1996 Ambient Air Quality Report

North Carolina Department of
Environment and Natural Resources

Division of Air Quality
Ambient Monitoring Section

Published April 1998

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STATE OF NORTH CAROLINA
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PUBLISHED
April 1998

Foreword

This report is issued by the Division of Air Quality of the Department of Environment, Health, and Natural Resources to inform the public of air pollution levels throughout the State of North Carolina. It describes the sources and effects of the following pollutants for which the U.S. Environmental Protection Agency and the State of North Carolina have established ambient air quality standards:

Particulate Matter	Nitrogen Dioxide
Carbon Monoxide	Ozone
Sulfur Dioxide	Lead

A brief discussion of the ambient air monitoring program, including a description of the monitoring network, is provided. Detailed results are presented of monitoring that was conducted in 1996 to measure the outdoor concentrations. The data are presented graphically and as statistical summaries, including comparisons to the ambient air quality standards. The report discusses the recorded data, seasonal variability of some pollutants. Data and areas exceeding the ambient air quality standards are identified. Factors which have contributed to those exceedances are also described.

Acid rain data from the National Atmospheric Deposition Program/National Trends Network for North Carolina also is included for 1996.

Current air pollution information and pollen information is available to the public 24 hours a day through the use of the air quality index telephone numbers listed below:

Charlotte area	703-333-SMOG
Statewide toll-free[1] including the following areas:	888-AIR-WISE
Asheville, Durham, Fayetteville, Greensboro, Raleigh, Winston-Salem.	

Additional copies of this report and previous annual reports are available from

Division of Air Quality
Department of Environment and Natural Resources
P O Box 29580
Raleigh, North Carolina 27626-0580

Comments regarding this report or suggestions for improving future reports are welcomed. Comments may be sent to Dr. Wayne L. Cornelius, at the above address.

Alan W. Klimek, P.E., Director
Division of Air Quality

[(1)]Starting in Fourth Quarter 1996.

Executive Summary

In 1996, the North Carolina Division of Air Quality (DAQ) and the three local program agencies (listed in Appendix A) collected 403,478 air quality samples. These samples included measurements of the U.S. Environmental Protection Agency's (EPA) criteria air pollutants: particulate matter, carbon monoxide, ozone, sulfur dioxide, and nitrogen dioxide. This report discusses each pollutant and presents summary tables, maps, charts and explanations of the data.

This report also includes data from weekly acid rain samples collected by the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) at seven North Carolina sites, one Tennessee site, and one Virginia site very close to the North Carolina border. It discusses acid rain and presents summary tables, maps, charts and explanations of the data. In addition, this report provides information on pollutant trends from 1972 (or the earliest year available) through 1996. The following summary discusses trends only for those pollutants having either increasing or decreasing tendencies.

Two different types of **particulate matter** were sampled in North Carolina during 1996. Total Suspended Particulate (TSP), generally considered to be particles having an aerodynamic diameter of 45 micrometers or less, is regulated by North Carolina standards. Particulate matter (PM_{10}) with an aerodynamic diameter less than or equal to a nominal 10 micrometers (0.00004 inches) is regulated by both EPA and N.C. standards.

TSP was sampled at 16 sites, yielding 797 samples. One exceedance of the state TSP ambient air quality standard for 24-hour samples (150 $\mu g/m^3$) was observed in 1996, at the Raleigh, North Hills site in Wake County. This exceedance was associated with a period of stagnant air.

PM_{10} was sampled at 47 sites, yielding 3,349 samples. There were no exceedances of the National Ambient Air Quality Standards for PM_{10} (150 $\mu g/m^3$ for 24-hour samples and 50 $\mu g/m^3$ for the annual arithmetic mean).

Carbon monoxide (CO), the most common air pollutant, largely results from fuel combustion. The most likely areas to have excessive CO concentrations are the larger cities where there are more cars and congested streets.

CO was sampled at 18 sites, yielding 128,262 valid hourly averages. The National Ambient Air Quality Standards for CO are 35 ppm for the maximum one-hour average and 9 ppm for the maximum eight-hour average. There were no exceedances of the one-hour or eight-hour standards at any site. The combined effects of newer cars in the vehicle fleet, traffic control strategies, and the Inspection and Maintenance program in Wake County have helped reduce the number and intensity of CO exceedances from previous years. Another control strategy was the use of oxygenated fuel in Forsyth County and Wake/Durham Counties from November to February.

Ozone (O_3) forms in the lower atmosphere when hydrocarbons (or volatile organic compounds) and nitrogen oxides chemically react in the presence of sunlight and high temperatures. The main emphasis in control of ozone has been to limit hydrocarbon emissions.

O_3 was sampled at 37 sites, yielding 162,100 valid hourly averages. During 1996, the National Ambient Air Quality Standard for O_3 was 0.12 ppm for the maximum one-hour average. Nine exceedances occurred in North Carolina in 1996, five in 1995, and none in 1994. In 1996, there were four sites with exceedances of the standard in and around the Charlotte area. These included: two exceedances at the Plaza Road site; two exceedances at the Westinghouse Blvd. (also called Arrowood Blvd.) site; one exceedance at the NC 29 North (also called County Line) site operated by Mecklenburg County; and two exceedances at the West and Gold Hill (also called Rockwell) site in Rowan County. In 1996, there also were two sites with exceedances of the standard in the Triad area. One exceedance occurred at the Baux Mountain Road (also known as Shiloh Church), Forsyth County site, and the other exceedance occurred at the Keely Park, Greensboro site in Guilford County.

Sulfur dioxide (SO_2) is mainly produced by combustion of fossil fuels containing sulfur compounds and the manufacture of sulfuric acid.

SO_2 was sampled at 15 sites, yielding 91,232 valid hourly averages. There were no exceedances of the National Ambient Air Quality Standards (.14 ppm for a 24-hour average, .50 ppm for a three-hour average, .03 ppm for the annual arithmetic mean).

Nitrogen oxides (NO_x) and reactive nitrogen oxides (NO_Y) are produced from the burning of fossil fuels such as coal, oil and gasoline, due to the oxidation of atmospheric nitrogen and nitrogen compounds in the fuel. The primary combustion product is NO, which reacts with hydrocarbons, ozone and other atmospheric compounds to form NO_2. NO_Y compounds play an important role in the formation of ozone. NO_Y was monitored in Charlotte, Raleigh, and Winston-Salem to gather data for the development of control strategies for ozone nonattainment areas.

The criteria pollutant NO_2 was sampled at three sites, yielding 17,617 valid hourly averages. There were no exceedances of the National Ambient Air Quality Standard (0.053 ppm for the annual arithmetic mean).

Lead (Pb) emissions result from coal combustion and the sandblasting of highway structures and water tanks. In the past, a major source was the combustion of gasoline containing tetraethyl lead as an additive.

Lead analyses were performed on 121 samples from 3 areas: Raleigh, Greensboro, and Spruce Pine. There were no recent exceedances of the ambient air quality standard for lead (1.5 $\mu g/m^3$ for a quarterly arithmetic mean).

Acid Rain is produced when nitrate and sulfate ions from motor vehicles and industrial sources reach the upper atmosphere, react with water vapor, and are deposited as acid precipitation. Monitoring of pH and other ion concentrations in precipitation helps identify trends and demonstrate the results of efforts to reduce emissions from mobile and industrial sources.

The annual mean pH in 1996 ranged from 4.44 (Rowan County) to 4.61 (Mt. Mitchell in Yancey County).

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1. Introduction

This annual report summarizes the ambient air monitoring performed in calendar year 1996 by the North Carolina Division of Air Quality (DAQ) and three local air pollution agencies, which are more fully described in Appendix A.

In 1996, there were 403,478 air quality samples of the U.S. Environmental Protection Agency's (EPA) criteria pollutants -- particulate matter, carbon monoxide, ozone, sulfur dioxide, nitrogen dioxide, and lead which are discussed in this report. This report also discusses 100,095 air quality samples from 1995 and 1994 for ozone and sulfur dioxide.

Chapter 2 describes the criteria pollutants and discusses their sources and effects on human health, plants and animals. Chapter 3 outlines the standards applied to criteria pollutant concentrations established by the EPA and the State of North Carolina to protect human health (primary standards) and plants, animals, and property (secondary standards). Chapter 4 describes the ambient monitoring program conducted by DAQ and three local program agencies. Chapter 5 gives detailed monitoring results for each pollutant, with a map of the monitor sites, a table of the summary statistics relevant to the standards, one or more maps summarizing the important statistics for each county with monitors, and additional summaries as appropriate to each individual pollutant. Chapter 6 describes the EPA Air Quality Index for the criteria pollutants and charts index measurements for five Metropolitan Statistical Areas of North Carolina. Chapter 7 presents sources, effects and monitoring of acid rain data conducted in North Carolina by the National Atmospheric Deposition Program and National Trends Network (NADP/NTN). It also includes a map of average pH levels and site statistics for the calendar year in two tables. Chapter 8 provides a summary of statewide trends for the criteria pollutants from the early 1970s (1985 for PM_{10}) and pH values from 1978 through 1996.

2. Description of Criteria Pollutants

2.1. Particulate Matter

Atmospheric particulate matter includes dust, dirt, soot, smoke and liquid droplets directly emitted into the air. More technically, particulate matter is defined as any airborne material, except uncombined water (such as mist or steam) that exists in a finely divided form as a liquid or solid at standard temperature (25°C) and pressure (760 mm mercury) and has an aerodynamic diameter of less than 100 micrometers. In 1996, two sizes of particulate matter were monitored, total suspended particulate (TSP) and PM_{10}. TSP is any particulate matter measured by the method described in EPA regulations 40 CFR 50 App. B (Office of the Federal Register 1993, p. 715-728) and is generally considered to be particles having an aerodynaic diameter of 45 micrometers or less. PM_{10} is particulate matter with an aerodynamic diameter less than or equal to 10 micrometers as measured according to EPA regulations 40 CFR 50 App. J (Office of the Federal Register 1993, p. 769-773). TSP measurements have been made in North Carolina since the early 1960s and PM_{10} has been sampled locally in Charlotte since 1985 and statewide since 1986 (North Carolina Department of Environment, Health, and Natural Resources 1991).

2.1.1. Sources

Particulates are emitted by many human activities, such as fuel combustion, motor vehicle operation, industrial processes, grass mowing, agricultural tilling and open burning. Natural sources include windblown dust, forest fires, volcanic eruptions and plant pollen. Particles formed in the atmosphere by condensation or the transformation of emitted gases such as sulfur dioxide and volatile organic compounds also are considered particulate matter.

Particles emitted directly from a source may be either fine (less than 2.5 micrometers) or coarse (2.5 - 60 micrometers), but particles formed in the atmosphere will usually be fine. Generally, coarse particles have slow settling velocities and are characterized as suspended particulate matter. Typically, fine particles originate by condensation of materials produced during combustion or atmospheric transformation.

2.1.2. Effects

Particulate matter can cause health problems affecting the breathing system, including aggravation of existing lung and heart disease, limitation of lung clearance, changes in form and structure of organs, and development of cancer. Individuals most sensitive to the effects of particulate matter include those with chronic obstructive lung or heart disease, those suffering from the flu, asthmatics, the elderly, children, and mouth breathers.

Health effects from inhaled particles are influenced by the depth of penetration of the particles into the respiratory system, the amount of particles deposited in the respiratory system, and by the biological reaction to the deposited particles. The risks of adverse health effects are greater when particles enter the tracheobronchial and alveolar portions of the respiratory system. Small particles can penetrate into these deeper regions of the respiratory system. Healthy respiratory systems can trap and remove particles larger than 10 micrometers more efficiently before they move deeply into the system.

Particulate matter also can interfere with plant photosynthesis, by forming a film on leaves reducing exposure to sunlight. Particles also can cause soiling and degradation of property, which can be costly to clean and maintain.

Suspended particles can absorb and scatter light, reducing visibility. This is a national concern, especially in areas such as national parks, historic sites and scenic attractions visited by sightseers.

2.2. Carbon Monoxide

Carbon monoxide (CO) is the most commonly occurring air pollutant. CO is a colorless and poisonous gas produced by incomplete burning of carbon-containing fuel.

2.2.1. Sources

Most atmospheric CO is produced by incomplete combustion of fuels used for vehicles, space heating, industrial processes and solid waste combustion. Transportation accounts for the majority of CO emissions. Boilers and other fuel burning heating systems are also significant sources.

2.2.2. Effects

Breathing carbon monoxide affects the oxygen-carrying capacity of the blood. Hemoglobin in the blood binds with CO more readily than with oxygen, starving the body of vital oxygen.

Individuals with anemia, lung and heart diseases are particularly sensitive to CO. Low concentrations affect mental function, vision and alertness. High concentrations can cause fatigue, dizziness, headaches, reduced work capacity and may adversely affect fetal development. Chronic exposure to CO at concentrations as low as 70 ppm (80 mg/m^3) can cause cardiac damage. Other health effects associated with exposure to CO include central nervous system effects and pulmonary function difficulties.

Ambient CO apparently does not adversely affect vegetation or materials.

2.3. Ozone

Ozone (O_3) is the major compound of a complex mixture of compounds known as photochemical oxidants. Ozone is a clear gas that forms in the troposphere (lower atmosphere) by chemical reactions involving hydrocarbons (or volatile organic compounds) and nitrogen oxides in the presence of sunlight and high temperatures. Even low concentrations of tropospheric ozone are harmful to people, animals, vegetation and materials. Ozone is the most widespread and serious criteria air pollutant in North Carolina.

Ozone in the upper atmosphere (stratosphere) shields the earth from harmful effects of ultraviolet solar radiation. Stratospheric ozone can be damaged by the emission of chlorofluoro-hydrocarbons (CFCs) such as Freon.

2.3.1. Sources

Ozone is not usually emitted directly into the atmosphere, but is formed by a series of complex reactions involving hydrocarbons, nitrogen oxides and sunlight. Hydrocarbons and nitrogen oxides are emitted by natural, transportation and industrial sources. Ozone concentrations are higher during the daytime in late spring, summer and early autumn when the temperature is above 60°F and sunlight is more intense. High levels typically occur under low wind speeds often associated with high pressure systems.

Two natural sources of upper atmosphere ozone are solar radiation and electrical discharge during thunderstorms. These are not significant sources of tropospheric ozone.

2.3.2. Effects

Ozone is a pulmonary irritant, affecting the respiratory mucous membranes, as well as other lung tissues and respiratory functions. Ozone has been shown to impair normal function of the lung–causing shallow, rapid breathing and a decrease in pulmonary function. Other symptoms of exposure include chest tightness, coughing and wheezing. People with asthma, bronchitis or emphysema probably will experience breathing difficulty when exposed to short-term concentrations between 0.15 and 0.25 ppm. Continued or repeated long-term exposure may result in permanent lung structure damage.

Exposure to lower levels of ozone can cause respiratory problems, aggravate asthma, cause temporary decreases in lung capacity, and cause inflammation of lung tissue. It also has been found that exposure to ozone impairs the body's immune system, causing an increased incidence of respiratory infections such as pneumonia and bronchitis.

Ozone damages vegetation by injuring plant leaves. Ozone also accelerates material aging–cracking rubber, fading dyes and eroding paint.

2.4. Sulfur Dioxide

Sulfur dioxide (SO_2) is a colorless, corrosive, harmful gas with a pungent odor. Smaller concentrations of sulfur trioxide and other sulfate compounds are also found in SO_2 emissions. Sulfur oxides contribute to the formation of acid rain and the formation of particles that reduce visibility.

2.4.1. Sources

The main sources of SO_2 are combustion of fossil fuels containing sulfur compounds and the manufacture of sulfuric acid. Other sources include paper mills, petroleum refineries, and smelting of ores that contain sulfur.

2.4.2. Effects

The most obvious health effect of sulfur dioxide is irritation and inflammation of body tissues brought in contact with the gas. Sulfur dioxide can increase the severity of existing respiratory diseases such as asthma, bronchitis and emphysema. It also can aggravate existing cardiovascular disease. Sulfuric acid and fine particulate sulfates that are formed from sulfur dioxide may cause significant health problems, as well.

Sulfur dioxide causes injury to many plants. A bleached appearance between the veins and along the margins of leaves indicate damage from SO_2 exposure. Commercially important plants sensitive to SO_2 include cotton, sweet potatoes, cucumber, alfalfa, tulips, apple trees, and several species of pine trees.

2.5. Nitrogen Oxides

Several gaseous oxides of nitrogen are normally found in the atmosphere, including nitrous oxide (N_2O), nitric oxide (NO) and nitrogen dioxide (NO_2). Nitrous oxide is a stable gas with anesthetic characteristics and typical ambient concentrations well below the threshold concentration for a biological effect. Nitric oxide is a colorless gas with ambient concentrations generally low enough to have no significant biological effect. Nitrogen dioxide is reddish-brown but is not usually visible at typical ambient concentrations.

2.5.1. Sources

The most significant nitrogen oxide emissions result from the burning of fossil fuels such as coal, oil and gasoline, due to the oxidation of atmospheric nitrogen and nitrogen compounds in the fuel. The primary combustion product is NO, which reacts with hydrocarbons, ozone and other atmospheric compounds to form NO_2.

2.5.2. Effects

At typical concentrations, nitrogen dioxide has significant health effects as a pulmonary irritant, especially upon asthmatics and children. In North Carolina a much greater health concern is the formation of ozone, which is promoted by the presence of nitrogen oxides.

Some types of vegetation are very sensitive to NO_2, including oats, alfalfa, tobacco, peas and carrots. Chronic exposure causes chlorosis (yellowing), and acute exposure usually causes irregularly shaped lesions on the leaves.

Nitric oxide and nitrogen dioxide do not directly damage materials. However, NO_2 can react with moisture in the air to produce nitric acid, which corrodes metal surfaces and contributes to acid rain.

High concentrations of NO_2 may reduce visibility. A significant portion of the brownish coloration sometimes observed in polluted air in winter months may be due to NO_2.

2.6. Lead

Lead is a ubiquitous, toxic heavy metal element occurring in the atmosphere as small particles.

2.6.1. Sources

The major source of atmospheric lead used to be the combustion of gasoline containing the additive tetraethyl lead as an antiknock agent. But the concentration of lead additive in fuel was decreased, and then eliminated, minimizing gasoline as a source. Significant remaining sources include coal combustion (lead exists in very small quantities as an impurity in coal) and sandblasting of highway structures and water tanks. Lead also is used in batteries and some paints, insecticides and newspaper inks.

2.6.2. Effects

Lead (Pb) persists and accumulates in the environment and the human body. It may be inhaled, ingested and eventually absorbed into the bloodstream and distributed to all body tissues. Exposure to low concentrations interferes with blood production and specific enzyme systems. It is believed to cause kidney and nerve cell damage, and severe lead poisoning is known to cause brain damage in children.

The major toxic effects of lead include: the reduction in the production of hemoglobin (the oxygen carrying component of the blood) and subsequently anemia; central nervous system damage; kidney and liver damage; and high blood pressure in older adults.

3. Standards

Ambient air quality status is determined by measuring pollutant concentrations in outdoor air and comparing the measured concentrations to corresponding standards. The US EPA (Environmental Protection Agency) defines ambient air as "that portion of the atmosphere, external to buildings, to which the general public has access."

Ambient air quality standards are classified as primary and secondary. Primary standards are those established to protect public health. Secondary standards are those established to protect the public welfare from adverse pollution effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility, climate, property, transportation, economy, personal comfort, and well-being. The scientific criteria upon which the standards are based are periodically reviewed by EPA, which may reestablish or change the standards according to its findings.

A pollutant measurement that is greater than the ambient air quality standard for an averaging time is called an "exceedance." The national primary, secondary and North Carolina ambient air quality standards are summarized in Table 3.1.

Table 3.1 National and North Carolina Ambient Air Quality Standards. For new or anticipated new standards, References in the Code of Federal Regulations are given. For standards expressed in parts per million (ppm), an equivalent mass per unit volume is also shown in micrograms per cubic meter ($\mu g/m^3$), or milligrams per cublic meter (mg/m^3).

Pollutant/ Ambient Measurement/ (Reference)	Averaging Period	Type of Summary	Primary National (Health Related) Standard	Secondary National (Welfare Related) Standard	North Carolina Standard
TSP	1 year	geometric mean	([1])	([1])	75 $\mu g/m^3$
24 hour average	1 day	2nd maximum	([1])	([1])	150 $\mu g/m^3$
PM-2.5	1 year	average[2] arithmetic mean	15 $\mu g/m^3$	15 $\mu g/m^3$	([3])
24 hour average (40CFR50, App. N)	1 day	average[2] 98th percentile	65 $\mu g/m^3$	65 $\mu g/m^3$	([3])
PM-10	1 year	average[2] arithmetic mean	50 $\mu g/m^3$	50 $\mu g/m^3$	50 $\mu g/m^3$
24 hour average (40CFR50, App. N)	1 day	average[2] 99th percentile[4]	150 $\mu g/m^3$	150 $\mu g/m^3$	150 $\mu g/m^3$
CO	8 hours	2nd maximum	9 ppm (10 mg/m^3)		9 ppm (10 mg/m^3)
1 hour average	1 hour	2nd maximum	35 ppm (40 mg/m^3)		35 ppm (40 mg/m^3)
O_3	1 hour	expected[5] 2nd maximum	0.12 ppm ([6]) (235 $\mu g/m^3$)	0.12 ppm ([6]) (235 $\mu g/m^3$)	0.12 ppm (235 $\mu g/m^3$)
1 hour average (40CFR50, App. I)	8 hours	average[7] arithmetic mean 4th maximum	0.08 ppm ([6]) (157 $\mu g/m^3$)	0.08 ppm ([6]) (157 $\mu g/m^3$)	([3])
SO_2	1 year	arithmetic mean	0.03 ppm (80 $\mu g/m^3$)		0.03 ppm (80 $\mu g/m^3$)
1 hour average	1 day	2nd maximum	0.14 ppm (365 $\mu g/m^3$)		0.14 ppm (365 $\mu g/m^3$)
	3 hours (non-overlapping)	2nd maximum		0.50 ppm (1,300 $\mu g/m^3$)	0.50 ppm (1,300 $\mu g/m^3$)
NO_2	1 year	arithmetic mean	0.053 ppm (100 $\mu g/m^3$)	0.053 ppm (100 $\mu g/m^3$)	0.053 ppm (100 $\mu g/m^3$)
1 hour average					
Pb	1 quarter	arithmetic mean	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$
24-hour average					

1. In 1987, National standards for PM-10 replaced those for TSP.
2. Arithmetic mean over the 3 most current years.
3. North Carolina probably will adopt the new national standard which became effective July, 1997.
4. In July 1997, this percentile-based statistic replaced the 2nd maximum.
5. Determined by adjusting for incomplete days and averaging over the most recent 3 consecutive, complete calendar years.
6. The eight-hour national standard, effective in July, 1997, probably will replace the one-hour standard.
7. Arithmetic mean value over the most recent 3 consecutive, complete calendar years.

4. Ambient Air Quality Monitoring Program

Ambient monitoring and analyses of samples were conducted by the Division of Air Quality and three local air pollution control programs (Appendix A). The air monitoring data are used to determine whether air quality standards are being met, to assist in enforcement actions, to gauge the improvement or decline of air quality, and to determine the extent of allowable industrial expansion. A listing of monitoring sites active in 1996 is presented in Table 4.1. The locations of sites are shown in Figures 5.1, 5.4, 5.7, 5.11, 5.15, and 5.18.

Siting of monitors involves several considerations, including population densities, size of the area represented, distance from roadways and nearby sources, unrestricted air flow, safety, availability of electricity and security.

Each site has a defined monitoring objective, and annual evaluations are conducted to ensure that the objectives are met. The four basic monitoring objectives are to determine:

- the highest concentration expected in an area;
- representative concentrations in areas of high population density;
- the impact of significant sources or source categories on ambient air quality;
- general background concentration levels.

All monitors have known precision, accuracy, interferences and operational parameters. The monitors–as well as all measurement devices–are carefully calibrated at predetermined frequencies, varying from daily to quarterly. Measurements are traceable to National Institute of Standards and Technology (NIST), when standards are available.

Monitoring and analyses are performed according to standard operating procedures. Field personnel visit manual sampling sites once every six days to replace sample media and check the operation and calibration of monitors. Personnel visit and check continuous monitors at least twice weekly for correct instrument operation.

Quality assurance activities are carried out to determine the quality of the collected ambient data, improve the quality of the data and evaluate how well the monitoring system operates. The objective of the quality assurance activities is to produce high quality air pollution data with defined completeness, precision, accuracy, representativeness and comparability.

Microprocessors are used at most sites to collect the data. A redundant microprocessor system is also used to assure data are not lost due to system malfunctions or power outages. A computerized telemetry system aids in assembly of the data for submission to the US EPA. This enhances data validity, minimizes travel costs, and allows real-time data to be available by computer polling when needed. Numerous checks are performed to ensure that only valid data are reported.

Table 4.1. Ambient Air Monitoring Sites Operated in North Carolina, 1996.

SITE COUNTY	STREET	POLLUTANTS		
37-001-0002 ALAMANCE	827 S GRAHAM & HOPEDALE RD	PM10		
37-003-0003 ALEXANDER	STATE ROAD 1177	O3	SO2	PM10
37-011-8001 AVERY	ROARING CREEK RD., PISGAH N.F.	O3		
37-013-0003 BEAUFORT	NC HIGHWAY 306	SO2		
37-013-0004 BEAUFORT	SOUTH FERRY LANDING PAMLICO RIVER	SO2		
37-013-0005 BEAUFORT	SLATESTONE ROAD (NEAR WATER TOWER)	PM10		
37-021-0003 BUNCOMBE	HEALTH & SOCIAL SERVICES BLDG WOODFIN ST	TSP	PM10	
37-021-0030 BUNCOMBE	ROUT 191 SOUTH BREVARD RD	O3		
37-021-0032 BUNCOMBE	LONDON RD ASHEVILLE	PM10		
37-021-0033 BUNCOMBE	US70 WEST SWANNANOA	PM10		
37-025-0004 CABARRUS	FLOYD ST. KANNAPOLIS	PM10		
37-031-0003 CARTERET	ARENDELL & 4TH MOREHEAD CITY	TSP		
37-031-8001 CARTERET	MERRIMON ROAD BEAUFORT	O3		

SITE COUNTY	STREET		POLLUTANTS
37-033-0001 CASWELL	CHERRY GROVE RECREATION	O3	HSCO[a]
37-035-0004 CATAWBA	1650 1ST. ST.	TSP	PM10
37-037-0004 CHATHAM	RT4 BOX62 PITTSBORO	O3	PM10
37-047-0001 COLUMBUS	ACME-DELCO SAMPLING SITE HWY 87	TSP	SO2
37-051-0004 CUMBERLAND	F.S. # 5 3296 VILLAGE DR.	TSP	PM10
37-051-0007 CUMBERLAND	CUMBERLAND CO ABC BOARD, 1705 OWEN DRIVE	CO	
37-051-0008 CUMBERLAND	1/4MI SR1857/US301/1857	O3	
37-051-1002 CUMBERLAND	HOPE MILLS POLICE DPT, ROCKFISH RD.	O3	SO2
37-057-0002 DAVIDSON	S.SALISBURY ST., LEXINGTON	PM10	
37-057-1002 DAVIDSON	400 SALEM STREET	TSP	PM10
37-059-0002 DAVIE	246 MAIN STREET	O3	
37-061-0002 DUPLIN	HWY 50 KENANSVILLE	O3	SO2
37-063-0001 DURHAM	HEALTH DEPT 300 E MAIN ST	PM10	

[a] high sensitivity carbon monoxide

SITE COUNTY	STREET	POLLUTANTS			
37-063-0011 DURHAM	201 NORTH ROXBORO ST	CO			
37-063-0012 DURHAM	4001 CHAPEL HILL BLVD	CO			
37-063-0013 DURHAM	2700 NORTH DUKE STREET	O3	HSCO		
37-065-0002 EDGECOMBE	LAGGED RD.,WASTE TREATMENT PLANT	PM10			
37-065-0099 EDGECOMBE	RT 2, BOX 195 TARBORO	O3	SO2	PM10	
37-067-0009 FORSYTH	INDIANA AV & AKRON DR HANES HOSIERY PK	PM10			
37-067-0013 FORSYTH	720 RIDGE AVENUE	PM10			
37-067-0022 FORSYTH	1300 BLK. HATTIE AVENUE	O3	HSCO	SO2	NO2
37-067-0023 FORSYTH	1401 CORPORATION PARKWAY	CO	PM10		
37-067-0024 FORSYTH	NORTH FORSYTH HIGH SCHOOL	PM10			
37-067-0025 FORSYTH	100 SW STRATFORD RD	CO			
37-067-0026 FORSYTH	1590 BOLTON STREET	CO			
37-067-0027 FORSYTH	7635 HOLLYBERRY LANE	O3			
37-067-0028 FORSYTH	6496 BAUX MOUNTAIN ROAD, WINSTON-SALEM	O3			

SITE COUNTY	STREET		POLLUTANTS
37-067-1008 FORSYTH	3656 PIEDMONT MEMORIAL DRIVE	O3	HSCO
37-069-0001 FRANKLIN	431 S HILLSBOROUGH ST FRANKLINTON	O3	
37-069-0001 FRANKLIN	431 S HILLSBOROUGH ST FRANKLINTON	CO	
37-071-0014 GASTON	RANKIN LAKE RD., GASTONIA	TSP	PM10
37-071-0015 GASTON	1555 EAST GARRISON BLVD	CO	
37-077-0001 GRANVILLE	WATER TREATMENT PLANT JOHN UMSTEAD HOSP	O3	HSCO
37-077-0002 GRANVILLE	3200 WEBB SCHOOL RD OXFORD	PM10	
37-081-0009 GUILFORD	EDGEWORTH & BELLEMEADE STS	TSP	PM10
37-081-0011 GUILFORD	KEELY PARK, KEELY RD,	O3	
37-081-1005 GUILFORD	E GREEN & S CENTENNIAL ST	PM10	
37-081-1011 GUILFORD	401 WEST WENDOVER	CO	
37-083-0002 HALIFAX	NE CORNER OF 5TH & CAROLINA ST.	PM10	
37-085-0001 HARNETT	MUNICIPAL BUILDING	TSP	PM10
37-087-0002 HAYWOOD	ROOF, CANTON FIRE DEPT.	PM10	

SITE COUNTY	STREET	POLLUTANTS			
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PKWY MILE MARKER 410	O3			
37-087-0036 HAYWOOD	GREAT SMOKY MOUNTAIN NATIONAL PARK	O3			
37-089-1006 HENDERSON	CORNER OF ALLEN & WASHINGTON STS	PM10			
37-101-0002 JOHNSTON	3411 JACK ROAD CLAYTON NC 27520	O3	SO2		
37-109-0003 LINCOLN	EAST CONGRESS ST	PM10			
37-109-0004 LINCOLN	RIVERVIEW ROAD	O3	SO2		
37-111-0002 MC DOWELL	COURTHOUSE	PM10			
37-113-8001 MACON	COWEETA HYDROLOGIC LABORATORY	O3			
37-119-0001 MECKLENBURG	600 EAST TRADE STREET	TSP	PM10		
37-119-0003 MECKLENBURG	FIRE STA #11 620 MORETZ STREET	PM10			
37-119-0010 MECKLENBURG	FIRE STA #10 2136 REMOUNT ROAD	TSP	PM10		
37-119-0032 MECKLENBURG	5137 CENTRAL AVE.	CO			
37-119-0034 MECKLENBURG	PLAZA ROAD AND LAKEDELL	O3	HSCO	SO2	NO2
37-119-0035 MECKLENBURG	1330 SPRING ST GRNVILLE NEIGHBORHOOD CNT	CO			

SITE COUNTY	STREET	POLLUTANTS	
37-119-0037 MECKLENBURG	415 EAST WOODLAWN RD	CO	
37-119-0038 MECKLENBURG	301 N TRYON ST	CO	
37-119-1001 MECKLENBURG	FILTER PLANT	PM10	
37-119-1005 MECKLENBURG	400 WESTINGHOUSE BLVD.	O3	PM10
37-119-1009 MECKLENBURG	29 N@ MECKLENBURG CAB CO	O3	HSCO
37-121-0001 MITCHELL	CITY HALL SUMMIT ST	TSP	PM10
37-123-8001 MONTGOMERY	112 PERRY DRIVE	O3	
37-129-0002 NEW HANOVER	6028 HOLLY SHELTER RD	O3	
37-129-0006 NEW HANOVER	HWY 421 NORTH	SO2	
37-129-0007 NEW HANOVER	WAREHSE & RECEIVING ST UNCW WILM	TSP	PM10
37-131-0002 NORTHAMPTON	RT 46 GASTON NORTH CAROLINA	SO2	
37-133-0004 ONSLOW	2553 ONSLOW DRIVE, JACKSONVILLE	PM10	
37-135-0005 ORANGE	109 ½ EAST FRANKLIN STREET	CO	
37-135-0006 ORANGE	147 EAST FRANKLIN ST CHAPEL HILL	CO	

SITE COUNTY	STREET	POLLUTANTS		
37-139-0001 PASQUOTANK	WATER PLANT N WILSON ST	TSP	PM10	
37-147-0003 PITT	1500 BEATTY ST GREENVILLE	PM10		
37-147-0099 PITT	US 264 NEAR FARMVILLE WATER TOWER	O3		
37-155-0003 ROBESON	SO. WATER ST.	PM10		
37-157-0099 ROCKINGHAM	6371 NC 65 @ BETHANY SCHOOL	O3		
37-159-0021 ROWAN	WEST ST & GOLD HILL AVENUE	O3	HSCO	NO2
37-159-0022 ROWAN	925 N ENOCHVILLE AVE	O3	HSCO	
37-159-1006 ROWAN	CORNER OF CHURCH & KERR STS	PM10		
37-173-0002 SWAIN	CENTER ST/PARKS 7 REC FACILITY	O3	SO2	PM10
37-183-0003 WAKE	FIRE STATION #9 SIX FORKS RD NORTH HILLS	TSP	PM10	
37-183-0011 WAKE	420 S PERSON ST	CO		
37-183-0013 WAKE	EF HUTTON, HWY 70 WEST	CO		
37-183-0014 WAKE	E MILLBROOK JR HI 3801 SPRING FOREST RD	O3		
37-183-0015 WAKE	808 NORTH STATE STREET	O3	HSCO	

SITE COUNTY	STREET		POLLUTANTS
37-183-0016 WAKE	201 NORTH BROAD STREET	O3	HSCO
37-183-0017 WAKE	5033 TV TOWER RD GARNER	O3	
37-183-0018 WAKE	HWY 70WEST AND HWY 50NORTH	CO	
37-187-0002 WASHINGTON	OLD ACRE RD.	TSP	
37-189-0003 WATAUGA	HARDIN PRK ELEMENTARY SCHL HWY194BOONE	PM10	
37-191-0004 WAYNE	HWY 70 WEST PATROL STA.GOLDSBORO	PM10	
37-195-0002 WILSON	N.W. CORNER OF KENAN ST.& TARBORO ST.	PM10	
37-199-0003 YANCEY	BLUE RIDGE PARKWAY	O3	SO2
Sites operated in 1996		104	

5. Pollutant Monitoring Results

Air quality in a given area is affected by many factors, including weather, the location of pollutant sources, and amount of pollutants emitted from them.

The speed and direction of air movement determine whether pollutant emissions will exceed ambient air quality standards and where those exceedances will occur. Atmospheric stability, precipitation, solar radiation and temperature also affect pollutant concentrations.

Other factors that affect concentrations include whether an area is urban or rural, and whether the area has mountains, valleys or plains.

Important economic factors affecting air quality include concentration of industries, growth or decline, and the day of the week.

Short term air quality also may be influenced by "exceptional events." Exceptional events may be either natural (e.g., forest fire) or manmade (e.g., construction or demolition). Unusual data that can be attributed to an exceptional event are considered biased and may be omitted from data summaries when they are not representative of normal conditions. Data affected by exceptional events are included but flagged, and they are omitted from summaries in charts. A list of typical exceptional events is given in Appendix B.

Data for the 1996 ambient air quality report were collected at 157 air pollutant monitoring sites operated by federal, state, and local agencies in North Carolina (listed in Appendix A). To save operating costs, some ozone and sulfur dioxide monitors are operated only every third year. Eighteen of the 157 monitors used for this report operated most recently in 1994 or 1995. In 1996 three lead monitoring sites were added to evaluate how lead concentrations have changed since the last lead samples were collected in 1990.

5.1. Total Suspended Particulates

Total Suspended Particulate matter (TSP) is collected on filters using a "high volume" sampler (an EPA Reference Method). The sampler motor is set and calibrated to an air flow rate of 40 ±4 feet^3/min. Gravimetric analysis is performed by comparing the exposed filter weight to the unexposed filter weight. Weights are measured to the nearest 0.1 milligram. The difference between the exposed and unexposed weights is the amount of particulate collected from a known volume of air.

In 1996, 16 sites were used to monitor TSP, and 797 samples were collected. A map of the TSP sampling sites is shown in Figure 5.1, and a detailed summary of the data from each site is given in Table 5.1.

One sample exceeded the N.C. TSP ambient air quality standards, compared to no exceedances in 1994 and one pollen-affected exceedance in 1995. The 1996 exceedance occurred on January 16 at the North Hills, Raleigh, Wake County site. The exceedance was representative of the particulate levels under a period of atmospheric stagnation. The PM-10 and carbon monoxide monitors

in Raleigh also reported higher than normal (but below the standards) concentrations during this period. Attainment status is based on the second highest 24-hour concentration and on the geometric mean of all the 24-hour concentrations at a given site. The Raleigh total suspended particulate site produced one maximum 24-hour sample with a concentration exceeding the standard. The second maximum at the site was 94 $\mu g/m^3$ and was below the standard. Statewide, the largest geometric mean TSP average was 48 $\mu g/m^3$, which is two thirds of the level of the air quality standard. This occurred at the Spruce Pine City Hall site.

The second highest 24-hour concentrations are shown by county in Figure 5.2 and the annual geometric means are similarly shown in Figure 5.3. (In counties with more than one TSP monitoring site, the concentration reported in Figure 5.2 is the county-wide second largest concentration, and the geometric mean reported in Figure 5.3 is the maximum geometric mean for the county.)

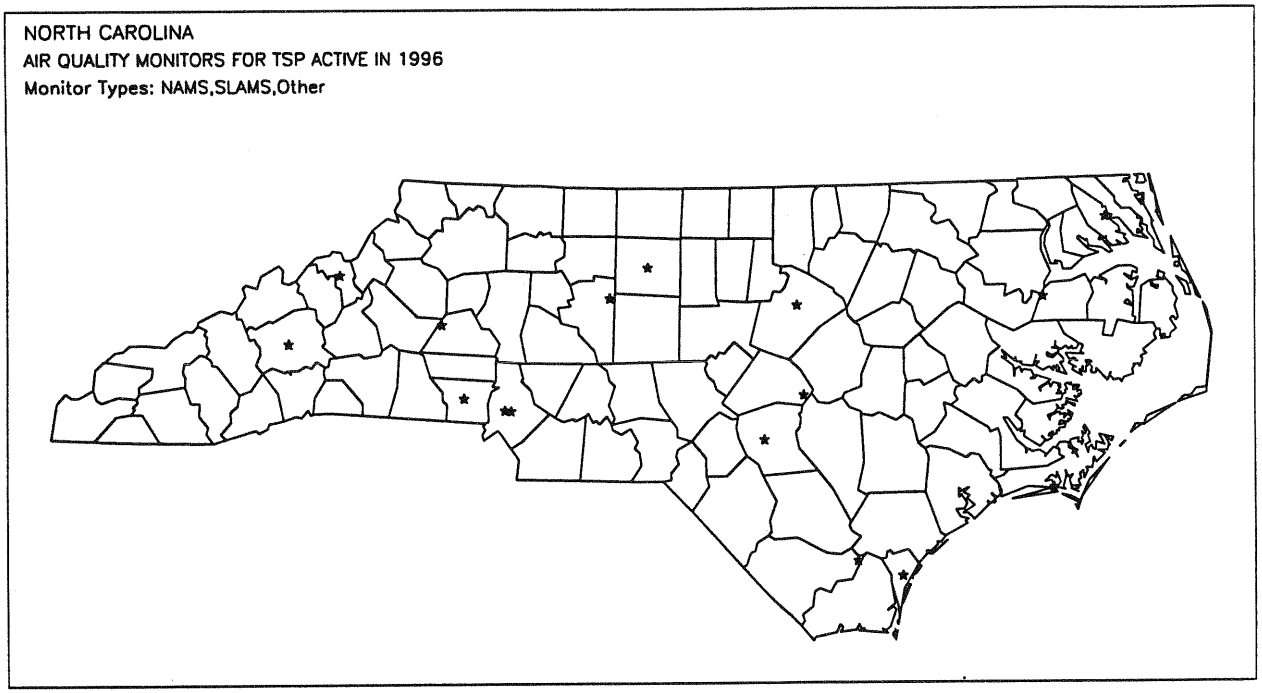

Figure 5.1. Location of TSP Monitoring Sites.

Table 5.1. Total Suspended Particulates in Micrograms Per Cubic Meter for 1996.

SITE NUMBER COUNTY	STREET	NUM OBS	24-HOUR MAXIMA 1ST	2ND	3RD	4TH	ARITH. MEAN	GEOM. MEAN	GEOM. SD
37-021-0003 BUNCOMBE	HEALTH & SOCIAL SERVICES BLDG	55	82	64	62	62	38.9	36.0	1.52
37-031-0003 CARTERET	ARENDELL & 4TH MOREHEAD CITY	60	91	87	85	85	48.5	44.2	1.56
37-035-0004 CATAWBA	1650 1ST. ST.	58	104	104	83	80	48.1	44.0	1.55
37-047-0001 COLUMBUS	ACME-DELCO SAMPLING SITE HWY 8	7	47	27	24	24	24.6	22.5	1.59
37-051-0004 CUMBERLAND	F.S. # 5 3296 VILLAGE DR.	56	98	84	83	80	46.5	43.5	1.44
37-057-1002 DAVIDSON	400 SALEM STREET	59	81	71	68	68	43.0	40.4	1.46
37-071-0014 GASTON	RANKIN LAKE RD GASTONIA	10	47	41	40	37	28.6	25.9	1.63
37-081-0009 GUILFORD	EDGEWORTH & BELLEMEADE STS	59	79	67	65	64	39.4	36.8	1.47
37-085-0001 HARNETT	MUNICIPAL BUILDING	56	83	73	72	68	45.0	42.2	1.46
37-119-0001 MECKLENBURG	600 EAST TRADE STREET	59	108	87	79	77	46.8	44.1	1.41
37-119-0010 MECKLENBURG	FIRE STA #10 2136 REMOUNT ROAD	44	94	88	79	71	46.1	42.8	1.48
37-121-0001 MITCHELL	CITY HALL SUMMIT ST	52	105	95	93	91	52.3	48.3	1.50
37-129-0007 NEW HANOVER	WAREHSE & RECEIVING ST UNCW WI	54	68	58	58	57	32.8	30.9	1.40
37-139-0001 PASQUOTANK	WATER PLANT N WILSON ST	47	76	69	55	51	31.3	27.2	1.78

SITE NUMBER COUNTY	STREET	NUM OBS	24-HOUR MAXIMA 1ST	2ND	3RD	4TH	ARITH. MEAN	GEOM. MEAN	GEOM. SD
37-183-0003 WAKE	FIRE STATION #9 SIX FORKS RD N	61	**195**[a]	94	71	69	44.4	40.2	1.54
37-187-0002 WASHINGTON	OLD ACRE RD.	60	70	66	52	49	31.8	29.6	1.50
Total samples		797							
Total sites sampled		16							

[a]Exceeds secondary standard of 150 μg/m^3. The exceedance sample occurred on 16 January 1996 and was attributed to below-normal temperatures and likely above-normal woodstove and fireplace usage. In addition, the season high CO concentration at 37-183-0011 occurred on the previous evening, suggesting the presence of an inversion.

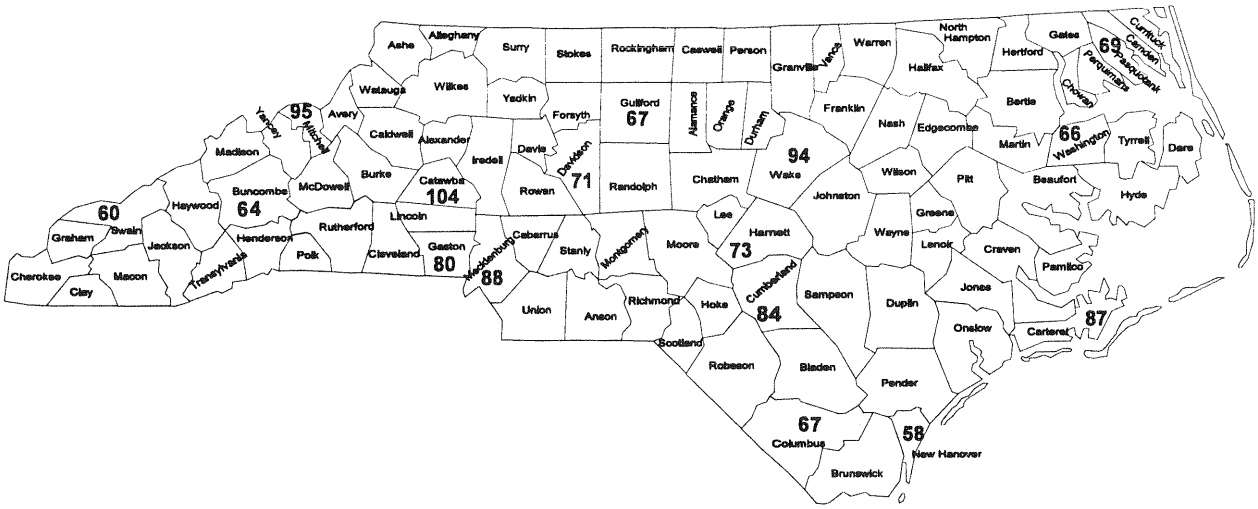

Figure 5.2. Total Suspended Particulates: Second Highest 24-Hour Averages in Most Recent Year, 1996 or 1995

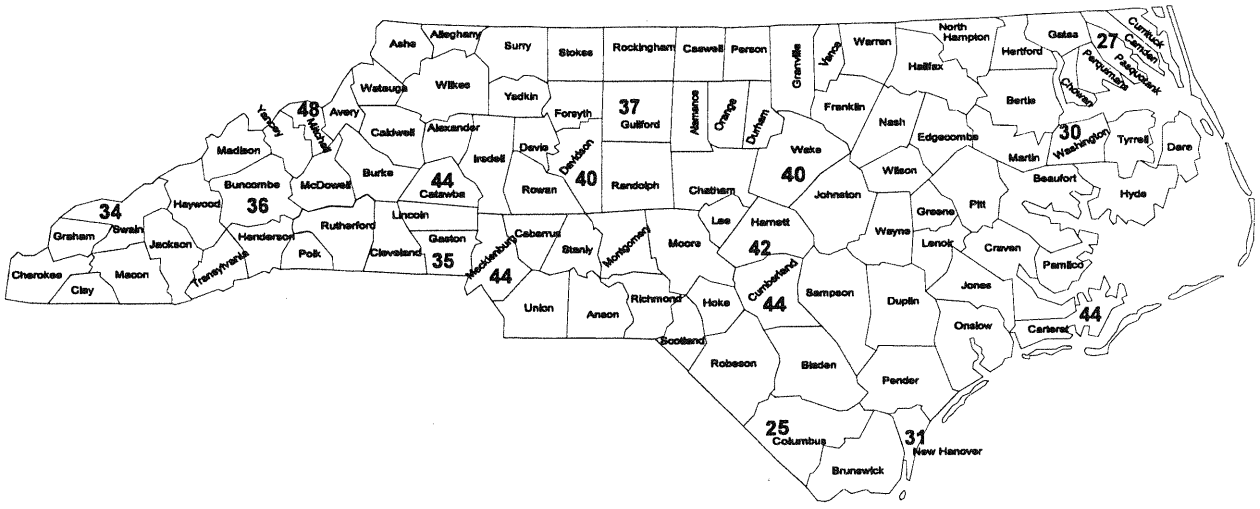

Figure 5.3. Total Suspended Particulates: Annual Geometric Means in Most Recent Year 1996 or 1995

5.2. PM_{10}

State and local program agencies in North Carolina use high volume samplers and size selective inlets to collect PM_{10} samples. A gravimetric analysis procedure (EPA Reference Method) is used to analyze the samples. Additionally, two local programs use tapered element oscillating microbalance (TEOM®) samplers to measure PM-10 continuously.

In 1996, 47 sites were used to monitor PM_{10}, and 3,349 samples were collected. A map of the PM_{10} sampling sites is presented in Figure 5.4, and a detailed summary of the data from each site is given in Table 5.2.

There were no exceedances of the PM_{10} ambient air quality standards in 1996. The greatest 24-hour maximum concentration was 106 $\mu g/m^3$, or about 70% of the standard (150 $\mu g/m^3$). The greatest annual arithmetic mean was 36 $\mu g/m^3$, which is 72% of the standard (50 $\mu g/m^3$).

The second highest 24-hour concentrations are charted by county in Figure 5.5 and the annual arithmetic means are shown in Figure 5.6. (In counties with more than one PM-10 monitoring site, the concentration reported in Figure 5.5 is the county-wide second maximum 24-hour concentration, and the mean reported in Figure 5.6 is the maximum arithmetic mean for the county.)

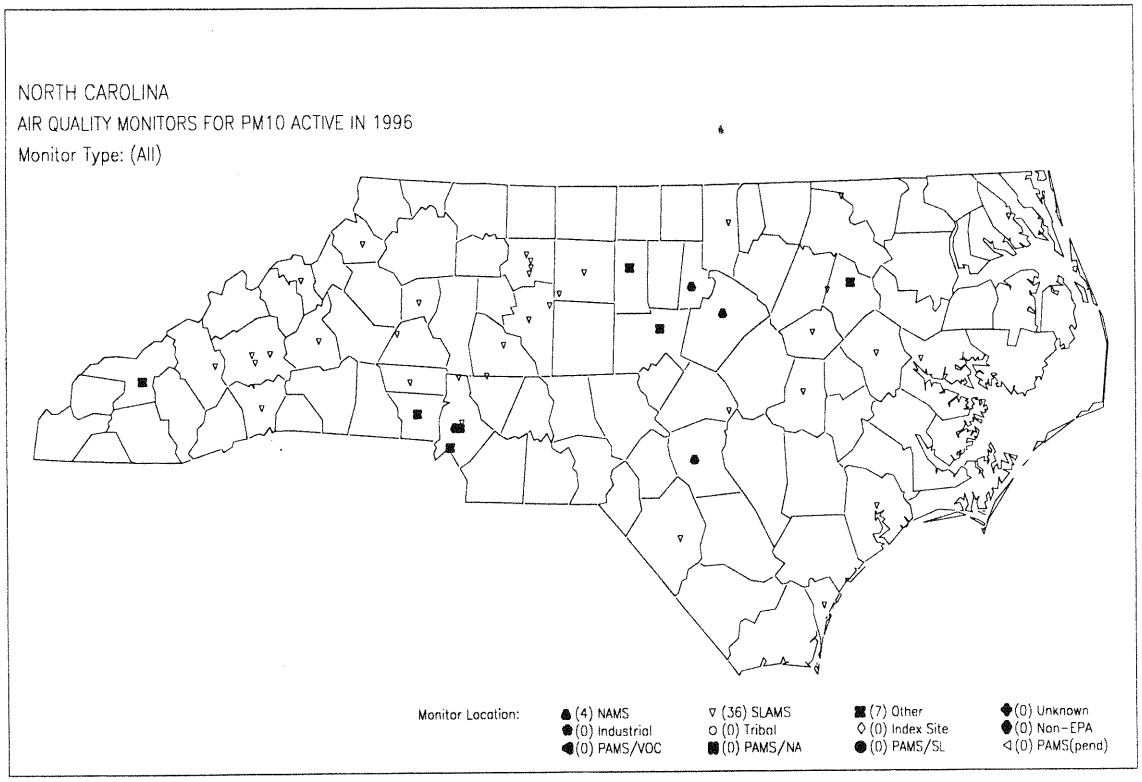

Figure 5.4. Locations of PM-10 Monitoring Sites

Table 5.2. PM-10 in Micrograms Per Cubic Meter for 1996.

SITE NUMBER COUNTY	STREET	NUM OBS	24-HOUR MAXIMA 1ST	2ND	3RD	4TH	ARITH MEAN
37-001-0002 ALAMANCE	827 S GRAHAM & HOPEDALE RD	59	50	50	42	37	21.5
37-003-0003 ALEXANDER	STATE ROAD 1177	58	106	60	55	47	24.1
37-013-0005 BEAUFORT	SLATESTONE ROAD (NEAR WATER TO	54	36	33	32	30	16.1
37-021-0003 BUNCOMBE	HEALTH & SOCIAL SERVICES BLDG	61	44	37	34	32	18.8
37-021-0032 BUNCOMBE	LONDON RD ASHEVILLE	327	79	76	56	55	24.5
37-021-0033 BUNCOMBE	US70 WEST SWANNANOA	249	78	55	54	52	21.8
37-025-0004 CABARRUS	FLOYD ST. KANNAPOLIS	59	49	46	36	35	22.4
37-035-0004 CATAWBA	1650 1ST. ST.	57	55	50	41	40	24.1
37-037-0004 CHATHAM	RT4 BOX62 PITTSBORO	38	40	37	35	33	20.4
37-051-0004 CUMBERLAND	F.S. # 5 3296 VILLAGE DR.	60	84	53	48	43	26.3
37-057-0002 DAVIDSON	S.SALISBURY ST. LEXINGTON	58	50	49	48	43	25.6
37-057-1002 DAVIDSON	400 SALEM STREET	61	48	47	47	47	25.3
37-063-0001 DURHAM	HEALTH DEPT 300 E MAIN ST	22	48	46	44	41	24.3
37-065-0002 EDGECOMBE	LEGGETT RD., ROCKY MOUNT	58	46	39	38	37	22.5

SITE NUMBER COUNTY	STREET	NUM OBS	24-HOUR MAXIMA 1ST	2ND	3RD	4TH	ARITH MEAN
37-065-0099 EDGECOMBE	NC 97 LEGETT	56	43	37	36	34	19.1
37-067-0009 FORSYTH	INDIANA AV & AKRON DR HANES HO	58	44	37	34	34	22.6
37-067-0013 FORSYTH	720 RIDGE AVENUE	42	46	39	37	36	24.8
37-067-0023 FORSYTH	1401 CORPORATION PARKWAY	53	48	47	46	44	26.3
37-067-0023 FORSYTH	1401 CORPORATION PARKWAY	362	58	58	55	55	25.1
37-067-0024 FORSYTH	NORTH FORSYTH HIGH SCHOOL	46	46	41	36	35	20.0
37-071-0014 GASTON	RANKIN LAKE RD GASTONIA	46	52	52	42	37	21.0
37-077-0002 GRANVILLE	3200 WEBB SCHOOL RD OXFORD	55	44	44	40	34	17.9
37-081-0009 GUILFORD	EDGEWORTH & BELLEMEADE STS	61	49	48	44	41	24.7
37-081-1005 GUILFORD	E GREEN & S CENTENNIAL ST	60	54	54	49	48	27.6
37-083-0002 HALIFAX	NE CORNER OF 5TH & CAROLINA ST	47	55	51	43	39	23.1
37-085-0001 HARNETT	MUNICIPAL BUILDING	54	45	45	43	40	25.1
37-087-0002 HAYWOOD	ROOF CANTON FIRE DEPT.	61	72	49	45	44	24.9
37-089-1006 HENDERSON	CORNER OF ALLEN & WASHINGTON S	60	55	53	47	44	24.4
37-109-0003 LINCOLN	EAST CONGRESS ST	60	54	50	38	38	22.9

SITE NUMBER COUNTY	STREET	NUM OBS	24-HOUR MAXIMA 1ST	2ND	3RD	4TH	ARITH MEAN
37-111-0002 MC DOWELL	COURTHOUSE	60	61	59	51	47	29.7
37-119-0001 MECKLENBURG	600 EAST TRADE STREET	59	58	48	47	47	26.5
37-119-0003 MECKLENBURG	FIRE STA #11 620 MORETZ STREET	60	49	47	46	46	27.8
37-119-0010 MECKLENBURG	FIRE STA #10 2136 REMOUNT ROAD	45	53	53	50	45	29.2
37-119-1001 MECKLENBURG	FILTER PLANT	58	49	42	36	35	21.7
37-119-1005 MECKLENBURG	400 WESTINGHOUSE BLVD.	31	53	53	49	47	35.9
37-121-0001 MITCHELL	CITY HALL SUMMIT ST	61	73	59	55	55	32.7
37-129-0007 NEW HANOVER	WAREHSE & RECEIVING ST UNCW WI	53	50	46	41	40	22.8
37-133-0004 ONSLOW	2553 ONSLOW DRIVE JACKSONVILLE	60	44	37	35	34	21.9
37-139-0001 PASQUOTANK	WATER PLANT N WILSON ST	55	38	33	32	31	16.6
37-147-0003 PITT	1500 BEATTY ST GREENVILLE	56	46	36	35	30	20.0
37-155-0003 ROBESON	SO. WATER ST.	58	55	53	42	39	22.9
37-159-1006 ROWAN	CORNER OF CHURCH & KERR STS	60	49	47	42	39	23.5
37-173-0002 SWAIN	CENTER ST/PARKS 7 REC FACILITY	60	51	48	38	36	20.9
37-183-0003 WAKE	FIRE STATION #9 SIX FORKS RD N	61	58	49	49	47	25.6

SITE NUMBER COUNTY	STREET	NUM OBS	24-HOUR MAXIMA 1ST	2ND	3RD	4TH	ARITH MEAN
37-189-0003 WATAUGA	HARDIN PRK ELEMENTARY SCHL HWY	53	50	46	40	35	19.5
37-191-0004 WAYNE	HWY 70 WEST PATROL STA. GOLDSBO	61	53	43	37	37	22.6
37-195-0002 WILSON	N.W. CORNER OF KENAN ST.& TARB	56	45	41	41	37	22.7
Total samples		3,349					
Total sites sampled		47					

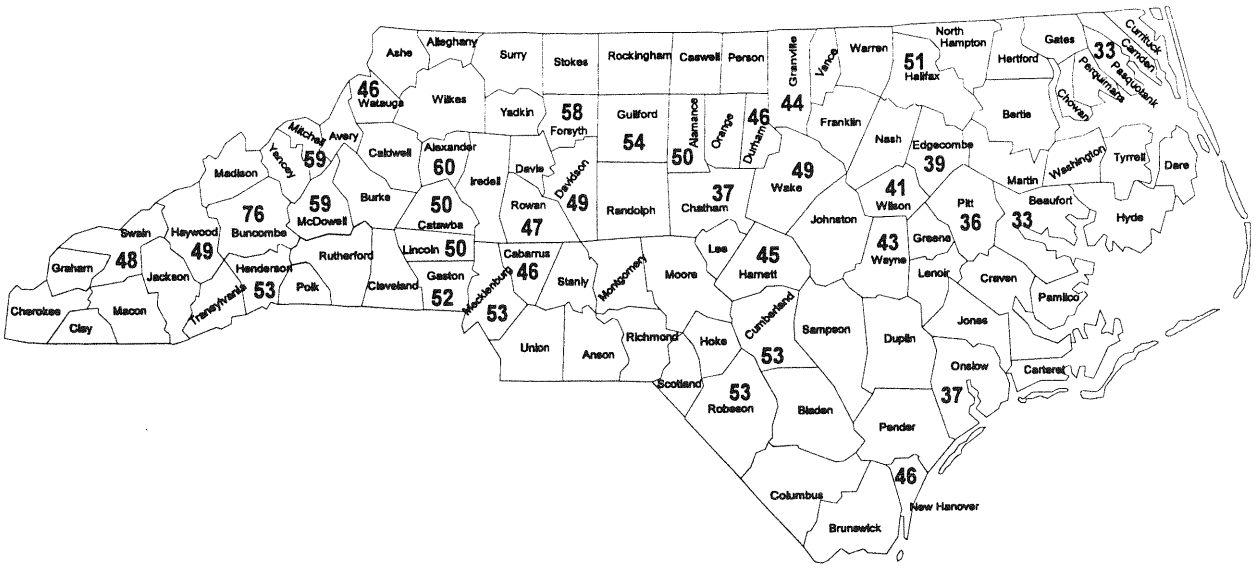

Figure 5.5. PM-10: Second Highest 24-Hour Averages, 1996

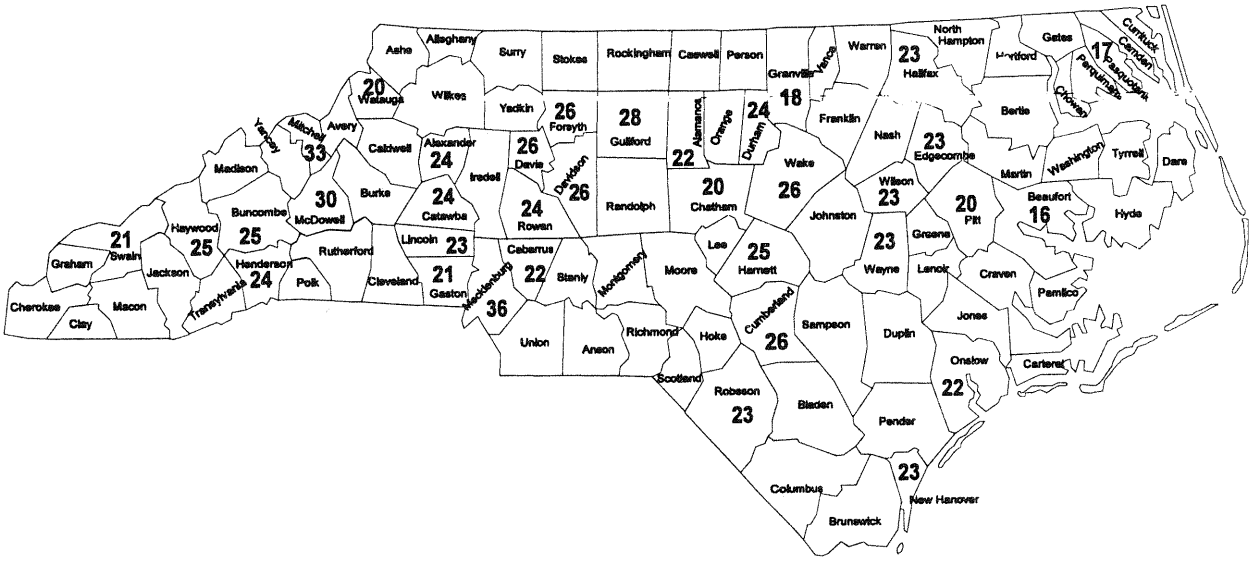

Figure 5.6. PM-10: Maximum Annual Arithmetic Means, 1996

5.3. Carbon Monoxide

Carbon monoxide (CO) data are collected for determination of attainment status with the ambient air quality standard and as ozone precursors data at selected sites. The carbon monoxide samples are collected as ozone precursor data in very low concentrations (0 to 2 ppm) at special Urban Airshed Modeling related sites. This report will focus on the data from attainment determination sites. The carbon monoxide data related to ozone formation monitoring are available by contacting the Division of Air Quality at the address in the Foreword. The division collects carbon monoxide (CO) data from ten monitors in Chapel Hill, Durham, Fayetteville, Durham, Gastonia, Greensboro and Raleigh, and local program agencies collect CO data from three monitors in Winston-Salem and five monitors in Charlotte. All the monitors use EPA Reference or equivalent methods to measure the concentrations.

In 1996, 18 sites were used to monitor CO for ambient air quality attainment status determinations, and 128,262 valid hourly averages were collected. A map of the CO sampling sites is presented in Figure 5.7, and a detailed summary of the data from each site is given in Table 5.3.

There were no exceedances of the CO ambient air quality standards in 1996. The greatest 1-hour average was 14.2 parts per million (ppm), or about 41% of the standard (35 ppm). The greatest 8-hour average was 5.7 ppm, or about 63% of the standard of 9 ppm. (In order for the national and State 8-hour standard to be exceeded, the *two* highest reported values for the same monitor must be equal to or greater than 9.5 ppm).

The second highest 1-hour concentrations in each county are charted in Figure 5.8 and the second highest concentrations are similarly charted in Figure 5.9.

Monthly distributions of 8-hour CO averages are graphed in Figure 5.10 as box-and-whisker plots. (See Appendix C on page 74 for an explanation of this type of chart.) Historical data have demonstrated that high concentrations of CO occur more frequently in Autumn and Winter than during the warmer months of the year. There are three main reasons for this seasonal variation: (1) North Carolina experiences more atmospheric inversions in colder months, trapping air pollutants at low heights; (2) motor vehicles emit more CO due to inefficient combustion during cold starts and warm up; and (3), more fuel is burned for comfort heating during colder temperatures.

All areas monitored are attaining the ambient air quality standards for carbon monoxide. Several factors have reduced CO concentrations, with the most significant being that older vehicles are gradually being replaced with newer, more efficient vehicles. The motor vehicle Inspection and Maintenance program in effect in Mecklenburg, Wake, Durham, Forsyth, Guilford, Gaston, Cabarrus, Orange and Union counties and is an intentional control strategy that helps assure cleaner-running cars. Other factors include increased news media interest and public awareness, and the reporting of the Air Quality Index (see Chapter 6 of this report). As a result of public awareness, more cars are kept in better running condition, thus operating more cleanly. Traffic flow improvements such as new roads and better coordinated traffic signals also help reduce CO.

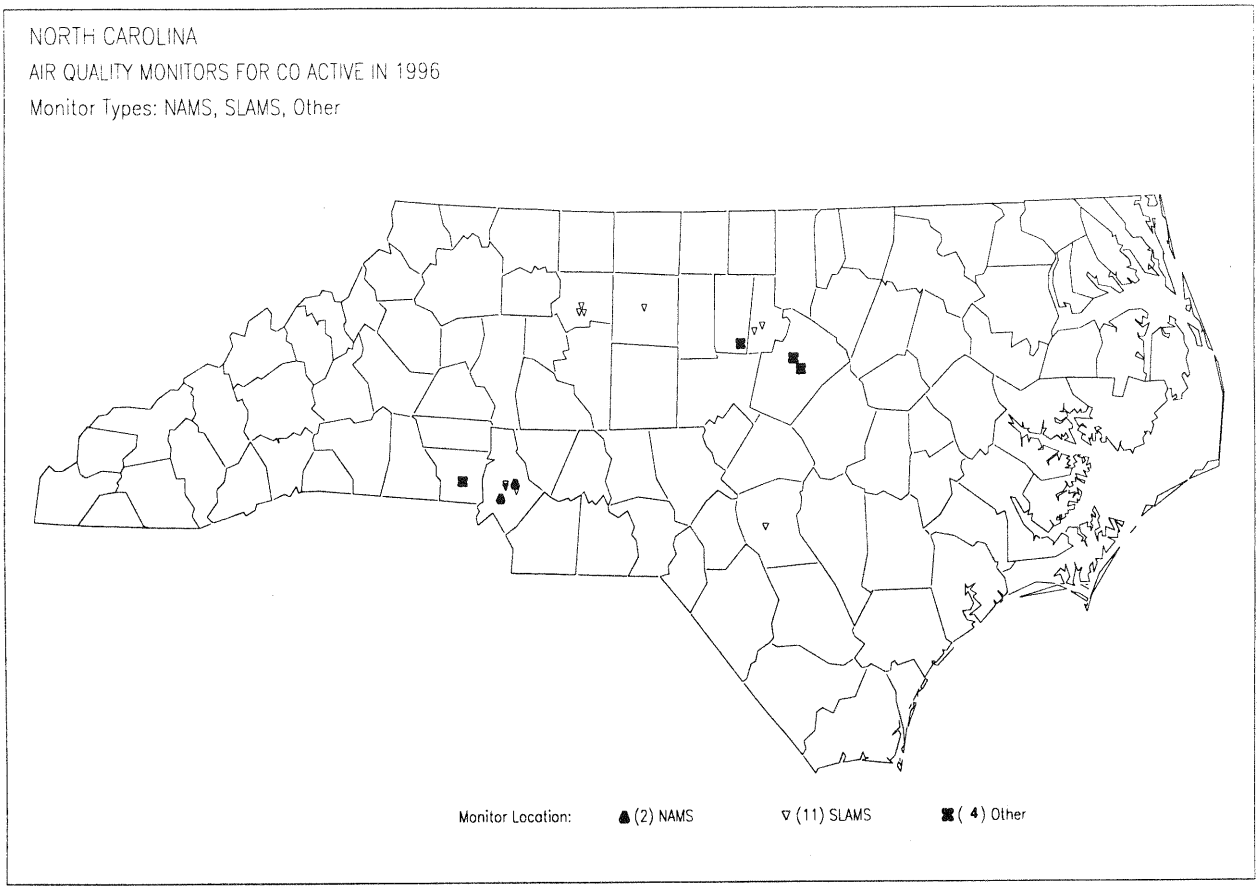

Figure 5.7. Location of Carbon Monoxide Monitoring Sites, 1996

Table 5.3. Carbon Monoxide in Parts Per Million from All Sites for 1996

SITE NUMBER COUNTY	ADDRESS	NUM OBS	1-HOUR MAXIMA		8-HOUR MAXIMA	
			1ST	2ND	1ST	2ND
1996 Data						
37-051-0007 CUMBERLAND	CUMBERLAND CO ABC BOARD, 1705	8,502	7.8	6.9	4.4	4.1
37-063-0011 DURHAM	201 NORTH ROXBORO ST	8,226	9.3	7.7	5.5	5.4
37-063-0012 DURHAM	4001 CHAPEL HILL BLVD	8,512	8.5	7.6	5.7	4.5
37-067-0023 FORSYTH	1401 CORPORATION PARKWAY	8,659	8.6	6.8	4.5	4.3
37-067-0025 FORSYTH	100 SW STRATFORD RD	8,719	5.4	5.1	2.5	2.4
37-067-0026 FORSYTH	1590 BOLTON STREET	8,731	4.6	4.2	3.2	3.0
37-071-0015 GASTON	1555 EAST GARRISON BLVD	4,339	5.7	5.5	4.0	3.6
37-081-1011 GUILFORD	401 WEST WENDOVER	8,585	6.9	5.3	4.0	3.8
37-119-0032 MECKLENBURG	5137 CENTRAL AVE.	8,425	11.3	8.5	4.4	4.4
37-119-0034 MECKLENBURG	PLAZA ROAD AND LAKEDELL	8,661	10.5	9.1	1.6	1.6
37-119-0035 MECKLENBURG	1330 SPRING ST GRNVILLE NEIGHB	8,707	6.0	5.9	5.3	5.1
37-119-0037 MECKLENBURG	415 EAST WOODLAWN RD	8,657	9.7	7.5	4.9	3.9

SITE NUMBER COUNTY	ADDRESS	NUM OBS	1-HOUR MAXIMA		8-HOUR MAXIMA	
			1ST	2ND	1ST	2ND
37-119-0038 MECKLENBURG	301 N TRYON ST	8,604	10.5	8.7	4.9	4.4
37-135-0005 ORANGE	109 ½ EAST FRANKLIN STREET	3,453	11.0	10.2	5.7	5.1
37-135-0006 ORANGE	147 EAST FRANKLIN STREET	2,387	12.3	8.4	5.1	5.0
37-183-0011 WAKE	420 S PERSON ST	8,550	14.2	10.4	5.6	5.6
37-183-0013 WAKE	EF HUTTON, HWY 70 WEST	2,168	10.2	9.6	5.6	5.3
37-183-0018 WAKE	HWY 70 WEST AND HWY 50 NORTH	4,377	9.6	8.5	5.5	5.2
Total samples		128,262				
Total sites sampled		18				

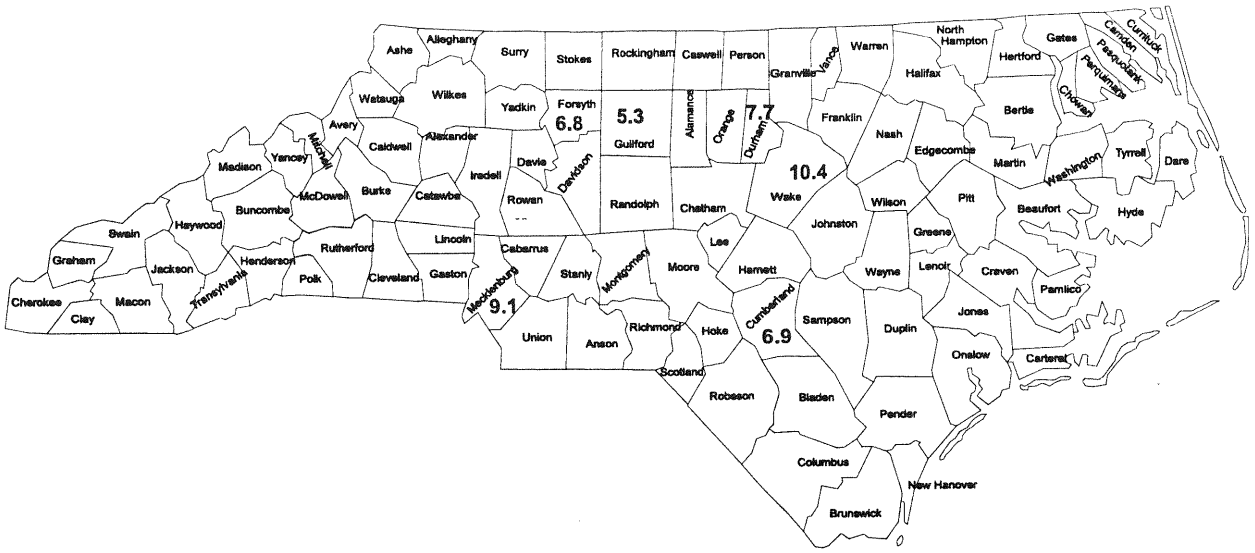

Figure 5.8. Carbon Monoxide: Second Highest One-Hour Average, 1996

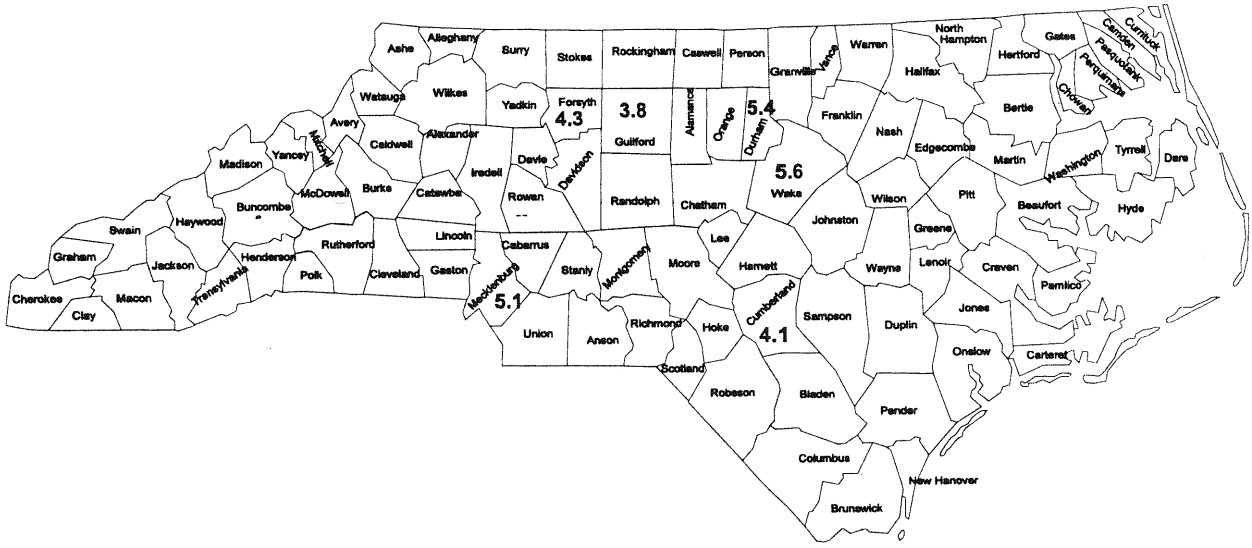

Figure 5.9. Carbon Monoxide: Second Highest Nonoverlapping Eight-Hour Average, 1996

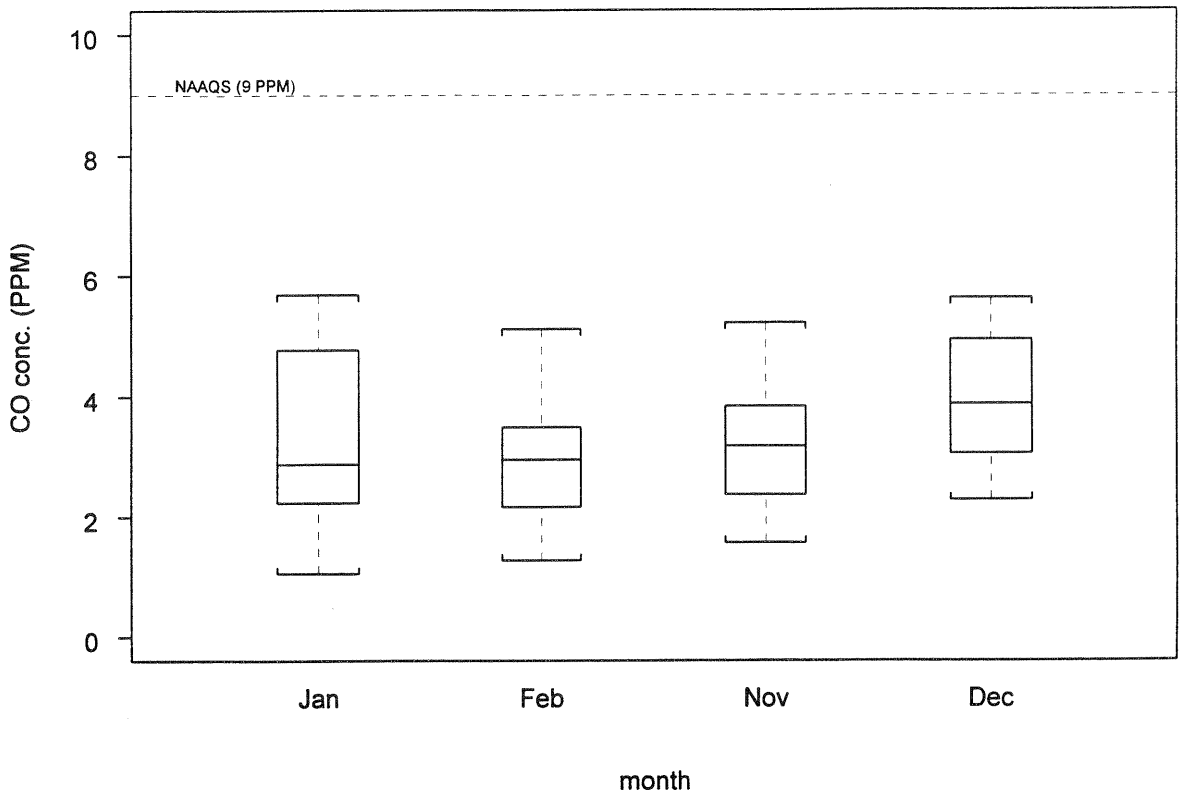

Figure 5.10. Carbon Monoxide: Monthly Distribution of Highest Daily 8-Hour Averages, 1996

5.4 Ozone

Ozone (O_3) concentrations are measured using EPA reference or equivalent continuous monitors. Ozone is a seasonal pollutant formed in the atmosphere as a result of many chemical reactions that occur in sunlight, mainly during the warmer months. Thus, most ozone monitors operate from April through October.

The federal, state, and local program agencies operated 37 monitoring sites in 1996 during the ozone season. A map of the O_3 sampling sites is presented in Figure 5.11, and a detailed summary of the data from each site is given in Table 5.4. In North Carolina, some O_3 sites are operated only every third year, so the monitors considered "active" in 1996 included seven sites that were last operated in 1995 and five sites that were last operated in 1994. These 49 active monitoring sites provided 219,555 hourly samples.

There were nine actual exceedances of the ambient air quality standard for ozone in 1996. Seven of these exceedances occurred near Charlotte as follows: two at Plaza Road, Charlotte; two at 400 Westinghouse Boulevard (Arrowood), Charlotte; one at 29N (County Line), Mecklenburg County; and two at West Street and Gold Hill (Rockwell) in Rowan County. The remaining two exceedances occurred in the Triad area: one at 6496 Baux Mountain Road (Shiloh Church) in Forsyth County and one at Keely Park in Guilford County.

The standard is exceeded when one valid one-hour average exceeds 0.124 ppm at a site and the expected number of exceedances is greater than 1. (To exceed the standard, the largest average must be larger than 0.12 ppm when *rounded* to two significant digits. The "expected number" of exceedances is determined from a 3-year average of exceedance day counts for an area. Moreover, when any ozone sampling day does not have a valid maximum ozone measurement for any reason, the missing day can be counted as an *estimated* exceedance day under certain circumstances [40 CFR 50 App. J, Office of the Federal Register 1993, p. 767-768].

Table 5.4 gives both the actually measured and the estimated number of exceedance days at each site.) Mecklenburg County also had one exceedance day in 1995 at Plaza Road and one exceedance day in 1995 at County Line. Rockwell also had one exceedance day in 1995. The only Triad exceedance in 1995 did not occur at the Shiloh Church or Keely Park Sites. There were no ozone exceedances statewide in 1994.

Mecklenburg County and the Triad Counties were redesignated as attainment/ maintenance areas on July 5, 1995 and November 8, 1993, respectively. The three exceedances each at the three sites in the Mecklenburg County area and the one exceedance each at the three sites in the Triad are not violations of the standard and do not cause the areas to again be designated as non-attainment areas. Generally an area is in violation if it exceeds the standard at a monitor four or more times in any three year period. (Note: No additional exceedances occurred at these sites in 1997.) The reader is referred to the discussion of attainment status in Appendix D of this report.

The second highest 1-hour concentrations in each county are charted in Figure 5.12 for areas with one or more monitors active in 1994, 1995 or 1996 (using only the latest available year of data).

Figure 5.13 shows the number of "high" ozone values on a monthly basis for 1996. Monthly distributions of all the 1-hour O_3 data for 1996 are graphed in Figure 5.14 as box-and-whisker plots.

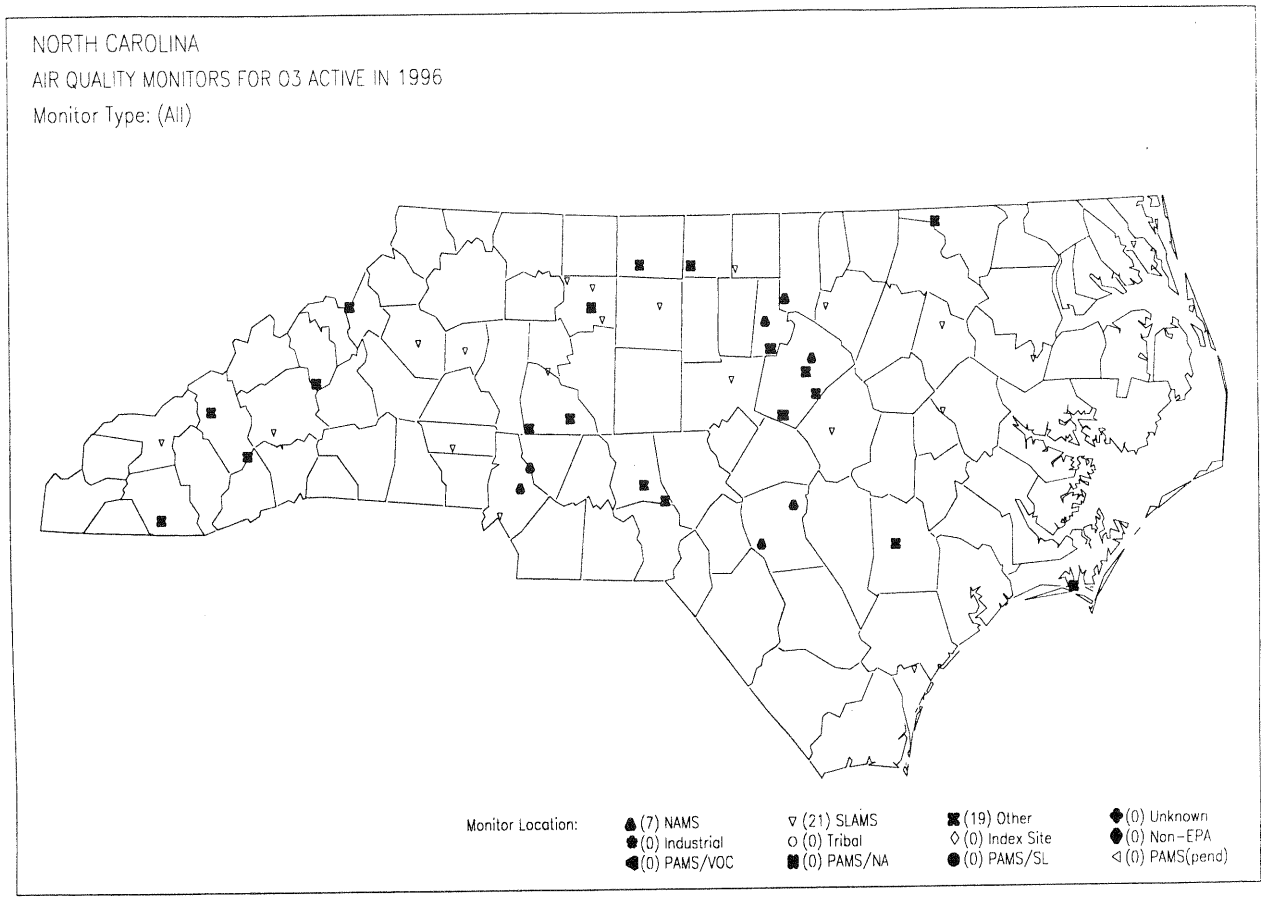

Figure 5.11. Location of Ozone Monitoring Sites

Table 5.4. Ozone in Parts Per Million for 1996.

SITE NUMBER COUNTY	ADDRESS	NUM OBS	DAILY 1-HR MAXIMA				NO. VALUES ≥ 0.125	
			1ST	2ND	3RD	4TH	MEAS	EST
1996 Data								
37-003-0003 ALEXANDER	STATE ROAD 1177 TAYLORSVILLE	4,844	0.094	0.094	0.089	0.089	0	0.0
37-021-0030 BUNCOMBE	ROUTE 191 S BREVARD RD ASHEVILLE	4,919	0.085	0.084	0.083	0.081	0	0.0
37-031-8001 CARTERET	MERRIMON ROAD BEAUFORT	1,993	0.092	0.090	0.088	0.087	0	0.0
37-033-0001 CASWELL	CHERRY GROVE RECREATION	3,877	0.109	0.108	0.103	0.099	0	0.0
37-037-0004 CHATHAM	RT4 BOX62 PITTSBORO	4,738	0.106	0.100	0.099	0.099	0	0.0
37-051-0008 CUMBERLAND	1/4MI SR1857/US301	4,781	0.100	0.099	0.095	0.095	0	0.0
37-051-1002 CUMBERLAND	HOPE MILLS POLICE DPT ROCKFISH RD. FAYETTEVILLE	4,667	0.106	0.106	0.105	0.100	0	0.0
37-059-0002 DAVIE	246 MAIN ST COOLEEMEE	4,391	0.108	0.103	0.100	0.100	0	0.0
37-061-0002 DUPLIN	HWY 50 KENANSVILLE	4,668	0.084	0.083	0.080	0.080	0	0.0
37-063-0013 DURHAM	2700 NORTH DUKE STREET	4,757	0.105	0.103	0.100	0.098	0	0.0
37-065-0099 EDGECOMBE	RT 2, BOX 195 TARBORO	4,820	0.094	0.091	0.090	0.088	0	0.0

SITE NUMBER COUNTY	ADDRESS	NUM OBS	DAILY 1-HR MAXIMA				NO. VALUES ≥ 0.125	
			1ST	2ND	3RD	4TH	MEAS	EST
37-067-0022 FORSYTH	1300 BLK. HATTIE AVENUE	4,789	0.112	0.102	0.099	0.095	0	0.0
37-067-0027 FORSYTH	7635 HOLLYBERRY LANE	5,101	0.109	0.096	0.096	0.095	0	0.0
37-067-0028 FORSYTH	6496 BAUX MTN RD, WINSTON-SALEM	5,086	0.126	0.118	0.107	0.099	1	1.0
37-067-1008 FORSYTH	3656 PIEDMONT MEMORIAL DRIVE, WINSTON-SALEM	5,101	0.121	0.119	0.109	0.104	0	0.0
37-069-0001 FRANKLIN	431 S HILLBOROUGH ST	4,856	0.107	0.107	0.104	0.102	0	0.0
37-077-0001 GRANVILLE	WATER TREATMENT PLANT JOHN UMSTEAD HOSP, BUTNER	4,872	0.124	0.124	0.116	0.115	0	0.0
37-081-0011 GUILFORD	KEELY PARK KEELY RD MCCLEANSVILL	4,704	0.125	0.109	0.103	0.100	1	1.0
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PKWY MILE MARKER 410	4,572	0.101	0.095	0.095	0.094	0	0.0
37-087-0036 HAYWOOD	GREAT SMOKY MOUNTAIN NATIONAL PARK	4,054	0.092	0.092	0.090	0.090	0	0.0
37-101-0002 JOHNSTON	3411 JACK ROAD CLAYTON	4,648	0.107	0.102	0.101	0.100	0	0.0

SITE NUMBER COUNTY	ADDRESS	NUM OBS	DAILY 1-HR MAXIMA				NO. VALUES ≥ 0.125	
			1ST	2ND	3RD	4TH	MEAS	EST
37-109-0004 LINCOLN	RIVERVIEW ROAD	4,847	0.102	0.100	0.099	0.099	0	0.0
37-113-8001 MACON	COWEETA HYDROLOGIC LABORATORY	2,150	0.094	0.080	0.077	0.076	0	0.0
37-119-0034 MECKLENBURG	PLAZA ROAD AND LAKEDELL CHARLOTTE	5,074	0.142	0.125	0.116	0.112	2	2.0
37-119-1005 MECKLENBURG	400 WESTINGHOUSE BLVD. CHARLOTTE	4,975	0.131	0.130	0.116	0.111	2	2.0
37-119-1009 MECKLENBURG	29 N@ MECKLENBURG CAB CO CHARLOTTE	5,071	0.131	0.123	0.120	0.110	1	1.0
37-129-0002 NEW HANOVER	6028 HOLLY SHELTER RD CASTLE HAYNE	4,694	0.103	0.090	0.088	0.085	0	0.0
37-147-0099 PITT	US 264 NEAR WATER TOWER FARMVILLE	4,803	0.102	0.097	0.097	0.097	0	0.0
37-157-0099 ROCKINGHAM	6371 NC 65 @ BETHANY SCHOOL	4,771	0.124	0.123	0.118	0.106	0	0.0
37-159-0021 ROWAN	WEST ST & GOLD HILL AVENUE ROCKWELL	4,408	0.134	0.133	0.120	0.113	2	2.2
37-159-0022 ROWAN	925 N ENOCHVILLE AVE	3,660	0.110	0.110	0.110	0.106	0	0.0
37-173-0002 SWAIN	CENTER ST/ PARKS 7 REC FACILITY	3,943	0.076	0.075	0.072	0.070	0	0.0
37-183-0014 WAKE	E MILLBROOK JR HI 3801 SPRING FOREST RD RALEIGH	4,554	0.108	0.093	0.093	0.093	0	0.0

SITE NUMBER COUNTY	ADDRESS	NUM OBS	DAILY 1-HR MAXIMA				NO. VALUES ≥ 0.125	
			1ST	2ND	3RD	4TH	MEAS	EST
37-183-0015 WAKE	808 NORTH STATE STREET RALEIGH	3,858	0.093	0.084	0.079	0.078	0	0.0
37-183-0016 WAKE	201 NORTH BROAD STREET FUQUAY-VARINA	3,586	0.109	0.107	0.099	0.098	0	0.0
37-183-0017 WAKE	5033 TV TOWER RD GARNER	2,535	0.119	0.105	0.103	0.101	0	0.0
37-199-0003 YANCEY	BLUE RIDGE PARKWAY	2,933	0.094	0.090	0.086	0.085	0	0.0
Total Samples		162,100						
Total Sites Sampled		37						
1995 Data								
37-027-0003 CALDWELL	HWY 321 N LENOIR	4,868	0.100	0.095	0.092	0.091	0	0.0
37-029-0099 CAMDEN	COUNTY ROAD 1136 & 1134 CAMDEN	4,689	0.100	0.093	0.093	0.091	0	0.0
37-067-0007 FORSYTH	5337 OLD RURAL HALL ROAD WINSTON-SALEM	4,957	0.117	0.111	0.109	0.099	0	0.0
37-117-0001 MARTIN	HAYES STREET (#2WELL SITE)	4,830	0.089	0.089	0.083	0.082	0	0.0
37-123-8001 MONTGOMERY	112 PERRY DRIVE	4,147	0.118	0.091	0.088	0.088	0	0.0
37-131-0002 NORTHAMPTON	RT 46 GASTON	4,781	0.106	0.101	0.100	0.096	0	0.0
37-145-0099 PERSON	SR 1102 & NC 49 GORDONTON	4,768	0.096	0.094	0.093	0.093	0	0.0
Total Samples	95	33,040						
Total Sites Sampled	95	7						

SITE NUMBER COUNTY	ADDRESS	NUM OBS	DAILY 1-HR MAXIMA				NO. VALUES ≥ 0.125	
			1ST	2ND	3RD	4TH	MEAS	EST
1994 Data								
37-003-0003 ALEXANDER	STATE ROAD 1177 TAYLORSVILLE	4,746	0.094	0.092	0.089	0.086	0	0.0
37-023-0004 BURKE	126 AND 1254	4,922	0.103	0.101	0.098	0.096	0	0.0
37-059-0099 DAVIE	FORK RECREATION CENTER	4,832	0.086	0.085	0.082	0.079	0	0.0
37-101-0099 JOHNSTON	HIGHWAY 301 & SR 2141	4,823	0.107	0.103	0.097	0.097	0	0.0
37-113-8001 MACON	COWEETA HYDROLOGIC LABORATORY	5,092	0.089	0.088	0.084	0.083	0	0.0
Total Samples		24,415						
Total Sites Sampled		5						

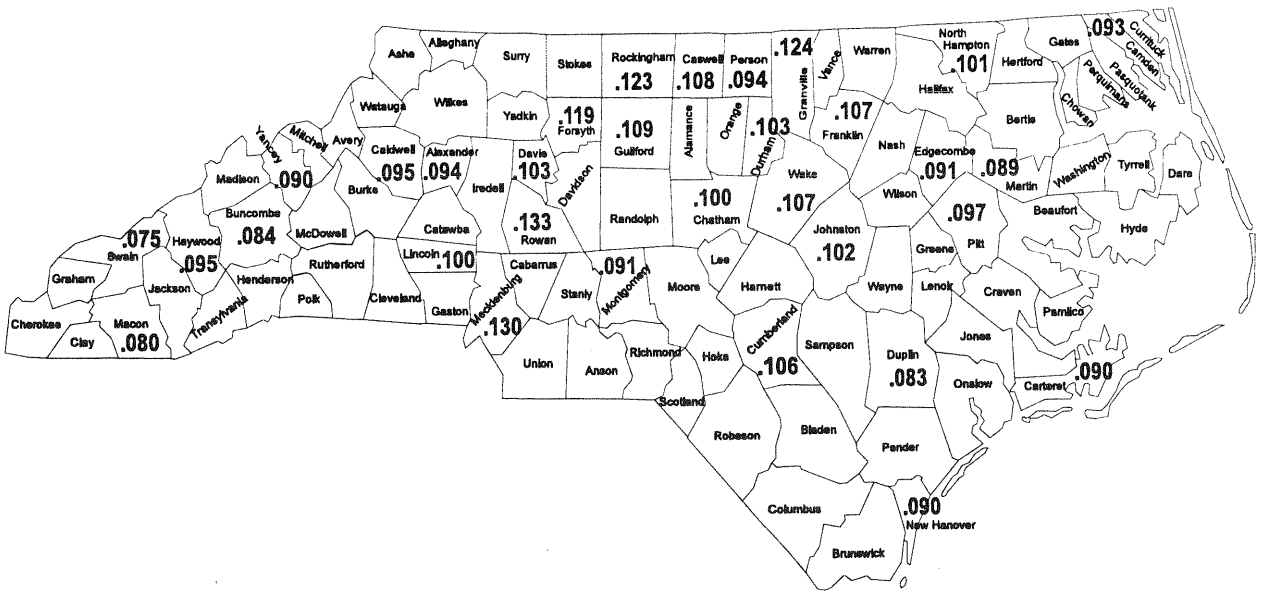

Figure 5.12. Ozone: Second Highest Annual One-Hour Average in the Most Recent Year of Data, from 1994, 1995 or 1996.

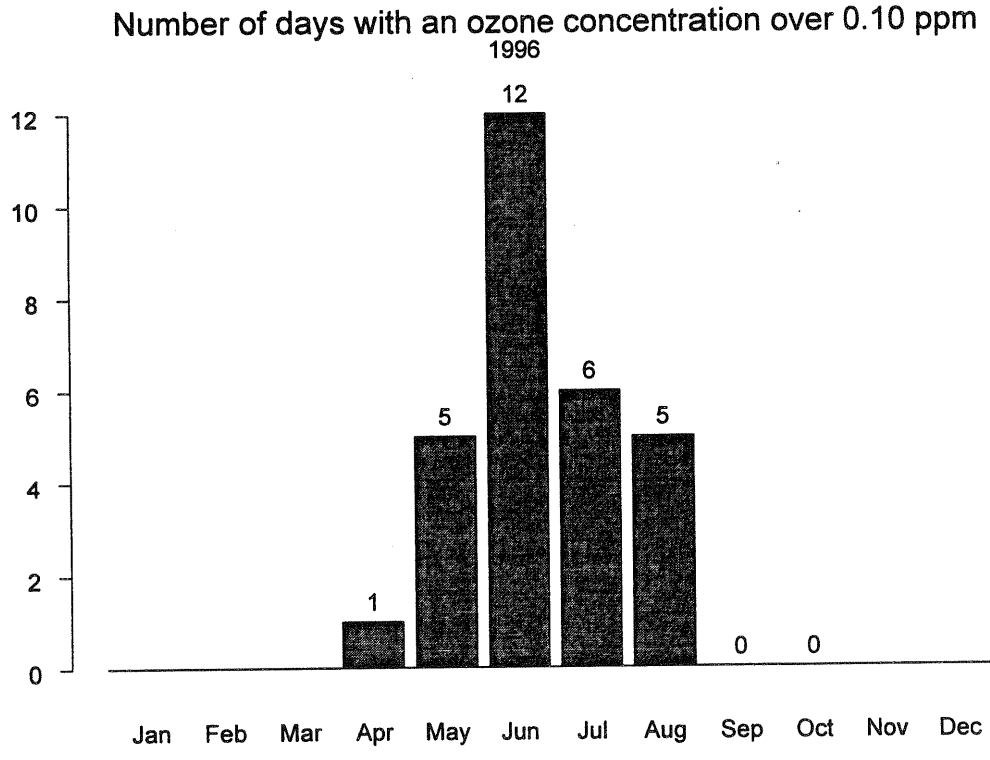

Figure 5.13. Number of Days with 1-Hour Ozone Averages in Excess of 0.10 ppm, 1996.

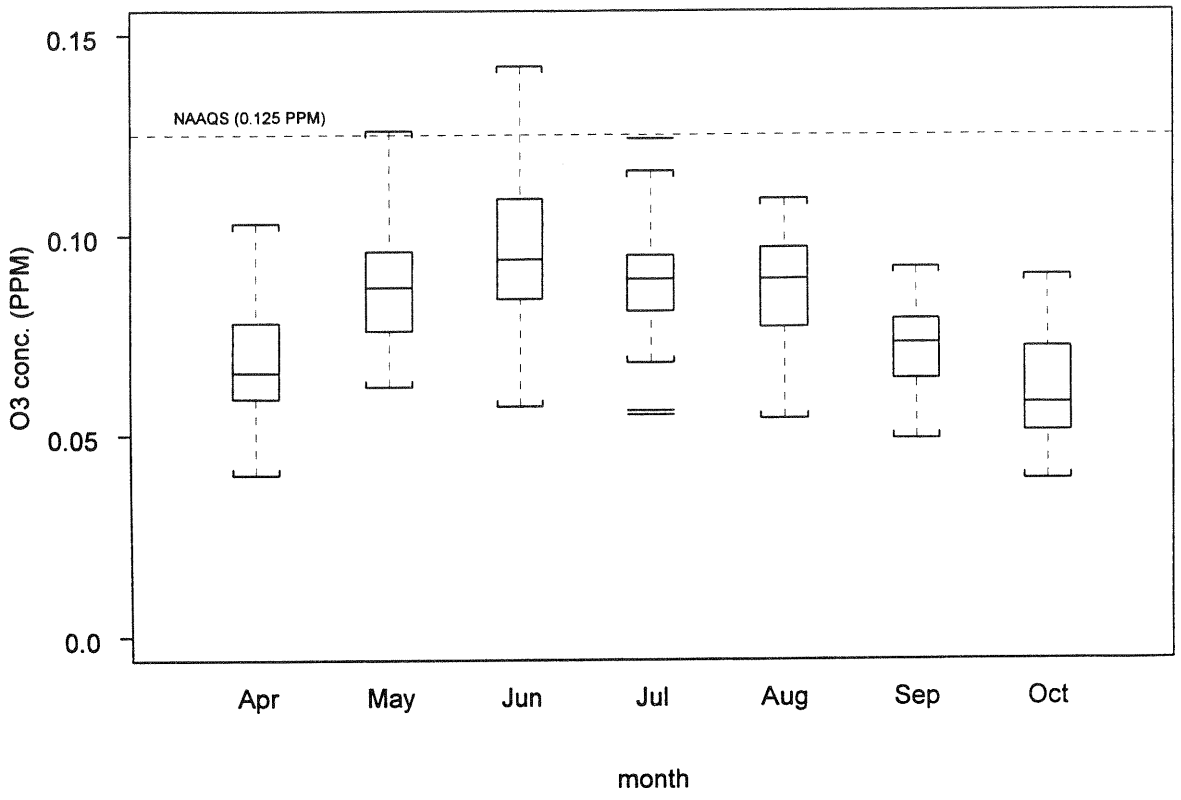

Figure 5.14. Monthly Distribution of Ozone Measurements, 1996

5.5. Sulfur Dioxide

Sulfur dioxide (SO_2) concentrations were measured by the state and two local program agencies using EPA reference or equivalent methods. Twenty-one SO_2 monitors were active in North Carolina in 1996. However, some SO_2 sites are operated only every third year, so fifteen sites provided data *in* 1996 and three sites provided data in 1995 (and will next be operated in 1998), and three sites provided data in 1994 (and will next be operated in 1997).

From the 21 sites with SO_2 data obtained between 1994 and 1996, 133,872 valid hourly averages were collected. A map of the (21 "active") SO_2 sampling sites is presented in Figure 5.15, and a detailed summary of the data from each site is given in Table 5.5.

There were no exceedances of the SO_2 ambient air quality standards in 1996. The greatest annual arithmetic mean was .007 ppm, or about 23% of the standard (0.03 ppm), the greatest maximum 24-hour average was .036 ppm, about 26% of the standard (.140 ppm), and the greatest maximum 3-hour average was .138 ppm, about 28% of the welfare-related (secondary) standard.

Apparently the size of an urban area has little effect on the ambient concentrations of SO_2 in North Carolina. Seasonal variations, such as those with CO and O_3, do not appear to exist for SO_2. Major source characteristics such as type, size, distribution, control devices, operating conditions and dispersion situations significantly affect the amount of SO_2 in ambient air.

The second highest three-hour concentrations in each county are charted in Figure 5.16. The second highest 24-hour concentrations in each county are charted in Figure 5.17.

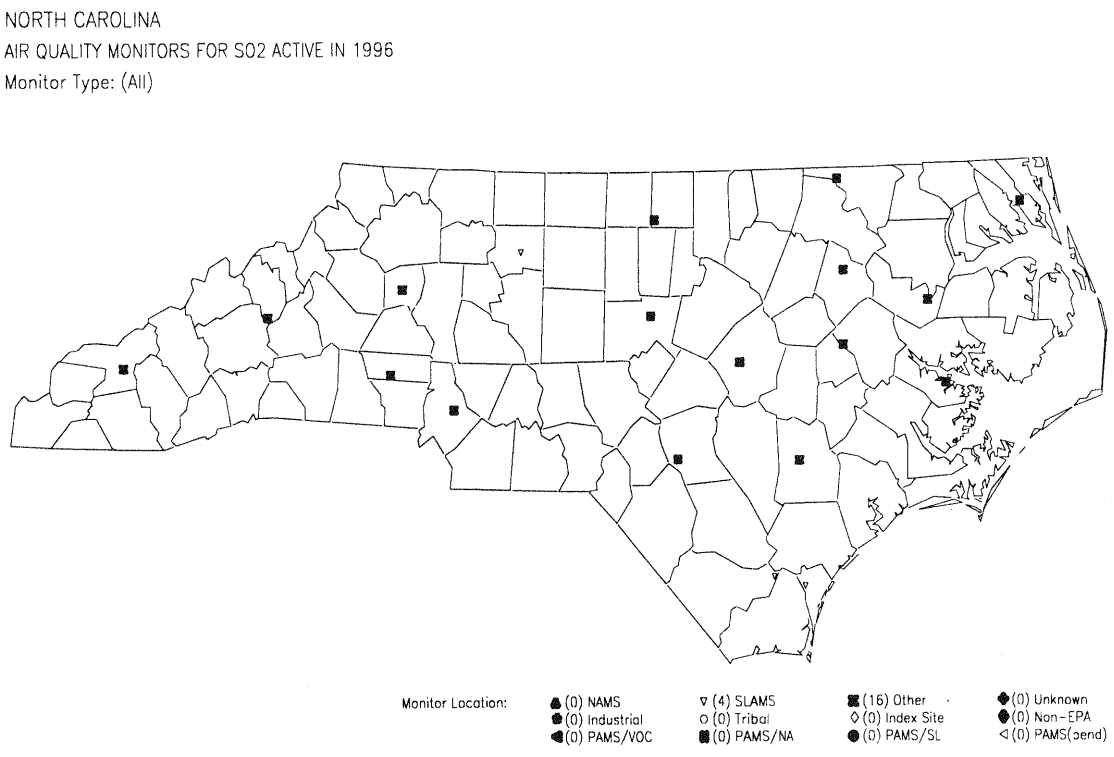

Figure 5.15. Locations of Sulfur Dioxide Monitoring Sites, 1996

Table 5.5 Sulfur Dioxide in Parts Per Million from All Sites for 1994-96.

SITE NUMBER COUNTY	ADDRESS	NUM OBS	ONE-HOUR MAXIMA		THREE-HOUR MAXIMA		24-HOUR MAXIMA		ARITH. MEAN
			1ST	2ND	1ST	2ND	1ST	2ND	
1996 Data									
37-003-0003 ALEXANDER	STATE ROAD 1177	8,258	0.046	0.044	0.031	0.026	0.015	0.012	0.0039
37-013-0003 BEAUFORT	NC HIGHWAY 306	7,914	0.069	0.068	0.055	0.051	0.026	0.024	0.0037
37-013-0004 BEAUFORT	SOUTH FERRY LANDING PAMLICO RI	7,450	0.082	0.080	0.055	0.039	0.015	0.013	0.0037
37-047-0001 COLUMBUS	ACME-DELCO SAMPLING SITE HWY 8	850	0.037	0.025	0.017	0.016	0.008	0.006	0.0039
37-051-1002 CUMBERLAND	HOPE MILLS POLICE DPT, ROCKFIS	8,160	0.054	0.052	0.037	0.029	0.018	0.012	0.0037
37-061-0002 DUPLIN	HWY 50 KENANSVILLE	7,907	0.017	0.017	0.016	0.016	0.010	0.010	0.0030
37-065-0099 EDGECOMBE	RT 2, BOX 195 TARBORO	7,841	0.021	0.020	0.016	0.015	0.011	0.010	0.0030
37-067-0022 FORSYTH	1300 BLK. HATTIE AVENUE	8,309	0.114	0.113	0.088	0.072	0.031	0.026	0.0069
37-101-0002 JOHNSTON	3411 JACK ROAD CLAYTON	8,084	0.081	0.028	0.021	0.019	0.010	0.010	0.0032
37-109-0004 LINCOLN	RIVERVIEW ROAD	2,761	0.080	0.076	0.043	0.038	0.014	0.013	0.0048
37-119-0034 MECKLENBURG	PLAZA ROAD AND LAKEDELL	8,667	0.127	0.072	0.078	0.043	0.018	0.015	0.0048
37-129-0006 NEW HANOVER	HWY 421 NORTH	7,937	0.321	0.177	0.138	0.100	0.036	0.036	0.0062
37-131-0002 NORTHAMPTON	RT 46 GASTON	1,773	0.044	0.034	0.030	0.029	0.016	0.012	0.0054

SITE NUMBER COUNTY	ADDRESS	NUM OBS	ONE-HOUR MAXIMA		THREE-HOUR MAXIMA		24-HOUR MAXIMA		ARITH. MEAN
			1ST	2ND	1ST	2ND	1ST	2ND	
37-173-0002 SWAIN	CENTER ST/PARKS 7 REC FACILITY	2,448	0.019	0.019	0.018	0.016	0.010	0.010	0.0034
37-199-0003 YANCEY	BLUE RIDGE PARKWAY	2,873	0.008	0.008	0.005	0.005	0.003	0.003	0.0027
Total samples		91,232							
Total sites sampled		15							
1995 Data									
37-037-0004 CHATHAM	RT4 BOX62 PITTSBORO	8,107	0.046	0.044	0.041	0.027	0.012	0.008	0.0030
37-047-0001 COLUMBUS	ACME-DELCO SAMPLING SITE HWY 8	8,057	0.069	0.059	0.036	0.035	0.014	0.013	0.0036
37-117-0001 MARTIN	HAYES STREET (#2WELL SITE)	8,237	0.019	0.018	0.015	0.014	0.009	0.007	0.0029
37-145-0099 PERSON	SR 1102 & NC 49	8,138	0.085	0.073	0.065	0.065	0.017	0.012	0.0036
Total samples		32,539							
Total sites sampled		4							
1994 Data									
37-029-0099 CAMDEN	COUNTY ROAD 1136 & 1134	2,014	0.031	0.030	0.027	0.025	0.014	0.010	0.0040
37-059-0099 DAVIE	FORK RECREATION CENTER	8,087	0.060	0.056	0.042	0.040	0.018	0.016	0.0042
Total samples		10,101							
Total sites sampled		2							

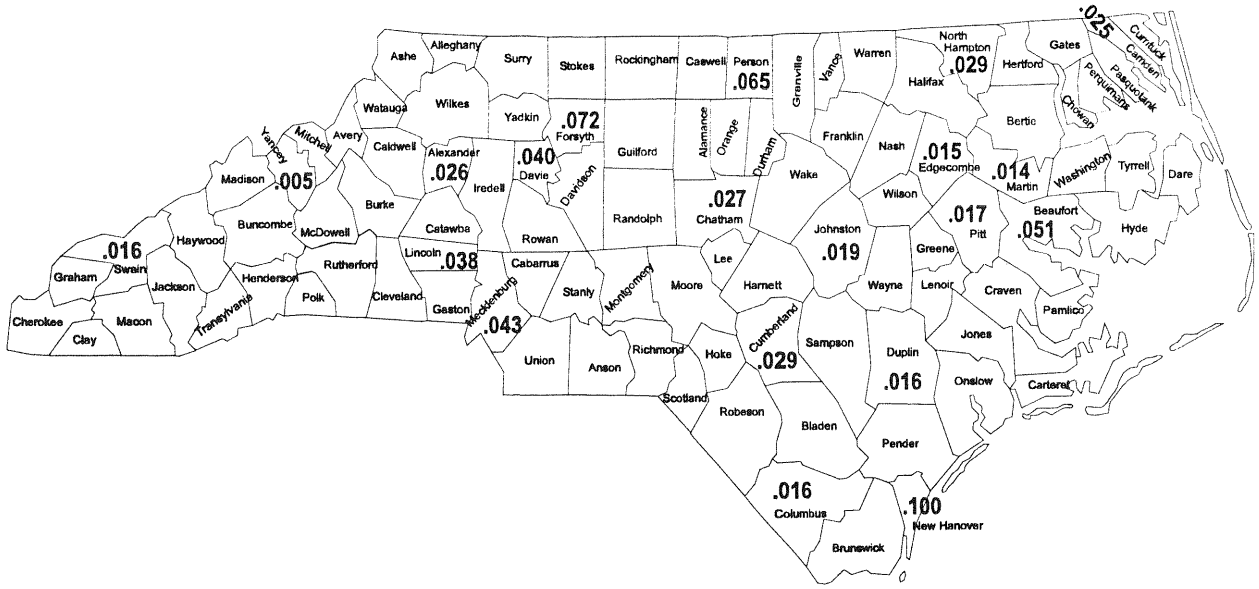

Figure 5.16. SO_2: Second Highest 3-Hour Averages, 1996

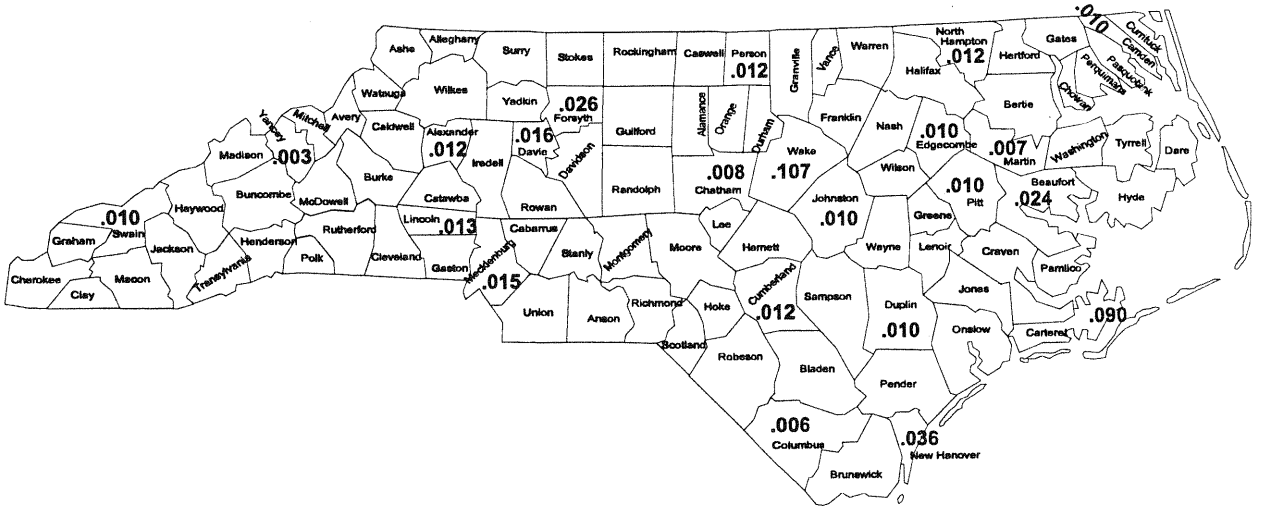

Figure 5.17. SO_2: Second Highest 24-Hour Averages, 1996

5.6. Nitrogen Dioxide

Nitrogen oxides data are collected for determination of attainment status with the ambient air quality standard and as ozone precursor data at selected sites. The nitrogen oxides data for ozone precursors are very low concentration measurements, 0-100 parts per billion (ppb) collected at special Urban Air Shed Modeling related sites. The nitrogen oxides data related to ozone formation are available by contacting the Division of Air Quality at the address in the Foreword. This report will focus on the data from attainment determination sites.

Nitrogen dioxide (NO_2) concentrations were measured using EPA reference or equivalent continuous monitors in 1996 at one state program site in Rowan County, one local program site in Forsyth County, and one local program site in Mecklenburg County.

From these three sites, 17,617 hourly NO_2 measurements were reported. A map of the three NO_2 sampling sites is presented in Figure 5.18, and a summary of the 1996 NO_2 data is given in Table 5.6. Figure 5.19 shows a box-and-whisker plot showing the distribution of hourly average concentrations compared to the annual arithmetic mean standard of 0.053 ppm for the two year-round sites. Each urban area site has only a few outlying high sample values that are above the standard defined for the arithmetic mean. The arithmetic means (Table 5.6) are about 30% or less of the standard.

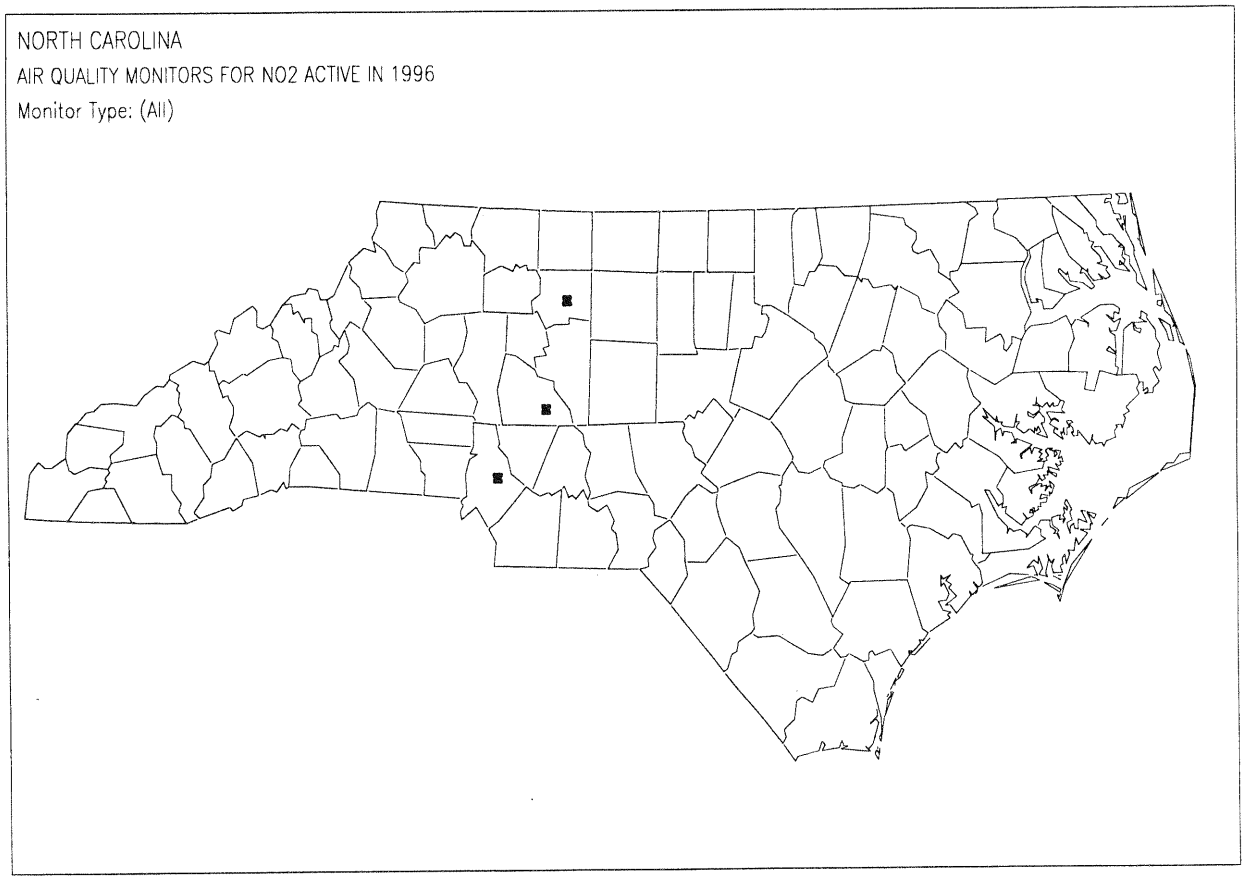

Figure 5.18. Location of Nitrogen Dioxide Monitoring Sites, 1996

Table 5.6. Nitrogen Dioxide in Parts Per Million (PPM) For 1996.

SITE NUMBER COUNTY	STREET	NUM OBS	ONE-HOUR MAXIMA		ARITH. MEAN
			1ST	2ND	
37-067-0022 FORSYTH	1300 BLK. HATTIE AVENUE	7,812	0.066	0.065	0.0164
37-119-0034 MECKLENBURG	PLAZA ROAD AND LAKEDELL	8,516	0.065	0.063	0.0163
37-159-0021 ROWAN	ROCKWELL	1,289	0.040	0.040	0.0080
Number of samples		17,617			

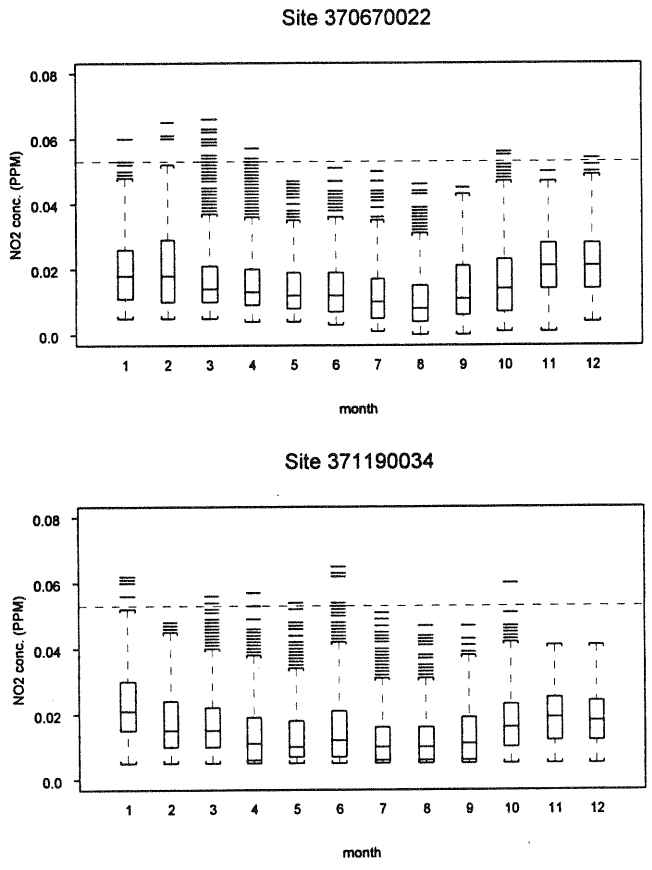

Figure 5.19. Monthly Distributions of Nitrogen Dioxide Concentrations by Site, 1996.

5.3. Lead

The state began metals analysis at 3 locations in 1996. These metals sites will be relocated to other locations in future years. The purpose of these sites is to gather background information about lead and other metals.

The state and local program agencies had not performed routine analysis of ambient lead (Pb) in North Carolina since 1982. Lead monitoring was discontinued as a result of the low values measured and a continuing decrease in the lead concentrations. Ambient Pb concentrations in 1982 were approximately one-half the concentrations observed in 1979. The decrease in ambient Pb concentrations was due to the reduction and elimination of leaded gasoline, resulting in greatly reduced lead emissions from automobiles.

Concentrations of most metals are below detectable limits of the method being used. Only summaries of the lead data are presented in this report. Summaries of the lead data from 1996 are given in Table 5.7.

Table 5.7. Lead in Micrograms Per Cubic Meter ($\mu g/m^3$) For 1996.

COUNTY SITE NUMBER ADDRESS CITY	NUM OBS	QUARTERLY ARITHMETIC MEANS				MEANS >1.5
		1ST	2ND	3RD	4TH	
GUILFORD 37-081-0009 EDGEWORTH AND BELLEMEADE ST GREENSBORO	44	0.04	0.04	0.04	0.04	0
MITCHELL 37-121-0001 CITY HALL, SUMMIT STREET SPRUCE PINE	35	0.04	0.04	0.04	0.04	0
WAKE 37-183-0003 FIRE STATION #9 NORTH HILLS PLAZA RALEIGH	42	0.04	0.04	0.04	0.04	0
Total Samples	121					
Total Sites Sampled	3					

6. Air Quality Index

The Air Quality Index (AQI) was developed by the EPA to provide the public with a simple, accessible and uniform assessment of air quality at a specific location, based on the criteria pollutants PM_{10}, CO, O_3, SO_2 and NO_2. AQI measurements are made and reported in all U.S. metropolitan areas with a population over 200,000. Ambient concentrations for each of these five pollutants is converted to a segmented linear numerical scale ranging from 0 to 500, where 100 corresponds to the EPA primary standard for a 24-hour average (8-hour CO average, 1-hour O_3 average) and 500 corresponds to a concentration associated with "significant harm." The AQI is determined by the pollutant with the highest scaled concentration. A subjective description of "good", "moderate", "unhealthful, "very unhealthful", or "hazardous" is included with the report, with the descriptions corresponding to AQI values of 0-50, 51-100, 101-200, 201-300, and 301-500, respectively. For AQI values between 101 and 500, an appropriate cautionary statement is included advising people susceptible to deleterious health effects to restrict activities and exposure to the ambient air.

An AQI of 101-200 (unhealthful) can produce mild aggravation of symptoms in susceptible persons and possible irritation in healthy persons. People with existing heart or lung ailments should reduce physical exertion and outdoor activity. The general population should reduce vigorous outdoor activity.

An AQI of 201 to 300 (very unhealthful) can produce significant aggravation of symptoms and decreased exercise tolerance in persons with heart or lung disease, and a variety of symptoms in healthy persons. Elderly people and those with existing heart or lung disease should stay indoors and reduce physical activity. The general population should avoid vigorous outdoor activity.

The health effects of an AQI of over 300 (hazardous) include early onset of certain diseases in addition to significant aggravation of symptoms and decreased exercise tolerance in healthy persons. The elderly and persons with existing diseases should stay indoors and avoid physical exertion.

At AQI values over 400, premature death of ill and elderly persons may result, and healthy people will experience adverse symptoms that affect normal activity. Outdoor activity should be avoided. All people should remain indoors, keeping windows and doors closed, and should minimize physical exertion.

During winter months in North Carolina, carbon monoxide usually has the highest pollution standard index value, and in summer months the highest index value is usually due to ozone.

In North Carolina, an AQI is reported to the public by telephone *via* computer-generated

recorded voice announcements 24 hours daily. The AQI report may also be published by local newspapers or broadcast on radio and television stations. Air Quality Index telephone numbers in North Carolina are as follows:

Charlotte Area: 704-333-SMOG (704-333-7664)

Statewide toll-free: 888-AIR-WISE (888-247-9473) for Asheville, Durham, Fayetteville, Greensboro, Greenville, Raleigh, Wilmington and Winston-Salem.

Air Quality Index values for 1996 at five metropolitan areas in North Carolina are given in Figures 6.1, 6.2, 6.3, 6.4, and 6.5.

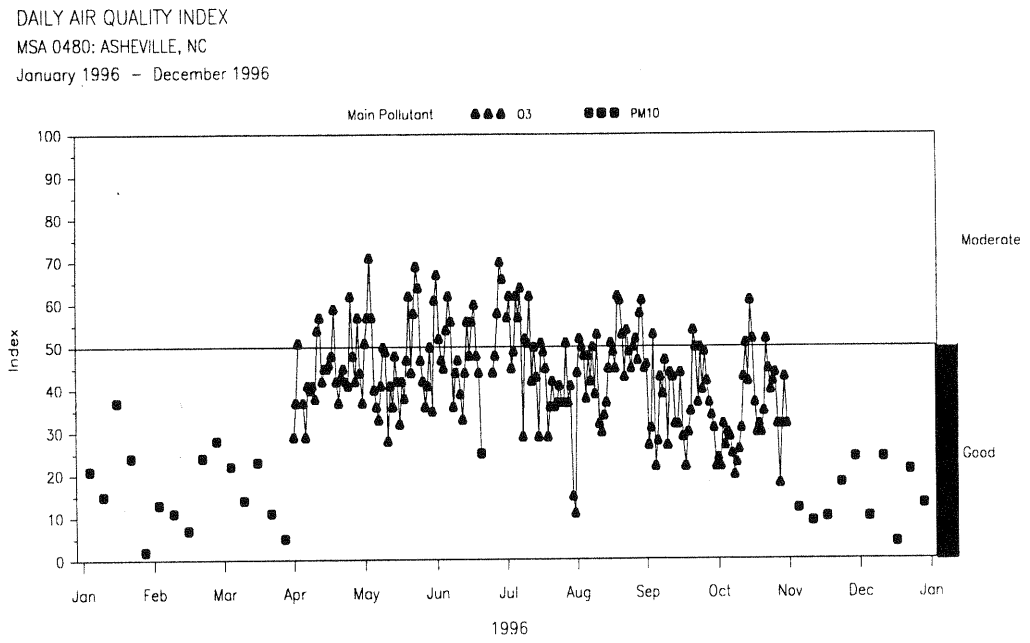

Figure 6.1. Daily Air Quality Index Values for Asheville, North Carolina, Metropolitan Statistical Area, 1996

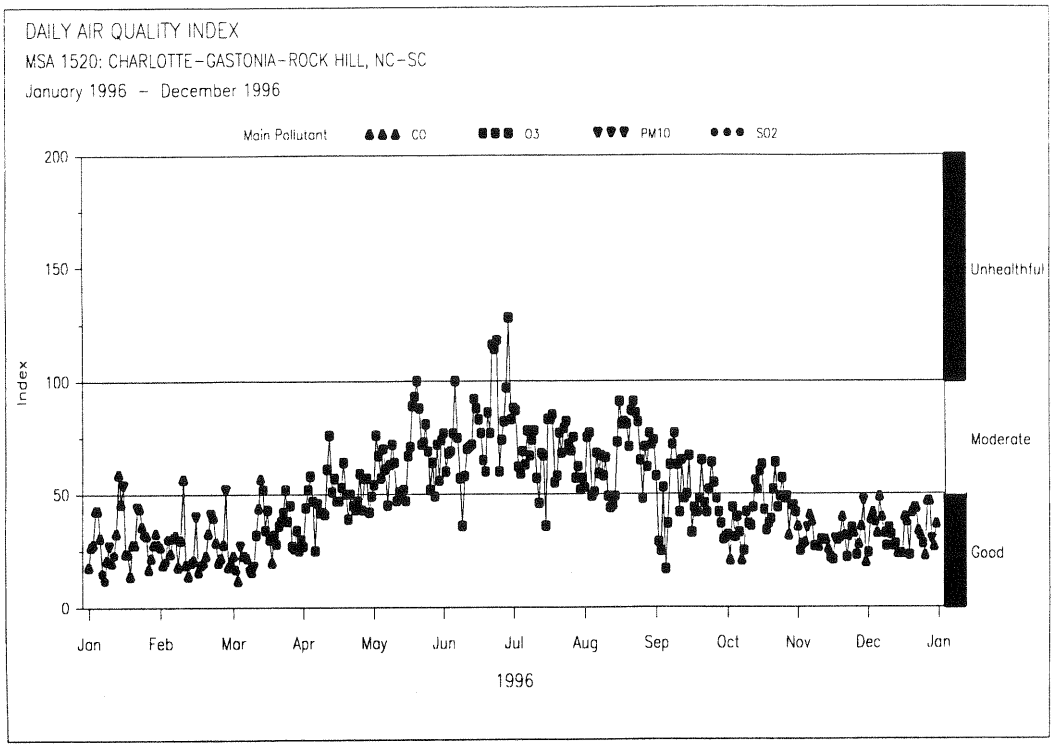

Figure 6.2. Daily Air Quality Index Values for Charlotte-Gastonia,North Carolina, Rock Hill, South Carolina, Metropolitan Statistical Area, 1996.

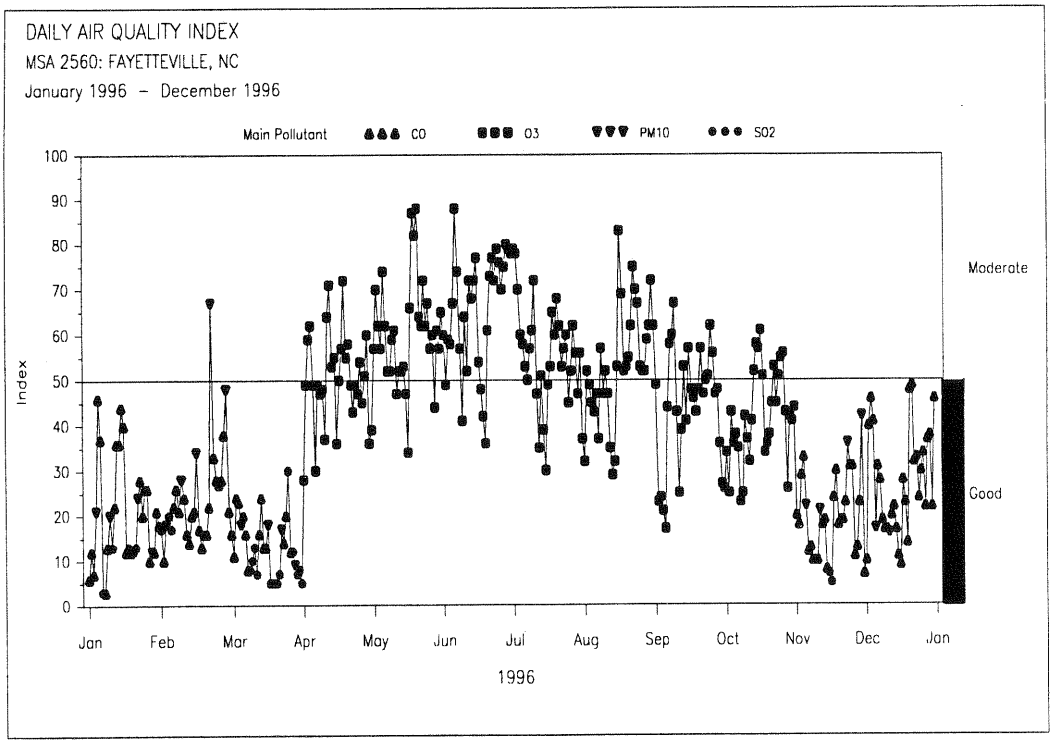

Figure 6.3. Daily Air Quality Index Values for the Fayetteville, North Carolina, Metropolitan Statistical Area, 1996.

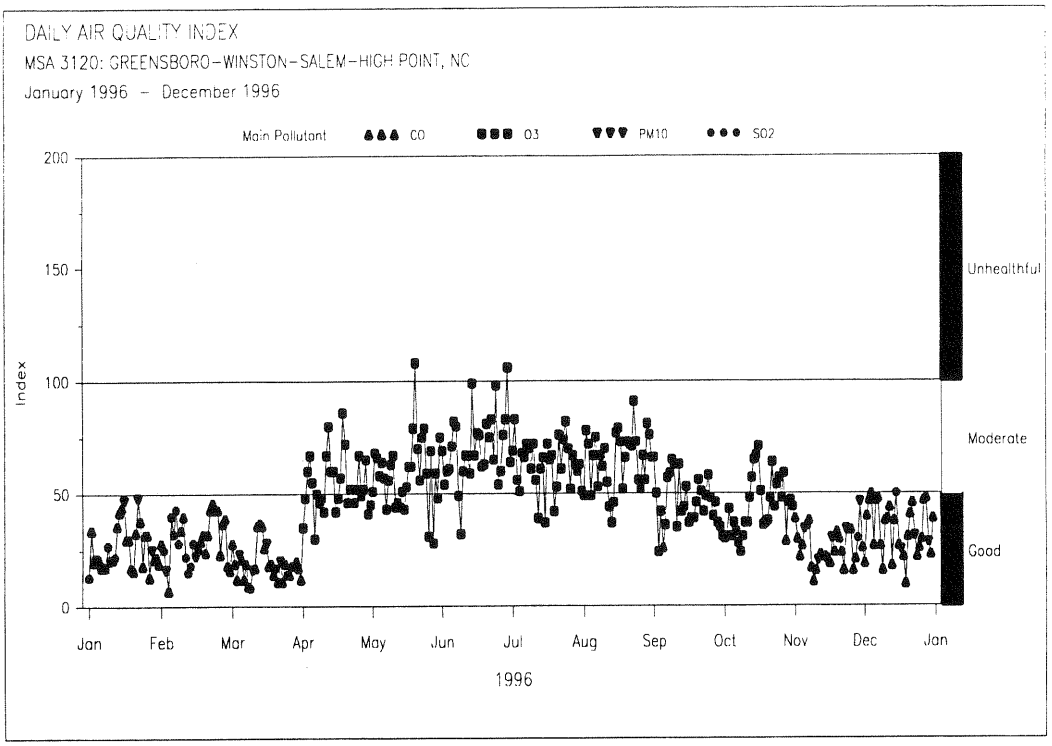

Figure 6.4. Daily Air Quality Index Values for Greensboro-Winston-Salem-High Point, North Carolina, Metropolitan Statistical Area, 1991.

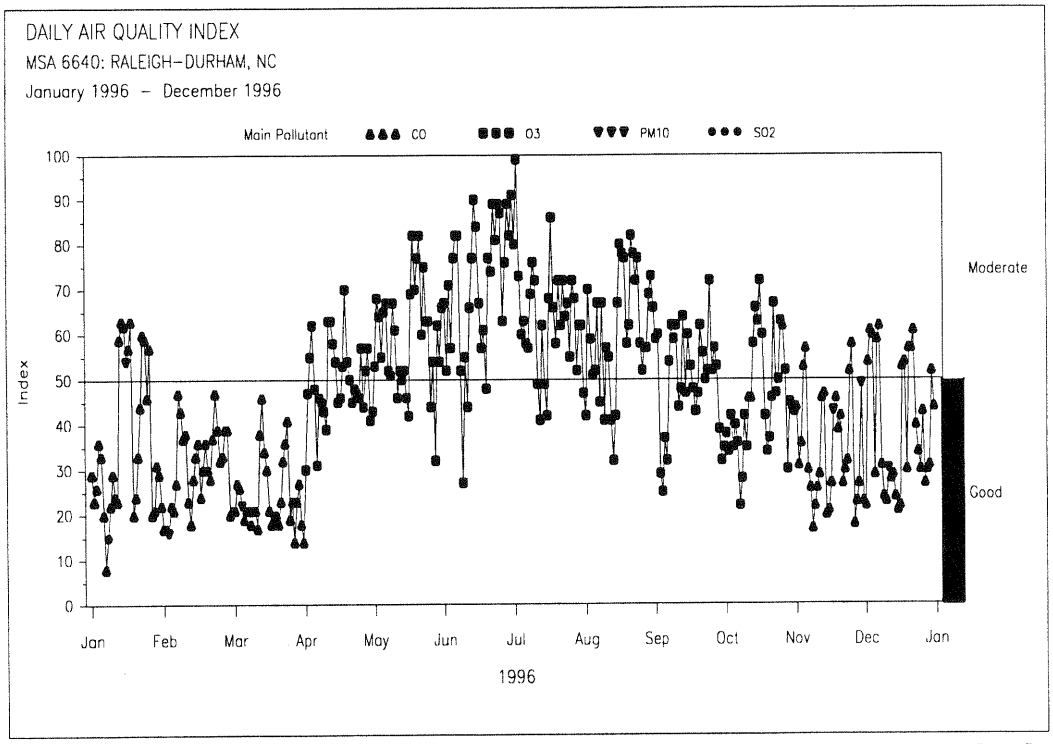

Figure 6.5. Daily Air Quality Index Values for the Raleigh-Durham, North Carolina, Metropolitan Statistical Area, 1996.

7. Acid Rain

7.1. Sources

Acid rain is produced when nitrate and sulfate ions from automobile and industrial emissions are released into the upper atmosphere, react with moisture in the air, and are deposited as acid precipitation. Acid ions are produced when sulfur dioxide and nitrogen oxides reach equilibrium with water to form sulfuric acid and nitric acid.

7.2. Effects

Many agricultural crops in North Carolina are sensitive to acid rain. Forests are subject to mineral loss from acid rain exposure and also may suffer root damage. Acid fogs and mists, typical in the mountains of North Carolina, can expose trees and plants to even higher acid concentrations and cause direct damage to foliage. Lakes, rivers and streams that are too acidic impede fish and plant growth.

7.3. Monitoring

Acid rain monitoring has been conducted nationally, including in North Carolina, since 1978 by the National Atmospheric Deposition Program (NADP) and the National Trends Network (NTN), which merged with NADP in 1982. Additional wet deposition data is also available from the National Dry Deposition Network (NDDN). In 1996, acid rain samples were collected at seven sites in North Carolina and one Tennessee site in the Great Smoky Mountains, less than 10 miles from the western border of North Carolina.

NADP/NTN conducts acid deposition monitoring using a wet/dry bucket type sampler. When rainfall is detected, a sensor is activated and a metal lid automatically covers and protects the "dry" sample, exposing the "wet" bucket to collect precipitation.

Acidity is measured using a "pH" scale. The pH scale is numbered from 0 to 14, with 0 being extremely acidic and 14 being extremely basic. A substance with a pH of five is ten times as acidic as one with a pH of six, 100 times as acidic as a substance with a pH of seven, etc. Neutral water with an equal concentration of acid and base ions has a pH of seven. The pH of vinegar is approximately 2.8, and lemon juice has a pH of about 2.3. The pH of ammonia is approximately 12.

Pure water in equilibrium with the air is slightly acidic and has a pH of approximately 5.6. The measurements of pH at the North Carolina monitoring sites in 1996 ranged from 4.39 to 4.86 with a mean of 4.62. The 1996 pH annual means for North Carolina from the NADP/NTN database are presented in Figure 7.1 and Table 7.1. Table 7.1 also shows conductivity averages and precipitation totals for rainfall. Measured concentrations of several other chemical constituents of precipitation are given in Table 7.2.

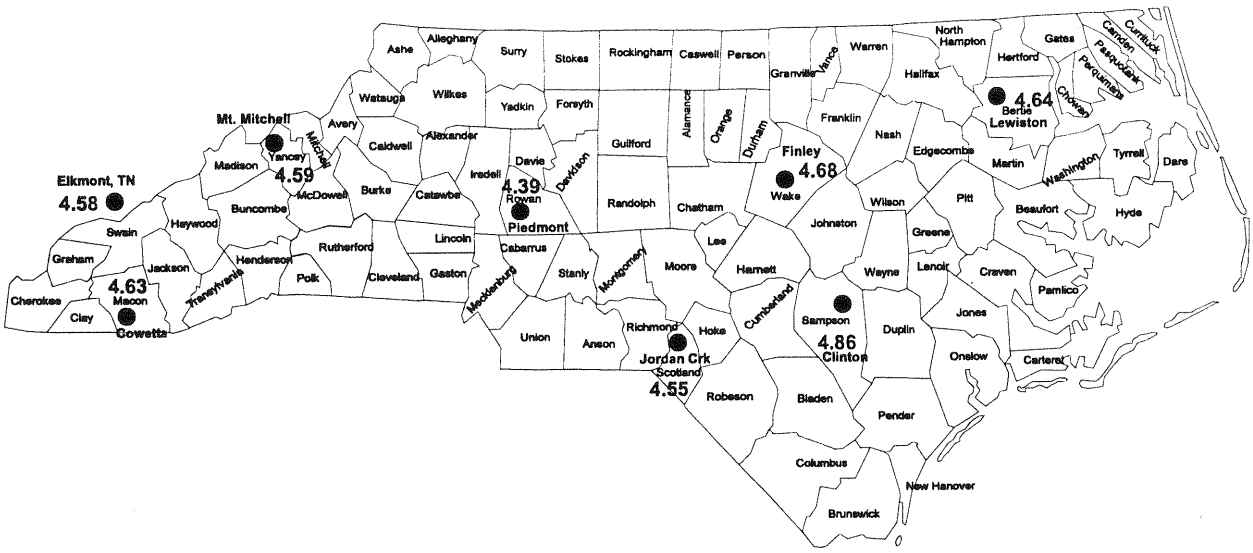

Figure 7.1. Annual Mean pH Values at North Carolina NADP/NTN/NDDN Sites, 1996

Table 7.1. pH, Conductivity in Microsiemans per Centimeter, and Precipitation in Inches from the National Atmospheric Deposition Program/National Trends Network and National Dry Deposition Network Data for 1996.

COUNTY SITE ADDRESS	pH	Conductivity	Precipitation
Bertie 340320 Lewiston	4.64	14.8	53.6
Macon 342500 Coweeta	4.63	13.1	74.3
Rowan 343460 Piedmont Research Station	4.39	24.0	35.4
Sampson 343560 Clinton Crops Res. Station	4.86	12.0	52.9
Scotland 343600 Jordan Creek	4.55	16.2	49.5
Wake 344160 Finley Farm	4.68	14.6	51.9
Yancey 344500 Mt. Mitchell	4.59	13.9	77.8
Sevier (TN) 441190 Great Smoky Mts Nat'l Park Elkmont TN	4.58	14.4	77.3

Table 7.2. Ion Concentrations in Milligrams per Liter (Precipitation-Weighted Annual Means) from the National Atmospheric Deposition Program/National Trends Network and National Dry Deposition Network Data for 1996.

COUNTY SITE ADDRESS	% com- pleteness	Ca	Mg	K	Na	NH4	NO3	Cl	SO4
Bertie 340320 Lewiston	84.6	0.06	0.037	0.032	0.296	0.20	0.82	0.52	1.15
Macon 342500 Coweeta	90.2	0.06	0.016	0.014	0.129	0.14	0.72	0.21	1.07
Rowan 343460 Piedmont Research Station	96.2	0.09	0.023	0.057	0.153	0.32	1.34	0.29	2.14
Sampson 343560 Clinton Crops Res. Station	88.5	0.06	0.038	0.034	0.328	0.33	0.74	0.57	1.08
Scotland 343600 Jordan Creek	82.7	0.07	0.025	0.016	0.202	0.17	0.87	0.34	1.31
Wake 344160 Finley Farm	94.2	0.06	0.030	0.077	0.232	0.34	0.87	0.41	1.29
Yancey 344500 Mt. Mitchell	70.4	0.04	0.010	0.012	0.076	0.16	0.65	0.12	1.23
Sevier (TN) 441190 Great Smoky Mts Nat'l Park Elkmont TN	82.7	0.07	0.012	0.016	0.064	0.14	0.82	0.11	1.20

8. Statewide Trends

The NC DENR published an analysis of long term trends in North Carolina, statewide and within the individual Air Quality Control Regions, covering air pollutant concentrations from 1972 through 1989 (North Carolina Department of Environment, Health, and Natural Resources 1991b). Such a review of year-to-year changes helps evaluate the success of programs intended to reduce pollution and prioritize future efforts. The next detailed update of the trends report is scheduled for publication in 1998. This chapter provides some interim analyses at the statewide level.

8.1. Particulate Matter

The statewide distribution of second-largest 24-hour PM_{10} concentrations for each monitor from 1985 to 1996 is shown in Figure 8.1. Concentrations have decreased from about 65 $\mu g/m^3$ to about 45 $\mu g/m^3$, a 30 percent decline.

8.2. Carbon Monoxide

The statewide distribution of second-largest one-hour carbon monoxide (CO) concentrations from 1973 to 1996 is shown in Figure 8.2. The average value of this concentration decreased from 25.9 ppm in 1973 to 18.8 ppm in 1980 (a 27.4 percent decline) and from 16.3 ppm in 1981 to 7.6 ppm in 1996 (a 53.4 percent decline).

North Carolina did not experience an exceedance of the one-hour standard for CO from 1973 through 1996.

The statewide distribution of second-largest eight-hour CO concentrations from 1973 to 1996 is shown in Figure 8.3. The average value of this concentration decreased from 15.6 ppm in 1973 to 9.9 ppm in 1980 (a 36.5 percent decline) and from 8.9 ppm in 1981 to 4.3 ppm in 1996 (a 51.7 percent decline).

There were more than 700 exceedances of the 8-hour standard for CO from 1973 through 1990, and the number of exceedances per year is shown in Figure 8.4. The average number of exceedances decreased steadily from about 60 per year in 1973-75 to 50 per year in 1978. That number stayed approximately constant through 1983, and finally decreased again, to 4 exceedances in 1990. There have been no CO exceedances since 1990.

8.3. Ozone

The statewide distribution of second-largest one-hour ozone concentrations is shown in Figure 8.5. The average ozone (O_3) concentration was nearly steady from 1972 to 1996, averaging 0.104 ppm (87 percent of the standard). Figure 8.5 suggests a possible downward trend beginning in the mid 1980's.

There were about 200 exceedances of the ozone standard from 1972 through 1996, and the number of exceedances per year is shown in Figure 8.6. The number of exceedances generally fluctuates considerably from year to year, between zero and 20. An exception was 1988, when

69 exceedances occurred. The solid trend line in Figure 8.6 suggests an average of 6.4 exceedances per year from 1973 through 1984, followed by a rapid increase from 1985 through 1987 and gradual decrease from 1987 through 1996. The average number of exceedances from 1985 through 1996 was 11 per year. The rapid increase in the trend in 1985 can be attributed almost entirely to the 69 exceedances of 1988. If the trend is examined with that year excluded (dashed line in Figure 8.6), the number of exceedances remained approximately constant through the entire interval from 1975 through 1996, averaging about seven per year.

8.4. Sulfur Dioxide

The statewide distribution of second-largest three-hour sulfur dioxide (SO_2) concentrations from 1972 to 1996 is shown in Figure 8.7. The average decreased from 0.090 ppm 1972 to 0.039 ppm in 1983 (8 percent of the standard) and remained generally between 0.04 and 0.06 ppm in the subsequent years.

The statewide distribution of second-largest 24-hour SO_2 concentrations from 1972 to 1996 is shown in Figure 8.8. The average was approximately constant around 0.015 ppm (10 percent of the standard) from 1973 through 1996.

8.5. Nitrogen Oxides

The statewide distribution of annual average nitrogen dioxide (NO_2) concentrations from 1972 to 1996 is shown in Figure 8.9. The mean concentration decreased from 0.0204 ppm in 1978 to 0.0136 ppm in 1996 (26 percent of the standard), or about 33.3 percent.

8.6. Lead

The statewide distribution of quarterly lead (Pb) concentrations is shown in Figure 8.10, using all available data from 1972 through 1990. The average lead concentration decreased from 0.125 in 1985 to 0.028 in 1988 and to 0.019 in 1990, a total decline of 84.8 percent.

8.7. pH

The statewide distribution of annual average pH values from 1978 to 1996 for the NADP/NTN sites (including two collocated sites and the Great Smoky Mountain, Tennessee site) is shown in Figure 8.11. The mean pH was approximately constant through the mid 1980's, and more recently seemed to increase slightly year by year.

The NADP/NTN instituted a change in sampling protocol during the first complete sample collected in 1994. As a consequence, acid rain data analyzed in the Central Analytical Laboratory before 1994 are not directly comparable to data analyzed in 1994 and after (NADP 1995). However, no attempt has been made here to adjust earlier or later data to be more properly comparable. The NADP study suggested that pH values less than 4.6 will decrease by a median amount of 0.03 (s.e. = 0.005) due to the protocol change (NADP 1995).

8.8 Ammonium Ion

The statewide distribution of annual average ammonium ion (NH_4+) concentrations from

1978 to 1996 for the NADP/NTN sites (including two collocated sites and the Great Smoky Mountain, Tennessee site) is shown in Figure 8.12. The average has stayed about 0.2 mg/L in the 1990s. The NADP study suggested that the 1994 protocol change had no net effect on measured NH_4+ concentrations (NADP 1995).

8.9 Nitrate Ion

The statewide distribution of annual average nitrate ion (NO_3-) concentrations from 1978 to 1996 for the NADP/NTN sites (including two collocated sites and the Great Smoky Mountain, Tennessee site) is shown in Figure 8.13. The mean has been slowly decreasing in the 1990s, about 1.75 percent per year. The NADP study suggested that NO_3- concentrations will decrease by a median amount of 0.01 (s.e. = 0.002) due to the protocol change in 1994 (NADP 1995).

8.10 Sulfate Ion

The statewide distribution of annual average sulfate ion (SO_4=) concentrations from 1978 to 1996 for the NADP/NTN sites (including two collocated sites and the Great Smoky Mountain, Tennessee site) is shown in Figure 8.14. The average has been decreasing about 2.3 percent per year, to about 1.3 mg/L in 1996. The NADP study suggested that SO_4= concentrations will decrease by a median amount of 0.02 (s.e. = 0.002) due to the protocol change in 1994 (NADP 1995).

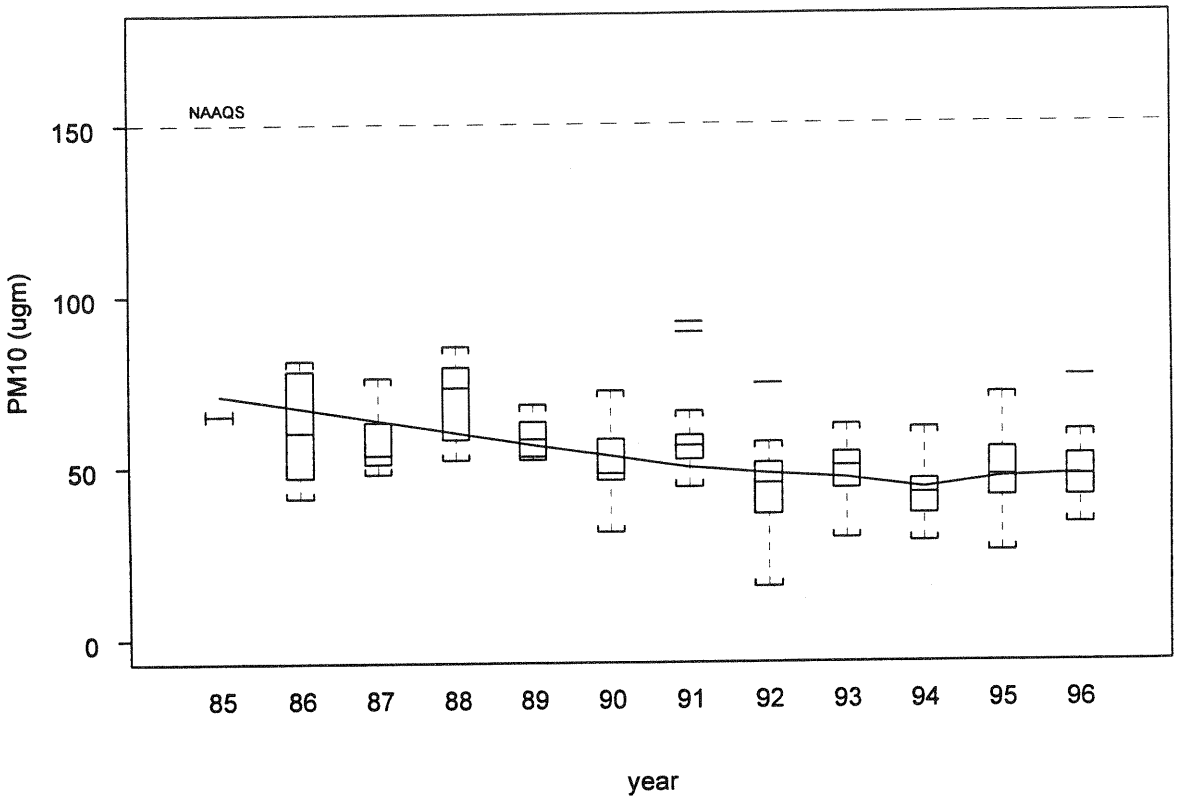

Figure 8.1. Distribution of Statewide 24-hour PM_{10} Concentrations 1985-96, and Smoothed Regression Trend Line

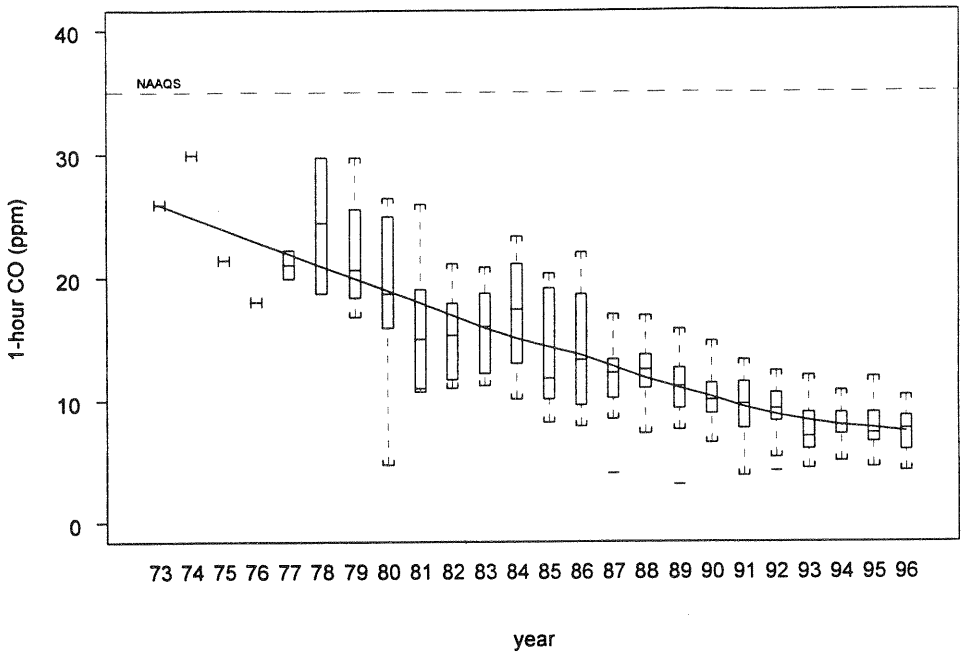

Figure 8.2. Distribution of Statewide 1-hour CO Concentrations 1973-96, and Smoothed Regression Trend Line

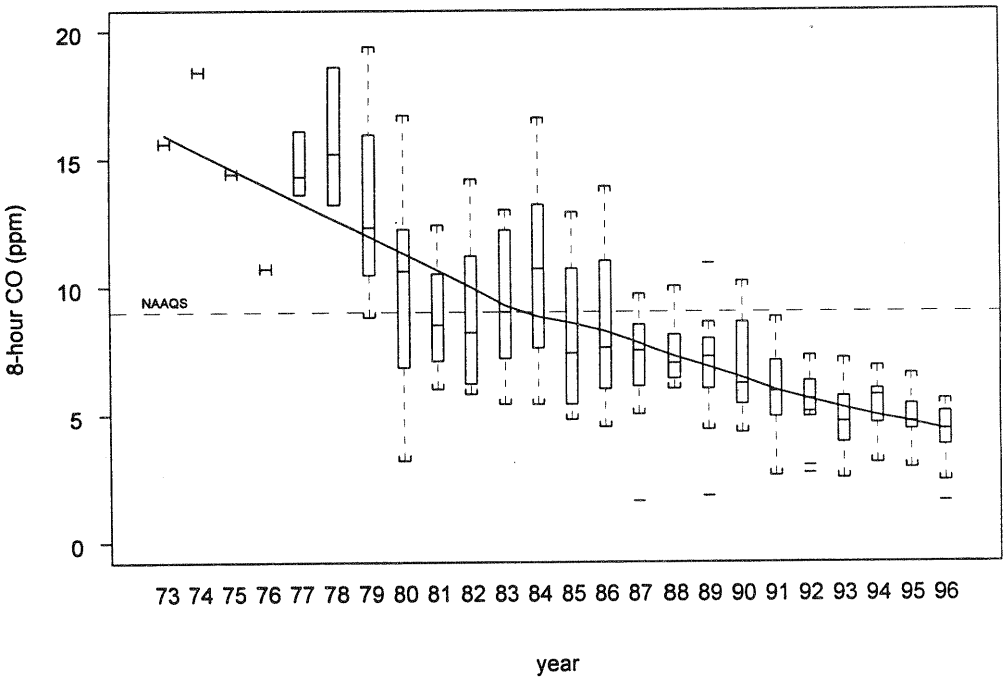

Figure 8.3. Distribution of Statewide 8-hour CO Concentrations 1973-96, and Smoothed Regression Trend Line

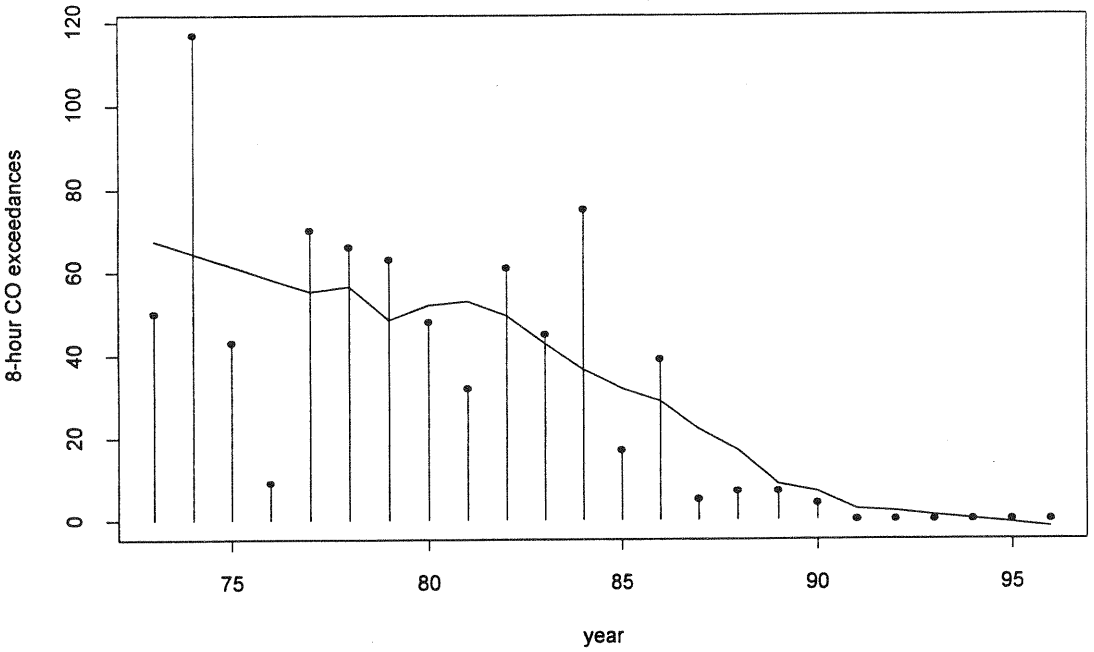

Figure 8.4. Number of Exceedances of 8-hour CO NAAQS, 1973-96, and Smoothed Regression Trend Line

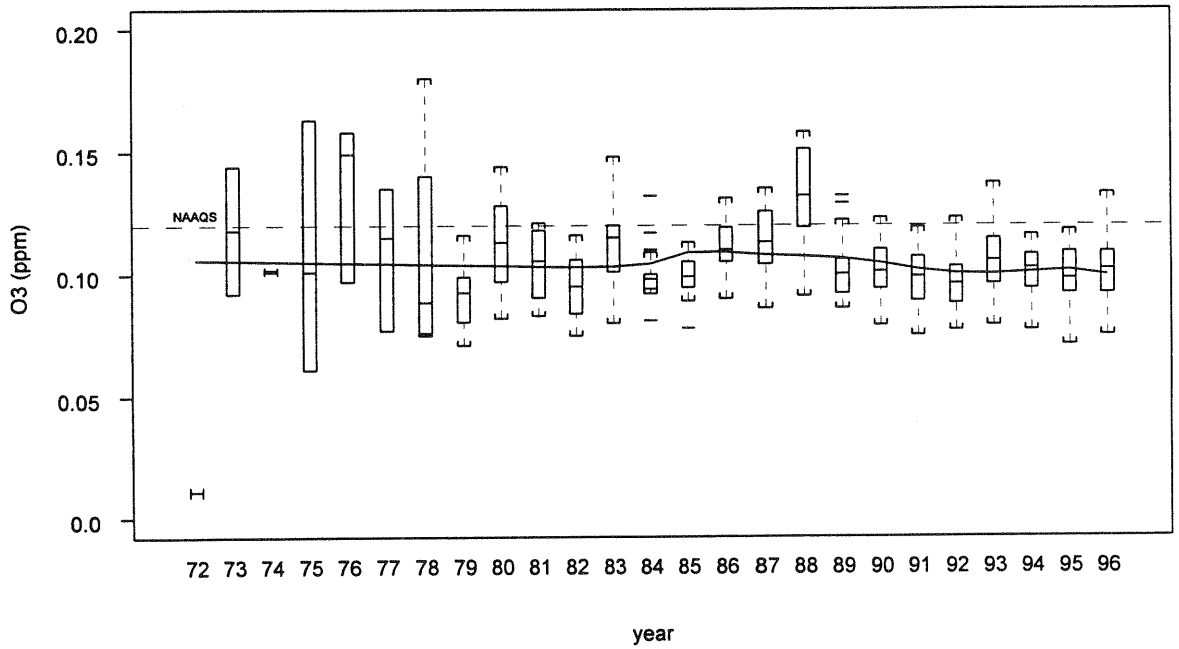

Figure 8.5. Distribution of Statewide 1-hour Ozone Concentrations 1972-96 and Smoothed Regression Trend Line

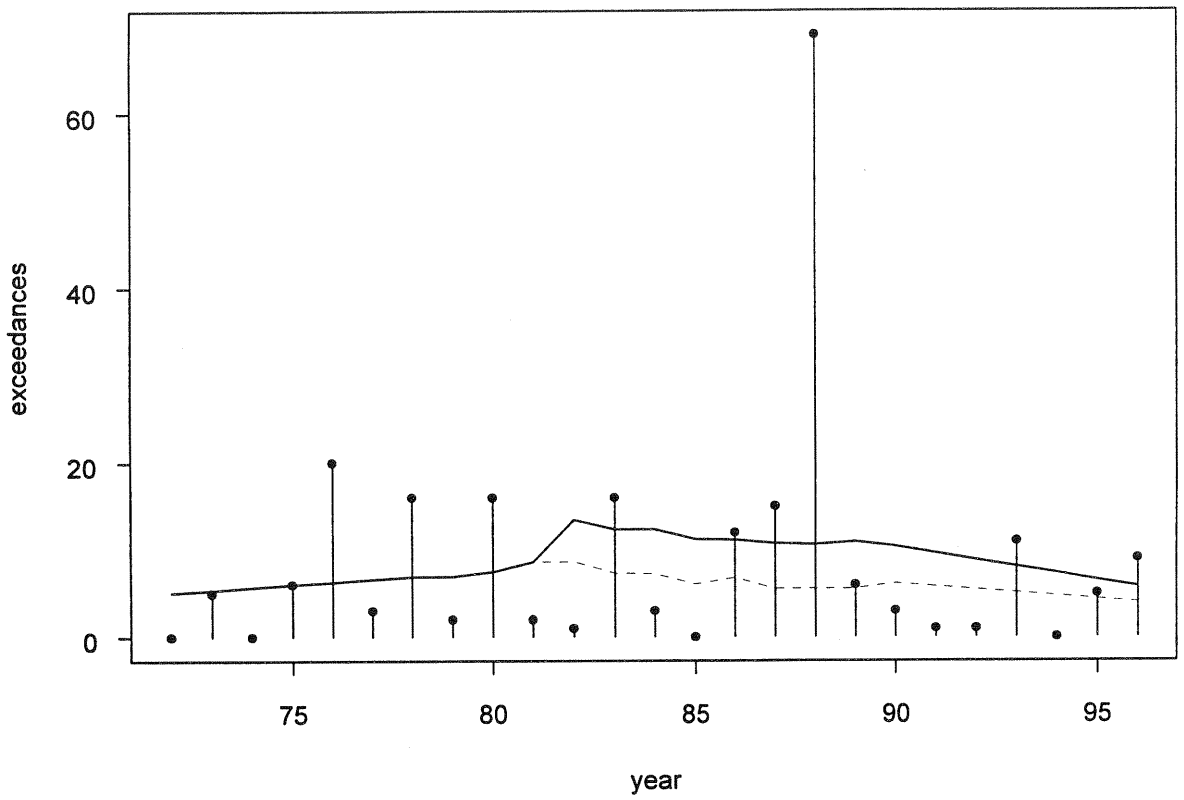

Figure 8.6. Number of Exceedances of Ozone NAAQS, 1972-96, and Smoothed Regression Trend Lines. Dotted trend line treats the 1988 data value as an outlier.

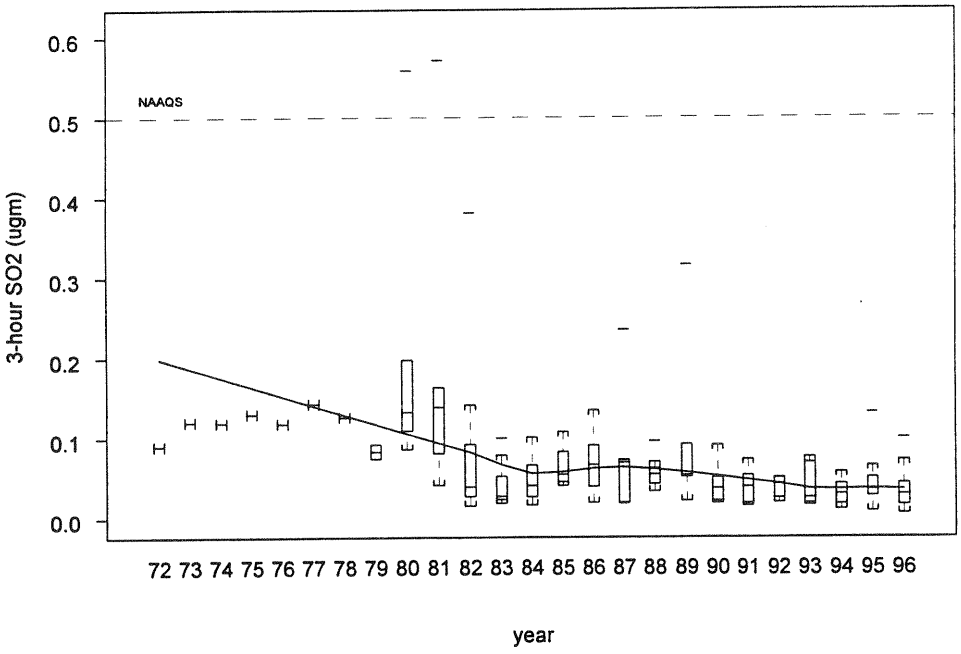

Figure 8.7. Distribution of Statewide 3-hour Sulfur Dioxide Concentrations, 1973-96, and Smoothed Regression Trend Line

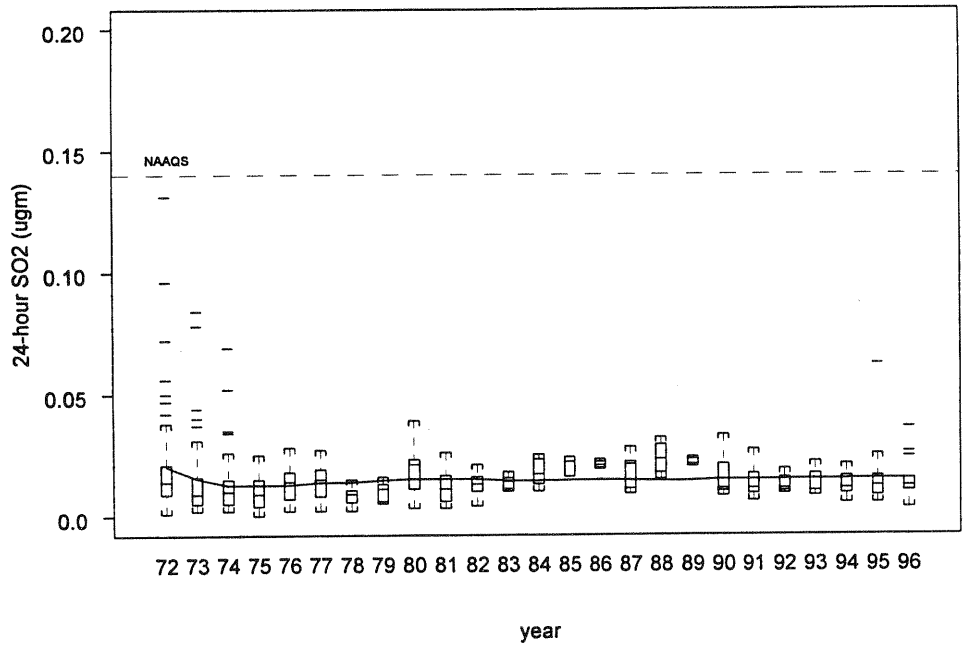

Figure 8.8. Distribution of Statewide 24-hour Sulfur Dioxide Concentrations, 1973-96, and Smoothed Regression Trend Line

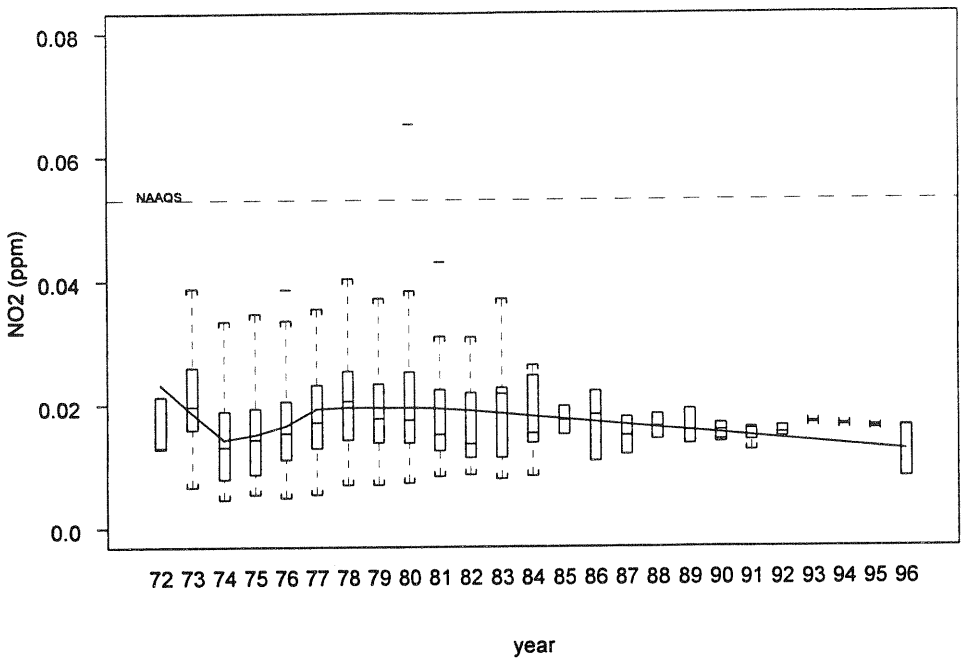

Figure 8.9. Distribution of Statewide Annual Mean Nitrogen Dioxide Concentrations, 1972-96, and Smoothed Regression Trend Line

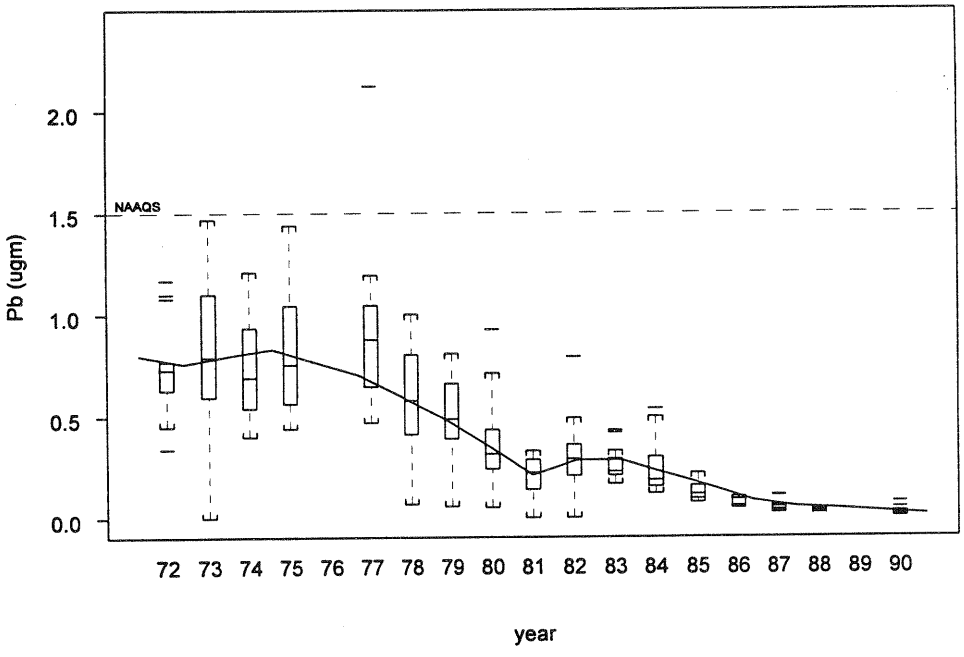

Figure 8.10. Distribution of Statewide Quarterly Lead Concentrations, 1972-90 and Smoothed Regression Trend Line

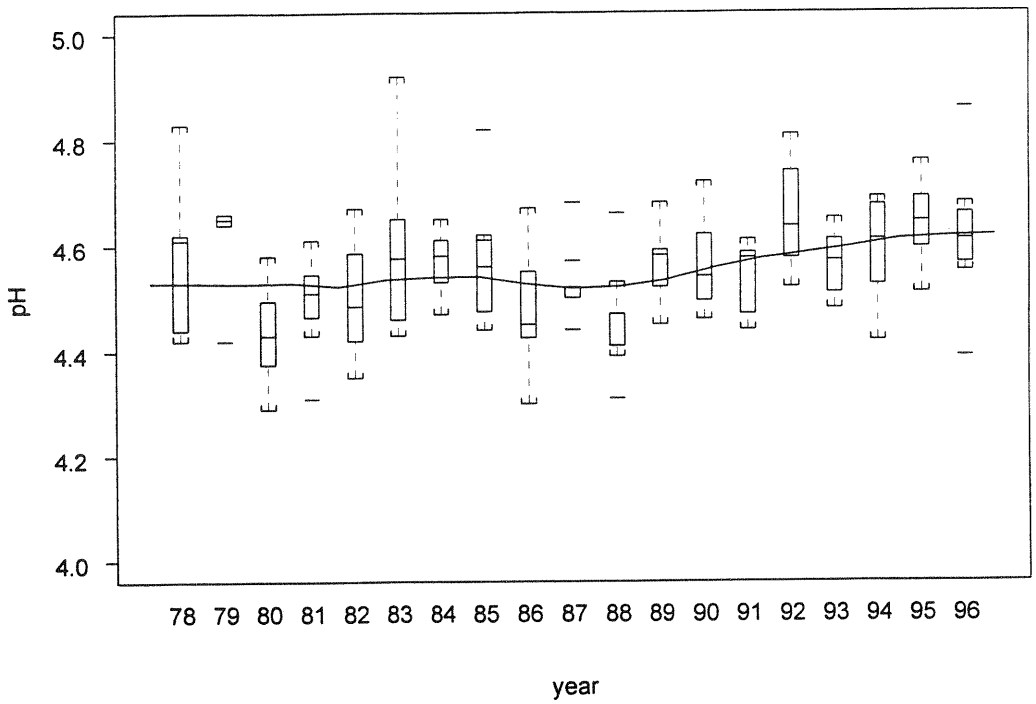

Figure 8.11. Distribution of Statewide Annual Mean pH 1978-96, and Smoothed Regression Trend Line

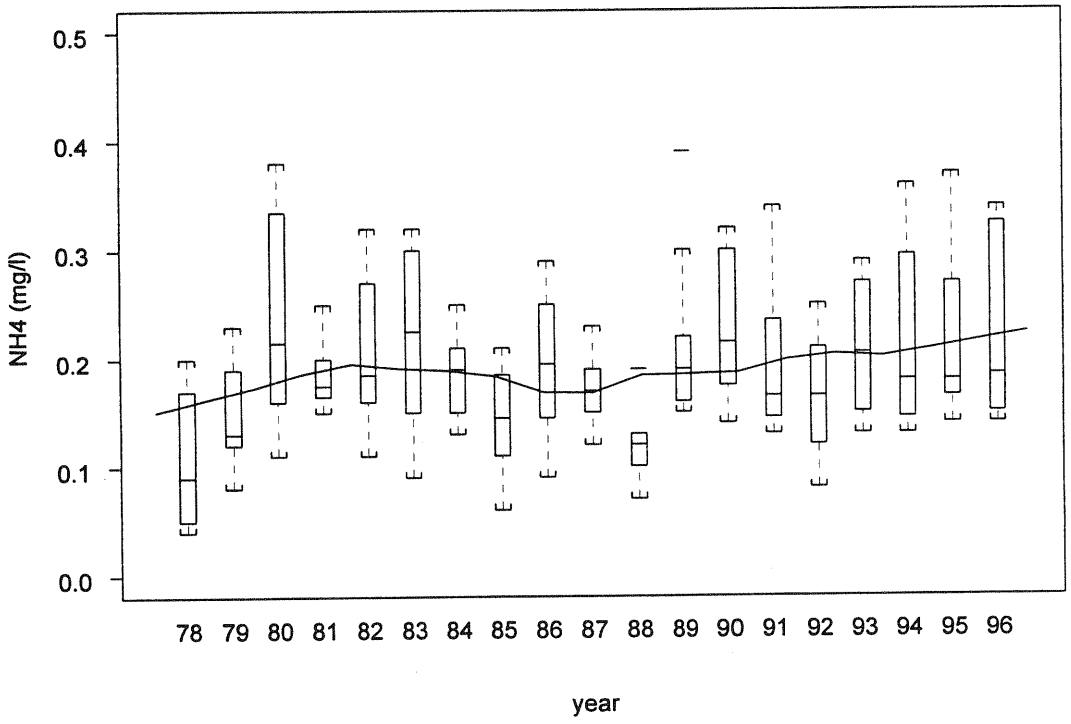

Figure 8.12. Distribution of Statewide Ammonium Ion 1978-96, and Smoothed Regression Trend Line

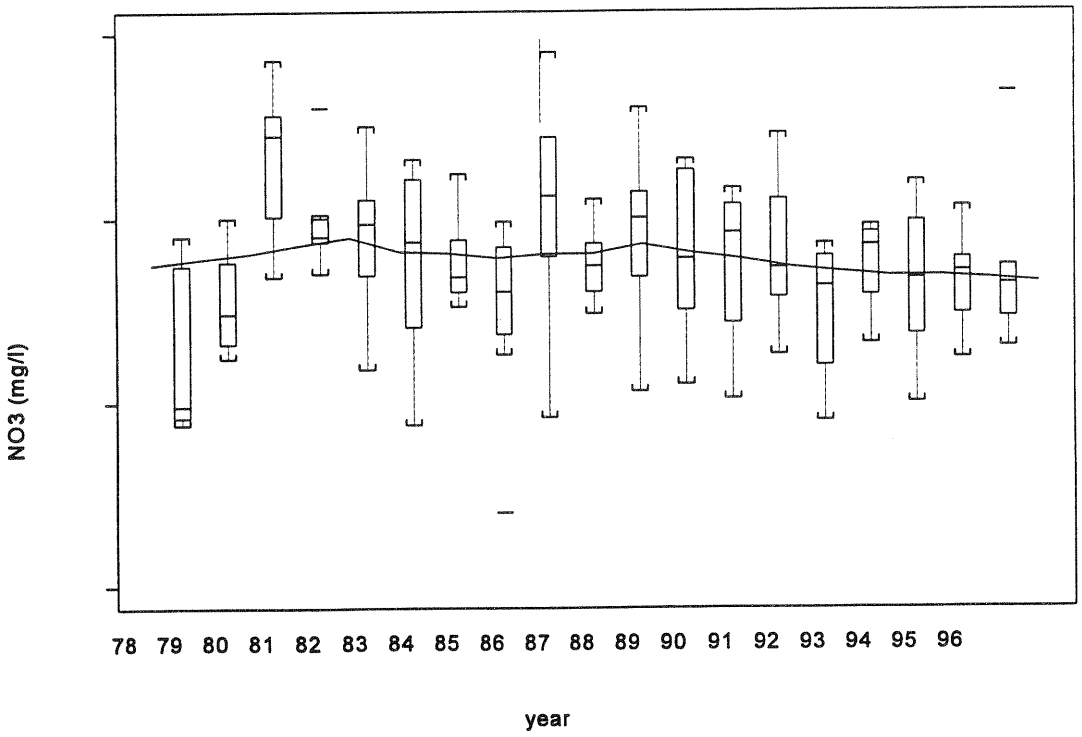

Figure 8.13. Distribution of Statewide Annual Average Nitrate Ion 1978-96, and Smoothed Regression Trend Line

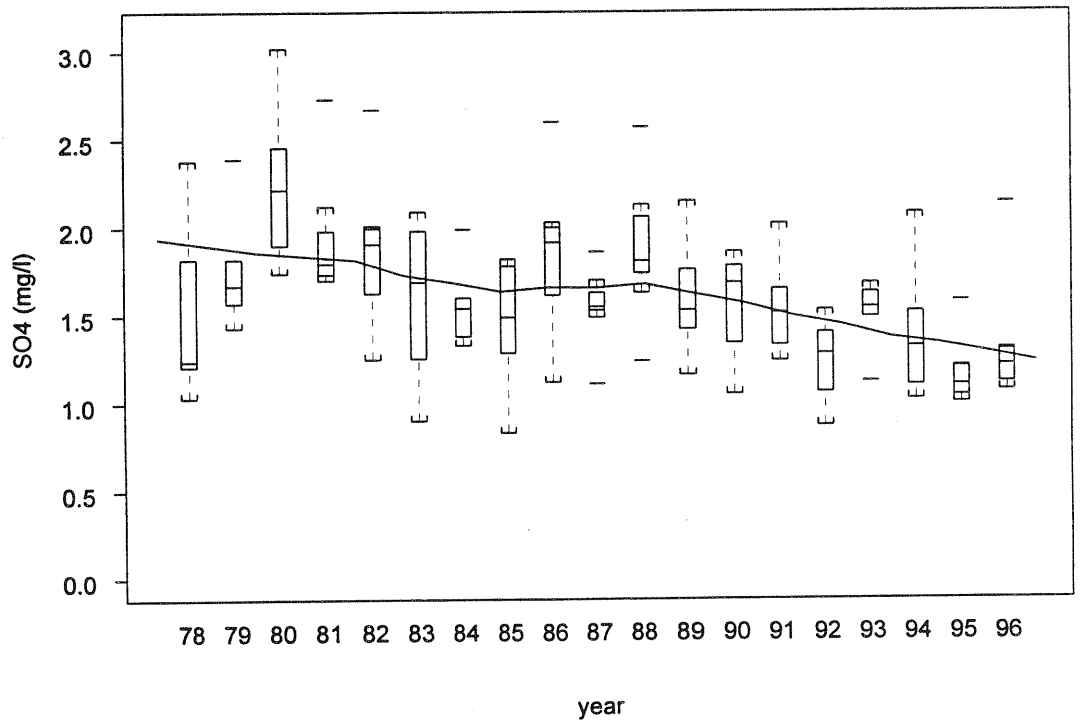

Figure 8.14. Distribution of Statewide Annual Mean Sulfate Ion 1978-96, and Smoothed Regression Trend Line

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North Carolina Department of Environment, Health, and Natural Resources (1991). Ambient Air Quality Trends in North Carolina 1972-1989. *Air Quality Section, Division of Environmental Management, N.C. Dept. Of Env., Health, and Nat. Res.*

Office of the Federal Register (National Archives and Records Administration) (1993), "Code of Federal Regulations, Title 40, Parts 1 to 51, Protection of Environment," (July 1 ed.), Washington, DC: Author.

Appendix A. Air Pollution Monitoring Agencies

North Carolina State Headquarters

Division of Air Quality
Parker Lincoln Building
2728 Capital Boulevard
P O Box 29580
Raleigh, North Carolina 27626-0580
(919) 715-0665

North Carolina Regional Offices

Asheville Regional Office
Interchange Building
59 Woodfin Place
Asheville, North Carolina 28801
(828) 251-6208

Counties of Avery, Buncombe, Burke, Caldwell, Cherokee, Clay, Graham, Haywood, Henderson, Jackson, Macon, Madison, McDowell, Mitchell, Polk, Rutherford, Swain, Transylvania, and Yancey.

Fayetteville Regional Office
Suite 714
225 Green Street
Fayetteville, North Carolina 28301
(910) 486-1541

Counties of Anson, Bladen, Cumberland, Harnett, Hoke, Montgomery, Moore, Robeson, Richmond, Sampson, and Scotland.

Mooresville Regional Office
919 North Main Street
P.O. Box 950
Mooresville, North Carolina 28115-0950
(704) 663-1699

Counties of Alexander, Cabarrus, Catawba, Cleveland, Gaston, Iredell, Lincoln, Mecklenburg, Rowan, Stanly and Union.

Raleigh Regional Office
3800 Barrett Drive
P.O. Box 27687
Raleigh, North Carolina 27611
(919) 733-2314

Counties of Chatham, Durham, Edgecombe, Franklin, Granville, Halifax, Johnston, Lee, Nash, Northampton, Orange, Person, Vance, Wake, Warren and Wilson.

Washington Regional Office
943 Washington Square Mall
Washington, North Carolina 27889-3314
(252) 946-6481

Counties of Beaufort, Bertie, Camden, Chowan, Craven, Currituck, Dare, Gates, Greene, Hertford, Hyde, Jones, Lenoir, Martin, Pamlico, Pasquotank, Perquimans, Pitt, Tyrrell, Washington and Wayne.

Wilmington Regional Office
127 Cardinal Drive Extension
Wilmington, North Carolina 28405-3845
(910) 395-3900

Counties of Brunswick, Carteret, Columbus, Duplin, New Hanover, Onslow and Pender.

Winston-Salem Regional Office
585 Waughtown Street
Winston-Salem, North Carolina 27107
(336) 771-4600

Counties of Alamance, Alleghany, Ashe, Caswell, Davidson, Davie, Forsyth, Guilford, Rockingham, Randolph, Stokes, Surry, Yadkin, Watauga and Wilkes.

Local Agencies

Forsyth County Environmental Affairs Department
537 North Spruce Street
Winston-Salem, North Carolina 27101
(336) 727-8064

Mecklenburg County Department of Environmental Protection
700 North Tryon Street, Suite 205
Charlotte, North Carolina 28202
(704) 376-4603

Western North Carolina Regional Air Pollution Control Agency
49 Mount Carmel Road
Asheville, North Carolina 28806
(828) 255-5655

Counties of Buncombe and Haywood.

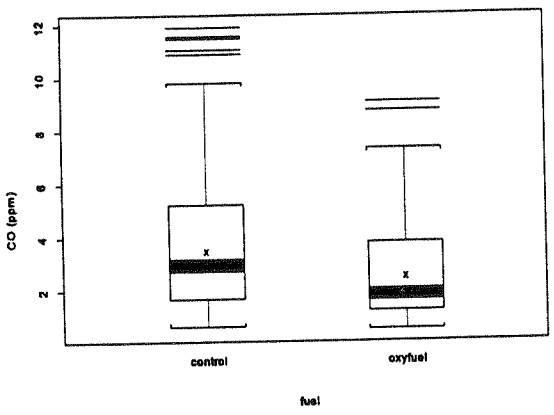
Appendix B. Exceptional Events

Type of Event	Pollutants Affected
Natural Events	
Sustained high wind speeds	particulate matter (PM)
Stagnations, inversions	all pollutants
Unusual lack of precipitation	PM
Stratospheric ozone intrusion	O_3
Volcanic eruption	CO, SO_2, PM
Forest fires	CO, PM
High pollen count	PM
Unintentional Manmade Events	
Large structural fires	CO, PM
Major traffic congestion due to accident or nonrecurring obstruction	CO
Chemical spills	SO_2, NO_2, PM, CO
Industrial accidents	SO_2, NO_2, PM, CO
Intentional Manmade Events	
Short-term construction/demolition	PM
Sandblasting	PM
High-sulfur oil refining	SO_2
Roofing operations	PM, SO_2
Salting or sanding of streets	PM
Infrequent large gatherings	PM, CO
Soot blowing from ships	PM
Agricultural tilling	PM
Prescribed burning	CO, PM
Noncompliance of local sources	CO, SO_2

Appendix C. Box-And-Whisker Plots

A *box-and-whisker plot* (also called *boxplot* or *schematic plot*) is a schematic diagram useful for depicting the location, spread and skewness of a continuous data variable. Box plots are constructed from *order statistics* (data values sorted from smallest to largest). The "box" of the box plot is oriented parallel to a continuous scale and is defined by 3 points: (1) a line or point in the interior of the box at the median of the data (a point that divides the order statistics into two equal parts), and (2) upper and (3) lower *fourths* or *quartiles.* (Fourths divide the upper and lower halves of the data values into two equal parts; quartiles divide the entire range of the data into 4 equal parts. Fourths and quartiles are not necessarily the *same*, because there may be more than one number that appropriately divides a given set of data in the prescribed way, and different computational techniques [or computer programs] may make different choices.)

The distance between the upper and lower fourth in the box plot is called the *interquartile range.* In most box plots, the length of each of the *whiskers* is 1.5 times the interquartile range or to the extreme (maximum or minimum) of the data, whichever is *shorter.* The endpoint of each whisker is called an *inner fence.* (In the box plots pictured below, the end of each whisker is marked by a "staple" for clarity.) There may be data points, called *outliers*, beyond the inner fences; if so, they are usually indicated individually on the box plot by a dot, small circle, or (as below) a short line segment perpendicular to the axis of the box. Box plots of variables with very long-tailed distributions may display two kinds of outliers—small dots for those just beyond the inner fences and larger dots or circles for *extreme outliers* at a distance of more than 3.0 times the interquartile range beyond the fourths. This boundary between outliers and extreme outliers is termed the *outer fence* and usually not explicitly shown in the plot.



The maximum and minimum values are always visible in a box-and-whisker plot as either the outermost outliers or, if there is no outlier, the position of the inner fence.

Box plots may have additional, optional features, such as a point marker at the *arithmetic mean* or a distinctive display of a *confidence interval for the median*, which is calculated from the fourths. In the figure, the arithmetic mean is marked with an "X", and the confidence interval for the median is displayed as a shaded or colored range. It is also common to display the confidence interval by cutting notches in the sides of the box at its endpoints.

Box plots are very useful for comparing two or more variables by placing two comparable variables side-by-side on the same scale (as in the figure). The statistics displayed can be directly compared, and statistical significance of difference between the medians can be assessed by examining overlap or lack of overlap of confidence intervals.

Appendix D. Nonattainment and North Carolina

What is nonattainment and what are the sources of the pollutants?

The United States Environmental Protection Agency (EPA) sets National Ambient Air Quality Standards. North Carolina monitors concentrations of air pollutants in the ambient air. Some of these monitors have measured concentrations of ozone and carbon monoxide exceeding the standards. Areas that have not met the National Ambient Air Quality Standards can be classified by EPA as "nonattainment."

Mobile sources such as cars and trucks are the primary cause of carbon monoxide and ozone precursors. About 90 percent of the carbon monoxide emissions come from motor vehicles. Approximately 50 percent of the nitrogen oxides come from motor vehicles, with the remainder coming from large stationary combustion sources. Thirty percent to 50 percent of the man-made hydrocarbons or volatile organic compound emissions come from motor vehicles, with the rest coming from petroleum marketing, factories, businesses and households. Volatile organic compounds react with nitrogen oxides and sunlight in warm weather to produce ozone.

Why is my county nonattainment?

Unless the state can demonstrate a better alternative, EPA has indicated that it will designate nonattainment areas based on Metropolitan Statistical Areas (MSAs). These MSAs were established by the Office of Management and Budget. Monitors showing violations of standards may not be located in every county. Previous emission control programs in single counties across the nation often have failed to produce compliance with standards. Pollution from one county blows into neighboring counties, especially with ozone. EPA concluded that control plans must cover metropolitan areas, not single counties.

Once we are nonattainment, what is the process for becoming attainment?

North Carolina is required by the federal Clean Air Act and EPA to produce and implement emission reduction plans and show that these plans are strong enough to produce compliance with the standards. The plans could involve resource-intensive monitoring, emissions inventory, modeling, public participation, and strategy formulation efforts. There are deadlines for producing the plans and for achieving compliance with the standards. EPA must approve the plans.

How does the public get involved in the formulation of the emission reduction plans, known as State Implementation Plan (SIP) revisions?

Local agencies and officials, as well as state agencies, will be involved in drawing up the SIP revisions. It is likely that there will be public meetings or special citizen panels. When draft SIP revisions are done, there will be public hearings on them. The SIP revisions must be approved by the N.C. Environmental Management Commission and possibly by local bodies as well. EPA's approval process includes an opportunity for public comment.

How will it affect citizens?

Emission reduction strategies fall into several categories. Motor vehicle inspection/maintenance may be required for hydrocarbons or carbon monoxide or both. Traffic patterns may be altered by changing roads

or traffic signals. Both new and existing factories and business may have to reduce emissions by installing control equipment or changing processes. This might include requiring that gas stations trap vapors that escape when vehicles are refueled or that gasoline contain pollution-reducing additives.

What happens if North Carolina refuses to address these air pollution problems?

Under the Clean Air Act, EPA has the authority to apply sanctions. EPA can ban the construction of major pollutant sources, and may withhold federal highway construction funds in the nonattainment areas.

What is the likelihood of receiving sanctions if we are showing progress in reducing pollution?

North Carolina can avoid sanctions if it produces and carries out SIP revisions that EPA approves by the deadlines. If pollution concentrations do not recede and attain the standards as projected, the EPA could impose construction bans. However, EPA has some discretion about imposing sanctions. Sanctions are a last step to persuade states to take required positive action.

What does inspection/maintenance cost?

The inspection/maintenance (I/M) or motor vehicle tailpipe testing process, costs the motorist $15.40 as of October 1, 1990. If a vehicle fails the test, it must be repaired. A waiver is available if a vehicle still fails after $50.00 worth of repairs have been done. The $50.00 limit does not apply to tampered or misfueled vehicles. The inspection/maintenance program includes tests for hydrocarbon (HC) and carbon monoxide (CO) emissions. Mecklenburg, Wake, Guilford, Forsyth, Durham, Gaston, Cabarrus, Orange and Union counties have I/M programs. Only gasoline powered motor vehicles built after 1974, excluding the current model year and motorcycles, are inspected in these counties. Inspection/maintenance pass-fail levels vary with vehicle age and pollutant.

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