Errol Ebanks

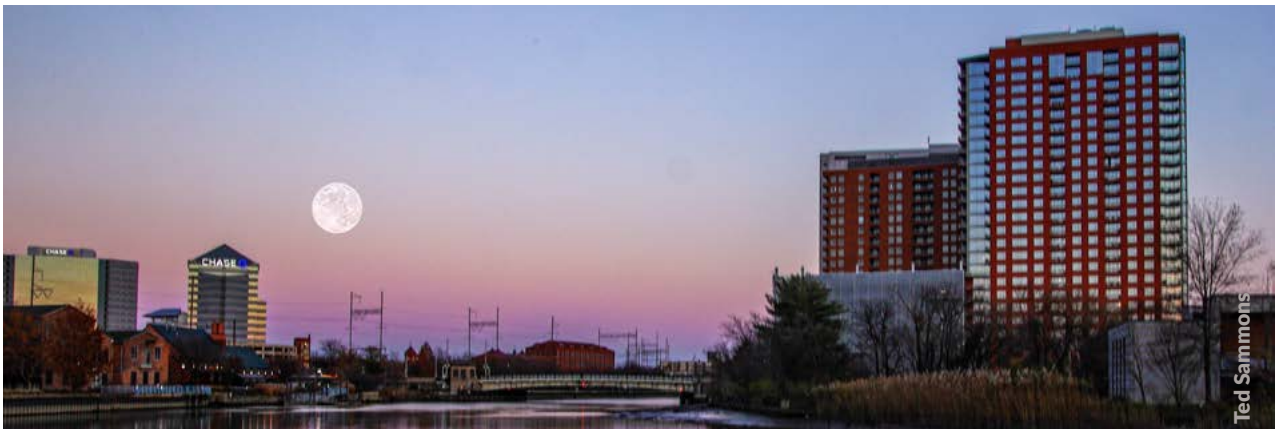
2023

Delaware Annual Air Quality Report

Published April 2025

Executive Summary

This annual air quality report documents the changes and overall improvement in ambient air quality in the state. This report focuses on air quality monitoring. For more information on pollution sources or climate change as it relates to air quality, please visit our website **dnrec.delaware.gov**. Appendix B includes annual data for 2022, 2021 and 2020.



City of Wilmington

In 2023, all pollutants except ozone and fine particulate matter ($PM_{2.5}$) remained below the National Ambient Air Quality Standards (NAAQS) throughout the year. Concentrations of air toxics in Wilmington continued to show low or declining levels.

Throughout the summer of 2023, significant amounts of smoke pollution entered the United States from Canadian wildfires. This had a detrimental impact on air quality throughout the United States, resulting in high ozone and particulates in affected areas, including Delaware.

As measured by the statewide Air Quality Index (AQI), the number of days during 2023 in "good" (green) and "moderate" (yellow) categories declined slightly to 353. In 2022, there were no NAAQS exceedances in Delaware. There were more yellow days in 2023 than typical in recent years. The remaining 12 days of the year had exceedances of the NAAQS for either ozone or $PM_{2.5}$ standards at one or more sites in the state. Of these days, eight were "unhealthy for sensitive populations" (orange), two were "unhealthy" (red) and two were "very unhealthy" (purple). These AQI exceedances do not necessarily indicate non-attainment of the NAAQS.

This report demonstrates, that while Delaware still faces air quality challenges, air quality continues to improve overall. In addition, through the use of continuous PM monitoring and tools like **AirNow.gov**, our ability to communicate air quality concerns continues to improve. It is fundamental to the mission of AQ to help the public make informed decisions about their life and their health, so we will continue to improve and expand access to this critically important information.

The Delaware Department of Natural Resources and Environmental Control's (DNREC) Division of Air Quality (AQ) produced an annual air quality report from 2002 through 2019. In 2020 through 2022, AQ faced some significant challenges. As a result, we did not produce reports in those years. AQ is proud to move forward with this, our annual air quality report for 2023.

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Introduction

In 1970, Congress passed the Clean Air Act (CAA) which authorized the U.S. 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, buildings, etc.).

Community in Selbyville, Delaware.

Six pollutants currently have NAAQS:

- carbon monoxide (CO)
- lead (Pb)
- nitrogen dioxide (NO_2)
- ozone (O_3)
- particulate matter (PM)
- sulfur dioxide (SO_2)

These are commonly called the “criteria” pollutants. When air quality does not meet the NAAQS, the area is said to be in “non-attainment” 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. Technical details regarding monitoring activities along with references and sources of more information are included in the appendices.

Lists of Abbreviations, Acronyms and Initialisms

AQ	Division of Air Quality
AQI	Air Quality Index
CAA	Clean Air Act
CAAA	Clean Air Act Amendments of 1990
CBSA	Core Based Statistical Area
CO	Carbon Monoxide
DCR	Delaware City Refinery
DV	Design Value
DNREC	Department of Natural Resources and Environment Control
EGUs	Electric Generating Units
EPA	Environmental Protection Agency
FRM	Federal Reference Method
FEM	Federal Equivalent Method
GC/MS	Gas Chromatograph/Mass Spectrometer
$\mu g/m^3$	Micrograms per cubic meter
mg/m^3	Milligrams per cubic meter
MSA	Metropolitan Statistical Area
NAAQS	National Ambient Air Quality Standards
NAMS	National Air Monitoring Station
NCore	National Core Monitoring Station
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_X	Oxides of Nitrogen
O_3	Ozone
OTR	Ozone Transport Region
PAMS	Photochemical Assessment Monitoring Station
Pb	Lead
$PM_{2.5}$	Particulate matter less than 2.5 microns
PM_{10}	Particulate matter less than 10 microns
PM_{coarse}	Difference between PM_{10} and $PM_{2.5}$ particulate concentrations
ppb	Parts per billion by volume
ppm	Parts per million by volume
RACT	Reasonably Available Control Technology
RGGI	Regional Greenhouse Gas Initiative
RSG	Refinery Support Group
SIP	State Implementation Plan
SLAMS	State and/or Local Air Monitoring Station
SPMS	Special Purpose Monitoring Station
SO_X	Sulfur Oxides
SO_2	Sulfur Dioxide
TSP	Total Suspended Particulate Matter
VOCs	Volatile Organic Compounds

General Information

DNREC Division of Air Quality

The DNREC Division of Air Quality is led by an Air Quality Division Director and is organized by two main sections that are defined as:

- Planning
- Engineering and Compliance

Planning Section

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 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 (SIP) development, evaluate air emission inventories and verify computer models.

Airshed Planning and Inventory Program

As mandated by the CAA, 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 (HAPs) as defined by the EPA. The Airshed Evaluation and Planning Program seeks to find ways to reverse the non-attainment of an air quality standard by evaluating the combination of air pollution problems that are either generated locally or result from emissions transported through the atmosphere from distant areas. SIPs are prepared and adopted to reduce air pollution burden and to provide a plan to meet "attainment" of air quality standards.

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.

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 Section

Permitting and Compliance Programs

The Engineering and Compliance Section issues air pollution control permits for minor and major stationary air pollution sources. Section personnel conduct periodic facility inspections, review reports and review emission test results to ensure that permit conditions and regulatory requirements are being met. Enforcement actions are initiated for violations 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 emission factors and to determine compliance with permit conditions after a permit has been issued. The program is responsible for observing emission tests to ensure that test methods are followed and reviewing emission test reports for accuracy. A variety of source testing methods are used to verify actual emissions.

Refinery Support Program

The Refinery Support Group (RSG) issues air pollution control permits, reviews reports and conducts inspections for the Delaware City Refinery (DCR), Delaware's largest source of air pollutant emissions. Personnel dedicated to DCR ensure that permit conditions and regulatory requirements are being met. Enforcement actions are initiated for violations of regulations or permit conditions when warranted.

Frequently Asked Questions

1. What is a "criteria" air pollutant?

A criteria air pollutant is an air pollutant that has a NAAQS established for it by the EPA. There are six criteria pollutants: CO, lead, NO_2, ozone, PM and SO_2. PM NAAQS are set for both PM less than 10 microns (PM_{10}) and PM less than 2.5 microns ($PM_{2.5}$). When discussing ozone in this report, we are concerned with ground-level ozone, or tropospheric ozone. This is different from stratospheric ozone, which makes up the protective ozone layer. Concentrations listed below are in either parts per million (ppm), parts per billion (ppb), or micrograms per cubic meter ($\mu g/m^3$).

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 and Secondary	Rolling 3 - month period	0.15 ug/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 and Secondary	1 year	53 ppb	Annual Mean
Ozone (O_3)	Primary and Secondary	8 hours	0.070 ppm	Annual 4th highest daily maxium 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	Primary	1 year	*12.0 $\mu g/m^3$	Annual mean, averaged over 3 years
$PM_{2.5}$	Secondary	1 year	15 $\mu g/m^3$	Annual mean, averaged over 3 years
	Primary and Secondary	24 hours	35 $\mu g/m^3$	98th percentile, averaged over 3 years
PM_{10}	Primary and Secondary	24 hours	150 $\mu g/m^3$	Not to be exceed 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, average over 3 years
	Secondary	3 hours	0.5 ppm	Not to be excceeded more than once per year

* EPA changed $PM_{2.5}$ annual average NAAQS to 9 $\mu g/m^3$ effective February 7, 2024.

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 factors including crop damage, architectural damage, damage to ecosystems and visibility in scenic areas.

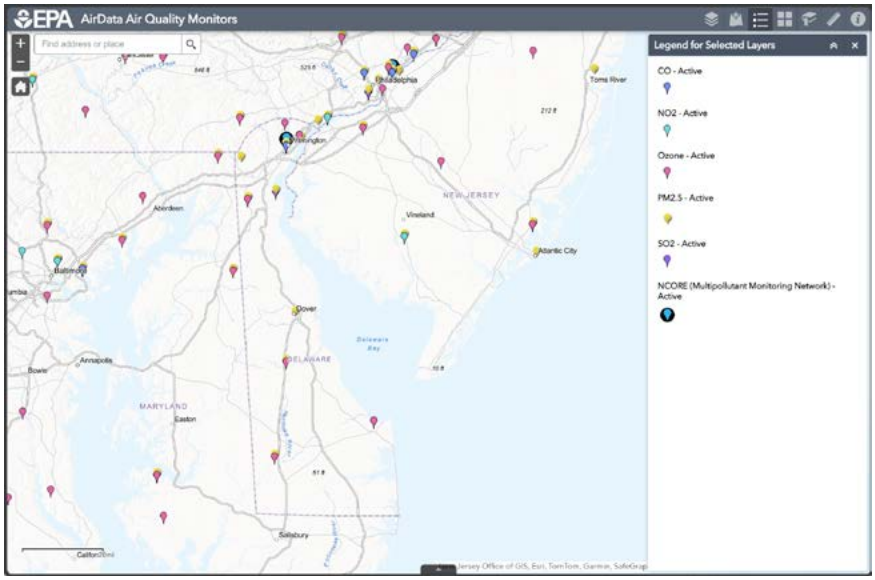
3. How is the location of an air monitoring station decided?

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 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, local zoning issues and long-term (10+ years) site availability. Unfortunately, ideal monitoring sites are difficult 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 NAAQS). Sampling (filter-type) particulate monitors are typically set up on a stand-alone platform or roof. Continuous particulate monitors are typically placed inside of a monitoring station with a roof intake or on a platform in a specialized protective cabinet with intake on top.

Delaware has had air monitoring sites located around the state since the late 1960s. 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 emissions from large facilities were brought into compliance with air quality regulations, the focus has shifted to monitoring ambient air to understand and report the levels on a regional scale.

To see locations of monitoring sites in Delaware and the rest of the country, visit EPA's **Interactive Air Quality Monitoring Tool**.



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.

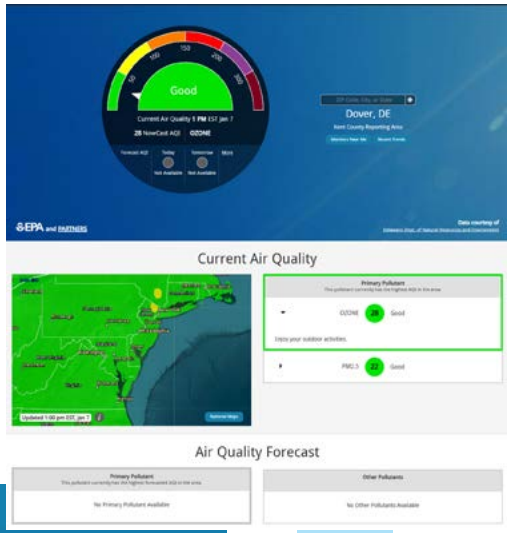
5. What do I do if I have a complaint about an odor or other air quality issues?

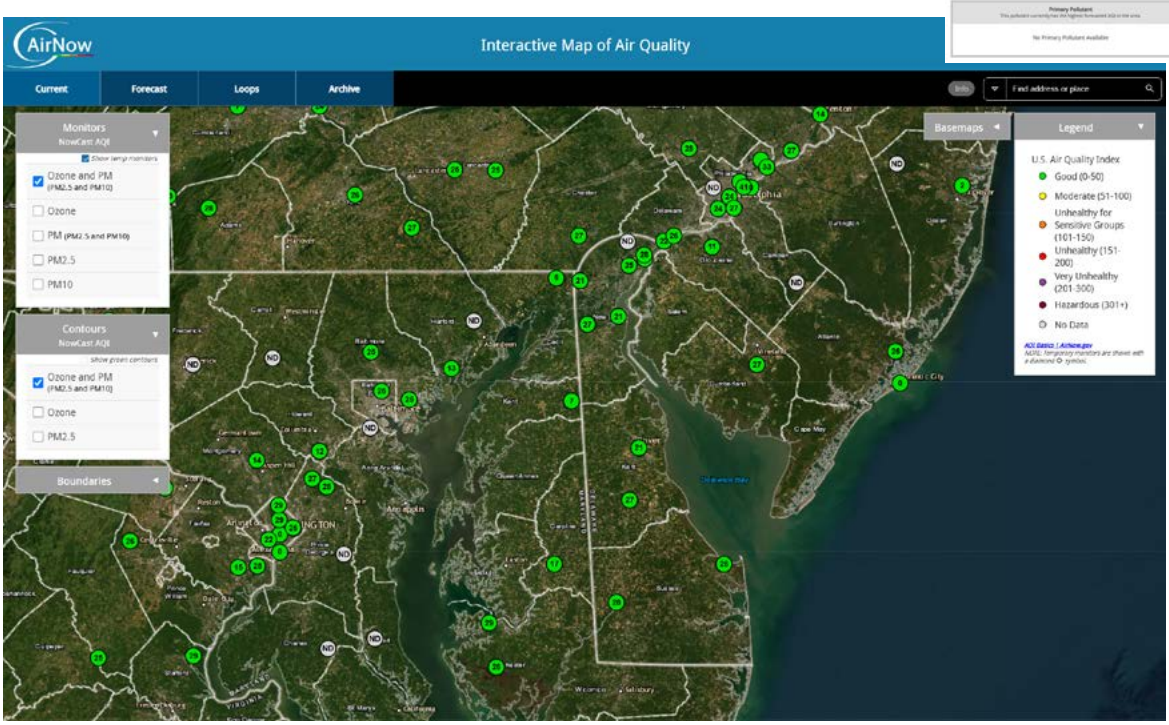
Odors and other environmental complaints can be reported to the Environmental Emergency and Complaints 24-hour Hotline at **1-800-662-8802**.

6. How do I find current air quality data?

Near real time air quality data and other information is available on the **AQ Air Monitoring web page.**

Alternatively, you can visit the **EPA's AirNow** site, which has been updated with the latest AQI ranges (May 2024) and an updated Fire and Smoke Map (September 2024).



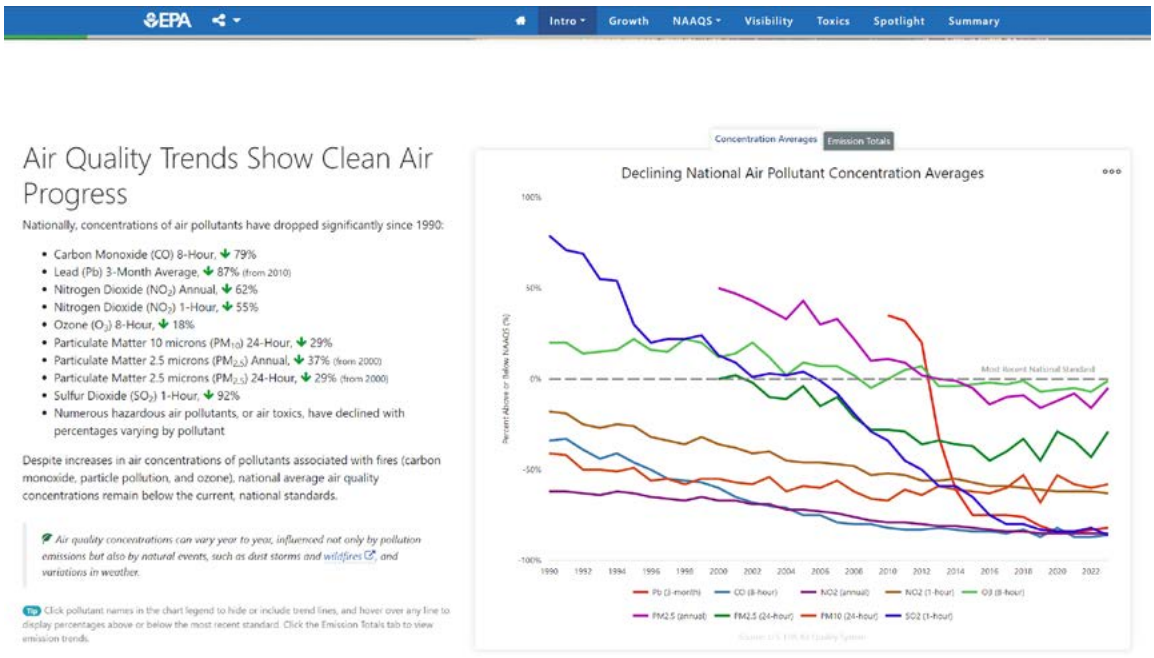


7. How can I find historical air quality data?

Historic air quality data for Delaware and other states is available on the internet from the **EPA's Air Data** site. Delaware's historic annual air quality reports are also available at **dnrec.delaware.gov/air/quality/monitoring/.**

8. How can I find out how air quality compares across the country?

At the Environmental Protection Agency 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 interactive **National Trends Report**.



9. What is open burning and why can't I burn leaves or trash?

Open burning is conducted outside where smoke and other emissions are released directly into the air. Open burning is prohibited in Delaware from May 1 through September 30 due to its contribution to harmful summertime ozone levels. Exemptions include small camping, cooking and ceremonial fires. Delaware's Open Burning Regulations prohibit certain types of burning at all times, to include the burning of leaves and trash which emits large amounts of harmful fine particulates and toxic air pollutants, some of which may be cancer-causing. Since 1968, Delaware has prohibited the burning of trash, while the burning of leaves has been prohibited statewide since 1995. Guidance for allowable burning under specific conditions can be found in a **Citizen's Guide to Residential Open Burning** on AQ's website.

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

Indoor air quality problems are handled by the Environmental Health section of the Division of Public Health, which can be reached at (302) 744-4700.

11. Where do I find the AQ regulations?

The State of Delaware regulations are posted on the **air quality regulations web site**.

Delaware's Air Quality Status

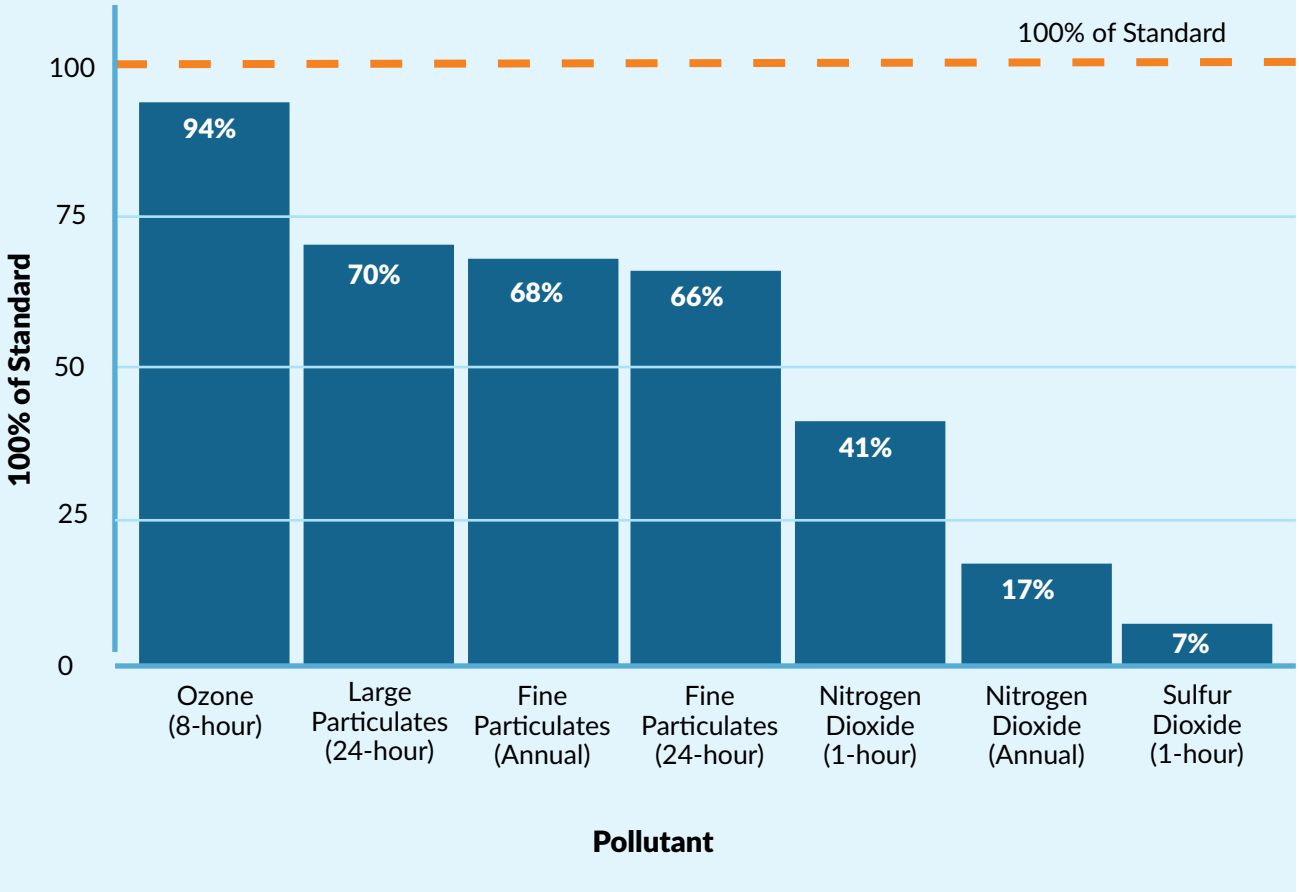
For 2023, Delaware met all NAAQS, based on three-year design values (DV) calculated by EPA. However, eight-hour ozone averages at Lums Pond (in New Castle County) exceeded the NAAQS standard on four separate days, three of which were due to Canadian wildfire smoke intrusions in June. Because the annual ozone DV is determined by the fourth-highest ozone day of the year, Lums Pond did not meet the ozone NAAQS for 2023. Delaware applied for an "Exceptional Event" designation due to the wildfire smoke, which would exclude it from the DV calculation. EPA approval decision is deferred at this time. However, because ozone DV are averaged over three years for regulatory purposes, the 2021-2023 ozone DV for New Castle County did meet the NAAQS.

Over the last 10 years, trends in ambient concentrations of criteria pollutants have been either level or declining. 2023 was an exception as ozone, PM_{10} and $PM_{2.5}$ 3-yr DV all increased in 2023, due to foreign wildfire smoke. Other criteria pollutants (NO_2, SO_2) continued to decline.

Note: Lead is a criteria pollutant. Delaware is in attainment for the NAAQS. In 2016 EPA ruled that monitoring for lead is no longer required at National Core (NCore) sites. (**Federal Register Vol. 81, No. 59, 3/28/2016**). Monitoring continues as part of the Chemical Speciation Network but is not reported here.

Figure 1: 2023 Polluntant Design Values as a Percent of Primary Standard

The maximum 3-year design value observed across all monitoring sites, converted to a percentage of primary National Ambient Air Quality Standards (NAAQS).



EPA Air Quality Index (AQI)

Description

The AQI was created by the EPA to ensure national uniformity of daily air quality reports. Ambient concentrations of five pollutants (CO, NO_2, ozone, PM_{10}/$PM_{2.5}$ and SO_2) are used to calculate a health-related value or index. The procedures and calculations used to generate the AQI are defined by the EPA.

For each pollutant, the AQI is calculated using mathematical functions to transform ambient pollutant concentrations onto a scale from zero to 301+, with 101 corresponding to the low end of the NAAQS orange "Unhealthy for Sensitive Groups" category. Index ranges and descriptions are listed in Table 2. The AQI is used most frequently for ozone and PM, because these pollutants are the most likely to be present at or above the NAAQS.

Table 2: Air Quality Indexes and Descriptions

Color	Levels of Concern	Value	Description of Air Quality
Green	Good	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Yellow	Moderate	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Orange	Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Red	Unhealthy	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Purple	Very Unhealthy	201 to 300	Health alert: The risk of health effects is increased for everyone.
Maroon	Hazardous	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

Delaware Annual AQI

Delaware reports criteria pollutant concentrations from the statewide monitoring network on an hourly basis to the **EPA AirNow** website. AirNow uses Delaware's data to calculate an AQI for each pollutant. The pollutant with the highest AQI determines the AQI category for the day. The figures below show the calculated AQI for each day in each county for 2023. New Castle County had 10 days in the orange category or higher; Kent County had eight; Sussex County had six. These high AQI days were mostly associated with Canadian wildfire smoke. Some pollutants such as ozone and PM are influenced by seasons. Warmer months tend to have higher ozone. Cooler months tend to have more particulates. More information on seasonal variations can be found in this report under pollutant sub-sections.

Figure 2: 2023 New Castle County, DE Air Quality Index Calendar

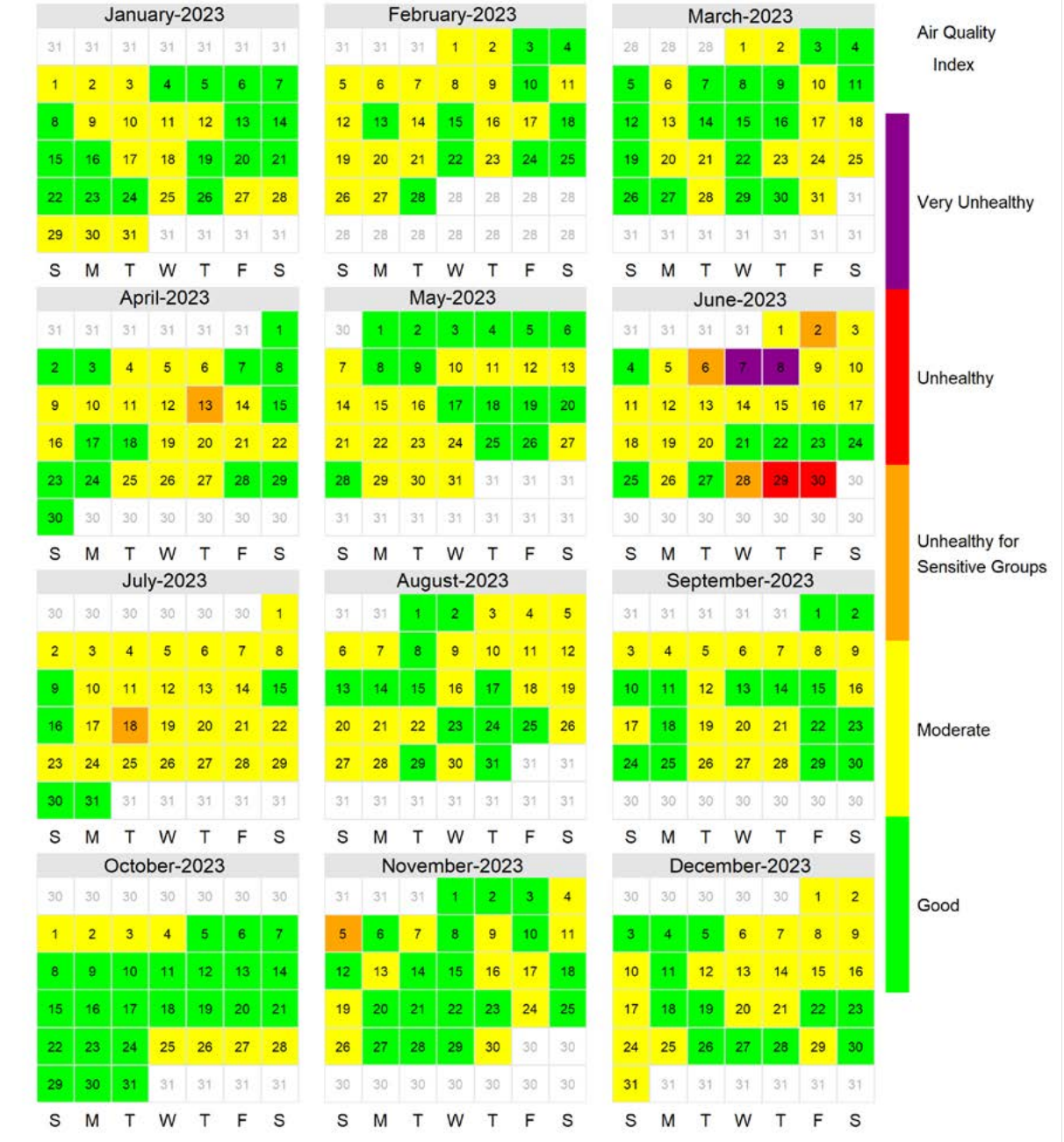


Figure 3: 2023 Kent County DE Air Quality Index Calendar

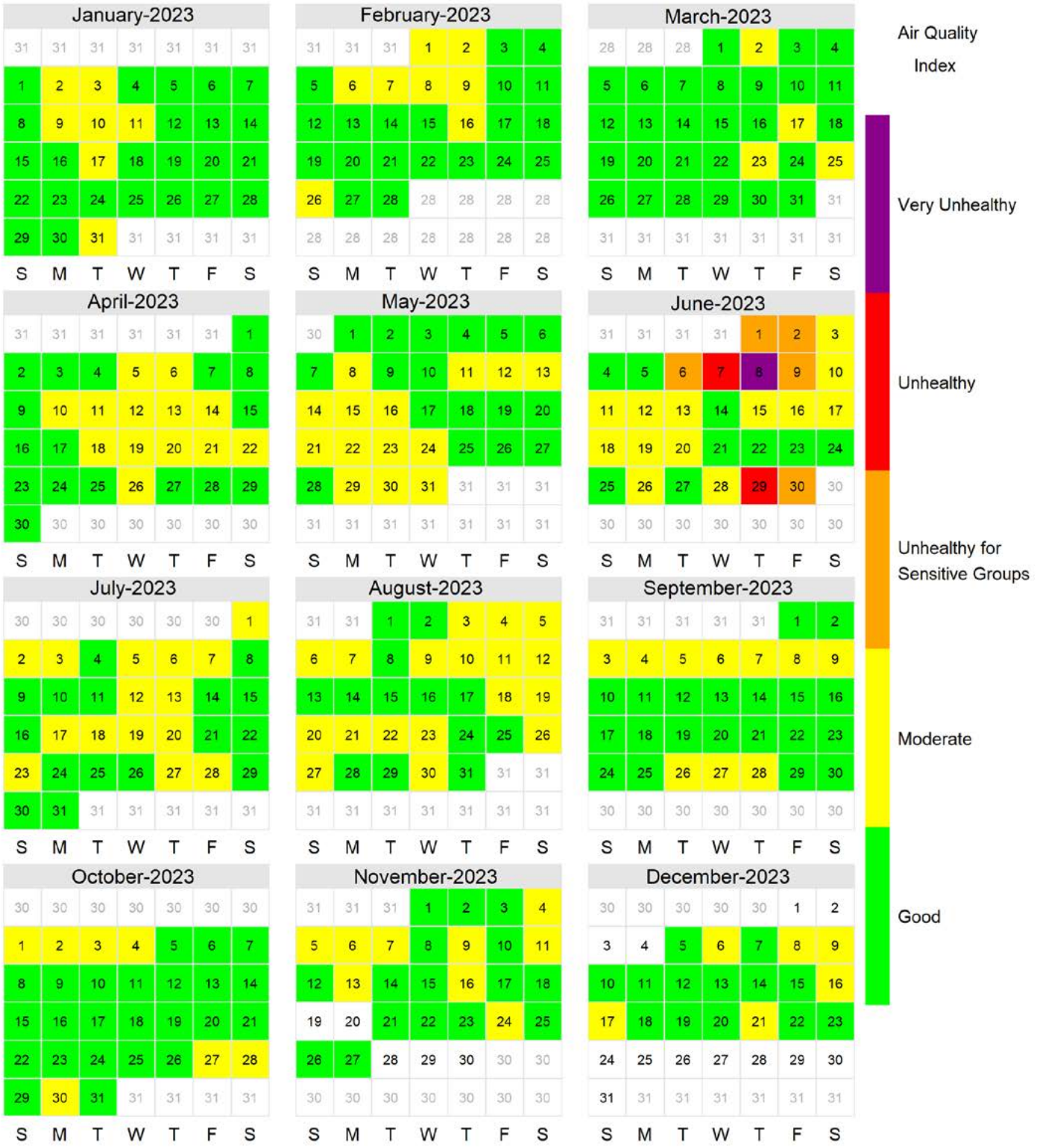
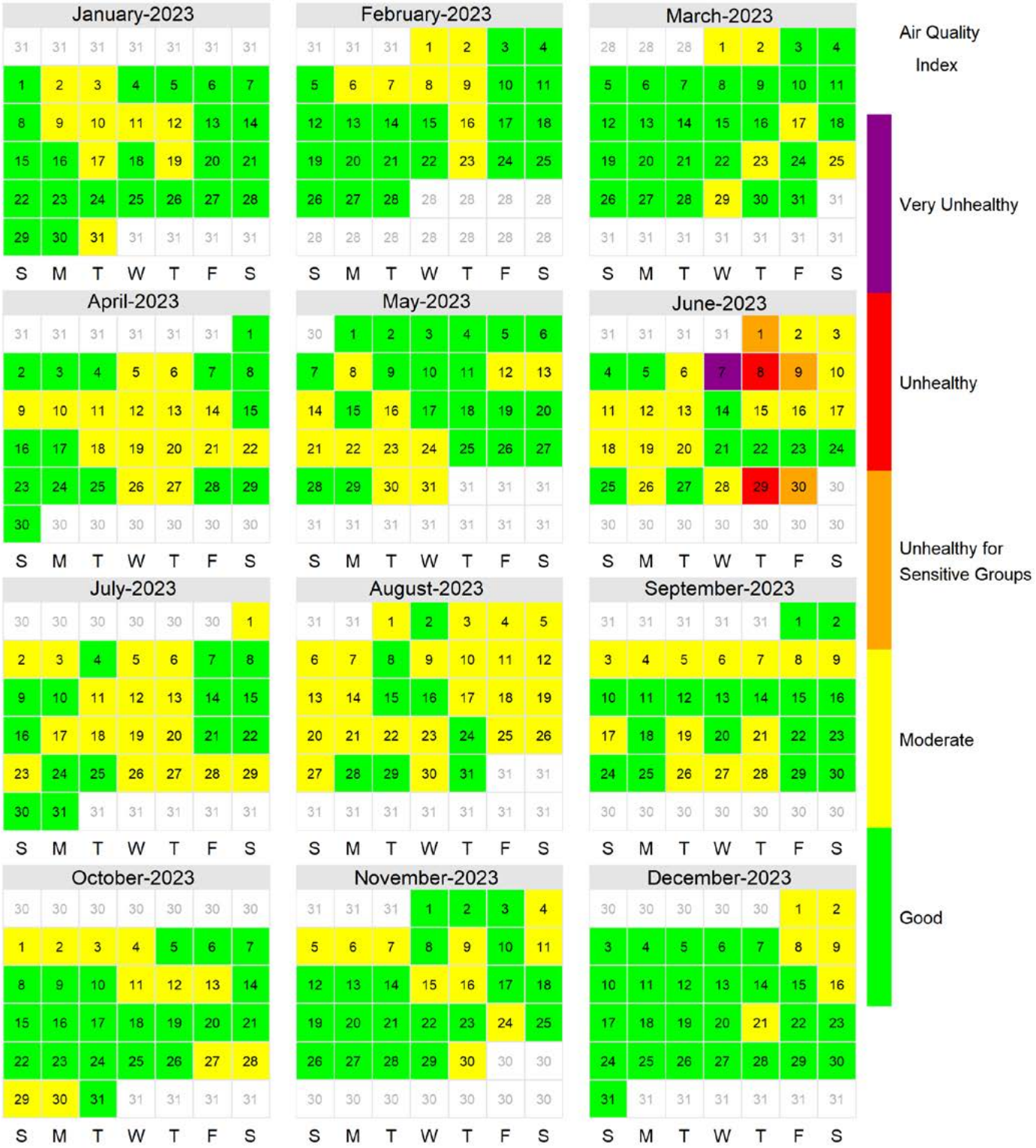


Figure 4: 2023 Sussex County DE Air Quality Index Calendar

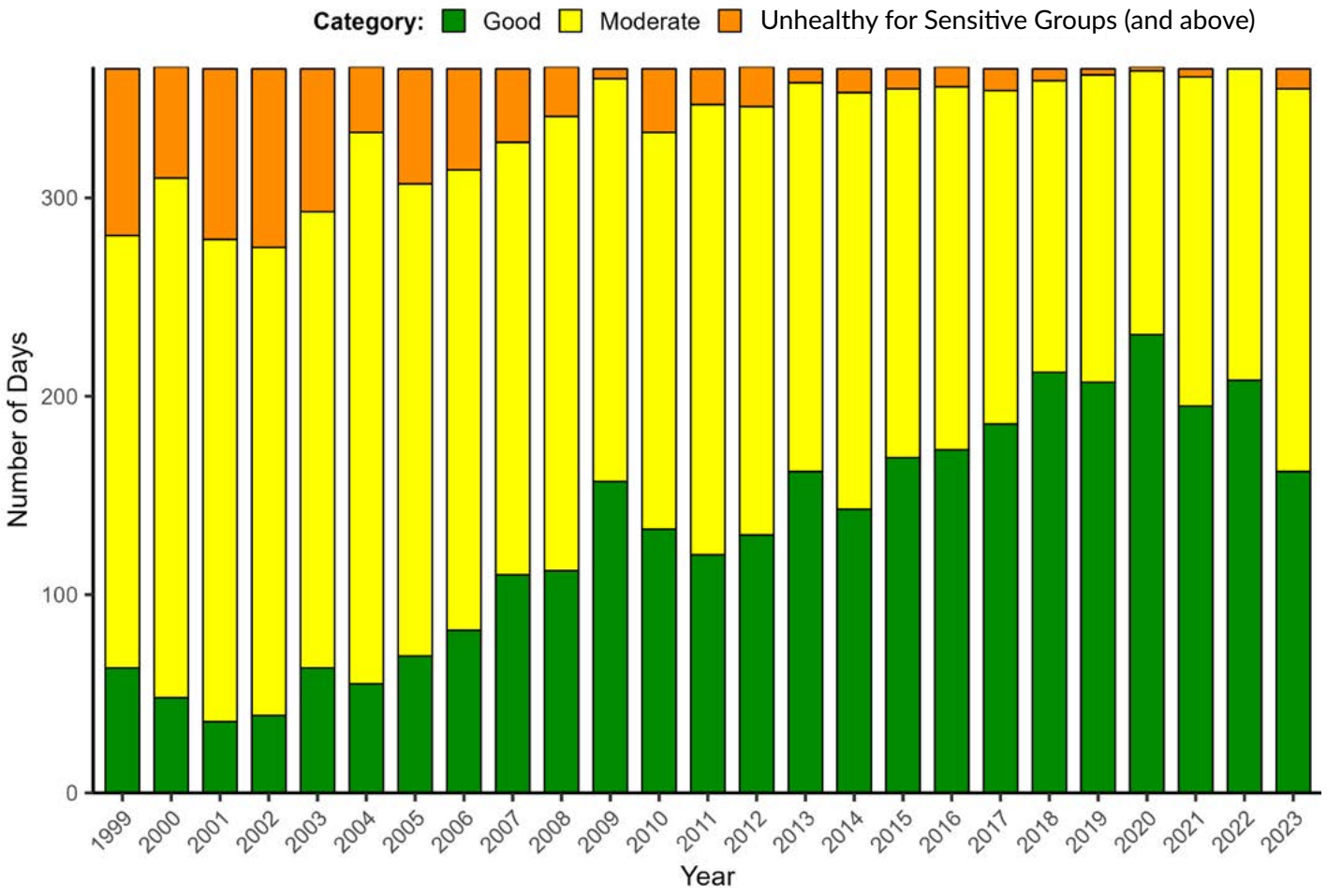


The definition of AQI levels has been updated through the years. For example, in 1999 an ozone level of 80 ppb would have been considered "Moderate" (yellow), while in 2023, 80 ppb is considered "Unhealthy for Sensitive Groups" (orange). For current AQI definitions, see Federal Regulation **40 CFR 58 appendix G** "Uniform AQI and Daily Reporting."

The graph below shows the daily AQI trends for New Castle County from 1999 through 2023, according to 2023 AQI definitions, so that data from different years is comparable.

The number of days with good-moderate air quality has been generally increasing. 2023 was an exception due to wildfire smoke from outside the State.

Figure 5: 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 pollutants for which NAAQS have been established. The earliest monitors were placed near pollution sources to measure direct impact of pollution emissions. As ambient air pollution standards became established and monitoring methods standardized, the monitoring network expanded to include monitors in both urban and suburban areas. Monitoring goals shifted to include measuring high pollution concentrations in population centers, detecting trends and determining compliance with the new national and ambient air quality standards, as well as establishing background levels and measuring pollution transported from areas outside of Delaware.

In 2006, the EPA introduced a requirement to establish NCore monitoring stations. National Core Monitoring Station 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.

Martin Luther King monitor station in Wilmington, Delaware.

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. Different stations also monitor different pollutants, depending on sources, population and monitoring goals for the station. As air quality has improved and ambient levels continue to be well below standards, monitoring for certain pollutants such as CO and Oxides of Nitrogen (NOx) are only monitored at the NCore monitoring site in Wilmington. More detailed information on the network is available in the **Delaware Air Monitoring Network Plan** which can be found under the Delaware Air Quality Monitoring Network heading of the **monitoring website**. See also question three in the FAQ section for more information on how and why monitors are sited.

The network is maintained and operated by the Air Monitoring Program within the Planning Section of the AQ. 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 a central data storage computer. Particulates are collected as 24 hour samples that run every day, every third day, every sixth day; or, collected continuously with hourly averages. The Delaware Air Monitoring Network consists of sites and monitors listed in Table 3 and Figure 6.

Table 3:
Delaware Air Monitoring Network and Criteria Pollutants Monitored County

Site	CO	NO_2	Ozone	PM_{10}	$PM_{2.5}$	SO_2
Brandywine Creek State Park			X			
Bellefonte I and II						
River Road Park (I)					X	
Bellevue State Park (II)			X			X
MLK National Core (NCore) *Wilmington*	X	X	X	X	X	X
Newark					X	
Delaware City (Rt. 9)					X	X
Lums Pond State Park			X		X	X
Dover					X	
Killens Pond State Park			X		X	
Lewes			X			X
Seaford			X		X	

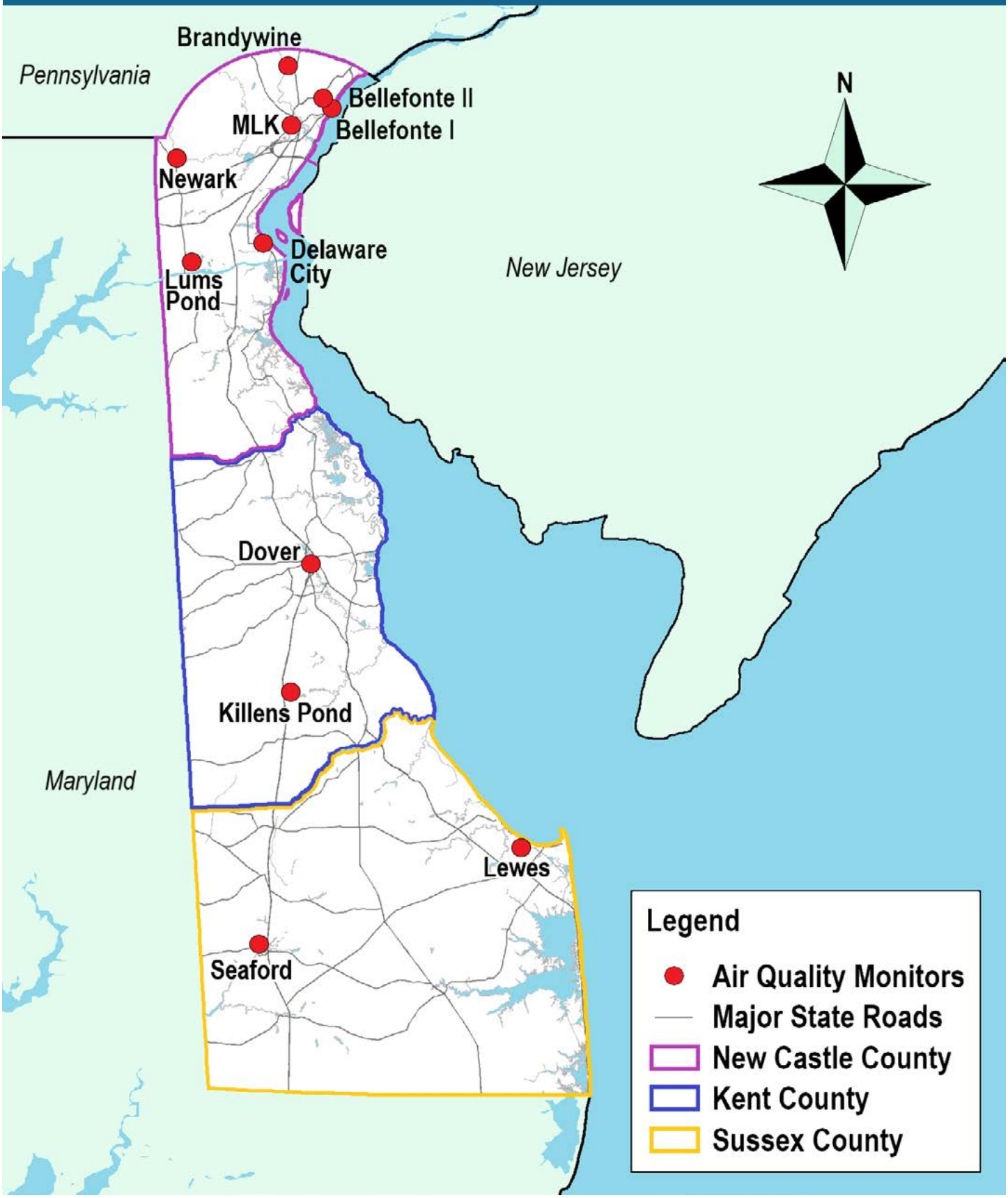
"X" indicates pollutant monitored

Bellefonte II Site Shelter

Dover Monitoring Platform

Lums Site Shelter

Figure 6: Map of Air Quality Monitoring Sites



Factors Influencing Air Quality and Air Quality Measurements

Wildfire Smoke

In the summer of 2023, large areas of the United States were plagued with poor air quality as the result of long-range transport of wildfire smoke from Canada. Delaware's air quality failed to meet the daily $PM_{2.5}$ NAAQS on 10 days in 2023 (June 1, 6, 7, 8, 9, 28, 29 and 30; July 1 and 18). Wildfire smoke not only contributes to elevated PM, but also to elevated ozone. The smoke contains a dense mixture of ozone precursors. This caused several ozone exceedances during or around the days when PM exceedances were measured. Ozone exceedances corresponding with wildfire smoke transport took place on June 2, 7, 29 and 30. The wildfire smoke contributed to ozone exceedances resulting in an annual DV at the Lums Pond site of 0.072 ppm, the highest annual DV in the State. This was above the NAAQS of 0.070 ppm.

The EPA defines exceptional events as "unusual or naturally occurring events that can affect air quality but are not reasonably controllable using techniques that tribal, state or local air agencies may implement in order to attain and maintain the National Ambient Air Quality Standards." Delaware drafted and submitted our first exceptional event demonstration to the EPA for the June 2, 2023 ozone exceedance at Lums Pond (**dnrec.delaware.gov/public-notices/aq20240114/**). EPA has deferred their decision on the demonstration due to the lack of regulatory significance.

Glimpse of smoky wildfire raging in Canada.

Approximately 270 individual wildfires burned across west-central Canada in mid-May of 2023. While a few fires commenced in earlier May, the period from May 13-20 effectively started the record setting wildfire season in Canada. In just these eight days, nearly as much acreage burned as the average annual total Canadian burn area, and 50-60% of previous highest annual totals. The fires were also intense, with one of the greatest collective and cumulative radiative power periods of the entire 2023 Canadian season. A prodigious smoke plume from these fires entered the contiguous United States (CONUS) on May 20.

Regional ozone concentrations, already increased by above average temperatures, were higher by more than 20 ppb on June 2, 2023, compared to otherwise similar days without smoke. Surface ozone production was enhanced near sources of nitrogen oxides (NO_X), such as urban centers. But it increased everywhere as plumes of smoke moved across the Mid-Atlantic. Furthermore, enhanced ozone was pre-existing within the regional smoke plume and was observed tracking with it long before arriving in Delaware. There is a clear causal relationship between the smoke and higher ozone, which led to ozone exceedances throughout Delaware's New Castle and Kent counties on June 2.

Communication with the public throughout the periods of poor air quality was imperative. AQ coordinated with other state agencies throughout Delaware and spoke with news organizations to ensure that the public was informed and aware of the situation and the actions they could take to be protective of their health.

PM Measurement Technique Update

In coordination with EPA and using funds from the American Rescue Plan (ARP) Grant, many states, including Delaware, are in the process of transitioning from filter based, Federal Reference Method (FRM), PM monitoring equipment to continuous, Federal Equivalent Method (FEM), PM monitoring equipment. This transition is necessary because it provides real-time data for communities and individuals to use when making decisions about their outdoor activities and health.

EPA is aware that there is a positive bias present in FEM data when compared to FRM data. Delaware and other states requested that EPA take steps to address the positive bias of continuous FEM data as compared to filter based FRM data.

Using EPA's **$PM_{2.5}$ Continuous Monitor Comparability Assessments** for 2019-2021 in New Castle County, Delaware's two collocated sites exhibited a positive bias that varied from 17% to 29%. This is consistent with reports from other state, local or tribal air agencies (SLTs) and from **EPA** about bias from different models of FEMs. When EPA proposed the new PM NAAQS, Delaware submitted a comment letter supporting a national solution for addressing bias. Delaware strongly requested that EPA work with FEM equipment manufacturers to diagnose causes of bias and address them appropriately.

Teledyne manufactures light scattering type continuous FEM monitors, models T640 and T640X. This is the equipment Delaware selected as the replacement for filter based FRM equipment. Since 2019, Delaware has transitioned all but one site (MLK) to use the T640 as primary monitor, relegating filter based Thermo Partisol 2025/2025i FRM models at those sites to collocated (secondary) monitors, or in some cases replacing FRM monitors entirely.

In 2023, Teledyne released a "correction algorithm" with EPA approval, which was made available to all T640 operators as a firmware update. EPA requested that all operators install the updates and enable the correction algorithm. EPA then applied the correction to all historical T640 data, while archiving the original uncorrected data. Delaware applied the new algorithm as directed by EPA before the end of 2023. Since then, all T640 PM data collected in Delaware has used the correction algorithm.

The effectiveness of the algorithm continues to be evaluated. While it provides some relief from known biases in T640 monitors at lower PM levels, it does not provide sufficient correction at higher levels, such as during wildfire smoke conditions. Delaware plans to continue evaluating possible alternatives for the future, seeking to improve accuracy over a wider operating range while still providing continuous measurements.

Air Quality – Pollutants that Exceeded Standards

Ozone

Description

Ozone 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. Tropospheric ozone is also called ground-level ozone. 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 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 & Secondary 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 = 0.120 ppm, former NAAQS, current Delaware AAQS.
  - Note: EPA revoked the one-hour standard for ozone in June 2005. Delaware has maintained the one-hour standard in its regulations (Regulation 1103) due to historical non-attainment designations and continues to track and record these values.
  - The one-hour standard is achieved when the number of days per calendar year, with a maximum hourly average of greater than 0.120 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 NOx and volatile organic compounds (VOCs) in the presence of sunlight and warm temperatures. When temperature and sunlight are not sufficient to form ozone, these same compounds destroy ozone, which may be referred to as “scavenging.” Sources of NOx include automobiles, power plants and other combustion activities. Volatile organic compounds 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 exhaust and regulation of VOC and NOx 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 to avoid "scavenging" of ozone by NOx emissions. While short-term one-hour average peak ozone levels are usually highest in New Castle County, longer-term eight-hour averages are normally below the standard throughout Delaware.

Figure 7:
Map of Delaware Ozone

Delaware Air Quality and Trends

Hot, dry weather and stagnant air conditions favor the formation of ozone and the greatest number of exceedance days typically occur during the summer.

Overall, Delaware ozone levels have shown a downward trend, with fewer exceedance days despite the standard being lowered twice in the past two decades.

Eight-hour Ozone Data and Trends

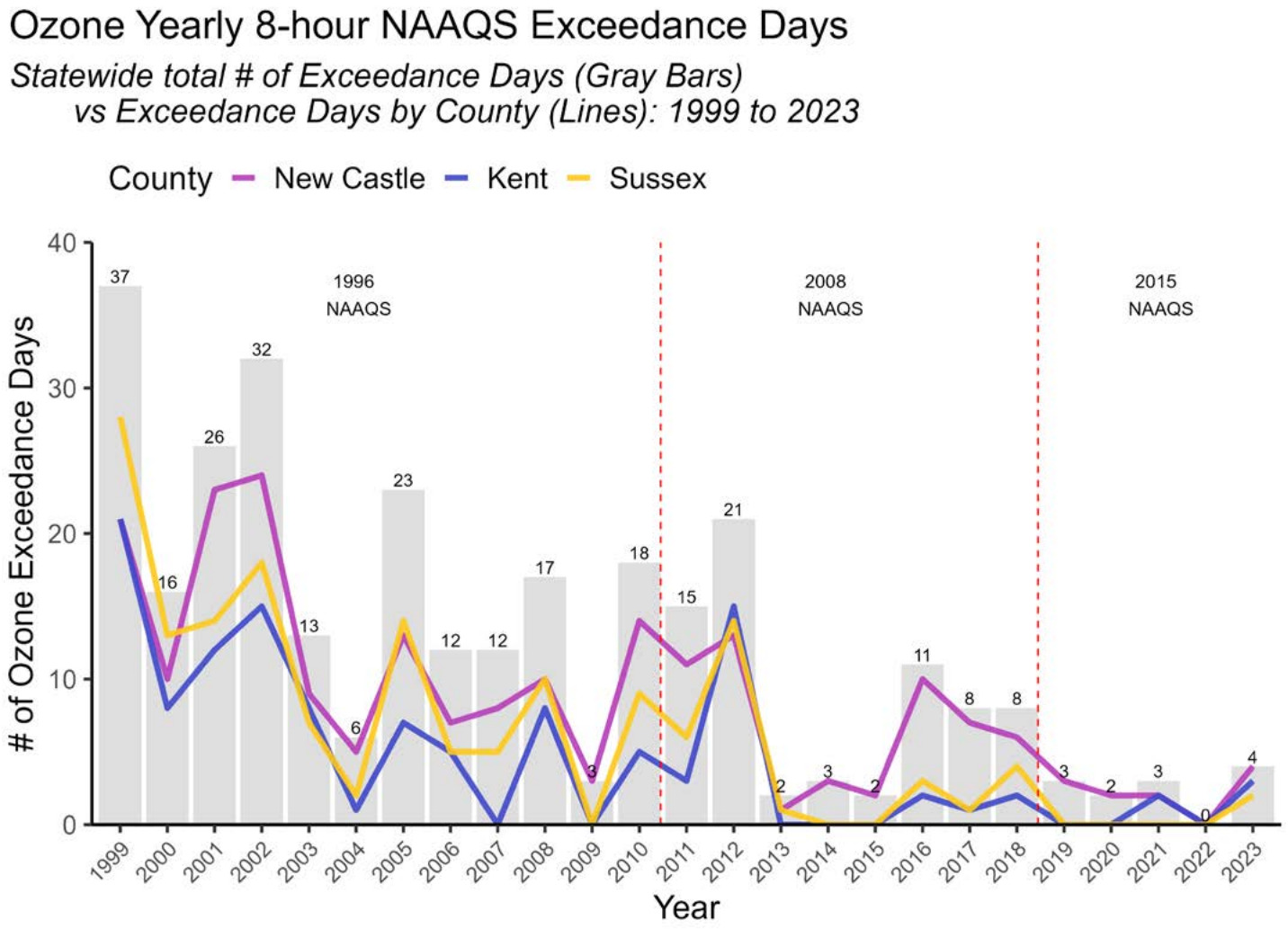
2008 NAAQS: Prior to 2008, a measured eight-hour average concentration would have exceeded the 0.08 ppm standard if the concentration was equal to or greater than 0.085 ppm. This is due to numerical rounding to two decimal places. In 2008 the eight-hour standard was revised to 0.075 ppm with numerical rounding to three decimal places.

2015 NAAQS: In October 2015 the eight-hour NAAQS was strengthened to 0.070 ppm (continuing with numerical rounding to three decimal places). Currently a measured 8-hour average concentration above 0.070 ppm is an exceedance of the standard. Exceedances in 2015 are counted based on the 2008 standard since the 2015 NAAQS was not enacted until after the 2015 Ozone Season.

In 2023 ozone exceedances occurred on four days in New Castle County, three days in Kent County, and two days in Sussex County. Lums Pond in New Castle County was the only site with four exceedance days. Since the fourth-highest day at each site is used for comparison, the NAAQS was met at all sites except Lums Pond, pending a decision by EPA on Delaware's Exceptional Event Demonstration submission for June 2nd at Lums Pond.

In the figure below, the total number of statewide exceedance days is shown as a bar chart in gray based on the applicable standard. The lines for each county do not necessarily correspond with the statewide count because an exceedance in a particular county may have occurred on the same day as another county.

Figure 8: Number of Days Exceeding 8-hr Ozone NAAQS



The "Ozone Design Value by county" numbers in the figure on the following page are the annual fourth-highest (4th Maximum) daily eight-hour concentration, averaged over three years, referred to as the DV. If the DV is less than or equal to the standard, the eight-hour standard is attained. Based on 2021–2023 data, all three counties in Delaware attained the ozone eight-hour NAAQS (see Table 5). However, New Castle county is part of the Philadelphia-Camden-Wilmington, PA-NJ-DE-MD Metropolitan Statistical Area (MSA), which may also be listed as Philadelphia-Wilmington-Atlantic City, Pennsylvania, New Jersey, Maryland and Delaware. If any monitor's Design Value in the MSA exceeds the standard, the highest DV determines the classification for the entire MSA. For 2021–2023 the MSA DV was 0.073 ppm which exceeded the 0.070 ppm standard. This only impacts New Castle County's attainment status; the other two counties are unaffected.

Figure 9: Ozone Design Value by County

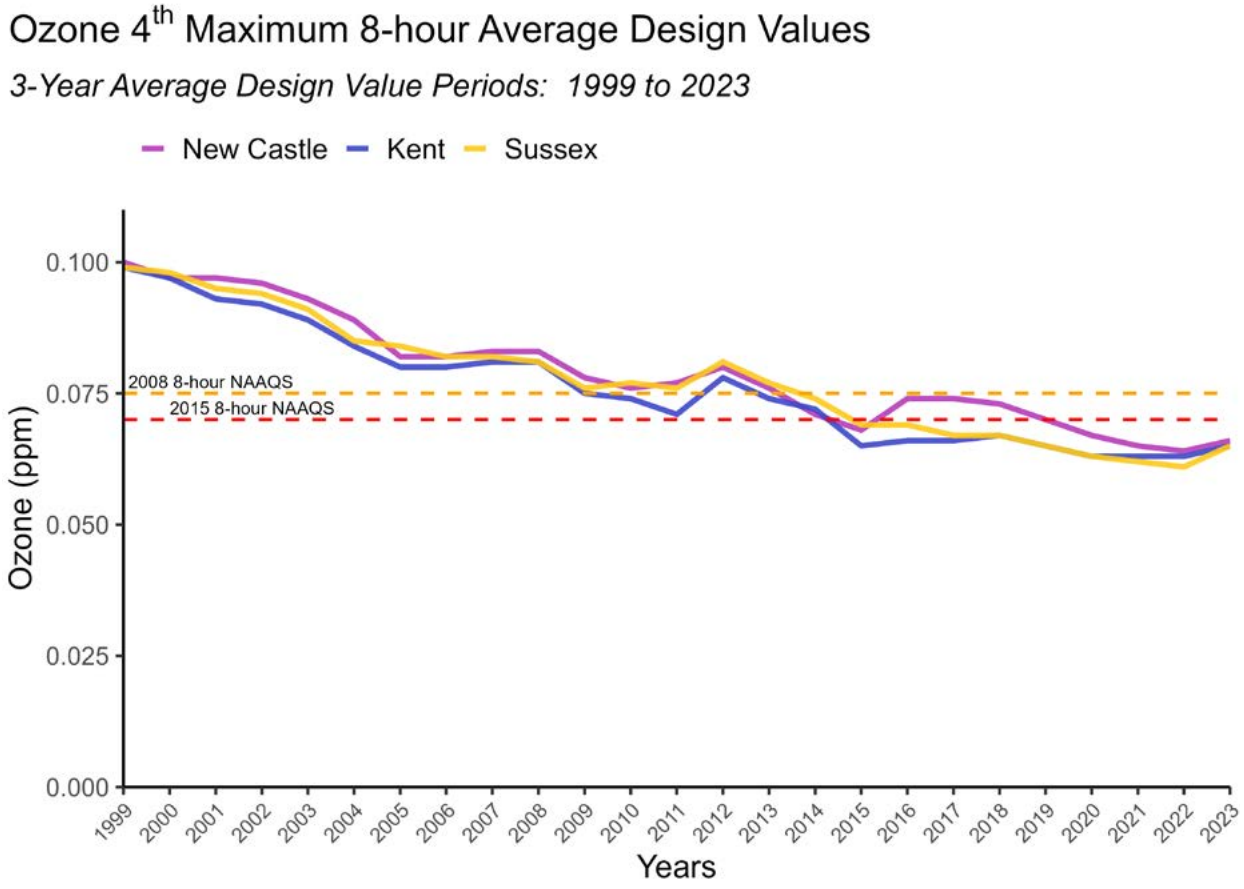


Table 4: Ozone 1-Year Site Design Value (ppm)

2023 Site (listed North to South)	Number of Ozone Exceedance Days and Maximum per Site (ppm) # Exceedances	1st Max.	2nd Max.	3rd Max.	(Design Value) 4th Max.
Brandywine Creek State Park	3	0.073	0.071	0.071	**0.070**
Bellefonte II	2	0.077	0.073	0.070	**0.069**
MLK National Core (NCore)	3	0.080	0.078	0.071	**0.069**
Lums Pond State Park	4	0.085	0.074	0.072	**0.072**
Killens Pond State Park (*Felton*)	3	0.073	0.072	0.071	**0.069**
Lewes	0	0.067	0.067	0.065	**0.065**
Seaford	2	0.079	0.073	0.070	**0.068**

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

Table 4 shows the 2023 one-year DV determination for each ozone monitoring site. For each day, the maximum eight-hour average is determined. The fourth-highest daily eight-hour maximum is taken as the one-year DV for that site. More information is available at **Air Quality Design Values** on the EPA website.

Table 5: Ozone Trends: 3-Year Design Value (ppm)

Site (listed North to South)	2011 to 2013	2012 to 2014	2013 to 2015	2014 to 2016	2015 to 2017	2016 to 2018	2017 to 2019	2018 to 2020	2019 to 2021	2020 to 2022	2021 to 2023
Brandywine Creek State Park	0.073	0.071	0.069	0.074	0.074	0.073	0.069	0.063	0.063	0.062	0.066
Bellefonte II	0.076	0.071	0.068	0.070	0.071	0.072	0.070	0.066	0.064	0.063	0.066
Lums Pond State Park	0.075	0.071	0.069	0.071	0.072	0.071	0.069	0.067	0.065	0.064	0.066
MLK National Core (NCore)	0.074	0.071	0.066	0.068	0.067	0.069	0.068	0.065	0.062	0.062	0.066
Killens Pond State Park	0.074	0.072	0.065	0.066	0.066	0.067	0.065	0.063	0.063	0.063	0.065
Seaford	0.077	0.074	0.069	0.069	0.067	0.067	0.063	0.062	0.059	0.060	0.062
Lewes	0.075	0.070	0.064	0.065	0.065	0.066	0.065	0.063	0.062	0.061	0.065

Note: Official EPA Design Values may vary due to data completeness rules for calculations. For historical consistency those complexities are not detailed or indicated in this document unless a value is unavailable.

Table 5 shows trends over the last decade for three-year Average DV at each Delaware ozone monitoring site.

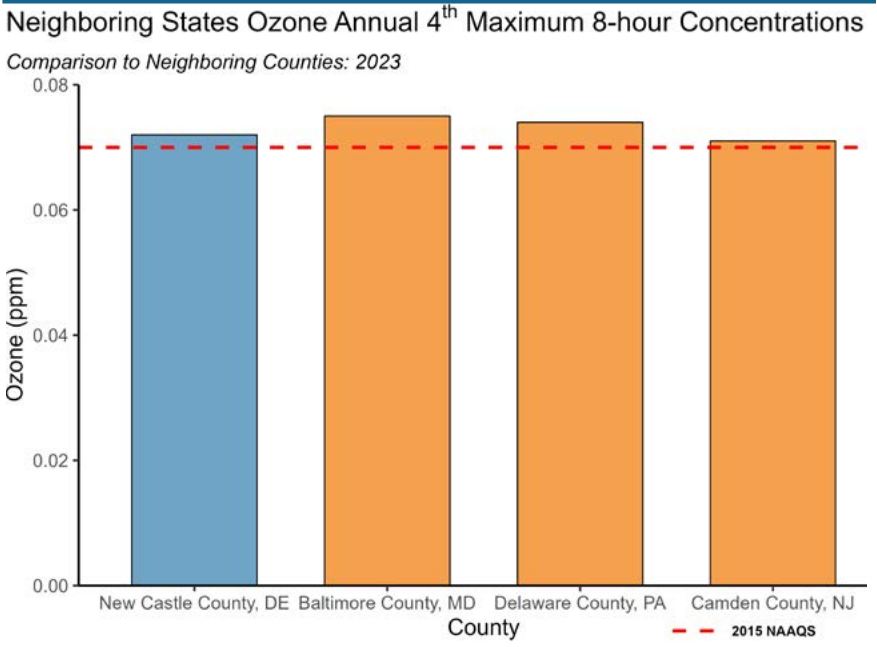
State Regulation

The State of Delaware primary and secondary ozone ambient air quality standards (separate from the NAAQS), per State Regulation 1103, are met when the number of days per calendar year with maximum hourly average concentrations above 235 µg/m^3 (0.12 ppm) is equal to or less than one. In 2023, the maximum one-hour average ozone concentration was 0.10 ppm on June 2, which met the State standards.

Regional Ozone Levels

Ozone levels recorded by Delaware monitors were similar to those recorded at other monitoring sites in the region in 2023. These are not DV, which are computed as a three-year average. Only data from 2023 is included here. These values do not include possible reductions due to EPA Exceptional Events determinations regarding Canadian wildfire smoke

Figure 10:
Ozone Design Value by County



Ozone Mapping Project (AirNow)

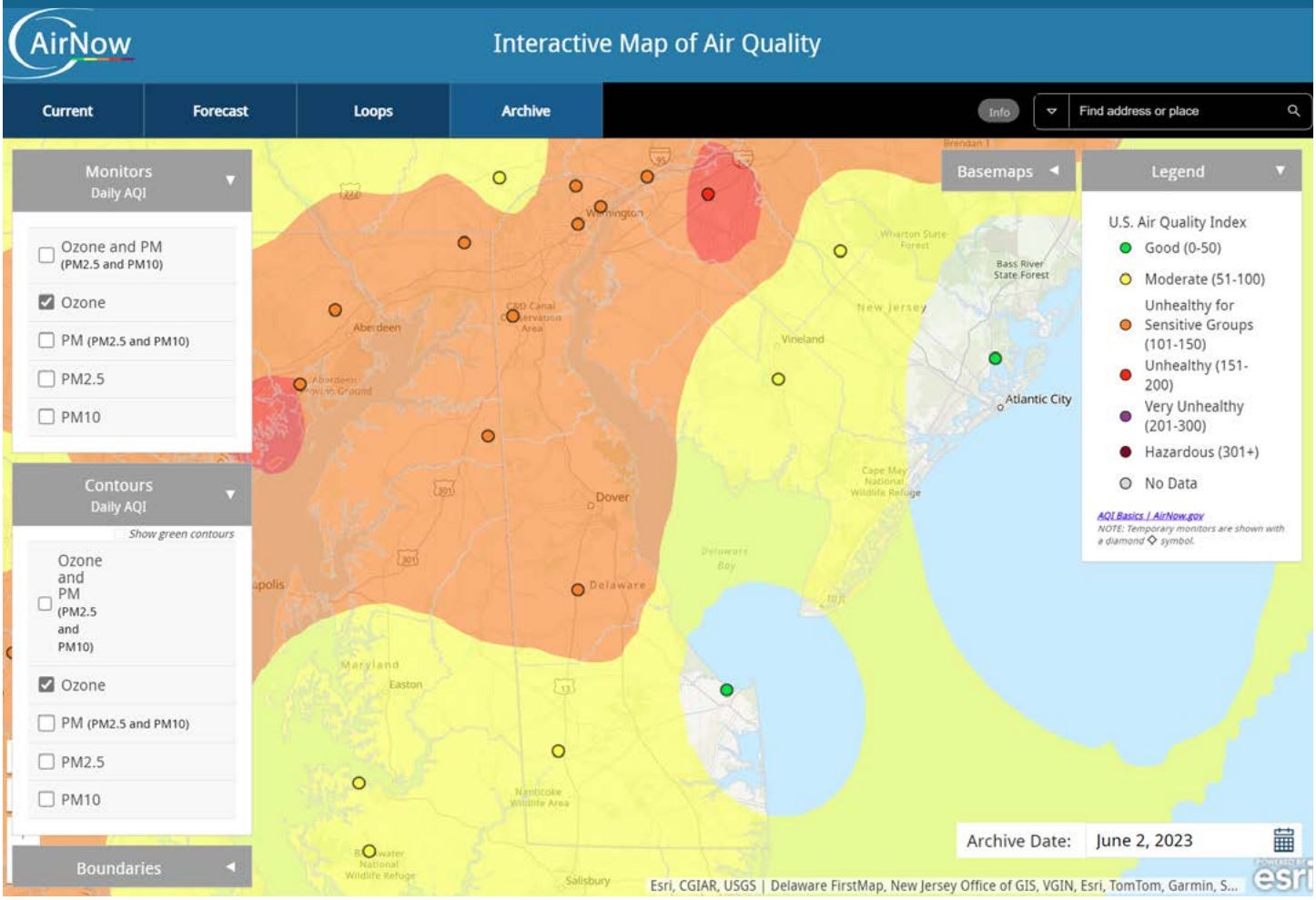
The Ozone Mapping Project has been integrated into EPA's **AirNow** website and includes PM and ozone data. Participating states and local agencies submit real-time pollutant data to the AirNow database where the data is converted into color-coded maps based on the AQI (Table 2). These maps are then distributed by AirNow 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 AirNow is to increase awareness of elevated ozone and PM concentrations so people can take protective measures and to educate the public about the regional nature of ozone formation and transport. For more information, current and historical maps, please visit the EPA **AirNow** web site.

Following is an example of an ozone map from the updated AirNow system showing the regional nature of increased ozone levels.

Air Quality Index Ozone Peak Values – June 2, 2023

Figure 11: Air Quality Index Ozone Peak Value Example



Source: EPA AirNow website Maps. Archived **maps** are available in the menu at the bottom right as seen in the screen capture above.

Air Quality – Pollutants that Met Standards

Carbon Monoxide (CO)

Description

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

The State standard is the same as the NAAQS.

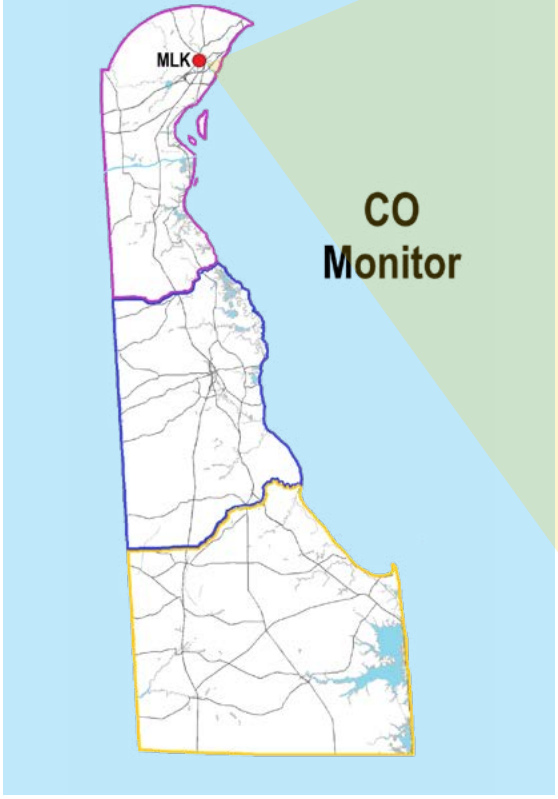
Sources

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

Locations

The monitor for CO is located at the Wilmington MLK NCore site, in New Castle County.

Figure 12:
Map of Delaware CO Monitors



CO Monitoring at MLK NCore

Delaware Air Quality and Trends

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

There has been a slight downward trend in CO concentrations since monitoring began in the 1970s, 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.

Due to equipment malfunctions and supply chain issues, Delaware was unable to monitor CO in 2023. EPA calculates the eight-hour average DV for CO as the higher of two consecutive years' second-highest values. Because of the lack of 2023 data, the Delaware CO DV for 2023 will be the second-highest value from 2022 (0.8 ppm). This is less than a tenth of the NAAQS value of 9 ppm.

Nearby sites show 2023 DV between 1.2 and 1.4 ppm. Historically, Delaware DV have been lower than these three nearest CO monitoring sites.

Figure 13: CO Design Value Trends - Primary 1-hour and 8-hour Averages

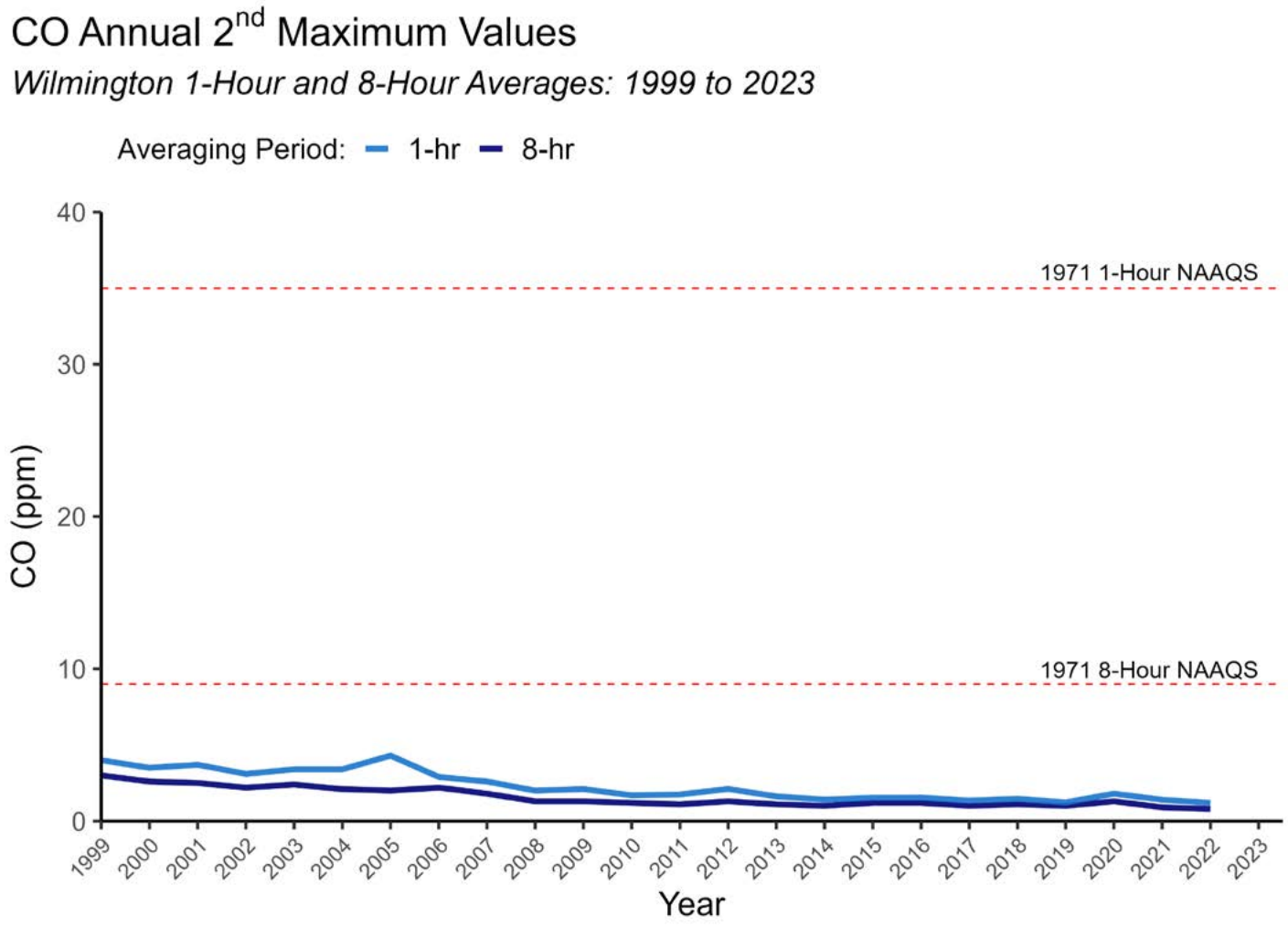


Table 6. Delaware CO Annual Maximum Values (ppm)

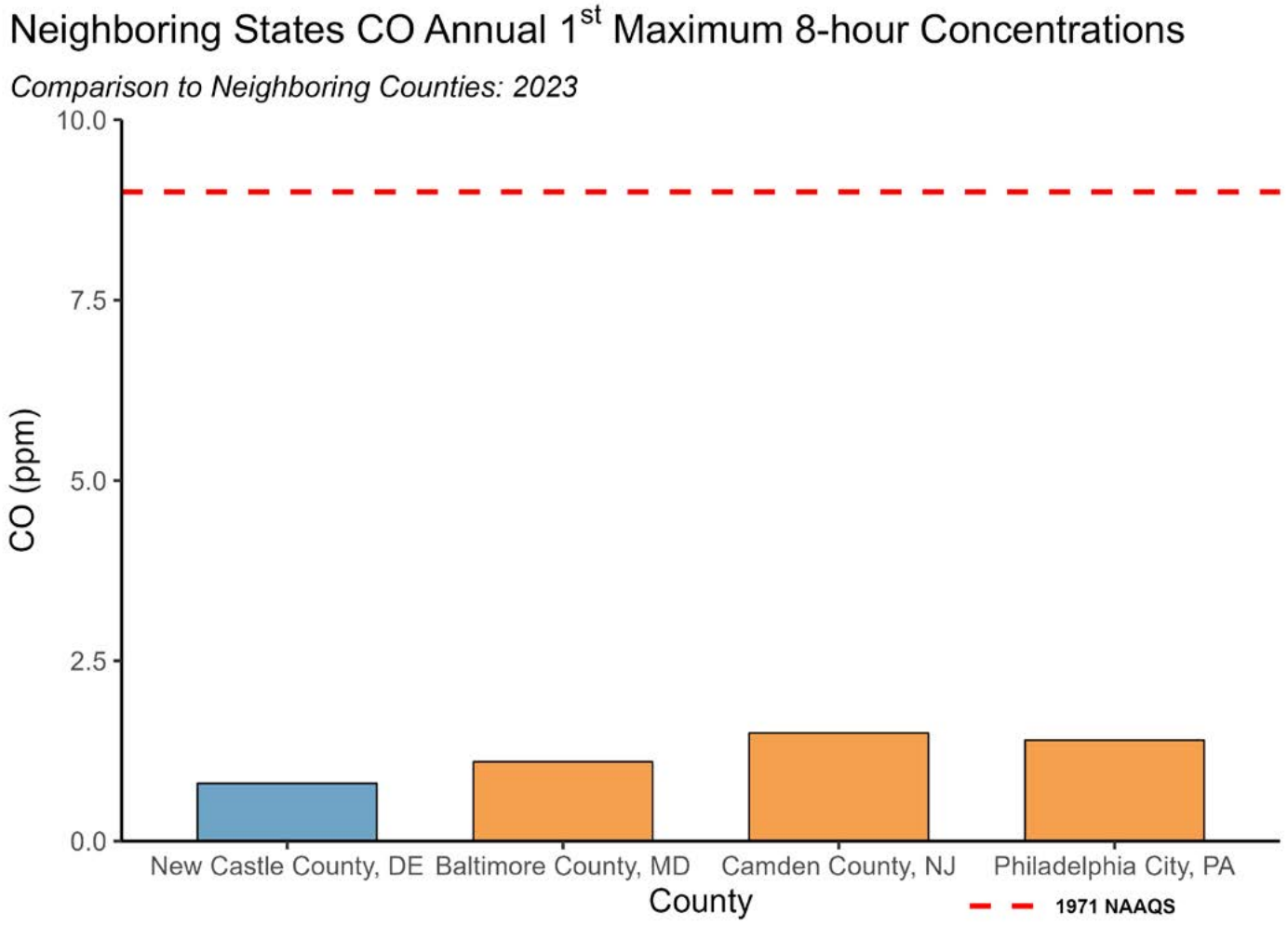
Site	8-Hour avg. (primary) NAAQS = 9 ppm		1-Hour Avg. (primary) NAAQS = 35 ppm	
	1st Max.	2nd Max.	1st Max.	2nd Max.
MLK National Core (NCore)	0.9	0.8	1.2	1.1

Note: These values are taken from 2022 data, due to lack of collected 2023 data.

Regional CO Levels

Most CO monitors are located in urban areas. CO concentrations monitored in New Castle County are similar to those concentrations reported in nearby cities.

Figure 14: CO compared to nearby monitored sites



Note: These values are taken from 2022 data, due to lack of collected 2023 data.

Nitrogen Dioxide (NO_2)

Description

Nitrogen dioxide is a reddish brown toxic gas that is part of a group of gases containing nitrogen and oxygen called 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 NO_2 and other compounds in the atmosphere can form nitric acid, which contributes to acid rain. 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 its ability to react with 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 NO_X has recently been estimated to be a significant source of nitrogen to bodies of water such as the Chesapeake Bay and Delaware's Inland Bays. Nitrogen acts as a nutrient and contributes to excess nutrient loading and algal blooms in estuary systems.

Standards

Primary NAAQS:

- 1-hour average = 100 ppb (98th percentile of one-hour daily max. concentrations, averaged over three years)

Primary & Secondary NAAQS:

- Annual arithmetic mean = 53 ppb

The State standard is the same as the NAAQS.

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 including power plants and industrial boilers.

Locations

Delaware monitors NO_2 at the Wilmington MLK NCore site.

Figure 15: Map of Delaware NO_2 Monitors

NO_2 Monitoring at MLK NCore

Delaware Air Quality and Trends

Nitrogen dioxide levels in Delaware have remained well below the NAAQS since monitoring began. In 2023, levels continued to remain well below the standard with a slight downward trend in the DV.

Figure 16: NO_2 Design Value Trends - Primary 1-hour and 8-hour Averages

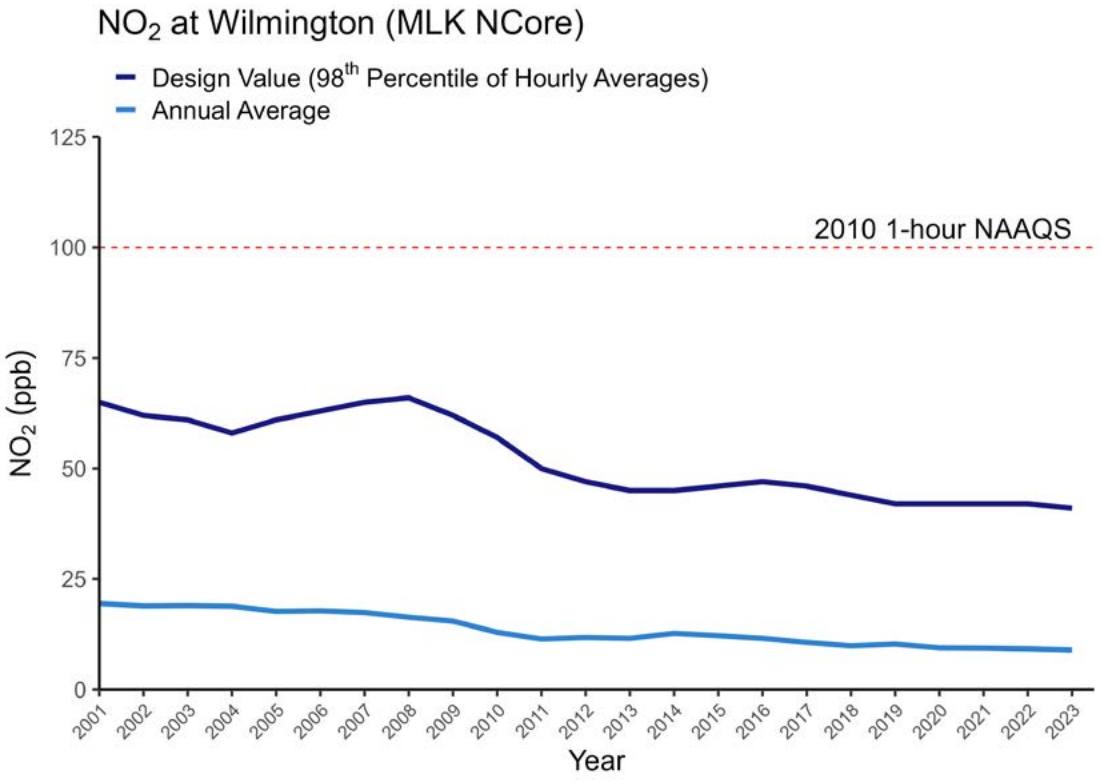
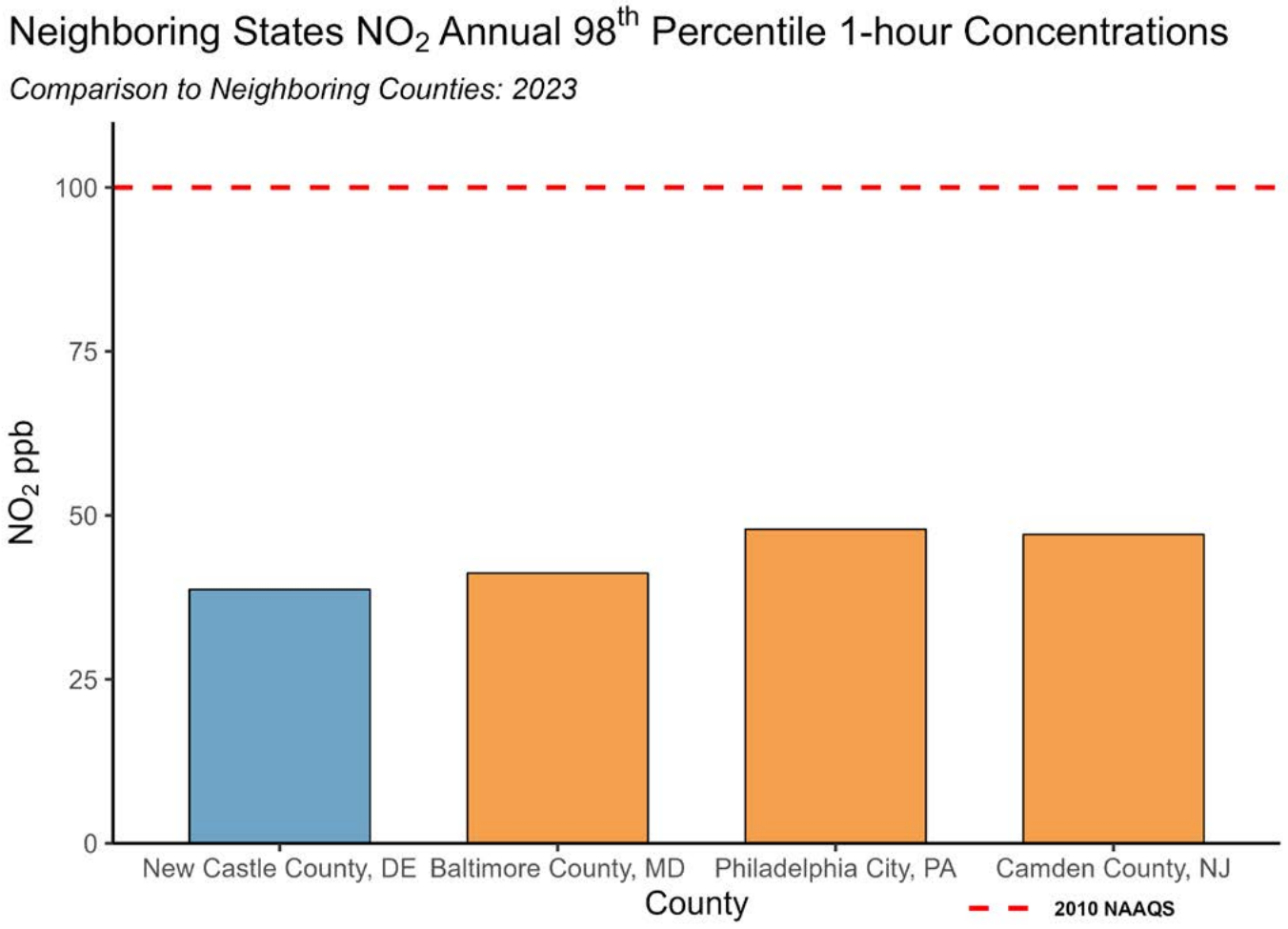


Table 7: NO_2 Design Value Trends (ppb)											
Site	**NO_2 Trends, Annual Mean & 98th Percentile of Daily Max 1-hr Avgs (ppb) Year**										
MLK National Core (NCore)	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Annual Average	12	13	12	12	11	10	10	9	9	9	9
98th Percentile	45	45	46	47	46	44	42	42	42	42	41

Regional NO_2 Levels

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 17: NO_2 compared to nearby monitored sites



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 Figure 21. 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)

The State standard is the same as the NAAQS for PM_{10}.
Delaware also retains TSP standards.

Primary State Standard:

- Annual Average = 75 µg/m^3
- 24-Hour maximum = 260 µg/m^3

Secondary State Standard:

- Annual Average = 60 µg/m^3
- 24-Hour maximum = 150 µg/m^3

EPA rules do not currently require PM_{10} to be monitored in Delaware, except at the MLK NCore site in Wilmington, where it is only used to determine PMcoarse, the concentration of particulate matter between 2.5 and 10 microns (the difference between PM_{10} and $PM_{2.5}$). Delaware measurements of PM_{10} are not compared to the NAAQS for regulatory purposes.

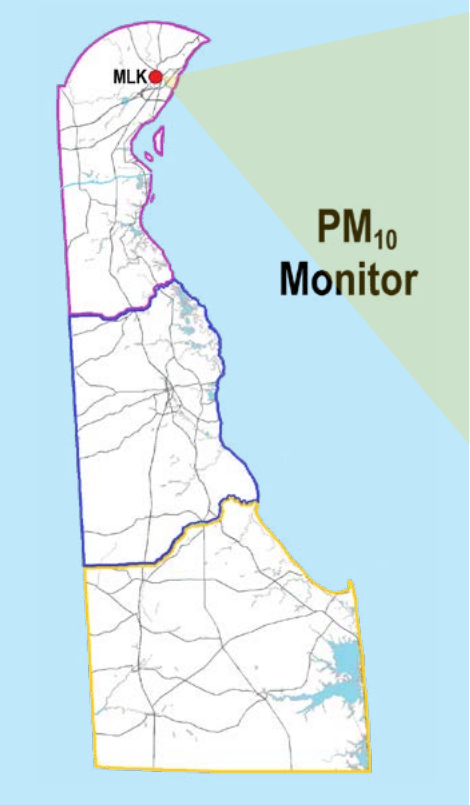
Sources

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

Locations

PM_{10} is currently monitored at the urban Wilmington MLK NCore site

Figure 18:
Map of Delaware PM_{10} Monitor



Particulate Monitoring at MLK NCore

Delaware Air Quality and Trends

Delaware would be in attainment with the PM_{10} NAAQS if EPA required the comparison to be made. The data shown below are only from approved Federal Reference Method (FRM) filter-based discrete sampling methods and are presented here for informational purposes only.

The significant increase for 2023 was due to wildfire smoke from Canada. The PM_{10} instrument was not operating in 2010.

Figure 19: PM_{10} Trends – Annual 1st and 2nd Highest 24-hour Concentrations

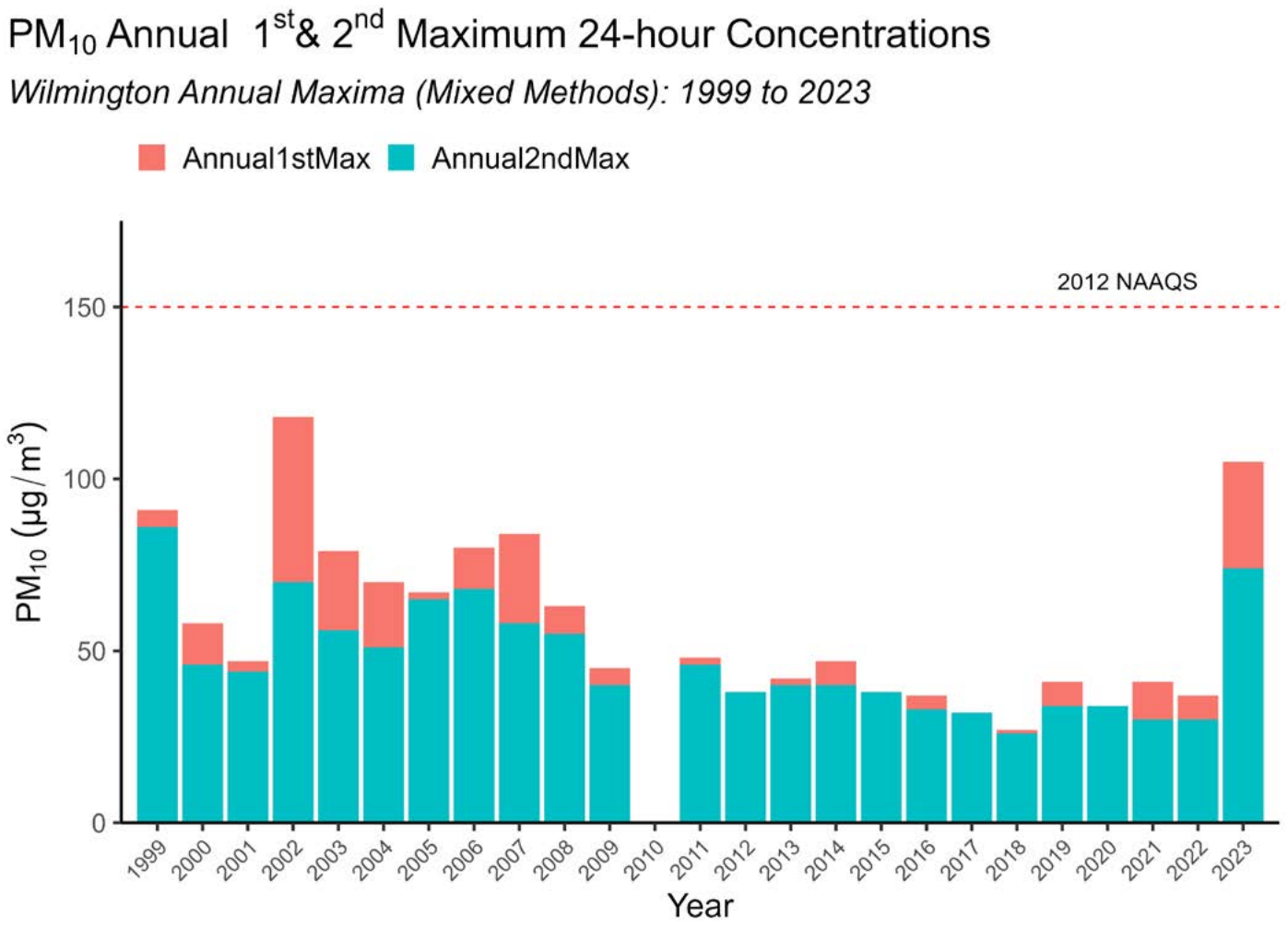


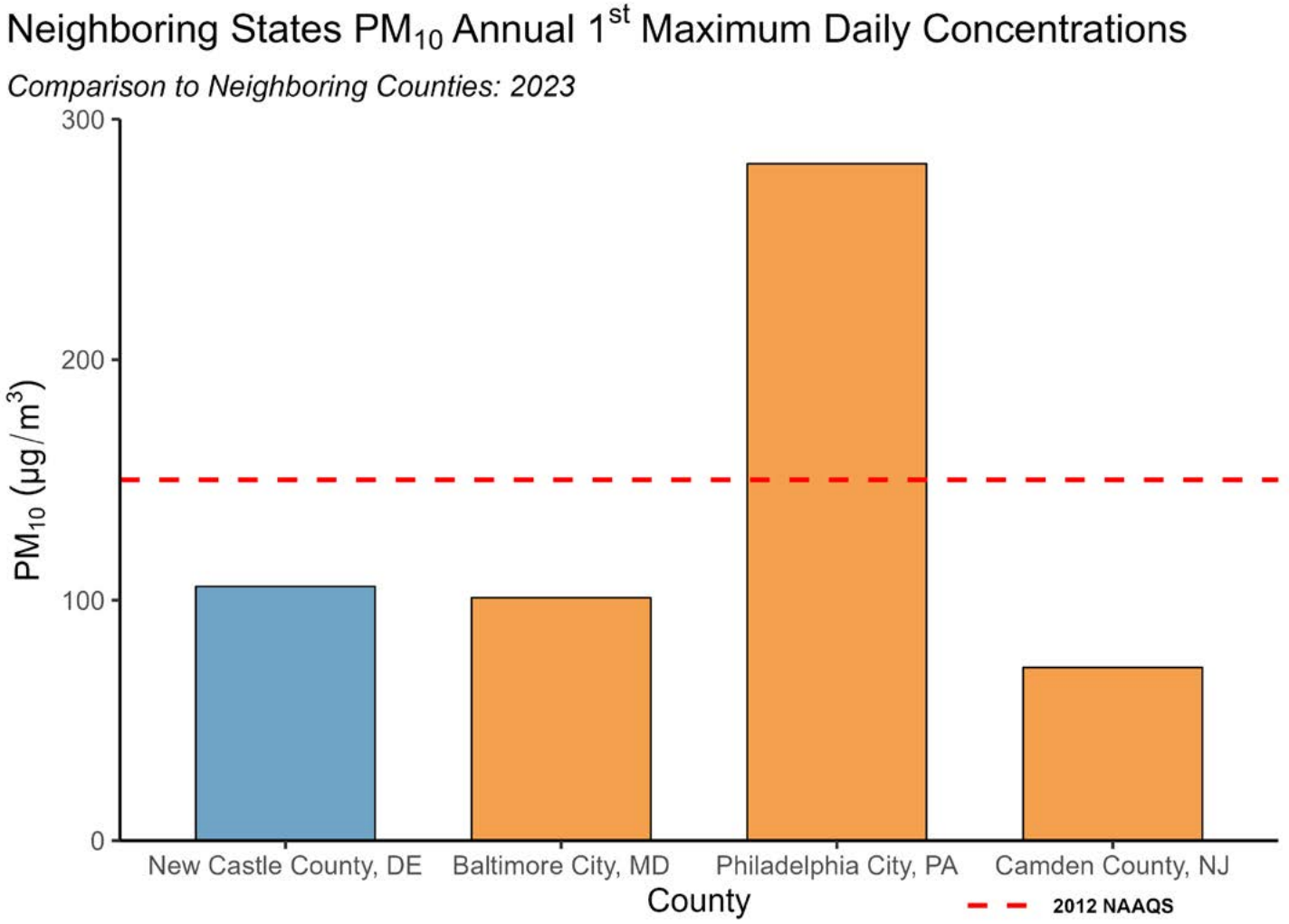
Table 8: PM_{10} Trends: Annual Average(µg/m³)

	Annual Arithmetic Mean (µg/m³)										
	Year										
Site	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
MLK National Core (NCore)	14.4	16.9	17.1	14.2	14.0	12.7	14.3	13.6	14.5	13.2	16.4

Regional PM_{10} Levels

PM_{10} peak daily concentrations in Delaware have been similar to those in nearby areas, with the exception of the Philadelphia site, which was using a continuous monitor. As already discussed, these instruments have a known bias especially at high concentration levels when compared with filter-based samples. The other three sites produced data using the FRM method, which uses 24-hour filter-based sampling. The peak days in 2023 (6/7-6/8) coincided with the arrival of a large plume of wildfire smoke from Canada.

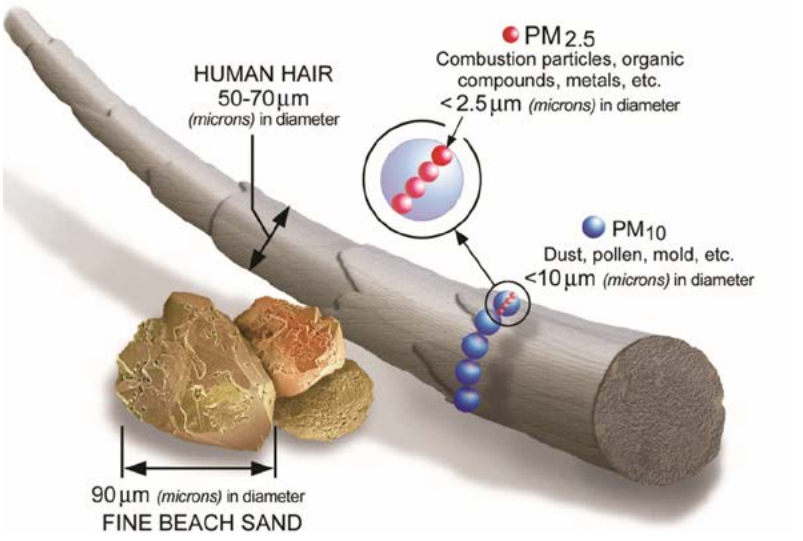
Figure 20: PM_{10} compared to nearby monitored sites



Particulate Matter – Fine ($PM_{2.5}$)

Description

Figure 21: Particulate Matter Size Comparison



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 (2.5-10.0 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.

Standards

Primary NAAQS:

- Annual arithmetic mean = *12.0 µg/m^3 (Averaged over three years)
  *Note: reduced to 9.0 µg/m^3 by EPA effective 2/7/2024
- 24-Hour maximum = 35 µg/m^3 (98th percentile of daily maximum one-hour average concentrations, averaged over three years)

Secondary NAAQS:

- Annual arithmetic mean = 15.0 µg/m^3 (Averaged over three years)

The State standard is the same as the NAAQS. The State regulation will need to be updated to match the updated Federal standard.

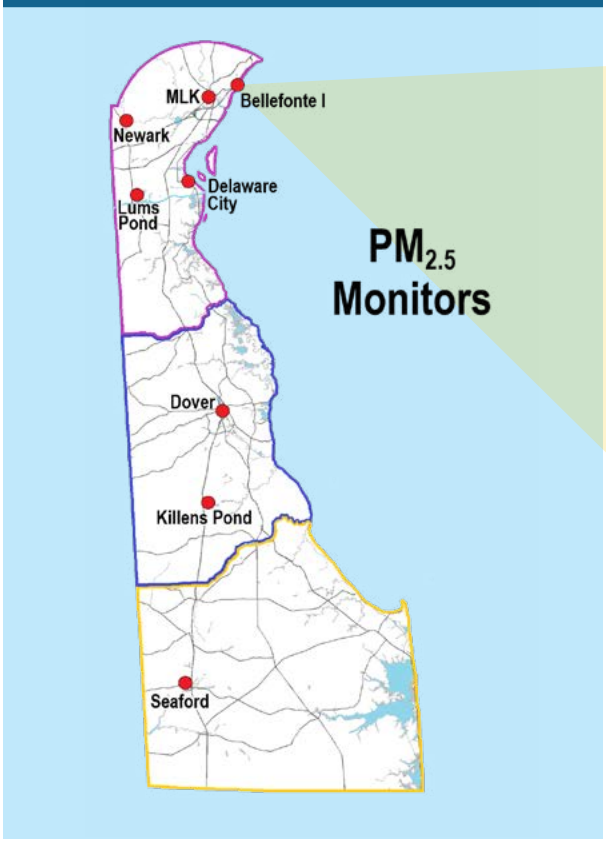
Sources

Fine particles 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. Fine particles can also form in the atmosphere from precursor compounds (substances that are the source of another substance), such as SO_2 and NO_X, through various physical and chemical processes.

Locations

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

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



Bellefonte I Monitoring Platform

Delaware Air Quality and Trends

Delaware's monitoring network began collecting $PM_{2.5}$ data in January 1999. Three years of complete data are required for comparison to the national standard. Both local and regional sources of fine particulate matter and its precursors contribute to concentrations seen in Delaware.

Annual Average

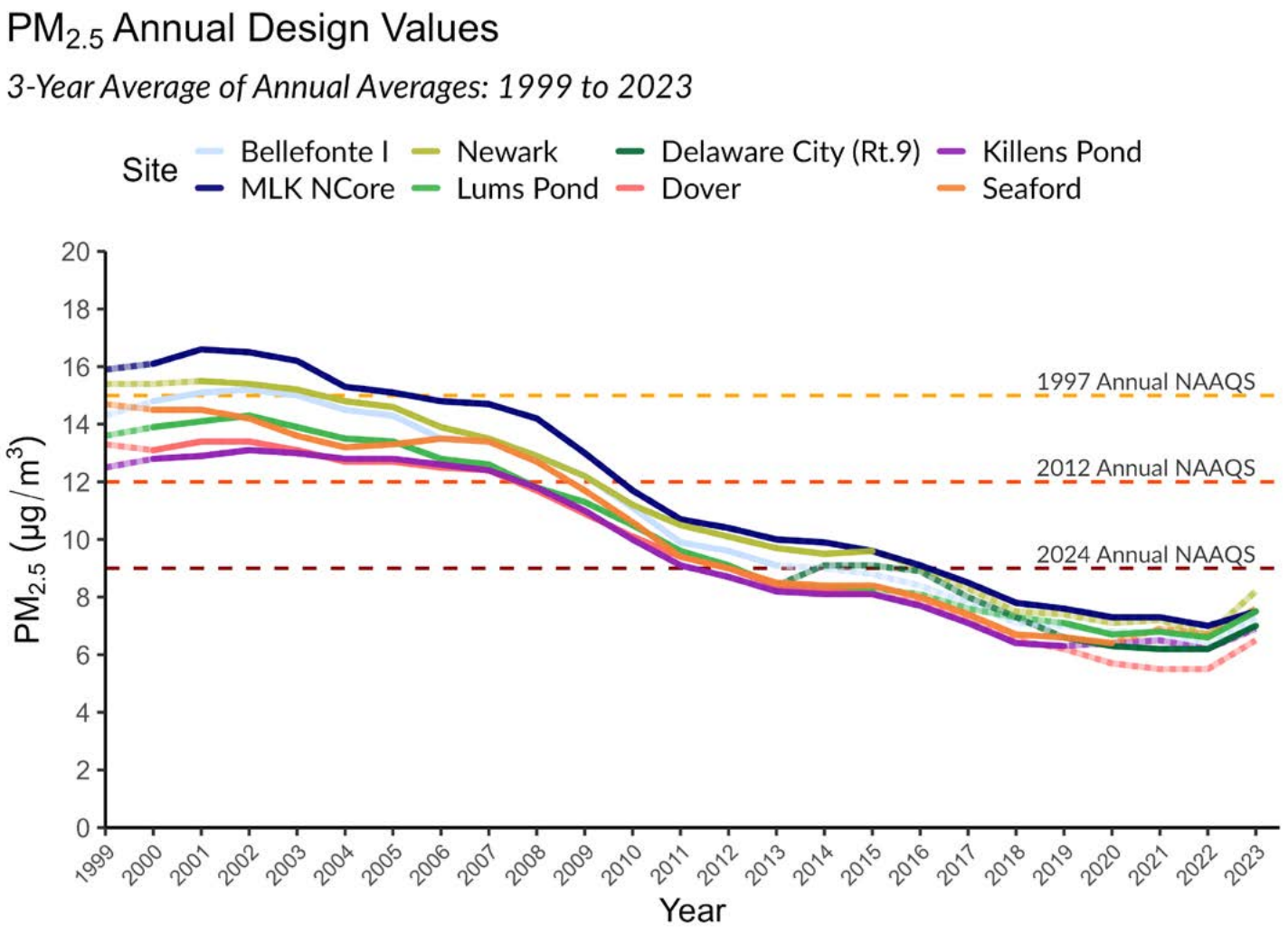
New Castle County was originally designated non-attainment for $PM_{2.5}$ based on the 16.0 µg/m^3 three-year average of the annual averages DV for 2001 to 2003 at the urban Wilmington MLK NCore site.

The figure below shows $PM_{2.5}$ three-year average of annual average DV for each site from 1999-2023. The highest site for the most recent three-year average period (2021-2023) was Newark (8.2 µg/m^3) in New Castle County. There is a downward trend showing continued air quality improvement across all sites, with a slight increase in 2023 due to wildfire smoke from outside the State.

Significant correlation persists among all monitoring sites in 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, except for local events such as some farming activities.

DV for all sites in Delaware have remained below the applicable $PM_{2.5}$ standard every year since 2006.

Figure 23: $PM_{2.5}$ Design Value Trends – Primary Annual Averages



24-hour Average

The current 98th percentile 24-hour average $PM_{2.5}$ standard of 35 µg/m^3 was met at all monitoring sites in Delaware for the 2021-2023 DV period.

The figure below shows the 98th percentile 24-hour average $PM_{2.5}$ DV for each site from 1999-2023. The highest for the most recent three-year average period (2021-2023) was 23 µg/m^3, at both the Newark (New Castle County) and Killens Pond (Kent County) sites. There is a downward trend showing continued air quality improvement across all sites, with a notable reversal for 2023 due to wildfire smoke from outside the State.

Killens Pond Monitoring Site

Like the annual average data, there is significant correlation between 24-hour concentrations measured at all sites throughout Delaware.

98th percentile of 24-hour averages DV for all sites in Delaware have remained below the applicable $PM_{2.5}$ annual average standard every year since 2009.

Figure 24: $PM_{2.5}$ Design Value Trends – Primary 24-hour Averages

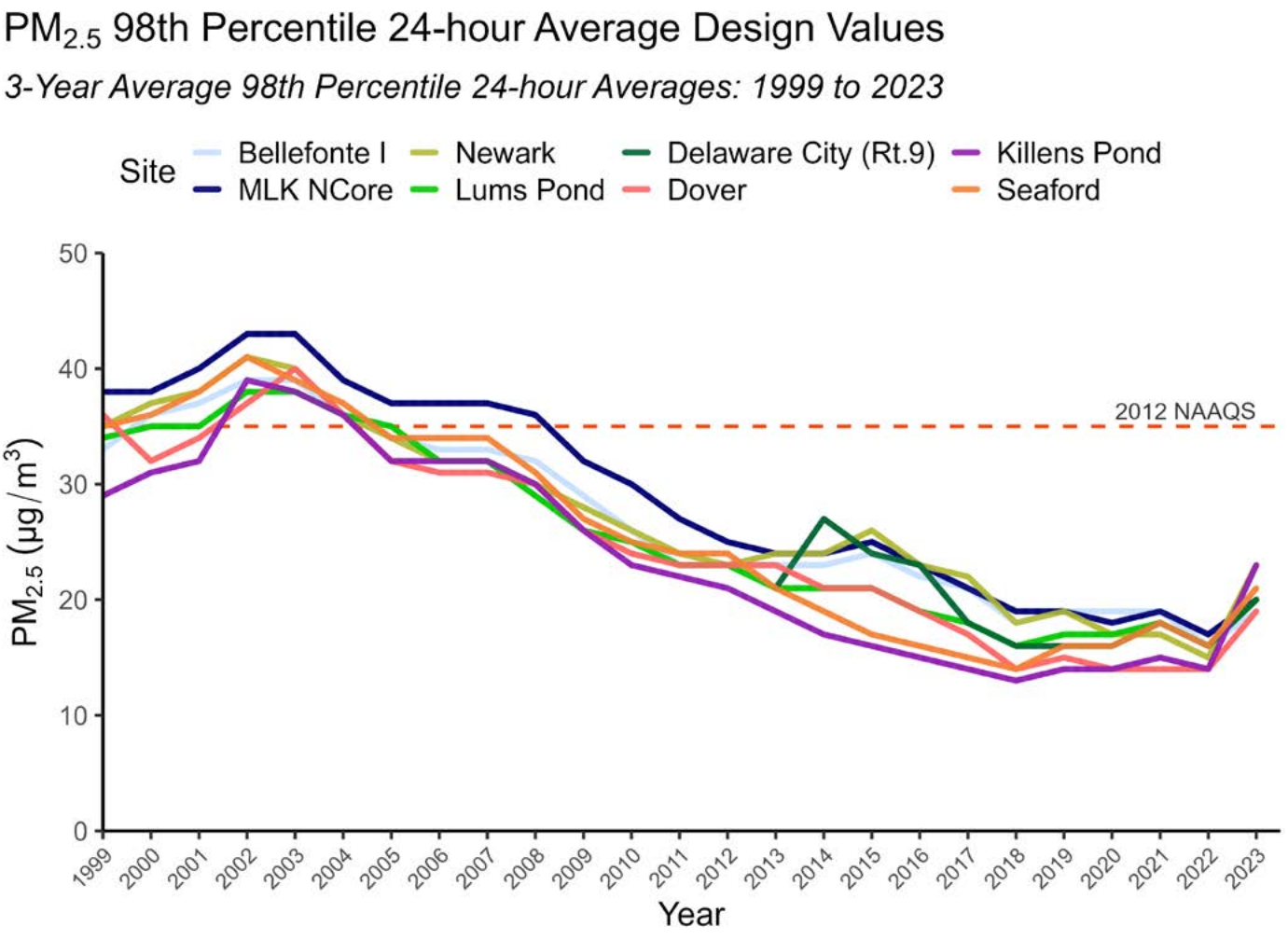


Table 9: $PM_{2.5}$ 3-Year Design Values Trends per Site: Annual Mean (µg/m³)

Site (listed North to South)	3-year Design Values: Annual Arithmetic Mean (NAAQS = 12 ug/m³)										
	2011 to 2013	2012 to 2014	2013 to 2015	2015 to 2017	2016 to 2018	2017 to 2019	2018 to 2020	2019 to 2021	2019 to 2021	2020 to 2022	2021 to 2023
Bellefonte I	9.1	9.0	8.8	8.4	7.8	7.1	7.0	6.8	6.8	6.3	7.3
MLK National Core (NCore)	10.0	9.9	9.6	9.1	8.5	7.8	7.6	7.3	7.3	7.0	7.5
Newark	8.4	8.3	8.3	8.1	7.6	7.3	7.1	6.7	6.8	6.6	7.5
Delaware City	9.7	9.5	9.6	9.0	8.3	7.5	7.4	7.1	7.2	6.7	8.2
Lums Pond State Park	8.4	9.1	9.1	8.9	8.0	7.3	6.6	6.3	6.2	6.2	7.0
Dover	8.4	8.2	8.1	7.8	7.2	6.5	6.2	5.7	5.5	5.5	6.5
Killens Pond	8.2	8.1	8.1	7.7	7.1	6.4	6.3	6.4	6.5	6.2	6.9
Seaford	8.5	8.4	8.4	8.0	7.4	6.7	6.6	6.4	6.9	6.7	7.6

Note: Official EPA DV may vary due to data completeness rules for calculations. For historical consistency those complexities are not detailed or indicated in this document unless a value is unavailable. Applies to both tables.

Table 10: $PM_{2.5}$ 3-Year Design Values Trends per Site: 98th Percentile of Daily (µg/m³)

Site (listed North to South)	3-year Design Values: 98th Percentile of Daily Averages (NAAQS = 35 ug/m³)										
	2011 to 2013	2012 to 2014	2013 to 2015	2014 to 2016	2015 to 2017	2016 to 2018	2017 to 2019	2018 to 2020	2019 to 2021	2020 to 2022	2021 to 2023
Bellefonte I	23	23	24	22	21	18	19	19	19	16	19
MLK National Core (NCore)	24	24	25	23	21	19	19	18	19	17	20
Newark	24	24	26	23	22	18	19	17	17	15	23
Delaware City	21	27	24	23	18	16	16	16	18	16	20
Lums Pond State Park	21	21	21	19	18	16	17	17	18	16	20
Dover	23	21	21	19	17	14	15	14	14	14	19
Killens Pond	19	17	16	15	14	13	14	14	15	14	23
Seaford	21	19	17	16	15	14	16	16	18	16	21

Regional $PM_{2.5}$ Levels

Fine particulate levels recorded by Delaware monitors were similar to those recorded at other monitoring sites in the region in 2023. These are not DV, which are computed as a three-year average. Only data from 2023 is included here. These values do not include possible reductions due to EPA Exceptional Events determinations regarding Canadian wildfire smoke.

Figure 25: $PM_{2.5}$ Annual Design Value compared to nearby monitored sites

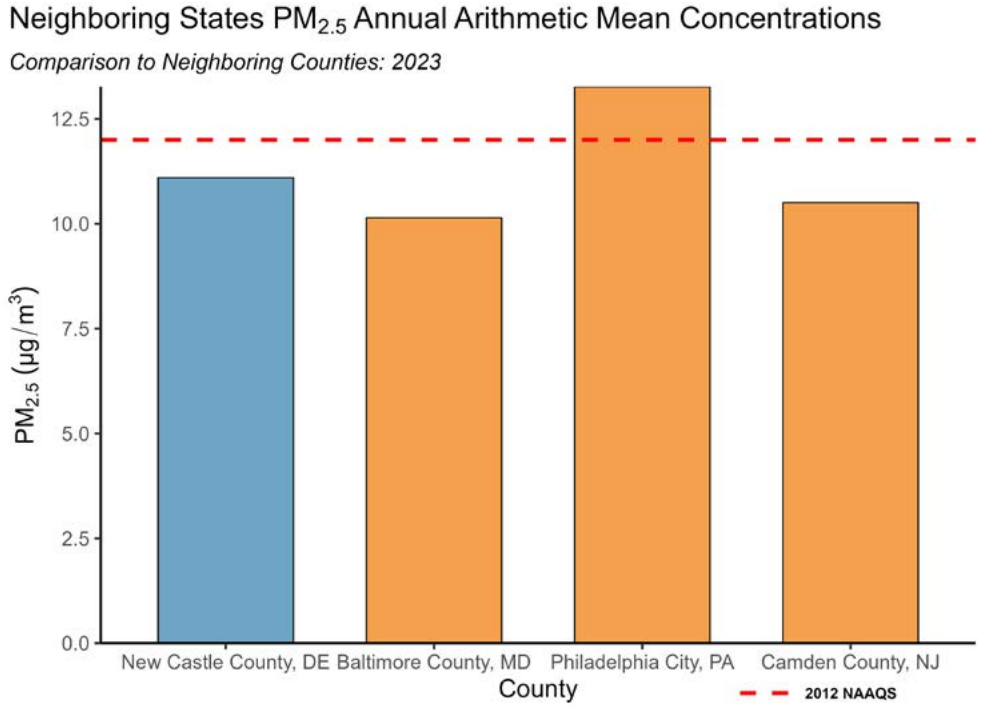
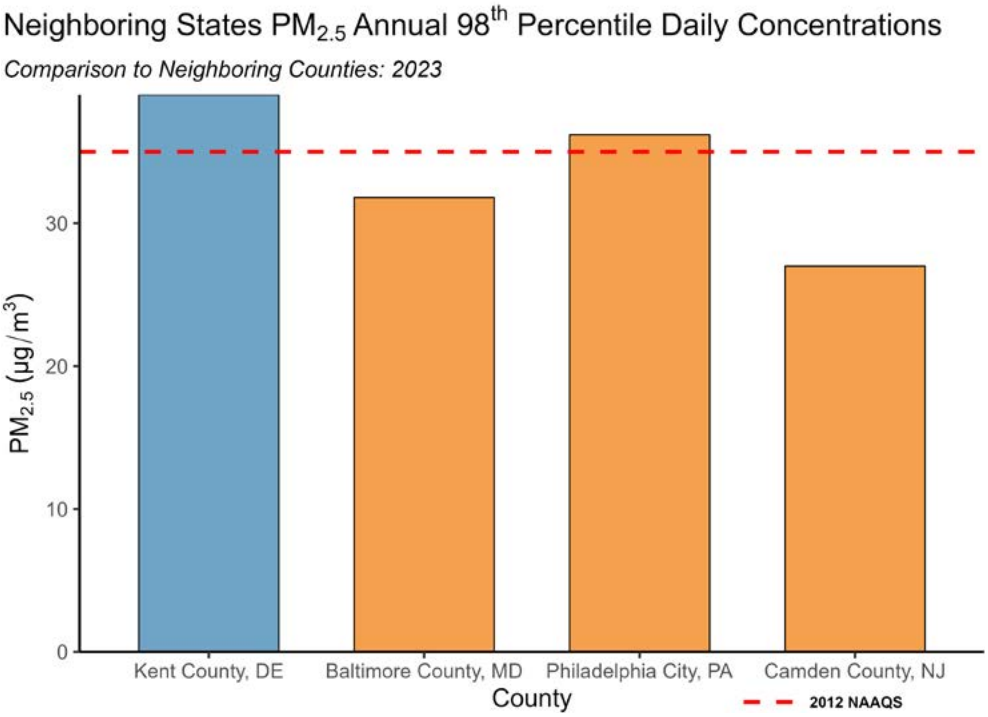


Figure 26: $PM_{2.5}$ 24-hour Design Value compared to nearby monitored sites



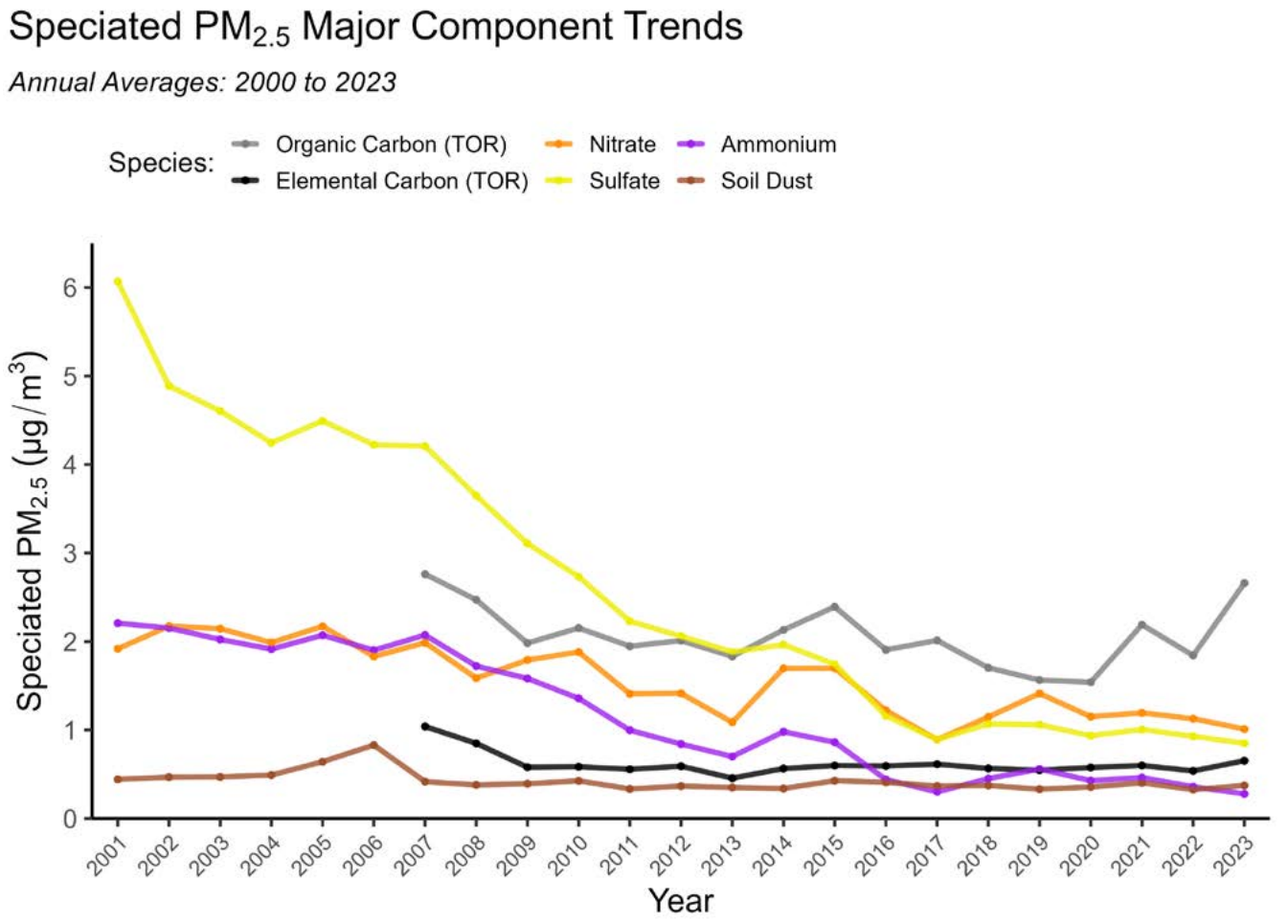
$PM_{2.5}$ Speciation

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, Delaware). Samples are collected on filters for 24 hours every third 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). There are no ambient air quality standards for the chemical components of $PM_{2.5}$, but understanding the components of this pollutant are important. This analysis is essential to the reduction of regional haze, which tracks visibility at national parks and wilderness areas, and to understanding regional differences in PM exposure and PM measurements using continuous instruments.

Trends for most major components of $PM_{2.5}$ are declining. The exceptions are organic and elemental carbon, which increased in 2023 most likely due to wildfire smoke from out of State. Soil dust showed a slight year-to-year increase for 2023, but still remained fairly flat over the last 15 years.

Figure 27: Annual Average Trends for some of the target $PM_{2.5}$ species



Sulfur Dioxide (SO_2)

Description

Sulfur dioxide 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_2 and combine with water vapor to form sulfuric acid and fall as acid rain, damaging materials 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 (loss of green color) and stunted growth.

Standards

Primary NAAQS:

- 1-hour average = 75 ppb (99^{th} percentile of 1-hour daily max. concentrations, averaged over three years)

Secondary NAAQS:

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

The State standard is the same as the NAAQS.

Sources

The largest source of SO_2 in the atmosphere is the burning of fossil fuels by power plants and other industrial facilities. Smaller sources of SO_2 emissions include industrial processes such as extracting metal from ore; natural sources such as volcanoes; and locomotives, ships, other vehicles and heavy equipment that burn fuel with a high sulfur content.

From 1995-2023, annual emissions of SO_2 from power plants fell by 95 percent and annual emissions of NOx from power plants fell by 89 percent. Since 2016, Delaware has required the use of ultra-low sulfur diesel fuel, which is distillate fuel containing less than 15 ppm sulfur by weight.

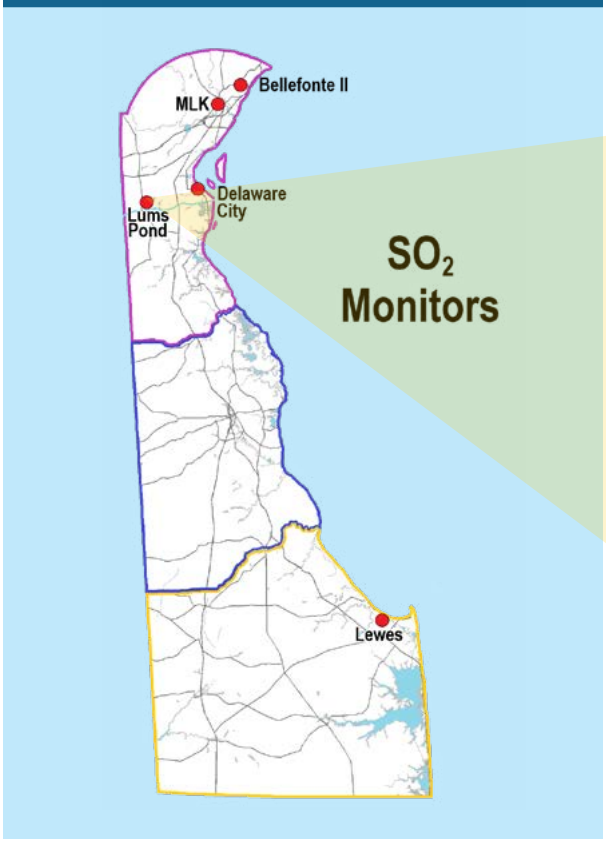
The NAAQS for SO_2 are designed to protect against exposure to the entire group of sulfur oxides (SOx). SO_2 is the component of greatest concern and is used as the indicator for the larger group of gaseous SOx. Other gaseous SOx (such as SO_3) are found in the atmosphere at concentrations much lower than SO_2.

Control measures that reduce SO_2 can generally be expected to reduce people's exposures to all gaseous SOx. This may have the important co-benefit of reducing the formation of particulate sulfur pollutants, such as fine sulfate particles.

Locations

Delaware's SO_2 monitors are located at the MLK NCore, Bellefonte II, Lums Pond and Delaware City sites in New Castle County. Due to resource restrictions, there was no monitoring at the Lums Pond site in 2009. Monitoring in Sussex County began at the Lewes site in 2012.

Figure 28:
Map of Delaware SO_2 Monitors



Lums Pond Monitoring Station

Delaware Air Quality and Trends

Over the last decade, measured ambient levels have remained well below the applicable 2010 primary hourly average standard of 75 ppb, and secondary three-hour average standard of 0.5 ppm (500 ppb), with a slight downward trend.

In comparing hourly averages to the 2010 standard, a significant improvement can be noted at the Delaware City monitoring site when additional emission controls were added to the nearby oil refinery. In 2023, SO_2 levels throughout Delaware remained well below the current NAAQS.

Figure 29: $PM_{2.5}$ Design Value Trends – Primary 24-hour Averages

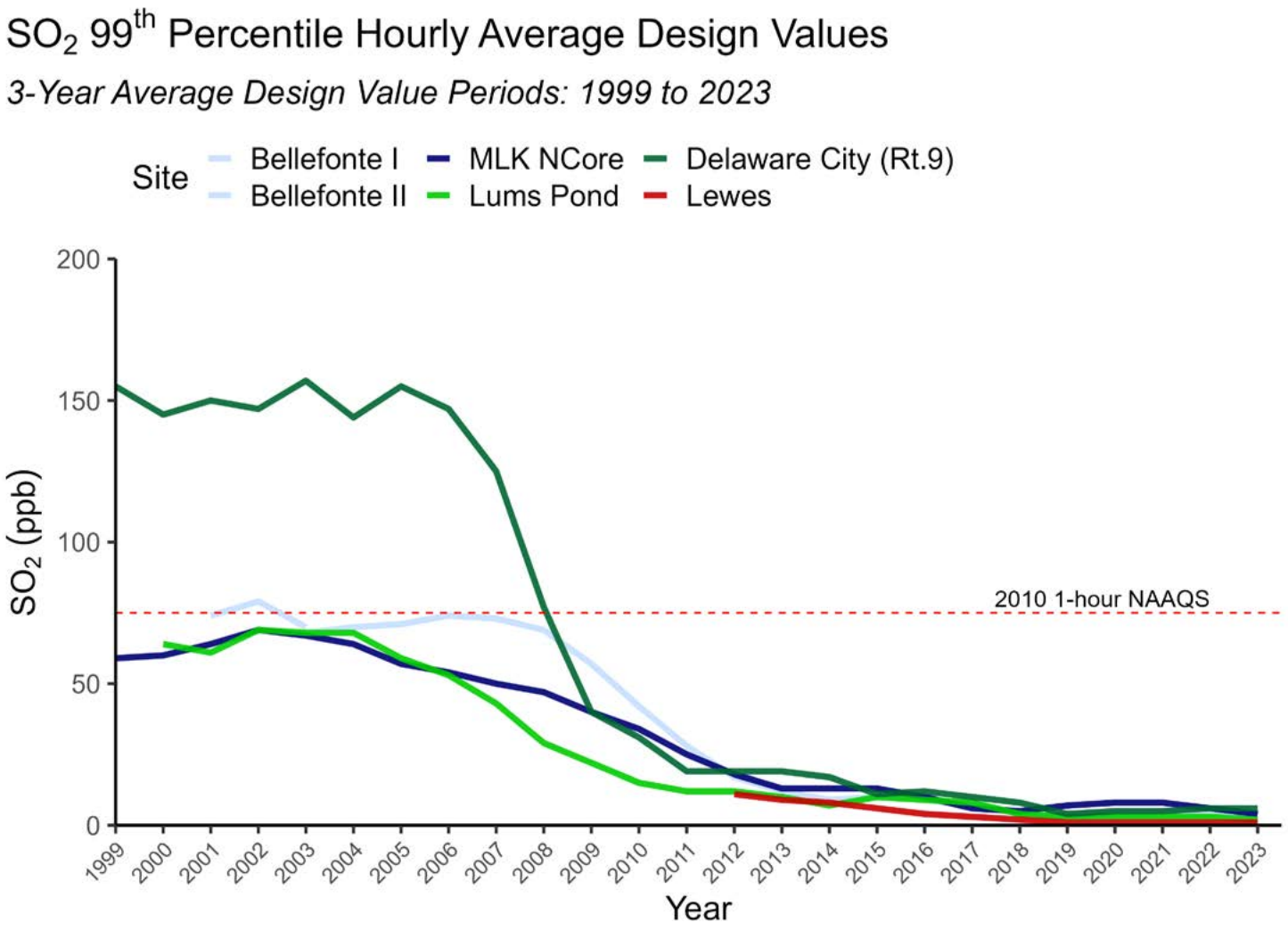


Table 11: SO_2 Primary 3-year Design Value Trends (ppb)

Site	SO_2 Primary Design Values: 3-yr Avg of 99th Percentile of Daily Max 1-hr Avgs (ppb)										
	2011 to 2013	2012 to 2014	2013 to 2015	2014 to 2016	2015 to 2017	2016 to 2018	2017 to 2019	2018 to 2020	2019 to 2021	2020 to 2022	2021 to 2023
Bellefonte II	12	9	10	9	7	4	3	4	5	5	4
MLK National Core (NCore)	13	13	13	10	6	5	7	8	8	6	4
Lums Pond State Park	10	7	10	9	8	4	3	3	3	3	2
Delaware City	19	17	11	12	10	8	4	5	5	6	6
Lewes	9	8	6	4	3	2	1	1	1	1	1

Table 12: SO_2 Secondary 1-year Design Value Trends (ppb)

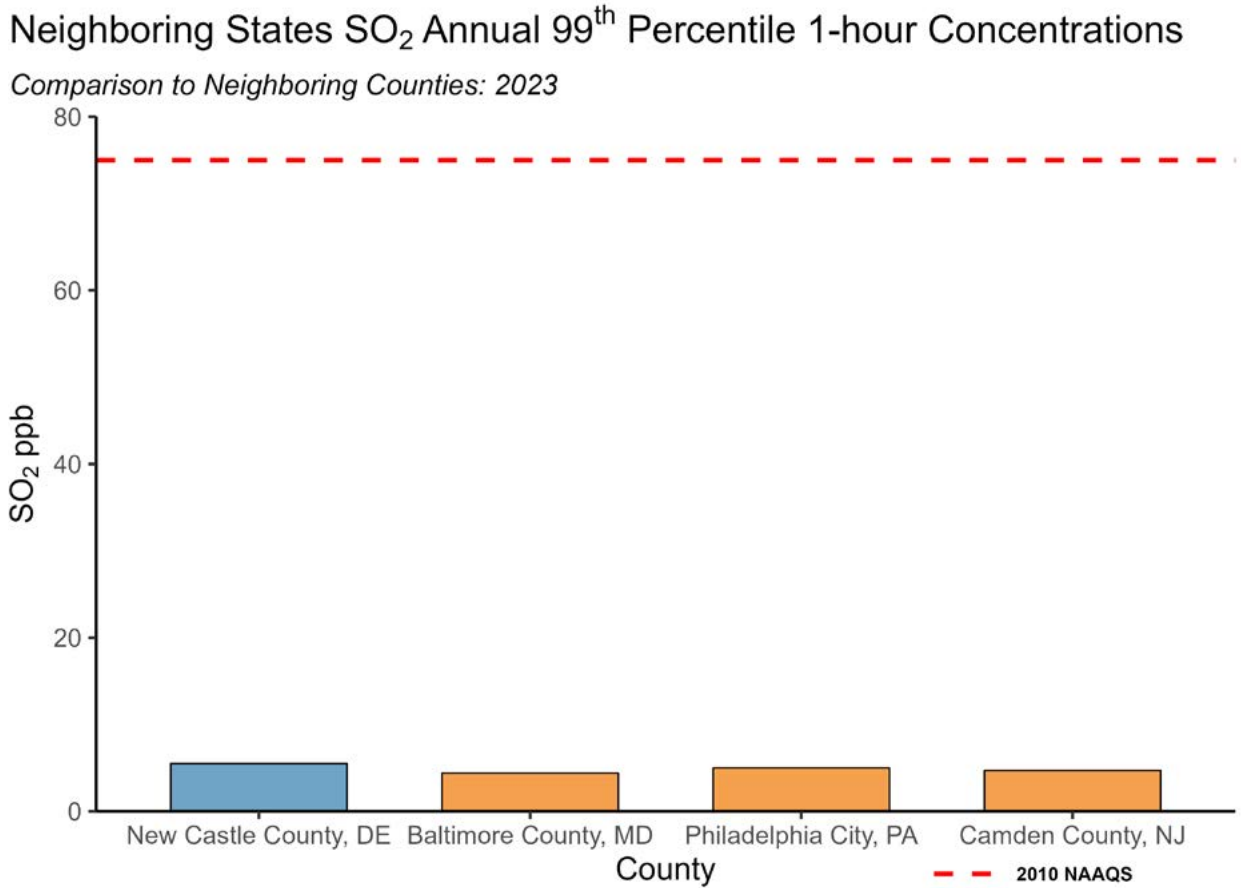
Site	SO_2 Secondary Design Values: Annual Maximum 3-hour Average (ppb)										
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Bellefonte II	7	11	12	7	3	13	8	4	5	3	2
MLK National Core (NCore)	15	10	16	5	4	7	10	9	4	3	5
Lums Pond State Park	6	12	43	4	2	3	3	2	3	3	3
Delaware City	31	127	10	21	43	4	10	11	4	6	4
Lewes	7	10	8	2	1	1	2	3	1	3	4

Note: Official EPA Design Values may vary due to data completeness rules for calculations. For historical consistency those complexities are not detailed or indicated in this document, unless a value is unavailable.

Regional SO_2 Levels

SO_2 concentrations in Delaware are like those in nearby monitored areas.

Figure 30: SO_2 compared to nearby monitored sites



Air Quality – Pollutants without Ambient Standards

Air Toxics

Description

Toxic air pollutants, also called air toxics or HAPs, 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 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 include power plants, chemical manufacturing plants and refineries. There are many small 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 marine craft and aircraft.

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. Monitoring for carbonyls beginning in 2003 was discontinued in 2015 due to resource restrictions but resumed in 2022. Historical data is available for certain pollutants at other sites in Delaware.

Figure 31: Map of Delaware Air Toxics Monitoring Site

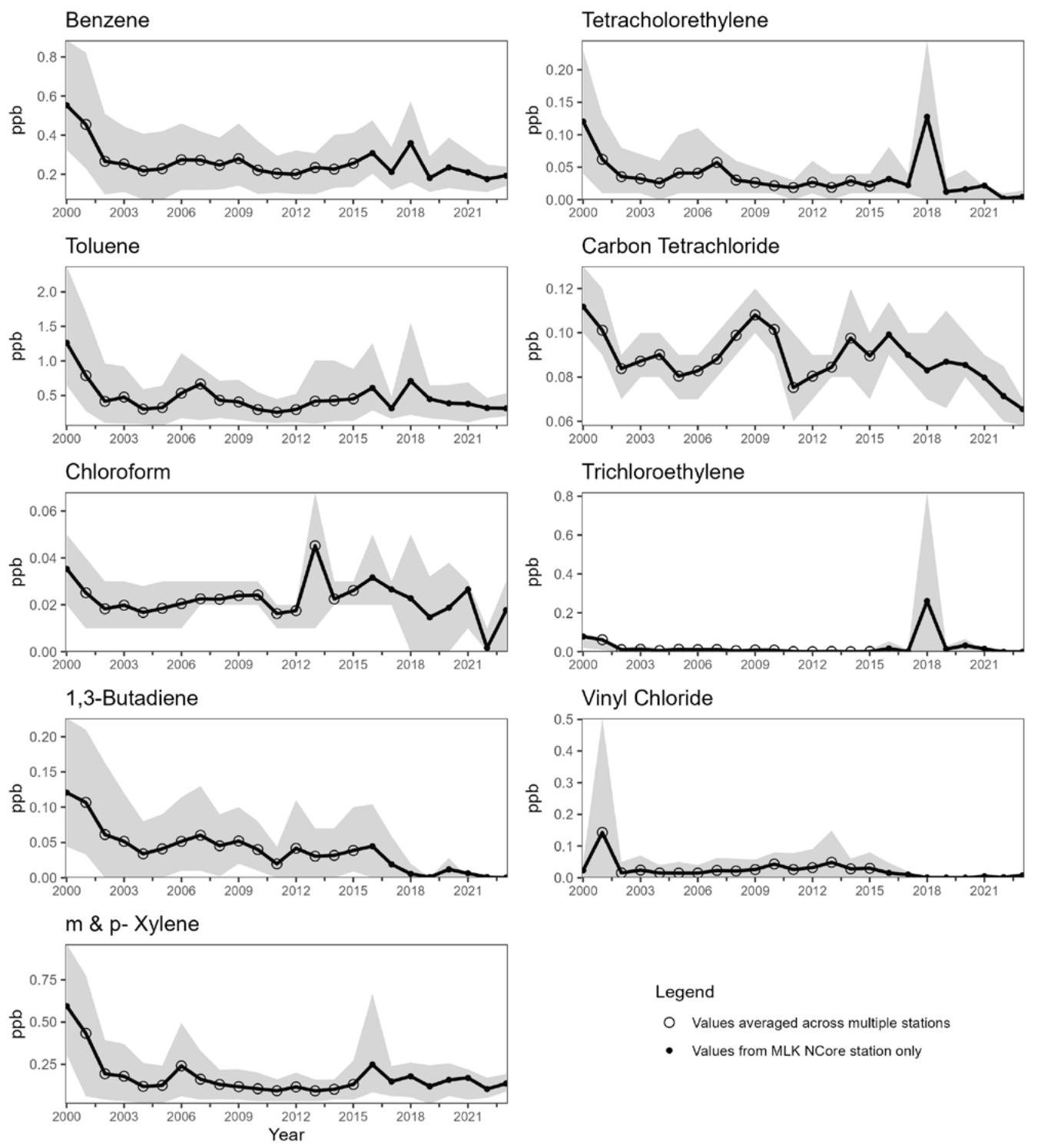
Delaware Air Quality and Trends

Ambient VOC levels remain 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 HAPs, are continuing to reduce ambient concentrations of many air toxics. In 2023, ambient concentrations of most VOCs continued their downward trend at the MLK NCore site. A slight increase in the average of some compounds was observed in 2023, generally close to 2019 (pre-Covid) levels, while most continued flat or declined.

Table 13: Air Toxics Data 2023, MLK NCore site (Wilminton, DE)			
Compound Name	AQS Code	Average (ppb)	Maximum (ppb)
Acetone	43551	4.41	6.35
Acrolein	43509	0.06	0.29
Benzene	45201	0.19	0.28
1,3-Butadiene	43218	0	0
Carbon tetrachloride	43804	0.07	0.07
Chlorobenzene	45801	0.01	0.03
Chloroform	43803	0.02	0.03
Chloromethane	43801	0.42	0.63
Cyclohexane	43248	0.03	0.24
1,4-Dichlorobenzene	45807	0.03	0.09
Dichlorodifluoromethane	43823	0.48	0.51
Dichloromethane	43802	0.11	0.17
1,2-Dichloropropane	43829	0	0
cis-1,3-Dichloropropene	43831	0	0
trans-1,3-Dichloropropene	43830	0	0
Ethylbenzene	45203	0.05	0.09
Ethylene dibromide	43843	0	0
Ethylene dichloride	43815	0	0
p-Ethyltoluene	45213	0.02	0.05
Freon 113	43207	0.06	0.07
Freon 114	43208	0.01	0.02
n-Heptane	43232	0.03	0.11
n-Hexane	43231	0.04	0.22
Methyl chloroform	43814	0	0
Methyl tert-butyl ether	43372	0	0.01
Styrene	45220	0.13	0.34
1,1,2,2-Tetrachloroethane	43818	0	0
Tetrachloroethylene	43817	0	0.03
Tetrahydrofuran	46401	0	0.01
Toluene	45202	0.31	0.57
Trichloroethylene	43824	0	0
Trichlorofluoromethane	43811	0.22	0.24
1,2,4-Trimethylbenzene	45208	0.04	0.06
1,3,5-Trimethylbenzene	45207	0.01	0.02
Vinyl chloride	43860	0.01	0.07
m/p-Xylene	45109	0.14	0.24
o-Xylene	45204	0.05	0.1

Figure 32: Wilmington Air Toxics Trends – Annual Averages Selected Compounds



In Figure 32, the grey areas around average lines represent 90% confidence intervals.

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 March 1 to October 31 during which monitors are required to be in operation (see section Delaware Air Monitoring Network). 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 CO.

Nitrogen Dioxide (NO_2)

Nitrogen oxides are measured using the chemiluminescence reaction of NO with ozone. 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 must be measured indirectly. Total 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 ($PM_{2.5}$)

Discrete sampling

Fine particulate matter 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 (MLK NCore) samples are collected for 24 hours every day, and a collocated sampler collects every sixth day. Delaware uses the Thermo model 2025i sampler, which is a Federal Reference Method (FRM).

Continuous Monitors
Fine particulate matter is also monitored continuously, recording 1-minute, hourly and daily averages. Delaware uses the Teledyne model T640 continuous particulate monitor for this type of sampling, which uses an optical method to count particles and measure their sizes, with a constant 5 liter per minute air flow through the optical detection chamber. This is a Federal Equivalent Method (FEM).

Particulate Matter (PM_{10})

Discrete sampling
Particulate matter is sampled every third day at the MLK NCore site, in the same manner as $PM_{2.5}$, but with a different inlet that excludes particles larger than 10 microns in diameter. Delaware uses the Thermo model 2025i sampler, which is a FRM.

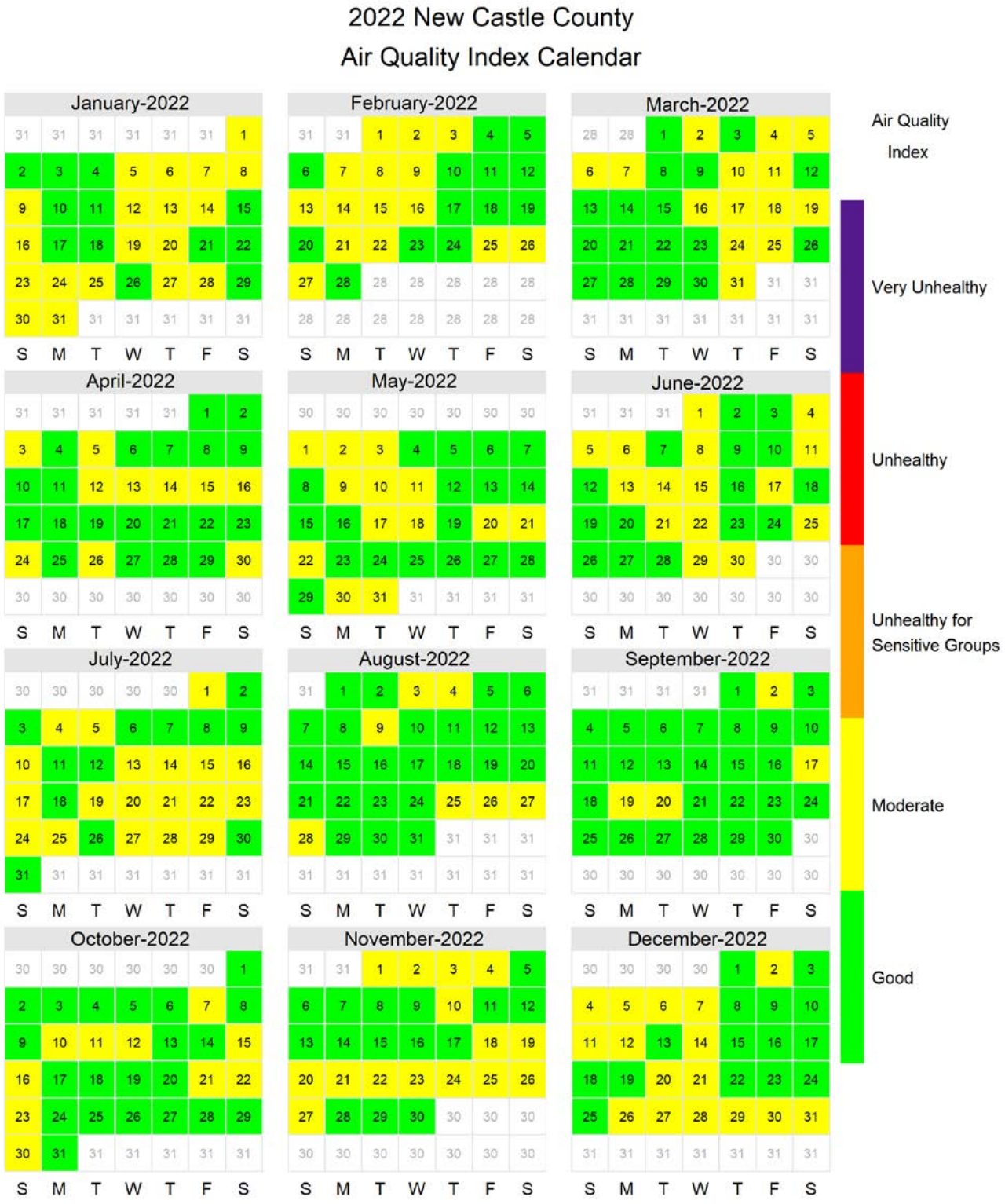
Continuous Monitors
Particulate matter can also be monitored continuously, recording 1-minute, hourly and daily averages, using the Teledyne model T640X. This is a FEM. Delaware is currently evaluating a T640X at the MLK NCore site, to possibly complement discrete sampling in the future.

Air Toxics

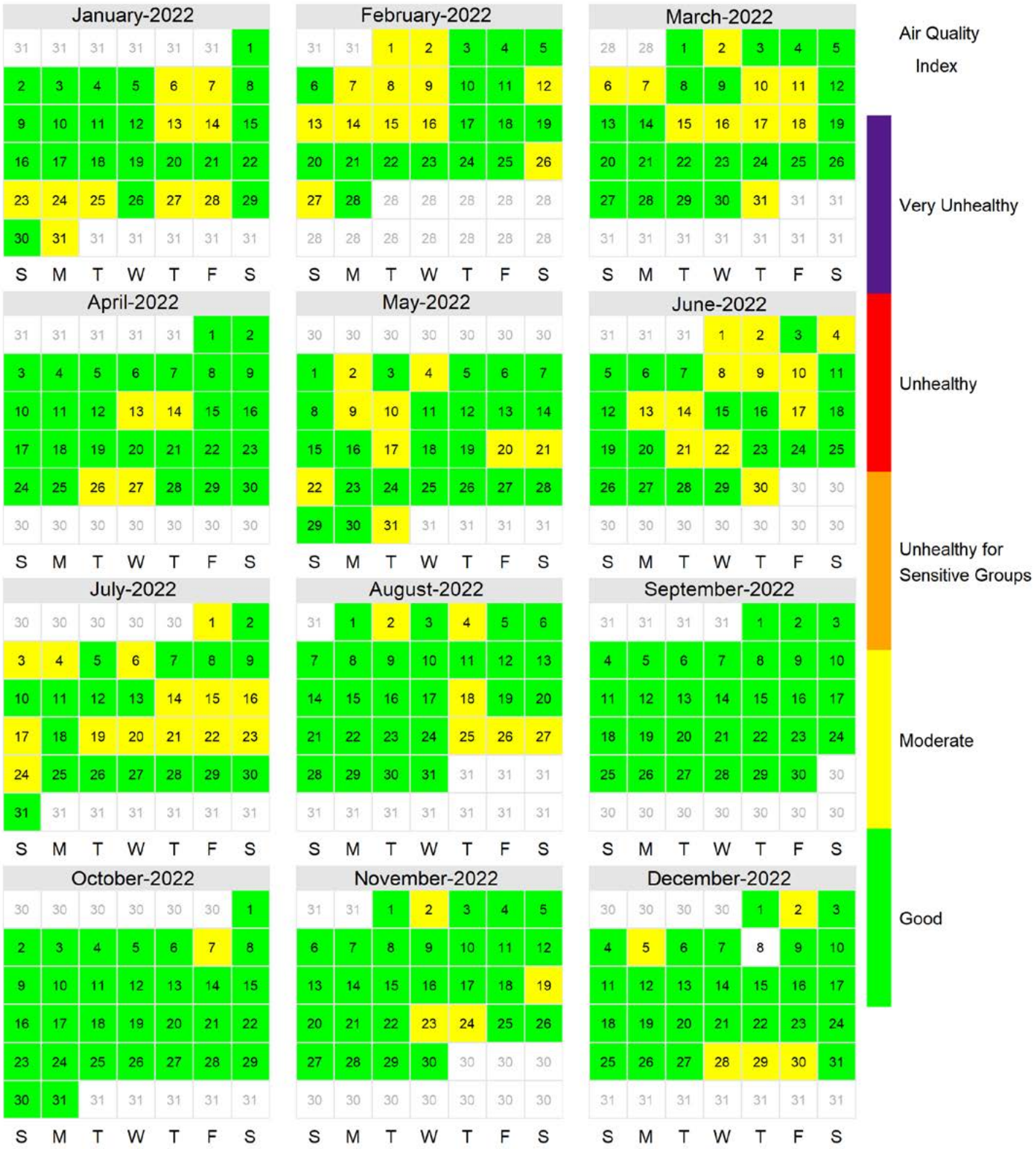
There are no EPA "reference" methods for monitoring ambient air for VOCs. In Delaware's program from 1991 through 1999, samples were taken on sorbent tubes once per week, rotating Monday through Thursday, for 24-hour intervals. The tubes were analyzed by the Department of Natural Resources and Environmental Control (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
Historical Data 2020-2022

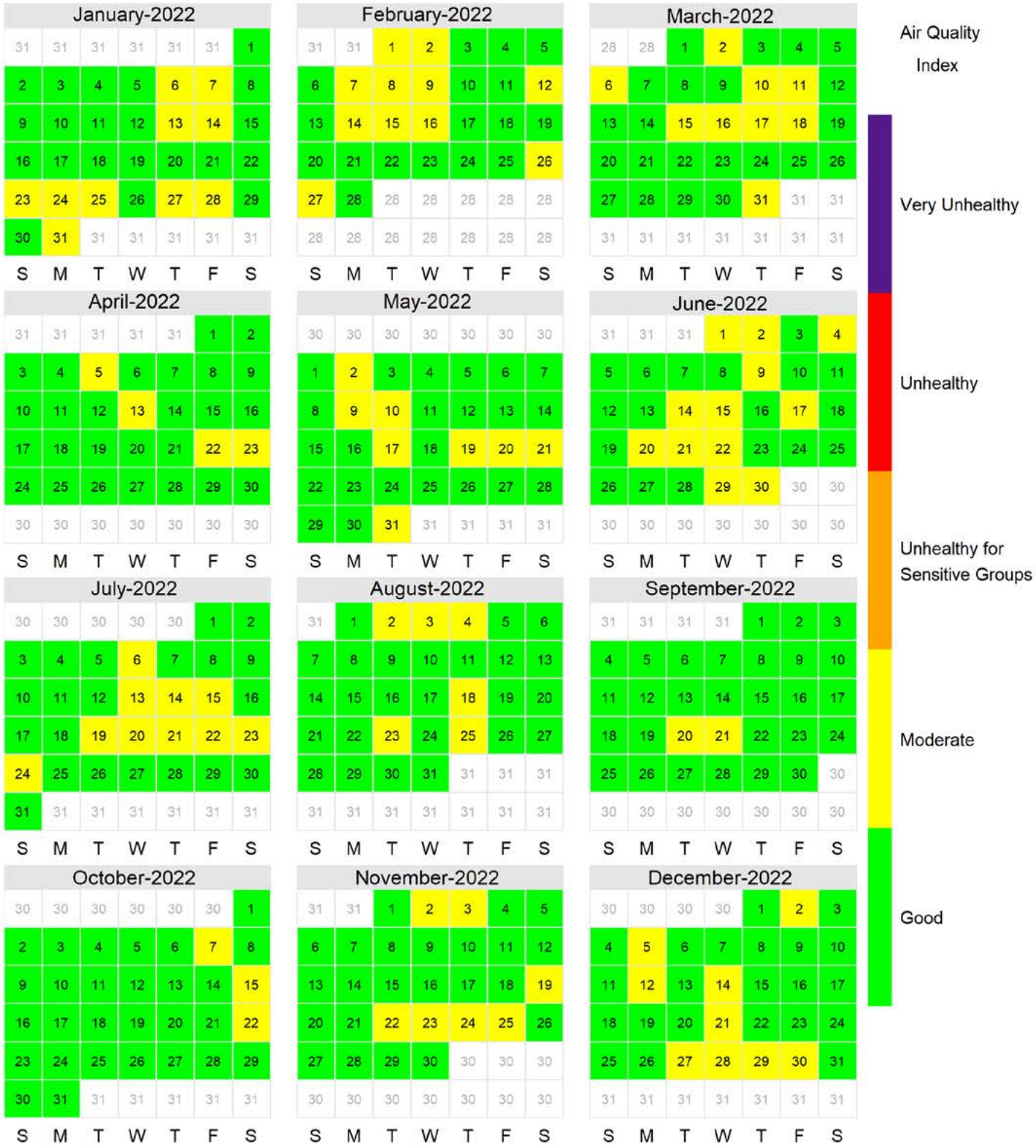
This appendix is included to provide data that would have been included in the Delaware Annual Air Quality Reports that were not produced for 2022, 2021 and 2020.



2022 Kent County
Air Quality Index Calendar

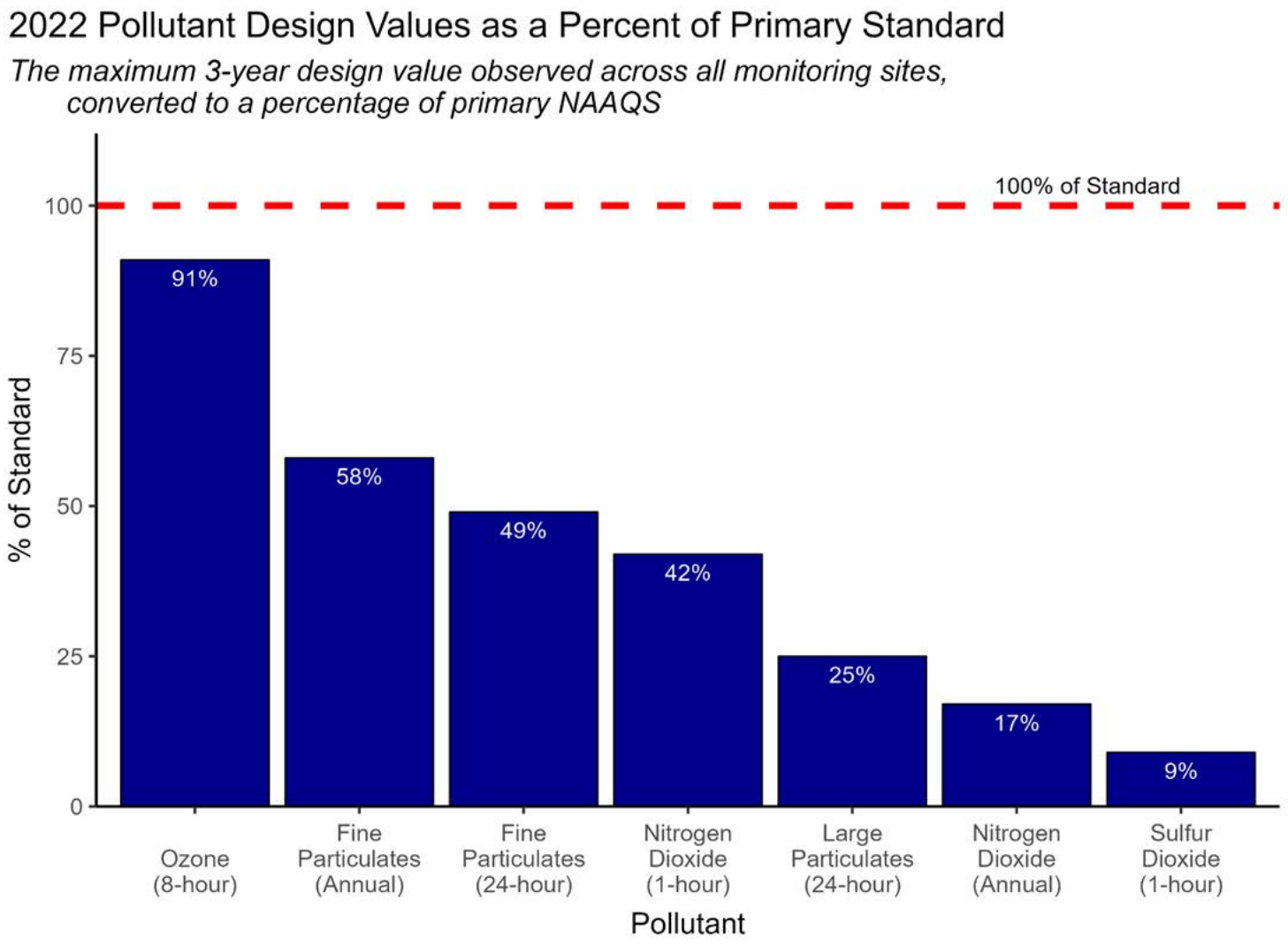


2022 Sussex County
Air Quality Index Calendar

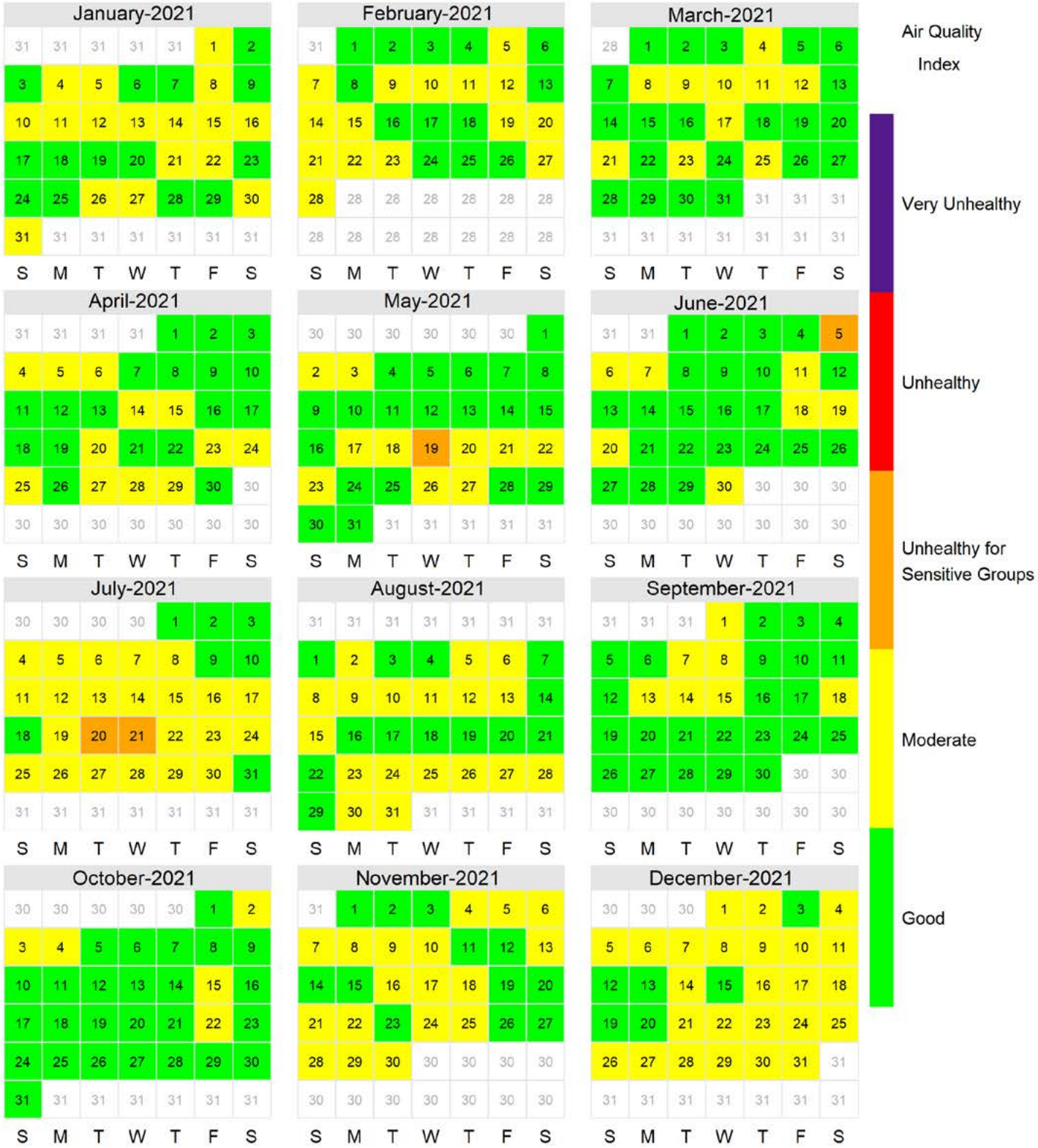


2022	Number of Ozone Exceedance Days and Maxima per Site (ppm)				
Site (listed North to South)	# Exceedances	1st Max.	2nd Max.	3rd Max.	(Design Value) 4th Max.
Brandywine Creek State Park	0	0.059	0.059	0.059	**0.064**
Bellefonte II	0	0.067	0.066	0.060	**0.060**
MLK National Core (NCore)	2	0.072	0.071	0.063	**0.063**
Lums Pond State Park	0	0.063	0.062	0.061	**0.061**
Killens Pond State Park	0	0.064	0.063	0.062	**0.062**
Lewes	0	0.066	0.062	0.061	**0.060**
Seaford	0	0.062	0.059	0.059	**0.058**

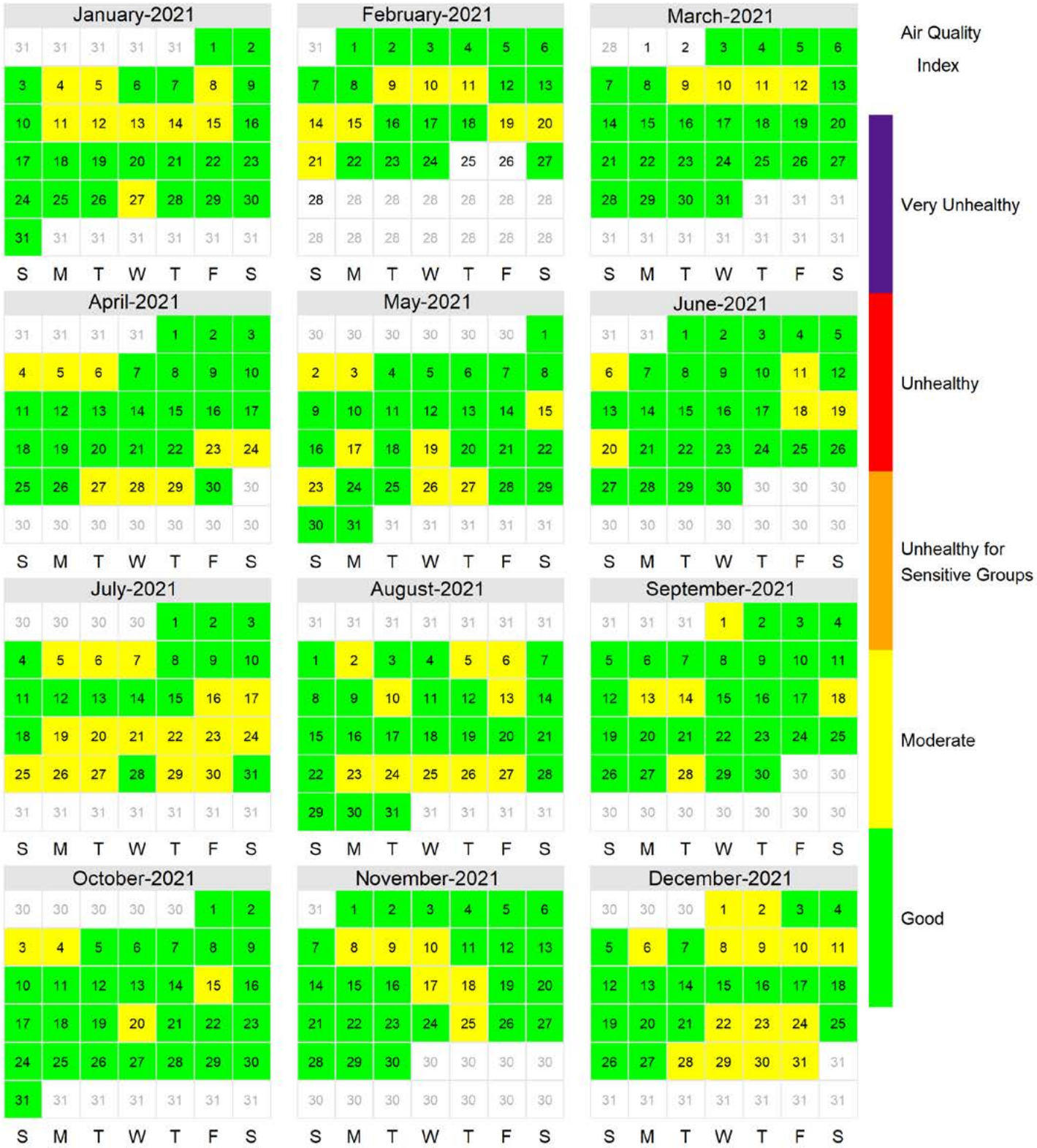
Exceedances = Number of days with at least one 8-hour average > 0.070 ppm.



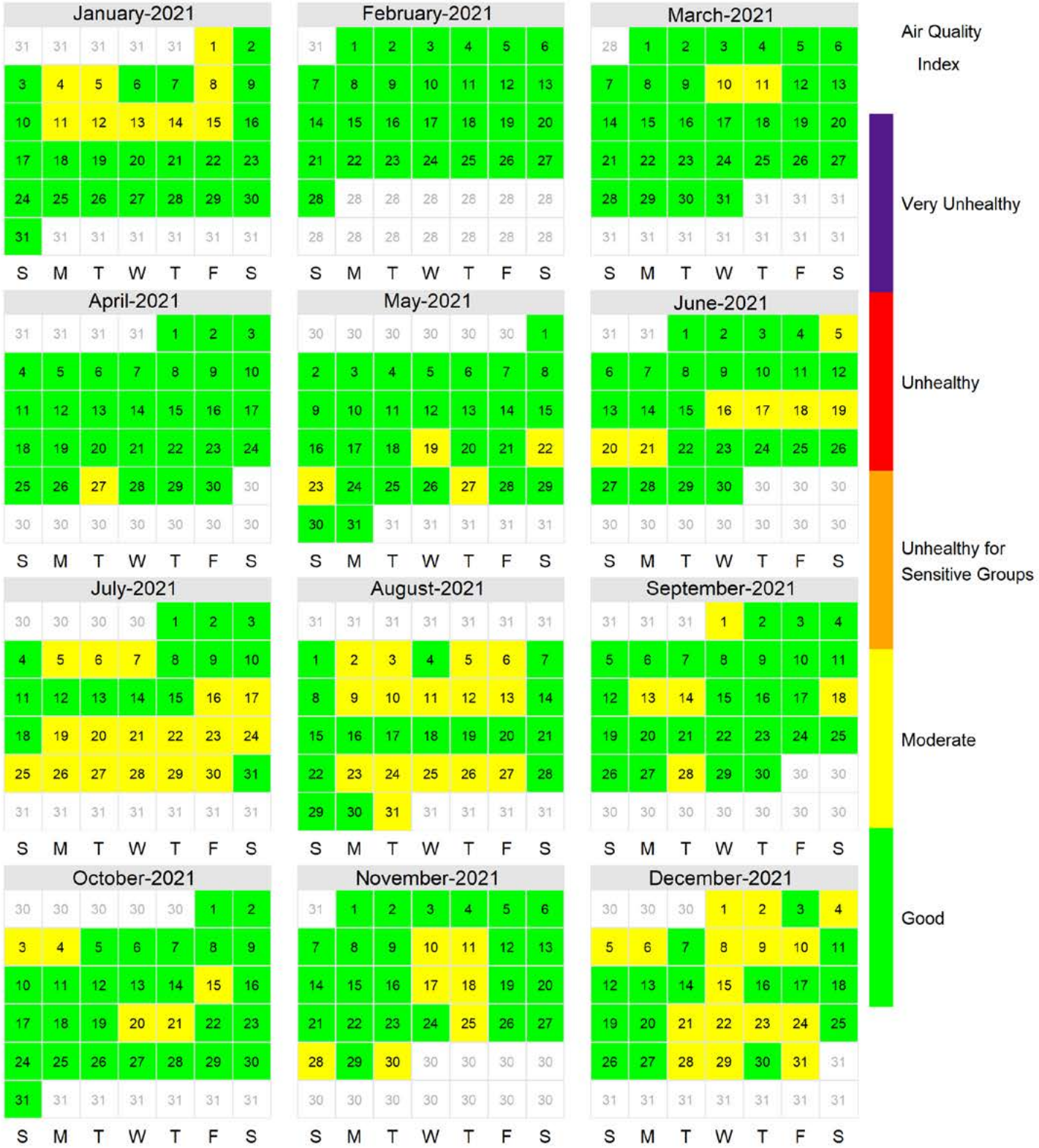
2021 New Castle County
Air Quality Index Calendar



2021 Kent County
Air Quality Index Calendar

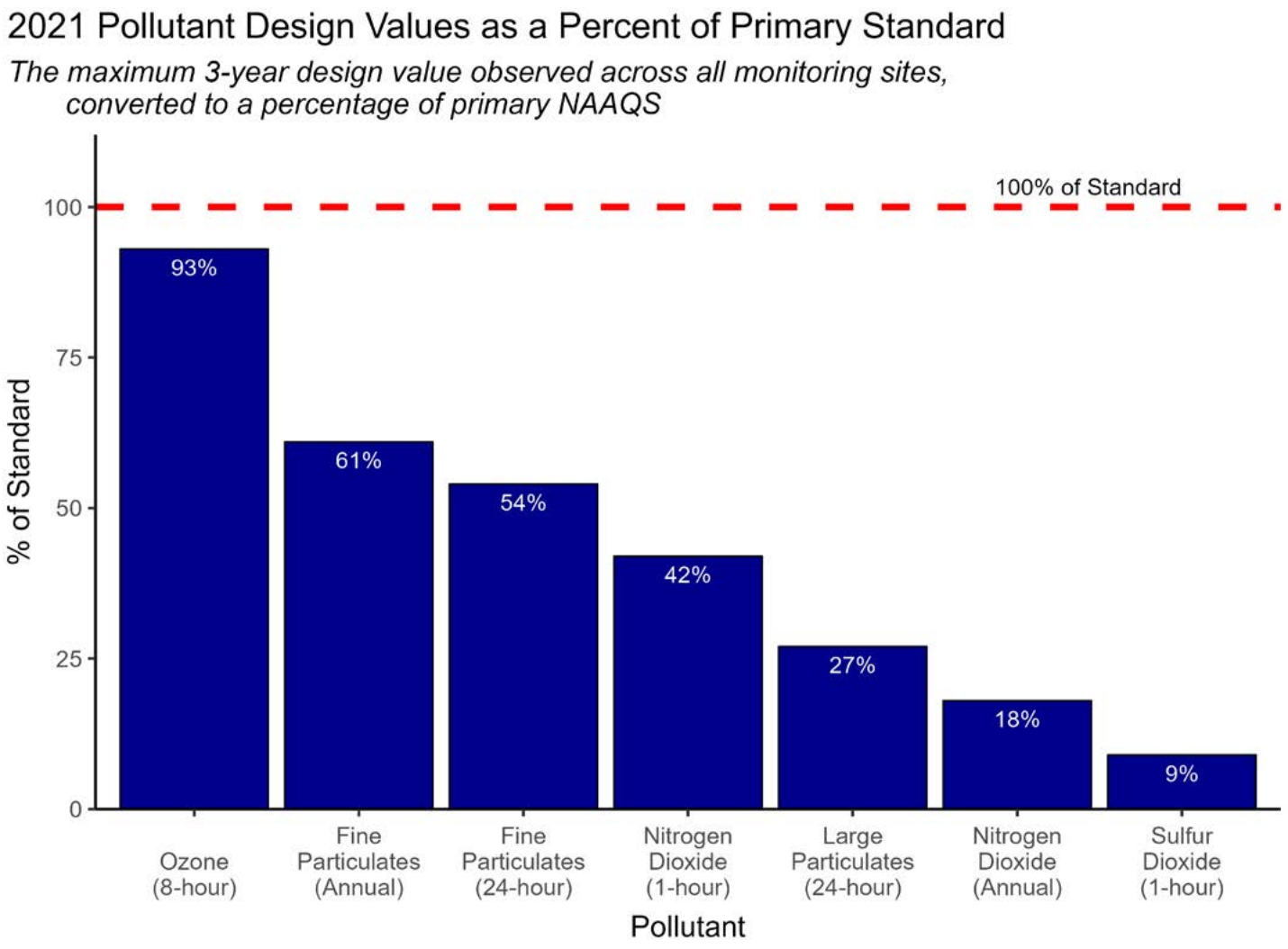


2021 Sussex County
Air Quality Index Calendar

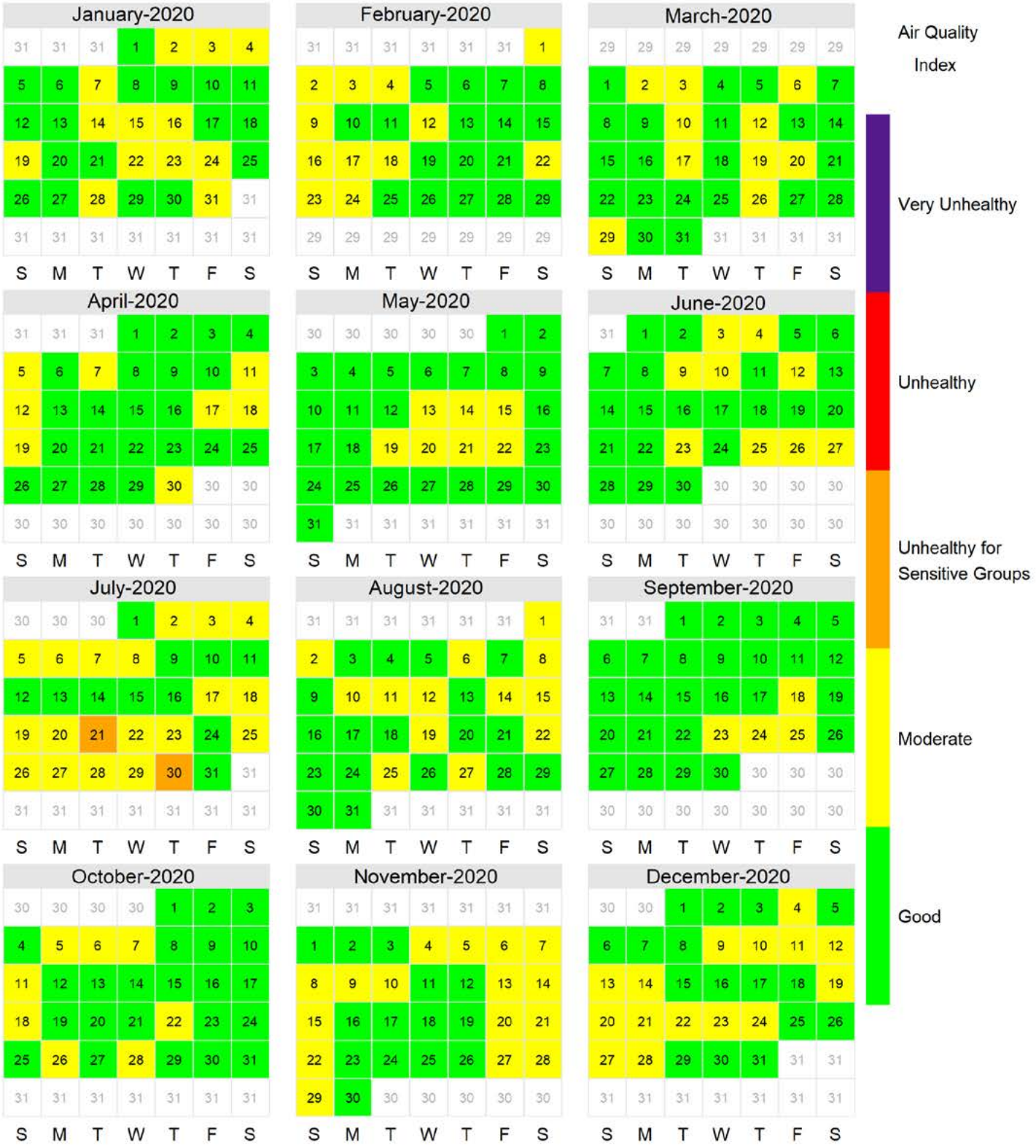


2021	Number of Ozone Exceedance Days and Maxima per Site (ppm)				
Site (listed North to South)	# Exceedances	1st Max.	2nd Max.	3rd Max.	(Design Value) 4th Max.
Brandywine Creek State Park	1	0.072	0.067	0.067	**0.065**
Bellefonte II	1	0.073	0.067	0.067	**0.064**
MLK National Core (NCore)	1	0.074	0.070	0.068	**0.066**
Lums Pond State Park	1	0.071	0.065	0.064	**0.063**
Killens Pond State Park	2	0.073	0.071	0.070	**0.067**
Lewes	0	0.064	0.063	0.062	**0.061**
Seaford	0	0.070	0.065	0.065	**0.064**

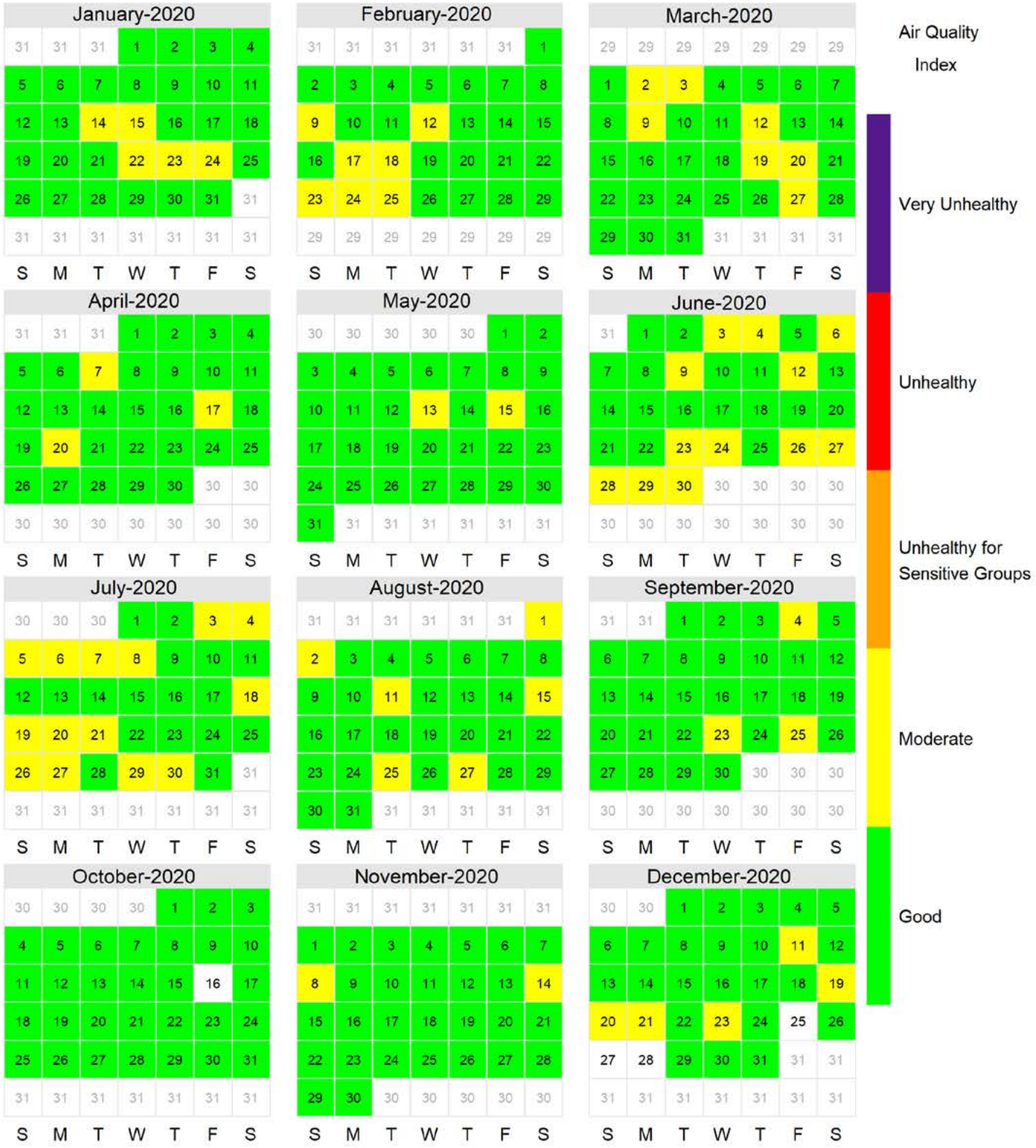
Exceedances = Number of days with at least one 8-hour average > 0.070 ppm.



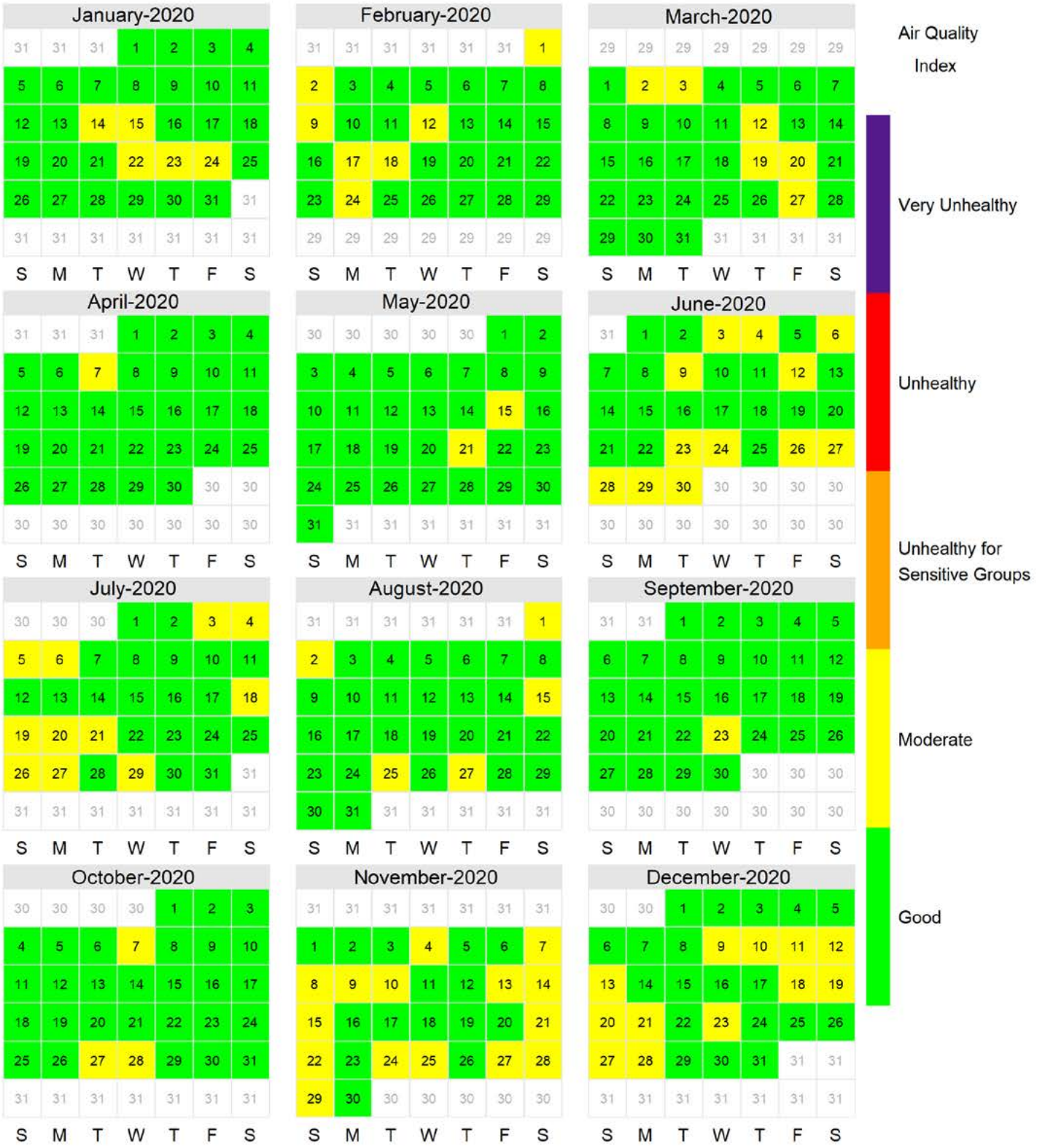
2020 New Castle County
Air Quality Index Calendar



2020 Kent County
Air Quality Index Calendar

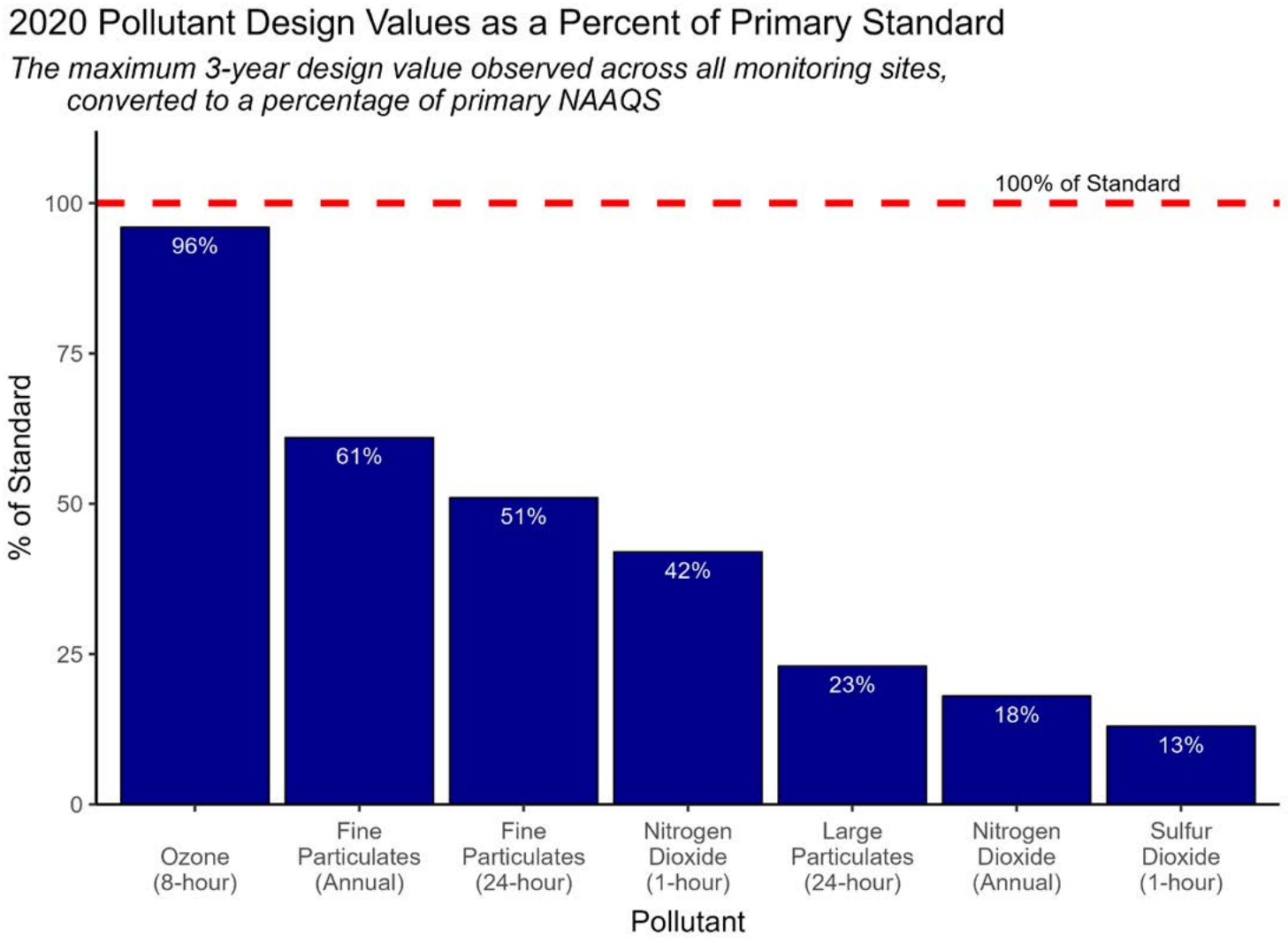


2020 Sussex County
Air Quality Index Calendar



2020	Number of Ozone Exceedance Days and Maxima per Site (ppm)				
Site (listed North to South)	# Exceedances	1st Max.	2nd Max.	3rd Max.	(Design Value) 4th Max.
Brandywine Creek State Park	0	0.059	0.059	0.059	**0.057**
Bellefonte II	0	0.067	0.066	0.060	**0.060**
MLK National Core (NCore)	2	0.072	0.071	0.063	**0.063**
Lums Pond State Park	0	0.063	0.062	0.061	**0.061**
Killens Pond State Park	0	0.064	0.063	0.062	**0.062**
Lewes	0	0.066	0.062	0.061	**0.060**
Seaford	0	0.062	0.059	0.059	**0.058**

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



References

References and Reports

Air Quality Index (AQI) - A Guide to Air Quality and Your Health, U.S. EPA
airnow.gov/aqi/aqi-basics/

National air quality and emissions trends, U.S. EPA
epa.gov/air-trends

Delaware Toxics Release Inventory Report, Delaware DNREC
dnrec.delaware.gov/waste-hazardous/emergency-response/community-right-to-know/tri/

Delaware Annual Air Quality Reports, Delaware DNREC
dnrec.delaware.gov/air/quality/monitoring/

Air Quality Related Web Sites

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

American Lung Association
lung.org

Delaware State Climatologist
climate.udel.edu/

Delaware Valley Regional Planning Commission
dvrpc.org/

Delaware Air Quality Forecast (Seasonally May – September)
dnrec.delaware.gov/air/quality/forecast/

Air Quality Partnership
airqualitypartnership.org/

DNREC Division of Air Quality current hourly monitoring data
de.gov/airdata

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

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

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

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

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

List of Websites Linked to in this Report

Department of Natural Resources and Environmental Control (DNREC)
dnrec.delaware.gov/

Interactive Air Quality Monitoring Tool
epa.gov/outdoor-air-quality-data/interactive-map-air-quality-monitors

Division of Air Quality web page
dnrec.delaware.gov/air/

EPA's AirNow
airnow.gov/

Citizens' Guide to Residential Open Burning
dnrec.delaware.gov/air/open-burning/residential/

Delaware Air Quality Regulations
regulations.delaware.gov/AdminCode/title7/1000/1100/index.shtml

Air Quality Design Values
epa.gov/air-trends/air-quality-design-values

Delaware Ambient Air Monitoring Network Plan
documents.dnrec.delaware.gov/Air/monitoring/delaware-air-monitoring-network-plan.pdf

Air Quality Monitoring website
dnrec.delaware.gov/air/quality/monitoring/

Archived AirNow Maps (No longer separate page, but a tab in the map view)
gispub.epa.gov/airnow/?tab=archive

EPA Particulate Matter Basics (graphic source)
Particulate Matter (PM) Basics | US EPA

$PM_{2.5}$ Continuous Monitor Comparability Assessments" EPA Website.
epa.gov/outdoor-air-quality-data/pm25-continuous-monitor-comparability-assessments

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