2004 Ambient Air Quality Report

STATE OF NORTH CAROLINA
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DEPARTMENT OF
ENVIRONMENT
AND
NATURAL RESOURCES
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Public Sources of Data:

North Carolina Division of Air Quality	http://daq.state.nc.us/
Forsyth County Environmental Affairs Department	http://www.co.forsyth.nc.us/EnvAffairs/weathereport.htm
EPA/AQS Air Quality Subsystem	http://www.epa.gov/airsweb
National Atmospheric Deposition Program	http://nadp.sws.uiuc.edu

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Preface

This report is issued by the Division of Air Quality of the Department of Environment 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
Carbon Monoxide
Sulfur Dioxide
Nitrogen Dioxide
Ozone
Lead

The report begins with a brief discussion of the ambient air monitoring program, including a description of the monitoring network. It presents detailed results of monitoring that was conducted in 2004 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, and the seasonal variability of some pollutants. Data and areas exceeding the ambient air quality standards are identified. Factors that have contributed to those exceedances are also described.

Acid rain data summaries from the National Atmospheric Deposition Program/National Trends Network for North Carolina also are included for 2004.

Current air pollution information is available for the Charlotte area 24 hours a day by telephoning 1-704-333-SMOG.

In 2002, the air monitoring program deployed a network of fine particle speciation monitors. This report provides data summaries from these monitors for 2004.

Also in 2002, the Division of Air Quality established a small network of Urban Air Toxics monitors. It supplements a new national toxics database, and some key toxics pollutants are summarized for 2004 in this report.

The report also contains graphical summaries of long-term annual trends for the criteria pollutants and acid rain data, highlighting successful efforts at pollution control and suggesting where future priorities should be placed.

Additional copies of this report and previous annual reports are available on the Division of Air Quality's website http://daq.state.nc.us/monitor/reports/ or by writing to:

Division of Air Quality
1641 Mail Service Center
Raleigh, North Carolina 27699-1641

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.

B. Keith Overcash, P.E., Director
Division of Air Quality

Executive Summary

In 2004, the North Carolina Division of Air Quality (DAQ), the three local program agencies and one tribal agency (listed in Appendix A) collected 350,245 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, nitrogen dioxide and lead. This report discusses each pollutant and presents summary tables, maps, charts and explanations of the data.

The report also includes data from weekly acid rain samples collected by the National Atmospheric Deposition Program/National Trends Network (NADP) at seven North Carolina sites and one Tennessee site very close to the North Carolina border. It discusses acid rain and presents summary tables, maps, charts and explanations of the data.

This report provides data summaries from a network of fine particle speciation monitors for 2004. The DAQ and two federal agencies deployed these monitors in 2002 to characterize more fully fine particulate matter by composition. This report presents a map and summary tables of the major speciation categories for 2004.

Also in 2002, the Division of Air Quality established a small network of Urban Air Toxics monitors. It supplements a new national toxics database, and some key toxics pollutants are summarized for 2004 in this report. This report presents a map and summary tables of formaldehyde and four important volatile organic compounds for 2004.

The report also contains graphical summaries of long-term annual trends for the criteria pollutants and acid rain data, highlighting successful efforts at pollution control and suggesting where future priorities should be placed.

Three different types of **particulate matter** were sampled in North Carolina during 2004. Total Suspended Particulate (TSP), considered to be particles having an aerodynamic diameter of 100 micrometers or less, is regulated by North Carolina standards. Particulate matter (PM_{10}), with a mean aerodynamic diameter less than or equal to a nominal 10 micrometers (0.00004 inches), is regulated by both EPA and N.C. standards. Fine particulate matter ($PM_{2.5}$), with a mean aerodynamic diameter less than or equal to a nominal 2.5 micrometers (0.00001 inches), has been regulated by EPA and NC since 1999.

TSP was sampled at 7 sites, yielding 43 daily samples. There were no exceedances of the state TSP ambient air quality standard for 24-hour samples (150 $\mu g/m^3$) observed in 2004.

PM_{10} was sampled at 16 sites, yielding 1,698 daily 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).

$PM_{2.5}$ was sampled at 37 sites yielding 5,554 daily samples. There were no exceedances of the ambient air quality standards for $PM_{2.5}$ (65 $\mu g/m^3$ for 24-hour samples). Five of the 37 sites exceeded the annual arithmetic mean standard of 15 $\mu g/m^3$.

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

CO was sampled at 7 sites, yielding 39,273 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 standards. The highest one-hour concentration of 8.6 ppm was observed at the ABC Board site in Cumberland. The highest eight hour concentration of 3.2 ppm was observed at the ABC Board site in Cumberland, Griffith site in Winston-Salem and Estway site in Mecklenburg. The mean one-hour average has been decreasing by about 20 percent per year and the mean eight-hour average has been decreasing by about 30 percent per year. The combined effects of newer cars in the vehicle fleet, traffic control strategies, and the Inspection and Maintenance program in Durham, Orange, Wake, Forsyth, Guilford, Cabarrus, Gaston, Mecklenburg, and Union Counties have helped reduce the number and intensity of CO exceedances from previous years.

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 emphases in control of ozone has been to limit hydrocarbon and nitrogen oxide emissions.

O_3 was sampled at 45 sites, yielding 223,656 valid hourly averages. The National Ambient Air Quality Standard for O_3 in 2004 was 0.08 ppm for the maximum eight-hour average and 0.12 ppm for the maximum one-hour average.

In 2004, there were no exceedances of the one-hour standard. Four exceedances occurred in North Carolina in 2003, and nineteen occurred in 2002. Mecklenburg, Rowan and Wake Counties met or exceeded the criteria for attainment of the one-hour ozone standard with four, ten and one exceedances respectively over a three-year period. Mecklenburg County was redesignated as in attainment for ozone in July 1995. Hydrocarbon and NO_x control strategies continue to be used there to help reduce ozone concentrations.

In 2004, the 8-hour standard was exceeded 15 times, on five different days, with one county having 4 exceedances at individual sites. The site at 1130 Eastway Drive, Charlotte in Mecklenburg County had the highest number, four.

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 8 sites, yielding 62,878 valid hourly averages. There were no exceedances of the National Ambient Air Quality Standards (365 $\mu g/m^3$ or 0.14 ppm for a 24-hour average, 1300 $\mu g/m^3$ or 0.50 ppm for a three-hour average, 80 $\mu g/m^3$ or 0.03 ppm for the annual arithmetic mean) at network monitoring sites.

Nitrogen oxides (NO_x) are produced primarily 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_x compounds play an important role in the formation of ozone. Reactive nitrogen species (NO_y) were monitored in Charlotte and Winston-Salem to gather data for the development of control strategies for ozone non-attainment areas.

The criteria pollutant NO_2 was sampled at two sites, yielding 17,143 valid hourly averages. There were no exceedances of the National Ambient Air Quality Standard (0.053 ppm for the annual arithmetic mean). The mean one-hour average concentration has been decreasing by about 10 percent per year.

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

Lead was not sampled in 2004 using a Federal Reference Method. There have been no recent exceedances of the ambient air quality standard for lead (1.5 $\mu g/m^3$ for a quarterly arithmetic mean). From 1979 through 1999, mean lead concentrations have decreased by 92 percent. The steady decline in the use of leaded gasoline is primarily responsible for this trend.

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

The annual mean pH in 2004 ranged from 4.51 (Rowan County) to 5.08 (Sampson County).

Speciated particulate samples were collected at thirteen sites by the DAQ, two sites by the National Park Service and one site by the U.S. Forest Service. Categorizing these as nitrates, sulfates, ammonium, organic carbon, elemental carbon, crustal material, and “other” constitutents (liquid water, trace elements, etc.), there were 5,391 quantifiable concentrations in 2003 and 5,776 quantifiable concentrations in 2004.

By category, the highest concentrations of speciated particulate samples in 2004 were: sulfate 18.60 $\mu g/m^3$; organic carbon 13.10 $\mu g/m^3$; ammonium 6.78 $\mu g/m^3$; nitrate 6.40 $\mu g/m^3$; crustal component 3.20 $\mu g/m^3$; elemental carbon 2.46 $\mu g/m^3$; and other 19.61 $\mu g/m^3$.

Although there was no sampling for lead using a criteria pollutant method, the speciated particulate monitoring network provided 564 samples of $PM_{2.5}$-lead in 2004; 554 of these sample concentrations (98.2 percent) were less than 0.01 $\mu g/m^3$. Three samples exceeded 0.014 $\mu g/m^3$.

Urban Air Toxics sampling in 2004 occurred at eight sites, seven urban and one rural. This effort contributes to the U.S. EPA's Air Toxics Monitoring Strategy by providing data to help assess health risks.

The median concentrations of formaldehyde were 0.63 ppb at the urban sites and 1.04 ppb at the rural site.

Median benzene concentrations ranged from 0.23 to 0.41 ppb at the urban sites and were 0.14 ppb at the rural site. Median toluene concentrations ranged from 0.26 to 0.66 ppb at the urban sites and were 0.12 ppb at the rural site. Median ethylbenzene concentrations ranged from 0.05 to 0.18 ppb at the urban sites and were 0.05 ppb at the rural site. Median m/p-Xylene concentrations ranged from 0.05 to 1.26 ppb at the urban sites and were less than 0.05 ppb at the rural site. Median o-Xylene concentrations ranged from 0.05 to 0.18 ppb at the urban sites and were 0.05 ppb at the rural site.

Ambient Trends: Annual average statewide concentrations of PM_{10} have decreased by 32 percent from 1989 to 2004. Annual average statewide concentrations of CO (as 8-hour averages) have decreased by 41 percent from 1993 to 2004. Annual average highest 8-hour ozone concentrations have decreased by 11 percent from 1985 to 2004. Annual average highest 3-hour sulfur dioxide concentrations have decreased by 45 percent from 1989 to 2004, and annual average of annual means decreased by 43 percent in the same time period. Annual average nitrogen dioxide concentrations have remained constant from 1989 to 2004 in Forsyth County and Mecklenburg County, the only locations where this pollutant is monitored at present.

Acid Rain Trends: Annual average pH in rain has increased about 4 percent from 1989 to 2004. Annual average ammonium concentrations have increased about 10 percent from 1989 to 2004, but this is dominated by very significant increases in Sampson County, associated with concentrated livestock animal production. Annual average nitrate concentrations in rain have decreased about 22 percent from 1989 to 2004. Annual average sulfate concentrations in rain have decreased about 28 percent from 1989 to 2004.

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1 Introduction

This annual report summarizes the ambient air monitoring performed in calendar year 2004 by the North Carolina Division of Air Quality (DAQ), three local air pollution agencies and one tribal agency, which are more fully described in Appendix A.

There were 350,245 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.

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 monitor 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 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). It also includes a map of the calendar year mean pH level and site statistics for the calendar year in two tables.

Chapter 8 describes a small network of fine particulate speciation compounds that DAQ initiated in 2002. The chapter contains annual summaries of seven main components of fine particles. We also report summary of lead here (instead of chapter 5).

Chapter 9 describes the Urban Air Toxics monitoring program in North Carolina. The DAQ and local air pollution agencies sampled volatile organic compounds at eight sites. This chapter contains annual summaries for five important toxics pollutants.

Chapter 10 provides a statewide summary of trends for the criteria pollutants from 1989 (1993 for CO and 1985 for O_3) through 2004.

2 Description of Criteria Pollutants

2.1 Particulate Matter

Atmospheric particulate matter is defined as any airborne material, except uncombined water (liquid, mist, steam, etc.), 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 (μm). In the period covered by this report, three sizes of particulate matter were monitored, total suspended particulate (TSP), PM_{10} and $PM_{2.5}$. TSP is any particulate matter measured by the method described in EPA regulations 40 CFR 50 App. B (United States Environmental Protection Agency [US EPA] 1993, p. 715-728) and is generally considered to be particles having an aerodynamic diameter of 40 μm or less (Watson and Chow 2001), although particles up to about 100 μm are sometimes captured by samplers. (The probability of inhalation for 100 μm particles is about 50 percent and increases with decreasing particle size [Maynard and Jensen 2001].) PM_{10} is particulate matter with an aerodynamic diameter less than or equal to 10 μm as measured according to EPA regulations 40 CFR 50 App. J (United States Environmental Protection Agency [US EPA] 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 1991a). The new $PM_{2.5}$ standard was adopted by North Carolina on April 1, 1999. On May 14, 1999, the U.S. Court of Appeals ruled the setting of the standard by EPA was an unconstitutional use of authority and could be vacated. The Supreme Court later upheld the new standard. EPA continues to require monitoring for $PM_{2.5.}$

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

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 particles larger than 10 micrometers more efficiently before they move deeply into the system and can more effectively remove the particles that are not trapped before deep movement.

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, causing reduction of 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 incineration. Transportation accounts for the majority of CO emissions. Boilers and other fuel burning heating systems are also significant sources.

2.1.2 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 effects. Low concentrations affect mental function, vision and alertness. High concentrations can cause fatigue, 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 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 (O_3) is the major component of a complex mixture of compounds known as photochemical oxidants. Ozone is not usually emitted directly into the atmosphere, but is formed by a series of complex reactions involving hydrocarbons, nitrogen oxides and sunlight. Ozone concentrations are higher during the daytime in late spring, summer and early autumn when the temperature is above 60° F and the sunlight is more intense.

Two natural sources of upper atmosphere ozone are solar radiation and lightning during thunderstorms. These are not significant sources of tropospheric (ground level) 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.

Ozone damages vegetation by injuring 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 refining of petroleum 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. Sulfuric acid and fine particulate sulfates, which are formed from sulfur dioxide, also may cause significant health problems. Sulfur dioxide causes injury to many plants. A bleached appearance between the veins and margins on leaves indicates 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 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 NO_2 and other 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. Much of the brownish coloration sometimes observed in polluted air in winter months may be due to NO_2.

2.6 Lead

Lead is a 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 anti-knock agent. However, the availability of leaded fuel has declined, and the concentration of lead in such fuel has decreased, 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 some batteries, paints, insecticides, newspaper inks and piston engine aircraft gasoline.

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.

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 the 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, and personal comfort and well-being. The scientific criteria upon which the standards are based are reviewed periodically by the 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 a specific averaging time is called an *exceedance*. The national primary, secondary and North Carolina ambient air quality standards that were in effect during 2004 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, an equivalent mass per unit volume is also shown.

Pollutant/ Ambient Measurement/ (Reference)	Averaging Period	Type of Summary	Primary National (Health Related) Standard	Secondary National (Welfare Related) Standard	North Carolina Standard
TSP 24 hour average	1 year	geometric mean	(1)	(1)	75 µg/m^3
	1 day	2nd maximum	(1)	(1)	150 µg/m^3
PM-2.5 24 hour average (40CFR50, App. N)	1 year	average[2] arithmetic mean	15 µg/m^3 (6)	15 µg/m^3 (6)	15 µg/m^3 (6)
	1 day	average[2] 98th percentile	65 µg/m^3	65 µg/m^3	65 µg/m^3 (6)
PM-10	1 year	average[2] arithmetic mean	50 µg/m^3	50 µg/m^3	50 µg/m^3
24 hour average (40CFR50, App. N)	1 day	average[2] 2nd maximum[3]	150 µg/m^3	150 µg/m^3	150 µg/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[4] 2nd maximum	0.12 ppm (6) (235 µg/m^3)	0.12 ppm (6) (235 µg/m^3)	0.12 ppm (235 µg/m^3) (6,7)
1 hour average (40CFR50, App. I)	8 hours	average[5] arithmetic mean 4th maximum	0.08 ppm (6) (157 µg/m^3)	0.08 ppm (6) (157 µg/m^3)	0.08 ppm (6) (157 µg/m^3)
SO$_2$	1 year	arithmetic mean	0.03 ppm (80 µg/m^3)		0.03 ppm (80 µg/m^3)
1 hour average	1 day	2nd maximum	0.14 ppm (365 µg/m^3)		0.14 ppm (365 µg/m^3)
	3 hours (non-overlapping)	2nd maximum		0.50 ppm (1,300 µg/m^3)	0.50 ppm (1,300 µg/m^3)
NO$_2$ 1 hour average	1 year	arithmetic mean	0.053 ppm (100 µg/m^3)	0.053 ppm (100 µg/m^3)	0.053 ppm (100 µg/m^3)
Pb 24-hour average	1 quarter	arithmetic mean	1.5 µg/m^3	1.5 µg/m^3	1.5 µg/m^3

1. In 1987, National standards for PM-10 replaced those for TSP.
2. Arithmetic mean over the 3 most current years.
3. In July 1997, a percentile-based statistic replaced the 2nd maximum, but in May 1999 the 2nd maximum standard was reinstated.
4. Determined by adjusting for incomplete days and averaging over the most recent 3 consecutive, complete calendar years.
5. Arithmetic mean value over the most recent 3 consecutive, complete calendar years.
6. On April 1, 2000, North Carolina adopted the EPA PM2.5 and Ozone standards. On May 14, 2000, the US Court of Appeals ruled the new EPA PM2.5 standard vacated and the new 8-hour ozone standard as unenforceable. On appeal to the US Supreme Court the new standard was upheld.
7. On May 27, 2000, the one-hour ozone standard was rescinded by the Environmental Management Commission based on EPA guidance. The one-hour standard is being reinstated by EPA.

4 Ambient Air Quality Monitoring Program

The North Carolina Division of Air Quality, three local air pollution control programs, and one tribal program (Appendix A) performed ambient monitoring and analyses of samples in 2004. Ambient air monitoring data are used to determine whether air quality standards are being met; to assist in enforcement actions; to determine the improvement or decline of air quality; to determine the extent of allowable industrial expansion; and to provide air pollution information to the public. A list of all monitoring sites active in 2004 is presented in Table 4.1 and shown as a map in Figure 4.1. The locations of sites for individual pollutants are shown in Figures 5.1, 5.4, 5.8, 5.11, 5.14, and 5.17.

In general, ambient monitors are operated year-round, but in some cases seasonal variations in pollutant levels make it feasible to suspend sampling at certain times. Ambient carbon monoxide associated with transportation and heating tends to produce significant concentrations only in cold weather conditions, so (with the US EPA's permission) we generally operate these monitors only from October through March. Ozone concentrations, by contrast, are correlated positively with ambient temperature. US EPA regulations accordingly require monitoring in NC from April through October. Along with ozone at some locations, we also monitor ozone precursor pollutants. Indeed, one of the ozone precursors is carbon monoxide. See 5.4 for more information about seasonal carbon monoxide monitoring and 5.5 for more information about seasonal ozone monitoring.

Siting of monitors involves several considerations, including 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.

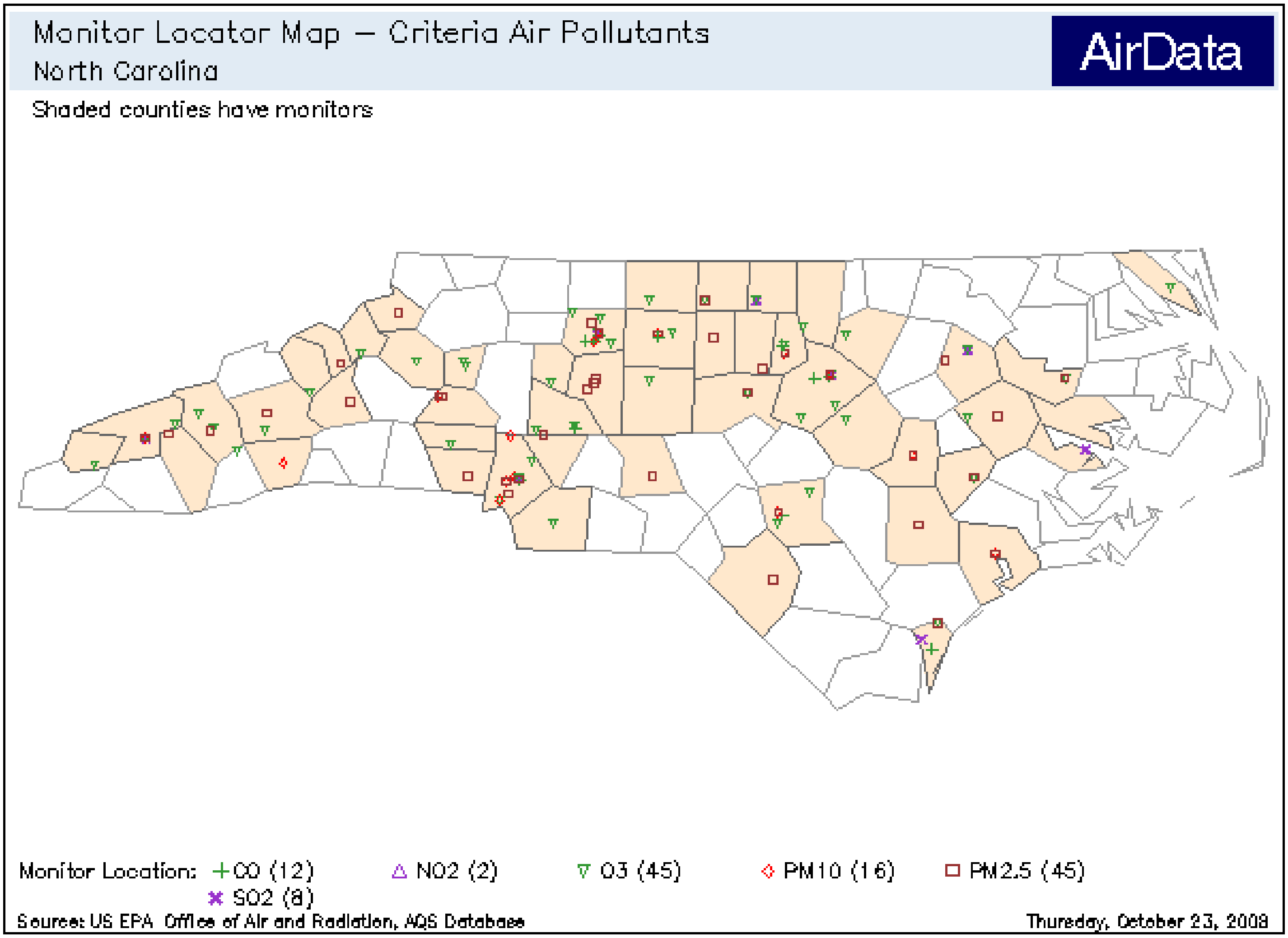
All monitors have known precision, accuracy, interferences and operational parameters. The monitors – as well as all measurement devices – are carefully calibrated at predetermined frequencies, varying from daily to quarterly. Measurements are traceable to National

Institute of Standards and Technology (NIST), when standards are available.

Monitoring and analyses are performed according to a set of 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 check continuous monitors at least twice monthly for correct instrument operation.

Monitoring agencies carry out quality assurance activities to determine the quality of the collected ambient data, improve the quality of the data and evaluate how well the monitoring system operates. The goal of 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 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.



Source: US EPA Office of Air and Radiation, AQS Database

Thursday, October 23, 2008

Figure 4.1 Monitoring Sites Active in 2004

Table 4.1 Ambient Air Monitoring Sites Operated in North Carolina, 2004

SITE COUNTY	ADDRESS	POLLUTANTS	
37-001-0002 ALAMANCE	827 S GRAHAM & HOPEDALE RD BURLINGTON	PM2.5	
37-003-0003 ALEXANDER	324 MINNIGAN LANE TAYLORSVILLE	O3	
37-003-0004 ALEXANDER	106 WAGGIN TRAIL RD TAYLORSVILLE	O3	
37-011-0002 AVERY	7510 BLUE RIDGE PARKWAY SPUR LINVILLE	O3	
37-013-0006 BEAUFORT	NC 306 @ PCS ENTRANCE AURORA	SO2	
37-021-0030 BUNCOMBE	ROUT 191 SOUTH BREVARD RD ASHEVILLE	O3	
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	PM2.5	
37-025-0004 CABARRUS	933 FLOYD STREET KANNAPOLIS	PM2.5	
37-027-0003 CALDWELL	HWY 321 NORTH LENOIR	O3	
37-029-0099 CAMDEN	101 MCKINNEY ROAD CAMDEN	O3	
37-033-0001 CASWELL	7074 CHERRY GROVE RD REIDSVILLE	O3	PM2.5
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	PM10	PM2.5
37-035-0006 CATAWBA	320 3RD STREET DR SW HICKORY	O3	PM2.5
37-037-0004 CHATHAM	325 RUSSETT RUN ROAD PITTSBORO	O3	PM2.5

SITE COUNTY	ADDRESS	POLLUTANTS
37-051-0007 CUMBERLAND	CUMBERLAND CO ABC BOARD, 1705 OWEN DR FAYETTEVILLE	CO
37-051-0008 CUMBERLAND	1/4 MILE SR1857/US301/1857 WADE	O3
37-051-0009 CUMBERLAND	4533 RAEFORD RD FAYETTEVILLE	PM10 PM2.5
37-051-1003 CUMBERLAND	3625 GOLFVIEW RD HOPE MILLS	O3
37-057-0002 DAVIDSON	SOUTH SALISBURY STREET LEXINGTON	PM2.5
37-057-0003 DAVIDSON	1673 AVIATION WAY LEXINGTON	PM2.5
37-057-0004 DAVIDSON	400 GREENSBORO STREET EXT LEXINGTON	PM2.5
37-059-0002 DAVIE	246 MAIN STREET COOLEEMEE	O3
37-061-0002 DUPLIN	HIGHWAY 50 KENANSVILLE	PM2.5
37-063-0001 DURHAM	HEALTH DEPT 300 E MAIN STREET DURHAM	PM10 PM2.5
37-063-0013 DURHAM	2700 NORTH DUKE STREET DURHAM	O3
37-065-0004 EDGECOMBE	900 SPRINGFIELD RD ROCKY MOUNT	PM2.5
37-065-0099 EDGECOMBE	7589 NC HIGHWAY 33 NW TARBORO	O3 SO2
37-067-0022 FORSYTH	1300 BLK HATTIE AVENUE WINSTON-SALEM	PM10 O3 SO2 NO2 PM2.5
37-067-0023 FORSYTH	1401 CORPORATION PARKWAY WINSTON-SALEM	CO PM10

SITE COUNTY	ADDRESS	POLLUTANTS
37-067-0024 FORSYTH	NORTH FORSYTH HIGH SCHOOL WINSTON-SALEM	PM2.5
37-067-0027 FORSYTH	7635 HOLLYBERRY LANE WINSTON-SALEM	O3
37-067-0028 FORSYTH	6496 BAUX MOUNTAIN ROAD WINSTON-SALEM	O3
37-067-0029 FORSYTH	1985 GRIFFITH ROAD WINSTON-SALEM	CO
37-067-1008 FORSYTH	3656 PIEDMONT MEMORIAL DRIVE WINSTON-SALEM	O3
37-069-0001 FRANKLIN	431 S. HILLSBOROUGH STREET FRANKLINTON	O3
37-071-0016 GASTON	1622 EAST GARRISON BLVD GASTONIA	PM2.5
37-075-0001 GRAHAM	FOREST ROAD 423 SPUR KILMER	O3
37-077-0001 GRANVILLE	WATER TREATMENT PLANT JOHN UMSTEAD HOSP BUTNER	O3
37-081-0011 GUILFORD	KELLY PARK , KELLY RD MC CLEANSVILLE	O3
37-081-0013 GUILFORD	205 WILOUGHBY BLVD GREENSBORO	PM2.5 PM10
37-081-1011 GUILFORD	401 WEST WENDOVER GREENSBORO	CO
37-087-0004 HAYWOOD	2177 ASHEVILLE ROAD WAYNESVILLE	O3
37-087-0010 HAYWOOD	9 MAIN STREET WAYNESVILLE	PM2.5
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	O3

SITE COUNTY	ADDRESS	POLLUTANTS				
37-087-0036 HAYWOOD	GREAT SMOKY MOUNTAINS NATIONAL PARK	O3				
37-089-1006 HENDERSON	CORNER OF ALLEN & WASHINGTON ST'S HENDERSONVILLE	PM10				
37-099-0005 JACKSON	BARNET KNOB FIRE TOWER RD CHEROKEE	O3				
37-099-0006 JACKSON	US ROUTE 19 NORTH CHEROKEE RESERVATION	PM2.5				
37-101-0002 JOHNSTON	1338 JACK ROAD CLAYTON	O3				
37-107-0004 LENOIR	HIGHWAY 70 EAST AND HIGHWAY 58 SOUTH KINSTON	O3	PM2.5			
37-109-0004 LINCOLN	1487 RIVERVIEW ROAD LINCOLNTON	O3				
37-111-0004 MC DOWELL	BALWIN AVENUE (EAST MARION JR. HIGH SCHOOL) MARION	PM2.5				
37-117-0001 MARTIN	1210 HAYES STREET JAMESVILLE	O3	PM2.5			
37-119-0003 MECKLENBURG	FIRE STATION # 11, 620 WEST 28TH STREET CHARLOTTE	PM10				
37-119-0010 MECKLENBURG	FIRE STATION # 10, 2136 FREMOUNT ROAD CHARLOTTE	PM10	PM2.5			
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	CO	SO2	PM2.5	O3	NO2
37-119-0042 MECKLENBURG	1935 EMERYWOOD DRIVE CHARLOTTE	PM2.5				
37-119-1001 MECKLENBURG	FILTER PLANT DAVIDSON	PM10				
37-119-1005 MECKLENBURG	400 WESTINGHOUSE BLVD. CHARLOTTE	O3	PM10			

SITE COUNTY	ADDRESS	POLLUTANTS	
37-119-1009 MECKLENBURG	29 N @ MECKLENBURG CAB CO. CHARLOTTE	O3	
37-121-0001 MITCHELL	CITY HALL, SUMMIT STREET SPRUCE PINE	PM2.5	
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	PM2.5	
37-129-0002 NEW HANOVER	6028 HOLLY SHELTER ROAD CASTLE HAYNE	O3	PM2.5
37-129-0006 NEW HANOVER	HIGHWAY 421 NORTH WILMINGTON	SO2	
37-129-0008 NEW HANOVER	CORNER OF OLEANDER & COLLEGE RD WILMINGTON	CO	
37-133-0005 ONSLOW	617 HENDERSON DR JACKSONVILLE	PM10	PM2.5
37-135-0007 ORANGE	MASON FARM ROAD CHAPEL HILL	PM2.5	
37-145-0003 PERSON	STATE ROAD 1102 & NC 49 ROXBORO	O3	SO2
37-147-0005 PITT	851 HOWELL STREET GREENVILLE	PM2.5	
37-147-0099 PITT	US 264 NEAR WATER TOWER FARMVILLE	O3	
37-151-0004 RANDOLPH	4507 BRANSON DAVIS ROAD SOPHIA	O3	
37-155-0005 ROBESON	1170 LINKHAW ROAD LUMBERTON	PM2.5	
37-157-0099 ROCKINGHAM	6371 NC 65 @ BETHANY SCHOOL BETHANY	O3	
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVENUE ROCKWELL	O3	

SITE COUNTY	ADDRESS	POLLUTANTS			
37-159-0022 ROWAN	925 NORTH ENOCHVILLE AVENUE CHINA GROVE	O3			
37-173-0002 SWAIN	CENTER ST/PARKS & RECREATION FACILITY BRYSON CITY	O3	PM2.5	PM10	SO2
37-179-0003 UNION	701 CHARLES STREET MONROE	O3			
37-183-0014 WAKE	3801 SPRING FOREST ROAD RALEIGH	O3	PM2.5	PM10	SO2
37-183-0016 WAKE	201 NORTH BROAD STREET FUQUAY-VARINA	O3			
37-183-0017 WAKE	5033 TV TOWER ROAD GARNER	O3			
37-183-0018 WAKE	US HIGHWAY 70 WEST & NC HIGHWAY 50 NOR RALEIGH	CO			
37-189-0003 WATAUGA	361 JEFFERSON ROAD BOONE	PM2.5			
37-191-0005 WAYNE	DILLARD MIDDLE SHOOL, DEVEREAU STREET GOLDSBORO	PM10	PM2.5		
37-199-0003 YANCEY	STATE HIGHWAY 128 BURNSVILLE	O3			
Sites operated in 2004	84				

5 Pollutant Monitoring Results

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

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

Geographic factors that affect concentrations include variables such as 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, conditions of the economy, and the day of the week.

Air quality also may be influenced by “exceptional events” in the short term. 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.

In the tabular listings in this report, data affected by exceptional events are excluded, and are omitted from summaries in charts. However they are addressed in the text of the report. A list of typical exceptional events is given in Appendix B.

Data for the 2004 ambient air quality report were collected at 138 air pollutant monitors operated by state and local agencies in North Carolina (listed in Appendix A). To minimize operating expenses, some sulfur dioxide monitors are operated only every third year. Three of the 138 monitors used for this report operated most recently in 2002 or 2003.

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 cubic feet per minute. 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.

The state and local program agencies discontinued routine ambient TSP sampling at the end of 2000, but resumed a limited sampling program again in 2003. In 2004, seven sites were used to monitor TSP and 43 samples were collected. A detailed summary of the data from each site is given in Table 5.1.

No sample exceeded the N.C. TSP ambient air quality standards in 2004. The highest 24-hour average was 56, which was 37 percent of the standard. This value occurred at the Prospect and Northside Street site in Canton. 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 largest geometric mean TSP average was 24 $\mu g/m^3$, which is 32 percent of the level of the air quality standard. This value occurred at the Prospect and Northside Street site in Canton.

Table 5.1 Total Suspended Particulates in Micrograms Per Cubic Meter for 2004

SITE NUMBER	ADDRESS	NUM OBS	24-HOUR MAX				ARITH MEAN	GEOM MEAN	GEOM SD
COUNTY			1st	2nd	3rd	4th			
37-035-0004 CATAWBA	1650 1st STREET HICKORY	5	35	35	32	23	29	28	1.3
37-065-0099 EDGECOMBE	7589 NC HWY 33-NW LEGGETT	11	21	20	18	16	13	12	1.5
37-081-0013 GUILFORD	205 WILOUGHBY BLVD GREENSBORO	8	26	23	20	18	17	16	1.4
37-087-0011 HAYWOOD	PROSPECT AND NORTHSIDE STR CANTON	4	56	29	17	12	29	24	2.0
37-129-0002 NEW HANOVER	6028 HOLLY SHELTER RD CASTLE HAYNE	5	19	15	14	14	15	15	1.2
37-155-0005 ROBESON	1170 LINKHAW ROAD LUMBERTON	5	30	22	22	21	23	23	1.2
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	5	35	21	21	17	22	21	1.3
Total Samples		43							
Total Sites Sampled		7							

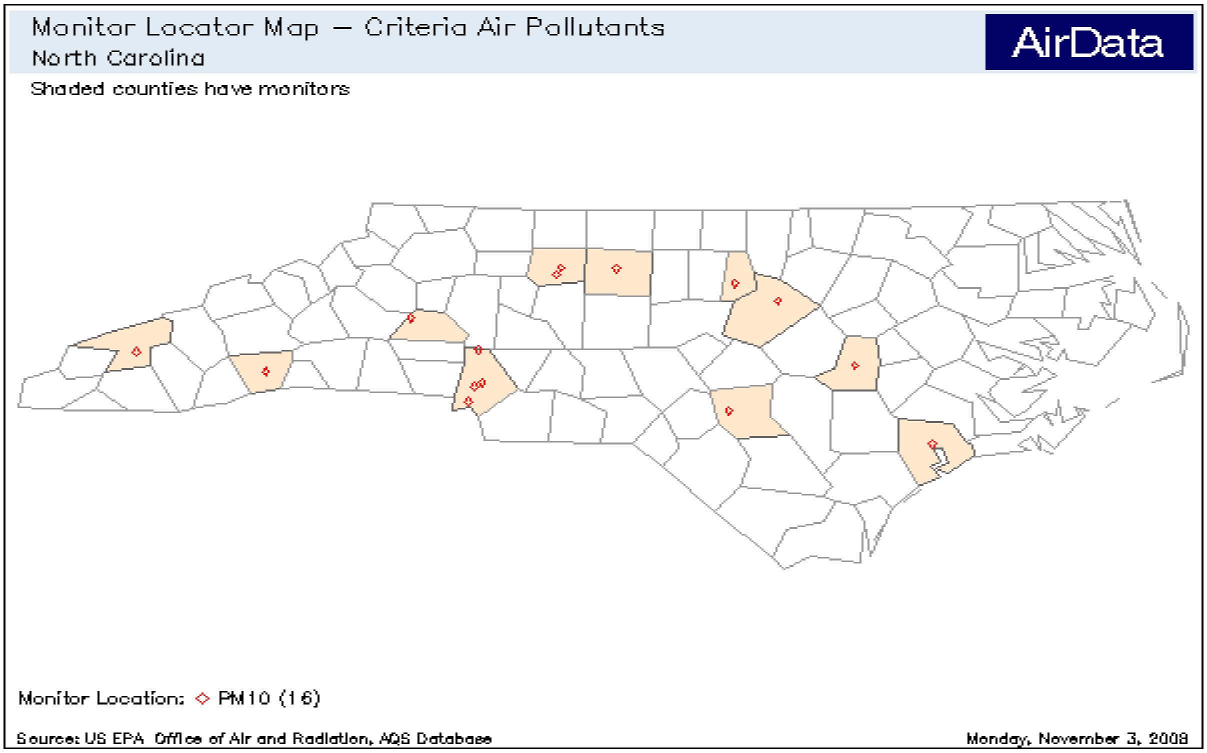
5.2 PM_{10}

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.

In 2004, 1,698 ordinary 24-hour samples of PM_{10} were collected from monitors located at 16 sites. A map of the PM_{10} sampling sites is shown in Figure 5.1, 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 2004. The highest 24-hour maximum concentration was 62 $\mu g/m^3$, or about 41 percent of the standard (150 $\mu g/m^3$). The highest annual arithmetic mean was 27.8 $\mu g/m^3$, which is about 56 percent of the standard (50 $\mu g/m^3$).

The second highest 24-hour concentrations are shown by county in Figure 5.2 and the annual arithmetic means are shown in Figure 5.3. (In counties with more than one PM_{10} monitoring site, the concentration reported in Figure 5.2 is the county-wide second maximum 24-hour concentration, and the mean reported in Figure 5.3 is the maximum arithmetic mean for the county.)



Source: US EPA Office of Air and Radiation, AQS Database

Monday, November 3, 2008

Figure 5.1 Location of PM10 Monitoring Sites

Table 5.2 PM_{10} in Micrograms Per Cubic Meter for 2004

SITE NUMBER	ADDRESS	NUM	24-HOUR MAXIMA				ARITH
COUNTY		OBS	1st	2nd	3rd	4th	MEAN
37-035-0004 CATAWBA	1650 1ST. ST. HICKORY	56	44	42	37	37	23.4
37-051-0009 CUMBERLAND	4533 RAEFORD ROAD FAYETTEVILLE	61	36	35	33	33	19.5
37-063-0001 DURHAM	HEALTH DEPT 300 E MAIN ST DURHAM	60	40	34	32	30	19.05
37-067-0022 FORSYTH	1300 BLK. HATTIE AVE WINSTON-SALEM	364	52	50	42	40	19.8
37-067-0023 FORSYTH	1401 CORPORATION PARKWAY WINSTON-SALEM	366	62	56	52	48	23.6
37-081-0013 GUILFORD	205 WILOUGHBY BLVD GREENSBORO	56	31	30	30	29	17.0
37-089-1006 HENDERSON	CORNER OF ALLEN & WASHINGTON STS HENDERSONVILLE	58	37	35	34	32	17.3

SITE NUMBER **COUNTY**	ADDRESS	NUM OBS	**24-HOUR MAXIMA** 1st	2nd	3rd	4th	**ARITH MEAN**
37-119-0003 MECKLENBURG	FIRE STA #11 620 MORETZ STREET CHARLOTTE	61	47	42	42	40	24.6
37-119-0010 MECKLENBURG	FIRE STA #10 2136 REMOUNT RD CHARLOTTE	59	50	43	40	40	24.6
37-119-1001 MECKLENBURG	FILTER PLANT DAVIDSON	57	45	43	41	40	21.5
37-119-1005 MECKLENBURG	400 WESTINGHOUSE BLVD. CHARLOTTE	60	58	53	52	51	27.8
37-133-0005 ONSLOW	617 HENDERSON DRIVE JACKSONVILLE	59	32	29	27	25	14.9
37-173-0002 SWAIN	CENTER ST/PARKS 7 REC FACILITY	59	34	26	26	25	15.8
37-183-0014 WAKE	3801 SPRING FOREST RD. RALEIGH	246	50	45	45	44	20.9
37-183-0014 WAKE	3801 SPRING FOREST RD. RALEIGH	20	35	35	32	21	19.3
37-191-0005 WAYNE	DILLARD MIDDLE SCHOOL DEVEREAU ST GOLDSBORO	56	38	34	32	28	17.5
Total Samples		1,698					
Total Sites Sampled		16					

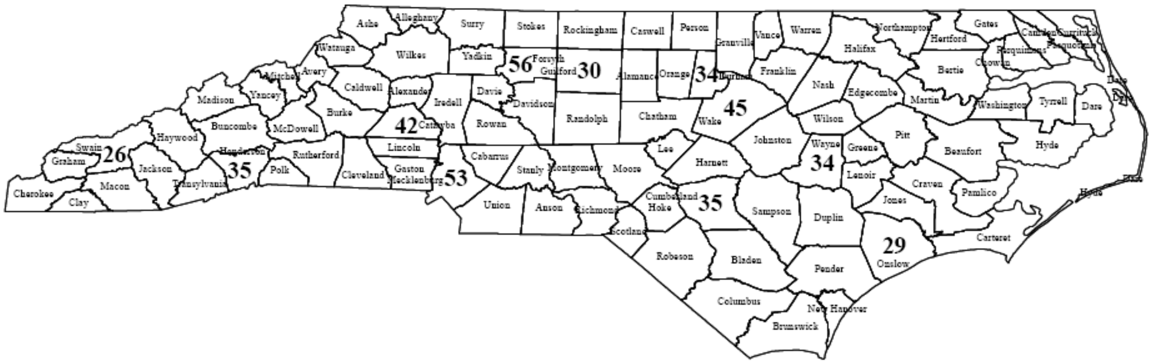


Figure 5.2 PM$_{10}$: Second Highest 24-Hour Averages, 2004

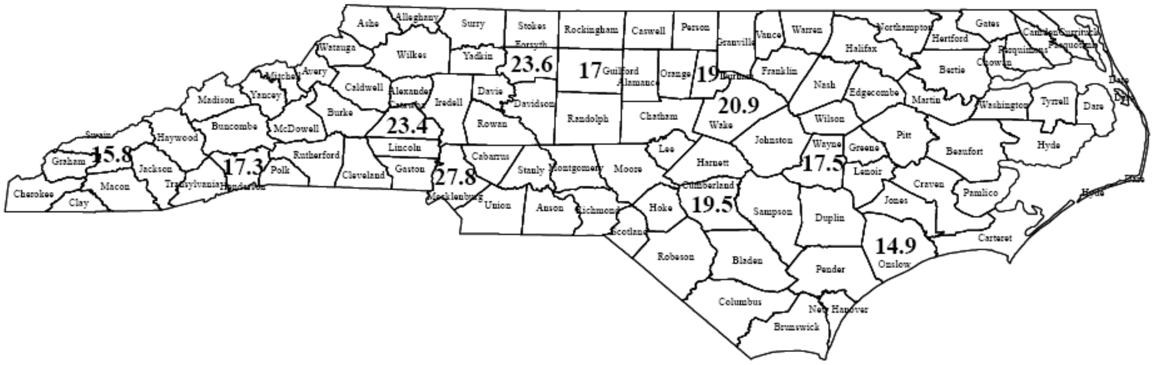


Figure 5.3 PM$_{10}$: Maximum Annual Arithmetic Means, 2004

5.3 Fine Particulate Matter, (PM$_{2.5}$)

In 2004, 37 sites were used to monitor PM$_{2.5}$ and 5,554 samples were collected. A map of the PM$_{2.5}$ sampling sites is shown in Figure 5.4 and a detailed summary of the data from each site is given in Table 5.3.

There were no exceedances of the PM$_{2.5}$ 24-hour ambient air quality standards in 2004.

The highest 24-hour maximum concentration was 43.9 $\mu g/m^3$, or about 68 percent of the standard (65 $\mu g/m^3$) (See Table 5.3).

The highest annual arithmetic mean was 15.69 $\mu g/m^3$, which is about 1 percent over the level of the standard (15 $\mu g/m^3$), at Lexington in Davidson County. The other monitors that exceeded the annual arithmetic mean standard in 2004 were Hickory in Catawba County and Charlotte in Mecklenburg County (See Table 5.3).

NAAQS attainment is based on both the level of the 98th percentile concentration of 24 hour averages and weighted annual means (Table 3.1). The 98th percentile concentrations are shown by county in Figure 5.5, and the annual arithmetic means are shown in Figure 5.6. (In counties with more than one monitoring site, the concentration reported in Figure 5.5 is the maximum 98th percentile and the mean reported in Figure 5.6 is the maximum arithmetic mean for the county.)

Figure 5.7 is a map of "design values" for PM$_{2.5}$, computed from the highest 3-year average arithmetic mean in each county for 2002 through 2004, using the federal reference method monitors. Thirty-one counties have enough reported data to compute this metric correctly, and two of them appear to be violating the ambient standard that is due to be implemented. Attainment decisions for PM$_{2.5}$ will be based on the design values observed during 2004 through 2006, which may or may not resemble the values illustrated here.

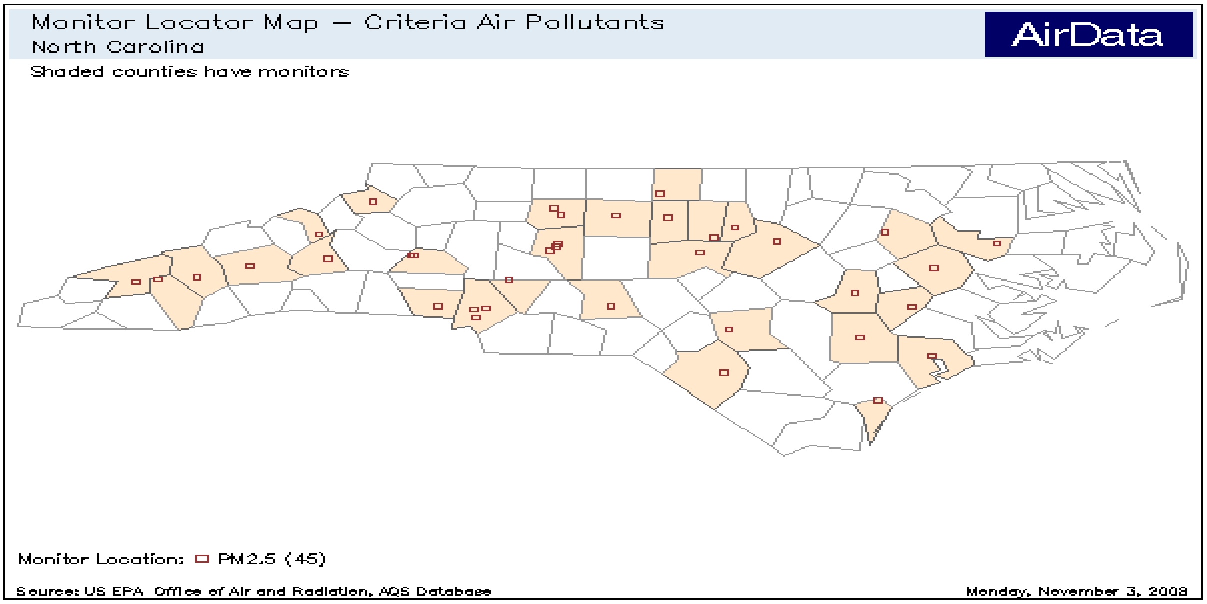


Figure 5.4 Location of PM$_{2.5}$ Monitoring Sites

Table 5.3 $PM_{2.5}$ in Micrograms Per Cubic Meter for 2004

SITE NUMBER	ADDRESS	NUM OBS	24-HOUR MAXIMA				PERCENTILE	ARITH MEAN
COUNTY			1st	2nd	3rd	4th	98TH	
37-001-0002 ALAMANCE	827 S. GRAHAM & HOPEDALE RD BURLINGTON	116	39.0	33.1	30.5	30.3	30.5	13.86
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	115	32.8	26.9	26.8	25.9	26.8	12.30
37-025-0004 CABARRUS	933 FLOYD STREET KANNAPOLIS	121	37.2	31.2	29.7	29.7	29.7	14.64
37-033-0001 CASWELL	7074 CHERRY GROVE RECREATION	117	42.6	32.5	28.3	27.9	28.3	13.5
37-035-0004 CATAWBA	1650 1ST. ST. HICKORY	118	37.4	35.9	34.0	32.9	34.0	15.01
37-035-0006 CATAWBA	320 3RD ST DR SW HICKORY	61	40.8	35.7	31.5	28.8	35.7	15.12
37-037-0004 CHATHAM	325 RUSSETT PITTSBORO	123	27.1	26.9	24.9	24.2	24.9	12.24
37-051-0009 CUMBERLAND	4533 RAEFORD ROAD FAYETTEVILLE	121	35.3	33.2	31.9	31.5	31.9	14.05
37-057-0002 DAVIDSON	SOUTH SALISBURY STREET LEXINGTON	119	42.6	31.0	29.0	28.6	29.0	15.17
37-057-0003 DAVIDSON	1673 AVIATION WAY LEXINGTON	85	43.6	32.1	30.5	29.9	32.1	15.69
37-057-0004 DAVIDSON	400 GREENSBORO STR EXT LEXINGTON	96	43.3	31.2	29.7	27.2	31.2	14.78
37-061-0002 DUPLIN	HWY 50 KENANANSVILLE	113	34.8	30.6	29.9	25.4	29.9	12.08
37-063-0001 DURHAM	HEALTH DEPT 300 E MAIN ST DURHAM	347	37.5	36.7	35.1	35.1	32.8	13.78
38-065-0004 EDGECOMBE	900 SPRINGFIELD ROCKY MOUNT	118	30.1	30.0	25.4	25.3	25.4	11.60
37-067-0022 FORSYTH	1300 BLOCK, HATTIE AVENUE WINSTON-SALEM	320	41.0	40.1	34.6	34.3	31.5	14.76
37-067-0024 FORSYTH	NORTH FORSYTH HIGH SCHOOL WINSTON-SALEM	109	39.4	36.3	33.6	30.9	33.6	14.05

SITE NUMBER COUNTY	ADDRESS	NUM OBS	24-HOUR MAXIMA 1st	2nd	3rd	4th	PERCENTILE 98TH	ARITH MEAN
37-071-0016 GASTON	1622 EAST GARRISON BLVD GASTONIA	121	33.7	32.6	30.8	30.4	30.8	14.16
37-081-0013 GUILFORD	205 WILOUGHBY BLVD GREENSBORO	347	43.4	39.4	38.9	37.4	30.8	13.97
37-087-0010 HAYWOOD	9 MAIN STREET WAYNESVILLE	119	28.2	27.5	24.9	23.6	24.9	12.54
37-099-0006 JACKSON	US RT 19 NORTH CHEROKEE RES	111	23.7	23.0	21.9	21.3	21.9	11.14
37-107-0004 LENOIR	CORNER HWY 70 EAST KINSTON	120	30.9	27.6	24.1	24.0	24.1	11.17
37-111-0004 MC DOWELL	BALDWIN AVE MARION	116	36.2	35.6	29.6	28.8	29.6	13.96
37-117-0001 MARTIN	1210 HAYES ST JAMESVILLE	113	31.5	31.3	29.5	27.8	29.5	11.55
37-119-0010 MECKLENBURG	FIRE STA #10 2136 REMOUNT ROAD CHARLOTTE	343	43.9	42.7	39.0	36.8	34.1	15.51
37-119-1041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	342	39.8	38.5	34.6	32.6	31.4	14.83
37-119-1042 MECKLENBURG	1935 EMERYWOOD DRIVE CHARLOTTE	119	32.3	29.3	29.2	29.2	29.2	14.41
37-121-0001 MITCHELL	CITY HALL SUMMIT ST SPRUCE PINE	119	32.8	29.4	28.9	27.3	28.9	12.47
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	118	30.5	29.7	27.0	26.6	27.0	12.58
37-129-0002 NEW HANOVER	6028 HOLLY SHELTER RD	112	27.6	23.1	22.8	20.1	22.8	10.46
37-133-0005 ONSLOW	617 HENDERSON DRIVE JACKSONVILLE	112	27.0	24.7	23.7	22.6	23.7	11.70
37-135-0007 ORANGE	MASON FARM ROAD CHAPEL HILL	120	36.6	32.8	29.7	29.2	29.7	13.45
37-147-0005 PITT	851 HOWELL STREET	120	33.0	29.1	26.9	23.7	26.9	11.80

SITE NUMBER	ADDRESS	NUM OBS	24-HOUR MAXIMA				PERCENTILE	ARITH MEAN
COUNTY			1st	2nd	3rd	4th	98TH	
	GREENVILLE							
37-155-0005 ROBESON	1170 LINKHAM ROAD LUMBERTON	120	39.4	33.3	31.6	28.3	31.6	12.87
37-173-0002 SWAIN	CENTER ST/PARKS 7 REC FACILITY	115	25.2	24.6	24.5	24.0	24.5	12.19
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	330	41.7	33.8	32.0	30.5	29.5	13.31
37-189-0003 WATAUGA	361JEFFERSON HWY BOONE	118	32.0	29.4	27.2	26.8	27.2	11.71
37-191-0005 WAYNE	DILLARD MIDDLE SCHOOL GOLDSBORO	120	39.4	33.1	25.3	24.7	25.3	12.93
Total Samples		5,554						
Total Sites Sampled		37						

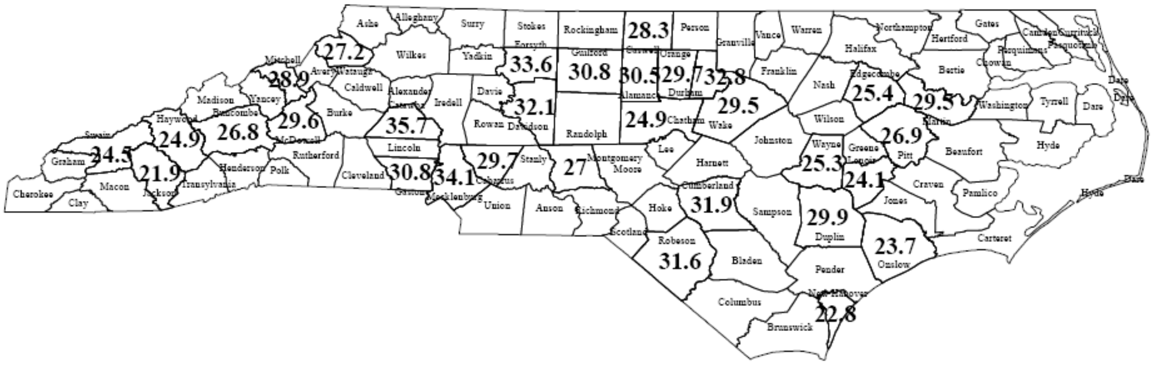


Figure 5.5 PM$_{2.5}$: 98th percentile, 2004

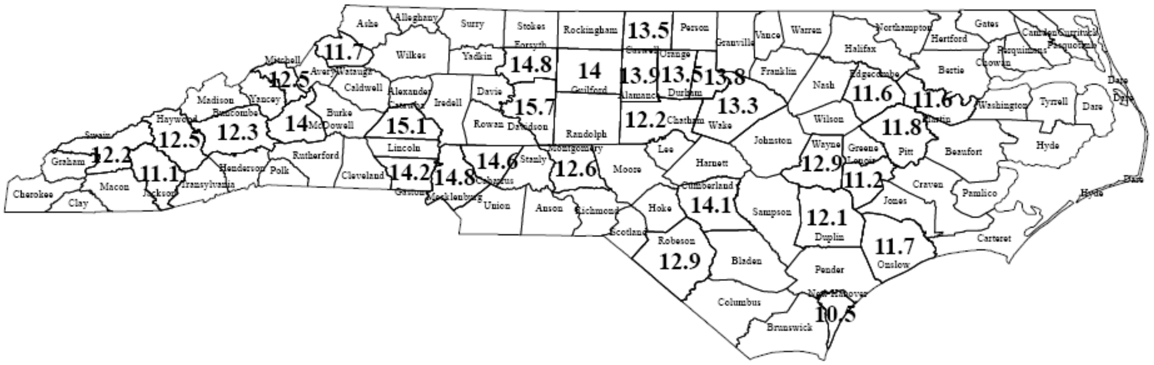


Figure 5.6 PM$_{2.5}$: Annual Arithmetic Means, 2004

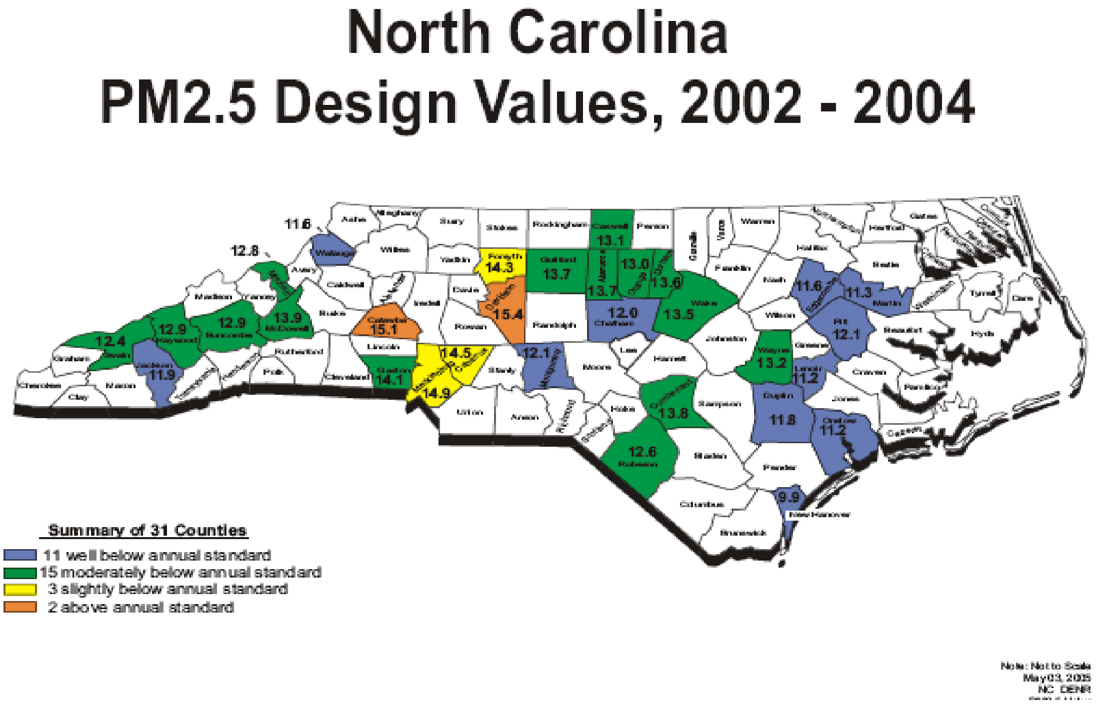


Figure 5.7 PM$_{2.5}$ Design Values by County, 2002-2004

5.4 Carbon Monoxide

Carbon monoxide (CO) data were collected for two purposes in 2004: to determine attainment status of the ambient air quality standard, and to gather data on CO as an ozone precursor. The carbon monoxide associated with ozone formation consists of very low concentrations (not greater than 2 ppm) collected at special sites considered optimal for input to a large photochemical grid model. This report will not further discuss the role of CO as an ozone precursor, but these data and more information are available on request from the Division of Air Quality (see the Preface for a mailing address).

To assess CO attainment status, the Division of Air Quality collected data from monitors in Fayetteville, Wilmington, Greensboro and Raleigh, and local program agencies collected data from three monitors in Winston-Salem and Charlotte using EPA Reference or equivalent methods to measure the concentrations.

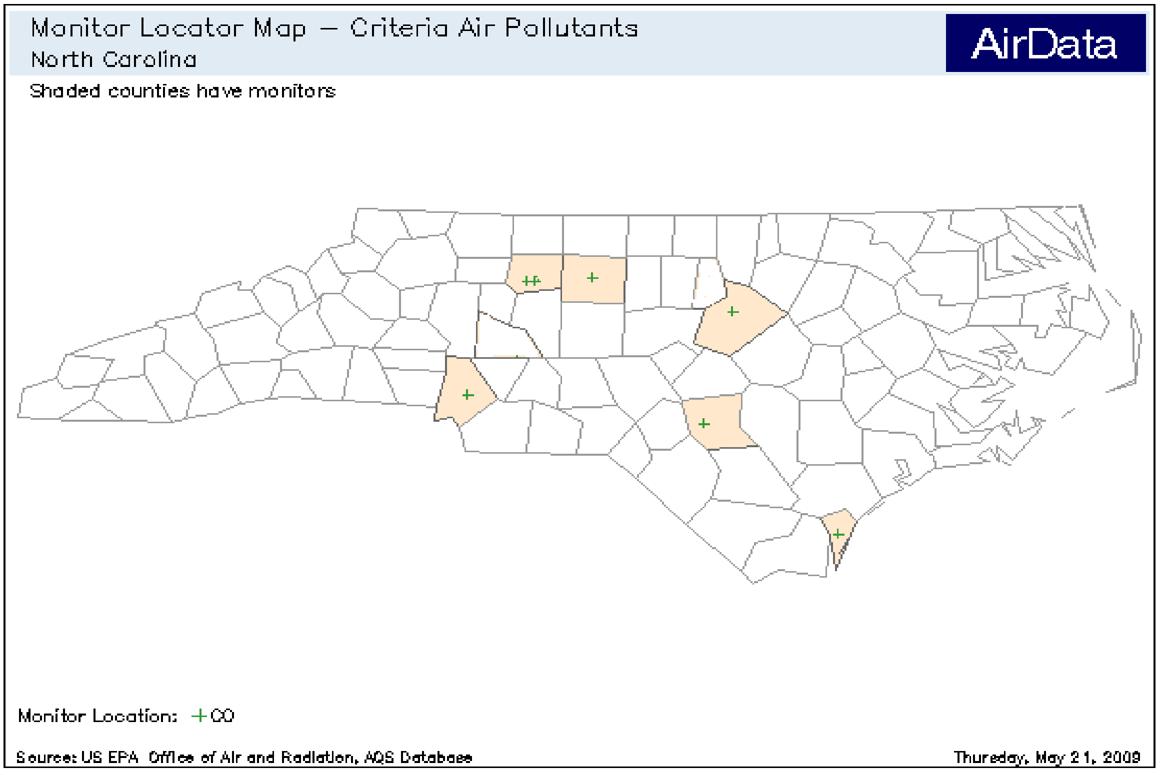
In 2004, seven sites were used to monitor CO and 39,273 valid hourly averages were collected. To keep operating costs minimal, sites are operated only in the colder months. A map of the CO sampling sites is shown in Figure 5.8, and a detailed summary of the data from each site is presented in Table 5.4.

There were no exceedances of the CO ambient air quality standards in 2004. The highest 1-hour average was 8.6 parts per million (ppm), or about 25 percent of the standard (35 ppm). This value occurred at the ABC Board site in Fayetteville. The highest 8-hour average was 3.2 ppm, at the ABC Borard site in Fayetteville, Corporation site in Winston-Salem, Griffith site in Winston-Salem, and Eastway site in Charlotte, which is about 36 percent of the standard.

The second highest 1-hour concentrations in each county are shown in Figure 5.9 and the second highest 8-hour concentrations are shown in Figure 5.10.

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) during colder temperatures, more fuel is burned for comfort heating.

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) 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 greater 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.



Source: US EPA Office of Air and Radiation, AQS Database

Thursday, May 21, 2009

Figure 5.8 Location of Carbon Monoxide Monitoring Sites

Table 5.4 Carbon Monoxide in Parts Per Million for 2004

SITE NUMBER COUNTY	ADDRESS	NUM OBS	ONE-HOUR MAXIMA		EIGHT-HOUR MAXIMA	
			1st	2nd	1st	2nd
37-051-0007 CUMBERLAND	ABC BOARD, 1705 OWEN DR FAYETTEVILLE	4,167	8.6	8.0	3.2	2.8
37-067-0023 FORSYTH	1401 CORPORATION PKY WINSTON-SALEM	8,151	4.1	3.8	3.2	3.1

SITE NUMBER COUNTY	ADDRESS	NUM OBS	ONE-HOUR MAXIMA		EIGHT-HOUR MAXIMA	
			1st	2nd	1st	2nd
37-067-0029 FORSYTH	1985 GRIFFITH ROAD WINSTON-SALEM	8,077	4.5	4.4	3.2	3.1
37-081-1011 GUILFORD	401 WEST WENDOVER GREENSBORO	4,087	3.0	3.0	2.6	2.6
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	8,557	3.8	3.5	3.2	3.1
37-129-0008 NEW HANOVER	OLEANDER & COLLEGE WILMINGTON	2,122	5.0	3.3	2.3	2.3
37-183-0018 WAKE	US HWY 70 WEST AND NC HWY 50 NORTH RALEIGH	4,112	3.7	3.4	2.8	2.7
Total Samples		39,273				
Total Sites Sampled		7				

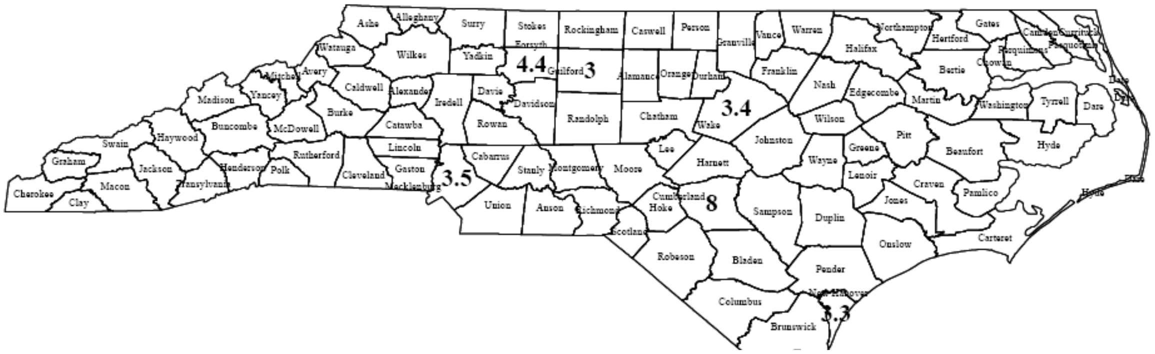


Figure 5.9 Carbon Monoxide: Second Highest 1-Hour Concentration, 2004

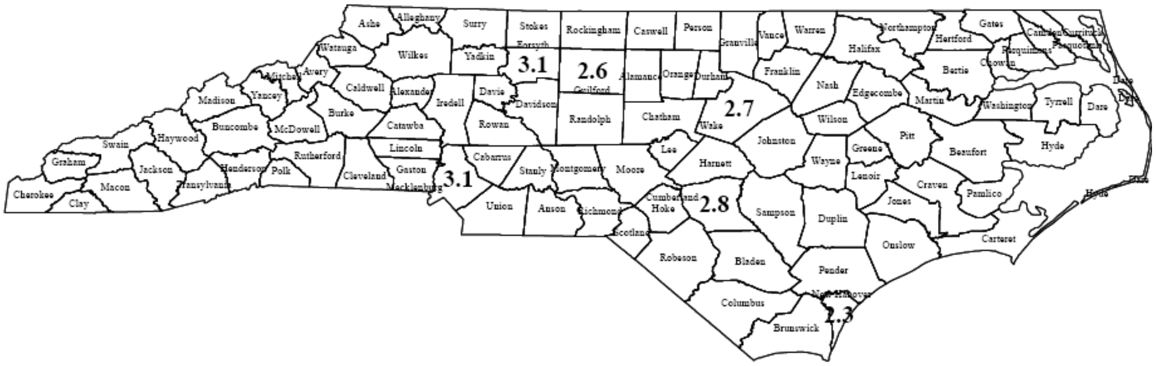


Figure 5.10 Carbon Monoxide: Second Highest Non-overlapping 8-Hour Concentration, 2004

5.5 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 only operate from April through October.

The state and local program agencies operated 45 monitoring sites in 2004 during the ozone season, April through October. A map of the O_3 sampling sites is presented in Figure 5.11, and a detailed summary of the one-hour data from each site is given in Table 5.5, and the 8-hour data in Table 5.6. These 45 monitoring sites provided 9,115 site-days of valid data (a success rate of 95 percent for the days that sampling is required).

There were no exceedances of the 1-hour ozone standard in North Carolina in 2004.

The one-hour 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, US EPA 1993, p. 767-768]. Table 5.5 gives both the actually measured and the estimated number of exceedance days at each site.)

The 8-hour standard was exceeded a total of 15 times at the 45 sites that monitored for O_3. Nine monitors had at least one exceedance. The largest number at one monitor was four in Charlotte (Meckenburg County). These exceedances were distributed over five days during the ozone season when at least one site within the state recorded values greater than 0.085 ppm.

The second highest 1-hour concentrations in each county are shown in Figure 5.12 for areas with one or more monitors active in 2004. Monitors whose second highest 1-hour concentration exceeds 0.124 ppm potentially violate the EPA one-hour standard (although it is no longer in effect in North Carolina).

Historical average fourth-highest 8-hour concentrations of O_3 in counties where monitors were operated in 2004 are shown in Figure 5.13. Monitors whose fourth-highest 8-hour ozone concentration (averaged over *three* years) exceeds 0.084 ppm are deemed in violation of the EPA 8-hour standard.

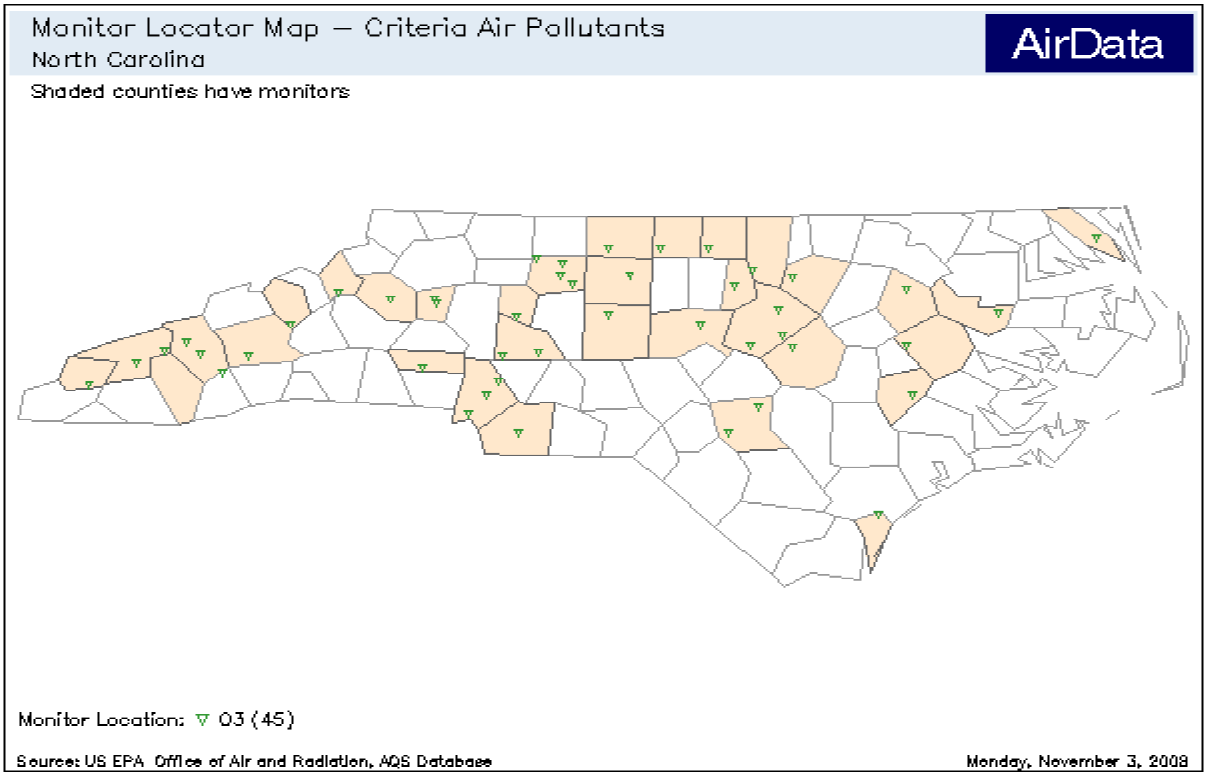


Figure 5.11 Location of Ozone Monitoring Sites

Table 5.5 One-Hour Ozone in Parts Per Million for 2004

SITE NUMBER	ADDRESS	NUM	DAILY 1-HR MAXIMA				NO. VALUES > 0.125	
COUNTY		OBS	1st	2nd	3rd	4th	MEAS	EST
37-003-0003 ALEXANDER	324 MINNIGAN LANE TAYLORSVILLE	5136	.084	.084	.079	.076	0	0.00
37-003-0004 ALEXANDER	106 WAGGIN' TRAIL TAYLORSVILLE	1944	.084	.075	.071	.065	0	0.00
37-011-0002 AVERY	7510 BLUE RIDGE	4968	.078	.077	.075	.074	0	0.00
37-021-0030 BUNCOMBE	ROUTE 191 SOUTH BREVARD RD ASHEVILLE	5136	.091	.089	.087	.083	0	0.00

SITE NUMBER COUNTY	ADDRESS	NUM OBS	DAILY 1-HR MAXIMA				NO. VALUES > 0.125	
			1st	2nd	3rd	4th	MEAS	EST
37-027-0003 CALDWELL	HWY 321 NORTH LENOIR	5016	.084	.081	.077	.076	0	0.00
37-029-0099 CAMDEN	101 MCKINNEY ROAD CAMDEN	4992	.086	.083	.083	.082	0	0.00
37-033-0001 CASWELL	7074 CHERRY GROVE REIDSVILLE	5136	.100	.088	.085	.084	0	0.00
37-037-0004 CHATHAM	325 RUSSETT RUN ROAD PITTSBORO	5136	.083	.076	.075	.074	0	0.00
37-051-0008 CUMBERLAND	1/4MI SR1857/US301/1857 WADE	5136	.085	.084	.082	.081	0	0.00
37-051-1003 CUMBERLAND	3625 GOLFVIEW ROAD HOPE MILLS	5136	.093	.088	.088	.085	0	0.00
37-059-0002 DAVIE	246 MAIN STREET COOLEEMEE	4944	.110	.096	.095	.088	0	0.00
37-063-0013 DURHAM	2700 NORTH DUKE STREET DURHAM	5088	.085	.085	.083	.083	0	0.00
37-065-0099 EDGECOMBE	7589 NC HWY 33-NW LEGGETT	4992	.084	.083	.082	.082	0	0.00
37-067-0022 FORSYTH	1300 BLK. HATTIE AVENUE WINSTON-SALEM	4944	.092	.085	.084	.084	0	0.00
37-067-0027 FORSYTH	7635 HOLLYBERRY LANE WINSTON-SALEM	5136	.082	.082	.080	.080	0	0.00
37-067-0028 FORSYTH	6496 BAUX MOUNTAIN RD WINSTON-SALEM	5136	.082	.082	.080	.080	0	0.00
37-067-1008 FORSYTH	3656 PIEDMONT MEMORIAL DRIVE WINSTON-SALEM	5112	.098	.089	.087	.087	0	0.00
37-069-0001 FRANKLIN	431 S. HILLBOROUGH ST FRANKLINTON	5136	.090	.090	.088	.088	0	0.00
37-075-0001 GRAHAM	FOREST ROAD 423 SPUR KILMER	5136	.101	.086	.081	.081	0	0.00

SITE NUMBER	ADDRESS	NUM	DAILY 1-HR MAXIMA				NO. VALUES > 0.125	
COUNTY		OBS	1st	2nd	3rd	4th	MEAS	EST
37-077-0001 GRANVILLE	WATER TREATMENT PLANT, JOHN UMSTEAD HOSPITAL BUTNER	5136	.097	.095	.095	.095	0	0.00
37-081-0011 GUILFORD	KEELY PARK, KEELY RD, GREENSBORO	4896	.087	.084	.084	.083	0	0.00
37-087-0004 HAYWOOD	2177 SCHEVILLS ROAD WAYNESVILLE	5112	.077	.076	.075	.075	0	0.00
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	4584	.091	.083	.079	.079	0	0.00
37-087-0036 HAYWOOD	GREAT SMOKY MOUNTAIN NATIONAL PARK	4968	.082	.077	.076	.075	0	0.00
37-099-0005 JACKSON	BARNET KNOB FIRE TOWER	4704	.078	.075	.072	.071	0	0.00
37-101-0002 JOHNSTON	1338 JACK ROAD CLAYTON	5088	.091	.088	.087	.086	0	0.00
37-107-0004 LENOIR	CORNER HWY EAST KINSTON	4704	.087	.077	.076	.075	0	0.00
37-109-0004 LINCOLN	1487 RIVERVIEW ROAD LINCOLNTON	5064	.085	.084	.083	.083	0	0.00
37-117-0001 MARTIN	1210 HAYES STREET JAMESVILLE	4920	.083	.082	.081	.079	0	0.00
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	5112	.124	.114	.102	.101	0	0.00
37-119-1005 MECKLENBURG	400 WESTINGHOUSE BLVD. CHARLOTTE	5136	.095	.095	.092	.087	0	0.00
37-119-1009 MECKLENBURG	29 N@ MECKLENBURG CAB CO CHARLOTTE	5136	.124	.104	.098	.097	0	0.00
37-129-0002 NEW HANOVER	6028 HOLLY SHELTER RD CASTLE HAYNE	5088	.084	.081	.080	.080	0	0.00

SITE NUMBER COUNTY	ADDRESS	NUM OBS	DAILY 1-HR MAXIMA 1st	2nd	3rd	4th	NO. VALUES > 0.125 MEAS	EST
37-145-0003 PERSON	STATE ROAD 1102 & NC49 ROXBORO	5016	.100	.088	.087	.086	0	0.00
37-147-0099 PITT	US 264 NEAR WATTER TOWER FARMVILLE	4992	.091	.086	.085	.083	0	0.00
37-151-0004 RANDOLPH	4507 BRANSON DAVIS ROAD SOPHIA	5136	.096	.095	.088	.084	0	0.00
37-157-0099 ROCKINGHAM	6371 NC 65 @ BETHANY SCHOOL BETHANY	5016	.088	.084	.083	.083	0	0.00
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVENUE ROCKWELL	5064	.117	.101	.097	.094	0	0.00
37-159-0022 ROWAN	925 N ENOCHVILLE AVE CHINA GROVE	5112	.122	.096	.096	.096	0	0.00
37-173-0002 SWAIN	CENTER STREET BRYSON CITY	5064	.076	.072	.067	.067	0	0.00
37-179-0003 UNION	701 CHARLES STREET MONROE	5112	.094	.094	.088	.087	0	0.00
37-183-0014 WAKE	3801 SPRING FOREST ROAD RALEIGH	5136	.090	.087	.086	.086	0	0.00
37-183-0016 WAKE	201 NORTH BROAD STREET FUQUAY-VARINA	5136	.092	.091	.088	.085	0	0.00
37-183-0017 WAKE	5033 TV TOWER ROAD GARNER	4944	.095	.095	.090	.090	0	0.00
37-199-0003 YANCY	STATE HIGHWAY 128	4920	.079	.076	.076	.076	0	0.00
Total Samples		223,656					0	0.00
Total Sites Sampled		45						

Table 5.6 Eight-Hour Ozone in Parts Per Million for 2004

SITE NUMBER COUNTY	ADDRESS	VALID DAYS	VALID DAILY 8-HR MAXIMUM				N0. VALUES .>.085 MEAS
			1st	2nd	3rd	4th	
37-003-0003 ALEXANDER	324 MINNIGAN LANE TAYLORSVILLE	203	.077	.074	.072	.071	0
37-003-0004 ALEXANDER	106 WAGGIN' TRAIL TAYLORSVILLE	78	.074	.067	.062	.056	0
37-011-0002 AVERY	7510 BLUE RIDGE	204	.071	.070	.070	.068	0
37-021-0030 BUNCOMBE	ROUT 191 SOUTH BREVARD RD ASHEVILLE	213	.080	.075	.074	.073	0
37-027-0003 CALDWELL	HWY 321 NORTH LENOIR	201	.074	.073	.070	.070	0
37-029-0099 CAMDEN	101 MCKINNEY ROAD CAMDEN	205	.078	.075	.074	.072	0
37-033-0001 CASWELL	7074 CHERRY GROVE RD REIDSVILLE	214	.079	.077	.077	.074	0
37-037-0004 CHATHAM	325 RUSSETT RUN PITTSBORO	209	.074	.070	.068	.068	0
37-051-0008 CUMBERLAND	1/4MI SR1857/US301/1857 WADE	211	.076	.075	.075	.072	0
37-051-1003 CUMBERLAND	3625 GOLFVIEW ROAD HOPE MILLS	211	.084	.078	.078	.077	0
37-059-0002 DAVIE	246 MAIN STREET COOLEEMEE	202	.081	.078	.076	.073	0
37-063-0013 DURHAM	2700 NORTH DUKE STREET DURHAM	208	.075	.074	073	.073	0
37-065-0099 EDGECOMBE	7589 NC HWY 33-NW LEGGETT	207	.077	.076	.075	.072	0
37-067-0022 FORSYTH	1300 BLK. HATTIE AVENUE WINSTON-SALEM	206	.077	.075	.075	.075	0
37-067-0027 FORSYTH	7635 HOLLYBERRY LANE WINSTON-SALEM	214	.075	.074	.072	.072	0
37-067-0028 FORSYTH	6496 BAUX MOUNTAIN RD WINSTON-SALEM	214	.075	.075	.073	.071	0
37-067-1008 FORSYTH	3656 PIEDMONT MEMORIAL DRIVE WINSTON-SALEM	213	.081	.079	.078	.078	0
37-069-0001 FRANKLIN	431 S. HILLBOROUGH ST FRANKLINTON	203	.079	.078	.078	.077	0
37-075-0001 GRAHAM	FOREST ROAD 423 SPUR KLIMER	214	.085	.085	.080	.079	2
37-077-0001	WATER TREATMENT PLANT	206	.084	.083	.083	.081	0

SITE NUMBER COUNTY	ADDRESS	VALID DAYS	VALID DAILY 8-HR MAXIMUM 1st	2nd	3rd	4th	N0. VALUES .>.085 MEAS
GRANVILLE	JOHN UMSTEAD HOSPITAL BUTNER						
37-081-0011 GUILFORD	KEELY PARK, KEELY RD, GREENSBORO	198	.077	.076	.075	.071	0
37-087-0004 HAYWOOD	2177 SHEVILLE ROAD WAYNESVILLE	213	.068	.067	.067	.066	0
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	177	.080	.079	.075	.073	0
37-087-0036 HAYWOOD	GREAT SMOKY MOUNTAIN NATIONAL PARK	202	.078	.075	.071	.071	0
37-099-0005 JACKSON	BARNET KNOB FIRE TOWER	193	.075	.074	.071	.070	0
37-101-0002 JOHNSTON	1338 JACK ROAD CLAYTON	200	.077	.076	.075	.074	0
37-107-0004 LENOIR	CORNER HWY 70 EAST KINSTON	192	.078	.071	.070	.069	0
37-109-0004 LINCOLN	1487 RIVERVIEW ROAD LINCOLNTON	206	.076	.074	.074	.074	0
37-117-0001 MARTIN	1210 HAYES STREET JAMESVILLE	200	.078	.076	.075	.075	0
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	213	.098	.097	.093	.085	4
37-119-1005 MECKLENBURG	400 WESTINGHOUSE BLVD. CHARLOTTE	213	.086	.078	.078	.077	1
37-119-1009 MECKLENBURG	29 N@ MECKLENBURG CAB CO CHARLOTTE	214	.107	.090	.087	.083	3
37-129-0002 NEW HANOVER	6028 HOLLY SHELTER RD	197	.077	.072	.070	.070	0
37-145-0003 PERSON	SR NC 49	206	.079	.078	.078	.076	0
37-147-0099 PITT	US 264 NEAR WATER TOWER FARMVILLE	204	.079	.077	.076	.073	0
37-151-0004 RANDOLPH	4507 BRANSON DAVIS RD SOPHIA	214	.085	.080	.076	.076	1
37-157-0099 ROCKINGHAM	6371 NC 65 @ BETHANY SCHOOL BETHANY	209	.078	.077	.075	.074	0
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	200	.090	.083	.081	.080	1
37-159-0022 ROWAN	925 N ENOCHVILLE AVE ENOCHVILLE	205	.096	.082	.080	.080	1
37-173-0002	CENTER STREET	201	.070	.068	.063	.062	0

SITE NUMBER COUNTY	ADDRESS	VALID DAYS	VALID DAILY 8-HR MAXIMUM 1st	2nd	3rd	4th	N0. VALUES .>.085 MEAS
SWAIN	PARKS 7 REC FACILITY						
37-179-0003 UNION	701 CHARLES STREET MONROE	205	.080	.076	.074	.074	0
37-183-0014 WAKE	E. MILLBROOK JR HI 3801 SPRING FOREST ROAD	210	.078	.077	.075	.075	0
37-183-0016 WAKE	201 NORTH BROAD STREET FUQUAY-VARINA	206	.085	.078	.077	.075	1
37-183-0017 WAKE	5033 TV TOWER ROAD GARNER	202	.082	.080	.079	.079	0
37-199-0003 YANCY	STATE HIGHWAY 128	199	.073	.072	.071	.070	1
Total Samples		9,115					15
Total Sites Sampled		45					

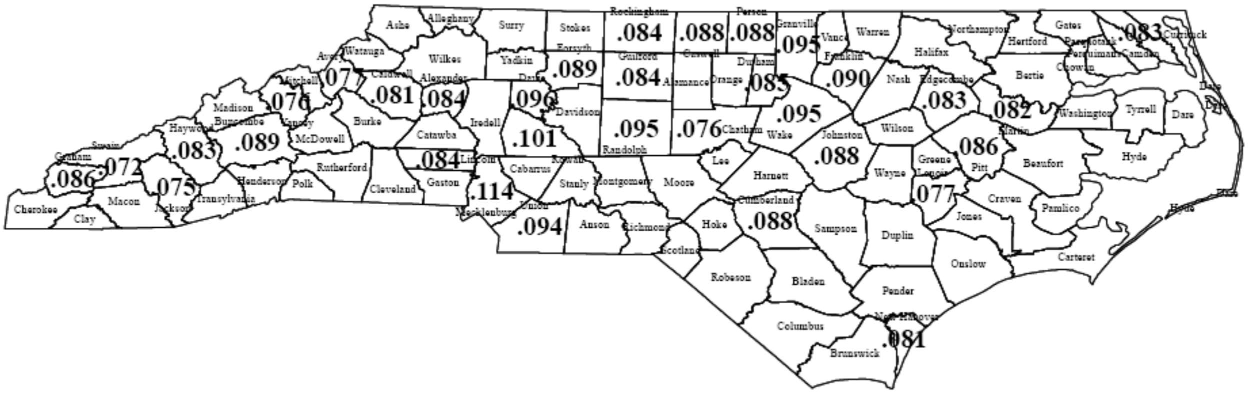
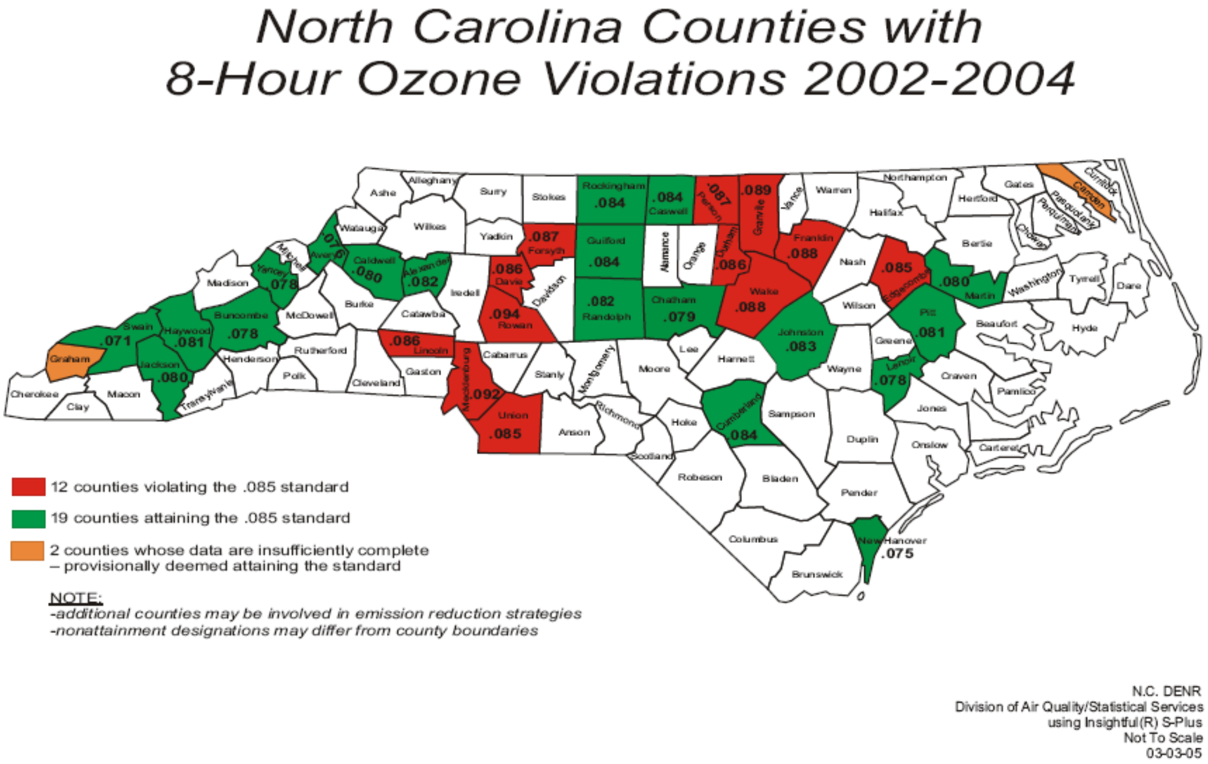


Figure 5.12 Ozone: Second Highest Annual 1-Hour Average, 2004


North Carolina Counties with 8-Hour Ozone Violations 2002-2004

🟥 12 counties violating the .085 standard

🟩 19 counties attaining the .085 standard

🟧 2 counties whose data are insufficiently complete – provisionally deemed attaining the standard

NOTE:
-additional counties may be involved in emission reduction strategies
-nonattainment designations may differ from county boundaries

N.C. DENR
Division of Air Quality/Statistical Services
using Insightful(R) S-Plus
Not To Scale
03-03-05

Figure 5.13 Ozone: Mean Annual Fourth Highest 8-Hour Average, 2002-2004

5.6 Sulfur Dioxide

Sulfur dioxide (SO_2) concentrations were measured by the State and two local program agencies using EPA reference or equivalent methods. Eight SO_2 monitors were active in North Carolina in 2004. Some SO_2 sites are operated only every third year. We supplemented this report with two monitors that operated last in 2003, (and will next be operated in 2006), and one monitor that operated last in 2002 (and will next be operated in 2005).

From the 11 sites with SO_2 data obtained between 2002 and 2004, 86,479 valid hourly averages were collected. A map of the active SO_2 sampling sites is presented in Figure 5.14 and a detailed summary of the data from each site is given in Table 5.7.

There were no exceedances of the SO_2 ambient air quality standards in 2004. The highest annual arithmetic mean was 0.005 ppm, or about 17 percent of the standard (0.03 ppm). The highest maximum 24-hour average was 0.026 ppm, about 19 percent of the standard (0.14 ppm), and the highest maximum 3-hour average was 0.095 ppm, about 19 percent of the welfare-related (secondary) standard (0.50 ppm).

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 shown in Figure 5.15. The second highest 24-hour concentrations in each county are shown in Figure 5.16.

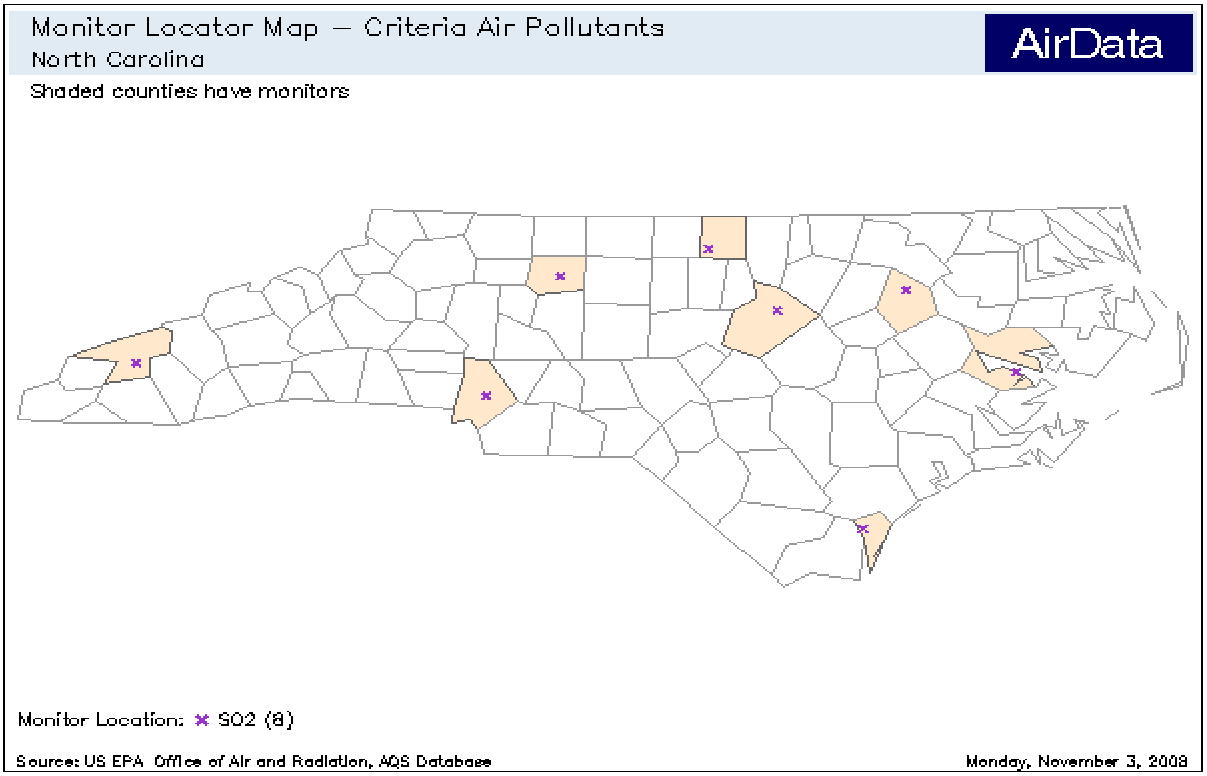


Figure 5.14 Locations of Sulfur Dioxide Monitoring Sites in 2002, 2003 and 2004.

Table 5.7 Sulfur Dioxide in Parts Per Million from All Sites for 2002-2004

SITE NUMBER	ADDRESS	NUM OBS	ONE-HOUR MAXIMA		THREE-HOUR MAXIMA		24-HOUR MAXIMA		ARITH MEAN
COUNTY			1st	2nd	1st	2nd	1st	2nd	
2004 DAT									
37-013-0006 **BEAUFORT**	NC 306@ PCS ENTRANCE AURORA	7,582	.122	.115	.092	.086	.027	.022	.0032
37-065-0099 EDGECOMBE	7589 NC HWY 33-NW **LEGGETT**	7,875	.018	.017	.016	.015	.009	.008	.0020
37-067-0022 **FORSYTH**	1300 BLK. HATTIE AVE WINSTON-SALEM	8,434	.149	.123	.084	.077	.026	.023	.0046
37-119-0041 **MECKLENBURG**	1130 EASTWAY DRIVE CHARLOTTE	8,677	.071	.068	.058	.037	.013	.012	.0032
37-129-0006 NEW HANOVER	HIGHWAY 421 NORTH WILMINGTON	8,212	.255	.194	.085	.072	.022	.022	.0052
37-145-0003 **PERSON**	STATE ROAD 1102 & NC 49 ROXBORO	8,276	.119	.096	.095	.073	.026	.021	.0039
37-173-0002 **SWAIN**	CENTER ST/PARKS & RECREATION FACILITY BRYSON CITY	8,230	.012	.012	.011	.010	.008	.006	.0021

SITE NUMBER	ADDRESS	NUM OBS	ONE-HOUR MAXIMA		THREE-HOUR MAXIMA		24-HOUR MAXIMA		ARITH MEAN
COUNTY			1st	2nd	1st	2nd	1st	2nd	
37-183-0014 **WAKE**	3801 SPRING FOREST RD. RALEIGH	5,592	.029	.028	.019	.019	.013	.010	.0027
Total Samples		62,878							
Total Sites Sampled		8							
2003 DAT									
37-037-0004 CHATHAM	RT4 BOX62 PITTSBORO	8,287	0.062	0.043	0.037	0.020	0.008	0.008	0.002
37-117-0001 MARTIN	1210 HAYES STREET	8,200	0.035	0.023	0.021	0.016	0.012	0.008	0.002
Total Samples		16,487							
Total Sites Sampled		2							
2002 DATA									
37-051-1003 CUMBERLAND	3625 GOLFVIEW ROAD HOPE MILLS	7,114	.016	.014	.011	.010	.007	.007	.002
Total Samples		7,114							
Total Sites Sampled		1							

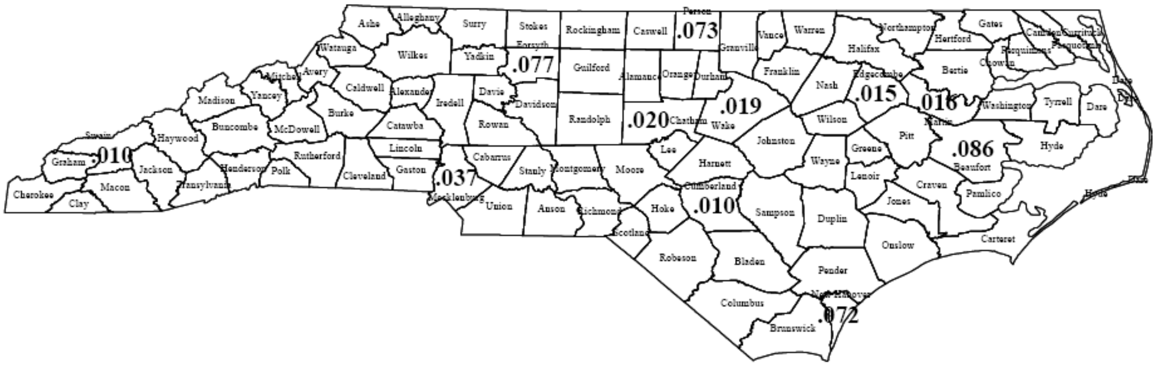


Figure 5.15 Sulfur Dioxide: Second Highest 3-Hour Averages in the Most Recent Year of Data from 2002, 2003 or 2004

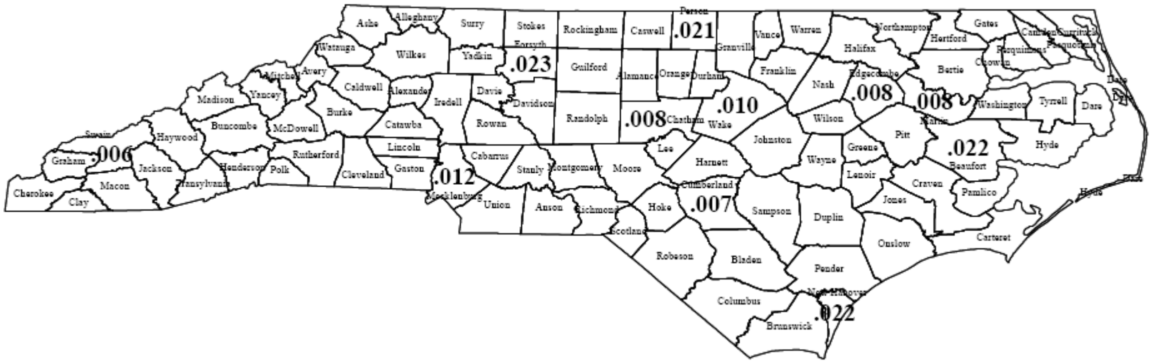


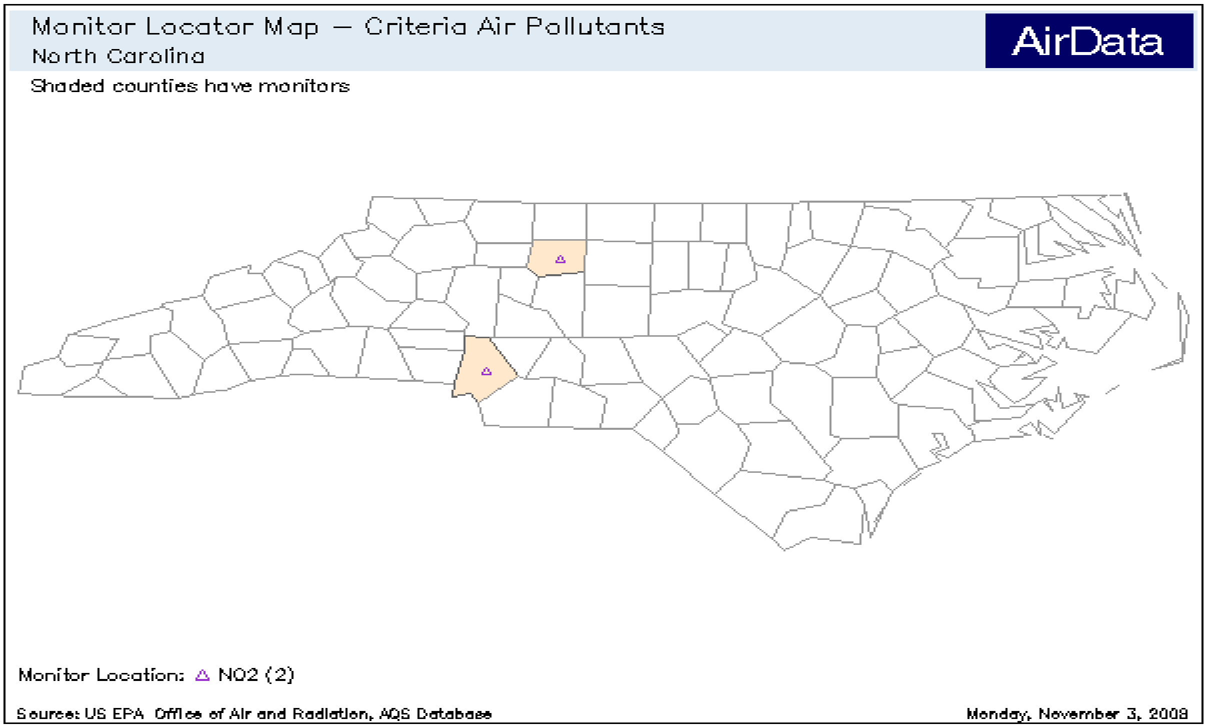
Figure 5.16 Sulfur Dioxide: Second Highest 24-Hour Averages in the Most Recent Year of Data from 2002, 2003 or 2004

5.7 Nitrogen Dioxide

Nitrogen dioxide (NO_2) concentrations were measured using EPA reference or equivalent continuous monitors in 2004 at one local program site in Forsyth County and one local program site in Mecklenburg County.

From these two sites, 17,143 hourly NO_2 measurements were reported. A map of the NO_2 sampling sites is presented in Figure 5.17, and a summary of the 2004 NO_2 data is given in Table 5.8.

Each urban area site has only a few outlying high hourly sample values that are above the standard defined for the annual arithmetic mean. The arithmetic means (Table 5.8) are about 28 percent of the standard.



Source: US EPA Office of Air and Radiation, AQS Database

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Figure 5.17 Location of Nitrogen Dioxide Monitoring Sites

Table 5.8 Nitrogen Dioxide in Parts Per Million for 2004

SITE NUMBER COUNTY	ADDRESS	NUM OBS	ONE-HOUR MAXIMA 1ST	ONE-HOUR MAXIMA 2ND	ARITH MEAN
37-067-0022 FORSYTH	1300 BLK. HATTIE AVENUE WINSTON-SALEM	8,591	0.061	0.061	0.013
37-067-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	8,552	0.080	0.064	0.015
Total Samples Total Sites Sampled		17,143 2			

5.8 Lead

The state and local program agencies have not performed routine analysis of ambient lead (Pb) in North Carolina since 1982. Lead monitoring was discontinued as a result of the low measurements and a continuing decrease in the lead concentrations being reported. The decrease in ambient Pb concentrations is due to the reduction and elimination of leaded gasoline, resulting in greatly reduced lead emissions from automobiles.

5.8.1 Special Studies

The most recent year of data available prior to 1996-97 was in 1990. Because the previous data were so old, the state began metals analysis at three locations in 1996. These metal 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. No lead sites operated in 2004.

The change in analytical laboratories from the EPA's National Particulate Analysis Program to the state program also changed the minimum detectable levels of the method from 0.01 to 0.04 $\mu g/m^3$, respectively. Concentrations of most metals are below detectable limits regardless of the method used.

During 1999 and 2000, a special study focusing on arsenic levels was undertaken. Lead, and other toxic metals were sampled on filters using the TSP Reference Method at selected ambient air monitoring sites, by a contract laboratory using inductively coupled plasma/mass spectrometry (ICP/MS). This method can detect sample concentrations of lead as small as 0.01 nanograms (0.00001 µg) per cubic meter. Of the 526 valid samples analyzed in 1999 only 18 exceeded the Reference Method's detection limits. Only one sample exceeded 0.04 $\mu g/m^3$, and 17 others exceeded 0.01 $\mu g/m^3$.

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 $PM_{2.5}$**,** PM_{10}, CO, O_3 (both 1 and 8 hour values), SO_2 and NO_2. AQI measurements are made and reported in all U.S. metropolitan statistical areas (MSA) with a population over 350,000. Ambient concentrations for each of these seven pollutants are converted to a 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 and 8-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, and a subjective description of *good*, *moderate*, "*unhealthy for sensitive groups*", "*unhealthy*", *very unhealthy*, or *hazardous* is included with the report, with the descriptions corresponding to AQI values of 0-50, 51-100, 101-150, 151-200, 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 (unhealthy for sensitive groups and unhealthy) 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 unhealthy) 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 air quality index value, and in summer months the highest index value is usually due to ozone.

In 2004, Charlotte area provided an AQI report to the public by telephone using computer- generated recorded voice announcements 24 hours daily. The AQI report also may be published by local newspapers or broadcast on radio and television stations.

The Air Quality Index report is available by telephone for Charlotte area at 704-333-SMOG. We also provide an AQI Report on the North Carolina DAQ web site, (http://www.daq.state.nc.us/monitor).

In this printed report, we have summarized AQI statistics for six metropolitan areas in North Carolina. Table 6.1 shows the number of days in each health category at each area.

In the Ashville MSA, the AQI was not "*unhealthy for sensitive groups*" or "*unhealthy*" for any days out of 357 days monitored.

Figure 6.1 shows the 2004 AQI time series for Asheville. Figure 6.2 shows summaries of the numbers of days each respective pollutant was responsible for the AQI, the number of days the AQI was in each respective health category, and the percentile distribution for each health category for Asheville.

In the Charlotte-Gastonia-Rock Hill MSA, the AQI was "*unhealthy for sensitive groups*" or "*unhealthy*" on six out of 366 days monitored. All six of these days occurred between May and July.

Figure 6.3 shows the 2004 AQI time series for Charlotte-Gastonia-Rock Hill. Figure 6.4 shows summaries of the numbers of days each respective pollutant was responsible for the AQI, the number of days the AQI was in each respective health category, and the percentile distribution for each health category for Charlotte-Gastonia-Rock Hill.

In the Fayetteville MSA, the AQI was "*unhealthy for sensitive groups*" or "*unhealthy*" on two out of 366 days monitored. All two of these days occurred in July. Figure 6.5 shows the 2004 AQI time series for Fayetteville. Figure 6.6 shows summaries of the numbers of days each respective pollutant was responsible for the AQI, the number of days the AQI was in each respective health category, and the percentile distribution for each health category for Fayetteville.

In the Greensboro-Winston-Salem-High Point MSA, the AQI was "*unhealthy for sensitive groups*" or "*unhealthy*" on seven out of 366 days monitored. All seven of these days occurred between March and August. Figure 6.7 shows the 2004 AQI time series for Greensboro-Winston-Salem-High Point. Figure 6.8 shows summaries of the numbers of days each respective pollutant was responsible for the AQI, the number of days the AQI was in each respective health category, and the percentile distribution for each health category for Greensboro-Winston-Salem-High Point.

In the Raleigh-Durham-Chapel Hill MSA, the AQI was "*unhealthy for sensitive groups*" or "*unhealthy*" on three out of 366 days monitored. All three of these days occurred between July and August. Figure 6.9 shows the 2004 AQI time series for Raleigh-Durham-Chapel Hill. Figure 6.10 shows summaries of the numbers of days each respective pollutant was responsible for the AQI, the number of days the AQI was in each respective health category, and the percentile distribution for each health category for Raleigh-Durham-Chapel Hill.

In the Wilmington MSA, the AQI was "*unhealthy for sensitive groups*" or "*unhealthy*" on two out of 366 days monitored. All two of these days occurred in July. Figure 6.11 shows the 2004 AQI time series for Wilmington. Figure 6.12 shows summaries of the numbers of days each respective pollutant was responsible for the AQI, the number of days the AQI was in each respective health category, and the percentile distribution for each health category for Wilmington.

Table 6.1 Air Quality Index Category Days in the Major Metropolitan Statistical Areas, 2004

MSA	STATISTICAL TREATMENT	GOOD	MODERATE	UNHEALTHY FOR SENSITIVE GROUPS	UNHEALTHY
Asheville	actual	266	91	0	0
Charlotte	actual	173	187	5	1
Fayetteville	actual	209	155	2	0
Greensboro	actual	148	211	7	0
Raleigh	actual	187	176	3	0
Wilmington	actual	283	81	2	0

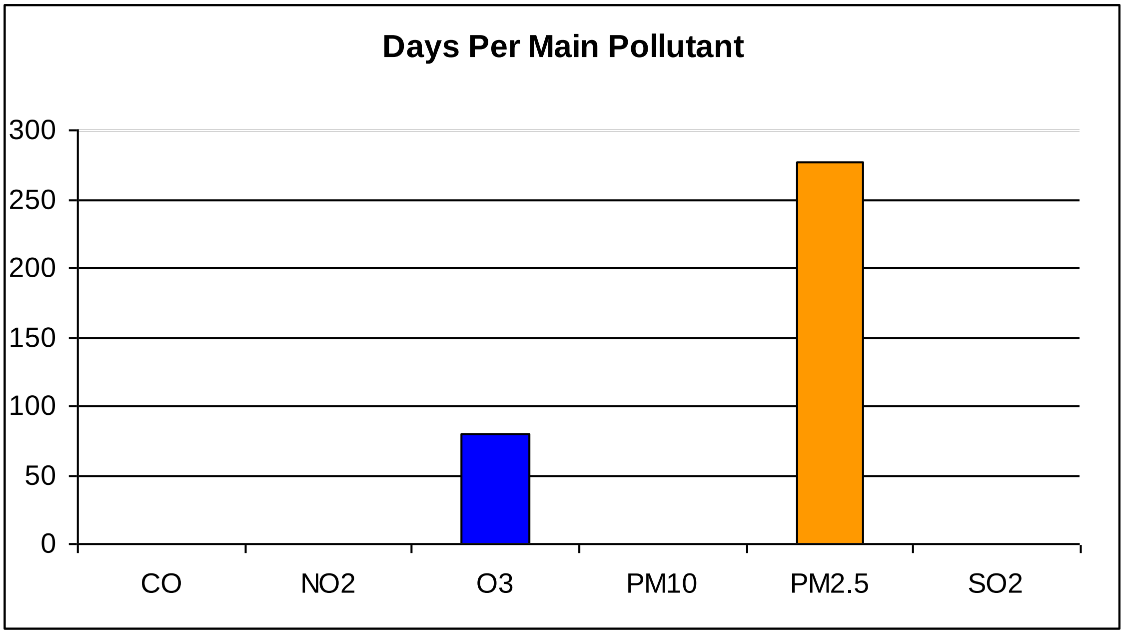

Figure 6.1 Daily Air Quality Index Values for Asheville

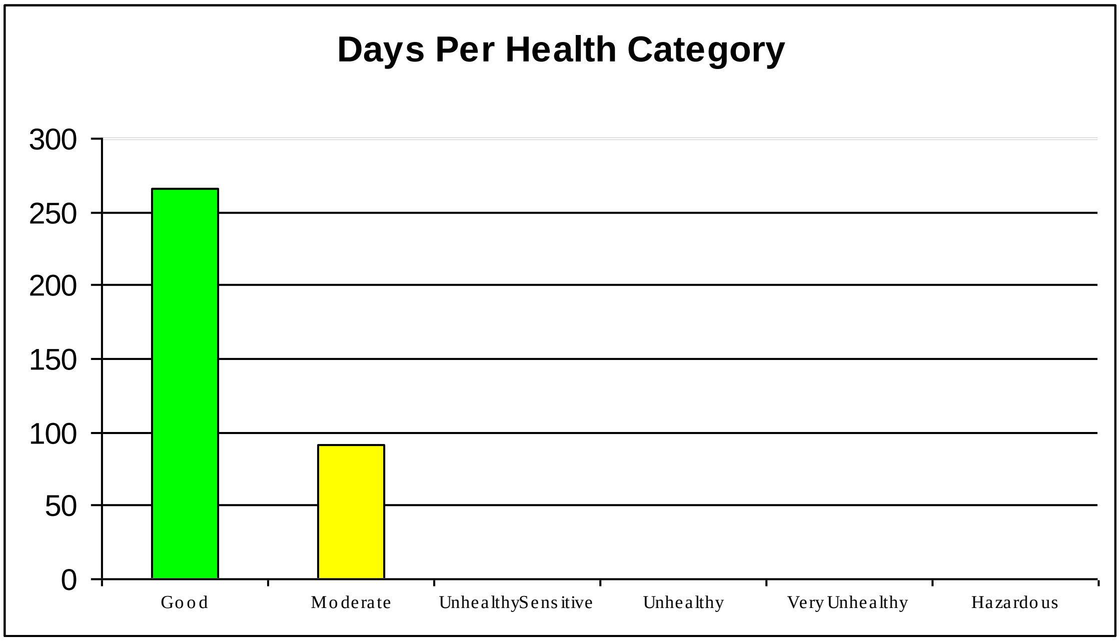

Figure 6.2 Daily Air Quality Index Summary for Asheville

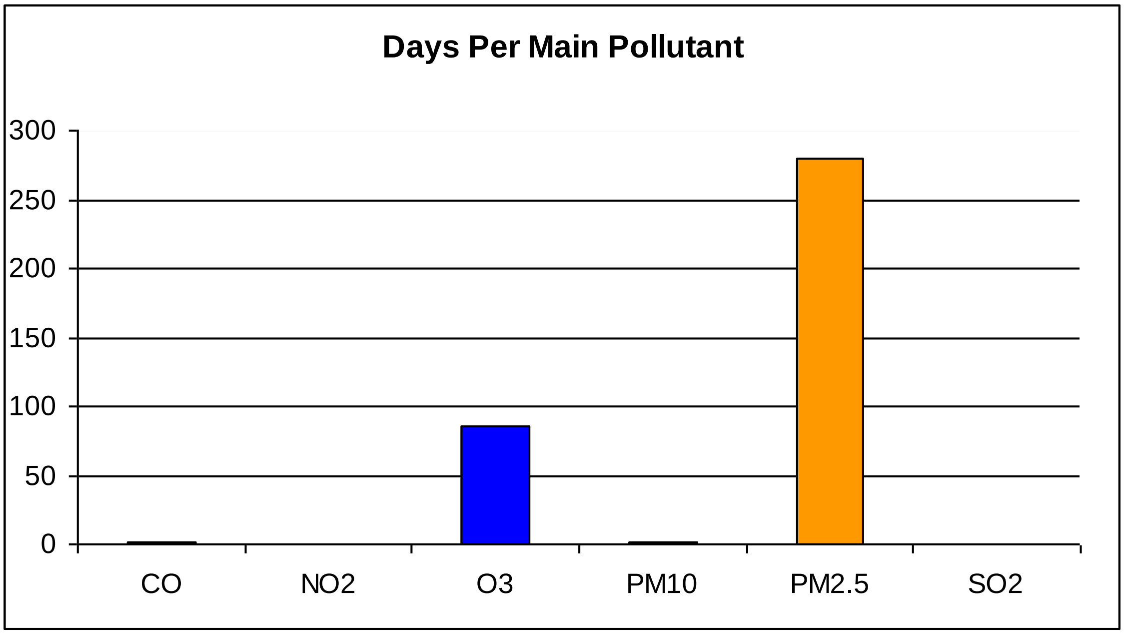

Figure 6.3 Daily Air Quality Index Values for Charlotte-Gastonia

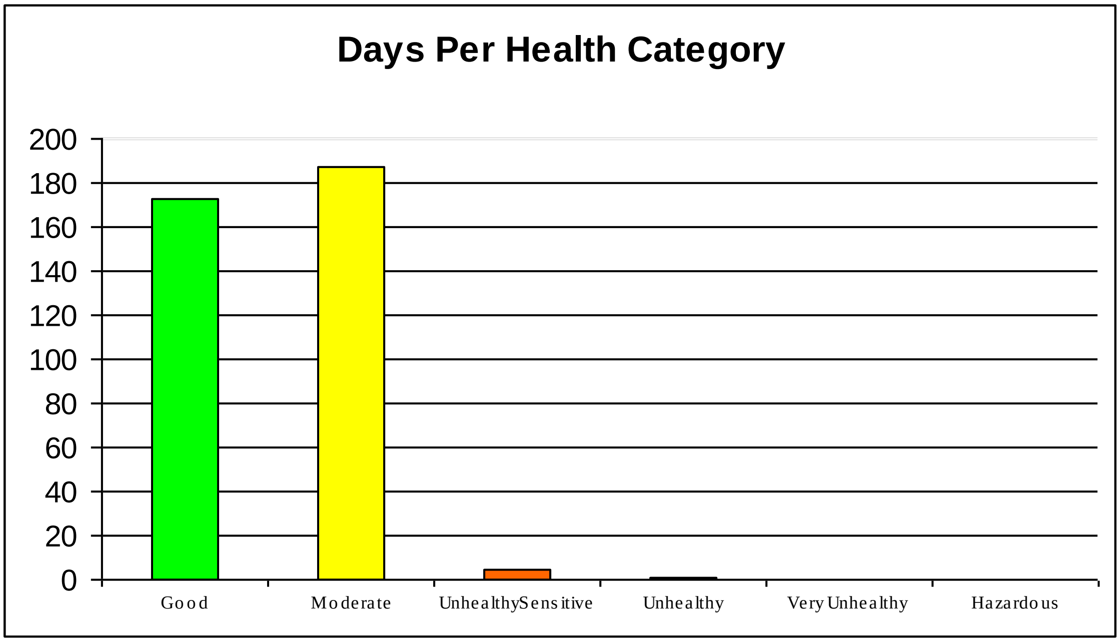

Figure 6.4 Daily Air Quality Index Summary for Charlotte-Gastonia

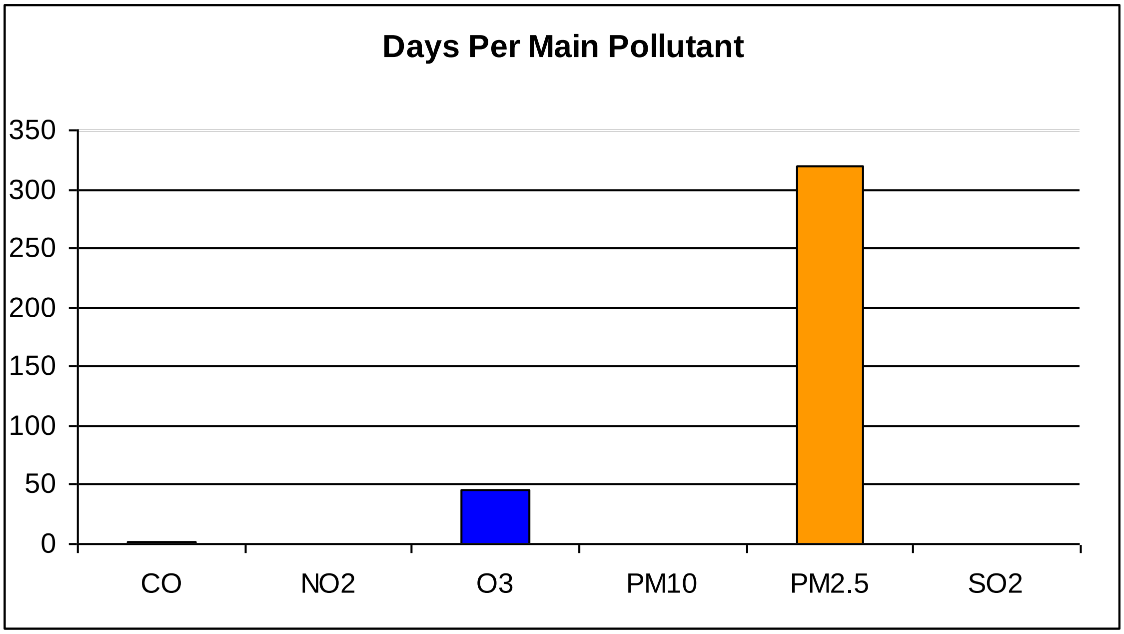

Figure 6.5 Daily Air Quality Index Values for Fayetteville

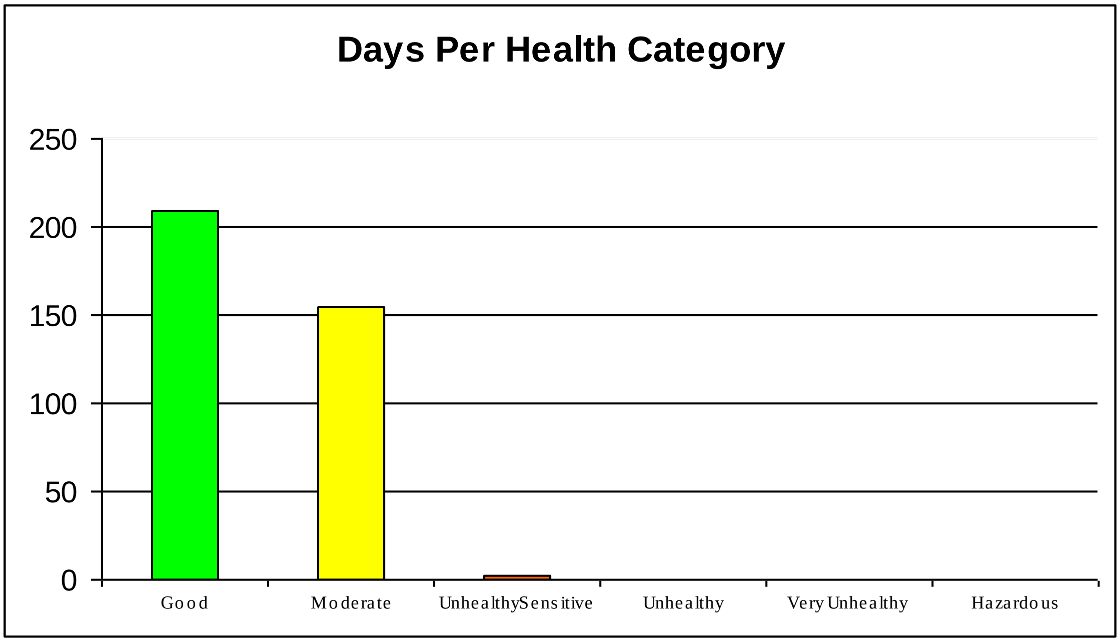

Figure 6.6 Daily Air Quality Index Summary for Fayetteville

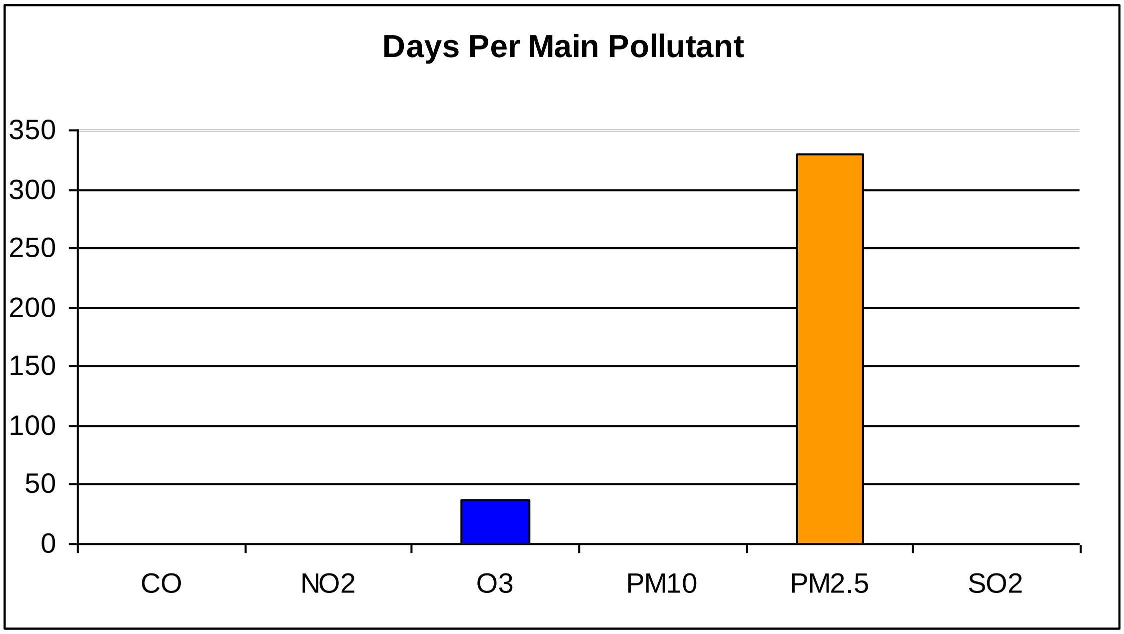

Figure 6.7 Daily Air Quality Index Values for Greensboro-Winston-Salem-High Point

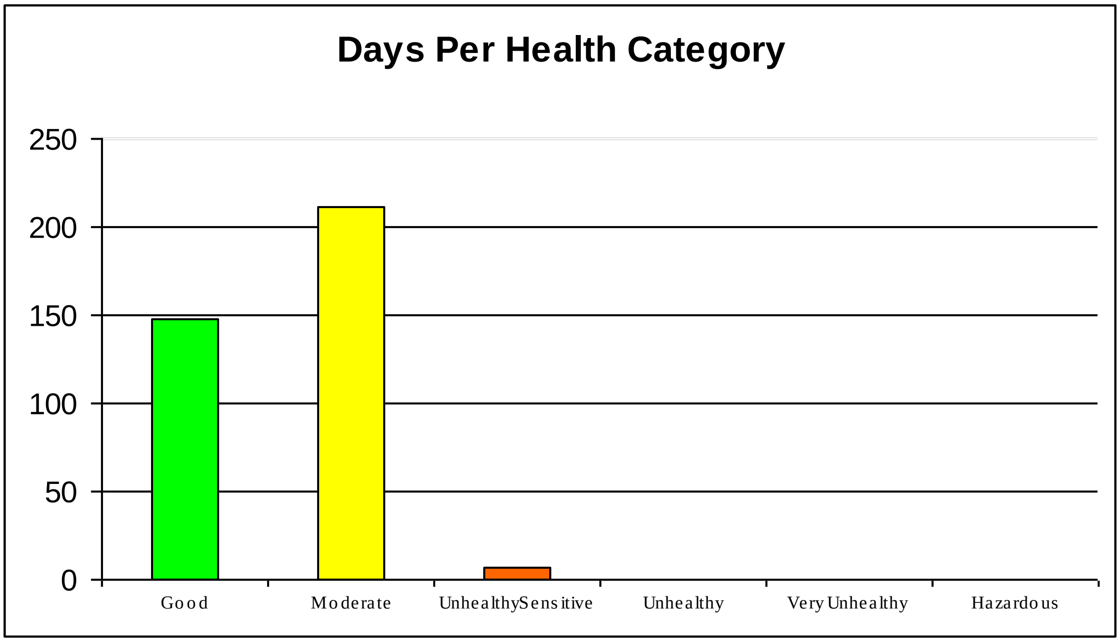

Figure 6.8 Daily Air Quality Index Summary for Greensboro-Winston-Salem-High Point

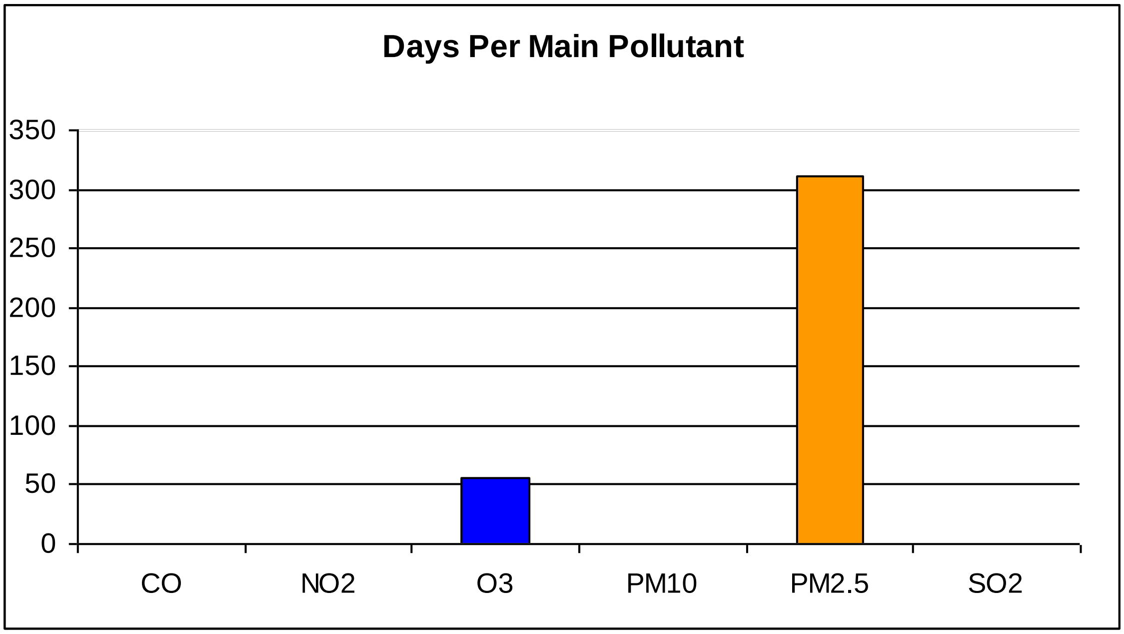

Figure 6.9 Daily Air Quality Index Values for Raleigh-Durham-Chapel Hill

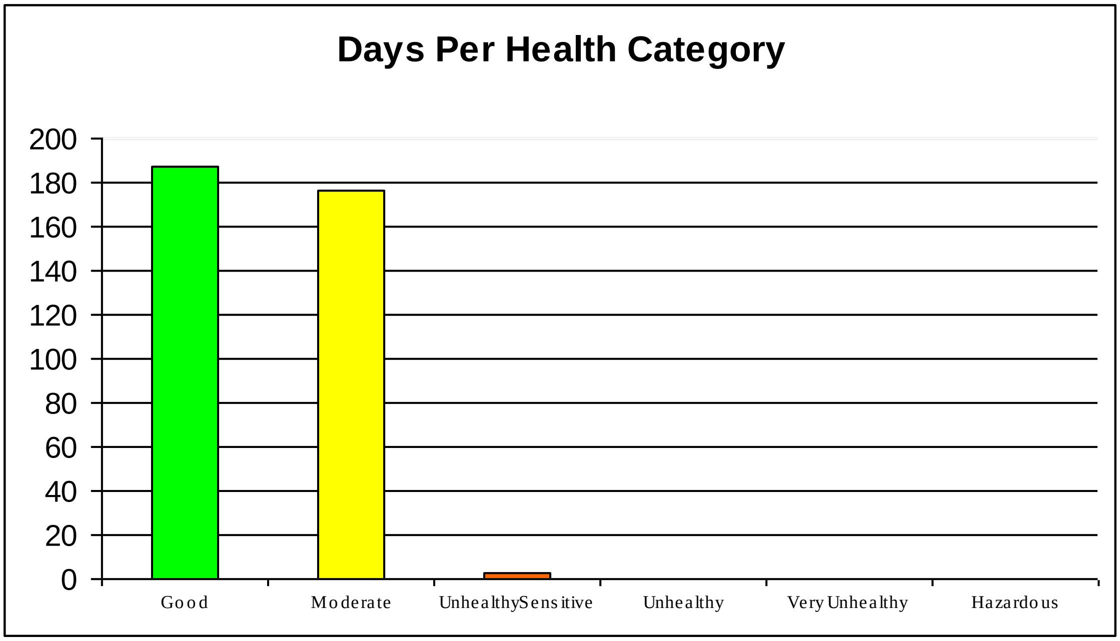

Figure 6.10 Daily Air Quality Index Summary for Raleigh-Durham-Chapel Hill

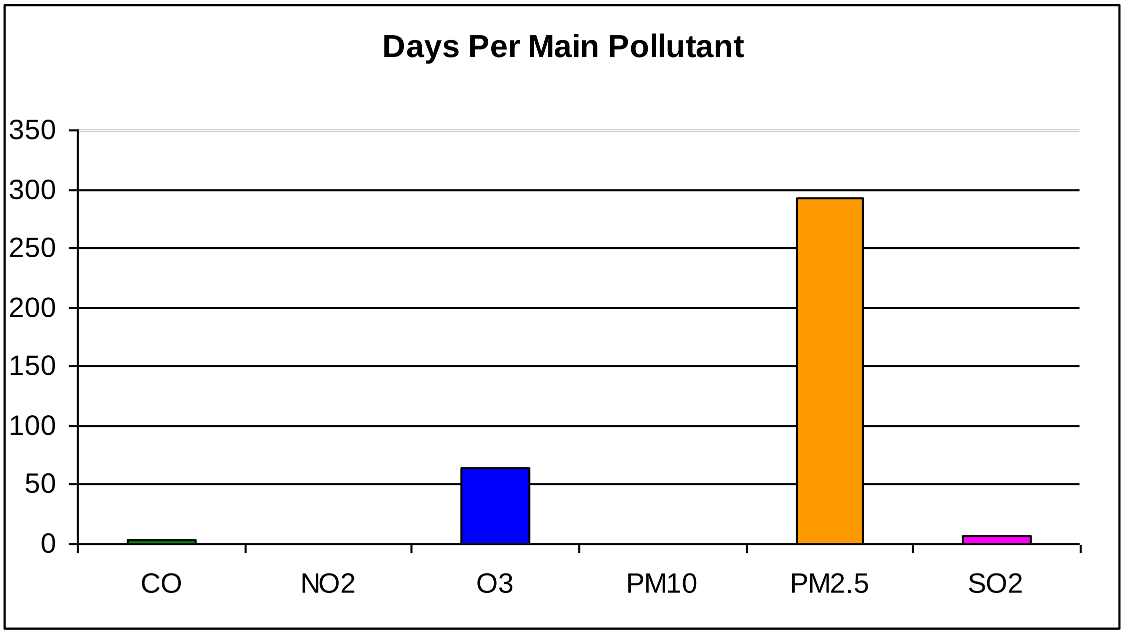

Figure 6.11 Daily Air Quality Index Values for Wilmington

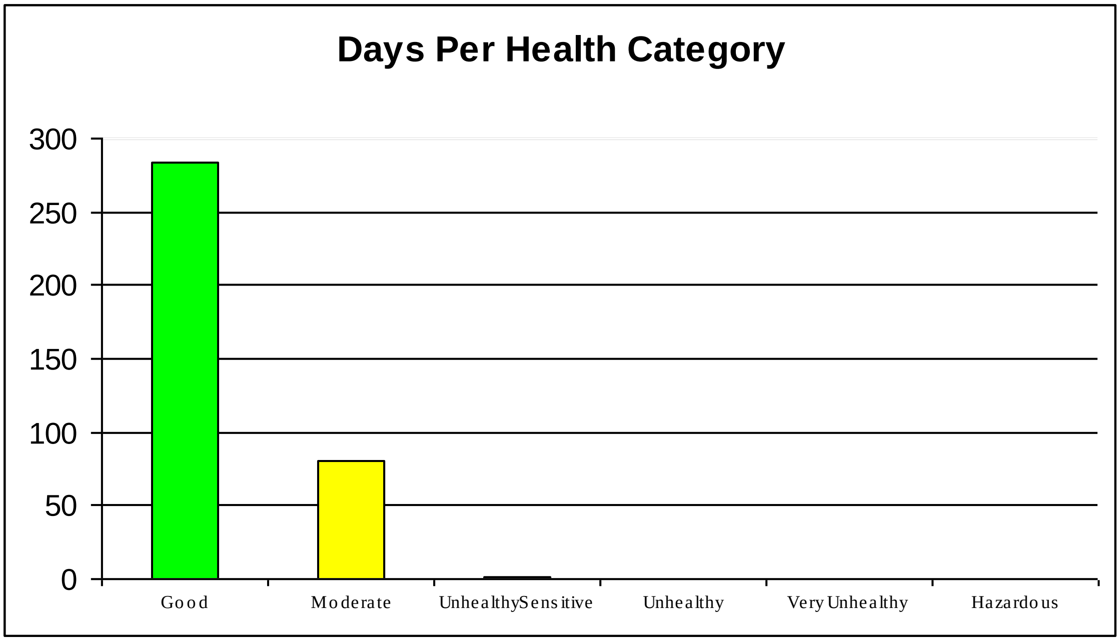

Figure 6.12 Daily Air Quality Index Summary for Wilmington

7 Acid Rain

7.1 Sources

Acid rain is produced when nitrate and sulfate ions from automobile and industrial sources are released into the atmosphere, undergo a reaction 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 may also 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 can 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. In 2004, acid rain samples were collected at nine 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 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 2004 ranged from 4.51 to 5.08 with a mean of 4.72. The 2004 pH annual means for North Carolina from the NADP database are presented in Figure 7.1 and Table 7.1. Table 7.1 also exhibits conductivity averages and precipitation totals for rainfall. Measured concentrations of several other chemical constituents of precipitation are given in Table 7.2.

The highest pH (and the least acidic) precipitation occurred at the Sampson County site. This general area in southeastern North Carolina has the greatest numbers of animal producing farms. This area has the highest emissions of ammonia, a basic gas emitted from animal wastes. Table 7.2 shows that the ammonium concentration in precipitation is the highest at the Sampson County site.

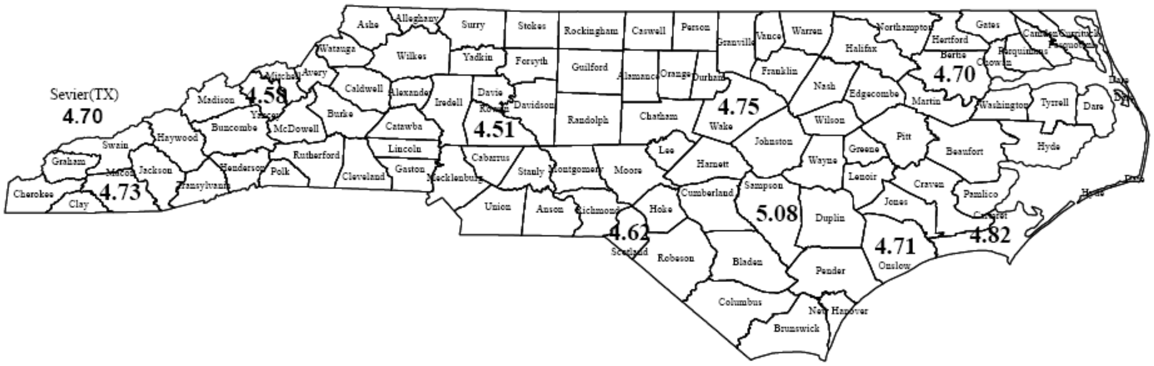

Figure 7.1 Annual Mean pH Values at North Carolina NADP Sites, 2004

Table 7.1 pH, Conductivity in Microsiemans per Centimeter and Precipitation in Inches from the National Atmospheric Deposition Program for 2004.

County Site ID Address	pH	Conductivity	Precipitation
Bertie NC03 Lewiston	4.70	13.41	44.00
Carteret NC06 Beaufort	4.82	13.08	50.71
Macon NC25 Coweeta	4.73	11.00	68.33
Onslow NC29 Hofmann Forest	4.71	13.07	53.63
Rowan NC34 Piedmont Research Station	4.51	18.53	40.78
Sampson NC35 Clinton Crops Research Station	5.08	10.32	43.54
Scotland NC36 Jordan Creek	4.62	14.76	41.51
Wake NC41 Finley Farm	4.75	13.16	45.65
Yancey NC45 Mt. Mitchell	4.58	14.20	96.96
Sevier (TN) TN11 Great Smoky Mountains National Park-Elkmont	4.70	10.93	79.76

Table 7.2 Ion Concentrations in Milligrams per Liter (Precipitation-weighted Annual Means) from the National Atmospheric Deposition Program Data for 2004.

County Site ID	% Completeness	Ca	Mg	K	Na	NH4	NO3	Cl	SO4
Bertie NC03	98	0.065	0.025	0.025	0.169	0.226	0.809	0.307	1.171
Beaufort NC06	91	0.082	0.074	0.031	0.637	0.119	0.587	1.157	0.860
Macon NC25	94	0.048	0.012	0.025	0.083	0.144	0.573	0.156	0.921
Onslow NC29	94	0.071	0.041	0.018	0.344	0.136	0.651	0.634	0.975
Rowan NC34	88	0.071	0.022	0.066	0.117	0.330	0.991	0.246	1.768
Sampson NC35	83	0.053	0.022	0.036	0.166	0.507	0.684	0.300	1.094
Scotland NC36	92	0.048	0.021	0.026	0.172	0.219	0.793	0.318	1.256
Wake NC41	98	0.053	0.023	0.069	0.156	0.388	0.819	0.290	1.170
Yancey NC45	38	0.044	0.008	0.011	0.043	0.197	0.670	0.082	1.310
Sevier (TN) TN11	77	0.057	0.011	0.032	0.027	0.118	0.610	0.056	0.923

8. Fine Particle Speciation

8.1 Description of pollutants

The main species or constituents of fine particles are classified as nitrates, sulfates, ammonium, organic carbon, elemental carbon, and crustal components (dust). These account for 75 to 85 percent of the composition of fine particles.

8.1.1 Nitrate

Ammonium nitrate (NH_4NO_3) is the most abundant nitrate compound, resulting from a reversible gas/particle equilibrium between ammonia gas (NH_3), nitric acid gas (HNO_3), and particulate ammonium nitrate. Sodium nitrate ($NaNO_3$) is found in $PM_{2.5}$ and PM_{10} near sea coasts and salt playas (e.g., Watson et al., 1995a) where nitric acid vapor irreversibly reacts with sea salt (NaCl).

8.1.2 Sulfate

Ammonium sulfate ($(NH_4)_2SO_4$), ammonium bisulfate (NH_4HSO_4), and sulfuric acid (H_2SO_4) are the most common forms of sulfate found in atmospheric particles, resulting from conversion of gases to particles as described below. These compound are water-soluble and reside almost exclusively in the $PM_{2.5}$ size fraction. Sodium sulfate (Na_2SO_4) may be found in coastal areas where sulfuric acid has been neutralized by sodium chloride (NaCl) in sea salt. Though gypsum (Ca_2SO_4) and some other geological compounds contain sulfate, these are not easily dissolved in water for chemical analysis, are more abundant in PM_{10} than in $PM_{2.5}$, and they are usually classified in the geological fraction.

8.1.3 Ammonium

Ammonium sulfate ($(NH_4)_2SO_4$), ammonium bisulfate (NH_4HSO_4), and ammonium nitrate (NH_4NO_3) are the most common compounds containing ammonium.

8.1.4 Organic Carbon

Particulate organic carbon consists of hundreds, possibly thousands, of separate compounds with more than 20 carbon atoms. Because of this lack of molecular specificity and the semi-volatile nature of many carbon compounds with 20 to 40 Carbon atoms, particulate “organic carbon” is operationally defined by the sampling and analysis method.

8.1.5 Elemental Carbon

Elemental carbon is black, often called “soot.” Elemental carbon contains pure, graphitic carbon, but it also contains high molecular weight, dark-colored, non-volatile organic materials such as tar, biogenic, and coke.

8.1.6 Crustal Component (Fine Dust)

Suspended dust consists mainly of oxides of aluminum, silicon, calcium, titanium, iron, lead and other metal oxides (Chow and Watson, 1998). The precise combination of these minerals depends on the geology of the area and industrial processes such as steel-making, smelting, mining, and cement production. Geological material is mostly in the coarse particle fraction, and typically constitutes ~50 percent of PM_{10} while only contributing 5 to 15 percent of $PM_{2.5}$ (Chow and Watson, 1998).

Lead is a toxic metal that was used for many years in products found in and around homes. Lead also is emitted into the air from motor vehicles and industrial sources. Lead may cause a range of health effects, from behavioral problems and learning disabilities, to seizures and death. The DAQ monitored lead as a federal criteria pollutant in the past (see chapter 5) until it become undetectable by the prescribed sampling method*. For these reasons we include concentration of the lead in PM2.5 in this report.

8.1.7 “Other” Speciated components.

We categorize the 15 to 25 percent of $PM_{2.5}$ not accounted for by nitrate, sulfate, ammonium, carbon and crustal components as “other” speciated data. For the purpose of this report “other” is not defined in any certain kind of particulate matter, but is simply the result of subtracting all the other components from the total $PM_{2.5}$ reported by the sampler. Among the constituents of “other” are liquid water and many trace chemical elements.

8.2 Sources

Sources of fine particles include all types of combustion activities (motor vehicles, power plants, wood burning, etc.) and certain industrial processes. Other particles may be formed in the air from the chemical reactions of gases. They are indirectly formed when gases from burning fuels react with sunlight and water vapor. These can result from fuel combustion in motor vehicles, at power plants, and in other industrial processes.

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

Fine particles also form from the reaction of gases or droplets in the atmosphere from sources such as power plants. These chemical reactions can occur miles from the original source of the emissions. Because fine particles can be carried long distances from their source, events such as wildfires or volcanic eruptions can raise fine particle concentrations hundreds of miles from the event.

$PM_{2.5}$ is also produced by common indoor activities. Some indoor sources of fine particles are tobacco smoke,

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* EPA promulgated a new lead standard in 2008, and DAQ anticipates establishing a reporting network for it in 2010.

cooking (e.g., frying, sautéing, and broiling), burning candles or oil lamps, and operating fireplaces and fuel-burning space heaters (e.g., kerosene heaters).

Particles and ozone are similar in many respects. Both can cause respiratory symptoms and other serious health problems. Fossil fuel combustion is a leading source of both pollutants. One significant difference is that particles can be a problem at any time of year, unlike ozone, which forms in warm, sunny weather and therefore tends to be seasonal in nature.

8.3 Effects

The size of the particles is what is most important from a public health viewpoint. Particles larger than 10 μm generally get caught in the nose and throat, never entering the lungs. Particles smaller than 10 μm can get into the large upper branches just below your throat where they are caught and removed (by coughing and spitting or by swallowing). Particles smaller than 5 μm can get into your bronchial tubes, at the top of the lungs; particles smaller than 2.5 μm in diameter can get down into the deepest (alveolar) portions of your lungs where gas exchange occurs between the air and your blood stream, oxygen moving in and carbon dioxide moving out. These are the really dangerous particles because the deepest (alveolar) portions of the lung have no efficient mechanisms for removing them. If these particles are soluble in water, they pass directly into the blood stream within minutes. If they are not soluble in water, they are retained in the deep lung for long periods (months or years). About 60 percent of PM_{10} particles (by weight) have a diameter of 2.5 μm or less. These are the particles that can enter the human lung directly.

8.4 Monitoring

The MetOne SASS monitor measures $PM_{2.5}$ mass and the chemical composition of $PM_{2.5}$ (sulfates, nitrates, organic carbon, soot-like carbon and metals). This is known as $PM_{2.5}$ chemical speciation. The MetOne SASS utilizes five independent channels (the Met One Super SASS utilizes eight independent channels) with spiral impactors attached directly to the filter cartridges that are arrayed in a raised carousel. Each canister has its own $PM_{2.5}$ inlet and Federal Reference Method/Monitor filter holders. The $PM_{2.5}$ separation is produced by a sharp cut cyclone that removes both solid and liquid coarse particles with equal efficiency without the use of impaction grease or oil.

The Interagency Monitoring of Protected Visual Environments (IMPROVE) is a cooperation between federal land managers, state and local agencies and EPA to collect aerosol particulate data. IMPROVE sites use a different monitoring method. The standard IMPROVE sampler has four modules: (1) $PM_{2.5}$ mass, (2) sulfate, nitrate and chloride, (3) $PM_{2.5}$ quartz and (4) PM_{10} mass.

Data are validated on a monthly basis when reports are received from the contract laboratory RTI International. NCDAQ collected data at ten sites using MetOne SASS method, the National Park Service collected at three sites during 2004 using the IMPROVE method. Figure 8.1 shows a map of all these sites. Table 8.1 identifies the sites and the specific sampling methods employed at each one.

Nitrate samples in 2004 are summarized in Table 8.2. The highest concentration observed was 6.40 μg/m^3 at Charlotte.

Sulfate samples in 2004 are summarized in Table 8.3. The highest concentration observed was 18.6 μg/m^3 at Hickory.

Ammonium samples in 2004 are summarized in Table 8.4. The highest concentration observed was 6.78 μg/m^3 at Hickory..

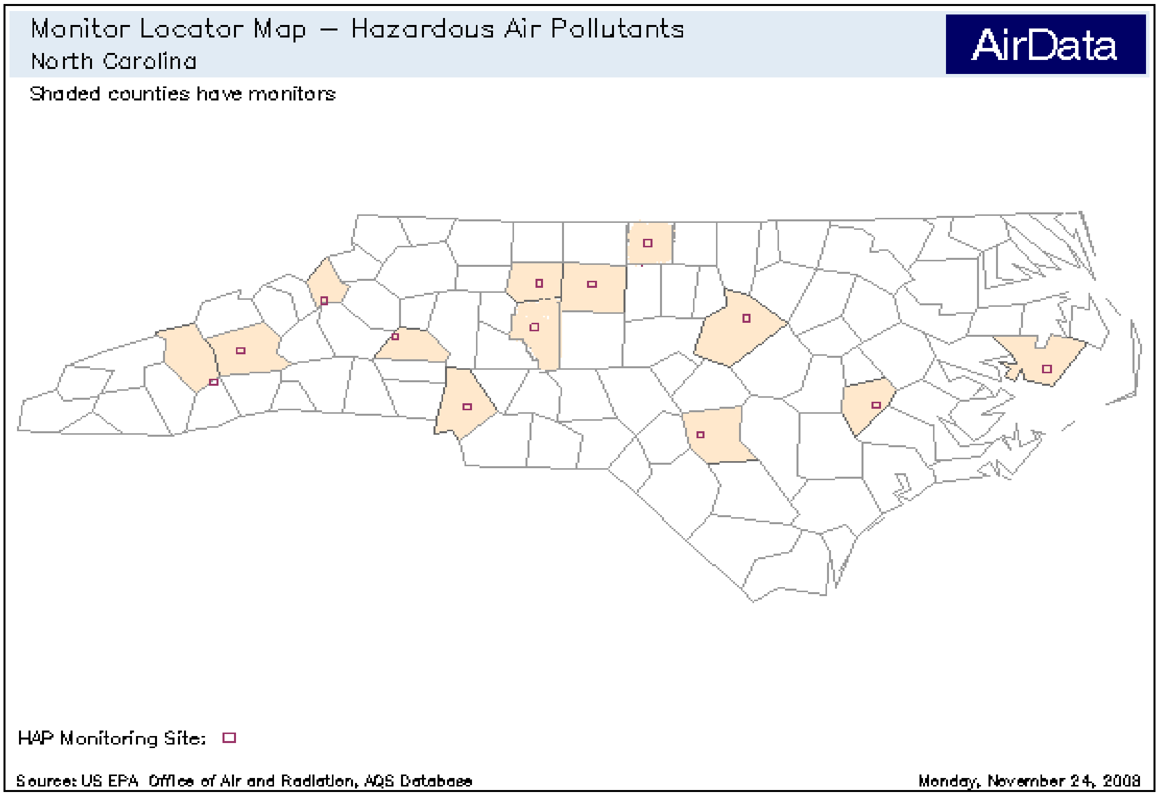
Organic Carbon samples in 2004 are summarized in Table 8.5. The highest concentration observed was 13.1 μg/m^3 at Fayetteville.

Elemental Carbon samples in 2004 are summarized in Table 8.6. The highest concentration observed was 2.46 μg/m^3 at Fayetteville.

Crustal Component samples in 2004 are summarized in Table 8.7. The highest concentration observed was 3.2 μg/m^3 at Greensboro.

Elemental lead samples for 2004 are summarized in Table 8.8. Out of 564 samples statewide 10 samples exceeded 0.01 μg/m^3 ; 554 of these sample concentrations (98. percent) were less than 0.01 μg/m^3. Three samples were greater than 0.014 μg/m^3 . The highest concentration observed was .019 μg/m^3 at Hickory and Charlotte.

“Other” samples in 2004 are summarized in Table 8.9. The highest concentration observed was 19.61 μg/m^3 at Hickory.



Source: US EPA Office of Air and Radiation, AQS Database

Monday, November 24, 2008

Figure 8.1 Location of Nitrate, Sulfate, Ammonium, Organic Carbon, Elemental Carbon, Crustal component, "Other" component, Monitoring Sites 2004

Table 8.1 Fine Particle Speciation Sites Operated in North Carolina in 2004

SITE NUMBER	ADDRESS	METHOD
COUNTY		
37-011-0002 AVERY	7510 BLUE RIDGE PARKWAY SPUR LINVILLE	IMPROVE
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	SASS
37-033-0001 CASWELL	7074 CHERRY GROVE RD REIDSVILLE	SASS
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	SASS
37-051-0009 CUMBERLAND	4533 RAEFORD RD FAYETTEVILLE	SASS
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	SASS
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	SASS

SITE NUMBER	ADDRESS	METHOD
COUNTY		
37-081-0013 GUILFORD	205 WILOUGHBY BLVD GREENSBORO	SASS
37-087-0035 HAYWOOD	SHINING ROCK WILDERNESS	IMPROVE
37-095-9000 HYDE	SWANQUARTER WILDLIFE REFUGE	IMPROVE
37-107-0004 LENOIR	HIGHWAY 70 EAST AND HIGHWAY 58 SOUTH KINSTON	SASS
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	SASS
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	SASS
SITES OPERATED IN 2004	13	

Table 8.2 Nitrate PM2.5 - Micrograms/Cubic Meter (LC) for 2004

SITE NUMBER	ADDRESS	NUM OBS	24-HOUR MAXIMA				ARITH MEAN
COUNTY			1st	2nd	3rd	4th	
37-011-0002 AVERY	7510 BLUE RIDGE PARKWAY SPUR LINVILLE	118	1.49	1.48	1.30	1.14	.246
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	57	1.91	1.68	1.53	1.48	.606
37-033-0001 CASWELL	7074 CHERRY GROVE RD REIDSVILLE	2	4.06	.65	N/A	N/A	2.356
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	57	4.08	3.94	2.97	2.59	1.105
37-051-0009 CUMBERLAND	4533 RAEFORD RD FAYETTEVILLE	57	4.29	4.11	3.14	3.14	1.124
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	58	2.96	2.85	2.76	2.57	1.027
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	60	4.26	3.09	2.80	2.78	1.102
37-081-0013 GUILFORD	205 WILOUGHBY BLVD GREENSBORO	56	4.63	3.38	2.72	2.68	.972
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	107	1.00	.91	.88	.75	.232

SITE NUMBER	ADDRESS	NUM OBS	24-HOUR MAXIMA				ARITH MEAN
COUNTY			1st	2nd	3rd	4th	
37-095-9000 HYDE	SWANQUARTER	117	2.43	1.71	1.22	1.15	.322
37-107-0004 LENOIR	HIGHWAY 70 EAST AND HIGHWAY 58 SOUTH KINSTON	55	4.94	3.43	3.35	3.22	1.025
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	103	6.40	4.41	3.93	3.51	1.057
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	119	4.12	3.87	3.42	3.25	.895
Total Samples		966					
Total Sites Sampled		13					

Table 8.3 Sulfate PM2.5 - Micrograms/Cubic Meter (LC) for 2004

SITE NUMBER	ADDRESS	NUM OBS	24-HOUR MAXIMA				ARITH MEAN
COUNTY			1st	2nd	3rd	4th	
37-011-0002 AVERY	7510 BLUE RIDGE PARKWAY SPUR LINVILLE	118	12.69	12.27	11.78	11.48	3.753
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	57	13.50	10.20	8.59	8.38	4.272
37-033-0001 CASWELL	7074 CHERRY GROVE RD REIDSVILLE	2	3.00	2.79	N/A	N/A	2.895
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	57	18.60	13.30	11.80	10.90	4.822
37-051-0009 CUMBERLAND	4533 RAEFORD RD FAYETTEVILLE	57	13.80	11.20	8.76	7.78	4.223
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	58	15.30	12.90	12.60	12.30	5.266
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	60	17.30	16.60	15.00	14.50	5.455
37-081-0013 GUILFORD	205 WILOUGHBY BLVD GREENSBORO	56	18.30	12.70	11.20	9.61	4.872
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	107	10.97	9.39	9.34	9.08	3.117
37-095-9000 HYDE	SWANQUARTER	117	14.22	13.76	12.04	11.73	3.219

SITE NUMBER	ADDRESS	NUM OBS	24-HOUR MAXIMA				ARITH MEAN
COUNTY			1st	2nd	3rd	4th	
37-107-0004 LENOIR	HIGHWAY 70 EAST AND HIGHWAY 58 SOUTH KINSTON	55	14.30	7.85	7.46	7.39	3.994
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	103	15.80	14.80	14.40	14.30	4.812
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	119	17.80	14.40	14.40	11.70	4.490
Total Samples		966					
Total Sites Sampled		13					

Table 8.4 Ammonium Ion PM2.5 - Micrograms/Cubic Meter (LC) for 2004

SITE NUMBER	ADDRESS	NUM OBS	24-HOUR MAXIMA				ARITH MEAN
COUNTY			1st	2nd	3rd	4th	
37-011-0002 AVERY	7510 BLUE RIDGE PARKWAY SPUR LINVILLE	118	3.00	3.00	3.00	3.00	.975
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	57	3.61	2.99	2.64	2.59	1.319
37-033-0001 CASWELL	7074 CHERRY GROVE RD REIDSVILLE	2	2.07	.90	N/A	N/A	1.486
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	57	6.78	4.29	4.26	3.63	1.787
37-051-0009 CUMBERLAND	4533 RAEFORD RD FAYETTEVILLE	57	4.96	3.99	2.71	2.70	1.579
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	58	4.78	4.39	4.06	3.88	1.813
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	60	5.03	4.65	4.36	4.12	1.904
37-081-0013 GUILFORD	205 WILOUGHBY BLVD GREENSBORO	56	4.25	4.00	3.37	3.33	1.649
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	107	3.00	3.00	3.00	2.00	.8131
37-095-9000 HYDE	SWANQUARTER	117	4.00	4.00	4.00	3.00	.9573
37-107-0004 LENOIR	HIGHWAY 70 EAST AND HIGHWAY 58 SOUTH KINSTON	55	6.61	3.58	3.19	2.78	1.574

SITE NUMBER COUNTY	ADDRESS	NUM OBS	24-HOUR MAXIMA 1st	2nd	3rd	4th	ARITH MEAN
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	103	6.54	4.94	4.41	4.22	1.680
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	119	5.68	4.89	4.07	3.66	1.578
Total Samples		966					
Total Sites Sampled		13					

Table 8.5 Organic Carbon CSN PM2.5 - Micrograms/Cubic Meter (LC) for 2004

SITE NUMBER COUNTY	ADDRESS	NUM OBS	24-HOUR MAXIMA 1st	2nd	3rd	4th	ARITH MEAN
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	57	6.47	5.90	5.88	5.88	3.577
37-033-0001 CASWELL	7074 CHERRY GROVE RD REIDSVILLE	2	4.91	3.77	N/A	N/A	4.340
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	57	10.10	9.48	9.30	7.38	4.856
37-051-0009 CUMBERLAND	4533 RAEFORD RD FAYETTEVILLE	57	13.10	10.60	9.94	8.79	4.853
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	58	9.74	9.31	7.96	7.80	5.013
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	60	8.50	7.85	7.68	7.46	4.476
37-081-0013 GUILFORD	205 WILOUGHBY BLVD GREENSBORO	56	8.41	8.17	7.28	7.14	4.281
37-107-0004 LENOIR	HIGHWAY 70 EAST AND HIGHWAY 58 SOUTH KINSTON	53	6.40	6.34	6.24	6.19	3.502
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	103	10.50	10.10	8.66	8.48	4.750
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	118	9.09	9.09	8.96	8.70	4.559
Total Samples		621					
Total Sites Sampled		10					

Table 8.6 Elemental Carbon CSN PM2.5 - Micrograms/Cubic Meter (LC) for 2004

SITE NUMBER COUNTY	ADDRESS	NUM OBS	24-HOUR MAXIMA 1st	2nd	3rd	4th	ARITH MEAN
37-011-0002 AVERY	7510 BLUE RIDGE PARKWAY SPUR LINVILLE	118	.77	.73	.69	.65	.323
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	57	1.37	1.08	1.06	.93	.443
37-033-0001 CASWELL	7074 CHERRY GROVE RD REIDSVILLE	2	.52	.26	N/A	N/A	.390
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	57	2.17	2.14	1.95	1.92	.762
37-051-0009 CUMBERLAND	4533 RAEFORD RD FAYETTEVILLE	57	2.46	1.57	1.24	1.02	.526
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	58	1.97	1.31	1.16	1.11	.617
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	60	1.61	1.28	1.26	1.17	.563
37-081-0013 GUILFORD	205 WILOUGHBY BLVD GREENSBORO	56	1.47	1.38	1.07	1.05	.535
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	107	.55	.50	.49	.46	.200
37-095-9000 HYDE	SWANQUARTER	115	.42	.31	.30	.30	.110
37-107-0004 LENOIR	HIGHWAY 70 EAST AND HIGHWAY 58 SOUTH KINSTON	53	.83	.69	.55	.49	.277
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	103	2.03	1.92	1.64	1.55	.628
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	118	1.65	1.52	1.51	1.42	.525
Total Samples		961					
Total Sites Sampled		13					

Table 8.7 Crustal Component PM2.5 - Micrograms/Cubic Meter (LC) for 2004

SITE NUMBER	ADDRESS	NUM OBS	24-HOUR MAXIMA				ARITH MEAN
COUNTY			1st	2nd	3rd	4th	
37-011-0002 AVERY	7510 BLUE RIDGE PARKWAY SPUR LINVILLE	118	2.54	1.98	1.88	1.62	.519
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	57	1.15	.86	.65	.65	.325
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	56	1.22	1.14	.90	.84	.388
37-051-0009 CUMBERLAND	4533 RAEFORD RD FAYETTEVILLE	57	1.19	.85	.83	.69	.329
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	60	1.19	.97	.89	.87	.359
37-081-0013 GUILFORD	205 WILOUGHBY BLVD GREENSBORO	56	3.20	1.92	1.29	1.22	.456
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	106	2.99	2.06	2.00	1.86	.583
37-107-0004 LENOIR	HIGHWAY 70 EAST AND HIGHWAY 58 SOUTH KINSTON	53	1.37	.94	.89	.85	.344
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	105	1.65	1.50	1.32	1.21	.463
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	120	1.30	1.30	1.27	1.23	.414
Total Samples		788					
Total Sites Sampled		10					

Table 8.8 Lead PM$_{2.5}$ - Micrograms/Cubic Meter for 2004

SITE NUMBER	ADDRESS	NUM OBS	24-HOUR MAXIMA				ARITH MEAN
COUNTY			1st	2nd	3rd	4th	
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	57	.008	.007	.006	.004	.0033
37-035-0004 CATAWBA	1650 1ST. ST HICKORY	56	.019	.006	.005	.005	.0034
37-051-0009 CUMBERLAND	4533 RAEFORD ROAD FAYETTEVILLE	57	.01	.007	.007	.007	.0038

SITE NUMBER COUNTY	ADDRESS	NUM OBS	24-HOUR MAXIMA 1st	2nd	3rd	4th	ARITH MEAN
37-067-0022 FORSYTH	1300 BLK. HATTIE AVENUE WINSTON-SALEM	60	.013	.010	.008	.007	.0036
37-081-0013 GUILFORD	205 WILOUGHBY BLD GREENSBORO	56	.010	.010	.008	.007	.0036
37-107-0004 LENOIR	HIGHWAY 70 EAST AND HIGHWAY 58 SOUTH KINSTON	53	.007	.006	.005	.005	.0031
37-119-0041 MEKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	105	.019	.015	.012	.009	.0042
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	120	.011	.008	.006	.006	.0031
Total Samples		564					
Total Sites Sampled		8					

Table 8.9 "Other" Component PM2.5 - Micrograms/Cubic Meter (LC) for 2004

SITE NUMBER COUNTY	ADDRESS	NUM OBS	24-HOUR MAXIMA 1st	2nd	3rd	4th	ARITH MEAN
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	57	8.40	7.00	6.43	5.89	2.45
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	56	19.61	7.42	6.69	5.88	2.44
37-051-0009 CUMBERLAND	4533 RAEFORD RD FAYETTEVILLE	57	7.65	7.18	6.72	6.49	2.60
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	60	10.37	8.22	8.04	7.70	2.82
37-107-0004 LENOIR	HIGHWAY 70 EAST AND HIGHWAY 58 SOUTH KINSTON	53	7.98	6.42	4.32	4.23	1.92
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	105	9.30	8.62	8.43	8.35	2.75
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	120	9.25	9.19	8.84	7.83	2.20
Total Samples		508					
Total Sites Sampled		7					

9. Urban Air Toxics

The NC Division of Air Quality (DAQ) operates an urban air toxics monitoring network in conjunction with a national program originally proposed and designed by the United States Environmental Protection Agency (EPA) in 1999.

In 2001, the EPA initiated a national network for monitoring air toxics compounds present in ambient air. Although no ‘national’ sites are located in NC, DAQ recognizes the importance of toxics monitoring and supports the continuation of the program. The objective of this monitoring is to generate ambient air data and to compile these data in an extensive air toxics database. The use of actual field measurements to compare and reconcile with estimates from source dispersion models will refine the model and ultimately allow a better overall estimate of population exposure. The ultimate goal of the EPA’s Air Toxics Monitoring Strategy is to assess health risks.

In the time period covered by this report, DAQ expanded the North Carolina air toxics monitoring program to include Volatile Organic Compound (VOC) sampling at six urban sites and one rural site. Carbonyl sampling was continued at one urban site and one rural site.

Volatile Organic Compounds (VOCs) are a large group of carbon-based chemicals that easily evaporate at room temperature. While most people can smell high levels of some VOCs, other VOCs have no odor. Odor is not an indicator of the level of danger posed from inhalation of this group of chemicals. There are thousands of different VOCs produced and used in our daily lives. Some common examples include: benzene, ethylbenzene, toluene, and xylene.

Carbonyl sampling measures common organic chemicals such as formaldehyde, acetaldehyde and acetone. (Only formaldehyde is reported here.)

9.1 Sources

VOCs are emitted by thousands of products. Examples include: paints and lacquers, paint strippers, cleaning supplies, pesticides, building materials and furnishings, office equipment such as copiers and printers, correction fluids and carbonless copy paper, graphics and craft materials including glues and adhesives, permanent markers, and photographic solutions.

9.2 Effects

The ability of organic chemicals to cause health effects varies greatly from those that are highly toxic, to those with no known health effect. As with other pollutants, the extent and nature of the health effect will depend on many factors including level of exposure and length of time exposed.

9.3 Formaldehyde

Formaldehyde (IUPAC name methanal) has a chemical formula of CH2O and is therefore the simplest aldehyde. Formaldehyde is a colorless gas at normal temperatures and is soluble in water, alcohols, and other polar solvents. The product of the aqueous-phase oxidation of formaldehyde is formic acid.

9.3.1 Sources

Occupational exposure to formaldehyde by inhalation is mainly from three types of sources: thermal or chemical decomposition of formaldehyde-based resins, formaldehyde emission from aqueous solutions (for example, embalming fluids), and the production of formaldehyde resulting from the combustion of a variety of organic compounds (for example, exhaust gases).

Formaldehyde is the most prevalent aldehyde in motor vehicle exhaust and is formed from incomplete combustion of the fuel. Formaldehyde is emitted in the exhaust of both gasoline and diesel-fueled vehicles. The motor vehicle contribution to ambient formaldehyde levels contains both primary (i.e., direct emissions) and secondary formaldehyde (i.e., formed from photo-oxidation of volatile organic compounds, or VOCs). It appears that roughly 33 percent of formaldehyde in the ambient air may be attributable to motor vehicles.

9.3.2 Effects

Formaldehyde is rarely encountered in living organisms. Formaldehyde is converted to formic acid in the body, leading to a rise in blood acidity (acidosis).

Formaldehyde can be toxic, allergenic, and carcinogenic. Because formaldehyde resins are used in many construction materials it is one of the more common indoor air pollutants.

9.4 Benzene

Benzene, or benzol, is a colorless or light yellow liquid at room temperature. It evaporates into the air very quickly and dissolves slightly in water. It is highly flammable with a sweet smell and a relatively high melting point**.**

9.4.1 Sources

Benzene is a natural component of crude oil, and gasoline contains 1 to 5 percent by volume. Benzene is produced in large quantities from petroleum sources and is used for the chemical synthesis of ethyl benzene, phenol, cyclohexane and other substituted aromatic hydrocarbons.

Besides these industrial sources, emissions also occur from different combustion sources, such as motor engines, wood combustion and stationary fossil fuel combustion. Motor vehicles account for approximately 60 percent of the total benzene emissions, with the remainder attributed to nonroad mobile sources (25%) and stationary sources (15%). The major source is exhaust emissions and evaporation losses from motor vehicles, and evaporation losses during the handling, distribution and storage of petrol.

9.4.2 Effects

The short term breathing of high levels of benzene can result in death, while low levels can cause drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness. Eating or drinking foods containing high levels of benzene can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, and death.

The major effects of benzene are chronic (long-term) exposure through the blood. Benzene damages the bone marrow and can cause a decrease in red blood cells, leading to anemia. It can also cause excessive bleeding and depress the immune system, increasing the chance of infection. Benzene targets liver, kidney, lung, heart and the brain and can cause chromosomal damage.

The US Department of Health and Human Services (DHHS) classifies benzene as a human carcinogen. Long-term exposure to excessive levels of benzene in the air causes leukemia, a potentially fatal cancer of the blood-forming organs, in susceptible individuals.

9.5 Toluene

Toluene, also known as methylbenzene or phenylmethane, is a clear, colorless, water-insoluble liquid with the typical smell of paint thinners, similar to the sweet smell of the related compound benzene. It is an aromatic hydrocarbon widely used as an industrial feedstock and as a solvent.

9.5.1 Sources

Toluene occurs naturally as a component of crude oil and is produced in petroleum refining and coke oven operations. Toluene is commonly used as an industrial solvent for the manufacturing of paints, chemicals, pharmaceuticals, and rubber. Toluene is a major aromatic constituent of gasoline (CEPA, OEHHA, 1999). It is used in household aerosols, nail polish, paints and paint thinners, lacquers, glues, rust inhibitor, adhesives and solvent based cleaning agents. Toluene is also utilized in printing operations, leather tanning and chemical processes. Benzene and other polycyclic aromatic hydrocarbons are common contaminants of toluene. Toluene is considered a sentinel chemical for benzene in air monitoring.

9.5.2 Effects

The primary routes of potential human exposure to toluene are inhalation and dermal contact. In humans and animals, the primary effect associated with inhalation exposure to toluene is central nervous system depression with effects such as fatigue, confusion, lack of coordination, and impairments in reaction time, perception, and motor control and function.

9.6 Ethylbenzene

Ethylbenzene is a colorless, flammable liquid that smells like gasoline. Ethylbenzene is used primarily to make another chemical, styrene. Ethylbenzene is also used as a solvent, in fuels, and to make other chemicals.

9.6.1 Sources

Sources of ethylbenzene to the atmosphere include petroleum and coal refining, vehicle emissions, and evaporation from solvents and thinners.

Ethylbenzene may be released to the air through the use of consumer products such as solvents, enamel brush paints and spray paints, stains and varnishes. It may be released to soil and water from leaking underground gasoline storage tanks, landfill sites, spills during transportation, pesticide use, and discharges of industrial and municipal waste. Ethylbenzene is also found in tobacco and wood smoke.

9.6.2 Effects

Respiratory effects, such as throat irritation and chest constriction, eye irritation, and neurological effects such as dizziness, have been noted from acute (short-term) inhalation exposure to ethylbenzene in humans. (ATSDR).

9.7 Xylene

There are three forms of xylene in which the methyl groups vary on the benzene ring: meta-xylene, ortho-xylene, and para-xylene (m-, o-, and p-xylene). These different forms are referred to as isomers. The term total xylenes refers to all three isomers of xylene. Mixed xylene is a mixture of the three isomers and usually also contains 6 to 15 percent ethylbenzene. Xylene is also known as xylol or dimethylbenzene. Xylene is a colorless, flammable liquid with a sweet odor.

9.7.1 Sources

Emissions of mixed xylenes have been detected from petroleum refining, motor vehicles, residential wood-burning stoves and fireplaces. Mixed xylenes are used as chemical intermediates, as solvents, in aviation fuel, and in household products such as aerosol paints and lacquers.

The primary stationary sources that have reported emissions of m-, o-, and p-xylene are manufacturers of motor vehicles and equipment, manufacturers of metal cans and shipping containers, and petroleum refining.

9.7.2 Effects

Short-term exposure of people to high levels of xylene can cause irritation of the skin, eyes, nose, and throat; difficulty in breathing; impaired function of the lungs; delayed response to a visual stimulus; impaired memory; stomach discomfort; and possible changes in the liver and kidneys. Both short- and long-term exposure to high concentrations of xylene can also cause a number of effects on the nervous system, such as headaches, lack of muscle coordination, dizziness, or confusion. (ATSDR).

9.8 1,3 Butadiene

1,3-Butadiene is a colorless, flammable gas at room temperature with a mild gasoline-like odor, is insoluble in water, and its two conjugated double bonds make it highly reactive.

9.8.1 Sources

1,3-Butadiene is a chemical made from the processing of petroleum. Large amounts of 1,3-butadiene are produced each year from petroleum gases. 1,3-Butadiene is formed in vehicle exhaust by the incomplete combustion of the fuel and is assumed not to be present in emissions. Small amounts of 1,3-butadiene are found in gasoline, cigarette smoke, and wood-fire smoke.

1,3-Butadiene is transformed rapidly in the atmosphere. Three chemical reactions of 1,3-butadiene are important in the ambient atmosphere: reaction with hydroxyl radical (OH), reaction with ozone (O_3), and reaction with nitrogen trioxide radical (NO_3). All three of these reactions are relatively rapid, and all produce formaldehyde and acrolein, species which are themselves toxic and/or irritants. The oxidation of 1,3-butadiene by NO_3 produces organic nitrates as well.

9.8.2 Effects

Most of the information on the health effects of 1,3-butadiene comes from studies where the exposure was from breathing contaminated air. Breathing very high levels of 1,3-butadiene for a short time can cause central nervous system damage, blurred vision, nausea, fatigue, headache, decreased blood pressure and pulse rate, and unconsciousness. Breathing lower levels may cause irritation of the eyes, nose, and throat (ATSDR).

9.9 Monitoring 2004

Air quality toxics air pollutants monitoring data are developed using two methods: 1) EPA Compendium Method TO-15, "Determination of Volatile Organic Compounds in Air Collected in Specially Prepared Canisters and Analyzed by Gas Chromatography / Mass Spectrometry," and 2) EPA Compendium Method TO-11a, "Determination of Formaldehyde in Ambient Air Using Adsorbent Cartridge Followed by High Performance Liquid Chromatography." Using these two methods, samples are obtained over a 24-hour period, generally from midnight to midnight and represent a 24-hour time weighted average. Samples of volatile organic compounds are obtained once every six days, while formaldehyde and other carbonyl compounds are sampled every 12 days.

During 2004, toxics monitoring data were collected at six urban monitoring sites in Asheville, Durham, Charlotte, Raleigh, Wilmington and Winston-Salem and one rural site near Candor, in Montgomery County (Figure 9.1).

The map in Figure 9.1 and the summaries in Table 9.1 through Table 9.7 show two sites in Asheville, but there was only one monitoring station operating at any given time. During the month of September 2004, Asheville was impacted with the remnants of three major Hurricanes (Frances, Ivan, and Jeanne), which produced high winds, heavy rains and severe flooding. The sampling site located on a rooftop at the Woodfin Street site was shut down due to heavy damage from these events. A new site located about 1 mile south of the Woodfin Street site on the AB Technical Community College was established in late November and sampling restarted.

We show summary statistics for 2004 in Table 9.1 through Table 9.6 and discuss averages of concentrations for each pollutant and site below. For some pollutants, many of the samples were not detectable. This introduces uncertainty and bias in the arithmetic mean, so we prefer to describe average concentrations in terms of the median, or second quartile, concentrations and to show all three of the data quartiles and the maximum in the tables. The "first (second, third) quartile" is a number selected so that ¼ (½, ¾) of the data values are less than or equal to the numeric value of these statistics.

For VOC samples at concentrations below an established detection limit, it is a standard (although controversial) practice to substitute ½ of the minimum reporting limit or detection limit for the observed or reported concentration. In the summary statistics discussions following, we report comparisons between North Carolina and other states as arithmetic means based on applying this type of substitution, where all data concentrations <0.10 ppb have been truncated to 0.05 ppb. Arithmetic mean averages are generally larger than the corresponding median values.

Formaldehyde samples in 2004 are summarized in Table 9.1. Median (2nd Quartile) concentration was 0.627 ppb at the urban site, while at the rural site the concentration was 1.040 ppb. Statewide average formaldehyde concentrations ranged from .043 ppb to 23.045 ppb. North Carolina was the 31st highest state among 37 reporting states, with 1.370 ppb.

Benzene samples in 2004 are summarized in Table 9.2. Median (2nd Quartile) concentrations ranged from 0.227 to 0.406 ppb at the urban site and 0.143 to 0.388 ppb at the rural site. State average benzene concentrations ranged from .140 ppb to .923 ppb. North Carolina was the 23rd highest state among 39 reporting states, with .295 ppb.

Toluene samples in 2004 are summarized in Table 9.3. Median (2nd Quartile) concentrations ranged from 0.262 to 0.664 ppb at the urban sites, and 0.117 to 0.508 ppb at the rural site. Statewide average toluene concentrations ranged from .225 ppb to 1.936 ppb. North Carolina was the 27th highest state among 38 reporting states, with .497 ppb.

Ethylbenzene samples in 2004 are summarized in Table 9.4. Median (2nd Quartile) concentrations ranged from 0.050 to 0.176 ppb at the urban sites, and 0.050 to .099 ppb at the rural site. (Data indicate that more than 83 percent of the sample concentrations at Candor were below the smallest value that could be reliably detected using TO-15.) Statewide average ethylbenzene concentrations ranged from .031 ppb to .308 ppb. North Carolina was the 23rd highest state among 38 reporting states, with .093 ppb.

m/p-Xylene samples in 2004 are summarized in Table 9.5. Median (2nd Quartile) concentrations ranged from 0.050 to 0.431 ppb at the urban sites, and 0.05 to 1.255 ppb at the rural site. (Data indicate that in 2004, 61 percent of the sample concentrations at Candor were below the smallest value that could be reliably detected using TO-15.) Statewide average m/p-Xylene concentrations ranged from .020 ppb to 1.312 ppb. North Carolina was the 12th highest state among 35 reporting states, with .349 ppb.

o-Xylene samples in 2004 are summarized in Table 9.6. Median (2nd Quartile) concentrations ranged from 0.050 to 0.182 ppb at the urban sites, and 0.05 to .161 ppb at the rural site. (Data indicate that about 83 percent of the sample concentrations at Candor were below the smallest value that could be reliably detected using TO-15.) Statewide average o-Xylene concentrations ranged from .028 ppb to .358 ppb. North Carolina was the 20th highest state among 37 reporting states, with .110 ppb.

1,3 Butadiene samples in 2004 are summarized in Table 9.7. Median (2nd Quartile) concentrations ranged from 0.05 to 0.281 ppb at the urban sites, and 0.05 to .234 ppb at the rural site.

Statewide average 1,3 Butadiene concentrations ranged from .013 ppb to .934 ppb. North Carolina was the 8th highest state among 37 reporting states, with .270 ppb.

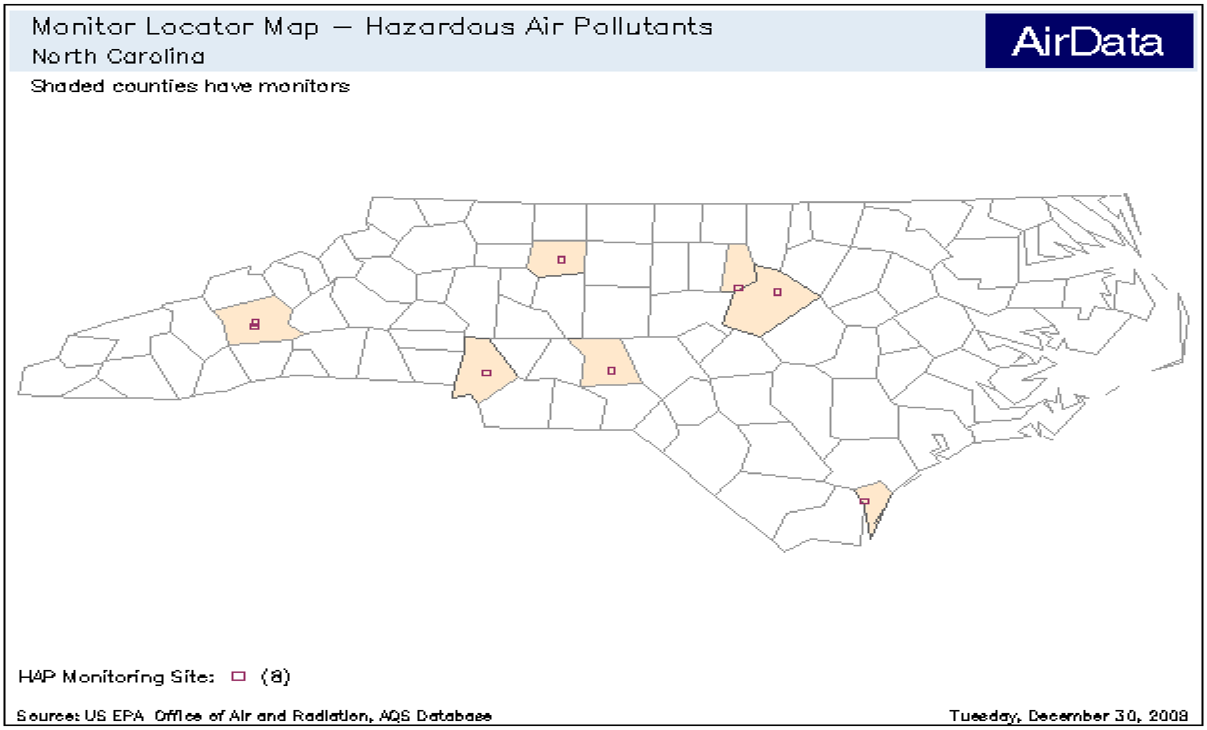


Figure 9.1 Location Urban Air Toxics Monitoring Sites 2004

Table 9.1 Formaldehyde - Parts per billion for 2004

SITE NUMBER	ADDRESS	NUM OBS	QUARTILES			MAXI NUM	ARITH MEAN
COUNTY			1st	2nd	3rd		
37-063-0014 DURHAM	ALEXANDER DR. N.OF HIGHWAY 54	9	.508	.627	1.410	3.260	1.163
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	24	.624	1.040	1.485	7.530	1.582
Total Samples		33					
Total Sites Sampled		2					

Table 9.2 Benzene - Parts per billion for 2004

SITE NUMBER	ADDRESS	NUM OBS	PC T OF DATA ≤ .05	QUARTILES			MAXI NUM	ARITH MEAN
COUNTY				1st	2nd	3rd		
37-021-0003 BUNCOMBE	HEALTH & SOCIAL SERVICE BLDG WOODFIN ST ASHEVILLE	41	0%	.226	.297	.383	.870	.323
37-021-0035 BUNCOMBE	AB TECHNICAL COLLEGE ASHEVILLE	6	0%	.327	.406	.472	.719	.419
37-063-0014 DURHAM	ALEXANDER DR. N.OF HIGHWAY 54	32	0%	.148	.227	.349	.618	.262
37-067-0022 FORSYTH	1300 BLK HATTIE AVE ST. BENEDICT THE MOOR CHURCH WINSTON-SALEM	23	0%	.254	.295	.389	.539	.326
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE GARINGER HIGH SCHOOL CHARLOTTE	56	4%	.248	.371	.493	1.640	.420
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	58	12%	.112	.143	.195	.281	.149
37-129-0010 NEW HANOVER	BATTLESHIP MUSEUM	4	0%	.303	.388	.518	.806	.434
37-183-0014 WAKE	3801 SPRING FOREST RD, MILLBROOK MS RALEIGH	25	8%	.164	.276	.331	.995	.301
Total Samples		245						
Total Sites Sampled		8						

Table 9.3 Toluene - Parts per billion for 2004

SITE NUMBER	ADDRESS	NUM OBS	PC T OF DATA ≤ .05	QUARTILES			MAXI NUM	ARITH MEAN
COUNTY				1st	2nd	3rd		
37-021-0003 BUNCOMBE	HEALTH & SOCIAL SERVICE BLDG WOODFIN ST ASHEVILLE	41	0%	.362	.521	.718	1.433	.598
37-021-0035 BUNCOMBE	AB TECHNICAL COLLEGE ASHEVILLE	6	0%	.461	.655	.795	1.804	.765

SITE NUMBER COUNTY	ADDRESS	NUM OBS	PC T OF DATA ≤ .05	QUARTILES 1st	QUARTILES 2nd	QUARTILES 3rd	MAXI NUM	ARITH MEAN
37-063-0014 DURHAM	ALEXANDER DR. N.OF HIGHWAY 54	32	6%	.155	.262	.405	1.300	.331
37-067-0022 FORSYTH	1300 BLK HATTIE AVE ST. BENEDICT THE MOOR CHURCH WINSTON-SALEM	23	0%	.515	.604	.897	2.378	.777
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE GARINGER HIGH SCHOOL CHARLOTTE	56	0%	.511	.664	.995	3.180	.803
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	58	19%	.066	.117	.175	.275	.128
37-129-0010 NEW HANOVER	BATTLESHIP MUSEUM	4	0%	.406	.508	.821	1.685	.719
37-183-0014 WAKE	3801 SPRING FOREST RD, MILLBROOK MS RALEIGH	25	0%	.247	.390	.575	1.854	.536
Total Samples		245						
Total Sites Sampled		8						

Table 9.4 Ethylbenzene - Parts per billion for 2004

SITE NUMBER COUNTY	ADDRESS	NUM OBS	PC T OF DATA ≤ .05	QUARTILES 1st	QUARTILES 2nd	QUARTILES 3rd	MAXI NUM	ARITH MEAN
37-021-0003 BUNCOMBE	HEALTH & SOCIAL SERVICE BLDG WOODFIN ST ASHEVILLE	41	27%	.050	.098	.137	.645	.123
37-021-0035 BUNCOMBE	AB TECHNICAL COLLEGE ASHEVILLE	6	50%	.050	.060	.213	.331	.129
37-063-0014 DURHAM	ALEXANDER DR. N.OF HIGHWAY 54	32	78%	.050	.050	.050	.195	.064
37-067-0022 FORSYTH	1300 BLK HATTIE AVE ST. BENEDICT THE MOOR CHURCH WINSTON-SALEM	23	9%	.106	.176	.260	.553	.200

SITE NUMBER	ADDRESS	NUM OBS	PC T OF DATA ≤ .05	QUARTILES			MAXI NUM	ARITH MEAN
COUNTY				1st	2nd	3rd		
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE GARINGER HIGH SCHOOL CHARLOTTE	56	30%	.050	.107	.187	.634	.140
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	58	83%	.050	.050	.050	.139	.056
37-129-0010 NEW HANOVER	BATTLESHIP MUSEUM	4	50%	.050	.099	.156	.180	.107
37-183-0014 WAKE	3801 SPRING FOREST RD MILLBROOK MS RALEIGH	25	72%	.050	.050	.056	.310	.079
Total Samples		245						
Total Sites Sampled		8						

Table 9.5 m/p-Xylene - Parts per billion for 2004

SITE NUMBER	ADDRESS	NUM OBS	PC T OF DATA ≤ .05	QUARTILES			MAXI NUM	ARITH MEAN
COUNTY				1st	2nd	3rd		
37-021-0003 BUNCOMBE	HEALTH & SOCIAL SERVICE BLDG WOODFIN ST ASHEVILLE	41	15%	.161	.291	.424	.930	.300
37-021-0035 BUNCOMBE	AB TECHNICAL COLLEGE ASHEVILLE	6	33%	.075	.158	.697	1.176	.411
37-063-0014 DURHAM	ALEXANDER DR. N.OF HIGHWAY 54	32	56%	.050	.050	.140	.659	.138
37-067-0022 FORSYTH	1300 BLK HATTIE AVE ST. BENEDICT THE MOOR CHURCH WINSTON-SALEM	23	0%	.250	.431	.633	1.132	.458
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE GARINGER HIGH SCHOOL CHARLOTTE	54	15%	.163	.340	.530	2.014	.404
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	57	61%	.050	.050	.101	.197	.077

SITE NUMBER COUNTY	ADDRESS	NUM OBS	PC T OF DATA ≤ .05	QUARTILES 1st	2nd	3rd	MAXI NUM	ARITH MEAN
37-129-0010 NEW HANOVER	BATTLESHIP MUSEUM	4	0%	.603	1.255	1.853	2.096	1.201
37-183-0014 WAKE	3801 SPRING FOREST RD MILLBROOK MS RALEIGH	25	44%	.050	.090	.184	1.032	.203
Total Samples		242						
Total Sites Sampled		8						

Table 9.6 o-Xylene - Parts per billion for 2004

SITE NUMBER COUNTY	ADDRESS	NUM OBS	PC T OF DATA ≤ .05	QUARTILES 1st	2nd	3rd	MAXI NUM	ARITH MEAN
37-021-0003 BUNCOMBE	HEALTH & SOCIAL SERVICE BLDG WOODFIN ST ASHEVILLE	41	27%	.050	.095	.154	.360	.120
37-021-0035 BUNCOMBE	AB TECHNICAL COLLEGE ASHEVILLE	6	67%	.050	.050	.280	.444	.167
37-063-0014 DURHAM	ALEXANDER DR. N.OF HIGHWAY 54	32	75%	.050	.050	.052	.289	.073
37-067-0022 FORSYTH	1300 BLK HATTIE AVE ST. BENEDICT THE MOOR CHURCH WINSTON-SALEM	23	0%	.144	.182	.381	.619	.251
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE GARINGER HIGH SCHOOL CHARLOTTE	54	28%	.050	.132	.214	.801	.157
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	58	83%	.050	.050	.050	.082	.053
37-129-0010 NEW HANOVER	BATTLESHIP MUSEUM	4	50%	.050	.161	.276	.291	.166
37-183-0014 WAKE	3801 SPRING FOREST RD MILLBROOK MS RALEIGH	25	68%	.050	.050	.073	.370	.090
Total Samples		243						
Total Sites Sampled		8						

Table 9.7 1,3 Butadiene - Parts per billion for 2004

SITE NUMBER	ADDRESS	NUM OBS	PC T OF DATA ≤ .05	QUARTILES			MAXI NUM	ARITH MEAN
COUNTY				1st	2nd	3rd		
37-021-0003 BUNCOMBE	HEALTH & SOCIAL SERVICE BLDG WOODFIN ST ASHEVILLE	12	33%	.05	.281	.448	.78	.313
37-021-0035 BUNCOMBE	AB TECHNICAL COLLEGE ASHEVILLE	6	100%	.05	.05	.05	.05	.05
37-063-0014 DURHAM	ALEXANDER DR. N.OF HIGHWAY 54	29	76%	.05	.05	.05	.202	.072
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE GARINGER HIGH SCHOOL CHARLOTTE	28	61%	.05	.05	.26	.614	.154
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	28	96%	.05	.05	.05	.069	.051
37-129-0010 NEW HANOVER	BATTLESHIP MUSEUM	4	50%	.05	.235	1.326	4.048	1.142
37-183-0014 WAKE	3801 SPRING FOREST RD MILLBROOK MS RALEIGH	25	60%	.05	.05	.066	.432	.100
Total Samples		132						
Total Sites Sampled		7						

10 Statewide Trends

DENR has 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 annual changes helps evaluate the success of programs intended to reduce pollution and prioritize future efforts.

10.1 Particulate Matter

The statewide distribution of second-highest 24-hour PM_{10} concentrations for each monitor from 1989 to 2004 is shown in Figure 10.1. Concentrations have decreased from 58 to about 40 $\mu g/m^3$ (a 32 percent decline).

10.2 Carbon Monoxide

The statewide distribution of second-highest eight-hour CO concentrations from 1993 to 2004 is shown in Figure 10.2. The average value of this concentration decreased from 4.78 ppm in 1993 to 2.81 ppm in 2004 (a decline of 41 percent). There have been no CO exceedances since 1991.

10.3 Ozone

The statewide distribution of fourth-highest eight-hour ozone concentrations is shown in Figure 10.3. Ozone concentrations oscillate in a long cycle and shows no specific trend to 2004.
In 2004, the end point of the 20 year period, the monitoring network average was 0.074, which is 92 percent of the standard.

Figure 10.4 shows the number of days with exceedances every year from 1985 to 2004. Exceedance days decreased steadily from 76 in 1998 to 5 in 2004. Then in 2002, an increase to 51 days of exceedances occurred, followed by a big decrease to 14 in 2003.

However, 1998 was the worst year for ozone on record on a national basis.

10.4 Sulfur Dioxide

The statewide distribution of second-largest three-hour sulfur dioxide (SO_2) concentrations from 1989 to 2004 is shown in Figure 10.5. The average decreased from 0.088 ppm in 1989 to 0.049 ppm in 2004 (10 percent of the standard), for a 45 percent decrease.

The statewide distribution of second-largest 24-hour SO_2 concentrations from 1989 to 2004 is shown in Figure 10.6. The average decreased from 0.027 ppm in 1989 to 0.015 ppm in 2004 (11 percent of the standard), for a 43 percent decrease.

10.5 Nitrogen Dioxide

The Forsyth and Mecklenburg County distributions of annual average nitrogen dioxide (NO_2) concentrations from 1989 to 2004 are shown in Figure 10.7. The average concentration was approximately constant around 0.014 ppm (26 percent of the standard).

10.6 pH

The statewide distribution of annual average pH values of rainfall from 1989 to 2004 for the NADP sites (including two collocated sites and the Great Smoky Mountain, Tennessee site) is shown in Figure 10.8. The mean pH has increased 4 percent over the 16 year time period. This is good news because it means that the rain is becoming less acidic.

The NADP network 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 and after 1994 (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).

10.7 Ammonium Ion

The statewide distribution of annual average ammonium ion (NH_4^+) concentrations from 1989 to 2004 for the NADP sites (including two collocated sites and the Great Smoky Mountain, Tennessee site) is shown in Figure 10.9. From 1989 to 2004 there appears to be an increase of 10 percent. Ammonium ion concentration in rain increased significantly in Sampson County in 2000 where there is concentrated livestock animal production. (Cornelius, 1997) but it decreased slightly in 2002 and increased again in 2003 and 2004. The NADP study suggested that the 1994 protocol change had no net effect on measured NH_4^+ concentrations (NADP 1995).

10.8 Nitrate Ion

The statewide distribution of annual average nitrate ion (NO_3^-) concentrations from 1989 to 2004 for the NADP/NTN sites (including two collocated sites and the Great Smoky Mountain, Tennessee site) is shown in Figure 10.10. The mean has decreased by 22 percent over the study period. 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).

10.9 Sulfate Ion

The statewide distribution of annual average sulfate ion (SO_4^{2-}) concentrations from 1989 to 2004 for the NADP sites (including two collocated sites and the Great Smoky Mountain, Tennessee site) is shown in Figure 10.11. The average has decreased from 1.6 mg/L in 1989 to 1.2 mg/L in 2004, for a 28 percent decrease. The NADP study suggested that SO_4^{2-} concentrations will decrease by a median amount of 0.02 (s.e. = 0.002) due to the protocol change in 1994 (NADP 1995).

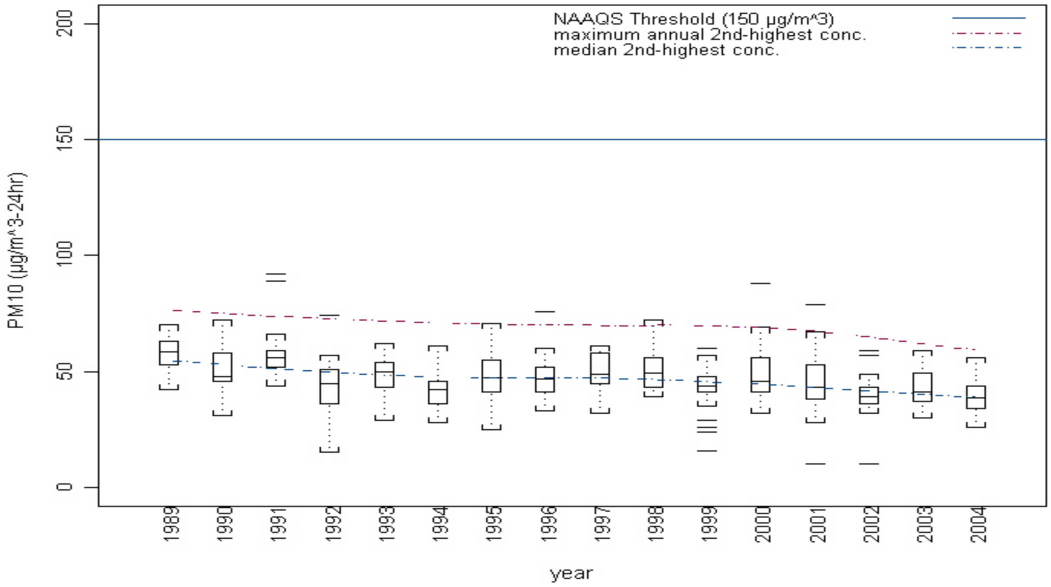


Figure 10.1 Distribution of Statewide Second-Maximum 24-Hour PM_{10} Concentrations, 1989- 2004, and Smoothed Regression Trend Line.

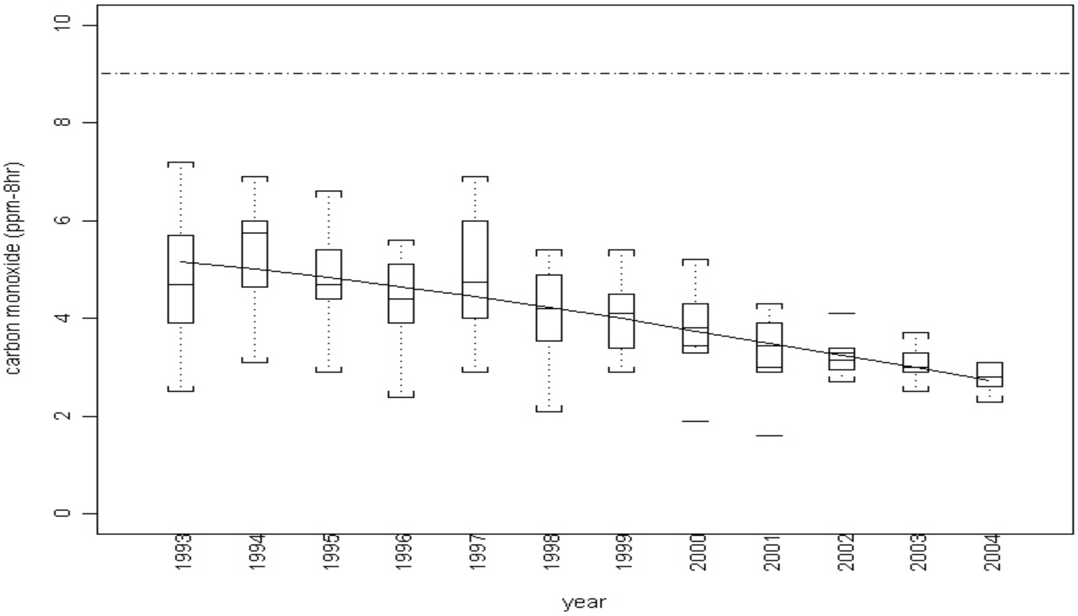


Figure 10.2 Distribution of Statewide Second-Maximum 8-Hour Carbon Monoxide Concentrations, 1993- 2004, and Smoothed Regression Trend Line.

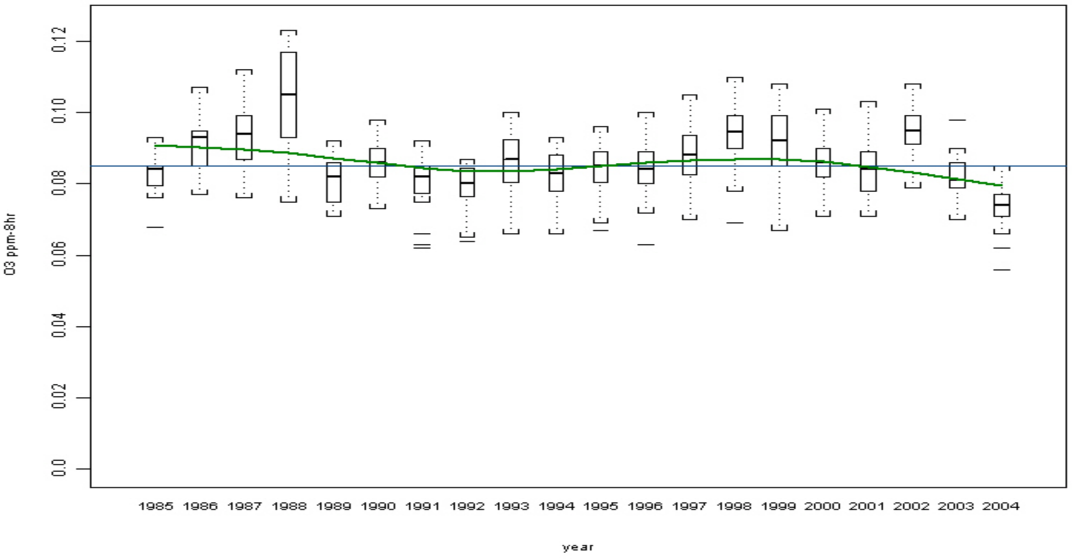


Figure 10.3 Distribution of Statewide Fourth-Maximum 8-Hour Ozone Concentrations, 1985- 2004, and Smoothed Regression Trend Line.

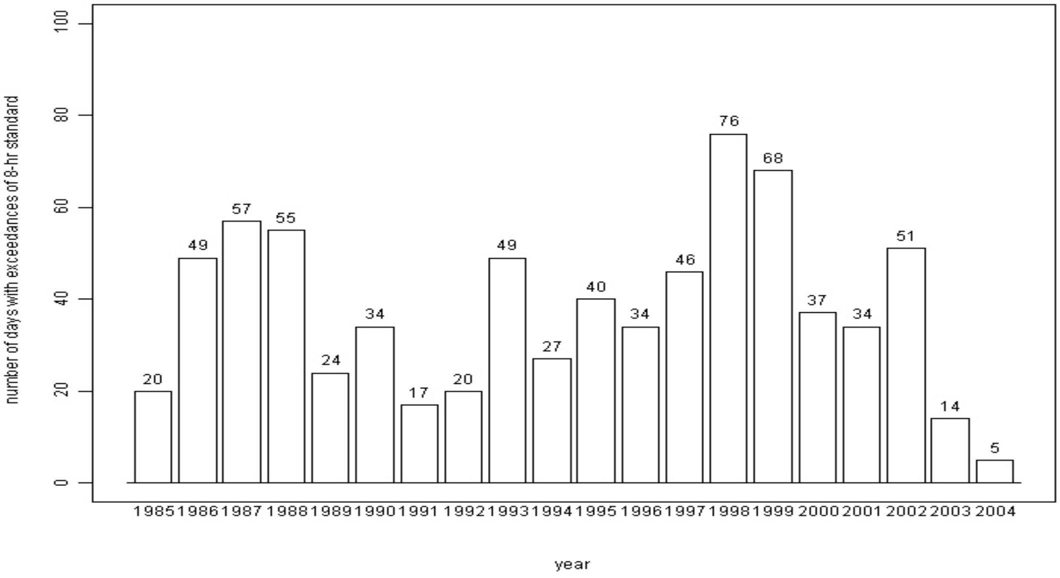


Figure 10.4 Number of days with exceedances of 8-Hour Ozone Averages of 0.085 ppm or Greater, 1985 – 2004.

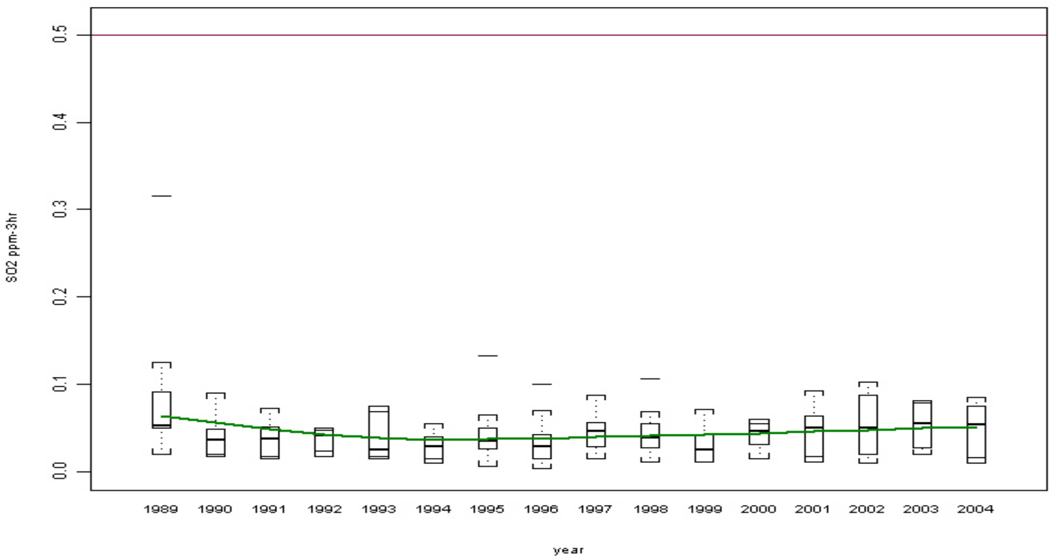


Figure 10.5 Distribution of Statewide Second-Maximum 3-Hour Sulfur Dioxide Concentrations, 1989- 2004, and Smoothed Regression Trend Line.

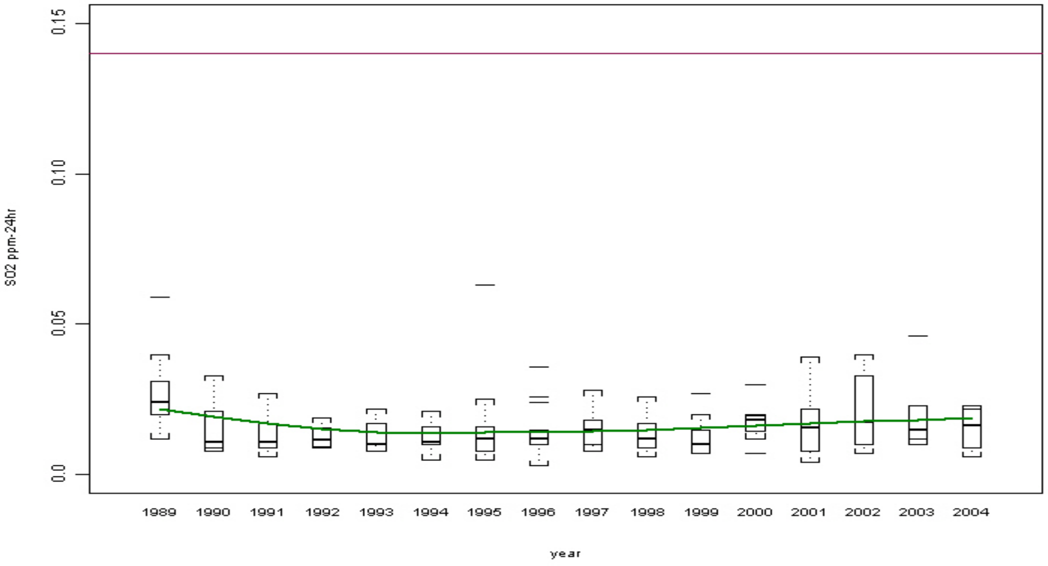


Figure 10.6 Distribution of Statewide Second- Maximum 24-Hour Sulfur Dioxide Concentrations, 1989- 2004, and Smoothed Regression Trend Line.

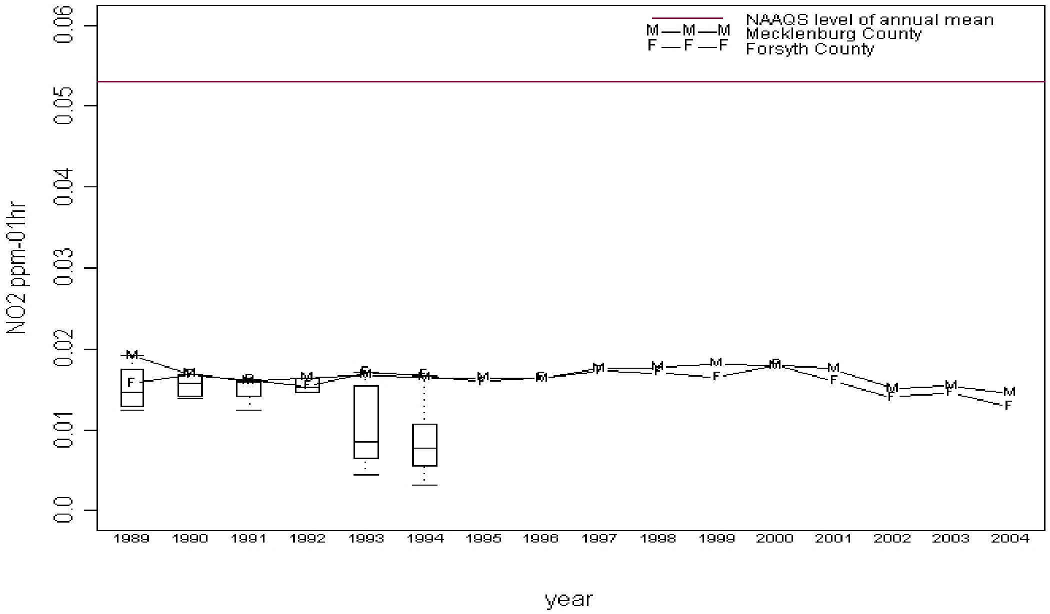


Figure 10.7 Distributions of Forsyth and Mecklenburg County Annual Mean Nitrogen Dioxide Concentrations, 1989- 2004, and Smoothed Regression Trend Line.

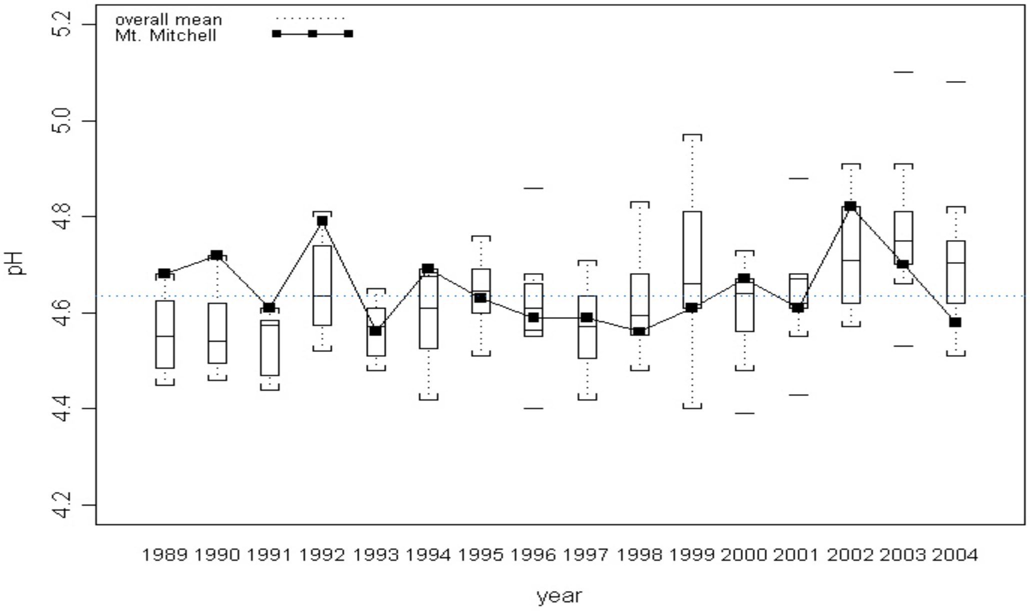


Figure 10.8 Distribution of Statewide Annual Mean pH, 1989- 2004.

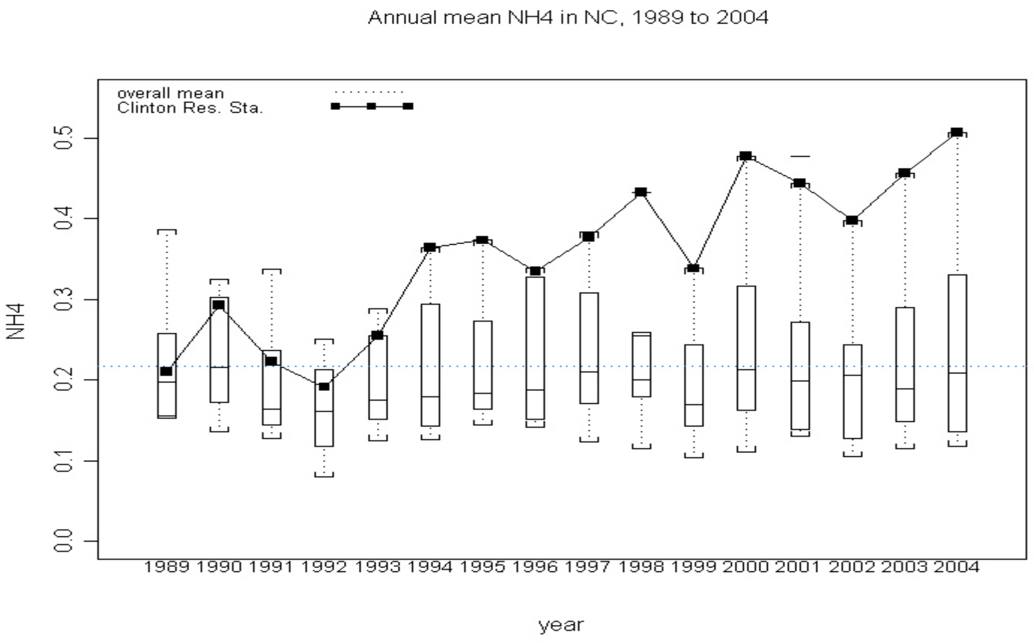


Figure 10.9 Distribution of Statewide Annual Mean Ammonium Ion Concentrations, 1989- 2004.

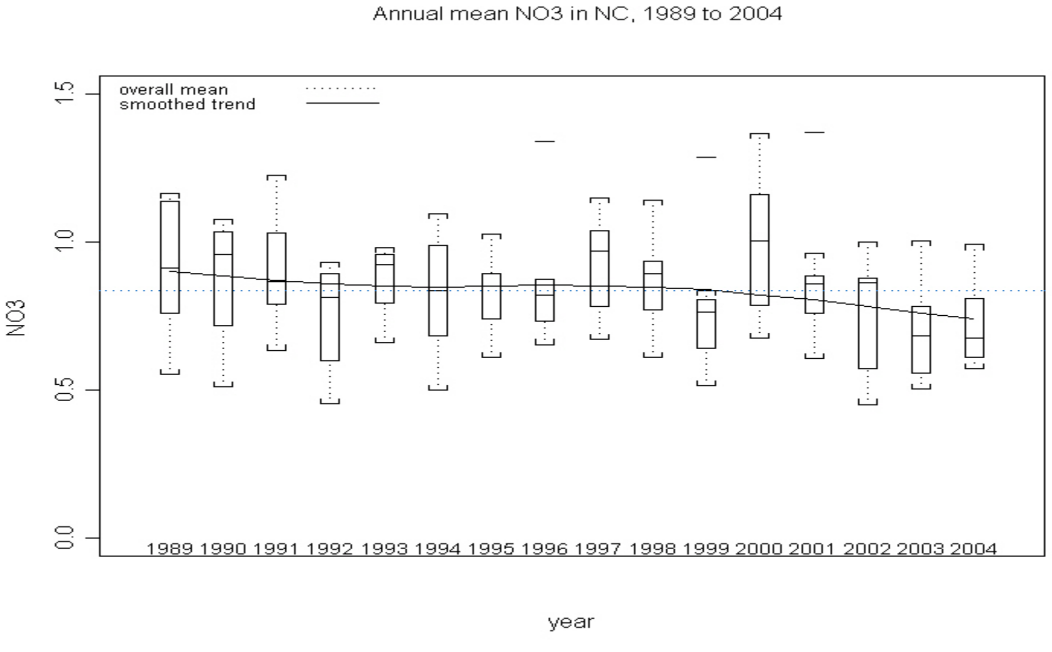


Figure 10.10 Distribution of Statewide Annual Mean Nitrate Ion Concentrations, 1989- 2004, and Smoothed Regression Trend Line.

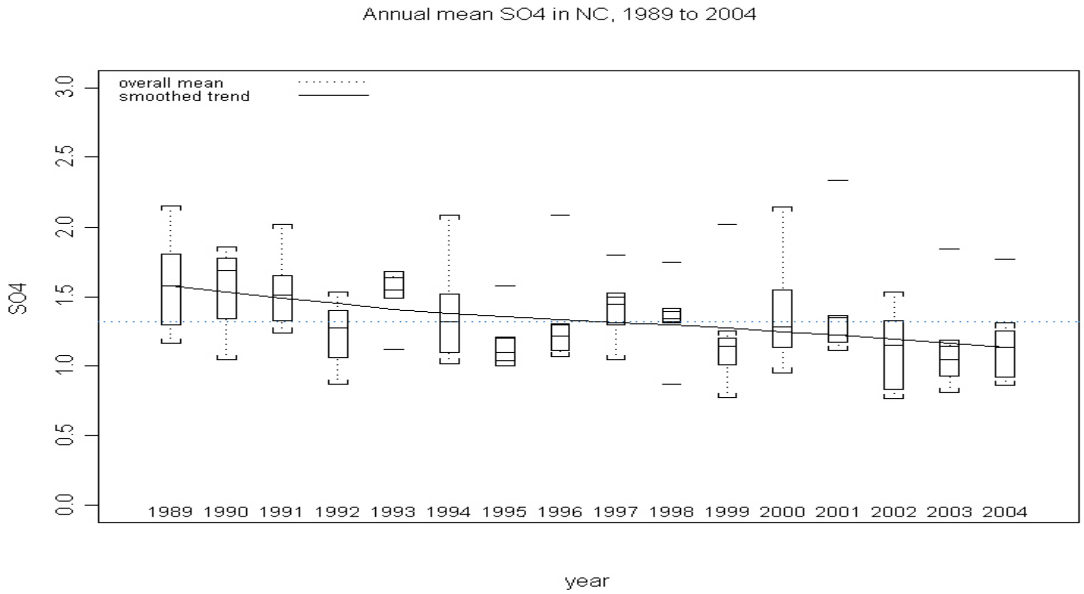


Figure 10.11 Distribution of Statewide Annual Mean Sulfate Ion Concentrations, 1989- 2004, and Smoothed Regression Trend Line.

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Appendix A. Air Pollution Monitoring Agencies

North Carolina Central Office

Division of Air Quality

Raleigh Central Office
2728 Capital Boulevard
1641 Mail Service Center
Raleigh, North Carolina 27699-1641
(919) 733-3340

North Carolina Regional Offices

Asheville Regional Office
2090 U.S. Highway 70
Swannanoa, North Carolina 28778
Phone: (828) 296-4500

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

Fayetteville Regional Office
225 Green Street, Suite 714
Fayetteville, North Carolina 28301
(910) 433-3300

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

Mooresville Regional Office
610 East Center Avenue, Suite 301
Mooresville, North Carolina 28115
Phone: (704) 663-1699

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

Raleigh Regional Office
3800 Barrett Drive
Raleigh, North Carolina 27609
(919) 791-4200

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
(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) 796-7215

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

Winston-Salem Regional Office
585 Waughtown Street
Winston-Salem, North Carolina 27107
(336) 771-5000

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

Local Agencies in North Carolina

Forsyth County Environmental Affairs Department

537 North Spruce Street
Winston-Salem, North Carolina 27101
(336) 703-2440

Mecklenburg County Air Quality
700 N. Tryon Street, Suite 205
Charlotte, North Carolina 28202-2236
(704) 336-5500

Western North Carolina Regional Air Quality Agency (Buncombe County and Asheville city)
49 Mount Carmel Road
Asheville, NC 28806
(828) 250-6777

Tribal Agency in North Carolina

Eastern Band of Cherokee Indians
Tribal Environmental Office
P. O. Box 455
Cherokee, North Carolina 28719
(828) 497-3814

Territory overlaps with portions of Swain and Jackson Counties

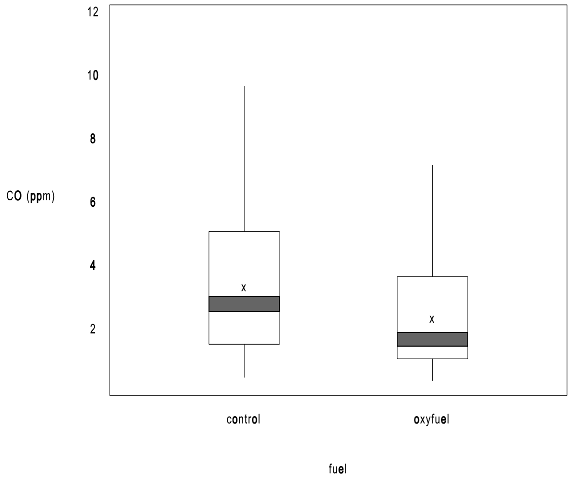
Appendix B. Exceptional Events

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, O_3
High pollen count	PM
Unintentional Man-made 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 Man-made 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 outliersXsmall 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, fine particles ($PM_{2.5}$) 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 $PM_{2.5}$ and ozone precursors. Other sources of $PM_{2.5}$ include industrial processes, grass mowing agricultural tilling and open burning. In the urban areas, 60 percent of the nitrogen oxides and 25 percent of the man-made hydrocarbons or volatile organic compound emissions come from motor vehicles; the rest comes from off-road vehicles, utility and industrial boilers, petroleum marketing, factories, businesses, and households. Nitrogen oxides react with volatile organic compounds and sunlight in warm weather to produce ozone.

Why is my county nonattainment?

EPA guidance recommends that an entire Metropolitan Statistical Area (MSA) be designated nonattainment when a monitor is found to be violating the National Ambient Air Quality Standards (NAAQS). This policy is due to the regional nature of certain pollutants, like ozone. Ozone is formed in the atmosphere under complex chemical reactions. Sometimes the ozone levels are higher just downwind of urban areas because of the time it takes the pollutants to react to form ozone. Therefore, larger areas are designated nonattainment to represent the likely area contributing to the air quality problems.

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. 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. The N. C. General Assembly also reviews the SIP. EPA's approval process also 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, carbon monoxide, and nitrogen oxides. 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. Cleaner burning gasoline may be required. More controls will be required on utility and industrial boilers. All of these measures may mean higher costs to the public.

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 require more stringent offsets for new facilities 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?

As of December, 2001, the inspection/maintenance (I/M), or motor vehicle emissions testing process, costs the motorist $30.00 maximum per vehicle. If a vehicle fails the test, it must be repaired. A waiver is available if a vehicle still fails after $200.00 worth of repairs have been done. The $200.00 limit does not apply to tampered or misfueled vehicles. The inspection/maintenance program includes tests for hydrocarbon (HC) and carbon monoxide (CO) emissions for the following counties, Mecklenburg, Wake, Guilford, Forsyth, Durham, Gaston, Cabarrus, Orange, and Union. The number of counties will increase to 48 by 2006 under the Clean Air bill passed in 2000. The cost for this new test was set by the General Assembly during the 2001 legislative session. Currently, 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.