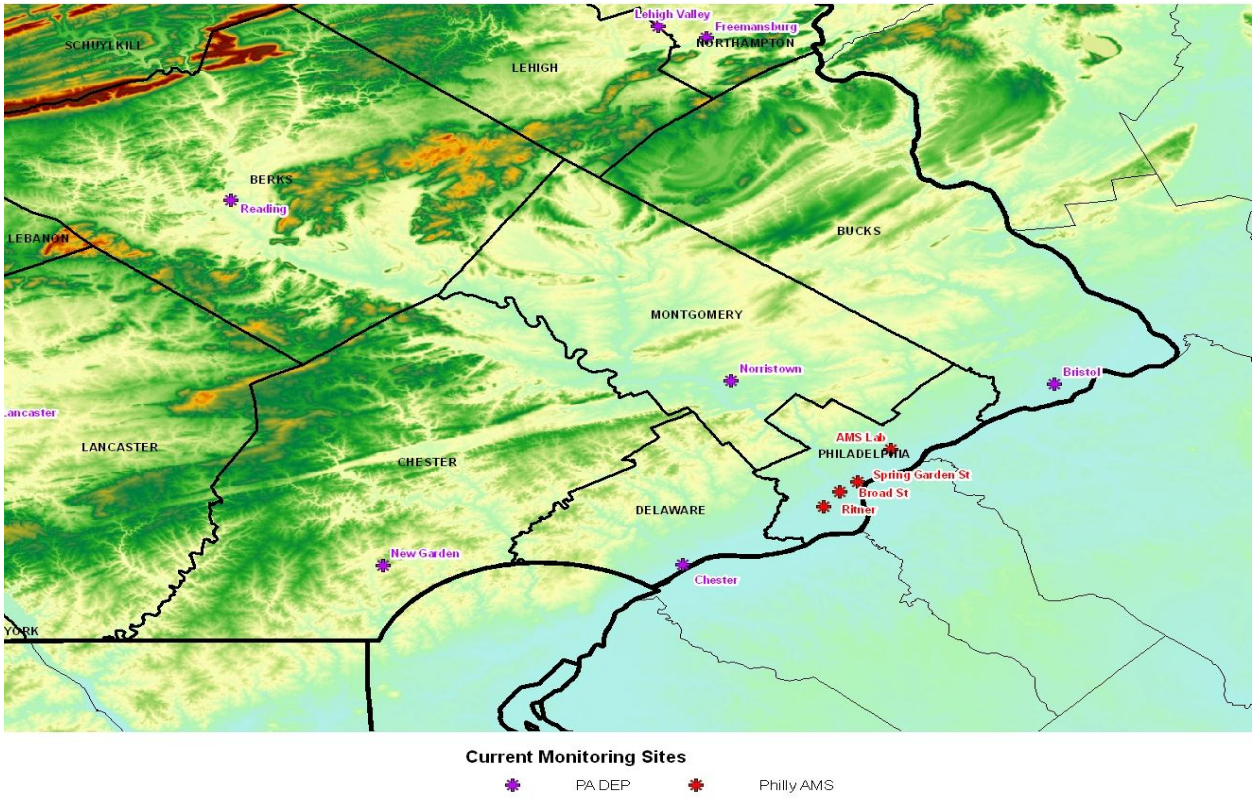
Appendix C-1
GREATER PHILADELPHIA AREA

The Department is recommending a Greater Philadelphia annual $PM_{2.5}$ NAAQS nonattainment area consisting of Chester, Delaware and Philadelphia counties. The Department completed an analysis of the $PM_{2.5}$ ambient air quality data, which outlines the reason for recommending a smaller nonattainment area than the five-county nonattainment area EPA designated for the 1997 and 2006 $PM_{2.5}$ standards. This analysis is provided below.

Analysis of the Ambient $PM_{2.5}$ Data – A Design Value Contribution Analysis

Based on EPA-certified 2012 $PM_{2.5}$ design values, three monitors in the Philadelphia metropolitan statistical area (MSA) are violating the 2012 $PM_{2.5}$ annual standard of 12 $\mu g/m^3$. The monitors and their design values are: AMS Lab (AIRS # 42-101-0004) at 13.4 $\mu g/m^3$ (in Philadelphia County); Chester (AIRS # 42-045-0002) at 13.1 $\mu g/m^3$ (in Delaware County) and New Garden (AIRS # 42-029-0100) at 12.3 $\mu g/m^3$ (in Chester County). Figure C-1.1 is a map showing the location of these monitors, along with monitors in attainment, in the five-county Philadelphia region.

Figure C-1.1: Greater Philadelphia Area $PM_{2.5}$ Monitoring Map



The Department has completed a design value contribution analysis for all of the $PM_{2.5}$ monitors in the five-county Philadelphia region. The analysis attempts to determine the daily contribution of $PM_{2.5}$ concentrations to the annual $PM_{2.5}$ design value. Daily $PM_{2.5}$ measurements were grouped into different $PM_{2.5}$ concentration ranges. An analysis of each range's contribution was then conducted to determine which measurements are contributing to the monitor's design value. Dates of these measurements were then further analyzed to determine if there are specific meteorological conditions or sources that are adversely impacting the monitor's design value.

Results from the design value contribution analysis for the five-county Philadelphia area are summarized in Table C-1.1. Ultimately, the type of contribution a given monitor's daily value had on the 3-year design value (by comparing this value to 12 $\mu g/m^3$) was determined. The daily value for each day a monitor measured $PM_{2.5}$ levels was placed in one of the ten categories. For example, on January 1, 2010, the Chester monitor's 24-hour $PM_{2.5}$ average was 19.1 $\mu g/m^3$. Since this value falls in the 18-24 $\mu g/m^3$ category in Table C-1.1, the calculated daily contribution to the design value was placed in this category. In the first quarter of 2010 (January 1 to March 31), the Chester monitor recorded 82 measurements. The Department determined that the January 1, 2010, contribution assessment to the 2012 design value was 0.007215 $\mu g/m^3$. The 0.007215 $\mu g/m^3$ was calculated by dividing the average daily value of 19.1 $\mu g/m^3$ by a factor of the number of measurements for the quarter (82) by 12 (there are a total of 12 quarters in a 3-year design value period). This type of analysis was completed for every day of measurements from January 1, 2010, through December 31, 2012. In Table C-1.1, the sum of the categorical breakdowns for the Chester monitor equals 1.09 $\mu g/m^3$, which demonstrates that the design value is 1.09 $\mu g/m^3$ above the annual standard of 12 $\mu g/m^3$.

Table C-1.1: Five-County Philadelphia Area
2012 $PM_{2.5}$ Annual Design Value Contribution Analysis

Site Name	Site ID	Owner	0 - 6.0	6.0 - 12.0	12.0 - 18.0	18.0 - 24.0	24.0 - 30.0	30.0 - 36.0	36.0 - 42.0	42.0 - 48.0	48.0 - 54.0	54.0 - 60.0	SUM
Monitors Attaining 2012 PM 2.5 Standard													
Bristol	420170012	PA DEP	-2.0077	-1.2251	0.5704	0.6417	0.5463	0.2973	0.0000	0.0288	0.0348	0.0000	-1.1136
Norristown	420910013	PA DEP	-2.3198	-1.3695	0.5001	0.6010	0.3150	0.0910	0.0246	0.0000	0.0000	0.0000	-2.1577
Broad St	421010047	Philly AMS	-1.5940	-1.4150	0.5896	0.6951	0.4013	0.1521	0.0229	0.0278	0.0000	0.0000	-1.1202
Ritner	421010055	Philly AMS	-1.7293	-1.2970	0.6520	0.6949	0.4003	0.2666	0.0000	0.0379	0.0000	0.0000	-0.9747
Spring Garden St	421010057	Philly AMS	-1.7675	-1.3664	0.5719	0.6756	0.4337	0.1647	0.0470	0.0340	0.0000	0.0000	-1.2070
Monitors Not Attaining 2012 PM 2.5 Standard													
New Garden	420290100	PA DEP	-1.4113	-1.2355	0.7396	0.9641	0.6423	0.3972	0.1618	0.0321	0.0000	0.0000	0.2904
Chester	420450002	PA DEP	-0.9361	-1.1286	0.7357	1.2684	0.7250	0.4323	0.0536	0.0293	0.0000	0.0000	1.0896
AMS Lab	421010004	Philly AMS	-1.0822	-0.9314	0.8128	1.2817	0.9323	0.3058	0.0771	0.0389	0.0000	0.0000	1.4351
Five-County Philadelphia Area Average			-1.6060	-1.2573	0.6465	0.8528	0.5495	0.2634	0.0484	0.0286	0.0044	0.0000	

Table C-1.1 illustrates the differences between the monitors that are attaining the 2012 $PM_{2.5}$ annual standard and the monitors that are not attaining the 2012 $PM_{2.5}$ annual standard. The monitors that are not attaining the standard have relatively fewer "clean" days (0-12 µg/m^3) than the monitors that are attaining the standard. For example, the Chester monitor's $PM_{2.5}$ contribution to the design value in the 0-12 µg/m^3 range was 0.7 µg/m^3 lower than the five-county average.

The analysis described in the remainder of this Appendix focuses on the Chester monitor because it is the monitor of most concern. Figure C-1.2a illustrates the trend of annual averages while Figure C-1.2b illustrates the trend of annual design values for monitors in the five-county region. The Chester monitor is the only monitor in this region with an annual average and annual design value constantly above the 2012 standard. Since 2003, annual $PM_{2.5}$ levels have been in a general decline in the Greater Philadelphia area. The Bristol monitor in Bucks County has been below the 2012 standard on an annual average since 2009 and under the annual design value since 2010. In addition, the Norristown monitor in Montgomery County has been under the 2012 standard on an annual average since 2008 and the annual design value since 2009. Over the last three years, levels at the New Garden monitor have fallen at a significant rate. If the trend continues, the New Garden monitor's 2013 design value is expected to reach attainment of the 12 µg/m^3 standard. As quickly as levels at the New Garden monitor have fallen, levels at the AMS Lab monitor have increased. In fact, the AMS Lab monitor's $PM_{2.5}$ annual average has increased an average of 3 µg/m^3 since 2010. The Department does not believe this trend will continue, however, because the annual average trend at this monitor does not coincide with what is occurring regionally. The Department is investigating the reason for the spike in $PM_{2.5}$ values at the AMS Lab monitor, especially since three other monitors in Philadelphia County have 2012 annual design values at or below 11.0 µg/m^3.

Figure C-1.2a: Greater Philadelphia Area $PM_{2.5}$ Annual Averages

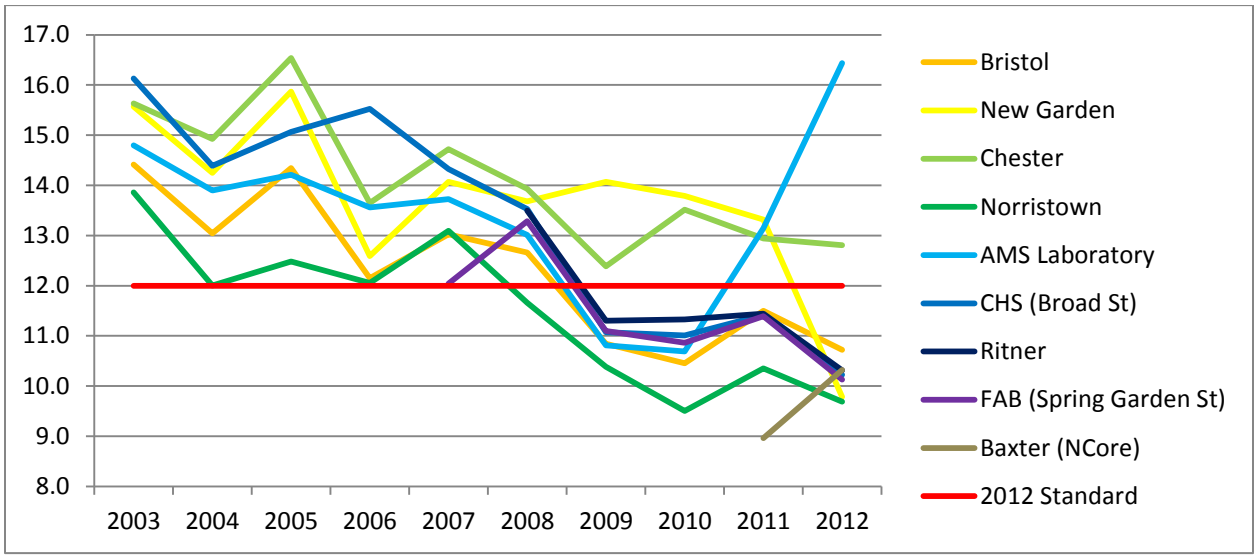
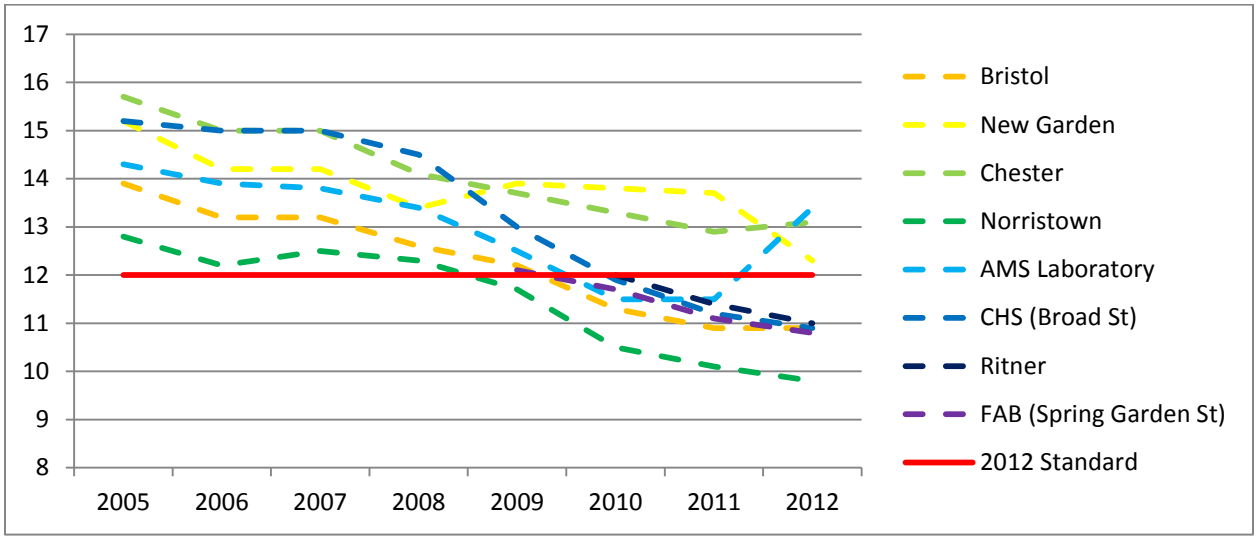


Figure C-1.2b: Greater Philadelphia Area $PM_{2.5}$ Annual Design Values



Additional analyses were completed to determine what was contributing to the fewer number of "clean" days at the Chester monitor. The Department identified days when the Chester monitor's $PM_{2.5}$ concentrations were relatively high but regional monitoring concentrations in the five-county Philadelphia area were "clean." Between 2010 and 2012, the Department identified 212 days in which the Chester monitor was at least one standard deviation above the five-county regional average while the regional average was at or below 12 µg/m^3. The most extreme events (top 25%) were further analyzed to determine why the Chester monitor's concentrations were high when regional concentrations were low.

Meteorological Conditions Impacting High $PM_{2.5}$ Days at the Chester Monitor

The top 25% days were examined to determine the reason the Chester monitor's concentrations were high. The Chester monitor has a collocated meteorological tower that monitors wind direction and wind speed. Figure C-1.3 illustrates the number of hours the wind is coming from a particular direction, while Figure C-1.4 illustrates the total $PM_{2.5}$ concentration coming from a particular direction.

Figure C-1.3: Chester Wind Direction Frequency
Top 25% of Regionally "Clean" Days

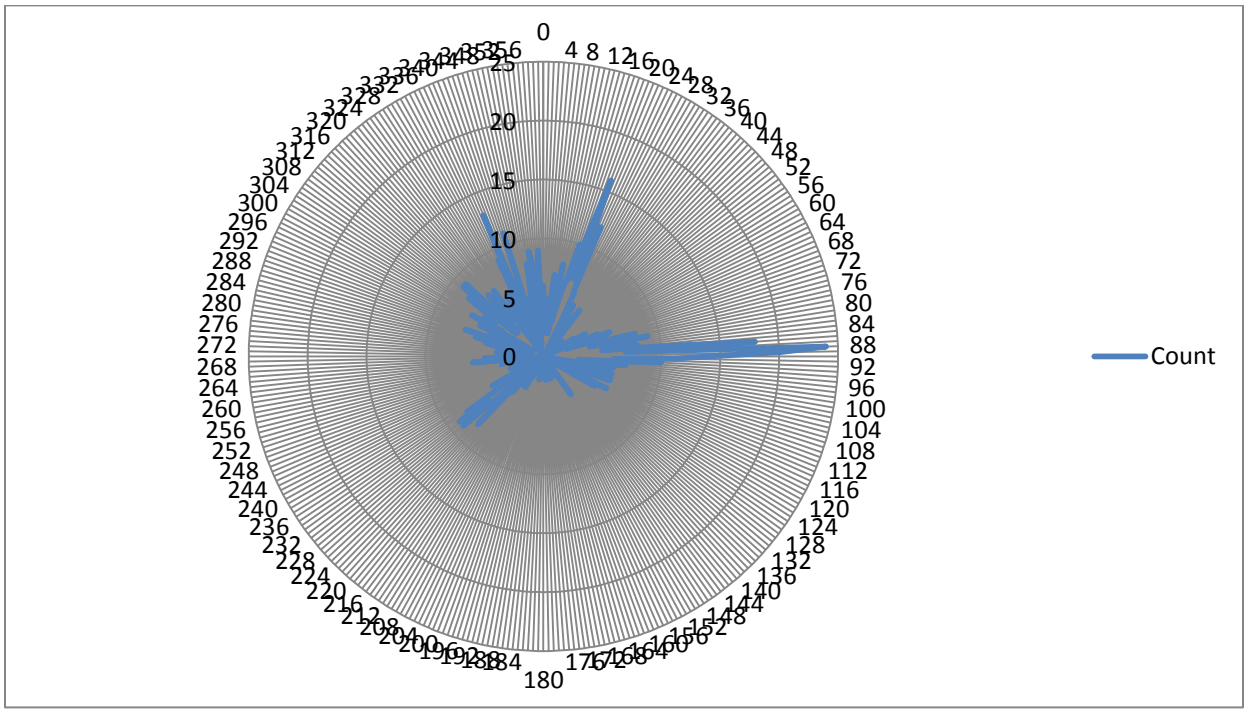


Figure C-1.4: Chester $PM_{2.5}$ Concentration Distribution by Wind Direction
Top 25% of Regionally "Clean" Days

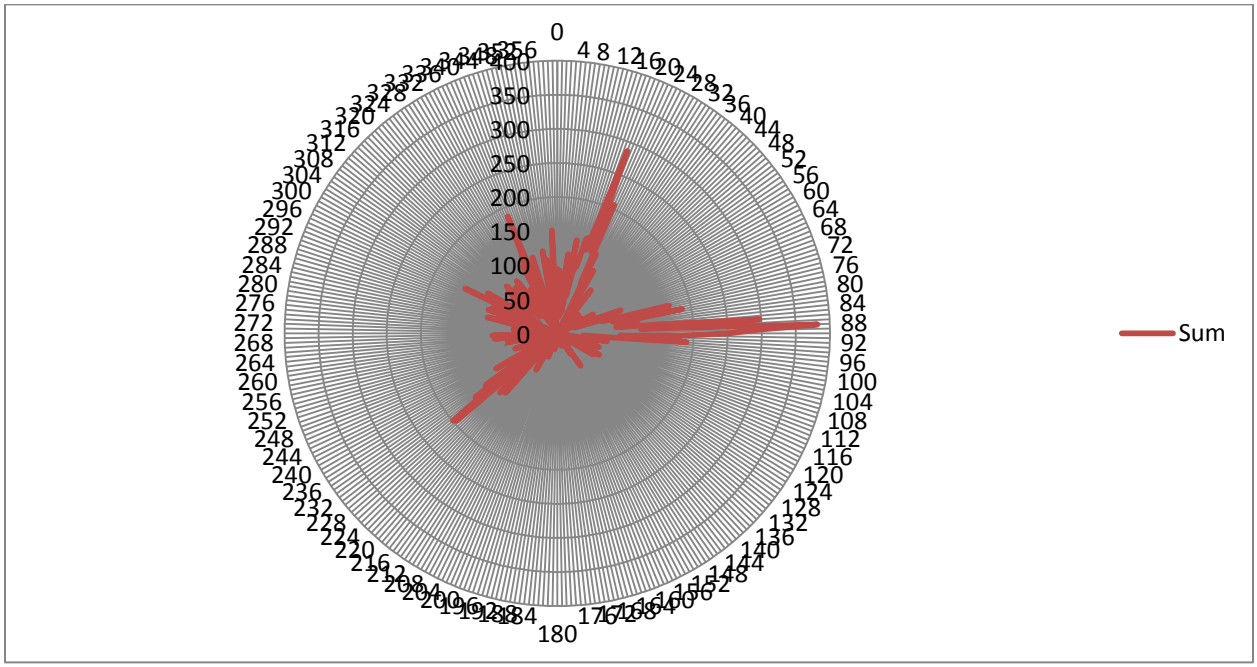
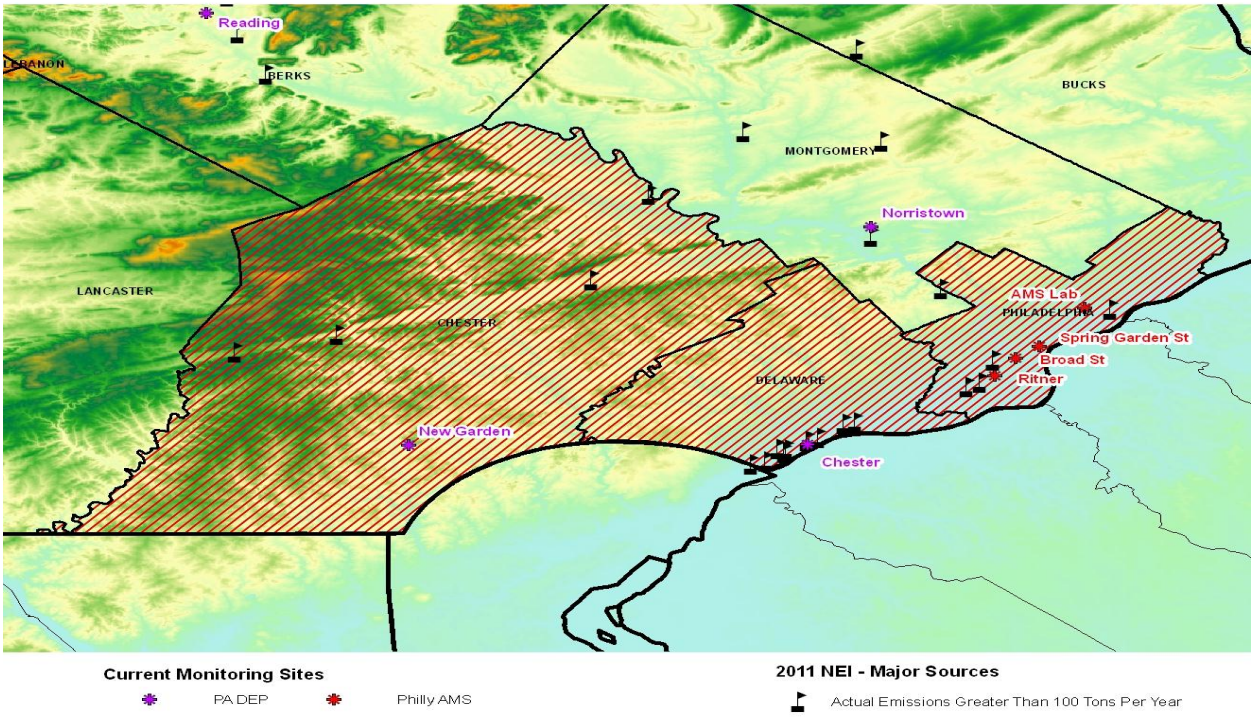


Figure C-1.3 illustrates that the highest frequency of wind distribution on the top 25% days is coming from due east. Figure C-1.4 illustrates that the highest $PM_{2.5}$ concentrations are coming from the same direction. These graphs also illustrate the local nature of the problem. Developed from the EPA PM online tool (http://geoplatform2.epa.gov/PM_Map/), Figure C-1.5 illustrates the sources within the immediate proximity of the Chester monitor.

Figure C-1.5: Greater Philadelphia Area
Major Sources (Over 100 Tons Per Year) Based on 2011 NEI



There are multiple major sources of $PM_{2.5}$, SO_2, and NO_X that are in close proximity of the Chester monitor. The wind direction analysis above shows that the predominant winds on the top 25% days travel directly over these sources. This analysis indicates the local nature of the problem near the Chester monitor.

The Change in the Composition of the $PM_{2.5}$

Up until 2009, the Chester monitor was recording speciated data. In 2009, the Chester speciation monitor was moved to Johnstown, in order to provide speciation data for the Johnstown region. However, it should be noted that the Department continues to operate a speciation monitor in New Garden. The composition of $PM_{2.5}$ has changed at the New Garden monitor since the height of $PM_{2.5}$ concentrations in the 2005 to 2007 time period. Table C-1.2 outlines the main speciated components of $PM_{2.5}$ during the cold season (1st quarter). Table C-1.3 outlines the

main speciated components of $PM_{2.5}$ during the warm season (3rd quarter). Overall, Table C-1.2 and Table C-1.3 illustrate the decline in the main speciated components of $PM_{2.5}$ from the 2005 to 2007 period to the 2010 to 2012 period.

Table C-1.2: New Garden Speciated $PM_{2.5}$ Data*
Cold Season (1st Quarter) Comparison – 2005-07 Versus 2010-12

Year	Ammonium	Nitrate	Sulfate	OC	EC	Crustal
2005 – 07	2.65328904	4.52661674	3.47913757	3.53138555	0.57891952	0.37101403
2010 – 12	1.73366732	3.44228334	2.34297412	2.39326413	0.26977607	0.22850717
Difference (2005 – 07 minus 2010 – 12)	0.91962172	1.08433340	1.13616344	1.13812142	0.30914344	0.14250686

*All concentrations are averages and have units of $\mu g/m^3$

Table C-1.3: New Garden Speciated $PM_{2.5}$ Data*
Warm Season (3rd Quarter) Comparison – 2005-07 Versus 2010-12

Year	Ammonium	Nitrate	Sulfate	OC	EC	Crustal
2005 – 07	3.27416025	2.01363812	6.99463900	4.57287913	0.62645942	0.56450840
2010 – 12	1.29830701	1.24423445	3.14620296	2.39450910	0.24473608	0.39749725
Difference (2005 – 07 minus 2010 – 12)	1.97585325	0.76940368	3.84843604	2.17837002	0.38172334	0.16701115

*All concentrations are averages and have units of $\mu g/m^3$

During the cold season, there has been an equal amount of reduction in ammonium, nitrate, sulfate, and organic carbon concentrations. During the warm season, the largest reductions have occurred in ammonium, sulfate and organic carbon concentrations.

To analyze this further, we chose to compare these seasonal values with what has occurred in Arendtsville (AIRS # 42-001-0001), located in Adams County. Arendtsville is in a rural location of Pennsylvania and does not have a major nitrogen oxide or sulfur dioxide source within 50 kilometers of the monitor. For that reason, the Arendtsville monitor reflects the transport that is coming into eastern Pennsylvania from areas to the west (prevailing wind flow is from west to east across Pennsylvania).

Table C-1.4: Arendtsville Speciated $PM_{2.5}$ Data*
Cold Season (1st Quarter) Comparison – 2005-07 Versus 2010-12

Year	Ammonium	Nitrate	Sulfate	OC	EC	Crustal
2005 – 07	2.22066410	3.57386769	3.39904757	3.17044419	0.45550711	0.22843761
2010 – 12	1.23919565	2.07028981	2.18818154	1.68097944	0.16095925	0.18801487
Difference (2005 – 07 minus 2010 – 12)	0.98146846	1.50654787	1.21086602	1.48946475	0.29454786	0.04042275

*All concentrations are averages and have units of $\mu g/m^3$

Table C-1.5: Arendtsville Speciated $PM_{2.5}$ Data*
Warm Season (3rd Quarter) Comparison – 2005-07 Versus 2010-12

Year	Ammonium	Nitrate	Sulfate	OC	EC	Crustal
2005 – 07	2.43772827	0.68269750	7.29288441	3.85331667	0.37004536	0.34223237
2010 – 12	0.98470271	0.50442874	3.13218233	2.13687247	0.15489114	0.32755852
Difference (2005 – 07 minus 2010 – 12)	1.45302555	0.17816876	4.16070208	1.71644420	0.21515422	0.01467385

*All concentrations are averages and have units of $\mu g/m^3$

The reductions at Arendtsville reflected in the "difference" row of Table C-1.5 are more representative of the reductions observed in eastern Pennsylvania due to emission control strategies of various sources (for example, the installation of flue gas desulfurization units on electric generation units across western Pennsylvania into the Ohio Valley). The data indicates that the greatest level of reduction at the New Garden and Arendtsville monitors occurs during the summer months (when sulfate is the primary constituent of $PM_{2.5}$). During the 2005 – 07 time frame, Arendtsville had a 3rd quarter total mass average of 19.08 $\mu g/m^3$, and during the 2010 – 12 time frame it had a 3rd quarter total mass average of 12.06 $\mu g/m^3$, a 7 $\mu g/m^3$ reduction.

An analysis of the 2010 – 12 differences between the New Garden and Arendtsville monitors indicates the nature of the problem at New Garden.

Figure C-1.6: Urban Excess
New Garden vs. Arendtsville
2010-12 - 1st Quarter

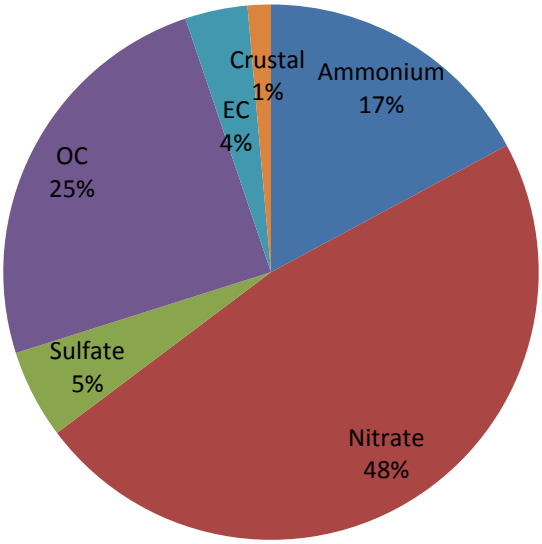


Figure C-1.7: Urban Excess
New Garden vs. Arendtsville
2010-12 - 3rd Quarter

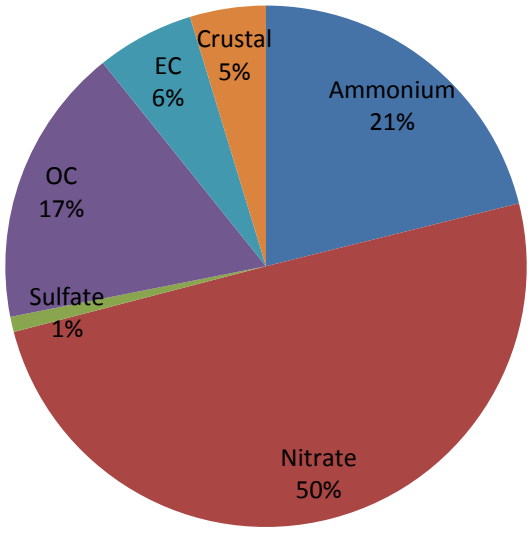


Figure C-1.6 and Figure C-1.7 display the same problem; New Garden has excess nitrate, ammonium, and organic carbon emissions compared to Arendtsville. Sulfate levels, which are

indicative of regional emissions from sources such as coal fired electric generation units, were fairly uniform at the New Garden and Arendtsville monitors. This indicates a miniscule change in concentration. The excess nitrate, ammonium, and organic carbon at the New Garden monitor links closely with sources of secondary nitrate formation, such as traffic, suggest that New Garden's emissions are local in nature.

Summary

The Department's analysis illustrates the need for one small multi-county nonattainment area in southeastern Pennsylvania. An analysis of the $PM_{2.5}$ data monitored at the Chester monitor in Delaware County illustrates that Chester sees concentrations in the 12-30 $\mu g/m^3$ range while the regional concentrations are in the 0-12 $\mu g/m^3$ range. A further examination into the monitoring data demonstrates that the high concentrations are coming out of three primary directions: southwesterly, easterly, and northeasterly. These wind profiles travel over local point source emissions, further illustrating the local issue at the Chester monitor. An analysis of the speciated data at the New Garden and Arendtsville monitors illustrates the excess nitrate, ammonium, and organic carbon at the New Garden monitor, in Chester County. This concentration profile is indicative of secondary nitrate formation, another local source of emissions near the New Garden monitor. The AMS Lab monitor in Philadelphia County has a 2012 annual design value that exceeds the 2012 annual $PM_{2.5}$ NAAQS. Finally, the Bristol and Norristown monitors, in Bucks and Montgomery counties, respectively, are and have been monitoring attainment of the 2012 standard for several years and are not contributing to excess emissions elsewhere. Therefore, the Department is recommending the Greater Philadelphia nonattainment area encompassing Chester, Delaware and Philadelphia counties in Pennsylvania be designated nonattainment for the 2012 annual $PM_{2.5}$ NAAQS. A map of the proposed nonattainment area is provided below as Figure C-1.8.

Figure C-1.8: Recommended Greater Philadelphia $PM_{2.5}$ Nonattainment Area