



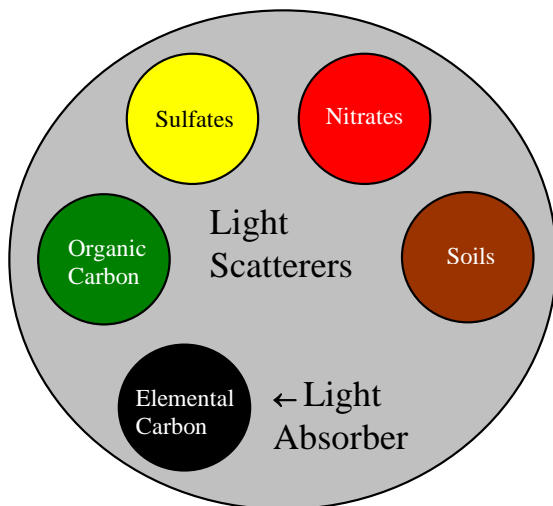
2009 Regional Haze & Visibility Summary

New Jersey Department of Environmental Protection

THE BASICS OF HAZE

Haze is caused when sunlight encounters tiny pollution particles in the air. Some light is absorbed by particles; other light is scattered away before it reaches an observer. Small particles and certain gaseous molecules in the atmosphere cause poor visibility by scattering or absorbing light (see Figure 1). More pollutants mean more absorption and scattering of light, which reduce the clarity and color of what we see. When high concentrations of such pollutants are well mixed in the atmosphere, they form a uniform haze that can obscure distant objects. Some types of particles such as sulfates scatter more light, particularly during humid conditions. Sometimes haze is the result of pollutants that have been transported considerable distances on the prevailing winds. While some visibility impairment occurs even under natural conditions, man-made aerosols are the primary cause. Air pollutants come from a variety of natural and manufactured sources. Natural sources can include windblown dust and soot from wildfires. Man-made sources can include motor vehicles, electric utility and industrial fuel burning, and manufacturing operations.

**Figure 1
Contributors to Visibility Impairment**



ANATOMY OF REGIONAL HAZE

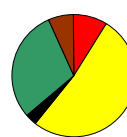
Data collected over the last decade show that fine particle concentrations, and hence visibility impairment, are highest in the industrialized and densely populated areas of the Northeast and Mid-Atlantic. Sulfate (SO₄) is the primary culprit and typically constitutes 40% of the total fine mass in the region even on clear days. It can account for 60-80% of the total fine mass on very hazy days. Organic carbon usually accounts for the next largest portion of total fine particle mass. It can account for 20-30% on the haziest days. The remainder of the mass is made up primarily of nitrate (NO₃), elemental carbon, and fine soil particles.

PARTICLES AND VISIBILITY

Figure 2 shows the makeup of fine particles collected at the IMPROVE (Interagency Monitoring of Protected Visual Environments) site located north of Atlantic City in the Edwin B. Forsythe Wildlife Refuge (Brigantine).

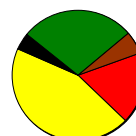
**Figure 2
Composition of Fine Particles on Days with Good Visibility Compared to Days with Poor Visibility
Brigantine,
New Jersey, 2009**

Average Fine Mass Composition on Days with Good Visibility



Ammonium Nitrate	0.20 $\mu\text{g}/\text{m}^3$	8.8%
Ammonium Sulfate	1.18 $\mu\text{g}/\text{m}^3$	51.8%
Elemental Carbon	0.07 $\mu\text{g}/\text{m}^3$	3.0%
Organic Carbon	0.68 $\mu\text{g}/\text{m}^3$	29.9%
Soils	0.15 $\mu\text{g}/\text{m}^3$	6.7%
Total 2.27 $\mu\text{g}/\text{m}^3$		

Average Fine Mass Composition on Days with Poor Visibility



Ammonium Nitrate	2.63 $\mu\text{g}/\text{m}^3$	17.8%
Ammonium Sulfate	6.58 $\mu\text{g}/\text{m}^3$	44.5%
Elemental Carbon	0.59 $\mu\text{g}/\text{m}^3$	4.0%
Organic Carbon	4.14 $\mu\text{g}/\text{m}^3$	28.0%
Soils	0.83 $\mu\text{g}/\text{m}^3$	5.6%
Total 14.77 $\mu\text{g}/\text{m}^3$		

Evaluations of the data for 2009 indicate that sulfates accounted for approximately half of the total fine particle mass. Most visibility impairment is due to sulfate, which can have a greater effect on light extinction (a measure of visibility impairment) than all other types of fine particles combined. Higher sulfate values in the summer can be attributed to the greater photochemical conversion of sulfur dioxide (SO₂) to SO₄ that results from the increased sunlight during the summertime. (Malm, 1999)

HOW IS HAZE REGULATED?

In 1999, the U.S. Environmental Protection Agency announced a major effort to improve air quality in national parks and wilderness areas aimed at achieving national visibility goals by 2064. The Regional Haze Rule calls for state and federal agencies to work together to improve visibility in 156 National Parks and wilderness areas such as the Grand Canyon, Yosemite, the Great Smokies and Shenandoah. This "regional haze rule" addresses the combined visibility effects of numerous pollution sources over a wide geographic region and how they impact Class I areas. Class I areas as defined by the Clean Air Act, 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 rule requires the states, in coordination with the Environmental Protection Agency, 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. The first State plans for regional haze were due in the 2003-2008 timeframe. Five multi-state regional planning organizations continue to work on the development of the technical basis for these plans in which regional haze will be regulated.

SOURCES OF HAZE CONTRIBUTORS

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 contributor to haze in the eastern U.S., due to 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 are emitted directly into the air and are also formed by the reaction of various gaseous hydrocarbons. Sources of direct and indirect organic carbon particles include vehicle exhaust, vehicle refueling, solvent evaporation (e.g., paints), food 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 (e.g., 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 very similar to soot. They 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.

Soils are very similar to dust. It enters 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 gasses, crustal material results from the crushing and grinding of larger, earth-born 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.

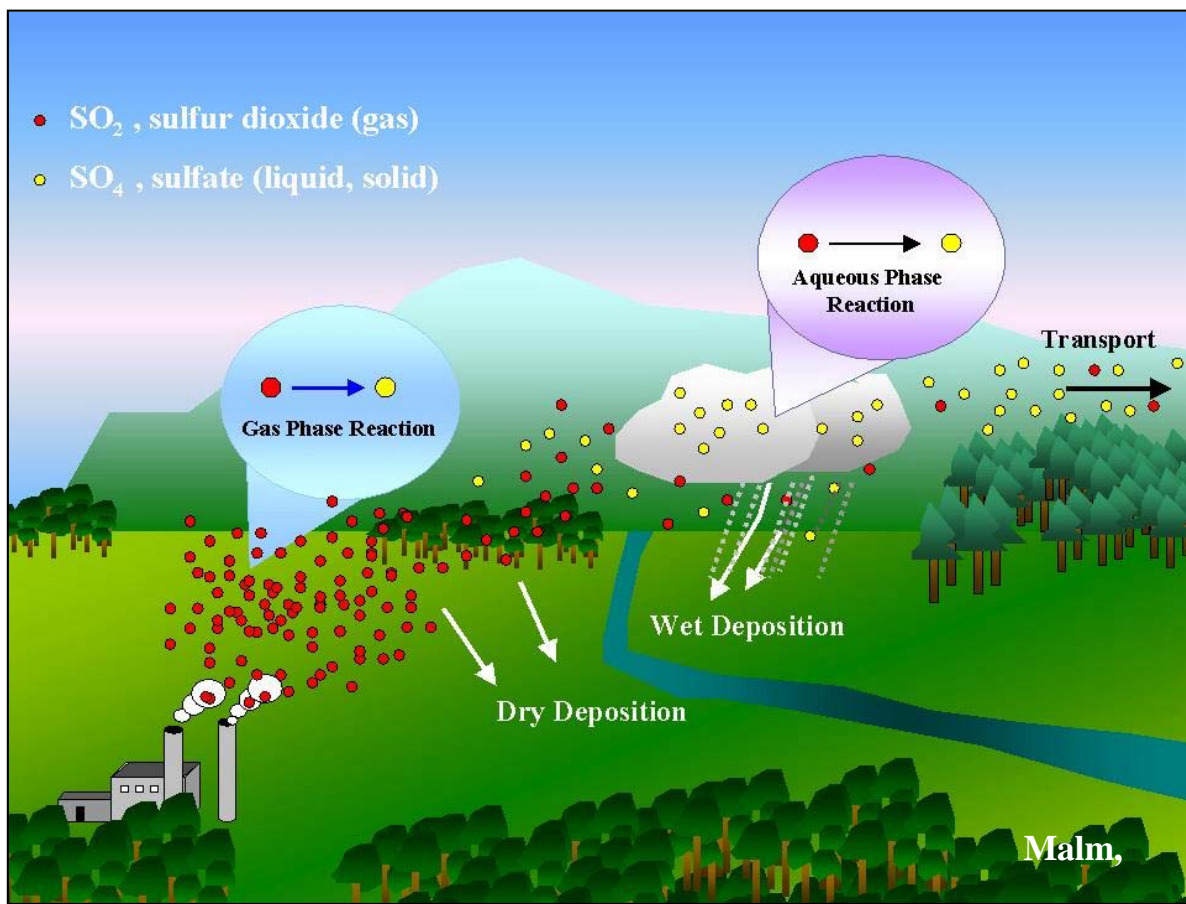
Source – www.hazecam.net

ENVIRONMENTAL EFFECTS

Regional haze is probably most closely associated with its effects on prized vistas such as the Grand Canyon or Acadia National Park. Its impacts may be difficult to quantify but it certainly has a negative overall effect on aesthetics and the outdoors, and how natural areas throughout the nation are enjoyed. But haze also affects urban area and scenes, and can obscure or eclipse the view of an urban skyline (see Figures 4 and 5) or other important urban landmarks such as the Washington Monument.

The pollution that causes regional haze has additional, multifaceted effects on the environment. The most abundant contributor to regional haze, sulfates, eventually make their way into the ecosystem through deposition - that is, they are transferred from the air into the water and soils (see Figure 3). Too much deposition can have adverse environmental effects, upsetting the delicate balance of the ecosystem. Increased sulfates in the atmosphere leads to acid rain while increased nitrates promote eutrophication of streams and lakes by depleting available oxygen (see section on Atmospheric Deposition).

Figure 3
Illustration of How Sulfates Enter the Ecosystem by way of Deposition



MONITORING OF HAZE IN NEW JERSEY

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 West, the typical visual range is 60 to 90 miles, or about one-half of the visual range under natural conditions. Haze diminishes the natural visual range. (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 each individual building, is easily distinguishable (Figure 4). The Manhattan skyline appears non-existent when conditions conducive to haze formation are in place (Figure 5).

Visibility Camera – New Jersey Transit Building

Figure 4



Figure 5



The IMPROVE site located within the Brigantine National Wildlife Refuge monitors haze and visibility using several types of instruments. Figure 6 below is an example of a clear day in Brigantine as the Atlantic City skyline is easily distinguishable along the horizon. The example of a hazy

day in Brigantine is illustrated below in Figure 7 and not only has the skyline disappeared but the water that was visible in the foreground in the clear picture also seems to have vanished in the haze.

Visibility Camera – Brigantine National Wildlife Refuge

Figure 6



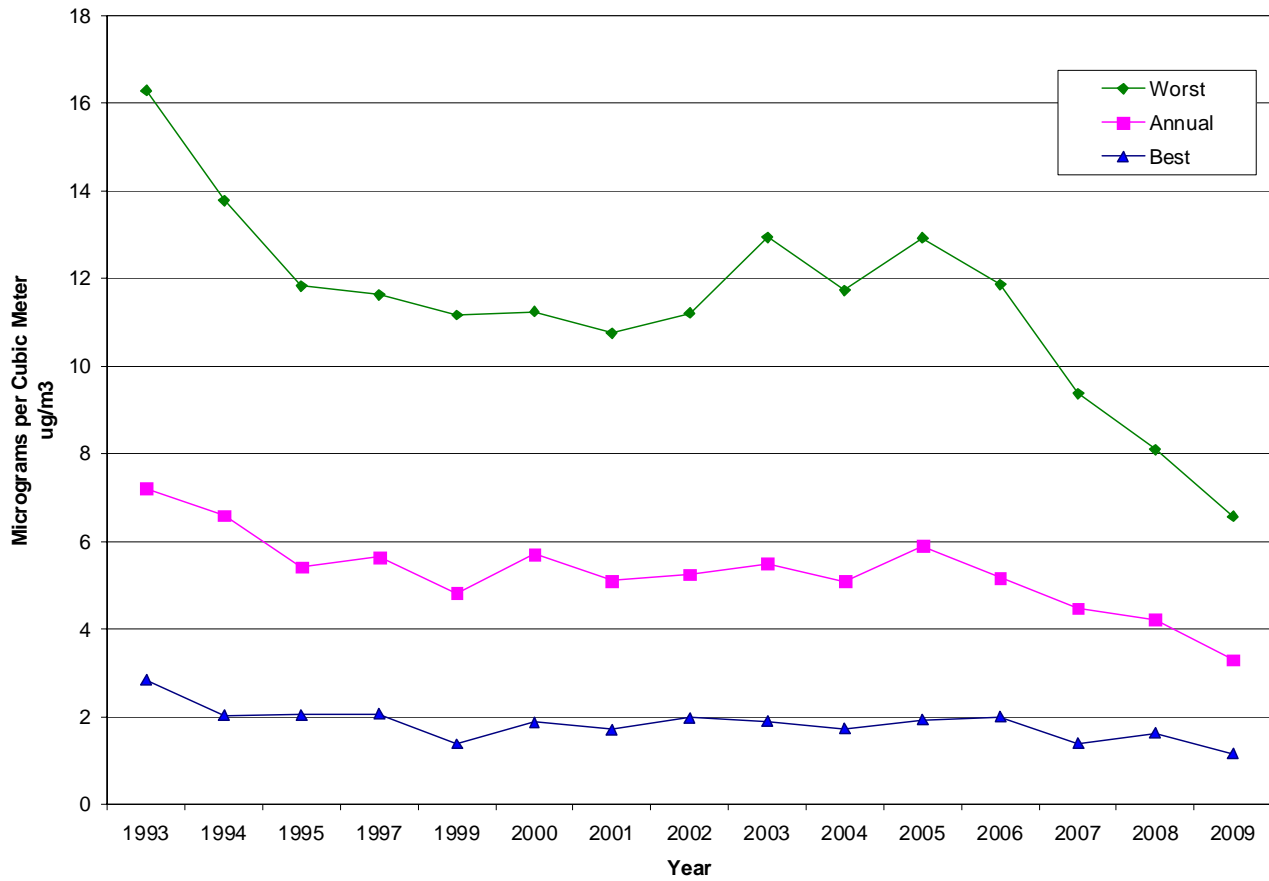
Figure 7



The graph below (Figure 8) represents the annual trend of sulfates expressed in micrograms per cubic meter measured at the Brigantine 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.

Figure 8
Sulfate Trend Summary
Brigantine, NJ
1993-2009



*Insufficient data available for 1996 and 1998

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