DELAWARE ANNUAL AIR QUALITY REPORT

2017

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Division of Air Quality

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EXECUTIVE SUMMARY

Delaware's 2017 annual air quality report continues to document the changes and overall improvement in ambient air quality in the state. In 2017 all pollutants except ozone are below the national air quality standards.

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.

On October 1, 2015, the EPA strengthened the primary and secondary National Ambient Air Quality Standards (NAAQS) for ground-level ozone from the 2008 NAAQS of 0.075 parts per million (ppm) over an 8-hour period to 0.070 ppm. The U.S. EPA announced on November 16, 2017 that New Castle County has been declared nonattainment for Ozone. In 2017 there were 8 days in Delaware that exceeded the current standard; seven days in New Castle County, one day each in Kent and Sussex Counties.

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. This report contains the most recent inventory data for 2014.

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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, such as 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 a section on climate change. Technical details regarding monitoring activities and emission inventories, along with references and sources of more information, are included in the appendices.

General Information

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 non-attainment" for 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. State Implementation Plans are prepared and adopted to reduce air pollution burden and to provide a plan to meet attainment of air quality standards.

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 variety 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 ($PM_{2.5}$). Concentrations listed below are in either parts per million (ppm), parts per billion (ppb), or micrograms per meter cubed ($\mu g/m^3$).

Table 1. National Ambient Air Quality Standards (NAAQS)

Pollutant (Scientific Notation)		Primary / Secondary Standard	Averaging Time	Concentration	Form
Carbon Monoxide (CO)		Primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead (Pb)		Primary & Secondary	Rolling 3 month period	0.15 $\mu g/m^3$	Not to be exceeded
Nitrogen Dioxide (NO_2)		Primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		Primary & Secondary	1 year	53 ppb	Annual Mean
Ozone (O_3)		Primary & Secondary	8 hours	0.070 ppm	Annual 4th highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	$PM_{2.5}$	Primary	1 year	12.0 $\mu g/m^3$	Annual mean, averaged over 3 years
		Secondary	1 year	15.0 $\mu g/m^3$	Annual mean, averaged over 3 years
		Primary & Secondary	24 hours	35 $\mu g/m^3$	98th percentile, averaged over 3 years
	PM_{10}	Primary & Secondary	24 hours	150 $\mu g/m^3$	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)		Primary	1 hour	75 ppb	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		Secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

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.

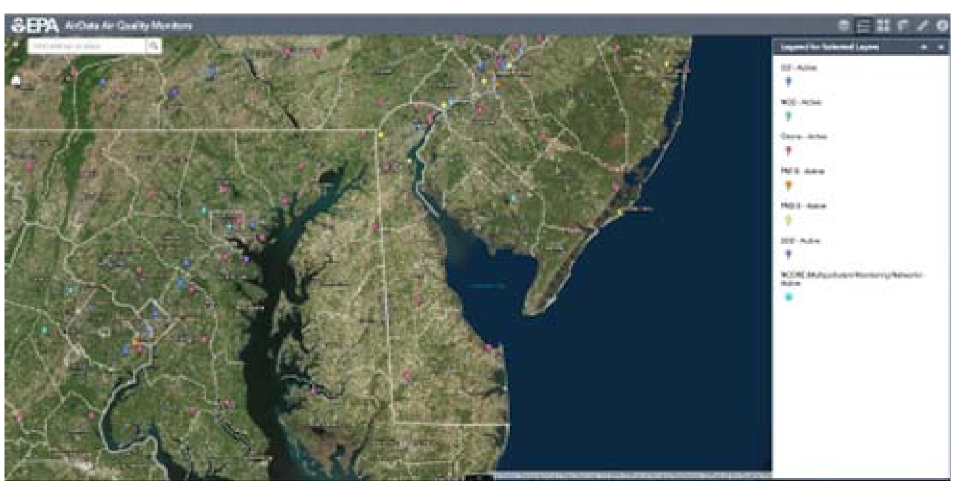
3. How is the location of an air monitoring station decided?

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.

To see locations of monitoring sites in Delaware and the rest of the country visit EPA's Interactive Air Quality Monitoring Tool:
https://www.epa.gov/outdoor-air-quality-data/interactive-map-air-quality-monitors



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.

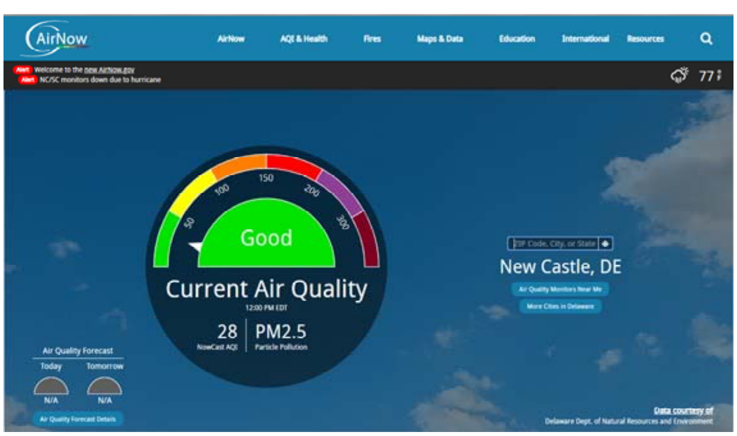
6. What do I do if I have a complaint about an odor or other air quality issues?

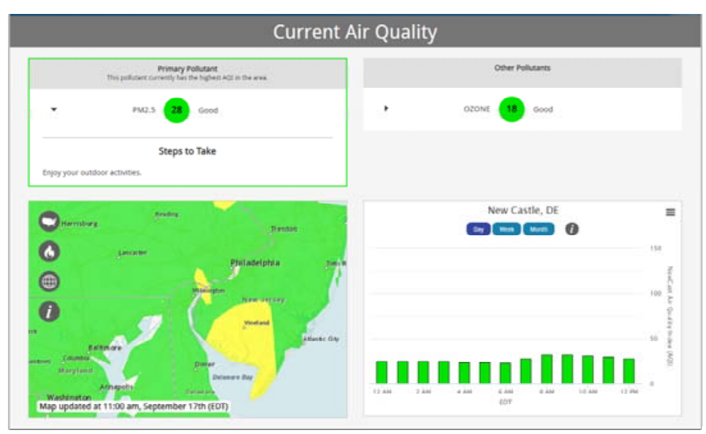
Odors and other environmental complaints can be reported to the Environmental Emergency and Complaints 24-hour Hotline at **1-800-662-8802**.

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/

Alternatively you can visit the EPA's AirNow site which has been redesigned in September of 2018 and view current air quality both locally and nationally.



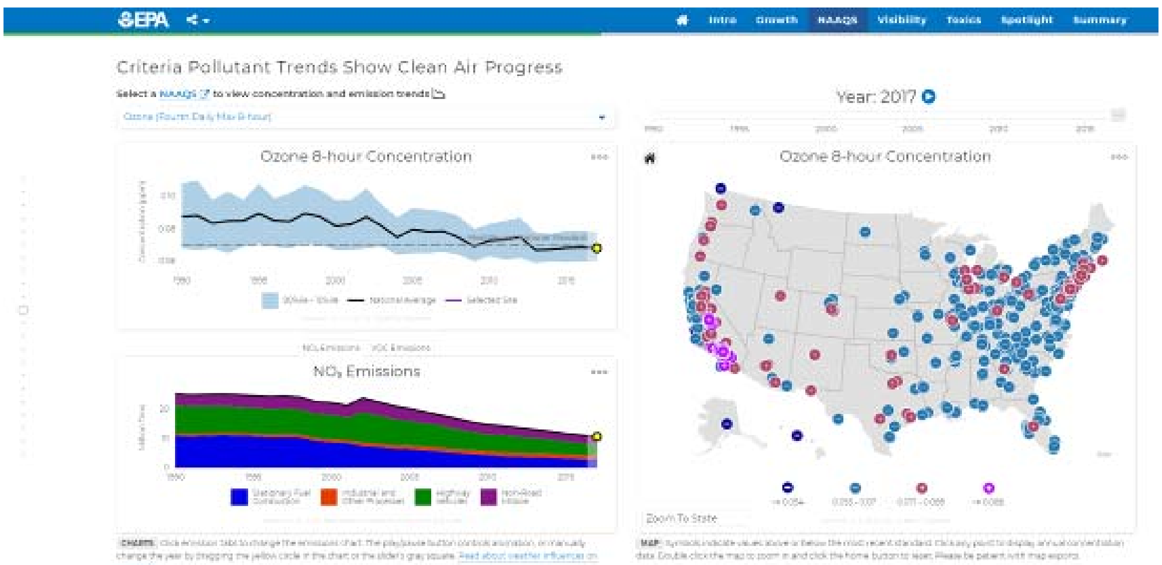


8. How can I get historical air quality data?

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

9. How does air quality compare across the country?

EPA has released a National Air Quality: Status and Trends of Key Air Pollutants report in an online interactive format since 2015. They have historical reports available as well. Visit the EPA's Trends Report at:
https://www.epa.gov/air-trends



10. 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.

11. 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.**

12. 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

Glossary – Acronyms & Definitions

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

CPP: Clean Power Plan

Chemiluminescence: Visible light produced by chemical reaction.

EGUs: Electric Generating Units

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

NCore: National Core monitoring station, part of an enhanced national EPA monitoring program, successor to the NAMS program

Nonattainment: EPA designation that an area does not 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.

RGGI: Regional Greenhouse Gas Initiative

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.

µg/m^3: Micrograms per cubic meter.

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

Delaware's Air Quality Status

For 2017 Delaware air quality met all the National Ambient Air Quality Standards (NAAQS) with the exception of the 8 hour ozone (O_3) standard.

Over the last ten years, trends in ambient concentrations of the criteria pollutants have been either level or declining.

Note: Even though Lead (Pb) is a Criteria Pollutant Delaware is in attainment for the NAAQS. As of 2016 EPA has ruled that it is no longer required to be monitored for at National Core (NCore) Sites. ([Federal Register Vol. 81, No. 59, 3/28/2016](#))

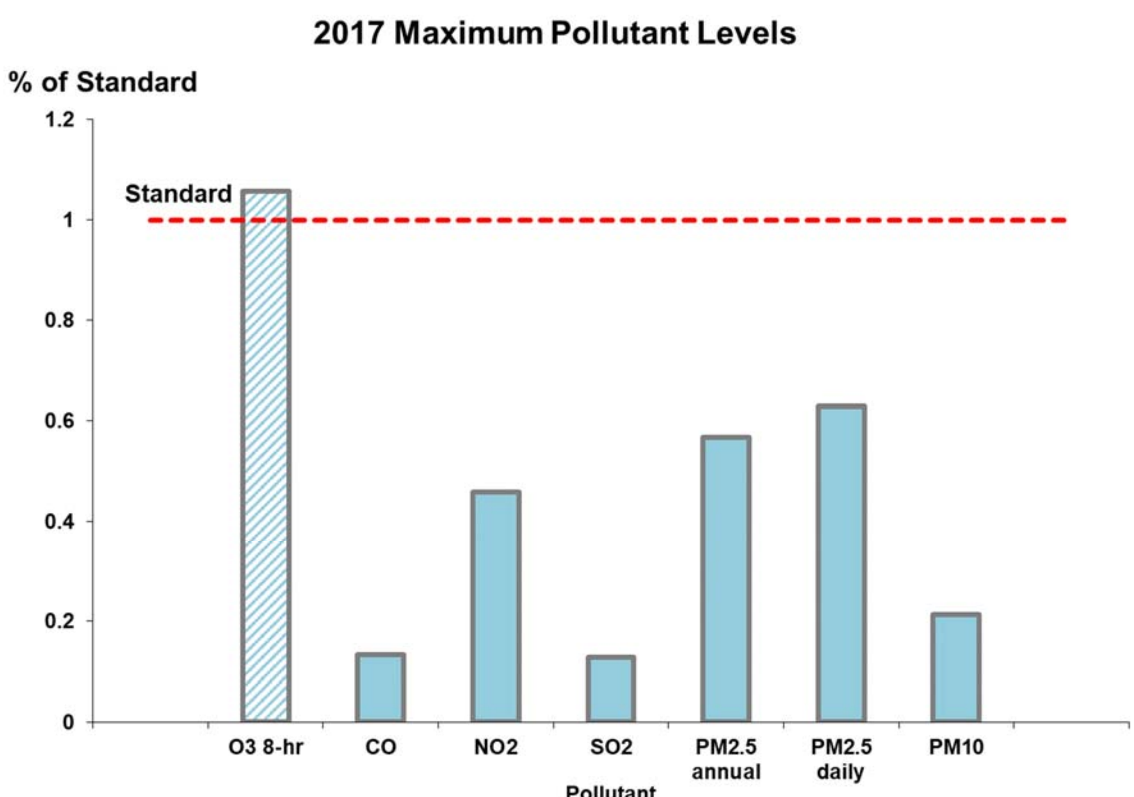
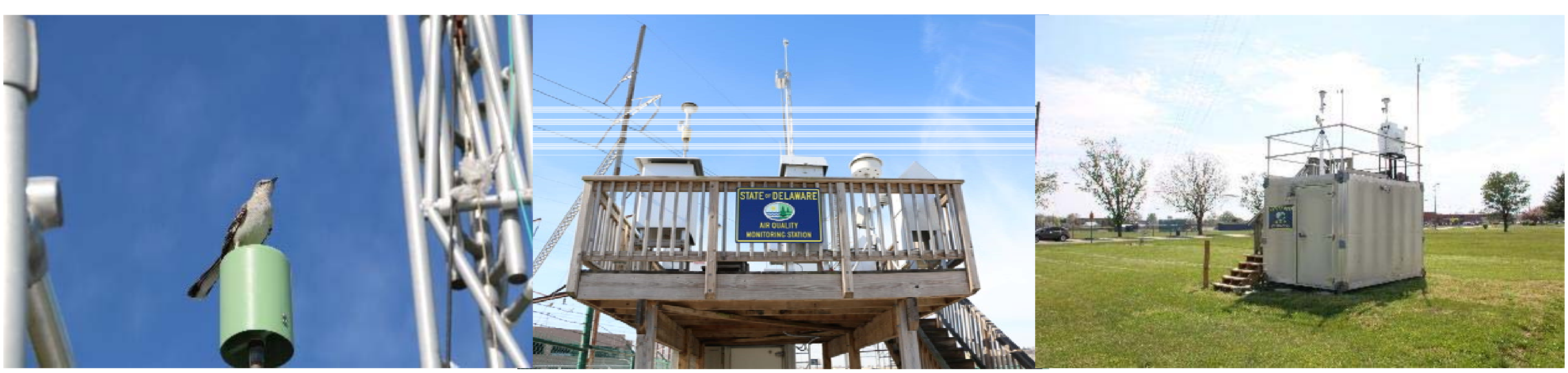


Figure 1. 2017 Maximum Pollutant Levels



Air Quality Monitoring Scenes in Delaware

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 (O_3, CO, NO_2, SO_2, and PM_{10}/$PM_{2.5}$) 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 101 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".

Table 2. 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 chart below indicates the calculated AQI for each day in New Castle County for 2017.

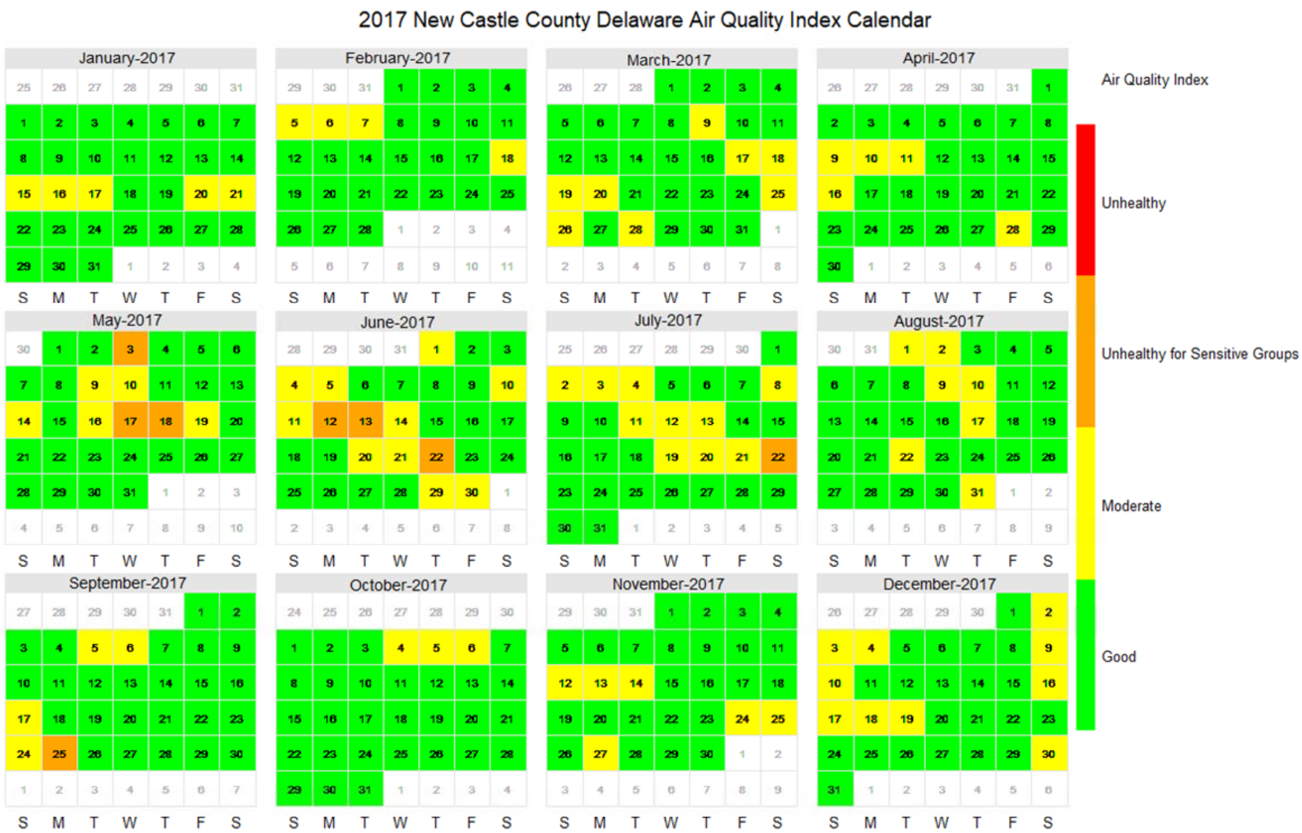


Figure 2. Air Quality Index Calendar for New Castle County

The graph below uses the daily AQI to evaluate trends for New Castle County from 1999 through 2017, according to the definitions applicable in that year. The number of days with unhealthy air quality has been generally declining in recent years. The number of days for each category are indicated in callouts for 2017.

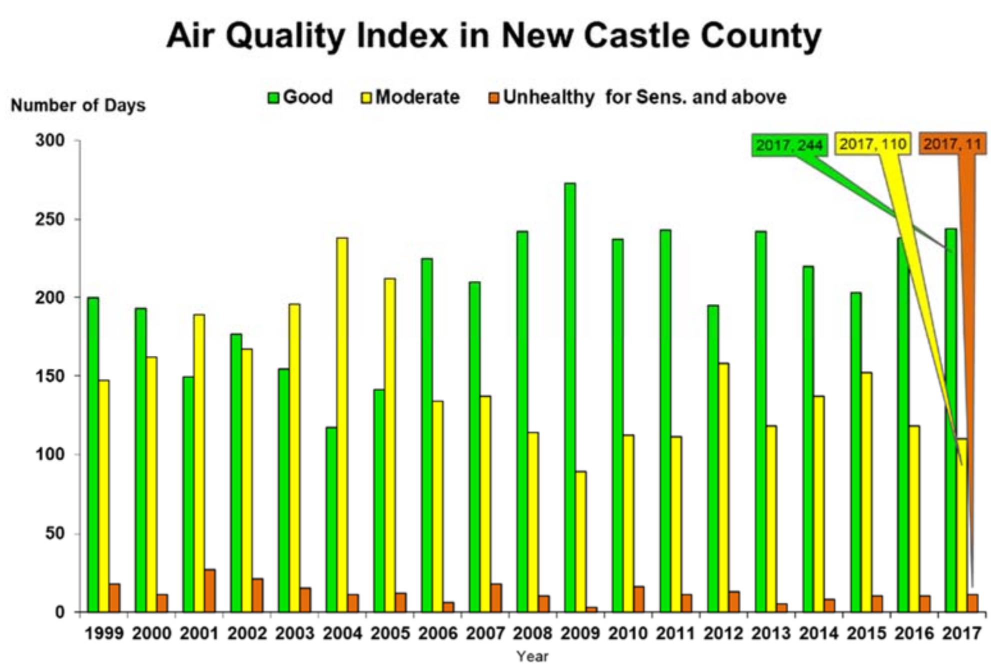


Figure 3. Annual Air Quality Index in New Castle County

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.

In 2006 the EPA introduced a requirement to establish the National Core (NCore) monitoring stations. NCore is a national multi-pollutant network that integrates several advanced measurement systems for particulates, gaseous pollutants, and meteorology. The purpose of this requirement was to enhance ambient air quality monitoring to better serve current and future air quality needs. Delaware's Wilmington site was configured to meet NCore requirements and began monitoring in 2010.

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 may be collected as 24-hour samples that run every third day and/or continuously with hourly averages.

Table 3. Delaware Air Monitoring Network 2017

"X" indicates pollutant monitored

SITE		O_3	CO	NO_2	SO_2	$PM_{2.5}$	PM_{10}	Wind Speed/ Direction
Brandywine Creek State Park (SP)		X						X
Bellefonte I & II	***River Road Park (I)***					X		
	Bellevue State Park (II)	X			X			
MLK National Core (NCore) ***Wilmington***		X	X	X	X	X	X	X
Newark						X		
Delaware City ***Route 9***					X	X		X
Lums Pond State Park (SP) ***Summit Bridge***		X			X	X		X
Dover						X		
Killens Pond State Park (SP) ***Felton***		X				X		X
Seaford		X				X		X
Lewes		X			X			X

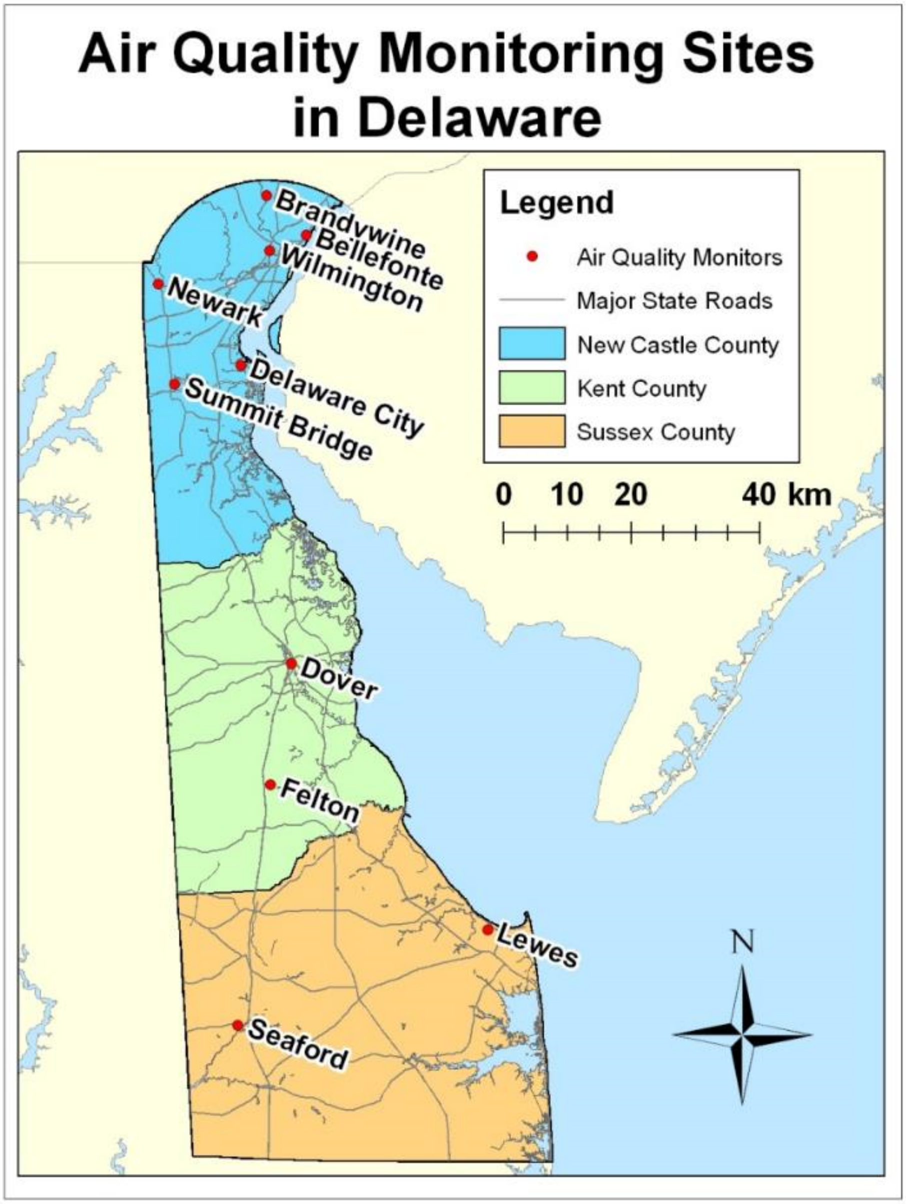


Figure 4. Map of Delaware Air Quality Monitoring Sites

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 Exceed Standards

Ozone (O_3)

Description

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

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

Standards

Primary NAAQS:

- Maximum eight-hour average = 0.070 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 generally 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.

Figure 5. Map of Delaware Ozone Monitors

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. 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.

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.

Eight-hour Ozone Data and Trends

2008 NAAQS: Prior to 2008, a measured 8-hour average concentration counted as an exceedance of the 0.08 ppm standard if the concentration was equal to or greater than 0.085 ppm. This is due to numerical rounding to two decimal places. In 2008 the 8-hour standard was revised to 0.075 ppm.

Current NAAQS: In October 2015 the 8-hour NAAQS was strengthened to 0.070 ppm. Currently a measured 8-hour average concentration above 0.070 is an exceedance of the standard.

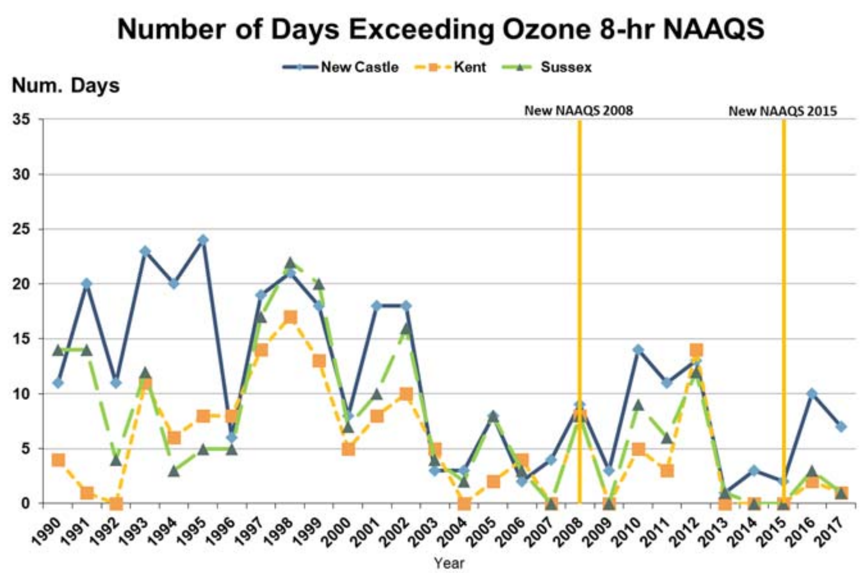


Figure 6. Number of Days Exceeding 8hr Ozone NAAQS

In the summer of 2015 there were two days that exceeded the 2008 8-hour standard in Delaware, with all exceedances occurring in New Castle County. If the 2015 standard had been in effect over the summer, there would have been ten days exceeding the standard, with ten in New Castle County, three in Sussex County, and none in Kent County.

In 2017 there were 8 days in Delaware that exceeded the current standard; seven days in New Castle County, one day each in Kent and Sussex Counties.

The "Ozone Design Value by County" numbers in the chart at right are the annual fourth highest (4th Maximum) daily 8-hour concentration, averaged over three years, referred to as the Design Value. If the Design Value is less than or equal to the standard, the 8-hour standard is achieved or met. Based on 2015 – 2017 data New Castle County exceeds the ozone 8-hour NAAQS.

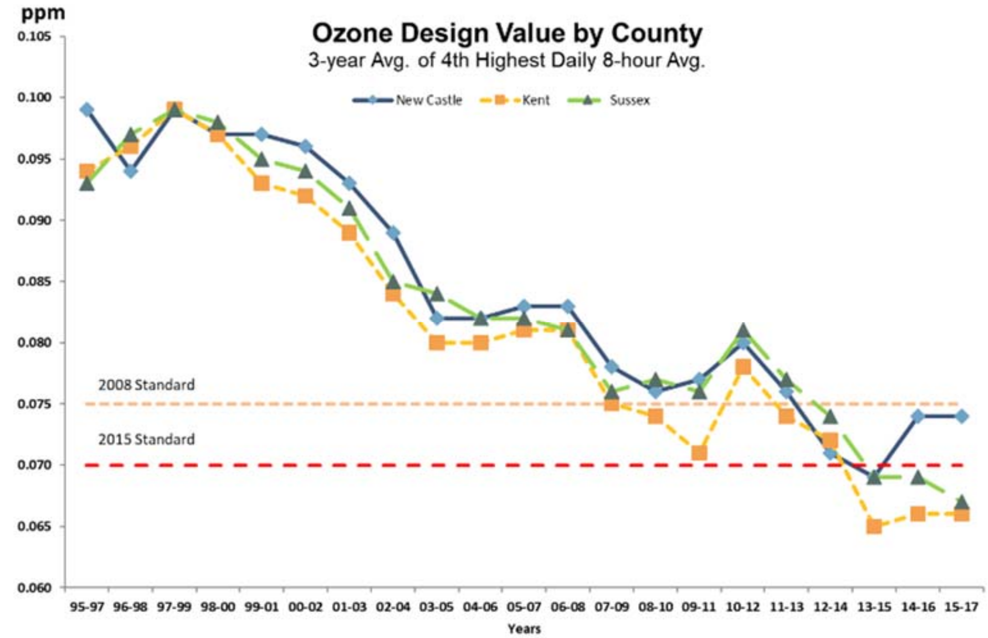


Figure 7. Ozone Design Value by County

The following tables contain more information on the 8-hour standard and trends for each monitoring site.

Table 4. 2017 Ozone Eight-hour Average Exceedance Days and Maxima (ppm)

2015 Standard

Site	# Exceedances > 0.070 ppm	1st Maximum	2nd Max.	3rd Max.	4th Max.
Brandywine Creek SP	7	0.082	0.080	0.074	0.074
Bellefonte II	3	0.072	0.071	0.071	0.070
Lums Pond SP	2	0.084	0.079	0.070	0.069
MLK NCore	4	0.084	0.071	0.071	0.071
Killens Pond SP	1	0.071	0.070	0.069	0.066
Seaford	0	0.066	0.065	0.065	0.063
Lewes	1	0.076	0.065	0.064	0.063

Exceedances = Number of days with at least one 8-hour average > 0.070 ppm.

Table 5. 3-Year Average of 4th Highest Daily Max. Eight-hour Avg. (ppm)

2008 NAAQS = 0.075 ppm, 2015 NAAQS = 0.070 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	2005 - 2007	2006 - 2008	2007 - 2009	2008 - 2010	2009 - 2011	2010 - 2012	2011 - 2013	2012 - 2014	2013 - 2015	2014 - 2016	2015 - 2017
Brandywine SP	0.083	0.083	0.078	0.076	0.075	0.078	0.073	0.071	0.069	0.074	0.074
Bellefonte II	0.081	0.078	0.074	0.075	0.077	0.080	0.076	0.071	0.068	0.070	0.071
Lums Pond SP	0.082	0.080	0.075	0.075	0.075	0.080	0.075	0.071	0.066	0.068	0.067
*MLK NCore	NA	NA	NA	NA	NA	0.079	0.074	0.071	0.069	0.071	0.072
Killens Pond SP	0.081	0.081	0.075	0.074	0.072	0.082	0.074	0.072	0.065	0.066	0.066
Seaford	0.082	0.081	0.076	0.077	0.076	0.082	0.075	0.070	0.064	0.065	0.065
Lewes	0.082	0.079	0.076	0.077	0.076	0.081	0.077	0.074	0.069	0.069	0.067

* Monitoring began in 2011.

How does Delaware's air quality compare to nearby monitored areas?
Ozone levels recorded by Delaware monitors in 2017 were similar to those recorded at other monitoring sites in the region.

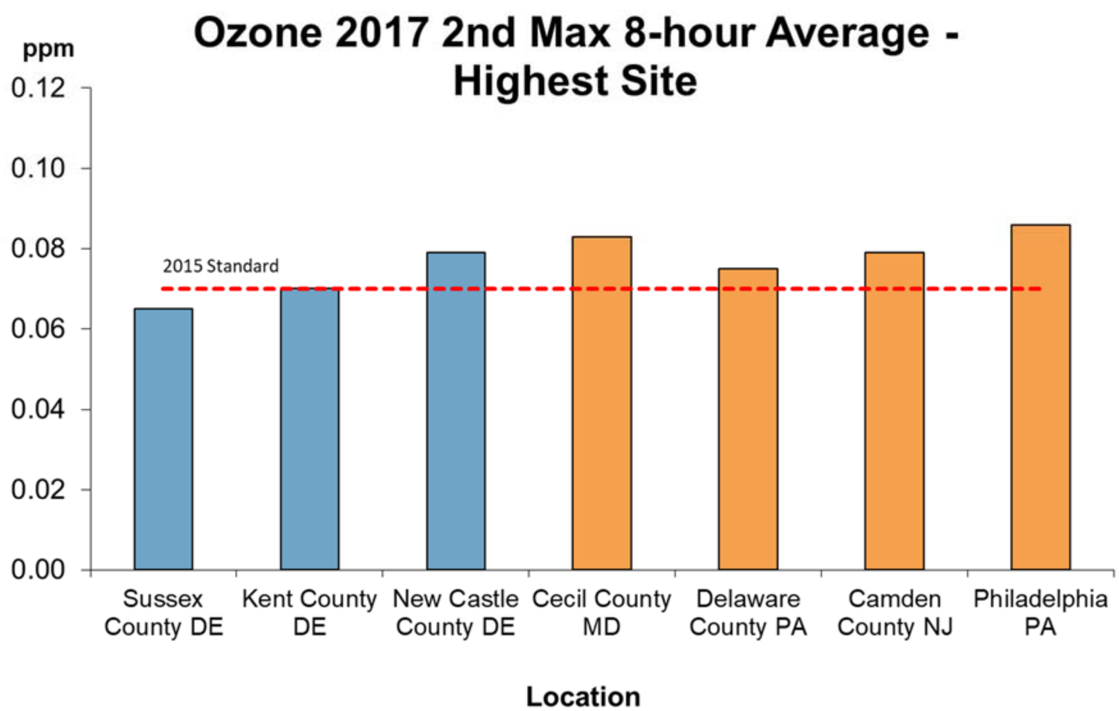


Figure 8. 2017 Ozone compared to nearby monitored sites

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.
Note: In September of 2018 AirNow was updated to a new format, see FAQ section

Air Quality Index Ozone Peak Values – May 18, 2017

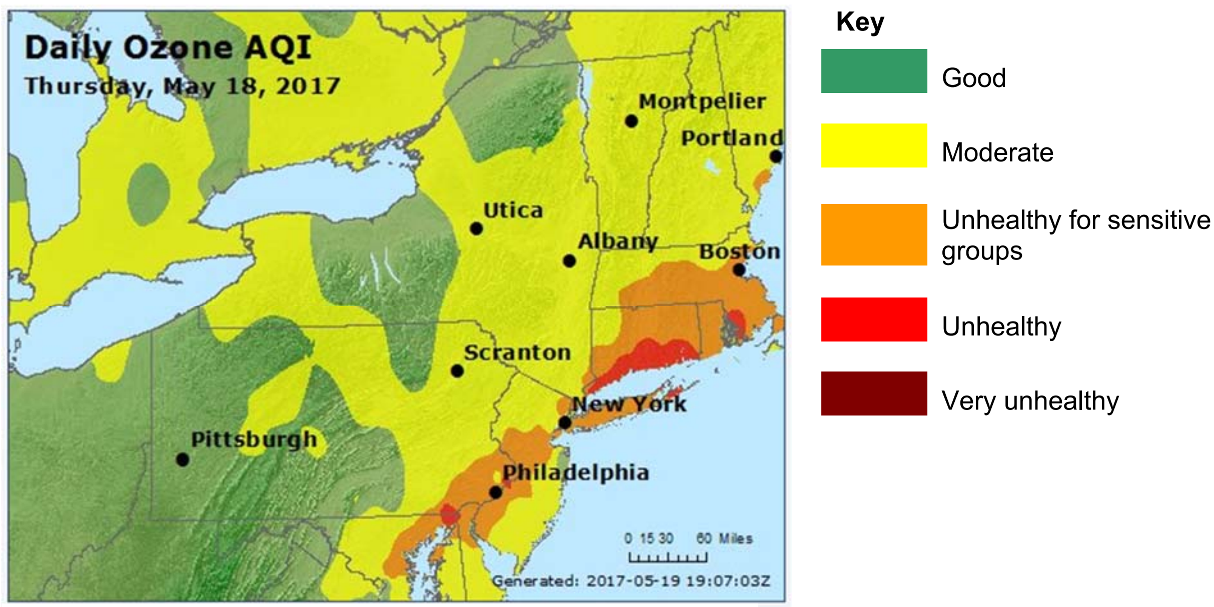


Figure 9. Air Quality Index Ozone Peak Values - May 18, 2017

Source: EPA AirNow website Archived Maps
https://www.airnow.gov/index.cfm?action=airnow.mapsarchivedetail&domainid=16&mapdate=20170518&tab=1

Air Quality – Pollutants that Meet Standards

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

Sources
Carbon monoxide is formed when carbon in fuel 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
The monitor for CO is located at the Wilmington MLK NCore site.

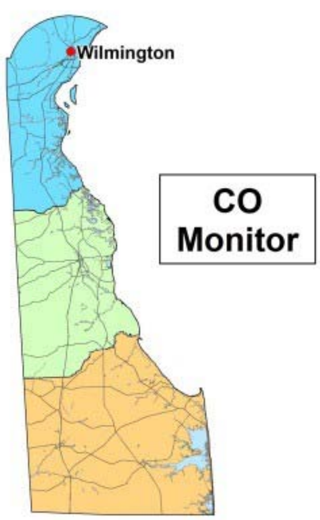


Figure 10. Map of Delaware CO Monitors

MLK NCore Station

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 2017.

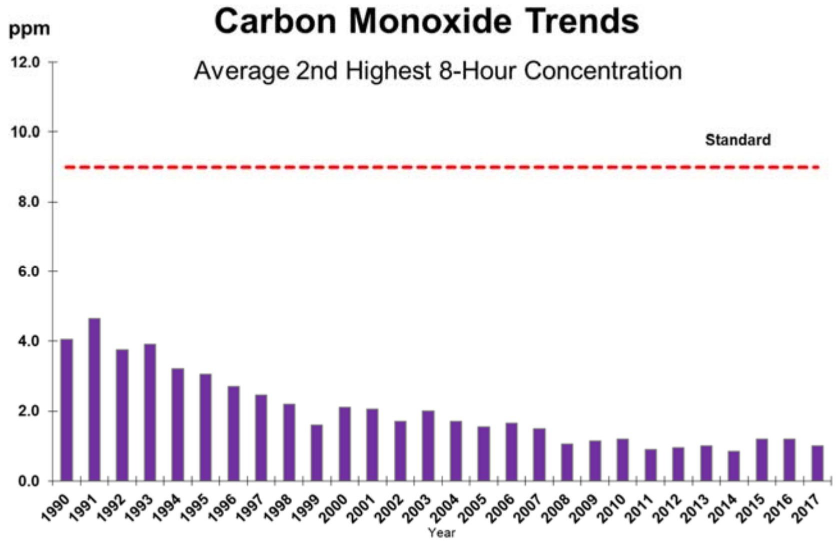


Figure 11. Delaware CO Trends since 1990

Table 6. Delaware CO 2017 Max. Values (ppm)

Site	1-Hour Avg. NAAQS = 35 ppm		8-Hour Avg. NAAQS = 9 ppm	
	1st Max.	2nd Max.	1st Max.	2nd Max.
MLK NCore	1.4	1.3	1.1	1.0

How does Delaware's air quality compare to nearby monitored areas?
Most CO monitors are located in urban areas. CO concentrations monitored in Wilmington are similar to those concentrations reported in nearby cities.

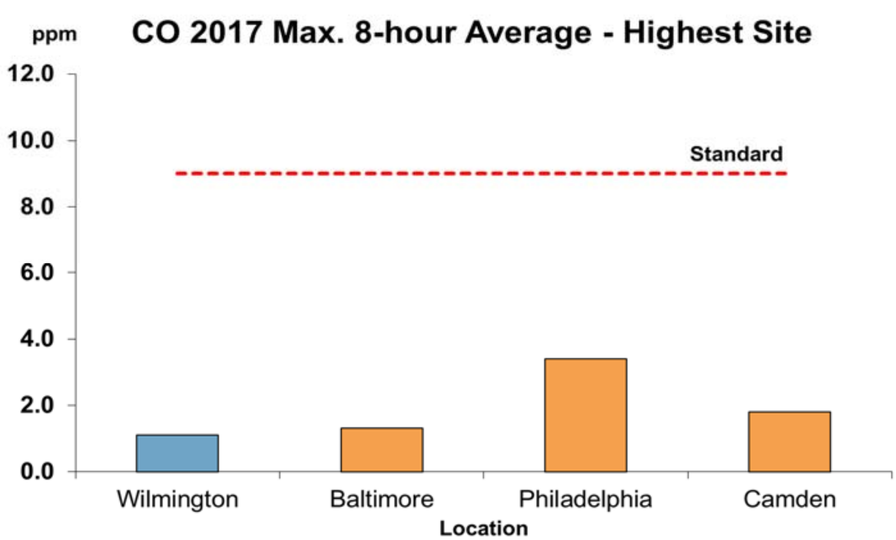


Figure 12. 2017 CO compared to nearby monitored sites

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 $\mu g/m^3$)
- 1-hour average = 100 ppb (3-year average of the 98th percentile daily max.)
  (*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.

Figure 13. Map of Delaware NO_2 Monitors

Locations

Delaware monitors NO_2 at the Wilmington MLK NCore site.

MLK NCore Criteria Gas Analyzers

Delaware Air Quality and Trends

Nitrogen dioxide levels in Delaware have remained well below the NAAQS since monitoring began. In 2017, levels continued to remain well below the standard.

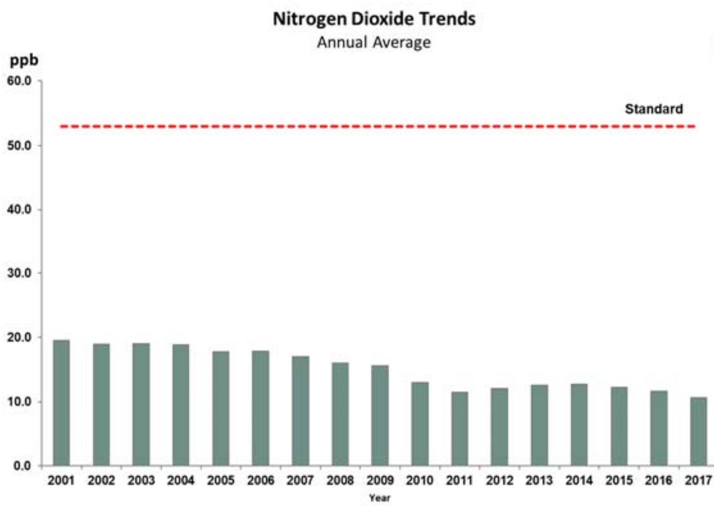


Figure 14. NO_2 Trends, Annual Average

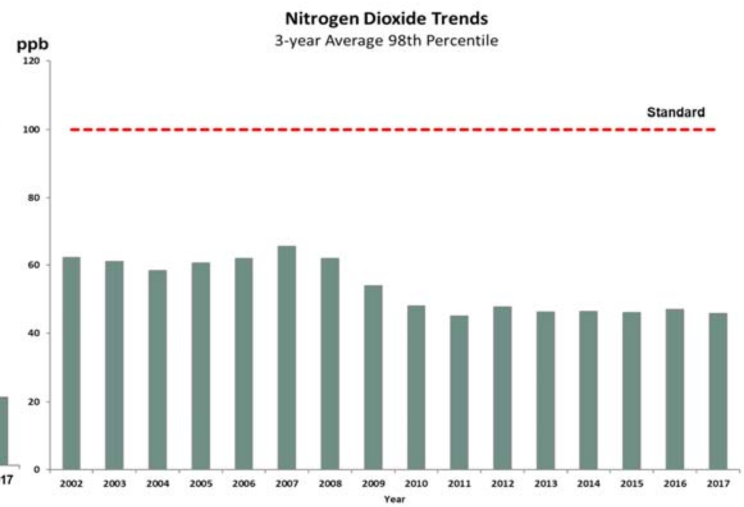


Figure 15. NO_2 Trends, 3-year Average 98th Percentile

Table 7. Delaware NO_2 Trends Annual Arithmetic Means (ppb)

Site	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
MLK NCore	17.7	17.8	17.0	16.0	15.5	12.9	11.4	12.0	12.5	12.7	12.2	11.6	10.7

Table 8. Delaware NO_2 Trends Annual 98th Percentile (ppb)

Site	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
MLK NCore	65	64	68	54	40	50	45	48	46	45	47	48	42

How does Delaware's air quality compare to nearby monitored 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 monitored areas.

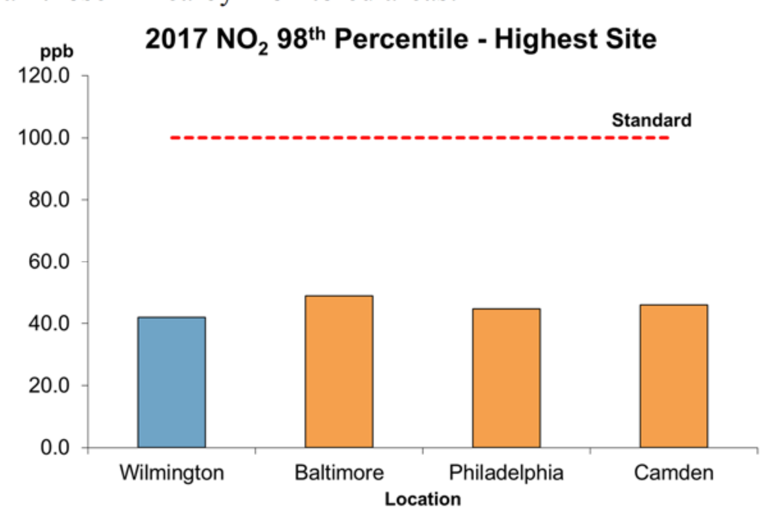


Figure 16. 2017 NO2 compared to nearby monitored sites

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 99^{th} percentile 1-hour avg.)

Secondary NAAQS:

- 3-hour average = 0.5 ppm (Not to be exceeded more than once per year)

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 at the MLK NCore, Bellefonte II, Lums Pond SP, and Delaware City sites. Due to resource restrictions, there was no monitoring at the Lums Pond SP site in 2009. Monitoring in Sussex County began at the Lewes site in 2012.

Figure 17. Map of Delaware SO_2 Monitors

Lums Pond SP Monitoring Station

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 2017, SO_2 levels remained well below the standards.

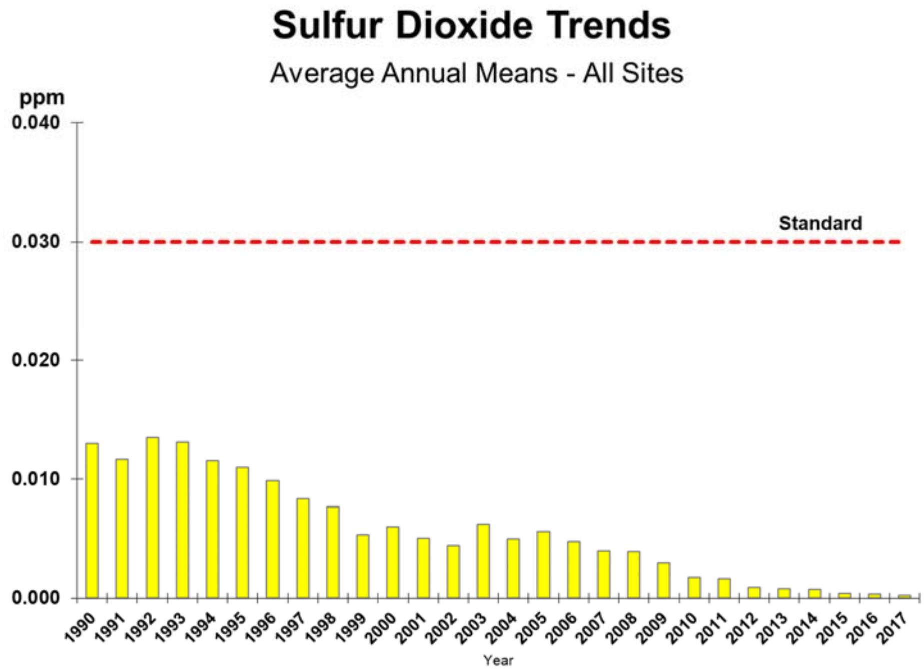


Figure 18. SO_2 Trends, Average Annual Means

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.

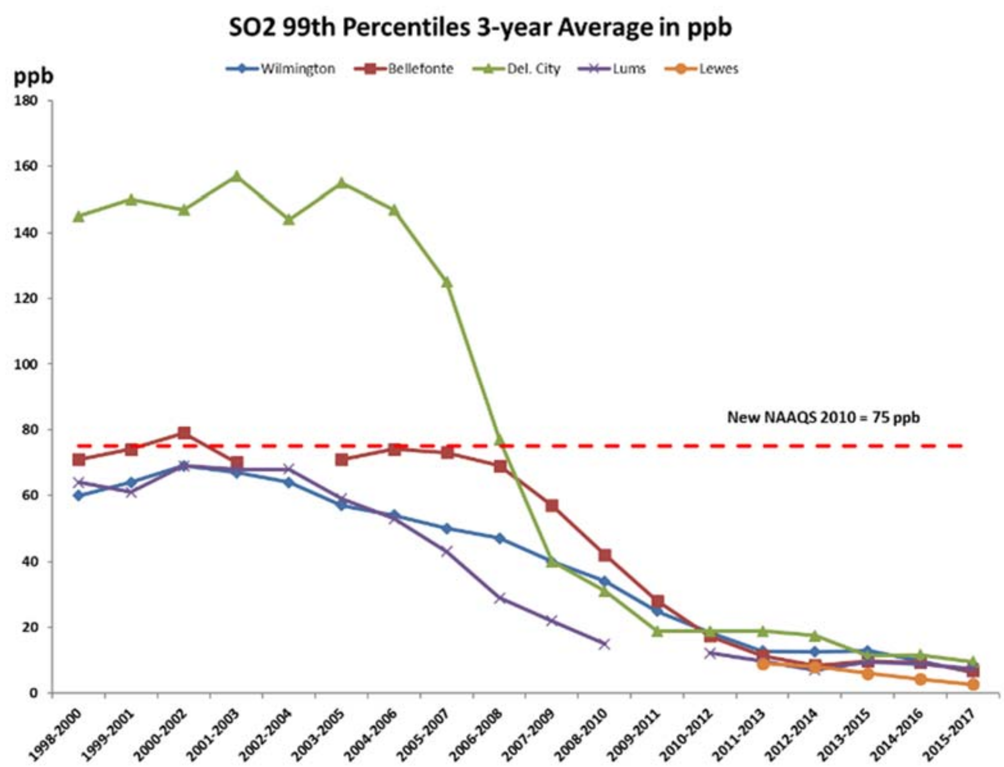


Figure 19. SO_2 Trends, 3-year Average 99^{th} Percentiles

Delaware Sulfur Dioxide

Table 9. SO_2 Annual 99th Percentile 1-hour Average (ppb)

Site	Years												
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Bellefonte II	72	77	69	60	41	25	19	8	7	10	11	6	3
MLK NCore	52	47	50	43	28	31	14	9	13	14	10	5	4
Lums Pond SP	59	42	29	*ND	*ND	*ND	*ND	*ND	7	7	14	5	3
Delaware City	195	139	41	51	28	13	15	29	13	11	10	14	4
Lewes								11	7	7	4	2	2

*ND=No Data

Table 10. SO_2 3-year Average of the 99th Percentile (ppb)

Site	Years (NAAQS = 75 ppb)										
	2005-2007	2006-2008	2007-2009	2008-2010	2009-2011	2010-2012	2011 - 2013	2012 - 2014	2013 - 2015	2014 – 2016	2015 – 2017
Bellefonte II	73	69	57	42	28	18	12	9	10	9	7
MLK NCore	50	47	40	34	25	18	12	12	13	10	6
Lums Pond SP	43	29	22	15	*ND	*ND	10	7	10	9	8
Delaware City	125	77	40	31	19	19	19	17	11	12	10
Lewes							9	8	6	4	3

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

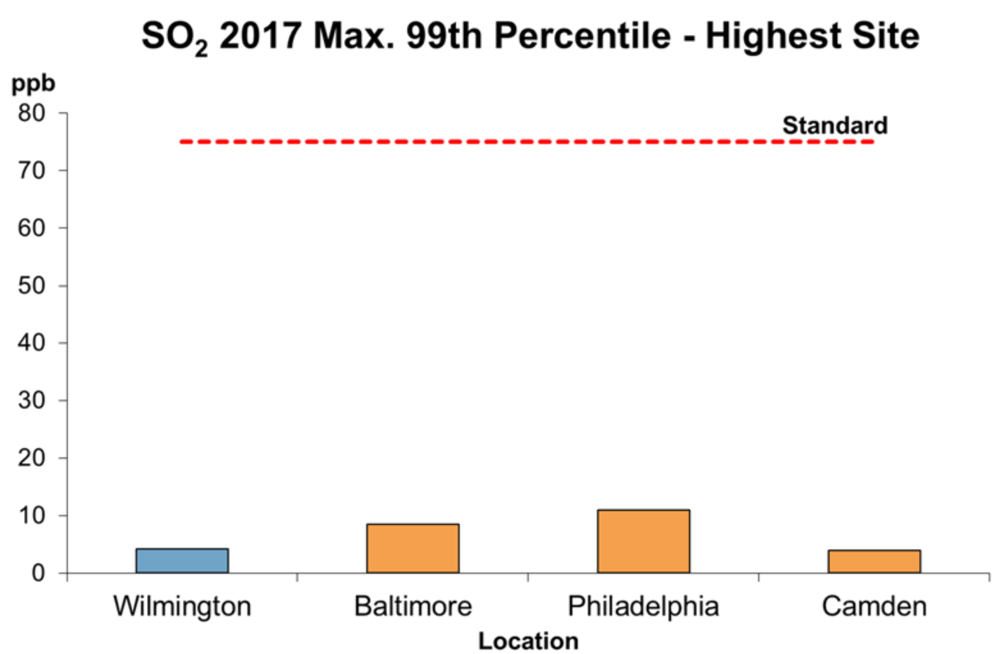


Figure 20. 2017 SO_2 compared to nearby monitored sites

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. The graphic at right illustrates a comparison of the different size classes of particulate matter compared to a human hair and beach sand.

Source: https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#PM

Figure 21. Particulate Matter Size Comparison

Standards

Primary NAAQS:

- Annual arithmetic mean = 12.0 µg/m^3 (Averaged over three years)
- 24-Hour maximum = 35 µg/m^3 (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.

Figure 22. Map of Delaware $PM_{2.5}$ Monitors

Locations

Monitors are located throughout Delaware, with the majority of monitors in New Castle County where the highest concentrations occur.

Bellefonte I Monitoring Platform

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.

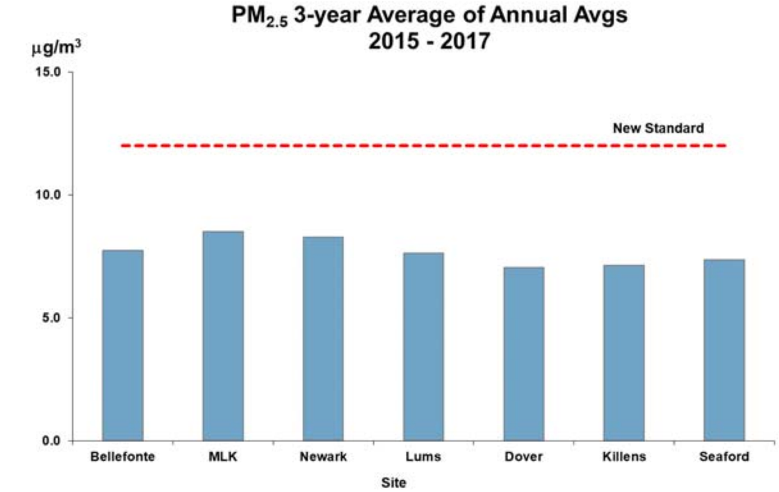


Figure 23. $PM_{2.5}$ 3 Year Average of Annual Averages

Annual Average

New Castle County was originally designated non-attainment for $PM_{2.5}$ based on the 16.0 $\mu g/m^3$ three-year average of the annual averages for 2001 to 2003 at the urban Wilmington MLK site. For the most recent three-year period (2015 - 2017), the highest average occurred in New Castle County (8.5 $\mu g/m^3$ 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.

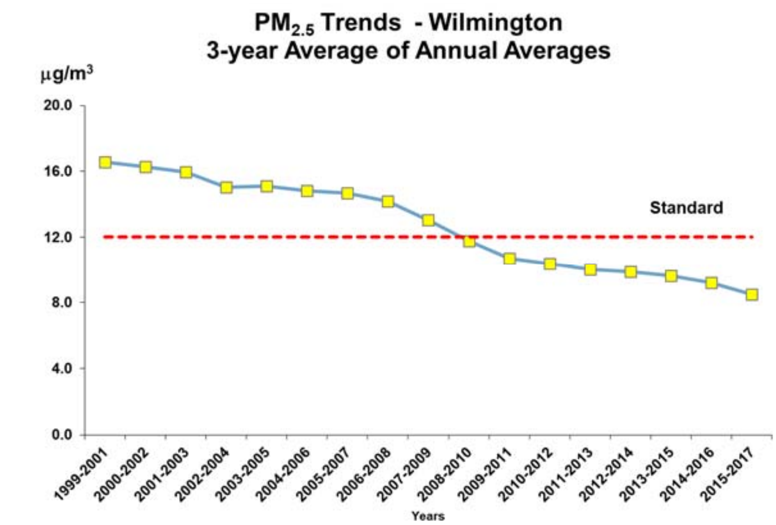


Figure 24. $PM_{2.5}$ Wilmington Trends 3 year Avg. of Annual Avg.

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 2015 – 2017 $PM_{2.5}$ data.

Killens Pond SP site $PM_{2.5}$ Monitoring on Roof

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.

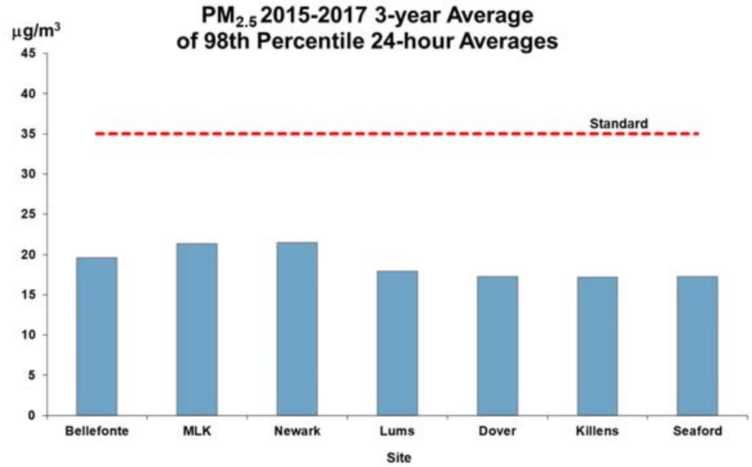


Figure 25. $PM_{2.5}$ 3 Year Avg. of 98th Percentile 24 hr. Avgs.

As with the annual average standard, three years of data are averaged to determine compliance with the NAAQS. The most recent three-year (2015 – 2017) average for the 98th percentiles at MLK was 21 µg/m^3 and 22 µg/m^3 at the Newark site.

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.

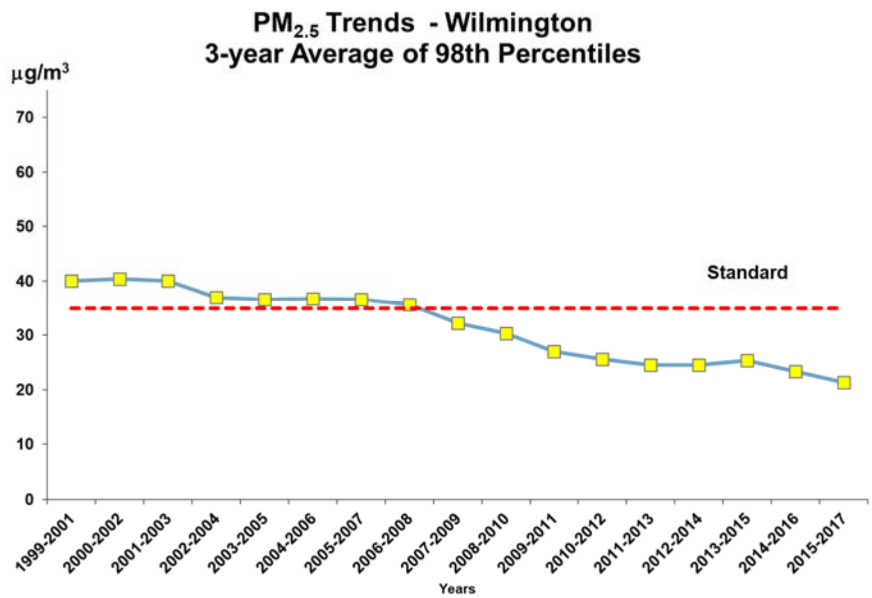


Figure 26. $PM_{2.5}$ Wilmington 3 Year Avg. of 98th Percentile 24 hr. Avgs.

Table 11. Delaware 2015-2017 $PM_{2.5}$ Data Summary

Site	3-year Average of Annual Averages NAAQS = 12 µg/m^3	3-year Average of 24-hour 98th Percentiles NAAQS = 35 µg/m^3
Bellefonte I	7.8	20
MLK NCore	8.5	21
Newark	8.3	22
Lums Pond SP	7.6	18
Dover	7.1	17
Killens Pond SP	7.2	17
Seaford	7.4	17

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

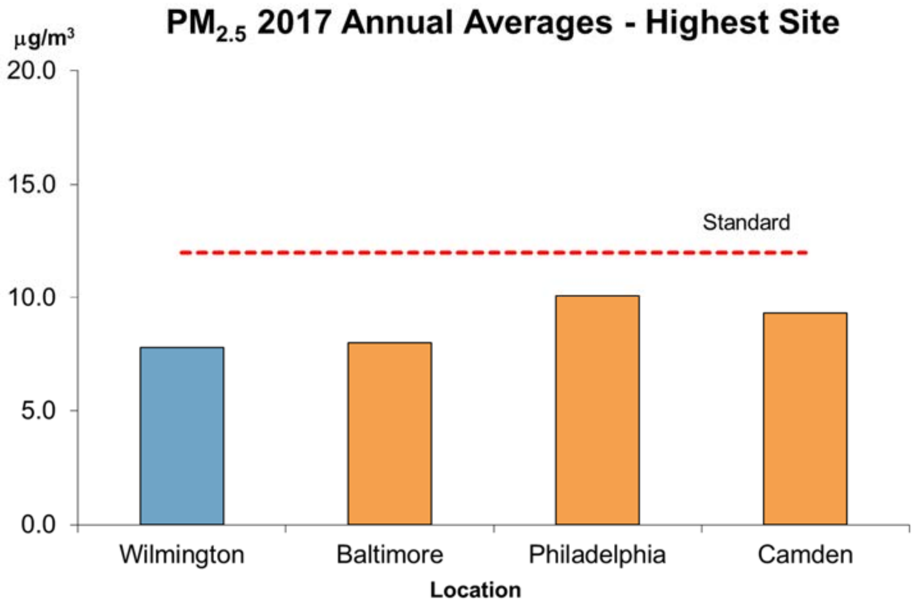


Figure 27. 2017 Highest Site $PM_{2.5}$ Annual Averages compared to nearby monitored sites

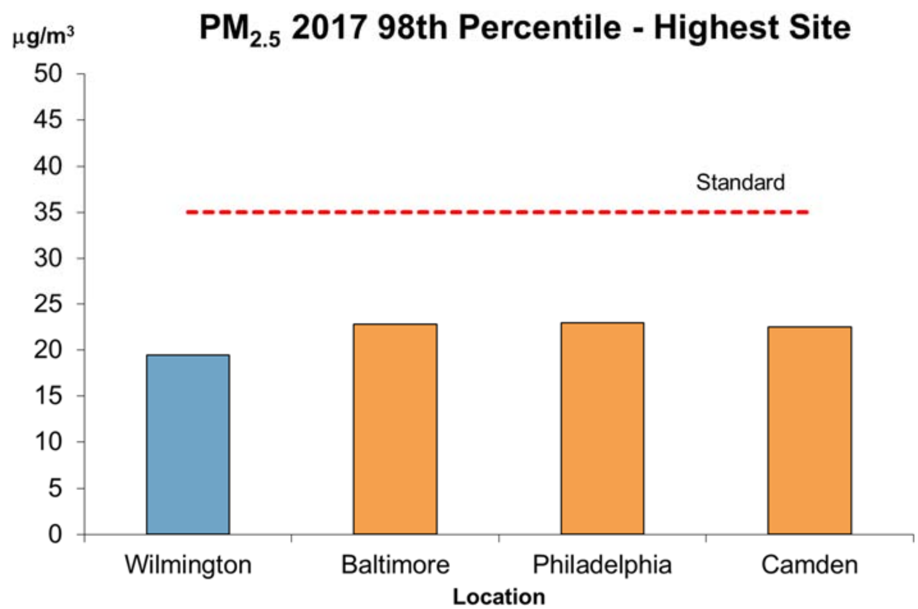


Figure 28. 2017 Highest Site $PM_{2.5}$ 98th Percentile compared to nearby monitored sites

$PM_{2.5}$ 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 one site: MLK NCore.(Wilmington, DE) Samples are collected on filters for 24 hours every 3rd day. 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: Until early 2014 monitoring also took place in Dover; however, as a result of EPA reassessment of the monitoring network, support for the Dover site was terminated due to low concentrations and redundancy with the MLK NCore 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.

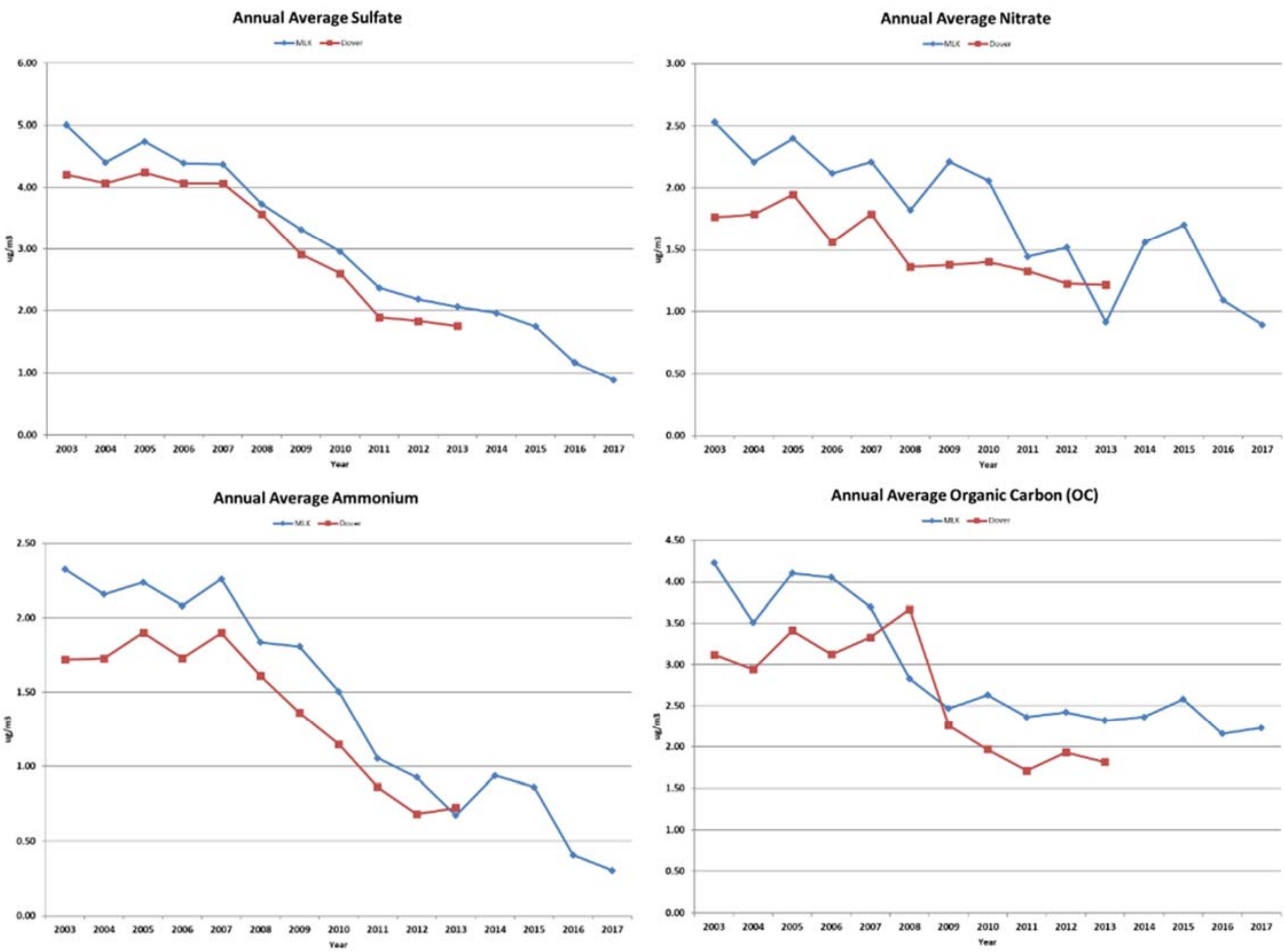


Figure 29. Annual Average Trends for some of the target $PM_{2.5}$ species

Particulate Matter (PM_{10})

Description

PM_{10} is the fraction of total suspended particulate matter (TSP) that is less than 10 microns in diameter, which is about 1/7 the diameter of a human hair. See graphic on page 21 under the $PM_{2.5}$ section. 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 µg/m^3 not to be exceeded more than once per year averaged over three years.

Sources

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

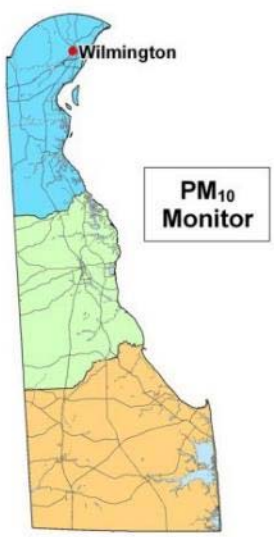


Figure 30. Map of Delaware PM_{10} Monitors

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.

Particulate Monitoring at MLK NCore

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.

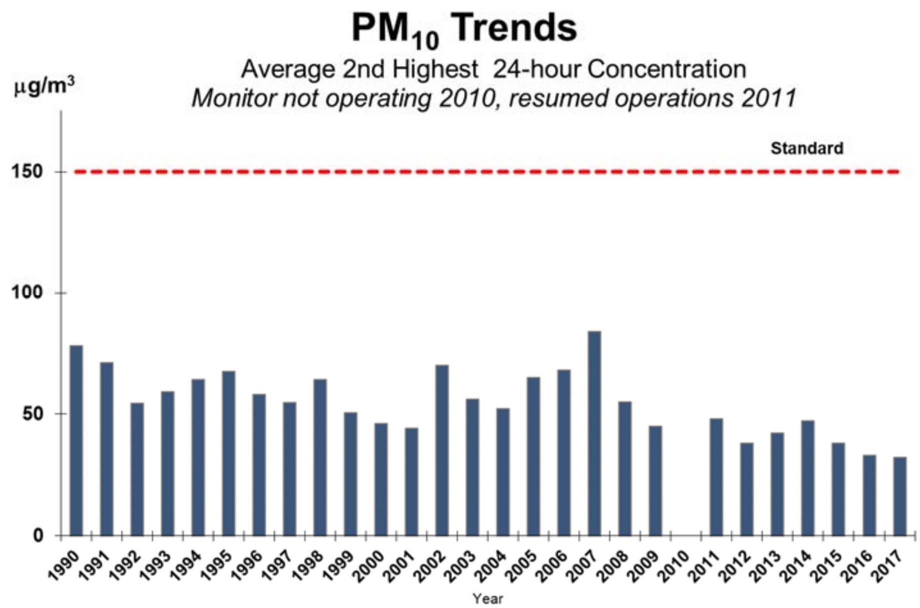


Figure 31. Delaware PM_{10} Trends 2nd Highest 24hr Concentration

Table 12. Delaware PM_{10} Trends

Annual Average µg/m^3

Site	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
MLK NCore	22.5	22.6	23.2	19.8	17.8	*No data	17.4	17.1	14.4	16.9	17.1	14.2	14.0

*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.

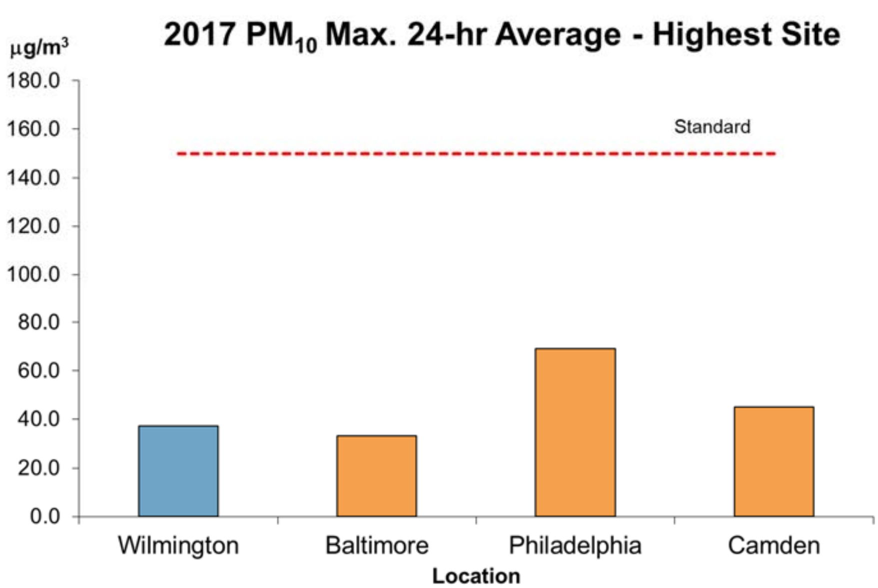


Figure 32. 2017 PM_{10} compared to nearby monitored sites

Air Quality – Pollutants without Ambient Standards

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.

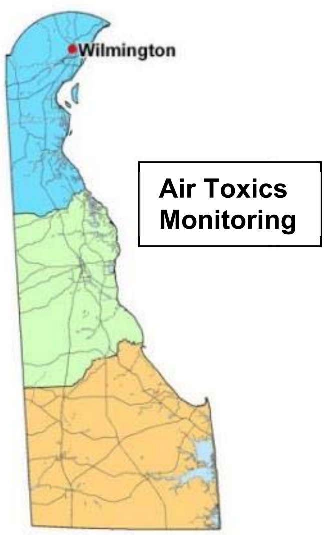


Figure 33. Map of Delaware Air Toxics Monitoring Site

Locations

The history of air toxics collection in Delaware has changed as requirements and methods varied as well as with restrictions in resources. Since 1990 VOC samples continue to be collected at the MLK NCore (Wilmington) site. Since 2003 heavy metals continue to be monitored at the MLK NCore site. Additionally at the MLK NCore site, monitoring for carbonyls beginning in 2003 was discontinued in 2015 due to resource restrictions. Historical data is available for certain pollutants at other sites in Delaware.

Delaware Air Quality and Trends

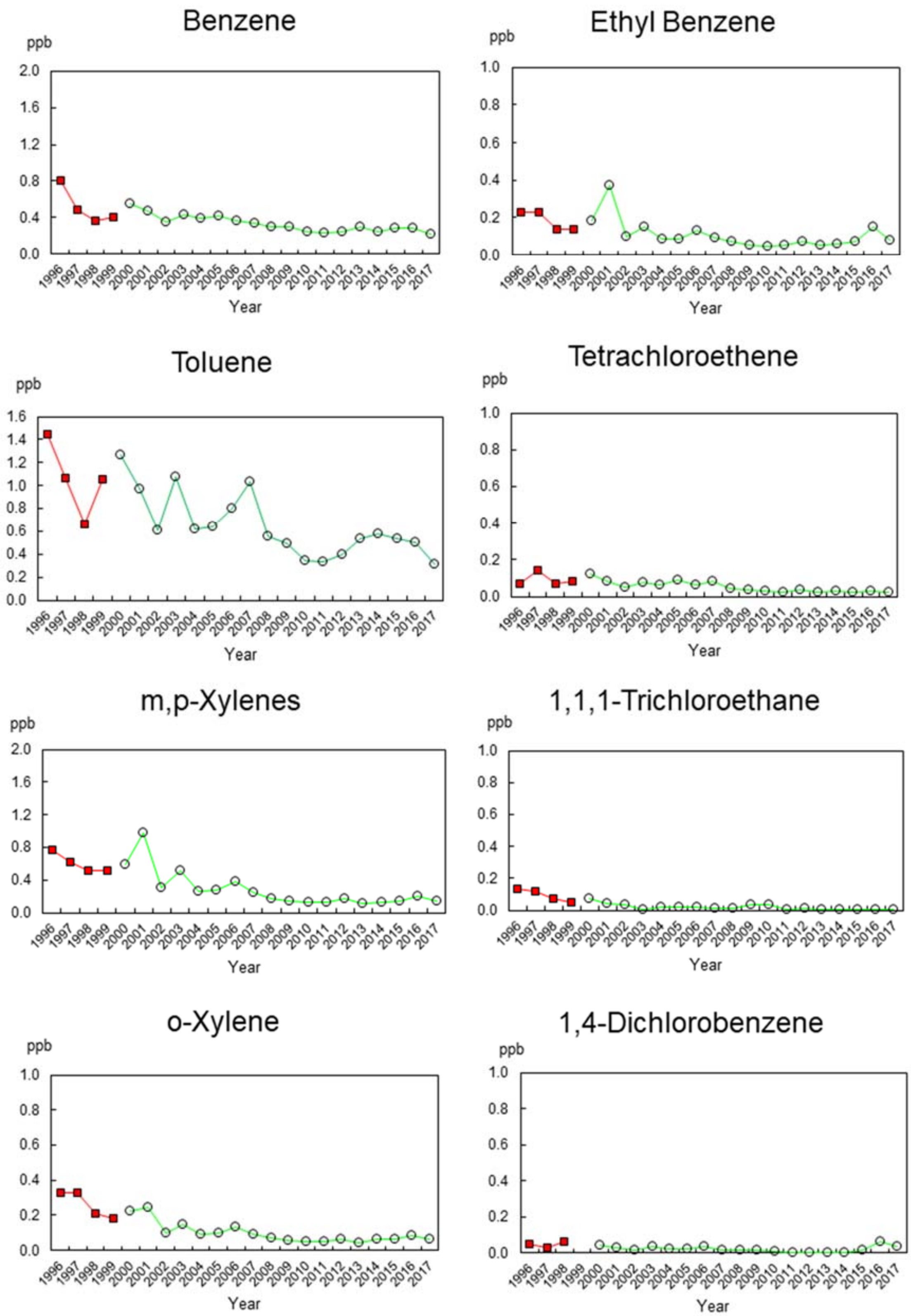
Ambient VOC levels are consistently below 10 ppb for all monitored compounds, and most are below 1 ppb.

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 MLK NCore site.

Table 13. 2017 Air Toxics Data, MLK NCore site (Wilmington, DE)

Compound Name	Average *ppb*	Maximum *ppb*
Dichlorodifluoromethane	0.54	0.75
Chloromethane	0.62	0.84
1,2-Dichloro-1,1,2,2,tetrafluoroleth	0.02	0.03
Chloroethene	0.01	0.09
1,3-Butadiene	0.02	0.16
Trichlorofluoromethane	0.27	0.36
Acetone	5.57	18.19
Methylene Chloride	0.12	0.23
1,1,2-Trichloro-1,2,2-trifluoroethane	0.09	0.11
2-methoxy-2-methyl-Propane	0.00	0.01
Hexane	0.14	0.39
Chloroform	0.03	0.05
Tetrahydrofuran	0.01	0.06
1,2-Dichloroethane	0.02	0.05
1,1,1-Trichloroethane	0.00	0.01
Benzene	0.21	0.47
Carbon tetrachloride	0.09	0.12
Cyclohexane	0.04	0.13
1,2-Dichloropropane	0.00	0.01
Trichloroethene	0.00	0.02
Heptane	0.05	0.15
Cis-1,3-Dichloro-1-Propene	0.00	0.00
Trans-1,3-Dichloro-1-Propene	0.00	0.00
Toluene	0.31	0.74
1,2-Dibromoethane	0.00	0.05
Tetrachloroethylene	0.02	0.05
Chlorobenzene	0.01	0.1
Ethylbenzene	0.08	0.19
m & p- Xylene	0.15	0.39
Styrene	1.07	5.48
1,1,2,2-Tetrachloroethane	0.01	0.03
o-Xylene	0.06	0.15
1-Ethyl-4-Methylbenzene	0.06	0.46
1,3,5-Trimethylbenzene	0.02	0.08
1,2,4-Trimethylbenzene	0.06	0.24
1,4-Dichlorobenzene	0.04	0.26

Wilmington Air Toxics Trends - Annual Averages Selected Compounds



Notes: Insufficient data in 1995 to calculate annual average. Color difference indicates method changed in 2000.

Figure 34. Wilmington Air Toxics Trends - Annual Averages Selected Compounds

Sources of Pollution

Emissions Inventory

What is an emissions inventory?

The emission inventory is a tool used to determine the amount of air pollutants released from various sources in a given geographic area over a specified range of time. 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. Because there are many and varied sources of air pollution, and it would be impossible to have exact data from all sources, emissions inventories are often estimates of emissions. These estimates are made with the most up to date scientific studies and the use of carefully reviewed public and non-public data.

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. Emission inventories can be used for planning, compliance, and trend analysis. An inventory can be used to identify future needed controls and regulations, as the inventory shows where the major source of each pollutant is. It is also a tool used by the air quality division to make plans to reduce pollution if a county is in non-attainment for a criteria air pollutant. Together with ambient monitoring data, emission inventory estimates are used to understand changes and trends in air quality.

Ozone

In October 2015, the U.S. Environmental Protection Agency (EPA) promulgated a revised National Ambient Air Quality Standard (NAAQS) for ground level ozone at a concentration of 0.070 ppm averaged over eight hours.

On April 30, 2018, the EPA designated New Castle County as nonattainment for the 2015 ozone standard, as part of the greater Philadelphia area nonattainment area. This attainment was based on 2014 to 2016 monitoring data. States which have a county in nonattainment for a criteria air pollutant standard must, as a part of their State Implementation Plan (SIP), submit a comprehensive,

Source: https://www3.epa.gov/airquality/greenbook/map/mddcvade8_2015.pdf

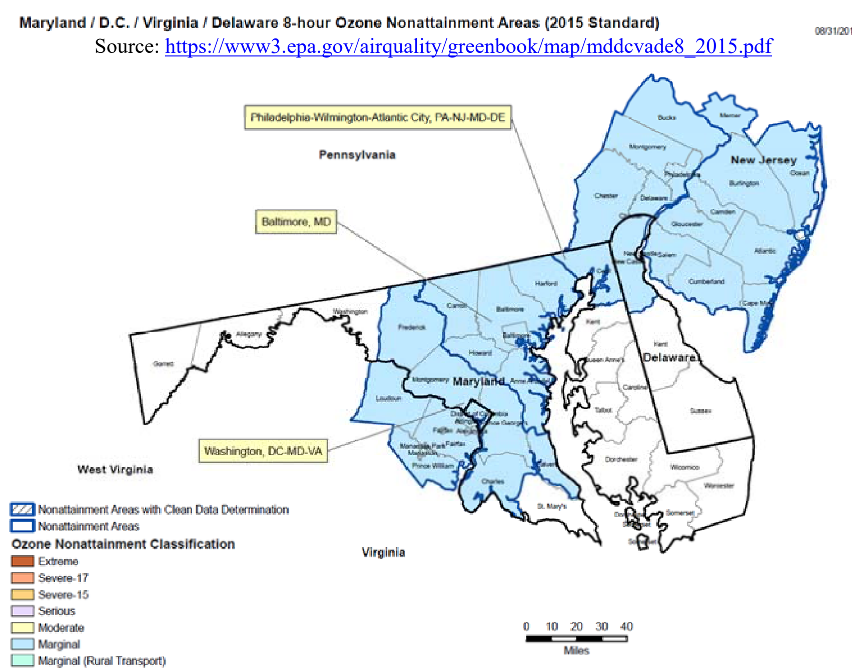


Figure 35. MD, DC, DE 8hour Ozone Nonattainment Areas

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 (NOX), and carbon monoxide (CO). The EPA has not officially established a base year for the 2015 ozone standard, but Delaware will likely use the 2014 inventory as its base year. The data from this inventory is presented, in part, in this report.

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 2014 for each ozone precursor.

Point sources

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.

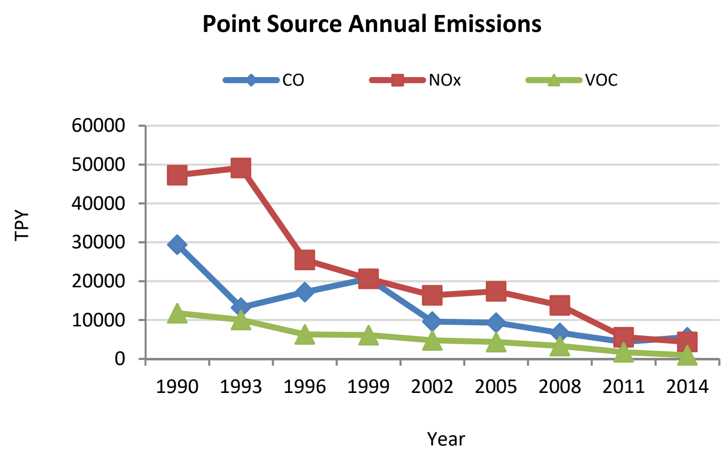


Figure 36. Point Source Annual Emissions

Stationary non-point sources

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.

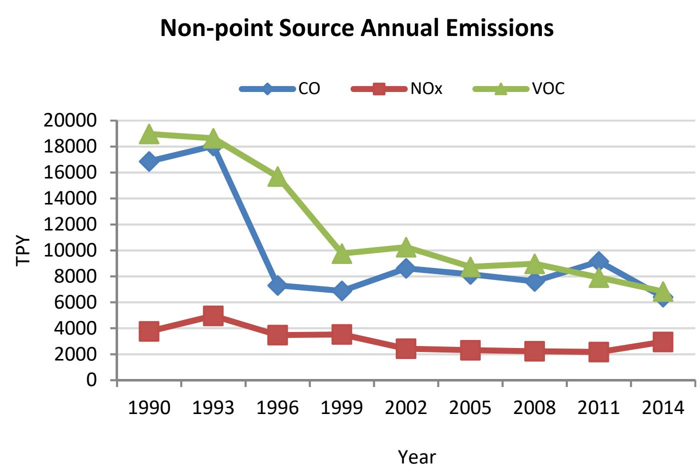


Figure 37. Non-point Source Annual Emissions

Mobile sources

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, NOx, 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.

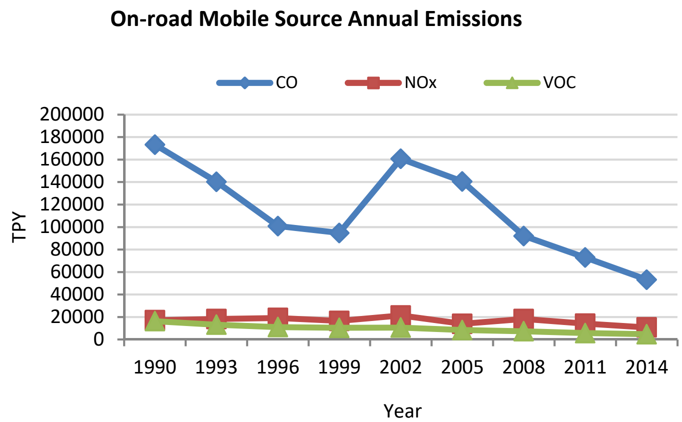


Figure 38. On-road Mobile Source Annual Emissions

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.

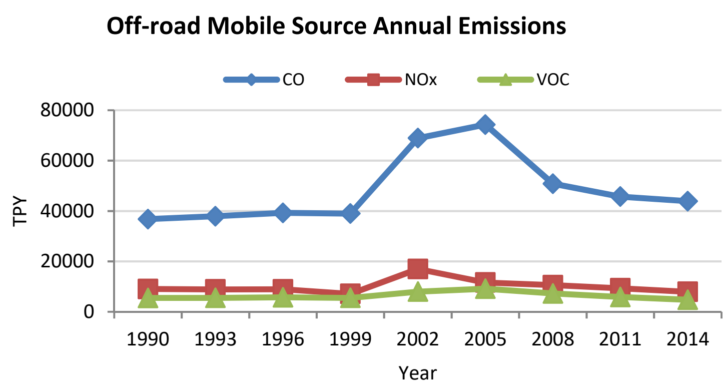


Figure 39. Off-road Mobile Source Annual Emissions

Natural sources

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 BEIS3.61 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.

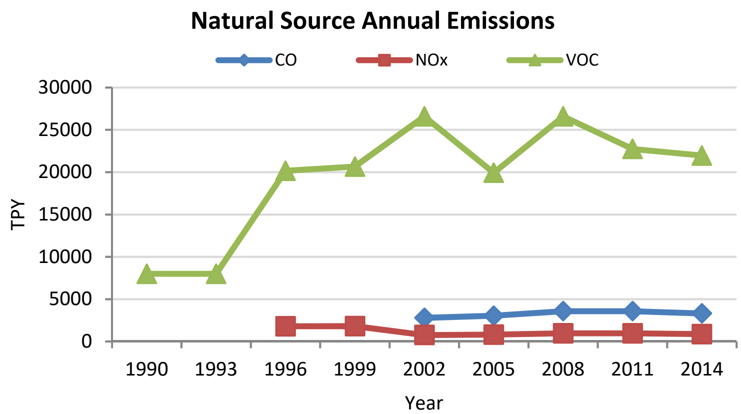


Figure 40. Natural Source Annual Emissions

Ozone Precursor Emissions by Source Category:

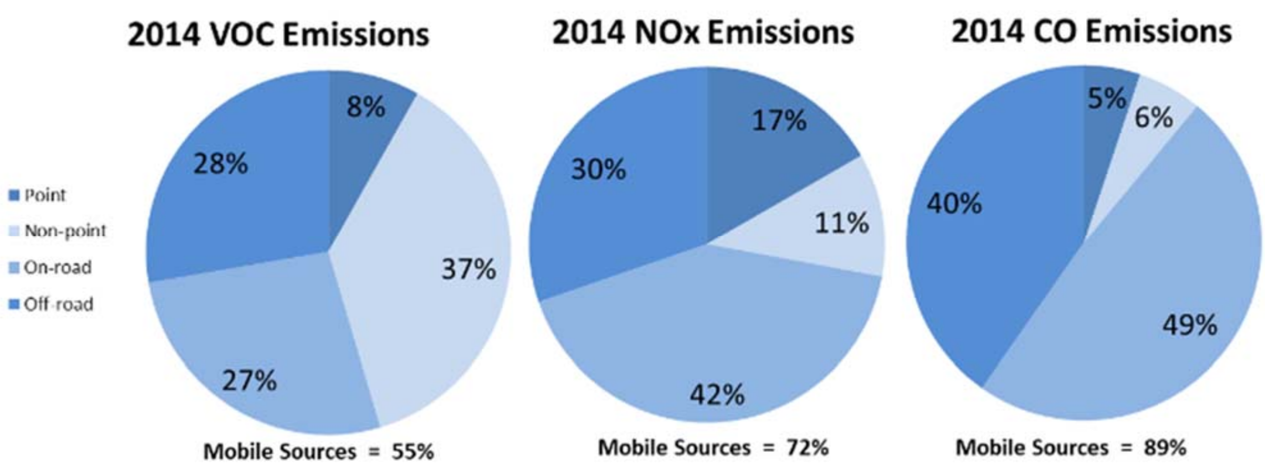


Figure 41. Ozone Precursor Emissions by Source Category

Sulfur Dioxide (SO_2) and Particulate Matter (PM_{10} & $PM_{2.5}$)

As a result of findings describing the adverse health effects associated with fine particulates, and the establishment of a fine particulate national ambient air quality standard, the Delaware's Air Emissions Inventory 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 fuel oil combustion. Electric generation utilities (EGUs) and petroleum refineries are the largest SO_2 emission sources, however, even these sources have significantly reduced SO_2 emissions by switching to natural gas, which contains almost no sulfur, or have reduced the sulfur content in distillate fuel. Motor vehicle fuel combustion is another source of SO_2.

Sulfur Dioxide and PM Emissions by source category:

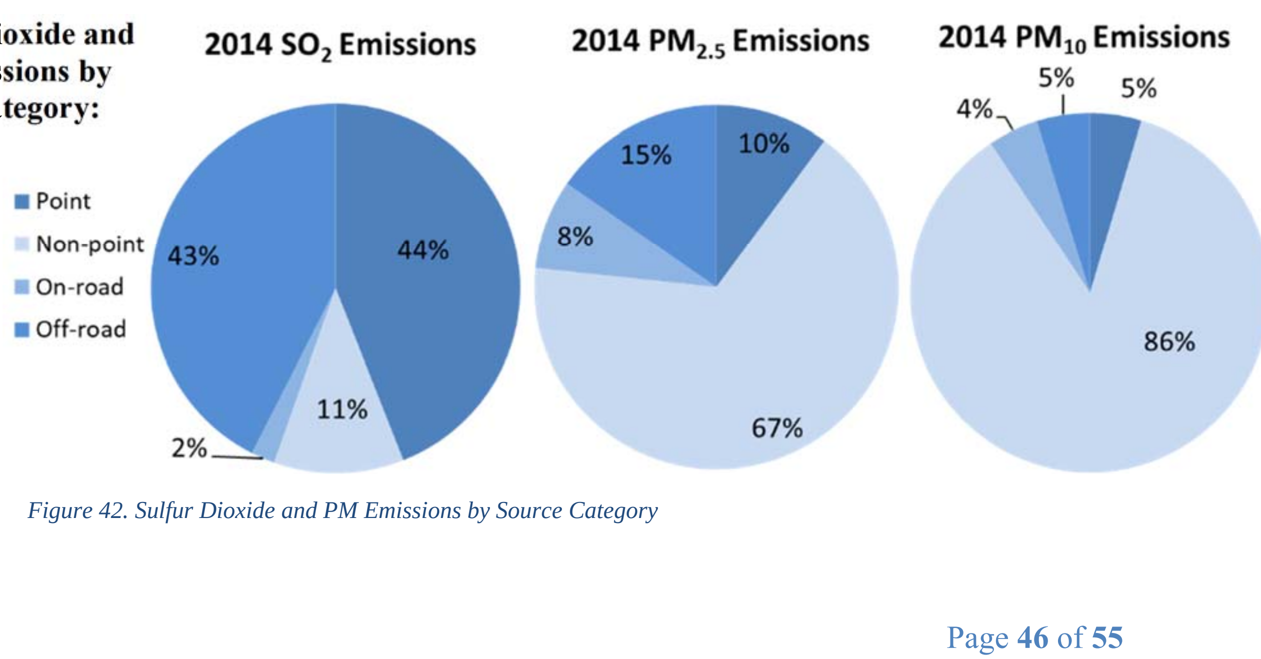


Figure 42. Sulfur Dioxide and PM Emissions by Source Category

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 Delaware Air Emissions Inventory 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.

Climate Change

What is Climate Change?

Climate change is the change in the statistical distribution of weather patterns over extended periods of time. However, this change can be extreme due to factors that force changes in the climate system. One major factor that is impacting climate change is the anthropogenic emission of greenhouse gases (GHG) such as carbon dioxide, methane, nitrous oxide chlorofluorocarbons and sulfur hexafluoride, resulting in the increase of Earth's average surface temperature (Global Warming). According to the EPA, the Earth's average temperature has risen by 1.5°F over the past century and is projected to rise another 0.5 to 8.6°F over the next hundred years[1]. Small changes in the average temperature of the planet can translate to large and potentially dangerous shifts in climate and weather such as increased hurricanes, heatwaves and heavy rainfall.

How will Climate Change impact Delaware?

Regional findings from the third U.S. National Climate Asseessment[2]for the Mid-Atlantic[2] revealed that heatwaves, coastal flooding, river flooding and sea level rise will pose a growing challenge to Delaware's environmental, social, and economic systems. This will increase the vulnerability of the State's residents, especially its most disadvantaged populations. Also, agriculture, fisheries, critical infrastructure and ecosystems will be increasingly compromised over the next century by climate change impacts.

What is Delaware Doing about Climate Change?

Delaware is committed to addressing climate change by incorporating clean energy and sustainability practices into policies and operations. The following describes programs and policies that Delaware is pursuing to address climate change:

Regional Greenhouse Gas Initiative

Regional Greenhouse Gas Initiative (RGGI)[3] is a competitive market-based carbon dioxide (CO2) emissions trading program that reduces carbon emissions from electric generating units (EGUs) that produce more than 25 megawatts of electricity. Delaware and eight other states (Connecticut, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island and Vermont) participate in RGGI.

The EGUs that are subject to RGGI are required b to hold and surrender one RGGI CO2 allowance for every ton of CO2 they emit into the atmosphere. Nine facilities in Delaware have EGUs covered by the RGGI program. They include Indian River, Hay Road, McKee Run, NRG Energy Center Dover, Vansant, Warren Beasley power Station, Edge Moor, Christiana Substation and Delaware City Refinery.

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[1] U.S.EPA. (Last updated August 09, 2016). *Climate Change Basic information*. Retrieved from https://www3.epa.gov/climatechange/basics/

[2] *2014 National Climate Assessment*. Retrieved from http://nca2014.globalchange.gov/report

[3] http://www.dnrec.delaware.gov/Air/Pages/RegionalGreenhouseGasInitiative.aspx

On August 23, 2017, the RGGI participating states announced an agreement on the 2016 Program Review design changes to be implemented beginning in 2021. The RGGI states proposed a regional cap trajectory that will provide an additional 30% cap reduction by the year 2030, relative to 2020 levels. The proposed regional program changes include the addition of an Emissions Containment Reserve (ECR) wherein states can withhold allowances from auction if emission-reduction costs are lower than projected. The proposed ECR is an innovative way to adaptively respond to supply and demand in the market. Through RGGI's implementation and through complementary state policies, the RGGI states have shown that economic benefits, consumer savings, public health improvements, and greenhouse gas emissions reductions can go hand-in-hand.

Delaware Climate Change Impact Assessment

The Delaware Climate Change Impact Assessment breaks down past and projected future climate trends in Delaware, and what these mean for Delaware's public health, water resources, agriculture, infrastructure, and ecosystems. Read the full report or a 12-page summary.

The Delaware Sea Level Rise Vulnerability Assessment takes a deep dive into the impacts that sea level rise will have on the state. The assessment includes:

- Causes of sea level rise
- Sea level rise trends in Delaware
- Future scenarios for sea level rise in Delaware
- Mapping and data for over 75 natural resources and structures that will be impacted by rising seas, like schools, fire stations, homes, wetlands, factories, wells, roads and habitats.

Community Sustainability Plan

Developed in consultation with community members, a community sustainability plan is a long-term plan to help the community realize its collective sustainability goals. The plan also employs indicators to track progress towards these goals, and includes action plans that have roles for government, citizens, businesses, and civic organizations. The overarching vision of a sustainability plan and its specific actions can be very different from one community to another, depending on local priorities, resources, and opportunities.

A community sustainability plan should look at a variety of factors that can affect a community and should lay out actions related to those factors. It can look at issues such as climate change, greenhouse gasses, natural areas, and conservation.

Climate Change Vulnerability Assessment and Action Plan

A climate vulnerability assessment and action plan assesses the likely effects of increasing temperatures, sea level rise and heavy rainfall caused by climate change on infrastructure, homes, businesses, public health, and quality of life. The assessment and planning process engages citizens to develop goals, assess risks, and propose additional studies, policies or on-the-ground actions to adapt to changing climate conditions.

Delaware has state-specific climate historical data and projections that can be used for assessment and planning by local governments.

Greenhouse Gas Inventory and Mitigation Plan

A greenhouse gas inventory is a measurement of the amount of greenhouse gas emissions produced by residents, schools, businesses, and industries in a given year. The greenhouse gas inventory can be conducted at the government operation scale or the community scale. The greenhouse gas inventory can be used as a proxy to find energy inefficiencies and identify opportunities for operational improvement. The inventory can be reported publicly to build awareness and support for actions that can reduce greenhouse gas emissions.

With the information gathered in a greenhouse gas inventory, municipalities can create a mitigation plan for reducing energy inefficiencies and greenhouse gas emissions. A mitigation plan is a set of strategies and actions designed to reduce the greenhouse gas emissions of a municipality. It establishes a timeline for achieving specific emission reduction goals, identifies key strategies for achieving these goals, and tracks progress. With a mitigation plan, organizations and agencies can identify which strategies will most significantly reduce greenhouse gasses at the lowest cost. This helps communities allocate funding and resources effectively.

Natural Areas Inventory and Conservation Plan

A natural areas inventory compiles and describes important natural resources such as forests, wetlands, surface and ground waters, and farmland within a community. It can also provide information about the economic, social, and public health benefits of maintain a community’s natural areas. Cultural resources, such as historic sites, scenic vistas, and recreation areas are often included as well. A conservation plan specifies actions that can be taken to protect important natural resources in a community and to augment their benefits to the community. This information provides the foundation for open space planning and protection, zoning updates, designation of critical environmental areas, flooding and drainage plans, green infrastructure implementation, comprehensive plans, and other municipal plans and policies.

U.S. Climate Alliance

In June 2017, Governor John Carney announced that Delaware joined the U.S. Climate Alliance, a bipartisan group of 15 states committed to upholding the 2015 Paris Agreement to combat climate change, after President Trump announced that he would withdraw the U.S. from the agreement.

The Alliance was formed in response to the U.S. federal government’s decision to withdraw from the Paris Agreement, and the states remain committed to meeting our share of the U.S. target under that agreement – a 26-28% reduction in greenhouse gas emissions below 2005 levels by 2025.

Transportation and Climate Initiative

The Transportation and Climate Initiative (TCI) is a regional collaboration of 12 Northeast and Mid-Atlantic states and the District of Columbia that seeks to improve transportation, develop the clean energy economy and reduce carbon emissions from the transportation sector. The participating states are: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Virginia.

The initiative builds on the region's strong leadership and commitment to energy efficiency and clean energy issues, and its programs to reduce carbon emissions in the power sector, which have resulted in the region becoming one of the most energy efficient areas in the nation. At the same time, the effort underscores the sense of urgency shared by all 13 jurisdictions, and their collective aspirations to become the leading region for sustainability and clean energy deployment in the country.

From April to August 2018, the TCI partnership hosted a series of regional listening sessions, inviting input on potential policy approaches to bring about a cleaner and more resilient transportation future across the Northeast and Mid-Atlantic region. These events directly followed a November 2017 announcement by seven states and the District of Columbia, who committed to initiating listening sessions to gather input on potential policy approaches to bring about a cleaner and more resilient transportation future across the Northeast and Mid-Atlantic region.

Appendix A - Monitoring Methods

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.

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.

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.

Particulate Matter - Fine ($PM_{2.5}$)
$PM_{2.5}$ is sampled by drawing air through a specially designed inlet that excludes particles larger than 2.5 microns in diameter. The particles are collected on a Teflon® microfiber filter that is weighed to 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.

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 TO-15a, which collects 24-hour samples once every six days using stainless-steel canisters followed by GC/MS analysis.

Appendix B – Further Information

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,
https://www.epa.gov/air-trends

Delaware Toxics Release Inventory Report, Delaware DNREC,
http://www.dnrec.delaware.gov/SERC/Pages/Reports.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/

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

USEPA Office of Transportation and Air Quality
www.epa.gov/air-pollution-transportation

USEPA Region III
https://www.epa.gov/aboutepa/epa-region-3-mid-atlantic

USEPA Ambient Monitoring Technology Information Center (AMTIC Web formerly TTN)
https://www.epa.gov/amtic

List of Division of Air Quality Contacts

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Branch Manager – Angela Marconi, New Castle Office

Planning Branch

Branch Manager – Valerie Gray, *Acting*, Dover Office

Emissions Inventory Development

Program Manager - David Fees, Dover Office
Point Sources – Frank Gao, New Castle Office
Stationary Area Sources – Shane Cone, New Castle Office
Mobile Sources (on-road) – Jolyon Shelton, New Castle Office

State Implementation Plan (SIP) - Regulations and Planning

Ozone SIP Development – Mark Prettyman, Dover Office
$PM_{2.5}$ SIP Development - David Fees, Dover Office
Mobile Source Controls – Valerie Gray, Dover Office

Air Monitoring Program

Program Manager - Chuck Sarnoski, New Castle Office