Evaluation of Potential $PM_{2.5}$ Reductions by Improving Performance of Control Devices: Conclusions and Recommendations

Draft Report

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ACRONYMS AND ABBREVIATIONS

acfm	actual cubic feet per minute
BOF	basic oxygen furnace
CAIR	Clean Air Interstate Rule
COHPAC	Compact Hybrid Particulate Collector
DSI	dry sorbent injection
EGU	electrical generating unit
EPA	United States Environmental Protection Agency
ESP	electrostatic precipitator
ETV	Environmental Technology Verification
FCCU	fluid catalytic cracking unit
FF	fabric filter
FGD	flue gas desulfurization
ft^2	square feet
gr/dscf	grains per dry standard cubic foot
in. H_20	inches of water
kW	kilowatt
lb	pound
MACT	maximum achievable control technology
mg/Nm^3	milligrams per normal cubic meter
MMBtu	million British thermal units
MW	megawatt
µm	micrometer
NAA	nonattainment area
NAAQS	National Ambient Air Quality Standard
NEI	National Emissions Inventory
NO_x	nitrogen oxide
PM	particulate matter
PPS	polyphensulfide
PTFE	polytetrafluoroethene
REF	recovered fuel
ROPE	Rapid Onset Pulsed Energization
SCA	specific collection area
SIP	state implementation plan
SO_2	sulfur dioxide
SO_3	sulfur trioxide
STN	Speciated Trends Network
tpy	tons per year
TSP	total suspended particulates
W	watts
WS	wet scrubber

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EVALUATION OF POTENTIAL $PM_{2.5}$ REDUCTIONS

1. INTRODUCTION

The EPA is evaluating emissions reduction strategies for implementing the 1997 $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS) standards ($PM_{2.5}$, is particulate matter (PM) that is less than 2.5 micrometers in diameter). Effective April 5, 2005, EPA completed the "designation" process in which EPA formally announced the areas of the country that are not attaining the $PM_{2.5}$ standards. States are required to develop and submit implementation plans (SIPs) to bring these areas into attainment. The SIPs will be due to EPA in April 2008 and must provide for attainment by April 2010 (based upon data for the 2007-2009 time period) unless EPA approves an extension of the time period to a date which may not be later than 2014.

EPA is investigating ways to reduce direct (primary) $PM_{2.5}$ emissions in areas that likely will not attain the $PM_{2.5}$ standards even after the Clean Air Interstate Rule (CAIR) is fully implemented. One possible way of reducing $PM_{2.5}$ emissions would be to modify existing control devices to improve their performance in reducing the "fine" (less than 2.5 micrometers) fraction of particulate matter. An extensive literature review was conducted to identify operational improvements, control device upgrades, and innovative control systems that could be used to reduce $PM_{2.5}$ emissions. The $PM_{2.5}$ emissions were also evaluated to estimate the contribution controlled point sources have to the total $PM_{2.5}$ emissions reported for each of the 16 non-attainment areas (NAAs) and to estimate the degree to which improving or replacing existing controls would reduce $PM_{2.5}$ emissions.

This report summarizes the results of the literature review and the evaluation of $PM_{2.5}$ emissions for the 16 NAAs and provides conclusions and recommendations regarding emission sources and control techniques for further evaluation in meeting ambient $PM_{2.5}$ standards.

2. BACKGROUND ON $PM_{2.5}$ AMBIENT AIR CONCENTRATIONS

2.1 National Ambient Air Quality Standards for $PM_{2.5}$

There are two NAAQS for $PM_{2.5}$. The short-term NAAQS for $PM_{2.5}$ is a 24-hour limit of 65 $\mu g/m^3$. None of the ambient monitors in any of the NAAs violated this standard. There is also an annual mean limit of 15 $\mu g/m^3$. It is this annual mean limit that is being exceeded in the $PM_{2.5}$ NAAs under consideration. Note that compliance with the long-term $PM_{2.5}$ NAAQS is based on the average of three consecutive annual averages.

We queried the AirData system to identify all ambient monitors in the counties that comprise the 16 NAAs being considered. Table 2-1 shows the results for the annual average ambient $PM_{2.5}$ concentration for the highest monitor in each NAA. It can be seen that the there has been significant progress within the NAA towards meeting the annual mean limit of 15 $\mu g/m^3$. In 2000, nine of the NAA had average ambient $PM_{2.5}$ concentrations exceeding 20 $\mu g/m^3$, and all 16 of the NAAs had average ambient $PM_{2.5}$ concentrations of 17.5 $\mu g/m^3$ or more. By 2004, only one NAA had a monitor that exceeded 20 $\mu g/m^3$ (Birmingham, at 36 percent above the NAAQS) and only two other areas with average ambient $PM_{2.5}$ concentrations of 17.5 $\mu g/m^3$ or more (Atlanta and Cleveland-Akron-Lorain). In 2004, 9 out of the 16 NAAs had highest

monitor values that were within 10 percent of the NAAQS (i.e., 16.5 µg/m^3 or less), and 13 out of 16 NAAs require only a 15 percent reduction in their annual average ambient air concentration to achieve the 15 µg/m^3 NAAQS. As compliance with the long-term $PM_{2.5}$ NAAQS is based on the average of three consecutive annual averages, the reductions described above would be valid only if the values for 2005 and 2006 are essentially equal to the 2004 values. If the trend of declining $PM_{2.5}$ ambient concentrations continues for 2005 and 2006, the necessary reductions would be even less.

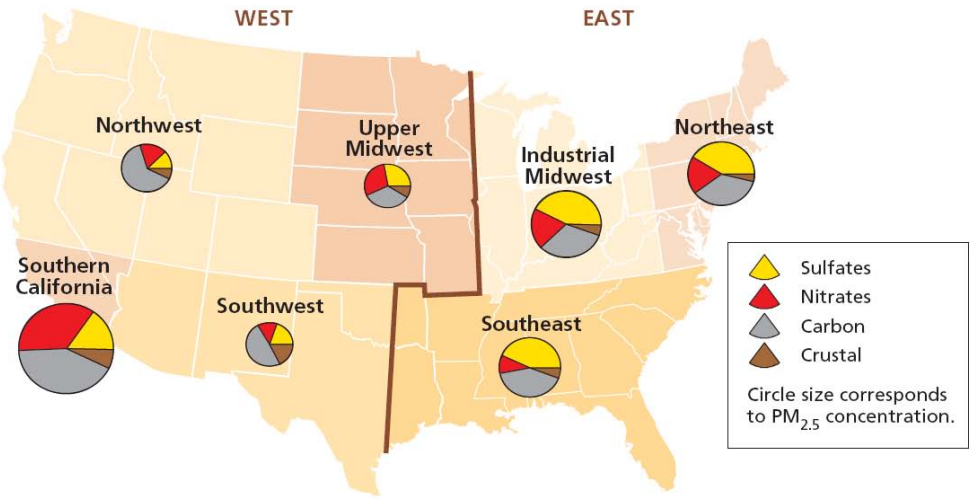
Table 2-1. Annual Average Ambient $PM_{2.5}$ Concentration for Highest Monitor in Each NAA

Nonattainment Area	Annual Average Ambient $PM_{2.5}$ Concentrations (µg/m^3) for Year:				
	2000	2001	2002	2003	2004
Atlanta	21.5	19.1	17.4	17.7	17.6
Birmingham	23.2	22.1	19.3	19.6	20.4
Canton-Masillon	18.7	17.8	17.3	16.8	15.6
Charleston	18.3	18.1	17.2	16.2	16.1
Chattanooga	19.0	16.7	15.1	16.5	15.7
Chicago-Gary	20.2	20.9	17.7	17.4	16.7
Cincinnati-Hamilton	20.6	23.0	17.9	17.3	16.4
Cleveland-Akron-Lorain	20.1	19.8	17.7	17.6	17.5
Columbus	18.3	17.9	16.2	16.4	15.0
Detroit-Ann Arbor	20.1	19.6	19.8	19.1	16.8
Huntington-Ashland	21.1	20.3	16.7	15.5	15.2
Indianapolis	18.9	18.6	18.4	17.5	16.7
Knoxville	20.1	17.5	16.9	16.4	15.1
Louisville	17.5	18.6	18.7	19.1	15.1
St. Louis	20.6	19.7	19.6	18.1	16.2
Steubenville-Weirton	19.2	18.9	17.6	17.7	16.6

2.2 Composition of Ambient $PM_{2.5}$

Figure 2-1 shows the compositional breakdown for $PM_{2.5}$ in 7 areas of the United States. All 16 of the NAAs under consideration are located in either the industrial Midwest or the Southeast. For the industrial Midwest and Southeast, sulfates form the largest component of $PM_{2.5}$, followed by carbon and nitrates.

Although this project focuses on primary (or direct) $PM_{2.5}$ emissions, a substantial portion of ambient $PM_{2.5}$ in both the industrial Midwest and the Southeast comes from secondary formation (e.g., sulfur dioxides and nitrogen oxide emissions that combine with ammonia to form ammonium sulfate and ammonium nitrate). Primary $PM_{2.5}$ emissions represent between 33 and 50 percent of the ambient $PM_{2.5}$.



Note: In this report, the term "sulfates" refers to ammonium sulfate and "nitrates" refers to ammonium nitrate. "Carbon" refers to total carbonaceous mass, which is the sum of estimated organic carbon mass and elemental carbon. "Crustal" is estimated using the IMPROVE equation for fine soil at vista.cira.colostate.edu/improve.

This report summarizes analysis results using the geographic areas shown in this map. The area definitions correspond to the regions used in EPA's 1996 PM Criteria Document (www.epa.gov/ttn/naaqs).

In this report, "East" includes three regions: the Northeast, the Industrial Midwest, and the Southeast.

Figure 2-1. Average Ambient $PM_{2.5}$ Composition in Urban Areas

3. SUMMARY OF $PM_{2.5}$ EMISSION ESTIMATES

This section summarizes key results of the analysis of $PM_{2.5}$ emissions data; the details of the $PM_{2.5}$ emissions analysis are documented in the "$PM_{2.5}$ Emission Estimates" report (Pechan and RTI, 2005). The $PM_{2.5}$ emission estimates were based on the data reported in the 2002 draft National Emissions Inventory (NEI) that EPA released for review by the state and local agencies during February 2005. EPA will be releasing the final 2002 NEI in the fall of 2005. This version will incorporate comments that state and local agencies provided to EPA on the draft 2002 NEI. In addition, EPA will be applying procedures to fill in missing PM25-FIL (i.e., the filterable portion of the $PM_{2.5}$ emissions) and PM-CON (i.e., the condensable portion of the $PM_{2.5}$ emissions) data and will sum the emissions for these two pollutants to obtain PM25-PRI emissions (i.e., the total or "primary" $PM_{2.5}$ emissions). Although a cursory attempt was made to augment the reported $PM_{2.5}$ data, it is important to note that the emissions reported here represent primarily 2002 draft NEI values.

Table 3-1 presents the PM25-PRI emissions data for all 16 NAAs by source type (point, nonpoint, onroad, and nonroad). The point source data are segregated between "controlled," "regulated," and "uncontrolled" point source emissions. The "controlled" classification directly correlates with the NEI classification of controlled units; these are essentially sources with add-on emission control devices. However, in reviewing the largest "uncontrolled" emission sources, certain large emission sources were identified, such as coke oven doors, that are subject to work practice or equipment standards to reduce their emissions. Although they do not have an external air pollution control device, it is misleading to characterize these emissions as completely uncontrolled since the current emissions from these sources has been significantly reduced through source-specific opacity limits or work practice standards. Therefore, we

subcategorized the point sources with no add-on control devices into "regulated" sources (i.e., sources subject to federal opacity/work practice standards) and "uncontrolled" sources (i.e., sources with no emission control systems).

Table 3-1. Comparison of PM25-PRI Emissions by Source Type

Nonattainment Area Name	Point Emissions (tpy)			Non-point (tpy)*	Onroad (tpy)	Non-road (tpy)	Total (tpy)
	Add-on Control	Regu-lated	Uncon-trolled				
Atlanta, GA	4,162	-	385	24,735	3,082	2,591	34,955
Birmingham, AL	10,309	4,070	4,034	4,205	526	514	23,658
Canton-Massillon, OH	123	1	147	1,330	143	194	1,938
Charleston, WV	1,633	-	282	1,596	195	242	3,948
Chattanooga, TN-GA	987	-	110	2,649	332	384	4,462
Chicago-Gary-Lake County, IL-IN	2,399	1,634	3,338	23,191	2,820	5,982	39,365
Cincinnati-Hamilton, OH-KY-IN	3,342	-	272	7,527	901	1,567	13,610
Cleveland-Akron-Lorain, OH	2,287	8	247	7,041	1,275	2,498	13,356
Columbus, OH	2,369	-	242	6,887	703	1,014	11,214
Detroit-Ann Arbor, MI	1,704	-	7	11,837	2,853	2,888	19,289
Huntington-Ashland, WV-KY-OH	4,488	-	333	3,092	236	1,184	9,334
Indianapolis, IN	243	80	352	9,915	682	886	12,158
Knoxville, TN	6,003	230	911	2,592	543	490	10,769
Louisville, KY-IN	4,651	-	2,548	5,209	698	865	13,970
St. Louis, MO-IL	2,008	-	4,502	16,301	1,677	2,260	26,748
Steubenville-Weirton, OH-WV	4,445	6,014	819	712	53	154	12,196
Total, all Nonattainment Areas	**51,153**	**12,036**	**18,529**	**128,819**	**16,719**	**23,713**	**250,969**

* Draft 2002 NEI PM25-FIL emissions for fugitive dust sources are adjusted using EPA county-level fugitive dust transport fractions.

Figure 3-1 shows the percentages of PM25-PRI that are from controlled point sources as compared to all other sources (including uncontrolled, nonpoint, onroad, and nonroad). For the 16 NAAs of interest, emissions of PM25-PRI that are controlled point sources average approximately 24 percent of all PM25-PRI emissions. Figure 3-2 shows the percentage contribution only for PM25-PRI from "controlled" point sources (i.e., point sources controlled using an add-on PM emissions control device). Figure 3-2 simply highlights the "controlled" point source contribution presented in Figure 3-1.

Figure 3-3 shows the percentages of total PM25-PRI point source emissions that are from "controlled" versus "regulated" versus "uncontrolled" point sources.

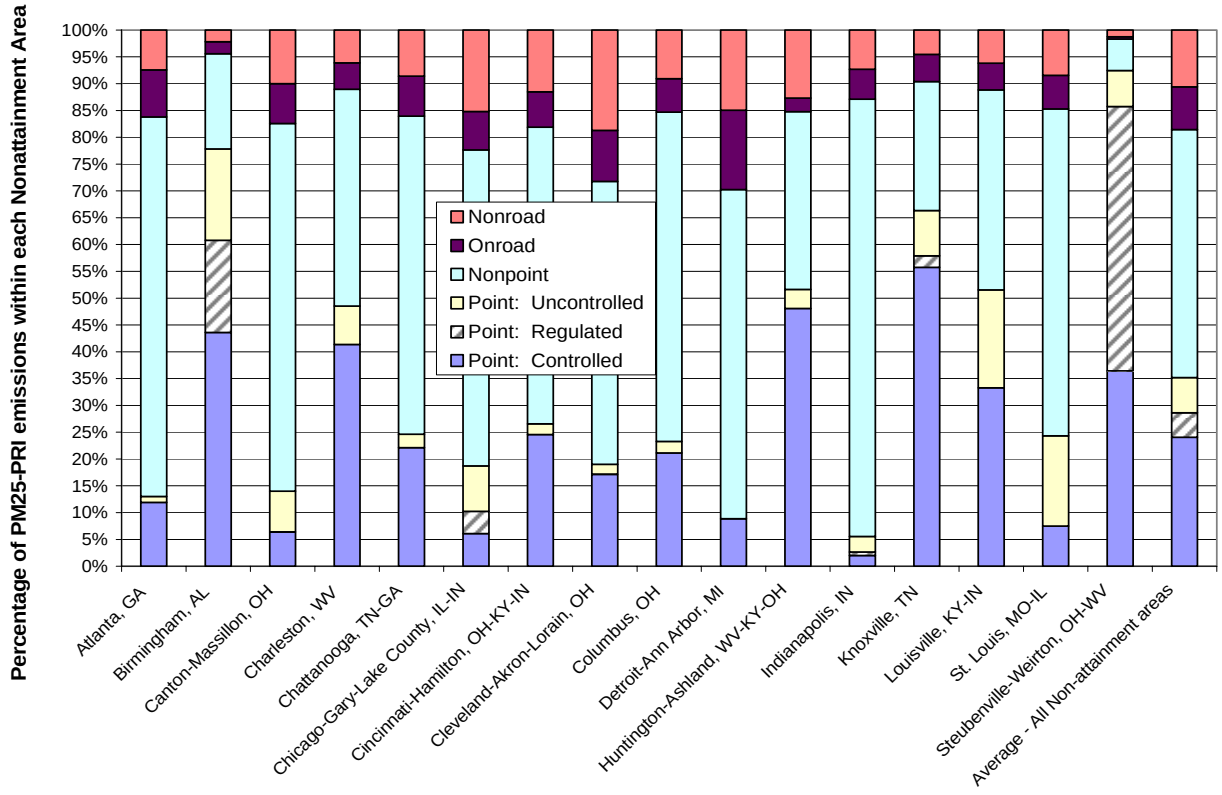


Figure 3-1. Breakdown of PM25-PRI Emissions According to Source Type by NAA

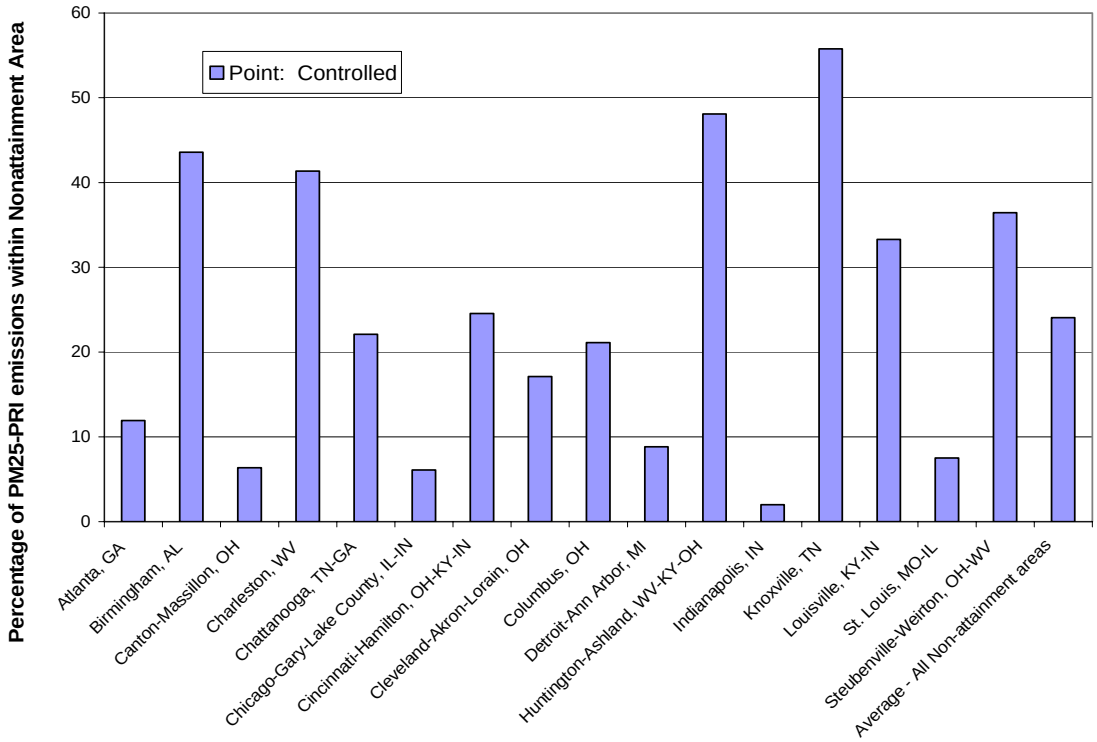


Figure 3-2. Point Source "Controlled" Emissions as a Percentage of Total PM25-PRI Emissions from All Sources by NAA

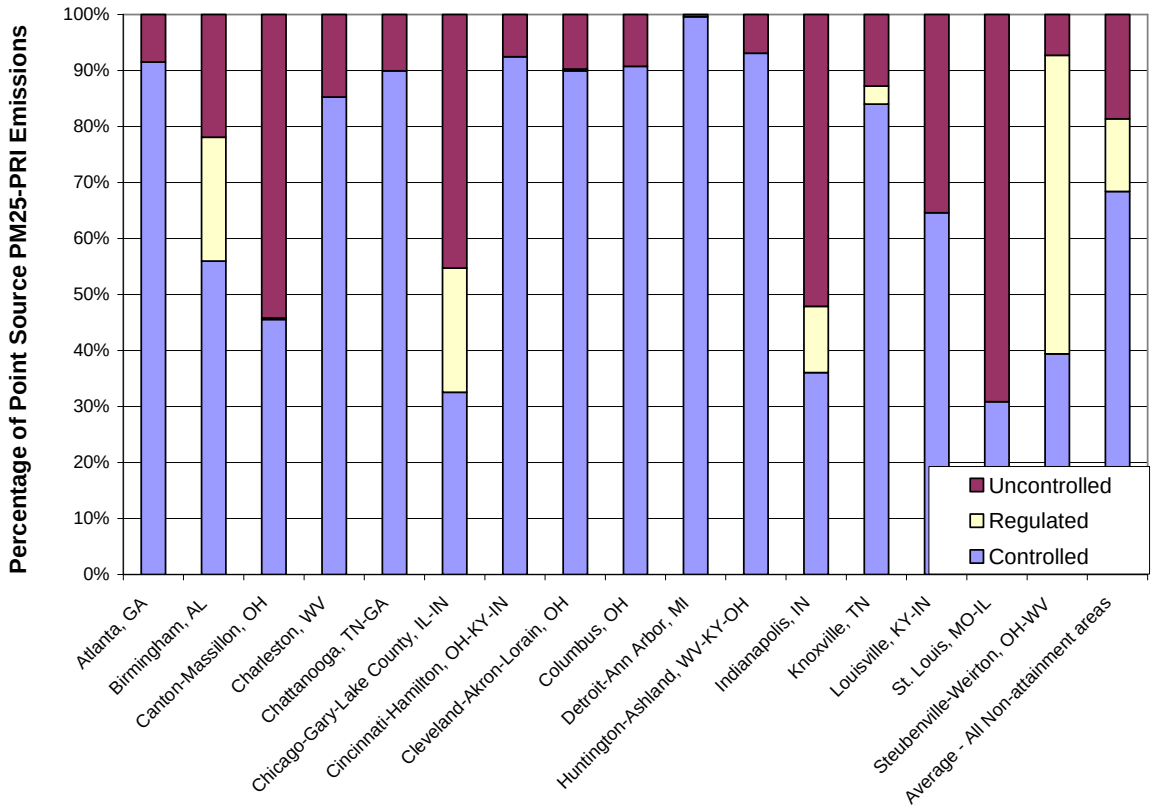


Figure 3-3. Contribution of PM25-PRI Point Source Emissions by Control Status and NAA

We also looked at the relative size of the sources of PM25-PRI emissions. The database developed for this project, based on adjustments to the draft NEI described previously, contains 8,716 records. Of these, 2,822 records were associated with emission sources using add-on control devices ("controlled" sources), 129 records were classified as "regulated" sources, and 5,765 were classified as "uncontrolled" sources. The total emissions were approximately 51,000 tpy, 12,000 tpy, and 18,000 tpy for controlled, regulated, and uncontrolled point sources, respectively. As shown in Figure 3-4, approximately half of the controlled and uncontrolled emissions came from the top 50 sources within that category. For "controlled" point sources, the top 252 emission sources (top 9% of controlled sources) accounted for 90 percent of the controlled point source emissions. For "regulated" sources, the top 28 (22% of) regulated sources accounted for 90 percent of the regulated point source emissions. For "uncontrolled" sources, the top 641 (11% of) uncontrolled sources accounted for 90 percent of the uncontrolled point source emissions. These data suggest that a significant reduction in point source emissions may be achieved by improving the $PM_{2.5}$ control efficiency of a relatively small number of emission sources.

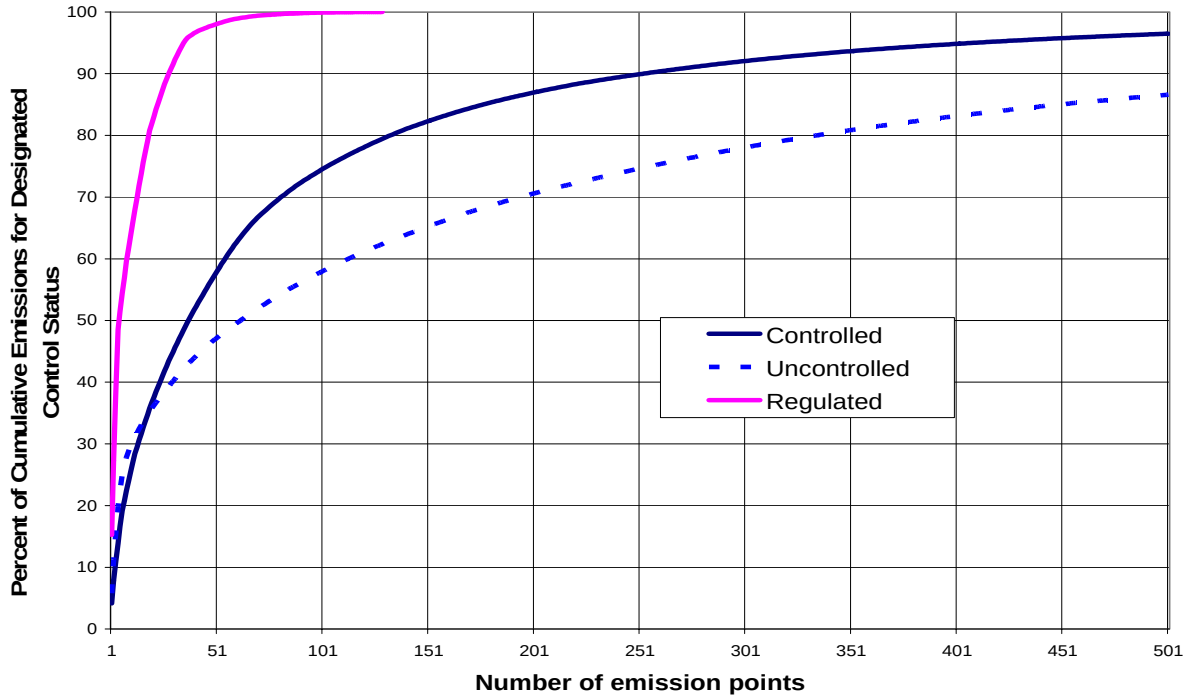


Figure 3-4. Emissions of PM25-PRI versus Number of Emission Points

4. ASSESSMENT OF DIRECT $PM_{2.5}$ EMISSION CONTROL AS A COMPLIANCE STRATEGY

This section provides a preliminary assessment of the importance of direct $PM_{2.5}$ point source emission control improvements as a candidate option in developing an overall strategy to meet the $PM_{2.5}$ NAAQS. For the NAAs where additional control of point sources appears to be a reasonable candidate option to consider, the largest $PM_{2.5}$ emission sources are presented to provide insight into potential control upgrades or replacements for these sources.

Table 4-1 provides a summary of the relative potential impact that control of point sources could make in reducing $PM_{2.5}$ ambient air concentrations. For this analysis, we assumed that the "direct $PM_{2.5}$ ambient air concentration" is 40 percent of the existing ambient concentration at the monitors with the highest concentrations (using 2004 data). This 40 percent value is based on the typical 60 to 70 percent contribution of sulfates and nitrates to the total ambient $PM_{2.5}$ concentration (see Figure 2-1). These sulfates and nitrates are considered "indirect" $PM_{2.5}$ as they are generally formed in secondary atmospheric reactions occurring subsequent to the emission releases of sulfur dioxide (SO_2), nitrogen oxide (NO_x), and ammonia. The percent of the direct PM25-PRI emissions within each NAA that are from point sources (see data reported in Table 3-1) is then used to further scale the "direct $PM_{2.5}$ ambient air concentration" to estimate the contribution that PM25-PRI point source emissions have on the total ambient $PM_{2.5}$ concentration.

This final value represents the maximum reduction in the ambient $PM_{2.5}$ concentration that could be achieved by reducing $PM_{2.5}$ emissions from point source. In fact, it represents an estimate of

the reduction in the ambient $PM_{2.5}$ concentration that may be achieved by a complete elimination of $PM_{2.5}$ point source emissions. Nonetheless, Table 4-1 provides some useful insights as to the practical significance of improving $PM_{2.5}$ point source controls for each of the NAAs: maximum concentration reductions of less than 1 $\mu g/m^3$ were designated as low priority; reductions of 1 to 2 $\mu g/m^3$ were designated as moderate priority; and reductions of more than 2 $\mu g/m^3$ were designated as high priority. Using this simplistic analysis, improving point source controls was designated as a high priority option for 6 of the 16 NAAs considered in this analysis, and improving point source controls was designated as a high or moderate priority option for 12 of the 16 NAAs. Therefore, the identification and characterization of methods of reducing PM25-PRI emissions at point sources (e.g., improving the performance of existing controls for $PM_{2.5}$) is important in the overall attainment strategy for many NAAs.

Table 4-1. Maximum Ambient $PM_{2.5}$ Concentration Reduction Achievable by Reducing Point Source PM25-PRI Emissions

Nonattainment Area Name	Annual Average Ambient $PM_{2.5}$ Conc. in 2004 ($\mu g/m^3$)	$PM_{2.5}$ Conc. Contribu-tion from direct $PM_{2.5}$ Emissions	Percent of Direct PM25-PRI Emissions from Point Sources	Maximum Conc. Reduction Achievable from Point Sources ($\mu g/m^3$)	Relative Importance of PM25-PRI Control as Candidate Attainment Option
Atlanta, GA	17.6	7.04	13.0%	0.92	low priority
Birmingham, AL	20.4	8.16	77.8%	6.35	high priority
Canton-Massillon, OH	15.6	6.24	14.0%	0.87	low priority
Charleston, WV	16.1	6.44	48.5%	3.12	high priority
Chattanooga, TN-GA	15.7	6.28	24.6%	1.54	moderate priority
Chicago-Gary-Lake County, IL-IN	16.7	6.68	18.7%	1.25	moderate priority
Cincinnati-Hamilton, OH-KY-IN	16.4	6.56	26.6%	1.74	moderate priority
Cleveland-Akron-Lorain, OH	17.5	7	19.0%	1.33	moderate priority
Columbus, OH	15	6	23.3%	1.40	moderate priority
Detroit-Ann Arbor, MI	16.8	6.72	8.9%	0.60	low priority
Huntington-Ashland, WV-KY-OH	15.2	6.08	51.7%	3.14	high priority
Indianapolis, IN	16.7	6.68	5.6%	0.37	low priority
Knoxville, TN	15.1	6.04	66.3%	4.01	high priority
Louisville, KY-IN	15.1	6.04	51.5%	3.11	high priority
St. Louis, MO-IL	16.2	6.48	24.3%	1.58	moderate priority
Steubenville-Weirton, OH-WV	16.6	6.64	92.5%	6.14	high priority

Appendix A provides the top point emission sources for each of the 16 NAAs. Generally, Appendix A includes all single point emission sources with PM25-PRI emission of 100 tons per year (tpy) or more. Some NAAs did not have any emission sources greater than 100 tpy (as reported in the 2002 draft NEI); for these NAAs, Appendix A provides information on the emission sources greater than 10 tpy. The remainder of this section presents a brief summary of the conclusions of the emissions analysis for each NAA.

4.1 Atlanta, GA

Table 5-1 shows that point sources account for only 13 percent of the direct PM25-PRI emissions in the Atlanta NAA. As seen in Table 3-1, nonpoint sources appear to be the most significant source of PM25-PRI emissions in the Atlanta NAA. Therefore, the ambient concentration reduction that would result from complete elimination of point source emissions would only reduce the ambient PM concentration by 0.92 $\mu g/m^3$, and more attainable emissions reductions would have even less impact. Although improved point source control may be part of the overall strategy to meet the $PM_{2.5}$ NAAQS, it does not appear to be a priority in that overall strategy. The highest point source emitters in this NAA are all coal-fired electric utilities.

4.2 Birmingham, AL

Table 4-1 shows that point sources contribute almost 80 percent of the total PM25-PRI emissions in the Birmingham, AL NAA. Approximately 55 percent of the PM25-PRI point source emissions are from controlled sources and the remaining emissions are split evenly between regulated and uncontrolled point sources (se Table 3-1). Therefore, improved control of controlled and regulated sources and application of controls to uncontrolled point sources all appear to be priorities in attempting to meet the $PM_{2.5}$ NAAQS in the Birmingham NAA. High emission sources within this NAA are coal-fired electric utilities, primary steel plants, iron and steel foundries, and a mineral wool plant.

4.3 Canton-Massillon, OH

Point sources account for only 14 percent of the direct PM25-PRI emissions in the Canton-Massillon NAA; nonpoint sources dominate the PM25-PRI emissions for this NAA. Overall, the Canton-Massillon area has the lowest PM25-PRI emissions of any of the 16 NAAs. Although Table 4-1 designates point source PM control as a low priority strategy, given the small incremental improvement needed in this NAA to achieve attainment, improved point source control may still be part of the overall strategy to meet the $PM_{2.5}$ NAAQS for this NAA. The largest point sources for this NAA are a primary steel production facility and a bearing manufacturing plant.

4.4 Charleston, WV

Point sources account for almost 50 percent of the direct PM25-PRI emissions in the Charleston, WV NAA; almost all of the point source emissions are from controlled sources. Coal-fired boilers completely dominate the PM25-PRI point source emissions for this NAA; improved control of these sources appears to be a high priority in the overall strategy to meet the $PM_{2.5}$ NAAQS for this NAA.

4.5 Chattanooga, TN-GA

Point sources account for approximately 25 percent of the direct PM25-PRI emissions in the Chattanooga NAA; nonpoint sources are a little over half the PM25-PRI emissions for this NAA. Coal-fired boilers dominate the PM25-PRI point source emissions for this NAA, although a few residual oil-fired boilers appear on the top emitting sources list. Improved control of these

sources appears to be a moderate priority in the overall strategy to meet the $PM_{2.5}$ NAAQS for this NAA.

4.6 Chicago-Gary-Lake County, IL-IN

Point sources account for approximately 20 percent of the direct PM25-PRI emissions while nonpoint sources account for almost 60 percent of the PM25-PRI emissions for this NAA. For this NAA, primary metal production (integrated iron and steel manufacturing) is the primary industry contributing to the point source emissions; petroleum refinery sources and coal-fired electric utilities also contribute to the overall emissions totals. Reducing point source emissions was designated as a moderate priority for this NAA based on the analysis in Table 4-1; however, this NAA has the third largest mass emissions from the point sources. As such, it would appear the improved control of point sources has a place in the overall strategy to meet the $PM_{2.5}$ NAAQS for this NAA.

4.7 Cincinnati-Hamilton, OH-KY-IN

Point sources account for approximately 25 percent of the direct PM25-PRI emissions; nonpoint sources account for 55 percent of the PM25-PRI emissions for this NAA. The major point sources in this NAA are several coal-fired electric utilities and one primary metal production (integrated iron and steel manufacturing) plant; all of the major point sources are designated as controlled. Improving the performance of existing controls appears to be a moderate priority for this NAA.

4.8 Cleveland-Akron-Lorain, OH

Point sources account for approximately 20 percent of the direct PM25-PRI emissions; nonpoint sources account for approximately 50 percent of the PM25-PRI emissions for this NAA. The major point sources in this NAA are more diverse than in other NAAs, which makes the implementation of improved $PM_{2.5}$ control as an attainment strategy more difficult. The major point sources for this NAA include: coal-fired and wood-fired boilers; a primary metal production facility; two mineral products manufacturers; and a major iron foundry. It appears that improving the performance of existing controls, especially at the two top power plants in this NAA, appears to be a moderate priority in the overall strategy to meet the $PM_{2.5}$ NAAQS for this NAA. The iron foundry is currently in the process of replacing their wet scrubber control device with a baghouse, which is projected to reduce the overall PM25-PRI emissions from the cupola sources by a factor of 2 or more.

4.9 Columbus, OH

Point sources account for 23 percent of the direct PM25-PRI emissions; nonpoint sources account for over 60 percent of the PM25-PRI emissions for this NAA. The major point sources for this NAA include: a glass manufacturer; a fiberglass manufacturer; and a coal-fired electric utility. The emissions from the glass manufacturer's furnace accounts for over 60 percent of the total point source emissions for this NAA. It appears that the reported emissions for this source may be in error. If it is not, improving the control device performance for this source would be a relatively high priority option to consider, especially given the small incremental improvement

needed to meet the $PM_{2.5}$ NAAQS given the average ambient $PM_{2.5}$ concentration for this NAA in 2004.

4.10 Detroit-Ann Arbor, MI

Although control of point sources is designated as a low priority in for this NAA in Table 4-1, we believe that there are significant PM emission sources that did not report $PM_{2.5}$ emission in the 2002 draft NEI; we suspect that, after the PM augmentation is completed and the final 2002 NEI is released, point sources will be a much more significant portion of the direct PM25-PRI emissions. The major point sources currently reporting PM25-PRI in the 2002 draft NEI are coal-fired electric utilities and a glass manufacturer. The "low priority" rating for improving the control device performance for point sources in Table 4-1 is highly uncertain, and should be re-evaluated when the final 2002 point source NEI becomes available.

4.11 Huntington-Ashland, WV-KY-OH

Point sources account for just over 50 percent of the direct PM25-PRI emissions for this NAA and improved control of point source emissions appears to be a high priority option for reducing the ambient PM concentration in this NAA. The major point sources currently reporting PM25-PRI emissions in the 2002 draft NEI are all coal-fired electric utilities. The Kentucky portion of the PM25 inventory, however, only includes electric utilities at this time; all other the point sources in Kentucky report only TSP (total suspended particulates) or PM_{10} (PM less than 10 µm in diameter) data. There is one significant petroleum refinery in KY within this NAA; however, this refinery is in the process of completing major revamps to its fluid catalytic cracking units (FCCUs) – the major PM source at refineries) to the FCCU control systems. Therefore, even after the PM augmentation is completed, targeted PM25-PRI emissions reductions at the major electric utilities within this NAA appears to be a high priority attainment strategy.

4.12 Indianapolis, IN

Point sources only account for approximately 6 percent of the direct PM25-PRI emissions for this NAA whereas nonpoint sources account for over 80 percent of this NAA's direct PM25-PRI emissions (as reported in the 2002 draft NEI). Unless some significant point sources are absent from PM25-PRI 2002 draft NEI, improving point source control does not appear to be a viable $PM_{2.5}$ NAAQS attainment strategy for this NAA.

4.13 Knoxville, TN

Point sources account for over 65 percent of the direct PM25-PRI emissions for this NAA and improved control of point source emissions appears to be a high priority option for reducing the ambient PM concentration in this NAA. The major point sources are coal-fired boilers, mostly at electric utilities, and a primary aluminum manufacturer. Targeted PM25-PRI emissions reductions for the major point sources within this NAA appears to be a high priority attainment strategy.

4.14 Louisville, KY-IN

Point sources account for over 50 percent of the direct PM25-PRI emissions for this NAA and improved control of point source emissions appears to be a high priority option for reducing the ambient PM concentration in this NAA. The major point sources in this NAA are two coal-fired electric utilities and a cement manufacturer. Note: for this NAA, we performed a cursory PM augmentation to proportion the reported TSP emissions for Kentucky to PM25-PRI. Therefore, there is added uncertainty to these point source emission estimates. Nonetheless, targeted PM25-PRI emissions reductions for the major point sources within this NAA appears to be a high priority attainment strategy.

4.15 St. Louis, MO-IL

Point sources account for about 25 percent of the direct PM25-PRI emissions for this NAA; nonpoint sources account for approximately 60 percent of the PM25-PRI emissions for this NAA. The major point sources in this NAA are more diverse than in other NAAs, which makes the implementation of improved $PM_{2.5}$ control as an attainment strategy more difficult. The major point sources for this NAA include: a major coal transfer station and two other mineral product plants; coal-fired boilers (mostly at electric utilities); and three different chemical manufacturing plants (organic acid, inorganic pigment, and paint). Note: a county-specific transport factor was of 0.36 was applied to American Commercial Terminals (the top emission source within this NAA) as the fugitive dust emissions from coal loading operations are not all expected to leave the plant boundaries. The "uncontrolled" emissions reported for this facility should be verified. If the reported emissions are realistic, capture and control of the emissions at this facility would appear to be a high priority in the overall attainment strategy for this NAA.

4.16 Steubenville-Weirton, OH-WV

Point sources account for over 90 percent of the direct PM25-PRI emissions for this NAA; therefore, improved control of point source emissions appears to be a high priority option for reducing the ambient PM concentration in this NAA. One integrated iron and steel manufacturer appears to drive the point source emissions in this NAA; other significant point sources include a coal-fired, a second integrated iron and steel manufacturer, and a coal processing plant. Targeted PM25-PRI emissions reductions for integrated iron and steel manufacturers within this NAA appears to be a high priority attainment strategy.

5. SUMMARY OF LITERATURE REVIEW FOR IMPROVED $PM_{2.5}$ EMISSIONS CONTROL

As discussed in Section 4, improving the control of point source PM25-PRI emissions is a high priority option to consider for many NAAs. Therefore, it is important to understand the emissions reductions that can be achieved by improving point source controls. To this end, a comprehensive literature review was conducted to assess:

1) The $PM_{2.5}$ control efficiency of existing particulate control devices;
2) Methods and modifications to existing control devices that improve control device performance for $PM_{2.5}$; and
3) Innovative $PM_{2.5}$ emissions control systems.

The literature review was limited to materials published in the last 7 years (1998 or more recent) so as not to duplicate information in the EPA document "Stationary Source Control Techniques for Fine Particulate Matter" (U.S. EPA, 1997). The literature search resulted in 217 pertinent abstracts. All abstracts were reviewed and approximately 55 articles/reports were ordered and reviewed. This section summarizes the information gleaned from these articles/reports.

5.1 Performance of Existing Controls

ESPs: EPA's "Stationary Source Control Techniques Guidance Document" contains the following statements regarding the efficiencies of ESPs:

- "Electrostatic precipitators are capable of collecting greater than 99 percent of all sizes of particulate."
- "The cumulative collection efficiency of an ESP is generally dependent on the fractional collection efficiency of these smaller particles, especially between 0.2 to 2.0 µm in size."
- "In general, the most difficult particles (for an ESP) to collect are those with aerodynamic diameters between 0.1 and 1.0 µm. Particles between 0.2 and 0.4 µm usually show the most penetration.

The literature reviewed by RTI is consistent with all three of those statements.

Lillieblad et al. (2003) evaluated the particulate control efficiency of a pulse-jet fabric filter on a coal-fired power plant in Finland. The results of this study are reviewed in Section 5.3, "Innovative Controls," since ESPs, not pulse-jet fabric filters, are presently the predominant means of control for utility boilers in the United States. However, Lillieblad et al. did contrast the results of their particulate testing with the results of Porle et al. (1995) on ESPs. Lillieblad et al characterize the results of Porle et al. as follows: "Typically, the average particle size of the particle emissions from pulverized coal combustion with an ESP is around 2 µm, $PM_{2.5}$ may be up to 80% of the emission, and a large fraction of the particle emissions are due to submicrometer mode particles."

Lind et al. (2003) reported the results for ESP fractional collection efficiency and trace metal emissions tests at a 66 MW biomass-fueled bubbling fluidized-bed combustion plant. The ESP had two fields, and operated at a flue gas temperature of 130-150ºC. "The particle mass concentration at the inlet was 510-1400 milligrams per normal cubic meter (mg/Nm^3). Particulate emission at the ESP outlet was 2.3-64 mg/Nm^3. Total ESP collection efficiency was 99.2-99.8 percent. Collection efficiency had a minimum in particle size range of 0.1-2µm. In this size range, collection efficiency was 96-97 percent." Further results from the Lind et al. testing are presented in Table 5-1. In introducing the results of the collection efficiency testing, Lind et al reported results from the research of others: "Typically, ESPs have a penetration window in the particle size range of 0.1-1µm. In pulverized coal combustion, even 10 percent of the particles in this size range may penetrate the ESP."

Table 5-1. Particle Mass Concentration at the ESP Inlet and Outlet for Biomass-Fueled Circulating Fluid Bed Boiler

Location	Fuel	PM <0.5µm	%	Total (mg/Nm3)
Inlet	no REF[1]	26	3.1	830
	no REF	25	4.9	510
	no REF	40	5.4	740
	Avg.-no REF[2]	**30**	**4.5**	**693**
	with REF	85	6.1	1400
	with REF	62	6.2	1000
	with REF	72	9.0	800
	Avg.-with REF[2]	**73**	**7.1**	**1067**
Outlet	no REF	1.1	22	5.1
	no REF	0.79	23	3.4
	no REF	1.4	24	5.6
	Avg.-no REF[2]	**1.1**	**23**	**4.7**
	with REF	3.1	49	6.4
	with REF	0.92	40	2.3
	Avg.-with REF[2]	**1.1**	**45**	**4.4**

Notes: 1) REF = Recovered Fuel, consisting of 70% wood residue, 18% peat, and 12% recovered fuel.
2) Averages calculated by RTI.

Fabric Filters: Lillieblad et al. (2003) examined $PM_{2.5}$ and mercury emissions from a high air-to-cloth ratio fabric filter located after a pulverized coal-fired boiler (located in Finland). The bags were polyphensulfide (PPS) with intrinsic Teflon (PTFE) coating. At the time of testing, the bags had been in service for more than 31,000 hours. An inspection of the filters was performed prior to the measurements, to check that the bags were in good condition. Results of the testing are shown in Table 5-2.

Lillieblad et al. (2003) noted that the particle emission breakdown (i.e., at the outlet of the fabric filter) during normal operation in $PM_{1.0}$ was 3 – 6 percent, in $PM_{2.5}$ it was 15 – 20 percent, in PM10 it was 79-88 percent; these ranges encompass the mass percentages calculated in Table 5-2. Lillieblad et al. also noted that, "The particle size distribution at the fabric filter (FF) outlet clearly differs from particle size distributions at an ESP outlet with a larger average particle size and the absence of the submicrometer mode. Typically, the average particle size of the particle emissions from pulverized coal combustion with an ESP is around 2 µm, $PM_{2.5}$ may be up to 80 percent of the emission, and a large fraction of the particle emissions are due to submicrometer mode particles."

Table 5-2. Particle Mass Concentration for Pulse-Jet Fabric Filter in Finland

FF Inlet	$PM_{1.0}$ (mg/Nm3, wg)[1]	$PM_{2.5}$ (mg/Nm3, wg)	PM_{10} (mg/Nm3, wg)	Total (mg/Nm3, wg)
Sample 1	170	580		8,200
Sample 2	130	410		12,000
Sample 3	170	590		18,000
Sample 4	280	680		8,200
Average(2)	188	565		11,600
Mass Percentage	1.62	4.88		100
FF Outlet	$PM_{1.0}$ (mg/Nm3, wg)[1]	$PM_{2.5}$ (mg/Nm3, wg)	PM_{10} (mg/Nm3, wg)	Total (mg/Nm3, wg)
Sample 1	0.74	2.6	11	13
Sample 2	0.47	2.4	12	15
Sample 3	0.61	2.1	8.6	11
Sample 4	0.54	2.5	14	15
Average	0.59	2.4	11.4	13.5
Mass Percentage	4.4	17.8	84.4	100
Removal Efficiency (%)	63.5	99.6		99.88

Notes: 1) mg/Nm^3 = milligrams per normal cubic meter, wet gas.
2) Averages, mass percentages and removal efficiency are as calculated by RTI.

One potential reason that the results of Lillieblad et al. show particularly strong performance for the collection of PM2.5 is that the fabrics were membrane-coated (with PTFE). The paper shows a photomicrograph of the PTFE membrane, with some collected particles on the surface. The photograph is remarkable in that the holes in the membrane (through which filtered flue gas passes) are circular, and are reported to be only 0.4 μm in size.

Wolf et al. (2004) examined the performance of a pulse jet FF replacing hot ESPs at a pulverized coal-fired power plant. The replacement in question was for Units 1 and 2 of the Craig Station near Craig, Colorado; Unit 3 of the station was already equipped with a reverse air baghouse, and was not modified. Units 1 and 2 are rated at 455 MW each, with controls initially consisting of hot ESPs and wet flue gas desulfurization (FGD) systems. The complete modification included construction of ductwork to bypass the ESPs (i.e., the hot ESPs were not demolished, but were instead simply bypassed), modification of the air preheaters to handle the additional particulate load created by bypassing the hot ESPs, installation of the pulse-jet fabric filter modules, and upgrading of the induced draft fans to handle the additional pressure drop created by switching from hot ESPs to pulse jet fabric filters. The wet FGD systems were retained. The entire project scope was awarded to the overall modification contractor for 72 $/kW (kilowatt), with a breakout price for the pulse jet fabric filters of 35 $/kW. At the time of the installation, the pulse jet fabric filters represented the largest pulse jet installation on coal-fired utility boilers in the United States.

The initial performance test results for Unit 1 met performance guarantees, as shown in Table 5-3. Performance test results for Unit 2 were not available at the time of the Wolf et al. paper. Wolf et al. report that the particulate removal performance of Unit 1 started to degrade soon after the performance test: "On Unit 1, the opacity, which averaged 3 percent or below for

approximately the first 6 months of operation, began to trend upward in May 2004 to approximately 7 percent with occasional spikes to near 10 percent." At the time the paper was written, investigations of the problems causing the opacity increase were still ongoing, but preliminary results indicated problems with the bag cage installation and gas flow distribution within the compartments. These problems led to multiple bag failures (holes in bags).

Table 5-3. Performance Test Results of the Unit 1 Pulse-Jet Fabric Filter

Parameter	Test Results	Guarantee Value
Particulate Emission Rate, lb/MMBtu	0.0079	0.015
Opacity, % (6-min. average)	3.6	5.0
Pressure Drop with all compartments on-line, in H_2O	5.5	6.0
Pressure Drop with one compartment off-line, in H_2O	6.0	6.0
Pressure Drop with two compartments off-line, in H_2O	5.9	7.0

Wet Scrubbers: Wet scrubbers are commonly used as particulate control systems in the primary and secondary metals industry, as well as the petroleum refinery industry. In some applications, wet scrubbers serve also as FGD control systems. However, wet scrubbers designed primarily for FGD and may have only moderate $PM_{2.5}$ removal efficiency. Therefore, the following discussion on the performance of wet scrubbers pertains to wet scrubbers designed and operated for particulate removal, e.g., high-energy venturi scrubbers.

Pressure drop and throat velocities are key operating parameters for venturi scrubbers. As seen by the design curves used for venturi scrubbers (U.S. EPA, 1991), the control efficiency for a given size particle is highly dependent on the venturi pressure drop. For example, assuming an aerodynamic mean particle diameter of 0.5 µm:

- A venturi with a pressure drop of 30 inches of water (in. H_2O) is expected to be 90% efficient;
- A venturi with a pressure drop of 40 in. H_2O is expected to be 97% efficient; and
- A venturi with a pressure drop of 50 in. H_2O is expected to be 99% efficient.

The particle removal efficiency for particles greater than 2 µm is expected to be 99.9 percent, but then starts decline for smaller particles. While a venturi with a pressure drop of 40 in. H_2O is expected to be 97% efficient for particles with a mean particle diameter of 0.5 µm, it is only expected to be 35% efficient for particles with a mean particle diameter of 0.1 µm. Wet scrubbers are generally ineffective for particles with diameters less than 0.1 µm. Thus, venturi scrubbers operating at pressure drops of more than 30 in. H_2O are expected to have similar removal of coarse PM, but can have significantly different removal efficiencies for fine PM (i.e., particles with diameters between 0.1 µm and 2 µm) depending on the design and operating conditions.

5.2 Improved Methods and Modifications of $PM_{2.5}$ Control

Methods to improve existing control device performance for $PM_{2.5}$ are described in this section. In general, improvements in methods and modifications to existing controls are relatively less expensive and produce relatively smaller emission reductions than addition of innovative controls. Their applicability to various control devices is given in parenthesis, i.e., FF (fabric filter), ESP (electrostatic precipitator), WS (wet scrubber).

Improved Monitoring (FF, ESP, WS). One traditional method for evaluating particulate emissions is an opacity monitor. However, opacity monitors are frequently not capable of evaluating performance within specific modules of a control device, and also are limited in value for low opacity emissions. Consequently, improved continuous particulate monitoring techniques have been developed, using techniques including the triboelectric effect (in which particle friction produces an electrical signal), and backscattering of light (as opposed to extinction of light, which is the effect measured by opacity monitors). These improved monitoring techniques can diagnose problems within specific sections of control devices (e.g. fabric filter bag leak detectors dedicated to specific fabric filter modules) and can detect problems sooner than they can be detected with traditional opacity monitors.

Addition of Conditioning Agents (ESP, WS). Pulverized-coal-fired power plants that switch to low-sulfur coal often experience problems with high resistivity fly ash. Operators may add "conditioning agents" to alter the properties of the ash, including attempting to lower resistivity and increase particulate "stickiness." Conditioning agents that are added include sulfur trioxide (SO_3), ammonia, trona (hydrated sodium carbonate/bicarbonate), and various proprietary agents. Although SO_3 conditioning can improve total particulate collection for ESPs, it can also lead to increased emission of very fine particulate, resulting in a "blue plume" (Bayless et al., 2000). Therefore, other conditioning agents are currently under evaluation. Ritzenthaler and Maziuk (2004) report the results of an evaluation of trona injection at Unit 2 of the General James M. Gavin Plant in Cheshire, OH. Injection of Trona (dry sorbent injection, or DSI) between the air heater outlet and the inlet of the ESP resulted in removal of SO_3. Removal rates ranged from a low of 63 percent at approximately 1 ton per hour to a high of 86 percent at a rate of approximately 5 tons per hour DSI. Similarly, additives can be injected in wet scrubbing solution to help condense and remove aerosol component in the exhaust gas.

ESP Upgrades (ESP). The general label of ESP upgrades includes replacement of weighted-wire electrodes with rigid discharge electrodes, and addition of advanced electronic controls, including pulsed energization. The corona discharge electrodes in ESPs have traditionally been weighted wires hung between the collecting plates. The problem with weighted wires is that the wire can snap, causing the discharge wire to short into the grounded collecting plate. Many ESP users and rebuilders have avoided this problem by going to rigid (non-wire) discharge electrodes. These electrodes avoid the shorting problem that can occur with weighted-wire electrodes. Another potential upgrade for ESPs is the conversion of antiquated electrical controls to modern electronic controls, including the possibility of pulsed energization. Traditionally, the amount of particulate charging that can be achieved by an ESP is limited, due to the problems of sparking and back-corona that occur, particularly with high resistivity fly ash. Modern computerized controls can reduce these problems; one technique is to substitute the steady voltage of traditional ESPs with voltage pulses (pulsed energization). Pulsed energization allows for higher voltages (improved particle charging) while minimizing the problems of back-corona and

sparking. One proprietary version of pulsed energization is ROPE (Rapid Onset Pulsed Energization). A pilot plant employing this technology was installed at the Miller Plant, and reported to result in a threefold reduction in particulate penetration (Southern Company, 2004).

ESP upgrades may also include increasing the size of the precipitator (i.e., adding an additional collection cell, either in series or in parallel). Increasing the size of the precipitator increases treatment time: the longer a particle spends in the precipitator, the greater its chance of being collected, other things being equal. Precipitator size also is related to the specific collection area (SCA), the ratio of the surface area of the collection electrodes to the gas flow. Higher collection areas tend to lead to better removal efficiencies. Modern ESPs in the U.S. have collection areas in the range of 200-800 square feet (ft^2)/1000 per actual cubic feet per minute (acfm). In order to achieve collection efficiencies of 99.5%, specific collection areas of 350-400 ft^2/1000 acfm are typically used. Some older precipitators on utility boilers are small, with specific collection areas below 200 ft^2/1000 acfm and correspondingly short treatment times. Expansion of these precipitators, or their replacement with larger precipitators, can lead to greatly enhanced performance (Institute of Clean Air Companies, 2004). However, space limitations at many plants limit the ability to significantly increase precipitator size.

Improved Filter Fabrics (FF). In the last decade, there has been increasing use of membrane-coated fabrics (e.g., Teflon, or PTFE) in fabric filters. The membranes on these fabrics have very small holes through which air flows. This type of filtration changes the method of filtration from filtration caused by the deposited dust layer to filtration caused by the membrane itself. Due to the very small holes (as small as 0.4 micrometers in diameter), penetration of $PM_{2.5}$ can be significantly reduced, as long as the membrane remains intact. Lillieblad et al. (2003) examined $PM_{2.5}$ and mercury emissions from a high air-to-cloth ratio fabric filter located after a pulverized coal-fired boiler (located in Finland). The bags were polyphensulfide (PPS) with intrinsic Teflon (PTFE) coating. At the time of testing, the bags had been in service for more than 31,000 hours. An inspection of the filters was performed prior to the measurements, to check that the bags were in good condition. The plant burned exclusively Polish coals. Results of the testing indicated an overall particulate collection efficiency of 99.88 percent, a $PM_{2.5}$ collection efficiency of 99.6 percent, and a $PM_{1.0}$ collection efficiency of 63.5 percent.

EPA's Environmental Technology Verification (ETV) Program has been evaluating the performance of advanced filter materials. The materials are all tested under the same conditions unless different test conditions are requested. The controlled conditions include flow rate, air-to-cloth ratio, temperature, type and concentration of inlet dust, number of conditioning cycles, etc. Although these test are performed in laboratory-type conditions and may not represent actual performance of these materials in industrial settings, these test conditions offer excellent comparability between the performance of different filter materials. Table 5-4 provides a summary of the fabric filter ETV tests that have been conducted to date.

Table 5-4. Performance Test Results from EPA's Environmental Technology Verification Program

TSP (gr/dscf)	$PM_{2.5}$ (gr/dscf)	Comment	Reference[1]
3.0E-05	1.4E-05	Mftr's test conditions	ETV Albany Int'l
1.0E-05	6.5E-06	ETV std test	ETV Air Purator
1.2E-04	1.1E-04	ETV std test	ETV BASF Corp
9.0E-07	9.0E-07	ETV std test	ETV BHA Group, QG061
1.7E-05	3.0E-06	ETV std test	ETV BHA Group, QP131
7.0E-06	4.5E-06	ETV std test	ETV BWF America
1.8E-04	1.6E-04	ETV std test	ETV Inspec Fibres
3.1E-05	8.3E-06	ETV std test	ETV Menardi-Criswell
3.0E-05	1.9E-05	ETV std test	ETV Polymer Group
3.2E-05	8.2E-06	Mftr's test conditions	ETV Polymer Group
8.2E-06	4.1E-06	ETV std test	ETV Standard Filter Corp
1.0E-05	2.3E-06	ETV std test	ETV Tetratec PTFE Technol., Tetratex 6212
5.2E-05	2.2E-05	ETV std test	ETV Tetratec PTFE Technol., Tetratex 8005
9.6E-06	5.9E-06	ETV std test	ETV W.L. Gore & Assoc., L4347
5.0E-06	2.1E-06	ETV std test	ETV W.L. Gore & Assoc., L4427

[1]All test and summary reports referenced here are available at: http://www.epa.gov/etv/verifications/vcenter5-2.html

Increased Scrubber Pressure Drop (WS). There are several old venturi scrubbers (30 to 50 years old) applied to basic oxygen furnaces (BOFs) at integrated iron and steel plants and to cupolas at iron foundries. During the development of the maximum achievable control technology (MACT) standards for these source categories, we identified plants with scrubbers operating at pressure drops of 25 to 30 inches of water or achieving PM control levels on the order of 0.05 grains per dry standard cubic foot (gr/dscf) and higher. For example, the venturi scrubbers at Ispat-Inland (Lake County, IN) and AK Steel (Middletown, OH) were evaluated, and the MACT analysis indicated they would have to be upgraded or replaced to meet the MACT standard when it becomes effective in 2006. The higher pressure drop scrubbers are expected to reduce PM emissions by about 50 percent. During a performance test of a cupola wet scrubber at an iron foundry, the performance of the wet scrubber improved by from 95 percent to 99 percent as the pressure drop increased from 33 to 42 in. H_2O (U.S. EPA, 1999). Nonetheless, the MACT standard for cupolas at iron foundries will likely force facilities with wet scrubbers to install a baghouses when it becomes effective in 2007. That is, this foundry source, the performance achieved by well-designed baghouses surpassed the performance of venturi scrubbers, even those operating at high pressure drops (up to 60 in. H_2O).

Reduce Temperature of the Exhaust Gas Inlet to the Control Device (ESP, FF, WS). In general, particulate control systems are ineffective at removing gaseous-phase components of the gas stream. Most of the significant $PM_{2.5}$ point source emissions occur from combustion processes or other sources operated at high temperatures. As discussed in Section 2, exhaust gas temperature is the primary factor influencing the state of PM-CON from stationary sources. Reducing the temperature of the exhaust gas prior to the PM control device increases the amount of "condensable" PM that is in particulate form within the control device. That is, at lower temperatures, the ratio of PM2.5-FIL to PM-CON increases, and the overall $PM_{2.5}$ removal

efficiency of the control system goes up since the control systems can now effectively reduce the "condensed" PM. The temperature of the exhaust gases can be reduced through the use of heat recovery or other gas cooling technologies.

5.3 Innovative $PM_{2.5}$ Controls

This section describes innovative control systems identified during the literature review. In general, addition of an innovative control system will be more expensive, but yield higher $PM_{2.5}$ emissions reductions than the methods identified to improve existing control device performance.

Advanced Hybrid Collector (ESP). The Advanced Hybrid™ filter combines electrostatic precipitation with fabric filtration. The internal geometry contains alternating rows of ESP components (discharge electrodes and perforated collector plates) and filter bags. Particulate-laden flue gas enters the ESP sections, and significant amounts are precipitated on the perforated collection plates. The perforated plates also allow flue gas to be drawn through the plates to be collected on the filter bags. The filter bags have a Gore-Tex® membrane coating, and are pulse-cleaned (Gebert et al., 2004). An full-scale Advanced Hybrid™ collector was recently installed on at the Big Stone Plant near Milbank, South Dakota. The goal of the project is a particulate capture efficiency of over 99.99%. This can be compared to the original ESP, which had a particulate capture efficiency of 99.5% (University of North Dakota Energy and Environmental Research Center, 2004).

COHPAC (ESP). The COHPAC ("Compact Hybrid Particulate Collector") is a pulse jet filter module operated at a very high filtration velocity (air-to-cloth ratio), installed downstream of an ESP. The function of a COHPAC is as a "polishing filter," collecting the particulate (especially fine particulate) that escapes an ESP. A full-scale COHPAC system has been installed at the Gaston power plant near Birmingham, AL (Southern Company, 2004).

Indigo Particle Agglomerator (ESP). The Indigo Agglomerator was developed in Australia to reduce visible emissions from coal fired boilers. The Indigo Agglomerator contains two sections, a bipolar charger followed by a mixing section. The bipolar charger has alternate passages with positive or negative charging. That is, the even passages may be positive and the odd passages negative, or vice versa. This can be contrasted with a conventional coal fired boiler precipitator, which has only negative charging electrodes. Following the charging sections, a mixing process takes place, where the negatively charged particles from a negative passage are mixed with the positively charged particles from a positive passage. The close proximity of particles with opposite charges causes them to electrostatically attaché to each other. These agglomerates enter the precipitator, where they are easily collected due to their larger size.

Crynack et al (2004) reported on the reductions in fine particulate ($PM_{2.5}$) emissions achieved when an Indigo Agglomerator was installed at the Watson plant, a 250 MW coal fired power plant in Mississippi. The agglomerator was installed on one of two identical, parallel precipitators, such that the results could be compared between a precipitator with the agglomerator and one without. Both precipitators had three mechanical zones and six electrical zones.

The agglomerator performance was tested with two coals, a western coal from Colorado, and an Eastern coal from Illinois. Both coals showed significant fine particulate emission reductions with the Indigo Agglomerator. Crynack et al. reported a "300 percent reduction" (presumably indicating a factor of 3 reduction or, in other words, a two-thirds reduction) in the emission of fine particles less than 5 µm in diameter, a two-thirds reduction in opacity, and a one-third reduction in total particulate mass emission. Crynack et al. also reported that, without the agglomerator, particle penetration peaked at 15 percent for 1 µm particles; this was reduced to 3 percent with the agglomerator. Finally, for particles with a size less than 2.5 µm, emissions were reduced by 75 percent with both coals. Further test results are show in Table 5-5.

Table 5-5. Performance Evaluation of the Indigo Agglomerator (Crynack et al., 2004)

Measurement	West Elk Coal, 4/17/03			West Elk Coal, 4/1/04			Emerald Coal, 4/13/03		
	A Pass	B Pass	% Reduc-tion	A Pass	B Pass	% Reduc-tion	A Pass	B Pass	% Reduc-tion
Opacity %	15	4	73.3%	20.2	7.25	64.1	13.25	2.3	82.6%
Mass Emission									
Grains/acf	0.012	0.0066	45.0%	0.02369	0.0159	32.9%	0.0137	0.0082	40.1%
mg/m3	27.5	15.1	45.1%	54.3	36.3	33.1%	31.3	18.8	39.9%
lb/MMBTU	0.0382	0.0231	39.5%	0.0735	0.0475	35.4%	0.045	0.026	42.2%
Gas Flow									
Acfm	408,718	450,700	-10.3%	433,093	395,412	8.7%	443,609	406,455	8.4%
m3/min, actual	11,575	12,764	-10.3%	12,265	11,198	8.7%	12,563	11,511	8.4%
Gas Temperature									
Degrees F.	276	273	1.1%	280	264	5.7%	269	260.5	3.2%
Degrees C.	135	134	0.7%	138	129	6.5%	132	127	3.8%

Wet ESP (ESP, WS, FF). As discussed previously, one significant barrier to improved ESP performance is that increasing energy levels can lead to excessive sparking and back-corona. This is particularly problematic with high-resistivity fly ash, as occurs with low-sulfur coals. Another problem with ESPs is that operating at lower temperatures, which can improve collection of condensable particulate matter, can result in condensation on the ESP collection plates, causing corrosion. One method of avoiding these problems is a wet ESP, which bathes the collection plates in liquid.

Farber et al. (2004) report that, for electrical utility power plants, a wet ESP is typically installed between a wet FGD absorber and the stack, for removing remaining flyash as well as condensed sulfuric acid. These wet ESPs may be mounted at grade for horizontal flow or on top of the absorber for vertical flow. Utility applications include the AES Deepwater cogeneration plant in Houston since 1986, Xcel Energy's Sherbourne County Station, and an installation on top of an FGD absorber at New Brunswick Power's Coleson Cove plant in 2002. Also, Wisconsin Energy selected wet ESPs for their 1000 MW Elm Road project. Farber et al. (2004) state that an advantage of wet ESPs is increased power level (2 W/acfm, versus 0.1 to 0.5 W/acfm for a dry ESP). They note that wet ESPs can "very effectively capture sulfuric acid aerosols (90%+)."

Wet Membrane ESP (ESP). The wet membrane ESP attempts to avoid problems of water channeling and resulting dry spots than can occur with wet ESPs, and avoiding the higher-cost metals that must be employed to avoid corrosion in a traditional wet ESP. The membranes are made from materials that transport flushing liquid by capillary action effectively removing collected material without spraying (Southern Environmental Corporation, 2004).

Horizontal Baghouse (FF). During the development of the iron and steel foundry MACT, two different facilities operated a cupola controlled with a baghouse with a horizontally supported bags (referred to as a horizontal baghouse). As the bag material in this type of baghouse does not need to be as thick and strong as a vertical baghouse simply to support the weight of the bag and collected dust. The thinner bags, low operating temperature, and low air-to-cloth ratios of these horizontal baghouses allowed for easier pulse-cleaning. Each of these horizontal baghouses exhibited lower outlet PM concentrations by more than a factor of 2 compared to the best-performing vertical baghouse system.

Tube-Slot Venturi Scrubber (WS). Reither, et al. (2001) provide interesting data for a tube-slot venturi scrubber. Two systems are described: one with a variable tube position (analogous to a variable throat venturi) and one with hybrid spray nozzles (spray nozzles that pulse scrubbing liquid and pressurized air). The hybrid spray nozzles provide improved particle wetting without the need for atomization of the spray in the venturi throat. A graph of the particle removal efficiencies by particle size diameter is reported; the efficiencies reported appear to be equivalent to a venturi scrubber operating at a pressure drop of 60 in. H_2O, but the reported pressure drop of system was approximately 1 in. H_2O. Reither et al. also provide data that shows 99 percent SO_2 scrubbing efficiency when using a diluted sodium hydroxide scrubbing solution. Although this system may not be able to achieve the same filterable PM removal efficiency of a fabric filter system, this system appears to have distinct advantages in situations where both PM and SO_2 need to be controlled.

ElectroCore Particulate Separator (ESP) (LSR Technologies, 2002). An Advanced ElectroCore particulate separator was designed and tested at Unit 4 of the E.C. Gaston Power plant. The testing was conducted on a 6000 acfm slipstream from the outlet of the plant's hot side ESP. The unit was burning low sulfur coal. The following performance was reported, based on measurements with a P5A particulate monitoring device: With the optimum voltage applied to the electrode, the ElectroCore unit achieved a maximum efficiency of 96.38 percent, and a minimum outlet loading of 0.0021 gr/dscf, while operating with a specific separating area (SSA) of 100 square feet per thousand acfm, according to measurements made by a P5A particulate monitoring device. The minimum outlet loading corresponds to 0.00575 lb_m/MMBtu, or less than one fifth of the current New Source Performance Standard of 0.03 lb_m/MMBtu. The highest collection efficiency for the upstream ESP was 99.75 percent, so the two systems combined achieved a collection efficiency of 99.991 percent of the particulate matter from the uncontrolled boiler. However, measurements made with EPA Method 5 showed the Electrocore to be approximately 85 percent efficient, versus the 95 percent measured using the P5A monitor.

6. CONCLUSIONS, UNCERTAINTIES, AND DATA NEEDS

6.1 Conclusions

- **Point source $PM_{2.5}$ emissions significantly contribute to the overall $PM_{2.5}$ balance in many of the 16 NAAs.**

As seen in Figure 3-1, point source emissions account for more than one-third of the $PM_{2.5}$ emissions for 6 of the 16 NAAs. Furthermore, as seen in Table 4-1, if point source $PM_{2.5}$ emissions can be reduced, these emission reductions could significantly contribute to the overall attainment strategy for these and other NAAs.

- **The performance of existing control systems for $PM_{2.5}$ can be improved through modifications, upgrades, and/or innovative control strategies.**

Section 5 of this report discusses control improvements, upgrades, and innovative control systems for PM. The potential emission reductions from the application of these systems were estimated to reduce the controlled PM25-PRI emissions by up to 60 percent. The performance enhancements with respect to PM25-FIL could exceed 90%; the performance enhancements with respect to PM-CON are highly uncertain, but were estimated to range between 0 and 60 percent (Pechan and RTI, 2005).

- **For most NAAs, a limited number of large emission sources dominate the $PM_{2.5}$ point source inventory.**

As seen in Figure 3-4 and in the data provided in Appendix A, a relatively small number of point sources account for the majority of the $PM_{2.5}$ point source inventory. Within a given NAA, the majority of emissions are typically released from the top 10 or so sources. Across all NAAs, the top 10 percent of point sources (controlled, regulated, and uncontrolled) account for approximately 90 percent of the $PM_{2.5}$ point source emissions.

- **Improving the control performance for $PM_{2.5}$ point sources appears to be a high or moderate priority option in the overall attainment strategy for many of the NAAs.**

This conclusion is supported by the first two conclusions. Furthermore, as the point source emissions within each NAA are typically dominated by a few large sources, an enhanced point source control strategy can focus on a relatively few sources or industry sectors, thereby easing the implementation of such a strategy.

- **When selecting the most-effective PM control strategy, it is important to consider all aspects that might impact ambient $PM_{2.5}$ concentrations.**

This project focused on direct $PM_{2.5}$ emissions. It is relatively easy to conclude that a FF control system will perform better than a WS for PM25-FIL. However, it is generally easier to cool the gas stream in a wet versus a dry system so that the WS may perform better than a FF (especially high-temperature FFs) for PM-CON. Additionally, a particulate WS is expected to be more-effective in reducing SO_2 emissions than a FF, and the importance of these SO_2 emissions as a precursor to ambient $PM_{2.5}$ should be considered in the control device selection process. Finally,

secondary impacts should also be considered as they may impact the ambient $PM_{2.5}$ concentration. For example, a high-energy particulate WS is expected to consume much more electricity than a FF system. This higher energy consumption may lead to higher $PM_{2.5}$ and SO_2 emissions depending on the type of electric utilities supplying power to the grid used by the point sources within a given NAA. All of these factors must be considered in identifying the most effective $PM_{2.5}$ control system. Therefore, there is not a one-size-fits-all solution to the "best" $PM_{2.5}$ control system. The most effective control system will be dependent on the relative ratio of PM25-FIL and PM-CON, the amount of $PM_{2.5}$ precursors in the emission stream, and possibly the emissions associated with electricity consumption for the local grid.

6.2 Uncertainties

- **Uncertainty due to 2002 NEI being in draft form**

This project used the draft 2002 NEI dated February 2005. As part of this project, an attempt was made to augment the draft $PM_{2.5}$ data in the NEI (Pechan and RTI, 2005). However, within the project constraints, it was not possible to augment the $PM_{2.5}$ draft completely. For example, when only PM25-FIL data were reported, the PM25-PRI emissions were calculated using one of three "default" PM25-FIL to PM25-PRI augmentation factors (specifically: 1, 2, or 5). When the NEI is finalized, point source-specific and control device-specific ratios will be used in the augmentation process. Additionally, some $PM_{2.5}$ emission sources may be missing in the draft NEI when the PM emissions were only reported as TSP or PM10-PRI. We augmented missing PM25-PRI data for Louisville, KY, but we expect other emission sources are missing from the current $PM_{2.5}$ inventory. For example, $PM_{2.5}$ emissions data appear to be missing for two steel mills in Detroit, MI. It is likely that such missing data will be added by the PM augmentation process that will be conducted on the point source NEI during October and November 2005.

- **Uncertainties related to the PM augmentation factors**

Even after the 2002 NEI is finalized, there will still be considerable uncertainty in the $PM_{2.5}$ emission inventory. This is because the primary test method currently employed to measure PM emissions from stationary sources is EPA Method 5, which measures TSP. The test method is designed to measure total filterable particulates ("front-half" PM catch). EPA Method 202 can be used to measure the condensable ("back-half" catch), but only a few states currently require EPA Method 202 testing. Consequently, one PM augmentation factor is used to estimate the fraction of TSP that is less than 2.5 μm in diameter and another PM augmentation factor is used to estimate PM-CON. There is some uncertainty associated with the size-distribution factors, but due to the more limited number of source test data available for PM-CON and the variability in PM-CON emissions, there is considerable uncertainty in the PM augmentation factors. Additionally, there is a concern that EPA Method 202 may overestimate the PM-CON due to the adsorption of SO_2. Therefore, even after the detailed PM augmentation is completed, there is still inherent uncertainty in the $PM_{2.5}$ because essentially no point sources currently directly measure their $PM_{2.5}$ emissions.

- **Uncertainty due to possibility that data reported as primary $PM_{2.5}$ is actually filterable $PM_{2.5}$**

A significant portion of the $PM_{2.5}$ data reported in the 2002 draft NEI are reported as PM25-PRI with no estimate of PM25-FIL or PM-CON. As discussed above, past experience in reviewing the sources of data used for reporting emissions in the NEI suggest that most of the directly reported PM25-PRI emissions are based on Method 5 source test data and application of AP-42 size fraction factors and actually reflect only PM25-FIL data. Based on a cursory uncertainty analysis, the misreporting of $PM_{2.5}$ data as PM25-PRI when the data actually represent PM25-FIL could result in a significant underestimation of the actual PM25-PRI emissions. Across all 16 NAAs, the cursory uncertainty analysis suggests that actual $PM_{2.5}$ emissions could be higher than those reported in this report by more than a factor of two; for specific NAAs, actual $PM_{2.5}$ emissions could be higher by a factor of 4 or more (Pechan and RTI, 2005).

- **Uncertainty due to inconsistent reporting of $PM_{2.5}$ point source emissions between NAAs**

The size of the emission sources that each NAA includes in its point versus nonpoint source inventory may vary between NAAs. For example, some state and local agencies include in their point source inventories emissions for sources that emit at or above the reporting thresholds specified in the Consolidated Emissions Reporting Rule. Emissions for point sources that emit less than the reporting thresholds may be summed to the county-level and included in their nonpoint inventory submittal to EPA which are then included in the nonpoint NEI. Other NAAs may include all permitted sources in their point source inventory including sources that emit below the Consolidated Emissions Reporting Rule emissions thresholds. Given the required reporting thresholds, it is possible a significant mass of $PM_{2.5}$ point source emissions may currently be included in the nonpoint inventory. As a result, the importance of improved point source $PM_{2.5}$ control as a candidate compliance option may be understated for these NAAs.

- **Uncertainty due to inaccurate reporting of control device information**

In reviewing the draft NEI we suspect that the control information reported for some NAAs is not reported or is reported incorrectly. For example, several coal-fired electric utility boilers were reported as "uncontrolled" where, in fact, we believe all coal-fired electric utility boilers will have some form of PM control. Also, several foundry sources that are known to have a control device were reported as "uncontrolled." If "uncontrolled" emission factors were applied to estimate the emissions from these sources, then the reported emissions for these could be significantly overstated. Additionally, certain large emission sources were identified, such as coke oven doors, that are subject to work practice or equipment standards to reduce their emissions. Although they do not have an external air pollution control device, it is misleading to characterize these emissions as completely uncontrolled since the current emissions from these sources has been significantly reduced through source-specific opacity limits or work practice standards. Again, the emissions from these sources may be over-estimated if "uncontrolled" emission factors are used for these sources.

- **Uncertainty in the $PM_{2.5}$ emission estimates for coal-fired electric utility boilers**

This project was based on point source $PM_{2.5}$ emissions from the draft 2002 NEI. However, The McIlvaine Company has published its own estimates of $PM_{2.5}$ emissions from coal-fired electric utility boilers. McIlvaine has estimated nationwide fly ash (filterable) $PM_{2.5}$ emissions from coal-fired electric utility boilers are between 3 and 17 times higher than those in the (1999) NEI (McIlvaine, undated). Coal-fired electric utility boilers are significant sources of $PM_{2.5}$ in nearly all the NAAs investigated for this project. Therefore, uncertainties in the $PM_{2.5}$ emission estimates for this source category greatly impact the overall $PM_{2.5}$ emissions inventory. Although it appears that McIlvaine's emission estimates for electric utilities focuses on the filterable $PM_{2.5}$ emission, condensable PM emissions are generally calculated based on the filterable PM emission estimates. Therefore, if McIlvaine's emission estimates for filterable $PM_{2.5}$ emissions are accurate, this also suggests that the current PM-CON estimates may be understated in the NEI.

- **Uncertainty in the fraction of $PM_{2.5}$ ambient concentrations attributable to local direct PM25-PRI emissions.**

There are two factors contributing to this uncertainty: one is the so-called "regional" contribution of $PM_{2.5}$ and the other is the contribution of secondary $PM_{2.5}$ for the specific locations monitoring locations that exceed the $PM_{2.5}$ NAAQS. For the purposes of evaluating the relative significance of the point sources, it was assumed that 40% of the ambient $PM_{2.5}$ concentration was attributable to local direct PM25-PRI emissions. This factor was based on the regional average the percent of ambient PM that was not sulfate or nitrate PM. However, the relative composition of PM in the specific NAAs may differ from these regional averages. Additionally, transport distances $PM_{2.5}$ can be significant. Therefore, some of the non-sulfate, non-nitrate PM is likely attributable to PM sources outside of the NAA. Some articles were found that reported "regional" contribution to "local" PM levels, but the methods used to develop the "regional" contributions were not well documented and appeared to exaggerate the regional contribution (if these regional contributions were accurate, then there should be more NAAs). Nonetheless, the approach used in this report likely overestimates the ambient $PM_{2.5}$ concentration reductions that can be achieved by control of "local" PM sources. Based on the literature reviewed during this research, "regional" contribution to the carbon component of particulates is estimated to be 50 percent (U.S. EPA, 2004)

6.3 Data Needs and Recommendations for Future Work

- **Update and verify the results of this analysis after finalization of the 2002 NEI**

Some of the uncertainties discussed in Section 6.2 are expected to be reduced after the PM augmentation of the 2002 draft NEI is completed. It would be relatively straight-forward, at that point, to re-analyze the augmented data to verify the primary findings of this report.

- **Verify/audit data reported in the NEI**

As discussed under the uncertainties, incorrect reporting of PM25-FIL data as PM25-PRI can result in a significantly underestimation of the actual PM25-PRI emissions. Furthermore, some sources appeared to have unexpectedly high emissions, while $PM_{2.5}$ data appeared to be missing

for some relatively large sources. Although the PM augmentation performed to finalize the 2002 inventory is expected to fill-in "missing" $PM_{2.5}$ data, it will not necessarily verify correct reporting. It is recommended that a sample of sources that currently only report PM25-PRI data be evaluated to determine the sources of these emission estimates and to ascertain if the reported data are estimates of PM25-PRI or PM25-FIL emissions. Furthermore, suspect data points, such as those reported for American Commercial Terminals in St. Louis and Techneglas, Inc. in Columbus, should be reviewed for accuracy and realism.

We also recommend that the criteria that the NAAs use for determining what they included in their point and nonpoint inventories be evaluated to determine if there are inconsistencies between NAAs based on the reporting thresholds. This information will help to improve evaluation of the importance of $PM_{2.5}$ point sources in the total $PM_{2.5}$ emission inventory.

To address uncertainties related to non-reported or incorrectly reported control information, we recommend that the control information reported in the final 2002 NEI be verified with each NAA. An evaluation of the emissions reported for selected controlled sources that are currently reported as "unknown" or "uncontrolled" will be useful to determine if the emission factors used overstate the emissions expected for the controlled emission source. It may be necessary to add codes to identify work practice or additional control practices to the list of control device codes used in the NEI. The inclusion of codes that identify control methods not currently included in the list of approved control codes for the NEI will improve understanding of the basis of the reported emissions and the accuracy of the analyses for determining where real reductions can be achieved for direct emissions of $PM_{2.5}$.

- **Project the 2002 $PM_{2.5}$ emission estimates forward in time**

The analysis for this project was based on emissions as reported in the draft 2002 NEI. However, it is known that some plants have already installed additional controls that are not reflected in the draft 2002 NEI emissions data. For example, in the Birmingham, AL, NAA, Alabama Power's Gaston Plant Unit 3 has already installed a COHPAC (Compact Hybrid Particulate Collector); COHPAC is one of the innovative controls examined in this report. Other coal-fired utility boilers will be installing various controls to meet CAIR and the Mercury Rule in the near future. Recent standards have also been promulgated that will reduce the PM emissions from coke ovens, iron and steel foundries, and petroleum refineries. The impact of these regulations on the $PM_{2.5}$ emissions inventory should be evaluated to better inform decision-makers who are attempting to develop attainment strategies.

- **Perform detailed evaluations of potential $PM_{2.5}$ control improvement options for major $PM_{2.5}$ sources**

As described in Section 6.1, the identification of the "best" control system for overall $PM_{2.5}$ requires a relatively detailed assessment that is source-specific. Given the relative importance of electric utilities and integrated iron and steel plants in the $PM_{2.5}$ emission inventories for the 16 NAAs, specific $PM_{2.5}$ control strategies should be pursued for these sources. By focusing on selected industry sectors, more accurate evaluations could be performed of the emissions reductions that could be achieved. Additionally, specific upgrades or control systems can be recommended based on the existing control devices for key individual sources. This information

would be highly useful for state and local agencies developing specific attainment strategies and it would greatly improve the accuracy of estimated emission reductions for scenario modeling.

- **Review/revise $PM_{2.5}$ emission estimates and PM augmentation factors for electric utilities**

Due to the significance of this industry category in the $PM_{2.5}$ emission inventory, the emission estimates for coal-fired electric utilities needs to be as accurate as possible. Underestimates of the $PM_{2.5}$ emissions from these sources by a factor of 3 to 17, as reported by McIlvaine, could have huge implications regarding potential attainment strategies. The first step in resolving this discrepancy is to solicit additional information about McIlvaines emission estimates in an attempt to understand the reasons for the large differences in estimated emissions. McIlvaine's emission estimates for each electric utility in the NEI could be compared with the emissions reported in the 2002 NEI. Most of the data reported in the NEI for electric utilities is based on source test data; these test data can be reviewed and compared to McIlvaine's estimates to assess the relative accuracy of his approach. However, some of the uncertainty may lie in the PM augmentation factors used to estimate PM25-PRI emissions from Method 5 (TSP) source test data. Therefore, an additional task would be to perform specific $PM_{2.5}$ emissions testing at a number of coal-fired electric utilities to determine which emission estimating approach is most accurate for PM25-PRI. Alternatively, continuous PM monitoring techniques may be used to assess the variability in PM emissions from these sources over one year to assess the accuracy of using annual source test data (typically representing only 3 to 6 hours of operation) to project annual emissions. Finally, the results of this evaluation can be used to update the emission factors and PM augmentation factors currently reported in AP-42 (U.S. EPA, 1995).

- **Review/revise $PM_{2.5}$ emission factors for integrated iron and steel plants**

Due to the significance of this industry category in the $PM_{2.5}$ emission inventory for certain NAAs, the emission estimates for integrated iron and steel plants needs to be as accurate as possible. Certain large emission sources were identified, such as coke oven doors, that are subject to work practice or equipment standards to reduce their emissions, but are characterized as "uncontrolled" in the NEI. This leads to questions regarding the emission factors used to estimate the emissions from these sources: do they adequately reflect current practices? The AP-42 emission factors for this industry have not been updated for almost 20 years (U.S. EPA, 1995). The "Iron and Steel Production" section of AP-42 needs to be updated to reflect current industry practices and emissions.

- **Evaluate performance of particulate controls on condensable $PM_{2.5}$**

An initial review of literature indicated that essentially no testing has been done to measure PM-CON at the inlet and outlet of ESPs and FFs, although limited data do exist for PM-CON at the outlet of control devices. Given the variability observed in PM-CON emissions for similar sources, it is difficult to assess the performance of different control systems on PM-CON. Additionally, current information suggests that PM-CON probably represents a substantial majority of primary $PM_{2.5}$ emissions for many combustion sources, such as coal-fired utility boilers. Therefore, a research program that conducts physical measurements of the collection efficiency of ESPs and FFs for PM-CON from coal-fired utility boilers, primary metal sources, and cement kilns would be very valuable. Alternatively, it may be possible to estimate PM-CON

collection efficiency for control devices on the basis of outlet measurements alone (if more PM-CON test data were identified or PM-CON testing was more widely required).

On a similar note, one specific research program related to PM-CON that would be valuable is an assessment of the efficiency of activated carbon injection as a PM-CON control technique. Activated carbon injection is currently being evaluated as a means to control mercury from coal-fired electric utilities. This practice may well be effective in reducing certain types of condensable matter. If this technique is effective in reducing PM-CON, the co-benefit of this control alternative may increase its utilization.

- **Evaluate $PM_{2.5}$ speciation data for the 16 NAAs**

To reduce uncertainties and inaccuracies with the current projection of the importance of point source emissions in the ambient $PM_{2.5}$ concentration, NAA-specific data can be compiled from the Speciated Trends Network (STN). These data are easily obtained and can be used to provide a more accurate assessment of the secondary PM fraction of ambient $PM_{2.5}$ for each NAA. Additionally, the detailed compositional analysis can be evaluated using source apportionment techniques to provide further insight regarding the importance of "local" versus "regional" contribution to the overall ambient $PM_{2.5}$ concentration for each NAA. This effort would require substantially more effort, but would help to answer pertinent and pressing questions currently being considered by various state, local, and regional organizations.

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APPENDIX A. TOP $PM_{2.5}$ POINT EMISSION SOURCES BY NONATTAINMENT AREA

Table A-1. Top $PM_{2.5}$ Point Emission Sources for Atlanta, GA Nonattainment Area

Facility Name	SCC	SCC_L2	SCC_L3	SCC_L4	PM25-PRI Emissions (tpy)	Control Classification
Georgia Power Company, Bowen Steam-Electric Generating Plant	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	806	Controlled
Georgia Power Company, Bowen Steam-Electric Generating Plant	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	732	Controlled
Georgia Power Company, Bowen Steam-Electric Generating Plant	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	508	Controlled
Georgia Power Company, Branch Steam-Electric Generating Plant	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	384	Controlled
Georgia Power Company, Branch Steam-Electric Generating Plant	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	376	Controlled
Georgia Power Company, Wansley Steam-Electric Generating Plant	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	272	Controlled
Georgia Power Company, Bowen Steam-Electric Generating Plant	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	211	Controlled
Georgia Power Company, Wansley Steam-Electric Generating Plant	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	195	Controlled

Table A-2. Top $PM_{2.5}$ Point Emission Sources for Birmingham, AL Nonattainment Area

Alabama Power Company (Miller Power Plant)	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	1,320	Controlled
Drummond Company, Inc.	30300303	Primary Metal Production	By-product Coke Manufacturing	Oven Pushing	1,225	Regulated
Alabama Power Company (Miller Power Plant)	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	850	Controlled
United States Steel Corporation-Fairfield Pipe Mil	30300999	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Other Not Classified	809	Uncontrolled
Alabama Power Company	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	554	Controlled
Alabama Power Company (Miller Power Plant)	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	428	Controlled
Sloss Industries Corporation - Coke/Utilities/Btf	30300306	Primary Metal Production	By-product Coke Manufacturing	Oven Underfiring	362	Regulated
Sloss Industries Corporation - Coke/Utilities/Btf	30300306	Primary Metal Production	By-product Coke Manufacturing	Oven Underfiring	362	Regulated
United States Steel Corporation - Fairfield Works	30300825	Primary Metal Production	Iron Production (See 3-03-015 for Integrated Iron & Steel MACT)	Cast House	333	Controlled
Nucor Steel Birmingham,Inc.	30300904	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Electric Arc Furnace: Alloy Steel (Stack)	318	Regulated
United States Steel Corporation - Fairfield Works	30300999	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Other Not Classified	311	Controlled
American Cast Iron Pipe Company	30400301	Secondary Metal Production	Grey Iron Foundries	Cupola	306	Controlled
U. S. Pipe & Foundry Company Inc.(No. B'ham Plant)	30400301	Secondary Metal Production	Grey Iron Foundries	Cupola	305	Controlled
United States Steel Corporation - Fairfield Works	30300999	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Other Not Classified	279	Controlled

Table A-2. Top $PM_{2.5}$ Point Emission Sources for Birmingham, AL Nonattainment Area

United States Steel Corporation - Fairfield Works	30300999	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Other Not Classified	279	Controlled
Alabama Power Company	10100201	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Wet Bottom (Bituminous Coal)	274	Controlled
Alabama Power Company (Miller Power Plant)	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	271	Controlled
United States Steel Corporation - Fairfield Works	30300922	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Continuous Casting	252	Regulated
U. S. Pipe & Foundry Company,Inc.(Bessemer Plant)	30400301	Secondary Metal Production	Grey Iron Foundries	Cupola	248	Controlled
Drummond Company, Inc.	30300306	Primary Metal Production	By-product Coke Manufacturing	Oven Underfiring	240	Regulated
Smi Steel, Inc.	30300933	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Reheat Furnaces	229	Regulated
Smi Steel, Inc.	30300908	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Electric Arc Furnace: Carbon Steel (Stack)	215	Controlled
United States Steel Corporation - Fairfield Works	30300899	Primary Metal Production	Iron Production (See 3-03-015 for Integrated Iron & Steel MACT)	See Comment **	197	Regulated
American Cast Iron Pipe Company	30300920	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Hot Metal Desulfurization	153	Controlled
Drummond Company, Inc.	30300303	Primary Metal Production	By-product Coke Manufacturing	Oven Pushing	148	Controlled
Sloss Industries Corporation - Coke/Utilities/Btf	30300303	Primary Metal Production	By-product Coke Manufacturing	Oven Pushing	144	Regulated
Alabama Power Company	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	143	Controlled
Lehigh Cement Company	30500606	Mineral Products	Cement Manufacturing (Dry Process)	Kilns	140	Controlled
Drummond Company, Inc.	30300304	Primary Metal Production	By-product Coke Manufacturing	Quenching	124	Regulated

Table A-2. Top $PM_{2.5}$ Point Emission Sources for Birmingham, AL Nonattainment Area

Facility Name	SCC	SCC_L2	SCC_L3	SCC_L4	PM25-PRI Emissions (tpy)	Control Classification
Drummond Company, Inc.	30300304	Primary Metal Production	By-product Coke Manufacturing	Quenching	124	Regulated
Mcwane Cast Iron Pipe Co.	30400301	Secondary Metal Production	Grey Iron Foundries	Cupola	111	Controlled
United States Steel Corporation - Fairfield Works	30300824	Primary Metal Production	Iron Production (See 3-03-015 for Integrated Iron & Steel MACT)	Blast Heating Stoves	108	Regulated
United States Steel Corporation - Fairfield Works	30300823	Primary Metal Production	Iron Production (See 3-03-015 for Integrated Iron & Steel MACT)	Charge Materials: Transfer/Handling	108	Controlled
Drummond Company, Inc.	30300303	Primary Metal Production	By-product Coke Manufacturing	Oven Pushing	105	Controlled
Drummond Company, Inc.	30300303	Primary Metal Production	By-product Coke Manufacturing	Oven Pushing	105	Controlled

Table A-3. Top $PM_{2.5}$ Point Emission Sources for Canton-Massilon, OH Nonattainment Area

Facility Name	SCC	SCC_L2	SCC_L3	SCC_L4	PM25-PRI Emissions (tpy)	Control Classification
The Timken Company - Steel Plants	30300999	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Other Not Classified	34	Controlled
Republic Engineered Products Llc	30300904	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Electric Arc Furnace: Alloy Steel (Stack)	28	Controlled
The Timken Company - Steel Plants	30300999	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Other Not Classified	23	Uncontrolled
The Timken Company - Bearing Plants	39999999	Miscellaneous Manufacturing Industries	Miscellaneous Industrial Processes	See Comment **	20	Uncontrolled
The Timken Company - Bearing Plants	39999999	Miscellaneous Manufacturing Industries	Miscellaneous Industrial Processes	See Comment **	16	Uncontrolled
Marathon Ashland Petroleum LLC, Canton Refinery	30600201	Petroleum Industry	Catalytic Cracking Units	Fluid Catalytic Cracking Unit	15	Controlled
The Timken Company - Bearing Plants	39999999	Miscellaneous Manufacturing Industries	Miscellaneous Industrial Processes	See Comment **	12	Uncontrolled
The Timken Company - Bearing Plants	39999999	Miscellaneous Manufacturing Industries	Miscellaneous Industrial Processes	See Comment **	11	Uncontrolled
The Timken Company - Steel Plants	30300999	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Other Not Classified	11	Controlled

Table A-4. Top $PM_{2.5}$ Point Emission Sources for Charleston, WV Nonattainment Area

Facility Name	SCC	SCC_L2	SCC_L3	SCC_L4	PM25-PRI Emissions (tpy)	Control Classification
Appalachian Power - John E Amos Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	527	Controlled
Appalachian Power - John E Amos Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	281	Controlled
Appalachian Power - John E Amos Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	276	Controlled
Appalachian Power - Kanawha River Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	243	Controlled
Appalachian Power - Kanawha River Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	235	Controlled
Union Carbide (Dow) So. Charleston Plant	10200202	Industrial	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom	60	Controlled

Table A-5. Top $PM_{2.5}$ Point Emission Sources for Chattanooga, TN-GA Nonattainment Area

Facility Name	SCC	SCC_L2	SCC_L3	SCC_L4	PM25-PRI Emissions (tpy)	Control Classification
TVA	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	428	Controlled
TVA	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	297	Controlled
TVA	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	49	Controlled
E. I. du Pont de Nemours and Company	10200204	Industrial	Bituminous/Subbituminous Coal	Spreader Stoker	39	Uncontrolled
Smurfit-Stone Stevenson	10200401	Industrial	Residual Oil	Grade 6 Oil	23	Controlled
Smurfit-Stone Stevenson	10200401	Industrial	Residual Oil	Grade 6 Oil	22	Controlled

Table A-6. Top $PM_{2.5}$ Point Emission Sources for Chicago-Gary-Lake County, IL-IN Nonattainment Area

Ispat Inland Inc.	30300999	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Other Not Classified	1,000	Uncontrolled
Bethlehem Steel Corp. - Burns Harbor	30300308	Primary Metal Production	By-product Coke Manufacturing	Oven/Door Leaks	261	Regulated
Bethlehem Steel Corp. - Burns Harbor	30300308	Primary Metal Production	By-product Coke Manufacturing	Oven/Door Leaks	259	Regulated
U S Steel Co Gary Works	30300306	Primary Metal Production	By-product Coke Manufacturing	Oven Underfiring	234	Regulated
U S Steel Co Gary Works	30300306	Primary Metal Production	By-product Coke Manufacturing	Oven Underfiring	217	Regulated
BP Products North America Inc, Whiting R	30600201	Petroleum Industry	Catalytic Cracking Units	Fluid Catalytic Cracking Unit	168	Controlled
State Line Energy LLC	10100223	Electric Generation	Bituminous/Subbituminous Coal	Cyclone Furnace (Subbituminous Coal)	144	Controlled
Bethlehem Steel Corp. - Burns Harbor	30300825	Primary Metal Production	Iron Production (See 3-03-015 for Integrated Iron & Steel MACT)	Cast House	143	Regulated
U S Steel Co Gary Works	30300999	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Other Not Classified	140	Controlled
Cokenergy Inc.	30300315	Primary Metal Production	By-product Coke Manufacturing	Gas By-product Plant	138	Controlled
U S Steel Co Gary Works	30300817	Primary Metal Production	Iron Production (See 3-03-015 for Integrated Iron & Steel MACT)	Cooler	124	Regulated
BP Products North America Inc, Whiting R	10200401	Industrial	Residual Oil	Grade 6 Oil	115	Uncontrolled
U S Steel Co Gary Works	30300999	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Other Not Classified	114	Controlled
BP Products North America Inc, Whiting R	30600701	Petroleum Industry	Cooling Towers	Cooling Towers	104	Uncontrolled
BP Products North America Inc, Whiting R	30600201	Petroleum Industry	Catalytic Cracking Units	Fluid Catalytic Cracking Unit	101	Controlled

Table A-6. Top $PM_{2.5}$ Point Emission Sources for Chicago-Gary-Lake County, IL-IN Nonattainment Area

Facility Name	SCC	SCC_L2	SCC_L3	SCC_L4	PM25-PRI Emissions (tpy)	Control Classification
U S Steel Co Gary Works	30300306	Primary Metal Production	By-product Coke Manufacturing	Oven Underfiring	98	Regulated
Nipsco - Bailly Station	10100203	Electric Generation	Bituminous/Subbituminous Coal	Cyclone Furnace (Bituminous Coal)	97	Controlled
ISG Indiana Harbor Inc.	30300917	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Tapping: BOF	97	Regulated
U S Steel Co Gary Works	30300306	Primary Metal Production	By-product Coke Manufacturing	Oven Underfiring	95	Regulated
Bethlehem Steel Corp. - Burns Harbor	30390004	Primary Metal Production	Fuel Fired Equipment	Process Gas: Process Heaters	93	Uncontrolled

Table A-7. Top $PM_{2.5}$ Point Emission Sources for Cincinnati-Hamilton, OH-KY-IN Nonattainment Area

East Bend	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	501	Controlled
Cinergy Corp Miami Fort Station	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	423	Controlled
Cinergy Corp Miami Fort Station	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	187	Controlled
AK Steel Corporation	30300813	Primary Metal Production	Iron Production (See 3-03-015 for Integrated Iron & Steel MACT)	Windbox	153	Controlled
Cinergy CG&E WC Beckjord Station	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	153	Controlled
Cincinnati Gas & Electric Co., Wm. H. Zimmer	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	131	Controlled
AK Steel Corporation	30300306	Primary Metal Production	By-product Coke Manufacturing	Oven Underfiring	130	Controlled
Cincinnati Machine Div. Unova I.A.S.	10200204	Industrial	Bituminous/Subbituminous Coal	Spreader Stoker	115	Controlled
Cinergy CG&E WC Beckjord Station	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	97	Controlled
Cinergy CG&E WC Beckjord Station	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	88	Controlled
Cinergy CG&E WC Beckjord Station	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	78	Controlled
Cincinnati Machine Div. Unova I.A.S.	10200204	Industrial	Bituminous/Subbituminous Coal	Spreader Stoker	77	Controlled
AK Steel Corporation	30300825	Primary Metal Production	Iron Production (See 3-03-015 for Integrated Iron & Steel MACT)	Cast House	74	Controlled
Cinergy CG&E WC Beckjord Station	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	72	Controlled

Table A-7. Top $PM_{2.5}$ Point Emission Sources for Cincinnati-Hamilton, OH-KY-IN Nonattainment Area

Facility Name	SCC	SCC_L2	SCC_L3	SCC_L4	PM25-PRI Emissions (tpy)	Control Classification
AK Steel Corporation	30300917	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Tapping: BOF	72	Controlled
AK Steel Corporation	30300917	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Tapping: BOF	70	Controlled

Table A-8. Top $PM_{2.5}$ Point Emission Sources for Cleveland-Akron -Lorain, OH Nonattainment Area

Facility Name	SCC	SCC_L2	SCC_L3	SCC_L4	PM25-PRI Emissions (tpy)	Control Classification
Akron Thermal Energy Corporation	10200204	Industrial	Bituminous/Subbituminous Coal	Spreader Stoker	549	Controlled
Akron Thermal Energy Corporation	10200903	Industrial	Wood/Bark Waste	Wood-fired Boiler - Wet Wood (>=20% moisture)	390	Controlled
Avon Lake Power Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	208	Controlled
Akron Thermal Energy Corporation	10200903	Industrial	Wood/Bark Waste	Wood-fired Boiler - Wet Wood (>=20% moisture)	150	Controlled
Republic Engineered Products, Inc	30300999	Primary Metal Production	Steel Manufacturing (See 3-03-015 for Integrated Iron & Steel MACT)	Other Not Classified	48	Controlled
Owens Corning, Medina Plant	30599999	Mineral Products	Other Not Defined	Specify in Comments Field	39	Controlled
Ford Motor Company, Cleveland Casting Plant	30400340	Secondary Metal Production	Grey Iron Foundries	Grinding/Cleaning	32	Controlled
Ford Motor Company, Cleveland Casting Plant	30400301	Secondary Metal Production	Grey Iron Foundries	Cupola	29	Controlled
Ford Motor Company, Cleveland Casting Plant	30400301	Secondary Metal Production	Grey Iron Foundries	Cupola	29	Controlled
Republic Engineered Products, Inc	30300822	Primary Metal Production	Iron Production (See 3-03-015 for Integrated Iron & Steel MACT)	Raw Material Stockpile: Ore, Pellets, Limestone, Coke, Sinter	26	Uncontrolled
Elkem Metals Company	30500401	Mineral Products	Calcium Carbide	Electric Furnace: Hoods and Main Stack	26	Controlled
Oberlin College	10300207	Commercial/Institutional	Bituminous/Subbituminous Coal	Overfeed Stoker (Bituminous Coal)	25	Controlled
ISG Cleveland Inc.	39000797	In-process Fuel Use	Process Gas	General	25	Controlled
Ford Motor Company, Cleveland Casting Plant	30400301	Secondary Metal Production	Grey Iron Foundries	Cupola	24	Controlled
Elkem Metals Company	30500401	Mineral Products	Calcium Carbide	Electric Furnace: Hoods and Main Stack	23	Controlled
ISG Cleveland Inc.	10200704	Industrial	Process Gas	Blast Furnace Gas	23	Uncontrolled
Elkem Metals Company	30501603	Mineral Products	Lime Manufacture	Calcining: Vertical Kiln	23	Controlled
ISG Cleveland Inc.	10200704	Industrial	Process Gas	Blast Furnace Gas	21	Controlled
Avon Lake Power Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	21	Controlled

Table A-9. Top $PM_{2.5}$ Point Emission Sources for Columbus, OH Nonattainment Area

Facility Name	SCC	SCC_L2	SCC_L3	SCC_L4	PM25-PRI Emissions (tpy)	Control Classification
Techneglas, Inc.	30501404	Mineral Products	Glass Manufacture	Pressed and Blown Glass: Melting Furnace	1,600	Controlled
Conesville Power Plant	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	193	Controlled
Owens Corning	30501204	Mineral Products	Fiberglass Manufacturing	Forming: Rotary Spun (Wool-type Fiber)	65	Controlled
Owens Corning	30501204	Mineral Products	Fiberglass Manufacturing	Forming: Rotary Spun (Wool-type Fiber)	62	Controlled
Owens Corning	30501204	Mineral Products	Fiberglass Manufacturing	Forming: Rotary Spun (Wool-type Fiber)	56	Controlled
Conesville Power Plant	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	48	Controlled
Conesville Power Plant	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	44	Controlled
Stone Container Corp.-Coshocton	10200905	Industrial	Wood/Bark Waste	Wood/Bark-fired Boiler (< 50,000 Lb Steam) **	35	Controlled
Owens Corning	30501205	Mineral Products	Fiberglass Manufacturing	Curing Oven: Rotary Spun (Wool-type Fiber)	35	Uncontrolled
Owens Corning	30501204	Mineral Products	Fiberglass Manufacturing	Forming: Rotary Spun (Wool-type Fiber)	30	Controlled
Owens Corning	30501204	Mineral Products	Fiberglass Manufacturing	Forming: Rotary Spun (Wool-type Fiber)	27	Controlled
Owens Corning	30501204	Mineral Products	Fiberglass Manufacturing	Forming: Rotary Spun (Wool-type Fiber)	21	Controlled
Owens Corning	30590003	Mineral Products	Fuel Fired Equipment	Natural Gas: Process Heaters	21	Uncontrolled
Owens Corning	30590003	Mineral Products	Fuel Fired Equipment	Natural Gas: Process Heaters	18	Uncontrolled

Table A-10. Top $PM_{2.5}$ Point Emission Sources for Detroit-Ann Arbor, MI Nonattainment Area

Facility Name	SCC	SCC_L2	SCC_L3	SCC_L4	PM25-PRI Emissions (tpy)	Control Classification
Belle River	10100222	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Subbituminous Coal)	442	Controlled
Belle River	10100222	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Subbituminous Coal)	263	Controlled
J.R. Whiting Co	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	212	Controlled
J.R. Whiting Co	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	174	Controlled
J.R. Whiting Co	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	162	Controlled
Guardian Industries	30501403	Mineral Products	Glass Manufacture	Flat Glass: Melting Furnace	64	Controlled
Guardian Industries	30501403	Mineral Products	Glass Manufacture	Flat Glass: Melting Furnace	60	Controlled
Cargill Salt	10100204	Electric Generation	Bituminous/Subbituminous Coal	Spreader Stoker (Bituminous Coal)	49	Controlled
Detroit Edison Greenwood Energy Center	10100401	Electric Generation	Residual Oil	Grade 6 Oil: Normal Firing	28	Controlled
Hayes Lemmerz International Inc	30400103	Secondary Metal Production	Aluminum	Smelting Furnace/Reverberatory	26	Controlled

Table A-11. Top $PM_{2.5}$ Point Emission Sources for Huntington-Ashland, WV-KY-OH Nonattainment Area

Big Sandy	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	1,405	Controlled
Big Sandy	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	534	Controlled
Appalachian Power - Mountaineer Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	531	Controlled
Dp&L, J.M. Stuart Generating Station	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	356	Controlled
Dp&L, J.M. Stuart Generating Station	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	296	Controlled
Appalachian Power Co.-Philip Sporn Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	129	Controlled
Dp&L, J.M. Stuart Generating Station	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	123	Controlled
Ohio Valley Electric Corp., Kyger Creek Station	10100201	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Wet Bottom (Bituminous Coal)	113	Controlled
Ohio Valley Electric Corp., Kyger Creek Station	10100201	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Wet Bottom (Bituminous Coal)	113	Controlled
Ohio Valley Electric Corp., Kyger Creek Station	10100201	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Wet Bottom (Bituminous Coal)	110	Controlled
Dp&L, J.M. Stuart Generating Station	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	108	Controlled
Gavin Power Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	102	Controlled

Table A-12. Top $PM_{2.5}$ Point Emission Sources for Indianapolis, IN Nonattainment Area

Facility Name	SCC	SCC_L2	SCC_L3	SCC_L4	PM25-PRI Emissions (tpy)	Control Classification
Hydraulic Press Brick Co.	30500908	Mineral Products	Clay and Fly Ash Sintering	Sintered Clay/Shale Product Crushing/Screening	38	Controlled
Citizens Gas & Coke	30300303	Primary Metal Production	By-product Coke Manufacturing	Oven Pushing	28	Regulated
Citizens Gas & Coke	30300306	Primary Metal Production	By-product Coke Manufacturing	Oven Underfiring	22	Regulated
Ipl Harding Street Station	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	18	Controlled
National Starch & Chemical Corporation	30290003	Food and Agriculture	Fuel Fired Equipment	Natural Gas: Process Heaters	15	Controlled
Hanson Aggregates Midwest, Inc-Stone	30504020	Mineral Products	Mining and Quarrying of Nonmetallic Minerals	Loading	15	Uncontrolled
International Truck And Engine Corp.	30400325	Secondary Metal Production	Grey Iron Foundries	Castings Cooling	14	Uncontrolled
Milestone Contractors, L.P.	10101302	Electric Generation	Liquid Waste	Waste Oil	13	Uncontrolled
Hydraulic Press Brick Co.	30500915	Mineral Products	Clay and Fly Ash Sintering	Rotary Kiln	13	Uncontrolled
Rieth-Riley Asphalt Plant #326	10301302	Commercial/Institutional	Liquid Waste	Waste Oil	12	Uncontrolled
National Starch & Chemical Corporation	30290003	Food and Agriculture	Fuel Fired Equipment	Natural Gas: Process Heaters	12	Controlled
Ipalco-Pritchard Station	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	11	Controlled
Rieth-Riley Asphalt Plant #325	10301302	Commercial/Institutional	Liquid Waste	Waste Oil	10	Uncontrolled
Hydraulic Press Brick Co.	30500909	Mineral Products	Clay and Fly Ash Sintering	Expanded Shale Clinker Cooling	10	Uncontrolled

Table A-13. Top $PM_{2.5}$ Point Emission Sources for Knoxville, TN Nonattainment Area

TVA Bull Run Fossil Plant	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	1,872	Controlled
TVA Kingston Fossil Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	441	Controlled
TVA Kingston Fossil Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	428	Controlled
TVA Kingston Fossil Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	417	Controlled
TVA Kingston Fossil Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	400	Controlled
TVA Kingston Fossil Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	360	Controlled
TVA Kingston Fossil Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	305	Controlled
TVA Kingston Fossil Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	291	Controlled
TVA Kingston Fossil Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	290	Controlled
TVA Kingston Fossil Plant	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	286	Controlled
Aluminum Company Of America - South Plant	30300104	Primary Metal Production	Aluminum Ore (Electro-reduction)	Materials Handling	134	Controlled
Aluminum Company Of America - South Plant	30300104	Primary Metal Production	Aluminum Ore (Electro-reduction)	Materials Handling	134	Controlled
Aluminum Company Of America - South Plant	30300104	Primary Metal Production	Aluminum Ore (Electro-reduction)	Materials Handling	129	Regulated
A.E. Staley Manufacturing Company	10200204	Industrial	Bituminous/Subbituminous Coal	Spreader Stoker	110	Controlled

Table A-14. Top $PM_{2.5}$ Point Emission Sources for Louisville, KY-IN Nonattainment Area

Lou Gas & Elec, Cane Run	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	799	Controlled
Kosmos Cement Co	30500699	Mineral Products	Cement Manufacturing (Dry Process)	Other Not Classified	784	Controlled
Kosmos Cement Co	30500699	Mineral Products	Cement Manufacturing (Dry Process)	Other Not Classified	762	Uncontrolled
Lou Gas & Elec, Mill Creek	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential,Bituminous Coal)	548	Controlled
Lou Gas & Elec, Mill Creek	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential,Bituminous Coal)	365	Controlled
Kosmos Cement Co	30500606	Mineral Products	Cement Manufacturing (Dry Process)	Kilns	340	Controlled
Kosmos Cement Co	30500699	Mineral Products	Cement Manufacturing (Dry Process)	Other Not Classified	334	Uncontrolled
Lou Gas & Elec, Cane Run	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential,Bituminous Coal)	308	Controlled
Kosmos Cement Co	30500699	Mineral Products	Cement Manufacturing (Dry Process)	Other Not Classified	252	Uncontrolled
Lou Gas & Elec, Mill Creek	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential,Bituminous Coal)	227	Controlled
Lou Gas & Elec, Mill Creek	10100212	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential,Bituminous Coal)	227	Controlled
Kosmos Cement Co	30500699	Mineral Products	Cement Manufacturing (Dry Process)	Other Not Classified	191	Uncontrolled
Kosmos Cement Co	30500614	Mineral Products	Cement Manufacturing (Dry Process)	Clinker Cooler	160	Controlled
Kosmos Cement Co	30500699	Mineral Products	Cement Manufacturing (Dry Process)	Other Not Classified	133	Uncontrolled
Lou Gas & Elec, Cane Run	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	124	Uncontrolled
Kosmos Cement Co	30500699	Mineral Products	Cement Manufacturing (Dry Process)	Other Not Classified	114	Uncontrolled

Table A-15. Top $PM_{2.5}$ Point Emission Sources for St. Louis, MO-IL Nonattainment Area

Facility Name	SCC	SCC_L2	SCC_L3	SCC_L4	PM25-PRI Emissions (tpy)	Control Classification
American Commercial Terminals	30501011	Mineral Products	Coal Mining, Cleaning, and Material Handling (See 305310)	Coal Transfer	1,052	Uncontrolled
Amerenue-Meramec Plant	10100226	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom Tangential (Subbituminous Coal)	754	Controlled
Pace Construction Co-Chesterfield	30500260	Mineral Products	Asphalt Concrete	Drum Mix Plant: Rotary Drum Dryer / Mixer, #2 Oil-Fired, Counterflow	494	Uncontrolled
Dial Corp-Dial Corp	30113210	Chemical Manufacturing	Organic Acid Manufacturing	Acetic Acid via Acetaldehyde	426	Uncontrolled
Dynegy Midwest Generation Inc	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	350	Controlled
Dynegy Midwest Generation Inc	10100203	Electric Generation	Bituminous/Subbituminous Coal	Cyclone Furnace (Bituminous Coal)	348	Controlled
Dynegy Midwest Generation Inc	10100203	Electric Generation	Bituminous/Subbituminous Coal	Cyclone Furnace (Bituminous Coal)	341	Controlled
Elementis Specialties Inc	30103553	Chemical Manufacturing	Inorganic Pigments	Pigment Dryer	184	Uncontrolled
Elementis Specialties Inc	30103553	Chemical Manufacturing	Inorganic Pigments	Pigment Dryer	184	Uncontrolled
Masterchem Industires Inc-Imperial	30101401	Chemical Manufacturing	Paint Manufacture	General Mixing and Handling	117	Uncontrolled
U. S. Silica Company-Pacific	30502511	Mineral Products	Construction Sand and Gravel	Screening	113	Uncontrolled
Anheuser-Busch Inc-St. Louis	10200202	Industrial	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom	102	Controlled

Table A-16. Top $PM_{2.5}$ Point Emission Sources for Steuvenville-Weirton, OH-WV Nonattainment Area

Facility Name	SCC	SCC_L2	SCC_L3	SCC_L4	PM25-PRI Emissions (tpy)	Control Classification
Weirton Steel Corporation	30300913	Primary Metal Prod'n	Steel Manufacturing*	Basic Oxygen Furnace: Open Hood-Stack	2,133	Controlled
Weirton Steel Corporation	30300824	Primary Metal Prod'n	Iron Production*	Blast Heating Stoves	1,873	Regulated
Weirton Steel Corporation	30300913	Primary Metal Prod'n	Steel Manufacturing*	Basic Oxygen Furnace: Open Hood-Stack	1,485	Controlled
Weirton Steel Corporation	30300824	Primary Metal Prod'n	Iron Production*	Blast Heating Stoves	1,479	Regulated
Weirton Steel Corporation	30300917	Primary Metal Prod'n	Steel Manufacturing *	Tapping: BOF	1,383	Regulated
Weirton Steel Corporation	30300825	Primary Metal Prod'n	Iron Production*	Cast House	320	Regulated
Weirton Steel Corporation	30390024	Primary Metal Prod'n	Fuel Fired Equipment	Process Gas: Flares	245	Regulated
Weirton Steel Corporation	30300841	Primary Metal Prod'n	Iron Production*	Flue Dust Unloading	215	Regulated
Weirton Steel Corporation	30390024	Primary Metal Prod'n	Fuel Fired Equipment	Process Gas: Flares	138	Regulated
Cardinal Power Plant (Cardinal Operating Company)	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	112	Controlled
Weirton Steel Corporation	30300917	Primary Metal Prod'n	Steel Manufacturing*	Tapping: BOF	96	Regulated
Cardinal Power Plant (Cardinal Operating Company)	10100202	Electric Generation	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)	91	Controlled
Wheeling-Pittsburgh Steel Corporation - Steubenvil	30300999	Primary Metal Production	Steel Manufacturing*	Other Not Classified	85	Controlled
Wheeling-Pittsburgh Steel Corporation	30300306	Primary Metal Production	By-product Coke Manufacturing	Oven Underfiring	82	Regulated
W. H. Sammis Plant	30501040	Mineral Products	Coal Mining, Cleaning, and Material Handling	Truck Unloading: End Dump - Coal	80	Uncontrolled
Wheeling-Pittsburgh Steel Corporation	30300308	Primary Metal Production	By-product Coke Manufacturing	Oven/Door Leaks	63	Regulated
Wheeling-Pittsburgh Steel Corporation	30300303	Primary Metal Production	By-product Coke Manufacturing	Oven Pushing	53	Controlled
Wheeling-Pittsburgh Steel Corporation	30102318	Chemical Manufacturing	Sulfuric Acid (Contact Process)	Absorber/@ 93.0% Conversion	52	Uncontrolled
Weirton Steel Corporation	30300915	Primary Metal Production	Steel Manufacturing*	Hot Metal (Iron) Transfer to Steelmaking Furnace	51	Controlled

*See 3-03-015 for Integrated Iron & Steel MACT