2005 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. Particles may travel hundreds of miles suspended in the atmosphere from their sources before reaching ground level.

Generally particulate pollution is categorized by size. Particles with diameters less than 2.5 microns are considered fine Particulates, often referred to as $PM_{2.5}$ (Figure 1). Particles with diameters greater than 2.5 microns are considered to be coarse Particulates. Coarse particles are further divided into Total Suspended Particulates (TSP) and PM_{10}. TSP consists of all suspended particles including the largest ones. PM_{10} consists of particles that are 10 microns in diameter or less. Particles smaller than 10 microns are considered to be inhalable and are a greater health risk. Particles of all sizes have an impact on the environment.

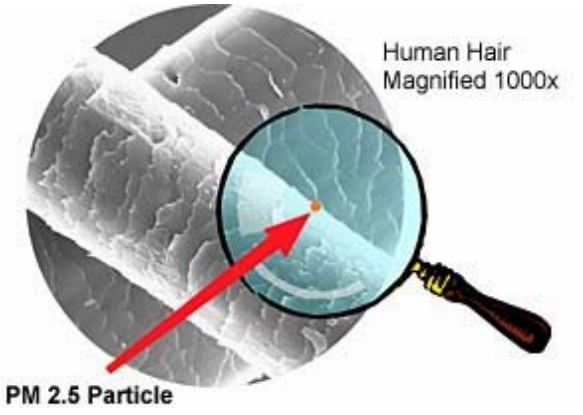
Particulates can occur naturally or be man made. Examples of naturally occurring particulates are windblown dust and sea salt. Man made particulates come from sources such as fossil fuel combustion and industrial processes. Man made sources can be divided into two categories Primary Particulates and 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 our WebCam site in Newark. Figure 2b is an example of a day with low particulate pollution and good visibiltiy. The backdrop is the New York City sky-line. Airborne particles can also impact vegetation and aquatic ecosystems, and can cause damage to paints and building materials. More information is provided in the Regional Haze section of this report.

Figure 1

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



Graphics Courtesy of the US Department of Energy

Figure 2a

Figure 2b

HEALTH EFFECTS

Inhalable particles (smaller than 10 microns) and especially fine particles ($PM_{2.5}$) are a health concern 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 (*US EPA, 2001).*

STANDARDS

In 1971, 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 (*US EPA, 1997)*. 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, monitoring for TSP has largely been discontinued, with the exception of one station, where TSP samples are taken to analyze for lead (Pb). See the Lead Summary section for more details.

In 1987, EPA replaced the TSP standards with standards that focused only on inhalable particles. Inhalable particles are defined as particles less than 10 microns in diameter (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, which it defined as particles less than 2.5 microns in diameter ($PM_{2.5}$). They kept the existing standards for PM_{10} as well. The $PM_{2.5}$ annual primary and secondary standards were set at 15 $\mu g/m^3$ and the 24-hour standard was set at 65 $\mu g/m^3$. 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 $\mu g/m^3$
	24-Hour Average	Primary & Secondary	----	65 $\mu g/m^3$

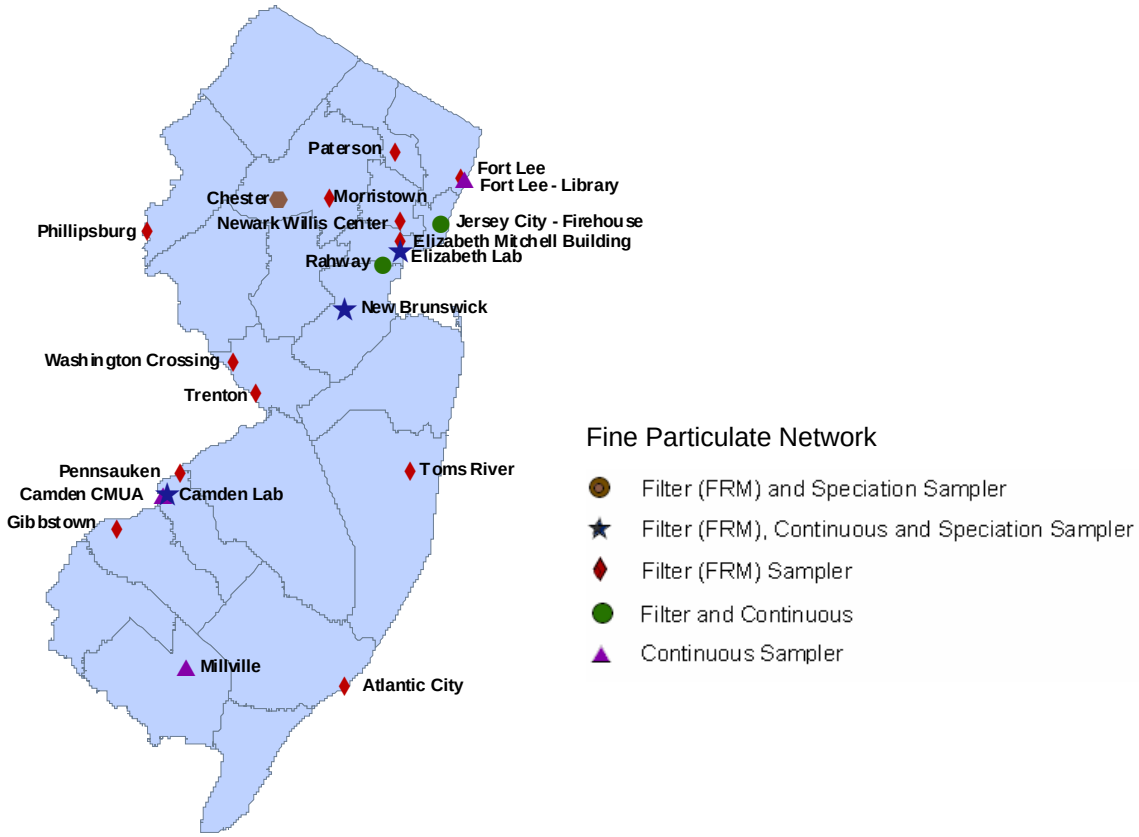
‡ Annual Geometric Mean
† Annual Arithmetic Mean

Particulate Monitoring Network

New Jersey's Particulate Monitoring Network consists of 22 fine particulate monitoring sites, 6 PM_{10} monitoring sites, 1 TSP monitoring site, and 10 sites where smoke shade is monitored.

Samplers that comply with strict EPA specifications are used for collecting data that is submitted to a national database maintained by the EPA. These samplers pull a predetermined amount of air through a filter for a 24-hour period capturing particles on the filter. Different sample inlets determine what size particles will be captured. 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, meet the federal health and welfare standards for particulate matter. Because these samplers are required to run for 24-hour period and can not provide data in real time the NJDEP employs additional samplers that continuously measure particulate concentrations. These samplers are used by the NJDEP to report current air quality to the public through the Air Quality Index (www.state.nj.us/dep/airmon). The NJDEP uses Tapered Element Oscillating Microbalance (TEOM) analyzers and smoke shade instruments for real-time particle reporting. The TEOM analyzers collect a sample of fine particles 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 particles 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 particle concentrations.

Figure 3
2005 $PM_{2.5}$
Monitoring Network



Fine Particle Summary

Fine Particle Monitoring Sites

There are 19 monitoring sites in New Jersey where a filter-based sampler routinely collects 24-hour $PM_{2.5}$ samples (see Figure 3). At 7 sites, continuous particulate monitors (TEOMs) measure the concentration 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.state.nj.us/dep/airmon). Additionally, at four of these locations a separate 24-hour filter based sampler collects fine particles on three types of filter media which are subsequently analyzed using ion chromatography (IC), X-ray fluorescence (XRF), and Thermal Optical Analysis (TOA) to determine the concentrations of the chemical analytes that constitute the sample.

Fine Particle Concentration Summary

The annual mean concentration of $PM_{2.5}$ ranged from 10.8 $\mu g/m^3$ in Chester to 15.2 $\mu g/m^3$ at Elizabeth Lab. The maximum 24-hour concentrations ranged from 26.5 $\mu g/m^3$ at Atlantic City to 51.4 $\mu g/m^3$ at Fort Lee Library.

Figure 4 and Table 2 depicts the mean and maximum concentrations at each site.

None of the sites exceeded the 24-hour standard of 65 $\mu g/m^3$. Two sites, Elizabeth Lab and Jersey City Firehouse exceeded the annual standard of 15.0 $\mu g/m^{3.}$ The annual mean concentration at Elizabeth Lab was 15.2 $\mu g/m^3$ and the annual mean concentration at Jersey City Firehouse was 15.1 $\mu g/m3$. The annual mean concentration at Union City was 16.9 $\mu g/m^3$, but not enough data was collected to calculate an annual average. In 2005 non-attainment designations were made in areas of the state that did not meet AQS guidelines for fine particulates. For more detail see page 8.

Figure 4
2005 Fine Particulate ($PM_{2.5}$)

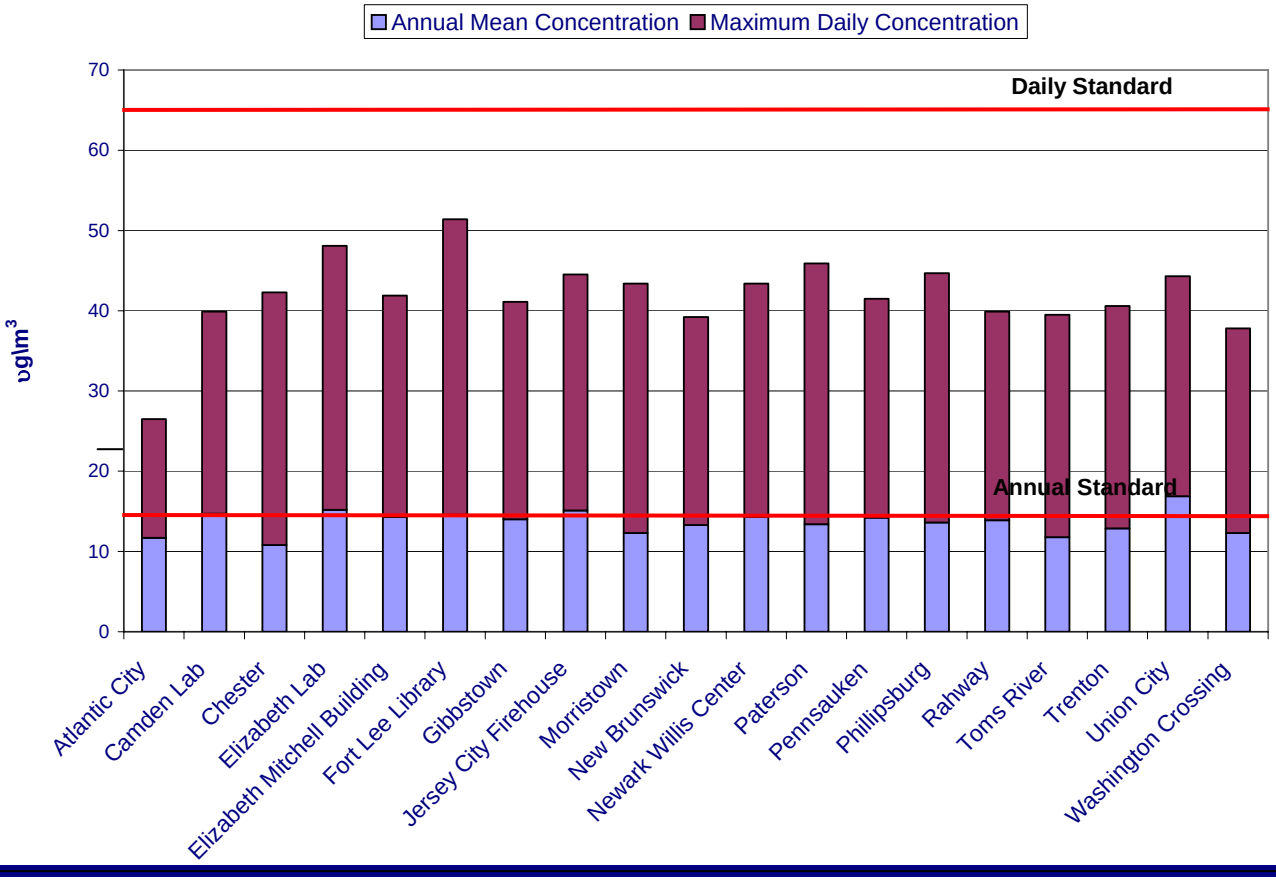


Table 2
$PM_{2.5}$ Summary Data – 2005

Monitoring Site	Number of Samples	24-Hour Maximum $\mu g/m^3$	Second Highest 24-Hour Maximum $\mu g/m^3$	Annual Mean $\mu g/m^3$
Atlantic City	84	26.5	25.4	11.7
Camden Lab	106	39.9	38.1	14.7
Chester	110	42.3	37.5	10.8
Elizabeth Lab	326	48.1	44.4	15.2
Elizabeth Mitchell Building	103	41.9	39.3	14.3
Fort Lee Library	109	51.4	44.0	14.6
Gibbstown	106	41.1	38.8	14.0
Jersey City Firehouse	107	44.5	41.1	15.1
Morristown	112	43.4	39.8	12.3
New Brunswick	108	39.2	34.7	13.3
Newark Willis Center	106	43.4	40.5	14.3
Paterson	104	45.9	42.1	13.4
Pennsauken	114	41.5	38.3	14.2
Phillipsburg	117	44.7	35.8	13.6
Rahway	104	39.9	38.7	13.9
Toms River	118	39.5	35.8	11.8
Trenton	107	40.6	36.0	12.9
Union City *	50	44.3	43.5	16.9
Washington Crossing	103	37.8	33.5	12.3

* Site did not start collecting data until July

Table 3
2005 Summary of Continuous $PM_{2.5}$ Data

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

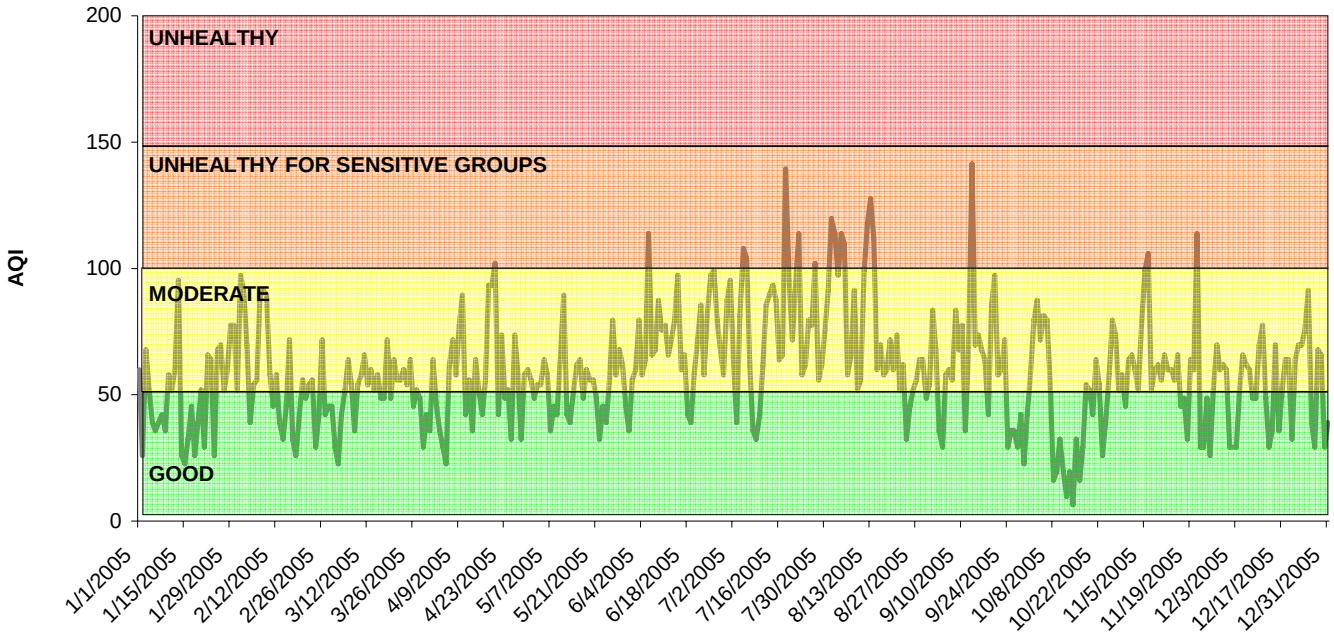
Monitoring Site	Annual Mean	Maximum Daily Concentration	2nd Highest Daily Concentration
Camden Lab	13	50	47
Elizabeth Lab	14	48	41
Fort Lee *	20	61	60
Jersey City-Firehouse	13	54	44
Millville *	13	47	41
New Brunswick	11	46	40
South Camden	14	49	48

* TEOM did not run entire year

$PM_{2.5}$ Real-Time Monitoring

New Jersey's continuous $PM_{2.5}$ monitoring network consists of 7 sites: Camden Lab, Elizabeth Lab, Fort Lee, Jersey City, Millville, New Brunswick, 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 maximum daily fine particulate concentration recorded in the state each day for the entire year.

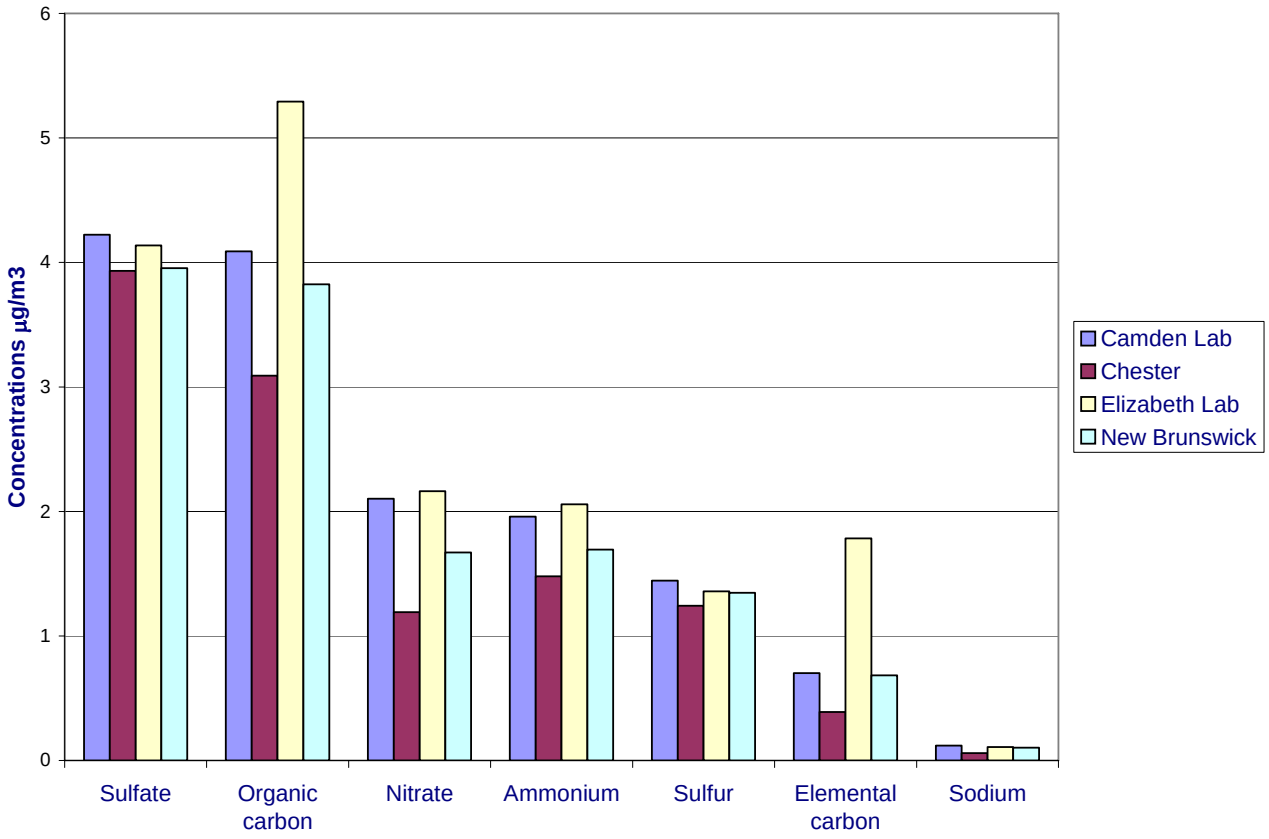
Figure 5
2005 Maximum Daily Fine Particulate Concentration
(Highest site)
Air Quality Index (AQI)



FINE PARTICLE SPECIATION SUMMARY

New Jerseys Fine Particulate Speciation Network consists of 4 monitoring sites: Camden Lab, Elizabeth Lab, New Brunswick, and Chester. Samplers run every third day on a schedule concurrent with the FRM sampling network. Of the 55 measured analytes, organic carbon and sulfate combined make up 56% of the total mass. Nitrate, ammonium, sulfur and elemental carbon make up an additional 39% of the mass. Figure 6 depicts the average concentration of each analyte at all the sites, with only the seven most prevalent constituents depicted. Appendix B shows the average, maximum, and 2nd highest concentrations for each compound for 2005.

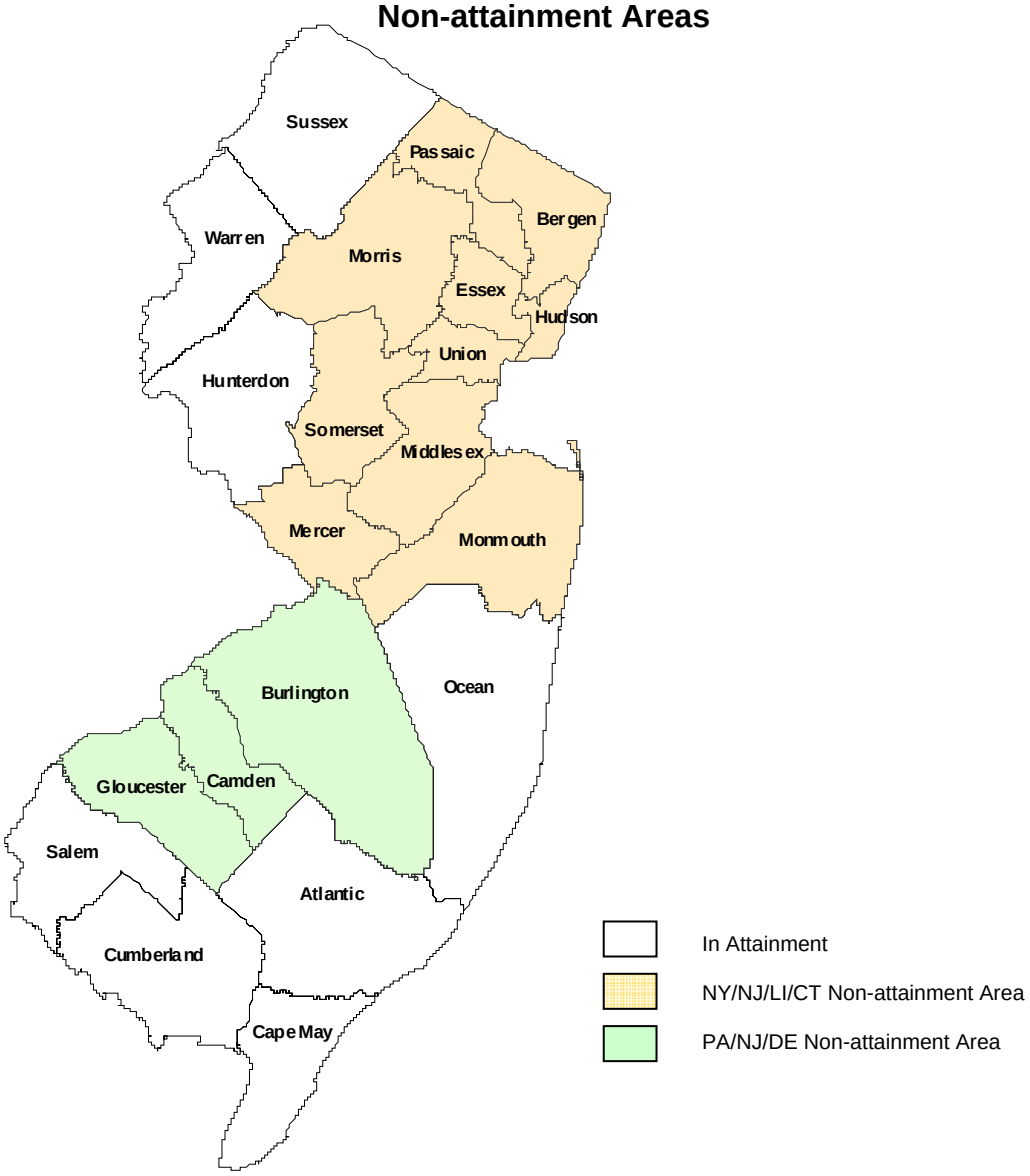
Figure 6
2005 Fine Particulate Analyte Composition
(Highest 7 Analytes Depicted)



Fine Particulate Non-Attainment Areas

In 2005 thirteen New Jersey counties were classified as non-attainment areas. Non-attainment classification is given to an area in which a monitor records a violation of the Ambient Air Quality Standards (see table 1). Areas surrounding a monitor that record a violation of the AQS can also be designated as non-attainment if $PM_{2.5}$ generated there is believed to contribute to the violation. While the Elizabeth Trailer $PM_{2.5}$ monitor was the only New Jersey monitor to exceed the AQS (15.9 $\mu g/m^3$), a 10 county area in the Northeast section of the state has been classified as non-attainment because of its contributing factor to both the violations at the Elizabeth Trailer monitor and violations at monitoring sites in New York City. Similarly, 3 counties in the southwestern part of the state have been classified as non-attainment due to their contribution to $PM_{2.5}$ violations in the city of Philadelphia. Data from sampling years 2000-2002 was used to make these designations. NJDEP is currently devising a strategy to lower $PM_{2.5}$ levels in these affected areas.

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

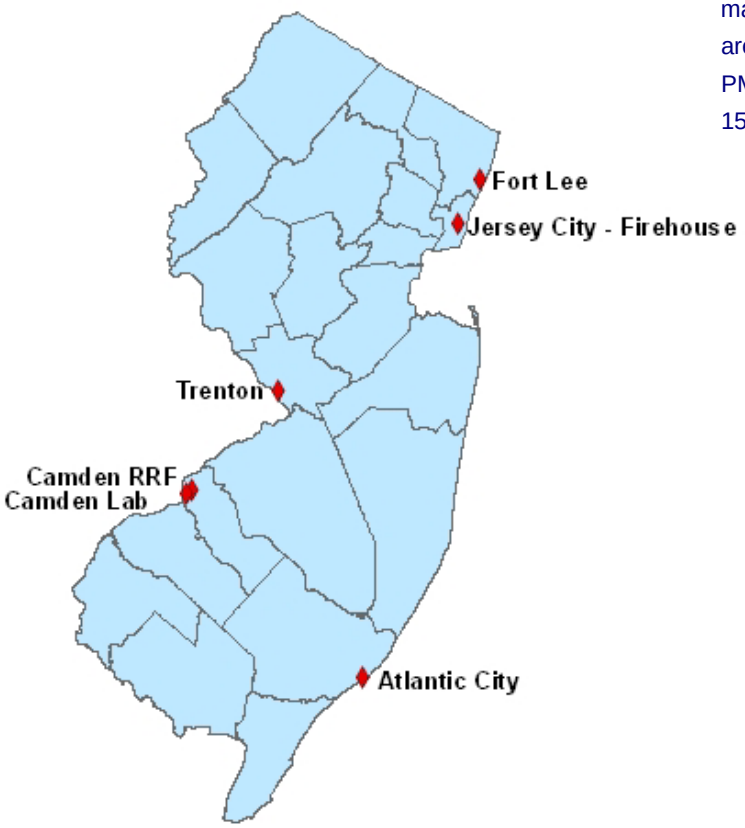


2005 Coarse Particle Summary

Coarse Particle Monitoring Sites

The coarse particulate monitoring network is composed of 6 PM_{10} sampling sites and 1 TSP sampling sites. Samples are collected on a filter, which is weighed before and after sampling to determine the concentration. Figure 8 depicts the PM_{10} particulate monitoring network in New Jersey.

Figure 8
2005 PM_{10}
Monitoring Network



TSP Concentration Summary

New Jersey currently operates one TSP monitoring site, located in New Brunswick. In 2005, the annual geometric mean concentration of TSP in New Brunswick was 33.6 $\mu g/m^3$, and the maximum 24-hour concentration recorded was 62.7$\mu g/m^3$. The site was in attainment for the primary and secondary annual TSP standards of 75 $\mu g/m^3$ and 60 $\mu g/m^3$ respectively, and the site did not surpass the 24-hour primary standard of 260 $\mu g/m^3$ or the 150 $\mu g/m^3$ secondary standard.

PM_{10} Concentration Summary

In 2005, the annual mean concentration of PM_{10} ranged from 23 $\mu g/m^3$ at Atlantic City to 40 $\mu g/m^3$ at Camden RRF. Table 4 and Figure 9 show the annual mean and 24-hour maximum PM_{10} concentrations throughout the state. 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$\mu g/m^3$.

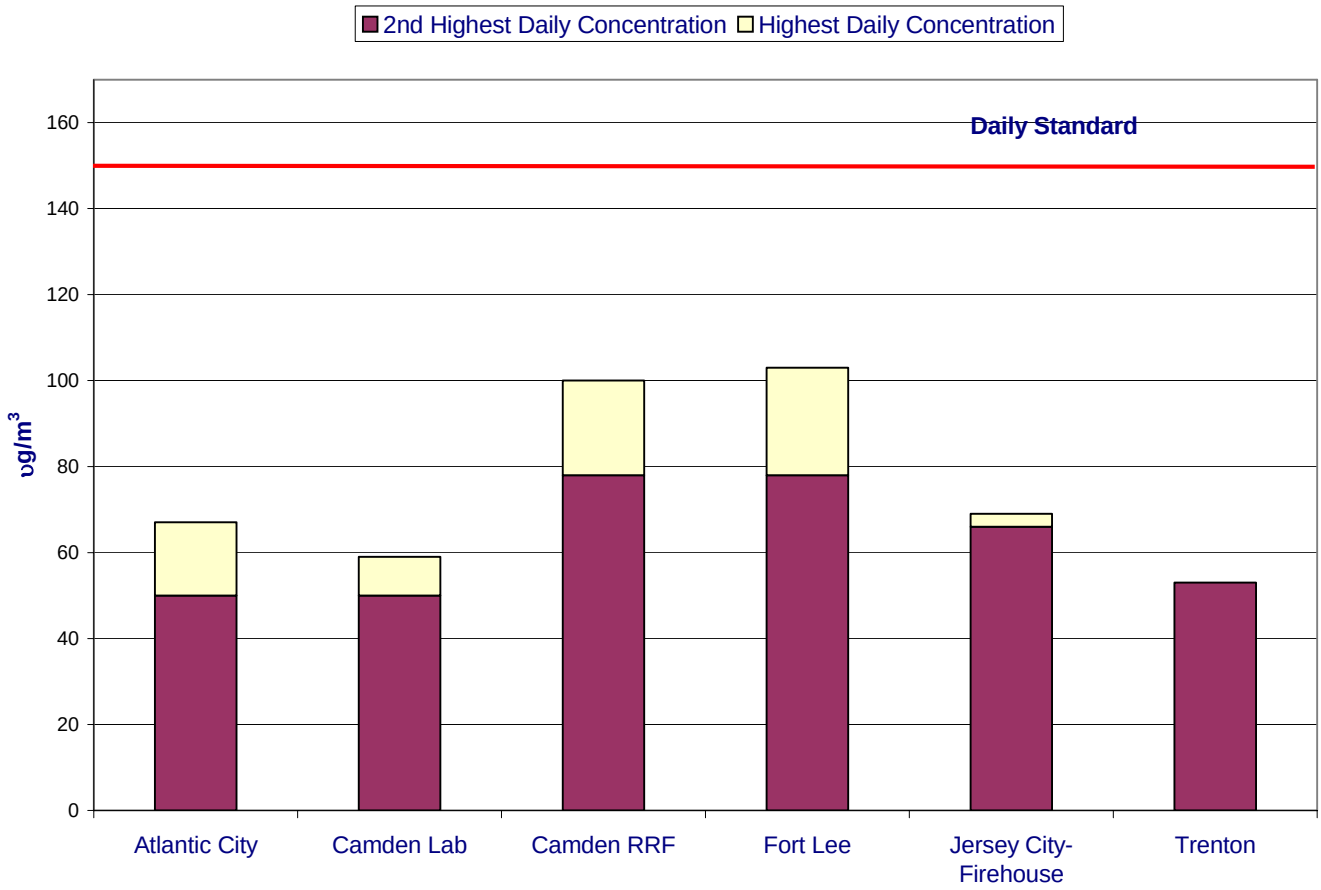
Table 4
PM_{10} Data - 2005
Daily and Annual Averages

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

Monitoring Site	Number of Samples	Daily Maximum	Second Highest Daily Maximum	Annual Mean
Atlantic City	54	67	50	23
Camden Lab	47	59	50	25
Camden RRF	56	100	78	40
Fort Lee *	44	103	78	35
Jersey City-Firehouse	55	69	66	30
Trenton	57	59	59	26

* Sampler did not run entire year

Figure 9
Summary of PM_{10} Concentrations, New Jersey 2005



* At Trenton the highest daily and second highest daily were both 59

Smoke Shade Summary

Smoke Shade Monitoring Sites

In addition to fine and coarse particulate monitoring, smoke shade is also monitored at 10 stations around the state. Smoke shade, which is an indirect measurement of particles in the atmosphere, has been monitored in New Jersey for over 30 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 2005, the annual mean concentration of smoke shade ranged from 0.17 Coefficient of Haze units (COH) at Flemington and Camden Lab to 0.60 COH at 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 maximum and second highest daily average and annual mean smoke shade levels recorded at the monitoring sites in 2005.

Figure 10
2005 Smoke Shade Monitoring Network

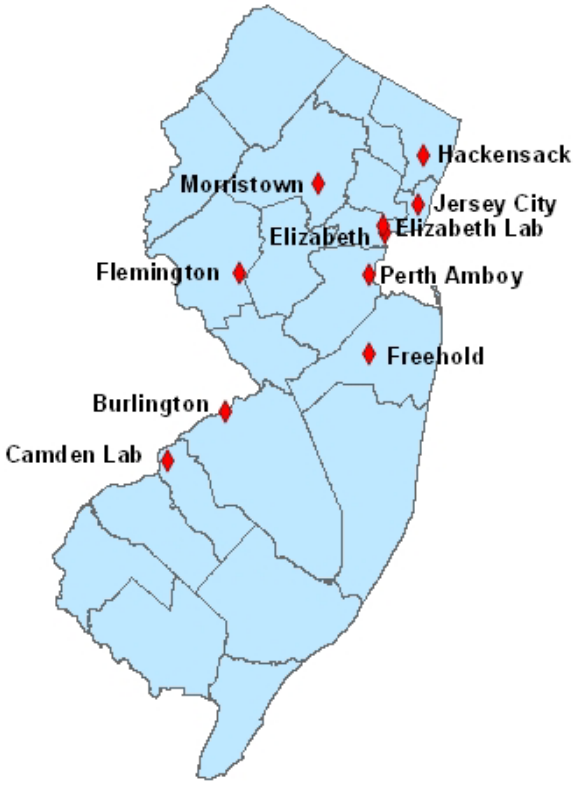


Table 5
Smoke Shade - 2005

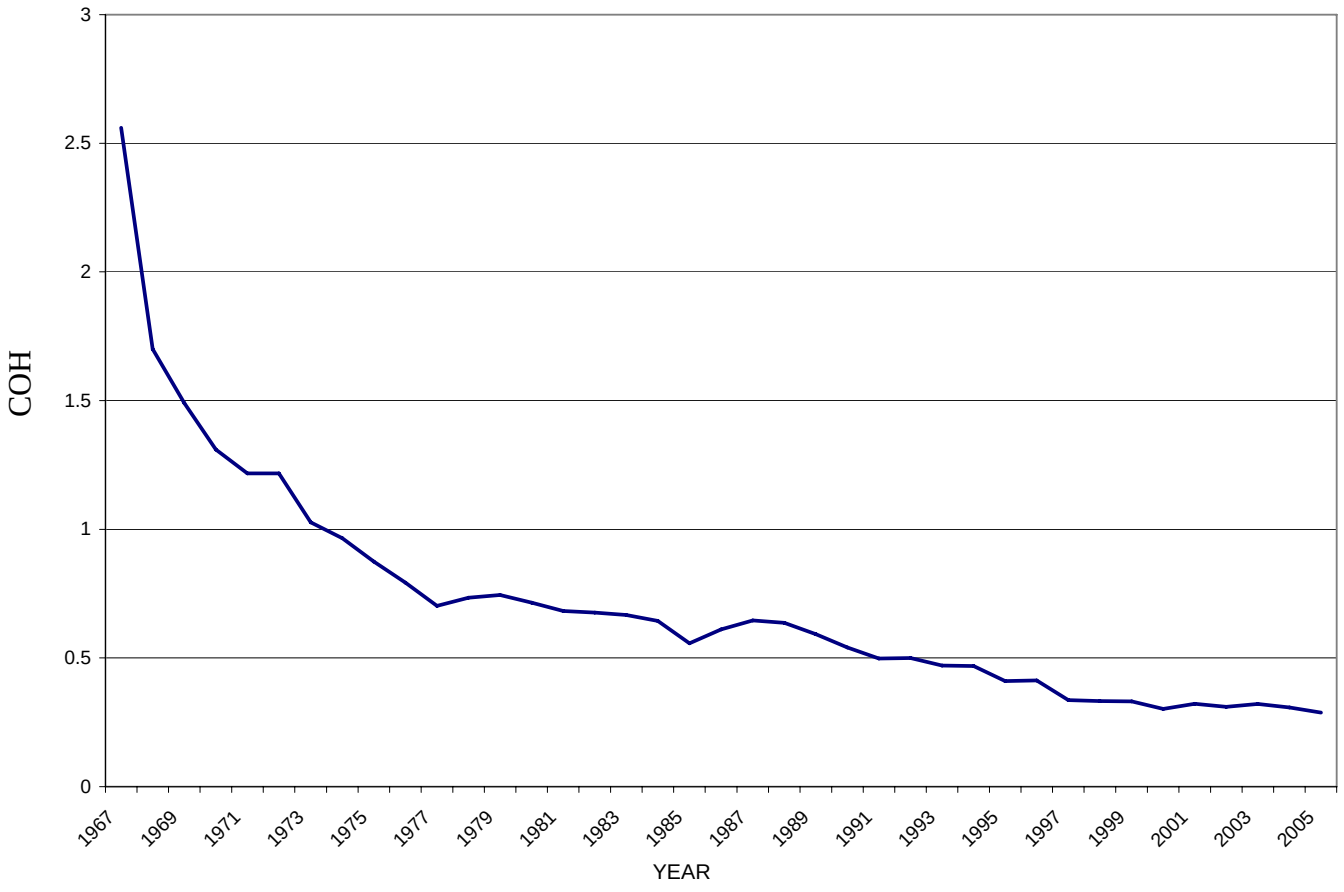
Coefficient of Haze (COHs)
No Standard

Site	Maximum Daily Average	2nd Highest Daily Average	Annual Mean
Burlington	1.02	0.69	0.18
Camden Lab	0.58	0.54	0.17
Elizabeth	1.41	1.23	0.39
Elizabeth Lab	1.85	1.71	0.60
Flemington	0.61	0.56	0.17
Freehold	0.54	0.51	0.19
Hackensack	1.25	1.05	0.23
Jersey City	1.60	1.31	0.54
Morristown	0.58	0.56	0.21
Perth Amboy	1.19	0.94	0.29

TRENDS IN PARTICULATE CONCENTRATIONS

The longest continuously operating particle 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 in effect for over thirty years and still has 10 active sites. The trend graph for smoke shade, shown in Figure 11 indicates that particulate levels have steadily declined over the past thirty 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.

Figure 11
Long Term Trend in Particulate
State Average
1967- 2005



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