

# **2009 Ambient Air Quality Report**

STATE OF NORTH CAROLINA  
**Beverly Eaves Perdue, Governor**

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ENVIRONMENT  
AND  
NATURAL RESOURCES  
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# 2009 Ambient Air Quality Report

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Department

EPA/AQS Air Quality <http://www.epa.gov/airsweb>  
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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 about 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 2009 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 2009.

Current air pollution information is available to the public 24 hours a day on the Division of Air Quality's website <http://www.ncair.org/monitor/aqi/>.

In 2002, the air monitoring program deployed a network of fine particle speciation monitors. This report provides data summaries from these monitors for 2009.

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 2009 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://www.ncair.org/monitor/reports/> or by writing to:

Division of Air Quality  
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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.

Sheila C. Holman, Director  
Division of Air Quality

## Executive Summary

In 2009, the North Carolina Division of Air Quality (DAQ), the three local program agencies and one tribal agency (listed in Appendix A) collected 301,578 ambient 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 (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 2009. 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 2009.

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 2009 in this report. This report presents a map and summary tables of formaldehyde and five important volatile organic compounds for 2009.

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** are routinely sampled in North Carolina. Total Suspended Particulate (TSP), or particles having an aerodynamic diameter of 100 micrometers or less, is regulated by North Carolina standards. Particulate matter (PM<sub>10</sub>), 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<sub>2.5</sub>), 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.

No TSP sampling occurred in 2009. In 2006, TSP was sampled at seven sites, yielding 361 daily samples. There were no exceedances of the state TSP ambient air quality standard for 24-hour samples (150 µg/m<sup>3</sup>) observed in 2006.

PM<sub>10</sub> was sampled at 13 sites, yielding 1,527 daily samples. There were no exceedances of the National Ambient Air Quality Standards for PM<sub>10</sub> (150 µg/m<sup>3</sup> for 24-hour samples and 50 µg/m<sup>3</sup> for the annual arithmetic mean).

PM<sub>2.5</sub> was sampled at 34 sites yielding 5,176 daily samples. There were no exceedances of the ambient air quality standards for PM<sub>2.5</sub> (35 µg/m<sup>3</sup> for 24-hour samples). None of the 35 sites exceeded the annual arithmetic mean standard of 15 µg/m<sup>3</sup>.

**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 five sites, yielding 33,443 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 3.9 ppm was observed at 1401 Corporation Pky in Winston-Salem. The highest eight-hour concentration of 2.0 ppm was observed at 1130 Eastway Drive in Charlotte. The mean one-hour average has been decreasing by about 34 percent per year and the mean eight-hour average has been decreasing by about 27 percent per year. The combined effects of newer cars in the vehicle fleet, traffic control strategies, and the Inspection and Maintenance program in 48 counties has helped reduce the number and intensity of CO exceedances from previous years.

**Ozone (O<sub>3</sub>)** forms in the lower atmosphere when hydrocarbons (or volatile organic compounds) and nitrogen oxides chemically react in the presence of sunlight and high temperatures. The main emphasis in control of ozone has been to limit hydrocarbon and nitrogen oxide emissions.

O<sub>3</sub> was sampled at 41 sites, yielding 206,232 valid hourly averages. The National Ambient Air Quality Standard for O<sub>3</sub> in 2009 was 0.075 ppm for the maximum 8-hour average and 0.12 ppm for the maximum 1-hour average.

In 2009, there were no exceedances of the 1-hour standard.

In 2009, the 8-hour standard was exceeded 13 times, on six different days, with one county having four exceedances at individual sites. The site at 1130 Eastway Drive, Charlotte in Mecklenburg County and 925 N Enochville Ave, Enochville in Rowan County had the highest number, three.

**Sulfur dioxide (SO<sub>2</sub>)** is mainly produced by combustion of fossil fuels containing sulfur compounds and the manufacture of sulfuric acid.

SO<sub>2</sub> was sampled at seven sites, yielding 50,497 valid hourly averages. There were no exceedances of the 1971 National Ambient Air Quality Standards (365 µg/m<sup>3</sup> or 140 ppb for a 24-hour average, 1300 µg/m<sup>3</sup> or 500 ppb for a three-hour average, 80 µg/m<sup>3</sup> or 30 ppb for the annual arithmetic mean) at network monitoring sites. However, there were 15 exceedances of the 2010 National Ambient Air Quality Standards (75 ppb for an 1-hour daily maximum concentrations) at one network monitoring site Highway 421 North in Wilmington.

**Nitrogen oxides** (NO<sub>x</sub>) 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<sub>2</sub>. NO<sub>x</sub> compounds play an important role in the formation of ozone. Reactive nitrogen species (NO<sub>y</sub>) 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<sub>2</sub> was sampled at two sites, yielding 12,886 valid hourly averages. There were no exceedances of the National Ambient Air Quality Standard (0.053 ppm for the annual arithmetic mean). The mean 1-hour average concentration has been decreasing by about 5 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 2009 using a Federal Reference Method. There have been no recent exceedances of the ambient air quality standard for lead (1.5 µg/m<sup>3</sup> 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.

The annual mean pH in 2009 ranged from 4.80 (Scotland County) to 5.20 (Sampson County). The annual total deposition of mercury in precipitation ranged from 6.57 ng/m<sup>2</sup> (Sevier, TN) to 8.46 ng/m<sup>2</sup> (Columbus County).

**Atmospheric mercury** is a by-product of combustion processes and mining and is also outgassed naturally by volcanoes and geothermal vents. 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.

**Speciated particulate samples** were collected at seven 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 and crustal material, there were 2,962 quantifiable concentrations in 2009.

By category, the highest concentrations of speciated particulate samples in 2009 were: organic carbon 17.10 µg/m<sup>3</sup>; crustal component 13.64 µg/m<sup>3</sup>; nitrate 13.60 µg/m<sup>3</sup>; sulfate 11.00 µg/m<sup>3</sup>; ammonium 3.13 µg/m<sup>3</sup> and elemental carbon 1.65 µg/m<sup>3</sup>.

Although there was no sampling for lead using a criteria pollutant method, the speciated particulate monitoring network provided 855 samples of PM<sub>2.5</sub> lead in 2009; 852 of these sample concentrations (99.6 percent) were less than 0.01 µg/m<sup>3</sup>. One sample exceeded 0.014 µg/m<sup>3</sup>.

**Urban Air Toxics sampling** in 2009 occurred at six sites, five 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 1.26 to 2.51 ppb at the urban sites and 1.93 ppb at the rural site. Median benzene concentrations were 0.09 to 0.37 ppb at the urban sites and 0.09 ppb at the rural site. Median toluene concentrations were 0.13 to 0.58 ppb at the urban sites and 0.08 ppb at the rural site. Median ethylbenzene concentrations were 0.01 to .05 ppb at the urban sites and 0.00 ppb at the rural site. Median m/p-xylene concentrations were 0.08 to 0.19 ppb at the urban sites and 0.00 ppb at the rural site. Median o-xylene concentrations were 0.01 to 0.06 ppb at the urban sites and 0.00 at the rural site. Median 1, 3-butadiene concentrations were 0.00 ppb at the urban sites and at the rural site. Ambient monitoring data for hazardous and/or toxic air pollutants are available in the Annual Air Toxics Report.

**Ambient Trends:** Annual average statewide concentrations of PM<sub>10</sub> decreased by 48 percent from 1989 to 2009. Annual average statewide concentrations of CO (as 8-hour averages) have decreased by 68 percent from 1997 to 2009. Annual average highest 8-hour ozone concentrations decreased by 23 percent from 1990 to 2009. Annual average highest 3-hour sulfur dioxide concentrations decreased by 80 percent from 1989 to 2009, and annual average of annual means decreased by 70 percent in the same time period. Annual average nitrogen dioxide concentrations remained constant from 1989 to 2009 in Forsyth County and Mecklenburg County, the only locations where this pollutant is monitored at present.

**Acid Rain Trends:** Annual average pH in rain increased about 10 percent from 1991 to 2009. Annual average ammonium concentrations increased about 26 percent from 1991 to 2009, but this was dominated by very significant increases in Sampson County associated with concentrated livestock animal production. Annual average nitrate concentrations in rain decreased about 33 percent from 1991 to 2009. Annual average sulfate concentrations in rain decreased about 48 percent from 1991 to 2009.



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# 1. Introduction

This annual report summarizes the ambient air monitoring performed in calendar year 2009 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.

These agencies collected 301,578 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, National Trends Network and Mercury Deposition Network. 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. 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 seven sites. This chapter contains annual summaries for five important toxic pollutants.

Chapter 10 provides a statewide summary of trends for the criteria pollutants from 1989 and 1991 (1997 for CO and 1990 for O<sub>3</sub>) through 2009.

## 2 Descriptions 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 ( $\mu\text{m}$ ). In the period covered by this report, three sizes of particulate matter were monitored, total suspended particulate (TSP),  $\text{PM}_{10}$  and  $\text{PM}_{2.5}$ . 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  $\mu\text{m}$  or less (Watson and Chow 2001), although particles up to about 100  $\mu\text{m}$  are sometimes captured by samplers. (The probability of inhalation for 100  $\mu\text{m}$  particles is about 50 percent and increases with decreasing particle size [Maynard and Jensen 2001].)  $\text{PM}_{10}$  is particulate matter with an aerodynamic diameter less than or equal to 10  $\mu\text{m}$  as measured according to EPA regulations 40 CFR 50 App. J (US EPA 1993, p. 769-773). TSP measurements have been made in North Carolina since the early 1960s, and  $\text{PM}_{10}$  has been sampled locally in Charlotte since 1985 and statewide since 1986 (North Carolina Department of Environment, Health, and Natural Resources 1991a). The  $\text{PM}_{2.5}$  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  $\text{PM}_{2.5}$ .

#### 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  $\mu\text{m}$ ) or larger (2.5 - 60  $\mu\text{m}$ ), 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 from 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.

### **2.2.2 Effects**

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

Individuals with anemia, lung and heart diseases are particularly sensitive to CO 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<sup>3</sup>) 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<sub>3</sub>) 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 by cracking rubber, fading dyes and eroding paint.

## 2.4 Sulfur Dioxide

Sulfur dioxide (SO<sub>2</sub>) is a colorless, corrosive, harmful gas with a pungent odor. Smaller concentrations of sulfur trioxide and other sulfate compounds are also found in SO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> exposure. Commercially important plants sensitive to SO<sub>2</sub> 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<sub>2</sub>O), nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>). 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<sub>2</sub>.

### **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<sub>2</sub> and other nitrogen oxides.

Some types of vegetation are very sensitive to NO<sub>2</sub>, 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<sub>2</sub> can react with moisture in the air to produce nitric acid, which corrodes metal surfaces and contributes to acid rain.

High concentrations of NO<sub>2</sub> may reduce visibility. Much of the brownish coloration sometimes observed in polluted air in winter months may be due to NO<sub>2</sub>.

## **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, man-made

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 2009 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 <sup>3</sup>
	1 day	2nd maximum	(1)	(1)	150 µg/m <sup>3</sup>
PM-2.5 24 hour average (40CFR50, App. N)	1 year	average <sup>2</sup> arithmetic mean	15 µg/m <sup>3</sup> (6)	15 µg/m <sup>3</sup> (6)	15 µg/m <sup>3</sup> (6)
	1 day	average <sup>2</sup> 98 <sup>th</sup> percentile	35 µg/m <sup>3</sup> (7)	35 µg/m <sup>3</sup>	35 µg/m <sup>3</sup> (6)
PM-10 24 hour average (40CFR50, App. N)	1 year	average <sup>2</sup> arithmetic mean	50 µg/m <sup>3</sup>	50 µg/m <sup>3</sup>	50 µg/m <sup>3</sup>
	1 day	average <sup>2</sup> 2 <sup>nd</sup> maximum <sup>3</sup>	150 µg/m <sup>3</sup>	150 µg/m <sup>3</sup>	150 µg/m <sup>3</sup>
CO 1 hour average	8 hours	2nd maximum	9 ppm (10 mg/m <sup>3</sup> )		9 ppm (10 mg/m <sup>3</sup> )
	1 hour	2nd maximum	35 ppm (40 mg/m <sup>3</sup> )		35 ppm (40 mg/m <sup>3</sup> )
O <sub>3</sub> 1 hour average (40CFR50, App. I)	1 hour	expected <sup>4</sup> 2nd maximum	0.12 ppm (235 µg/m <sup>3</sup> )	0.12 ppm (235 µg/m <sup>3</sup> )	0.12 ppm (235 µg/m <sup>3</sup> )
	8 hours	average <sup>5</sup> arithmetic mean 4th maximum	0.075 ppm (8) (157 µg/m <sup>3</sup> )	0.075 ppm (8) (157 µg/m <sup>3</sup> )	0.075 ppm (8) (157 µg/m <sup>3</sup> )
SO <sub>2</sub> 1 hour average	1 year	arithmetic mean	30 ppb (80 µg/m <sup>3</sup> )		0.03 ppm (80 µg/m <sup>3</sup> )
	1 day	2nd maximum	140 ppb (365 µg/m <sup>3</sup> )		0.14 ppm (365 µg/m <sup>3</sup> )
		3 hours (non-overlapping)	2nd maximum		500 ppb (1,300 µg/m <sup>3</sup> )
	1 year	99 <sup>th</sup> percentile of Daily Maximum	75 ppb <sup>(10)</sup>		75 ppb <sup>(10)</sup>
NO <sub>2</sub> 1 hour average	1 year	arithmetic mean	0.053 ppm (100 µg/m <sup>3</sup> )	0.053 ppm (100 µg/m <sup>3</sup> )	0.053 ppm (100 µg/m <sup>3</sup> )
Pb 24-hour average	3 months	arithmetic mean	0.15 µg/m <sup>3</sup> (9)	0.15 µg/m <sup>3</sup> (9)	0.15 µg/m <sup>3</sup> (9)

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 2<sup>nd</sup> maximum, but in May 1999 the 2<sup>nd</sup> 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. To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m<sup>3</sup> (effective December 17, 2006).

8. Effective May 27, 2008.

9. Effective October 15, 2008.

10. To attain this standard, the 3-year average of the 99th percentile of 1-hour daily maximum concentrations must not exceed 75 ppm (effective June 2, 2010).

## 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 2009. 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 2009 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

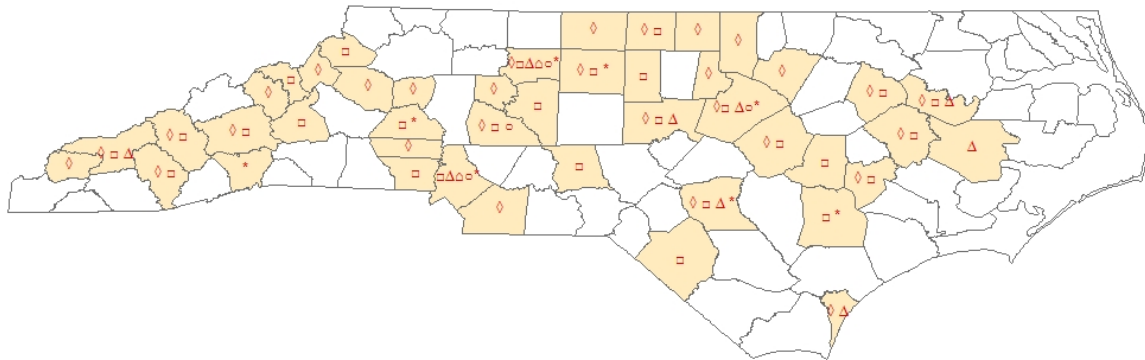
sampling sites once every six days to replace sample media and check the operation and calibration of monitors. Personnel check continuous monitors at least twice monthly for correct instrument operation.

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.

**Shaded counties have monitors.**



Monitor Location:    ◇ O3    □ PM2.5    ○ CO    △ SO2    ▽ NO2    \* PM10

**Figure 4.1 Monitoring Sites Active in 2009**



**Table 4.1 Ambient Air Monitoring Sites Operated in North Carolina, 2009**

SITE	ADDRESS	POLLUTANTS		
COUNTY				
37-001-0002 ALAMANCE	827 S GRAHAM & HOPEDALE RD BURLINGTON	PM2.5		
37-003-0004 ALEXANDER	106 WAGGIN TRAIL RD TAYLORSVILLE	O3		
37-011-0002 AVERY	7510 BLUE RIDGE PARKWAY SPUR LINVILLE	O3		
37-013-0007 BEAUFORT	1945 SANDY FORKS RD AURORA	SO2		
37-021-0030 BUNCOMBE	ROUTE 191 SOUTH BREVARD RD ASHEVILLE	O3		
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	PM2.5		
37-027-0003 CALDWELL	HWY 321 NORTH LENOIR	O3		
37-033-0001 CASWELL	7074 CHERRY GROVE RD REIDSVILLE	O3	PM2.5	CO
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	PM10	PM2.5	
37-037-0004 CHATHAM	325 RUSSETT RUN ROAD PITTSBORO	O3	PM2.5	SO2
37-051-0007 CUMBERLAND	CUMBERLAND CO ABC BOARD, 1705 OWEN CO DR FAYETTEVILLE			
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		

SITE COUNTY	ADDRESS	POLLUTANTS
37-057-0002 DAVIDSON	SOUTH SALISBURY STREET LEXINGTON	PM2.5
37-059-0002 DAVIE	246 MAIN STREET COOLEEMEE	O3
37-061-0002 DUPLIN	HIGHWAY 50 KENANSVILLE	PM2.5 PM10
37-063-0015 DURHAM	801 STADIUM DRIVE DURHAM	CO O3 PM2.5
37-065-0004 EDGECOME	900 SPRINGFIELD RD ROCKY MOUNT	PM2.5
37-065-0099 EDGECOME	7589 NC HIGHWAY 33 NW TARBORO	O3
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
37-067-0028 FORSYTH	6496 BAUX MOUNTAIN ROAD WINSTON-SALEM	O3
37-067-0030 FORSYTH	FRATERNITY CHURCH WINSTON-SALEM	O3 PM2.5
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

SITE COUNTY	ADDRESS	POLLUTANTS
37-081-0013 GUILFORD	205 WILOUGHBY BLVD GREENSBORO	PM2.5 PM10 O3
37-081-0014 GUILFORD	2127 SANDY RIDGE ROAD COLFAX	PM2.5
37-081-1011 GUILFORD	401 WEST WENDOVER GREENSBORO	CO
37-087-0004 HAYWOOD	2177 ASHEVILLE ROAD WAYNESVILLE	O3
37-087-0012 HAYWOOD	550 VANCE STREET WAYNESVILLE	PM2.5
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	O3
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	BARTNET KNOB FIRETOWER ROAD CHEROKEE	O3
37-099-0006 JACKSON	US ROUTE 19 NORTH CHEROKEE RESERVATION	PM2.5
37-101-0002 JOHNSTON	1338 JACK ROAD CLAYTON	O3 PM2.5
37-107-0004 LENOIR	HIGHWAY 70 EAST AND HIGHWAY 58 SOUTH KINSTON	O3 PM2.5
37-109-0004 LINCOLN	1487 RIVERVIEW ROAD LINCOLN	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

SITE COUNTY	ADDRESS	POLLUTANTS
37-119-0003 MECKLENBURG	FIRE STATION # 11, 620 WEST 28 <sup>TH</sup> STR CHARLOTTE	PM10
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	CO SO2 PM2.5 NO2 O3 PM10
37-119-0042 MECKLENBURG	1935 EMERYWOOD DRIVE CHARLOTTE	PM2.5 PM10
37-119-0043 MECKLENBURG	513 RADIO ROAD CHARLOTTE	PM2.5
37-119-1001 MECKLENBURG	FILTER PLANT DAVIDSON	PM10
37-119-1005 MECKLENBURG	400 WESTINGHOUSE BLVD. CHARLOTTE	O3 PM10
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
37-135-0007 ORANGE	MASON FARM ROAD CHAPEL HILL	PM2.5
37-145-0003 PERSON	STATE HIGHWAY 49 SOUTH ROXBORO	O3
37-147-0005 PITT	851 HOWELL STREET GREENVILLE	PM2.5
37-147-0006 PITT	403 GOVERNMENT CIRCLE GREENVILLE	O3 PM2.5
37-155-0005	1170 LINKHAW ROAD	PM2.5

SITE	ADDRESS	POLLUTANTS				
COUNTY						
ROBESON	LUMBERTON					
37-157-0099 ROCKINGHAM	6371 NC 65 @ BETHANY SCHOOL BETHANY	O3				
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVENUE ROCKWELL	CO	O3	PM2.5		
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			
37-179-0003 UNION	701 CHARLES STREET MONROE	O3				
37-183-0014 WAKE	3801 SPRING FOREST ROAD RALEIGH	O3	PM2.5	PM10	SO2	CO
37-183-0016 WAKE	201 NORTH BROAD STREET FUQUAY-VARINA	O3				
37-183-0018 WAKE	US HIGHWAY 70 WEST AND NC HIGHWAY 50 NORD RALEIGH	CO				
37-183-0020 WAKE	3720 LAKE WHEELER RD RALEIGH	PM2.5				
37-189-0003 WATAUGA	361 JEFFERSON ROAD BOONE	PM2.5				
37-191-0005 WAYNE	DILLARD MIDDLE SHOOL, DEVEREAU STREET GOLDSBORO	PM2.5				
37-199-0004 YANCEY	STATE HIGHWAY 128 BURNSVILLE	O3				
Sites operated in 2009	71					

## 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 2009 ambient air quality report were collected at 112 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 112 monitors used for this report operated most recently in 2008 or 2007.

### **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  $40\pm 4$  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. The agencies did not collect TSP samples in 2009, but in 2006 seven sites were used to monitor TSP and 361 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 2006. The highest 24-hour average was 69  $\mu\text{g}/\text{m}^3$ , which was 46 percent of the standard. This value occurred at the 6028 Holly Shelter Road site in Castle Hayne. 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 29  $\mu\text{g}/\text{m}^3$ , which is 39 percent of the level of the air quality standard. This value occurred at the 1650 1<sup>st</sup> Street site in Hickory and 205 Willoughby Boulevard site in Greensboro.

**Table 5.1 Total Suspended Particulates in Micrograms Per Cubic Meter for 2006**

SITE NUMBER COUNTY	ADDRESS	NUM OBS	24-HOUR MAX				ARITH MEAN	GEOM MEAN	GEOM SD
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>			
37-035-0004 CATAWBA	1650 1 <sup>ST</sup> STREET HICKORY	53	68	60	55	53	33	29	1.7
37-081-0013 GUILFORD	205 WILLOUGHBY BLVD GREENSBORO	42	65	55	52	52	32	29	1.6
37-087-0011 HAYWOOD	PROSPECT AND NORTHSIDE STR CANTON	58	62	50	50	49	29	26	1.7
37-117-0001 MARTIN	1210 HAYES STREET JAMESVILLE	60	46	43	37	35	22	20	1.4
37-129-0002 NEW HANOVER	6028 HOLLY SHELTER RD CASTLE HAYNE	56	69	40	36	35	21	19	1.6
37-155-0005 ROBESON	1170 LINKHAW ROAD LUMBERTON	56	57	49	48	43	28	25	1.7
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	36	65	58	52	51	34	32	1.5
Total Samples		361							
Total Sites Sampled		7							

## 5.2 $PM_{10}$

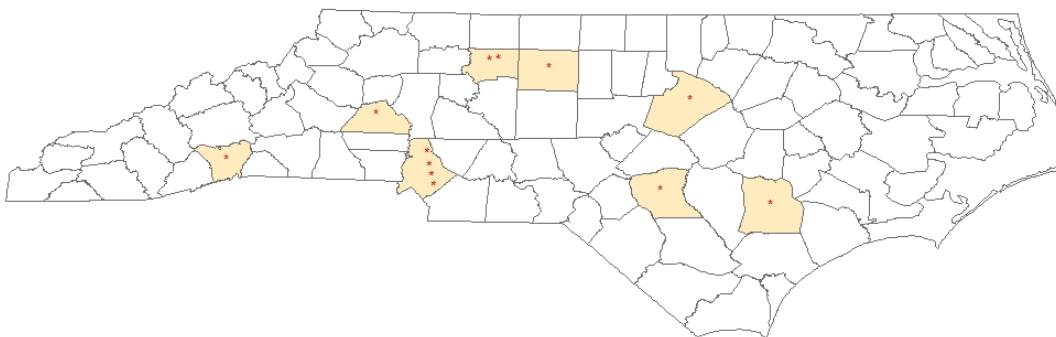
State and local program agencies in North Carolina use high volume samplers and size selective inlets to collect  $PM_{10}$  samples. A gravimetric analysis procedure (EPA Reference Method) is used to analyze the samples.

In 2009, 1,527 ordinary 24-hour samples of  $PM_{10}$  were collected from monitors located at 13 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 2009. The

highest 24-hour maximum concentration was  $56 \mu\text{g}/\text{m}^3$ , or about 37 percent of the standard ( $150 \mu\text{g}/\text{m}^3$ ). The highest annual arithmetic mean was  $22.4 \mu\text{g}/\text{m}^3$ , which is about 45 percent of the standard ( $50 \mu\text{g}/\text{m}^3$ ).

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.)



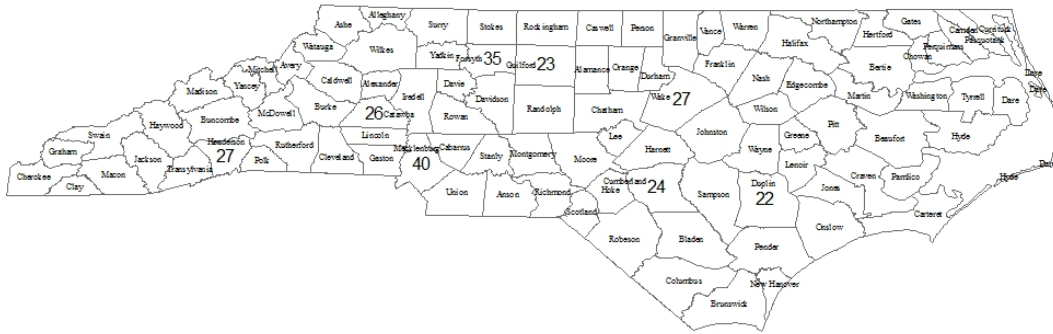
**Figure 5.1 Location of  $PM_{10}$  Monitoring Sites**



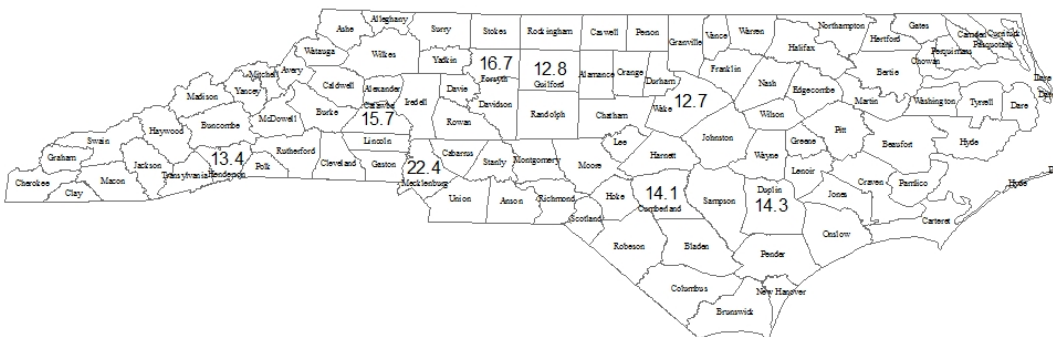
**Table 5.2 PM<sub>10</sub> in Micrograms Per Cubic Meter for 2009**

SITE NUMBER COUNTY	ADDRESS	NUM OBS	24-HOUR MAXIMA				ARITH MEAN
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	
37-035-0004 CATAWBA	1650 1ST. ST. HICKORY	58	36	26	25	25	15.7
37-051-0009 CUMBERLAND	4533 RAEFORD ROAD FAYETTEVILLE	61	25	24	22	22	14.1
37-061-002 DUPLIN	HWY 50 KENANVILLE	46	24	22	21	20	14.3
37-067-0022 FORSYTH	1300 BLK. HATTIE AVE WINSTON-SALEM	365	32	31	30	28	13.8
37-067-0023 FORSYTH	1401 CORPORATION PARKWAY WINSTON-SALEM	365	37	35	35	34	16.7
37-081-0013 GUILFORD	205 WILOUGHBY BLVD GREENSBORO	54	25	23	21	21	12.8
37-089-1006 HENDERSON	CORNER OF ALLEN & WASHINGTON STS HENDERSON-VILLE	53	30	27	26	21	13.4
37-119-0003 MECKLENBURG	FIRE STA #11 620 MORETZ STREET CHARLOTTE	56	44	38	32	31	20.5
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	116	29	28	28	27	15.5
37-119-0042 MECKLENBURG	1935 EMERYWOOD DRIVE CHARLOTTE	116	56	39	33	29	17.2
37-119-1001 MECKLENBURG	FILTER PLANT DAVIDSON	54	35	33	29	29	18.1
37-119-1005 MECKLENBURG	400 WESTINGHOUSE BLVD. CHARLOTTE	61	45	40	35	35	22.4
37-183-0014* WAKE	3801 SPRING FOREST RD. RALEIGH	122	28	27	27	26	13.7
Total Samples		1,527					
Total Sites Sampled		13					

\*Two different monitor covered the year, overlapping for two months.



**Figure 5.2 PM<sub>10</sub>: Second Highest 24-Hour Averages, 2009**



**Figure 5.3 PM<sub>10</sub>: Maximum Annual Arithmetic Means, 2009**

### 5.3 Fine Particulate Matter, (PM<sub>2.5</sub>)

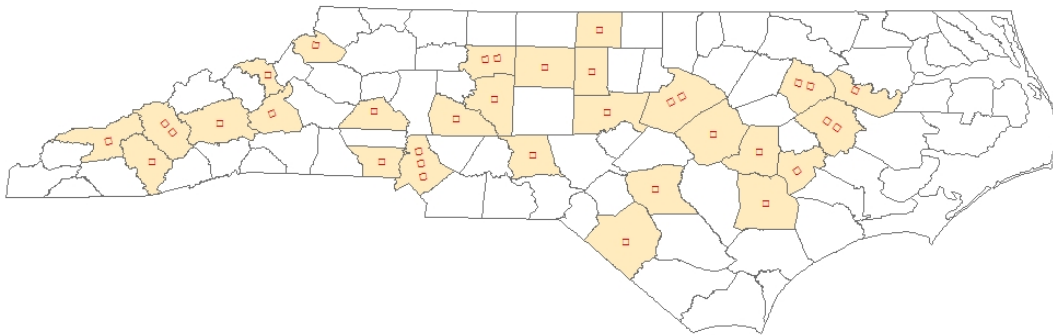
In 2009, 34 sites were used to monitor PM<sub>2.5</sub> and 5,176 samples were collected. A map of the PM<sub>2.5</sub> sampling sites is shown in Figure 5.4 and a detailed summary of the data from each site is given in Table 5.3.

There were no exceedances of the PM<sub>2.5</sub> 24-hour ambient air quality standards in 2009. The highest annual arithmetic mean was 10.71 µg/m<sup>3</sup>, which is about 29 percent below the level of the standard (15 µg/m<sup>3</sup>), at Chalotte in Mecklenburg County. (See Table 5.3).

NAAQS attainment is based on both the level of the 98<sup>th</sup> percentile concentration of 24 hour averages and weighted annual means (Table 3.1). The 98<sup>th</sup> 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 98<sup>th</sup> 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<sub>2.5</sub>, computed from the highest 3-year average arithmetic mean in each county for 2007 through 2009, using the federal reference method monitors. Thirty-one counties have enough reported data to compute this metric correctly, and two appear to be violating the ambient standard Catawba and Davidson. Attainment decisions for PM<sub>2.5</sub> will be based on the design values observed during 2007 through 2009.



**Figure 5.4 Location of PM<sub>2.5</sub> Monitoring Sites**

**Table 5.3 PM<sub>2.5</sub> in Micrograms Per Cubic Meter for 2009**

SITE NUMBER	ADDRESS	NUM OBS	24-HOUR MAXIMA				PERCENTILE	ARITH MEAN
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	98TH	
37-001-0002 ALAMANCE	827 S. GRAHAM & HOPEDALE RD BURLINGTON	117	22.3	20.9	19.9	19.6	19.9	9.58
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	118	20.1	18.9	18.1	17.2	18.1	8.46
37-033-0001 CASWELL	7074 CHERRY GROVE RECREATION	55	17.9	17.9	14.2	13.4	17.9	8.26
37-035-0004 CATAWBA	1650 1ST. ST. HICKORY	332	29.4	23.6	22.9	22.3	20.7	10.26
37-037-0004 CHATHAM	325 RUSSETT PITTSBORO	119	18.7	18.5	18.2	17.8	18.2	8.27
37-051-0009 CUMBERLAND	4533 RAEFORD ROAD FAYETTEVILLE	112	21.5	20.5	20.1	19.7	20.1	9.65
37-057-0002 DAVIDSON	SOUTH SALISBURY STREET LEXINGTON	119	23.7	22.8	20.7	19.1	20.7	10.61
37-061-0002 DUPLIN	HWY 50 KENANSVILLE	108	19.8	17.8	16.8	16.2	16.8	8.22
37-063-0015 DURHAM	801 STADIUM DRIVE DURHAM	115	21.4	19.5	18.8	18.2	18.8	9.75
37-065-0004 EDGECOMBE	900 SPRINGFIELD ROCKY MOUNT	117	20.0	18.9	17.0	16.8	17.0	8.59
37-067-0022 FORSYTH	1300 BLOCK, HATTIE AVENUE WINSTON-SALEM	332	23.6	23.0	22.4	22.0	21.0	9.59
37-067-0030 FORSYTH	FRATERNITY CHURCH ROAD WINSTON-SALEM	112	22.6	21.8	21.2	20.8	21.2	9.70
37-071-0016 GASTON	1622 EAST GARRISON BLVD GASTONIA	115	20.6	20.6	20.5	19.9	20.5	10.16
37-081-0013 GUILFORD	205 WILOUGHBY BLVD GREENSBORO	354	22.6	22.2	21.6	21.6	20.3	9.31
37-081-0014 HAYWOOD	2127 SANDY RIDGE ROAD WAYNESVILLE	121	22.5	21.9	21.5	20.2	21.5	9.63
37-087-0012	550 VANCE STREET	120	22.5	21.6	20.8	20.8	20.8	9.34

SITE NUMBER	ADDRESS	NUM OBS	24-HOUR MAXIMA				PERCENTILE	ARITH MEAN
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	98TH	
HAYWOOD	WAYNESVILLE							
37-099-0006 JACKSON	US RT 19 NORTH CHEROKEE	117	20.5	16.3	15.6	15.5	15.6	8.50
37-101-0002 JOHNSTON	1338 JACK ROAD CLAYTON	111	19.7	19.0	16.7	16.5	16.7	8.75
37-107-0004 LENOIR	CORNER HWY 70 EAST KINSTON	117	27.0	19.6	19.0	17.1	19.0	8.51
37-111-0004 MC DOWELL	BALDWIN AVE MARION	120	21.0	18.9	17.4	17.4	17.4	9.26
37-117-0001 MARTIN	1210 HAYES ST JAMESVILLE	115	22.3	18.0	16.8	16.4	16.8	8.06
37-119-1041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	351	26.1	25.0	24.3	24.0	21.2	10.25
37-119-1042 MECKLENBURG	1935 EMERYWOOD DRIVE CHARLOTTE	114	21.9	21.7	20.9	20.4	20.9	10.71
37-119-0043 MECKLENBURG	513 RADIO ROAD CHARLOTTE	354	25.5	23.7	23.0	22.8	20.6	10.03
37-121-0001 MITCHELL	CITY HALL SUMMIT ST SPRUCE PINE	112	20.1	19.7	18.2	17.6	18.2	9.02
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	103	20.1	18.9	18.3	18.2	18.3	8.80
37-147-0006 PITT	403 GOVERNMENT CIRCLE	115	21.8	18.4	18.2	18.0	18.2	8.70
37-155-0005 ROBESON	1170 LINKHAM ROAD LUMBERTON	117	20.1	19.8	19.6	18.7	19.6	9.36
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	118	21.0	20.2	18.8	18.7	18.8	10.33
37-173-0002 SWAIN	CENTER ST/PARKS 7 REC FACILITY	118	18.1	17.1	16.7	16.0	16.7	8.66
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	337	24.1	22.9	22.0	21.0	19.9	9.20
37-183-0020 WAKE	3720 LAKE WHEELER RD	118	19.6	19.2	18.4	17.0	18.4	9.00
37-189-0003 WATAUGA	361JEFFERSON HWY	117	19.7	18.7	17.1	16.9	17.1	7.91

SITE NUMBER	ADDRESS	NUM OBS	24-HOUR MAXIMA				PERCENTILE	ARITH MEAN	
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	98 <sup>TH</sup>		
37-191-0005 WAYNE	BOONE DILLARD MIDDLE SCHOOL GOLDSBORO	56	20.3	18.3	17.8	17.7	18.3	9.75	
Total Samples		5,176							
Total Sites Sampled		34							

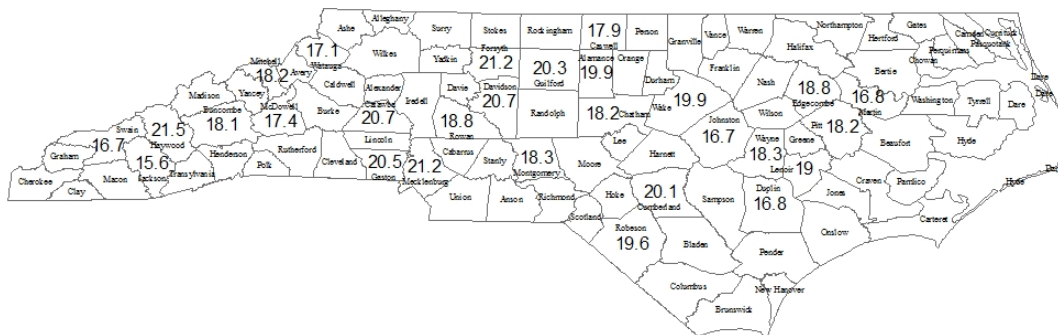


Figure 5.5 PM<sub>2.5</sub>: 98<sup>th</sup> Percentile, 2009

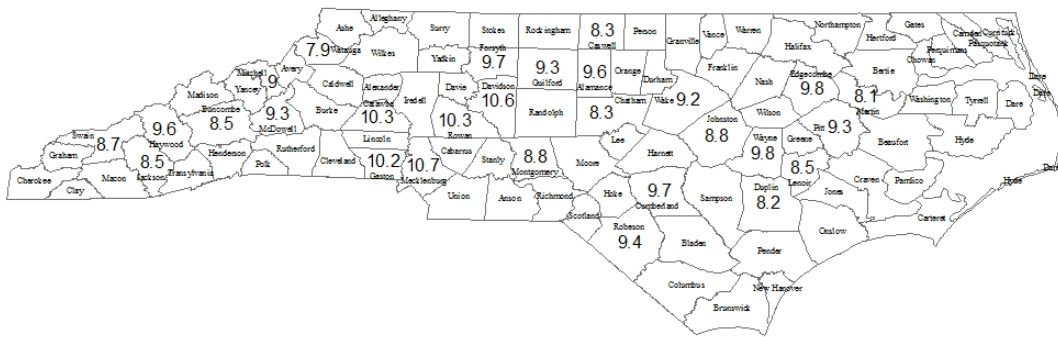


Figure 5.6 PM<sub>2.5</sub>: Annual Arithmetic Means, 2009

### North Carolina PM<sub>2.5</sub> Design Values 2007-2009

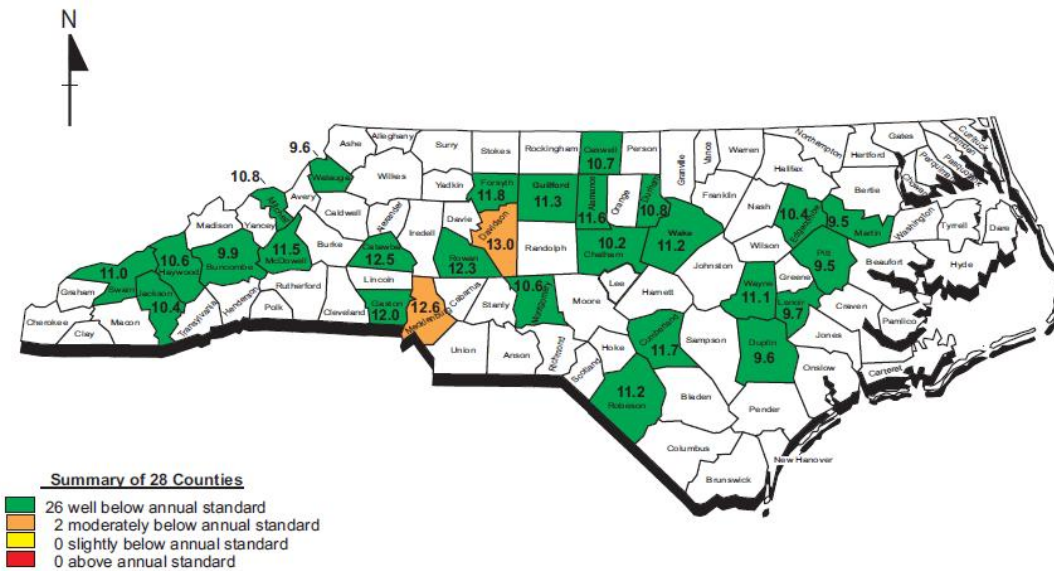


Figure 5.7 PM<sub>2.5</sub> Design Values by County, 2007-2009

N.C. DENR  
 Division of Air Quality/Statistical Services  
 using TIBCO Spotfire S+ (R)  
 Not to Scale  
 01 -12-2011

## 5.4 Carbon Monoxide

Carbon monoxide (CO) data were collected for two purposes in 2009: 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 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 2009, four sites were used to monitor CO and 25,260 valid hourly averages were collected. The data were collected from monitors:

- Charlotte, Winston-Salem-all year;
- Greensboro, Raleigh and Fayetteville – 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.

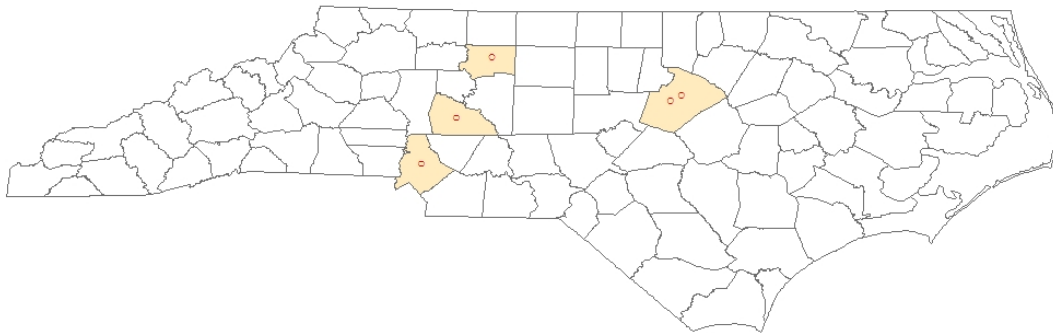
There were no exceedances of the CO ambient air quality standards in 2009. The highest 1-hour average was 3.9 parts per million (ppm), or about 11 percent of the standard (35 ppm). This value occurred at the 1401 Corporation Pky. site in

Winston-Salem (Forsyth County). The highest 8-hour average was 2.0 ppm, at the 1130 Eastway Drive site, which is about 22 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 48 counties [NC Dept of Environmental and Natural Resources, N.D]) 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.





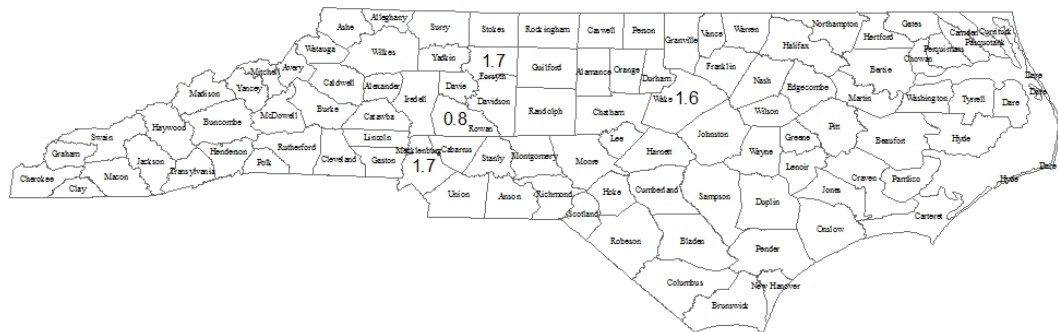
**Figure 5.8 Location of Carbon Monoxide Monitoring Sites**

**Table 5.4 Carbon Monoxide in Parts Per Million for 2009**

SITE NUMBER COUNTY	ADDRESS	NUM OBS	ONE-HOUR MAXIMA		EIGHT-HOUR MAXIMA	
			1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>
37-067-0023 FORSYTH	1401 CORPORATION PKY WINSTON-SALEM	8,709	3.9	2.3	1.8	1.7
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	8,654	2.2	2.1	2.0	1.7
37-183-0014 WAKE	3801 SPRING FOREST RD. RALEIGH	3,844	1.9	1.6	1.4	1.2
37-183-0018 WAKE	US HWY 70 WEST AND NC HWY 50 NORTH RALEIGH	4,053	2.3	2.3	1.6	1.6
Total Samples		25,260				
Total Sites Sampled		4				



**Figure 5.9 Carbon Monoxide: Second Highest 1-Hour Concentration, 2009**



**Figure 5.10 Carbon Monoxide: Second Highest Non-overlapping 8-Hour Concentration, 2009**

## 5.5 Ozone

Ozone (O<sub>3</sub>) 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, local and tribal program agencies operated 41 monitoring sites in 2009 during the ozone season, April through October. A map of the O<sub>3</sub> 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 41 monitoring sites provided 8,372 site-days of valid data (a success rate of 95 percent for the days that sampling is required).

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 one. (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.

There were no exceedances of the 1-hour ozone standard in North Carolina in 2009.

The 8-hour standard is exceeded at the monitoring site when any of the highest daily 8-hour averages in the same

calendar year are greater than 0.075 ppm. The 8-hour standard was exceeded total of 13 times at the 41 sites that monitored for O<sub>3</sub>. Eight monitors had at least one exceedance. The largest number at one monitor was three in Charlotte (Mecklenburg County) and Enochville (Rowan County). These exceedances were distributed over six days during the ozone season when at least one site within the state recorded values greater than 0.075 ppm. More information about dates and places of these ozone exceedances can be found online in [http://www.ncair.org/monitor/data/files/o3data\\_2009.pdf](http://www.ncair.org/monitor/data/files/o3data_2009.pdf) or [http://www.ncair.org/monitor/data/files/o3data\\_2009.xls](http://www.ncair.org/monitor/data/files/o3data_2009.xls).

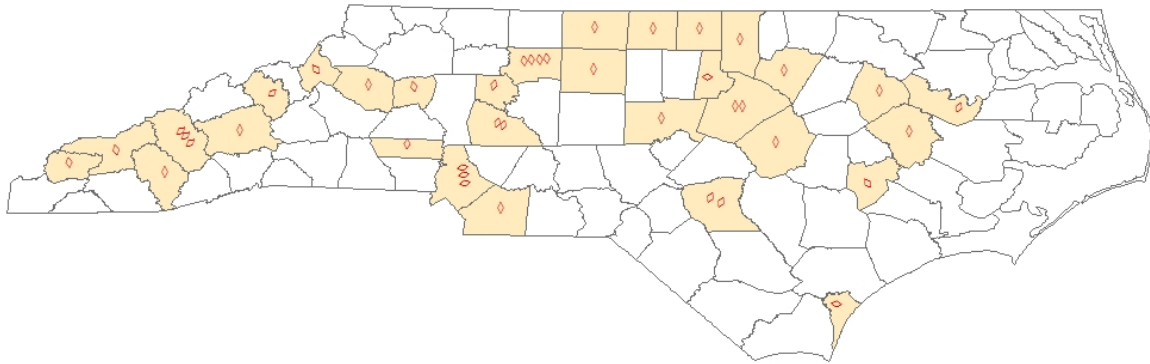
Moreover, when any ozone sampling day does not have a valid maximum ozone measurement for any reason, the missing day can be counted as an *estimated* exceedance day under certain circumstances [40 CFR 50 App. J, US EPA 1993, p. 767-768]. Table 5.5 gives both the actually measured and the estimated number of exceedance days at each site.)

The second highest 1-hour concentrations in each county are shown in Figure 5.12 for areas with one or more monitors active in 2009. 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<sub>3</sub> in counties where monitors were operated in 2009 are shown in Figure 5.13. Monitors whose fourth-highest 8-hour ozone

concentration (averaged over *three* years) exceeds 0.075 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 2009**

SITE NUMBER	ADDRESS	NUM	DAILY 1-HR MAXIMA				NO. VALUES > 0.125	
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	MEAS	EST
COUNTY		OBS						
37-003-0004	106 WAGGIN' TRAIL	4,920	.072	.071	.068	.067	0	0.00
ALEXANDER	TAYLORSVILLE							
37-011-0002	7510 BLUE RIDGE	5,088	.072	.070	.069	.066	0	0.00
AVERY	LINVILLE							
37-021-0030	ROUTE 191 SOUTH BREVARD RD	5,136	.081	.073	.071	.070	0	0.00
BUNCOMBE	ASHEVILLE							
37-027-0003	HWY 321 NORTH	5,112	.070	.070	.070	.070	0	0.00
CALDWELL	LENOIR							
37-033-0001	7074 CHERRY GROVE	5,112	.082	.079	.077	.074	0	0.00
CASWELL	REIDSVILLE							
37-037-0004	325 RUSSETT RUN ROAD	5,136	.080	.073	.070	.069	0	0.00
CHATHAM	PITTSBORO							
37-051-0008	1/4MI SR1857/US301/1857	5,136	.078	.075	.073	.072	0	0.00

SITE NUMBER	ADDRESS	NUM	DAILY 1-HR MAXIMA				NO. VALUES > 0.125	
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	MEAS	EST
COUNTY		OBS						
CUMBERLAND	WADE							
37-051-1003 CUMBERLAND	3625 GOLFVIEW ROAD HOPE MILLS	5,088	.084	.080	.075	.074	0	0.00
37-059-0002 DAVIE	246 MAIN STREET COOLEEMEE	5,040	.084	.082	.081	.075	0	0.00
37-063-0015 DURHAM	801 STADIUM DRIVE DURHAM	5,112	.079	.077	.072	.072	0	0.00
37-065-0099 EDGEcombe	7589 NC HWY 33-NW LEGGETT	5,136	.081	.074	.073	.071	0	0.00
37-067-0022 FORSYTH	1300 BLK. HATTIE AVENUE WINSTON-SALEM	5,112	.086	.080	.078	.076	0	0.00
37-067-0028 FORSYTH	6496 BAUX MOUNTAIN ROAD WINSTON-SALEM	5,136	.082	.075	.074	.070	0	0.00
37-067-0030 FORSYTH	FRATERNITY CHURCH ROAD WINSTON-SALEM	4,608	.069	.068	.068	.068	0	0.00
37-067-1008 FORSYTH	3656 PIEDMONT MEMORIAL DRIVE WINSTON-SALEM	4,368	.075	.075	.075	.074	0	0.00
37-069-0001 FRANKLIN	431 S. HILLBOROUGH ST FRANKLINTON	5,088	.077	.076	.076	.076	0	0.00
37-075-0001 GRAHAM	FOREST ROAD 423 SPUR KILMER	4,416	.077	.075	.073	.072	0	0.00
37-077-0001 GRANVILLE	WATER TREATMENT PLANT, JOHN UMSTEAD HOSPITAL BUTNER	5,136	.081	.080	.078	.076	0	0.00
37-081-0013 GUILFORD	205 WILOUGHBY BLVD GREENSBORO	5,136	.085	.084	.079	.079	0	0.00
37-087-0004 HAYWOOD	2177 ASHEVILLE ROAD WAYNESVILLE	5,136	.074	.071	.069	.069	0	0.00
37-087-0035	TOWER BLUE RIDGE PARKWAY	4,920	.082	.074	.072	.071	0	0.00

SITE NUMBER	ADDRESS	NUM	DAILY 1-HR MAXIMA				NO. VALUES > 0.125	
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	MEAS	EST
COUNTY		OBS						
HAYWOOD	MILE MARKER 410							
37-087-0036 HAYWOOD	GREAT SMOKY MOUNTAIN NATIONAL PARK	5,064	.072	.071	.069	.069	0	0.00
37-099-0005 JACKSON	BARNET KNOB FIRETOWER ROAD CHEROKEE	4,656	.068	.067	.067	.065	0	0.0
37-101-0002 JOHNSTON	1338 JACK ROAD CLAYTON	5,136	.074	.073	.073	.072	0	0.00
37-107-0004 LENOIR	CORNER HWY EAST KINSTON	5,136	.073	.071	.070	.069	0	0.00
37-109-0004 LINCOLN	1487 RIVERVIEW ROAD LINCOLNTON	5,136	.075	.073	.073	.072	0	0.00
37-117-0001 MARTIN	1210 HAYES STREET JAMESVILLE	5,136	.079	.072	.070	.068	0	0.00
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	5,136	.088	.087	.086	.083	0	0.00
37-119-1005 MECKLENBURG	400 WESTINGHOUSE BLVD. CHARLOTTE	5,136	.096	.082	.081	.079	0	0.00
37-119-1009 MECKLENBURG	29 N@ MECKLENBURG CAB CO CHARLOTTE	5,136	.090	.086	.086	.084	0	0.00
37-129-0002 NEW HANOVER	6028 HOLLY SHELTER RD CASTLE HAYNE	5,136	.068	.066	.065	.064	0	0.00
37-145-0003 PERSON	STATE HIGHWAY 49 SOUTH ROXBORO	5,136	.081	.080	.076	.074	0	0.00
37-147-0006 PITT	403 GOVERNMENT CIRCLE GREENVILLE	5,064	.075	.074	.072	.072	0	0.00
37-157-0099 ROCKINGHAM	6371 NC 65 @ BETHANY SCHOOL BETHANY	5,136	.085	.081	.078	.075	0	0.00
37-159-0021	301 WEST ST & GOLD HILL AVENUE	5,112	.092	.089	.087	.087	0	0.00

SITE NUMBER	ADDRESS	NUM	DAILY 1-HR MAXIMA				NO. VALUES > 0.125	
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	MEAS	EST
COUNTY		OBS						
ROWAN	ROCKWELL							
37-159-0022	925 N ENOCHVILLE AVE	5,064	.093	.089	.089	.088	0	0.00
ROWAN	CHINA GROVE							
37-173-0002	CENTER STREET	5,064	.071	.068	.067	.065	0	0.00
SWAIN	BRYSON CITY							
37-179-0003	701 CHARLES STREET	5,064	.103	.083	.081	.079	0	0.00
UNION	MONROE							
37-183-0014	3801 SPRING FOREST ROAD	5,112	.080	.079	.079	.077	0	0.00
WAKE	RALEIGH							
37-183-0016	201 NORTH BROAD STREET	5,040	.081	.080	.078	.075	0	0.00
WAKE	FUQUAY-VARINA							
37-199-004	STATE HIGHWAY 128	4,560	.076	.075	.070	.070	0	0.00
YANCY	BURNSVILLE							
Total Samples		206,232					0	0.00
Total Sites Sampled		41						

**Table 5.6 Eight-Hour Ozone in Parts Per Million for 2009**

SITE NUMBER	ADDRESS	VALID	VALID DAILY 8-HR MAXIMUM				NO. VALUES >.075 MEAS
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	
COUNTY		DAYS					
37-003-0004	106 WAGGIN' TRAIL	184	.068	.066	.066	.063	0
ALEXANDER	TAYLORSVILLE						
37-011-0002	7510 BLUE RIDGE	209	.067	.062	.062	.061	0
AVERY	LINVILLE						
37-021-0030	ROUTE 191 SOUTH BREVARD RD	214	.069	.066	.065	.064	0
BUNCOMBE	ASHEVILLE						
37-027-0003	HWY 321 NORTH	210	.067	.067	.065	.064	0
CALDWELL	LENOIR						
37-033-0001	7074 CHERRY GROVE RD	213	.071	.068	.067	.067	0
CASWELL	REIDSVILLE						
37-037-0004	325 RUSSETT RUN	214	.071	.063	.063	.063	0
CHATHAM	PITTSBORO						

SITE NUMBER	ADDRESS	VALID DAYS	VALID DAILY 8-HR MAXIMUM				NO. VALUES .>.075 MEAS
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	
37-051-0008 CUMBERLAND	1/4MI SR1857/US301/1857 WADE	199	.072	.065	.065	.065	0
37-051-1003 CUMBERLAND	3625 GOLFVIEW ROAD HOPE MILLS	200	.077	.071	.069	.066	1
37-059-0002 DAVIE	246 MAIN STREET COOLEEMEE	209	.070	.070	.070	.068	0
37-063-0015 DURHAM	801 STADIUM DRIVE DURHAM	209	.069	.069	.067	.066	0
37-065-0099 EDGEcombe	7589 NC HWY 33-NW LEGGETT	213	.071	.068	.068	.066	0
37-067-0022 FORSYTH	1300 BLK. HATTIE AVENUE WINSTON-SALEM	213	.078	.069	.068	.068	1
37-067-0028 FORSYTH	6496 BAUX MOUNTAIN RD WINSTON-SALEM	214	.075	.067	.066	.066	0
37-067-0030 FORSYTH	FRATERNITY CHURCH ROAD WINSTON-SALEM	192	.066	.063	.062	.062	0
37-067-1008 FORSYTH	3656 PIEDMONT MEMORIAL DRIVE WINSTON-SALEM	180	.072	.068	.068	.066	0
37-069-0001 FRANKLIN	431 S. HILLBOROUGH ST FRANKLINTON	205	.069	.069	.069	.064	0
37-075-0001 GRAHAM	FOREST ROAD 423 SPUR KLIMER	183	.071	.068	.066	.066	0
37-077-0001 GRANVILLE	WATER TREATMENT PLANT JOHN UMSTEAD HOSPITAL BUTNER	208	.073	.073	.071	.068	0
37-081-0013 GUILFORD	205 WILOUGHBY GREENSBORO	203	.075	.073	.073	.072	0
37-087-0004 HAYWOOD	2177 ASHEVILLE ROAD WAYNESVILLE	211	.067	.066	.063	.060	0
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	197	.070	.067	.066	.066	0
37-087-0036 HAYWOOD	GREAT SMOKY MOUNTAIN NATIONAL PARK	208	.067	.066	.066	.065	0
37-099-0005 JACKSON	BARNET KNOB FIRETOWER RD CHEROKEE	187	.066	.063	.063	.063	0
37-101-0002 JOHNSTON	1338 JACK ROAD CLAYTON	206	.067	.066	.066	.066	0
37-107-0004 LENOIR	CORNER HWY 70 EAST KINSTON	211	.067	.067	.067	.064	0
37-109-0004 LINCOLN	1487 RIVERVIEW ROAD LINCOLNTON	209	.067	.067	.065	.065	0
37-117-0001	1210 HAYES STREET	210	.069	.065	.064	.064	0



SITE NUMBER	ADDRESS	VALID DAYS	VALID DAILY 8-HR MAXIMUM				NO. VALUES .>.075 MEAS
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	
COUNTY							
MARTIN	JAMESVILLE						
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	208	.077	.076	.076	.069	3
37-119-1005 MECKLENBURG	400 WESTINGHOUSE BLVD. CHARLOTTE	207	.080	.072	.070	.068	1
37-119-1009 MECKLENBURG	29 N@ MECKLENBURG CAB CO CHARLOTTE	210	.080	.072	.072	.071	1
37-129-0002 NEW HANOVER	6028 HOLLY SHELTER RD CASTLE HAYNE	206	.063	.061	.060	.060	0
37-145-0003 PERSON	STATE HIGHWAY 49 SOUTH ROXBORO	207	.071	.070	.067	.065	0
37-147-0006 PITT	403 GOVERNMENT CIRCLE GREENVILLE	209	.067	.067	.066	.066	0
37-157-0099 ROCKINGHAM	6371 NC 65 @ BETHANY SCHOOL BETHANY	214	.071	.070	.070	.068	0
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	195	.079	.077	.073	.071	2
37-159-0022 ROWAN	925 N ENOCHVILLE AVE ENOCHVILLE	207	.078	.077	.076	.073	3
37-173-0002 SWAIN	CENTER STREET PARKS 7 REC FACILITY	203	.065	.064	.061	.060	0
37-179-0003 UNION	701 CHARLES STREET MONROE	206	.080	.073	.069	.067	1
37-183-0014 WAKE	E. MILLBROOK JR HI 3801 SPRING FOREST ROAD	201	.071	.069	.068	.068	0
37-183-0016 WAKE	201 NORTH BROAD STREET FUQUAY-VARINA	201	.074	.073	.070	.069	0
37-199-0004 YANCEY	NEW LOC MT MITCHELL BURNSVILLE	187	.068	.068	.066	.066	0
Total Samples		8,372					13
Total Sites Sampled		41					

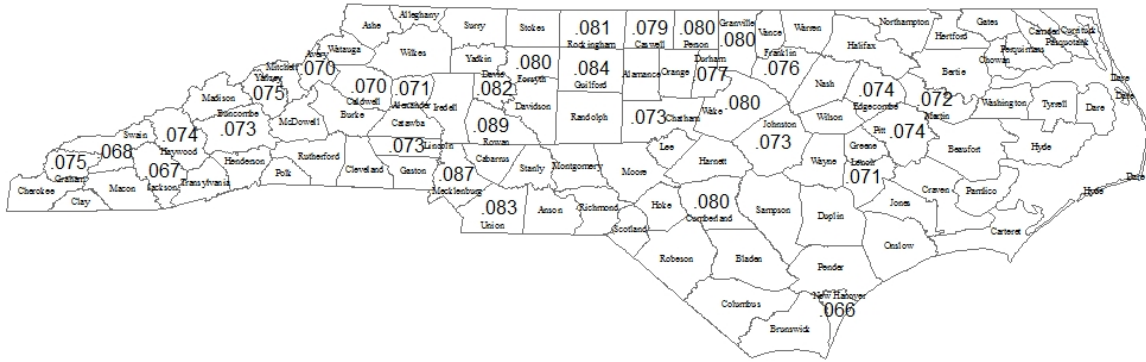
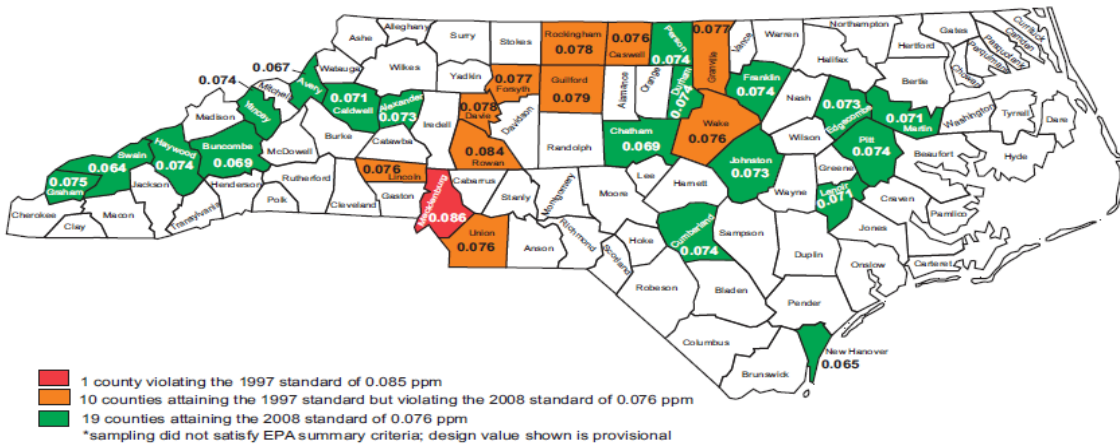


Figure 5.12 Ozone: Second Highest Annual 1-Hour Average, 2009

### North Carolina Counties with 8-Hour Ozone Violations, 2007-2009



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

N.C. DENR  
 DAQ/Statistical Services  
 using TIBCO Spotfire S+ (R)  
 Not To Scale  
 Thu Sep 23 15:48:46 EDT 2010  
 Revised Aug 10, 2011

Figure 5.13 Ozone: Mean Annual Fourth Highest 8-Hour Average, 2007-2009

## 5.6 Sulfur Dioxide

Sulfur dioxide (SO<sub>2</sub>) concentrations were measured by the state and two local program agencies using EPA reference or equivalent methods. Eight SO<sub>2</sub> monitors were active in North Carolina in 2009. Some SO<sub>2</sub> sites are operated only every third year. We supplemented this report with one monitor that operated last in 2008, (and will next be operated in 2011), and one monitor that operated last in 2007 (and will next be operated in 2010).

From the 10 sites with SO<sub>2</sub> data obtained between 2007 and 2009, 74,507 valid hourly averages were collected. A map of the active SO<sub>2</sub> sampling sites is presented in Figure 5.14 and a detailed summary of the data from each site is given in Table 5.7.

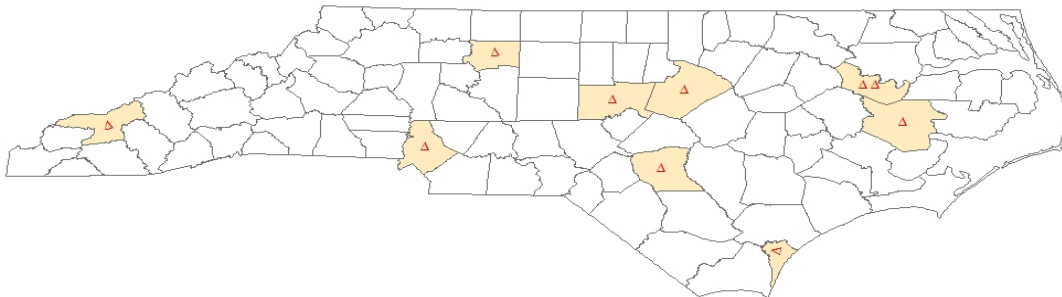
There were no exceedances of the 1971, SO<sub>2</sub> ambient air quality standards. The highest annual arithmetic mean was 4.33 ppb, or about 14 percent of the 1971 annual standard (30 ppb). The highest maximum 24-hour average was 42.5

ppb, about 30 percent of the 1971 24-hour standard (140 ppb).

Although the 2010 Standard was not in effect during 2009, there were 15 exceedances at one site, in New Hanover County, where the 99<sup>th</sup> percentile value of the daily maximum concentration was 99 ppb. These concentrations and the dates on which they occurred are listed in Table 5.8

Apparently, the size of an urban area has little effect on the ambient concentrations of SO<sub>2</sub> in North Carolina. Seasonal variations, such as those with CO and O<sub>3</sub>, do not appear to exist for SO<sub>2</sub>. Major source characteristics such as type, size, distribution, control devices, operating conditions and dispersion situations significantly affect the amount of SO<sub>2</sub> in ambient air.

The second highest one-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 2007, 2008 and 2009**

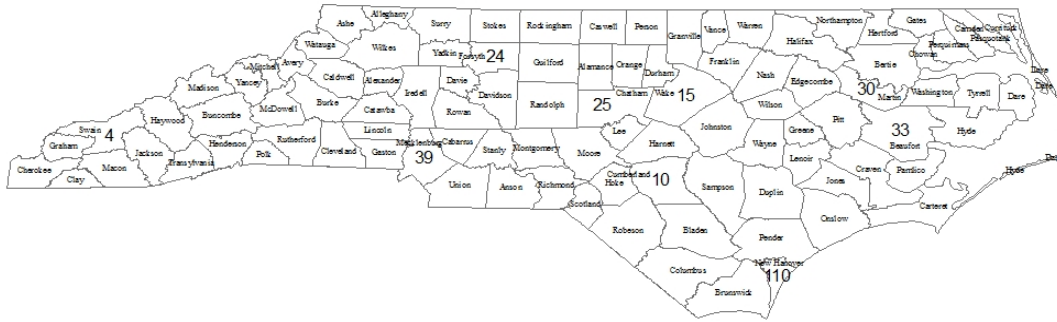
**Table 5.7 Sulfur Dioxide in Parts Per Billion from All Sites for 2007-2009**

SITE NUMBER	ADDRESS	NUM OBS	ONE-HOUR MAXIMA		24-HOUR MAXIMA		99 <sup>th</sup> percent ile	ARITH MEAN
			1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>		
2009								
37-013-0007 BEAUFORT	1645 SANDY LANDING AURORA	8,159	37.0	33.0	6.7	5.6	27.0	.63
37-051-1003 CUMBERLAND	3625 GOLFVIEW RD HOPE MILLS	8,314	11.0	10.0	4.3	4.2	10.0	1.11
37-067-0022 FORSYTH	1300 BLK. HATTIE AVE WINSTON-SALEM	8,085	24.0	24.0	10.3	10.2	18.0	4.16
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	8,352	62.2	39.4	6.3	6.3	26.1	.84
37-129-0006 NEW HANOVER	HIGHWAY 421 NORTH WILMINGTON	8,143	118.0	110.0	42.5	33.9	99.0	4.33
37-173-0002 SWAIN	30 RECREATION PARK DRIVE BRYSON CITY	1,285*	5.0*	4.0*	3.4*	1.6*	5.0*	.61*
37-183-0014 WAKE	3801 SPRING FOREST RD. RALEIGH	8,159	34.0	18.0	7.1	6.1	15.0	1.00
Total Samples		50,497						
Total Sites Sampled		7						
2008								
37-037-0004 CHATHAM	325 RUSSETT RUN ROAD WINSTON-SALEM	8,332	40.0	25.0	8.7	6.2		1.62
Total Samples		8,332						
Total Sites Sampled		1						
2007								
37-117-0001 MARTIN	1210 HAYES STREET JAMESVILLE	8,225	19.0	14.0	7.5	5.9		1.27
37-117-0002 MARTIN	33215 US HIGHWAY 64 JAMESVILLE	7,453	40.0	30.0	9.7	8.4		1.66
Total Samples		15,678						
Total Sites Sampled		2						

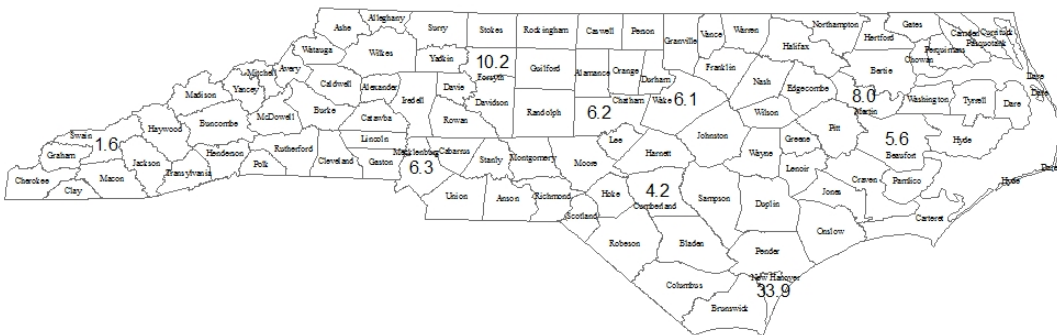
\* These statistics do not represent the full calendar year, but only the last two months.

**Table 5.8 Exceedances of the Sulfur Dioxide 2010 Standard in 2009**

SITE NUMBER COUNTY	CONCENTRATION	DATE
37-129-0006 NEW HANOVER	80	01/17
	118	02/15
	81	03/04
	110	03/24
	90	04/14
	84	05/12
	99	05/20
	84	06/27
	79	07/10
	79	09/01
	92	09/13
	101	09/18
	95	10/14
	82	10/20
	80	11/18
Total Exceedances	15	
Number of Sites with Exceedances	1	
Number of Days with Exceedances	15	



**Figure 5.15 Sulfur Dioxide: Second Highest 1-Hour Averages in the Most Recent Year of Data from 2007, 2008 or 2009**



**Figure 5.16 Sulfur Dioxide: Second Highest 24-Hour Averages in the Most Recent Year of Data from 2007, 2008 or 2009**

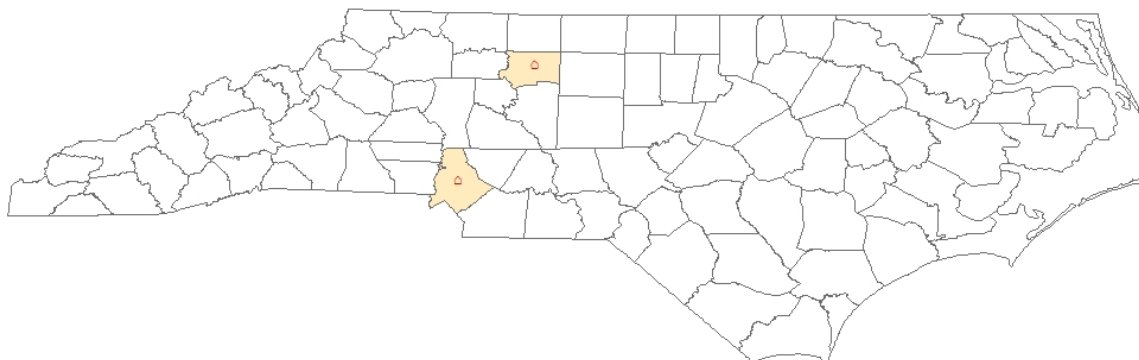
## 5.7 Nitrogen Dioxide

Nitrogen dioxide (NO<sub>2</sub>) concentrations were measured using EPA reference or equivalent continuous monitors in 2009 at one local program site in Forsyth County and one local program site in Mecklenburg County.

From these two sites, 12,886 hourly NO<sub>2</sub> measurements were reported. A map of the

NO<sub>2</sub> sampling sites is presented in Figure 5.17, and a summary of the 2009 NO<sub>2</sub> 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 24 percent of the standard.



**Figure 5.17 Location of Nitrogen Dioxide Monitoring Sites**

**Table 5.9 Nitrogen Dioxide in Parts Per Billion for 2009**

SITE NUMBER COUNTY	ADDRESS	NUM OBS	ONE-HOUR MAXIMA		ARITH MEAN
			1ST	2ND	
37-067-0022 FORSYTH	1300 BLK. HATTIE AVENUE WINSTON-SALEM	4,347	58.0	55.0	12.89
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	8,539	56.0	48.0	10.0
Total Samples		12,886			
Total Sites Sampled		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 2009.

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  $\mu\text{g}/\text{m}^3$ , 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  $\mu\text{g}$ ) 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  $\mu\text{g}/\text{m}^3$ , and 17 others exceeded 0.01  $\mu\text{g}/\text{m}^3$ .



## 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<sub>2.5</sub>, PM<sub>10</sub>, CO, O<sub>3</sub> (both 1 and 8 hour values), SO<sub>2</sub> and NO<sub>2</sub>. 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, in which 100 corresponds to the EPA primary standard for a 24-hour average (8-hour CO average, 1 and 8-hour O<sub>3</sub> 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 summer months in North Carolina the highest air quality index value tends to be attributed to ozone, but during winter months PM<sub>2.5</sub> predominates, except where carbon monoxide monitors are operated.

In 2009, 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 Asheville MSA, the AQI was not “*unhealthy for sensitive groups*” or “*unhealthy*” for any of the 363 days monitored.

Figure 6.1 shows the 2009 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 365 days monitored. All six of

these days occurred between June and September.

Figure 6.3 shows the 2009 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 one out of 365 days monitored. This day occurred in September.

Figure 6.5 shows the 2009 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 Goldsboro MSA, the AQI was not “*unhealthy for sensitive groups*” or “*unhealthy*” for any of the 359 days monitored.

Figure 6.7 shows the 2009 AQI time series for Goldsboro. 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 Goldsboro.

In the Greensboro-Winston-Salem-High Point MSA, the AQI was “*unhealthy for sensitive groups*” or “*unhealthy*” on three out of 365 days monitored. All three of these days occurred between June and September.

Figure 6.9 shows the 2009 AQI time series for Greensboro- Winston-Salem-High Point. 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 Greensboro-Winston-Salem-High Point

In the Greenville MSA, the AQI was not “*unhealthy for sensitive groups*” or “*unhealthy*” for any of the 269 days monitored.

Figure 6.11 shows the 2009 AQI time series for Greenville. 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 Greenville.

In the Hickory-Morganton-Lenoir MSA, the AQI was not “*unhealthy for sensitive groups*” or “*unhealthy*” for any of the 365 days monitored.

Figure 6.13 shows the 2009 AQI time series for Hickory-Morganton-Lenoir. Figure 6.14 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

Point MSA, the AQI was “*unhealthy for sensitive groups*” or “*unhealthy*” for any of the 365 days monitored.

Figure 6.15 shows the 2009 AQI time series for Raleigh-Durham-Chapel Hill. Figure 6.16 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 Rocky Mount MSA, the AQI was not “*unhealthy for sensitive groups*” or “*unhealthy*” for any of the 269 days monitored.

Figure 6.17 shows the 2009 AQI time series for Greenville. Figure 6.18 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 Greenville.

In the Wilmington MSA, the AQI was “*unhealthy for sensitive groups*” or “*unhealthy*” on 15 out of 365 days monitored. All 15 of these days occurred between January and November.

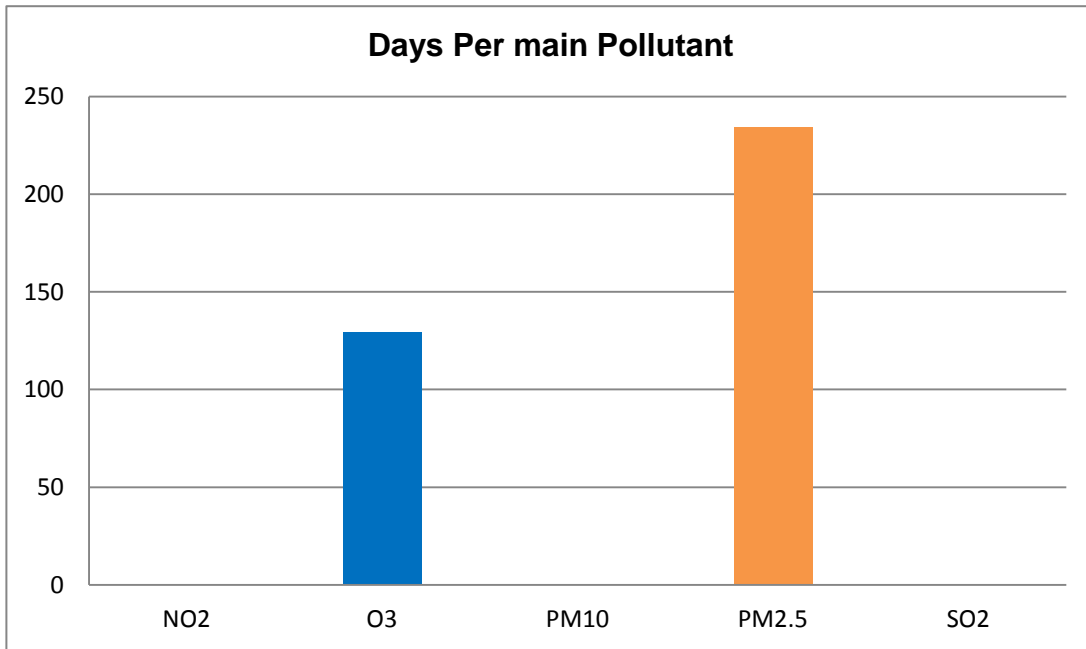
Figure 6.19 shows the 2009 AQI time series for Wilmington. Figure 6.20 shows summaries of the numbers of days each respective pollutant was

responsible for the AQI, the number of days the AQI was in each respective health category, and the percentile

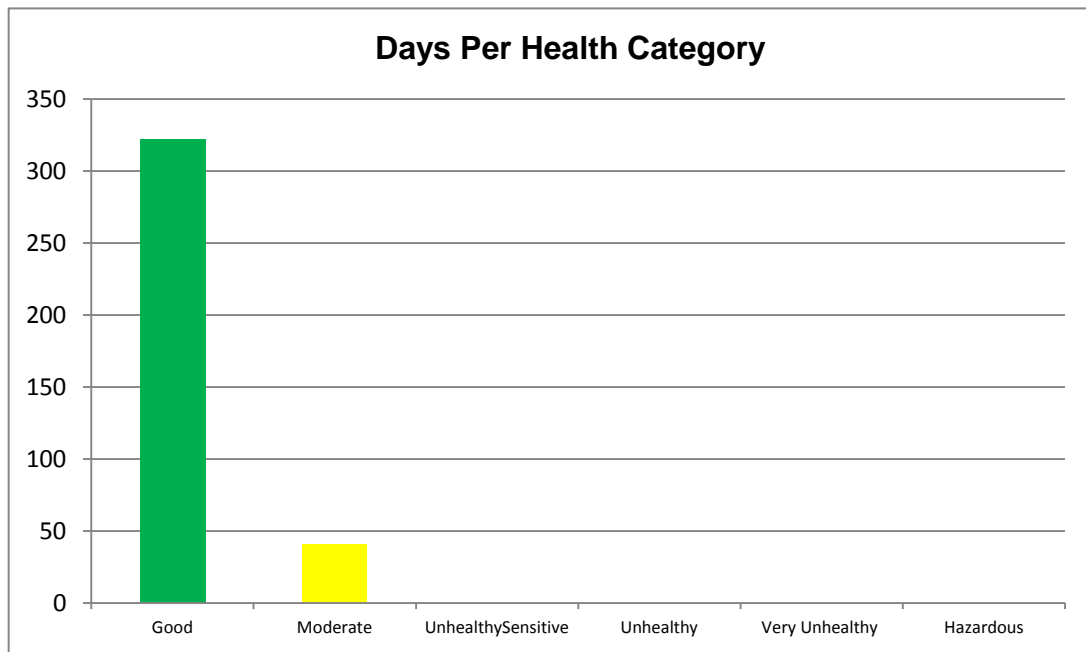
distribution for each health category for Wilmington.

**Table 6.1 Air Quality Index Category Days in the Major Metropolitan Statistical Areas, 2009**

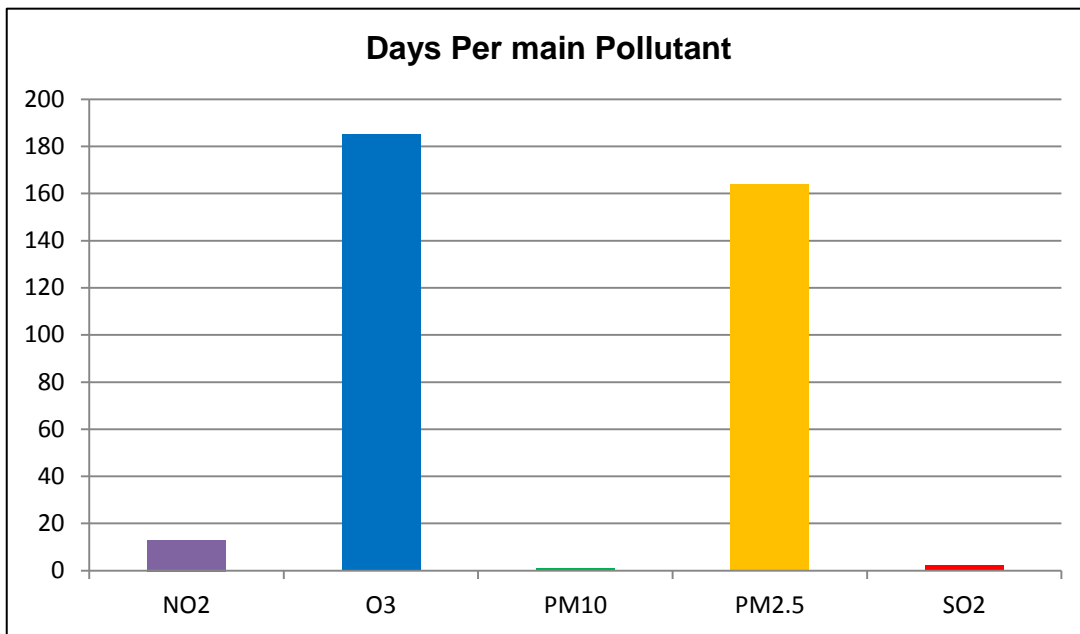
MSA	STATISTICAL TREATMENT	GOOD	MODERATE	UNHEALTHY FOR SENSITIVE GROUPS	UNHEALTHY
Asheville	actual	322	41	0	0
Charlotte	actual	246	113	6	0
Fayetteville	actual	305	59	1	0
Goldsboro	actual	321	38	0	0
Greensboro	actual	261	101	2	1
Greenville	actual	248	21	0	0
Hickory	actual	291	74	0	0
Raleigh	actual	289	76	0	0
Rocky Mount	actual	246	23	0	0
Wilmington	actual	252	98	15	0



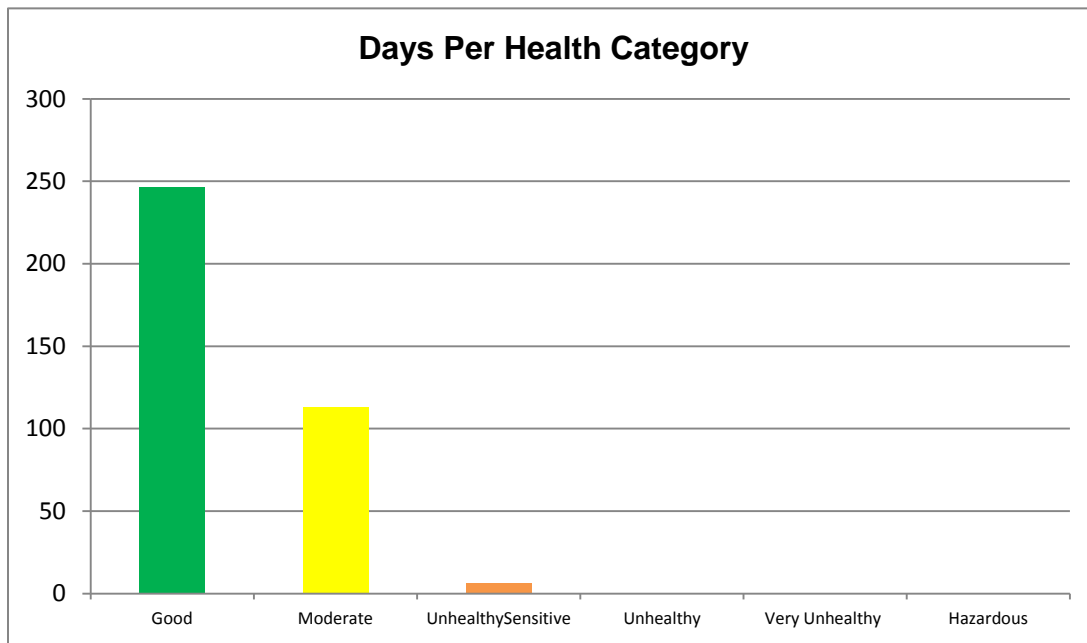
**Figure 6.1 Daily Air Quality Index Values for Asheville**



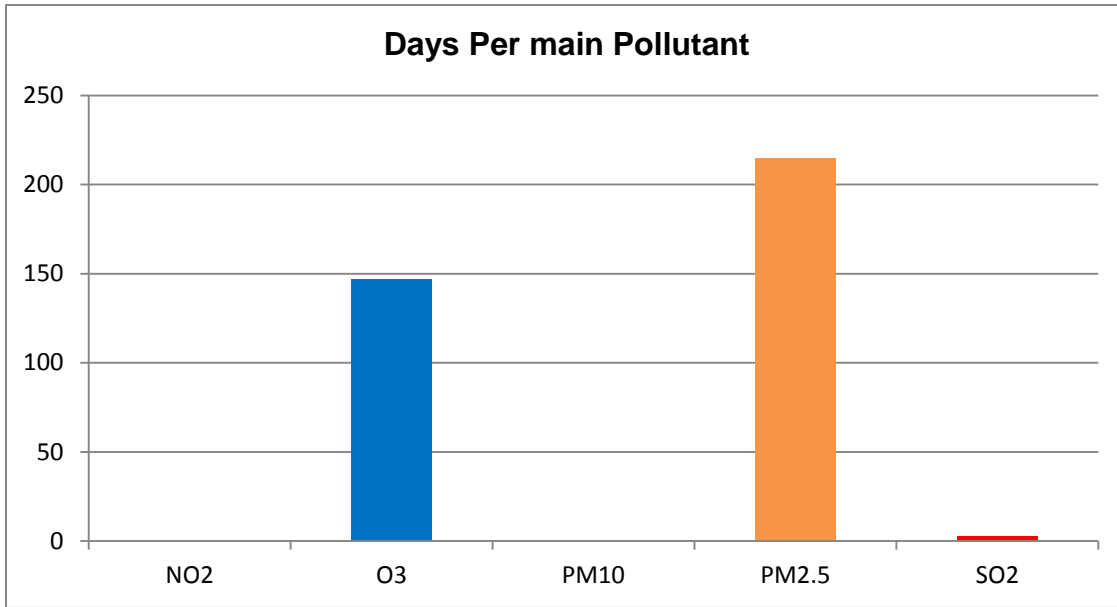
**Figure 6.2 Daily Air Quality Index Summary for Asheville**



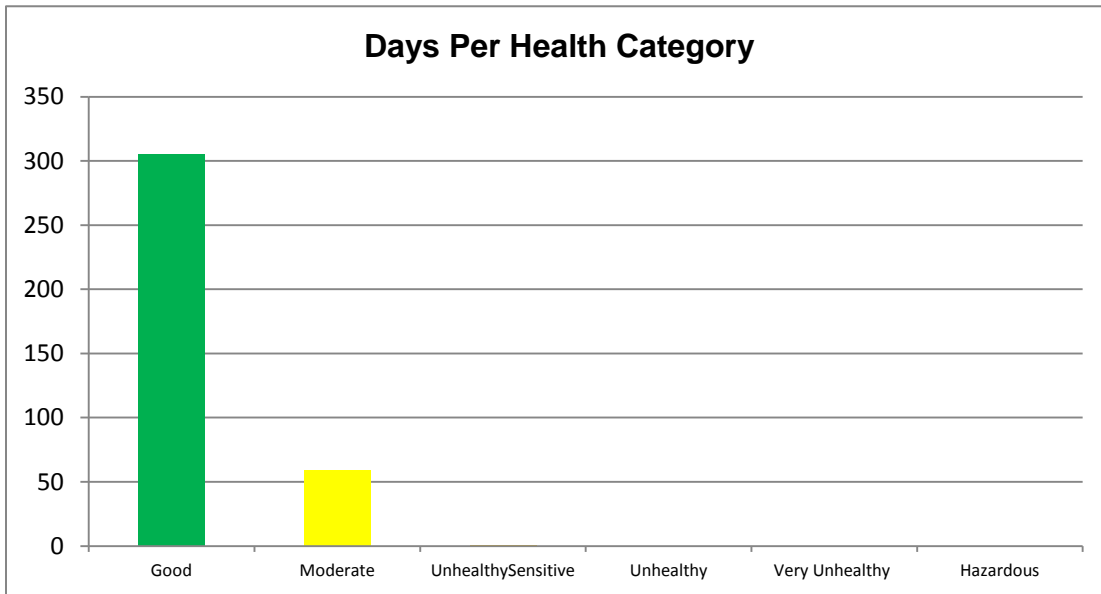
**Figure 6.3 Daily Air Quality Index Values for Charlotte-Gastonia**



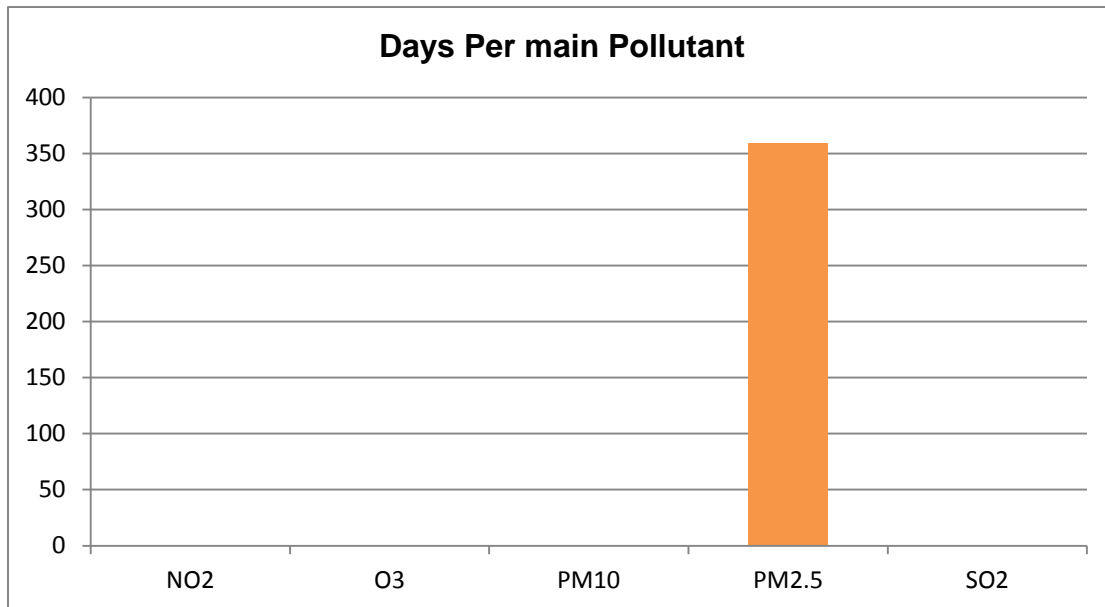
**Figure 6.4 Daily Air Quality Index Summary for Charlotte-Gastonia**



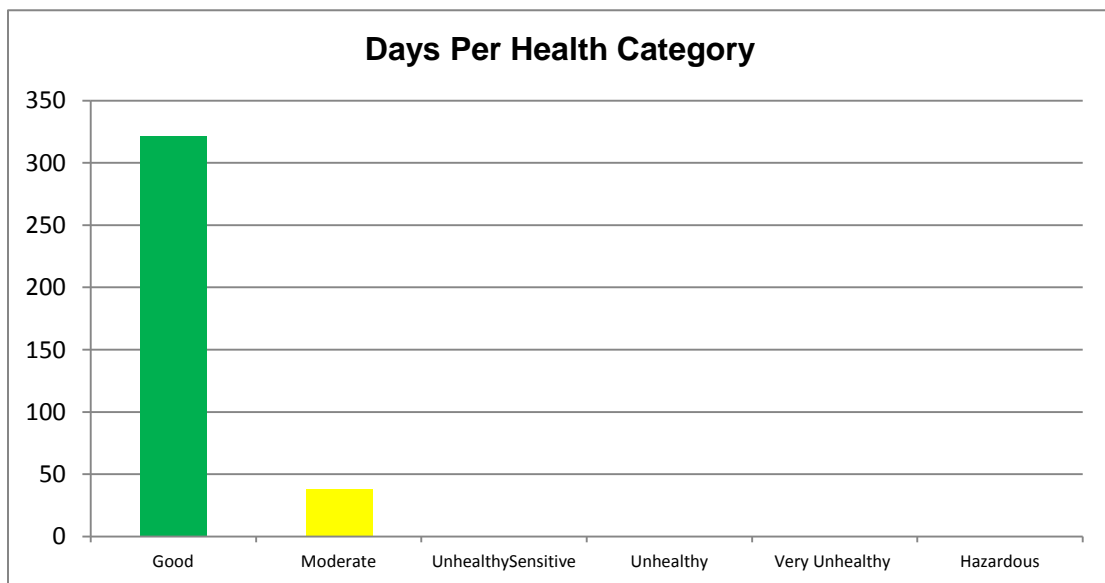
**Figure 6.5 Daily Air Quality Index Values for Fayetteville**



**Figure 6.6 Daily Air Quality Index Summary for Fayetteville**

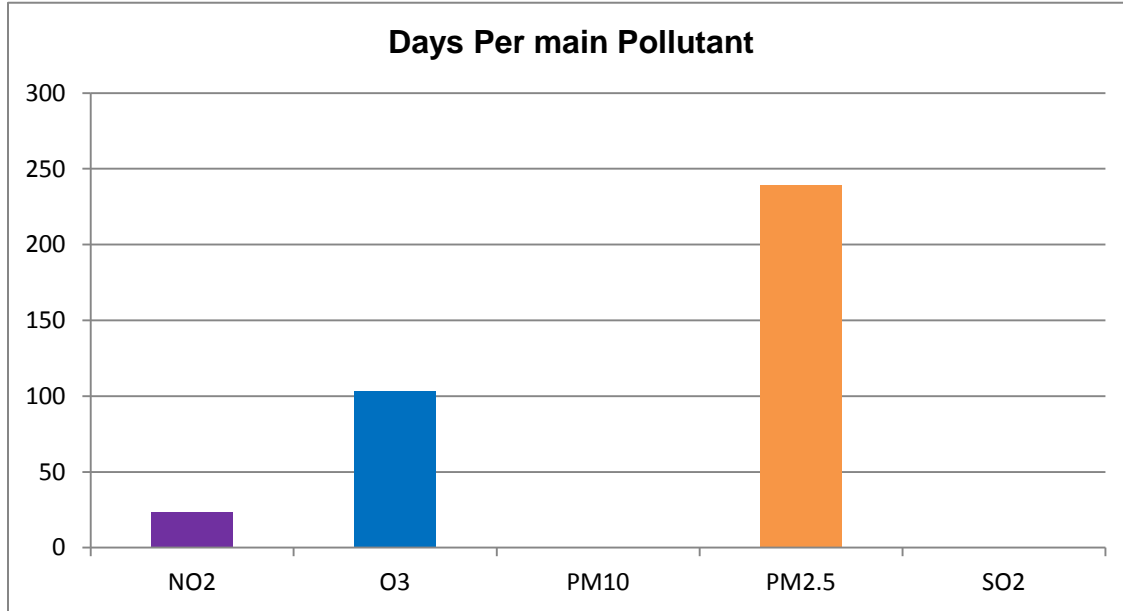


**Figure 6.7 Daily Air Quality Index Values for Goldsboro**

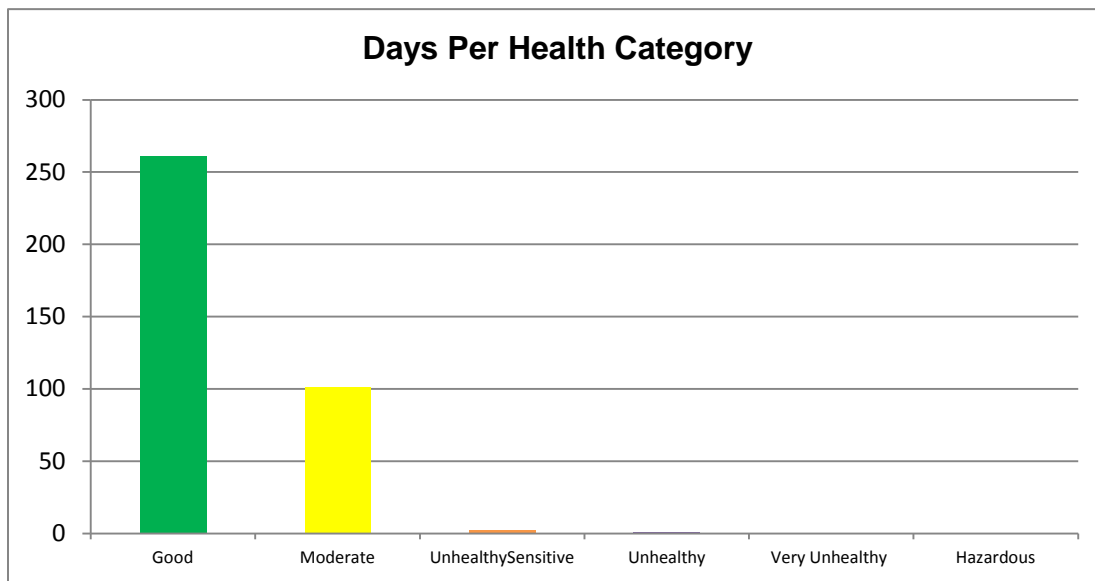


**Figure 6.8 Daily Air Quality Index Summary for Goldsboro**

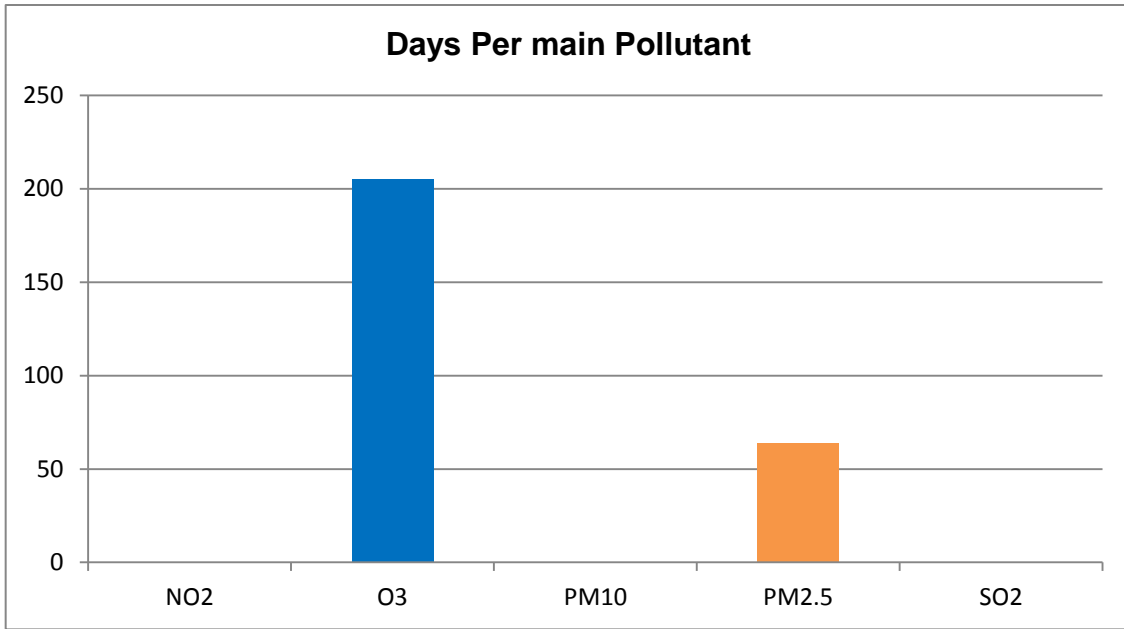




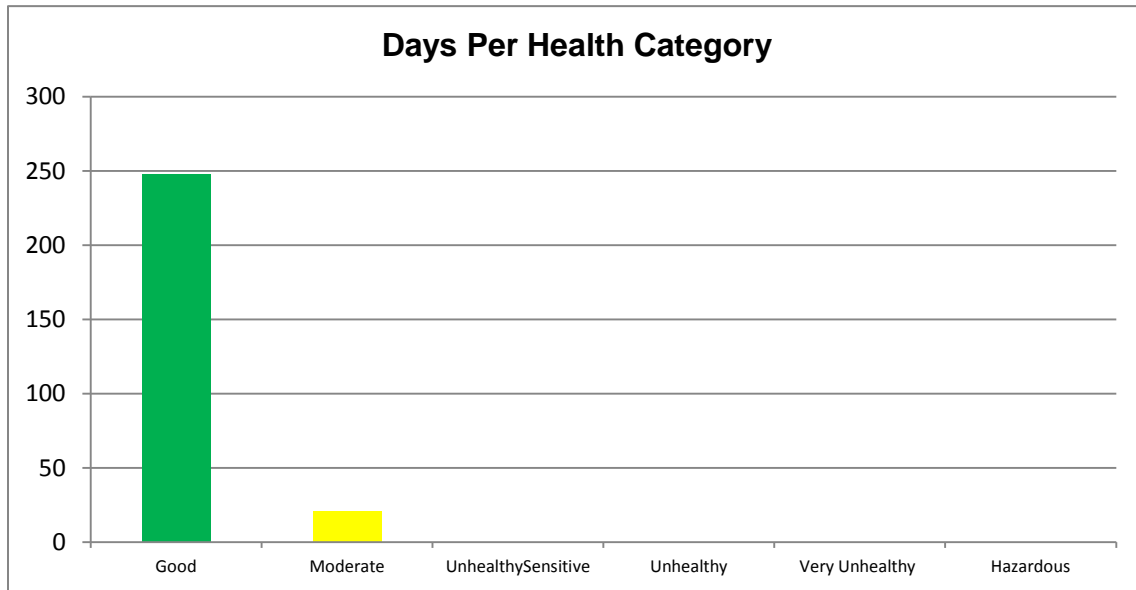
**Figure 6.9 Daily Air Quality Index Values for Greensboro-Winston-Salem-High Point**



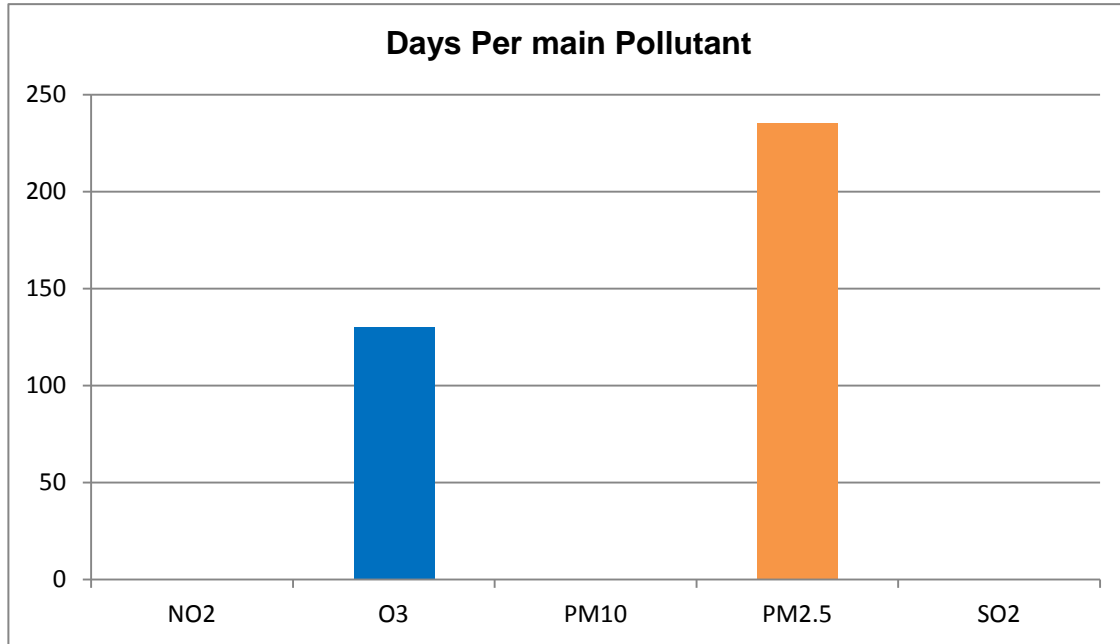
**Figure 6.10 Daily Air Quality Index Summary for Greensboro-Winston-Salem-High Point**



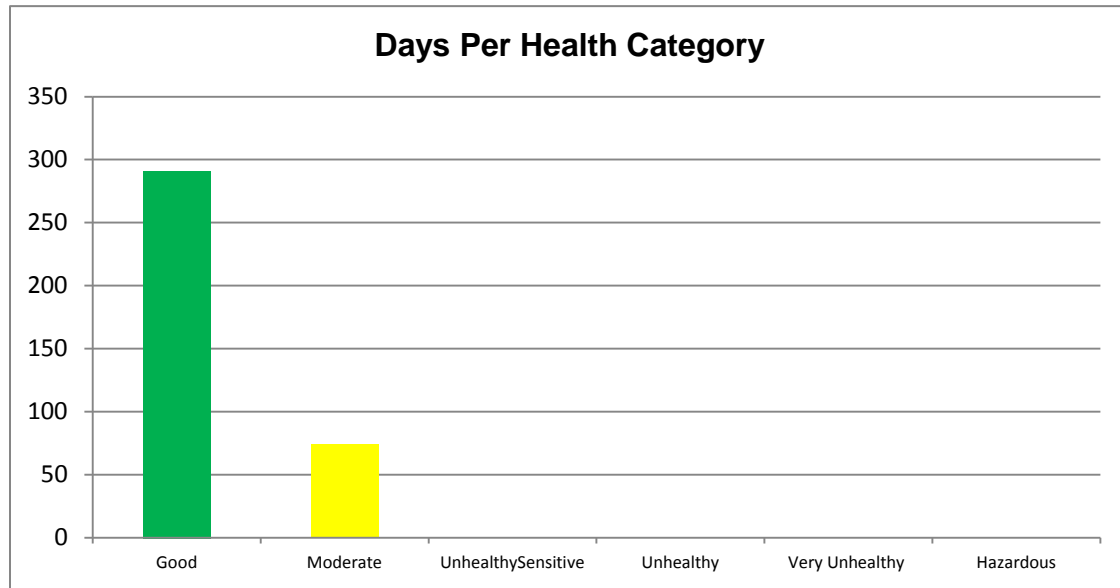
**Figure 6.11 Daily Air Quality Index Values for Greenville**



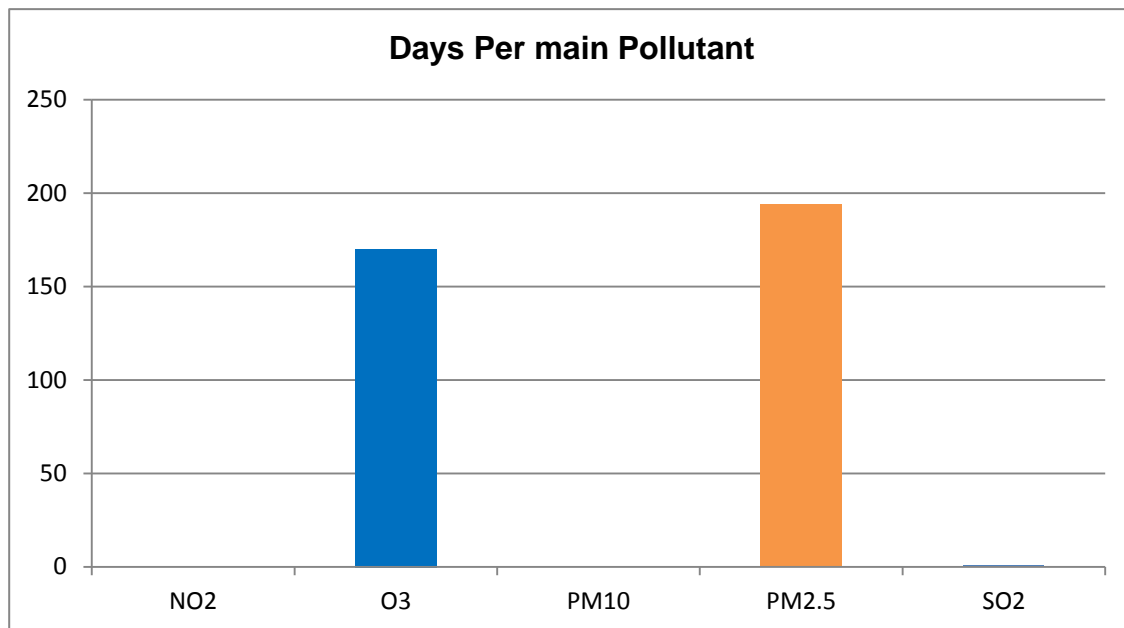
**Figure 6.12 Daily Air Quality Index Summary for Greenville**



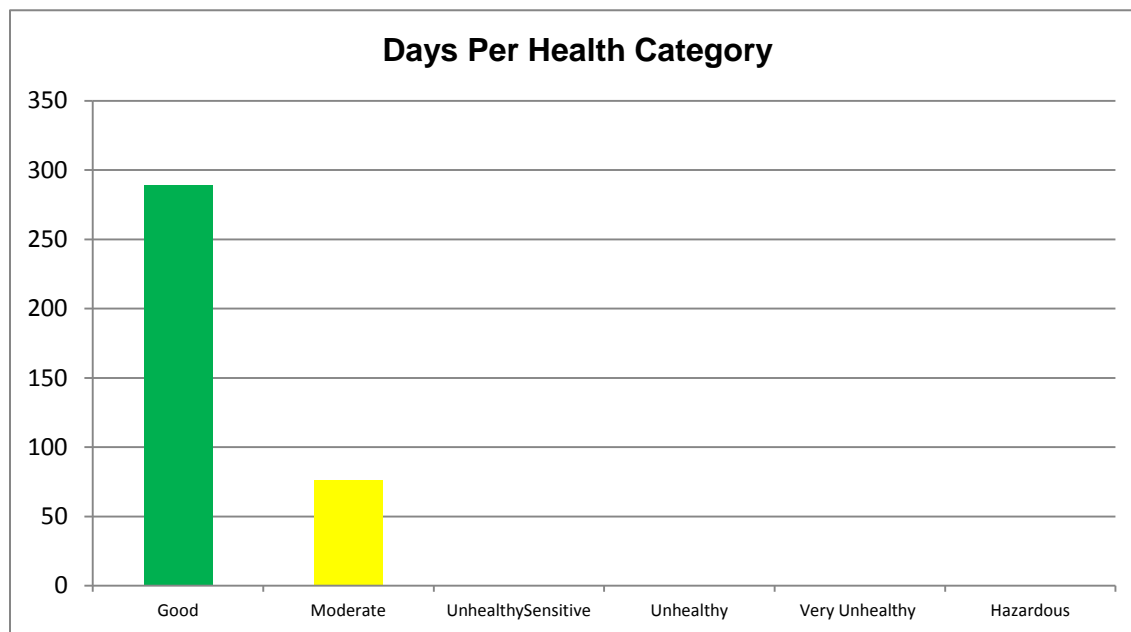
**Figure 6.13 Daily Air Quality Index Values for Hickory-Morganton-Lenoir**



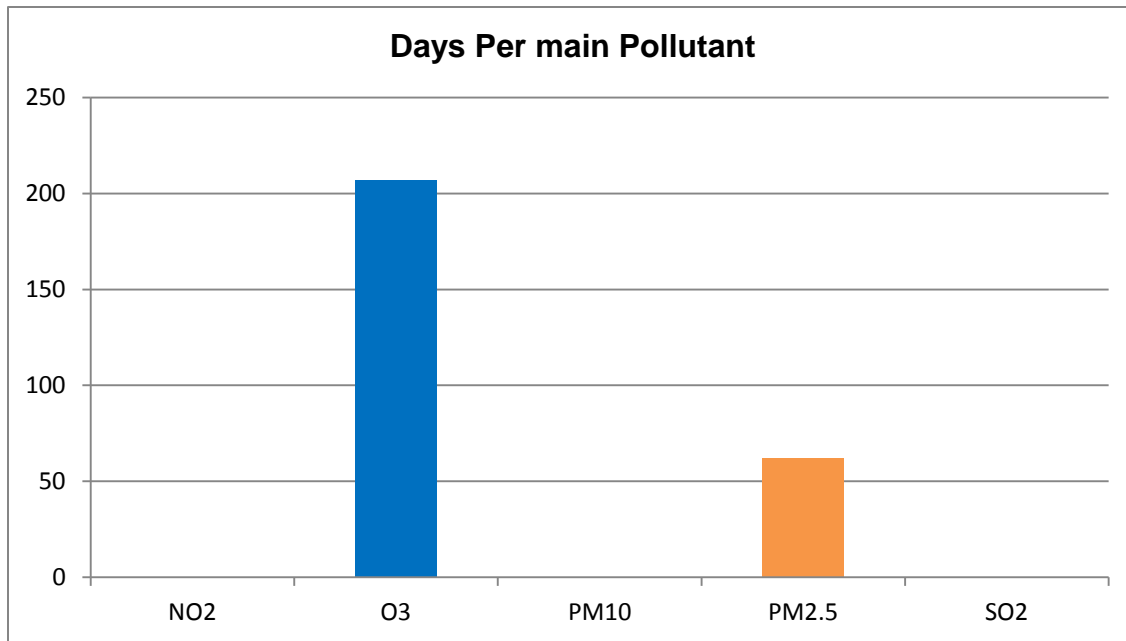
**Figure 6.14 Daily Air Quality Index Summary for Hickory-Morganton-Lenoir**



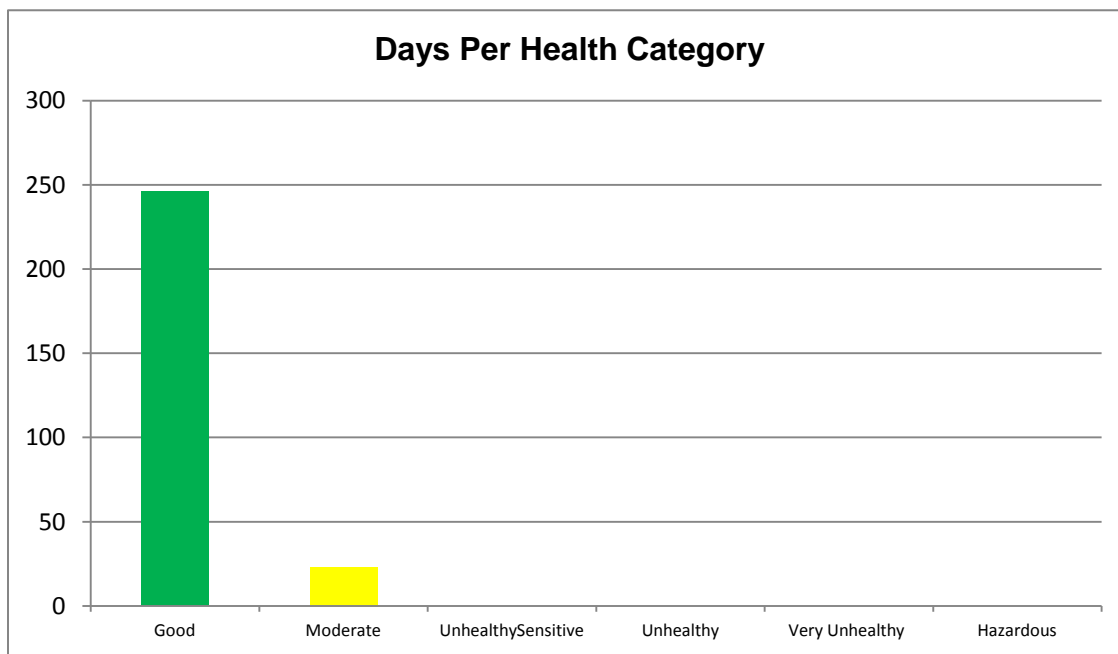
**Figure 6.15 Daily Air Quality Index Values for Raleigh-Durham-Chapel Hill**



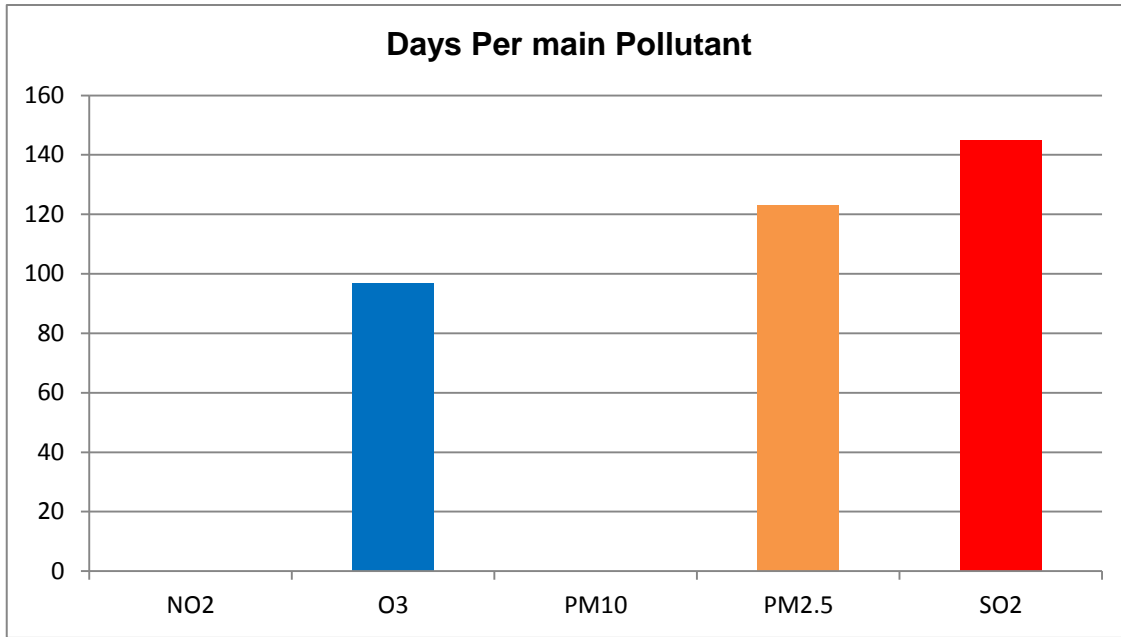
**Figure 6.16 Daily Air Quality Index Summary for Raleigh-Durham-Chapel Hill**



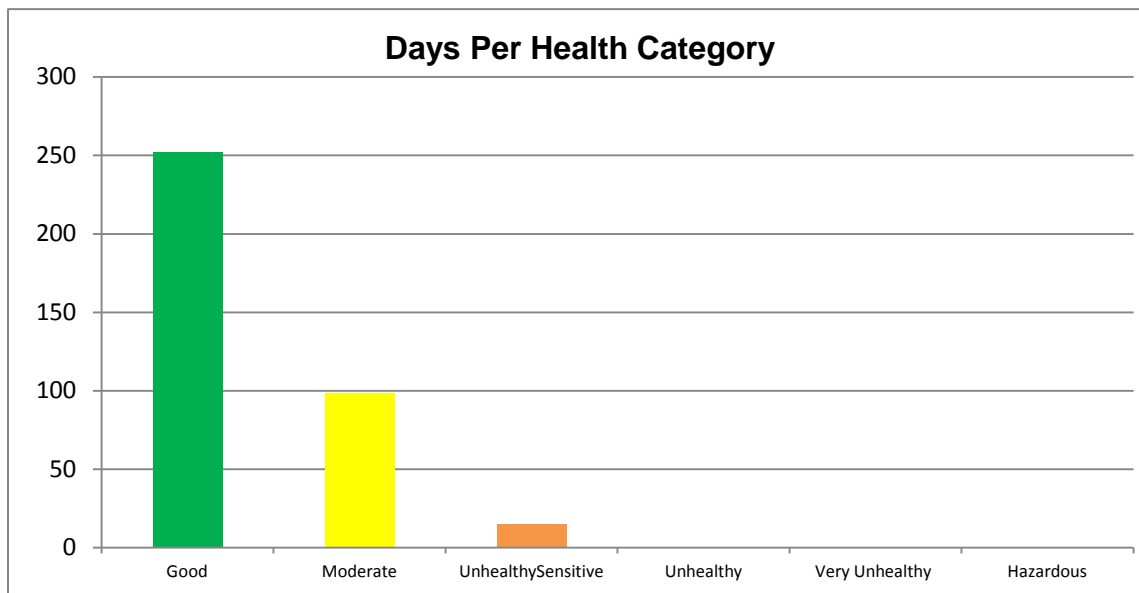
**Figure 6.17 Daily Air Quality Index Values for Rocky Mount**



**Figure 6.18 Daily Air Quality Index Summary for Rocky Mount**



**Figure 6.19 Daily Air Quality Index Values for Wilmington**



**Figure 6.20 Daily Air Quality Index Summary for Wilmington**

## 7 Acid Rain and Atmospheric Mercury

### 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 react with water to form sulfuric acid and nitric acid.

Atmospheric mercury is a by-product of coal-fire combustion, municipal and medical incineration, and mining of metals for industry, among other processes. Natural sources of atmospheric mercury include outgassing from volcanoes and geothermal vents, and evaporation from naturally enriched soils, wetlands, and oceans.

### 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.

Mercury persists in the environment for long periods (especially in the chemical form of methyl mercury), eventually

accumulating in soils and sediments. It is converted to organic forms by bacteria and then consumed in the aquatic food chain, through which it reaches fish, birds, wildlife and humans. The most important health concern is neurotoxicity. Methyl mercury can contaminate all tissues of the human body. The EPA considers methyl mercury and mercuric chloride to be possible carcinogens (NADP 2005)

### 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 2009, acid rain samples were collected at eight 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.

The NADP also administers a mercury deposition network (MDN). The MDN began measuring mercury in precipitation in 1996. In 2009 mercury deposition samples were obtained from two MDN sites in the eastern coastal

area of NC and one Tennessee site in the Great Smoky Mountains National Park. Figure 7.2 shows locations of the monitors.

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 10 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.

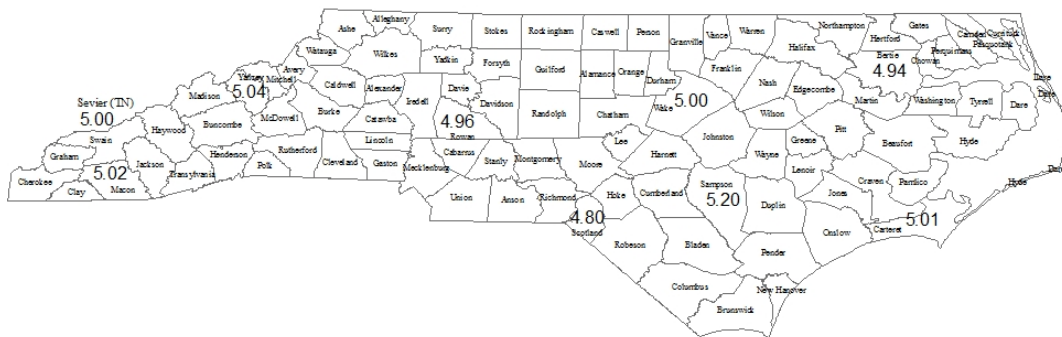
Pure water in equilibrium with the air is slightly acidic and has a pH of approximately 5.6. The measurements of pH at the North Carolina monitoring sites in 2009 ranged from 4.80 to 5.20 with a mean of 5.00. The 2009 pH annual means for North Carolina from the NADP database are presented in

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.

Table 7.3 shows precipitation-weighted mercury deposition totals for 2009. Another publication by the NCDAQ, the Annual Air Toxics Report (NC DENR, 2010), shows a time series graph of mercury deposition rates per week for a longer series of years.



**Figure 7.1 Annual Mean pH Values at North Carolina NADP Sites, 2009**

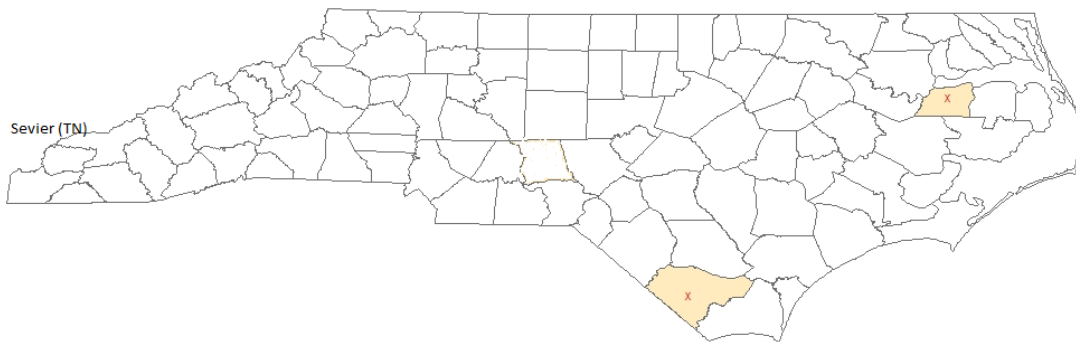


**Table 7.1 pH, Conductivity in Microsiemens per Centimeter and Precipitation in Inches from the National Atmospheric Deposition Program for 2009**

County Site ID Address	pH	Conductivity	Precipitation
Bertie NC03 Lewiston	4.94	9.64	44.54
Carteret NC06 Beaufort	5.01	11.46	59.64
Macon NC25 Coweeta	5.02	6.24	87.71
Rowan NC34 Piedmont Research Station	4.96	9.32	49.69
Sampson NC35 Clinton Crops Research Station	5.20	8.62	42.12
Scotland NC36 Jordan Creek	4.80	11.19	36.56
Wake NC41 Finley Farm	5.00	8.97	46.01
Yancey NC45 Mt. Mitchell	5.04	6.02	83.06
Sevier (TN) TN11 Great Smoky Mountains National Park- Elkmont	5.00	6.72	69.51

**Table 7.2 Ion Concentrations in Milligrams per Liter (Precipitation-weighted Annual Means) from the National Atmospheric Deposition Program Data for 2009**

County Site ID	% Completeness	Ca	Mg	K	Na	NH4	NO3	Cl	SO4
Bertie NC03	90	0.068	0.035	0.033	0.223	0.279	0.643	0.402	.874
Beaufort NC06	72	0.079	0.092	0.037	0.773	0.108	0.427	1.379	0.695
Macon NC25	94	0.046	0.009	0.013	0.070	0.113	0.384	0.123	0.517
Rowan NC34	95	0.080	0.020	0.057	0.090	0.361	0.683	0.163	0.887
Sampson NC35	65	0.063	0.027	0.036	0.207	0.502	0.663	0.370	0.933
Scotland NC36	92	0.073	0.027	0.027	0.207	0.254	0.759	0.359	0.991
Wake NC41	98	0.052	0.023	0.040	0.179	0.337	0.573	0.317	0.849
Yancey NC45	81	0.041	0.006	0.011	0.037	0.118	0.345	0.065	0.527
Sevier (TN) TN11	88	0.056	0.010	0.047	0.037	0.148	0.468	0.068	0.618



**Figure 7.2 Location of Mercury Monitoring Sites**

**Table 7.3 Precipitation-weighted mercury deposition in total nanograms per square meter per year for 2009.**

County Site ID Address	2009
Columbus NC08 Waccamaw State Park	8.63
Washington NC42 Pettigrew State Park	8.03
Sevier (TN) TN11 Great Smoky Mountains National Park Elkmont	9.96

## 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 ( $\text{NH}_4\text{NO}_3$ ) is the most abundant nitrate compound, resulting from a reversible gas/particle equilibrium between ammonia gas ( $\text{NH}_3$ ), nitric acid gas ( $\text{HNO}_3$ ), and particulate ammonium nitrate. Sodium nitrate ( $\text{NaNO}_3$ ) is found in  $\text{PM}_{2.5}$  and  $\text{PM}_{10}$  near sea coasts and salt playas (e.g., Watson et al., 1995a) where nitric acid vapor irreversibly reacts with sea salt ( $\text{NaCl}$ ).

#### 8.1.2 Sulfate

Ammonium sulfate ( $(\text{NH}_4)_2\text{SO}_4$ ), ammonium bisulfate ( $\text{NH}_4\text{HSO}_4$ ), and sulfuric acid ( $\text{H}_2\text{SO}_4$ ) are the most common forms of sulfate found in atmospheric particles, resulting from conversion of gases to particles as described below. These compounds are water-soluble and reside almost exclusively in the  $\text{PM}_{2.5}$  size fraction. Sodium sulfate ( $\text{Na}_2\text{SO}_4$ ) may be found in coastal areas where sulfuric acid has been neutralized by sodium chloride

( $\text{NaCl}$ ) in sea salt. Though gypsum ( $\text{Ca}_2\text{SO}_4$ ) and some other geological compounds contain sulfate, these are not easily dissolved in water for chemical analysis, are more abundant in  $\text{PM}_{10}$  than in  $\text{PM}_{2.5}$ , and they are usually classified in the geological fraction.

#### 8.1.3 Ammonium

Ammonium sulfate ( $(\text{NH}_4)_2\text{SO}_4$ ), ammonium bisulfate ( $\text{NH}_4\text{HSO}_4$ ), and ammonium nitrate ( $\text{NH}_4\text{NO}_3$ ) 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 about 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 became undetectable by the prescribed sampling method\*. For these reasons we include concentration of the lead in  $PM_{2.5}$  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 terms of any certain kind of particulate matter, but is simply the

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\* EPA promulgated a new lead standard in 2008, and DAQ anticipates establishing a reporting network for it in 2012.

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  $2.5 \mu\text{m}$ ) or larger ( $2.5 - 60 \mu\text{m}$ ), 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.

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<sub>2.5</sub> is also produced by common indoor activities. Some indoor sources of fine particles are tobacco smoke, 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<sub>10</sub> 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 state and local programs in NC used two kinds of samplers to acquire PM<sub>2.5</sub> mass and its chemical composition: MetOne SASS monitors and URG 3000N monitors. Another entity, the Interagency Monitoring of Protected Visual Environments, used their own sampling system, called the IMPROVE monitor.

The MetOne SASS monitor measures PM<sub>2.5</sub> mass and the chemical composition of PM<sub>2.5</sub> (sulfates, nitrates, organic carbon, soot-like carbon and metals). This is known as PM<sub>2.5</sub> 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<sub>2.5</sub> inlet and Federal Reference Method/Monitor filter holders. The PM<sub>2.5</sub> 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<sub>2.5</sub> mass, (2) sulfate, nitrate and chloride, (3) PM<sub>2.5</sub> quartz and (4) PM<sub>10</sub> mass.

During 2009, the state and local programs discontinued using the SASS for organic and elemental carbon in favor of the new URG 3000N monitors that use quartz filters and thermal optical reflective (TOR) analysis, the same method as IMPROVE samplers. Mecklenburg County switched to the URG sampler in March; all other locations switched in October.

State and local program data are validated on a monthly basis when reports are received from the contract laboratory RTI International. NCDAQ collected data at seven sites using MetOne SASS and the URG 3000N methods, the National Park Service collected at three sites during 2009 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 2009 are summarized in Table 8.2 and 8.3. The highest concentration observed was  $13.60 \mu\text{g}/\text{m}^3$  at Hickory.

Sulfate samples in 2009 are summarized in Table 8.4 and 8.5. The highest

concentration observed was  $11.00 \mu\text{g}/\text{m}^3$  at Hickory.

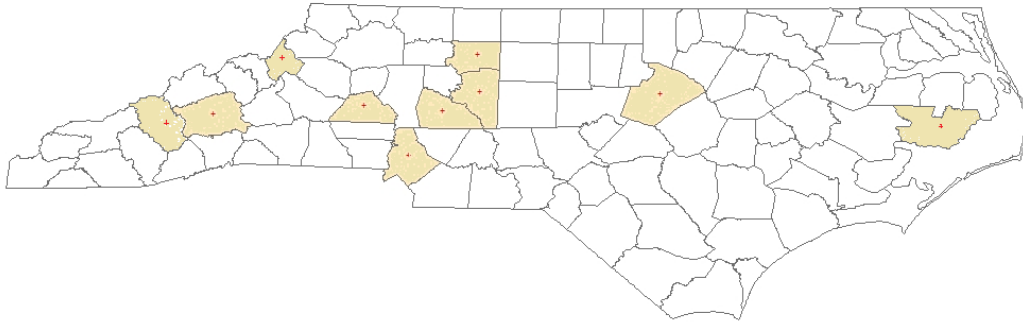
Ammonium samples in 2009 are summarized in Table 8.6 and 8.7. The highest concentration observed was  $3.13 \mu\text{g}/\text{m}^3$  at Raleigh.

Organic Carbon samples in 2009 are summarized in Table 8.8 and 8.9. The highest concentration observed was  $17.10 \mu\text{g}/\text{m}^3$  at Asheville.

Elemental Carbon samples in 2009 are summarized in Table 8.10 and 8.11. The highest concentration observed was  $1.65 \mu\text{g}/\text{m}^3$  at Hickory.

Crustal Component samples in 2009 are summarized in Table 8.12 and 8.13. The highest concentration observed was  $13.64 \mu\text{g}/\text{m}^3$  at Winston-Salem.

Elemental lead samples for 2009 are summarized in Table 8.14 and 8.15. Out of 855 samples statewide, one sample exceeded  $0.01 \mu\text{g}/\text{m}^3$ ; 852 of these sample concentrations (99.6 percent) were less than  $0.01 \mu\text{g}/\text{m}^3$ . One sample was greater than  $0.014 \mu\text{g}/\text{m}^3$ . The highest concentration observed was  $0.075 \mu\text{g}/\text{m}^3$  at Rockwell .



**Figure 8.1 Location of Nitrate, Sulfate, Ammonium, Organic Carbon, Elemental Carbon, Crustal component, Monitoring Sites 2009.**

**Table 8.1 Fine Particle Speciation Sites Operated in North Carolina in 2009**

SITE NUMBER COUNTY	ADDRESS	METHOD
37-011-0002 AVERY	7510 BLUE RIDGE PARKWAY SPUR LINVILLE	IMPROVE
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	SASS/URG
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	SASS/URG
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	SASS/URG
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	SASS/URG
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	IMPROVE
37-095-9000 HYDE	SWANQUARTER	IMPROVE
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	SASS/URG
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	SASS/URG
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	SASS/URG
SITES OPERATED IN 2009	10	



**Table 8.2 Mean and Maximum Nitrate PM2.5 Concentration for 2009**

SITE NUMBER COUNTY	ADDRESS	NUM OBS	24-HOUR MAXIMA				ARITH MEAN
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	
37-011-0002 AVERY	7510 BLUE RIDGE PARKWAY SPUR LINVILLE	112	2.53	1.93	1.47	.95	.23
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	59	3.87	2.09	2.09	1.80	.60
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	57	13.60	3.58	3.47	3.21	1.06
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	54	3.57	2.83	2.63	2.36	.72
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	58	4.05	3.92	3.50	3.32	.80
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	112	1.35	.97	.83	.79	.22
37-095-9000 HYDE	SWANQUARTER	116	1.48	1.25	1.23	.94	.35
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	121	3.82	3.13	2.85	2.83	.76
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	60	3.46	3.06	2.74	2.37	.68
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	100	4.69	3.44	3.20	3.09	.59
Total Samples		849					
Total Sites Sampled		10					

**Table 8.3 Nitrate PM2.5 - Quartile statistics - Micrograms/Cubic Meter (LC) for 2009**

SITE NUMBER	ADDRESS	NUM OBS	QUARTILES Mg/m <sup>2</sup>			MAXI NUM
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	
37-011-0002 AVERY	7510 BLUE RIDDGE PARKWAY SPUR LINVILLE	112	.06	.10	.26	2.53
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	59	.23	.35	.74	3.87
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	57	.25	.45	1.07	13.60
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	54	.31	.52	.82	3.57
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	58	.26	.50	.84	4.05
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	112	.08	.14	.29	1.35
37-095-9000 HYDE	SWANQUARTER	116	.20	.27	.43	1.48
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	121	.27	.47	1.02	3.82
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	60	.25	.44	.75	3.46
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	100	.25	.38	.57	4.69
Effective Sample Count*		849				
Total Sites Sampled		10				

\* Not including collocated samples.

**Table 8.4 Mean and Maximum Sulfate PM2.5 Concentration for 2009**

SITE NUMBER COUNTY	ADDRESS	NUM OBS	24-HOUR MAXIMA				ARITH MEAN
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	
37-011-0002 AVERY	7510 BLUE RIDDGE PARKWAY SPUR LINVILLE	112	6.31	5.21	5.12	4.92	1.99
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	59	4.81	4.58	4.25	4.13	2.07
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	57	11.00	4.95	4.89	4.84	2.52
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	54	5.64	5.39	4.83	4.20	2.41
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	58	5.47	5.31	5.07	4.90	2.51
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	112	6.53	5.68	4.66	4.27	1.57
37-095-9000 HYDE	SWANQUARTER	116	6.25	6.10	5.80	4.75	2.18
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	121	7.67	7.12	6.43	5.97	2.62
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	60	5.63	4.95	4.31	3.89	2.31
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	100	7.66	7.23	6.69	5.65	2.58
Total Samples		849					
Total Sites Sampled		10					

**Table 8.5 Sulfate PM2.5 - Quartile statistics - Micrograms/Cubic Meter (LC) for 2009**

SITE NUMBER	ADDRESS	NUM OBS	QUARTILES			MAXI NUM
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	
COUNTY						
37-011-0002 AVERY	7510 BLUE RIDDGE PARKWAY SPUR LINVILLE	112	0.98	1.76	2.72	6.31
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	59	1.19	1.89	2.82	4.81
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	57	1.54	2.21	3.32	11.00
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	54	1.50	2.42	3.17	5.64
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	58	1.70	2.38	3.26	5.47
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	112	0.68	1.28	1.90	6.53
37-095-9000 HYDE	SWANQUARTER	116	1.34	2.01	2.67	6.25
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	121	1.55	2.32	3.55	7.67
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	60	1.43	2.24	2.98	5.63
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	100	1.53	2.31	3.36	7.66
Effective Sample Count*		849				
Total Sites Sampled		10				

\* Not including collocated samples.

**Table 8.6 Mean and Maximum Ammonium Ion PM2.5 Concentration for 2009**

SITE NUMBER COUNTY	ADDRESS	NUM OBS	24-HOUR MAXIMA				ARITH MEAN
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	
37-011-0002^ AVERY	7510 BLUE RIDDGE PARKWAY SPUR LINVILLE	0					
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	59	2.33	1.96	1.39	1.36	.73
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	57	2.66	2.38	2.01	1.86	.99
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	54	2.08	1.94	1.93	1.92	.95
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	58	2.47	2.32	2.18	2.16	1.03
37-087-0035^ HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	0					
37-095-9000^ HYDE	SWANQUARTER	0					
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	121	2.79	2.55	2.25	2.25	1.01
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	60	1.98	1.81	1.66	1.63	.86
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	100	3.13	2.67	2.48	2.34	.96
Total Samples		509					
Total Sites Sampled		7					

^ These IMPROVE monitors do not report this speciation component

**Table 8.7 Ammonium Ion PM2.5 - Quartile statistics - Micrograms/Cubic Meter (LC) for 2009**

SITE NUMBER	ADDRESS	NUM OBS	QUARTILES			MAXI NUM
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	
37-011-0002^ AVERY	7510 BLUE RIDDGE PARKWAY SPUR LINVILLE	0				
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	59	.35	.72	1.00	2.33
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	57	.51	.81	1.44	2.66
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	54	.61	.90	1.20	2.08
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM KINSTON	58	.60	.89	1.36	2.47
37-087-0035^ HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	0				
37-095-9000^ HYDE	SWANQUARTER	0				
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	121	.61	.89	1.39	2.79
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	60	.47	.78	1.19	1.98
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	100	.51	.81	1.24	3.13
Effective Sample Count*		509				
Total Sites Sampled		7				

^ These IMPROVE monitors do not report this speciation component

\* Not including collocated samples.

**Table 8.8 Mean and Maximum Organic Carbon CSN PM2.5 Concentration for 2009**

SITE NUMBER COUNTY	ADDRESS	NUM OBS	24-HOUR MAXIMA				ARITH MEAN
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	
37-011-0002^ AVERY	7510 BLUE RIDGE PARKWAY SPUR LINVILLE	0					
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	59	17.1	10.5	7.62	6.22	3.78
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	56	9.21	9.20	7.31	7.11	4.32
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	57	9.56	6.78	6.75	6.43	4.09
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	60	7.50	5.51	4.94	4.84	2.58
37-087-0035^ HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	0					
37-095-9000^ HYDE	SWANQUARTER	0					
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	106	12.30	8.05	7.39	7.26	3.17
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	61	9.52	7.34	7.20	7.04	4.03
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	97	10.60	10.10	7.76	7.01	4.20
Total Samples		496					
Total Sites Sampled		7					

^ These IMPROVE monitors do not report this speciation component

**Table 8.9 Organic Carbon CSN PM2.5 - Quartile statistics - Micrograms/Cubic Meter (LC) for 2009**

SITE NUMBER	ADDRESS	NUM OBS	QUARTILES			MAXI NUM
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	
37-011-0002^ AVERY	7510 BLUE RIDDGE PARKWAY SPUR LINVILLE	0				
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	59	2.77	3.54	4.25	17.10
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	56	3.11	4.00	5.51	9.21
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	57	2.85	4.14	5.21	9.56
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	60	1.73	2.30	3.20	7.50
37-087-0035^ HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	0				
37-095-9000^ HYDE	SWANQUARTER	0				
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	106	1.94	2.73	3.92	12.30
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	61	2.99	3.77	4.99	9.52
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	97	2.95	4.00	5.53	10.60
Effective Sample Count*		496				
Total Sites Sampled		7				

\* Not including collocated samples.

^ These IMPROVE monitors do not report this speciation component



**Table 8.10 Mean and Maximum Elemental Carbon CSN PM2.5 Concentration for 2009**

SITE NUMBER COUNTY	ADDRESS	NUM OBS	24-HOUR MAXIMA				ARITH MEAN
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	
37-011-0002^ AVERY	7510 BLUE RIDDGE PARKWAY SPUR LINVILLE	0					
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	59	1.26	.98	.79	.76	.40
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	56	1.65	1.32	1.22	1.01	.52
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	55	1.35	1.14	1.04	.94	.45
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	60	.94	.90	.86	.81	.30
37-087-0035^ HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	0					
37-095-90001^ HYDE	SWANQUARTER	0					
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	106	1.14	1.00	.99	.96	.34
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	61	1.16	.90	.66	.63	.36
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	97	1.15	1.12	.98	.84	.38
Total Samples		494					
Total Sites Sampled		7					

^ These IMPROVE monitors do not report this speciation component

**Table 8.11 Elemental Carbon CSN PM2.5 - Quartile statistics - Micrograms/Cubic Meter (LC) for 2009**

SITE NUMBER	ADDRESS	NUM OBS	QUARTILES			MAXI NUM
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	
37-011-0002^ AVERY	7510 BLUE RIDDGE PARKWAY SPUR LINVILLE	0				
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	59	.25	.40	.52	1.26
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	56	.32	.47	.64	1.65
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	55	.28	.42	.55	1.35
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	60	.17	.25	.34	.94
37-087-0035^ HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	0				
37-095-9000^ HYDE	SWANQUARTER	0				
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	106	.17	.27	.41	1.14
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	61	.14	.35	.47	1.16
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	97	.12	.33	.57	1.15
Effective Sample Count*		494				
Total Sites Sampled		7				

\* Not including collocated samples.

^ These IMPROVE monitors do not report this speciation component

**Table 8.12 Mean and Maximum Crustal Component PM2.5 Concentration for 2009**

SITE NUMBER COUNTY	ADDRESS	NUM OBS	24-HOUR MAXIMA				ARITH MEAN
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	
37-011-0002 AVERY	7510 BLUE RIDDGE PARKWAY SPUR LINVILLE	114	2.68	1.61	1.42	0.93	0.40
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	59	2.81	1.44	1.29	.86	.32
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	57	3.08	2.23	1.65	1.12	.40
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	58	3.47	2.71	2.62	2.36	.50
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	57	13.64	7.98	1.65	1.12	.40
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	112	4.60	3.79	2.49	2.17	0.44
37-095-9000 HYDE	SWANQUARTER	116	5.33	5.14	3.66	2.44	0.51
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	121	4.59	3.81	3.72	2.85	.46
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	60	3.97	3.06	2.70	1.04	.46
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	101	6.84	2.91	1.23	.99	.44
Total Samples		855					
Total Sites Sampled		10					

**Table 8.13 Crustal Component CSN PM2.5 - Quartile statistics - Micrograms/Cubic Meter (LC) for 2009**

SITE NUMBER	ADDRESS	NUM OBS	QUARTILES			MAXI NUM
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	
37-011-0002 AVERY	7510 BLUE RIDDGE PARKWAY SPUR LINVILLE	114	.21	.33	.51	2.68
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	59	.15	.21	.36	2.81
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	57	.17	.27	.40	3.08
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	58	.16	.31	.47	3.47
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	57	.15	.28	.47	13.64
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	112	.16	.29	.50	4.60
37-095-9000 HYDE	SWANQUARTER	116	.20	.30	.51	5.33
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	121	.19	.35	.44	4.59
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	60	.16	.28	.45	3.97
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	101	.20	.30	.46	6.84
Effective Sample Count*		855				
Total Sites Sampled		10				

\* Not including collocated samples.

**Table 8.14 Mean and Maximum Lead PM<sub>2.5</sub> Concentration for 2009**

SITE NUMBER COUNTY	ADDRESS	NUM OBS	24-HOUR MAXIMA				ARITH MEAN
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	
37-011-0002 AVERY	7510 BLUE RIDDGE PARKWAY SPUR LINVILLE	114	.003	.002	.002	.002	.001
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	59	.005	.004	.003	.003	.002
37-035-0004 CATAWBA	1650 1ST. ST HICKORY	57	.008	.008	.008	.006	.002
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	58	.009	.007	.005	.005	.002
37-067-0022 FORSYTH	1300 BLK. HATTIE AVENUE WINSTON-SALEM	57	.012	.011	.006	.006	.002
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	112	.002	.002	.002	.002	.001
37-095-9000 HYDE	SWANQUARTER	116	.006	.005	.002	.002	.001
37-119-0041 MEKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	121	.008	.006	.006	.005	.002
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	60	.075	.008	.006	.006	.003
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	101	.007	.005	.004	.004	.002
Total Samples		855					
Total Sites Sampled		10					

**Table 8.15 Lead PM<sub>2.5</sub> - Quartile statistics - Micrograms/Cubic Meter (LC) for 2009**

SITE NUMBER COUNTY	ADDRESS	NUM OBS	QUARTILES			MAXI NUM
			1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	
37-011-0002 AVERY	7510 BLUE RIDDGE PARKWAY SPUR LINVILLE	114	.001	.001	.001	.003
37-021-0034 BUNCOMBE	175 BINGHAM ROAD ASHEVILLE	59	.001	.002	.002	.005
37-035-0004 CATAWBA	1650 1ST STREET HICKORY	57	.001	.002	.003	.008
37-057-0002 DAVIDSON	S.SALISBURY ST LEXINGTON	58	.001	.002	.003	.009
37-067-0022 FORSYTH	1300 BLK HATTIE AVE WINSTON-SALEM	57	.001	.002	.002	.012
37-087-0035 HAYWOOD	TOWER BLUE RIDGE PARKWAY MILE MARKER 410	112	.000	.001	.001	.002
37-095-9000 HYDE	SWANQUARTER	116	.001	.001	.001	.006
37-119-0041 MECKLENBURG	1130 EASTWAY DRIVE CHARLOTTE	121	.001	.002	.002	.008
37-159-0021 ROWAN	301 WEST ST & GOLD HILL AVE ROCKWELL	60	.001	.002	.002	.075
37-183-0014 WAKE	3801 SPRING FOREST RD RALEIGH	101	.001	.002	.002	.007
Effective Sample Count*		855				
Total Sites Sampled		10				

\* Not including collocated samples.

## 9. Urban Air Toxics

The DAQ operates an urban air toxics monitoring network in conjunction with a national program originally proposed and designed by the EPA in 1999.

In 2001, the EPA initiated a national network for monitoring air toxics compounds present in ambient air. Although no 'national network' 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 continued the North Carolina air toxics monitoring program for Volatile Organic Compounds (VOC) and carbonyl sampling at six urban sites and one rural site.

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

Thousands of products emit VOCs. 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, such as 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 depends on many factors, including level of exposure and length of time exposed.

### 9.3 Formaldehyde

Formaldehyde (IUPAC name methanal) has a chemical formula of  $\text{CH}_2\text{O}$  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 VOCs). It appears that roughly one-third 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 50-80 percent of the total benzene emissions, with the remainder attributed to nonroad mobile sources (25 percent) and stationary sources (15 percent). The major source is exhaust emissions and evaporation losses from motor vehicles, and evaporation losses during the handling, distribution and storage of motor vehicle fuels.



## 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 percent 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. It 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<sub>3</sub>), and reaction with nitrogen

trioxide radical (NO<sub>3</sub>). 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<sub>3</sub> 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 in 2009

Toxic air pollutant monitoring data were 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 were obtained over a 24-hour period, generally from midnight to midnight and represent a 24-hour aggregated average. Samples of volatile organic compounds were obtained once every six days, while formaldehyde and other carbonyl compounds were sampled every 12 days.

During 2009, toxics monitoring data were collected at five urban monitoring sites in Asheville, Charlotte, Raleigh, Wilmington and Winston-Salem and at one rural site, near Candor, in Montgomery County (Figure 9.1). The map in Figure 9.1 shows the locations of the six sites.

This report shows summary statistics for 2009 in Table 9.1 through Table 9.7 and discusses averages of concentrations for each pollutant and site below. Some pollutants were not detectable in many of the samples. This introduces uncertainty and bias in the arithmetic mean, so this report describes 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  $\frac{1}{4}$  ( $\frac{1}{2}$ ,  $\frac{3}{4}$ ) 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 one-half of the minimum reporting limit or detection limit for the observed or reported concentration. In the summary statistics discussions following, report comparisons between North Carolina and other states are based on medians, rather than problematic arithmetic means. When there are concentrations "less than or equal to" the lowest quantitation limit, concentrations are represented by one-half of the lowest quantitation limit.

Formaldehyde samples in 2009 are summarized in Table 9.1. Median (2nd quartile) concentration ranged from 1.3 to 2.5 ppb at the urban sites, while at the rural site the median concentration was

1.9 ppb. Nationwide median formaldehyde concentrations ranged from 0.7 ppb to 3.0 ppb with the overall median of 1.7 ppb. North Carolina was the 15<sup>th</sup> highest state among 33 reporting states with a median of 1.9 ppb.

Benzene samples in 2009 are summarized in Table 9.2. Median (2nd quartile) concentrations ranged from 0.09 to 0.37 ppb at urban sites, while at the rural site the median concentration was 0.09 ppb. Nationwide median benzene concentrations ranged from  $\leq 0.017$  ppb to 0.54 ppb with the overall median of 0.20 ppb. North Carolina was the 34<sup>th</sup> highest state among 43 reporting states with a median of 0.15 ppb.

Toluene samples in 2009 are summarized in Table 9.3. Median (2nd quartile) concentrations ranged from 0.13 to 0.58 ppb at the urban sites, while at the rural site the median concentration was 0.08 ppb. Nationwide median toluene concentrations ranged from  $\leq 0.01$  ppb to .85 ppb with the overall median of 0.27 ppb. North Carolina was the 21<sup>th</sup> highest state among 41 reporting states with a median of 0.27 ppb.

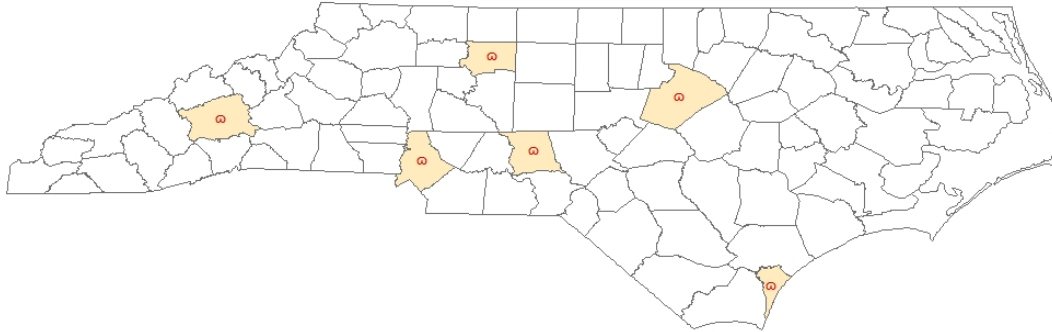
Ethylbenzene samples in 2009 are summarized in Table 9.4. Median (2nd quartile) concentrations ranged from 0.01 to 0.05 ppb at the urban sites, while at the rural site the median concentration was 0.00. Data indicate that 100 percent of the sample concentrations at Candor, the rural site, were below the smallest value that could be reliably detected using TO-15. Nationwide median ethylbenzene concentrations ranged from  $\leq 0.01$  ppb to 0.10 ppb with the overall median of 0.04 ppb. North Carolina was the 15<sup>th</sup> highest state among 41 reporting states with a median of 0.03 ppb.

The results for m/p-Xylene in 2009 are summarized in Table 9.5. Sample medians ranged from 0.08 to 0.19 ppb at the urban sites, while at the rural site the median concentration was 0.00. Data indicate that in 2009, 91 percent of the sample concentrations at Candor, the rural site, were below the smallest value that could be reliably detected using TO-15. Nationwide median m/p-Xylene concentrations ranged from  $\leq 0.01$  ppb to 0.35 ppb with the overall median of 0.09 ppb. North Carolina was the 35<sup>th</sup> highest state among 40 reporting states with a median of 0.10 ppb.

o-Xylene samples in 2009 are summarized in Table 9.6. Median (2nd quartile) concentrations ranged from 0.01 to 0.06 ppb at the urban sites, while at the rural site the median concentration was 0.00. Data indicate that 100 percent of the sample concentrations at Candor, the rural site, were below the smallest value that could be reliably detected using TO-15. Nationwide median o-Xylene concentrations ranged from  $\leq 0.01$  ppb to 0.11 ppb with the overall median of 0.04 ppb. North Carolina was the 16<sup>th</sup> highest state among 40 reporting states with a median of 0.03 ppb.

1,3-Butadiene samples in 2009 are summarized in Table 9.7. Median (2nd quartile) concentrations were 0.00 ppb at the urban sites and at the rural site. Nationwide median 1,3-Butadiene concentrations ranged from 0.01 ppb to 0.08 ppb with the overall median of  $\leq 0.03$  ppb. Ranking the states using the median 1,3-Butadiene concentration is ambiguous, because the median is less than or equal to 0.05 ppb for North Carolina and almost every other reporting state. However, based on the fourth maximum sample concentrations, North Carolina was the 17<sup>th</sup> highest state among 42 reporting states and based on

the 90 percentile North Carolina was the 16<sup>th</sup> highest state .



**Figure 9.1 Locations of NC Urban Air Toxics Monitoring Sites**

**Table 9.1 Formaldehyde - Parts per billion for 2009**

SITE NUMBER	ADDRESS	NUM OBS	PC T OF DATA ≤ .05	QUARTILES			MAXI NUM	ARITH MEAN
				1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>		
37-021-0035 BUNCOMBE	AB TECHNICAL COLLEGE ASHEVILLE	27	0%	1.51	1.74	2.06	3.3	1.74
37-067-0022 FORSYTH	HATTIE AVENUE WINSTON-SALEM	26	0%	1.67	2.13	2.87	4.4	2.28
37-119-0041 MECKLENBURG	GARINGER HIGH SCHOOL 1130 EASTWAY DRIVE CHARLOTTE	29	0%	2.26	2.51	3.26	6.22	3.01
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	24	0%	1.02	1.93	2.84	6.46	2.27
37-129-0010 NEW HANOVER	BATTLESHIP MUSEUM	29	0%	0.97	1.26	1.62	2.46	1.35

SITE NUMBER	ADDRESS	NUM OBS	PC T OF DATA ≤ .05	QUARTILES			MAXI NUM	ARITH MEAN
				1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>		
COUNTY								
37-183-0014 WAKE	MILLBROOK MS 3801 SPRING FOREST RD, RALEIGH	27	0%	1.31	1.64	2.86	4.24	2.06
Effective Sample Count*		162						
Total Sites Sampled		6						

**Table 9.2 Benzene - Parts per billion for 2009**

SITE NUMBER	ADDRESS	NUM OBS	PC T OF DATA ≤ .05	QUARTILES			MAXI NUM	ARITH MEAN
				1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>		
COUNTY								
37-021-0035 BUNCOMBE	AB TECHNICAL COLLEGE ASHEVILLE	56	0%	.12	.18	.25	.60	.20
37-067-0022 FORSYTH	HATTIE AVENUE WINSTON-SALEM	55	0%	.13	.18	.28	.68	.23
37-119-0041 MECKLENBURG	GARINGER HIGH SCHOOL 1130 EASTWAY DRIVE CHARLOTTE	40	0%	.24	.37	.92	1.58	.55
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	54	22%	.05	.09	.15	.23	.10
37-129-0010 NEW HANOVER	BATTLESHIP MUSEUM WILMINGTON	58	17%	.06	.09	.17	.46	.12
37-183-0014 WAKE	MILLBROOK MS 3801 SPRING FOREST RD, RALEIGH	54	0%	.12	.16	.29	.71	.22
Effective Sample Count*		317						
Total Sites Sampled		6						

\* Not including collocated samples.

**Table 9.3 Toluene - Parts per billion for 2009**

SITE NUMBER	ADDRESS	NUM OBS	PCT OF DATA ≤ .05	QUARTILES			MAXI NUM	ARITH MEAN
				1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>		
COUNTY								
37-021-0035 BUNCOMBE	AB TECHNICAL COLLEGE ASHEVILLE	56	0%	.24	.38	.50	.98	.40
37-067-0022 FORSYTH	HATTIE AVENUE WINSTON-SALEM	55	0%	.23	.30	.54	1.61	.42
37-119-0041 MECKLENBURG	GARINGER HIGH SCHOOL 1130 EASTWAY DRIVE CHARLOTTE	56	0%	.32	.58	.89	3.26	.74
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	54	19%	.05	.08	.11	.22	.09
37-129-0010 NEW HANOVER	BATTLESHIP MUSEUM	58	16%	.08	.13	.24	1.18	.20
37-183-0014 WAKE	MILLBROOK MS 3801 SPRING FOREST RD, RALEIGH	54	0%	.19	.28	.50	1.30	.40
Effective Sample Count*		333						
Total Sites Sampled		6						

**Table 9.4 Ethylbenzene - Parts per billion for 2009**

SITE NUMBER	ADDRESS	NUM OBS	PCT OF DATA ≤ .05	QUARTILES			MAXI NUM	ARITH MEAN
				1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>		
COUNTY								
37-021-0035 BUNCOMBE	AB TECHNICAL COLLEGE ASHEVILLE	56	59%	.02	.04	.07	.16	.05
37-067-0022 FORSYTH	HATTIE AVENUE WINSTON-SALEM	55	67%	.01	.04	.06	.32	.05
37-119-0041	GARINGER HIGH	56	48%	.02	.05	.12	.50	.08

\* Not including collocated samples.

SITE NUMBER	ADDRESS	NUM OBS	PCT OF DATA ≤ .05	QUARTILES			MAXI NUM	ARITH MEAN
				1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>		
COUNTY								
MECKLENBURG	SCHOOL 1130 EASTWAY DRIVE CHARLOTTE							
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	54	100%	.00	.00	.01	.04	.01
37-129-0010 NEW HANOVER	BATTLESHIP MUSEUM	58	88%	.00	.01	.03	.16	.02
37-183-0014 WAKE	MILLBROOK MS 3801 SPRING FOREST RD RALEIGH	54	72%	.01	.03	.06	.26	.05
Effective Sample Count*		333						
Total Sites Sampled		6						

**Table 9.5 m/p-Xylene - Parts per billion for 2009**

SITE NUMBER	ADDRESS	NUM OBS	PCT OF DATA ≤ .05	QUARTILES			MAXI NUM	ARITH MEAN
				1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>		
COUNTY								
37-021-0035 BUNCOMBE	AB TECHNICAL COLLEGE ASHEVILLE	56	23%	.05	.13	.23	.46	.15
37-067-0022 FORSYTH	HATTIE AVENUE WINSTON-SALEM	55	22%	.06	.12	.24	1.10	.18
37-119-0041 MECKLENBURG	GARINGER HIGH SCHOOL 1130 EASTWAY DRIVE CHARLOTTE	56	25%	.07	.19	.40	1.69	.29
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	54	91%	.00	.00	.02	.08	.01
37-129-0010 NEW HANOVER	BATTLESHIP MUSEUM	58	47%	.00	.08	.23	1.32	.21
37-183-0014 WAKE	MILLBROOK MS 3801 SPRING FOREST RD RALEIGH	54	24%	.05	.11	.20	.92	.18
Effective Sample Count*		333						
Total Sites Sampled		6						

\* Not including collocated samples.



**Table 9.6 o-Xylene - Parts per billion for 2009**

SITE NUMBER	ADDRESS	NUM OBS	PCT OF DATA ≤ .05	QUARTILES			MAXI NUM	ARITH MEAN
				1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>		
37-021-0035 BUNCOMBE	AB TECHNICAL COLLEGE ASHEVILLE	56	55%	.02	.05	.08	.20	.05
37-067-0022 FORSYTH	HATTIE AVENUE WINSTON-SALEM	54	52%	.01	.05	.09	.41	.07
37-119-0041 MECKLENBURG	GARINGER HIGH SCHOOL 1130 EASTWAY DRIVE CHARLOTTE	53	40%	.02	.06	.15	.48	.09
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	54	100%	.00	.00	.01	.05	.01
37-129-0010 NEW HANOVER	BATTLESHIP MUSEUM	58	74%	.00	.01	.05	.55	.04
37-183-0014 WAKE	MILLBROOK MS 3801 SPRING FOREST RD RALEIGH	51	57%	.00	.04	.06	.34	.06
Effective Sample Count*		326						
Total Sites Sampled		6						

\* Not including collocated samples.

**Table 9.7 1,3-Butadiene - Parts per billion for 2009**

SITE NUMBER	ADDRESS	NUM OBS	PC T OF DATA ≤ .05	QUARTILES			MAXI NUM	ARITH MEAN
				1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>		
COUNTY								
37-021-0035 BUNCOMBE	AB TECHNICAL COLLEGE ASHEVILLE	56	84%	.00	.00	.03	.19	.03
37-067-0022 FORSYTH	HATTIE AVENUE WINSTON-SALEM	55	76%	.00	.00	.04	.14	.03
37-119-0041 MECKLENBURG	GARINGER HIGH SCHOOL 1130 EASTWAY DRIVE CHARLOTTE	55	71%	.00	.00	.06	.27	.04
37-123-0001 MONTGOMERY	112 PERRY DRIVE CANDOR	54	100%	.00	.00	.00	.03	.00
37-129-0010 NEW HANOVER	BATTLESHIP MUSEUM	58	91%	.00	.00	.00	.10	.01
37-183-0014 WAKE	MILLBROOK MS 3801 SPRING FOREST RD RALEIGH	54	83%	.00	.00	.02	.17	.02
Effective Sample Count*		332						
Total Sites Sampled		6						

\* Not including collocated samples.

## 10 Statewide Trends

Summarizing statewide annual changes in the criteria pollutants and acid deposition ions helps evaluate the success of programs intended to reduce pollution and prioritize future efforts. The emphasis in this annual report is on general, moderately long-term trends. In 1991, DENR published a more detailed analysis of trends within the regions of the state and at individual monitoring stations covering air pollutant concentrations from 1972 through 1989 (North Carolina Department of Environment, Health, and Natural Resources 1991b).

### 10.1 Particulate Matter

The statewide distribution of second-highest 24-hour PM<sub>10</sub> concentrations for each monitor from 1989 to 2009 is shown in Figure 10.1. Concentrations have decreased from 58 to about 28  $\mu\text{g}/\text{m}^3$  (a 48 percent decline).

### 10.2 Carbon Monoxide

The statewide distribution of second-highest eight-hour CO concentrations from 1997 to 2009 is shown in Figure 10.2. The average value of this concentration decreased from 4.87 ppm in 1996 to 1.58 ppm in 2009 (a decline of 68 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 showed no specific trend from the early 1990s to mid 2000s, but there has been a decreasing trend since the early 2000s, and in 2009, the monitoring network average was 0.066, which is 88 percent of the standard. Figure 10.4 shows the number of days with exceedances every year from 1990 to 2009. Exceedance days decreased steadily from 112 in 1999 to 27 in 2004 followed by an increase to 65 in 2007 and a decrease to six in 2009. 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<sub>2</sub>) concentrations from 1989 to 2009 is shown in Figure 10.5. The average decreased from 0.088 ppm in 1989 to 0.018 ppm in 2009 (4 percent of the standard), a decrease of 80 percent.

The statewide distribution of second-largest 24-hour SO<sub>2</sub> concentrations from 1989 to 2009 is shown in Figure 10.6. The average decreased from 0.027 ppm in 1989 to 0.08 ppm in 2009 (6 percent of the standard), a decrease of 70 percent.

### 10.5 Nitrogen Dioxide

The Forsyth and Mecklenburg County distributions of annual average nitrogen dioxide (NO<sub>2</sub>) concentrations from 1989 to 2009 are shown in Figure 10.7. The

average concentration was approximately constant around 0.012 ppm (22 percent of the standard).

### **10.6 pH**

The statewide distribution of annual average pH values of rainfall from 1991 to 2009 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 10 percent over the 19 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 ( $\text{NH}_4^+$ ) concentrations from 1991 to 2009 for the NADP sites (including two collocated sites and the Great Smoky Mountain, Tennessee site) is shown in Figure 10.9. From 1991 to 2009 there appears to be an increase of 26 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 2007. The NADP study suggested that the 1994 protocol change had no net effect on measured  $\text{NH}_4^+$  concentrations (NADP 1995).

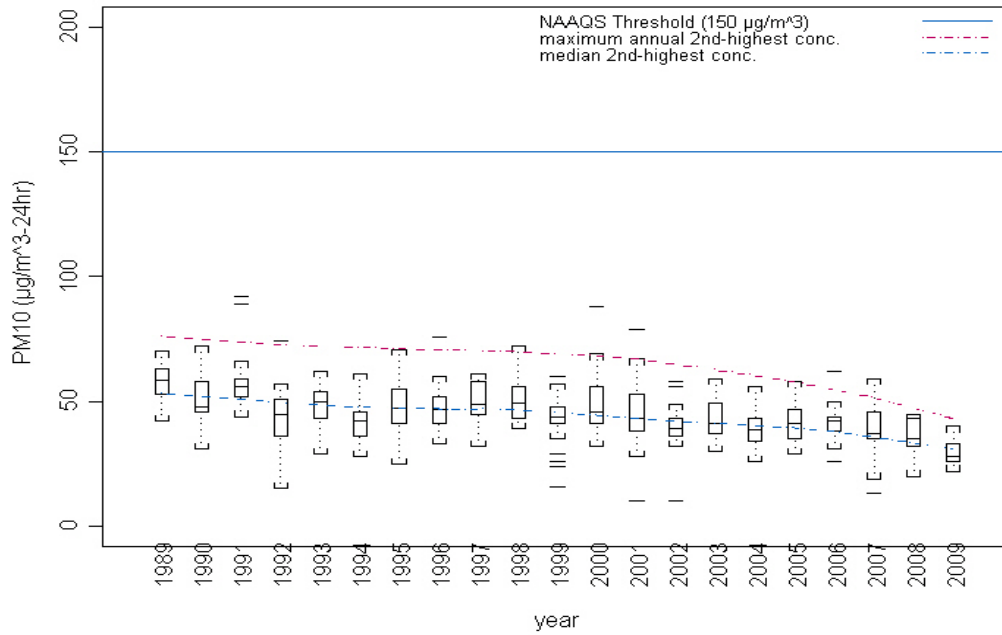
### **10.8 Nitrate Ion**

The statewide distribution of annual average nitrate ion ( $\text{NO}_3^-$ ) concentrations from 1991 to 2009 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 39 percent over the study period. The NADP study suggested that  $\text{NO}_3^-$  concentrations will decrease by a median amount of 0.01 (s.e. = 0.002) due to the protocol change in 1994 (NADP 1995).

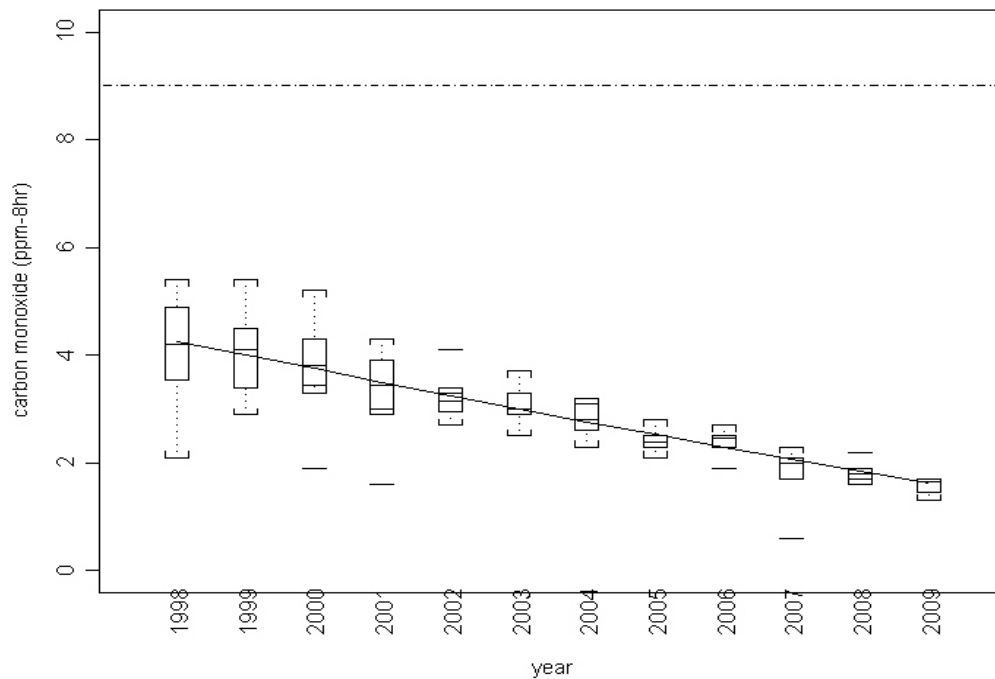
### **10.9 Sulfate Ion**

The statewide distribution of annual average sulfate ion ( $\text{SO}_4^{2-}$ ) concentrations from 1991 to 2009 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 1.530 mg/L in 1991 to 0.781 mg/L in 2009, for a 48 percent decrease. The NADP study suggested that  $\text{SO}_4^{2-}$  concentrations will decrease by a median amount of 0.02 (s.e. = 0.002) due to the protocol change in 1994 (NADP 1995).

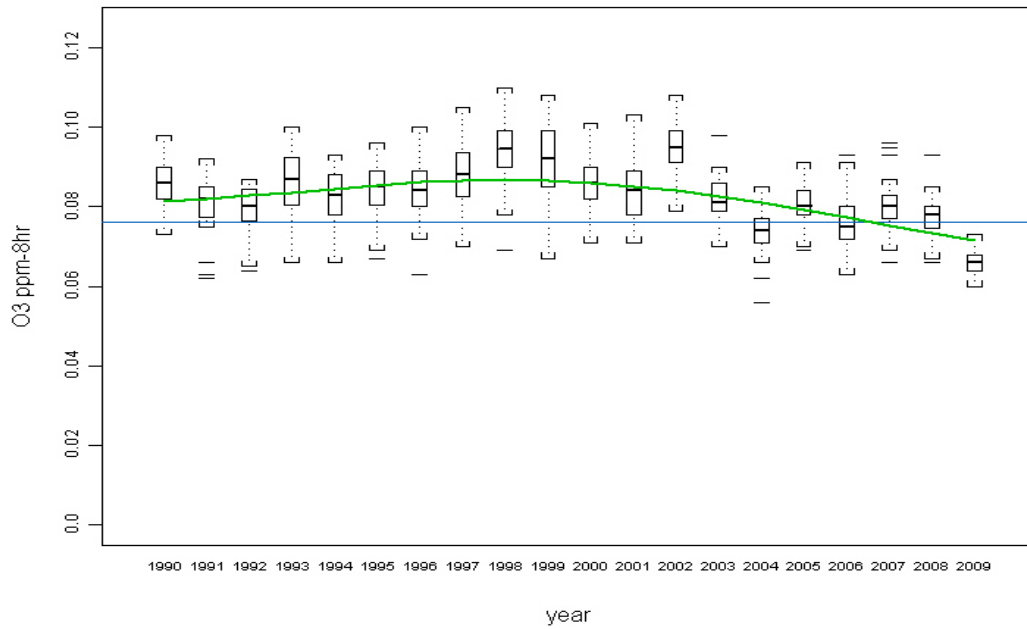
PM10 trend (2nd maximums) in NC, 1989 to 2009



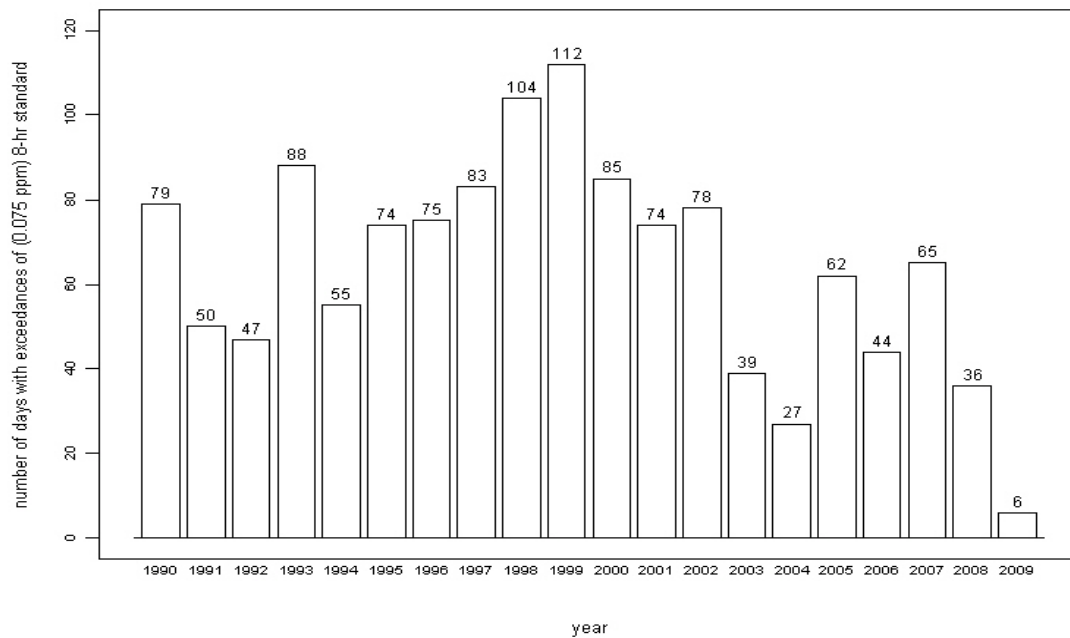
**Figure 10.1 Distribution of Statewide Second-Maximum 24-Hour PM<sub>10</sub> Concentrations, 1989- 2009, and Smoothed Regression Trend Line.**



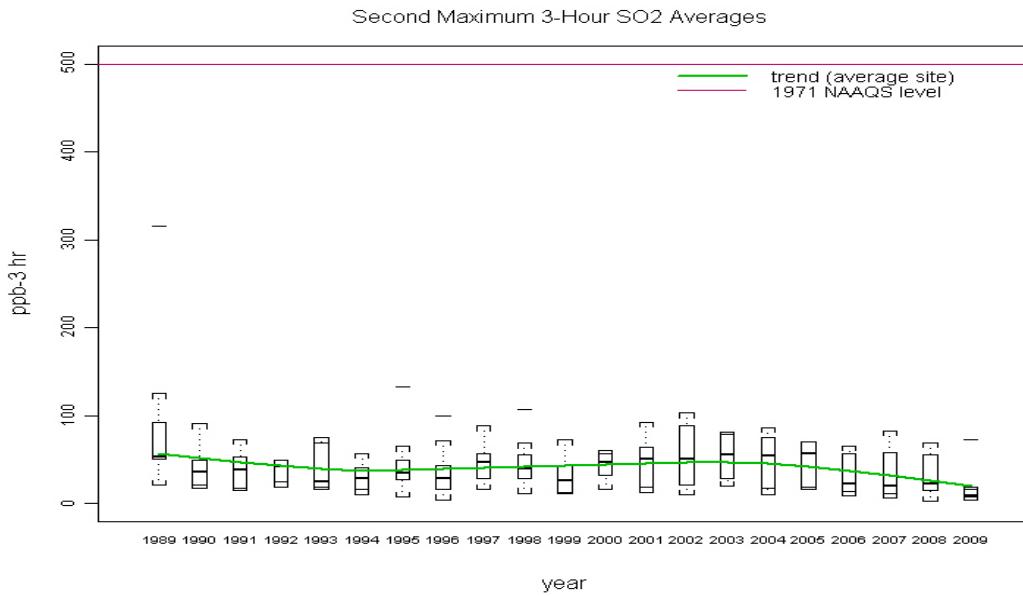
**Figure 10.2 Distribution of Statewide Second-Maximum 8-Hour Carbon Monoxide Concentrations, 1998- 2009, and Smoothed Regression Trend Line.**



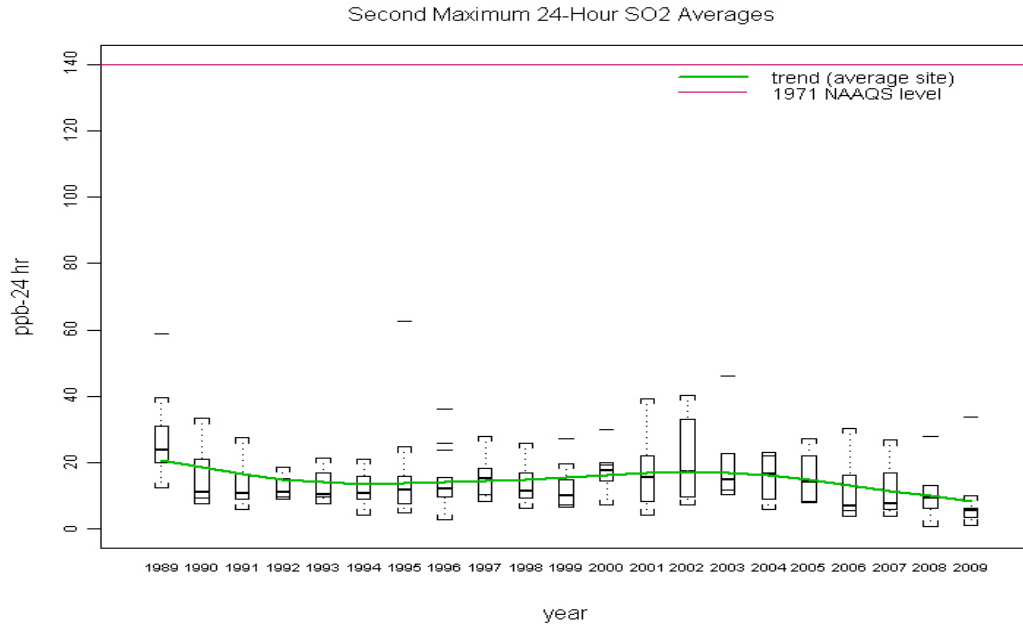
**Figure 10.3 Distribution of Statewide Fourth-Maximum 8-Hour Ozone Concentrations, 1990- 2009, and Smoothed Regression Trend Line.**



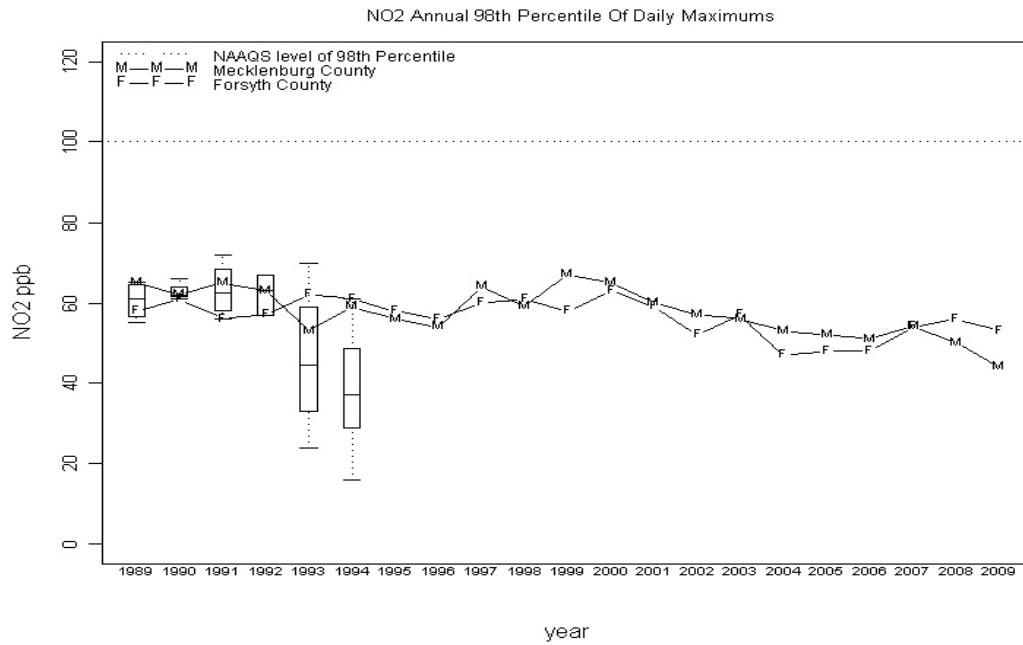
**Figure 10.4 Number of days with exceedances of 8-Hour Ozone Averages of 0.085 ppm or Greater, 1990 – 2009.**



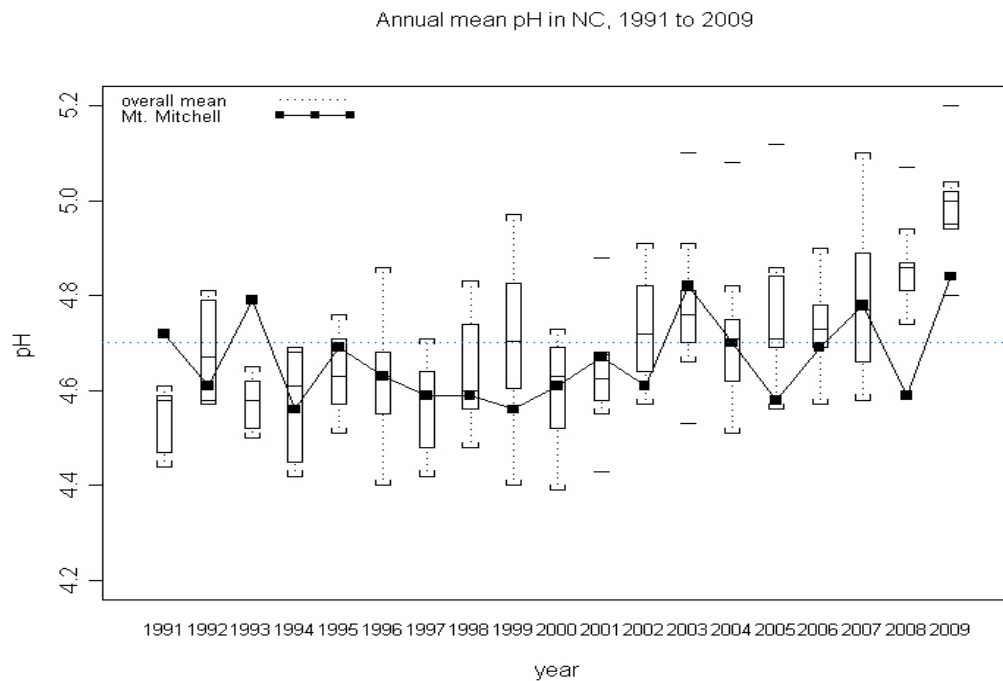
**Figure 10.5 Distribution of Statewide Second-Maximum 3-Hour Sulfur Dioxide Concentrations, 1989- 2009, and Smoothed Regression Trend Line.**



**Figure 10.6 Distribution of Statewide Second- Maximum 24-Hour Sulfur Dioxide Concentrations, 1989- 2009, and Smoothed Regression Trend Line.**

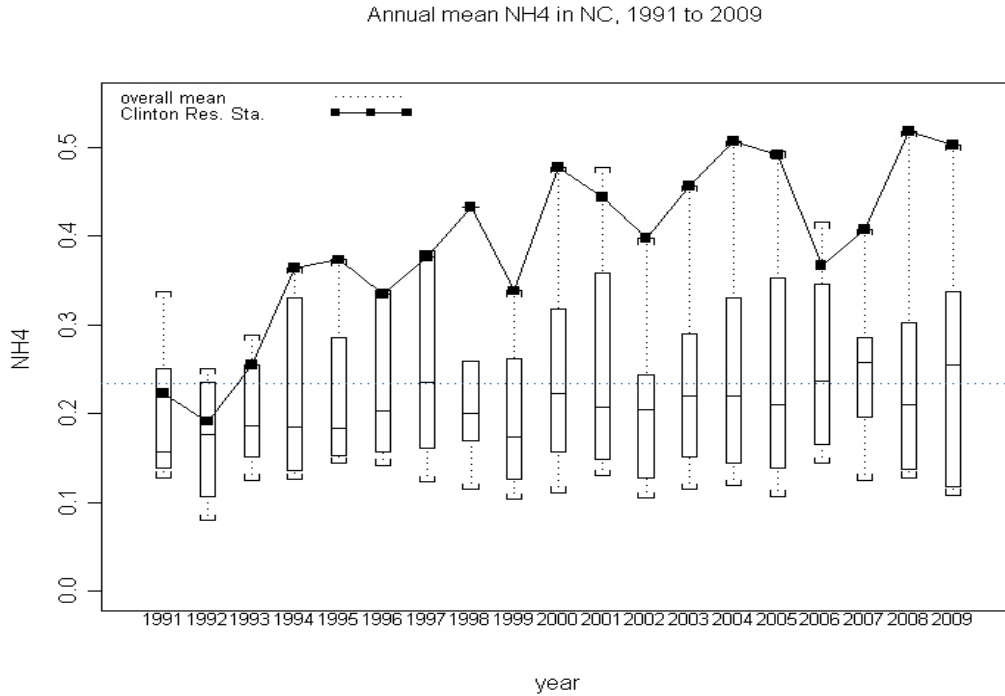


**Figure 10.7 Distributions of Forsyth and Mecklenburg County Annual Mean Nitrogen Dioxide Concentrations, 1989- 2009, and Smoothed Regression Trend Line.**

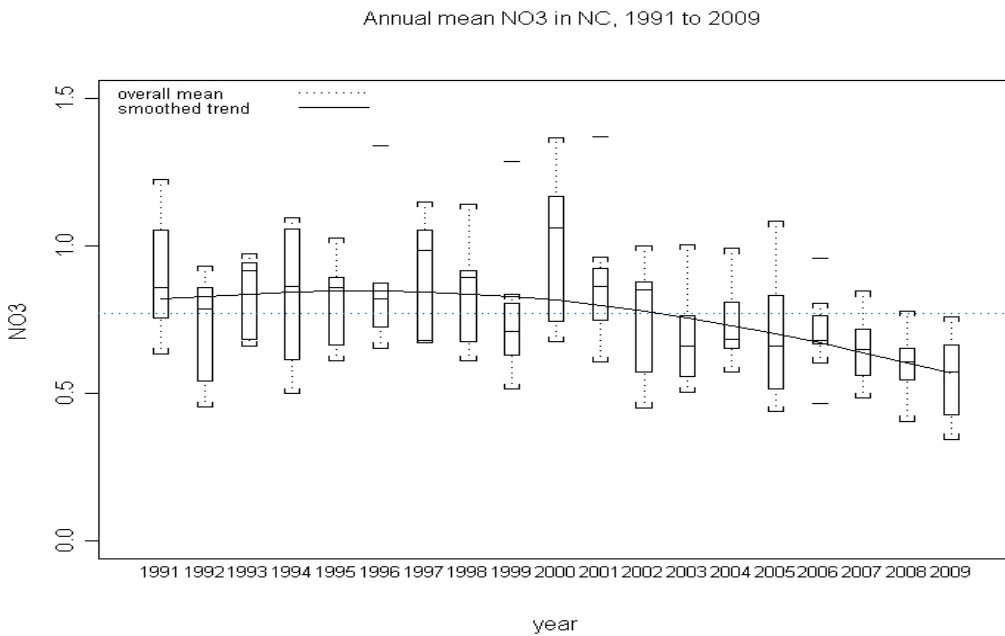


**Figure 10.8 Distribution of Statewide Annual Mean pH, 1991- 2009.**

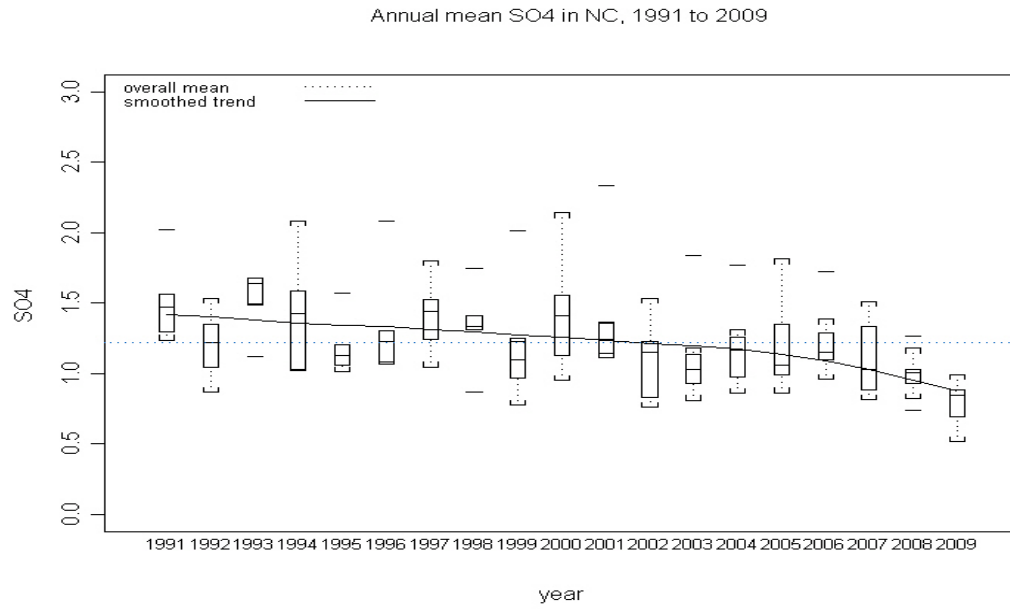




**Figure 10.9 Distribution of Statewide Annual Mean Ammonium Ion Concentrations, 1991- 2009.**



**Figure 10.10 Distribution of Statewide Annual Mean Nitrate Ion Concentrations, 1991- 2009, and Smoothed Regression Trend Line.**



**Figure 10.11 Distribution of Statewide Annual Mean Sulfate Ion Concentrations, 1991- 2009, 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  
217 West Jones Street  
Raleigh, North Carolina 27603  
1641 Mail Service Center  
Raleigh, North Carolina 27699-1641  
(919) 707-8400

### **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**

201 North Chestnut 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

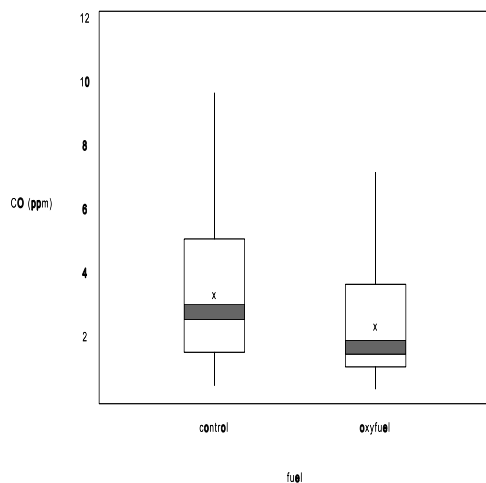
## **Appendix B. Exceptional Events**

<b>Type of Event</b>	<b>Pollutants Affected</b>
<b>Natural Events</b>	
Sustained high wind speeds	particulate matter (PM)
Stagnations, inversions	all pollutants
Unusual lack of precipitation	PM
Stratospheric ozone intrusion	O <sub>3</sub>
Volcanic eruption	CO, SO <sub>2</sub> , PM
Forest fires	CO, PM, O <sub>3</sub>
High pollen count	PM
<b>Unintentional Man-made Events</b>	
Large structural fires	CO, PM
Major traffic congestion due to accident or nonrecurring obstruction	CO
Chemical spills	SO <sub>2</sub> , NO <sub>2</sub> , PM, CO
Industrial accidents	SO <sub>2</sub> , NO <sub>2</sub> , PM, CO
<b>Intentional Man-made Events</b>	
Short-term construction/demolition	PM
Sandblasting	PM
High-sulfur oil refining	SO <sub>2</sub>
Roofing operations	PM, SO <sub>2</sub>
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 <sub>2</sub>

## Appendix C. Box-And-Whisker Plots

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

The distance between the upper and lower fourth in the box plot is called the *interquartile range*. In most box plots, the length of each of the *whiskers* is 1.5 times the interquartile range or to the extreme (maximum or minimum) of the data, whichever is *shorter*. The endpoint of each whisker is called an *inner fence*. (In the box plots pictured below, the end of each whisker is marked by a "staple" for clarity.) There may be data points, called *outliers*, beyond the inner fences; if so, they are usually indicated individually on the box plot by a dot, small circle, or (as below) a short line segment perpendicular to the axis of the box. Box plots of variables with very



long-tailed distributions may display two kinds of outliers: small dots for those just beyond the inner fences and larger dots or circles for *extreme outliers* at a distance of more than 3.0 times the interquartile range beyond the fourths. This boundary between outliers and extreme outliers is termed the *outer fence* and usually not explicitly shown in the plot.

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

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

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



## ***Appendix D. Nonattainment and North Carolina***

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

The United States Environmental Protection Agency (EPA) sets National Ambient Air Quality Standards. North Carolina monitors concentrations of air pollutants in the ambient air. Some of these monitors have measured concentrations of ozone and, fine particles (PM<sub>2.5</sub>) 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<sub>2.5</sub> and ozone precursors. Other sources of PM<sub>2.5</sub> 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 increased to 48 in 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.