be most sensitive to the effects of particulate matter include individuals with chronic obstructive pulmonary or cardiovascular disease, individuals with influenza, asthmatics, the elderly and children. Particulate matter causes damage to materials, soiling and is a major cause of substantial visibility impairment in many parts of the U.S.

Annual and 24-hour National Ambient Air Quality Standards (NAAQS) for particulate matter were first set in 1971. Total suspended particulate (TSP) was the indicator used to represent suspended particles in the ambient air. TSP is measured using a high volume sampler (Hi-Vol) which collects suspended particles ranging up to approximately 45 micrometers in diameter.

On July 1, 1987 EPA promulgated new annual and 24-hour standards for particulate matter, using a new indicator, PM-10, that includes only those particles with aerodynamic diameter smaller than 10 micrometers. These smaller particles are likely responsible for most adverse health effects of particulate because of their ability to reach the thoracic or lower regions of the respiratory tract. The original (TSP) standards were an annual geometric mean of 75 $\mu g/m^3$, not to be exceeded, and a 24-hour concentration of 260 $\mu g/m^3$, not to be exceeded more than once per year. The new (PM-10) standards specify an expected annual arithmetic mean not to exceed 50 $\mu g/m^3$ and an expected number of 24-hour concentrations greater than 150 $\mu g/m^3$ per year not to exceed one.

With the change from TSP to PM-10 as the indicator for particulate matter, the number of TSP monitors has been steadily declining and a network of locations to monitor PM-10 has evolved. Figure 3-26 shows the 10-year decline of the number of TSP monitors nationally, contrasted with the developing PM-10 network. Approximately 1360 PM-10 sites were active in 1991, compared with about 825 for TSP. In 1981 there were approximately 4000 TSP monitoring locations.

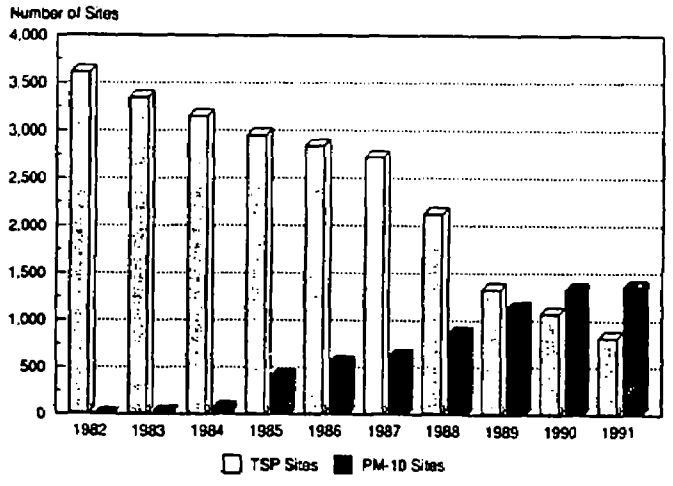


Figure 3-26. National trend in the number of TSP and PM-10 monitoring locations, 1982-1991.

There are basically two types of reference instruments currently used to sample PM-10. The first is essentially a Hi-Vol, like the one used for TSP, but with a different size selective inlet (SSI). This sampler uses an inert quartz filter. The other type of instrument is a "dichotomous" sampler. It uses a different PM-10 inlet, operates at a slower flow rate, and produces two separate samples: 2.5 to 10 microns and less than 2.5 microns, each collected on a teflon filter.

With the new PM-10 standards, more emphasis is being placed on detection of peak 24-hour concentrations. Unlike monitoring regulations for TSP which only required once in 6-day sampling, new specifications for PM-10 now dictate more frequent sampling. Approximately 15 percent of all PM-10 sampling sites operate either every other day or everyday. In contrast, only 5 percent of TSP Hi-Vols had been operating more frequently than once in 6 days.

Although some monitoring for PM-10 was initiated prior to promulgation of the new standards, most networks did not produce data with approved reference samplers until mid-1987 or 1988. Thus, only a limited data base is currently available to examine trends in PM-10 air quality and longer-term trends in particulate matter can only be based on TSP. However, because the number of TSP sites has declined during the past decade from about 4000 to about 825, the interpretation of the available data is limited. Additionally, only 594 TSP sites were appropriate to be considered in the 3-year (1989-91) comparison. Therefore, this report will utilize the increasingly prevalent PM-10 monitoring data to characterize particulate matter trends. Previous annual reports are a valuable source of TSP information.[5,11,17] Available information on PM-10 air quality will be used to report the 1989-1991 changes in PM-10 concentration levels. Two PM-10 statistics are presented. The annual arithmetic mean concentration is used to reflect average air quality, and the 90th percentile of 24-hour concentrations is used to represent the behavior of peak concentrations. Because PM-10 sampling frequency varies among sites and may have changed during the 3-year period, the 90th percentile is used. This statistic is less sensitive to changes in sampling frequency than the peak values. Finally, cross sectional PM-10 data are

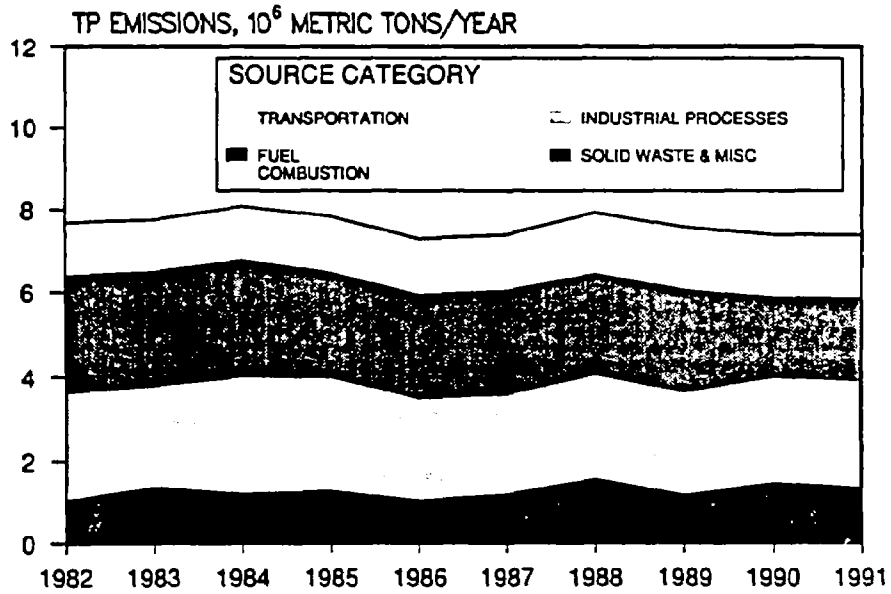


Figure 3-27. National trend in total particulate emissions, 1982-1991.

TABLE 3-5. National Total Particulate Emission Estimates, 1982-1991

(million metric tons/year)										
SOURCE CATEGORY	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Transportation	1.30	1.28	1.31	1.38	1.36	1.39	1.48	1.52	1.54	1.57
Fuel Combustion	2.75	2.72	2.76	2.47	2.46	2.44	2.40	2.41	1.87	1.94
Industrial Processes	2.57	2.39	2.80	2.70	2.43	2.38	2.48	2.46	2.53	2.55
Solid Waste Disposal	0.31	0.29	0.29	0.29	0.28	0.28	0.28	0.27	0.28	0.34
Miscellaneous	0.75	1.09	0.93	1.01	0.78	0.93	1.30	0.92	1.19	1.01
TOTAL	7.67	7.77	8.08	7.85	7.31	7.42	7.94	7.57	7.40	7.41
NOTE: The sums of sub-categories may not equal total due to rounding.										

included for the more comprehensive data available for calendar year 1991.

3.5.1 Total Particulate Emission Trends

Nationwide Total Particulate (TP) emission trends from historical inventoried sources, which exclude fugitive dust, show an overall decrease of 3 percent from 1982 to 1991. (See Table 3-5 and Figure 3-27). The general 10-year emission pattern has similarity to that of composite average air quality. Additionally, the TP emission estimates and trend are quite similar to those for PM-10 for each year since 1985 when PM-10 national estimates became available. The last 10 years have experienced a general decline in annual TP emissions. In 1991, TP emissions increased very slightly (less than 1 percent) compared to 1990. Each major source category for TP emissions, except the miscellaneous grouping, showed an increase, although always small, between 1990 and 1991.

3.5.2 Recent PM-10 Air Quality: 1989-91

The 1989 to 1991 change in the PM-10 portion of total particulate concentrations is examined at 682 monitoring locations which produced data in all three years.

The sample of 682 trend sites reveals a 10 percent decrease in average PM-10 concentrations between 1989 and 1991. (This is consistent with a 9 percent decrease in total particulates over the same period). Peak 24-hour PM-10 concentrations similarly decreased 6 percent since 1988 and 13 percent since 1989. The temporal pattern of the 682 trend sites also was observed for the 249 NAMS sites, for which average PM-10 concentrations decreased 10 percent between 1989 and 1991 and peak 24-hour PM-10 concentrations decreased 13 percent for this same two year period. Change in peak concentrations was examined in terms of the average of the 90th percentiles of 24-hour concentrations among sampling locations.

Figures 3-28 and 3-29 display boxplots of the concentration distribution for the two PM-10 trend statistics - annual arithmetic mean and 90th percentile of 24-hour concentrations. The 1988 and 1989 national distributions are very similar for both annual average and 90th percentile of 24-hour PM-10 concentrations. The distributions for 1990

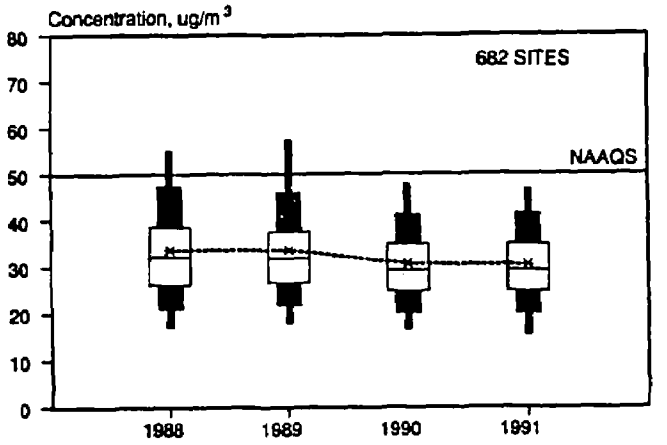


Figure 3-28. Boxplot comparisons of trends in annual mean PM-10 concentrations at 682 sites, 1988-1991.

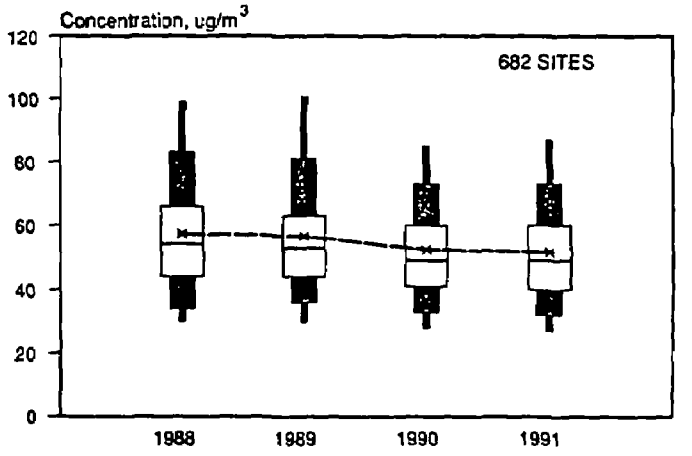


Figure 3-29. Boxplot comparisons of trends in the 90th percentile of 24-hour PM-10 concentrations at 682 sites, 1988-1991.

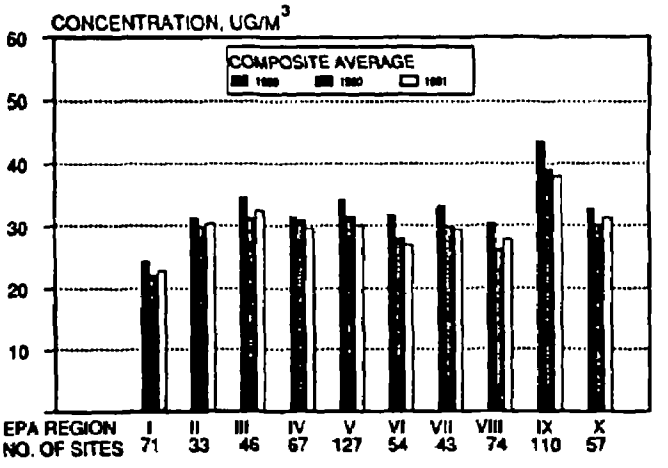


Figure 3-30. Regional comparisons of the 1989, 1990, 1991 composite averages of the annual average PM-10 concentrations.

Klamath Falls, Oregon: A Wood Smoke Success Story

Among the highest particulate matter (PM-10) concentrations recorded anywhere in the nation were those that occurred in a south central Oregon community of 37,500 called Klamath Falls. In January 1988, a PM-10 24-hour average concentration of 792 micrograms per cubic meter was measured. This is over five times the 24-hour Federal health standard. The major problem was residential wood stoves and fireplaces: nearly 10,000 homes burn wood in Klamath Falls and release about 1,200 tons of PM-10 into the air annually. Almost half of the homes burn wood as the main source of heat.

In the wintertime, Klamath Falls is subject to extreme nighttime inversions. An inversion creates an impenetrable barrier, trapping wood smoke at ground level at the time of day when home wood burning is at its greatest. These conditions produce PM-10 concentrations at very unhealthful levels. On inversion days when air quality is the worst, residential wood stoves and fireplaces contribute about 80 percent of the emissions causing the problem.

In response to the wood smoke problem Klamath County initiated strong public awareness and voluntary wood burning curtailment programs. An extensive public awareness effort, led by local officials, adopted the campaign slogan "particulate matters" and sought to educate the community on the health effects of wood smoke and the need to control it. In addition, beginning in November 1988, a call also went out to the community to voluntarily cease or reduce wood burning during inversion periods to try to avoid violating the 24-hour Federal health standard. This effort proved to be successful and participation has increased from year to year. But, to comply with Federal health air standards, air quality officials determined that wood burning emissions would have to be reduced on the worst days by about 90 percent and a voluntary curtailment program was judged to be insufficient.

In 1991, the community adopted a mandatory curtailment program which requires wood burners (with certain exceptions) to stop burning when health officials predict periods of unhealthy PM-10 air quality. The temporary bans are enforced with routine "drive-by" inspections to ensure compliance. Violations of the bans are punishable with fines. To further improve air quality, in 1991-92 over 325 wood stoves have been replaced with alternative heat sources using Federal and local funds.

So far, these renewed efforts appear to have paid off: preliminary data for the 1991/1992 wood heating season indicate that the health standard was not exceeded. While favorable weather conditions may have contributed in part to this winter's air quality, Klamath Falls has made significant and praiseworthy progress in advancing its efforts to improve air quality and ultimately to assure long-term protection of public health.

and for 1991 are lower for all percentiles than those for the preceding two years.

Figure 3-30 presents the 1989 to 1991 changes in annual average PM-10 concentrations by EPA Region. The 3-year national decrease is evident in all Regions. Most of this decrease occurred everywhere between 1989 and 1990. Average PM-10 concentrations in five Regions displayed an increase between 1990 and 1991, but in each case the 1991 levels remained lower than those of 1989.

3.5.3 PM-10 Emission Trends

Trends in the PM-10 portion of historically inventoried particulate matter emissions are presented for the 7-year period, 1985-1991 in Figure 3-31 and Table 3-6. For 1991, PM-10 emissions, while slightly (less than 1 percent) higher than in 1990, still represent a 3 percent decrease compared to both 1989 and to 1985. During the past seven years, a relatively consistent annual increase in PM-10 transportation emissions has been more than offset by a decrease in fuel combustion emissions which occurred between 1989 and 1990 and was largely maintained in 1991.

National estimates are also provided for PM-10 fugitive emissions for 1985-1991, in Figure 3-32 and Table 3-7. These estimates provide a good indication of the relative impacts of major contributors to particulate matter air quality. In total, these fugitive emissions are 6 to 8 times more than the

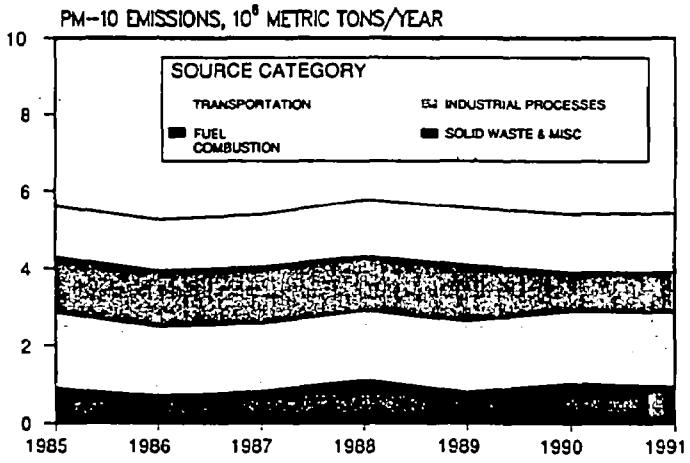


Figure 3-31. National trend in PM-10 emissions, 1982-1991.

TABLE 3-6. National PM-10 Emission Estimates, 1985-1991

(million metric tons/year)							
SOURCE CATEGORY	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**
Transportation	1.32	1.31	1.35	1.43	1.47	1.48	1.51
Fuel Combustion	1.46	1.48	1.49	1.45	1.49	1.05	1.10
Industrial Processes	1.90	1.74	1.70	1.73	1.77	1.81	1.84
Solid Waste Disposal	0.21	0.20	0.20	0.20	0.20	0.20	0.26
Miscellaneous	0.73	0.54	0.66	0.96	0.65	0.87	0.73
TOTAL	5.61	5.27	5.40	5.76	5.59	5.42	5.45

NOTE: The sums of sub-categories may not equal total due to rounding.

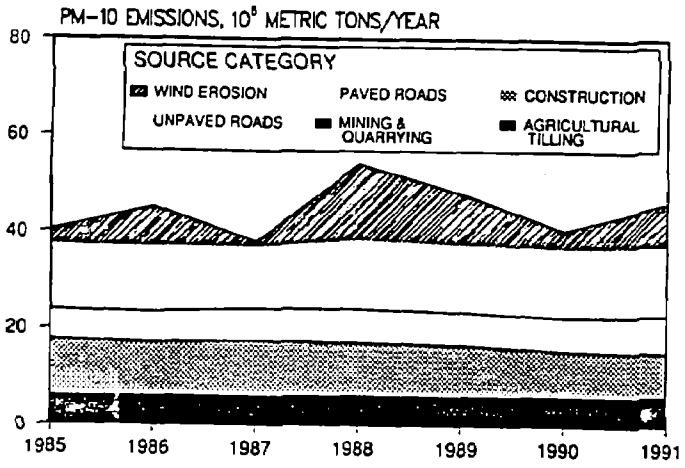


Figure 3-32. National trend in PM-10 fugitive emissions, 1982-1991.

historically inventoried particulate matter sources categories.

Note that PM-10 estimates are not included for contributions from gas phase particulate matter precursors, principally sulfur oxides and nitrogen oxides.

Construction activity and unpaved roads are consistently the major contributors of fugitive PM-10 emissions over time for most Regions. Nationally, roadway particulate matter emissions are estimated to have increased due to increased vehicle traffic. Among road types, emissions from unpaved and paved roads are estimated to have increased 8 percent and 24 percent, respectively, since 1985. Emissions from unpaved roads are highest in Regions which cover large geographic areas. Emissions due to construction are estimated to have decreased over 23 percent since 1985.

TABLE 3-7. National PM-10 Fugitive Emission Estimates, 1985-1991

(million metric tons/year)							
SOURCE CATEGORY	1985	1986	1987	1988	1989	1990	1991
Agricultural Tilling	6.20	6.26	6.36	6.43	6.29	6.35	6.32
Construction	11.49	10.73	11.00	10.58	10.22	9.11	8.77
Mining and Quarrying	0.31	0.28	0.34	0.31	0.35	0.34	0.36
Paved Roads	5.95	6.18	6.47	6.91	6.72	6.83	7.39
Unpaved Roads	13.34	13.30	12.65	14.17	13.91	14.20	14.36
Wind Erosion	3.23	8.52	1.32	15.88	10.73	3.80	9.19
TOTAL	40.53	45.27	38.14	54.28	48.22	40.63	46.38
NOTE: The sums of sub-categories may not equal total due to rounding.							

Agricultural activity is a smaller contributor to the national total, but estimated to be the major source in specific Regions. Tilling is estimated to be a big contributor in Regions V, VII, VIII and X, but has not shown much change over the 7-year period. Wind erosion particulate emissions are estimated to be extremely variable from year to year and can also be a major contributor in some Regions. Particulate emissions due to wind erosion are very sensitive to regional soil conditions and year-to-year changes in total precipitation. Accordingly, estimated emissions from wind erosion were extremely high for the drought year of 1988, particularly for Regions VI and VII. Finally, among all fugitive categories surveyed, mining and quarrying is estimated to be a relatively small contributor to total fugitive particulate matter emissions at the national level.[1]

3.5.4 Visibility Trends

Many parts of the nation have experienced long-term impairment in visibility due to build-up of emissions around urban areas and from long range transport of small particles (< 2.5 microns) across broad regions of the country. This increase in haze has occurred in the summer season across the Eastern U.S., although there has been improvement in the winter. In the Eastern and Southwestern U.S., regional visibility is mostly attributed to sulfates formed by release of sulfur oxides. In the Northwestern U.S., carbon particles play an important role in the degradation. The Clean Air Act Amendments of 1990 addressed regional haze in the East through the acid rain program which will substantially reduce sulfur oxides emissions. To address regional haze in the West, the new Act has strengthened the work already started on protection of visibility in national park and wilderness areas. Required research will focus on transport mechanisms and atmospheric conditions which contribute to hazes.

During 1991, the first major regulatory action solely to improve visibility was issued. This rule will reduce air pollution from a large electric power generating facility in northern Arizona. As a result, it is estimated that visibility in the Grand Canyon National Park will be improved by as much as 300 percent during the worst episodes and by more than 7 percent average improvement during the winter months of November through March. This rule, which is consistent with an agreement between business and environmental groups that was facilitated by EPA, is more stringent yet less costly than originally proposed. The SO_2 reductions from the power plant will be eligible for allowance credits which under the acid rain control program can be sold to other utilities to reduce a significant portion of its control costs.

3.6 TRENDS IN SULFUR DIOXIDE

Ambient sulfur dioxide (SO_2) results largely from stationary source coal and oil combustion, refineries, pulp and paper mills and from nonferrous smelters. There are three NAAQS for SO_2: an annual arithmetic mean of 0.03 ppm (80 $\mu g/m^3$), a 24-hour level of 0.14 ppm (365 $\mu g/m^3$) and a 3-hour level of 0.50 ppm (1300 $\mu g/m^3$). The first two standards are primary (health-related) standards, while the 3-hour NAAQS is a secondary (welfare-related) standard. The annual mean standard is not to be exceeded, while the short-term standards are not to be exceeded more than once per year. The trend analyses which follow are for the primary standards.

High concentrations of SO_2 affect breathing and may aggravate existing respiratory and cardiovascular disease. Sensitive populations include asthmatics, individuals with bronchitis or emphysema, children and the elderly. Although this report does not directly address trends in acid deposition, of which SO_2 is a major contributor, it does include information on total nationwide emissions which is a measure relating to total atmospheric loadings. SO_2 also produces foliar damage on trees and agricultural crops.

The trends in ambient concentrations are derived from continuous monitoring instruments which can measure as many as 8760 hourly values per year. The SO_2 measurements reported in this section are summarized into a variety of summary statistics which relate to the SO_2 NAAQS. The statistics on which ambient trends will be reported are the annual arithmetic mean concentration, the second highest annual 24-hour average (summarized midnight to midnight), and the expected annual number of 24-hour exceedances of the 24-hour standard of 0.14 ppm.

3.6.1 Long-term SO_2 Trends: 1982-91

The long-term trend in ambient SO_2, 1982 through 1991, is graphically presented in Figures 3-33 through 3-35. In each figure, the trend at the NAMS is contrasted with the trend at all sites. For each of the statistics presented, a 10-year downward trend is evident, although the rate of decline has slowed over the last 3 years. Nationally, the annual mean SO_2, examined at 479 sites, decreased at a median rate of approximately 2 percent per year; this resulted in an overall change of about 20 percent (Figure 3-33). The

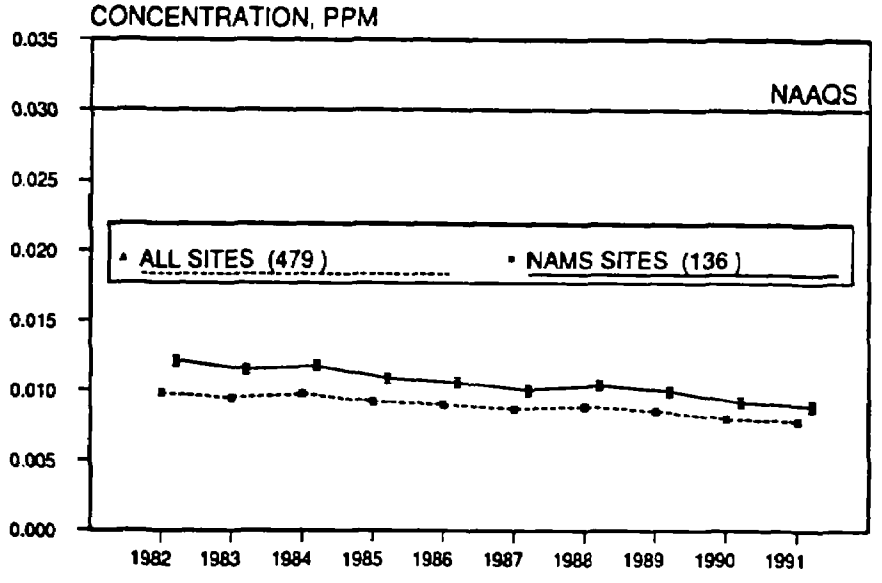


Figure 3-33. National trend in annual average sulfur dioxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1982-1991.

subset of 136 NAMS recorded higher average concentrations but declined at a median rate of 3 percent per year, with a net change of 26 percent for the 10-year period.

The annual second highest 24-hour values displayed a similar improvement between 1982 and 1991. Nationally, among 479 stations with adequate trend data, the median rate of change was 3 percent per year, with an overall decline of 31 percent (Figure 3-34). The 137 NAMS exhibited an overall decrease of 33 percent. The estimated number of exceedances also showed declines for the NAMS as well as for the composite of all sites (Figure 3-35). The national composite estimated number of exceedances decreased 98 percent from 1982 to 1991. However, the vast majority of SO_2 sites do not show any exceedances of the 24-hour NAAQS. Most of the exceedances, as well as the bulk of the improvements, occurred at source-oriented sites.

The statistical significance of these long-term trends is graphically illustrated in Figures 3-33 to 3-35 with the 95 percent confidence intervals. These figures show that the 1991 composite average and composite second maximum 24-hour SO_2 levels are the lowest reported in EPA trends reports. The 1991 composite annual mean, and the composite 1991 peak values, are statistically lower than all previous years except for 1990.

The inter-site variability for annual mean and annual second highest 24-hour SO_2 concentrations is graphically displayed in Figures 3-36 and 3-37. These figures show that higher concentration sites decreased more rapidly and that the concentration range among sites has also diminished during the 1980's.

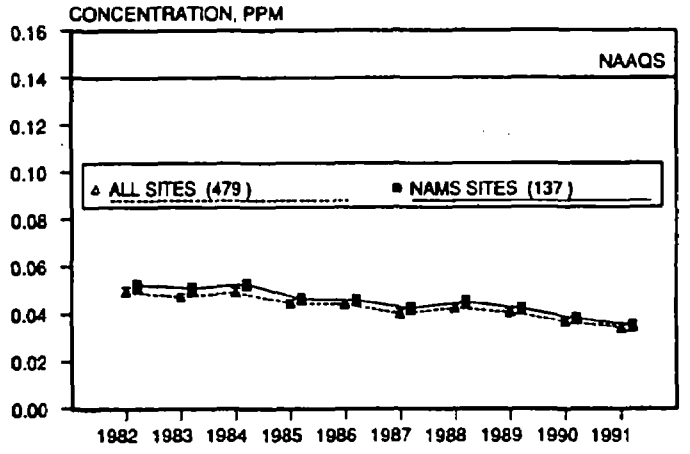


Figure 3-34. National trend in the second highest 24-hour sulfur dioxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1982-1991.

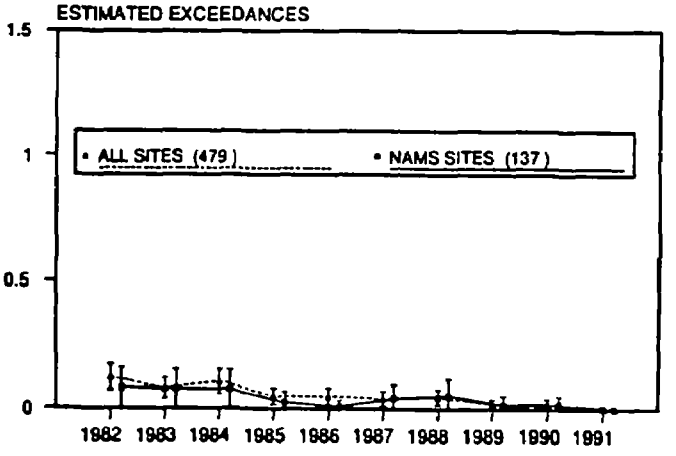


Figure 3-35. National trend in the estimated number of exceedances of the 24-hour sulfur dioxide NAAQS at both NAMS and all sites with 95 percent confidence intervals, 1982-1991.

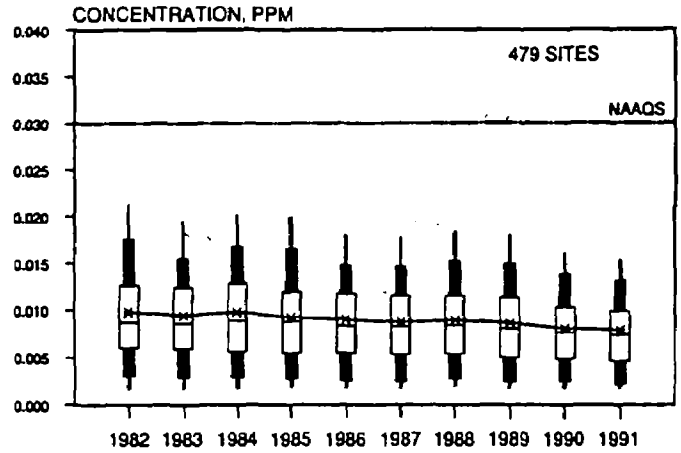


Figure 3-36. Boxplot comparisons of trends in annual mean sulfur dioxide concentrations at 479 sites, 1982-1991.

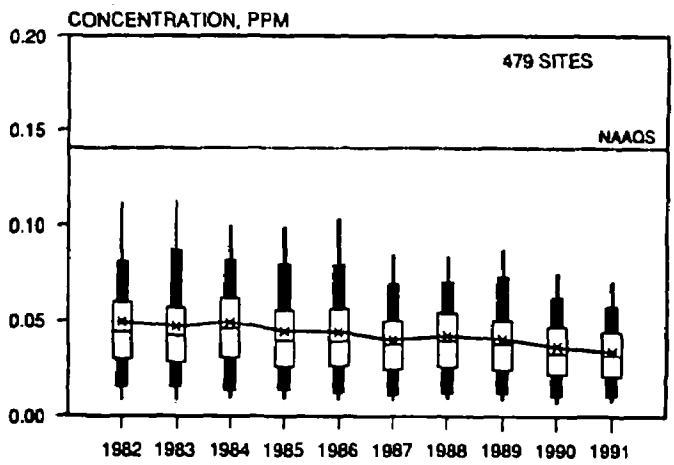


Figure 3-37. Boxplot comparisons of trends in second highest 24-hour average sulfur dioxide concentrations at 479 sites, 1982-1991.

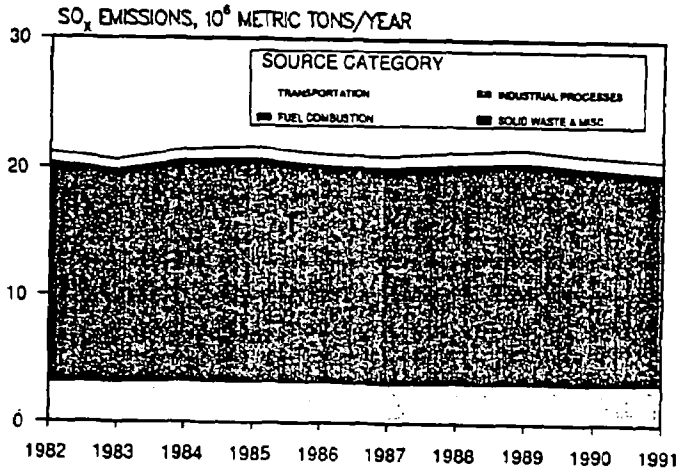


Figure 3-38. National trend in sulfur oxides emissions, 1982-1991.

TABLE 3-8. National Sulfur Oxides Emission Estimates, 1982-1991

(million metric tons/year)										
SOURCE CATEGORY	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Transportation	0.83	0.79	0.82	0.88	0.87	0.89	0.94	0.96	0.99	0.99
Fuel Combustion	17.27	16.69	17.41	17.58	17.09	17.04	17.25	17.42	16.98	16.55
Industrial Processes	3.08	3.11	3.20	3.17	3.16	3.01	3.08	3.10	3.05	3.16
Solid Waste Disposal	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Miscellaneous	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
TOTAL	21.21	20.62	21.47	21.67	21.15	20.97	21.30	21.51	21.05	20.73
NOTE: The sums of sub-categories may not equal total due to rounding.										

Nationally, sulfur oxides (SO_x) emissions decreased 2 percent from 1982 to 1991 (Figure 3-38 and Table 3-8). After experiencing a 25 percent decrease from 1970 - 1982, total emissions, and individual source category emissions, have remained relatively unchanged over the last decade.

Title IV of the Clean Air Act Amendments of 1990 addresses the control of pollutants associated with acid deposition and includes a goal of reducing sulfur oxide emissions by 10 million tons relative to 1980 levels. The focus in this control program is an innovative market-based emission allowance program which will provide affected sources flexibility in meeting the mandated emission reductions. This is the first large scale regulatory use of market-based incentives.

The first two acid rain emissions allowance trades under this program were recently completed in May 1992. The trades involved the Tennessee Valley Authority and Duquesne Light Company acquiring emissions allowances from the Wisconsin Power and Light Company. These and future emission trading actions, in combination with existing NAAQS requirements, can be expected to reduce acid deposition and lower costs of industry compliance with the Clean Air Act.

3.6.2 Recent SO_2 Trends: 1989-91

Nationally, SO_2 showed improvement over the last three years in both average and peak 24-hour concentrations. Composite annual mean concentrations consistently decreased for a total of 11 percent between 1989 and 1991. Over the last 2 years, the average annual mean SO_2 decrease was 5 percent. Composite 24-hour SO_2 concentrations declined 18 percent since 1989 and 9 percent since 1990.

Figure 3-39 presents the Regional changes in composite annual average SO_2 concentrations for the last 3 years, 1989-1991. All Regions except for Region II in which 1991 is unchanged from 1990 follow the national pattern of change in annual mean SO_2. However, Region II still shows a 3-year decline as both 1990 and 1991 are lower than 1989. Although not presented here in graphical format, every Region of the country reported 3-year declines in peak 24-hour SO_2 concentrations.

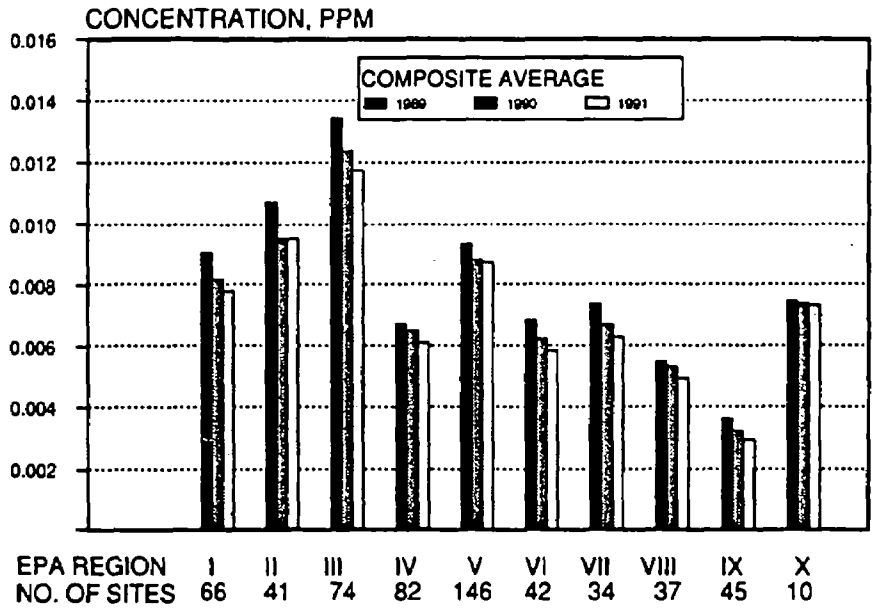


Figure 3-39. Regional comparisons of the 1989, 1990, 1991 composite averages of the annual average sulfur dioxide concentrations.

3.7 REFERENCES

1. National Air Pollutant Emission Estimates, 1900-1991, EPA-454/R-92-013, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, October 1992.

2. Rethinking the Ozone Problem in Urban and Regional Air Pollution, National Research Council, National Academy Press, Washington, DC, December 1991.

3. Curran, T.C., "Trends in Ambient Ozone and Precursor Emissions in U.S. Urban Areas", Atmospheric Ozone Research and Its Policy Implications, Amsterdam, The Netherlands, 1989.

4. Curran, T.C. and N.H. Frank, "Ambient Ozone Trends Using Alternative Indicators", Tropospheric Ozone and the Environment, Los Angeles, CA, March 1990.

5. National Air Quality and Emissions Trends Report, 1990, EPA-450/4-91-023, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, November 1991.

6. National Primary and Secondary Ambient Air Quality Standards for Lead, 43 FR 46246, October 5, 1978.

7. Memorandum. Joseph S. Carra to Office Directors Lead Committee. Final Agency Lead Strategy. February 26, 1991.

8. R. B. Faoro and T. B. McMullen, National Trends in Trace Metals Ambient Air, 1965-1974, EPA-450/1-77-003, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1977.

9. W. Hunt, "Experimental Design in Air Quality Management," Andrews Memorial Technical Supplement, American Society for Quality Control, Milwaukee, WI, 1984.

10. Ambient Air Quality Surveillance, 46 FR 44159, September 3, 1981.

11. National Air Quality and Emissions Trends Report, 1989, EPA-450/4-91-003, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1991.

12. T. Furmanczyk, Environment Canada, personal communication to R. Faoro, U.S. Environmental Protection Agency, September 9, 1992.

13. Hazardous Air Pollutants Project Country Report of Japan, Organization For Economic Co-operation and Development, Paris, France, March, 1991.

14. 40CFR Part 58, Appendix D.

15. D.J. Kolaz and R.L. Swinford, "How to Remove the Influence of Meteorology from the Chicago Areas Ozone Trend," presented at the 83rd Annual AWMA Meeting, Pittsburgh, PA, June 1990.

16. Use of Meteorological Data in Air Quality Trend Analysis, EPA-450/3-78-024, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, May 1978.

17. National Air Quality and Emissions Trends Report, 1988, EPA-450/4-90-002, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, March 1990.

18. R. H. Heim, Jr., "United States Summer Climate in Historical Perspective", National Climatic Data Center, NOAA, Asheville, NC, August 1991.

19. Volatility Regulations for Gasoline and Alcohol Blends Sold in Calendar Years 1989 and Beyond, 54 FR 11868, March 22, 1989.

20. National Fuel Survey: Motor Gasoline - Summer 1988, Motor Vehicle Manufacturers Association, Washington, D.C., 1988.

21. National Fuel Survey: Gasoline and Diesel Fuel - Summer 1989, Motor Vehicle Manufacturers Association, Washington, D.C., 1989.

22. National Fuel Survey: Motor Gasoline - Summer 1990, Motor Vehicle Manufacturers Association, Washington, D.C., 1990.

23. EHPA NEWSLETTER, Vol. 9, No. 3, E.H. Pechan & Associates, Inc., Springfield, VA, Summer 1992.

4. AIR QUALITY STATUS OF METROPOLITAN AREAS, 1991

This chapter provides general information on the current air quality status of metropolitan areas[1] within the United States. Four different summaries are presented in the following sections. First, the current status of the number of areas designated nonattainment for the National Ambient Air Quality Standards (NAAQS) for carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM-10), and sulfur dioxide (SO_2) is given. Next, an estimate is provided of the number of people living in counties which did not meet the NAAQS based on only 1991 air quality data. (Note that nonattainment designations typically involve multi-year periods.) Third, pollutant-specific maps are presented to provide the reader with a geographical view of how peak 1991 air quality levels varied throughout the 90 largest Metropolitan Statistical Areas (MSAs) in the continental United States. Finally, the peak pollutant-specific statistics are listed for each MSA with 1991 air quality monitoring data.

Table 4-1. Nonattainment Areas for NAAQS Pollutants as of August 1992

Pollutant	Number of Nonattainment Areas*
Carbon Monoxide (CO)	42
Lead (Pb)	12
Nitrogen Dioxide (NO_2)	1
Ozone (O_3)	97
Particulate Matter (PM-10)	70
Sulfur Dioxide (SO_2)	50

* Unclassified areas are not included in the totals.

4.1 Nonattainment Areas

Last year's report presented maps of the nonattainment areas for each of the six NAAQS pollutants, except nitrogen dioxide. Because Los Angeles, CA is the only area currently not meeting the NO_2 standard, a map was not presented for this pollutant. The nonattainment designation is the result of a formal rulemaking process but, for the purposes of this section, may be viewed as simply indicating those areas which do not meet the air quality standard for a particular criteria pollutant. The Clean Air Act Amendments (CAAA) of 1990 further classify ozone and carbon monoxide nonattainment areas based upon the magnitude of the problem. Depending on its particular nonattainment classification, an area must adopt, at a minimum, certain air pollution reduction measures. The classification of an area also determines when the area must reach attainment. The technical details underlying these classifications are discussed elsewhere.[2]

The Clean Air Act Amendments (CAAA) of 1990 designated 12 transitional ozone areas that were required to attain the NAAQS by December 31, 1991. All twelve transitional areas successfully met the NAAQS as determined from ozone air quality data for the years 1989-91[3]. However, in order to be redesignated to attainment, transitional areas must meet the redesignation requirements prescribed in the CAAA of 1990.

Since the initial nonattainment area designations under the 1990 Clean Air Act Amendments, one area, Kansas City, has been redesignated to attainment for ozone[4] and one area, Brown County, Wisconsin, was redesignated to attainment for SO_2.[5] Table 4-1 displays the number of nonattainment areas for each pollutant as of August 1992.

4.2 Population Estimates For Counties Not Meeting NAAQS, 1991

Figure 4-1 provides an estimate of the number of people living in counties in which the levels of the pollutant-specific primary health NAAQS were not met by measured air quality in 1991. These estimates use a single-year interpretation of the NAAQS to indicate the current extent of the problem for each pollutant. Selected air quality statistics and their associated NAAQS were listed in Table 2-1. Figure 4-1 clearly demonstrates that O_3 was the most pervasive air pollution problem in 1991 for the United States with an estimated 69.7 million people living in counties which did not meet the O_3 standard. This estimate is slightly higher than last year's estimate for 1990 of 62.9 million people. However, the population estimates for the past 3 years are substantially lower than the 112 million people living in areas which did not meet the ozone NAAQS in 1988. This large decrease is likely due in part to meteorological conditions in 1988 being more conducive to ozone formation than recent years (recall the hot, dry summer in the eastern U.S.), and to new and ongoing emission control programs. Between 1988 and 1989, implementation of gasoline volatility regulations lowered the average Reid Vapor Pressure (RVP) of regular unleaded gasoline from 10.0 to 8.9 pounds per square inch (psi). RVP was reduced an additional 3 percent between 1989 and 1990.

PM-10 follows with 21.5 million people; CO with 19.9 million people; Pb with 14.7 million people; NO_2 with 8.9 million people and SO_2 with 5.2 million people. The higher population numbers for lead reflect the impact of data from additional Pb monitoring in the vicinity of lead sources. As noted earlier, there is an increased emphasis in characterizing the impact of lead point sources. A total of 86 million persons resided in counties not meeting at least one air quality standard during 1991 (out of a total 1990 population of 249 million). This is the first annual report to use the 1990 Census county population estimates, which are two percent

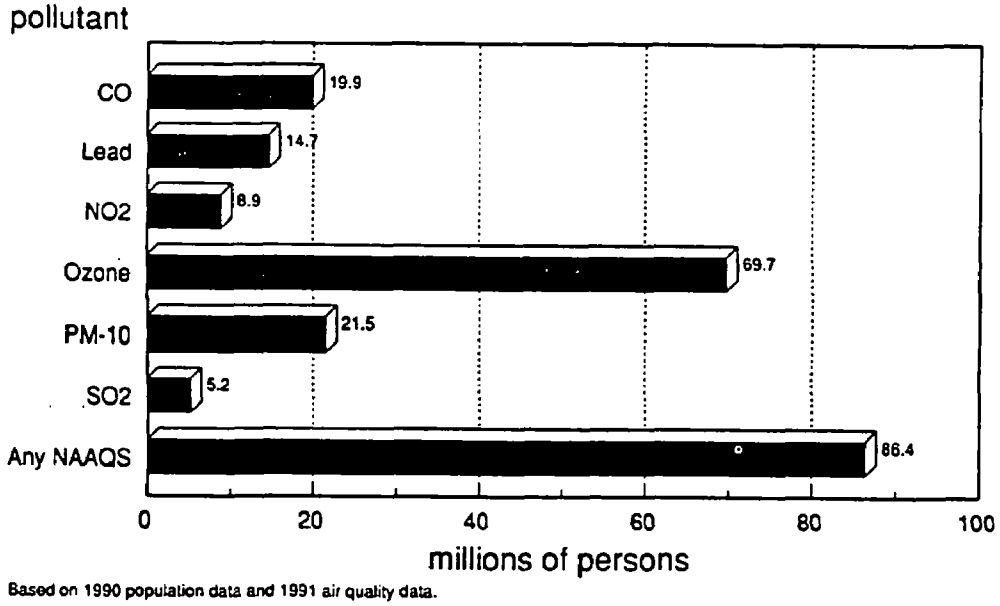


Figure 4-1. Number of persons living in counties with air quality levels above the primary national ambient air quality standards in 1991 (based on 1990 population data).

higher nationwide than the 1987 population estimates used in last year's report.

These population estimates are intended to provide a relative measure of the extent of the problem for each pollutant. The limitations of this indicator should be recognized. An individual living in a county that violates an air quality standard may not actually be exposed to unhealthy air. For example, if CO violations were confined to a traffic-congested center city location during evening rush hours in the winter, it is possible that an individual may never be in that area, or may be there only at other times of the day or during other seasons. The lead monitors typically reflect the impact of lead sources in the immediate vicinity of the monitoring location, and may not be representative of county-wide air quality. However, it is worth noting that ozone, which appears to be the most pervasive pollution problem by this measure, is also the pollutant most likely to have fairly uniform concentrations throughout an area.

The assumptions and methodology used in any population estimate can, in some cases, yield a wide swing in the estimate. For example, while there are an estimated 70 million people living in counties that had 1991 ozone data not meeting the ozone NAAQS, there are an estimated 140 million people living in EPA designated ozone nonattainment areas, based on air quality data from the years 1987-89. Although these numbers are properly qualified, with such a large difference, it is important to highlight some of the factors involved in these estimates. The estimate of 70 million people only considers data from the single year, 1991 and only considers counties with ozone monitoring data. In contrast, designated ozone nonattainment areas are typically based upon three years of data to ensure a broader representation of possible meteorological conditions. This use of multiple years of data, rather than a single year, is based on the procedure for determining compliance with the ozone NAAQS.

Another difference is that the estimate of 70 million people living in counties with air quality levels not meeting the ozone NAAQS only considers counties that had ozone monitoring data for 1991. As shown in Table 2-2, there were only 835 ozone monitors reporting in 1991. These monitors were located in 500 counties, which clearly falls far short of the more than 3100 counties in the U.S. This shortfall is not as bad as it may initially appear because it is often possible to take advantage of other air quality considerations in interpreting the monitoring data. This, in fact, is why other factors are considered in determining nonattainment areas. Ozone tends to be an area-wide problem with fairly similar levels occurring across broad regions. Because ozone is not simply a localized hot-spot problem, effective ozone control strategies have to incorporate a broad view of the problem. Nonattainment boundaries may consider other air quality related information, such as emission inventories and modeling, and may extend beyond those counties with monitoring data to more fully characterize the ozone problem and to facilitate the development of an adequate control strategy.

Since the early 1970's, there has been a growing awareness that ozone and ozone precursors are transported beyond the political jurisdiction of source areas and affect air quality levels at considerable distances downwind. The transport of ozone concentrations generated from urban manmade emissions of precursors in numerous areas to locations further downwind can result in rather widespread areas of elevated levels of ozone across regional spatial scales.

4.3 Maximum Daily Carbon Monoxide and Ozone Concentrations (1982-91)

This section introduces a new graphical technique which shows the variation in daily maximum 8-hour CO and daily maximum 1-hour O_3 concentrations in three large urban areas for the 1982-91 time period. Every day in this period, approximately a total of 3650 days, is shown as a colored block based on the daily maximum CO or O_3 concentrations recorded at the network of monitors in three Consolidated Metropolitan Statistical Areas (CMSAs): Houston, TX; Los Angeles, CA; and New York, NY. Each of these urban areas are currently non-attainment for O_3, with Los Angeles and New York also being in non-attainment status for CO. The CO plot in Houston is not shown here because Houston is currently attainment for CO and has not recorded any exceedances of the CO NAAQS since 1986. The principal advantage of this new approach is that weekday and seasonal patterns, and annual trends in daily maximum CO and O_3 levels are presented on a single plot. The mosaic of the colored blocks will enable the reader to form a visual impression of differences in CO and O_3 concentrations during the 10-year period and among the urban areas studied. The concentration ranges correspond to the Pollutant Standards Index (PSI) which is discussed in Chapter 5.

To obtain a consistent data base for trend purposes, only those CO and O_3 monitoring sites which satisfied the annual data completeness criteria as described in Chapter 2 of this report (i.e., a minimum of 8 out of the 10 years (1982-91) were included in these displays. In Houston, Los Angeles and New York, there were respectively, 9, 39, and 17 O_3 sites which met this criteria. For CO there were 22 and 11 sites respectively, in Los Angeles and New York. The CO and O_3 concentration displayed for each day represents the highest 8-hour average for CO and the highest hourly O_3 concentration measured at any of the sites satisfying the trend criteria within the CMSA. Tables 4-2 and 4-3 show the colors and their associated O_3 and CO concentration ranges. The yellow and orange categories represent days when either CO or O_3 levels were above their NAAQS of 9 ppm for CO or 0.12 ppm for O_3. Conversely, days in the lowest categories (either blue or green) represent days below the NAAQS.

The annual matrices of the color blocks displaying daily maximum 1-hour O_3 levels are shown in Figures 4-2, 4-3, and 4-4 respectively for Houston, Los Angeles, and New York. The CO plots for Los Angeles and New York are shown in Figures 4-5 and 4-6. All days in the year are plotted by the day of week and the week and month of occurrence. Each matrix is read first from the top (Sunday) to bottom (Saturday) and then from left to right across the weeks and months of the year. For example, New Years day is the first block in the left most column, while December 31st is the last block shown for the last week of the year.

4.3.1 Variation in Daily Maximum Ozone

The days in the lowest O_3 category (blue) are mostly clustered at the beginning and end of

Table 4-2. Colors and Associated Ozone Concentration Ranges

COLOR	OZONE CONCENTRATION RANGE	POLLUTANT STANDARDS INDEX CATEGORY
Blue	0.000 to 0.064 PPM	GOOD
Green	0.065 to 0.124 PPM	MODERATE
Yellow	0.125 to 0.204 PPM	UNHEALTHFUL
Orange	0.205 to 0.400 PPM	VERY UNHEALTHFUL

the year as expected; while, days above the NAAQS, represented by yellow or orange, occur generally during the summer months. The highest O_3 category represented in these plots is 0.205 to 0.400 ppm shown in orange. The orange and yellow blocks represent days above the O_3 NAAQS. It is strikingly apparent that the frequency of days above the O_3 NAAQS are far greater in Los Angeles than in the other two cities. Particularly, in Los Angeles and in New York, there appears to be a shift from colors in the higher O_3 categories to colors in the lower categories over the course of the 10-year period. This can be clearly seen in Los Angeles with more orange showing up in the first half (1982-86) of the period than in the latter half. In Houston and New York the frequency of yellow blocks diminishes over this time period as well. Also, in Los Angeles there are far less extended episodes of consecutive days in the orange category in the most recent years. In 1983 and 1984, there were episodes of 25 and 21 consecutive days in the orange category as compared with only 3 and 5 days respectively in 1990 and 1991. In Los Angeles it appears that there are more days in the green category during the summer months (June-September) i.e. below the O_3 NAAQS in 1990 and 1991. In Houston and New York the frequency of days above the O_3 NAAQS is less in the last 3 years (1989-91) than in the first several years. For example, in New York in the last 3 years there were a total of only 2 days that fell in the orange category as compared with 22 of these days in the first 3 years of the period. The O_3 levels in Chapter 5 of this report are shown to be decreasing in these 3 cities which confirms the visual interpretation of these plots presented here.

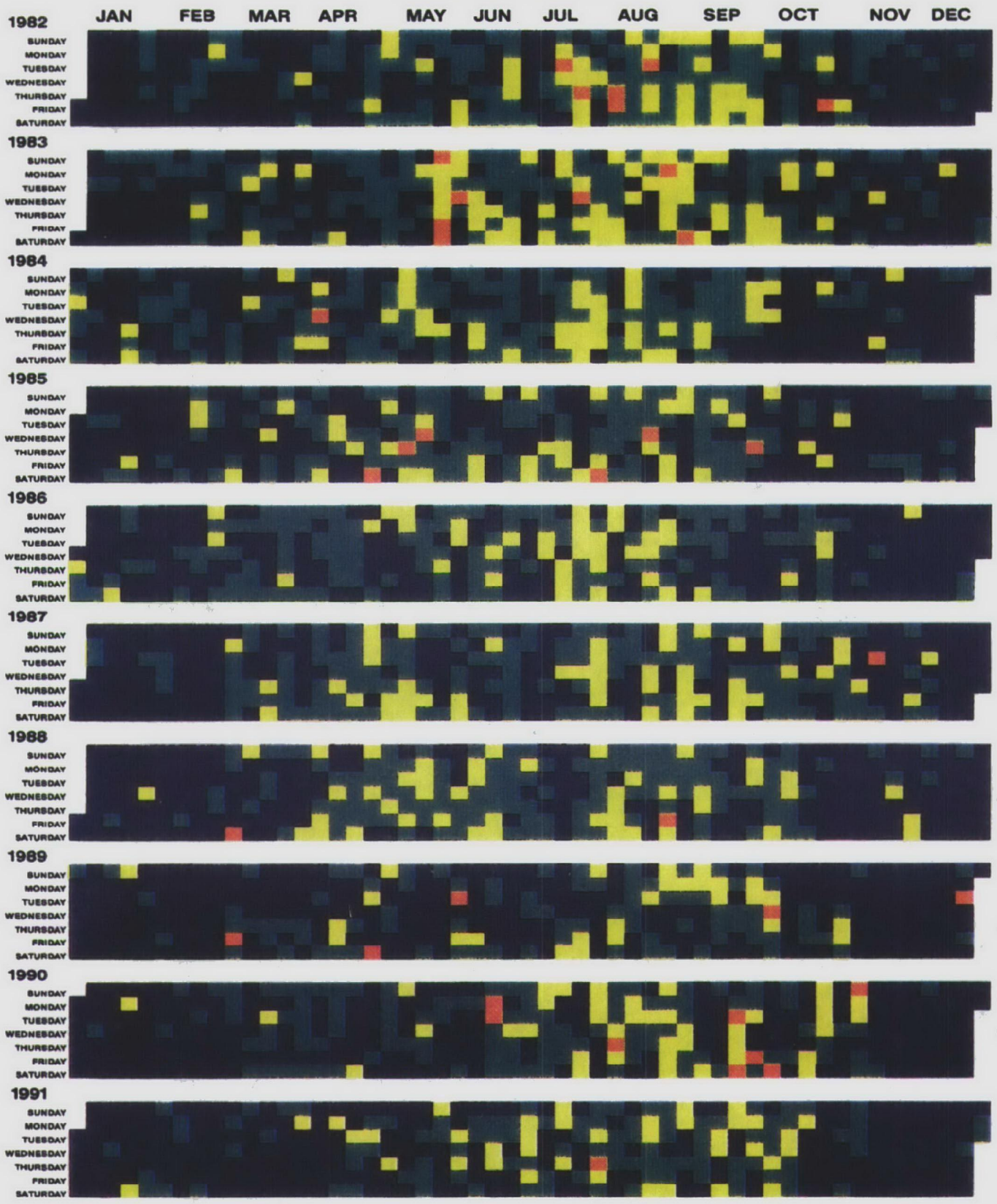
4.3.2 Variation in Daily Maximum CO

In Los Angeles, there does not appear to be evidence of a change in the frequency of days above the NAAQS (yellow and orange colors) over the 10-year period; whereas, in New York the frequency of these days has fallen dramatically over this time period. In New York, the number of days above the NAAQS fell from an annual peak of 128 in 1984 to a low of 4 in 1991. Also, in New York the frequency of days in the blue category is much higher in more recent years. Another interesting difference between CO levels in these areas is that CO levels above the NAAQS occur in Los Angeles exclusively during fall and winter months; while, in New York occurrences of these days are spread out throughout the entire year.

Table 4-3. Colors and Associated CO Concentration Ranges

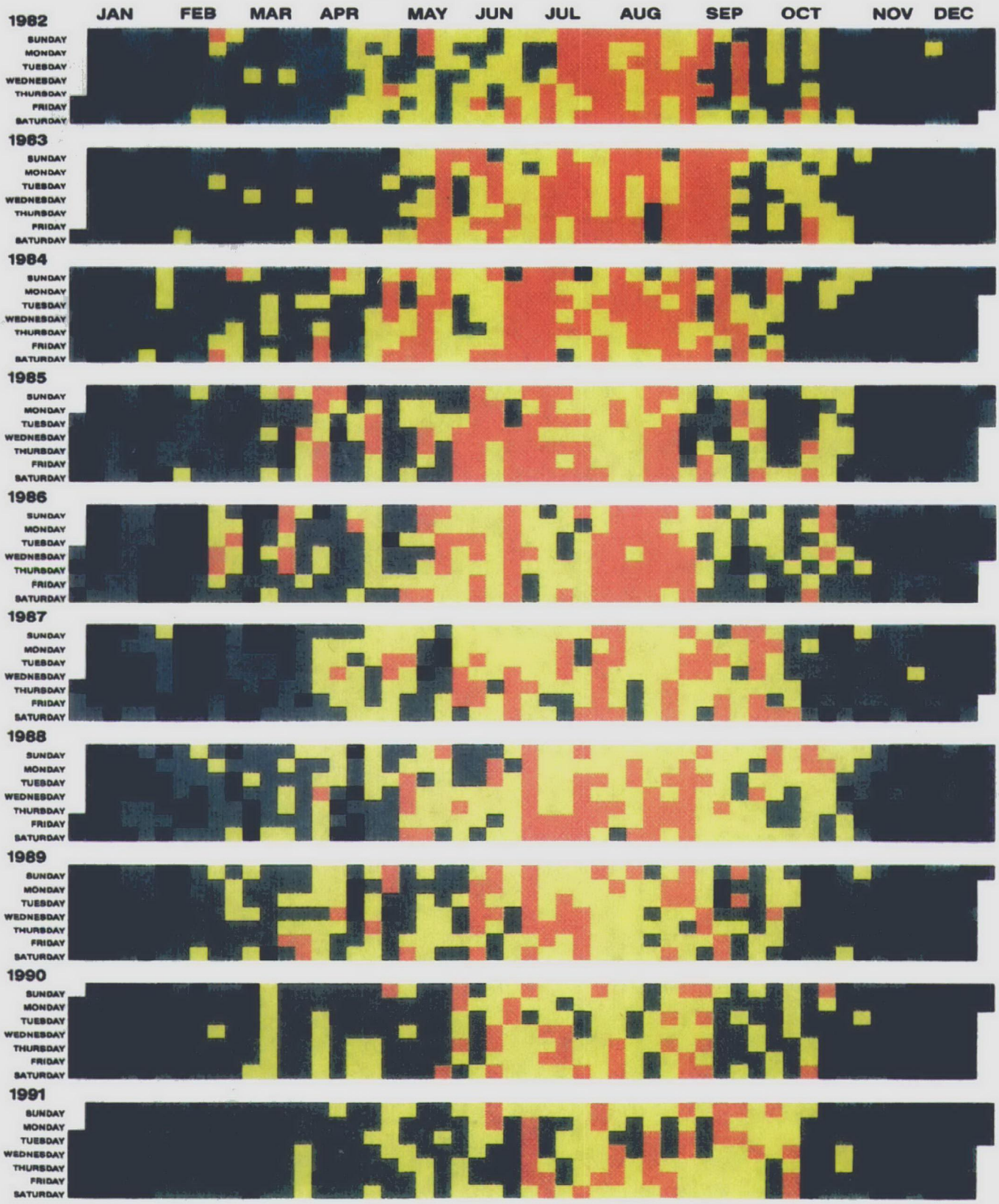
COLOR	CO CONCENTRATION RANGE	POLLUTANT STANDARDS INDEX CATEGORY
Blue	0.0 to 4.5 PPM	GOOD
Green	4.6 to 9.0 PPM	MODERATE
Yellow	9.1 to 15.0 PPM	UNHEALTHFUL
Orange	15.1 to 30.0 PPM	VERY UNHEALTHFUL

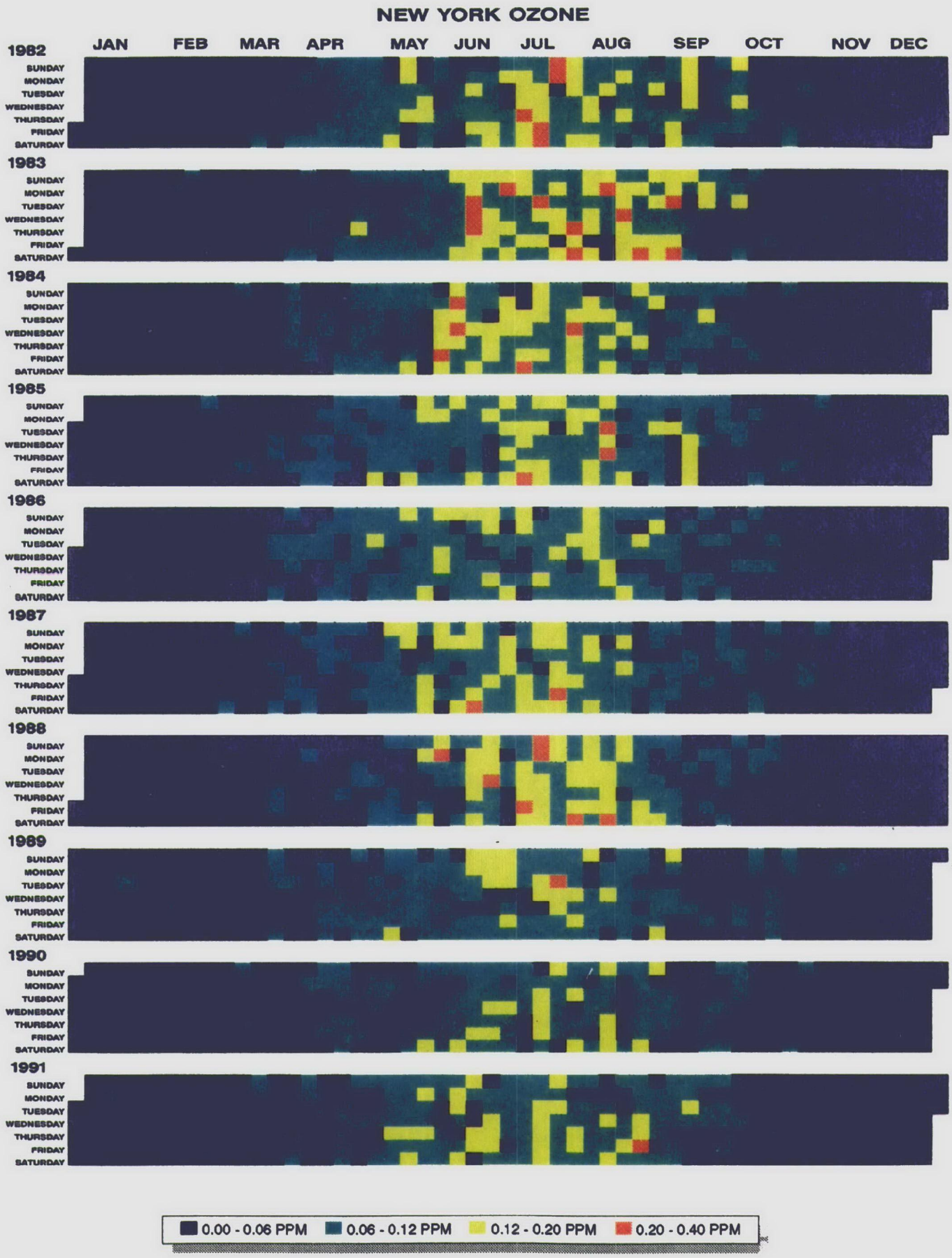
HOUSTON OZONE



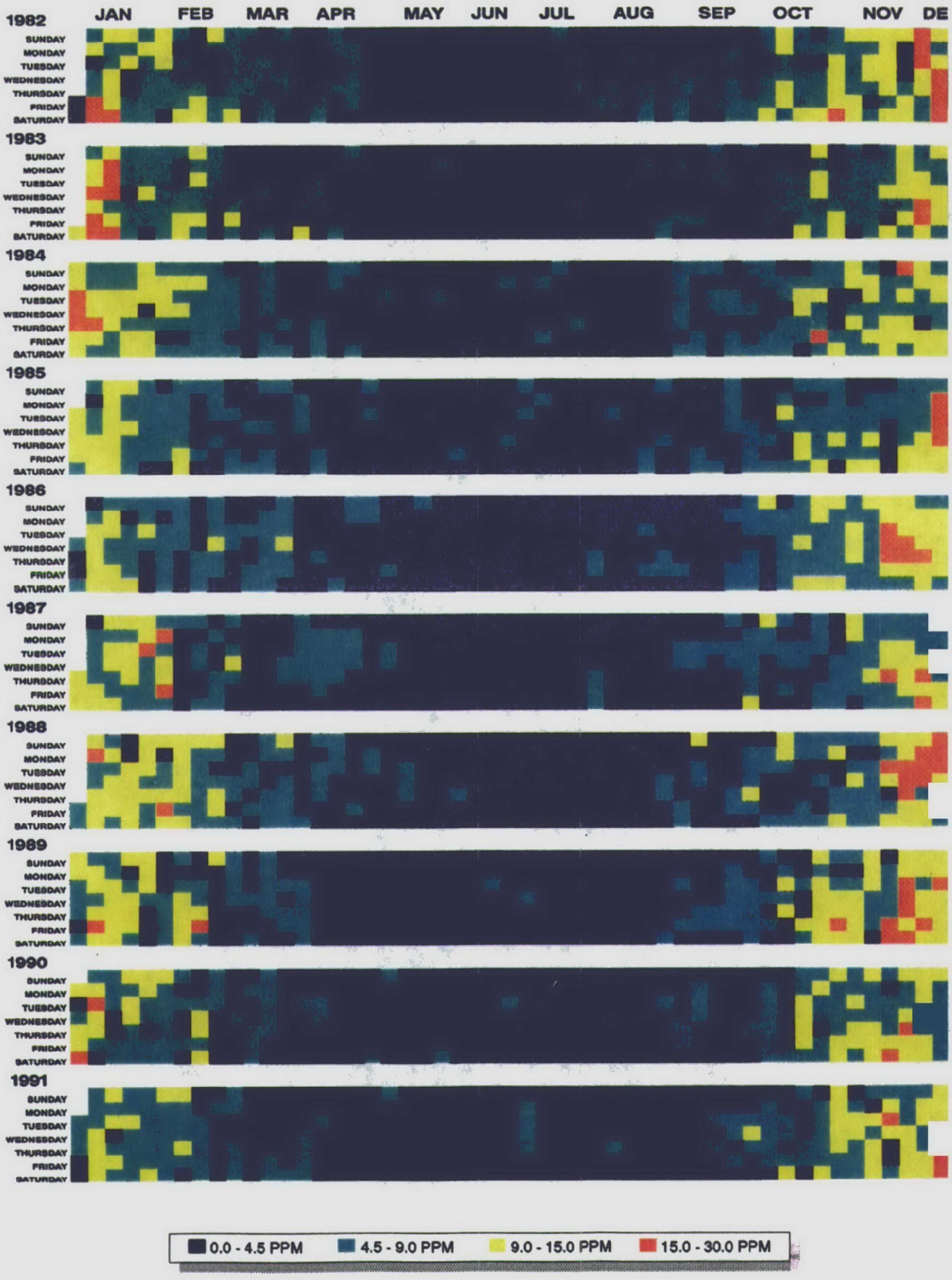
0.00 - 0.06 PPM 0.06 - 0.12 PPM 0.12 - 0.20 PPM 0.20 - 0.40 PPM

LOS ANGELES OZONE

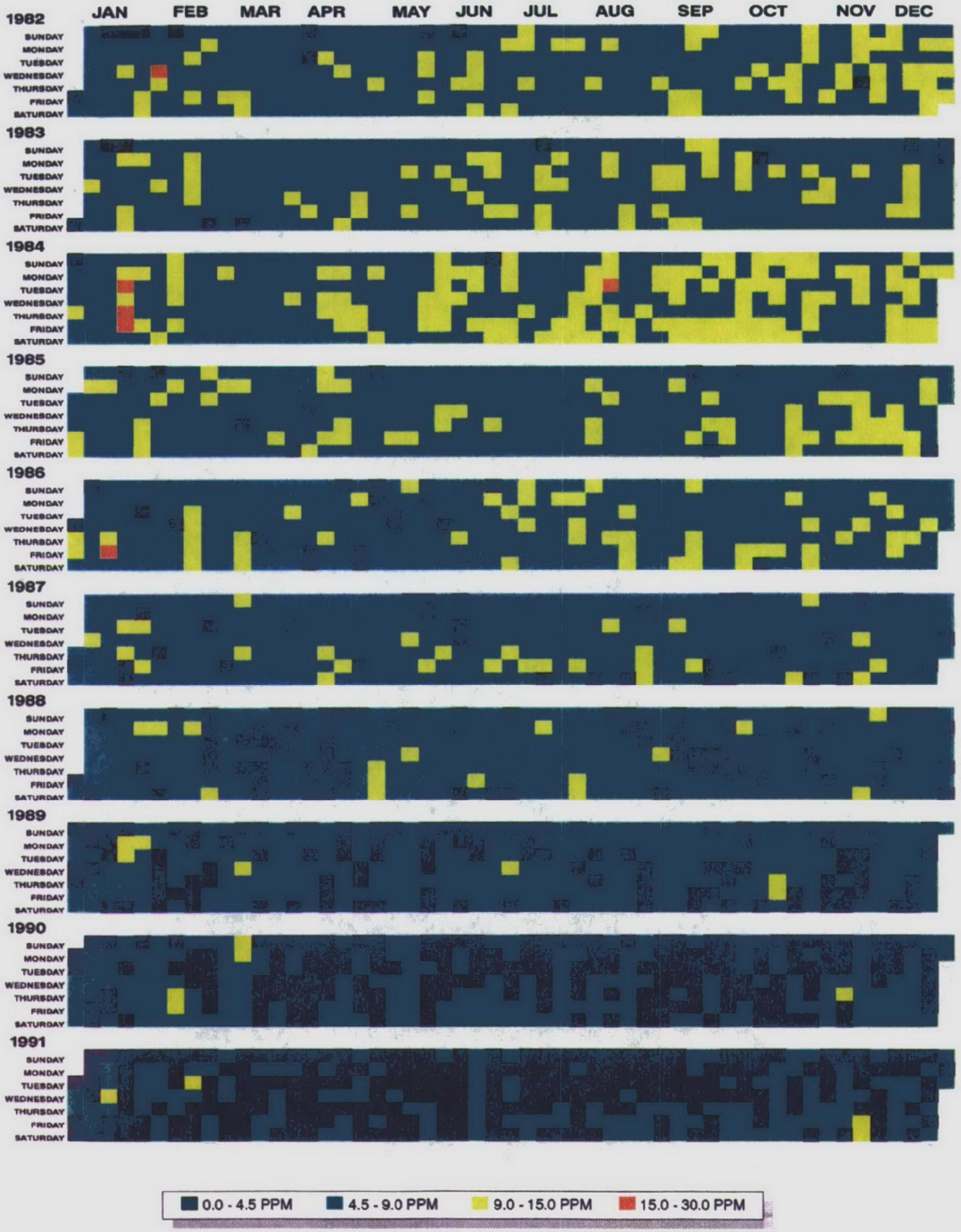



NEW YORK OZONE
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
SUNDAY
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
0.00 - 0.06 PPM
0.06 - 0.12 PPM
0.12 - 0.20 PPM
0.20 - 0.40 PPM

LOS ANGELES CARBON MONOXIDE



NEW YORK CARBON MONOXIDE



4.4 Air Quality Levels in Metropolitan Statistical Areas

This section provides information on 1991 air quality levels in each Metropolitan Statistical Area (MSA) in the United States for general air pollution audiences. For those large MSAs with populations greater than 500,000, the 1991 annual air quality statistics are also displayed geographically on three-dimensional maps.

The general concept of a metropolitan area is one of a large population center, with adjacent communities which have a high degree of economic and social integration with the urban center. Metropolitan Statistical Areas contain a central county(ies), and any adjacent counties with at least 50 percent of their population in the urbanized area.[1] Although MSAs compose only 16 percent of the land area in the U.S., they account for 78 percent of the total population of 249 million. Table 4-4 displays the population distribution of the 341 MSAs, based on 1990 population estimates.[1] The Los Angeles, CA MSA is the nation's largest metropolitan area with a 1990 population of almost 9 million. The smallest MSA is Enid, OK with a population of 57,000.

4.4.1 Metropolitan Statistical Area Air Quality Maps, 1991

Figures 4-7 through 4-13 introduce air quality maps of the United States that show at a glance how air quality varies among the largest MSAs within the contiguous United States. To enable the reader to distinguish individual urban areas, only the 90 MSAs within the continental U.S. having populations greater than 500,000 are shown. Two large MSAs, Honolulu, HI and San Juan, PR are not shown. San Juan is nonattainment for PM-10, however, neither area has exceeded any of the NAAQS during 1991. In each map, a spike is plotted at the city location on the map surface. This represents the highest pollutant concentration recorded in 1991, corresponding to the appropriate air quality standard. Each spike is projected onto a back-drop for comparison with the level of the standard. The backdrop also provides an east-west profile of concentration variability throughout the country.

TABLE 4-4. Population Distribution of Metropolitan Statistical Areas Based on 1990 Population Estimates

POPULATION RANGE	NUMBER OF MSA'S	POPULATION
$\leq$ 100,000	27	2,280,000
100,000 < population $\leq$ 250,000	147	23,576,000
250,000 < population $\leq$ 500,000	75	26,327,000
500,000 < population $\leq$ 1,000,000	45	32,450,000
1,000,000 < population $\leq$ 2,000,000	26	36,761,000
population > 2,000,000	21	74,116,000
MSA TOTAL	341	195,510,000

4.4.2 Metropolitan Statistical Area Air Quality Summary, 1991

Table 4-5 presents a summary of 1991 air quality for each Metropolitan Statistical Area (MSA) in the United States. The air quality levels reported for each metropolitan area are the highest levels measured from all available sites within the MSA. The MSAs are listed alphabetically, with the 1990 population estimate and air quality statistics for each pollutant. Concentrations above the level of the respective NAAQS are shown in ***bold*** type.

In the case of O_3, the problem is pervasive, and the high values associated with the pollutant can reflect a large part of the MSA. However in many cases, peak ozone concentrations occur downwind of major urban areas, e.g., peak ozone levels attributed to the Chicago metropolitan area are recorded in and near Kenosha, Wisconsin. In contrast, high CO values generally are highly localized and reflect areas with heavy traffic. The scale of measurement for the pollutants - PM-10, SO_2 and NO_2 - falls somewhere in between. Finally, while Pb measurements generally reflect Pb concentrations near roadways in the MSA, if a monitor is located near a point source of lead emissions it can produce readings substantially higher. Such is the case in several MSAs. Pb monitors located near a point source are footnoted accordingly in Table 4-5.

The pollutant-specific statistics reported in this section are for a single year of data. For example, if an MSA has three ozone monitors in 1991 with second highest daily hourly maxima of 0.15 ppm, 0.14 ppm and 0.12 ppm, the highest of these, 0.15 ppm, would be reported for that MSA. The associated primary NAAQS concentrations for each pollutant are summarized in Table 2-1.

The same annual data completeness criteria used in the air quality trends data base for continuous data was used here for the calculation of annual means. (i.e., 50 percent of the required samples for SO_2 and NO_2). If some data have been collected at one or more sites, but none of these sites meet the annual data completeness criteria, then the reader will be advised that there are insufficient data to calculate the annual mean. With respect to the summary statistics on air quality levels with averaging times less than or equal to 24-hours, all sites are included, even if they do not meet the annual data completeness requirement.

For PM-10 and Pb, the arithmetic mean statistics are based on 24-hour measurements, which are typically obtained from a systematic sampling schedule. In contrast to the trends analyses in Section 3 which used a more relaxed indicator, only maximum quarterly average Pb concentrations meeting the AIRS validity criteria are displayed in Table 4-5.

This summary provides the reader with information on how air quality varied among the nation's metropolitan areas in 1991. The highest air quality levels measured in each MSA are summarized for each pollutant monitored in 1991. Individual MSAs are listed to provide more extensive spatial coverage for large metropolitan complexes.

The reader is cautioned that this summary is not adequate in itself to numerically rank MSAs according to their air quality. The monitoring data represent the quality of the air in the vicinity of the monitoring site but may not necessarily represent urban-wide air quality.

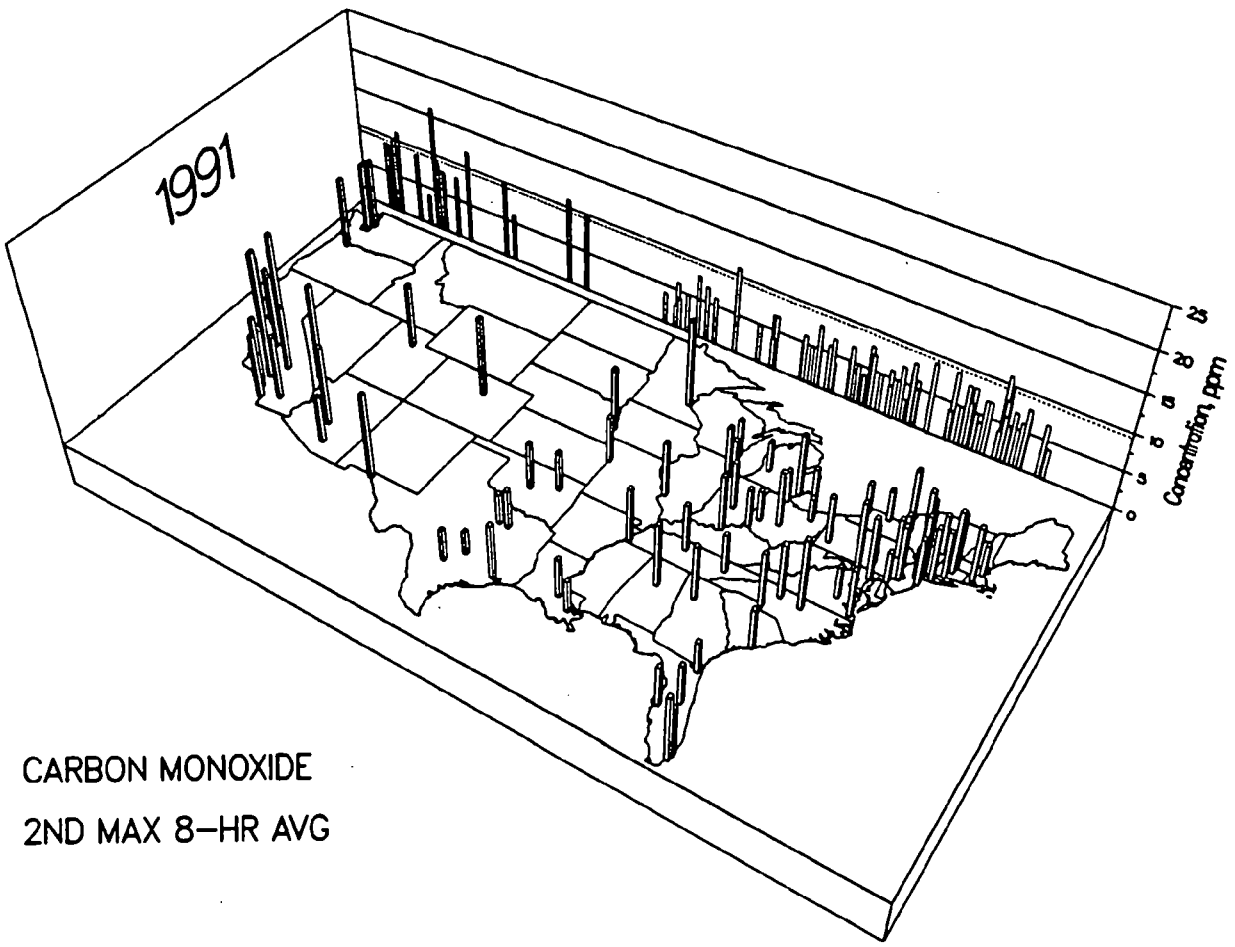


Figure 4-7. United States map of the highest second maximum nonoverlapping 8-hour average carbon monoxide concentration by MSA, 1991.

The map for carbon monoxide shows the highest second highest 8-hour value recorded in 1991. Ten of these urban areas have air quality exceeding the 9 ppm level of the standard. The highest concentration recorded in 1991 is found in Los Angeles, CA.

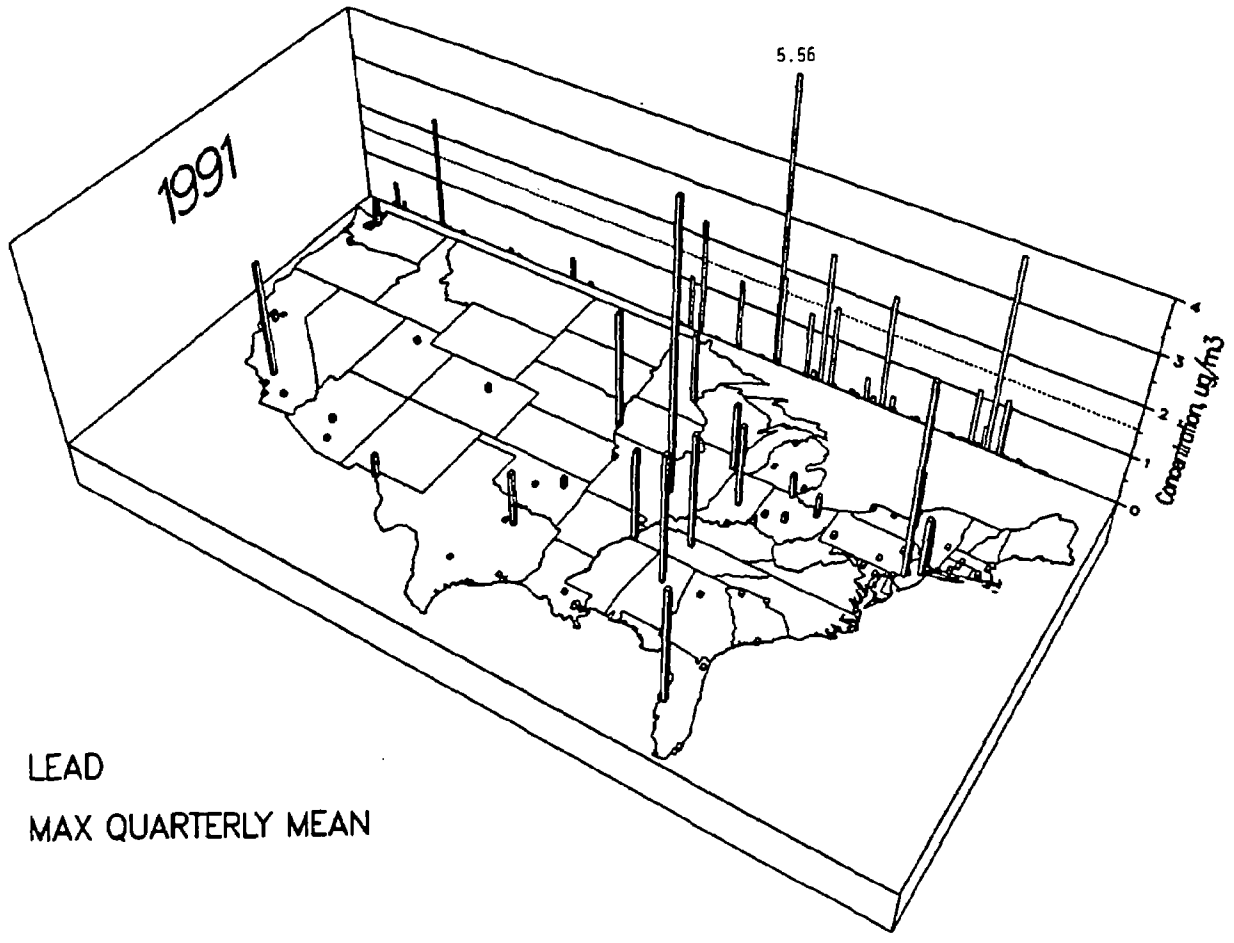


Figure 4-8. United States map of the highest maximum quarterly average lead concentration by MSA, 1991.

The map for Pb displays maximum quarterly average concentrations in the nation's largest metropolitan areas. Exceedances of the Pb NAAQS are found in nine areas in the vicinity of nonferrous smelters or other point sources of lead. Because of the switch to unleaded gasoline, areas primarily affected by automotive lead emissions show levels below the current standard of 1.5 $\mu g/m^3$.

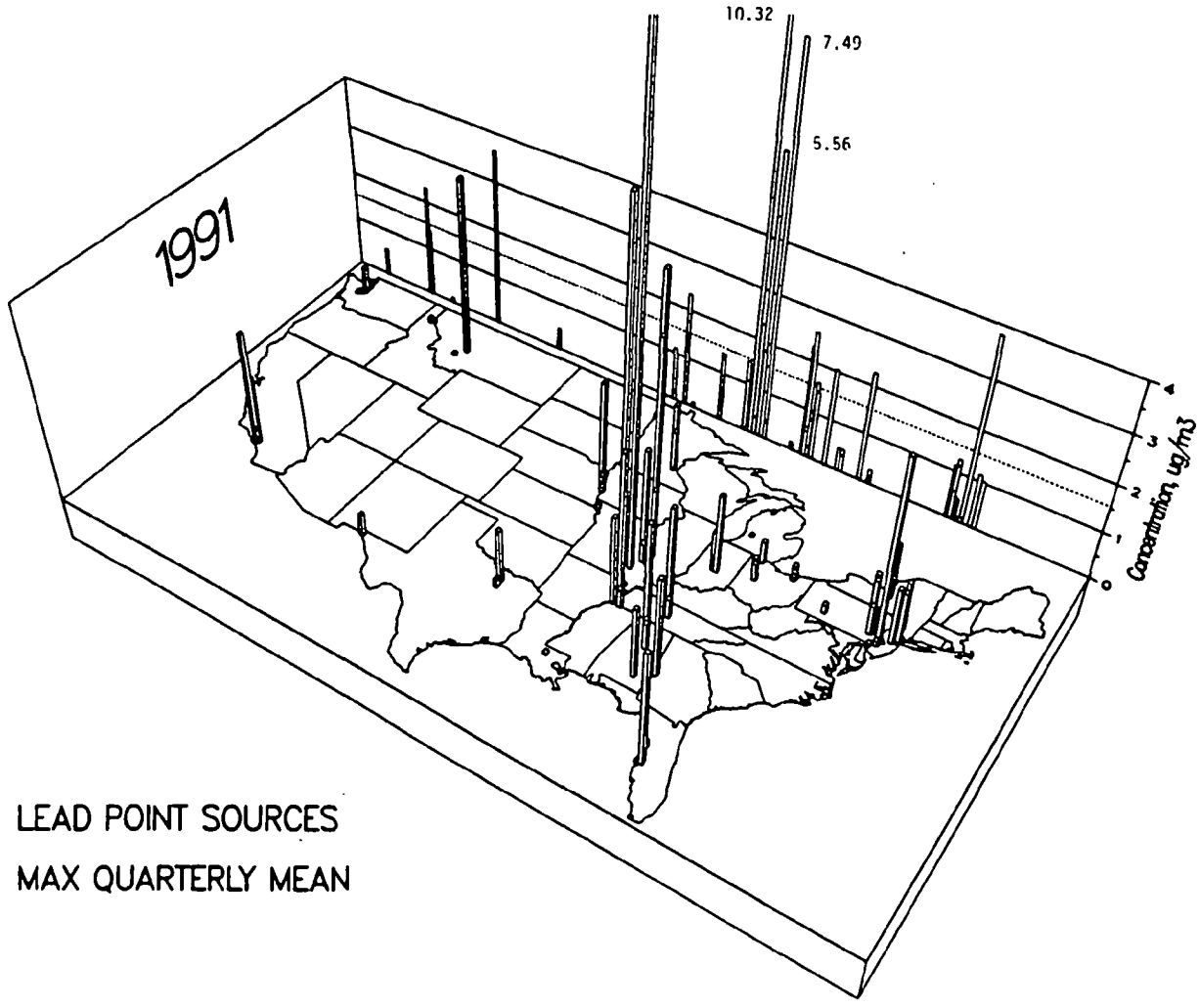


Figure 4-9. United States map of the maximum quarterly average lead concentration at source oriented sites, 1991.

EPA's current lead monitoring strategy is focused on the need to better characterize ambient lead levels near specific point sources. The map displays the maximum quarterly average Pb concentrations at 125 monitoring sites located in the vicinity of lead point sources. These concentrations are shown on the same scale as the previous map to highlight the difference in magnitude. The peak concentrations are found in Iron County, MO (10.32 $\mu g/m^3$); Fayette County, TN (7.49 $\mu g/m^3$) and Madison County, IL (5.56 $\mu g/m^3$). Twenty-four of these monitoring sites, located in 14 counties, did not meet the NAAQS in 1991.

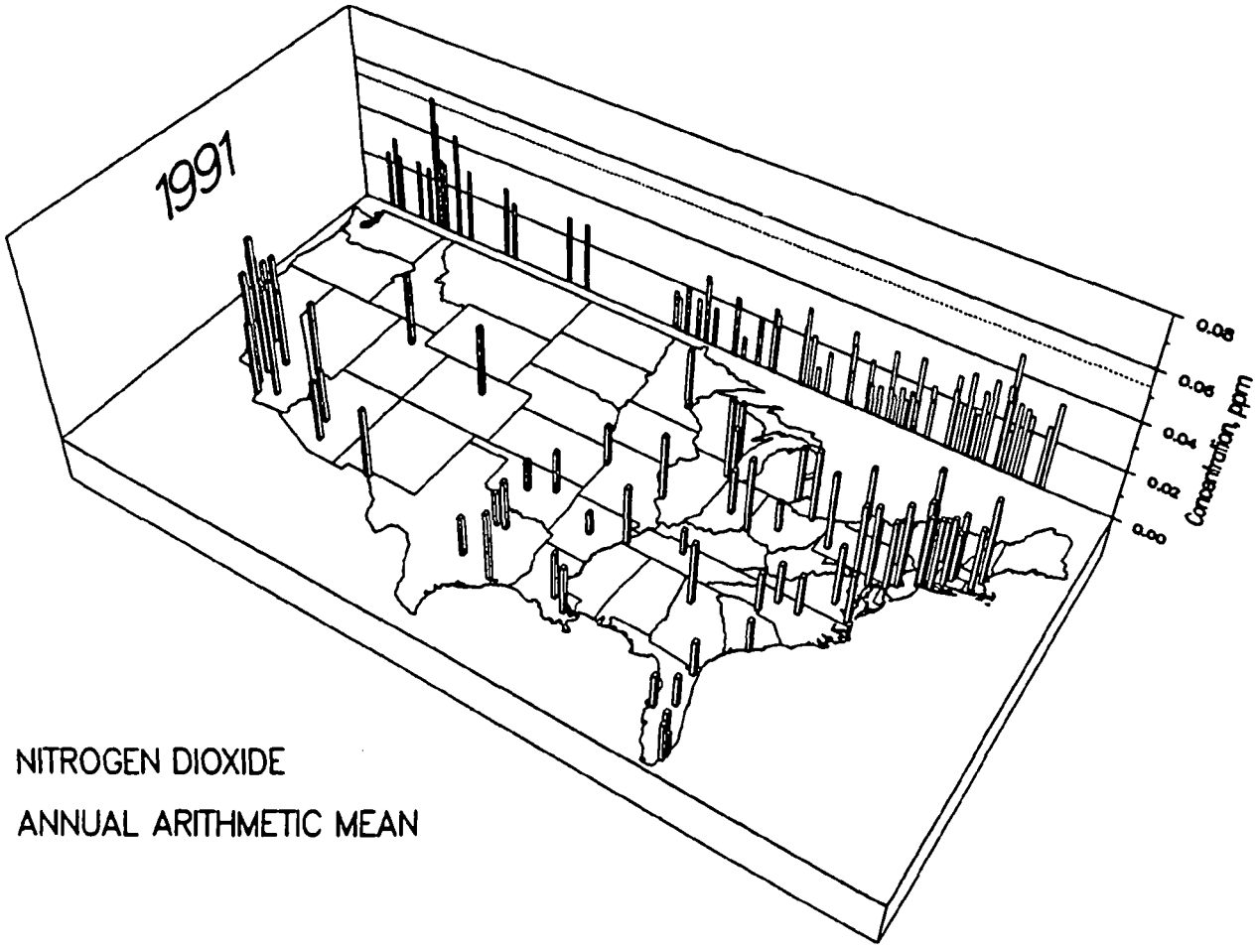


Figure 4-10. United States map of the highest annual arithmetic mean nitrogen dioxide concentration by MSA, 1991.

The map for nitrogen dioxide displays the maximum annual mean measured in the nation's largest metropolitan areas during 1991. Los Angeles, California, with an annual NO_2 mean of 0.055 ppm is the only area in the country exceeding the NO_2 air quality standard of 0.053 ppm.

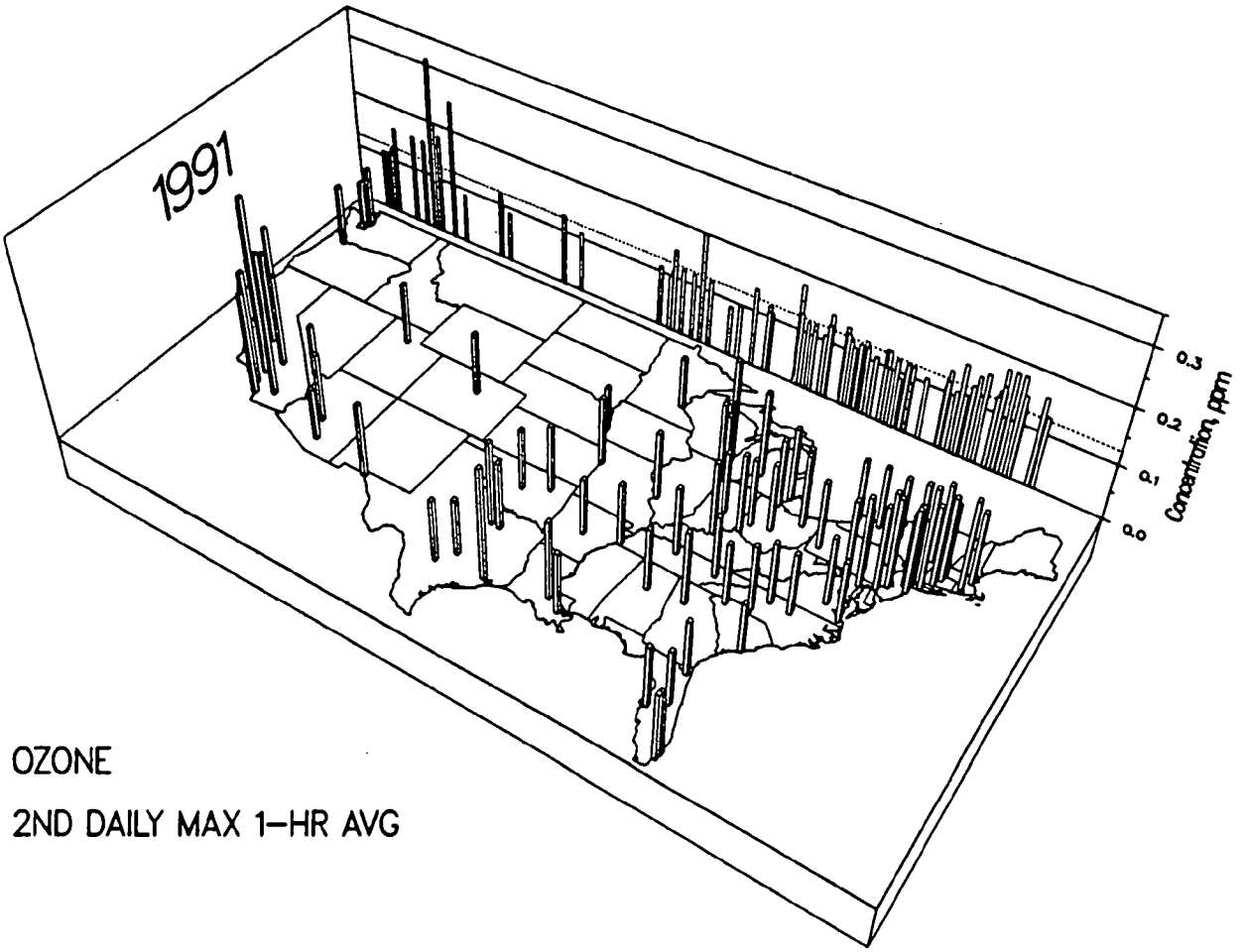


Figure 4-11. United States map of the highest second daily maximum 1-hour average ozone concentration by MSA, 1991.

The ozone map shows the second highest daily maximum 1-hour concentration in the 90 largest metropolitan areas in the Continental U.S. As shown, 38 of these areas did not meet the 0.12 ppm standard in 1991. The highest concentrations are observed in Southern California, but high levels also persist in the Texas Gulf Coast, Northeast Corridor and other heavily populated regions.

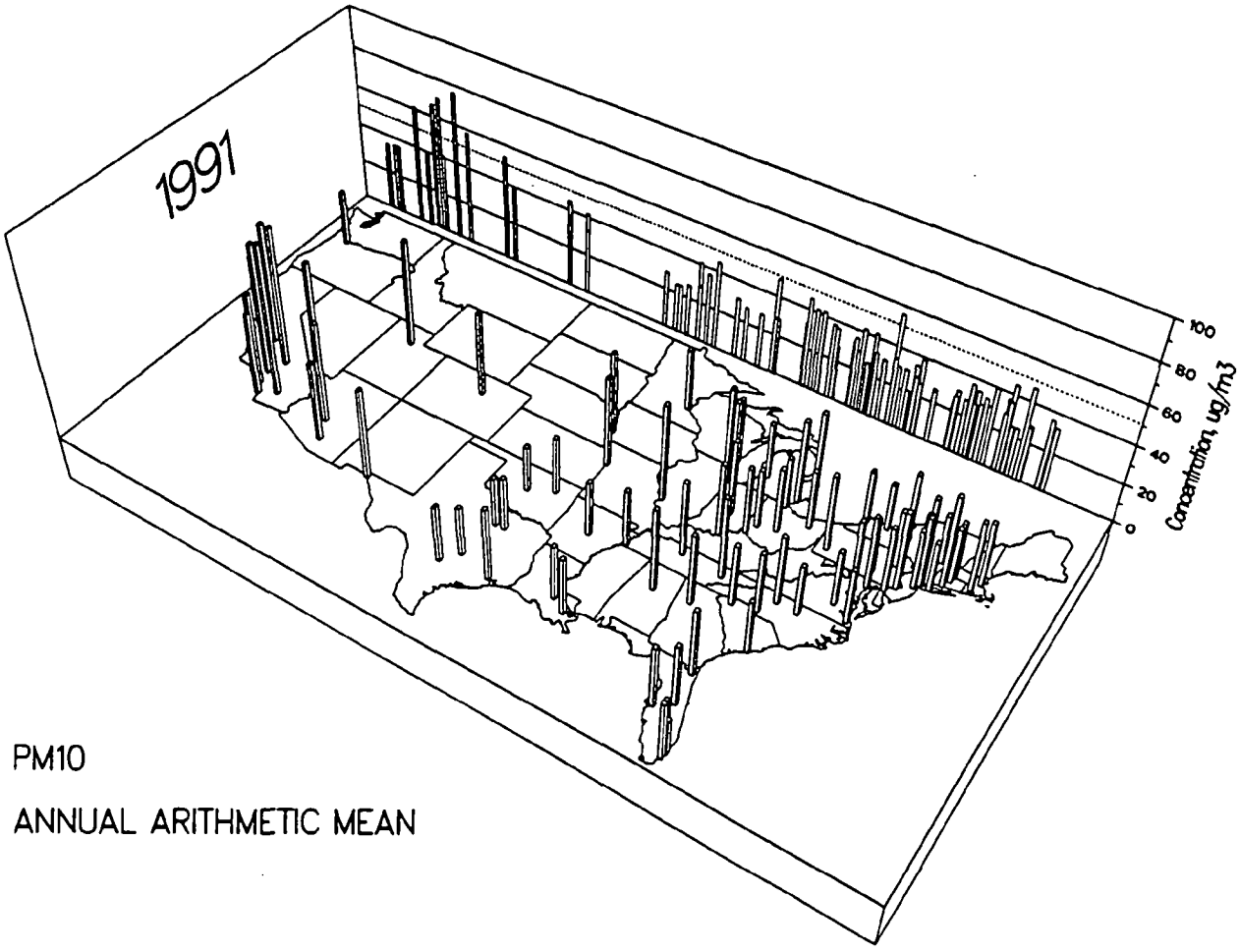


Figure 4-12. United States map of the highest annual arithmetic mean PM-10 concentration by MSA, 1991.

The map for PM-10 shows the 1991 maximum annual arithmetic means in metropolitan areas greater than 500,000 population. Concentrations above the level of the annual mean PM-10 standard of 50 $\mu g/m^3$ are found in 7 of these metropolitan areas.

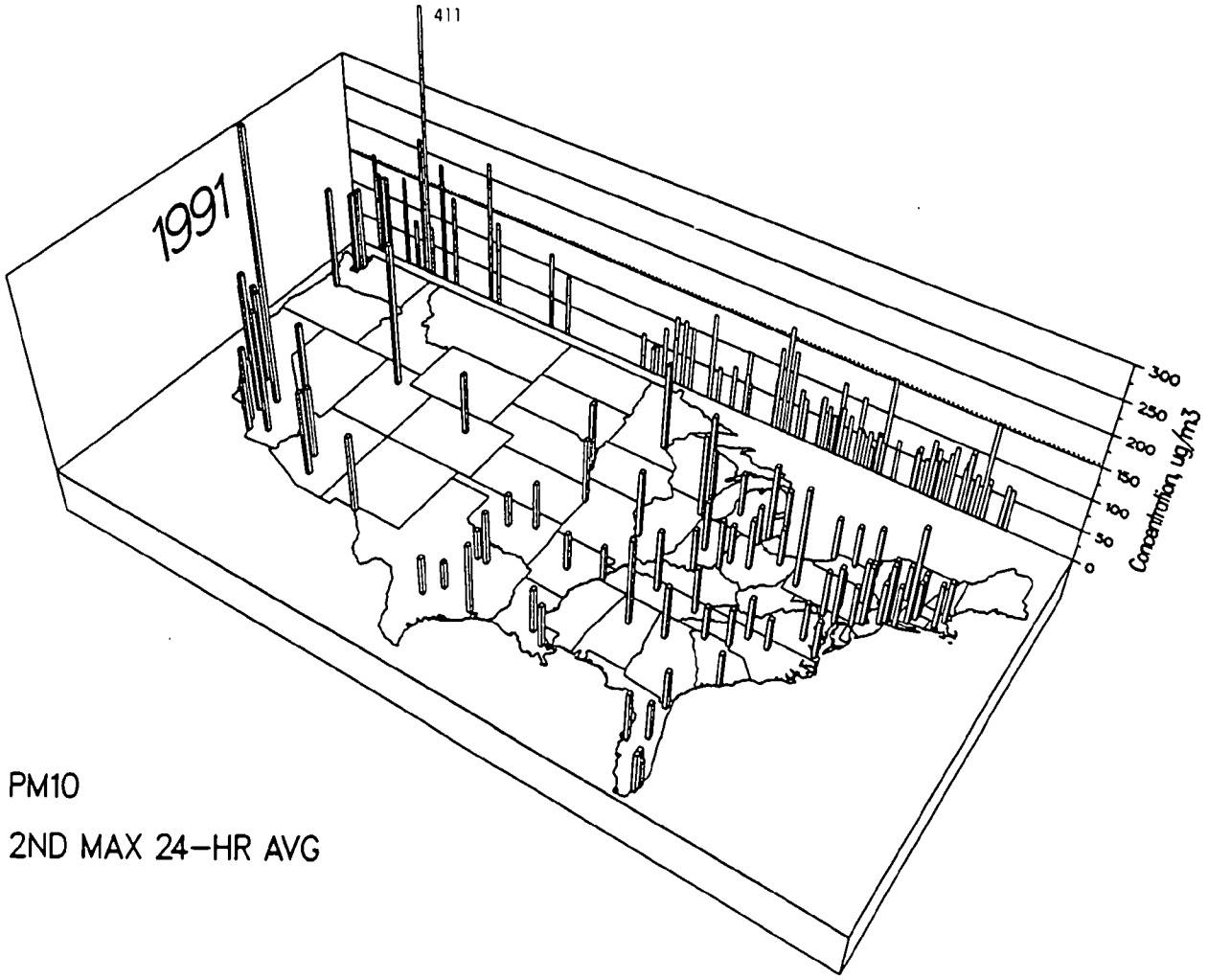


Figure 4-13. United States map of the highest second maximum 24-hour average PM-10 concentration by MSA, 1991.

The map for PM-10 shows the 1991 highest second maximum 24-hour average PM-10 concentration in metropolitan areas greater than 500,000 population. Concentrations above the level of the 24-hour PM-10 standard of 150 $\mu g/m^3$ are found in 6 of these metropolitan areas. The highest value of 411 $\mu g/m^3$ was recorded in the China Lake area in Kern County, California.

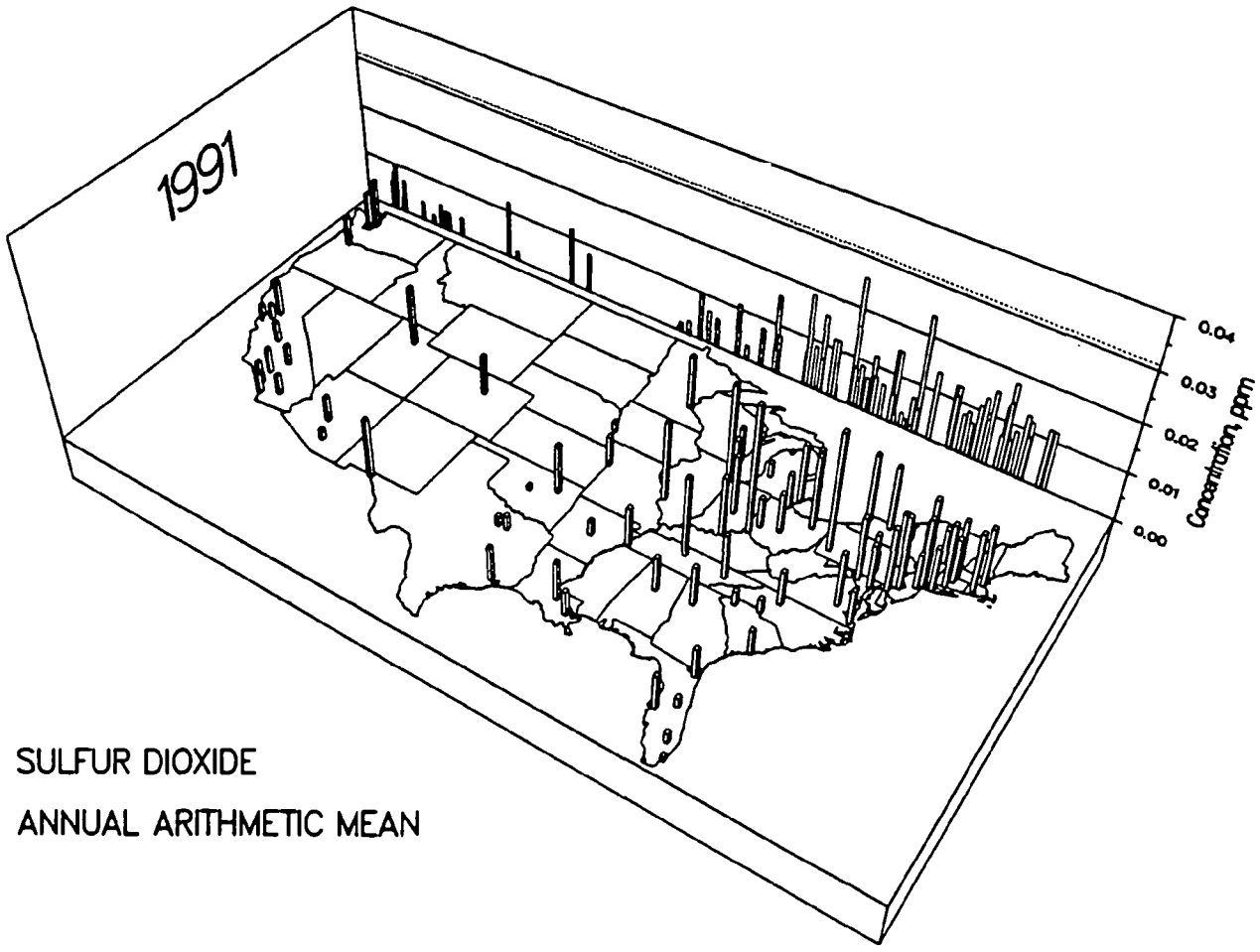


Figure 4-14. United States map of the highest annual arithmetic mean sulfur dioxide concentration by MSA, 1991.

The map for sulfur dioxide shows maximum annual mean concentrations in 1991. Among these large metropolitan areas, the higher concentrations are found in the heavily populated Midwest and Northeast and near point sources in the west. All these large urban areas have ambient air quality concentrations lower than the current annual standard of 80 $\mu g/m^3$ (0.03 ppm). Because this map only represents areas with population greater than one half million, it does not reflect air quality in the vicinity of smelters or large power plants in rural areas.

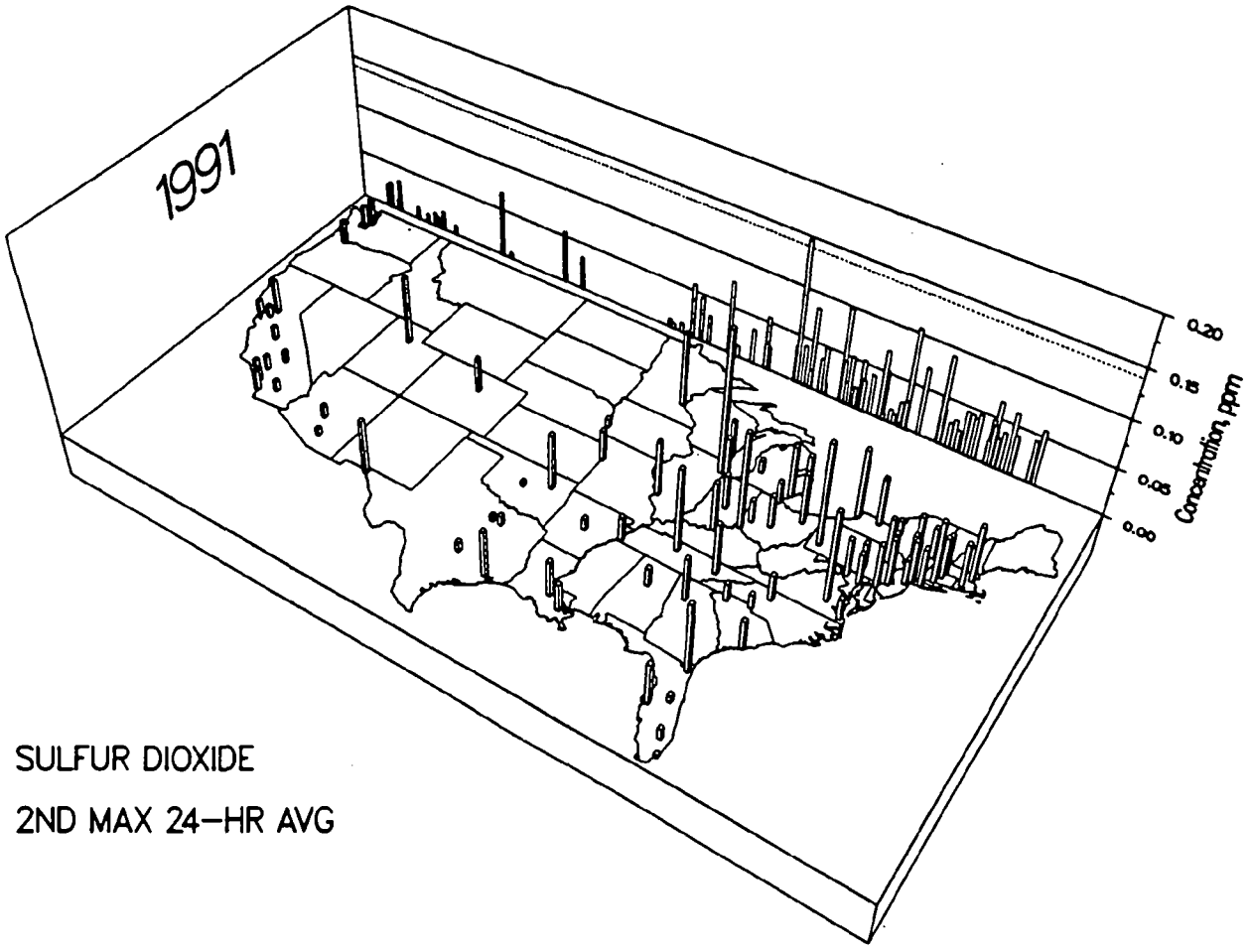


Figure 4-15. United States map of the highest second maximum 24-hour average sulfur dioxide concentration by MSA, 1991.

The map for sulfur dioxide shows the highest second highest 24-hour average sulfur dioxide concentration by MSA in 1991. Chicago, IL (at a point source oriented monitor in Blue Lake, IL) is the only large urban area which had ambient concentrations above the 24-hour NAAQS of 365 $\mu g/m^3$ (0.14 ppm).

TABLE 4-5. 1991 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK
PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1990 POPULATION	PM10 2ND MAX (UGM)	PM10 WTD AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8-HR (PPM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PB QMAX (UGM)
ABILENE, TX	120,000	ND	ND	ND	ND	ND	ND	ND	ND
AGUADILLA, PR	156,000	ND	ND	ND	ND	ND	ND	ND	ND
AKRON, OH	658,000	59	30	0.015	0.052	3	ND	***0.13***	0.07
ALBANY, GA	113,000	ND	ND	ND	ND	ND	ND	ND	ND
ALBANY-SCHENECTADY-TROY, NY	874,000	55	25	0.007	0.031	5	0.017	0.1	0.04
ALBUQUERQUE, NM	481,000	117	31	ND	ND	***10***	0.003	0.09	ND
ALEXANDRIA, LA	132,000	ND	ND	ND	ND	ND	ND	ND	ND
ALLENTOWN-BETHLEHEM, PA-NJ	687,000	80	30	0.009	0.041	7	0.02	0.12	0.46
ALTOONA, PA	131,000	65	26	0.011	0.044	2	0.015	0.11	ND
AMARILLO, TX	188,000	46	IN	ND	ND	ND	ND	ND	ND
ANAHEIM-SANTA ANA, CA	2,411,000	116	46	0.002	0.012	9	0.045	***0.2***	0.06
ANCHORAGE, AK	226,000	148	37	ND	ND	***10***	ND	ND	ND
ANDERSON, IN	131,000	65	28	ND	ND	ND	ND	ND	ND
ANDERSON, SC	145,000	ND	ND	ND	ND	ND	ND	0.09	0.02
ANN ARBOR, MI	283,000	ND	ND	ND	ND	ND	ND	0.11	0.01
ANNISTON, AL	116,000	78	29	ND	ND	ND	ND	ND	ND
APPLETON-OSHKOSH-NEENAH, WI	315,000	ND	ND	ND	ND	ND	ND	0.09	ND
ARECIBO, PR	170,000	ND	ND	0.004	0.011	ND	ND	ND	ND
ASHEVILLE, NC	175,000	53	24	ND	ND	ND	ND	0.08	ND
ATHENS, GA	156,000	ND	ND	ND	ND	ND	ND	ND	ND
ATLANTA, GA	2,834,000	83	36	0.008	0.044	7	0.025	***0.13***	0.04
ATLANTIC CITY, NJ	319,000	71	34	0.004	0.011	5	ND	***0.14***	0.03
AUGUSTA, GA-SC	397,000	50	IN	0.004	0.017	ND	ND	0.1	0.01
AURORA-ELGIN, IL	357,000	ND	ND	ND	ND	ND	ND	***0.13***	ND
AUSTIN, TX	782,000	42	25	IN	0.01	3	0.016	0.1	ND
BAKERSFIELD, CA	543,000	***411***	***70***	0.004	0.011	8	0.03	***0.16***	ND
BALTIMORE, MD	2,382,000	90	37	0.009	0.031	8	0.033	***0.16***	0.04
BANGOR, ME	89,000	48	25	ND	ND	ND	ND	ND	0.01
BATON ROUGE, LA	528,000	70	28	0.008	0.036	5	0.019	***0.14***	0.05
BATTLE CREEK, MI	136,000	72	29	ND	ND	ND	ND	ND	ND
BEAUMONT-PORT ARTHUR, TX	361,000	58	26	0.008	0.059	2	0.012	***0.13***	0.03
BEAVER COUNTY, PA	186,000	66	30	0.02	0.087	3	0.019	0.11	0.19
BELLINGHAM, WA	128,000	98	IN	0.006	0.021	ND	ND	0.07	ND
BENTON HARBOR, MI	161,000	ND	ND	ND	ND	ND	IN	0.12	ND
BERGEN-PASSAIC, NJ	1,278,000	92	45	0.01	0.04	8	0.031	***0.14***	0.03
BILLINGS, MT	113,000	65	23	0.017	0.085	6	ND	ND	ND
BILOXI-GULFPORT, MS	197,000	ND	ND	0.006	0.034	ND	ND	ND	ND
BINGHAMTON, NY	264,000	52	26	ND	ND	ND	ND	ND	ND
BIRMINGHAM, AL	908,000	133	42	0.007	0.019	8	ND	0.11	***2.6***
BISMARK, ND	84,000	51	21	ND	ND	ND	ND	ND	ND

BLOOMINGTON, IN	109,000	ND	ND	ND	ND		ND	ND	ND	ND
BLOOMINGTON-NORMAL, IL	129,000	ND	ND	ND	ND		ND	ND	ND	ND
BOISE CITY, ID	206,000	152	IN	ND	ND		9	ND	ND	ND
BOSTON, MA	2,871,000	65	33	0.012	0.057		4	0.035	***0.13***	0.04
BOULDER-LONGMONT, CO	225,000	72	24	ND	ND		7	ND	0.1	ND
BRADENTON, FL	212,000	ND	ND	ND	ND		ND	ND	0.1	ND
BRAZORIA, TX	192,000	ND	ND	ND	ND		ND	ND	***0.13***	ND
BREMERTON, WA	190,000	ND	ND	ND	ND		ND	ND	ND	ND
BRIDGEPORT-MILFORD, CT	444,000	64	33	0.012	0.045		6	0.025	***0.15***	0.02
BRISTOL, CT	79,000	51	23	ND	ND		ND	ND	ND	ND
BROCKTON, MA	189,000	ND	ND	ND	ND		ND	ND	***0.15***	ND
BROWNSVILLE-HARLINGEN, TX	260,000	72	28	ND	ND		ND	ND	ND	ND
BRYAN-COLLEGE STATION, TX	122,000	ND	ND	ND	ND		ND	ND	ND	ND
BUFFALO, NY	969,000	66	27	0.014	0.071		4	0.022	0.11	0.04
BURLINGTON, NC	108,000	ND	ND	ND	ND		ND	ND	ND	ND
BURLINGTON, VT	131,000	53	24	0.008	0.022		4	0.017	ND	ND
CAGUAS, PR	275,000	ND	ND	ND	ND		ND	ND	ND	ND
CANTON, OH	397,000	62	33	0.01	0.037		3	IN	0.12	ND
CASPER, WY	61,000	19	IN	ND	ND		ND	ND	ND	ND
CEDAR RAPIDS, IA	169,000	73	30	0.008	0.053		5	ND	0.08	ND
CHAMPAIGN-URBANA-RANTOUL, IL	173,000	61	30	0.005	0.038		ND	ND	0.08	ND
CHARLESTON, SC	507,000	52	27	0.005	0.03		5	0.013	0.09	0.05
CHARLESTON, WV	250,000	59	29	0.009	0.04		2	0.02	0.12	0.03
CHARLOTTE-GASTONIA-ROCK HILL, NC-SC	1,162,000	61	31	0.003	0.015		7	0.016	0.12	0.01
CHARLOTTESVILLE, VA	131,000	57	28	ND	ND		ND	ND	ND	ND
CHATTANOOGA, TN-GA	433,000	83	38	ND	ND		ND	ND	0.1	ND
CHEYENNE, WY	73,000	45	IN	ND	ND		ND	ND	ND	ND
CHICAGO, IL	6,070,000	129	46	0.019	***0.147*** #		6	0.032	***0.13***	1.32 @
CHICO, CA	182,000	95	38	ND	ND		9	0.016	0.09	ND
CINCINNATI, OH-KY-IN	1,453,000	78	34	0.026	0.099		5	0.03	***0.14***	0.11

PM10 = HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 150 ug/m3)
= HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m3)
SO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.03 ppm)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
CO = HIGHEST SECOND MAXIMUM NON-OVERLAPPING 8-HOUR CONCENTRATION (Applicable NAAQS is 9 ppm)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.5 ug/m3)
ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

* - Impact from an industrial source in Leeds, AL. Highest site in Birmingham, AL is 0.15 ug/m3.

- Localized impact from an industrial source. Compliance action has been taken and problem has been resolved.

@ - Impact from an industrial source in Chicago, IL. Highest population oriented site in Chicago is 0.10 ug/m3.

TABLE 4-5. 1991 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK
PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1990 POPULATION	PM10 2ND MAX (UGM)	PM10 WTD AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8-HR (PPM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PB QMAX (UGM)	
CLARKSVILLE-HOPKINSVILLE, TN-KY	169,000	ND	ND	0.006	0.029	ND	ND	ND	ND	
CLEVELAND, OH	1,831,000	109	***56***	0.015	0.064	6	0.029	***0.13***	0.31	
COLORADO SPRINGS, CO	397,000	107	29	ND	ND	7	ND	0.09	0.03	
COLUMBIA, MO	112,000	ND	ND	ND	ND	ND	ND	ND	ND	
COLUMBIA, SC	453,000	114	34	0.004	0.025	6	0.009	0.11	0.05	
COLUMBUS, GA-AL	243,000	75	27	ND	ND	ND	ND	0.1	***2.04***	*
COLUMBUS, OH	1,377,000	79	33	0.008	0.033	7	0.012	0.12	0.15	
CORPUS CHRISTI, TX	350,000	72	IN	0.004	0.035	ND	ND	0.11	ND	
CUMBERLAND, MD-WV	102,000	32	IN	0.009	0.028	5	ND	0.1	ND	
DALLAS, TX	2,553,000	83	27	0.003	0.01	5	0.02	0.12	1.11	#
DANBURY, CT	188,000	53	26	0.008	0.032	ND	ND	***0.14***	ND	
DANVILLE, VA	109,000	ND	ND	ND	ND	ND	ND	ND	ND	
DAVENPORT-ROCK ISLAND-MOLINE, IA-IL	351,000	72	38	0.007	0.024	ND	ND	0.1	0.01	
DAYTON-SPRINGFIELD, OH	951,000	61	30	0.006	0.023	4	ND	0.12	0.08	
DAYTONA BEACH, FL	371,000	ND	ND	ND	ND	ND	ND	ND	ND	
DECATUR, AL	132,000	68	28	ND	ND	ND	ND	ND	ND	
DECATUR, IL	117,000	85	36	0.007	0.039	ND	ND	0.1	0.03	
DENVER, CO	1,623,000	96	42	0.008	0.035	***10***	0.028	0.11	0.11	
DES MOINES, IA	393,000	77	33	ND	ND	6	ND	0.07	ND	
DETROIT, MI	4,382,000	117	42	0.012	0.053	8	0.022	***0.13***	0.07	
DOTHAN, AL	131,000	62	28	ND	ND	ND	ND	ND	ND	
DUBUQUE, IA	86,000	ND	ND	0.004	0.028	ND	ND	ND	ND	
DULUTH, MN-WI	240,000	62	26	0.004	0.039	5	ND	ND	ND	
EAU CLAIRE, WI	138,000	ND	ND	ND	ND	ND	ND	ND	ND	
EL PASO, TX	592,000	121	45	0.012	0.055	***11***	0.028	***0.13***	0.46	
ELKHART-GOSHEN, IN	156,000	ND	ND	ND	ND	ND	ND	ND	ND	
ELMIRA, NY	95,000	61	IN	0.005	0.022	ND	ND	0.1	ND	
ENID, OK	57,000	ND	ND	ND	ND	ND	ND	ND	ND	
ERIE, PA	276,000	68	IN	0.01	0.044	4	0.013	0.11	0.07	
EUGENE-SPRINGFIELD, OR	283,000	***184***	30	ND	ND	5	ND	0.09	0.02	
EVANSVILLE, IN-KY	279,000	68	37	0.019	0.095	3	0.021	0.12	ND	
FALL RIVER, MA-RI	157,000	50	IN	0.009	0.052	ND	ND	ND	ND	
FARGO-MOORHEAD, ND-MN	153,000	45	19	ND	ND	3	ND	ND	ND	
FAYETTEVILLE, NC	275,000	52	27	ND	ND	6	ND	0.1	ND	
FAYETTEVILLE-SPRINGDALE, AR	113,000	46	24	ND	ND	ND	ND	ND	ND	
FITCHBURG-LEOMINSTER, MA	103,000	ND	ND	ND	ND	ND	ND	ND	ND	
FLINT, MI	430,000	61	25	0.005	0.019	ND	ND	0.1	0.01	
FLORENCE, AL	131,000	57	24	0.004	0.033	ND	ND	ND	ND	
FLORENCE, SC	114,000	ND	ND	ND	ND	ND	ND	ND	ND	
FORT COLLINS, CO	186,000	58	25	ND	ND	***10***	ND	0.09	ND	

FORT LAUDERDALE-HOLLYWOOD-POMPANO BEAC	1,255,000	42	18	ND	ND	6	0.009	0.1	0.03
FORT MYERS-CAPE CORAL, FL	335,000	ND	ND	ND	ND	ND	ND	0.08	ND
FORT PIERCE, FL	251,000	ND	ND	ND	ND	ND	ND	ND	ND
FORT SMITH, AR-OK	176,000	47	25	ND	ND	ND	ND	ND	ND
FORT WALTON BEACH, FL	144,000	ND	ND	ND	ND	ND	ND	ND	ND
FORT WAYNE, IN	364,000	57	28	0.005	0.019	5	0.011	0.1	ND
FORT WORTH-ARLINGTON, TX	1,332,000	48	25	0.002	0.006	4	0.014	***0.15***	0.02
FRESNO, CA	667,000	142	***60***	0.004	0.013	9	0.025	***0.16***	ND
GADSDEN, AL	100,000	82	33	ND	ND	ND	ND	ND	ND
GAINESVILLE, FL	204,000	ND	ND	ND	ND	ND	ND	ND	ND
GALVESTON-TEXAS CITY, TX	217,000	43	23	0.007	0.05	ND	ND	***0.15***	0.02
GARY-HAMMOND, IN	605,000	***167***	42	0.009	0.042	5	0.022	0.12	0.17
GLENS FALLS, NY	119,000	41	20	0.004	0.02	ND	ND	ND	ND
GRAND FORKS, ND	71,000	67	IN	0.004	0.06	ND	IN	ND	ND
GRAND RAPIDS, MI	688,000	67	28	0.003	0.013	4	IN	***0.15***	0.02
GREAT FALLS, MT	78,000	72	IN	ND	ND	7	ND	ND	ND
GREELEY, CO	132,000	80	IN	ND	ND	8	ND	0.1	ND
GREEN BAY, WI	195,000	55	23	0.006	0.042	ND	ND	0.1	ND
GREENSBORO-WINSTON SALEM-HIGH POINT, NC	942,000	66	35	0.007	0.027	7	0.016	0.11	ND
GREENVILLE-SPARTANBURG, SC	641,000	52	31	0.003	0.018	ND	IN	0.11	0.04
HAGERSTOWN, MD	121,000	ND	ND	ND	ND	ND	ND	ND	ND
HAMILTON-MIDDLETOWN, OH	291,000	87	35	0.009	0.044	ND	ND	0.12	ND
HARRISBURG-LEBANON-CARLISLE, PA	588,000	56	28	0.008	0.026	5	0.02	0.11	0.04
HARTFORD, CT	768,000	58	28	0.009	0.041	9	0.02	***0.15***	0.04
HICKORY, NC	222,000	ND	ND	ND	ND	ND	ND	ND	ND
HONOLULU, HI	836,000	63	18	0.002	0.01	3	ND	0.05	0.02
HOUMA-THIBODAUX, LA	183,000	ND	ND	ND	ND	ND	ND	0.1	ND
HOUSTON, TX	3,302,000	108	37	0.007	0.047	7	0.028	***0.2***	0.03
HUNTINGTON-ASHLAND, WV-KY-OH	313,000	63	36	0.017	0.073	5	0.014	***0.14***	0.04
HUNTSVILLE, AL	239,000	71	28	ND	ND	4	0.014	0.11	ND

PM10 = HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 150 ug/m3)
= HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m3)
SO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.03 ppm)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
CO = HIGHEST SECOND MAXIMUM NON-OVERLAPPING 8-HOUR CONCENTRATION (Applicable NAAQS is 9 ppm)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.5 ug/m3)
ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

* - Impact from industrial source.

- Impact from an industrial source in Collin County, TX. Highest site in Dallas, TX is 0.19 ug/m3.

TABLE 4-5. 1991 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK
PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1990 POPULATION	PM10 2ND MAX (UGM)	PM10 WTD AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8-HR (PPM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PB QMAX (UGM)
INDIANAPOLIS, IN	1,250,000	79	38	0.012	0.036	6	0.018	0.11	***1.64*** *
IOWA CITY, IA	96,000	ND	ND	ND	ND	ND	ND	0.06	ND
JACKSON, MI	150,000	ND	ND	ND	ND	ND	ND	ND	ND
JACKSON, MS	395,000	48	24	0.005	0.011	5	ND	0.09	0.07
JACKSON, TN	78,000	47	27	ND	ND	ND	ND	ND	ND
JACKSONVILLE, FL	907,000	59	34	0.006	0.072	4	0.014	0.1	0.03
JACKSONVILLE, NC	150,000	44	24	ND	ND	ND	ND	ND	ND
JAMESTOWN-DUNKIRK, NY	142,000	53	23	0.013	0.048	ND	ND	0.1	ND
JANESVILLE-BELOIT, WI	140,000	ND	ND	ND	ND	ND	ND	0.11	ND
JERSEY CITY, NJ	553,000	92	36	0.014	0.042	8	0.028	***0.14***	0.06
JOHNSON CITY-KINGSPORT-BRISTOL, TN-VA	436,000	78	33	0.014	0.055	3	0.019	0.12	ND
JOHNSTOWN, PA	241,000	70	33	0.015	0.043	5	0.019	0.11	0.19
JOLIET, IL	390,000	77	34	0.006	0.022	ND	ND	0.12	0.02
JOPLIN, MO	135,000	ND	ND	ND	ND	ND	ND	ND	ND
KALAMAZOO, MI	223,000	59	IN	IN	0.015	3	IN	0.08	0.02
KANKAKEE, IL	96,000	ND	ND	ND	ND	ND	ND	ND	ND
KANSAS CITY, MO-KS	1,566,000	101	45	0.006	0.031	6	0.016	0.12	0.05
KENOSHA, WI	128,000	ND	ND	0.003	0.015	ND	0.012	***0.15***	ND
KILLEN-TEMPLE, TX	255,000	41	22	ND	ND	ND	ND	ND	ND
KNOXVILLE, TN	605,000	72	42	0.009	0.052	5	ND	0.11	ND
KOKOMO, IN	97,000	ND	ND	ND	ND	ND	ND	ND	ND
LA CROSSE, WI	98,000	ND	ND	ND	ND	ND	ND	ND	ND
LAFAYETTE, LA	209,000	ND	ND	ND	ND	ND	ND	0.08	ND
LAFAYETTE, IN	131,000	ND	ND	0.01	0.074	ND	ND	ND	ND
LAKE CHARLES, LA	168,000	52	23	0.004	0.02	ND	ND	0.12	ND
LAKE COUNTY, IL	516,000	ND	ND	ND	ND	ND	IN	0.12	ND
LAKELAND-WINTER HAVEN, FL	405,000	ND	ND	0.005	0.016	ND	ND	ND	ND
LANCASTER, PA	423,000	51	IN	0.006	0.023	3	0.018	0.12	0.04
LANSING-EAST LANSING, MI	433,000	ND	ND	ND	ND	ND	ND	0.11	0.02
LAREDO, TX	133,000	72	IN	ND	ND	ND	ND	ND	ND
LAS CRUCES, NM	136,000	108	40	0.016	0.09	7	ND	0.1	0.16
LAS VEGAS, NV	741,000	143	***58***	ND	ND	***12***	0.03	0.09	ND
LAWRENCE, KS	82,000	ND	ND	ND	ND	ND	ND	ND	ND
LAWRENCE-HAVERHILL, MA-NH	394,000	35	18	0.008	0.032	ND	ND	***0.13***	ND
LAWTON, OK	111,000	54	IN	0.002	0.005	ND	ND	ND	ND
LEWISTON-AUBURN, ME	88,000	66	IN	0.006	0.023	ND	ND	ND	0.02
LEXINGTON-FAYETTE, KY	348,000	53	27	0.008	0.026	5	0.016	0.1	ND
LIMA, OH	154,000	ND	ND	0.006	0.021	ND	ND	0.1	ND
LINCOLN, NE	214,000	67	30	ND	ND	9	ND	0.07	ND
LITTLE ROCK-NORTH LITTLE ROCK, AR	513,000	58	28	0.003	0.012	ND	0.009	0.1	0

LONGVIEW-MARSHALL, TX	162,000	ND	ND	ND	ND	ND	ND	0.11	ND	
LORAIN-ELYRIA, OH	271,000	87	31	0.008	0.033	ND	ND	0.1	ND	
LOS ANGELES-LONG BEACH, CA	8,863,000	***215***	***66***	0.005	0.015	***16***	***0.055***	***0.31***	***2.31***	#
LOUISVILLE, KY-IN	953,000	67	37	0.012	0.05	7	ND	***0.13***	0.06	
LOWELL, MA-NH	273,000	ND	ND	ND	ND	6	ND	ND	ND	
LUBBOCK, TX	223,000	79	26	ND	ND	ND	ND	ND	ND	
LYNCHBURG, VA	142,000	53	28	ND	ND	ND	ND	0.09	ND	
MACON-WARNER ROBINS, GA	281,000	ND	ND	0.003	0.016	ND	ND	ND	ND	
MADISON, WI	367,000	55	IN	0.002	0.014	5	ND	0.11	ND	
MANCHESTER, NH	148,000	49	20	0.009	0.049	6	0.016	0.1	0.02	
MANSFIELD, OH	126,000	62	IN	ND	ND	ND	ND	ND	ND	
MAYAGUEZ, PR	210,000	ND	ND	ND	ND	ND	ND	ND	ND	
MCALLEN-EDINBURG-MISSION, TX	384,000	ND	ND	ND	ND	ND	ND	ND	ND	
MEDFORD, OR	146,000	***166***	44	ND	ND	***11***	ND	0.07	0.03	
MELBOURNE-TITUSVILLE-PALM BAY, FL	399,000	ND	ND	ND	ND	ND	ND	0.09	ND	
MEMPHIS, TN-AR-MS	982,000	54	29	0.008	0.025	7	0.024	0.11	***1.83***	@
MERCED, CA	178,000	122	***52***	ND	ND	ND	ND	ND	ND	
MIAMI-HIALEAH, FL	1,937,000	61	29	0.001	0.003	8	0.015	0.12	0.02	
MIDDLESEX-SOMERSET-HUNTERDON, NJ	1,020,000	65	30	0.007	0.025	4	ND	***0.13***	1.15	
MIDDLETOWN, CT	90,000	51	25	ND	ND	ND	ND	***0.17***	ND	
MIDLAND, TX	107,000	ND	ND	ND	ND	ND	ND	ND	ND	
MILWAUKEE, WI	1,432,000	78	33	0.007	0.038	5	0.024	***0.18***	0.06	
MINNEAPOLIS-ST. PAUL, MN-WI	2,464,000	136	31	0.011	0.076	***11***	0.024	0.09	1.42	+
MOBILE, AL	477,000	73	38	0.009	0.05	ND	ND	0.09	ND	
MODESTO, CA	371,000	145	***54***	ND	ND	9	0.024	0.11	ND	

PM10 = HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 150 ug/m3)
= HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m3)
SO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.03 ppm)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
CO = HIGHEST SECOND MAXIMUM NON-OVERLAPPING 8-HOUR CONCENTRATION (Applicable NAAQS is 9 ppm)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.5 ug/m3)
ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

* - Impact from an industrial source in Indianapolis, IN. Highest population oriented site in Indianapolis, IN is 0.05 ug/m3.

- Impact from an industrial source in Commerce, CA. Compliance action was taken and the problem was corrected. Highest population oriented site in Los Angeles, CA is 0.14 ug/m3.

@ - Impact from an industrial source in Memphis, TN. Highest population oriented site in Memphis, TN is 0.06 ug/m3.

+ - Impact from an industrial source in Eagan, MN. Highest population oriented site in Minneapolis, MN is 0.05 ug/m3.

TABLE 4-5. 1991 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK
PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1990 POPULATION	PM10 2ND MAX (UGM)	PM10 WTD AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8-HR (PPM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PB QMAX (UGM)	
MONMOUTH-OCEAN, NJ	986,000	ND	ND	ND	ND	6	ND	***0.15***	ND	
MONROE, LA	142,000	58	25	ND	ND	ND	ND	ND	ND	
MONTGOMERY, AL	293,000	60	26	ND	ND	ND	ND	0.09	ND	
MUNCIE, IN	120,000	ND	ND	ND	ND	ND	ND	ND	ND	
MUSKEGON, MI	159,000	ND	ND	ND	ND	ND	ND	***0.15***	0.01	
NAPLES, FL	152,000	ND	ND	ND	ND	ND	ND	ND	ND	
NASHUA, NH	181,000	58	21	0.005	0.02	7	ND	0.11	0.01	
NASHVILLE, TN	985,000	95	38	0.016	0.085	6	0.01	0.12	***2.31***	*
NASSAU-SUFFOLK, NY	2,609,000	65	25	0.009	0.039	7	0.029	***0.18***	ND	
NEW BEDFORD, MA	176,000	51	20	ND	ND	ND	ND	***0.13***	ND	
NEW BRITAIN, CT	148,000	55	IN	ND	ND	ND	ND	ND	ND	
NEW HAVEN-MERIDEN, CT	530,000	152	47	0.013	0.063	6	0.028	***0.18***	0.08	
NEW LONDON-NORWICH, CT-RI	267,000	59	24	0.007	0.027	ND	ND	***0.14***	ND	
NEW ORLEANS, LA	1,239,000	66	29	0.005	0.028	4	0.019	0.11	0.03	
NEW YORK, NY	8,547,000	101	IN	0.018	0.068	***10***	0.047	***0.18***	0.05	
NEWARK, NJ	1,824,000	77	37	0.013	0.047	***11***	0.034	***0.14***	1.04	
NIAGARA FALLS, NY	221,000	70	27	0.012	0.056	2	ND	0.1	ND	
NORFOLK-VIRGINIA BEACH-NEWPORT NEWS, VA	1,396,000	60	28	0.007	0.022	6	0.02	0.11	0.03	
NORWALK, CT	127,000	77	39	ND	ND	ND	ND	ND	ND	
OAKLAND, CA	2,083,000	118	36	0.003	0.012	7	0.024	0.12	0.2	
OCALA, FL	195,000	ND	ND	ND	ND	ND	ND	ND	ND	
ODESSA, TX	119,000	31	IN	ND	ND	ND	ND	ND	ND	
OKLAHOMA CITY, OK	959,000	51	23	0.001	0.005	6	0.012	0.11	0.04	
OLYMPIA, WA	161,000	99	26	ND	ND	ND	ND	ND	ND	
OMAHA, NE-IA	618,000	108	41	0.002	0.009	8	ND	0.08	***2.33***	#
ORANGE COUNTY, NY	308,000	ND	ND	ND	ND	ND	ND	ND	1.03	@
ORLANDO, FL	1,073,000	55	31	0.002	0.007	5	0.012	0.1	0	
OWENSBORO, KY	87,000	60	30	0.009	0.044	4	0.011	0.09	ND	
OXNARD-VENTURA, CA	669,000	79	39	0.002	0.01	4	0.024	***0.16***	ND	
PANAMA CITY, FL	127,000	ND	ND	ND	ND	ND	ND	ND	ND	
PARKERBURG-MARIETTA, WV-OH	149,000	57	IN	0.014	0.06	ND	ND	0.12	0.02	
PASCAGOULA, MS	115,000	ND	ND	0.006	0.017	ND	ND	0.1	ND	
PAWTUCKET-WOONSOCKET-ATTLEBORO, RI-MA	329,000	85	32	0.008	0.031	ND	ND	ND	ND	
PENSACOLA, FL	344,000	ND	ND	0.006	0.127	ND	ND	0.11	0	
PEORIA, IL	339,000	52	28	0.008	0.089	6	ND	0.1	0.02	
PHILADELPHIA, PA-NJ	4,857,000	93	40	0.015	0.047	7	0.034	***0.16***	***3.82***	+
PHOENIX, AZ	2,122,000	112	50	0.005	0.013	***10***	0.021	0.12	0.11	
PINE BLUFF, AR	85,000	42	IN	ND	ND	ND	ND	ND	ND	
PITTSBURGH, PA	2,243,000	154	39	0.024	0.105	6	0.031	0.12	0.08	
PITTSFIELD, MA	79,000	ND	ND	ND	ND	ND	ND	0.1	ND	

PONCE, PR	235,000	58	IN	ND	ND	ND	ND	ND	ND	
PORTLAND, ME	215,000	71	22	0.009	0.032	ND	0.016	***0.14***	0.03	
PORTLAND, OR-WA	1,240,000	***159***	28	0.006	0.024	9	IN	0.11	0.1	
PORTSMOUTH-DOVER-ROCHESTER, NH-ME	224,000	50	20	0.007	0.021	ND	0.015	***0.13***	0.02	
POUGHKEEPSIE, NY	259,000	ND	ND	0.008	0.03	ND	ND	***0.13***	ND	
PROVIDENCE, RI	655,000	69	36	0.012	0.044	7	0.025	***0.16***	0.04	
PROVO-OREM, UT	264,000	***241***	47	ND	ND	***12***	0.023	0.08	ND	
PUEBLO, CO	123,000	57	30	ND	ND	ND	ND	ND	ND	
RACINE, WI	175,000	ND	ND	ND	ND	6	ND	***0.14***	ND	
RALEIGH-DURHAM, NC	735,000	51	26	ND	ND	9	0.016	0.11	ND	
RAPID CITY, SD	81,000	***166***	30	ND	ND	ND	ND	ND	ND	
READING, PA	337,000	67	28	0.011	0.039	5	0.022	0.12	1.28	$
REDDING, CA	147,000	74	29	ND	ND	2	ND	0.08	ND	
RENO, NV	255,000	***181***	39	ND	ND	***12***	ND	0.09	ND	
RICHLAND-KENNEWICK-PASCO, WA	155,000	***281***	31	ND	ND	ND	ND	ND	ND	
RICHMOND-PETERSBURG, VA	866,000	60	28	0.011	0.092	4	0.024	0.12	ND	
RIVERSIDE-SAN BERNARDINO, CA	2,589,000	***189***	***76***	0.004	0.011	8	0.043	***0.25***	0.07	
ROANOKE, VA	224,000	63	34	0.004	0.019	ND	0.014	0.1	ND	
ROCHESTER, MN	106,000	43	23	0.003	0.039	6	ND	ND	ND	
ROCHESTER, NY	1,002,000	65	24	0.013	0.049	4	ND	0.11	0.03	
ROCKFORD, IL	284,000	55	22	ND	ND	5	ND	0.09	0.04	
SACRAMENTO, CA	1,481,000	130	36	0.007	0.034	***11***	0.024	***0.16***	0.04	
SAGINAW-BAY CITY-MIDLAND, MI	399,000	86	30	ND	ND	2	0.008	ND	0.03	
ST. CLOUD, MN	191,000	34	13	0.002	0.008	ND	ND	ND	ND	
ST. JOSEPH, MO	83,000	120	44	ND	ND	ND	ND	ND	ND	

PM10 = HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 150 ug/m3)
= HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m3)
SO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.03 ppm)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
CO = HIGHEST SECOND MAXIMUM NON-OVERLAPPING 8-HOUR CONCENTRATION (Applicable NAAQS is 9 ppm)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.5 ug/m3)
ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

* - Impact from an industrial source in Williamson County, TN. Highest site in Nashville, TN is 0.11 ug/m3.

- Impact from an industrial source in Omaha, NE.

@ - Impact from an industrial source in Orange County, NY.

+ - Impact from an industrial source in Philadelphia, PA. Highest site in Philadelphia, PA is 0.11 ug/m3.

$ - Impact from an industrial source in Reading, PA.

TABLE 4-5. 1991 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK
PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1990 POPULATION	PM10 2ND MAX (UGM)	PM10 WTD AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8-HR (PPM)	NO2 AM (PPM)	OZONE 2ND MAX (PPM)	PB QMAX (UGM)
ST. LOUIS, MO-IL	2,444,000	103	49	0.016	0.056	7	0.026	0.12	***5.56*** *
SALEM, OR	278,000	ND	ND	ND	ND	8	ND	ND	ND
SALEM-GLOUCESTER, MA	264,000	ND	ND	0.009	0.032	ND	ND	ND	ND
SALINAS-SEASIDE-MONTEREY, CA	356,000	48	23	ND	ND	2	0.012	0.09	ND
SALT LAKE CITY-OGDEN, UT	1,072,000	***221***	***54***	0.012	0.069	8	0.029	0.11	0.09
SAN ANGELO, TX	98,000	ND	ND	ND	ND	ND	ND	ND	ND
SAN ANTONIO, TX	1,302,000	58	29	ND	ND	4	ND	0.11	0.03
SAN DIEGO, CA	2,498,000	79	41	0.004	0.02	8	0.029	***0.18***	0.04
SAN FRANCISCO, CA	1,604,000	85	35	0.002	0.013	8	0.024	0.07	0.06
SAN JOSE, CA	1,498,000	128	36	ND	ND	***10***	0.031	0.12	0.05
SAN JUAN, PR	1,541,000	98	IN	0.003	0.022	6	ND	0.08	0.03
SANTA BARBARA-SANTA MARIA-LOMPOC, CA	370,000	67	37	0.001	0.007	6	0.024	0.1	ND
SANTA CRUZ, CA	230,000	43	24	ND	ND	1	0.01	0.1	ND
SANTA FE, NM	117,000	40	15	0.001	0.005	4	0.003	0.08	ND
SANTA ROSA-PETALUMA, CA	388,000	77	IN	ND	ND	4	0.015	0.1	0.02
SARASOTA, FL	278,000	68	29	0.003	0.034	7	ND	0.1	ND
SAVANNAH, GA	243,000	ND	ND	0.002	0.009	ND	ND	ND	ND
SCRANTON-WILKES-BARRE, PA	734,000	66	29	0.011	0.045	5	0.018	***0.13***	0.06
SEATTLE, WA	1,973,000	131	IN	0.01	0.028	9	ND	0.11	0.56
SHARON, PA	121,000	73	36	0.008	0.032	ND	ND	0.11	0.09
SHEBOYGAN, WI	104,000	ND	ND	IN	0.012	ND	IN	***0.16***	ND
SHERMAN-DENISON, TX	95,000	ND	ND	ND	ND	ND	ND	ND	ND
SHREVEPORT, LA	334,000	100	28	0.002	0.009	ND	ND	0.11	ND
SIOUX CITY, IA-NE	115,000	66	28	ND	ND	ND	ND	ND	ND
SIOUX FALLS, SD	124,000	57	19	ND	ND	ND	ND	ND	ND
SOUTH BEND-MISHAWAKA, IN	247,000	65	30	0.007	0.031	3	IN	0.11	ND
SPOKANE, WA	361,000	103	44	ND	ND	***12***	ND	0.08	ND
SPRINGFIELD, IL	190,000	49	25	0.008	0.048	4	ND	0.1	ND
SPRINGFIELD, MO	241,000	35	19	0.005	0.053	7	0.008	0.08	ND
SPRINGFIELD, MA	530,000	67	29	0.012	0.039	7	0.026	***0.13***	0.04
STAMFORD, CT	203,000	56	33	0.01	0.041	6	ND	***0.15***	ND
STATE COLLEGE, PA	124,000	ND	ND	ND	ND	ND	ND	ND	ND
STEUBENVILLE-WEIRTON, OH-WV	143,000	130	44	***0.034***	0.11	***14***	0.021	0.12	0.1
STOCKTON, CA	481,000	134	***52***	ND	ND	8	0.025	0.11	ND
SYRACUSE, NY	660,000	79	35	0.003	0.016	8	ND	0.11	1.13
TACOMA, WA	586,000	129	IN	0.008	0.024	9	ND	0.09	0.02
TALLAHASSEE, FL	234,000	ND	ND	ND	ND	ND	ND	0.05	ND
TAMPA-ST. PETERSBURG-CLEARWATER, FL	2,068,000	72	31	0.007	0.042	5	0.013	0.11	***2.27*** #
TERRE HAUTE, IN	131,000	95	32	0.013	0.044	ND	ND	0.1	ND
TEXARKANA, TX-AR	120,000	45	22	ND	ND	ND	ND	ND	ND

TOLEDO, OH	614,000	62	26	0.007	0.022	4	ND	0.12	0.48
TOPEKA, KS	161,000	56	IN	ND	ND	ND	ND	ND	0.02
TRENTON, NJ	326,000	58	31	0.012	0.033	4	ND	***0.15***	ND
TUCSON, AZ	667,000	133	39	0.002	0.007	6	0.024	0.09	0.05
TULSA, OK	709,000	73	29	0.01	0.057	5	0.017	0.12	0.21
TUSCALOOSA, AL	151,000	62	28	ND	ND	ND	ND	ND	ND
TYLER, TX	151,000	37	19	ND	ND	ND	ND	ND	ND
UTICA-ROME, NY	317,000	60	24	ND	ND	ND	ND	0.1	ND
VALLEJO-FAIRFIELD-NAPA, CA	451,000	90	33	0.002	0.008	8	0.019	0.11	0.06
VANCOUVER, WA	238,000	87	25	IN	0.028	***10***	ND	0.1	ND
VICTORIA, TX	74,000	ND	ND	ND	ND	ND	ND	0.1	ND
VINELAND-MILLVILE-BRIDGETON, NJ	138,000	ND	ND	0.007	0.023	ND	ND	0.12	ND
VISALIA-TULARE-PORTERVILLE, CA	312,000	135	***66***	ND	ND	5	0.022	0.12	ND
WACO, TX	189,000	ND	ND	ND	ND	ND	ND	ND	ND
WASHINGTON, DC-MD-VA	3,924,000	71	31	0.013	0.038	9	0.03	***0.14***	0.05
WATERBURY, CT	222,000	65	31	0.009	0.038	ND	ND	ND	0.69
WATERLOO-CEDAR FALLS, IA	147,000	73	IN	ND	ND	ND	ND	ND	ND
WAUSAU, WI	115,000	ND	ND	0.005	0.026	ND	ND	ND	ND
WEST PALM BEACH-BOCA RATON-DELRAY BEACH	864,000	38	21	0.002	0.011	3	0.012	0.09	ND
WHEELING, WV-OH	159,000	68	34	0.026	0.085	6	ND	0.11	0.04
WICHITA, KS	485,000	94	39	0.006	0.038	6	ND	0.1	0.02
WICHITA FALLS, TX	122,000	55	27	ND	ND	ND	ND	ND	ND
WILLIAMSPORT, PA	119,000	67	31	0.007	0.026	ND	ND	0.1	ND
WILMINGTON, DE-NJ-MD	579,000	65	33	0.013	0.044	4	0.028	***0.15***	0.07
WILMINGTON, NC	120,000	50	26	ND	ND	ND	ND	ND	ND
WORCESTER, MA	437,000	47	21	0.009	0.029	7	0.023	***0.14***	ND
YAKIMA, WA	189,000	***173***	37	ND	ND	9	ND	ND	ND
YORK, PA	418,000	69	IN	0.007	0.02	4	0.021	0.11	0.05
YOUNGSTOWN-WARREN, OH	493,000	85	34	0.01	0.035	2	ND	0.12	ND
YUBA CITY, CA	123,000	101	39	ND	ND	ND	ND	0.1	ND
YUMA, AZ	107,000	56	IN	ND	ND	ND	ND	0.09	ND

PM10 = HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 150 ug/m3)
= HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m3)
SO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.03 ppm)
= HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
CO = HIGHEST SECOND MAXIMUM NON-OVERLAPPING 8-HOUR CONCENTRATION (Applicable NAAQS is 9 ppm)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.5 ug/m3)
ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

* - Impact from an industrial source in Madison County, IL. Highest population oriented site in St. Louis, IL is 0.21 ug/m3.

- Impact from an industrial source in Tampa, FL.

4.5 REFERENCES

1. Statistical Abstract of the United States, 1991, U. S. Department of Commerce, U. S. Bureau of the Census, Appendix II.

2. 40CFR, PART 81 (Federal Register, November 6, 1991).

3. Memorandum from W. Freas to T. Helms, U.S. Environmental Protection Agency, Research Triangle Park, NC, July 20, 1992.

4. Federal Register, June 23, 1992.

5. Federal Register, January 27, 1992.

5. SELECTED METROPOLITAN AREA TRENDS

This chapter discusses 1982-91 air quality trends in fifteen major urban areas: the ten EPA Regional Offices (Boston, New York, Philadelphia, Atlanta, Chicago, Dallas, Kansas City, Denver, San Francisco and Seattle) and five additional cities (Detroit, Houston, Los Angeles, Pittsburgh and Washington, DC.)

The presentation of urban area trends includes maps of the urban area showing the ozone monitoring network that was in place in 1991. To complement the map and show the general orientation of the ambient monitoring network with respect to wind flow patterns, a wind rose is presented. The wind rose shows the direction the winds came from during the morning hours of 7 AM to 10 AM on days when the maximum daily temperature was 85 F or higher. The wind rose represents days that have the potential for high O_3 concentrations. Also, three graphical displays are used to depict urban air quality trends. One graph uses the Pollutant Standards Index (PSI) as the measure of air quality. The trend is shown in the number of days in 5 PSI categories. The other two graphs display the trend in average CO and O_3 concentrations. For O_3 the trend is based on three different averages - two of which incorporate the maximum daily temperature.

The air quality data used for the trend statistics were obtained from the EPA Aerometric Information Retrieval System (AIRS). This is the third year that the report presents trends in the PSI, used locally in many areas to characterize and publicly report air quality. The PSI analyses are based on daily maximum statistics from selected monitoring sites. The urban area trends for CO and O_3 use the same annual validity and site selection criteria that were used for the national trends. It should be noted that no interpolation is used in this chapter; this corresponds with typical PSI reporting.

5.1 The Pollutant Standards Index

The PSI is used in this section as an air quality indicator for describing urban area trends. Only CO and O_3 monitoring sites had to satisfy the trends selection criteria discussed in Section 2.1 to be included in these PSI trend analyses. Data for other pollutants were used without applying this historical trends criterion, except for SO_2 in Pittsburgh because this pollutant contributed a significant number of days in the high PSI range. Results for individual years could be somewhat different if data from all monitoring sites and all pollutants were considered in an area. This is illustrated for 1991, where the number of PSI days from all monitoring sites is compared to the results for the subset of trend sites.

The PSI has found widespread use in the air pollution field to report daily air quality to the general public. The index integrates information from many pollutants across an entire monitoring network into a single number that represents the worst daily air quality experienced in the urban area. The PSI is computed for PM-10, SO_2, CO, O_3 and NO_2 based on their short-term National

Table 5-1. PSI Categories and Health Effect Descriptor Words

INDEX RANGE	DESCRIPTOR WORDS
0 to 50	Good
51 to 100	Moderate
101 to 199	Unhealthful
200 to 299	Very Unhealthful
300 and Above	Hazardous

Ambient Air Quality Standards (NAAQS), Federal Episode Criteria and Significant Harm Levels. Lead is the only criteria pollutant not included in the index because it does not have a short-term NAAQS, a Federal Episode Criteria or a Significant Harm Level.

The PSI converts daily monitoring information into a single measure of air quality by first computing a separate sub-index for each pollutant with data for the day. The PSI index value used in this analysis represents the highest of the pollutant sub-index values for all sites selected for the MSA. Local agencies may use only selected monitoring sites to determine the PSI value so that differences are possible between the PSI values reported here and those done by the local agencies.

The PSI simplifies the presentation of air quality data by producing a single dimensionless number ranging from 0 to 500. The PSI uses data from all selected sites in the MSA and combines different air pollutants with different averaging times, different units of concentration, and more importantly, with different NAAQS, Federal Episode Criteria and Significant Harm Levels. Table 5-1 shows the 5 PSI categories and health effect descriptor words. The PSI is primarily used to report the daily air quality of a large urban area as a single number or descriptor word. Frequently, the index is reported as a regular feature on local TV or radio news programs or in newspapers.

Throughout this section, emphasis is placed on CO and O_3 which cause most of the NAAQS violations in urban areas.

5.2 Summary of PSI Analyses

Table 5-2 shows the trend in the number of PSI days greater than 100 (unhealthful or worse days). The impact of the very hot and dry summers in 1983 and 1988 in the eastern United States on O_3 concentrations can clearly be seen. Pittsburgh is the only city where a significant number of PSI days greater than 100 are due to pollutants other than CO or O_3. For Pittsburgh, SO_2 and PM-10 account for the additional days. The two right most columns show the number of currently active monitoring sites and the corresponding total number of PSI days > 100, using all of these sites. Note that for all urban areas except Detroit and New York there is close agreement between the two totals for 1991 of the number of days when the PSI is greater than 100. The differences are attributed to currently active sites without sufficient historical data to be used for trends.

For all practical purposes CO, O_3, PM-10 and SO_2 are the only pollutants that contribute to the PSI in these analyses. NO_2 rarely is a factor because it does not have a short-term NAAQS and can only be included when concentrations exceed one of the Federal Episode Criteria or Significant Harm levels. TSP is not included in the index because the revised particulate matter NAAQS is for PM-10, not TSP. As noted above, lead is not included in the index because it does not have a short-term NAAQS or Federal Episode Criteria and Significant Harm Levels.

Table 5-3 shows the trend in the number of PSI days greater than 100 (unhealthful or worse) due to only O_3. The 5 areas where O_3 did not account for all of the PSI>100 days in 1991 were: Chicago, Denver, Los Angeles, New York City and Pittsburgh. In Denver, Los Angeles and New York City, CO accounted for the additional PSI>100 days. In Chicago and Pittsburgh, PM-10 and SO_2 accounted for the extra PSI>100 days. Because of the overall improvement in CO levels (see Section 3.3 in this report), CO accounts for far less of these days in the latter half of the 10-year period. Overall, 66% of the PSI greater than 100 days were due to O_3.

Figure 5-1 is a bar chart showing the number of PSI days above 100 in 1989, 1990 and 1991 for fourteen of the cities being studied. To permit better scaling, Los Angeles is not shown on the graph but the values were 213, 167 and 158 for 1989, 1990 and 1991 respectively. This comparison

---

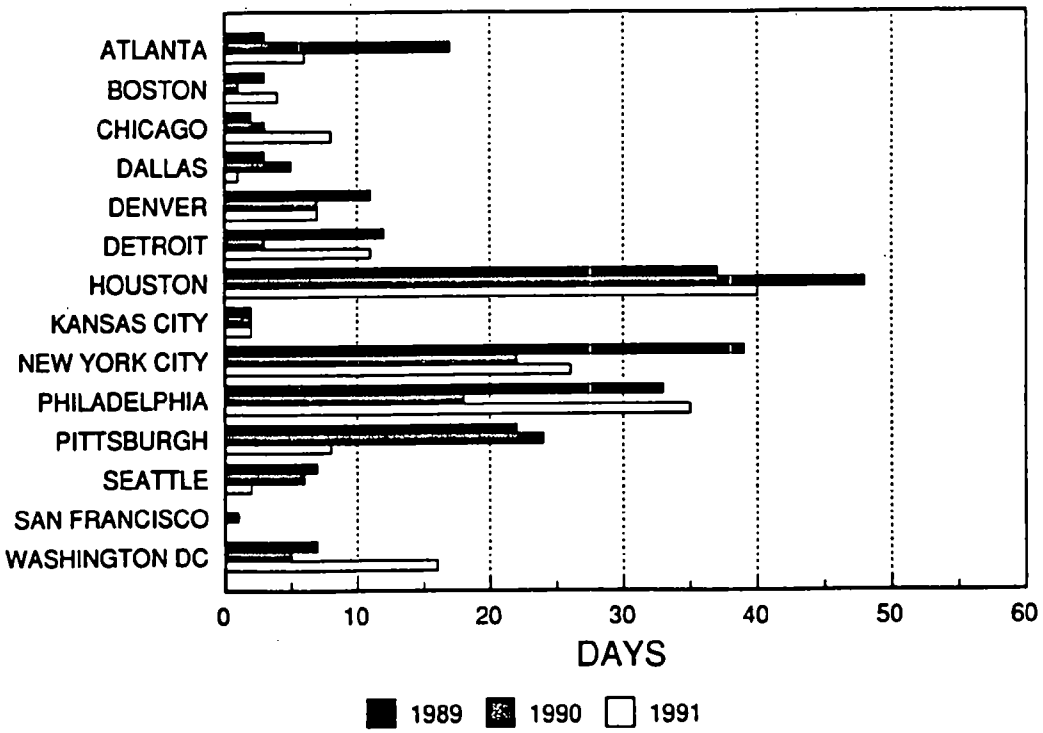
Note: Urban lead concentrations have dropped dramatically over the past 15 or so years (See Chapter 3). As a result, only 9 urban areas violated the lead NAAQS based upon 1991 data only. Los Angeles and Philadelphia are the only two of these 15 urban areas that have a 1991 lead violation. In Los Angeles, the problem occurred near a smelter located in Los Angeles County. In Philadelphia, the problem occurred near a smelting and a materials handling operation.

Table 5-2. Number of PSI Days Greater Than 100 at Trend Sites, 1982-91, and All Sites in 1991.

Number of PSI Days Greater than 100 at Trend Sites												All active monitoring sites in PMSA 1991	
		YEAR											
PMSA	# trend sites	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	total # sites	PSI > 100
ATLANTA	3	5	23	8	9	17	19	15	3	16	5	13	6
BOSTON	4	5	16	7	3	2	5	12	2	1	3	29	4
CHICAGO	7	3	16	8	6	4	10	18	2	3	8	45	8
DALLAS	4	12	18	11	15	5	8	3	3	5	0	28	1
DENVER	5	52	67	61	38	45	36	18	11	7	7	27	7
DETROIT	9	19	18	7	2	6	9	17	12	3	7	29	11
HOUSTON	10	49	70	48	47	44	54	48	32	48	39	27	40
KANSAS CITY	8	0	4	12	4	8	6	3	2	2	1	21	2
LOS ANGELES	14	195	184	208	196	210	187	226	212	164	156	33	158
NEW YORK	8	69	62	110	60	53	40	41	10	12	16	25	26
PHILADELPHIA	15	44	56	31	25	21	36	34	19	11	24	41	24
PITTSBURGH	13	13	33	15	5	6	14	26	11	11	3	39	4
SAN FRANCISCO	3	2	4	2	5	4	1	1	0	1	0	8	0
SEATTLE	7	19	19	4	26	18	13	8	4	2	0	20	2
WASHINGTON	14	25	53	30	15	11	23	34	7	5	16	37	16
TOTAL	124	512	643	562	456	454	461	504	330	291	285	422	309

Table 5-3. (Ozone Only) Number of PSI Days Greater Than 100 at Trend Sites, 1982-91, and All Sites in 1991.

Number Of PSI Days Greater Than 100 At All Ozone Trend Sites												All active O3 monitoring sites in PMSA 1991	
		YEAR											
PMSA	O3 trend sites	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	total O3 sites	PSI > 100
ATLANTA	2	3	23	8	9	17	19	15	3	16	5	5	6
BOSTON	2	3	10	7	3	2	4	12	2	1	3	5	4
CHICAGO	6	3	14	6	6	2	10	15	1	0	5	14	5
DALLAS	3	12	18	11	14	5	8	3	3	5	0	6	1
DENVER	2	4	11	1	0	1	4	3	0	0	0	6	0
DETROIT	8	17	16	4	1	3	6	16	10	3	7	9	11
HOUSTON	9	46	68	48	47	42	51	48	32	48	39	11	40
KANSAS CITY	5	0	4	11	3	3	2	3	1	2	1	6	2
LOS ANGELES	13	133	142	154	153	159	146	165	137	116	108	17	109
NEW YORK	4	20	29	11	13	6	13	30	3	8	13	6	19
PHILADELPHIA	10	33	52	22	25	19	32	34	17	11	24	10	24
PITTSBURGH	5	4	15	0	2	2	7	21	4	0	1	7	2
SAN FRANCISCO	2	0	2	0	1	0	0	0	0	0	0	4	0
SEATTLE	1	0	0	0	0	1	0	1	0	2	0	3	0
WASHINGTON	11	19	38	12	12	9	18	33	4	5	16	13	16
TOTAL	83	297	442	295	289	271	320	399	217	217	222	122	239



*NOTE: Los Angeles not shown because of scaling problem.
See Table 5-2 for the PSI>100 days in Los Angeles.

Figure 5-1. PSI days > 100 in 1989, 1990 and 1991 using all sites.

uses all the monitoring sites available in an area for the 3 years. The use of all sites explains why these figures may not agree with Table 5-2, where only the CO and O_3 sites that met the trend criteria were used. There were about an equal number of areas which showed an increase or a decrease in the number of PSI>100 days between 1989 and 1991. The average for the 14 cities, excluding Los Angeles, dropped from 12.9 to 11.9 between 1989 and 1991. The 1990 average was 11.6 slightly less than the 11.9 in 1991.

The pollutant having the highest sub-index value, from all the monitoring sites considered in an MSA, becomes the PSI value used for that day. PSI estimates depend upon the number of pollutants monitored and the number of monitoring sites collecting data. The more pollutants and sites that are available in an area, the better the estimate of the maximum PSI for that day is likely to be. Ozone accounts for most of the days with a PSI above 100 and O_3 air quality is relatively uniform over large areas so that a small number of sites can still estimate maximum pollutant concentrations. All of the included cities had at least one CO trend site and one O_3 trend site. Table 5-4 separately shows the number of CO and O_3 trend sites used in each of the MSA's. In addition, 9 SO_2 trend sites were used in Pittsburgh because SO_2 accounted for a sizeable number of days when the PSI was greater than 100. In Table 5-4, the months corresponding to the O_3 season in the 15 areas are also provided. The PSI trend analyses are presented for the Primary MSA (PMSA) in each city studied, not the larger Consolidated Metropolitan Statistical Area (CMSA). Using the principal PMSA limits the geographical area studied and emphasizes the area having the highest population density. The PMSA monitors are in the core of the urban area; there are typically additional sites in surrounding areas.

Table 5-4. Number of Trend Monitoring Sites for the 15 Urban Area Analyses

Primary Metropolitan Statistical Area (PMSA)	CO Sites	O_3 Sites	O_3 Season
Atlanta, GA	1	2	MAR - NOV
Boston, MA	2	2	APR - OCT
Chicago, IL	3	6	APR - OCT
Dallas, TX	1	3	MAR - OCT
Denver, CO	5	2	MAR - SEP
Detroit, MI	6	8	APR - OCT
Houston, TX	4	9	JAN - DEC
Kansas City, MO-KS	4	5	APR - OCT
Los Angeles, CA	12	13	JAN - DEC
New York, NY	4	4	APR - OCT
Philadelphia, PA	9	10	APR - OCT
Pittsburgh, PA	3	5	APR - OCT
San Francisco, CA	3	2	JAN - DEC
Seattle, WA	6	1	APR - OCT
Washington, DC-MD-VA	10	11	APR - OCT

There are several assumptions that are implicit in the PSI analysis. Probably the most important is that the monitoring data available for a given area provide a reasonable estimate of maximum short-term concentration levels. The PSI procedure uses the maximum concentration which may not represent the air pollution exposure for the entire area. If the downwind maximum concentration site for ozone is outside the PMSA, these data are not used in this analysis. Finally, the PSI assumes that synergism does not exist between pollutants. Each pollutant is examined independently. Combining pollutant concentrations is not possible at this time because the synergistic effects are not known.

5.3 Description of Graphics

Each of the fifteen cities has all of the principal analyses' highlights expressed in term of a few important bullets and the supporting graphics on a single page. The bullets refer to facts about the MSA's including the 1990 population, the number of active monitoring sites in general and the number specifically for O_3, and the number of CO and O_3 sites used in the 1982-91 trend analysis. The number of trend sites means the number of distinct sites - in some cases there are co-located monitors for CO and O_3 monitors at the same site. The other highlights pertain to the trend graphs presented i.e. the trend in the number of days in the various PSI categories, or in average CO and O_3 concentrations. The wind rose shows the

frequency of hourly wind direction measurements for the morning hours of 7 AM to 10 AM on days when the daily maximum temperature was 85° F or higher over the 1982-91 period. This corresponds to the days that high O_3 concentrations would be expected. The wind direction refers to the direction the wind is blowing from. The wind data comes from one of the National Oceanographic and Atmospheric Administration (NOAA) meteorological observation stations in the area, usually located at the principal airport.

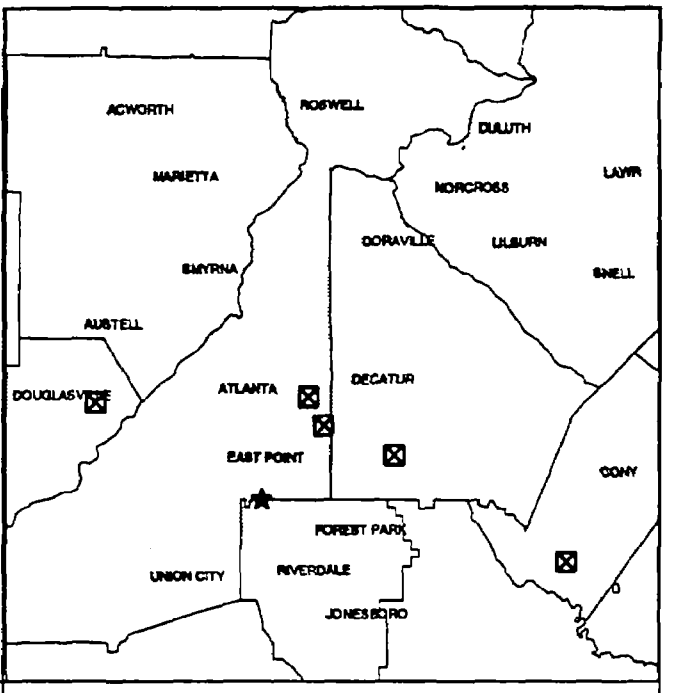
The accompanying graphs are based on the PSI methodology described earlier. The PSI graphs feature a bar chart which shows the number of PSI days in four PSI categories: 0-50, 51-100, 101-199 and $\geq$200. Table 5-1 shows the PSI descriptor words associated with these categories. The last 2 PSI categories (very unhealthful and hazardous) were combined because there were so few hazardous days reported. The total number of unhealthful, very unhealthful and hazardous days is used to indicate trends. These days are sometimes referred to as the days when the PSI is greater than 100. It is important to note that a PSI of 100 means that the pollutant with the highest sub-index value is at the level of its NAAQS. Because of numerical rounding, the number of days with PSI > 100 does not necessarily correspond exactly to the number of NAAQS exceedances.

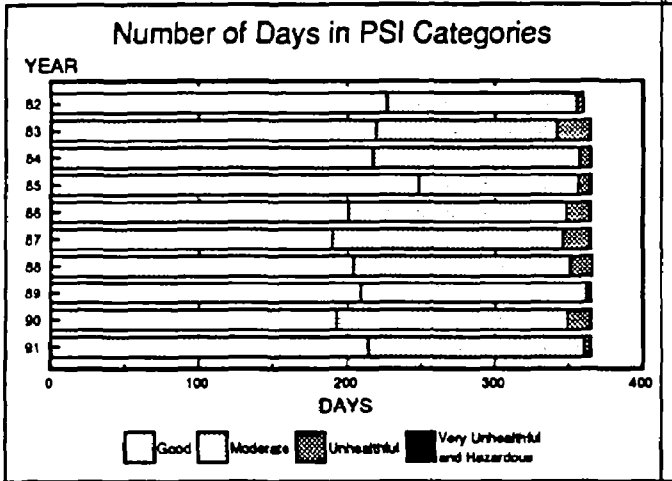
CO and O_3 trends are shown on separate plots with the O_3 graph incorporating information on temperature. CO trends are displayed in terms of the daily maximum 8-hour average data. The CO averages represent all days during the year with data. Maximum daily temperatures are used for O_3. The O_3 plots show the trend in average daily maximum 1-hour concentrations for three categories during the O_3 season: 1.) the ten highest O_3 concentration days, 2.) the days when the maximum temperature was 80° F or more and 3.) for all days. The average maximum temperature on the days with the ten highest ozone values are shown as bars in the background of these graphs. The O_3 season for each of these areas is shown in Table 5-4. These plots are an attempt to indicate the impact of temperature, an important meteorological variable. Ozone levels are highest in the summer, especially on very hot stagnant days, while CO is highest usually in the winter months. The New York MSA is an exception; with high CO levels also occurring on warmer days. The winter, spring, summer and fall seasons that are referred to correspond respectively to the following months: December-February, March-May, June-August and September-November.

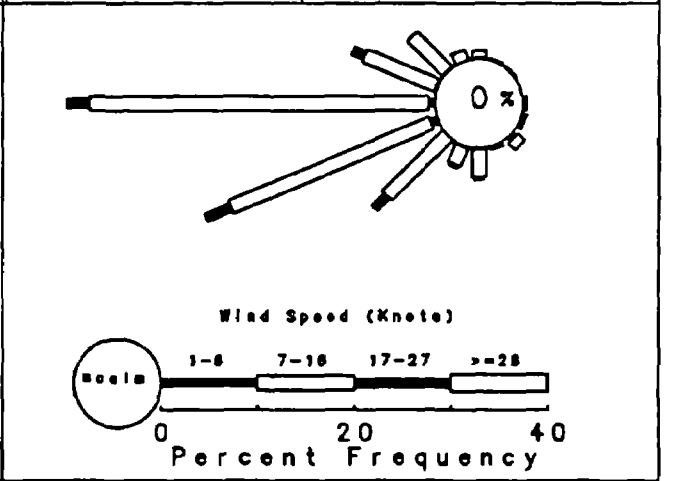
A simple nonparametric test was used to determine the statistical significance of the trends. This test correlated the ranks of the pollution variable, either the number of days that the PSI was above 100 or the annual CO average or the O_3 average in various temperature categories, with the corresponding rank of year. The magnitude of the observed correlation, known as the Spearman correlation coefficient (Rs), indicates the strength of the trend. Coefficients near 1 signify a close agreement between the ranks; whereas, coefficients near 0 signify no agreement. When a trend is noted, it is understood that the Rs was significant at the 0.10 level. The following sections present the metropolitan areas analyses.

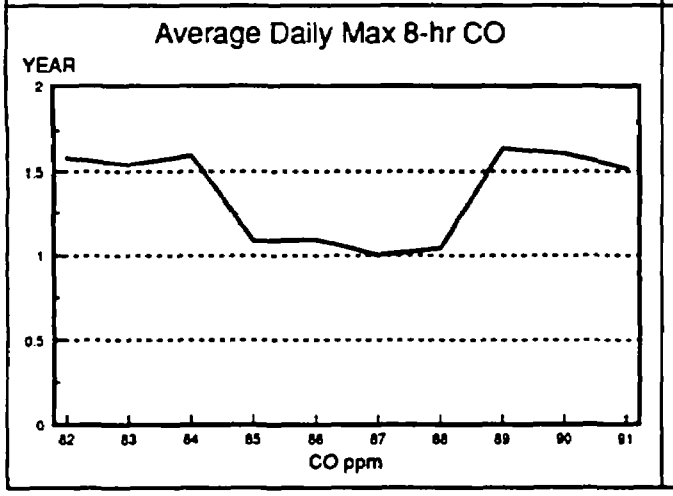
Atlanta, GA

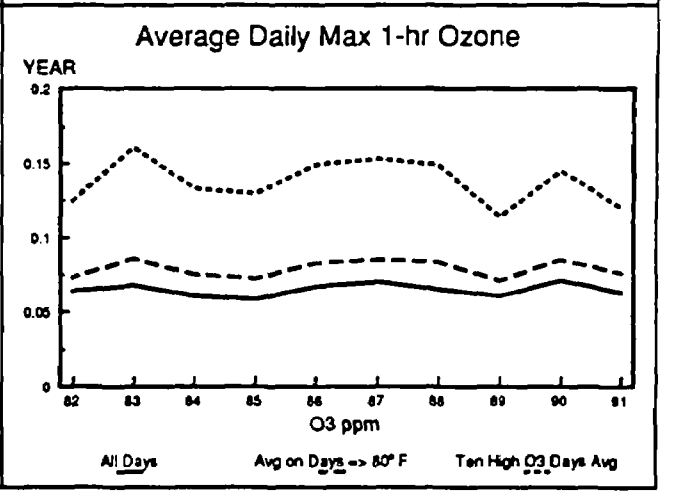
* 1990 POPULATION 2.8 MILLION
* 13 ACTIVE MONITORING SITES - 5 O3 SITES
* 3 PSI TREND SITES (1 CO, 2 O3)
* 1991 - 5 DAYS WHEN PSI>100
* DAYS PSI>100 - 98% DUE TO O3 (1982-91)
* AVERAGE CO LEVELS LOW DURING 1985-88
* AVERAGE O3 LEVELS STABLE (1982-91)





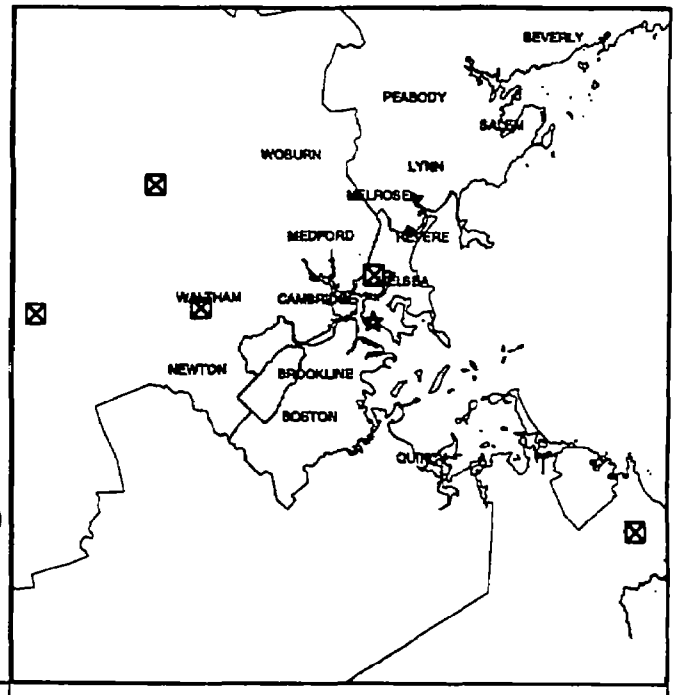


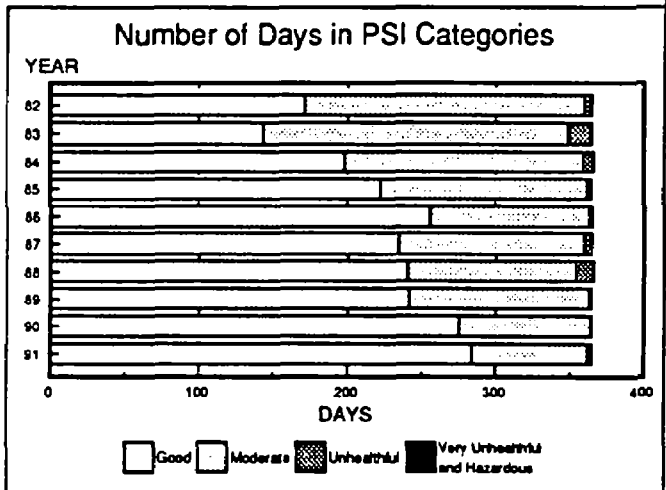


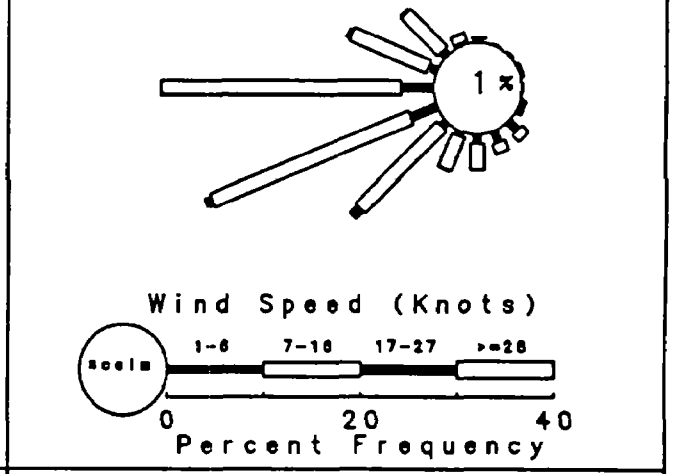


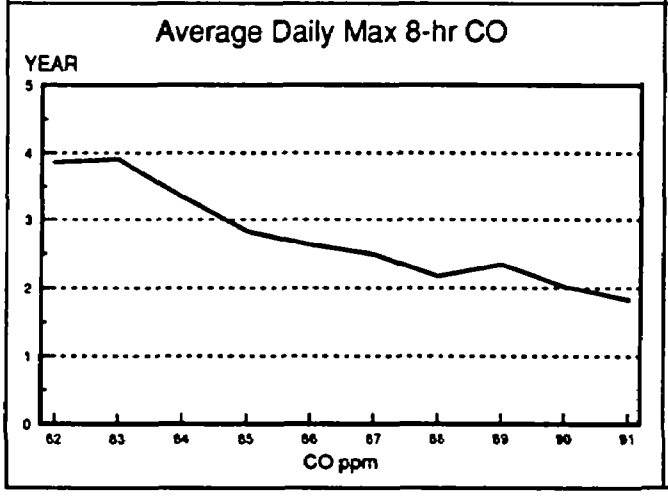
Boston, MA

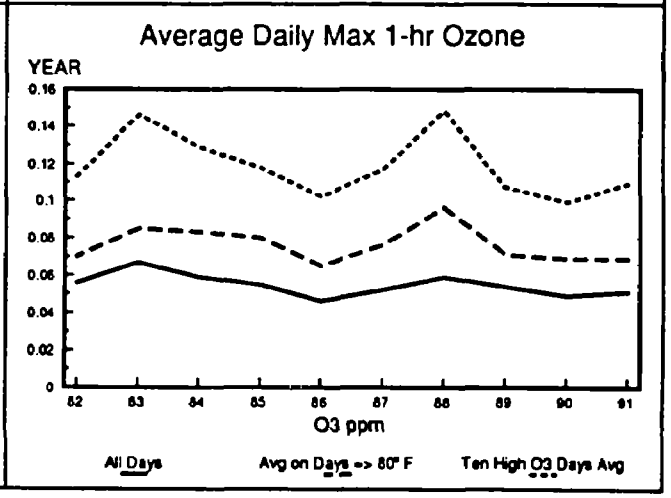
* 1990 POPULATION 2.9 MILLION
* 29 ACTIVE MONITORING SITES - 5 O3 SITES
* 4 PSI TREND SITES (2 CO, 2 O3)
* 1991 - 3 DAYS WHEN PSI>100
* DAYS PSI>100 - 84% DUE TO O3 (1982-91)
* AVERAGE CO LEVELS DECREASED - 53% (1982-91)
* AVERAGE O3 LEVELS STABLE (1982-91)





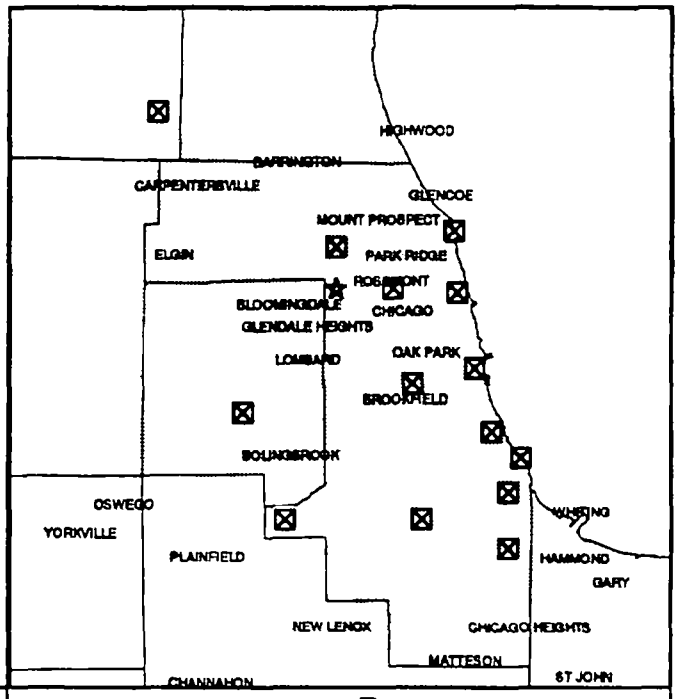


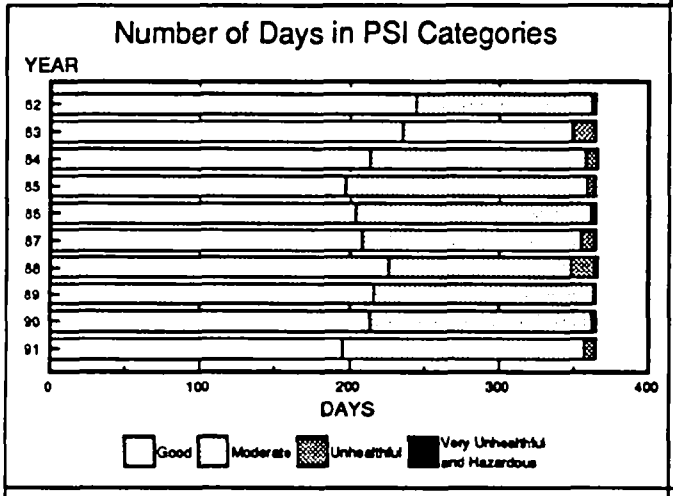


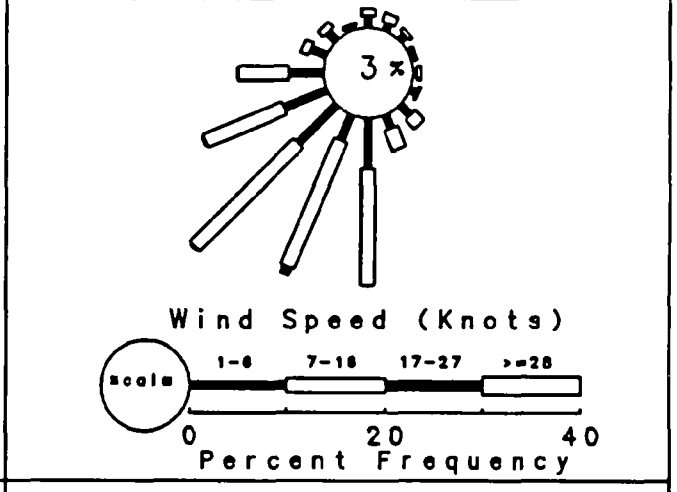


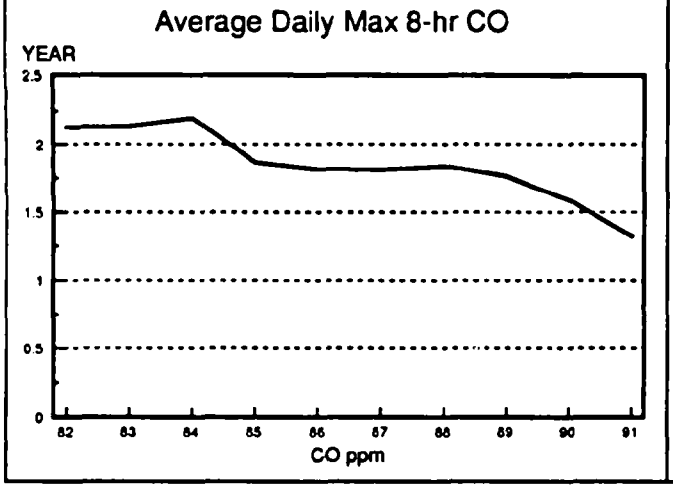
Chicago, IL

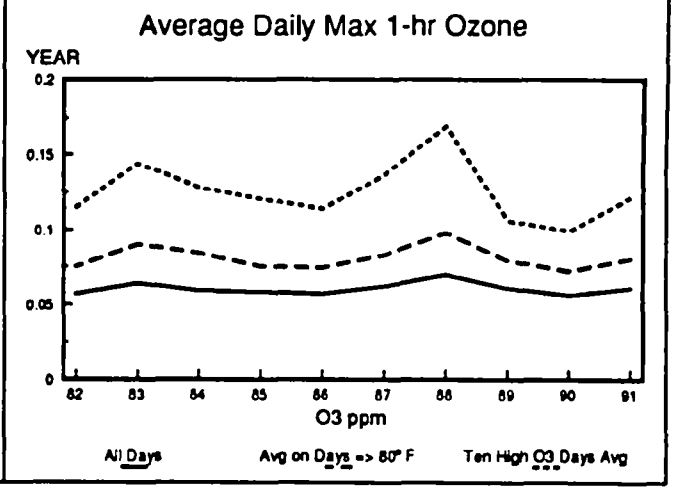
* 1990 POPULATION 6.1 MILLION
* 45 ACTIVE MONITORING SITES - 14 O3 SITES
* 7 PSI TREND SITES (2 CO&O3, 1 CO, 4 O3)
* 1991 - 8 DAYS WHEN PSI>100
* DAYS PSI>100 - 79% DUE TO O3 (1982-91)
* AVERAGE CO LEVELS DECREASED (1982-91)
* AVERAGE O3 LEVELS STABLE (1982-91)











Dallas, TX

* 1990 POPULATION 2.6 MILLION

* 28 ACTIVE MONITORING SITES - 6 O3 SITES

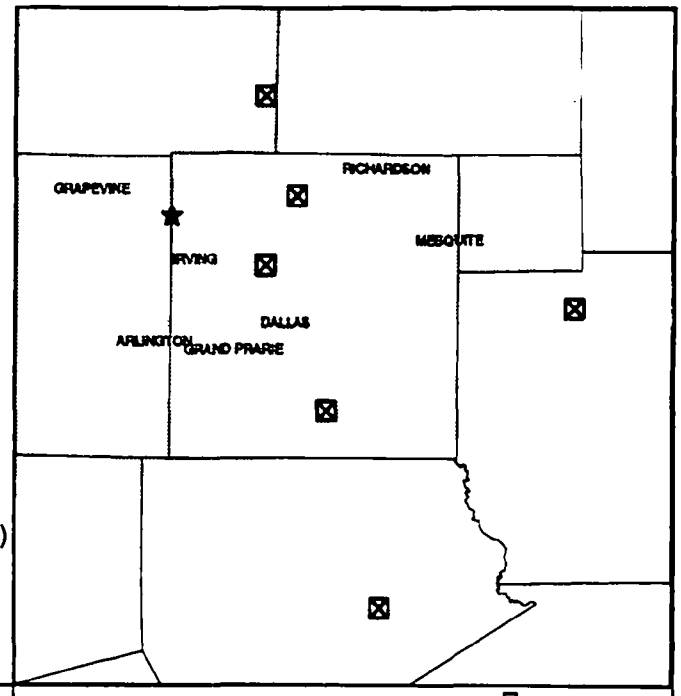
* 4 PSI TREND SITES (1 CO, 3 O3)

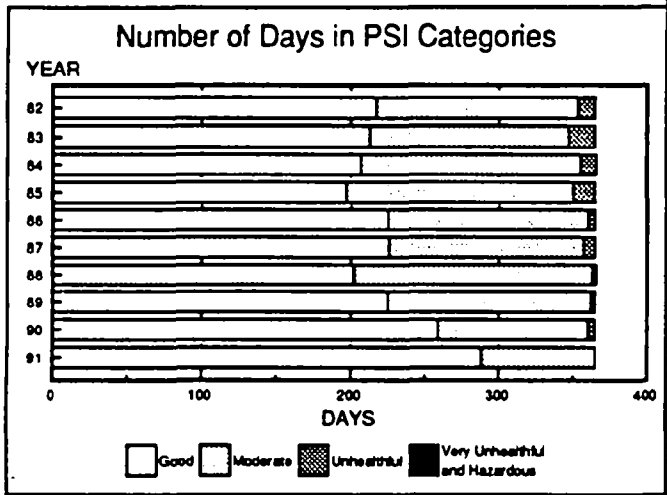
* 1991 - 0 DAYS WHEN PSI>100
  - 1st TIME IN LAST 10 YEARS

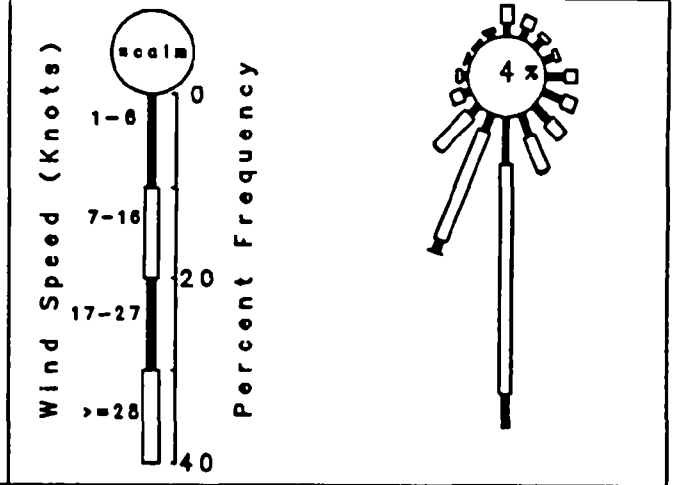
* DAYS PSI>100 - 99% DUE TO O3 (1982-91)

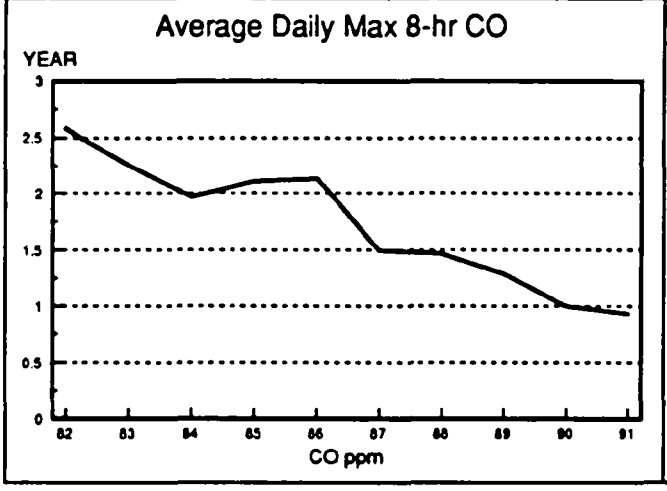
* AVERAGE CO LEVELS DECREASED - 64% (1982-91)

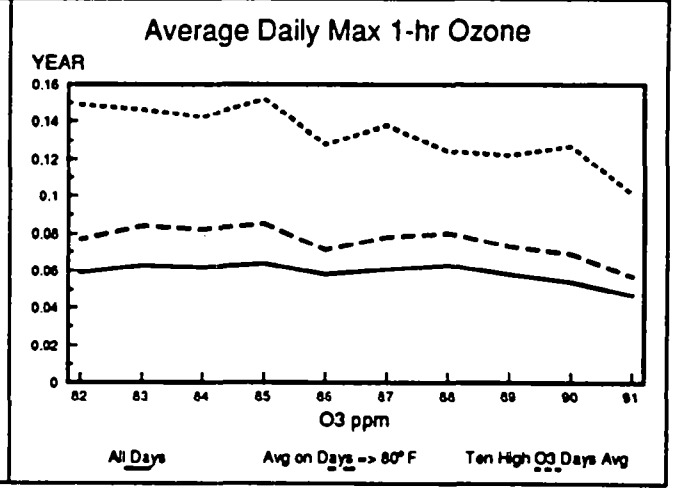
* AVERAGE O3 LEVELS DECREASED (1982-91)





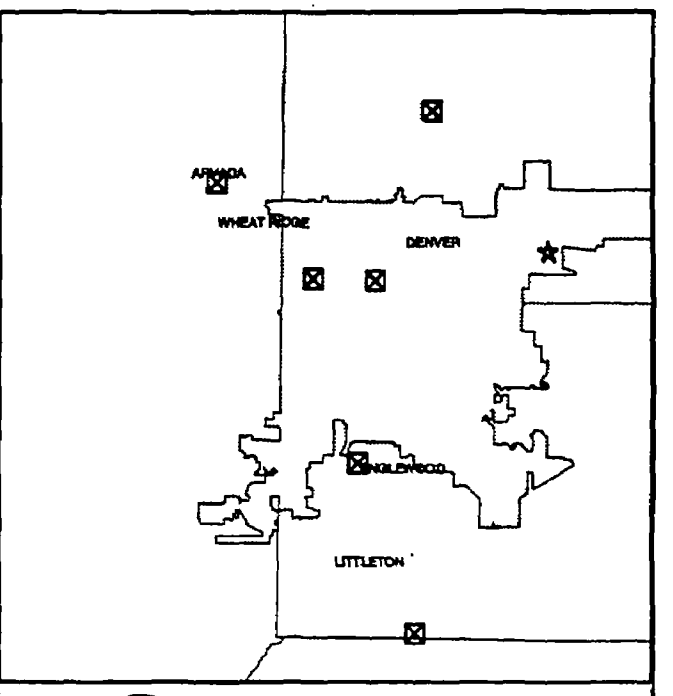


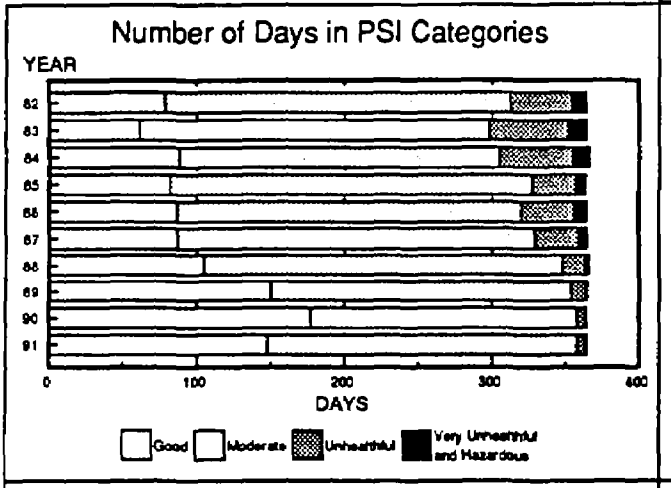


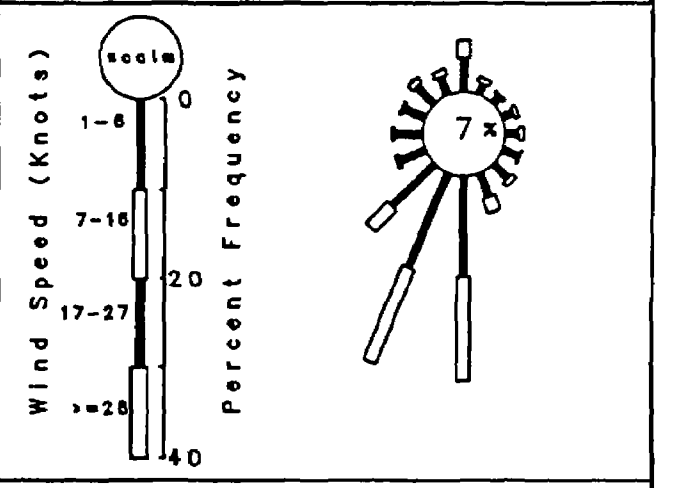


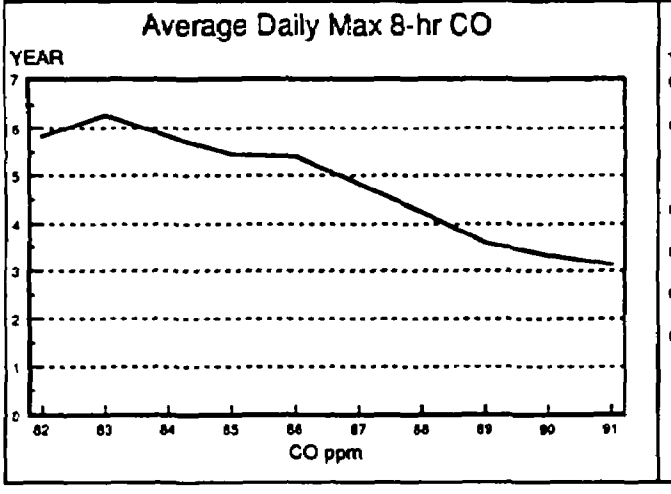
Denver, CO

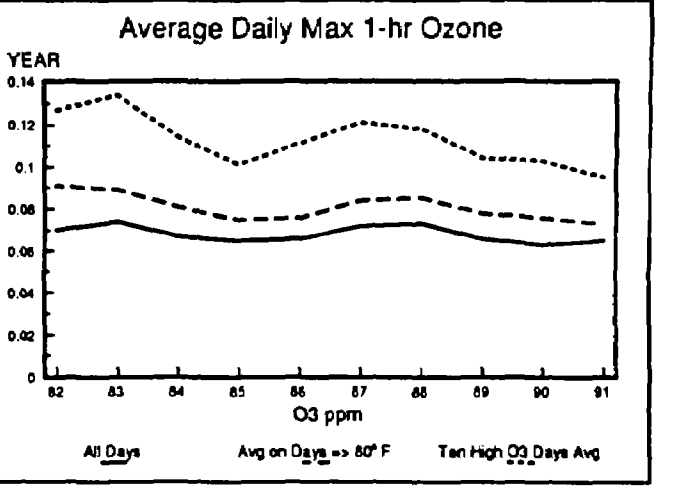
* 1990 POPULATION 1.6 MILLION
* 27 ACTIVE MONITORING SITES - 6 O3 SITES
* 5 PSI TREND SITES (2 CO&O3, 3 CO)
* # OF DAYS WHEN PSI>100 DECREASED (1982-91)
* 1990-91 - 7 DAYS WHEN PSI>100
* DAYS PSI>100 - 92% DUE TO CO (1982-91)
* AVERAGE CO LEVELS DECREASED - 46% (1982-91)
* AVERAGE O3 LEVELS DECREASED (1982-91)





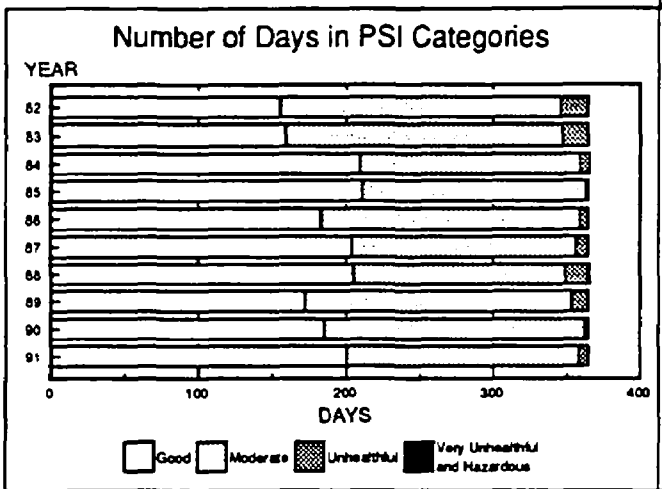


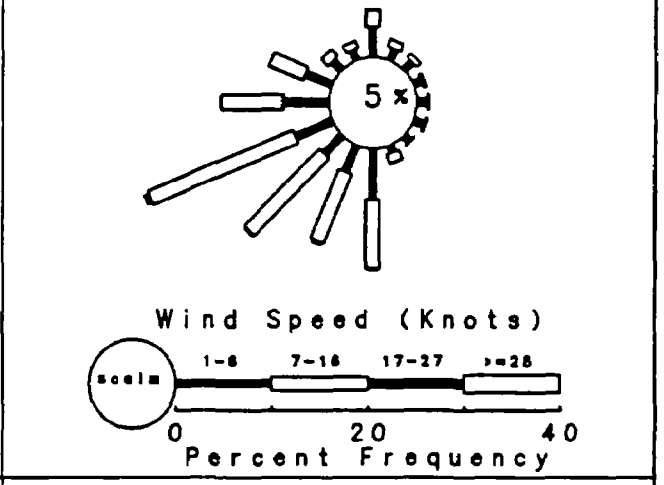


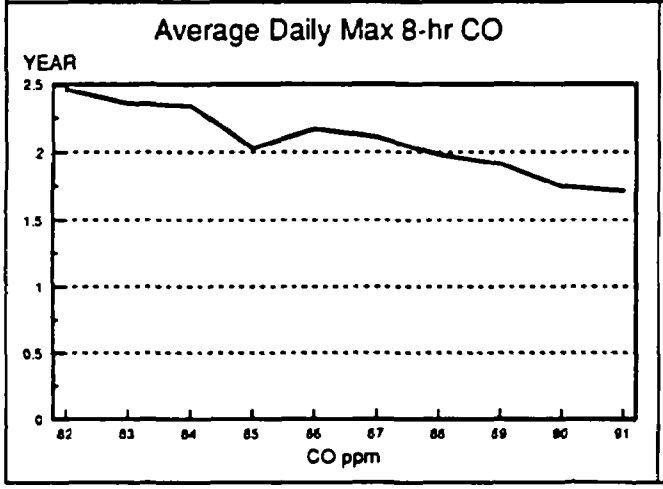


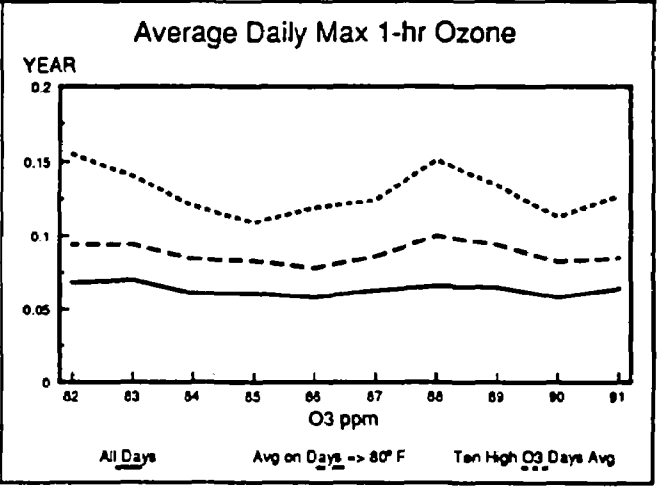
Detroit, MI

* 1990 POPULATION 4.4 MILLION
* 29 ACTIVE MONITORING SITES - 9 O3 SITES
* 9 PSI TREND SITES (5 CO&O3, 1 CO, 3 O3)
* DAYS WHEN PSI>100 - 83% DUE TO O3 (1982-91)
* AVERAGE CO LEVELS DECREASED - 30% (1982-91)
* AVERAGLE O3 LEVELS STABLE (1982-91)









Houston, TX

* 1990 POPULATION 3.3 MILLION

* 27 ACTIVE MONITORING SITES - 11 O3 SITES

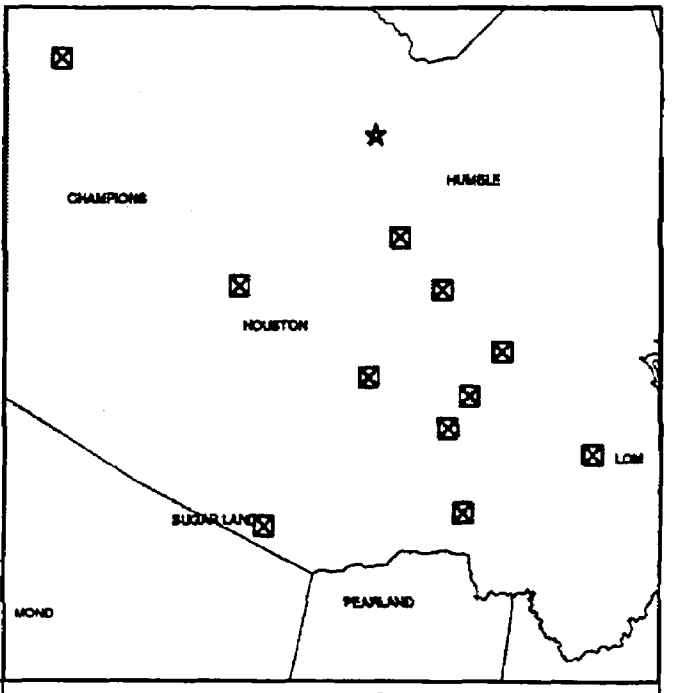
* 10 PSI TREND SITES (3 CO&O3, 1 CO, 6 O3)

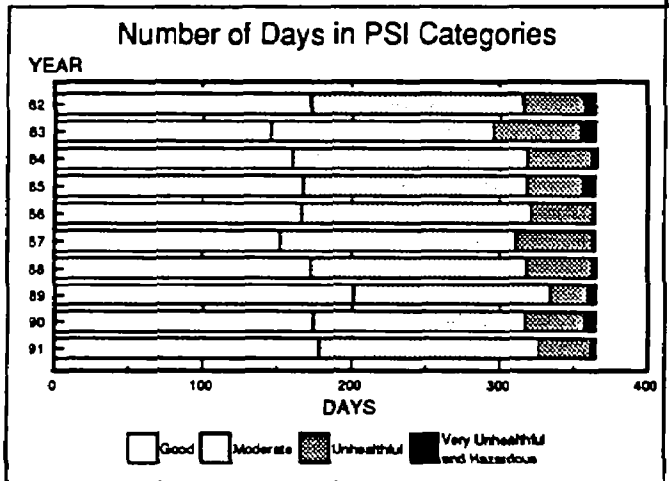
* 1991 - 39 DAYS WHEN PSI>100
  - 2nd LOWEST IN PAST 10 YEARS

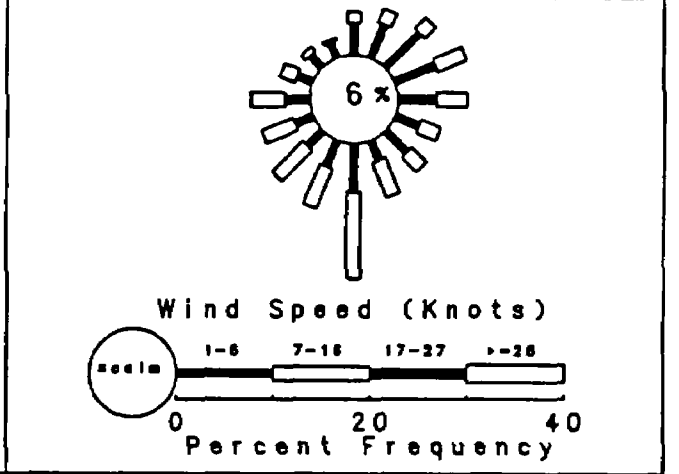
* DAYS PSI>100 - 98% DUE TO O3 (1982-91)

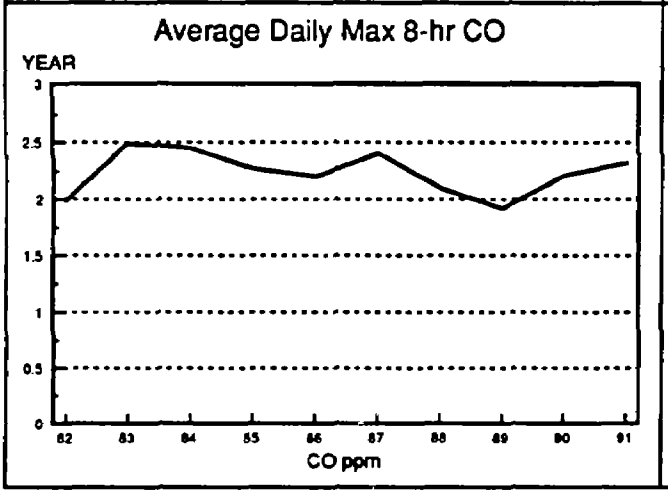
* AVERAGE CO LEVELS STABLE (1982-91)

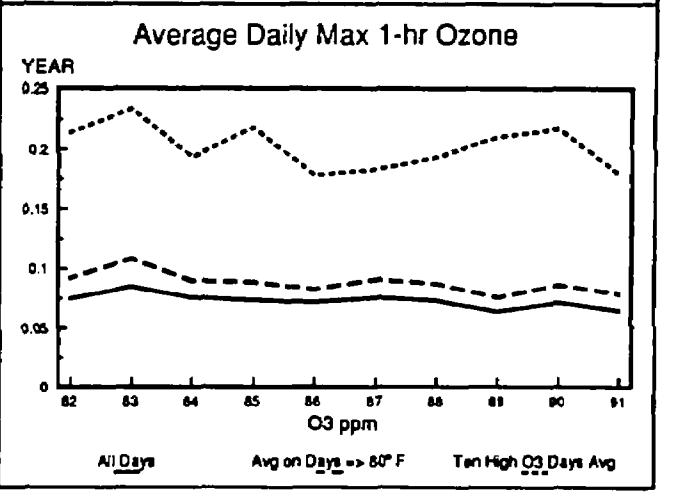
* AVERAGE O3 LEVELS DECREASED (1982-91)





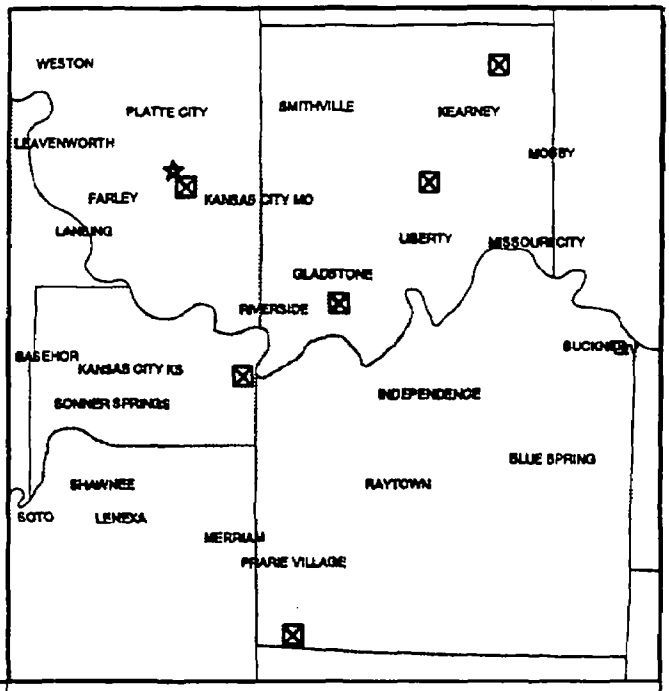


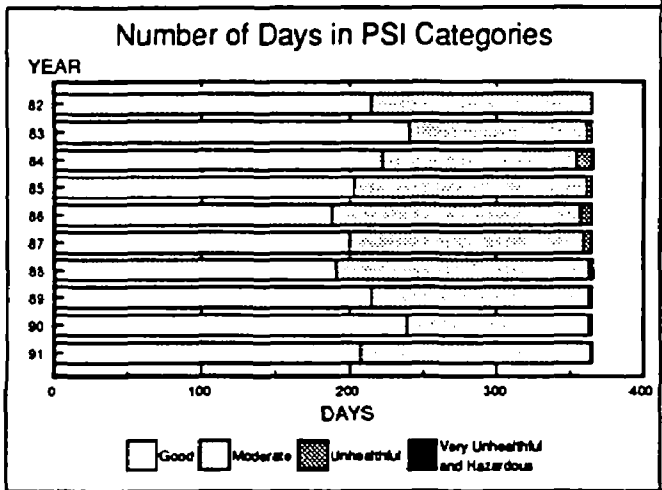


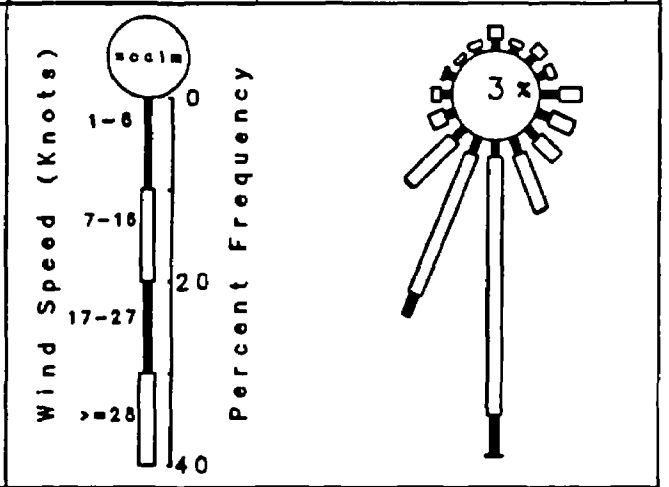


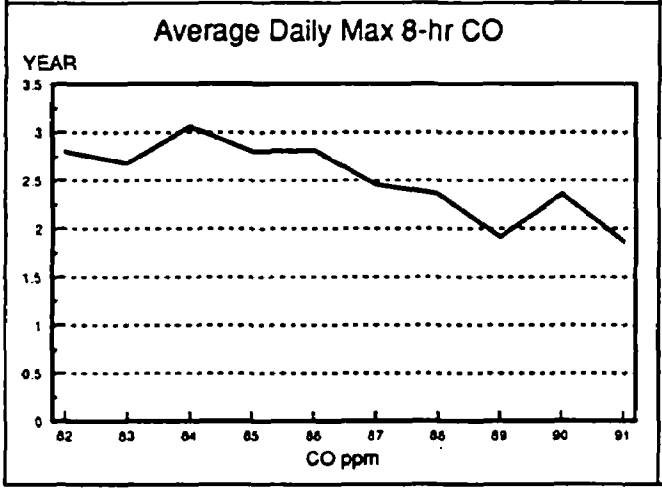
Kansas City, MO-KS

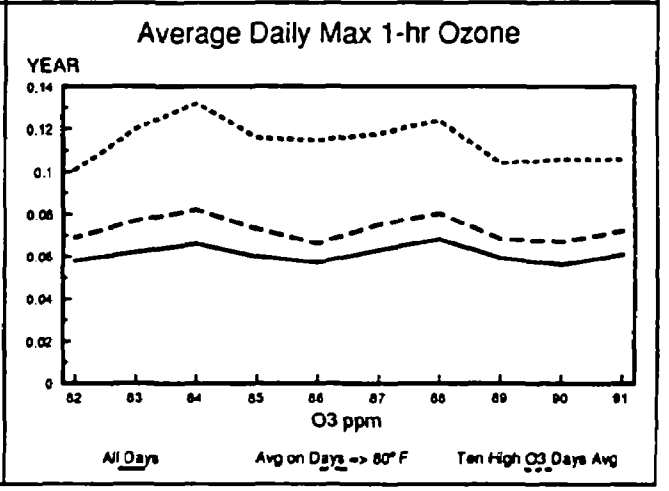
* 1990 POPULATION 1.6 MILLION
* 21 ACTIVE MONITORING SITES - 6 O3 SITES
* 8 PSI TREND SITES (1 CO&O3, 3 CO, 4 O3)
* # OF DAYS WHEN PSI>100 DECREASED (1982-91)
* 1991 - ONLY 1 DAY WHEN PSI>100
* DAYS PSI>100 - 71% DUE TO O3 (1982-91)
* AVERAGE CO LEVELS DECREASED - 33% (1982-91)
* BECAME ATTAINMENT FOR OZONE IN 1992





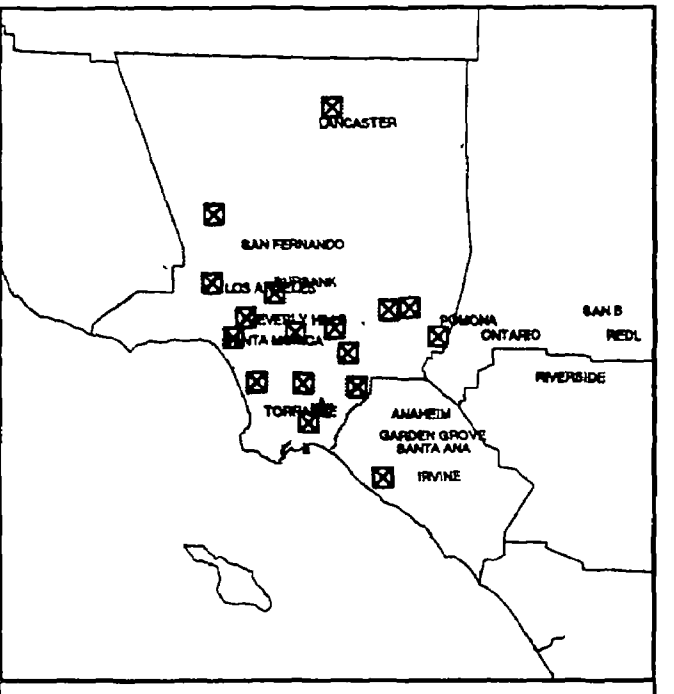


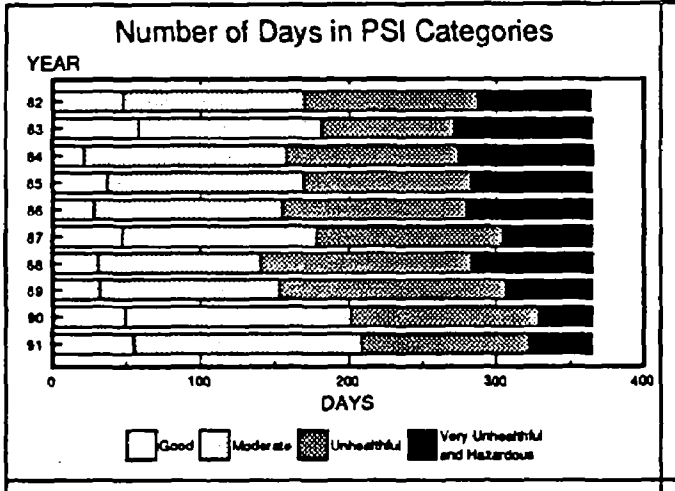


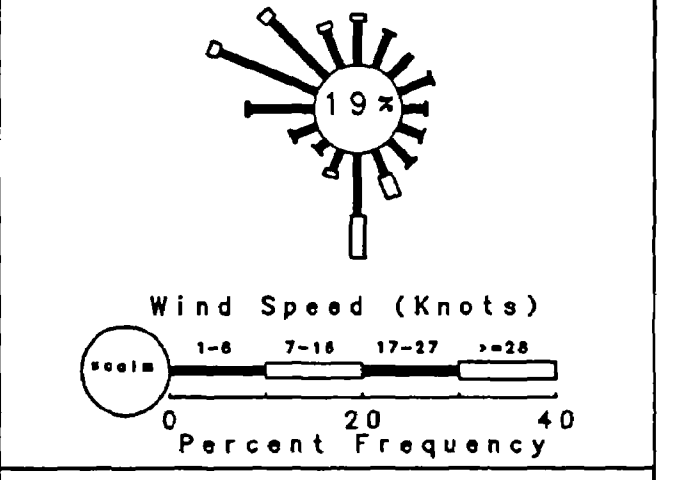


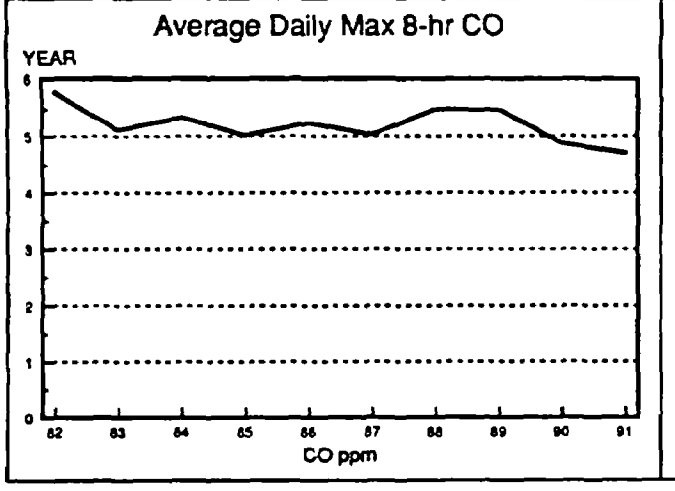
Los Angeles, CA

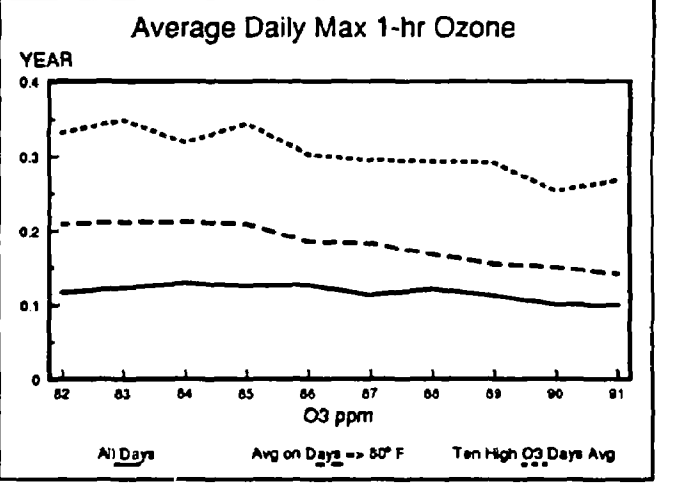
* 1990 POPULATION 8.9 MILLION
* 33 ACTIVE MONITORING SITES - 17 O3 SITES
* 14 PSI TREND SITES (11 CO&O3, 1 CO, 2 O3)
* 1991 - 156 DAYS WHEN PSI>100
  - LOWEST IN PAST 10 YEARS
* DAYS PSI>100 - 73% DUE TO O3 (1982-91)
* AVERAGE OF 194 DAYS WHEN PSI>100 (1982-91)
* AVERAGE CO LEVELS STABLE (1982-91)
* AVERAGE O3 LEVELS DECREASED (1982-91)





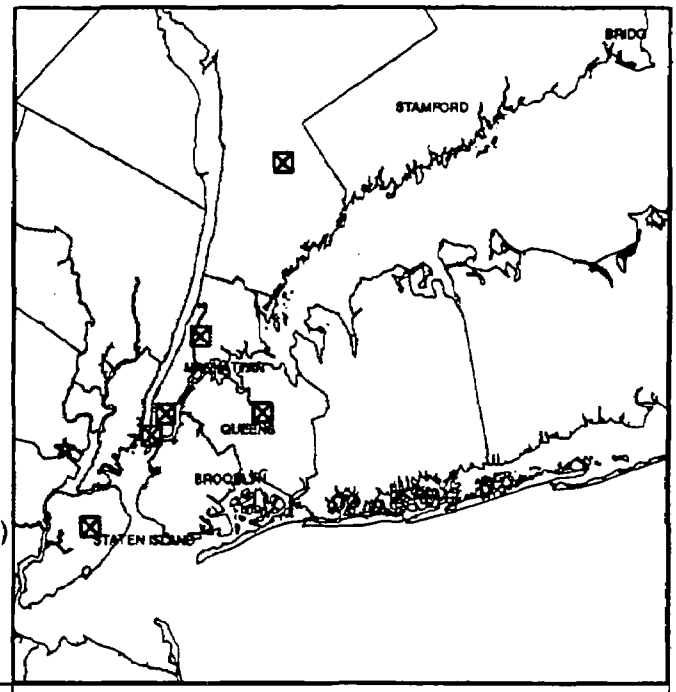


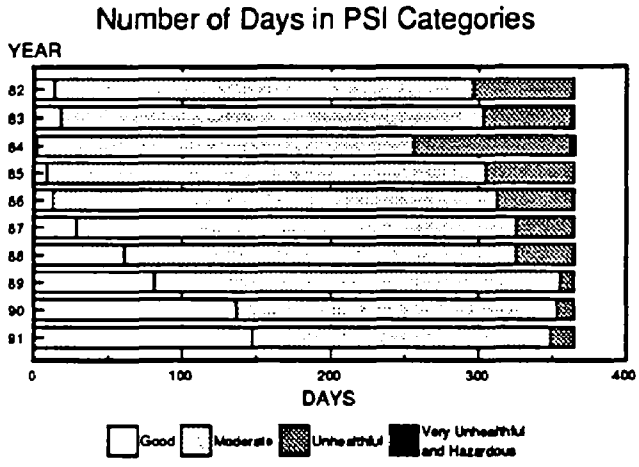


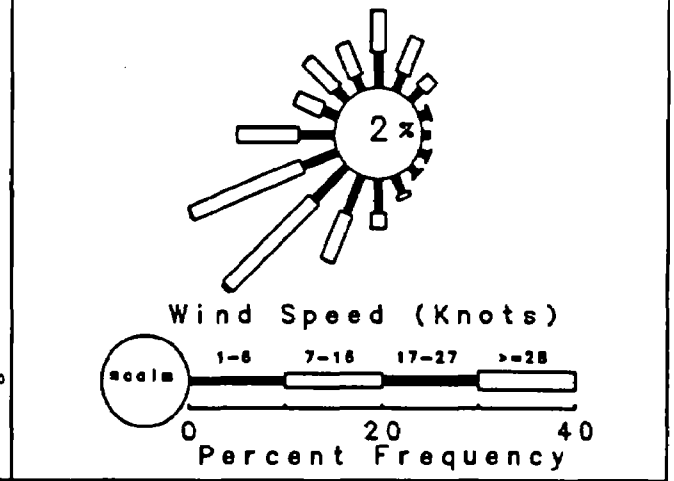


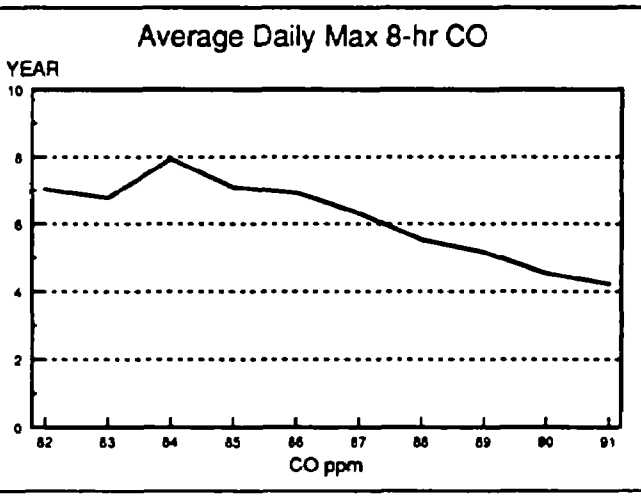
New York, NY

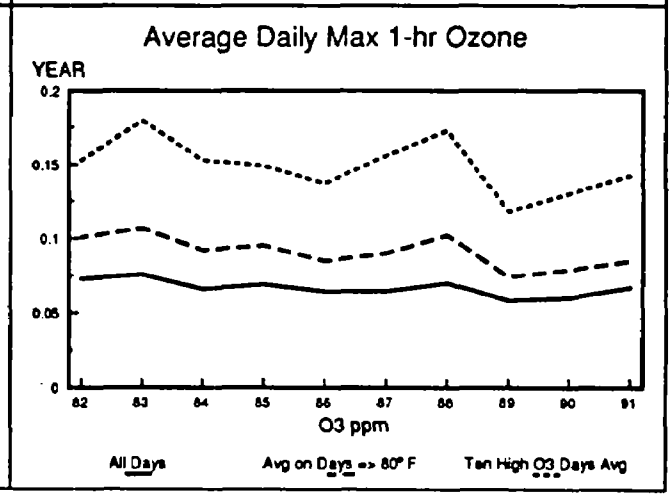
* 1990 POPULATION 8.5 MILLION
* 25 ACTIVE MONITORING SITES - 6 O3 SITES
* 8 PSI TREND SITES (4 CO, 4 O3)
* # OF DAYS WHEN PSI>100 DECREASED (1982-91)
* DAYS PSI>100 - 69% DUE TO CO (1982-91)
* AVERAGE CO LEVELS DECREASED - 40% (1982-91)
* AVERAGE O3 LEVELS DECREASED (1982-91)





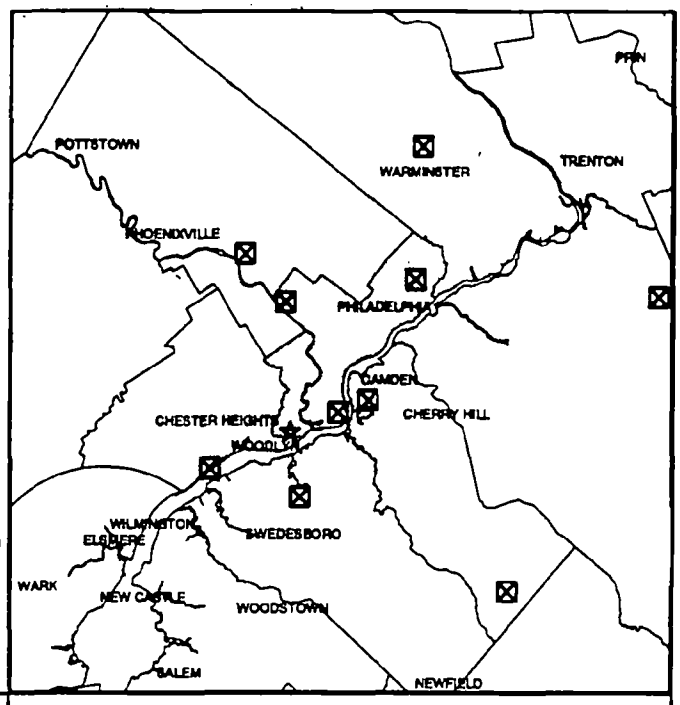


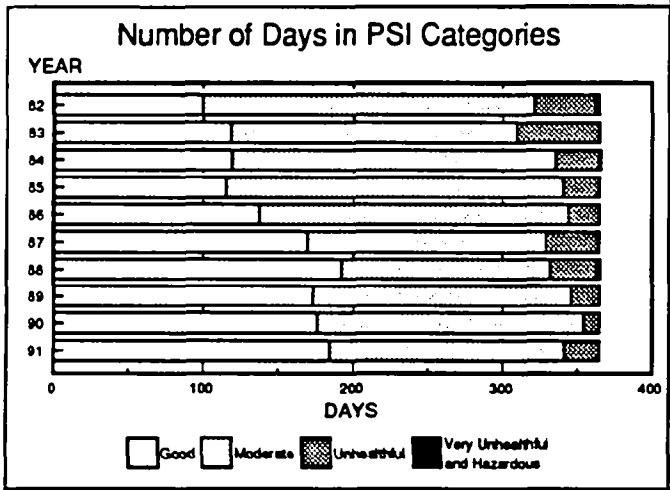


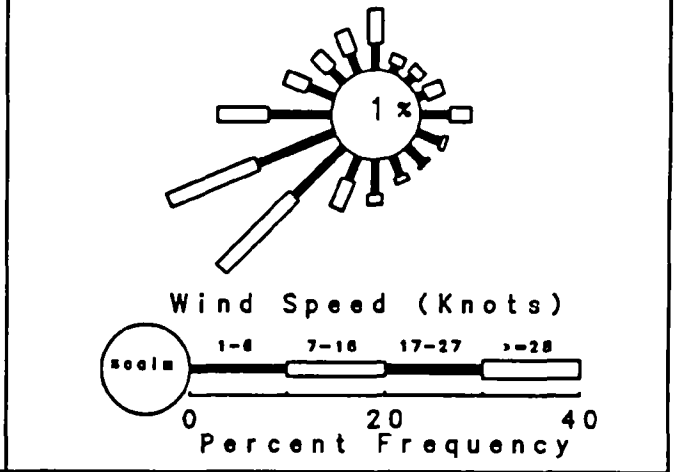


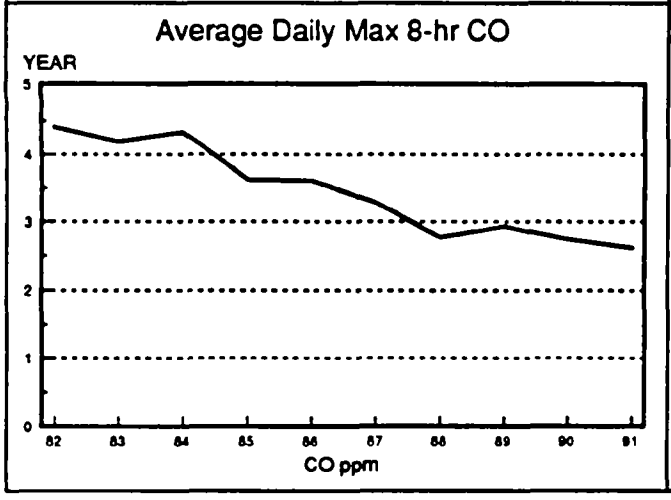
Philadelphia, PA

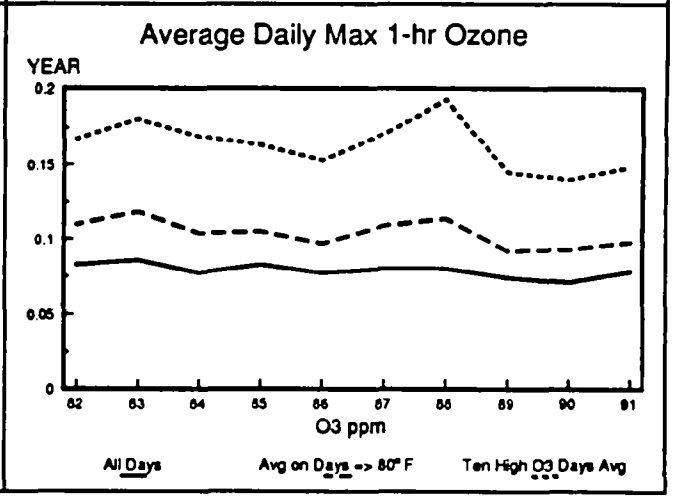
* 1990 POPULATION 4.9 MILLION
* 41 ACTIVE MONITORING SITES - 10 O3 SITES
* 15 PSI TREND SITES (4 CO&O3, 5 CO, 6 O3)
* 1991 - 24 DAYS WHEN PSI>100 - UP FROM 1989&90
* DAYS PSI>100 - 89% DUE TO O3 (1982-91)
* AVERAGE CO LEVELS DECREASED - 40% (1982-91)
* AVERAGE O3 LEVELS STABLE (1982-91)





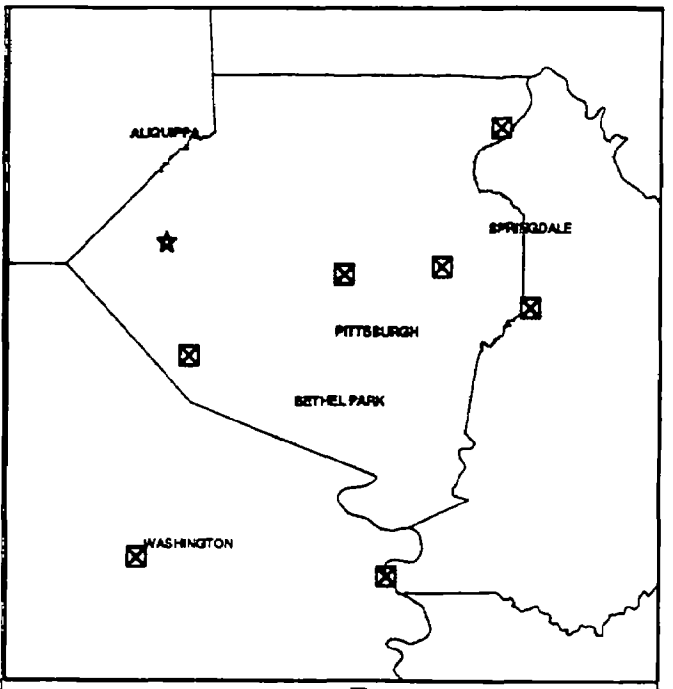


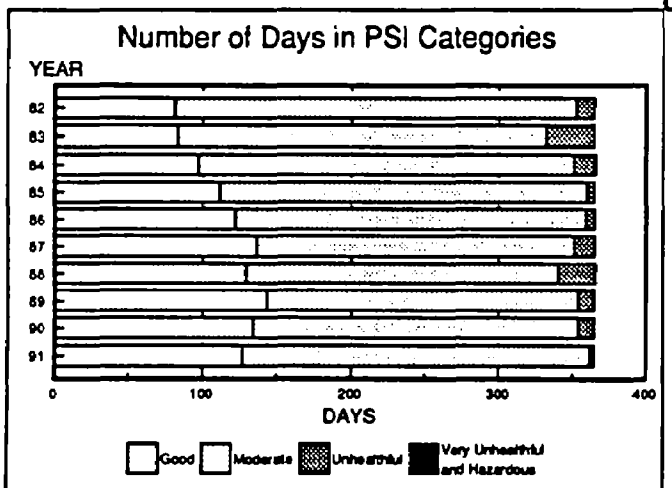


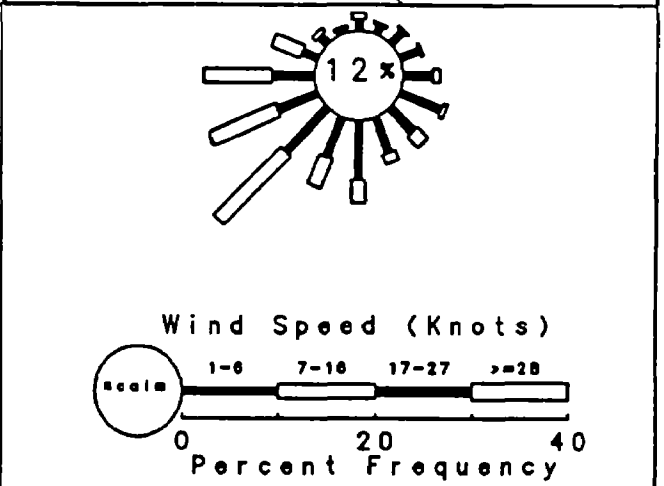


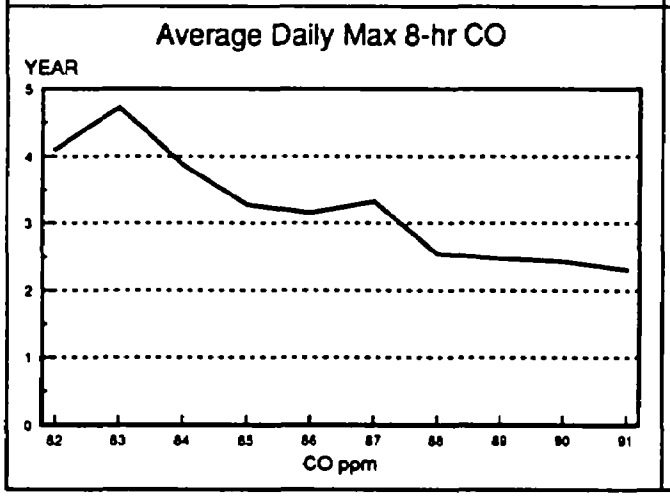
Pittsburgh, PA

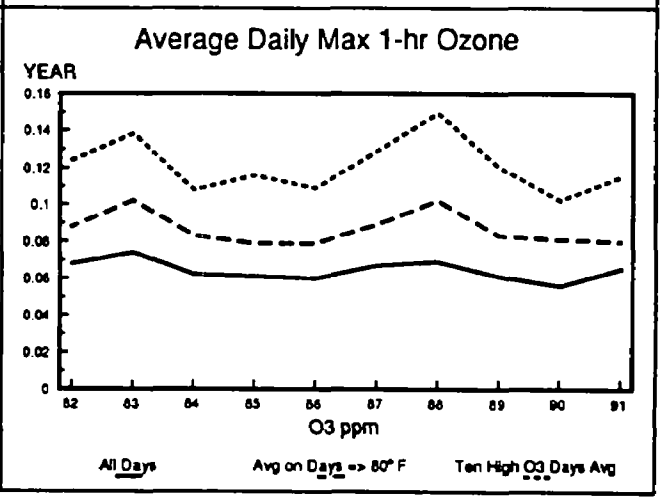
* 1990 POPULATION 2.1 MILLION
* 39 ACTIVE MONITORING SITES - 7 O3 SITES
* 12 PSI TREND SITES (3 CO, 5 O3, 4 SO2)
* 1991 - 3 DAYS WHEN PSI>100
  - LOWEST IN PAST 10 YEARS
* DAYS PSI>100 - 41% DUE TO O3 (1982-91)
* AVERAGE CO LEVELS DECREASED
  - 44% (1982-91)
* AVERAGE O3 LEVELS STABLE (1982-91)





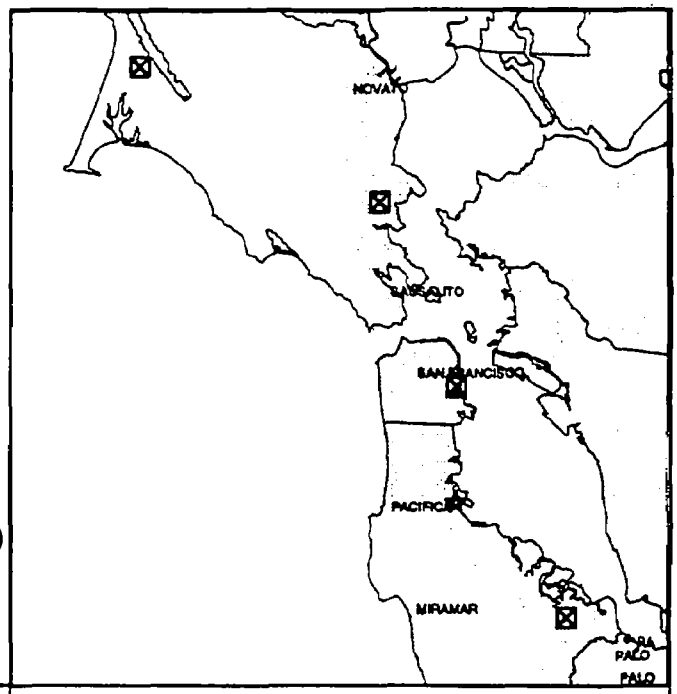


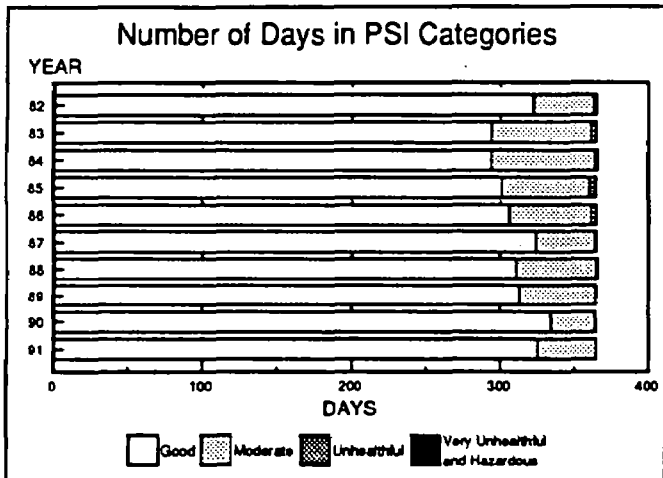


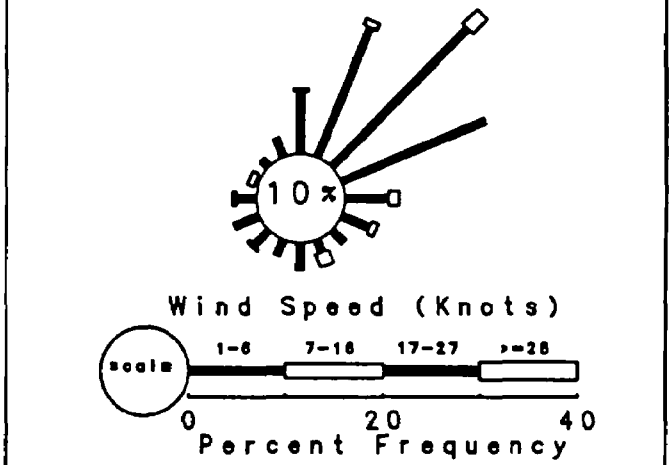


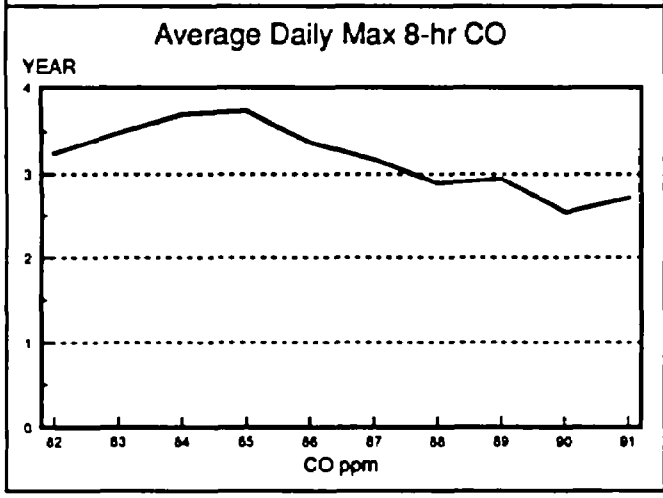
San Francisco, CA

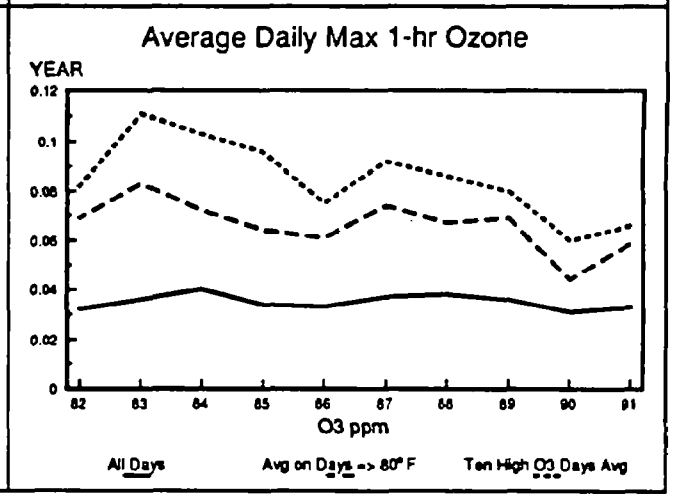
* 1990 POPULATION 1.6 MILLION
* 8 ACTIVE MONITORING SITES - 4 O3 SITES
* 3 PSI TREND SITES (2 CO&O3, 1 CO)
* 1990 - 1 DAY WHEN PSI>100
  1989&91 - 0 DAYS WHEN PSI>100
* DAYS PSI>100 - 80% DUE TO CO (1982-91)
* AVERAGE CO LEVELS DECREASED - 16%(1982-91)
* AVERAGE O3 LEVELS DECREASED (1982-91)











Seattle, WA

* 1990 POPULATION 2.0 MILLION

* 20 ACTIVE MONITORING SITES - 3 O3 SITES

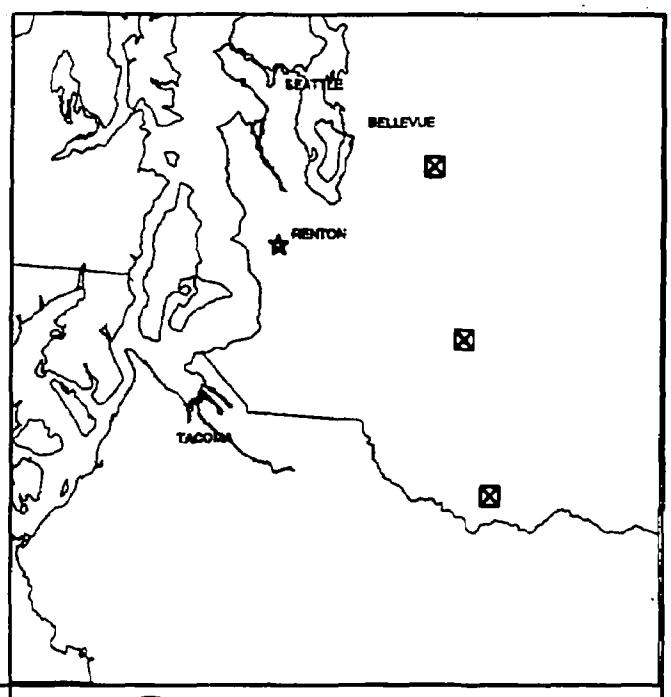
* 7 PSI TREND SITES (6 CO, 1 O3)

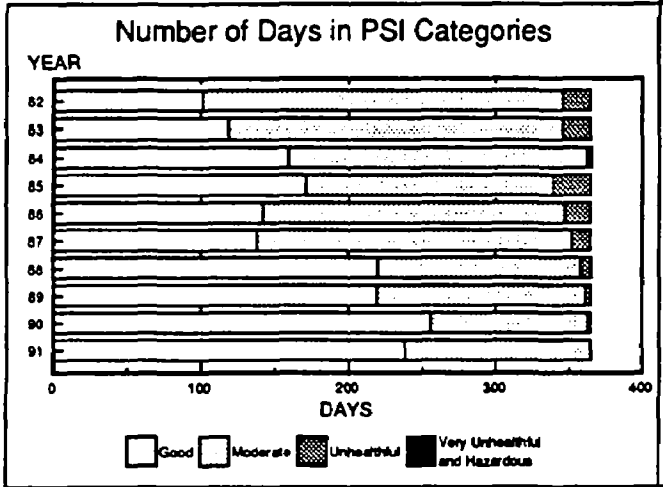
* 1991 - 0 DAYS WHEN PSI>100
  - 1st TIME IN LAST 10 YEARS

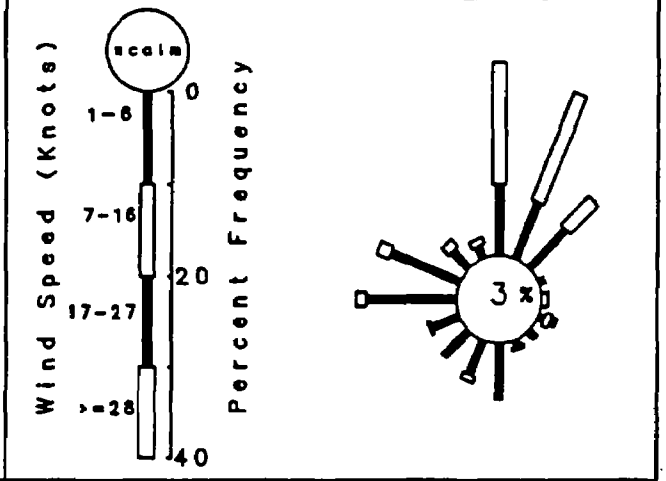
* DAYS PSI>100 - 88% DUE TO CO (1982-91)

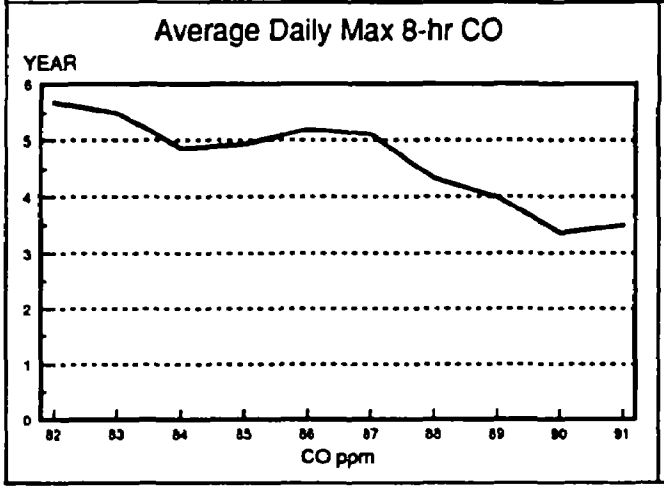
* AVERAGE CO LEVELS DECREASED 38% (1982-91)

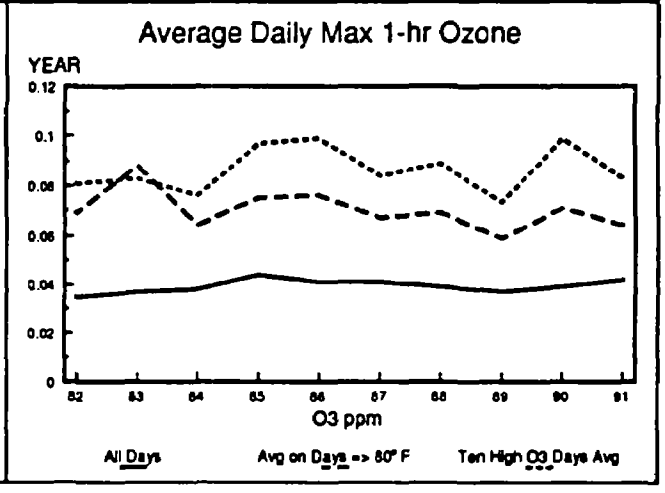
* AVERAGE O3 LEVELS STABLE (1982-91)





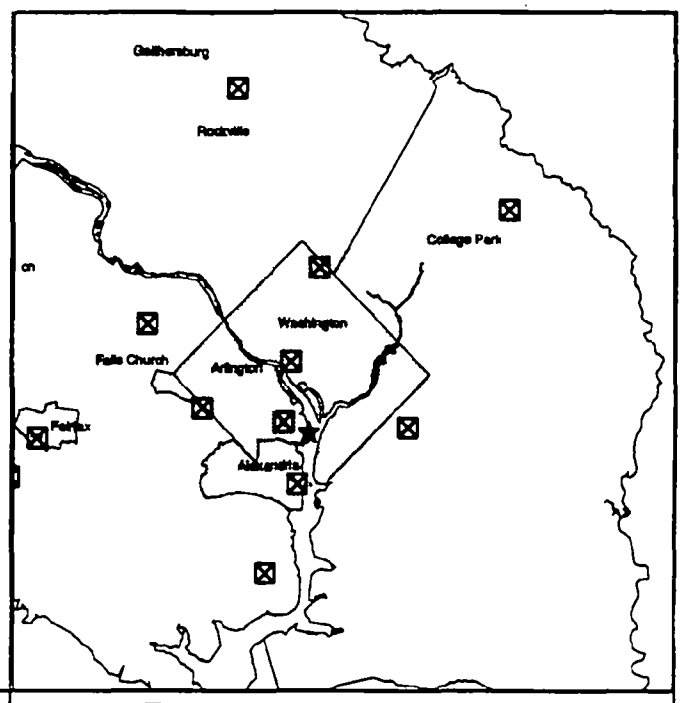


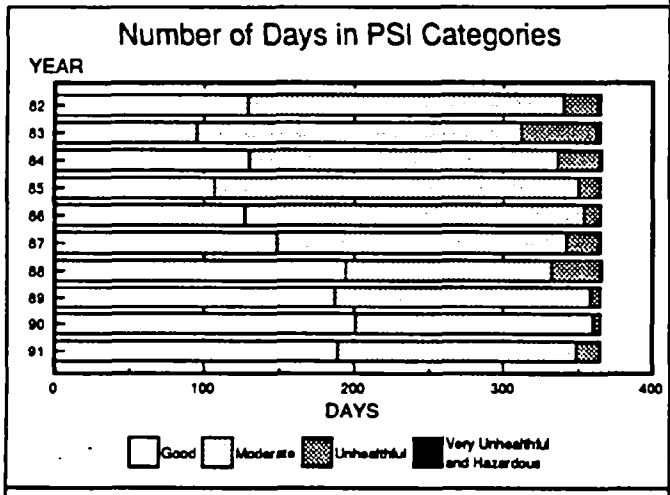


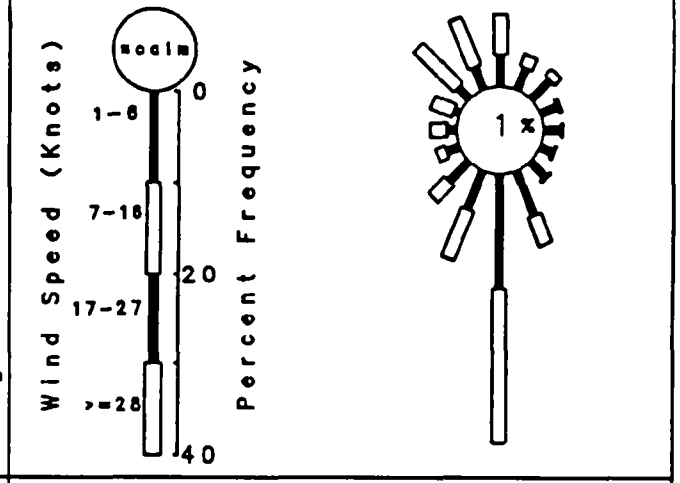


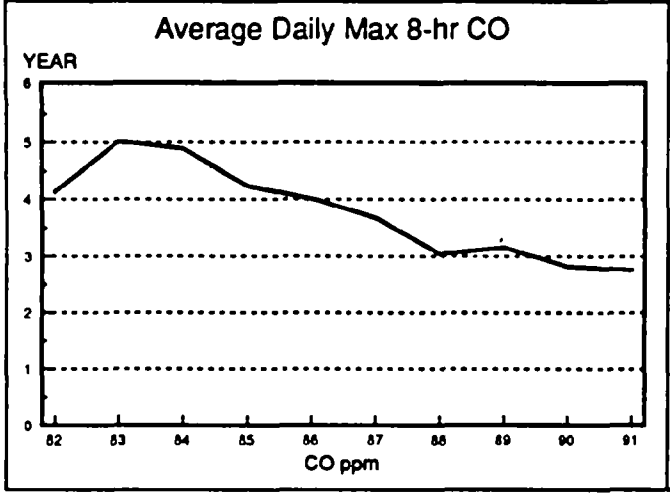
Washington, DC-MD-VA

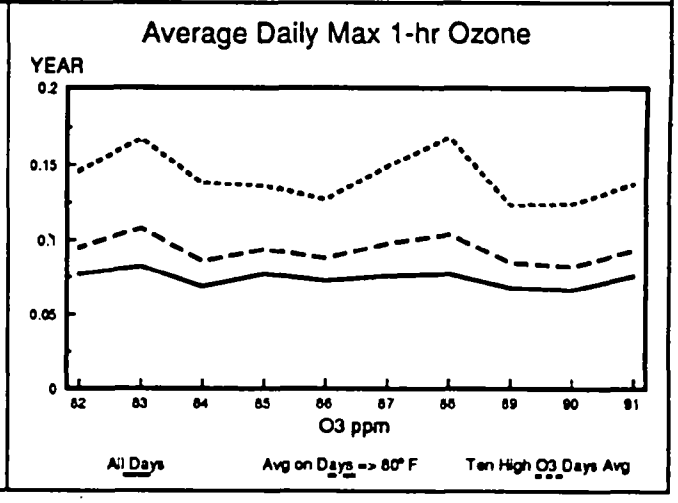
* 1990 POPULATION 3.9 MILLION
* 37 ACTIVE MONITORING SITES - 13 O3 SITES
* 14 PSI TREND SITES (7 CO&O3, 3 CO, 4 O3)
* 1991 - 16 DAYS WHEN PSI>100
* DAYS PSI>100 - 76% DUE TO O3 (1982-91)
* AVERAGE CO LEVELS DECREASED - 33% (1982-91)
* AVERAGE O3 LEVELS STABLE (1982-91)











6. INTERNATIONAL AIR POLLUTION PERSPECTIVE

This chapter discusses air pollution emissions, trend patterns, and levels for selected cities around the world. Because the form of air quality standards and goals may differ among countries, common air quality statistics have been selected for comparison purposes. Definitions and monitoring methods may vary from country to country, therefore, comparisons among nations are subject to caution. Trends observed within each country may be more reliable than comparisons between countries.

6.1 EMISSIONS

As a result of human activities involving stationary and mobile sources, world-wide anthropogenic emissions of SO_x are currently estimated to be approximately 99 million metric tons.[1] Fossil fuel combustion accounts for approximately 90% of the global human-induced SO_x emissions.[2] Over the past few decades, global SO_x emissions have increased by approximately 4% per year, corresponding to the increase in world energy consumption.

Recent data indicate that emissions of SO_x have been significantly reduced in many developed countries (Figure 6-1). Table 6-1 provides additional comparative information on SO_x emissions. About 90% of the human-induced emissions originate in the Northern Hemisphere. The United States and countries within the former Soviet Union are the two biggest sources.[3] For example, in 1975, the United States emitted approximately 26 million metric tons of SO_x, which had been reduced to approximately 21 million metric tons by 1990.[3,4] Countries within the former Soviet Union emitted approximately 20 million metric tons in 1981 compared to approximately 18 million metric tons in 1988.[5] Much less information is available for emission trends in developing countries. However, there are indications that SO_x emissions are increasing in these developing areas and SO_x pollution is evident in countries such as China, Mexico, and India.[2,3,5]

In 1990, global emissions of suspended particulate matter was estimated to be approximately 57 million metric tons per year.[6] However, estimates vary widely. The United Nations Environment Program (UNEP) has estimated the global total to be closer to 135 million metric tons.[3] Despite increased coal combustion, in many industrialized countries, particulate emissions have decreased because of cleaner burning techniques.[3] Table 6-1 provides additional information on particulate emissions to allow for comparisons among countries. For Eastern Europe and other developing countries, although information is scarce, particulate emissions appear to be increasing.[3]

6.2 AMBIENT CONCENTRATIONS

On a global scale, in general, declining annual average SO_2 levels over time correspond with declining emission trends (Figure 6-1). Trends in SO_2 annual average concentration levels for developed countries within the Organization for Economic Cooperation and Development (OECD) are displayed in Table 6-2. Again, the focus should be more on the direction of change rather than on a comparison of absolute levels, because monitoring methods and siting objectives may vary among countries. Figure 6-2 compares changes in the second-highest 24-hour sulfur dioxide concentrations at two sites in the United States with similar data at sites located in Montreal (Quebec) and Toronto (Ontario), Canada.[7]

Similar to trend estimates for SO_2 concentrations, suspended particulate matter annual average concentrations in cities are

declining in many of the world's industrialized cities. Urban particulate matter concentrations have declined in OECD countries from annual average concentrations of between 50 and 100 $\mu g/m^3$ in the early 1970s, to levels now ranging between 20 and 60 $\mu g/m^3$ on an annual basis.[1] A comparison of the annual geometric mean suspended particulate matter concentrations between New York and Chicago in the United States and Hamilton (Ontario), Montreal, and Vancouver (British Columbia) in Canada is illustrated in Figure 6-3.

Hourly average values of O_3 vary from year to year, depending on factors such as precursor emissions and meteorological conditions. Although surface O_3 measurements are made in many countries, O_3 has not been routinely summarized on an international basis. In many OECD countries, O_3 levels exceed the recommended standards. In Japan, the limit of 235 $\mu g/m^3$ is exceeded on a few days of the year, mostly in the Tokyo and Osaka areas.[1] Mexico City has experienced some of the highest O_3 hourly average concentrations in the world. For the period 1990-1991, at some locations in Mexico City, maximum hourly average concentrations exceeded 0.40 ppm. In 1992, similar high hourly average values were reported. These values are higher than those that normally occur in Los Angeles, California. In general, O_3 levels at urban locations are lower in Canada than in the United States. The lower O_3 levels in Canada may be associated with the country's geographical location (i.e., lower temperature and solar radiation). Figure 6-4 shows a comparison of the second highest daily maximum O_3 levels between some selected sites in the United States and in Canada.

Concentrations for suspended particulate matter, sulfur dioxide, and ozone vary substantially among cities in the world. Figure 6-5 presents a summary of the extent of these variations. The concentration information presented in the figure was derived from several sources.[1,5,7-9]

Table 6-1. Human-Induced Emissions of Sulfur Dioxide and Particulates

Country	Sulfur Oxides (1000 metric tons/year)	Sulfur Oxides (kg/capita)	Particulates (1000 metric tons/year)
Canada	3800	146.4	1709
USA	20700	84.0	6900
Japan	835	6.8	101
France	1335	22.8	298
Germany (FRG)	1306	21.3	532
Italy	2070	36.0	413
Netherlands	256	17.3	95
Norway	65	15.4	25
Sweden	199	23.6	170
United Kingdom	3664	63.1	533
North America	24500	-	9000
OECD Europe	13200	-	4000
World	99000	-	57000

Source: OECD (1991)

Table 6-2. Urban Trends in Annual Average Sulfur Dioxide Concentrations ($\mu g/m^3$)

Country	City	1970	1975	1980	1985	Late 1980s
CANADA	Montreal (Queb.)	--	40.3	40.7	20.2	16.1
USA	New York (NY)	--	43.1	37.5	36.6	32.3
JAPAN	Tokyo	109.2	60.0	48.0	25.2	19.8
BELGIUM	Brussels	160.4	99.0	62.4	33.7	31.7
DENMARK	Copenhagen	--	45.0	31.0	26.1	21.2
FINLAND	Tampere	--	103.0	58.7	41.2	7.2
FRANCE	Paris	121.9	115.0	88.6	54.0	43.7
	Rouen	--	63.0	69.9	37.2	35.3
GERMANY	Berlin (West)	--	95.0	90.2	67.4	60.8
ITALY	Milan	258.6	244.0	200.0	87.8	56.1
LUXEMBOURG	National Network	--	61.0	37.2	18.9	17.1
NETHERLANDS	Amsterdam	76.2	34.0	25.2	16.0	13.9
NORWAY	Oslo	--	48.0	36.0	14.9	13.0
PORTUGAL	Lisbon	--	36.2	44.2	31.1	43.1
SWEDEN	Gõtenborg	--	41.0	24.2	22.1	13.1
	Stockholm	--	59.0	41.9	21.2	14.2
UK	London	--	116.0	69.6	41.8	39.4
	Newcastle	143.4	112.0	69.4	40.3	35.8

Source: Adapted from OECD (1991)

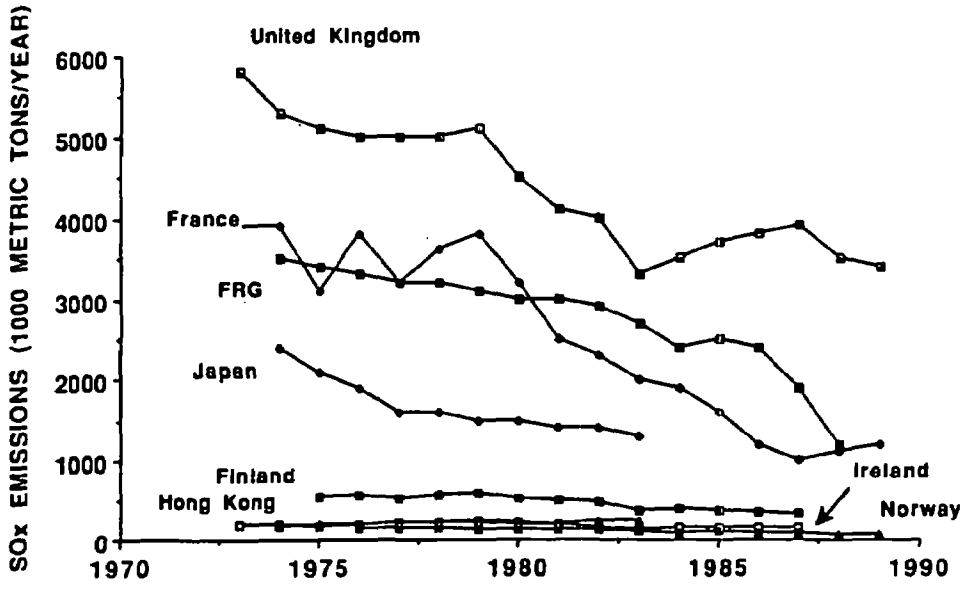


Figure 6-1. Trend in sulfur oxides emissions in selected developed countries.

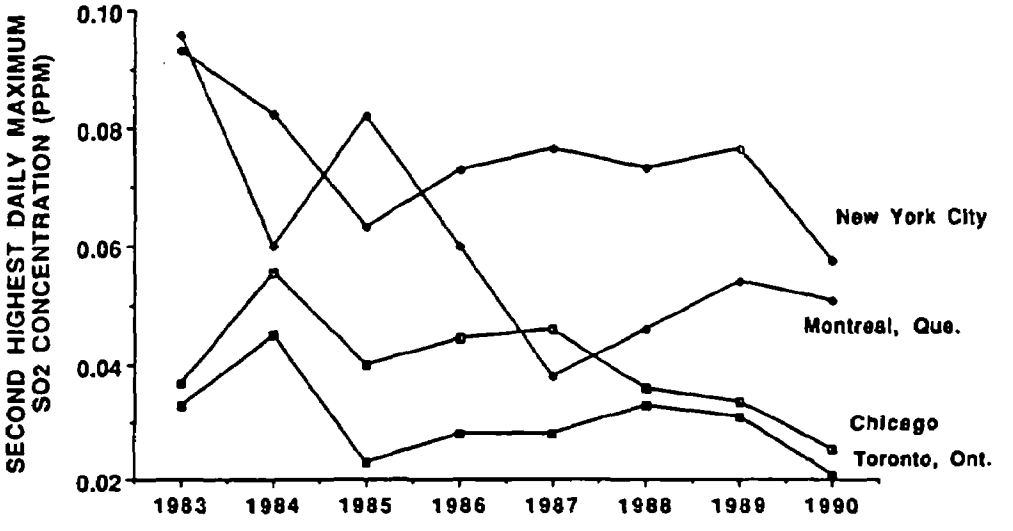


Figure 6-2. Trend in annual second highest 24-hour sulfur dioxide concentrations in selected U.S. and Canadian cities, 1983-1990.

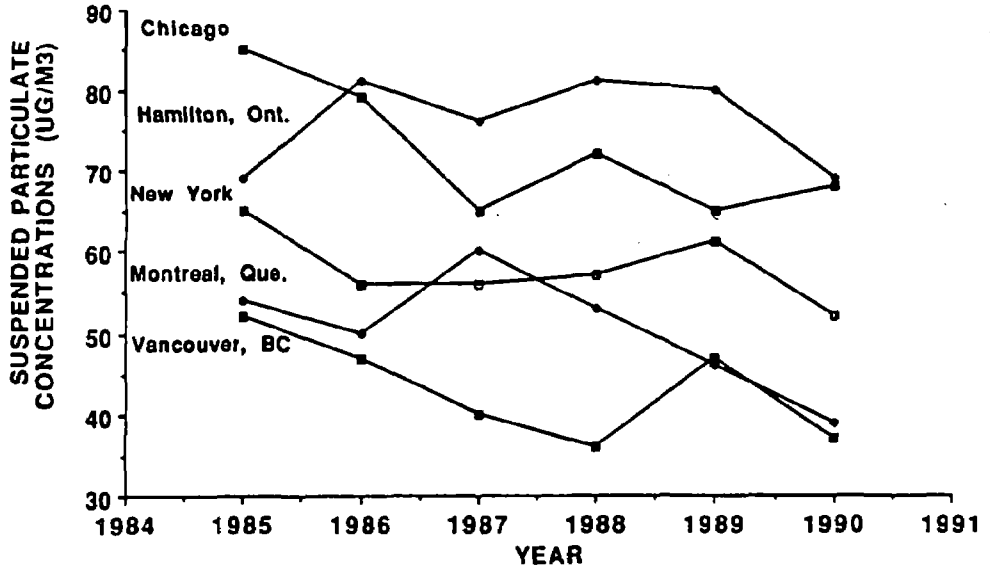


Figure 6-3. Trend in annual geometric mean total suspended particulate concentrations in selected U.S. and Canadian cities, 1985-1990.

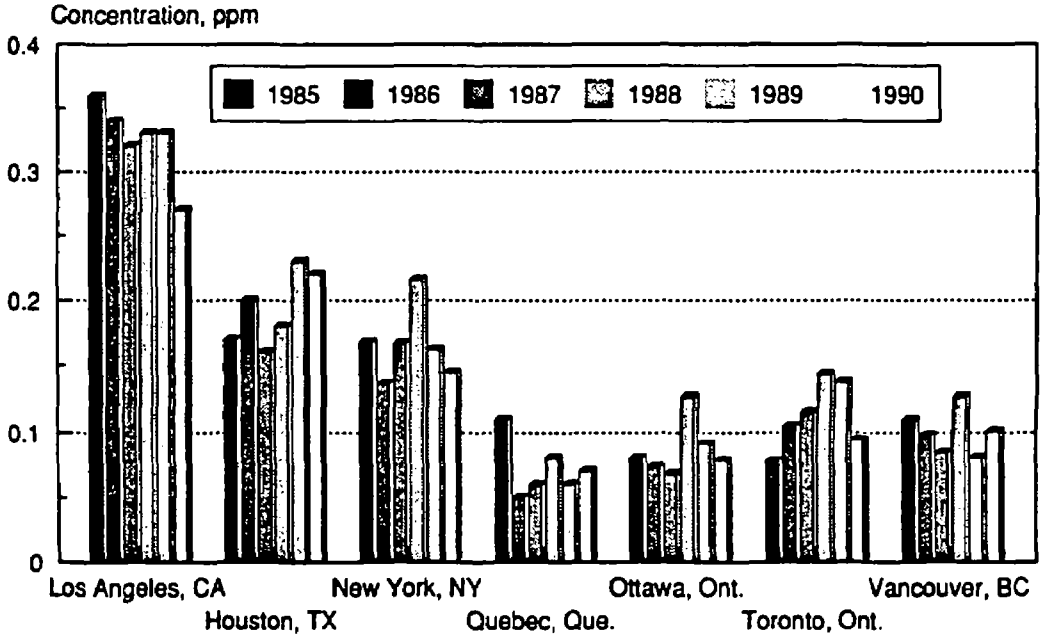


Figure 6-4. Trend in annual second highest daily maximum 1-hour ozone concentrations in selected U.S. and Canadian cities, 1985-1990.

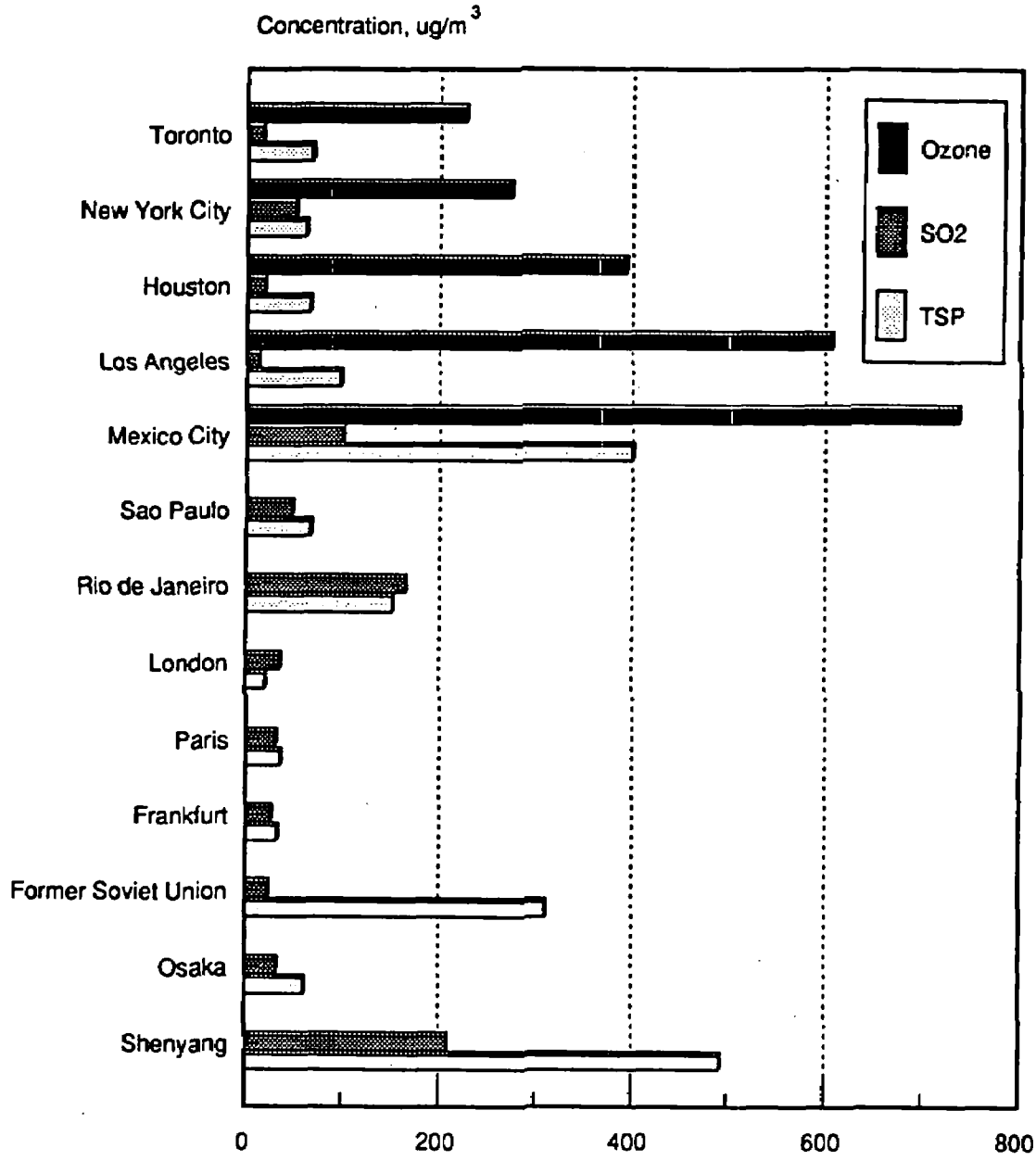


Figure 6-5. Comparison of ambient levels of annual second daily maximum 1-hour ozone, annual average total suspended particulate matter and sulfur dioxide among selected cities.

6.3 REFERENCES

1. The State of the Environment, Published by the Organization for Economic Co-operation and Development, Paris, France, 1991.

2. Assessment of Urban Air Quality, Published by the United Nations Environment Program and the World Health Organization, Global Environment Monitoring System, Nairobi, Kenya, 1988.

3. Urban Air Pollution, UNEP/GEMS Environment Library No 4, Published by the United Nations Environment Program, Nairobi, Kenya, 1991.

4. National Air Pollutant Emission Estimates, 1940-1990, EPA-450/4-91-026, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, November 1991.

5. Environmental Data Report 1991/92, Published by the UNEP/GEMS Monitoring and Assessment Research Centre, London, United Kingdom, Basil Blackwell, Oxford, 1991.

6. The State of the Environment (1972-1992), UNEP/GCSS, III/2, Published by the United Nations Environment Program, Nairobi, Kenya, 1992.

7. Written communication from T. Dann, Environment Canada to A.S. Lefohn, ASL and Associates, Helena, MT, February 11, 1992.

8. Romieu, I., H. Weitzenfeld, J. Finkelman, "Urban air pollution in Latin America and the Caribbean", *Journal of the Air Waste Management Association*, 41:1166-1171, 1991.

9. Aerometric Information Retrieval System (AIRS), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, August 1992.