DELAWARE ANNUAL AIR QUALITY REPORT

2014

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EXECUTIVE SUMMARY

Delaware's 2014 annual air quality report continues to document the changes and overall improvement in ambient air quality in the state. In 2014 all pollutants are below the national air quality standards. Only one pollutant, ozone, was close to the national standard.

As measured by the air quality index (AQI), there are only a few days that fall into the category of moderate or unhealthy for sensitive populations. Continuing recent trends, the number of days with good air quality continues to increase.

The U.S. Environmental Protection Agency (EPA) announced on August 4, 2014 that New Castle County has met the previous annual and 24-hour air quality standards for fine particulate matter. The full announcement is available in the Federal Register. On August 19, 2014, EPA also determined that all of Delaware has met the even stricter annual fine particulate standards that were put into place in 2012. Substantial pollution control improvements due to federal rules and Delaware regulations have contributed to the much improved fine particulate air quality.

For ozone, there were three days with exceedances of the 8-hour ozone standard in 2014, all in New Castle County. There were no exceedances of the state 1-hour ozone standard. Ozone concentrations continue to show a generally decreasing trend in all three counties over recent years, and the most recent three-year average of the 4th annual maximum 8-hour average is below the current NAAQS in all three counties in Delaware.

Concentrations of air toxics in Wilmington continue to show generally low or declining levels.

Emissions of air pollutants are calculated every three years as part of a comprehensive emissions inventory.

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DELAWARE ANNUAL AIR QUALITY REPORT 2014

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 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 and $PM_{2.5}$ formation. Accompanying these data is 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.

A new section on climate change is planned for the 2015 Annual Air Quality Report. This year's report briefly introduces the section and contains internet web site references for more information.

GENERAL INFORMATION

ABOUT DELAWARE'S DIVISION OF AIR QUALITY

The Division of Air Quality is operated through an Air Quality Director and is organized by two main branches that are defined as:

- Planning
- Engineering and Compliance

Planning Branch

Ambient Air Quality Monitoring Program

The Ambient Air Quality Monitoring Program monitors 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. The data are used to provide the public with information on current air quality conditions, assess compliance with or progress made towards meeting 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.

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 non-point 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 Anon-attainment" of some 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 called State Implementation Plans. These are usually in the form of revisions to existing plans.

Area Sources Compliance Program
The Areas Source Compliance group inspects and issues air pollution control permits for smaller sources, such as dry cleaners, auto body shops, gasoline tank trucks, open burning activity and asbestos abatement projects. Group personnel make periodic facility inspections and review data to ensure that permit and regulatory requirements are being met. Enforcement actions are initiated for violation of regulations or permit conditions when warranted.

Greenhouse Gas, Mobile Sources, Air Toxics Program
The Greenhouse Gas, Mobile Source, and Air Toxics program identifies and develops strategies on a multi-pollutant basis (i.e., considering impacts of climate change, ozone, $PM_{2.5}$ and toxics). The Greenhouse Gas program covers all greenhouse gas related planning and regulatory development activities, including Regional Greenhouse Gas Initiative (RGGI) administration tasks such as management of Delaware's portion of the RGGI allowance accounts, reviewing and approving offset projects, and development of strategies to reduce greenhouse gas emissions from outside the power sector (i.e., the sector that is regulated under RGGI). The Mobile Source program oversees land use and general/transportation conformity related planning and regulatory development activities, including identifying mitigation measures for reducing those emissions from both on-road and non-road sources. The Air Toxics program administers and implements related planning and regulatory development activities associated with the mitigation of air toxics.

Engineering and Compliance Branch
Permitting and Compliance Programs
The Engineering and Compliance Branch inspects and issues 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. Enforcement actions are initiated for violation of regulations or permit conditions when warranted.

Source Testing Program
The Source Testing Program verifies 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. There are a verity of source testing methods used to verify actual emissions.

Refinery Support Program

The Refinery Support Group (RSG) within the Engineering and Compliance Branch inspects and issues air pollution control permits for the Delaware City Refinery (DCR) which is Delaware's largest source of air pollutant emissions. The RSG is responsible for providing regulatory and technical oversight of the DCR with respect to all air compliance issues. Because of the inherent

complexity of this source, the RSG conducts a full compliance evaluation of the facility once every 3 years during which each unit operation is inspected. The RSG works in close concert with other groups within the Division as well as intra and inter agency spheres of interest. The RSG is also responsible for initiating enforcement action as appropriate and works closely with the Attorney General's Office and the US EPA to ensure compliance with all aspects of the Clean air Act.

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 determining the location of air monitoring stations. Sites are selected based on the purpose of the monitoring (representative ambient concentrations, maximum source impact, etc.), the pollutant or pollutants to be monitored, the population density, location of 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, 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 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 buildup 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.

   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. Use the DNREC Environmental Navigator (DEN) website at http://www.nav.dnrec.delaware.gov/DEN3/ to explore the many types of information collected by DNREC, such as permitted facilities, enforcement actions and environmental monitoring.

   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 Division of Air Quality web page.
   http://apps.dnrec.delaware.gov/AirMonitoring/

8. How can I get historical air quality data?

   Historic air quality data for Delaware and other states is available on the internet at:
   http://www.epa.gov/airdata/

9. Why can't I burn my trash?

The open burning of trash, where smoke and other emissions are released directly into the air without passing through a chimney, is illegal throughout all of Delaware at all times of the year. Open trash burning 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.**

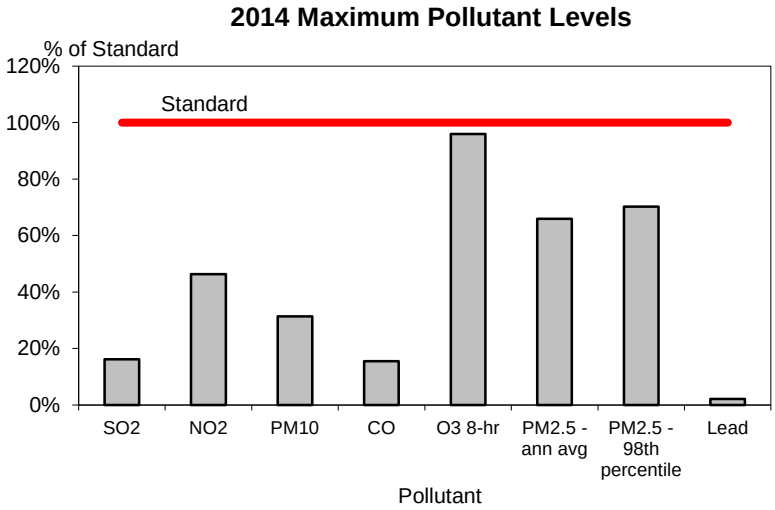
11. Where do I find the Division of Air Quality regulations?

    The regulations are posted on the air quality regulations web page:
    http://regulations.delaware.gov/AdminCode/title7/1000/1100/index.shtml

DELAWARE'S AIR QUALITY STATUS

Delaware air quality currently meets all the National Ambient Air Quality Standards.

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 sub-index 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".

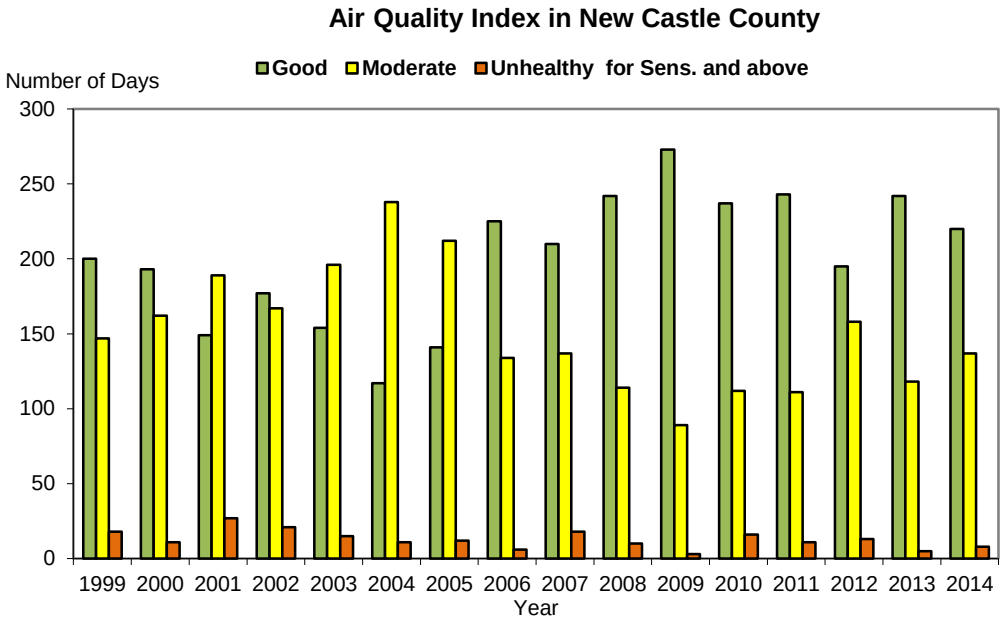
Air Quality Indexes and Descriptions

Index Value	Name	Color	Advisory
0 to 50	Good	Green	None
51 to 100	Moderate	Yellow	Unusually sensitive individuals should consider limiting prolonged outdoor exertion
101 to 150	Unhealthy for Sensitive Groups	Orange	Children, active adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion
151 to 200	Unhealthy	Red	Children, active adults, and people with respiratory disease, such as asthma, should avoid prolonged outdoor exertion; everyone else should limit prolonged outdoor exertion
201 to 300	Very Unhealthy	Purple	Children, active adults, and people with respiratory disease, such as asthma, should avoid outdoor exertion; everyone else should limit outdoor exertion
301-500	Hazardous	Maroon	Everyone should avoid all physical activity outdoors.

Local Air Quality Index (AQI)

Delaware reports criteria pollutant concentrations from the statewide monitoring network on an hourly basis to the EPA AIRNow website (http://www.airnow.gov/) which uses the data to calculate an Air Quality Index (AQI).

The accompanying graph uses the daily AQI to evaluate trends for New Castle County from 1999 through 2014. The number of days with unhealthy air quality has been generally declining in recent years, and the number of days with good air quality has been increasing.



Delaware Air Monitoring Network

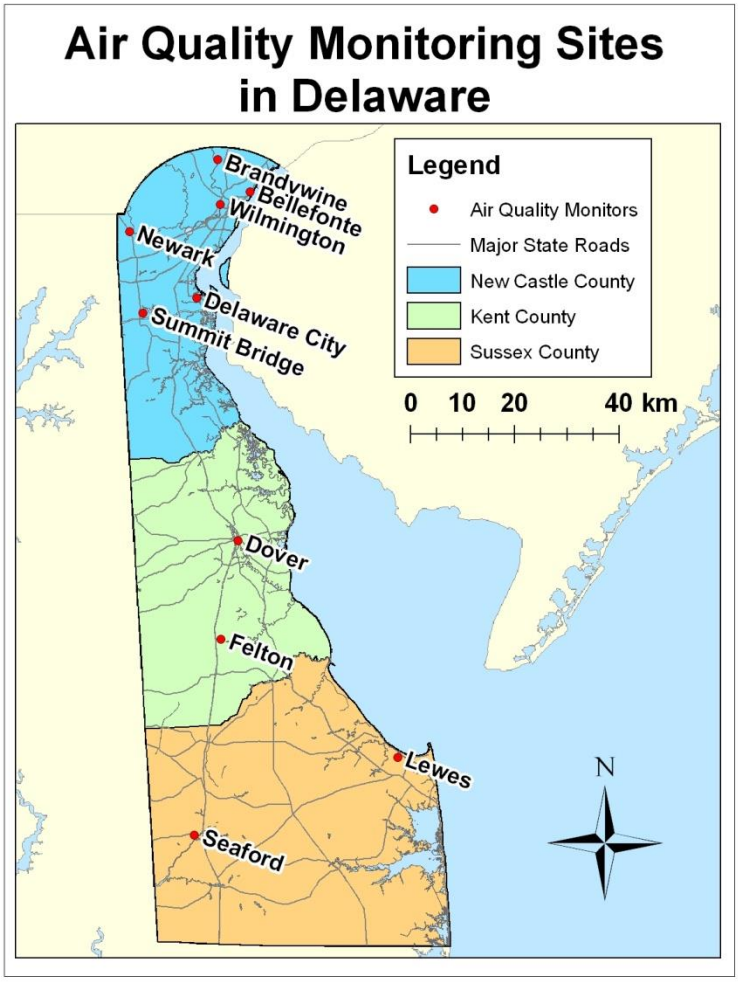
The State of Delaware has established an air monitoring network to determine the ambient levels of the pollutants for which NAAQS have been established. The Delaware Air Monitoring Network consists of the sites and monitors listed in the following table and figure. Although monitoring takes place statewide, 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 Monitoring Program within the Planning Branch of the Division of Air Quality (DAQ), DNREC.

The gaseous criteria pollutants, along with wind speed and wind direction, are measured continuously with hourly averages computed and reported via a telemetry system to the central data storage computer in the DAQ New Castle office. Particulates are collected as 24-hour samples that run every sixth day, and acid rain is monitored weekly.

Delaware Air Monitoring Network 2014

"X" indicates pollutant monitored

SITE	SO_2	NO_2	CO	O_3	PM_{10}	$PM_{2.5}$	Wind Speed/ Directi	Lead
Brandywine				X			X	
Bellefonte	X			X		X		
Wilmington MLK	X	X	X	X	X	X	X	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			X	



More information on Delaware's ambient air monitoring network can be found on the Division of Air Quality's webpage as the Delaware Ambient Air Monitoring Network Plan, which is updated annually (http://www.dnrec.delaware.gov/Air/Pages/PubCommAmbientAir.aspx).

AIR QUALITY - POLLUTANTS THAT ARE CLOSE TO OR HAVE RECENTLY EXCEEDED STANDARDS: OZONE

OZONE (O3)

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 eight-hour average = 0.075 ppm
The eight-hour standard is achieved when the annual fourth highest daily eight-hour concentration, averaged over three years, is less than or equal to the standard.

State standard:

Maximum one-hour = 0.12 ppm, former NAAQS, current Delaware AAQS.
Note: EPA revoked the one-hour standard for ozone in June 2005 but Delaware has maintained the one-hour standard in its regulations (Regulation 1103).
The one-hour standard 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.

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 task 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.

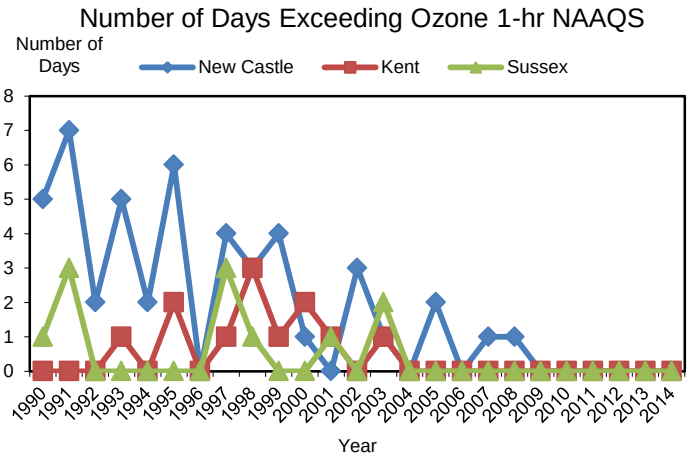
Locations

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 NOx emissions. See the "Delaware Air Monitoring Network" table on page 9 for specific sites. While short-term 1-hour average peak ozone levels are usually highest in New Castle County, longer-term 8-hour averages are close to or above the standard throughout Delaware.

In 2011 a new urban monitor was added at the Wilmington MLK.

Delaware Air Quality and Trends

Trends in ozone concentrations can be difficult to discern due to the effect of meteorology. Hot, dry weather and stagnant air conditions favor the formation of ozone, and the greatest number of exceedance days typically occurs during the hottest and driest summers.



Overall, Delaware ozone levels in the 1990's were lower than in the 1980's, with continued improvement into the 2000's.

One-hour Ozone Data and Trends

In 2014 there were no days on which the one-hour NAAQS was exceeded in Delaware. This demonstrates significant improvement in air quality since the 1990's when multiple exceedances occurred throughout the state every summer.

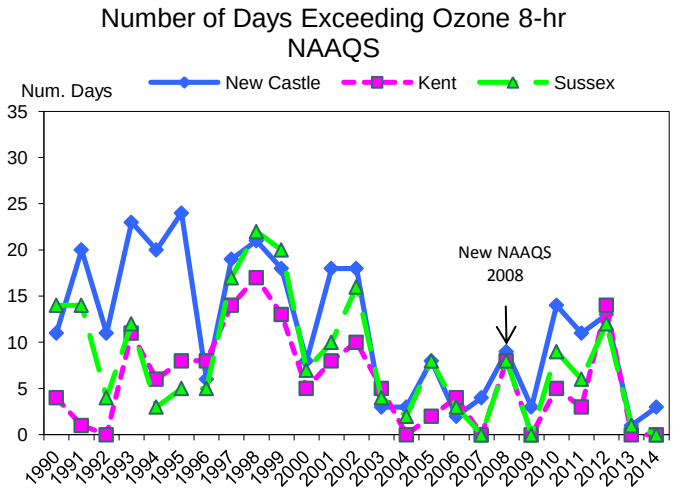
Eight-hour Ozone Data and Trends

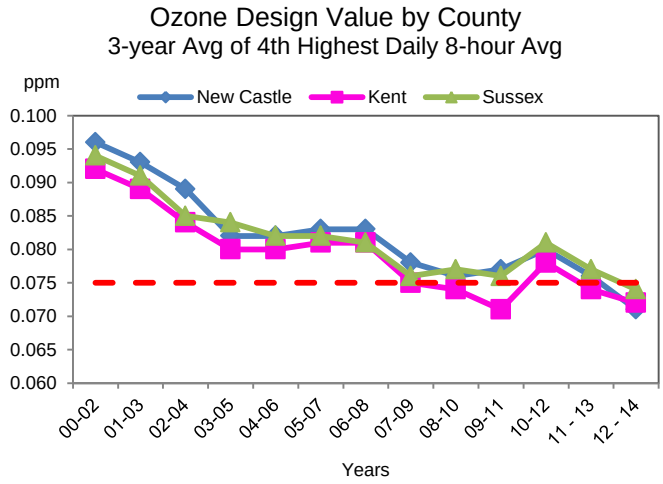
Former NAAQS: Prior to 2008, a measured 8-hour average concentration must have been equal to or greater than 0.085 ppm to be counted as an exceedance of the 0.08 ppm standard because of numerical rounding to two decimal places.

Current NAAQS: The current eight hour NAAQS does not have the rounding issue of the former standard; a measured 8-hour average concentration above 0.075 is an exceedance of the standard.

In 2014 there were three days that exceeded the 8-hour standard in Delaware, with all exceedances occurring in New Castle County. The following tables contain more information on the 8-hour standard and trends for each monitoring site.

The eight-hour standard is achieved when the annual fourth highest daily eight-hour concentration, averaged over three years, is less than or equal to the standard. This number is referred to as the "design value". Based on 2012 – 2014 data, all counties in Delaware meet the NAAQS.





2014 Ozone Eight-hour Average Exceedance Days and Maxima (ppm)

Site	Num. Exc. > 0.075 ppm	1st Max.	2nd Max.	3rd Max.	4th Max.
Brandywine	1	0.077	0.072	0.066	0.066
Bellefonte	0	0.072	0.070	0.068	0.067
Summit Bridge	0	0.066	0.065	0.063	0.062
Wilmington MLK	0	0.073	0.070	0.068	0.067
Felton	0	0.070	0.070	0.064	0.064
Seaford	0	0.071	0.070	0.068	0.065
Lewes	1	0.081	0.075	0.075	0.072

Num. Exceedances = Number of days with at least one 8-hour average > 0.075 ppm.

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

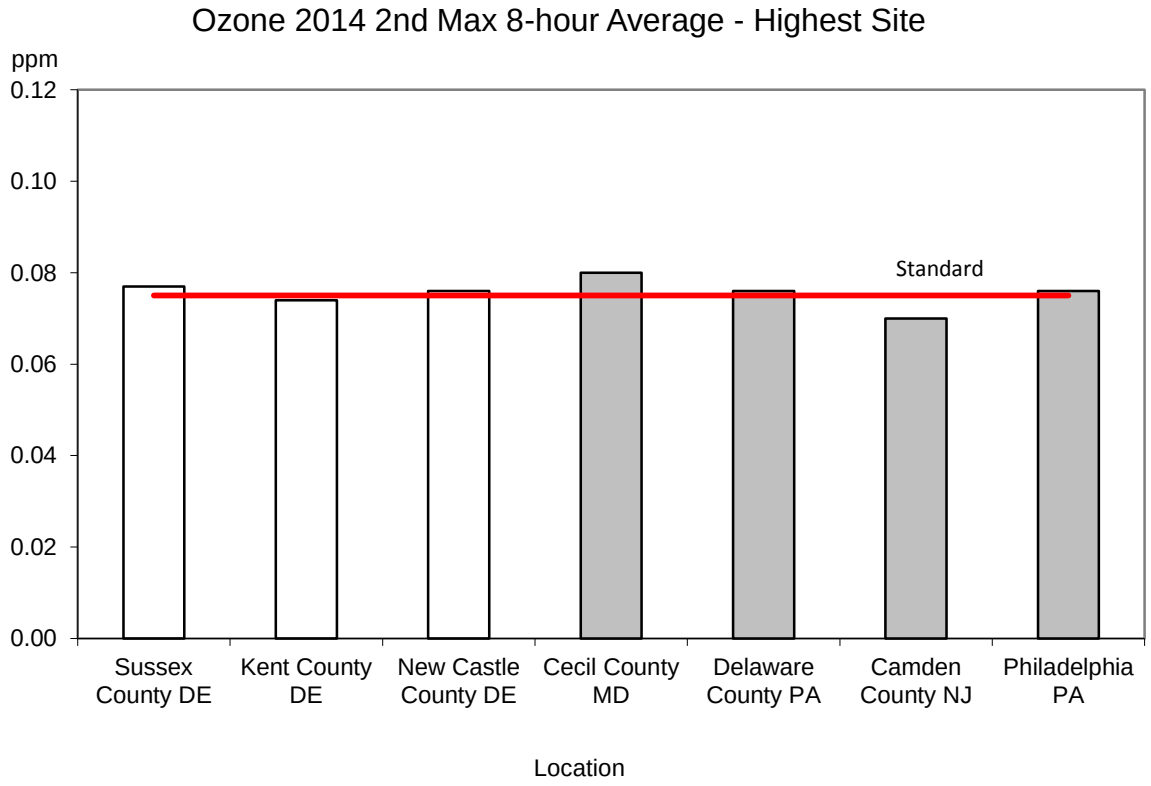
NAAQS = 0.075 ppm

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

Site	2004 - 2006	2005 - 2007	2006 - 2008	2007 - 2009	2008 - 2010	2009 - 2011	2010 - 2012	2011 - 2013	2012 - 2014
Brandywine	0.082	0.083	0.083	0.078	0.076	0.075	0.078	0.073	0.071
Bellefonte	0.081	0.081	0.078	0.074	0.075	0.077	0.080	0.076	0.071
Summit Bridge	0.078	0.082	0.080	0.075	0.075	0.075	0.080	0.075	0.071
*Wilmington MLK	NA	NA	NA	NA	NA	NA	*0.079	0.074	0.071
Felton	0.080	0.081	0.081	0.075	0.074	0.072	0.082	0.074	0.072
Seaford	0.080	0.082	0.081	0.076	0.077	0.076	0.082	0.075	0.070
Lewes	0.082	0.082	0.079	0.076	0.077	0.076	0.081	0.077	0.074

* Monitoring began in 2011.

How does Delaware's air quality compare to nearby areas?
Ozone levels in Delaware in 2014 were similar to those in nearby areas.



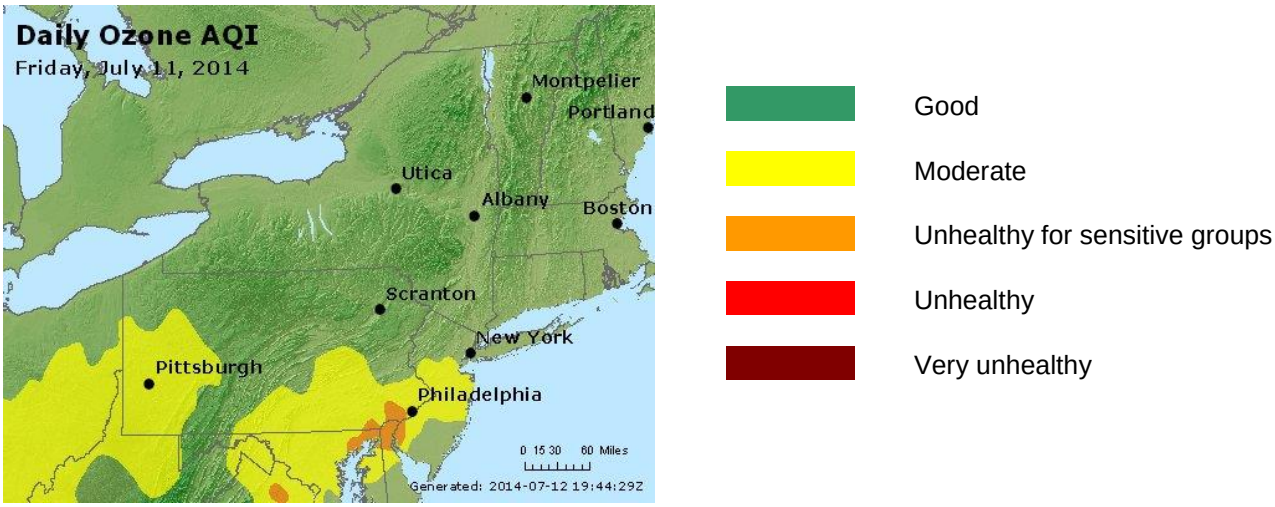
Ozone Mapping Project

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.airnow.gov.

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

Air Quality Index Ozone Peak Values – July 11, 2014



Source: EPA AIRNOW website:
http://www.airnow.gov/index.cfm?action=airnow.mapsarchivecalendar

AIR QUALITY - POLLUTANTS THAT MEET STANDARDS: CO, NO_2, $PM_{2.5}$, PM_{10}, SO_2, Lead

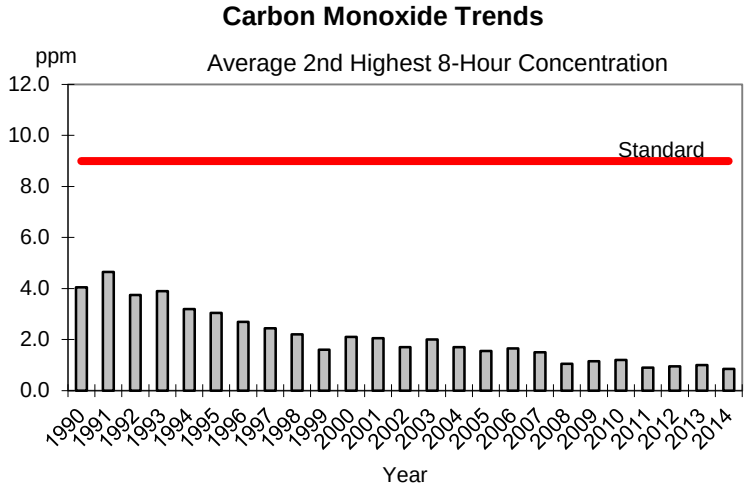
CARBON MONOXIDE (CO)

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 judgment 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 mg/m^3)
1-hour average = 35 ppm (40 mg/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 U.S.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 at Wilmington MLK and Delaware City.



Delaware Air Quality and Trends
Mobile sources cause most of the ambient CO detected at the Wilmington MLK site.

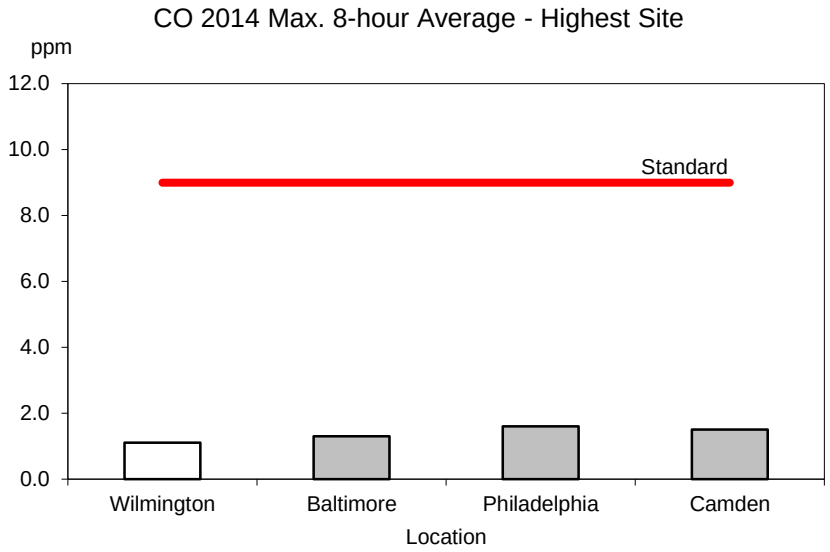
There has been a slight downward trend in CO concentrations since monitoring began in the 1970's, and no violations of the ambient standards have occurred since 1977. Improvements are largely due to cleaner burning engines in cars and tighter automobile emission standards. Low concentrations continued in 2014.

Delaware Carbon Monoxide (CO) 2014 Max. Values

ppm

Site	1-Hour Avg. NAAQS = 35 ppm		8-Hour Avg. NAAQS = 9 ppm	
	1st Max.	2nd Max.	1st Max.	2nd Max.
Wilmington MLK	1.8	1.6	1.3	1.1
Delaware City	2.2	1.9	1.0	0.9

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 dioxide and other compounds in the atmosphere can form nitric acid, which contributes to the acid rain problem. Oxides of nitrogen 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.

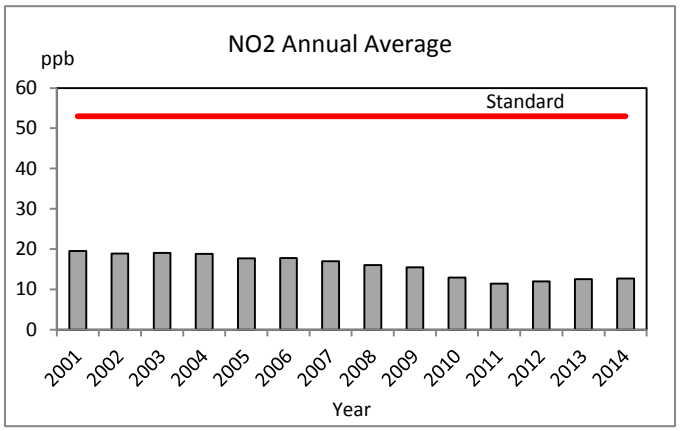
Atmospheric deposition of oxides of nitrogen has recently been estimated to be a significant source of nitrogen to bodies of water such as the Chesapeake Bay and Delaware's Inland Bays. Nitrogen acts as a nutrient and contributes to excess nutrient loading and algal blooms in estuary systems.

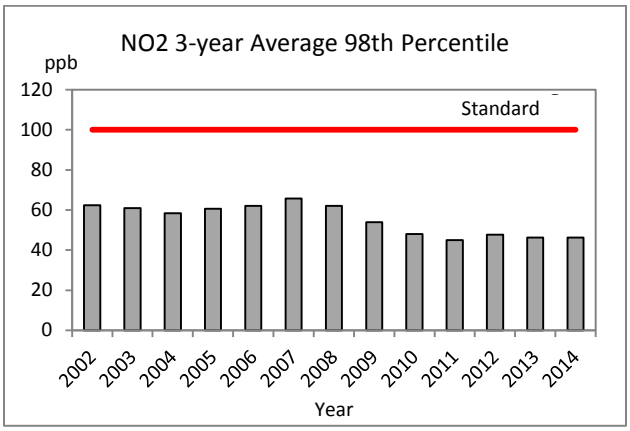
Standards
Primary NO_2 NAAQS: Annual arithmetic mean = 53 ppb (100 µg/m^3)
1-hour average = 100 ppb as 3-year average of the 98th percentile daily max.
(*New in 2011: 1-hour average and standards changed from ppm to ppb*)

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 2014, levels continued to remain well below the standard.





Delaware Nitrogen Dioxide (NO_2)

Annual Arithmetic Means in ppb

Site	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Wilmington MLK	19	19	18	18	17	16	16	13	11	12	13	13

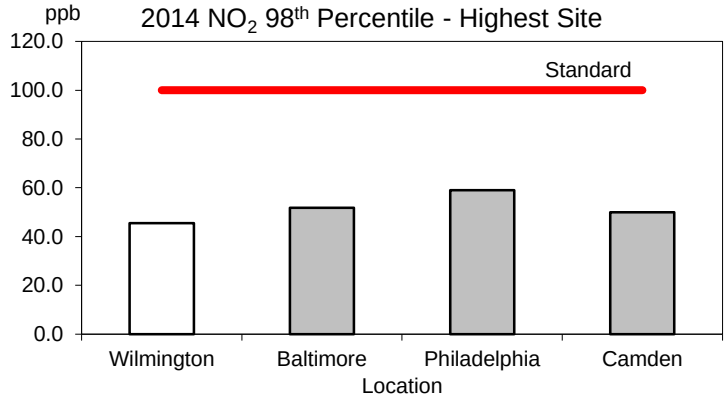
* Insufficient data to calculate annual average

Annual 98th Percentile in ppb

Site	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Wilmington MLK	60	57	65	64	68	54	40	50	45	48	46	45

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 or lower than those in nearby areas.



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

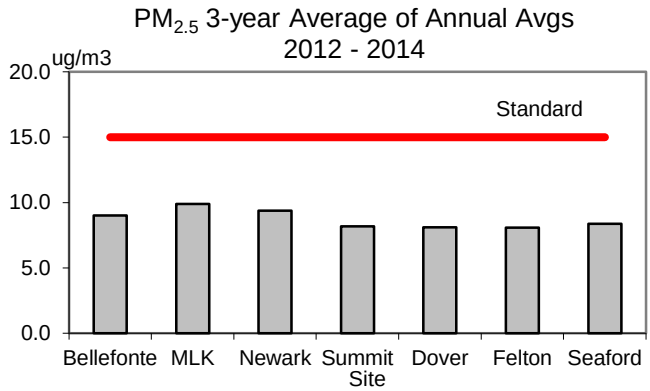
Primary NAAQS: Annual arithmetic mean = 12.0 µg/m^3 averaged over three years. *(On Dec. 14, 2012 the EPA lowered the annual NAAQS from 15.0 to 12.0µg/m^3)*
24-Hour maximum = 35 µg/m^3 as the 98th percentile averaged over three years

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, such as SO_2 and NO_X, 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 Delaware Ambient Monitoring Network 2014 (page 9) for specific sites.



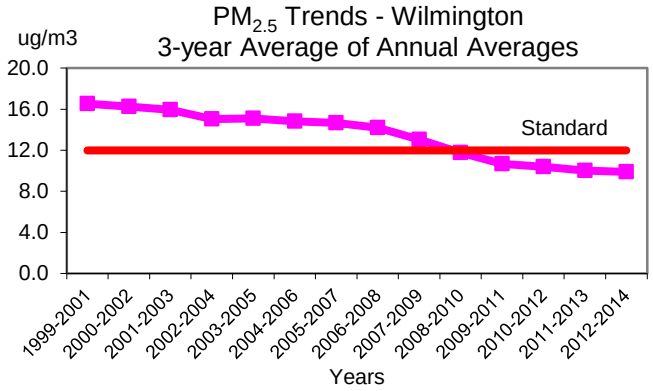
Delaware Air Quality and Trends

Delaware's monitoring network began collecting data in January 1999. Three years of complete data are required for comparison to the national standard.

Annual Average

New Castle County was originally 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 MLK site. For the most recent three-year period (2012 - 2014), the highest average occurred in New Castle

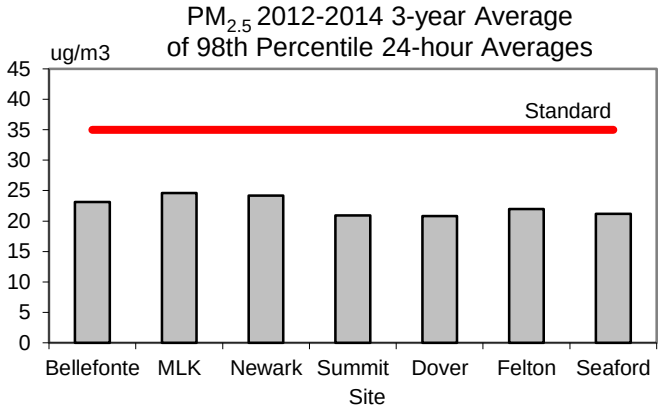
County (9.9 µg/m^3 at the Wilmington MLK site). Currently, all sites in Delaware meet the annual average standard.



The trends chart shows the 3-year averages for the highest concentration site in Delaware, which is the Wilmington MLK site. There is a downward trend showing continued air quality improvement at this site. Similar trends are present at other monitoring sites throughout the state, reflecting the significant correlation between average concentrations at all monitoring sites in Delaware. Both local and regional sources of fine particulate matter and its precursors (substances that are the source of another substance) contribute to concentrations seen in Delaware.

24-hour Average

The current 98th percentile 24-hour average $PM_{2.5}$ standard was met at all monitoring sites in Delaware as calculated with the 2012 – 2014 $PM_{2.5}$ data.

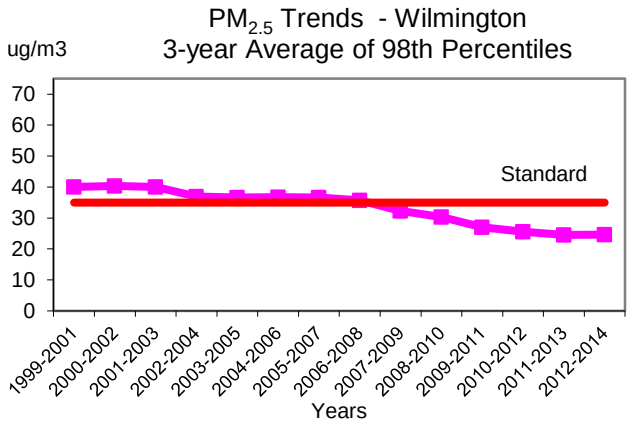


Similar to the annual average data, there is significant correlation between 24-hour concentrations measured at all sites throughout Delaware. In other words, if high concentrations of $PM_{2.5}$ are recorded at one site, all other sites in Delaware usually record high concentrations on that same day.

As with the annual average standard, three years of data are averaged to determine compliance with the NAAQS. The most recent three-year (2012 – 2014) average for the 98th percentiles at Wilmington MLK was 25 µg/m^3.

The 98th percentile for 24-hour average trends chart shows the 3-year averages for the highest concentration site in Delaware, which is the MLK site in Wilmington. There is less variation in the 98th percentile averages than in the annual averages, but a downward trend is still apparent.

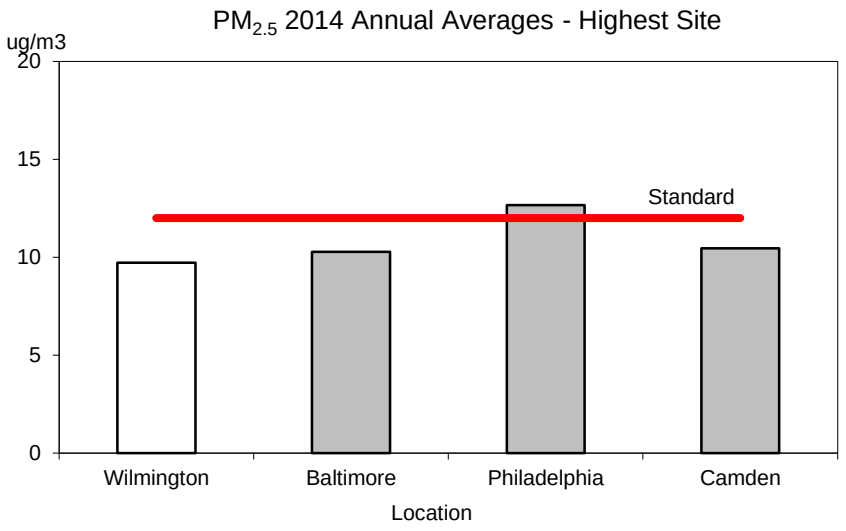
Although only the MLK site is shown in the graph, the same overall improvement in air quality has been occurring at all monitoring sites in Delaware.

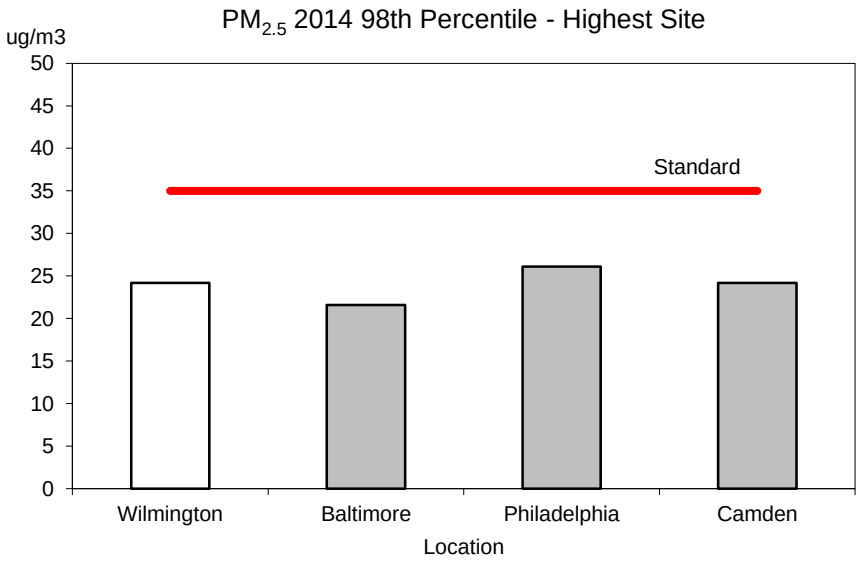


Delaware 2012 - 2014 $PM_{2.5}$ Data Summary

Site	3-year Average of Annual Averages NAAQS = 15µg/m^3	3-year Average of 24-hour 98th Percentiles NAAQS = 35 µg/m^3
Bellefonte	9.0	23
Wilmington MLK	9.9	25
Newark	9.4	24
Summit Bridge	8.2	21
Dover	8.1	21
Felton	8.1	22
Seaford	8.4	21

How does Delaware's air quality compare to nearby areas?
Air quality in Delaware is similar to nearby areas.



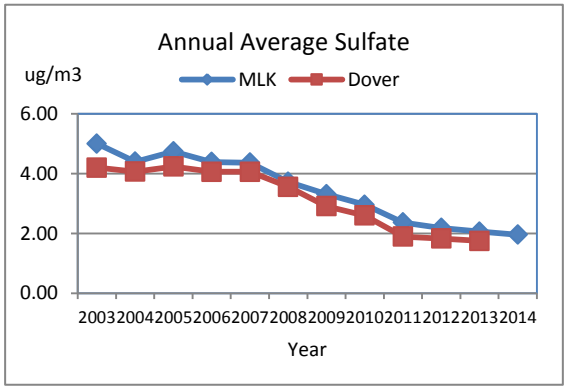


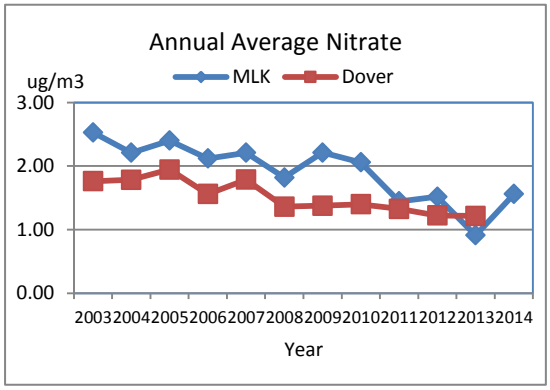
$PM_{2.5}$ Speciation

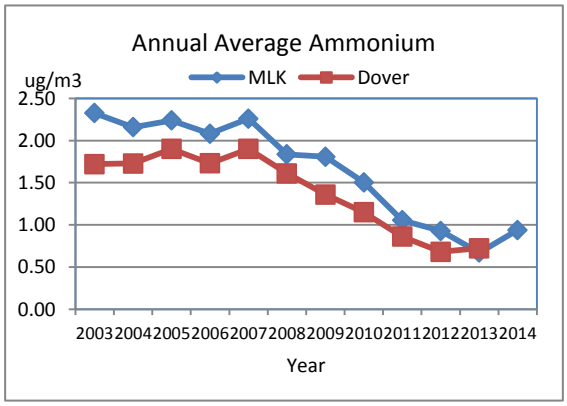
To understand the nature of fine particle pollution and possible sources, EPA initiated a program to monitor the major components, or "species", that make up $PM_{2.5}$. The main objectives of the $PM_{2.5}$ speciation monitoring program are to provide additional information to characterize the annual and spatial aspects of $PM_{2.5}$, detect and track trends in aerosol component concentrations, and provide information to develop and evaluate emission control programs.

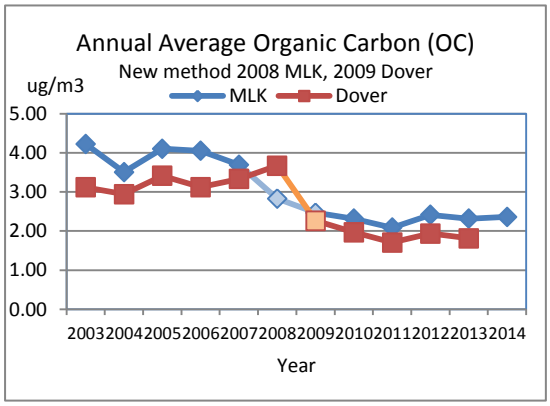
The $PM_{2.5}$ speciation program in Delaware consists of monitors at two sites: Wilmington MLK and Dover. Samples are collected on filters for 24 hours every 6th day in Dover and every 3rd day in Wilmington. The filters are sent to a contract laboratory for chemical analyses. The target species are ions (sulfate, nitrate, ammonium, sodium, and potassium), trace elements/metals, and carbon (elemental and organic carbon). There are no ambient air quality standards for the chemical components of $PM_{2.5}$. *Note:* Monitoring at Dover ended in early 2014 due to EPA reassessment of the monitoring network and termination of support for the Dover site due to low concentrations and redundancy with the Wilmington MLK site.

Following are trends charts for some of the major components of $PM_{2.5}$. Trends for most major components are slightly declining. Analysis of the data is ongoing.









PARTICULATE MATTER (PM10)

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

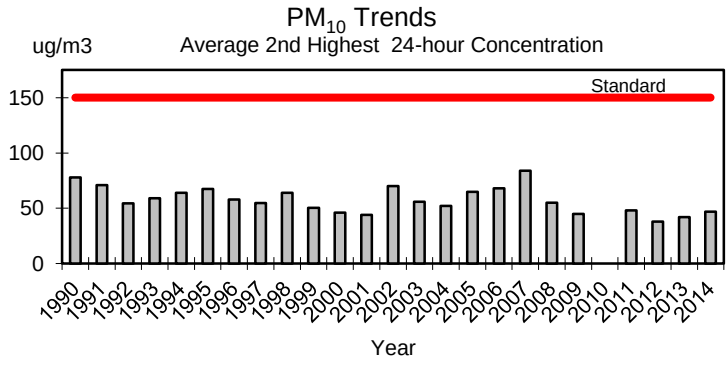
Primary NAAQS: 24-Hour maximum = 150 $\mu g/m^3$ not to be exceeded more than once per year averaged over three years.

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 is 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 MLK site.



Delaware Air Quality and Trends

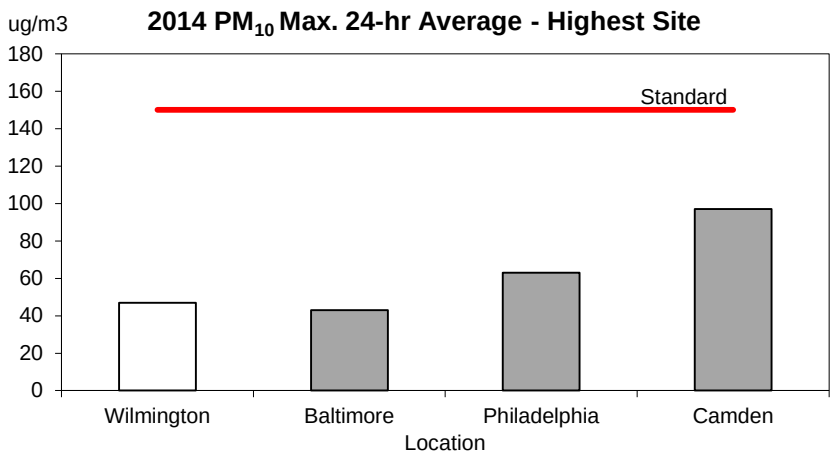
Delaware is in attainment with the PM_{10} NAAQS. The increases in concentrations in 2005 - 2007 were probably related to construction and road improvement projects in the Riverfront area, which is close to the monitor location. *Note: Monitoring was suspended in 2010 due to equipment problems; a new monitor was installed and operational for 2011.*

Delaware PM_{10} Trends
Annual Average $\mu g/m^3$

Site	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Wilmington MLK	20.3	19.8	22.5	22.6	23.2	19.8	17.8	No data	17.4	17.1	14.4	16.9

There was no PM_{10} data for 2010 due to monitor failure; a new monitor was installed and data collected starting in January 2011.

How does Delaware's air quality compare to nearby areas?
PM_{10} concentrations in Delaware have been similar to those in nearby areas.



SULFUR DIOXIDE (SO_2)

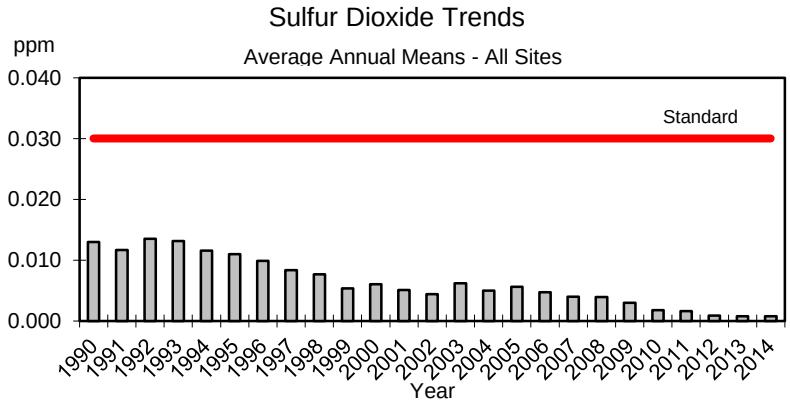
Description
Sulfur dioxide (SO_2) is a pungent, poisonous gas. It is an irritant that can interfere with normal breathing functions even at low levels. It aggravates respiratory diseases such as asthma, emphysema, and bronchitis. These effects can be magnified by high particulate levels. High SO_2 levels 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: 1-hour average = 75 ppb (3-year average of the 99th percentile 1-hour avg.)
Secondary NAAQS: 3-hour average = 0.5 ppm (1300 µg/m^3)
Note: In 2010 EPA revoked the annual average (0.03 ppm) and 24-hour average (0.14 ppm) standards, but these still remain in Delaware's regulations regarding ambient air quality standards.

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. Due to resource restrictions, there was no monitoring at the Summit Bridge site in 2009. Monitoring in Sussex County began at the Lewes site in 2012.

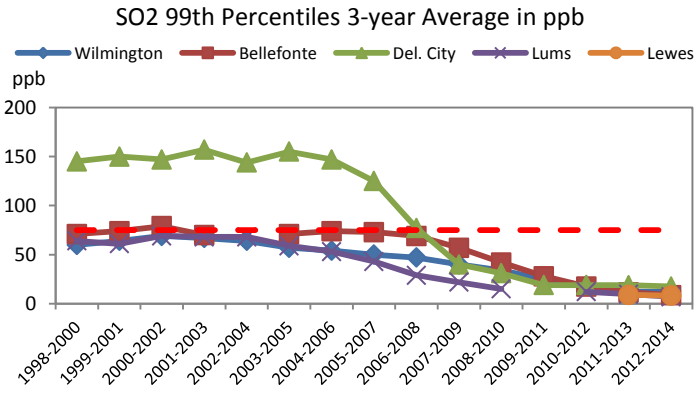


Delaware Air Quality and Trends
Delaware is in attainment with the NAAQS for SO_2. Over the last decade, measured ambient levels have remained well below the standard with a slight downward trend. Locally, higher levels are found only in areas impacted by a single large source (such as a coal burning power

plant or oil refinery).

In 2014, SO_2 levels remained well below the standards.

In comparing the 1-hour averages to the new standard, a significant improvement can be noted at the Delaware City site when additional emission controls were added to the nearby oil refinery.



Delaware Sulfur Dioxide

Annual 99th percentile 1-hour Average in ppb

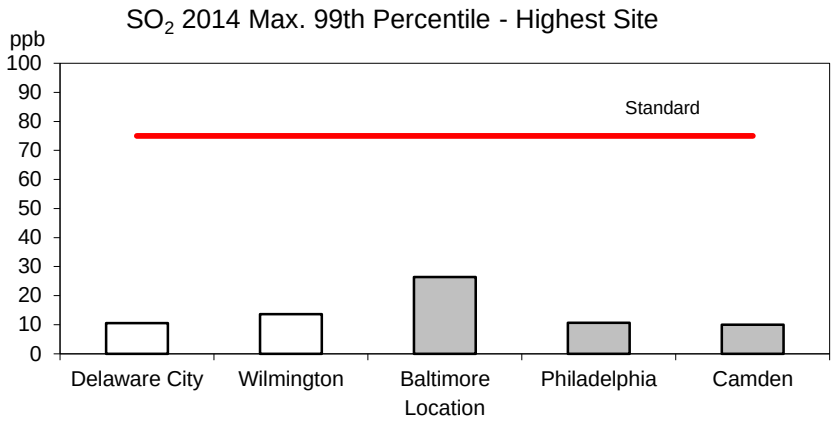
Site	Year											
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Bellefonte	68	72	72	77	69	60	41	25	19	8	7	10
Wilm.-MLK	57	63	52	47	50	43	28	31	14	9	13	14
Summit Br.	61	58	59	42	29	ND	ND	ND	ND	ND	7	7
Del City	164	106	195	139	41	51	28	13	15	29	13	11
Lewes										11	7	7

SO_2 3-year Average of the 99th Percentile

NAAQS = 75 ppb

Site	Years									
	2003-2005	2004-2006	2005-2007	2006-2008	2007-2009	2008-2010	2009-2011	2010-2012	2011 - 2013	2012 - 2014
Bellefonte	71	74	73	69	57	42	28	18	12	9
Wilm.-MLK	57	54	50	47	40	34	25	18	12	12
Summit Br.	59	53	43	29	22	15	ND	ND	10	7
Del City	155	147	125	77	40	31	19	19	19	17
Lewes										8

How does Delaware's air quality compare to nearby areas?
SO_2 concentrations in Delaware are similar to those in nearby areas.



LEAD (Pb)

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.

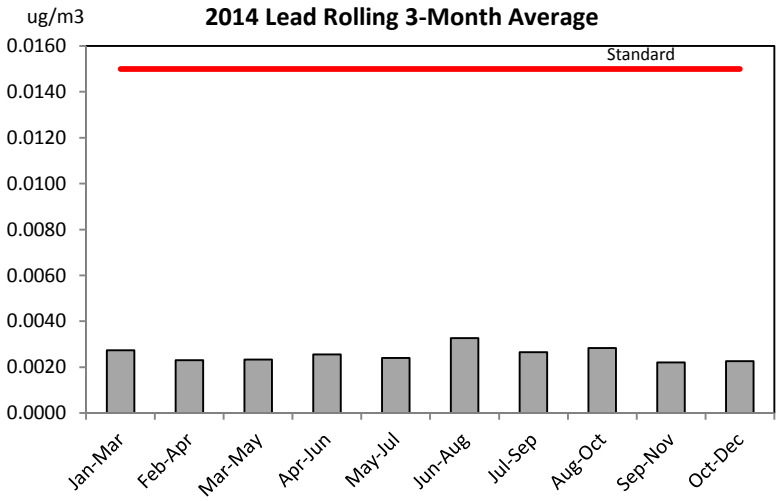
Exposure can occur through a number of pathways including ingestion and inhalation. Lead affects several physiological processes including the blood-forming, reproductive, nervous and renal (kidney) systems. It accumulates in both bone and soft tissues and can cause problems long after exposure is ended.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

Standard
Primary NAAQS: Rolling 3-month average of 0.015 $\mu g/m^3$
Revised NAAQS October 15, 2008 with monitoring in urban areas required to begin by January 1, 2012.

Locations
Monitors were formerly located in Claymont and Wilmington and monitoring ended in 1989. Monitoring for lead was renewed at the current Wilmington MLK site in 2012.

Delaware Air Quality and Trend
Monitoring for the new lead NAAQS is part of the National Core (NCore) multi-pollutant monitoring station at the Wilmington MLK site, and began in January 2012 in accordance with EPA regulations.

Delaware is in attainment with the NAAQS for lead.



AIR QUALITY - POLLUTANTS WITHOUT STANDARDS: Air Toxics

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-road and off-road motor vehicles as well as boats and aircraft.

Locations

From 1990 to 1999, VOC samples were collected at four monitoring 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. From 2003 through 2004, VOCs, carbonyls, and heavy metals were collected at five sites throughout the state. Due to resource restrictions, in 2006 monitoring ended at three of those sites in September, and only MLK and Delaware City had a full year of data. Since then monitoring has continued at those two sites.

Delaware Air Quality and Trends

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

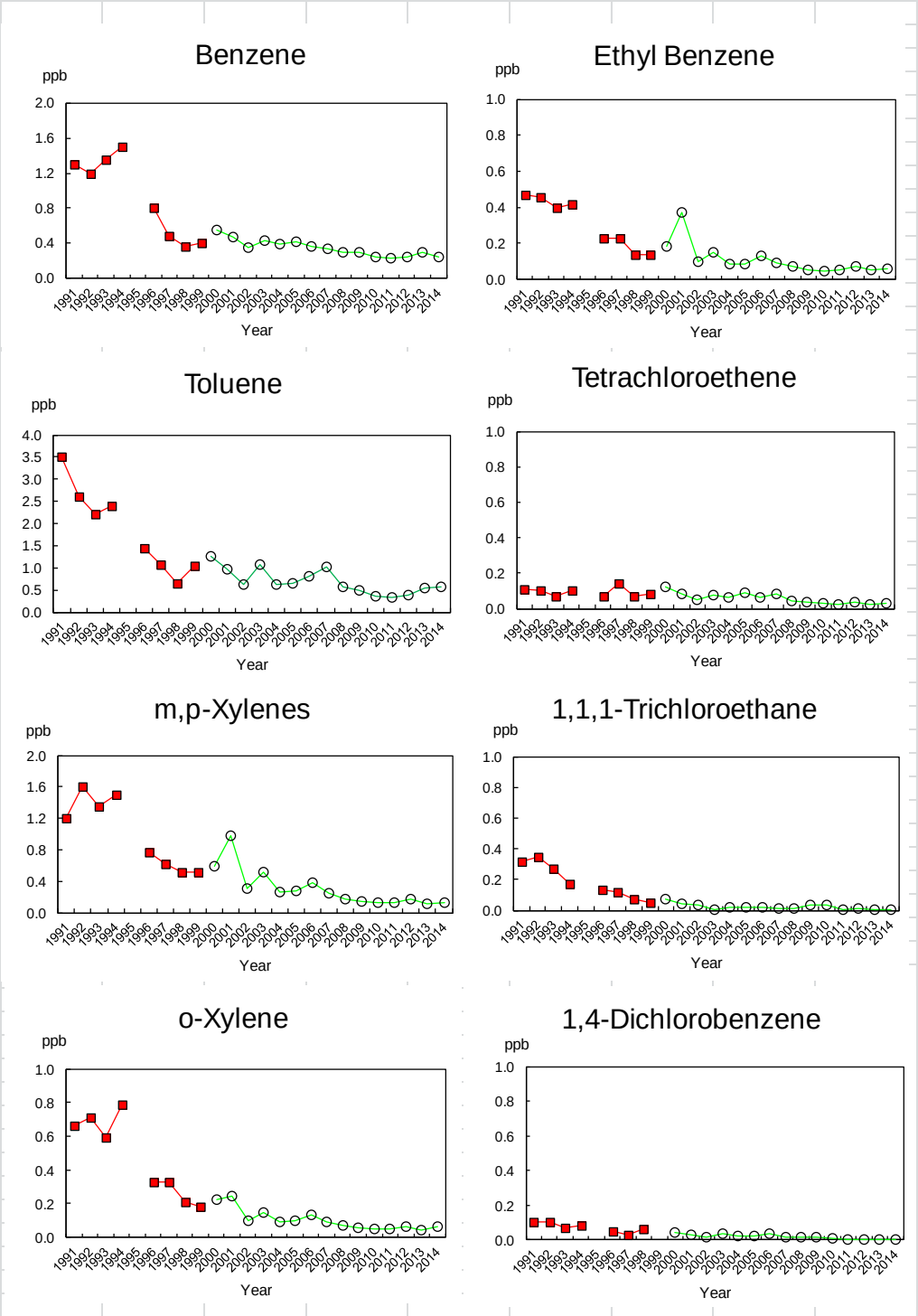
Control programs that focus on improving ambient ozone levels by reducing emissions of VOCs, as well as programs specifically aimed at controlling emissions of hazardous air pollutants, are continuing to reduce ambient concentrations of many air toxics. Although the change in monitoring method makes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

2014 Air Toxics Data in ppb – Wilmington (MLK) and Delaware City (DC)

	MLK Avg	MLK Max	DC Avg	DC Max
Dichlorodifluoromethane	0.51	0.70	0.54	0.95
Chloromethane	0.60	0.74	0.63	1.15
1,2-Dichloro-1,1,2,2,tetrafluoroleth	0.02	0.03	0.02	0.04
Chloroethene	0.01	0.09	0.06	0.49
1,3-Butadiene	0.05	0.20	0.01	0.05
Trichlorofluoromethane	0.25	0.30	0.27	0.39
Acetone	4.41	17.90	3.37	9.54
Methylene Chloride	0.16	0.30	0.14	0.35
1,1,2-Trichloro-1,2,2-trifluoroethane	0.08	0.09	0.08	0.12
2-methoxy-2-methyl-Propane	0.00	0.01	0.00	0.02
Hexane	0.11	0.81	0.14	1.16
Chloroform	0.02	0.04	0.02	0.04
Tetrahydrofuran	0.02	0.07	0.01	0.09
1,2-Dichloroethane	0.01	0.05	0.02	0.23
1,1,1-Trichloroethane	0.00	0.03	0.00	0.05
Benzene	0.25	0.59	0.20	0.52
Carbon tetrachloride	0.10	0.14	0.10	0.15
Cyclohexane	0.04	0.22	0.06	0.62
1,2-Dichloropropane	0.00	0.08	0.00	0.01
Trichloroethene	0.00	0.01	0.00	0.01
Heptane	0.05	0.19	0.06	0.55
Cis-1,3-Dichloro-1-Propene	0.00	0.00	0.00	0.00
Trans-1,3-Dichloro-1-Propene	0.00	0.02	0.00	0.02
Toluene	0.57	2.12	0.20	0.47
1,2-Dibromoethane	0.00	0.00	0.00	0.00
Tetrachloroethylene	0.03	0.37	0.02	0.09
Chlorobenzene	0.00	0.01	0.00	0.02
Ethylbenzene	0.06	0.21	0.03	0.06
m & p- Xylene	0.12	0.47	0.06	0.16
Styrene	0.03	0.14	0.02	0.08
1,1,2,2-Tetrachloroethane	0.00	0.00	0.00	0.00
o-Xylene	0.06	0.25	0.03	0.14
1-Ethyl-4-Methylbenzene	0.02	0.06	0.01	0.04
1,3,5-Trimethylbenzene	0.02	0.19	0.01	0.16
1,2,4-Trimethylbenzene	0.06	0.33	0.03	0.12
1,4-Dichlorobenzene	0.00	0.03	0.01	0.03

Wilmington Air Toxics Trends - Annual Averages Selected Compounds

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

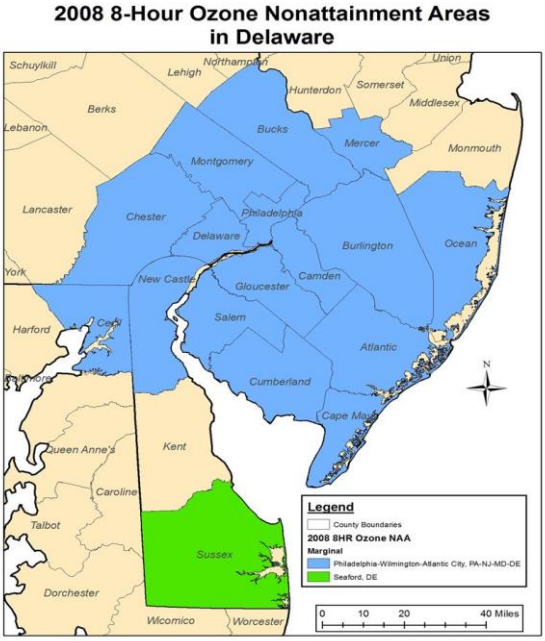


SOURCES OF POLLUTION

OZONE

EMISSIONS INVENTORY

In 2008, the U.S. Environmental Protection Agency (EPA) promulgated a revised National Ambient Air Quality Standard (NAAQS) for ground level ozone at a concentration of 0.075 ppm averaged over eight hours. Based on the 2009-2011 monitoring data, EPA designated New Castle County a "marginal non-attainment area (NAA)" within the Philadelphia-Wilmington-Atlantic City NAA (hereafter referred to as the Philadelphia NAA), and Sussex County a stand-alone "marginal Seaford NAA," under the new 0.075 ppm standard (77 FR 30088). Meanwhile, Kent County was designated as an attainment area. Based on 2012-2014 monitoring data, all of Delaware now meets the current ozone standard.



The EPA established the calendar year 2011 as the base year inventory for the new 0.075 ppm ozone standard, thus requiring states with 8-hour ozone non-attainment areas to submit as part of their State Implementation Plan (SIP) a comprehensive, accurate, and current base year inventory of actual emissions of ozone causing pollutants. Ozone causing pollutants, also known as ozone precursors, include volatile organic compounds (VOCs), oxides of nitrogen (NO_X), and carbon monoxide (CO).

What is an emissions inventory?
The emission inventory is a tool used to determine the amount of air pollutants released from various air emission sources in a given geographic area. The inventory 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.

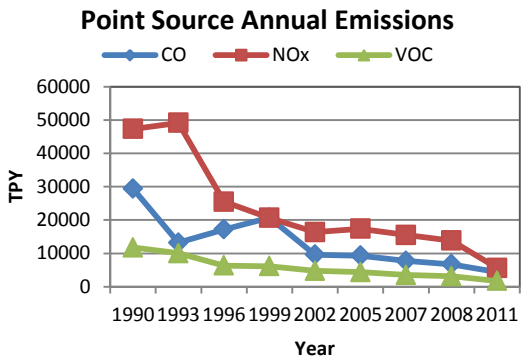
Why are emissions inventories necessary?
The Clean Air Act Amendments (CAAA) of 1990 require states with nonattainment areas to submit a comprehensive, accurate, current inventory of actual emissions of ozone precursors from all sources every three years since 1990. These consecutive inventories provide the historic documentation needed to assist in demonstrating an area's progress in emission reductions and towards attainment of the NAAQS for ozone.

How are these inventories used?
Emission inventories can serve many purposes. They are the basis of overall air quality management planning, and 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.

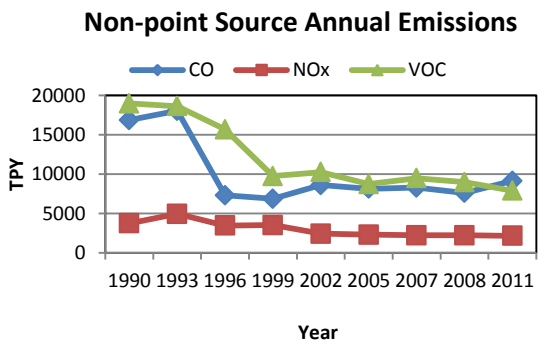
CHARACTERIZATION OF OZONE PRECURSOR EMISSIONS SOURCES

Sources of air emissions are classified into five sectors by the nature of the emissions and the physical characteristics of the emitter. These five sectors are described below and are accompanied with graphics depicting state-wide emissions from 1990 through 2011 for each ozone precursor.

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 NO_X or CO emissions of 25 TPY or greater. Owners or operators of about 60 such sources in Delaware are required to report annually the quantity and type of emissions. Refineries, petroleum transporting facilities, chemical manufacturing facilities, power plants, auto assembly plants, solid waste landfills, food processing plants, and large building heating systems are examples included in this sector.

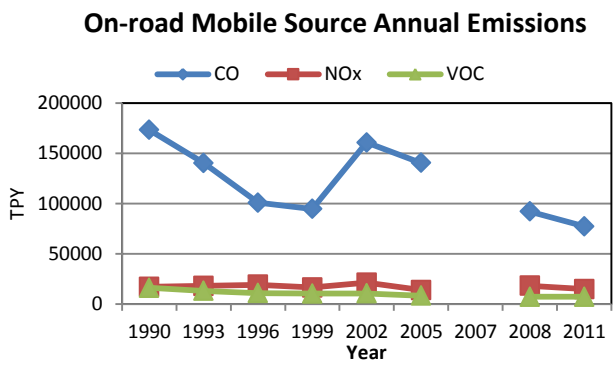


Stationary non-point sources are sources that fall below the point source emission threshold definitions given above and are thus not practical to identify individually for emission inventory purposes. The quantity and type of emissions from these sources are estimated by using established emission factors and appropriate activity data from the covered area. For example, emissions from gasoline service stations can be estimated based on the number of such facilities in Delaware 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 sector.

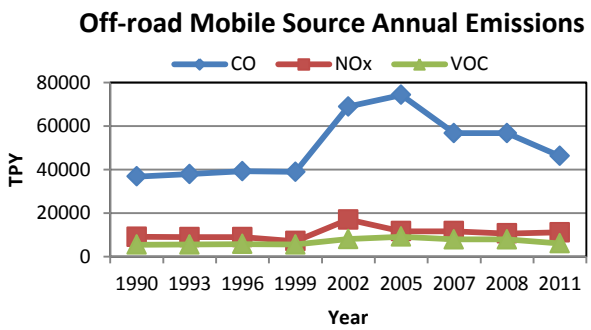


Mobile sources are usually divided into two sub-sectors: on-road sources and off-road sources.

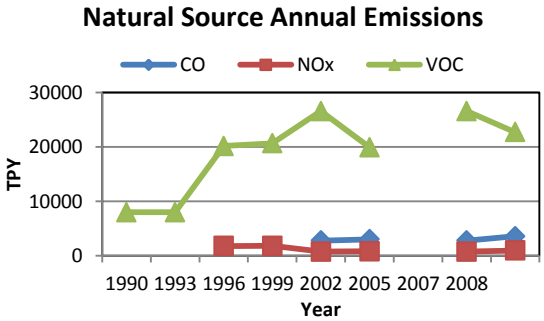
On-road mobile sources consist of automobiles, trucks, motorcycles, and other vehicles traveling on roadways in the nonattainment area. Delaware relies on the U.S. EPA's MOVES model to estimate emissions for VOCs, NO_X, and CO. Emissions from the tailpipe of vehicles, as well as emissions due to evaporation of fuels, are estimated. Despite steady increases on overall vehicle miles traveled, emissions have decreased significantly in the past twenty years due to cleaner, and more fuel efficient cars and trucks, as well as new and more effective controls.



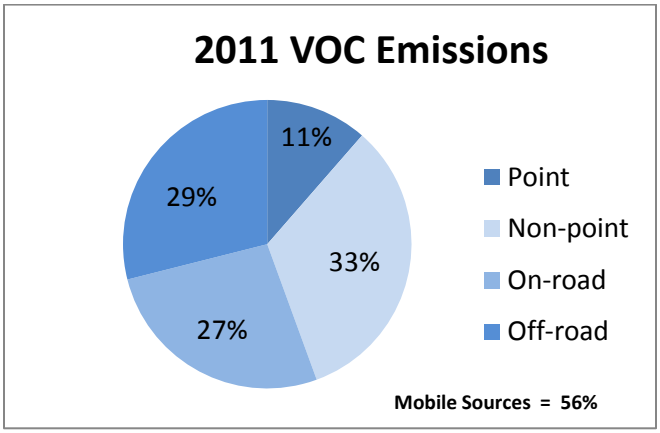
Off-road mobile sources include commercial, military, and general aircraft, marine vessels, recreational boats, railroad locomotives, and a very broad subcategory that includes everything from construction equipment, forklifts, and farm tractors to lawn mowers, chain saws, and leaf blowers. Except new standards on fuels being used, most engines in this sub-sector have no effective emission controls and are considered high emitters of VOCs. Emissions from them are estimated primarily through the use of EPA's NONROAD model.

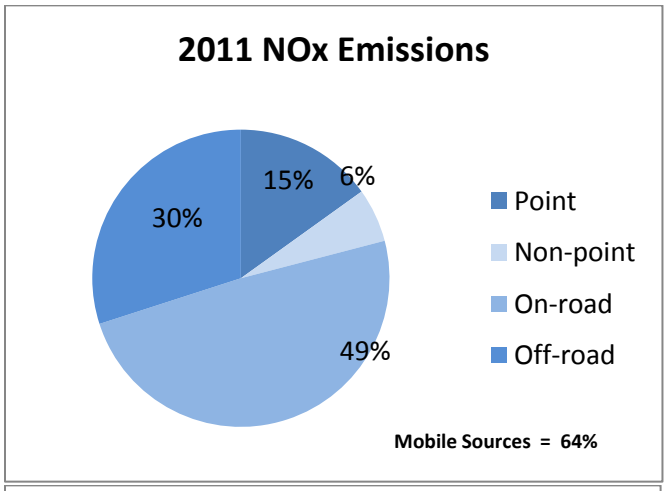


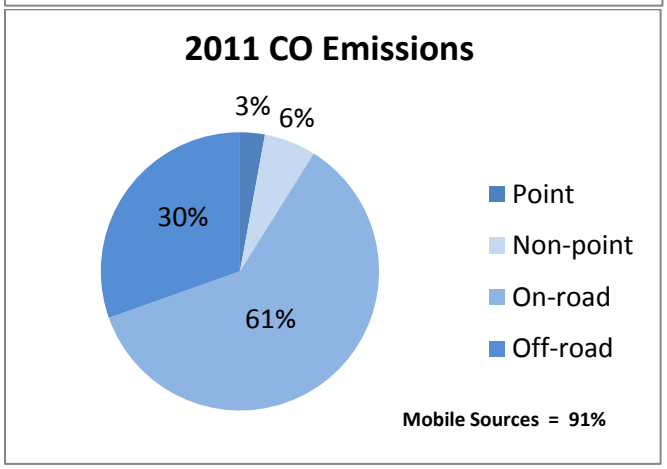
Natural sources include plant life in the area, such as crops, trees, grasses, and other vegetation. Microbial activity within soil is a source of NO_X and CO. The EPA's BEIS3.12 model is used to estimate the quantity and type of emissions from vegetation making use of tools such as satellite imaging 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, SO_2, NO_X, O_3, and PM_{10} from the air, and cool the air through shade and transpiration, thus reducing pollution from other sources.



Ozone Precursor Emissions by Source Category:


2011 VOC Emissions
11%
33%
27%
29%
Point
Non-point
On-road
Off-road
Mobile Sources = 56%


2011 NOx Emissions
15%
6%
49%
30%
Point
Non-point
On-road
Off-road
Mobile Sources = 64%


2011 CO Emissions
3%
6%
61%
30%
Point
Non-point
On-road
Off-road
Mobile Sources = 91%

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

As a result of recent findings describing the adverse health effects 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 task of compiling the 3-year periodic particulate inventory, including both primary particulate and particulate precursors.

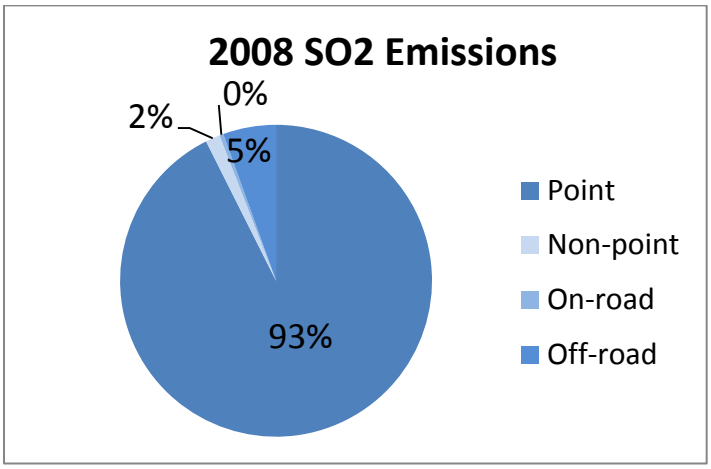
Primary particulate emissions consist of both solid particles of various sizes and aerosols. The solid particles can be delineated by size, such as $PM_{2.5}$, which designates particles with a diameter of 2.5 microns or less. PM_{10} defines particles with a diameter of 10 microns or less, and thus includes $PM_{2.5}$ as well as particles that range from 2.5 microns up to 10 microns. Secondary particulate emissions are precursors that react in the atmosphere to produce fine particles away from the emitting source. The precursors include sulfur dioxide (SO_2), nitrogen oxides (NO_X), ammonia, and certain organic and inorganic compounds. Since NO_X and VOCs are already inventoried due to their contribution to ground-level ozone formation, the inventory program only adds sulfur dioxide and ammonia to its list of pollutants to be inventoried from all sources.

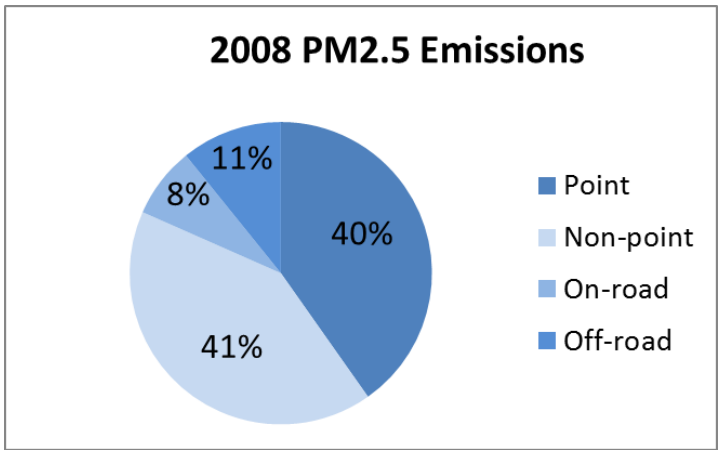
The majority of PM_{10} emissions are primary particulate, with a large proportion being fugitive emissions, usually dust particles from non-point and natural sources. Significant contributions also come from mobile, non-point and point source fuel combustion.

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 estimated 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 combustions. Electric generation utilities (EGUs) and petroleum refineries are by far the largest SO_2 emission sources. Motor vehicle fuel combustion is also a significant source of SO_2, although on a much smaller scale than stationary source fuel combustion.

Sulfur Dioxide and $PM_{2.5}$ Emissions by source category:





HAZARDOUS AIR POLLUTANTS (HAPs)

In addition to ozone precursors, particulate and its precursors, Delaware also has regulations that address the emissions of air toxics. The Permitting & Compliance Branch of the Division of Air Quality 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.

The EID Program has developed comprehensive air toxics inventories since 2002. All sources (point, non-point, on-road mobile and off-road mobile) have been 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 in Delaware.

POLLUTION CONTROL/PREVENTION

OVERVIEW OF CLEAN AIR ACT AMENDMENTS OF 1990 AND OZONE NAAQS

The Clean Air Act Amendments (CAAA) of 1990 require EPA, states, and cities to implement a series of programs and controls that continuously reduce emissions of ozone precursors (VOCs and NO_X) from cars, fuels, industrial and chemical facilities, power plants, and consumer and commercial products among other sources, to attain the ozone NAAQS and then to maintain it. Stringent emission limits for EGUs and petroleum refineries, lower VOC content limits for industrial solvents, cleaner cars and fuels, new kinds of gasoline nozzles, enhanced vehicle inspection, and other programs along with new control strategies have been implemented in the past two decades or so. Additional and/or more stringent control measures will be phased in over the next decade.

The CAAA of 1990 requires EPA to review the ozone standard periodically, and to revise it if a new and tighter standard is necessary, based on new studies and data, to better protect public health and welfare. Since 1990, EPA has promulgated a series of ozone standards through this review-revision process.

The CAAA of 1990 set up a 1-hour ozone NAAQS of 0.12 ppm. The Philadelphia-Trenton-Wilmington Consolidated Metropolitan Statistical Area (CMSA) was classified by EPA in the early 1990s as severe non-attainment area under the 1-hour ozone NAAQS (0.12 ppm). Delaware's Kent and New Castle Counties fell into this several non-attainment area, while Sussex County was designated separately as a marginal non-attainment area. Under the 1-hour ozone NAAQS, Delaware fulfilled the following strategies and control programs that were required by the CAAA of 1990:

- submission and implementation of an ozone 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 NO_X emissions 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 ozone air quality SIP;
- 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 could 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.

In 1997, EPA revised the 1-hour ozone NAAQS (0.12 ppm) to an 8-hour standard of 0.08 ppm to better protect human health and public welfare. In June 2004, EPA designated all three counties in Delaware as moderate non-attainment area, as a part of Philadelphia-Wilmington-Atlantic City PA-NJ-MD-DE moderate non-attainment area, under the 1997 8-hour ozone NAAQS. In June 2005, EPA revoked the 1-hour ozone standard. However, the 1-hour ozone standard stays valid in Delaware as required 7 DE Admin Code 1103 "Ambient Air Quality Standards." All control strategies and programs listed above under the 1-hour ozone standard stay in effect under the 1997 8-hour ozone NAAQS in Delaware, as required by the Clean Air Act (CAA) and Delaware's regulations, to maintain the attainment status for the 1-hour ozone NAAQS. Additional controls and programs were developed and implemented in Delaware to further reduce emissions of VOC and NOx for attaining the 0.08 ppm ozone NAAQS.

In 2008, EPA revised the 1997 8-hour ozone standard (0.08 ppm) to a tighter standard of 0.075 ppm. In 2012, EPA designated New Castle County as part of the Philadelphia marginal NAA, and Sussex County as a stand-alone "marginal Seaford NAA," under the new 0.075 ppm standard. Meanwhile, Kent County was designated as an attainment area. Delaware continues its efforts towards attaining the new ozone NAAQS.

PROGRESS TOWARD ATTAINMENT OF THE NAAQS FOR OZONE

The 1990 Clean Air Act Amendments (CAAA) contain provisions for the attainment and maintenance of the ozone NAAQS. State implementation plans (SIP) must be developed in designated nonattainment areas. Plan requirements vary depending on the severity of the individual area's air pollution problem with respect to the ozone NAAQS. Since 1990, Delaware has endeavored in a continuous effort in achieving ozone air quality goals with respect to the afore-mentioned ozone standards.

1990 1-Hour Ozone NAAQS of 0.12 ppm

Under the 1-hour ozone standard, New Castle and Kent Counties were designated by EPA to be in severe nonattainment while Sussex County was 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. Under the 1-hour ozone standard, 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 three percent per year reduction of VOC and/or NO_X emissions must be achieved between 1997 and 2005. The year 2005 was the year for which severe nonattainment areas must attain the 1-hour ozone standard.

Progress toward attainment of the 1-hour ozone NAAQS in the year 2005 was measured by periodic emission inventories conducted every three years, beginning in 1993. Actual air emission data were inventoried for reactive VOCs, NO_X, and CO from point, area and mobile sources.

Point sources, as defined for the 1990 base year inventory and successive 1993/1996/1999 periodic inventories, are those facilities or plants 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. Since 2002, point source thresholds for the inventory has become 5 TPY for VOC and 25 TPY for NOx. 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 non-point sources are too small and/or too numerous to be surveyed and characterized individually, their emissions must be estimated collectively. Mobile sources are represented by all forms of transportation. Mobile sources are usually divided into two sub-sectors: on-road sources and off-road sources. On-road mobile sources include all kinds of vehicles running on roadways such as automobiles, trucks, motorcycles, etc. Off-road mobile sources include aircrafts, marine vessels, recreational boats, railroad locomotives, a very broad subcategory of construction equipment, forklifts, farm tractors, lawn mowers, as well as portable implements and tools powered by internal combustion engines such as chain saws, and leaf blowers.

In 1995, DNREC submitted its 15 percent VOC reduction SIP for 1996 to the EPA. It targeted reductions through multiple control strategies including, to name just a few, gasoline vapor collection, low volatility coatings and solvents, and controlling leaks in manufacturing processes. To further reduce VOCs, Delaware implemented 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 RFP plan 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 RFP (as amended) was designed to achieve significant NO_X reductions through implementing controls over a variety of NO_X sources, especially large industrial sources. Afterwards, Delaware submitted its 2002 RFP plan and 2005 RFP plan in February 2000 and December 2000, respectively, implementing additional control programs over a wide range of VOC and NO_X emission sources. Many of those control programs were implemented along with other

states within the northeast Ozone Transport Region (OTR).

Delaware's efforts in controlling the 1-hour ozone problem made remarkable progresses. Both VOC and NO_X emissions in Delaware were reduced significantly since 1990. Delaware's 1993, 1996, 1999 and 2002 periodic emission inventories demonstrated that all RFP emission reductions under the 1-hour ozone standard were achieved. In 2003, 2004 and 2005, ambient monitors in all three counties in Delaware recorded ozone concentrations in compliance with the 1-hour ozone standard, indicating that Delaware attained the 1-hour ozone standard in 2005. Since then, all VOC and NO_X emission control programs in Delaware stay in effect for maintaining this attainment status.

1997 8-Hour Ozone NAAQS of 0.08 ppm

Under the 1997 ozone standard of 0.08 ppm, the entire state of Delaware was designated by EPA as a part of Philadelphia-Wilmington-Atlantic City PA-NJ-MD-DE moderate non-attainment area, with an attainment target year of 2010. To fulfill the CAAA's requirements on the moderate non-attainment areas, Delaware submitted to EPA its Reasonably Available Control Technology (RACT) SIP revision in September 2006, and its RFP and Attainment Demonstration SIP revision in June 2007. In addition to continuing all control measures and programs implemented under the 1-hour ozone standard, Delaware implemented additional and/or improved (i.e., revised) control measures to further reduce VOC and NO_X emissions to attain the 0.08 ppm standard. In the 2009-2010-2011 period, ambient monitors in all three counties in Delaware recorded design-values (the three-year averages of the 4th highest monitored ozone concentrations) in compliance with the 8-hour ozone standard of 0.08 ppm, indicating that Delaware attained the standard in 2011, one year after the targeted attainment year of 2010 (the one-year extension was allowed by the CAAA of 1990). Since then, all VOC and NO_X emission control programs in Delaware stay in effect for maintaining this attainment status.

2008 8-Hour Ozone NAAQS of 0.075 ppm

Under this current ozone standard of 0.075 ppm, New Castle County is designated by EPA as a "marginal non-attainment area (NAA)" within the Philadelphia-Wilmington-Atlantic City NAA, Sussex County as a stand-alone "marginal Seaford NAA," and Kent County as an attainment area. Requirements of the CAAA on marginal ozone non-attainment areas include fulfilling a 2011 base-year emission inventory SIP revision and a RACT SIP revision. Delaware fulfilled those two requirements by submitting the base-year inventory and the RACT SIP revisions to EPA in July 2014 and August 2014, respectively.

All controls measures and programs implemented under the 1990 1-hour standard and the 1997 8-hour standard remain effective in Delaware, even in Kent County, as required by the CAAA's anti-backsliding provisions. In addition, Delaware has implemented or committed to new and/or

improved (i.e., revised) control measures, as outlined in its August-2014 RACT SIP revision. Monitoring data of recent years from Delaware ambient monitors have indicated that the ozone air quality in Delaware continues to improve toward the attainment of the current standard of 0.075 ppm.

Upcoming New Ozone NAAQS

The CAAA of 1990 requires EPA to review the ozone standard periodically, and to revise it if a new and tighter standard is necessary, based on the new studies and data, to better protect public health and welfare. The current standard of 0.075 ppm has been under review since 2011. In August 2014, EPA published three assessment documents from this review.1 In the policy assessment, the EPA staff in charge of the review concludes that (1) it is appropriate to consider a revised ozone primary standard level with the range of 0.070 to 0.060 ppm, and (2) it is appropriate to give consideration to a revised secondary standard in a range of levels from 17 to 7 ppm-hours, expressed in terms of the W126 index. The EPA plans to propose the revised ozone standards by the end of 2015.

Delaware supports EPA's efforts in promulgating tighter ozone standards to better protect public health and welfare. The Division of Air Quality is committed to working continuously on all necessary control measures to further reduce ozone precursor emissions in Delaware, and in upwind states, to achieve sustainable air quality improvement in Delaware with respect to the ozone NAAQS.

1 (1) Policy Assessment for the Review of the Ozone National Ambient Air Quality Standard, EPA-452/R-14-006; (2) Health Risk and Exposure Assessment for Ozone, EPA-452/R-14-004f; (3) Welfare Risk and Exposure Assessment for Ozone, EPA-452/P-14-005c. All three documents are dated August 2014.

OTHER POLLUTANTS

The Clean Air Act Amendments of 1990 also 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 the 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. The expanded standards 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.

Delaware has relevant control programs that fulfill the above requirements.

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 sources 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.delaware.gov/Air/Pages/Air-Quality-Monitoring-Homepage.aspx

CLIMATE CHANGE

Global climate change is a major concern because it poses serious risks to human health and it will continue to negatively affect terrestrial and aquatic ecosystems, especially as temperatures are projected to rise through the 21st Century. Delaware is not immune to its effects. In fact, there are strong indications that climate change is occurring in Delaware and that it is affecting the state's natural resources.

In future annual air quality reports, this section will contain information on climate change as it relates to air quality in Delaware, including greenhouse gas initiatives.

More information can be found on the following websites:

http://www.dnrec.delaware.gov/energy/Pages/Climate.aspx

http://www.dnrec.delaware.gov/energy/Pages/Reducing-Greenhouse-Gases.aspx

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.

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 required to be in operation at six sites (see Delaware monitoring network description). Delaware currently maintains monitoring year-round at all sites to provide additional information for trends analyses.

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 Teflon7 microfiber filter that is weighed to determine 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 in the same manner as $PM_{2.5}$ but with a different inlet that excluded particles larger than 10 microns in diameter.

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 Teflon fiber filter (PM_{10} method). Part of the filter is removed and chemically extracted. This is followed by laboratory analysis using inductively Coupled Plasma Mass Spectrometry (ICP-MS) to determine the lead concentration.

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.

CAA: Clean Air Act

CAAA: Clean Air Act Amendments of 1990.

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 <u>does not</u> meet the NAAQS.

OTR: Ozone Transport Region.

PAMS: Photochemical Assessment Monitoring Stations

PEI: Periodical Emission Inventory

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.

RACT: Reasonably Available Control Technology.

RFP: Reasonable Further Progress.

SIP: State Implementation Plan.

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 Reports

Air Quality Index (AQI) - A Guide to Air Quality and Your Health, U.S. EPA,
http://airnow.gov/index.cfm?action=aqibasics.aqi

National air quality and emissions trends, U. S. EPA,
http://www.epa.gov/airtrends/index.html

Delaware Toxics Release Inventory Report, Delaware DNREC,
http://www.dnrec.delaware.gov/serc/Pages/Default.aspx

Delaware Final 2002 Ozone Precursor Emissions Inventory Report, Delaware DNREC,
http://www.awm.delaware.gov/Info/Pages/2002OzoneReport.aspx

Delaware rate of progress plans, SIP emissions inventories, and other reports, Delaware DNREC,
http://www.awm.delaware.gov/AQM/Pages/AQMPublicationsandReports.aspx

Delaware Annual Air Quality Reports, Delaware DNREC,
http://www.dnrec.delaware.gov/Air/Pages/DAQ-Annual-Reports.aspx

Air Quality Related World Wide Web Sites

AIRData - Access to national and state air pollution concentrations and emissions data
http://www.epa.gov/airdata/

American Lung Association
http://lung.org

Delaware State Climatologist
http://climate.udel.edu/

Delaware Valley Regional Planning Commission
http://www.dvrpc.org/Environment/AirQuality

Delaware Valley Air Quality Forecast
http://www.airqualitypartnership.org/

State of Delaware Division of Air Quality current hourly monitoring data
http://apps.dnrec.delaware.gov/AirMonitoring/

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

USEPA Office of Air and Radiation, Air Trends reports
http://www.epa.gov/airtrends/reports.html

USEPA Office of Air Quality Planning and Standards "AirNow" - ozone maps, real-time data
http://airnow.gov

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

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Mobile Source Controls – Valerie Gray, New Castle Office

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