DELAWARE ANNUAL AIR QUALITY REPORT

2004

Air Quality Management Section
Division of Air and Waste Management
Department of Natural Resources and Environmental Control

715 Grantham Lane
New Castle, DE 19720
(302) 323-4542

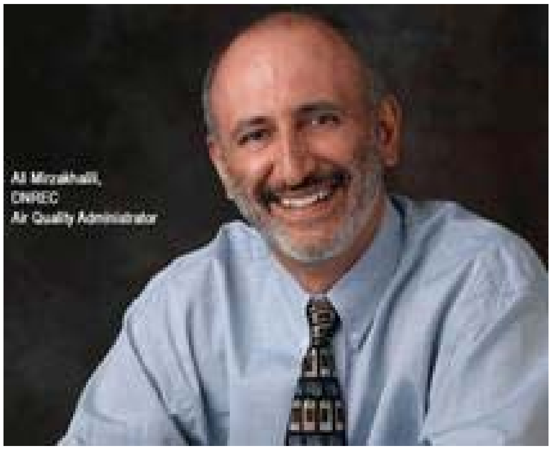
and

156 South State Street
Dover, DE 19901
(302) 739-4791

Doc. No. 40-09-02/-5/11/30

Air Quality Management

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL



A word from Ali Mirzakhalili,

Delaware’’s Air Quality Administrator

Air quality? Yes, it really DOES matter. And it matters to us all.

We at Air Quality Management are driven by this notion. That is why our work is focused so completely on protecting the public from harmful effects of air pollution.

It is our group, which has a collective and concerned finger firmly on the pulse of Delaware’’s air quality status and trends. In this document, the Delaware Annual Air Quality Report for 2004, you will find incisive detail on pollutant concentrations and treands as well as:

- Material specifying the sources of air pollution
- Inventory data related to the compounds responsible for ozone formation
- Information on air toxics emissions
- Air pollution prevention measures

Effective control of air pollution is a community effort. It requires cooperation of State, local and Federal officials in partnership with private citizens, business and industry. It requries adoption and implementaiton of policies that promote conservations, environmental stewardship, and innovations in pollution control strategies.

Thanks to the commitment and dedication of a smart and insightful team of scientists, we can continue to monitor and report accurately on our air quality, and move forward to ensure that the issue of air quality remains relevant in Delaware

Air Quality Management

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

EXECUTIVE SUMMARY

Delaware's 2004 annual air quality report continues to document the changes and overall improvement in ambient air quality in the state. In 2004 only two polllutants, ozone and $PM_{2.5}$, exceed or meet the national ambient air quality standards. Other pollutants monitored in Delaware(SO_2, CO, NO_2, and PM_{10}) are well below the national standards.

As measured by the air quality index (AQI), there are fewer days that fall into the category of unhealthy for sensitive populations. There are also, however, more days with moderate air quality and fewer with good air quality.

For ozone, 2004 is the first year since 1996 that no exceedances of the 1-hour ozone standard were recorded in Delaware. Ozone 8-hour average concentrations also show a generally decreasing trend in all three counties over recent years.

New Castle County was declared non-attainment for $PM_{2.5}$ based on concentrations that were above the annual average air quality standard during 2001 - 2003; the most recent three years show concentrations that are at the level of the air quality standard. Kent and Sussex counties continue to record concentrations below the standard.

Concentrations of air toxics in Wilmington continue to show generally low or declining levels. Measurements made throughout the state in 2003 as part of the DATAS study will be reported in next year's annual air quality report and can be used as a baseline for comparisons with measurements made in future years.

Emissions of air pollutants are calculated every three years as part of a comprehensive emissions inventory. The most recent inventory was for 2002 and the next update will cover 2005.

Table of Contents

DELAWARE ANNUAL AIR QUALITY REPORT
2004

INTRODUCTION

In 1970 Congress passed the Clean Air Act that authorized the Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) for pollutants shown to threaten human health and welfare. Primary standards were set according to criteria designed to protect public health, including an adequate margin of safety to protect sensitive populations such as children and asthmatics. Secondary standards were set according to criteria designed to protect public welfare (decreased visibility, damage to crops, vegetation, and buildings, etc.).

Seven pollutants currently have NAAQS: ozone (O_3), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter less than 10 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$) and lead (Pb). These are commonly called the "criteria" pollutants. When air quality does not meet the NAAQS, the area is said to be in “nonattainment” with the NAAQS.

This report covers Delaware’s air quality status and trends for the criteria pollutants and some non-criteria pollutants. Non-criteria pollutants are substances that do not have acceptable standard criteria for ambient concentrations. These include acid precipitation and air toxics.

This document also contains material specifying the sources of air pollution and actual inventory data detailing information related to the compounds responsible for ozone formation. Accompanying these data are information concerning in-use emission control measures as well as suggestions on what we can do to prevent air pollution. Technical details regarding monitoring activities and emission inventories, along with references and sources of more information, are included in the appendices.

GENERAL INFORMATION

ABOUT DELAWARE’S AIR QUALITY MANAGEMENT SECTION

Engineering and Compliance Branch

The mission of the Engineering and Compliance Branch is to help protect public health and welfare by inspecting and issuing air pollution control permits for minor and major stationary air pollution sources. Branch personnel make periodic facility inspections and review emission test results to ensure that permit conditions are being met. Compliance or enforcement actions are initiated for violation of regulations or permit conditions when warranted. The Branch is also responsible for the development of new air pollution control regulations and making sure that contractors comply with the state asbestos renovation and demolition rules.

Air Surveillance Branch

Source Monitoring Program

The primary mission of the Source Monitoring Program is to help protect public health and welfare by verifying actual air pollution emission levels from industrial sources. Actual emission levels are needed to establish air pollution control permit conditions and to verify compliance with permit conditions after a permit has been issued. The program is also responsible for verifying the accuracy of source emission testing. This is done to evaluate the operation of facility owned Continuous Emission Monitoring Systems (CEMS).

Ambient Air Quality Monitoring Program

The mission of the Ambient Air Quality Monitoring Program is to help protect public health and welfare by monitoring pollutants in ambient air. This is primarily accomplished by conducting long-term, fixed-site air monitoring of specific air pollutants. Most monitoring is focused on the pollutants that have standards set by the U.S. EPA to protect public health and are commonly called “criteria” pollutants. This program also conducts or assists in special short-term air monitoring studies as resources allow. Data are used to provide the public with information on current air quality conditions, assess compliance with or progress made towards meeting National Ambient Air Quality Standards (NAAQS), measure long term air quality trends for urban and non-urban areas, verify the effectiveness of air pollution control strategies, support State Implementation Plan development, evaluate air emission inventories, and verify computer models.

Planning Branch

Emission Inventory Development Program

The Emission Inventory Development Program works to develop comprehensive emission inventories of regulated pollutants from all emission source sectors, including point sources, stationary area sources, mobile sources and natural sources, as well as to compile periodic inventory data, procedures and documentation into comprehensive reports that are available to the public.

Airshed Evaluation and Planning Program

As mandated by the Federal Clean Air Act, all states must achieve and maintain attainment of the NAAQS. Delaware and the surrounding states are in “non-attainment” of those standards. The air quality problem that requires immediate attention is ground-level ozone. Other pollutants to be addressed include fine particulate matter, regional haze and hazardous air pollutants as defined by the Environmental Protection Agency. The Airshed Evaluation and Planning Program seeks to find ways to reverse the non-attainment of an air quality standard--the combination of air pollution problems that are either generated locally or result from emissions transported through the atmosphere from distant areas. The vehicle used to accomplish this result is the preparation and adoption of planning documents entitled State Implementation Plans. These are usually in the form of revisions to existing plans.

FREQUENTLY ASKED QUESTIONS

1. What is a “criteria” air pollutant?

A “criteria” air pollutant is an air pollutant that has had a National Ambient Air Quality Standard (NAAQS) established for it by the U.S. EPA. There are currently seven criteria pollutants: sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, particulate matter less than 10 microns in diameter (PM_{10}), and particulate matter less than 2.5 microns in diameter ($PM_{2.5}$).

2. What is the difference between a primary and secondary National Ambient Air Quality Standard?

Primary standards are set to protect human health. Secondary standards are set to protect public welfare and take into consideration such factors as crop damage, architectural damage, damage to ecosystems, and visibility in scenic areas.

3. How is the location of an air monitoring station decided?

Multiple factors are considered when deciding the location of air monitoring stations. Sites are selected based on the purpose of the monitoring (representative ambient concentrations, maximum point source impact, etc.), the pollutant or pollutants to be monitored, the population density, proximity to other monitoring stations (including those in other states) and operational efficiency. The U.S. EPA has developed siting requirements for each of the “criteria” air pollutants. These requirements include distance from trees, buildings and roadways, distance from major point sources, and height of the sampler probe or inlet. Other factors include site security and access, availability of electricity and telephone service, aesthetics and local zoning issues, and long-term (+10 years) site availability. Unfortunately the ideal monitoring site is virtually impossible to acquire, especially in urban areas.

Air monitoring stations are primarily used to house continuous instruments that measure “criteria” air pollutants (those that have established National Ambient Air Quality Standards). Monitoring for particulate matter is often accomplished by setting up instrumentation on a sampling platform.

Delaware has had air monitoring sites located around the state since the late 1960’s. The original focus of the monitoring network was on monitoring close to “point” sources (large facilities with high emissions). As air pollution control strategies were successfully implemented and the emissions from large facilities were brought into compliance with air quality regulations, the focus has shifted to pollutants that are more of a regional problem.

4. How large of an area does an air monitoring station represent?

   Depending on the location of a station and the pollutant being monitored, the data from a given site can represent a large geographical area or a smaller local area impacted by specific sources.

5. What air quality factors should be considered when buying a house?

   The air quality problem that affects the most Delawareans is the build up of ground-level ozone on certain hot summer days. Ozone is a regional air quality problem that does not vary dramatically over distances of several miles, and all three counties in Delaware can have days exceeding the air quality standard.

   New Castle County also does not meet the air quality standard for fine particulate matter.

   Become an informed consumer. Drive and walk around the area. Do you see any potential air pollution sources? Where are the major roadways? Does anyone in your family have any known allergies or personal health problems that could make them more sensitive to a specific pollutant? Ask the current residents and neighbors if they have observed any problems. Be aware that you can sometimes be bothered more by a small air pollution source that is close than by a large source that is farther away.

6. What do I do if I have a complaint about an odor or other air quality issues?

   Odors and other environmental complaints can be reported to the Environmental Emergency and Complaints 24-hour Hotline at **1-800-662-8802**.

7. How can I get current air quality data?

   Near real time air quality data and other information is available on the Air Quality Management Section web page.

   www.dnrec.state.de.us/air/aqm_page/aqm_nets.htm

8. How can I get historical air quality data?

   Historic air quality data for Delaware and other states is available on the world wide web at: www.epa.gov/air/data/

9. Why can’t I burn my trash?

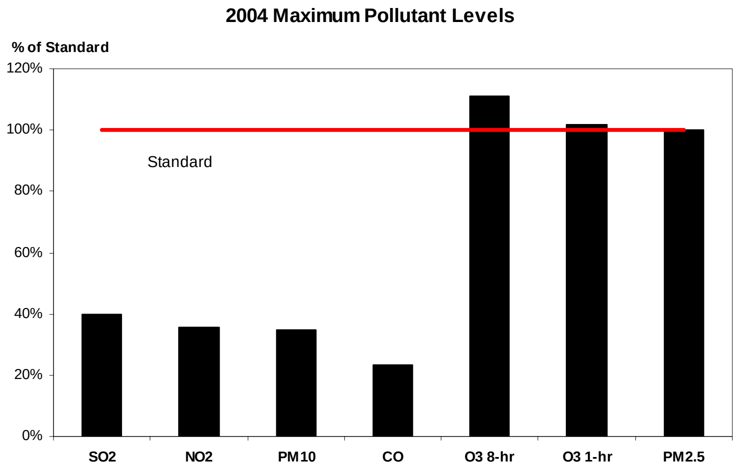
   Burning of any type of trash is illegal throughout all of Delaware at all times of the year. The burning of trash emits large amounts of toxic air pollutants some of which may be cancer causing. The amount of air pollution from 35 average burn barrels has been estimated as the equivalent of 1 regulated hazardous waste incinerator. The burning of trash also emits pollutants that contribute to other air quality problems such as ground-level ozone formation, odor complaints, fine particles, and visibility.

10. Who can I call about an indoor air quality problem?

    Indoor air quality problems are handled by the Environmental Health Evaluation Branch of the Division of Public Health. **(302) 744-4540.**

DELAWARE’S AIR QUALITY STATUS

Delaware is currently in attainment with all the National Ambient Air Quality Standards except ozone and $PM_{2.5}$. Over the last ten years, trends in ambient concentrations of the criteria pollutants have been either level or declining.



AIR QUALITY INDEX (AQI)

Description

The Air Quality Index or AQI was created by the U.S. EPA as a measure of overall air quality. The AQI was developed to ensure national uniformity of daily air quality reports, and the procedures and calculations used to generate the AQI are defined by EPA.

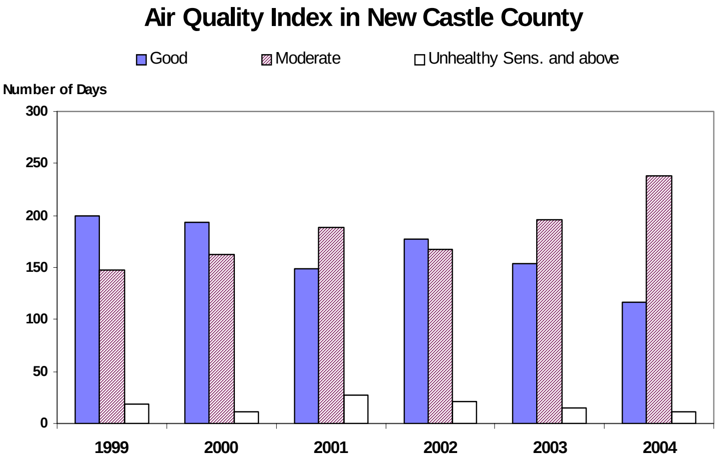
Ambient concentrations of five pollutants (PM_{10}/$PM_{2.5}$, SO_2, CO, O_3, and NO_2) are used to calculate a health-related value or index. The data represents the previous 24 hours. For each pollutant, a subindex is calculated using a mathematical function that transforms ambient pollutant concentrations onto a scale from zero to 500, with 100 corresponding to the National Ambient Air Quality Standard (NAAQS). Index ranges and descriptions are listed below. In 2000 the U.S. EPA added a new category “Unhealthy for Sensitive Groups”.

0 to 50	"Good"
51 to 100	"Moderate"
101 to 150	"Unhealthy for Sensitive Groups”
151 to 200	“Unhealthy”
200 to 299	"Very Unhealthy"
300 and above	"Hazardous"

Air Quality Index (AQI)

Delaware calculates and reports an AQI for the Wilmington area every working day and reports it to the American Lung Association for distribution to the local media. According to EPA guidelines, only monitors that represent air quality in the Wilmington urban area are used to generate this index. In June 2000 the U.S. EPA changed the AQI to include $PM_{2.5}$ for the first time. This resulted in more days falling into the Moderate or Unhealthy for Sensitive People categories.

The accompanying graph reflects the AQI calculated for New Castle County for 2004. Data for the entire county, not just the city of Wilmington, is used in this graph. The number of days with unhealthy air quality has been generally declining in recent years; however, the number of days with moderate air quality is increasing while the number of days with good air quality is decreasing.



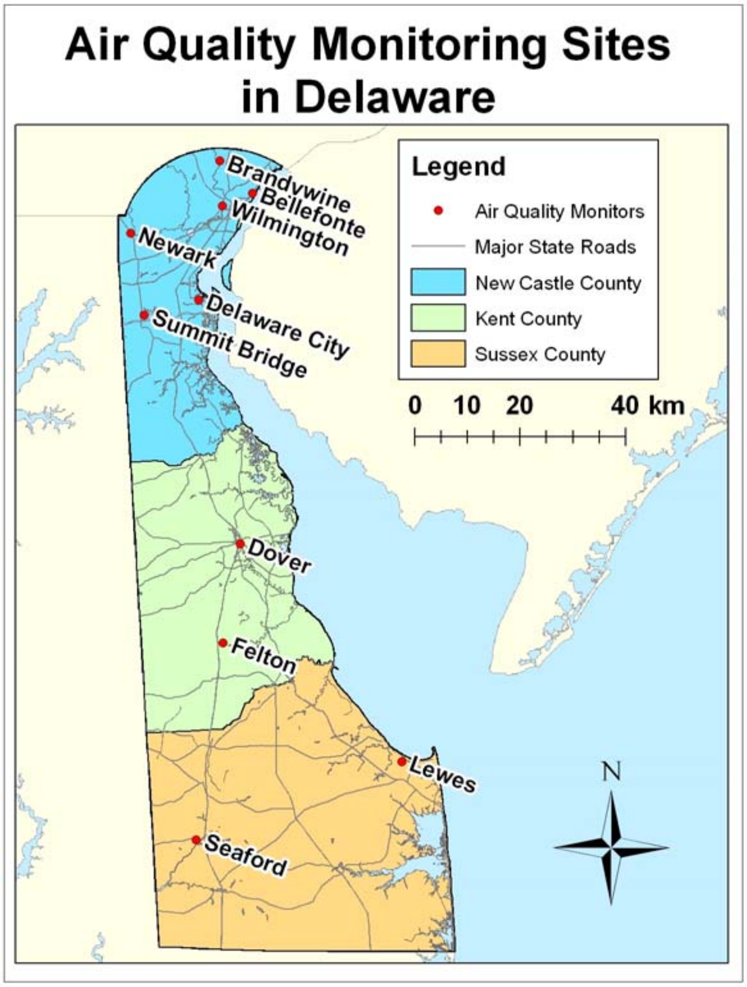
Delaware Air Monitoring Network

The State of Delaware has established an air monitoring network to determine the ambient levels of the pollutants for which NAAQS have been established. The Delaware Air Monitoring Network consists of the sites and monitors listed in the following table. Although monitoring takes place statewide, most of the stations are concentrated in the northern urban/industrial areas, which have the highest population and number of pollutant sources. This network is maintained and operated by the Air Surveillance Branch of the Air Quality Management Section, Division of Air and Waste Management, DNREC.

The gaseous criteria pollutants are measured continuously with hourly averages computed and reported via a telemetry system to the central data storage computer in the New Castle office. Particulates are collected as 24-hour samples that run every sixth day.

Delaware Air Monitoring Network
2004

SITE	SO_2	NO_2	CO	O_3	PM_{10}	$PM_{2.5}$	WS/ WD	Acid Rain
Brandywine				X				
Bellefonte	X			X		X		
Wilm. - MLK Blvd	X	X	X		X	X	X	
Ommelanden								X
Newark						X		
Delaware City	X		X				X	
Summit Bridge	X			X		X	X	
Dover						X		
Felton				X		X	X	
Seaford				X		X	X	
Lewes				X			X	


Air Quality Monitoring Sites in Delaware

AIR QUALITY - POLLUTANTS THAT EXCEED STANDARDS: Ozone and $PM_{2.5}$

OZONE (O_3)

Description

Ozone (O_3) is a highly reactive gas that is the main component of smog. Ozone in the lower atmosphere (troposphere) is considered a pollutant and is distinct from the ozone layer in the upper atmosphere (stratosphere) where it acts as a shield from ultraviolet radiation. Ozone is a strong respiratory irritant that affects healthy individuals as well as those with impaired respiratory systems. It can cause respiratory inflammation and reduce lung function.

Ozone also adversely affects trees, crops (soybeans are a particularly sensitive species), and other vegetation. The national agricultural loss from ozone pollution is estimated by the U.S. EPA to be several billion dollars annually. It is also implicated in white pine damage and reduced growth rates for red spruce; studies have shown forest and ecosystem damage can result from high ozone concentrations.

Standards

Primary NAAQS:

Maximum one-hour = 0.12 ppm

The one-hour NAAQS is achieved when the expected number of days, averaged over three years, with a maximum hourly average of greater than 0.12 ppm (235 $\mu g/m^3$) is less than or equal to one.

Maximum eight-hour average = 0.08 ppm

The eight-hour NAAQS is achieved when the annual fourth highest daily eight-hour concentration, averaged over three years, is less than or equal to 0.08 ppm.

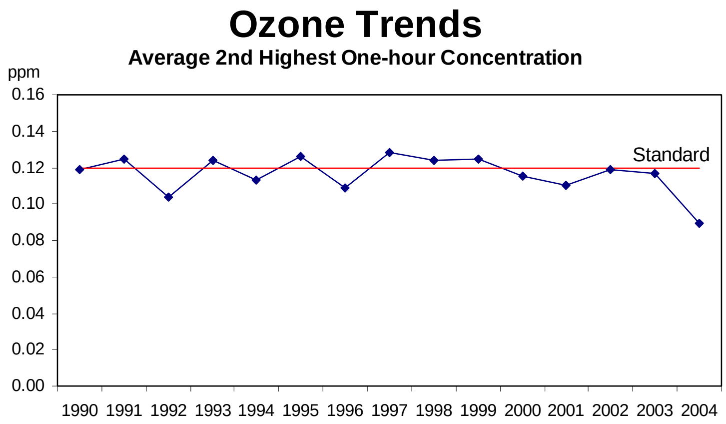
Sources

Ozone is not emitted directly from a pollution source but is formed in the lower atmosphere by the reaction of nitrogen oxides (NO_X) and volatile organic compounds (VOCs) in the presence of sunlight and warm temperatures. Sources of nitrogen oxides include automobiles, power plants and other combustion activities. VOCs can come from automobiles, gasoline vapors, and a variety of large and small commercial and industrial sources that use chemical solvents, paint thinners, and other chemical compounds. These compounds or “precursors of ozone” can travel for miles before chemical reactions in the atmosphere form ozone.

Controlling ozone is a complex problem due to the wide variety of sources for nitrogen oxides and VOCs as well as the long-distance transport of ozone and its precursors. Control methods include regulation to control gasoline vapor emissions, inspection and maintenance programs for motor vehicle exhausts, and regulation of VOC and NO_X emissions from industrial sources.

Locations

Ozone is monitored throughout the state. Monitors are located away from or at some distance downwind of urban areas and major traffic corridors in order to avoid “scavenging” of ozone by NO emissions. See the “Delaware Air Monitoring Network” table on page 9 for specific sites. While short-term 1-hour average peak ozone levels are highest in New Castle County, longer-term 8-hour averages are above the standard throughout Delaware.

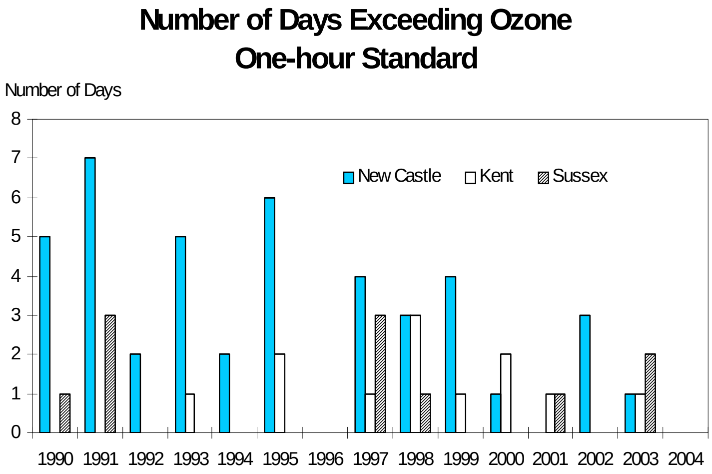


Status and Trends

Trends in ozone concentrations are often difficult to discern due to the effect of meteorology. Hot, dry weather and stagnant air favor the formation of ozone, and the greatest number of exceedance days typically occur during the hottest and driest summers. Ozone levels in the 1990's were better than in the 1980's and are continuing to show generally decreasing levels.

One-hour Ozone Data and Trends

2004 was a relatively cool, wet summer. There were no days on which the one-hour NAAQS was exceeded in Delaware, the first year since 1996 with no exceedances of the one-hour standard.



Delaware Exceedances of the One-Hour Ozone NAAQS

Total number of days at each site with a daily one-hour maximum $ 0.12 ppm

0030011201122

Year	Site								County			State
	Smt	Blfte	Clmt	Brnd	Dver	Fltn	Sfrd	Lws	NC	K	S	
1982	1	4	8		0		ND		11	0	ND	11
1983	14	11	13		7		11		29	7	11	29
1984	3	2	2		1		0		4	1	0	5
1985	5	4	2		2		1		8	2	1	10
1986	0	6	0		0		0		6	0	0	6
1987	3	6	6		3		1		9	3	1	12
1988	15	15	15		10		8		23	10	8	28
1989	2	1	2		0		0		4	0	0	4
1990	4	4	2		0		1		5	0	1	6
1991	6	3	2		*0		3		7	0	3	9
1992	1	1	0		0		0		2	0	0	2
1993	5	2	0		1		0		5	1	0	5
1994	2	0		[a]0	0		0		2	0	0	2
1995	5	5		3		2	0		6	2	0	6
1996	0	0		0		0	0		0	0	0	0
1997	4	1		2		1	3	1	4	1	3	7
1998	2	1		1		3	1	0	3	3	1	6
1999	2	2		4		1	0	0	4	1	0	4
2000	1	1		1		2	0	0	1	2	0	3
2001	0	0		0		1	1	0	0	1	1	2
2002	1	2		3		0	0	0	3	0	0	2
2003	0	0		1		1	2	0	1	1	2	2
2004	0	0		0		0	0	0	0	0	0	0

* No data May 22 - July 22, 1991

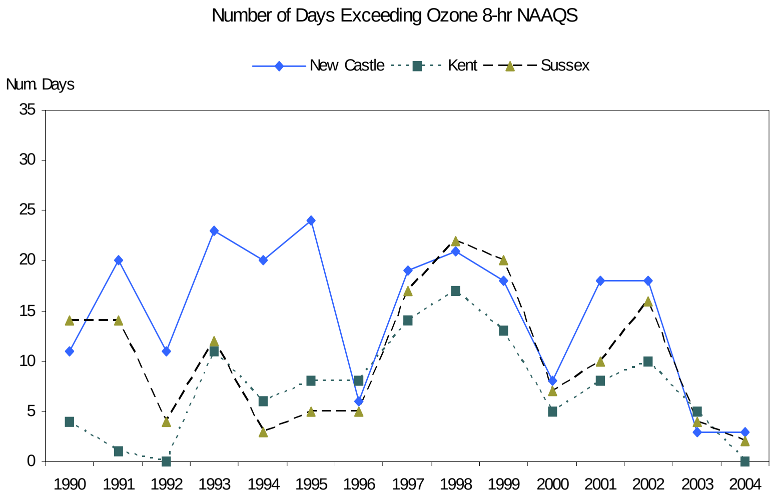
[a] Site became operational 8/1/94

ND = no data

Eight-hour Ozone Data and Trends

There were several days with exceedances of the eight-hour ozone standard of 0.08 ppm in New Castle and Sussex counties, while there were no exceedances recorded in Kent county.

There was a total of five days in Delaware that exceeded the 8-hour standard. As with the 1-hour exceedances, weather plays a major role and makes it difficult to determine pollutant trends; however, 2003 and 2004 represent two consecutive years with relatively few days exceeding the 8-hour standard in New Castle County.



2004 Eight-hour Averages Exceedances and Maximum (ppm)

NAAQS = 0.08 ppm

Site	Num. Exc.	1st Max.	2nd Max.	3rd Max.	4th Max.
Brandywine	3	0.094	0.085	0.085	0.082
Bellefonte	1	0.094	0.080	0.078	0.077
Summit Bridge	0	0.075	0.072	0.071	0.068
Felton	0	0.084	0.078	0.076	0.075
Seaford	0	0.080	0.080	0.077	0.076
Lewes	2	0.087	0.086	0.079	0.078

Num. Exceedances = Number of days with at least one 8-hour average $ 0.085 ppm.

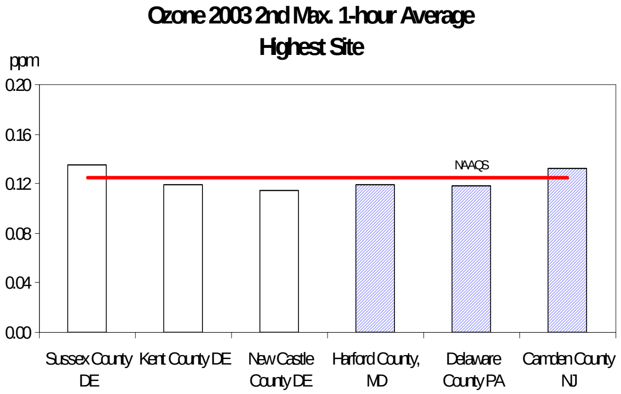
3-Year Average of 4th Daily Max. Eight-hour Avg.

NAAQS = 0.08 ppm

Site	1997-1999	1998-2000	1999-2001	2000-2002	2001-2003	2002-2004
Brandywine	0.099	0.096	0.096	0.096	0.093	0.089
Bellefonte	0.086	0.090	0.092	0.092	0.090	0.086
Summit Bridge	0.099	0.097	0.097	0.097	0.093	0.084
Felton	0.099	0.097	0.094	0.093	0.089	0.084
Seaford	0.099	0.098	0.095	0.094	0.091	0.086
Lewes	0.099	0.095	0.091	0.088	0.088	0.085

How does Delaware's air quality compare to nearby areas?

Ozone levels in Delaware are similar to those in nearby areas.



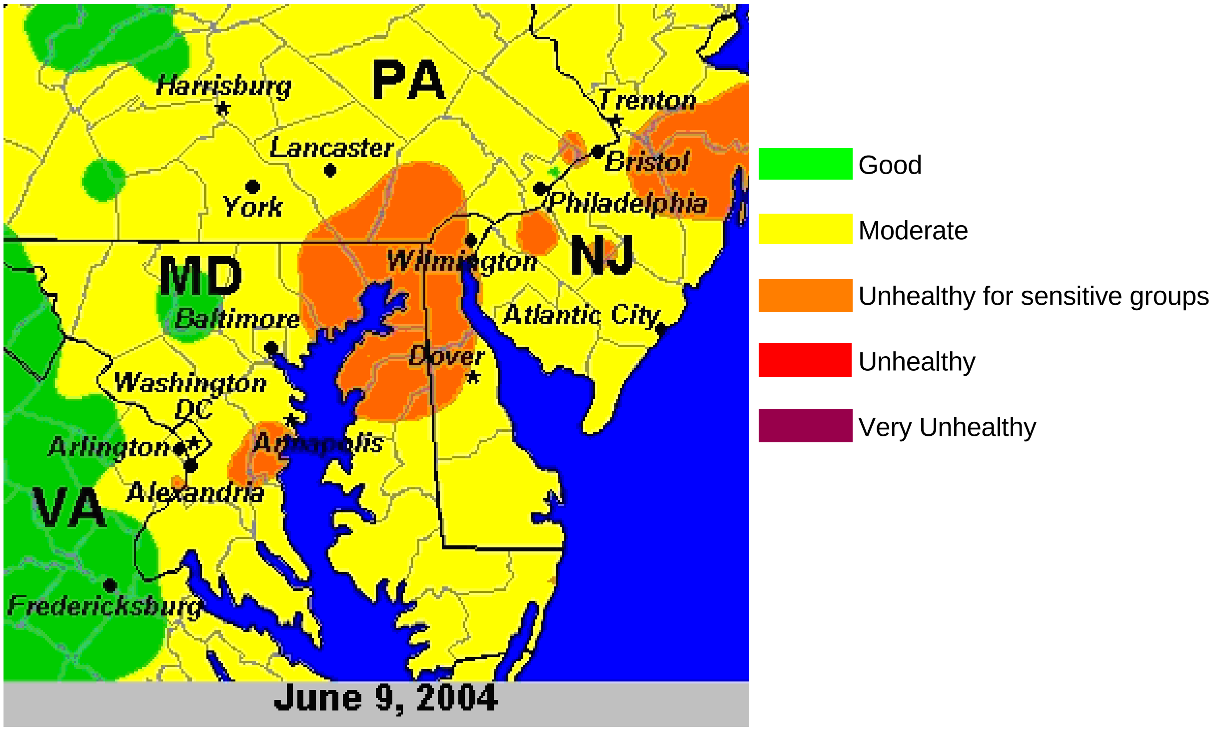
Ozone Mapping Project

As part of the Ozone Mapping Project, participating states and local agencies submit real-time ground-level ozone data to a centralized computer. The data is converted into color-coded maps of ground-level ozone concentrations. These maps are then distributed to local television stations for inclusion in the weather segment of the news program. Stations are most likely to broadcast the map during periods of poor air quality.

The purpose of the ozone mapping project is to increase awareness of elevated ozone concentrations so people can take protective measures and to educate the public about the regional nature of ozone formation and transport. For more information and examples of maps, please visit the EPA "AirNow" web site at http://www.epa.gov/airnow.

Following is an example of an ozone map showing the regional nature of ozone episodes.

Air Quality Index Peak Values - June 9, 2004



Source: EPA Ozone Mapping Project, AIRNOW website http://www.epa.gov/airnow/

PARTICULATE MATTER - FINE ($PM_{2.5}$)

Description

Fine particulate matter is made up of particles smaller than 2.5 microns in diameter. These fine particles, also called $PM_{2.5}$, penetrate more deeply into the lungs than coarse particles (2.5 - 10 microns) and are more likely to contribute to health effects. Health effects of concern associated with particulate matter pollution demonstrated in recent community studies include premature death and increased hospital admissions and emergency room visits, primarily by the elderly and individuals with cardiopulmonary disease, increased respiratory symptoms and disease in children and individuals with cardiopulmonary disease, and decreased lung function and alterations in lung tissue and structure, particularly in children and people with asthma.

Standards

Primary NAAQS:	Annual arithmetic mean = 15 µg/m^3 averaged over three years
	24-Hour maximum = 65 µg/m^3 as the 98th percentile averaged over three years

Sources

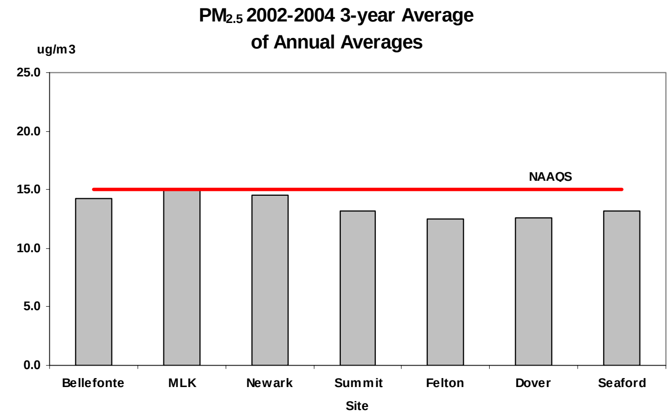
Fine particles ($PM_{2.5}$) are generally emitted from combustion activities (such as industrial and residential fuel burning and motor vehicles) while coarse particles come from dust emitted during activities such as construction and agricultural tilling. $PM_{2.5}$ can also form in the atmosphere from precursor compounds through various physical and chemical processes.

Locations

Monitors are located throughout Delaware, with the majority of monitors in New Castle County where the highest concentrations occur. See the table on page 9 for specific sites.

Delaware Air Quality and Trends

Since $PM_{2.5}$ had not been previously designated as a criteria pollutant, new standardized monitoring methods needed to be developed before state and local monitoring networks could be established. Delaware's monitoring network began collecting data in January 1999. The first complete year of data collected was 2000. Three years of complete data are required for comparison to the national standard.



$PM_{2.5}$ 2002-2004 3-year Average of Annual Averages

New Castle County has been designated non-attainment for $PM_{2.5}$ based on the 16.0 µg/m^3 three-year average of the annual averages for 2001 to 2003 at the urban Wilmington site. For the most recent three-year period (2002 - 2004), the highest average in New Castle County was equal to the $PM_{2.5}$ annual standard, while Kent and Sussex counties were below the standard. The 98th percentile 24-hour average $PM_{2.5}$ standard is met in all three counties. There is not yet enough data to determine trends.

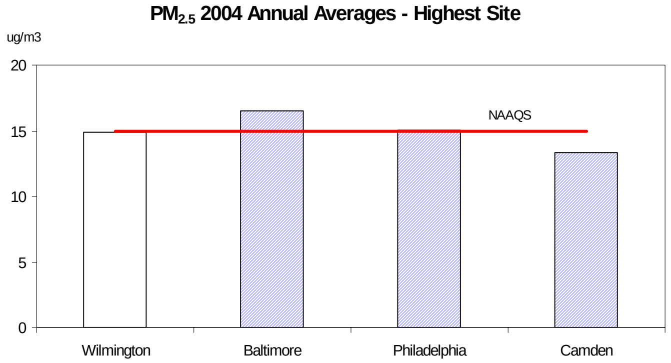
The highest concentrations continue to be at the urban Wilmington MLK site; however, there is significant correlation between all sites. For example, if high concentrations of $PM_{2.5}$ are recorded at one site, all other sites also record high concentrations on that day. Both local and regional sources of fine particulate matter and its precursors contribute to concentrations seen in Delaware.

Delaware 2002 - 2004 $PM_{2.5}$ Data Summary

Site	3-year Average of Annual Averages µg/m^3 NAAQS = 15	3-year Average of 98th Percentile 24-hour Avg. µg/m^3 NAAQS = 65
Felton	12.5	36
Dover	12.6	36
Bellefonte	14.3	36
Summit Bridge	13.2	36
Wilmington MLK	15.0	38
Newark	14.6	36
Seaford	13.1	36

How does Delaware's air quality compare to nearby areas?

Air quality in Delaware is similar to nearby areas.



AIR QUALITY - POLLUTANTS THAT MEET STANDARDS: CO, NO_2, PM_{10}, SO_2, Lead

CARBON MONOXIDE (CO)

Description

Carbon monoxide is a colorless, odorless, poisonous gas produced by incomplete combustion of fossil fuels. It reduces the blood's ability to carry oxygen. Exposure can cause fatigue, headache, and impaired judgement and reflexes at moderate concentrations; at high levels unconsciousness and death can result. People with heart disease, angina, emphysema and other lung or cardiovascular diseases are most susceptible.

Standards

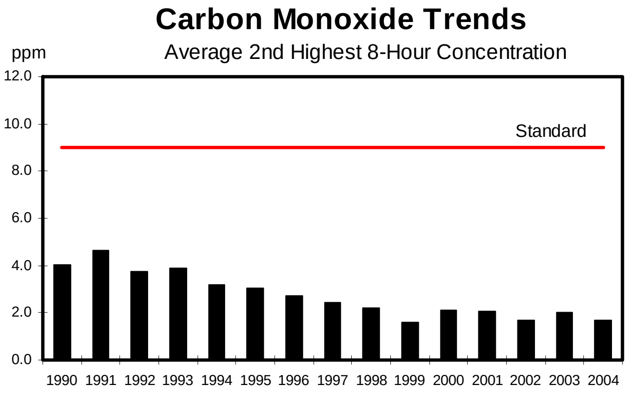
Primary NAAQS: 8-hour average = 9 ppm (10 µg/m^3)
1-hour average = 35 ppm (40 µg/m^3)
Not to be exceeded more than once per year

Sources

Carbon monoxide is formed when carbon in fuels is not completely burned. The EPA estimates that approximately 60% of all CO emissions are from motor vehicle exhaust. Other sources include incinerators, wood stoves, furnaces, and some industrial processes. Concentrations are highest along heavily traveled highways, and decrease significantly with increasing distance from traffic. Therefore, CO monitors are usually located close to roadways or in urban areas.

Locations

Monitors for CO are located in Wilmington and along Route 9 north of Delaware City.



Air Quality and Trends

Mobile sources cause most of the ambient CO detected at the Wilmington site.

There has been a slight downward trend in CO concentrations since monitoring began in the 1970's, and no violations of the ambient standards have occurred since 1977. Improvements are largely due to cleaner burning engines in cars and tighter automobile emission standards. Low concentrations continued in 2004.

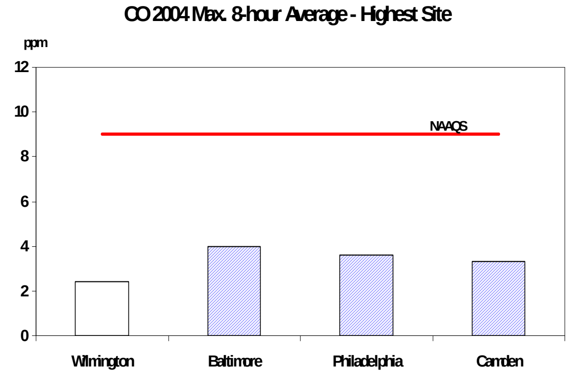
Delaware Carbon Monoxide (CO) 2004 Max. Values

ppm

	1-Hour Avg. NAAQS = 35 ppm		8-Hour Avg. NAAQS = 9 ppm	
Site	1st Max.	2nd Max.	1st Max.	2nd Max.
Wilmington	3.6	3.4	2.4	2.1
Delaware City	1.8	1.7	1.3	1.2

How does Delaware's air quality compare to nearby areas?

Most CO monitors are located in urban areas. CO concentrations monitored in Wilmington are similar to those in nearby areas.



NITROGEN DIOXIDE (NO_2)

Description

Nitrogen dioxide (NO_2) is a reddish-brown toxic gas that is part of a group of gases containing nitrogen and oxygen called oxides of nitrogen or NO_X. Nitrogen dioxide irritates the lungs and upper respiratory system and lowers resistance to respiratory infections. It can be fatal in high concentrations. Nitrogen dioxide is also known to damage vegetation by stunting growth and reducing seed production. It acts to reduce visibility. Reactions between nitrogen oxides and other compounds in the atmosphere can form nitric acid, which contributes to the acid rain problem. Nitrogen oxides can also have a significant impact on fine particulate matter concentrations, most notably in the western areas of the United States.

One of the most important features of NO_X is their ability to react with volatile organic compounds (VOCs) to form ozone. Air quality computer models have shown that control of NO_X is necessary in many areas of the United States to reach attainment of the ozone standard.

Atmospheric deposition of oxides of nitrogen has recently been estimated to be a significant source of nitrogen to bodies of water such as the Chesapeake Bay and Delaware's Inland Bays. Nitrogen acts as a nutrient and contributes to excess nutrient loading and algal blooms in estuary systems.

Standards

Primary NAAQS: Annual arithmetic mean = 0.053 ppm (100 µg/m^3)

Sources

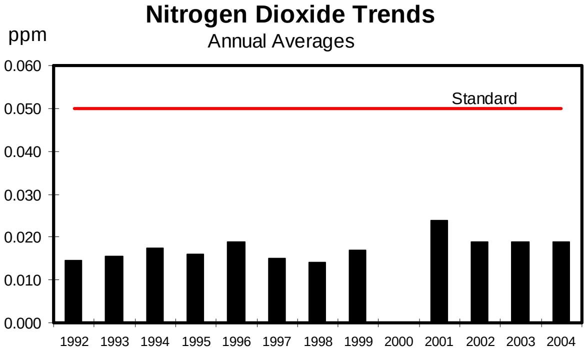
Oxides of nitrogen are produced during high-temperature burning of fuels. Sources of NO_X include motor vehicles and stationary sources that burn fossil fuels such as power plants and industrial boilers.

Locations

Since 2001 Delaware has monitored NO_2 only in Wilmington. There was insufficient data to generate an average for 2000.

Delaware Air Quality and Trends

Nitrogen dioxide levels in Delaware have remained well below the NAAQS since monitoring began. In 2004 levels continued to remain well below the standard.



Delaware Nitrogen Dioxide (NO_2)

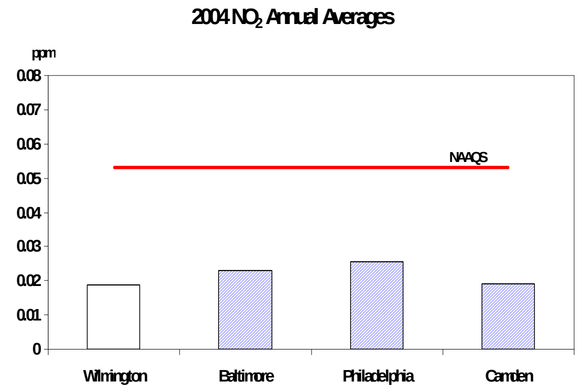
Annual Arithmetic Means in ppm

Site	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Wilmington							*	.024	.019	.019	.019
Bellefonte	.019	.017	.019	.018	.016	.017	*				
Summit	.016	.015	*	.012	.012						

* Insufficient data to calculate annual average.

How does Delaware's air quality compare to nearby areas?

Most NO_2 monitors are located in urban areas. NO_2 concentrations monitored in Delaware are similar to those in nearby areas.



PARTICULATE MATTER (PM_{10})

Description

PM_{10} is the fraction of total suspended particulate matter (TSP) that is less than 10 microns in diameter, which is about 1/7 the diameter of a human hair. Particles of this size are small enough to be inhaled into the lungs. Particulate matter can include solid or liquid droplets that remain suspended in the air for various lengths of time.

Particulates small enough to be inhaled can carry other pollutants and toxic chemicals into the lungs while larger particulates can cause coughing and throat irritation. Major effects of PM_{10} listed by EPA include aggravation of existing respiratory and cardiovascular disease, alterations in immune responses in the lung, damage to lung tissue, carcinogenesis and premature mortality. The most sensitive populations are those with chronic obstructive pulmonary or cardiovascular disease, asthmatics, the elderly, and children. Particulates are also a major cause of reduced visibility and can be involved in corrosion of metals (acidic dry deposition).

Standards

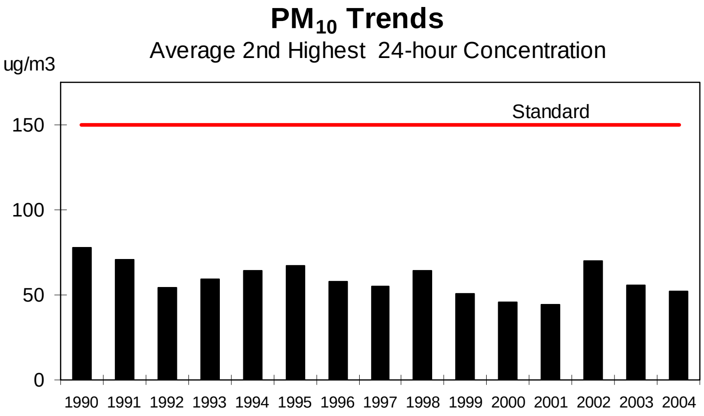
Primary NAAQS:	Annual arithmetic mean = 50 µg/m^3
	24-Hour maximum = 150 µg/m^3 not to be exceeded more than once per year averaged over three years.

Sources

Major sources include steel mills, power plants, motor vehicles, industrial plants, unpaved roads, and agricultural tilling. The wide variety of PM_{10} sources means that the chemical and physical composition of the particles are highly variable.

Locations

Because resources were shifted to support $PM_{2.5}$ monitoring, and PM_{10} concentrations have been consistently below the standard, PM_{10} is currently monitored only at the urban Wilmington site.



Delaware Air Quality and Trends

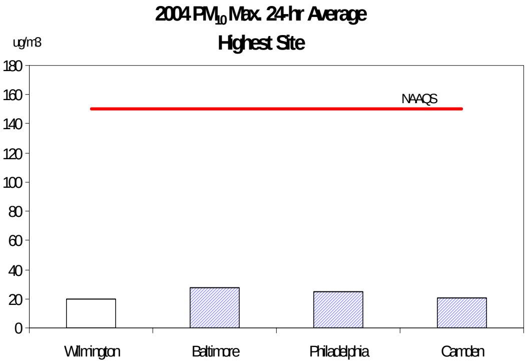
Delaware is in attainment with the PM_{10} NAAQS. The increase in the 2002 second highest 24-hour average seen in the trends graph is due to smoke from fires in Quebec in July 2002. The same fires also affected $PM_{2.5}$ concentrations throughout the northeastern United States.

Delaware PM_{10} Trends

Site	Annual Average µg/m^3									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Bellefonte	29.2	25.9	25.3	29.0	24.4	24.9				
Wilmington	37.0	32.1	31.9	28.4	27.8	26.4	23.0	23.0	20.3	19.8
Seaford	29.0	24.0	24.4							

How does Delaware's air quality compare to nearby areas?

PM_{10} concentrations in Delaware are similar to nearby areas.



SULFUR DIOXIDE (SO_2)

Description

Sulfur dioxide (SO_2) is a pungent, poisonous gas. It is an irritant that can interfere with normal breathing functions even at low levels. It aggravates respiratory diseases such as asthma, emphysema, and bronchitis. These effects can be magnified by high particulate levels. High SO_2 levels can obstruct breathing passages and cause increased death rates among people with existing heart and lung disease.

Sulfur dioxide can bind to dust particles and aerosols in the atmosphere, traveling long distances on the prevailing winds. It can also be oxidized to SO_3 and combine with water vapor to form sulfuric acid and fall as acid rain, causing materials damage and harming aquatic life. Sulfur compounds contribute to visibility degradation in many areas including national parks. Sulfur dioxide in the atmosphere can also cause plant chlorosis and stunted growth.

Standards

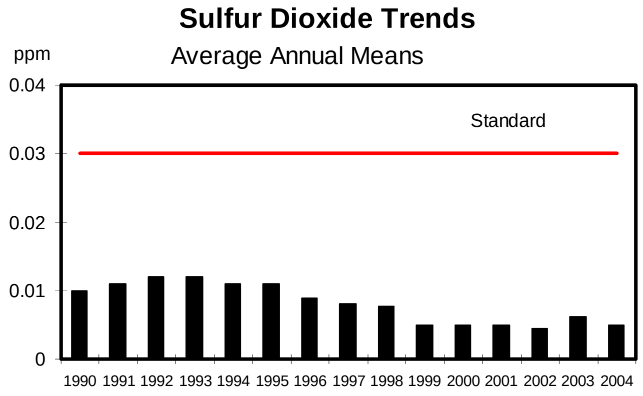
Primary NAAQS: Annual arithmetic mean = 0.03 ppm (80 µg/m^3)
24-hour average = 0.14 ppm (365 µg/m^3)
Secondary NAAQS: 3-hour average = 0.5 ppm (1300 µg/m^3)

Sources

The main sources of SO_2 are combustion of coal and oil (mostly by power plants), refineries, smelters, and industrial boilers. Nationally, two-thirds of all sulfur dioxide emissions are from power plants, and coal-fired plants account for 95% of these emissions.

Locations

Delaware's SO_2 monitors are located in Wilmington, Bellefonte, Summit Bridge, and Delaware City.



Delaware Air Quality and Trends

Delaware is in attainment with the NAAQS for SO_2. Levels declined rapidly in the 1970's due largely to the change to low or lower sulfur fuels in power plants and improved control technologies. Over the last decade, measured ambient levels have remained well below the standard with a slight downward trend. Locally, higher levels are found only in areas impacted by a single large source (such as a coal-burning power plant or oil refinery).

In 2004 SO_2 levels remained well below the standards.

Delaware Sulfur Dioxide 2003 Max. Values ppm

Site	24-Hour Averages NAAQS = 0.14 ppm		3-Hour Averages NAAQS = 0.5 ppm	
	1st Max	2nd Max	1st Max	2nd Max
Bellefonte	0.023	0.022	0.059	0.050
Wilm. - MLK	0.021	0.019	0.049	0.045
Del. City/Rte 9	0.057	0.056	0.127	0.115
Summit Bridge	0.013	0.013	0.037	0.036

Delaware Sulfur Dioxide Trends

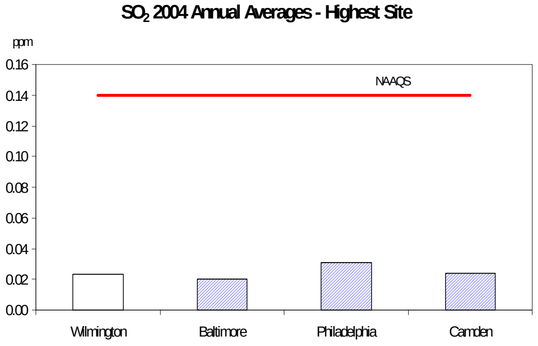
Annual Averages in ppm

NAAQS: Annual Arithmetic Mean = 0.03 ppm

Site	Year										
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Bellefonte	.010	.008	.008	.007	.007	.005	.007	.005	.004	.007	.005
Wilmington	.014	.012	.011	.008	.008						
Wilm.-MLK						.004	.005	.006	.005	.006	.005
Summit Br.								.003	.003	.004	.004
Del City	.011	.013	.011	.011	.008	.007	.006	.006	.006	.008	.006
Dover											
Seaford	.008	.008	.008	.006							

How does Delaware's air quality compare to nearby areas?

SO_2 concentrations in Delaware are similar to those in nearby areas.



LEAD (Pb) - no monitors currently active in Delaware

Description and Sources

Lead is a highly toxic metal emitted into the air from both mobile and stationary sources. Mobile sources include vehicles that use leaded fuel. Major stationary sources include metal smelters and lead battery plants.

Exposure can occur through a number of pathways including ingestion and inhalation. Lead affects several physiological processes including the blood-forming, reproductive, nervous and renal (kidney) systems. It accumulates in both bone and soft tissues and can cause problems long after exposure is ended. Infants and children are most susceptible to effects that can include anemia, seizures, mental retardation, and decreased learning abilities.

Standard

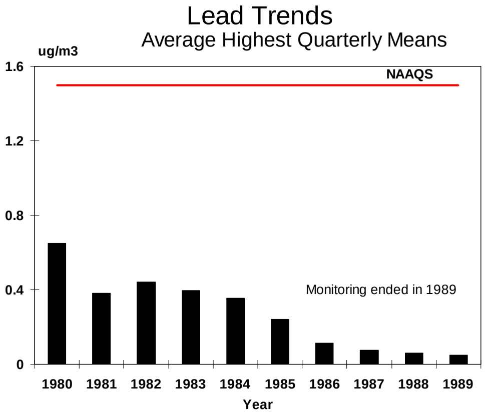
Primary NAAQS: 24-hour average (averaged over one calendar quarter) = 1.5 µg/m^3

Locations

Monitors were formerly located in Claymont and Wilmington.

Delaware Air Quality and Trends

Delaware is in attainment with the NAAQS for lead and does not currently monitor lead in ambient air. .Previously, there were two lead monitoring sites placed for measuring lead coming mostly from mobile sources. Measured ambient concentrations decreased approximately 94% between 1978 and 1988 due to the change to unleaded gasoline in cars. In 1989, the last year in which samples were collected, 63% of the samples were below the analytical detection limits.



AIR QUALITY - POLLUTANTS WITHOUT STANDARDS:
Acid Precipitation and Air Toxics

ACID PRECIPITATION

Description

Acid precipitation, more commonly called acid rain, is rain, snow, or fog that contains significant amounts of sulfuric and/or nitric acids. Various combustion processes release sulfur and nitrogen oxides into the air where they react to form acids and can travel for many miles. Acid rain is measured using a scale called "pH." The lower a substance's pH, the more acidic it is. Pure water has a pH of 7.0. According to the U.S. EPA, normal rain is slightly acidic because carbon dioxide dissolves into it, so it has a pH of about 5.5. As of the year 2000, the most acidic rain falling in the US has a pH of about 4.3.

Sources

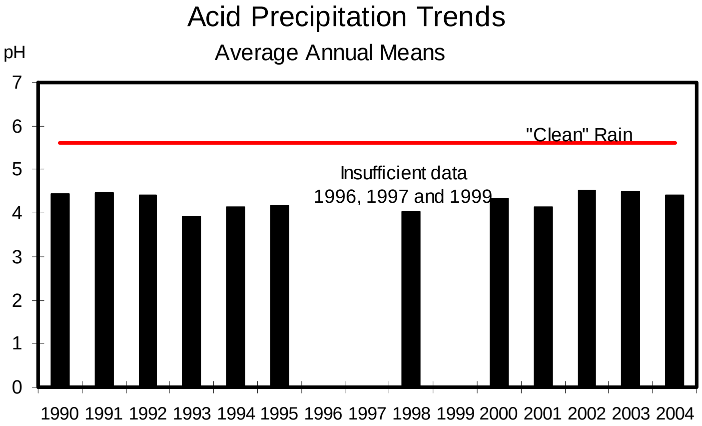
The largest sources of sulfur oxides are coal burning power plants, which are mainly located along the Ohio River valley. These plants are also significant sources of nitrogen oxides, as are motor vehicles. Prevailing winds carry these pollutants to the east and north, resulting in the most acidic precipitation occurring in the northeastern United States and Canada.

Locations

Acid precipitation was monitored at two sites, Georgetown and Summit Bridge, from 1984 to 1993. The Georgetown site was terminated in 1993. In 2000 the Summit Bridge monitor was relocated to the Ommelandan range on Route 9.

Delaware Air Quality and Trends

There was insufficient data to calculate an annual average for 1996, 1997 and 1999 due to a combination of resource and quality control issues. The relocation of the monitor in early 2000 and improved analytical equipment resolved the problems. In 2004 precipitation remained acidic, with an average annual pH of 4.41.



AIR TOXICS

Description

Toxic air pollutants, also called air toxics or hazardous air pollutants, are pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. In 1990, Delaware began developing a routine ambient air sampling program for selected volatile organic compounds (VOCs). In 2000 this program was updated by changing the sampling and analytical method to detect a greater number of VOCs. In 2003 the program was expanded to include other types of chemical compounds such as carbonyls and heavy metals.

Sources

Sources of ambient air toxics include both stationary and mobile types. Stationary industrial sources can include power plants, chemical manufacturing plants, and refineries. There are many smaller stationary sources (sometimes referred to as "area" sources) such as dry cleaners, printers, and automobile paint shops. Mobile sources include both on- and off-road motor vehicles as well as boats and aircraft.

Locations

From 1990 to 1999 samples were collected at several sites, including Wilmington, Delaware City, Summit Bridge, and Seaford. With the change in monitoring method in 2000, samples were collected only at the Wilmington MLK site. In the fall of 2002 two other sites, Delaware City and Summit Bridge, began collecting data. In 2003 two more sites, Seaford and Felton, were added for a total of five air toxics monitoring sites.

Delaware Air Quality and Trends

Ambient levels are consistently below 10 ppb for all monitored compounds, and most are below 1 ppb.

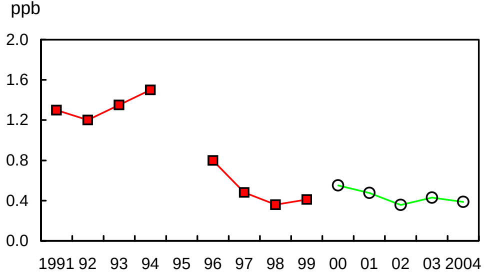
Control programs that focus on improving ambient ozone levels by reducing emissions of VOCs, as well as programs specifically aimed at controlling emissions of hazardous air pollutants, are continuing to reduce ambient concentrations of many air toxics. Although the change in monitoring method makes interpretation difficult, ambient concentrations of most VOCs are generally declining at the Wilmington site.

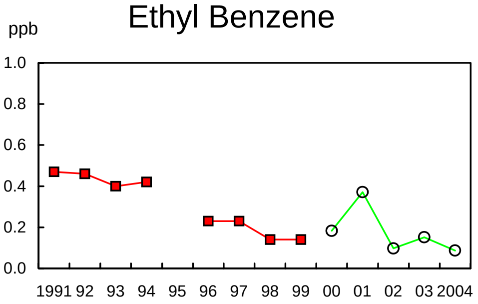
2004 Air Toxics Data in ppb - Wilmington

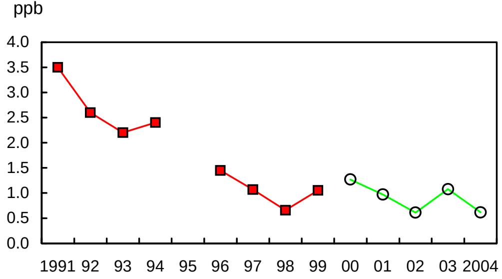
Compound	Average	Minimum	Maximum
Dichlorodifluoromethane	0.54	0.45	0.65
Chloromethane	0.52	0.40	0.69
1,2-Dichloro-1,1,2,2,tetrachloroleth	0.02	0.01	0.03
Chloroethene	0.02	0.00	0.13
1,3-Butadiene	0.08	0.00	0.38
Bromomethane	0.03	0.00	1.47
Chloroethane	0.01	0.00	0.09
Trichlorofluoromethane	0.26	0.22	0.37
Acrylonitrile	0.02	0.00	0.11
1,1-Dichloroethene	0.00	0.00	0.01
Methylene Chloride	0.14	0.06	0.44
3-Chloro-1-propene	0.02	0.00	0.10
1,1,2-Trichloro-1,2,2-trifluoroethane	0.08	0.07	0.10
1,1-Dichloroethane	0.00	0.00	0.01
Cis-1,2-Dichloroethene	0.00	0.00	0.01
Chloroform	0.02	0.00	0.05
1,2-Dichloroethane	0.00	0.00	0.02
1,1,1-Trichloroethane	0.02	0.00	0.04
Benzene	0.39	0.20	1.07
Carbon tetrachloride	0.09	0.07	0.14
1,2-Dichloropropane	0.00	0.00	0.01
Trichloroethene	0.01	0.00	0.06
Cis-1,3-Dichloro-1-Propene	0.00	0.00	0.01
Trans-1,3-Dichloro-1-Propene	0.00	0.00	0.00
1,1,2-Trichloroethane	0.00	0.00	0.00
Toluene	0.62	0.22	2.79
1,2-Dibromoethane	0.00	0.00	0.01
Tetrachloroethylene	0.07	0.00	0.33
Chlorobenzene	0.01	0.00	0.03
Ethylbenzene	0.09	0.03	0.31
m & p- Xylene	0.26	0.07	1.14
Styrene	0.02	0.00	0.08
1,1,2,2-Tetrachloroethane	0.00	0.00	0.01
o-Xylene	0.09	0.03	0.37
1-Ethyl-4-Methylbenzene	0.05	0.00	0.20
1,3,5-Trimethylbenzene	0.03	0.00	0.12
1,2,4-Trimethylbenzene	0.11	0.00	0.50
1,3-dichlorobenzene	0.00	0.00	0.02
1,4-Dichlorobenzene	0.02	0.00	0.07
1,2-Dichlorobenzene	0.00	0.00	0.02
1,2,4-Trichlorobenzene	0.00	0.00	0.01
Hexachloro-1,3-Butadiene	0.00	0.00	0.01

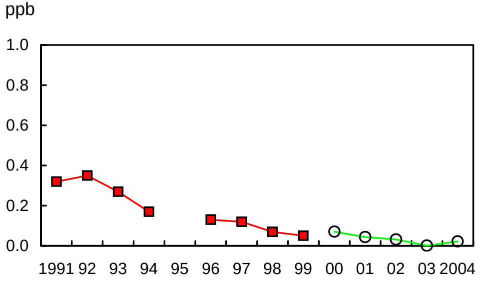
Wilmington Air Toxics Trends - Annual Averages

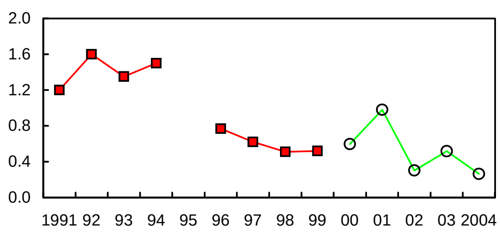
Notes: Insufficient data in 1995 to calculate annual average. New Method used in 2000.

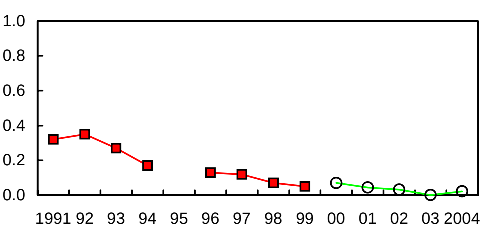

Benzene

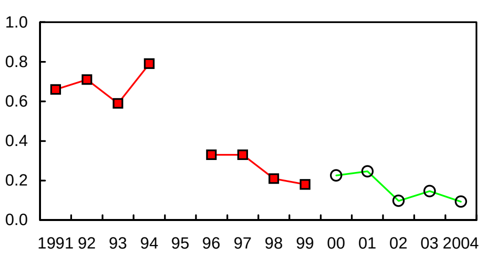

Ethyl Benzene

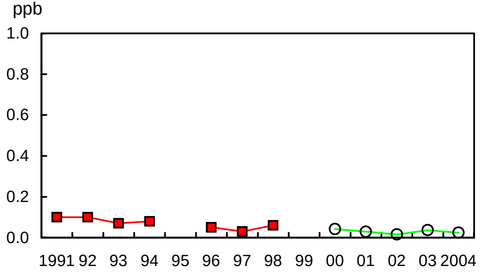

Toluene


Tetrachloroethene


m,p-Xylenes


1,1,1-Trichloroethane


o-Xylene


1,4-Dichlorobenzene

The Delaware Air Toxics Assessment Study (DATAS)

DNREC initiated a comprehensive study to characterize the statewide distribution of toxic air pollutants and identify locations that are likely to be of public health concern. This project, the Delaware Air Toxics Assessment Study or DATAS, involved the development of a monitoring network and a hazardous air pollutant (HAP) emission inventory that has provided data that can be used with ambient air quality computer modeling to assist in characterizing risk, both regionally and locally.

The AQM designed DATAS to quantify air toxic concentrations by direct measurement at five locations and perform air dispersion modeling to develop ambient concentrations throughout Delaware. The project included the development of a comprehensive Delaware-specific emission inventory to serve as input to the modeling effort. Finally, the project included risk assessments of the measured and modeled concentrations to determine the potential health impacts associated with air toxics.

Phase I of DATAS was completed as of June 30, 2005. It includes a full year of measured air toxic concentrations at five locations, a risk assessment of those concentrations, an emission inventory, and a prototype study of modeling performance. Phase II will be completed in 2006 and the subsequent report will include results of the statewide modeling effort and a risk assessment of the modeled concentrations. Further analysis of the monitoring and inventory data will also be included in the Phase II report.

The full report is available at: http://www.dnrec.state.de.us/air/aqm_page/DATAS.htm

Monitoring of air toxics was conducted throughout 2003 at three locations in New Castle County (Martin Luther King Blvd. site in Wilmington, Delaware City, and Summit Bridge), and one location each in Kent and Sussex Counties (Felton, also known as Killens Pond, and Seaford, respectively.) The DATAS air toxics of concern were grouped into five compound categories based on sampling requirements. The categories included volatile organic compounds (VOC), carbonyls, metals, polycyclic aromatic hydrocarbons (PAH), and dioxins/furans (D/F). Sampling occurred every sixth day for all chemicals except D/F, which were sampled as 12-day composites.

Most DATAS chemicals included in the monitoring effort were detected with sufficient frequency to develop annual average concentrations for use in the risk assessment. The results of the monitoring effort reveal, in general, the highest annual average concentrations observed at the MLK site for most chemicals in each of the five chemical groups. Some notable exceptions include the highest formaldehyde and bromomethane annual average concentrations observed at the Seaford site, naphthalene at the Summit Bridge site, seven of the seventeen D/F at Felton site, (the remaining ten were highest at MLK) and vinyl chloride at the Delaware City site. Measured concentrations at MLK site were similar to those observed at other urban sites outside Delaware.

Major source sectors that comprise the inventory include point sources (facilities that report to AQM), stationary area sources, on-road mobile sources, and off-road vehicles and equipment. A statewide air toxics inventory was created for 2002 for all sources of DATAS chemicals, and projected to 2003 to align with the monitoring data. The inventory represents only directly-emitted DATAS chemicals; the modeling work will characterize any secondary formation of air toxics. Mobile sources (on-road and off-road) accounted for two-thirds of the mass of emissions of reported DATAS chemicals. Majority of metal emissions were reported by point sources, while the majority of PAH and D/F were reported under area sources.

Whereas the monitored data represent only five sites in Delaware, the air dispersion modeling effort will generate ambient concentrations at a finer resolution throughout Delaware, providing a comprehensive picture of air toxics. In order to have confidence in the model's ability to accurately predict ambient concentrations, the modeling results will be compared to the monitored data. Adjustments to the model assumptions and inputs, including reassessment of the emission inventory, may be necessary based on comparability with the monitored results.

As part of this Phase I effort, a modeling prototype study was performed to assess the modeling design. The design is comprised of two modeling scales, local-scale modeling to address the impact from nearby sources, and regional-scale modeling for assessing long-range transport and the secondary production of compounds due to photochemistry. Local-scale modeling demonstrated the ability to capture spatial and temporal variability of air toxics compounds which help identify and characterize hot spots of air toxics. Regional-scale simulation provided evidence of the important role of photochemistry in modeling and the importance of long-range transport.

The Division of Public Health (DPH) was charged with performing an assessment of potential risk posed by the air toxic concentrations observed at the five monitoring sites. Individual chemical risks and cumulative impact to the human health from exposure to these toxics was calculated. Such risks for cancer and non-cancer effects was calculated for three scenarios - adult exposure, child exposure and an age-adjusted exposure, which is a mix of child and adult factors. The methodology used included a conservative margin of safety given the inherent uncertainties with risk characterization. The methodology used inhalation risk factors when available, and also used oral risk factors when inhalation factors did not exist for certain chemicals.

The DPH established three categories of risk based on previous risk assessment studies performed for hazardous waste cleanup sites. These include low risk, increased risk, and high risk, visually defined as green (negligible), yellow (increased), and red (high). For the cancer endpoint, negligible risk was defined as an increased potential of one additional cancer case per 100,000 persons or less, increased risk between one and ten per 100,000 persons, and high risk as ten additional cases and above. For the non-cancer endpoint, negligible risk is defined by a hazard quotient (HI) of one or less, increased risk as an HI between one and ten, and high risk an HI of 10 and above. Hazard quotients are used to evaluate non-cancer adverse systemic health effects, which are not carcinogenic. These are the ratio of potential exposure to a particular compound to the level of exposure at which no hazardous effects are expected.

On an individual basis none of the chemicals evaluated were found to have increased or high risk in either the cancer or non-cancer categories for any of the three scenarios. When the risk levels were summed for each scenario at the various monitoring stations some of the summations were found to be in the increased risk range. The cumulative risk was highest at the MLK site, with a potential cancer risk of between four and five additional cancer cases per 100,000 persons for the age-adjusted scenario, and a potential non-cancer hazard quotient of between two and three for the child scenario. For the other monitoring stations one or more of the cancer and non-cancer scenarios had a summed risk in the increased risk range. None of the five monitoring sites had a summed risk in the high risk range.

Carbon tetrachloride, chromium, and trichloroethylene were risk drivers for cancer at all five monitoring sites. Carbon tetrachloride and manganese were risk drivers for non-cancer at all five monitoring sites. In addition, for the MLK site, benzene and 1,3-butadiene were cancer risk drivers, while 1,3-butadiene and 1,2,4-trimethylbenzene were non-cancer risk drivers. Finally, benzene and vinyl chloride were cancer risk drivers for the Delaware City site.

The existing programs seem to have provided a reasonable level of protection for human exposure to individual compounds. However, this picture may change as the study expands its geographical scope and expands the list of compounds during its further monitoring and modeling phase.

The next step for DATAS is to complete Phase II (air dispersion modeling) and assess potential risk throughout Delaware. Only then will AQM be able to prioritize actions to address the highest areas of risk found in Delaware. The AQM has proposed a Risk Management Plan (RMP) as part of its Air Toxics Strategic Plan that was submitted to EPA Region III in February 2005. The AQM proposes to establish a stakeholder process to develop (1) action levels based on risk and (2) a process for addressing risks that require action. Depending on the risk drivers and the sources contributing most to the risk, the process will develop a set of solutions, which may include regulatory and/or non-regulatory options to reduce risk. In addition, the results of DATAS will assist the permitting process base its decisions on cumulative impacts. The modeling tool developed through DATAS will be used with future inventories to periodically assess ambient concentrations of air toxics in the future.

III. SOURCES OF POLLUTION

OZONE

EMISSIONS INVENTORY

The Clean Air Act Amendments (CAAA) require states with ozone nonattainment areas to submit a comprehensive, accurate, and current inventory of actual emissions of ozone precursors from all sources within two years of enactment. For ozone nonattainment areas, three precursor pollutants must be inventoried: volatile organic compounds (VOCs), oxides of nitrogen (NO_x), and carbon monoxide (CO). This initial inventory is for calendar year 1990, and is widely known as the 1990 Base Year Ozone State Implementation Plan (SIP) Inventory. The CAAA further requires states with ozone nonattainment areas to submit periodic emissions inventories starting with 1993 and every three years thereafter until the area is redesignated to attainment or until the year 2005. The emissions inventory portion of this annual air quality report focuses on the Periodic Emissions Inventories (PEIs) for 1990, 1993, 1996, 1999, and 2002.

Two of Delaware's counties are classified by the EPA as "nonattainment" for meeting the 1-hour NAAQS for ozone. The EPA rates nonattainment areas for the ozone 1-hour NAAQS on a scale from "marginal" to "extreme." As shown here, New Castle and Kent Counties are part of the Philadelphia-Wilmington-Trenton Consolidated Metropolitan Statistical Area (Philadelphia CMSA) which is classified as "severe" nonattainment. The 1-hour ozone NAAQS does not currently apply to Sussex County. The Philadelphia CMSA also contains parts of Pennsylvania, New Jersey, and Maryland that are not covered within the PEIs.

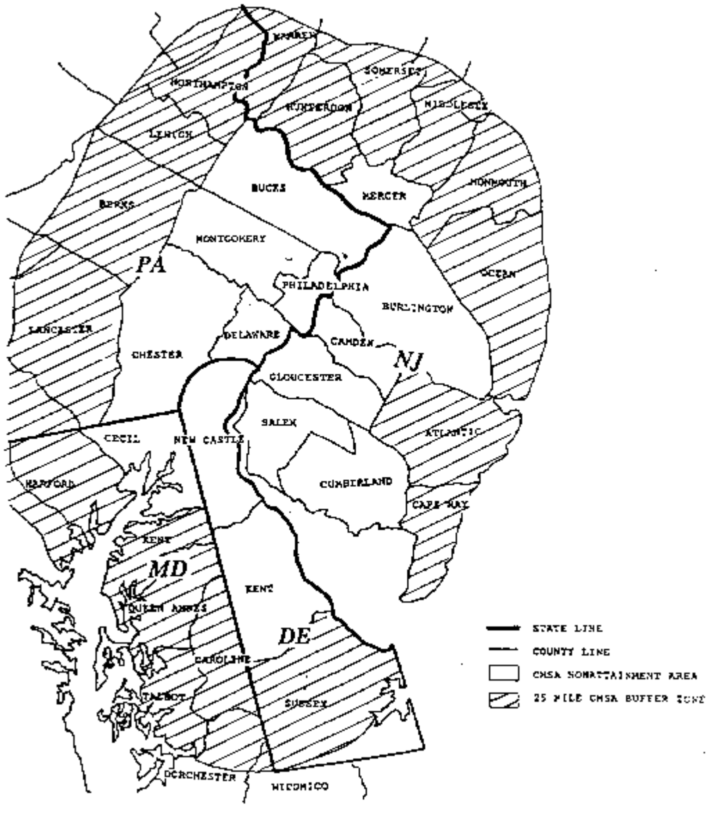


Figure 1-1. Philadelphia-Wilmington-Trenton CMSA Ozone Nonattainment Area[1]

---

[1] This map was adapted from *Major CO, NO_2 and VOC Sources In the 25-Mile Boundary Around Ozone Nonattainment Areas, Volume I: Classified Ozone Nonattainment Area*, EPA450/4-92-005a, U.S. Environment Protection Agency, Office of Air Quality Planning and Standards, Office of Air and Radiation, Research Triangle Park, NC, February 1992.

Delaware has until 2005 to lower New Castle and Kent County ozone levels to meet the federal standard. Sussex County appears to have met the federal standards but full compliance must be assured over the long term.

What is an emissions inventory?

According to the EPA, the emission inventory is a tool used to determine the amount of air pollution released from various air emission sources in a given geographic area. This compilation identifies the source types present in an area, the amount of each pollutant emitted, the types of processes and control devices employed, and other information.

Why are emissions inventories necessary?

The CAAA of 1990 requires states with nonattainment areas to submit a comprehensive, accurate, current inventory of actual emissions of ozone precursors from all sources every three years from the base year 1990. These consecutive inventories provide the historic documentation needed to assist in demonstrating an area's progress toward attainment of the NAAQS for ozone.

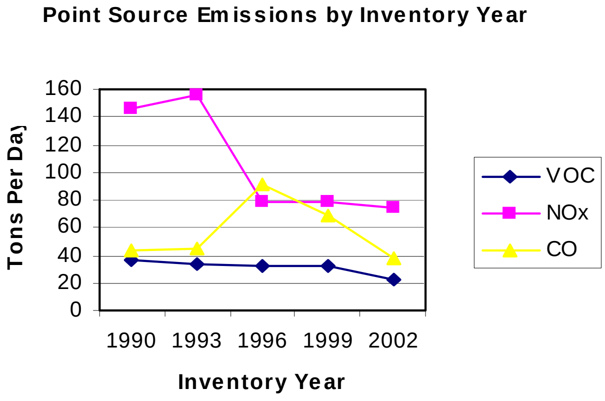
How are these inventories used?

Emission inventories can serve many purposes. They are used in ambient dispersion modeling and analysis, control strategy development, and in screening sources for compliance investigations. Together with ambient monitoring data, inventory emission estimates are used to understand changes and trends in air quality.

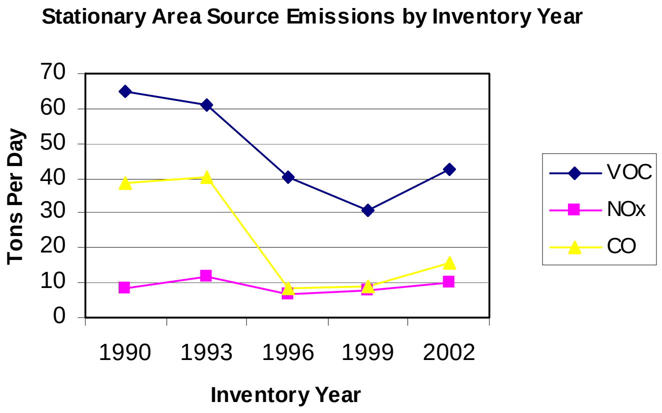
CHARACTERIZATION OF OZONE PRECURSOR EMISSIONS SOURCES

Sources of air emissions are classified into the five categories by the nature of the emissions and the physical characteristics of the emitter. These five categories are described below and are accompanied with a graphic depicting 1990, 1993, 1996, 1999, and 2002 emissions for each source category.

Point sources are defined for emission inventory purposes as industrial, commercial, or institutional plants/operations that emit VOCs of 10 tons per year (TPY) or greater and/or NOx or CO emissions of 25 TPY or greater. Owners or operators of such sources are required to report annually the quantity and type of emissions. Refineries, chemical manufacturing facilities, power plants, auto assembly plants, solid waste landfills, and large building heating systems are included in this category.

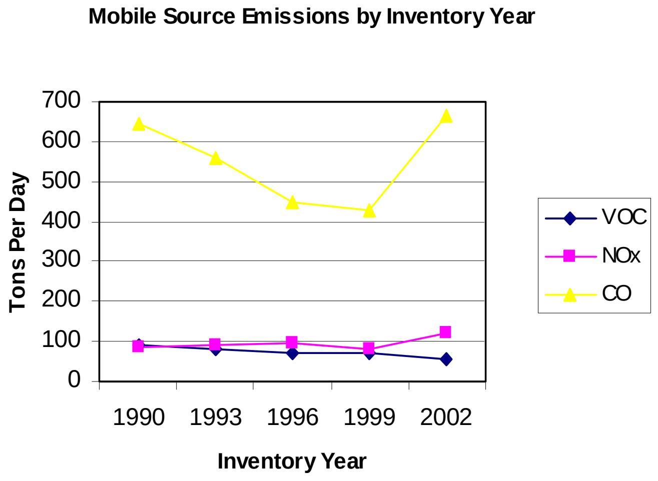


Stationary area sources are sources that fall below the stationary point source emission threshold definitions given above and are thus not practical to identify individually for emission inventory purposes. The quantity and type of emissions from these sources are estimated by using established emission factors and appropriate activity data from the area. For example, emissions from service stations can be estimated based on the number of such facilities in the area and knowledge of the amount of gasoline sold. Print shops, dry cleaners, painting operations, degreasing and other solvent-using operations, small building heating, and outdoor burning are a few of the operations included in this category.



Mobile sources are usually divided into two categories: on-road and off-road.

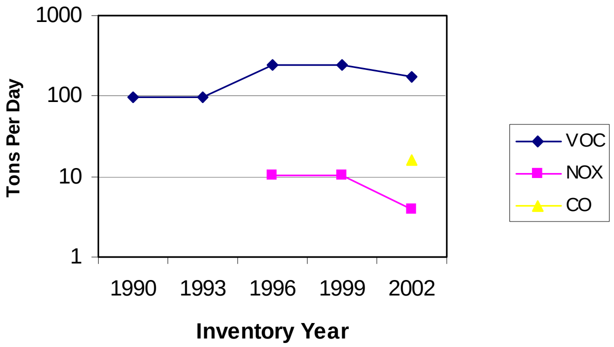
On-road mobile sources consist of automobiles, trucks, motorcycles, and other vehicles traveling on roadways in the nonattainment area. The MOBILE6 model developed by EPA estimates emission rates for VOCs, NO_x, and CO; these rates combined with vehicle miles traveled, are then used to develop estimates of the quantity of emissions produced by this source. This model estimates emissions from the tailpipe of vehicles as well as emissions due to evaporation of gasoline and other fluids.



Off-road mobile sources include emissions from commercial, military, and general aircraft operations, marine vessels, recreational boats, railroad locomotives, and a very broad subcategory that includes everything from engines on construction equipment to lawn mowers, chain saws, and leaf blowers. Most engines in this category have no emission controls and are considered high emitters of VOCs. Emissions in this category are estimated primarily through mathematical manipulation of personal interview and survey data as prescribed by EPA procedures.

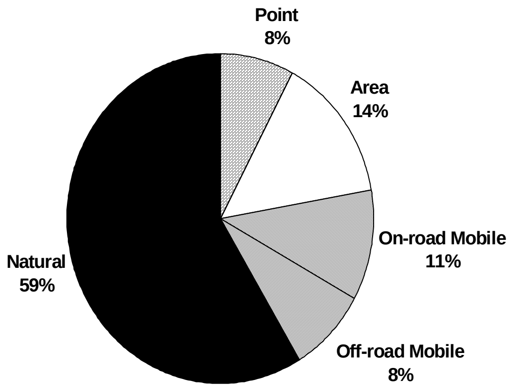
Natural sources included emissions from plant life in the area, including crops, trees, grasses, microbial activity which is a source of NOx & greenhouse gasses, and other vegetation. The BEIS3.12 model estimates the quantity and type of emissions from vegetation making use of tools such as satellite imaging to develop county specific land use data. While biogenic sources do emit VOCs into the atmosphere that may contribute to ozone formation, they also remove significant amounts of CO, SO2, NOx, O3, and PM_{10} from the air, and cool the air through shade and transpiration, thus reducing pollution from other sources. Natural sources that are not biogenic sources include lightning a source of NO and oil and gas seeps; however, oil and gas seeps are not found in Delaware.

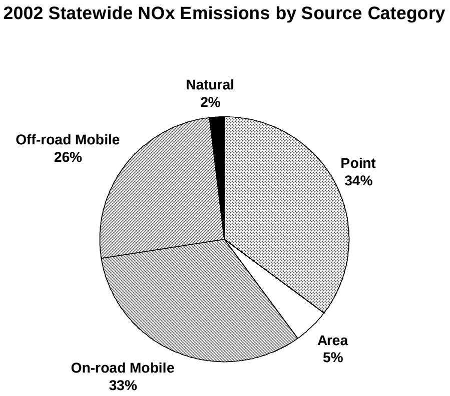
Natural Source Emissions by Inventory Year

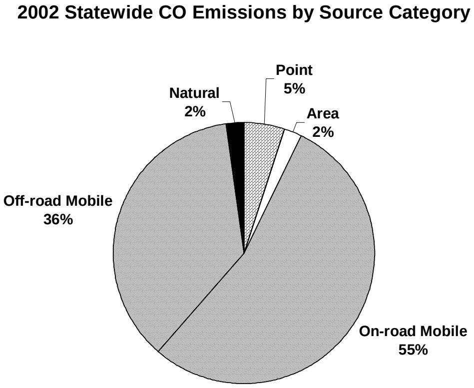


* Nox Emissions not estimated for 1990 and 1993
* CO Emissions not estimated for 1990 thru 1999

2002 Statewide VOC Emissions by Source Category







2002 Statewide Peak Ozone Season Daily Emissions			
	Pollutant Emissions (TPD)		
Source Category	**VOC**	**NOx**	**CO**
Point	23.1	74.2	37.3
Stationary Area	42.5	9.9	15.7
Mobile on-road	32.4	69.0	396.9
Mobile off-road	24.8	53.9	267.8
Natural	173.9	3.9	16.1

SULFUR DIOXIDE (SO_2) AND PARTICULATE MATTER (PM_{10} and $PM_{2.5}$)

As a result of recent findings describing the adverse health affects associated with fine particulates, and the establishment of a fine particulate national ambient air quality standard, the Emission Inventory Development (EID) Program has undertaken the creation of a complete 2002 particulate inventory, including both primary particulate and particulate precursors.

Primary particulate emissions consist of both solid particles of various sizes and aerosols. The solid particles can be delineated by size, such as $PM_{2.5}$, which designates particulate with a diameter of 2.5 microns or less. PM_{10} defines particles with a diameter of 10 microns or less, and thus includes $PM_{2.5}$ as well as particles that range from 2.5 microns up to 10 microns. Since EPA has only recently established an air quality standard specifically for $PM_{2.5}$, emission estimation methodologies and emission factors are currently lacking for some source categories.

Secondary particulate emissions are precursors that react in the atmosphere to produce fine particles away from the emitting source. The precursors include sulfur dioxide (SO2), nitrogen oxides (NOx), ammonia, and certain organic and inorganic compounds. Since NOx and VOCs are already inventoried due to their contribution to ground-level ozone formation, the inventory program only needed to add SO2 and ammonia to its list of pollutants to be inventoried from all sources.

The majority of PM_{10} emissions are primary particulate, with a large proportion being fugitive emissions, usually dust particles from area and natural sources. Significant contributions also come from mobile, area and point source fuel combustion.

The profile for $PM_{2.5}$ is significantly different, with the vast majority of emissions being secondary emissions. Sulfates and nitrates, which are secondary compounds of $PM_{2.5}$, are expected to comprise almost two-thirds of the total inventory. Roughly one-third of the $PM_{2.5}$ inventory is comprised of emissions from combustion sources. Only a very small amount, approximately 5%, is due to primary fugitive emissions, mostly dust.

Sulfur dioxide is largely a result of fossil fuel combustion, particularly from coal and diesel fuel. Electric utility generation and refineries are by far the largest SO2 emission sources. Motor vehicle fuel combustion is also a significant source of SO2, although on a much smaller scale than stationary source fuel combustion.

HAZARDOUS AIR POLLUTANTS (HAPs)

In addition to ozone precursors, and particulate and its precursors, Delaware also has regulations that address the emissions of air toxics. The Permitting & Compliance group of the Air Quality Management Section maintains air permits on various processes that emit air toxics. Specific toxic chemicals, called Hazardous Air Pollutants (HAPs), are regulated under these permits. The Clean Air Act mandates that EPA set national standards for HAPs. These standards are based on specific emission source types, and are called Maximum Achievable Control Technology (MACT) standards.

For the first time, the EID Program developed a comprehensive air toxics inventory for 2002 in support of the Delaware Air Toxics Assessment Study (see page 35). All sources (point, area, on-road mobile, and off-road mobile) were included in the toxics inventory. Additional information on emissions of air toxics is contained in the annual Delaware Toxics Release Inventory Report (see References). These inventories can be used to track progress associated with implementing the MACT standards.

IV. POLLUTION CONTROL/PREVENTION

OZONE

CLEAN AIR ACT AMENDMENTS OF 1990

The Clean Air Act Amendments of 1990 require EPA, states, and cities to implement a series of programs that will further reduce emissions of VOCs and NO_X from cars, fuels, industrial and chemical facilities, power plants, and consumer and commercial products among other sources. Cleaner cars and fuels, new kinds of gasoline nozzles, enhanced vehicle inspection, and other programs along with new control strategies will be phased in over the next decade.

For the Philadelphia-Trenton-Wilmington CMSA area, the following interim strategies are required by the 1990 CAAAs:

- submission and implementation of an air quality SIP;
- development of a periodic emissions inventory for ozone precursors every three years;
- a 15% net-of-growth reduction in VOC emissions by 1996 and a 3% reduction in VOC and/or NOx each year after 1996 until 2005;
- development of Rate-of-Progress Plans (RPPs) for 1996, 1999, 2002, and 2005 to achieve the above VOC and/or NO_x emission reductions;
- a demonstration that transportation plans conform to air quality SIPs;
- an enhanced vehicle inspection-and-maintenance program;
- reformulated gasoline;
- clean, alternatively fueled vehicles;
- demonstration using EPA-recommended modeling methods that the 1-hour ozone standard will be attained in 2005;
- collection of additional pollutant and meteorological data to support modeling efforts;
- a program to prevent the addition of new large sources of emissions from increasing total emissions;
- new emissions controls on small business;
- new controls on fugitive emissions;
- reasonably available control technology (RACT) for sources of VOC or NO_x emissions; and
- enhanced monitoring by industrial sources; and maximum achievable control technology on large sources of hazardous air pollutants, some of which are VOCs.

PROGRESS TOWARD ATTAINMENT OF THE NAAQS FOR OZONE

The 1990 Clean Air Act Amendments (CAAA) contain provisions for the attainment and maintenance of the National Ambient Air Quality Standards (NAAQS). Control plans must be developed in designated nonattainment areas. Plan requirements vary depending on the severity of the individual area's air pollution problem. New Castle and Kent Counties have been designated to be in severe nonattainment while Sussex County has been placed in marginal nonattainment status.

One key requirement of the CAAA for moderate and above ozone nonattainment areas is the achievement of Reasonable Further Progress (RFP) toward the attainment of the NAAQS. States must demonstrate RFP by achieving at least a 15 percent reduction of VOC emissions from 1990 levels by 1996. In addition, states must offset any growth in emissions projected from 1990 to 1996. A nine percent reduction of VOC and/or NO_x is required for every three years between 1997 and 2005. The year 2005 is the year for which severe nonattainment areas must demonstrate attainment through computer modeling. Modeling results may indicate that reductions greater than the RFP reductions are required to achieve attainment of the ozone NAAQS.

Progress toward attainment of the NAAQS in the year 2005 is measured by periodic emission inventories conducted every three years, beginning in 1993. Actual air emission data are inventoried for reactive VOCs, NO_x, and carbon monoxide CO from point, area and mobile sources.

Point sources, as defined for the 1990 base year and successive inventories, are those facilities/plants/activities that have actual emissions greater than or equal to at least one of the following: 10 tons per year VOC, 100 tons per year NO_x, or 100 tons per year CO. Detailed plant, point and process data is maintained by each point source. Area sources represent collections of many small air pollutant emitters existing within a specified geographical area. Because area sources are too small and/or too numerous to be surveyed and characterized individually, area source emissions must be estimated collectively. Mobile sources are represented by all forms of transportation commercial/recreational/private, as well as portable implements and tools powered by internal combustion engines. Emissions for mobile sources are estimated through primary data, computer modeling and collective estimates.

In 1995, DNREC submitted its 15 percent VOC reduction plan for 1996 to the EPA. It targeted reductions through multiple control strategies including gasoline vapor collection, low volatility coatings and solvents, and controlling leaks in manufacturing processes. To further reduce VOCs in Delaware, there is a statewide use of reformulated gasoline and an open burning ban in Kent and New Castle Counties during the months of June, July, and August.

Delaware submitted its 1999 RPP to the EPA in December 1997, and amended it in June 1999. In addition to continuing the VOC emissions controls in the 15 Percent Plan, the 1999 RPP (as amended) was designed to achieve significant NO_x reductions through implementing controls over a variety of NO_x sources, especially large industrial sources.

OTHER POLLUTANTS

The Clean Air Act Amendments of 1990 include a number of sections devoted to air pollutants besides ozone. Requirements for other pollutants include:

- Reduction of sulfur dioxide (SO_2) emissions nationally to reduce acid deposition; the goal is a reduction of 10 million tons per year from 1980 levels. This represents a reduction of approximately 40% by the year 2000. There is also a national cap on major point-source emissions after the year 2000.

- Expansion of Maximum Available Control Technology standards to sources of toxic emissions not previously covered. Standards nearing completion will result in reduced emissions of benzene from wastewater treatment plants, chrome from cooling towers, and tetrachloroethylene from dry cleaning and chrome plating.

- Implementation of Title V of the Clean Air Act Amendments by establishing a new operating permit program for all major stationary sources of air pollutant emissions. This program will ensure that both industry and the public are knowledgeable as to the rules and regulations that all major stationary sources are required to meet.

V. WHAT YOU CAN DO

Air pollution is a worldwide problem. No political boundaries stop the flow of polluted air. No humans have been able to retrieve pollutants once they have been released. Because air pollutants spread rapidly, almost instantaneously, polluters rarely feel affected by their decision to pollute.

By choosing to act, each person can reduce air pollution and make a difference in the environment. Since the primary source of air pollution are from vehicular transportation and energy production, the main thing you can do is ***conserve energy and use alternative forms of transportation***.

Reduce pollution in the following manner:

- Limit single passenger trips in the car, plan your trips, form a car pool.
- Use public transportation.
- Walk or bike whenever possible.
- Turn off lights and appliances not in use.
- Recycle everything you can and use products made from recycled materials.
- Use environmentally friendly household products.
- Keep your automobile well tuned and maintained.
- Be careful not to spill gasoline when filling up your car, boat, or lawn and garden equipment.
- Seal containers containing household cleaners, workshop chemicals and solvents, and garden chemicals to prevent volatile organic chemicals from evaporating into the air.

You can also stay informed by reading and listening for information on air quality data, legislation, and regulations. For more air quality information and what you can do, visit our website: *http://www.dnrec.state.de.us/air/aqm_page/aqm.htm*.

APPENDIX A - Monitoring Methods

Carbon Monoxide (CO)
Carbon monoxide is measured by infrared absorption photometry. Air is drawn continuously through a sample cell where infrared light passes through it. Carbon monoxide molecules in the air absorb part of the infrared light, reducing the intensity of the light reaching a light sensor. The light is converted into an electrical signal related to the concentration of carbon monoxide in the sample cell.

Nitrogen Dioxide (NO_2)
Nitrogen oxides are measured using the chemiluminescence reaction of nitric oxide (NO) with ozone (O_3). Air is drawn into a reaction chamber where it is mixed with a high concentration of ozone from an internal ozone generator. Any NO in the air reacts with the ozone to produce NO_2. Light emitted from this reaction is detected with a photo multiplier tube and converted to an electrical signal proportional to the NO concentration. Nitrogen dioxide (NO_2) must be measured indirectly. Total nitrogen oxides (NO_X) are measured by passing the air through a converter where any NO_2 in the air is reduced to NO before the air is passed to the reaction chamber. By alternately passing the air directly to the reaction chamber, and through the converter before the reaction chamber, the analyzer alternately measures NO and NO_X. The NO_2 concentration is equal to the difference between NO and NO_X.

Ozone (O_3)
Ozone is measured by ultraviolet absorption photometry. Air is drawn through a sample cell where ultraviolet light (254 nm wavelength) passes through it. Light not absorbed by the ozone is converted into an electrical signal proportional to the ozone concentration.

In Delaware the ozone season runs from April 1 to October 31 during which monitors are in operation at six sites (see Delaware monitoring network description Table 1). Monitoring continues at Bellefonte and Summit Bridge year-round.

Particulate Matter - Fine ($PM_{2.5}$)
$PM_{2.5}$ is sampled by drawing air through a specially designed inlet that excludes particles larger than 2.5 microns in diameter. The particles are collected on a Teflon® microfiber filter that is weighed to determined the particulate mass. The normal sampling schedule is 24 hours every third day, however, at one site (Wilmington-MLK) samples are collected for 24 hours every day.

Particulate Matter (PM_{10})
PM_{10} is sampled continuously using a tapered element oscillating microbalance (TEOM). Air is drawn through a specially designed inlet that excludes particles larger than 10 microns in diameter. Particle accumulation causes changes in the microbalance oscillation which are recorded by the instrument.

Sulfur Dioxide (SO_2)

Sulfur dioxide is measured with a fluorescence analyzer. Air is drawn through a sample cell where it is subjected to high intensity ultraviolet light. This causes the sulfur dioxide molecules in the air to fluoresce and release light. The fluorescence is detected with a photo multiplier tube and converted to an electrical signal proportional to the SO_2 concentration.

Lead

A large volume of air is drawn through a glass fiber filter (Hi-vol method). Part of the filter is removed and chemically extracted. This is followed by laboratory analysis using atomic absorption spectrometry to determine the lead concentration.

Acid Rain

Acidity is reported as pH, which is a measure of hydrogen ion concentration. The scale is logarithmic with a pH of 7.0 being neutral, pH 10.0 highly basic and pH 1.0 highly acidic. Clean precipitation is approximately pH 5.6.

Weekly precipitation samples are collected at the Ommelanden range. This monitor is for wet deposition only; dry deposition is not measured in Delaware. In the past, there was a second monitoring site in Georgetown. This site was terminated due to questions of site quality (too close to roadways) and restrictions on resources. Samples are analyzed for pH and conductivity at the Air Surveillance lab ("field" measurements). From 1983 through April 1995, the samples were mailed to a contractor for detailed chemical analysis for pH, conductivity, and ion species; this has been discontinued due to lack of financial support by the EPA.

Community Air Toxics

There are no EPA "reference" methods for monitoring ambient air for VOCs. In Delaware's program from 1991 through 1999, samples were taken on sorbent tubes once per week, rotating Monday through Thursday, for 24 hour intervals. The tubes were analyzed by the DNREC Environmental Services Laboratory using a gas chromatograph/mass spectrometer (GC/MS). Quality control measurements included collocated samplers, travel and laboratory blanks, spiked tubes, internal and various calibration standards. This method was replaced in 2000 by EPA Method TO15a, which collects 24-hour samples once every six days using stainless-steel canisters followed by GC/MS analysis.

APPENDIX B - Definitions, References, and Contacts

Ambient Air: Generally, the atmosphere; usually refers to the troposphere**.**

Annual Arithmetic Mean: The numerical average of the data for the year.

Annual Geometric Mean: The geometric average of the data for the year (the nth root of the product of n numbers).

Attainment: EPA designation that an area meets the NAAQS.

24-hour Average: The average concentration for a 24-hour period.

CMSA: Consolidated Metropolitan Statistical Area

Chemiluminescence: Visible light produced by chemical reaction.

Exceedance: An incident occurring when the concentration of a pollutant in ambient air is higher than the NAAQS.

Fluorescence: The production of light in response to the application of radiant energy such as ultraviolet rays.

Infrared: Lying just beyond the red end of the visible electromagnetic spectrum.

MSA: Metropolitan Statistical Area

NAAQS: National Ambient Air Quality Standard, set by EPA to protect human health and welfare.

NAMS: National Air Monitoring Stations

Nonattainment: EPA designation that an area does not meet the NAAQS.

PAMS: Photochemical Assessment Monitoring Stations

Photometry: The measurement of the intensity of light.

Photomultiplier: A device that converts light into an electrical current, amplifying it in the process.

ppb: Parts per billion by volume.

ppm: Parts per million by volume.

Precursor: A substance that is the source of, or aids in the formation of, another substance.

SLAMS: State and/or Local Air Monitoring Stations

SPMS: Special Purpose Monitoring Stations

Spectrometry: The measurement of electromagnetic wavelengths (spectra**).**

Troposphere: The region of the atmosphere nearest to the earth in which temperature generally decreases with height.

$\mu g/m^3$: Micrograms per cubic meter.

Ultraviolet: Lying just beyond the violet end of the visible electromagnetic spectrum.

References and WWW Addresses

The Delaware 1999 Rate-of-Progress Plan for Kent and New Castle Counties. State of Delaware, Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management, Air Quality Management Section, Dover, Delaware, December 1997.

McKee, David J., *Tropospheric Ozone: Human Health and Agricultural Impacts,* Lewis Publishers, Boca Raton, FL, 1994.

Measuring Air Quality - The Pollutant Standards Index, EPA 451/K-94-001, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1994.

National Air Pollutant Emission Trends, 1900 - 1993, EPA 454/R-94-027, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, October 1994.

National Air Quality and Emissions Trends Report, 1999, EPA 454/F-00-002, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, August 2000.

State of Delaware Annual Air Quality Report, 1999, 40-09/00/06/01, State of Delaware, Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management, Air Quality Management Section, New Castle, DE, June 2000.

1996 Periodic Ozone State Implementation Plan Emissions Inventory for VOC, NO_x*, and CO for the State of Delaware*. Doc. No. 40-09/99/11/01. State of Delaware, Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management, Air Quality Management Section, Dover, Delaware, November 1999.

1993 Periodic Ozone State Implementation Plan Emissions Inventory of VOC, NO_x*, and CO for the State of Delaware*. Doc. No. 40-09/97/08/03. State of Delaware, Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management, Air Quality Management Section, Dover, Delaware, January 1998.

1990 Base Year Ozone SIP Emission Inventory for VOC, CO, and NO_x *for the State of Delaware*. State of Delaware, Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management, Air Quality Management Section, Dover, Delaware, May 1994 (revised).

1997 Data Summary Delaware Toxics Release Inventory Report, 40-09/99/04/01, State of Delaware, Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management, Air Quality Management Section, Dover, Delaware, May 1999.

Some Air Quality Related World Wide Web Sites

AIRSData - Access to national and state air pollution concentrations and emissions data
www.epa.gov/air/data/index.html

American Lung Association
www.lungsusa.org

Delaware State Climatologist
www.udel.edu/leathers/stclim.html

Delaware Valley Regional Planning Commission (daily ozone forecasts)
www.AirQualityPartnership.org

Mid-Atlantic/Northeast Visibility Union - Regional Planning for Improved Visibility
www.manevu.org

State of Delaware Air Quality Management Section current hourly monitoring data
www.dnrec.state.de.us/air/aqm_page/airmont/air.asp

US National Oceanic and Atmospheric Administration, Environmental Research Laboratories, Air Resources Laboratory
www.arl.noaa.gov

USEPA Emission Factor and Inventory Group
www.epa.gov/ttn/chief

USEPA Office of Air and Radiation
www.epa.gov/oar/

USEPA Office of Air Quality Planning and Standards “AirNow” - ozone maps, real-time data
www.epa.gov/airnow/

USEPA Office of Transportation and Air Quality (formerly Office of Mobile Sources)
www.epa.gov/oms

USEPA Region III Air Protection Division
www.epa.gov/reg3artd

USEPA Technology Transfer Network (TTN Web)
www.epa.gov/ttn

List of contacts

Department of Natural Resources and Environmental Control
Division of Air and Waste Management
Air Quality Management Section

Air Monitoring 302-323-4542
715 Grantham Lane
New Castle, DE 19720

Program Manager	Joe Martini
Air Quality Data	Betsy Frey
Air Toxics Data	Joe Martini

Planning and Community Protection Branch 302-739-9402
156 South State Street
Dover, DE 19901

Emissions Inventory Development

Program Manager	David Fees
Point Sources	John Outten
Stationary Area Sources	David Fees
Mobile Sources (on- and off-road)	David Fees

State Implementation Plan (SIP) - Regulations and Planning

Program Manager	Ron Amirikian