Commonwealth of Pennsylvania
Department of Environmental Protection

State Implementation Plan Revision: Attainment Demonstration and Base Year Inventory

Bucks, Chester, Delaware, Montgomery and Philadelphia Counties located in the Philadelphia-Wilmington-Atlantic City, PA-NJ-DE Eight-Hour Ozone Nonattainment Area

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Executive Summary

In July 1997, the United States Environmental Protection Agency (EPA) revised the primary health-based national ambient air quality standard (NAAQS) "to provide increased protection to the public, especially children and other at risk populations against a wide range of ozone induced health effects including decreased lung function, primarily in children active outdoors; increased respiratory systems, particularly in highly sensitive individuals; hospital admissions and emergency room visits for respiratory causes, among children and adults with pre-existing respiratory disease such as asthma; inflammation of the lung, and possible long-term damage to the lungs." EPA indicated that the secondary standard would "provide increased protection to the public welfare against O_3-induced effects on vegetation, such as agricultural crop loss, damage to forests and ecosystems, and visible foliar injury to sensitive species." 62 Fed. Reg. 2 (July 18, 1997). The 8–hour standard was established at a level of 0.08 parts per million (ppm) averaged over eight hours.

Achieving and maintaining concentrations of ground-level ozone below the health-based standard eight-hour ozone NAAQS established by EPA is important because ozone is a serious human health threat, and can also cause damage to important food crops, forests, and wildlife. Ozone is not emitted directly into the atmosphere, but is formed by photochemical reactions between volatile organic compounds (VOCs) and oxides of nitrogen (NOx) in the presence of sunlight. Ozone is therefore primarily a summertime problem. EPA has established the maximum limit for ozone pollution allowed in the ambient air.

In June 2004, EPA designated seventeen areas (37 counties) in Pennsylvania eight-hour ozone nonattainment areas based on air quality monitoring data from 2001-2003. The Philadelphia-Wilmington-Atlantic City Nonattainment Area (Philadelphia Nonattainment Area) is comprised of 18 counties in Pennsylvania, New Jersey, Delaware and Maryland. Classified as a "moderate" nonattainment area, the Philadelphia Nonattainment Area is required to attain the eight-hour ozone NAAQS by June 15, 2010. Bucks, Chester, Delaware, Montgomery and Philadelphia counties (five-county Philadelphia area) in Pennsylvania are included in the Philadelphia Nonattainment Area.

This document contains information on ozone trends, emissions, and demonstrates that the five-county Philadelphia area meets all requirements necessary for an approvable State Implementation Plan (SIP) revision for a moderate attainment area.

While measures to reduce VOCs and NOx have reduced ozone transport within the nonattainment areas along the I-95 corridor, ozone transport is still a major contributor to elevated concentrations in the Philadelphia Nonattainment Area. There are three types of ozone transport that contribute to elevated ozone concentrations, including large-scale regional transport, near-scale or local transport, and transport via low-level or nocturnal jets in the atmosphere. The monitor with the highest ozone concentration within the Philadelphia Nonattainment Area is located in Ocean County, New Jersey.

Since the summer of 2002, the year that is considered the "base year" for purposes of the eight-hour ozone NAAQS, considerable progress has been made in reducing eight-hour ozone concentrations both within the Philadelphia Area and elsewhere in Pennsylvania. From 2002 to 2006, the number of days exceeding the standard, days with unhealthy air, and days with many monitors exceeding the standard in the Philadelphia Nonattainment Area have all decreased significantly. The design value (an averaged value EPA uses to determine attainment) has also decreased at all monitor sites within Pennsylvania. Although temperature and precipitation trends favor elevated ozone concentrations, the concentrations have actually declined substantially, presumably due to programs requiring reductions in VOC and NOx emissions. While daily ozone concentrations are very dependent on meteorological conditions, ozone design values are less dependent.

Emissions of VOC and NOx (tons per typical summer day) are projected to decrease significantly from 2002 to 2009, taking into account both growth in economic activity and control measures implemented to reduce emissions.

Table E-1: Comparison of Total Ozone Precursor Emissions

Pollutant	2002	2009
VOC	353	285
NOx	354	254

These decreases enable the Pennsylvania portion of the Philadelphia Nonattainment Area to meet the specific emission reduction requirements under the Reasonable Further Progress (RFP) provisions of the Clean Air Act for two milestone years, 2008 (six years after the baseline year) and 2009 (modeled attainment year). The RFP demonstration takes into account that specific motor vehicle emissions reductions achieved through measures prior to 1990 cannot be used to meet the RFP targets. Since there is at least an 18 percent reduction achieved, the contingency measure requirement for 2008 is also met.

This SIP revision also establishes motor vehicle budgets for purposes of transportation conformity. Once EPA approves the budgets for purposes of conformity, the Delaware Regional Planning Commission must use these budgets in its air quality analyses for transportation planning purposes.

The permanent and enforceable control measures, which enable the Pennsylvania portion of the Philadelphia Nonattainment Area to demonstrate attainment of the eight-hour ozone NAAQS, include:

- The Clean Air Interstate Rule (CAIR)
- The NOx SIP Call reducing interstate pollution transport

- State regulation of smaller sources of nitrogen oxides, cement kilns and large stationary internal combustion engines
- Federal standards for hazardous air pollutants, many of which are also ozone precursors
- State regulation of portable fuel containers
- State regulation of consumer products
- State regulation of architectural and industrial maintenance coatings
- The Pennsylvania and federal new motor vehicle control programs for passenger and light-duty trucks, including reformulated and low sulfur gasoline
- The Pennsylvania and federal heavy-duty diesel control programs, including ultra-low sulfur diesel fuel
- Vehicle emission inspection and maintenance program
- Continued operation of state regulation of refueling pumps
- Federal regulation of offroad diesel and gasoline powered vehicles/equipment, including lower sulfur fuel

The Department, in cooperation with stakeholders and the Ozone Transport Commission member states, concluded that there are no additional reasonable cost-effective measures that would advance the ability of the area to attain the standard by one year or more.

The demonstration of achieving the eight-hour ozone NAAQS is based on results from the Community Multiscale Air-Quality Model and the supporting Weight of Evidence (WOE) analysis. Photochemical grid-modeling and the WOE analyses provide strong evidence that the Philadelphia region will attain the eight-hour ozone standard "as expeditious as practicable" but no later than June 15, 2010, six years after the effective date of the "moderate" classification of the nonattainment area.

Photochemical ozone models are mathematical representations of the changes that occur when air pollutants are emitted into the atmosphere, travel downwind and, in the presence of sunlight, react photochemically to form ozone. The photochemical modeling analysis predicts that all 22 monitors in the Philadelphia area will experience significant reductions in ozone concentrations (design values) by the 2009 ozone season. Seven monitors are predicted to remain within the range of design values for which EPA guidance requires supplemental analyses to consider the weight of the evidence.

Pennsylvania is also providing other corroboratory evidence of attainment, in accordance with EPA guidance. The weight of evidence (WOE) section shows why all evidence, viewed as a whole, supports a conclusion that the Philadelphia Nonattainment Area will attain the eight-hour ozone NAAQS despite the model predicting that some monitors' future design values exceed the current eight-hour ozone standard. The range of closeness is similar to what was observed in the one-hour ozone demonstrations submitted in the late 1990s. This experience increases the probability that the models are again under-predicting the benefits of emission control programs. The persistent elevated ozone levels at the Colliers Mills monitor in Ocean County, New Jersey may be caused by special circumstances affecting ozone concentrations at this monitor.

The five-county Philadelphia Area is required to have a contingency plan in the event that the Philadelphia Nonattainment Area does not attain the eight-hour standard in June 2010. The Department has identified state and federal programs that will provide continued emission reductions past 2009 as well as additional control measures anticipated to be in effect by that time. These measures include new motor vehicle emission standards (reductions from fleet turnover), federal nonroad emission standards, enhancement of portable fuel container and consumer product requirements, and regulation of adhesives, sealants, adhesive primers and sealant primers.

I. INTRODUCTION AND OVERVIEW

This document describes the air quality demonstration mandated under the Federal Clean Air Act for attainment of the eight-hour National Ambient Air Quality Standard (NAAQS) for ground-level ozone in the Pennsylvania portion of the Philadelphia-Wilmington-Atlantic City Eight-Hour Ozone Nonattainment Area (Philadelphia Nonattainment Area).

A. Health and Environmental Effects of Ground-level Ozone

Maintaining concentrations of ground-level ozone below the health-based standard is important because ozone is a serious human health threat, and also can cause damage to important food crops, forests, and wildlife.

Repeated exposure to ozone pollution may cause a variety of adverse health effects for both healthy people and those with existing conditions including difficulty in breathing, chest pains, coughing, nausea, throat irritation, and congestion. It can worsen bronchitis, heart disease, emphysema, and asthma, and reduce lung capacity. Asthma is a significant and growing threat to children and adults. Ozone can aggravate asthma, causing more asthma attacks, increased use of medication, more medical treatment and more frequent visits to hospital emergency clinics. Because ozone pollution usually forms in hot weather, anyone who spends time outdoors in the summer may be affected, particularly children, the elderly, outdoor workers and people exercising. Children are most at risk from exposure to ozone because they are active outside, playing and exercising, during the summertime when ozone levels are highest.

Ozone is one of the most pervasive and detrimental pollutants known to affect vegetation, causing more injury to trees and crops than any other air pollutant in the United States. Ozone interferes with photosynthesis, the process by which plants convert water and sunlight to food. Ozone makes plants more susceptible to disease, insects, other pollutants, and harsh weather. It damages the foliage of trees and other plants, ruining the landscape of cities, parks and forests, and recreation areas. Research has shown that current ozone concentrations result in reductions in wood growth in forests of the Northeast of over 10 percent. There is strong scientific evidence showing that current levels of ozone are reducing crop yields, particularly in sensitive species - soybean, cotton, and peanuts. Annual crop loss from ozone for soybeans alone in Illinois, Indiana and Ohio has been calculated to fall between $199 million and $345 million. The U.S. Environmental Protection Agency (EPA) has estimated national crop yield losses due to ozone in excess of $1 billion annually. One of the key components of ozone, oxides of nitrogen (NO_x), contributes to fish kills and algae blooms in sensitive waterways, such as the Chesapeake Bay.

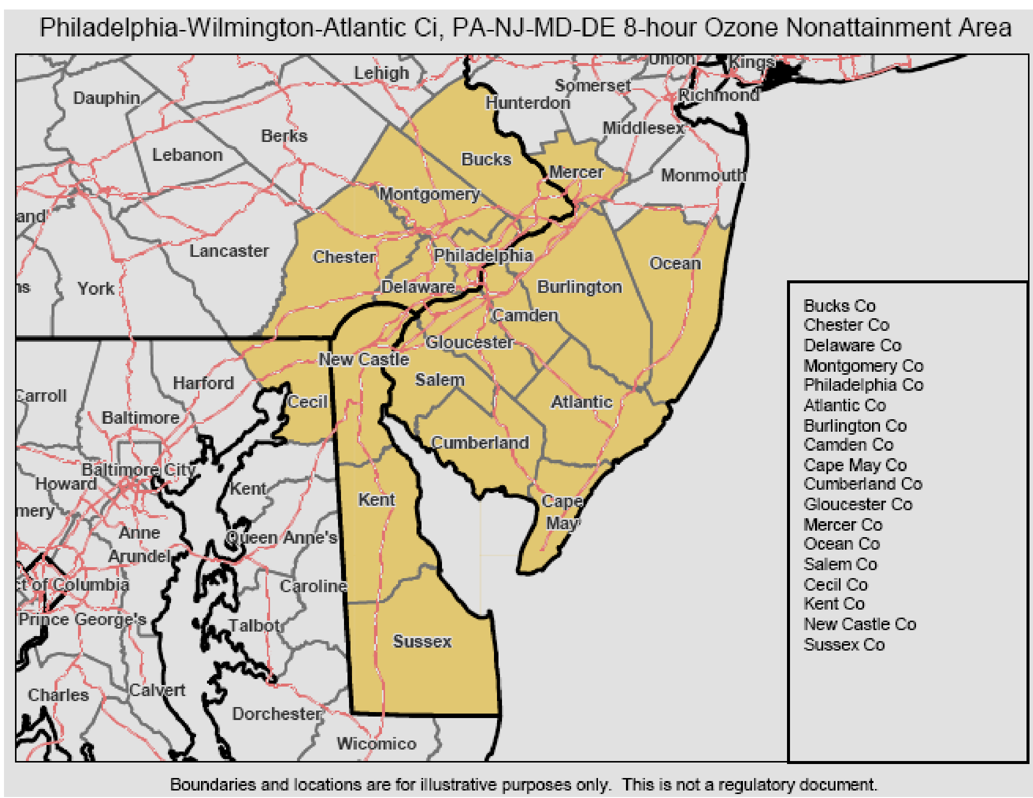
Ozone is not emitted directly to the atmosphere, but is formed by photochemical reactions between volatile organic compounds (VOCs) and NO_x in the presence of sunlight. The long, hot, humid days of summer are particularly conducive to ozone formation, so ozone levels are of concern primarily during the months of May through September. The primary sources of man-made VOCs and NO_x, the ozone precursors, are the evaporation of fuels and solvents (gasoline and consumer products), combustion of fuels (motor vehicles, power plants and non-road engines), and industrial processes.

EPA has established the maximum limit for ozone pollution allowed in the ambient air. The NAAQS for ozone is 0.08 parts per million (ppm) averaged over eight hours.

B. Purpose And Structure Of This Document

In 2004, EPA designated seventeen areas (37 counties) in Pennsylvania as eight-hour ozone nonattainment areas based on air quality monitoring data from 2001-2003. The Philadelphia Nonattainment Area is comprised of 18 counties in Pennsylvania, New Jersey, Delaware and Maryland as shown in Figure 1-1. Ocean County, New Jersey and Sussex County, Delaware were added to the previous ozone nonattainment area. The Pennsylvania portion of the Philadelphia nonattainment area consists of Bucks, Chester, Delaware, Montgomery and Philadelphia counties.

Figure 1-1



EPA classified the Philadelphia Nonattainment Area as a “moderate” nonattainment area. Therefore, the area is required to attain the eight-hour ozone standard by June 15, 2010. States are required to develop revisions to the State Implementation Plan (SIP) to demonstrate how the area will attain the standard by the required date, meet emission reduction requirements in the CAA and ensure that in the event of a future violation or failure to meet emission reduction milestones, the area is brought back to attainment as quickly as possible.

Pennsylvania was required to develop a SIP revision for the previous one-hour ozone standard. The SIP-approved attainment demonstration for the one-hour ozone standardincluded requirements necessary to improve air quality in order to meet the one-hour standard by November 2005. The plan was successful; the Philadelphia Area did attain the one-hour ozone standard by 2005.

This SIP revision for the eight-hour “moderate” ozone nonattainment areas in Southeastern Pennsylvania is intended to strengthen that plan in order to meet the more protective eight-hour standard. This SIP revision shows the progress already made to improve air quality in the Philadelphia Area and the efforts underway to assure that all necessary steps are taken to attain the eight-hour ozone NAAQS by June 15, 2010 and meets all of the SIP requirements for a “moderate” area under CAA sections 110, 172 and 182 and regulations.

Sections II and III provide information which characterizes the ozone in the Philadelphia Area specifically as well as the I-95 corridor, stretching from the Washington DC to the Boston areas. Section II presents the “conceptual model,” as required by EPA, for formation of ozone in the Philadelphia Nonattainment area. It examines the ways ozone is formed and transported in the area. Section III examines current ozone monitoring information and analyzes trends in ozone as well as ambient oxides of nitrogen values along with meteorological trends.

Section IV describes emission inventories for the ozone precursors, VOCs and NOx, and demonstrates that sources in the Pennsylvania portion of the Philadelphia Area will:

- reduce ozone related pollutants by at least 15 percent between 2002, the base year, and 2008 to meet “reasonable further progress” requirements for the Pennsylvania portion of the nonattainment area through permanent and enforceable control measures.
- reduce all ozone precursor emissions sufficient to attain the standard by June 15, 2010 to meet “reasonable further progress” requirements for the Pennsylvania portion of the nonattainment area through permanent and enforceable control measures.[1]

1 However, because ozone is a summer-time problem, the region is actually required to demonstrate attainment in the preceding ozone season, 2009, which is considered the attainment year for planning purposes.

- demonstrate that the area will meet the NAAQS by June 15, 2010 (2009, as noted below) through photochemical modeling, statistical analyses and other evidence.

Section IV also contains the highway vehicle emission budgets for purposes of transportation conformity. Technical information on all emission inventories is contained in the Appendices B through F.

Section V describes the control measures implemented in the Pennsylvania portion of the Philadelphia area, which produce emission reductions between 2002 and 2009 in order to attain the NAAQS in a timely fashion. It also describes the required analysis of Reasonably Available Control Measures that could advance the attainment of the standard by one year or more. Additional information is contained in the Appendix G.

Section VI discusses the photochemical modeling that was done to evaluate attainment by June 2010 and the "weight of evidence" analysis. Together, these comprise the attainment demonstration. Additional information is contained in the Appendix H.

Section VII contains contingency measures that the Commonwealth will implement to address unanticipated failures to attain and maintain the eight-hour ozone standard.

The EPA Administrator is authorized under Section 179(a) of the CAA to impose sanctions after making a finding, determination, or disapproving a SIP revision, in whole or part. Mandatory sanctions would be imposed for (1) a state's failure to submit a plan or plan element meeting the minimum criteria of section 110(k) of the CAA; (2), EPA's disapproval of a State plan in whole or in part; (3) a state's failure to make any required submission satisfying the minimum criteria of section 110(k); and (4) a state's failure to implement any requirement of an approved plan. If the State fails to correct any SIP deficiency within 18 months from the Administrator's finding, determination or disapproval, mandatory sanctions would be imposed. Under § 179(b), 42 U.S.C. § 7509(b), there are two mandatory sanctions for non-complying states: (1) limitations on certain federal highway funding, and (2) "offset" limitations on certain developments in affected areas that require each new stationary emission source to be paired with a reduction in area emissions amounting to double the amount of increased emissions from the new source.

In addition, failure to submit, disapproval, or failure to implement a plan can also affect the ability of transportation planning agencies to meet transportation conformity requirements, and thus the ability to implement transportation projects. EPA may also impose discretionary sanctions under Section 110 of the CAA.

C. Public participation

Requirements for a public comment process are set forth in Section 110(a)(2) of the CAA and 40 CFR Section 51.102(d). On May 19, 2007, the Pennsylvania Department of Environmental Protection (PADEP or Department) published a notice of public hearing and a 30-day written comment period on the proposed Attainment Demonstration for the eight-hour ozone nonattainment area (Bucks, Chester, Delaware, Montgomery and Philadelphia counties) 37 Pa.B. 1317. The public hearing was held at the Department's Southeast Regional Office, 2 East Main Street, Norristown, PA on Friday, June 22, at 1 p.m. The comment period closed on June 26, 2007. A Comment/Response Document has been prepared and is included in this submittal to EPA.

II. Nature of the Ozone Problem in the Philadelphia Nonattainment Area

A. Background

Ozone has been a chronic problem in the Philadelphia Area since EPA originally established a health-based ozone standard in accordance with the 1970 CAA Amendments. Other metropolitan areas along the I-95 corridor stretching from Washington, DC to Boston, MA share the same persistent ozone problems.

Ozone noncompliance across the Northeast and Mid-Atlantic regions is due to a combination of regional ozone transport and enhanced anthropogenic (man-made) emissions. Many of the nonattainment areas along the I-95 corridor have recognized this problem for many years. In 1995, the Ozone Transport and Assessment Group (OTAG) was formed to address ozone transport issues raised by many northeast states. In 1998, the EPA issued the NO_x SIP call requiring twenty-two (22) states and the District of Columbia to reduce NO_x emissions, a major contributor to ground-level ozone formation. The full implementation of this control program only recently occurred. The bulk of the reductions were in place across the eastern United States at the start of the 2005 ozone season (see EPA Report NO_x Budget Trading Program, 2006).

While there has been some evidence that these control measures have reduced ozone transport within the nonattainment areas along the I-95 corridor (EPA NO_x Budget Trading Program, 2006, and EPA Air Trends Report, 2004) it appears that regional transport is still a major contributor to Philadelphia's continuing nonattainment problem.

B. Conceptual Model

The Department sponsored research by several universities to examine ozone and fine-particulate concentrations in northern Philadelphia County during the summers of 1998-2002 (NEOPS, 2003). This project was collectively known as the Northeast Oxidant and Particulate Study or NEOPS. The project's goal was to use a variety of monitoring instruments to assess air quality during episodes of elevated ozone and fine-particulates ($PM_{2.5}$) concentrations.

The conceptual model of how ozone episodes occur in eastern Pennsylvania is a conglomeration of studies like NEOPS, analyses by air-quality forecasters, regional data-analysis assessments (MARAMA, 2005, NESCAUM, 2006) and regional air-quality modeling efforts. While our understanding of the entire process is still incomplete, there are many more processes we are aware of and understand now than we did a decade ago.

Ozone transport has a significant affect on ozone concentrations within the Philadelphia nonattainment area. Modeling included in the Department's Philadelphia Area One-Hour Ozone SIP showed modeled concentrations exceeded the previous one-hour ozone standard even with all anthropogenic emissions eliminated from the nonattainment area

(Aranachalam and Georgopoulos, 1998) demonstrating the dominant impact of transported air pollution.

A monitor's ozone concentration reflects contributions from regional transport, local sources of ozone precursors and natural background concentrations. The contributions from each of these contributors vary from day to day in response to the weather. Air-quality forecasters have long recognized several common features that occur during ozone episodes (Ryan et al, 1998). An analysis by ENVIRON sponsored by the Ozone Transport Committee (OTC) examined six (6) years of ozone data to determine common meteorological features for various elevated ozone episode regimes across the Northeast and Mid-Atlantic regions (ENVIRON Report, 2005). Common meteorological features for all ozone episodes in the Philadelphia region include:

- A ridge of high pressure situated over the southeast (creating southwesterly flow at the surface).
- Elevated temperatures at the surface and 850 millibars (mb).
- A stable air mass (allows for clear skies and light winds).
- Westerly to northwesterly flow at 500 mb.

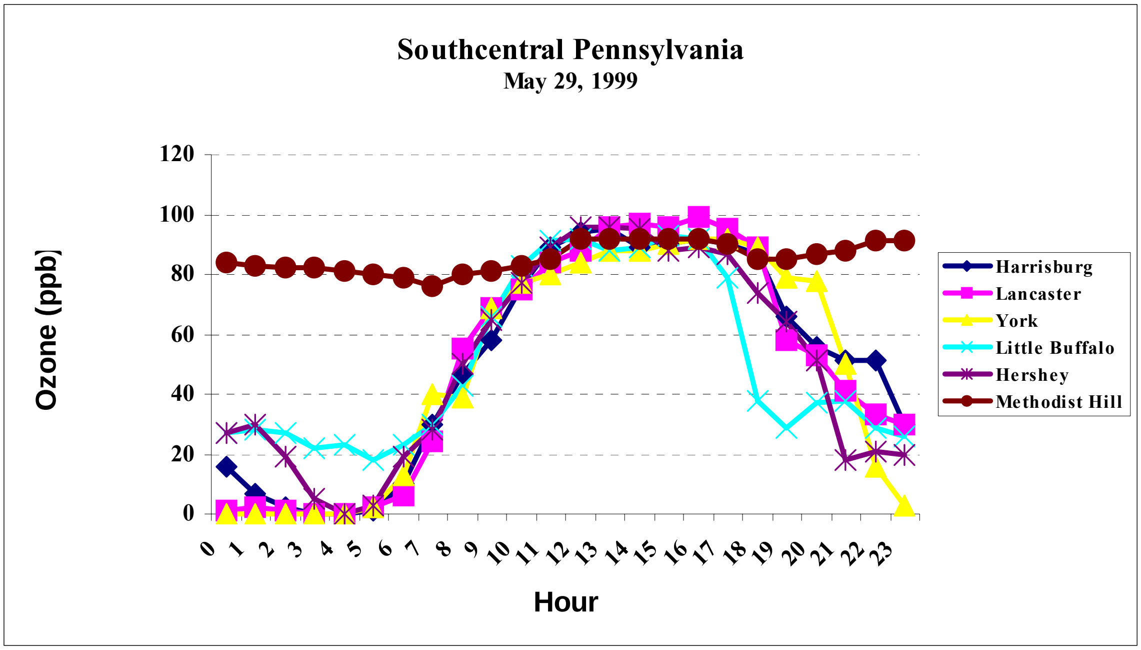
Ozone transport is an important factor when ozone concentrations are elevated in the Philadelphia Nonattainment Area. There are three types of ozone transport that contribute to elevated ozone concentrations in the Philadelphia Nonattainment Area. They include large-scale regional transport, near-scale or local transport, and transport via low-level jets (LLJ).

1. Regional Transport

Regional ozone transport typically begins when a large area of high pressure develops over the Midwest. Emissions from large power plants along the Ohio River combined with emissions from various urban areas such as Chicago become imbedded in the regional flow and then move eastward. This type of scenario was described by the OTAG air-quality analysis workgroup (1998). Ozone typically becomes imbedded in the middle to upper portions of the daytime boundary layer forming a pool or reservoir of ozone and ozone precursors. These reservoirs are "tapped" when daytime heating occurs in downwind areas causing rapid increases in surface ozone concentrations.

One way to illustrate this process is to examine ozone data from high elevation ozone monitors that can measure ozone concentrations in these aloft ozone reservoirs. Pennsylvania has operated a high-elevation ozone monitor (Methodist Hill) on South Mountain in Franklin County (elevation 1900 feet) since the mid-1990s. Figure 1-1 shows what happens when regional ozone plumes enter southcentral Pennsylvania. Ozone concentrations at the high-elevation monitor, Methodist Hill, remain high during the overnight hours reflecting the large pool of ozone from the previous day's mixed boundary layer. Ozone concentrations at the low-elevation monitors remain depressed until the morning temperature inversion dissolves as daytime heating occurs. Atmospheric mixing taps the regional pool of ozone aloft and ozone concentrations rise rapidly to match those at the high-elevation monitor. This process has also been documented in the Philadelphia region (NEOPS, 2003) as well as other areas along the I-95 corridor.

Figure 2-1. Effect of Regional Ozone Plumes



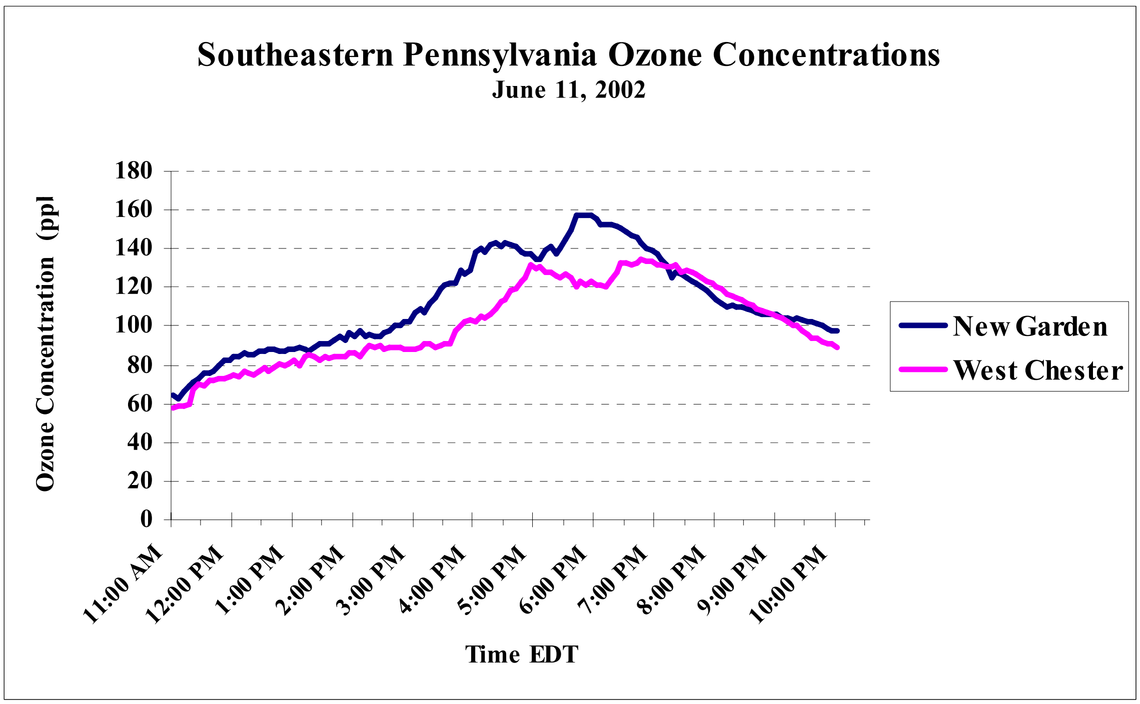
Other areas along the I-95 corridor have documented similar findings using aircraft measurements (Maryland Department of the Environment, 2005). Monitoring instruments in the aircraft have measured ozone concentrations exceeding the eight-hour standard as air masses enter the Mid-Atlantic region from the Midwest. Vertical profiles at various times of the day have shown that, once tapped, regional plumes of ozone can have profound affects on local ozone concentrations often causing concentrations to easily exceed the health-based eight-hour ozone standard.

2. Near-Scale (Local) Transport

Near-scale or local transport refers to the movement of ozone plumes that originate from the large metropolitan areas along the I-95 corridor (Baltimore, Washington DC, Philadelphia and New York City). Ozone plumes typically form downwind of these cities due to their high concentration of anthropogenic emissions (particularly motor vehicles). Ozone plumes are carried by surface winds during the late afternoon and evening hours. Monitors in the southern portion of the Philadelphia eight-hour nonattainment area typically pick up Baltimore's ozone plume late in the afternoon or early evening hours. Peak values can often be staggered (in time) between nearby monitors as the ozone plume moves across the region. These plumes typically "dissipate" shortly after sunset as fresh NO_x emissions react with ozone. The "dissipated" ozone plume will reform downwind the next day when the solar-driven photochemistry resumes.

Figure 2-2 shows the Baltimore ozone plume impacting monitors in southern Chester County forming a “double peak”. The first peak corresponds to the ozone maximum that typically occurs in the afternoon, usually at the time of maximum temperature. A second peak often occurs afterwards as urban plumes make their way across the countryside. This second peak in the Chester County monitors is due to the Baltimore ozone plume traveling northeast towards Philadelphia. These peaks are sometimes observed well after sunset. Baltimore plumes have been observed moving across southcentral Pennsylvania and under ideal conditions reaching monitors in the Lehigh Valley well after sunset (Ozone Exceedance Report, 1999).

Figure 2-2. Plume Impact on Ozone Monitors in Southern Chester County



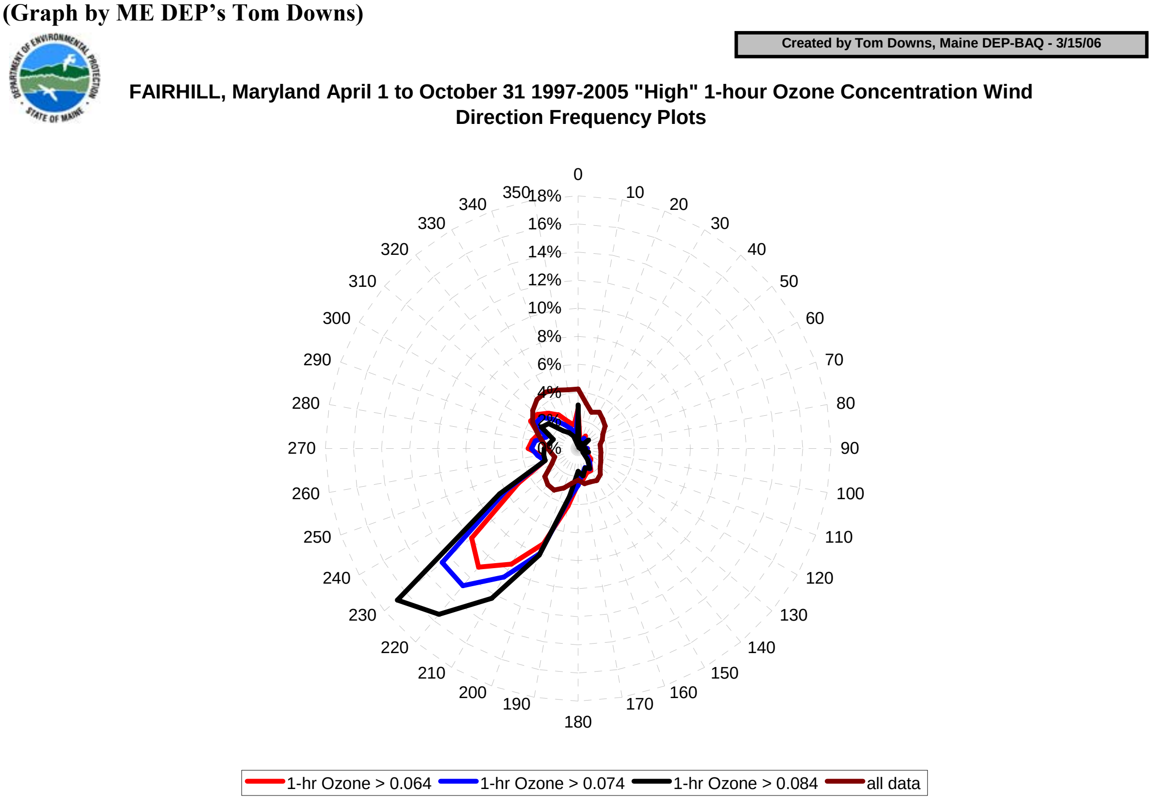
Examining wind fields and corresponding ozone concentrations can determine if a particular monitor is susceptible to local ozone transport from know urban sources. This can be accomplished by examining hourly averaged wind directions during times of elevated ozone concentrations. Three monitors in the Philadelphia eight-hour ozone nonattainment area were examined; one in the southern portion of the nonattainment area (Fair Hill in Cecil County, MD), one in the central portion of the nonattainment area (Bristol in Bucks County, PA) and one in the eastern portion of the domain (Rider University in Mercer County, NJ).

<u>Fair Hill, MD:</u> Figure 1-3 plots one-hour wind direction versus ozone concentration. The plot breaks down wind-direction frequency by ozone concentration. This graph was created by Tom Downs of the Maine Department of Environmental Protection (ME DEP).

The graph includes all wind directions and wind directions for hours when ozone concentrations exceed 0.084 ppm, 0.074 ppm and 0.064 ppm respectively. Wind direction frequency for all of the data indicates a preference for winds from the north to northwest with a less prevalent component from the southwest. The data suggest a marked increase in winds from the southwest for hours in which one-hour ozone concentrations exceed 0.084 ppm. This wind direction accounts for approximately 16% of the wind directions when one-hour ozone concentrations exceed 0.084 ppm versus less than 4% when all of the wind directions are considered. There is also some preference for high ozone concentrations when winds are from the west and northwest but neither is as large as the southwesterly component. Similar frequency spreads are seen in the data when one-hour ozone concentrations exceed 0.074 ppm and 0.064 ppm.

Figure 2-3. Fair Hill, MD

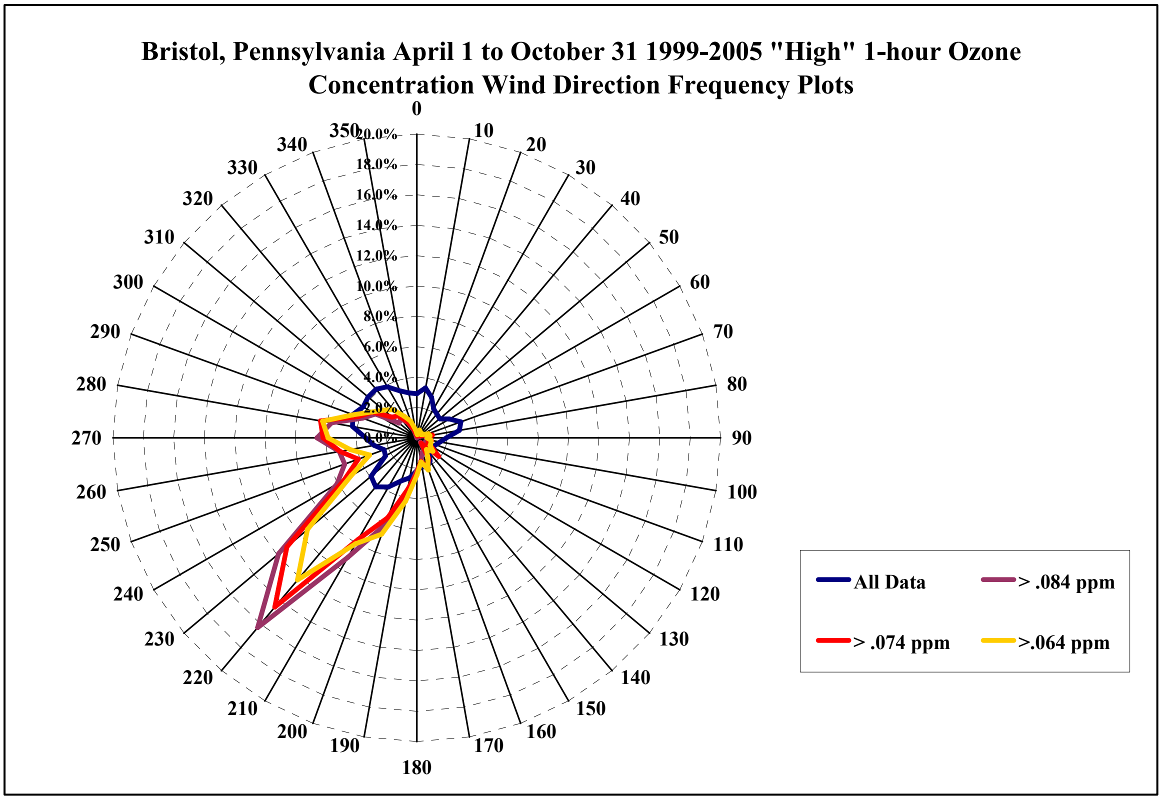
(Graph by ME DEP's Tom Downs)



The preferred wind directions during periods of elevated ozone concentrations suggests which direction ozone is being transported. The graph suggests the Fair Hill monitor is frequently subjected to plumes from the Baltimore/Washington DC area. The monitor also seems to be affected, to a lesser extent, from transport from the west and northwest. In this case regional transport from areas of the Midwest and southwest Pennsylvania could account for these small peaks. Transport from Philadelphia, which lies to the northeast, does not appear to be much of a factor during periods of elevated one-hour ozone concentrations.

Bristol, PA: Figure 2-4 plots one-hour wind direction versus ozone concentration for the Bristol monitor located in Bucks County. This graph by the Department used a slightly smaller data set (1999-2005) than was used by Tom Downs. The cut-off points are the same as the ones used in the Fair Hill, MD monitor analysis.

Figure 2-4. Bristol, PA



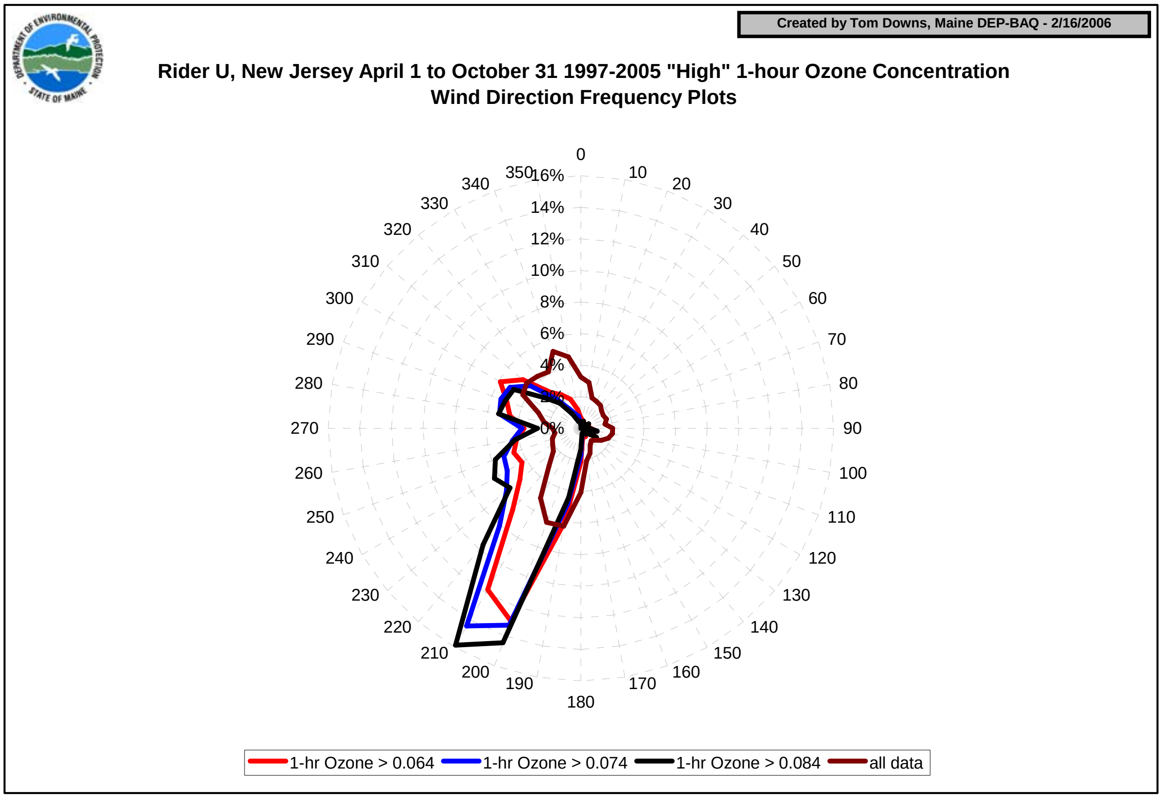
Bristol's one-hour ozone/wind relationship is similar to Fair Hill's. When all of the wind direction data is examined, monitor winds tend to be from the northwest to north with smaller components in the easterly and southwesterly sectors. During periods of elevated one-hour ozone concentrations preferred wind directions tend to be from the southwest and west-northwest directions. The southwesterly component is probably due to local transport from the city of Philadelphia (located southwest of the monitor), while the more westerly component is probably due to regional transport from western Pennsylvania and the Midwest.

Rider University, NJ: Figure 2-5 plots one-hour wind direction versus ozone concentration for the Rider University monitor located in Mercer County, New Jersey. The plot shows wind direction frequency versus ozone concentrations. Tom Downs (ME DEP) created this graph.

The pattern for Rider University is similar to the pattern noted at the Bristol, PA monitor.

Overall, winds tend to be from the south-southwest and the northwest to north. During periods of elevated one-hour ozone concentrations winds tend to be from the south-southwest and the northwest. The south-southwesterly component is probably due to local ozone transport from the city of Philadelphia while the northwesterly west-northwesterly component is probably due regional transport from western Pennsylvania and the Midwest.

Figure 2-5. Rider University, NJ



(Graph by ME DEP's Tom Downs)

3. Ozone Transport by Lower Level Jets

Ozone transport via low-level jets (LLJ), sometimes referred to as nocturnal jets, is another important process affecting ozone concentrations in the Philadelphia Nonattainment Area. The process of LLJ formation has been understood for some time but determining their affects on ground-level ozone has been a relatively recent undertaking. Our lack of understanding of the LLJ transport mechanisms has been hampered by the lack of direct measurements along the Mid-Atlantic coast. The installation of vertical wind profilers and more fine-scale forecast models has improved our understanding of when and where LLJs form over the region and how they affect ground-level concentrations.

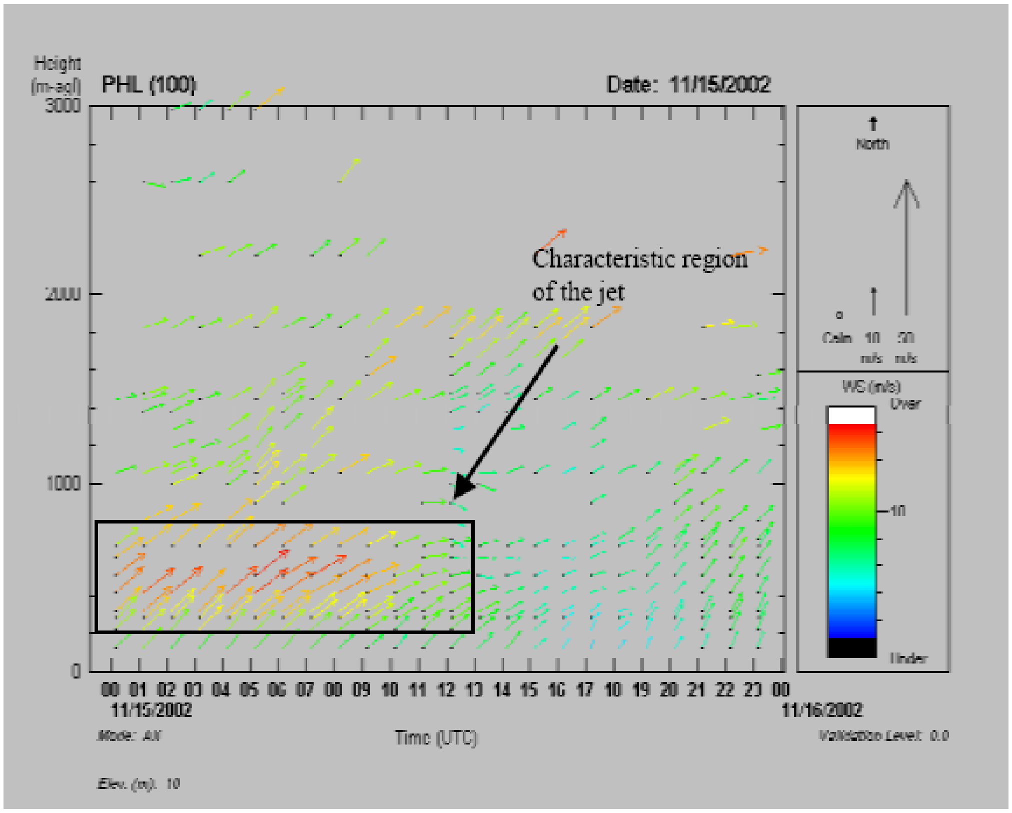
The NEOPS monitoring program did significant research into LLJs over Philadelphia and their affects on local ozone concentrations. LLJs are nocturnal features that typically form over flat areas under weak synoptic forcing. Historically, the term LLJ has applied to features long known to form over the Great Plains. This term has only recently been applied to features observed over the Mid-Atlantic region. While LLJ dynamics are well known, their impact on pollution transport in the northeast has been typically overlooked since most studies have focused on their effects on precipitation and severe weather (Verghese, 2003).

Verghese (2003) and Verghese et al. (2003) examined several years of profiler data over Philadelphia to determine the frequency and importance of LLJs. They determined that LLJs are typically observed during periods of elevated ozone concentrations and are often present during the overnight and early morning hours on days when eight-hour ozone concentrations exceed 85 ppb. Based on their analysis, they determined the following characteristics regarding LLJs over the Philadelphia region:

- LLJs over Philadelphia typically form under clear-sky conditions that are accompanied by ridges of high pressure.
- LLJs typically reside between 300 and 1000 meters above the surface and have maximum velocities between 10 and 20 meters/second (23-45 mph).
- By definition, LLJ wind speeds exceed wind speeds (core wind maximum) in the layers of the atmosphere immediately above and below them by at least 3 meters/second (~ 7mph).
- LLJs have the capability of transporting ozone and ozone precursors (as well as other pollutants) over distances of 250 kilometers (~160 miles) during the night.
- LLJs tend to move pollution along the I-95 corridor from south to north. Wind directions tend to start out from the south then deflect to the right (due to the Coriolis force), becoming more westerly as the night progresses.

Results from the NEOPS program suggest ozone concentrations within these LLJs are near or exceed levels associated with the health-based eight-hour ozone standard (85 ppb). Relative humidity profiles suggest some of these jets originate over continental areas (dry, low humidity). While the profiles and approximate distances suggest relatively local sources (within 250 kilometers of Philadelphia) they are probably indicative of a more regional transport signal.

Figure 2-6. Low Level Jets



(From Verghese, 2003) Characteristic LLJ; Vertical wind speed (m/s) along the y-axis, time (hours) along the x-axis. Note wind core strength within the jet increases overnight then dissipates shortly after sunrise. Note the date; indicates LLJs occur at various times of the year.

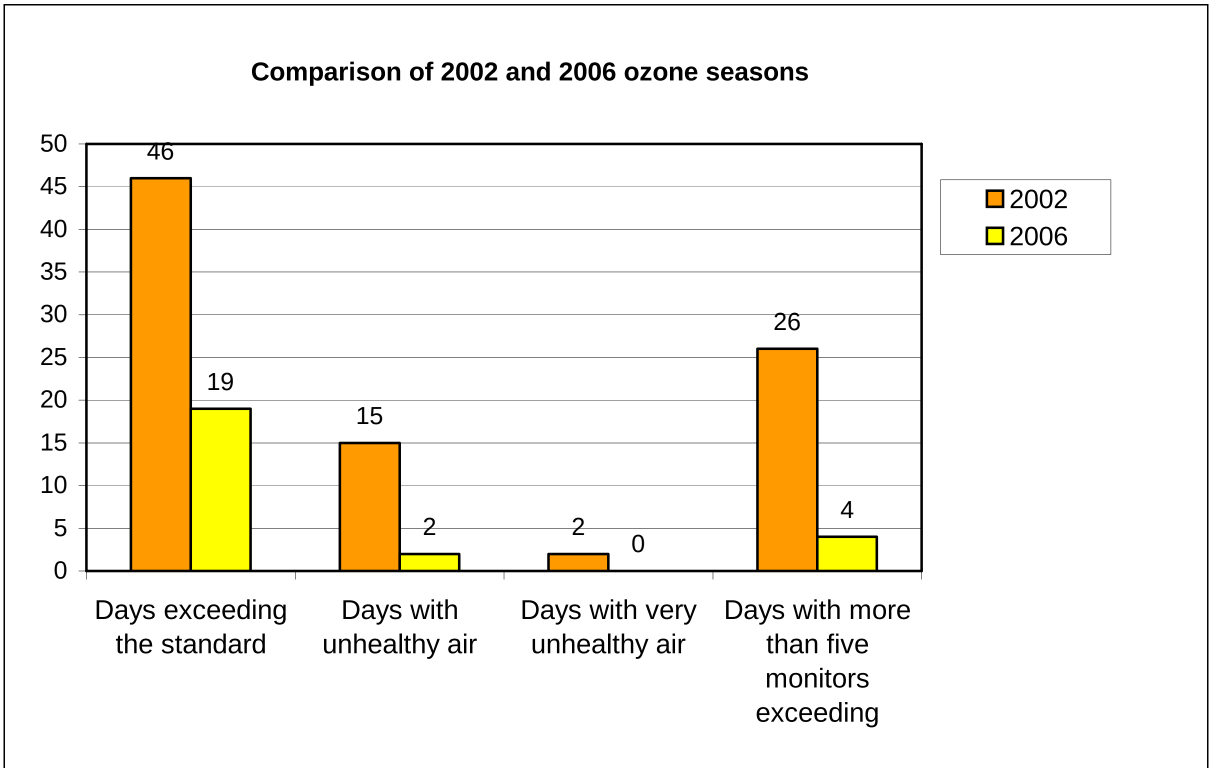
III. Air-Quality Monitoring Trends Analysis

A. Summary

Since the summer of 2002, the year that is considered the “base year” for purposes of the eight-hour standard, considerable progress has been made in reducing eight-hour ozone concentrations both within the Philadelphia Area and elsewhere in Pennsylvania. Through the summer of 2006, only the five-county Philadelphia Area continues to monitor ozone values above the NAAQS. Redesignation requests and maintenance plans were submitted to EPA for 32 counties in Pennsylvania designated nonattainment for the eight-hour ozone NAAQS.

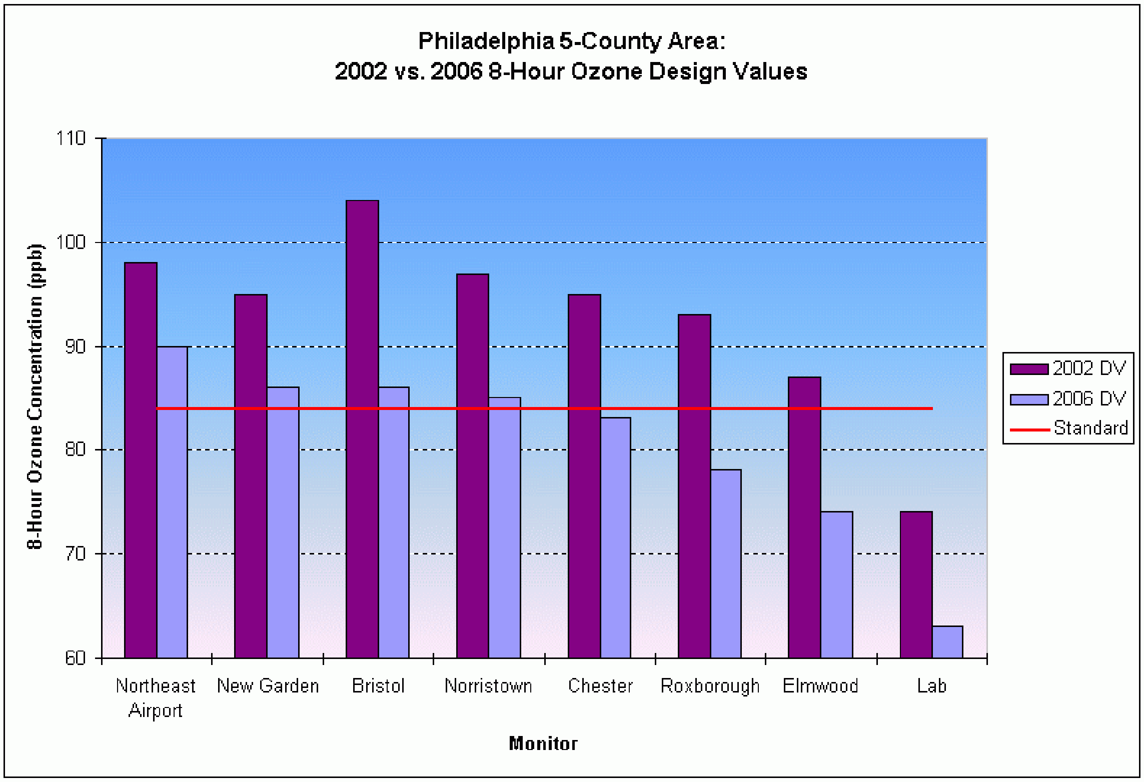
Figure 3-1 below shows the improvement in air quality from 2002 to 2006, with 2006 having fewer days per year over the standard and fewer air quality monitoring stations measuring levels above the standard. Figure 3-1 considers all monitors in the interstate area.

Figure 3-1: Trends in the Philadelphia Area



The Philadelphia Area's design values for the eight-hour ozone standard are shown below in Figure 3-2. The eight-hour ozone design value is the fourth highest maximum ozone concentration at a monitor averaged over a continuous three-year period. Values of 84 parts per billion (ppb) and above (0.084 ppm) are exceeding the standard. The monitors reflected in this chart are only those located in Pennsylvania.

Figure 3-2



In addition to progress in achieving the current eight-hour ozone NAAQS, the Philadelphia Area attained the previous one-hour ozone standard in 2005 as required by the CAA.

This section examines the current status of the Philadelphia eight-hour ozone nonattainment area. Current eight-hour ozone design values and exceedances were examined for the 2005 (the most recent year with complete data) and 2006 ozone seasons. Data for the 2006 season is not currently complete.

Long-term ozone trends are also examined. These include trends in ozone concentrations and exceedances across the Philadelphia nonattainment area. Additional trends in NO_x/NO_2 and meteorology were also examined.

This is a short summary of the analyses provided in this section.

Current Ozone Levels:

- 2006 Design Value: 0.093 ppm (Colliers Mill, NJ)
- Less than half (nine out of twenty-one) of the valid monitors are projected to exceed the ozone standard at the end of the 2006 ozone season.
- Preliminary data indicate there were nineteen days in 2006 that exceeded the eight-hour ozone standard out of a two hundred fourteen-day ozone season.

Ozone Trends:

- There have been significant improvements in ozone design values after implementation of the federal Reid Vapor Pressure (RVP) program in the early 1990s, and the NO_x Budget trading Program (NBP) in 2003-04 time period. Average design values dropped by ~15% after RVP and ~11% after NBP.
- The number of ozone exceedances has dropped significantly after the implementation of RVP and NBP. The average number of exceedance days has dropped from 56 days to 36 days after RVP and from 36 days to 19 days after NBP.
- The number of days air quality ranks as "Unhealthy" on the Air-Quality Index (AQI) scale, > 0.104 ppm, and "Very Unhealthy", > 0.124 ppm have dropped significantly since the implementation of RVP and NBP. There have been no days with AQI ratings of "Very Unhealthy" since 2003.
- The number of days with multiple monitors (greater than five) exceeding the standard has decreased since implementation of RVP and NBP indicating the aerial extent of nonattainment has also declined.

NO_x/NO_2 Trends:

- NO_x/NO_2 are ozone precursors and ultimately contribute to ozone formation.
- There have been substantial reductions in NO_x/NO_2 emissions due to the 1990 Clean Air Act and the NBP.
- Monitored NO_2 concentrations have fallen approximately 30 percent since the late 1980s.

Meteorological Trends:

- Ozone formation can be driven by meteorological factors such as temperature, available sunlight, atmospheric stability and boundary layer winds.

- Philadelphia International Airport data was used to reconstruct thirty-year trends in temperature, cooling-degree days and precipitation.

- No overall long-term trends were easily detectable from the Philadelphia International Airport data.

- Temperatures were generally above average and precipitation below average for a period extending from the late 1980s through the middle of the 1990s. Both of these factor favor elevated ozone concentrations. Ozone concentrations, however, actually declined quite substantially (due to RVP emission reductions) during this time period.

- While daily ozone concentrations are very dependent on meteorological conditions, our review suggests ozone design values are less dependent on temperature and precipitation than first thought.

- Ozone reductions due to emission control programs like RVP and NBP are much greater than ozone fluctuations due to meteorological factors.

B. Current Ozone Levels

Table 3-2 lists eight-hour ozone design values for all monitors within the Philadelphia nonattainment area. The design values for 2005 and preliminary values for 2006 are listed in the table. Only those monitors that had an average of 90 percent valid days during the ozone season (April 1 through October 31) over the three years used in the design value calculation were included. Monitoring data used in this section are included in Appendix A.

Twenty-two (22) ozone monitors currently operate in the Philadelphia Nonattainment Area. Most of these monitors have enough valid data to calculate an ozone design value. Design values for 2005 and 2006 were included in this analysis because not all of the 2006 data has undergone the proper Quality Assurance/Quality Control (QA/QC).

1. Current Ozone Design Values

The Philadelphia Nonattainment Area’s 2005 eight-hour ozone design value was 94 ppb. Preliminary data from 2006 indicate the Philadelphia nonattainment area’s design value has fallen to 93 ppb. Figures 3-3 and 3-4 and Table 3-1 show the locations of the monitors within the Philadelphia Nonattainment area as well as the 2005 design value and the 2006 preliminary design value.

The bulk of the monitors inside the Philadelphia Nonattainment area have design values below the health-based eight-hour ozone standard (85 ppb). Preliminary data from 2006 indicates nine (9) monitors exceed the eight-hour ozone standard. Colliers Mills (Ocean County, NJ) has the highest design value in the Philadelphia Nonattainment Area at 93 ppb. Two other monitors have values of 90 ppb (Fair Hill, MD and Northeast Airport, PA). The other six monitors have design vales within a couple of ppb of the standard.

Only four of the eight ozone monitors in the five-county Philadelphia region, which includes Bucks, Chester, Delaware, Montgomery and Philadelphia counties, currently exceed the eight-hour ozone standard. With the exception of the Northeast Airport monitor in Philadelphia County (90 ppb), all of the exceedance monitors in Pennsylvania are within two ppb of the standard.

Figure 3-3. Philadelphia Ozone Nonattainment Area Monitor Locations

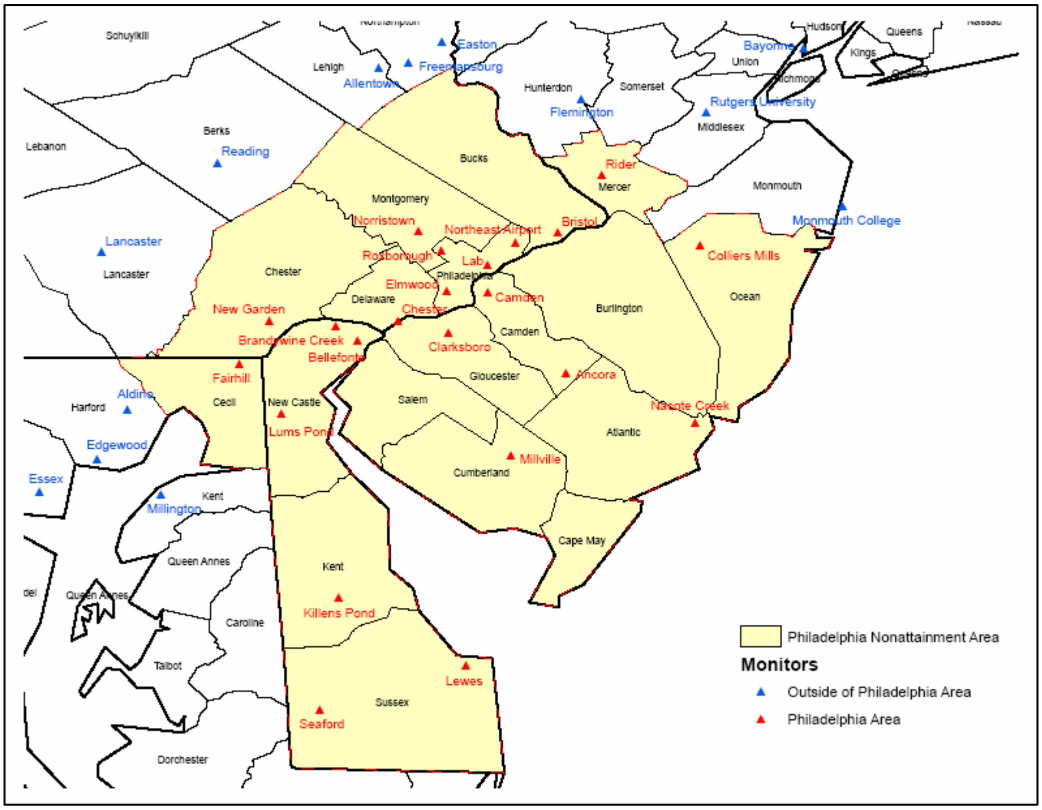


Figure 3-4. Philadelphia Nonattainment Area 2005 Eight-Hour Ozone Design Values

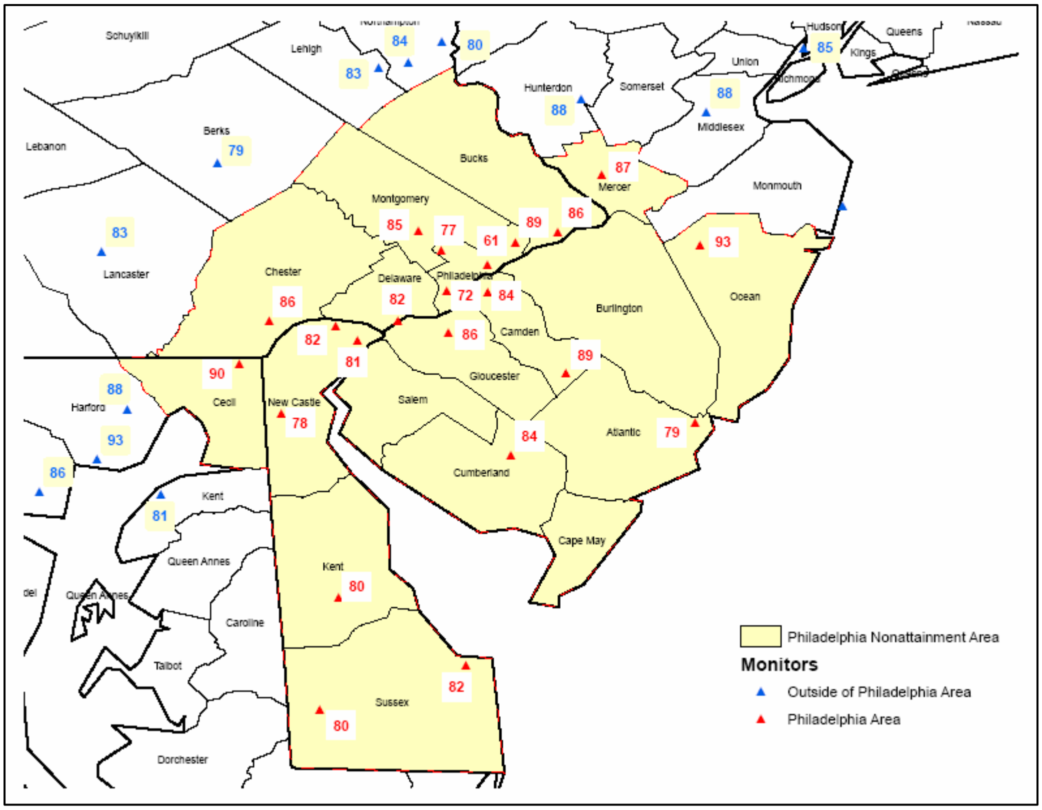


Table 3-1. Philadelphia Nonattainment Ozone Design Values

Monitor	State	County	2005 DV	2006 DV **
Felton	DE	Kent	0.080	0.080
Summit Bridge	DE	New Castle	0.080	0.078
Brandywine	DE	New Castle	0.082	0.082
Bellefonte	DE	New Castle	0.082	0.081
Seaford	DE	Sussex	0.082	0.081
Lewes	DE	Sussex	0.084	0.082
Fair Hill	MD	Cecil	**0.089**	**0.090**
Nacote Creek	NJ	Atlantic	0.082	0.079
Camden	NJ	Camden	INV	0.084
Ancora State Hospital	NJ	Camden	**0.091**	**0.088**
Millville	NJ	Cumberland	0.084	0.084
Clarksboro	NJ	Gloucester	**0.088**	**0.086**
Ride College	NJ	Mercer	**0.086**	**0.087**
Colliers Mills	NJ	Ocean	**0.094**	**0.093**
Bristol	PA	Bucks	**0.086**	**0.086**
New Garden Airport	PA	Chester	**0.087**	**0.086**
Chester	PA	Delaware	0.082	0.083
Norristown	PA	Montgomery	**0.086**	**0.085**
AMS Lab	PA	Philadelphia	0.064	0.063
Roxboro	PA	Philadelphia	0.081	0.078
Northeast Airport	PA	Philadelphia	**0.090**	**0.090**
Elmwood	PA	Philadelphia	INV	INV

**** Preliminary - monitor may not have proper QA/QC. INV=EPA Criteria for valid data is not met**

2. Current Ozone Exceedances

Exceedances in the Philadelphia Nonattainment Area for 2005 and 2006 (preliminary) are summarized using three matrices; exceedance days, exceedance monitors and exceedance site days. These matrices are summarized by state then summed over the entire nonattainment area.

Table 3-3 summarizes exceedances within the Philadelphia Nonattainment Area for the 2005 ozone season and preliminary results for the 2006 ozone season. Three matrices are given. They include exceedance days, the number of days in which at least one monitor exceeded the eight-hour ozone standard, exceedance sites, the number of monitors recording at least one exceedance during the ozone season and exceedance site-days, the total count of the number of monitor exceedances.

A total of twenty-two (22) monitors operated in the Philadelphia Nonattainment Area in 2005 and 2006. Only one monitor in the nonattainment area did not have concentrations that exceeded the eight-hour standard for 2005 or 2006. Exceedance numbers for 2005 are generally higher than the preliminary numbers for 2006.

Table 3-2. Philadelphia Exceedance Summary
2005 Ozone Season

	PA	MD	DE	NJ	Philadelphia
# of Exceedance Days	14	9	16	19	**26**
# of Exceedance Sites	6	1	6	7	**20**
# of Exceedance Site-Days	38	9	25	51	**123**

2006 Ozone Season (Preliminary Data)

	PA	MD	DE	NJ	Philadelphia
# of Exceedance Days	9	6	6	15	**19**
# of Exceedance Sites	7	1	6	7	**21**
# of Exceedance Site-Days	24	6	13	32	**75**

C. Monitor Trends

1. Design Value Trends

Eight-hour ozone trends in the Philadelphia Nonattainment Area were examined over a twenty (20) year period, 1986-2005. Monitor data from this time period was used to calculate eight-hour ozone design values. The design value is calculated following a formula developed by the U.S. EPA. This number is then compared with the health-based standard to determine compliance.

There are twenty-two (22) ozone monitors currently operating in the Philadelphia Nonattainment Area. Thirty-two (32) ozone monitors have operated in the nonattainment area between 1986 and 2005 (the latest year with valid data). Of these monitors, only seven (7) monitors have complete records for the twenty-year period; two in Pennsylvania and five in New Jersey. An analysis over this long a time period allows for an assessment of the magnitude of the changes that have occurred after implementation of major control programs and the affects of meteorological variables that contribute to ozone formation.

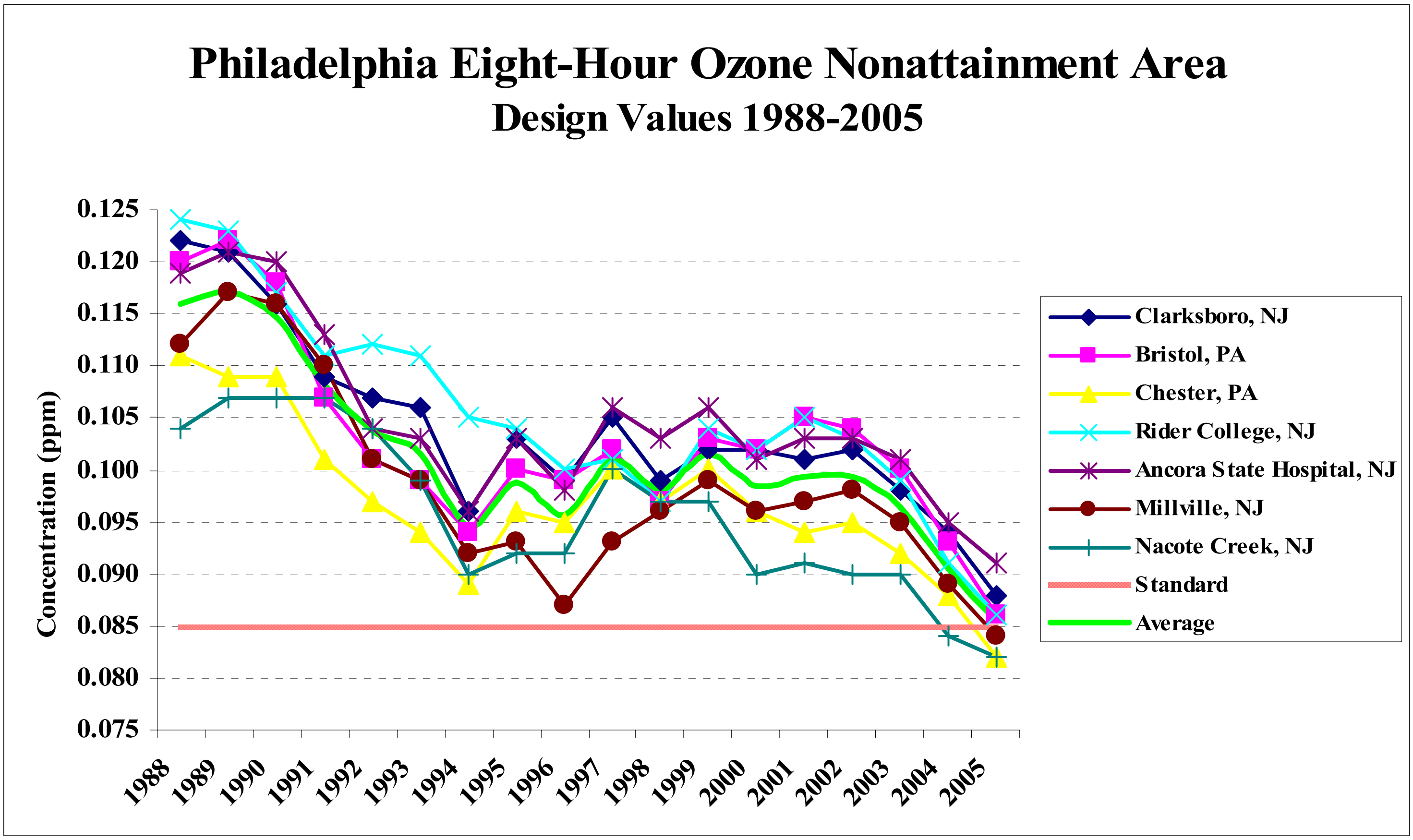
Figure 3-5 shows design value trends for the seven monitors in the Philadelphia Nonattainment Area with complete data over the last twenty years. Design values can be grouped into three tiers that roughly correspond to the two major emission control programs instituted over the last twenty years.

The first (earliest) period contains the highest eight-hour design values and corresponds to the time before reductions in the Reid Vapor Pressure (RVP) were applied to gasoline (Pre-RVP). These controls were included as part of the 1990 Clean Air Act (1990 CAA). RVP controls became effective during the 1991 ozone season but were not enforced until the start of the 1992 ozone season. Average eight-hour design values in the Philadelphia Nonattainment Area averaged about 114 ppb prior to enactment of RVP (pre 1992). After enforcement began, design values averaged about 99 ppb, a reduction of approximately 15 ppb or about 15 percent from pre-RVP levels.

Design values varied by about +/-5 ppb between enactment of RVP and the implementation of the NO_x SIP Call. This fluctuation in design values is probably due to differences in meteorology favoring or reducing ozone production from one ozone season to another. There is a slight rise in the Philadelphia Nonattainment Area's average design values from the mid 1990s to the late 1990s. This may correspond to increased economic activity in the region, which could have led to more emissions during the later half of the 1990s. This trend and correlation was noted in the Department's Philadelphia One-Hour Ozone Midcourse Review.

The next major control measure to affect the Philadelphia Nonattainment Area was the NO_x SIP Call. Program installation, like the RVP controls, was staggered over several ozone seasons. NO_x reductions from power plants within the Ozone Transport Region (OTR) took place during the 2003 ozone season. The NO_x SIP Call became effective for most states outside the OTR during the 2004 ozone season. Average eight-hour ozone design values in the Philadelphia Nonattainment Area dropped from 99 ppb before the NO_x SIP Call to approximately 89 ppb afterwards; a reduction of 10 ppb or about 11 percent. This decrease is in line with ozone reductions noted in the U.S. EPA's September 2006 report (Section 3, Figure 15).

Figure 3-5. Eight-Hour Ozone Design Values



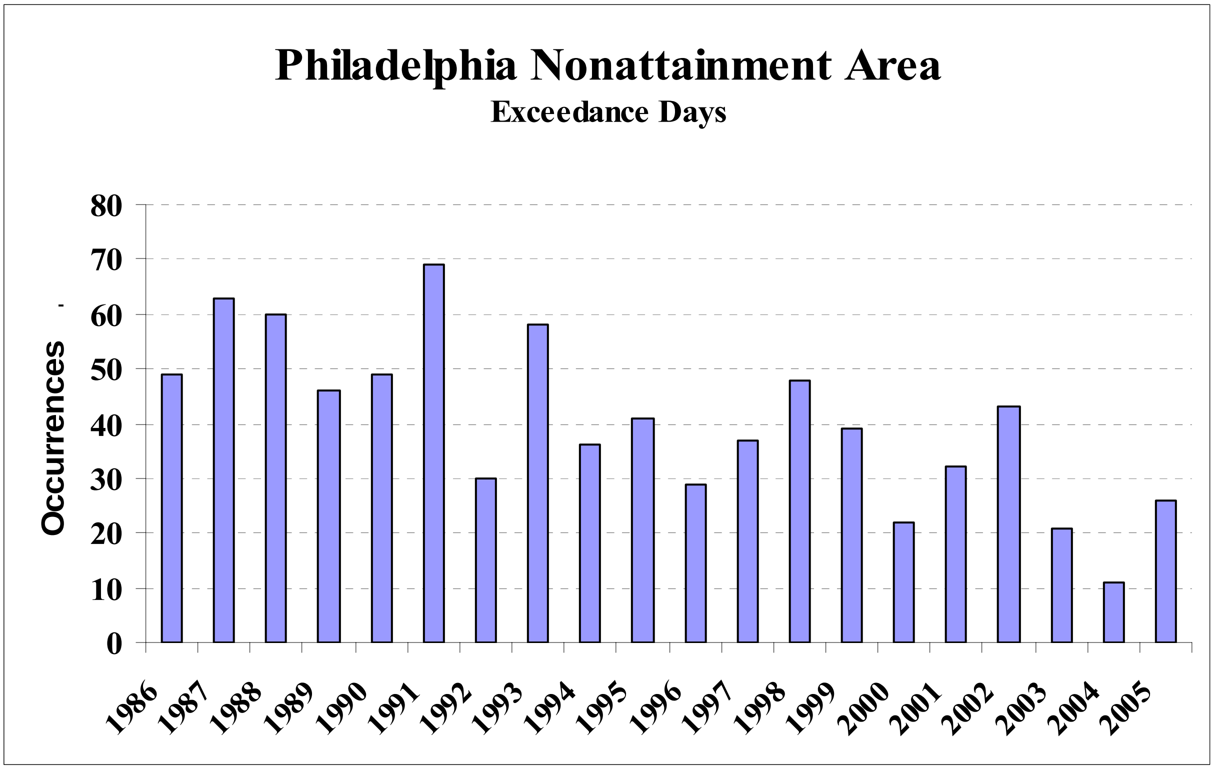
2. Exceedance Trends

Exceedance information over the same twenty-year time period was examined to determine if some of the trends in the Philadelphia Nonattainment Area's design values carried over into the exceedance counts. Three exceedance statistics were examined. These include exceedance days, the number of days at least one monitor within the Philadelphia Nonattainment Area exceeds the standard, monitor exceedances, the number of times monitors within the Philadelphia Nonattainment Area exceed the eight-hour ozone standard during the ozone season, and finally the number of exceedance monitors, the number of monitors whose design value exceeds the eight-hour ozone standard. No adjustments were used to remove monitors that did not have at least 90 percent valid days during an ozone season for the exceedance day and monitor exceedance statistics.

a. Exceedance Day Trends

Figure 2-6 graphs the exceedance information for monitors in the Philadelphia Nonattainment Area. There is more year-to-year variability than the design values. Much of the year-to-year variability is due to differences in meteorological conditions for a particular ozone season. Exceedance day counts have generally decreased over time. Following the same breakdown as the design values, the average number of exceedance days before RVP was ~56, after RVP was introduced the average number of exceedance days dropped to ~36, and after the NO_x SIP Call the average number of exceedance days has dropped to ~18.5.

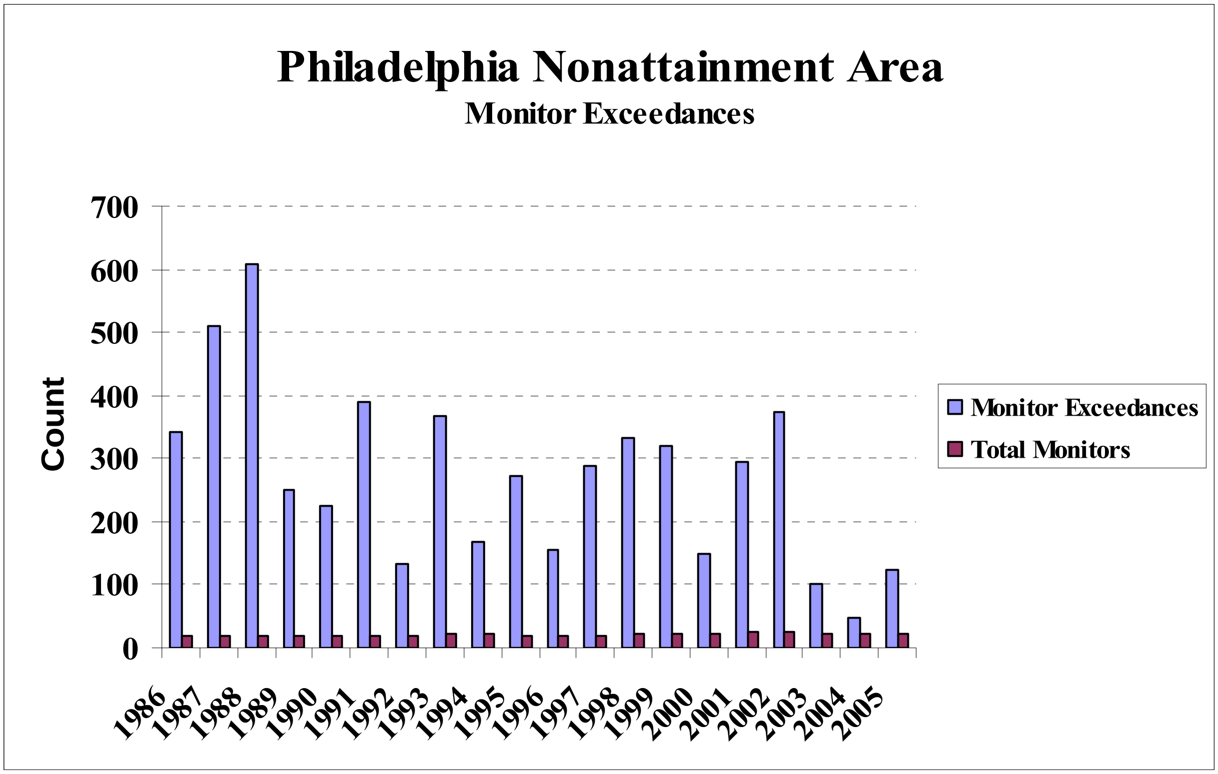
Figure 3-6. Exceedance Day Summary 1986-2005



b. Monitor Exceedance Trends

The trends in the total number of monitor exceedances within the Philadelphia Nonattainment Area are similar to what was observed in the design values and exceedance day counts. Prior to the introduction of lower RVP fuels the Philadelphia Nonattainment Area had an average of ~387 monitor exceedances per ozone season. This number dropped to an average of ~246 monitor exceedances after RVP became effective and was reduced to ~86 monitor exceedances per ozone season after the NO_x SIP Call became effective. Figure 3-7 graphs the number of monitor exceedances in the Philadelphia Nonattainment Area over the last twenty years.

Figure 3-7. Monitor Exceedance Summary



c. Trends in Number of Monitors Violating the NAAQS

There have been approximately thirty or so monitors that have operated in the Philadelphia Nonattainment Area at one time or another over the last twenty years. The number of monitors operating during any particular season has ranged from eighteen to twenty-four with an average of approximately twenty. A monitor must have collected enough valid data to determine a design value. Therefore, there may be significantly fewer "valid" monitors in the Philadelphia Nonattainment Area than operating monitors.

Table 3-3 lists the number of valid monitors in the Philadelphia Nonattainment Area between 1988 and 2005 along with the number of monitors that exceeded the eight-hour ozone standard.

Two trends are apparent in the exceedance monitor count. First, the number of valid monitors in the Philadelphia Nonattainment Area has gradually increased over time nearly doubling from 1991 to 1994. This means that nearly half of the twenty or so monitors in the Philadelphia Nonattainment Area had a substantial amount of missing data prior to 1994. Therefore the exceedance day counts and monitor exceedance counts probably represent a lower range of values. The second trend noted in the exceedance monitor count is that the percentage of exceedance monitors remained relatively unchanged after RFP. The percentage, however, dropped precipitously after the NO_x SIP Call.

Table 3-3. Exceedance Monitors

	Monitors with Design Values > 84 ppb	Valid Monitors	Percent of Valid Monitors
1988	10	10	100.0%
1989	9	9	100.0%
1990	9	9	100.0%
1991	9	9	100.0%
1992	13	14	92.9%
1993	14	14	100.0%
1994	17	19	89.5%
1995	17	17	100.0%
1996	17	18	94.4%
1997	18	20	90.0%
1998	17	19	89.5%
1999	16	17	94.1%
2000	17	18	94.4%
2001	18	19	94.7%
2002	21	22	95.5%
2003	20	22	90.9%
2004	18	23	78.3%
2005	10	21	47.6%

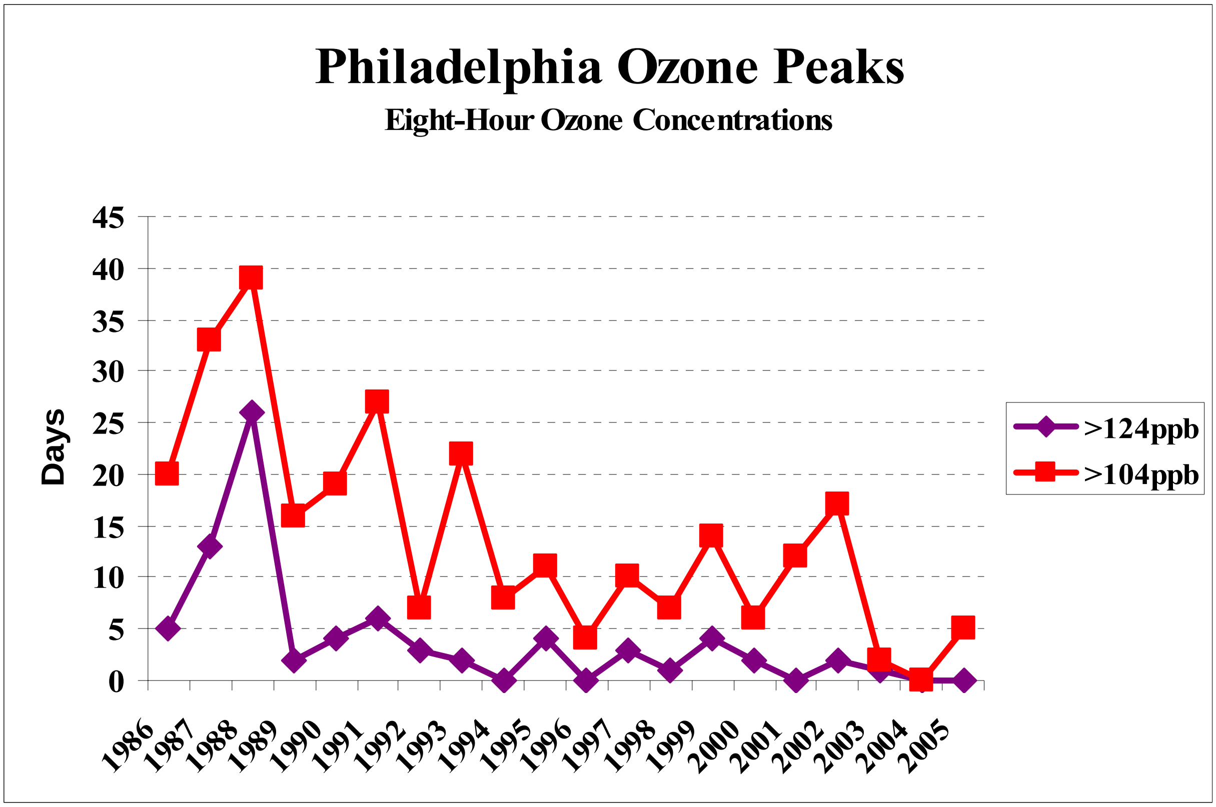
3. Severity

Two severity trends were considered in the Philadelphia Nonattainment Area. The first trend pertains to the peak eight-hour concentrations over the last twenty years and the second pertains to the extent of nonattainment in the area.

a. Peak Ozone Concentrations

Trends in the peak ozone concentrations within the Philadelphia nonattainment area over the last twenty years are examined. Over the last twenty years the magnitude and frequency of extremely elevated eight-hour ozone concentrations has declined. The number of days in which peak ozone concentrations exceed 104 ppb (Unhealthy on the U.S. EPA Air-Quality Index) and 124 ppb (Very Unhealthy on the U.S. EPA Air-Quality Index) are shown in Figure 3-8.

Figure 3-8. Very Unhealthy and Unhealthy Air Quality

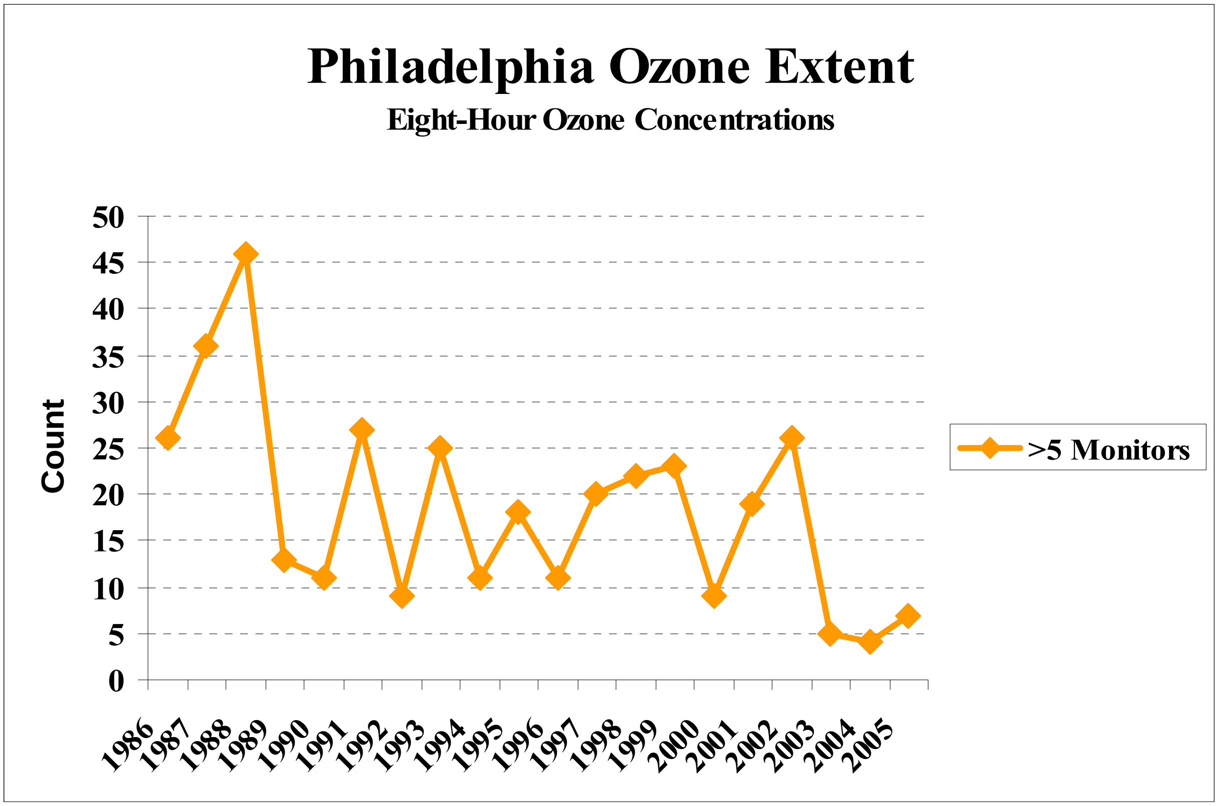


The number of days of very unhealthy air quality (at least one monitor above 124 ppb) in the Philadelphia Nonattainment Area has decreased significantly over the last twenty years. There was a significant reduction after RVP was enacted in the early 1990s and there have been no instances of monitor concentrations entering the very unhealthy range since the implementation of the NO_x SIP Call (the 2004 ozone season). Similar reductions in the number of unhealthy air quality days (above 104 ppb) are also noted over the same time period, though the Philadelphia Nonattainment Area still has some instances when this occurs (post NO_x SIP Call).

b. Extent

The extent of the monitored exceedance problem as also examined. Figure 2-9 shows the number of days within the Philadelphia Nonattainment Area in which more than five monitors exceeded the eight-hour standard (above 84 ppb). The number of days when multiple monitors (greater than five) in the Philadelphia Nonattainment Area exceeded the standard has fallen significantly over the last twenty years. This means that in addition to fewer days in which the eight-hour ozone standard is exceeded the aerial extent or area exceeding the standard within the Philadelphia Nonattainment Area has decreased.

Figure 3-9. Number of Days When More Than Five Monitors Exceeded the Standard



D. NO_x Trends

NO_x is an important ozone precursor. Various NO_x control programs have been enacted since the 1990 Clean Air Act. Emission trends and monitoring trends are examined in this section. Reductions in NO_x emissions have had an effect on ozone concentrations in the Philadelphia nonattainment area.

1. NO_x Emission Trends

The NO_x emission trends included in this section are taken from the U.S. EPA's September 2006 report that examined the affects of the NO_x Budget trading Program (NBP) or NO_x SIP Call. In general, NO_x emissions have fallen significantly since the 1990 Clean Air Act. According to the U.S. EPA, ozone season NO_x emissions have fallen by nearly 72 percent between 1990 and 2005. Emissions have declined (between 2004 and 2005) by a more modest 11 percent due to reductions imposed by the OTC model rules and the NBP. This reduction came in spite of a 7 percent increase in heat input from units affected by the NBP.

NO_x emission within Pennsylvania and inside the OTR declined over 50 percent between 1990 and 2000 according to the U.S. EPA's report. Pennsylvania emissions fell by approximately 40 percent due to the NBP and by 33 percent within the OTR. NO_x reductions in NBP affected states outside the OTR fell by about 28 percent between 1990 and 2000, by almost 55% between 2000 and 2004, and another 15 percent between 2004 and 2005.

2. NO_x Monitoring Trends

Pennsylvania operates three NO_x monitors inside the Philadelphia Nonattainment Area. These monitors are in place to demonstrate attainment with the annual NO_2 ambient standard. Long-term trends in these monitors and other monitors within Pennsylvania can be examined to determine the affect of NO_x control programs on background concentrations.

NO_2 concentrations have fallen roughly 30 percent since the late 1980s for the three Department monitors inside the Philadelphia Nonattainment Area. This is roughly in line with NO_2 reductions observed at other Department-operated monitors within the Commonwealth.

E. Meteorological Trends

Ozone is a secondary pollutant formed from the reactions of VOCs and NO_x. These chemical reactions are heavily dependent on sunlight and temperature. Therefore, ozone production is heavily dependent on meteorological conditions. The region's air-quality forecasters recognize this fact. The severity of any particular ozone season is therefore dependent on several meteorological factors including temperature and amount of available sunshine (which actually drives ozone chemistry).

This section will examine trends in ozone season temperatures and precipitation (proxy for available sunshine) to determine if ozone concentrations in the Philadelphia Nonattainment Area mirror any trends in the meteorological data. Ozone transport is another important factor in the severity of a particular ozone season. Temperature and precipitation trends will not be able to capture any transport contributions to a particularly severe ozone season.

1. Temperature Trends

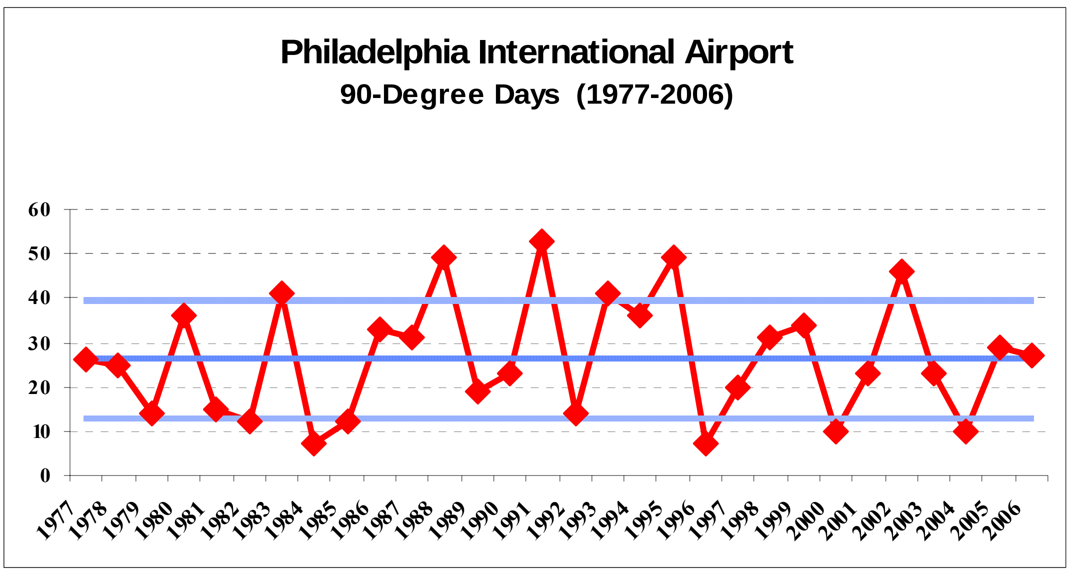
Three measures of temperature from the Philadelphia International Airport are examined to determine any trends in the data. Trends are examined over a thirty-year period (1977-2006). The three temperature measurements examined include 90-degree days, average peak temperatures for June, July and August and cooling-degree days for June, July and August.

An initial analysis indicates no overall trends in the temperature data. It appears from this analysis that eight-hour ozone design value trends do not really follow any distinguishable trends in the temperatures. For instance, temperatures at Philadelphia International Airport were well above the thirty-year average during the early 1990s than during the later half of that decade. Eight-hour ozone design values, however, were lower in the early 1990's than the later 1990s.

a. Ninety-Degree Days

Figure 3-10 shows the number ozone season 90-degree days at the Philadelphia International Airport from 1977 through 2006. The thirty-year average and one standard deviation from the average are also depicted on the graph. There do not seem to be any long-term trends in the 90-degree data. It does appear that there were some unusually warm summers that extended from the late 1980s through the mid-1990s. Unusually cool summers were evident in the early 1980s.

Figure 3-10. Ozone Season Ninety-Degree Days at Philadelphia International Airport: 1977-2006



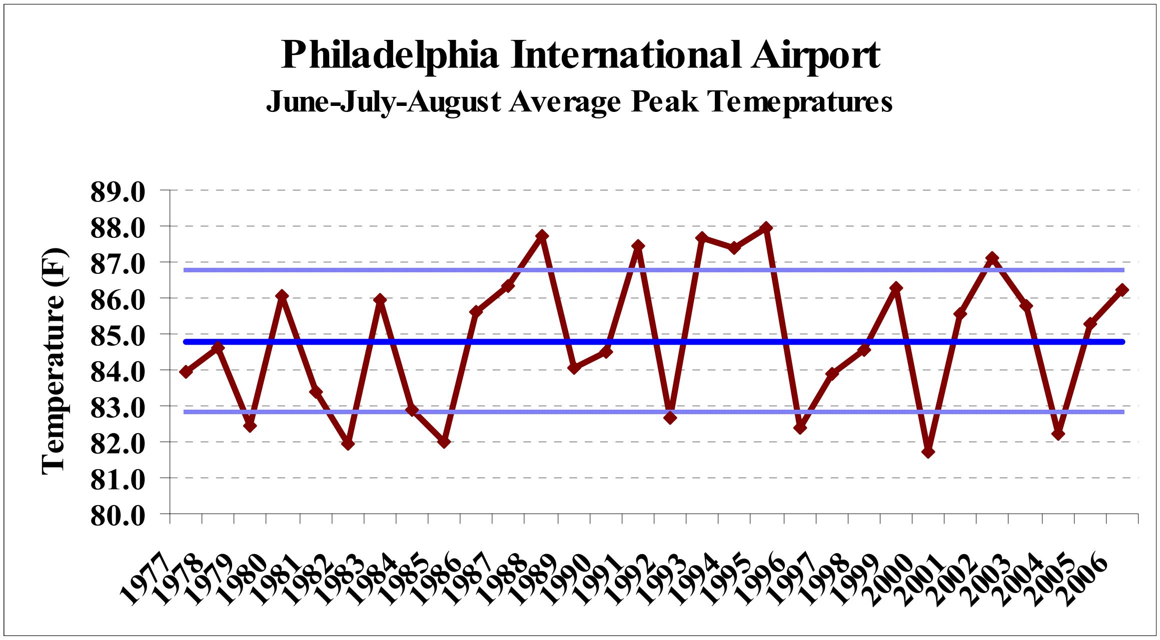
b. June-July-August Mean Peak Temperatures

Another way to gauge temperatures in the Philadelphia Nonattainment Area is to examine the average peak temperatures for the months on June, July and August. These three months are generally the warmest months of the year and correspond to the height of the ozone season. Average peak temperatures over the last thirty years are compared to the average peak temperature over the entire period (plus/minus one standard deviation).

Figure 3-11 shows the average June, July and August peak temperatures at the Philadelphia International Airport over the last thirty years. Like the 90-degree day chart, there doesn't appear to be any long-term trends in the average peak temperatures.

Average peak temperatures were unusually high from the late 1980s through the early 1990s. A similar pattern was noted in the 90-degree days.

Figure 3-11. June-July-August Average Peak Temperatures at Philadelphia International Airport: 1977-2006

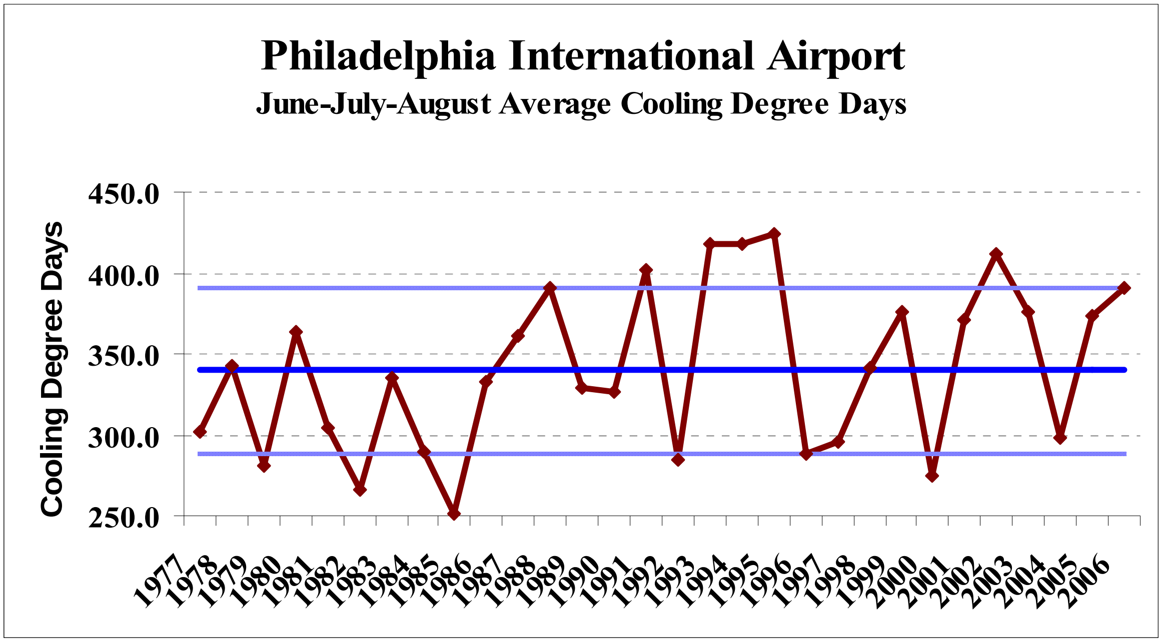


c. June-July-August Cooling-Degree Days

A cooling degree day is a measure that relates the day's temperature to the energy demands of air conditioning. This has two advantages in that it is a measure of how warm it is and a proxy for electricity demand (and thus ozone producing emissions). Cooling degree days for the months of June, July and August are examined over the last thirty years. Each individual year is plotted versus the thirty-year period average (plus/minus one standard deviation).

Figure 3-12 shows the average June, July and August cooling degree days for the Philadelphia International Airport over the last thirty years. Again there is a trend towards higher cooling degree days extending from the late 1980s through the early 1990. Cooling degree days generally are below average during the early half of the 1980s.

Figure 3-12. June-July-August Cooling Degree Days at Philadelphia International Airport: 1977-2006



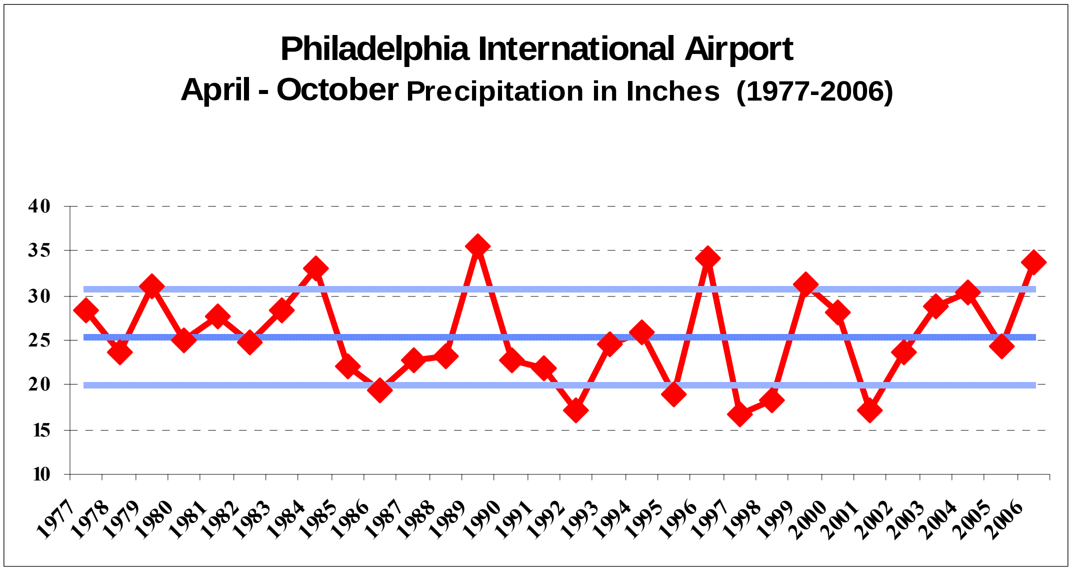
2. Precipitation Trends

Precipitation trends at the Philadelphia International Airport are also examined. Thirty years of ozone season (April through October) precipitation totals (inches of rain) and precipitation frequency (days with measurable precipitation) are examined. Precipitation is used to estimate available sunshine. Sunlight drives ozone chemistry. Therefore ozone seasons with more precipitation and more days with measurable precipitation should have less available sunlight and possibly lower ozone concentrations.

a. Total Precipitation Trends

Figure 3-13 shows ozone-season precipitation totals from 1977 through 2006. The average total for that thirty-year period along with one standard deviation (plus and minus) is also shown on the graph. Ozone season precipitation totals for the late 1980s through middle 1990s tended on the whole to run below average. A wetter period seems to have occurred in the early 2000 time frame. It is interesting to note that the decreases in the Philadelphia Nonattainment Area's ozone concentrations that occurred in the early 1990s corresponded with conditions more favorable for ozone production, i.e. less precipitation.

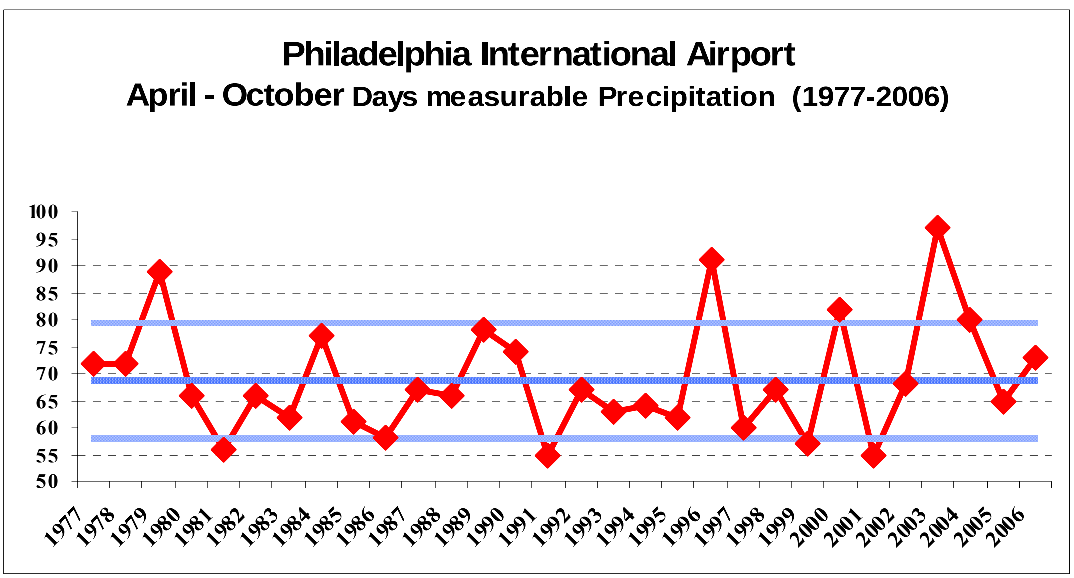
Figure 3-13. Ozone Season Total Precipitation at Philadelphia International Airport: 1977-2006



b. Days with Measurable Precipitation

Figure 3-14 shows the number of days during the ozone season in which measurable precipitation (≥ 0.01 inches) fell at the Philadelphia International Airport. Each year's total is depicted on the graph from 1977 through 2006 along with the thirty-year average plus/minus one standard deviation.

Figure 3-14. Ozone Season Days With Measurable Precipitation at Philadelphia International Airport: 1977-2006



The trends in days with measurable precipitation are similar to the total precipitation trends. The relatively dry period noted in the precipitation totals from the late 1980s through the middle of the 1990s is also evident in the days with measurable precipitation statistics. Overall, the number of ozone seasons with below average number of days outnumber years with above average number of days with measurable precipitation.

IV. EMISSION INVENTORIES

Information on the manmade sources of ozone precursors, VOC and NOx, is compiled for:

- "Stationary sources" (or "point" sources), which refer to those sources for which the Department collects individual emissions-related information. Generally they represent major stationary sources but may be smaller.

- "Stationary area sources", which are industrial/commercial/residential sources too small or too numerous to be handled individually, such as commercial and residential open burning, architectural and industrial maintenance coatings application and clean-up, consumer product use, and vehicle refueling at service stations. Where there is overlap between stationary point sources and stationary area sources, the area source values are adjusted to remove any double counting.

- "Highway vehicles", which include passenger cars and light-duty trucks, other trucks, buses and motorcycles.

- "Nonroad sources", which covers a diverse collection of engines for uses including outdoor power equipment, recreational vehicles, farm and construction machinery, lawn and garden equipment, industrial equipment, recreational marine, commercial marine vessels, locomotives, ships, aircraft and many other applications.

All inventories are for the Pennsylvania portion of the Philadelphia Area only.

A. Summary of 2002 Emissions

An emissions inventory for the base year, 2002, was developed for ozone precursors in accordance with EPA guidance. More specific information on the inventory, including annual inventories and information for carbon monoxide is compiled in the Appendices.

Table 4-1. 2002 Emissions In Tons Per Summer Day

	VOC	**NOx**
Stationary Point Sources[2]	25.21	83.59
Stationary Area Sources	149.84	14.64
Highway Vehicles	98.76	184.66
Nonroad Engines/Vehicles	79.06	70.95
TOTAL	**352.87**	**353.84**

2 This does not include emission reduction credits described in Appendix B.

B. Summary of Inventory Methodologies

More information on the methodology for inventory development is available in the appendix or appendices for that type of emission source. Inventory development methodology is summarized below.

Stationary Point Sources. The Department requires owners and operators of larger facilities to submit annual production figures and emission calculations each year. Throughput data are multiplied by emission factors from Factor Information Retrieval (FIRE) Data System and EPA's publication series AP-42 and are based on Source Classification Code (SCC). Each process has at least one SCC assigned to it. If the owners and operators of facilities provide more accurate emission data based upon other factors, these emission estimates supersede those calculated using SCC codes.

Stationary Area Sources. Area source emissions are generally estimated by multiplying an emission factor by some known indicator or collective activity for each area source category at the county level. Pennsylvania estimates emissions from area sources using emission factors and SCC codes in a method similar to that used for Stationary Point Sources. Emission factors may also be derived from research and guidance documents if those documents are more accurate than FIRE and AP-42 factors. Throughput estimates are derived from county-level activity data, by apportioning national or statewide activity data to counties, from census numbers, and from county employee numbers. County employee numbers are based upon North American Industry Classification System (NAICS) codes to establish that those numbers are specific to the industry covered. More specific information on the procedure used for each industry type is contained in Pennsylvania 2002 Area Source Criteria Air Pollutant Emission Estimation Methods, (E.H. Pechan & Associates, Inc., February 2004) which is contained in Appendix C.

Highway Vehicle Sources. The Department employs an emissions estimation methodology that uses the current EPA-approved highway vehicle emission model, MOBILE 6.2, to estimate highway vehicle emissions. In addition, Pennsylvania uses a MOBILE pre- and post-processing software package called PPSUITE to process and compile Pennsylvania's robust highway network and detailed highway vehicle data. PennDOT provided estimates of vehicle miles traveled (VMT) by vehicle type and roadway type. The Pennsylvania methodology is consistent with the January 2002 guidance published by EPA's Office of Transportation and Air Quality (OTAQ) entitled "Technical Guidance on the Use of MOBILE6 for Emissions Inventory Preparation." More information on highway methods is available in the Technical Appendices, Appendix E. The estimate used information specific to the Philadelphia Area where appropriate.

Nonroad Sources. The 2002 emissions for the majority of nonroad emission source categories were estimated using the EPA NONROAD 2005 model. The NONROAD model estimates emissions for diesel, gasoline, liquefied petroleum gasoline, and compressed natural gas-fueled nonroad equipment types and includes growth factors. The NONROAD model does not estimate emissions from aircraft, locomotives or commercial marine vessels. Emissions from aircraft, locomotives, and commercial marine vessels were estimated using EPA guidance and best available information. If specific local operational data was available, that data was used to estimate emissions. State and national data was used if local data was unavailable.

The Department has worked with the staff of the Philadelphia Division of Aviation to obtain accurate operational information for emission sources at Philadelphia International Airport (PHL). The Division of Aviation operates PHL as well as the Northeast Philadelphia Airport. The 2002 PHL Inventory described in Appendix F-3 includes aircraft and aircraft-related equipment from the EPA-approved model, Emissions and Dispersion Modeling System (EDMS), and also additional on-airport highway, stationary and area source emissions. In some cases, emissions occurring at PHL are accounted for only in the regional inventory; these emissions are identified as such in the Appendix.

For 2002 aircraft emissions from the Northeast Philadelphia Airport, the Department estimated emissions using operations data obtained from the Federal Aviation Administration's Terminal Area forecast and modeling the emissions directly with the EDMS.

For 2002 locomotive emissions, the Department projected emissions from a 1999 survey, conducted by the Department, when the Department obtained fuel use statistics from class II and III railroads. For class I railroads, which produce most of the emissions in the state, the Department conducted a 2002 inventory because the 1999 fuel use data for class I railroads was compromised by gridlock caused by the acquisition of Conrail by CSX and Norfolk Southern. Emissions were generated using EPA emission factors. Emissions were grown using national railroad fuel use trends.

The Philadelphia Area contains the Port of Philadelphia. All air emissions from commercial vessel traffic were estimated using the methodology outlined in EPA's publication *Commercial Marine Activity for Great Lakes and Inland River Ports in the United States, Final Report*. Additional information was obtained from conversations with tug operators in the port.

C. Projected Inventories

1. Summary of 2009 Estimated Emissions

Table 4-2 summarizes the emissions expected in 2009. These emissions take activity and emissions growth and/or controls from 2002 into account. More specific information on the inventory is compiled in the Appendices.

Table 4-2. 2009 Projected Emissions

TONS PER SUMMER DAY

	VOC	NOx
Stationary Point Sources[3]	24.52	75.24
Stationary Area Sources	142.13	15.64
Highway Vehicles	58.71	101.60
Nonroad Engines/Vehicles	60.11	61.13
TOTAL	**285.47**	**253.61**

2. Growth Projection Methodologies

This section describes the data, methods, and assumptions utilized in developing estimates of emissions changes between 2002 and the milestone years, 2008 (reasonable further progress milestone) and 2009 (reasonable further progress milestone and attainment ozone season).

Stationary Point Sources. The methodology for projecting emissions to 2009 is the same as the methodology described below for stationary area sources. Additional information about these projected methodologies can also be found in Appendix D.

The Department used EPA's IPM modeling as adjusted by the Visibility Improvement State and Tribal Association of the Southeast (VISTAS), specifically VISTAS 2.1.9, to predict the results of the federal CAIR regulation at affected facilities throughout the CAIR region. The emissions for 2009 resulting from application of the CAIR cap and trade program for ozone season NOx emissions as predicted by IPM were used in the modeling demonstration for the Philadelphia Area.

However, for the Philadelphia Area Reasonable Further Progress demonstration where there are several CAIR-affected facilities, the Department decided to project future emissions of these facilities using growth factors from the Economic Growth Analysis System (EGAS). The facilities are: Exelon Generating Company, Croydon, Fairless Hills, Falls Township, Pennsbury, Cromby, Chester, Eddystone, Moser, Limerick, Delaware, Richmond, Southwark and Schuylkill; and also the Liberty Electric, Eddystone Station. This projection is consistent with the approach used for other stationary sources in the Philadelphia Area plan. While the IPM model is effective in predicting future regional emissions, it is not necessarily accurate on an individual boiler basis. The Department has determined that EGAS is a more accurate prediction of expected future NOx emission levels for the subject boilers. Appendix I contains all of the CAIR-affected EGU facilities in the state and their projected emissions using growth factors for 2009.

3 This does not include emission reduction credits described in the Technical Appendix A.

Stationary Area Sources. Area source emissions were projected from the 2002 inventory. The factors used for the temporal allocation of projections to 2004 from the 2002 baseline inventory were provided by the Mid-Atlantic Regional Air Management Association (MARAMA), which is performing air quality modeling for the Northeast and Mid-Atlantic states. The factors were in the form of Sparse Matrix Operator Kernel Emissions (SMOKE) v2.2 input files[4]. A temporal allocation was then performed to generate tons per summer day[5]. Area source temporal cross-reference codes were selected, based on Source Category Codes (SCC), from files named ATREF (Area Temporal Reference) and PTREF (Point Temporal Reference), respectively. Once a cross-reference code was obtained, the actual temporal profile weights were obtained from files named ATPRO (Area Temporal Profile) and PTPRO (Point Temporal Profile).

Once the necessary weighting factors were obtained, the following formula was used to convert annual emissions to daily emissions:

$$Emissions_{Daily} = \frac{\left(\frac{TW_{July}}{TW_{Total}}\right) \times Emissions_{Annual}}{31}$$

Where:

TW_{July} is the Temporal weight for July from the appropriate file named TPRO
TW_{Total} is the total of temporal weights for the entire year.

A table of growth factors for 2009, 2012, and 2018 was provided by MARAMA. For each state, county and SCC, this table includes state growth factors derived from the Energy Information Administration (EIA) Annual Energy Outlook, 2005; and/or factors extracted from the Economic Growth Analysis System (EGAS). Where more than one factor was available, the first choice was the EIA factor followed by the EGAS factor.

MARAMA also supplied tables of control factors, rule effectiveness factors, and rule penetrations factors for any control measures applicable to these sources.

For the area sources, these factors were available by SCC and pollutant. There may be more than one generic control factor that applies to a given SCC and pollutant. In cases where there was more than one applicable factor, the following formula may have been applied recursively to generate reductions that are a composite of those factors.

$$Emissions_{Controlled} = Emissions - ((CF \times RE \times RP) \times Emissions)$$

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4 For additional information on the SMOKE file formats, please refer to the SMOKE v2.2 Users Manual, available from the Center for Environmental Modeling for Policy Development (CEMPD) at http://cf.unc.edu/cep/empd/products/smoke/index.cfm#Documentation.

5 Consistent with its prior SIP submissions, the PADEP did not attempt to calculate weekday vs. weekend emissions for area sources. Reliable allocation factors for such a calculation were not readily available, and it would be unlikely to result in significant differences for SIP purposes.

Where

CF is the control factor
RE is the rule effectiveness factor
RP is the rule penetration factor

Highway Vehicle Sources. EPA's approved highway vehicle emission model, MOBILE 6.2, projects highway vehicle average fleet emission factors. Information specific to the Philadelphia Area, for example, gasoline type, was used where appropriate. Traffic forecasts were compiled using information from PennDOT's Traffic Information System and socioeconomic data. Furthermore, county specific VMT totals were upwardly adjusted to equal the five-county regional VMT estimated by the Delaware Valley Regional Planning Commission (DVRPC) using their area-specific traffic demand model and forecasting tools. The Pennsylvania methodology for estimating highway vehicle emissions is consistent with the January 2002 guidance published by EPA's Office of Transportation and Air Quality (OTAQ) entitled "Technical Guidance on the Use of MOBILE6 for Emissions Inventory Preparation." Specific information on the methodology is found in Appendix E.

Nonroad Sources. Projected emissions for the majority of nonroad emission source categories were estimated using the EPA NONROAD 2005 model, which contains default assumptions for projected years. The NONROAD model estimates emissions for diesel, gasoline, liquefied petroleum gasoline, and compressed natural gas-fueled nonroad equipment types and includes growth factors.

For locomotive emissions, the Department projected emissions from a 1999 survey using national fuel consumption information and EPA emission and conversion factors.

The Department has worked with the staff of the Philadelphia Division of Aviation to obtain accurate operational information for emission sources at Philadelphia International Airport (PHL) in 2002. Emissions from commercial aircraft are estimated using the EPA-approved Emissions & Dispersion Modeling System (EDMS). Growth was estimated using estimates of future operations at PHL from the FAA APO Terminal Area Forecast Detailed Report. Major construction is anticipated at PHL to relieve aircraft congestion, potentially starting in 2010. The preferred alternative for this Capacity Enhancement Program has not yet been selected; these alternatives are being reviewed under the National Environmental Policy Act. Emissions for January – June 15, 2010 are included under the alternative with the highest level of construction for that year. Additional information on PHL emissions is found in Appendix F-3.

Small aircraft emissions were calculated by using small airport operation statistics, which can be found at www.airnav.com and the Federal Aviation Administration's (FAA) APO Terminal Area Forecast Detailed Report.

Emissions growth for commercial marine vessels is based on two factors: future fuel consumption and future emissions standards. Emissions standards or programs that take place in the future will greatly lower emissions produced by commercial marine vessel engines. Fuel use growth and future emission reductions used to calculate total future emissions were based upon information contained in the EPA publication, *Final Regulatory Impact Analysis: Control of Emissions from Marine Diesel Engines*.

D. Reasonable Further Progress (RFP) Requirements

1. Introduction

As a moderate eight-hour ozone nonattainment area, the Philadelphia Nonattainment Area is required to demonstrate Reasonable Further Progress (RFP) towards attainment by 2008. EPA regulations and guidance define RFP as demonstrating a 15 percent (VOC and/or NOx) emissions reduction from 2002 to 2008. The Philadelphia Nonattainment Area is required to demonstrate that the remainder of the emission reductions needed for attainment will be achieved by the attainment date.

To demonstrate RFP, an area must show that its expected emissions of NOx and VOC will be less than or equal to the target levels set for the end of the RFP period. For the RFP period 2002-2008, the target levels are the maximum quantity of anthropogenic emissions permissible during the 2008 "milestone year".

This section describes the methodologies used to establish the target levels, estimate expected emissions and demonstrate that the expected emissions are less than or equal to the target levels in the Pennsylvania portion of the Philadelphia Nonattainment Area.

The Pennsylvania portion (Bucks, Chester, Delaware, Montgomery and Philadelphia Counties) of the Philadelphia Nonattainment Area, which was classified as a severe one-hour ozone nonattainment area, has an approved 15 percent VOC plan for the period 1990-1996 as required for moderate and above one-hour nonattainment areas. (62 Fed. Reg. (Jun. 9, 1997); 40 CFR 52.2020(e)) The Philadelphia Area was also required to demonstrate additional reductions after 1996 of 3 percent per year (9 percent every three years) until attainment. The Pennsylvania rate of progress plans were approved in 2001. (66 *FR* 54143, October 26, 2001)

2. Calculating RFP Emission Target Levels

a. Procedure

The procedure for developing target levels for an RFP plan is contained in EPA guidance.[6] Phase 2 of EPA's implementation rule[7] and additional guidance[8] also discuss RFP requirements.

The CAA included restrictions on the ability of states to take emissions reduction credits to meet the 15 percent requirements resulting from the Federal Motor Vehicle Control Program (FMVCP) standards issued as of January 1, 1990, federal regulations limiting the Reid Vapor Pressure (RVP) or evaporability of gasoline issued prior to the passage of the CAA amendments, state rules correcting prior deficiencies in reasonably available

6 *Adjusted Base Year Emissions Inventory and the 1996 Target for the 15% Rate of Progress Plans*, October 1992.
7 70 FR 71612, November 29, 2005
8 *8-Hour Ozone Implementation Q's and A's Concerning RFP*, August 15, 2006

control technology, and certain revisions to vehicle emission inspection/maintenance plans. Of these three restrictions, only that relating to the FMVCP as of January 1, 1990, has a bearing on the 8-hour RFP plan. This is because the latter two restrictions were fully reflected in the 2002 base year inventory whereas some emissions reductions in highway vehicle emissions after 2002 can be attributable to the FMVCP as of January 1, 1990. Reductions in emissions after 2002 are attributable to the FMVCP as of January 1, 1990, when the oldest vehicles in the fleet that were not required to meet the standards of the FMVCP as of January 1, 1990, are replaced with newer vehicles. The replacement vehicles must meet the most current standards in effect at the time of manufacture.

The RFP plan is allowed to credit only the changes in emissions that result from the difference between the current standard and the standards set by the FMVCP as of January 1, 1990. Appendix A to the Preamble of the Phase 2 implementation rule provides step-by-step guidance for how to adjust inventories to comply with these exclusions.[9] Since Pennsylvania's portion of the Philadelphia Nonattainment Area has an approved 15 percent plan under the one-hour standard, the 2002-2008 RFP demonstration uses Method 2. While not all portions of the nonattainment area have a one-hour 15 percent plan, (Sussex County, Delaware is one portion and Atlantic City portion is another), the Phase 2 Rule allows nonattainment areas that are partly covered by a one-hour plan to split the area and demonstrate 15 percent VOC RFP in the part that is not covered, and, use 15 percent VOC and NOx in the part that is covered. Therefore, Pennsylvania's portions can use the 15 percent VOC and NOx option.

Method 2 states that the target level of VOC and NOx emissions in 2008 is any combination of VOC and NOx reductions from the adjusted base year 2002 inventories (adjusted to exclude non-creditable emission reductions) that total 15 percent.

The general formula for 2008 target levels is as follows:

> TARGET LEVEL = (2002 emissions) – (non-creditable emissions reductions between 2002 and 2008) – (reductions required to meet the RFP requirement)

b. The Inventories

The 2002 base year inventory is an inventory of actual anthropogenic emissions on a typical summer day. This is indicated as section A of Method 2 in Appendix A of the Final Implementation rule.

Table 4-3. 2002 Anthropogenic Base Year Inventory

	VOC	NOx
Point	25.21	83.59
Area	149.84	14.64
Highway	98.76	184.66
Nonroad	19.06	70.95
TOTAL	352.87	353.84

9 70 FR 71696, November 29, 2005

In step B of Method 2, the same highway vehicle activity inputs used to calculate the 2002 base year inventory are used to calculate both 2002 and 2008 highway emissions but without all post-1990 Clean Air Act FMVCP standards. Since there were no adjustments to RACT since 2002, all non-creditable reductions are in the highway inventory. Appendix E-3 shows the inputs to the MOBILE model used to calculate all highway vehicle inventories. Tables 4-4 and 4-5 show the results of these adjustments.

Table 4-4. 2002 Adjusted Emissions (tpd)

	VOC	NOx
Point	25.21	83.59
Area	149.84	14.64
Highway	170.33	224.80
Nonroad	79.06	70.95
TOTAL	424.44	393.98

Table 4-5. 2008 Adjusted Emissions (tpd)

	VOC	NOx
Point	25.21	83.59
Area	149.84	14.64
Highway	157.61	209.22
Nonroad	79.06	70.95
TOTAL	411.72	378.40

The difference between 2002 and 2008 adjusted inventories represent the amount of non-creditable VOC and NOx emissions. This calculation is described in Step C of Method 2.

Non-creditable emissions = (2002 Adjusted Emissions) – (2008 Adjusted Emissions)

12.72 tpd VOC = 424.44 tpd VOC – 411.72 tpd VOC
15.58 tpd NOx = 393.98 tpd NOx – 378.40 tpd NOx

Non-creditable emissions are then subtracted from the 2002 anthropogenic base year inventory (Table 4-3) These adjusted inventories serve as the basis for calculating the 2008 target level of emissions. This calculation is described in step D of Method 2.

Table 4-6. Calculation of Basis of Target Levels (tpd)

	VOC	NOx
2002 base year inventory (a): *from Table 4-3*	352.87	353.84
Non-creditable emission reduction (b)	12.72	15.58
2002 Basis of Target Levels (c) = (a-b)	**340.15**	**338.26**

3. Compliance with 2008 RFP Requirements

In order to demonstrate compliance with the 15 percent RFP requirement, Pennsylvania must demonstrate that 2008 expected emissions of any combination of VOC and NOx have been reduced by 15 percent. Expected emissions are those which both project growth in the activities creating the emissions and estimate reductions from the resulting level of emissions through permanent and enforceable control measures. Table 4-7 shows 2008 expected emissions for the Pennsylvania portion of the Philadelphia Nonattainment Area.

Table 4-7. 2008 Expected Emissions (tpd)

	VOC	NOx
Point	24.62	76.43
Area	147.64	14.92
Highway	61.09	108.78
Nonroad	62.84	62.67
TOTAL	**296.19**	**262.80**

The target level for reduction is any combination of VOC and NOx reductions that total 15 percent when comparing the 2002 basis for target level emissions (Table 4-3) to the 2008 expected emissions (Table 4-7). EPA guidance allows for the substitution of NOx reductions in instances where VOC reductions alone are not equal to or greater than 15 percent. The EPA guidance provides for NOx substitution on a percentage basis equal to or less than the total percentage reduction estimated in 2008 relative to the 2002 basis for target level emissions. An area can then demonstrate RFP if the actual 2008 VOC percent reductions (relative to the 2002 basis for target level emissions) plus the estimated 2008 NOx percent reductions are greater than or equal to 15 percent.

Table 4-8. Actual 2008 VOC and NOx Reductions Relative to the 2002 Basis for Target Level Emissions

	VOC	**NOx**
2008 Expected Emissions (tpd) *(a); from Table 4-7*	**296.19**	**262.80**
2002 Basis for Target Level (tpd) *(b); from Table 4-6*	**340.15**	**338.26**
Percent Reduction *(c) = [1- (a)/(b)] x 100*	**12.92%**	**22.31%**

As there is sufficient NOx percent reductions combined with VOC percent reduction equal to or greater than 15 percent, the area can demonstrate RFP consistent with EPA NOx substitution guidance. The 2008 target levels for emissions using a combined VOC and NOx reduction percentage of 15 percent are summarized in table 4-9.

Table 4-9. Calculation of 2008 Target Levels with NOx Substitution

	VOC	NOx
2002 anthropogenic base year inventory (tpd) *(a): from Table 4-3*	352.87	353.84
Noncreditable emission reduction (tpd) *(b)*	12.72	15.58
2002 adjusted base-year inventory (tpd) *(c) = (a-b): from table 4-6*	340.15	338.26
Target % Reduction Required for RFP *(d)*	7.5	7.5
2008 Target Levels (tpd) *(e) = c*(1-(d/100))*	**314.64**	**312.89**

Table 4-10. Comparison of 2008 Target and Expected Emissions (tpd)

	VOC	NOx
2008 Target Levels: from table 4-9	**314.64**	**312.89**
2008 Expected Emissions: from table 4-7	**296.19**	**262.80**

As shown in Table 4-10, both 2008 estimated VOC and NOx emissions are below the 2008 VOC and NOx target levels.

4. RFP Contingency Plan

The SIP for a moderate nonattainment area must include contingency measures to provide for additional reductions for failure to achieve RFP. Early implementation of contingency measures is acceptable. The contingency plan must provide for a 3 percent reduction (by any combination of VOC and NOx) in emissions from the Pennsylvania portion of the area compared to the 2002 adjusted base year inventory.[10,11,12,13,14] Furthermore at least 0.3 percent of the total 3 percent must be attributable to VOC reductions.

The contingency plan for potential RFP failures is to include in the SIP an RFP plan that demonstrates an 18 percent reduction in emissions by 2008. This is 3 percent above the required 15 percent reduction and consists of at least 0.3 percent reductions attributable to VOC. The additional 3 percent reduction above the requirement can be attributed to Tier 2 vehicle emission standards. Table 4-8 demonstrates that the Pennsylvania portion of the Philadelphia Area can demonstrate more than 18 percent combined VOC and NOx reduction by 2008 and thus meets the RFP contingency plan requirement.

E. Motor Vehicle Emission Budgets For Transportation Conformity

Section 176 of the CAA provides a mechanism by which federally funded or approved highway and transit plans, programs, and projects are determined not to produce new air quality violations, worsen existing violations, or delay timely attainment of national air quality standards. EPA regulations issued to implement transportation conformity provide that motor vehicle emission "budgets" establish caps of these emissions that cannot be exceeded by the predicted transportation system emissions in the future. Transportation agencies in Pennsylvania are responsible for making timely transportation conformity determinations. The responsible agency in the Pennsylvania portion of the

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10 "General Preamble for the Implementation of Title I of the Clean Air Act Amendments of 1990," 57 FR 13498, April 16, 1992.
11 "Guidance for Growth Factors, Projections, and Control Strategies for the 15 Percent Rate-of-Progress Plans" (EPA-452/R-93-002), March 1993
12 "Early Implementation of Contingency Measures for Ozone and Carbon Monoxide (CO) Nonattainment Areas," Memorandum from G.T. Helms, Chief, Ozone/Carbon Monoxide Programs Branch, August 13, 1993;
13 "Guidance on the Post '96 Rate-of-Progress Plan (RPP) and Attainment Demonstration" (Corrected version of February 18, 1994).
14 Preamble of the Phase 2 implementation rule (70 FR 71696, November 29, 2005)

Philadelphia Area is the Delaware Regional Planning Commission, the designated Metropolitan Planning Organization (MPO) under federal transportation planning requirements.

Pennsylvania proposes to establish budgets for highway emissions in order to ensure that transportation emissions do not impede clean air goals in the next decade and beyond. The information in Table 2-3, once EPA approves it for purposes of conformity, will establish transportation conformity budgets for the Pennsylvania portion of the Philadelphia Area.

Table 4-11. Motor Vehicle Emission Budgets

2008	**VOC**	**NOX**
Kilograms/day	55,421	98,686
Tons/day	61.09	108.78
2009	**VOC**	**NOX**
Kilograms/day	53,258	92,172
Tons/day	58.71	101.60

V. CONTROL STRATEGIES

A. Permanent and Enforceable Control Measures

This section describes the federal and state measures that will provide the emission reductions leading to the attainment of the standard.

A summary of the quantity of emission reductions expected from 2002 to 2009 is included in Table 5-1. The emission reduction estimates account for any anticipated growth in the activity of sources regulated by the strategy. Each measure is explained in greater detail in the following sections.

Table 5-1: Summary of Emission Reductions 2002-2009 from Control Measures

	VOC	NOx
Stationary Point Sources		
Clean Air Interstate Rule, NOx SIP Call, Smaller Sources of Nox	-	8.35
Hazardous Air Pollutant Regulations	0.69	-
Stationary Area Sources		
Portable Fuel Containers	2.58	-
Consumer Products	4.43	
Architectural and Industrial Maintenance Coatings	4.86	
Highway Vehicle Programs including fuel standards	40.05	83.06
Federal Nonroad Regulations including fuel standards	18.95	9.82

1. Stationary Point Sources

Clean Air Interstate Rule (CAIR) -- The federal CAIR regulations (70 FR 25162, May 12, 2005) will transition from the NOx SIP Call electric generating unit regulations in 2009 and continue to ensure that large electric generation facilities within and upwind of the area will maintain background emissions at or below 2002 levels while any new facilities locating within the area will be required to obtain both offsets and allowances. Pennsylvania and other nearby states are required to adopt a regulation implementing the requirements of the CAIR or an equivalent program. On April 28, 2006, EPA promulgated Federal Implementation Plans (FIPs) to reduce the interstate transport of NOx and sulfur dioxides that contribute significantly to nonattainment and maintenance of the 8-hour ozone and $PM_{2.5}$ NAAQS. The electric generating units (EGUs) in Pennsylvania will be regulated under the FIP until SIP revisions for the implementation of CAIR for the affected EGUs are approved by EPA.

Interstate Pollution Transport Reduction -- In response to the Federal NOx SIP call rule, Pennsylvania and other covered states adopted NOx control regulations for large industrial boilers and internal combustion engines, electric generating units, and cement plants. The regulation covering industrial boilers and electric generators required emission reductions to commence May 1, 2003, while the regulation covering large internal combustion engines and cement plants required emission reductions to commence May 1, 2005. EPA approved this regulation, found in 25 Pa. Code Chapter 145, on September 29, 2006 (71 FR 57428).

Small Sources of NOx, Cement Kilns, and Large Stationary Internal Combustion Engines. The Department established additional ozone season requirements for small sources of NOx in the counties of Bucks, Chester, Delaware, Montgomery, and Philadelphia in regulations that were adopted December 11, 2004. The rules (25 Pa. Code Chapter 129) apply to owners and operators of certain boilers, turbines, and stationary internal combustion units located in Bucks, Chester, Delaware, Montgomery, and Philadelphia Counties. The emission limits are differentiated by fuel type and allow alternative compliance mechanisms. By November 1st of each year, owners and operators of these sources must surrender NOx allowances if actual emissions exceed allowable emissions. The amendments required the NOx emission limits to be implemented by May 1, 2005. EPA approved this program on September 29, 2006 (71 FR 57428).

Federal Standards for Hazardous Air Pollutants. Federal standards to control hazardous air pollutants (HAPs) by requiring Maximum Achievable Control Technology (MACT) at units located at a major source of HAPs. EPA has issued a series of regulations for a variety of sources that are then applicable to sources in Pennsylvania. These MACT standards are incorporated by reference into Pennsylvania's regulations and are also included in the Department's permits for affected sources. EPA has delegated enforcement of the MACT program to the Department. Controls with a compliance date of 2002 and earlier are included in the base year inventory for 2002, while controls with a compliance date of 2003 and later are included in the projection inventories. A list of the categories for which federal MACT standards have been issued is contained in Appendix D.

2. Stationary Area Sources

Portable Fuel Containers. The Department adopted a portable fuel container regulation, 25 *Pa. Code* Chapter 130, Subchapter A, to address VOC loss resulting from permeation through portable gasoline containers, evaporative loss through container openings, and from spillage during the filling of small tanks on machines such as lawn mowers, chain saws, jet skis and the like. This regulation requires that portable fuel containers manufactured after January 1, 2003 for sale in Pennsylvania meet certain requirements. (A "sell-through" provision allowed the sale during 2003 of containers manufactured before January 1, 2003.) The Department predicted, as part of the one-hour ozone SIP demonstration for the Southeast Pennsylvania area, that the portable fuel container regulation would be fully phased in over a 10-year period, i.e. approximately 10 percent of the existing containers would be replaced each year. Emission reduction estimates for the program reflect this phased-in replacement of the containers. The regulation was submitted to EPA as a SIP revision on March 26, 2003 and approved on December 8, 2004 (69 FR 70893).

Consumer Products. This regulation applies statewide to any person who sells, supplies, offers for sale, or manufactures certain consumer products on or after January 1, 2005, for use in the Commonwealth. The Consumer Products regulation includes general provisions, VOC standards, provisions for exemptions, provisions for innovative products, administrative requirements, reporting requirements, provisions for variances, test methods, and provisions for alternative control plans for consumer products. The program is contained in 25 *Pa. Code* Chapter 130, Subchapter B. It was submitted to EPA as a SIP revision on March 26, 2003 and approved on December 8, 2004 (69 FR 70895).

Architectural and Industrial Maintenance Coatings. The Pennsylvania Architectural and Industrial Maintenance (AIM) Coatings regulation applies statewide to any person who supplies, sells, offers for sale, or manufactures, blends or repackages an AIM coating for use within the Commonwealth, as well as a person who applies or solicits the application of an AIM coating within the Commonwealth. The regulation does not apply to the following: (1) Any AIM coating that is sold or manufactured for use outside the Commonwealth or for shipment to other manufacturers for reformulation or repackaging; (2) any aerosol coating product; or (3) any AIM coating that is sold in a container with a volume of one liter (1.057 quarts) or less. The AIM Coatings regulation sets specific VOC content limits, in grams per liter, for AIM coatings categories with a compliance date of January 1, 2005. Manufacturers ensure compliance with the limits by reformulating coatings and substituting coatings with compliant coatings that are already in the market. The regulation contains VOC content requirements for a wide variety of field-applied coatings, including graphic arts coatings, lacquers, primers and stains. The regulation also contains provisions for a variance from the VOC content limits, which can be issued only after public hearing and with conditions for achieving timely compliance. In addition, the regulation contains administrative requirements for labeling and reporting. There are a number of test methods that would be used to demonstrate compliance with the AIM Coatings regulation. Some of these test methods include those promulgated by EPA and South Coast Air Quality Management District of California. The methods used to test coatings must be the most current approved method at the time testing is performed.

The AIM coating program requirements are specified in 25 *Pa. Code* Chapter 130, Subchapter C. The final-form regulation was submitted to EPA as a SIP revision on December 3, 2003, with a supplement submitted on October 19, 2004. EPA approved the provisions as an element of the SIP on November 23, 2004 (69 FR 69080).

3. Highway Vehicle Sources

Even with increases in vehicle miles traveled (VMT) that occur from 2002 through 2009 highway vehicle emissions of both VOC and NOx will continue to decrease. As more vehicles subject to cleaner new car standards replace older vehicles subject to less stringent new vehicle standards, the fleet as a whole emits fewer emissions, compensating for the increase in vehicle miles traveled. These decreases can be attributed to the programs described below.

Federal Motor Vehicle Control Programs (FMVCP) and Pennsylvania Clean Vehicle Program for passenger vehicles and light-duty trucks and cleaner gasoline.

Tier 1 tailpipe standards established by the CAA Amendments of 1990 include NOx and VOC limits for light-duty gasoline vehicles (LDGVs) and light-duty gasoline trucks (LDGTs). These standards began to be phased in starting in 1994. Evaporative VOC emissions were also reduced in gasoline-powered cars starting with model year 1998.

In 1998, under the authority of section 177 of the CAA, the Department adopted the Pennsylvania Clean Vehicles Program. (28 Pa. B. 5873, Dec. 5, 1998.) The Pennsylvania Clean Vehicles Program incorporates certain California Low Emission Vehicle emission standards for passenger cars and light-duty trucks by reference. As required under Section 177 of the CAA, these provisions are identical to the low emission standards adopted by California, except that the regulation does not incorporate by reference the California zero emissions vehicle (ZEV) or emissions control warranty systems statement provisions.

In the same rulemaking, the Department adopted the National Low Emission Vehicle (NLEV) program as a compliance alternative to the Pennsylvania Clean Vehicles Program. The NLEV program became effective in the Ozone Transport Region in 1999. Pennsylvania's New Motor Vehicle Emissions Control Program regulations (25 *Pa. Code* Subchapter 126.401-126.441) allowed automobile manufacturers to comply with NLEV instead of the California Low Emission Vehicle (CA LEV) program through MY 2005. These regulations affected vehicles 6,000 pounds and less and were the regulations in effect for new motor vehicles in the baseline year, 2002.

In 1999, EPA promulgated regulations more stringent than NLEV (Tier 2), starting with MY 2004. In order to participate in NLEV, Pennsylvania had been required to adopt language that extended its "commitment" to NLEV until MY 2006. In practical terms, the NLEV program was replaced for MY 2004 and later by the more stringent Federal "Tier 2" vehicle emissions regulations, 65 F.R. 6698 (Feb. 10, 2000), and vehicle manufacturers operating under the NLEV program became subject to the Tier 2 requirements.

Pennsylvania amended the former New Motor Vehicle Control Program (which included the Pennsylvania Clean Vehicles Program) in 2006. The Clean Vehicles Program continues to incorporate the California Low Emission Vehicle Program (CA LEV II) by reference. As amended, the program affects MY 2008 and newer passenger cars and light-duty trucks vehicles. 36 *Pa B.* 7424 (December 9, 2006).

Emissions for milestone years were estimated based on compliance with the Pennsylvania Clean Vehicles Program according to the methodology described in section 7.4.1 of the "Technical Guidance on the Use of MOBILE6.2 for Emissions Inventory Preparation" published by EPA's Office of Transportation and Air Quality (OTAQ) in January 2002. This methodology is further explained in Appendix E. The Department is assuming in its MOBILE modeling that the federal Tier 2 program applies to subject vehicles sold in Pennsylvania from MY 2004 through MY 2007 and the Pennsylvania Clean Vehicles Program applies to subject vehicles sold in model year 2008 and beyond.

Heavy-Duty Diesel Control Programs. EPA promulgated more stringent national regulations for heavy-duty engines and vehicles (over 14,000 pounds) starting with model year 2004. In addition, consent decrees with seven of the largest heavy-duty engine manufacturers required, among other terms, that diesel engines made by these companies comply with these 2004 standards two model years early, in model year 2002. Pennsylvania includes these programs as provided in the MOBILE model.

In 2002, the Department adopted the Heavy-Duty Diesel Emissions Control Program for model years starting after May 2004. The program incorporates California standards by reference and requires model year 2005 and subsequent new heavy-duty diesel highway engines to be those certified by California. California standards are more stringent than federal standards for the two model years between expiration of the consent decrees discussed above and the implementation of more stringent federal standards affecting model year 2007 and beyond. However, EPA's MOBILE model already assumes that the engines would comply with consent decree standards, even without an enforcement mechanism. The Department has used MOBILE defaults to calculate emissions from model year 2005 and 2006 highway engines.

EPA adopted new emission standards for heavy-duty engines and vehicles for model year 2007 and subsequent. For diesel engines, the standards will be phased in from 2007 to 2010 for NOx and VOCs. For gasoline engines, the standards will be phased in during model years 2008 and 2009. Federal and California standards are virtually identical for model year 2007. For model year 2008, California adopted requirements for anti-idling engine programming which will be required in Pennsylvania by virtue of Pennsylvania's incorporation by reference. However, there is no EPA-approved methodology to estimate emission reductions from this requirement. Therefore, the emission estimates use assumptions of the federal rule for these years.

Because the new engine standards are adversely affected by sulfur in fuel, EPA also requires most highway diesel fuel to contain no more than 15 parts per million (ppm) of sulfur in the fall of 2006. There is a temporary compliance option allowing refiners to continue to produce up to 20 percent of their highway diesel fuel at 500 ppm fuel until 2010. Pennsylvania uses MOBILE defaults to estimate the effects of the phase-in provision.

Vehicle Emission Inspection/Maintenance Program. The Philadelphia area has had a vehicle emissions inspection program since 1984. The program was most recently amended in 2003 when on-board diagnostics technology was incorporated into the Philadelphia Area program. In early 2004, Pennsylvania implemented its revised Vehicle Emission Inspection/Maintenance (I/M) Program in the Philadelphia Area. The program applies to gasoline-powered vehicles 9,000 pounds and under, model years 1975 and newer. For vehicles 1996 and newer, the program consists of an annual on-board diagnostics test and a gas cap pressure test. For most subject vehicles 1995 and older, the program consists of a tailpipe test, visual inspection of pollution control devices to ensure they are present, connected and the proper type for the vehicle and a gas cap pressure test. For vehicles older than 25 years, the program is a visual inspection and gas cap test. These regulations can be found in 67 *Pa. Code* Chapter 177. Pennsylvania submitted the revised emissions program as a SIP revision on December 1, 2003. EPA approved the SIP revision on October 6, 2005.

Low sulfur gasoline. Simultaneously with the Tier 2 program, EPA published a regulation requiring the reduction of sulfur in gasoline beginning in 2004, with full implementation in 2006. Sulfur levels are capped at 80 parts per million (ppm) per gallon and annual refinery averages must be no more than 30 ppm. This analysis uses the default assumptions provided in MOBILE6 to account for the implementation of the federal sulfur standard rule in an area in which reformulated gasoline is required.

Additional programs related to motor vehicles. Pennsylvania's Stage II requirements were adopted in February 1992. This program required vapor recovery nozzles on gasoline pumps that ensure that the gasoline vapors from the filling of motor vehicle gasoline tanks are collected and returned to the service station's storage tanks. Emission reductions from this strategy primarily come from vehicles without the federally-required on-board vapor recovery controls phased in between 1998 and 2000 model years, although the requirement provides some additional reductions from the newer vehicles as well.

Gasoline sold in the Philadelphia Area is required by the CAA to be the cleaner-burning reformulated gasoline meeting standards established in Section 211 of the CAA. This federally-enforced program has been in place since January 1995.

4. Nonroad Sources

EPA has adopted a series of regulations affecting new diesel-powered ("compression ignition") and gasoline-powered ("spark ignition") nonroad engines of various sizes (horsepower) and applications. Information on these federal rules, including their implementation dates, can be found at www.epa.gov/nonroad. The Department used the assumptions built into the nonroad model (NONROAD2005) to estimate emissions for all milestone years.

No new national or international regulations are expected to be applicable to aircraft by the ozone season of 2009. While EPA has published a notice of proposed rulemaking for more stringent standards for locomotives and large commercial marine diesel engines, the agency has not finalized any new standards.

EPA will also require diesel fuel used in most nonroad applications to contain less sulfur. The sulfur will prevent damage to the more advanced emission control systems needed to meet the engine standards; it will also reduce fine particulate emissions from diesel engines. In 2007, fuel sulfur levels will be limited to 500 parts per million (ppm) for nonroad applications other than ocean-going marine vessels. In 2010, fuel sulfur levels will be reduced to the same sulfur concentration as in highway fuel, 15 ppm; this requirement applies in 2012 to locomotive and marine diesel fuel.

B. Reasonably Available Control Measures Analysis

Section 712(c) of the Clean Air Act requires states to "provide for implementation of all reasonably available control measures (RACM) as expeditiously as practicable."

In 40 CFR section 51.912(d), EPA interprets this provision to include the following criteria:

- ability of a measure to advance the area's attainment date;
- significance level of emissions reduction;
- technological feasibility;
- costs of control;
- adverse regional impacts; and
- resources and ability to implement and enforce a measure.

EPA requires states to submit a RACM analysis for all nonattainment areas that are required to submit an attainment demonstration, which includes the Philadelphia Area.

Since the Philadelphia Area, classified as moderate, is required to attain the ozone standard during the 2009 ozone season, advancing the attainment date would mean that a RACM must enable the Area to meet the standard during the 2008 ozone season, and thus produce effective emission reductions no later than May 1, 2008.

The Department has worked with the member states of the Ozone Transport Commission (OTC) to review potential additional control measures that could assist in the attainment of the eight-hour ozone NAAQS in Pennsylvania. More information on controls that have been considered and how that analysis was conducted is available at www.otcair.org/ and also in Appendix G-1 and G-2. However, modeling results of those potential regional and local control measures did not advance the attainment date of the Philadelphia Area.

In addition, regional modeling performed for the Washington, DC Metropolitan Area indicates that 20-40 tons per day of VOC or NOx would be necessary to advance the attainment date by one year. A similar result would be expected for the Philadelphia Area. There are no measures that would individually or collectively attain that level of emission reduction for the 5 county Philadelphia Area.

The Department submitted to the EPA in July 2001 a RACM analysis in a SIP revision as part of the one-hour ozone NAAQS attainment demonstration plan for the Philadelphia Area. The RACM analysis for the one-hour ozone NAAQS was approved by the EPA in October 2001, and is contained in Appendix G-3 of this document.

The most recently adopted control measures are listed below and discussed in more detail in the preceding section of this SIP revision (see permanent and enforceable control measures). All references are to Title 25 of the Pennsylvania Code except where noted.

- Small Source NOx Provisions: Chapter 129 (Sections 129.201-129.205)
- Portable Fuel Containers: Chapter 130 (Sections 130.101-108)
- Consumer Products: Chapter 130 (Sections 130.201-471)
- Architectural and Industrial Maintenance Coatings: Chapter 130 (Sections 130.601-611)
- Degreasing Operations: Chapter 129 (Section 129.63)
- NOx SIP Call: Chapter 145 (Sections145.111-145.113) affecting NOx emissions from stationary internal combustion engines
- NOx SIP Call: Chapter 145 (Sections145.141-145.144) affecting NOx emissions from Portland cement kilns
- Clean Air Interstate Rule (CAIR): Federal implementation plan under 70 FR 25162
- RACT for the 8-Hour Ozone NAAQS: SIP revision submitted to EPA September 2006
- Federal Motor Vehicle Control Programs (light-duty and heavy-duty)
- Vehicle emission inspection/maintenance program: 67 *Pa. Code* Chapter 177
- Pennsylvania Clean Vehicle Program: Chapter 126, Subchapter D
- Pennsylvania Heavy-Duty Diesel Emissions Control Program: Chapter 126, Subchapter E
- Federal programs for nonroad engines

The Department has reviewed the lists of potential reasonably available control measures, including those analyzed by other adjacent nonattainment areas and believes that there are no additional RACM appropriate for this SIP.

VI. ATTAINMENT DEMONSTRATION AND WEIGHT OF EVIDENCE (WOE)

This section analyzes the potential for the Philadelphia Nonattainment Area to comply with the current eight-hour ozone standard. The demonstration of achieving the eight-hour ozone standard is based on results from the Community Multiscale Air-Quality Model (CMAQ) and the supporting Weight of Evidence (WOE) analysis. Photochemical grid-modeling and the WOE analyses provide strong evidence that the Philadelphia region will attain the current eight-hour ozone standard by June 15, 2010. Details of both the CMAQ model results and the WOE analyses are provided in the following sections.

A. Modeling Demonstration

1. Overview

Complex photochemical modeling is required for the Philadelphia Nonattainment Area to demonstrate that the area will attain the eight-hour standard. Photochemical ozone models are mathematical representations of the changes that occur when air pollutants are emitted into the atmosphere, travel downwind and, in the presence of sunlight, react photochemically to form ozone. Application of photochemical modeling requires coordinating a large number of technical and policy decisions in order to operate, interpret and use the model consistently.

Several types of inputs are necessary to run the model, including baseline and future year controlled emissions and their location, meteorological conditions and boundary conditions (emissions at the boundaries of the domain).

The model must be tested and validated to demonstrate that it is a valid tool for prediction. This is done by determining whether the model can accurately predict ozone values for historical ozone episodes (when the actual measured ozone concentrations are already known). The model is run for several different episodes and refined until it can make these predictions.

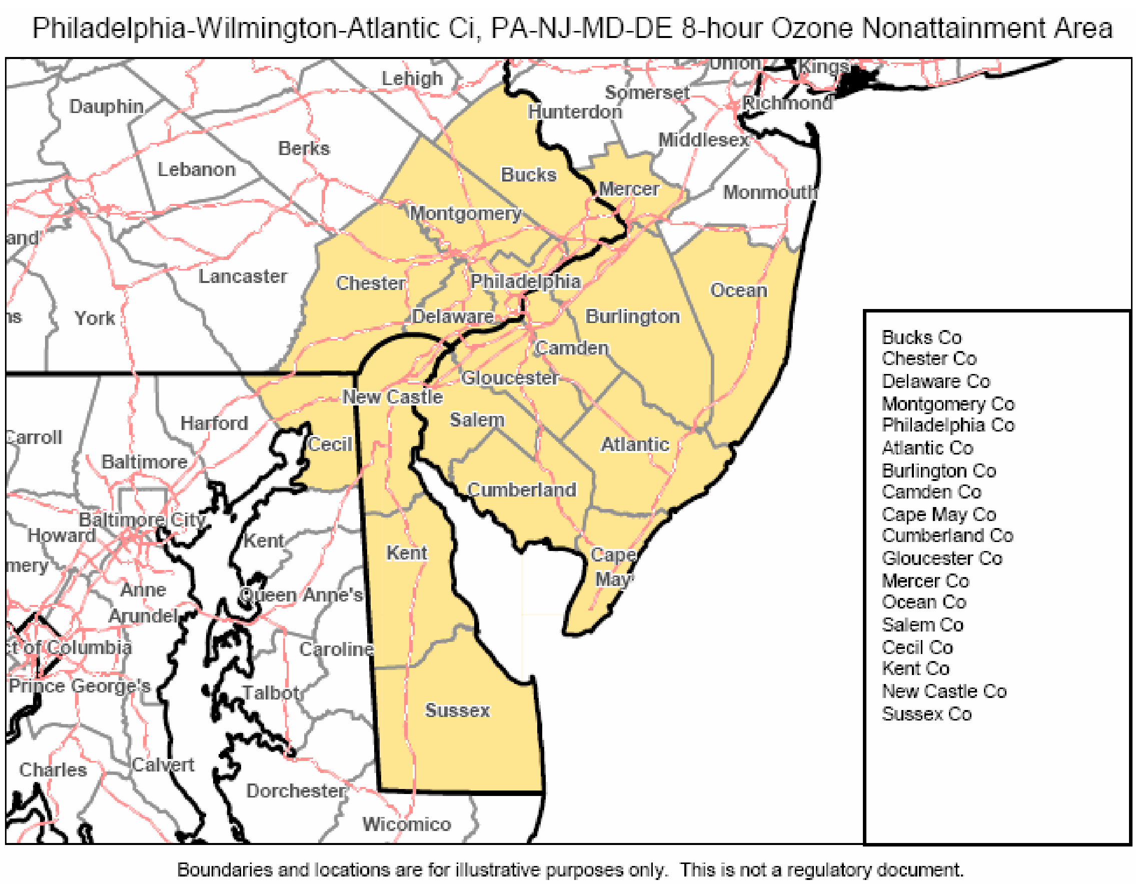
The model is then run to predict future ozone levels based on expected changes in emissions within the modeling domain and ozone/ozone precursor concentrations along the domain boundary. These simulations are run for the same meteorological episodes as the validation run.

The modeling demonstration for the Philadelphia nonattainment areas relies heavily on the modeling work completed as part of the OTC's SIP Quality Modeling System. The OTC Directors endorsed the Modeling Protocol for the OTC SIP Quality Modeling System For Assessment of the Ozone National Ambient Air Quality Standard in the Ozone Transport Region at their November 12-13, 2003 Fall meeting.

The Department has been an active participant in the OTC's modeling process. The Department provided the necessary emissions files for Commonwealth sources needed to run the photochemical model used in the attainment demonstration. The following sections provide brief summaries of the OTC modeling study. More detailed information can be found in OTC documentation produced as part of this modeling analysis. This document is included in Appendix H-1 (see A Modeling Protocol for the OTC SIP Quality Modeling System For Assessment of the Ozone National Ambient Air Quality Standard in the Ozone Transport Region).

The state agencies responsible for creating attainment demonstrations for the Philadelphia nonattainment area include the Pennsylvania Department of Environmental Protection, the New Jersey Department of Environmental Protection (NJ DEP), the Maryland Department of the Environment (MDE) and the Delaware Department of Natural Resources and Environmental Control (DE DNREC). Each of these agencies is responsible for preparing a plan to attain the eight-hour ozone standard as part of their SIP. This SIP includes a modeling analysis, emission inventories, emission control measures, contingency plans and supporting documentation to demonstrate that emission controls enacted by the various agencies will result in the Philadelphia nonattainment area complying with the current eight-hour ozone standard by the region's designated attainment date (June 15, 2010). Figure 6-1 replicates the nonattainment area map shown in Section I for the reader's convenience.

Figure 6-1



2. Domain and Database Issues

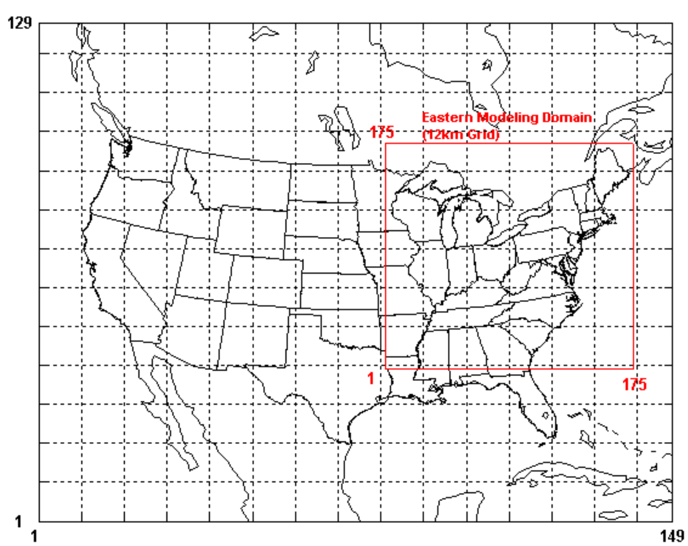
a. Episode Selection

The OTC modeling committee decided to run almost the entire 2002 ozone season as part of its modeling analysis. 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). The ENVIRON report is included in Appendix H-2. A web-link to Ryan and Piety (2002) is provided in the Reference section. Recent research has shown that model performance evaluations and the response to emissions controls need to consider model 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 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.

b. Modeling Domain

Figure 6-2 shows the proposed modeling domain used by the OTC. The modeling analysis uses a nested-grid approach with the lower resolution outer grid providing boundary conditions for a more refined grid covering the area of interest (the ozone transport region (OTR)). The model domain was chosen to be large enough to properly simulate regional transport within the OTR and transport from upwind areas outside of the OTR. Analyses have demonstrated that the Philadelphia nonattainment area is often affected by long-range ozone transport (Aranachalam and Georgopoulos, 1998 and Philadelphia Mid-Course review, 2005). The outer domain boundary should be adequately far from the inner grid such that clean-boundary condition assumptions are realistic and probably do not unduly influence concentrations within the inner domain.

Figure 6-2. OTC Modeling Study Domain



c. Horizontal and Vertical Grid Resolution

The inner (fine) grid covering the OTR region and the Philadelphia nonattainment area has a horizontal grid resolution of 12 kilometers (km). The photochemical grid model's horizontal grid resolution matches the grid resolution of the meteorological model (MM5). This proposed resolution is within the upper range of the fine-grid resolution size recommended in the US EPA's modeling guidance document. The resolution should be adequate to realistically simulate air-quality within the Philadelphia Nonattainment Area.

The model's vertical resolution is also in part defined by the vertical resolution of the meteorological model. The definition of the vertical structure could also have adopted the one-to-one resolution of the meteorological model. However, based upon prior experience, the vertical extent of the model was set around a height of 6 to 8 km. The number of vertical layers permitted in the model is limited by computational considerations as well as storage limits; too many layers increase the amount of time needed to complete a simulation and the amount of information being stored, processed and exchanged. Limiting the vertical resolution to a few layers, however, would inherently discard the detailed information provided by the meteorological model. A compromise solution would be to maintain the high resolution with a one-to-one design of the vertical layers up to approximately 1 or 2 km yielding around 7 to 10 levels, followed by a collapse of the MM5 upper layers to around 6 to 8 km to form another 6 to 8 levels. Thus, under this scenario there would be a total of 13 to 18 layers in the vertical with 7 to 10 levels below 2 km and the remaining between 2 and 8 km. It should be noted that the mid-point of layer 1 in this analysis is around 10 meters.

d. Model Initial and Boundary Conditions

The OTC modeling study simulated almost entire ozone season (May 1 through September 30, 2002) instead of the episodic approach used in the previous (one-hour) Philadelphia Nonattainment Area's modeling study. The photochemical grid model is started three days before the start of the analysis period using "clean" conditions across the domain. Prior experiences have shown that a three-day ramp-up period is sufficient to establish pollutant levels that are encountered in the beginning of the ozone episode.

Clean conditions are assumed along the outer boundary of the air-quality model. This assumption should not unduly influence modeled concentrations over the Philadelphia Nonattainment Area since these conditions are far enough away that they should be realistic. The coarse 36-km grid provides concentrations along the inner 12-km grid (see Figure 4-2) in a one-way nesting scheme. This is standard for most air-quality modeling studies.

e. Meteorological Model Selection and Configuration

The meteorological files used in the photochemical grid model were produced using the Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) mesoscale model more commonly know as MM5. MM5 is a limited-area, nonhydrostatic, terrain-following sigma-coordinate model designed to simulate or predict mesoscale atmospheric circulation (Grell et al., 1995). The model is publicly available and has been used for various air-quality modeling studies.

The OTC thoroughly reviewed MM5 results to ensure the model adequately simulated the meteorological fields needed to run CMAQ (the air-quality model). A general summary and overview of the MM5 results is contained in documentation produced by the University of Maryland (who actually ran MM5) and the New York Department of Conservation (NYDEC). The University of MD document is included in Appendix H-3 while the NYDEC document is included in Appendix H-4.

f. Emissions Inventories

The emissions data for 2002 were generated by individual states within the OTR and were assembled and processed through the Mid Atlantic Northeast Visibility Union (MANE-VU), a Regional Planning Organization (RPO). These emissions were then processed by NYDEC using the SMOKE processor to provide CMAQ compatible inputs (NYDEC tsd-1d, 2007). The 2002 emissions for the non-OTR areas within the modeling domain were obtained from the corresponding RPOs and were processed using SMOKE, in a manner similar to that of the OTR emissions.

The OTR states through MANE-VU contracted MACTEC Federal Programs (called Contractor) develop the 2009, 2012 and 2018 inventories based upon 2002 inventories that the states had previously developed for use in the base-year model work. The Contractor, in consultation with the states, developed the necessary growth and control factors and applied them to the 2002 inventory. It should be noted that emissions for mobile sources and the electric energy generating units (EGUs) was not part of the Contractor's effort. The states provided Virginia Department of Environmental Quality and NESCAUM with appropriate MOBILE 6 input files along with the projected VMT, which coupled with the hourly "gridded temperature" information was used to generate mobile source emissions. As for the emissions from the EGU sector, the inter-RPO work group utilized the Integrated Planning Model (IPM) to develop the state and unit-level emissions. Details on these topics can be found in MACTEC (2007a) for non-EGU sectors and in ICF (2006) for the EGU sector (see NYDEC tsd-1f, 2007). These inventories are identified as 2009 on the way (2009OTW), since they reflect all emission control measures that were promulgated or would become effective on or before 2009.

Appendix H-5 provides a general overview of the emission processing completed for the OTC's ozone modeling platform. Additional information on the modeling emission inventory for both the base-case and future year inventories can be found in two technical support documents produced by the NYDEC. The base-case can be found in Appendix H-6 while the future-year is in Appendix H-7.

g. Air-Quality Model Selection and Configuration

EPA's Models-3/CMAQ modeling system was selected for the attainment demonstration primarily because it is a "one-atmosphere" photochemical grid model capable of addressing ozone at 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).

3. Model Performance Evaluation

The Department performed a model evaluation to determine how well CMAQ reproduced the Philadelphia nonattainment area's 2002 ozone season concentrations. Model evaluation followed performance statistics outlined in EPA modeling guidance.

Our evaluation included performance statistics for all monitors inside the Philadelphia nonattainment area and monitors within Pennsylvania. This analysis is meant to supplement analyses completed by the NYDEC. Results from both analyses are included in Appendix H-8 and Appendix H-9. Both analyses indicate the modeling system does an adequate job of estimating the eight-hour surface ozone concentrations throughout the Philadelphia area.

4. Model Attainment Demonstration

The Philadelphia Nonattainment Area's demonstration of achieving the eight-hour ozone standard is based on two bodies of evidence: (1) CMAQ and (2) a number of WOE tests supporting the attainment modeling results. Details of the CMAQ model are outlined in the next section. The WOE analysis is included as a separate section.

a. Model Results Summary

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

$(DVF)_I = (RRF)_I \, (DVC)_I$

Where:

$(DVC)_I$ = 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.

Results for all monitors inside the Philadelphia Nonattainment Area are summarized in Table 6-1. This table includes baseline design values for all monitors. These values are based on the eight-hour ozone design values and RRFs from the OTC SIP-quality modeling. The final values represent the projected 2009 eight-hour ozone design values. Highlighted values indicate the monitors projected to be above the current eight-hour ozone standard at the end of the 2009 ozone season.

Nearly all of the monitors in the five-county Philadelphia region (Bucks, Chester, Delaware, Montgomery and Philadelphia counties) are projected to be in attainment by the end of the 2009 ozone season. Only two of the eight monitors in the five-county Philadelphia region, Bristol (Bucks) and the Northeast Airport (Philadelphia), are projected to exceed the standard. The Bristol site is projected to be at 88 ppb and the Northeast Airport site is projected to be at 87 ppb.

Table 6-1
Summary of Model Attainment Test Results

Monitor ID	Site Name	County	State	DVC	RRF OTB/OTW V4	DVF
100010002	Felton	Kent	DE	88.3	0.8934	78
100031007	Bellefonte	New Castle	DE	91.0	0.8462	77
100031010	Summit Bridge	New Castle	DE	92.7	0.8781	81
100031013	Bellefonte	New Castle	DE	87.5	0.8759	76
100051002	Seaford	Sussex	DE	90.0	0.8462	76
100051003	Lewes	Sussex	DE	86.7	0.8956	77
240150003	Fair Hill	Cecil	MD	97.7	0.8336	81
340010005	Nacote Creek	Atlantic	NJ	88.0	0.8762	77
340070003	Camden	Camden	NJ	98.0	0.8996	**88**
340071001	Ancora State Hospital	Camden	NJ	99.7	0.8733	**87**
340110007	Millville	Cumberland	NJ	94.0	0.8486	79
340150002	Clarksboro	Gloucester	NJ	98.0	0.9004	**88**
340210005	Rider College	Mercer	NJ	97.7	0.8908	**87**
340290006	Colliers Mills	Ocean	NJ	105.7	0.8703	**91**
420170012	Bristol	Bucks	PA	99.0	0.8976	**88**
420290100	New Garden Airport	Chester	PA	94.7	0.8387	79
420450002	Chester	Delaware	PA	91.7	0.8705	79
420910013	Norristown	Montgomery	PA	92.3	0.8861	81
421010004	AMS Lab	Philadelphia	PA	72.7	0.9081	65
421010014	Roxboro	Philadelphia	PA	90.7	0.9070	82
421010024	NE Airport	Philadelphia	PA	96.7	0.9035	**87**
421010136	Elmwood	Philadelphia	PA	83.7	0.9070	75

Baseline design values are calculated using the average of the three design value periods that include the baseline inventory year. Specifically, the average design value is calculated using the 2000-2002, 2001-2003, and 2002-2004 periods.

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

1. 3 years of data - The current design value will be based on a single design value.
2. 4 years of data - The current design value will be based on an average of two design value periods.

3. Less than 3 years of data – The site shall not be used in the attainment test.

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

The predicted eight-hour daily maximum concentrations from each modeled day are used in the modeled attainment test with the nearby grid cell with the highest predicted eight-hour daily maximum concentration with baseline emissions for each day considered in the test, and the grid cell with the highest predicted eight-hour daily maximum concentration with the future emissions for each day in the test. The RRFs used in the modeled attainment test is computed by taking the ratio of the mean of the eight-hour daily maximum predictions in the future to the mean of the eight-hour daily maximum predictions with baseline emissions, over all relevant days.

To avoid overestimates of future design values and provide for more robust RRFs and future design values, the following rules are applied to determine the number of days and the minimum threshold at each ozone monitor:

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

b. Unmonitored Area Analysis

This analysis was prepared in accordance with section 3.4 of the EPA's Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality goals for Ozone, PM2.5, and Regional Haze using the US EPA's MATS software (version 1.1.043, February 2007). Results are included in Appendix H-10 and demonstrate compliance in the unmonitored areas within the Philadelphia Nonattainment Area.

B. Weight of Evidence Demonstration

In accordance with U.S. EPA guidance, corroboratory evidence shall accompany the model attainment demonstration. The weight of evidence (WOE) submittal describes the analyses performed, databases used, key assumptions and outcomes of each analysis, and why the evidence, viewed as a whole, supports a conclusion that the Philadelphia Nonattainment Area will attain the NAAQS despite the model predicting that some monitors' future design values exceed the current eight-hour ozone standard.

Table 6-2 outlines under what circumstances a WOE demonstration is needed. Model-predicted design values are summarized in Table 6-2. Of the twenty-two (22) ozone monitors in the Philadelphia nonattainment area only eight (8) exceed the threshold requiring a WOE demonstration. Four of the monitors fall within the 82-87 ppb threshold outlined in Table 6-2 and four others fall within the last category listed in the WOE table included in the US EPA guidance. The Roxboro monitor will be excluded from the WOE analysis since its current design value is significantly lower than the eight-hour standard (modeled 82 ppb, actual 78 ppb).

The WOE analysis for the remaining seven monitors will include the following sections:

- A comparison of predicted 2009 ozone design values and current projected design values for 2006;
- An analysis of recent ozone trends in the Philadelphia nonattainment area;
- Alternative methods for calculating the 2009 ozone design value;
- An analysis of model-predicted regional transport;
- University of Maryland's analysis of model sensitivity to emission changes.

Table 6-2
Guidelines for Supplemental Analyses and Weight of Evidence Determinations

Results of Modeled Attainment Test	Supplemental Analyses
Future Design Value < 82 ppb, all monitor sites	Basic supplemental analyses should be completed to confirm the outcome of the modeled attainment test
Future Design Value 82 - 87 ppb, at one or more sites/grid cells	A weight of evidence demonstration should be conducted to determine if aggregate supplemental analyses support the modeled attainment test
Future Design Value > 88 ppb, at one or more sites/grid cells	More qualitative results are unlikely to support a conclusion differing from the outcome of the modeled attainment test.

1. Overview of Modeled Concentrations and Current Design Values

Table 6-3 lists the OTC modeled 2009 design values and the projected design values for 2006. Modeled 2009 and projected 2006 design values are surprisingly close to one another with most modeled concentrations slightly lower than the projected 2006 design values (NJ monitors still not QA/QC'ed). This result suggests additional reductions over the next three ozone seasons are still possible. This would bring several of the monitors that are currently just over the eight-hour ozone standard into compliance.

2. Recent Ozone Trends

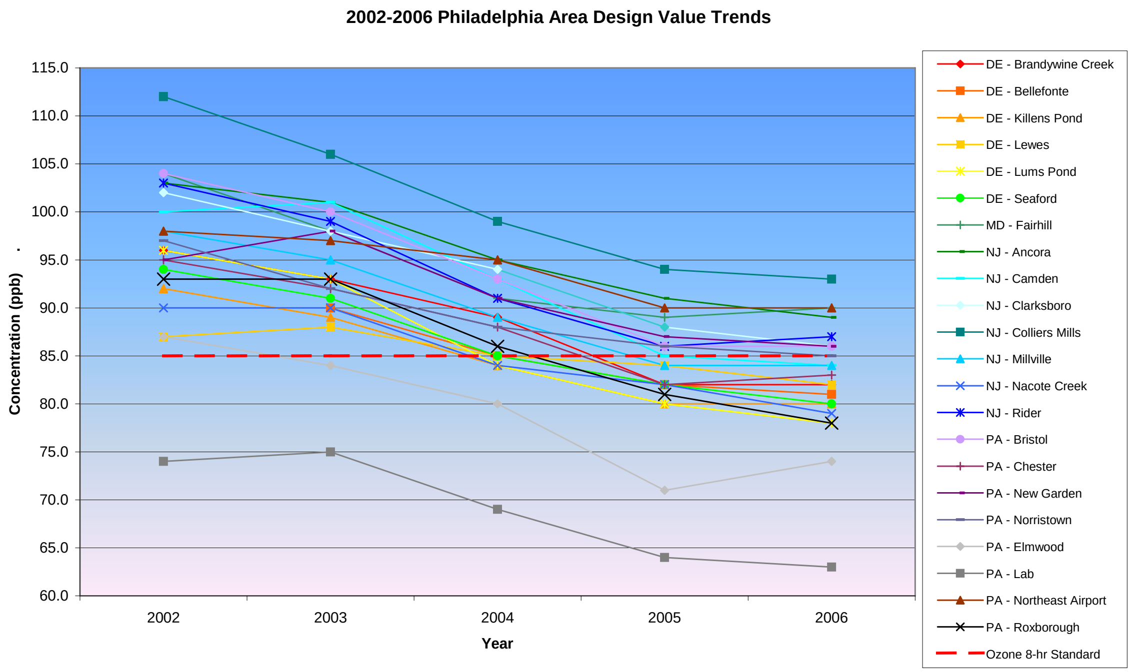
Long-term trends in ozone design values can be found in Section III of this attainment demonstration. There have been significant declines in the Philadelphia nonattainment area's eight-hour ozone design values over the last several decades. Significant declines have occurred after implementation of the RVP program in the early 1990's and the more recent enactment of the NO_x SIP Call.

Table 6-3. Comparison of Modeled 2009 and Projected 2006 Ozone Design Values

AQS Code	Site Name	State	Modeled 2009	Actual 2006
100010002	Killens Pond	DE	78	80
100031007	Lums Pond	DE	77	78
100031010	Brandywine Creek	DE	81	82
100031013	Bellefonte	DE	76	81
100051002	Seaford	DE	76	80
100051003	Lewes	DE	77	82
240150003	Fairhill	MD	81	**90**
340010005	Nacote Creek	NJ	77	79
340070003	Camden	NJ	**88**	84
340071001	Ancora	NJ	**87**	**89**
340110007	Millville	NJ	79	84
340150002	Clarksboro	NJ	**88**	**86**
340210005	Rider	NJ	**87**	**87**
340290006	Colliers Mills	NJ	**91**	**93**
420170012	Bristol	PA	**88**	**86**
420290100	New Garden	PA	79	**86**
420450002	Chester	PA	79	83
420910013	Norristown	PA	81	**85**
421010004	Lab	PA	65	63
421010014	Roxboro	PA	82	78
421010024	Northeast Airport	PA	**87**	**90**
421010136	Elmwood	PA	75	74

It is interesting to note that ozone design values in the Philadelphia nonattainment area have fallen roughly fourteen percent (14%) since enactment of the NO_x SIP Call. Figure 6-3 shows the most recent design value trends in the Philadelphia nonattainment area. Nearly all of the monitors show steady declines in ozone design values since 2002 (the year prior to phased-in enactment of the NO_x SIP Call). Additional reductions via the NO_x SIP Call and controls on the mobile source sector should provide additional reductions in the Philadelphia Nonattainment Area's design values. This should allow all monitors to meet the current eight-hour ozone standard by the Philadelphia Nonattainment Area's designated attainment date.

Figure 6-3
Eight-Hour Ozone 2002-2006 Design Value Trends



3. Alternative Approaches

Two alternatives to the U.S. EPA's standard method for estimating future monitor design values are examined in this section. One looks at an alternative method for calculating the baseline design value and another looks at constructing an alternative RRF. The effects of both methods will be analyzed separately and then combined.

a. Alternative Baseline Design Value

Seven monitors within the Philadelphia Nonattainment Area are projected to exceed the current eight-hour ozone standard following the U.S. EPA guidance. The recommended baseline concentration used in the attainment demonstration is the average of the eight-hour ozone design values that include in the emission base year (2002). Thus, the baseline concentration is the average of the 2002, 2003 and 2004 eight-hour ozone design values.

Using the U.S. EPA recommended method for calculating a monitor's baseline concentration places undo weight on the 2002 ozone season, one of the worst ozone seasons in since the enactment of RVP controls in the late 1990s. The 2002 ozone season contributes a third of the baseline concentration; 2001 and 2003 contribute ~22% each, 2000 and 2004 contribute ~11% each.

An alternative to the U.S. EPA's baseline concentration calculation is to take the straight average of the 4th highs over the same years (2000-2004). This approach weighs each year equally. Table 6-4 lists the alternative baseline value and the projected 2009 concentration for the seven monitors that are projected to exceed the current eight-hour ozone standard in 2009. This reduces the modeled 2009 values slightly but still leaves them close to the projected 2006 design values. Only one monitor (Colliers Mills) remains above the highest concentrations listed in EPA's WOE cut-offs.

Table 6-4
Alternative Baseline Concentration Analysis

Site Name	State	Alternative Baseline	OTW/OTB V4 RRF	Alternate 2009	2006 Design Value
Camden	NJ	94.0	0.8996	84	84
Ancora S.H.	NJ	98.6	0.8733	86	89
Clarksboro	NJ	96.4	0.9004	86	86
Rider College	NJ	95.6	0.8908	85	87
Colliers Mills	NJ	104.2	0.8703	90	93
Bristol	PA	96.6	0.8976	86	86
NE Phila	PA	94.6	0.9035	85	90

b. Alternative Relative Response Factor (RRF)

OTC model data was re-examined to determine the seven WOE monitors' variation in RRFs in which modeled 2009 concentrations exceeded the current eight-hour ozone standard. RRFs are recalculated for several different ozone levels; 2002 baseline model concentrations ≥ 85 ppb, 2002 baseline model concentrations ≥ 90 ppb and 2002 baseline model concentrations ≥ 95 ppb. The idea is to see if the air-quality model predicts more reductions on days with higher ozone concentrations (more benefit on the worst days). Table 5-6 lists the different RRFs based on the 2002 baseline model concentrations.

Recalculating the projected modeled 2009 design values using the alternative RRFs lowered nearly all seven monitors by 1 ppb, except Bristol and Colliers Mills which were unchanged. The Bristol and Colliers Mills monitors remained above the highest concentrations listed in EPA's WOE cut offs.

Table 6-5
Alternative RRF Calculation Analysis

Site	RRF ≥ 95 ppb	RRF ≥ 90 ppb	RRF ≥ 85 ppb	RRF ≥ 75 ppb	Min
Camden	0.8915	0.8946	0.8996	0.9036	0.8915
Ancora S.H.	0.8723	0.8749	0.8733	0.8760	0.8723
Clarksboro	0.8875	0.8894	0.9004	0.8953	0.8875
Rider	0.8914	0.8941	0.8908	0.9022	0.8908
Colliers Mills	0.8726	0.8704	0.8703	0.8757	0.8703
Bristol	0.8892	0.8925	0.8976	0.9060	0.8892
NE Airport	0.8991	0.9031	0.9035	0.9108	0.8991

Alternative Projected 2009 Modeled Values Using Alternative RRFs

Site	Alt RRF	DV Base	Alt Projected 2009	2006 Design Value
Camden	0.8915	98.0	87	84
Ancora S.H.	0.8723	99.7	86	89
Clarksboro	0.8875	98.0	86	86
Rider	0.8908	97.7	86	87
Colliers Mills	0.8703	105.7	91	93
Bristol	0.8892	99.0	88	86
NE Airport	0.8991	96.7	86	90

c. Combining Alternative Baseline Concentrations and Alternative RRFs

Table 6-6 lists the projected 2009 modeled design values from combining the alternative baseline concentrations and the alternative RRF calculations described in the previous two sections. The combination of these two alternative approaches lowers the projected 2009-modeled concentrations significantly, but still leaves the Colliers Mills monitor above the highest concentrations listed in the U.S. EPA's WOE chart. The other six monitors are close to the current eight-hour ozone standard but for the most part not significantly different than the projected 2006 design values.

Table 6-6
Combined Effects of Alternative Baseline Concentrations and Alternative RRFs

Site	Alt RRF	Alt DV Base	Alt Projected 2009	2006 Design Value
Camden	0.8915	94.0	83	84
Ancora S.H.	0.8723	98.6	86	89
Clarksboro	0.8875	96.4	85	86
Rider	0.8908	95.6	85	87
Colliers Mills	0.8703	104.2	90	93
Bristol	0.8892	96.6	85	86
NE Airport	0.8991	94.6	85	90

4. Regional Transport Analysis

The NO_x SIP Call reduced ozone precursor emissions over a large region of the eastern US. These reductions undoubtedly reduced regional transport from the large power plants along the Ohio River into the Philadelphia nonattainment area. The PA DEP maintains an elevated monitoring site (Methodist Hill) on South Mountain in south-central Pennsylvania approximately 40 miles southwest of the City of Harrisburg. Methodist Hill sits at approximately 1900 ft above mean-sea level and is well position to sample ozone concentrations entering the eastern OTR (see Section II for regional transport description).

A quick review of design value trends at Methodist Hill shows substantial reductions in ozone levels since full implementation of the NO_x SIP Call. Table 6-7 lists Methodist Hill's eight-hour ozone design values, 4th high eight-hour ozone concentrations and the number of days the monitor exceeded the current eight-hour ozone standard. All of the values listed in the table have fallen precipitously since enactment of the NO_x SIP Call (2003 ozone season). Ozone design values have fallen ~15%, 4th high values have fallen ~23% and exceedances have fallen ~95% since 2003.

Table 6-7
Methodist Hill Statistics, Proxy for Regional Transport

	Design Value	4th high	Exceedances
1996		0.082	3
1997		0.091	7
1998		0.104	22
1999	0.097	0.098	20
2000	0.095	0.085	4
2001	0.092	0.095	15
2002	0.094	0.104	27
2003	0.093	0.080	3
2004	0.085	0.071	0
2005	0.075	0.074	0
2006	0.070	0.066	0

One way to gauge how well the OTC air quality model is simulating regional transport is to examine how well the modeled 2009 eight-hour ozone design value compares to the actual 2006 design value. Table 6-8 lists the US EPA derived modeled 2009 concentration and the actual 2006 ozone design value. The model appears to be over predicting Methodist Hill's design value by approximately 6 ppb. This indicates the model is not adequately characterizing the effects of the NO_x SIP Call on upwind sources (under predicting the benefit). This suggests modeled 2009 design values may be overestimated by as much as 6 ppb within the Philadelphia Nonattainment Area. The 6 ppb difference represents the overestimation of background (regional) concentrations entering the eastern OTR.

Table 6-8
Examination of Modeled 2009 Ozone Design Values at Methodist Hill

EPA Baseline	RRF OTB/OTW V4	Modeled 2009	DV 2006
90.6	0.8488	76	70

Though ozone concentrations entering the eastern OTR are significantly lower since the NO_x SIP Call, they still represent a significant portion of the current eight-hour standard; almost 80% on the worst ozone days within the Philadelphia Nonattainment Area. This suggests further reduction in regional (upwind) ozone concentrations may be needed for the Philadelphia Nonattainment Area to achieve the current eight-hour ozone standard.

5. Analysis of Air-Quality Model Sensitivity to Emission Changes

Recent work by the University of Maryland to estimate uncertainty in the CMAQ model (Stehr, Peity and Allen, 2007) has determined a tendency to under predict emission reduction benefits. This conclusion is based on modeling work done to reproduce ozone concentrations during the August 2003 Northeast Blackout and ongoing studies by the US EPA.

Modeling work to simulate the August 2003 Northeast Blackout by Hu, Odman and Russell (2006) indicate air-quality models significantly under predicted ozone concentrations when compared to aircraft measurements made by the University of Maryland. Modeled ozone reductions due to the large number of power plant shutdowns during the blackout were on the order of 2.2 ppb while reductions of up to 7 ppb were noted in the aircraft data. The University of Maryland concluded air-quality models such as CMAQ might under predict ozone reductions due to control programs such as the NO_x SIP Call by up to a factor of two. To be cautious, these estimates were lowered to an approximately 50% under prediction of benefits. These arguments were incorporated in the State of Maryland's SIPs for Washington DC, Baltimore and Cecil County. Maryland's modeled design values for 2009 were less than 85 ppb for all monitors inside the Philadelphia Nonattainment Area (see table 3 of Appendix H-11).

These results are similar to what was observed in the modeling submitted as part of the Philadelphia One-Hour Attainment SIP (Phase II Philadelphia SIP, April 1998). Modeled 2005 one-hour ozone concentrations were predicted to be in the 161-152 ppb range while actual 2005 one-hour ozone design values were 121 ppb, a significant over prediction.

6. WOE Summary

The Department has performed a WOE analysis for all of the monitors within the Philadelphia nonattainment area whose modeled 2009 eight-hour ozone design values exceed 82 ppb. There are twenty-two (22) ozone monitors currently operating in the Philadelphia nonattainment area. Of these monitors, only eight have modeled 2009 concentrations above 82 ppb. This by itself represents a significant improvement in air quality.

Of the eight monitors requiring a WOE analysis, two (Roxboro and Camden) have 2006 design values less than 85 ppb. The Roxboro monitor is dropped from the WOE analysis since its 2006 design value is significantly below the current eight-hour ozone standard (78 ppb vs. 85 ppb standard). For the remaining seven sites, a number of analyses are undertaken to determine if there is a reasonable chance these sites would meet the current eight-hour ozone standard by the June 2010 attainment date. These include an analysis of recent ozone trends, alternative methods for developing baseline concentrations and RRFs, an analysis of regional transport and finally an assessment of the air-quality models response to emission changes.

Nearly all of the design values at the seven monitors declined over the last several years. Only one, Rider College, had a slight increase. Table 6-9 shows the last several years of design values at these seven monitors. It is expected that additional emission reductions due to the NO_x SIP Call, mobile source reductions from fleet turnover, as well as other additional measures, will continue to lower monitor ozone design values in the future. If this trend continues, it is possible that most of these monitors will attain the standard by the attainment date for “moderate” areas, June 2010.

Table 6-9
Summary of Design Value Trends

Site	2003	2004	2005	2006
Camden	101	93	85	84
Ancora S.H.	101	95	91	89
Clarksboro	98	94	88	86
Rider	99	91	86	87
Colliers Mills	106	99	94	93
Bristol	100	93	86	86
NE Airport	97	95	90	90

Table 6-10 summarizes the results for the EPA method as well as some alternative methods including alternative background concentrations calculations and alternative RRF calculations as well as the results from employing both methods simultaneously. Descriptions of these alternative methods and the reasons for employing them can be found in previous sections. Results from the alternative methods analysis indicate nearly all seven of the monitors will be near the standard by the projected attainment date.

Table 6-10
Alternative Methods WOE Summary

Site	Modeled 2009			
	EPA Method	**Alt Baseline DV**	**Alt RRF**	**Both**
Camden	88	84	87	83
Ancora S.H.	87	86	86	86
Clarksboro	88	86	86	85
Rider	87	85	86	85
Colliers Mills	91	90	91	90
Bristol	88	86	88	85
NE Airport	87	85	86	85

Regional transport is a significant contributor to nonattainment in the Philadelphia region. An analysis of modeled ozone concentrations at the Methodist Hill site in south-central Pennsylvania, a high elevation site, determine how well the OTC air-quality model simulates the regional transport component. The modeled 2009 concentration at Methodist Hill is approximately 6 ppb higher than the monitor's current design value. This suggests the model is underpredicting the benefits of the NO_x SIP Call in upwind regions. To counter this underestimation, a uniform reduction of 6 ppb could be taken off the modeled 2009 concentrations at the seven WOE monitors. This brings all values below the current eight-hour ozone standard (Colliers Mills adjusted to 85 ppb).

Work by the University of Maryland indicates air-quality models underestimate ozone responses to emission changes by up to a factor of two. Model overestimation was also noted in Philadelphia's one-hour ozone SIP. To conservatively estimate this under prediction, RRFs need to be adjusted down by a factor of 50 percent. Table 6-11 re-adjusts the RRFs and recalculates the modeled 2009 ozone design values. The results indicate the seven WOE monitors reach the current eight-hour ozone standard after this adjustment.

Table 6-11
Summary of RRF Adjustments Due To Model Under-Prediction of Benefits

SITE	BASELINE DV	MODELED 2009 DV	Δ PPB	1.5 x Δ PPB	ADJUSTED 2009 DV
Camden	98.0	88	-10.0	-15.0	83.0
Ancora S.H.	99.7	87	-12.7	-19.0	80.7
Clarksboro	98.0	88	-10.0	-15.0	83.0
Rider	97.7	87	-10.7	-16.0	81.7
Colliers Mills	105.7	91	-14.7	-22.0	83.7
Bristol	99.0	88	-11.0	-16.5	82.5
NE Airport	96.7	87	-9.7	-14.5	82.2

C. Conclusions

The model attainment demonstration uses results from the OTC's SIP quality-modeling platform. This includes an air-quality model, CMAQ; a meteorological model, the PSU/NCAR mesoscale model more commonly know as MM5; and processed emissions files.

The 2009 eight-hour ozone design values are calculated following EPA's guidance. The results indicated the majority of monitors within the Philadelphia Nonattainment Area are projected to meet the current eight-hour ozone standard by the region's mandated attainment date (June 2010). Only seven (of twenty-two) monitors are projected to exceed the current standard, still a significant improvement over the model base year (2002).

A WOE demonstration is presented following EPA guidance. A total of eight monitors exceed the WOE thresholds. One of these monitors, Roxboro, is excluded from the WOE analysis since its 2006 ozone design value (78 ppb) is well below the current standard (85 ppb). The leaves seven monitors for which a WOE analysis is needed.

The Department presented several methods to demonstrate that it is reasonable to predict that the seven WOE monitors will attain the current eight-hour ozone standard by the designated attainment date (June 2010). Quantitative results are presented in the previous sections that all indicate projected concentrations the WOE monitors will be below 85 ppb (the current eight-hour standard) by the projected attainment date. The range of closeness is similar to what was observed in the one-hour ozone demonstrations submitted in the late 1990s. This experience increases the probability that the models are again under-predicting the benefits of emission control programs.

It is important to note that two judicial decisions have supported WOE demonstrations in which the modeled results for the projected attainment date exceeded the standard. In Environmental Defense v. EPA, 369 F.3d 193 (2d Cir. 2004) the United States Court of Appeals for the Second Circuit upheld New York's WOE approach for its one-hour SIP demonstration even though the projected modeled concentration, 170 ppb, far exceeded the then one-hour standard of 124 ppb. Pennsylvania's eight-hour projected model concentration, 91 ppb, is much closer to the standard, 84 ppb, than the one-hour ozone attainment demonstration approved by EPA for the New York area. SIP-approved WOE demonstrations for the Houston-Galveston nonattainment area were also upheld under similar circumstances in BCCA Appeal Group v. EPA, 355 F.3d 817 (5th Cir. 2003).

Our analysis indicates persistent elevated ozone concentrations at the Colliers Mills monitor in Ocean County, New Jersey. Several of our analyses indicate there may be special circumstances affecting ozone concentrations at this monitor. However, we are unable to determine at this time if further analyses will be needed to ascertain local and regional influences on this monitor.

VII. CONTINGENCY MEASURES FOR THE ATTAINMENT DEMONSTRATION

Section IV-C, Reasonable Further Progress (RFP) Demonstration, describes the calculations that demonstrate that Pennsylvania fulfills the contingency measure requirements for the RFP milestones.

EPA also requires the Philadelphia Nonattainment Area to include a contingency plan containing measures that qualify as contingency measures for the attainment demonstration. This section fulfills the contingency measures requirement for the attainment demonstration.

A. Required Reductions

The Philadelphia Nonattainment Area must identify contingency measures to be implemented in the event that the region does not attain the 8-hour ozone standard in June 2010. The contingency measures for the attainment demonstration must provide reductions of either VOC or NOx that total 3 percent of the 2002 Adjusted Base Year Inventory. The adjusted inventory is calculated as described in Section IV-C. Table 6-1 shows the calculation of the necessary reductions.

Table 7-1. Calculation of VOC and NOx Reduction Requirements for Attainment Contingency Plan

Description	**VOC**	**NOx**
2002 Base-Year Inventory (a)	352.87	353.84
Non-creditable Emissions Reduction (b)	12.72	15.58
Adjusted Base-Year Inventory (c) = (a-b)	**340.15**	**338.26**
VOC Reduction Required for RFP Contingency if all reductions were obtained from VOC	10.20	
NOx Reduction Required for RFP Contingency if all reductions were obtained from NOx		10.15

Contingency reductions must occur on a timetable that is directly related to the attainment SIP schedule. States have no more than one year after notification by EPA of an attainment failure to achieve the contingency plan reductions.

B. Identified Contingency Measures

Table 1-2 lists the contingency measures for the attainment demonstration. These measures deliver total benefits of almost 13 tpd of VOC and 10 tpd of NOx, exceeding the contingency measure requirement calculated in Table 6-1. Therefore, this measure fulfills the area's contingency measure requirement.

Table 7-2. Additional Contingency Measures for Attainment Demonstration

Contingency Measure	**VOC (tons per day)**	**NOx (tons per day)**
New Motor Vehicle Emission Standards	2.38	7.18
Federal Nonroad Emission Standards	1.77	1.83
Portable Fuel Container Regulation Enhancement	0.51	0
Consumer Product Regulation enhancement	0.66	0
Adhesives, Sealants, Adhesive Primers and Sealant Primers Regulation	5.64	0
TOTAL	**10.96**	**9.01**

EPA guidance encourages early implementation of contingency measures to guard against failure to either meet a milestone or attain. EPA's guidance on early implementation of control measures is as follows:

> *The EPA encourages the early implementation of required control measures and of contingency measures as a means of guarding against failures to meet a milestone or to attain. Any implemented measures (that are not needed for the rate-of-progress requirements or for the attainment requirements) would need to be backfilled only to the extent they are used to meet a milestone.*

The reductions from the designated contingency measures are surplus vis-à-vis the attainment demonstration contained in this SIP. They will not be used to meet the 2008 or 2009 milestone requirements. As a result, the Department will not be required to backfill any contingency measures that it chooses to implement in advance of the contingency plan requirement.

1. New Motor Vehicle Programs for Highway Vehicles

Emission estimates for the contingency plan were made using the EPA-approved model for highway emissions. EPA's Tier 2 regulation required more stringent tailpipe emissions standards for all new passenger vehicles, including sport utility vehicles (SUVs), minivans, vans and pick-up trucks starting with model year 2004. These regulations also require lower levels of sulfur in gasoline, which will ensure the effectiveness of low emission-control technologies in vehicles and reduce harmful air pollution. The Pennsylvania Clean Vehicles Program requires passenger cars and light-duty trucks sold or leased in the Commonwealth to be those certified by the California Air Resources Board (CARB) starting with model year 2008. More information on these programs is contained in Section V-A. Both of these programs will generate additional reductions after 2009. The emissions shown in Table 7.2 are the additional emission reductions expected to be realized in 2010.

Pennsylvania has incorporated the CARB heavy-duty engine and vehicle (over 14,000 pounds gross vehicle weight) standards starting with model year 2005. These standards (and identical federal standards) require significant emission reductions from these engines starting with model year 2007 and additional reductions in NOx starting with model year 2010. In addition, CARB has incorporated an anti-idling technology requirement starting in model year 2008; quantification of this emission reduction has not been included since there is no EPA-approved methodology. This program will generate additional reductions after 2009.

2. Federal Nonroad Vehicle and Equipment Emission Standards

EPA has promulgated a series of regulations to control VOC and NOx emissions from nonroad vehicles including:

- Phase 1 and 2 emissions standards for gasoline-powered non-road utility engines, such as lawn and garden equipment, chain saws and similar outdoor utility equipment;
- emissions standards for diesel-powered (compression ignition) non-road utility engines of 50+ horsepower and reduction in nonroad sulfur levels in diesel fuel;
- emissions standards for spark ignition marine engines, including outboard, personal watercraft and jet boat engines; and
- emissions standards for large spark ignition engines, used in a variety of commercial applications.

These standards will either be implemented after 2009 or will continue to generate emission reductions. The contingency reductions for these programs are estimated using EPA's NONROAD model. The emissions shown in Table 7.2 are the additional emission reductions expected to be realized in 2010.

3. State Regulations for Stationary Area Sources

Portable Fuel Containers. Amendments to the portable fuel container requirements in Chapter 130, Subchapter A will result in additional volatile organic compound (VOC) emission reductions beyond those presently achieved through the existing requirements. The revisions to Subchapter A will reduce VOC emissions through:

- Increased stringency of the permeability requirements from a limit of 0.4 grams per gallon stored to 0.3 grams per gallon stored per day.
- Changes to the fill spout requirements that will reduce spillage of gasoline, primarily during the filling of target tanks on small engines such as those on leaf blowers.
- Imposing the permeability and spout requirements for gasoline containers on containers used for diesel fuel and kerosene to discourage consumers from

purchasing and using the currently less expensive diesel fuel and kerosene containers to transport and store gasoline.

Consumer Products. Amendments to the consumer products requirements will add 11 new classes of products to the list of regulated materials and will make other minor revisions to existing requirements. Establishment of VOC content limits for the 11 newly-listed classes of consumer products will result in lower VOC emissions from the classes of materials.

Adhesives, Sealants, Adhesive Primers, and Sealant Primers. This strategy will regulate the application of adhesives, sealants, adhesive primers and sealant primers by providing options for appliers to either to use a product with a VOC content equal to or less than a specified limit or to use add-on controls. There will be provisions limiting the VOC content of aerosol adhesives; establishing requirements for cleanup solvents; limiting surface preparation solvents; providing an alternative add-on control system requirement of at least 85 percent overall control efficiency (capture and destruction efficiency), by weight; imposing material storage requirements; and, establishing labeling requirements.

These regulations are currently in the process of development under the schedule described below in general terms: Once the Bureau of Air Quality has obtained an approved request to initiate a rulemaking, the rulemaking may proceed as follows:

Within 2 months: Review by Air Quality Technical Advisory Committee (AQTAC), Citizens Advisory Council and other advisory committees[15] as appropriate.
Within 5 months: Environmental Quality Board (EQB) meeting/action.
Within 7 months: Publish in the Pennsylvania Bulletin for comment as proposed rulemaking.
Within 9 months: Public hearing takes place and comment period on proposed rule closes.
Within 10 months: House and Senate Standing Committees and Independent Regulatory Review Commission (IRRC) comment on proposed rule.
Within 12 months: AQTAC, Citizens Advisory Council and other committee review responses to comments and draft final rulemaking.
Within 15 months: EQB meeting/action.
Within 16 months: Independent Regulatory Review Commission action on final rulemaking.
Within 17 months: Attorney General's review/action.
Within 18 months: Publish in the *Pennsylvania Bulletin* as final rulemaking and submit to EPA as a SIP revision. The regulation would become effective upon publication in the Pennsylvania Bulletin.

15 Other committees could include the Small Business Compliance Advisory Committee, and Agriculture Advisory Committee.

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ACRONYMS AND ABBREVIATIONS

CAA	Clean Air Act
CAIR	Clean Air Interstate Rule
CA LEV	California Low Emission Vehicle (program)
CMAQ	Community Multiscale Air-Quality Model
DOT	Department of Transportation (U.S.)
DV	Design Value
EGU	Electric Generating Unit
EPA	U.S. Environmental Protection Agency
FMVCP	Federal Motor Vehicle Control Program
I/M	Inspection and Maintenance
IPM	Integrated Planning Model
JJA	June, July and August
LLJ	Low level jets
MANE-VU	Mid Atlantic Northeast Visibility Union
NAAQS	National Ambient Air Quality Standard
NLEV	National Low Emission Vehicle (program)
NEOPS	North East Oxidant and Particle Study
NO_x	Oxides of Nitrogen
NO2	Nitrogen Dioxide
NBP	NOx Budget Program
OTAG	Ozone Transport and Assessment Group
OTB	On the books
OTC	Ozone Transport Commission
OTW	On the way
OTR	Ozone Transport Region
PennDOT	Pennsylvania Department of Transportation
ppb	parts per billion
ppm	parts per million
QA/QC	Quality Assurance/Quality Control
PM2.5	fine particulates (less than 2.5 microns in size)
RACM	Reasonably Available Control Measure
RACT	Reasonably Available Control Technology
RFF	Relative Response Factor
RFG	Reformulated Gasoline
RFP	Reasonable Further Progress
RPO	Regional Planning Organization
RVP	Reid Vapor Pressure
SIP	State Implementation Plan
SMOKE	Sparse Matrix Operator Kernel Emissions
TSD	Technical Support Document
tpsd	tons per summer day
VISTAS	Visibility Improvement State and Tribal Association of the Southeast
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound
WOE	Weight of Evidence