2014 Particulate Summary

New Jersey Department of Environmental Protection

Nature and Sources

Particulate air pollution is a complex mixture of organic and inorganic substances present in the atmosphere in the form of 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 sources suspended in the atmosphere before reaching ground level.

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

Particulates can occur naturally or can be man-made. Examples of naturally-occurring particulates 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 a source, while secondary particulates are created in the atmosphere through reactions of gaseous emissions.

Figure 1
Size of $PM_{2.5}$ Particle Compared to a Human Hair

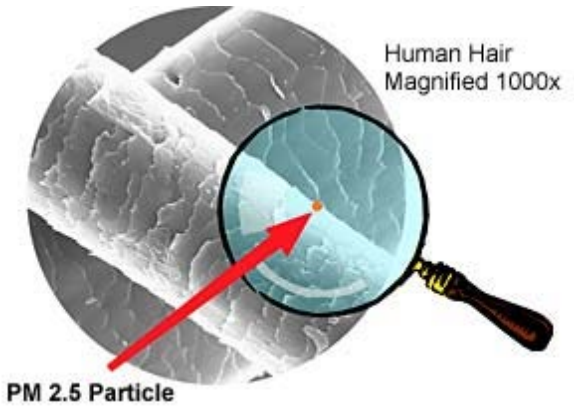


Figure 2a

Figure 2b

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 New Jersey Department of Environmental Protection's (NJDEP) visibility camera in Newark, which shows 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 regarding NJDEP's visibility efforts can be found in the Regional Haze and Visibility Summary section of the 2014 Air Quality Report.

HEALTH EFFECTS

Inhalable particulates (PM_{10}) and especially fine particulates ($PM_{2.5}$) 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, and can even contribute to premature death. People that appear to be at the greatest risk from particulates include children, the elderly, and individuals with heart and lung diseases.

AMBIENT AIR QUALITY STANDARDS

In 1971, the U.S. Environmental Protection Agency (USEPA) set primary (health-based) and secondary (welfare-based) standards for total suspended particulate matter (TSP). These standards, known as the National Ambient Air Quality Standards (NAAQS), were set for annual and maximum 24-hour concentrations. The annual standards were based on the geometric mean concentrations over a calendar year, and the 24-hour standards were based on the arithmetic average concentration from midnight to midnight. The primary 24-hour average standard for TSP was 260 micrograms per cubic meter ($\mu g/m^3$) and the annual geometric mean health standard was 75 $\mu g/m^3$. The 24-hour secondary standard was set at 150 $\mu g/m^3$. While USEPA did not establish a secondary annual standard for TSP, they did set a guideline of 60 $\mu g/m^3$ to be used to ensure that the secondary 24-hour standard was being met throughout the year. Although New Jersey still maintains a state standard for TSP, the national standards have been replaced with standards for smaller particles, as described below. As a result, the monitoring effort for TSP has steadily diminished. NJDEP's last TSP sampler was discontinued in early 2008.

In 1987, USEPA replaced the TSP standards with standards that focused only on PM_{10}. The 24-hour PM_{10} primary and secondary standards were set at 150 $\mu g/m^3$, and the annual primary and secondary standards were set at 50 $\mu g/m^3$. The annual standard for PM_{10} is based on the arithmetic mean, as opposed to the geometric mean that was used for TSP.

In 1997 USEPA promulgated new standards for $PM_{2.5}$, while maintaining the existing standards for PM_{10}. The $PM_{2.5}$ annual primary and secondary standards were set at 15.0 $\mu g/m^3$ and the 24-hour standard was set at 65 $\mu g/m^3$. In October 2006 USEPA lowered the 24-hour standard to the current value of 35 $\mu g/m^3$.

On December 14, 2012, USEPA promulgated a revised $PM_{2.5}$ annual standard of 12.0 $\mu g/m^3$ that went into effect on March 18, 2013. The 24-hour standard was unchanged and remains at 35 $\mu g/m^3$. Table 1 provides a summary of the particulate matter standards.

Table 1
National and New Jersey
Ambient Air Quality Standards for Particulate Matter
Micrograms Per Cubic Meter ($\mu g/m^3$)

Standard	Averaging Period	Type	New Jersey	National
Total Suspended Particulates (TSP)	12-Month‡	Primary	75 $\mu g/m^3$	---
	24-Hour	Primary	260 $\mu g/m^3$	---
	12-Month‡	Secondary	60 $\mu g/m^3$	---
	24-Hour	Secondary	150 $\mu g/m^3$	---
Inhalable Particulates (PM_{10})	Annual†	Primary & Secondary	---	50 $\mu g/m^3$
	24-Hour Average	Primary & Secondary	---	150 $\mu g/m^3$
Fine Particulates ($PM_{2.5}$)	Annual†	Primary & Secondary	----	12.0 $\mu g/m^3$ @
	24-Hour Average	Primary & Secondary	----	35 $\mu g/m^3$

‡ Annual geometric mean
† Annual arithmetic mean
@ Revision effective 2013.

PARTICULATE MONITORING NETWORK

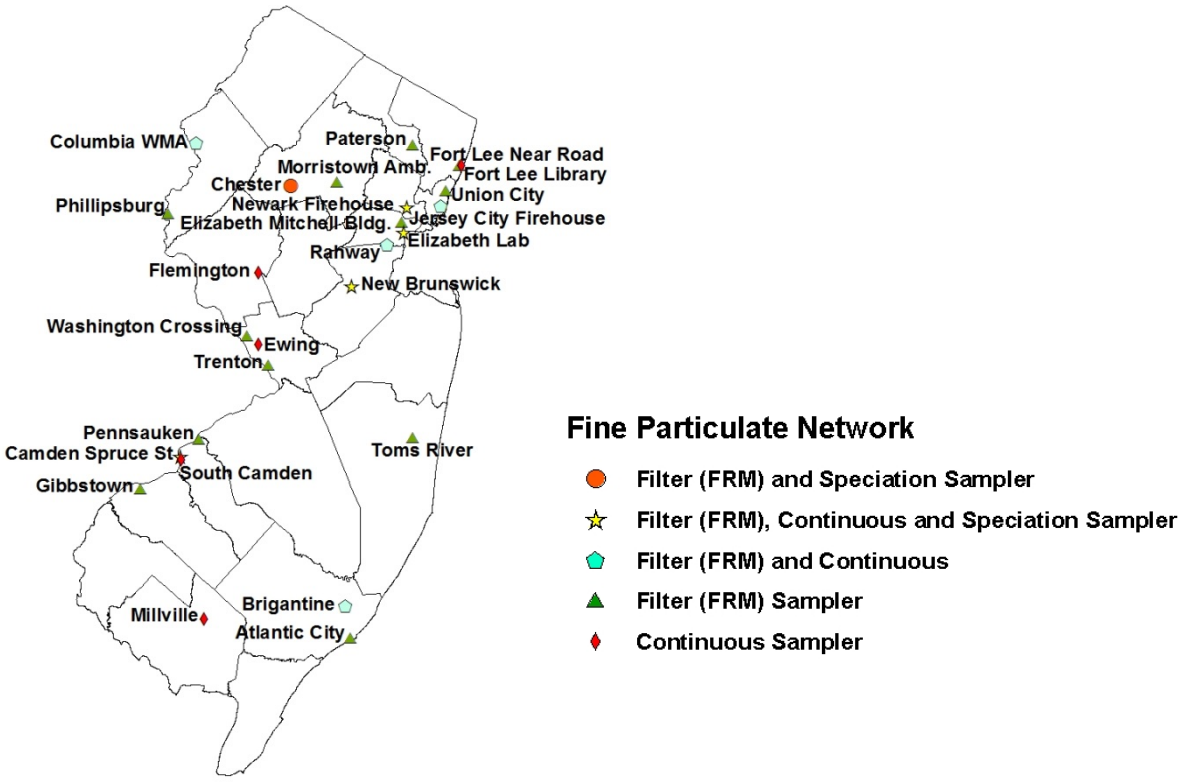
New Jersey's Particulate Monitoring Network consists of twenty-six $PM_{2.5}$ monitoring sites, two PM_{10} monitoring sites, and three sites where smoke shade is monitored.

NJDEP operates $PM_{2.5}$ and PM_{10} samplers that comply with strict USEPA requirements, and are designated as Federal Reference Method (FRM) samplers. These samplers pull a predetermined amount of air through $PM_{2.5}$ or PM_{10} size-selective inlets onto a filter 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. The data is then used by NJDEP and USEPA to determine whether the state, or portions of the state, meet the NAAQS for particulate matter.

The FRM samplers are required to run for a 24-hour period and 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 particulate concentrations. These include Beta Attenuation Monitors (BAM), Tapered Element Oscillating Microbalance (TEOM) analyzers, and smoke shade instruments. 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. 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. 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 will pass through the spot is measured, the tape is advanced, and the cycle is started over. The amount of light transmittance measured is used as an estimate of actual particulate concentrations.

Five monitoring stations make up a speciation network, employing a separate 24-hour filter-based sampler to determine the concentrations of the chemical analytes that constitute the sample. $PM_{2.5}$ 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
2014 $PM_{2.5}$
Monitoring Network



Fine Particle ($PM_{2.5}$) Summary

$PM_{2.5}$ Monitoring Sites

The 21 monitoring sites in New Jersey with FRM samplers that collect 24-hour $PM_{2.5}$ samples are shown on Figure 3. Also shown are thirteen sites that have continuous particulate monitors that measure the concentrations of fine particles every minute and transmit the data to the NJDEP website (www.njaqinow.net).

$PM_{2.5}$ Concentration Summary

The annual mean concentrations of $PM_{2.5}$ ranged from 7.1 $\mu g/m^3$ at Chester to 10.6 $\mu g/m^3$ at both the Camden Spruce St. and Union City monitoring locations. The highest 24-hour concentrations ranged from 19.1 $\mu g/m^3$ at Brigantine to 51.7 $\mu g/m^3$ at the Elizabeth Lab. Figures 4a and 4b depict the annual mean concentrations and the 98th percentile 24-hour concentrations for all the sites in 2014. Table 2 shows the 2014 annual mean, highest 24-hour and 98th percentile 24-hour concentrations, as well as the 2012-2014 annual and 24-hour design values. Design values are used to determine NAAQS attainment status. An annual design value for a given site is calculated by averaging the annual mean concentrations for the three most recent consecutive calendar years, in this case 2012-2014. Similarly, the 24-hour 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. 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 4a
2014 Fine Particulate ($PM_{2.5}$) Concentrations
Annual Average Concentration

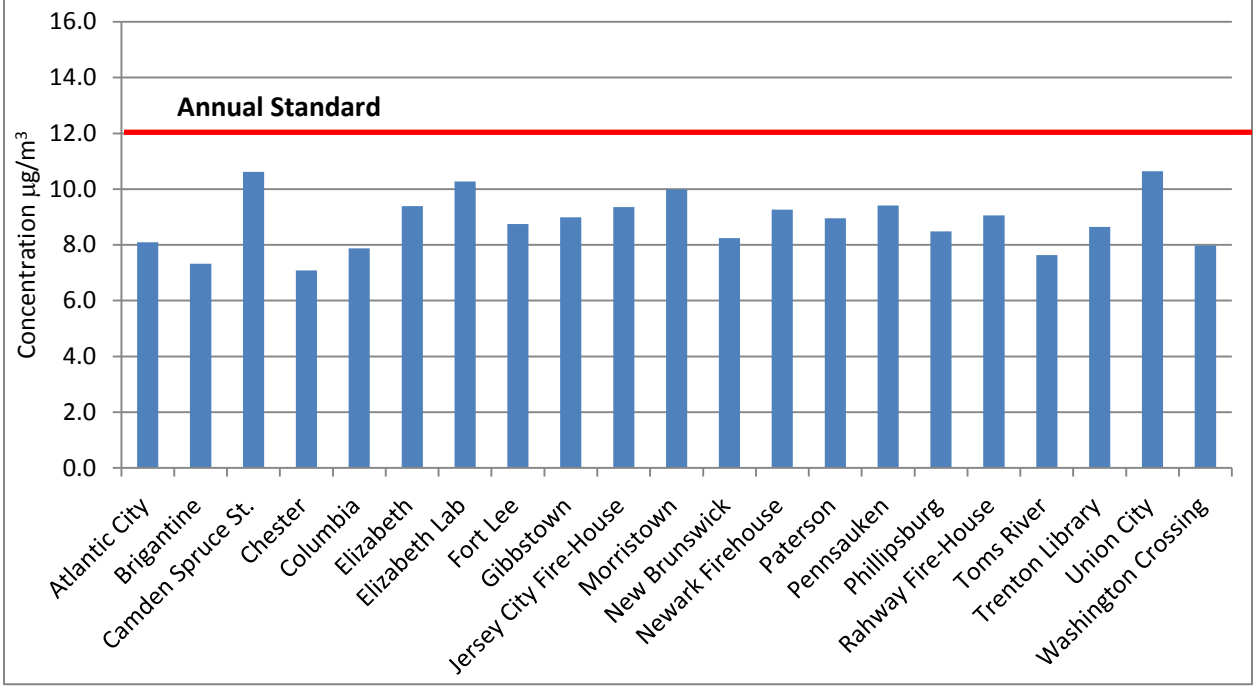


Figure 4b
2014 Fine Particulate ($PM_{2.5}$) Concentrations
98th Percentile 24-Hour Concentration

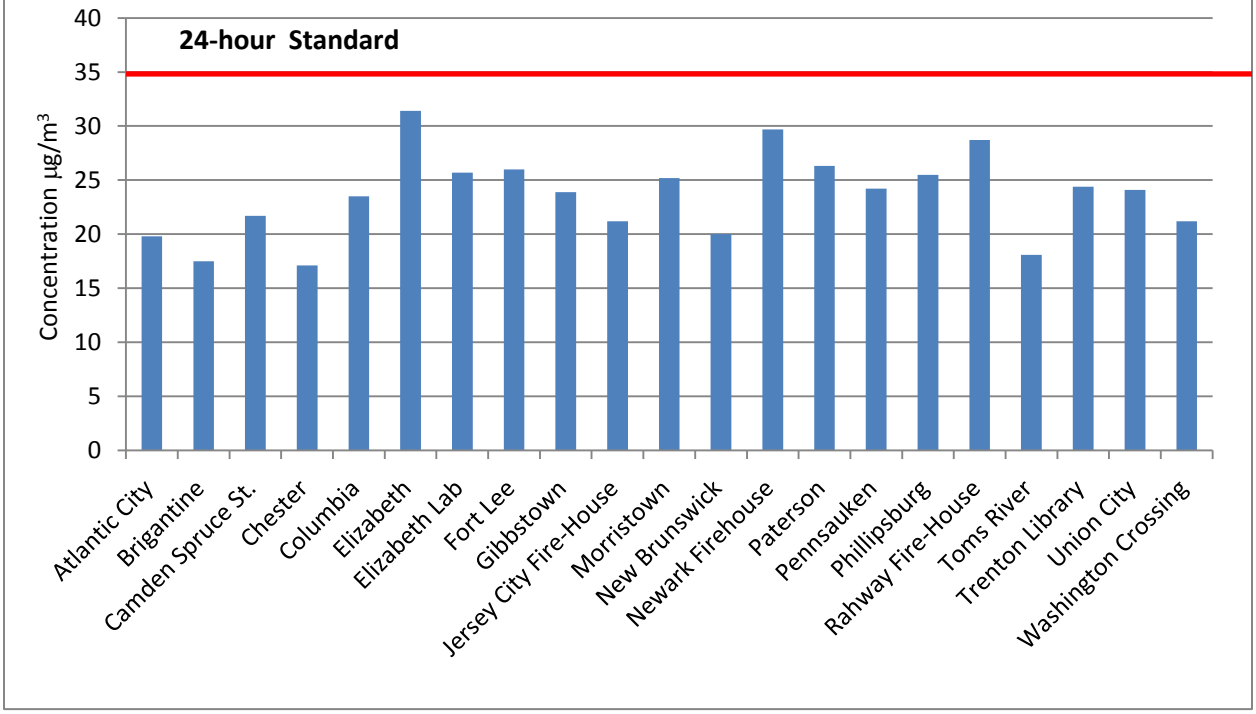


Table 2

2014 Summary of $PM_{2.5}$ Sampler Data

Concentrations in Micrograms per Cubic Meter (µg/m^3)

Monitoring Site	Number of Samples	Annual Mean Concen-tration	Highest 24-Hour Concen-tration	98th%-ile24-Hour Concen-tration	2012-2014 24-Hour Design Value (98th%-ile)	2012-2014 Annual Design Value
Atlantic City *	116	8.1	20.5	19.8	--	--
Brigantine	112	7.3	19.1	17.5	19	7.4
Camden Spruce St.*	119	10.6	27.6	21.7	--	--
Chester	112	7.1	19.6	17.1	17	7.2
Columbia WMA*	119	7.9	27.2	23.5	23	8.1
Elizabeth Mitchell Bldg.	120	9.4	37.9	31.4	26	9.3
Elizabeth Lab	360	10.3	51.7	25.7	27	10.5
Fort Lee Library	116	8.7	28.4	26.0	24	8.8
Gibbstown	116	9.0	27.5	23.9	23	9.2
Jersey City Firehouse	345	9.4	32.8	21.2	26	9.6
Morristown Amb. Squad	121	10.0	32.4	25.2	22	8.7
New Brunswick *	114	8.2	32.5	20.0	--	--
Newark Firehouse	118	9.3	41.4	29.7	24	9.0
Paterson	119	9.0	33.5	26.3	24	8.9
Pennsauken	116	9.4	28.4	24.2	21	9.1
Phillipsburg	117	8.5	31.2	25.5	23	8.7
Rahway	117	9.1	40.0	28.7	25	9.3
Toms River	335	7.6	21.0	18.1	19	7.8
Trenton	350	8.6	30.9	24.4	23	8.8
Union City	116	10.6	35.5	24.1	26	10.6
Washington Crossing	118	8.0	25.3	21.2	21	8.1

*Site does not have enough data to calculate 2012-2014 design values.

$PM_{2.5}$ Real-Time Monitoring

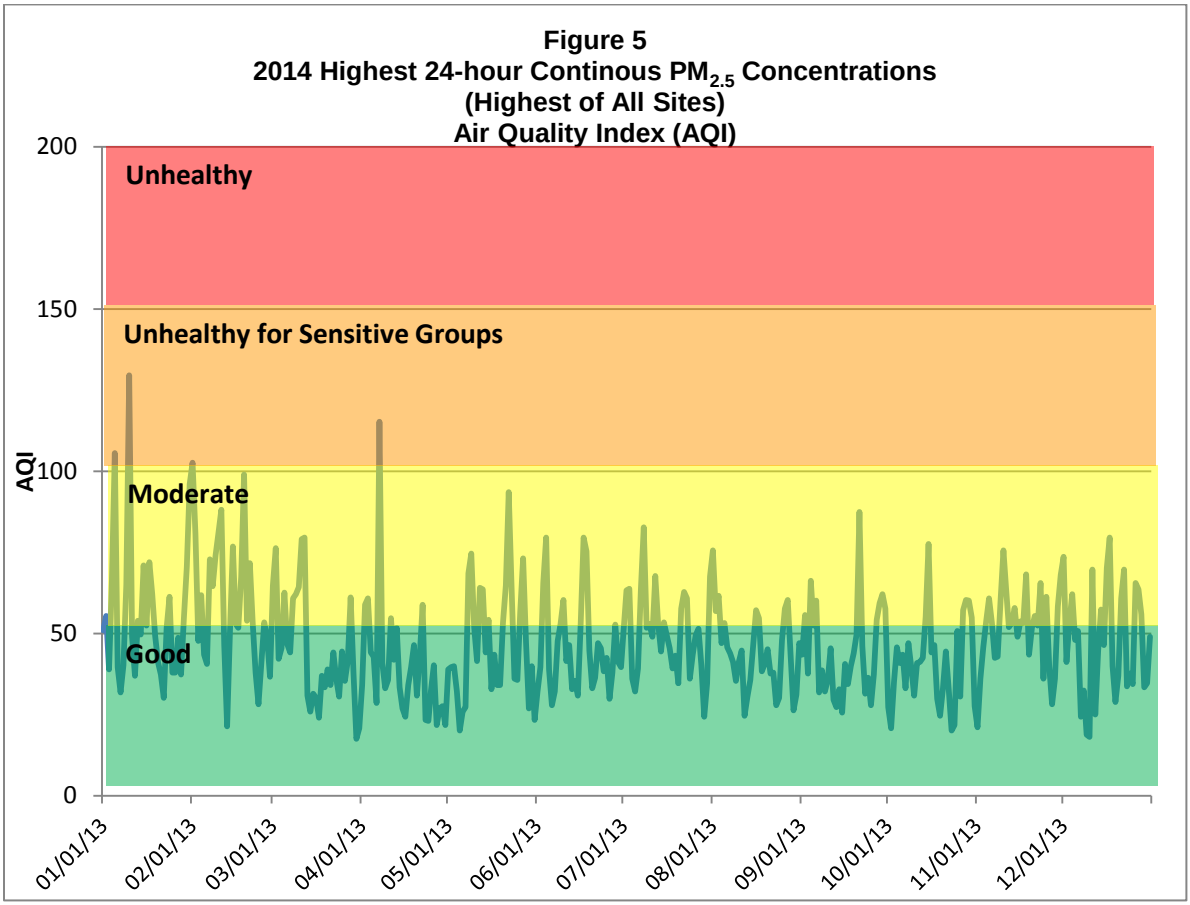
New Jersey's continuous $PM_{2.5}$ monitoring network includes thirteen sites: Brigantine, Camden Spruce Street, Columbia WMA, Elizabeth Lab, Ewing, Flemington, Fort Lee Near Road, Jersey City Firehouse, Millville, New Brunswick, Newark Firehouse, Rahway, and South Camden. The data is transmitted at least hourly to a central computer in Trenton, where it is averaged and automatically updated on the NJDEP website every hour. Table 3 provides a summary of the data from these sites. Figure 5 depicts the health level associated with the highest 24-hour fine particulate concentration recorded in the state each day for the entire year.

Table 3

2014 Summary of Continuous $PM_{2.5}$ Data

Concentration in Micrograms Per Cubic Meter ($\mu g/m^3$)

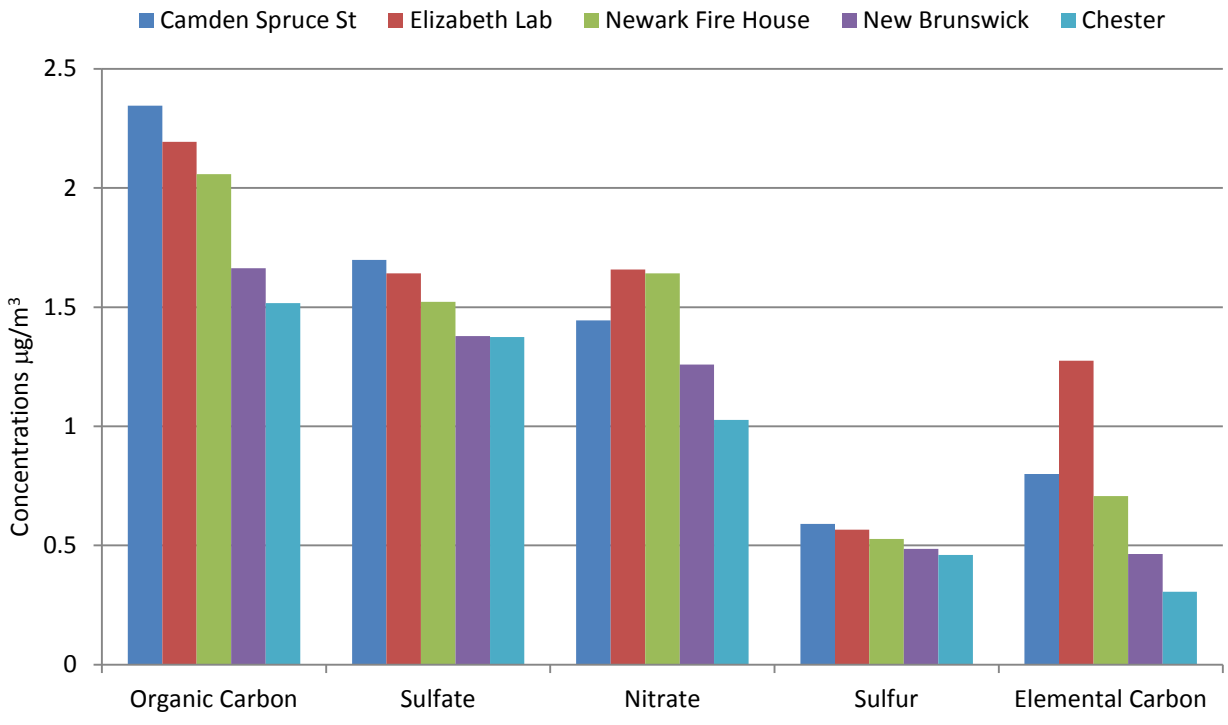
Monitoring Site	Annual Mean Concentration	Highest 24-Hour Concentration	Number of Unhealthy Air Quality Days
Brigantine	8.2	22.1	0
Camden Spruce St.	11.9	29.6	0
Columbia WMA	10.4	36.5	1
Elizabeth Lab	11.6	52.9	2
Ewing	8.1	21.0	0
Flemington	7.2	21.9	0
Fort Lee Near Road	11.0	32.8	0
Jersey City Firehouse	7.0	31.9	0
Millville	10.5	30.6	0
New Brunswick	10.3	44.2	2
Newark Firehouse	12.0	41.2	2
Rahway	9.6	28.5	0
South Camden	8.8	27.4	0



$PM_{2.5}$ Speciation Summary

New Jersey's $PM_{2.5}$ speciation network is located at five monitoring sites: Camden Spruce St., 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 6 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 2014 Air Quality Report.

Figure 6
2014 $PM_{2.5}$ Analyte Composition
(Highest Analytes Depicted)



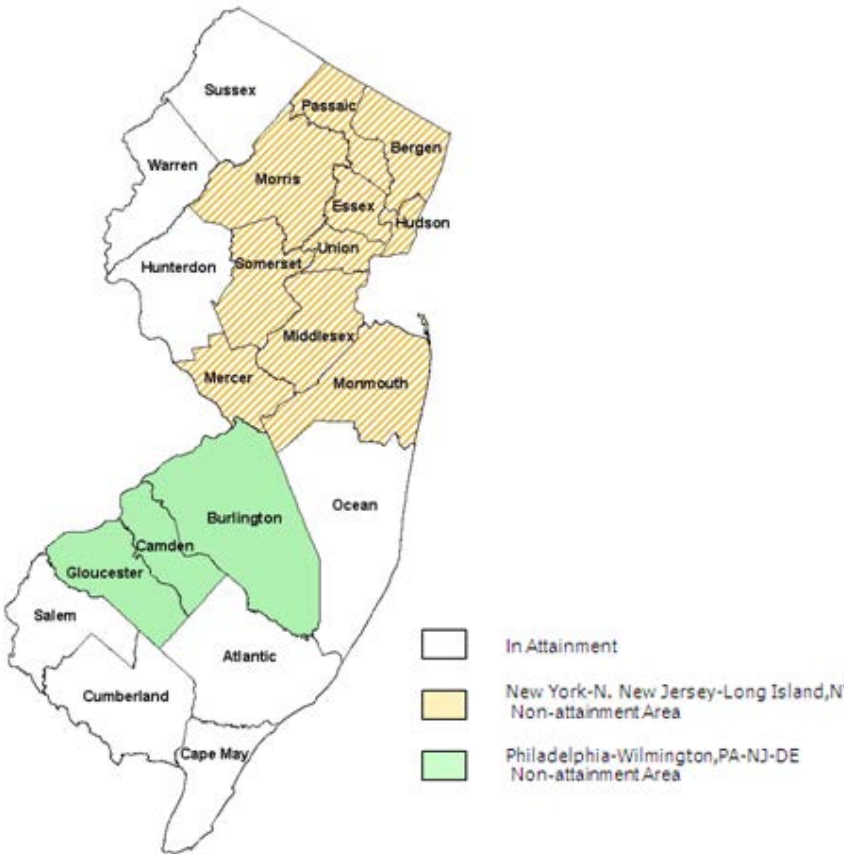
$PM_{2.5}$ Non-Attainment Areas

In order to determine if the $PM_{2.5}$ annual and 24-hour NAAQS are met in New Jersey, twelve consecutive quarters of valid data within three calendar years are required. A non-attainment classification is given to an area that violates the air quality standard or contributes to the violation of that standard. The state proposes the classification of attainment or non-attainment areas for the $PM_{2.5}$ NAAQS, but the final attainment or non-attainment designations are made by USEPA.

On April 5, 2005, thirteen New Jersey counties were designated by USEPA as non-attainment areas for $PM_{2.5}$. These counties are shown in Figure 7. While Elizabeth Lab was the only site to record a violation of the annual standard, 10 counties in the northeast and central region of the state were designated as non-attainment due to their potential $PM_{2.5}$ contribution to the Elizabeth Lab monitor, and to additional sites in New York City that also recorded violations of the $PM_{2.5}$ annual standard.

Similarly, three counties in the southwestern part of the state have been classified as non-attainment, due to their $PM_{2.5}$ contribution to monitors in the city of Philadelphia that violated the $PM_{2.5}$ NAAQS. NJDEP is currently devising a strategy to lower $PM_{2.5}$ levels in these affected areas.

Figure 7
New Jersey Fine Particulate Matter ($PM_{2.5}$)
Non-Attainment Areas

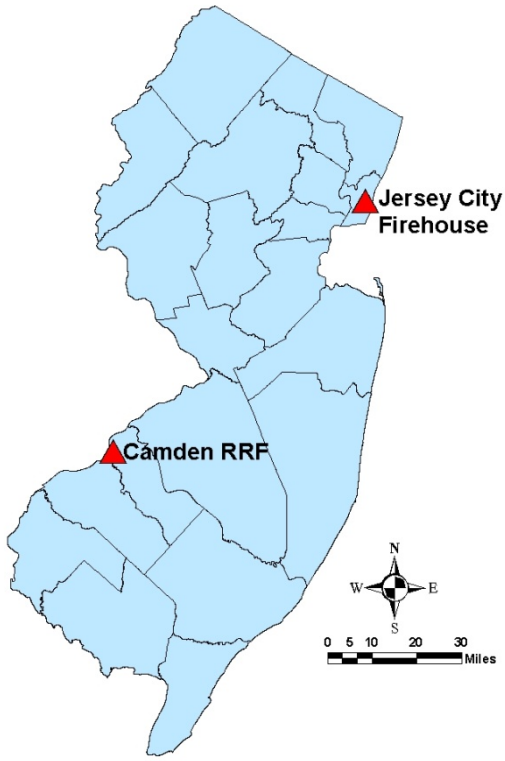


2014 INHALABLE PARTICULATE (PM_{10}) SUMMARY

PM_{10} MONITORING SITES

At one time, NJDEP's PM_{10} monitoring network consisted of more than 20 sampling sites. Due to many years of low concentrations and the shift in emphasis to fine particulate ($PM_{2.5}$) monitoring, the network has been reduced to only two sites, the Camden Resource Recovery Facility (RRF) and the Jersey City Firehouse. PM_{10} samples, taken once every six days, are collected on a filter that is weighed before and after sampling to determine the concentration. Figure 8 depicts the PM_{10} particulate monitoring network in New Jersey.

Figure 8
2014 $PM_{2.5}$ Monitoring Network



PM_{10} CONCENTRATION SUMMARY

In 2014, the annual mean concentrations measured at the Camden RRF and at the Jersey City Firehouse were 24 $\mu g/m^3$ and 17 $\mu g/m^3$, respectively. Table 4 and Figures 9a and 9b show the highest 24-hour and the annual mean PM_{10} concentrations. All areas of the state are in attainment for the both the annual PM_{10} standard of 50 $\mu g/m^3$ and the 24-hour standard of 150 $\mu g/m^3$.

Table 4
PM_{10} Data - 2014
24-Hour and Annual Averages

Micrograms Per Cubic Meter ($\mu g/m^3$)
24-hour Standard = 150 ($\mu g/m^3$)
Annual Standard = 50 $\mu g/m^3$

Monitoring Site	Number of Samples	Highest 24-Hour Concentration	Second Highest 24-Hour Concentration	Annual Mean
Camden RRF	52	97	57	24
Jersey City Firehouse	57	38	37	17

Figure 9a
Summary of 2014 New Jersey PM_{10} Concentrations

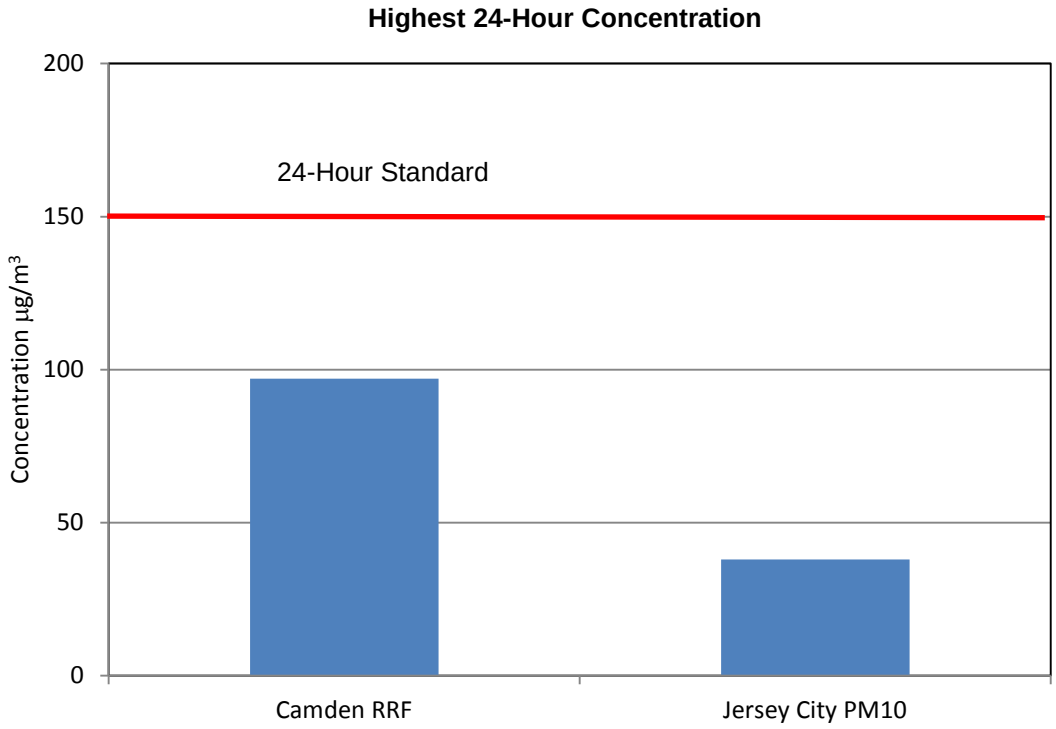
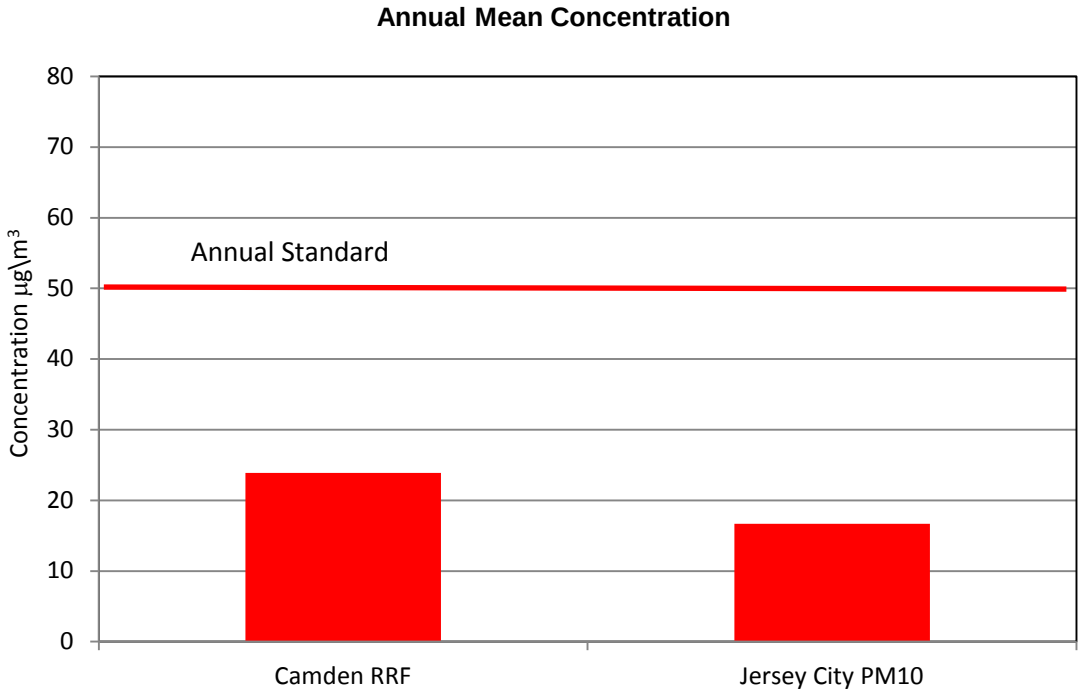


Figure 9b
Summary of 2014 New Jersey PM_{10} Concentrations



SMOKE SHADE SUMMARY

SMOKE SHADE MONITORING SITES

In addition to $PM_{2.5}$ and PM_{10}, smoke shade is also monitored at three stations around the state. Smoke shade, which is an indirect measurement of particles in the atmosphere, has been monitored in New Jersey for over 40 years. Smoke shade is primarily used for the daily reporting of particulate levels in the Air Quality Index. The sites which monitor smoke shade are shown in Figure 10.

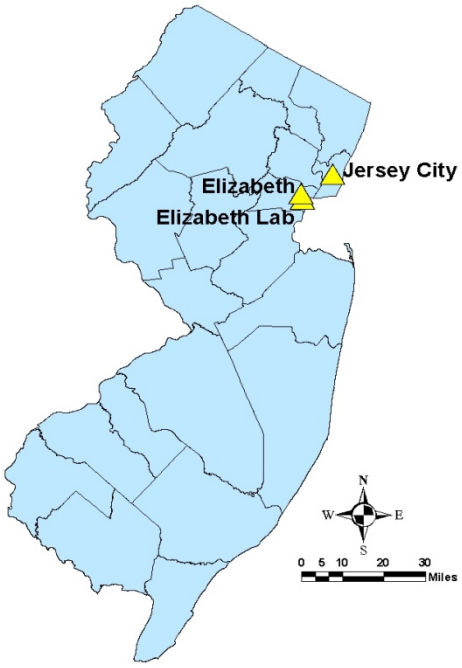
SMOKE SHADE CONCENTRATION SUMMARY

In 2014, the annual mean concentration of smoke shade ranged from 0.14 Coefficient of Haze units (COH) at the Elizabeth site, to 0.26 COH at both the Elizabeth Lab and Jersey City monitoring stations. COH are units of light transmittance; smoke shade is not a direct measure of particle mass. A 24-hour average level of 2.0 COH is used as a benchmark. Readings above the 2.0 COH benchmark are reported as "Unhealthy for Sensitive Groups" on the daily Air Quality Index. For more details see the Air Quality Index section of this report. Table 5 lists the highest and second highest 24-hour average, and annual mean smoke shade levels recorded at the monitoring sites in 2014.

Table 5
Smoke Shade - 2014
Coefficient of Haze (COHs)
No Standard

Site	Highest 24-Hour Average	2nd Highest 24-Hour Average	Annual Mean
Elizabeth	1.03	0.79	0.14
Elizabeth Lab	1.29	0.82	0.26
Jersey City	1.02	0.70	0.26

Figure 10
2014 Smoke Shade Network



TRENDS IN PARTICULATE CONCENTRATIONS

The longest continuously operating particulate monitoring network in the state that is suitable for looking at trends is the smoke shade network. As noted earlier, this monitoring program has been running for over forty years and still has three active sites. The trend graph for smoke shade in Figure 11 shows that particulate levels have steadily declined over the past 40 years. Smoke shade is not a direct measurement of particle mass, but can be related to TSP, PM_{10}, and $PM_{2.5}$ health standards.

The $PM_{2.5}$ monitoring network has been in place since 1999. Fifteen years of sampling has also shown a noticeable decline in fine particulate concentrations. Figure 12 shows the trend of the annual mean $PM_{2.5}$ concentrations for all FRM sampler sites since the network began operating.

Figure 11
Long-Term Trend in Particulate Levels as Smoke Shade
New Jersey State Averages
1967-2014

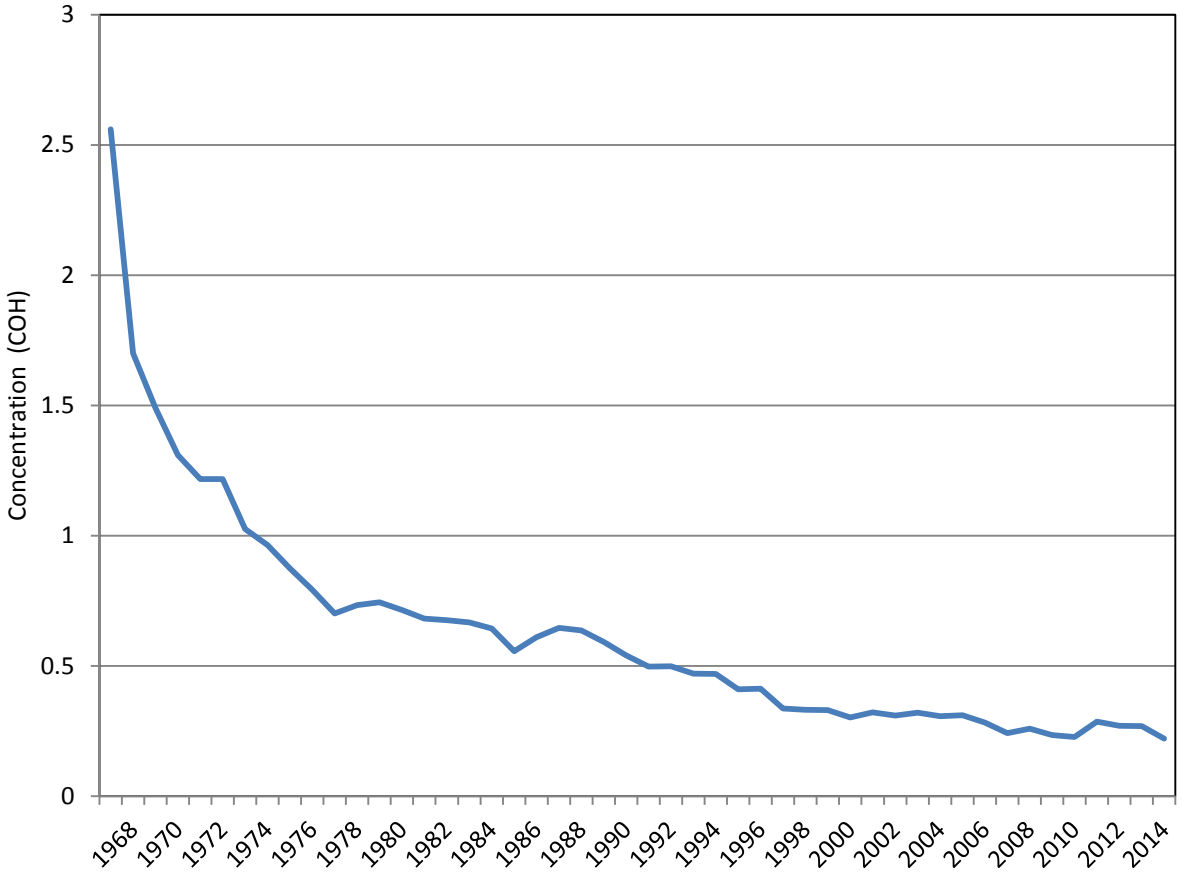
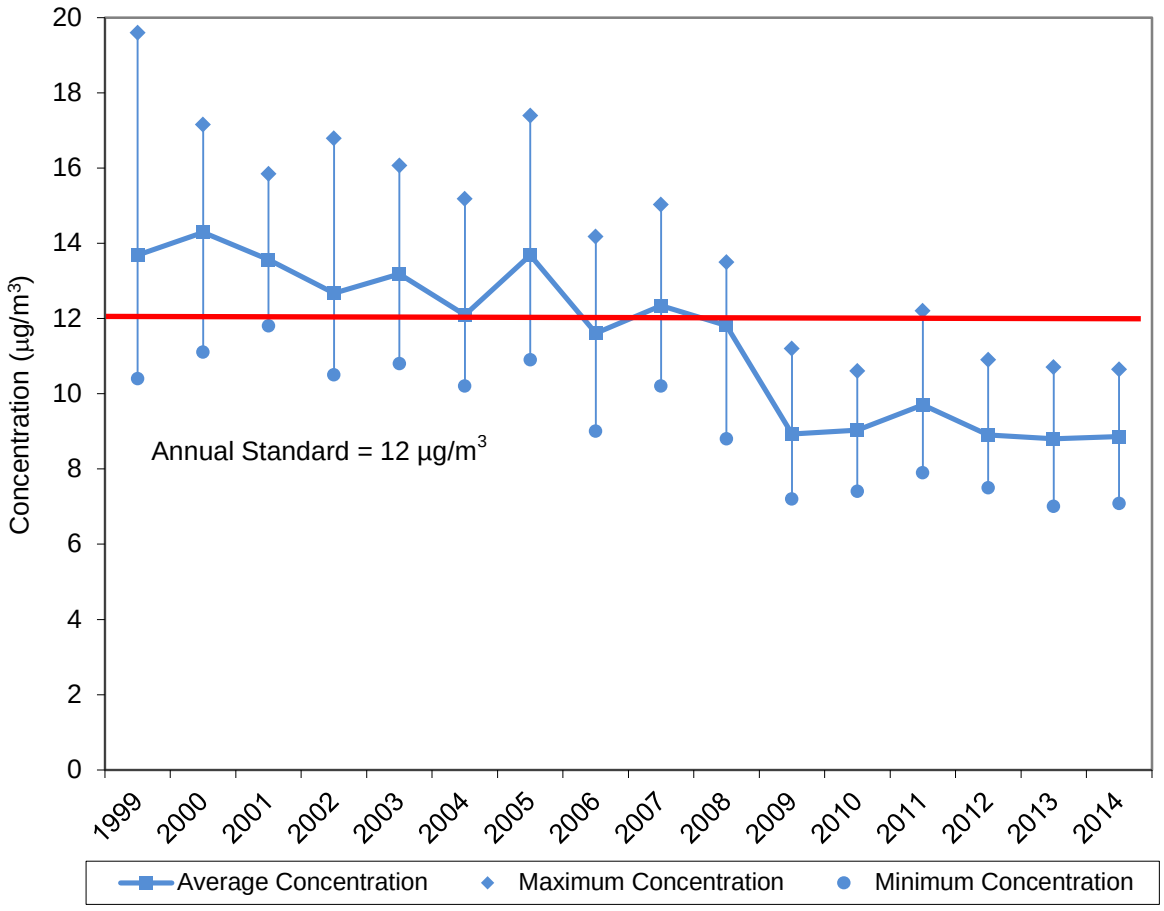


Figure 12
Long-Term Trend in $PM_{2.5}$ Annual Averages
for All Sites in New Jersey
1999-2014



Average Concentration = Average of all sites
Maximum Concentration = Maximum annual average site
Minimum Concentration = Minimum annual average site

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