Indicator: Criteria Air Pollutants in Southeast Michigan

Background

The federal Clean Air Act (CAA) requires the U.S. Environmental Protection Agency (U.S. EPA) to establish National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to the public and the environment. These standards define the maximum permissible concentration[1] of "criteria pollutants" in the air. Criteria pollutants are those common throughout the United States. They are carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ground-level ozone (O_3), particulate matter (PM) less than or equal to 10 (PM_{10}) or 2.5 ($PM_{2.5}$) micrometers in diameter, and sulfur dioxide (SO_2). Of the six pollutants, PM and ground-level ozone are the most widespread health threats. In the Detroit area, $PM_{2.5}$ and ozone continue to violate the NAAQS.

The NAAQS established for the six criteria pollutants are monitored by the Michigan Department of Environmental Quality (MDEQ) through the Michigan Air Sampling Network (MASN) for compliance. Currently there are eleven MASN stations in Wayne County for the various criteria pollutants.

Carbon Monoxide
Carbon monoxide is a colorless, odorless, and poisonous gas that is created during the incomplete burning of fuel. In cities, as much as 95% of all CO emissions come from automobile exhaust. Michigan's on-road motor vehicle sources account for 69% of the state's CO emissions. Michigan's non-road vehicle sources contribute 28% of the state's CO emissions. These sources include aircraft, marine vessels, non-road two and four stroke engines, and railroads. CO emissions from Michigan's industries (point sources) account for only 2%. For the Detroit area, fossil fuel combustion from electric utilities, industrial, commercial and residential sources, as well as iron and steel manufacturing and foundries, were the leading point sources of CO.

Lead
In the past, automobile sources were the major contributor of lead emissions to the atmosphere. Industrial and combustion sources are now the dominant lead emission sources, especially smelting/refining of lead, copper and zinc, and the production of iron, steel, brass and bronze. The highest air concentrations of lead are usually found in the vicinity of smelters and battery manufacturers. For combustion sources, lead is an

[1] For this report, the NAAQS for criteria pollutants are: **CO** – 8-hour average < 10,000 $\mu g/m^3$ (9 ppm), not more than one exceedance/year; 1-hour average < 40,000 $\mu g/m^3$ (35 ppm), not more than once/year. **Pb** – max quarterly average ≤ 1.5 $\mu g/m^3$. **NO_2** – annual average ≤ 100 $\mu g/m^3$ (0.053 ppm). **Ozone** – annual second highest 1-hour daily max average across 3 years ≤ 235 $\mu g/m^3$ (0.12 ppm); annual fourth highest 8-hour daily max average across 3 years ≤ 166 $\mu g/m^3$ (0.085 ppm). **PM_{10}** – annual average must not exceed 50 $\mu g/m^3$; 24-hour concentration limit of 150 $\mu g/m^3$ (average number of expected exceedances per year not to exceed one over the most recent 3-year period). **$PM_{2.5}$** – annual average ≤ 15 $\mu g/m^3$, averaged over 3 years; 98th percentile of 24-hour concentration not to exceed 65 $\mu g/m^3$ (based on a 3-year average). **SO_2** – annual average ≤ 80 $\mu g/m^3$ (0.030 ppm); 24-hour concentration limit not to exceed 365 $\mu g/m^3$ (0.14 ppm) more than once/year.

impurity found in coal, oil, and waste oil, as well as municipal solid waste and sewage sludge incineration.

Nitrogen Dioxide

The major man-made sources that result in the production of NO_2 are high temperature combustion processes. In Michigan, 46% of NO_2 producing compounds come from on-road sources, and 31% come from point sources such as industrial, commercial, institutional and residential fossil fuel combustion. Nitrogen dioxide can sometimes be seen as a reddish-brown layer over the city.

Ozone

Depending on its location in the atmosphere, ozone is considered either good or bad. Good ozone occurs naturally in the stratosphere approximately 16-48 km (10-30 miles) above the Earth's surface and forms a layer that protects the Earth from the sun's harmful rays. In the Earth's lower atmosphere, ground-level ozone is considered bad. Ground-level ozone is created by chemical reactions in the atmosphere involving other air pollutants in the presence of sunlight. These reactions usually occur during the hot summer months.

Major sources of the pollutants that form ozone are engine exhaust, emissions from industrial facilities, combustion from electric utilities, gasoline vapors, chemical solvents, and emissions from natural sources. Ground-level ozone can be transported hundreds of kilometers. As a result, the long-range transport of air pollutants impacts the air quality of areas far downwind. Transported ozone and ozone precursors from Gary, Indiana, Chicago, Illinois, and Milwaukee, Wisconsin, and other upwind source areas affect the levels of ground-level ozone in Michigan.

Of the sources of ozone producing pollutants in Michigan, 63% are emitted by vehicles, and the other 37% are emitted from combustion of fuels, chemical and petroleum manufacturing, and naturally from vegetation.

Particulate Matter

Particulate matter is a general term used for a mixture of solid particles and liquid droplets found in the air. Some particles are large enough to be seen as dust or dirt where others are so small they can only be detected with an electron microscope. The larger PM (PM_{10}) are particles less than 10 micrometers [µm] in diameter which is equal to about 1/7th the diameter of a human hair. In Michigan, 34% of PM_{10} comes from particles that originate from point sources, such as power plants, and various manufacturing and industrial processes; 32% comes from "area" sources, such as wood stoves and fireplaces, agriculture and forestry practices, oil and gas production, paper manufacturing, and small airborne particles that do not originate from any specific point; and another 34% comes from vehicle emissions. Fine PM ($PM_{2.5}$) are particles less than 2.5 µm in diameter. $PM_{2.5}$ comes from the same sources as PM_{10}, but can also form in the air through chemical reactions with atmospheric pollutants. $PM_{2.5}$ from vehicle emissions comprises 50% of the ambient $PM_{2.5}$ in Michigan. Area sources make up 37% and point sources contribute 13%. Particles with diameters of less than 50 µm are classified as total suspended particulates (TSP), an older measure of PM.

Sulfur Dioxide
In Michigan, 85% of the overall SO_2 emissions are from point sources. These point sources are from industrial processes that burn fossil fuels, chemical manufacturing, metals processing, petroleum-related industries, and incineration. Other sources include residential, commercial, and industrial space-heating.

Status and Trends

Carbon Monoxide
From 1979 to 1984, the CO levels in the Detroit area had exceeded the NAAQS for 8-hour exposure. Since that time, there have been no exceedances. Figure 1 indicates a clear downward trend since 1979 (when U.S. EPA first established criteria for the National Air Monitoring Sites). This trend represents a 50% decrease in average CO levels every 10 years, or 0.31 ppm/year. On August 30, 1999, the Detroit area was taken off the list of problem areas for carbon monoxide.

The decline of CO in the Detroit area follows a national trend, even though there is an increase in the distance vehicles travel. Starting with the Clean Air Act of 1970, catalytic converters, fuel economy standards, national standards for tailpipe emissions, new vehicle technologies, clean fuels programs, and state and local emissions reduction measures are credited with the decrease in emissions of CO.

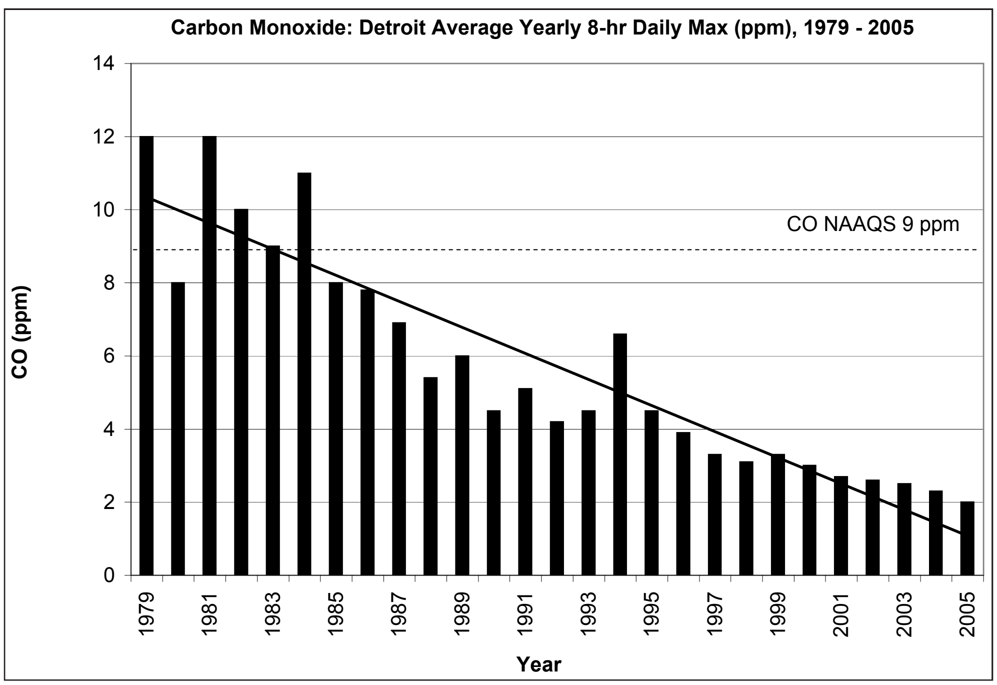

Figure 1. The average yearly 8-hour daily maximum levels of CO in Detroit, 1979-2005. Compliance with the CO standard is met when the 35 ppm 1-hour average standard and/or the 9 ppm 8-hour average standard is not exceeded more than once per year.

Lead
Ambient lead levels have been consistently below NAAQS since 1981, when the U.S. EPA established new ambient lead monitoring criteria, and the average air quality concentration for lead in the Detroit area in 2005 was 98% lower than the high in 1983 (Figure 2).

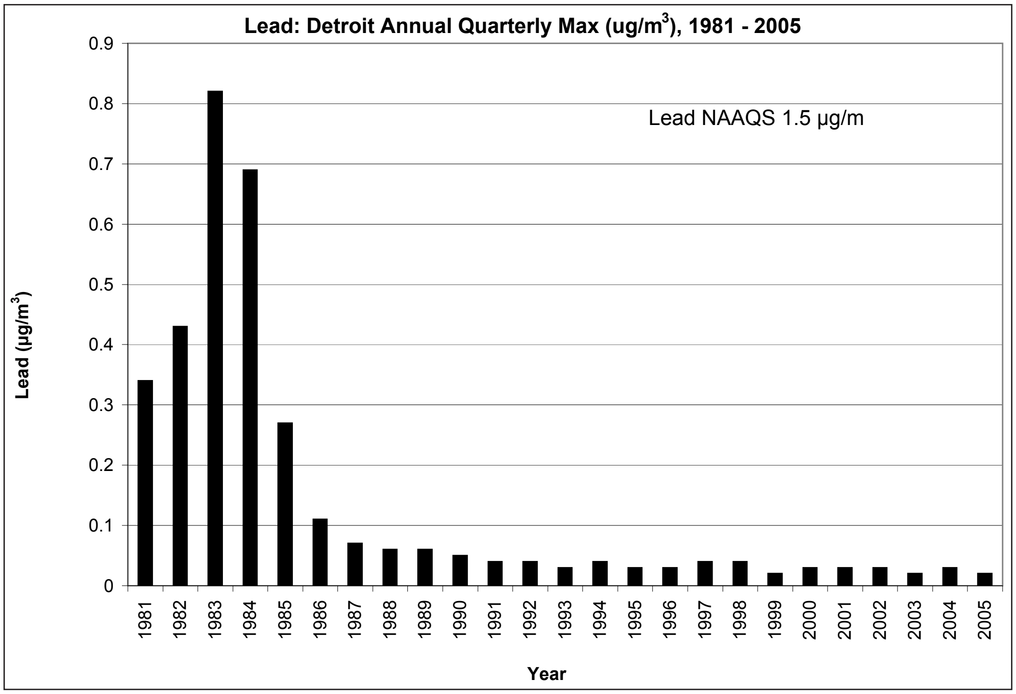

Figure 2. The annual quarterly maximum (µg/m^3) lead levels in Detroit, 1981-2005. Daily values are collected for three consecutive months (by calendar quarter), averaged, and then compared to the 1.5 µg/m^3 standard.

Due to the phase-out of leaded gasoline, ambient lead concentrations in air sharply declined during the 1980s and early 1990s, and in Michigan, vehicle emissions no longer contribute quantifiable lead emissions. Because of the success of reduction of lead from auto emissions, in 1999, the U.S. EPA reduced requirements for measuring lead air pollutant concentrations near major highways, while focusing on point sources. Point sources such as nonferrous smelters and battery plants now contribute 100% of Michigan's overall lead emissions. However, there are no large sources of lead in Michigan and the average ambient lead levels are less than one-tenth of the NAAQS.

Nitrogen Dioxide

Michigan has never recorded a violation of the nitrogen dioxide standard. From 1979 to 2005, the Detroit area has been well below the NAAQS for NO_2 at an average of 43% (Figure 3). Regulations on vehicle emissions over the past few decades and reductions in emissions from power plants due to stricter regulations and new technologies have contributed to a decreasing trend.

Ozone

In 1979, the U.S. EPA established a 1-hour standard for ozone. Since then, there has been a slight downward trend in the 1-hour ozone level in the Detroit area (Figure 4a). From 1979 to 1989, the standard was exceeded five out of the ten years. From 1990 to 2000, the standard was exceeded only once, and since 1995 there have been no exceedances.

In the past, 8-hour ozone measurements were taken to help estimate the 1-hour standard. In 1997, based on the latest scientific information showing adverse effects from exposures allowed by the 1-hour standard, the U.S. EPA strengthened the ozone NAAQS by adopting the 8-hour averaging time. By 2005, the 1-hour standard was mostly phased out in favor of the 8-hour standard.

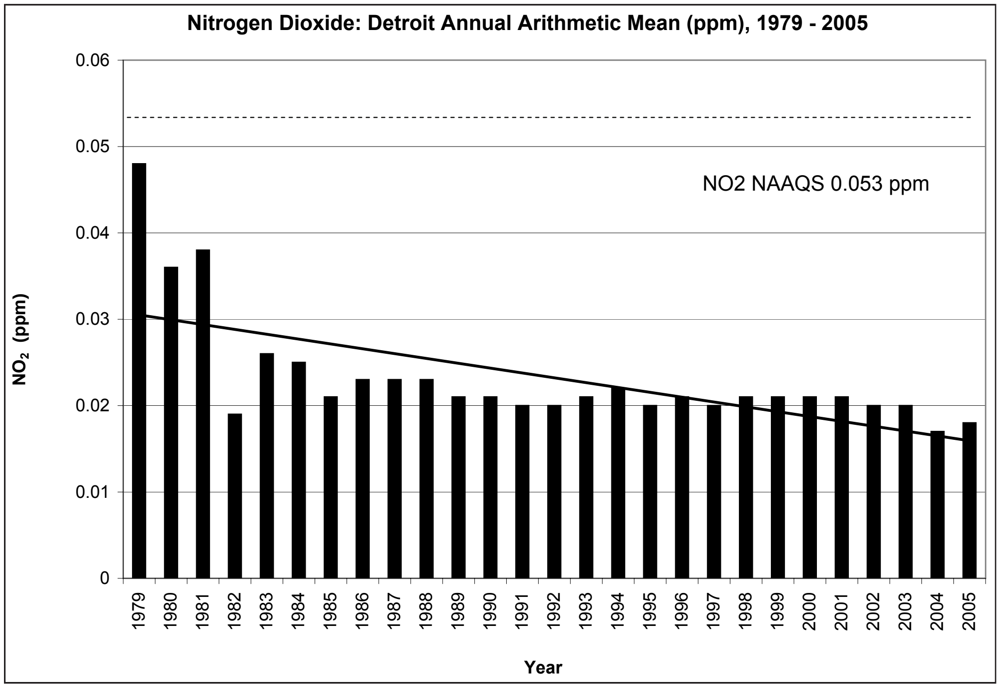

Figure 3. The annual average (ppm) of nitrogen dioxide in Detroit, 1979-2005. Compliance is met when the annual average concentration does not exceed 0.053 ppm.

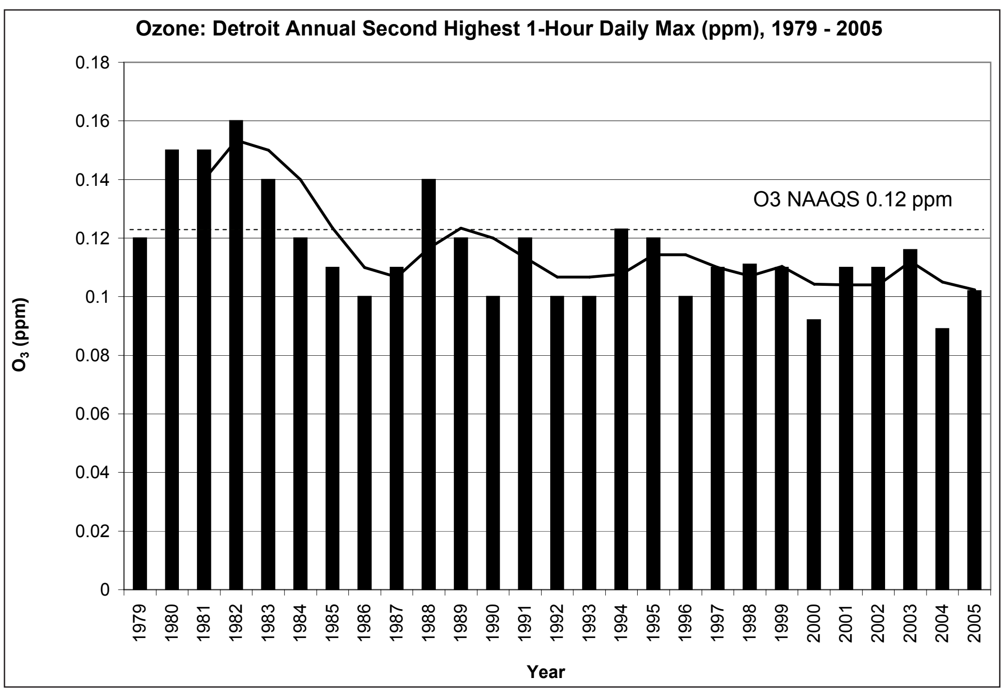

Figure 4a. The annual second highest 1-hour daily maximum average (ppm) of ground-level ozone in Detroit, 1979-2005. The 1-hour ozone standard is violated when the annual second highest maximum hourly average concentration, averaged over three years, exceeds 0.12 ppm (see bold line).

There is no clear trend for the Detroit area 8-hour ozone levels (Figure 4b). Currently, the Detroit area is not considered in compliance with the NAAQS. In 2006, MDEQ instituted measures aimed at meeting the NAAQS by 2007. The most significant action is a requirement for low-vapor pressure gasoline to be sold in the Detroit area during summer months to reduce the amount of ozone-causing air pollutants.

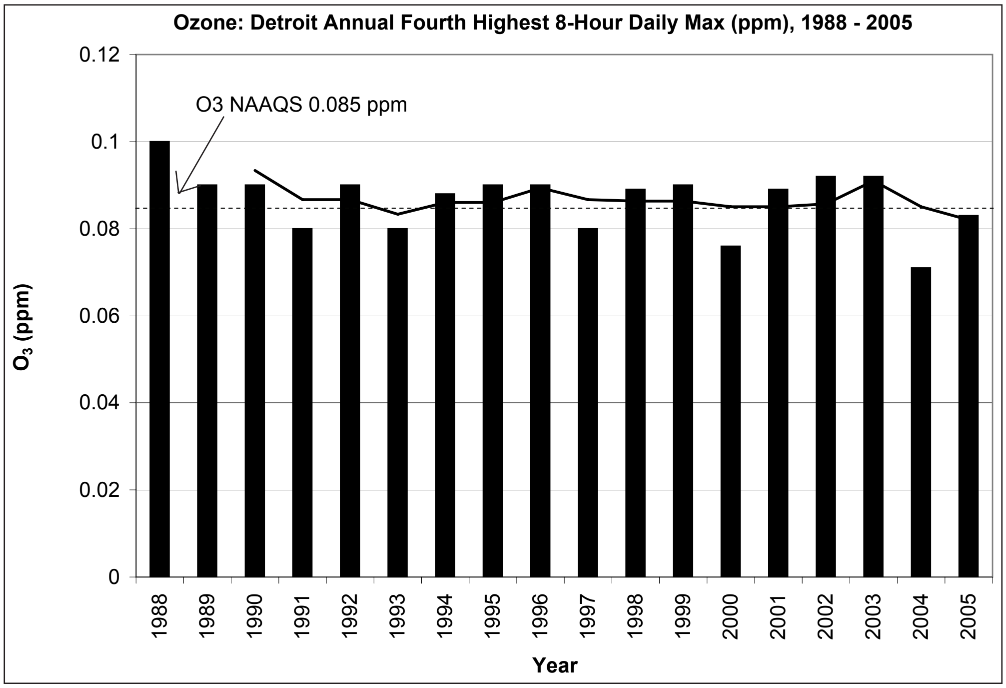

Figure 4b. The annual fourth highest 8-hour average daily maximum (ppm) for ground-level ozone in Detroit, 1988-2005. The 8-hour ozone standard is violated when the annual fourth highest daily maximum 8-hour concentration, averaged over three years, exceeds 0.085 ppm (see bold line).

Particulate Matter

From 1960 to 1985, the TSP standard in the Detroit area was exceeded every year, with no clear trend toward improvement (Figure 5). The standard was revised from TSP to PM_{10} in 1987, as research demonstrated smaller sized particles presented a greater health risk. From 1988 (the first full year of monitoring under the new PM_{10} standard) to 2005, there were no exceedances, on average, of the NAAQS for PM_{10} in the Detroit area. However, the Dearborn station did register a few exceedances of the 24-hour PM_{10} standard during that time and continues to have the highest maximum annual average (39.7 $\mu g/m^3$) in the state. In 1997, the PM_{10} standard was revised and a new standard was added for $PM_{2.5}$. Since 1999 (the first full year of monitoring under the new $PM_{2.5}$ standard), the Detroit area has met the standard only once (in 2004). Due to failure to meet the $PM_{2.5}$ standard, MDEQ is required to develop control strategies to bring the area into attainment by 2010.

Along with the requirement for MDEQ to reduce the level of $PM_{2.5}$, there are several federal measures in place that are intended to reduce vehicle emissions nationwide, which is expected to have an impact for Wayne County. One program is aimed at reducing the level of sulfur in gasoline and sets standards for tailpipe emissions. Another addresses emission control technologies for new diesel engines and reduces the allowable level of sulfur in non-road diesel fuel. Other measures to reduce air pollutants from

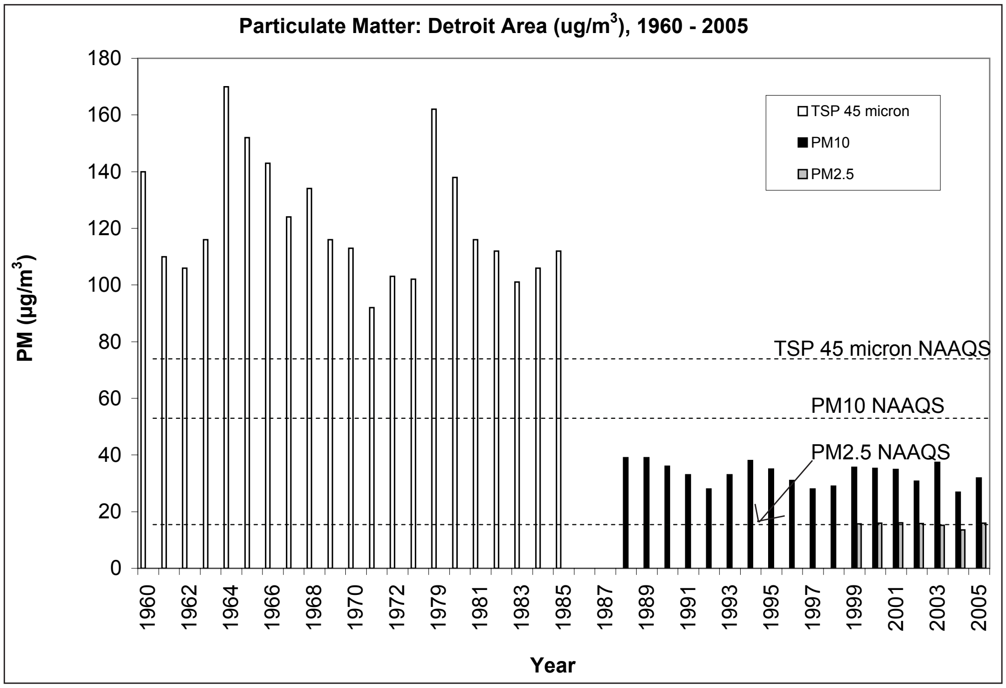

Figure 5. Particulate matter in the Detroit area using three criteria, TSP 45 micrometers, PM_{10} and $PM_{2.5}$, 1960-2005. TSP NAAQS - 75 µg/m³ annual geometric mean. PM_{10} NAAQS - annual average must not exceed 50 µg/m³. (Average number of expected exceedances per year not to exceed one over the most recent three-year period). $PM_{2.5}$ NAAQS - annual average must not exceed 15 µg/m³ (based on a 3-year average).

power plants are also expected to have a positive effect on limiting the generation of $PM_{2.5}$. Controls being implemented at local steel mills and oil refineries are expected to result in significant reductions and will help bring the area into attainment by 2010.

Sulfur Dioxide

In the Detroit area, SO_2 levels have consistently been well below the NAAQS since 1979 and show a clear downward trend. The ambient level of sulfur dioxide has decreased by 73% since 1979 (Figure 6). This reduction was due to new technology at coal-burning power plants, reducing the average sulfur content of fuels burned, and the increased use of natural gas for heating homes and businesses.

Management Next Steps

Efforts must continue to increase the availability and implementation of new technologies so that all air quality standards are met. There must be open dialogue with all parties involved and allow public access to data on current air conditions to foster an environment of continuous improvement in emissions reductions. On March 29, 2007, the U.S. EPA defined requirements for plans submitted by states that did not reach attainment based on their compliance with $PM_{2.5}$ standards implemented in 1997. Nonattainment states have been required to submit plans by April 2008 outlining measures to reach attainment by 2010. MDEQ submitted documentation in February 2005 showing only Wayne County as nonattainment for $PM_{2.5}$. The U.S. EPA determined that the six counties surrounding Wayne were contributing to its nonattainment status. Michigan is required to bring these areas into attainment by 2010.

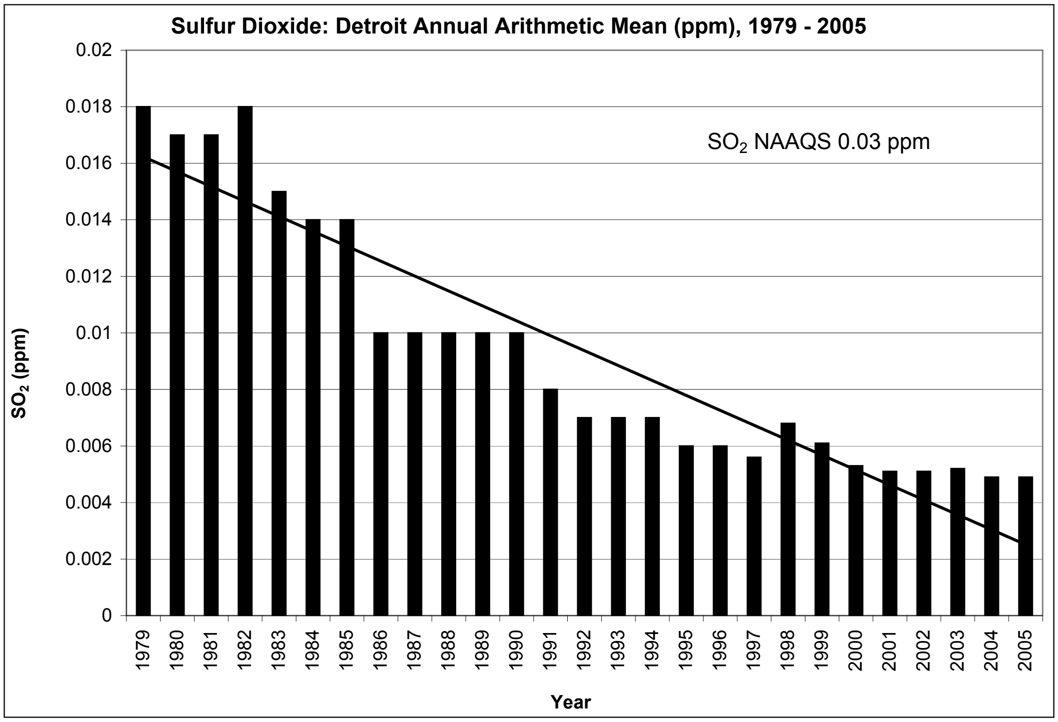

Figure 6. The annual arithmetic mean (ppm) of sulfur dioxide in Detroit, 1979-2005. The annual arithmetic mean concentration shall not exceed 0.03 ppm more than once per year and/or 24-hour limit not to exceed 0.14 ppm more than once per year.

SEMCOG's Southeast Michigan Air Quality Task Force and MDEQ have developed an attainment strategy for bringing the region into compliance with the annual standard by 2010. However, the new daily standard poses additional challenges. Much work still needs to be done to understand the characteristics of different species of $PM_{2.5}$, particularly organic carbon.

In 2005, MDEQ and SEMCOG submitted an ozone attainment strategy to U.S. EPA, identifying the control measures that would be implemented to meet the 8-hour ozone standard. While southeast Michigan has not measured a violation of the standard in the last three years, and MDEQ has requested the region be redesignated as attainment, the State and SEMCOG have moved forward with implementation of the control measures in the attainment strategy. These include a decrease in the allowable vapor pressure of summertime gasoline from 7.8 to 7.0 psi, and a reduction in allowable volatile organic compound emissions from consumer and commercial products. Both of these measures went into effect in 2007.

Research/Monitoring Needs

Air quality monitoring that will support the development of effective attainment strategies is critical to meeting standards. More quality monitoring data are needed to understand the specific sources of the various pollutants and the most effective ways to control them. Additional research exploring the specific links between air pollution and respiratory problems is also needed. In particular, a better understanding is needed of why asthma rates are increasing at the same time air quality is improving.

$PM_{2.5}$ is currently monitored according to a federal reference method which allows comparisons to NAAQS. Hourly $PM_{2.5}$ is monitored using a Tapered Element Oscillating Microbalance (TEOM) instrument. In order to identify and characterize the components within $PM_{2.5}$ samples, a Met-One spiral ambient speciation sampler (SASS) is used. Both TEOM and SASS have been recently implemented throughout the state. There must be a close coupling of monitoring and characterization (i.e., stack testing and other analyses to understand where pollutants are coming from) with the response to meet air quality objectives for all six criteria pollutants. According to the Air Quality Technical Advisory Group at SEMCOG, there is more need for high-frequency speciated data collection and analysis of $PM_{2.5}$. More information is also needed specifically for condensable PM. In addition, research must address how quickly and under what conditions secondary $PM_{2.5}$ forms in the region. Measures need to be undertaken to properly identify the sources of organic carbon in certain areas. Ozone research must address the specific types of volatile organic compounds in the air so that effective strategies for attainment can be implemented. Increased air quality regulations are being implemented in the midst of federal funding cutbacks for monitoring. However, reduced monitoring decreases the ability to develop effective attainment strategies. Every effort must be made to ensure adequate monitoring to be able to achieve effective management.

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Links for More Information

U.S. EPA Technology Transfer Network, Air Quality System: http://www.epa.gov/ttn/airs/aqsdatamart/

U.S. EPA Office of Air and Radiation: http://www.epa.gov/air/

- U.S. EPA Air Trends website: http://www.epa.gov/air/airtrends/
- U.S. EPA National Ambient Air Quality Standards (NAAQS): http://www.epa.gov/air/criteria.html

MDEQ Air website: http://www.michigan.gov/deq/0,1607,7-135-3310---,00.html

MDEQ Annual Air Quality Reports: http://www.michigan.gov/deq/0,1607,7-135-3310_4195-79055--,00.html

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