AIR QUALITY

INTRODUCTION

Never seen, yet ever present, the atmosphere moderates climatic extremes, filters incoming solar radiation, and provides the oxygen that fuels organic metabolism and chemical combustion. With the introduction of anthropogenic (human caused) pollutants into the atmosphere, air quality becomes degraded in many ways that adversely affect human health, natural ecosystem function, drinking water quality, and building integrity and aesthetics.

Air quality is negatively affected by pollution that originates from numerous sources: stationary sources such as factories, power plants, smelters, and smaller sources such as dry cleaners and degreasing operations; mobile sources such as cars, buses, planes, trucks and trains; and naturally occurring sources such as windblown dust and volcanic eruptions. Air pollution is found all over the United States and is becoming a global problem that has disrupted the natural balance of the environment. The most well known and controversial issue is that of the global warming – the increase in carbon dioxide (CO_2) in the atmosphere that traps solar energy, raising the earth's temperature.

AIR POLLUTANT CRITERIA

As a means of addressing the problems of air pollution across the nation, Congress enacted the Clean Air Act (CAA) in 1970, and charged the Environmental Protection Agency (EPA) with regulating air pollution. The CAA provides the principal framework for national, state, and local efforts to protect air quality. Regulations, known as National Ambient Air Quality Standards (NAAQS), serve to control the release of pollutants which are considered harmful to people and the environment. The EPA Office of Air Quality Planning and Standards (OAQPS) works to ensure that these air quality standards are met, or attained (in cooperation with state, Tribal, and local governments) through national standards and strategies to control pollutant emissions from automobiles, factories, and other sources. The New Jersey Department of Environmental Protection's Bureau of Air Monitoring addresses these issues on the state level.

The EPA calls such pollutants **criteria air pollutants** because permissible standards are based on health risk (scientifically-based) factors. **Primary Standards** are set based on a pollutant's risk to human health whereas **secondary standards** are set based on risk of environmental or property damage. A geographic region that meets or exceeds the primary standard for a particular pollutant is called an **attainment area**; regions that do not meet the primary standard are called **non-attainment** areas.

Although the EPA has been regulating criteria air pollutants since the early 1970s, many urban areas are classified as non-attainment for at least one criteria air pollutant. It has been estimated that about 90 million Americans live in non-attainment areas. Of the common contaminates that comprise air pollution the EPA has classified six principal, or criteria, pollutants. The six criteria pollutants are Carbon Monoxide, Nitrogen Dioxide, Sulfur Dioxide, Lead, Particulate Matter, and Ozone (or smog):

Carbon Monoxide (CO)

- **Source** - burning of gasoline, natural gas, coal, oil etc.
- **Health Effects** - reduces ability of blood to bring oxygen to body cells and tissues; cells and tissues need oxygen to work. Carbon monoxide may be particularly hazardous to people who have heart or circulatory (blood vessel) problems and people who have damaged lungs or breathing passages
- **Criterion** - 8-hour Average 9 ppm (10 mg/m^3) Primary 1-hour Average 35 ppm (40 mg/m^3) Primary

Nitrogen Dioxide (One of the NOx); smog-forming chemical

- **Source** - burning of gasoline, natural gas, coal, oil etc. Cars are an important source of NO2.
- **Health Effects** - lung damage, illnesses of breathing passages and lungs (respiratory system)
- **Environmental Effects** - nitrogen dioxide is an ingredient of acid rain (acid aerosols), which can damage trees and lakes. Acid aerosols can reduce visibility.
- **Property Damage** - acid aerosols can eat away stone used on buildings, statues, monuments, etc.
- **Criterion** - Annual Arithmetic Mean 0.053 ppm (100 µg/m^3) Primary & Secondary

Sulfur Dioxide (SO_2)

- **Source** - burning of coal and oil, especially high-sulfur coal from the Eastern United States; industrial processes (paper, metals)
- **Health Effects** - breathing problems, may cause permanent damage to lungs
- **Environmental Effects** - SO2 is an ingredient in acid rain (acid aerosols), which can damage trees and lakes. Acid aerosols can also reduce visibility.
- **Property Damage** - acid aerosols can eat away stone used in buildings, statues, monuments, etc.
- **Criterion** - Annual Arithmetic Mean 0.03 ppm (80 µg/m^3) Primary 24-hour Average 0.14 ppm (365 µg/m^3) Primary 3-hour Average 0.50 ppm (1300 µg/m^3) Secondary

Lead (Pb)

- **Source** - leaded gasoline (being phased out), paint (houses, cars), smelters (metal refineries); manufacture of lead storage batteries
- **Health Effects** - brain and other nervous system damage; children are at special risk. Some lead-containing chemicals cause cancer in animals. Lead causes digestive and other health problems.
- **Environmental Effects** - Lead can harm wildlife.
- **Criterion** - Quarterly Average 1.5 µg/m^3 Primary & Secondary

Particulate Matter (PM-10, PM-2.5); (dust, smoke, soot)

- **Source** - burning of wood, diesel and other fuels; industrial plants; agriculture (plowing, burning off fields); unpaved roads
- **Health Effects** - nose and throat irritation, lung damage, bronchitis, early death
- **Environmental Effects** - particulates are the main source of haze that reduces visibility
- **Property Damage** - ash, soot, smoke and dust can dirty and discolor structures and other property, including clothes and furniture
- **Criteria** -
  - **PM 10** *Particles with diameters of 10 micrometers or less* Annual Arithmetic Mean 50 µg/m^3 Primary & Secondary 24-hour Average 150 µg/m^3 Primary & Secondary
  - **PM 2.5** *Particles with diameters of 2.5 micrometers or less* Annual Arithmetic Mean ** 15 µg/m^3 Primary & Secondary 24-hour Average ** 65 µg/m^3 Primary & Secondary

Ozone (O_3) (ground-level ozone is the principal component of smog)

- **Source** - chemical reaction of pollutants; VOCs and NOx
- **Health Effects** - breathing problems, reduced lung function, asthma, irritates eyes, stuffy nose, reduced resistance to colds and other infections, may speed up aging of lung tissue
- **Environmental Effects** - ozone can damage plants and trees; smog can cause reduced visibility
- **Property Damage** - Damages rubber, fabrics, etc.
- **Criterion** - **Ozone** 1-hour Average 0.12 ppm (235 µg/m^3) Primary & Secondary 8-hour Average ** 0.08 ppm (157 µg/m^3) Primary & Secondary

VOCs* (volatile organic compounds); smog-formers

- **Source** - VOCs are released from burning fuel (gasoline, oil, wood coal, natural gas, etc.), solvents, paints glues and other products used at work or at home. Cars are an important source of VOCs. VOCs include chemicals such as benzene, toluene, methylene chloride and methyl chloroform
- **Health Effects** - In addition to ozone (smog) effects, many VOCs can cause serious health problems such as cancer and other effects
- **Environmental Effects** - In addition to ozone (smog) effects, some VOCs such as formaldehyde and ethylene may harm plants

*All VOCs contain carbon (C), the basic chemical element found in living beings. Carbon-containing chemicals are called organic. Volatile chemicals escape into the air easily. Many VOCs are also hazardous air pollutants, which can cause very serious illnesses. EPA does not list VOCs as criteria air pollutants, but they are included in this list of pollutants because efforts to control smog target VOCs for reduction.

AIR MONITORING

The US Environmental Protection Agency (EPA) monitors and reports air quality using a Pollutant Standard Index (PSI). The PSI was established in 1976 as a consistent and easy to understand way of stating air pollutant concentrations and associated health implications. The PSI allows the EPA to use a uniform system for five of the six criteria pollutants. Lead is not reported using the PSI because lead tests take several weeks, and the PSI is meant to report real time data. Data is recorded in parts per million (ppm) and then converted to a PSI value. The PSI does not report each individual pollutant, but rather assigns a measure of air quality based on the sum of the multiple pollutants. The scale spans from zero to five hundred, assigning a degree of air quality to ranges within (**Table 2**).

Table 2. Health Cautions for Pollutant Standard Index. Data modified United States Environmental Protection Agency: Office of Air and Radiation, Office of Air Quality Planning and Standards.

Index Value	PSI Descriptor	General Health Effects	Cautionary Statements
0-50	Good	None for the general population	None required.
50-100	Moderate	Few or none for the general population	None required.
100-200	Unhealthy	Mild aggravation of symptoms among susceptible people, with irritation symptoms in the healthy population.	Persons with existing heart or respiratory ailments should reduce physical exertion & outdoor activity. General population should reduce vigorous outdoor activity.
200-300	Very Unhealthy	Significant aggravation of symptoms & decreased exercise tolerance in persons with heart or lung disease; widespread symptoms in the healthy population.	Elderly and persons with existing heart or lung disease should stay indoors & reduce physical activity. General population should avoid outdoor activity. All people should remain indoors, keeping windows & doors closed, and minimize physical exertion.

In June 2000, EPA updated the index and renamed it Air Quality Index (AQI) (**Table 3**). PSI and AQI are similar. They both:

- Focus on health risks of brief exposure to pollutants- a few hours or days
- Involve air pollutants regulated by the Clean Air Act (criteria pollutants)
- Use the same method to calculate index values
- Use an index value of 100 to represent pollutants concentration at the level of Air Quality Standards (NAAQS)

New qualities featured in the Air Quality Index include:

- A health risk category, *unhealthy for sensitive groups*
- Two additional pollutants: ozone averaged over 8 hours, and fine particulate matter (particle size2.5 micrometers or less)

The AQI provides a descriptive rating and a colorcode (e.g. green=good) in real-time on the internet for many sites. New Jersey is divided into 9 AirQuality Regions.

The closest stations for each parameter are as follows: Ozone (O_3) at Ramapo (Ramapo Mountain State Forest, Passaic County); $PM_{2.5}$ was measured at Paterson (Passaic County) until 2012, but currently the closest station is Newark Firehouse (Essex County; where O_3, SO_2 and CO are also measured); and nitrogen dioxide (NO_2) is measured at East Orange (Essex County, also CO) (NJDEP Bureau of Air Monitoring, February 13,

2013)**.** It should benoted that some of these monitoring sites may receive much higher local air pollution (e.g. from traffic and industry) than Hawthorne.

Table 3. Air Quality Index. Table obtained from AIRNow Air Quality Index 2010

Category	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	Very Unhealthy	Hazardous
Index Value	0-50	51-100	101-150	151-200	201-300	301-500
CO (ppm)	0.0-4.4	4.5-9.4	9.5-12.4	12.5-15.4	15.5-30.4	30.5-50.4
NO_2 (ppb)	0.0-53	54-100	101-360	361-644	645-1244	1245-2044
O_3 1-hour (ppb)	-	--	125-164	165-204	205-404	405-604
O_3 8-hour (ppb)	0-59	60-75	76 -95	96-115	116-374	405-604
PM 2.5 (ug/m3)	0-15.4	15.5-35.4	35.5-65.4	65.5-150.4	150.5-250.4	250.5-500.4
PM 10 (ug/m3)	0-54	55-154	155-254	255-354	355-424	425-604
SO_2 (ppb)	0-34	35-144	145-224	225-304	305-604	605-1004

Air Quality monitoring is a tricky and expensive undertaking. Due to the way wind influences air quality and the fact that Hawthorne does not have its own air monitor, data were obtained for Passaic County as recorded by the EPA (**Table 4**). Air Quality appears to be increasing slightly over the years, but longer test ranges are needed to properly assess.

Table 4. Air Quality Measurements for Passaic County, NJ. Measurements obtained at the Ramapo Air Quality Station. Table modified from data on EPA AIRS website.

Number of days Monitored	Percent of days monitored PSI Good	Percent of days monitored PSI Moderate	Percent of days monitored PSI Unhealthful for Sensitive Groups	Percent of days monitored PSI Unhealthy	Year
277	73%	23%	3%	0%	2008
279	84%	16%	1%	0%	2009
286	74%	22%	3%	0.35%	2010
293	81%	16%	2%	0%	2011
302	78%	20%	2%	0.33%	2012
287	84%	15%	1%	0%	2013
283	83%	17%	0%	0%	2014
279	78%	20%	3%	0%	2015
270	81%	17%	2%	0%	2016
299	87%	12%	0%	0%	2017
277	84%	15%	1%	0%	2018
277	87%	12%	0%	0%	2019
262	94%	6%	0%	0%	2020

SMOG

An August 2000 study by INFORM, Inc. (Golden 2000) reports that "95 percent of New Jersey's 8.1 million residents live in areas that fail to meet federal public health standards, compared to 38 percent of the U.S. population as a whole." The report also claims "18 of New Jersey's 21 counties are in non-attainment of federal ground-level ozone standards." In addition, twelve counties, including Passaic, were ranked as being in 'severe' non-attainment just below the 'extreme' level.

Ground-level ozone is the primary component of what we typically refer to as **smog**. Ozone can be good or bad depending on its location in the atmosphere. Ozone in the **stratosphere** high above the Earth protects human health and the environment whereas ground-level ozone is the main harmful ingredient in smog. Ground-level ozone is produced by the combination of pollutants from various sources, including smokestacks, cars, paints and solvents. When a car burns gasoline, releasing exhaust fumes, or a painter paints a house, smog-forming pollutants rise into the sky. Often, wind blows smog-forming pollutants away from their sources. The smog-forming reactions take place while the pollutants are being blown through the air by the wind. Higher smokestacks are sometimes installed with the idea that they will reduce pollutant levels. While the higher stacks do reduce local levels of pollutants, they increase regional levels by placing chemicals at higher altitudes where they are exposed to hotter temperatures and remain in the atmosphere up to seven times the normal period. This, along with the influence of winds, explains why smog is often more severe miles away from the source of smog-forming pollutants. The smog-forming pollutants literally cook in the sky, and if the weather is hot and sunny, smog will form more easily. Similar to baking a cake, it takes time to cook up smog- several hours from the time pollutants get into the air until the smog gets increasingly detrimental.

Weather and geography determine where smog will go and its severity. When **temperature inversions** occur (warm air stays near the ground instead of rising) and winds are calm, smog may stay in place for days at a time. As traffic and other sources add more pollutants to the air, the smog gets worse. Since smog travels across county and state lines, when a metropolitan area covers more than one state (for instance, the New York metropolitan area includes parts of New Jersey and Connecticut), their governments and air pollution control agencies must cooperate to solve their problem. Governments on the East Coast from Maine to Washington, D.C., will have to work together in a **multistate** effort to reduce the area's smog problem.

The 1990 Clean Air Act amendments helped to further reduce pollution from criteria air pollutants, including smog. The EPA and state governors must first cooperate to identify non-attainment areas for each criteria air pollutant. The EPA then classifies the non-attainment areas according to severity of pollution. There are five classes of nonattainment areas for smog, ranging from **marginal** (relatively easy to clean up quickly) to **extreme** (will take a lot of work and a long time to clean up).

The 1990 Clean Air Act uses this new classification system to tailor clean-up requirements to the severity of the pollution and set realistic deadlines for reaching clean-up goals. If deadlines are missed, the law allows more time to clean up, but usually a nonattainment area that has missed a clean-up deadline will have to meet the stricter clean-up requirements set for more polluted areas. Not only must nonattainment areas meet deadlines, but states with non-attainment areas must also show the EPA

that they are moving on clean-up before the deadline- making reasonable further progress. States will usually do most of the planning for cleaning up criteria air pollutants, using the permit system to make sure power plants, factories and other pollution sources meet their clean-up goals. The comprehensive approach to reducing criteria air pollutants taken by the 1990 Act covers many different sources and a variety of clean-up methods. Many of the smog clean-up requirements involve motor vehicles (cars, trucks, buses). Also, as air quality continues to decline, pollution controls are mandated for smaller sources.

THE GREENHOUSE EFFECT

Water vapor and several other gases such as carbon dioxide, methane and chlorofluorocarbons (CFCs), warm the Earth's atmosphere by absorbing and reemitting radiation. They trap some of the heat energy radiating from the Earth's atmospheric system, heating the earth. This process is known as the greenhouse effect. Human activity contributes certain gases including carbon dioxide, methane, nitrous oxides and ozone, all of which have significantly increased in recent years but began with the Industrial Revolution. This increase of gases in the atmosphere is hypothesized as being responsible for global warming- the increase in average global temperature near the Earth's surface.

ACID DEPOSITION

Hawthorne, much like the rest of the United States is experiencing acid deposition, more commonly known as acid rain. Acid rain is the result of sulfur and nitrogen oxides in addition to several other acids produced from stationary sources such as power plants that burn fossil fuels and mobile sources such as automobiles. Pure rainfall has a pH of 5.0-5.6 (Miller 1996), which is slightly acidic- neutral being a pH of 7.0 on the pH scale of 0.0-14.0; a pH greater than 7.0 being alkaline. Areas most sensitive to acid deposition are those in which the bedrock or soil cannot buffer (neutralize) the acid input. Hawthorne's pH precipitation range is 4.0-4.5 (Pardi and Swanson, unpublished data). These values are concurrent with much of the pH values throughout the Northeast United States from which 80 percent of sulfur dioxide emissions and 65 percent of nitric oxides for the country come (Botkin and Keller 1995). High acidity can damage structures and ecosystems and threaten human health with respiratory problems. Acid deposition is known to cause bronchitis and asthma sufferings to be more severe (US EPA 2000).

MOBILE EMISSIONS

Mobile emissions were identified as the main cause of pollution levels in New Jersey in 2001. The state's 5.8 million vehicles are responsible for 43 percent of the volatile organic compounds and 44 percent of the nitrogen oxides, the product of combustion of fuel, utilities, and industries, which contribute to smog. Major contributing trends include:

- A higher density of truck traffic traversing the state
- A 36 percent increase in vehicle miles traveled between 1970 and 1997
- Sprawl development (the number of automobile-dependent office developments quadrupled between 1990 and 1997 while the number of transit-accessible offices remained unchanged
- The growing popularity of sport utility vehicles, which emit 40 percent more pollutants per vehicle

Motor vehicles are also major contributors to carbon monoxide and carbon dioxide emissions among other greenhouse gases. They contribute up to 70 percent of carbon monoxide emissions throughout the Northeast. In addition, New Jersey as a whole has the highest percentage of carbon dioxide emissions from transportation than any other state. Carbon dioxide makes up 82 percent of all greenhouse emissions in New Jersey, 38 percent of which arise from mobile sources.

In 2002, the EPA conducted its National Air Toxics Assessment (NATA), which revealed that mobile sources in New Jersey contributed to 67 percent of all emissions of air toxics in New Jersey; on-road mobile emissions accounted for 34 percent of these hazardous air pollutants while non-road mobile emissions accounted for 33 percent. And, of the 181 air toxics included in the NATA, the NJDEP considers 21 to be of particular concern because they exceed health benchmarks in at least one county; 14 of the 21 pollutants are a problem in 18 or more counties. 7 of the 21 pollutants come, at least in part, from mobile sources: Acetaldehyde, Acrolein, Benzene, 1,3-Butadiene, Diesel Particulate Matter, Ethylbenzene, & Formaldehyde. With the exemption of acrolein, these toxics are labeled as known or probable carcinogens. It is estimated that Passaic County emits about 3200 tons of emissions in 2002 ranking number 8 for lowest in the state, while Bergen County estimated to emit about 7800 tons of emissions in 2002 ranks highest in the state.