2011 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 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. Also, particulates may travel hundreds of miles suspended in the atmosphere from their sources 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) consists of all suspended Particulates including the largest ones. Particulates smaller than 10 microns are considered to be inhalable and are a greater health risk, but particulates of all sizes have an impact on the environment.

Particulates can occur naturally or 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 two categories: Primary Particulates and Secondary Particulates. Primary Particulates are directly emitted from their sources while Secondary Particulates are created 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 New Jersey

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

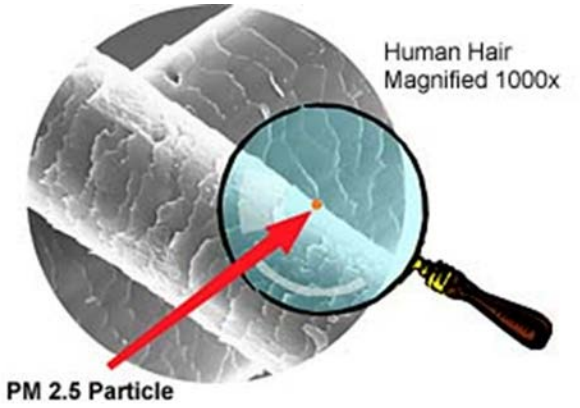


Figure 2a

Figure 2b

Department of Environmental Protection's (NJDEP) visibility camera in Newark that 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 is provided in the Regional Haze and Visibility section of the 2011 Air Quality Report.

HEALTH EFFECTS

Inhalable Particulates (PM_{10}) and especially Fine Particulates ($PM_{2.5}$) are health concerns because they are easily breathed into the lungs. Various health problems are associated with both long and short-term exposures. When inhaled, these particles can accumulate in the respiratory system and are responsible for heart and lung conditions, such as asthma, bronchitis, cardiac arrhythmias, heart attacks, and can even be attributed to premature death. Groups that appear to be at the greatest risk from particulates include children, the elderly, and individuals with heart and lung diseases, such as asthma.

STANDARDS

In 1971, U.S. Environmental Protection Agency (EPA) 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 based on maximum 24-hour and annual 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 set at 260 micrograms per cubic meter ($\mu g/m^3$) and the annual geometric mean health standard was set at 75 $\mu g/m^3$. The 24-hour secondary standard was set at 150 $\mu g/m^3$. While EPA 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 state standards 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 sole TSP sampler was discontinued in early 2008.

In 1987, EPA replaced the TSP standards with standards that focused only on Inhalable Particulates (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 arithmethic mean, as opposed to the geometric mean that was used for TSP.

In 1997, EPA promulgated new standards for Fine Particulates ($PM_{2.5}$), while maintaining the existing standards for PM_{10} as well. 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 the EPA revised the 24-hour Standard to the current value 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	----	15.0 $\mu g/m^3$
	24-Hour Average	Primary & Secondary	----	35 $\mu g/m^3$

‡ Annual Geometric Mean
† Annual Arithmetic Mean

PARTICULATE MONITORING NETWORK

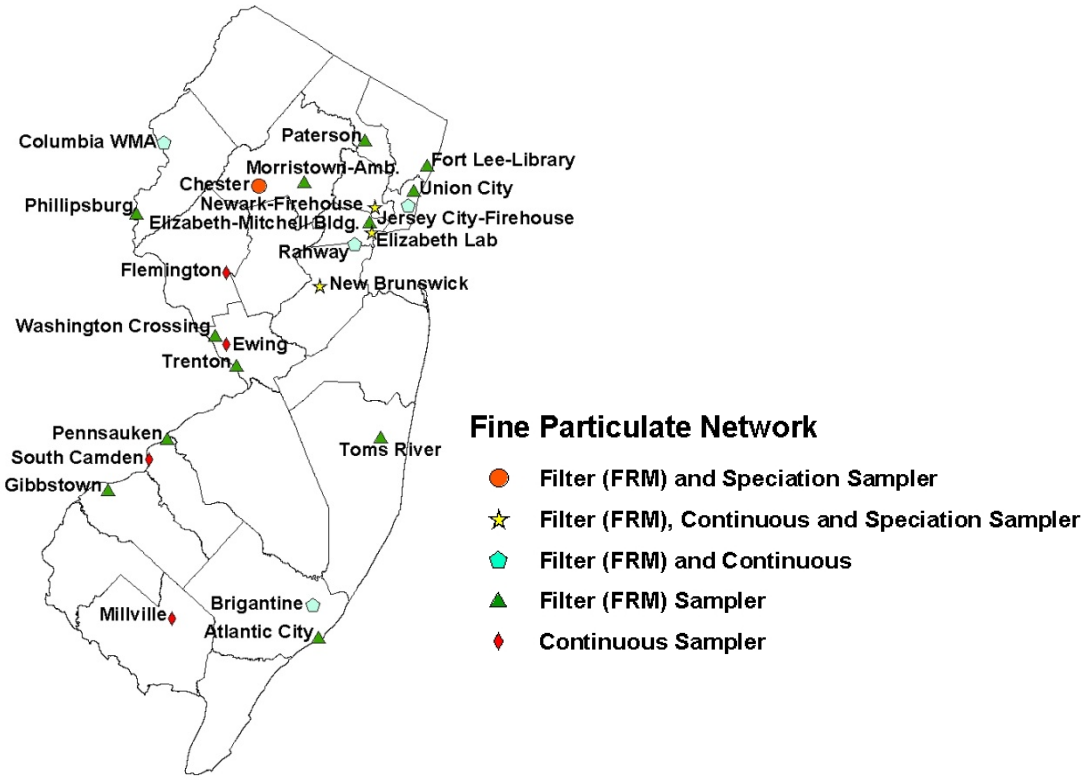
New Jersey's Particulate Monitoring Network consists of 24 $PM_{2.5}$ monitoring sites, 2 PM_{10} monitoring sites, and 3 sites where smoke shade is monitored. A third PM_{10} monitoring site at Trenton was discontinued in March 2011 due to many years of low concentrations.

The NJDEP operates $PM_{2.5}$ and PM_{10} samplers that comply with strict EPA 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, thereby capturing particles on the filter. The filters are weighed before and after sampling under controlled environmental conditions to determine the concentration. The data is then used by the NJDEP and EPA to determine whether the state, or portions of the state, meets the NAAQS for particulate matter.

Because these samplers are required to run for 24-hour period and do not provide data in real time, the NJDEP employs additional monitors that continuously measure particulate concentrations. These monitors are used by the NJDEP to report current air quality to the public through the Air Quality Index (www.njaqinow.net). The NJDEP uses Tapered Element Oscillating Microbalance (TEOM) analyzers and smoke shade instruments for real-time particulate reporting. 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. At the end of each hour the amount of light that will pass through the spot that has formed on the tape is measured, the tape advanced, and the cycle started over. The amount of light transmittance measured is used as an estimate of actual particulate concentrations.

Additionally, at four locations, a separate 24-hour filter based sampler collects $PM_{2.5}$ on three types of filter media which are subsequently analyzed using ion chromatography (IC), X-ray fluorescence (XRF), and Thermal Optical Transmittance (TOT) to determine the concentrations of the chemical analytes that constitute the sample.

Figure 3
2011 $PM_{2.5}$
Monitoring Network



FINE PARTICLE ($PM_{2.5}$) SUMMARY

$PM_{2.5}$ MONITORING SITES

The 20 monitoring sites in New Jersey where FRM samplers routinely collect 24-hour $PM_{2.5}$ samples are shown on Figure 3**.** At 11 sites, continuous particulate monitors (TEOMs) measure the concentrations of fine particles every minute and transmit the data to the Bureau of Air Monitoring's central computer, where it is made available on the Bureau's public website (www.njaqinow.net).

$PM_{2.5}$ CONCENTRATION SUMMARY

The annual mean concentrations of $PM_{2.5}$ ranged from 7.9 $\mu g/m^3$ at Chester to 12.2 $\mu g/m^3$ at the Elizabeth Lab. The highest 24-hour concentrations ranged from 24.8 $\mu g/m^3$ at Morristown to 42.4 $\mu g/m^3$ at the Elizabeth Lab. Figure 4a and 4b depict the annual mean concentrations and the 98th percentile 24-hour concentrations in 2011 for all the sites. Table 2 shows the 2011 annual mean, highest 24-hour and 98th percentile 24-hour concentrations as well as the 2009-2011 annual and 24-hour design values. An annual design value for a given site is calculated by averaging the annual mean concentrations for the 3 most recent consecutive calendar years, in this case 2009-2011. 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. Design values are used to determine attainment status. No sites were in violation of either the annual standard of 15.0 $\mu g/m^3$ or the 24-hour standard of 35 $\mu g/m^3$.

Figure 4a
2011 Fine Particulate ($PM_{2.5}$) Concentrations
Annual Mean Concentration

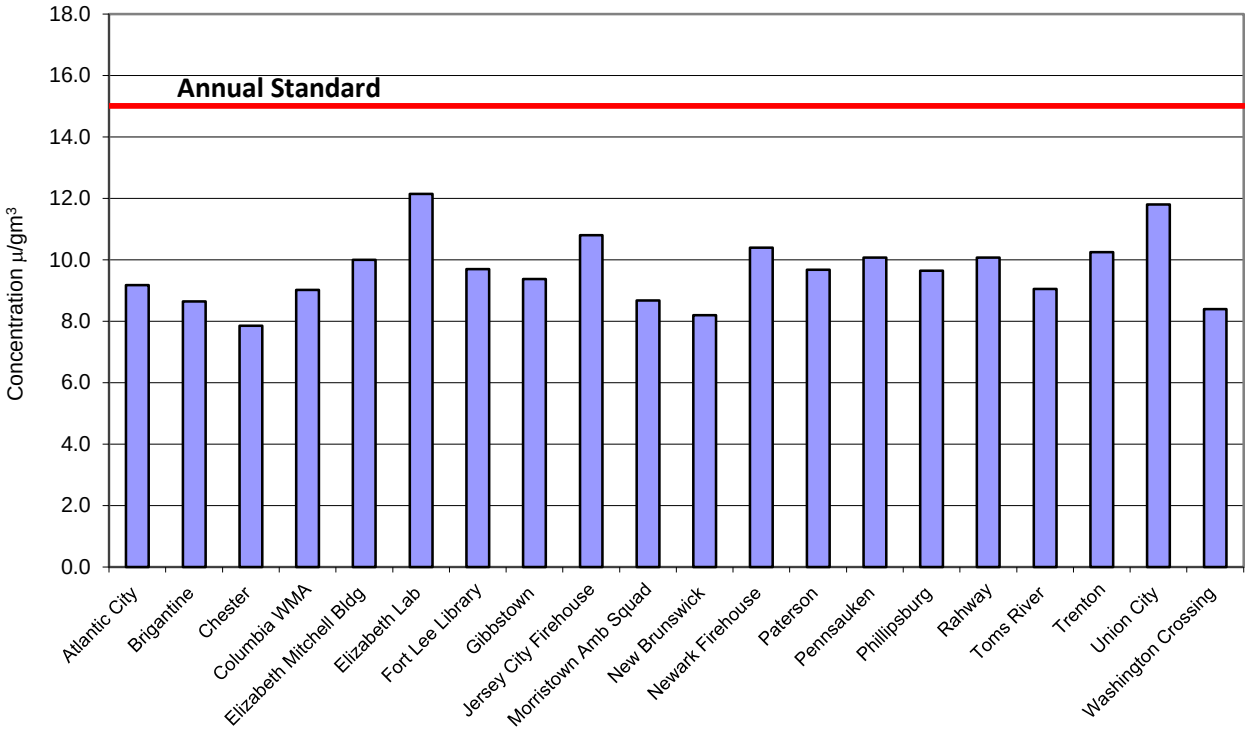


Figure 4b
2011 Fine Particulate ($PM_{2.5}$) Concentrations
98th Percentile 24-Hour Concentration

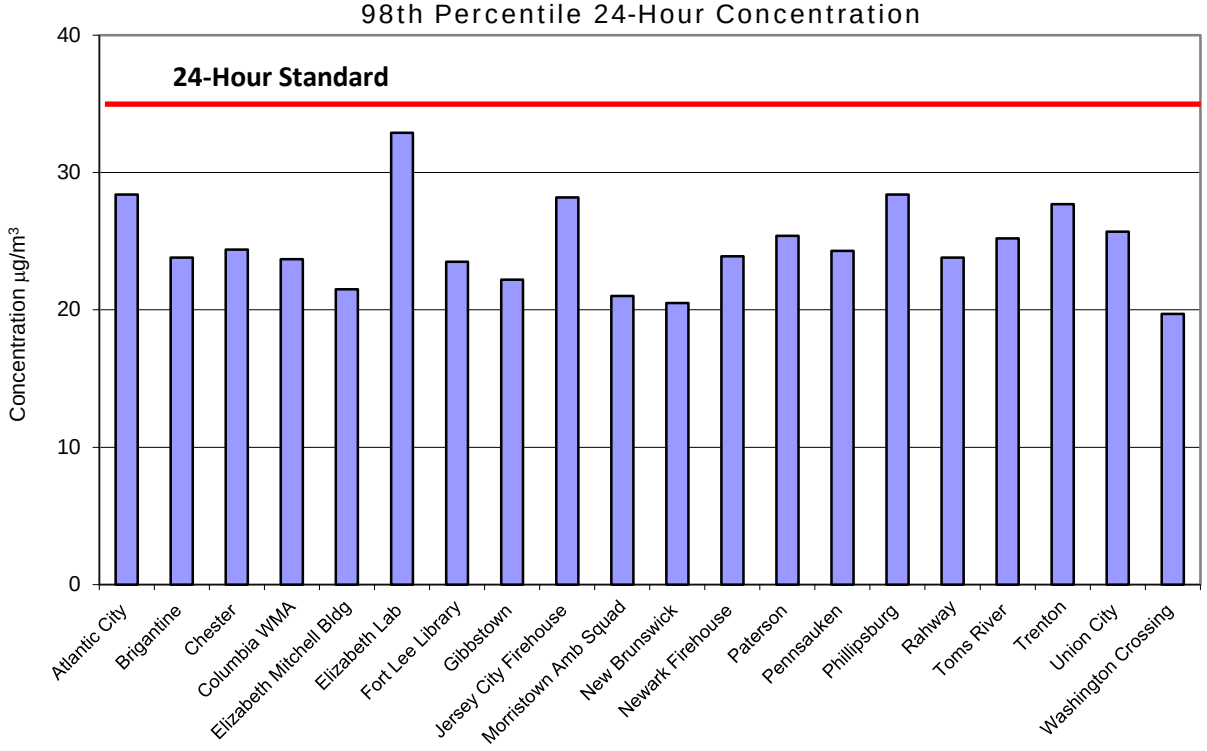


Table 2
2011 Summary of $PM_{2.5}$ Sampler Data

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

Monitoring Site	Number of Samples	Annual Mean Concentration	Highest 24-Hour Concentration	98th %-ile 24-Hour Concentration	2009-2011 24-Hour Design Value (98th %-ile)	2009-2011 Annual Design Value
Atlantic City	111	9.3	32.1	28.4	23	9.1
Brigantine	114	8.7	25.4	23.8	21	8.3
Chester	108	7.9	25.4	24.4	23	7.5
Columbia WMA*	319	9.0	39.1	27.8	-	-
Elizabeth Mitchell Bldg	109	10.0	29.5	21.5	24	9.5
Elizabeth Lab	330	12.2	42.4	32.9	30	11.3
Fort Lee Library	112	9.8	26.4	23.5	25	9.2
Gibbstown	117	9.4	30.7	22.2	22	9.2
Jersey City Firehouse	336	10.8	40.8	28.2	28	10.2
Morristown Amb Squad	112	8.7	24.8	21.0	22	8.4
New Brunswick	115	8.3	25.8	20.5	20	7.9
Newark Firehouse*	116	10.5	27.7	23.9	-	-
Paterson	107	10.1	34.0	25.4	25	9.2
Pennsauken	120	10.1	27.0	24.3	24	9.6
Phillipsburg	111	9.7	28.8	28.4	26	9.2
Rahway	116	10.1	27.0	23.8	24	9.6
Toms River	333	9.1	32.6	25.2	23	8.6
Trenton	349	10.3	33.8	27.7	26	9.7
Union City	115	11.9	26.8	25.7	26	11.0
Washington Crossing	108	8.4	25.4	19.7	20	8.1

* Site does not have enough data to calculate 2009-2011 design values.

$PM_{2.5}$ Real-Time Monitoring

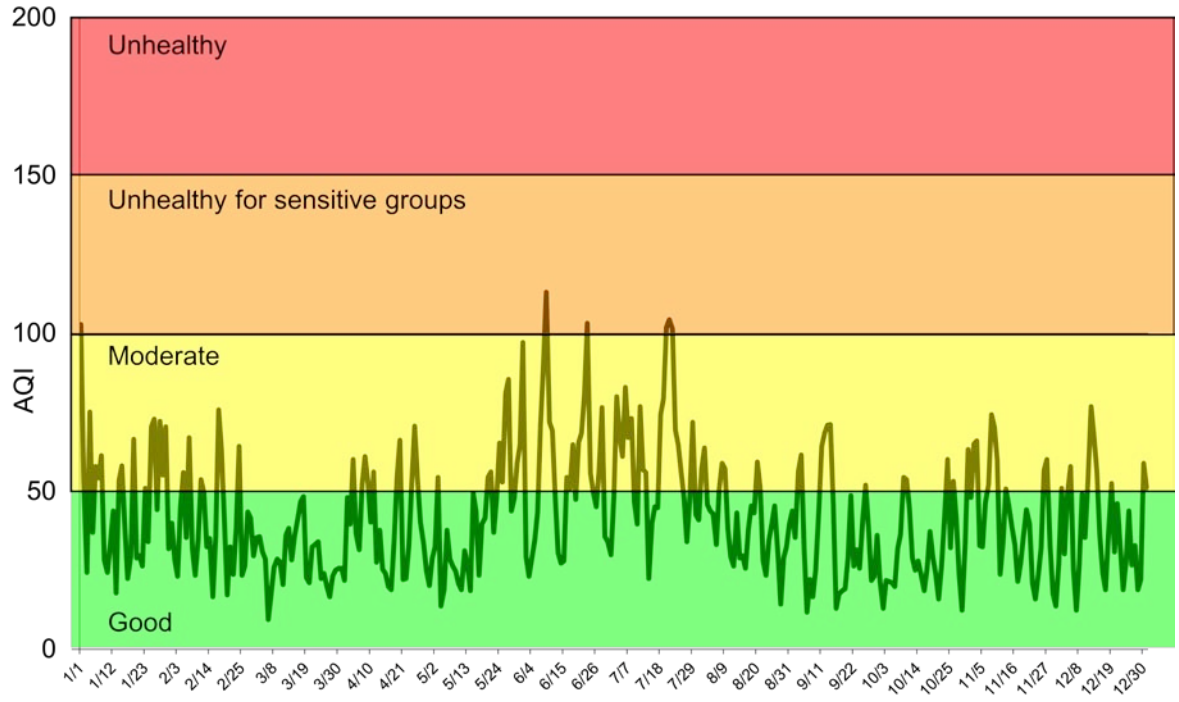
New Jersey's continuous $PM_{2.5}$ monitoring network consists of 11 sites: Brigantine, Columbia WMA, Elizabeth Lab, Ewing, Flemington, Jersey City Firehouse, Millville, New Brunswick, Newark Firehouse, Rahway and South Camden. The data is transmitted once a minute to a central computer in Trenton, where it is averaged and automatically updated on the Bureau's website every hour. Table 3 provides a summary of the data from these sites, and 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
2011 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	7.7	32.5	0
Columbia WMA	8.8	33.6	0
Elizabeth Lab	11.1	39.0	5
Ewing	6.9	27.3	0
Flemington	9.3	34.7	0
Jersey City Firehouse	10.1	38.7	3
Millville	8.8	37.9	1
New Brunswick	8.2	34.7	0
Newark Firehouse	8.4	36.6	1
Rahway	10.4	33.2	0
South Camden	9.7	42.8	2

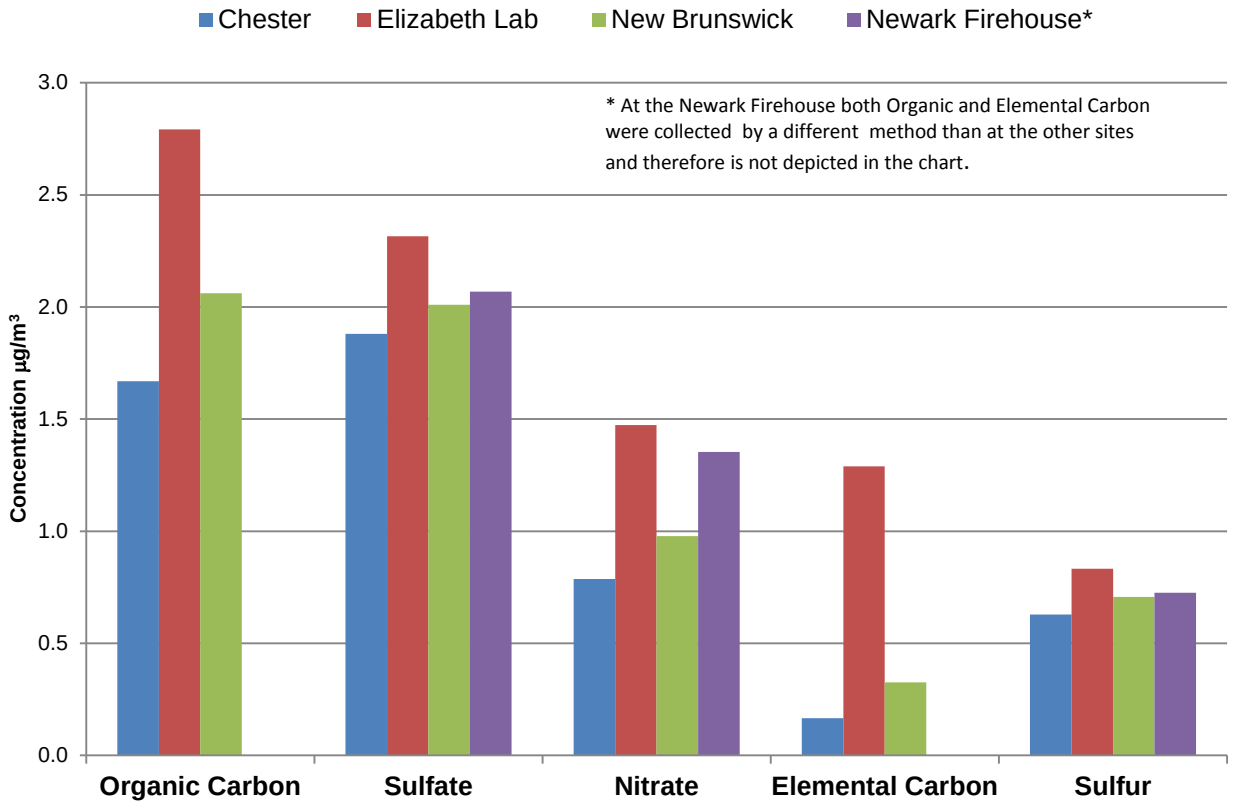
Figure 5
2011 Highest 24-Hour Continuous $PM_{2.5}$ Concentrations
(Highest of all Sites)
Air Quality Index (AQI)



$PM_{2.5}$ Speciation Summary

New Jersey's $PM_{2.5}$ Speciation Network consists of 4 monitoring sites: Elizabeth Lab, Newark Firehouse, New Brunswick, and Chester. Samplers run every third 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; and combined, they create the majority of the $PM_{2.5}$ total mass concentration. Figure 6 depicts the average concentration of these five most prevalent species. High organic and elemental carbon concentrations at Elizabeth Lab are due to the sites' proximity to high traffic volume, and motor vehicles are a primary source for those species. Appendix B of the 2011 Air Quality Report provides the average, highest, and 2nd highest 24-hour average concentrations for each species for 2011.

Figure 6
2011 $PM_{2.5}$ Analyte Composition
(Highest Analytes Depicted)



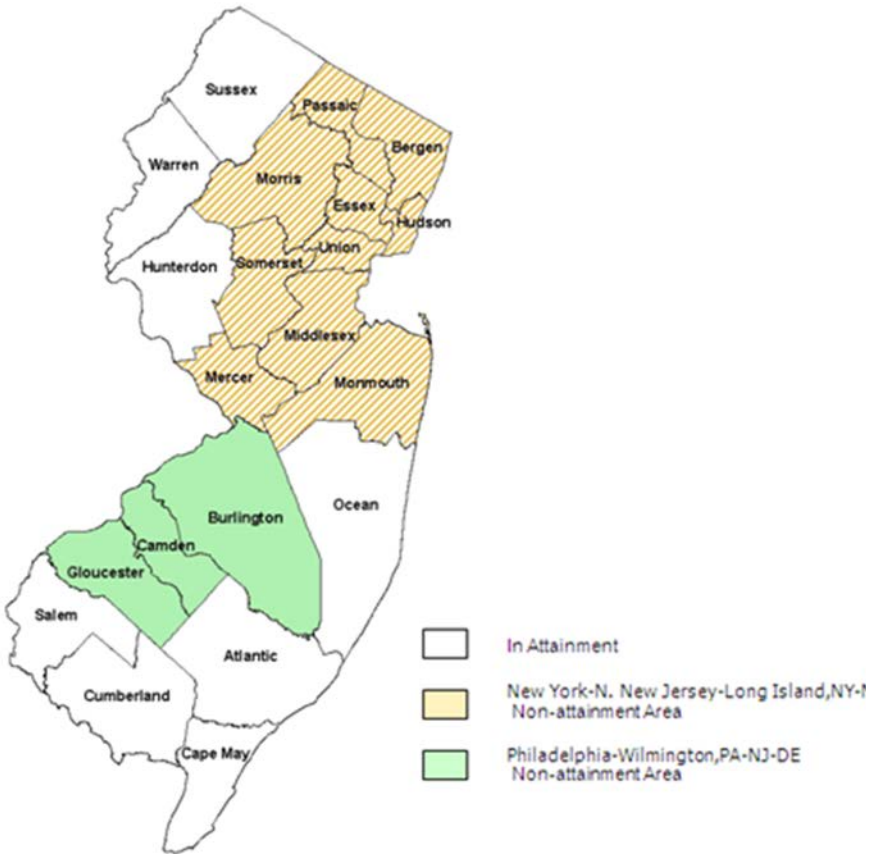
$PM_{2.5}$ NON-ATTAINMENT AREAS

In order to determine if the $PM_{2.5}$ annual or 24-hour NAAQS are met in New Jersey, 12 consecutive quarters of valid data within 3 calendar years are required. The classification of attainment or non-attainment areas for the $PM_{2.5}$ NAAQS is proposed by New Jersey, and final attainment or non-attainment designations are made by the EPA. Non-attainment classification is given to an area that violates the air quality standard or contributes to the violation of that standard.

On April 5, 2005, thirteen New Jersey counties were designated by the EPA as non-attainment areas for $PM_{2.5}$. 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 recorded violations of the $PM_{2.5}$ annual standard.

Similarly, 3 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. DEP 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

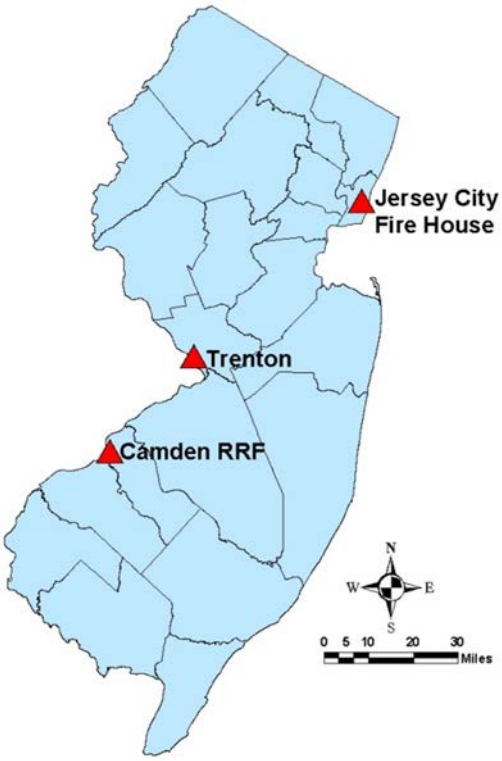


2011 INHALABLE PARTICULATE (PM_{10}) SUMMARY

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 greater focus on fine particulate monitoring ($PM_{2.5}$), the network has been reduced to its current level of only 2 sites, Camden RRF and the Jersey City Firehouse. A third site, Trenton was discontinued in March 2011 due to many years of low concentrations. 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
2011 PM_{10}
Monitoring Network



PM_{10} Concentration Summary

In 2011, the annual mean concentration measured at the Camden RRF and at the Jersey City Firehouse was 33 $\mu g/m^3$ and 30 $\mu g/m^3$ respectively. Table 4 and Figures 9a and 9b show the annual mean and highest 24-hour PM_{10} concentrations. All areas of the state are in attainment for the both the annual PM_{10} standards of 50 $\mu g/m^3$ and the 24-hour standard of 150 $\mu g/m^3$.

Table 4
PM_{10} Data - 2011
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	60	77	74	33
Jersey City Firehouse	57	63	61	30
Trenton*	14	29	26	-

*The Trenton sampler was discontinued on March 31, 2011 and therefore does not have enough data to calculate the annual mean

Figure 9a
Summary of PM_{10} Concentrations, New Jersey 2011

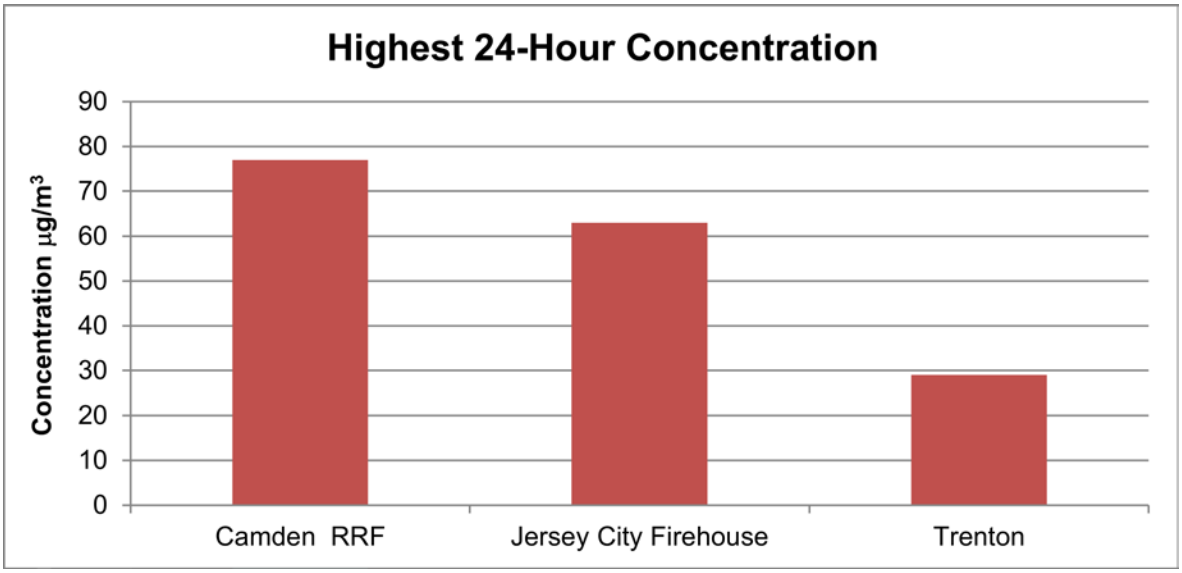
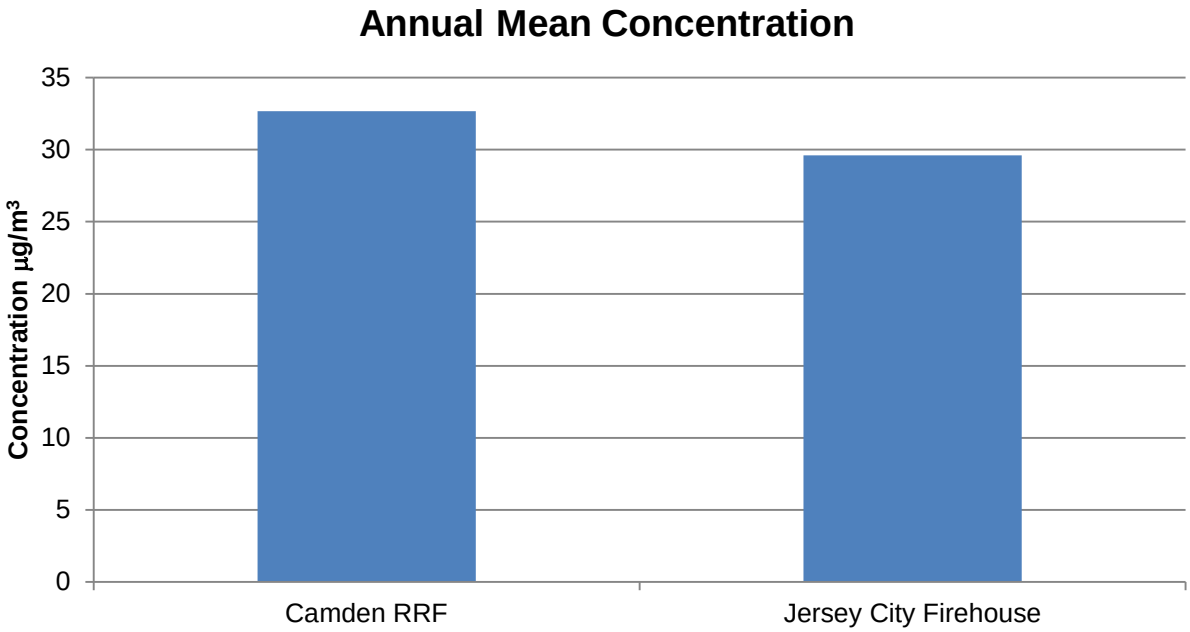


FIGURE 9B
Summary of PM_{10} Concentrations, New Jersey 2011



SMOKE SHADE SUMMARY

SMOKE SHADE MONITORING SITES

In addition to $PM_{2.5}$ and PM_{10} monitoring, smoke shade is also monitored at 3 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 monitoring smoke shade are shown in Figure 10.

SMOKE SHADE CONCENTRATION SUMMARY

In 2011, the annual mean concentration of smoke shade ranged from 0.21 Coefficient of Haze units (COH) at the Elizabeth site to 0.39 COH at the Elizabeth Lab. COH are units of light transmittance, and 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 2011.

Figure 10

2011 Smoke Shade Network

Table 5
Smoke Shade - 2011

Coefficient of Haze (COHs)
No Standard

Site	Highest 24-Hour Average	2nd Highest 24-Hour Average	Annual Mean
Elizabeth	0.65	0.59	0.20
Elizabeth Lab	0.99	0.95	0.39
Jersey City	0.90	0.88	0.29

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 40 years and still has 3 active sites. The trend graph for smoke shade, shown in Figure 11 indicates 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. Twelve years of sampling has shown a noticeable decline in fine particulate concentrations. Figure 12 shows the trend of the annual mean $PM_{2.5}$ concentrations for all sites since the network began.

Figure 11
Long Term Trends in Particulate Levels as Smoke Shade
State Average
1967-2011

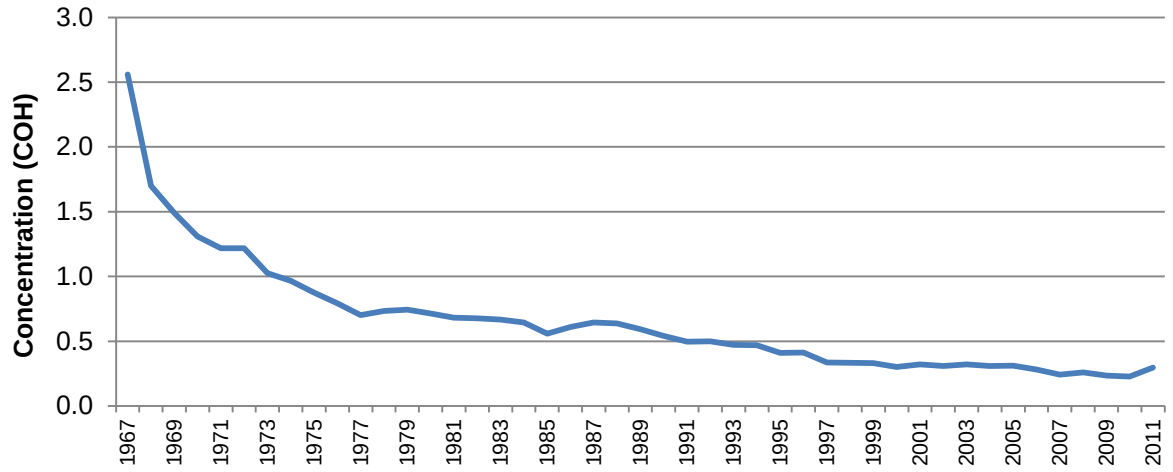
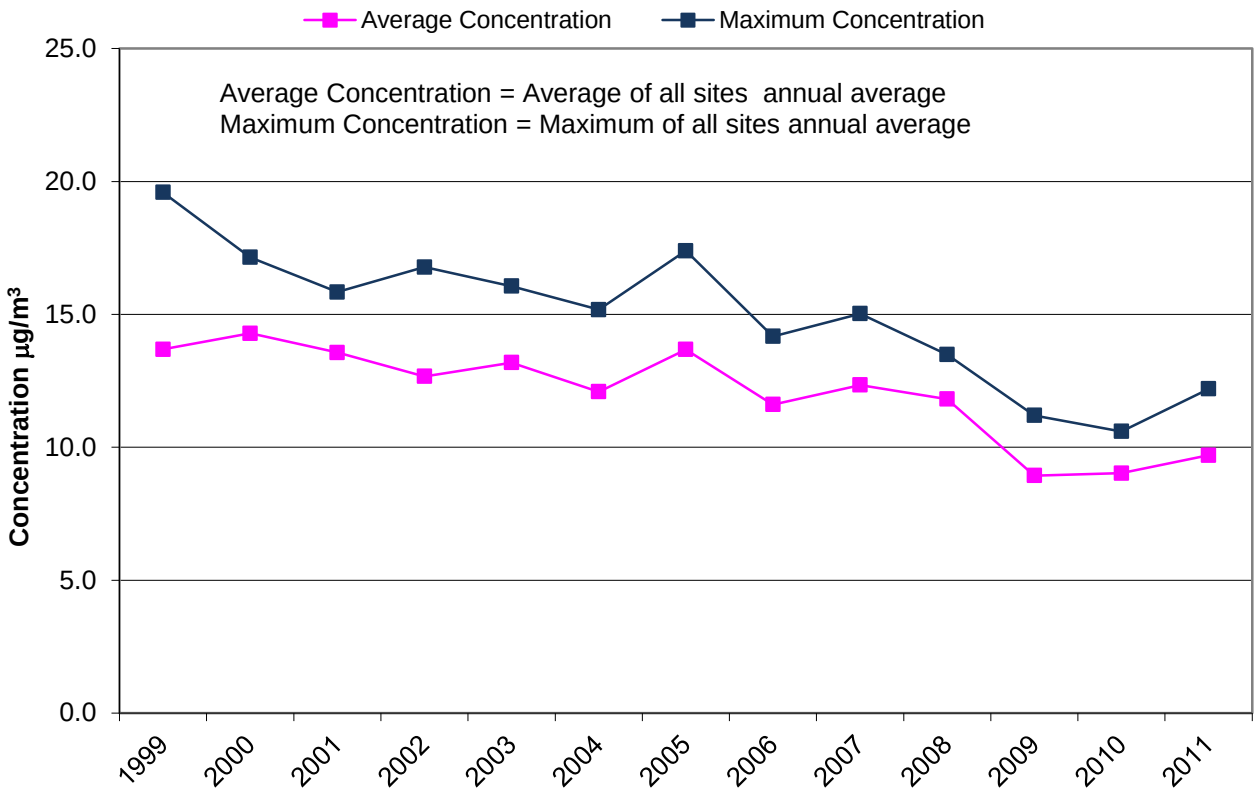


Figure 12
New Jersey
Trend of $PM_{2.5}$ Annual Averages of All Sites
1999-2011



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