2015 Air Quality Summaries Introduction

New Jersey Department of Environmental Protection
Bureau of Air Monitoring
Trenton, New Jersey

www.njaqinow.net

LIST OF CONTENTS

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INTRODUCTION

This series of reports summarizes the New Jersey air quality monitoring data for 2015, collected from New Jersey's extensive air monitoring network. The state of New Jersey has been monitoring air quality since 1965. During that time pollution levels have improved significantly as a result of state, regional and national air pollution reduction efforts.

The summaries contain information on the Air Quality Index (AQI), and concentrations of individual pollutants including carbon monoxide, nitrogen oxides, ozone, particulate matter, and sulfur dioxide. These are known as criteria pollutants, for which National Ambient Air Quality Standards (NAAQS) have been set.   Data on atmospheric deposition, haze, speciation of fine particulates, air toxics, and meteorological data are also provided.

Figures 1 through 5 below illustrate the remarkable downward trends in concentrations of criteria pollutants over the past few decades.

Because ozone is formed in the presence of sunlight and high temperatures, it can reach significant levels in the summer months. It also has been found to have serious health effects at lower levels than previously thought.   In response, the United States Environmental Protection Agency (USEPA) periodically revises and lowers the NAAQS. Thanks to pollution control efforts both in and out of state, New Jersey was able to comply with the ozone NAAQS of 0.075 ppm in 2015. However, USEPA will lower the standard to 0.070 ppm in 2016. In order to meet the new standard, New Jersey will continue to implement emission control strategies while pursuing emissions reductions in upwind states that affect New Jersey's air.

The sharp increase and subsequent decrease in sulfur dioxide (SO_2) concentrations in Figure 3 are attributable to a coal-burning facility across the river in Pennsylvania.   The New Jersey Department of Environmental Protection established the Columbia Wildlife Management Area monitoring station in 2010 to determine whether the facility was impacting New Jersey's air quality. Exceedances of the SO_2 NAAQS were recorded that same year. Since it stopped operating under a court agreement, SO_2 levels in New Jersey have fallen below the standard once again.

Nitrogen dioxide (NO_2) is also known cause serious health problems, especially for sensitive individuals such as children, the elderly, and people with asthma. New Jersey has always been in compliance with the NAAQS for NO_2.

Particulate air pollution less than 2.5 micrometers in diameter is referred to as fine particulate or $PM_{2.5}$. These small particles can be inhaled deep into the lungs, and are known to have a greater impact on public health than larger particles, which were the focus of previous ambient air quality standards. Monitoring data in New Jersey shows a steady decline in $PM_{2.5}$ levels, and is now in compliance with the NAAQS.

Questions or comments can be made by e-mailing us at bamweb@dep.nj.gov, by phone at (609) 292-0138, or by writing to us at:

<div align="center">

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Figure 1
Ozone Design Value* Trend in New Jersey, 1990-2015
*3-Year Average of 4th-Highest Daily Maximum 8-Hour Average Concentrations
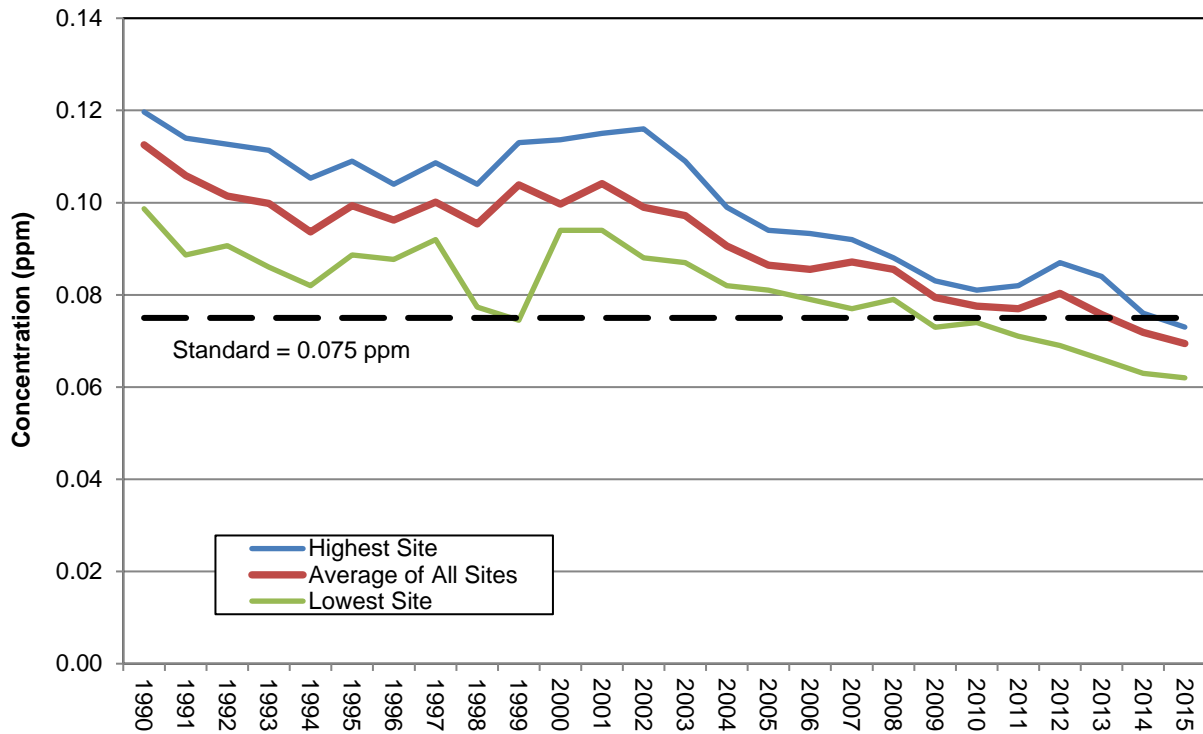**in Parts per Million (ppm)**

Figure 2
Sulfur Dioxide (SO₂) Trend in New Jersey, 2000-2015
99th Percentile of Daily Maximum 1-Hour Average Concentrations
in Parts per Million (ppm)

Figure 3
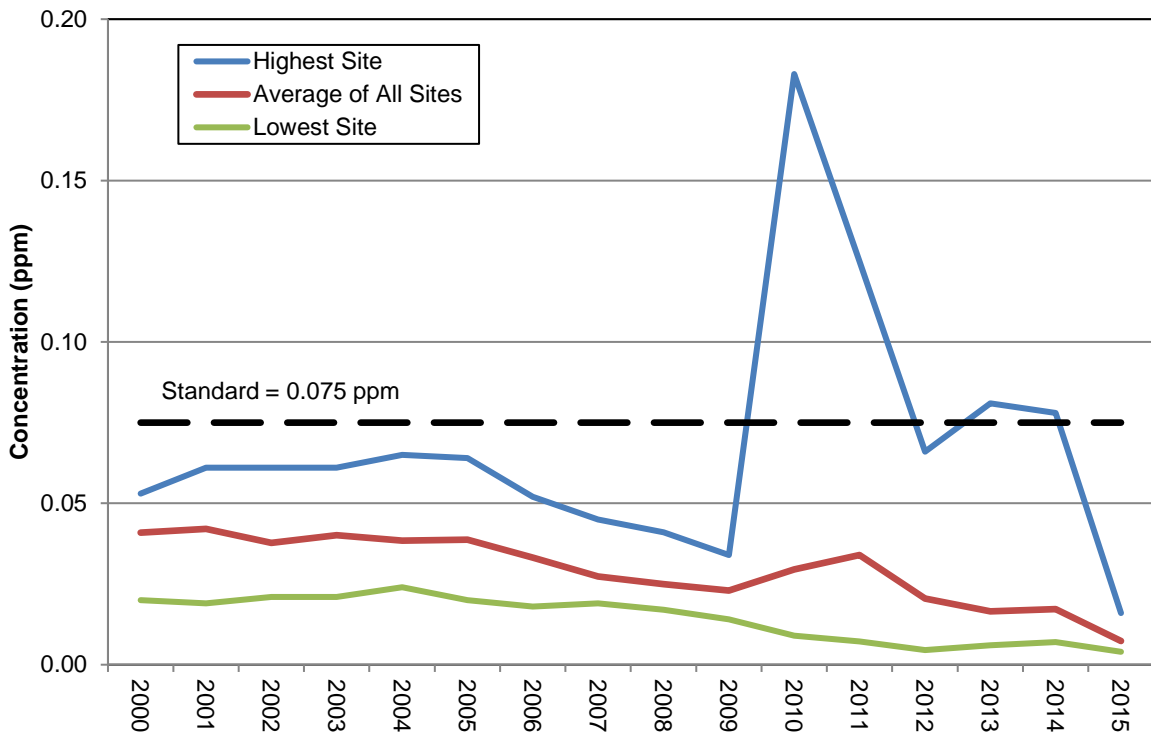**Nitrogen Dioxide (NO$_2$) Trend in New Jersey, 1990-2015**
Annual Average Concentrations in Parts per Million (ppm)

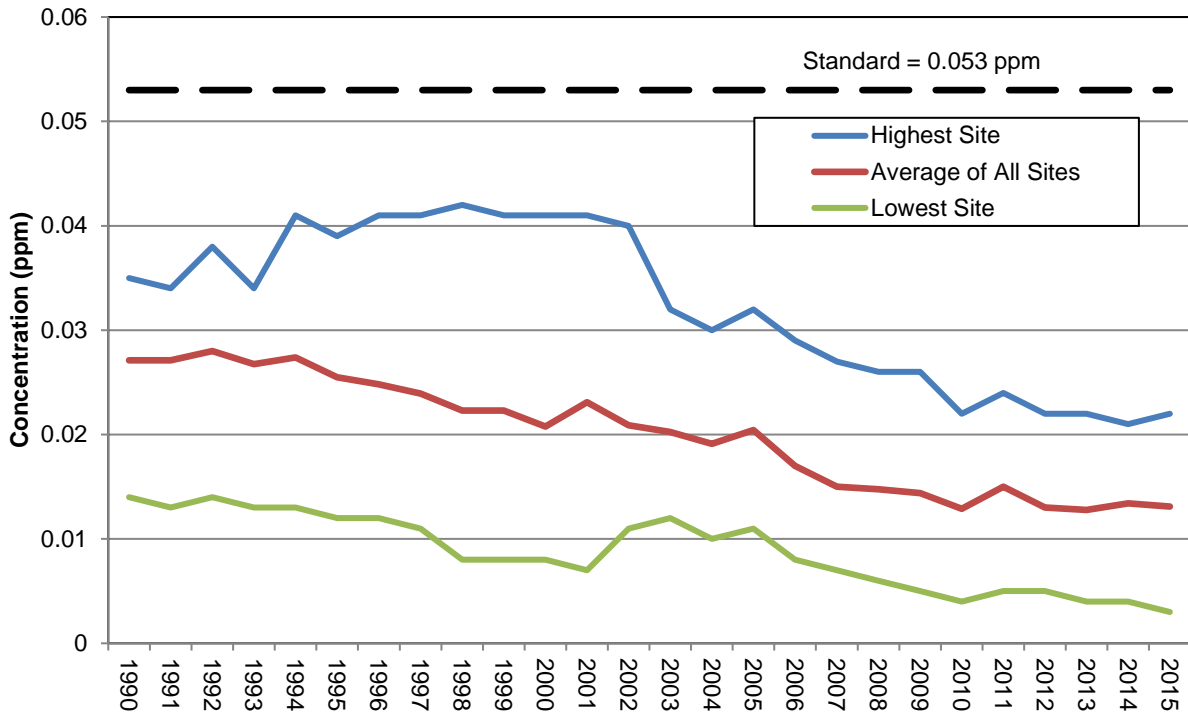**Figure 4**
Fine Particulate (PM$_{2.5}$) Trend in New Jersey, 1999-2015
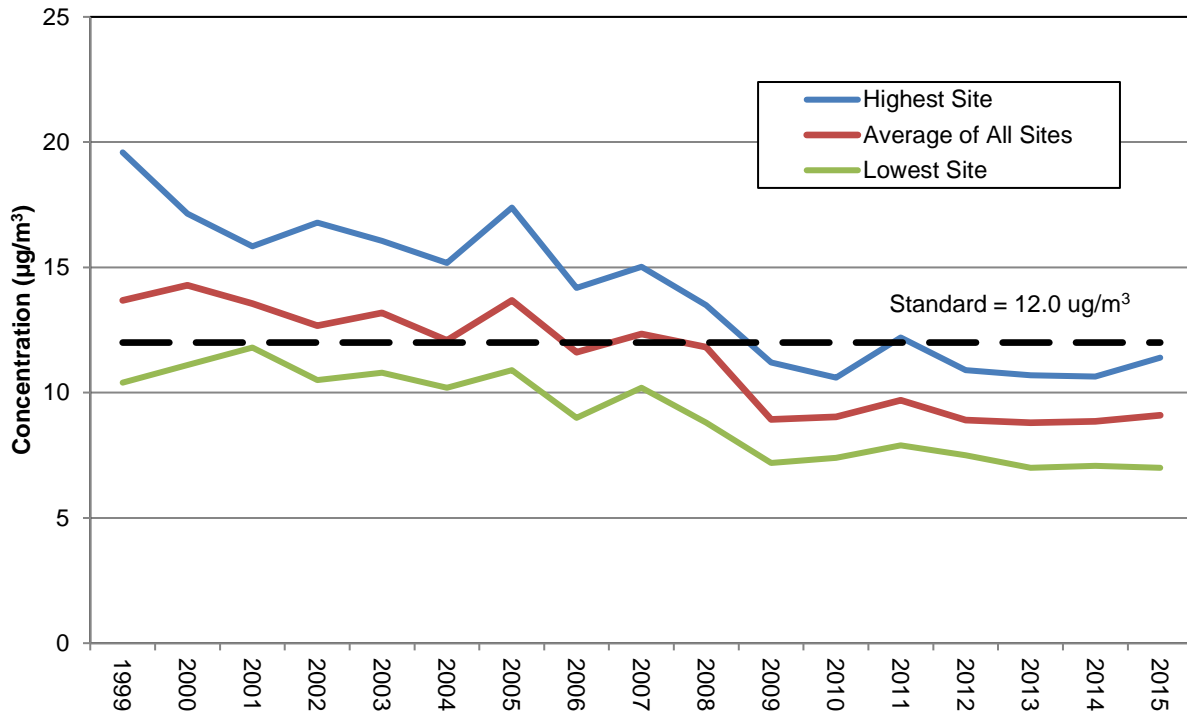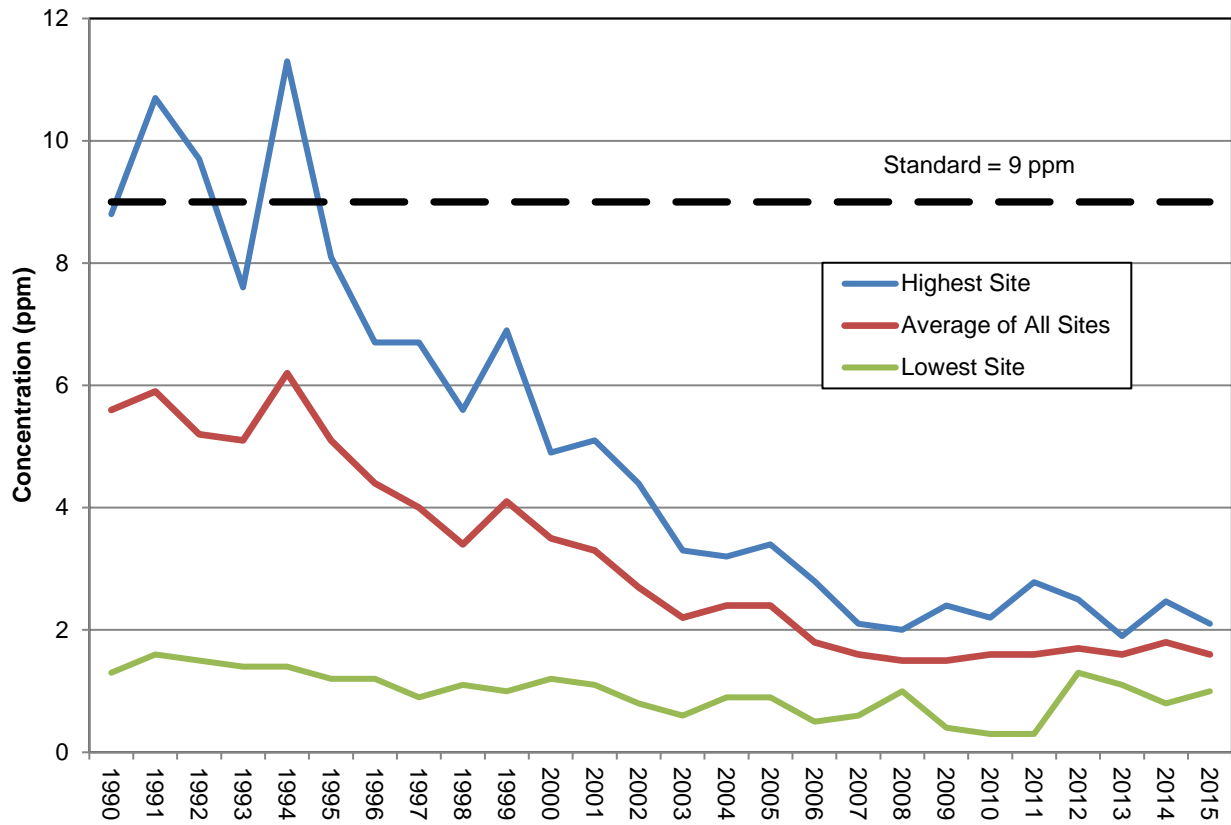**Annual Average Concentrations in Micrograms per Cubic Meter (µg/m³)**

Figure 5
Carbon Monoxide (CO) Trend in New Jersey, 1990-2015
2nd-Highest 8-Hour Average Concentrations in Parts per Million (ppm)

2015 Network Summary

New Jersey Department of Environmental Protection

NETWORK DESCRIPTION

In 2015, the New Jersey Department of Environmental Protection (NJDEP) Bureau of Air Monitoring (BAM) operated 37 ambient air monitoring stations. The stations vary in the number and type of monitors operating at each site. The NJDEP air monitoring program is primarily focused on the measurement of pollutants for which National Ambient Air Quality Standards (NAAQS) have been established, also known as criteria pollutants. Criteria pollutant monitoring is regulated by the United States Environmental Protection Agency (USEPA), which prescribes the design and siting of the monitoring networks, the acceptable monitoring methods, and the minimum quality assurance activities. Only data which meet USEPA requirements can be used to determine compliance with the NAAQS.

Figure 1
Columbia Air Monitoring Station
Warren County

There are six criteria air pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM). Because particulate matter encompasses such a wide range of contaminants, there are NAAQS for two different size fractions of particles. There are separate standards for inhalable particles, less than 10 microns in size (1 micron = one millionth of a meter), referred to as PM_{10}, and for fine particles, less than 2.5 microns, referred to as $PM_{2.5}$.

In New Jersey, O_3, CO, NO_2, and SO_2 are measured using USEPA-approved real-time monitoring methods, and data collected for these pollutants are continuously transmitted to a central data acquisition system. Once an hour, the Bureau of Air Monitoring posts this air quality data to its web site (www.njaqinow.net) and to the USEPA's Air Now web site (www.airnow.gov). However, for lead, PM_{10}, PM_{coarse}, and some $PM_{2.5}$ measurements, compliance with the NAAQS is determined using a USEPA-approved 24-hour sampler that uses a filter that must be installed and then removed for weighing and analysis. In order to provide hourly information to disseminate to the public in real time, NJDEP operates additional USEPA-equivalent-method $PM_{2.5}$ instruments that continuously measure concentrations. The most recent of these, $PM_{2.5}$ Beta Attenuation Analyzers, have been installed at numerous stations, replacing an earlier model of real-time particulate monitor, the Tapered Element Oscillating Microbalance (TEOM) analyzer.

In addition to monitoring criteria pollutants, the NJDEP also measures "non-criteria pollutants," or pollutants that do not have health-based National Ambient Air Quality Standards. Certain non-criteria pollutants are grouped together by their purpose or collection method. USEPA's Photochemical Assessment Monitoring Station (PAMS) program, for example, measures non-criteria pollutants that are important in the formation of ozone. Since most ozone is not directly emitted from sources but forms in the atmosphere when volatile organic compounds and oxides of nitrogen react in the presence of sunlight, it is important to know the levels of these "precursor" pollutants.

Other non-criteria pollutants that the Bureau monitors include some that are commonly emitted by motor vehicles and other combustion sources: Benzene, toluene, ethylbenzene, ortho-xylene, meta-xylene, para-xylene (measured with a "BTEX" analyzer), and black carbon (measured with an aethalometer).

Five sites in the monitoring network collect samples of $PM_{2.5}$ that are analyzed to determine the chemical makeup of the particles. These are part of USEPA's Chemical Speciation Network (CSN). This data is used in helping to identify the primary sources of particles, and in assessing potential health effects.

At four monitoring sites, samples are collected and analyzed for non-criteria pollutants that are classified as "air toxics." These are pollutants that have potential health effects but for which NAAQS have not been established. They can be carcinogenic or have other serious health effects, and are very diverse in their chemical composition.

Two sites, Cattus Island and Washington Crossing, are part of the National Atmospheric Deposition Network. BAM staff collect the samples and ship them to a national laboratory for analysis of acids, nutrients, and base cations in precipitation.

A number of sites within the air monitoring network also take measurements of meteorological parameters, such as temperature, relative humidity, barometric pressure, wind speed, wind direction, and solar radiation. Figure 1 shows the monitoring station at the Columbia Wildlife Management Area in Warren County, which measures criteria pollutant data as well as weather parameters. Figure 2 shows a USEPA-approved manual $PM_{2.5}$ sampler located on the roof of Atlantic Cape Community College in Atlantic City.

Figure 2
USEPA-Approved PM$_{2.5}$ Sampler in Atlantic City

The map in Figure 3 shows the locations of all the sites that operated in 2015, and Table 1 lists the parameters that were measured at each site.

Figure 3
New Jersey Air Monitoring Sites
2015 Network Summary
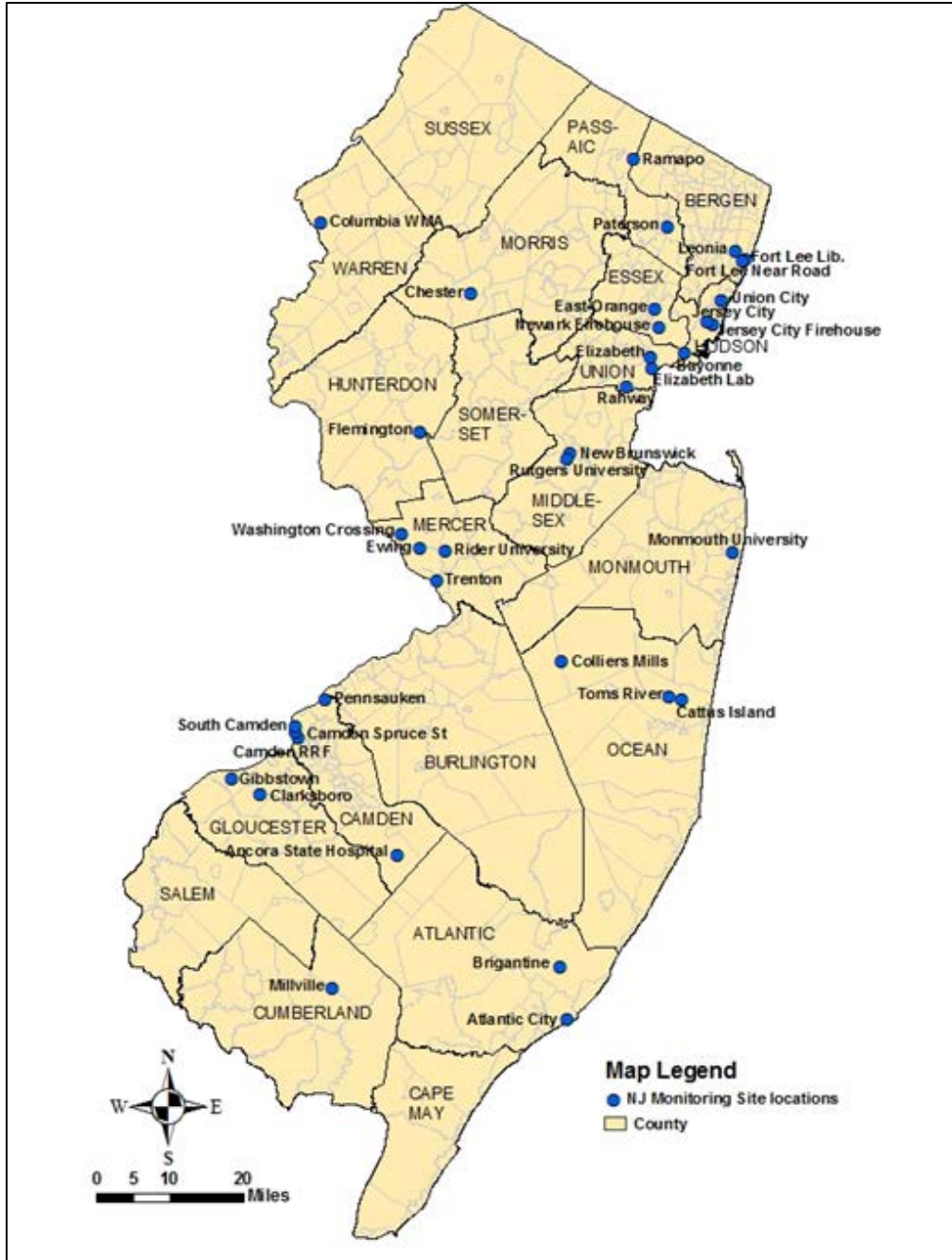
Table 1
2015 New Jersey Air Monitoring Network Summary

		CO	NOx	NOy	O3	SO2	Smoke Shade	PM2.5	PM2.5-Speciation	Real-Time PM2.5 TEOM	Real-Time PM2.5 Beta	Visibility	PM10	O3 Precursors - PAMS	Toxics	BTEX/ Black Carbon	Lead/PMcoarse	Acid Deposition	Mercury	Bar./ Pres./ Rel. Humidity	Solar Radiation	Temperature	Wind Speed/ Direction
1	Ancora State Hospital				1																		
2	Atlantic City							1															
3	Bayonne		1		1	1										1				1		1	1
4	Brigantine				1	1		1			1	1						1	1				
5	Camden RRF												1										
6	Camden Spruce Street	1	1		1	1		1	1		1				1	1				1		1	1
7	Cattus Island																	1					
8	Chester		1		1	1		1	1						1				1		1		
9	Clarksboro				1																		
10	Colliers Mills				1																		
11	Columbia WMA		1		1	1		1			1									1		1	1
12	East Orange	1	1																	1		1	1
13	Elizabeth	1			1		1																
14	Elizabeth Lab	1	1		1	1		2	1		1				1	1			1				1
15	Ewing									1													
16	Flemington		1							1										1	1	1	1
17	Fort Lee Library							1															
18	Fort Lee Near Road	1	1								1					1				1		1	1
19	Gibbstown							1															
20	Jersey City	1			1		1																
21	Jersey City Firehouse							2		1	1		2										
22	Leonia				1																		
23	Millville		1		1						1												
24	Monmouth University				1																		
25	New Brunswick							1	2		1				1								
26	Newark Firehouse	1	1	1	1	1		1	1		1					1	1			1	1	1	1
27	Paterson							1															
28	Pennsauken							1															
29	Rahway							1	1														
30	Ramapo				1																		
31	Rider University				1						1									1	1	1	1
32	Rutgers University		1		1						1			1									
33	South Camden										1												
34	Toms River							1															
35	Trenton							1															
36	Union City							1															
37	Washington Crossing																	1					
	TOTAL	7	10	1	16	9	3	20	6	5	11	1	3	1	4	5	1	3	3	8	4	8	9

1 - Parameter measured in 2015.
2 - Collocated parameter measured in 2015.

Began measuring in 2015. See Table 2.
Stopped measuring in 2015. See Table 2.

CHANGES TO THE NETWORK IN 2015

In 2015 the PM$_{2.5}$ speciation sampling schedules at Chester and Camden Spruce Street were changed from every three days to every six days. This will conserve resources while still providing valuable data. The PM$_{2.5}$ sampling sites in Morristown, Philipsburg, and the Elizabeth Mitchell Building were shut down because they were close to other monitoring sites that were measuring very similar data. The Jersey City and Elizabeth smoke shade instruments finally stopped functioning after about forty years. They are not being replaced because the technology is obsolete. The New Brunswick site is gradually being replaced by the newly refurbished Rutgers University site, which is located approximately a mile away. The New Brunswick PM$_{2.5}$ Beta analyzer was relocated to the Rutgers University site in August, and the toxics instrument will be installed there in 2016. PM$_{2.5}$ TEOM analyzers at Flemington and the Jersey City Firehouse were both discontinued. New PM$_{2.5}$ Beta analyzers were installed at the Jersey City Firehouse and Rider University.

Table 2
2015 Network Changes (by Date)

Monitoring Site	Parameter(s)	Action	Date
Chester	Speciation	Decreased sampling from every 3 days to every 6 days	1/1/2015
Camden Spruce St.	Speciation	Decreased sampling from every 3 days to every 6 days	1/1/2015
Elizabeth Mitchell Building	PM2.5	Discontinued	1/1/2015
Morristown Ambulance	PM2.5	Discontinued	1/1/2015
Phillipsburg	PM2.5	Discontinued	1/1/2015
Jersey City	Smoke Shade	Discontinued	1/13/2015
Jersey City Firehouse	Real-time PM$_{2.5}$ (TEOM Analyzer)	Discontinued	3/17/2015
Jersey City Firehouse	Real-time PM$_{2.5}$ (Beta Analyzer)	Start-up	3/26/2015
Rider University	Real-time PM$_{2.5}$ (Beta Analyzer)	Start-up	5/30/2015
New Brunswick	Real-time PM$_{2.5}$ (Beta Analyzer)	Relocated to Rutgers	8/06/2015
Rutgers University	Real-time PM$_{2.5}$ (Beta Analyzer)	Start-up	8/26/2015
Elizabeth	Smoke Shade	Discontinued	10/13/2015
Flemington	Real-time PM$_{2.5}$ (TEOM Analyzer)	Shut down	12/31/2015
New Brunswick	Toxics	Relocated to Rutgers	12/31/2015

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2015 Air Quality Index Summary

New Jersey Department of Environmental Protection

WHAT IS THE AIR QUALITY INDEX (AQI)?

The Air Quality Index (AQI) is a nationwide air quality rating system based on the National Ambient Air Quality Standards (NAAQS). An AQI value of 100 is equal to the primary, or health-based, NAAQS for each pollutant. This allows for a direct comparison of each of the pollutants used in the AQI. These pollutants are ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. Although air concentrations of pollutants have been dropping over the years, the U.S. Environmental Protection Agency (USEPA) must periodically review the NAAQS in response to new research to make sure that they continue to be protective of public health. The ozone NAAQS was just revised in October 2015.

Every morning an air pollution forecast for the current and following day is prepared by the New Jersey Department of Environmental Protection (NJDEP) using the AQI format. The forecast is provided to USEPA, and is disseminated through the Enviroflash system to subscribers who sign up to receive air quality forecast and alert emails or texts (www.enviroflash.info). Anyone can view the forecast and current air quality conditions at USEPA's AirNow website (www.airnow.gov) or on NJDEP's air monitoring webpage (www.njaqinow.net/).

In an effort to make the AQI easier to understand, a color code and descriptive interpretation are assigned to the numerical ratings (see Table 1). Table 2 contains USEPA's suggested actions to take to protect public health in correspondence with AQI levels. For more details on the AQI, visit USEPA's web site at www.airnow.gov.

Table 1
Air Quality Index Levels and Associated Health Impacts

AQI Level of Health Concern	Numerical Value	Meaning	Color Code
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk.	Green
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.	Yellow
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.	Orange
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.	Red
Very Unhealthy	201 to 300	Health warnings of emergency conditions. The entire population is more likely to be affected.	Purple
Hazardous	301 to 500	Health alert: everyone may experience more serious health effects.	Maroon

Table 2
AQI Value Suggested Actions to Protect Health

Air Quality Index Level	AQI Value Actions to Protect Your Health
Good (1-50)	None
Moderate (51-100)	Unusually sensitive people should consider reducing prolonged or heavy exertion.
Unhealthy for Sensitive Groups (101-150)	The following groups should **reduce prolonged or heavy outdoor exertion**: People with lung disease, such as asthma; Children and older adults; People who are active outdoors.
Unhealthy (151-200)	The following groups should **avoid prolonged or heavy outdoor exertion**: People with lung disease, such as asthma; Children and older adults; People who are active outdoors. Everyone else should limit prolonged outdoor exertion.
Very Unhealthy (201-300)	The following groups should avoid **all outdoor exertion**: People with lung disease, such as asthma; Children and older adults; People who are active outdoors. Everyone else should limit outdoor exertion.

Table 3 shows the pollutant-specific ranges for the AQI categories. These are set according to the corresponding NAAQS. The table includes the ranges for the 2015 revised ozone NAAQS.

Table 3
AQI Pollutant-Specific Ranges

Category	AQI	O_3 (ppm) 8-hour	O_3 (new)* (ppm) 8-hour	$PM_{2.5}$ ($\mu g/m^3$) 24-hour	CO (ppm) 8-hour	SO_2 (ppm) 1-hour	NO_2 (ppm) 1-hour
Good	0-50	0.000-0.059	0.000-0.054	0.0-12.0	0.0-4.4	0-0.035	0-0.053
Moderate	51-100	0.060-0.075	0.055-0.070	12.1-35.4	4.5-9.4	0.036-0.075	0.054-0.100
Unhealthy for Sensitive Groups	101-150	0.076-0.095	0.071-0.085	35.5-55.4	9.5-12.4	0.076-0.185	0.101- 0.360
Unhealthy	151- 200	0.096-0.115	0.086-0.115	55.5-150.4	12.5-15.4	0.186-0.304	0.361-0.649

*Ozone ranges as of October 2015.

Pollutants:
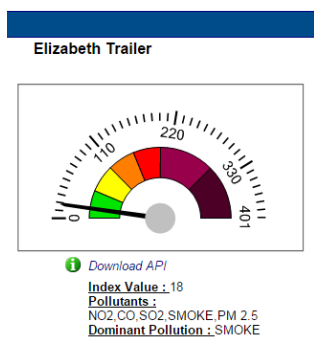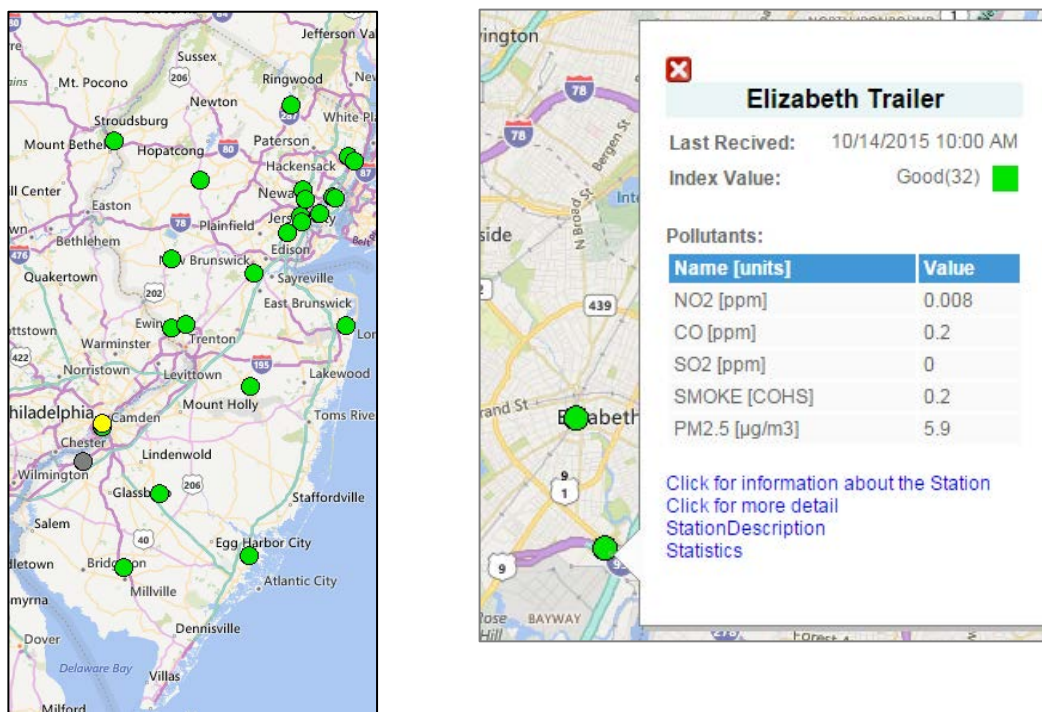O_3 – Ozone
$PM_{2.5}$ – Fine particulate matter
CO – Carbon monoxide
SO_2 – Sulfur dioxide
NO_2 – Nitrogen dioxide

On days when the air quality is expected to reach the "Unhealthy for Sensitive Groups" range or above, cautionary statements similar to those in Table 1 are provided as part of the forecast. These air quality alerts are issued through Enviroflash emails, are displayed on the AirNow and NJDEP air monitoring websites, and can also be viewed on the National Weather Service page (http://airquality.weather.gov/). Maps, charts, site photos, and other air quality information are also available on the NJDEP air monitoring web site, as shown in Figure 1 below.

Figure 1
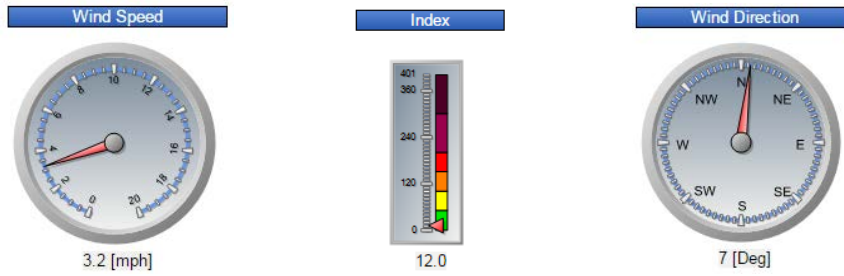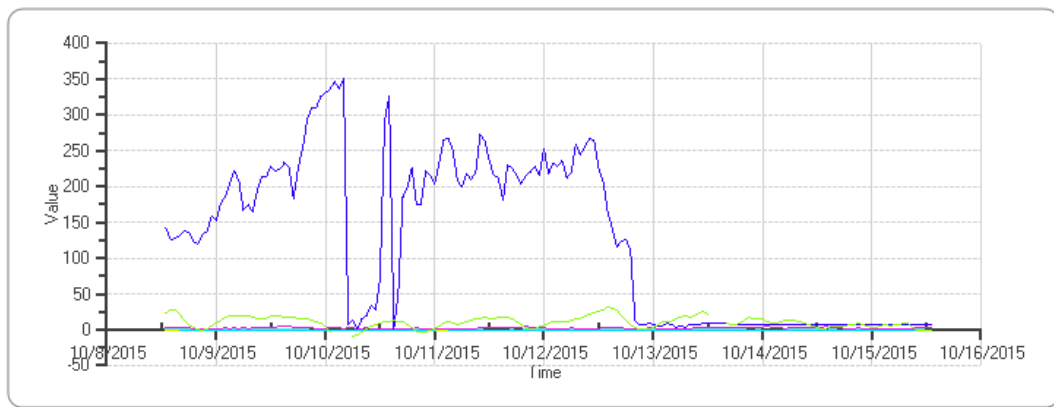**Examples of Information Available on NJDEP's Air Monitoring Website**

Figure 1 (continued)
Examples of Information Available on NJDEP's Air Monitoring Website

2015 AQI Summary

Not all monitoring sites have 365 valid days of reported air quality index values. Certain ozone monitors only operate during "ozone season," from April through October. Table 4 shows which pollutants measured at New Jersey's monitoring stations are used to determine the daily AQI.

Table 4
Pollutants Monitored at Each Air Quality Index Monitoring Site
in New Jersey in 2015

	Monitoring Site	Ozone	Particulate Matter	Sulfur Dioxide	Nitrogen Dioxide	Carbon Monoxide
1	Ancora State Hospital	√ (s)				
2	Bayonne	√		√	√	
3	Brigantine	√	√	√		
4	Camden Spruce St.	√	√	√	√	√
5	Chester	√		√	√	
6	Clarksboro	√ (s)				
7	Colliers Mills	√ (s)				
8	Columbia WMA	√	√	√	√	
9	East Orange				√	√
10	Elizabeth			√		√
11	Elizabeth Lab		√	√	√	√
12	Ewing		√			
13	Flemington	√	√			
14	Fort Lee Near Road		√		√	√
15	Jersey City			√	√	√
16	Jersey City Firehouse		√			
17	Leonia	√ (s)				
18	Millville	√	√		√	
19	Monmouth University	√ (s)				
20	New Brunswick		√			
21	Newark Firehouse	√	√	√	√	√
22	Rahway		√			
23	Ramapo	√ (s)				
24	Rider University	√	√			
25	Rutgers University	√	√		√	
26	South Camden		√			

(s) – Seasonal operation only (April 1 through October 31)

A summary of the AQI ratings for New Jersey in 2015 is presented in the pie chart in Figure 3 below. There were 190 "Good" days, 150 days were "Moderate," 25 were rated "Unhealthy for Sensitive Groups," zero were considered "Unhealthy," and zero were rated "Very Unhealthy." This indicates that air quality in New Jersey is considered good or moderate most of the time, but that pollution is still bad enough to adversely affect some people on about one day in fourteen. This is worse than last year, when one in twenty-four days was unhealthy for sensitive groups. It is, however, the third year in a row to have no days exceed the "Unhealthy" limit for the general population.

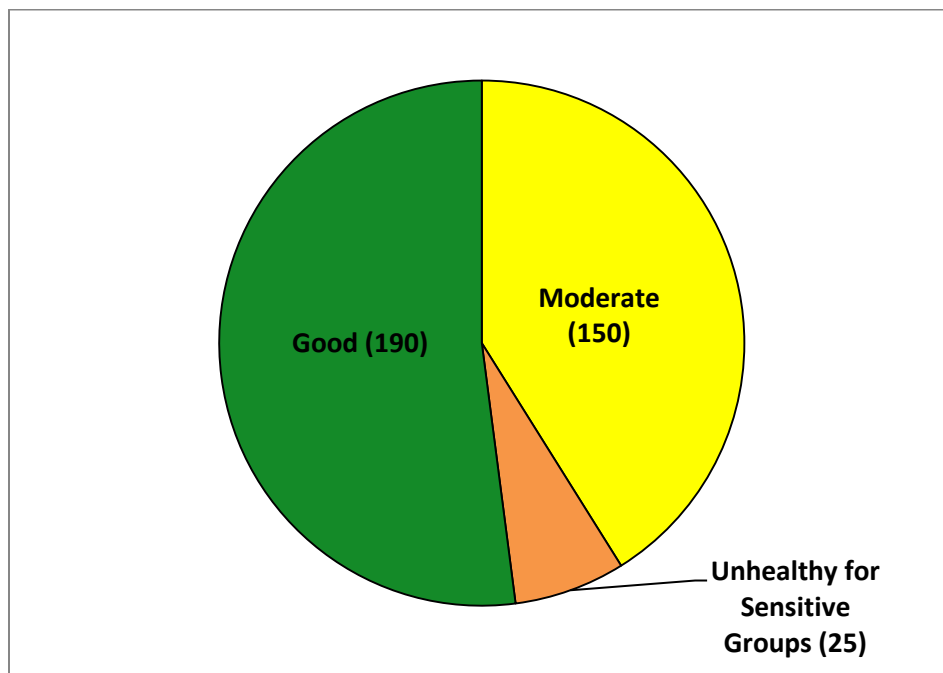**Figure 2**
2015 Air Quality Summary by Days

Table 5 below lists the dates when the AQI reached the "Unhealthy for Sensitive Groups" threshold at any monitoring location, and shows which pollutant or pollutants were in that range or higher.

Table 5
AQI Days Over 100 in New Jersey During 2015

Day	Date	Location	AQI Value	Pollutant	Rating
1	2/25/2015	Fort Lee Near Road	111	NO_2	USG
2	3/10/2015	Elizabeth Trailer	107	NO_2	USG
3	5/5/2015	Colliers Mills	103	O_3	USG
4	5/8/2015	Columbia	101	O_3	USG
5	6/11/2015	Bayonne	101	O_3	USG
	6/11/2015	Camden Spruce St.	134	O_3	USG
	6/11/2015	Colliers Mills	113	O_3	USG
	6/11/2015	Clarksboro	113	O_3	USG
	6/11/2015	Flemington	101	O_3	USG
	6/11/2015	Leonia	106	O_3	USG
	6/11/2015	Monmouth University	127	O_3	USG
	6/11/2015	New Brunswick	110	O_3	USG
	6/11/2015	Rider University	120	O_3	USG
6	6/12/2015	Ramapo	112	O_3	USG
7	6/14/2015	Leonia	101	O_3	USG
8	7/2/2015	Bayonne	119	NO_2	USG
9	7/5/2015	Camden Spruce St.	106	O_3	USG
10	7/12/2015	Camden Spruce St.	101	O_3	USG
11	7/25/2015	Monmouth University	106	O_3	USG
12	7/28/2015	Bayonne	110	O_3	USG
	7/28/2015	Camden Spruce St.	120	O_3	USG
	7/28/2015	Clarksboro	108	O_3	USG
13	7/29/2015	Leonia	110	O_3	USG
	7/29/2015	Rider University	108	O_3	USG
	7/29/2015	Rutgers University	115	O_3	USG
14	8/15/2015	Bayonne	101	O_3	USG
	8/15/2015	Camden Spruce St.	101	O_3	USG
15	8/17/2015	Bayonne	106	O_3	USG
16	8/23/2015	Camden Spruce St.	115	O_3	USG
17	9/1/2015	Camden Spruce St.	108	O_3	USG
	9/1/2015	Clarksboro	101	O_3	USG
	9/1/2015	Colliers Mills	101	O_3	USG
	9/1/2015	Rutgers University	113	O_3	USG

Table 5 (continued)
AQI Days Over 100 in New Jersey During 2015

Day	Date	Location	AQI Value	Pollutant	Rating
18	9/2/2015	Camden Spruce St.	106	O_3	USG
	9/2/2015	Clarksboro	106	O_3	USG
	9/2/2015	Rutgers University	101	O_3	USG
19	9/3/2015	Bayonne	115	O_3	USG
	9/3/2015	Brigantine	101	O_3	USG
	9/3/2015	Colliers Mills	134	O_3	USG
	9/3/2015	Monmouth University	108	O_3	USG
	9/3/2015	Rutgers University	106	O_3	USG
	9/3/2015	Rahway	103	$PM_{2.5}$	USG
20	9/8/2015	Bayonne	101	O_3	USG
	9/8/2015	Leonia	103	O_3	USG
	9/8/2015	Rutgers University	101	O_3	USG
21	9/16/2015	Ancora State Hospital	103	O_3	USG
	9/16/2015	Camden Spruce St.	106	O_3	USG
22	9/17/2015	Ancora State Hospital	103	O_3	USG
	9/17/2015	Bayonne	138	O_3	USG
	9/17/2015	Brigantine	106	O_3	USG
	9/17/2015	Camden Spruce St.	110	O_3	USG
	9/17/2015	Leonia	113	O_3	USG
	9/17/2015	Monmouth University	103	O_3	USG
	9/17/2015	Rider University	103	O_3	USG
	9/17/2015	Rutgers University	103	O_3	USG
23	9/18/2015	Ramapo	122	O_3	USG
24	12/6/2015	Camden Spruce St.	113	$PM_{2.5}$	USG
	12/6/2015	South Camden	104	$PM_{2.5}$	USG
25	12/7/2015	Camden Spruce St.	102	$PM_{2.5}$	USG

Pollutants
NO_2 – Nitrogen dioxide
O_3 – Ozone
$PM_{2.5}$ – Fine particulate matter

Ratings
USG – Unhealthy for Sensitive Groups

Figure 3 shows the distribution of AQI days since 2000. It should be noted that AQI ranges change whenever the NAAQS is revised (so far, always to be more stringent) for a specific pollutant. So even though improvement in AQI days appears to be somewhat erratic, to see how things have really improved refer to the concentration trend graphs in the individual criteria pollutant reports.

New Jersey has not been in the "Very Unhealthy" range since 2003, when the range was reached because of high ozone levels. Only ozone, particulate matter and nitrogen dioxide have been responsible for AQI days above the moderate range since at least the year 2000.

Figure 3
Number of Days in Each AQI Category Since 2000
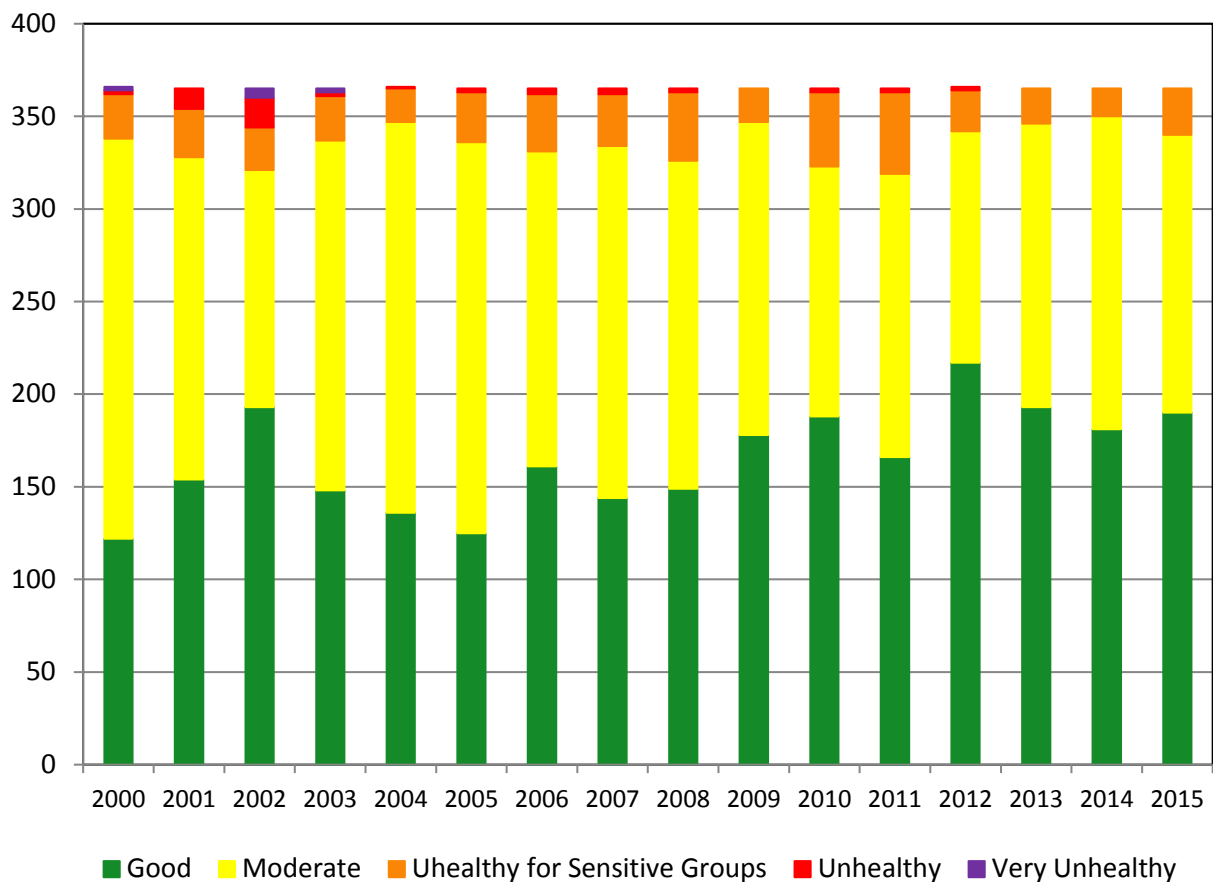
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2015 Ozone Summary

New Jersey Department of Environmental Protection

SOURCES

Ozone (O_3) is a gas consisting of three oxygen atoms. It occurs naturally in the upper atmosphere (stratospheric ozone) where it protects us from harmful ultraviolet rays (see Figure 1). However, at ground-level (tropospheric ozone), it is considered an air pollutant and can have serious adverse health effects. Ground-level ozone is created when nitrogen oxides (NO_x) and volatile organic compounds (VOCs) react in the presence of sunlight (see Figure 2). NO_x is primarily emitted by motor vehicles, power plants, and other sources of combustion. VOCs are emitted from sources such as motor vehicles, chemical plants, factories, consumer and commercial products, and even natural sources such as trees. The pollutants that form ozone, referred to as "precursor" pollutants, and ozone itself can also be transported into an area from sources hundreds of miles upwind.

Since ground-level ozone needs sunlight to form, it is mainly a daytime problem during the summer months. Weather patterns have a significant effect on ozone formation and hot, dry summers will result in more ozone than cool, wet ones. In New Jersey, the ozone monitoring season runs from April 1st to October 31st. For a more complete explanation of the difference between ozone in the upper and lower atmosphere, see the U.S. Environmental Protection Agency (USEPA) publication, "Ozone: Good Up High, Bad Nearby."

Figure 1: Good and Bad Ozone
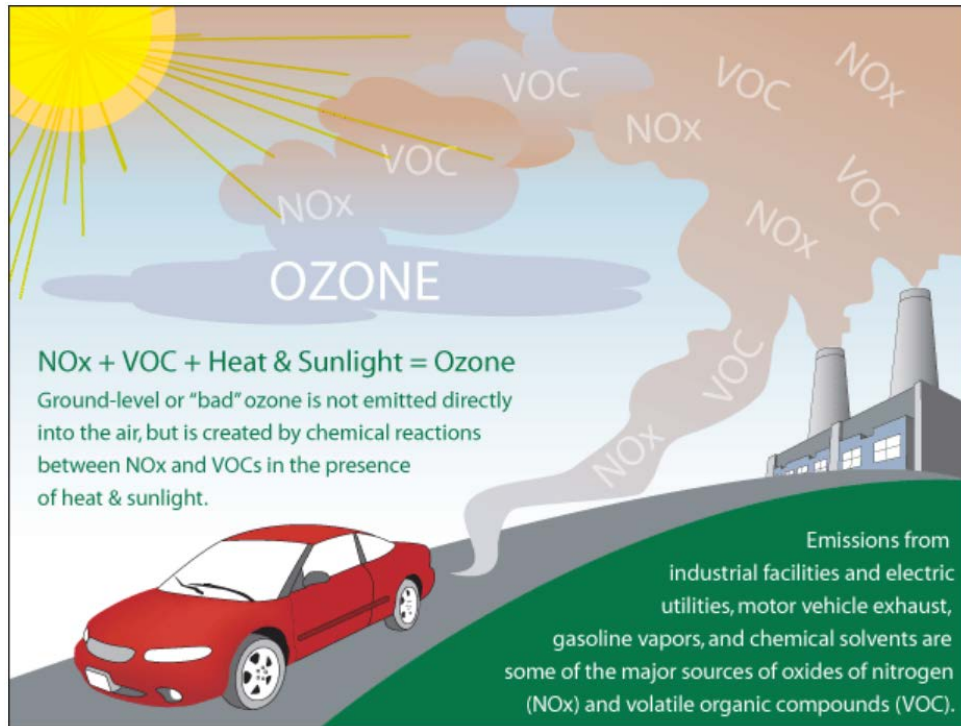
OZONE IS GOOD UP HERE…MANY POPULAR CONSUMER PRODUCTS LIKE AIR CONDITIONERS AND REFRIGERATORS INVOLVE CFCS OR HALONS DURING EITHER MANUFACTURING OR USE. OVER TIME, THESE CHEMICALS DAMAGE THE EARTH'S PROTECTIVE OZONE LAYER.
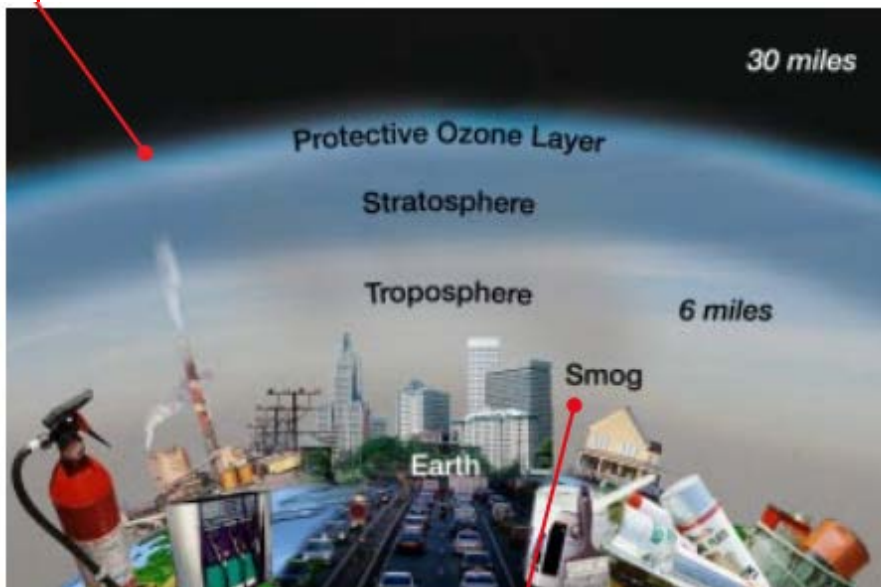
OZONE IS BAD DOWN HERE… CARS, TRUCKS, POWER PLANTS AND FACTORIES ALL EMIT AIR POLLUTION THAT FORMS GROUND-LEVEL OZONE, A PRIMARY COMPONENT OF SMOG.

Source:USEPA

Figure 2
Ozone Formation

NOx + VOC + Heat & Sunlight = Ozone
Ground-level or "bad" ozone is not emitted directly into the air, but is created by chemical reactions between NOx and VOCs in the presence of heat & sunlight.

Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of oxides of nitrogen (NOx) and volatile organic compounds (VOC).

Source: USEPA. https://airnow.gov/index.cfm?action=aqibasics.ozone

ENVIRONMENTAL EFFECTS

Ground-level ozone damages plant life and is responsible for 500 million dollars in reduced crop production in the United States each year. It interferes with the ability of plants to produce and store food, making them more susceptible to disease, insects, other pollutants, and harsh weather. "Bad" ozone damages the foliage of trees and other plants, sometimes marring the landscape of cities, national parks and forests, and recreation areas. The black areas on the leaves of the watermelon plant, shown in Figure 3, are damage caused by exposure to ground-level ozone.

Figure 3
Leaf Damage Caused by Ozone
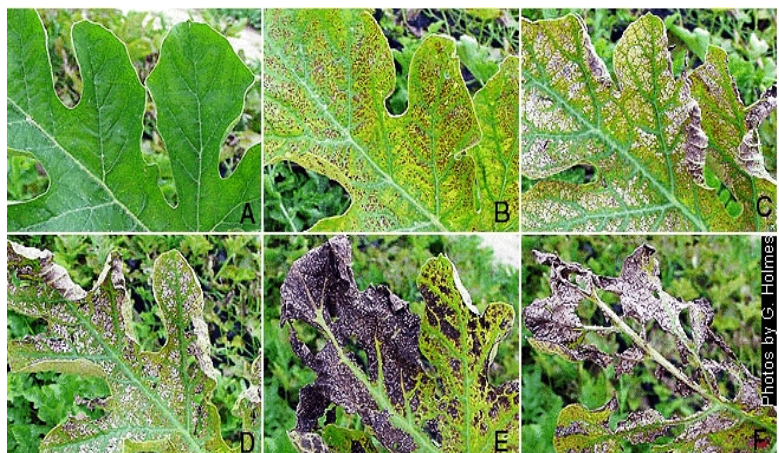
Photos: Gerald Holmes, NCSU Dept. of Horticulture

HEALTH EFFECTS

Ozone can irritate the entire respiratory tract. Repeated exposure to ozone pollution may cause permanent damage to the lungs. Even when ozone is present at low levels, inhaling it can trigger a variety of health problems including chest pains, coughing, nausea, throat irritation, and congestion. Ozone also can aggravate other medical conditions such as bronchitis, heart disease, emphysema, and asthma, and can reduce lung capacity. People with pre-existing respiratory ailments are especially prone to the effects of ozone. For example, asthmatics affected by ozone may have more frequent or severe attacks during periods when ozone levels are high. Children are also at special risk for ozone-related problems. Their respiratory systems are still developing and they breathe more air per pound of body weight than adults. They are also active outdoors during the summer when ozone levels are at their highest. Anyone who spends time outdoors in the summer can be affected, and studies have shown that even healthy adults can experience difficulty in breathing when exposed to ozone. Anyone engaged in strenuous outdoor activities, such as jogging, should limit activity to the early morning or late evening hours on days when ozone levels are expected to be high.

AMBIENT AIR QUALITY STANDARDS FOR OZONE

National and state air quality standards for ground-level ozone were first promulgated in 1971. There are both primary standards, which are based on health effects, and secondary standards, which are based on welfare effects (such as damage to trees, crops and materials). For ground-level ozone, the primary and secondary National Ambient Air Quality Standards (NAAQS) are the same (see Table 1). In 2008 the ozone NAAQS were revised by USEPA because it was determined that the old standard of 0.08 parts per million (ppm) maximum daily eight-hour average was not sufficiently protective of public health. The 8-hour average daily maximum was changed to 0.075 ppm. The primary 1-hour NAAQS was revoked, but is still used for comparison purposes, although not to determine compliance. In October 2015, the 8-hour ozone NAAQS was lowered once again, to 0.070 ppm. The new standard goes into effect in 2016.

The 8-hour NAAQS for ozone is set so that determining compliance is based a two-step process using data from the most recent three years. The first step involves determining the fourth-highest daily maximum 8-hour average concentration for each monitoring site for each of the three years. The values for each site are then used to calculate a three-year average. If this value exceeds the NAAQS at any site in the state, the state is determined to be in nonattainment. This is the "design value" for the NAAQS, the actual statistic that determines whether an area meets the standard.

Table 1
National and New Jersey Ambient Air Quality Standards for Ozone
Parts per Million (ppm)

Averaging Period	Type	New Jersey	National
1-Hour	Primary	0.12 ppm	---
8-Hour	Primary	---	0.075 ppm
8-Hour	Secondary	---	0.075 ppm

OZONE MONITORING NETWORK

Ozone was measured at 16 monitoring stations in New Jersey during 2015 (see Figure 5). Of those 16 sites, ten operated year-round and six operated only during the ozone season, which is April 1st through October 31st. Bayonne, Brigantine, Camden Spruce Street, Chester, Columbia WMA, Flemington, Millville, Newark Firehouse, Rider University and Rutgers University operate year-round. Ancora, Clarksboro, Colliers Mills, Leonia, Monmouth University, and Ramapo sites operate only during the ozone season.
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Figure 5
2015 Ozone Monitoring Network
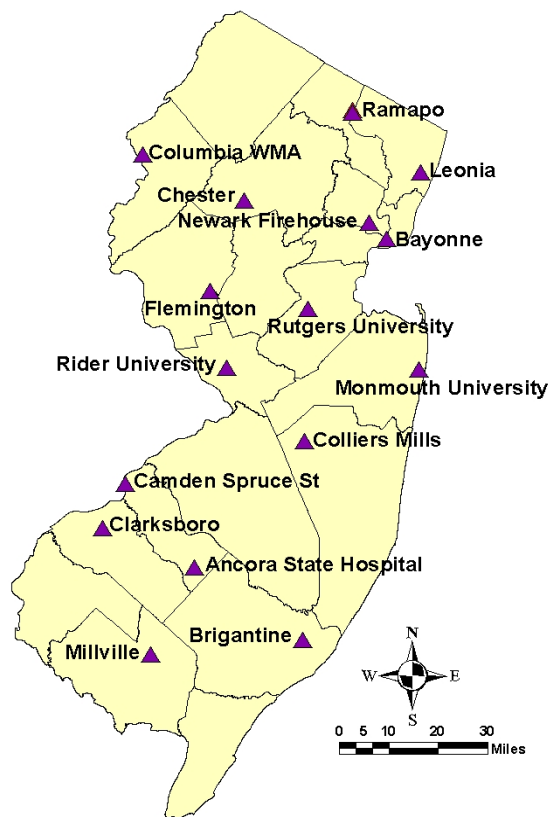
OZONE LEVELS IN 2015

Table 2 shows ozone concentrations in New Jersey for 2015. Of the 16 monitoring sites that were operating during the 2015 ozone season, none recorded levels above the old 1-hour standard of 0.12 ppm. The highest 1-hour concentration was 0.105 ppm, recorded at Bayonne on July 28th.

Eleven of the sixteen ozone monitoring sites recorded levels above the 8-hour NAAQS of 0.075 ppm. The highest daily maximum 8-hour concentration was 0.092 at Bayonne on September 17th. The fourth-highest daily maximum 8-hour values were above the NAAQS at Bayonne, Camden Spruce Street, Clarksboro, Leonia, Monmouth University, and Rutgers University. However, the design value for each of the sites was below the 8-hour standard of 0.075 ppm for the none of the sites in New Jersey were above the design value for the 8-hour standard, based on data from 2013 through 2015. Figure 7 on the following page charts the 8-hour design values for the 2013-2015 period.

Table 2
2015 Ozone Concentrations in New Jersey
Parts per Million (ppm)

Monitoring Site	1-Hour Average Maximum	8-Hour Averages		
		Highest Daily Maximum	4th-Highest Daily Maximum	2013-2015 Average of 4th-Highest Daily Max.
Ancora	0.086	0.076	0.072	0.069
Bayonne	0.105	0.092	0.077	0.071
Brigantine	0.086	0.077	0.064	0.065
Camden Spruce St.	0.103	0.090	0.079	0.070
Chester	0.084	0.073	0.070	0.070
Clarksboro	0.091	0.080	0.076	0.073
Colliers Mills	0.100	0.090	0.075	0.072
Columbia WMA	0.093	0.075	0.066	0.062
Flemington	0.090	0.075	0.073	0.070
Leonia	0.099	0.080	0.076	0.073
Millville	0.078	0.073	0.068	0.065
Monmouth Univ.	0.100	0.087	0.077	0.070
Newark Firehouse	0.099	0.074	0.072	0.070
Ramapo	0.100	0.084	0.071	0.068
Rider University	0.100	0.084	0.073	0.071
Rutgers University	0.104	0.081	0.077	0.072

Figure 6
New Jersey Ozone Design Values for 2013-2015
3-Year Average of the 4th Highest Daily Maximum 8-hour Average
Parts per Million (ppm)
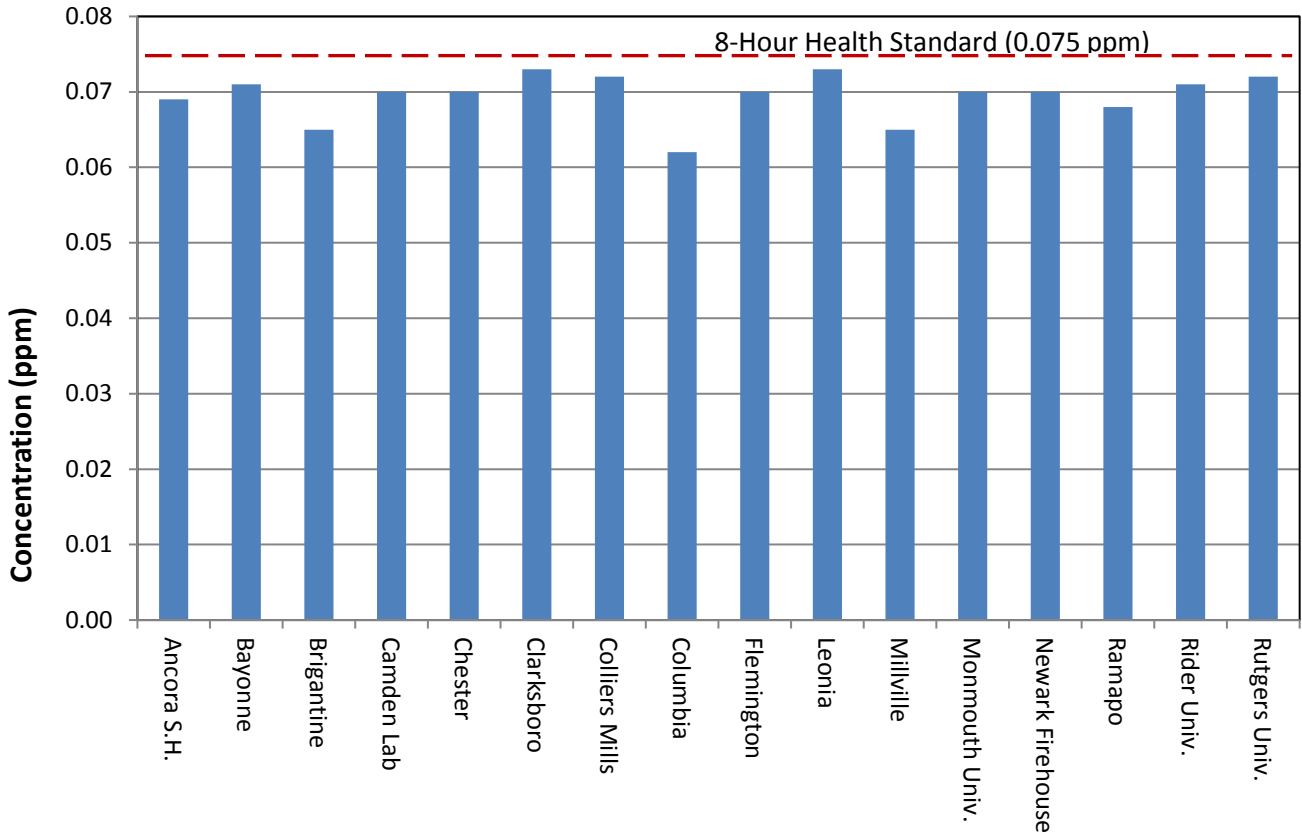
OZONE TRENDS

Efforts to reduce concentrations of ground-level ozone in New Jersey have been focused on reducing emissions of VOCs and NOx. Studies have shown that such an approach should lower peak ozone concentrations, and it does appear to have been effective in achieving that goal. The chart in Figure 8 is based on the fourth-highest 8-hour average concentrations recorded each year, which is the basis of the ozone NAAQS. As Figure 8 illustrates, the maximum 8-hour concentrations have decreased fairly steadily since 1988, with the maximum site for 2015 just barely exceeding 0.075 ppm. In 2015, the design value (three-year average of the 4th-highest daily maximum 8-hour concentrations at any site) was actually finally met, as shown in Figure 9. However, the standard will be lowered to 0.070 ppm in 2016, so further improvements will be needed. Ozone levels in New Jersey are greatly impacted by emissions from upwind sources in other states, so reductions in VOCs and NOx emissions will have to be achieved over a region beyond state borders.

Figure 8
Ozone Concentrations in New Jersey, 1986-2015
4th-Highest Daily Maximum 8-Hour Averages
Parts per Million (ppm)
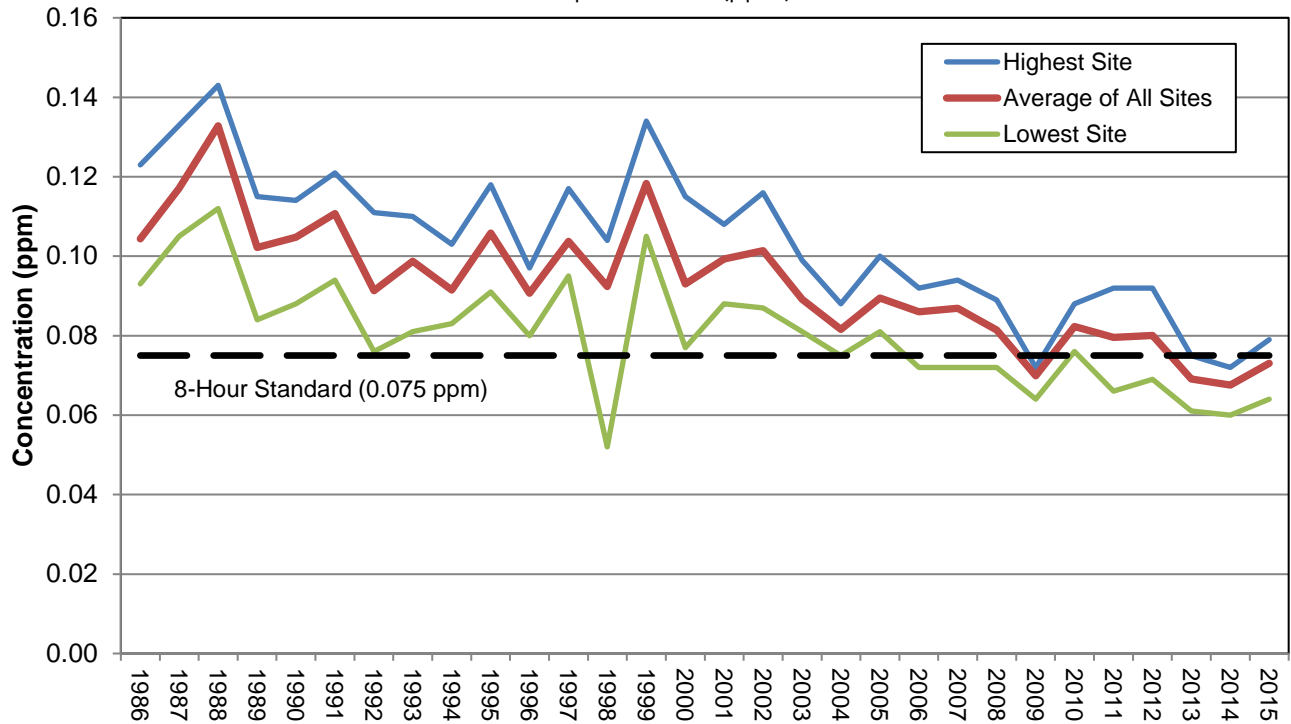
Figure 9
Ozone Design Values in New Jersey, 1990-2015
3-Year Averages of 4th-Highest Daily Maximum 8-Hour Average Concentrations
Parts per Million (ppm)
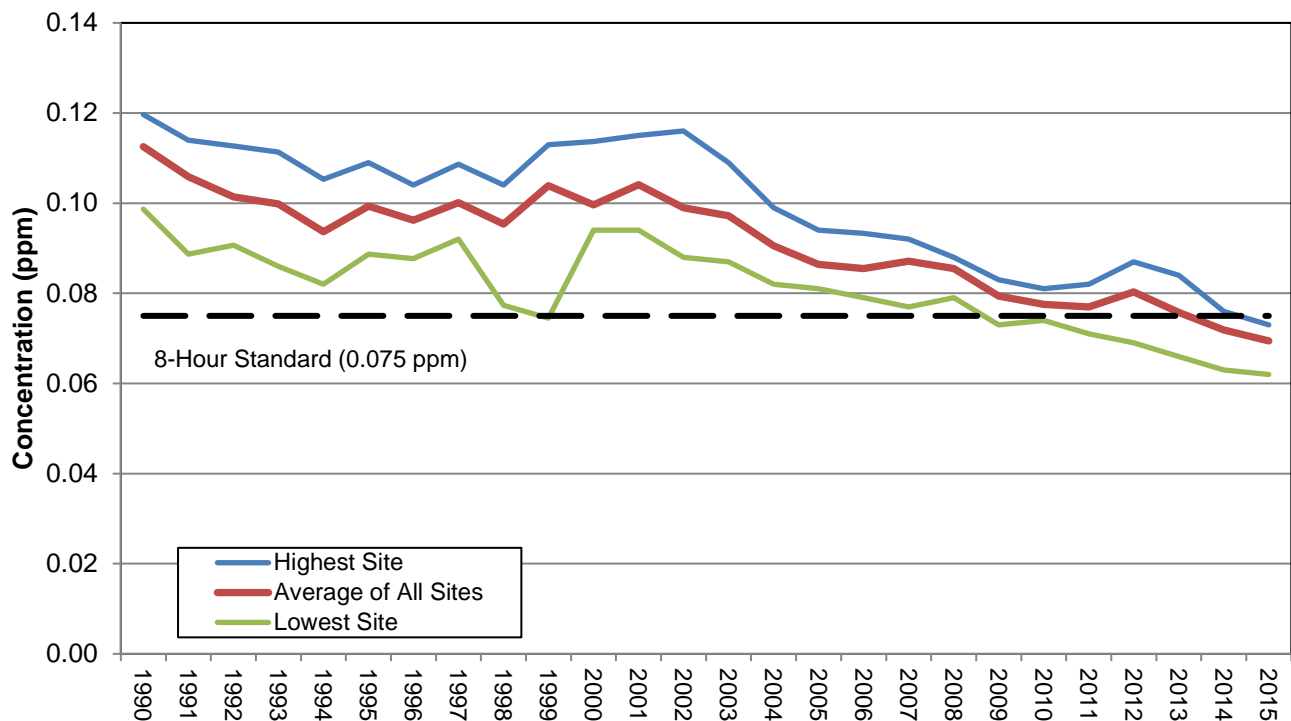
OZONE NONATTAINMENT AREAS IN NEW JERSEY

The Clean Air Act requires that all areas of the country be evaluated for attainment or nonattainment for each of the NAAQS. The 1990 amendments to the Clean Air Act required that areas be further classified based on the severity of nonattainment. The classifications range from "marginal" to "extreme" and are based on the design values that determine whether an area meets the standard.

The entire state of New Jersey has been in nonattainment for the ozone NAAQS, and is classified as being "marginal." A "marginal" area has a design value of 0.076 up to but not including 0.086 ppm. New Jersey's current classification with respect to the 8-hour standard is shown in Figure 9.

Figure 9
New Jersey 8-Hour Ozone Nonattainment Areas
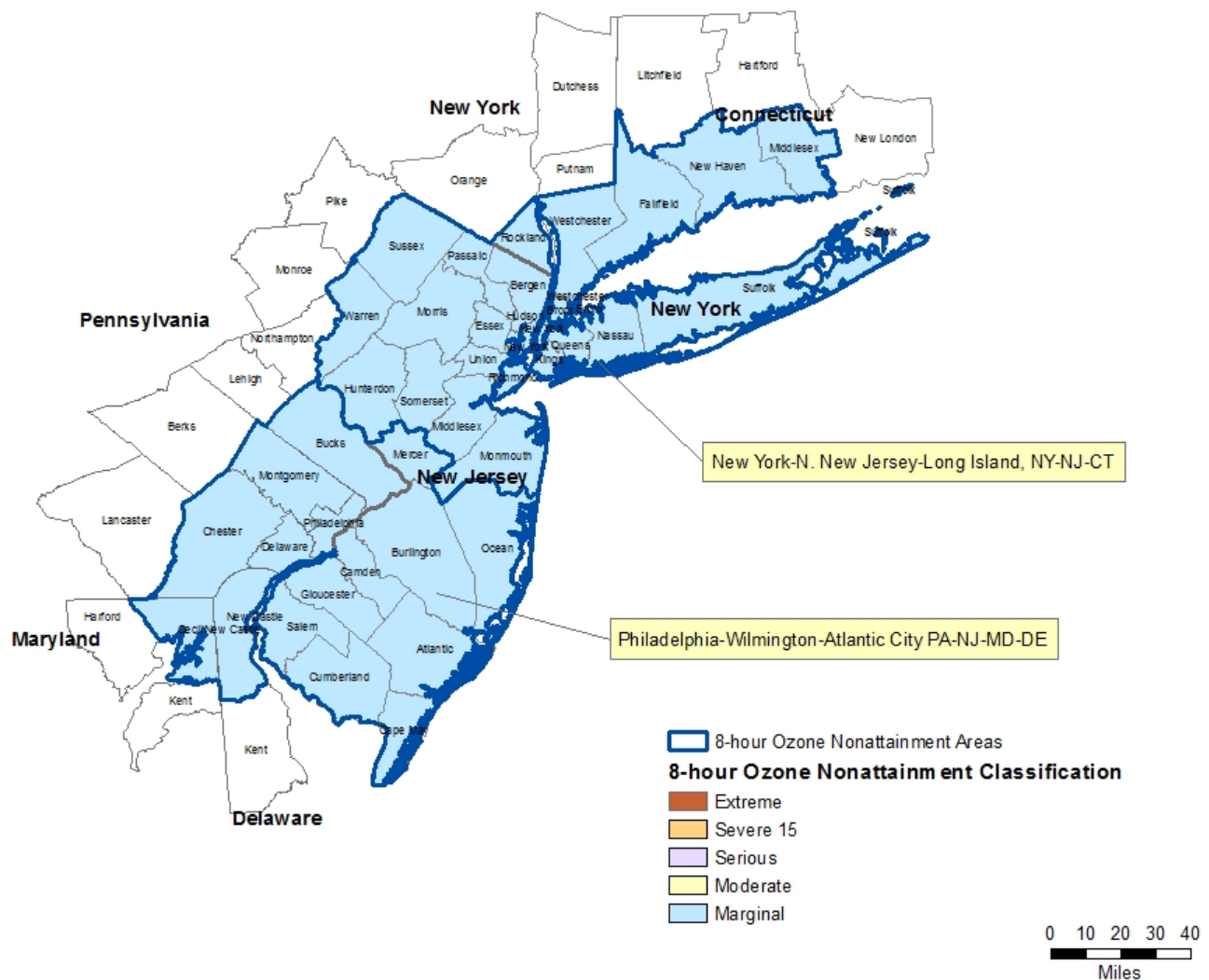
Source: www3.epa.gov/airquality/greenbook/map/nj8_2008.pdf

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2015 Particulate Summary

New Jersey Department of Environmental Protection

SOURCES

Particulate air pollution is a complex mixture of organic and inorganic substances in the atmosphere, present as either liquids or solids. Particulates may be as large as 70 microns in diameter or smaller than 1 micron in diameter. Most particulates are small enough that individual particles are undetectable by the human eye. Particulates may travel hundreds of miles from their original sources, suspended in the atmosphere, before falling to ground level.

Particulate pollution is categorized by size. Particulates with diameters of 2.5 micrometers (or microns) or less are considered "fine particulate matter," referred to as $PM_{2.5}$ (Figure 1). Particulates with diameters of 10 microns or less are considered to be "inhalable particulate matter," and are referred to as PM_{10}. "Total suspended particulates" (TSP) refers to all suspended particulates, including the largest ones. Because particles smaller than 10 microns are inhalable, they are a health risk, but particulates of all sizes have an impact on the environment.

Figure 1
Size Comparisons for PM Particles

USEPA. www.epa.gov/pm-pollution

Particulates can occur naturally or can be man-made. Examples of naturally-occurring particles are windblown dust and sea salt. Man-made particulates, which come from sources such as fossil fuel combustion and industrial processes, can be divided into primary particulates and secondary particulates. Primary particulates are directly emitted from their sources, while secondary particulates form in the atmosphere through reactions of gaseous emissions.

ENVIRONMENTAL EFFECTS

Particulate matter is the major cause of reduced visibility in many parts of the United States. Figure 2a provides an example of reduced visibility due to particulate pollution, recorded by the Camnet visibility camera in Newark (www.hazecam.net) that focuses on the New York City skyline. Figure 2b is an example of a day with low particulate pollution and good visibility. Airborne particles can also impact vegetation and aquatic ecosystems, and can cause damage to paints and building materials. More information about visibility in New Jersey can be found in the Regional Haze and Visibility section of the 2015 Air Quality Summary.

Figure 2a.

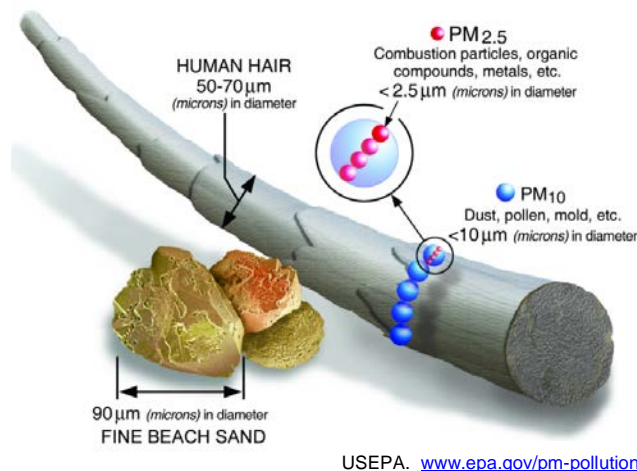**Figure 2b.**

HEALTH EFFECTS

PM_{10} and especially $PM_{2.5}$ are health concerns because they are easily taken into the lungs. Various health problems are associated with both long- and short-term exposures. These particles can accumulate in the respiratory system, and are responsible for heart and lung conditions such as asthma, bronchitis, cardiac arrhythmias, and heart attacks. Particle pollution can even cause premature death. Groups that appear to be at greatest risk from particulates include children, the elderly, and people with heart and lung diseases.

AMBIENT AIR QUALITY STANDARDS

The U.S. Environmental Protection Agency (USEPA) first established National Ambient Air Quality Standards (NAAQS) for particulate matter in 1971. It set primary (health-based) and secondary (welfare-based) for total suspended particulate matter (TSP), which included PM up to about 25 to 45 micrometers. Over the years, new health data have shifted the focus toward smaller and smaller particles. In 1987, USEPA replaced the TSP standards with standards for PM_{10}. The 24-hour PM_{10} primary and secondary standards were set at 150 µg/m^3. Ten years later, USEPA began regulating $PM_{2.5}$. The annual $PM_{2.5}$ primary and secondary standards were set at 15.0 µg/m^3 until 2013, when the primary standard was lowered to 12.0 µg/m^3. A 24-hour standard of 65 µg/m^3.was promulgated in 1997, then lowered in 2006 to 35 µg/m^3. Table 1 provides a summary of the current particulate matter standards. Note that the actual statistic that determines whether an area meets a NAAQS is referred to as the design value. This is generally a three-year average of a monitoring site's data specific to the particular NAAQS. This is described in more detail in the data summary discussions below.

Table 1
National Ambient Air Quality Standards for Particulate Matter
Micrograms Per Cubic Meter (µg/m^3)

Pollutant	Averaging Time	Type	Level
Fine Particulate (PM2.5)	Annual	Primary	12.0 µg/m^3
	Annual	Secondary	15.0 µg/m^3
	24-Hour Average	Primary & Secondary	35 µg/m^3
Inhalable Particulate (PM10)	24-Hour Average	Primary & Secondary	150 µg/m^3

PARTICULATE MONITORING NETWORK

The New Jersey Department of Environmental Protection (NJDEP) Particulate Monitoring Network consists of twenty-four $PM_{2.5}$ monitoring sites, three PM_{10} monitoring sites, and one site where smoke shade is monitored.

NJDEP operates $PM_{2.5}$ and PM_{10} monitors that comply with strict USEPA requirements, and are designated as Federal Reference Method (FRM) samplers. These instruments use a filter, and pull a predetermined amount of air through $PM_{2.5}$ or PM_{10} size-selective inlets for a 24-hour period. The filters are weighed before and after sampling under controlled environmental conditions to determine the concentration of the particles collected. This is the data that is then used by NJDEP and USEPA to determine whether the state, or portions of the state, meet the NAAQS for particulate matter.

Since these FRM samplers do not provide data in real time, in order to report current air quality to the public through the Air Quality Index (www.njaqinow.net) NJDEP uses additional monitors that continuously measure PM concentrations. These include Beta Attenuation Monitors (BAM), Tapered Element Oscillating Microbalance (TEOM) analyzers, and smoke shade instruments.   The Beta Attenuation Monitors measure the loss of intensity (attenuation) of beta particles due to absorption by $PM_{2.5}$ particles collected on a filter tape. The TEOM analyzers collect a sample of $PM_{2.5}$ on an oscillating filter and determine the concentration based on the change in the frequency at which the filter oscillates. Smoke shade instruments collect a sample of TSP on a paper tape for one hour, forming a spot. At the end of each hour the amount of light that passes through the spot is measured, the tape is advanced, and the cycle is started over. The measurement of light transmittance is used as an estimate of actual particulate concentrations.

Five monitoring stations are part of the national Chemical Speciation Network. They use a separate 24-hour filter-based $PM_{2.5}$ sampler to determine the concentrations of the chemical analytes that make up the particle sample. The sample is collected on three types of filter media which are subsequently analyzed using ion chromatography (IC), X-ray fluorescence (XRF), and Thermal Optical Transmittance (TOT).

Figure 3 shows the locations of all of the $PM_{2.5}$ monitors in New Jersey.

FINE PARTICLE ($PM_{2.5}$) SUMMARY

$PM_{2.5}$ SUMMARY FOR FRM MONITORS

The annual mean concentrations of $PM_{2.5}$ measured by the filter-based FRM samplers ranged from 7.0 $\mu g/m^3$ at the Brigantine monitoring site to 11.4 $\mu g/m^3$ at Union City. The highest 24-hour concentrations ranged from 24.3 $\mu g/m^3$ at Brigantine to 37.3 $\mu g/m^3$ at Toms River. Table 2 shows the 2015 annual mean, highest 24-hour and 98th percentile 24-hour concentrations as well as the 2013-2015 annual and 24-hour design values. The design value for the annual NAAQS is calculated for each monitoring site by averaging the annual mean concentrations for the three most recent consecutive calendar years, in this case 2013-2015. Similarly, the 24-hour NAAQS design value for a given site is calculated by averaging the 98th percentile 24-hour concentrations for each year for the same 3-year period. Figures 4 and 5 show the annual mean concentrations and the 98th percentile of the 24-hour average concentrations in 2015 for all the sites. In 2015, no sites were in violation of either the annual standard of 12.0 $\mu g/m^3$ or the 24-hour standard of 35 $\mu g/m^3$.

Figure 3
2015 PM$_{2.5}$ Monitoring Network

Columbia WMA
Paterson
Fort Lee Near Road
Fort Lee Library
Chester
Union City
Newark Firehouse
Jersey City Firehouse
Rahway
Elizabeth Lab
Flemington
New Brunswick
Washington Crossing
Ewing
Rider University
Trenton
Pennsauken
Camden Spruce St.
Toms River
South Camden
Gibbstown
Brigantine
Millville
Atlantic City

Fine Particulate Network

⬤ Filter (FRM) and Speciation Sampler

☆ Filter (FRM), Continuous and Speciation Sampler

⬠ Filter (FRM) and Continuous

▲ Filter (FRM) Sampler

♦ Continuous Sampler

Table 2
2015 PM$_{2.5}$ Concentrations in New Jersey
Annual and 24-Hour Averages (FRM)
Micrograms Per Cubic Meter (µg/m³)

Monitoring Site	Number of Samples	Annual Mean Concentration	2013-2015 Annual Design Value	Highest 24-Hour Concentration	98th %-ile 24-Hour Concentration	2013-2015 24-Hour Design Value (98th %-ile)
Atlantic City	102	7.7	8.1	24.9	16.2	19
Brigantine	120	7.0	7.2	24.3	16.8	18
Camden Spruce Street	113	10.2	10.4	30.2	26.3	26
Chester	109	7.4	7.1	26.3	21.8	18
Columbia WMA	114	9.2	8.3	30	24.8	23
Elizabeth Lab	346	10.2	10.4	33.4	26.8	28
Fort Lee Library	117	10.0	9.1	29.2	28.4	27
Gibbstown	108	8.6	8.9	25.8	22.6	24
Jersey City Firehouse	348	9.0	9.3	29.5	25.7	27
New Brunswick	116	7.9	8.0	26.8	19.8	20
Newark Firehouse	116	8.9	8.9	26.7	23.5	25
Paterson	114	9.0	8.9	27.2	24.3	25
Pennsauken	116	9.0	9.1	27.3	21.9	22
Rahway	116	8.8	9.0	31.5	24.7	25
Toms River	348	7.4	7.7	37.3	20.8	19
Trenton Library	346	8.2	8.6	28.8	24.2	24
Union City	115	11.4	10.8	33.1	29	27
Washington Crossing	118	7.8	8.0	25.5	21.3	22

Figure 4
2015 PM$_{2.5}$ Concentrations in New Jersey
Annual Averages (FRM)
Micrograms Per Cubic Meter (µg/m³)
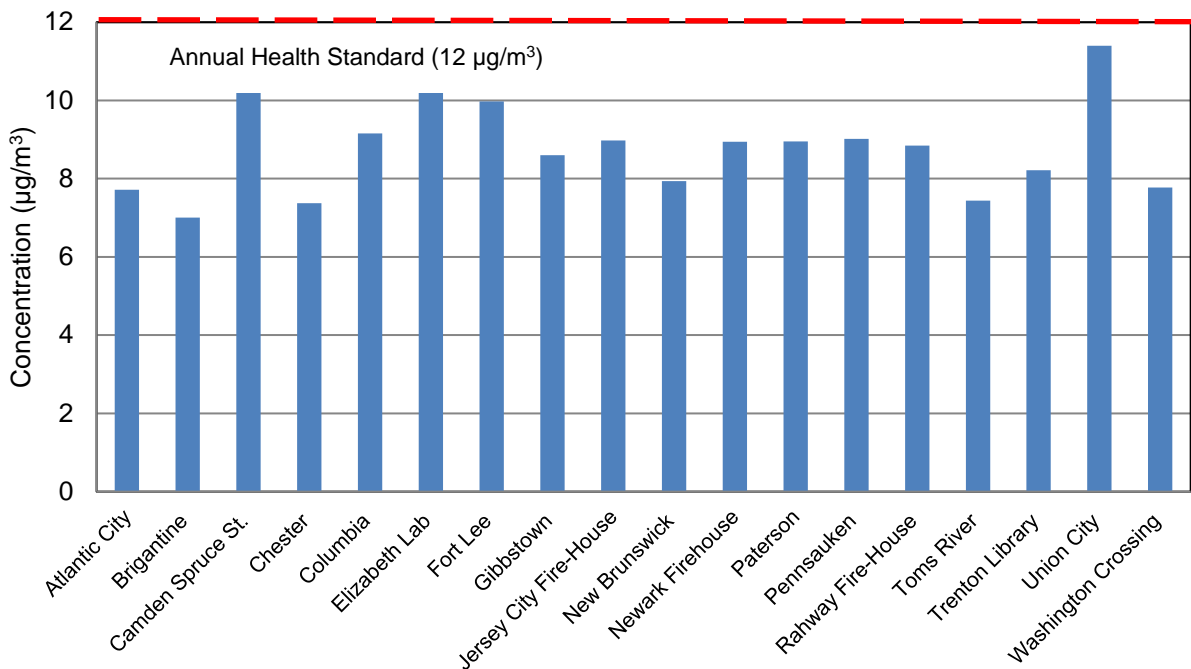
Figure 5
2015 PM$_{2.5}$ Concentrations in New Jersey
98th Percentile 24-Hour Averages (FRM)
Micrograms Per Cubic Meter (μg/m³)
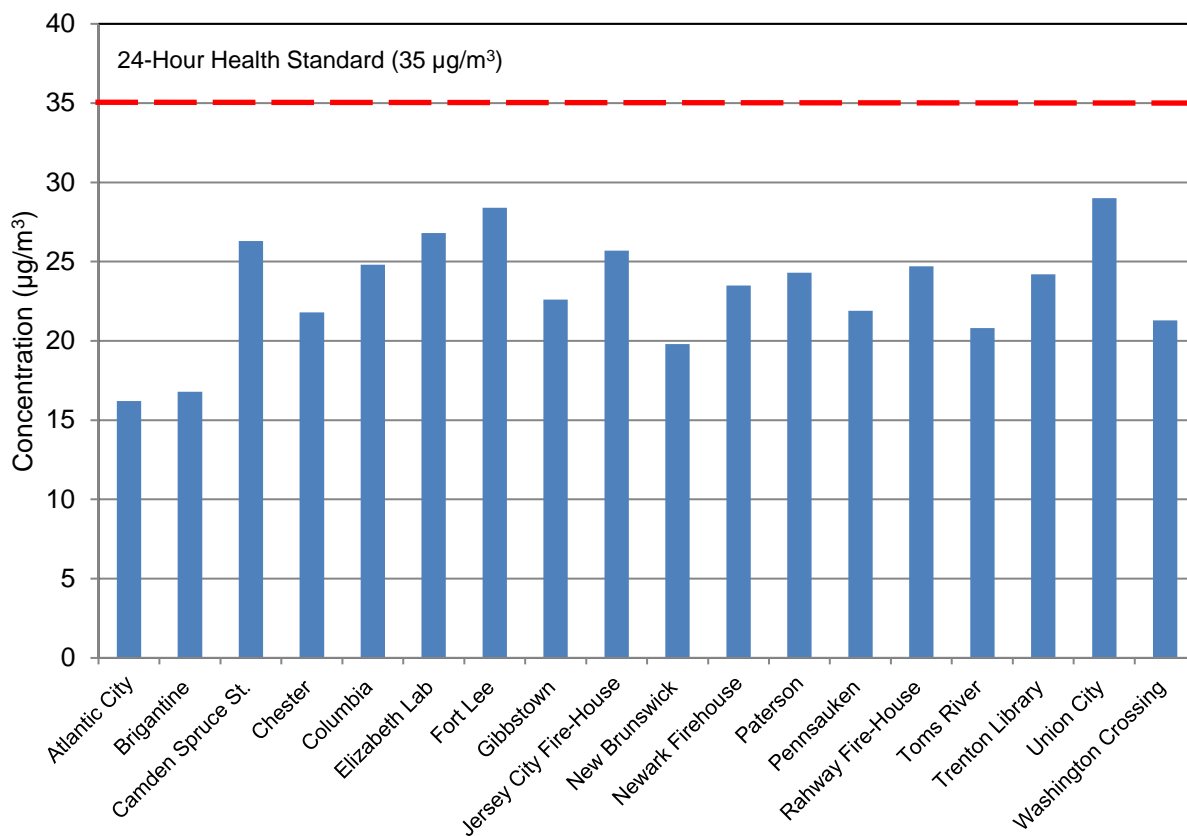
PM$_{2.5}$ Continuous Monitoring

New Jersey's continuous PM$_{2.5}$ monitoring network consists of thirteen sites: Brigantine, Columbia WMA, Elizabeth Lab, Ewing, Flemington, Jersey City Firehouse, Millville, New Brunswick, Newark Firehouse, Rahway, Rider University and South Camden. The data is transmitted at least hourly to a central computer in Trenton, where it is averaged and automatically updated on the Bureau's website every hour. Table 3 provides a summary of the data from these sites for 2015. Figure 6 shows the health level associated with the highest 24-hour PM$_{2.5}$ recorded in the state each day for the entire year.

Table 3
2015 PM$_{2.5}$ Concentrations in New Jersey
Annual and 24-Hour Averages (Continuous Monitors)
Micrograms Per Cubic Meter (µg/m³)

Monitoring Site	Annual Mean Concentration	Highest 24-Hour Concentration	Number of Days Unhealthy for Sensitive Groups
Brigantine	7.8	26.6	0
Camden Spruce Street	11.4	42.7	2
Columbia WMA	9.6	32.6	0
Elizabeth Lab	11.1	33.3	0
Ewing	6.8	22.2	0
Flemington	5.6	21.4	0
Fort Lee Near Road	11.3	34.6	0
Jersey City Firehouse	10.0	33.3	0
Millville	9.4	27.1	0
New Brunswick	9.7	27.9	0
Newark Firehouse	10.4	31.3	0
Rahway	10.2	36.9	1
Rider University	8.7	28.6	0
South Camden	10.1	37.5	1

Figure 6
2015 PM$_{2.5}$ Air Quality Index (AQI) Concentrations
(Highest 24-Hour Site)
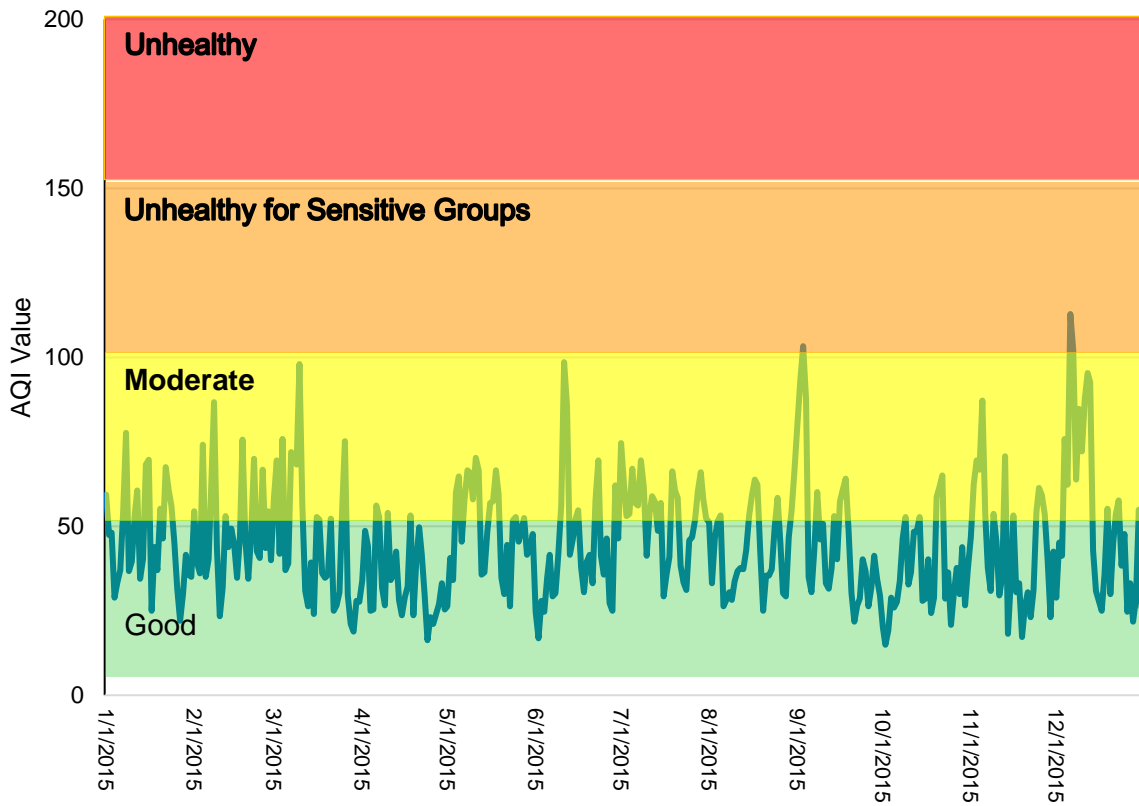
PM$_{2.5}$ SPECIATION SUMMARY

New Jersey's PM$_{2.5}$ speciation network is located at five monitoring sites: Camden Spruce Street, Chester, Elizabeth Lab, Newark Firehouse, and New Brunswick. Samplers run every third or sixth day on a schedule concurrent with the Federal Reference Method sampling network. Of the 39 measured analytes, organic carbon, sulfate, nitrate, sulfur and elemental carbon are the most prevalent species. Combined, they create the majority of the PM$_{2.5}$ total mass concentration. Figure 7 presents the average concentrations of these five most prevalent species. High elemental carbon concentrations at Elizabeth Lab, located adjacent to the New Jersey Turnpike Exit 13 tollbooths, are due to the site's proximity to high traffic volume, as motor vehicles are a primary source of elemental carbon. More information about the speciated analytes, including average, highest, and 2nd highest 24-hour average concentrations, can be found in Appendix B - Fine Particulate Speciation Summary of the 2015 Air Quality Report.

Figure 7
2015 PM$_{2.5}$ Analyte Composition
Analytes with the Highest Concentrations
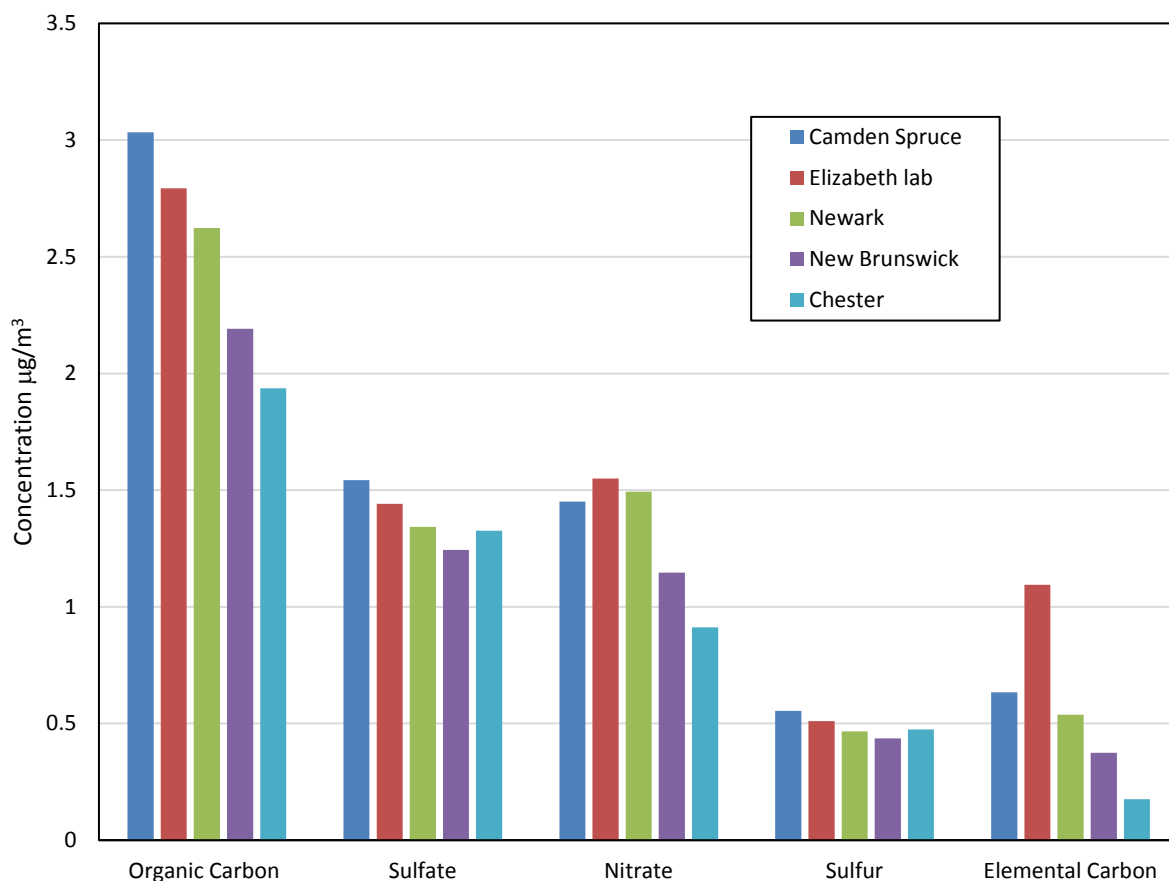
2015 INHALABLE PARTICULATE (PM₁₀) SUMMARY

PM₁₀ MONITORING SITES

At one time, NJDEP PM$_{10}$ monitoring network consisted of more than twenty sampling sites. Due to many years of low concentrations and the shift in emphasis to PM$_{2.5}$ monitoring, the network has been reduced to only three sites, the Camden Resource Recovery Facility (RRF), Jersey City Firehouse, and Newark Firehouse. PM$_{10}$ samples, taken once every six days, are collected on a filter that is weighed before and after sampling to determine air concentrations. Figure 8 shows the locations of New Jersey's PM$_{10}$ monitors.

PM₁₀ CONCENTRATION SUMMARY

In 2015, the highest PM$_{10}$ values were measured at Camden RRF. Table 4 shows each site's highest and second-highest 24-hour concentrations, as well as the annual average. All areas of the state are in attainment for the 24-hour standard of 150 $\mu g/m^3$, as can be seen in Figure 9.

Figure 8
2015 PM₁₀ Monitoring Network
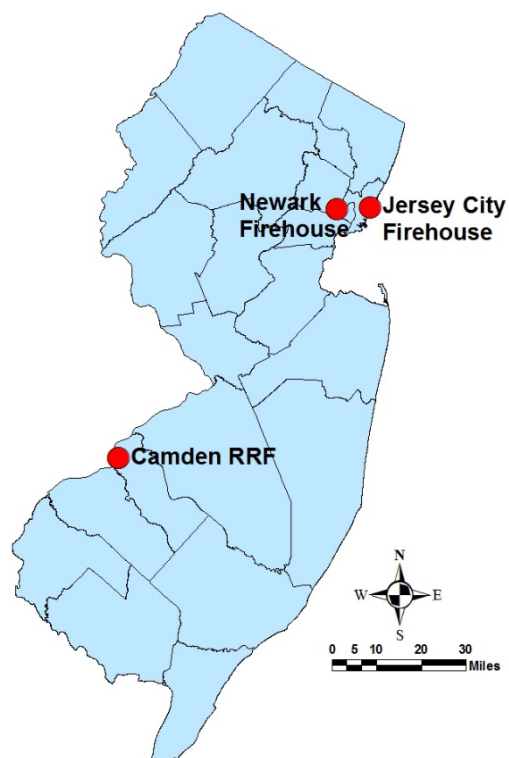
Table 4
2015 PM₁₀ Concentrations in New Jersey
24-Hour and Annual Averages
Micrograms Per Cubic Meter ($\mu g/m^3$)

Monitoring Site	Number of Samples	24-Hour Averages		Annual Mean
		Highest	Second-Highest	
Camden RRF	44	114	110	37
Jersey City Firehouse	60	44	43	19
Newark Firehouse	117	38	38	16

Figure 9
2015 PM$_{10}$ Concentrations in New Jersey
Maximum 24-Hour Averages
Micrograms per Cubic Meter (µg/m³)
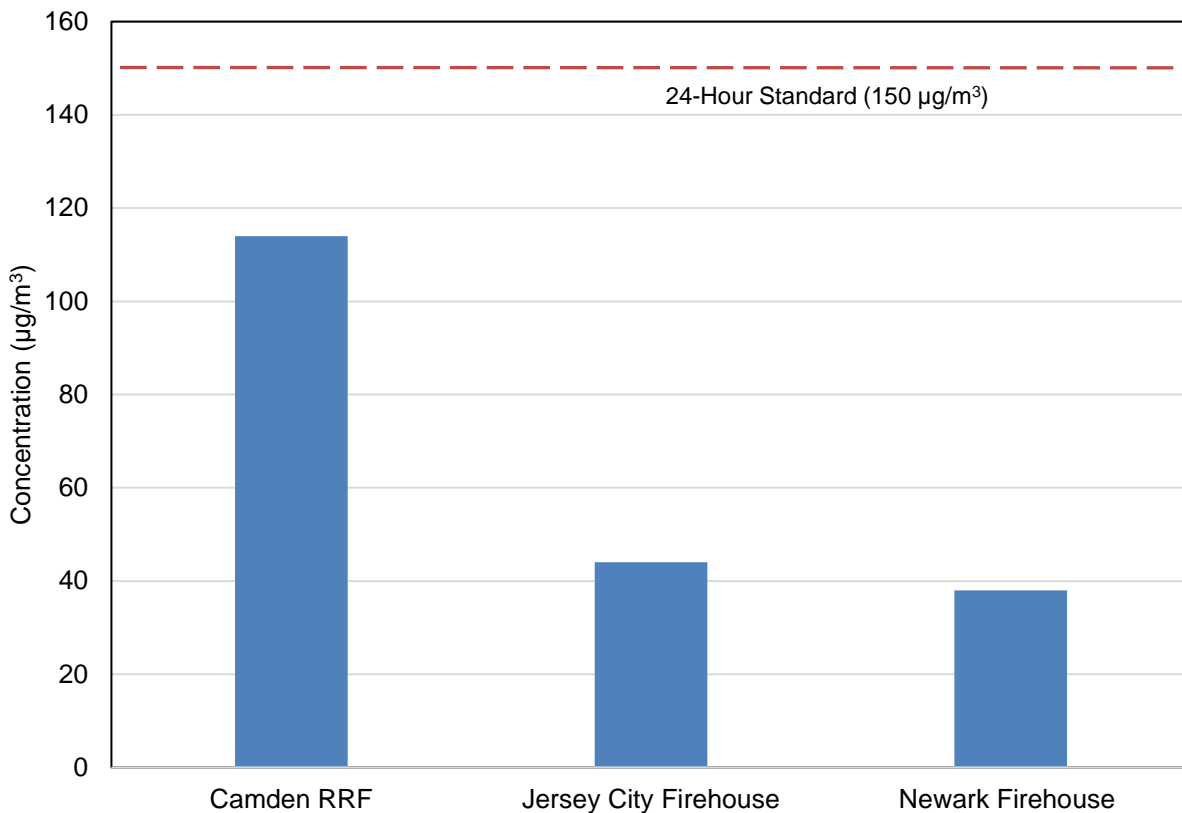
SMOKE SHADE SUMMARY

SMOKE SHADE MONITORING SITES

Smoke shade is an indirect measurement of particles in the atmosphere. Smoke shade was once measured at about a dozen locations in New Jersey, beginning about forty years ago. Its primary use was for the daily reporting of particulate levels in the Air Quality Index, before there were newer continuous PM monitoring methods. The instruments are now obsolete and can no longer be repaired. 2015 began with three operating smoke shade monitors. The Jersey City instrument stopped functioning in January, and the Elizabeth one stopped in mid-October. The one remaining smoke shade monitor is located at the Elizabeth Lab site. Table 5 lists the highest and second-highest 24-hour and annual average smoke shade levels recorded at the monitoring site in 2015.

Table 5
2015 Smoke Shade Measurements in New Jersey
Coefficient of Haze (COH)

Site	Highest 24-Hour Average	2nd-Highest 24-Hour Average	Annual Mean
Elizabeth Lab	1.03	0.79	0.14

TRENDS IN PARTICULATE CONCENTRATIONS

The longest continuously operating particulate monitoring network in the state is the smoke shade network. As noted earlier, this monitoring program has been running for decades and still had one active site in 2015. The trend graph for smoke shade, shown in Figure 10, shows how particulate levels have steadily declined over the past 48 years. Smoke shade is not a direct measurement of particle mass, but can be viewed in relation to TSP, PM_{10} and $PM_{2.5}$ health standards.

The $PM_{2.5}$ monitoring network has been in place since 1999. Sixteen years of sampling has shown a noticeable decline in fine particulate concentrations. Figure 11 shows the trend of the annual mean $PM_{2.5}$ concentrations for all FRM sampler sites since the network began.

Figure 10
Annual Average Particulate Levels as Smoke Shade in New Jersey, 1967-2015
Coefficient of Haze (COH)
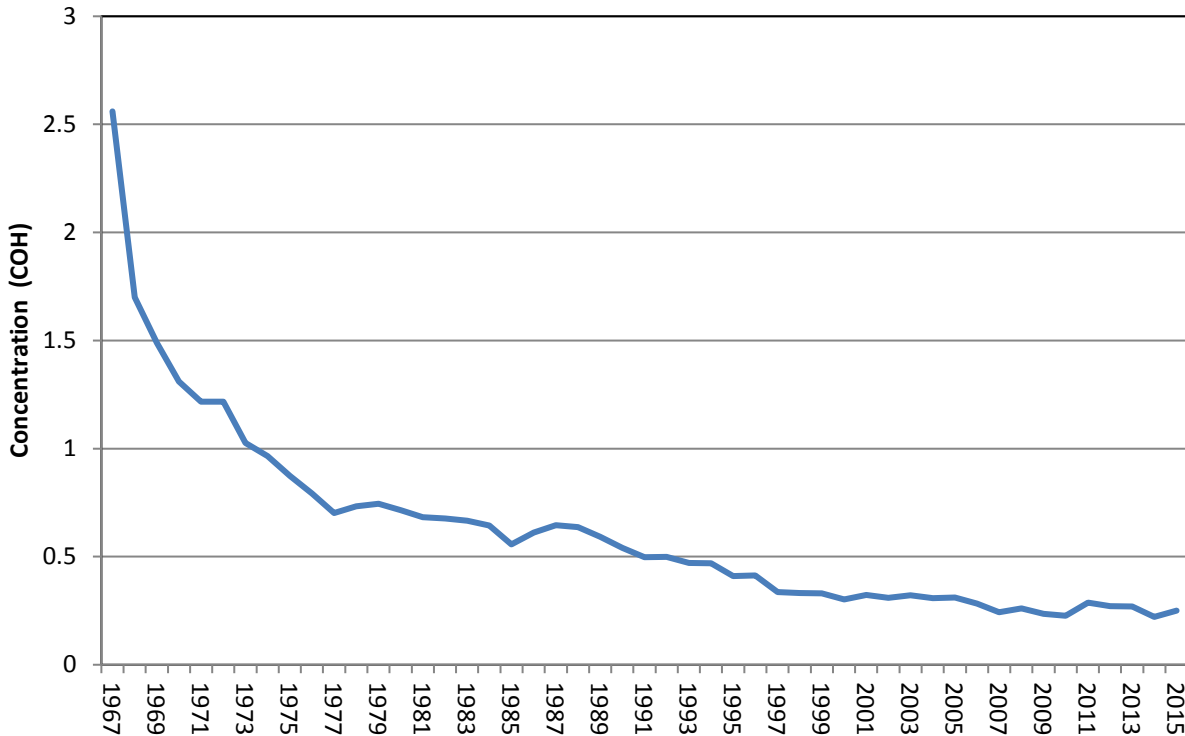
Figure 11
PM$_{2.5}$ Air Concentrations in New Jersey, 1999-2015
Annual Averages of All Sites
Micrograms per Cubic Meter (ug/m^3)
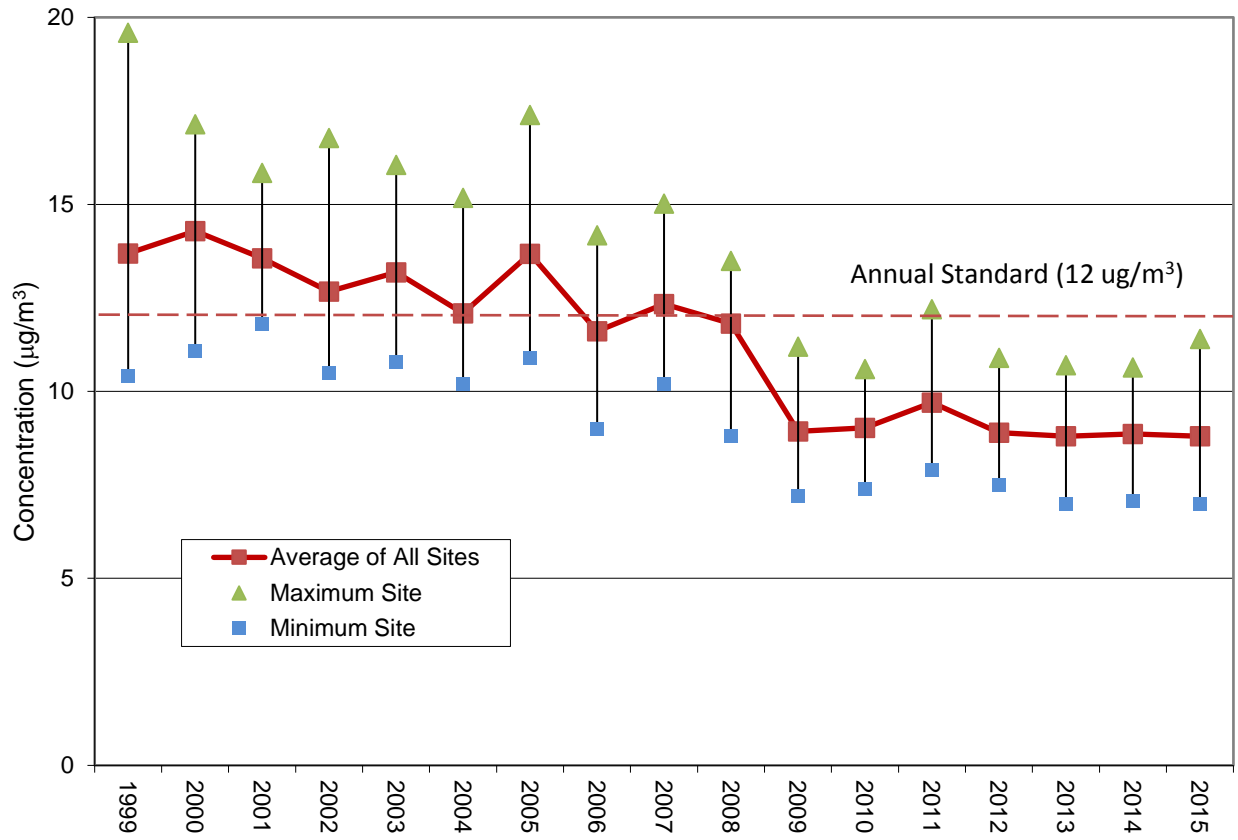
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Camnet. Realtime Air Pollution & Visibility Monitoring. www.hazecam.net

2015 Nitrogen Dioxide Summary

New Jersey Department of Environmental Protection

SOURCES

Nitrogen dioxide (NO_2) is a reddish-brown highly reactive gas that is formed in the air through the oxidation of nitric oxide (NO). NO_2 is used by regulatory agencies as the indicator for the group of gases known as nitrogen oxides (NOx). These gases are emitted from motor vehicle exhaust, combustion of coal, oil or natural gas, and industrial processes such as welding, electroplating, and dynamite blasting. Although most NOx is emitted as NO, it is readily converted to NO_2 in the atmosphere.   In the home, gas stoves and heaters produce substantial amounts of nitrogen dioxide. When NO_2 reacts with other chemicals it can form ozone, particulate matter, and other pollutant compounds. A pie chart summarizing the major sources of NOx in New Jersey is shown in Figure 1. Because much of the NOx in the air is emitted by motor vehicles, concentrations tend to peak during the morning and afternoon rush hours. This is shown in Figure 2.

Figure 1
2011 New Jersey NOx Emissions by Source Category

Industrial Processes 2%
Other 2%
Fuel Combustion 20%
Mobile 76%
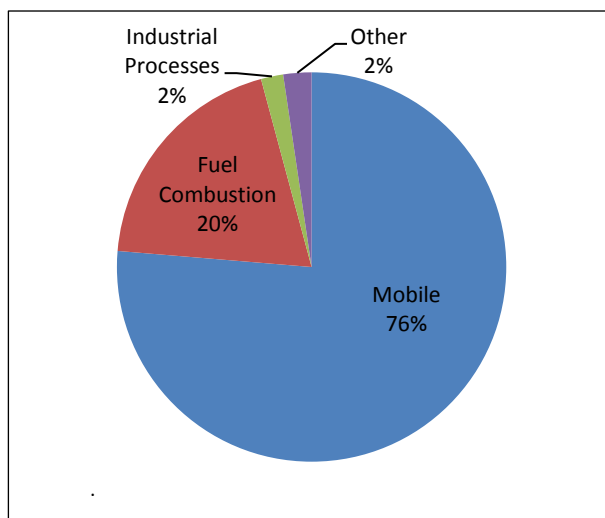
www3.epa.gov/air/emissions/index.htm

HEALTH AND ENVIRONMENTAL EFFECTS

Short-term exposures to low levels of nitrogen dioxide may aggravate pre-existing respiratory illnesses and cause respiratory illnesses in children, people with asthma, and the elderly. Symptoms of low-level exposure to NO and NO_2 include irritation to eyes, nose, throat and lungs, coughing, shortness of breath, tiredness and nausea. Long-term exposures to NO_2 may increase susceptibility to respiratory infection and may cause permanent damage to the lung. Studies show a connection between breathing elevated short-term NO_2 concentrations and increases in hospital emergency department visits and hospital admissions for respiratory issues, especially asthma. Individuals who spend time on or near major roadways can experience high short-term NO_2 exposures.

Nitrogen oxides contribute to a wide range of environmental problems. Chemical reactions in the air form both ozone and particulate matter. Nitrate particles make the air hazy and impair visibility, and contribute to nutrient pollution in coastal waters, resulting in eutrophication. NO_2 also reacts with water and oxygen to form nitric acid, a component of acid rain, which causes acidification of freshwater bodies and harms sensitive ecosystems such as lakes and forests.

Figure 2
2015 Nitrogen Oxides Concentrations in New Jersey
Hourly Variation
Parts per Million (ppm)
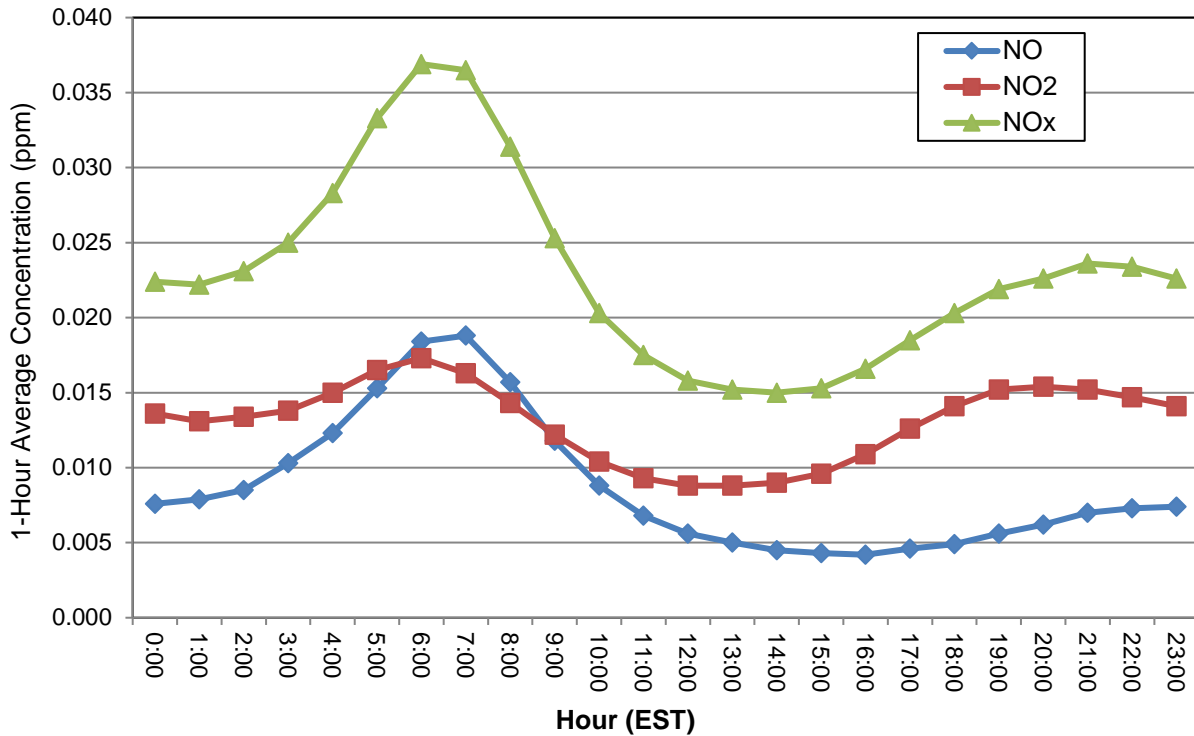
AMBIENT AIR QUALITY STANDARDS

The primary (health-based) and secondary (welfare-based) annual average National Ambient Air Quality Standards (NAAQS) for NO_2 are the same: a calendar year average concentration of 0.053 parts per million (ppm). The New Jersey Ambient Air Quality Standards (NJAAQS) are identical to the NAAQS except that micrograms per cubic meter ($\mu g/m^3$) are the standard units and the averaging time is any 12-month period instead of a calendar year. In 2010, the U.S. Environmental Protection Agency (USEPA) strengthened the primary NAAQS by adding a 1-hour NO_2 standard of 0.100 ppm, based on the 98th percentile of the daily maximum 1-hour concentration. Table 1 provides a summary of the NO_2 standards.

Table 1
National and New Jersey Ambient Air Quality Standards for Nitrogen Dioxide (NO_2)
Micrograms per Cubic Meter ($\mu g/m^3$)
Parts per Million (ppm)

Averaging Period	Type	New Jersey	National
12-month average	Primary	100 $\mu g/m^3$ (0.053 ppm)	
Annual average	Primary		0.053 ppm (100 $\mu g/m^3$)
12-month average	Secondary	100 $\mu g/m^3$ (0.053 ppm)	
Annual average	Secondary		0.053 ppm (100 $\mu g/m^3$)
1-hour average	Primary		0.100 ppm (190 $\mu g/m^3$)

An area is in compliance with the 1-hour NO_2 standard when the 3-year average of the 98th percentile of the daily maximum 1-hour NO_2 concentrations is less than 0.100 ppm. This statistic, also known as the design value, is calculated by first obtaining the maximum 1-hour average NO_2 concentrations for each day at each monitor. Then the 98th percentile value of the daily maximum NO_2 concentrations must be determined for the current year, and for each of the previous two years. Finally, the average of these three annual 98th percentile values is the design value.

As part of the 2010 revision to the NAAQS, in addition to adopting a 1-hour NO_2 standard, USEPA required that in urban areas with populations of 1 million or more, an NO_2 near-road monitoring station be established and operational by January 1, 2014. A near-road station must be located no more than 50 meters (164 feet) from the nearest traffic lane of a major roadway. The near-road site for the New York-Northern New Jersey-Long Island Metropolitan area was established in Fort Lee, along Interstate 95 and adjacent to the tollbooths for the George Washington Bridge.

MONITORING LOCATIONS

NJDEP monitored NO_2 levels at 10 locations in 2015. These sites are shown in Figure 3.

Figure 3
2015 Nitrogen Dioxide Monitoring Network
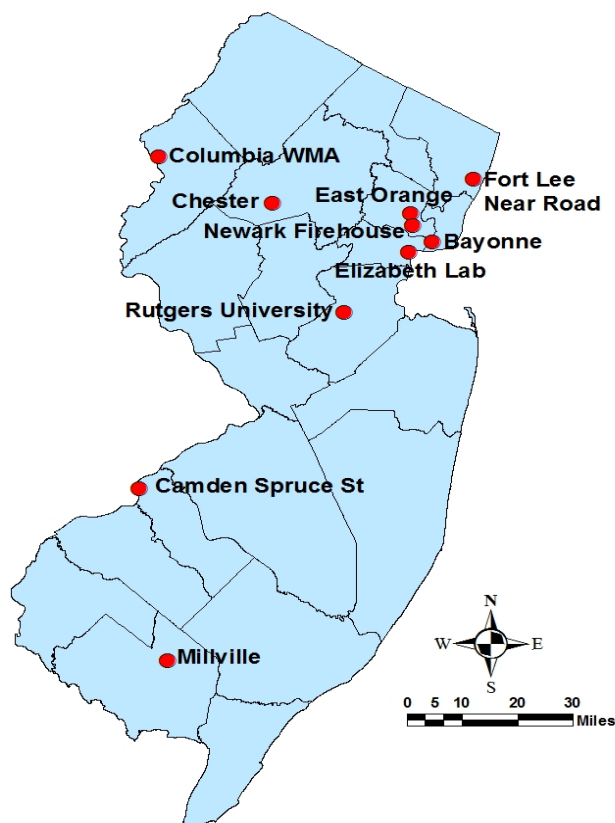
NO_2 LEVELS IN 2015

Fort Lee Near Road, Elizabeth Lab, and Bayonne monitoring sites all recorded exceedances of the 1-hour NO_2 NAAQS (0.100 ppm) during 2015. The maximum 1-hour concentrations were 0.195 ppm at Bayonne, 0.154 ppm at Fort Lee Near Road, and 0.135 ppm at Elizabeth Lab (see Table 2). However, these are not violations of the NAAQS, which is based on the 98th percentile of the daily one-hour maximum concentrations. Those 98th percentile values are given in Table 2 and Figure 4 for each monitoring station. The design value for NO_2, which determines whether or not there is a violation of the NAAQS, is actually the 3-year average of the 98th percentile of the 1-hour daily maximum concentrations. The 2013-2015 design value for each site is given in Table 2 and Figure 5. The site with the highest design value for 2013-2015 was Elizabeth Lab, with 0.066 ppm. The three-year averages for Bayonne, Fort Lee Near Road, Millville, and Rutgers University stations could not be calculated because of incomplete data for certain years (see Table 2 footnotes). The exceedances of the 1-hour NAAQS at Bayonne and Fort Lee Near Road can be attributed to vehicles idling near the monitors. The exceedance at Elizabeth Lab occurred on March 10th during an air stagnation period, which prevented pollutants from being dispersed.

The highest running-12-month and calendar-year average concentrations of NO_2 were the same, 0.022 ppm at the Elizabeth Lab site, located at Exit 13 of the New Jersey Turnpike (Table 2 and Figure 6).

Table 2
2015 Nitrogen Dioxide Concentrations in New Jersey
1-Hour and 12-Month Averages
Parts per Million (ppm)

Monitoring Site	1-Hour Average (ppm)				12-Month Average (ppm)	
	Daily Maximum	2nd Highest Daily Max.	98th %-ile	2013-2015 98th%-ile 3-year Avg.	Maximum Running 12-Month	Calendar Year
Bayonne	0.195	0.090	0.057	a	0.016	0.016
Camden Spruce Street	0.066	0.058	0.051	0.049	0.013	0.013
Chester	0.055	0.046	0.028	0.035	0.004	0.003
Columbia WMA	0.057	0.054	0.051	0.048	0.012	0.012
East Orange	0.075	0.067	0.055	0.058	0.015	0.014
Elizabeth Lab	0.135	0.091	0.067	0.066	0.022	0.022
Fort Lee Near Road	0.154	0.081	0.066	b	0.019	0.019
Millville	0.048	0.045	0.039	c	0.007	0.006
Newark Firehouse	0.078	0.077	0.058	0.063	0.018	0.016
Rutgers University	0.074	0.054	0.048	d	0.010	0.010

a Bayonne site temporarily shut down October 2012 through July 2013 due to damage from Superstorm Sandy.
b Fort Lee Near Road site began operating March 2014.
c Millville temporarily shut down for site renovations December 2012 to March 2013.
d Rutgers University temporarily shut down for site renovations April 2015 to June 2015.

Figure 4
2015 Nitrogen Dioxide Concentrations in New Jersey
Daily Maximum 1-Hour Values
Parts per Million (ppm)
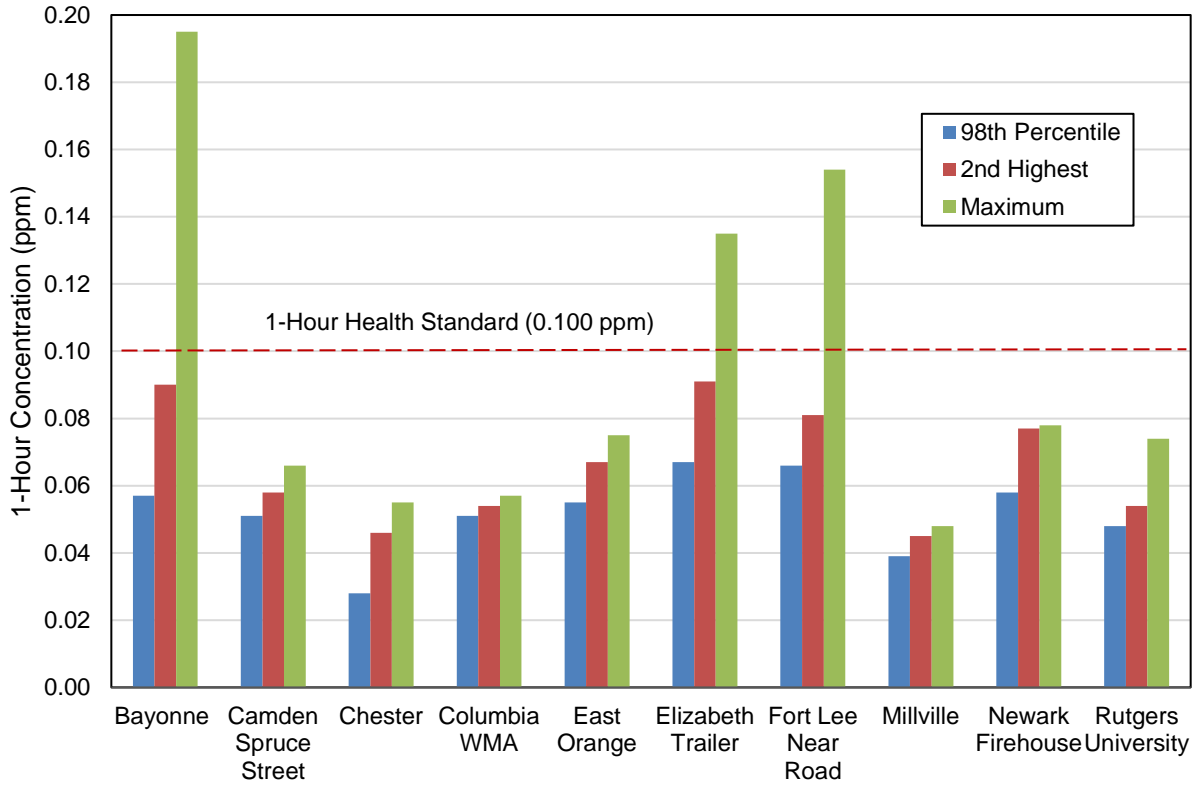
Figure 5
2015 Nitrogen Dioxide Concentrations in New Jersey
3-Year Design Value (2013-2015)
(Average of 98th Percentile Daily Maximum 1-Hour Average Concentrations)
Parts per Million (ppm)
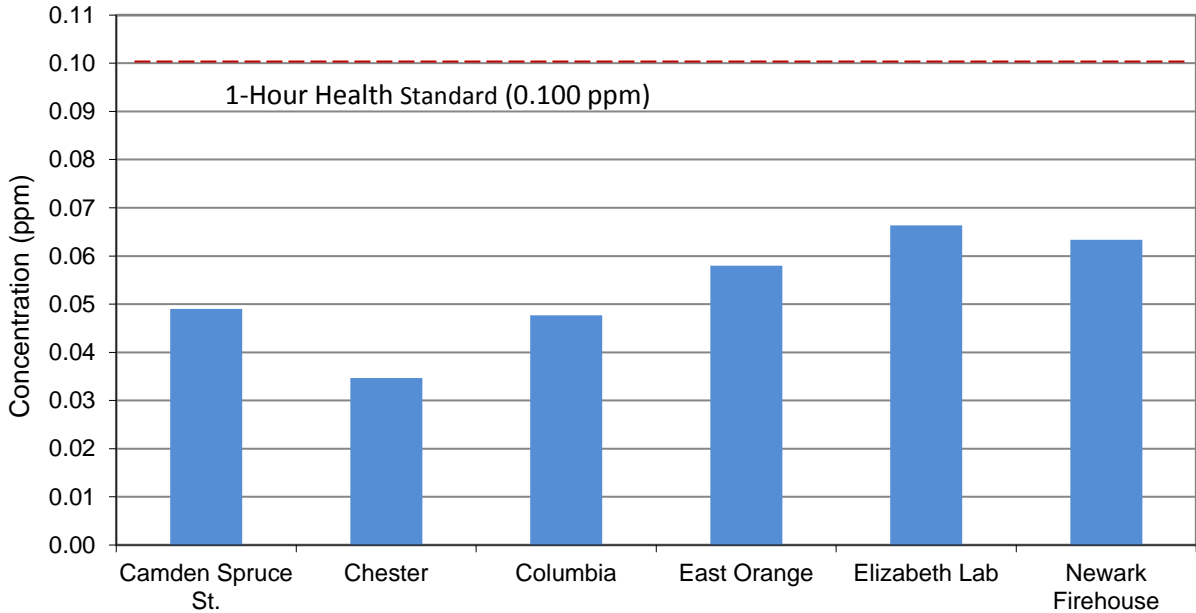
Figure 6 shows the calendar year annual average concentrations for nitrogen dioxide at each site. The annual NAAQS is 0.053 ppm (or 53 parts per billion). Figure 6 also includes values for nitric oxide. The New Jersey monitoring stations that measure NO_2 levels also measure NO and NOx levels. NOx levels are approximately the sum of the NO_2 and NO concentrations. The concentration of NO tends to be lower than NO_2, because as it is emitted it quickly reacts with other air pollutants (particularly ozone) and converts to NO_2. The higher concentration at the Columbia WMA monitor is believed to result from high NO emissions from vehicles on nearby Interstate 80 and relatively low levels of other pollutants.

Figure 6
2015 Nitrogen Dioxide & Nitric Oxide Concentrations in New Jersey
Calendar Year Annual Average
Parts per Million (ppm)
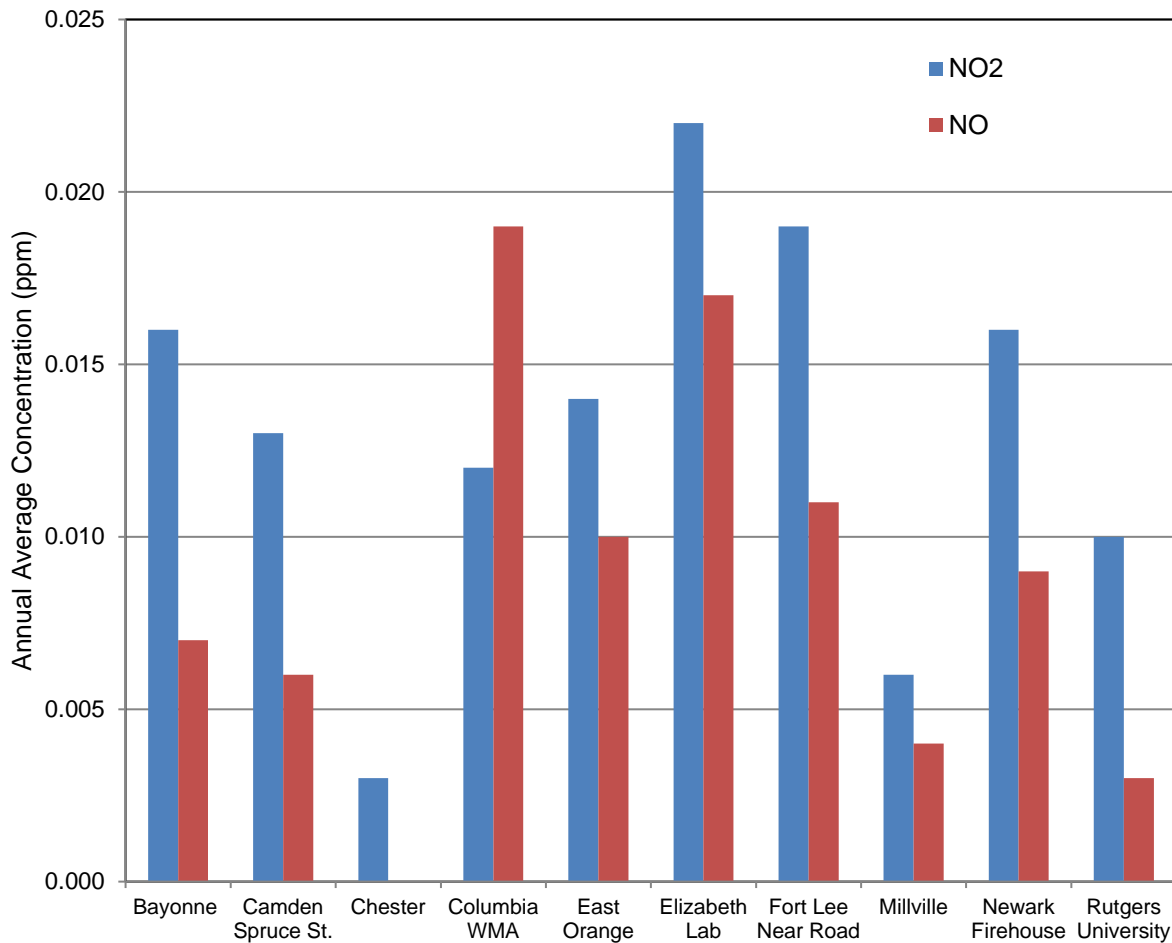
Note: The annual average concentration of NO at Chester was 0 ppm.

NOx Trends

Figure 7 shows that NOx concentrations tend to be higher in the winter than in the summer. This is due in part to building heating, and to poorer local dispersion conditions caused by light winds and other weather conditions that are more prevalent in the colder months of the year.

Routine monitoring for NO_2 in New Jersey began in 1966, but 1974 was the last year in which the annual mean NO_2 concentrations exceeded the NAAQS. The graph of NO_2 levels in Figure 8 shows the statewide average annual mean concentrations recorded from 1975 to 2015 in the form of a trend line. The graph also includes the levels at of the sites that measured the highest annual mean and lowest annual mean in each year, as points above and below this trend line. Although NO_2 concentrations are well within the NAAQS, there is still a great deal of concern about oxides of nitrogen because of their role in the formation of other pollutants, most notably ozone and fine particles. Both of these pollutants are of interest over much of the northeastern United States, and efforts to reduce levels of ozone and fine particles are likely to require continued reductions in NOx emissions.

Figure 9 shows the highest, lowest, and average 98th percentile values of the daily maximum one-hour concentrations for the years 2000 to 2015 at each New Jersey monitoring site. The average values are well below the 1-hour NAAQS of 0.100 ppm.

Figure 7
2015 Concentrations of Nitrogen Oxides in New Jersey
Monthly Variation
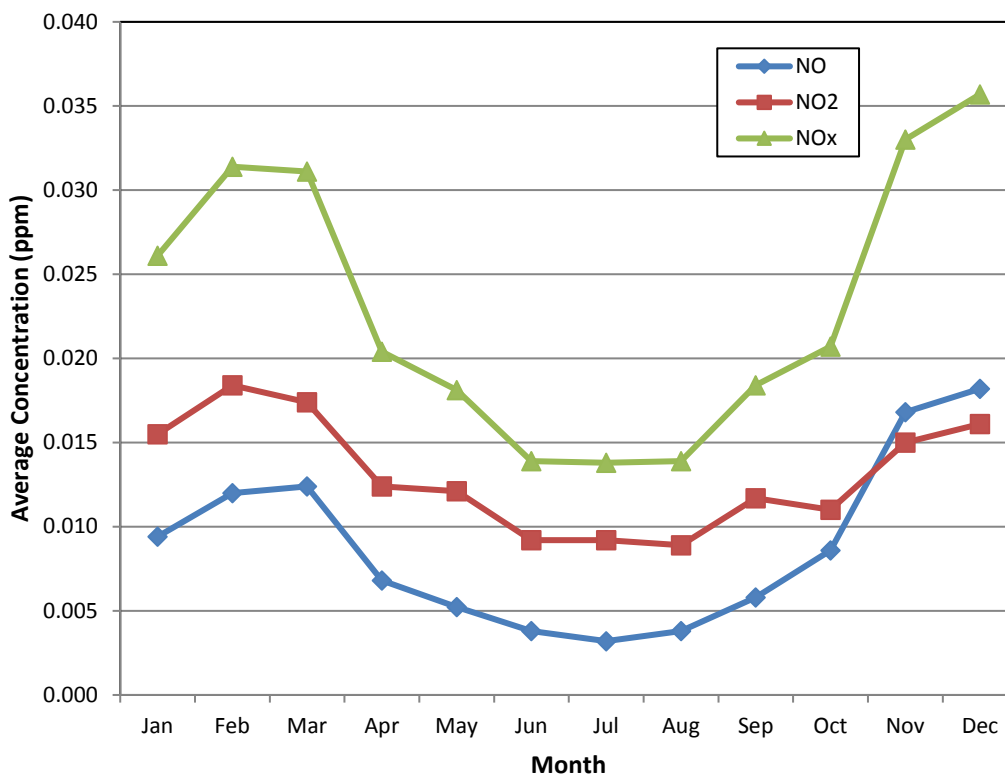
Figure 8
Nitrogen Dioxide Concentrations in New Jersey, 1975-2015
12-Month (Calendar Year) Average
Parts per Million (ppm)
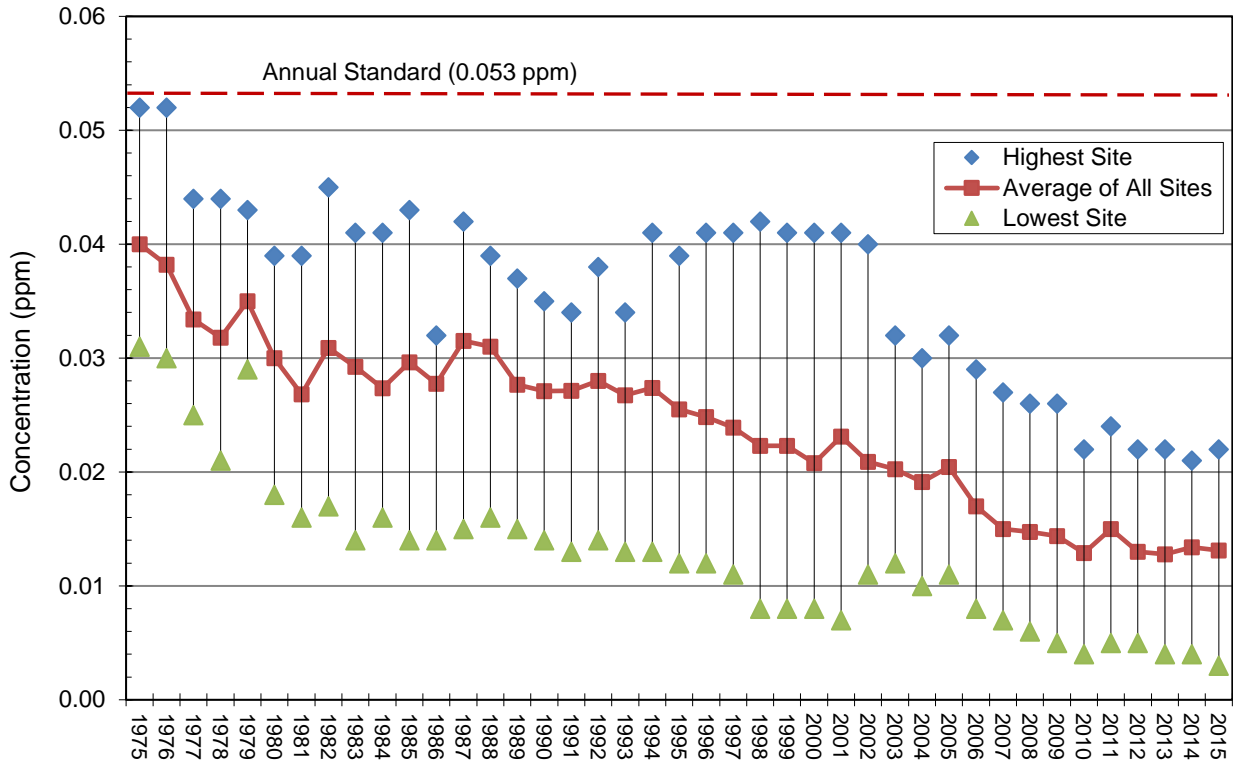
Figure 9
Nitrogen Dioxide Concentrations in New Jersey, 2000-2015
98th Percentile of Daily Maximum 1-Hour Concentrations
Parts per Million (ppm)
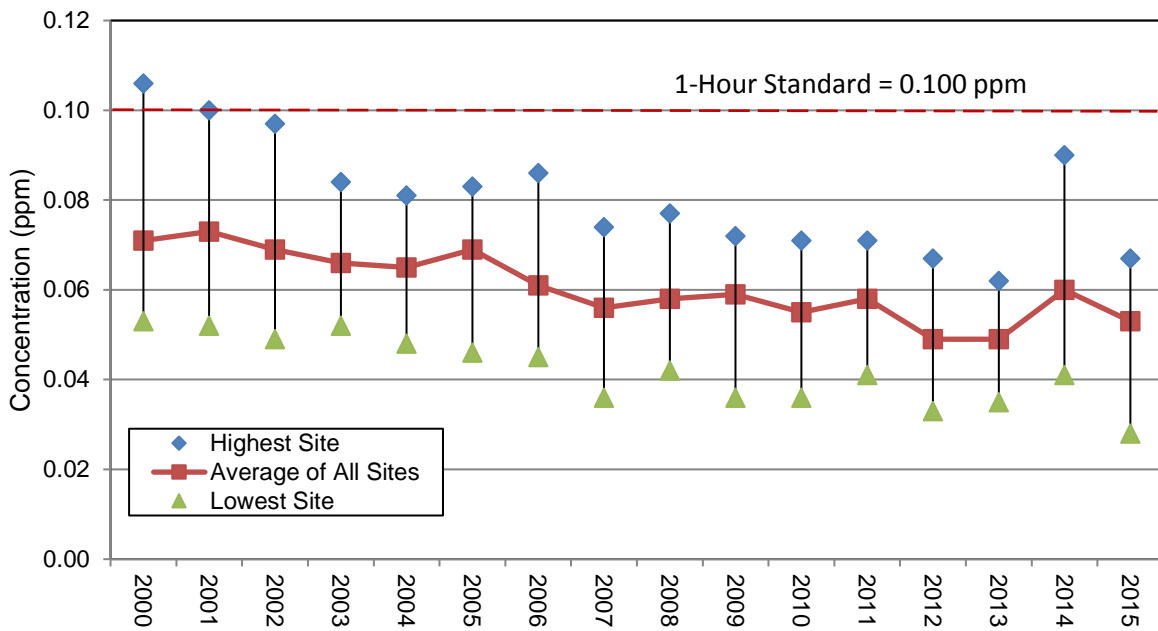
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USEPA. What is Acid Rain? www.epa.gov/acidrain/what-acid-rain. Accessed 9/15/16.

2015 Sulfur Dioxide Summary

New Jersey Department of Environmental Protection

SOURCES

Sulfur dioxide (SO_2) is a heavy, colorless gas with a suffocating odor that easily dissolves in water to form sulfuric acid. SO_2 gases can be formed when fuels containing sulfur are burned, or when gasoline is extracted from oil. Most of the sulfur dioxide released into the air comes from fuel combustion in electric utilities, especially those that burn coal with a high sulfur content. Sulfur is found in raw materials such as crude oil, coal, and ores that contain metals, including aluminum, copper, zinc, lead and iron. Industrial facilities that derive their products from these materials may also release SO_2. A pie chart summarizing the primary sources of SO_2 in New Jersey is shown in Figure 1 for 2011 (the most recent year available).

Figure 2 shows that SO_2 concentrations in New Jersey are generally higher in the winter than in the summer because of higher emissions from heating buildings and other sources. As shown in Figure 3, daily SO_2 levels tend to peak in the morning as emissions accumulate during rush hour, prior to being dispersed later in the day when wind speeds and atmospheric mixing increase.

Figure 1
2011 New Jersey SO$_2$ Emissions by Source Category
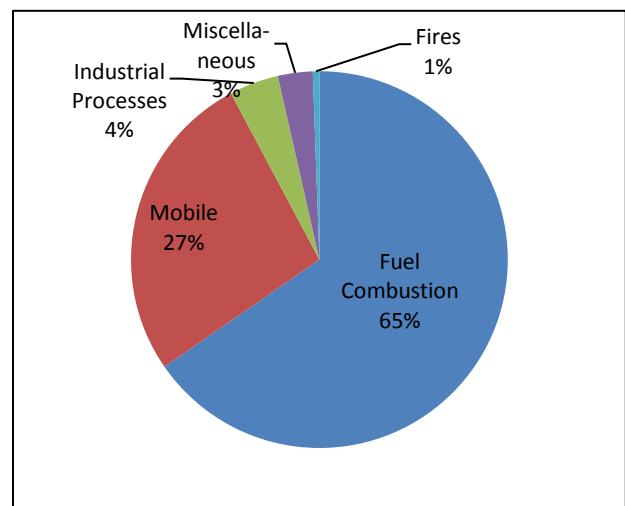
www3.epa.gov/air/emissions/index.htm

HEALTH AND ENVIRONMENTAL EFFECTS

Sulfur dioxide causes irritation of the mucous membranes. This is probably the result of sulfurous acid forming when the highly soluble SO_2 gas dissolves at the surface of the membranes. Groups that are especially susceptible to the harmful health effects of SO_2 include children, the elderly, and people with heart or lung disorders such as asthma. When SO_2 concentrations in the air become elevated, people in these sensitive groups and those who are active outdoors may have trouble breathing.

Sulfur dioxide reacts with other gases and particles in the air to form sulfates, which also can be harmful to people and the environment. Sulfate particles are the major cause of reduced visibility in the eastern United States. SO_2 forms acids that fall to the earth in rain and snow. Better known as acid rain, this acidic precipitation can damage forests and crops, can make lakes and streams too acidic for fish, and can speed up the decay of building materials and paints.

Figure 2
2015 Sulfur Dioxide Concentrations in New Jersey
Monthly Variation
Parts per Million (ppm)
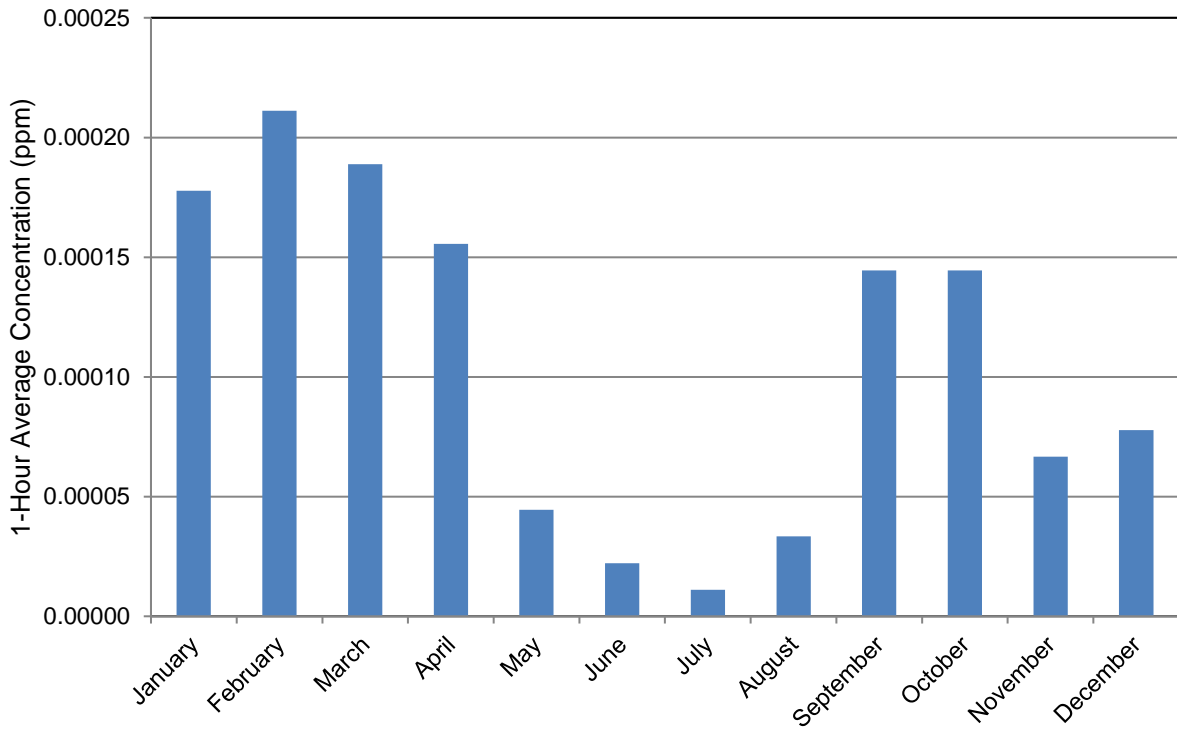
Figure 3
2015 Sulfur Dioxide Concentrations in New Jersey
Hourly Variation
Parts per Million (ppm)
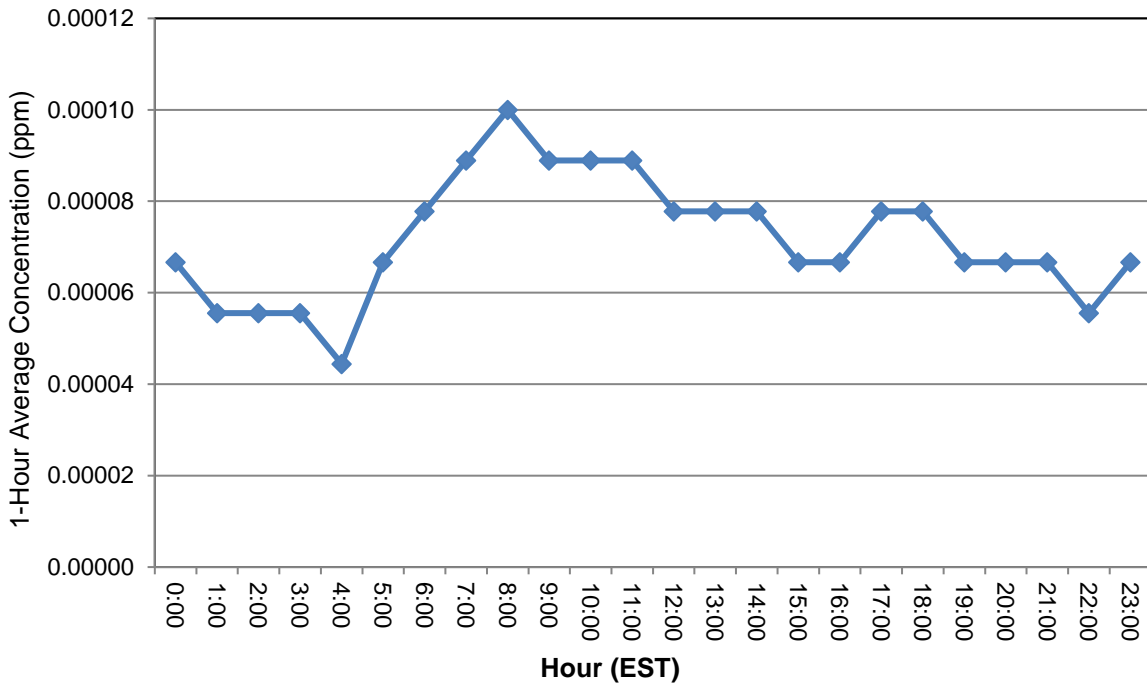
AMBIENT AIR QUALITY STANDARDS

The National Ambient Air Quality Standards (NAAQS) for SO_2 are shown in Table 1. In June 2010 the United States Environmental Protection Agency (USEPA) established a new 1-hour NAAQS for SO_2 at a level of 75 parts per billion (ppb). At the same time, the old 24-hour and annual average NAAQS were revoked, and the 3-hour secondary NAAQS was retained. Compliance with the 1-hour standard is determined by calculating the 99th percentile of 1-hour daily maximum concentrations for each monitoring site in the state each year, and then averaging each site's values for the three most recent years. This statistic is called the design value. The New Jersey Ambient Air Quality Standards (NJAAQS) for SO_2 are expressed in micrograms per cubic meter ($\mu g/m^3$) instead of ppm. The 12-month and 24-hour NJAAQS are based on rolling averages. For the annual average, that is any 12-month average recorded during two consecutive years. As shown in Table 1, New Jersey also has secondary 12-month and 24-hour standards. The secondary 3-hour standard is the same as the NAAQS.

Table 1
National and New Jersey Ambient Air Quality Standards for Sulfur Dioxide (SO_2)
Micrograms per Cubic Meter ($\mu g/m^3$)
Parts per Million (ppm)
Parts per Billion (ppb)

Averaging Period	Type	New Jersey	National
12–month average[a]	Primary	80 $\mu g/m^3$ (0.03 ppm)	---
12–month average[a]	Secondary	60 $\mu g/m^3$ (0.02 ppm)	---
24–hour average[b]	Primary	365 $\mu g/m^3$ (0.14 ppm)	---
24–hour average[b]	Secondary	260 $\mu g/m^3$ (0.10 ppm)	---
3–hour average,[b,c]	Secondary	1300 $\mu g/m^3$ (0.5 ppm)	0.5 ppm
1–hour average[d]	Primary	---	75 ppb

[a] Based on rolling averages.
[b] Based on non-overlapping rolling averages.
[c] Not to be exceeded more than once per year.
[d] To meet this standard, the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within the state must not exceed 75 ppb.

MONITORING LOCATIONS

The New Jersey Department of Environmental Protection (NJDEP) monitored SO_2 levels at nine locations in 2015. These sites are shown in Figure 4. Two sites, Brigantine and Newark Firehouse, measure SO_2 concentrations at trace levels, down to a hundredth of a part per million. The newest SO_2 monitoring site is at Camden Spruce Street, which became operational in April 2012. In September 2010, the monitoring station at the Columbia Wildlife Management Area (WMA) in Warren County was established in support of a petition submitted to USEPA by NJDEP under Section 126 of the Clean Air Act. The petition showed that emissions from the Portland Generating Station, located in Pennsylvania, significantly contributed to nonattainment or interfered with maintenance of the 1-hour SO_2 NAAQS in New Jersey. The facility stopped operating in 2014.

Figure 4
2015 Sulfur Dioxide
Monitoring Network
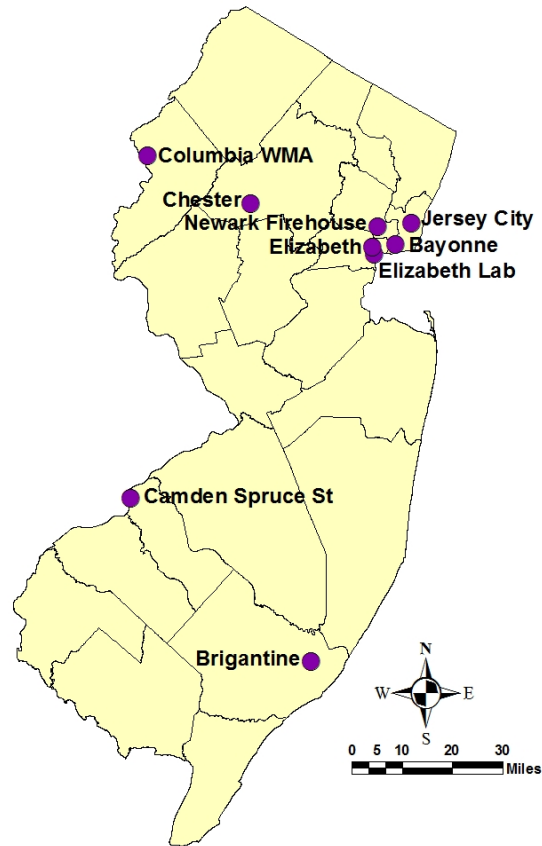
SO$_2$ LEVELS IN 2015

In 2015, there were no exceedances of the 1-hour NAAQS of 75 ppb recorded at any site. This is in contrast to 2014, when five exceedances were recorded at the Columbia station. The highest 99th-percentile of the daily maximum 1-hour concentration for 2015 was 16 ppb recorded at Camden Spruce Street. However, for 2015 Columbia still has the highest design value, the 3-year average of the 99th percentile of the daily maximum 1-hour SO$_2$ concentration, at 55 ppb. This is because of the high values recorded in 2013 and 2014. The Bayonne site did not have sufficient data from 2013 to determine the three-year design value for the 1-hour SO$_2$ standard. The Bayonne site did not operate between October 2012 and July 2013 because of damage from Superstorm Sandy.

No monitoring sites showed exceedances of the primary or secondary SO$_2$ standards during 2015. The maximum 12-month average concentration was 0.001 ppm, recorded at Columbia WMA, Elizabeth, Elizabeth Lab, and Jersey City. The maximum 24-hour average concentration recorded was 0.011 ppm at the Elizabeth Lab site. The highest 3-hour average recorded was 0.042 ppm at the Elizabeth Lab site. Summaries of the 2015 data are provided in Tables 2, 3, 4, and 5, and Figures 5 and 6.

Table 2
2015 Sulfur Dioxide Concentrations in New Jersey
Daily Maximums and 99th Percentile 1-Hour Averages
Parts per Billion (ppb)

Monitoring Site	1-Hour Average (ppb)			2013-2015 Design Value[a]
	Highest Daily Maximum	2nd-Highest Daily Maximum	99th %-ile Daily Maximum	
Bayonne[b]	8	7	5	--
Brigantine	6.8	6.7	5	6
Camden Spruce St.	20	17	16	12
Chester	11	7	7	8
Columbia WMA	9	6	5	55
Elizabeth	9	6	4	6
Elizabeth Lab	42	29	15	14
Jersey City	8	5	4	7
Newark Firehouse	8.8	5.3	5.1	7

[a] 3-Year (2013-2015) average of the 99th %-ile 1-hour daily maximum concentrations.
[b] Bayonne site temporarily shut down October 2012 to July 2013 due to Superstorm Sandy.

Figure 5
2015 Sulfur Dioxide Concentrations in New Jersey
3-Year Design Value (2013-2015)
(99th Percentile of the 1-Hour Daily Maximum Concentrations)
Parts per Billion (ppb)
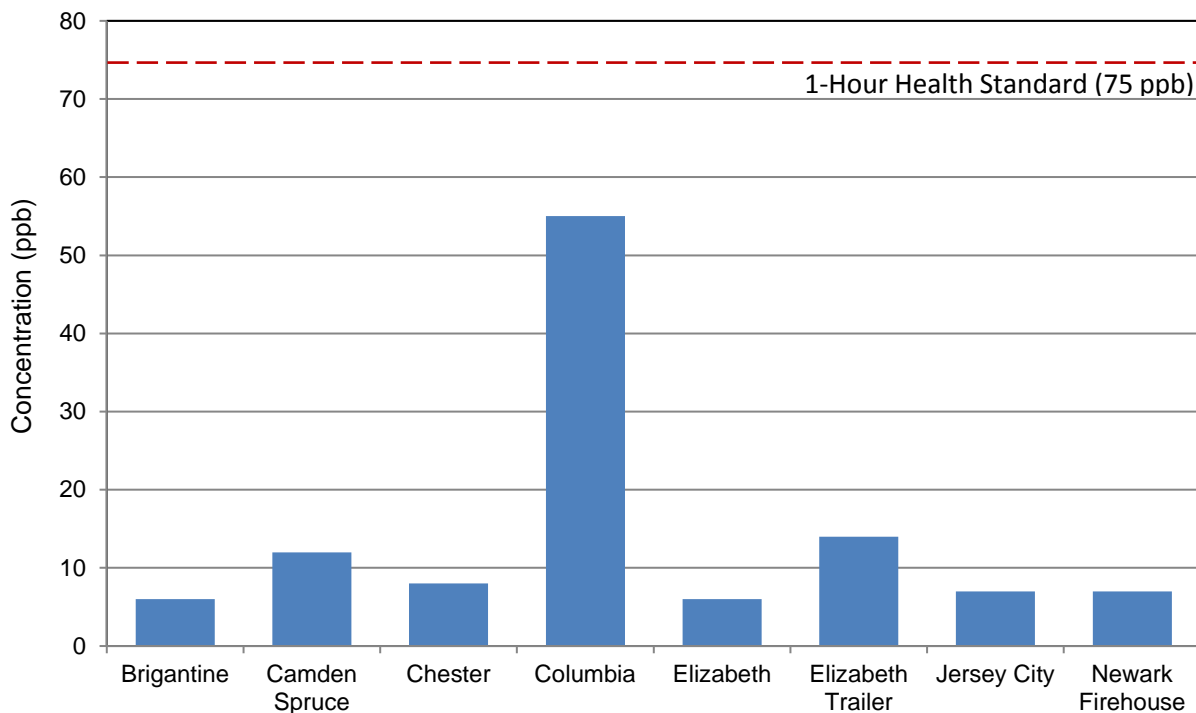
Table 3
2015 Sulfur Dioxide Concentrations in New Jersey
3-Hour Averages
Parts per Million (ppm)

Monitoring Site	3-Hour Average	
	Maximum	2nd Highest [a]
Bayonne	0.005	0.004
Brigantine	0.0060	0.0059
Camden Spruce St.	0.012	0.012
Chester	0.006	0.005
Columbia WMA	0.007	0.004
Elizabeth	0.006	0.005
Elizabeth Lab	0.042	0.021
Jersey City	0.005	0.004
Newark Firehouse	0.0070	0.0049

[a] Based on non-overlapping 3–hour rolling averages.

Table 4
2015 Sulfur Dioxide Concentrations in New Jersey
24-Hour and Daily Averages
Parts per Million (ppm)

Monitoring Site	24-Hour Average [a]		Daily Average [b]	
	Maximum	2nd-Highest	Maximum	2nd Highest
Bayonne	0.003	0.002	0.003	0.002
Brigantine	0.0032	0.0023	0.0031	0.0021
Camden Spruce St.	0.003	0.003	0.003	0.003
Chester	0.004	0.003	0.004	0.002
Columbia WMA	0.002	0.001	0.003	0.002
Elizabeth	0.003	0.003	0.003	0.002
Elizabeth Lab	0.011	0.005	0.007	0.005
Jersey City	0.003	0.003	0.003	0.003
Newark Firehouse	0.0044	0.0038	0.0040	0.0029

[a] Based on non-overlapping 24–hour rolling averages.
[b] Based on daily 24-hour block averages, midnight to midnight.

Table 5
2015 Sulfur Dioxide Concentrations in New Jersey
12-Month and Annual Averages
Parts per Million (ppm)

Monitoring Site	12-Month Maximum Average	Annual Average
Bayonne	0.000	0.000
Brigantine	0.0004	0.0003
Camden Spruce St.	0.000	0.000
Chester	0.000	0.000
Columbia WMA	0.001	0.000
Elizabeth	0.001	0.001
Elizabeth Lab	0.001	0.000
Jersey City	0.001	0.000
Newark Firehouse	0.0007	0.0004

Figure 6
2015 Sulfur Dioxide Concentrations in New Jersey
Highest and 2nd-Highest 24-Hour Averages
Parts per Million (ppm)
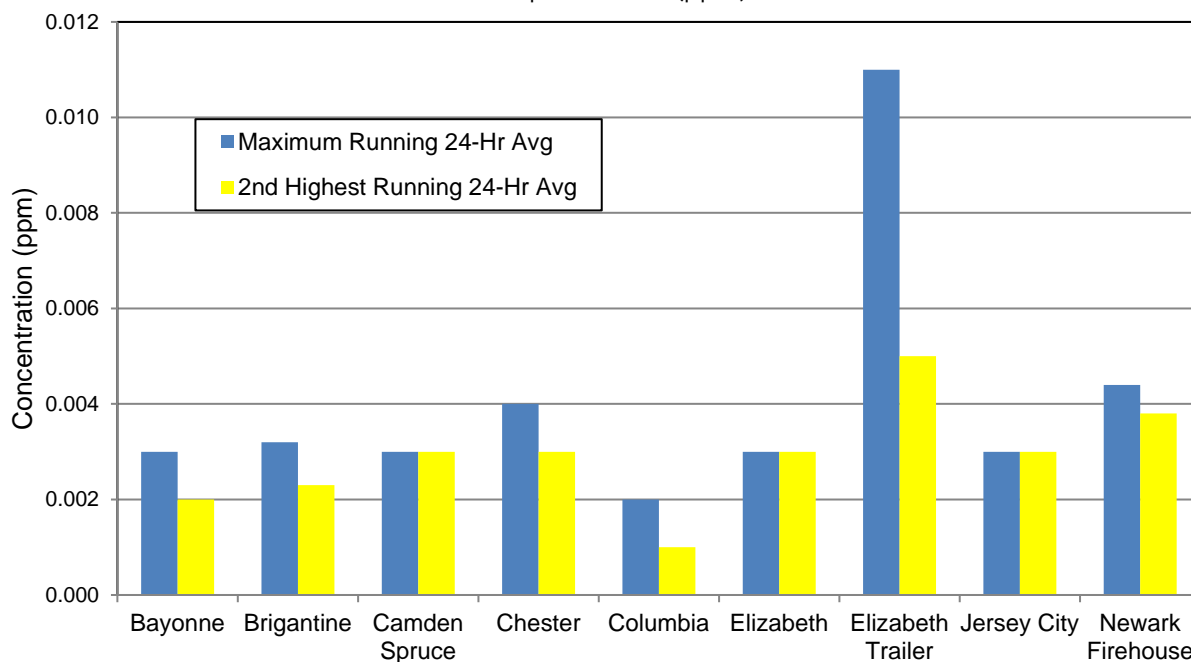
SO₂ TRENDS

Since the implementation of federal regulations requiring the nationwide use of lower sulfur fuels, SO$_2$ concentrations have improved significantly. The last time an exceedance of the 3-hour, 24-hour, or 12-month national and New Jersey AAQS for SO$_2$ was recorded was in 1980. A trend graph of SO$_2$ levels in Figure 7 shows the second-highest daily average concentrations recorded for the highest site, average of all sites, and lowest site for each year since 1975.

Figure 8 shows the trend in one-hour concentrations of SO$_2$ since 2000. The graph uses the 99th percentile of the daily maximum 1-hour concentrations. The increase in maximum values that begins in 2010 is attributable to the start-up of the Columbia WMA monitoring site, which was impacted by the Portland Power Plant across the Delaware River in Pennsylvania (which has since shut down).

Air dispersion modeling carried out by NJDEP in 2009-2010 showed that New Jersey was being impacted by SO$_2$ emissions from a coal-burning power plant across the Delaware River in Pennsylvania, causing likely violations of the 2010 1-hour NAAQS of 75 ppb. New Jersey petitioned the USEPA under Section 126 of the Clean Air Act to take action against the Portland Power Plant. In support of the petition, NJDEP established an SO$_2$ monitoring station at the Columbia Wildlife Management Area in Knowlton Township, Warren County, in September 2010. In October 2011, USEPA finalized a rule to grant New Jersey's petition. This final rule required the Portland Power Plant to reduce its SO$_2$ emissions such that the plant's contribution to predicted air quality standard violations would be lowered within one year, and completely eliminated within three years. The power plant stopped operating in mid-2014. Recent monitoring data have shown that Warren County and its vicinity are now able to meet the 1-hour SO$_2$ NAAQS.

Figure 7
Sulfur Dioxide Concentrations in New Jersey, 1975-2015
Second-Highest Daily Average
Parts per Million (ppm)
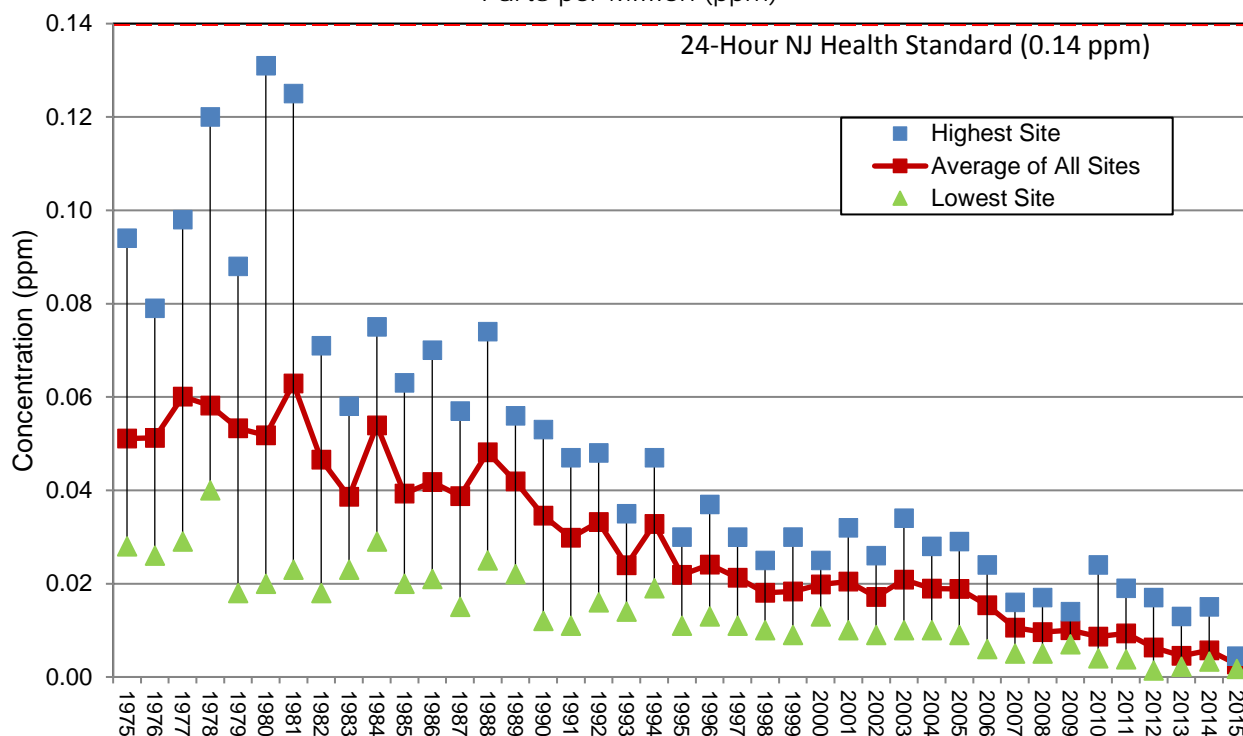
Figure 8
Sulfur Dioxide Concentrations in New Jersey, 1975-2015
99th Percentile of the Daily Maximum 1-Hour Concentrations
Parts per Billion (ppb)
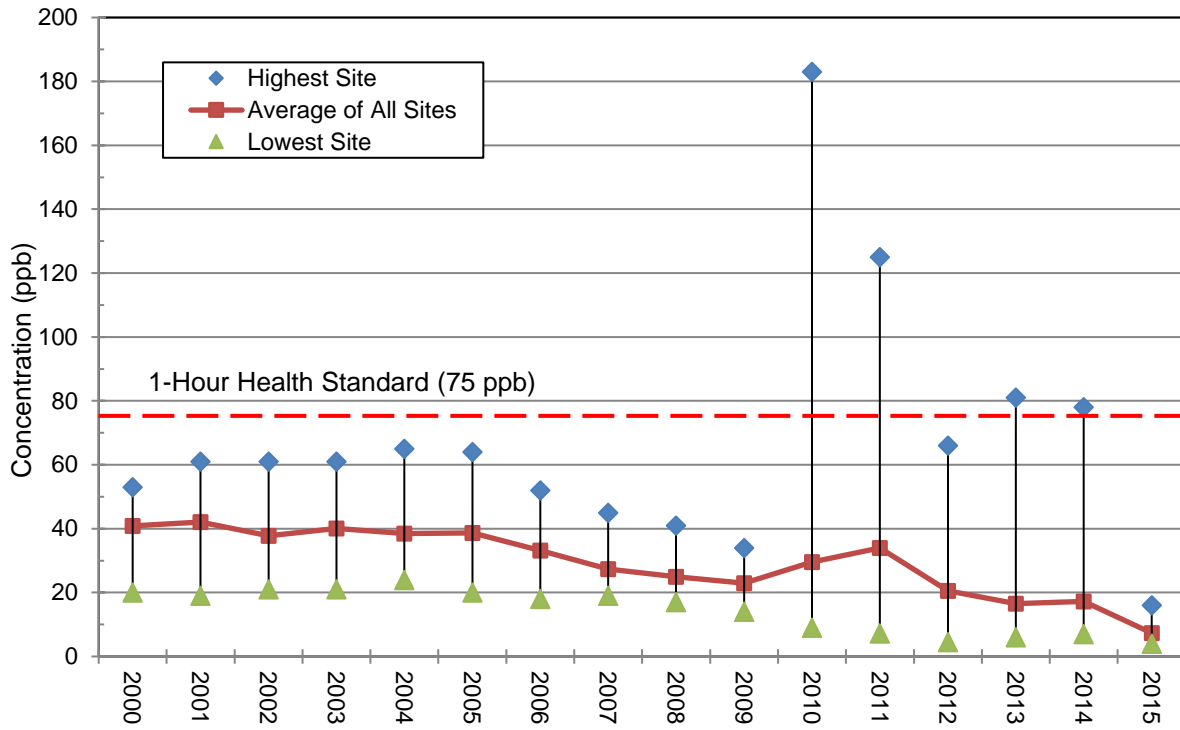
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2015 Carbon Monoxide Summary

New Jersey Department of Environmental Protection

SOURCES

Carbon monoxide (CO) is a colorless, odorless gas that is formed when carbon in fuels is not burned completely. It is a by-product of motor vehicle exhaust, which contributes over 51% of all CO emissions nationwide, and 90% in New Jersey. In addition to cars, trucks and buses, mobile sources include non-road vehicles like construction equipment and boats. CO is also emitted from fuel combustion in boilers and incinerators, natural sources such as forest fires, and various industrial processes. Figure 1 shows the average contributions of these sources in New Jersey for 2011 (the most recent year available).

Figure 1
2011 New Jersey CO Emissions
by Source Category

www.epa.gov/air/emissions/index.htm

Figure 2
Effect of Atmospheric Inversion of Pollution
www.sciencelearn.org.nz
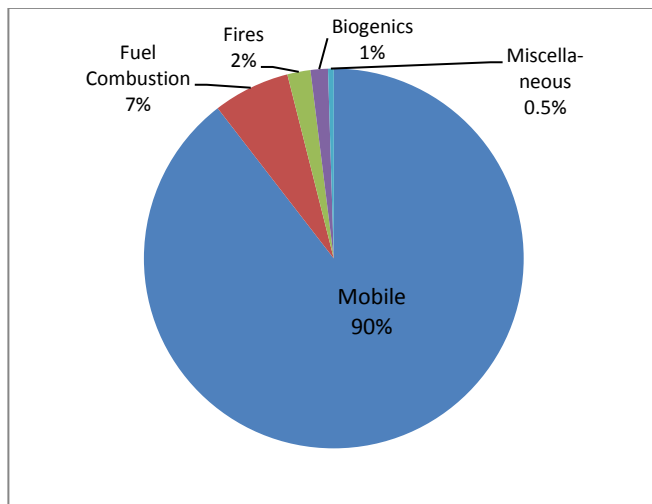
When cooler air is trapped beneath a layer of warmer air, which usually occurs overnight, the result is an atmospheric inversion. The inversion acts like a lid, preventing pollution from mixing in the atmosphere and effectively trapping it close to the ground (see Figure 2). This can allow CO to accumulate at ground-level. Figure 3 shows that CO concentrations are slightly higher in the winter, probably because inversions are more frequent during the winter months. Also, high CO levels often coincide with morning and afternoon rush hours; this diurnal variation is displayed in Figure 4.

Figure 3
Carbon Monoxide Concentrations in New Jersey
2015 Monthly Variation
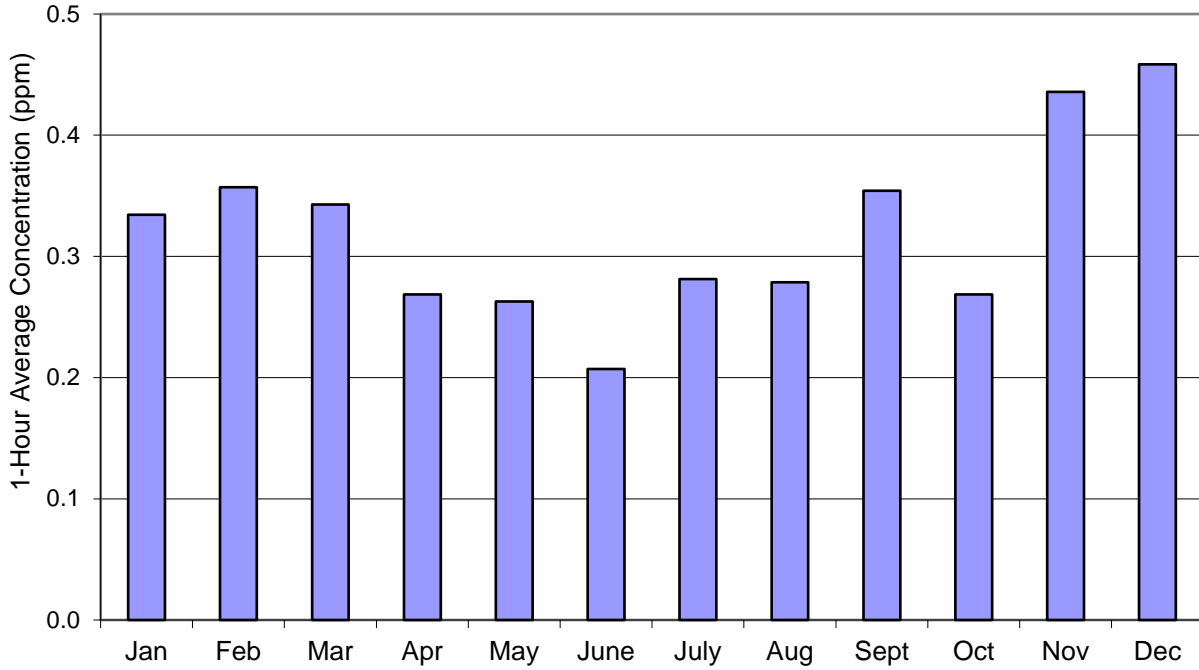
Figure 4
Carbon Monoxide Concentrations in New Jersey
2015 Hourly Variation
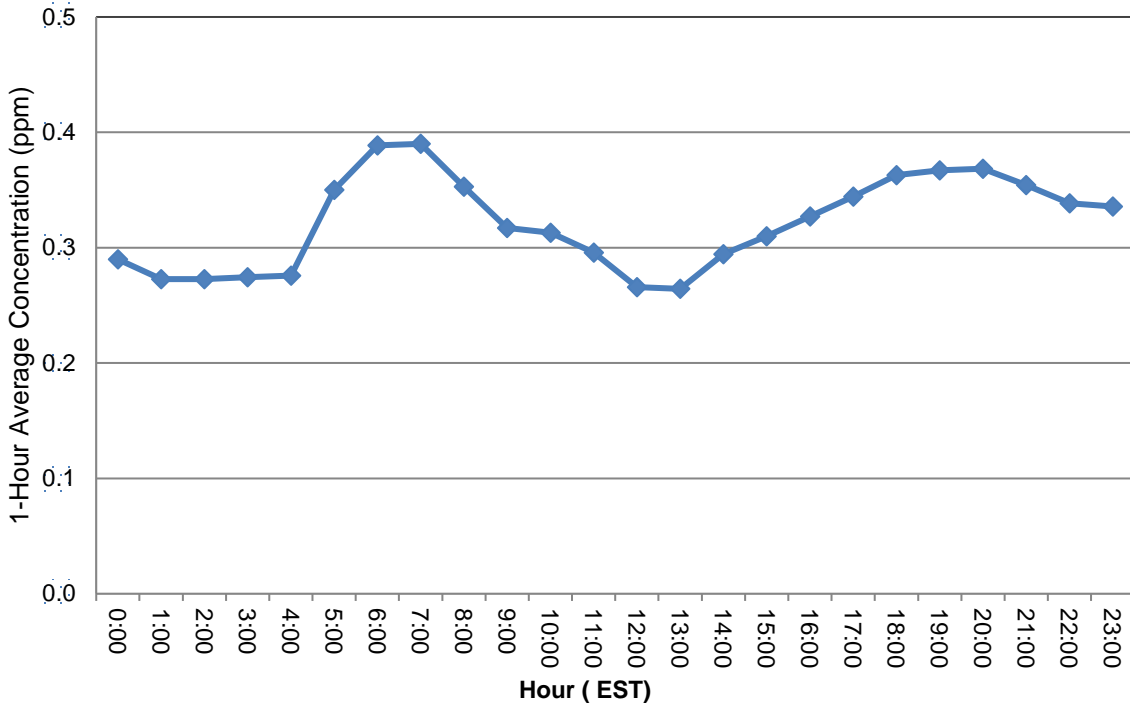
HEALTH EFFECTS

Carbon monoxide reduces the oxygen-carrying capacity of blood, therefore reducing the distribution of oxygen to organs and tissues. The most common symptoms associated with exposure to carbon monoxide are headaches and nausea. The health threat from exposure to CO is most serious for those who suffer from cardiovascular disease. For a person with heart disease, a single exposure to CO at low levels may cause chest pain and may reduce that individual's ability to exercise. Healthy people are also affected by CO, but only at higher levels of exposure. Elevated CO levels are associated with visual impairment, reduced work capacity, reduced manual dexterity, decreased learning ability, and difficulty in performing complex tasks. At extremely high levels, CO can cause death.

AMBIENT AIR QUALITY STANDARDS

There are currently two national primary (health-based) standards for carbon monoxide in ambient air. They are a 1-hour average concentration of 35 parts per million (ppm), and an 8-hour average concentration of 9 ppm. These levels are not to be exceeded more than once in any calendar year. There are no national secondary, or welfare-based, standards for CO at this time. The national standards are commonly known as National Ambient Air Quality Standards (NAAQS). New Jersey also has standards for CO, and they are based on different units (milligrams per cubic meter as opposed to parts per million). The state standards are not to be exceeded more than once in any 12-month period. The state has set secondary standards for CO at the same level as the primary standards. The standards are summarized in Table 1.

Table 1
National and New Jersey Ambient Air Quality Standards
for Carbon Monoxide
Parts per Million (ppm)
Milligrams per Cubic Meter (mg/m^3)

Averaging Period	Type	National	New Jersey
1-Hour	Primary	35 ppm	40 mg/m^3 (35 ppm)
1-Hour	Secondary	----	40 mg/m^3 (35 ppm)
8-Hour	Primary	9 ppm	10 mg/m^3 (9 ppm)
8-Hour	Secondary	----	10 mg/m^3 (9 ppm)

MONITORING LOCATIONS

The New Jersey Department of Environmental Protection (NJDEP) operated seven CO monitoring stations in 2015. These sites are shown in the map in Figure 5. The Newark Firehouse station is part of the U.S. Environmental Protection Agency's (USEPA) National Core Multipollutant Monitoring Network (NCore). It measures and reports CO concentrations at trace levels, down to a hundredth of a ppm.

CO LEVELS IN 2015

None of the New Jersey monitoring sites recorded exceedances of any CO standards during 2015. The maximum 1-hour average CO concentration recorded in 2015 was 3.6 ppm at the Elizabeth station. The highest 8-hour average CO concentration recorded was 2.2 ppm at the Elizabeth station. Summaries of the 2015 data are provided in Table 2, Figure 6 and Figure 7.

Figure 5
2015 Carbon Monoxide
Monitoring Network
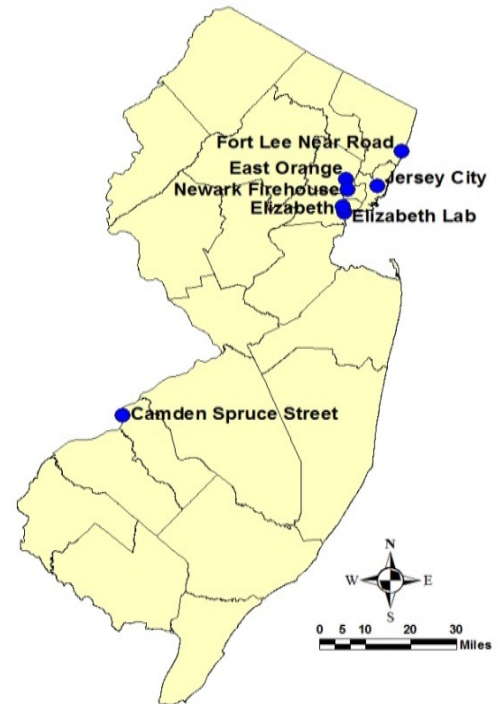
Table 2
2015 Carbon Monoxide Concentrations in New Jersey
1-Hour and 8-Hour Averages
Parts per Million (ppm)

Monitoring Site	1-Hour Average Concentrations		8-Hour Average Concentrations	
	Highest	2nd-Highest	Highest	2nd-Highest (NOL*)
Camden Spruce St.	2	1.9	1.7	1.5
East Orange	3	2.9	2.1	2.1
Elizabeth	3.6	2.6	2.2	1.7
Elizabeth Lab	2.8	2.4	1.6	1.6
Fort Lee Near Rd.	2.2	1.9	1.6	1
Jersey City	3.4	2.1	1.6	1.6
Newark Firehouse	2.86	2.72	2.04	1.9

*NOL – Non-overlapping 8-hour periods

Figure 6
2015 Carbon Monoxide Concentrations in New Jersey
Highest & 2nd-Highest 1-Hour Averages
Parts per Million (ppm)
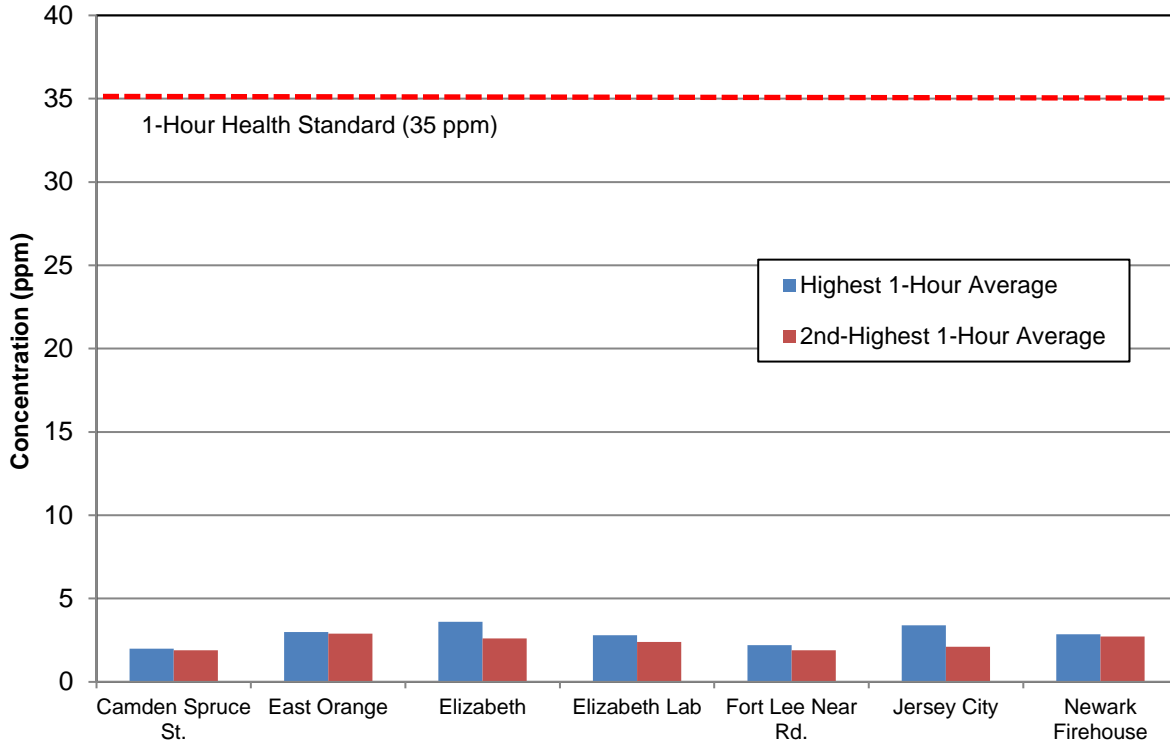
Figure 7
2015 Carbon Monoxide Concentrations in New Jersey
8-Hour Averages
Parts per Million (ppm)
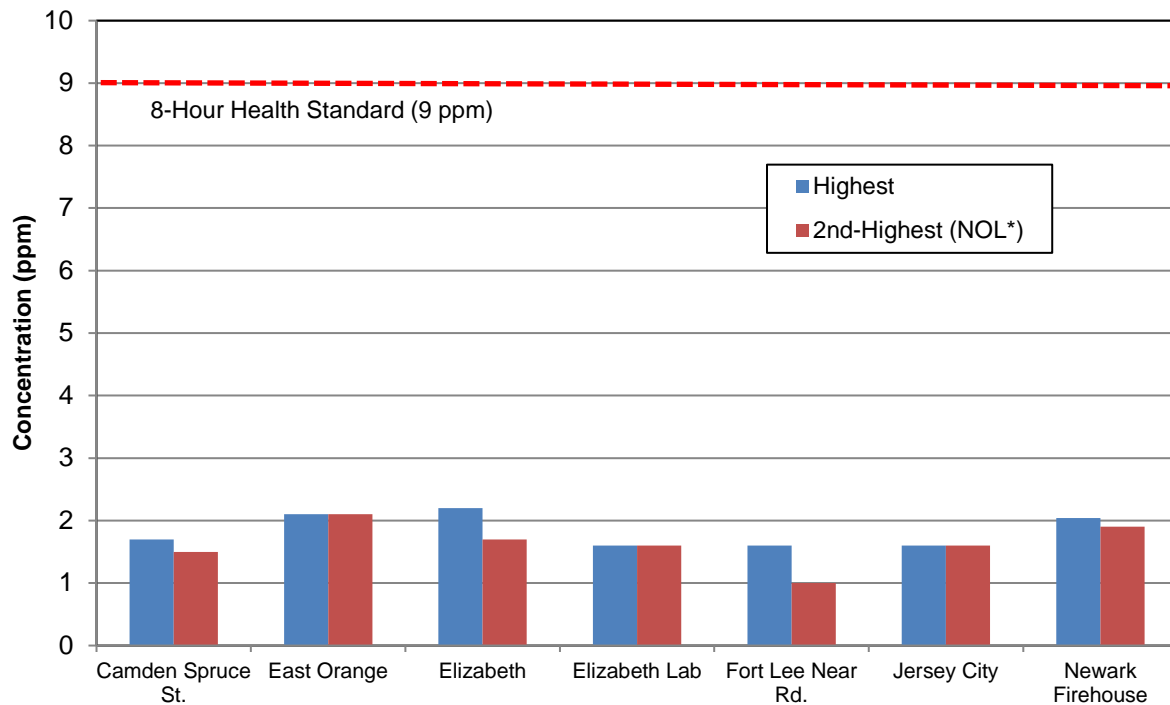
CO Trends

Carbon monoxide levels have improved dramatically over the past thirty-nine years. Figure 8 presents the trend in CO levels since 1975, showing the 8-hour average concentrations recorded each year for the highest site, average of all sites, and lowest site. The graph actually shows the second highest 8-hour value recorded, because this is the value that determines if the NAAQS are being met (one exceedance per site is allowed each year). The last time the 8-hour CO standard was exceeded in New Jersey was in January 1995. The entire state was officially declared to have attained the CO standards as of August 23, 2002. Decades ago, unhealthy levels of CO were recorded on a regular basis. The reduction in CO levels is due primarily to cleaner-running cars, which are by far the largest source of this pollutant.

Figure 8
Carbon Monoxide Concentrations in New Jersey, 1975-2015
2nd Highest 8-hour Average
Parts per Million (ppm)
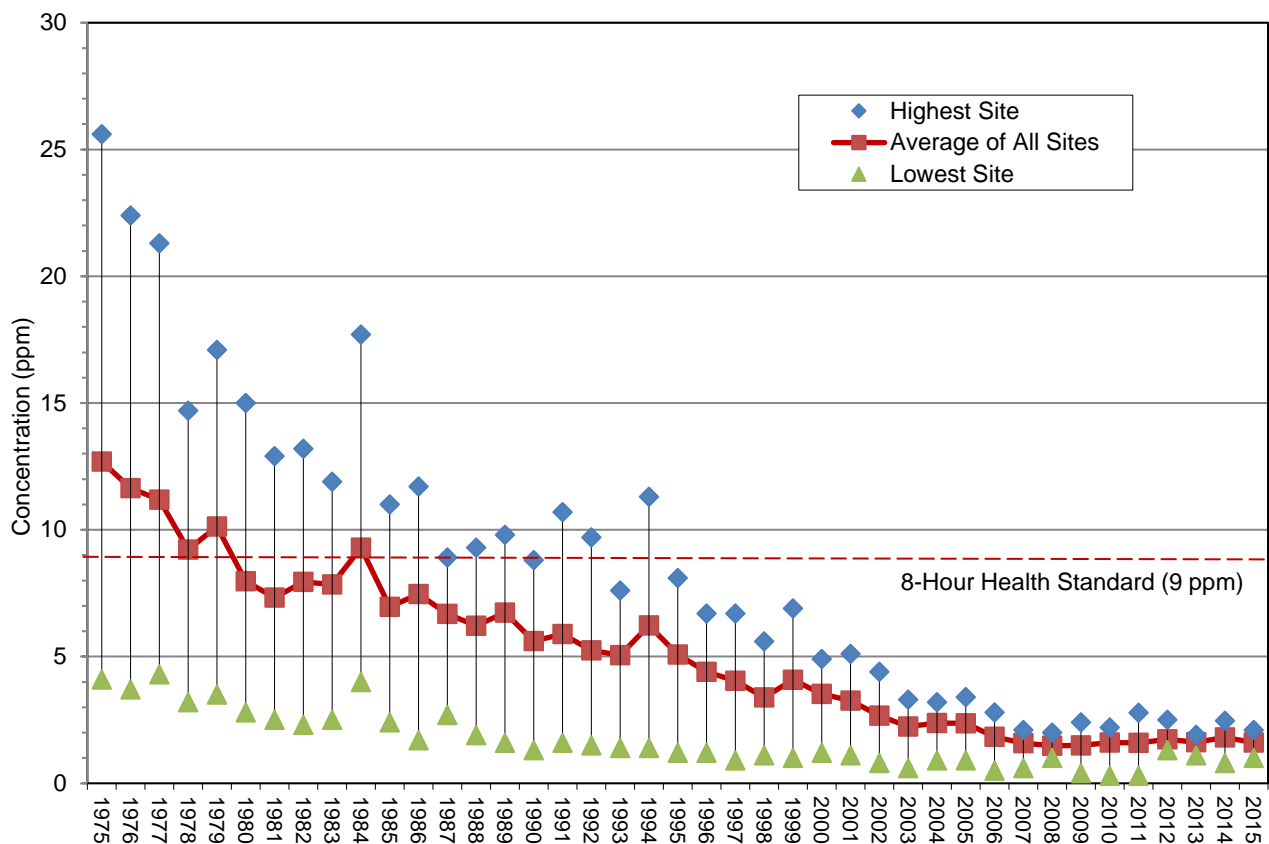
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2015 Air Toxics Summary

New Jersey Department of Environmental Protection

INTRODUCTION

Air pollutants can be divided into two categories: criteria pollutants (ozone, sulfur dioxide, carbon monoxide, nitrogen dioxide, particulate matter, and lead); and air toxics. The criteria pollutants have been addressed at the national level since the 1970s. The United States Environmental Protection Agency (USEPA) has set National Ambient Air Quality Standards (NAAQS) for them, and they are subject to a standard planning process that includes monitoring, reporting, and control requirements. Each of these pollutants is discussed in its own section of this New Jersey Department of Environmental Protection (NJDEP) 2015 Air Quality Report.

Air toxics are basically all the other chemicals released into the air that have the potential to cause adverse health effects in humans. These effects cover a wide range of conditions, from lung irritation to birth defects to cancer. There are no NAAQS for these pollutants, but in 1990 the U.S. Congress directed the USEPA to begin addressing a list of almost 200 air toxics by developing control technology standards for specific categories of sources that emit them. These air toxics are known as the Clean Air Act Hazardous Air Pollutants (HAPs). You can get more information about HAPs at the USEPA Air Toxics web site at www.epa.gov/ttn/atw. NJDEP also has several web pages dedicated to air toxics. They can be accessed at www.nj.gov/dep/airtoxics.

SOURCES OF AIR TOXICS

USEPA compiles a National Emissions Inventory (NEI) every three years. In addition to criteria pollutants and criteria precursors, it also collects information on emissions of hazardous air pollutants. This data is then used for the National-Scale Air Toxics Assessment (NATA), which combines emissions data and complex dispersion and exposure models to estimate people's exposure to air toxics around the country. The pie chart in Figure 1, taken from the 2011 NEI, shows that mobile sources are the largest contributors of air toxics emissions in New Jersey. More information can be found at www.epa.gov/national-air-toxics-assessment.

On-road mobile sources (cars and trucks) account for 37% of the air toxics emissions, and non-road mobile sources (airplanes, trains, construction equipment, lawnmowers, boats, dirt bikes, etc.) contribute an additional 31%. Nonpoint sources (residential, commercial, and small industrial sources) represent 29% of the inventory, and point sources (such as factories and power plants) account for the remaining 3%.

Figure 1
2011 Air Toxics Emissions Source
Estimates for New Jersey

Point
3%

Nonpoint
29%

Onroad
Mobile
37%

Nonroad
Mobile
31%

Pie chart does not include emissions of diesel PM.
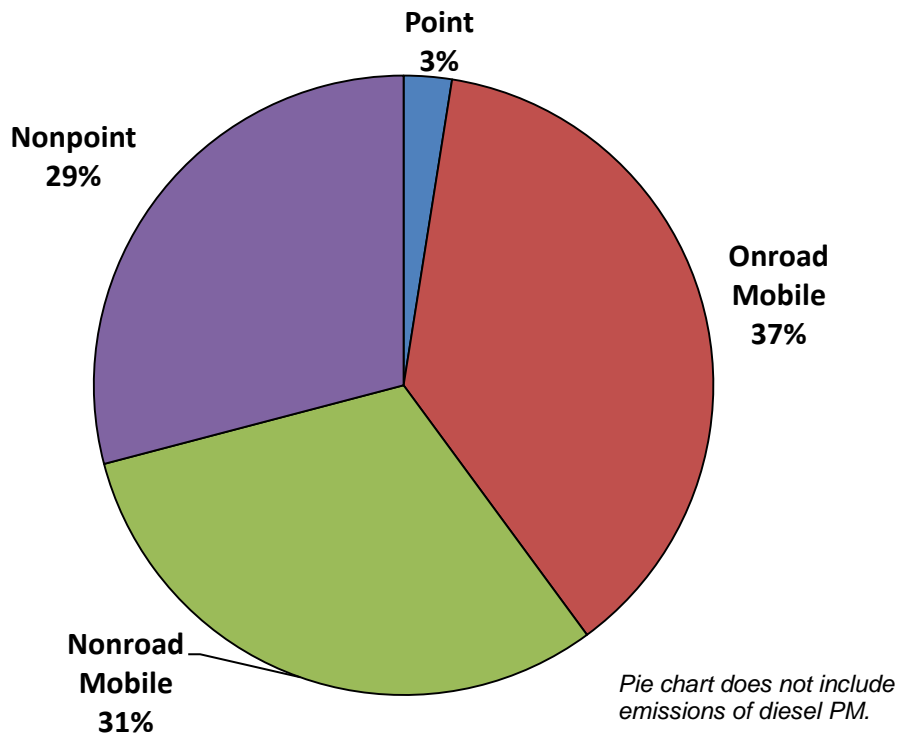
HEALTH EFFECTS

People exposed to significant amounts of air toxics may have an increased chance of getting cancer or experiencing other serious health effects. The noncancer health effects can range from respiratory, neurological, reproductive, developmental, or immune system damage, to irritation and effects on specific organs (see Figure 2). In addition to inhalation exposure, there can be risks from the deposition of toxic pollutants onto soil or surface water. There, they can be taken up by plants and animals which are later consumed by humans.

Figure 2
Potential Effects of Air Toxics

Kidney, Liver Damage

Cancer

Skin Rashes

Asthma, Chronic Bronchitis

Developmental Problems in Children

Birth Defects, Miscarriages

Cough, Throat Irritation

Nervous System Damage
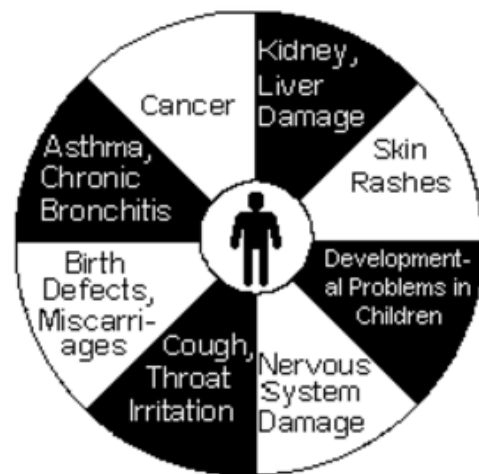
Source: www3.epa.gov/ttn/atw/3_90_024.html

MONITORING LOCATIONS

NJDEP has four air toxics monitoring sites around the state that measure volatile organic compounds (VOCs) and carbonyls, a subset of VOCs that includes formaldehyde, acetaldehyde and other related compounds. They are located in Camden, Chester, Elizabeth, and New Brunswick. Toxic metals data is collected at five monitoring stations, Camden Spruce Street, Chester, Elizabeth Lab, New Brunswick, and Newark Firehouse.

The Chester monitoring site is in rural Morris County, away from known sources, and serves as kind of a "background" monitor. The New Brunswick monitoring station is in a suburban setting. The Elizabeth Lab monitoring station sits next to the Exit 13 tollbooths on the New Jersey Turnpike. The Camden Spruce Street monitoring station is located in an industrial urban setting. The Newark Firehouse monitoring station is in an urban residential area. More information about the air monitoring sites can be found in the Network Summary section of the annual Air Quality Report at www.njaqinow.net/.

A previous monitoring site in Camden (officially called the Camden Lab site) had been measuring several toxics since 1989. It was shut down on September 29, 2008, because NJDEP lost access to the location. A new monitoring station in Camden, the Camden Spruce Street

Figure 3
2015 Air Toxics Monitoring Network

monitoring site, became operational in 2013. The Elizabeth Lab site began measuring VOCs in 2000, and the New Brunswick and Chester sites started in July 2001. New Jersey's VOC monitors are part of the Urban Air Toxics Monitoring Program (UATMP), sponsored by the USEPA. A 24-hour integrated air sample is collected in a canister every six days, and then sent to the USEPA contract laboratory (ERG, located in North Carolina) to be analyzed for VOCs and carbonyls.

Analysis of metals at Camden Spruce Street, Chester, Elizabeth Lab and New Brunswick also began in 2001 as part of USEPA's Chemical Speciation Network (CSN), with the Newark Firehouse site added in 2010. The CSN was established to characterize the metals, ions and carbon constituents of $PM_{2.5}$. Filters are collected every three days and sent to a national lab for analysis. This report focuses on the toxic metals collected through the CSN program. Additional data from the CSN monitors can be found in Appendix B (Fine Particulate Speciation Summary) of the annual Air Quality Report (www.njaqinow.net/).

NEW JERSEY AIR TOXICS MONITORING RESULTS FOR 2015

2015 air toxic monitoring results for VOCs and carbonyls are shown in Table 1. This table contains the annual average concentration for each air toxic measured at the four New Jersey monitoring sites. All values are in micrograms per cubic meter (μg/m^3). More detail can be found in Tables 4 through 7, including additional statistics, detection limit information, health benchmarks used by NJDEP, risk ratios, and concentrations in parts per billion by volume (ppbv). The ppbv units are more common in air monitoring, while µg/m^3 units are generally used in air dispersion modeling and health studies. A number of compounds that were analyzed were mostly below the detection limit of the method used. However, this does not mean they are not present in the air below the detection limit level. Chemical-specific detection limits for VOCs can be found in Tables 4 through 7. Detection limits for the metals can be found in Appendix B of the annual Air Quality Report.

Reported averages for chemicals with less than 50% of the samples above the detection limit should be viewed with caution. Median values (the value of the middle sample value when the results are ranked) are reported in Tables 4 through 7 along with the mean (average) concentrations because for some compounds only a single or very few high values were recorded. These high values will tend to increase the average concentration significantly, but would have less effect on the median value. In such cases, the median value may be a better indicator of long-term exposures.

USEPA has determined that the methods used to collect and analyze acrolein in ambient air are not producing reliable results. More information is available at http://archive.epa.gov/schoolair/web/html/acrolein.html. Although we are including the 2015 New Jersey acrolein data in this report, the concentrations are highly uncertain and should be viewed as such.

Table 3 presents the annual average concentrations for the toxic metals collected through the CSN monitors in Camden, Chester, Elizabeth, New Brunswick, and Newark, along with chemical-specific health benchmarks and estimated risk ratios. For more information see the section on "Estimating Health Risk" below. Chromium and nickel have health benchmarks that are based on carcinogenicity of specific compounds. Since the monitoring method only measures total chromium or nickel and cannot distinguish between different types of compounds, cancer risk ratios are not calculated with those benchmarks. However, risk ratios are calculated for nickel based on noncancer effects.

Table 1
2015 Summary of Toxic Volatile Organic Compounds Monitored in New Jersey

Annual Average Concentration
Micrograms per Cubic Meter (μg/m³)

	Pollutant	Synonym	HAP	CAS No.	Camden	Chester	Elizabeth	New Bruns-wick
1	Acetaldehyde		*	75-07-0	1.880	0.536	1.732	1.446
2	Acetone			67-64-1	1.972	1.030	2.111	1.987
3	Acetonitrile		*	75-05-8	0.970	0.359	0.669	1.129
4	Acetylene			74-86-2	1.062	0.510	1.227	0.750
5	Acrolein[a]		*	107-02-8	0.924	0.682	0.949	0.696
6	Acrylonitrile		*	107-13-1	*ND*	*ND*	*ND*	*0.001*
7	tert-Amyl Methyl Ether			994-05-8	*0*	*0.001*	*0.0005*	*0.002*
8	Benzaldehyde			100-52-7	*0.671*	*0.027*	0.761	0.100
9	Benzene		*	71-43-2	0.857	0.397	0.818	0.528
10	Bromochloromethane			74-97-5	*ND*	*ND*	*ND*	*ND*
11	Bromodichloromethane			75-27-4	*0.008*	*0.004*	*0.001*	*0.006*
12	Bromoform		*	75-25-2	*0.011*	*0.008*	*0.009*	*0.006*
13	Bromomethane	Methyl bromide	*	74-83-9	0.931	0.049	0.057	0.048
14	1,3-Butadiene		*	106-99-0	0.089	0.022	0.117	0.048
15	Butyraldehyde			123-72-8	0.294	0.113	0.517	0.258
16	Carbon Disulfide		*	75-15-0	0.083	0.062	0.046	0.090
17	Carbon Tetrachloride		*	56-23-5	0.623	0.641	0.615	0.641
18	Chlorobenzene		*	108-90-7	*0.005*	*0.006*	*0.003*	*0.006*
19	Chloroethane	Ethyl chloride	*	75-00-3	0.082	0.066	0.074	0.100
20	Chloroform		*	67-66-3	0.148	0.114	0.151	0.137
21	Chloromethane	Methyl chloride	*	74-87-3	1.253	1.222	1.258	1.218
22	Chloroprene	2-Chloro-1,3-butadiene	*	126-99-8	*ND*	*ND*	*ND*	*ND*
23	Crotonaldehyde			123-73-9	0.273	0.081	0.445	0.333
24	Dibromochloromethane	Chlorodibromomethane		124-48-1	*0.021*	*0.016*	*0.015*	*0.015*
25	1,2-Dibromoethane	Ethylene dibromide	*	106-93-4	*0.005*	*0.002*	*0.003*	*0.002*
26	m-Dichlorobenzene	1,3-Dichlorobenzene		541-73-1	*0.005*	*0.006*	*0.004*	*0.003*
27	o-Dichlorobenzene	1,2-Dichlorobenzene		95-50-1	*0.006*	*0.006*	*0.005*	*0.003*
28	p-Dichlorobenzene	1,4-Dichlorobenzene	*	106-46-7	0.046	*0.016*	0.036	*0.017*
29	Dichlorodifluoromethane			75-71-8	2.612	2.547	2.533	2.520
30	1,1-Dichloroethane	Ethylidene dichloride	*	75-34-3	*0.001*	*0.002*	*ND*	*0.002*
31	1,2-Dichloroethane	Ethylene dichloride	*	107-06-2	0.085	0.068	0.074	0.073
32	1,1-Dichloroethylene	Vinylidene chloride	*	75-35-4	*0.005*	*0.004*	*0.004*	*0.003*
33	cis-1,2-Dichloroethylene	cis-1,2-Dichloroethene		156-59-2	*ND*	*0.005*	*ND*	*ND*
34	trans-1,2-Dichloroethylene	trans-1,2-Dichloroethene		156-60-5	*0.010*	*0.001*	*0.003*	*0.001*

- *Values in **italics** indicate averages based on less than 50% of samples above the detection limit.*
- **ND** indicates that all samples were below the detection limit.
- HAP = Hazardous air pollutant as listed in the Clean Air Act.

[a] Acrolein concentrations are highly uncertain because of problems with collection and analysis methods.

Annual Average Concentration
Micrograms per Cubic Meter (µg/m³)

	Pollutant	Synonym	HAP	CAS No.	Camden	Chester	Elizabeth	New Bruns-wick
35	Dichloromethane	Methylene chloride	*	75-09-2	2.614	0.517	0.607	0.516
36	1,2-Dichloropropane	Propylene dichloride	*	78-87-5	*0.002*	*0.006*	*0.002*	*0.001*
37	cis-1,3-Dichloropropene	cis-1,3-Dichloropropylene	*	542-75-6	*ND*	*ND*	*ND*	*ND*
38	trans-1,3-Dichloropropene	trans-1,3-Dichloropropylene	*	542-75-6	*ND*	*ND*	*ND*	*ND*
39	Dichlorotetrafluoroethane	Freon 114		76-14-2	0.123	0.121	0.119	0.119
40	2,5-Dimethylbenzaldehyde			5799-94-2	*0.287*	*ND*	*0.003*	*0.043*
41	Ethyl Acrylate		*	140-88-5	*0.001*	*ND*	*0.002*	*ND*
42	Ethyl tert-Butyl Ether	tert-Butyl ethyl ether		637-92-3	*0.002*	0.077	*0.003*	*0.016*
43	Ethylbenzene		*	100-41-4	0.422	0.084	0.276	0.135
44	Formaldehyde		*	50-00-0	2.667	1.002	3.147	2.942
45	Hexachloro-1,3-butadiene	Hexachlorobutadiene	*	87-68-3	*0.017*	*0.021*	*0.020*	*0.018*
46	Hexaldehyde	Hexanaldehyde		66-25-1	0.132	0.026	1.610	0.090
47	Isovaleraldehyde			590-86-3	*0.059*	*0.004*	*0.365*	*0.098*
48	Methyl Ethyl Ketone	MEK		78-93-3	0.397	0.191	0.483	0.343
49	Methyl Isobutyl Ketone	MIBK	*	108-10-1	0.248	0.084	0.184	0.093
50	Methyl Methacrylate		*	80-62-6	*0.027*	*0.003*	*0.037*	*0.005*
51	Methyl tert-Butyl Ether	MTBE	*	1634-04-4	*0.003*	*0.009*	*0.005*	*0.008*
52	n-Octane			111-65-9	0.231	0.098	0.282	0.106
53	Propionaldehyde		*	123-38-6	1.151	0.194	0.353	0.672
54	Propylene			115-07-1	1.128	0.372	2.616	0.510
55	Styrene		*	100-42-5	3.078	*0.020*	0.054	0.042
56	1,1,2,2-Tetrachloroethane		*	79-34-5	*0.007*	*0.007*	*0.007*	*0.005*
57	Tetrachloroethylene	Perchloroethylene	*	127-18-4	0.161	0.066	0.163	0.084
58	Tolualdehydes				0.234	0.052	0.120	0.078
59	Toluene		*	108-88-3	6.145	0.475	1.845	0.814
60	1,2,4-Trichlorobenzene		*	102-82-1	*0.004*	*ND*	*ND*	*0.004*
61	1,1,1-Trichloroethane	Methyl chloroform	*	71-55-6	0.039	0.027	0.033	0.030
62	1,1,2-Trichloroethane		*	79-00-5	*ND*	*0.002*	*ND*	*0.001*
63	Trichloroethylene		*	79-01-6	0.073	*0.006*	*0.016*	*0.006*
64	Trichlorofluoromethane			75-69-4	2.283	1.348	1.371	1.348
65	Trichlorotrifluoroethane	1,1,2-Trichloro-1,2,2-trifluoroethane		76-13-1	0.628	0.626	0.618	0.619
66	1,2,4-Trimethylbenzene			95-63-6	0.592	0.075	0.275	0.119
67	1,3,5-Trimethylbenzene			108-67-8	0.175	0.023	0.089	0.037
68	Valeraldehyde			110-62-3	0.089	0.023	0.223	0.582
69	Vinyl chloride		*	75-01-4	*0.014*	*0.004*	*0.006*	*0.004*
70	m,p-Xylene		*	1330-20-7	0.939	0.165	0.693	0.286
71	o-Xylene		*	95-47-6	0.459	0.084	0.309	0.135

- *Values in **italics** indicate averages based on less than 50% of samples above the detection limit.*
- **ND** indicates that all samples were below the detection limit.
- HAP = Hazardous air pollutant as listed in the Clean Air Act.

Table 2
2015 New Jersey Toxic Metals Summary & Risk Ratios

Pollutant	HAP[a]	Annual average concentration (µg/m³)					Health Bench-mark (µg/m³)[b]	Risk Ratio[c]				
		Camden	Chester	Eliza-beth	New Bruns-wick	Newark		Camden	Chester	Eliza-beth	New Bruns-wick	Newark
Antimony	*	0.018	0.016	0.018	0.017	0.019	0.2	0.1	0.1	0.1	0.1	0.1
Arsenic	*	*0.001*	*0.0004*	*0.0004*	*0.001*	*0.0003*	*2.30E-04*	*4.3*	*1.7*	*1.7*	*2.2*	*1.3*
Cadmium	*	*0.002*	*0.002*	*0.003*	*0.002*	*0.001*	*2.40E-04*	*8*	*7*	*12*	*8*	*5*
Chlorine	*	0.215	0.007	0.077	0.034	0.064	0.2	1	0.04	0.4	0.2	0.3
Chromium[d]	*	0.003	*0.002*	0.002	0.003	0.005	*8.30E-05*	See "e" below				
Cobalt	*	0.001	0.001	0.001	0.001	0.001	*1.10E-04*	**7**	**5**	**7**	**6**	**6**
Lead	*	0.003	*0.001*	0.003	0.002	0.002	*0.083*	0.03	0.01	0.03	0.02	0.02
Manganese	*	0.003	*0.001*	0.002	0.001	0.002	0.05	0.05	0.01	0.04	0.02	0.03
Nickel	*	0.001	*0.001*	0.001	0.001	0.002	0.014	0.1	0.1	0.1	0.1	0.1
Nickel[e]	*	0.001	*0.001*	0.001	0.001	0.002	*2.10E-03*	See "f" below				
Phosphorus	*	0.005	0.005	0.005	0.005	0.005	0.07	0.07	0.07	0.07	0.07	0.07
Selenium	*	0.001	0.001	0.001	0.001	0.001	20	0.0001	0.00005	0.0001	0.0001	0.00005
Silicon		0.079	0.046	0.149	0.057	0.108	3	0.03	0.02	0.05	0.02	0.04
Vanadium		0.001	0.001	0.002	0.001	0.002	0.1	0.01	0.01	0.02	0.01	0.02

NOTE: Concentrations and risk ratios in **_italics_** are based on less than 50% of samples above the detection limit.

[a] HAP = Hazardous air pollutant listed in the Clean Air Act.

[b] The health benchmark is defined as the chemical-specific air concentration above which there may be human health concerns. Toxicity values are not available for all chemicals. For more information, go to www.nj.gov/dep/aqpp/risk.html.
- *Health benchmarks in italics have a cancer endpoint.*
- For a carcinogen (cancer-causing chemical), the health benchmark is set at the air concentration that would cause no more than a one-in-a-million increase in the likelihood of getting cancer, even after a lifetime of exposure.
- For a non-carcinogen, the health benchmark is the maximum air concentration to which exposure is likely to cause no harm, even if that exposure occurs on a daily basis for a lifetime.

[c] The risk ratio for a chemical is a comparison of the annual mean air concentration to the health benchmark. A risk ratio greater than one may be of concern.

[d] Chromium - The health benchmark is based on carcinogenicity of hexavalent chromium (Cr^{+6}). It is not known how much of the chromium measured by the monitor is hexavalent.

[e] Nickel - The cancer-based health benchmark for nickel is based on specific nickel compounds. It is not known how much of the nickel measured by the monitor is in that form.

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More information on speciated fine particulate matter measured in New Jersey can be found in the NJDEP's 2015 Air Quality Report, Appendix B - Fine Particulate Speciation Summary, at www.njaqinow.net/.

ESTIMATING HEALTH RISK

The effects on human health resulting from exposure to specific air toxics can be estimated by using chemical-specific **health benchmarks**. These are based on toxicity values developed by the USEPA and other agencies, using chemical-specific animal or human health studies. For carcinogens, chemicals suspected of causing cancer, the health benchmark is the concentration of the pollutant that corresponds to a one-in-a-million increase in the risk of getting cancer if a person was to breathe that concentration over his or her entire lifetime. The health benchmark for a noncarcinogen is the air concentration at which no adverse health effect is expected to occur, even if a person is exposed to that concentration on a daily basis for a lifetime (this is also known as a reference concentration). Not all air toxics have health benchmarks, because of a lack of toxicity studies. Available health benchmarks for the VOCs and carbonyls monitored in New Jersey are listed in Tables 4 through 7.

If ambient air concentrations exceed health benchmarks, regulatory agencies can focus their efforts on reducing emissions or exposure to those chemicals. Dividing the air concentration of a chemical by its health benchmark gives us a number referred to as a **risk ratio**. If the risk ratio is less than one, the air concentration should not pose a health risk. If it is greater than one, it may be of concern. The risk ratio also indicates how much higher or lower the estimated air concentration is compared to the health benchmark.

The pollutants with risk ratios greater than one for at least one monitoring site are summarized in Table 3. Camden had fourteen pollutants with annual average concentrations that exceeded their health benchmarks. Elizabeth had twelve, and New Brunswick and Chester had eleven. The Newark Firehouse site does not have a VOC monitor. The toxic VOCs with risk ratios greater than one at all sites are acetaldehyde, acrylonitrile, benzene, carbon tetrachloride, chloroform, chloromethane (methyl chloride), 1,2-dichloroethane (ethylene dichloride), and formaldehyde. Toxic metals that had risk ratios greater than one at the five CSN monitoring sites were arsenic, cadmium, and cobalt.

Although the mean concentrations of acrolein exceeded the health benchmark at all sites (see Tables 4 through 7), risk ratios were not calculated because of problems with the sampling and analysis method. Formaldehyde contributed the highest risks, but note that the risks varied substantially. Risk ratios for ethylbenzene and styrene were of concern only at the Camden site.

Table 3
Monitored Toxic Air Pollutants with Risk Ratios Greater Than One in NJ for 2015

	POLLUTANT	Risk Ratio				
		Camden	Chester	Elizabeth	New Brunswick	Newark
1	Acetaldehyde	4	1.2	4	3	
2	Arsenic	*2.6*	*1.7*	*1.7*	*2.2*	*1.3*
3	Benzene	7	3	6	4	
4	1,3-Butadiene	3		4	1.5	
5	Cadmium	*6*	*7*	*12*	*8*	*5*
6	Carbon Tetrachloride	4	4	4	4	
7	Chloroform	3	3	4	3	
8	Chloromethane	2.2	2.2	2.2	2.2	
9	Cobalt	7	5	7	6	6
10	1,2 Dibromoethane	*3*	1.1	1.6		
11	1,2-Dichloroethane	2.2	1.8	2	1.9	
12	Ethylbenzene	1.1				
13	Formaldehyde	35	13	41	38	
14	Styrene	1.7				

NOTE: Values in italics are based on less than 50% of samples above the detection limit.

TRENDS AND COMPARISONS

Monitoring of air toxics in New Jersey has been going on for over a decade, although it continues to evolve, with improvements in the ability to detect given chemicals at lower concentrations. Figures 5 through 15 present data for some of the VOCs that have been sampled over the past decade. As mentioned previously, the first toxics monitoring site in Camden (Camden Lab) was shut down in 2008. It is identified in Figures 4 through 20 as "Camden 1." The new Camden site (Camden Spruce Street), located about two miles from the old site, is designated "Camden 2."

According to USEPA's National Air Toxics Assessment (NATA), **acetaldehyde** concentrations in New Jersey (Figure 4) are primarily influenced by secondary formation, a process in which chemicals in the air are transformed into other chemicals by chemical reactions. Mobile sources also contribute to ambient levels. In 2003, no data was collected in Camden after September, which could have had an influence on the low annual average for that year. In 2004 in both Camden and New Brunswick, high levels of acetaldehyde were measured over a number of weeks.

Figure 5 shows a gradual decrease in **benzene** concentrations over the past decade. Most benzene now comes from mobile and area sources, and is also transported from other regions (background). Sources of **1,3-butadiene** (Figure 6) are similar to those of benzene.

Carbon tetrachloride (Figure 7) was once used extensively as a degreaser, household cleaner, propellant, refrigerant, and fumigant. It has been phased out of most production and use because of its toxicity and its ability to deplete stratospheric ozone. However, about 100 tons are still emitted annually by industry in the U.S, although no emissions have been reported in New Jersey for a number of years. It degrades slowly in the environment, so it can be transported from other area and levels in the air can remain relatively steady.

Some of the increase in **chloroform** concentrations shown in Figure 8 is believed to be from improvements in the detection limit. Nonpoint sources and background are the major contributors to ambient chloroform levels. The high annual average concentration for New Brunswick in 2014 is attributable to a period of high values in May and June.

Chloromethane (also known as methyl chloride) levels are influenced primarily by background. Figure 9 shows that concentrations have remained relatively stable from year to year, and that all the sites show similar levels.

1,2-Dibromoethane (or ethylene dibromide) (Figure 10) is currently used in the treatment of felled logs for bark beetles and termites, and control of wax moths in beehives. It is also used as an intermediate for dyes, resins, waxes, and gums. It was once used as an additive to leaded gasoline and as a soil and grain fumigant, but those uses have been banned by USEPA.

1,4-Dichlorobenzene (Figure 11) is emitted primarily from nonpoint sources. It is used in products such as pesticides, disinfectant, mothballs and toilet deodorizer blocks. There is also a significant background level. The high annual average for New Brunswick in 2005 is attributable to an exceptionally high reading on July 27th that may be a lab error.

1,2-Dichloroethane (also called ethylene dichloride) (Figure 12) is primarily used in the production of vinyl chloride, as well as other chemicals. It is used in solvents for various extraction and cleaning purposes in organic synthesis. It is also used as a dispersant in rubber and plastics, as a wetting and penetrating agent.

Ethylbenzene is associated with mobile sources, which is probably why it is lowest at Chester (Figure 13). 2001 data for Chester and New Brunswick have been omitted from the graph because of technical problems encountered when sampling was begun that May.

Formaldehyde (Figure 14) is a ubiquitous pollutant that is often found at higher concentrations indoors rather than outdoors because of its use in many consumer goods. It is used in the production of fertilizer, paper, plywood, urea-formaldehyde resins, and many other products. In New Jersey the primary emitters of formaldehyde are on-road mobile sources, although secondary formation and transport contribute significantly to high outdoor concentrations. In 2014, concentrations at the New Brunswick site were consistently higher than at the other monitors, although levels dropped in 2015.

Styrene is used predominantly in the production of polystyrene plastics and resins. It is also used as an intermediate in the synthesis of materials used for ion exchange resins and to produce copolymers. A possible source of the higher concentrations at the Camden Spruce Street monitor (see Figure 15) has not been identified.

Figure 4
ACETALDEHYDE – New Jersey Monitored Concentrations
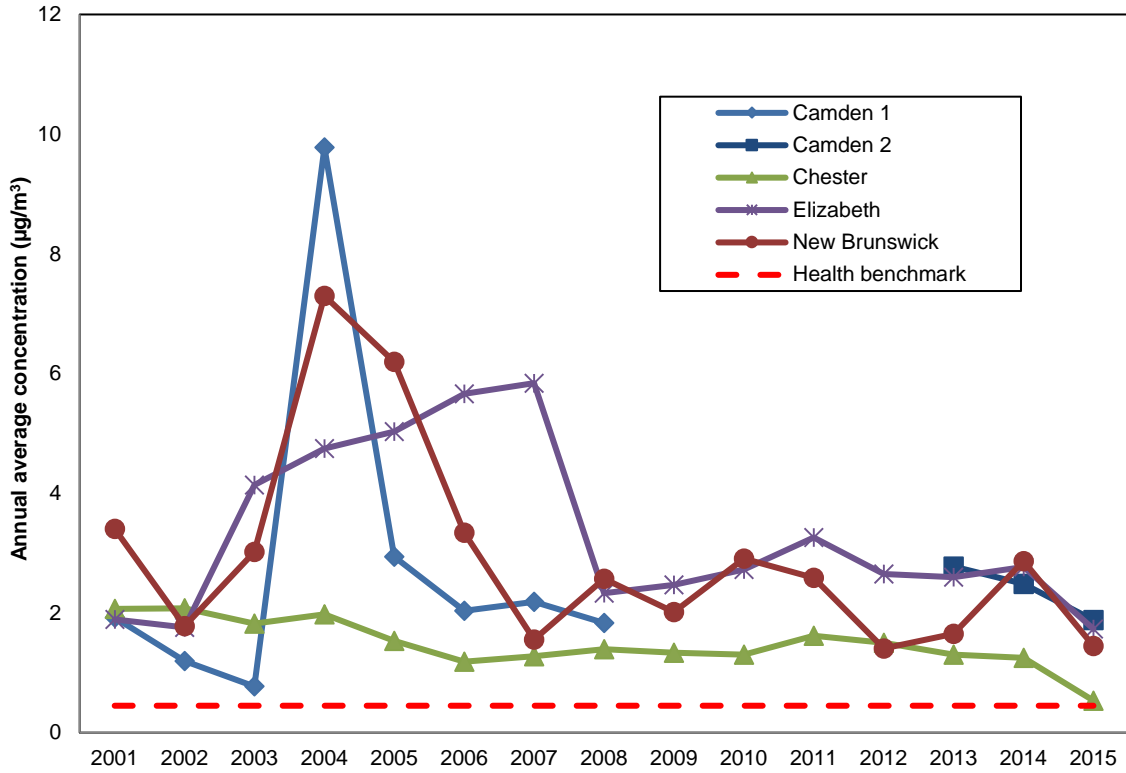
Figure 5
BENZENE – New Jersey Monitored Concentrations
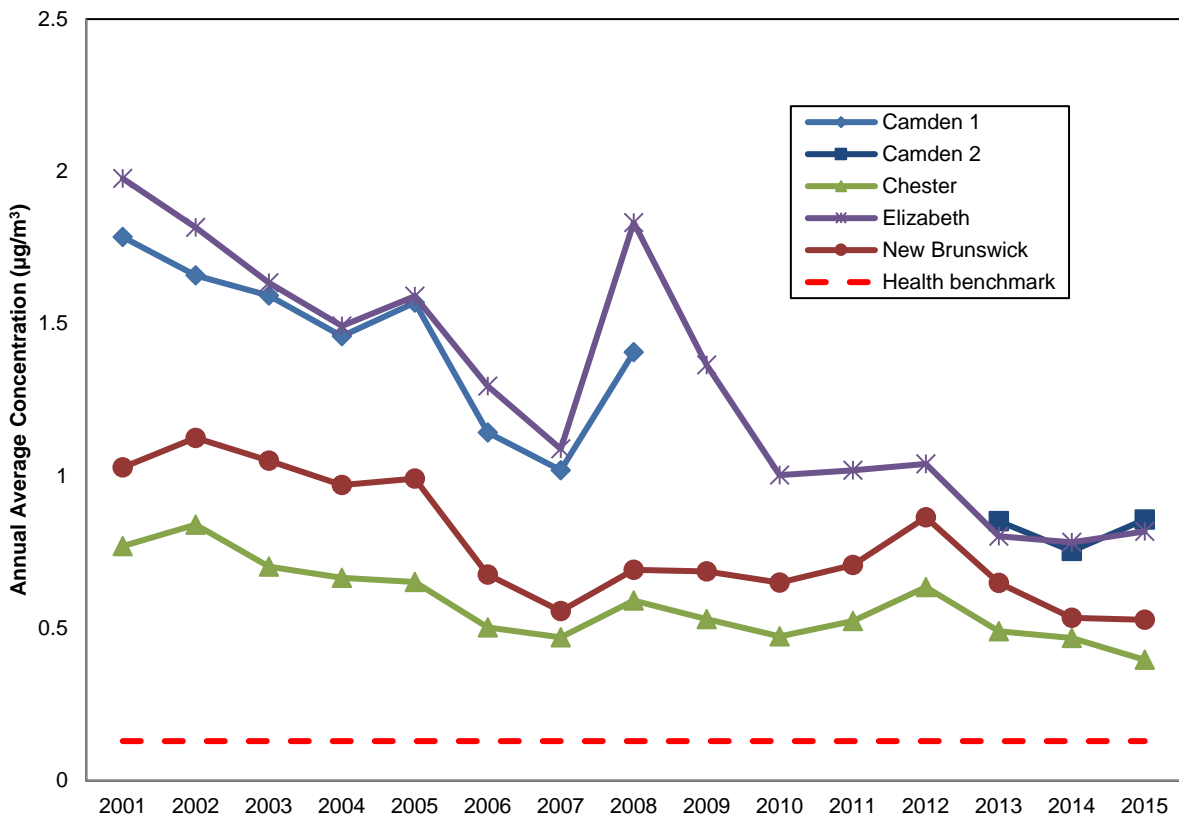
Figure 6
1,3-BUTADIENE – New Jersey Monitored Concentrations
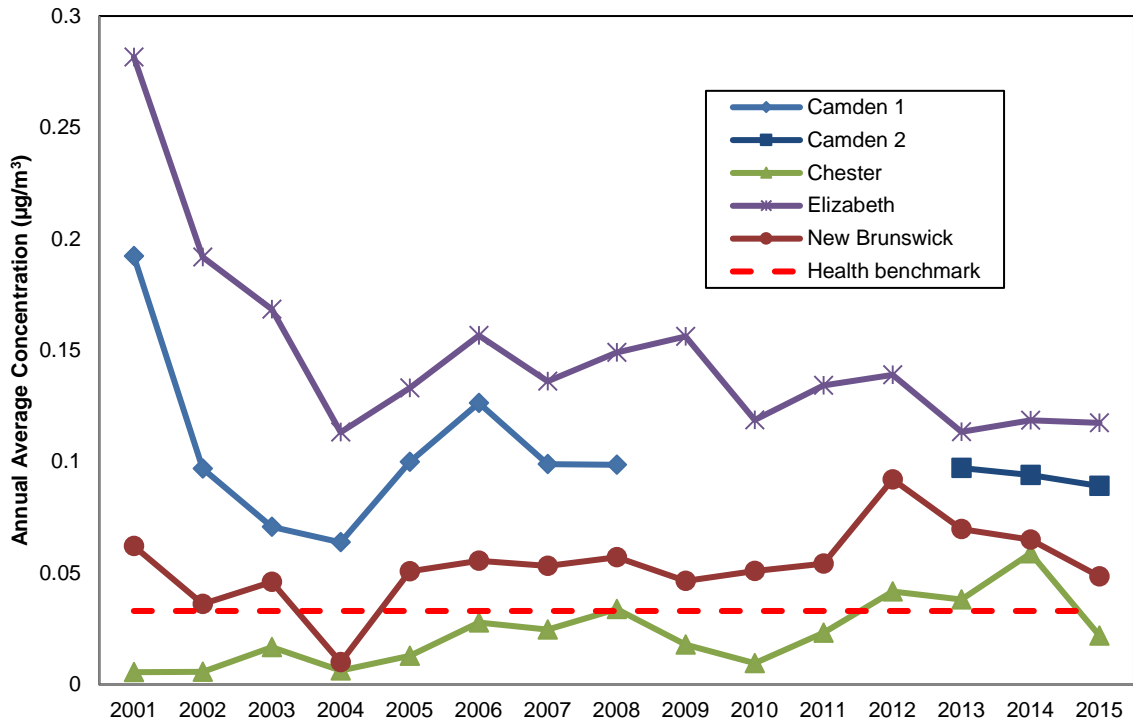
Figure 7
CARBON TETRACHLORIDE – New Jersey Monitored Concentrations
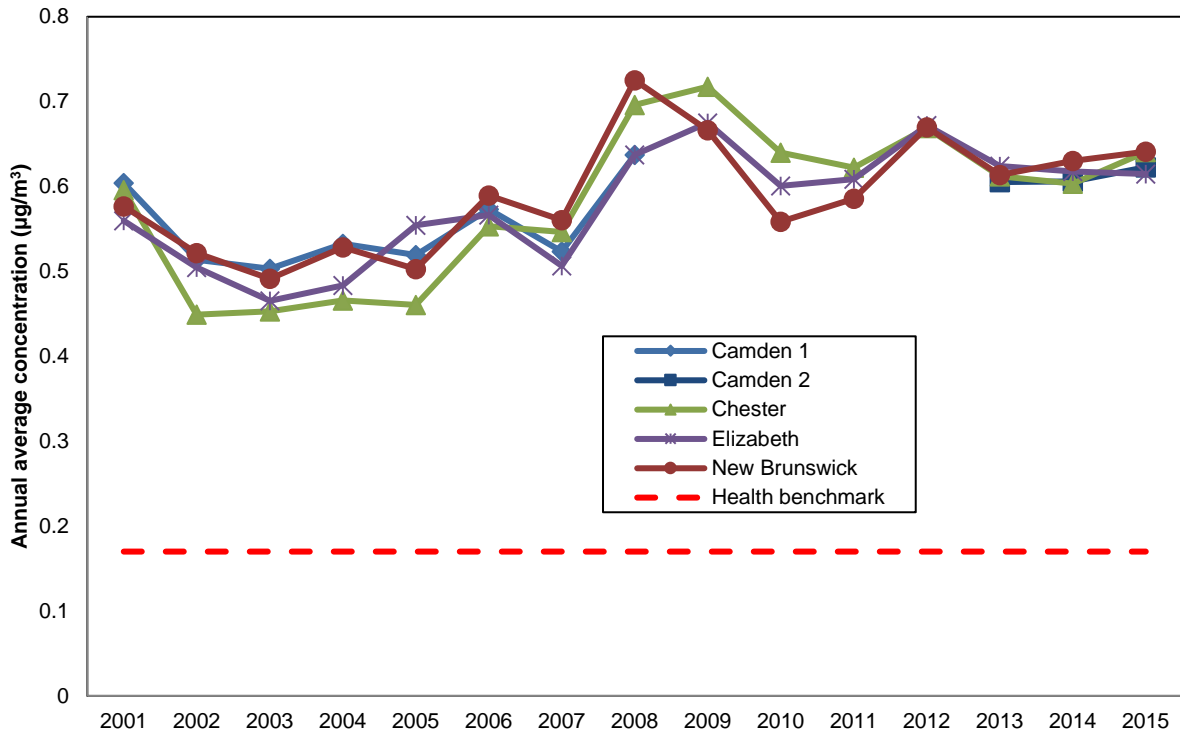
Figure 8
CHLOROFORM – New Jersey Monitored Concentrations

NOTE: Annual averages prior to 2006 are based on less than 50% of data above the detection limit.
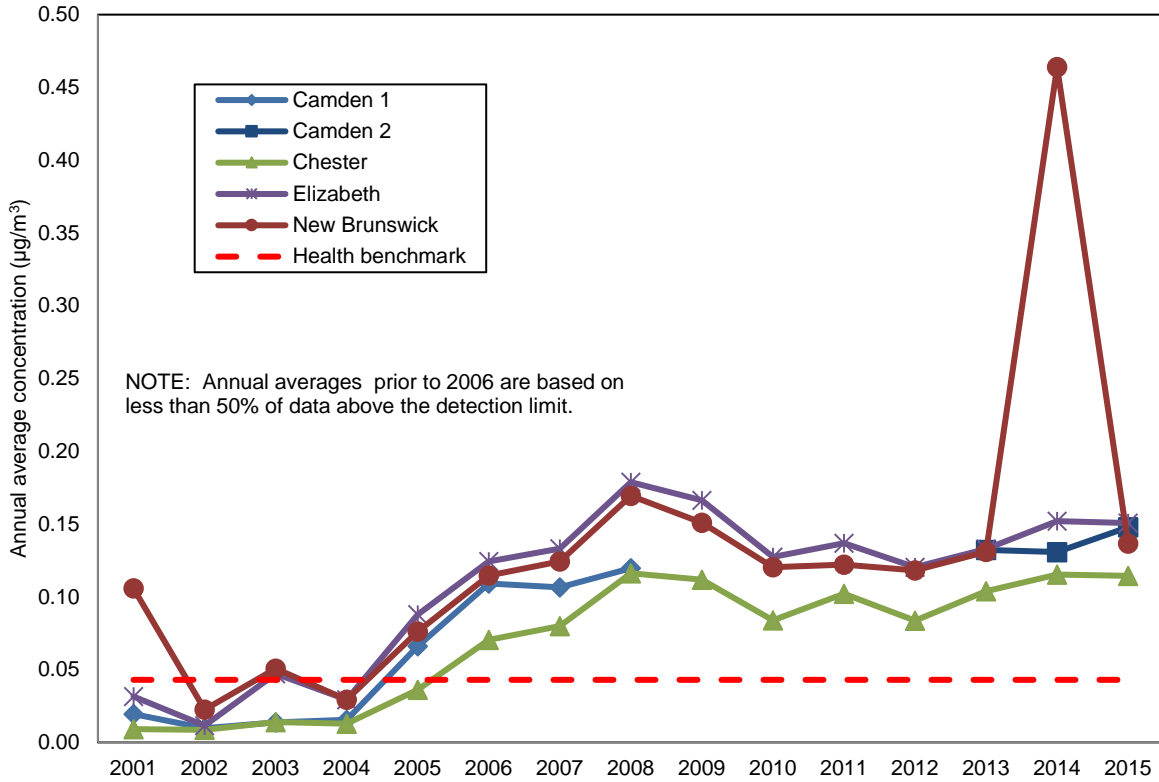
Figure 9
CHLOROMETHANE (Methyl Chloride) – New Jersey Monitored Concentrations
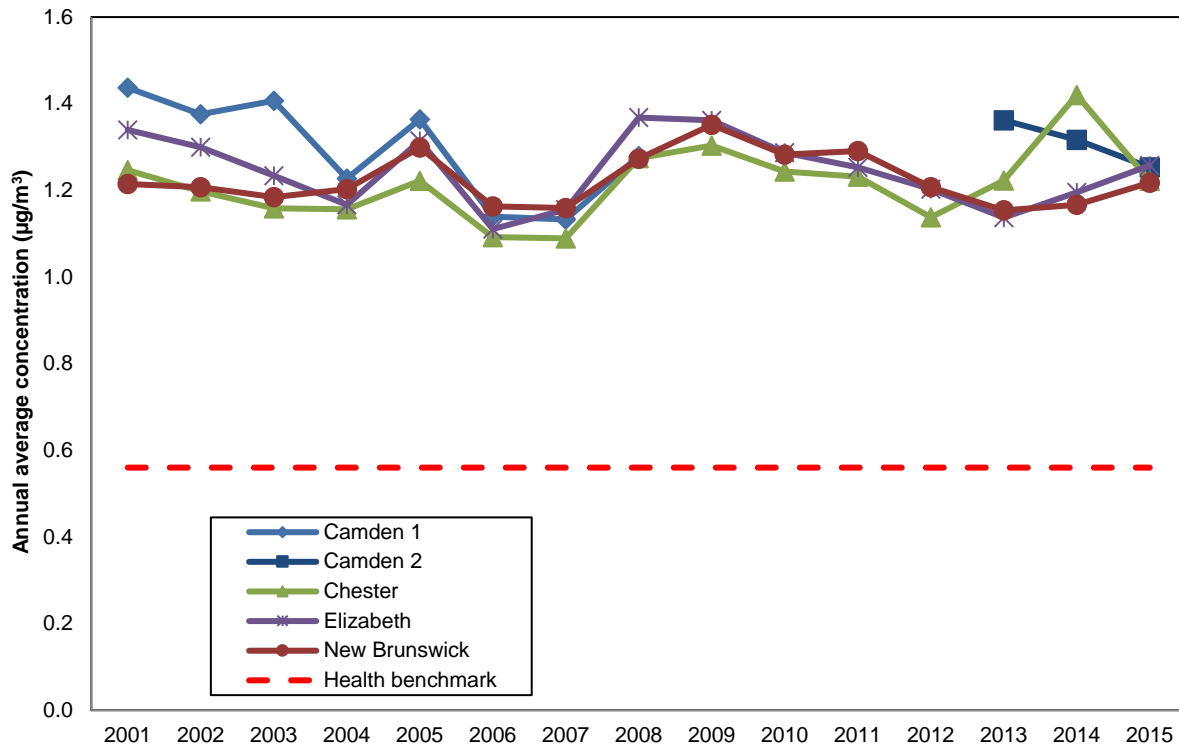
Figure 10
1,2-DIBROMOETHANE (Ethylene Dibromide) – New Jersey Monitored Concentrations

NOTE: Annual averages prior to 2012 are based on less than 50% of data above the detection limit.
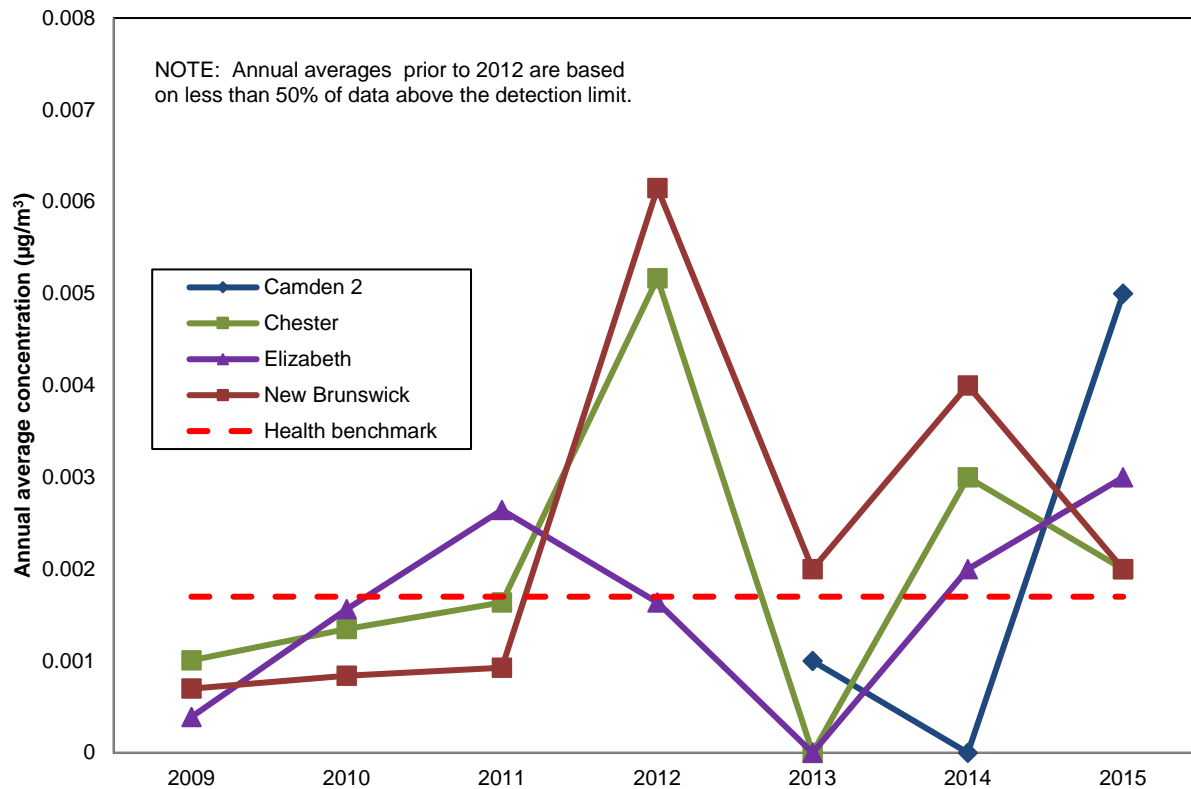
Figure 11
1,4-DICHLOROBENZENE – New Jersey Monitored Concentrations
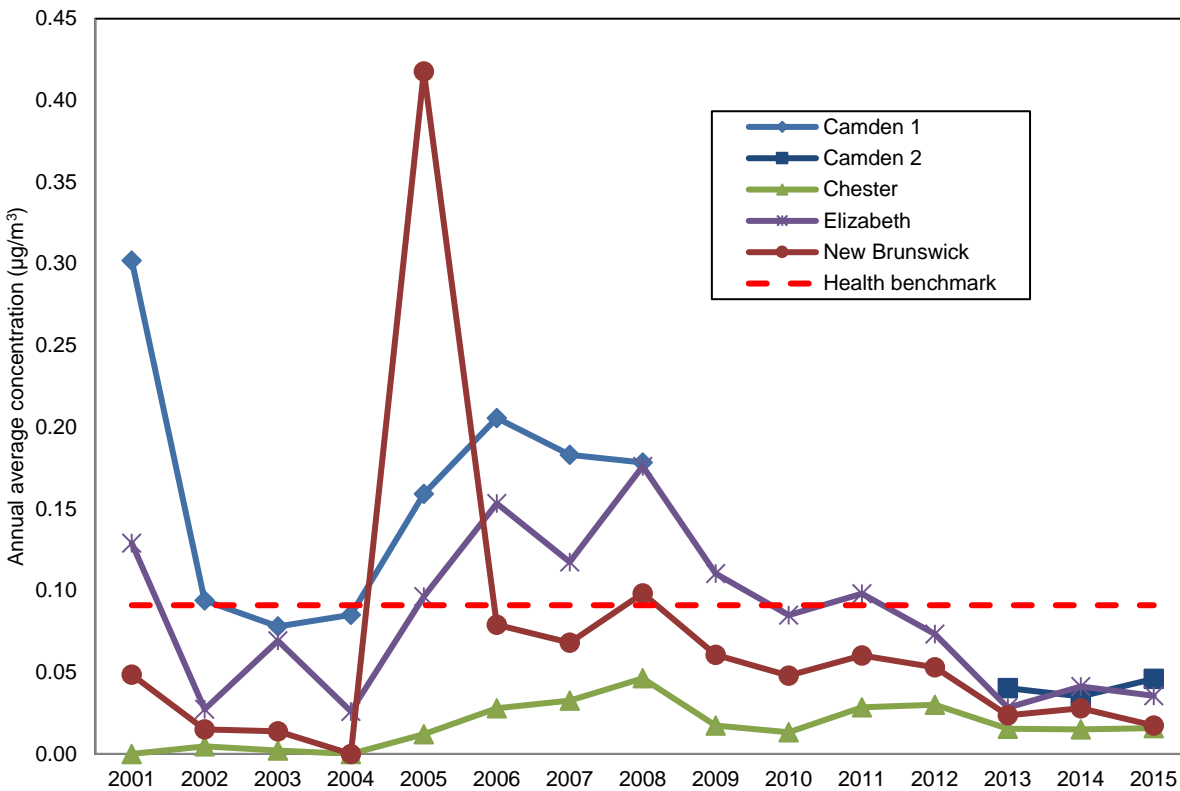
Figure 12
1,2-DICHLOROETHANE (Ethylene Dichloride) – New Jersey Monitored Concentrations
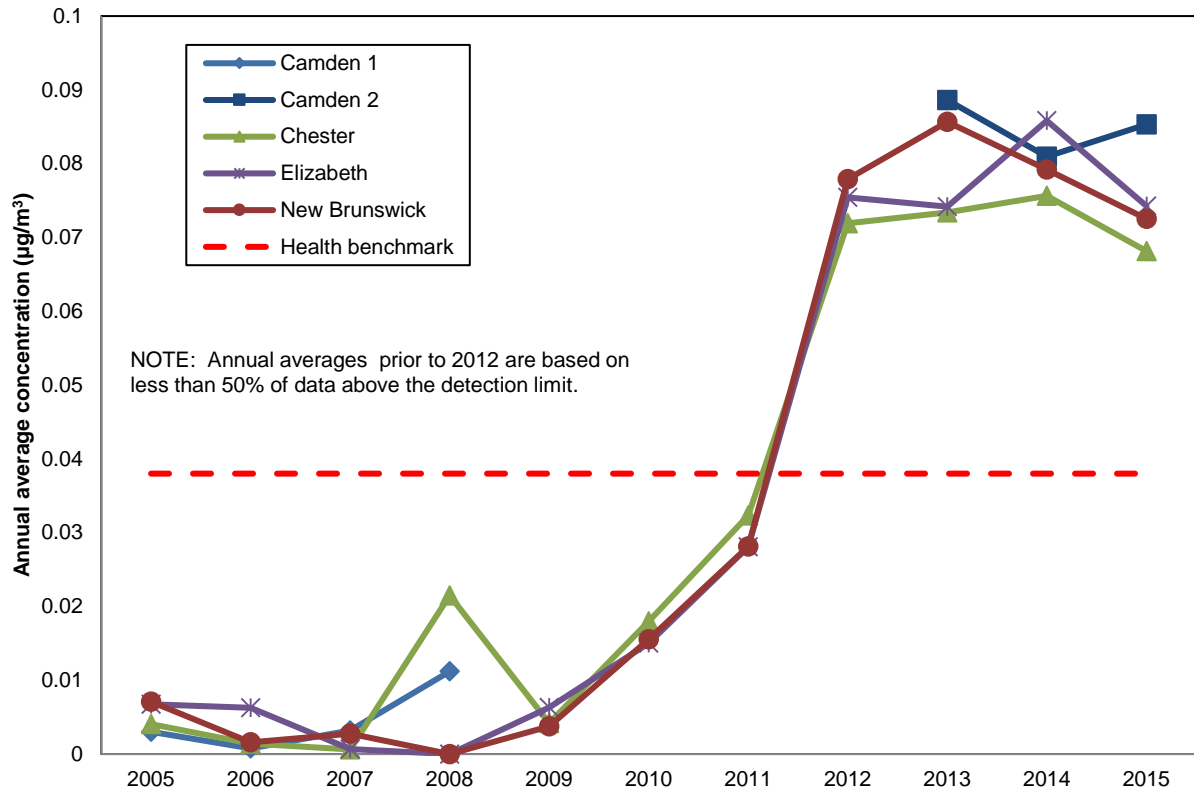
Figure 13
ETHYLBENZENE – New Jersey Monitored Concentrations
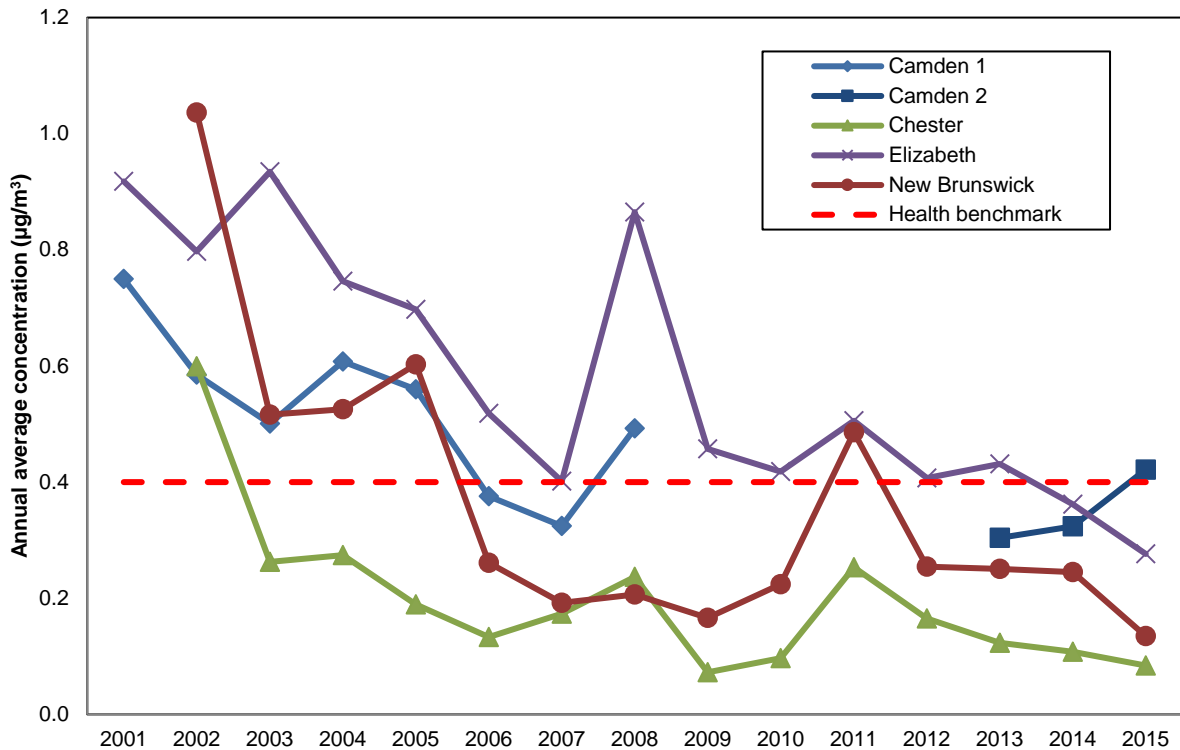
Figure 14
FORMALDEHYDE – New Jersey Monitored Concentrations
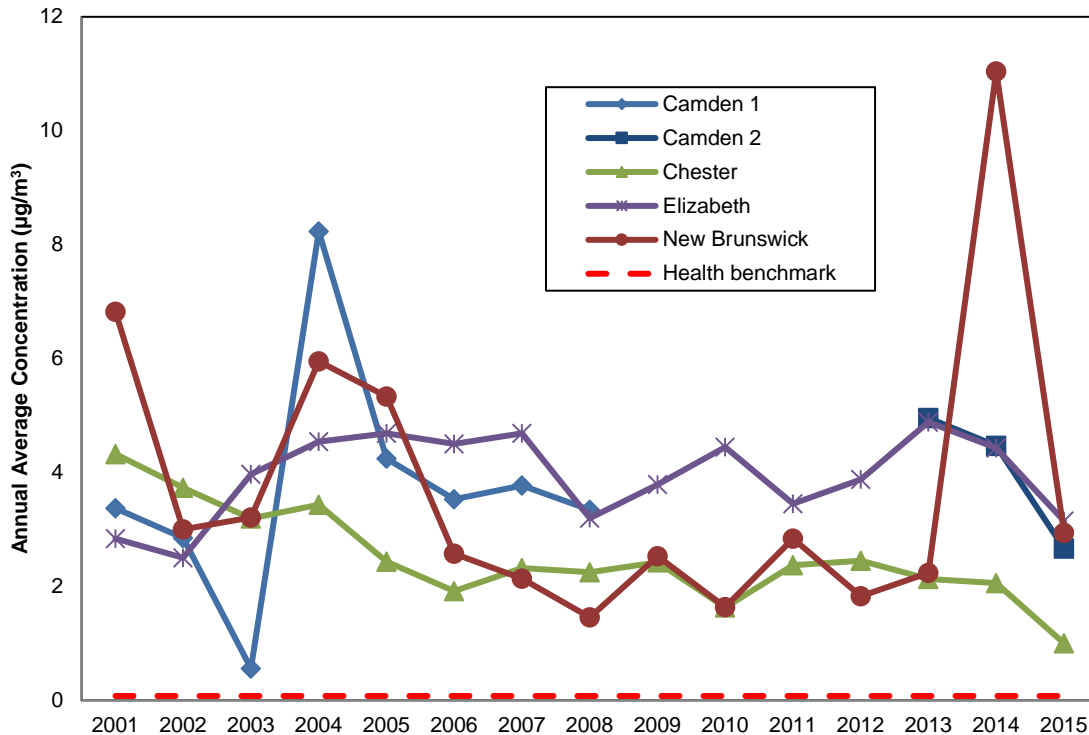
Figure 15
STYRENE – New Jersey Monitored Concentrations

NOTE: Annual averages prior to 2012 are based on less than 50% of data above the detection limit.
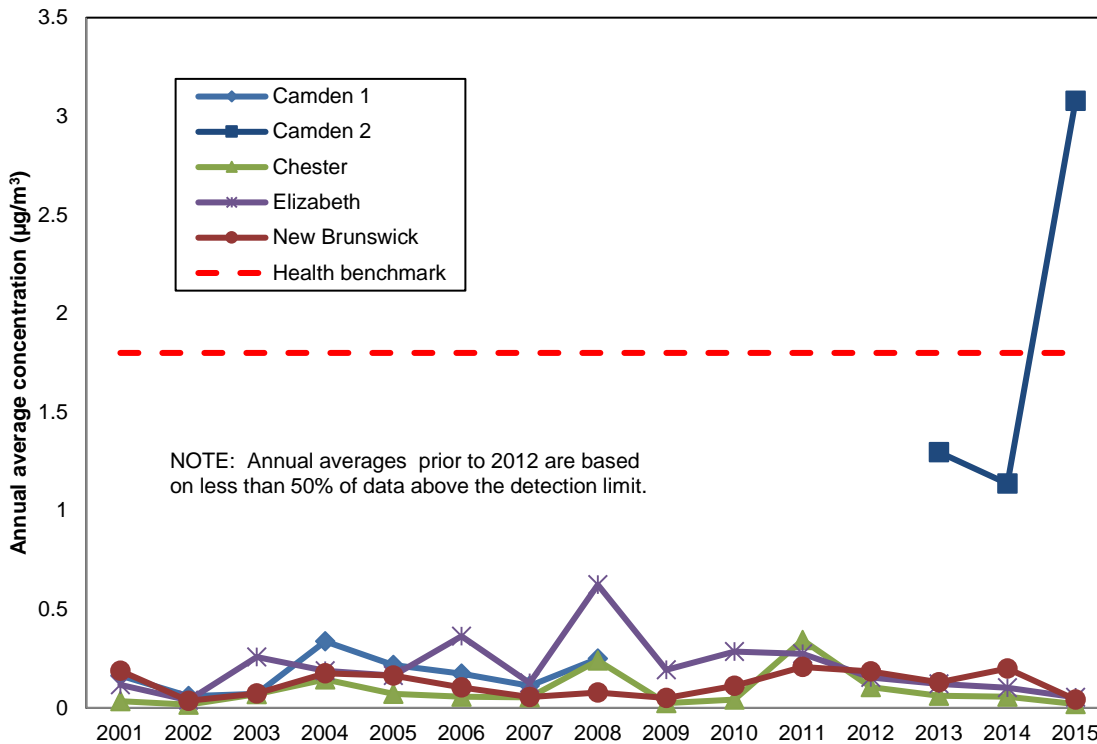
Toxic metals data from the PM$_{2.5}$ speciation monitors at Camden Spruce Street, Chester, Elizabeth Lab, New Brunswick and Newark Firehouse are presented in Figures 16 through 20. The Newark site became operational in 2010, and a new Camden site was established in 2013. The original Camden site was shut down in 2008.

Chromium and nickel are shown here because USEPA NATA modeling indicated that there are levels of their carcinogenic forms in the air above the one-in-a-million cancer risk level. The data in Figures 18 and 20 are for total chromium and total nickel. The specific carcinogenic compounds cannot be measured with available monitoring methods.

Arsenic, cadmium, and cobalt concentrations are all influenced by combustion, industrial processes, and transport.

Note that in some of the graphs specific years are marked with an asterisk, indicating that less than 50% of the samples used to calculate the annual average were above the detection limit. Values below the detection limit are considered to be zero.

Figure 16
ARSENIC – New Jersey Monitored Concentrations
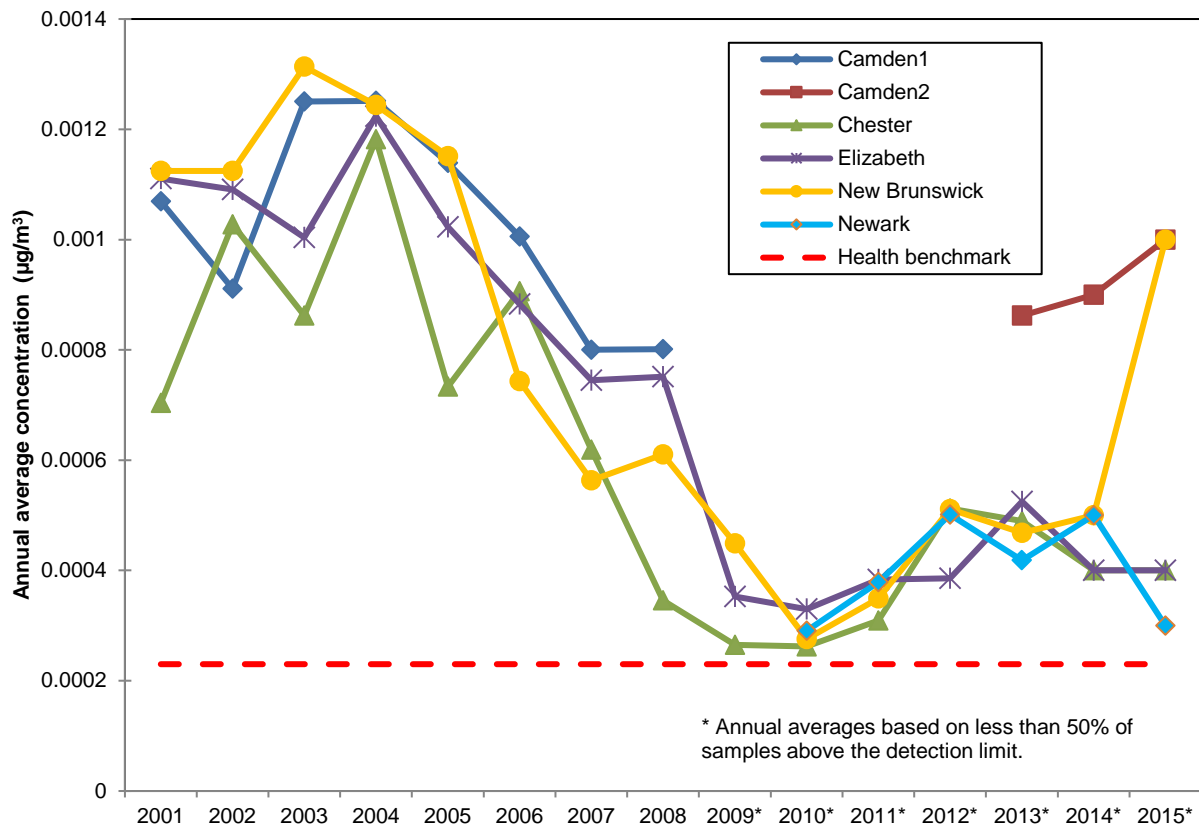
Figure 17
CADMIUM – New Jersey Monitored Concentrations
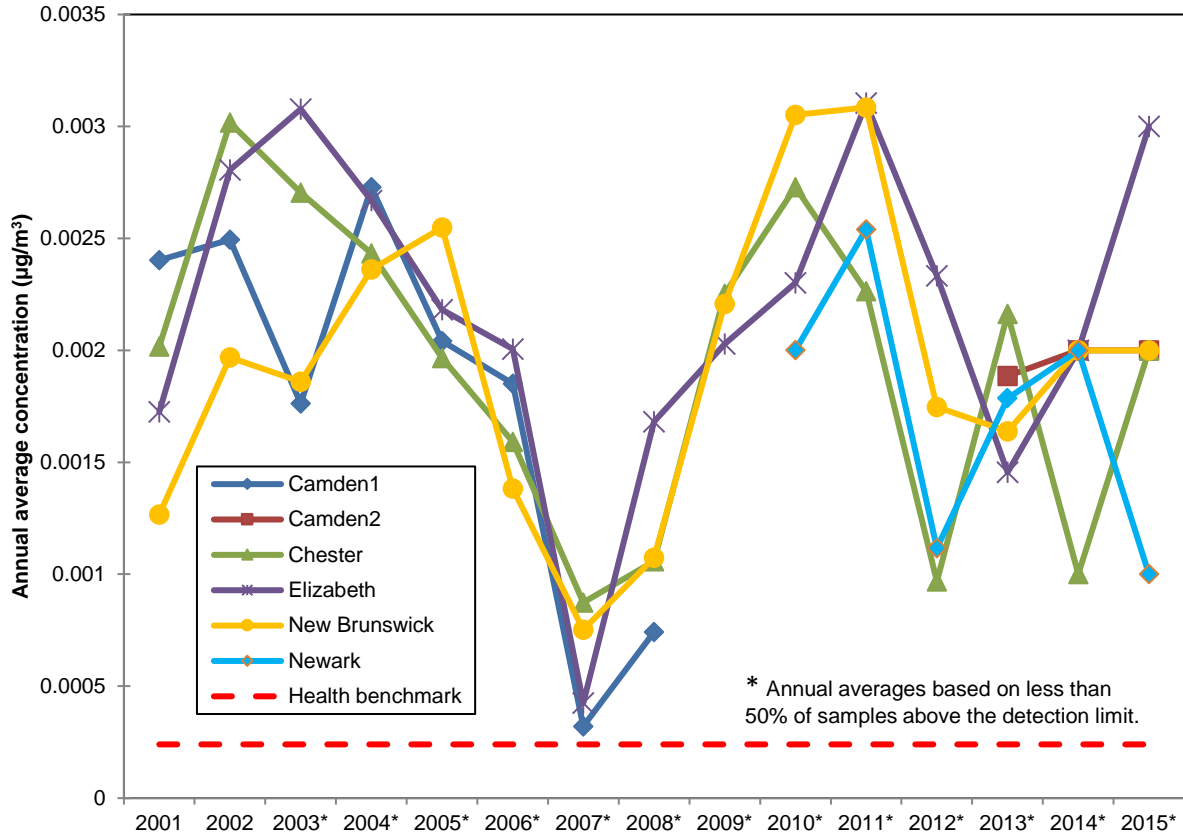
Figure 18
CHROMIUM – New Jersey Monitored Concentrations
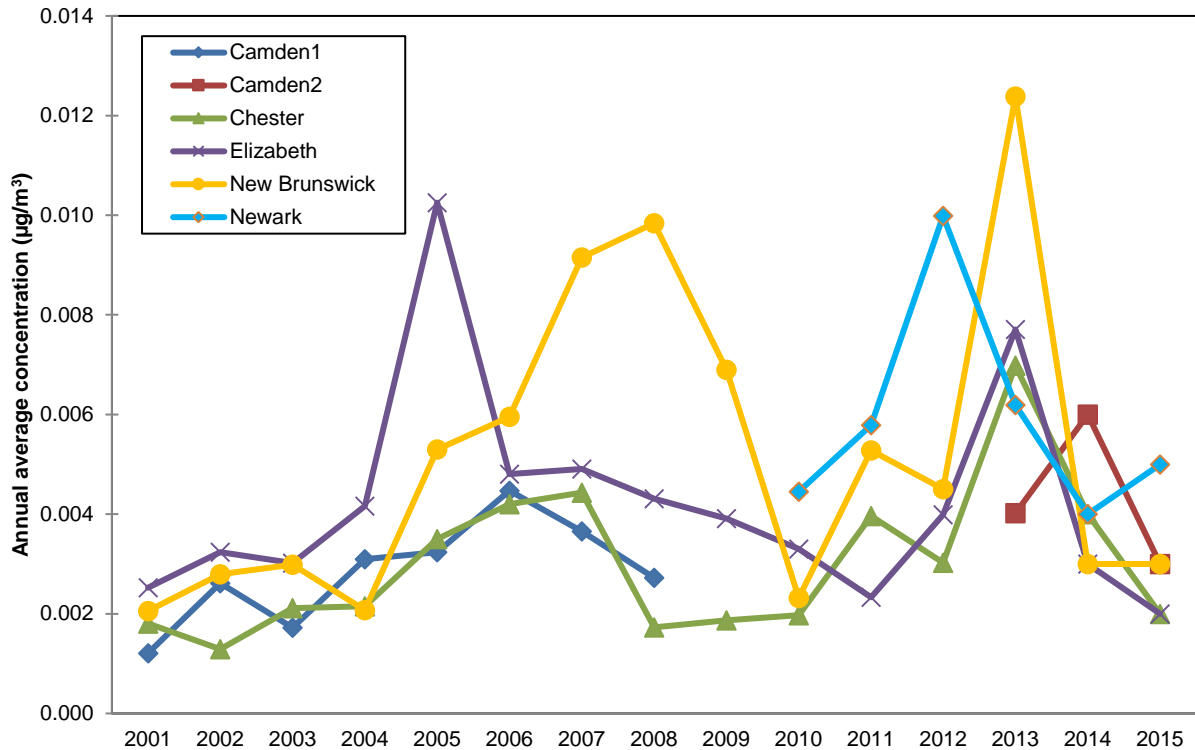
Figure 19
COBALT – New Jersey Monitored Concentrations

* Annual averages based on less than 50% of samples above the detection limit.
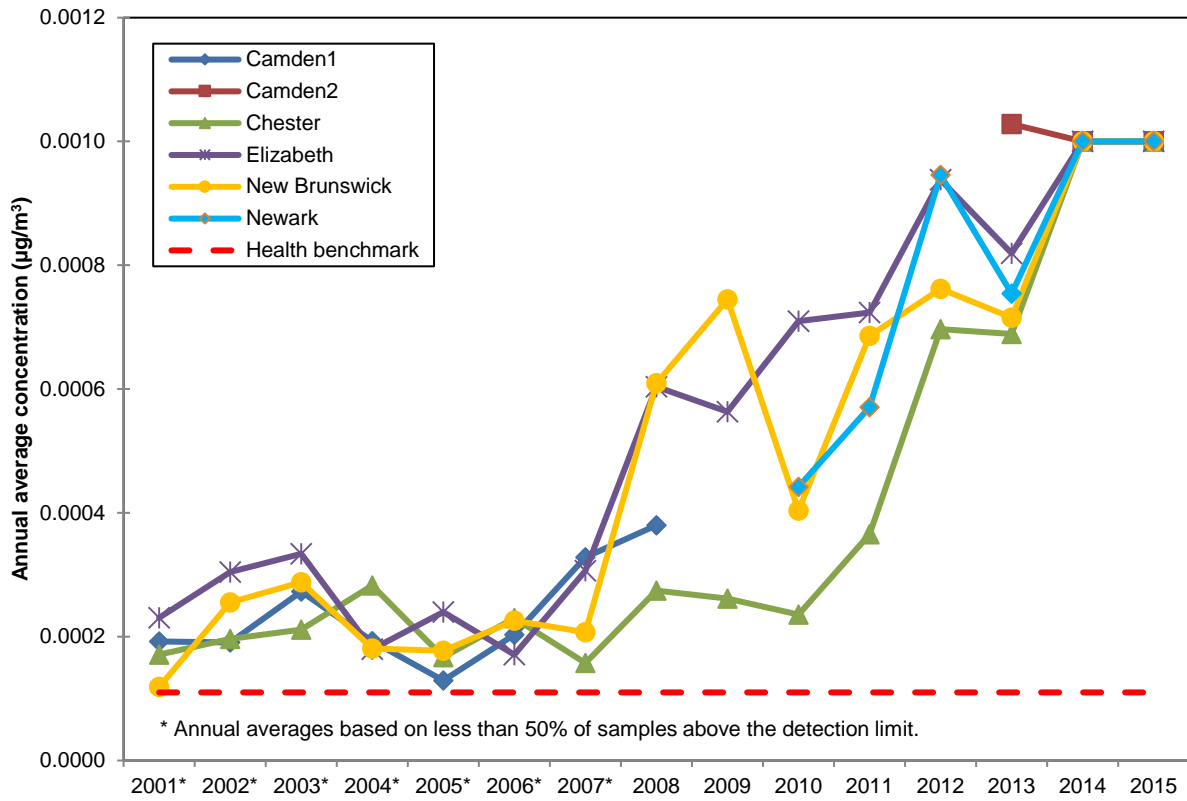
Figure 20
NICKEL – New Jersey Monitored Concentrations
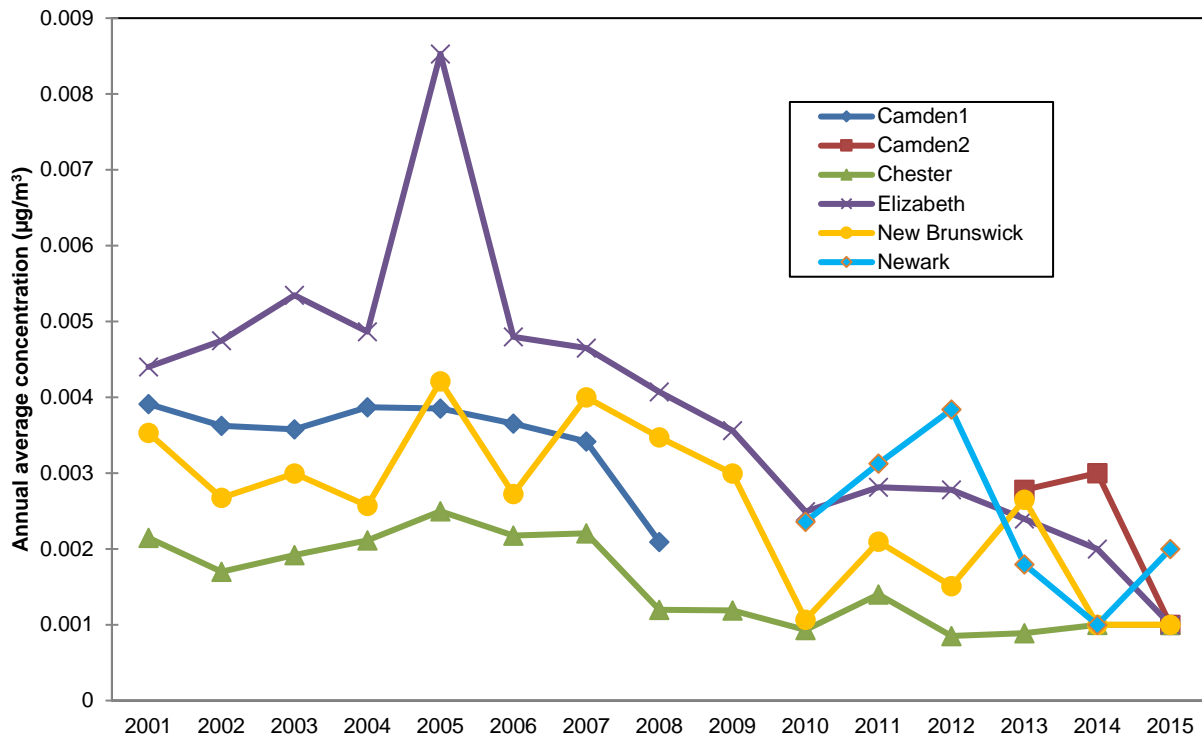
Table 4

CAMDEN SPRUCE ST-NJ 2015 Toxic VOCs Monitoring Data[a]

Analyte[b]	CAS No.	Annual Mean (ppbv)[c,d]	Annual Median (ppbv)[d]	24-Hour Max. (ppbv)	Annual Mean (ug/m³)[c,d]	Annual Median (ug/m³)[d]	24-Hour Max. (ug/m³)	Health Bench-mark (ug/m³)[e]	Annual Mean Risk Ratio[f]	Detection Limit (ug/m³)	% Above Minimum Detection Limit
Acetaldehyde	75-07-0	1.044	0.978	3.750	1.880	1.762	6.757	0.45	**4**	0.005	100
Acetone	67-64-1	0.830	0.812	2.570	1.972	1.929	6.105	31000	0.0001	0.014	75
Acetonitrile	75-05-8	0.578	0.481	6.460	0.970	0.808	10.847	60	0.02	0.020	100
Acetylene	74-86-2	0.997	0.845	3.130	1.062	0.900	3.333			0.033	100
Acrolein[g]	107-02-8	0.403	0.386	0.968	0.924	0.885	2.220	0.02		0.046	100
Acrylonitrile	107-13-1	*0*	0	0	*0*	0	0	0.015		0.065	2
tert-Amyl Methyl Ether	994-05-8	*0*	0	0	*0*	0	0			0.033	2
Benzaldehyde	100-52-7	0.155	0.036	1.33	0.671	0.156	5.773			0.074	100
Benzene	71-43-2	0.268	0.224	1.24	0.857	0.716	3.962	0.13	**7**	0.010	100
Bromochloromethane	74-97-5	*0*	0	0	*0*	0	0	40		0.206	2
Bromodichloromethane	75-27-4	*0.001*	0	0.012	*0.008*	0	0.080	0.027	0.3	0.101	13
Bromoform	75-25-2	*0.001*	0	0.012	*0.011*	0	0.124	0.91	0.01	0.186	15
Bromomethane	74-83-9	0.240	0.018	5.14	0.931	0.070	19.958	5	0.2	0.066	100
1,3-Butadiene	106-99-0	0.040	0.029	0.18	0.089	0.064	0.398	0.033	**3**	0.031	100
Butyraldehyde	123-72-8	0.100	0.089	0.305	0.294	0.262	0.899			0.027	100
Carbon Disulfide	75-15-0	0.027	0.024	0.162	0.083	0.075	0.505	700	0.0001	0.009	100
Carbon Tetrachloride	56-23-5	0.099	0.1	0.125	0.623	0.629	0.786	0.17	**4**	0.075	100
Chlorobenzene	108-90-7	0.001	0	0.014	*0.005*	0	0.064	1000	0.00001	0.046	15
Chloroethane	75-00-3	0.031	0.028	0.087	0.082	0.074	0.230	10000	0.00001	0.047	94
Chloroform	67-66-3	0.030	0.029	0.056	0.148	0.142	0.273	0.043	**3**	0.044	100
Chloromethane	74-87-3	0.607	0.6	0.873	1.253	1.239	1.803	0.56	**2.2**	0.033	100
Chloroprene	126-99-8	*0*	0	0	*0*	0	0	0.002		0.040	2
Crotonaldehyde	123-73-9	0.095	0.04	0.462	0.273	0.115	1.324			0.049	75
Dibromochloromethane	124-48-1	*0.002*	0	0.011	*0.021*	0	0.094	0.037	0.6	0.051	44
1,2-Dibromoethane	106-93-4	*0.001*	0	0.01	*0.005*	0	0.077	0.0017	**3**	0.138	10
m-Dichlorobenzene	541-73-1	*0.001*	0	0.009	*0.005*	0	0.054			0.168	16
o-Dichlorobenzene	95-50-1	*0.001*	0	0.01	*0.006*	0	0.060	200	0.00003	0.144	16
p-Dichlorobenzene	106-46-7	0.008	0.008	0.031	0.046	0.048	0.186	0.091	0.5	0.156	56
Dichlorodifluoromethane	75-71-8	0.528	0.522	0.708	2.612	2.581	3.501	100	0.03	0.064	100
1,1-Dichloroethane	75-34-3	*0.000*	0	0.021	*0.001*	0	0.085	0.63	0.002	0.061	3
1,2-Dichloroethane	107-06-2	0.021	0.02	0.062	0.085	0.081	0.251	0.038	**2.2**	0.053	98
1,1-Dichloroethene	75-35-4	0.001	0	0.01	0.005	0	0.040	200	0.00002	0.032	19
cis-1,2-Dichloroethylene	156-59-2	*0*	0	0	*0*	0	0			0.048	2
trans-1,2-Dichloroethylene	156-60-5	*0.002*	0	0.044	*0.010*	0	0.174			0.048	19
Dichloromethane	75-09-2	0.752	0.129	36.800	2.614	0.448	127.833	77	0.03	0.028	100

[a] See page 31 for footnotes.

Analyte[b]	CAS No.	Annual Mean (ppbv)[c,d]	Annual Median (ppbv)[d]	24-Hour Max. (ppbv)	Annual Mean (ug/m³)[c,d]	Annual Median (ug/m³)[d]	24-Hour Max. (ug/m³)	Health Bench-mark (ug/m³)[e]	Annual Mean Risk Ratio[f]	Detection Limit (ug/m³)	% Above Minimum Detection Limit
1,2-Dichloropropane	78-87-5	*0.0004*	0	0.015	*0.002*	0	0.069	0.1	0.02	0.079	5
cis-1,3-Dichloropropene	542-75-6	*0*	0	0	*0*	0	0			0.064	2
trans-1,3-Dichloropropene	542-75-6	*0*	0	0	*0*	0	0			0.095	2
Dichlorotetrafluoroethane	76-14-2	0.018	0.017	0.027	0.123	0.119	0.189			0.133	100
2,5-Dimethylbenzaldehyde	5799-94-2	*0.052*	0	0.56	*0.287*	0	3.073			0.011	23
Ethyl Acrylate	140-88-5	*0.000*	0	0.008	*0.001*	0	0.033	8	0.0001	0.033	3
Ethyl tert-Butyl Ether	637-92-3	*0.000*	0	0.009	*0.002*	0	0.038			0.046	6
Ethylbenzene	100-41-4	0.097	0.088	0.323	0.422	0.382	1.403	0.4	**1.1**	0.035	100
Formaldehyde	50-00-0	2.172	2.05	6.55	2.667	2.518	8.044	0.077	**35**	0.023	100
Hexachloro-1,3-butadiene	87-68-3	*0.002*	0	0.007	*0.017*	0	0.075	0.045	0.4	0.117	33
Hexaldehyde	66-25-1	0.032	0.025	0.361	0.132	0.102	1.479			0.139	77
Isovaleraldehyde	590-86-3	*0.017*	0	0.134	*0.059*	0	0.472			0.007	28
Methyl Ethyl Ketone	78-93-3	0.135	0.128	0.538	0.397	0.377	1.586	5000	0.0001	0.074	84
Methyl Isobutyl Ketone	108-10-1	0.061	0.05	0.262	0.248	0.205	1.073	3000	0.0001	0.057	100
Methyl Methacrylate	80-62-6	*0.007*	0	0.045	*0.027*	0	0.184	700	0.00004	0.115	35
Methyl tert-Butyl Ether	1634-04-4	*0.001*	0	0.017	*0.003*	0	0.061	3.8	0.001	0.050	8
n-Octane	111-65-9	0.049	0.045	0.134	0.231	0.210	0.626			0.079	98
Propionaldehyde	123-38-6	0.484	0.190	3.130	1.151	0.451	7.435	8	0.1	0.007	100
Propylene	115-07-1	0.656	0.548	3.540	1.128	0.943	6.093	3000	0.0004	0.055	100
Styrene	100-42-5	0.722	0.622	2.520	3.078	2.650	10.735	1.8	**1.7**	0.068	100
1,1,2,2-Tetrachloroethane	79-34-5	*0.001*	0	0.012	*0.007*	0	0.082	0.017	0.4	0.124	16
Tetrachloroethylene	127-18-4	0.024	0.021	0.058	0.161	0.142	0.393	0.17	0.9	0.095	100
Tolualdehydes		0.048	0.0315	0.453	0.234	0.155	2.226			0.020	100
Toluene	108-88-3	1.631	1.43	6.970	6.145	5.389	26.267	5000	0.001	0.068	100
1,2,4-Trichlorobenzene	102-82-1	*0.001*	0	0.006	*0.004*	0	0.045	2	0.002	0.371	17
1,1,1-Trichloroethane	71-55-6	0.007	0.007	0.018	0.039	0.038	0.098	1000	0.00004	0.071	87
1,1,2-Trichloroethane	79-00-5	*0*	0	0	*0*	0	0	0.063		0.093	2
Trichloroethylene	79-01-6	0.014	0.008	0.136	0.073	0.043	0.731	0.2	0.4	0.091	55
Trichlorofluoromethane	75-69-4	0.406	0.320	1.230	2.283	1.798	6.911	700	0.003	0.045	100
Trichlorotrifluoroethane	76-13-1	0.082	0.081	0.106	0.628	0.621	0.812	30000	0.00002	0.069	100
1,2,4-Trimethylbenzene	95-63-6	0.120	0.115	0.374	0.592	0.565	1.839			0.103	100
1,3,5-Trimethylbenzene	108-67-8	0.036	0.033	0.115	0.175	0.162	0.565			0.103	100
Valeraldehyde	110-62-3	0.025	0.022	0.161	0.089	0.078	0.567			0.007	73
Vinyl chloride	75-01-4	*0.005*	0	0.031	*0.014*	0	0.079	0.11	0.1	0.020	44
m,p-Xylene	1330-20-7	0.216	0.179	0.905	0.939	0.777	3.930	100	0.01	0.017	100
o-Xylene	95-47-6	0.106	0.092	0.418	0.459	0.399	1.815	100	0.005	0.069	100

[a] See page 31 for footnotes.

Table 5

CHESTER-NJ 2015 Toxic VOCs Monitoring Data[a]

Analyte[b]	CAS No.	Annual Mean (ppbv)[c,d]	Annual Median (ppbv)[c,d]	24-Hour Max. (ppbv)	Annual Mean (ug/m³)[c,d]	Annual Median (ug/m³)[c,d]	24-Hour Max. (ug/m³)	Health Bench-mark (ug/m³)[e]	Annual Mean Risk Ratio[f]	Detection Limit (ug/m³)	% Above Minimum Detection Limit
Acetaldehyde	75-07-0	0.693	0.669	1.800	1.249	1.205	3.243	0.45	**3**	0.007	100
Acetone	67-64-1	0.905	0.832	2.790	2.149	1.975	6.628	31000	0.0001	0.014	100
Acetonitrile	75-05-8	0.397	0.369	0.896	0.666	0.620	1.504	60	0.01	0.012	100
Acetylene	74-86-2	0.450	0.360	1.580	0.479	0.383	1.681			0.078	100
Acrolein[g]	107-02-8	0.499	0.469	0.902	1.145	1.075	2.068	0.02	57[g]	0.165	100
Acrylonitrile	107-13-1	*0.037*	0	0.134	*0.081*	0	0.291	0.015	**5**	0.130	48
tert-Amyl Methyl Ether	994-05-8	*0.0001*	0	0.005	*0.0003*	0	0.021			0.067	2
Benzaldehyde	100-52-7	0.014	0.012	0.064	0.059	0.052	0.278			0.087	100
Benzene	71-43-2	0.147	0.128	0.412	0.469	0.409	1.316	0.13	**4**	0.010	100
Bromochloromethane	74-97-5	0	0	0	0	0	0			0.323	0
Bromodichloromethane	75-27-4	*0.0003*	0	0.010	*0.002*	0	0.067			0.094	3
Bromoform	75-25-2	*0.0009*	0	0.016	*0.009*	0	0.165	0.91	0.01	0.217	10
Bromomethane	74-83-9	0.0159	0.015	0.069	0.062	0.058	0.268	5	0.01	0.078	97
1,3-Butadiene	106-99-0	0.0266	0.026	0.079	0.059	0.058	0.175	0.033	**1.8**	0.024	93
Butyraldehyde	123-72-8	0.0532	0.049	0.176	0.157	0.145	0.519			0.035	100
Carbon Disulfide	75-15-0	0.7773	0.794	1.810	2.420	2.473	5.637	700	0.003	0.009	100
Carbon Tetrachloride	56-23-5	0.0959	0.098	0.124	0.604	0.617	0.780	0.067	**9**	0.088	100
Chlorobenzene	108-90-7	*0.0008*	0	0.013	*0.004*	0	0.060	1000	0.000004	0.110	7
Chloroethane	75-00-3	*0.0147*	0	0.060	*0.039*	0	0.158	10000	0.000004	0.066	49
Chloroform	67-66-3	0.0236	0.022	0.040	0.115	0.107	0.195	0.043	**3**	0.083	100
Chloromethane	74-87-3	0.6877	0.612	2.530	1.420	1.264	5.225	0.56	**3**	0.029	100
Chloroprene	126-99-8	0	0	0	0	0	0	7		0.119	0
Crotonaldehyde	123-73-9	0.087	0.0225	0.478	0.250	0.065	1.370			0.043	100
Dibromochloromethane	124-48-1	0.003	0.003	0.011	0.032	0.030	0.109			0.030	52
1,2-Dibromoethane	106-93-4	*0.0004*	0	0.013	*0.003*	0	0.100	0.0017	**1.7**	0.131	3
m-Dichlorobenzene	541-73-1	*0.004*	0	0.014	*0.024*	0	0.084			0.222	43
o-Dichlorobenzene	95-50-1	*0.001*	0	0.009	*0.004*	0	0.054	200	0.00002	0.126	8
p-Dichlorobenzene	106-46-7	*0.003*	0	0.017	*0.015*	0	0.102	0.091	0.2	0.114	26
Dichlorodifluoromethane	75-71-8	0.502	0.508	0.551	2.482	2.512	2.725	200	0.01	0.089	100
1,1-Dichloroethane	75-34-3	0.0004	0	0.012	0.001	0	0.049	0.63	0.002	0.061	3
1,2-Dichloroethane	107-06-2	0.019	0.019	0.029	0.076	0.077	0.117	0.038	**2**	0.065	97
1,1-Dichloroethylene	75-35-4	*0.0001*	0	0.009	*0.001*	0	0.036	200	0.000003	0.056	2
cis-1,2-Dichloroethylene	156-59-2	0	0	0	0	0	0			0.048	0
trans-1,2-Dichloroethylene	156-60-5	0	0	0	0	0	0			0.048	0
Dichloromethane	75-09-2	0.14285	0.1135	0.401	0.496	0.394	1.393	2.1	0.2	0.080	100

[a] See page 31 for footnotes.

Table 5 (continued)
CHESTER-NJ 2015 Toxic VOCs Monitoring Data[a]

Analyte[b]	CAS No.	Annual Mean (ppbv)[c,d]	Annual Median (ppbv)[d]	24-Hour Max. (ppbv)	Annual Mean (µg/m³)[c,d]	Annual Median (µg/m³)[d]	24-Hour Max. (µg/m³)	Health Bench-mark (µg/m³)[e]	Annual Mean Risk Ratio[f]	Detection Limit (µg/m³)	% Above Minimum Detection Limit
1,2-Dichloropropane	78-87-5	0	0	0	0	0	0	0.1		0.088	0
cis-1,3-Dichloropropene	542-75-6	*0.0002*	0	0.010	*0.001*	0	0.045			0.082	2
trans-1,3-Dichloropropene	542-75-6	0	0	0	0	0	0			0.073	0
Dichlorotetrafluoroethane	76-14-2	0.018	0.017	0.024	0.123	0.119	0.168			0.161	100
2,5-Dimethylbenzaldehyde	5799-94-2	0	0	0	0	0	0			0.016	0
Ethyl Acrylate	140-88-5	0	0	0	0	0	0	2		0.049	0
Ethyl tert-Butyl Ether	637-92-3	*0.008*	0	0.176	*0.034*	0	0.736			0.059	28
Ethylbenzene	100-41-4	0.025	0.019	0.093	0.108	0.082	0.404	0.40	0.3	0.048	100
Formaldehyde	50-00-0	1.677	1.395	4.930	2.059	1.713	6.054	0.077	**27**	0.028	100
Hexachloro-1,3-butadiene	87-68-3	*0.002*	0	0.012	*0.023*	0	0.128	0.045	0.5	0.085	26
Hexaldehyde	66-25-1	0.011	0.009	0.032	0.046	0.037	0.131			0.090	100
Isovaleraldehyde	590-86-3	0	0	0	0	0	0			0.007	0
Methyl Ethyl Ketone	78-93-3	0.107	0.095	0.434	0.315	0.278	1.278	5000	0.0001	0.071	100
Methyl Isobutyl Ketone	108-10-1	0.029	0.024	0.095	0.117	0.098	0.389	3000	0.00004	0.061	100
Methyl Methacrylate	80-62-6	*0.001*	0	0.010	*0.003*	0	0.035	700	0.000004	0.088	8
Methyl tert-Butyl Ether	1634-04-4	0.049	0.047	0.142	0.178	0.169	0.512	3.8	0.05	0.040	97
n-Octane	111-65-9	0.039	0.038	0.073	0.183	0.178	0.341			0.093	100
Propionaldehyde	123-38-6	0.083	0.072	0.211	0.198	0.171	0.501	8	0.02	0.007	100
Propylene	115-07-1	0.327	0.295	0.714	0.563	0.508	1.229	3000	0.0002	0.057	100
Styrene	100-42-5	0.013	0.013	0.031	0.057	0.055	0.132	1.8	0.03	0.102	79
1,1,2,2-Tetrachloroethane	79-34-5	*0.002*	0	0.012	*0.011*	0	0.082	0.017	0.7	0.124	18
Tetrachloroethylene	127-18-4	0.010	0.010	0.042	0.069	0.068	0.285	0.17	0.4	0.136	77
Tolualdehydes		0.012	0.010	0.053	0.057	0.049	0.260			0.025	85
Toluene	108-88-3	0.163	0.143	0.520	0.615	0.539	1.959	5000	0.0001	0.170	100
1,2,4-Trichlorobenzene	102-82-1	*0.001*	0	0.021	*0.004*	0	0.156	4	0.001	0.163	5
1,1,1-Trichloroethane	71-55-6	0.006	0.007	0.016	0.032	0.038	0.087	1000	0.00003	0.109	69
1,1,2-Trichloroethane	79-00-5	0	0	0	0	0	0	0.063		0.115	0
Trichloroethylene	79-01-6	*0.001*	0	0.012	*0.003*	0	0.064	0.5	0.01	0.118	5
Trichlorofluoromethane	75-69-4	0.232	0.233	0.260	1.304	1.309	1.461	700	0.002	0.084	100
Trichlorotrifluoroethane	76-13-1	0.081	0.081	0.090	0.619	0.621	0.690	30000	0.00002	0.130	100
1,2,4-Trimethylbenzene	95-63-6	0.022	0.018	0.067	0.111	0.088	0.329			0.123	98
1,3,5-Trimethylbenzene	108-67-8	0.012	0.010	0.031	0.060	0.049	0.152			0.108	87
Valeraldehyde	110-62-3	0.013	0.011	0.043	0.047	0.039	0.151			0.011	100
Vinyl chloride	75-01-4	*0.0004*	0	0.011	*0.001*	0	0.028	0.11	0.01	0.028	5
m,p-Xylene	1330-20-7	0.051	0.040	0.278	0.220	0.174	1.207	100	0.002	0.009	100
o-Xylene	95-47-6	0.024	0.019	0.104	0.103	0.082	0.452	100	0.001	0.087	100

[a] See page 31 for footnotes.

Table 6

ELIZABETH LAB-NJ 2015 Toxic VOCs Monitoring Data[a]

Analyte[b]	CAS No.	Annual Mean (ppbv)[c,d]	Annual Median (ppbv)[d]	24-Hour Max. (ppbv)	Annual Mean (ug/m³)[c,d]	Annual Median (ug/m³)[d]	24-Hour Max. (ug/m³)	Health Bench-mark (ug/m³)[e]	Annual Mean Risk Ratio[f]	Detection Limit (ug/m³)	% Above Minimum Detection Limit
Acetaldehyde	75-07-0	0.961	1.045	2.830	1.732	1.883	5.099	0.45	**4**	0.005	76
Acetone	67-64-1	0.889	0.962	2.630	2.111	2.284	6.247	31000	0.0001	0.014	100
Acetonitrile	75-05-8	0.399	0.172	12.500	0.669	0.288	20.988	60	0.01	0.020	100
Acetylene	74-86-2	1.152	0.891	4.860	1.227	0.948	5.176			0.033	100
Acrolein[g]	107-02-8	0.414	0.409	0.938	0.949	0.938	2.151	0.02		0.046	100
Acrylonitrile	107-13-1	0	0	0	0	0	0	0.015		0.065	0
tert-Amyl Methyl Ether	994-05-8	*0.0001*	0	0.007	*0.0005*	0	0.029			0.033	2
Benzaldehyde	100-52-7	0.175	0.032	1.520	0.761	0.139	6.597			0.074	100
Benzene	71-43-2	0.256	0.224	0.553	0.818	0.714	1.767	0.13	**6**	0.010	100
Bromochloromethane	74-97-5	0	0	0	0	0	0	40		0.206	0
Bromodichloromethane	75-27-4	*0.0002*	0	0.005	*0.001*	0	0.034	0.027	0.04	0.101	3
Bromoform	75-25-2	*0.001*	0	0.01	*0.009*	0	0.103	0.91	0.01	0.186	12
Bromomethane	74-83-9	0.015	0.013	0.088	0.057	0.049	0.342	5	0.01	0.066	100
1,3-Butadiene	106-99-0	0.053	0.045	0.171	0.117	0.098	0.378	0.033	**4**	0.031	100
Butyraldehyde	123-72-8	0.175	0.129	0.905	0.517	0.380	2.669			0.027	100
Carbon Disulfide	75-15-0	0.015	0.014	0.045	0.046	0.044	0.140	700	0.0001	0.009	100
Carbon Tetrachloride	56-23-5	0.098	0.099	0.128	0.615	0.623	0.805	0.17	**4**	0.075	100
Chlorobenzene	108-90-7	*0.001*	0	0.010	*0.003*	0	0.046	1000	0.000003	0.046	10
Chloroethane	75-00-3	0.028	0.029	0.059	0.074	0.077	0.156	10000	0.00001	0.047	87
Chloroform	67-66-3	0.031	0.030	0.051	0.151	0.146	0.249	0.043	**4**	0.044	100
Chloromethane	74-87-3	0.609	0.584	1.390	1.258	1.205	2.870	0.56	**2.2**	0.033	100
Chloroprene	126-99-8	0	0	0	0	0	0	0.002		0.040	0
Crotonaldehyde	123-73-9	0.155	0.089	0.604	0.445	0.254	1.731			0.049	100
Dibromochloromethane	594-18-3	*0.002*	0	0.009	*0.015*	0	0.077	0.037	0.4	0.051	33
1,2-Dibromoethane	106-93-4	*0.0004*	0	0.008	*0.003*	0	0.061	0.0017	**1.6**	0.138	5
m-Dichlorobenzene	541-73-1	*0.001*	0	0.008	*0.004*	0	0.048			0.168	12
o-Dichlorobenzene	95-50-1	*0.001*	0	0.008	*0.005*	0	0.048	200	0.00002	0.144	13
p-Dichlorobenzene	106-46-7	0.006	0.006	0.026	0.036	0.033	0.156	0.091	0.4	0.156	57
Dichlorodifluoromethane	75-71-8	0.512	0.508	0.691	2.533	2.512	3.417	100	0.03	0.064	100
1,1-Dichloroethane	75-34-3	0	0	0	0	0	0	0.63		0.061	0
1,2-Dichloroethane	107-06-2	0.018	0.019	0.029	0.074	0.077	0.117	0.038	**2.0**	0.053	95
1,1-Dichloroethene	75-35-4	*0.001*	0	0.009	*0.004*	0	0.036	200	0.00002	0.032	17
cis-1,2-Dichloroethylene	156-59-2	0	0	0	0	0	0			0.048	0
trans-1,2-Dichloroethylene	156-60-5	*0.001*	0	0.016	*0.003*	0	0.063			0.048	7
Dichloromethane	75-09-2	0.175	0.144	1.160	0.607	0.498	4.030	77	0.01	0.028	100

[a] See page 31 for footnotes.

Table 6 (continued)

ELIZABETH LAB-NJ 2015 Toxic VOCs Monitoring Data[a]

Analyte[b]	CAS No.	Annual Mean (ppbv)[c,d]	Annual Median (ppbv)[d]	24-Hour Max. (ppbv)	Annual Mean (ug/m³)[c,d]	Annual Median (ug/m³)[d]	24-Hour Max. (ug/m³)	Health Bench-mark (ug/m³)[e]	Annual Mean Risk Ratio[f]	Detection Limit (ug/m³)	% Above Minimum Detection Limit
1,2-Dichloropropane	78-87-5	*0.0004*	0	0.013	*0.002*	0	0.060	0.1	0.02	0.079	3
cis-1,3-Dichloropropene	542-75-6	0	0	0	0	0	0			0.064	0
trans-1,3-Dichloropropene	542-75-6	0	0	0	0	0	0			0.095	0
Dichlorotetrafluoroethane	76-14-2	0.017	0.016	0.024	0.119	0.112	0.168			0.133	100
2,5-Dimethylbenzaldehyde	5799-94-2	*0.001*	0	0.014	*0.003*	0	0.077			0.011	5
Ethyl Acrylate	140-88-5	*0.0005*	0	0.012	*0.002*	0	0.049	8	0.0002	0.033	5
Ethyl tert-Butyl Ether	637-92-3	*0.001*	0	0.012	*0.003*	0	0.050			0.046	8
Ethylbenzene	100-41-4	0.064	0.055	0.167	0.276	0.237	0.725	0.40	0.7	0.035	100
Formaldehyde	50-00-0	2.562	2.2	10.200	3.147	2.702	12.526	0.077	**41**	0.023	73
Hexachloro-1,3-butadiene	87-68-3	*0.002*	0	0.006	*0.020*	0	0.064	0.045	0.5	0.117	40
Hexaldehyde	66-25-1	0.393	0.051	3.450	1.610	0.207	14.133			0.139	100
Isovaleraldehyde	590-86-3	*0.103*	0	1.240	*0.365*	0	4.368			0.007	27
Methyl Ethyl Ketone	78-93-3	0.164	0.153	0.422	0.483	0.451	1.244	5000	0.0001	0.074	100
Methyl Isobutyl Ketone	108-10-1	0.045	0.040	0.346	0.184	0.164	1.417	3000	0.0001	0.057	97
Methyl Methacrylate	80-62-6	*0.009*	0	0.236	*0.037*	0	0.966	700	0.0001	0.115	15
Methyl tert-Butyl Ether	1634-04-4	*0.001*	0	0.025	*0.005*	0	0.090	3.8	0.001	0.050	7
n-Octane	111-65-9	0.060	0.055	0.174	0.282	0.257	0.813			0.079	100
Propionaldehyde	123-38-6	0.149	0.136	0.456	0.353	0.323	1.083	8	0.04	0.007	94
Propylene	115-07-1	1.520	0.721	9.390	2.616	1.240	16.161	3000	0.001	0.055	100
Styrene	100-42-5	0.013	0.013	0.036	0.054	0.055	0.153	1.8	0.03	0.068	72
1,1,2,2-Tetrachloroethane	79-34-5	*0.001*	0	0.011	*0.007*	0	0.076	0.017	0.4	0.124	15
Tetrachloroethylene	127-18-4	0.024	0.017	0.170	0.163	0.115	1.153	0.17	1.0	0.095	92
Tolualdehydes		0.024	0.024	0.076	0.120	0.118	0.373			0.020	75
Toluene	108-88-3	0.490	0.461	1.040	1.845	1.737	3.919	5000	0.0004	0.068	100
1,2,4-Trichlorobenzene	102-82-1	0	0	0	0	0	0	2		0.371	0
1,1,1-Trichloroethane	71-55-6	0.006	0.006	0.013	0.033	0.033	0.071	1000	0.00003	0.071	90
1,1,2-Trichloroethane	79-00-5	0	0	0	0	0	0	0.063		0.093	0
Trichloroethylene	79-01-6	*0.003*	0	0.022	*0.016*	0	0.118	0.2	0.1	0.091	28
Trichlorofluoromethane	75-69-4	0.244	0.242	0.305	1.371	1.360	1.714	700	0.002	0.045	100
Trichlorotrifluoroethane	76-13-1	0.081	0.080	0.109	0.618	0.613	0.835	30000	0.00002	0.069	100
1,2,4-Trimethylbenzene	95-63-6	0.056	0.051	0.169	0.275	0.248	0.831			0.103	98
1,3,5-Trimethylbenzene	108-67-8	0.018	0.017	0.052	0.089	0.084	0.256			0.103	92
Valeraldehyde	110-62-3	0.063	0.044	0.323	0.223	0.155	1.138			0.007	100
Vinyl chloride	75-01-4	*0.002*	0	0.011	*0.006*	0	0.028	0.11	0.1	0.020	30
m,p-Xylene	1330-20-7	0.160	0.130	0.440	0.693	0.564	1.911	100	0.01	0.017	100
o-Xylene	95-47-6	0.071	0.064	0.203	0.309	0.276	0.881	100	0.003	0.069	100

[a] See page 31 for footnotes.

Table 7

NEW BRUNSWICK-NJ 2015 Toxic VOCs Monitoring Data[a]

Analyte[b]	CAS No.	Annual Mean (ppbv)[c,d]	Annual Median (ppbv)[d]	24-Hour Max. (ppbv)	Annual Mean (ug/m³)[c,d]	Annual Median (ug/m³)[d]	24-Hour Max. (ug/m³)	Health Bench-mark (ug/m³)[e]	Annual Mean Risk Ratio[f]	Detection Limit (ug/m³)	% Above Minimum Detection Limit
Acetaldehyde	75-07-0	0.803	0.819	2.230	1.446	1.476	4.018	0.45	**3**	0.005	73
Acetone	67-64-1	0.837	0.890	2.300	1.987	2.113	5.464	31000	0.0001	0.014	74
Acetonitrile	75-05-8	0.673	0.276	5.640	1.129	0.463	9.470	60	0.02	0.020	100
Acetylene	74-86-2	0.704	0.540	2.710	0.750	0.575	2.886			0.033	100
Acrolein[g]	107-02-8	0.303	0.260	0.682	0.696	0.596	1.564	0.02		0.046	100
Acrylonitrile	107-13-1	*0.000*	0	0.025	*0.001*	0	0.054	0.015	0.1	0.065	2
tert-Amyl Methyl Ether	994-05-8	*0.000*	0	0.009	*0.002*	0	0.038			0.033	5
Benzaldehyde	100-52-7	0.023	0.022	0.066	0.100	0.095	0.286			0.074	98
Benzene	71-43-2	0.165	0.145	0.411	0.528	0.463	1.313	0.13	**4**	0.010	100
Bromochloromethane	74-97-5	0	0	0	0	0	0	40		0.206	0
Bromodichloromethane	75-27-4	*0.001*	0	0.012	*0.006*	0	0.080	0.027	0.2	0.101	12
Bromoform	75-25-2	*0.001*	0	0.009	*0.006*	0	0.093	0.91	0.01	0.186	8
Bromomethane	74-83-9	0.012	0.011	0.062	0.048	0.043	0.241	5	0.01	0.066	100
1,3-Butadiene	106-99-0	0.022	0.021	0.083	0.048	0.046	0.184	0.033	**1.5**	0.031	92
Butyraldehyde	123-72-8	0.088	0.085	0.191	0.258	0.251	0.563			0.027	100
Carbon Disulfide	75-15-0	0.029	0.024	0.124	0.090	0.075	0.386	700	0.0001	0.009	100
Carbon Tetrachloride	56-23-5	0.102	0.101	0.124	0.641	0.635	0.780	0.17	**4**	0.075	100
Chlorobenzene	108-90-7	*0.001*	0	0.017	*0.006*	0	0.078	1000	0.00001	0.046	14
Chloroethane	75-00-3	0.038	0.027	0.152	0.100	0.071	0.401	10000	0.00001	0.047	90
Chloroform	67-66-3	0.028	0.027	0.045	0.137	0.132	0.220	0.043	**3**	0.044	100
Chloromethane	74-87-3	0.590	0.588	0.787	1.218	1.214	1.625	0.56	**2.2**	0.033	100
Chloroprene	126-99-8	0	0	0	0	0	0	0.002		0.040	0
Crotonaldehyde	123-73-9	0.116	0.045	0.531	0.333	0.129	1.522			0.049	100
Dibromochloromethane	594-18-3	*0.002*	0	0.010	*0.015*	0	0.085	0.037	0.4	0.051	36
1,2-Dibromoethane	106-93-4	*0.0002*	0	0.007	*0.002*	0	0.054	0.0017	1.0	0.138	3
m-Dichlorobenzene	541-73-1	*0.001*	0	0.009	*0.003*	0	0.054			0.168	8
o-Dichlorobenzene	95-50-1	*0.001*	0	0.009	*0.003*	0	0.054	200	0.00002	0.144	8
p-Dichlorobenzene	106-46-7	*0.003*	0	0.019	*0.017*	0	0.114	0.091	0.2	0.156	37
Dichlorodifluoromethane	75-71-8	0.510	0.508	0.660	2.520	2.512	3.264	100	0.03	0.064	100
1,1-Dichloroethane	75-34-3	*0.001*	0	0.012	*0.002*	0	0.049	0.63	0.004	0.061	7
1,2-Dichloroethane	107-06-2	0.018	0.018	0.032	0.073	0.073	0.130	0.038	**1.9**	0.053	100
1,1-Dichloroethene	75-35-4	*0.001*	0	0.010	*0.003*	0	0.040	200	0.00002	0.032	12
cis-1,2-Dichloroethylene	156-59-2	0	0	0	0	0	0			0.048	0
trans-1,2-Dichloroethylene	156-60-5	*0.0003*	0	0.008	*0.001*	0	0.032			0.048	3
Dichloromethane	75-09-2	0.149	0.128	0.828	0.516	0.445	2.876	77	0.01	0.028	100

[a] See page 31 for footnotes.

Table 7 (continued)

NEW BRUNSWICK-NJ 2015 Toxic VOCs Monitoring Data[a]

Analyte[b]	CAS No.	Annual Mean (ppbv)[c,d]	Annual Median (ppbv)[d]	24-Hour Max. (ppbv)	Annual Mean (ug/m³)[c,d]	Annual Median (ug/m³)[d]	24-Hour Max. (ug/m³)	Health Bench-mark (ug/m³)[e]	Annual Mean Risk Ratio[f]	Detection Limit (ug/m³)	% Above Minimum Detection Limit
1,2-Dichloropropane	78-87-5	*0.0003*	0	0.018	*0.001*	0	0.083	0.1	0.01	0.079	2
cis-1,3-Dichloropropene	542-75-6	0	0	0	0	0	0			0.064	0
trans-1,3-Dichloropropene	542-75-6	0	0	0	0	0	0			0.095	0
Dichlorotetrafluoroethane	76-14-2	0.017	0.016	0.026	0.119	0.112	0.182			0.133	100
2,5-Dimethylbenzaldehyde	5799-94-2	*0.008*	0	0.056	*0.043*	0	0.307			0.011	27
Ethyl Acrylate	140-88-5	0	0	0	0	0	0	8		0.033	0
Ethyl tert-Butyl Ether	637-92-3	*0.004*	0	0.022	*0.016*	0	0.092			0.046	24
Ethylbenzene	100-41-4	0.031	0.029	0.081	0.135	0.126	0.352	0.40	0.3	0.035	100
Formaldehyde	50-00-0	2.396	2.240	8.210	2.942	2.751	10.082	0.077	**38**	0.023	100
Hexachloro-1,3-butadiene	87-68-3	*0.002*	0	0.006	*0.018*	0	0.064	0.045	0.4	0.117	30
Hexaldehyde	66-25-1	0.022	0.020	0.068	0.090	0.082	0.279			0.139	76
Isovaleraldehyde	590-86-3	*0.028*	0	0.121	*0.098*	0	0.426			0.007	27
Methyl Ethyl Ketone	78-93-3	0.116	0.130	0.265	0.343	0.383	0.781	5000	0.0001	0.074	100
Methyl Isobutyl Ketone	108-10-1	0.023	0.021	0.052	0.093	0.086	0.213	3000	0.00003	0.057	98
Methyl Methacrylate	80-62-6	*0.001*	0	0.016	*0.005*	0	0.066	700	0.00001	0.115	12
Methyl tert-Butyl Ether	1634-04-4	*0.002*	0	0.028	*0.008*	0	0.101	3.8	0.002	0.050	14
n-Octane	111-65-9	0.023	0.021	0.047	0.106	0.098	0.220			0.079	100
Propionaldehyde	123-38-6	0.283	0.187	0.767	0.672	0.443	1.822	8	0.1	0.007	100
Propylene	115-07-1	0.296	0.252	0.817	0.510	0.434	1.406	3000	0.0002	0.055	100
Styrene	100-42-5	0.010	0.010	0.034	0.042	0.043	0.145	1.8	0.02	0.068	66
1,1,2,2-Tetrachloroethane	79-34-5	*0.001*	0	0.009	*0.005*	0	0.062	0.017	0.3	0.124	12
Tetrachloroethylene	127-18-4	0.012	0.011	0.041	0.084	0.075	0.278	0.17	0.5	0.095	81
Tolualdehydes		0.016	0.017	0.056	0.078	0.081	0.275			0.020	73
Toluene	108-88-3	0.216	0.189	0.587	0.814	0.712	2.212	5000	0.0002	0.068	100
1,2,4-Trichlorobenzene	102-82-1	*0.001*	0	0.005	*0.004*	0	0.037	2	0.002	0.371	10
1,1,1-Trichloroethane	71-55-6	0.005	0.005	0.012	0.030	0.027	0.065	1000	0.00003	0.071	85
1,1,2-Trichloroethane	79-00-5	*0.0002*	0	0.010	*0.001*	0	0.055	0.063	0.01	0.093	2
Trichloroethylene	79-01-6	*0.001*	0	0.012	*0.006*	0	0.064	0.2	0.03	0.091	10
Trichlorofluoromethane	75-69-4	0.240	0.236	0.298	1.348	1.326	1.674	700	0.002	0.045	100
Trichlorotrifluoroethane	76-13-1	0.081	0.081	0.100	0.619	0.621	0.766	30000	0.00002	0.069	100
1,2,4-Trimethylbenzene	95-63-6	0.024	0.024	0.068	0.119	0.118	0.334			0.103	97
1,3,5-Trimethylbenzene	108-67-8	0.008	0.008	0.020	0.037	0.039	0.098			0.103	78
Valeraldehyde	110-62-3	0.165	0.048	1.110	0.582	0.169	3.910			0.007	100
Vinyl chloride	75-01-4	*0.002*	0	0.014	*0.004*	0	0.036	0.11	0.04	0.020	20
m,p-Xylene	1330-20-7	0.066	0.059	0.200	0.286	0.256	0.868	100	0.003	0.017	100
o-Xylene	95-47-6	0.031	0.029	0.085	0.135	0.126	0.369	100	0.001	0.069	100

[a] See page 31 for footnotes.

Footnotes for Tables 4 through 7

[b] Analytes in bold text had annual means above the long-term health benchmark.

[c] Numbers in italics are arithmetic means (or averages) based on less than 50% of the samples above the detection limit.

[d] For a valid 24-hour sampling event, when the analyzing laboratory reports the term "Not Detected" for a particular pollutant, the concentration of 0.0 ppbv is assigned to that pollutant. These zero concentrations were included in the calculation of annual averages and medians for each pollutant regardless of percent detection.

[e] The health benchmark is defined as the chemical-specific air concentration above which there may be human health concerns. For a carcinogen (cancer-causing chemical), the health benchmark is set at the air concentration that would cause no more than a one-in-a-million increase in the likelihood of getting cancer, even after a lifetime of exposure. For a non-carcinogen, the health benchmark is the maximum air concentration to which exposure is likely to cause no harm, even if that exposure occurs on a daily basis for a lifetime. These toxicity values are not available for all chemicals. For more information, go to www.nj.gov/dep/aqpp/risk.html.

[f] The risk ratio for a chemical is a comparison of the annual mean air concentration to the long-term health benchmark. If the annual mean is 0, then the annual mean risk ratio is not calculated.

[g] Acrolein concentrations are highly uncertain because of problems with collection and analysis methods.

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2015 Meteorology Summary

New Jersey Department of Environmental Protection

AIR POLLUTION AND METEOROLOGY

Meteorology plays an important role in the distribution of pollution throughout the troposphere, the layer of the atmosphere closest to the earth's surface. Atmospheric processes such as wind speed and wind direction affect the transport and dispersion of air pollution. Precipitation, solar radiation, and other weather phenomena influence chemical reactions and atmospheric transformations. By studying meteorological and air pollution data together, scientists and mathematicians have developed reasonably accurate models for predicting the fate of pollutants as they go through the stages of transport, dispersion, transformation, and removal.

Scientists, engineers, and policy makers can use air pollution models as a screening tool, for comparing predicted pollutant concentrations to National Ambient Air Quality Standards (NAAQS), to determine the impacts of new and existing air pollution sources, and to design ambient air monitoring networks. The meteorological data collected by the New Jersey Department of Environmental Protection (NJDEP) can assist planners in preparing State Implementation Plans (SIPs) to reduce pollutant emissions; engineers in designing or evaluating air pollution permit applications; and scientists in siting air monitoring stations.

CLIMATOLOGY IN NEW JERSEY

New Jersey is located about halfway between the Equator and the North Pole, on the eastern coast of the United States. Its geographic location results in the state being influenced by different air streams at different times (wet, dry, hot, cold), making for daily weather that is highly variable.

Although New Jersey is one of the smallest states in the Union, with a land area of 7,836 square miles, it has five distinct climate zones, which are classified as the Northern, Central, Pine Barrens, Southwest, and Coastal Zones. The topography of the different zones, their distance from the Atlantic Ocean, and the prevailing atmospheric flow patterns affecting them produce distinct variations in the daily weather. These climate zones are shown in Figure 1.

Figure 1
New Jersey Climate Zones

- North
- Central
- Southwest
- Pine Barrens
- Coastal

Source: Office of the New Jersey State Climatologist

Monitoring Locations

NJDEP collects meteorological data at eleven stations in its monitoring network. Not all meteorological parameters are measured at each site. Table 1 lists the parameters monitored at a given station, and Figure 2 is a map of the 2015 meteorological monitoring network. In Tables 2 through 6, the 2015 meteorological data is summarized for temperature, precipitation, relative humidity, solar radiation, and barometric pressure. Figure 3 presents the average temperature for each monitoring site compared with the statewide 30-year average. Figure 4 shows the monthly precipitation at each site, as well as the statewide 30-year average. (Newark Firehouse is not included because it only began collecting rainfall data in November.)

Figures 5 through 14 present annual wind roses for Bayonne, Camden Spruce Street, Columbia, East Orange, Elizabeth Trailer, Flemington, Fort Lee Near Road, Newark Firehouse, Passaic and Rider University, respectively. Presented in a circular format, a wind rose shows the frequency of winds blowing *from* a specific direction for a specified period. The length of each "spoke" around the circle is related to the frequency that the wind blows from a particular direction per unit time. Each concentric circle represents a different frequency, starting with zero at the center and increasing frequencies at the outer circles. Each spoke is broken down into color-coded bands that show wind speed ranges.

Table 1
2015 New Jersey Meteorological Monitoring Network
Parameter Summary

	Site Name	Temperature	Relative Humidity	Wind Speed	Wind Direction	Barometric Pressure	Solar Radiation	Precipitation
1	Bayonne	X	X	X	X	X		X
2	Camden Spruce Street	X	X	X	X	X		X
3	Chester						X	
4	Columbia	X	X	X	X	X		X
5	East Orange	X	X	X	X	X		
6	Elizabeth Lab			X	X			
7	Flemington	X	X	X	X	X	X	
8	Fort Lee Near Road	X	X	X	X	X		X
9	Newark Firehouse	X	X	X	X	X	X	X
10	Passaic	X	X	X	X	X		
11	Rider University	X	X	X	X	X	X	

Figure 2
2015 Meteorological Monitoring Network
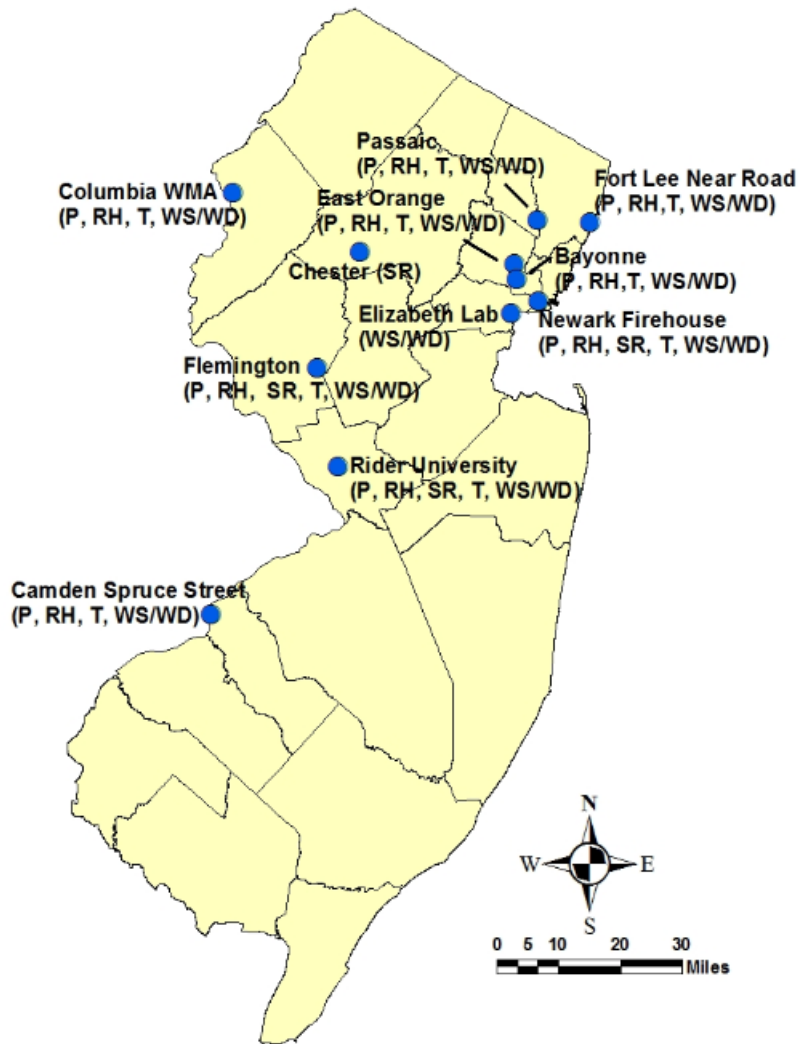
Legend

●	Meteorological Site
P	Barometric Pressure
RH	Relative Humidity
SR	Solar Radiation
T	Temperature
WS/WD	Wind Speed/Wind Direction

Table 2
2015 Summary of Temperature Data (in Degrees Fahrenheit)
from NJ's Air Monitoring Sites

SITE		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Bayonne	Mean	28	23	36	51	65	69	76	76	71	55	51	48	54
	Minimum	8	2	13	33	46	50	64	64	55	35	30	33	2
	Maximum	53	40	61	74	88	87	93	93	94	77	71	68	94
Camden Spruce St	Mean	30	25	38	54	68	72	77	77	72	57	52	50	56
	Minimum	10	2	12	35	47	51	64	64	57	36	32	32	2
	Maximum	57	47	65	79	88	92	93	92	92	77	77	70	93
Columbia	Mean	23	18	32	49	63	67	71	68	65	50	46	43	50
	Minimum	3	-7	5	24	38	43	54	51	46	26	22	26	-7
	Maximum	39	41	58	78	86	88	90	86	91	75	73	68	91
East Orange	Mean	27	22	35	52	65	69	76	76	71	54	50	48	54
	Minimum	6	0	10	32	45	49	61	60	53	32	28	32	0
	Maximum	53	41	59	80	87	88	94	93	93	76	75	69	94
Flemington	Mean	26	20	34	50	64	68	73	72	68	52	47	45	52
	Minimum	3	-4	0	26	38	45	56	51	45	25	20	24	-4
	Maximum	50	42	63	78	86	90	91	89	92	76	74	69	92
Fort Lee Near Road	Mean	26	21	35	51	64	68	76	75	70	54	50	47	53
	Minimum	5	0	11	31	46	47	62	61	53	32	30	32	0
	Maximum	53	39	58	78	85	89	92	89	91	74	71	68	92
Newark Firehouse	Mean	28	22	36	53	ND	ND	ND	ND	ND	ND	49	48	*
	Minimum	6	0	11	33	ND	ND	ND	ND	ND	ND	29	33	*
	Maximum	54	41	63	80	ND	ND	ND	ND	ND	ND	72	69	*
Passaic	Mean	28	22	36	52	67	72	78	77	72	55	50	47	55
	Minimum	7	1	12	32	45	49	62	61	52	31	28	32	1
	Maximum	53	41	59	80	90	91	97	95	96	77	74	69	97
Rider University	Mean	27	21	35	52	65	70	74	73	69	53	49	47	53
	Minimum	7	0	3	28	39	49	58	55	49	28	23	26	0
	Maximum	55	44	64	79	88	91	92	91	92	77	74	71	92

ND = no data
*Not enough data to determine an annual statistic.

Table 3
2015 Total Monthly Precipitation Data (Inches) from NJ's Air Monitoring Sites

SITE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
Bayonne	2.614	1.075	2.843	1.35	2.047	4.21	2.553	1.728	2.401	1.979	0.636	2.978	26.41
Camden Spruce St	3.372	1.048	4.716	2.6	0.963	8.486	4.385	1.828	5.064	3.411	1.162	4.326	41.36
Columbia	0.814	0.37	2.73	1.796	1.973	7.372	4.286	0.159	5.391	1.742	1.015	3.659	31.31
Fort Lee Near Road	2.886	1.827	3.283	2.444	2.013	4.835	2.136	1.802	2.74	2.843	1.368	4.07	32.25
Newark Firehouse	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.534	4.45	*
Passaic	2.109	0.533	1.61	0.306	0.619	2.431	1.434	0.684	2.237	2.678	0.454	1.878	16.97

ND = no data
*Not enough data to determine an annual statistic.

Table 4
2015 Summary of Relative Humidity Data (%) from NJ's Air Monitoring Sites

SITE		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Bayonne	Mean	58.6	58.2	57.8	53.2	58.5	66.1	59.6	56.1	62.3	60.3	61.7	70	60.2
	Minimum	29.2	26.7	21.5	18.9	20.9	24	27.1	28	26.2	29.8	29	37.3	18.9
	Maximum	90.9	90.2	90.4	91	90.9	90.5	89.2	87.9	90	89	90.3	90.8	91.0
Camden Spruce St	Mean	56.4	51.4	53.6	49.3	55.4	64	59.5	53.4	60.9	59.2	60.4	69.2	57.7
	Minimum	26.3	22	14.4	13.8	19.1	32.6	24	23.6	23.9	25.2	24.1	33.7	13.8
	Maximum	91.1	90.6	91.1	90.6	90	90.1	88.8	88.3	90.8	88	91.1	91.6	91.6
Columbia	Mean	56.9	56.4	57.6	54.4	61.8	74.2	73.3	73.6	75	69	66.2	74.4	66.1
	Minimum	25.2	27.3	15.2	14.2	17.9	36.9	31.5	36.4	33.4	27.7	24.5	30.6	14.2
	Maximum	89	87.3	90.4	90.8	91.6	92.4	92.4	91.9	92.2	91.4	91.6	92.2	92.4
East Orange	Mean	54.1	53.6	53.1	48.8	55	64.1	56.5	53.4	59.3	58.4	59.1	67.4	56.9
	Minimum	25.2	24.9	14.4	12.7	17.4	16.8	24.6	25	22.7	26.5	22.4	31.6	12.7
	Maximum	91	90.7	89.9	91.4	90.8	90.7	89.5	88.4	90.1	89.6	90	91.3	91.4
Flemington	Mean	59.5	57.5	58.4	53.9	60.9	71.4	68.3	64.4	67.6	66	64.2	73.1	63.8
	Minimum	26.3	24.3	16.4	14.3	20.2	27.8	30.3	30.5	27.1	27.2	24.9	35.3	14.3
	Maximum	92.6	91.7	92.1	92.3	92.4	92.9	92.7	91.4	92.6	92.3	91.6	93.4	93.4
Fort Lee Near Road	Mean	57.4	57	55.9	51.1	57.2	65	58.8	54.1	60.9	57.7	59.8	68.7	58.6
	Minimum	28.9	26.1	13.8	13.1	17.1	21.6	25.5	25.8	23.7	26.9	24.1	34.1	13.1
	Maximum	93.8	92.9	92.8	94	92.7	94.1	91.4	89.1	91.6	91.1	91.2	93.1	94.1
Newark Firehouse	Mean	53	52.7	51.9	50.7	ND	ND	ND	ND	ND	ND	59	70.4	*
	Minimum	22.7	21.4	10.6	10	ND	ND	ND	ND	ND	ND	22.9	33.4	*
	Maximum	92.5	91.9	92.1	92.6	ND	ND	ND	ND	ND	ND	93.5	94	*
Passaic	Mean	53.9	54.5	51.3	47.1	51.9	58.2	54.6	50.6	58.2	57.6	59.2	65.9	55.3
	Minimum	26.2	26.5	13.7	12.1	17.1	16.2	24.8	23.1	16.9	26.5	23.7	32.3	12.1
	Maximum	91.7	89.5	89.8	88.6	90	91.9	87.5	88.8	90.7	90.6	90.5	90.9	91.9
Rider University	Mean	64.4	61	62	56.3	63.5	74.2	71.5	67.5	72.3	72.9	70.7	78.9	67.9
	Minimum	25	23.8	15.1	13.7	18.4	24.2	29.2	23.3	24	26.8	23.3	35.3	13.7
	Maximum	99.7	99.1	98.8	97.8	98.5	97.8	98.5	98.3	98.4	98.9	99.5	99.6	99.7

ND = no data
*Not enough data to determine an annual statistic.

Table 5
2015 Summary of Solar Radiation Data (in Langleys) from NJ's Air Monitoring Sites

SITE		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Chester	Mean	0.092	0.172	0.214	0.300	0.346	0.281	0.374	0.346	0.258	0.178	0.100	0.061	0.227
	Maximum	0.924	1.157	1.402	1.562	1.610	1.611	1.576	1.645	1.328	1.132	0.953	0.590	1.645
Flemington	Mean	0.111	0.185	0.208	0.289	0.337	0.298	0.354	0.349	0.266	0.195	ND	0.071	0.242
	Maximum	0.875	1.106	1.287	1.438	1.419	1.346	1.360	1.321	1.198	1.059	ND	0.661	1.438
Newark Firehouse	Mean	0.096	0.150	0.204	0.288	0.345	0.313	0.359	0.363	0.270	0.185	0.115	0.069	0.230
	Maximum	0.748	0.964	1.221	1.345	1.441	1.428	1.443	1.424	1.225	1.017	0.787	0.621	1.443
Rider University	Mean	0.093	0.156	0.190	0.273	0.333	0.303	0.340	0.335	0.251	0.169	0.107	0.068	0.218
	Maximum	0.708	0.921	1.131	1.328	1.331	1.325	1.389	1.241	1.127	0.954	0.725	0.568	1.389

ND = no data

Table 6
2015 Summary of Barometric Pressure Data (in inches of Hg)
from NJ's Air Monitoring Sites

SITE		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Bayonne	Mean	30.08	30.04	30.08	29.95	30.10	29.94	29.88	29.95	30.04	30.06	30.16	30.07	30.03
	Minimum	29.26	29.37	29.53	29.44	29.73	29.61	29.53	29.70	29.62	29.50	29.51	29.35	29.26
	Maximum	30.66	30.80	30.69	30.46	30.40	30.26	30.14	30.20	30.45	30.55	30.79	30.66	30.80
Camden Spruce St.	Mean	30.10	30.06	30.09	29.96	30.10	29.93	29.89	29.96	30.04	30.07	30.17	30.08	30.04
	Minimum	29.31	29.39	29.56	29.50	29.77	29.60	29.52	29.71	29.61	29.51	29.53	29.40	29.31
	Maximum	30.69	30.82	30.70	30.43	30.42	30.22	30.13	30.20	30.42	30.52	30.78	30.68	30.82
Columbia	Mean	29.55	29.51	29.56	29.45	29.59	29.45	29.41	29.49	29.56	29.56	29.65	29.56	29.53
	Minimum	28.79	28.87	29.08	28.99	29.25	29.14	29.05	29.27	29.12	29.02	29.02	28.89	28.79
	Maximum	30.09	30.25	30.15	29.94	29.90	29.75	29.65	29.71	29.94	30.04	30.26	30.15	30.26
East Orange	Mean	29.91	29.87	29.91	29.79	29.93	29.78	29.72	29.79	29.88	29.90	29.99	29.90	29.86
	Minimum	29.10	29.21	29.37	29.28	29.57	29.46	29.37	29.54	29.45	29.34	29.35	29.19	29.10
	Maximum	30.48	30.62	30.51	30.29	30.23	30.09	29.98	30.03	30.28	30.38	30.62	30.49	30.62
Flemington	Mean	29.92	29.88	29.91	29.79	29.93	29.77	29.73	29.80	29.87	29.90	29.99	29.90	29.87
	Minimum	29.13	29.21	29.39	29.29	29.58	29.47	29.36	29.55	29.44	29.35	29.35	29.21	29.13
	Maximum	30.48	30.63	30.52	30.28	30.25	30.08	29.97	30.03	30.27	30.37	30.61	30.50	30.63
Fort Lee Near Road	Mean	29.75	29.71	29.75	29.64	29.79	29.64	29.58	29.65	29.74	29.76	29.84	29.75	29.72
	Minimum	28.94	29.05	29.22	29.14	29.43	29.31	29.24	29.40	29.32	29.20	29.20	29.04	28.94
	Maximum	30.32	30.46	30.36	30.15	30.08	29.95	29.84	29.89	30.14	30.23	30.46	30.34	30.46
Newark Firehouse	Mean	29.97	29.93	29.96	29.85	29.99	29.83	29.77	29.84	29.94	29.96	30.05	29.96	29.92
	Minimum	29.15	29.26	29.43	29.35	29.62	29.50	29.42	29.59	29.51	29.39	29.40	29.24	29.15
	Maximum	30.53	30.67	30.57	30.35	30.30	30.15	30.03	30.09	30.35	30.44	30.68	30.55	30.68
Passaic	Mean	30.02	29.97	30.02	29.92	30.03	29.87	29.82	29.89	29.98	30.00	30.10	30.03	29.97
	Minimum	29.20	29.32	29.46	29.37	29.66	29.55	29.47	29.67	29.55	29.44	29.45	29.28	29.20
	Maximum	30.59	30.73	30.63	30.40	30.33	30.20	30.07	30.13	30.39	30.49	30.73	30.60	30.73
Rider University	Mean	30.34	30.30	30.34	30.20	30.35	30.19	30.13	30.21	30.29	30.32	30.43	30.33	30.29
	Minimum	29.50	29.58	29.79	29.69	29.98	29.85	29.74	29.95	29.84	29.73	29.74	29.60	29.50
	Maximum	30.93	31.10	30.99	30.72	30.69	30.51	30.39	30.46	30.71	30.81	31.07	30.96	31.10

Figure 3
2015 Average Temperatures at NJDEP Air Monitoring Sites
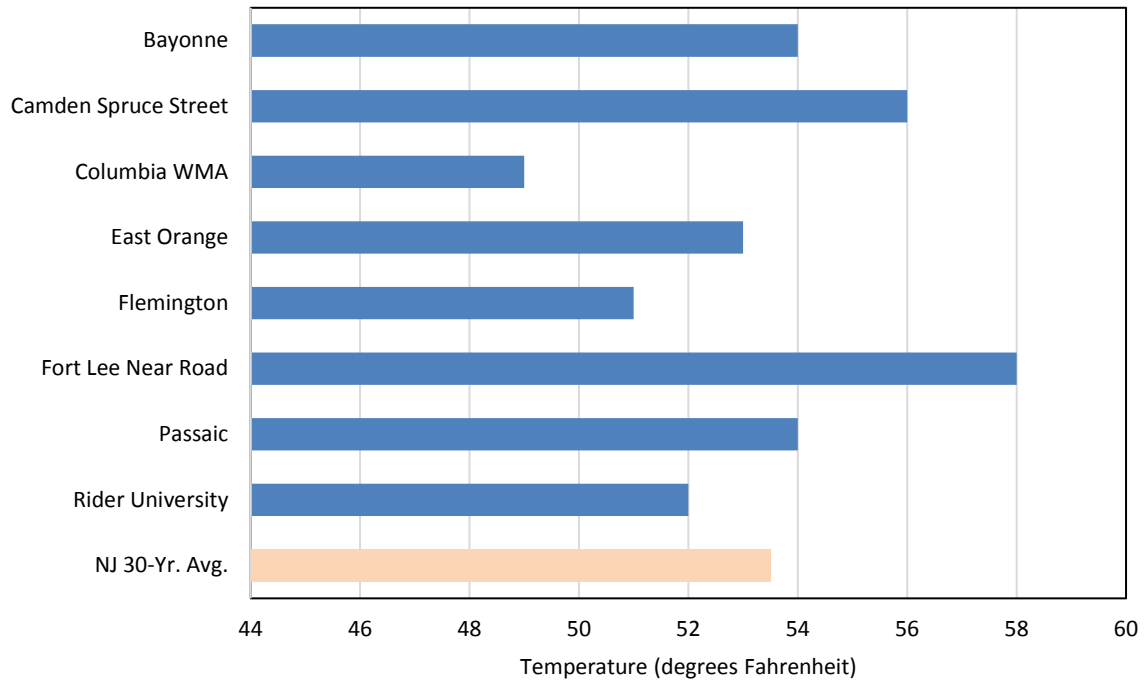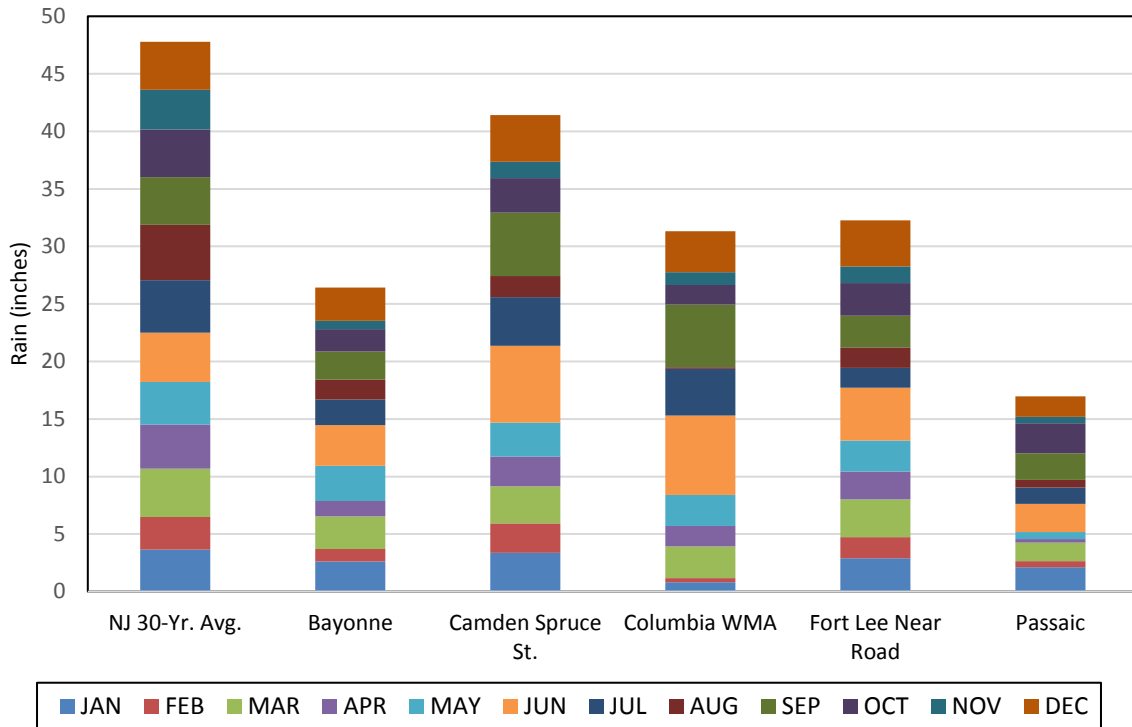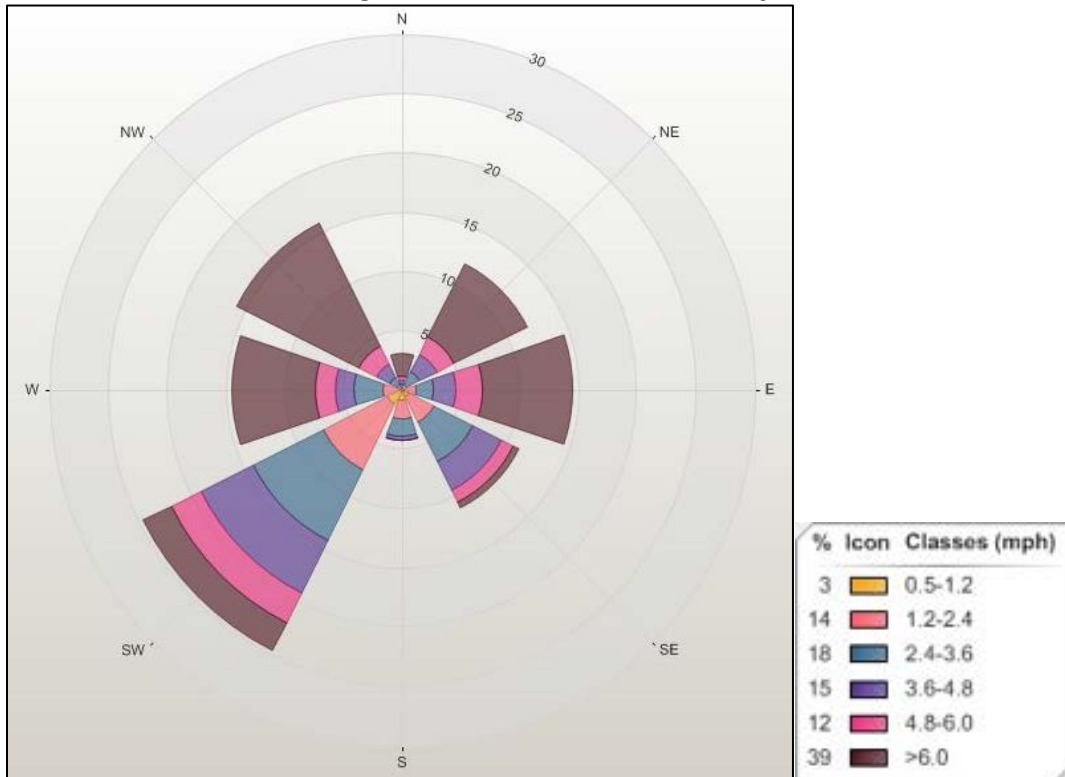## Compared to the Statewide 30-Year Average

Figure 4
2015 Total Rainfall at NJDEP Air Monitoring Sites
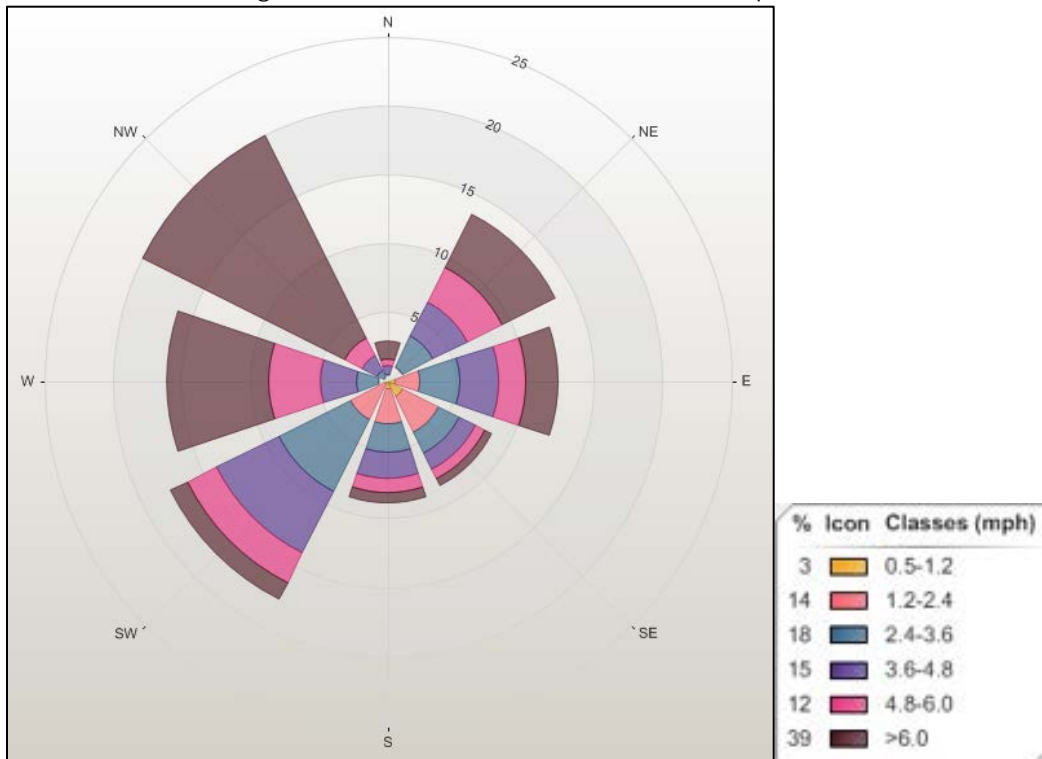## Compared to the Statewide 30-Year Average

Wind Roses - Distribution of Wind Speed & Wind Direction

Figure 5. 2015 Wind Rose for Bayonne

Bayonne 1/1/2015 12:00 AM - 12/31/2015 11:59 PM Calm: 0.03% Calm Wind Avg Speed: 0.41(mph)
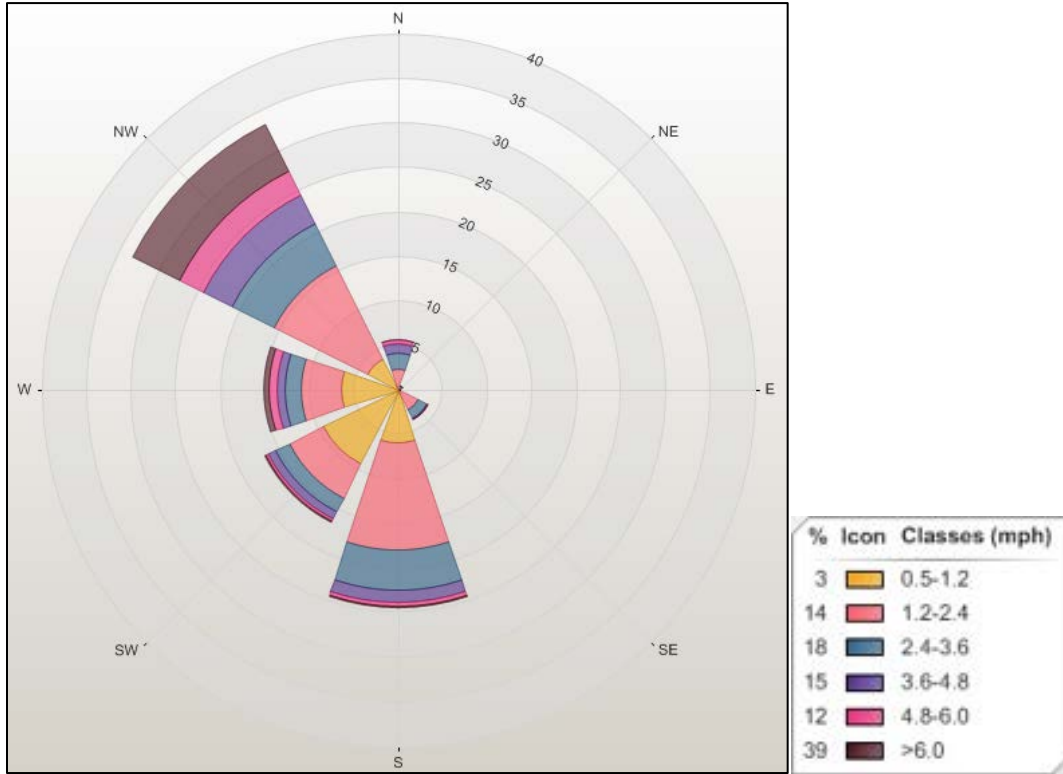
Figure 6. 2015 Wind Rose for Camden Spruce Street

Camden Spruce St 1/1/2015 12:00 AM - 12/31/2015 11:59 PM Calm: 0.01% Calm Wind Avg Speed: 0.30(mph)
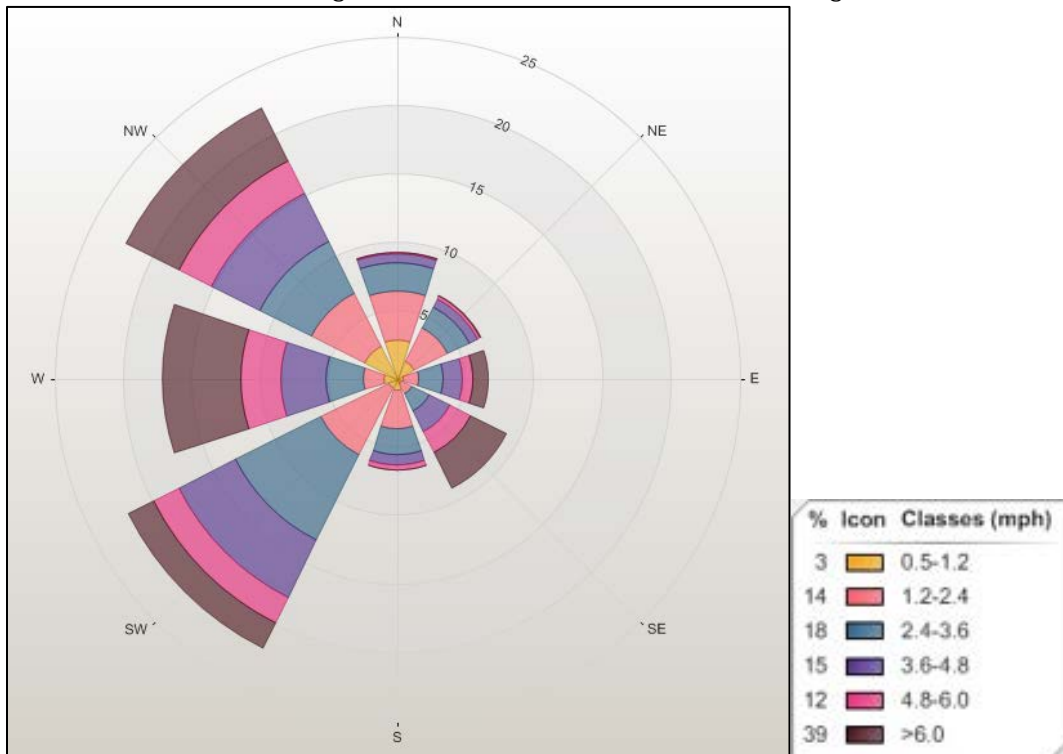
Figure 7. 2015 Wind Rose for Columbia

Columbia 1/1/2015 12:00 AM - 12/31/2015 11:59 PM Calm: 0.10% Calm Wind Avg Speed: 0.44(mph)

Figure 8. 2015 Wind Rose for East Orange

East Orange 1/1/2015 12:00 AM - 12/31/2015 11:59 PM Calm: 0.43% Calm Wind Avg Speed: 0.39(mph)

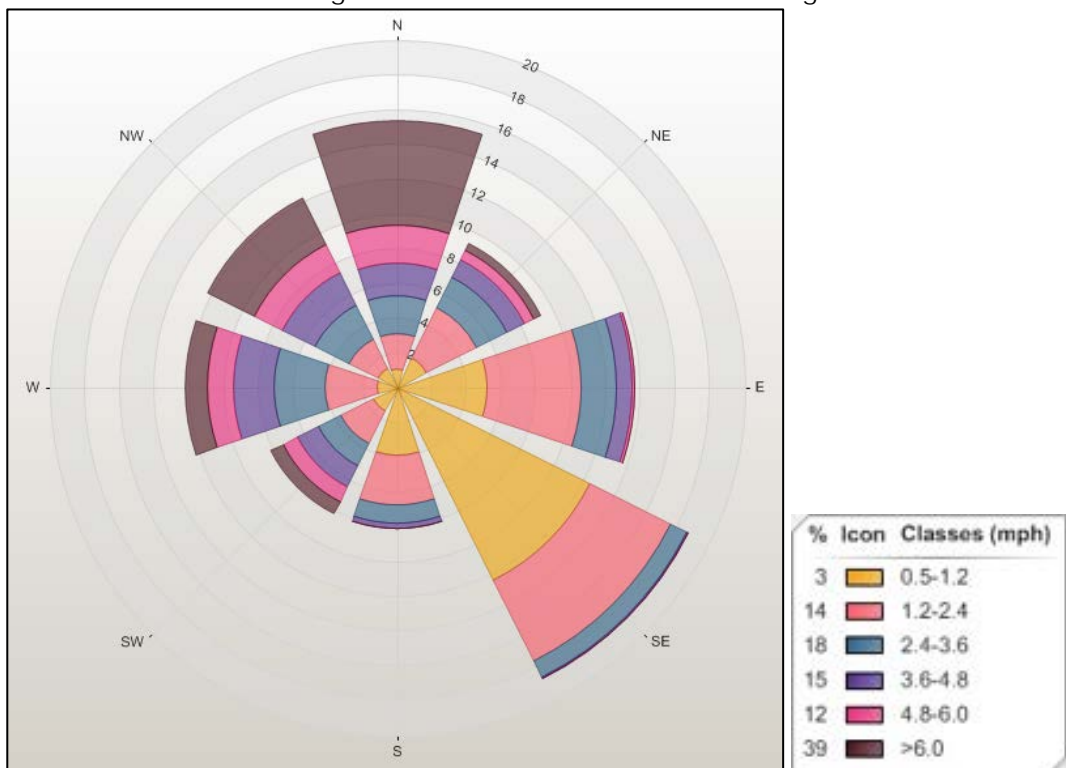**Figure 9. 2015 Wind Rose for Elizabeth Trailer**
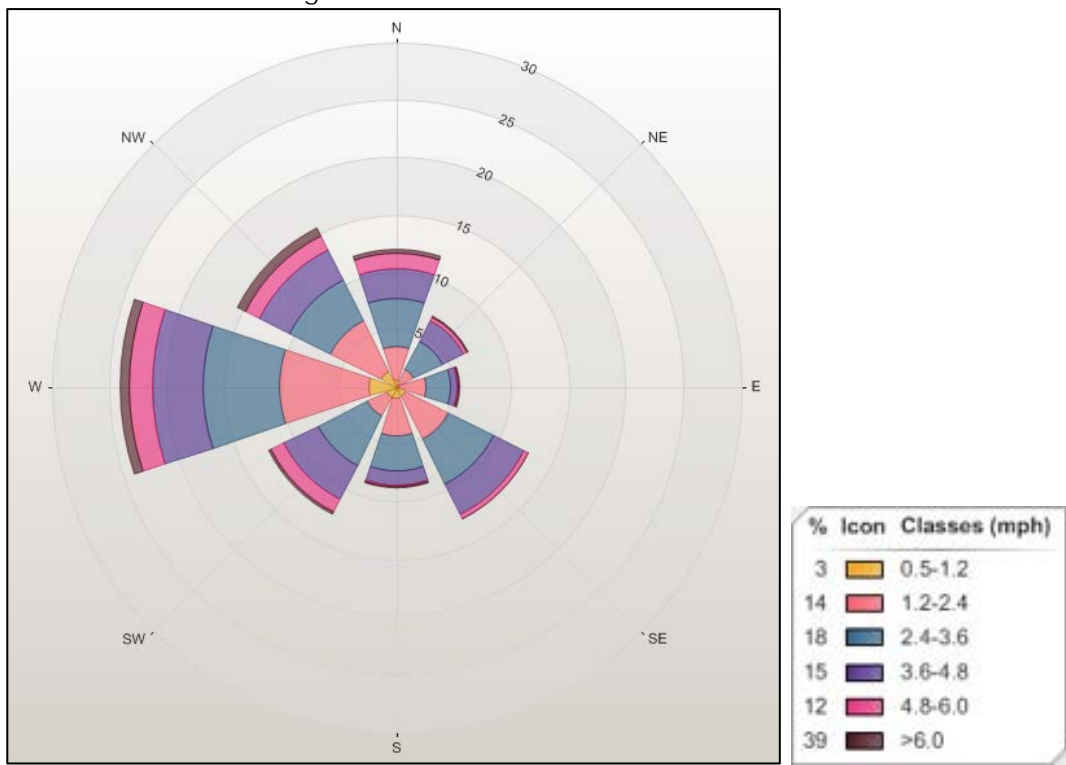
Elizabeth Trailer 1/1/2015 12:00 AM - 12/31/2015 11:59 PM Calm: 1.87% Calm Wind Avg Speed: 0.27(mph)

Figure 10. 2015 Wind Rose for Flemington

Flemington 1/1/2015 12:00 AM - 12/31/2015 11:59 PM Calm: 2.28% Calm Wind Avg Speed: 0.39(mph)

Figure 11. 2015 Wind Rose for Fort Lee Near Road
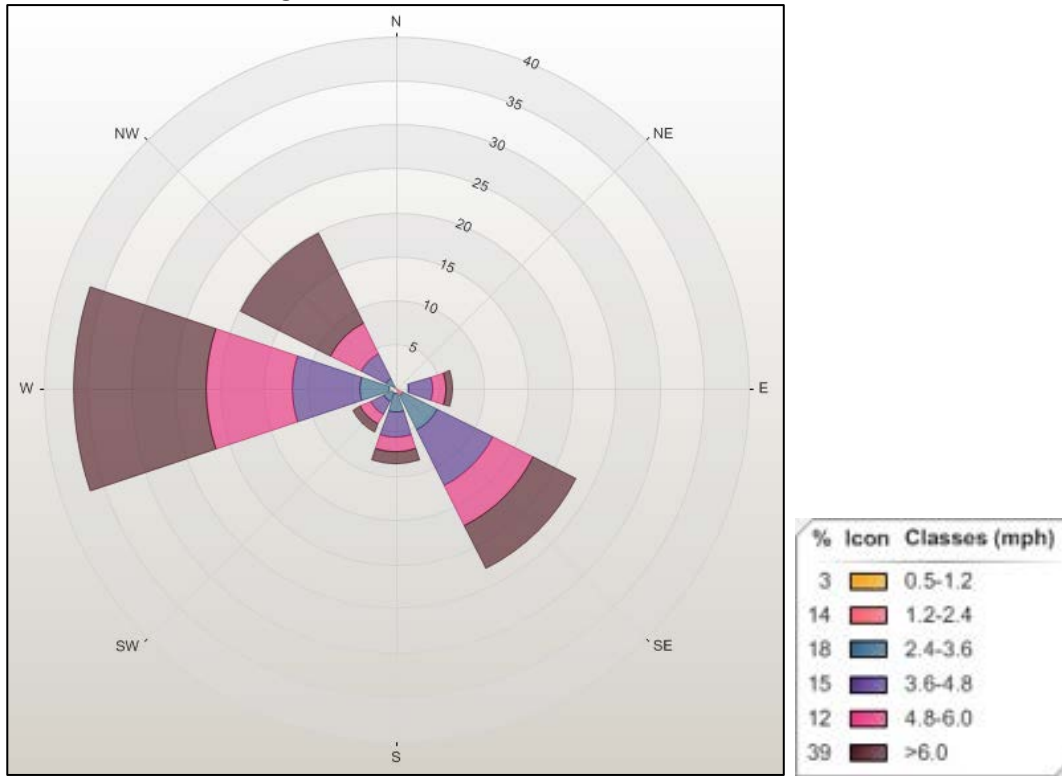
Fort Lee Near Road 1/1/2015 12:00 AM - 12/31/2015 11:59 PM Calm: 0.00%

%	Icon	Classes (mph)
3		0.5-1.2
14		1.2-2.4
18		2.4-3.6
15		3.6-4.8
12		4.8-6.0
39		>6.0

Figure 12. 2015 Wind Rose for Newark Firehouse
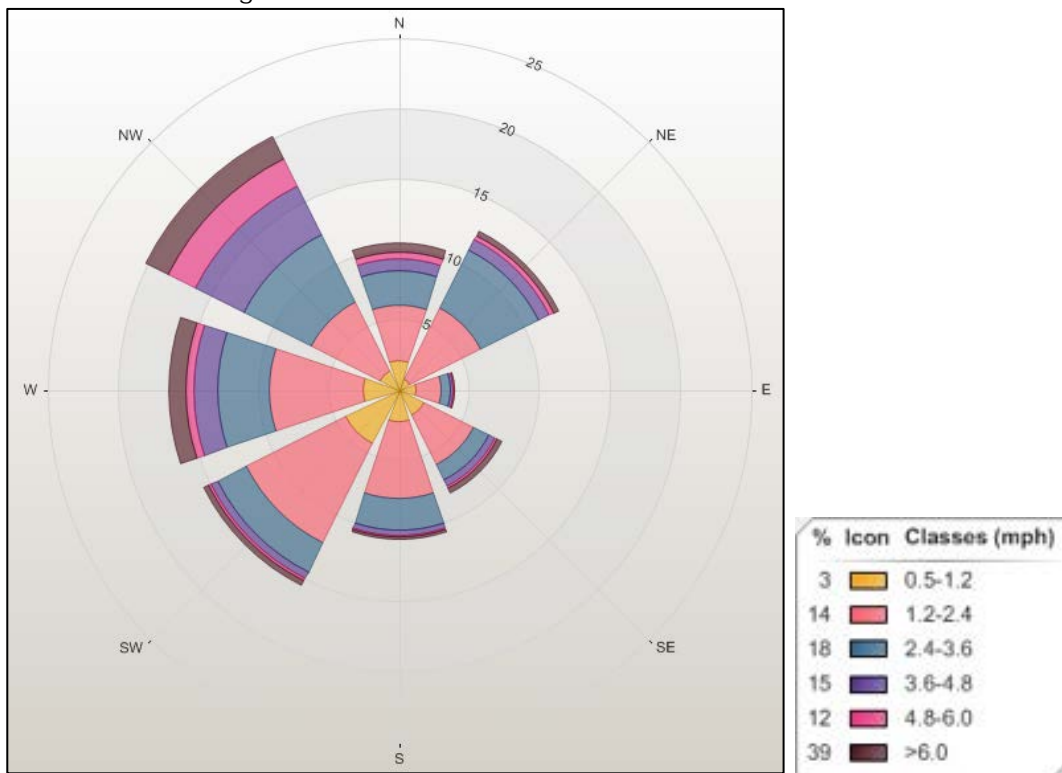
Newark Firehouse 1/1/2015 12:00 AM - 12/31/2015 11:59 PM Calm: 1.99% Calm Wind Avg Speed: 0.38(mph)

%	Icon	Classes (mph)
3		0.5-1.2
14		1.2-2.4
18		2.4-3.6
15		3.6-4.8
12		4.8-6.0
39		>6.0

Figure 13. 2015 Wind Rose for Passaic
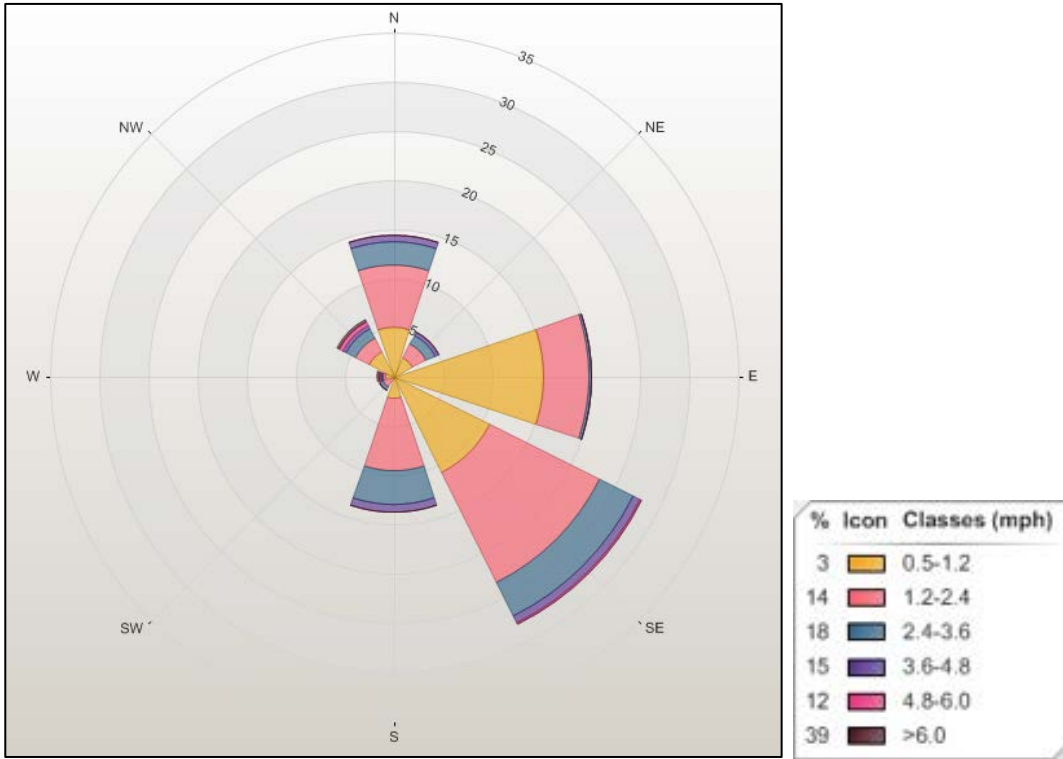
Passaic 1/1/2015 12:00 AM - 12/31/2015 11:59 PM Calm: 8.63% Calm Wind Avg Speed: 0.37(mph)

Figure 14: 2015 Wind Rose for Rider University
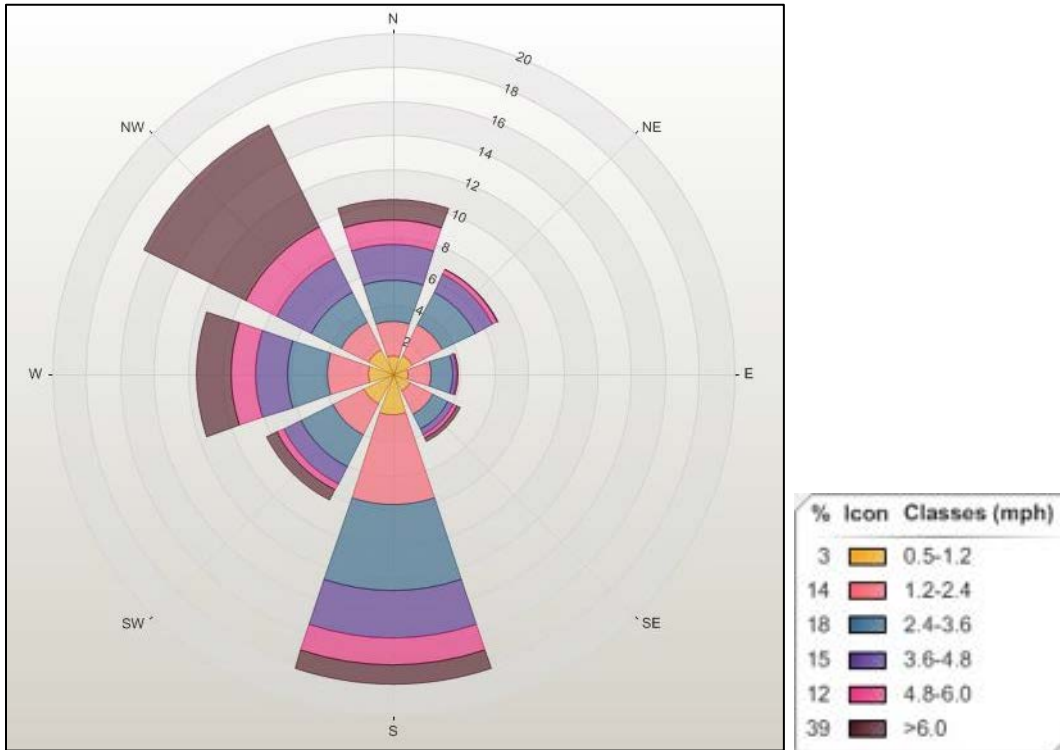
Rider University 1/1/2015 12:00 AM - 12/31/2015 11:59 PM Calm: 20.15% Calm Wind Avg Speed: 0.13(mph)

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2015 Regional Haze & Visibility Summary

New Jersey Department of Environmental Protection

THE BASICS OF HAZE

Haze is a type of visibility impairment usually associated with air pollution, and to a lesser extent, moisture in the atmosphere. Small particles and certain gaseous molecules can cause poor visibility by scattering or absorbing light before it reaches an observer (Figure 1). When high concentrations of such pollutants are well-mixed in the atmosphere they form a uniform haze that can obscure distant objects.

Air pollutants come from a variety of natural and man-made sources, and haze can occur at any time of year. Natural sources include small particles from windblown dust and soot from wildfires and volcanoes. Man-made sources, which are the primary cause of visibility impairment, include motor vehicle emissions, electric utility and industrial fuel burning emissions, and manufacturing operations.

Pollution from both natural and man-made sources can be transported over long distances and across state borders on prevailing winds, contributing to the problem of regional haze.

**Figure 1
Contributors to Visibility Impairment**

Malm 1999

ANATOMY OF REGIONAL HAZE

The following categories of air pollutants are the major contributors to haze:

Sulfate particles form in the air from sulfur dioxide gas. Most of this gas is released from coal-burning power plants and other industrial sources, such as smelters, industrial boilers, and oil refineries. Sulfates are the largest contributors to haze in the eastern U.S. because of the large number of coal-fired power plants that affect the region. In humid environments, sulfate particles grow rapidly to a size that is very efficient at scattering light, thereby exacerbating the problem in the east.

Organic carbon particles can be emitted directly into the air or formed by the reaction of various gaseous hydrocarbons. Sources of direct and indirect organic carbon particles include vehicle exhaust, vehicle refueling, solvent evaporation (for example, from paints), cooking, and various commercial and industrial sources. Gaseous hydrocarbons are also emitted naturally from trees and from fires, but these sources usually have only a small or short-term effect on overall visibility.

Nitrate particles form in the air from nitrogen oxide gas. This gas is released from virtually all combustion activities, especially those involving cars, trucks, off-road engines (such as construction equipment, lawn mowers, and boats), power plants, and other industrial sources. Like sulfates, nitrates scatter more light in humid environments.

Elemental carbon particles are smaller than most other particles and tend to absorb rather than scatter light. The "brown clouds" often seen in winter over urban areas and in mountain valleys can be largely attributed to elemental carbon. These particles are emitted directly into the air from virtually all combustion activities, but are especially prevalent in diesel exhaust and smoke from the burning of wood and wastes.

Soil particles enter the air from dirt roads, fields, and other open spaces as a result of wind, traffic, and other surface activities. Whereas other types of particles form from the condensation and growth of microscopic particles and gases, crustal particles result from the crushing and grinding of larger, earth-borne material. Because it is difficult to reduce this material to microscopic sizes, crustal material tends to be larger than other particles and tends to fall from the air sooner, contributing less to the overall effect of haze.

PARTICLES AND VISIBILITY

Figure 2 below shows the composition of fine particles collected at the Interagency Monitoring of Protected Visual Environments (IMPROVE) site, located at the Brigantine air monitoring station. It is operated by the New Jersey Department of Environmental Protection (NJDEP), in the Edwin B. Forsythe National Wildlife Refuge, just north of Atlantic City. Note that a year of data is reported from July 1 to June 30 of the following year.

Most visibility impairment is due to sulfate, which can have a greater effect on light extinction (a measure of visibility impairment) because of its ability to accumulate water and grow in size in humid conditions. The data for 2014-2015 in Figure 2 show that sulfates accounted for approximately 48.8% of the total fine particle mass on days with good visibility, and approximately 35.6% on bad visibility days.

The graph below in Figure 3 represents the annual trend of sulfates, expressed in micrograms per cubic meter, measured at the Forsythe National Wildlife Refuge. The graph shows the annual average for each year as well as the average concentration on the days with the best visibility, and the average on the days with the worst visibility, using the upper and lower 20% of the data as a cut-off. Sulfate trends have improved over the last few years as a result of more stringent regulations and guidelines from both the United States Environmental Protection Agency (USEPA) and the state of New Jersey.

Figure 2
Composition of Fine Particles on Days with Good Visibility
Compared to Days with Poor Visibility at Brigantine, NJ
July 2014 – June 2015

Average Fine Mass Composition on Days with Good Visibility

🟥	Ammonium Nitrate	0.17 $\mu g/m^3$	9.2%
🟨	Ammonium Sulfate	0.90 $\mu g/m^3$	48.8%
⬛	Elemental Carbon	0.07 $\mu g/m^3$	3.8%
🟩	Organic Carbon	0.62 $\mu g/m^3$	33.7%
🟫	Soils	0.08 $\mu g/m^3$	4.6%

Total 1.85 $\mu g/m^3$

Average Fine Mass Composition on Days with Poor Visibility

🟥	Ammonium Nitrate	3.03 $\mu g/m^3$	29.2%
🟨	Ammonium Sulfate	3.70 $\mu g/m^3$	35.6%
⬛	Elemental Carbon	0.46 $\mu g/m^3$	4.5%
🟩	Organic Carbon	2.31 $\mu g/m^3$	22.2%
🟫	Soils	0.89 $\mu g/m^3$	8.5%

Total 10.39 $\mu g/m^3$

Figure 3
Annual Average Sulfate Concentrations at Brigantine, NJ, 2004-2015
Micrograms per Cubic Meter (µg/m³)
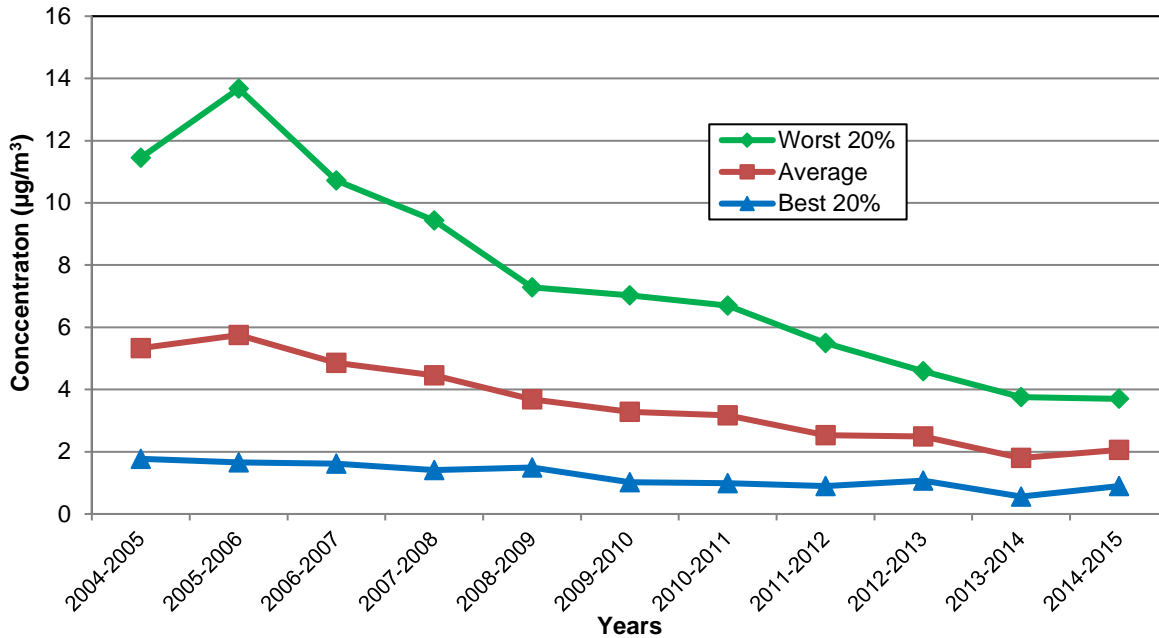
For this report annual data for a given year is defined as data from July 1 to June 30 of the following year.

ENVIRONMENTAL EFFECTS

Regional haze is most closely associated with its effects on prized vistas such as the Grand Canyon, Acadia National Park, and other Class I areas, such as the Edwin B. Forsythe National Wildlife. The impact of haze may be difficult to quantify but it certainly has a negative overall effect on aesthetics and the outdoors, and the enjoyment of natural areas throughout the nation. Haze also affects urban vistas, and can obscure or eclipse the view of an urban skyline, or important landmarks such as the Washington Monument. The pollution that causes regional haze has other detrimental effects on the environment because of the acidic makeup of fine particles such as sulfates. Sulfates eventually make their way into the ecosystem through atmospheric deposition, that is, they are transferred from the air into the water and soils (Figure 4). Too much atmospheric deposition can have adverse environmental effects by upsetting the delicate balance of the ecosystem, causing damage to waterways, plants, soils, and wildlife. For more information, see the summary on Atmospheric Deposition.

Figure 4
How Sulfates Enter the
Ecosystem by Way of Deposition
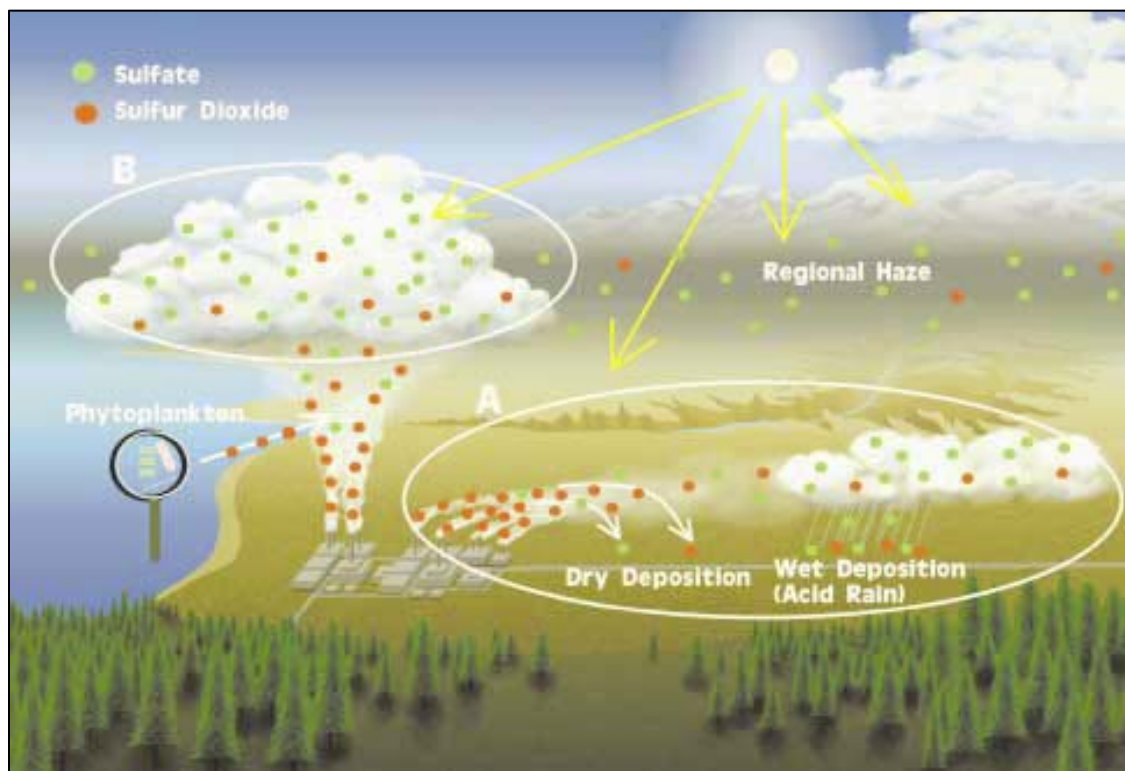
Malm 1999

HOW IS HAZE REGULATED?

In 1999, USEPA announced a major effort to improve air quality in national parks and wilderness areas, aimed at achieving national visibility goals of no man-made impairment by 2064. The Regional Haze Rule calls for state and federal agencies to work together to improve visibility in national parks and wilderness areas such as the Grand Canyon and the Great Smokies. This rule addresses the combined visibility effects of numerous pollution sources over a wide geographic region and how they impact Class I areas. As defined by the Clean Air Act, Class I areas include national parks greater than 6,000 acres, wilderness areas and national memorial parks greater than 5,000 acres, and international parks that existed as of August 1977. The Edwin B. Forsythe National Wildlife Refuge–Brigantine Wilderness in Brigantine is the only Class I area in New Jersey. The haze rule requires states, in coordination with USEPA, the National Park Service, U.S. Fish and Wildlife Service, the U.S. Forest Service, and other interested parties, to develop and implement air quality protection plans to reduce the pollution that causes visibility impairment. New Jersey proposed its first regional haze plan for the Brigantine Class I area in September 2008, and it was finalized in July 2009. A five-year progress report, required as part of the approved plan, is available at http://www.state.nj.us/dep/baqp/5yearhaze.html. Figures 5 and 6 below from the progress report show the downward trend in all visibility-impairing pollutants on the 20% worst and best days of visibility impairment at the Brigantine Wilderness since 2000.

Figure 5
Visibility Improvements on the 20% Worst Days
at the Brigantine Wilderness
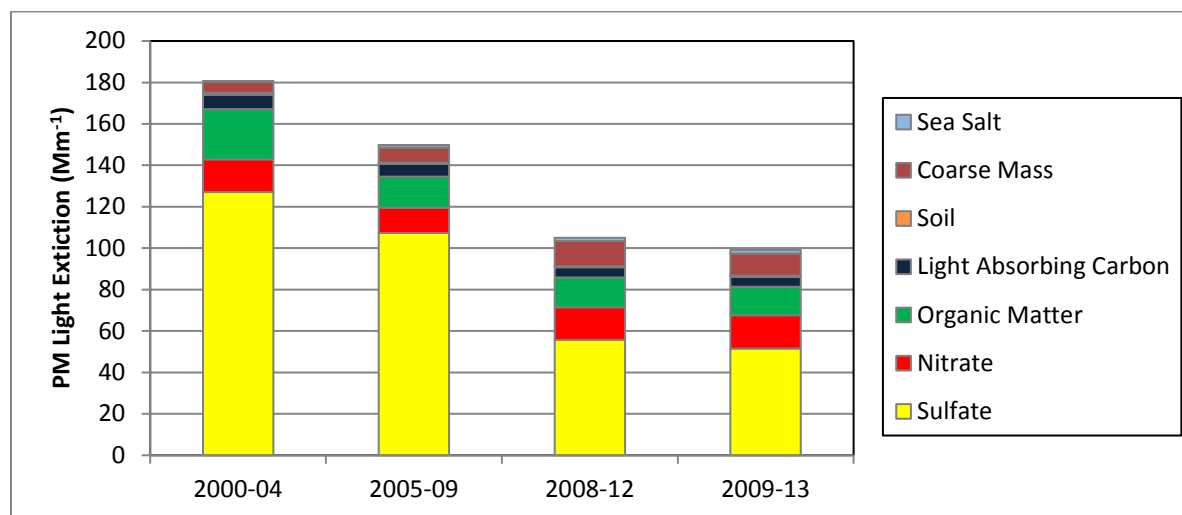
Figure 6
Visibility Improvements on 20% Best Days
at the Brigantine Wilderness
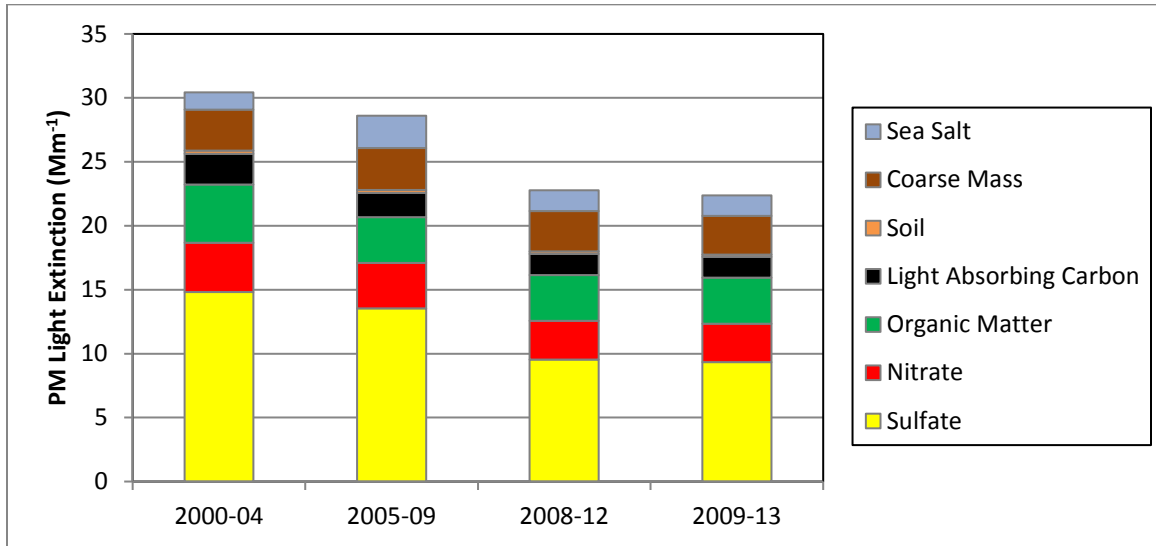
MONITORING HAZE IN NEW JERSEY

The typical visual range in the eastern U.S. is 15 to 30 miles, or about one-third of what it would be without man-made air pollution. In the western U.S. the typical visual range is 60 to 90 miles, or about one-half of the visual range under natural conditions. Haze diminishes this natural visual range (see www.hazecam.net).

Visibility and haze are monitored in two locations in New Jersey, Newark and Brigantine. The monitor in Newark measures the impact of haze on visibility by using a digital camera. The camera is located inside the New Jersey Transit building and is pointed at the New York City skyline. On clear days the entire skyline, as well as individual buildings, are easily distinguishable (Figure 7). The Manhattan skyline appears nonexistent when conditions are conducive to haze formation (Figure 8).

Visibility of New York City from the New Jersey Transit Building, Newark, NJ

Figure 7

Figure 8

The IMPROVE site located within the Edwin B. Forsythe National Wildlife Refuge in Brigantine also monitors haze and visibility using a digital camera. Figure 9 below is an example of a clear day in Brigantine, when the Atlantic City skyline is easily distinguishable along the horizon. The example of a hazy day in Brigantine is illustrated in Figure 10, where the skyline is barely visible.

Visibility at the Edwin B. Forsythe National Wildlife Refuge, Brigantine, NJ

Figure 9

Figure 10

The Brigantine air monitoring station also provides a real-time estimate of visibility using a nephelometer, an instrument that measures the scattering of light by particles in the air. The nephelometer in Brigantine does not measure moisture in the air, and therefore the visual range values reported below in Figure 11 are higher than those normally reported for the eastern United States. Visual range is most impaired during the summer when warm, hazy, humid conditions are most frequent, as illustrated by the following graph.

Figure 11
Monthly Average Visual Range
Brigantine, NJ
2012-2015
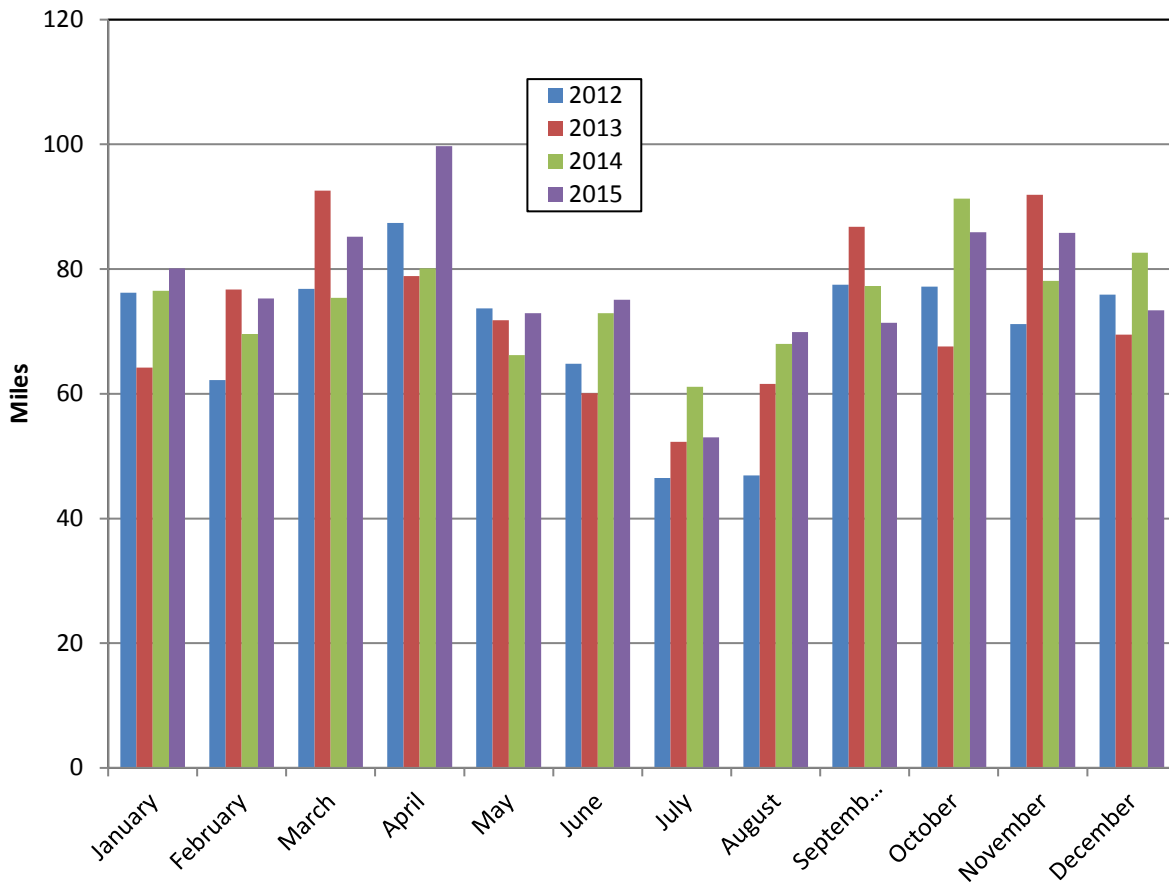
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New Jersey Department of Environmental Protection

Northern New Jersey

Central New Jersey

Southern New Jersey

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S

○ Air Monitoring Sites

FIGURE 1
NORTHERN NEW JERSEY
AIR MONITORING SITES

Table 1
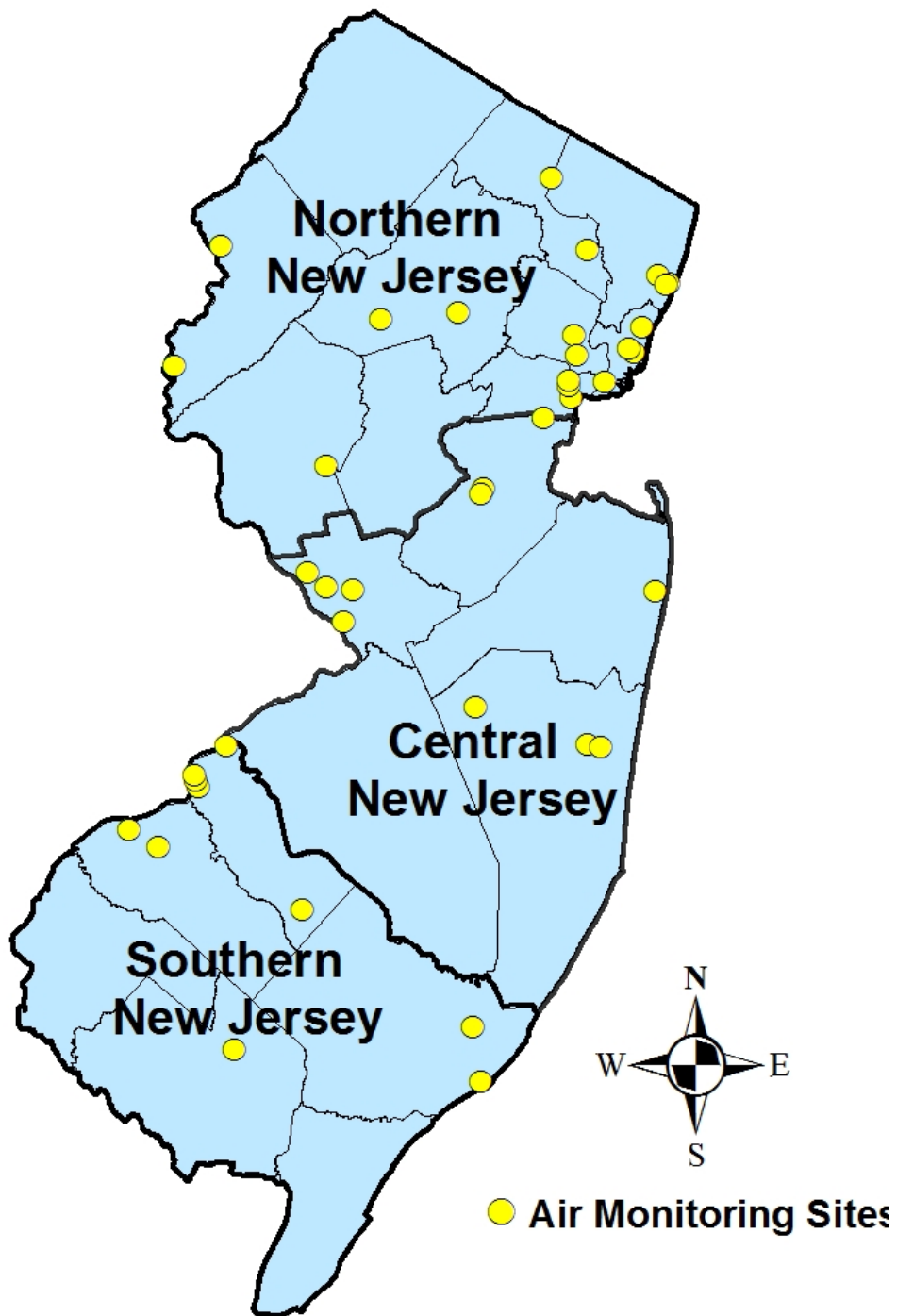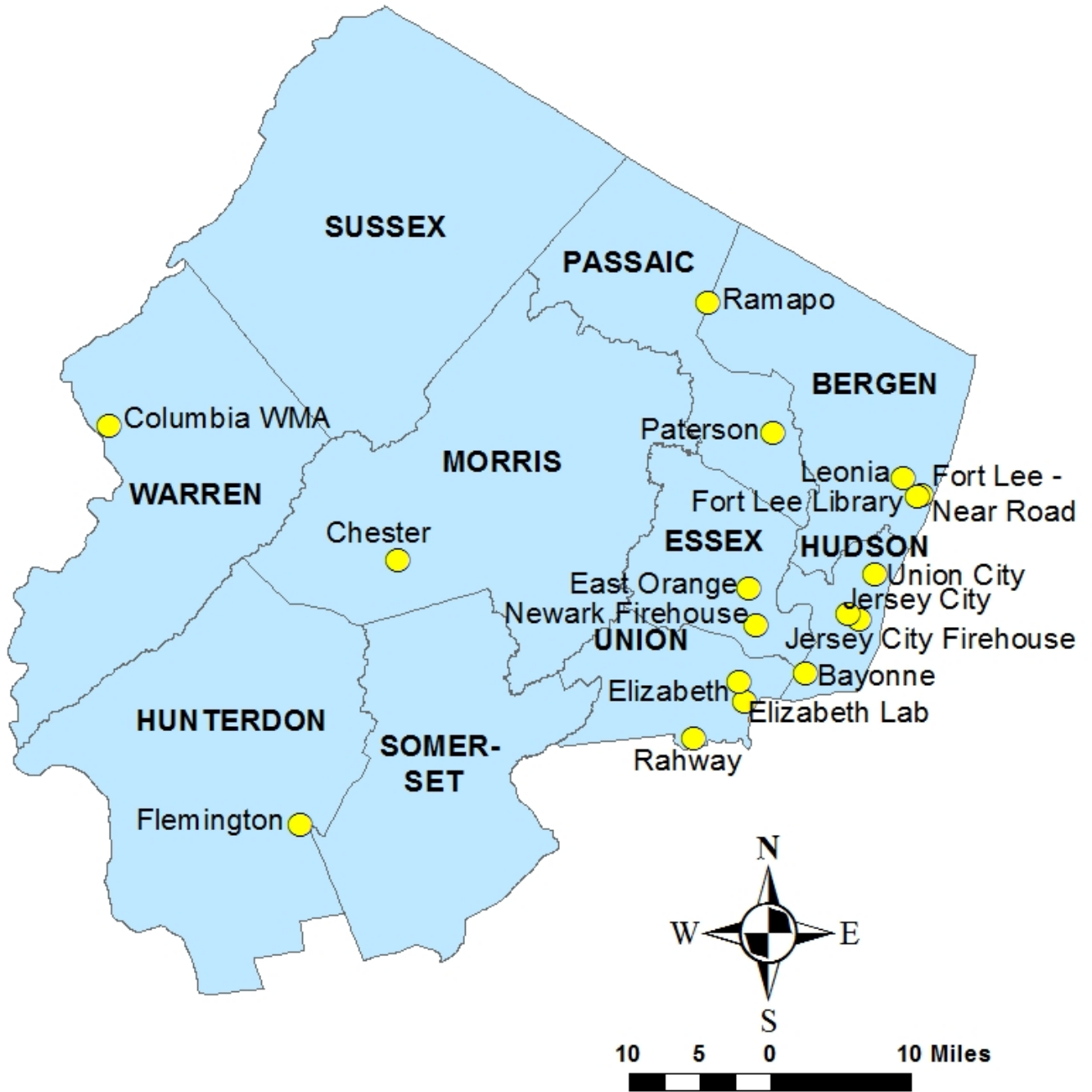**Northern New Jersey Air Monitoring Sites**

County	Monitoring Site	AIRS Code	Parameter(s) Measured[1]	Coordinates (Decimal degrees) Latitude	Longitude	Address
BERGEN	Fort Lee Library	34 003 0003	$PM_{2.5}$	40.852256	- 73.973314	Fort Lee Public Library, 320 Main Street
	Fort Lee Near Road	34 003 0010	CO, NO_x, Beta, BTEX, BC, Met	40.85355	-73.9661	2047 Central Ave.
	Leonia	34 003 0006	O_3	40.870436	-73.991994	Overpeck Park, 40 Fort Lee Road
ESSEX	East Orange	34 013 1003	CO, NO_x, Met	40.757501	- 74.200500	Engine No. 2, Main Street and Greenwood Avenue
	Newark Firehouse	34 013 0003	CO, O_3 ,SO_2, $PM_{2.5}$, Spec, NOy, NO_x, BTEX, Pb, Beta, BC, Met, PM_{coarse}	40.720989	-74.192892	360 Clinton Avenue
HUDSON	Bayonne	34 017 0006	NO_x, O_3, SO_2, BTEX, BC, Met	40.670250	- 74.126081	Park Rd at end of W. 25th St.
	Jersey City	34 017 1002	CO, SS, SO_2	40.731645	- 74.066308	2828 Kennedy Boulevard
	Jersey City Firehouse	34 017 1003	$PM_{2.5}$, PM_{10}, Beta, TEOM	40.725454	- 74.052290	Consolidated Firehouse, 355 Newark Avenue
	Union City	34 017 2002	$PM_{2.5}$	40.772793	-74.031718	Health Department, 714 31st Street
HUNTERDON	Flemington	34 019 0001	O_3, Met, TEOM	40.515262	-74.806671	Raritan Twp. Municipal Utilities Authority, 365 Old York Road
MORRIS	Chester	34 027 3001	NO_x, O_3, SO_2, $PM_{2.5}$, Toxics, Hg, Spec, Met	40.787628	- 74.676301	Bldg. #1, Department of Public Works, (DPW), 50 North Road
PASSAIC	Paterson	34 031 0005	$PM_{2.5}$	40.918381	-74.168092	Health Department, 176 Broadway
	Ramapo	34 031 5001	O_3	41.058617	- 74.255544	Ramapo Mountain State Forest, Access Road, off Skyline Drive, Wanaque
UNION	Elizabeth	34 039 0003	CO, SO_2, SS	40.662389	- 74.214817	7 Broad Street
	Elizabeth Lab	34 039 0004	CO, NO_x, SO_2, SS, Met, $PM_{2.5}$, Toxics, Hg, Spec, BTEX, BC, Beta	40.641440	- 74.208365	Interchange 13 Toll Plaza, New Jersey Turnpike
	Rahway	34 039 2003	$PM_{2.5}$, TEOM	40.603943	- 74.276174	Fire Dept. Hqtrs., 1300 Main Street
WARREN	Columbia WMA	34 041 0007	NO_x, O_3, SO_2, $PM_{2.5}$, Met, Beta	40.924580	-75.067815	Columbia Wildlife Management Area, 105 Delaware Road

[1] See Parameter Codes, Table 4 (page 8)

FIGURE 2
CENTRAL NEW JERSEY
AIR MONITORING SITES

New Brunswick

Rutgers University

MIDDLESEX

Washington
Crossing

Ewing

Rider University

MERCER

Trenton

MONMOUTH

Monmouth
University

Colliers Mills

Toms River
Cattus Island

BURLINGTON

OCEAN

N
W E
S

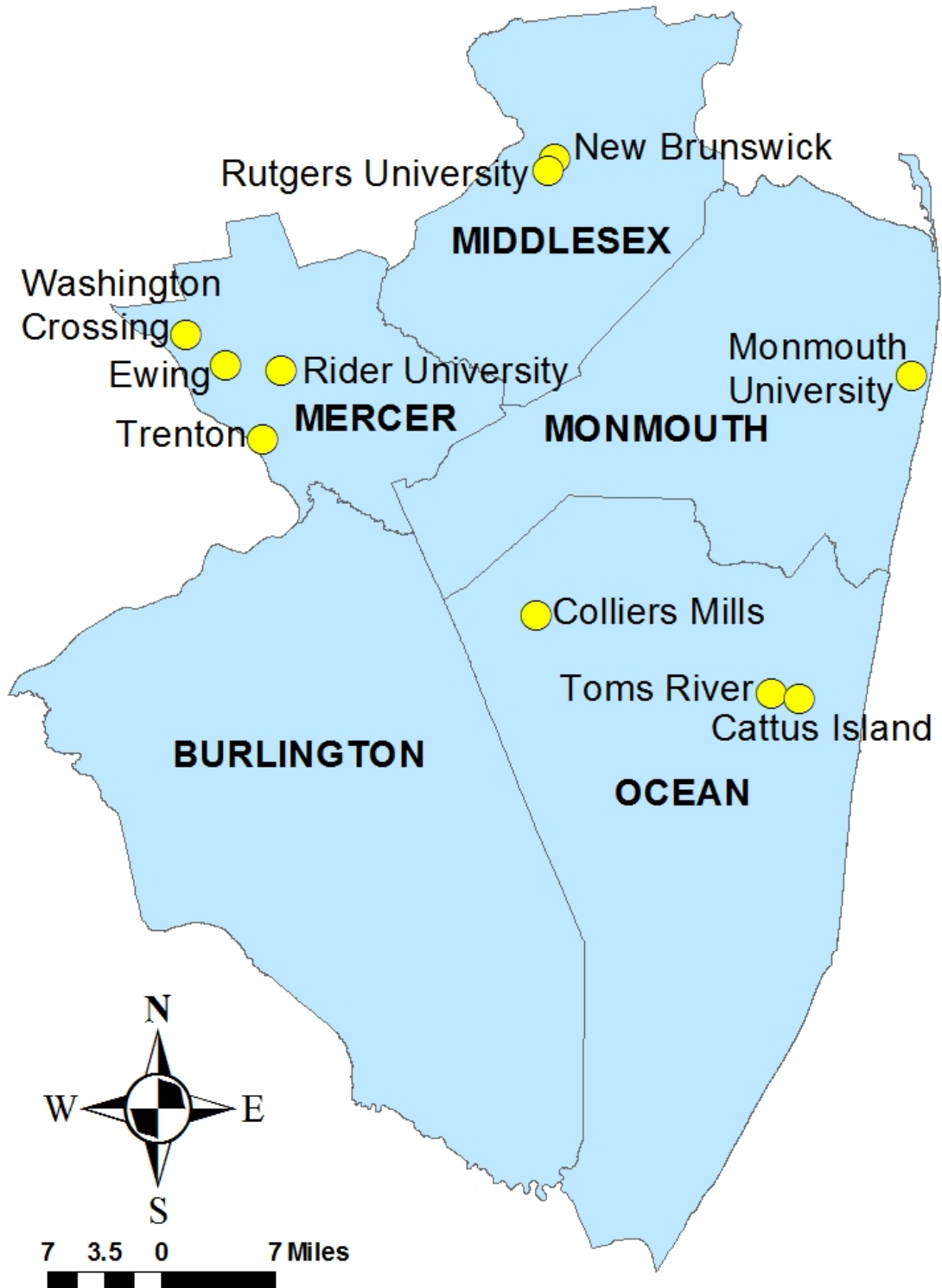7 3.5 0   7 Miles

Table 2
Central New Jersey Air Monitoring Sites

County	Monitoring Site	AIRS Code	Parameter(s) Measured[1]	Coordinates (Decimal degrees)		Address
				Latitude	Longitude	
MERCER	Ewing	34 021 0010	TEOM	40.287530	-74.807770	Bureau of Air Monitoring Technical Center, 380 Scotch Road
	Rider University	34 021 0005	O_3, Met, Beta	40.283092	-74.742644	2083 Lawrenceville Rd, Athletic Fields, Lawrence Twp.
	Trenton	34 021 0008	$PM_{2.5}$	40.222411	-74.763167	Trenton Library, 120 Academy Street
	Washington Crossing	34 021 8001	$PM_{2.5}$, ACID	40.312390	-74.872660	Washington Crossing State Park, near 66 Church Road, Hopewell
MIDDLESEX	New Brunswick	34 023 0006	$PM_{2.5}$, Beta, Spec, Toxics	40.472825	- 74.422403	Cook College, Log Cabin Road near Horticulture Lab
	Rutgers University	34 023 0011	NO_X, O_3, Met[2], PAMS, Beta	40.462182	- 74.429439	Horticultural Farm #3, 67 Ryders Lane, East Brunswick
MONMOUTH	Monmouth University	34 025 0005	O_3	40.277647	- 74.005100	Edison Science Bldg., 400 Cedar Avenue, West Long Branch
OCEAN	Cattus Island	N/A	ACID[3]	39.989400	-74.134400	1170 Cattus Island Blvd, Toms River
	Colliers Mills	34 029 0006	O_3	40.064830	-74.444050	Colliers Mills Wildlife Management Area, Success Rd. near Hawkin Rd., Jackson Twp.
	Toms River	34 029 2002	$PM_{2.5}$	39.994908	-74.170447	Hooper Avenue Elementary School, 1517 Hooper Avenue

[1] See Parameter Codes, Table 4 (page 8)
[2] Meteorological measurements at the site are collected by Rutgers University
[3] United States Fish and Wildlife Service-Air Quality Branch (USFWS-AQB) is responsible for sample collection.

FIGURE 3
SOUTHERN NEW JERSEY
AIR MONITORING SITES

Table 3
Southern New Jersey Air Monitoring Sites

County	Monitoring Site	AIRS Code	Parameter(s) Measured[1]	Coordinates (Decimal degrees)		Address
				Latitude	Longitude	
ATLANTIC	Atlantic City	34 001 1006	$PM_{2.5}$	39.363260	-74.431000	Atlantic Cape Community College, 1535 Bacharach Boulevard
	Brigantine	34 001 0006	Visibility, O_3, SO_2, Beta, $PM_{2.5}$, Hg, ACID[2]	39.464872	-74.448736	Edwin B. Forsythe National Wildlife Refuge Visitor Center, 800 Great Creek Road, Galloway
CAMDEN	Ancora State Hospital	34 007 1001	O_3	39.684250	- 74.861491	301 Spring Garden Road, Hammonton
	South Camden	34 007 0010	TEOM	39.923969	-75.122317	Camden County Municipal Utilities Authority, 1645 Ferry Avenue
	Camden RRF	34 007 0009	PM_{10}	39.912431	- 75.116864	600 Morgan Street
	Camden Spruce Street	34 007 0002	CO, NO_X, O_3, SO_2, $PM_{2.5}$, Spec, BTEX, BC, Toxics, Met, Beta	39.934446	-75.125291	226-298 Spruce Street
	Pennsauken	34 007 1007	$PM_{2.5}$	39.989036	-75.050008	Morris-Delair Water Treatment Plant, 8999 Zimmerman Ave.
CUMBERLAND	Millville	34 011 0007	NO_X, O_3, Beta	39.422273	- 75.025204	Next to 4425 South Main Road
GLOUCESTER	Clarksboro	34 015 0002	O_3	39.800339	-75.212119	Shady Lane Complex, 256 County House Road
	Gibbstown	34 015 0004	$PM_{2.5}$	39.830837	-75.284682	Municipal Maintenance Yard, 61 North School Street

[1] See Parameter Codes, Table 4 (page 8)

[2] United States Fish and Wildlife Service-Air Quality Branch (USFWS-AQB) is responsible for sample collection.

Table 4
Parameter Codes

ACID	Acid Deposition	Pb	Lead
BC	Black carbon measured by aethalometer	$PM_{2.5}$	Fine particles (2.5 microns or less) collected by a Federal Reference Method $PM_{2.5}$ sampler
Beta	Real-time $PM_{2.5}$ analyzer	PM_{10}	Coarse particles (10 microns or less) collected by a Federal Reference Method PM_{10} sampler
BTEX	Measures benzene, toluene, ethylbenzene and xylenes	PM_{coarse}	Difference between PM_{10} and $PM_{2.5}$ measurements
CO	Carbon monoxide	SO_2	Sulfur dioxide
Hg	Mercury	Spec	Speciated fine particles (2.5 microns or less)
Met	Meteorological parameters	SS	Smoke shade
NO_X	Nitrogen dioxide and nitric oxide	TEOM	Real-time $PM_{2.5}$ analyzer
NOy	Total reactive oxides of nitrogen	Toxics	Air toxics
O_3	Ozone	Visibility	Measured by nephelometer
PAMS	Photochemical Assessment Monitoring Station, measures ozone precursors		

Appendix B: 2015
Fine Particulate Speciation Summary

New Jersey Department of Environmental Protection

Table 1
2015 Fine Particulate Speciation Data
CAMDEN SPRUCE STREET NJ
Micrograms per Cubic Meter (μg/m³)

	Pollutant	Annual Average Concentration	Daily Average Maximum Concentration	Daily Average 2nd-Highest Concentration	Percent Above Minimum Detection Limit
1	Aluminum	0.037	0.268	0.189	93
2	Ammonium	0.751	2.670	2.360	100
3	Antimony	0.018	0.076	0.028	90
4	Arsenic	0.001	0.005	0.003	38
5	Barium	0.007	0.069	0.026	86
6	Bromine	0.004	0.015	0.014	98
7	Cadmium	0.002	0.019	0.014	22
8	Calcium	0.049	0.211	0.197	100
9	Cerium	0.006	0.092	0.039	88
10	Cesium	0.005	0.015	0.015	83
11	Chlorine	0.215	2.400	1.800	100
12	Chromium	0.003	0.034	0.017	59
13	Cobalt	0.001	0.004	0.002	90
14	Copper	0.005	0.039	0.018	100
15	Elemental carbon	0.634	2.160	1.808	100
16	Indium	0.011	0.030	0.027	91
17	Iron	0.140	1.130	0.552	100
18	Lead	0.003	0.019	0.012	78
19	Magnesium	0.017	0.157	0.069	97
20	Manganese	0.003	0.010	0.010	67
21	Nickel	0.001	0.008	0.006	64
22	Nitrate	1.450	6.860	5.010	100
23	Organic carbon	3.034	14.200	8.530	100
24	Phosphorus	0.005	0.008	0.008	88
25	Potassium	0.119	1.300	0.458	100
26	Rubidium	0.001	0.002	0.002	88
27	Selenium	0.001	0.005	0.003	98
28	Silicon	0.079	0.520	0.412	100
29	Silver	0.007	0.019	0.019	79
30	Sodium	0.142	0.522	0.428	100
31	Strontium	0.002	0.028	0.007	90
32	Sulfate	1.542	5.560	4.170	100
33	Sulfur	0.554	2.050	1.630	100
34	Tin	0.010	0.026	0.018	84
35	Titanium	0.004	0.021	0.016	98
36	Vanadium	0.001	0.002	0.002	86
37	Zinc	0.049	1.870	0.066	100
38	Zirconium	0.004	0.015	0.012	88

Table 2
2015 Fine Particulate Speciation Data
CHESTER NJ
Micrograms per Cubic Meter (µg/m³)

	Pollutant	Annual Average Concentration	Daily Average Maximum Concentration	Daily Average 2nd-Highest Concentration	Percent Above Minimum Detection Limit
1	Aluminum	0.026	0.252	0.122	88
2	Ammonium	0.505	2.120	2.000	98
3	Antimony	0.016	0.032	0.026	88
4	Arsenic	0.0004	0.004	0.002	23
5	Barium	0.006	0.045	0.027	88
6	Bromine	0.003	0.011	0.007	97
7	Cadmium	0.002	0.019	0.014	30
8	Calcium	0.015	0.136	0.048	95
9	Cerium	0.006	0.067	0.060	87
10	Cesium	0.004	0.013	0.008	82
11	Chlorine	0.007	0.038	0.031	91
12	Chromium	0.002	0.018	0.017	47
13	Cobalt	0.001	0.002	0.002	92
14	Copper	0.001	0.009	0.007	90
15	Elemental carbon	0.176	0.377	0.360	100
16	Indium	0.009	0.030	0.029	90
17	Iron	0.035	0.165	0.094	100
18	Lead	0.001	0.013	0.006	30
19	Magnesium	0.008	0.021	0.021	88
20	Manganese	0.001	0.004	0.003	43
21	Nickel	0.001	0.006	0.005	47
22	Nitrate	0.913	5.050	4.780	100
23	Organic carbon	1.936	10.200	6.310	100
24	Phosphorus	0.005	0.008	0.008	88
25	Potassium	0.043	0.377	0.132	100
26	Rubidium	0.001	0.003	0.002	83
27	Selenium	0.001	0.001	0.001	88
28	Silicon	0.046	0.486	0.275	97
29	Silver	0.007	0.019	0.019	83
30	Sodium	0.071	0.315	0.206	100
31	Strontium	0.001	0.007	0.003	80
32	Sulfate	1.326	5.110	3.400	100
33	Sulfur	0.475	1.910	1.320	100
34	Tin	0.010	0.018	0.018	83
35	Titanium	0.004	0.045	0.015	95
36	Vanadium	0.001	0.002	0.002	78
37	Zinc	0.005	0.013	0.013	98
38	Zirconium	0.004	0.012	0.012	85

Table 3
2015 Fine Particulate Speciation Data
ELIZABETH LAB NJ
Micrograms per Cubic Meter (µg/m^3)

	Pollutant	Annual Average Concentration	Daily Average Maximum Concentration	Daily Average 2nd-Highest Concentration	Percent Above Minimum Detection Limit
1	Aluminum	0.058	0.334	0.314	99
2	Ammonium	0.713	4.210	3.860	100
3	Antimony	0.018	0.063	0.059	88
4	Arsenic	0.0004	0.006	0.002	25
5	Barium	0.016	0.101	0.075	97
6	Bromine	0.003	0.021	0.018	97
7	Cadmium	0.003	0.028	0.024	35
8	Calcium	0.064	0.281	0.262	100
9	Cerium	0.004	0.026	0.022	84
10	Cesium	0.006	0.027	0.025	90
11	Chlorine	0.077	1.040	0.347	100
12	Chromium	0.002	0.038	0.019	59
13	Cobalt	0.001	0.003	0.003	89
14	Copper	0.009	0.051	0.031	100
15	Elemental carbon	1.088	3.720	3.242	100
16	Indium	0.009	0.043	0.036	86
17	Iron	0.194	0.519	0.498	100
18	Lead	0.003	0.028	0.021	61
19	Magnesium	0.016	0.066	0.051	94
20	Manganese	0.002	0.007	0.007	76
21	Nickel	0.001	0.013	0.008	66
22	Nitrate	1.578	8.190	7.810	100
23	Organic carbon	2.785	10.100	9.960	100
24	Phosphorus	0.005	0.008	0.008	89
25	Potassium	0.058	0.444	0.184	100
26	Rubidium	0.001	0.004	0.002	88
27	Selenium	0.001	0.003	0.003	88
28	Silicon	0.149	0.839	0.679	100
29	Silver	0.007	0.019	0.019	87
30	Sodium	0.146	0.555	0.482	100
31	Strontium	0.001	0.012	0.010	91
32	Sulfate	1.448	5.230	4.650	100
33	Sulfur	0.511	1.900	1.590	100
34	Tin	0.010	0.039	0.024	84
35	Titanium	0.007	0.030	0.027	99
36	Vanadium	0.002	0.009	0.005	85
37	Zinc	0.014	0.053	0.048	100
38	Zirconium	0.004	0.021	0.014	83

Table 4
2015 Fine Particulate Speciation Data
NEW BRUNSWICK NJ
Micrograms per Cubic Meter (μg/m³)

	Pollutant	Annual Average Concentration	Daily Average Maximum Concentration	Daily Average 2nd-Highest Concentration	Percent Above Minimum Detection Limit
1	Aluminum	0.026	0.281	0.222	86
2	Ammonium	0.493	2.960	2.910	99
3	Antimony	0.017	0.054	0.046	85
4	Arsenic	0.001	0.005	0.003	37
5	Barium	0.007	0.055	0.033	92
6	Bromine	0.003	0.011	0.007	95
7	Cadmium	0.002	0.027	0.019	26
8	Calcium	0.019	0.124	0.066	99
9	Cerium	0.005	0.057	0.042	87
10	Cesium	0.005	0.024	0.021	88
11	Chlorine	0.034	0.501	0.460	97
12	Chromium	0.003	0.096	0.021	53
13	Cobalt	0.001	0.002	0.002	94
14	Copper	0.003	0.020	0.017	97
15	Elemental carbon	0.375	1.068	0.955	100
16	Indium	0.009	0.027	0.023	87
17	Iron	0.068	0.381	0.256	100
18	Lead	0.002	0.034	0.013	58
19	Magnesium	0.011	0.062	0.044	90
20	Manganese	0.001	0.006	0.006	55
21	Nickel	0.001	0.030	0.006	54
22	Nitrate	1.180	6.820	6.340	100
23	Organic carbon	2.188	8.860	8.240	100
24	Phosphorus	0.005	0.008	0.008	89
25	Potassium	0.047	0.689	0.132	100
26	Rubidium	0.001	0.010	0.005	91
27	Selenium	0.001	0.003	0.003	87
28	Silicon	0.057	0.541	0.523	98
29	Silver	0.007	0.019	0.019	86
30	Sodium	0.099	0.451	0.447	100
31	Strontium	0.001	0.012	0.006	88
32	Sulfate	1.251	4.800	3.640	100
33	Sulfur	0.438	1.690	1.280	100
34	Tin	0.011	0.031	0.018	87
35	Titanium	0.004	0.025	0.022	96
36	Vanadium	0.001	0.004	0.002	86
37	Zinc	0.008	0.039	0.034	100
38	Zirconium	0.004	0.022	0.012	83

Table 5
2015 Fine Particulate Speciation Data
NEWARK NJ
Concentrations in Micrograms per Cubic Meter (µg/m³)

	Pollutant	Annual Average Concentration	Daily Average Maximum Concentration	Daily Average 2nd-Highest Concentration	Percent Above Minimum Detection Limit
1	Aluminum	0.052	0.591	0.402	93
2	Ammonium	0.632	3.990	3.040	100
3	Antimony	0.019	0.064	0.054	86
4	Arsenic	0.0003	0.003	0.002	24
5	Barium	0.009	0.062	0.050	90
6	Bromine	0.003	0.010	0.010	97
7	Cadmium	0.001	0.022	0.013	26
8	Calcium	0.046	0.243	0.198	98
9	Cerium	0.005	0.075	0.035	88
10	Cesium	0.005	0.033	0.023	87
11	Chlorine	0.064	0.557	0.394	98
12	Chromium	0.005	0.100	0.043	57
13	Cobalt	0.001	0.002	0.002	88
14	Copper	0.007	0.046	0.034	98
15	Elemental carbon	0.537	2.190	2.047	100
16	Indium	0.010	0.042	0.034	89
17	Iron	0.126	0.689	0.550	100
18	Lead	0.002	0.015	0.011	61
19	Magnesium	0.015	0.101	0.076	92
20	Manganese	0.002	0.011	0.009	63
21	Nickel	0.002	0.029	0.011	59
22	Nitrate	1.493	8.480	7.710	100
23	Organic carbon	2.624	9.780	9.740	100
24	Phosphorus	0.005	0.008	0.008	91
25	Potassium	0.064	1.450	0.158	100
26	Rubidium	0.001	0.002	0.002	87
27	Selenium	0.001	0.003	0.002	89
28	Silicon	0.108	1.280	1.060	100
29	Silver	0.007	0.019	0.019	84
30	Sodium	0.142	0.705	0.516	100
31	Strontium	0.001	0.028	0.005	90
32	Sulfate	1.343	5.110	4.060	100
33	Sulfur	0.466	1.840	1.350	100
34	Tin	0.012	0.055	0.054	87
35	Titanium	0.005	0.050	0.038	96
36	Vanadium	0.001	0.005	0.002	89
37	Zinc	0.013	0.060	0.052	99
38	Zirconium	0.004	0.020	0.015	82