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Cecil County, Maryland 8-Hour Ozone State Implementation Plan and Base Year Inventory

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Prepared for:

U.S. Environmental Protection Agency

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Introduction

Ground level ozone is considered a significant health based pollutant and the US Environmental Protection Agency (EPA) has set a specific national ambient air quality standard for ozone to best protect public health. This standard, known as the 8-Hour Ozone standard, is implemented under the federal Clean Air Act (CAA). Areas of the county that monitor air pollution above the federal standard are designated "nonattainment" and are therefore required to develop and implement air quality plans called State Implementation Plans or SIPs that show how a particular region will reduce pollution to the point where the region meets the federal standards.

The Philadelphia Nonattainment Area (Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ ozone nonattainment region), which includes Cecil County, Maryland, has been designated nonattainment under the 8-Hour Ozone standard. The following document explains the process by which Cecil County and the region will reduce pollution and meet the federal ozone standard by June 15th 2010, which is the designated attainment date for the region.

This is a substantial good news story regarding Maryland's improving air quality. The Maryland Department of the Environment (MDE) is very proud of this SIP document as it shows, based on significant modeling and weight of evidence analysis, that Cecil County will indeed attain the ozone standard during the 2009 ozone season.

Emissions

A significant portion of this document is related to emissions. Nitrogen Oxides (NOx) and Volatile Organic Compounds (VOC) emissions create ozone under heat and sunlight. Reductions in these precursor emissions are a necessity to reduce ozone pollution. MDE is responsible for creating an emissions inventory for NOx and VOC that estimates the actual emissions created by all the different emission sources in our state. Emissions come from a variety of sources including mobile sources like cars and trucks, point sources like power plants, area sources like lawnmowers, and non-road sources like construction equipment and all terrain vehicles.

This document details the current emission inventory for NOx and VOC and predicted emissions for the future. It is important to predict emissions in the future to track progress from emission reduction programs and for incorporation into attainment analyses that predict whether a region will meet the air quality standard or not.

The good news exhibited by this document is that NOx and VOC emissions are going down in Cecil County and the region. Control programs aimed at reducing emissions have been developed and implemented and the reductions required by these programs are significant. Population growth, economic growth, and the public need tend to tax the emission reductions that come from control programs. Despite these obstacles, the overall trend in ozone forming emissions is downward and MDE predicts that with additional reductions will come even cleaner air.

Control Programs

Over the past several decades MDE has adopted and implemented numerous control programs (laws, regulations, voluntary measures) that reduce NOx and VOC emissions in Maryland. In addition, several new control measures are being adopted specifically to help Maryland attain the federal ozone standard. The programs, in addition to the existing control programs that continue to be implemented and enforced, allow Maryland to develop an attainment demonstration that shows how Maryland will meet the federal ozone standard.

The most significant new control program is the Maryland Healthy Air Act (HAA), which significantly reduces NOx from Maryland's older coal burning power plants. The HAA is more stringent than the parallel federal rule called the Clean Air Interstate Rule and is the most substantial emission control program ever adopted in Maryland. The HAA is the most aggressive power plant control program on the east coast. Overall, the HAA will reduce Maryland power plant NOx emissions by 70% (compared to 2002 levels) in 2009 and by 75% by 2012. The 2009 reductions are a significant part of the attainment scheme developed by MDE to meet the federal ozone standard.

Additional control programs being implemented to help Maryland meet the federal ozone standard include several VOC rules targeted at adhesives and sealants, lower VOC portable fuel containers, and lower VOC consumer products. Other non-traditional measures include an aggressive telework program and a tree canopy program.

The following is a brief summary of new control measures being implemented to assist Cecil County with attaining the 8-hour Ozone standard.

Control Measures Summary*

	2009	
Control Measure	**VOC (tpd)**	**NOx (tpd)**
On Road Mobile Measures	1.85	3.78
Stage II/Refuel	0.00	0.00
OTC - Consumer Products Phase 1	0.14	0.00
OTC - Consumer Products Phase 2	0.02	0.00
OTC – Low VOC Paints - AIM	0.39	0.00
OTC - PFC Phase 1	0.32	0.00
OTC - PFC Phase 2	0.03	0.00
OTC - Industrial Adhesives	0.10	0.00
Open Burning	0.00	0.00
Nonroad Model	1.50	0.36
Railroads (Tier 2)	0.00	0.16
Healthy Air Act (HAA)	0.00	0.00
Total	**4.35**	**4.30**

** All control level totals are rounded*

Modeling

A significant part of the attainment demonstration for Maryland consists of air quality modeling analysis. Required by the CAA, air quality models are run to examine what future air quality conditions will be and whether a region will attain the standard or not by their designated attainment date. The models are not relied upon as the only attainment test, but are an important part of the attainment demonstration for Maryland.

The air quality modeling analysis completed for this SIP shows that Cecil County, Maryland will attain the 8-hour ozone standard during the 2009 ozone season. The predicted ozone level for the Fair Hill Monitor in Cecil County for the summer of 2009 is 81 ppb, lower than the standard of 85 ppb. Other locations in the larger Philadelphia Nonattainment area are not showing such robust improvements in overall air quality and the direct modeling completed for this SIP does not show predicted air quality levels below 85 ppb. However, using other analytical methods under an approach called weight of evidence, Maryland believes that the entire region will indeed attain the 8-hour ozone standard.

Weight of Evidence

As mentioned above, air quality models are not the only tool available that can be used to predict attainment of the federal ozone standard. A weight of evidence approach can be used to further analyze air quality data, trends, meteorology, model performance and model chemistry. The MDE has developed a significant weight of evidence that Cecil County and the Philadelphia Nonattainment area will indeed meet the federal ozone standard during the 2009 ozone season.

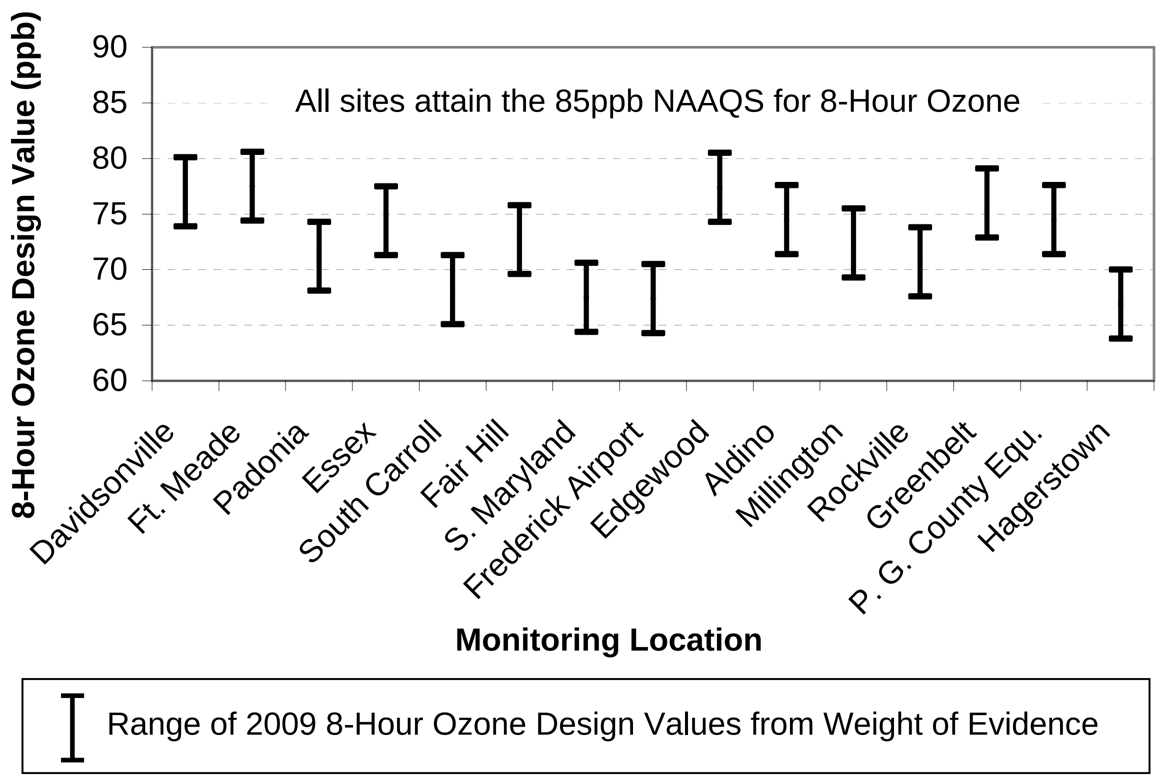
Some of the weight of evidence analyses utilized for the region includes:

- an analysis of the chemistry component of the Community Multi-scale Air Quality (CMAQ) model
- an analysis to the ozone sensitivity to NOx emission reductions
- the effect of land-sea interactions on ozone at the Edgewood air quality monitor
- an analysis of the regional nature of ozone transport
- an analysis of the potential benefits of an aggressive telecommuting strategy
- an analysis of the uncertainty in the CMAQ air quality model and the over-prediction of ozone design values
- an analysis of the effects of urban tree canopy cover on temperature and ozone levels

In addition, other states in the nonattainment area are providing other substantial weight of evidence analysis that lead to an attainment demonstration for the region. These additional weight of evidence chapters from other states were not available in time for inclusion in this SIP document.

Based on all of the above analysis and the air quality modeling performed for Cecil County and the Philadelphia Nonattainment area, there is a dramatic weight of evidence available that shows the region will attain the 8-hour ozone standard. The chart below shows a summary of the Maryland ozone monitor design value ranges expected in the region based on the modeling/

weight of evidence analysis. All of the air quality monitors in the region are predicted to be well below the 85ppb 8-hour ozone standard.



2.0 Introduction and Background

This document, entitled *Cecil County, Maryland / Philadelphia Nonattainment Area 8-Hour Ground Level Ozone State Implementation Plan,* presents the Maryland Department of the Environment's (MDE's) progress in adopting and implementing air pollution control programs needed to attain the 8-hour ozone standard by 2010 in Cecil County, Maryland.

2.1 State Implementation Plans

The State Implementation Plan (SIP) is a detailed document required for states or regions that do not meet air quality levels set by the federal government. The Plan identifies how that State will attain and/or maintain the primary and secondary National Ambient Air Quality Standards (NAAQS) set forth in section 109 of the Clean Air Act ("the Act") and 40 Code of Federal Regulations 50.4 through 50.12 and which includes federally-enforceable requirements. Each State is required to have a SIP that contains control measures and strategies that demonstrate how each area will attain and maintain the NAAQS. These plans are developed through a public process, formally adopted by the State, and submitted by the Governor's designee to EPA. The Clean Air Act requires EPA to review each plan and any plan revisions and to approve the plan or plan revisions if consistent with the Clean Air Act.

SIP requirements applicable to all areas are provided in section 110 of the Act. Part D of Title I of the Act specifies additional requirements applicable to nonattainment areas. Section 110 and part D describe the elements of a SIP and include, among other things, emission inventories, a monitoring network, an air quality analysis, modeling, attainment demonstrations, enforcement mechanisms, and regulations which have been adopted by the State to attain or maintain NAAQS. EPA has adopted regulatory requirements which spell out the procedures for preparing, adopting and submitting SIPs and SIP revisions that are codified in 40 CFR part 51. EPA's action on each State's SIP is promulgated in 40 CFR part 52.

The contents of a typical SIP fall into several categories: (1) State-adopted control measures which consists of either rules/regulations or source-specific requirements (e.g., orders and consent decrees); (2) State-submitted comprehensive air quality plans, such as attainment plans, maintenance plans rate of progress plans, and transportation control plans demonstrating how these state regulatory and source-specific controls, in conjunction with federal programs, will bring and/or keep air quality in compliance with federal air quality standards; (3) State-submitted "non-regulatory" requirements, such as emission inventories, small business compliance assistance programs; statutes demonstrating legal authority, monitoring networks, etc.); and (4) additional requirements promulgated by EPA (in the absence of a commensurate State provision) to satisfy a mandatory section 110 or part D (Clean Air Act) requirement.

Once the Administrator of the EPA approves a state plan, the plan is enforceable as a state law and as federal law under Section 113 of the Act. If the SIP is found to be inadequate in EPA's judgment to attain the NAAQS in all or any region of the state, and if the state fails to make the requisite amendments, under Section110(c)(1), the EPA Administrator may issue amendments to the SIP that are binding. EPA is required to impose severe sanctions on the states under three circumstances: the state's failure to submit a SIP revision; on the finding of the inadequacy of the SIP to meet prescribed air quality requirements; and the state's failure to enforce the control strategies that are contained in the SIP. Sanctions include: withholding federal funds for highway projects other than those for safety, mass transit, or transportation improvement projects related to air quality improvement or maintenance beginning 24 months after EPA announcement. No federal agency or department will be able to award a grant or fund, license, or permit any transportation activity that does not conform to the most recently approved SIP.

2.2 Clean Air Act

The Clean Air Act was passed in 1970 to protect public health and welfare. Congress amended the Act in 1990 to establish requirements for areas not meeting the National Ambient Air Quality Standards. The Clean Air Act Amendments of 1990 (CAAA) established a process for evaluating air quality in each region and identifying and classifying nonattainment areas according to the severity of its air pollution problem. The CAAA defines ground-level ozone as a criteria pollutant. In 1979 EPA promulgated the 0.12 parts per million (ppm) 1-hour ozone standard. In 1997, EPA issued a revised and stricter ozone standard of 0.08 ppm, or 85 parts per billion (ppb), measured over an eight-hour period. The one-hour ozone standard was consequently revoked in June 2005. The Clean Air Act also sets National Ambient Air Quality Standards for five other criteria pollutants; carbon monoxide, particulate matter, lead, sulfur dioxide and nitrogen dioxide.

In April 2004, EPA designated the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ ozone nonattainment region as a “moderate” nonattainment area for the eight-hour ozone standard under Subpart 2 area of Section 182 part b. Cecil County is the Maryland portion of the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ ozone nonattainment region. A map of the nonattainment area is shown in Figure 2.1.

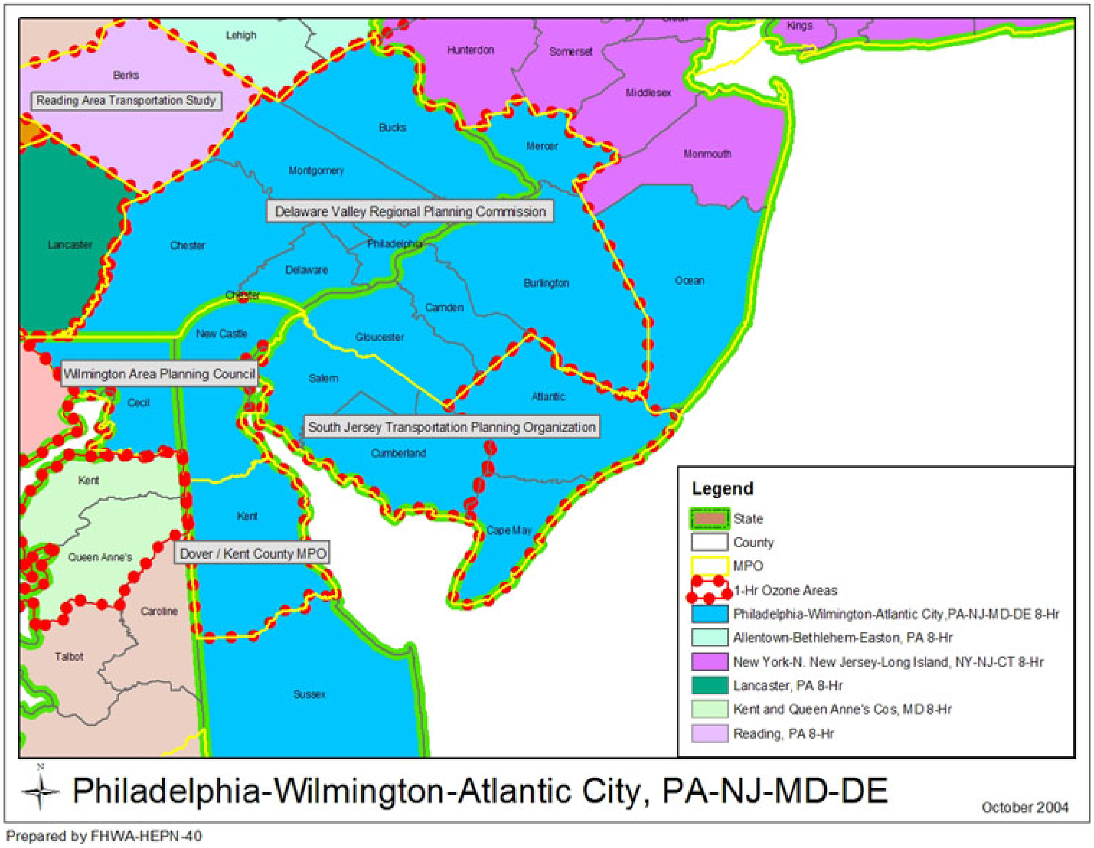


Figure 2.1 - Map of the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ ozone nonattainment region

To meet the federal 8-hour standard for ozone, nonattainment areas are required to develop their SIP documents to reduce ozone-forming emissions of volatile organic compounds (VOCs) by at least 15 percent between 2002-2008, and to reduce all ozone precursor emissions to a level sufficient to attain the federal eight-hour standard by June 15, 2010. However, the region is required to demonstrate attainment of the standard by the end of the last ozone season before that date, which is September 2009.

2.3 SIP Requirements for Moderate Nonattainment Areas

The Clean Air Act Section 182 sets requirements for nonattainment areas based on their classification. Under the 1hr Ozone Standard, Cecil County was classified as severe. Under the 8-hour Ozone Standard Cecil County was reevaluated and classified as moderate.

Based on the Severe 1hr Ozone Standard classification very stringent measures were required in Cecil County:

- Low new source review threshold for point sources at 25 tons per year;
- Low threshold for definition of "Major" source requiring controls to 25 tons per year;
- New Source Review offsets at 1.3 to 1
- Enhanced I&M

Maryland will continue to implement the above listed 1hr ozone requirements. In addition to these restrictive severe area requirements, Maryland will also implement the necessary moderate area requirements listed below.

- Reasonable Further Progress: 15% emission reduction from baseline
- Attainment demonstration: Due 3 years from designation
- NSR permits: required for new or modified major stationary sources
- NOx control for RACT: requirement for major stationary VOC sources also applies to major NOx sources
- RACM/RACT: RACT required for all Control Technique Guideline (CTG) sources and all other major sources
- Stage II vapor recovery: required for all gas stations
- Contingency measures: required for failure to meet Reasonable Further Progress (RFP) milestones or attain

2.4 Eight-Hour Ozone Standard

In 1997, EPA issued a revised ozone health standard based on an 8-hour measurement to protect human health against longer exposure periods. Since the late 1980's, more than 3,000 published health studies indicated that health effects occur at levels lower than the previous standard and that exposure times longer than one hour are of concern. EPA established an 8-hour standard at 0.08 ppm / 85 ppb and defined the new standard as a "concentration-based" form, specifically the 3-year average of the 4th highest daily maximum 8-hour ozone concentration.

EPA changed the form of the standard to a concentration-based form because it more accurately reflects actual human exposure and related health effects. Even at relatively low levels, ozone may cause inflammation and irritation of the respiratory tract, particularly during physical activity. The resulting symptoms can include breathing difficulty, coughing, and throat irritation. Breathing ozone can affect lung function and worsen asthma attacks. Ozone can increase the susceptibility of the lungs to infections, allergens, and other air pollutants. Medical studies have shown that ozone damages lung tissue and complete recovery may take several days after exposure has ended.

2.5 Ground Level Ozone

Ground-level ozone is an extremely reactive gas comprised of three atoms of oxygen. Ozone (the primary constituent of smog) continues to be a pollution problem throughout many areas of the United States. Unlike many other pollutants, ground-level ozone is not directly emitted into the atmosphere from a specific source. Instead, ground-level ozone is formed when nitrogen oxides (NOx) chemically react with volatile organic compounds (VOCs) through a series of complicated chemical reactions in the presence of strong sunshine (ultraviolet light).

Because ozone formation is greatest when the sunlight is most intense, the peak ozone levels typically occur in Maryland during hot, dry, stagnant summertime conditions generally referred to as the ozone season (May 1 to September 30). Peak Ozone concentrations exhibit a clear seasonal cycle, with concentrations rising with the onset of warmer weather in the spring and declining again as the autumn approaches. Changing weather patterns can significantly contribute to yearly differences in ozone concentrations. Years with summertime weather conditions that are hot and dry will generally result in many more days of poor air quality than cool and wet summers.

Figure 2.2 Formation of Ground Level Ozone

The formation of ozone is not an instantaneous process, nor is it limited in geographical scope. While many urban areas tend to have high levels of ozone, even rural areas are subject to increased ozone levels because wind carries ozone, and pollutants that form it, hundreds of miles from their original sources. Numerous studies and modeling data show compelling evidence that weather patterns often transport ozone, and the pollutants responsible for ozone formation, well beyond the locality that produced the emissions. In many cases, unhealthy days of air pollution experienced in Maryland are exacerbated by pollutants transported into Maryland from neighboring states.

2.6 Air Pollution and the Chesapeake Bay

Typically, air pollution is thought of as smog that affects people's health and reduces visibility. However, air pollution also contributes to land and water pollution that affects the health of the Chesapeake Bay's resources - its fish, shellfish, and other animals. Over the last thirty years, research has provided us with more knowledge on how air pollution can directly affect the Bay.

Pollutants released into the air will eventually make their way back down to the earth's surface. Some of the factors that determine how far pollutants can travel through the air include, the makeup of the pollutant, weather conditions (wind, temperature, humidity), type and height of the emission source (smokestack, automobile tail pipe), and the presence of other chemicals in the air. Airborne pollutants fall to the earth's surface by wet deposition (precipitation), or dry deposition (settling or adsorption). Airborne pollutants that deposit on the landscape can be transported into streams, rivers, and the Bay by runoff or through groundwater flow.

Excess nitrogen and chemical contaminants from atmospheric deposition impact the Chesapeake Bay and its watershed. Too much nitrogen entering the Chesapeake Bay leads to eutrophication; a process that causes an accelerated growth of algae. Too much algae in the Bay blocks sunlight needed for submerged aquatic vegetation to grow. Also, when the algae dies it sinks to the bottom and decomposes in a process that depletes the oxygen in the water.

The effects of nitrogen can also be seen in acid rain. Nitrogen oxides (NOx) are one of the key air pollutants that cause acid deposition, and results in adverse effects on aquatic and terrestrial ecosystems. Acid deposition increases the acidity of water and soils. Increases in water acidity can impair the ability of certain fish and aquatic life to grow, reproduce, and survive. Increases in soil acidity can impair the ability of some types of trees to grow and resist disease.

2.7 Health Effects

Ozone is a highly reactive gas that reacts strongly with living tissues, as well as many man-made substances. Ninety percent of the ozone breathed into the lungs is never exhaled, ozone molecules react with lung tissue to cause several health consequences.[1] Too much ozone in the air we breathe can be harmful to people who work or exercise outdoors regularly, anyone with respiratory difficulties, and especially to our children. The most common symptom that people have when exposed to ozone is pain when taking a deep breath. Exposure to ozone can result in both long-term and short-term effects in healthy individuals as well as those who are already sensitive to air pollution, such as children, asthmatics and the elderly.

Ozone long-term effects may include reduced lung function, scarring of lung tissue, and even premature death[2]. Research suggests that repeated exposure to ozone may cause damage to lung tissue, thereby reducing lung function. According to EPA, "Long-term exposures to ozone can cause repeated inflammation of the lung, impairment of lung defense mechanisms, and irreversible changes in lung structure, which could lead to premature aging of the lungs and/or chronic respiratory illnesses such as emphysema and chronic bronchitis." [3]

Children are at greater risk for ozone-related respiratory problems because their lungs are still developing, they breathe more rapidly, and they play outside during the afternoons when ozone

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[1] Sources and Health effects of Ground-Level Ozone, downloaded from http://www.dnr.state.wi.us/eq/aie/ozone/b_effect.htm.

[2] Bell ML, Dominici F, and Samet JM. *A Meta-Anaysis of Time-Series Studies of Ozone and Mortality with Comparison to the National Morbidity, Mortality, and Air Pollution Study*. Epdidemiology 2005; 16:436 445.

[3] United States Environmental Protection Agecny. (17 July, 1997), Factsheet: EPA's Revised Ozone Standard. United State Environmental Protection Agency, Technology Transfer Network, OAR Policy and Guidance. Retrived on December 28, 2005 from the World Wide Web: http://www.epa.gov/ttn/oarpg/naaqsfin/03fact.html/

is at its highest levels. Children also inhale more air, hence more pollution per pound of body weight than adults do.[4] Additionally, anyone suffering from lung disease has even more trouble breathing when air is polluted with high levels of ozone. Prolonged exposure, even to relatively low levels of ozone, can even significantly reduce a healthy adult's lung function. [5]

Short-term effects among healthy populations include impaired lung function and reduced ability to perform physical exercise. For example, healthy young people developed significant reduction of lung function, additional coughing and breathing pains, and enhanced airway reactivity to irritants when exposed to ozone at concentrations between 80-120 parts per billion (ppb) for 6.6 to 7.0 hours while moderately exercising.[6] For reference, the new ozone standard issued by EPA in 1997 is a concentration of 0.08 ppm averaged over an eight-hour time period. The Philadelphia Nonattainment Area does not currently achieve this standard. Among people who are especially sensitive to ozone pollution, short-term effects include increased hospital admissions and emergency room visits for respiratory diseases, like asthma.

In sum, health effects from exposure to ozone can include any or all of the following:

- Increased susceptibility to respiratory infection.
- Impaired lung function and reduced ability to perform physical exercise.
- Severe lung swelling and death, due to short-term exposures greater than 300 ppb.
- Increased hospital admissions and emergency room visits from respiratory diseases.

Ozone also poses a threat to the health of natural ecosystems. Scientific evidence suggests that air pollution weakens the immune systems of many types of vegetation and can cause significant crop damage. In addition, rain and snow wash air pollution deposited on vegetation and architectural surfaces into the streams and rivers of the region and finally into the Chesapeake Bay.

2.8 Maryland Specific Health Effects

According to the U.S. Census Bureau, Census 2000 data, there are 5,296,486 people living in Maryland, of whom 1,136,846 were under 15 years of age, and of whom 599,307 were 65 or over[7]. This means that the total number of children and elderly in Maryland was 1,736,153.

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[4] Ambient Air Pollution: Respiratory Hazards to Children Committee on Environmental Health Pediatrics 1993 91: 1210-1213.

[5] Galizia, A. and Kinney, P.L. Long-Term Residence in Areas of High Ozone: Associations with Respiratory Health in Nationalwide Sample of Nonsmoking Young Adults. August 1999. Environ Health Perspect, Vol. 107, No. 8, pp. 675-679

[6] Foinsbee et al., 1990; Horstman et al., 1990; McDonnell et al., 1991. Out of Breath: A Report on the Health Consequences of Ozone and Acidic Air Pollution in Metropolitan Chicago. American Lung Association of Metropolitan Chicago, October 19, 1994

[7] United States Census Bureau. Census 2000 Demographic Profile highlights: Maryland. (Online, follow link to Maryland). United Stated Census Bureau, American FactFinder, 2000. Retrieved on March 28, 2005 from the World Wide Web: http://factfinder.census.gov/

Approximately one third of Maryland’s population is more likely to suffer the adverse effects of air pollution simply as a result of their age.

According to an April 2006[8] report from the American Lung Association, the group of people with respiratory disease in the state of Maryland includes:

- 274,967 adult asthmatics and 100,370 child asthmatics;
- 147,226 residents with chronic bronchitis; and
- 57,310 residents with emphysema.

2.9 The Impact of Ozone on Agriculture

Because ozone formation requires sunlight, periods of high ozone concentration coincide with the agriculture growing season in Maryland. Ozone damage to plants can occur with or without any visible signs. Consequently, many farmers are unaware that ozone is reducing their yields. Ozone enters the plant’s leaves through its gas exchange pores (stomata), just as other atmospheric gases do in normal gas exchange. The ozone then dissolves in the water within the plant and reacts with other chemicals, causing a variety of problems.

Ozone damage in the plant causes photosynthesis to slow, resulting in slower plant growth. Such ozone induced problems also decrease the numbers of flowers and fruits a plant will produce, and impair water use efficiency and other functions. Plants weakened by ozone may be more susceptible to pests, disease, and drought.

Most studies of the economic impact of air pollution on agriculture have found that a 25 percent reduction in ambient ozone would provide benefits of at least $1-2 billion annually in the United States. Studies of soybean yields at the University of Maryland found a 10 percent loss of the soybean crop due to current levels of ozone in the state. The same study showed that ozone exposure causes the loss of 6-8 percent of winter wheat and 5 percent of the corn crop yields to Maryland farmers.

2.10 The Air Quality Index (AQI)

The AQI is an index used for reporting forecasted and daily air quality. The AQI uses both a color-coded and numerical scale to report how clean or polluted the air is and what associated health effects might be of concern. The AQI focuses on health effects people may experience within a few hours or days after breathing polluted air. The AQI is calculated for five major pollutants regulated by the Clean Air Act: particulate matter, ozone, carbon monoxide, sulfur dioxide, and nitrogen dioxide.

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[8] America Lung Association State of the Air, April 2006, pp. 1-207

Air Quality Numerical Value	Action Steps To Protect Your Health and Our Environment
GOOD **0-50**	No pollution. Enjoy outdoor activities. ◆ Keep engines tuned. ◆ Use environmentally friendly products. ◆ Conserve electricity, set air conditioning to 78 degrees.
MODERATE **51-100**	Air quality may pose a moderate risk, especially for those who are unusually sensitive to air pollution. ◆ Carpool, use public transit, bike, or walk. ◆ Limit driving, consolidate trips. ◆ Reduce car idling.
UNHEALTHY for Sensitive Groups **101-150**	**Sensitive Groups**—children and active adults, people with respiratory disease, such as asthma and emphysema and heart ailments should limit prolonged outdoor physical activity. Follow all of the action steps listed previously AND: ◆ Refuel after dusk, use fuel-efficient vehicles. ◆ Avoid driving, use transit, telework. ◆ Avoid using aerosol products.
UNHEALTHY **151-200**	**Unhealthy for Everyone** Sensitive Groups in particular should avoid outdoor physical activities. Everyone else, especially children, should limit prolonged outdoor exertion. Follow all of the action steps listed previously AND: ◆ Avoid lawn mowing or use electric mowers. ◆ Avoid using any gas powered lawn equipment. ◆ Put off painting until air quality improves.
VERY UNHEALTHY **201-300**	**Very Unhealthy for Everyone** When air quality reaches very unhealthy levels everyone is strongly urged to follow all of the actions steps listed previously AND avoid outdoor physical activities.

Figure 2.3 The Air Quality Index and Action Guide

Using the Air Quality Index, the Maryland Department of the Environment and the Metropolitan Washington Council of Governments (COG) issue daily air quality forecasts for the Baltimore metropolitan area (including Cecil County), Washington metropolitan area, Western Maryland, and the Eastern Shore. Extended range forecasts provide a three-day forecast so people can better plan their week and take the opportunity to arrange car pools, take mass transit, or take other actions to limit pollution when air quality is predicted to be unhealthful.

MDE and COG issue the air quality forecasts to local media and hundreds of businesses and individuals throughout the region. Anyone can sign up to receive the free, daily email by visiting the AirWatch web site at www.air-watch.net. The AirWatch web site provides the public with easy access local and national air quality information. AirWatch offers daily AQI forecasts and real-time AQI conditions throughout most of Maryland, the District of Columbia, and Northern Virginia. Users of AirWatch may also sign-up for AirAlerts to receive real-time email notifications for when air quality reaches unhealthy levels in the region.

Figure 2.4 Air-Watch.net Real-time air quality data and Forecasts

2.11 Sources of Ozone Pollution in the Cecil County Area

There are a number of diverse sources that discharge VOCs and NOx, the two primary pollutants responsible for ozone formation. Human made sources, called anthropogenic sources, are divided into four categories: point, area, on-road mobile and non-road mobile sources. A fifth category, "biogenic" emissions, includes all naturally occurring sources of VOC emissions from trees, crops and other forms of vegetation.

Point sources are primarily manufacturing businesses that produce emissions equal to or greater than 10 tons per year (tpy) of VOCs or 25 tpy of NOx. Large industrial plants such as power plants and chemical manufacturers are examples of point sources.

Area sources are smaller sources of air pollution whose emissions are too small to be measured individually. Examples of area sources include commercial and consumer products (such as paints and hairspray), bakeries, gasoline refueling stations, printing facilities, and autobody refinishing shops.

Sources of air pollution that are not stationary are referred to as mobile sources and are broken down into two categories: on-road mobile sources and non-road mobile sources. The former include cars, vans, trucks and buses (i.e. vehicles that operate on highways). Non-road mobile sources include boats, lawn and garden equipment, construction equipment and locomotives.

Table 2-1
TOP TEN SOURCES OF MAN-MADE VOLATILE ORGANIC COMPOUNDS (VOCs) IN THE CECIL COUNTY AREA FOR 2002 and 2009

			VOC (Tons/Day)	
Rank	***Source Category***	***Source***	***2002***	***2009***
1	Nonroad	Pleasure Craft Total	5.55	3.98
2	On-Road Mobile	Cars, Buses, Trucks	4.00	2.16
3	Nonroad	Recreational Equipment Total	1.68	2.45
4	Area	Architectural Surface Coatings	1.12	0.88
5	Area	Commercial & Consumer Solvents	0.87	0.83
4	Nonroad	Lawn and Garden Total	0.72	0.51
5	Area	Portable Fuel Containers	0.70	0.41
7	Area	Industrial Surface Coating	0.54	0.68
8	Area	Pesticide Application	0.37	0.37
9	Area	Residential Fuel Combustion	0.34	0.38
10	Area	Gasoline Marketing	0.31	0.35
			16.20	12.98

** The emissions estimates above are rounded to the nearest whole number. The figures are MDE's best estimates. Total anthropogenic VOC emissions in the Cecil County area were 17.58 tons per day in 2002 and 14.36 tons per day in 2009.*

Table 2-2
TOP TEN SOURCES OF MAN-MADE NITROGEN OXIDES (NOx) IN THE CECIL COUNTY AREA IN 2002 and 2009

			NOx (Tons/Day)	
Rank	***Source Category***	***Source***	***2002***	***2009***
1	On-Road Mobile	Cars, Buses, Trucks	14.21	7.23
2	Nonroad	Construction and Mining	1.02	0.85
3	Nonroad	Railroad-Line Haul	0.59	0.43
4	Nonroad	Pleasure Craft	0.44	0.58
5	Nonroad	Agricultural	0.37	0.32
6	Nonroad	Industrial	0.27	0.17
7	Area	Residential Fuel Combustion	0.10	0.11
8	Nonroad	Lawn and Garden	0.09	0.08
9	Nonroad	Recreational	0.06	0.08
10	Nonroad	Marine Vessels	0.06	0.08
			17.22	9.93

**The emissions estimates above are rounded to the nearest whole number. The figures are MDE's best estimates. Total anthropogenic NOx emissions in the Cecil County area were 17.40 tons per day in 2002 and 10.29 tons per day in 2009*

2.12 Frequency of Violation of Federal Health Standard for Ozone

Since the Clean Air Act Amendments of 1990, Maryland has made significant improvements in the quality of air. National, State, and Local programs have all contributed to dramatically limit the amount of pollution that is generated, which has reduced the number of days that unhealthful air is experienced throughout the region. Mandated reductions in emissions from businesses and industries, and technological improvements in automobiles have brought about a steady progress in air quality.

The federal 8-hour ozone standard is set at 0.08 parts per million (85 parts per billion) of ozone averaged over an eight hour period. Figure 2.5 applies the eight-hour standard to historic data and shows the number of days that exceeded levels under the new standard. The figure also clearly shows an improving trend for Maryland's air quality since 1980. While annual fluctuations can be attributed to weather (hot, stagnant summers are favorable for ozone formation), the downward trend is indicative of controls on sources of air pollution and the resulting levels of ozone precursors present in the ambient air.

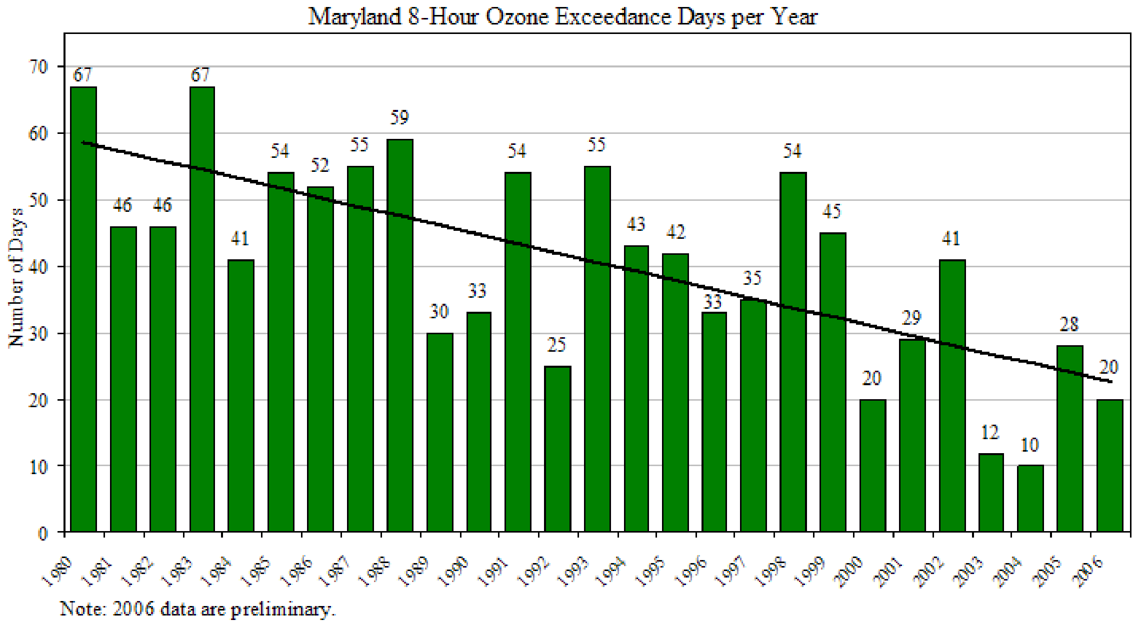

Figure 2.5 Maryland 8-Hour Ozone Exceedance Days per Year

2.13 Required SIP Principles

Section 110 of the 1990 CAAA specifies the conditions under which EPA approves SIP submissions. These requirements are being followed by the Maryland Department of the Environment in developing this air quality plan or SIP. In order to develop effective control strategies, EPA has identified four fundamental principles that SIP control strategies must adhere to in order to achieve the desired emissions reductions. These four fundamental principles are outlined in the General Preamble to Title I of the Clean Air Act Amendments of 1990 at *Federal Register* 13567 (EPA, 1992a). The four fundamental principles are:

1. emissions reductions ascribed to the control measure must be quantifiable and measurable;

2. the control measures must be enforceable, in that the state must show that they have adopted legal means for ensuring that sources are in compliance with the control measure;

3. measures are replicable; and

4. the control strategy be accountable in that the SIP must contain provisions to track emissions changes at sources and to provide for corrective actions if the emissions reductions are not achieved according to the plan.

2.14 Sanctions

EPA must impose various sanctions if the State does not submit a plan; or submits a plan that the EPA does not approve; or fails to implement the plan. These sanctions include: withholding federal highway funding; withholding air quality planning grants; and imposing a federal plan ("federal implementation plan."). Failure to submit or implement a plan will have significant consequences for compliance with conformity requirements.

2.15 Reasonable Further Progress

As a moderate area, EPA requires the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ ozone nonattainment area (Philadelphia NAA) to demonstrate Reasonable Further Progress towards attainment by 2008.[9] Each state in the Philadelphia NAA is responsible for meeting this requirements for the counties from each state connected to the nonattainment area.

EPA's implementation guidance requires that a state's moderate ozone nonattainment areas, such as Cecil County, MD, with an approved 15% VOC reduction plan for the period 1990-1996 (required for former 1-hour ozone non-attainment areas) demonstrate a 15% Reasonable Further Progress by 2008. Chapter 5 contains Cecil County's reasonable further progress demonstration for the years 2002-2008. The region will need to fulfill the 2002-2008 reasonable further progress requirements by January 1, 2009.

In order to demonstrate reasonable further progress, a region must show that its expected emissions, termed controlled inventories, of NOx and VOC will be less than or equal to the target levels set for the end of the reasonable further progress period, or "milestone year". For the RFP period 2002-2008, the "target inventories" of emissions are the maximum quantity of anthropogenic emissions permissible during the 2008 milestone year.

2.16 Analysis of Reasonably Available Control Measures (RACM)

An extensive list of potential control measures was analyzed and evaluated against criteria used for potential RACM measures. Individual measures must meet the following criteria: will reduce emissions in Cecil County by the beginning of the 2008 ozone season (May 1, 2008); are enforceable; are technically feasible; are economically feasible, defined as a cost of $3,500 to $5,000 per ton or less; would not create substantial or widespread adverse impacts within the region; and do the emissions from the source being controlled exceed a de minimus threshold, defined as 0.1 tons per day. Based on the analysis completed for Cecil County which relied heavily upon a very formal RACM analysis completed for the Washington DC Nonattainment area (where MDE actively participated in a RACM workgroup) there were no identified RACM measures that if implemented would advance attainment in Cecil County.

[9] Final Rule to Implement the 8-Hour Ozone National Ambient Air Quality Standard, Federal Register, Vol 70, No. 228, Nov.29, 2005, pp. 71612-71705.

2.17 Contingency Measures

In the event that the reductions anticipated in the 2008 Reasonable Further Progress demonstrations or the 2009 attainment demonstration are not realized within the timeframes specified, there must be contingency measures ready for implementation. EPA issued guidance says that contingency measures must provide for a 3% reduction in adjusted 2002 base year inventory for both Reasonable Further Progress and attainment. A minimum of 0.3 % VOC must be included. The total reductions required for RFP contingency are 0.51 tons per day of VOC, which Cecil County meets The measures proposed as contingency measures are listed in Chapter 10. Chapter 10 contains detail on these measures, how they would be implemented, enforced, and the amount of reduction benefit expected.

3.0 The 2002 Base-Year Inventory

3.1 Background and requirements

The 2002 Base-Year Inventory is published in a separate document, "2002 Base Year Emissions Inventory & QA/QC Plan Maryland," (June 15, 2006). This document was submitted to EPA Region III. This document was prepared the Maryland Department of the Environment. It is available for inspection at the Air and Radiation Management Administration, 1800 Washington Boulevard, Suite 730, Baltimore, Maryland 21230. Relevant portions of this document including, source category listings and descriptions, methods and data sources, emission factors, controls, spatial and temporal allocations, and example calculations are included in Appendix A1. The full base year inventory document is attached to this SIP in Appendix A.

This emissions inventory covers Cecil County Maryland, which is classified as a moderate nonattainment areas (part of the larger Philadelphia NAA) for ozone by the U.S. Environmental Protection Agency (EPA). The 2002 emissions inventory is the starting point for calculating the emissions reduction requirement needed to meet the 15% VOC/NOx emissions (for man-made sources of emissions) reduction goal by 2008 to meet reasonable further progress requirements prescribed for moderate nonattainment areas by the Clean Air Act Amendments and EPA.

This separately published document, which was previously submitted to EPA, addresses emissions of volatile organic compounds (VOCs), oxides of nitrogen (NOx), and carbon monoxide (CO) on a typical summer ozone season day and annual basis. Included in the inventory are stationary anthropogenic (man-made), biogenic (naturally occurring), and non-road and on-road mobile sources of ozone precursors.

Table 3-1
2002 Base-Year Inventory - Cecil County, MD
Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ Nonattainment Area
(Tons/Day)

Source Category	***VOC*** [10]	***NOx*** [10]
Point	0.28	0.02
Area	4.93	0.20
Non-Road	8.37	2.97
On-Road Mobile	4.00	14.22
Biogenics	42.94	0
Total (excluding Biogenics)	17.58	17.40

3.2 Total Emissions by Source

Point Sources

For emissions inventory purposes, point sources are defined as stationary, commercial, or industrial operations that emit more than 10 tons per year (tons/year) of VOCs or 25 tons/year or more of NOx or CO. The point source inventory consists of actual emissions for the base-year 2002 and includes sources within the geographical area of the Maryland portion of the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ ozone nonattainment area.

For source category listings and descriptions, methods and data sources, emission factors, controls, spatial and temporal allocations, and example calculations please refer to Appendix A1.

For Base-Year Emission Inventory data please refer to Appendix A2.

Quasi-Point Sources

The Maryland Department of the Environment Air and Radiation Management has identified several facilities that due to size and/or function are not considered point sources. The MDE has established quasi-point source emissions to simplify the data collection process and the inventory summary process. These establishments contain a wide variety of air emission sources, including traditional point sources, on-road mobile sources, off-road mobile sources and area sources. For each particular establishment, the emissions from these sources are totaled under a

[10] Small discrepancies may result due to rounding.

single point source and summary documents include these “quasi-point” sources as point sources.

Quasi-point sources will include all emissions at the facility regardless of whether they are classified as point, area, nonroad, or mobile source emissions. These emissions are actual emissions reported for the facilities. No quasi-point sources were identified within the Maryland portion of the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ ozone nonattainment area.

For source category listings and descriptions, methods and data sources, emission factors, controls, spatial and temporal allocations, and example calculations please refer to Appendix A1.

For Base-Year Emission Inventory data please refer to Appendix A3.

Area Sources

Area sources are sources of emissions too small to be inventoried individually and which collectively contribute significant emissions. Area sources include smaller stationary point sources not included in the states' point source inventories such as printing establishments, dry cleaners, and auto refinishing companies, as well as small stationary sources.

Area source emissions typically are estimated by multiplying an emission factor by some known indicator of collective activity for each source category at the county (or county-equivalent) level. An activity level is any parameter associated with the activity of a source, such as production rate or fuel consumption that may be correlated with the air pollutant emissions from that source. For example, the total amount of VOC emissions emitted by commercial aircraft can be calculated by multiplying the number of landing and takeoff cycles (LTOs) by an EPA-approved emission factor per LTO cycle for each specific aircraft type.

Several approaches are available for estimating area source activity levels and emissions. These include apportioning statewide activity totals to the local inventory area and using emissions per employee (or other unit) factors. For example, solvent evaporation from consumer and commercial products such as waxes, aerosol products, and window cleaners cannot be routinely determined for many local sources. The per capita emission factor assumes that emissions in a given area can be reasonably associated with population. This assumption is valid over broad areas for certain activities such as dry cleaning and small degreasing operations. For some other sources an employment based factor is more appropriate as an activity surrogate.

For source category listings and descriptions, methods and data sources, emission factors, controls, spatial and temporal allocations, and example calculations please refer to Appendix A1.

For Base-Year Emission Inventory data please refer to Appendix A4.

Mobile Sources

On-road mobile sources include all vehicles registered to use the public roadways. The predominant emission source in this category is the automobiles, although trucks and buses are also significant sources of emissions.

The computation of highway vehicle emissions required two primary entities: a) vehicle emission factors and b) vehicle activity.

The Emission factors are generated by using the latest version of U.S. EPA's emission factor model MOBILE6.2. Vehicle activity (vehicle miles traveled – termed VMT for short) was obtained from the Maryland State Highway Administration (SHA) and the Maryland Department of Transportation. VMT data from SHA, based on vehicle traffic counts on the roadway system, is mainly used for rural counties.

In a simple modeling scenario, the product of emission factor and vehicle miles traveled should yield emission levels for that scenario. Proper units and conversion are used to arrive at reasonable emission estimates.

In a complex modeling scenario many types of emissions such as exhaust, evaporative, diurnal, crankcase, refueling, etc., emissions are computed separately and treated with the appropriate activity levels to yield a complex model result.

MOBILE6 expects enormous amount of local data input such as the fleet characteristics, fleet mileage accrual rates, speed, fuel parameters, inspection and maintenance (I/M) program in place, weather data, and so on.

In MOBILE6 emission factor model, the total highway vehicle population is characterized by the following 16 composite vehicle type categories:

LDV - Light-Duty Vehicles (Passenger Cars)
LDT1 - Light-Duty Trucks 1
LDT2 - Light-Duty Trucks 2
LDT3 - Light-Duty Trucks 3
LDT4 - Light-Duty Trucks 4
HDV2B- Class 2b Heavy Duty Vehicles
HDV3 - Class 3 Heavy Duty Vehicles
HDV4 - Class 4 Heavy Duty Vehicles
HDV5 - Class 5 Heavy Duty Vehicles
HDV6 - Class 6 Heavy Duty Vehicles
HDV7 - Class 7 Heavy Duty Vehicles
HDV8A- Class 8a Heavy Duty Vehicles
HDV8B- Class 8b Heavy Duty Vehicles
HDBS - School Buses
HDBT - Transit and Urban Buses
MC - Motorcycles

These composite vehicle types are further classified into 28 vehicle types - gasoline or diesel vehicles depending on the vehicle types. All motorcycles are gasoline based and transit and urban buses are diesels. The category of "School Bus" can be either a gasoline or diesel powered vehicle.

MOBILE6 also allows for the modeling of other fuel type vehicle such as hybrids and alternate fuel vehicles (AFV) as a special case in a complex modeling initiative.

MOBILE6 model produces emission factors, for each of the 28 vehicle types, and one composite factor for all vehicle types.

A post-processing system takes care of all emission computations of the modeling domain by aggregating the emissions from roads/links appropriate to the area and produces meaningful reports by area, by vehicle type and by roadway type.

For source category listings and descriptions, methods and data sources, emission factors, controls, spatial and temporal allocations, and example calculations please refer to Appendix A1.

For Base-Year Emission Inventory data please refer to Appendix A5.

Nonroad Sources

Emissions for all nonroad vehicles and engines except airport (aircraft, ground support equipment (GSE) and, auxiliary power units (APU)), locomotives, and diesel marine vessels were calculated using EPA's NONROAD2005.0.0 (dt. 12/02/2005) model. Since the time it was first issued on 12/02/2005, this model version underwent several corrections. The base year nonroad inventory was created using the version current as of 3/21/2006.

Emissions from the "nonroad vehicles and engines" category result from the use of fuel in a diverse collection of vehicles and equipment, including vehicles and equipment in the following categories:

- Recreational vehicles, such as all-terrain vehicles and off-road motorcycles;
- Logging equipment, such as chain saws;
- Agricultural equipment, such as tractors;
- Construction equipment, such as graders and back hoes;
- Industrial equipment, such as fork lifts and sweepers;
- Residential and commercial lawn and garden equipment, such as leaf and snow blowers.
- Aircraft ground support equipment.

The nonroad model estimates emissions for each specific type of nonroad equipment by multiplying the following input data estimates:

- Equipment population for base year (or base year population grown to a future year), distributed by age, power, fuel type, and application;
- Average load factor expressed as average fraction of available power;
- Available power in horsepower;
- Activity in hours of use per year; and
- Emission factor with deterioration and/or new standards.

The emissions are then temporally and geographically allocated using appropriate allocation factors.

Aircraft (military, commercial, general aviation, and air taxi) and auxiliary power units (APU) operated at airports along with locomotives and diesel marine vessels are also considered nonroad sources and are included in the nonroad category.

For source category listings and descriptions, methods and data sources, emission factors, controls, spatial and temporal allocations, and example calculations please refer to Appendix A1.

For Base-Year Emission Inventory data please refer to Appendix A6.

<u>Biogenic Emissions</u>

An important component of the inventory is biogenic emissions. Biogenic emissions are those resulting from natural sources. Biogenic emissions are primarily VOCs that are released from vegetation throughout the day. Biogenic emissions of NOx include lightning and forest fires. EPA used a biogenic computer model (BEIS3.12) to estimate biogenic emissions for each county in the country for all twelve months of the year 2002.

Emissions data for Cecil County, MD ozone non-attainment area counties were acquired from the EPA website (ftp://ftp.epa.gov/EmisInventory/2002finalnei/biogenic_sector_data/). EPA has recommended that states use these emissions in case they do not have their own estimated biogenic emissions. Cecil County, MD portion of the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ ozone nonattainment area decided to use the inventories provided by the EPA.

For Base-Year Emission Inventory data please refer to Appendix C1.

3.3 Emissions Trends

Reviewing emissions trends is an excellent way of tracking air quality progress and control measure progress. The difficulties in trending emissions are however significant. Emission estimating methodologies and emission estimating models change constantly and it is difficult to compare decades worth of emissions data. As these emission estimating methodologies become more specific and more accurate emissions may go up or down depending on the methodology. In addition, increases in population and economic growth tend to make trending difficult. It is important to note these issues when reviewing emissions trends over long time periods.

The following emissions trends have been prepared to examine the Maryland portion of the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ ozone nonattainment area emissions over the past 30 years. The 1970’s and 1980’s data was extracted from the 1-hr ozone SIPs developed in the 1990’s.

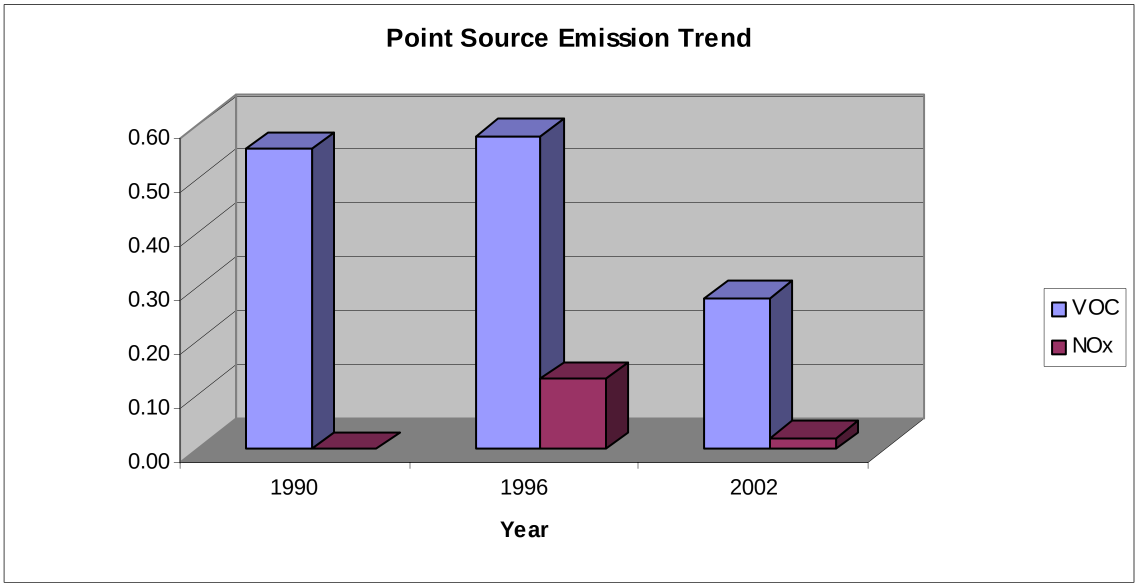

Figure 3.1 Point Source Emission Trends in Tons Per Day*

*As point source data became increasingly important in the 1990's, the data collection process for these sources became more rigid. Overall trends in point sources are difficult to gauge, as historic data was not provided in detail to MDE.

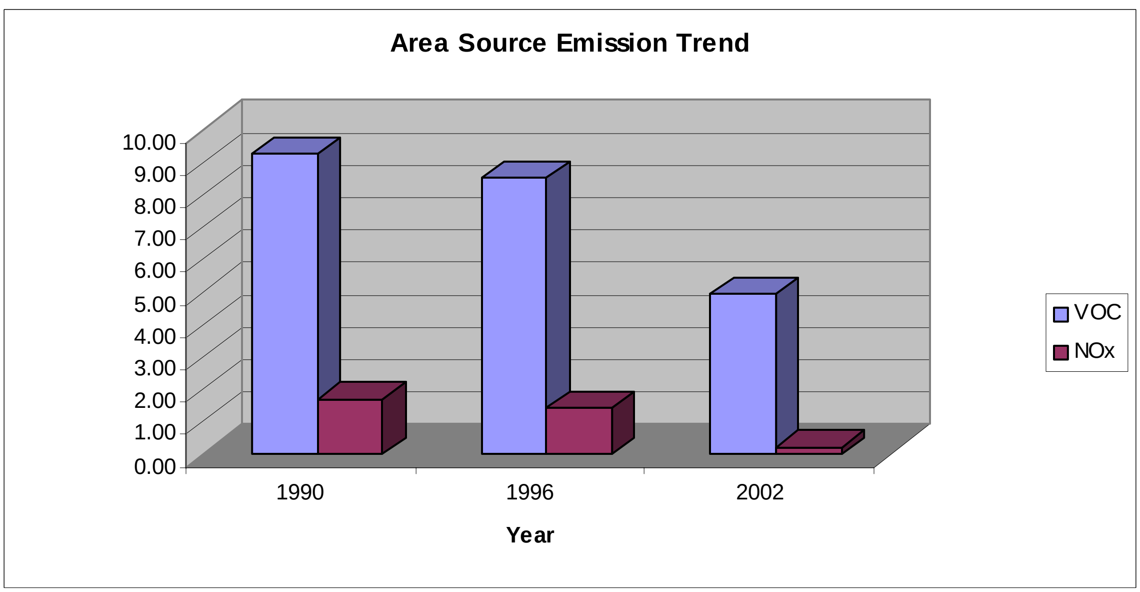

Figure 3.2 Area Source Emission Trends in Tons Per Day

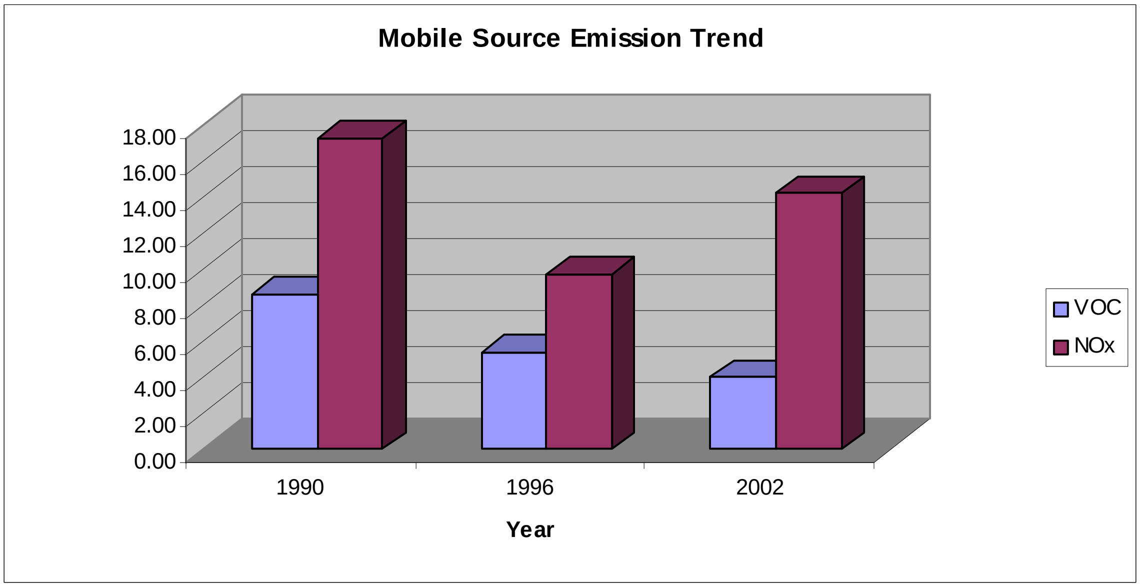

Figure 3.3 Mobile Source Emission Trends in Tons Per Day

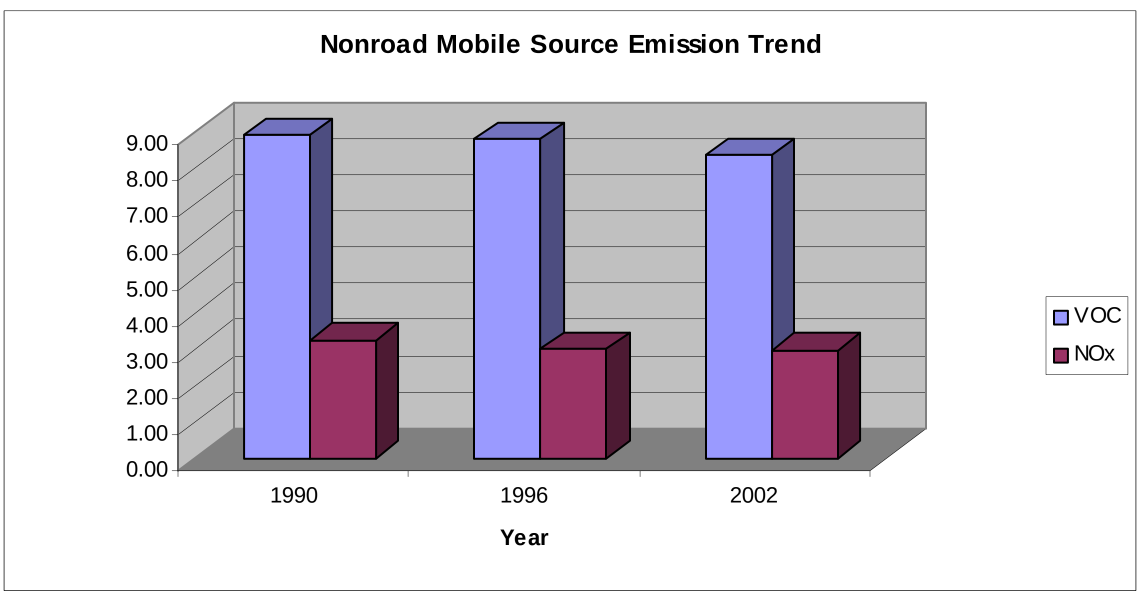

Figure 3.4 Nonroad Source Emission Trends in Tons Per Day

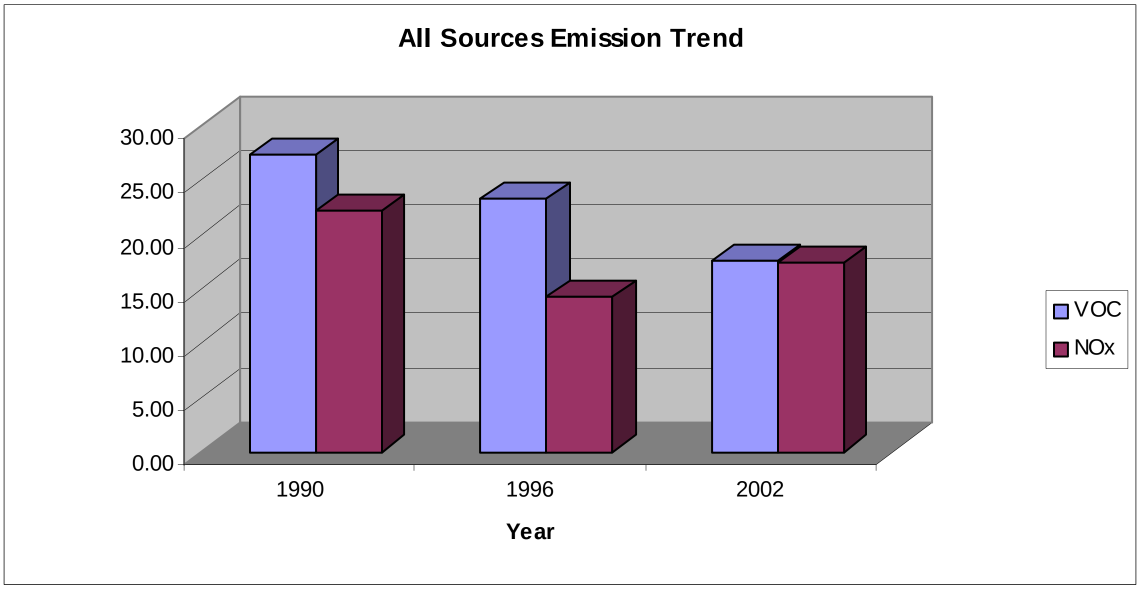

Figure 3.5 All Sources Emission Trends in Tons Per Day

4.0 The 2008 and 2009 Projected Inventories

Part II of EPA's rule to implement the 8-hour NAAQS requires that Cecil County achieve a 15% reduction by 2008 using reductions in either VOC or NOx emissions or with any combination of the two.[11] Also an inventory for the attainment year 2009 is required for the region. The reduction must be calculated from the anthropogenic emissions levels reported in the 2002 Base-Year Inventory after those levels have been adjusted to reflect the expected growth in emissions between 2002 and 2008. The 2002 Base-Year Inventory is described in Chapter 3. This chapter presents the 2008 and 2009 Projection Inventories, the estimation of the levels of emissions to be expected in those years before the consideration of emission controls.

The 2008 and 2009 projected inventories are derived by applying the appropriate growth factors to the 2002 Base-Year Emissions Inventory. EPA guidance describes four typical indicators of growth. In order of priority, these are product output, value added, earnings, and employment. Surrogate indicators of activity, for example population growth, are also acceptable methods.

Maryland Department of Planning, Planning Data Services employment projections and Cooperative Forecasting results (population and housing projections), prepared and officially adopted by the Baltimore Metropolitan Council (BMC) were used to project emissions from area sources. Projections for onroad emissions were developed using MOBILE6.2 (January 2003) model (please see Appendix F for information on mobile source emissions).

EPA's nonroad model, NONROAD2005, was used for developing both 2008 and 2009 nonroad model inventories. BMC's Round 6A Cooperative Forecasting results, Maryland Department of Planning, Planning Data Services projections and the Economic Growth Analysis System (EGAS) model were used to project growth in the additional nonroad source categories such as railroad locomotives, marine vessels and airports. The Economic Growth Analysis System (EGAS) model was used to project growth in point source emissions.

4.1 Growth Projection Methodology

The following sections describe the method followed to determine the projected inventories for 2008 and 2009.

<u>Growth Projection Methodology for Point Sources: EGAS</u>

The growth in point source emissions is projected using EGAS version 5.0. Point source emissions for 2002 are provided from the state data sources and the model is run with the following options selected: projections are run by Source Classification Code; the Bureau of Labor Statistics national economic forecast; and the baseline regional economic forecast.
For source category listings and descriptions, projection methods and data sources, and surrogate growth indicators please refer to Appendix B1.

Point source emission projection data is contained in Appendix A2

[11] EPA 40 CFR Parts 51, 52 & 90, *Federal Register.* Vol.70, No. 228, Nov. 29, 2005, pp.71612-71705.

Growth Projection Methodology for Quasi-Point Sources

Quasi-point sources will include all emissions at the facility regardless of whether they are classified as point, area, nonroad, or mobile source emissions. These emissions are actual emissions reported for the facilities.

No quasi-point sources are located in Cecil County, MD.

Growth Projection Methodology: Area Sources

Base-year area source surrogate growth factors for 2002 were calculated using 2002 population, household, and employment data. Linearly interpolating between 2000 and 2005 data produced the 2002 data. Dividing Round 6A population, household, and employment forecasts for the analysis year by the derived 2002 values for the region produced the growth factors for the periods of 2002 to 2008 and 2002 to 2009. Categories related to transport and storage of gasoline were grown using projected vehicle miles traveled (VMT) for analyses years. Area projection inventories are contained in Appendix B. The growth factors used for the 2008 and 2009 projection years are presented in Tables 4-1 and 4-2. The growth factors were applied to emissions categories by specific jurisdictions.

Table 4-1: 2002-2008 Growth Factors

Jurisdiction	**Employment** [12]	**Population** [13]	**Household** [13]	**VMT** [14]
Cecil County	1.2247	1.0957	1.1181	1.1189

Table 4-2: 2002-2009 Growth Factors

Jurisdiction	**Employment** [12]	**Population** [13]	**Household** [13]	**VMT** [14]
Cecil County	1.2636	1.1080	1.1359	1.1431

The 2008 and 2009 emissions for area sources are calculated by multiplying the 2002 base-year area emissions by the above growth factors for the appropriate year for each jurisdiction. Each area source category was matched to an appropriate growth surrogate based on the activity used to generate the base-year emission estimates. Surrogates were chosen as follows:

Surface Coating – depending on whether emission factors were based on employment or population, surrogate chosen varied with individual sub-categories. For example, automobile refinishing category was grown using employment as the emission factor was based on it, but

[12] Growth factors based on Total Job Projections from the Maryland Department of Planning, Planning Data Services, July 2004
[13] Growth factors based on BMC Final Round 6A Cooperative Forecasts.
[14] Growth factors based on VMT estimates provided by MDE Mobile Source Division

population was chosen for growing traffic markings as its emission factor was based on population.

Commercial/Consumer Solvent Use - population was chosen as the growth surrogate since 2002 emissions are based on per capita emission factors.

Residential Fuel Combustion – households was chosen as the growth surrogate.

Industrial/Commercial/Institutional Fuel Combustion - employment was chosen as the growth surrogate except for the commercial/institutional coal combustion category, where no growth was assumed.

Vehicle Fueling (Stage II) and Underground Tank Breathing - all gasoline marketing categories were based on vehicle miles traveled (VMT) data since VMT is an appropriate surrogate for gasoline sales. Emission factors for these categories are based on gasoline sales.

Open Burning - population was chosen as the growth surrogate as yard wastes, land debris, etc. increase with population.

Structural Fires, Motor Vehicle Fires – population was chosen as the growth surrogate.

Publicly Owned Treatment Works (POTW) – households was chosen as the growth surrogate.

Dry Cleaning - population was chosen as the surrogate.

Graphic Arts - population was used to estimate growth since emissions are based on per capita emission factors.

Surface Cleaning - employment growth was used as the surrogate.

Tank Truck Unloading –growth in VMT was applied to this category since base-year emissions are calculated using gasoline sales.

Municipal Landfills - Base-year emissions are estimated using data on total refuse deposited. Population was chosen as a surrogate since deposited waste is from the general population rather than industrial facilities.

Asphalt Paving - population was chosen as the surrogate since base-year emissions are calculated using per capita emission factors.

Bakeries, Breweries - population was chosen as the surrogate.

Soil/Groundwater Remediation - zero growth was applied to this category. The number of remediations during the ozone season, used to generate base-year emissions, does not directly correlate to population, households, or employment growth.

General Aviation and Air Taxi Emissions - Emissions from small airports were projected using the EGAS 5.0 model.

Aircraft Refueling Emissions - emissions from refueling of aircrafts was projected based on employment.

Portable Fuel Container Emissions - emissions from portable fuel containers were grown based on population.

Railroad Locomotives - employment growth was used as the surrogate.

Forest Fires, Slash Burning, Prescribed Burning – zero growth was applied to this category.

Accidental Oil Spills - zero growth was applied to this category.

Incineration– zero growth was applied to this category.

Pesticide Application - zero growth was applied to this category.

For source category listings and descriptions, projection methods and data sources, and surrogate growth indicators please refer to Appendix B1.

Area source emission projection data is contained in Appendix A4.

Growth Projection Methodology: Nonroad Sources

The 2008 and 2009 nonroad source inventories were created through the use of EPA's NONROAD2005.1.0 model (dt. 06/12/2006), except for locomotives, marine diesel vessels, and aircrafts. The base year 2002 nonroad source inventory was created using NONROAD2005.0.0 model (dt. 12/02/2005). Since the time it was first issued on 12/02/2005, this model version underwent several corrections. The base year nonroad inventory was created using the version current as of 3/21/2006.

The two model versions (NONROAD2005.0.0 and NONROAD2005.1.0) differ only in the options provided in their graphic user interfaces (GUI) and not in emission factors, base year equipment population, activity, load factor, average lifetime, scrappage function, growth estimates, and geographic and temporal allocation for any nonroad equipment and engine. Therefore, emissions produced by the two versions for a particular county, month, season, or year are the same.

Nonroad model runs were made Cecil County, Maryland for an average ozone season day. First the model was run for the entire summer season (June-August) and then total emissions calculated this way was divided by the total number of days (92) in the season to get an average ozone season day emissions. Since ozone season extends from May through September, monthly fuel data was averaged for this period to get fuel parameters reflecting the ozone season period. These ozone season averaged fuel parameters were then used in the above mentioned ozone season runs for the region.

Methodology to prepare inputs for the ozone season day is provided below.

Temperature:

Temperature data was acquired from the National Climatic Data Center (NCDC). Hourly average temperature data were collected for Baltimore Washington International (BWI) station for the top ten 8-hour maximum ozone days between 2002-2004. Then minimum, maximum, and average temperatures were computed from this hourly temperature dataset.

Fuel inputs:

Month specific data for fuel RVP and oxygen weight percent were collected from the MDE Mobile Source Division. The data was averaged for the period May through September to get ozone season average inputs. Model defaults were used for gas, diesel, marine diesel, and CNG/LPG sulfur percent. Stage II controls of zero percent was assumed for the model runs.

Model inputs (temperature, fuel, and other parameters) for both 2008 and 2009 are listed below:

NONROAD Model Inputs

Parameters	**2008 Values**	**2009 Values**
Min. Temperature	65.55	65.55
Max. Temperature	87.6	87.6
Avg. Temperature	76.8	76.8
Reid Vapor Pressure (RVP)	6.6	6.6
Gas Sulfur (%)	0.003	0.003
Diesel Sulfur (%)	0.0348	0.0348
Marine Diesel Sulfur (%)	0.0408	0.0408
CNG/LPG Sulfur (%)	0.003	0.003
Oxygen Weight (%)	2.0	2.0
Stage II Control (%)	0	0

Since the nonroad model does not generate emissions for aircraft, APU, locomotives, and commercial diesel marine vessels, these were either projected from the base year emissions using the BMC Round 6A Cooperative Forecast or the EGAS model. Below are the details for projecting emissions for the above mentioned individual nonroad categories.

Aircraft emissions (military, commercial, general aviation, air taxi)

Aviation emissions from small airports were projected using the EGAS 5.0 model.

Ground support equipment emissions

The NONROAD2005.1.0 model generated these emissions for small airports. The Nonroad model calculates emissions based on GSE population only.

Commercial Diesel Marine Vessels

Base year emissions from commercial diesel marine vessels were grown to future years using employment as the surrogate.

Railroad

Railroad or locomotive emissions were grown using employment as the surrogate.

For source category listings and descriptions, projection methods and data sources, and surrogate growth indicators please refer to Appendix B1.

Nonroad mobile source emission projection data is contained in Appendix A6.

Growth Projection Methodology: Onroad Sources

The 2008 and 2009 mobile source inventories were created through the use of several models including Mobile6.2, the Highway Performance Monitoring System (HPMS), and a transportation model described in the appendix of this report. A full description of this mobile emission estimating process can be found in Appendix F of this report.

Biogenic Emission Projections

Biogenic emission inventories for 2009 are the same as those used for the 2002 base year for Cecil County. Year specific biogenic inventories for 2009 were not estimated. 2002 base year emissions were estimated by EPA using BEIS3.12 model. No 2008 biogenic inventories were prepared as they are not used to determine rate of progress.

4.2 Offset Provisions, Emission Reduction Credits and Point Source Growth

The Act requires that emission growth from major stationary sources in nonattainment areas be offset by reductions that would not otherwise be achieved by other mandated controls. The offset requirement applies to all new major stationary sources and existing major stationary sources that have undergone major modifications. Increases in emissions from existing sources resulting from increases in capacity utilization are not subject to the offset requirement. For the purposes of the offset requirement, major stationary sources include all stationary sources exceeding an applicable size cutoff. The NSR thresholds for Cecil County are 25 tpy VOC and 25 tpy NOx.

EPA has issued guidance on the inclusion of emission reduction credits in the projected emissions inventory. The guidance states "The base year inventory includes actual emissions from existing sources and would not normally reflect emissions from units that were shutdown or curtailed before the base year (2002), as these emissions are not "in the air" for purposes of demonstrating attainment, they must be specifically included in the projected emissions inventory used in the attainment demonstration along with other growth in emission over the base year inventory. This step assures that emissions from shutdown and curtailed units are accounted for in attainment planning." [15] Emission reduction credits are included in a revised

[15] Federal Register/Vol. 71, No. 243/ Tuesday, December 19, 2006/ Proposed Rules

attainment demonstration projected inventory. A list of these emission reduction credits and associated facilities is shown in Table 4.2.1.

Table 4.2.1 Emission Reduction Credits

Facility Name	*State Facility Identifier*	*Pollutant Code*	*Emission Reduction Credits (TPY)*
Bethlehem Steel	005-0147	NOX	701
Pulaski Incinerator	510-0498	NOX	302
Quebecor Printing	003-0274	NOX	2
G. Heileman Brewing (Strohs)	005-0129	NOX	24
Grief Brothers Corp.	005-0134	NOX	1
U.S.Can - Sparrows Pt. (Amer Nat)	005-0183	NOX	7
TPS Technologies, Inc. -Todd's La.	005-2131	NOX	16
Simpkins Industries - River Rd	027-0005	NOX	87
General Electric	027-0020	NOX	82
Alltrista Metal Services	510-0508	NOX	2
Trigen (Leadenhall St)	510-2796	NOX	33
Chevron Asphalt	510-0072	NOX	49
Coca Cola	510-0242	NOX	5
Crown Cork & Seal - Duncanwood	510-0320	NOX	10
Gordon D. Garratt	510-0360	NOX	1
Proctor & Gamble	510-0185	NOX	12
Schluderberg-Kurdle	510-0283	NOX	19
(Westport 510-0006 & Riverside 005-0078)	510-0006	NOX	1480
Giant - Bakery (930 King St)	031-0224	NOX	2
Armco Stainless/	510-0340	NOX	16
Bausch & Lomb	023-0019	NOX	1
Rohr Industries	043-0104	NOX	6
Showell Farms	047-0036	NOX	8
WR Grace	510-0076	NOX	17
General Motors - Truck & Bus	510-0354	NOX	119
Andrews Air Force Base	033-0655	NOX	15
Millenium Inorganic Chemicals	510-0109	NOX	30
Quebecor Printing	003-0274	VOC	322
Bethlehem Steel	005-0147	VOC	0
Pulaski Incinerator	510-0498	VOC	11
BARCO - Fairlawn	510-2854	VOC	5
Crown Cork & Seal - Duncanwood	510-0320	VOC	13
Giant - Bakery - 930 King St	031-0224	VOC	0
Cello Professional Products	025-0145	VOC	0
Grief Brothers Corporation	005-0134	VOC	0
General Motors - Truck & Bus	510-0354	VOC	0
General Motors - Electromotive	005-0692	VOC	15
Crown Central Petroleum	003-0234	VOC	21
BGE - SNG Plant	005-1054	VOC	7

Facility Name	*State Facility Identifier*	*Pollutant Code*	*Emission Reduction Credits (TPY)*
Ecko-Glaco Ltd.	005-0310	VOC	27
G. Heileman Brewing Co. (Strohs)	005-0129	VOC	48
Maryland Paper Box	005-2220	VOC	15
Schlumberger Malco, Inc.	005-1614	VOC	12
U.S.Can-Sparrows Pt. (Amer Nat)	005-0183	VOC	90
TPS Technologies (Todd's La.)	005-2131	VOC	4
Simpkins Industries (River Rd)	027-0005	VOC	7
3M Commercial Graphics	013-0052	VOC	30
Blue Chip Products	015-0058	VOC	35
Baycraft Fiberglass Engineering	025-0231	VOC	10
Alltrista Metal Services	510-00508	VOC	11
Armco/Balto. Specialty Steel	510-0340	VOC	11
CE Stevens Packaging (printer)	510-2900	VOC	10
Chevron Asphalt	510-0072	VOC	2
Conoco Sun Gasoline Terminal	510-0676	VOC	27
Bata Shoe	025-0003	VOC	18
Cherokee Sanford	033-0565	VOC	0
PPG Industries	001-0005	VOC	28
Tidewater Industrial Corp.	011-0039	VOC	11
Crown Cork & Seal - Hurlock	019-0073	VOC	96
Mail-Weil Graphics	019-0097	VOC	8
Metalfab - Grove Road	021-0317	VOC	11
Bausch & Lomb	023-0019	VOC	16
American Mouldings	043-0191	VOC	69
Carpenter Insulation	043-0189	VOC	146
CSX Minerals	043-0110	VOC	10
Rohr Industries	043-0104	VOC	4
Constellation - Westport 510-0006 & Riverside 005-0078	510-0006	VOC	23
Thomas Mfg.	005-0240	VOC	22
LeSaffre Yeast	510-0191	VOC	179

4.3 Actual vs. Allowable Emissions in Development of the 2008 and 2009 Projected Emissions Inventories

To simplify comparisons between the base-year and the projected year, EPA guidance states that comparison should be made only between like emissions: actual to actual, or allowable to allowable, not actual to allowable. Therefore, all base-year and all projection-year emissions estimates are based on actual emissions.

The term "actual emissions" means the data was directly provided by the registered sources via annual emission certification reports. Actual emissions are calculated using the source's operating hours, production rates, and types of material processed, stored, or combusted during the selected time period.

"Allowable emissions" are defined as the maximum emissions a source or installation is capable of discharging after consideration of any physical, operations, or emissions limitations required by state regulations or by federally enforceable conditions, which restrict operations and which are included in an applicable air quality permit to construct or permit to operate, secretarial order, plan for compliance, consent agreement, court order, or applicable federal requirement.

4.4 Projection Inventory Results

Chapter 6 of this SIP describes the control measures that have been or will be implemented by 2008 and 2009 that will reduce emissions. Most control measures are required by federal or state regulations. Projected controlled inventories for 2008 and 2009 assume a number of control measures to be in place by these years as identified in Chapter 6.

Tables 4-3 and 4-4 present the projected controlled emissions for the 2008 rate-of-progress and 2009 attainment years resulting from implementation of the control measures.

4.5 2008 Controlled Emissions for Rate-of-Progress

The projection of 2008 controlled emissions is simply the 2008 uncontrolled emissions minus the emission reductions achieved from the federal control measures and the rate-of-progress control measures implemented by states for the 8-hour ozone plan. This information is presented in Tables 4-3 and 4-4. Controlled inventories are contained in Appendix C1. Details on mobile source emissions can be found in Appendix F.

Table 4-3:
2008 Projected Controlled VOC & NOx Emissions (tons/day)
MD Portion of the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ Area

Emission Source Category	Cecil County VOC Emissions (tons per day)[16]	Cecil County NOx Emissions (tons per day)[17]
Point	0.39	0.02
Area	4.75	0.23
Non-road	7.23	2.87
Mobile	2.29	7.93
Total	14.65	11.05

[16] Small discrepancies may result due to rounding.
[17] Small discrepancies may result due to rounding.

4.6 2009 Controlled Emissions for Attainment

The projection of 2009 controlled emissions is simply the 2009 uncontrolled emissions minus the emission reductions achieved from the federal control measures and the rate-of-progress control measures implemented by states for the 8-hour ozone plan.

Table 4-4:
2009 Projected Controlled VOC & NOx Emissions (tons/day)
MD Portion of the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ Area

Emission Source Category	***Cecil County* VOC Emissions (tons per day)** [7]	***Cecil County* NOx Emissions *(tons per day)*** [8]
Point	0.40	0.02
Area	4.57	0.24
Non-road	7.23	2.81
Mobile	2.20	7.6
Total	14.40	10.66

5.0 2008 Reasonable Further Progress Requirements

5.1 Introduction

In June 2005 EPA revoked the 1-hour ozone standard and published implementation guidance for the 8-hour ozone standard. Cecil County was classified as a moderate nonattainment of the 8-hour ozone standard. EPA classified the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ ozone nonattainment area (Philadelphia NAA) as a moderate area under Subpart 2 area of Section 182 part b.

As part of a moderate nonattainment area, EPA requires Cecil County to demonstrate Reasonable Further Progress towards attainment by 2008.[18] EPA's implementation guidance requires that a moderate ozone nonattainment areas, such as Cecil County, with an approved 15% VOC reduction plan for the period 1990-1996 (required for former 1-hour ozone non-attainment areas) demonstrate a 15% Reasonable Further Progress for VOC and NOx by 2008. This chapter contains Cecil County's reasonable further progress demonstration for the years 2002-2008. Cecil County will need to fulfill the 2002-2008 reasonable further progress requirements by January 1, 2009.

In order to demonstrate reasonable further progress, a region must show that its expected emissions, termed controlled inventories, of NOx and VOC will be less than or equal to the target levels set for the end of the reasonable further progress period, or "milestone year". For the RFP period 2002-2008, the "target inventories" of emissions are the maximum quantity of anthropogenic emissions permissible during the 2008 milestone year.

This section describes the methodology used to establish the regional target inventories and controlled inventories for 2008. Because the expected NOx and VOC emissions will be less than or equal to the target levels, Cecil County will meet the reasonable further progress requirements for 2008.

<u>Rate of Progress Demonstrated in Previous State Implementation Plans</u>

Since 1990, the Clean Air Act has required ozone nonattainment areas to demonstrate progress towards attaining the ozone standard. This requirement is referred to as the reasonable further progress (RFP) or reasonable further progress requirement. During the period 1990-1996, areas in nonattainment for the one-hour ozone standard were required to reduce VOC emissions by 15%. Since 1996, regions have been required to demonstrate a 9% rate of progress every three years until the region's attainment date.

The CAA included restrictions on the use of control measures to meet the 15% requirements. Reductions in ozone precursors resulting from four types of federal and state regulations could not be used to meet rate of progress. These four types of programs are:

[18] Final Rule to Implement the 8-Hour Ozone National Ambient Air Quality Standard, Federal Register, Vol 70, No. 228, Nov.29, 2005, pp. 71612-71705.

(1) Federal Motor Vehicle Control Program (FMVCP) tailpipe and evaporative standards issued in January 1, 1990,
(2) Federal regulations limiting the Reid Vapor Pressure (RVP) of gasoline in ozone nonattainment areas issued by June 15, 1990;
(3) State regulations correcting deficiencies in reasonably available control technology (RACT) rules
(4) State regulations establishing or correcting inspection and maintenance (I/M) programs for on-road vehicles.

The basic procedures of developing target levels for the 15% Plan are describe in EPA's guidance on the *Adjusted Base Year Emissions Inventory and the 1996 Target for the 15% Rate of Progress Plans*.

5.2 Guidance for Calculating Reasonable Further Progress (RFP) Emission Target Levels

The Clean Air Act Amendments (CAAA) of 1990 provide the primary guidance for calculating the VOC and NOx target levels used in a region's reasonable further progress (RFP) plans. In November 2005 as part of its final implementation rule for the 8-hour ozone standard, EPA issued guidance to assist the states in RFP development.

The guidance that applies to the Cecil County, Maryland area is guidance for previously severe 1-hour ozone nonattainment areas with an approved 15% Reasonable further progress plan for the period 1990-1996. Since the Cecil County, Maryland region is a former severe 1-hour ozone nonattainment area and has an approved 15% ROP plan for the above period, "Method 2" of the guidance applies to the region.[19] The region is required to reduce emissions by 15% from 2002-2008 to demonstrate Reasonable Further Progress, according to Method 2.

EPA's guidance (Method 2) states that the target level of VOC and NOx emissions in 2008 needed to meet the 2008 ROP requirement is any combination of VOC and NOx reductions from the adjusted base year 2002 inventories (base year 2002 emissions less non-creditable emissions reduction occurring between 2002 and 2008) that total 15%. For example, the target level of VOC emissions in 2008 could be a 10% reduction from the adjusted base year 2002 VOC inventory and a 5% reduction from the adjusted NOx inventory. The actual projected 2008 VOC and NOx inventories for all sources with all control measures in place and including projected 2008 growth in activity must be at or lower than the target levels of VOC and NOx emissions. The actual projected 2008 VOC and NOx inventories for all sources with all control measures in place and including projected 2008 growth in activity must be at or lower than the target levels of VOC and NOx emissions.[20]

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[19] *"Appendix A to Preamble—Methods to Account for Non-Creditable Reductions When Calculating ROP Targets for the 2008 and Later ROP Milestone Years," in Final Rule to Implement the 8-Hour Ozone National Ambient Air Quality Standard, Federal Register, Vol 70, No. 228, Nov.29, 2005,.*

[20] *If a region chooses to substitute reductions in NOx for reductions in VOC, the substitution must be made in accordance with EPA's NOx Substitution Guidance. This guidance states the use of NOx emission reductions must be consistent with the photochemical modeling used in the region's attainment demonstration. As photochemical attainment modeling performed for the Metropolitan Baltimore region shows that NOx reductions significantly reduce ozone formation, the region can substitute NOx reductions for VOC reductions. Based on this modeling, the Baltimore region can substitute NOx reductions for some or all (0-15%) of the required VOC reductions for the*

This section briefly summarizes the requirements and procedures for calculating the target emission levels required for a RFP demonstration. RFP demonstrations build upon each other, starting from the base year of 2002.

<u>2008 VOC and NOx Target Levels</u>

EPA's *Final Rule To Implement the 8-Hour Ozone National Ambient Air Quality Standard* – Phase II mandates that to meet the reasonable further progress requirement, the Cecil County, MD portion of the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ ozone nonattainment area ozone nonattainment area needs to reduce its emissions by 15% between 2002 and 2008 using either reduction in VOC or NOx or any combination of the two. The Cecil County, MD portion of the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ ozone nonattainment area is able to demonstrate reasonable further progress for the period 2002-2008 using 15% VOC reduction.

The target levels for 2008 reasonable further progress plans are calculated according to the EPA's final rule mentioned above. The general formula for calculation of 2008 target levels is as follows:

Equation: 5-6

$$\text{Target Level} = \left[\text{RFP base year emissions}\right] - \left[\text{reductions required to meet the reasonable further progress requirement}\right] - \left[\text{non-creditable emissions reduction between 2002 and 2008}\right]$$

<u>Calculation of 2008 Target Levels</u>

Equation 5-6 gives the general formula for calculating post-1996 target levels. Since the region has chosen to demonstrate the 2008 reasonable further progress using 15% VOC reduction, the 2008 VOC target level becomes:

Equation: 5-7

$$\text{2008 VOC Target Level} = \left[\text{2002 RFP Base-Year emissions}\right] - \left[\text{7.5\% VOC Reduction}\right] - \left[\text{non-creditable emissions reduction between 2002 and 2008}\right]$$

Equation: 5-8

$$\text{2008 NOx Target Level} = \left[\text{2002 RFP Base-Year emissions}\right] - \left[\text{7.5\% NOx Reduction}\right] - \left[\text{non-creditable emissions reduction between 2002 and 2008}\right]$$

2008 reasonable further progress (App. F – Severe SIP).

Step 1 Develop 2002 Base Year Inventories and 2002 Reasonable Further Progress Base Year Inventories

The 2002 base year inventory is an inventory of actual anthropogenic and biogenic VOC emissions on a typical weekday during peak ozone season. The inventory was calculated as described in Chapter 3 and is presented in Table 3-1. The reasonable further progress base-year inventory includes only anthropogenic emissions generated within the Cecil County, MD portion of the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ ozone nonattainment area. As the 2002 base-year inventory included no emissions generated outside the Cecil County, MD area, the only difference between the base year inventory and the reasonable further progress base year inventory is the removal of biogenic emissions. The reasonable further progress base year VOC inventory is presented in Table 5-1.

Table 5-1
2002 Reasonable Further Progress Base-Year Inventory
(Ozone Season tons per day)

Source	**VOC**	**NOx**
Point	0.28	0.02
Area	4.93	0.20
Non-Road	8.37	2.97
On-Road	4.00	14.22
TOTAL	17.58	17.40

Note: Small discrepancies may result due to rounding

Step 2 Develop 2002 and 2008 Reasonable Further Progress Adjusted Year Inventories

According to the 1990 CAAA, reductions necessary to meet the reasonable further progress requirement must be calculated from an emission baseline that excludes the effects of the non-creditable Federal Motor Vehicle Control Program (FMVCP) and Reid Vapor Pressure (RVP) programs described in Section 5.2. Therefore the 2002 baseline must be adjusted by subtracting the VOC and NOx reductions that will result from these two programs between 2002 and 2008. The resulting inventory is referred to as the 2002 Adjusted Base Year Inventory.

In order to calculate the non-creditable emissions reductions, which occur between 2002 and 2008, the following two mobile inventories are needed:

1) 2002 Reasonable Further Progress Adjusted-Year Inventory
2) 2008 Reasonable Further Progress Adjusted-Year Inventory

Both of these mobile inventories were created using the same inputs (listed below), with the only difference between them being the automobile model year (inventory #1 and #2 were created for 2002 and 2008 respectively).

a) 1990 I/M Program
b) RVP = 7.8 psi (RVP required according to June 1990 fuel RVP regulations)[21]
c) No Post-1990 Clean Air Act Measures
d) 2002 Vehicle Activity Inputs
e) 2002 Vehicle Miles Traveled (VMT)

The MOBILE6 input files are included in Appendix F. Table 5-2 & 5-3 show RFP adjusted-year inventories for 2002 and 2008 respectively.

Table 5-2
2002 Reasonable Further Progress Adjusted-Year Inventory
(Ozone Season tons per day)

Source	VOC	NOx
Point	0.28	0.02
Area	4.93	0.20
Non-Road	8.37	2.97
On-Road	5.42	16.09
TOTAL	19.00	19.28

Note: Small discrepancies may result due to rounding

[21] *The 1990 Phase II regulations specify 7.8 psi as the maximum RVP of gasoline being sold in the Baltimore, DC-MD-VA ozone nonattainment area in 1992.*

Table 5-3
2008 Reasonable Further Progress Adjusted-Year Inventory
(Ozone Season tons per day)

Source	**VOC**	**NOx**
Point	0.28	0.02
Area	4.93	0.20
Non-Road	8.37	2.97
On-Road	4.73	13.90
TOTAL	18.31	17.09

Note: Small discrepancies may result due to rounding

Step 3 Non-creditable Emissions Reductions

The non-creditable emissions reductions that occur in absence of any post-1990 CAA measures during a reasonable further progress period can be determined by taking the difference between the RFP adjusted-year inventories for the relevant milestone years. For VOC and NOx, the relevant milestone years are 2002 and 2008.

Equation: 5-9

$$\text{Non-creditable Emissions Reductions} = \left[\begin{array}{c}\text{2002 RFP} \\ \text{Adjusted Year} \\ \text{Inventory}\end{array}\right] - \left[\begin{array}{c}\text{2008 RFP Adjusted} \\ \text{Year Inventory}\end{array}\right]$$

Table 5-3
Calculation of Non-creditable Emissions Reductions
(Ozone Season tons per day)

Description	**VOC**	**NOx**
2002 Adjusted Year Inventory (a)	5.42	16.09
2008 Adjusted Year Inventory (b)	4.73	13.90
Non-creditable Emissions Reduction (a-b)	0.69	2.19

Step 4 Calculation of 2008 Target Levels

Following Equations 5-7, 5-8 and 5-9, the VOC and NOx target levels for 2008 are calculated in Table 5-4 below:

Table 5-4
Calculation of VOC and NOx Target Levels for 2008
(Ozone Season tons per day)

	Description	Formula	VOC	NOx
A	2002 Base Year Inventory		60.52	17.40
B	Biogenic Emissions		42.94	0.00
C	2002 Rate-of Progress Base Year Inventory	A - B	17.58	17.40
D	FMVCP/RVP Reductions Between 2002 and 2008		0.69	2.19
E	2002 Adjusted Base Year Inventory Calculated Relative to 2008	C - D	16.89	15.21
F	Ratio		0.07	0.08
G	Emissions Reductions Required Between 2002 and 2008	E * F	1.18	1.22
H	Target Level for 2008 [$TL_{(2008)}$]	C - D - G	15.71	13.99

5.3 Compliance with 2008 Reasonable Further Progress Requirements

In order to demonstrate reasonable further progress for the period 2002-2008, the Cecil County, MD portion of the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ ozone nonattainment area must show that expected emissions in 2008 are equal to or less than the 2008 target levels presented in Table 5-4.

The 2008 controlled inventories are inventories of all anthropogenic VOC and NOx emissions expected to occur in Cecil County, MD during 2008. The inventories were developed as described in Chapter 4 and are displayed in Tables 4-3 and 4-4. As summarized in Table 5-5, the 2008 controlled VOC and NOx inventories are less than the 2008 target inventories. Table 5-5 demonstrates that the Cecil County, MD area of the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ ozone nonattainment area fulfills the 2002-2008 reasonable further progress requirements.

Table 5-5
Comparison of 2008 Controlled and Target Inventories
Ozone Season Daily Emissions (tons per day)

Description	VOC	NOx
2008 Target Levels	15.71	13.99
2008 Controlled Emissions	14.59	11.05

References

U.S. EPA, “Guidance on the Adjusted Base Year Emissions Inventory and the 1996 Target for the 15% Rate of Progress Plans”

U.S. EPA, “Guidance on the Post-1996 Reasonable Further Progress Plan and the Attainment Demonstration”, February 18, 1994.

U.S. EPA, “NOx Substitution Guidance”, December 1993.

6.0 Control Measures

This chapter is divided into three sections. Section 6.1 identifies the control measures that were part of the 1-Hour Ozone SIP for Cecil County, Maryland. These regulations/ control measures continue to be in existence and continue to reduce emissions in the region. All of the emission reductions from the measures identified in Section 6.1 were part of the baseline emission inventory for Cecil County, Maryland.

Section 6.2 of this chapter identifies measures implemented after 2002 that were not part of the baseline inventory and are giving specific emission reductions to the region's 8-hour Ozone reasonable further progress demonstration.

Section 6.3 identified voluntary/ innovative measures that the Maryland is not taking formal credit for in the SIP. These measures are not commitments to programs but present information on programs that are directionally correct and could provide ozone benefits.

6.1 1-Hour Ozone Control Measures

<u>On-Road Mobile Measures</u>

Enhanced Vehicle Inspection and Maintenance (Enhanced I/M)

The Clean Air Act requires enhanced motor vehicle inspection and maintenance (I/M) programs in serious, severe, and extreme ozone nonattainment areas and MSA/CMSA portions of the OTR with urbanized populations over 200,000. In Maryland, this required enhanced I/M program in the eight jurisdictions operating a basic I/M program as well as six new jurisdictions, for a total of 14 of the 23 jurisdictions in the state. Tailpipe emissions are measured over a transient driving cycle conducted on a dynamometer, which provides a much better indication of actual on-road vehicle performance than the existing idle test.

Tier I Vehicle Emission Standards and New Federal Evaporative Test Procedures

The Act requires a new and cleaner set of federal motor vehicle emissions standards (Tier I standards) beginning with model year 1994. The Act also requires a uniform level of evaporative emission controls, which are more stringent than most evaporative controls used in existing vehicles. These federally implemented programs affect light duty vehicles and trucks.

Reformulated Gasoline in On-road Vehicles

All gasoline-powered vehicles are affected by this control measure. Vehicle refueling emissions at service stations are also reduced. In addition, emissions from gasoline powered nonroad vehicles and equipment will be reduced by this control strategy. Since January of 1995, only gasoline that the EPA has certified as reformulated may be sold to consumers in the nine worst ozone nonattainment areas with populations exceeding 250,000.

National Low Emission Vehicle Program

The NLEV program is a vehicle technology program that provides light duty vehicles and trucks that are significantly cleaner than pre-1998 models. The National LEV program was developed through an unprecedented, cooperative effort by the northeastern states, auto manufacturers, environmentalists, fuel providers, U.S. EPA and other interested parties. National LEV vehicles are 70% cleaner than 1998 models. The National LEV program will result in substantial reductions in volatile organic compounds (VOCs) and oxides of nitrogen (NOx), which contribute to unhealthy levels of smog in many areas across the country.

Tier 2 Vehicle Emission Standards

In 1999, EPA proposed more stringent tailpipe emissions standards for cars and light trucks weighing up to 8,500 pounds. Commonly referred to as Tier 2, these standards take effect beginning in 2004 when manufacturers start producing passenger cars that are 77 percent cleaner than those on the road today. Light-duty trucks, such as SUVs, which are subject to standards that are less protective than those for cars, would be as much as 95 percent cleaner under the new standards.

Federal Heavy-Duty Diesel Engine Rule

EPA’s heavy-duty engines rule will address diesel vehicles weighing more than 8,500 pounds, These standards will take effect in 2007 and reduce emissions from new HDDEs by 95%. In order to achieve the new standards, ultra-low sulfur diesel fuel will be needed.

Stage II Recovery Systems

This measure required the installation of Stage II vapor recovery nozzles at gasoline pumps. Maryland adopted Stage II vapor recovery regulations for the Baltimore and Washington nonattainment areas and Cecil County in January of 1993. The Stage II vapor recovery regulation requires that the dispensing system be equipped with nozzles that are designed to return the vapors through a vapor line into the gasoline tank.

New Vehicle On-Board Vapor Recovery Systems

This measure required the installation of onboard refueling emissions controls for new passenger cars and light trucks beginning in the 1998 model year. The onboard refueling vapor recovery (ORVR) system was required for new passenger cars and light trucks beginning in model 1998.

Area Source Measures

VOC Controls in Maryland

- Automotive and Light-Duty Truck Coating
- Can Coating
- Coil Coating
- Large Appliance Coating
- Paper, Fabric, Vinyl, and Other Plastic Parts Coating
- Control of VOC Emissions from Solid Resin Decorative Surface Manufacturing
- Metal Furniture Coating
- Control of VOC Emissions from Cold and Vapor Degreasing
- Flexographic and Rotogravure Printing
- Lithographic Printing
- Dry Cleaning Installations
- Miscellaneous Metal Coating
- Aerospace Coating Operations
- Brake Shoe Coating Operations
- Control of Volatile Organic Compounds from Structural Steel Coating Operations
- Manufacture of Synthesized Pharmaceutical Products
- Paint, Resin and Adhesive Manufacturing and Adhesive Application
- Control of VOC Equipment Leaks
- Control of Volatile Organic Compound (VOC) Emissions from Yeast Manufacturing
- Control of Volatile Organic Compound Emissions from Screen Printing and Digital Imaging
- Control of Volatile Organic Compounds (VOC) Emissions from Expandable Polystyrene Operations
- Control of Landfill Gas Emissions from Municipal Solid Waste Landfills
- Control of Volatile Organic Compounds (VOC) Emissions from Commercial Bakery Ovens
- Control of Volatile Organic Compounds (VOC) from Vinegar Generators
- Control of VOC Emissions from Vehicle Refinishing
- Control of VOC Emissions from Leather Coating
- Control of Volatile Organic Compounds from Explosives and Propellant Manufacturing
- Control of Volatile Organic Compound Emissions from Reinforced Plastic Manufacturing
- Control of Volatile Organic Compounds from Marine Vessel Coating Operations
- Control of Volatile Organic Compounds from Bread and Snack Food Drying Operations
- Control of Volatile Organic Compounds from Distilled Facilities
- Control of Volatile Organic Compounds from Organic Chemical Production
- Iron and Steel Production Installations
- Control of Kraft Pulp Mill Emissions

Municipal Landfills

A municipal solid waste landfill is a disposal facility where household waste is placed and periodically covered with inert material. Landfill gases are produced from the decomposition and chemical reactions of the refuse in the landfill. They consist primarily of methane and carbon dioxide, with volatile organic compounds making up less than one percent of the total emissions. The control strategy for this source category is based upon federal rules.

Burning Ban

Open burning is primarily used for the disposal of brush, trees, and yard waste and as a method of land clearing by both developers and individual citizens alike. Emissions from open burning include oxides of nitrogen, hydrocarbons, carbon dioxide, carbon monoxide and other toxic compounds. Emissions levels from open burning are high due to the inefficient and uncontrolled manner in which the material is burned. The Department adopted a regulation that prohibits open burning during the peak ozone period (June to August). There are exemptions for agricultural burning, fire training and recreational activities.

Surface Cleaning/Degreasing

Cold degreasing is an operation that uses solvents and other materials to remove oils and grease from metal parts including automotive parts, machined products, and fabricated metal components. MDE adopted regulations in 1995 to require small degreasing operations such as gasoline stations, autobody paint shops, and machine shops to use less polluting degreasing solvents in serious and severe ozone nonattainment areas. Also, solvent baths and rags soaked with solvents must be covered under this regulation.

Architectural and Industrial Maintenance Coatings

Architectural and industrial maintenance coatings are field-applied coatings used by industry, contractors, and homeowners to coat houses, buildings, highway surfaces, and industrial equipment for decorative or protective purposes. VOC emissions result from the evaporation of solvents from the coatings during application and drying. A federal measure requires reformulation of architectural and industrial maintenance coatings. The users of these coatings are small and widespread, making the use of add-on control devices technically and economically infeasible.

Commercial and Consumer Products

Consumer and commercial products are items sold to retail customers for household, personal or automotive use, along with the products marketed by wholesale distributors for use in institutional or commercial settings such as beauty shops, schools, and hospitals. VOC emissions result from the evaporation of solvent contents in the products or solvents used as propellants. This measure requires the reformulation of certain consumer products to reduce their VOC content. Product reformulation can be accomplished by substituting water, other non-VOC ingredients, or low-VOC solvents for VOCs in the product.

Automobile Refinishing

Automobile refinishing is the repainting of worn or damaged automobiles, light trucks, and other vehicles. Volatile organic compound emissions result from the evaporation of solvents from the coatings during application, drying and clean up techniques. This measure based on state regulation requires large and small autobody refinishing operations to use low VOC content materials in the refinishing process and cleanup, and to use efficient spray guns to control application. The Department adopted regulations in 1995 requiring the use of reformulated coatings.

Screen Printing

A screen-printing process is used to apply printing or an image to virtually any substrate. In the screen-printing operation, ink is distributed through a porous screen mesh to which a stencil may have been applied to define an image to be printed on a substrate. VOC emissions result from the evaporation of ink solvents and from the use of solvents for cleaning. The major source of VOC emissions is the printing process. This measure requires smaller printers to use water based and/or low VOC materials to reduce VOC emissions. Because the users of these coatings are relatively small, requiring the use of add-on control devices is technically and economically infeasible. Reductions in VOC emissions were obtained through the use of ink reformulation, process printing modification, and material substitution for cleaning operations. This regulation became effective on June 5, 1995.

Graphic Arts – Lithographic Printing

This source category consists of numerous small sheet-fed printers that perform non-continuous printing and web printers that print on a continuous web or roll. Heat-set web printers use drying ovens to force dry the printed matter. Web printing sources perform high volume printing on paper or paperboard. VOC emissions to the air are caused by evaporation of the ink solvents, alcohol in the fountain or dampening solution, and equipment wash solvents. These VOC discharges may also cause visible emissions and nuisance odors. MDE adopted a regulation in 1995 to require printers to use control devices and/or low VOC materials to reduce VOC emissions.

Graphic Arts – Flexographic and Rotogravure Printing

This source category consists of numerous small flexographic or rotogravure printers that perform non-continuous sheet fed printing and continuous web or roll printing. MDE adopted a printing regulation in 1987 that requires smaller printers to use control devices and/or low VOC materials to reduce VOC emissions. VOC emissions to the air are caused almost entirely by evaporation of the ink solvents. Although several control devices were evaluated over the years for rotogravure and flexographic web printers, a catalytic oxidizer has proven to be most successful. A typical oxidizer yields 96-98 percent destruction of VOC. Most sources were in compliance with all requirements by early 1992.

Non-Road Measures

Nonroad Small Gasoline Engines

This measure requires small gasoline-powered engine equipment, such as lawn and garden equipment, manufactured after August 1, 1996 to meet federal emissions standards. Small gasoline-powered engine equipment includes lawn mowers, trimmers, generators, compressors, etc. These measures apply to equipment with engines of less than 25 horsepower. VOC emissions result from combustion and evaporation of gasoline used to power this equipment.

Non-Road Diesel Engines Tier I and Tier II

This measure takes credit for NOx emissions reductions from emissions standards promulgated by the EPA for non-road, compression-ignition (i.e., diesel-powered) utility engines. The measure affects diesel-powered (or other compression-ignition) heavy-duty farm, construction equipment, industrial equipment, etc., rated at or above 37 kilowatts (37 kilowatts is approximately equal to 50 horsepower). Heavy-duty farm and construction equipment includes asphalt pavers, rollers, scrapers, rubber-tired dozers, agricultural tractors, combines, balers, and harvesters. This measure applies to all compression-ignition engines except engines used in aircraft, marine vessels, locomotives and underground mining activity. NOx emissions result from combustion of diesel fuel used to power this equipment.

Marine Engine Standards

Of the nonroad sources studied by EPA, gasoline marine engines were found to be one of the largest contributors of hydrocarbon (HC) emissions (30% of the nationwide nonroad total). This measure controls exhaust emissions from new spark-ignition (SI) gasoline marine engines, including outboard engines, personal watercraft engines, and jet boat engines.

Emissions standards for large spark ignition engines

This EPA measure controls VOC and NOx emissions from several groups of previously unregulated nonroad engines, including large industrial spark-ignition engines, recreational vehicles, and diesel marine engines. The emission standards apply to all new engines sold in the United States and any imported engines manufactured after these standards begin. Controls on the category of large industrial spark-ignition engines are first required in 2004. Controls on the other engine categories are required beginning in years after 2005. Large industrial spark-ignition engines are those rated over 19 kW used in a variety of commercial applications; most use liquefied petroleum gas, with others operating on gasoline or natural gas.

Reformulated gasoline use in non-road motor vehicles and equipment

This federally mandated measure requires the use of lower polluting "reformulated" gasoline in Cecil County. The measure involves taking credit for reductions due to the use of the reformulated gasoline in non-road mobile sources. Nonattainment areas classified as severe were required to opt in on the delivery of reformulated gasoline. This measure affects the various non-road mobile sources that burn gasoline; such as small gasoline-powered engine equipment includes lawn mowers, trimmers, generators, compressors, etc. VOC emissions result from combustion and evaporation of gasoline used to power this equipment.

Railroad Engine Standards

This measure establishes emission standards for oxides of nitrogen (NOx), hydrocarbons (HC), carbon monoxide (CO), particulate matter (PM), and smoke for newly manufactured and remanufactured diesel-powered locomotives and locomotive engines, which have previously been unregulated. This regulation took effect in 2000 and affects railroad manufacturers and locomotive re-manufacturers. It involves adoption of three separate sets of emission standards with applicability dependent on the date a locomotive is first manufactured.

<u>Point Source Measures</u>

Expandable Polystyrene Products

These sources use expandable polystyrene beads that contain pentane, a VOC, to manufacture foam products such as foam cups, board insulation, and custom shapes. VOC emissions typically occur during storage and pre-expansion of the beads, during manufacturing, and during "aging" when the blowing agent (pentane) slowly diffuses from the foam before shipping. This control measure requires RACT (Reasonably Available Control Technologies) to be installed at operations that manufacture foam cups, foam insulation and other foam products. The regulation became effective in July 1995.

Yeast Manufacturing

Yeast is produced using an aerated fermentation process under controlled conditions. In June 1995, MDE required RACT to be installed at two yeast-manufacturing operations in the Baltimore nonattainment area. The regulation results in an overall emission reduction of approximately 60 to 70 percent from the 1990 baseline by requiring affected sources to meet specific VOC emission standards.

Commercial Bakery Ovens

This measure requires commercial bakeries using yeast to leaven bread and bread products to install RACT. Commercial bakeries generate VOC emissions from the fermentation and baking processes used to produce yeast-raised baked goods. These emissions are primarily ethanol. The regulation requires control equipment dependent upon thresholds that are based on cost effectiveness criteria.

Federal Air Toxics

This measure covers sources that are required to comply with Federal air toxics requirements. The Department has delegation to implement Federal air toxics rules that will achieve VOC emissions reductions. Federal rules that may achieve such reductions include Federal NESHAPs for vinyl chloride production plants and benzene emissions from equipment leaks, benzene storage vessels, coke by-product recovery plants, benzene transfer operations and waste operations and the EPA Maximum Achievable Control Technology (MACT) program.

Enhanced Rule Compliance

Enhanced Rule Compliance or rule effectiveness (RE) improvement refers to an improvement in the implementation of and compliance with a regulation. These RE improvements may take several forms, ranging from more frequent and in-depth training of inspectors to larger fines for sources that do not comply with a given rule.

State Air Toxics

This measure addresses stationary sources that are covered by Maryland's air toxics regulations that have achieved VOC reductions above and beyond current federally enforceable limits. In general, Maryland's air toxics regulations cover any source required to obtain a permit to construct or annually renewed state permit to operate. The Department adopted the air toxics regulations in 1988.

NOx RACT -- Reasonably Available Control Technology

This measure requires control of nitrogen oxides (NOx) emissions by installing RACT. NOx RACT will apply to utility, industrial and commercial fuel burning equipment and combustion installations. The regulation established cost-effective controls on all installations located at major NOx sources. This first phase of stationary source NOx reductions resulted in an approximate 22% reduction in NOx emissions.

NOx Phase II/Phase III Ozone Transport Commission (OTC)/NOx Budget Rule (Phase II) and NOx SIP Call (Phase III)

In 1994, the OTC member states signed a major agreement to reduce NOx emissions from power plants and other major stationary sources of pollution throughout the Northeast and Mid-Atlantic States. The agreement recognized that further reductions in NOx emissions are needed to enable the entire Ozone Transport Region (OTR) to meet the NAAQS. The Department adopted a “NOx Budget” rule to require a second phase of stationary source NOx reductions as part of this regulatory initiative. This regulation requires large stationary sources to reduce summertime NOx emissions by approximately 65% from 1990 levels. The regulation also includes provisions allowing sources to comply by trading “allowances.” This regulation requires affected sources to have met these requirements by May 2000.

In late 1998, the U.S. EPA adopted its “NOx SIP Call” to reduce ozone transport in the Eastern United States. This regional NOx reduction program requires 22 states, including Maryland, to submit regulations and a revision to State Implementation Plans (SIPs) to further reduce NOx emission by 2007. Maryland’s Phase III regulations achieve approximately 23% additional reductions from large stationary sources like power plants, cement kilns and large industrial boilers. The regulations require affected sources to add specific control equipment or to reduce emissions or trade to meet the allowable amount ("cap") of seasonal NOx emissions by 2003.

6.2 8-Hour Ozone Control Measures

The following measures have been implemented in Maryland since 2002 (the baseline emissions inventory year for 8-Hour Ozone). These measures were not part of the baseline emissions inventory for the 8-Hour Ozone SIP and emission reductions from these measures were forecasted for both 2008 (reasonable further progress calculation) and 2009 (attainment inventory) for use in the reasonable further progress calculations for Cecil County as well as the attainment modeling for the region. A summary of the control measures and their benefits is presented in Table 6.1 below. The benefits below summarize the emission credits available from the listed measures based on the difference between a 2008/2009 controlled and uncontrolled inventory.

Table 6.1: Control Measures Summary

	2008		2009	
Control Measure	**VOC (tpd)**	**NOx (tpd)**	**VOC (tpd)**	**NOx (tpd)**
Enhanced I/M				
Tier I				
Reform Gas				
LEV				
HDDE				
Total Mobile	1.75	3.78	1.85	3.78
Stage II/Refuel	0.00	0.00	0.00	0.00
OTC - Consumer Products Phase 1	0.14	0.00	0.14	0.00
OTC - Consumer Products Phase 2	0.00	0.00	0.02	0.00
OTC – AIM	0.39	0.00	0.39	0.00
OTC - PFC Phase 1	0.26	0.00	0.32	0.00
OTC - PFC Phase 2	0.00	0.00	0.03	0.00
OTC - Industrial Adhesives	0.00	0.00	0.10	0.00
Open Burning	0.00	0.00	0.00	0.00
Nonroad Model	1.18	0.28	1.50	0.36
Railroads (Tier 2)	0.00	0.15	0.00	0.16
Healthy Air Act (HAA)	0.00	0.00	0.00	0.00
Total	3.71	4.21	4.35	4.30

<u>The Maryland Healthy Air Act (HAA)</u>

In April of 2006, the Maryland General Assembly enacted the Maryland Healthy Air Act. The Maryland General Assembly record related to the HAA and the final version of the Act itself can be found at: http://mlis.state.md.us/2006rs/billfile/SB0154.htm

The MDE Regulations (Code of Maryland Regulations) can be found at:

http://www.mde.state.md.us/assets/document/CPR_12-26-06_Emergency_and_Permanent_HAA_Regs_for_AELR.pdf

The HAA is one of the most stringent power plant emission laws on the east coast. The HAA requires reductions in Nitrogen Oxide (NO_x), Sulfur Dioxide (SO2) and Mercury emissions from large coal burning power plants. The Healthy Air Act also requires that Maryland become involved in the Regional Greenhouse Gas Initiative (RGGI) which is aimed at reducing greenhouse gas emissions.

The Maryland Department of the Environment (MDE) has been charged with implementing the HAA through regulations. As enacted, these regulations constitute the most comprehensive air pollution emission reduction measure proposed in Maryland history.

Affected Sources

These Healthy Air Act NOx reduction requirements affect the following fossil fuel fired electric generating units (only the Constellation Energy Group Systems are located in the Baltimore Nonattainment Area):

Constellation Energy Group System
Brandon Shores 1 & 2 Anne Arundel County
H. A. Wagner 2 & 3 Anne Arundel County
C. P. Crane 1 & 2 Baltimore County

Mirant System
Chalk Point 1 & 2 Prince George's County
Dickerson 1, 2, & 3 Montgomery County
Morgantown 1 & 2 Charles County

Allegheny Energy Washington County
R. Paul Smith, 3 & 4

Overview of Expected Emission Reductions

While none of the HAA affected sources are located in Cecil County, Maryland, the MDE lists this important regulation in the SIP as emission reductions from these upwind facilities will have a substantial impact on the air quality in Cecil County.

Over ninety-five percent of the air pollution emitted from Maryland's power plants comes from the largest and oldest coal burning plants. The emission reductions from the HAA come in two phases. The first phase requires reductions in the 2009/ 2010 timeframe and compared to a 2002 emissions baseline reduce NO_x emissions by almost 70%, SO2 emissions by 80% and mercury emissions by 80%.

The second phase of emission control occurs in the 2012/ 2013 timeframe. At full implementation the HAA will reduce NO_x emissions by approximately 75% from 2002 levels, SO_2 emissions will be reduced by approximately 85% from 2002 levels, and mercury emissions will be reduced by 90%.

Table 6.2 Annual Maryland Healthy Air Act NOx Emissions Reductions (TPY):

Unit	2002 Emissions	Uncontrolled 2009 Emissions	2009 HAA Caps	**2009 HAA Emission Reductions**	2009 HAA Emission Reduction %	2012 HAA Caps	2009 Uncontrolled Emissions - 2012 HAA Cap	2012 HAA Emission Reduction %
Brandon Shores 1	6329	7558	2927	**4631**	61.27	2414	5144	68.06
Brandon Shores 2	6034	7206	3055	**4151**	57.60	2519	4687	65.04
Wagner 2	2232	2666	673	**1993**	74.76	555	2111	79.18
Wagner 3	1718	2052	1352	**700**	34.11	1115	937	45.66
Crane 1	6245	7458	832	**6626**	88.84	686	6772	90.80
Crane 2	4285	5117	894	**4223**	82.53	737	4380	85.60
TOTALS	**26843**	**32057**	**9733**	**22324**	**69.64**	**8026**	**24031**	**74.96**

Table 6.3 Ozone Season Maryland Healthy Air Act NOx Emissions Reductions:

Unit	2002 Emissions (Ozone Season Day)	2002 Emissions (Ozone Season = 153 Days)	Uncontrolled 2009 Emissions (Ozone Season Day)	Uncontrolled 2009 Emissions (Ozone Season = 153 Days)	2009 HAA Caps (Ozone Season = 153 Days)	**2009 HAA Emission Reductions (Ozone Season)**	**2009 HAA Reductions (Tons per Ozone Season Day)**	2012 HAA Caps (Ozone Season = 153 Days)	2009 Uncontrolled Emissions - 2012 HAA Cap (Ozone Season)	2009 Uncontrolled Emissions - 2012 HAA Cap (Tons Per Ozone Season day)
Brandon Shores 1	9.68	1481.04	11.56	1768.68	1363	**405.68**	**2.65**	1124	644.68	4.21
Brandon Shores 2	7.60	1162.80	9.08	1389.24	1449	**-59.76**	**-0.39**	1195	194.24	1.27
Wagner 2	6.88	1052.64	8.21	1256.13	278	**978.13**	**6.39**	229	1027.13	6.71
Wagner 3	3.28	501.84	3.91	598.23	583	**15.23**	**0.10**	481	117.23	0.77
Crane 1	11.86	1814.58	14.16	2166.48	345	**1821.48**	**11.91**	284	1882.48	12.30
Crane 2	10.56	1615.68	12.61	1929.33	385	**1544.33**	**10.09**	317	1612.33	10.54
TOTALS	**49.86**	**7628.58**	**59.53**	**9108.09**	**4403**	**4705**	**30.75**	**3630**	**5478**	**36**

Portable Fuel Containers Rule: Phase I

This measure introduces performance standards for portable fuel containers and spouts. The standards are intended to reduce emissions from storage, transport and refueling activities. The rule also included administrative and labeling requirements. Compliant containers must have: only one opening for both pouring and filling, an automatic shut-off to prevent overfill, an automatic sealing mechanism when not dispensing fuel and specified fuel flow rates, permeation rates and warranties.

Source Type Affected

Any person or entity selling, supplying or manufacturing portable fuel containers, except containers with a capacity of less than or equal to one quart, rapid refueling devices with capacities greater than or equal to four gallons, safety cans and portable marine fuel tanks operating with outboard motors, and products resulting in cumulative VOC emissions below those of a representative container or spout.

Control Strategy

Maryland adopted Phase I of the Ozone Transport Commission (OTC) Model Rule for Portable Fuel Containers in January 2002. The rule applies to all counties in the nonattainment area. Reductions from this rule increase annually beginning with implementation in the State of Maryland on January 1, 2004.

Projected Reductions

VOC Emission Reductions for 2008 (TPD): 0.26
VOC Emission Reductions for 2009 (TPD): 0.32

Emission Benefit Calculations

Projected reductions are based on an emission reduction factor of 75% after full implementation after 10 years. Implementation began in 2004. In 2008, the emission reduction factor is 41.3%. In 2009, the emission reduction factor is 48.8%.

References

E.H. Pechan, "Control Measure Development Support Analysis for the Ozone Transport Commission Model Rules", March 31, 2001.

<u>Architectural and Industrial Maintenance Coatings Rule</u>

This rule requires manufacturers to reformulate various types of coatings to meet VOC content limits. Affected products include architectural coatings, traffic markings, high-performance maintenance coatings and other special-purpose coatings. It uses more stringent VOC content limits than the existing Federal consumer products rule.

Source Type Affected

The measure affects all manufacturers of affected coatings.

Control Strategy

Maryland adopted this rule on March 29, 2004. The rule will apply to all counties in the nonattainment area. Compliance with this rule was required as of January 1, 2004.

The VOC content limits in this rule are based on a Suggested Control Measure (SCM) adopted by the California Air Resources Board (CARB) and a State and Territorial Air Pollution Program Administrators/Association of Local Air Pollution Officials (STAPPA/ALAPCO) model rule or OTC coatings. Manufacturers are expected to comply with this rule using primarily EPA Test Method 24.

Projected Reductions

VOC Emission Reductions for 2008 (TPD): 0.39
VOC Emission Reductions for 2009 (TPD): 0.39

Emission Benefit Calculations

Projected reductions are based on an emission reduction factor of 31%, based on Pechan (2001).

References

E.H. Pechan, "Control Measure Development Support Analysis for the Ozone Transport Commission Model Rules", March 31, 2001.

<u>Consumer Products Rule: Phase I</u>

Phase I of the Consumer Products Rule required reformulation of approximately 80 types of consumer products to reduce their VOC content. It uses more stringent VOC content limits than the existing Federal consumer products rule. The rule also contains requirements for labeling and reporting.

Source Type Affected

Manufacturers of various specialty chemicals named in the rule, such as aerosol adhesives, floor wax strippers, dry cleaning fluids and general purpose cleaners.

Control Strategy

Phase I of the Ozone Transport Commission (OTC) Model Rule for Reformulated Consumer Products became effective in the State of Maryland on August 18, 2003.

Manufacturers are expected to demonstrate compliance with the rule primarily through a California Air Resources Board (CARB) test method. If complying with the VOC contents becomes difficult, flexibility options are provided.

Projected Reductions

VOC Emission Reductions for 2008 (TPD): 0.14
VOC Emission Reductions for 2009 (TPD): 0.14

Emission Benefit Calculations

Projected reductions are based on an emission reduction factor of 14.2 percent, based on Pechan (2001).

References

E.H. Pechan, "Control Measure Development Support Analysis for the Ozone Transport Commission Model Rules", March 31, 2001.

Industrial Adhesives and Sealants Rule

This rule establishes VOC content limitations for industrial and commercial application of solvent-based adhesives and sealants. Controls will cover adhesives, sealants, adhesive primers, sealer primers, adhesive application to substrates, and aerosol adhesives. VOC content limits are similar to those contained in the CARB Reasonably Available Control Technology (RACT) or Best Available Control Technology (BACT) document for adhesives and sealants (Dec. 1998).

Source Type Affected

Manufacturers and distributors of industrial adhesives and sealants.

Control Strategy

The State of Maryland will adopt the Ozone Transport Commission (OTC) Model Rule for Industrial Adhesives and Sealants by May 1, 2008.

Projected Reductions

VOC Emission Reductions for 2008 (TPD): 0.00
VOC Emission Reductions for 2009 (TPD): 0.10

Emission Benefit Calculations

Emission reductions are based on a 64 percent reduction in emissions of VOC from the baseline. Further details are available in OTC Technical Support Document (2006).

References

OTC 2006. *Identification and Evaluation of Candidate Control Measures: Draft Technical Support Document.* Prepared by MACTEC Federal Programs, Inc., Herndon, Virginia for the Ozone Transport Commission. August 4, 2006]

Portable Fuel Containers Rule: Phase II

This measure expands existing performance standards for portable gasoline containers and spouts to kerosene containers. The standards are intended to reduce emissions from storage, transport and refueling activities. The rule also included administrative and labeling requirements. Compliant containers must have: only one opening for both pouring and filling, an automatic shut-off to prevent overfill, an automatic sealing mechanism when not dispensing fuel and specified fuel flow rates, permeation rates and warranties.

Source Type Affected

Any person or entity selling, supplying or manufacturing portable fuel containers, except containers with a capacity of less than or equal to one quart, rapid refueling devices with capacities greater than or equal to four gallons, safety cans and portable marine fuel tanks operating with outboard motors, and products resulting in cumulative VOC emissions below those of a representative container or spout.

Control Strategy

The State of Maryland will adopt the Ozone Transport Commission (OTC) Model Rule for the second phase of the portable fuel container rule by May 1, 2008.

Projected Reductions

VOC Emission Reductions for 2008 (TPD): 0.00
VOC Emission Reductions for 2009 (TPD): 0.03

Emission Benefit Calculations

Projected reductions are based on an emission reduction factor of 58% after full implementation after 10 years. Implementation will begin in 2009. In 2008, the emission reduction factor is 0.00%. In 2009, the emission reduction factor is 5.8%. Further details are available in OTC Technical Support Document (2006).

References

OTC 2006. *Identification and Evaluation of Candidate Control Measures: Draft Technical Support Document.* Prepared by MACTEC Federal Programs, Inc., Herndon, Virginia for the Ozone Transport Commission. August 4, 2006

<u>Consumer Products Rule: Phase II</u>

Phase II of the Consumer Products Rule involves adopting the CARB 7/20/05 Amendments which sets new or revises existing limits on 13 consumer product categories. It uses more stringent VOC content limits than the existing federal consumer products rule. The rule also contains requirements for labeling and reporting.

Source Type Affected

Manufacturers of various specialty chemicals named in the rule, such as aerosol adhesives, floor wax strippers, dry cleaning fluids and general purpose cleaners.

Control Strategy

The State of Maryland will adopt the Ozone Transport Commission (OTC) Model Rule for the second phase of the consumer products rule by May 1, 2008.

Projected Reductions

VOC Emission Reductions for 2008 (TPD): 0.00
VOC Emission Reductions for 2009 (TPD): 0.02

Emission Benefit Calculations

Emission reductions are based on an additional 2 percent reduction in emissions of VOC from the baseline. Further details are available in OTC Technical Support Document (2006).

References

OTC 2006. *Identification and Evaluation of Candidate Control Measures: Draft Technical Support Document.* Prepared by MACTEC Federal Programs, Inc., Herndon, Virginia for the Ozone Transport Commission. August 4, 2006

Rule Phase In

The following rules have a phase in period for the Baltimore Nonattainment Area and give the region phased in emissions benefits:

Area Sources:
- Additional phase in of reductions from Federal Locomotives Rule
- Federal Rule related to On-Board Refueling/vapor recovery for LD Trucks (2004)

Nonroad Sources:
- Federal 2004 Nonroad Heavy Duty Diesel Rule (negligible benefits by 2009)

6.3 Voluntary and Innovative Measures

EPA's voluntary measures policy, "Guidance on Incorporating Voluntary Mobile Source Emission Reduction Programs in State Implementation Plans", establishes criteria under which emission reductions from voluntary programs are creditable in a SIP. This policy permits states to develop and implement innovative programs that partner with local jurisdictions, businesses and private citizens to implement emission-reducing behaviors at the local level.

Inclusion of the following programs in the control measures portion of this attainment plan is not intended to create an enforceable commitment by MDE or the State to implement the programs or to achieve any specific emission reductions projected as a result of implementation of the programs, and neither MDE, nor the State makes any such commitment. In addition, MDE does not rely on any emission reductions projected as a result of implementation of these programs to demonstrate attainment. While the emission reductions from these programs could be substantial and could lead to significant regional air quality benefits, actual air quality benefits are uncertain. Consequently, projected emission reductions from these programs are not included in the emission inventory, the attainment modeling, the reasonable further progress calculation or any other area of the SIP where specific projected emission reductions are identified.

<u>Regional Forest Canopy Program: Conservation, Restoration, and Expansion</u>

Expanded tree canopy cover is an innovative voluntary measure proposed to improve the air quality in Cecil County, Maryland. Trees reduce ground-level ozone concentrations by:

1) reducing air temperatures and reducing energy used for cooling, and
2) directly removing ozone and NOx from the air.

Modeling has clearly shown that trees reduce ozone levels. In addition, trees in an urban setting have far-reaching water quality (e.g. decreasing storm water runoff), habit and societal benefits. To achieve a reduction in ground-level ozone under a tree canopy program, it will be necessary to preserve the current canopy and plant and maintain a significant number of new trees.

The current regional tree canopy is composed of mixed native hardwoods and urban plantings. On average these species require 30 years to mature so the short term benefits of a tree program are not substantial yet still significant. To achieve area wide canopy expansion will require long-term commitment by the state and local agencies, volunteer organizations, and private landowners.

Achieving maximum benefits from this type of program will require the following types of commitments:

1) Initiate and/or enhance efforts to support, monitor, evaluate, and report preservation of existing urban tree canopy and canopy expansion efforts.

2) Implement urban forestry programs to affect air and surface temperature, wind speed, and reduce VOC emissions. Programs include sustained tree planting, reduced mowing and lawn maintenance and tree planting initiatives for streets, parking lots, and government-owned facilities.

3) Providing assistance and outreach to the landowners and businesses to encourage tree conservation, planting and maintenance.

4) Initiate development of a comprehensive plan that will establish a detailed regional baseline and outline strategies to preserve, enhance, increase, and protect measure and track overall forest canopy change in the region over the next 20 years.

5) Monitor these activities and report annually.

Current Programs

While Maryland has over 40 state programs that support, encourage, or require the planting of trees, five of these tools are of special importance for implementation at the local level:

- Forest Conservation Act
- Critical Areas Act
- Mitigation Requirements
- Comprehensive Plans Requirements
- Urban and Community Forestry Programs

Special attention will be paid to how these programs can be coordinated with new local ordinances and initiatives to enhance their use in tree protection, canopy preservation, and expansion to achieve regional air quality (SIP) goals.

Control Strategy

Coordination

This type of measure will require collaboration among the various state and local agencies that support, encourage, and require tree planting. Currently, numerous agencies bear responsibility for implementing and tracking tree planting related activities, but there is no centralized repository for this information. The state can be encouraged to commit to create a new program to coordinate tree-planting programs. This program would be housed within the Department of Natural Resources Maryland Forest Service and would be charged with management of a tree planting database and promoting outreach efforts to landowners and stakeholder groups. This database would be used to compile baseline data (including maps and descriptive information about each nonattainment county in the planning area), information about tree plantings (new and replacement trees) and canopy change.

Canopy Preservation

The state coordinating office will work with local governments to fully implement key programs. Particular attention will be given to those who set conservation, tree planting and canopy goals and reforestation standards for local authorities to track during the development process. Local authorities will be encouraged to:

1) track efforts aimed at preserving existing canopy,

2) provide the Resource agency with data regarding preservation efforts including new ordinances and development tools,

3) work with federal, state, and private landowners to identify development mitigation areas.

The effectiveness of canopy preservation efforts could then be periodically evaluated.

Public Outreach

The region would need to commit to undertake a public outreach program designed to promote tree planting. This need could build upon the Chesapeake Bay Agreement Forestry Directive and local land use guidelines. Past initiatives under Maryland programs have included financial incentives to private landowners for planting trees. MDE could potentially approach Baltimore

Metropolitan Council, state government agencies, and local governments to work with volunteer tree planting organizations, landowners, and stakeholder groups to support tree planting and conduct educational outreach regarding documenting and reporting voluntary planting and maintenance programs.

Canopy Goals

Each jurisdiction in the nonattainment area could be encouraged to adopt a tree canopy goal. Local and state governments could evaluate reforestation of public lands to meet canopy goals. Governments could collaborate with private citizens to address canopy goals.

Strategic Tree Planting

Biogenic volatile organic compounds (BVOCs), an ozone precursor, are emitted by some tree species as a natural process. Expanding the canopy primarily with trees whose BVOC emissions are lower will have a significant impact on overall emissions, a key issue in reducing BVOCs. A right tree –right place strategy will need to be encouraged to garner the maximum benefits from this type of program.

<u>Clean Air Teleworking Initiative</u>

The state of Maryland, on occasion, experiences unhealthful levels of the air pollutants ground level ozone and fine particles. When air quality elevates to unhealthful levels it poses significant health and economic impacts to the citizens of the state of Maryland. To address air pollution concerns and requirements, the State of Maryland has implemented over 100 pollution control programs affecting industries, small businesses, mobile sources, and the general public since 1990, when the modern-day Clean Air Act was passed. These programs have prevented nearly 800 tons of ozone-forming pollutants from entering the air each day. In order to inform the public about daily air pollution levels the Maryland Department of the Environment has been accurately forecasting and reporting air quality information since 1993.

Traffic congestion is a major problem in Maryland's metropolitan areas where individuals waste hundreds of hours every year stuck in traffic due to congested roadways. Numerous studies have demonstrated that telework programs are advantageous in addressing major environmental, transportation, productivity, quality of life, and employment issues.

Reduced commuter road miles decrease air polluting vehicle emissions, gasoline consumption, traffic congestion, and highway maintenance costs for the citizens of Maryland. It has been proven that telework provides economic and organizational benefits to employers, resulting in increased employee productivity, enhanced employee morale, improved recruitment and retention of employees, reduced office space and parking needs, reduced stress, increased job satisfaction, decreased absenteeism costs, an expanded labor pool, and increased flexibility to meet the needs of citizens. The state of Maryland, as a major employer, has recognized its leadership role to develop substantive programs, such as teleworking, to reduce commuter road miles traveled by state employees and enhance productivity

Objective

The objectives of this campaign are to 1) increase the number of employees who telework in the Baltimore/Washington metropolitan area and 2) increase the frequency of employees who telework by linking teleworking and air quality; specifically, encouraging employees to telework on days when air quality is at its worst.

The decision to encourage teleworking on bad air days will be guided by the **Air Quality Index (AQI)**, a nationwide, color-coded scale used by the U.S. Environmental Protection Agency to communicate air quality to the public. "Code Orange" is considered ***unhealthy for sensitive groups*** (children, the elderly, and those with heart or lung conditions) and "Code Red" is considered ***unhealthy for everyone***. "Code Purple," which occurs very infrequently in the region, is considered ***very unhealthy for everyone***. Clean Air Partners, a nonprofit organization that encourages voluntary action to improve air quality, provides a three-day air quality forecast to local employers through its Air Quality Action Day (AQAD) program. A copy of Clean Air Partners' Air Quality Action Guide, which incorporated the AQI, is shown in Figure 6.1. Teleworking is encouraged at Code Orange and above.

CLEAN AIR PARTNERS™

Air Quality Action Guide (AQAG)

Your guide to cleaner, healthier air in the metropolitan Washington-Baltimore region.

Air Quality Numerical Value	**Action Steps To Protect Your Health and Our Environment**
GOOD **0-50**	No pollution. Enjoy outdoor activities. ◆ Keep engines tuned. ◆ Use environmentally friendly products. ◆ Conserve electricity, set air conditioning to 78 degrees.
MODERATE **51-100**	Air quality may pose a moderate risk, especially for those who are unusually sensitive to air pollution. ◆ Carpool, use public transit, bike, or walk. ◆ Limit driving, consolidate trips. ◆ Reduce car idling.
UNHEALTHY for Sensitive Groups **101-150**	**Sensitive Groups**–children and active adults, people with respiratory disease, such as asthma and emphysema and heart ailments should limit prolonged outdoor physical activity. Follow all of the action steps listed previously AND: ◆ Refuel after dusk, use fuel-efficient vehicles. ◆ Avoid driving, use transit, telework. ◆ Avoid using aerosol products.
UNHEALTHY **151-200**	**Unhealthy for Everyone** Sensitive Groups in particular should avoid outdoor physical activities. Everyone else, especially children, should limit prolonged outdoor exertion. Follow all of the action steps listed previously AND: ◆ Avoid lawn mowing or use electric mowers. ◆ Avoid using any gas powered lawn equipment. ◆ Put off painting until air quality improves.
VERY UNHEALTHY **201-300**	**Very Unhealthy for Everyone** When air quality reaches very unhealthy levels everyone is strongly urged to follow all of the actions steps listed previously AND avoid outdoor physical activities.

For more information visit Clean Air Partners' website at **www.cleanairpartners.net**

Figure 6.1 Air Quality Action Guide

Approach

Encouraging employees to telework on poor air quality days may result in numerous employees and managers working at home for several consecutive days. This will require advanced preparation by employees, managers, and coworkers (in the office) to ensure transparency and a consistent level of productivity. While this may initially seem challenging from a management perspective, the added benefit is that employees and managers will become adept at teleworking concurrently, thereby increasing the organization's business continuity capabilities in the event of an actual emergency.

Implementation

The following steps are recommended to help businesses successfully launch their “Clean Air Teleworking” initiative in 2007:

Get Input from Managers* –** businesses should get input from several managers to identify potential barriers and solutions to the “Clean Air Teleworking” initiative. This could be accomplished by conducting one-on-one interviews with 4-5 managers or a small discussion group. The input from the managers could then be used to shape how the program is developed and implemented, starting with a small pilot involving a couple of managers supportive of teleworking ***and the “Clean Air Teleworking” initiative.

***Become an AQAD Participant* –** businesses should become an Air Quality Action Days participant so it can receive the Clean Air Partners’ three-day air quality forecast, which can then be distributed by email to employees when a poor air quality day (Code Orange, Code Red, or Code Purple) is forecasted.

***Conduct Pilot* –** Select managers and employees who will be participating in the “Clean Air Teleworking” pilot and launch the program over the summer of 2007. Conduct an orientation/training session for participants prior to implementation and follow-up with brief phone interviews after a multi-day episode to determine if there were any problems. Prepare a summary report at the end of the pilot and share with management and employees.

***Implement Tracking System* –** Ask participants to track their participation using a web-based system that tracks auto emission reductions resulting from teleworking (NOx, VOC, CO, and CO2), such as TeleTrips (https://www.secure-teletrips.com/). This information can be reported at the individual, department/team, and organizational level and provides continuous feedback on how the program and participants are improving air quality. Furthermore, businesses should consider recognizing individuals or teams/departments with the highest level of participation and emissions reductions.

***Communicate* –** businesses should send out several email communications to all their employees prior to the launch of the “Clean Air Teleworking” pilot, during implementation, and at the conclusion of the pilot to explain objectives and keep employees informed. Furthermore, employees not participating in the pilot should also receive the air quality forecast for Code Orange, Code Red, and Code Purple days and be encouraged to take other voluntary measures at work and at home (e.g., carpooling, eating in the cafeteria rather than going out for lunch, refueling after dusk, and postponing mowing.)

***Expand Program* –** Share the results of the pilot with all staff and encourage other managers and employees to participate in the program in future years. Repeat orientation/training for new participants prior to implementation, conduct phone or on-line survey with participants during implementation, track participation/results for all participants, and recognize or reward individuals teams/departments with the highest level of participation and emissions reductions. An initial pilot program will be initiated throughout the Maryland Department of the Environment (MDE) that will encourage telecommuting opportunities for qualified personnel when air quality is forecasted to be in the Code Orange (Unhealthy for Sensitive Groups) range or above. The MDE pilot program will launch in May 2007.

Expansion of Program

Additional strategies will be employed to encourage a wider participation in the Clean Air Teleworking Initiative. Some of these strategies will include: Promoting participation amongst all Maryland State agencies. Working with the Baltimore Metropolitan Council and the Metropolitan Washington Council of Governments to promote program throughout local jurisdictions. Clean Air Partners will serve as the work group to implement the program. Develop strategic plan for local governments and federal agencies. Encourage participation within private sector. Develop a merit-based recognition/award system for participation. Promote program throughout the Ozone Transport Commission. A timeline of the implementation steps is shown in Table 6.3.

Table 6.4 Clean Air Teleworking Time Line

Task/Step		Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07
1.0	**Telework Toolkit**									
1.1	Research materials	x								
1.2	Compile toolkit	x								
1.3	Integrate with Clean Air Partners web site		x							
2.0	**Clean Air Teleworking Pilot**									
2.1	Recruit organization(s)		x	x						
2.2	Develop/implement communications plan		x	x						
2.3	Conduct interviews/focus groups with managers		x	x						
2.4	Identify participants (e.g., specific units/departments)		x	x						
2.5	Conduct orientation			x						
2.6	Launch and conduct pilot			x	x	x	x			
2.6	Conduct "spot" phone interviews/email surveys			x	x	x	x			
2.7	Implement tracking system		x	x	x	x	x			
2.8	Track and report results		x	x	x	x	x	x	x	
2.9	Expand program								x	x

The Clean Air Teleworking Initiative will develop the program in close coordination with other entities who have some role in telework implementation (Commuter Connections, Maryland Telework Partnership with Employers, Telework!Va, and the newly created Office of Telework Promotion and Broadband Assistance in VA.

Supporting Material

Clean Air Partners will compile and customize a telework tool kit that would be posted on the organization’s web site. The tool kit would provide on-line resources to help employers start or expand a telework program, including the use of “episodic” teleworking on poor air quality days.

Air Quality Benefits of an Aggressive Telecommute Strategy

To simulate the effects of a very aggressive telecommute program, the University of Maryland modeled the air quality change that would result from a 40% reduction of vehicle miles traveled from the road in the nonattainment areas of Baltimore, Philadelphia, and Washington, D.C. on 38 high ozone days in the summer of 2002. Changes in emissions were implemented as a flat 40% reduction in vehicle miles traveled in each county of the three nonattainment areas. The effects of implementing such a program were modeled using version 4.4 of the CMAQ model. The model results showed that across the three nonattainment areas tested, an aggressive telecommute program has the potential for considerable benefit to air quality, with fairly uniform benefits across all three areas. The highest monitors in the Philadelphia and Washington, D.C. nonattainment areas would see the largest benefits from this program, suggesting that it is targeting the most troublesome monitors on the worst ozone days. Benefits in all three nonattainment areas averaged over 2 ppbv ozone. The full report is included in appendix G

<u>High Electricity Demand Day (HEDD) Initiative</u>

Emissions from Electric Generating Units (EGUs) are higher on high electric demand days, resulting in poorer air quality. High electrical demand day (HEDD) operation of EGUs generally have not been addressed under existing air quality control requirements, and these units are called into service on the very hot days of summer when air pollution levels typically reach their peaks.

The Ozone Transport Commission (OTC) has been meeting with state environmental and utility regulators, EPA staff, EGU owners and operators and the independent regional systems operators to assess emissions associated with HEDD during the ozone season and to address excess NOx emissions on HEDDs. The OTC has found that NOx emissions are much higher on a high electrical demand day than on a typical summer day and there is the potential to reduce HEDD emissions by approximately 25 percent in the short term through the application of known control technologies. HEDD units consists of gasoline and diesel combustion turbines, coal and residual oil burning units.

On March 2, 2007, the OTC states and the District of Columbia agreed to a Memorandum of Understanding (MOU) committing to reductions from the HEDD source sector. The MOU includes specific targets for a group of six states to achieve reductions in NOx emissions associated with HEDD units on high electrical demand days during the ozone season. These states agreed to achieve these reductions beginning with the 2009 ozone season or as soon as feasible thereafter, but no later than 2012. The remaining OTC states including Virginia and the District of Columbia agreed to continue to review the HEDD program and seek reductions where possible but they do not have a formal emissions reduction target in the MOU. The OTC MOU is included in Appendix D.

<u>Emission Reductions from Transportation Measures</u>

Substantial funding commitments have come from State and local agencies and private employers for promotion of strategies to reduce mobile emissions. Examples of these measures include idling reduction, ridesharing, telecommuting, and transit use as well as vehicle replacement and retrofit measures, and bicycle and pedestrian programs. These funding commitments produce reductions in emissions, some of which are being reflected in transportation plans.

Although these programs are working to reduce emissions from mobile sources and play an important role in the transportation sector's contribution to cleaner air, neither MDE, nor the State intends their inclusion in this SIP to constitute enforceable commitments to implement these programs or to achieve any emission reductions projected as a result of implementing these programs, and neither MDE, nor the State makes any such commitment. These directionally correct programs will continue to be used outside of the SIP for transportation planning purposes as needed.

The following are descriptions of selected emission reduction strategies in Cecil County.

Traffic Flow Improvements (CHART)

The Coordinated Highways Action Response Team program, operated by MDOT and Maryland State Police, focuses its operations on non-recurring congestion such as backups caused by accidents. The Statewide Operations Center, and the three satellite Operations Centers in the region, survey the state's roadways to quickly identify incidents through the use of ITS (Intelligent Transportation System) technology. CHART also includes traffic patrols, which have been operating during peak periods on many of the state's highways since the early 1990s. CHART and MdTA have a number of ITS devices in Cecil County. These include CCTV cameras, variable message signs and 24 response vehicle and emergency traffic controls along I-95 in Cecil County. Currently MdTA and CHART are working together to install a CHART workstation that will allow the opportunity to view all CHART and MdTA cameras in the county. These continued incident management and emergency information improvements to motorists will help reduce vehicular delay. In addition to existing MdTA and CHART devices there are other additional installations proposed that will help improve or maintain traffic flow along the following Cecil County roadways: US 40, US 301, MD 213, and I-95.

Truck Stop Electrification (TSE)

Truck Stop Electrification allows truckers to shut down their engine and obtain electric power and "creature comforts" while resting. TSEs reduce diesel emissions and reduce noise and wear and tear on the truck engine. IdleAire truck stops provide electricity (110V AC), cab heating/cooling, television and movies, telephone and Internet access. IdleAire has over 100 locations nationally, three in Maryland. The Maryland sites are located in Baltimore and Jessup, both in the Baltimore region. An additional TSE has been put in place in Cecil County at I-95 and MD 279.

Electronic Toll Collection

The Maryland Transportation Authority (MdTA) commenced operation of its electronic toll collection system, MTAG, at the authority's three Baltimore harbor crossing facilities in 1999. The I-95 Tydings Memorial Bridge and US 40 Thomas J. Hatem Memorial Bridge crossings of the Susquehanna River are also now equipped with electronic toll facilities. An Automatic Vehicle Identification (AVI) toll decal, a form of electronic toll collection, also is offered at the Hatem Bridge. This $5 AVI decal allows unlimited trips across the bridge during a one-year period. Decals can be used only on two-axle vehicles and cannot be used by vehicles being towed or towing other vehicles. As of January 2004, 45 percent of vehicles using MdTA facilities used electronic toll tags. MdTA is a member of the E-Z Pass InterAgency Group, a coalition of Northeast Toll Authorities. MdTA established reciprocity with the E-Z Pass system in 2001, enabling travelers in Maryland, as well as at most toll facilities in New York, New Jersey, Delaware, Pennsylvania, Massachusetts, Virginia, and West Virginia to pay tolls using one electronic device.

Maryland Commuter Tax Credit

As of January 2000, a tax credit went into effect statewide that allows employers to claim a 50% state tax credit for providing transit benefits (subsidy) to an employee of up to $52.50 per month, which an employer may provide to an employee without tax consequences under the Federal tax law. It is expected that the state tax credit will be even more attractive to employers as a benefit to offer employees than the Federal law (a direct tax credit as opposed to an allowable business expense). This feature of the Maryland law also has the potential to encourage increased transit use by low and moderate-income employees. Under provisions of both the 1999 and 2000 Maryland laws, private non-profit organizations will also be able to participate in the program. Employers will be able to claim tax credits for providing transit passes and vouchers, guaranteed ride home, and parking cash-out programs. Similar to the IRS benefits, the Maryland Commuter Tax Benefit program does not provide financial assistance to carpoolers. Information is also provided online and employers are able to register to participate in the program over the internet.

Bicycle/pedestrian Enhancements

Through MDOT, the Maryland State Highway Administration (SHA) has worked to engineer and implement new and improved bicycle and pedestrian facilities, and has implemented programs to encourage pedestrians. SHA has a stated goal of providing 200 miles of marked bicycle lanes throughout Maryland by December 31, 2006. In addition, SHA has developed the *Maryland SHA Bicycle and Pedestrian Guidelines* to provide general guidance on design. The state has a policy of considering sidewalks to reinforce pedestrian safety and promote pedestrian access adjacent to roadway projects being constructed or reconstructed. Special efforts are made to facilitate pedestrian travel near schools. In addition, bicycle safety and travel are being accommodated by construction of wider shoulders and/or curb lanes to separate motor vehicles from the cyclists. In regard to bicycle or pedestrian travel in controlled access roadway corridors there is almost always a separation between the bike or pedestrian travel and the motor vehicles. Only along roadways where speeds or mix of the travel modes could result in serious accidents are sidewalks and bicycle travel not promoted.

Refurbishing MARC and other rail vehicles

In order to insure the reliability, safety and comfort of MARC equipment the rolling stock is periodically overhauled. These include 26 MARC cars that have been or are scheduled to be refurbished between FY2005 and FY 2008. In addition, 23 locomotives are in the process of being overhauled and retrofitted to cleaner Federally required TIER standards in force at the time of the improvement. This is an ongoing effort that started in FY 2005. All the locomotives will not be improved until 2012. 100 Metro rail cars have recently been overhauled to extend their life and make them more comfortable and reliable for passengers and commuters. The MARC Penn Line includes service to the Perryville station in western Cecil County.

Park and Ride Lots

The SHA and MdTA have three park and ride lots in Cecil County adjacent to I-95. These lots serve to accommodate carpool based work trips into the Baltimore and Wilmington regions. The benefits of the reduction in VMT and VT provides for a reduction in regional congestion and vehicular emissions.

7.0 Reasonably Available Control Measure (RACM) Analysis

Section 172(c)(1) of the Clean Air Act requires State Implementation Plans (SIPs) to include an analysis of Reasonably Available Control Measures (RACM). This analysis is designed to ensure that the Cecil County is implementing all reasonably available control measures in order to demonstrate attainment with the 8-hour ozone standard on the earliest date possible. This chapter presents a summary of analysis conducted to determine whether the SIP includes all reasonably available control measures. Full details of the analysis are included in Appendix E.

The Maryland Department of the Environment (MDE) has prepared this RACM analysis using two independently developed lists of potential control measures. The first list consists of the RACM analysis performed for the Washington DC Region's 8-hour Ozone SIP. The MDE worked very closely with all the DC region's jurisdictions in the development of the DC Region's RACM analysis. Understanding that the adjacent Washington, DC non-attainment region is both extremely similar to the metropolitan Philadelphia region and was also undertaking their RACM analysis, MDE incorporated the Washington RACM criteria and analysis into the 8-hour ozone SIP for Cecil County.

The Washington RACM analysis included a series of regional calls over several months to review over 200 suggested measures from numerous sources to create a master listing of measures. Each of over 200 measures was individually evaluated against established RACM criteria (the criteria is explained below).

In addition to a careful review of the Washington DC Region's RACM analysis the MDE also worked closely with the Baltimore Metropolitan Council (BMC) in developing a small list of potential transportation emission reduction measures during the fall of 2006. This analysis yielded a list of 24 specific measures that could be implemented in the Baltimore Nonattainment area for emission reduction purposes. Based on the criteria used for RACM none of these 24 measures are to be considered RACM but these measures shall be kept on a short list of measures if the region needs additional reductions.

At the completion of the RACM analysis it was determined that no measures met the criteria.

7.1 Analysis Overview and Criteria

The RACM requirement is rooted in Section 172(c)(1) of the Clean Air Act, which directs states to "provide for implementation of all reasonably available control measures as expeditiously as practicable". In its 1992 General Preamble for implementation of the 1990 Clean Air Act Amendments (57 FR 13498), EPA explains that it interprets Section 172(c)(1) as a requirement that states incorporate in a SIP all reasonably available control measures that would advance a region's attainment date. However, regions are obligated to adopt only those measures that are reasonably available for implementation in light of local circumstances. In the Preamble, EPA laid out guidelines to help states determine which measures should be considered reasonably available:

If it can be shown that one or more measures are unreasonable because emissions from the sources affected are insignificant (i.e. de minimis), those measures may be excluded from further consideration…the resulting available control measures should then be evaluated for reasonableness, considering their technological feasibility and the cost of control in the area to which the SIP applies…In the case of public sector sources and control measures, this evaluation should consider the impact of the reasonableness of the measures on the municipal or other government entity that must bear the responsibility for their implementation.

In its opinion on *Sierra Club v. EPA,* decided July 2, 2002, the U.S. Court of Appeals for the DC Circuit upheld EPA's definition of RACM, including the consideration of economic and technological feasibility, ability to cause substantial widespread and long-term adverse impacts, collective ability of the measures to advance a region's attainment date, and whether an intensive or costly effort will be required to implement the measures. Consistent with EPA guidance and the U.S. District Court's opinion, the Cecil County/Wilmapco region has developed specific criteria for evaluation of potential RACM measures. Individual measures must meet the following criteria:

- Will reduce emissions by the beginning of the 2008 ozone season (May 1, 2008)
- Enforceable
- Technically feasible
- Economically feasible (proposed as a cost of <u>$3,500-$5,000</u> per ton or less)
- Would not create substantial or widespread adverse impacts within the region
- Emissions from the source being controlled exceed a *de minimis* threshold, proposed as 0.1 tons per day

An explanation of these criteria is given in succeeding sections.

<u>Implementation Date</u>

EPA has traditionally instructed regions to evaluate RACM measures on their ability to advance the region's attainment date. This means that implementation of a measure or a group of measures must enable the region to reduce ozone levels to the 84 ppb required to attain the eight-hour ozone standard at least one year earlier than expected. As the Cecil County, Maryland/Wilmapco region currently expects to reduce ozone levels to 84 ppb during the 2009 ozone season, any RACM measures must enable the region to meet the 84 ppb standard by May 1, 2008, the beginning of the 2008 ozone season.

<u>Enforceability</u>

When a control measure is added to a SIP, the measure becomes legally binding, as are any specific performance targets associated with the measure. If the state or local government does not have the authority necessary to implement or enforce a measure, the measure is not creditable in the SIP and therefore cannot be declared a RACM. A measure is considered enforceable when all state or local government agencies responsible for funding, implementation and enforcement of the measure have committed in writing to its implementation and enforcement.

In addition to theoretical enforceability, a measure must also be practically enforceable. If a measure cannot practically be enforced because the sources are unidentifiable or cannot be located, or because it is otherwise impossible to ensure that the sources will implement the control measure, the measure cannot be declared a RACM. One exception is voluntary measures, such as those implemented under EPA's Voluntary Measures Guidance.

Technological Feasibility

All technology-based control measures must include technologies that have been verified by EPA. The region cannot take SIP credit for technologies that do not produce EPA-verified reductions.

Economic Feasibility and Cost Effectiveness

EPA guidance states that regions should consider both economic feasibility and cost of control when evaluating potential RACM measures. Therefore, the Cecil County/Wilmapco region has specified a cost-effectiveness threshold for all possible RACM measures. Measures for which the cost of compliance exceeds this threshold will not be considered RACM.

In setting this threshold, the region took into consideration two major factors. First, EPA has issued guidance regarding the relationship between RACT and RACM. In its RACM analysis for the Dallas/Forth Worth nonattainment area, EPA states:

"RACT is defined by EPA as the lowest emission rate achievable considering economic and technical feasibility. RACT level control is generally considered RACM for major sources."

In Cecil County, installation of Reasonably Available Control Technology (RACT) costs is as low as approximately $3,500 per ton. The region proposes a threshold of $3,500-$5,000 for cost effectiveness.

Substantial and Widespread Adverse Impacts

Some candidate RACM measures have the potential to cause substantial and widespread adverse impacts to a particular social group or sector of the economy. Due to environmental justice concerns, measures that cause substantial or widespread adverse impacts will not be considered RACM.

De Minimis Threshold

In the General Preamble, EPA allows regions to exclude from the RACM analysis measures that control emissions from insignificant sources and measures that would impose an undue administrative burden. Under moderate area RACT requirements, the smallest major source subject to RACT emits 50 tpy (however, MDE considered 25 tpy sources), or approximately 0.1 tpd. Following these requirements and the precedent set by the San Francisco RACM analysis, the region will not consider control measures affecting source categories that produce less that 0.1 tpd NOx or VOC emissions.

Advancing Achievement of 84 ppb Standard

In order for measures to be collectively declared RACM, implementation of the measures must enable the region to demonstrate attainment of the 85 ppb ozone standard one full ozone season earlier than currently expected. As discussed in this SIP document and the relevant appendices Cecil County currently expects to demonstrate attainment in *2009.* Therefore, any RACM measures would need to enable the region to meet the 84 ppb standard during the 2008 ozone season.

Intensive and Costly Effort

When considered together, the implementation requirements of any RACM measures cannot be so great as to preclude effective implementation and administration given the budget and staff resources available to Cecil County.

7.2 RACM Measure Analysis

Analysis Methodology

The sources of strategies analyzed for the Cecil County include the following:

- Clean Air Act Section 108(f) measures (Transportation Control Measures)
- Transportation Emissions Reduction Measures (TERMs) listed in recent Transportation Improvement Programs (TIPs) for the Metropolitan Baltimore and Washington DC regions
- Measures identified through a review of emission reduction strategies report prepared for the Baltimore Metropolitan Council
- Measures considered in Washington, Atlanta and Houston RACM analyses

Analysis Results

Appendix E provides lists (in tabular form) organized by source sector, of potential measures evaluated against the RACM criteria. Each specific RACM criteria was reviewed for each individual measure identified on the lists.

Based on this analysis none of the measures reviewed were identified as RACM for Cecil County.

7.3 RACM Determination

Though the measures listed in Appendix E did not meet the criteria for RACM, many of the measures are worthwhile measures that reduce emissions. These measures will be considered potential control measures for future SIPs prepared for Cecil County.

References

US EPA, “State Implementation Plans; General Preamble for the Implementation of Title I of the Clean Air Act Amendments of 1990”, (57 FR 13498), April 16, 1992.

US EPA Region VI, “Reasonably Available Control Measures (RACM) Analysis for the Dallas/Fort Worth Ozone Nonattainment Area”, December 2000.

Bay Area Air Quality Management District, Metropolitan Transportation Commission and Association of Bay Area Governments, “Bay Area 2001 Ozone Attainment Plan,” October 24, 2001, Appendix C.

E.H. Pechan & Associates, Inc., “ Review of Emission Reductions Strategies”, December 8, 2006.

8.0 Mobile Source Conformity

Transportation conformity ("conformity") is a provision of the Clean Air Act that ensures that Federal funding and approval goes to those transportation activities that are consistent with air quality goals. Conformity applies to transportation plans and projects funded or approved by the Federal Highway Administration (FHWA) or the Federal Transit Administration (FTA) in areas that do not meet or previously have not met air quality standards for ozone, carbon monoxide, particulate matter, or nitrogen dioxide.

In order to balance growing metropolitan regions and expanding transportation systems with improving air quality, EPA established regulations ensuring that enhancements to existing transportation networks will not impair progress towards air quality goals. Under the Clean Air Act Conformity Regulations, transportation modifications in a nonattainment area must not impair progress made in air quality improvements. These regulations, published in EPA's Transportation Conformity rule on November 24, 1993 in the Federal Register and amended in a final rule signed on July 31, 1997, require that transportation modifications "conform" to air quality planning goals established in air quality SIP documents. The 1997 amendments were followed by further amendments in 2002 and 2004.

In essence, this SIP submission includes mobile emissions budgets for NOx and VOC. These budgets, once found adequate by EPA, shall be used in all conformity documents for Cecil County. In order for a transportation plan to “conform” the estimated emissions from the transportation plan can’t exceed the emissions budgets set via this SIP submission. If the estimated emissions are shown to exceed the budget then mitigation measures must be taken to ensure emissions will not exceed the emission budgets.

Responsibility for Making a Conformity Determination

The policy board of a Metropolitan Planning Organization (MPO), in consultation with the Maryland Department of Transportation (MDOT) and MDE, is responsible to formally make a conformity determination on its transportation plans and transportation improvement programs (TIPs) prior to submittal to the FHWA and FTA for review. The USEPA also may review and comment on proposed conformity determinations.

If a particular transportation plan’s projected emissions exceed the mobile emissions budget, the MPO has a variety of mitigation options to reduce emissions. These may include, but are not limited to, specific transportation emission reduction measures such as HOV lanes, transit enhancements, bicycle lanes, diesel retrofits, and idling reductions.

The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) was enacted on August 10, 2005. Under this act, amendments were made to the transportation conformity rules (Section 6011 of the Act), which required states that have nonattainment areas like Maryland to revise their existing transportation conformity SIPs. Maryland submitted a revised transportation conformity SIP to USEPA in February of 2007. Because of changes mandated by SAFETEA-LU, conformity determinations have to be done at least every four years instead of the previous three years.

When a positive conformity determination is not made according to the required frequency, or in the event that emission mitigation can't be agreed upon, a nonattainment area is in conformity "lapse". This means that Federal transportation funds allocated to the state, which contains the lapsed nonattainment area, can only be used for the following kinds of projects:

1. TCMs in Approved SIPs;
2. Non-Regionally Significant Non-federal Projects;
3. Regionally Significant Non-federal Projects - only if the project was approved by all necessary non-federal entities before the lapse. (See Approval of a Regionally Significant Non-Federal Project by a Non-Federal Entity later in this Chapter.)
4. Project phases (i.e., design, right-of-way acquisition, or construction) that received funding commitments or an equivalent approval or authorization prior to the conformity lapse.
5. Exempt Projects - identified under 40 CFR §93.126and 40 CFR §93.127; and,
6. Traffic Synchronization Projects - however, these projects must be included in subsequent regional conformity analysis of MPO's transportation plan/TIP under 40 CFR §93.128.

The amount of federal funding a state receives is not reduced but such funds are restricted until the area can again demonstrate conformity.

8.1 Mobile Emissions Budget and the Wilmington Region Transportation Conformity Process (includes Cecil County)

Mobile source emissions for Cecil County's portion of the long-range transportation plan known as the Regional Transportation Plan (RTP 2025- **DRAFT RTP 2030**), and the three-year Transportation Improvement Program (TIP) cannot exceed the mobile emissions budget set in this SIP. The RTP and the TIP are developed by the Wilmington Area Planning Council for Cecil County, Maryland and New Castle County, Delaware. The transportation plans are required to conform to the mobile budget established in the SIP for the short-term TIP years, as well as for the forecast period of the long-range plan, which must be at least twenty years. Separate and individual mobile emissions budgets are created for Maryland and Delaware.

In Cecil County, modifications to the existing transportation network are advanced through the Wilmington Area Planning Council (WILMAPCO) by state and local transportation agencies through periodic updates to the Regional Transportation Plan (RTP) and TIP. The TIP is updated annually for the region and includes transportation modifications and improvements on a three-year program cycle. The latest draft TIP is for fiscal years 2008-2011. Pursuant to the conformity regulations, the RTP and TIP must contain analyses of the motor vehicle emissions estimates for the region resulting from the transportation improvements. These analyses must show that the transportation improvements in the TIP and the plan do not result in a deterioration of (conform to) the air quality goals established in the SIP.

8.2 Budget Level for On-Road Mobile Source Emissions

As part of the development of this SIP, the MDE formally establishes an 8-hour ozone mobile source emissions budget. This budget will be the benchmark used to determine if the region's long-range transportation plan (RTP) and three-year transportation improvements program (TIP) conform to the SIP. Under EPA regulations the projected mobile source emissions for 2008 (for purposes of meeting the CAA requirements related to reasonable further progress) and 2009 (the region's attainment ozone season) become the mobile emissions budgets for the region unless MDE takes actions to set other budget levels.

Modeling and Data

The 2008 and 2009 mobile emissions inventories are calculated using the following models and tools: EPA's MOBILE6.2, the Highway Performance Monitoring System (HPMS) model, and the Upper Eastern Short Transportation Model. A detailed explanation of the models and the emission estimating methodology can be found in Appendix F.

The mobile emissions budget for 2008 Reasonable Further Progress and 2009 attainment are based on the projected 2008 and 2009 mobile source emissions accounting for all the mobile control measures and projected regional growth.

<u>Reasonable Further Progress Mobile Budgets</u>

The mobile emissions budgets for the 2008 Reasonable Further Progress are based on the projected 2008 mobile source emissions accounting for all mobile control measures. The mobile emissions budgets for the 2008 Reasonable Further Progress, based upon the projected 2008 mobile source emissions accounting for all the mobile control measures, are:

2008 RFP Mobile Budgets for the Cecil County Nonattainment Area

VOC (TPD)	**2.3**
NOx (TPD)	**7.9**

<u>Attainment Year Mobile Budgets</u>

The mobile emissions budgets for the 2009 attainment year are based on the projected 2009 mobile source emissions accounting for all mobile control measures. The mobile emissions budgets for the 2009 Attainment Year, based upon the projected 2009 mobile source emissions accounting for all the mobile control measures, are:

2009 Attainment Mobile Budgets for the Cecil County Nonattainment Area

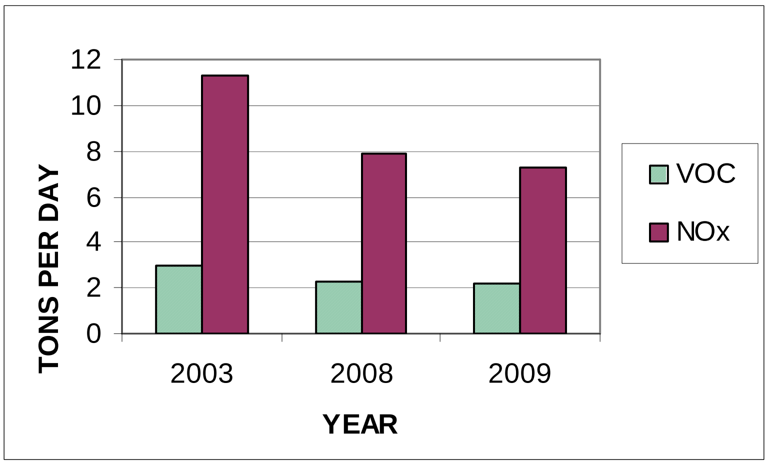
VOC (TPD)	**2.2**
NOx (TPD)	**7.3**

The 2009 NOx budget is 7.3 tpd. An adjustment has been made to the model output to set the 2009 NOx budget. Based on table 10-4 in Chapter 10 of this document there are 0.03 tpd of available NOx credits not needed to satisfy the contingency measures part of this plan. The

MDE is assigning 0.02 tpd of these additional NOx credits to the 2009 NOx budget to create the 7.3 tpd NOx budget.

8.3 Trends in Mobile Emissions

The mobile emissions budgets for 2008 and 2009 for Volatile Organic Compounds (VOCs) and Nitrogen Oxides (NOx) reflect a continuation of a downward trend in mobile emissions over time. The VOC and NOx emission levels for mobile sources provided in Section 8.2 are lower than the most recently approved mobile budgets for Cecil County of 3.0 tons/day VOC and 11.3 tons/day NOx from the 2003 modified Phase II Attainment Plan for the Cecil County nonattainment area. The trend in smaller Cecil County mobile emissions budgets from 2003 to the 2009 attainment year is shown in the following chart.



The steady reductions in mobile emissions are attributable largely to a series of increasingly stringent federal regulations requiring cleaner vehicles and fuels, including the federal Tier II regulations for motor vehicles. Trends toward reduced mobile emissions are occurring despite the negative effects of a shift toward the use of higher-emitting, less fuel-efficient light-duty trucks, such as SUVs instead of passenger cars and a steady increase in population, employment and vehicle miles traveled (VMT) within the WILMAPCO region.

The trends of increasing population, employment, and VMT are expected to remain strong well beyond 2009. The regional cooperative forecasting process (from the latest Regional Transportation Plan- RTP 2025) predicts that from 2000 to 2025, regional population will grow by 19%, households will increase by 24%, and employment will grow by 28%. Regional VMT is predicted to still outpace these increases over the same time period with a projected growth of 46%. These trends, however, will not reverse the expected decline in regional mobile emissions resulting from cleaner fuels and improved vehicle technology. The recent Tier II passenger vehicle standards and regulations on emissions from heavy-duty diesel vehicles and fuels are expected to produce further dramatic reductions in VOC and NOx emissions as vehicles are replaced and retrofitted over the next 20 years. It is important to keep in mind, however, that despite cleaner fuels and improved vehicle technology, the relationship between land use planning, transportation, and air quality is important for long-term air quality goals.

9.0 Moderate Area Plan Commitments

Achieving the results shown in this Plan requires a commitment to implement the regulatory measures upon which the plan is based. Maryland (Cecil County) is taking action to implement regional and local measures to effectively reduce ozone transport throughout the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ Nonattainment Area. Tables 9-1 through 9-5 provide information on the implementation of each measure.

9.1 Schedules of Adopted Control Measures

Table 9-1
Maryland (Cecil County) Schedule of Adopted Control Measures
Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ Nonattainment Area

Control Measure	Regulation Number	Effective Date
Federally Mandated Measures		
High Tech Inspections & Maintenance	11.14.08	1/2/95
State II Vapor Recovery Nozzle	26.11.24	2/15/93
Federal Tier I Vehicle Standards and new Car Evaporative Standards	40 CFR part 86	Model Year 1994-1996; Evap Stds. 1996
Tier 2 Motor Vehicle Emission Standards	65 FR 6698	2/10/2000
Non-CTG RACT	See Table 9-3	-
Phase II Gasoline Volatility Controls	03.03.03.05	10/26/92
EPA Non-Road Gasoline Engines Rule	40 CFR parts 90 and 91	12/3/96
EPA Non-Road Diesel Engines Rule	40 CFR Part 9 et al.	Model Year 2000-2008 depending on engine size
State NOx RACT Requirements	26.11.29.08	5/10/93
EPA Nonroad Spark Ignition Marine Engine Rule	40 CFR Parts 89, 90, 91	1998 Model Year
EPA Large Spark Ignition Engines Rule	40 CFR Parts 89, 90, 91, 94, 1048, 1051, 1065, and 1068	11/8/2002
Federal Programs		

Reformulated Surface Coatings	63 FR 48849 64 FR 34997 65 FR 7736	9/11/98 6/30/99 2/16/00
National Volatile Organic Compound Emission Standards for Consumer Products	63 FR 48819	9/11/98
National Low Emissions Vehicle Program	26.11.20.04	3/22/99
Emissions Controls for Locomotives	63 FR 18998	6/15/98
Heavy-Duty Diesel Engine Rule	63 FR 54694	12/22/97
State and Local Measures		
Reformulated Gasoline (on-road)	Federal - local opt-in	1/1/95
Reformulated Gasoline (off-road)	Federal - local opt-in	1/1/95
Surface Cleaning/Degreasing for Machinery/Automobile Repair	26.11.19.09	6/5/95
Landfill Regulations	26.11.19.20	3/9/98
Seasonal Open Burning Restrictions	26.11.07	5/22/95
Stage I Expansion	26.11.13.04C	4/26/93
Expanded Point Source Regulations to 25 tpy	26.11.19.01B(4)	5/8/95
Graphic Arts Controls	26.11.19.11 & .18	6/5/95 & 11/7/94
Auto and Light Duty Truck Coating Operations	26.11.19.23	5/22/95
Control of VOC Emissions from Vehicle Refinishing	26.11.19.23	5/22/95
Portable Fuel Containers Rule: Phase I	26.11.13.07	1/21/02
Architectural and Industrial Maintenance Coatings Rule	26.11.33	3/29/04
Reformulated Consumer Products Rule: Phase I	26.11.32	8/18/03
Control of VOC Emissions from Cold and Vapor Degreasing	26.11.19.09	6/5/1995
Maryland Healthy Air Act	26.11.27	Emergency Regulations Adopted 1/18/07 - Permanent Regulations to be adopted by December 2007

Industrial Adhesives and Sealants Rule		Prior to May 2008
Portable Fuel Containers Rule: Phase II		Prior to May 2008
Reformulated Consumer Products Rule: Phase II		Prior to May 2008
Regional Control Measures		
NOx Phase II Controls	26.11.27 & .28 26.11.29 & 30	10/18/99

<u>Table 9-2</u>
Maryland (Cecil County) Non-CTG RACT
Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ Nonattainment Area

Overall requirement in COMAR 26.11.19.02G effective 4-26-93 (20: Md. R 726)
The following case-by-case RACT regulations have been adopted to ensure consistency.

RACT Regulation	Regulation Number	Effective Date	MD Register
Plastic Parts Coating	26.11.19.07E	6-5-95	22:11 Md R 823
Definition of Gasoline to include JP-4	26.11.13.01	8-11-97	24:16 Md R. 1161
Printing on Plastic	26.11.19.07F	9-8-97	24:18 Md R 1298
Aerospace Coating Operations	26.11.19.13-1	9-22-97	24:19 Md R 1344
Yeast Manufacturing	26.11.19.17	11-7-94	21:22 Md R 1879
Expandable Polystyrene Operations	26.11.19.19	7-3-95	22:13 Md R 970
Commercial Bakery Ovens	26.11.19.21	7-3-95	22:13 Md R 970

Vinegar Generators	26.11.19.22	8-11-97	24:16 Md R 1161
Leather Coating	26.11.19.24	8-11-97	24:16 Md R 1161
Explosives and Propellant Manufacturing	26.11.19.25	8-11-97	24:16 Md R 1161
Reinforced Plastic Manufacturing	26.11.19.26	8-11-97	24:16 Md R 1162
Marine Vessel Coating Operations	26.11.19.27	10-20-97	24:21 Md R 1453

9.2 Stationary Source Thresholds

Under the moderate designation for the 8-hour ozone standard, the new source review threshold is 50 tons per year VOC and 100 tons per year NOx. Maryland is committed to maintaining the Cecil County new source review threshold at 25 tons per year for both VOC and NOx.

10.0 Contingency Measures

10.1 Contingency Overview

The Clean Air Act requires States containing nonattainment areas to adopt contingency measures that will take effect without further action by the State or EPA upon a determination by EPA that an area failed to demonstrate Reasonable Further Progress (RFP) or to timely attain the applicable National Ambient Air Quality Standards (NAAQS), as described in section 172(c)(9).

10.2 Contingency Emission Reductions for RFP Demonstration

The Act requires the State to adopt specific contingency measures that will take effect without further action by the State or the EPA if the State fails to demonstrate VOC/NOx emission reductions by an additional 3% per year from 2002 through 2009 in accordance with Rate of Further Progress Demonstrations.

The contingency measures identified by the State must be sufficient to secure an additional 3% reduction in ozone precursor emissions in the year following the year in which the failure has been identified. If the shortfall is less than 3%, a contingency measure need only cover that smaller percentage. If the shortfall is greater than 3%, the State, in an annual tracking report to EPA, must either identify the additional actions it will take to cure the shortfall before the next milestone or maintain a reserve of contingency measures capable of covering a shortfall greater than 3%. Early implementation of an emission reduction measure to be implemented in the future is acceptable as a contingency measure.

The RFP contingency requirement may be met by including in the SIP a demonstration of 18% RFP and by attributing the additional 3% reduction above the 15% requirement to specific measures. As shown in the Tables 10.1 below, the Maryland portion of the Philadelphia - Wilmington - Atlantic City, PA - DE - MD - NJ can demonstrate 18% RFP.

Table 10.1: RFP Contingency Measure Calculation

RFP Contingency Measure Calculation Cecil County, MD Nonattainment Area VOC Emissions			
		Formula	Tons/Day
A	2002 Base Year Inventory		60.52
B	Biogenic Emissions		42.94
C	2002 Rate-of Progress Base Year Inventory	A - B	17.58
D	FMVCP/RVP Reductions Between 2002 and 2008		0.69
E	2002 Adjusted Base Year Inventory Calculated Relative to 2008	C - D	16.89
F	Percent Emission Reductions for RFP		0.0700
G	Emission Reductions Required Between 2002 & 2008	E * F	1.18
H	Target Level for 2008 [$TL_{(2008)}$]	C - D - G	**15.71**
I	Contingency Percentage		3.00%
J	Contingency Emission Reduction Requirements	D * I	0.51
K	Contingency Target Level (15% + 3% Contingency)	H - J	**15.20**
L	2008 Controlled Emission Level Obtained		**14.65**

RFP Contingency Measure Calculation Cecil County, MD Nonattainment Area NOx Emissions			
		Formula	Tons/Day
A	2002 Base Year Inventory		17.40
B	Biogenic Emissions		0.00
C	2002 Rate-of Progress Base Year Inventory	A - B	17.40
D	FMVCP/RVP Reductions Between 2002 and 2008		2.19
E	2002 Adjusted Base Year Inventory Calculated Relative to 2008	C - D	15.21
F	Percent Emission Reductions for RFP		0.0800
G	Emission Reductions Required Between 2002 & 2008	E * F	1.22
H	Target Level for 2008 [$TL_{(2008)}$]	C - D - G	**13.99**
I	Contingency Percentage		0.00
J	Contingency Emission Reduction Requirements	D * I	0.00
K	Contingency Target Level (15% + 3% Contingency)	H - J	**13.99**
L	2008 Controlled Emission Level Obtained		**11.05**

Surplus Reductions from Existing Measures

Some emission control strategies listed to meet the 2008 target level are expected to result in more emission reductions than are needed to meet the requirements. If other measures fail to meet expected reductions, the excess from the following measures will be used to make up the difference:

- NONROAD MODEL
- OTC - Portable Fuel Container Phase 1 and Phase 2
- OTC - Architectural Surface Coatings

- OTC – Commercial and Consumer Products
- Railroad Locomotives Tier 2
- On-Road MOBILE

10.3 Contingency Emission Reductions for Failure to Attain

The Clean Air Act requires nonattainment areas to implement control measures necessary to meet the federal air quality standards. Through analysis and modeling a state demonstrates attainment based the implementation of a State Implementation Plan. If a nonattainment area does not attain the federal standard by the prescribed attainment date then the nonattainment area is required to implement contingency measures within one year of a federal register notice that the area did not meet its attainment date.

The attainment date for the Philadelphia Nonattainment Area including Cecil County is June 15, 2010. However, attainment of the standard is based on the three-year design value that averages the ozone seasons of 2007, 2008, and 2009. Therefore, the 2009 design value is the marker by which attainment will be judged. States will be notified if they did not meet the 8-hr Ozone standard in 2010 based on a review of the 2009 design value. One year from the date of notification the identified contingency measures must be in fully implemented. This means that contingency measure must provide emission reductions in the 2011 timeframe to meet the contingency requirements.

The attainment contingency requirement can be met by demonstrating that emission reduction benefits from specific measures occurring after 2009 meet or exceed 3% of the Adjusted 2002 Base Year inventory. As shown in the Tables 10.2, 10.3, and 10.4 below, Cecil County can demonstrate compliance with the Failure to Attain Contingency Measure Requirements. The future benefits from existing control measures, calculated between 2011 and 2009, are shown in Table 10.2. The VOC reduction requirement is shown in Table 10.3. The NOx reduction requirement is shown in Table 10.4.

Table 10.2: Failure to Attain Contingency Measure Benefit Calculation

Failure to Attain Contingency Measure Benefit Calculation
Cecil County, MD Nonattainment Area
Future Benefits from Existing Measures

	2009 Controlled Emissions		2011 Controlled Emissions		Benefits (tpd)	
Control Measure	VOC	NOx	VOC	NOx	VOC	NOx
OTC – PFC	0.42	0.00	0.26	0.00	0.15	0.00
Nonroad Model	7.20	2.14	6.69	2.05	0.50	0.09
Railroads (Tier 2)	0.03	0.43	0.03	0.41	0.00	0.02
TOTAL BENEFITS					**0.65**	**0.11**

Table 10.3: Failure to Attain VOC Emission Reduction Requirement Calculation

Contingency Measure Calculation Cecil County, MD Nonattainment Area VOC Emission Reduction Requirements			
		Formula	Tons/Day
A	2002 Base Year Inventory		60.52
B	Biogenic Emissions		42.94
C	2002 Rate-of Progress Base Year Inventory	A - B	17.58
D	FMVCP/RVP Reductions Between 2002 and 2008		0.69
E	2002 Adjusted Base Year Inventory Calculated Relative to 2008	C - D	16.89
F	Contingency Percentage		2.50%
G	Contingency Emission Reduction Requirements	E * F	0.42
	REDUCTIONS ACHIEVED		0.65

Table 10.4: Failure to Attain NOx Emission Reduction Requirement Calculation

Contingency Measure Calculation Cecil County, MD Nonattainment Area NOx Emission Reduction Requirements			
		Formula	Tons/Day
A	2002 Base Year Inventory		17.40
B	Biogenic Emissions		0.00
C	2002 Rate-of Progress Base Year Inventory	A - B	17.40
D	FMVCP/RVP Reductions Between 2002 and 2008		2.19
E	2002 Adjusted Base Year Inventory Calculated Relative to 2008	C - D	15.21
F	Contingency Percentage		0.50%
G	Contingency Emission Reduction Requirements	E * F	0.08
	REDUCTIONS ACHIEVED		0.11

As identified above there are 0.03 tpd of additional credit under the NOx contingency plan. As stated in Section 8.2, the MDE has allocated 0.02 tpd of this additional NOx to the 2009 NOx mobile budget.

11.0 Weight of Evidence Attainment Demonstration

The approach to attainment demonstration taken by MDE considers the cumulative body of science with respect to ambient ozone concentrations in the Baltimore 8-hour ozone non-attainment area. MDE has employed an ensemble approach to the attainment demonstration comprised of numerous technical tools including rigorous data analysis, observations, and modeling. The weight of evidence produced by MDE features contributions from institutions with a plethora of expertise in air quality, atmospheric chemistry, and meteorology. The institutions include The University of Maryland Department of Atmospheric and Oceanic Science, The Pennsylvania State University Department of Meteorology, The Howard University Department of Physics, The University of Maryland at Baltimore County Department of Physics, and The University of Maryland Center for Environmental Science at Frostburg University. As academic centers, these institutions have published peer-reviewed journal articles in periodicals of the atmospheric sciences. MDE has relied heavily on such publications for the analysis presented in the weight of evidence. Highly qualified, private consultants, including SAIC and Environ provided additional contributions to the weight of evidence.

An important distinguishing characteristic of the attainment demonstration approach taken by MDE is not only the overall assembly of analysis, observations, and modeling, but also the ensemble focused solely on three-dimensional photochemical grid modeling. Whereas the EPA guidance emphasizes a single design value from a single modeling simulation as the core of an attainment demonstration, the preponderance of atmospheric science knowledge shows intelligent use of models should consider all of the model uncertainties and biases, include multiple simulations, and ultimately produce, not a single design value, but a range of predicted future design values. The ensemble approach is analogous to how a meteorologist determines a precipitation forecast. The meteorologist looks at multiple meteorological models, considers uncertainties and biases of each model, reviews circumstances the model may not account for, determines if there are any other outside extenuating factors, and finally ascertains a range of possible outcomes. This range is then delivered to the forecast audience. Similarly, the MDE ensemble approach to weight of evidence modeling provides a comprehensive evaluation of model performance for various scales of time, area, height, and chemistry. Based on the sensitivity of the model under the evaluation schemes, a range of predicted 2009 8-hour ozone design values is forecasted for every monitoring site in the Philadelphia non-attainment area.

The net result of applying techniques of data analysis, observations, and modeling in the weight of evidence is a favorable indication for successfully attaining the 8-hour ozone NAAQS in 2009 for Cecil County, Maryland and for the area presently classified as the Philadelphia non-attainment area. Figure 11.0.1 shows the weight of evidence range of probable design values for 2009 for all sites in the state of Maryland. No single value is provided for each site; instead, a range is provided in order to more accurately represent the expected accuracy of the modeling exercises. The fundamental knowledge gained through comparisons to observations, analysis of trends, and sensitivity model runs resulted in the ranges put forth in Figure 11.0.1. All sites in Maryland show attainment of the 8-hour ozone NAAQS of 85 ppb for 2009.

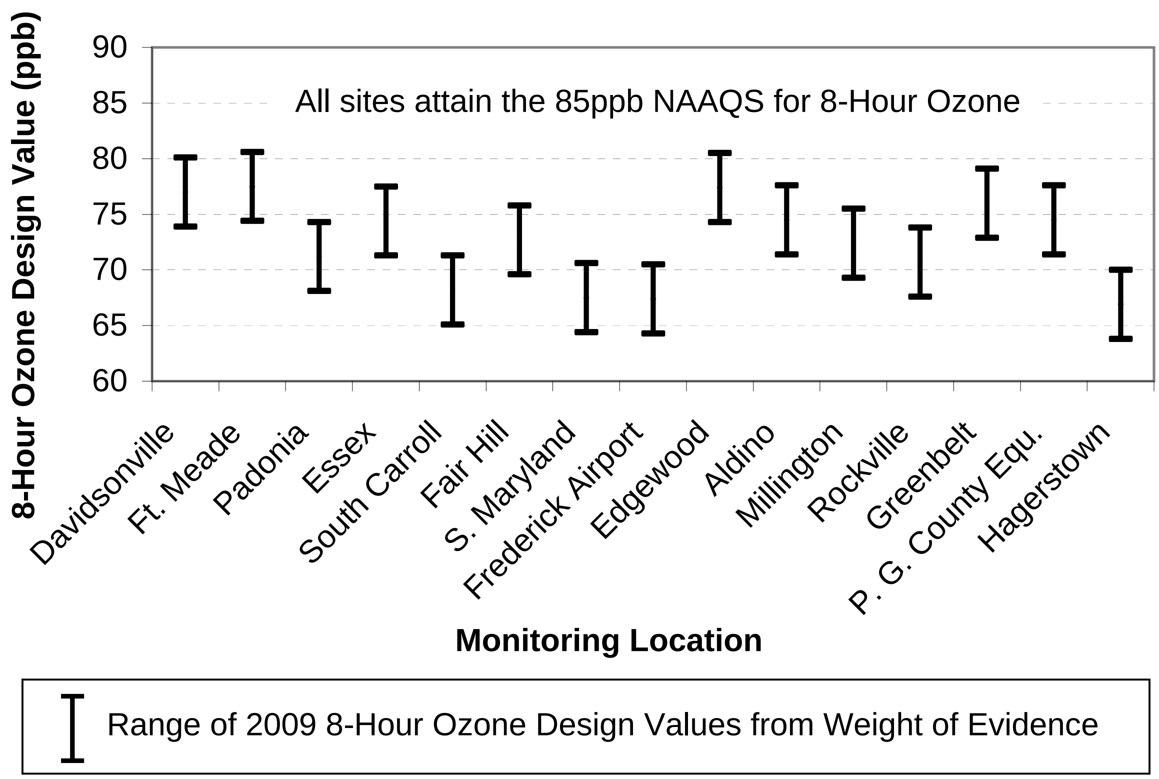


Figure 11.0.1 Range of probable 2009 8-hour ozone design values for all sites in Maryland

11.1 Ambient Air Monitoring Measurements and Trends

Measurements from surface monitoring stations provide the most fundamental indication of air quality improvement in the Baltimore non-attainment area. Basic trends of ozone from the network of monitors show continuously improving air quality Maryland and the Baltimore NAA with respect to multi-year design values, annual exceedance day counts, 24-hour daily peak concentrations, single-hour concentrations, spatial area, warm weather days when ozone is usually highest, and finally with respect to ozone precursor trends.

<u>The Ambient Monitoring Network</u>

MDE operates a relatively dense network of ozone monitoring stations, which has enabled the collection of high resolution ozone data on various scales of time and space. Figure 11.1.1 shows maps of the ambient ozone monitoring network for Maryland, the Mid-Atlantic, and the Eastern U.S. Despite the small size of Maryland, MDE operates a relatively dense network of ozone monitors. Comparing the spatial density of monitoring sites on a wider domain of the Mid-Atlantic region shows that Maryland has no large expanses without monitors, like Virginia, West Virginia, and Pennsylvania. An even larger perspective over the entire Eastern U.S. reveals that Maryland is actually covered by one of the more dense monitoring networks due to the required monitoring associated with the cluster of large metropolitan areas extending from Richmond, VA through New York, NY.

The code of federal regulations requires four ozone sites for a metropolitan statistical area of > 10 million people for an 8-hour ozone non-attainment area (40CFR58 Appendix D §4.1). MDE currently has seven ozone sites deployed in the Baltimore NAA and one site in the Cecil County, Maryland portion of the Philadelphia NAA. Due to logistical reasons, slight changes are made in the deployment of sites over the years, such as the unavoidable relocation of the Fort Meade monitoring site due to the U.S. military's need for additional space on the grounds of the Fort Meade military post. MDE was fortunate to find a new location for the site at Beltsville, where inter-agency collaborations and opportunities for long-term studies are more viable. On the whole, the number of sites remains relatively constant.

Ozone Trends

Ozone concentrations exhibit an improving air quality trend on multiple temporal scales. Perhaps the simplest regulatory measure of improving air quality is the downward trend in 8-hour ozone design values for the sites in Maryland. Design values offer the benefit of a multi-year metric, which removes the statistical bias of single high values by taking the fourth highest value of three consecutive years and averaging those values together. Figure 11.1.2 displays the decreasing trend of 8-hour ozone design values in Maryland. The trend is a good fit to the data with an R^2 of ~0.4 and a slope of –0.7 ppb / year. The last three years highlight the disproportionate benefit of the NOx SIP Call when regional controls were put in place between 2003 and 2004.

The downward trend in 8-hour ozone concentrations on an annual basis is highlighted in Figure 11.1.3 by showing the number of 8-hour ozone exceedance days per year. This trend is also a good fit with an R^2 of ~0.5 and a steeper declining slope of –1.4 days / year. Since 2002, an average of 17.5 days per year have experienced 8-hour ozone concentrations ≥ 85ppb or in other words 2.5 weeks, which is a sharp contrast to the 2 months worth of exceedance days, which existed in the 1980s.

Taking yet another step down in temporal scales brings the study of trends to the daily scale. Average daily peak 8-hour ozone is shown in Figure 11.1.4. In order to see a clearer picture of the trends without the noise of short-term fluctuations, the data are grouped in four-year bins. The methodology of choosing bins is carried out in reverse chronological order, beginning with the first four-year bin of 2003-2006, the NOx SIP Call years. Scientific consensus is that ozone concentrations in the eastern U.S., outside of large urban areas, are NOx-limited[22]. As a result, reductions in region-wide NO_x emissions should reduce the overall background ozone concentrations. Local emissions and photochemistry will still lead to short-term spikes in ozone, often ≥ 85 ppb, but these spikes will occur on top of a lower base-level of ozone. The magnitude of each individual ozone spike should also have reduced amplitude from the base-level. Such a change in the base-level of ozone was created by the NOx SIP Call and is demonstrated in Figure 11.1.4.

[22] Ryan, W.F., "Local Ozone Forecasting and the NOx SIP Call Rule", EPA National Air Quality Conference, Orlando, FL, 2007.

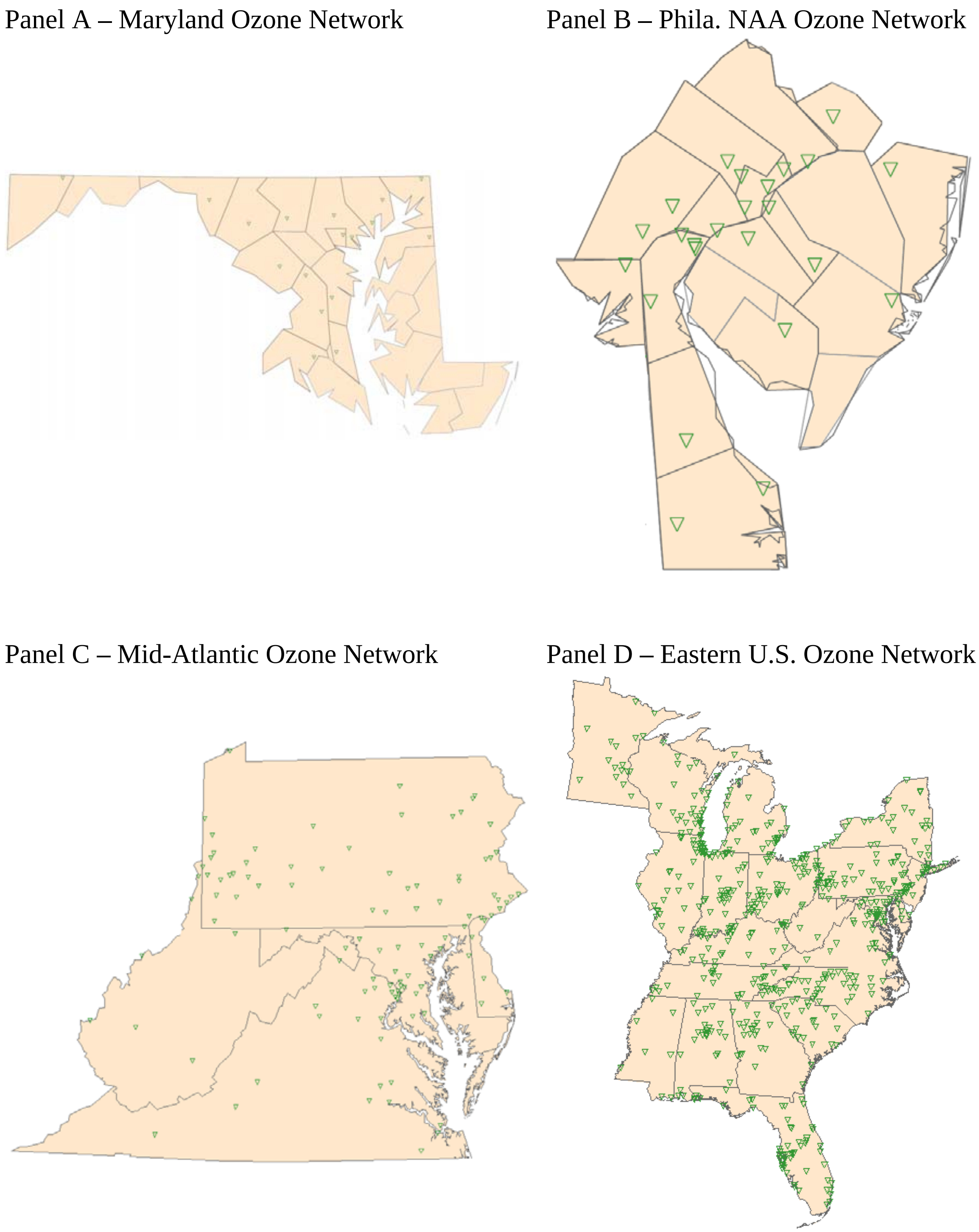


Figure 11.1.1 Maps of ozone monitoring sites (inverted green triangles). Panels A, C, and D show sites active during 2006. Panel B shows sites active during the period of 2002-2006. There are 17 ozone monitoring sites in the state of Maryland, a dense network for a relatively small state.

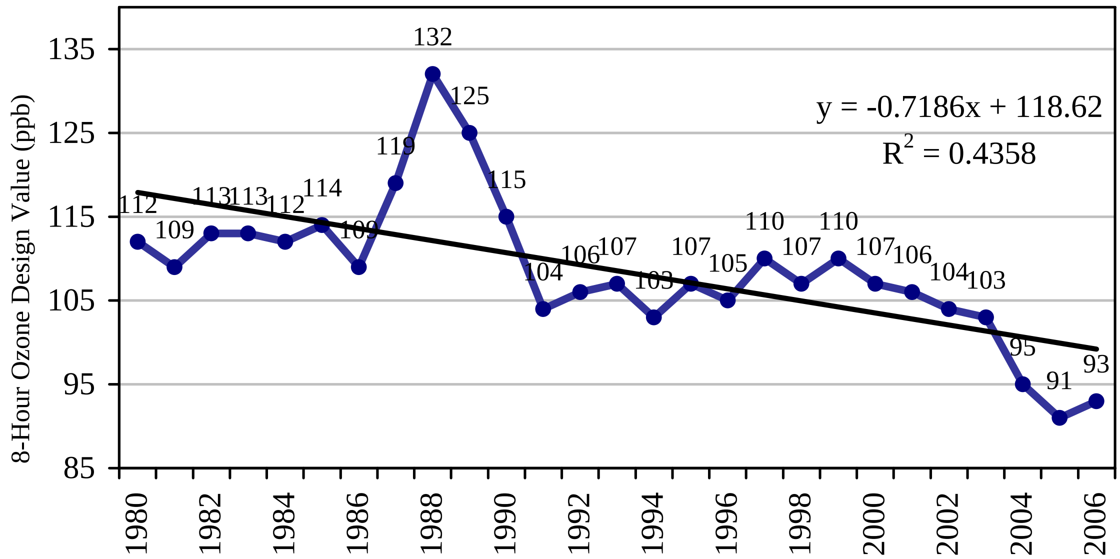


Figure 11.1.2 Trend in 8-hour ozone design values per year for all Maryland sites. The declining trend is a sign of improving air quality.

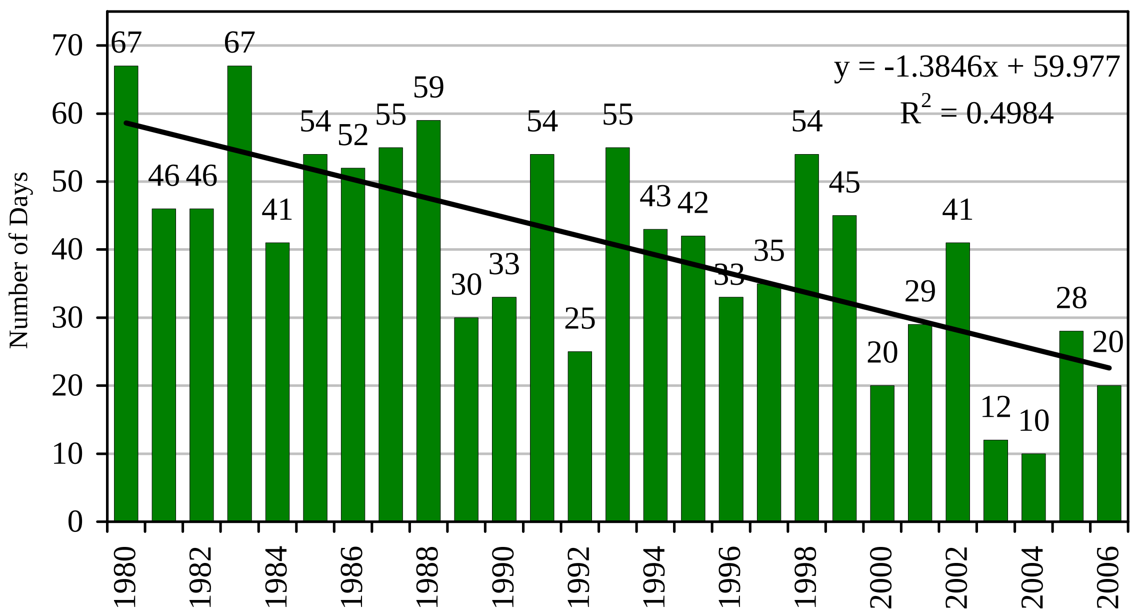


Figure 11.1.3 Trend in 8-hour ozone exceedance days per year for all Maryland sites. The declining trend is an indicator of improving air quality.

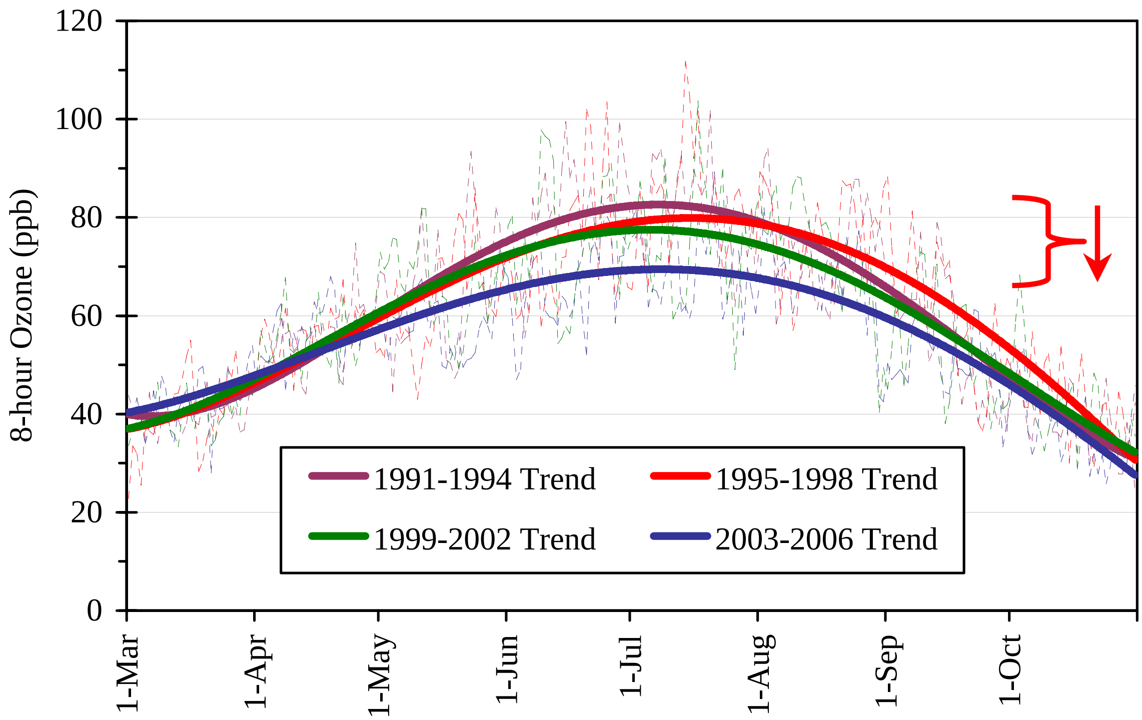


Figure 11.1.4 Trends in average daily peak 8-hour ozone for all Maryland sites binned by four-year periods. The red brace and arrow indicate improving air quality shown by the decreasing trend of average daily peak 8-hour ozone. Each trend line is fourth order.

Continuing in reverse chronological order, each of the prior bins also consisted of a four-year period for the sake of consistency. The most important feature of Figure 11.1.4 is the steady decline in the trend of each bin, indicated by the red arrow. The part of the summer when peak ozone concentrations occur (June-August) is exactly when the greatest benefit is seen with reductions in the daily peak 8-hour ozone. The improving trend in 1999-2002 (green) is partially due to meteorology because the summers of 2000 and 2001 were not conducive to photochemical formation as temperatures were cooler than normal, precipitation was more prevalent, and the synoptic scale systems rarely created long-lived high pressure centers over the South Eastern U.S. which typically plays a large role in high ozone episodes. The improving trend in 2003-2006 (blue) shows another marked decrease in ozone values, a sign of the valuable impact of the NOx SIP Call.

Not only have ozone concentrations been steadily declining during the part of the summer when ozone production is greatest, but ozone concentrations have also been steadily declining during the part of each day when ozone production is greatest. Being a photochemical pollutant, ambient ozone concentrations reach their peak during the afternoon when the sun angle is high and temperatures are at their warmest. Figure 11.1.5 shows the diurnal trend in ozone from 1993 to 2006. The years are binned by 3-year rolling averages in order to eliminate the noise of hourly fluctuations present in the raw data. The steady progression from each rolling average to the next shows an undeniable improvement of air quality. The red arrow indicates the decline of ozone concentrations. The last three rolling averages (yellow, gray, black) experienced a distinct decline in magnitude of hourly ozone after the NOx SIP Call.

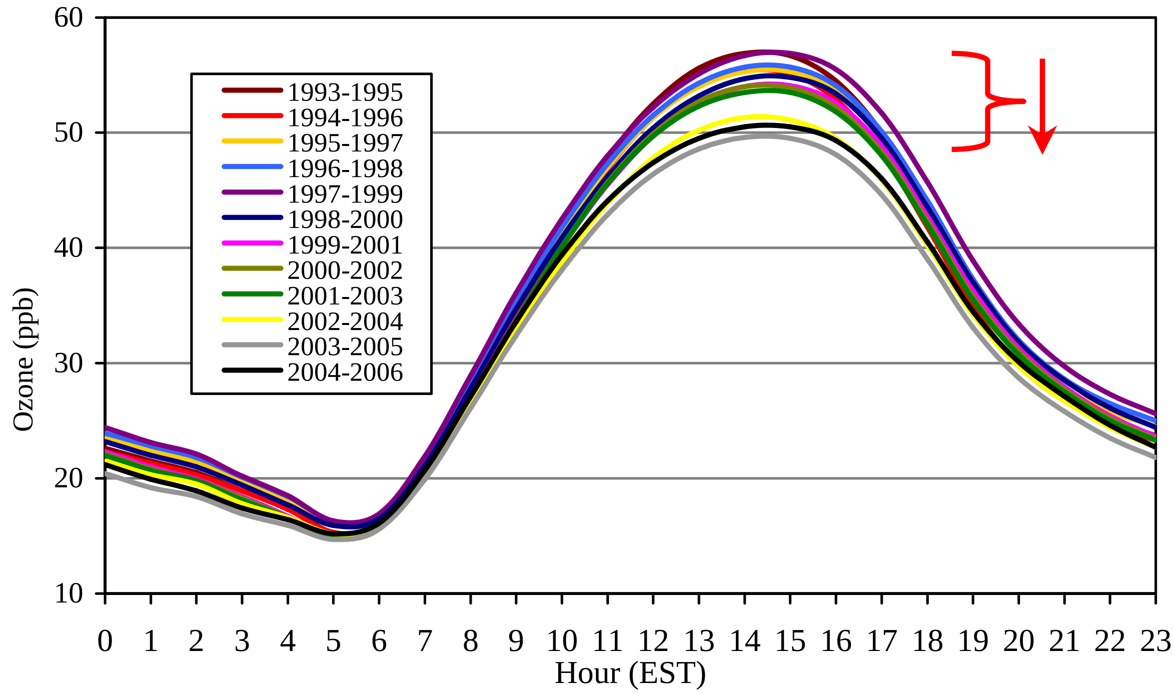
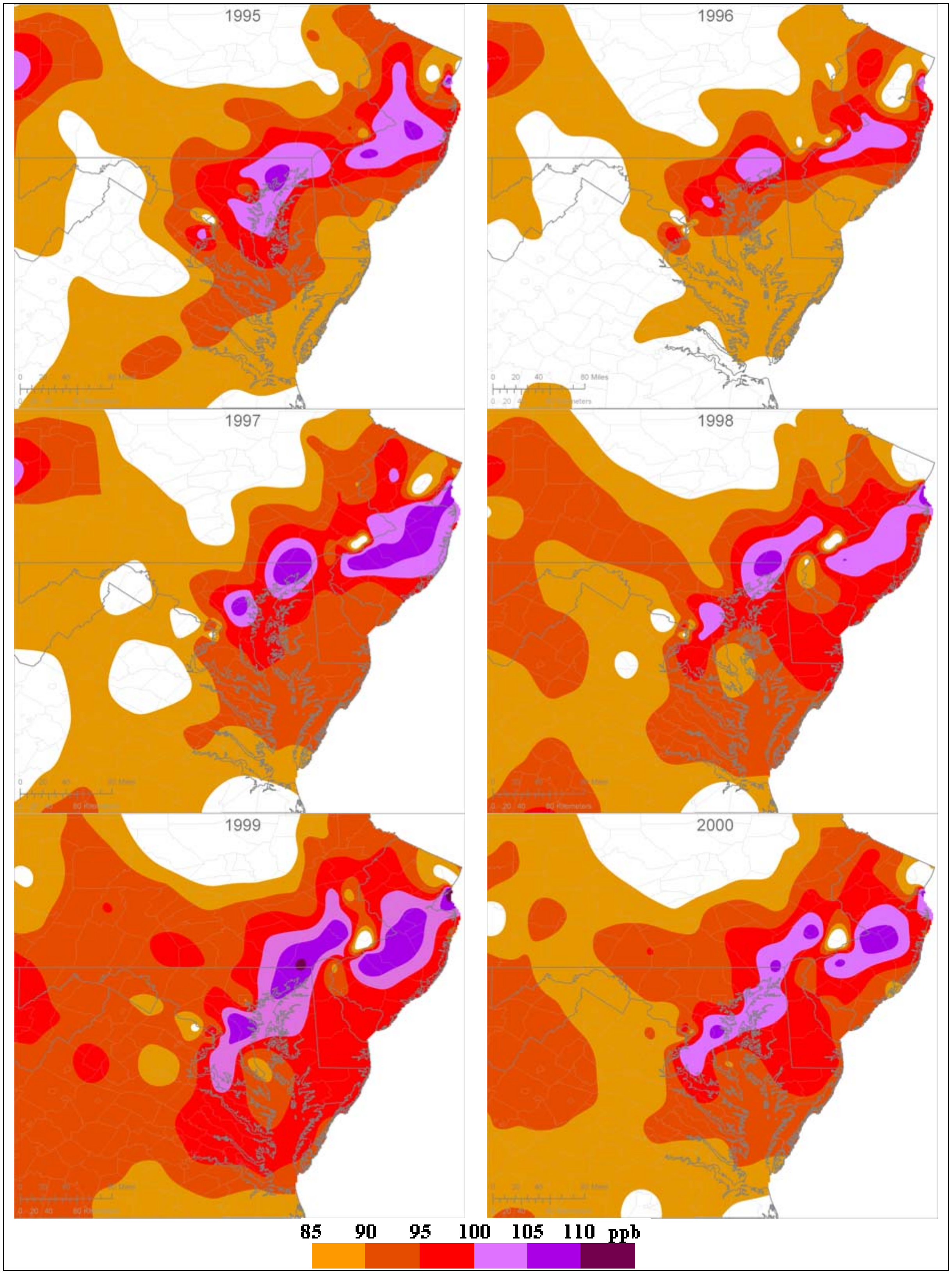


Figure 11.1.5 Trend in diurnal ozone by 3-year rolling averages for all Maryland sites from the summers (April 1 – October 31) of 1993 through 2006. The red brace and arrow indicate improving air quality shown by the decreasing trend of peak mid-day hourly concentrations.

While various temporal scales have shown declining concentrations of ozone over the year, one of the most concise methods for displaying year-to-year improvement in air quality is to map interpolated ozone concentrations across a wide domain. Figure 11.1.6 shows the trend in the spatial extent of 8-hour ozone design values ≥ 85ppb from 1995 to 2006. Improving air quality is exhibited by the steady decrease of the spatial extent as well as the magnitude of design values that are ≥ 85ppb. The maps indicate the region as a whole has been experiencing continuous progress towards attaining the NAAQS for ozone. Substantial improvements are observed after 2004 as indicated by the shrinking spatial extent of the area ≥ 85ppb and the decrease in regional maximum 8-hour ozone design values. The maps were created using Tension Spline interpolation in ESRI ArcGIS with the Spatial Analyst extension. Tension Spline interpolation enforces precise representation of all observed measurements and employs smooth contours that avoid falsely characterizing the spatial extent of the design values. As with all interpolation techniques there are inevitably some portions of the domain that will be misrepresented by either over or under estimations. Portions of the domain over the Chesapeake Bay appear to have estimates on the high end, weighting the Washington-Baltimore corridor sites more heavily than the DEL-MAR-VA peninsula where sites are in attainment.


1995
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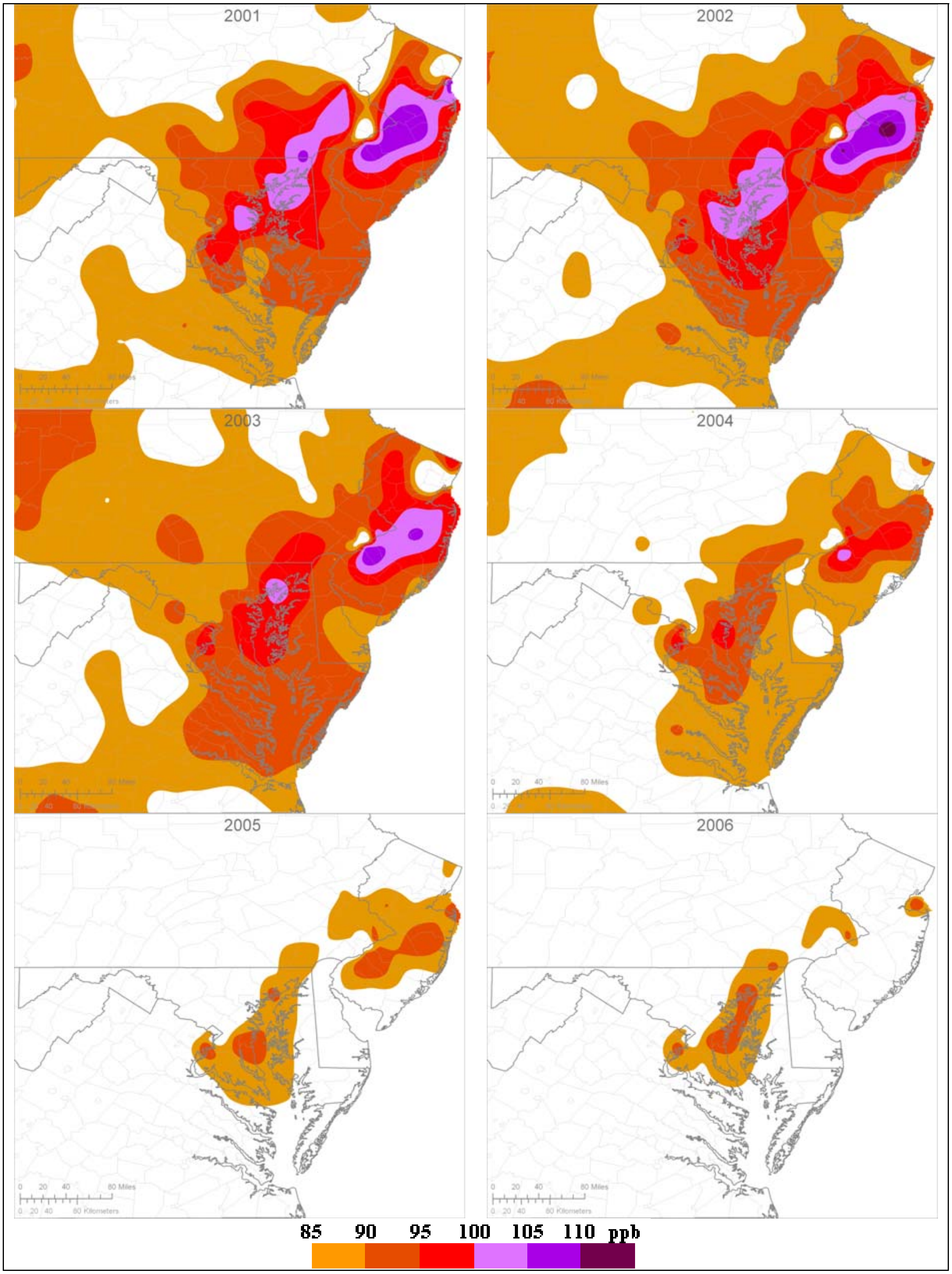


Figure 11.1.6 1995-2006 improving trend exhibited by decreasing spatial extent and magnitude of 8-hour ozone design values ≥ 85ppb.

The approach to trends thus far has focused entirely on the ozone concentrations themselves. A more comprehensive look at ozone trends must also consider meteorology and precursors. Ozone is a photochemical pollutant and as such, it is highly dependent upon meteorological conditions.

Temperature Adjusted Ozone Trend

The data shown in Figure 11.1.7 provide insight to the trend of 8-hour ozone with respect to temperature.

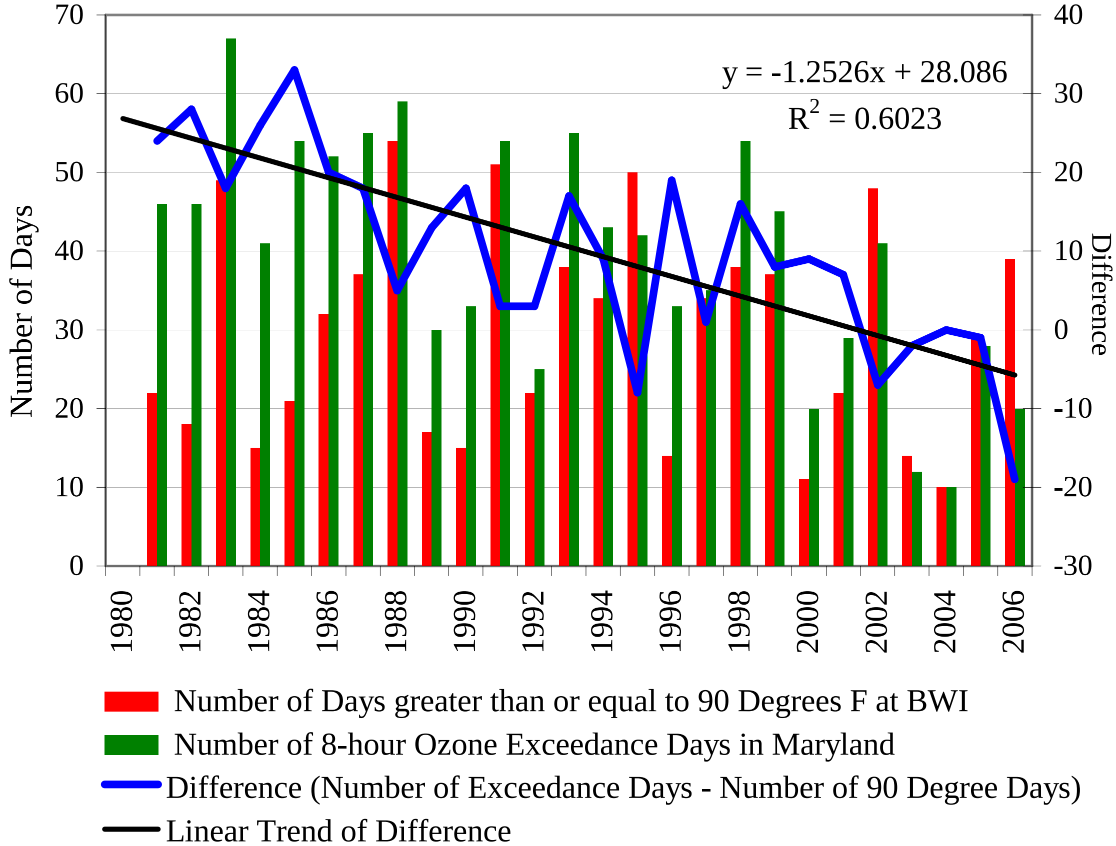


Figure 11.1.7 Improving air quality in Maryland is shown by the downward linear trend (black line) of the difference between (blue line) the number of 8-hour ozone exceedance days per year (green bars) and the number of days with a daily maximum temperature ≥ 90°F per year at BWI (red bars). The time period is 1981-2006.

Temperature is the single strongest environmental predictor of ozone concentrations, as such there has historically been a strong correlation between the number of 8-hour ozone exceedance days per year and the number of days with a daily maximum temperature ≥ 90°F per year at BWI. In fact, in the early 1980's the number of exceedance days was typically double the number of 90°F days. This statistic has steadily changed through, so that in 2006 the ratio was the exact opposite with the number of 90°F days doubling the number of exceedance days. The trend in the difference between the two counts (black line) has an R^2 of 0.6 and a downward slope of –1.3. Despite stable numbers of 90°F days, ambient ozone concentrations continue to experience a continuous downward trend reflecting improvements in air quality. Besides ozone itself and meteorology, the third important subject which should be explored by trends is precursors to ozone formation.

Ambient Ozone Precursor Trend

As described in Chapter 2, the precursors to ozone formation include VOCs and NOx. VOCs are a somewhat difficult to depict in terms of simple trends because the list of VOCs is so large. MDE collects 56 species of VOCs as part of the PAMS (Photochemical Assessment Monitoring Sites) network and a separate list (with some commonality) of 61 Toxic VOCs. VOC measurements have uniformly experienced declines in concentrations since 1994 due to the reforumulated gasoline rule, hydrocarbon reductions for Ozone, and also some associated benefits since 1990s restrictions on CFC (chlorofluorocarbon) emissions. NOx on the other hand, is more simply analyzed and it is widely available. Based on observations, ozone concentrations vary linearly with integrated upwind NOx emissions (Appendix G-1). A given percent reduction of NOx should result in an equal percent reduction of ozone. NO_x is measured by the same trace gas instrumentation used to simultaneously measure ambient NO and NO_2. NO_2 is commonly measured to show compliance with the NO_2 NAAQS. Figure 11.1.8 displays the decreasing trend of NOx for the BNAA since 1993.

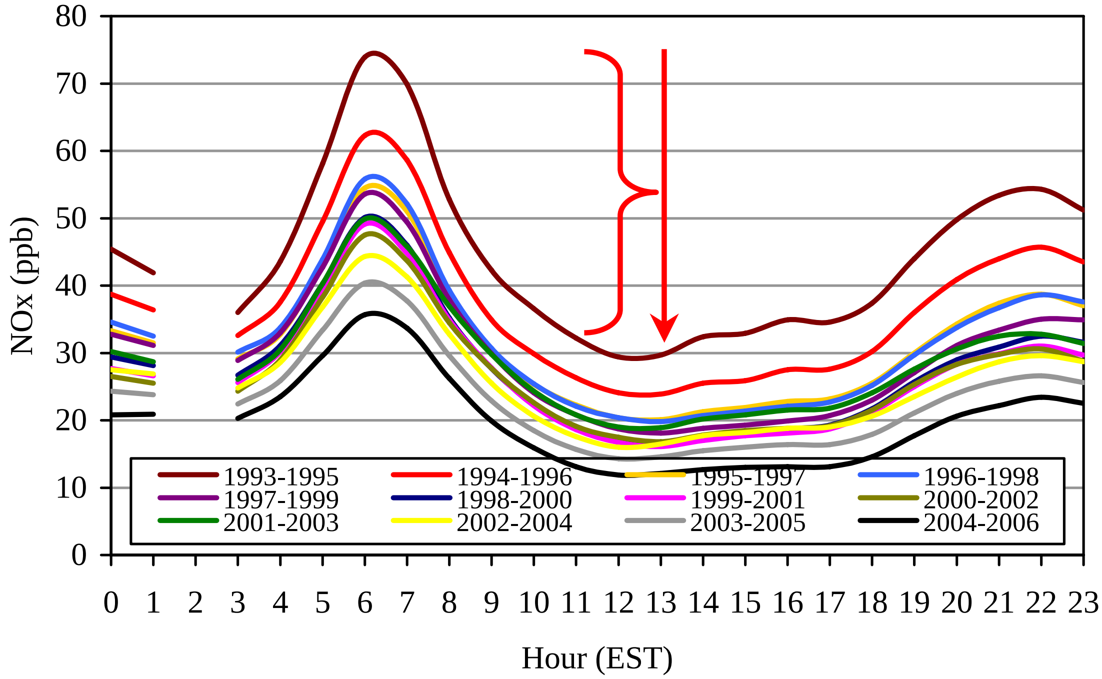


Figure 11.1.8 Trend in diurnal NOx by 3-year rolling averages for all sites in Maryland from the summers (April 1 – October 31) of 1993 through 2006. The red brace and arrow indicate improving air quality shown by the decreasing trend of peak hourly concentrations. Instrument calibration occurs during the data gap at 2:00 AM EST.

Supplemental Monitoring Initiatives

Monitoring in order to show compliance with the NAAQS and in order to quantify exposure while protecting the health of the public and environment, is the first goal of ambient air quality monitoring. As such, the CFR requirements focus on monitoring for exposure and monitoring for background concentrations. MDE takes great care to go beyond the CFR requirements to ensure ambient concentrations are being measured in rural, suburban, and urban locales. 17 ozone monitoring sties are operated in Maryland and 7 of them lie within the Baltimore NAA where only 5 monitors are required by the CFR. While monitoring for compliance and exposure does allow the state to ensure healthy air quality is maintained, monitoring for compliance and exposure does little to explain why poor air quality episodes develop. In fact, compliance and exposure monitoring tells virtually nothing about the source of an air mass and where the emissions originated. In order to discover where poor air quality is coming from, monitoring has to be conducted with an eye towards culpability.

MDE dedicates large resources to monitoring for culpability in order to discover the origins of poor air quality episodes, so that the problem may be addressed at its source. Tracking the history of air parcels involves taking measurements from above the ground surface and deploying instrumentation into the atmosphere at varying heights. In this vane, MDE has created several atmospheric profiling initiatives including various platforms: aircraft, ozonesonde balloons, RADAR (Radio Detection And Ranging), LIDAR (LIght Detection And Ranging), and high-elevation, mountain-top sites. Figure 11.1.9 shows photographs of the first four platforms.

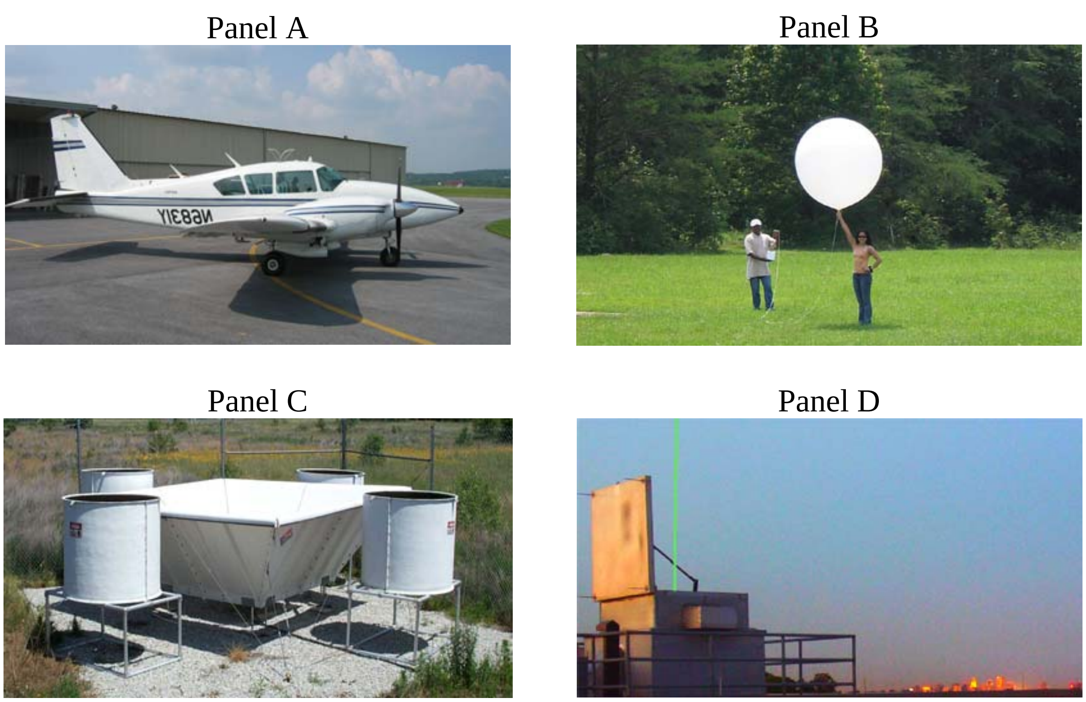


Figure 11.1.9 Supplemental atmospheric profiling initiatives supported by MDE.
A. Aircraft, B. Ozonesonde Balloon, C. RADAR, D. LIDAR

Data collected from these projects allow MDE to understand interstate pollutant transport and to state the case for equitable emission control strategies across state boundaries. The data products are priceless tools for examining model performance, analyzing air quality episodes, and educating the general public. The remainder of this section is dedicated to describing each of these supplemental monitoring initiatives, each of which serves an important role in quantifying the degree of interstate air pollutant transport coming into Maryland.

Aircraft

MDE has contracted with the University of Maryland since 1995 to make aircraft profile spirals over locations throughout the Mid-Atlantic and as far away as North Carolina and Vermont. Measurements include trace gases and aerosol characteristics from 100m – 4,000m in altitude in variable intervals with 10-second resolution.

Ozonesonde Balloons

MDE has contracted with Howard University since 2005 to make ozonesonde balloon profiles over Beltsville, Maryland. Measurements include temperature, relative humidity, wind speed, wind direction, and ozone from 0m – 32,000m in altitude at variable intervals with 1-second resolution. The ozonesonde is made up of two paired modules: A wet-chemistry ozone-sensing module and a GPS rawinsonde meteorology-sensing module.

RADAR

MDE owns and operates two radar wind profilers. One was originally deployed in 1998 at Fort Meade, Maryland. It was subsequently moved to Beltsville, Maryland in 2005. During the same year a second radar wind profiler was purchased by MDE and deployed at the Piney Run monitoring site near Frostburg, Maryland. The RADAR measures wind speed, wind direction, and virtual temperature from 120m – 4,000m in altitude in intervals of 100m with 15-minute resolution. RADAR emits electromagnetic energy and detects shifts in the backscattered energy, which mathematically translate to information about the winds and temperature in the atmosphere.

LIDAR

MDE has contracted with the University of Maryland at Baltimore County since 2005 to measure aerosols over Catonsville, Maryland. Measurements include aerosols scattering from 0m – 10,000m in altitude in 1m intervals with 1-minute resolution. LIDAR emits laser light and detects changes in the backscattered light which mathematically translate to information about the aerosol content and dynamics in the atmosphere.

High-Elevation Mountain-Top Sites

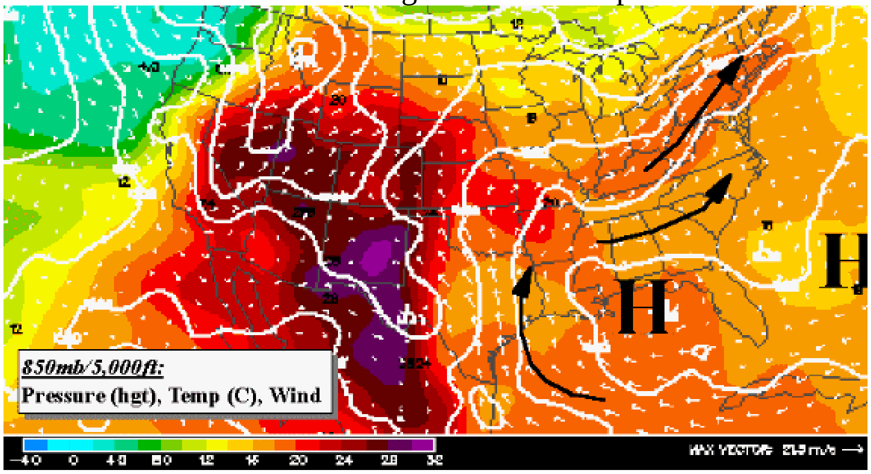
MDE deployed a high-elevation, mountain-top surface monitoring site in 2004 called Piney Run, located near Frostburg, Maryland. The site sits along the western boundary of Maryland in a rural setting with minimal local emissions. The site serves as a front-line indicator of westerly transport arriving in Maryland and fills a gap in high elevation monitors between Methodist Hill, Pennsylvania, and Shenandoah National Park, Virginia.

11.2 The Challenge of Interstate Transport

In terms of geography, Maryland enjoys the benefit of many natural resources. The state's location on the east coast provides considerable shoreline along the Atlantic Ocean, a wealth of fresh water resources in the Chesapeake Bay, and in the west, high elevation access to the Appalachian Mountains. While there are tremendous benefits to the state's geographical location; there is a major challenge in terms of air quality: downwind interstate air pollution transport. Maps of the four main patterns associated with air pollution transport into Maryland are provided in Figure 11.2.1.

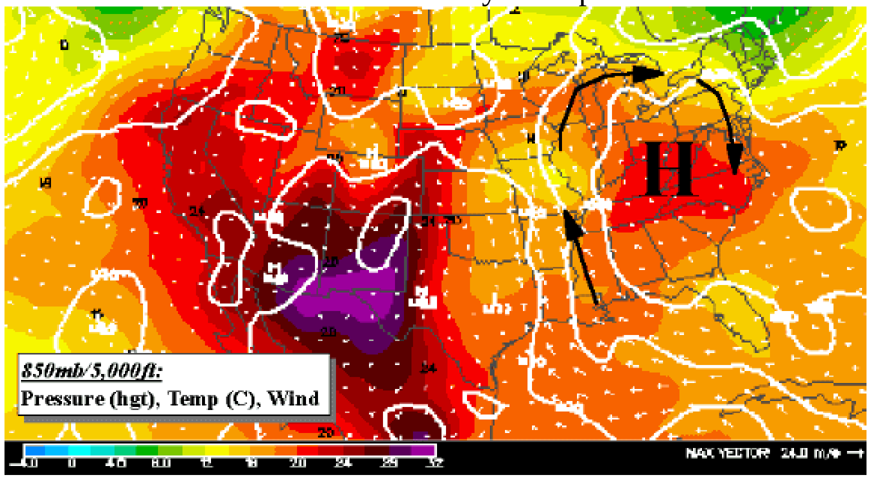
Depending largely on the placement and severity of the Bermuda High Pressure Center, the worst ozone episodes are almost always associated with one of the four main transport patterns: Along Corridor, Northerly, Westerly, and Pre-Frontal. The concentration of ozone in each of the upwind areas determines just how severe of an impact the interstate air pollution transport will have on air quality in Maryland. All four of the transport patterns have one thing in common: a westerly transport component. Westerly transport is well documented in peer-reviewed publications. One such description of the role of transport in regional ozone episodes was described by Taubman[23]: "Regional high ozone events often occur when the Bermuda high strengthens and extends west into the eastern United States. Subsidence east of the ridge induces clear skies, high temperatures, atmospheric stability, and stagnant winds. These factors enhance photochemistry and inhibit vertical mixing, thereby contributing to increased local concentrations of ozone. Circulation around the ridge results in westerly transport of ozone and ozone precursors from the Midwest to the eastern United States, where they combine with local emissions."

Panel A – Along Corridor Transport

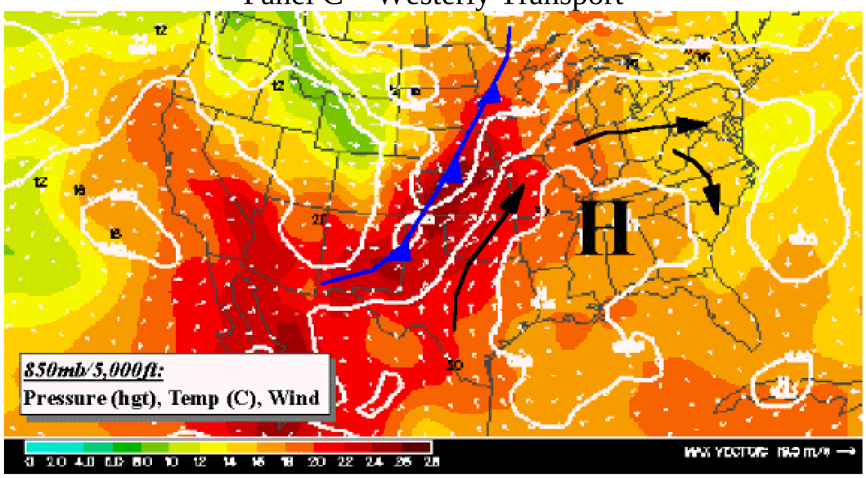


[23]Taubman, et al., "Airborne characterization of the chemical, optical, and meteorological properties, and origins of a combined ozone-haze episode over the Eastern United States", J. Atmos. Sci., 61, 1781-1793, 2004.

Panel B – Northerly Transport



Panel C – Westerly Transport



Panel D – Pre-Frontal Transport

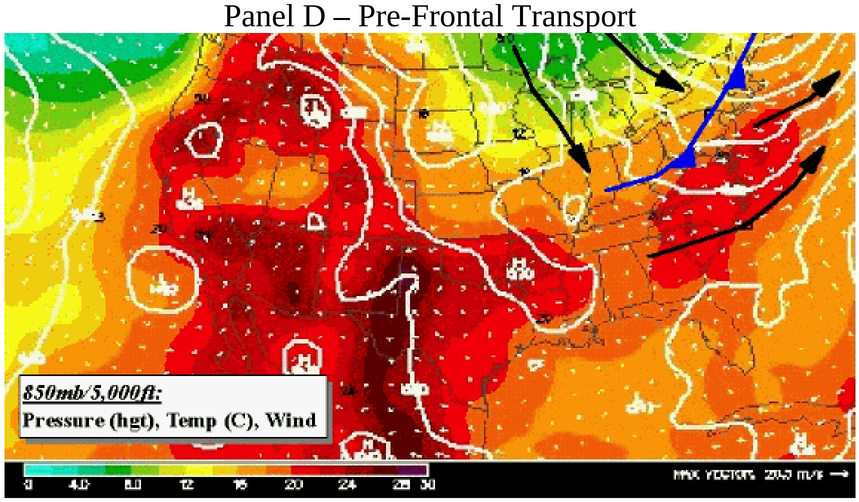
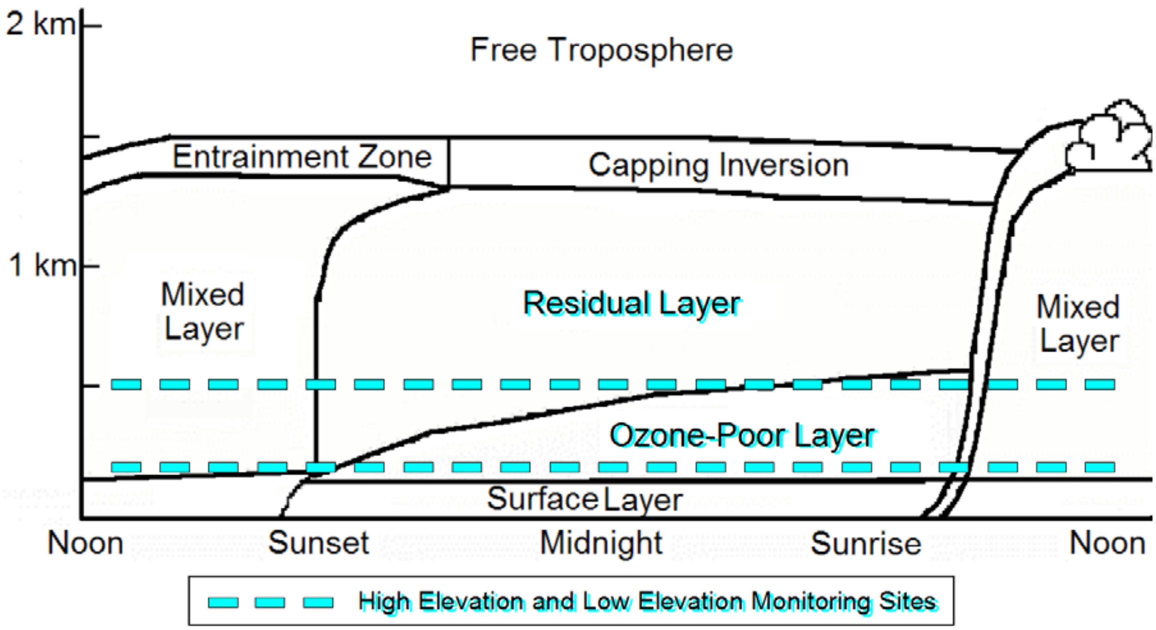


Figure 11.2.1 The four main synoptic meteorology patterns associated with transport of air pollution into Maryland. The colored background represents temperature. The pressure is indicated by white isobars with "H" at the center of high pressure systems. Winds are shown as small white arrows and general circulation is shown as large black arrows.

Westerly Transport

Major upwind ozone precursor sources lie just beyond the borders of Maryland in states such as West Virginia, Virginia, Pennsylvania, and Delaware. Long-range interstate transport also extends beyond the adjoining states to states such as Ohio, Michigan, Kentucky, North Carolina, and Georgia. The direction of transport coming into Maryland includes just about every compass direction, but the primary concern is transport from the west where the dense number of point sources along the Ohio River Valley has a direct impact on Maryland's air quality on a regular basis.

As the atmosphere exhibits no boundaries in space or time, interstate pollutant transport occurs continuously throughout the diurnal cycle. During the daytime when the atmospheric column is well mixed, it is difficult to apportion the relative impact of long-range emissions versus local emissions. However, during the night when the atmosphere stratifies, pollutant concentrations can sometimes become isolated above the ozone-poor, nocturnal boundary layer in a layer referred to as the "residual layer". Figure 11.2.2 shows the development of the nocturnal residual layer where interstate transport may be frequently observed.



Reference: Stull, R.B., *An Introduction to Boundary Layer Meteorology;* Kluwer Academic, Norwell, MA, 1988

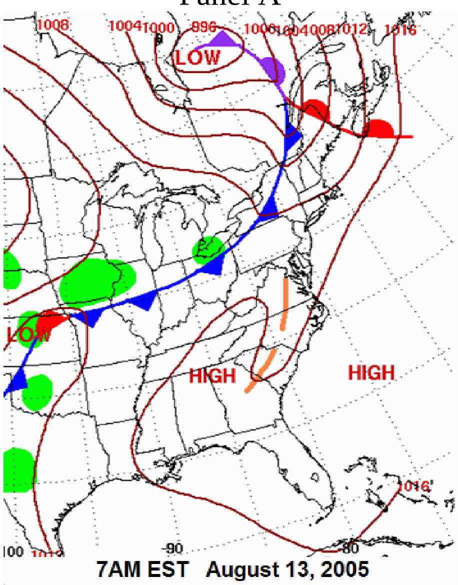
Figure 11.2.2 Diagram of the atmospheric boundary layer. The nocturnal atmosphere stratifies into a residual layer aloft where interstate pollutant transport may be measured.

At night during the summer when the surface cools faster than the air above it, a temperature inversion will develop that stratifies the lower planetary boundary layer. Below the inversion dry deposition with the surface, brings ozone concentrations to minimum in the "ozone-poor layer". Above the temperature inversion, pollutants that were emitted throughout the day and pollutants that continue to be injected high into the atmosphere by tall point sources with hot buoyant plume rise, are trapped in the residual layer. The boundary between the residual layer and the ozone-poor layer creates a stratified atmosphere and pollutants travel above with laminar characteristics through the residual layer.

The residual layer creates an opportunity to observe interstate transport before local emissions contribute to the total pollutant load. The obstacle is finding a way to take measurements from within the residual layer, which is typically 300-600m above the ground surface. MDE has utilized three separate measurement platforms to make in-situ vertical profile observations of westerly transport within the residual layer. These include high elevation surface monitoring sites, ozonsonde balloons, and aircraft. A case is presented here from August 13, 2005 which shows the detection of residual layer ozone transported from upwind locations into the Maryland air shed. August 13, 2005 did experience exceedances of the 8-hour ozone NAAQS in the Baltimore non-attainment area; however, there are many other cases when higher ozone concentrations have been measured. The case is chosen as a case study primarily because of the balloon and aircraft data availability for the episode. The synoptic circumstances observed do represent the conditions that are frequently present during extended ozone episodes such as the kind that result in being relevant to design value calculations. The fact that conditions for the case were so theoretically perfect for an ozone episode is precisely why the air quality forecasters recommended the balloons and aircraft be put into operation for the period.

On August 13, 2005 a high pressure center was in place over the southeastern United States (Figure 11.2.3, Panel A).

Panel A



Panel B

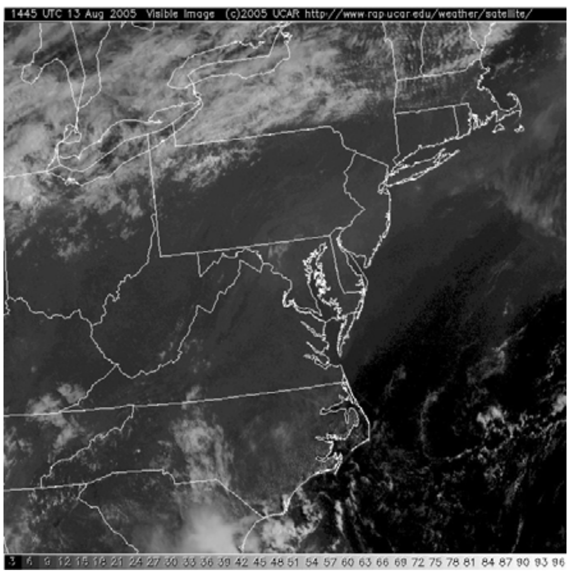


Figure 11.2.3 A. Synoptic analysis from 7:00 AM EST of August 13, 2005. High pressure over the south east United States, an approaching cold front, and a lee-side trough all serve as strong indicators for an ozone episode.

B. Visible Satellite imagery from 10:45 AM EST of August 13, 2005. Cloud cover is associated with the cold front and haze is present over much of the Mid-Atlantic.

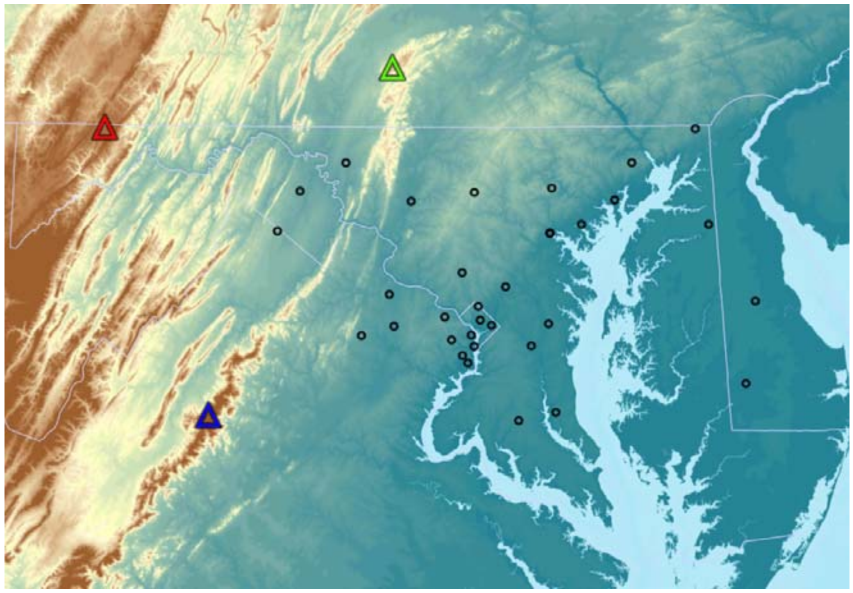
This high-pressure system created clockwise circulation with streamlines crossing the Ohio River Valley and carrying its point sources emissions into Maryland. The high-pressure circulation was reinforced by an approaching cold front (blue line with triangles) which served to suppress horizontal ventilation to the NorthEast. In addition a lee-side trough was analyzed east of the Appalachian Mountains (dashed orange line) which typically coincides with an enhanced mesoscale southwesterly flow within the residual layer called the Nocturnal Low Level Jet. Visible satellite imagery (Figure 11.2.3, Panel B) shows haze over much of the Mid-Atlantic and cloud cover associated with the cold front. There are three measurement platforms, which successfully observed residual layer transport of ozone on August 13, 2005. The first platform described is the network of surface monitoring sites including some sites at high elevation.

Demonstration of Residual Layer Westerly Transport using High Elevation Monitors

MDE forecasts air quality for the state of Maryland using not only the network of surface ozone monitors owned and operated by MDE, but also several monitors in surrounding states including Delaware, the District of Columbia, Pennsylvania, Virginia, and West Virginia. Sites from the other states serve a supplementary function in providing data where the geographical boundary of Maryland has made it impractical to make heavy deployment of monitoring sites. Figure 11.2.4, Panel A provides a map of every sites used by the MDE air quality forecasting program during the summer of 2005. The topography of the map reveals that three of the sites indicated by colored triangles lie at high elevation. In fact the elevation of those three sites is approximately double the height of any other site in the domain. The three high elevation sites are Piney Run, Maryland, Methodist Hill, Pennsylvania, and Shenandoah National Park, Virginia. Figure 11.2.4, Panel B shows a plot of hourly ozone concentrations for August 13, 2005 for every site shown in the Panel A map. During the night time hours of 2:00 AM – 7:00 AM EST the three high elevation monitors exhibit a remarkably different sample of ozone concentrations from the rest of the sites. In fact during the night hours, the high elevation monitors registered concentrations of ~55ppb. On average, that is more than double the ~20ppb concentrations sampled by the low-lying sites in the ozone-poor layer of the atmosphere. Piney Run (red triangle) appears to have initially begun to lie within the ozone-poor layer of the boundary layer from 12:00 AM – 2:00 AM EST, but it quickly soon returned to higher concentrations of ozone as the residual layer settled down to the elevation of the monitoring station.

These important high elevation measurements show that when the morning mixing begins, residual layer ozone may have an immediate contribution of 55ppb to the daily ozone concentrations in Maryland. This creates a situation in Maryland where an ozone allotment of only 30ppb may be produced locally before the NAAQS will be exceeded for the day.

Panel A.



Panel B.

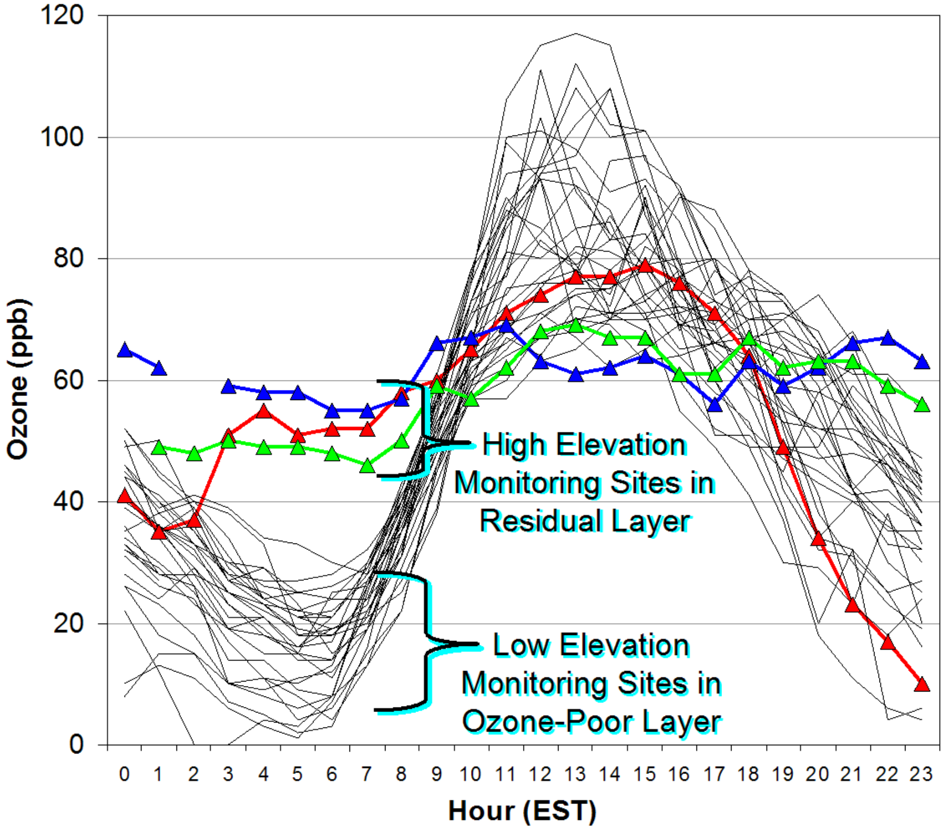


Figure 11.2.4 **A. Topographical map of Maryland and the surrounding states with an overlay of ozone monitoring sites used for Maryland air quality forecasting. Topographical shades of green represent low elevations and topographical shades of brown represent high elevations.**

Black Circles: Low Elevation Monitoring Sites (< 365m)

Colored Triangles: High Elevation Monitoring Sites

Red = 781m, Green = 630m, Blue = 1,072m

B. Hourly Ozone on August 13, 2005 for all sites shown in Panel A.

Demonstration of Residual Layer Westerly Transport using Ozonesonde Balloons

The second platform used to measure residual layer ozone transport for the case of August 15, 2005 was the ozonesonde balloon launched from Beltsville, Maryland. In fact, two balloons were launched during this period, one at 6:00 AM EST and one at 2:00 PM EST. At the 6 AM launch (Figure 11.2.5) the nocturnal inversion is pronounced at ~ 400m in the temperature profile (red). The wind speed profile (blue) shows a 10m/s local maxima between 300-1000m indicating the presence of a nocturnal low level jet. The wind direction (purple) confirms another jet characteristic, veering winds from the surface to the top of the jet at 1000m. The ozone profile (black) shows minor increases in ozone within the LLJ.

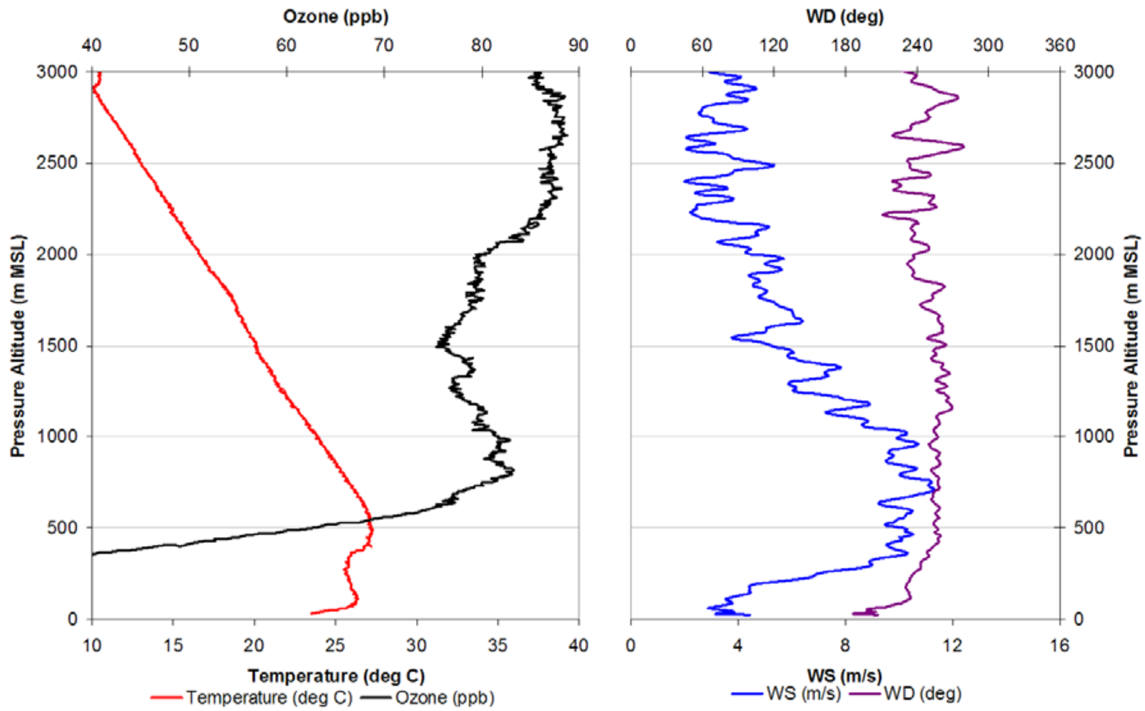


Figure 11.2.5 Ozonesonde balloon launch at 6:00 AM EST on August 15, 2005 from Beltsville, Maryland. Ozone is in black, temperature is in red, wind speed is in blue, and wind direction is in purple.

Demonstration of Residual Layer Westerly Transport using Aircraft

The third platform used to measure residual layer ozone transport for the case of August 15, 2005 was the aircraft, which made several spirals along the western boundary of Maryland and over locations south of western Maryland. The spirals were flown over Luray, VA at 10:00 AM EST, Winchester, VA at 11:00 AM EST, and Cumberland, MD at 11:45 AM EST. Figure 11.2.6 shows profiles from over the three locations in three panels. Panel A shows concentrations of almost 80ppb in the nocturnal residual layer from 1400-1800m in height. SO2 concentrations are correspondingly large over the same height; however, CO shows its largest concentrations near the surface, where mobile emissions are trapped beneath the boundary layer.

Panel A
10:00 AM
EST
Luray
VA

Panel B
11:00 AM
EST
Winchester
VA

Panel C
11:45 AM
EST
Cumberland
MD

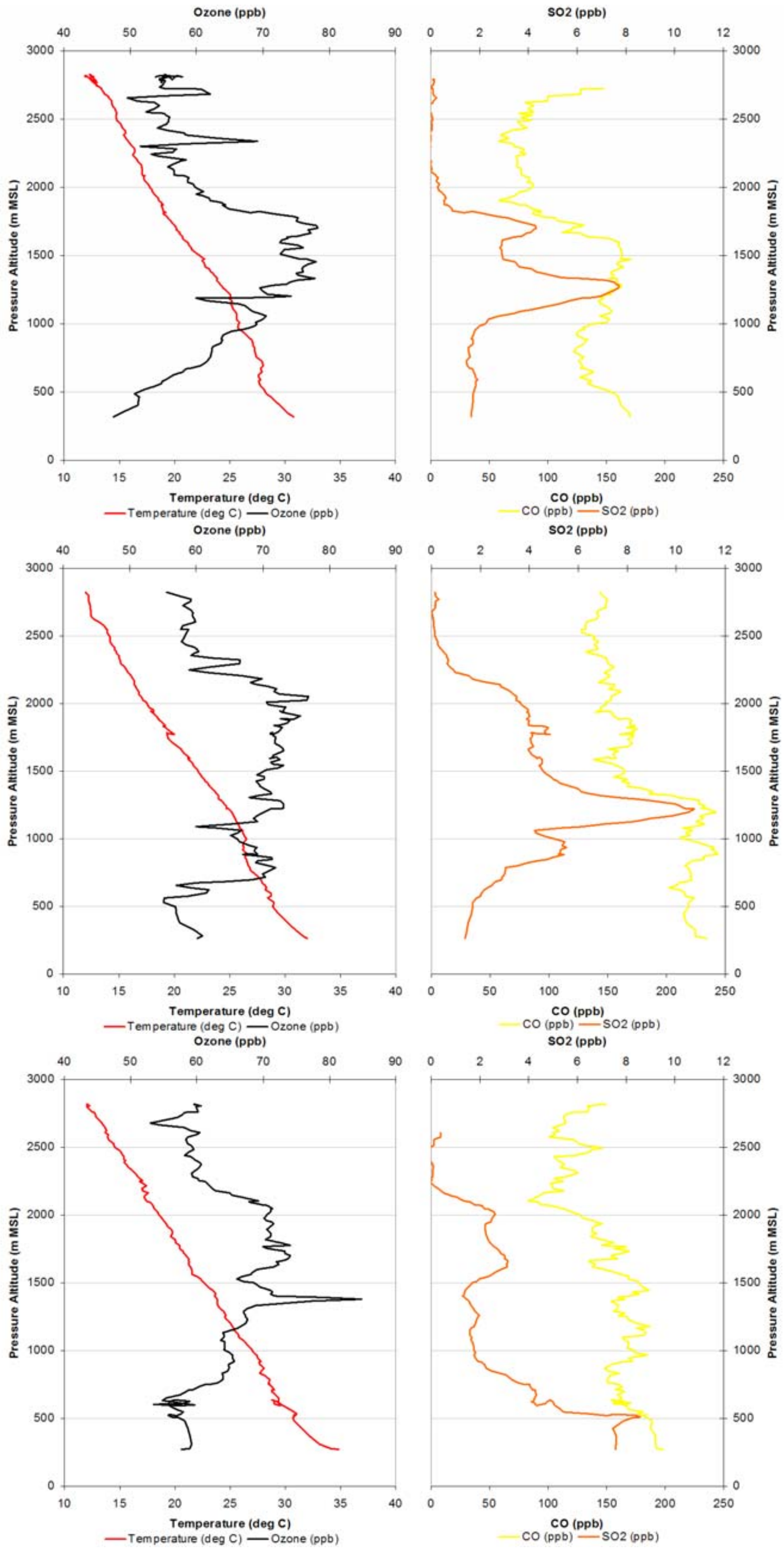


Figure 11.2.6 Aircraft spirals on August 15, 2005. Ozone is in black, temperature is in red, SO2 is in orange, and CO is in yellow.

Similar structure is observed in Panels B and C as the day progresses, but with increased mixing of the high concentrations which broadens the height of the localized maxima to 700-2100m in height.

Animated Google Earth Movie of Westerly Transport

All of the observations recorded by the three platforms presented in section 11.2 are incorporated in an animated movie MDE has created for the August 15, 2005 westerly transport case. Additional profiles are also included for later in the day showing the impact of transport on the eventual concentrations of ozone in the major metropolitan corridor including Washington, DC, Baltimore, MD, and Philadelphia, PA. HYSPLIT 24-hour back-trajectories are plotted for every vertical profile using the NOAA EDAS 40km data archive and modeled vertical velocity. Additionally, the 1999 EPA NOx point source emissions inventory was used to plot all NOx sources that emit 25 tons per day or more of NOx. Counts of the number of point sources per state that emit 25 tons per day or more of NOx are also presented. The animated movie was created using Google Earth Professional Version and was recorded and burned to DVD. Appendix G-2 contains the DVD.

Nocturnal Low Level Jet Transport

In addition to the large-scale westerly transport resulting from the four synoptic meteorological patterns described at the beginning of section 11.2, a smaller-scale transport mechanism created by mesoscale meteorological conditions also has a significant impact on poor air quality episodes in Maryland. This mechanism is the nocturnal low-level jet (NLLJ) which flow from SW to NE in the Mid-Atlantic region, parallel to and on the lee-side of the Appalachian Mountains. Taubman[24] describes the NLLJ in simple terms:
"The NLLJ occurs between 12:00 AM and 6:00 AM EST and has the following characteristics:

- Generally located between 300 and 1000 m in altitude
- South-Southwesterly wind maximum in the residual layer of 10–20 m/s
- NLLJ "core" with wind speed maximum greater than those in the underlying nocturnal boundary layer and those just above, but still in the jet
- Veering winds (turning from S to W) from the surface up through the NLLJ core

The nocturnal boundary layer provides a low-friction surface over which the jet can travel. This phenomenon also seems to be orographically derived, possibly resulting from the differential heating and pressure gradients associated with sloping terrain on the lee-side of the Appalachian Mountains. Pollutant transport via the NLLJ is disproportionately important during periods of stagnation when geostrophic winds are light." Figure 11.2.7 shows the synoptic weather analysis for August 5, 2005 at 7:00 AM EST. Much like the westerly transport example detailed in earlier sections, August 5, 2005 also had high pressure over the southeast U.S. with a cold front approaching from the northwest. The pink arrow indicates the theoretical position of the NLLJ, based upon other field studies which documented the presence of the NLLJ in New Jersey, Pennsylvania, Maryland, Virginia, and North Carolina.

[24]Taubman, et al., "Airborne characterization of the chemical, optical, and meteorological properties, and origins of a combined ozone-haze episode over the Eastern United States", J. Atmos. Sci., 61, 1781-1793, 2004.

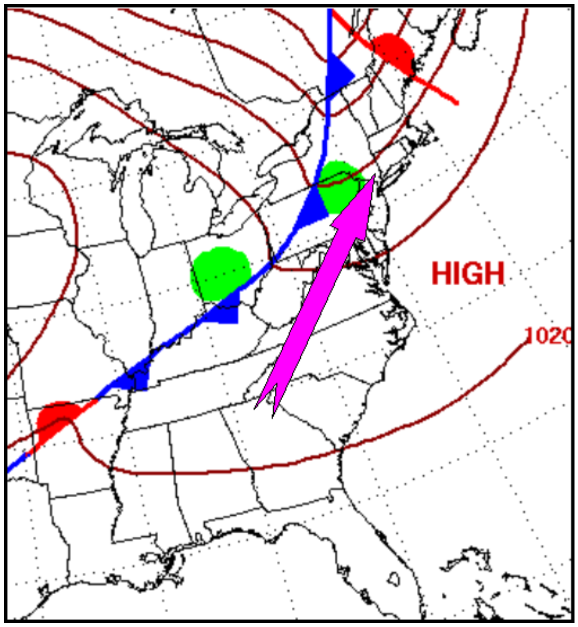


Figure 11.2.7 Synoptic weather analysis from August 5, 2005 at 7:00 AM EST. The pink arrow indicates the theoretical position of the NLLJ.

The NLLJ is an important mechanism for transport for two reasons. It acts as a conduit for air pollutant transport and like westerly transport, the residual pollutants within the NLLJ will mix down to the surface when the nocturnal inversion breaks down. Secondly, the NLLJ creates turbulence between the ozone-poor nocturnal surface layer and the ozone-rich residual layer during the night, which increases nocturnal ozone exposure at the surface when benign ozone concentrations would otherwise be expected. There are three measurement platforms, which successfully observed the NLLJ and associated ozone transport on August 4-5, 2005. In total, four independent measurements were made of the NLLJ in this case: RADAR, LIDAR, and two separate ozonesonde balloons. Figure 11.1.1 Panel A shows the location of the Beltsville monitoring site where the RADAR is located and where the ozonesonde balloons were launched. The LIDAR is located in Catonsville, MD on the campus of the University of Maryland at Baltimore County near the intersection of three Maryland counties: Baltimore County, Howard County, and Anne Arundel County. Both the RADAR and LIDAR platforms are described simultaneously in this first portion of the case description.

Demonstration of Residual Layer NLLJ Transport using RADAR and LIDAR

The MDE RADAR in Beltsville, Maryland observed the August 4-5, 2005 NLLJ for 8.5 hours beginning at 11:00 PM EST on August 4, 2005 and ending at 7:30 AM EST on August 5, 2005. The top portion of Figure 11.2.8 shows a time-height plot of wind observed by the RADAR. Portions of the plot, which fit the accepted fingerprints of a NLLJ are enclosed by the black, amoeba-shaped line. Wind speeds of 15 m/s, veering with height, were observed throughout the jet, which was observed from 200-800 meters in altitude.

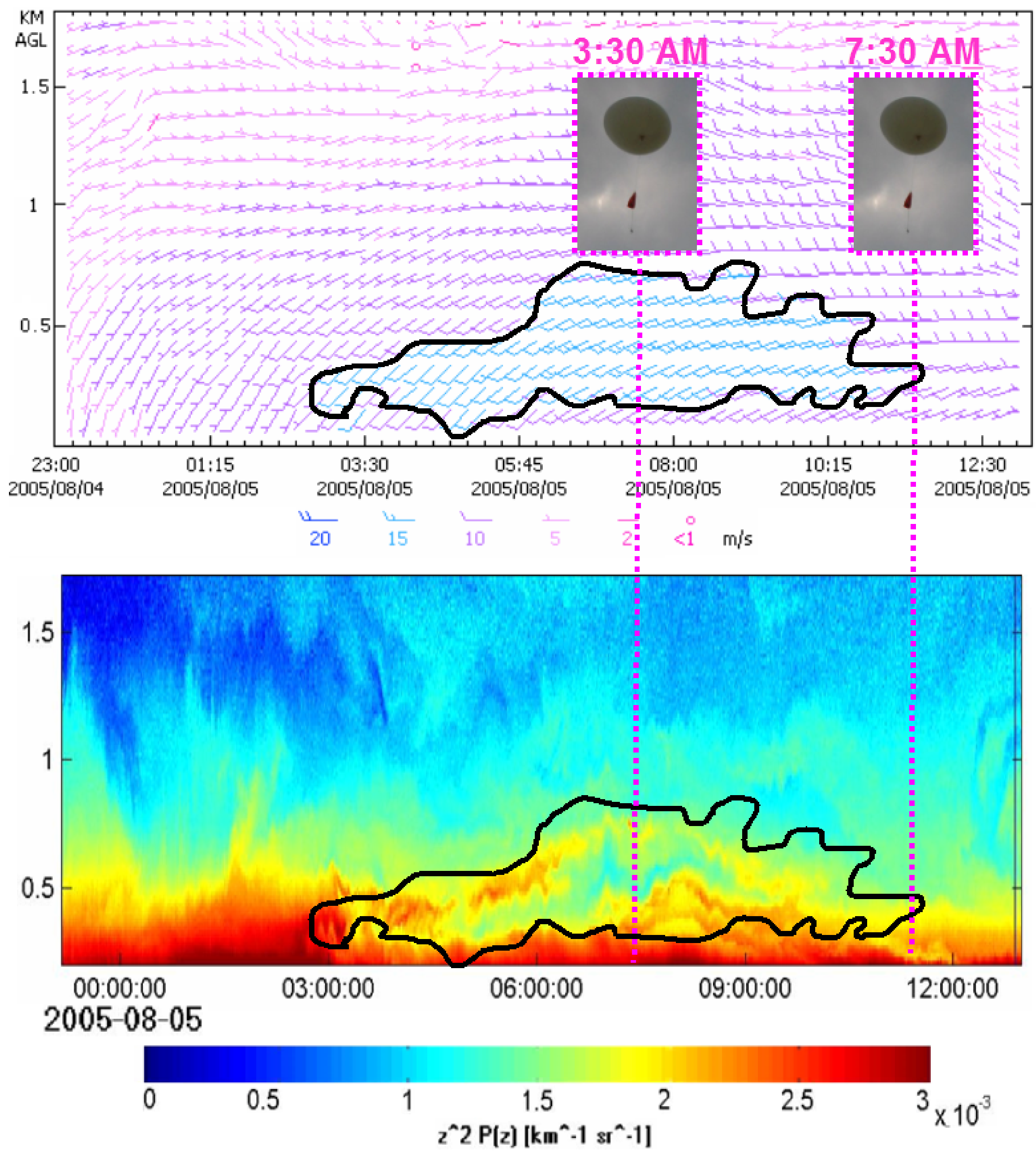


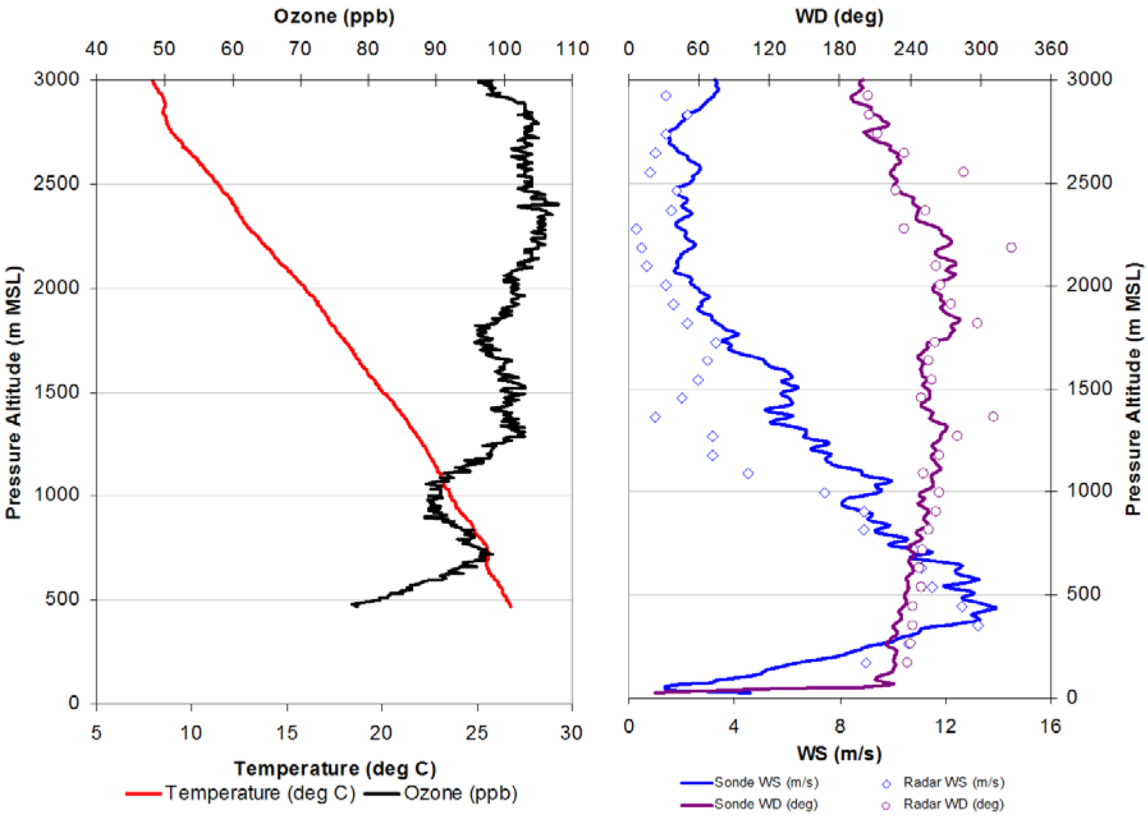
Figure 11.2.8 **The top portion of the time-height plot depicts winds from the RADAR at Beltsville, Maryland. The bottom portion of the time-height plot depicts aerosol scattering from the LIDAR at Catonsville, Maryland. The black, amoeba-shaped, line is drawn around the portion of the RADAR data that fits the stereotypical characteristics of a NLLJ. The same black shape was also overlayed on the LIDAR data. The timing of two ozonesonde balloon launches from Beltsville, Maryland are also overlayed in pink, dashed lines at their respective launch times.**

The same black outline was overlayed on the LIDAR data in the lower portion of Figure 11.2.8. The outline provided an excellent qualitative match to the portion of the LIDAR data exhibiting a signature of the NLLJ, namely enhanced turbulent inhomogeneties and stratification at the same heights and for the same period of time as the RADAR winds. The final piece of information in Figure 11.2.8 is the overlay of ozonesonde balloons (pink dashed lines) at their respective launch times.

Demonstration of Residual Layer NLLJ Transport using Ozonesonde Balloons

The data collected by the two ozonesonde balloons are displayed in Figure 11.2.9. Panel A shows the launch at 3:30 AM EST and Panel B shows the launch at 7:30 AM EST. Both launches revealed fast wind speeds (blue profiles) in the jet and veering wind directions (purple profiles). In the earlier launch, the jet speed is 14 m/s with a jet core from 200-800 m in altitude. In the later launch, the jet speed is 10 m/s with a jet core from 250-500 m in altitude. The black profiles of ozone in each plot show a local maximum in ozone between 500-1000 m in altitude. The local ozone maxima appear to be associated with the presence of the NLLJ. Recent, unpublished work documents secondary nocturnal maxima occurring during the night at surface monitors when the presence of a NLLJ is confirmed. The magnitude of the secondary nocturnal ozone maxima has been measured as high as 30ppb when monitored at the surface using 10-minute average data.

Panel A



Panel B

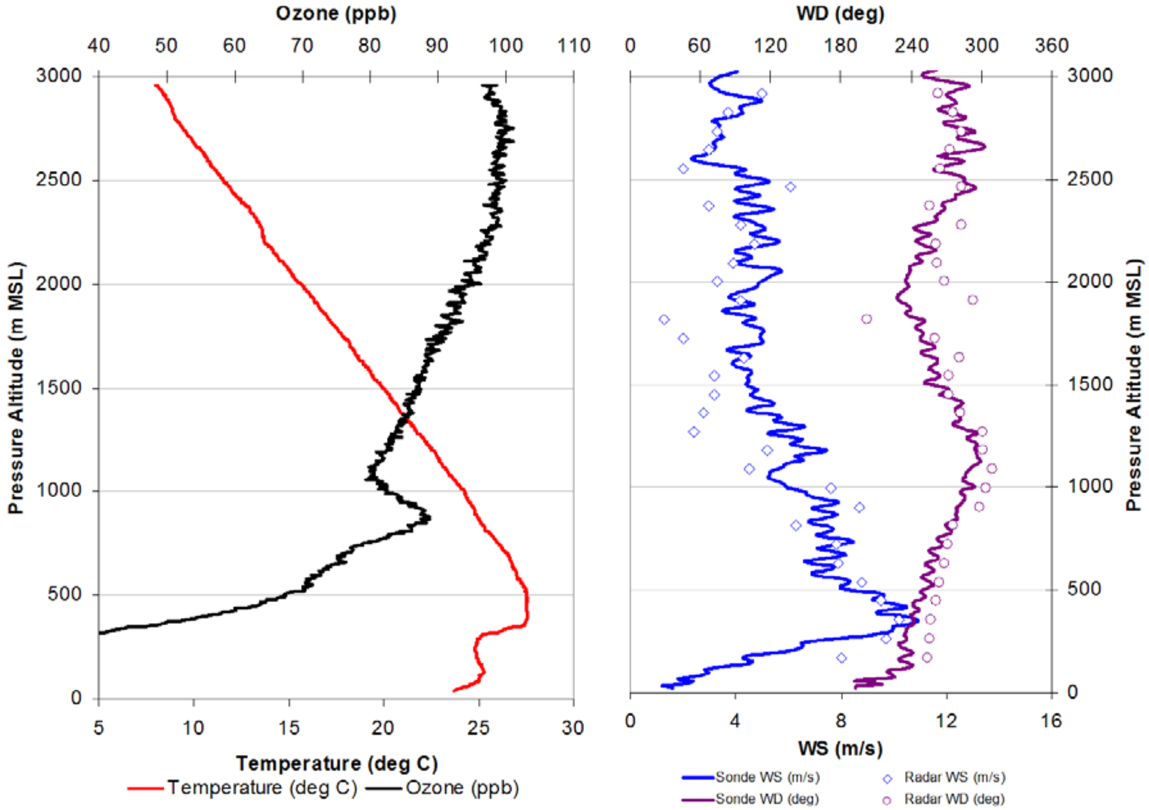


Figure 11.2.9 Ozonesonde balloon data are shown as vertical profiles through the atmosphere. Radar winds are overlayed with the blue and purple data points. Two balloon launches took place on August 5, 2005.
A. 3:30 AM EST on August 5, 2005
B. 7:30 AM EST on August 5, 2005

Animated Google Earth Movie of Nocturnal Low Level Jet Transport

All of the observations recorded for the NLLJ case on August 4-5, 2005 are also incorporated in an animated movie created by MDE. Additional details are provided along with animated versions of the RADAR wind profiles. The animated movie was created using Google Earth Professional Version and was recorded and burned to DVD. Appendix G-3 contains the DVD.

Climatology of the NLLJ in Maryland

A lengthier investigation of the NLLJ over Maryland for multiple years has been compiled in two separate reports. Appendix G-4 contains "Radar Wind Profiler Observations in Maryland: A Preliminary Climatology of the Low Level Jet" written by the University of Maryland and Appendix G-5 contains "The Low Level Jet in Maryland: Profiler Observations and Preliminary Climatology" written by Pennsylvania State University.

<u>Apportionment of Ozone Transport</u>

The prior sections on Westerly Transport and the NLLJ provide case studies of important transport mechanisms. MDE has funded several projects to take a closer look into the apportionment of ozone transport culpability, to investigate how much ozone is transported by the mechanisms and to discover from what states or regions the transported ozone and ozone precursors originate. There is strong evidence from statistical analysis, modeling, and observations that points towards heavy contributions of westerly transport and nocturnal low-level jet transport to the 8-hour ozone non-attainment status in Baltimore non-attainment area, which is often the upwind source for Cecil County.

Cumulative evidence suggests 60-80% of the 8-hour ozone non-attainment in the Baltimore corridor is due to westerly transport. A statistical analysis of ozone trends by meteorological regime (Appendix G-6), estimates that 40-64% of the 8-hour ozone concentrations at Baltimore can be attributed to regional effects rather than localized effects that influence only the Baltimore area. EPA modeling[25] found that upwind contributions are responsible for up to 68% of the non-attainment problem in the BNAA. UMD completed a cluster analysis of hundreds of aircraft profile spirals[26] that found when the greatest cluster trajectory density lay over the Ohio River Valley (~59% of the profiles), transport accounted for 69–82% of the afternoon boundary layer ozone. Under stagnant conditions (~27% of the profiles), transport still accounted for 58% of the afternoon boundary layer ozone.

Cumulative evidence also suggests the nocturnal low level jet plays a role in the 8-hour ozone non-attainment status for the BNAA. Statistical analysis reports the presence of LLJs in Baltimore results in a 7ppb increase in ozone concentrations and a 5ppb increase in Washington DC (Appendix G-6). A climatological study of RADAR observations, shows that for the period of August, 1998 to November, 2002, NLLJs occurred on 70% of Code Orange 8-Hour Ozone days and 42% of Code Red 8-Hour Ozone days (Appendix G-5).

Using 232 aircraft vertical profiles performed in the Mid-Atlantic and Northeast U.S. between 1997 and 2003, greater NO_x emissions along back trajectories from the aircraft profiles were positively correlated with greater ozone mixing. Ozone column contents during the flights were strongly influenced by point source emissions with a slope of 61.6 ppb ozone / (g NO_x m^{-2} day^{-1}) and a correlation (R^2) of 0.997 (Appendix G-1). This shows that if upwind point source emissions are reduced, ozone in Maryland will also be reduced at the same rate.

A study of the relative contribution of transported and local photochemistry to the ozone data for six exceedance days in August 2002 shows that if local photochemistry were the only source of ozone, none of the 6 days examined would have exceeded the 8-hour ozone standard (Appendix G-7). The effect of the transported ozone is to add ozone early in the day and hence to expand the time interval over which the ozone levels may exceed 85 ppbv. All indications point to the importance of transported upwind point source emissions on the air quality of Maryland. Clearly transport is a paramount consideration, which must be account for in an attainment plan especially in modeled simulations.

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[25] EPA, "Air Quality Modeling Technical Support Document for the NOx SIP Call Appendix E", Office of Air and Radiation, Table E-29 ("Percent contribution from upwind states to 8-hour non-attainment in Maryland"), Sept 23, 1998.

[26] Taubman, B.F., J.C. Hains, A.M. Thompson, L.T. Marufu, B.G. Doddridge, J.W. Stehr, C.A. Piety, and R.R. Dickerson, "Aircraft vertical profiles of trace gas and aerosol pollution over the mid-Atlantic United States: Statistics and meteorological cluster analysis", J. Geophys. Res., 111, D10S07, 2006.

11.3 Modeled and Probable Range Attainment Demonstration

Instead of emphasizing a single design value from a single modeling simulation as the core of an attainment demonstration, the preponderance of atmospheric science knowledge shows intelligent use of models should consider all of the model uncertainties and biases, include multiple simulations, and ultimately produce, not a single design value, but a range of predicted future design values. This ensemble approach is analogous to how a meteorologist determines a precipitation forecast. The meteorologist looks at multiple meteorological models, considers uncertainties and biases of each model, reviews circumstances the model may not account for, determines if there are any other outside extenuating factors, and finally ascertains a range of possible outcomes. This range is then delivered to the forecast audience. Similarly, the MDE ensemble approach to weight of evidence modeling provides a comprehensive evaluation of model performance for various scales of time, area, height, and chemistry. Based on the sensitivity of the model under the evaluation schemes, a range of predicted 2009 8-hour ozone design values is forecasted for every monitoring site in the Philadelphia non-attainment area. The net result of applying techniques of data analysis, observations, and modeling in the weight of evidence is a favorable indication for successfully attaining the 8-hour ozone NAAQS in 2009 for the area presently classified as the Philadelphia non-attainment area. This section provides a rigourous scientific evaluation of the CMAQ performance, base case and future year modeling, calculation of probable ranges, and alternative control strategy modeling.

<u>Evaluation of Model Abilities</u>

An evaluation of model performance is performed using comparisons to aircraft observations. This analysis is important in understanding the limitations of CMAQ and its strengths and weaknesses in simulating air quality over the Mid-Atlantic in particular and the Ozone Transport Region in general. Appendix G-8 contains the full evaluation of CMAQ against observations.

Evaluation using Observations

In an effort to assess the ability of the Community Multi-scale Air Quality model (CMAQ) to replicate ozone patterns, particularly high ozone events over the Ozone Transport Region (OTR), comparisons are performed between surface and aircraft ozone measurements and CMAQ ozone simulations using the 2002 base case B1 emissions inventory. Overall, CMAQ does an excellent job of capturing the mean distribution of surface layer ozone during the ozone season. However, the success is somewhat misleading. EPA performance criteria may appear to be independent or offer different information, but in reality, nearly all criteria are strongly geared toward average performance at the surface. This analysis explores several other means of evaluating the CMAQ model by examining its performance only on high ozone days, by separating performance at rural, suburban, and urban sites, and by comparing CMAQ to aloft ozone data from aircraft campaigns. The mixed results of these comparisons show that CMAQ has critical shortcomings (e.g., transport appears to be underrepresented) that appear to be magnified during periods when high ground level ozone concentrations are a concern.

Comparison with aircraft profiles from 136 Regional Atmospheric Measurement Modeling and Prediction Program (RAMMPP) flights reveals that CMAQ has an overall high bias of ~15%

from the surface to ~500 meters above sea level (ASL) and a low bias aloft (600-2600 meters ASL) of ~10%. Agreement between CMAQ-calculated and aircraft-measured ozone varies substantially from flight to flight. CMAQ, in general, replicates the spatial pattern of high ozone events but often does not capture the full spatial extent or magnitude of the high ozone patterns. Mean CMAQ-calculated and measured 8-hour ozone values from 66 surface ozone monitors in the Baltimore, Washington, D.C., and Philadelphia non-attainment areas are highly correlated (correlation coefficient, R, of 0.92) over the ozone season (May 15 – September 15) and well correlated (R=0.81) when a subset of 38 high ozone days (i.e. days when the peak daily 8-hour average ozone in Maryland exceeded 85 ppb) are compared. Biases between CMAQ-calculated and observed 8-hour ozone mixing ratios are minimal (-1.6 ppb) when averaged over the entire ozone season. However, larger negative biases are seen during high ozone days (-2.2 ppb at urban sites and -7.7 ppb at rural/suburban sites).

The high bias near the surface and low bias aloft is indicative of an underestimation of ozone transport by CMAQ. Aloft is where most transport occurs; ground-level air does not move as readily. On the highest ozone days, CMAQ's performance is not as good as on lower ozone days. This is a statistical reflection of CMAQ's inability to capture large-scale deviations from average or median conditions. These deviations occur on days with poor air quality. CMAQ performs better at urban sites than at suburban and rural areas. This bias provides more evidence that CMAQ is missing incoming ozone, possibly transport. In some instances, these rural/suburban areas are dominated by power-plant emissions more than they are dominated by motor vehicle emissions. The bias may also indicate that CMAQ's relatively coarse vertical resolution is unable to resolve the transport of point source (i.e. power plant) emissions. In particular, performance at upwind sites with fewer nearby sources is poorer on the whole than it is at other sites (see Appendix G-9).

None of these shortcomings are reflected in EPA's traditional ozone model performance measures. However, these shortcomings make it necessary to consider CMAQ output and other evidence when evaluating the probability of success of State Implementation Plans (SIPs). EPA model performance criteria reveals that CMAQ does a good job of capturing temporal fluctuations in 8-hour ozone over the ozone season. However, excellent performance in predicting domain-wide ozone averages does not mean CMAQ will predict extreme ozone, ozone changes, or the dynamic range of ozone concentrations at particular locations with similar accuracy. In this analysis, we show that CMAQ-calculated ozone concentrations have systematic biases. These biases must be considered when using CMAQ for predicting ozone changes at particularly poor air quality sites for the purpose of demonstrating future attainment status with respect to the 8-hour ozone NAAQS.

Biases between CMAQ-calculated and measured 8-hour ozone concentrations are minimal (1-2 ppbv) when averaged over the summer but larger (7-8 ppbv) on days when air quality is poor. The inability of CMAQ to capture the dynamic range of ozone concentrations is evidence that CMAQ under responds to changes in meteorology and/or emissions. Further examples of the under responsive nature of CMAQ and the resulting implications for SIP modeling are discussed in Appendix G-9. Aircraft observations show that CMAQ underestimates transport and has compensating errors that overestimate the significance of local sources. This suggests that regional control programs should be more effective than predicted by CMAQ and local programs somewhat less effective. Since the bulk of the control programs are regional (e.g. fleet turnover, heavy duty diesels, and the Clean Air Interstate Rule), greater changes in surface ozone can be expected than those predicted by CMAQ, especially given CMAQ's lack of response to change (see Appendix G-9).

CMAQ exhibits its best performance in urban areas (small bias), less success in suburban areas (underestimates ozone, a larger negative bias), and its worst performance in rural areas (underestimates ozone more, larger negative bias). Since ozone must pass through rural areas to get to urban areas, CMAQ is likely underestimating transport. CMAQ's performance in capturing surface ozone is worst in the Ohio River Valley and in central and southern Virginia, which are known to be source regions for Maryland during high ozone episodes. This relatively poor performance adds uncertainty to estimates of transport into the Mid-Atlantic region that are already likely biased low.

A detailed examination of Maryland ozone reveals that Maryland ozone values improved significantly after the implementation of the NO_x SIP Call. Ozone values were binned according to peak temperature to remove most of the effects of meteorology from the analysis, revealing a consistent 12% downward trend in ozone after the NO_x SIP Call.

In regards to the demonstration of attainment, Maryland should be in better, perhaps far better shape, than CMAQ predicts (see Appendix G-9). Demonstrated uncertainties and biases in CMAQ's performance, particularly with respect to extreme values and transport, imply that CMAQ predicted future ozone concentrations are overestimated for the Baltimore, Washington DC, and Philadelphia non-attainment areas. Given that CMAQ predicts a maximum 2009 8-hour ozone design value of 81 ppb at the Fairhill monitor, this strongly suggests that Cecil County should be firmly in attainment of the 8-hour ozone NAAQS in 2009.

Analysis of ozone trends before and after the NO_x SIP Call reveals that Maryland's ozone concentrations improved significantly after the NO_x SIP Call. This suggests that NO_x controls, and especially power plant controls are likely to be similarly effective in lowering ozone in the future.

The ozone concentrations in Virginia and the Ohio River Valley (known source regions for Maryland) are under-predicted. In addition, CMAQ's performance is at its worst in upwind, rural areas, and at its best in downwind urban areas with a small positive bias. As a result, the significance of regional controls including fleet turnover, heavy-duty diesel controls, and the NO_x SIP Call are all probably underestimated. Conversely, the significance of local controls may be slightly overestimated. Finally, transport is likely underrepresented.

Figure 11.3.1 shows the median, 25th and 75th percentiles for all aircraft-measured ozone (136 profiles) and matching CMAQ ozone predictions for 2002. While differences between the model-calculated and observed profiles are substantial, the model-calculated profile always remains between the 25th and 75th percentile of the observed profile. The data in Figure 11.3.1 suggests CMAQ has a high bias of ~15 % from the near surface to ~500 m above ground, and the aircraft profiles have on average 10% more ozone than the CMAQ profiles aloft, from 600 – 2600 m.

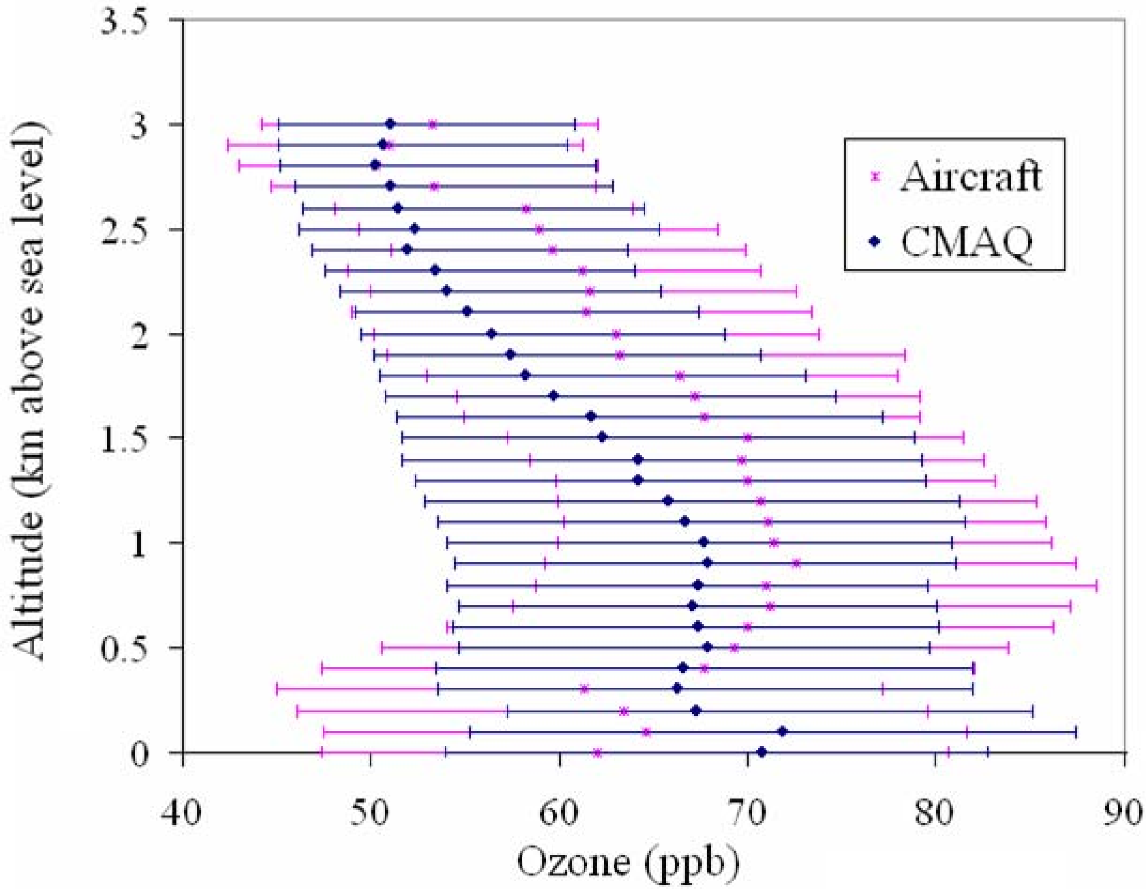


Figure 11.3.1 Median CMAQ and aircraft O_3 profiles from 2002 (June–August, 136 profiles). The ends of the horizontal bars represent the 25th and 75th percentiles.

A number of case studies are provided in Appendix G-8. One such case occurred on Tuesday, June 25, 2002 beginning at 10:00 AM EST.

June 25th was classified as "high ozone in the western OTR." Figure 11.3.2 Panel A shows back-trajectories for the morning of June 25 (10:00 AM EST) over Winchester VA. The trajectory is weak from the northwest reaching only southwestern PA and eastern OH. Analysis of the morning flight presented in this case study reveals that CMAQ over-predicted ozone aloft (~200 m through 700 m) by ~20 ppb (Figure 11.3.2 Panel B). At 700 m, aircraft observations sharply increase to match CMAQ simulations of ~90 ppb in a thin layer at 900m; farther aloft, the two measurements diverge again, with CMAQ still higher than observations (by as much as 50 ppb).

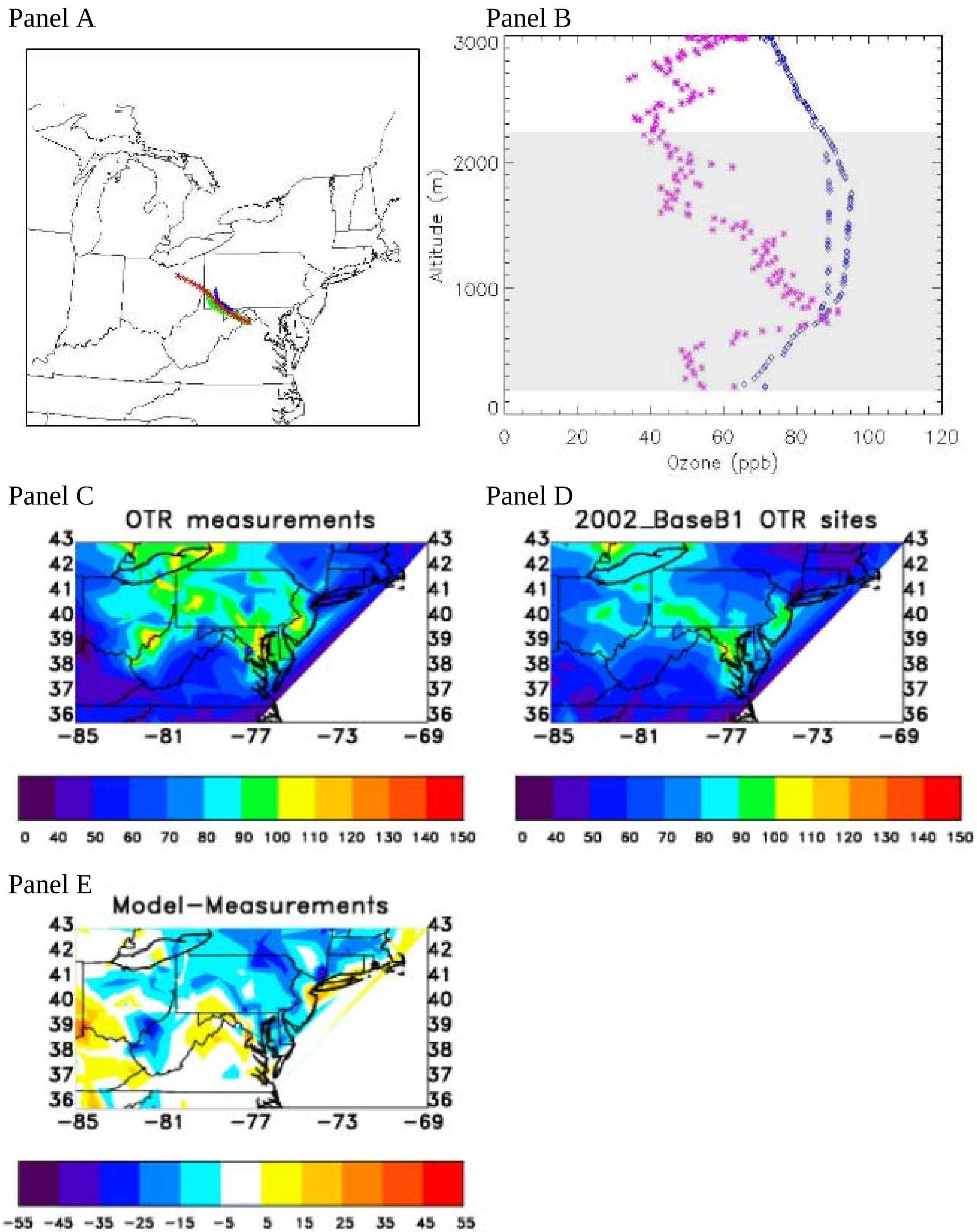


Figure 11.3.2 Tuesday, June 25, 2002, 10:00 AM EST, Winchester, VA. Case Study

A. 24-hour HYSPLIT back trajectories terminating over Winchester, VA. Blue = 500m, Green = 1000m, Red = 1500m
B. Aircraft (pink stars) and CMAQ (blue diamonds) ozone profiles.
C. OTR surface ozone monitor data.
D. 2002 base B1 CMAQ simulation averaged for OTR monitor locations.
E. Difference plot. Negative values indicate model under-prediction.

Based on surface comparisons from over that region, one conclusion is that CMAQ is just missing the location of a local ozone plume (which the aircraft interacts with briefly at ~700 m). Thus, spatially, CMAQ appears to be representing existing conditions with reasonable accuracy. However, because of the sharp ozone gradient over the measurement location and resolution limitations of the model, CMAQ does not compare favorably with aircraft observations.

Clustered and case study comparisons of modeled results versus observations are not the only way to evaluate model performance. A thorough investigation also includes a review of the chemistry in CMAQ.

Evaluation of Chemistry

In Appendix G-10, an analysis of photochemistry and nighttime reactions identifies uncertainties in CMAQ and reasons it may underestimate the benefit of NO_x reductions. This implies that Maryland may be more likely to comply with the ozone standard than CMAQ indicates. The CB4 mechanism and photochemical processor used in the version of CMAQ run for this SIP (4.5.1) are simplified and missing reactions that were thought to be inconsequential, but are now known or in some instances at least suspected to play a major role in ozone production. The attainment demonstration CMAQ modeling can overestimate the rate of formation and concentration of ozone, especially in VOC-rich urban plumes. The overall chemistry may be more NO_x-limited than CMAQ would suggest. Comparison of observations to the chemical processes simulated in CMAQ shows that the model may still underestimate the importance of photochemistry in large-scale, multi-day processes involving transport and processing at higher altitudes, thus the simulations may underestimate the benefit of decreasing NO_x emissions, especially from elevated sources such as power plants.

In order to accurately predict changes in ozone resulting from changes in emissions, CMAQ must accurately represent the chemistry of the lower atmosphere in both urban and rural locations and during both daytime and nighttime conditions. Several studies suggest that CMAQ underestimates the benefit from reduced emissions of NO_x from elevated sources. Comparison of aircraft profiles to CMAQ-generated ozone profiles show that CMAQ calculates too much ozone in the lowest few hundred meters and too little between 600 and 2500 m altitude.

The take away message from study presented in Appendix G-10 is that the CB4 mechanism and photochemical processor used in the version of CMAQ run for this SIP are simplified and missing reactions that were thought to be inconsequential, but are now known or in some instances suspected to play a major role. All higher aldehydes are treated as acetaldehyde (C_2), but other higher aldehydes (such as C_3 and C_4) are certainly formed and they react faster with NO_3 radicals to form HNO_3 at night, representing an irreversible removal of NO_x. CB4 also neglects the small fraction of alkanes that react directly with NO_3 radicals to form HNO_3 at night, as well as a fraction of higher alkanes that rearrange to form alkyl nitrates in daytime reactions with OH and NO. Altogether, these reactions probably sequester at least 1.5 ppb NO_x, and unless there are compensating errors, CMAQ may be overestimating the mixing ratio of ozone formed in the Baltimore urban plume by about 6 ppb at the surface. Scattering of radiation by aerosols can accelerate ozone formation in the lower free troposphere and inhibit it closer to the Earth's surface. Model simulations of the impact of aerosols on jNO_2 indicates that CMAQ should calculate 1-18 ppb less ozone in the lowest few hundred meters and 1-3 ppb more ozone aloft - this moves the model closer to aircraft observations, but not into agreement.

Indirect evidence suggests that MM5/CMAQ is underestimating low level cloud cover, and this could contribute substantially to the disagreement between measurements and CMAQ. Maryland's attainment demonstration CMAQ runs may well overestimate the rate of formation and concentration of ozone, especially in VOC-rich urban plumes. The overall chemistry may be more NO_x-limited than CMAQ would suggest. In comparison to aircraft observations, the base-case CMAQ run underestimates the rate of photochemical smog production above about 500 m and overestimates it below this altitude. Comparison of the details of the chemical processes simulated in CMAQ to observations shows that CMAQ may still underestimate the importance of photochemistry in large-scale, multi-day processes involving transport and processing at higher altitudes, thus the simulations may underestimate the benefit of decreasing NO_x emissions, especially from elevated emissions sources such as power plants.

Reasons for measurement/model differences may include problems with emissions inventories, advection, vertical mixing, cloud cover, and chemistry. The NO_2 photolysis rates that CMAQ uses, directly impacts how much ozone is produced by CMAQ. The rate coefficient for the photolysis of NO_2 (hereafter referred to as jNO_2 value) used by the default version of CMAQ assumes no aerosol loading. In Figure 11.3.3, aircraft profiles are compared against CMAQ values both with and without aerosols. Above 1000 m the revised CMAQ profiles (with revised jNO_2 values, shown in green) are about 1 ppb larger than the standard CMAQ profiles shown in blue. Below 1000 m the standard CMAQ profiles are as much as 18 ppb larger than the revised CMAQ profiles.

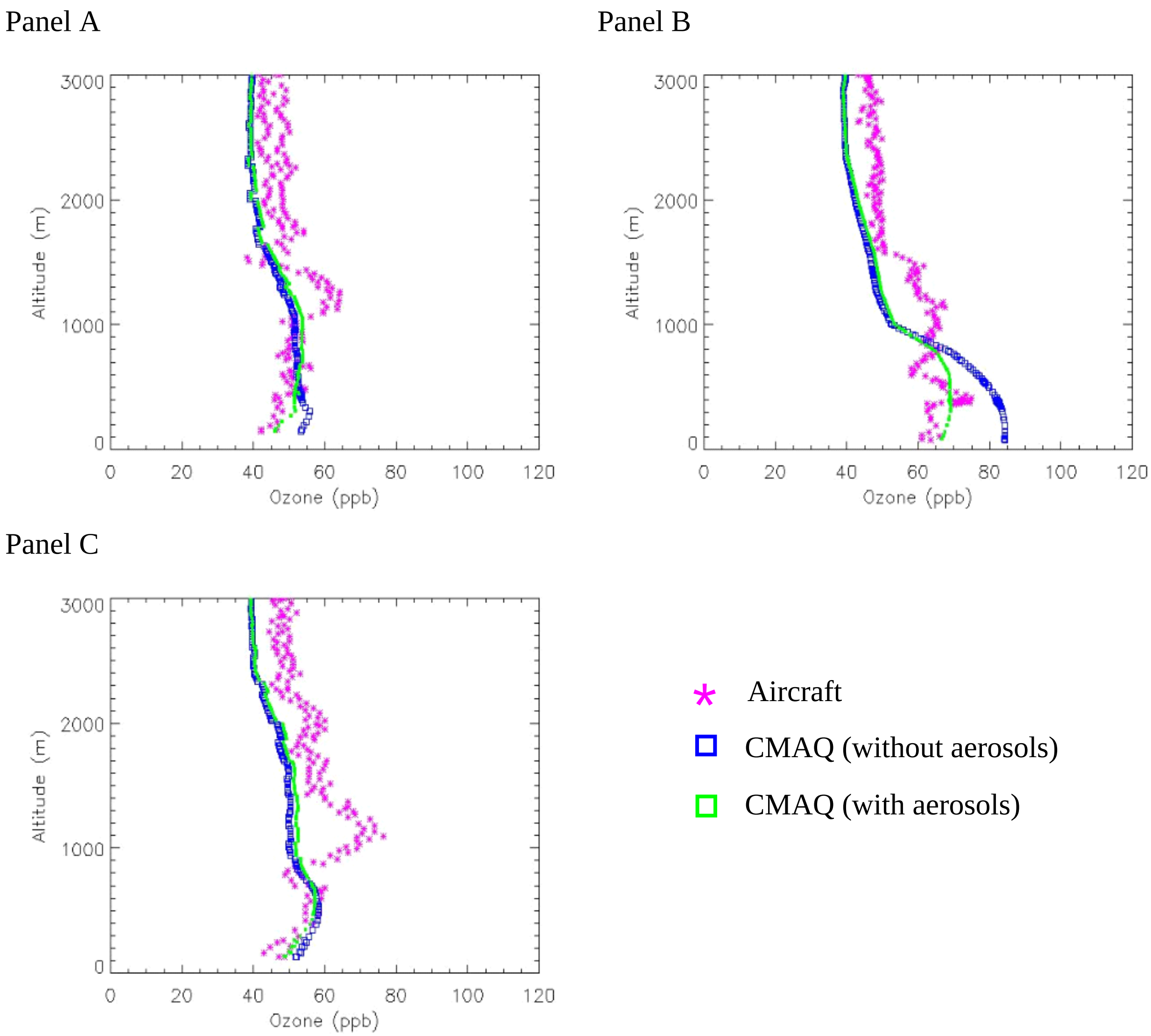


Figure 11.3.3 Ozone profiles from the aircraft (pink stars), CMAQ using standard jNO_2 values (without aerosols, and shown in blue open squares), and CMAQ using revised jNO_2 values (with aerosols, shown in green closed squares) for July 17, 2002.

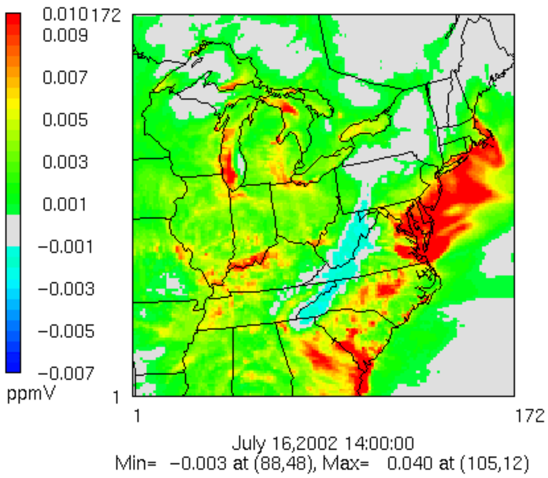
A. Aircraft profile flown over Louisa, VA 8:00 AM EST

B. Aircraft profile flown over Richmond, VA 10:00 AM EST

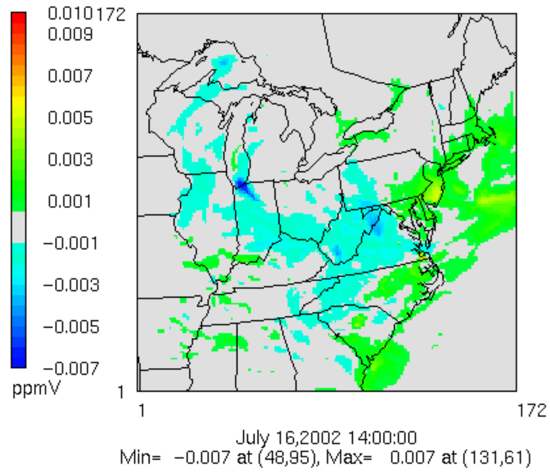
C. Aircraft profile flown over Crewe, VA 9:00 AM EST

Differences in CMAQ runs with and without revised photolysis rate coefficients are seen in Figure 11.3.3 for model levels 1, 8, and 16 (approximately at the surface, 500 m, and 2000 m altitude) at 9:00 AM EST when the largest differences occurred. Values from the revised run are subtracted from the standard run so that negative numbers mean the standard CMAQ overestimated ozone (generally at low altitudes) and positive numbers mean that the standard CMAQ underestimated ozone (generally in the free troposphere). There are positive changes of 10 ppbv or more near the surface, representing overestimation by CMAQ, and small negative changes (mean of 1 ppbv) above 500 m, indicating the revised CMAQ run produces more ozone than the standard CMAQ, generally in better agreement with observations. .

Panel A



Panel B



Panel C

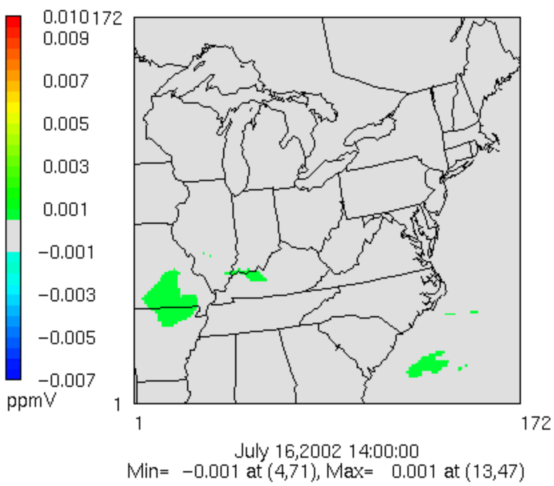


Figure 11.3.3 Differences between standard and revised CMAQ ozone (standard – revised). The standard CMAQ used jNO_2 values that did not account for aerosols, while the revised CMAQ used jNO_2 values that did account for aerosols measured for a July 2002 smog and haze episode. These plots are for 9:00 EST at the surface (Panel A), 500m (Panel B), and 3400m (Panel C) AGL.

Evaluation of Special Site Circumstances

An extenuating circumstance for the Collier’s Mill monitor, which is the highest 8-hour ozone design value in the Philadelphia NAA, is the geographic challenge of ventilating air pollutants in the face of a sea breeze coming off of the ocean. Field studies and numerical modeling efforts around the country and internationally have shown that a sea breeze circulation can influence local ozone concentrations. A sea breeze may exacerbate air pollution levels by constricting horizontal and vertical ventilation. Instead, the sea breeze re-circulates air that would otherwise move off shore. On other occasions, a sea breeze may move relatively clean air onshore that will rapidly lower ozone concentrations. Understanding ozone formation and transport occurring at the Collier’s Mill, New Jersey ozone monitor is important because ozone levels at this location are likely enhanced by a "bay-breeze" because of the proximity of the site to the Atlantic Ocean. Appendix G-11 provides an in depth look at the theoretical impact of the Chesapeake Bay sea breeze on the Edgewood, Maryland ozone monitoring site. The same concepts apply at Collier's Mill. The impact of the sea breeze is an important consideration because there is a real possibility CMAQ could be making the planetary boundary layer too shallow, forcing ventilation to calm conditions, which would effectively create CMAQ over-predictions at Collier's Mill.

Base Case and Future Year Modeling

This section presents a discussion of the basic attainment run for the Philadelphia NAA with no adjustments to account for any issues CMAQ has in predicting ozone changes. This is the base case and future year modeling. By the conservative measure of this modeling, the Fairhill monitor has the predicted 2009 design value of 81 ppb. Based upon the model evaluations and WOE presented throughout this chapter, this strongly suggests that Cecil County should be firmly in attainment of the 8-hour ozone standard in 2009 and all of Maryland will attain the 8-hour ozone standard by 2009. The full modeling results are presented in Chapter 12 and Appendix G-12.

Outputs from CMAQ were used to calculate ozone concentrations for a base year (2002) and a future year (2009). Multiple analyses and sensitivity tests in this SIP (see Weight of Evidence Appendices, in particular) show that CMAQ is less responsive than it should be to changes in emissions. Be that as it may, in this study the outputs from CMAQ were evaluated with no consideration for any correction due to its demonstrated lack of response. Even by taking the outputs straight from CMAQ, Cecil County should attain the 8-hour standard for ozone by 2010. All other Phildelphia NAA monitors are projected to have weight of evidence ranges that attain 85 ppb. As discussed in detail in Appendix G-9 and G-12, CMAQ's under-prediction of change means that Cecil County area ozone is likely to be well below the 8-hour standard in 2010. Also discussed in Appendix G-9 and G-12, by 2012, all monitors in the Northeastern U.S. are predicted by CMAQ to be nearly in attainment. Given that CMAQ under-predicts changes in ozone, in 2012, the entire Northeast and Mid-Atlantic should be well below the 8-hour standard for ozone. Chapter 12 provides more details on the preparation and methodology employed in the base case and future year modeling.

CMAQ has traditionally been evaluated by using measures that reflect its ability to represent average conditions instead of its ability to respond to changes in emissions. This represents a disconnect between how the model is evaluated and how it is used. It also means that CMAQ was developed with its static performance in mind, not its dynamic performance. It is therefore likely that even though CMAQ meets traditional performance measures such as mean error and bias, it will under-predict the magnitude of ozone changes due to emissions changes. The probably range analysis in the next section quantifies some of the uncertainties associated with CMAQ predictions and explains why future year ozone will likely be lower than CMAQ predicts.

Probable Ranges

Several different methods have been used to compare the measured effects from changes in emissions to those predicted by CMAQ, and all affirm the idea that the reduction in ozone will be larger (e.g. ozone will be better) than predicted by CMAQ. For this reason, the weight of evidence approach has been employed, resulting in the 2009 Probable Range of design values at each site in the Baltimore NAA for 2009 (Figure 11.3.4). Full details of the uncertainty in CMAQ and over-predictions of future year ozone design values are provided in Appendix G-9.

A study of the 2003 Northeast Blackout [Marufu et al., 2004] shows that the blackout caused a drop of at least 7 ppbv ozone, and likely considerably more, while a modeling study of the same event [Hu et al., 2006] used CMAQ to predict only a 2.2 ppbv change. An ongoing study by EPA reveals that the NO_x SIP call likely produced double the benefit that CMAQ predicted. Meanwhile, the State of New Jersey reports that its ozone monitor locations appear to have reached their predicted 2009 design values in 2006, three years ahead of time. When compared to observations from the 2002 ozone season, CMAQ underpredicts diurnal variability, and shows important performance uncertainties and biases in areas just upwind of Maryland on high ozone days, namely the Ohio River Valley and the state of Virginia. Furthermore, performance on high ozone days tends to be best in urban areas, next best in suburban areas, and worst in rural areas, so CMAQ is under-predicting ozone in upwind areas from which it would enter the largely urban and suburban non-attainment areas.

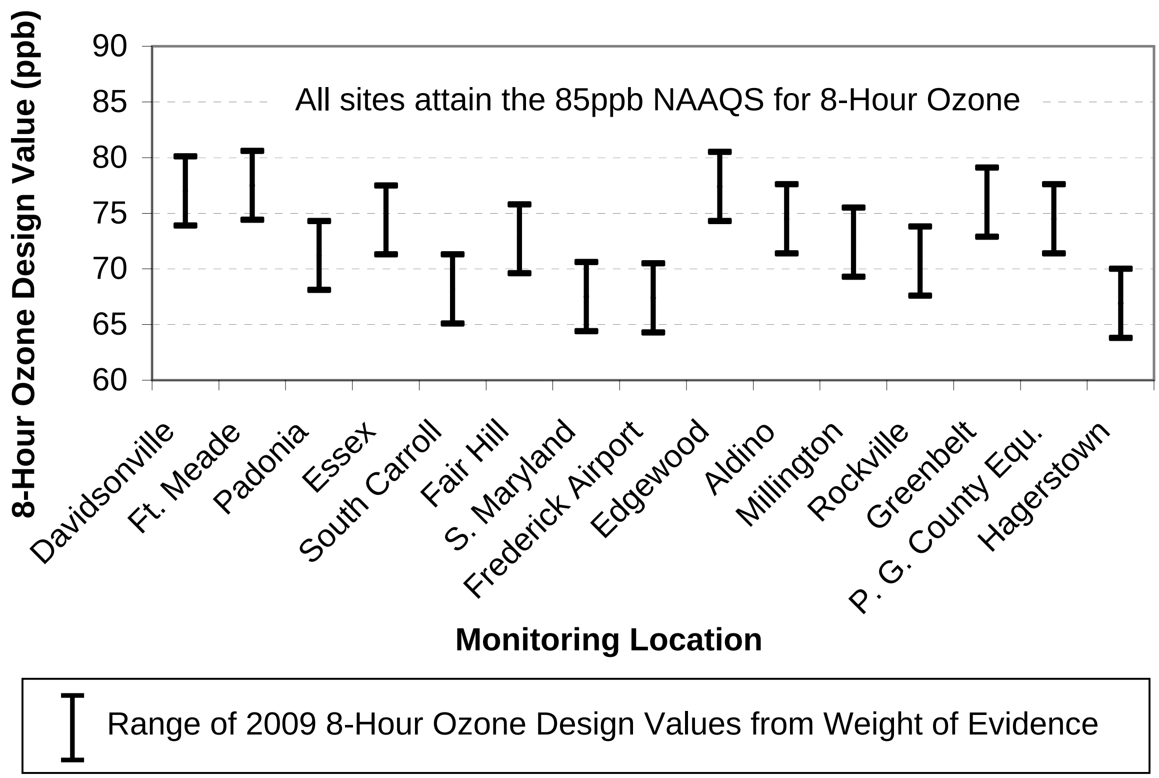


Figure 11.3.4 2009 probable ranges for design values in Maryland. The lower end of each bar represents the lower bound of the most likely future year design value, while the upper end of each bar represents an upper bound.

In this section uncertainties are estimated for two types of errors in CMAQ modeling. One source of uncertainty is the range of possible meteorological conditions that might be encountered in future years. This is not to say that 2002 was not representative, but instead that meteorological variability from year to year is well known, and any future projections must account for this to achieve a reasonable margin of safety, so particularly bad future year meteorology will not result in numerous exceedances of the 8-hour ozone standard. Some of the uncertainty arising from the model and its emissions was estimated by examining several different 2009 scenarios and determining the range of possible 2009 ozone design values from those scenarios. These two sources of uncertainty do not cover all the possible sources of uncertainty in CMAQ projections; errors in the inventory, meteorology, and model formulation all play a role, but are significantly more difficult to estimate. The error estimate and the future year meteorological variability estimate were combined to generate an estimate of future year uncertainty in ozone design values.

To account for CMAQ's resistance to change, CMAQ changes were increased by 50%, and probable future ozone design values were calculated, along with probable ranges of ozone concentrations to account for meteorological variability and some model errors. The resulting picture of future ozone is that likely 2009 ozone design values correspond to 2012 design values calculated directly by CMAQ. This is in line with current observations from New Jersey (home to the ozone monitoring location with the highest design value in the Northeast) that show predicted 2009 ozone design values occurring in 2006. Table 11.3.1 and Figure 11.3.5 show the full results of the Weight of Evidence Probable Design Value Range approach.

Table 11.3.1
2009 Observed, Modeled, and WOE design values for Cecil County, Maryland. Modeled and WOE results are provided for both 2009 and 2012.

Cecil County, Maryland 8-Hour Ozone WOE Attainment Demonstration

Site Name - County, State	Site ID Number	Observed	Modeled		WOE			
		2002 Base Year	2009 BOTW-B4	2012 BOTW-B4	2009 Probable	2009 Probable Range	2012 Probable	2012 Probable Range
Fairhill - CECIL CO, MD	240150003	97.7	81	75	72.7	75.8 - 69.6	63.7	66.8 - 60.6

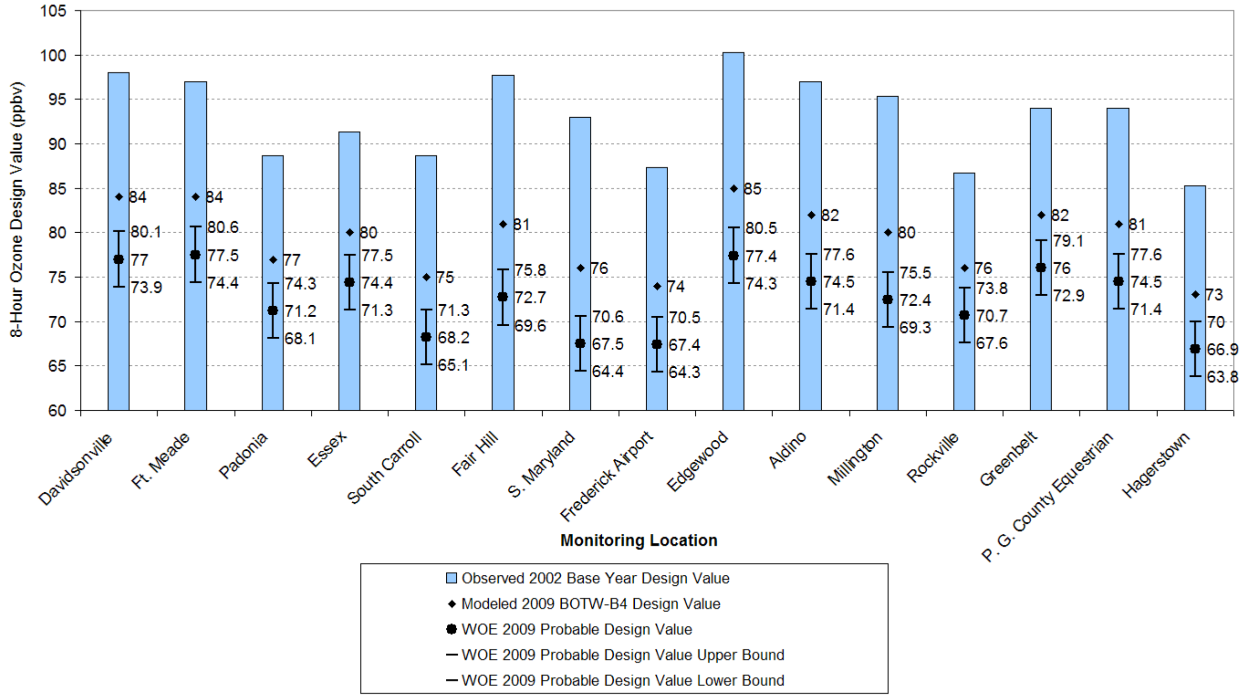


Figure 11.3.5 A graphical depiction of the data from Table 11.3.1, depicting 2002 base year design values (blue columns), modeled 2009 design values (black diamonds), and the WOE probable future year design values along with the upper and lower bounds for those future year values (round circles and associated error bars, respectively). All Maryland monitoring locations are shown. All sites are under the NAAQS for 8-hour ozone.

The methodology and calculations employed to arrive at the WOE 2009 & 2012 Probable Design Value Ranges, shown in Table 11.3.1 and Figure 11.3.5 are outlined below:

Given:

The monitoring station at Fairhill, Maryland was used for the following sample calculations.
All values are 8-hour ozone design values (ppb)

Observed 2002	= 97.7 ppb
Modeled 2009 BOTW-B4	= 81 ppb
Modeled Benefit	= Observed 2002 –Modeled 2009 BOTW-B4
	= 97.7 ppb – 81 ppb = **<u>16.7 ppb</u>**

WOE Benefit = Modeled Benefit x 2 → (Explanation: Due to 100% underestimation of the emissions reduction benefits by CMAQ because of the model's insensitivity to emissions changes)

Allowing for considerable margin, the underestimation of the WOE Benefit is conservatively cut in half (50%). The conservative WOE Benefit is calculated as follows:

$\text{WOE Benefit}_{\text{Conservative}}$ = Modeled Benefit x 1.5 = 16.7 ppb x 1.5 = **25.05 ppb**

WOE 2009 Probable = Observed 2002 – $\text{WOE Benefit}_{\text{Conservative}}$
= 97.7 ppb – 25.05 ppb = **72.7 ppb**

WOE 2009 Probable Range Calculations:
Upper Bound = Probable 2009 + 3.1 ppb = 72.7 ppb + 3.1 ppb = **75.8 ppb**
Lower Bound = Probable 2009 – 3.1 ppb = 72.7 ppb – 3.1 ppb = **69.6 ppb**

The 3.1 ppb adjustment to calculate the lower bound and upper bound represents the uncertainty in future design values. More detailed information can be found in Appendix G-9.

WOE 2012 Probable Range Calculations: Process is identical to the steps described above, except for the substitution of Modeled 2012 BOTW-B4 instead of Modeled 2009 BOTW-B4.

Based on the WOE Design Value Probable Range, Fairhill is likely to be in attainment of the 8-hour ozone standard in 2009 with a fair margin for error. CMAQ's response to reductions in emissions is too rigid, so CMAQ will underestimate the corresponding magnitude of ozone reductions. Even with CMAQ's demonstrated uncertainties and biases, when applied to attainment modeling exercises, CMAQ predicts Maryland will attain the 8-hour ozone standard by 2012 and CMAQ predicts the entire Northeast will attain the 8-hour ozone standard by 2018. Maryland has taken the extra step of modeling and performing WOE probable design value range calculations for an additional suite of alternative control strategies.

Alternative Control Strategies

Three alternative control strategies were employed for sensitivity modeling and additional WOE probable design value range calculations: Programs for tree planting, telecommuting, and high electricity demand days (HEDD). The three strategies are all potential measures to be taken in future years to make appreciable reductions in 8-hour ozone design values.

An urban tree canopy program is an important strategy because a large-scale tree-planting program may offer a method to improve air quality over the Philadelphia non-attainment area. Additionally, a loss of tree cover would harm air quality over the Philadelphia non-attainment area. Results from an analysis for Baltimore suggest that decreases in ground level ozone concentrations on the order of 1-3 ppb could be realized with an increase in urban tree cover ranging from 20-40%. Full results are provided in Appendix G-13.

The telecommuting sensitivity run is an effective, targeted approach. Ozone levels are episodic, and high ozone concentrations are largely influenced by meteorology, so a forecast-driven program of emissions reductions makes a lot of sense. To this end, telecommuting is strongly encouraged on high ozone days during the summer to take vehicles off of the roads and vehicle emissions out of the air. To simulate the effects of an aggressive telecommute program, the

University of Maryland modeled the ozone reduction that would result if 40% of all light duty vehicles were taken off the road in the non-attainment areas of Baltimore, Philadelphia, and Washington, D.C. on 38 high ozone days during the summer of 2002. Changes in mobile emissions were implemented as a flat 40% reduction in vehicle miles traveled in each county of the three non-attainment areas. The effects of implementing such a program were modeled using version 4.4 of the CMAQ model. CMAQ results showed that across the three non-attainment areas modeled, an aggressive telecommute program has the potential for considerable benefit to air quality with a reduction in ozone of over 2 ppb. Full results are provided in Appendix G-14.

The high electricity demand day (HEDD) program is setup based on the climatology of hot weather and the associated higher ozone concentrations. Ozone levels are driven during the summer months by a combination of both pollutant emissions (i.e., NO_X) and the meteorological conditions (i.e., hot sunny days). Another by product of a hot summer day is an increase in peak electrical demand. In order to meet the spike in demand for electricity, additional electrical generating units (EGUs) must be brought online by power companies. These types of EGUs typically do not have pollution control devices and are therefore not necessarily clean. This type of scenario results in having the EGUs, which do not operate cleanly, operating on the hottest summer days, which compounds the issue of poor air quality. Since these types of EGUs are only used sparsely during the year, they appear as insignificant sources of pollutant emissions in the inventory and thus their emissions have been over looked in the past. However, now reducing NO_X on peak days is seen as an opportunity to provide a significant ozone reduction benefit for Maryland and some other Ozone Transport Commission (OTC) states. With guidance from the OTC a strategy is being formulated, which involves OTC staff, state environmental and utility regulators, EPA staff, EGU owners and operators and the independent system operators. Maryland and some other OTC States are committed to pursuing reductions in NO_X emissions associated with HEDD units on high electrical demand days during the ozone season with such reductions to be achieved beginning in 2009 but no later than 2012. Additional modeling is planned using CMAQ to calculate a range of benefit that would be associated with this type of program.

In addition to the WOE probable design value range analysis performed for the Philadelphia non-attainment area, the voluntary measures provide supplementary evidence further exemplifying the probability that the region will attain the 8-hour ozone standard assuming voluntary control measures are put in place. The “WOE With Voluntary Measures” analysis was completed to examine how the model-predicted future year 8-hour ozone design values might be lowered and given as a range based on voluntary controls which were not included in the full modeling demonstration completed by the Ozone Transport Commission (OTC) modeling centers for the Ozone Transport Region (OTR) states and is used in this modeling demonstration as part of this State Implementation Plan. The potential benefits from voluntary programs (i.e., an aggressive telecommuting program, the high electricity demand day (HEDD) program, and even an aggressive tree canopy program) help demonstrate that all of the region’s monitors are progressing towards attaining the 8-hour ozone standard. Table 11.3.2 shows the results of the WOE Design Values With Voluntary Measures and additional details are provided in Appendix G-15. The analysis was completed to present supplemental evidence that leads to the conclusion that MDE is confident that the Philadelphia non-attainment area will attain the 8-hour ozone NAAQS standard by June 15, 2010.

Table 11.3.2
Design values for Cecil County, Maryland: 2009 Observed, Modeled, and WOE-Without Voluntary Measures, and WOE-With Voluntary Measures. Modeled results and WOE-Without Voluntary Measures results are provided for both 2009 and 2012.

Cecil County, Maryland 8-Hour Ozone NAA WOE Attainment Demonstration

Site Name - County, State	Site ID Number	Observed	Modeled		WOE - Without Voluntary Measures				Modeled	WOE - With Voluntary Measures	
		2002 Base Year	2009 BOTW-B4	2012 BOTW-B4	2009 Probable	2009 Probable Range	2012 Probable	2012 Probable Range	2009 Telecommute	2009 Probable	2009 Probable Range
Fairhill - CECIL CO, MD	240150003	97.7	81	75	72.7	75.8 - 69.6	63.7	66.8 - 60.6	78.1	70.7	73.8 - 67.6

12.0 Attainment Demonstration

The 8-hour Ozone Standard Attainment Demonstration analyzes the potential of the Cecil County Maryland portion of the Philadelphia, Wilmington, Atlantic City, PA-NJ-MD-DE non-attainment area (Philadelphia NAA) to achieve attainment of the 8-hour ozone standard by June 15, 2010. The attainment demonstration is comprised of the following sections: Modeling Study Overview, Domain and Data Base Issues, Model Performance Evaluation, Attainment Demonstration and Procedural Requirements.

12.1 Modeling Study Overview

Background and Objectives

In 1997, the ozone National Ambient Air Quality Standard (NAAQS) was reviewed, and the Environmental Protection Agency (EPA) recommended that the ozone standard be changed from 0.12 parts per million (ppm) of ozone measured over one hour to a standard of 0.08 ppb measured over eight hours, with the average fourth highest concentration over a three-year period determining whether or not an area is in compliance. On June 15, 2005, EPA revoked the 1-hour ozone standard and re-designated the Philadelphia NAA as a "Moderate" ozone NAA for the new 8-hour ozone standard. The new 8-hour ozone Philadelphia NAA was formed with counties in the old 1-hour Philadelphia NAA and the additional four counties of Sussex County (DE), Atlantic County (NJ), Cape May County (NJ) and Ocean County (NJ). Moderate ozone NAAs are required to demonstrate attainment of the new 8-hour ozone standard using photochemical modeling and Weight-of-Evidence analyses. Chapter 11 contains all the Weight-of-Evidence analyses supporting the Philadelphia NAA attainment of the 8-hour ozone standard.

The objective of the photochemical modeling study is to enable the Maryland Department of the Environment (MDE) in coordination with the Delaware Department of Natural Resources and Environmental Control (DE DNREC), Pennsylvania Department of Environmental Protection (PA DEP), the Philadelphia Air Management Services (Philadelphia AMS), and the New Jersey Department of Environmental Protection (NJ DEP) to analyze the efficacy of various control strategies, and to demonstrate that the measures adopted as part of the State Implementation Plan (SIP) will result in attainment of the 8-hour ozone standard by June 15, 2010. The modeling exercise predicts future year 2009 air quality conditions based on the worst episodes in the base year 2002, and applies control measures to demonstrate the effectiveness of new control measures in reducing air pollution.

For the reason previously mentioned, the Ozone Transport Commission (OTC) on behalf of the Ozone Transport Region (OTR) member states (of which Maryland, Delaware, Pennsylvania and New Jersey are members) undertook a photochemical modeling study to demonstrate compliance with the 8-hour ozone NAAQS. The 8-hour ozone attainment modeling study was directed by the OTC Modeling Committee which consisted of the following workgroups: OTC Photochemical Workgroup, OTC Meteorological Modeling Workgroup, OTC Emissions Inventory Development Workgroup, and the OTC Control Strategy Workgroup.

The OTC Air Directors served on the OTC Oversight Committee and provided oversight of the process.

Table 12-1 identifies all jurisdictions within the 8-hour ozone Philadelphia NAA.

Table 12-1 Jurisdictions Within the 8-Hour Ozone Philadelphia NAA

Jurisdiction	Counties	Classification	Attainment Date
Maryland	Cecil	Moderate	June 2010
Delaware	Kent New Castle Sussex[1]		
Pennsylvania	Bucks Chester Delaware Montgomery Philadelphia		
New Jersey	Atlantic[1] Burlington Camden Cape May[1] Cumberland Gloucester Mercer Ocean[1] Salem		

Notes:
[1] Counties added to the old 1-hour ozone Philadelphia NAA to comprise the new 8-hour ozone Philadelphia NAA.

Figure 12-1 provides a graphical representation of the 8-hour ozone Philadelphia NAA.

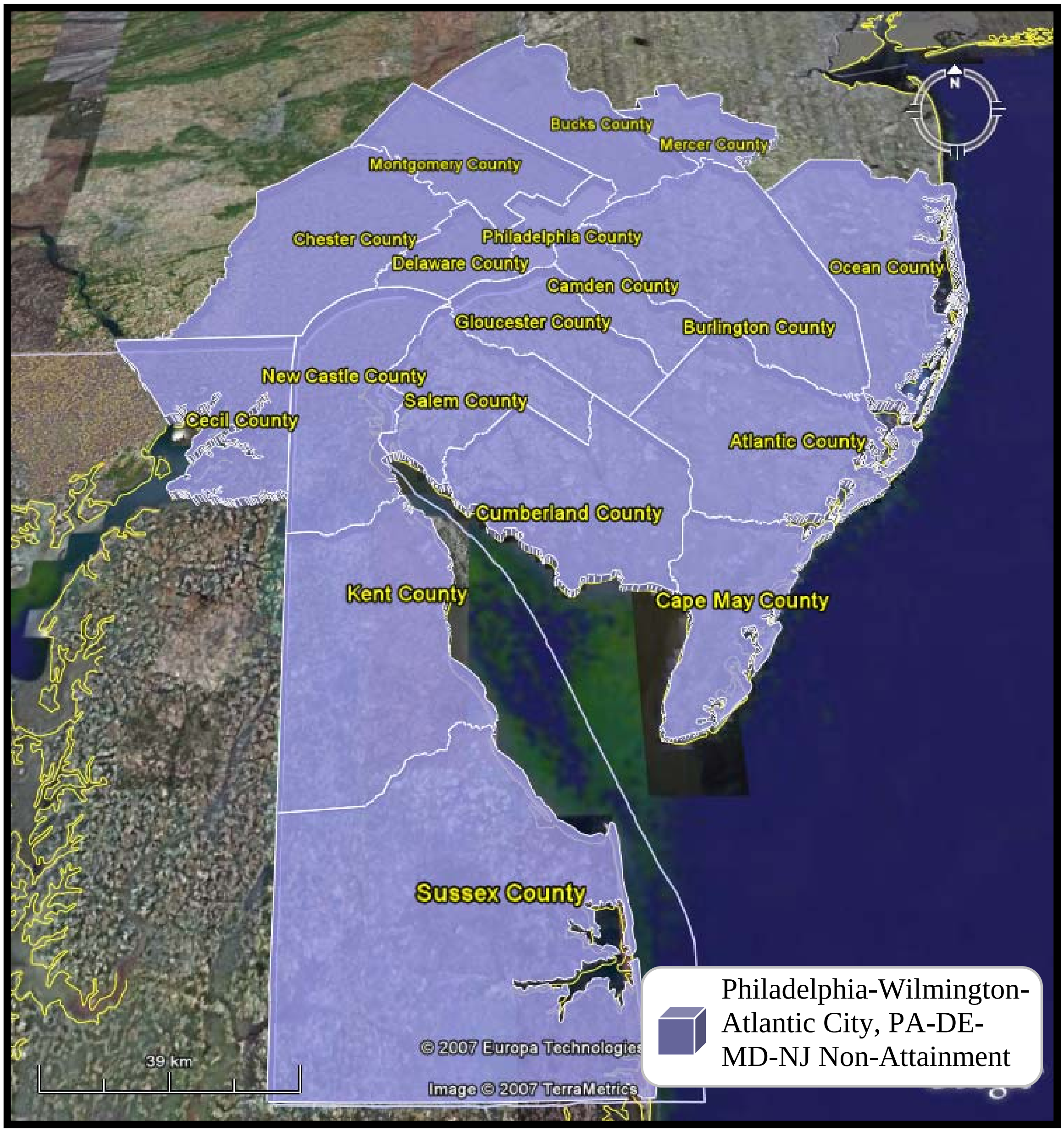


Figure 12-1 8-Hour Ozone Philadelphia NAA

The photochemical model selected for the attainment modeling demonstration was the EPA Models-3/Community Multi-scale Air Quality (CMAQ) modeling system, which is a "One-Atmosphere" photochemical grid model capable of addressing ozone at a regional scale and is considered one of the preferred models for regulatory modeling applications. The modeling analyses set forth in this report have been conducted in accordance with the Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze (Draft 3.2- September 2006).

Relationship to Regional Modeling Protocols

The states of Maryland, Delaware, Pennsylvania and New Jersey are all members of the OTC and along with other member OTC states were able to coordinate the modeling analyses performed for the Philadelphia NAA with the regional modeling analysis conducted by the OTC Modeling Committee.

The lead agency for coordinating the running of the CMAQ model and performing the modeling runs for the OTC was the New York State Department of Environmental Conservation (NYSDEC). Modeling centers for the OTC included the NYSDEC, the University of Maryland at College Park (UMD), and the Northeast States for Coordinated Air Use Management (NESCAUM), the NJDEP and the Virginia Department of Environmental Quality (VADEQ). The lead modeling agency for coordinating the running of the CMAQ model for the OTC and performing the modeling runs was the NYSDEC, but member states of the OTC within the frame work of the OTC managed the modeling project jointly. All additional modeling for the Philadelphia NAA was directed by MDE, DE DNREC, PA DEP, Philadelphia AMS, and the NJ DEP and performed by NJ DEP and UMD under contract with the MDE.

All OTC modeling inventories were developed, updated and shared among the OTC states modeling centers and were provided by MARAMA.

Installation of the CMAQ model at all participating modeling centers was completed and diagnostic procedures were run successfully. The CMAQ model has been benchmarked against other modeling platforms across the OTR to ensure accurate results.

The OTC modeling committee oversaw the modeling effort and reported to the OTC Oversight Committee through regular briefings and presentations, and when needed offered additional information in cases where specific technical decisions had policy implications. MDE were members of the various OTC committees to ensure that the Philadelphia NAA ozone modeling protocol followed the same analyses being conducted by the OTC. Provided in Appendix H-1 is the Philadelphia NAA ozone modeling protocol.

Conceptual Description

EPA recommends that a conceptual description of an area's ozone problem be developed prior to the initiation of any air quality modeling study. A "conceptual description" is a qualitative way of characterizing the nature of an area's non-attainment problem. Within the conceptual description of a particular modeling exercise, it is recommended that the specific meteorological parameters that influence air quality be identified and qualitatively ranked in importance.

The conceptual description for this study was prepared by the NESCAUM for use by the OTR member States. The conceptual description document, The Nature of the Ozone Air Quality Problem in the Ozone Transport Region: A Conceptual Description (NESCAUM, October 2006), is provided in Appendix H-2. This document provides the conceptual description of the ozone problem in the OTR states, consistent with the EPA's guidance.

12.2 Domain and Data Base Issues

Episode Selection

The procedures for selecting 8-hour ozone modeling episodes seek to achieve a balance between the best possible science and regulatory needs and constraints. Modeling episodes, once selected, influence technical and policy decisions for many years. Clearly, both the direct and implicit procedures used in selecting episodes warrant full consideration.

The rationale for the selection of 2002 meteorology as input to the air quality simulations includes a qualitative analysis (Ryan and Piety 2002) and a quantitative analysis (Environ 2005). These documents are provided in Appendix H-3.

Recent research has shown that model performance evaluations and the response to emissions controls need to consider modeling results over long time periods, in particular full synoptic cycles or even full ozone seasons. Based on this factor the entire ozone season was simulated for the 2002 and 2009 State Implementation Plan (SIP) modeling runs (May 1 to September 30). As a result, the total number of days examined for the complete ozone season far exceeds EPA recommendations, and provides for better assessment of the simulated pollutant fields.

Size of the Modeling Domain

In defining the modeling domain, one must consider the location of the local urban area, the downwind extent of the elevated ozone levels, the location of large emission sources, and the availability of meteorological and air quality data. The domain or spatial extent to be modeled includes as its core the NAA. Beyond this, the domain includes enough of the surrounding area such that major upwind sources fall within the domain and emissions produced in the NAA remain within the domain throughout the day.

The boundaries of the OTC modeling domain are provided in Appendix H-4. This domain covers the Northeast region, including the northeastern, central and southeastern US as well as Southeastern Canada. The final SIP modeling analysis utilized this modeling domain.

Horizontal Grid Size

The OTC platform provided the basic platform for the Philadelphia NAA modeling analysis and utilized a coarse grid continental United States (US) domain with a 36 km horizontal grid resolution. The CMAQ domain is nested in the MM5 domain. A larger MM5 domain was selected for the MM5 simulations to provide a buffer of several grid cells around each boundary of the CMAQ 36 km domain. This was designed to eliminate any errors in the meteorology from boundary effects in the MM5 simulation at the interface of the MM5 model. A 12 km inner domain was selected to better characterize air quality in OTR and surrounding Regional Planning Organization (RPO) regions. Appendix H-5 contains the horizontal grid definitions for the MM5 and CMAQ modeling domains.

Vertical Resolution

The vertical grid used in the CMAQ modeling was primarily defined by the MM5 vertical structure. The MM5 model employed a terrain following coordinate system defined by pressure. The layer averaging scheme adopted for CMAQ is designed to reduce the computational cost of the CMAQ simulations. Only the uppermost layers of the CMAQ domain were coalesced. All layers in the planetary boundary layer were left undisturbed in moving from the MM5 to the CMAQ simulation. This ensures that the near-surface processes that affect air pollution the most are faithfully represented in CMAQ, while the meteorological systems that are driven by upper-level winds are allowed to develop properly in MM5. The effects of layer averaging have a relatively minor effect on the model performance metrics when compared to ambient monitoring data.

Appendix H-6 contains the vertical layer definitions for the MM5 and CMAQ modeling domains.

Initial and Boundary Conditions

The objective of a photochemical grid model is to estimate the air quality given a set of meteorological and emissions conditions. When initializing a modeling simulation, the exact concentration fields are not known in every grid cell for the start time. Therefore, typically photochemical grid models are started with clean conditions within the domain and allowed to stabilize before the period of interest is simulated. In practice this is accomplished by starting the model several days, call spin-up time, prior to the period of interest.

The winds move pollutants into, out of, and within the domain. The model handles the movement of pollutants within the domain and out of the domain. An estimate of the concentration of pollutants at the edge of the domain and therefore the quantity of pollutants moving into the domain is needed. These are called boundary conditions. The 12 km grid boundary conditions were extracted from the 36 km CMAQ simulation. To estimate the boundary conditions for the modeling study, boundary conditions for the outer 36 km domain were derived every three hours from an annual model run performed by researchers at Harvard University using the GEOS-CHEM global chemical transport model (Moon and Byun 2004, Baker 2005). The influence of boundary conditions was minimized by using a 15-day spin-up period, which is sufficient to establish pollutant levels that are encountered in the Eastern U.S. Additional information on the extraction of boundary conditions is provided in Appendix H-7.

Meteorological Model Selection and Configuration

The Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) Mesoscale Meteorological Model (MM5) version 3.6 was used to generate the annual 2002 meteorology for the OTC modeling analysis. The MM5 model is a non-hydrostatic, prognostic meteorological model routinely used for urban- and regional-scale photochemical regulatory modeling studies. Professor Da-Lin Zhang (UMD) performed the MM5 modeling in consultation with the NYSDEC and MDE staff.

A more detailed description and performance evaluation of the MM5 modeling results are provided in Appendix H-8. Based on model validation and sensitivity testing, the MM5 configurations provided in Appendix H-9 were selected.

Emissions Model Selection and Configuration

The Sparse Matrix Operator Kernel Emissions (SMOKE) Emissions Processing System was selected for the OTC modeling analysis. SMOKE is principally an emissions processing system and not a true emissions inventory preparation system in which emissions estimates are simulated from ‘first principles’. This means that, with the exception of mobile and biogenic sources, its purpose is to provide an efficient, modern tool for converting emissions inventory data into the formatted emissions files required for a photochemical air quality model.

Inside the OTR, the emissions inventories prepared for the modeling analyses were developed through a coordinated effort between the OTR states and the Mid-Atlantic Northeast Visibility Union (MANE-VU) Regional Planning Organization (RPO). The 2002 emissions were first generated by the individual OTR states. These inventories were then assembled and processed through the MANE-VU RPO. The 2002 emissions for non-OTR areas within the modeling domain were obtained from other RPOs for their corresponding areas. These RPOs included the Visibility Improvement State and Tribal Association of the Southeast (VISTAS), the Midwest Regional Planning Organization (MRPO) and the Central Regional Air Planning Association (CENRAP). These emissions were then processed by the NYSDEC using the SMOKE (Version 2.1) processor to provide inputs for the photochemical model. Wherever possible, the mobile source emission inventories (in VMT format) were replaced with SCC-specific county level emissions to more accurately reflect actual emissions for typical ozone season day

The emissions inventories included a base case (2002), which serves as the “parent” inventory off which all future year inventories (i.e., 2009) are based. The future year emissions inventories include emissions growth due to projected increases in economic activity as well as the emissions reductions due to the implementation of control measures.

A detailed description of all SMOKE input files such as area, mobile, fire, point and biogenic emissions files and the SMOKE model configuration are provided in Appendix H-10.

Air Quality Model Selection and Configuration

EPA's Models-3/Community Multi-scale Air Quality (CMAQ) modeling system was selected for the attainment demonstration primarily because it is a "one-atmosphere" photochemical grid model capable of addressing ozone on a regional scale and is considered one of the preferred models for regulatory modeling applications. The model is also recommended by the Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze (Draft 3.2- September 2006).

The CMAQ configuration is provided in Appendix H-11.

Quality Assurance

All air quality, emissions, and meteorological data were reviewed to ensure completeness, accuracy, and consistency before proceeding with modeling. Any errors, missing data or inconsistencies, were addressed using appropriate methods that are consistent with standard practices. All modeling was benchmarked through the duplication of a set of standard modeling results across different modeling centers.

Quality Assurance (QA) activities were carried out for the various emissions, meteorological, and photochemical modeling components of the modeling study. Emissions inventories obtained from the RPOs were examined to check for errors in the emissions estimates. When such errors were discovered, the problems in the input data files were corrected, and the models were run again.

The MM5 meteorological model and CMAQ air quality model inputs and outputs were plotted and examined to ensure sufficiently accurate representation of the observed data in the model-ready fields, and temporal and spatial consistency and reasonableness. Both MM5 and CMAQ underwent operational and scientific evaluations in order to facilitate the quality assurance review of the meteorological and air quality modeling procedures and are discussed in greater detail throughout this document.

12.3 Model Performance Evaluation

Overview

There are many aspects of model performance. This section will focus primarily on the methods and techniques recommended by EPA for evaluating the performance of the air quality model. It should be noted that other parts of the modeling process, the emissions and meteorology, also undergo an evaluation. It is with this knowledge and the desire to keep the report concise, that the air quality model became the primary focus of this section.

The first step in the modeling process is to verify the model's performance in terms of its ability to predict ozone in the right locations and at the right levels. To do this, model predictions for the base year simulation are compared to the ambient data observed in the historical episode. This verification is a combination of statistical and graphical evaluations. If the model appears to be predicting ozone in the right locations for the right reasons, then the model can be used as a predictive tool to evaluate various control strategies and their effects on ozone. The purpose of the model performance evaluation is to assess how accurately the model predicts ozone levels observed in the historical episode and to use the knowledge of CMAQ's performance to put CMAQ's predictions of future year air quality in the appropriate context so that future policy decisions are informed by CMAQ's predictions and its performance.

The results of a model performance evaluation were examined prior to using CMAQ's results to support the attainment demonstration. The performance of CMAQ was evaluated using both operational and diagnostic methods. Operational evaluation refers to the model's ability to replicate observed concentrations of ozone and/or precursors (surface and aloft), whereas diagnostic evaluation assesses the model's accuracy with respect to characterizing the sensitivity of ozone to changes in emissions (i.e., relative response factors).

UMD performed an analysis to assess how well the CMAQ model simulated the 2002 base case. This analysis compared the 2002 CMAQ modeling results with surface measurements and aloft ozone measurements obtained from the UMD aircraft. This analysis (Comparison of CMAQ Calculated Ozone to Surface and Aloft Measurements) is provided in the Weight-of-Evidence Chapter 11 of this document.

The NYSDEC conducted a performance evaluation of the 2002 base case CMAQ simulation (May 15-September 30) on behalf of the OTR member States. Appendix H-12 provides comprehensive operational and diagnostic evaluation results, including spreadsheets containing the assumptions made to compute statistics. Highlights of this evaluation are provided in the following sections.

Diagnostic and Operational Evaluation

The issue of model performance goals for ozone is an area of ongoing research and debate. To evaluate model performance, EPA recommends that several statistical metrics be calculated for air quality modeling. Two of the common metrics that are most often used to assess performance are the mean normalized gross error and the mean normalized bias. The mean normalized gross error parameter provides an overall assessment of model performance and can be interpreted as precision, and the mean normalized bias parameter measures a model's ability to reproduce observed spatial and temporal patterns and can be interpreted as accuracy. EPA suggests the following criteria: a mean normalized gross error (MNGE) of < 35%, and a mean normalized bias (MNB) of < ±15% above a threshold of 40-60 ppb. These results are presented in Table 12-2 for the Philadelphia NAA and in Tables 12-3 and 12-4 on a monitor-by-monitor basis averaged over all days for the 40 ppb and 60 ppb thresholds. Figure 12-2 shows the location of the monitors in the Philadelphia NAA.

Table 12-2 Philadelphia NAA Statistics for 8-hour Ozone

Location	Ozone Cutoff Threshold (ppb)	Mean Normalized Gross Error (MNGE) (%)	Mean Normalized Bias (MNB) (%)
Philadelphia NAA	40	12.94	-1.11
	60	11.90	-7.12

Table 12-3 Individual Site Statistics for 8-hour Ozone using 40 ppb Cutoff

AIRS ID	Site Name	County	State	MNGE (%)	MNB (%)
240150003	Fairhill	Cecil	MD	12.57	0.13
100031010	Brandywine Creek	New Castle	DE	11.57	-4.06
100031013	Bellefonte	New Castle	DE	12.27	4.47
100031007	Lums Pond	New Castle	DE	14.60	9.40
100010002	Killens Pond	Kent	DE	11.58	-2.12
100051003	Lewes	Sussex	DE	11.61	-0.09
100051002	Seaford	Sussex	DE	12.77	-5.21
420170012	Bristol	Bucks	PA	12.65	-0.06
420450002	Chester	Delaware	PA	13.31	-4.83
420290050	West Chester	Chester	PA	12.36	-6.87
420290100	New Garden	Chester	PA	14.15	-9.27
420910013	Norristown	Montgomery	PA	11.98	1.36
421010136	Elmwood	Philadelphia	PA	13.93	8.49
421010004	Lab	Philadelphia	PA	25.00	22.89
421010014	Roxborough	Philadelphia	PA	13.91	-3.48
421010024	Northeast Airport	Philadelphia	PA	14.20	-8.42
340071001	Ancora	Camden	NJ	11.32	-3.60
340070003	Camden	Camden	NJ	12.20	-4.57
340150002	Clarksboro	Gloucester	NJ	12.27	-4.86

AIRS ID	Site Name	County	State	MNGE (%)	MNB (%)
340110007	Millville	Cumberland	NJ	11.98	1.41
340010005	Nacote Creek	Atlantic	NJ	11.78	5.14
340290006	Colliers Mills	Ocean	NJ	13.31	-3.23
340210005	Rider	Mercer	NJ	12.79	-1.80

Table 12-4 Individual Site Statistics for 8-hr Ozone using 60 ppb Cutoff

AIRS ID	Site Name	County	State	MNGE (%)	MNB (%)
240150003	Fairhill	Cecil	MD	11.08	-6.58
100031010	Brandywine Creek	New Castle	DE	10.91	-9.07
100031013	Bellefonte	New Castle	DE	9.67	-0.21
100031007	Lums Pond	New Castle	DE	11.04	1.66
100010002	Killens Pond	Kent	DE	11.84	-9.47
100051003	Lewes	Sussex	DE	10.92	-7.26
100051002	Seaford	Sussex	DE	13.88	-12.41
420170012	Bristol	Bucks	PA	11.85	-6.29
420450002	Chester	Delaware	PA	13.00	-9.07
420290050	West Chester	Chester	PA	12.72	-11.53
420290100	New Garden	Chester	PA	15.38	-14.26
420910013	Norristown	Montgomery	PA	9.26	-2.73
421010136	Elmwood	Philadelphia	PA	10.98	4.34
421010004	Lab	Philadelphia	PA	21.07	18.03
421010014	Roxborough	Philadelphia	PA	12.21	-5.86
421010024	Northeast Airport	Philadelphia	PA	14.85	-12.77
340071001	Ancora	Camden	NJ	10.55	-9.06
340070003	Camden	Camden	NJ	11.68	-6.82
340150002	Clarksboro	Gloucester	NJ	11.90	-8.84
340110007	Millville	Cumberland	NJ	10.66	-7.58
340010005	Nacote Creek	Atlantic	NJ	8.28	-1.42
340290006	Colliers Mills	Ocean	NJ	13.77	-11.57
340210005	Rider	Mercer	NJ	11.58	-8.37

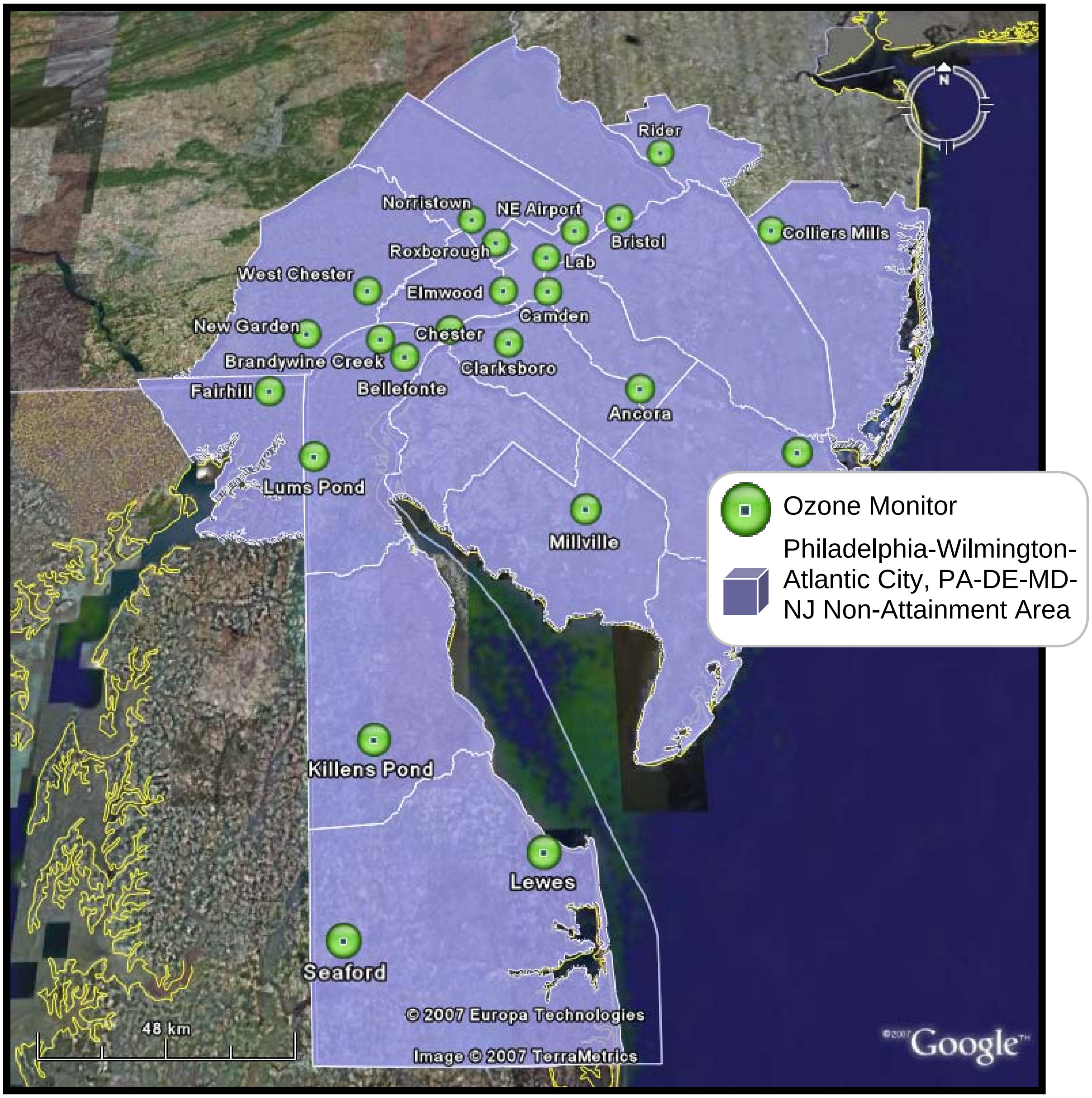


Figure 12-2 Locations of Ozone Monitors in the Philadelphia NAA

The following statistics for the OTR domain have also been provided in Appendix H-12.

1. Archive file containing 8-hour average observed and predicted ozone organized by state.
2. Observed and predicted composite diurnal variations of selected species, including but not limited to ozone at SLAMS/NAMS sites, ozone at CASTNet and other sites, VOC species such as ethene, isoprene, formaldehyde and gas phase compounds such as CO, NO and NO_2.
3. Statistical evaluation of daily maximum 8-hour ozone at SLAMS/NAMS sites and CASTNet/other sites; statistics are computed using two different thresholds for observed

daily maximum ozone of 40 and 60 ppb. Statistics are computed by date (all sites on a given day) and by site (one site over all days).

4. Statistical evaluation of daily maximum 8-hour ozone at SLAMS/NAMS sites that fall within non-attainment counties; statistics are computed by non-attainment area.
5. Statistical evaluation of daily average CO, NO, NO_2, and SO_2 at SLAMS/NAMS and other sites; statistics are computed by date and by site.
6. Statistical evaluation of daily average ethene, isoprene, and formaldehyde at SLAMS/NAMS and other sites; statistics are computed by date and by site.
7. Plots of composite time series for daily max 8-hour ozone, root mean square error and mean bias for illustrative purposes.
8. Maps of daily 8-hour maximum predicted ozone across the modeling domain compared with actual observations.

<u>Summary of Model Performance</u>

The CMAQ model was employed to simulate ozone for the 2002 season (May through September). A comparison of the temporal and spatial distributions of ozone and its precursors was conducted for the study domain, with additional focus placed on performance in the Philadelphia NAA.

The CMAQ model performance for surface ozone is quite good with low bias and error. Model performance is generally consistent from day to day. The results of the 2002 ozone season show that the modeling system tends to over-predict minimum concentrations and slightly under-predict peak concentrations. The over-prediction of minimum concentrations is not of great regulatory concern since attainment tests are based on the application of relative response factors to daily peak concentrations. Prediction of minimum concentrations is still important to appropriately model regional transport and nighttime ozone removal processes in order to accurately estimate peak concentrations.

The model performance for the Philadelphia NAA averaged over all stations and all days meet the guidelines suggested by EPA. Applying those criteria to individual days is a much more stringent test that is not required by EPA. If those long-term average standards are applied to daily performance, those criteria for acceptable model performance are met on most individual days as well.

No significant differences in model performance for ozone and its precursors were encountered across different areas of the OTR. While there are some differences in the spatial data among sub-regions, there is nothing to suggest a tendency for the model to respond in a systematically different manner between regions. Examination of the statistical metrics by sub-region confirms the absence of significant performance problems arising in one area but not in another, building confidence that the CMAQ modeling system is operating consistently across the full OTR domain.

The evaluations discussed above show that the modeling system is doing a good job of appropriately estimating 8-hour average surface ozone throughout the OTR and in the Philadelphia NAA. This confidence in the modeling results allows the modeling system to be used to support the development of emissions control scenarios and the State Implementation Plan (SIP) to meet the 8-hour ozone NAAQS.

As stated previously, the model performance for the 2002 ozone season meets all EPA guidelines and thus demonstrates that the modeling platform is appropriate for modeling emissions control scenarios for the Philadelphia NAA 8-hr ozone SIP. At the same time it must be remembered that CMAQ has been evaluated by using measures that reflect its ability to represent average conditions instead of its ability to respond to changes in emissions. Thus it is likely that although CMAQ has met the traditional performance measures as stated in EPA guidance, it may in fact under predict the magnitude of ozone changes due to various control measures being modeled. This means future year (i.e., 2009) modeling results should be viewed not in the traditional sense as being exact, but should be seen as an upper limit.

Provided in the Weight-of-Evidence Chapter 11 (are sections on the Comparison of CMAQ – Calculated Ozone to Surface and Aloft Measurements, A Summary of the 2002 Base Case and 2009 Future Base Case CMAQ Runs, Analysis of the Details of CMAQ 4.5 Chemistry, and Uncertainty in CMAQ and Over Predictions of Future Year Ozone Design Values) of this document is additional information on the uncertainty in the CMAQ model and over predictions of future year ozone design values.

12.4 Attainment Demonstration

Overview

The 8-hour ozone standard attainment demonstration analyzes the potential of the Philadelphia NAA to achieve attainment of the 8-hour ozone standard. The demonstration of achieving the 8-hour ozone standard is based on both the CMAQ modeling results and a number of Weight-of-Evidence analyses (provided in Chapter 11) that support the attainment modeling results. Details of the CMAQ modeling are provided in the following sections.

Modeling Attainment Test

The modeled attainment test applied at each monitor was performed using the following equation:

$(DVF)_I = (RRF)_I \ (DVB)_I$

Where:

$(DVB)_I$ = the baseline concentration monitored at site I, in ppb
$(RRF)_I$ = the relative response factor, calculated near site I
$(DVF)_I$ = the estimated future design value for the time attainment is required, in ppb.

The future design value for each monitor in the Philadelphia NAA is provided in Table 12-5 and in Figure 12-3.

Table 12-5 Modeling Attainment Test Using EPA Preferred Methodology

AIRS ID	Site Name	County	State	DVB	RRF	DVF
240150003	Fairhill	Cecil	MD	97.7	0.831	81
100031010	Brandywine Creek	New Castle	DE	92.7	0.875	81
100031013	Bellefonte	New Castle	DE	90.3	0.873	78
100031007	Lums Pond	New Castle	DE	94.5	0.843	79
100010002	Killens Pond	Kent	DE	88.3	0.891	78
100051003	Lewes	Sussex	DE	87.0	0.893	77
100051002	Seaford	Sussex	DE	90.0	0.843	75
420170012	Bristol	Bucks	PA	99.0	0.896	88
420450002	Chester	Delaware	PA	91.7	0.885	81
420290050	West Chester	Chester	PA	95.0	0.868	82
420290100	New Garden	Chester	PA	94.7	0.835	79
420910013	Norristown	Montgomery	PA	92.3	0.883	81
421010136	Elmwood	Philadelphia	PA	83.0	0.905	75
421010004	Lab	Philadelphia	PA	71.3	0.906	64
421010014	Roxborough	Philadelphia	PA	90.7	0.911	82

AIRS ID	Site Name	County	State	DVB	RRF	DVF
421010024	Northeast Airport	Philadelphia	PA	96.7	0.901	87
340071001	Ancora	Camden	NJ	100.7	0.872	87
340070003	Camden	Camden	NJ	98.3	0.898	88
340150002	Clarksboro	Gloucester	NJ	98.3	0.898	88
340110007	Millville	Cumberland	NJ	95.7	0.847	81
340010005	Nacote Creek	Atlantic	NJ	89.0	0.874	77
340290006	Colliers Mills	Ocean	NJ	105.7	0.868	91
340210005	Rider	Mercer	NJ	97.0	0.889	86

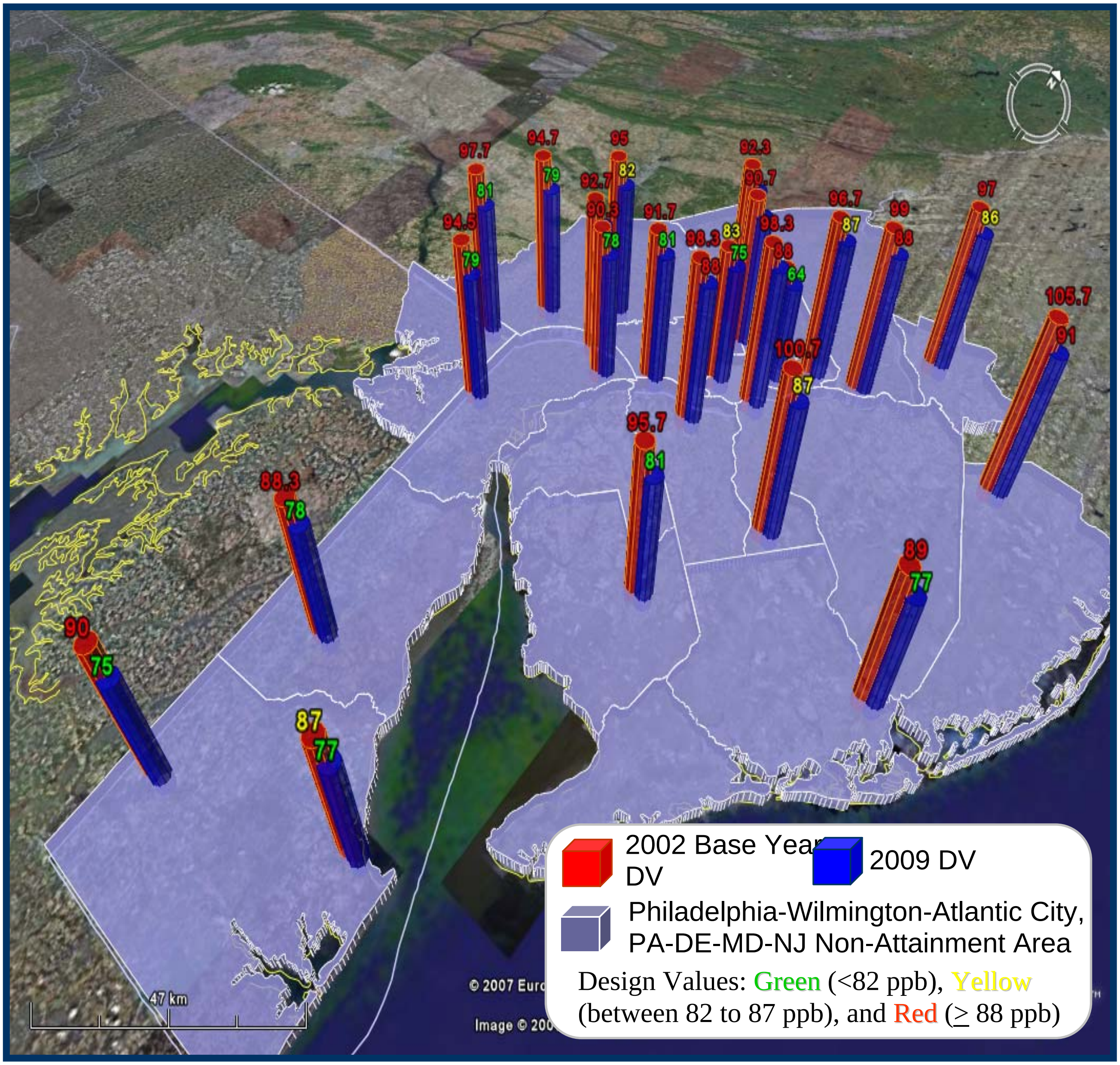


Figure 12-3 Philadelphia NAA 8-Hour Ozone Base Year (2002) and Future Year (2009) Design Values

Current design values were calculated using the EPA approved method of averaging the three design value periods that include the baseline inventory year. Specifically, the average design value was calculated using the 2000-2002, 2001-2003, and 2002-2004 periods.

In the event that there were less than five years of available data at a monitoring site the following procedure was used:

1. 3 years of data - The current design value was based on a single design value.
2. 4 years of data - The current design value was based on an average of two design value periods.
3. Less than 3 years of data – The site was not used in the attainment test.

A 3x3 array of grid cells surrounding each monitor was used in the modeled attainment test as recommended by EPA for 12 km grid resolution modeling to calculate RRFs.

The predicted 8-hour daily maximum ozone concentrations from each modeled day were used in the modeled attainment test, with the nearby grid cell with the highest predicted 8-hour daily maximum ozone concentration with baseline emissions for each day considered in the test, and the grid cell with the highest predicted 8-hour daily maximum ozone concentration with the future emissions for each day in the test.

The RRFs used in the modeled attainment test were computed by taking the ratio of the mean of the 8-hour daily maximum predictions in the future to the mean of the 8-hour daily maximum predictions with baseline emissions, over all relevant days, as defined below.

The following rules were applied to determine the number of days and the minimum threshold at each ozone monitor:

1. If there were 10 or more days with daily maximum 8-hour average modeled ozone > 85 ppb an 85 ppb threshold was used.
2. If there were less than 10 days with daily maximum 8-hour average modeled ozone > 85 ppb, the threshold was reduced in 1 ppb increments to as low as 70 ppb, until there were 10 days in the mean RRF calculation.
3. If there were less than 10 days but more than 5 days with daily maximum 8-hour average modeled ozone > 70 ppb, then all days > 70 ppb were used.
4. No RRF calculations were performed for sites with less than 5 days > 70 ppb.

Provided in Appendix H-13 is additional information on the RRF and the modeled attainment test.

Unmonitored Area Analysis

An “unmonitored area analysis” using model adjusted spatial fields was performed. The basic steps of this process were as follows:

1. Interpolated ambient ozone design value data to create a set of spatial fields.
2. Adjusted the spatial fields using gridded model output gradients (base year values).
3. Applied gridded model RRFs to the model adjusted spatial fields.
4. Determined if any unmonitored areas are predicted to exceed the NAAQS in the future.

Recommended EPA guidance was utilized in the “unmonitored area analysis”.
Provided in Figure 12-4 is a map showing the spatially interpolated extent of 8-hour ozone above the NAAQS in the Philadelphia NAA based on a future case (2009) modeling simulation.

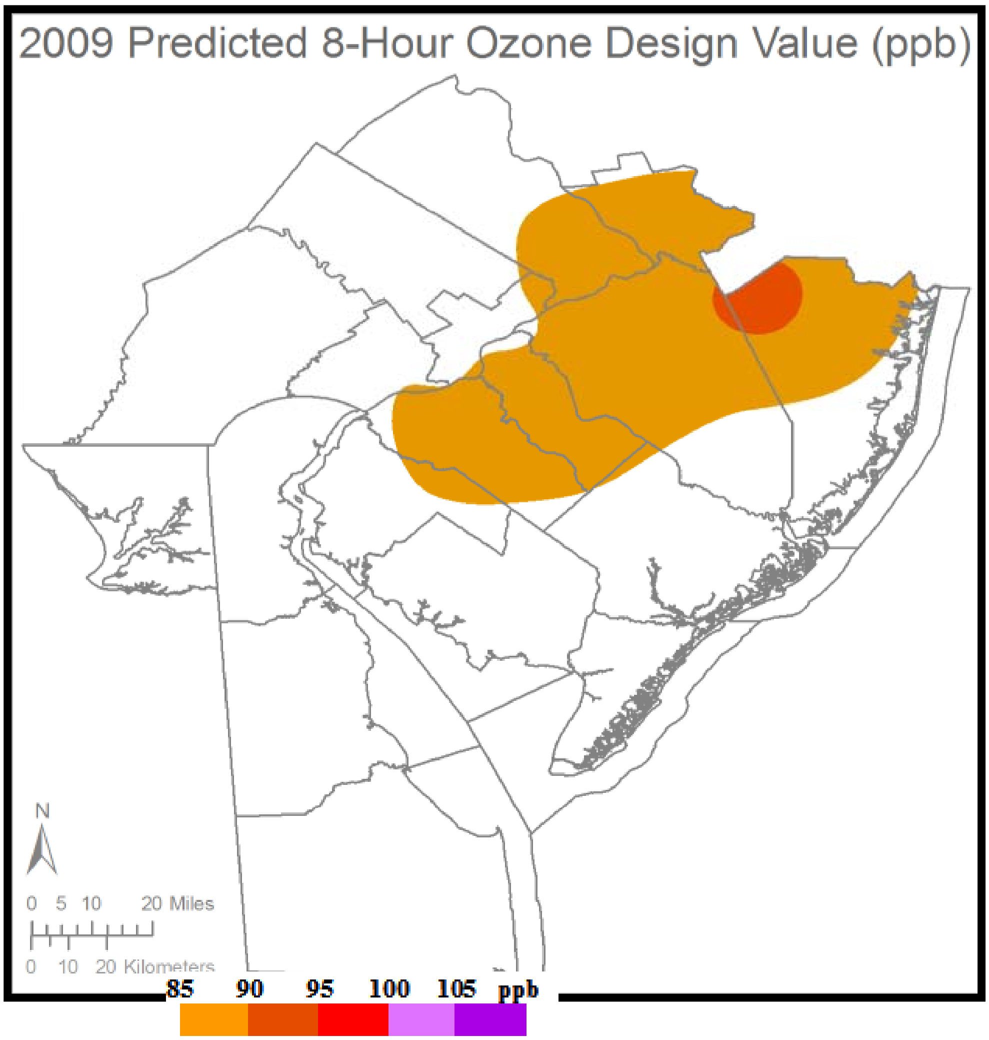


Figure 12-4 Spatially Interpolated Extent of the 8-Hour Ozone in the Philadelphia NAA Using Predicted 2009 Design Values

In Figure 12-4 the clear areas within the Philadelphia NAA indicate the areas that will be below the 8-hour NAAQS of 85 ppb. Figure 12-4 clearly demonstrates that the Cecil County Maryland portion of the Philadelphia NAA is predicted to be in attainment of the 8-hour ozone NAAQS in 2009 as is a vast majority of the Philadelphia NAA.

<u>Emissions Inventories</u>

For areas with an attainment date of no later than June 15, 2010, the emission reductions need to be implemented no later than the beginning of the 2009 ozone season. A determination of attainment will likely be based on air quality monitoring data collected in 2007, 2008, and 2009. Therefore, the year to project future emissions should be no later than the last year of the three-year monitoring period; in this case 2009.

The 2002 base year emissions inventory were projected to 2009 using standard emissions projection techniques discussed previously and in Appendix 10. The 2009 inventories developed by MANE-VU were used in the attainment demonstration.

Emission inventory guidance documents were followed for developing future year inventories for point, area, mobile, and biogenic emissions. These procedures addressed projections of spatial, temporal, and chemical composition change between the base year and projection year.

The OTC selected several control strategies for evaluation in the attainment demonstration. These were selected from groups of strategies developed by the technical subcommittees responsible for identifying and developing the regulations and/or control measures.

Consideration was given to maintaining consistency with control measures likely to be implemented in other RPOs. Technology-based emission reduction requirements mandated by the Clean Air Act were also included in projecting future year emissions.

Provided in Appendix H-14 is additional information on the emissions used in future year modeling.

<u>Summary and Conclusions of Attainment Demonstration</u>

The results of the future year (2009) modeling simulation indicate that the maximum 8-hour ozone design value for the Maryland portion of the Philadelphia NAA will be in the range of 81 ppb at the Fairhill, MD Cecil County ozone monitor. This translates into an 8-hour ozone design value reduction of approximately 17 ppb from 2002 to 2009.

The same future year (2009) modeling simulation indicates that the maximum 8-hour ozone design value for the entire Philadelphia NAA will be in the range of 91 ppb at the Colliers Mills ozone monitor located in Ocean County New Jersey. This translates into an 8-hour ozone design value reduction of approximately 15 ppb. The significance of 91 ppb range is that it falls just outside the Weight of Evidence range of 82 to 87 ppb. According to EPA Guidance this means that the monitor might be able to demonstrate attainment if there is enough sufficient information in the form of a Weight-of-Evidence demonstration to indicate that the future year (2009) design value will be less than the 8-hour ozone NAAQS.

The Weight-of-Evidence demonstration (Chapter 11) presents numerous analyses from monitoring trends to the CMAQ model's inability to precisely predict the effects of future year emissions reductions on ambient concentrations of ozone. All the analyses combined present significant supplementary evidence to the future year (2009) modeling that the Philadelphia NAA design value will be below the 8-hour ozone NAAQS.

Presented in Figures 12-5, 12-6 and 12-7 are three maps of the Philadelphia NAA 8-hour ozone design values for 2002 (the base year), and the predicted 8-hour ozone design values for future years 2009 and 2102, respectively. In each map of the Philadelphia NAA, clear areas have 8-hour ozone design values below the NAAQS and the colored areas have design values that are equal to or exceed the 8-hour ozone NAAQS. These three design value maps clearly demonstrate the trend of improved air quality through 2012 and attainment of the 8-hour ozone NAAQS for a majority of the Maryland/Delaware/Pennsylvania/New Jersey region.

Presented in Figure 12-8 are the 2002 8-hour ozone design values and the predicted 8-hour ozone design values for future year 2012 for each ozone monitor in the Philadelphia NAA. These design values demonstrate that the trend of improved air quality continues into 2012 and within the range of attainment for the 8-hour ozone NAAQS.

Based on a combination of the future year (2009) modeling simulation results and the rigorous Weight-of-Evidence (Chapter 11) analyses there is over whelming evidence to demonstrate that the Philadelphia NAA will attain the 8-hour ozone NAAQS by June 15, 2010.

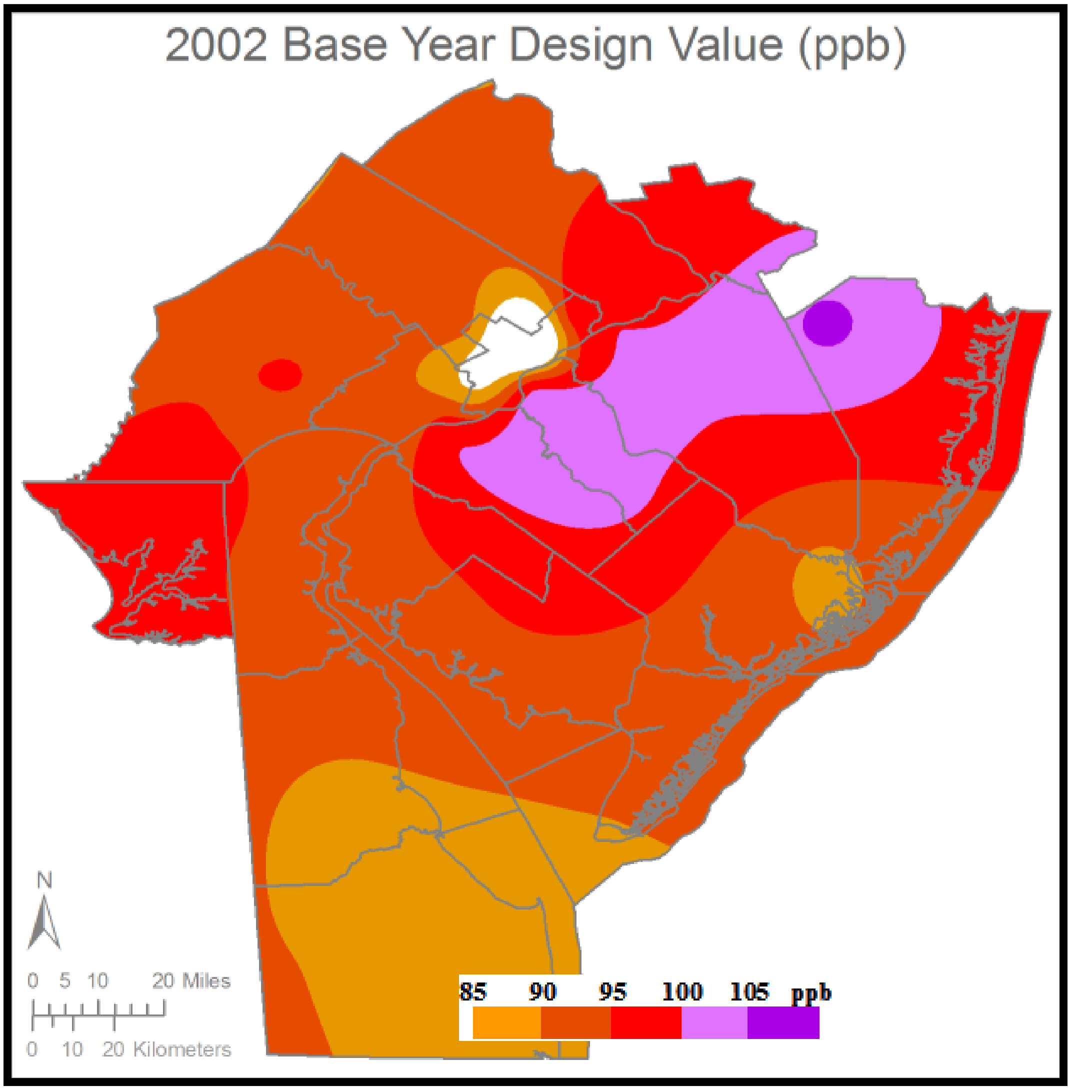


Figure 12-5 Spatially Interpolated Extent of the 8-Hour Ozone Within the Philadelphia NAA Using 2002 Base Year Design Values

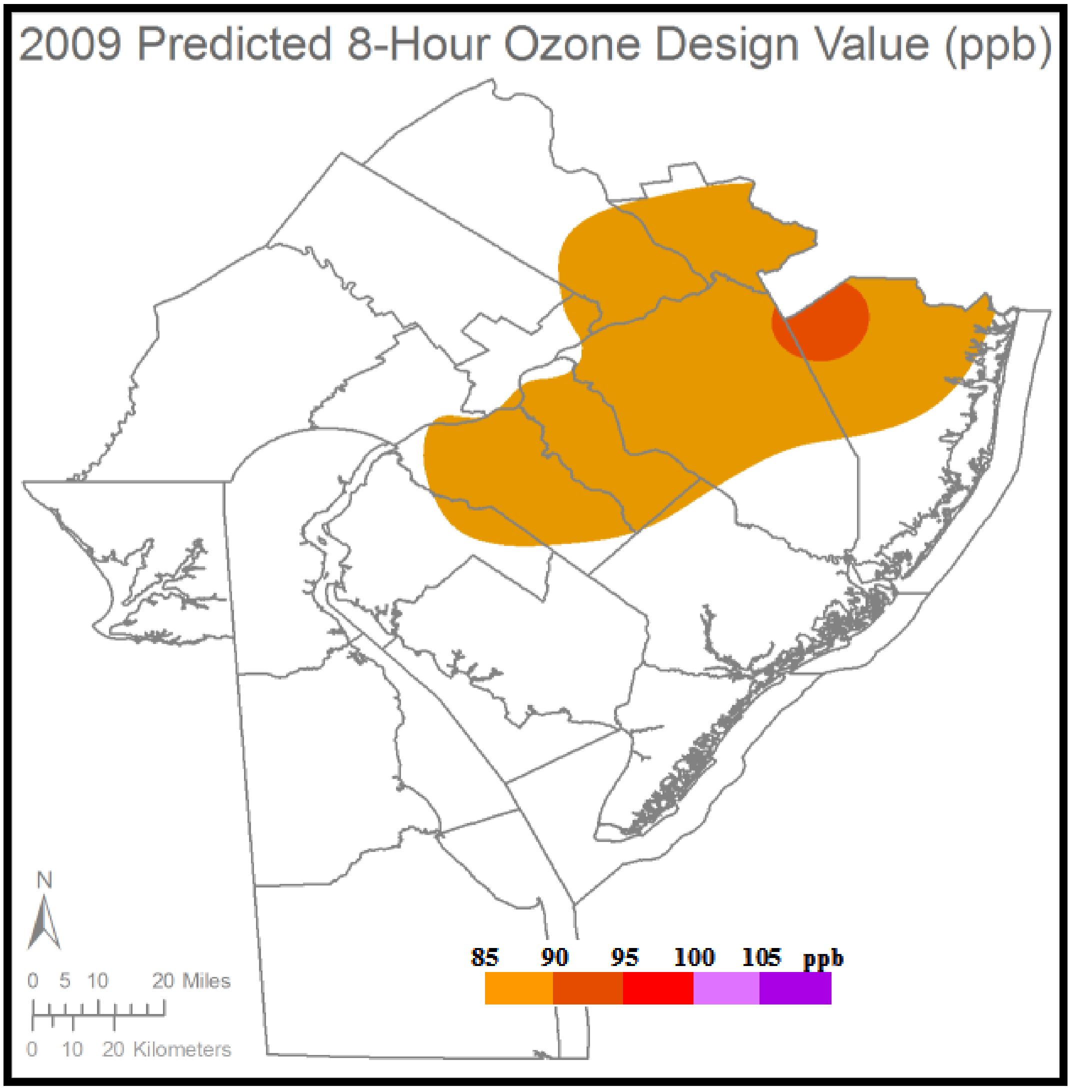


Figure 12-6 Spatially Interpolated Extent of the 8-Hour Ozone Within the Philadelphia NAA Using 2009 Predicted Future Year Design Values

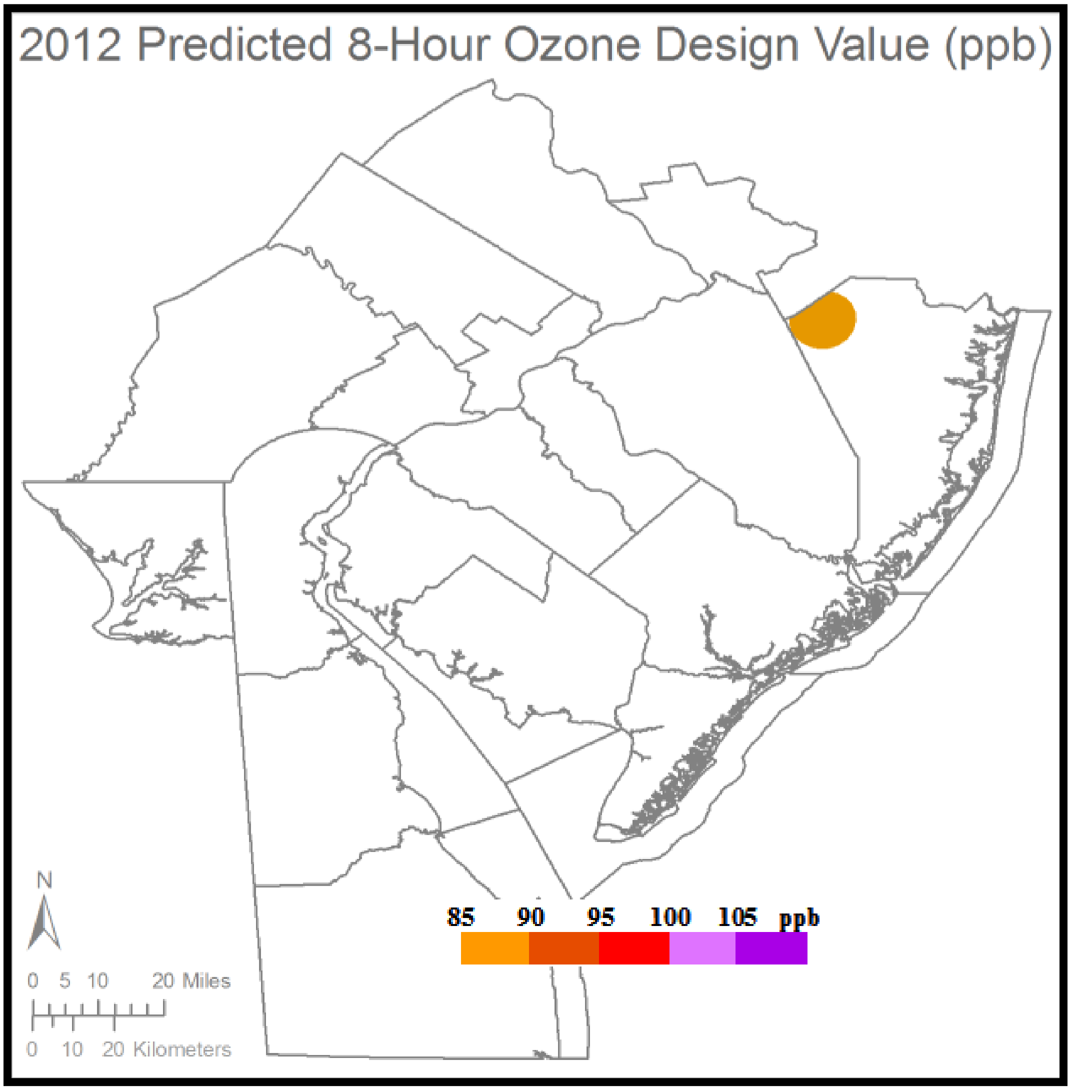


Figure 12-7 Spatially Interpolated Extent of the 8-Hour Ozone Within the Philadelphia NAA Using 2012 Predicted Future Year Design Values

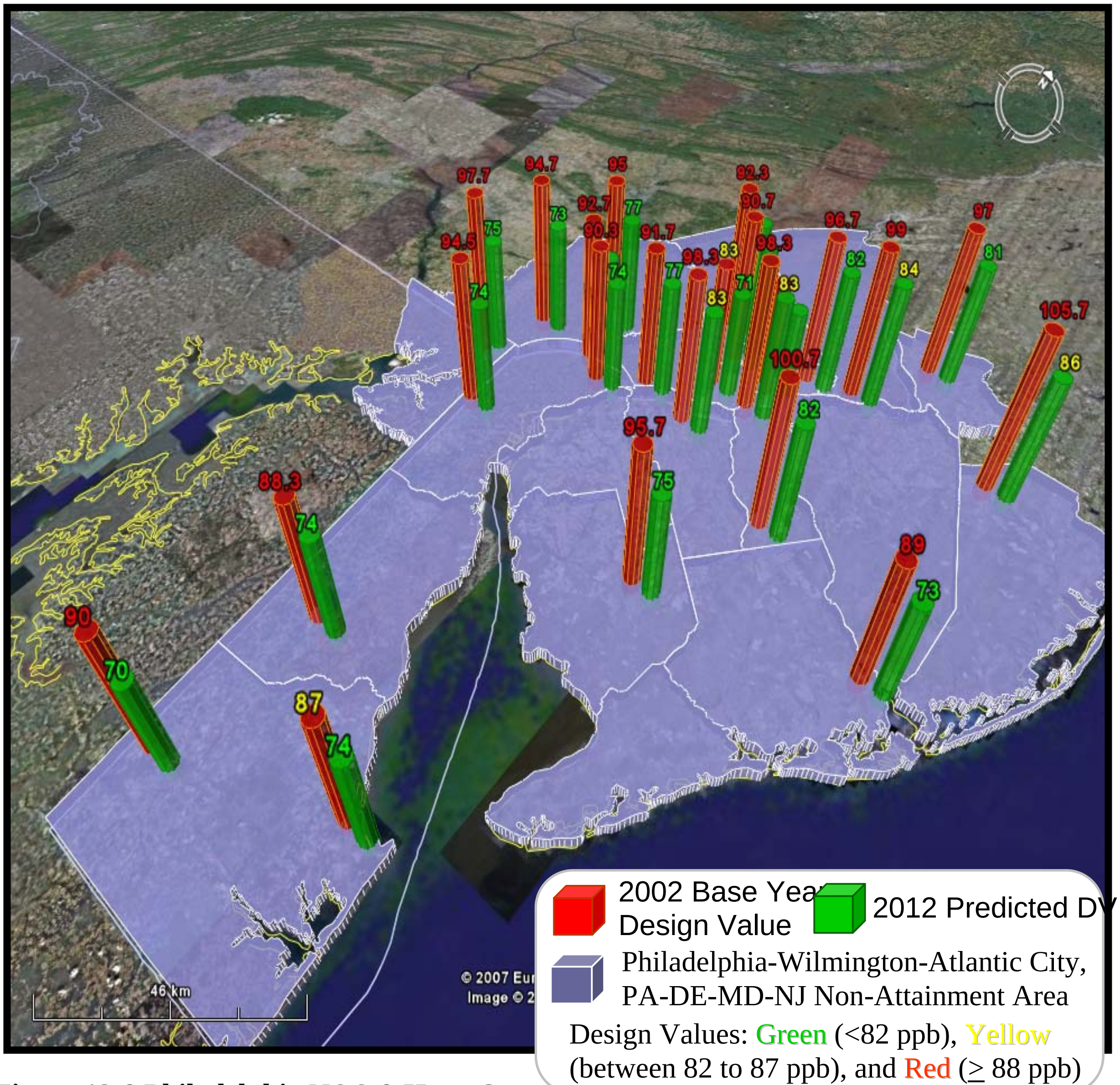


Figure 12-8 Philadelphia NAA 8-Hour Ozone Base Year (2002) and Predicted Future Year (2012) Design Values

12.5 Procedural Requirements

Reporting

Documents, technical memorandums, and data bases developed in this study are available for distribution as appropriate. This report contains the essential methods and results of the conceptual model, episode selection, modeling protocol, base case model development and performance testing, future year and control strategy modeling, quality assurance, weight of evidence analyses (Chapter 11), and calculation of 8-hr ozone attainment via EPA's relative response factor (RRF) methodology.

Data Archival and Transfer of Modeling Files

All relevant data sets, model codes, scripts, and related software required by any project participant necessary to corroborate the study findings (e.g., performance evaluations, control strategy runs) will be provided in an electronic format approved by the OTC Modeling Committee within the framework of the OTC. The OTC Modeling Committee has archived all modeling data relevant to this project. Transfer of data may be facilitated through the combination of a project website and the transfer of large databases via overnight mail. Database transfers will be accomplished using an ftp protocol for smaller datasets, and the use of IDE and Firewire disk drives for larger data sets.

GENERAL REFERENCES

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