ES.1 OVERVIEW

This Regulatory Impact Analysis (RIA) estimates the incremental costs and monetized human health benefits of attaining a revised primary lead (Pb) National Ambient Air Quality Standard (NAAQS). There are important overall data limitations and uncertainties in these estimates. They are described in section E.S.4 below. Hypothetical control strategies were developed for final NAAQS of 0.15 $\mu g/m^3$ plus several alternative lead standards. These alternatives include at least one more stringent and one less stringent alternative than the selected standard, consistent with the OMB Circular A-4 Guidelines. This summary outlines the basis for and approach used for estimating the incremental costs and monetized benefits of these standards, presents the key results of the analysis, and highlights key uncertainties and limitations.

This Regulatory Impact Analysis (RIA) provides illustrative estimates of the incremental costs and monetized human health benefits of attaining a revised primary lead (Pb) National Ambient Air Quality Standard (NAAQS) within the current monitoring network of 189 monitors representing 86 counties. Many of the highest-emitting lead sources do not have nearby Pb-TSP monitors, and it is important to note that there may be many more potential nonattainment areas than have been analyzed in this RIA.

It is important to note at the outset that overall data limitations are very significant for this analysis, compared to other NAAQS reviews. One critical area of uncertainty is the limited TSP-Pb monitoring network (discussed in chapter 2). Because monitors are present in only 86 counties nationwide, the universe of monitors exceeding the final NAAQS level of 0.15 $\mu g/m^3$ represent only 16 counties. It is important to note that data limitations prevented us from identifying a full range of controls which would bring eight of these counties all the way to attainment of the final NAAQS. It is also important to note that because many of the highest-emitting Pb sources in the 2002 NEI do not have nearby Pb-TSP monitors (see section 2.1.7), it is likely that there may be many more potential nonattainment areas than have been analyzed in this RIA.

In addition, EPA would prefer to use a detailed air quality model that simulates the dispersion and transport of lead to estimate local ambient lead concentrations with the hypothetical alternative emission control strategies expected under the NAAQS. Although models with such capabilities are available for pollutants for which EPA frequently conducts air quality analyses (e.g., particulate matter and ozone), regional scale models are currently neither available nor appropriate for lead.[1] As discussed in Chapter 3, EPA developed an air quality assessment tool to estimate the air quality impacts of each lead emissions control strategy.

In setting primary ambient air quality standards, EPA's responsibility under the law is to establish standards that protect public health, regardless of the costs of implementing a new standard. The Clean Air Act requires EPA, for each criteria pollutant, to set a standard that

[1] U.S. Environmental Protection Agency (2007c), Review of the National Ambient Air Quality Standards for Lead: Policy Assessment of Scientific and Technical Information, OAQPS Staff Paper, section 2.4, EPA-452/R-07-013, Office of Air Quality Planning and Standards, RTP, NC.

protects public health with "an adequate margin of safety." As interpreted by the Agency and the courts, the Act requires EPA to create standards based on health considerations only.

The prohibition against the consideration of cost in the setting of the primary air quality standard, however, does not mean that costs or other economic considerations are unimportant or should be ignored. The Agency believes that consideration of costs and benefits is essential to making efficient, cost effective decisions for implementation of these standards. The impacts of cost and efficiency are considered by states during this process, as they decide what timelines, strategies, and policies are most appropriate. This RIA is intended to inform the public about the potential costs and benefits associated with a hypothetical scenario that may result when a new lead standard is implemented, but is not relevant to establishing the standards themselves.

The analysis year for this regulatory impact analysis is 2016, consistent with the attainment year for the final lead NAAQS. For the purposes of this analysis, we assess attainment by 2016 for all areas. Some areas for which we assume 2016 attainment may in fact need more time to meet one or more of the analyzed standards, while others will need less time. This analysis does not prejudge the attainment dates that will ultimately be assigned to individual areas under the Clean Air Act, which provides flexibility to postpone compliance dates, provided that the date is as expeditious as practicable.

EPA presents this RIA pursuant to Executive Order 12866 and the guidelines of OMB Circular A-4.[2] These documents present guidelines for EPA to assess the benefits and costs of the selected regulatory option, as well as one less stringent and one more stringent option. OMB Circular A-4 also requires both a benefit-cost, and a cost-effectiveness analysis for rules where health is the primary effect. Within this RIA we provide a benefit-cost analysis.

ES.2 Summary of Analytic Approach

Our assessment of the selected lead NAAQS includes several key elements, including specification of baseline lead emissions and concentrations; development of illustrative control strategies to attain the standard in 2016; development of an air quality assessment tool to assess the air quality impacts of these control strategies; and analyses of the incremental impacts of attaining the alternative standards. Figure ES-1 provides an illustration of the methodological framework of this RIA. Additional information on the methods employed by the Agency for this RIA is presented below.

Overview of Baseline Emissions Forecast and Baseline Lead Concentrations

The baseline lead emissions and lead concentrations for this RIA are based on lead emissions data from the 2002 National Emissions Inventory (NEI) and lead concentration values for 21 lead monitors included in the 2003-2005 Pb-TSP NAAQS-review database. Consistent with the $PM_{2.5}$ NAAQS RIA and ozone RIA, no growth factors were applied to the 2002 NEI emissions estimates to generate the emissions or air quality projections for 2016. Where

[2] U.S. Office of Management and Budget. Circular A-4, September 17, 2003. Found on the Internet at <http://www.whitehouse.gov/omb/circulars/a004/a-4.pdf>.

possible, however, we adjusted these values to reflect the estimated control efficiency of MACT standards with post-2002 compliance deadlines, because the 2002 NEI and observed lead concentrations during the 2003-2005 period would not reflect the impact of MACT controls reasonably anticipated to be in place by 2016. The analysis includes similar adjustments for compliance measures simulated by the September 2006 revision to the $PM_{2.5}$ NAAQS (as included in the illustrative $PM_{2.5}$ control strategy described in the $PM_{2.5}$ NAAQS RIA) and measures listed in the 2007 Missouri Lead SIP revisions.[3]

Development of Illustrative Control Strategies

Our analysis of the emissions control measures required to meet the selected standard is limited to controls for point source emissions at active sources inventoried in the 2002 NEI. To identify point source lead emissions controls for our analysis, we collected information on PM control technologies, assuming that the control efficiency for PM would also apply to lead emissions. Most of this information was obtained from EPA's AirControlNET database, but a limited number of controls were identified from New Source Performance Standards and operating permits that apply to facilities with similar Source Classification Codes as the point sources included in our analysis.[4] Controls identified through this process include major emissions controls, such as fabric filters, impingement-plate scrubbers, and electrostatic precipitators; and minor controls, such as increased monitoring frequency, upgrades to continuous emissions monitors, and diesel particulate filters for stationary sources. In addition, we modeled replacement of the large primary lead smelter in Jefferson County, Missouri with a more modern, lower-emitting smelter.

To identify the least-cost approach for reaching attainment in each area, EPA developed a linear programming optimization model that systematically evaluates the changes in air quality and costs associated with controlling each source to find the optimal control strategy for each area. The optimization model first identifies the measures that each source would implement if it were controlled as part of a local lead attainment strategy. Based on these controls, the optimization model then identifies sources to control such that each area would reach attainment at the least aggregate cost possible for the area.

It is important to remember that, compared to recent NAAQS RIAs, our current knowledge of the costs and nature of lead emissions controls is relatively poor. Lead in ambient air has not been a focus for all but a few areas of the country for the last decade or more; the selected standard of 0.15 $\mu g/m^3$ represents a substantial tightening of the existing NAAQS. As a result, although AirControlNET contains information on a large number of different point source controls, we would expect that State and local air quality managers would have access to additional information on the controls available to the most significant source.

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[3] U.S. Environmental Protection Agency. (2006). *Final Regulatory Impact Analysis: $PM_{2.5}$ NAAQS*. Office of Air and Radiation, Research Triangle Park, NC. The Missouri lead SIP was finalized by EPA on April 14, 2006 with a requirement that this SIP will provide attainment with the current lead standard by April 7, 2008. The SIP is available at http://www.dnr.mo.gov/env/apcp/docs/2007revision.pdf.

[4] Source Classification Codes are the identifiers that EPA uses to classify different types of emissions activity.

In addition, as discussed in the final monitoring provisions, the existing monitoring network will need to be updated. It is possible that some areas shown to be out of attainment based on the current monitoring information will be shown to be in attainment with more recent monitoring. After the revised monitoring network is in place, other areas not identified in this analysis may be found to be violating the new standard. Since many of the existing sources of ambient Pb are relatively small, states are likely to work closely with the sources to reduce emissions in a cost-effective manner.

Note also that in this RIA we have not accounted for the effect of improvements that tend to occur, such as technology improvement, process changes, efficiency improvements, materials substitution, etc. We believe these typical improvements will tend to result in more cost effective approaches than simply adding extremely expensive pollution controls in many areas by the attainment date of 2016. Many industrial sources of lead emissions emit very small quantities of lead in absolute terms. Our cost modeling shows that some could face significant costs to reduce these low levels of lead, costs which could be prohibitively expensive. Rather than applying additional controls, it may be possible for firms emitting small amounts of Pb to modify their production processes or other operational parameters, including pollution prevention techniques, which would be more cost effective than adding additional control technology. Such measures might include increasing the enclosure of buildings, increasing air flow in hoods, modifying operation and maintenance procedures, changing feed materials to lower Pb content, measures to suppress dust from tailings piles, etc.

Finally, some monitor areas are not projected to reach attainment with the proposed NAAQS or alternative standard through the application of identified controls alone. (For the selected NAAQS, identified controls account for about 94% of the emission reductions needed to reach full attainment in all areas). For the selected NAAQS and each alternative standard, we applied unspecified emission reductions to all sources until attainment was reached in each county that failed to reach attainment with identified controls alone.

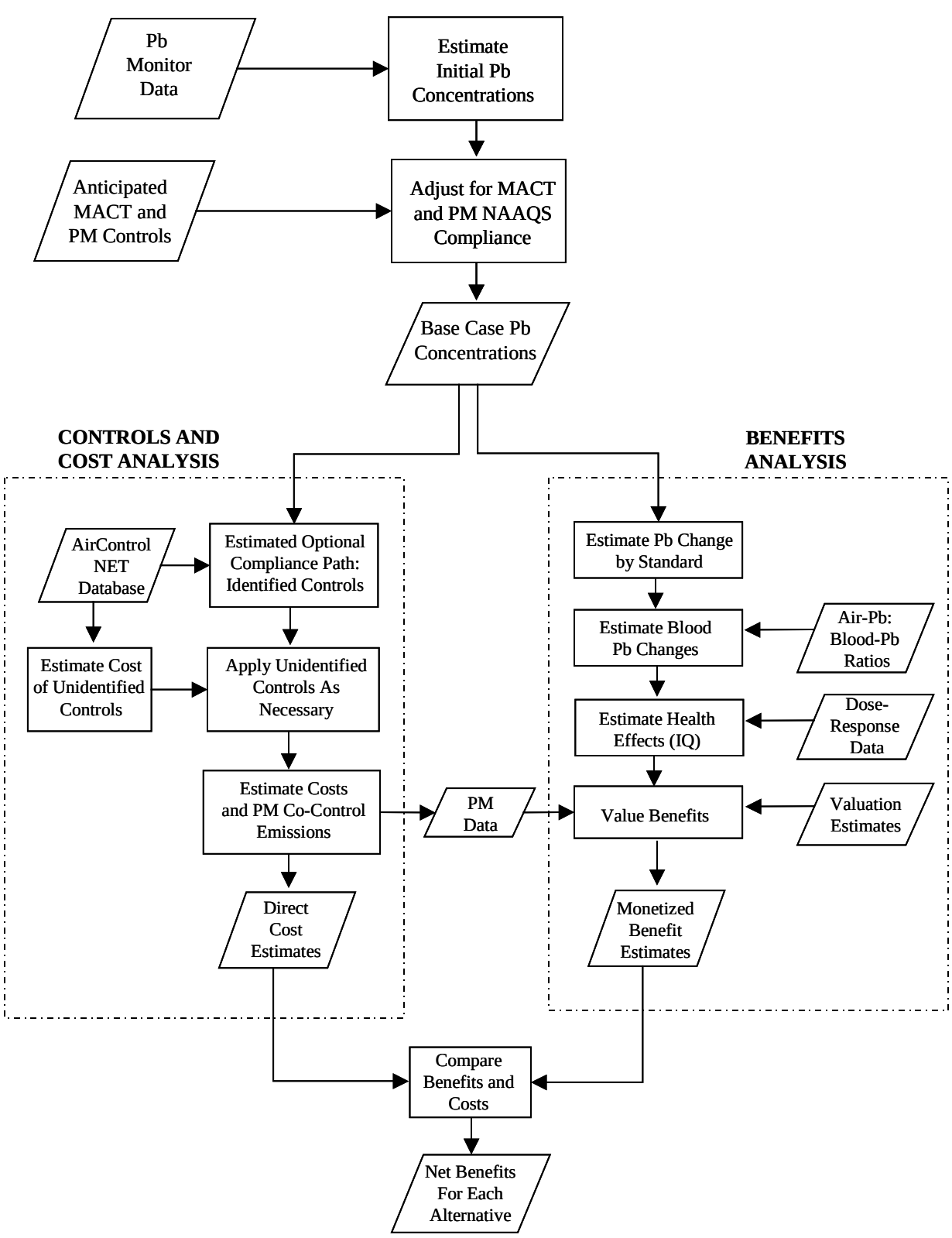

Figure ES-1. The Process Used to Create this RIA

Air Quality Assessment Tool

To assess the air quality impact of the emissions controls implemented under the selected NAAQS, EPA would ideally use a detailed air quality model that simulates the dispersion and transport of lead to estimate local ambient lead concentrations. Although models with such capabilities are available for pollutants for which EPA frequently conducts air quality analyses (e.g., particulate matter and ozone), regional scale models are currently neither available nor appropriate for Pb.[5] Dispersion, or plume-based, models are recommended for compliance with the Pb NAAQS; however, dispersion models are data –intensive and more appropriate for local scale analyses of emissions from individual sources. It was not feasible to conduct such a large-scale data-intensive analysis for this RIA.

Our air quality assessment tool, developed for the purposes of this analysis, employs a source-apportionment approach to estimate the extent to which each of the following emissions sources contribute to observed lead concentrations in each monitor area:

- Background lead
- Miscellaneous, re-entrained dust
- Emissions from area non-point sources
- Indirect fugitive emissions from active industrial sites
- Point source emissions[6]

After allocating a portion of the observed lead concentration for each monitor area to the first four categories listed above, the assessment tool apportions the remaining concentration among all inventoried point sources within ten kilometers of each monitor location by distance-weighting individual source contributions to ambient Pb concentrations.[7] Through this process, the tool establishes a point source influence factor that can be used to translate changes in the lead emissions of individual point sources to changes in the lead concentration for each monitor area.

Analysis of Benefits

[5] See Chapter 2 of U.S. Environmental Protection Agency. (2007). Review of the National Ambient Air Quality Standards for Lead: Policy Assessment of Scientific and Technical Information – OAQPS Staff Paper. Office of Air Quality Planning and Standards, Research Triangle Park, NC. EPA-452/R-07-013.

[6] For the purposes of this analysis, airports servicing piston-engine aircraft that use leaded aviation gasoline are treated as point sources.

[7] Note that although the air quality assessment tool distinguishes between the portion of the observed lead concentration attributable to point source emissions and that attributable to indirect fugitive emissions from active point sources, this analysis assumes that the two contributions are directly related, and any reduction in the air quality impact of point source emissions would produce a corresponding reduction in the air quality impact of indirect fugitive emissions from point sources in that monitor area. The process used to relate the contributions of these two categories is described in further detail in Chapter 3 of this RIA.

Our analysis of the benefits associated with the selected NAAQS includes benefits related to reducing ambient lead concentrations and the ancillary benefits of reducing direct emissions of particulate matter. To assess benefits specific to reduced lead concentrations, we created a spreadsheet model that provides a screening-level assessment of health benefits occurring as a result of implementing the selected NAAQS level. The model uses various simplifying assumptions and is intended only to provide an approximate, preliminary estimate of the potential health benefits. For the purposes of this analysis, the model estimates the adverse health impact of blood lead levels on cognitive function (which is most often measured as changes in IQ) in young children below seven years of age. Cognitive effects are thought to strongly relate to a child's future productivity and earning potential.[8]

The model was constructed in Microsoft Excel and provides an integrated tool to complete five benefits estimation steps: 1) estimate lead in air concentrations for the "base case" and "control scenarios"; 2) estimate population exposures to air lead concentrations for each scenario; 3) estimate blood lead levels in the population for each scenario; 4) estimate avoided cases of health effects due to changes in blood lead levels; and 5) apply an economic unit value to each avoided case to calculate total monetized benefits.

Because most of the point source measures implemented to achieve the NAAQS standard are focused on controlling emissions of lead in particulate form, virtually all of these measures also have a significant impact on emissions of directly emitted particulate matter. To estimate the value of these $PM_{2.5}$ emissions reductions, EPA utilized $PM_{2.5}$ benefit-per-ton estimates. These $PM_{2.5}$ benefit-per-ton estimates provide the total monetized human health benefits (the sum of premature mortality and premature morbidity) of reducing one ton of $PM_{2.5}$ from a specified source. EPA has used a similar technique in previous RIAs, including the recent ozone NAAQS RIA.[9] The complete methodology for creating the benefit per-ton estimates used in this analysis is available in the Technical Support Document (TSD) accompanying the recent final ozone NAAQS RIA.[10]

Analysis of Costs

Consistent with our development of the illustrative control strategies described above, our analysis of the costs associated with the selected NAAQS focuses on point source PM controls. For the purposes of this analysis, these controls largely include measures from the AirControlNET control technology database, but also include additional measures associated with operating permits and/or New Source Performance Review standards applicable to sources similar to those included in our analysis. For controls identified in AirControlNET, we estimated

[8] U.S. Environmental Protection Agency. (2006b). *Economic Analysis for the Renovation, Repair, and Painting Program Proposed Rule*. Office of Pollution Prevention and Toxics. Washington, DC.

[9] U.S. Environmental Protection Agency. (2008). *Final Ozone NAAQS Regulatory Impact Analysis*. Office of Air and Radiation. Research Triangle Park, NC, March.

[10] The Technical Support Document, entitled: *Calculating Benefit Per-Ton Estimates*, can be found in EPA Docket EPA-HQ-OAR-2007-0225-0284.

costs based on the cost equations included in AirControlNET. Our cost estimates for controls associated with operating permits and/or New Source Performance Review standards are based on cost data compiled by EPA for previous analyses.

As indicated in the above discussion on illustrative control strategies, implementation of the PM control measures identified from AirControlNET and other sources does not result in attainment with the selected NAAQS in several areas. In these areas, additional unspecified emission reductions will likely be necessary to reach attainment. In order to bring these monitor areas into attainment, we calculated control costs using two different approaches. Under one approach, we extrapolated the cost of unspecified emission reductions by constructing a cost curve using data on identified control costs. We then derived a total cost equation in quadratic form which best fit the total cost curve. Under our second approach, we calculated the cost of unspecified emission reductions by deriving an average cost per microgram of air quality improvement obtained from identified controls. For each standard, we then selected all monitor areas that failed to reach attainment and applied unspecified emission reductions to all sources until attainment was reached.

ES.3 Results of Analysis

Air Quality

Table ES-1 summarizes the number of monitor sites that reach attainment with the selected NAAQS and alternative standards in 2016 following the implementation of identified and unspecified emission reductions. According to the data presented in Table ES-2, 13 of the 21 monitor areas are expected to reach attainment with the selected NAAQS following implementation of identified controls. Table ES-2 also shows results for alternative NAAQS of 0.10 and 0.40 $\mu g/m^3$. (In the body of the RIA, we also provide analysis of three other alternative NAAQS.) For the alternative of 0.10 $\mu g/m^3$, only 9 of the 21 monitors are able to reach attainment from application of identified controls. By comparison, all but one monitor area reach attainment through the implementation of identified controls under the 0.40 $\mu g/m^3$ standard.

Table ES-1. Number of Monitor Sites Reaching Attainment with Each Alternative Standard using Identified and Unidentified Controls

Standard	Number of Sites Analyzed	Number of Sites in Attainment with No Additional Controls	Number of Sites in Attainment with Identified Point Source Controls	Number of Sites in Attainment with Unspecified Emission Reductions and Identified Point Source Controls
0.40 µg/m3 Second Maximum Monthly Mean	21	12	20	21
0.15 µg/m3 Second Maximum Monthly Mean		5	13	21
0.10 µg/m3 Second Maximum Monthly Mean		0	9	20

The failure of certain areas to reach attainment with identified controls may partially reflect the lack of control information for point sources in these areas. Sources for which the AirControlNET analysis identified no controls make up a small portion of the ambient lead concentration in many of the areas not projected to reach attainment with the selected standard. For such sources in nonattainment areas, we assume that unspecified emission reductions will be obtained. When unspecified emission reductions are implemented in addition to identified controls, we project widespread attainment with the selected and alternative standards.

Benefit and Cost Estimates

Tables ES-2, ES-3 and ES-4 summarize the costs and benefits associated with the selected and alternative NAAQS standards in 2016, based on both 3 percent and 7 percent discount rates.

The results in Table ES-2 show that the assumptions used in estimating the unspecified emission reductions drive the cost estimates. Under the first approach, the majority of the costs for the selected standard (88%) come from our analysis of current known control technologies, with only 12% of the total costs coming from extrapolated costs. Under the second approach, 5% of the total costs come from our analysis of currently known control technologies, and the majority of the costs (95%) comes from our assumptions about the cost of controlling the last few ambient increments of Pb needed to reach full attainment. This reflects the limited information available to EPA on the control measures that lead sources may implement. It is important to remember that, compared to recent NAAQS RIAs, our current knowledge of the costs and nature of lead emissions controls is relatively poor. Lead in ambient air has not been a

focus for all but a few areas of the country for the last decade or more; the alternative standards represent a substantial tightening of the existing NAAQS. As a result, although AirControlNET contains information on a large number of different point source controls, we would expect that State and local air quality managers would have access to additional information on the controls available to the most significant sources.

Table ES-3 presents the benefits of the proposed and alternative standards as a range to account for uncertainties associated with the benefits of the standards. The range in the benefits estimates related to IQ gains reflects two estimates of the earnings impacts associated with such gains. The low end of the range reflects an analysis by Schwartz, which estimated that a 1-point increase in IQ would increase earnings by 1.76 percent, while the high end of the range reflects the results of Salkever, which found that earnings increase by 2.38 percent for each 1-point increase in IQ.[11] The range of estimates presented for PM-related benefits is based on the upper and lower ends of the range of $PM_{2.5}$ premature mortality functions obtained by EPA through its expert elicitation study on the PM-mortality relationship, as first reported by Industrial Economics and interpreted for benefits analysis in EPA's final RIA for the PM NAAQS, published in September 2006.[12]

Table ES-4 presents a comparison of costs and benefits.

[11] Schwartz, J. (1994). Societal Benefits of Reducing Lead Exposure. *Environmental Research* 66: 105-124 and Salkever, D.S. (1995). Updated Estimates of Earnings Benefits from Reduced Exposure of Children to Environmental Lead. *Environmental Research* 70:1-6.

[112] Industrial Economics, Inc. (2006). *Expanded Expert Judgment Assessment of the Concentration-Response Relationship between $PM_{2.5}$ Exposure and Mortality*. Prepared for: Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC; U.S. Environmental Protection Agency. (2006). *Final Regulatory Impact Analysis: $PM_{2.5}$ NAAQS*. Office of Air and Radiation, Research Triangle Park, NC.

Table ES-2. Summary of Costs for Regulatory Alternatives (Millions of 2006$)*

		Alternative NAAQS: 0.4 µg/m^3 2nd Maximum Monthly Mean		Final NAAQS: 0.15 µg/m^3 2nd Maximum Monthly Mean		Alternative NAAQS: 0.1 µg/m^3 2nd Maximum Monthly Mean	
		3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate
Identified Control Costs		$46	$57	$130	$150	$160	$180
Extrapolated Costs	**Cost Curve Extrapolation**	$0.32	$0.32	$20	$20	$33	$33
	Ambient Extrapolation	$390	$460	$2,600	$3,100	$3,400	$3,900
Total RIA Costs	**Cost Curve**	**$46**	**$57**	**$150**	**$170**	**$190**	**$210**
	Ambient	**$430**	**$510**	**$2,800**	**$3,200**	**$3,500**	**$4,100**
Monitoring Costs**		$4.2	$4.2	$4.2	$4.2	$4.2	$4.2

* All estimates rounded to two significant figures. As such, totals will not sum down columns.

** Consistent with the scope of this rulemaking, which includes monitoring provisions, monitoring costs are included here. See OMB 2060-0084, ICR #940.21 for a complete discussion.

Table ES-3. Summary of Benefits for Regulatory Alternatives (Millions of 2006$)

	Alternative Standard: 0.40 µg/m^3 2nd Maximum Monthly Mean		Final NAAQS: 0.15 µg/m^3 2nd Maximum Monthly Mean		Alternative Standard: 0.10 µg/m^3 2nd Maximum Monthly Mean	
	3% Discount rate	*7% Discount rate*	*3% Discount rate*	*7% Discount rate*	*3% Discount rate*	*7% Discount rate*
Annualized Benefit - IQ Gains (Range)**	$2,000 - $2,800	$250 - $490	$3,500 - $5,000	$440 - $870	$4,500 - $6,400	$560 - $1,100
Annualized Benefit - PM Co-control (Range)***	$100 - $880	$100 - $800	$230 - $1,900	$210 - $1,700	$260 - $2,200	$240 - $2,000
Total Benefits	$2,100 - $3,700	$350 -$1,300	$3,700 - $6,900	$650 - $2,600	$4,800 - $8,600	$800 - $3,100

Table ES-4. Summary of Net Benefits for Regulatory Alternatives (Millions of 2006$)[13]

	Alternative Standard: 0.40 µg/m^3 2nd Maximum Monthly Mean		Final NAAQS: 0.15 µg/m^3 2nd Maximum Monthly Mean		Alternative Standard: 0.10 µg/m^3 2nd Maximum Monthly Mean	
	3% Discount rate	**7% Discount rate**	**3% Discount rate**	**7% Discount rate**	**3% Discount rate**	**7% Discount rate**
Total RIA Costs + Monitoring Costs	$50—$430	$61—$510	$150—$2,800	$170—$3,200	$190—$3,500	$210—$4,100
Total Benefits	$2,100—$3,700	$350—$1,300	$3,700—$6,900	$650—$2,600	$4,800—$8,600	$800—$3,100
Net Benefits	**$1,700 - $3,700**	**$(160) - $1,200**	**$900 - $6,800**	**$(2,600) - $2,400**	**$1,300 - $8,400**	**$(3,300) - $2,900**

[13] Note that bounds of the full range of net benefits is derived by subtracting the high costs from the low benefits at the lower end, and subtracting the low costs from the high benefits at the upper end. This is the only way to fully represent the uncertainty.

To provide additional context for the results presented in Table ES-3, Table ES-5 presents the total number of IQ points expected to be gained in the US in the year 2016 by achieving each of the alternate NAAQS level options, relative to the "base case" (i.e., the lead NAAQS remains at its current level). The results presented in the table demonstrate that lowering the current (1.5 $\mu g/m^3$ maximum quarterly mean) lead NAAQS to the revised or alternative NAAQS would be expected to have a significant impact on the IQ of young children. More specifically, the results indicate that the number of IQ points gained in 2016 ranges from 230,000 if a 0.4 $\mu g/m^3$ second maximum monthly mean NAAQS is achieved up to 510,000 for a 0.10 $\mu g/m^3$ second maximum monthly mean NAAQS.

Table ES-5. Number of IQ Points Gained in 2016

Standard	*IQ Points Gained*
0.40 $\mu g/m^3$ Second Maximum Monthly Mean	230,000
0.15 $\mu g/m^3$ Second Maximum Monthly Mean	400,000
0.10 $\mu g/m^3$ Second Maximum Monthly Mean	510,000

Our analysis suggests that the benefits presented in Table ES-5 will be concentrated in a small number of counties. Table ES-6 below shows the distribution of total benefits due to IQ points gained for the 0.15 $\mu g/m^3$ second maximum monthly mean NAAQS alternative. For this standard, approximately 60 percent of the total benefits are due to changes in lead air concentrations in three counties: Hillsborough, Florida; Delaware, Indiana; and Berks, PA. In these areas, sources of lead exposure and the monitors that measure ambient lead appear to be in relatively close proximity to exposed populations.

Table ES-6. Percentage of Benefits by Monitor (0.15 $\mu g/m^3$ Second Maximum Monthly Mean NAAQS)

County	State	Population of Children in Affected Area	Affected Population (%)	Percentage of Benefits (%)
Hillsborough	FL	67,359	17%	38%
Delaware	IN	7,957	2%	13%
Berks	PA	27,966	7%	13%
Collin	TX	22,192	6%	12%
Denton	TX	8,243	2%	5%
Cuyahoga	OH	60,605	16%	4%
Pike	AL	2,621	1%	4%
Jefferson	MO	6,472	2%	2%
Orange	NY	9,186	2%	2%
Dakota	MN	23,216	6%	1%
Beaver	PA	9,120	2%	1%
Fulton	OH	1,644	0%	1%
Rutherford	TN	707	0%	1%
Williamson	TN	804	0%	1%
Logan	OH	2,993	1%	1%

Note: There were several other counties that constituted less than 1 percent of benefits that are not included in this table.

The costs of the selected NAAQS are also expected to be concentrated in a limited number of areas, as summarized in chapter 6. Many of the monitor sites listed in the exhibit represent areas with the largest sources of lead emissions, such as primary or secondary lead smelters, mining operations, or battery manufacturers.

ES.4 Caveats and Limitations

Air Quality Data, Modeling and Emissions

- ***Limited TSP-Pb monitoring network.*** Because monitors are present in only 86 counties nationwide, the universe of monitors exceeding the various target NAAQS levels is very small; only 21 counties exceeding the lowest alternative NAAQS level of 0.10 $\mu g/m^3$. Because we know that many of the highest-emitting Pb sources in the 2002 NEI do not have nearby Pb-TSP monitors (see section 2.1.7), it is likely that there may be many more potential nonattainment areas than have been analyzed in this RIA.

- ***Simplified Air Quality Assessment Approach***. Dispersion, or plume-based models are recommended for compliance with the Pb NAAQS; however, dispersion models are data–intensive and more appropriate for local scale analyses of emissions from individual sources. It was not feasible to conduct such a large-scale data intensive analysis for this RIA. As a result, the simplified analysis developed for this RIA while distance-weighting individual source contributions to ambient Pb concentrations, could not account for such locally critical variables as meteorology and source stack height.

- ***Analysis Only Considers Controls on Point Source Emission Reductions.*** Because the available data are not sufficiently detailed to assess the impact of indirect fugitive or area nonpoint source controls, the analysis of air quality impacts does not account for the potential implementation of such controls in areas where they might be effective. Although the analysis estimates the impact of point source controls on indirect fugitives, it does not consider the impact of controlling these emissions directly. This and the lack of control information for area nonpoint sources may have contributed to our projection of nonattainment in some areas. Additionally, for this analysis we have not modeled the effect of any potential changes in emissions at airports with lead emissions associated with use of leaded aviation gasoline by piston-engine powered aircraft. (EPA received a petition from Friends of the Earth requesting that the Agency find that aircraft lead emissions may reasonably be anticipated to endanger the public health or welfare, and to take action to control lead emissions from piston-engine aircraft. EPA, in coordination with FAA, is analyzing the petition.)

- ***Limited Point Source Controls Considered***. As discussed above, we were not able to obtain emissions control information for a large number of point sources in our analysis. Although these sources collectively accounted for less than one fourth of all lead emissions considered, many of those sources were located in areas that were not able to reach attainment with one or more of the standards using identified controls alone.

- ***Actual State Implementation Plans May Differ from our Simulation***. In order to reach attainment with each selected NAAQS, each state will develop its own implementation plan implementing a combination of emissions controls that may differ from those simulated in this analysis. This analysis therefore represents an approximation of the emissions reductions that would be required to reach attainment and should not be treated as a precise estimate.

- ***Unspecified Emissions Reductions***. In this RIA, we report emissions reductions from both identified controls and unspecified emission reductions. We have taken care to report these separately, in recognition of the greater uncertainty associated with achieving emissions reductions from measures that may not be currently in use or known to EPA. Nonetheless, EPA believes it is reasonable to project that, with at least 10 years of lead time before a 2016 compliance deadline, a large number of existing measures will be adapted to be applicable to additional sources, and new measures may be developed that are specifically focused on cost-effectively reducing PM emissions with high lead content. Because the current standard is attained in all but a few areas of the country, and has been for many years since the phase down of lead in gasoline, it is likely that very little effort has been devoted to development of lead emissions control technologies except for industries where regulations have been imposed to reduce lead (e.g., large MWC standard, primary and secondary lead smelter MACTs, etc.).

Costs

- ***Uncertainty associated with unspecified emission reductions.*** As indicated above, some areas are expected to rely on unspecified emission reductions to reach attainment with the standards. The cost of implementing these measures, though estimated here based on the costs for identified controls, is uncertain. Many of these sources are already well-controlled for particulate matter, and additional control for the remaining increment of Pb might be difficult to achieve. Some sources have very low particulate matter (PM) emissions overall, and therefore controls are generally not applied at that emissions level.

- ***Uncertainty associated with emissions estimates for smaller sources.*** Note that there is often greater inherent uncertainty in reported emissions from smaller sources than from larger sources, and that a large portion of the lead emissions inventory consists of sources emitting less than five tons per year of lead.

- ***Uncertainty associated with estimating the extrapolated costs of unspecified emission reductions.*** The ambient extrapolation methodology emphasizes control costs that are the most expensive within an area, and assumes that knowledge of control costs from monitor areas that attain have no influence on the average control costs for areas that need unspecified emission reductions. It also assumes there will be no increased knowledge of sources or changed in technology between now and 2016. Lastly, most of the costs are based upon areas that make less than 1% progress towards attainment, indicating what little knowledge we have about controls in those areas.

  The cost curve methodology for unspecified emission reductions also presents a poor conceptual relationship between the costs of identified controls at a national level and the

costs of control at a local level. The data underlying this curve contains data points which we believe to be invalid (presented as part of the distributional analysis in Section 6.1.3.3). The estimated curve estimates negative costs over a portion of emission reductions. In addition this approach relies heavily on the control strategy for the tightest standard alternative analyzed in this RIA, and does not account for variability in control strategies across alternative standards analyzed. Lastly, we do not believe this curve well represents the knowledge of how control costs behave over time.

Benefits

- ***Exposure*.** The benefits of IQ point gains in children were very sensitive to the method employed for estimating exposures to the population. When comparing the default method, which involved concentrations that were interpolated from multiple monitors, to the method assuming a uniform concentration within a 10 km radius around an individual monitor, the results increase by 40 percent. Increasing the radius to include the entire county in which the monitor resides results in roughly 3-fold increase in benefits. Decreasing the radius size also has a large impact on benefits, decreasing the value by as much as 94 percent when a radius of 1 km is used.

- ***Dose-response relationship***. The dose-response function selected for quantifying the number of IQ points gained as a result of achieving the alternative NAAQS levels affected the results. Utilizing alternate epidemiological studies decreased the primary estimate by as much as 72 percent or increased it by 140 percent.

- ***Earnings-based metric of IQ.*** The earnings-based value-per-IQ-point lost that we apply in this analysis most likely represents a lower bound on the true value of a lost IQ point, because it is essentially a cost-of-illness measure, not a measure of an individual's willingness-to-pay (WTP) to avoid the loss of an IQ point. Welfare economics emphasizes WTP measures as the more complete estimate of economic value.

- ***Co-control benefits related to PM.*** Co-control benefits estimated here reflect the application of a national dollar benefit per ton estimate of the benefits of reducing directly emitted fine particulates from point sources. Because they are based on national-level analysis, the benefit-per-ton estimates used here do not reflect local meteorology, exposure, baseline health incidence rates, or other local factors that might lead to an over-estimate or under-estimate of the actual benefits of controlling directly emitted fine particulates.

ES.5 Conclusions and Insights

Our analysis has estimated the health benefits of reductions in ambient concentrations of lead resulting from a set of illustrative control strategies to reduce emissions of lead at point sources. The results suggest there will be significant additional health benefits arising from reducing emissions from a variety of sources in and around projected nonattaining counties in

2016. While 2016 is the latest date by which states would generally need to demonstrate attainment with the revised standards, it is expected that benefits (and costs) may begin occurring earlier, as states begin implementing control measures to show progress towards attainment.

CHAPTER 1: INTRODUCTION AND BACKGROUND

Synopsis

This document estimates the incremental costs and monetized human health benefits of attaining a revised primary lead (Pb) National Ambient Air Quality Standard (NAAQS) nationwide. This document contains illustrative analyses that consider limited emission control scenarios that states, tribes and regional planning organizations might implement to achieve a revised lead NAAQS. EPA weighed the available empirical data to make judgments regarding the proposed attainment status of certain urban areas in the future. According to the Clean Air Act, EPA must use health-based criteria in setting the NAAQS and cannot consider estimates of compliance cost. This Regulatory Impact Analysis (RIA) is intended to provide the public a sense of the benefits and costs of meeting new alternative lead NAAQS, and to meet the requirements of Executive Order 12866 and OMB Circular A-4 (described below in Section 1.2.2).

This RIA provides illustrative estimates of the incremental costs and monetized human health benefits of attaining a revised primary lead (Pb) National Ambient Air Quality Standard (NAAQS) within the current monitoring network[1]. Many of the highest-emitting Pb sources do not have nearby Pb-TSP monitors, and it is important to note that there may be many more potential nonattainment areas than have been analyzed in this RIA.

1.1 Background

Two sections of the Clean Air Act ("Act") govern the establishment and revision of NAAQS. Section 108 (42 U.S.C. 7408) directs the Administrator to identify pollutants which "may reasonably be anticipated to endanger public health or welfare," and to issue air quality criteria for them. These air quality criteria are intended to "accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare which may be expected from the presence of [a] pollutant in the ambient air." Lead is one of six pollutants for which EPA has developed air quality criteria.

Section 109 (42 U.S.C. 7409) directs the Administrator to propose and promulgate "primary" and "secondary" NAAQS for pollutants identified under section 108. Section 109(b)(1) defines a primary standard as "the attainment and maintenance of which in the judgment of the Administrator, based on [the] criteria and allowing an adequate margin of safety, [are] requisite to protect the public health." A secondary standard, as defined in section 109(b)(2), must "specify a level of air quality the attainment and maintenance of which in the judgment of the Administrator, based on [the] criteria, [are] requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of [the] pollutant in the ambient air." Welfare effects as defined in section 302(h) [42 U.S.C. 7602(h)] include but are not limited to "effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility and climate, damage to and deterioration of property, and

[1] There are currently 189 monitors representing 86 counties, but only 21 counties have monitors which exceed the final NAAQS of 0.15 ug/m^3.

hazards to transportation, as well as effects on economic values and on personal comfort and well-being."

Section 109(d) of the Act directs the Administrator to review existing criteria and standards at 5-year intervals. When warranted by such review, the Administrator is to retain or revise the NAAQS. After promulgation or revision of the NAAQS, the standards are implemented by the States.

1.2 Role of the Regulatory Impact Analysis in the NAAQS Setting Process

1.2.1 Legislative Roles

In setting primary ambient air quality standards, EPA's responsibility under the law is to establish standards that protect public health, regardless of the costs of implementing a new standard. The Clean Air Act requires EPA, for each criteria pollutant, to set a standard that protects public health with "an adequate margin of safety." As interpreted by the Agency and the courts, the Act requires EPA to create standards based on health considerations only.

The prohibition against the consideration of cost in the setting of the primary air quality standard, however, does not mean that costs or other economic considerations are unimportant or should be ignored. The Agency believes that consideration of costs and benefits are essential to making efficient, cost effective decisions for implementation of these standards. The impact of cost and efficiency are considered by states during this process, as they decide what timelines, strategies, and policies make the most sense. This RIA is intended to inform the public about the potential costs and benefits that may result when a new lead standard is implemented, but is not relevant to establishing the standards themselves.

1.2.2 Role of Statutory and Executive Orders

There are several statutory and executive orders that dictate the manner in which EPA considers rulemaking and public documents. This document is separate from the NAAQS decision making process, but there are several statutes and executive orders that still apply to any public documentation. The analysis required by these statutes and executive orders is presented in Chapter 8.

EPA presents this RIA pursuant to Executive Order 12866 and the guidelines of OMB Circular A-4.[2] These documents present guidelines for EPA to assess the benefits and costs of the selected regulatory option, as well as one less stringent and one more stringent option. OMB circular A-4 also requires both a benefit-cost, and a cost-effectiveness analysis for rules where health is the primary effect. Within this RIA we provide a benefit-cost analysis. Methodological and data limitations prevent us from performing a cost-effectiveness analysis and a meaningful more formal uncertainty analysis for the final RIA.

[2] U.S. Office of Management and Budget. Circular A-4, September 17, 2003. Found on the Internet at <http://www.whitehouse.gov/omb/circulars/a004/a-4.pdf>.

1.2.3 Market Failure or Other Social Purpose

OMB Circular A-4 indicates that one of the reasons a regulation such as the NAAQS may be issued is to address market failure. The major types of market failure include: externality, market power, and inadequate or asymmetric information. Correcting market failures is one reason for regulation, but it is not the only reason. Other possible justifications include improving the function of government, removing distributional unfairness, or promoting privacy and personal freedom.

An externality occurs when one party's actions impose uncompensated benefits or costs on another party. Environmental problems are a classic case of externality. For example, the smoke from a factory may adversely affect the health of local residents while soiling the property in nearby neighborhoods. If bargaining was costless and all property rights were well defined, people would eliminate externalities through bargaining without the need for government regulation. From this perspective, externalities arise from high transaction costs and/or poorly defined property rights that prevent people from reaching efficient outcomes through market transactions.

Firms exercise market power when they reduce output below what would be offered in a competitive industry in order to obtain higher prices. They may exercise market power collectively or unilaterally. Government action can be a source of market power, such as when regulatory actions exclude low-cost imports. Generally, regulations that increase market power for selected entities should be avoided. However, there are some circumstances in which government may choose to validate a monopoly. If a market can be served at lowest cost only when production is limited to a single producer of local gas and electricity distribution services, a natural monopoly is said to exist. In such cases, the government may choose to approve the monopoly and to regulate its prices and/or production decisions. Nevertheless, it should be noted that technological advances often affect economies of scale. This can, in turn, transform what was once considered a natural monopoly into a market where competition can flourish.

Market failures may also result from inadequate or asymmetric information. Because information, like other goods, is costly to produce and disseminate, an evaluation will need to do more than demonstrate the possible existence of incomplete or asymmetric information. Even though the market may supply less than the full amount of information, the amount it does supply may be reasonably adequate and therefore not require government regulation. Sellers have an incentive to provide information through advertising that can increase sales by highlighting distinctive characteristics of their products. Buyers may also obtain reasonably adequate information about product characteristics through other channels, such as a seller offering a warranty or a third party providing information.

There are justifications for regulations in addition to correcting market failures. A regulation may be appropriate when there are clearly identified measures that can make government operate more efficiently. In addition, Congress establishes some regulatory programs to redistribute resources to select groups. Such regulations should be examined to ensure that they are both effective and cost-effective. Congress also authorizes some regulations to prohibit discrimination that conflicts with generally accepted norms within our society.

Rulemaking may also be appropriate to protect privacy, permit more personal freedom or promote other democratic aspirations.

From an economics perspective, setting an air quality standard is a straightforward case of addressing an externality, in this case where firms are emitting pollutants, which cause health and environmental problems without compensation for those suffering the problems. Setting a standard with a reasonable margin of safety attempts to place the cost of control on those who emit the pollutants and lessens the impact on those who suffer the health and environmental problems from higher levels of pollution.

1.2.4 Illustrative Nature of the Analysis

This Pb NAAQS RIA is an illustrative analysis that provides useful insights into a limited number of emissions control scenarios that states might implement to achieve a revised lead NAAQS. Because states are ultimately responsible for implementing strategies to meet any revised standard, the control scenarios in this RIA are necessarily hypothetical in nature. They are not forecasts of expected future outcomes. Important uncertainties and limitations are documented in the relevant portions of the analysis.

The illustrative goals of this RIA are somewhat different from other EPA analyses of national rules, or the implementation plans states develop, and the distinctions are worth brief mention. This RIA does not assess the regulatory impact of an EPA-prescribed national or regional rule such as the Clean Air Interstate Rule, nor does it attempt to model the specific actions that any state would take to implement a revised lead standard. This analysis attempts to estimate the costs and human and welfare benefits of cost-effective implementation strategies which might be undertaken to achieve national attainment of new standards. These hypothetical strategies represent a scenario where states use one set of cost-effective controls to attain a revised lead NAAQS. Because states—not EPA—will implement any revised NAAQS, they will ultimately determine appropriate emissions control scenarios. State implementation plans would likely vary from EPA's estimates due to differences in the data and assumptions that states use to develop these plans.

The illustrative attainment scenarios presented in this RIA were constructed with the understanding that there are inherent uncertainties in projecting emissions and controls. Furthermore, certain emissions inventory, control, modeling and monitoring limitations and uncertainties inhibit EPA's ability to model full attainment in all areas. Despite these limitations, EPA has used the best available data and methods to produce this RIA.

1.3 Overview and Design of the RIA

This Regulatory Impact Analysis evaluates the costs and benefits of hypothetical national strategies to attain several potential revised primary lead standards. The document is intended to be straightforward and written for the lay person with a minimal background in chemistry, economics, and/or epidemiology. Figure 1-1 provides an illustration of the framework of this RIA.

Analytic Sequence for Lead NAAQS RIA

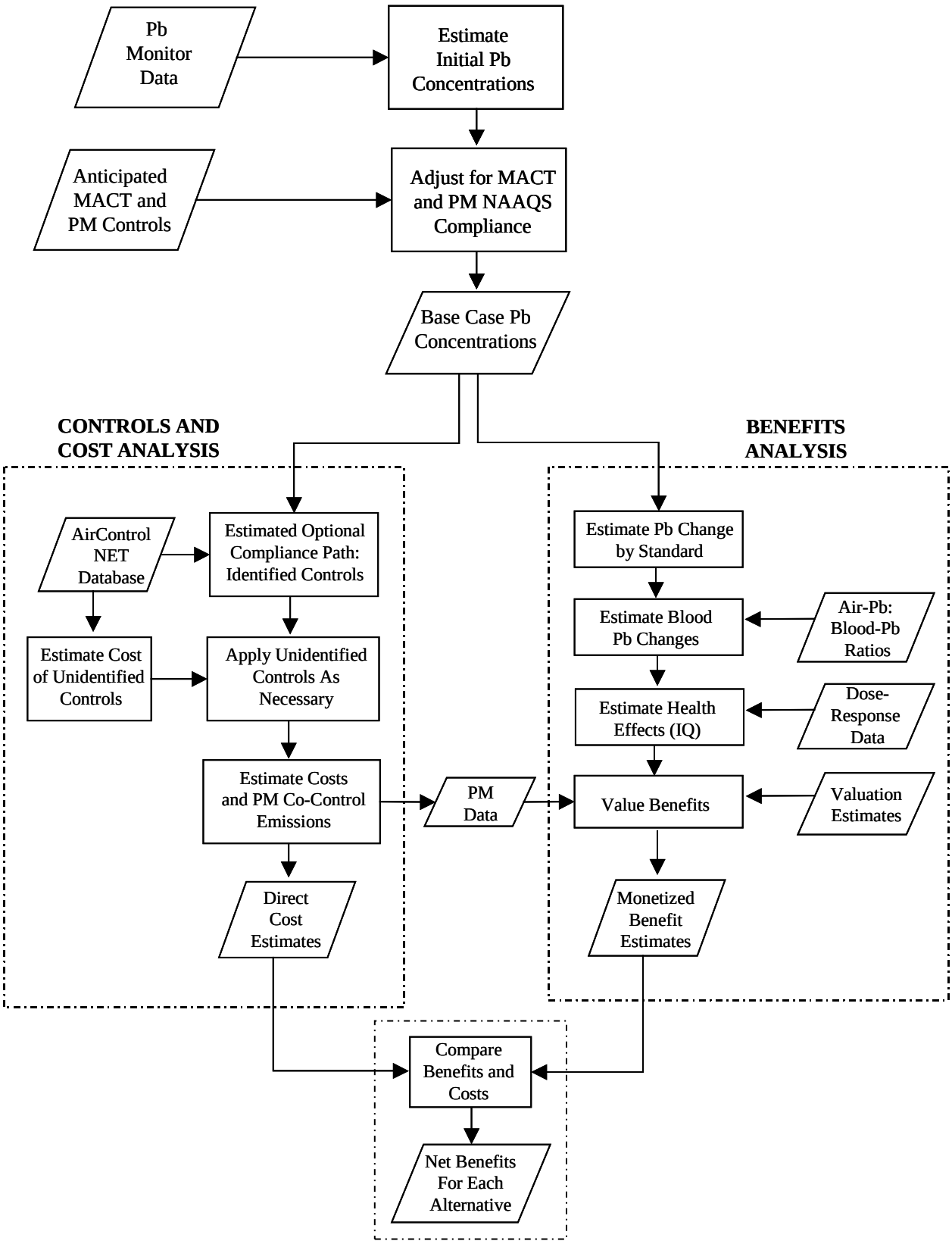

Figure 1-1: The Process Used to Create this RIA

1.3.1 Baseline and Years of Analysis

The analysis year for this regulatory impact analysis is 2016, which represents the required attainment year under the Clean Air Act. Many areas will reach attainment of any alternative Pb standard by 2016. For purposes of this analysis, we assess attainment by 2016 for all areas. Some areas for which we assume 2016 attainment may in fact need more time to meet one or more of the analyzed standards, while others will need less time. This analysis does not prejudge the attainment dates that will ultimately be assigned to individual areas under the Clean Air Act, which contains a variety of potential dates and flexibility to move to later dates, provided that the date is as expeditious as practicable.

The methodology first estimates what baseline lead levels might look like in 2016 with existing Clean Air Act programs, including application of controls to meet the current Pb NAAQS, various maximum achievable control technology (MACT) standards, and the newly revised PM NAAQS standard, and then predicts the change in Pb levels following the application of additional controls to reach tighter alternative standards. This allows for an analysis of the incremental change between the current standard and alternative standards. Since Pb is also a component of PM, it is important that we account for the impact on Pb concentrations of PM controls used in the hypothetical control scenario in the PM NAAQS RIA, so as to avoid double counting the benefits and costs of these controls.

1.3.2 Control Scenarios Considered in this RIA

Hypothetical control strategies were developed for the final Pb NAAQS of 0.15 $\mu g/m^3$. plus four alternative Pb standards encompassing a range of 0.10 $\mu g/m^3$ to 0.50 $\mu g/m^3$. First, EPA developed an air quality assessment tool to estimate air quality changes that would result from the application of emissions control options that are known to be available to different types of sources in areas with monitoring levels currently exceeding the alternative standards. However, given the limitations of current technology and the amount of improvement in air quality needed to reach some alternative standards in some areas, it was also expected that applying these known controls would not reduce lead concentrations sufficiently to allow all areas to reach the more stringent standards. In order to bring these monitor areas into attainment, we calculated controls costs using two different approaches. Under one scenario, we calculated the cost of unspecified emission reductions by extrapolating from current average national identified control costs. Under our second scenario, we calculated the cost of unspecified emission reductions by deriving an average cost per microgram of air quality improvement obtained from identified controls. For each standard, we then selected all monitor areas that failed to reach attainment and applied unspecified emission reductions to all sources until attainment was reached.

1.3.3 Evaluating Costs and Benefits

Applying a two step methodology for estimating emission reductions needed to reach full attainment enabled EPA to evaluate nationwide costs and benefits of attaining a tighter Pb standard using hypothetical strategies, albeit with substantial additional uncertainty regarding the second step estimates. First, the costs associated with applying known controls were quantified.

Second, EPA estimated costs of the additional tons of extrapolated emission reductions estimated which were needed to reach full attainment.

It is important to note that this analysis did not estimate any separate costs or benefits of attaining a secondary NAAQS standard due to resource and time constraints. Since the secondary is being set to be equivalent to the primary standard, no additional costs and benefits are expected.

To streamline this RIA, this document refers to several previously published documents, including three technical documents EPA produced to prepare for promulgation of the Pb NAAQS. The first was a Criteria Document created by EPA's Office of Research and Development (published in 2006), which presented the latest available pertinent information on atmospheric science, air quality, exposure, dosimetry, health effect, and environmental effects of lead. The second was a "Staff Paper" (published in 2007) that evaluated the policy implications of the key studies and scientific information contained in the Criteria Document. The third was a risk assessment for various standard levels. The Staff Paper also includes staff conclusions and recommendations to the Administrator regarding potential revisions to the standards.

1.4 Pb Standard Alternatives Considered

EPA has performed an illustrative analysis of the potential costs and human health and visibility benefits of nationally attaining the final NAAQS of 0.15 $\mu g/m^3$. Per Executive Order 12866 and the guidelines of OMB Circular A-4, this Regulatory Impact Analysis (RIA) also presents analyses of a more stringent option of 0.10 $\mu g/m^3$ and a less stringent option of 0.40 $\mu g/m^3$. EPA also analyzed alternative Pb standards of 0.20 $\mu g/m^3$, 0.30 $\mu g/m^3$, and 0.50 $\mu g/m^3$. The benefit and cost estimates below are calculated incremental to a 2020 baseline that incorporates air quality improvements achieved through the projected implementation of existing regulations and full attainment of the existing Pb and particulate matter (PM) National Ambient Air Quality Standards (NAAQS). The baseline also includes the MACT program, which will help many areas move toward attainment of the current lead standard.

1.5 References

Henderson, R. 2006. October 24, 2006. Letter from CASAC Chairman Rogene Henderson to EPA Administrator Stephen Johnson, EPA-CASAC-07-001.

U.S. EPA. 1970. Clean Air Act. 40CFR50.

U.S. EPA. 2006. Air Quality Criteria for Lead and Related Photochemical Oxidants (Final). U.S. Environmental Protection Agency, Washington, DC, EPA-452/R-07-013.

U.S. EPA. 2007. Review of the National Ambient Air Quality Standards for Lead: Policy Assessment of Scientific and Technical Information. OAQPS Staff Paper. North Carolina. EPA-452/R-07-013, Office of Air Quality Planning and Standards, RTP, NC.

CHAPTER 2. CHARACTERIZING PB AIR QUALITY AND EMISSIONS DATA

This chapter describes the available Pb air quality and emission data used to inform and develop the controls strategies outlined in this RIA. We first describe data sources for air quality measurement. We then provide an overview of data on Pb emission sources contained in available EPA emission inventories. For a more in-depth discussion of Pb air quality and emissions data, see the OAQPS Staff Paper for the Pb NAAQS.[1]

2.1 Air Quality Monitoring Data

Ambient air Pb concentrations are measured by four monitoring networks in the United States, all funded in whole or in part by EPA. These networks provide Pb measurements for three different size classes of airborne particulate matter (PM): total suspended PM (TSP), PM less than or equal to 2.5 μm in diameter ($PM_{2.5}$), and PM less than or equal to 10 μm in diameter (PM_{10}). The networks include the Pb TSP network, the $PM_{2.5}$ Chemical Speciation Network (CSN), the Interagency Monitoring of Protected Visual Environments (IMPROVE) network, and the National Air Toxics Trends Stations (NATTS) network. The subsections below describe each network and the Pb measurements made at these sites.

In addition to these four networks, various organizations have operated other sampling sites yielding data on ambient air concentrations of Pb, often for limited periods and/or for primary purposes other than quantification of Pb itself. Most of these data are accessible via EPA's Air Quality System (AQS): http://www.epa.gov/ttn/airs/airsaqs/. In an effort to gather as much air toxics data, including Pb, into one database, the EPA and National Association of Clean Air Agencies (NACAA) created the Air Toxics Data Archive. The Air Toxics Data Archive can be accessed at: http://vista.cira.colostate.edu/atda/.

2.1.1 Ambient Pb Measurement Methods

A number of methods are used to collect Pb and measure Pb concentrations in the atmosphere. Most methods use similar sample collection approaches. Ambient air is drawn through an inlet for a predetermined amount of time (typically 24 hours) and the PM is collected on a suitable filter media. After the sample has been collected, the filter may be used to determine the mass of PM collected prior to then being used for determination of Pb. The filter is chemically extracted and analyzed to determine the Pb concentration in the particulate material. The concentration of Pb found in the atmosphere, in $\mu g/m^3$, is calculated based on the concentration of Pb in the volume extracted, the size of the collection filter, and the volume of air drawn through the filter.

The primary factors affecting the measurements made are the sampling frequency, duration of sampling, type of inlet used, volume of air sampled, and the method of

[1] U.S. Environmental Protection Agency (2007c), Review of the National Ambient Air Quality Standards for Lead: Policy Assessment of Scientific and Technical Information, OAQPS Staff Paper, Chapter 2, EPA-452/R-07-013, Office of Air Quality Planning and Standards, RTP, NC.

analyzing the filter for Pb content. The following paragraphs describe how these factors affect the Pb measurements.

2.1.2 Inlet Design

In ambient air monitors, a number of inlet designs have been developed that allow certain particle size ranges to be sampled. The inlets use either impaction or cyclone techniques to remove particles larger than a certain size (the size cutpoint) from the sample stream. Three particle size cutpoints are used in ambient Pb measurements including TSP, $PM_{2.5}$, PM_{10}. The TSP inlet is designed to allow as much suspended particulate into the sampling device as possible while protecting against precipitation and direct deposition on to the filter (nominally 25 to 45 micrometers) (USEPA, 2004c). Sampling systems employing inlets other than the TSP inlet will not collect Pb contained in the PM larger than the size cutpoint. Therefore, they do not provide an estimate of the total Pb in the ambient air. This is particularly important near sources which may emit Pb in the larger PM size fractions (e.g., fugitive dust from materials handling and storage).

2.1.3 Volume of Air Sampled

The amount of Pb collected is directly proportional to the volume of air sampled. Two different sampler types have evolved for PM and Pb sampling – a high-volume and a low-volume sampler. High-volume samplers draw between 70 and 100 m^3/hr of air through an 8 inch by 10 inch filter (0.05 m^2 filter area). Low-volume samplers typically draw 1 m^3/hr through a 47 mm diameter filter (0.002 m^2 filter area). Currently all Federal Reference Method (FRM) and Federal Equivalence Method (FEM) for Pb-TSP are based on high-volume samplers.

2.1.4 Sampling Frequency

The frequency of Pb sampling used in the U.S. varies between one sample every day (1 in 1 sampling) to the more common frequency of one sample every 6 days (1 in 6 sampling). Semi-continuous methods for the measurement of ambient metals (including Pb) are currently being explored which would allow for more frequent sampling (as frequent as 1 sample per hour), but much more work is needed on these methods before they can be deployed in a network setting.

More frequent sampling reduces the uncertainty in estimates of quarterly or annual averages associated with temporal variations in ambient concentrations. However, the costs of sampling and analysis are directly tied to sample frequency. As such, it is necessary to evaluate the reduction in measurement error versus the increase in sampling and analysis costs when selecting the required sampling frequency. A discussion of the observed temporal variation of Pb measurements is given later in this section.

2.1.5 Sample Analysis

After the samples have been collected on filters and the filters have been weighed, the filters are analyzed for Pb content. A number of analytical methods can be used to analyze the filters for Pb content including x-ray fluorescence analysis (XRF), proton-

induced x-ray emission (PIXE), neutron activation analysis (NAA), atomic absorption (AA), or inductively-coupled plasma mass spectrometry (ICP/MS) (CD, pp. 2-80 to 2-81). A detailed discussion of these methods was given in the 1986 CD (USEPA, 1986), and the reader is referred to that document for more information on these analytical methods. A search conducted on the AQS database[2] shows that the method detection limits for all of these analytical methods (coupled with the sampling methods) are very low, ranging from 0.01 $\mu g/m^3$ to as low as 0.00001 $\mu g/m^3$, and are more than adequate for determining compliance with the current NAAQS.

2.1.6 Pb-TSP

This network is comprised of state and locally managed Pb monitoring stations which measure Pb in TSP, i.e., particles up to 25 to 45 microns. These stations use samplers and laboratory analysis methods which have either FRM or FEM status. The FRM and FEM method descriptions can be found in the U.S. Code of Federal Regulations, Section 40 part 50, Appendix G. Sampling is conducted for 24-hour periods, with a typical sampling schedule of 1 in 6 days. Some monitoring agencies "composite" samples by analyzing several consecutive samples together to save costs and/or increase detection limits.

2.1.7 Monitor Locations

The locations of Pb-TSP sites in operation between 2003 and 2005 are shown in Figure 2-1. The state and local agencies which operate these sites report the data to EPA's AQS where they are accessible via several web-based tools. EPA's series of annual air quality trends reports have used data from this network to quantify trends in ambient air Pb concentrations. The most recent Trends report for Pb-TSP can be found at http://www.epa.gov/airtrends/lead.html.

A review of the Pb-TSP network's coverage of the highest Pb emitting sources (as identified in the current version of the 2002 NEI) was conducted as part of preparing this document. This review indicates that many of the highest Pb emitting sources in the 2002 NEI do not have nearby Pb-TSP monitors. This review indicates that only 2 of 26 facilities (both Pb smelters[3]) identified as emitting greater than 5 tpy have a Pb-TSP monitor within 1 mile. The lack of monitors near large sources indicates we are likely currently underestimating the extent of occurrences of relatively higher Pb concentrations. Additionally, none of the 189 Pb-TSP are located within a mile of airports identified in the NEI as an airport where piston-engine aircraft operate (i.e., aircraft that still use leaded aviation fuel). However, there are historical data for 12 Pb-TSP monitoring sites operating within 1 mile of such airports (going back to 1993). Nine of these sites reported maximum quarterly mean values (for 1993-2002) that ranged from 0.03 to 0.06 $\mu g/m^3$ and across all 12 sites, the maximum quarterly mean values ranged from 0.004 to 0.15 $\mu g/m^3$.

[2] EPA's AQS can be accessed at http://www.epa.gov/ttn/airs/airsaqs/

[3] Primary and secondary smelters were the source types given particular priority at the time of the last Pb NAAQS review (USEPA, 1990; USEPA, 1991).

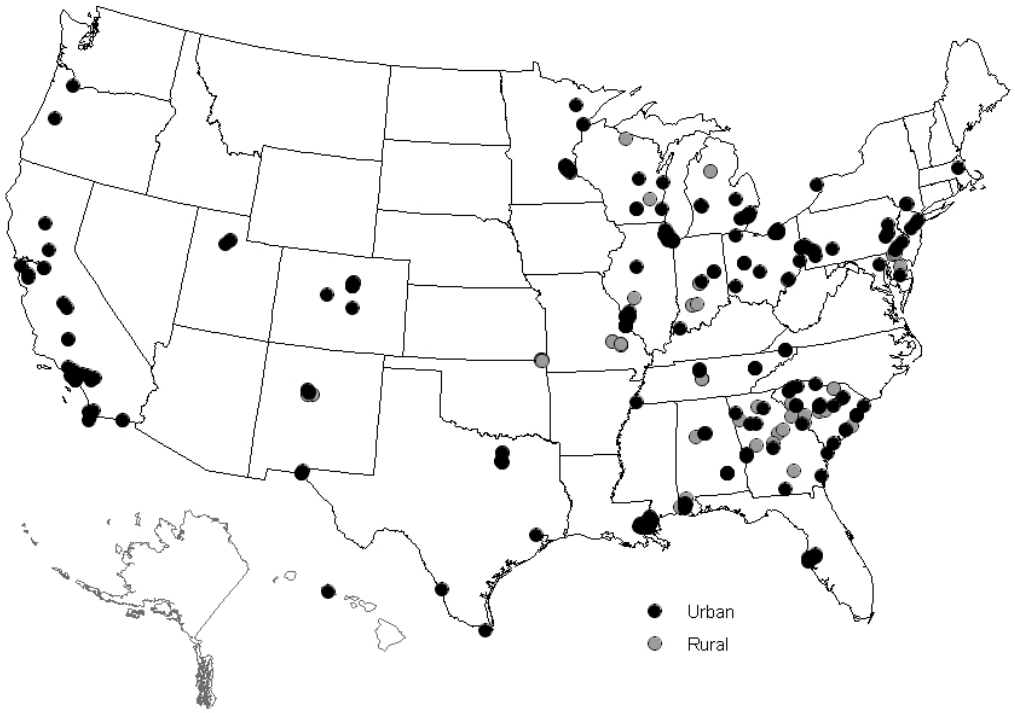

Figure 2-1. Pb-TSP monitoring sites: 2003-2005.

The number of sites in the Pb-TSP network has decreased significantly since the 1980s. The number of sites in the network reached its highest point in 1981 (946 sites). About 250 sampling sites operated during 2005. This decline in the number of Pb-TSP sites is attributable to the dramatic decrease in Pb concentrations observed since the 1980s and the need to fund new monitoring objectives (e.g., $PM_{2.5}$ and ozone monitoring). Lead-TSP sites in lower concentration areas were shut down to free up resources needed for monitoring of other pollutants such as $PM_{2.5}$ and ozone.

2.2 Air Quality Modeling

As part of the Agency's national air toxics assessment (NATA) activities, a national scale assessment of hazardous air pollutants including Pb compounds has been performed twice over the past few years (USEPA 2006c, 2002c, 2001a). These two assessments included the use of the NEI for the years 1996 and 1999, respectively, with atmospheric dispersion modeling to predict associated annual average Pb air concentrations across the country. A national scale assessment is not yet available based on the 2002 NEI. A number of limitations are associated with the 1996 and 1999 ambient concentration estimates and the underlying emissions estimates.

Historical studies show that Gaussian dispersion models, such as ASPEN, typically agree with monitoring data within a factor of 2 most of the time. In the case of Pb in the NATA assessment, model estimates at monitor locations were generally lower than the

monitor averages for Pb, suggesting that the modeling system (i.e., emissions estimates, spatial allocation estimates, dispersion modeling) may be systematically underestimating ambient concentrations. This may be particularly true for Pb as metals tend to deposit rapidly with distance from the source according to their particle size and weight. The model-to-monitor analysis is described in detail at http://www.epa.gov/ttn/atw/nata1999/99compare.html. The modeling system underestimation may also be due in part to a lack of accounting for emissions re-entrainment (these "re-entrained" particles may be observed by the monitors, but they are not accounted for in the emissions inventory, and thus would not contribute to the model estimate). For more details on the limitations of the 1999 NATA national scale assessment, see http://www.epa.gov/ttn/atw/nata1999/limitations.html.

For more information on Pb modeling, see section 2.4 of the OAQPS Staff Paper for the Pb NAAQS.[4] For reasons discussed in section 3.1.1, we did not use an air quality model for this analysis.

2.3 Sources of Pb Emissions to Ambient Air

The primary data source for this discussion is the National Emissions Inventory (NEI) for 2002 (USEPA, 2007a). As a result of Clean Air Act requirements, emissions standards promulgated for many source categories that have taken effect since 2002 are projected to result in much lower emissions at the current time or in the near future. For a more comprehensive discussion of Pb sources, see section 2.2 of the OAQPS Staff Paper for the Pb NAAQS.[5]

2.3.1 Types of Pb Sources

Lead is emitted from a wide variety of source types, some of which are small individually but the cumulative emissions of which are large, and some for which the opposite is true. The categories of Pb sources estimated via the 2002 NEI to emit –as a category- more than five tons per year (tpy) of Pb are listed in Table 2-2. Note that there is often greater inherent uncertainty in reported emissions from small sources than from larger sources, and that a large portion of the lead inventory consists of sources emitting less than than five tons per year of lead.

2.3.1.1 Stationary Sources

The main sources of emissions in the 2002 NEI are comprised primarily of combustion-related emissions and industrial process-related emissions. Point source emissions account for about 66% of the national Pb emissions in the 2002 NEI. The

[4] U.S. Environmental Protection Agency (2007c), Review of the National Ambient Air Quality Standards for Lead: Policy Assessment of Scientific and Technical Information, OAQPS Staff Paper, section 2.4, EPA-452/R-07-013, Office of Air Quality Planning and Standards, RTP, NC.

[5] *Ibid.*, section 2.2.

point source emissions are roughly split between combustion and industrial processes, while mobile, non-road sources (e.g. piston-engine aircraft using leaded fuel) account for 29%.

Table 2-1 presents emissions estimates for stationary sources grouped into descriptive categories. Presence and relative position of a source category on this list does not necessarily provide an indication of the significance of the emissions from individual sources within the source category. A source category, for example, may be composed of many small (i.e., low-emitting) sources, or of just a few very large (high-emitting) sources.

Table 2-1. Source categories emitting greater than 5 tpy of Pb

ALL CATEGORIES - Total tons	1371	**% of Total**
Mobile sources	623	45.44
Iron and Steel Foundries	83	6.05
Primary Lead Smelting	59	4.30
Industrial/Commercial/ Institutional Boilers & Process Heaters	53	3.87
Hazardous Waste Incineration	47	3.43
Secondary Lead Smelting	44	3.21
Municipal Waste Combustors	33	2.41
Military Installations	27	1.97
Pressed and Blown Glass and Glassware Manufacturing	26	1.90
Utility Boilers	23	1.68
Secondary Nonferrous Metals	22	1.60
Portland Cement Manufacturing	18	1.31
Integrated Iron & Steel Manufacturing	17	1.24
Lead Acid Battery Manufacturing	17	1.24
Stainless and Nonstainless Steel Manufacturing (EAF)	17	1.24
Mining	15	1.09
Primary Metal Products Manufacturing	13	0.95
Waste Disposal - Solid Waste Disposal	10	0.73
Primary Copper Smelting	10	0.73
Secondary Aluminum Production	9	0.66
Fabricated Metal Products Manufacturing	9	0.66
Pulp & Paper Production	9	0.66
Transportation Equipment Manufacturing	8	0.58
Electrical and Electronics Equipment Manufacturing	8	0.58
Sewage Sludge Incineration	7	0.51
Nonferrous Foundries	7	0.51
Ferroalloys Production	7	0.51
Industrial Inorganic Chemical Manufacturing	7	0.51
Industrial and Commercial Machinery Manufacturing	7	0.51
Residential Heating	6	0.44
Secondary Copper Smelting	6	0.44
Miscellaneous Metal Parts & Products (Surface Coating)	6	0.44
Commercial and Industrial Solid Waste Incineration	6	0.44
Autobody Refinishing Paint Shops	5	0.36
Coke Ovens	5	0.36
Stationary Reciprocating Internal Combustion Engines	5	0.36
Other	97	7.08

There are some 13,067 point sources (industrial, commercial or institutional) in the 2002 NEI, each with one or more processes that emit Pb to the atmosphere. Most of these sources emit less than 0.1 tpy Pb. There are approximately 1300 point sources of Pb in the NEI with estimates of emissions greater than or equal to 0.1 tpy and these point sources, combined, emit 1058 tpy, or 94% of the Pb point source emissions. In other words, 94% of Pb point source emissions are emitted by the largest 10% of these sources.

Chapter 3 of this RIA discusses our methodology for characterizing the relative contributions of stationary point sources (defined in this analysis as sources emitting > 1 ton per year of Pb), area nonpoint sources (defined in this analysis as sources emitting less than 1 ton per year), and mobile sources.

2.3.1.2 Mobile Sources

Thirty-five years ago, combustion of leaded gasoline was the main contributor of Pb to the air. In the early 1970s, EPA set national regulations to gradually reduce the Pb content in gasoline. In 1975, unleaded gasoline was introduced for motor vehicles equipped with catalytic converters. EPA banned the use of leaded gasoline in highway vehicles after December 1995. Currently, tetraethyl lead (TEL) is still added to aviation gasoline (avgas) which is used in most piston-engine powered aircraft. TEL is added to avgas to increase octane, prevent knock[6], and prevent valve seat recession and subsequent loss of compression for engines without hardened valves. The 2002 National Emissions Inventory (NEI) estimates that lead emissions from the use of leaded aviation gasoline (commonly referred to as avgas) are 491 tons; this accounts for 29% of the air emission inventory for lead. These estimates are based on the volume of avgas supplied nationally, the concentration of lead in avgas and the retention of some lead in the engine and engine oil of these aircraft. The Department of Energy estimates that about 281 million gallons of avgas were supplied in the U.S. in 2002.[7] In 2006 the volume was about 280 million gallons. The majority of avgas contains up to 0.56 grams of lead per liter (2.12 grams of lead/ gallon); this is referred to as 100 Low Lead (100LL). There is another grade of 100 octane avgas that contains 1.12 grams of lead per liter, but this product is not widely available. Based on newly available information, the retention of lead in the engine and oil of piston-engine aircraft was recently revised from a value of 25% which was more related to lead retention in light-duty vehicles operating on leaded fuel to 5% retention for piston-engine aircraft.[8] Using these recently available data on lead retention, EPA now estimates that lead emissions from the use of avgas in 2002 were approximately 623 tons or 35% of the national inventory. This estimate is based on all leaded avgas used in the U.S. This estimate does not account for the fact that some lead is emitted in the local area of an airport facility and some lead is emitted at altitude. EPA's method for estimating airport-specific lead inventories is discussed in detail elsewhere.[9]

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[6] Knocking is the sound produced when some of the unburned fuel in the cylinder ignites spontaneously resulting in rapid burning and a precipitous rise in cylinder pressure that creates the characteristic knocking or pinging sound (Chevron 2005 available at: http://www.chevronglobalaviation.com/docs/aviation_tech_review.pdf).

[7] data available at http://tonto.eia.doe.gov/dnav/pet/hist/mgaupus1A.htm

[8] For more information see the memo to the docket titled "Revised Methodology for Esimating Lead Emissions from Piston-Engine Aircraft Operating on Leaded Aviation Gasoline."

[9] See memo to the docket titled For more information see the memo to the docket titled "Revised Methodology for Esimating Lead Emissions from Piston-Engine Aircraft Operating on Leaded Aviation Gasoline."

Lead is also present as a trace contaminant in gasoline and diesel fuel and is a component of lubricating oil (CD, pp. 2-45 to 2-48). Inventory estimates from these sources are not currently available. Additional mobile sources of Pb include brake wear, tire wear, and loss of Pb wheel weights (CD, pp. 2-48 to 2-50). Emission rates for Pb from brake wear have been published but inventory estimates have not yet been developed from these data (Schauer et al., 2006). Robust estimates of Pb from tire wear and wheel weights are not available. Currently, Pb from combustion of leaded avgas is the only mobile source of Pb included in the 2002 NEI.

CHAPTER 3. AIR QUALITY ASSESSMENT METHODOLOGY

This chapter presents the methods used to estimate the air quality impacts of the emissions control strategies outlined in Chapter 4 of this document. To begin, we first describe the air quality assessment tool developed by EPA to relate lead emissions to ambient lead concentrations. We then explain how this tool was used to estimate the air quality impacts of each hypothetical emissions control strategy. The air quality impacts of these hypothetical control strategies are summarized in Chapter 4.

EPA used the air quality assessment methodology presented in this chapter to assess the final lead NAAQS of 0.15 $\mu g/m^3$ and the five alternative standards included in this document. We note that the Agency is setting the final standard as the maximum quarterly rolling average concentration, whereas the proposed rule included two options for the averaging time and form of the standard: the maximum quarterly average concentration across a three-year period (i.e., the maximum quarterly mean) and the second highest monthly average concentration across a three-year period (i.e., the second maximum monthly mean). The decision to set the final standard as a maximum quarterly rolling average concentration, however, was made after much effort had been expended to assess the costs and benefits of the final and alternative standards as second maximum monthly mean concentrations. Because this decision was reached late in the analytic process, EPA used the air quality assessment methodology presented in this chapter to assess the 0.15 $\mu g/m^3$ standard as a second maximum monthly mean concentration rather than as a maximum quarterly rolling average concentration.

To assess the implications of using second maximum monthly mean concentrations for this analysis, we compared second maximum monthly mean concentrations to maximum quarterly concentrations. Ideally, we would compare second maximum monthly concentrations for each monitor area to the corresponding maximum quarterly rolling average concentration, but historical data for the latter were not readily available. In the absence of these data, we compared the second maximum monthly mean to the maximum quarterly mean. For the full universe of 86 counties where monitor readings for lead were available, the second maximum monthly mean is, on average, 0.03 $\mu g/m^3$ higher than the maximum quarterly mean. In addition, when we statistically test the difference between the second maximum monthly mean and the maximum quarterly mean concentrations in these 86 counties, we confirm that the former is likely to be higher than the latter.[1] When we limit the analysis to the 21 counties included in this analysis (i.e., the 21 counties with second maximum monthly mean concentrations above 0.1 $\mu g/m^3$, which is the most stringent standard analyzed in this document), we reach the same general conclusion—that the second maximum monthly mean is, on average, higher than the maximum quarterly mean.[2] This suggests that we may overestimate the emissions reductions,

[1] For all 86 counties where monitor data are available, the 95 percent confidence interval for the difference between the second maximum monthly mean and the maximum quarterly mean suggests that the former is 0.007 to 0.062 $\mu g/m^3$ higher than the latter.

[2] For the 21 counties analyzed in this RIA, the 95 percent confidence interval for the difference between the second maximum monthly mean and the maximum quarterly mean suggests that the second maximum monthly mean is 0.002 to 0.146 $\mu g/m^3$ higher than the maximum quarterly mean.

costs, and benefits associated with the final and alternative standards and that we may underestimate the number of areas able to attain each standard.

3.1 Air Quality Assessment Tool

To assess the air quality impact of the hypothetical emissions controls implemented under the final NAAQS, EPA would ideally use a detailed air quality model that simulates the dispersion and transport of lead to estimate local ambient lead concentrations. Although models with such capabilities are available for pollutants for which EPA frequently conducts air quality analyses (e.g., particulate matter and ozone), regional scale models are currently neither available nor appropriate for Pb.[3] Dispersion, or plume-based models, are recommended for compliance with the Pb NAAQS and were used for the Pb NAAQS risk assessment case studies. However, dispersion models are data-intensive and more appropriate for local scale analyses of emissions from individual sources. It was not feasible to conduct such a large-scale data intensive analysis for this RIA. As a result, the simplified analysis developed for this RIA, while distance-weighting individual source contributions to ambient Pb concentrations, could not account for such locally critical variables as meteorology and source stack height. Instead of using a data-intensive modeling approach, EPA developed a more simplified air quality assessment tool to estimate the air quality impacts of each lead emissions control strategy.

In general, air quality analyses conducted in support of the current Agency Pb NAAQS review focused on the Pb-TSP monitoring sites represented in the Air Quality System (AQS) database with sufficient 1-, 2-, or 3-year data records for the years 2003-2005; this database encompasses 189 monitoring sites located in 86 distinct counties. For this particular analysis, we concentrated on county maxima monitors exceeding the lowest alternative target NAAQS level (0.1 $\mu g/m^3$). The identification of the county maxima monitors and subsequent processing were based on the alternative NAAQS form of second maximum monthly Pb-TSP average over a 3-year period (in this case, 2003-2005).[4] Specifically, we identified 21 monitors (located in 21 counties) which we analyzed with the hereto described air quality assessment tool. This assessment tool employs a source-apportionment approach to estimate the extent to which each of the following emissions sources contribute to observed lead concentrations in the proximate areas of those 21 monitors:

[3] U.S. Environmental Protection Agency (2007c), Review of the National Ambient Air Quality Standards for Lead: Policy Assessment of Scientific and Technical Information, OAQPS Staff Paper, section 2.4, EPA-452/R-07-013, Office of Air Quality Planning and Standards, RTP, NC.

[4] In the Proposed Rule Analysis, monitors / counties were initially selected based on an alternative NAAQS form of maximum monthly Pb-TSP average. The Agency focus switched to second maximum monthly after considerable effort had already been made in the Proposed Rule RIA assessment. Although the metric values were switched for all monitors included in the analysis and reprocessed accordingly, the initial monitor selection was not repeated using the different metric. Thus, in some isolated instances, a monitor utilized for the Proposed Rule RIA was not the monitor with the county highest second maximum monthly average (though it was the one with the county highest maximum monthly average). For the Final Rule Analysis, the identification of monitors with maximum second monthly means was corrected; accordingly, some of the monitors in this analysis differ from those used in the Proposed Rule Analysis.

- Background lead
- Miscellaneous, re-entrained dust
- Emissions from area non-point sources
- Indirect fugitive emissions from active industrial sites
- Direct point source emissions[5]

After allocating a portion of the observed lead concentration for each monitor area to the first three categories listed above, the assessment tool apportions the remaining concentration among all inventoried point sources within ten kilometers of each monitor location.[6] Once the tool has determined the contribution of each point source to the observed lead concentration, it is then possible to determine how the application of pollution controls to individual point sources translates into changes in the observed lead concentration for each monitor area. To apportion the ambient lead concentration for each monitor area to the five categories presented above, the air quality assessment tool employs the following approach:

Step 1: Estimate baseline air quality value. Drawing from the 2003-2005 Pb-TSP NAAQS-review database, the air quality assessment tool records the second maximum monthly mean ambient lead concentration for the 21 monitor locations where this concentration exceeds 0.1 $\mu g/m^3$, the most stringent of the NAAQS alternatives considered in this document. These concentrations, adjusted for the expected implementation of MACT controls implemented after 2002, $PM_{2.5}$ NAAQS controls included as part of the illustrative $PM_{2.5}$ control strategy described in the $PM_{2.5}$ NAAQS RIA,[7] and the controls listed in the 2007 Missouri Lead SIP revisions, serve as the baseline air quality values for this analysis.[8]

For the final rule, the specification of baseline air quality values differs from the proposed rule in two ways:

1. First, in some areas, monitor geo-coordinates and ambient lead concentration data were adjusted to reflect the air quality monitor with the limiting value for the alternative NAAQS form of second maximum monthly Pb-TSP average. For the Proposed Rule analysis, we incorrectly used the geo-coordinates and ambient lead

[5] For the purposes of this analysis, airports servicing piston-engine aircraft that use leaded aviation gasoline are treated as point sources. The volume of avgas produced in the U.S. in 2002 was 6,682 thousand barrels or 280,644,000 gallons. This information is provided by the DOE Energy Information Administration. Fuel production volume data obtained from http://tonto.eia.doe.gov/dnav/pet/hist/mgaupus1A.htm accessed November 2006.

[6] Note that although the air quality assessment tool distinguishes between the portion of the observed lead concentration attributable to point source emissions and that attributable to indirect fugitive emissions from active point sources, this analysis assumes that the two contributions are directly related, and any reduction in the air quality impact of point source emissions would produce a corresponding reduction in the air quality impact of indirect fugitive emissions from point sources in that monitor area. The process used to relate the contributions of these two categories is described in further detail below.

[7] U.S. Environmental Protection Agency. *Regulatory Impact Analysis: 2006 National Ambient Air Quality Standards for Particle Pollution*. October 2006.

[8] Note also that to estimate the value of the point source influence factor described above, the air quality assessment tool uses lead concentration data from 2003 through 2005 and lead emissions data for 2002. Ideally, this factor would be estimated based on concentration and emissions data for the same time period.

concentration data from the monitor in each geographic area of analysis with the highest maximum monthly Pb-TSP average, rather than the monitor with the highest *second* maximum monthly Pb-TSP average. In most areas, the limiting monitor was the same for both NAAQS forms, but in three monitor areas (Jefferson County, MO, Sullivan County, TN, and Dallas County, TX), the air quality monitor changed. Where the monitor location changed, the set of sources with emissions affecting each monitor area also changed to reflect the new range of influence surrounding the new monitor locations.

2. Secondly, because the 0.05 $\mu g/m^3$ standard examined in the proposed rule RIA is not considered in this analysis, monitors with lead concentrations exceeding only that standard (i.e., monitors with second maximum monthly Pb-TSP averages between 0.05 $\mu g/m^3$ and 0.1 $\mu g/m^3$) are excluded from the analysis. Thus, the number of monitor locations analyzed has therefore decreased from 36 in the proposed rule RIA to 21 in this analysis.

***MACT controls*:** For most point sources, lead emissions as specified in the 2002 National Emissions Inventory (NEI) served as the base case emissions for our 2016 analysis; as with the $PM_{2.5}$ NAAQS RIA and ozone RIA, no growth factors were applied to the 2002 NEI emissions estimates for industrial sources to generate our emissions estimates for 2016. In general, lead emissions from these source categories are trending downward over time due to various factors including lack of growth in particular industrial sectors, implementation of alternative lower-emitting production practices at facilities, and/or recent regulations coming into effect. However, where possible, we adjusted the 2002 NEI lead emissions values to reflect the estimated control efficiency of MACT standards with post-2002 compliance deadlines, because the 2002 NEI would not reflect the impact of those controls reasonably anticipated to be in place by 2016.

We identified 41 existing MACT rules with post-2002 compliance deadlines that affect sources included in this analysis. Of these, we focused on rules affecting the 20 industries responsible for the largest lead emissions according to the 2002 NEI. Ideally, we would apply control efficiency data for each of these rules to the 2002 lead emissions estimates for the corresponding emissions sources. Consulting Federal Register documentation for these rules, as well as EPA's internal MACT rule summary data, we were able to identify control efficiency information for just nine of these rules. The sources affected by these nine rules, however, represent 78 percent of the lead emissions from sources affected by MACT rules with post-2002 compliance deadlines. For three of these rules, EPA expects no incremental reduction in lead emissions. For two of these rules (integrated iron & steel and pressed & blown glass), the control efficiency information that we identified is specific to metal Hazardous Air Pollutants (HAPs, e.g., lead). For the remaining four rules, we obtained information on their overall HAP control efficiency from the Federal Register and from EPA's internal MACT summary data. Table 3-1 summarizes the control efficiencies found for each of the nine MACT rules with available control efficiency data. Due to the uncertainty that future MACT rules may cover sources of Pb emissions, this analysis does not assume the promulgation of future MACT rules.

***$PM_{2.5}$ NAAQS controls*:** In addition to adjustments for MACT rules, we also adjusted the 2002 NEI emissions estimates to account for compliance measures required by the

September 2006 revision to the $PM_{2.5}$ NAAQS included as part of the illustrative $PM_{2.5}$ control strategy described in the $PM_{2.5}$ NAAQS RIA. Because EPA expects PM emissions controls to be implemented at certain of these sources in order to reach attainment with the $PM_{2.5}$ standard, we incorporated them into the base case emissions values used in our analysis.

Table 3-1.
CONTROL EFFICIENCIES FOR POST-2002 MACT RULES AFFECTING SOURCES OF LEAD EMISSIONS

MACT Rule	Data Source	Control Efficiency	Observed Pollutant
Integrated Iron and Steel Manufacturing	1	65.4%	Metal HAP
Iron and Steel Foundries	2,3	36.5%	HAP
Petroleum Refineries	4	86.6%	HAP
Secondary Aluminum Production	4	68.6%	HAP
Industrial/Commercial/Institutional Boilers & Heaters – Coal	4	33.3%	HAP
Pressed and Blown Glass and Glassware Manufacturing	5	97.6%	Metal HAP
Primary Nonferrous Metals – Zinc, Cadmium, and Beryllium	6	0%	N/A
Secondary Nonferrous Metals	5	0%	N/A
Primary Copper Smelting	6	0%	N/A

Key to Data sources:
1. Economic Impact Analysis of Final Integrated Iron and Steel NESHAP, Center for Regulatory Economics and Policy Research, September 2002
2. 67 FR 78273
3. Economic Impact Analysis of Final Iron and Steel Foundries NESHAP, RTI International, August 2003
4. EPA's internal MACT summary data
5. 72 FR 73179
6. 72 FR 2929

Of the 21 lead monitor areas considered in this RIA, five are located in counties predicted to be in nonattainment with the revised $PM_{2.5}$ standard in 2016, as specified in the $PM_{2.5}$ NAAQS RIA. For 20 point sources in these areas, EPA identified PM controls from the control technology database used in the controls and cost analysis for the PM NAAQS RIA. The controls anticipated to be applied consisted of fabric filters (with a 99 percent expected control efficiency), upgrades to electrostatic precipitators (67 percent), and the installation of capture hoods vented to a baghouse (85 percent). For each source with controls identified in the PM NAAQS RIA, we applied the control efficiency for the appropriate control technology to its 2002 NEI emissions to produce the new, PM NAAQS-adjusted baseline emissions for that source. For this analysis, we assume that these expected control efficiencies will remain constant throughout the relevant time period.

Step 2: Estimate background lead concentration: EPA estimates that the average background lead concentration is so small (0.0005 $\mu g/m^3$) as to be irrelevant for the purposes of this analysis. Given the resolution of the lead monitoring devices supporting this analysis, the air quality assessment tool assumes that background lead concentrations have no measurable contribution to violations at the design value monitors. However, given the nature of the

conducted analysis for estimating "miscellaneous re-entrained dust" (see Step 3 below), background concentrations are, in fact, encompassed in that category.

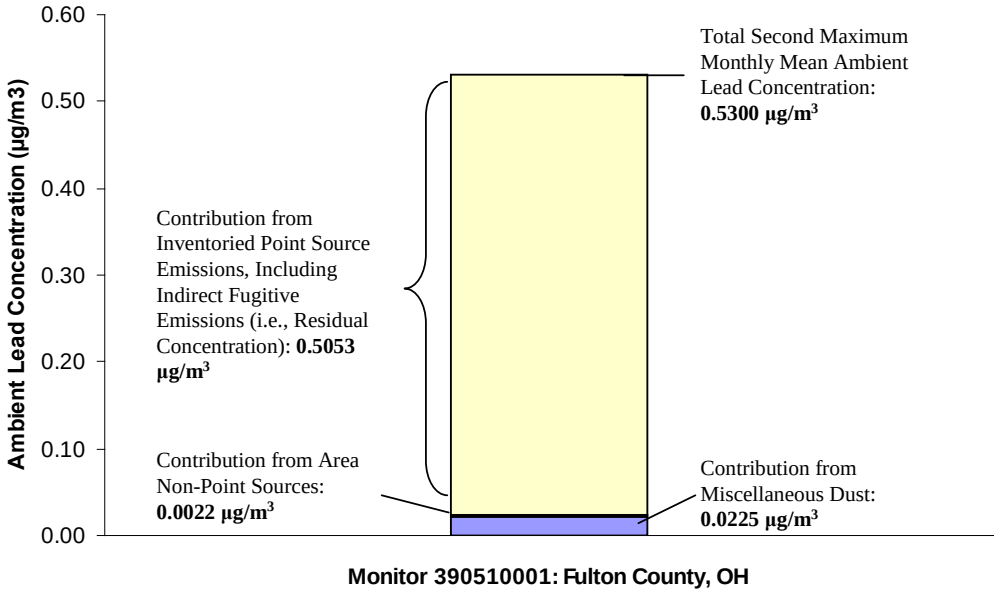
Step 3: Estimate the contribution of miscellaneous re-entrained dust. Although the lead emissions constituting the miscellaneous re-entrained dust category are of uncertain origin, they are believed to encompass 1) re-entrained dust emitted from past stationary and past mobile sources (e.g., leaded gas), including the contribution from transport; and 2) dust emitted from demolition, construction, and/or sandblasting activities, and 3) uninventoried mobile-related emissions (e.g., from Pb wheel weights, brake wear and trace Pb from gas/diesel and lube oil consumption) . Rather than estimating the site-by-site contribution of miscellaneous re-entrained dust, the air quality assessment tool applies a national estimate of the central tendency of the contribution of miscellaneous re-entrained dust to ambient lead concentrations. EPA developed this national estimate by evaluating data from ambient TSP monitors with a negligible impact from NEI lead emission sources. For the purposes of this analysis, EPA defines "negligible impact" to mean that NEI point and non-point lead-emitting sources, with associated fugitive emissions, have no contribution to the measured ambient lead concentration. Accordingly, EPA judged the ambient lead concentration measured at these TSP monitors to be entirely due to miscellaneous re-entrained dust.

Of the 189 sites included in the 2003-2005 TSP NAAQS-review database, EPA deemed 90 sites to have negligible impact from active sources based on two criteria: 1) each site was not identified as "source oriented" in previous EPA analysis; and 2) each site had cumulative point and area non-point emissions of 0.01 tons per year or less within a one-mile radius of the monitor.[9] As a central tendency of the contribution of miscellaneous, re-entrained dust, EPA found the median ambient lead concentration at these sites to be 0.0225 :g/m^3. Although this represents the average concentration at the national level, actual concentrations associated with miscellaneous re-entrained dust may vary by area. Nevertheless, in general this value typically represents a small portion of the baseline concentration at each monitor, as indicated by Figure 3-1, which illustrates the composition of the baseline lead concentration at the Fulton County, Ohio monitor.

Step 4: Estimate the contribution of area nonpoint sources. A portion of observed lead concentrations results from emissions from area non-point sources (e.g., households). The air quality assessment tool estimates the contribution of lead-emitting area non-point sources to ambient lead concentrations based on data from the 2002 area non-point lead emission inventory. This inventory is generally summarized at the county level, and EPA assumes that each county's area non-point emissions were uniformly distributed within each county. Based on this assumption, the air quality assessment tool also assumes that the extent to which area non-point sources contribute to ambient lead concentrations is proportional to the ratio of county-level area non-point lead emissions to total county-level lead emissions. Because this ratio differs by county, the area non-point source contribution to ambient lead concentrations also differs for each monitor site, but it generally composes a small portion of the overall concentration, as illustrated by the Fulton County, Ohio example in Figure 3-1.

[9] Sites classified as source oriented in previous EPA analysis were identified via a reference list used in EPA Trends Report analyses. This list encompasses 119 sources and was last updated in 2003.

Figure 3-1.
APPORTIONMENT OF THE BASELINE SECOND MAXIMUM MONTHLY MEAN LEAD CONCENTRATION AMONG SOURCE CATEGORIES IN FULTON COUNTY, OHIO



Step 5: Estimate the residual concentration after removing the contributions of miscellaneous re-entrained dust and area non-point source emissions. Based on the results of the four previous steps, the air quality assessment tool estimates the intermediate remaining second maximum monthly mean lead concentration (hereafter, "residual concentration") by subtracting the contributions of miscellaneous re-entrained dust and area non-point source emissions from the baseline air quality value. The residual concentration represents the total concentration fraction associated with emissions from inventoried point sources and indirect fugitive emissions from industrial sites. In the case of Fulton County, Ohio, the residual concentration is 0.5053 :g/m^3, or the baseline concentration of 0.5300 :g/m^3 less the 0.0225 :g/m^3 and 0.0022 :g/m^3 concentration fractions associated with miscellaneous dust and area non-point sources, respectively.

Step 6: Determine the contribution of each inventoried point source to the ambient lead concentration at each monitor, accounting for indirect fugitive emissions from nearby active industrial sites. For each monitor area, the air quality assessment tool attributes the residual concentration derived in Step 5 to each point source according to its lead emissions as well as its distance from the monitor. After weighting each source's emissions according to its distance from the monitor and applying an adjustment to account for the impact of indirect fugitive emissions, the air quality assessment tool then estimates the total contribution of each source to the ambient lead concentration at the nearest monitor. We describe this approach in more detail below.

Step 6.1: Weight the emissions from each source by its distance from the monitor.

To account for the fact that, all else equal, lead emissions closer to the monitor have a greater impact on ambient lead concentrations, the tool assumes that each source's contribution to the concentration is proportional to its share of the total distance-weighted point source emissions for the monitor area. [Note that the tool does not contain data sufficient to assess the influence of other factors, such as stackheight and local meteorological conditions, that could affect the relative contribution of each point source to monitored Pb concentrations.]

For each source, the tool calculates distance-weighted emissions using the following equation:

(Equation 3-1) $$DWE_S = \frac{E_S}{D_S^{3/2}}$$

where:

- DWE_S = Distance-weighted 2002 NEI emissions for source *S*,
- E_S = 2002 NEI emissions for source *S*, and
- D_S = Distance between source *S* and the monitor location.

Step 6.2: Adjust the distance-weighted emissions to incorporate the impacts of indirect fugitive emissions.

After calculating the distance-weighted emissions for each source, the air quality assessment tool applies an additional adjustment to account for indirect fugitive emissions from active industrial sites near each monitor.[10] These indirect fugitive emissions are thought to result from materials handling and on-site activities that re-entrain previously deposited lead-containing dust. Unlike area non-point source emissions, indirect fugitive emissions are linked to point sources and are not captured in the 2002 NEI. Indirect fugitive emissions, however, do not include fugitives associated with industrial processes at point sources, as these direct, process-based fugitive emissions are reflected in the 2002 NEI point source inventory. Relative to point source emissions, fugitive emissions tend to consist of coarser particles that are emitted closer to the ground and are therefore assumed to have a more localized effect on ambient air

[10] Airport emissions are also reflected in the residual concentration. For the purposes of this analysis, airports are treated as point sources, although as discussed further in chapter 4, no controls are applied to airports.

quality. Reflecting this consideration, the air quality assessment tool assumes that only indirect fugitive emissions from sources within one mile of the monitor would have an impact on the monitor reading, and even then only in situations where the cumulative emissions of such nearby sources are "significant" (i.e., typically where the aggregate 1-mile radius point source emissions are greater than one ton).

To estimate the extent to which indirect fugitive emissions contribute to ambient lead concentrations near active industrial sites, EPA conducted a study of nine sites where previously active lead-emitting sources had ceased or paused production. Assuming that activities conducive to re-entrainment continue for a short period after production had ceased, EPA compared ambient lead concentrations before and after these production stoppages. After subtracting the contribution from un-inventoried miscellaneous dust (as in Step 3 above) and from area non-point sources (as in Step 4 above), EPA found that the average post-stoppage lead concentration represented approximately 15 percent of the average pre-stoppage concentration. For this analysis, therefore, EPA assumes that the contribution of indirect fugitive emissions from active industrial sites within one mile of the lead monitors represents approximately 15 percent of the total contribution attributable to these sources.

The air quality assessment tool estimates contribution of indirect fugitive emissions to observed lead concentrations as follows:

- First EPA identified large sources within one mile of the monitor location that were expected to have indirect fugitive emissions that would affect the monitor's air quality reading.

- For each identified source, EPA adjusted its distance-weighted emissions to account for the additional fugitive emissions emanating from that source. Reflecting the results of the analysis described above, EPA adjusted sources with indirect fugitive emissions by multiplying their distance-weighted emissions by 20/17, or 117.65 percent.[11]

For all sources, the air quality assessment tool applies the adjustment for indirect fugitive emissions using the following equation:

(Equation 3-2) $$fDWE_S = DWE_S \cdot \left(1 + f_S \cdot {}^{3}\!/\!_{17}\right)$$

where:

- $fDWE_S$ = Distance-weighted 2002 NEI emissions for source *S*, adjusted to account for indirect fugitive emissions,
- DWE_S = Distance-weighted 2002 NEI emissions for source *S*,

[11] As stated above, EPA estimates that 15 percent of the total contribution from active industrial sites within one mile of lead monitors is attributable to indirect fugitive emissions. Accordingly, 85 percent of the total contribution from these sites is attributable to direct emissions. The ratio of the total contribution from these sources to the contribution from direct emissions is therefore 100/85, or 20/17.

- f_S = Indicator for whether a source has indirect fugitive emissions affecting the monitor (assigned a value of 1 if a source is within one mile of the monitor and has indirect fugitive emissions, and 0 otherwise).

Step 6.3: Estimate contribution of each source to ambient lead concentrations based on fugitive-adjusted distance-weighted emissions.

After calculating the distance-weighted emissions for each source using Equation 3-1 and incorporating the impacts of indirect fugitive emissions using Equation 3-2, the air quality assessment tool estimates each source's contribution to the ambient lead concentration as follows:

(Equation 3-3) $$C_S = C_P \cdot \frac{fDWE_S}{fDWE_P}$$

where:

- C_S = The portion of that monitor area's ambient lead concentration attributable to source *S*,
- C_P = Total contribution of point source emissions (and associated industrial fugitives) to the ambient lead concentration (i.e., the remaining concentration after subtracting background and area source contributions from the baseline air quality value),
- $fDWE_S$ = Fugitive-adjusted, distance-weighted 2002 NEI emissions for source *S*, and
- $fDWE_P$ = Sum of fugitive-adjusted, distance-weighted 2002 NEI emissions for all point sources in the monitor area.

Continuing with the Fulton County, Ohio example presented in Figure 3-1, Table 3-2 illustrates the process by which the contribution of each point source in Fulton County is apportioned based on its emissions and distance from the monitor location. Note that the source contribution from Source B is several orders of magnitude larger than the source contribution from Source A, even though lead emissions from Source B are only twice those from Source A.

Table 3-2.
APPORTIONMENT OF THE TOTAL POINT SOURCE CONTRIBUTION TO THE AMBIENT LEAD CONCENTRATION AMONG INVENTORIED POINT SOURCES IN FULTON COUNTY, OHIO

Monitor Location	**Fulton County, OH**	
Total Point Source Contribution to Ambient Lead Concentration (:g/m^3) **[C_P]**	0.5053	
Source	Source A	Source B
2002 NEI Emissions (tpy) **[E_S]**	0.1500	0.338
Distance from Monitor to Source (km) **[D_S]**	3.4707	0.0554
2002 NEI Distance-Weighted Emissions (tpy/$km^{3/2}$) **[DWE_S]**	0.0232	25.8982
Fugitive Emissions Affect Monitor? **[f_S]**[1]	No	Yes
Distance-Weighted Emissions with Fugitive Adjustment (tpy/$km^{3/2}$) **[$fDWE_S$]**	0.0232	30.4685
Total Distance-Weighted Emissions (tpy/$km^{3/2}$) **[$fDWE_P$]**	30.4917	
Share of Total Distance-Weighted Emissions **[$fDWE_S$ / $fDWE_P$]**	0.0761%	99.9239%
Source Contribution to ambient lead concentration (:g/m^3) **[$C_S = C_P * fDWE_S/fDWE_P$]**	0.0004	0.5049

[1] "No" and "Yes" in this row correspond to values of 0 and 1 for f_S, respectively, as defined in Equation 3-2.

In this analysis, airports were treated as point sources. Currently, there are 3,410 aviation facilities in the NEI of which, 24 are included in this analysis due to their proximity to one of the 24 monitors that were identified using the criteria described in Section 3.1. Among the 21 monitors in this analysis, there are 18 monitors with at least one airport located within ten kilometers of the monitor (six monitors have two airport facilities within ten kilometers). This analysis estimates that the contribution of leaded aviation gasoline to lead measured at the monitors ranges from 0.00002 to 0.047 :g/m^3. There are currently no TSP lead monitors located within one mile of an airport servicing aircraft that operate on leaded aviation gasoline. In addition to the 24 airport facilities within ten kilometers of the monitors in this analysis, there are heliport and airport facilities where piston-engine aircraft might operate that are not currently in the NEI and for which we do not currently have lead emissions estimates.[12]

[12] Memo to the RIA Docket -HQ-OAR-2008-0253 Titled 'Small airport facilities within ten kilometers of monitors in the Lead Regulatory Impact Analysis that are currently missing from EPA's National Emissions Inventory' submitted by Marion Hoyer, Meredith Pedde and Bryan Manning.

3.2. Using the Air Quality Assessment Tool to Estimate Impacts of Point Source Emissions Controls

Through the process described in Chapter 4, we used a least-cost optimization model to estimate the extent to which point source lead emissions could decline under the control strategies developed for the final NAAQS and the alternative standards summarized in Chapter 1.[13] To estimate the air quality impact of these reductions, we developed a three-step process for estimating ambient lead concentrations based on the air quality assessment tool described above. This process is as follows:

1. For each alternative standard, we applied identified controls to individual point sources, according to the cost optimization model. Because the air quality assessment tool translates lead emissions to air quality impacts by applying a constant distance-weighting for each source, the percent reduction in a source's contribution to ambient lead concentrations was the same as the combined control efficiency of all emissions controls applied to that source. Based on these source-specific reductions, we estimated each point source's contribution (including the contribution from indirect fugitive emissions) to the ambient lead concentration following the implementation of emissions controls.

2. For each monitor area, we summed the individual point source contributions estimated in Step 1 to obtain the total ambient lead concentration attributable to inventoried point sources (including ambient lead associated with indirect fugitive emissions).

3. Holding the contributions from area non-point sources and miscellaneous re-entrained dust constant between the baseline and policy case, we added these to the total contribution from point sources (estimated in step 2) to yield the new estimate for the total ambient lead concentration.

[13] As described in Chapter 4, our analysis did not consider controls on lead emissions from airports. Therefore, we kept lead emissions from airports constant in both the baseline and policy scenarios.

CHAPTER 4. EMISSIONS CONTROL ANALYSIS: DESIGN AND ANALYTIC RESULTS

This chapter documents the illustrative emission control strategy we applied to simulate attainment with the selected standard and alternative standards. Section 4.1 describes the approach we followed to select cost-effective emissions controls to simulate attainment in each geographic area of analysis. Section 4.2 summarizes the emission reductions we simulated in each area based on current knowledge of emissions controls applicable to existing sources of lead emissions, while Section 4.3 presents the air quality impacts of these emissions reductions. Section 4.4 discusses the application of additional controls, beyond those already known to be available, that we estimate will be necessary to reach attainment in certain monitor areas. Section 4.5 discusses key limitations in the approach we used to estimate the optimal control strategies for each alternative standard.

4.1. Estimation of Optimal Emissions Control Strategies

Our analysis of the emissions control measures required to meet the selected standard and alternative standards is limited to controls for point source emissions at active sources inventoried in the 2002 NEI. [Note that while airports are included as point sources in the NEI, our analysis considers the impact of emissions from use of leaded aviation gasoline (avgas) at airports, but does not consider controls on those emissions as a strategy for compliance. EPA received a petition from Friends of the Earth requesting that the Agency find that aircraft lead emissions may reasonably be anticipated to endanger the public health or welfare, and to take action to control lead emissions from piston-engine aircraft. We published a Federal Register notice discussing the petition and requested comment on specific aspects of the use of leaded avgas and potential control of lead emissions from the consumption of avgas.[1]] As discussed in Chapter 3, a portion of ambient lead concentrations can be attributed not to point sources but to miscellaneous re-entrained dust and area nonpoint emissions. Nevertheless, this RIA deals only with the application of controls on emissions at active non-aviation point sources, including stack emissions and fugitive emissions from industrial processes.

[1] The petition requested that EPA find that such emissions cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare. And, if EPA makes such a finding, the petitioner requested that EPA take steps to reduce lead emissions under the authority of the Clean Air Act Section 231 Approximately 70 different parties commented on the petition and the questions presented in the notice (72 FR 64570, November 16, 2007). These comments can be found in EPA public docket OAR-2007-0294 (at www.regulations.gov). A clear theme in many of the comments was the dependence of much of the current piston-powered aircraft fleet on leaded avgas either because of engine design, performance demands, or lack of mogas availability at airports. However, several comments identified potential near and longer term measures to reduce these lead emissions. These potential measures fall into five general categories: (1) Continued work on identifying fuel blends or additives which would provide the octane and other performance characteristics needed for a transparent fuel replacement, (2) Measures to ensure greater availability of ethanol-free unleaded avgas at airports for those aircraft which otherwise could use it, (3) Laboratory and field work to assess the potential to reduce the amount of lead now added to current leaded avgas, (4) Add-on engine technology or fuel management technology to allow for equivalent engine performance at lower avgas octane ratings and (5) Long-term measures or standards for new engines which provide the needed and desired performance characteristics using modified engine designs and calibrations on fuels or fuel blends not containing lead. For more information about the petition, see http://www.epa.gov/otaq/aviation.htm.

To simulate attainment with the selected standard and the five regulatory alternatives considered in all 21 monitor areas, we first modeled the most cost-effective application of identified emissions controls in each area, using the following four-step process:

1. Specification of baseline emissions for inventoried point sources in each geographic area of analysis.

2. Identification of potential controls for inventoried point sources.

3. Identification of an alternative lead abatement strategy for the primary lead smelter in Jefferson County, Missouri.

4. Identification of the least cost strategy for using point source controls.

In areas where identified emissions controls were not sufficient to reach attainment with one or more of the alternative standards considered, we also simulated emission reductions needed beyond identified controls at inventoried point sources. Further discussion of theseunspecified emission reductions is presented in Section 4.4.

The analysis used for the Final Rule differs from that presented in the Proposed Rule RIA in the following ways:

1. We no longer remove from consideration all identified controls with a cost/ton higher than the 98th percentile of control costs at point sources emitting more than 0.05 tons/year of lead. This was described as the "Stage 3 Filter in the Proposed Rule RIA."

2. We updated control efficiency and cost information for many of the identified emission controls used in the Proposed Rule RIA, after determining that the prior values were unlikely to reflect the performance and cost of these controls in 2016, the analysis year for this RIA.

3. Rather than applying PM emission controls to the primary lead smelter in Jefferson County, Missouri, we simulated a complete rebuild of the smelter to utilize a less-polluting smelting process.

4. We modified the analysis of emission reductions needed beyond identified controls such that these reductions are distributed across all sources in areas projected to violate any alternate standard. In the Proposed Rule analysis, these reductions were achieved by controls applied to a limited number of sources.

These changes to the analysis relative to the Proposed Rule RIA are described in greater detail throughout this chapter.

4.1.1. Specification of Baseline Lead Emissions for Inventoried Point Sources in Each Geographic Area of Analysis.

For most sources, lead emissions as specified in the 2002 National Emissions Inventory (NEI) served as the baseline for our analysis. However, for some sources (e.g., natural gas-fired utility boilers), we corrected the 2002 NEI lead emissions data with updated information. As discussed

in Chapter 2, we did not apply growth factors to the 2002 NEI emissions estimates to predict emissions in 2016 (the analysis year for this RIA) because we believe that the number of Pb emitting sources will not increase with population growth. We did, however, adjust the 2002 NEI lead emissions values to reflect anticipated emissions controls necessary to comply with other regulations that have compliance deadlines after 2002, wherever possible. These adjustments included application of MACT for air toxics rules with post 2002 compliance deadlines,[2] PM controls at sources in designated nonattainment areas in the 2006 revisions to the $PM_{2.5}$ NAAQS as modeled in the illustrative control strategy in the $PM_{2.5}$ NAAQS RIA,[3] and controls planned for the primary lead smelter in Jefferson County, Missouri, as part of the 2007 Missouri lead SIP (at the one current nonattainment area for ambient lead under the Federal CAA).[4] After applying these adjustments to all affected point sources, the remaining lead emissions served as our baseline for the application of identified controls. Table 4-1 illustrates the process used to specify the baseline lead emissions for inventoried point sources in the analysis.

Table 4-1.
TOTAL BASELINE LEAD EMISSIONS FOR ALL INVENTORIED POINT SOURCES IN 23 DESIGNATED MONITOR AREAS

Original Baseline: 2002 NEI Emissions (point sources, excluding airports)	109.2 tons/year (tpy)
2002 NEI Emissions adjusted for PM NAAQS controls	109.0 tpy
2002 NEI Emissions adjusted for PM NAAQS and Missouri SIP controls	101.2 tpy
Final Baseline: 2002 NEI Emissions adjusted for PM NAAQS, Missouri SIP, and MACT controls	99.7 tpy

Following the same process as described above, we also specified baseline PM_{10} and $PM_{2.5}$ emissions for all inventoried point sources. Although the non-lead fraction of PM emissions did not play a role in simulating attainment with the selected standard and alternative standards, we did use these baseline values to estimate the ancillary benefits of co-controlling PM emissions in the process of implementing lead control strategies, as discussed in Chapter 5. Recent promulgation of mobile source rules that reduce PM is not relevant for this analysis.

4.1.2. Identification of Potential Controls for Inventoried Point Sources.

To identify point source lead emissions controls for our analysis, we collected information on PM control technologies, assuming that the control efficiency for PM emissions would also apply to lead emissions. We collected this information in the following way:

[2] The MACT standards included covered the following industries: Integrated Iron and Steel Manufacturing; Iron and Steel Foundries; Petroleum Refineries; Secondary Aluminum Production; Industrial/Commercial/Institutional Boilers & Heaters – Coal; Pressed and Blown Glass and Glassware Manufacturing; Primary Nonferrous Metals – Zinc, Cadmium, and Beryllium; Secondary Nonferrous Metals; and Primary Copper Smelting.

[3] Available at http://www.epa.gov/ttn/ecas/ria.html

[4] This lead SIP was finalized by EPA on April 14, 2006 with a requirement that this SIP will provide attainment with the current lead standard by April 7, 2008. The SIP is available at: http://www.dnr.mo.gov/env/apcp/docs/2007revision.pdf

1. We queried EPA's AirControlNET database for information on potential PM controls available for each source, accounting for any control measures already in place, according to the 2002 NEI.[5]

2. For sources with Standard Industrial Classifications (SICs) but without identified NEI Source Classification Codes (SCCs), we used the SIC/SCC crosswalk in Appendix C of AirControlNET's Documentation Report to identify SCCs for those sources.[6] We then found controls in AirControlNET's database associated with these SCCs.

3. EPA identified additional controls from technical documents prepared in support of New Source Performance Standards, EPA memos prepared to support analyses for the $PM_{2.5}$ RIA, and operating permits that apply to facilities with similar SCCs as the point sources in our analysis. These controls include the following:

   - ***Capture hoods vented to a baghouse at iron and steel mills.*** Virtually all iron and steel mills have some type of PM control measure, but there is additional equipment that could be installed to reduce emissions further. Capture hoods that route PM emissions from a blast furnace casthouse to a fabric filter can provide 80 to 90 percent additional emission reductions from an iron or steel mill.

   - ***Diesel particulate filter (for stationary sources such as diesel generators).*** This control incorporates directly-emitted $PM_{2.5}$ reductions from stationary internal combustion engines that will be affected by the compression-ignition internal combustion engine new source performance standard (NSPS) promulgated on June 28, 2006. Diesel particulate filters (DPF) are likely to be the control technology required for these engines to meet the NSPS requirements. The control is applied here as a retrofit to existing stationary internal combustion engines in our inventory. Based on the technical support documents prepared for the final compression-ignition NSPS, the $PM_{2.5}$ control efficiency for DPF is 90 percent.[7]

   - ***Upgrade of CEMs and increased monitoring frequency of PM controls (for sources where not already identified as a control by ACN).*** This control is an upgrade to existing control measures or an improvement in control efficiency due to how existing control measures operate from increases in monitoring. Such controls can lead to small reductions in PM emissions (5 to 7 percent).[8]

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[5] Documentation available at http://www.epa.gov/ttnecas1/models/DocumentationReport.pdf. AirControlNET's database of PM controls normally excludes sources emitting fewer than 10 tons/year of PM_{10}. Because many of the point sources included in our analysis fall below this threshold and because this analysis focuses entirely on obtaining emission reductions from point sources, we effectively reduced the threshold from 10 tons/year to zero in order to identify controls for a larger number of inventoried point sources.

[6] Available at http://www.epa.gov/ttnecas1/models/DocumentationReport.pdf.

[7] U.S. Environmental Protection Agency. "Emission Reduction Associated with NSPS for Stationary CI ICE." Prepared by Alpha-Gamma, Inc. June 3, 2005, and U.S. Environmental Protection Agency. "Cost per Ton for NSPS for Stationary CI ICE." Prepared by Alpha-Gamma, Inc. June 9, 2005.

[8] U.S. Environmental Protection Agency. Regulatory Impact Analysis for the Particulate Matter NAAQS. October, 2006. Appendix E, pp. E-16 to E-24. This document is available at http://www.epa.gov/ttn/ecas/regdata/RIAs/Appendix%20E--Controls%20List.pdf.

4. In response to the degree of residual nonattainment found in a number of monitor areas in the Proposed Rule analysis, we reviewed the PM control measures in our databases in order to determine if the data for these measures were fully up to date and appropriate for an analysis year of 2016. In the course of our review, we found that the control efficiencies for a variety of PM control measures as applied in our proposal RIA were quite conservative (i.e., more likely to be underestimates than overestimates) for control strategy analyses to be conducted for 2016. A number of recent EPA references provided findings that showed that increases in PM control efficiencies from those applied in our proposal RIA were reasonable for a future year analysis. Based on these findings, we increased the control efficiencies and costs for a number of the PM control measures in our database, as summarized below:[9]

   - ***Dry and Wet ESPs:*** Control efficiency modified from 95 percent to 99 percent.

   - ***Fabric Filters (pulse jet type and mechanical shaker type):*** Control efficiency modified from 99.5 percent to 99.9 percent.

   - ***Venturi Scrubbers:*** For those source classification codes (SCCs) to which AirControlNET applies a control efficiency of 50 percent, we modified this value to 90 percent for the 2016 target year. For SCCs, where the control efficiency in AirControlNET is 25 percent, we adjusted this value to 70 percent.

   - ***Paper/Nonwoven Filters – Cartridge Collectors:*** The AirControlNET control efficiency value of 99 percent was modified to 99.5 percent.

Completion of the procedure outlined above yielded identified controls for about 43 percent of the total inventoried point sources in our analysis. However, because of the skewed distribution of lead emissions in the 2002 NEI (the top 10 percent of inventoried point sources account for more than 97 percent of total lead emissions), these sources accounted for approximately 92 percent of total lead emissions, as shown in Table 4-2.

Table 4-2.
PROFILE OF INVENTORIED POINT SOURCES, WITH AND WITHOUT IDENTIFIED CONTROLS

	Count	**Percent of Total**	**Emissions (tons/year)**	**Percent of Total**
Sources with Identified Controls[1]	266	42.6%	91.8	92.1%
Sources without Identified Controls	359	57.4%	7.9	7.9%
Total	**625**	**100.0%**	**99.7**	**100.0%**

[1] Identified controls, as represented in this table, include the potential rebuild of the primary lead smelter in Jefferson County, MO, as described in greater detail below. Therefore, all emissions sources at this facility are included in this table as sources with identified controls.

[9] PM control efficiencies were increased for the following control measures: dry and wet ESPs, all types of fabric filters, venturi scrubbers, impingement-plate/tray-tower scrubbers, and paper/nonwoven filters - cartridge collectors. We also revised the capital and annualized costs for these control devices to reflect the increased control efficiencies associated with these control measures, as discussed in Chapter 6.

Controls identified through this process include major emissions controls, such as fabric filters, impingement-plate scrubbers, and electrostatic precipitators; and minor controls, such as increased monitoring frequency, upgrades to continuous emissions monitors, and diesel particulate filters. For each identified control, we identified both the expected control efficiency for the technology and the annualized cost of installing and operating the control.[10] For those point sources where the 2002 NEI indicated that control measures were already in place, we estimated the effective emissions control efficiency for each identified control by estimating the emissions reductions that would result if the pre-existing control were replaced by the identified control technology. For example, while a fabric filter might have an expected control efficiency of 90 percent when installed in the absence of pre-existing controls, if it were applied at a source that already had an electrostatic precipitator with an 80 percent control efficiency, the *effective* control efficiency of the Fabric Filter would be 50 percent.[11] We also assumed that each identified control technology would be installed in addition to any controls required under the 2006 $PM_{2.5}$ NAAQS and any MACT rules with enforcement dates after 2002, but before 2016. We therefore applied each control's effective control efficiency to the adjusted baseline lead emissions at each inventoried point source.[12]

4.1.3. Identification of an Alternative Lead Abatement Strategy for the Primary Lead Smelter in Jefferson County, Missouri.

In the Proposed Rule analysis, a significant portion of the estimated costs of the rule—ranging from 55 percent for the 0.05 $\mu g/m^3$ standard alternative to 95 percent for the 0.3 $\mu g/m^3$ standard alternative - represented reductions beyond identified controls at the primary lead smelter in Jefferson County, Missouri. To reduce the extent to which the costs and emissions reductions associated with the lead NAAQS depend on reductions beyond identified controls for a single source, we have modeled the replacement of the primary lead smelter in Jefferson County with a more modern, lower-emitting smelter, utilizing the Kivcet smelting process, as a means of reducing the facility's lead emissions. The Kivcet process is currently employed at the primary lead smelter operated by Teck Cominco in Trail, British Columbia, as well as in plants in Kazakhstan, Bolivia, and Italy.[13] While it may be more cost-effective for the facility to implement more targeted emissions controls under the selected standard, information on such controls is not available.

To estimate the emissions reductions associated with transitioning to Kivcet technology at the smelter in Jefferson County, we relied on emissions data for Teck Cominco's Trail, British Columbia, facility, which began using the Kivcet process in 1997. We derived lead emissions per ton of lead produced at this facility by obtaining lead emission values from Canada's

[10] See Chapter 6 for a detailed discussion of how annualized control costs were estimated.

[11] With the electrostatic precipitator, 20 percent of the source's original, uncontrolled emissions would remain uncontrolled, but with the fabric filter, only 10 percent of the source's original emissions would remain uncontrolled. Thus, replacing the electrostatic precipitator with the fabric filter would represent a 50 percent (10/20 = 0.5) decrease in uncontrolled emissions.

[12] The one exception to this assumption is the installation of capture hoods vented to baghouses, a control included at some sites as part of the control strategies applied for the 2006 $PM_{2.5}$ revised NAAQS RIA. Because baghouses are major controls which would be replaced by the installation of any other major control, we applied the effective control efficiency of major controls to the *unadjusted* baseline emissions at any site with a capture hood installed.

[13] The Eastern Mining and Metallurgical Research Institute for Non-Ferrous Metals, Pyrometallurgy. http://vcm.ukg.kz/eng/v3_6.htm. Accessed September 23, 2008.

National Pollutant Release Inventory (NPRI)[14] and annual lead production values from Teck Cominco's annual reports. Taking the average value for the past five years for which NPRI data are available, we estimated that the Trail, BC, facility emits 0.07 pounds of lead for every ton of lead produced using its Kivcet smelter. Applying this emissions rate to the facility in Jefferson County, which produced 150,000 thousand tons of lead in 2002, we estimate lead emissions of 5.50 tons per year for this facility.[15] This represents an 89 percent reduction in lead emissions relative to the facility's baseline emissions of 51 tons per year. When modeling this lead emissions control strategy, we divided these reductions among the emissions sources at the Jefferson County primary lead smelter in proportion to each source's 2002 NEI emissions.

4.1.4. Identification of the Optimal Strategy for Using Point Source Controls to Reach Attainment in Each Area.

To identify the least-cost approach for reaching attainment in each area projected to violate the NAAQS, EPA developed a linear programming optimization model that systematically evaluates the air quality and cost information discussed below and in Chapter 6 to find the optimal control strategy for each area. The optimization model first identifies the measures that each source would implement if it were controlled as part of a local lead attainment strategy. Based on these controls, the optimization model then identifies sources to control such that each area would reach attainment at the least aggregate cost possible for the area. Minimizing total costs across all sources is not always equivalent to minimizing marginal costs at each source. Therefore, although the model selects major controls for each source by minimizing the marginal cost/ton of lead controlled at the source, the objective for each area is to minimize total costs associated with reaching attainment. It should be noted that unlike major controls, all minor controls identified can be implemented in conjunction with other controls, so the optimization model selects all minor controls as well.

Rather than considering all emissions controls at every inventoried point source, the optimization model utilizes a two-stage filtering process to select only the most cost-effective controls at sources making a significant impact on ambient air quality. The stages are as follows:

1. ***Stage 1 filter:*** First, the model selects all controls at sources deemed "relevant" by virtue of the fact that they account for at least 0.001 percent of all point source contributions to the ambient lead concentration in their monitor area. This stage mostly affects monitor areas with large numbers of inventoried point sources, such as Dakota County, Minnesota, where 105 out of 126 inventoried sources do not meet the 0.001 percent threshold.

2. ***Stage 2 filter:*** Because we identified multiple major emissions controls for many sources, the second stage of the model assumes that the most cost-effective major control for each relevant source would be installed, as determined by the cost/ton of lead emissions reduced. For example, consider a source that could install either an electrostatic precipitator (ESP) that would reduce lead emissions by 0.1 tons/year with an annualized cost of $1 million or a

[14] Available at http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm. Communication with David Niemi, Head Emissions Inventory Reporting and Outreach at Environment Canada, confirmed that the methods used to collect the NPRI were comparable to the methods used to collect the NEI.

[15] The estimate of 2002 lead production at this smelter comes from The Doe Run Company, Primary Mining and Smelting Division, *2002 Annual Report to our Community.*

fabric filter that would reduce lead emissions by 0.11 tons/year at a cost of $2 million/year. Because the cost/ton is lower for the ESP, the optimization model assumes that the source would (potentially) install the ESP rather than the fabric filter.[16]

In the Proposed Rule RIA, we implemented a third filter, in which we removed from consideration all point source controls with a cost/ton higher than the 98th percentile of control costs at point sources emitting more than 0.05 tons/year of lead. For this analysis, we have eliminated that filter, in order to maximize the emission reductions achieved with identified controls.

After selecting the most cost-effective emissions controls at all relevant point sources for each monitor area, the model then proceeds to evaluate every possible combination of control technologies until the monitor area reaches attainment with the selected standard or alternative standard at the lowest possible cost. If the monitor area is already in attainment with the selected standard, the model applies no controls. On the other hand, if the monitor area is unable to reach attainment with the selected standard when all cost-effective controls at relevant sources are applied, then the model assumes that all sources in the area are controlled, including those that account for less than 0.001 percent of point source contributions in the area (i.e., the model eliminates the stage 1 filter described above and thus applies controls to smaller sources).

As indicated above, this approach is not the equivalent of moving up the marginal abatement cost curve for lead. If the control strategy were selected based on the marginal cost per $\mu g/m^3$ reduced, we would not necessarily identify the least-cost strategy for attainment in each area.

4.2. Lead Emissions Reductions Achieved with each Control Strategy

Utilizing the optimization model described above, we determined the most cost-effective control strategies required to meet attainment at the largest number of monitor areas.[17] Table 4-3 presents the lead emissions reductions realized at each monitor area under the control strategies followed for each alternative standard.

4.3. Impacts Using Identified Controls

Following the steps described in Section 3.2, we estimated the overall change in ambient air quality achieved as a result of each of the control strategies identified in the AirControlNET-based emissions analysis. Table 4-4 presents a detailed breakdown of the estimated ambient lead

[16] If there are two available control options, the least-cost approach chooses the option with a lower cost/ton. It does this even if a slightly more expensive control option can achieve greater emission reduction. Although in theory this filter could cause some emission reduction to be missed, in practice, the impact is negligible. For example, in the simulation of attainment with the 0.1 $\mu g/m^3$ standard, removal of this filter increases the emission reduction by less than 0.0001 tons per year.

[17] As will be discussed below, the application of identified controls was insufficient to bring all monitor areas into compliance with the selected standard and the alternative standards.

concentrations in 2016 at each of the 21 monitor sites under the selected standard and the five alternative standards described in Chapter 1.

According to the data presented in Table 4-4, 13 of the 21 monitor areas are expected to reach attainment with the selected standard of 0.15 $\mu g/m^3$ following implementation of the controls identified in the AirControlNET analysis (i.e., identified controls). In addition, 20 areas are expected to reach attainment with identified controls under a NAAQS of 0.5 or 0.4 $\mu g/m^3$. For the most stringent alternative considered, 0.1 $\mu g/m^3$, 9 of the 21 monitors are expected to reach attainment following the application of identified controls. For some areas, identified controls are not sufficient to reach attainment with the selected standard.

The failure of certain areas to reach attainment with identified controls partially reflects the lack of control information for point sources in these areas. As indicated in Table 4-5, emissions from sources for which the AirControlNET analysis identified no controls contribute to a significant portion of the ambient lead concentration in many of the areas not projected to reach attainment with the selected standard and four alternative standards. For such sources in areas projected to violate the NAAQS with the application of identified controls, we assume that emission reductions beyond identified controls will be applied, as discussed further below.

Table 4-6 presents the additional air quality change needed for monitor areas that did not attain at least one of the alternative standards analyzed in this RIA. In addition, Figure 1 presents the additional air quality improvement needed in each monitor area that did not attain the 0.15 ug/m3 selected standard with the application of identified controls. This figure illustrates that the progress made through the application of identified controls varies greatly by monitor area.

FIGURE 1.
AIR QUALITY CHANGE ACHIEVED THROUGH APPLICATION OF IDENTIFIED CONTROLS AND ADDITIONAL INCREMENT NEEDED TO REACH ATTAINMENT OF SELECTED STANDARD 0.15 UG/M3

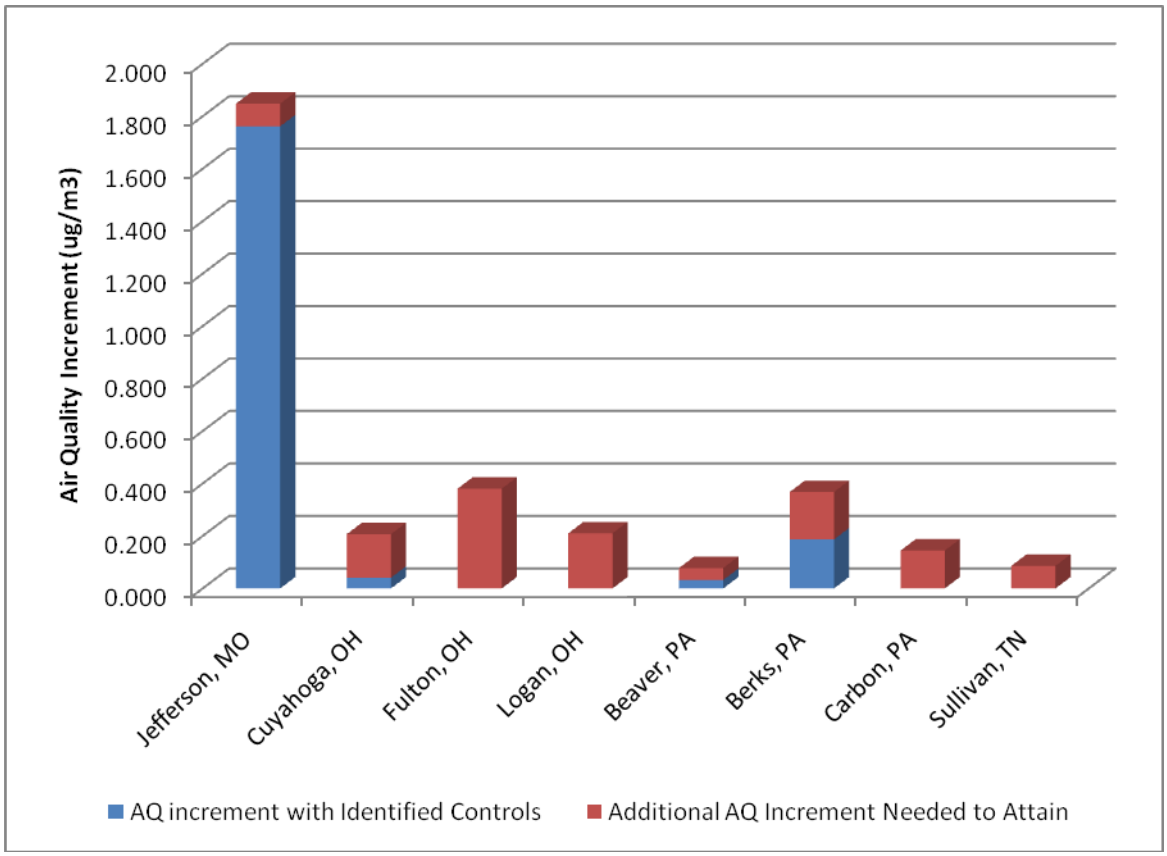


TABLE 4-3.
REDUCTION IN LEAD EMISSIONS UNDER ALTERNATIVE NAAQS AT EACH MONITOR AREA, IDENTIFIED CONTROLS ONLY

Monitor State	Monitor County	Baseline Lead Emissions in 2016	Reduction in Lead Emissions (tpy)					
			Standard Alternative: 0.5 $\mu g/m^3$ 2nd Maximum Monthly Mean	Standard Alternative: 0.4 $\mu g/m^3$ 2nd Maximum Monthly Mean	Standard Alternative: 0.3 $\mu g/m^3$ 2nd Maximum Monthly Mean	Standard Alternative: 0.2 $\mu g/m^3$ 2nd Maximum Monthly Mean	Selected Standard: 0.15 $\mu g/m^3$ 2nd Maximum Monthly Mean	Standard Alternative: 0.1 $\mu g/m^3$ 2nd Maximum Monthly Mean
AL	Pike	4.45	4.02	4.02	4.02	4.13	4.31	4.31
CO	El Paso	0.95	0.00	0.00	0.00	0.00	0.00	0.00*
FL	Hillsborough	1.48	1.00	1.00	1.09	1.19	1.19	1.26
IL	Madison	0.53	0.00	0.00	0.00	0.00	0.00	0.09*
IN	Delaware	1.53	1.37	1.37	1.40	1.42	1.44	1.46
MN	Dakota	3.55	0.00	0.00	0.00	0.00	1.29	3.07
MO	Iron	16.12	12.26	12.26	12.26	12.26	12.26	12.26
MO	Jefferson	51.02	45.52	45.52	45.52	45.52*	45.52*	45.52*
NY	Orange	1.80	0.00	0.00	0.00	1.39	1.39	1.39
OH	Cuyahoga	0.94	0.00	0.00	0.13*	0.13*	0.13*	0.13*
OH	Fulton	0.49	0.14*	0.14*	0.14*	0.14*	0.14*	0.14*
OH	Logan	0.12	0.00	0.00	0.00*	0.00*	0.00*	0.00*
OK	Ottawa	0.00	0.00	0.00	0.00	0.00	0.00	0.00*
PA	Beaver	4.28	0.00	0.00	0.00	0.64	0.73*	0.73*
PA	Berks	2.16	1.00	1.02	1.61*	1.61*	1.61*	1.61*
PA	Carbon	0.45	0.00	0.00	0.00	0.00*	0.00*	0.00*
TN	Sullivan	0.38	0.00	0.00	0.00	0.00*	0.00*	0.00*
TN	Williamson	2.55	1.25	1.35	1.95	2.00	2.19	2.32
TX	Collin	3.18	2.19	2.19	2.20	2.69	2.75	2.95
TX	Dallas	0.06	0.00	0.00	0.00	0.00	0.00	0.00*
UT	Salt Lake	3.66	0.00	0.00	0.00	0.00	0.00	0.62
Total		**99.7**	**68.74**	**68.86**	**70.31**	**73.11**	**74.96**	**77.87**

* Indicates monitor area does not reach attainment using identified controls.

Table 4-4.
AMBIENT LEAD CONCENTRATIONS ACHIEVED WITH IDENTIFIED CONTROLS UNDER THE ALTERNATIVE STANDARDS IN 2016

Monitor State	Monitor County	Baseline Lead Concentration in 2016	Ambient Lead Concentration (µg/m3)					
			Standard Alternative: 0.5 µg/m^3 2nd Maximum Monthly Mean	Standard Alternative: 0.4 µg/m^3 2nd Maximum Monthly Mean	Standard Alternative: 0.3 µg/m^3 2nd Maximum Monthly Mean	Standard Alternative: 0.2 µg/m^3 2nd Maximum Monthly Mean	Selected Standard: 0.15 µg/m^3 2nd Maximum Monthly Mean	Standard Alternative: 0.1 µg/m^3 2nd Maximum Monthly Mean
AL	Pike	2.420	0.256	0.256	0.256	0.197	0.098	0.098
CO	El Paso	0.131	0.131	0.131	0.131	0.131	0.131	0.131*
FL	Hillsborough	1.380	0.327	0.327	0.222	0.123	0.123	0.049
IL	Madison	0.128	0.128	0.128	0.128	0.128	0.128	0.104*
IN	Delaware	5.022	0.397	0.397	0.285	0.199	0.148	0.078
MN	Dakota	0.192	0.192	0.192	0.192	0.192	0.127	0.039
MO	Iron	1.454	0.091	0.091	0.091	0.091	0.091	0.091
MO	Jefferson	1.998	0.236	0.236	0.236	0.236*	0.236*	0.236*
NY	Orange	0.240	0.240	0.240	0.240	0.085	0.085	0.085
OH	Cuyahoga	0.357	0.357	0.357	0.316*	0.316*	0.316*	0.316*
OH	Fulton	0.530	0.530*	0.530*	0.530*	0.530*	0.530*	0.530*
OH	Logan	0.360	0.360	0.360	0.360*	0.360*	0.360*	0.360*
OK	Ottawa	0.114	0.114	0.114	0.114	0.114	0.114	0.114*
PA	Beaver	0.228	0.228	0.228	0.228	0.200	0.196*	0.196*
PA	Berks	0.518	0.404	0.400	0.331*	0.331*	0.331*	0.331*
PA	Carbon	0.294	0.294	0.294	0.294	0.294*	0.294*	0.294*
TN	Sullivan	0.236	0.236	0.236	0.236	0.236*	0.236*	0.236*
TN	Williamson	0.820	0.429	0.398	0.212	0.198	0.137	0.097
TX	Collin	0.891	0.302	0.302	0.300	0.168	0.150	0.098
TX	Dallas	0.101	0.101	0.101	0.101	0.101	0.101	0.101*
UT	Salt Lake	0.107	0.107	0.107	0.107	0.107	0.107	0.093

* Indicates that this monitor area did not reach attainment with the alternative standard.

TABLE 4-5.
BASELINE LEAD CONCENTRATIONS IN µg/m^3 IN AREAS WITH MONITORED CONCENTRATIONS GREATER THAN ANY OF THE ALTERNATIVE STANDARDS USING ONLY IDENTIFIED CONTROLS

Monitor State	Monitor County	Baseline Pb Concentration in 2016	Pb Concentration related to area non-point emissions and misc. re-entrained dust	Baseline Pb Concentration related to indirect fugitive and point source emissions		Total concentration associated with sources for which no control information available
				Point sources with no Identified Controls	Point sources with Identified Controls	
CO	El Paso	0.131	0.024	0.101	0.006	0.125
IL	Madison	0.128	0.024	0.000	0.104	0.024
MO	Jefferson	1.998	0.023	0.000	1.975	0.023
OH	Cuyahoga	0.357	0.027	0.288	0.042	0.315
OH	Fulton	0.530	0.025	0.505	0.000	0.530
OH	Logan	0.360	0.027	0.333	0.000	0.360
OK	Ottawa	0.114	0.023	0.091	0.000	0.114
PA	Beaver	0.228	0.027	0.000	0.201	0.027
PA	Berks	0.518	0.037	0.275	0.205	0.312
PA	Carbon	0.294	0.036	0.259	0.000	0.294
TN	Sullivan	0.236	0.024	0.212	0.000	0.236
TX	Dallas	0.101	0.046	0.055	0.000	0.101

TABLE 4-6.
ADDITIONAL AIR QUALITY INCREMENT (µg/m^3) POST APPLICATION OF IDENTIFIED CONTROLS IN AREAS WITH MONITORED CONCENTRATIONS GREATER THAN ANY OF THE ALTERNATIVE STANDARDS

Monitor State	Monitor County	Standard Alternative: 0.5 µg/m^3 2nd Maximum Monthly Mean	Standard Alternative: 0.4 µg/m^3 2nd Maximum Monthly Mean	Standard Alternative: 0.3 µg/m^3 2nd Maximum Monthly Mean	Standard Alternative: 0.2 µg/m^3 2nd Maximum Monthly Mean	Selected Standard: 0.15 µg/m^3 2nd Maximum Monthly Mean	Standard Alternative: 0.1 µg/m^3 2nd Maximum Monthly Mean
CO	El Paso						0.031
IL	Madison						0.004
MO	Jefferson				0.036	0.086	0.136
OH	Cuyahoga			0.016	0.116	0.166	0.216
OH	Fulton	0.030	0.130	0.230	0.330	0.380	0.430
OH	Logan			0.060	0.160	0.210	0.260
OK	Ottawa						0.014
PA	Beaver					0.046	0.096
PA	Berks			0.031	0.131	0.181	0.231
PA	Carbon				0.094	0.144	0.194
TN	Sullivan				0.036	0.086	0.136
TX	Dallas						0.001

4.4. Emission Reductions Needed Beyond Identified Controls

As discussed above, some monitor areas did not reach attainment with the selected standard or alternative standards through the application of identified controls alone in these illustrative control scenarios. In order to bring these monitor areas into attainment, we simulated the effects of unspecified emission reductions beyond identified controls. The manner in which these reductions would be achieved is yet to be determined.

4.4.1. Application of Unspecified Emission Reductions to Point Sources in Areas Projected to Violate the Standard Alternatives with the Application of Identified Controls

To model emission reductions beyond identified controls, we assumed that all point sources in an area projected to violate a standard alternative (excluding airports) would be controlled with measures employing the same control efficiency. To simulate attainment with each alternative standard, we find the minimum control efficiency required to bring each area's second maximum monthly mean lead concentration exactly to the level of the standard alternative considered. As a result, the effective control efficiency applied to point sources differs by area and by standard alternative. For example, for the 0.2 $\mu g/m^3$ standard alternative, we apply a control efficiency of 16.9 percent to all sources in Sullivan County, Tennessee, but a control efficiency of 65.3 percent to all sources in Fulton County, Ohio. We multiply the appropriate control efficiency by the remaining emissions for each point source in each county. We then sum the point source emission reductions to get a total for each county.

This process differs from the method we used in the Proposed Rule RIA for modeling emission reductions beyond identified controls. In that analysis, we applied controls to a limited number of point sources, beginning with those sources closest to the monitor and proceeding outward until each area reached attainment. In this analysis, we instead apply the same control efficiency to all point sources within each area projected to violate any alternate standard.

4.4.2. Lead Emission Reductions Needed Beyond Identified Controls

After applying unspecified emission reductions beyond identified controls using the process described above, all monitor areas reached attainment with the 0.5 $\mu g/m^3$, 0.4 $\mu g/m^3$, 0.3 $\mu g/m^3$, 0.2 $\mu g/m^3$, and 0.15 $\mu g/m^3$ alternative standards. Under the 0.1 $\mu g/m^3$ standard alternative, however, Ottawa County, Oklahoma fails to reach attainment because there are no point sources of lead to control in this county. Table 4-7 presents the lead emissions reductions required to bring the maximum number of monitor areas into attainment with each standard alternative. Table 4-8 presents the lead emissions reductions realized for each monitor area based on both identified controls alone and emission reductions beyond identified controls. Tables 4-9 and 4-10 present the air quality impacts of these emissions reductions and summarize the number of areas reaching attainment with the application of identified controls and emission reductions beyond identified controls. Lastly, Figure 2 presents the quantity of emissions reductions

needed through the identified controls analysis, and the emissions reductions needed beyond identified controls.

Table 4-7.
TOTAL LEAD EMISSIONS REMAINING AND LEAD EMISSIONS REDUCTIONS REQUIRED BEYOND IDENTIFIED CONTROLS TO REACH ATTAINMENT WITH THE ALTERNATIVE STANDARDS

Standard Alternative	Lead emissions Remaining after applying identified controls (Tons/Year)	Additional emission reductions needed beyond identified controls (Tons/Year)	Emissions remaining after applying identified controls and unspecified emission reductions beyond identified controls (Tons/Year)
0.5 $\mu g/m^3$ 2nd Maximum Monthly Mean	30.96	0.02	30.94*
0.4 $\mu g/m^3$ 2nd Maximum Monthly Mean	30.84	0.08	30.76*
0.3 $\mu g/m^3$ 2nd Maximum Monthly Mean	29.39	0.29	29.10*
0.2 $\mu g/m^3$ 2nd Maximum Monthly Mean	26.59	2.06	24.53*
0.15 $\mu g/m^3$ 2nd Maximum Monthly Mean	24.74	4.79	19.95*
0.1 $\mu g/m^3$ 2nd Maximum Monthly Mean	21.83	7.91	13.92**

* 21 out of 21 monitor areas reached attainment with this standard alternative using identified point source emissions controls and unspecified emission reductions.

** 20 out of 21 monitor areas reached attainment with this standard alternative using identified point source emissions controls and unspecified emission reductions.

Table 4-8.
REDUCTION IN LEAD EMISSIONS UNDER ALTERNATIVE STANDARDS AT EACH MONITOR AREA WITH IDENTIFIED CONTROLS AND UNSPECIFIED EMISSION REDUCTIONS BEYOND IDENTIFIED CONTROLS

Monitor State	Monitor County	Baseline Lead Emissions in 2016	Reduction in Lead Emissions (tpy)					
			Standard Alternative: 0.5 $\mu g/m^3$ 2nd Maximum Monthly Mean	Standard Alternative: 0.4 $\mu g/m^3$ 2nd Maximum Monthly Mean	Standard Alternative: 0.3 $\mu g/m^3$ 2nd Maximum Monthly Mean	Standard Alternative: 0.2 $\mu g/m^3$ 2nd Maximum Monthly Mean	Selected Standard: 0.15 $\mu g/m^3$ 2nd Maximum Monthly Mean	Standard Alternative: 0.1 $\mu g/m^3$ 2nd Maximum Monthly Mean
AL	Pike	4.45	4.02	4.02	4.02	4.13	4.31	4.31
CO	El Paso	0.95	0.00	0.00	0.00	0.00	0.00	0.27
FL	Hillsborough	1.48	1.00	1.00	1.09	1.19	1.19	1.26
IL	Madison	0.53	0.00	0.00	0.00	0.00	0.00	0.11
IN	Delaware	1.53	1.37	1.37	1.40	1.42	1.44	1.46
MN	Dakota	3.55	0.00	0.00	0.00	0.00	1.29	3.07
MO	Iron	16.12	12.26	12.26	12.26	12.26	12.26	12.26
MO	Jefferson	51.02	45.52	45.52	45.52	46.46	47.75	49.04
NY	Orange	1.80	0.00	0.00	0.00	1.39	1.39	1.39
OH	Cuyahoga	0.94	0.00	0.00	0.18	0.49	0.65	0.81
OH	Fulton	0.49	0.16	0.23	0.30	0.37	0.40	0.44
OH	Logan	0.12	0.00	0.00	0.02	0.06	0.08	0.09
OK	Ottawa	0.00	0.00	0.00	0.00	0.00	0.00	0.00*
PA	Beaver	4.28	0.00	0.00	0.00	0.64	1.69	2.74
PA	Berks	2.16	1.00	1.02	1.66	1.86	1.95	2.05
PA	Carbon	0.45	0.00	0.00	0.00	0.16	0.25	0.34
TN	Sullivan	0.38	0.00	0.00	0.00	0.06	0.15	0.24
TN	Williamson	2.55	1.25	1.35	1.95	2.00	2.19	2.32
TX	Collin	3.18	2.19	2.19	2.20	2.69	2.75	2.95
TX	Dallas	0.06	0.00	0.00	0.00	0.00	0.00	0.01
UT	Salt Lake	3.66	0.00	0.00	0.00	0.00	0.00	0.62
Total		**99.7**	**68.76**	**68.94**	**70.6**	**75.17**	**79.75**	**85.78**

* Indicates monitor area does not reach attainment with identified controls and unspecified emission reductions beyond identified controls. Ottawa, OK contains no point sources and a large Superfund site.

Table 4-9.
AMBIENT LEAD CONCENTRATIONS ACHIEVED WITH IDENTIFIED CONTROLS AND UNSPECIFIED EMISSION REDUCTIONS BEYOND IDENTIFIED CONTROLS UNDER ALTERNATIVE STANDARDS IN 2016

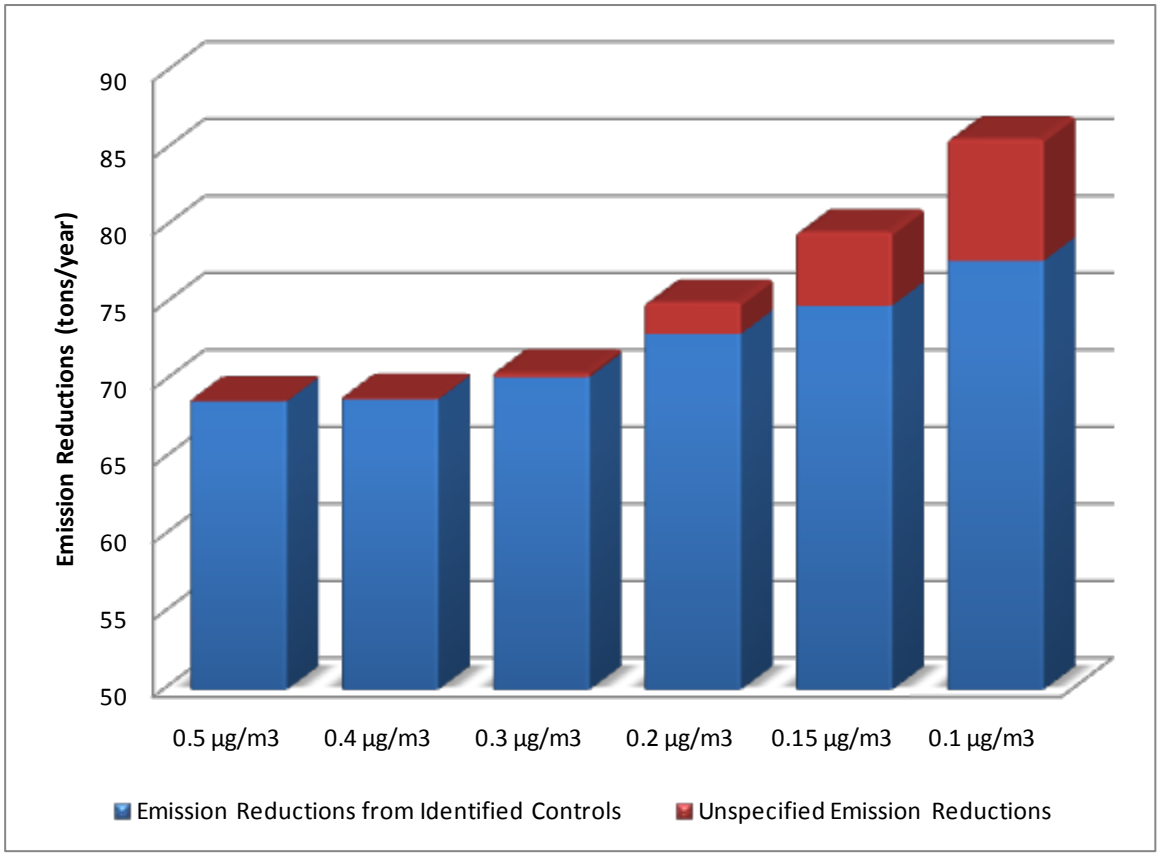
Monitor State	Monitor County	Baseline Lead Concentration in 2016	Ambient Lead Concentration (µg/m3)					
			Standard Alternative: 0.5 µg/m^3 2nd Maximum Monthly Mean	Standard Alternative: 0.4 µg/m^3 2nd Maximum Monthly Mean	Standard Alternative: 0.3 µg/m^3 2nd Maximum Monthly Mean	Standard Alternative: 0.2 µg/m^3 2nd Maximum Monthly Mean	Selected Standard: 0.15 µg/m^3 2nd Maximum Monthly Mean	Standard Alternative: 0.1 µg/m^3 2nd Maximum Monthly Mean
AL	Pike	2.420	0.256	0.256	0.256	0.197	0.098	0.098
CO	El Paso	0.131	0.131	0.131	0.131	0.131	0.131	0.100
FL	Hillsborough	1.380	0.327	0.327	0.222	0.123	0.123	0.049
IL	Madison	0.128	0.128	0.128	0.128	0.128	0.128	0.100
IN	Delaware	5.022	0.397	0.397	0.285	0.199	0.148	0.078
MN	Dakota	0.192	0.192	0.192	0.192	0.192	0.127	0.039
MO	Iron	1.454	0.091	0.091	0.091	0.091	0.091	0.091
MO	Jefferson	1.998	0.236	0.236	0.236	0.200	0.150	0.100
NY	Orange	0.240	0.240	0.240	0.240	0.085	0.085	0.085
OH	Cuyahoga	0.357	0.357	0.357	0.300	0.200	0.150	0.100
OH	Fulton	0.530	0.500	0.400	0.300	0.200	0.150	0.100
OH	Logan	0.360	0.360	0.360	0.300	0.200	0.150	0.100
OK	Ottawa	0.114	0.114	0.114	0.114	0.114	0.114	0.114*
PA	Beaver	0.228	0.228	0.228	0.228	0.200	0.150	0.100
PA	Berks	0.518	0.404	0.400	0.300	0.200	0.150	0.100
PA	Carbon	0.294	0.294	0.294	0.294	0.200	0.150	0.100
TN	Sullivan	0.236	0.236	0.236	0.236	0.200	0.150	0.100
TN	Williamson	0.820	0.429	0.398	0.212	0.198	0.137	0.097
TX	Collin	0.891	0.302	0.302	0.300	0.168	0.150	0.098
TX	Dallas	0.101	0.101	0.101	0.101	0.101	0.101	0.100
UT	Salt Lake	0.107	0.107	0.107	0.107	0.107	0.107	0.093

* Indicates monitor area does not reach attainment with identified controls and unspecified emission reductions beyond identified controls. Ottawa, OK contains no point sources and a large Superfund site.

Table 4-10.
NUMBER OF MONITOR SITES REACHING ATTAINMENT WITH EACH ALTERNATIVE STANDARD WITH IDENTIFIED CONTROLS AND EMISSION REDUCTIONS BEYOND IDENTIFIED CONTROLS

Standard Alternative	Number of Sites Analyzed	Number of Sites in Attainment with No Additional Controls	Number of Sites in Attainment with Identified Point Source Controls	Number of Sites in Attainment with Identified Point Source Controls and Unspecified Emission Reductions
0.50 µg/m^3 Second Maximum Monthly Mean	21	12	20	21
0.40 µg/m^3 Second Maximum Monthly Mean		12	20	21
0.30 µg/m^3 Second Maximum Monthly Mean		10	17	21
0.20 µg/m^3 Second Maximum Monthly Mean		6	14	21
0.15 µg/m^3 Second Maximum Monthly Mean		5	13	21
0.10 µg/m^3 Second Maximum Monthly Mean		0	9	20

FIGURE 2.
EMISSIONS REDUCTIONS FROM IDENTIFIED CONTROLS AND REDUCTIONS NEEDED BEYOND IDENTIFIED CONTROLS



4.5 Key Limitations

The estimates of emission reductions associated with the control strategies described above are subject to important limitations and uncertainties. We summarize these limitations as follows:

- ***Analysis Only Considers Controls on Point Source Emissions.*** Because the available data are not sufficiently detailed to assess the impact of indirect fugitive or area nonpoint source controls, the analysis of air quality impacts does not account for the potential implementation of such controls in areas where they might be effective. Although the analysis estimates the impact of point source controls on indirect fugitives, it does not consider the impact of controlling these emissions directly. This and the lack of control information for area nonpoint sources may have contributed to our projection that some areas would violate the NAAQS.

- ***Actual State Implementation Plans May Differ from our Simulation***: In order to reach attainment with the selected standard, each state will develop its own implementation plan implementing a combination of emissions controls that may differ from those simulated in this analysis. This analysis therefore represents an approximation of the emissions

reductions that would be required to reach attainment and should not be treated as a precise estimate.

- ***Limited Sources Considered***: For this analysis we have not modeled the effect of any potential changes in emissions at airports with lead emissions associated with use of leaded aviation gasoline. Furthermore, as discussed above, we were not able to obtain emissions control information for a large number of point sources in our analysis. Although these sources collectively accounted for less than one tenth of all lead emissions considered, many of those sources were located in areas that were not able to reach attainment with one or more of the standard alternatives using identified controls alone. If more emissions control information were available, it may not be necessary to rely on estimated emissions reductions beyond identified controls in order to simulate attainment with the alternative standards.

- ***Emissions Reductions from the Rebuild of the Primary Lead Smelter in Jefferson County, Missouri:*** To estimate the emissions reductions associated with the selected standard for Jefferson County, this analysis models the replacement of the primary lead smelter in this area with a more modern, lower emitting Kivcet smelter. We estimate the emissions reductions that such a project would achieve based on the emissions performance of Teck Cominco's Kivcet smelter in Trail, British Columbia, scaling for differences in lead production volumes between the two facilities. While this is a reasonable approach for estimating the extent to which the Jefferson County smelter's emissions may decline if it rebuilds its smelter, facility-specific characteristics not included in our analysis may influence lead smelter emissions. Therefore, we may overestimate or underestimate the lead reductions that would be achieved by a rebuild of this smelter.

- ***Emissions Reduction Beyond Identified Controls***: In this chapter we report both emissions reductions from identified emissions controls and unspecified emission reductions beyond identified controls. We have taken care to report these separately, in recognition of the greater uncertainty associated with achieving emissions reductions from measures that may not be currently in use or known to EPA. Nonetheless, EPA believes it is reasonable to project that, with at least seven years of lead time before a 2016 compliance deadline, a large number of existing measures will be adapted to be applicable to additional sources, and new measures may be developed that are specifically focused on cost-effectively reducing PM emissions with high lead content. Because the current standard is attained in all but a few areas of the country, and has been for many years since the phase down of lead in gasoline, it is likely that very little effort has been devoted to development of lead emissions control technologies except in industries where regulations have been imposed to reduce lead (e.g., large MWC standard, primary and secondary lead smelter MACTs, etc.). As a result, EPA believes that the projection of emission reductions beyond identified controls is particularly appropriate for compliance with a more stringent lead standard.

Chapter 5 - Benefits Analysis Approach and Results

Synopsis

This chapter describes our analysis of the benefits associated with attaining the selected National Ambient Air Quality Standard (NAAQS) for lead and the alternative standards outlined in Chapter 1.[1] The estimates outlined in this benefits analysis indicate that achieving a lower National Ambient Air Quality Standard (NAAQS) for lead from its current level of 1.5 $\mu g/m^3$ maximum quarterly mean to a second maximum monthly value of 0.15 $\mu g/m^3$ could result in significant reductions in adverse health effects due to reduced exposure from lead and fine particles ($PM_{2.5}$). We estimate a potential increase in intelligence quotient (IQ) points across the population (approximately 400,000) with the selected NAAQS under various assumptions, including baseline non-air background blood lead levels at 2002 levels.

This Regulatory Impact Analysis (RIA) seeks to estimate benefits for the year 2016 using a 2002 baseline blood lead level; this may result in an under- or over-estimate of benefits in the year 2016.[2] State and federal regulatory interventions, including the recently promulgated Renovation and Repair Rule (RRP), are likely to reduce non-air background blood lead levels significantly. In the draft RIA, EPA committed to explore the possibility of updating the baseline to reflect expected effects on blood lead levels from other lead rules and potentially from an anticipated decline in population blood lead levels. EPA has determined that such a projection of baseline non-air background blood lead levels is not technically feasible in the time available. Specifically, EPA lacks data regarding the distribution of the housing stock and populations to which rules such as the RRP apply. As an alternative, we provide a sensitivity analysis, found in Table 5-8, which indicates that the total benefits estimate shows little sensitivity to alternate background non-air blood lead levels.

This RIA provides illustrative estimates of the incremental monetized human health benefits of attaining a revised primary lead (Pb) National Ambient Air Quality Standard (NAAQS) within the current monitoring network.[3] Some of the highest-emitting Pb sources do not have nearby Pb-TSP monitors, and it is important to note that there may be more potential nonattainment areas than have been analyzed in this RIA. Because monitors are present in only 86 counties nationwide, the universe of monitors exceeding the various target NAAQS levels is

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[1] The costs presented in this chapter represent the direct pollution control expenditures associated with NAAQS compliance. As such, they do not reflect the general equilibrium impacts of the proposed rule.

[2] The level of non-air background blood lead levels affects the portion of the health impact function curve on which IQ changes are estimated. A change in the background level may cause IQ changes to be estimated on a shallower or steeper portion of the curve.

[3] There are currently 189 monitors representing 86 counties, but only 21 counties have monitors which exceed 0.10 ug/m^3.

very small; only 21 counties exceed the lowest alternate NAAQS level of 0.10 ug/m^3. Because we know that Pb-TSP monitors are not located near some of the highest-emitting Pb sources in the 2002 NEI (see Chapter 2), it is likely that there may be more potential nonattainment areas than have been analyzed in this RIA.

As shown in Table 5-1 below, when applying a 3 percent discount rate, the monetary value of avoided IQ point loss for the least stringent standard alternative (0.5 μg/m^3) ranges between $2.0 and $2.8 billion (all values in 2006$).[4] If future non-air background blood levels change, benefits may be higher or lower. For the selected standard of 0.15 μg/m^3, benefits range from $3.5 to $5.0 billion. For the most stringent standard alternative (0.1 μg/m^3), monetary benefits range from $4.5 to $6.4 billion. Additional co-control benefits of reduced PM emissions are expected to range between $0.1 and $0.9 billion for the least stringent standard alternative, between $0.2 and $1.9 billion for the selected standard and up to a range of $0.3 to $2.2 billion for the most stringent standard alternative. Therefore, the combined monetized health benefits from reductions in both lead and PM exposures as a result of lowering the current NAAQS range from $2.1 to $3.7 billion for the least stringent standard alternative, between $3.7 and $6.9 billion for the selected standard and between $4.8 to $8.6 billion for the most stringent standard alternative.

When applying a 7 percent discount rate, the monetary benefits for changes in IQ the least stringent standard alternative (0.5 μg/m^3) range between $0.3 and $0.5 billion. For the selected standard, benefits range from $0.4 and $0.9 billion. For the most stringent standard alternative (0.1 μg/m^3), monetary benefits of IQ gains range from $0.6 to $1.1 billion. Additional co-control benefits of reduced PM emissions are expected to range between $0.1 and $0.8 billion for the least stringent standard alternative, between $0.2 and $1.7 billion for the selected standard and a range of $0.2 to $2 billion for the most stringent standard alternative. Therefore, the combined monetized health benefits from reductions in both lead and PM exposures as a result of lowering the current NAAQS range from $0.4 to $1.3 billion for the least stringent standard alternative, between $0.7 and $2.6 billion for the selected standard and between $0.8 and $3.1 billion for the most stringent standard alternative.

The benefits summarized in the table below are the product of the air quality change associated with both identified and unidentified emission controls. The proportion of benefits attributable to identified controls varies by standard alternative. At the less stringent alternatives of 0.5 μg/m^3, 0.4 μg/m^3, 0.3 μg/m^3 and 0.2 μg/m^3 the identified emission controls account for all, or nearly all, of the estimated benefits. For the selected standard of 0.15 μg/m^3, the identified controls represent about 85% of total benefits. Finally, the more stringent alternative standard of 0.1 μg/m^3, the identified controls represent about 80% of total benefits.

[4] When monetizing benefits, we applied two alternate valuation functions. These functions are discussed further in this chapter.

Table 5-1. Monetary Benefits of Alternate Lead NAAQS (in Millions of 2006$) in 2016

	Estimated Net Present Value of IQ Points Gained[2][3]		*Monetized Benefits of Co-Controlled $PM_{2.5}$ Emissions*[4]		*Total Benefits*[5]	
Standard Alternative[1]	**3% Discount Rate**	**7% Discount Rate**	**3% Discount Rate**	**7% Discount Rate**	**3% Discount Rate**	**7% Discount Rate**
0.5 μg/m³	$2,000—$2,800	$250—$490	$110—$880	$100—$790	$2,100—$3,700	$350—$1,300
0.4 μg/m³	$2,000—$2,800	$250—$490	$100—$880	$100—$800	$2,100—$3,700	$350—$1,300
0.3 μg/m³	$2,400—$3,400	$300—$580	$190—$1,600	$170—$1,400	$2,600—$5,000	$470—$2,000
0.2 μg/m³	$3,200—$4,500	$390—$780	$220—$1,800	$200—$1,600	$3,400—$6,300	$590—$2,400
0.15 μg/m³	$3,500—$5,000	$440—$870	$230—$1,900	$210—$1,700	$3,700—$6,900	$650—$2,600
0.1 μg/m³	$4,500—$6,400	$560—$1,100	$260—$2,200	$240—$2,000	$4,800—$8,600	$800—$3,100

[1] All standard alternatives are for a second maximum monthly mean concentration.

[2] Results reflect the use a 2002 derived non-air background blood lead applied to analysis year of 2016. To the extent that state and federal interventions such as the Renovation and Repair Rule (EPA, 2008c) reduce future non-air blood lead levels, the estimate of IQ change above may be different.

[3] The lower end of the range of presented values was calculated using the Schwartz (1994b) valuation estimate; the upper end was calculated using the Salkever (1995) valuation estimate.

[4] The range of presented values represent 14 different estimates from the PM epidemiological literature and an expert judgment study.

[5] Numbers are rounded to two significant figures. Therefore, the sums in these columns may not total.

Figures 5-1 and 5-2 below display the health benefits from both lead and $PM_{2.5}$ exposure reductions for each of the six alternative standards using a 3 percent and 7 percent discount rate, respectively.[5] Figures 5-3 and 5-4 below display some examples of the total health benefits from both lead and PM2.5 exposure reductions using different input assumptions for each of the six alternative standards using a 3 percent and 7 percent discount rate, respectively.

[5] Note that these figures present the lead benefits results that incorporate valuation estimates from Schwartz (1994b) and PM co-control benefits using the Pope et al. (2002) epidemiological study and therefore do not represent the full range of uncertainty in the expected benefits.

Figure 5-1. Lead and PM $_{2.5}$ Benefits by Standard Alternative (3% Discount Rate)

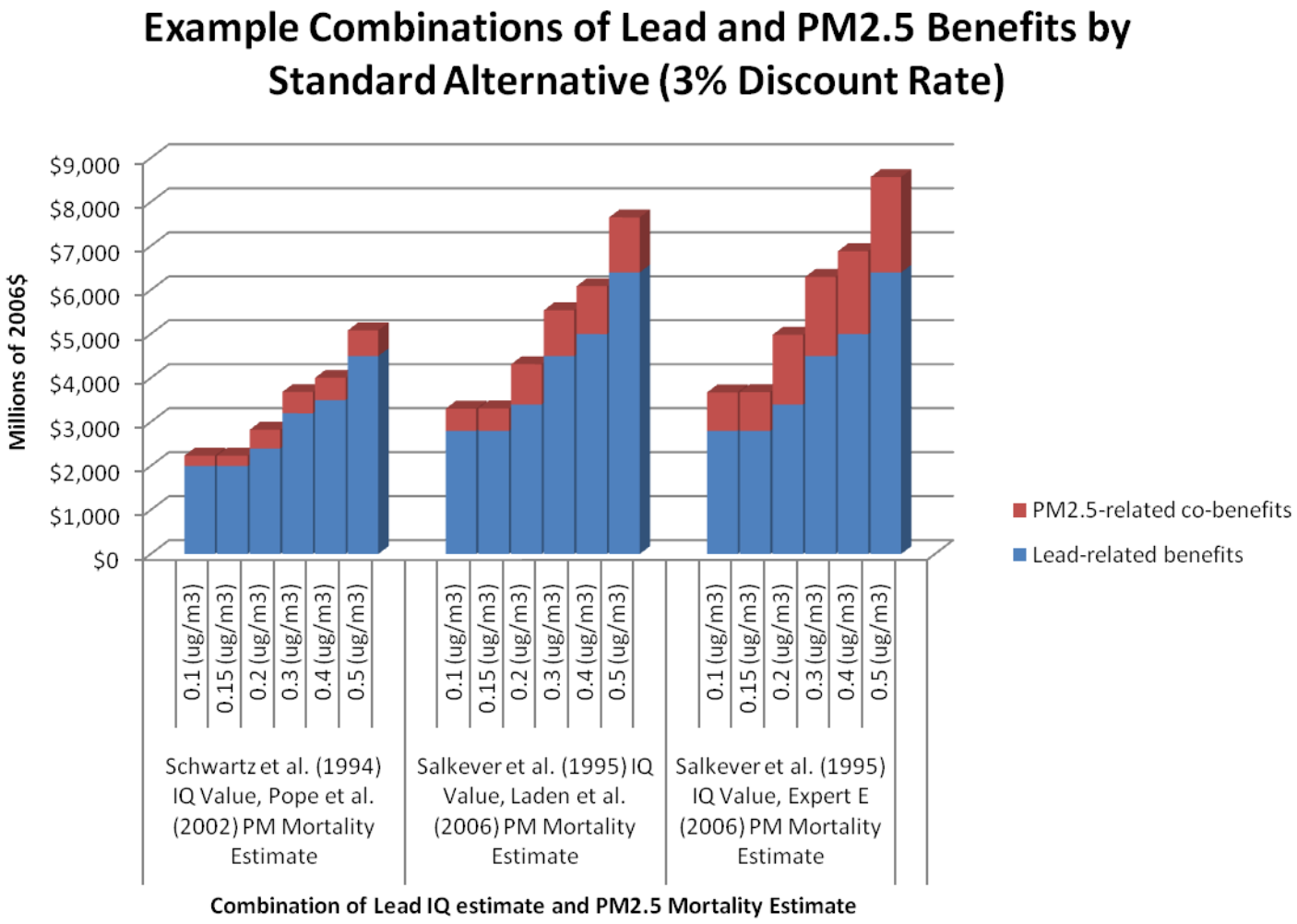


Figure 5-2. Lead and PM 2.5 Benefits by Standard Alternative (7% Discount Rate)

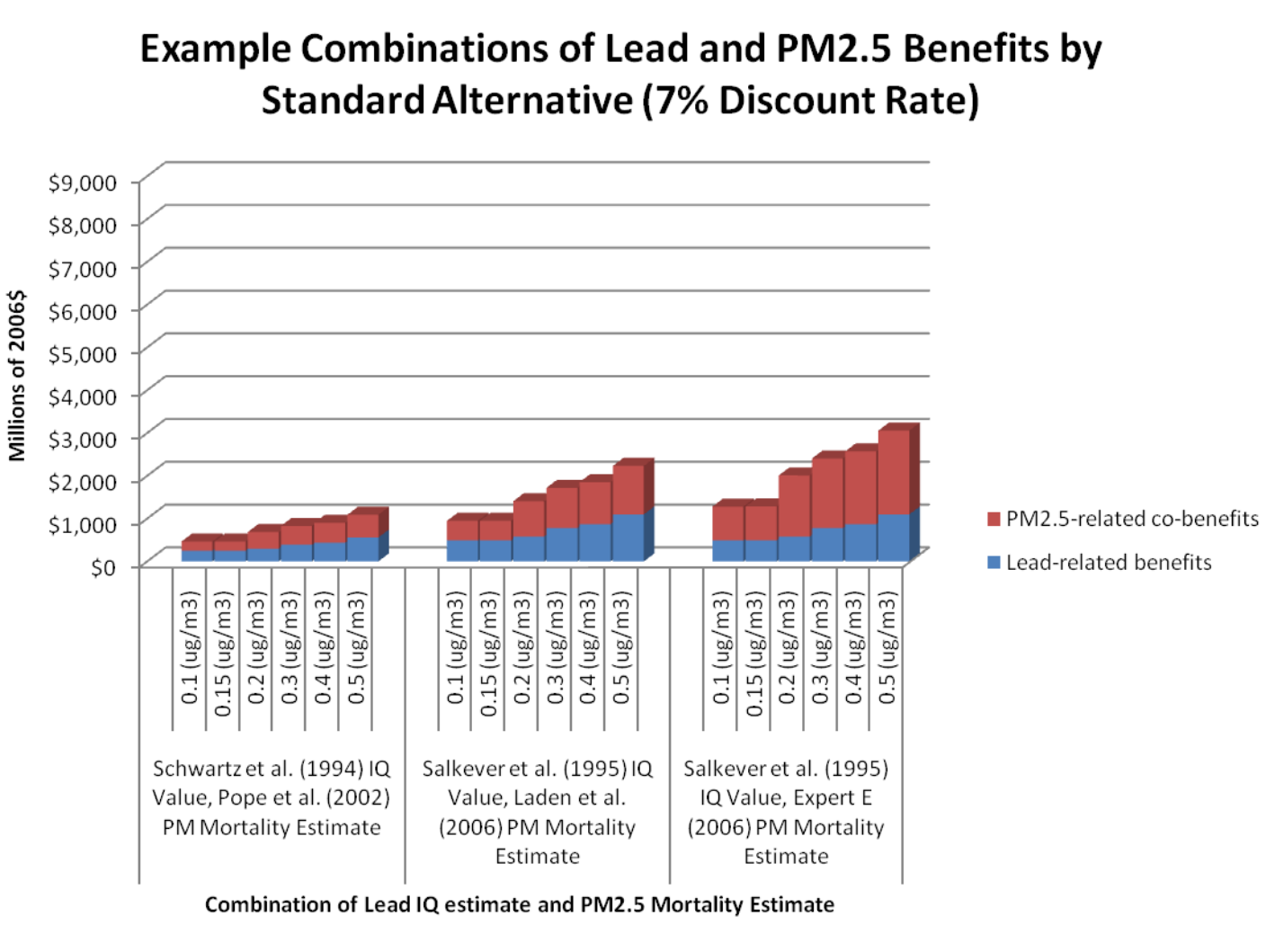
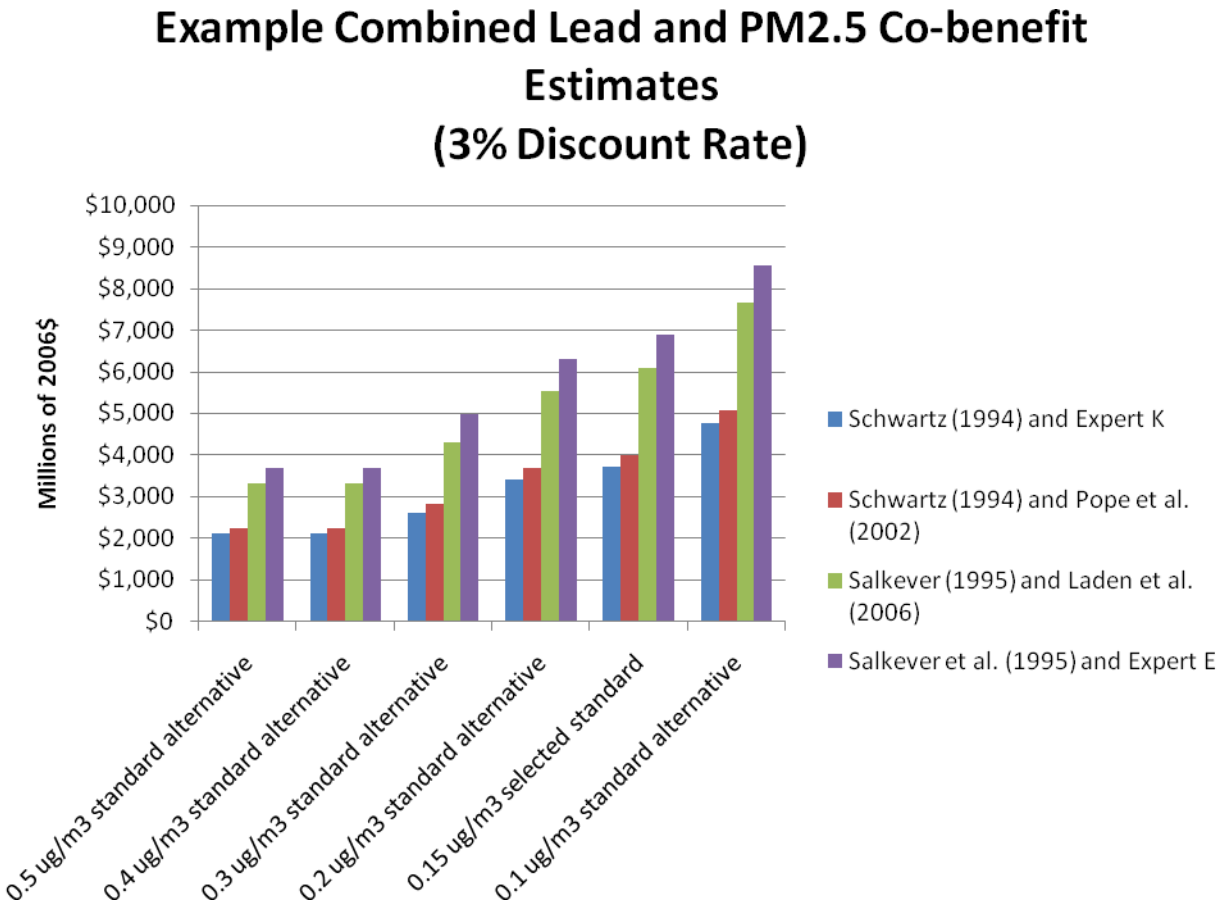
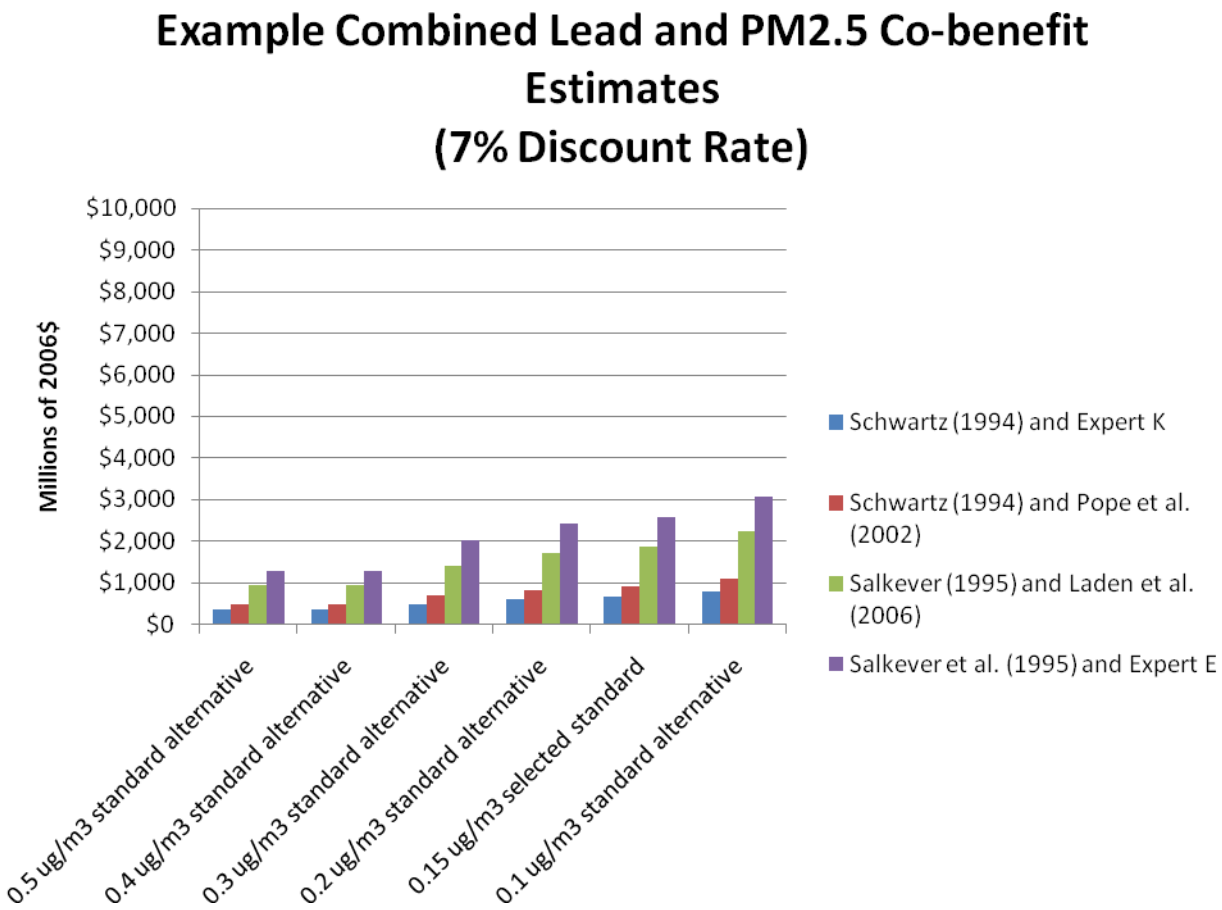


Figure 5-3. Example Combined Lead and Total $PM_{2.5}$ Monetized Benefits Estimates by



Standard Alternative (3% Discount Rate)

Figure 5-4. Example Combined Lead and Total $PM_{2.5}$ Monetized Benefits Estimates by Standard



Introduction

This chapter documents our analysis of health benefits expected to result from achieving alternative levels of the lead NAAQS, relative to baseline ambient air lead levels. We first describe our approach for estimating and monetizing the health benefits associated with reductions of lead in air. Next, we provide a summary of our results, including an analysis of the sensitivity of the benefits model. We then review our approach to and results from estimating benefits from co-control of direct $PM_{2.5}$ emissions associated with implementing measures necessary to achieve alternative of the selected lead NAAQS. Finally, we discuss the key results of the benefits analysis and indicate areas of uncertainty in our approach.

Benefits Approach

This section presents our approach for estimating avoided adverse health effects in humans resulting from achieving alternative levels of the lead NAAQS, relative to a base case ambient air lead level. We first review the epidemiological evidence concerning potential health effects of lead exposure and present the health endpoints we selected for our primary benefits estimate. We then describe our screening-level spreadsheet benefits model, including the data used and key assumptions. Finally, we describe our approach for assigning an economic value to the health benefits.

Benefits Scenario

We calculated the economic benefits from annual avoided health effects expected to result from achieving alternative levels of the lead NAAQS (the "control scenarios") in the year 2016. We measured benefits in the control scenarios relative to the incidence of health effects consistent with ambient lead levels in air expected under the current standard (1.5 $\mu g/m^3$ maximum quarterly mean; the "base case") in 2016. Note that this "base case" reflects emissions reductions and ambient air quality improvements that we anticipate will result from implementation of other air quality rules, including compliance with all relevant Maximum Achievable Control Technology (MACT) rules and the recently revised NAAQS for $PM_{2.5}$.[6] We compared benefits across six alternative second maximum monthly mean NAAQS levels of 0.5, 0.4, 0.3, 0.2, 0.15, and 0.1 $\mu g/m^3$.

Selection of Health Endpoints

Epidemiological researchers have associated lead exposure with adverse health effects in numerous studies, as described in the *Air Quality Criteria for Lead* (USEPA, 2006a; hereafter, *Lead Criteria Document*). Young children are particularly sensitive to lead exposures; neurobehavioral effects of lead exposure in infants and young children (less than 7 years of age)

[6] Development of this base case is described further in Chapter 3.

have been observed consistently across multiple studies that control for an array of confounding factors (USEPA, 2006a).

The Criteria Document provides a comprehensive review of the current evidence of health and environmental effects of Pb. With regard to health effects, the Criteria document summarizes the evidence as follows (CD, Section 8.4.1):

> "…Pb has been shown to exert a broad array of deleterious effects on multiple organ systems via widely diverse mechanisms of action. Truly remarkable progress has been made during the past several decades with regard to (a) more fully delineating over time the wide variety of pathophysiologic effects associated with Pb exposure of human population groups and laboratory animals and (b) the characterization of applicable exposure durations and dose-response relationships for the induction of the multifaceted Pb effects. This progress has been well documented by the previous Pb NAAQS criteria reviews carried out by EPA in the late 1970s and during the 1980s, as well as being well reflected by previous chapters of this document.
>
> The 1977 Lead AQCD (U.S. Environmental Protection Agency, 1977) that provided key scientific bases for the setting in 1978 of the current Pb NAAQS included discussion of both: (a) historical literature accumulated during several preceding decades that established Pb encephalopathy and other signs and symptoms of persisting severe central and/or peripheral nervous system damage, as well as renal and hepatic damage, and anemia as typifying the classic syndrome of acute and/or chronic high-level Pb poisoning among human pediatric and /or adult population groups, and (b) evaluation of then newly-emerging evidence for more subtle and difficult-to-detect "subclinical" Pb effects on IQ, other neurological endpoints, and moderate blood hemoglobin deficits or other erythropoietic indicators of heme synthesis impairment, which collectively were judged to constitute an array of adverse Pb health effects associated with Pb exposures indexed by blood Pb concentrations ranging down to ~30 µg/dL. The next Pb NAAQS criteria review during the 1980's, as contained in the 1986 Lead AQCD/Addendum and its 1990 Supplement (U.S. Environmental Protection Agency, 1986a, b, 1990) documented further rapid advances in Pb health effects research that provided (a) increasingly stronger evidence that substantiated still lower fetal and/or postnatal Pb-exposure levels (indexed by blood-Pb levels extending to as low as 10 to 15 µg/dL or, possibly, below) as being associated with slowed physical and neurobehavioral development, lower IQ, impaired learning, and/or other indicators of adverse neurological impacts and (b) other pathophysiological effects of Pb on cardiovascular function, immune system components, calcium and vitamin D metabolism, and other selected health endpoints.
>
> Newly available scientific information published since the 1986 Lead AQCD/Addendum and the 1990 Supplement, as assessed in previous chapters of this document, further expands our understanding of a wide array of Pb-induced health effects, underlying mechanisms, and factors that enhance or lessen susceptibility to Pb effects. Very importantly, the newly available toxicologic and epidemiologic information, as integrated below, includes assessment of new evidence substantiating risks of deleterious effects on certain health endpoints being induced by distinctly lower than previously demonstrated Pb exposures indexed by blood-Pb levels extending well below 10 µg/dL in children and/or adults.

> The ensuing subsections *[of the CD]* provide concise summarization and integrative synthesis of the most salient health-related findings and conclusions derived from the current criteria assessment. This includes discussion of new toxicologic and/or epidemiologic evidence concerning Pb induced (a) effects on neurobehavioral development and other indicators of nervous system effects; (b) cardiovascular effects; (c) heme synthesis effects; (d) renal effects; (e) immune system functions; (f) effects on calcium and vitamin D metabolism; (g) inter-relationships to bone and teeth formation and demineralization; (h) effects on reproduction and other neuroendocrine effects; and (i) genotoxicity and carcinogenic effects."

The differing evidence and associated strength of the evidence for these different effects is described in detail in the Criteria Document. The evidence with regard to adverse effects on plants and animals is also described in the Criteria Document.

Although a number of adverse health effects have been found to be associated with lead exposure, this benefits analysis only includes a subset, due to limitations in understanding and quantifying the dose-response relationship for some of these health endpoints and the fact that for some of these endpoints the science is less certain. We analyzed only those endpoints with sufficient evidence to support a quantified dose-response relationship. This determination was made using the information presented in the *Lead Criteria Document*, which contains an extensive literature review for several health endpoints related to lead exposure. However, this document only included studies published or accepted for publication through December 2005. Therefore, we performed supplemental searches in the online search engine PubMed to identify studies published between January 2006 and the present (see Appendix A for more information). Finally, we reviewed previous EPA lead benefits analyses to identify dose-response relationships that have been used previously (USEPA, 1997, 2006b & 2007a).

Our analysis focuses primarily on children's health effects due to our use of child-specific data to convert air quality data to a blood lead level, which is the most common biomarker of exposure used in dose-response functions.

This human health benefits analysis does not attempt to estimate the changes in lead-related health effects among adults. Several key data limitations prevented EPA from quantifying these important endpoints:

- *The available peer reviewed air:blood ratios to estimate adult blood lead changes are dated.* Previous EPA analysis of the costs and benefits of the Clean Air Act (USEPA, 1997) utilized air:blood ratios for adults from based on Snee et al. (1981), a meta-analysis of several studies, including Johnson et al..(1976), Fugas et al.(1973), and Nordman (1975). While these studies do provide insight into the responsiveness of adult blood lead levels to changes in lead concentrations in air, the age of these studies suggests that these ratios may not be appropriate for application in 2016. The more-recent peer-reviewed estimates of air:blood ratios have been derived for children.

Applying these ratios to adults would be inappropriate given the important differences between the two populations in their ambient exposure to Pb.

- *There is a lack of current, peer reviewed non-air-related blood lead background estimates for adults*. Quantification of adult endpoints would require a non-air-related blood background for adults. CASAC recommends a range of values for children in their review of the Lead Risk Assessment. However, due to differences between adults and children in the routes of exposure to lead, it is possible that background levels would differ between these two receptor groups. Therefore, applying the child-specific non-air-related background blood lead levels to adults could misestimate the true adult background levels.
- *The adult health impact functions relating changes in blood lead to health outcomes are dated*. Certain adult health impact functions, such as those quantifying the relationship between blood lead and diastolic blood pressure (Nawrot, 2002) are current. However, the functions relating changes in blood pressure to changes in premature mortality, chronic heart disease and stroke were each drawn from studies published in the 1970s; advances in the treatment of high blood pressure suggest that these functions may over-predict of changes in these health effects in the current population. One newer study, Schober et al. (2006), quantifies the relationship between blood lead and cardiovascular mortality. However, according to the *Lead Criteria Document*, "…until the Schober et al. findings are replicated and more fully understood, the Schober et al. (2006) estimates for Pb-induced cardiovascular mortality should probably not be used for quantitative risk assessment" USEPA, 2006a, page 8-89.

Taken together, these data limitations make a credible quantified assessment of adult endpoints very challenging and subject to considerable uncertainty. The Agency is working to addressing these data limitations so that it may be possible to provide a quantitative estimate of the adult endpoints for the next Pb NAAQS review in approximately 5 years.

Table 5-3 below presents the health effects related to exposure to lead in the air that are quantified in this benefits analysis. In addition, the table includes a list of other endpoints that potentially are linked to lead exposure, but which do not have dose-response functions available for quantifying benefits.

As shown in Table 5-3, our primary estimate is based on the effect of IQ loss on lifetime earnings. There are several recent epidemiological analyses that have found potential adverse health impacts of blood lead levels on cognitive function (most often measured as changes in IQ) in young children under 7 years of age, as described in the *Lead Criteria Document*. However, as also noted in that document, there has been conflicting evidence as to whether there exists a discrete period of neurological vulnerability to lead exposure during childhood.

For instance, the first three years of life represent the maximal period of lead ingestion as well as a period of time when important development of the central nervous system is occurring,

which suggests that biologically this could be a vulnerable period (USEPA, 2006a). In addition, there are two major meta-analyses that focused on the association between school age IQ and blood lead concentrations at two years of age or average blood lead concentrations up to three years of age (Pocock et al., 1994; Schwartz, 1994a). However, several recent prospective epidemiological studies have found concurrent blood lead level (i.e., blood lead measured at the same time as school age IQ) or lifetime average blood lead level (i.e., a mean of blood lead level from infancy to measurement of school age IQ) to be more strongly associated with school age IQ and other measures of neurodevelopment (Canfield et al., 2003; Dietrich et al., 1993; Tong et al., 1996, Wasserman et al., 2000). In addition, a large, international meta-analysis by Lanphear et al. (2005) included four measures of blood lead level: concurrent, peak, lifetime average, and early childhood. The authors found that the concurrent and lifetime blood lead levels were the strongest predictors of IQ deficits associated with lead exposure.

A study by Chen et al. (2005) specifically evaluated whether a window of enhanced susceptibility to lead exists. This study examined whether cross-sectional associations observed in school age children represent residual effects from two years of age or "new" effects emerging among these children (USEPA, 2006a). Chen et al. found that the blood lead metric with the strongest association with IQ was concurrent, and this relationship grew stronger with age. The authors did not find any association between peak blood lead level and IQ measured at seven years of age. In addition, a stronger relationship was found between IQ at seven years of age and blood lead level at seven years of age compared with blood lead at two years of age. The *Lead Criteria Document* concluded that "[t]hese results support the idea that lead exposure continues to be toxic to children as they reach school age, and do not lend support to the interpretation that all damage is done by the time the child reaches two to three years of age" (USEPA, 2006a, page 6-63). Based on this evidence, it is reasonable to assume that all children under seven years of age in the study area for this analysis will experience some cognitive benefit (i.e., IQ loss avoided) from reduced ambient air lead in 2016. Therefore, we have designed our benefits analysis to measure benefits to all children under seven in our study area.

Table 5-3. Human Health Effects of Lead

Quantified Health Effects	*Unquantified Health Effects*[a]
-Intelligence Quotient (IQ) loss effect on lifetime earnings	-Other neurobehavioral and physiological effects -Delinquent and anti-social behavior -IQ loss effects on compensatory education -Hypertension -Non-fatal coronary heart disease -Non-fatal strokes -Premature mortality -Other cardiovascular diseases -Neurobehavioral function -Renal effects -Reproductive effects -Fetal effects from maternal exposure (including diminished IQ)

[a] The categorization of unquantified toxic health effects is not exhaustive. Health endpoints in this column include both a) those for which there is not consensus; and b) those for which associations, to various degrees, has been determined but empirical data are not available to allow calculation of benefits.

Benefits Estimation Model

Overview

For this benefits analysis, we created a spreadsheet model to provide a screening-level assessment of health benefits occurring as a result of implementing alternative NAAQS levels. The model uses various simplifying assumptions and is intended only to provide an approximate, preliminary estimate of the potential health benefits.

The model was constructed in Microsoft Excel and provides an integrated tool to complete five benefits estimation steps: 1) estimate lead in air concentrations for the "base case" and "control scenarios"; 2) estimate population exposures to air lead concentrations for each scenario; 3) estimate blood lead levels in the population for each scenario; 4) estimate avoided cases of health effects due to changes in blood lead levels; and 5) apply an economic unit value to each avoided case to calculate total monetized benefits. These steps and the data inputs required are shown in Figure 5-5 and are discussed in further detail below.

Estimating Lead in Air Concentrations

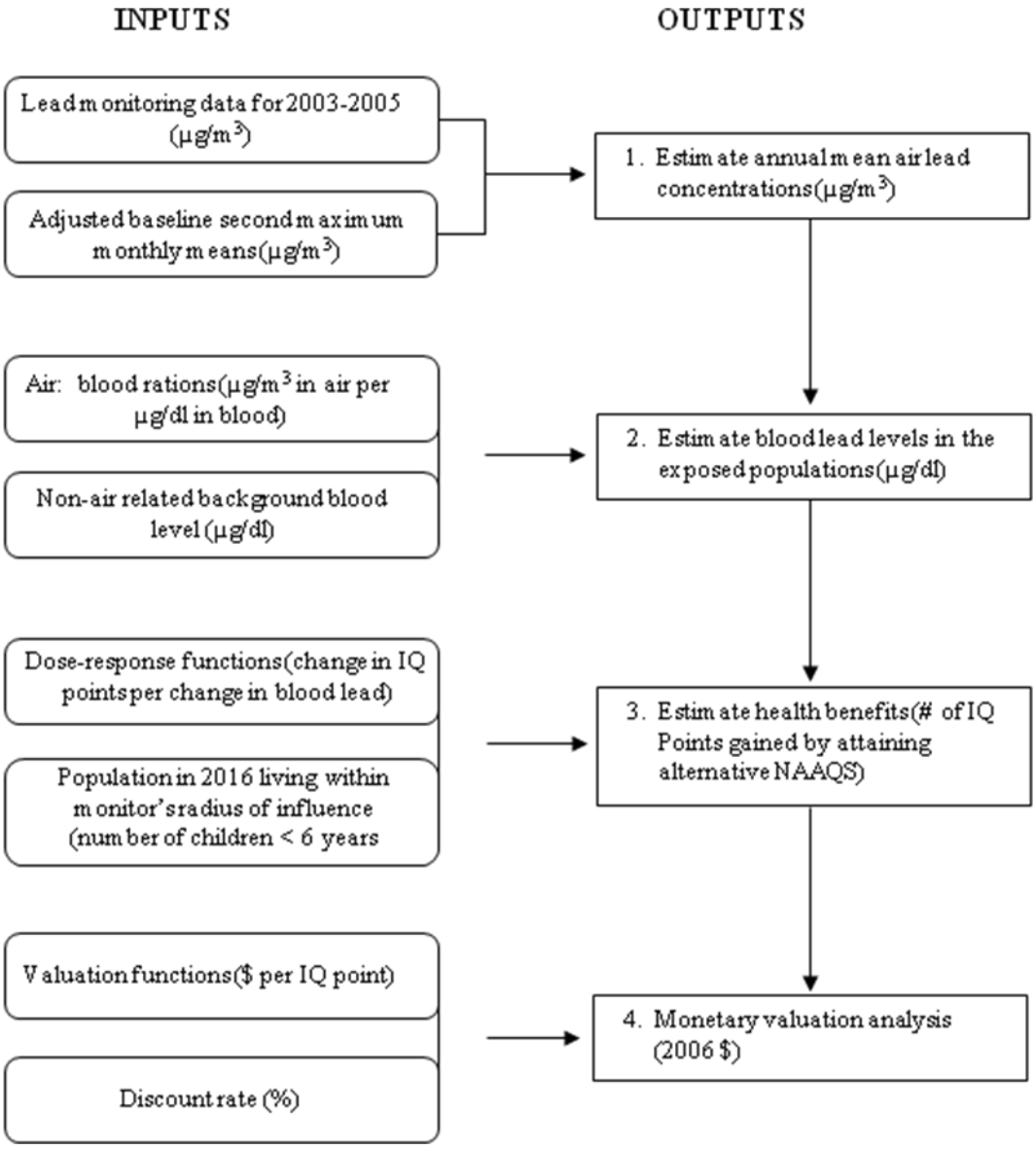
We used estimates of the second maximum monthly mean lead total suspended particles (TSP) for each monitor included in our study to characterize ambient air lead concentrations for the "base case" in 2016 (USEPA, 2007b). These estimates were calculated by adjusting second maximum monthly mean lead TSP monitoring values for the years 2003 to 2005 to account for

emissions reductions due to compliance with MACT requirements and the NAAQS for $PM_{2.5}$ occurring by 2016 (see Chapter 4 for additional information). We assumed that under the "control scenario" for each standard alternative, each monitor would meet the second maximum monthly mean level achieved under the cost analysis for that alternative described in Chapter 4.

While the alternative standards were specified in terms of second maximum monthly mean lead concentrations, the benefits model used estimates of maximum quarterly mean lead concentrations in order to calculate avoided cases of health endpoints. This decision was based on a number of studies outlined in EPA's 2007 Staff Paper (USEPA, 2007c; Section 5.5.2), which indicate that changes in blood lead levels resulting from changes in air lead concentrations occur within a relatively short timeframe (i.e., within a few weeks to months). This finding is also supported by a simulation of changes in urban residential dust lead levels following a change in ambient air lead using the hybrid mechanistic empirical model developed for the *Lead Risk Assessment*. That analysis showed that changes in indoor dust lead levels (the primary source of children's exposure) tracked closely with changes in ambient lead air concentrations. The hybrid model developed for the general urban case study suggested that 90% of steady-state impacts will be recognized within the three months and take up to one year for a full change to be realized.

Figure 5-5

OVERVIEW OF LEAD BENEFITS MODEL



Therefore, for the "base case" estimates of lead air concentrations used in the model, we estimated the expected maximum quarterly mean air lead concentration in 2016 in each census block group based on the second maximum monthly mean values for the "base case." This was achieved by calculating census block group-specific ratios of the second maximum monthly mean to the maximum quarterly mean for the period 2003-2005 and then dividing the second maximum monthly mean for the "base case" by this ratio.[7]

For the "control scenario" we estimated the maximum quarterly mean lead in air concentration that would be expected in 2016, based on the second maximum monthly mean NAAQS concentration. As in the "base case," we used census block group-specific ratios of the second maximum monthly means to maximum quarterly means for 2003-2005 and then divided the selected NAAQS by this ratio.

Estimating Population Exposure

The first input to any benefits assessment is the estimated changes in ambient air quality expected to result from simulated attainment of a NAAQS. EPA typically relies upon air quality modeling to generate these data. For this analysis, time and technical limitations prevented us from performing formal air quality modeling. Instead, EPA employed two alternate approaches to approximate the air quality change resulting from attainment of alternate lead NAAQS. Each approach relies upon the lead monitoring network as the basis for subsequent air quality estimates. The first approach, which we employed to generate our primary benefits estimate, uses an interpolation method utilized in previous RIAs to estimate changes in lead concentrations in projected non-attainment areas. The second approach, which we utilized as a sensitivity analysis, applies a radius of a fixed size around each non-attaining lead monitor and estimates a fixed concentration of lead within that radius. We describe the process for using each approach below.

Interpolation Method

This approach applies an interpolation method to generate an air quality surface from available lead monitoring data to better represent the spatial heterogeneity of lead concentrations in a projected non-attainment area. It utilizes both the lead monitoring network as well as the lead-speciating TSP monitoring network; we added the lead-speciating monitors to increase the number of data points available for the interpolation. We interpolated lead concentrations to the census tract, rather than census block group, to increase the computational efficiency of the model.

[7] This ratio technique is detailed further in Chapter 3.

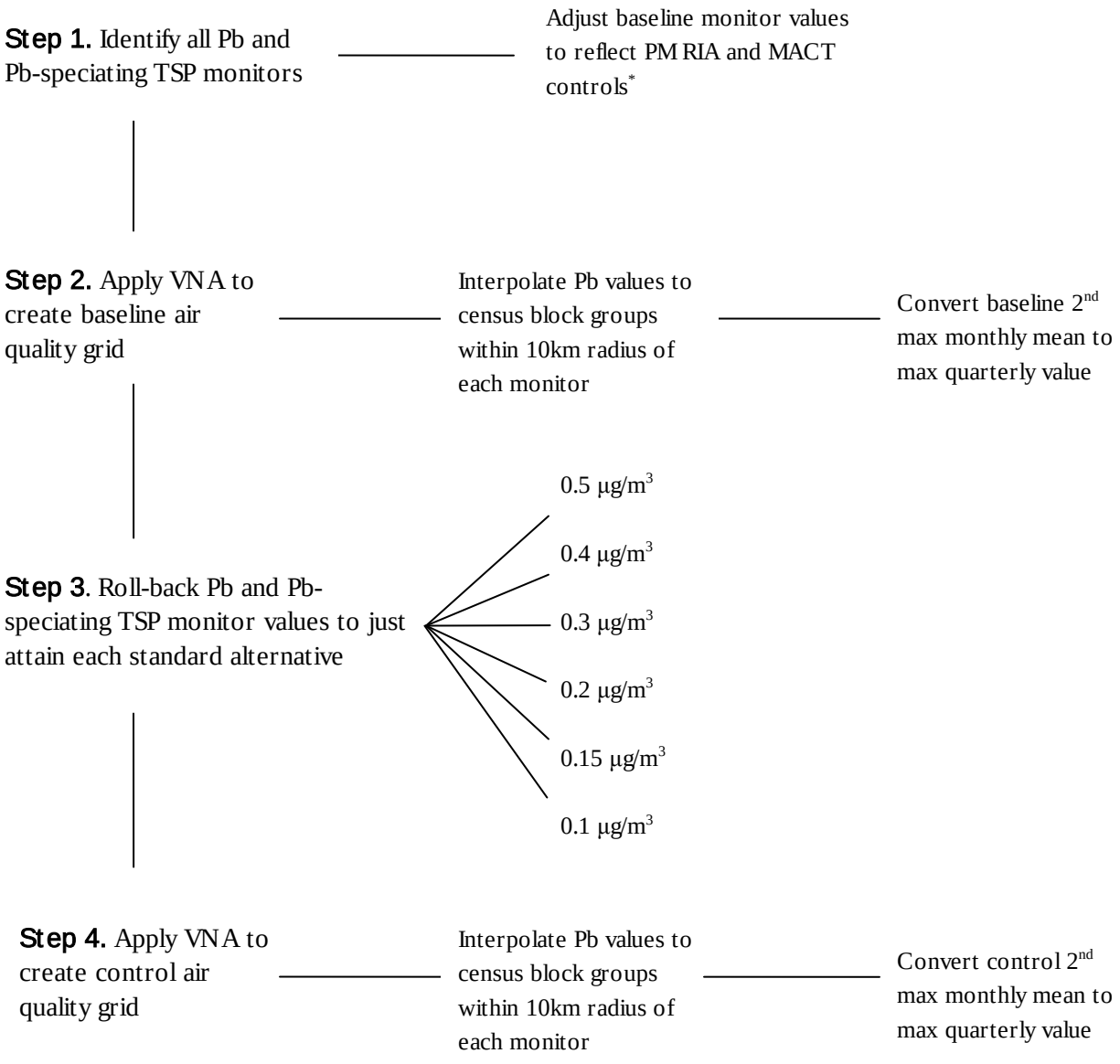
To create an air quality surface of ambient lead values we applied the Voronoi Neighborhood Averaging (VNA) method.[8] The VNA is an inverse-distance-weighting technique that interpolates point monitor data to a user-defined grid cell for the purpose of creating an air quality surface. The VNA approach is well suited for this type of analysis because the inverse distance weighting approach can approximate the gradient of ambient lead surrounding each monitor. VNA is a well-established technique that EPA has used in combination with modeled air quality changes to estimate the air quality change associated with full attainment of $PM_{2.5}$ and Ozone NAAQS (USEPA, 2006c & 2008a).

Figure 5-6 below summarizes how we applied the VNA method in this analysis. The VNA approach is expected to provide a better representation of the gradient of ambient lead around each monitor as compared to the radius approach. For this reason, we utilized this approach to generate our primary benefits estimate. However, this validity of this method is to some extent contingent upon the availability of a sufficient number of monitors to support an interpolation. In certain locations, such as Hillsborough County, FL, there are a sufficient number of lead and TSP monitors to generate an interpolation with a pronounced gradient around each monitor (see Figure 5-7). The lead and TSP monitoring network in other non-attainment areas can in some cases be sparse, and the resulting interpolation does not appear to generate a meaningful gradient, such as in Delaware County, IN (see Figure 5-8). To the extent that there was a denser lead monitoring network in such locations, the interpolation approach would produce a gradient that better represents actual ambient lead concentrations. While both the VNA and radius approaches exhibit limitations, we hold more confidence in the results of the interpolation approach and so rely upon it as our primary method of simulating air quality changes. As a means of acknowledging the limitations to the interpolation method we also provide sensitivity estimates using the radius method.

[8] For technical details of the VNA approach, see the technical appendices to the BenMAP User manual , found at: http://www.epa.gov/air/benmap/models/BenMAPTechnicalAppendicesDraftMay2005.pdf

Figure 5-6

Steps in the VNA Interpolation Technique



*This step required us to adjust the Pb-speciating TSP monitors to reflect the presence of PM RIA and MACT emission controls. The emissions controls team performed this adjustment for the Pb monitors. To make a conforming adjustment to the Pb-speciating TSP monitors, we used VNA to interpolate the PM RIA and MACT-related air quality improvement from the Pb monitors to the Pb-speciating TSP monitors.

Figure 5-7. Air Lead Concentration Gradient in Hillsborough County, Florida

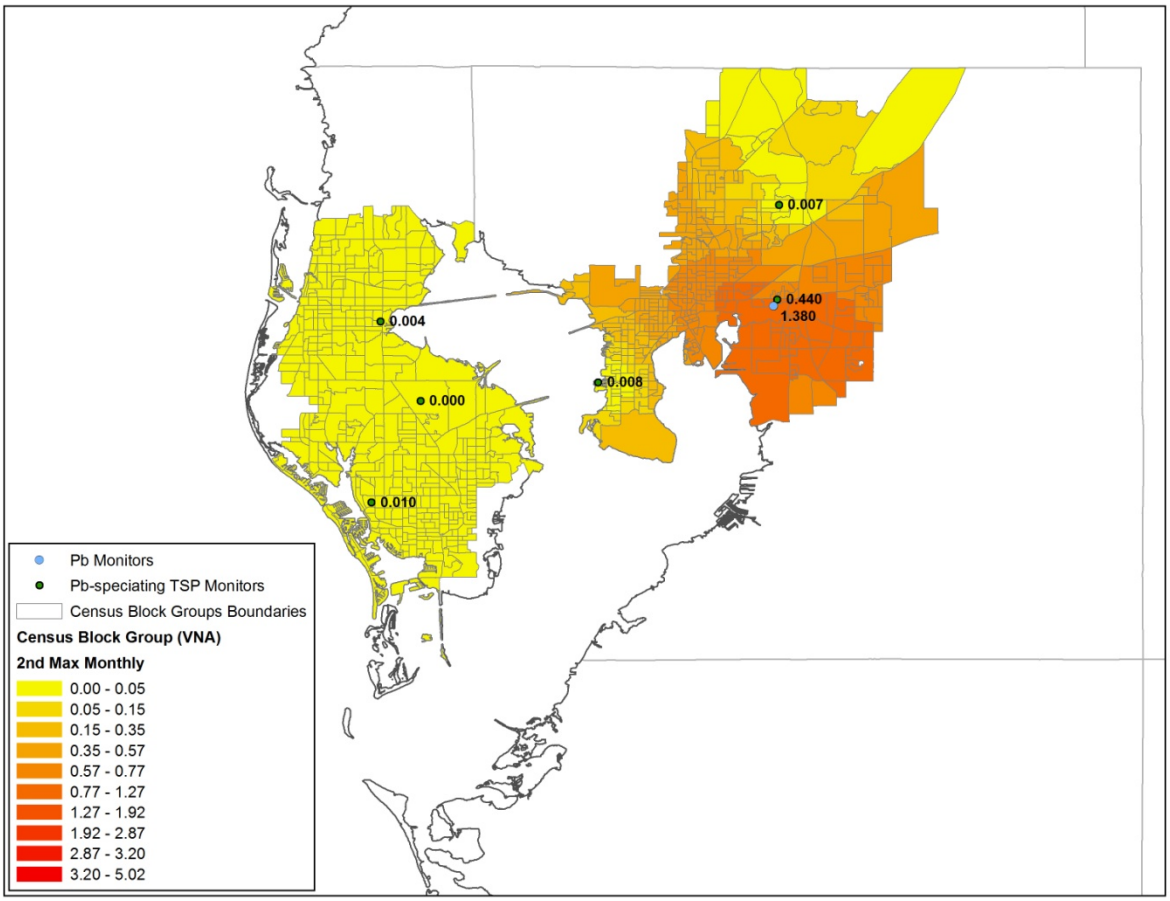
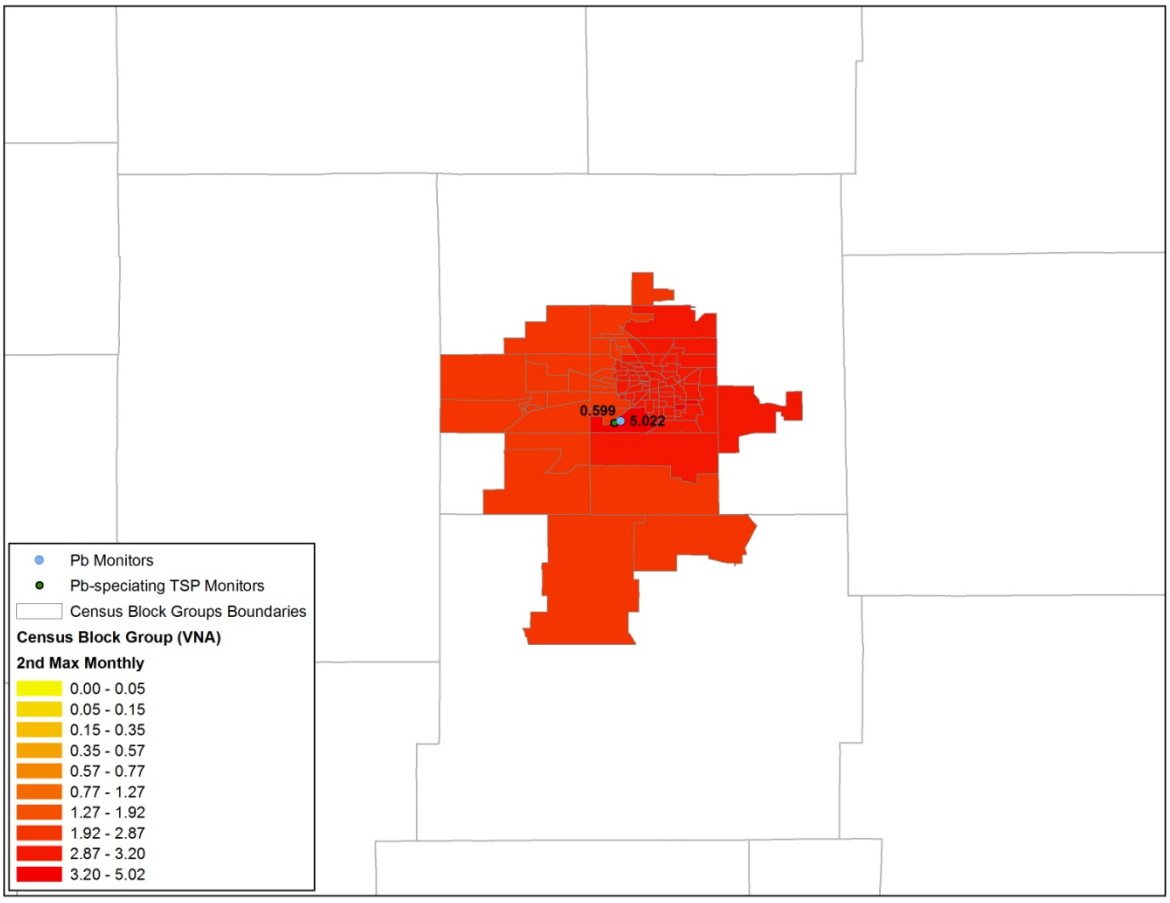


Figure 5-8. Air Lead Concentration Gradient in Delaware County, Indiana



Radius Method

In this approach we focused on the 21 monitors in counties that potentially could be designated as non-attainment areas under at least one of these alternative lead NAAQS levels. These monitor concentration values likely only apply to the population of people living within the vicinity of these monitors, especially if the monitor is oriented near a source of lead contamination (e.g., a primary or secondary lead smelter). As a default, we defined the affected population as those individuals living within a 10-kilometer radius around the monitor. The 10-kilometer radius is consistent with source-specific modeling in the EPA *Lead Risk Assessment* case studies for primary and secondary sources (USEPA, 2007a). In the absence of detailed air quality modeling for the lead sources in the vicinity of each monitor, we assumed in this screening-level analysis that the lead concentrations in air measured at each monitor are uniform throughout the specified radius. To develop a conservative upper-bound estimate of lead benefits, we assumed the entire population of the county was exposed to the concentration measured at the monitor (the geographic extent of a county generally exceeds 10 km). Also, we performed sensitivity analysis using alternate, smaller radii of one, two, and five kilometers, since lead air concentrations can in some cases display significant gradients with distance from a source-oriented monitor. For example, second maximum monthly mean values measured at monitors in close proximity to the Herculaneum, MO lead smelter drop off 40 percent within roughly 1 km of the source and decrease by an additional 95 percent within 2 km.[9]

We used ArcGIS to establish the radii around each monitor. Our spatial dataset contained US Census population data at the block group level for the year 2000. We calculated the total population within each radius in 2000 by adding the population of each Census block group that at least partially resided within the radius. We then distributed the estimate of the total population for each radius in 2000 into gender- and age-specific groups (in five-year increments, consistent with the age ranges reported by the Census).[10]

Population Projections

For both the interpolation and radius methods, we extrapolated the 2000 age- and gender-specific population data to 2016, using Woods and Poole county-level projection data (Woods and Poole, 2001). We calculated a growth rate for each gender and age group combination by taking the ratio of the 2016 estimate from Woods and Poole to the corresponding 2000 county-level estimates from the Census. We applied the calculated growth rates to each gender and age group to estimate the total population in 2016 residing within each census tract or radius. This approach to population projection is consistent with previous EPA RIA's that estimate future-year human health benefits (USEPA 2006c, 2007c, 2008a). However EPA does not assume that

[9] This was assessed using second maximum monthly mean monitoring data between 2003-2005 for eight monitors located near the Herculaneum Lead Smelter (operated by the Doe Run Company) (USEPA, 2007b).

[10] The five-year age groups were 0-4, 5-9, 10-14, … up to 85 and above.

the number of Pb emitting sources will grow correspondingly with the population growth as discussed in Chapter 4.

In order to determine the number of children under the age of seven, we added the population of children in the 0-4 age group for both genders and then added two-fifths of the population in the 5-9 age group, assuming the population was uniformly distributed across all five ages in that group.

Estimating Blood Lead Levels

The concentration-response functions we employ in this benefits analysis require estimates of blood lead levels in the exposed population to calculate avoided incidence of adverse health effects. We chose to develop a first approximation of the blood lead levels associated with reductions in air lead concentrations for each of the alternative NAAQS by using the air lead to blood lead ratio ("air:blood ratio") approach applied by EPA in deriving the current NAAQS in 1978 (43 FR 46246). These ratios predict geometric blood lead levels due to direct lead exposure via inhalation as well as indirect exposures via ingestion of dust and soils contaminated by lead deposition, based on comparisons of historical data on lead in ambient air and measured or modeled geometric mean blood lead levels in an exposed population. Table 5-4 lists the ratios considered for the current NAAQS analysis; for its primary estimate, EPA chose a ratio of 1:7 $\mu g/m^3$ to $\mu g/dl$. That is, for every one microgram per cubic meter reduction in air lead, EPA assumed that geometric mean blood lead levels would be reduced by seven micrograms per deciliter. We selected this value based on advice from the Clean Air Scientific Advisory Committee (CASAC) and analysis conducted as part of EPA's *Lead Risk Assessment* (USEPA, 2007a & 2007d).

CASAC in its March 2007 review of EPA's *Lead Risk Assessment* recommended that EPA apply these ratios as part of a population level lead risk analysis to inform alternative proposals for a new lead NAAQS (USEPA, 2007d; see Appendix D). In its previous NAAQS analysis, EPA used a ratio of 1:2 $\mu g/m^3$ to 1:6 $\mu g/dl$; however, CASAC suggested that ratios higher than 1:2 may be appropriate based on more recent literature. CASAC cites the use of a ratio of 1:5 by the World Health Organization (WHO) in 2000 to better account for lead deposition from air to dust and soil, and they cite a ratio of 1:9-1:10 based on the data in Schwartz and Pitcher (1989) on blood lead changes resulting from the phase-out of lead in gasoline.

As part of its *Lead Risk Assessment*, EPA calculated air:blood ratios based on the extensive modeling conducted for its case studies and compared these ratios to values reported in the literature (USEPA, 2007a). For the benefits analysis, we reviewed the ratios in Table 5-7 of the *Lead Risk Assessment* that compare the incremental reduction in air concentrations required to meet lower alternative NAAQS levels to the corresponding incremental change in blood lead. The ratios for the general urban and primary lead smelter case studies range from 1:2 to 1:6 for scenarios ranging from the current NAAQS to an alternative NAAQS of 0.05 $\mu g/m^3$ maximum monthly mean. EPA found these values to be similar to ratios available in the literature, specifically to ratios reported in a 1984 meta-analysis by Brunekreef (1:3 to 1:6) and to values

calculated from a more recent 2003 study by Hilts (1:7). More recently, a study of changes in children's blood Pb levels associated with reduced Pb emissions and associated air concentrations near a Pb smelter in Canada (for children through age six in age) reports a ratio of 1:6 and additional analysis of the data by EPA for the initial time period of the study resulted in a ratio of 1:7 (CD, pp. 3-23 to 3-24; Hilts, 2003).[11] Ambient air and blood Pb levels associated with the Hilts (2003) study range from 1.1 to 0.03 µg/m3, and associated population mean blood Pb levels range from 11.5 to 4.7 µg/dL, which are lower than levels associated with the older studies cited in the 1986 Criteria Document (USEPA, 1986).

We also reviewed the ratio of 1:9-1:10 cited by CASAC that was based on the data in Schwartz and Pitcher (1989) on blood lead changes resulting from the phase-out of lead in gasoline. Schwartz and Pitcher developed a regression equation to estimate blood lead levels from gasoline-based lead usage (hundreds of metric tons per day) in the period 1976-1980. Their main analysis used a nationally representative sample of the U.S. population from the second National Health and Nutrition Examination Survey (NHANES II) and controlled for a range of factors such as age, income, smoking, educational attainment, nutrition, occupational exposure, alcohol intake, and urban/rural status.[12] (Another potential confounder, dietary lead intake, was found to exhibit no temporal trend over the study period and thus was not included in the model.) Schwartz and Pitcher's analysis found that for every 100 metric tons (MT) of gasoline lead used per day, the general population blood lead level would increase 2.14 µg/dL. This finding was corroborated by a supplemental analysis by the authors of a dataset of blood lead screening results for inner-city children in Chicago over the same time period. CASAC developed its ratio of 1:9 – 1:10 by first multiplying the 2.14 µg/dL per hundred MT of gasoline lead to an estimate of gasoline usage in 1976 (426 MT per day) to produce a blood lead attributable to lead in gasoline of 9.12 µg/dL. CASAC then divided this value by EPA's estimated reduction in ambient air levels in urban cities of 1 $\mu g/m^3$ between 1976 and the elimination of lead in gasoline (USEPA, 1986) to produce the ratio.

We also considered a 1:5 air:blood ratio, which represented the ratio for the change in the urban case study from current (mean) conditions to an alternative NAAQS of 0.2 $\mu g/m^3$ maximum monthly mean. According to the Notice of Proposed Rulemaking, "There are a number of sources of uncertainty associated with these model-derived ratios. The hybrid indoor dust Pb model, which is used in estimating indoor dust Pb levels for the urban case studies, uses a HUD dataset reflecting housing constructed before 1980 in establishing the relationship

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[11] This study considered changes in ambient air Pb levels and associated blood Pb levels over a five-year period which included closure of an older Pb smelter and subsequent opening of a newer facility in 1997 and a temporary (3 month) shutdown of all smelting activity in the summer of 2001. The author observed that the air-to-blood ratio for children in the area over the full period was approximately 1:6. The author noted limitations in the dataset associated with exposures in the second time period, after the temporary shutdown of the facility in 2001, including sampling of a different age group at that time and a shorter time period (3 months) at these lower ambient air Pb levels prior to collection of blood Pb levels. Consequently, EPA calculated an alternate air-to blood Pb ratio based on consideration for ambient air Pb and blood Pb reductions in the first time period (after opening of the new facility in 1997).

[12] Race was addressed using stratified regression analysis and was not found to modify results by more than 10 percent (Schwartz and Pitcher, 1989).

between dust loading and concentration, which is a key component in the hybrid dust model (see Section Attachment G-1 of the Risk Assessment, Volume II). Given this application of the HUD dataset, there is the potential that the non-linear relationship between indoor dust Pb loading and concentration (which is reflected in the structure of the hybrid dust model) could be driven more by the presence of indoor Pb paint than contributions from outdoor ambient air Pb. We also note that only recent air pathways were adjusted in modeling the impact of ambient air Pb reductions on blood Pb levels in the urban case studies, which could have implications for the air-to-blood ratios." (US EPA, 2008b).

As a sensitivity analysis, we selected a lower bound of the 1:2 ratio from the U.S. EPA *Lead Risk Assessment* and an upper bound of 1:10 as upper bound of the CASAC Schwartz and Pitcher study-based estimates. We believe the inclusion of the 1:10 ratio as an upper bound is justified by the strengths of the design of the Schwartz and Pitcher study, which like the Hilts study, captured the effects of a natural experiment, by its extensive control for confounders, including dietary exposures, and by the robustness of its findings using national-level and urban inner-city samples.

We divided the maximum quarterly mean lead in air concentrations for each scenario by the air:blood ratio to estimate the blood lead level in the population due solely to exposure to ambient air. We then added an estimate of non-air-related background blood lead level (e.g., from ingestion of indoor dust or outdoor soil contaminated by lead paint) to calculate the total geometric mean blood lead level expected in the population.[13] For our estimate of non-air-related background, we selected the midpoint from a range of values reported by CASAC as being most appropriate for children under 7 years of age (USEPA, 2007d).[14] We apply this estimate of current-year non-air background blood lead for an analysis year of 2016. State and federal interventions such as the Renovation and Repair Rule (EPA, 2008c) may reduce future non-air blood lead to a level below this estimate. EPA alternate approaches to projecting non-air blood lead levels to reflect such regulatory interventions. However, data limitations prevented EPA from generating credible estimates.

The air:blood ratio provided us with an estimate of the geometric mean blood lead level across the population of exposed children, which we then used to estimate the magnitude of health effects benefits. We assumed that the blood lead level changes in 2016 estimated in this way are a reasonable representation of lifetime average blood lead level for children under seven years of age in our study and were used with the selected dose-response functions without further adjustment.

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[13] We estimated total blood lead level to be consistent with the epidemiological studies underlying the dose-response functions we used for estimating changes in IQ due to changes in lead exposure, which are based on total blood lead level.

[14] CASAC provided a range of non-air-related background geometric mean concentrations of 1.0 – 1.4 μg/dl in their comments on EPA's *Lead Risk Assessment* (USEPA, 2007a). We selected the midpoint of this range, 1.2 μg/dl, for this analysis.

Table 5-4. Air Lead to Blood Lead Ratios

Ratio	*Source*	*Description*
1:2 to 1:6	USEPA, 2007a	Ratios in Table 5-7 of EPA's current *Lead Risk Assessment* (USEPA, 2007a) estimated from modeling of exposures in urban areas and areas near lead smelters. These ratios compare the incremental reduction in air concentrations required to meet lower alternative NAAQS levels to the corresponding incremental change in blood lead. This ratio is likely to provide the best estimate of blood lead associated with recent changes in air lead concentrations. These ratios for the general urban and primary lead smelter case studies range from 1:2 to 1:6 for scenarios ranging from the current NAAQS to an alternative NAAQS of 0.05 $\mu g/m^3$ maximum monthly mean, respectively.
1:5	USEPA, 2007a WHO, 2005	Ratio applied by WHO to establish current lead Air Quality Guideline for Europe. Also reported in Table 5-7 of EPA's *Lead Risk Assessment* (USEPA, 2007a; see above) for the ratio for the change in the urban case study from current (mean) conditions to an alternative NAAQS of 0.2 $\mu g/m^3$ maximum monthly mean.
1:3 to 1:6	Brunekreef, 1984	Ratios reported in a meta-analysis of surveys of smelters and urban areas. Based on older studies that typically reflect ratios for children with blood lead levels > 10 μg/dl.
1:6 to 1:7	Hilts, 2003[15]	Ratio calculated from more recent study of air concentrations and blood lead levels for children living near a British Columbia smelter during a period of decreasing lead emissions. Blood lead levels in this study (4 – 10 μg/dl) are lower than in the Brunekreef studies, but still higher than those modeled in EPA's 2007 *Lead Risk Assessment*.
1:9-1:10	USEPA, 2007d; Schwartz and Pitcher (1989)	Ratio cited by CASAC in its March 2007 advisory that was derived from calculations in Schwartz and Pitcher analysis of the impacts of phasing out lead in gasoline. Reflects ratios for changes from higher baseline lead concentrations than expected under current conditions.

[15] This study considered changes in ambient air Pb levels and associated blood Pb levels over a five-year period which included closure of an older Pb smelter and subsequent opening of a newer facility in 1997 and a temporary (3 month) shutdown of all smelting activity in the summer of 2001. The author observed that the air-to-blood ratio for children in the area over the full period was approximately 1:6. The author noted limitations in the dataset associated with exposures in the second time period, after the temporary shutdown of the facility in 2001, including sampling of a different age group at that time and a shorter time period (3 months) at these lower ambient air Pb levels prior to collection of blood Pb levels. Consequently, EPA calculated an alternate air-to blood Pb ratio based on consideration for ambient air Pb and blood Pb reductions in the first time period (after opening of the new facility in 1997).

Estimating Avoided Health Effects

The following section presents the approach we used to quantify the health benefits of lead due to reductions in the blood lead levels in the population resulting from lowering the NAAQS. This analysis estimates the adverse health impact of blood lead levels on changes in IQ in young children below seven years of age. Cognitive effects are thought to strongly relate to a child's future productivity and earning potential (USEPA, 2006b).

Multiple epidemiologic studies of Pb and child development have demonstrated inverse associations between blood Pb concentrations and children's IQ and other cognitive-related outcomes at successively lower Pb exposure levels over the past 30 years (as discussed in the CD, section 6.2.13). Numerous epidemiological studies have reported neurocognitive, neurobehavioral, sensory, and motor function effects in children with blood Pb levels below 10 µg/dL (CD, sections 6.2 and 8.4). As discussed in the Criteria Document, "extensive experimental laboratory animal evidence has been generated that (a) substantiates well the plausibility of the epidemiologic findings observed in human children and adults and (b) expands our understanding of likely mechanisms underlying the neurotoxic effects" (CD, p. 8-25; section 5.3).

Threshold levels for neurological effects, in terms of blood Pb levels in individual children, cannot be discerned from the currently available studies (CD, pp. 8-60 to 8-63). The Criteria Document states "[t]here is no level of Pb exposure that can yet be identified, with confidence, as clearly not being associated with some risk of deleterious health effects" (CD, p. 8-63). The Criteria Document also notes that "a threshold for Pb neurotoxic effects may exist at levels distinctly lower than the lowest exposures examined in these epidemiologic studies" (CD, p. 8-67). The current evidence indicates the occurrence of a variety of health effects, including neurological effects in children, associated with blood Pb levels extending well below 10 µg/dL (CD, Sections 6.2, 8.4 and 8.5). For example, as noted in the Criteria Document with regard to the neurocognitive effects in children, the "weight of overall evidence strongly substantiates likely occurrence of [this] type of effect in association with blood-Pb concentrations in range of 5-10 µg/dL, or possibly lower … Although no evident threshold has yet been clearly established for those effects, the existence of such effects at still lower blood-Pb levels cannot be ruled out based on available data." (CD, p. 8-61). The Criteria Document further notes that any such threshold may exist "at levels distinctly lower than the lowest exposures examined in these epidemiological studies" (CD, p. 8-67).

In comparing across the individual epidemiological studies and the international pooled analysis, the Criteria Document observed that at higher blood Pb levels (e.g., above 10 µg/dL), the slopes (for change in IQ with blood Pb) derived for log-linear and linear models are almost identical, and for studies with lower blood Pb levels, the slopes appear to be steeper than those observed in studies involving higher blood Pb levels (CD, p. 8-78, Figure 8-7).

The current evidence reviewed in the Criteria Document with regard to the quantitative relationship between neurocognitive decrement, such as IQ, and blood Pb levels indicates that

the slope for Pb effects on IQ is nonlinear and is steeper at lower blood Pb levels, such that each µg/dL increase in blood Pb may have a greater effect on IQ at lower blood Pb levels (e.g., below 10 µg/dL) than at higher levels (CD, section 6.2.13; pp. 8-63 to 8-64; Figure 8-7). As stated in the CD, "the most compelling evidence for effects at blood Pb levels <10 µg/dL, as well as a nonlinear relationship between blood Pb levels and IQ, comes from the international pooled analysis of seven prospective cohort studies (n=1,333) by Lanphear et al. (2005)" (CD, pp. 6-67 and 8-37 and section 6.2.3.1.11). Using the full pooled dataset with concurrent blood Pb level as the exposure metric and IQ as the response from the pooled dataset of seven international studies, Lanphear and others (2005) employed mathematical models of various forms, including linear, cubic spline, log-linear, and piece-wise linear, in their investigation of the blood Pb concentration-response relationship (CD, p. 6-29; Lanphear et al., 2005). They observed for this pooled dataset that the shape of the concentration-response relationship is nonlinear and the log-linear model provides a better fit over the full range of blood Pb measurements than a linear one (CD, p. 6-29 and pp. 6-67 to 6-70; Lanphear et al., 2005). In addition, they found that no individual study among the seven was responsible for the estimated nonlinear relationship between Pb and deficits in IQ (CD p. 6-30). Others have also analyzed the same dataset and similarly concluded that, across the range of the dataset's blood Pb levels, a log-linear relationship was a significantly better fit than the linear relationship (p=0.009) with little evidence of residual confounding from included model variables (CD, section 6.2.13; Rothenberg and Rothenberg, 2005).

In order to quantify the expected changes in IQ points in the population of children due to the implementation of alternative NAAQS, we utilized available dose-response functions in the literature. For our primary estimate, we selected a dose-response relationship from a pooled analysis of seven prospective studies in North America and Europe examining the effect of lead on full-scale IQ in children (Lanphear et al., 2005).[16,17] Blood lead levels were measured in each study five times over early childhood (at 6, 12 (or 15), 36, 48, and 60 months). Full-scale IQ was measured when the children were between 4 and 10 years of age. Four measures of blood lead were examined by the authors: concurrent blood lead (defined as the blood lead measured closest to the IQ test), maximum blood lead (defined as the peak blood lead measured at any time before the IQ test), average lifetime blood lead (defined as the mean blood lead from six months to concurrent blood lead tests), and early childhood blood lead (defined as the mean blood lead from 6 to 24 months). The authors found that the concurrent and lifetime blood lead levels were the strongest predictors of IQ deficits associated with lead exposure.

[16] Full-scale IQ is a composite score of verbal and performance tests. Children were administered a version of the Wechsler Intelligence Scales for Children under uniform conditions within each study (Lanphear et al., 2005).

[17] The seven cohort studies included in this analysis include sites in Boston, Massachusetts (Bellinger et al., 1992); Cincinnati and Cleveland, Ohio (Dietrich et al., 1993 and Ernhart et al., 1989); Mexico City, Mexico (Schnaas et al., 2000); Rochester, New York (Canfield et al., 2003); and Yugoslavia (Wasserman et al., 1997).

We used an estimate from this study based on a log-linear relationship between lifetime blood lead level and IQ score.[18] The log-linear relationship was found to be the best fit for the data and the lifetime blood lead levels exhibited a strong relationship with IQ. In addition, we found this measure to be the most consistent with the benefits scenario (see the section in this chapter entitled "Selection of Health Endpoints for further information). Lanphear reports an IQ decrement of 6.2 points for an increase in lifetime blood lead level from 6.1 to 47.0 μg/dl for the selected model. However, the lowest measured lifetime blood lead level represented in the Lanphear pooled analysis was 1.47 μg/dl. To estimate IQ effects at blood lead levels below this "cutpoint," we used a linearized slope, obtained by taking the tangent to the log-linear function at the point of departure (USEPA, 2007a).

To estimate IQ benefits from blood lead reductions, we first calculated the expected IQ point loss per child under each of the two scenarios (the "base case" and the "control scenarios") for each monitor (Equation 1). We then subtracted the "base case" IQ loss from the "control scenario" IQ loss and multiplied by the population of children six years of age and younger living within the radius of influence of each monitor to estimate the total number of IQ points that would be gained by reducing the NAAQS (Equation 2).

Equation 1

For blood lead levels ≥ cutpoint:

$$\text{IQ loss} = \beta_1 \times \ln(\text{PbB}/\text{cutpoint}) + \beta_2 \times \text{cutpoint}$$

For blood lead levels < cutpoint:

$$\text{IQ loss} = \beta_2 \times \text{PbB}$$

Where:

Cutpoint = 1.47 μg/dl (i.e., the lowest observed lifetime blood lead level);
β_1 = -3.04 (log-linear regression coefficient from Lanphear (2005), Table 4);
β_2 = -2.1 (linear slope); and
PbB = blood lead level (μg/dl).

Equation 2

$$\Delta \text{IQ} = (\text{IQ loss}_{\text{Control}} - \text{IQ loss}_{\text{Base}}) \times \text{P}$$

Where:

Δ IQ = total number of IQ points gained under the "control scenario" in comparison with the "base case" in 2016;

[18] The natural log of the blood lead levels were used for this analysis.

IQ loss $_{Control}$ = IQ point loss under the "control scenario" per child;

IQ loss $_{Base}$ = IQ point loss under the "base case" per child; and

P = the population of children aged 0 – 6 within the monitor's radius of influence.

To assess the sensitivity of selecting the log-linear model with low-exposure linearization from Lanphear et al. (2005), we estimated the IQ points gained using another function from this study. This function represents an analysis performed by stratifying the study population based on the child's peak blood lead level measurement (i.e., maximal blood lead level above and below 7.5 μg/dl). A linear slope was then was then fit to each group relating the concurrent blood lead level index to IQ score. We used these slopes to calculate the IQ loss for each scenario on a per child basis, using Equation 3 below. We then calculated the total IQ points gained as in the primary estimate, by using Equation 2 described above.

Equation 3

For blood lead levels ≥ cutpoint:

$$\text{IQ loss} = \beta_1 \times (\text{PbB} - \text{cutpoint}) + \beta_2 \times \text{cutpoint}$$

For blood lead levels < cutpoint:

$$\text{IQ loss} = \beta_2 \times \text{PbB}$$

Where:

Cutpoint = 5.17 μg/dl;[19]

β_1 = -0.16 (linear coefficients from Lanphear et al. (2005) for blood lead levels greater than or equal to the cutpoint);

β_2 = -2.94 (linear coefficients from Lanphear et al. (2005) for blood lead levels below the cutpoint); and

PbB = blood lead level (μg/dl).

We also assessed the sensitivity of the IQ benefits to the epidemiological study selected, using alternative estimates from a study of 172 children in Rochester, New York (Canfield et al, 2003), a linear function developed for the Lead Renovation and Repair Rule (U.S. EPA, 2008c)

[19] This cutpoint refers to the lifetime average blood lead level. Using the data presented in Table 1 of Lanphear et al. (2005), we multiplied the peak blood lead level cutpoint value of 7.5 μg/dl by the ratio of median lifetime average (12.4 μg/dl) to the median peak (18.0 μg/dl) blood lead levels in the study population.

and the linear function found in table 3 of the Lead NAAQS rule. Using a linear model between lifetime blood lead level and IQ score, Canfield et al. (2003) found a decrement of 0.46 IQ points per 1 μg/dl increase in blood lead level.[20] The RRP rule specified a linear function, finding a decrement of 0.88 IQ points per 1 μg/dl increase in blood lead.[21] Finally, the Lead NAAQS cites four key studies that have "a mean blood Pb level closest to today's mean for U.S. children yields four slopes ranging from -1.56 to -2.94, with a median of -1.75 IQ points per μg/dL."[22] We summarize these studies below in table 5-5. We used the following equation (Equation 4) for these three linear dose-response functions:

Equation 4

$$\Delta \text{ IQ} = [\beta \times (PbB_1 - PbB_2)] \times P$$

Where:

Δ IQ = total number of IQ points gained under the "control scenario" in comparison with the "base case" in 2016;

β = linear regression coefficient (-0.46 for Canfield, -0.88 for RRP and -1.75 for the lead NAAQS);

PbB_1 = blood lead level under the "control scenario" (μg/dl);

PbB_2 = blood lead level under the "base case" (μg/dl); and

P = the population of children aged 0 – 6 within the monitor's radius of influence.

[20] See table 3 of Canfield, R.L, Henderson, C.R., Cory-Slechta, D.A., et al. (2003). Intellectual Impairment in Children with Blood Lead Concentrations below 10 μg per Deciliter. *The New England Journal of Medicine* 348(16): 1517-26.

[21] Note that we include this function for comparative purposes. This function was designed to characterize IQ changes among children exposed to lead during renovation activities, a policy context that differs from the analysis here.

[22] U.S. Environmental Protection Agency (2008b) *National Ambient Air Quality Standards for Lead*. Office of Air and Radiation. EPA-HQ-OAR-2006-0735. Pp156.

Table 5-5. Summary of Quantitative Relationships of IQ and Blood Pb for Analyses with Blood Pb Levels Closest to those of Children in the U.S. Today.

Blood Pb Levels (μg/dL) Geometric Mean	Range (min-max)	Study/Analysis	Average Linear Slope[A] (IQ points per μg/dL)
2.9	0.8 – 4.9	Tellez-Rojo et al 2006, <5 subgroup	-1.71
3.24	0.9 – 7.4	Lanphear et al 2005[B], <7.5 peak subgroup	-2.94
3.32	0.5 – 8.4	Canfield et al 2003 [B], <10 peak subgroup	-1.79
3.8	1 - 9.3	Bellinger and Needleman 2003 [B] , <10 peak subgroup	-1.56
		Median value	**-1.75**

[A] Average linear slope estimates here are for relationship between IQ and concurrent blood Pb levels (BLL), except for Bellinger & Needleman for which study reports relationship fir 10 year old IQ with 24 month blood Pb levels.

[B] The Lanphear et al 2005 pooled International study includes blood Pb data from the Rochester and Boston cohorts, although for different ages (6 and 5 years, respectively) than the ages analyzed in Canfield et al 2003 and Bellinger and Needleman 2003.

Benefit Valuation

Value of Avoided IQ decrements

The valuation approach we apply for assessing monetary losses associated with IQ decrements is based on an approach applied in previous EPA analyses (USEPA, 1997, 2005 & 2006b). The approach expresses the loss to an affected individual resulting from IQ decrements in terms of foregone future earnings for that individual.

To estimate the expected monetary value of these effects, we first estimated the median present value of future earnings at time of birth for a person born in the U.S., based on earnings and labor force participation rate data from the 2006 Current Population Survey (CPS).[23] When calculating the lifetime earnings estimate, we assumed an individual born today would begin working at age 16 and retire at age 67. We assumed a real growth rate for wages of one percent per year, as assumed in EPA's Section 812 retrospective analysis (US EPA, 1997); adjusted for survival probabilities based on current US vital statistics from the CDC's National Center for Health Statistics;[24] and adjusted for labor force participation by age. We then discounted the expected lifetime stream of wages using a three percent annual rate. As in EPA's *Economic Analysis for the Renovation, Repair, and Painting Program Proposed Rule* (EPA, 2008c), we assumed children will be affected by lead at age three, the midpoint of the range during which children are thought to be most susceptible to lead. Therefore, we discounted lifetime earnings back to age three. We estimated present value median lifetime earnings to be $606,930 in 2006 dollars.

[23] See http://www.bls.gov/cps/home.htm - data.

[24] See http://www.cdc.gov/nchs/data/nvsr/nvsr54/nvsr54_14.pdf.

In the previous EPA analyses cited above, the Agency has applied an average estimate of the effect of IQ on earnings of 2.379 percent per IQ point from an analysis by Salkever (1995).[25] An analysis by Schwartz (1994b) estimated that a 1-point increase in IQ would increase earnings by 1.76 percent. The percentage increases in both studies reflect both direct impact of IQ on hourly wages and indirect effects on annual earnings as the result of additional schooling and increased labor force participation. A recent review of literature from the labor economics and environmental health fields by CDC economist Scott Grosse suggests that both of these studies may have overestimated the association of IQ with earnings (2007). Specifically, he found the Salkever estimate of direct impacts of IQ on wages to be higher than estimates reported in the labor economics literature. Grosse also found that the Schwartz study overestimates the cognitive impact of lead exposure on earnings, but he argues that the Schwartz estimate may still be appropriate for estimating the total effect of lead on earnings, because it includes the effects of lead on education and earnings that result from both cognitive and non-cognitive changes. Thus, it may be a more comprehensive estimate than one based on cognitive changes alone.

In recognition of the fact that the economics literature continues to evolve, and because EPA has traditionally relied upon the Salkever (1995) estimate to value changes in IQ, for this analysis we provide a range of valuation estimates based on both the Salkever (1995) and the Schwartz (1994b) functions. Below we describe how we estimate the cost per IQ decrement using each function.

The 1.76 percent estimate from Schwartz represents a gross impact on earnings; it does not account for the costs of additional schooling. EPA's Clean Air Mercury Rule (CAMR) RIA (USEPA, 2005) reported an estimate of $16,425 per additional year of schooling in 1992 dollars, based on U.S. Department of Education data reflecting both direct annual expenditures per student and annual average opportunity cost (i.e., lost income from being in school). Consistent with the CAMR analysis, we assume that these costs are incurred when an individual born today turns 19, based on an average 12.9 years of education among people aged 25 and over in the U.S. We discount the educational costs back to a present value at age 3, to be consistent with the present value of lifetime earnings. We then adjust this value to 2006 dollars, resulting in an estimated $14,700 per additional year of schooling. Schwartz reports an increase of 0.131 years of schooling per IQ point (1994b); thus the change in average education costs per IQ point is $\$14{,}700 \times 0.131 = \$1{,}930$.

Using the Schwartz function, we calculated the present value of the median net earnings loss associated with one IQ point as the present value of median lost earnings per IQ point lost ($\$606{,}930 \times 0.0176 = \$10{,}682$) minus the change in average education costs per IQ point ($1,930). These calculations yield a value of $8,760 of net earnings lost per a one-point decrease in IQ using a 3% discount rate and a value of $1,094 at a 7% discount rate.

To estimate the cost per IQ point using Salkever (1995), we followed the same set of steps as above, substituting the Salkever estimate of the change in lifetime earnings. These

[25] The 812 Retrospective analysis also included an estimate based on older work by Needleman et al. (1990).

calculations yield a value of $12,512 of net earnings lost per a one point decrease in IQ using a 3% discount rate and a value of $2,156 at a 7% discount rate.

Results

This section presents the health effects results and the associated monetary benefits. We first present the expected IQ point gains in 2016, comparing each of the "control scenarios" to the "base case." We then provide the expected monetized value of those gains in IQ in 2016. We also describe an analysis we performed to assess the sensitivity of the model to the various inputs used and assumptions made. Finally, we explain the methodology we applied for estimating monetized health benefits from co-control of $PM_{2.5}$ and the results of that analysis.

Changes in IQ

Table 5-6 below presents the total number of IQ points expected to be gained in the US in the year 2016 by achieving each of the alternate NAAQS level options, when compared to the "base case" (i.e., the lead NAAQS remains at its current level). Our results indicate that the number of IQ points gained in 2016 ranges from 230,000 if a 0.5 maximum quarterly mean NAAQS is achieved up to 510,000 for a 0.1 maximum quarterly mean NAAQS. These IQ point gains are valued at between $2.0 and $6.4 billion at a 3% discount rate and between $0.3 and $1.1 billion at a 7% discount rate (2006$).

Table 5-6. Number of IQ Points Gained and Monetary Benefits (in Millions of 2006$) in 2016

		*Estimated Net Present Value of IQ Points Gained**	
Standard Alternative	*IQ Points Gained*	3% Discount Rate	7% Discount Rate
0.5 Maximum Quarterly Mean	230,000	$2,000—$2,800	$250—$490
0.4 Maximum Quarterly Mean	230,000	$2,000—$2,800	$250—$490
0.3 Maximum Quarterly Mean	270,000	$2,400—$3,400	$300—$580
0.2 Maximum Quarterly Mean	360,000	$3,200—$4,500	$390—$780
0.15 Maximum Quarterly Mean	400,000	$3,500—$5,000	$440—$870
0.1 Maximum Quarterly Mean	510,000	$4,500—$6,400	$560—$1,100

*Lower end of range calculated using Schwartz (1994b) estimate; upper end calculated using Salkever (1995) estimate.

** Results reflect the use a 2002 derived non-air background blood lead applied to analysis year of 2016. To the extent that state and federal interventions such as the Renovation and Repair Rule (EPA, 2008c) reduce future non-air blood lead levels, the estimate of IQ change above may be overstated.

We also assessed the geographic distribution of these benefits. We found that the benefits were concentrated in a small number of counties. Table 5-7 below is an example of the distribution of total benefits due to IQ points gained for the selected 0.15 $\mu g/m^3$ maximum quarterly mean NAAQS standard. For this standard, approximately 60 percent of the total benefits are due to changes in lead air concentrations in four counties: Hillsborough, FL; Delaware, IN; and Berks, PA.

Table 5-7. Percentage of Benefits by County (0.15 μg/m^3 Second Maximum Monthly Mean NAAQS)

County	State	Population of Children in Affected Area	Affected Population (%)	Percentage of Benefits (%)
Hillsborough	FL	67,359	17%	38%
Delaware	IN	7,957	2%	13%
Berks	PA	27,966	7%	13%
Collin	TX	22,192	6%	12%
Denton	TX	8,243	2%	5%
Cuyahoga	OH	60,605	16%	4%
Pike	AL	2,621	1%	4%
Jefferson	MO	6,472	2%	2%
Orange	NY	9,186	2%	2%
Dakota	MN	23,216	6%	1%
Beaver	PA	9,120	2%	1%
Fulton	OH	1,644	0%	1%
Rutherford	TN	707	0%	1%
Williamson	TN	804	0%	1%
Logan	OH	2,993	1%	1%

Note: There were several other counties that constituted less than 1 percent of benefits that are not included in this table.

IQ Sensitivity Analysis

We performed a sensitivity analysis on the benefits model in order to assess the total range of potential benefits and to determine the sensitivity of the primary model results to various data inputs and assumptions. We used the model to calculate the total monetary benefits due to gains in children's IQ for the 0.15 maximum quarterly monthly mean NAAQS option using our default model input assumptions.[26] We then changed each default input one at a time and recalculated the total benefits to assess the percent change from the default. Table 5-8 below presents the results of this sensitivity analysis. The table indicates for each input parameter the value used as the default (in bold) and the values for the sensitivity analyses. It then provides the total monetary benefits for each input and the percent change from the default value.

Our sensitivity analysis results indicate that the benefits model is most sensitive to the method used for assigning air lead exposure concentrations to the population of exposed children. Our primary estimate relied on an interpolation method, where several monitor concentrations were used in determining the exposure concentration. When the radius method was employed as part of the sensitivity analysis, the results varied. We assumed that monitor concentration applied to the population residing within a 10 km radius as a best estimate of the

[26] Note that for the sensitivity analysis, we relied on the results that incorporated the valuation estimate for IQ from Schwartz (1994b).

exposed population, which as we noted above, produces a conservative upper-bound estimate of exposure. When compared with the interpolation method, this increased results by 40 percent. The size of the radius assumed when using the radius method also had a large impact on the results. When the radius size was reduced to 5, 2, and 1 km for monitors associated with a lead source, the benefits are significantly reduced (i.e., total monetary benefits are reduced by 48, 87, and 94 percent, respectively). In addition, if the monitor concentration is assumed to apply to the population of the entire county in which that monitor resides, the benefits increase significantly (320 percent).

The discount rate also had a significant impact on results, because the benefits of lead on earnings occur over a lifetime, and the net present value of those earnings is highly sensitive to the discount rate applied. When the discount rate was changed from the default (3 percent) to a rate of 7 percent, the benefits fell by 83 percent.

Table 5-8. Sensitivity Analysis for the Primary Estimate of Health Benefits (for the 0.15 µg/m^3 Maximum Quarterly Mean Results)

	Model Input	Total Benefits (Millions 2006$)	Percent Change from Default
Exposure Estimation Method	**Interpolation**	**$5,000**	N/A
	County	$21,000	320%
	10 km Radius	$7,000	40%
	5 km Radius	$2,600	-48%
	2 km Radius	$670	-87%
	1 km Radius	$300	-94%
Discount Rate	**3 Percent**	**$5,000**	N/A
	7 Percent	$870	-83%
Epidemiological Study for IQ	**Lanphear et. al (2005)**	**$5,000**	N/A
	Canfield et. al (2003) Linear slope of *-0.46*	$2,600	-48%
	Lanphear et al. (2005) Dual Linear	$12,000	140%
	Median of 4 Functions in Rule	$10,000	100%
	LRRP Function Linear slope of *-0.88*	$5,000	0%
Air:Blood (µg/m3 in air:µg/dl in blood)	**1:7**	**$5,000**	N/A
	1:10	$5,900	18%
	1:2	$2,500	-50%
Non-Air-Related Background Geometric Mean Blood Lead Level (µg/dl)	**1.2**	**$5,000**	N/A
	1.0	$5,400	8%
	1.4	$4,700	-6%
Valuation Study	**Salkever (1995)**	**$5,000**	N/A
	Schwartz (1994)	$3,500	-30%

Finally, the results are also sensitivity to the selection of the concentration-response function. Compared to the default function, the use of the Canfield et al. (2003) estimate generates IQ change estimates that aer 48% lower. Conversely, the Lanphear dual-linear function

generates an IQ change estimate that is 140% that of the default, while the function based on the median of the four functions in Table 5-5 generates an estimate twice that of the default.

Inputs that had a moderate impact on the benefits results include the air:blood ratio selected to convert lead air concentrations into blood lead levels in the population, the non-air-related geometric mean blood lead level used, as well as the IQ valuation function.

PM Co-Control Benefits – Methodology and Results

As outlined in Chapter 4, most of the point source measures implemented to achieve the NAAQS standards are focused on controlling emissions of lead in particulate form. As a result, virtually all of these measures also have a significant impact on emissions of directly emitted particulate matter. Table 5-9 lists the PM-related health effects that are included in our monetized benefits estimate incorporating PM co-benefits.[27]

In Chapter 4 we identified control technologies to reduce emissions of lead that also reduce $PM_{2.5}$. However, in some areas, more emission reductions are needed than can be achieved through identified control options (i.e., unidentified controls). The identified and unidentified controls are shown in Table 5-10 below. These emission reduction estimates are incremental to a baseline that reflects emission reductions from MACT controls and the $PM_{2.5}$ NAAQS RIA.

[27] Because the PM co-benefits are estimated on a $-per-ton basis, we do not report quantitative estimates for individual PM health effects.

Table 5-9. Health Effects of $PM_{2.5}$.

Effect	*Quantified Health Effects*	*Unquantified Health Effects*[e]
Health[a,b]	-Premature mortality based on both cohort study estimates and on expert elicitation[c,d] -Bronchitis: chronic and acute -Hospital admissions: respiratory and cardiovascular -Emergency room visits for asthma -Nonfatal heart attacks (myocardial infarction) -Lower and upper respiratory illness -Minor restricted-activity days -Work loss days -Asthma exacerbations (asthmatic population) -Respiratory symptoms (asthmatic population) -Infant mortality	-Subchronic bronchitis cases -Low birth weight -Pulmonary function -Chronic respiratory diseases other than chronic bronchitis -Non-asthma respiratory emergency room visits

[a] Because the PM co-benefits are estimated on a $-per-ton basis, we do not report quantitative estimates for individual PM health effects.

[b] In addition to primary economic endpoints, there are a number of biological responses that have been associated with PM health effects, including morphological changes and altered host defense mechanisms. The public health impact of these biological responses may be partly represented by our quantified endpoints.

[c] Cohort estimates are designed to examine the effects of long-term exposures to ambient pollution, but relative risk estimates may also incorporate some effects due to shorter-term exposures (see Kunzli et al., 20 01).

[d] While some of the effects of short-term exposure are likely to be captured by the cohort estimates, there may be additional premature mortality from short-term PM exposure not captured in the estimates included in the primary analysis.

[e] The categorization of unquantified toxic health effects is not exhaustive. Health endpoints in this column include both a) those for which there is not consensus on causality; and b) those for which causality has been determined but empirical data are not available to allow calculation of benefits.

Table 5-10. Summary of Estimated Co-Controlled $PM_{2.5}$ Emissions Reductions (in Tons)

Alternate NAAQS (Second Maximum Monthly Mean)	*Identified Controls*	*Unidentified Controls*	*All Controls*
0.5 $\mu g/m^3$	1,532	1	1,534
0.4 $\mu g/m^3$	1,538	5	1,544
0.3 $\mu g/m^3$	2,743	30	2,772
0.2 $\mu g/m^3$	3,037	114	3,150
0.15 $\mu g/m^3$	3,122	175	3,297
0.1 $\mu g/m^3$	3,492	304	3,795

To estimate the value of these $PM_{2.5}$ emissions reductions, EPA utilized $PM_{2.5}$ benefit-per-ton estimates. These $PM_{2.5}$ benefit-per-ton estimates provide the total monetized human health benefits (the sum of premature mortality and premature morbidity) of reducing one ton of $PM_{2.5}$ from a specified source. EPA has used a similar technique in previous RIAs, including the recent ozone NAAQS RIA (USEPA, 2008a). The fourteen estimates presented below derive from the application of three alternative methods:

- One estimate is based on the concentration-response (C-R) function developed from a study of the American Cancer Society (ACS) cohort reported in Pope et al. (2002), which has previously been reported as the primary estimate in recent RIAs (USEPA, 2006c).

- One estimate is based on Laden et al.'s (2006) reporting of the extended Six Cities cohort study; this study is a more recent PM epidemiological study that was used as an alternative in the PM NAAQS RIA.

- The other twelve estimates are based on the results of EPA's expert elicitation study on the PM-mortality relationship, as first reported in Industrial Economics (2006) and interpreted for benefits analysis in EPA's final RIA for the PM NAAQS, published in September 2006 (USEPA, 2006c). For that study, twelve experts (labeled A through L) provided independent estimates of the PM-mortality C-R function. EPA practice has been to develop independent estimates of PM-mortality estimates corresponding to the C-R function provided by each of the twelve experts.

Readers interested in reviewing the complete methodology for creating the benefit per-ton estimates used in this analysis can consult the Technical Support Document (TSD) accompanying the recent final ozone NAAQS RIA (USEPA 2008a).[28] As described in the documentation for the benefit per-ton estimates cited above, national per-ton estimates are developed for selected pollutant/source category combinations. The per ton values calculated therefore apply only to tons reduced from those specific pollutant/source combinations (e.g., SO_2 emitted from electric generating units; NO_x emitted from mobile sources). Emissions controls

[28] The Technical Support Document, entitled: *Calculating Benefit Per-Ton Estimates*, can be found in EPA Docket EPA-HQ-OAR-2007-0225-0284.

modeled in this RIA are all applied to point sources; a few are at electric generating units (EGUs), but most are at industrial facilities involved in handling lead as a manufacturing product, byproduct, or input. From among the list of pollutant/source combinations outlined in the TSD referenced above, the combination most appropriate for valuation of $PM_{2.5}$ emissions reductions from the sources controlled for lead emissions is the combination for $PM_{2.5}$ from EGU and non-EGU point sources. Estimates of this per-ton value for a 3 percent discount rate vary from a low of $68,000 per ton to a high of $570,000 per ton (based on a change in emissions of 50 percent or less from a 2015 PM emissions base, in 2006$). Our estimate of $PM_{2.5}$ co-control benefits is therefore based on the total $PM_{2.5}$ emissions controlled multiplied by this per-ton value. The results of this calculation are provided in Table 5-11 below. Figures 5-9 and 5-10 provide a graphical representation of the 14 estimates of PM co-control benefits for $PM_{2.5}$, using both a 3 percent and 7 percent discount rate.

Table 5-11. Monetized Benefits of Co-Controlled $PM_{2.5}$ Emissions (in Millions of 2006$)

Alternative	*Pope et al. (2002)*	*Laden et al. (2006)*	*Expert A*	*Expert B*	*Expert C*	*Expert D*	*Expert E*	*Expert F*	*Expert G*	*Expert H*	*Expert I*	*Expert J*	*Expert K*	*Expert L*
						3 Percent Discount Rate								
0.5 μg/m³	$240	$510	$710	$550	$540	$380	$880	$490	$320	$410	$540	$440	$110	$400
0.4 μg/m³	$240	$510	$710	$550	$540	$390	$880	$500	$330	$410	$540	$440	$110	$400
0.3 μg/m³	$430	$920	$1,280	$990	$980	$690	$1,600	$890	$590	$740	$970	$790	$190	$720
0.2 μg/m³	$480	$1,000	$1,500	$1,100	$1,100	$790	$1,800	$1,000	$670	$840	$1,100	$900	$220	$820
0.15 μg/m³	$510	$1,100	$1,500	$1,200	$1,200	$820	$1,900	$1,100	$700	$880	$1,200	$940	$230	$860
0.1 μg/m³	$580	$1,300	$1,800	$1,400	$1,300	$950	$2,200	$1,200	$800	$1,000	$1,300	$1,100	$260	$990
						7 Percent Discount Rate								
0.5 μg/m³	$210	$460	$640	$490	$490	$350	$790	$450	$290	$370	$480	$400	$96	$360
0.4 μg/m³	$220	$460	$640	$500	$490	$350	$800	$450	$300	$370	$490	$400	$97	$360
0.3 μg/m³	$390	$830	$1,200	$890	$880	$630	$1,400	$810	$530	$670	$870	$710	$170	$650
0.2 μg/m³	$440	$940	$1,300	$1,000	$1,000	$710	$1,600	$920	$600	$760	$990	$810	$200	$740
0.15 μg/m³	$460	$980	$1,400	$1,100	$1,100	$750	$1,700	$960	$630	$790	$1,000	$850	$210	$780
0.1 μg/m³	$530	$1,100	$1,600	$1,200	$1,200	$860	$2,000	$1,100	$730	$910	$1,200	$980	$240	$890

Note: All estimates have been rounded to two significant figures. All estimates are incremental to the 2006 PM NAAQS RIA. These estimates do not include confidence intervals because they were derived through a scaling technique described in the text.

Figure 5-9. Distribution of Total $PM_{2.5}$ Monetized Co-Benefits by Lead Standard Alternative (3% Discount Rate)

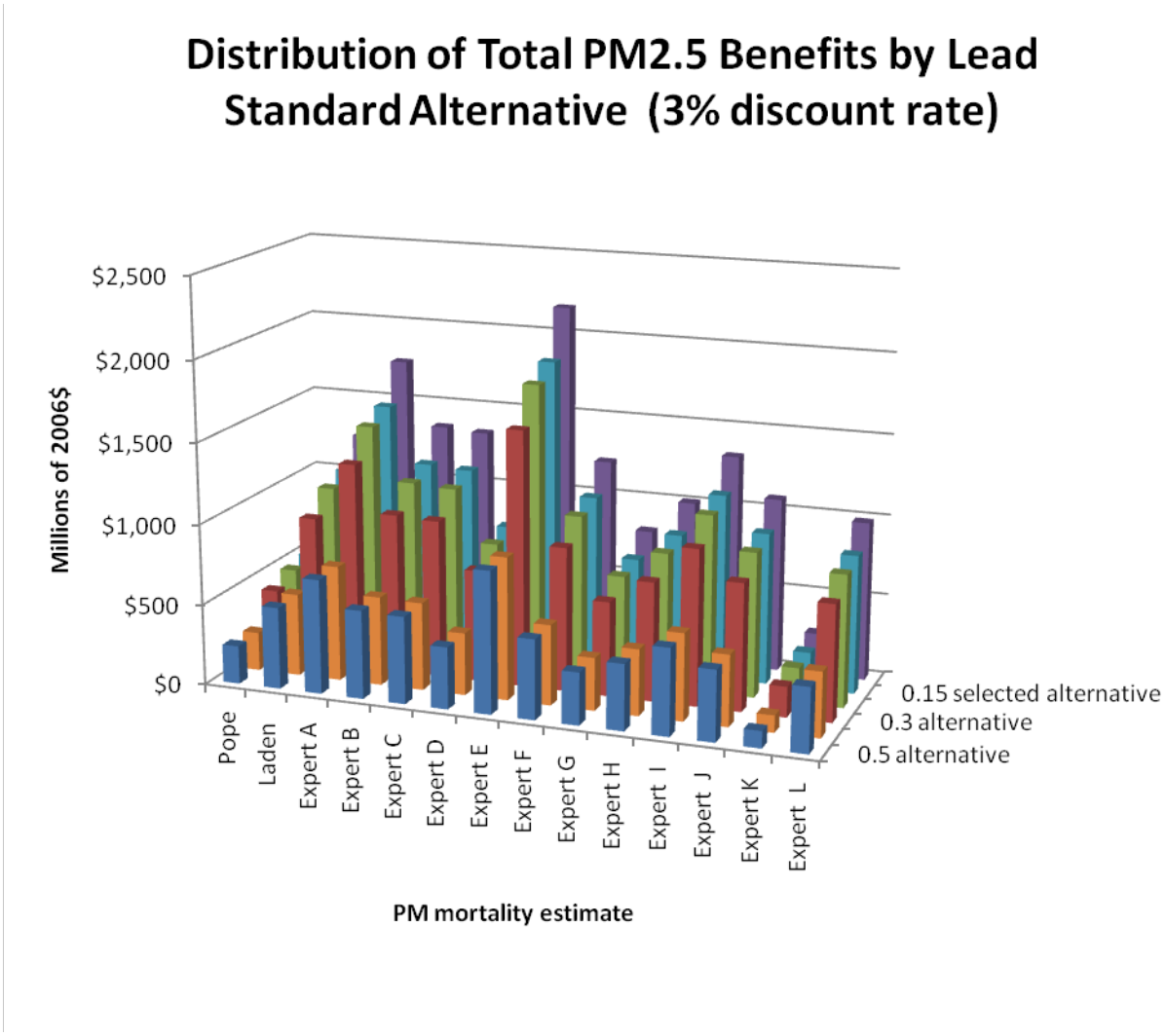
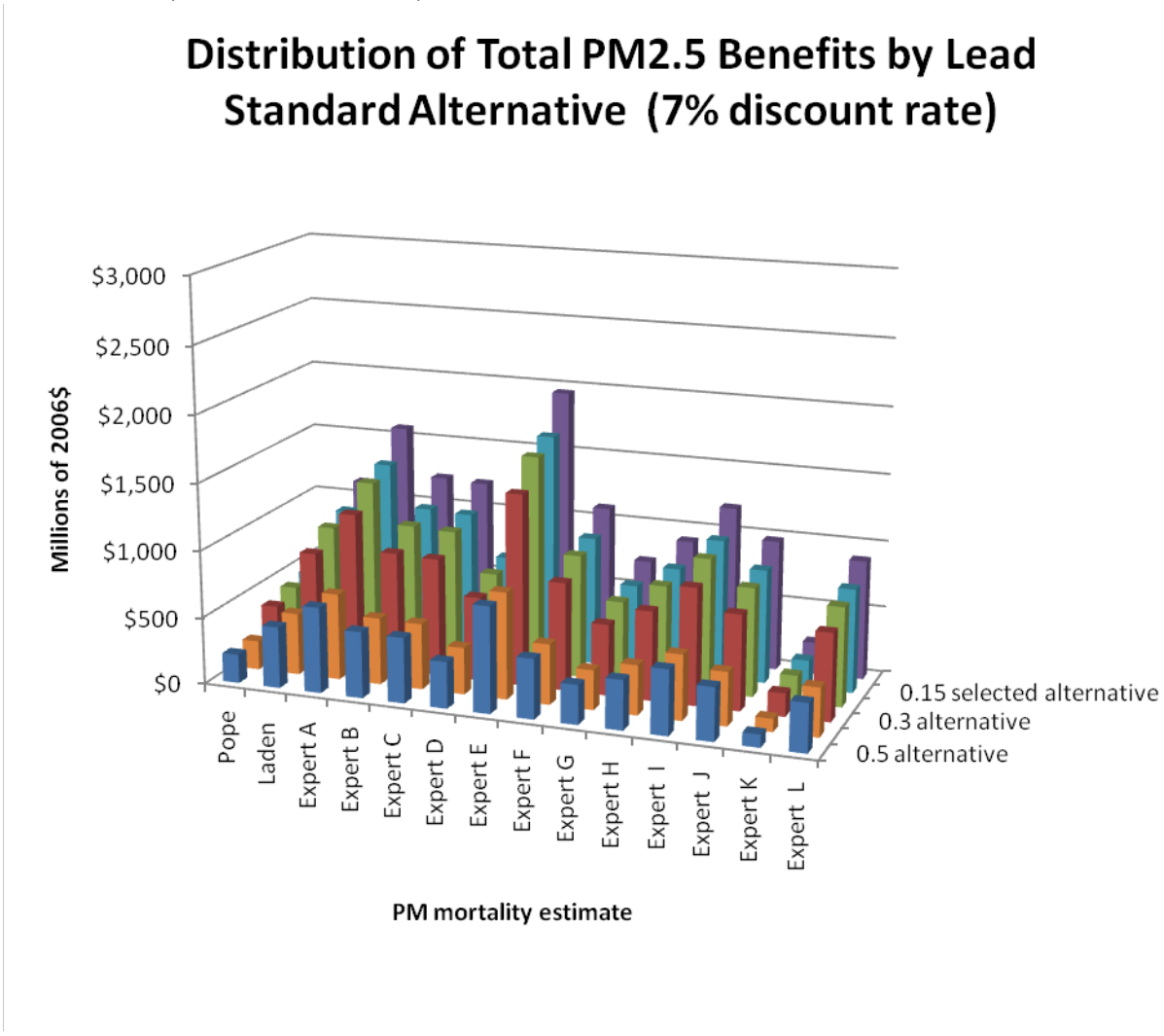


Figure 5-10. Distribution of Total $PM_{2.5}$ Monetized Co-Benefits by Lead Standard Alternative (7% Discount Rate)



Discussion

The results of this benefits analysis demonstrate that lowering the current (1.5 $\mu g/m^3$ maximum quarterly mean) lead NAAQS to the selected standard of 0.15 $\mu g/m^3$ would be expected to have a significant impact on the IQ of young children. Lowering the standard could cause an increase in total IQ points to about 400,000 points in 2016, which would be valued at between $3.5 and $5.0 billion (2006$, 3% discount rate). In addition, controls installed to achieve the lead NAAQS standards will also reduce emissions of fine particulates. As a result, this analysis includes a screening level calculation that indicates each of the alternatives considered could have a significant benefit in terms of improved particulate air quality, reduced health effects, and increased economic welfare of currently exposed individuals.

This benefits analysis is intended to be a screening investigation to provide an estimate of the potential magnitude of the benefits of reducing the lead NAAQS. Therefore, the results of this analysis are associated with a number of uncertainties. The benefits of IQ point gains in children were very sensitive to the method employed for estimating exposures to the population. When comparing the default method, which involved concentrations interpolated from multiple monitors, to the method assuming a uniform concentration within a 10 km radius around an individual monitor, the results increase by 40 percent. Increasing the radius to include the entire county in which the monitor resides results in roughly 3-fold increase in benefits. Decreasing the radius size also has a large impact on benefits, decreasing the value by as much as 94 percent when a radius of 1 km is used. The results were also fairly sensitive to the discount rate selected. When a 7 percent discount rate was used in place of the default rate of 3 percent, results decreased by 83 percent. This is in part because the benefits of lead on earnings occur over a lifetime, and the net present value of those earnings is highly sensitive to the discount rate applied. The dose-response function selected for quantifying the number of IQ points gained as a result of achieving the alternative NAAQS levels affected the results. Utilizing alternate epidemiological studies decreased the primary estimate by as much as 72 percent or increased the primary estimate by as much as 140 percent. However, we believe the Lanphear et al. (2005) study was the best choice for our primary estimate. This study was a meta-analysis that synthesized a range of existing information and is based on more recent data than the studies included in the Schwartz (1993) study. In addition, the log-linear model was the most robust estimate from this study, in that it was the best fit for the data.

Additional uncertainties related to the benefits estimates include the following:

- For our primary estimate of the benefits due to gains in children's IQ, we used a log-linear estimate from a recently published pooled analysis of seven studies (Lanphear et al., 2005). Using alternate estimates from other epidemiological studies examining the link between blood lead level and children's IQ has significant impact on benefits results. We found the benefits to decrease by as much as 72 percent when an alternate estimate from a paper by Schwartz (1993) is used. This is due in part to the underlying shape of the dose-response relationship assumed by each of the functions. In the Lanphear study, a log-linear relationship was found to be the best fit for the data (i.e., the natural log-transformed blood lead level is used to predict changes in IQ score). This model implies

that the magnitude of changes in IQ increases with lower blood lead levels. However, in the Schwartz (1993) and Canfield et al. (2003) studies, a single linear model is assumed (i.e., untransformed blood lead levels are used to predict changes in IQ score). The single linear model implies that the magnitude of change in IQ is constant over the entire range of blood lead levels. Therefore, at lower blood lead levels, the log-linear model predicts larger changes in IQ than the linear model. Note that CASAC, in their review of EPA's *Lead Risk Assessment* indicated that "studies show that the decrements in intellectual (cognitive) functions in children are proportionately greater at PbB concentrations <10 µg/dl" (USEPA, 2007d, page 3). However, if the true dose-response relationship is linear, than our primary estimate of benefits is an overestimation.

- Some uncertainty is involved in the estimates of maximum quarterly mean lead air concentrations used for the benefits model. We used ratios of second maximum monthly mean values to maximum quarterly mean values from lead monitoring data from 2003-2005 to convert the second maximum monthly mean values in 2016 into a maximum quarterly mean for the "base case" as well as to convert the alternative second maximum monthly mean NAAQS into a maximum quarterly mean for the "control scenarios." If the true ratio between the second maximum monthly means to the maximum quarterly mean is different in 2016 than in 2003-2005 because the pattern and distribution of daily values differs, then our results could be either over- or underestimated.

- The interpolation method of estimating exposure concentrations that we used for our primary estimate is associated with some uncertainty. The validity of this method is to some extent contingent upon the availability of a sufficient number of monitors to support an interpolation. In certain locations, such as Hillsborough County, FL, there are a sufficient number of lead and TSP monitors to generate an interpolation with a pronounced gradient around each monitor. The lead and TSP monitoring network in other non-attainment areas can in some cases be sparse, and the resulting interpolation does not appear to generate a meaningful gradient, such as in Delaware County, IN.

- We assumed that the IQ point effects of a change in lifetime blood lead (i.e., the effects of a change in 2016) apply to all children in our study population that were under seven years of age in 2016. If there is a critical window of exposure for IQ effects (e.g., between the ages of one and two), then we could potentially be overestimating benefits in 2016 because we would have overestimated the population affected by reduced lead exposure in that year. However, if partial or full achievement of the alternative NAAQS levels might occur earlier than 2016, the children in our 0-6 age cohort who are past any critical window in 2016 would have realized the partial or full benefits of reduced lead exposures in those earlier years. Thus, the issue of a potential critical developmental window reflects uncertainty in both the timing and size of benefits.

- The use of air:blood ratios represents an approximation to the impact of changes in ambient air concentrations of lead on concurrent blood lead levels, applied in the absence of modeling data on lead transport and deposition and the on direct and indirect human exposures. While the values we apply match fairly well with available literature, there

are relatively few studies that report such values or provide sufficient data to calculate such ratios. Further, the lead concentrations in those studies tend to be higher than those modeled here (USEPA, 2007a); thus uncertainty remains as to whether the same ratios would be expected at lower levels, or whether air exposures are more or less efficient at changing concurrent blood lead levels at these lower concentrations.

- If the air:blood ratio we apply for children or a similar value is also valid for estimating adult exposures, then our primary benefits understate the true health benefits accruing to the lead-exposed populations because they exclude impacts on morbidity and mortality impacts on adults as well as impacts on prenatal mortality. Additional research is needed to improve our understanding of the impacts of adult air exposure on adult blood lead levels.

- The earnings-based value-per-IQ-point lost that we apply in this analysis most likely represents a lower bound on the true value of a lost IQ point, because it is essentially a cost-of-illness measure, not a measure of an individual's willingness-to-pay (WTP) to avoid the loss of an IQ point. Welfare economics emphasizes WTP measures as the more complete estimate of economic value.

- The earnings-based estimate of the value-per-IQ-point lost is based on current data on labor-force participation rates, survival probabilities, and assumptions about educational costs and real wage growth in the future. To the extent these factors diverge from these values in the future, our lifetime earnings estimate may be under- or overestimated.

- Co-control benefits estimated here reflect the application of a national dollar benefit per ton estimate of the benefits of reducing directly emitted fine particulates from point sources. Because they are based on national-level analysis, the benefit-per-ton estimates used here do not reflect local meteorology, exposure, baseline health incidence rates, or other local factors that might lead to an over-estimate or under-estimate of the actual benefits of controlling directly emitted fine particulates.

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CHAPTER 6. COST ANALYSIS APPROACH AND RESULTS

This chapter describes our analysis of the engineering costs and monitoring costs associated with attaining the final National Ambient Air Quality Standard (NAAQS) for lead and the alternative standards outlined in Chapter 1.[1] We present our analysis of these costs in four separate sections. Section 6.1 presents the cost estimates. Sections 6.2 and 6.3 summarize the economic and energy impacts of the Final Rule, respectively, while Section 6.4 outlines the main limitations of the analysis.

Section 6.1 breaks out discussion of cost estimates into five subsections. The first subsection summarizes the data and methods that we employed to estimate the costs associated with the control strategies outlined in Chapter 4. As indicated in Chapter 4, these strategies rely exclusively on the application of point source controls and, in the case of Jefferson County, Missouri, the rebuild of a primary lead smelter with modern, low-emitting lead smelting technology. The second subsection presents county level estimates of the costs of identified controls associated with the regulatory alternatives examined in this RIA. Following this discussion, the third subsection describes the two approaches used to estimate the extrapolated costs of unspecified emission reductions that may be needed to comply with the selected standard. The fourth subsection provides a brief discussion of the monitoring costs associated with the NAAQS. The fifth subsection provides the estimated total costs of the regulatory alternatives examined. This section concludes with a discussion of technological change in regulatory cost estimates.

It should be noted again that overall data limitations are very significant for this analysis. One critical area of uncertainty is the limited TSP-Pb monitoring network (discussed in chapter 2). Because monitors are present in only 86 counties nationwide, the universe of monitors exceeding the various target NAAQS levels is very small—only 21 counties above 0.1 $\mu g/m^3$, the lowest alternative NAAQS level examined in this RIA. Because we know that many of the highest-emitting Pb sources in the 2002 NEI do not have nearby Pb-TSP monitors (see section 2.1.7), it is likely that there may be many more potential nonattainment areas than have been analyzed in this RIA. We should also emphasize that these cost estimates represent hypothetical emission control strategies that, in some cases, reflect assumptions about technological advances that will improve the effectiveness of specific control technologies.

It is important also to note that this chapter presents cost estimates associated with both identified point source measures and unspecified emission reductions needed to reach attainment. For the selected standard of 0.15 $\mu g/m^3$, over 94% of the estimated emission reductions needed for attainment are achieved through application of identified controls, and less than 6% through unspecified emission reductions. Identified point source controls include known measures for known sources that may be implemented to attain the selected standard, whereas the achievement of unspecified emission reductions requires implementation of hypothetical additional measures in areas that would not attain the selected standard following the implementation of identified controls to known sources.

[1] The costs presented in this chapter represent the direct pollution control expenditures associated with NAAQS compliance. As such, they do not reflect the general equilibrium impacts of the final rule.

Note that the universe of sources achieving unspecified emission reductions beyond identified controls is not completely understood; therefore we are not able to identify known control devices or work practices to achieve these reductions. We calculated extrapolated costs for unspecified emission reductions using two different methods. Both acknowledge the lack of data for this analysis. One estimates the extrapolated cost based upon recognition that the marginal cost of reducing progressively smaller amounts of emissions will increase over time. This approach estimates a total cost curve given the identified control data and estimates the additional incremental extrapolated cost. The other approach estimates extrapolated costs by costing the remaining air quality increment to attainment in each monitor area using an area-specific cost per microgram of air quality improvement. Section 6.1 below describes in more detail our approaches for estimating both the costs of identified controls and the extrapolated costs of unspecified emission reductions needed beyond identified controls.

As is discussed throughout this RIA, the technologies and control strategies selected for this analysis are illustrative of one approach that nonattainment areas may employ to comply with the revised lead standard. Potential control programs may be designed and implemented in a number of ways, and EPA anticipates that State and Local governments will consider those programs that are best suited for local conditions. As such, the costs described in this chapter generally cover the annualized costs of purchasing, installing, and operating the referenced technologies. We also present monitoring costs. Because we are uncertain of the specific actions that State Agencies will take to design State Implementation Plans to meet the revised standard, we do not estimate the costs that government agencies may incur to implement these control strategies.

The methods used in the analysis for the final NAAQS differ from those used in the analysis for the proposed NAAQS in the following ways:

1. As discussed in Chapter 4, we updated the control efficiency and cost information for many of the identified emission controls used in the Proposed Rule RIA. We determined that the values originally provided by AirControlNET were unlikely to reflect the performance and cost of these controls in 2016, the analysis year for this RIA.

2. We changed the way we estimated extrapolated costs of unspecified emission reductions. In the Proposed Rule analysis, we applied a fixed cost/ton of lead emissions reduced beyond identified controls, based on the 98^{th} percentile of the cost/ton for identified controls at large point sources. We recognize that a single fixed cost of control does not account for the different sets of conditions that might describe situations where controls are needed beyond identified controls. In this analysis, we instead estimate extrapolated costs by two approaches, the cost curve approach and the ambient extrapolation approach.

3. Rather than applying particulate matter (PM) emission controls to the primary lead smelter in Jefferson County, Missouri, we simulated a complete rebuild of the smelter to utilize a less-polluting smelting process. We estimated the cost of this rebuild based on the experience of a lead smelter in Trail, British Columbia that underwent a similar process in the mid 1990s.

We describe these changes to the analysis relative to the RIA for the proposed NAAQS in greater detail throughout this chapter.

6.1 Engineering Cost Estimates

6.1.1 Data and Methods: Identified Control Costs

Consistent with the emissions analysis presented in Chapter 3, our analysis of the costs associated with the final lead NAAQS focuses on point source particulate matter (PM) controls. For the purposes of this analysis, these controls largely include measures from the AirControlNET control technology database. The analysis also includes additional measures associated with operating permits, upgrades to existing PM control devices, and/or New Source Performance Review standards applicable to sources similar to those included in our analysis.

6.1.1.1 AirControlNET Control Costs

AirControlNET, a PC based database tool that EPA has used extensively for previous analyses of air pollution control costs, served as the primary source of cost information for our analysis of the final lead NAAQS. For the analysis of the final lead NAAQS, AirControlNET used one of two methods to estimate the costs of a given control:

1. *Dollar per ton of PM_{10} controlled.* For minor PM controls (i.e., increased monitoring frequency for PM controls and improvements to continuous emissions monitoring systems), AirControlNET estimates costs by applying a fixed cost per ton value to the tonnage of PM controlled.[2]

2. *Hybrid - cost per ton/detailed cost function.* For several PM emissions controls, AirControlNET includes a detailed cost equation that estimates costs as a function of several key engineering parameters, such as the source's capacity or stack flow rate. AirControlNET uses these equations only if a source's stack flow rate is at least 5 cubic feet/minute. If the stack flow rate is below this threshold, AirControlNET applies a fixed cost per ton value to the tonnage of PM_{10} controlled.[3] AirControlNET employs this hybrid approach for most of the major PM controls included in our analysis.[4]

To estimate costs based on the cost per ton values described under items 1 and 2 above, it was necessary to first estimate the reduction in $PM_{2.5}$ or PM_{10} emissions for each relevant source. Where possible, we developed these estimates based on the baseline PM emissions of each source, as adapted from the 2002 NEI, and the estimated control efficiency of each measure.[5] The 2002 NEI, however, does not include baseline PM emissions data for many of the sources

[2] In some cases, this cost/ton value is specific to $PM_{2.5}$, while in other cases it is specific to all PM.
[3] This stands in contrast to the cost/ton values for the controls summarized under method 1, which are estimated as a cost/ton of $PM_{2.5}$ controlled or cost/ton of total PM controlled.
[4] By major controls, we mean all controls except for increased monitoring frequency and improvements to continuous monitoring systems.
[5] Chapter 4 describes the adjustments that we made to the 2002 NEI to account for controls expected to be implemented prior to the 2016 target year for this analysis.

included in our analysis. For each of these sources, we employed one of two approaches to estimate baseline PM emissions:

1. *SPECIATE approach.* EPA's SPECIATE database includes sample PM speciation profiles for a variety of sources and maps these profiles to individual source classification codes (SCCs). For lead sources with SCCs represented by these profiles, we estimated baseline $PM_{2.5}$ and PM_{10} emissions based on the baseline lead emissions of these sources and the corresponding PM speciation profile in SPECIATE. For example, if a source has baseline lead emissions of 0.02 tons/year and the SPECIATE database suggests that lead, on average, represents two percent of the PM_{10} emissions for other sources that share its SCC, we assume that the source emits one ton of PM_{10}/year in the baseline. We used this approach to estimate the baseline $PM_{2.5}$ and PM_{10} emissions of all sources for which the 2002 NEI includes no PM emissions data but that are represented by the speciation profiles in SPECIATE.[6]

2. *Average speciation approach.* Although SPECIATE includes speciation profiles for a wide range of sources, the database does not include profiles applicable to all of the sources included in our analysis. Therefore, we were unable to use SPECIATE to estimate the baseline $PM_{2.5}$ and PM_{10} emissions for several of the lead sources for which the 2002 NEI includes no PM data. For these sources, we estimated baseline $PM_{2.5}$ and PM_{10} emissions based on the PM speciation profile of lead sources included in our analysis for which the 2002 NEI includes PM emissions data. Our analysis of these sources suggests that lead represents approximately 1.4 percent of their PM_{10} emissions and 1.9 percent of their $PM_{2.5}$ emissions. We assume that these values apply to all lead sources for which the 2002 NEI includes no PM emissions estimates and for which SPECIATE includes no relevant PM speciation profiles.

Within AirControlNET's standard format, the tool provides estimates of control costs for direct PM controls only for those sources emitting 10 or more tons of PM_{10} per year. Because many of the point sources included in our analysis fall below this emissions threshold, we have changed this standard format so that AirControlNET can apply direct PM controls to sources emitting any amount of PM_{10}.[7] The cost equations and cost per ton values for major controls, however, do not necessarily apply with great accuracy to such controls for sources below this PM emissions threshold.

To better estimate the costs of direct PM controls for such small point sources, we used AirControlNET's technology-specific cost estimates for these sources in order to estimate cost per ton values for small sources. Such costs may be quite high on a per ton basis; for example, applying a pulse-jet fabric filter on a PM_{10} source with less than 10 tons per year yields a cost per ton of $558,000. We expect that application of these point source controls to such small PM

[6] U.S. EPA, SPECIATE Version 4.0, updated January 18, 2007, http://www.epa.gov/ttn/chief/software/speciate/index.html>.

[7] In this analysis, we apply controls to small point sources with emissions below the 10 tons per year PM_{10} AirControlNET application threshold. We apply controls to small point sources due to the extent of lead nonattainment associated with the alternative standards examined in this RIA and the lack of identified point source and other controls available to examine attainment with these standards as noted in Chapter 4.

sources will be highly limited in actual practice for lead SIPs. More information on these point source controls can be found in the AirControlNET control measures documentation.[8]

As noted above, we adjusted AirControlNET's control efficiency values for a number of the emissions controls used in the Proposed Rule analysis to reflect improvements in control efficiency likely to be realized for these technologies by the 2016 target year of this analysis.[9] A number of recent EPA references provided findings that showed that increases in PM control efficiencies from those applied in our proposal RIA were reasonable for a future year analysis. These references include EPA fact sheets published in 2003 that summarize the capabilities of PM control measures and associated data. This information provided more recent data on control efficiencies and costs for PM control measures than is currently in AirControlNET. All of these fact sheets can be found at http://www.epa.gov/ttn/catc/products.html#aptecfacts. We revised the control efficiencies, and also the capital and annualized costs for these PM control devices as listed above to reflect the increased control efficiencies associated with these control measures.[10]

To account for the costs of these improvements, we also modified AirControlNET's cost estimates for these technologies as follows:

- *Fabric filters:* The estimated cost increase for fabric filters reflects an upgrade of fabric filter bags and an increase in the number of bags used by each fabric filter.
  - Pulse-Jet: Capital costs increased by 75 percent. O&M costs increased by 20 percent.
  - Mechanical Shaker: Capital costs increased by 30 percent. O&M increased by 7 percent.
  - Reverse-Air or Reverse-Jet: Capital costs increased by 40 percent. O&M increased by 5 percent.

- *Paper/Nonwoven Filters - Cartridge Collector Type:* The estimated cost increase for these units reflects the incremental cost of a more advanced filter material.

[8] Available at http://www.epa.gov/ttnecas1/models/DocumentationReport.pdf.

[9] PM control efficiencies were increased for the following control measures: dry and wet ESPs, all types of fabric filters, venturi scrubbers, impingement-plate/tray-tower scrubbers, and paper/nonwoven filters - cartridge collectors.

[10] These fact sheets are the following: U.S. EPA-CICA Air Pollution Technology Fact Sheet: Paper/Nonwoven Filters - Cartridge Collector Type with Pulse-Jet Cleaning. EPA-452/F-03-004. 2003.
U.S. EPA-CICA Air Pollution Technology Fact Sheet: Impingement-Plate/Tray-Tower Scrubber. EPA-452/F-03-012. 2003.
U.S. EPA-CICA Air Pollution Technology Fact Sheet: Venturi Scrubber. EPA-452/F-03-017. 2003.
U.S. EPA-CICA Air Pollution Technology Fact Sheet: Fabric Filter - Mechanical Shaker Cleaned Type. EPA-452/F-03-024. 2003.
U.S. EPA-CICA Air Pollution Technology Fact Sheet: Fabric Filter - Pulse-Jet Cleaned Type. EPA-452/F-03-025. 2003.
U.S. EPA-CICA Air Pollution Technology Fact Sheet: Fabric Filter - Reverse-Air Cleaned Type. EPA-452/F-03-026. 2003.
U.S. EPA-CICA Air Pollution Technology Fact Sheet: Dry Electrostatic Precipitator (ESP) - Wire-Plate Type. EPA-452/F-03-028. 2003.
U.S. EPA-CICA Air Pollution Technology Fact Sheet: Wet Electrostatic Precipitator (ESP) - Wire-Plate Type. EPA-452/F-03-030. 2003.

- Capital cost increase: 75 percent.
- O&M increase: 10 percent.

- *Dry or Wet ESP:* For ESPs, the estimated increase in costs reflects additional charging inside the ESP.
  - Capital cost increase: 25 percent.
  - O&M increase: 10 percent.

- *Venturi Scrubber:* The cost increase for venturi scrubbers reflects an upgrade in scrubber material and higher operating pressure.
  - Capital cost increase: 35 percent.
  - O&M increase: 40 percent.

6.1.1.2 Control Measure Upgrades and Controls Identified from New Source Performance Standards and Recent Operating Permits

In addition to controls included in AirControlNET, our analysis of the costs associated with the final lead NAAQS reflects the potential implementation of controls identified from other sources. These include measures enumerated in recent operating permits for sources similar to those included in this RIA as well as measures that new and modified/reconstructed sources of PM emissions are expected to implement for compliance with New Source Performance Standards. The specific measures identified for these sources include the following:

- *Capture hoods vented to a baghouse at iron and steel mills:*
  - We estimate the annualized costs for this control measure at $5,000/ton of $PM_{2.5}$ emission reduction.[11]

- *Diesel particulate filter (DPF) (for stationary sources such as diesel generators);*
  - We have taken the control efficiency and cost data from technical support documents prepared for the U.S. EPA as part of analyses undertaken for the final compression-ignition NSPS.[12] The annualized cost for $PM_{2.5}$ reductions from applying DPF is $9,000/ton.

- *Upgrade of CEMs and increased monitoring frequency of PM controls (for sources where not already identified as a control by ACN).*
  - The annualized costs for this control range from $600 to $5,200/ton of $PM_{2.5.}$ This control is applicable to ESPs and baghouses at both EGU and non-EGU sources.[13] This

[11] U.S. Environmental Protection Agency. Regulatory Impact Analysis for the Particulate Matter NAAQS. October, 2006. Chapter 3, p. 3-13. This document is available at http://www.epa.gov/ttn/ecas/regdata/RIAs/Chapter%203--Controls.pdf.

[12] U.S. Environmental Protection Agency. "Emission Reduction Associated with NSPS for Stationary CI ICE." Prepared by Alpha-Gamma, Inc. June 3, 2005, and U.S. Environmental Protection Agency. "Cost per Ton for NSPS for Stationary CI ICE." Prepared by Alpha-Gamma, Inc. June 9, 2005.

[13] U.S. Environmental Protection Agency. Regulatory Impact Analysis for the Particulate Matter NAAQS. October, 2006. Appendix E, pp. E-16 to E-24. This document is available at http://www.epa.gov/ttn/ecas/regdata/RIAs/Appendix%20E--Controls%20List.pdf.

control was applied to existing sources identified as having ESPs and baghouses according to their operating permits.

6.1.1.3 Costs of Rebuilding the Primary Lead Smelter in Jefferson County, Missouri

In the proposed rule RIA, a significant portion of the estimated costs of the rule— ranging from 55 percent for the 0.05 μg/m^3 standard to 95 percent for the 0.3 μg/m^3 standard—reflected the implementation of emission reductions beyond identified controls at the primary lead smelter in Jefferson County, Missouri. To reduce the extent to which the estimated costs of the lead NAAQS depend on emission reductions beyond identified controls at a single facility, EPA estimated the cost of replacing the Jefferson County smelter's current lead smelting unit with a more modern, lower-emitting Kivcet furnace, similar to the unit that Teck Cominco built in the mid-1990s at the primary lead smelter it operates in Trail, British Columbia[15]. In addition to the facility in Trail, BC, the Kivcet process is currently employed at plants in Kazakhstan, Bolivia, and Italy.[14] While more targeted measures may allow the smelter in Jefferson County to reduce its lead emissions more cost effectively than the replacement of its smelting unit, information on such measures is not available. In the absence of this information, we use the estimated costs of building and opening a Kivcet furnace at the Jefferson County facility as a reasonable indicator of the facility's *potential* identified control lead abatement costs. Our approach for estimating these costs is as follows:

1. *Obtain cost information on the Teck Cominco Kivcet furnace:* According to Cominco's 1996 annual report, the total cost of building the Kivcet furnace was approximately $152 million (year 1996 Canadian dollars).[15] In addition, based on communications with the facility's management, we estimate that the facility incurred additional costs of approximately $30.4 million (year 1996 Canadian dollars) to address unanticipated operational problems with the Kivcet furnace after it was initially brought online in 1997, bringing the total cost of the project to approximately $182.4 million (year 1996 Canadian dollars).[16] Converting to U.S. dollars and adjusting for inflation, this translates to approximately $184.5 million in year 2006 U.S. dollars.[17]

2. *Scale Teck Cominco's costs to reflect the capacity of the primary smelter in Jefferson County:* The capacity of the primary lead smelter in Jefferson County is significantly higher than that of Teck Cominco's Trail facility—250,000 tons per year for the Jefferson County smelter versus 132,000 tons per year for the Trail facility. Scaling the cost of the Teck Cominco Kivcet furnace to account for this difference in capacity, we estimate that the total upfront cost of building a Kivcet furnace at the Jefferson County smelter would be approximately $349 million.

[14] The Eastern Mining and Metallurgical Research Institute for Non-Ferrous Metals, Pyrometallurgy. http://vcm.ukg.kz/eng/v3_6.htm. Accessed September 23, 2008.

[15] Cominco Ltd. 1996 Annual Report, p. 12. Cominco and Teck Corporation merged in 2001 to form Teck Cominco Limited.

[16] According to the general manager of Teck Cominco's Trail operations, these additional costs were equal to approximately 20 percent of the construction costs for the Kivcet furnace. Personal communication with Mike Martin, general manager of Teck Cominco's Trail operations, August 25, 2008.

[17] To adjust for inflation, we use the *Engineering News Record* construction cost index.

3. *Annualize Kivcet furnace construction costs:* To annualize the estimated $349 million in costs for the construction of a Kivcet furnace at the primary lead smelter in Jefferson County, we assume that the furnace would have a 30-year lifespan. Based on this assumption, we estimate annualized costs of $31.7 million, using a 3 percent discount rate, and $42.0 million, applying a 7 percent discount rate.

Based on Teck Cominco's experience, transitioning to a Kivcet furnace could potentially reduce O&M costs for the primary lead smelter in Jefferson County. After the Kivcet furnace went online at Teck Cominco's Trail facility in 1997, its O&M costs declined significantly, largely due to reduced labor costs.[18] We do not incorporate potential O&M savings into our cost assessment for the Jefferson County smelter; therefore, we may overestimate the *net* costs associated with installing a Kivcet furnace at the facility.

6.1.2 Engineering Cost Estimates for Identified Controls

Based on the data and methods outlined above, we estimated the costs associated with implementing the control strategies presented in Chapter 4. Table 6-1 summarizes these costs by monitor area. As indicated in the table, the estimated costs of these controls under the selected standard are approximately $150 million per year, assuming a discount rate of seven percent. Applying a three percent discount rate this value becomes $130 million per year. The annual costs of identified controls under the alternative standards included in Table 6-1 range from $57 million under the 0.5 $\mu g/m^3$ standard to $180 million under the 0.1 $\mu g/m^3$ standard, assuming a discount rate of seven percent. If we apply a three percent discount rate, these values adjust to $46 million and $160 million for the 0.5 and 0.1 $\mu g/m^3$ standards, respectively. Consistent with Chapter 4's summary of the air quality impacts associated with identified controls, the cost estimates in Table 6-1 reflect partial attainment with several of the standards examined in this RIA. For the selected standard of 0.15 $\mu g/m^3$, the costs in Table 6-1 reflect attainment in 13 of the 21 monitor areas included in this analysis.

The results in Table 6-1 illustrate that the costs of the selected standard are likely to vary by monitor area. The costs of identified measures are expected to be highest in Jefferson County, Missouri. As indicated in Chapter 4, Jefferson County has the highest baseline lead emissions of any county in the U.S. This largely reflects emissions from the primary lead smelter located in the county. Table 6-2 presents the costs of identified controls/pound of lead emissions avoided in each monitor area. The estimates presented in this table suggest that, in general, the cost/pound of avoided lead emissions increases significantly for a given monitor as the standard becomes more stringent. For example, the cost/pound for Delaware County, Indiana steadily increases from $700/pound under the 0.5 $\mu g/m^3$ standard to $3,100/pound under the 0.1 $\mu g/m^3$ standard, assuming a 7 percent discount rate. This is consistent with local areas first targeting sources where relatively low cost reductions may be achieved and subsequently achieving reductions from sources that are more costly to control (i.e., moving up the area's marginal abatement cost curve).

[18] Personal communication with Mike Martin, general manager of Teck Cominco's Trail operations, August 25, 2008.

Table 6-1
ANNUAL COSTS RELATED TO IDENTIFIED CONTROLS*

Monitor State	Monitor County	Annual Cost of Identified Controls in 2016 (Millions of 2006$)											
		Standard Alternative: 0.5 µg/m^3 2nd Maximum Monthly Mean**		Standard Alternative: 0.4 µg/m^3 2nd Maximum Monthly Mean**		Standard Alternative: 0.3 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.2 µg/m^3 2nd Maximum Monthly Mean		Selected Standard: 0.15 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.1 µg/m^3 2nd Maximum Monthly Mean	
		3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate
AL	Pike	$3.1	$3.3	$3.1	$3.3	$3.1	$3.3	$4.0	$4.2	$4.3	$4.6	$4.3	$4.6
CO	El Paso	-	-	-	-	-	-	-	-	-	-	$0.2	$0.2
FL	Hillsborough	<$0.1	<$0.1	<$0.1	<$0.1	$0.4	$0.4	$0.8	$0.9	$0.8	$0.9	$1.4	$1.5
IL	Madison	-	-	-	-	-	-	-	-	-	-	$13	$14
IN	Delaware	$1.8	$1.9	$1.8	$1.9	$3.6	$3.8	$5.4	$5.7	$6.1	$6.5	$8.5	$9.0
MN	Dakota	-	-	-	-	-	-	-	-	<$0.1	<$0.1	$2.4	$2.5
MO	Iron	$6.3	$6.7	$6.3	$6.7	$6.3	$6.7	$6.3	$6.7	$6.3	$6.7	$6.3	$6.7
MO	Jefferson	$32	$42	$32	$42	$32	$42	$32	$42	$32	$42	$32	$42
NY	Orange	-	-	-	-	-	-	<$0.1	<$0.1	<$0.1	<$0.1	<$0.1	<$0.1
OH	Cuyahoga	-	-	-	-	$30	$32	$30	$32	$30	$32	$30	$32
OH	Fulton	$1.5	$1.5	$1.5	$1.5	$1.5	$1.5	$1.5	$1.5	$1.5	$1.5	$1.5	$1.5
OH	Logan	-	-	-	-	-	-	-	-	-	-	-	-
OK	Ottawa	-	-	-	-	-	-	-	-	-	-	-	-
PA	Beaver	-	-	-	-	-	-	$11	$12	$35	$37	$35	$37
PA	Berks	<$0.1	<$0.1	<$0.1	<$0.1	$11	$12	$11	$12	$11	$12	$11	$12
PA	Carbon	-	-	-	-	-	-	<$0.1	<$0.1	<$0.1	<$0.1	<$0.1	<$0.1
TN	Sullivan	-	-	-	-	-	-	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4
TN	Williamson	$1.0	$1.1	$1.0	$1.1	$1.3	$1.4	$1.3	$1.4	$2.8	$3.0	$3.4	$3.6
TX	Collin	<$0.1	<$0.1	<$0.1	<$0.1	<$0.1	<$0.1	$2.0	$2.1	$2.3	$2.5	$3.3	$3.5
TX	Dallas	-	-	-	-	-	-	-	-	-	-	$7.0	$8.4
UT	Salt Lake	-	-	-	-	-	-	-	-	-	-	<$0.1	<$0.1
Total		**$46**	**$57**	**$46**	**$57**	**$89**	**$100**	**$110**	**$120**	**$130**	**$150**	**$160**	**$180**

*All estimates rounded to two significant figures. As such, totals will not sum down columns.
** Identified Control Costs are the same for alternative standard 0.5 µg/m^3 and for alternative standard 0.4 µg/m^3. This is because the same monitor areas violate both standards and the same controls were chosen in the least cost optimization for both standard alternatives.

Table 6-2.
ANNUAL COST/POUND OF REDUCED LEAD EMISSIONS: IDENTIFIED CONTROLS*

Monitor State	Monitor County	Annual Cost/Pound for Identified Controls in 2016 (2006$)											
		Standard Alternative: 0.5 µg/m^3 2nd Maximum Monthly Mean**		Standard Alternative: 0.4 µg/m^3 2nd Maximum Monthly Mean**		Standard Alternative: 0.3 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.2 µg/m^3 2nd Maximum Monthly Mean		Selected Standard: 0.15 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.1 µg/m^3 2nd Maximum Monthly Mean	
		3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate
AL	Pike	$400	$400	$400	$400	$400	$400	$500	$500	$500	$500	$500	$500
CO	El Paso	-	-	-	-	-	-	-	-	-	-	$170,000	$170,000
FL	Hillsborough	<$100	<$100	<$100	<$100	$200	$200	$300	$400	$300	$400	$600	$600
IL	Madison	-	-	-	-	-	-	-	-	-	-	$75,000	$79,000
IN	Delaware	$700	$700	$700	$700	$1,300	$1,400	$1,900	$2,000	$2,100	$2,200	$2,900	$3,100
MN	Dakota	-	-	-	-	-	-	-	-	<$100	<$100	$400	$400
MO	Iron	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300	$300
MO	Jefferson	$300	$500	$300	$500	$300	$500	$400	$500	$400	$500	$400	$500
NY	Orange	-	-	-	-	-	-	<$100	<$100	<$100	<$100	<$100	<$100
OH	Cuyahoga	-	-	-	-	$120,000	$130,000	$120,000	$130,000	$120,000	$130,000	$120,000	$130,000
OH	Fulton	$5,100	$5,100	$5,100	$5,100	$5,100	$5,100	$5,100	$5,100	$5,100	$5,100	$5,100	$5,100
OH	Logan	-	-	-	-	-	-	-	-	-	-	-	-
OK	Ottawa	-	-	-	-	-	-	-	-	-	-	-	-
PA	Beaver	-	-	-	-	-	-	$8,300	$9,000	$24,000	$25,000	$24,000	$25,000
PA	Berks	<$100	<$100	<$100	<$100	$3,500	$3,700	$3,500	$3,700	$3,500	$3,700	$3,500	$3,700
PA	Carbon	-	-	-	-	-	-	$1,400	$1,400	$1,400	$1,400	$1,400	$1,400
TN	Sullivan	-	-	-	-	-	-	$120,000	$130,000	$120,000	$130,000	$120,000	$130,000
TN	Williamson	$400	$400	$400	$400	$300	$400	$300	$400	$600	$700	$700	$800
TX	Collin	<$100	<$100	<$100	<$100	<$100	<$100	$400	$400	$400	$500	$600	$600
TX	Dallas	-	-	-	-	-	-	-	-	-	-	$90,000	$1,100,00
UT	Salt Lake	-	-	-	-	-	-	-	-	-	-	<$100	<$100
Total		**$300**	**$400**	**$300**	**$400**	**$600**	**$700**	**$700**	**$800**	**$900**	**$1,000**	**$1,000**	**$1,200**

* All estimates rounded to two significant figures. As such, totals will not sum down columns

** Identified Control Costs are the same for alternative standard 0.5 µg/m^3 and for alternative standard 0.4 µg/m^3. This is because the same monitor areas violate both standards and the same controls were chosen in the least cost optimization for both standard alternatives.

6.1.3 Extrapolated Costs

Prior to presenting the methodology for estimating costs for unspecified emission reductions, it is important to provide information from EPA's Science Advisory Board Council Advisory on the issue of estimating costs of unidentified control measures.[19]

> *812 Council Advisory, Direct Cost Report, Unidentified Measures (charge question 2.a):*
>
> *"The Project Team has been unable to identify measures that yield sufficient emission reductions to comply with the National Ambient Air Quality Standards (NAAQS) and relies on unidentified pollution control measures to make up the difference. Emission reductions attributed to unidentified measures appear to account for a large share of emission reductions required for a few large metropolitan areas but a relatively small share of emission reductions in other locations and nationwide.*
>
> *"The Council agrees with the Project Team that there is little credibility and hence limited value to assigning costs to these unidentified measures. It suggests taking great care in reporting cost estimates in cases where unidentified measures account for a significant share of emission reductions. At a minimum, the components of the total cost associated with identified and unidentified measures should be clearly distinguished. In some cases, it may be preferable to not quantify the costs of unidentified measures and to simply report the quantity and share of emissions reductions attributed to these measures.*
>
> *"When assigning costs to unidentified measures, the Council suggests that a simple, transparent method that is sensitive to the degree of uncertainty about these costs is best. Of the three approaches outlined, assuming a fixed cost/ton appears to be the simplest and most straightforward. Uncertainty might be represented using alternative fixed costs per ton of emissions avoided."*

EPA has considered this advice and the requirements of E.O. 12866 and OMB circular A-4, which provides guidance on the estimation of benefits and costs of regulations.

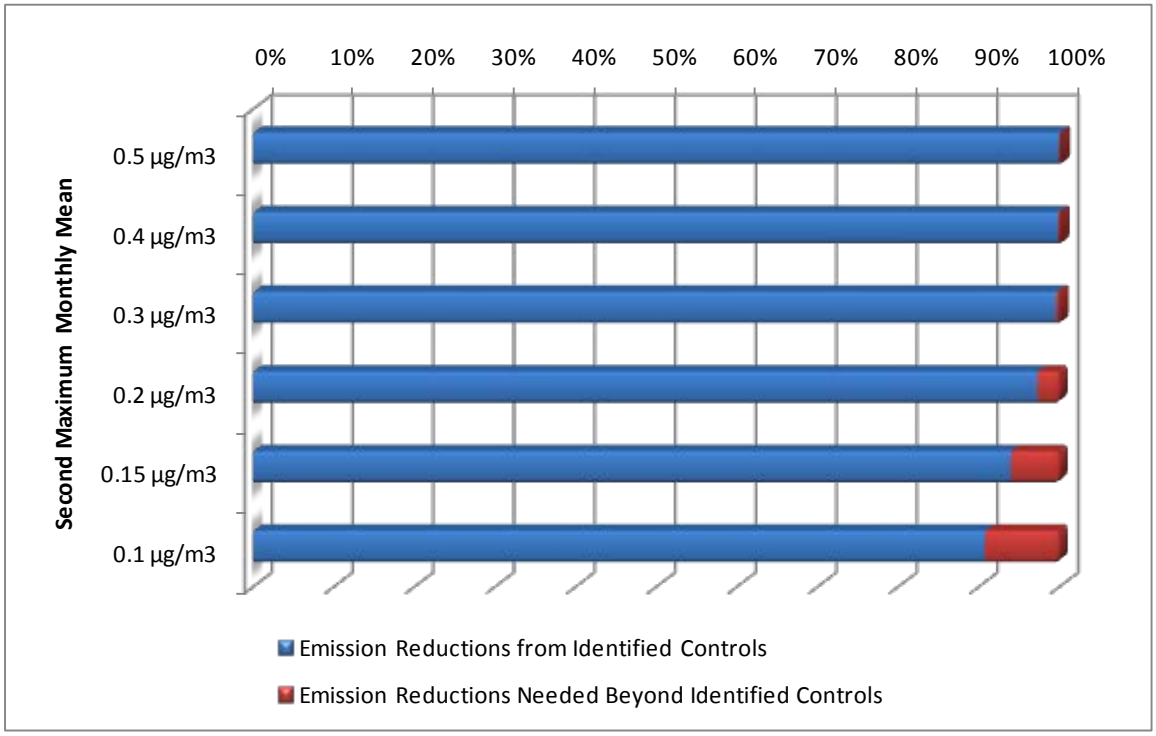
EPA estimated the costs of unspecified future controls using two approaches. The first is calculated by estimating a cost curve for the identified control costs and extrapolating the cost of the remaining unspecified emission reductions. The second approach is the ambient extrapolation approach, this approach uses an average cost per microgram for each area. We

[19] U.S. Environmental Protection Agency, Advisory Council on Clean Air Compliance Analysis (COUNCIL), *Council Advisory on OAR's Direct Cost Report and Uncertainty Analysis Plan*, Washington, DC. June 8, 2007.

believe this approach best represents a fixed cost approach given the data limitations of this analysis. Please note, the fixed cost methodology was preferred by EPA's Science Advisory Board over two other options, including a marginal cost-based approach. Extrapolated costs were calculated for the recent Ozone NAAQS RIA, and they are calculated again here for the final Lead NAAQS. EPA has developed a few approaches to try to estimate the extrapolated costs of future unspecified emissions reductions, which take into account the analysis context and data availability. Now that EPA has gained some additional experience in estimating the extrapolated costs for these two RIAs, we intend to seek additional SAB advice on extrapolated cost approaches after further investigation of these and other approaches.

As indicated above the identified control costs reflected in Tables 6-1 and 6-2 do not result in attainment of the selected or alternative standards in several areas. In these areas, unspecified emission reductions needed beyond identified controls will likely be necessary to reach attainment. As noted in chapter 4, the overwhelming majority of emissions reductions needed to attain the various target NAAQS levels would be obtained from identified controls (see table 4-6). Also, the unspecified emission reductions needed beyond identified controls are small enough to fall within the expected error associated with the precision of the modeling of the emissions. Figure 6-1 below illustrates this point: the percentage of remaining emissions after applying identified controls ranges from a low of 0.03% to a high of only 9.23%.

Figure 6-1.
PERCENTAGE OF REMAINING EMISSION REDUCTIONS NEEDED POST APPLICATION OF IDENTIFIED CONTROLS



The estimation of engineering costs for unspecified emission reductions needed to reach attainment many years in the future is inherently a difficult issue. As described later in this chapter, our experience with Clean Air Act implementation shows that technological advances

and development of innovative strategies can make possible emissions reductions that are unforeseen today, and to reduce costs of emerging technologies over time. But we cannot quantitatively predict the amount of technology advance in the future. For areas needing significant additional emission reductions, much of the control must be for sources that historically have not been controlled. The relationship of the cost of such control to the cost of control options available today is not at all clear. Available, current known control measures increase in cost beyond the range of what has ever been implemented and would still not provide the needed additional control for full attainment in the analysis year 2016.

The emission inventories, air quality modeling, and control options that would address these very small remaining increments of lead in ambient air are highly uncertain. In the RIA for the proposed NAAQS, a fixed cost of $32 million/ton, or $16,000/lb. in 2006 dollars was applied to the unspecified emission reductions needed beyond identified controls. This fixed cost was consistent with the 98th percentile of total possible emission reductions for identified controls.

We recognize that a single fixed cost of control does not account for the different sets of conditions that might describe situations where controls are needed beyond identified controls. Recall that we did not cap identified control costs in the final RIA analysis because we lack good information regarding lead emission controls on small emission sources. This same lack of information also makes it difficult to extrapolated costs using either of the techniques described below. Therefore in this RIA for the final Pb NAAQS, we take a broader approach to estimating the costs associated with the remaining increment to attainment.

Finally, it is also important to emphasize here that the universe of sources where unspecified emission reductions beyond identified controls are achieved is not completely understood; therefore, we are not able to identify known control devices or work practices to achieve these reductions.

We expect that additional control measures that we were not able to identify may be available today, or may be developed by 2016. We believe such an expectation is reasonable for the following reasons:

1. Because the revised Pb NAAQS is ten times lower than the previous standard, the Pb emission inventory has not been used in the past for estimating controls for such small sources of lead emissions. Thus the quality control of data in the emission inventory may not have been appropriate for this use of the emission inventory. For example, some sources for which we know of no control may be incorrectly characterized; leading us to believe, incorrectly, that no appropriate control is available.

2. Our knowledge of add-on controls is greater than our knowledge of process modifications. For example in the months since proposal of the revised NAAQS, we conducted additional research and discovered the process modification used in the analysis for Herculaneum. There may be other similar modifications available today that we do not know about.

3. Controls for emission sources other than point sources may be available but are not captured under the data constraints built into the air quality monitor to emissions source relationship used to estimate air quality improvement.

On the other hand, there are several reasons why identified controls may not be sufficient to reach attainment in a given monitor area:

1. There may be no other available controls that are similar to the identified controls. For example, the area might be characterized by emissions from several very large sources. This is true in only a few areas (e.g., Jefferson County, MO). In these areas, there may be large reductions achieved with identified or even pre-existing controls, but there are no further known controls available to reduce the remaining emissions after those identified controls are applied.

2. It is possible that fugitive dust emissions from area sources containing deposited Pb will also contribute to violations of the NAAQS, or that historically deposited Pb, when disturbed, may be re-entrained into the ambient air. These fugitive or area source controls may be more expensive than the identified controls.

3. More expensive process modifications may be the only way to reduce the remaining emissions.

Finally, there is uncertainty inherent in estimating the progress in development of control measures that will occur between today and 2016. For example:

1. Technological change unrelated to this regulation may lead to different baseline emissions or changes in industrial processes (e.g. will battery technology changes lead to fewer lead battery recycling facilities?).

2. Changes in pollution control technology may make more control options available or reduce the costs of current ones.

3. Some emissions sources may close rather than impose the identified controls (in this case the cost of identified controls has been overestimated and the emission reduction has been underestimated).

There are many limitations to each approach taken to estimate the extrapolated costs of unspecified emissions, for example:

- The ambient extrapolation methodology emphasizes control costs that are the most expensive within an area, and assumes that knowledge of control costs from monitor areas that attain have no influence on the average control costs for areas that need unspecified emission reductions. It also assumes there will be no increased knowledge of sources or changed in technology between now and 2016. Lastly, most of the costs are based upon areas that make less than 1% progress towards attainment, indicating what little knowledge we have about controls in those areas.

- The cost curve methodology presents a poor conceptual relationship between the costs of identified controls at a national level and the costs of control at a local level. The data this curve is developed upon contains data points which we believe to be invalid

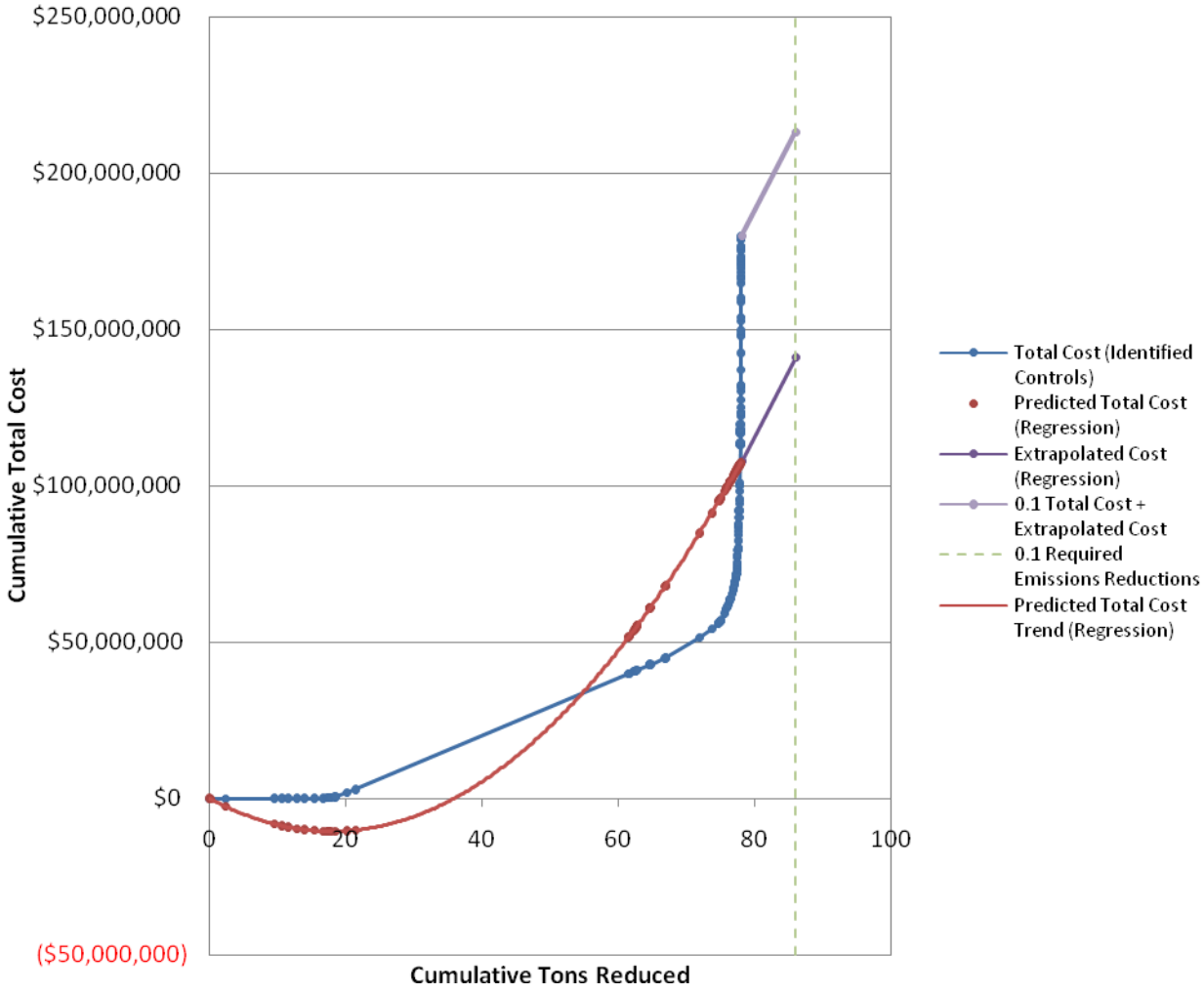
(presented as part of the distributional analysis in Section 6.1.3.2). The estimated curve estimates negative costs over a portion of emission reductions. In addition this approach relies heavily on the control strategy for tightest standard alternative analyzed in this RIA, and does not account for variability in control strategies across alternative standards analyzed. Lastly, we do not believe this curve well represents the knowledge of how control costs behave over time.

6.1.3.2 Estimated Cost Curve Approach

The cost curve method was used to estimate extrapolated costs and the associated total cost of meeting the selected and alternative standards analyzed. However, before describing this approach it is again important to note the EPA Science Advisory Board Council's position on the use of similar methods when estimating costs of unidentified control measures (U.S. Environmental Protection Agency. June 2007. Advisory Council on Clean Air Compliance Analysis (COUNCIL), Council Advisory on OAR's Direct Cost Report and Uncertainty Analysis Plan. Washington, DC). The Council advises against any approach that deviates from using a fixed cost/ton estimate such as the approach described below.

This noted, in addition to the SAB advised fixed cost per ton in cases of extreme uncertainty presented earlier, an alternative methods was used to estimate extrapolated costs, involving the use of regression analysis to estimate a total cost curve for the identified controls. The portion of the curve extending beyond emission reductions achieved through identified controls up to the emission reductions required to meet the standard is the extrapolated cost curve. This curve is then appended to the total cost curve whose data was used in the regression to calculate a total cost estimate. These curves can be seen in Figure 6-2 below.

Figure 6-2. COST CURVE APPROACH



The regression approach to estimating extrapolated costs uses the data used to construct the cost curve and estimates the equation *Cumulative Total Cost = Cumulative Emissions Reduced + Cumulative Emissions Reduced*^{2}. The resulting regression equation is *Cumulative Total Cost = -1,175,430 · Cumulative Emissions Reduced + 32,690 · Cumulative Emissions Reduced*^{2}, a graph of which can be seen in Figure 6-2. The adjusted R-squared value for this equation is 0.88, indicating a relatively good fit to the data. All variables are highly significant. Table 6-3 shows the extrapolated costs for each of the analyzed standard levels when using this regression to estimate the cost for the remaining tons required. These estimated costs range from $79,000 for the 0.5 standard to $33 million for the 0.1 standard. For the selected 0.15 standard, the costs are $20 million.

Table 6-3.
EXTRAPOLATED COSTS USING TOTAL COST REGRESSION (7% Discount Rate)

Standard Alternative	Additional emission reductions needed)	Extrapolated cost (M 2006$)
0.5 μg/m^3 2nd Maximum Monthly Mean	0.02	$0.08
0.4 μg/m^3 2nd Maximum Monthly Mean	0.08	$0.32
0.3 μg/m^3 2nd Maximum Monthly Mean	0.29	$1.1
0.2 μg/m^3 2nd Maximum Monthly Mean	2.06	$8.3
0.15 μg/m^3 2nd Maximum Monthly Mean	4.79	$20
0.1 μg/m^3 2nd Maximum Monthly Mean	7.91	$33

6.1.3.2.1 Regression Diagnostics

While the deletion of outliers is a controversial practice in statistics, especially when there is uncertainty as to the underlying distribution of the data, it is an accepted practice in regression to exclude data points that exhibit a large degree of influence on the resulting parameter estimates, while dutifully noting that such exclusions have taken place. Several statistics for measuring the influence of specific data points on estimation results are readily calculated, and for this analysis Cook's Distance, DFFITS, studentized residuals, and leverage statistics were used to identify potentially influential observations.

Before discussion of these results, it may be informative to analyze the descriptive statistics of the variables used to construct the cost curve upon which the extrapolated cost curve using the maximum marginal costs as well as the extrapolated cost curve from the regression analysis are based. These statistics are presented in Table 6-4 below.

Table 6-4.
DESCRIPTIVE STATISTICS FOR VARIABLES USED IN COST CURVE

	Emissions Reduced	Cost per Ton
Number of Observations	211	211
Minimum	0.000000039	2,656
Median	0.0042	12,277,347
Mean	0.37	34,754,959,220
Max	40.05	6,179,483,400,000
Interquartile Range	0.038	224,882,280
Standard Error	2.83	426,342,369,723
Skewness	13.31	14.40
Kurtosis	185.86	208.39

As can be seen by these statistics, these data exhibit a wide range with the median values considerably different from the mean values. The statistics together provide evidence that the distribution of these variables is non-normal. As a result, we may expect the presence of outliers that may bias the regression results.

Estimates of were Cook's Distance, DFFITS, studentized residuals, and leverage were calculated for the regression equation *Cumulative Total Cost = Cumulative Emissions Reduced + Cumulative Emissions Reduced*^{2}. The number of points identified by each of these techniques as influential varied slightly, as seen in Table 6-5.

Table 6-5.
REGRESSION DIAGNOSTICS

Statistic	Cutoff	Identified observations
Cook's Distance	$4/n$	9
DFFITS	$2 \cdot \sqrt{k/n}$	11
Studentized Residuals	±2	19
Leverage	$(2k+2)/n$	0

All of the observations that were deemed influential under the various measures are at the upper portion of the cumulative cost curve (i.e., the last 9, 11, and 19 points on the curve for Cook's Distance, DFFITS, and studentized residuals, respectively). That no points are identified by the leverage statistic is puzzling, and provides some counter-evidence that these points are outliers. Nonetheless, there is significant evidence that the distributions of the underlying variables used to construct the variables used in the regression are non-normal, and three measures of influence identify the upper 10-20 observations as suspect. This calls into question the use of the estimated regression to calculate additional extrapolated costs.

6.1.3.3 Ambient Extrapolation Methodology

To derive costs using this ambient extrapolation methodology, we first examined the seven monitor areas that make some progress towards attainment with identified controls, but cannot reach the target NAAQS. We calculated an average cost per microgram of air quality improvement for each area based upon the identified control costs analysis. For each monitor area, we then applied its area-specific cost per microgram to the remaining air quality increment, in order to calculate the extrapolated cost of attainment. We performed these calculations for each target NAAQS in our analysis.

(Additional ug needed to attain) x ($/ug for identified controls) = Additional cost to attain

There were four areas that made little to no progress towards attainment with identified controls for one or more of the target NAAQS. For these monitor areas, we did not have a cost/ug for identified controls to plug into the above equation. As a surrogate cost/ug, we used the overall average cost/ug of the monitor areas that *had* made some progress towards attainment. To derive the extrapolated costs for each monitor area, we then multiplied that overall average cost/ug by the remaining air quality increment in each of the monitor areas.

(Additional ug needed to attain) x (overall average $/ug for identified controls) = Additional cost to attain

Table 6-6 presents the cost per air quality improvement for all 11 monitor areas. Table 6-7 presents the total extrapolated costs for each monitor area. As indicated in Table 6-7, the estimated extrapolated costs using this approach are approximately $3.1 billion per year, assuming a discount rate of seven percent. Applying a three percent discount rate this value becomes $2.6 billion per year. The annual extrapolated costs for the ambient approach under the each alternative standard analyzed included in Table 6-7 range from $100 million under the 0.5 $\mu g/m^3$ standard alternative to $3.9 billion under the 0.1 $\mu g/m^3$ standard alternative, assuming a discount rate of seven percent. If we apply a three percent discount rate, these values adjust to $89 million and $3.4 billion for the 0.5 and 0.1 $\mu g/m^3$ standard alternatives, respectively. These costs come out to be much larger than costs under the cost curve approach; this is because they are driven by extremely expensive controls that provide only a very small increment of air quality improvement.

Table 6-6.
COST PER AIR QUALITY IMPROVEMENT BY MONITOR AREA

Monitor State	Monitor County	Annual Cost/Microgram (Millions of 2006$)	
		3% Discount rate	7% Discount rate
CO	El Paso	$330	$340
IL	Madison	$550	$580
MO	Jefferson	$18	$24
OH	Cuyahoga	$730	$780
OH	Fulton *	$3,000	$3,500
OH	Logan *	$3,000	$3,500
PA	Beaver	$1,100	$1,200
PA	Berks	$60	$63
PA	Carbon*	$3,000	$3,500
TN	Sullivan*	$3,000	$3,500
TX	Dallas	$18,000	$22,000

*Represents monitor areas that made less than 1% progress towards attainment with identified controls.

Table 6-7.
AMBIENT APPROACH EXTRAPOLATED COSTS BY MONITOR AREA*

Monitor State	Monitor County	Annual Extrapolated Costs of Emission Reductions Needed Beyond Identified Controls in 2016 (Millions of 2006$)											
		Standard Alternative: 0.5 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.4 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.3 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.2 µg/m^3 2nd Maximum Monthly Mean		Selected Standard: 0.15 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.1 µg/m^3 2nd Maximum Monthly Mean	
		3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate
CO	El Paso	-	-	-	-	-	-	-	-	-	-	$10	$10
IL	Madison	-	-	-	-	-	-	-	-	-	-	$2.3	$2.4
MO	Jefferson	-	-	-	-	-	-	$0.7	$0.9	$1.6	$2.1	$2.5	$3.3
OH	Cuyahoga	-	-	-	-	$12	$12	$85	$90	$120	$130	$160	$170
OH	Fulton	$89	$100	$390	$460	$690	$810	$990	$1,200	$1,100	$1,300	$1,300	$1,500
OH	Logan	-	-	-	-	$180	$210	$480	$560	$630	$740	$780	$920
PA	Beaver	-	-	-	-	-	-	-	-	$49	$53	$100	$110
PA	Berks	-	-	-	-	$1.8	$1.9	$7.8	$8.2	$11	$11	$14	$15
PA	Carbon	-	-	-	-	-	-	$280	$330	$430	$510	$580	$690
TN	Sullivan	-	-	-	-	-	-	$110	$130	$260	$300	$410	$480
TX	Dallas	-	-	-	-	-	-	-	-	-	-	$19	$23
Total		**$89**	**$100**	**$390**	**$460**	**$880**	**$1,000**	**$1,900**	**$2,300**	**$2,600**	**$3,100**	**$3,400**	**$3,900**

*All estimates rounded to two significant figures. As such, totals will not sum down columns.

6.1.4 Monitoring Costs

Consistent with the scope of this rulemaking, which includes monitoring provisions, monitoring costs are included here. As part of the regulatory package accompanying the revised standard, revised lead monitoring requirements are being issued. The rule includes revisions to the network design requirements, QA requirements, and the minimum sampling frequency for lead monitoring. These changes will ensure that adequate lead monitoring will be performed to determine compliance with the proposed lead NAAQS. In addition, the level of the standard and the averaging time for the standard directly affect the associated monitoring burden. For the final Pb NAAQS, total monitoring costs are estimated to be $4.2 million, which include $3.2 million for expansion of the monitoring network.

In the final information collection request (ICR), EPA has estimated the potential burden for the final Pb NAAQS (i.e. 0.15 ug/m^3; rolling quarterly average). EPA estimates that there are approximately 260 facilities that would require monitoring at a level of 0.15 µg/m^3 (see: http://www.epa.gov/oar/lead/pdfs/20080502_maps4.pdf). Monitors will also be required in 52 urban areas (those metropolitan statistical areas with a population greater than one million). For more detail, see OMB 2060-0084, ICR #940.21.

6.1.5 Summary of Cost Estimates

Table 6-9 provides a summary of total costs to achieve the selected standard and each alternative standard. As suggested by Tables[20] 6-1, 6-8, the extent to which these costs exceed those associated with identified controls alone increases with the stringency of the standard. This is consistent with the emissions analysis presented in Chapter 4, which suggests that local areas' reliance on emission reductions beyond identified controls would increase as the standard becomes more stringent. Figures 6-3 and 6-4 present the portion of total costs that is represented by identified controls and the portion of costs that is represented by unspecified emission reductions.

The significant difference between the costs of identified controls alone and the cost of achieving attainment (i.e. including both identified controls and emission reductions beyond identified controls) in this and other areas reflects the limited information available to EPA on the control measures that sources may implement. It is important to remember that, compared to recent NAAQS RIAs, our current knowledge of the costs and nature of lead emissions controls is relatively poor. Lead in ambient air has not been a focus for all but a few areas of the country for the last decade or more; the alternative standards represent a substantial tightening of the existing NAAQS. As a result, although AirControlNET contains information on a large number of different point source controls, we would expect that State and local air quality managers would have access to additional information on the controls available to the most significant sources.

It is important to remember also that these cost estimates are highly uncertain. As discussed in the final monitoring provisions, the existing monitoring network will need to be updated. It is possible that some areas shown to be out of attainment based on the current monitoring information will be shown to be in attainment with more recent monitoring. After the revised

[20] Note there is no breakdown of costs by monitor area for the cost curve approach. This approach was generated at an aggregate level and therefore does not break down costs to local areas.

monitoring network is in place, other areas not identified in this analysis may be found to be violating the new standard. Since many of the existing sources of ambient Pb are relatively small, states are likely to work closely with the sources to reduce emissions in a cost-effective manner.

Note also that if any facility chooses to close rather than incur either the costs associated with identified controls or extrapolated costs then for that facility costs are overestimated and emission reductions are underestimated. We would then also expect the required emission reductions and control costs for other facilities to be lower. We did not attempt to quantify facility closures in this RIA. However, in interpreting the costs, the possibility of savings from closures should be recalled.

Finally, many of the control techniques identified in this analysis do not appear to be cost effective because a high dollar value control has been added to reduce a small amount of Pb emissions – sometimes only a few pounds per year. Rather than applying additional controls, it may be possible for firms emitting small amounts of Pb to modify their production processes or other operational parameters, including pollution prevention techniques, which would be more cost effective than adding additional control technology. Such measures might include increasing the enclosure of buildings, increasing air flow in hoods, modifying operation and maintenance procedures, changing feed materials to lower Pb content, etc. While we have estimated the cost of attainment of this revised NAAQS, we have not accounted for the effect of improvements that tend to occur, such as technology improvement, process changes, efficiency improvements, materials substitution, etc. We believe these typical improvements will tend to result in more cost effective approaches than simply adding extremely expensive pollution controls in many areas by the attainment date of 2016. It is also worth noting that it is possible that fugitive dust emissions from area sources containing deposited Pb will also contribute to violations of the NAAQS, or that historically deposited Pb, when disturbed, may be re-entrained into the ambient air. For areas where point source controls are sufficient to reach attainment, we may have overestimated costs if more cost effective fugitive or area source controls are likely to be available in these areas.

To further inform our understanding of the potential difficulties in reaching attainment, EPA took a closer look at the eight counties for which identified controls are insufficient to attain the final NAAQS of 0.15 ug/m^3 in our analysis. All eight counties contained some type of metals processing facilities, such as battery manufacturers, zinc smelters, and foundries. Some have baghouses for controlling particulate matter, but for others we found no information on applicable controls (possibly because of their relatively low overall particulate emissions). Three of the eight counties host contaminated industrial soil sites that are the focus of significant ongoing remediation efforts (Fulton, OH; Berks, PA; and Carbon, PA). Many of those sites are associated with industrial metals sources including Pb battery manufacturing, Pb battery recycling and disposal, zinc processing, metal alloy production, and iron and steel manufacturing.

Table 6-8. ANNUAL TOTAL COSTS BY MONITOR AREA*
(INCLUDES IDENTIFIED CONTROL COSTS AND EXTRAPOLATED COSTS USING AMBIENT EXTRAPOLATION APPROACH)

Monitor State	Monitor County	Annual Total Costs in 2016 (Millions of 2006$)											
		Standard Alternative: 0.5 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.4 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.3 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.2 µg/m^3 2nd Maximum Monthly Mean		Selected Standard: 0.15 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.1 µg/m^3 2nd Maximum Monthly Mean	
		3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate
AL	Pike	$3.1	$3.3	$3.1	$3.3	$3.1	$3.3	$4.0	$4.2	$4.3	$4.6	$4.3	$4.6
CO	Adams	-	-	-	-	-	-	-	-	-	-	$10	$11
CO	Denver	$0.01	$0.01	$0.01	$0.01	$0.38	$0.40	$0.81	$0.87	$0.81	$0.87	$1.4	$1.5
CO	El Paso	-	-	-	-	-	-	-	-	-	-	$16	$16
FL	Hillsborough	$1.8	$1.9	$1.8	$1.9	$3.6	$3.8	$5.4	$5.7	$6.1	$6.5	$8.5	$9.0
IL	Madison	-	-	-	-	-	-	-	-	$0.02	$0.02	$2.4	$2.5
IN	Delaware	$6.3	$6.7	$6.3	$6.7	$6.3	$6.7	$6.3	$6.7	$6.3	$6.7	$6.3	$6.7
MN	Dakota	$32	$42	$32	$42	$32	$42	$33	$43	$34	$44	$35	$46
MO	Iron	-	-	-	-	-	-	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02
MO	Jefferson	-	-	-	-	$42	$44	$110	$120	$150	$160	$190	$200
NY	Orange	$90	$110	$390	$460	$690	$810	$990	$1,200	$1,100	$1,300	$1,300	$1,500
OH	Cuyahoga	-	-	-	-	$180	$210	$480	$560	$630	$740	$780	$920
OH	Fulton	-	-	-	-	-	-	-	-	-	-	-	-
OH	Logan	-	-	-	-	-	-	$11	$12	$84	$90	$140	$150
OK	Ottawa	$0.01	$0.01	$0.01	$0.01	$13	$14	$19	$20	$22	$23	$25	$26
PA	Beaver	-	-	-	-	-	-	$280	$330	$430	$510	$580	$690
PA	Berks	-	-	-	-	-	-	$110	$130	$260	$300	$410	$480
PA	Carbon	$1.0	$1.1	$1.0	$1.1	$1.3	$1.4	$1.3	$1.4	$2.8	$3.0	$3.4	$3.6
TN	Sullivan	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$2.0	$2.1	$2.3	$2.5	$3.3	$3.5
TN	Williamson	-	-	-	-	-	-	-	-	-	-	$26	$31
TX	Collin	-	-	-	-	-	-	-	-	-	-	$0.01	$0.01
TX	Dallas	$3.1	$3.3	$3.1	$3.3	$3.1	$3.3	$4.0	$4.2	$4.3	$4.6	$4.3	$4.6
UT	Salt Lake	-	-	-	-	-	-	-	-	-	-	$10	$11
Total		**$130**	**$160**	**$430**	**$510**	**$970**	**$1,100**	**$2,100**	**$2,400**	**$2,800**	**$3,200**	**$3,500**	**$4,100**

*All estimates rounded to two significant figures. As such, totals will not sum down columns.

Table 6-9.
TOTAL COSTS BY STANDARD*

		Annual Total Costs in 2016 (Millions of 2006$)											
		Standard Alternative: 0.5 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.4 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.3 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.2 µg/m^3 2nd Maximum Monthly Mean		Selected Standard: 0.15 µg/m^3 2nd Maximum Monthly Mean		Standard Alternative: 0.1 µg/m^3 2nd Maximum Monthly Mean	
		3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate
Monitoring Costs**										$4.2	$4.2		
Identified Control Costs***		$46	$57	$46	$57	$89	$100	$110	$120	$130	$150	$160	$180
Extrapolated Costs	**Cost Curve Extrapolation**	**$0.08**	**$0.08**	**$0.32**	**$0.32**	**$1.1**	**$1.1**	**$8.3**	**$8.3**	**$20**	**$20**	**$33**	**$33**
	Ambient Extrapolation	$89	$100	$390	$460	$880	$1,000	$1,900	$2,300	$2,600	$3,100	$3,400	$3,900
Total Costs	**Cost Curve Extrapolation******	**$46**	**$57**	**$46**	**$57**	**$90**	**$100**	**$110**	**$130**	**$150**	**$170**	**$190**	**$210**
	Ambient Extrapolation	**$130**	**$160**	**$430**	**$510**	**$970**	**$1,100**	**$2,100**	**$2,400**	**$2,800**	**$3,200**	**$3,500**	**$4,100**

* All estimates rounded to two significant figures. As such, totals will not sum down columns.

** Consistent with the scope of this rulemaking, which includes monitoring provisions, monitoring costs are included here. See OMB 2060-0084, ICR #940.21 for a complete discussion.

*** Identified Control Costs are the same for alternative standard 0.5 µg/m^3 and for alternative standard 0.4 µg/m^3. This is because the same monitor areas violate both standards and the same controls were chosen in the least cost optimization for both standard alternatives.

**** Estimates for the 0.5 µg/m^3 and the 0.4 µg/m^3 appear similar; this is due to rounding conventions.

Figure 6-3.
PERCENTAGE OF TOTAL COSTS BY EXTRAPOLATED COST APPROACH

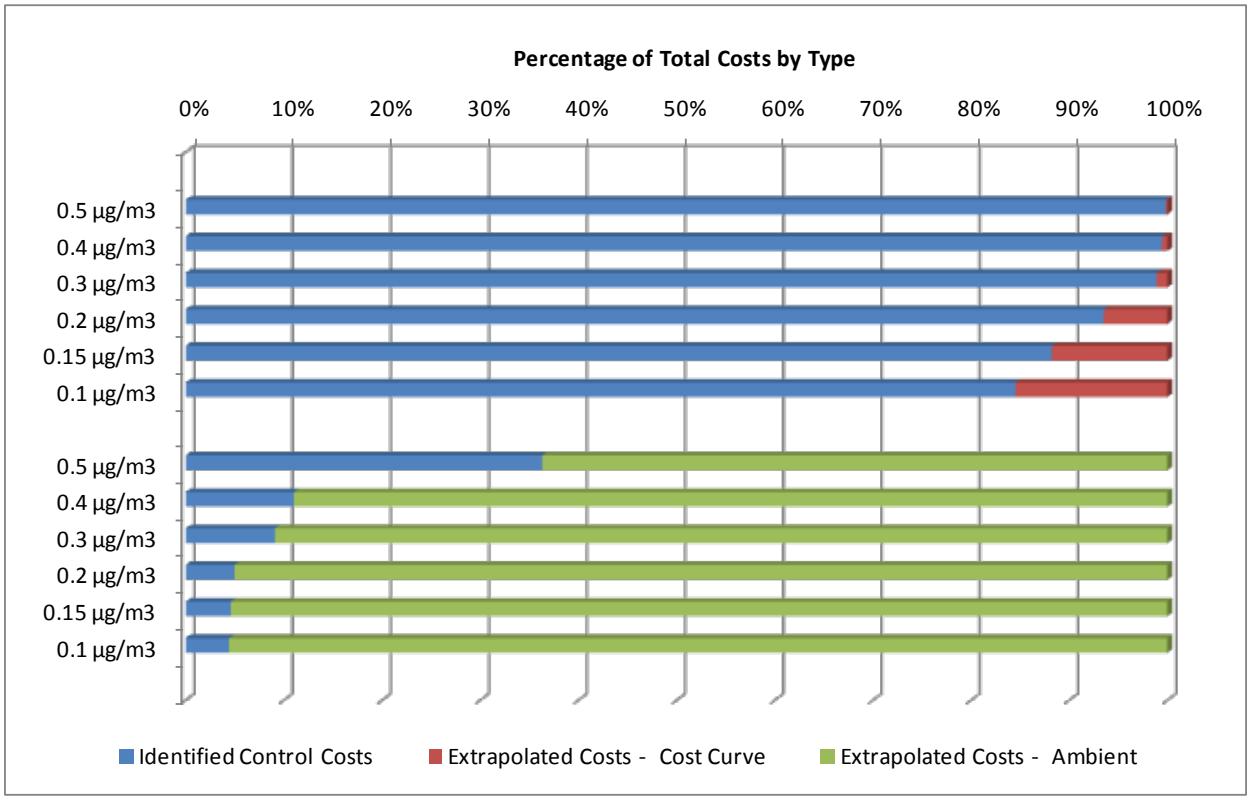
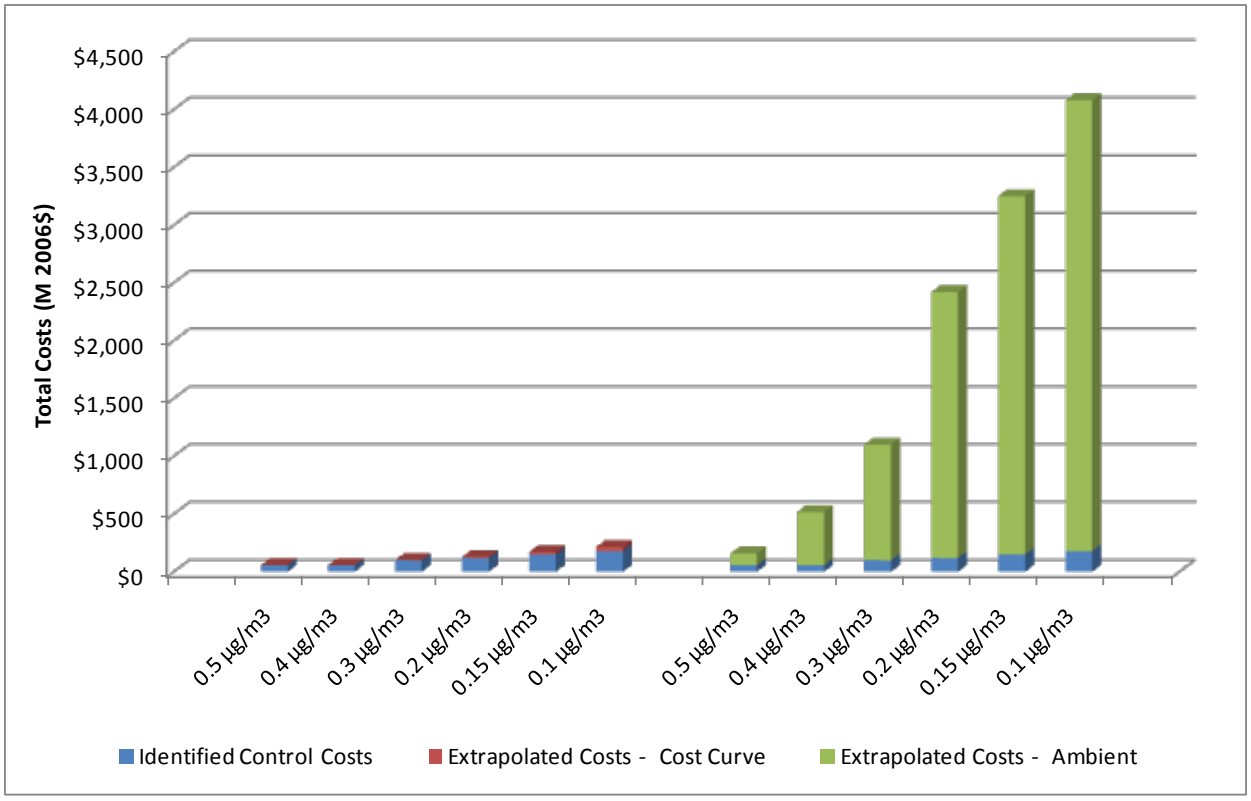


Figure 6-4.
TOTAL COSTS IN 2016 BY EXTRAPOLATED COST APPROACH



6.1.6 Technology Innovation and Regulatory Cost Estimates

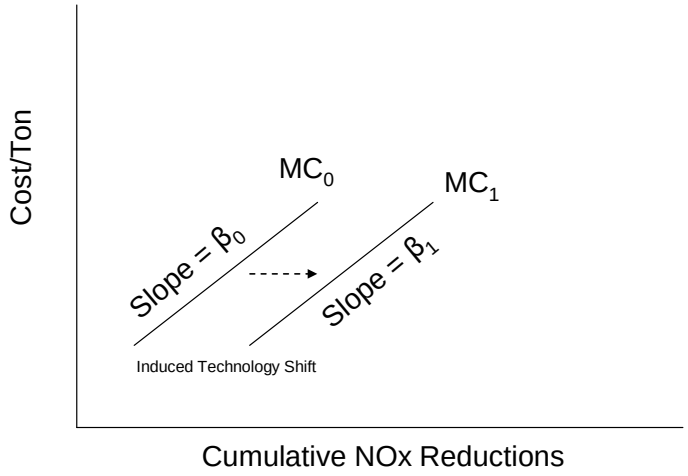
There are many examples in which technological innovation and "learning by doing" have made it possible to achieve greater emissions reductions than had been feasible earlier, or have reduced the costs of emission control in relation to original estimates. Studies[21] have suggested that costs of some EPA programs have been less than originally estimated due in part to inadequate inability to predict and account for future technological innovation in regulatory impact analyses.

Constantly increasing marginal costs are likely to induce the type of innovation that would result in lower costs than estimated early in this chapter. Breakthrough technologies in control equipment could by 2016 result in a rightward shift in the marginal cost curve for such equipment (Figure 6-5)[22] as well as perhaps a decrease in its slope, reducing marginal costs per unit of abatement, and thus deviate from the assumption of one constantly increasing marginal cost curve. In addition, elevated abatement costs may result in significant increases in the cost of

[21] Harrington et al. (2000) and previous studies cited by Harrington.
Harrington, W., R.D. Morgenstern, and P. Nelson. 2000. "On the Accuracy of Regulatory Cost Estimates." *Journal of Policy Analysis and Management* 19(2):297-322.
[22] Figure 5.2 shows a linear marginal abatement cost curve. It is possible that the shape of the marginal abatement cost curve is non-linear.

production and would likely induce production efficiencies, in particular those related to energy inputs, which would lower emissions from the production side.

Figure 6-5.
TECHNOLOGICAL INNOVATION REFLECTED BY MARGINAL COST SHIFT



6.1.6.1 Examples of Technological Advances in Pollution Control

There are numerous examples of low-emission technologies developed and/or commercialized over the past 15 or 20 years, such as:

- Selective catalytic reduction (SCR) and ultra-low NOx burners for NOx emissions
- Scrubbers which achieve 95% and even greater SO2 control on boilers
- Sophisticated new valve seals and leak detection equipment for refineries and chemical plans
- Low or zero VOC paints, consumer products and cleaning processes
- Chlorofluorocarbon (*CFC)* free air conditioners, refrigerators, and solvents
- Water and powder-based coatings to replace petroleum-based formulations
- Vehicles far cleaner than believed possible in the late 1980s due to improvements in evaporative controls, catalyst design and fuel control systems for light-duty vehicles; and treatment devices and retrofit technologies for heavy-duty engines
- Idle-reduction technologies for engines, including truck stop electrification efforts
- Market penetration of gas-electric hybrid vehicles, and clean fuels

These technologies were not commercially available two decades ago, and some were not even in existence. Yet today, all of these technologies are on the market, and many are widely employed. Several are key components of major pollution control programs.

What is known as "learning by doing" or "learning curve impacts" have also made it possible to achieve greater emissions reductions than had been feasible earlier, or have reduced the costs of emission control in relation to original estimates. Learning curve impacts can be defined generally as the extent to which variable costs (of production and/or pollution control) decline as firms gain experience with a specific technology. Such impacts have been identified to occur in a number of studies conducted for various production processes. Impacts such as these would manifest themselves as a lowering of expected costs for operation of technologies in the future below what they may have been.

The magnitude of learning curve impacts on pollution control costs has been estimated for a variety of sectors as part of the cost analyses done for the Draft Direct Cost Report for the second EPA Section 812 Prospective Analysis of the Clean Air Act Amendments of 1990.[23] In that report, learning curve adjustments were included for those sectors and technologies for which learning curve data was available. A typical learning curve adjustment example is to reduce either capital or O&M costs by a certain percentage given a doubling of output from that sector or for that technology. In other words, capital or O&M costs will be reduced by some percentage for every doubling of output for the given sector or technology.

T.P. Wright, in 1936, was the first to characterize the relationship between increased productivity and cumulative production. He analyzed man-hours required to assemble successive airplane bodies. He suggested the relationship is a log linear function, since he observed a constant linear reduction in man-hours every time the total number of airplanes assembled was doubled. The relationship he devised between number assembled and assembly time is called Wright's Equation (Gumerman and Marnay, 2004)[24]. This equation, shown below, has been shown to be widely applicable in manufacturing:

$$\text{Wright's Equation: } C_N = C_o * N^b,$$

Where:

- N = cumulative production
- C_N = cost to produce N^{th} unit of capacity
- C_o = cost to produce the first unit
- B = learning parameter = $\ln(1\text{-}LR)/\ln(2)$, where
- LR = learning by doing rate, or cost reduction per doubling of capacity or output.

[23] E.H. Pechan and Associates and Industrial Economics, Direct Cost Estimates for the Clean Air Act Second Section 812 Prospective Analysis: Draft Report, prepared for U.S. EPA, Office of Air and Radiation, February 2007. Available at http://www.epa.gov/oar/sect812/mar07/direct_cost_draft.pdf.

[24] Gumerman, Etan and Marnay, Chris. Learning and Cost Reductions for Generating Technologies in the National Energy Modeling System (NEMS), Ernest Orlando Lawrence Berkeley National Laboratory, University of California at Berkeley, Berkeley, CA. January 2004, LBNL-52559.

The percentage adjustments can range from 5 to 20 percent, depending on the sector and technology. Learning curve adjustments were prepared in a memo by IEc supplied to US EPA and applied for the mobile source sector (both onroad and nonroad) and for application of various EGU control technologies within the Draft Direct Cost Report.[25] Advice received from the SAB Advisory Council on Clean Air Compliance Analysis in June 2007 indicated an interest in expanding the treatment of learning curves to those portions of the cost analysis for which no learning curve impact data are currently available. Examples of these sectors are non-EGU point sources and area sources. The memo by IEc outlined various approaches by which learning curve impacts can be addressed for those sectors. The recommended learning curve impact adjustment for virtually every sector considered in the Draft Direct Cost Report is a 10% reduction in O&M costs for two doubling of cumulative output, with proxies such as cumulative fuel sales or cumulative emission reductions being used when output data was unavailable.

For this RIA, we do not have the necessary data for cumulative output, fuel sales, or emission reductions for sectors included in our analysis in order to properly generate control costs that reflect learning curve impacts. Clearly, the effect of including these impacts would be to lower our estimates of costs for our control strategies in 2016, but we are not able to include such an analysis in this RIA.

6.1.6.2 Influence on Regulatory Cost Estimates

Studies indicate that it is not uncommon for pre-regulatory cost estimates to be higher than later estimates, in part because of inability to predict technological advances. Over longer time horizons the opportunity for technical advances is greater.

- *Multi-rule study:* Harrington et al. of Resources for the Future[26] conducted an analysis of the predicted and actual costs of 28 federal and state rules, including 21 issued by EPA and the Occupational Safety and Health Administration (OSHA), and found a tendency for predicted costs to overstate actual implementation costs. Costs were considered accurate if they fell within the analysis error bounds or if they fall within 25 percent (greater or less than) the predicted amount. They found that predicted total costs were overestimated for 14 of the 28 rules, while total costs were underestimated for only three rules. Differences can result because of quantity differences (e.g., overestimate of pollution reductions) or differences in per-unit costs (e.g., cost per unit of pollution reduction). Per-unit costs of regulations were overestimated in 14 cases, while they were underestimated in six cases. In the case of EPA rules, the agency overestimated per-unit costs for five regulations, underestimated them for four regulations (three of these were relatively small pesticide rules), and accurately estimated them for four. Based on examination of eight economic incentive rules, "for those rules that employed economic incentive mechanisms, overestimation of per-unit costs seems to be the norm," the study said.

[25] Industrial Economics, Inc. Proposed Approach for Expanding the Treatment of Learning Curve Impacts for the Second Section 812 Prospective Analysis: Memorandum, prepared for U.S. EPA, Office of Air and Radiation, August 13, 2007.

[26] Harrington, W., R.D. Morgenstern, and P. Nelson. 2000. "On the Accuracy of Regulatory Cost Estimates." *Journal of Policy Analysis and Management* 19(2):297-322.

Based on the case study results and existing literature, the authors identified technological innovation as one of five explanations of why predicted and actual regulatory cost estimates differ: "Most regulatory cost estimates ignore the possibility of technological innovation … Technical change is, after all, notoriously difficult to forecast … In numerous case studies actual compliance costs are lower than predicted because of unanticipated use of new technology."

It should be noted that many (though not all) of the EPA rules examined by Harrington had compliance dates of several years, which allowed a limited period for technical innovation.

- *Acid Rain SO2 Trading Program*: Recent cost estimates of the Acid Rain SO2 trading program by Resources for the Future (RFF) and MIT have been as much as 83 percent lower than originally projected by EPA.[27] Note that the original EPA cost analysis also relied on an optimization model like IPM to approximate the results of emissions trading. As noted in the RIA for the Clean Air Interstate Rule, the ex ante numbers in 1989 were an overestimate in part because of the limitation of economic modeling to predict technological improvement of pollution controls and other compliance options such as fuel switching. The fuel switching from high-sulfur to low-sulfur coal was spurred by a reduction in rail transportation costs due to deregulation of rail rates during the 1990'sHarrington et al. report that scrubbing turned out to be more efficient (95% removal vs. 80-85% removal) and more reliable (95% vs. 85% reliability) than expected, and that unanticipated opportunities arose to blend low and high sulfur coal in older boilers up to a 40/60 mixture, compared with the 5/95 mixture originally estimated.

Phase 2 Cost Estimates	
Ex ante estimates	\$2.7 to \$6.2 billion[a]
Ex post estimates	\$1.0 to \$1.4 billion

[a] 2010 Phase II cost estimate in \$1995.

- *EPA Fuel Control Rules:* A 2002 study by two economists with EPA's Office of Transportation and Air Quality[28] examined EPA vehicle and fuels rules and found a general pattern that "all ex ante estimates tended to exceed actual price impacts, with the EPA estimates exceeding actual prices by the smallest amount." The paper notes that cost is not the same as price, but suggests that a comparison nonetheless can be instructive.[29] An example focusing on fuel rules is provided:

[27] Carlson, Curtis, Dallas R. Burtraw, Maureen, Cropper, and Karen L. Palmer. 2000. "Sulfur Dioxide Control by Electric Utilities: What Are the Gains from Trade?" *Journal of Political Economy* 108(#6):1292-1326.
Ellerman, Denny. January 2003. Ex Post Evaluation of Tradable Permits: The U.S. SO2 Cap-and-Trade Program. Massachusetts Institute of Technology Center for Energy and Environmental Policy Research.
[28] Anderson, J.F., and Sherwood, T., 2002. "Comparison of EPA and Other Estimates of Mobile Source Rule Costs to Actual Price Changes," Office of Transportation and Air Quality, U.S. Environmental Protection Agency. Technical Paper published by the Society of Automotive Engineers. SAE 2002-01-1980.
[29] The paper notes: "Cost is not the same as price. This simple statement reflects the fact that a lot happens between a producer's determination of manufacturing cost and its decisions about what the market will bear in terms of price change."

Table 6-10.
COMPARISON OF INFLATION-ADJUSTED ESTIMATED COSTS AND ACTUAL PRICE CHANGES FOR EPA FUEL CONTROL RULES [A]

	Inflation-adjusted Cost Estimates (c/gal)				Actual Price Changes (c/gal)
	EPA	DOE	API	Other	
Gasoline					
Phase 2 RVP Control (7.8 RVP—Summer) (1995$)	1.1	1.8		0.5	
Reformulated Gasoline Phase 1 (1997$)	3.1-5.1	3.4-4.1	8.2-14.0	7.4 (CRA)	2.2
Reformulated Gasoline Phase 2 (Summer) (2000$)	4.6-6.8	7.6-10.2	10.8-19.4	12	7.2 (5.1, when corrected to 5yr MTBE price)
30 ppm sulfur gasoline (Tier 2)	1.7-1.9	2.9-3.4	2.6	5.7 (NPRA), 3.1 (AIAM)	N/A
Diesel					
500 ppm sulfur highway diesel fuel (1997$)	1.9-2.4		3.3 (NPRA)	2.2	
15 ppm sulfur highway diesel fuel	4.5	4.2-6.0	6.2	4.2-6.1 (NPRA)	N/A

[a] Anderson, J.F., and Sherwood, T., 2002. "Comparison of EPA and Other Estimates of Mobile Source Rule Costs to Actual Price Changes," Office of Transportation and Air Quality, U.S. Environmental Protection Agency. Technical Paper published by the Society of Automotive Engineers. SAE 2002-01-1980.

- Chlorofluorocarbon (*CFC) Phase-Out:* EPA used a combination of regulatory, market based (i.e., a cap-and-trade system among manufacturers), and voluntary approaches to phase out the most harmful ozone depleting substances. This was done more efficiently than either EPA or industry originally anticipated. The phaseout for Class I substances was implemented 4-6 years faster, included 13 more chemicals, and cost 30 percent less than was predicted at the time the 1990 Clean Air Act Amendments were enacted.[30]

  The Harrington study states, "When the original cost analysis was performed for the CFC phase-out it was not anticipated that the hydrofluorocarbon HFC-134a could be substituted for CFC-12 in refrigeration. However, as Hammit[31] notes, 'since 1991 most new U.S. automobile air conditioners have contained HFC-134a (a compound for which no commercial production technology was available in 1986) instead of CFC-12" (p.13). He cites a similar story for HCFRC-141b and 142b, which are currently substituting for CFC-11 in important foam-blowing applications."

[30] Holmstead, Jeffrey, 2002. "Testimony of Jeffrey Holmstead, Assistant Administrator, Office of Air and Radiation, U.S. Environmental Protection Agency, Before the Subcommittee on Energy and air Quality of the committee on Energy and Commerce, U.S. House of Representatives, May 1, 2002, p. 10.

[31] Hammit, J.K. (1997). "Are the costs of proposed environmental regulations overestimated? Evidence from the CFC phaseout." Unpublished paper, Center for Risk Analysis, Harvard School of Public Health, Cambridge, MA.

- Additional examples of decreasing costs of emissions controls include: SCR catalyst costs decreasing from $11k-$14k in 1998 to $3.5k-$5k in 2004, and improved low NOx burners reduced emissions by 50% from 1993-2003 while the associated capital cost dropped from $25-$38/kw to $15/kw[32].

We can not estimate the interplay between EPA regulation and technology improvement, but it is clear that a *priori* cost estimation often results in overestimation of costs because changes in technology (whatever the cause) make less costly control possible.

[32] ICF Consulting. October 2005. The Clean Air Act Amendment: Spurring Innovation and Growth While Cleaning the Air. Washington, DC. Available at http://www.icfi.com/Markets/Environment/doc_files/caaa-success.pdf.

6.2 Economic Impacts

The assessment of economic impacts was conducted simply based on those source categories which are controlled in this analysis. The impacts presented here are an extension of the engineering costs, where engineering costs are allocated to specific source categories by North American Industry Classification System (NAICS) code. Although the costs outlined in the previous section may affect a range of industries, we expect that most of the costs associated with the selected standard will be concentrated in a limited number of industry sectors. As indicated in Table 6-11, we estimate that primary smelters & refiners of nonferrous metals (NAICS 331419) are expected to incur most of the identified control costs associated with the alternative standards included in this RIA. For primary smelters, the estimated costs of the alternative standards range from $32 million to $76 million per year, depending on the standard and the discount rate. This represents 1.2 to 2.9 percent of the industry's value of shipments in 2002. Table 6-11 also shows that other industry sectors expected to incur significant costs include secondary smelting, refining, and alloying of nonferrous metals excluding copper and aluminum (NAICS 331492); iron and steel mills (NAICS 331111); and steam and air-conditioning supply (NAICS 221330). The projected compliance costs for these industries range from 0.0 to 1.3 percent of their total shipments (or receipts, in the case of steam and air-conditioning supply) in 2002.

Table 6-12 presents capital and O&M costs by industry for identified measures under the Final NAAQS.[33] Costs associated with emission reductions beyond identified controls are not reflected in the table because the distribution of costs between capital and O&M is uncertain for these measures. As indicated in the table, O&M represents approximately 54 percent of costs under the selected standard of 0.15$\mu g/m^3$. This implies that although the upfront capital costs associated with the selected standard may be significant for affected industries, these costs are expected to represent a fraction of the selected standard's total costs.

[33] The costs presented in the table reflect a discount rate of seven percent. Because the purpose of the table is to show the approximate distribution of costs between capital and O&M, the table presents costs based on just one discount rate for ease of presentation.

Table 6-11. ANNUAL COSTS OF IDENTIFIED CONTROLS BY INDUSTRY

NAICS Code	Industry Description	Total Cost with Identified Controls (Millions of 2006$)												Industry Revenue in 2005 (millions of 2006$)[1]
		Standard Alternative: 0.5 µg/m³ 2nd Maximum Monthly Mean		Standard Alternative: 0.4 µg/m³ 2nd Maximum Monthly Mean		Standard Alternative: 0.3 µg/m³ 2nd Maximum Monthly Mean		Standard Alternative: 0.2 µg/m³ 2nd Maximum Monthly Mean		Selected Standard: 0.15 µg/m³ 2nd Maximum Monthly Mean		Standard Alternative: 0.1 µg/m³ 2nd Maximum Monthly Mean		
		3% Disc rate	7% Disc rate	3% Disc rate	7% Disc rate	3% Disc rate	7% Disc rate	3% Disc rate	7% Disc rate	3% Disc rate	7% Disc rate	3% Disc rate	7% Disc rate	
2211	Electric Power Generation, Transmission and Distribution	-	-	-	-	$2	$2.3	$4.4	$5.1	$4.6	$5.2	$11.2	$13.2	$363,990
331419	Primary Smelting and Refining of Nonferrous Metal (except Copper and Aluminum)	$31.7	$42	$31.7	$42	$31.7	$42	$40	$50.8	$63.9	$76.3	$63.9	$76.3	$2,649
331492	Secondary Smelting, Refining, and Alloying of Nonferrous Metal (except Copper and Aluminum)	$12.3	$13	$12.3	$13.1	$23.3	$24.7	$28.4	$30.2	$31.2	$33.3	$35.8	$38.1	$3,009
331111	Iron and Steel Mills	$1.5	$1.5	$1.5	$1.5	$22.1	$23.3	$22.1	$23.3	$22.1	$23.3	$24.4	$25.8	$51,762
221330	Steam and Air-Conditioning Supply	-	-	-	-	$7.3	$7.6	$7.3	$7.6	$7.3	$7.6	$7.3	$7.6	$723
331491	Nonferrous Metal (except Copper and Aluminum) Rolling, Drawing, and Extruding	-	-	-	-	-	-	-	-	-	-	$4.6	$4.9	$5,041
331513	Steel Foundries (except Investment)	-	-	-	-	-	-	-	-	-	-	$3.9	$4.0	$2,941
331314	Secondary Smelting and Alloying of Aluminum	-	-	-	-	-	-	-	-	<$0.1	<$0.1	$2.4	$2.5	$4,150
32511	Petrochemical Manufacturing	-	-	-	-	-	-	-	-	-	-	$1.1	$1.1	$23,611
622110	General Medical and Surgical Hospitals	-	-	-	-	-	-	-	-	-	-	-	-	$526,034
335911	Storage Battery Manufacturing	-	-	<$0.1	<$0.1	$0.8	$0.8	$0.8	$0.8	$0.8	$0.8	$0.8	$0.8	$3,961
331511	Iron Foundries	-	-	-	-	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.7	$0.8	$11,541
Other Industries		-	-	-	-	$1.5	$1.8	$2.2	$2.5	$2.2	$2.5	$3.8	$4.2	
Total		**$45.5**	**$56.5**	**$45.5**	**$56.6**	**$89.1**	**$103**	**$105.5**	**$120.7**	**$132.5**	**$149.4**	**$159.9**	**$179.4**	

1. Source: U.S. Census Bureau 2002 Economic Census

Table 6-12.
ANNUAL CAPITAL AND O&M COSTS BY INDUSTRY FOR IDENTIFIED CONTROLS
(7 percent discount rate)

SIC Code	Description	Annual Cost of Identified Controls in 2016 (Millions of 2006$)		
		Final NAAQS: 0.15 µg/m3 2nd Maximum Monthly Mean		
		Capital	O&M	Total Annual Cost
2211	Electric Power Generation, Transmission and Distribution	$3.1	$2.2	$5.2
331419	Primary Smelting and Refining of Nonferrous Metal (except Copper and Aluminum)	$52.4	$24	$76.3
331492	Secondary Smelting, Refining, and Alloying of Nonferrous Metal (except Copper and Aluminum)	$10	$23.2	$33.3
331111	Iron and Steel Mills	$0.6	$22.7	$23.3
221330	Steam and Air-Conditioning Supply	$1.5	$6.2	$7.6
331491	Nonferrous Metal (except Copper and Aluminum) Rolling, Drawing, and Extruding	-	-	-
331513	Steel Foundries (except Investment)	-	-	-
331314	Secondary Smelting and Alloying of Aluminum	<$0.1	<$0.1	<$0.1
32511	Petrochemical Manufacturing	-	-	-
622110	General Medical and Surgical Hospitals	-	-	-
335911	Storage Battery Manufacturing	$0.2	$0.6	$0.8
331511	Iron Foundries	$0.1	$0.3	$0.4
Other		$0.6	$1.9	$2.5
Total		**$68.5**	**$80.9**	**$149.4**

6.3 Energy Impacts

This section summarizes the energy consumption impacts of the final and alternative lead NAAQS. The Pb NAAQS revisions do not constitute a "significant energy action" as defined in Executive Order 13211; this information merely represents impacts of the illustrative control strategies applied in the RIA. The rule does not prescribe specific control strategies by which these ambient standards will be met. Such strategies will be developed by States on a case-by-case basis, and EPA cannot predict whether the control options selected by States will include regulations on energy suppliers, distributors, or users. Thus, EPA concludes that this rule is not likely to have any adverse energy effects.

For this RIA, implementation of the control measures needed for attainment with the alternative standards will likely lead to increased energy consumption among lead emitting facilities. To control emissions effectively, these measures require a significant amount of electricity that affected facilities are not expected to consume under baseline conditions. The available information on these controls suggests that they are not typically powered by natural gas or other fossil fuels; therefore, our analysis of energy impacts focuses exclusively on electricity consumption. In addition, because the energy consumption associated with emission reductions beyond identified controls is uncertain, we only consider the energy impacts associated with

identified controls. Similarly, the electricity consumption associated with the construction of a Kivcet furnace at the primary lead smelter in Jefferson County, MO is also uncertain. We therefore exclude energy impacts for this facility from our analysis of energy impacts.

To assess the electricity consumption impacts associated with identified controls, we relied on the AirControlNET outputs generated for this analysis. For most identified controls, AirControlNET estimates electricity costs separately from other operating and maintenance (O&M) costs. Therefore, for sources expected to implement these controls, AirControlNET provides direct estimates of the additional electricity costs expected under the standard alternatives. We calculate the electricity consumption associated with these costs based on the unit cost of electricity assumed by AirControlNET (7.8 cents/kilowatt hour in 2006 dollars).

For a number of identified controls, AirControlNET does not separate the cost of electricity from other O&M costs. Similarly, the cost data for several controls identified from sources other than AirControlNET do not distinguish between electricity and other O&M costs. We estimate the electricity costs associated with these measures based on electricity's assumed share of total O&M, which we estimate based on AirControlNET's results for those controls where it separates electricity costs from other O&M costs. For some controls, O&M costs are not estimated separately from capital costs. In these cases, we assume that O&M represents a fixed share of annual costs based on the cost data for those controls where O&M and capital are calculated separately.

Table 6-13 summarizes the estimated energy impacts associated with the selected and alternative standards. As indicated in the table, we estimate that sources installing identified controls under the alternative standards will increase their electricity consumption in 2016 by approximately 121,800 megawatt-hours (MWh) under the selected standard. By comparison, the iron and steel industry alone is projected to purchase 66 million MWh of electricity in 2016.[34]

Table 6-13.
SUMMARY OF ENERGY IMPACTS

	Standard Alternative: 0.5 µg/m^3 2nd Maximum Monthly Mean	**Standard Alternative: 0.4 µg/m^3 2nd Maximum Monthly Mean**	**Standard Alternative: 0.3 µg/m^3 2nd Maximum Monthly Mean**	**Standard Alternative: 0.2 µg/m^3 2nd Maximum Monthly Mean**	**Selected Standard: 0.15 µg/m^3 2nd Maximum Monthly Mean**	**Standard Alternative: 0.1 µg/m^3 2nd Maximum Monthly Mean**
Electricity Cost (millions of year 2006$)	$1.4	$1.4	$6.2	$8.7	$9.5	$17.3
Electricity Consumption (Megawatt-hours consumed in 2016)	17,800	18,200	79,900	111,700	121,800	222,000

[34] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2007*, February 2007.

6.4 Limitations

Although the cost analysis presented in this chapter provides a reasonable approximation of the costs associated with the final lead NAAQS using hypothetical control scenarios given the available information, we note the following limitations of the analysis:

- ***Analysis limited to point source controls.*** Because limited data are available on fugitive and area source emissions, our analysis of the costs associated with the final and alternative lead NAAQS does not consider area source and direct fugitive controls that may be implemented to comply with these standards.[35] Therefore, in the few areas where point source controls are insufficient to attain the standard, and where we were unable to model full compliance with the revised NAAQS, it is possible that fugitive dust emissions from area sources containing deposited Pb will also contribute to violations of the NAAQS, or that historically deposited Pb, when disturbed, may be re-entrained into the ambient air. For areas where point source controls are sufficient to reach attainment, we may have overestimated costs if more cost effective fugitive or area source controls are likely to be available in these areas.

- ***Incomplete information for point source controls.*** To assess the cost of reducing point source lead emissions, this analysis relies upon PM control cost information from AirControlNET. For several sources, however, AirControlNET contains no information on the PM controls available, and we are unable to estimate costs for these sources. Such sources represent approximately 9 percent of the point source lead emissions included in our analysis (i.e., AirControlNET contains control measure data for those lead sources that represent 91 percent of the lead emissions included in the analysis). Costs to control lead emissions from these sources may be less than or greater than the costs to control emissions from other sources.

- ***Uncertainty about methods for reaching tighter control levels in the future.*** It is not known whether industrial sources will in the future make improvements to existing particulate matter controls to control Pb emissions, whether there will be further application of existing control technology in series with controls that might already be employed at a source, or whether we might expect new control technology to be developed.

- ***Uncertainty in the cost estimates for the primary lead smelter in Jefferson County, Missouri:*** To estimate the costs of the selected standard for Jefferson County, Missouri, this analysis models the replacement of the primary lead smelter in that area with a modern, lower emitting Kivcet smelter. We estimate the cost of this project based on the costs of Teck Cominco's Kivcet smelter in Trail, British Columbia, scaling for differences in lead production capacities between the Teck Cominco facility and the smelter in Jefferson County. While this is a reasonable approach for estimating costs for the smelter in Jefferson County, our analysis may not capture facility-specific characteristics that would affect the

[35] Although our analysis considers the impact of point source controls on certain fugitive emissions, as described in Chapter 4, it does not consider direct fugitive controls.

costs of building and operating a Kivcet smelter at this facility. Furthermore, more targeted measures for reducing lead emissions may be more cost-effective than the construction of a new Kivcet unit. Given these uncertainties, we may overestimate or underestimate costs for Jefferson County.

- ***Uncertainty associated with extrapolated costs of emission reductions beyond identified controls.*** As indicated above, many areas are expected to rely heavily on emission reductions beyond identified controls to reach attainment with the selected and alternative standards. The cost of implementing these measures is uncertain. Many of these sources are already well-controlled for particulate matter, and additional control for the remaining increment of Pb might be difficult to achieve. In addition to these uncertainties there are also many uncertainties associated with the two approaches used in this RIA to estimated extrapolated costs. The ambient extrapolation methodology emphasizes control costs that are the most expensive within an area, and assumes that knowledge of control costs from monitor areas that attain have no influence on the average control costs for areas that need unspecified emission reductions. It also assumes there will be no increased knowledge of sources or changed in technology between now and 2016. Lastly, most of the costs are based upon areas that make less than 1% progress towards attainment, indicating what little knowledge we have about controls in those areas. The cost curve methodology presents a poor conceptual relationship between the costs of identified controls at a national level and the costs of control at a local level. The data this curve is developed upon contains data points which we believe to be invalid (presented as part of the distributional analysis in Section 6.1.3.2). The estimated curve estimates negative costs over a portion of emission reductions. In addition this approach relies heavily on the control strategy for tightest standard alternative analyzed in this RIA, and does not account for variability in control strategies across alternative standards analyzed. Lastly, we do not believe this curve well represents the knowledge of how control costs behave over time.

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CHAPTER 7. ESTIMATES OF BENEFITS AND COSTS

EPA has performed an illustrative analysis to estimate the costs and human health benefits of nationally attaining the selected lead National Ambient Air Quality Standards (NAAQS). This chapter first presents benefits and costs for scenarios using consistent assumptions. We then discuss key uncertainties and limitations. Finally, we provide a summary of key conclusions, considering both the primary results and key uncertainties.

This Regulatory Impact Analysis (RIA) provides illustrative estimates of the incremental costs and monetized human health benefits of attaining a revised primary lead (Pb) National Ambient Air Quality Standard (NAAQS) within the current monitoring network of 189 monitors representing 86 counties. Many of the highest-emitting lead sources do not have nearby Pb-TSP monitors, and it is important to note that there may be many more potential nonattainment areas than have been analyzed in this RIA.

It is important to note at the outset that overall data limitations are very significant for this analysis, compared to other NAAQS reviews. One critical area of uncertainty is the limited TSP-Pb monitoring network (discussed in chapter 2). Because monitors are present in only 86 counties nationwide, the universe of monitors exceeding the final NAAQS level of 0.15 $\mu g/m^3$ represent only 16 counties. It is important to note that data limitations prevented us from identifying a full range of controls which would bring eight of these counties all the way to attainment of the final NAAQS. It is also important to note that because many of the highest-emitting Pb sources in the 2002 NEI do not have nearby Pb-TSP monitors (see section 2.1.7), it is likely that there may be many more potential nonattainment areas than have been analyzed in this RIA.

In addition, as discussed in chapter 3 it is not appropriate to conduct regional scale modeling for Pb similar to the regional scale modeling conducted for PM and ozone. Dispersion, or plume-based, models are recommended for compliance with the Pb NAAQS; however, dispersion models are data –intensive and more appropriate for local scale analyses of emissions from individual sources. It was not feasible to conduct such a large-scale data intensive analysis for this RIA. As a result, the simplified analysis developed for this RIA, while distance-weighting individual source contributions to ambient Pb concentrations, could not account for such locally critical variables as meteorology and source stack height.

Benefits and Costs

The estimates of benefits and costs presented here reflect illustrative scenarios of future lead NAAQS compliance that are consistent in most respects. In all cases, estimates are based on a 2016 compliance date; as a result, such inputs as population and baseline emissions and air quality compliance with existing Clean Air Act requirements (including MACT rules affecting lead emissions and the recently promulgated PM NAAQS revision) are consistently applied in all

estimates presented here. In addition, the two alternative discount rates - 3% and 7% - are used in all relevant components of both benefit and cost calculations, for all estimates presented here.

Consistent with our development of the illustrative control strategies described above, our analysis of the costs associated with the selected NAAQS focuses on point source PM controls. For the purposes of this analysis, these controls largely include measures from the AirControlNET control technology database, but also include additional measures associated with operating permits and/or New Source Performance Review standards applicable to sources similar to those included in our analysis. For controls identified in AirControlNET, we estimated costs based on the cost equations included in AirControlNET. Our cost estimates for controls associated with operating permits and/or New Source Performance Review standards are based on cost data compiled by EPA for previous analyses.

As indicated in the above discussion on illustrative control strategies, implementation of the PM control measures identified from AirControlNET and other sources does not result in attainment with the selected NAAQS in several areas. In these areas, additional unspecified emission reductions will likely be necessary to reach attainment. In order to bring these monitor areas into attainment, we calculated control costs using two different approaches. Under one approach, we extrapolated the cost of unspecified emission reductions by constructing a total cost curve using data on identified control costs. We then derived a total cost equation in quadratic form which best fit the total cost curve. Under our second approach, we calculated the cost of unspecified emission reductions by deriving an average cost per microgram of air quality improvement obtained from identified controls. For each standard, we then selected all monitor areas that failed to reach attainment and applied unspecified emission reductions to all sources until attainment was reached.

For the selected standard and each alternative, we then selected all monitor areas that failed to reach attainment and applied unspecified emission reductions to all sources until attainment was reached. It is important to remember that under the first approach, the majority of the costs for the selected standard (88%) come from our analysis of current known control technologies, with only 12% of the total costs coming from extrapolated costs. Under the second scenario, 5% of the total costs come from our analysis of currently known control technologies, and the majority of the costs (95%) comes from our assumptions about the cost of controlling the last few ambient increments of Pb needed to reach full attainment.

Tables 7.1 and 7.2 presents total national primary estimates of costs and benefits for a 3% discount rate and a 7% discount rate.

Table 7.1. Summary of Costs (Millions of 2006$)

		Alternative NAAQS: 0.4 µg/m^3 2nd Maximum Monthly Mean		Final NAAQS: 0.15 µg/m^3 2nd Maximum Monthly Mean		Alternative NAAQS: 0.1 µg/m^3 2nd Maximum Monthly Mean	
		3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate
Identified Control Costs		\$46	\$57	\$130	\$150	\$160	\$180
Extrapolated Costs	**Cost Curve Extrapolation**	\$0.32	\$0.32	\$20	\$20	\$33	\$33
	Ambient Extrapolation	\$390	\$460	\$2,600	\$3,100	\$3,400	\$3,900
Total RIA Costs	**Cost Curve**	**\$46**	**\$57**	**\$150**	**\$170**	**\$190**	**\$210**
	Ambient	**\$430**	**\$510**	**\$2,800**	**\$3,200**	**\$3,500**	**\$4,100**
Monitoring Costs**		\$4.2	\$4.2	\$4.2	\$4.2	\$4.2	\$4.2

* All estimates rounded to two significant figures. As such, totals will not sum down columns.

** Consistent with the scope of this rulemaking, which includes monitoring provisions, monitoring costs are included here. See OMB 2060-0084, ICR #940.21 for a complete discussion.

The ranges of benefits presented reflect uncertainty about the earnings impact associated with IQ gains and variability in the estimates of the PM mortality co-benefits across the available effects estimates. The total benefits range of estimates was developed by first adding the low and high ends of the range of monetized lead IQ benefits to the low and high ends of the range of PM co-benefits, and then subtracting the total cost estimate from the low and high end of the resulting range of total benefits.

Table 7.2. Summary of Benefits (Millions of 2006$)

	Alternative Standard: 0.40 µg/m^3 2nd Maximum Monthly Mean		Final NAAQS: 0.15 µg/m^3 2nd Maximum Monthly Mean		Alternative Standard: 0.10 µg/m^3 2nd Maximum Monthly Mean	
	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate
Annualized Benefit - IQ Gains (Range)**	$2,000—$2,800	$250—$490	$3,500—$5,000	$440—$870	$4,500—$6,400	$560—$1,100
Annualized Benefit - PM Co-control (Range)***	$100—$880	$100—$800	$230—$1,900	$210—$1,700	$260—$2,200	$240—$2,000
Total Benefits	$2,100—$3,700	$350—$1,300	$3,700—$6,900	$650—$2,600	$4,800—$8,600	$800—$3,100

Table 7.3 shows net benefits of the selected NAAQS and alternative standards.

Table 7.3. Summary of Net Benefits (Millions of 2006$)[1]

	Alternative Standard: 0.40 µg/m^3 2nd Maximum Monthly Mean		Final NAAQS: 0.15 µg/m^3 2nd Maximum Monthly Mean		Alternative Standard: 0.10 µg/m^3 2nd Maximum Monthly Mean	
	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate	3% Discount rate	7% Discount rate
Total RIA Costs + Monitoring Costs	$50—$430	$61—$510	$150—$2,800	$170—$3,200	$190—$3,500	$210—$4,100
Total Benefits	$2,100—$3,700	$350—$1,300	$3,700—$6,900	$650—$2,600	$4,800—$8,600	$800—$3,100
Net Benefits	**$1,700 - $3,700**	**$(160) - $1,200**	**$900 - $6,800**	**$(2,600) - $2,400**	**$1,300 - $8,400**	**$(3,300) - $2,900**

Discussion of Uncertainties and Limitations

As with other NAAQS RIAs, it should be recognized that all estimates of future costs and benefits are not intended to be forecasts of the actual costs and benefits of implementing revised standards. Ultimately, states and urban areas will be responsible for developing and implementing emissions control programs to reach attainment of the lead NAAQS, with the timing of attainment being determined by future decisions by states and EPA. Our estimates are intended to provide information on the general magnitude of the costs and benefits of alternative

[1] Note that bounds of the full range of net benefits is derived by subtracting the high costs from the low benefits at the lower end, and subtracting the low costs from the high benefits at the upper end. This is the only way to fully represent the uncertainty.

standards, rather than precise predictions of control measures, costs, or benefits. With these caveats, we expect that this analysis can provide a reasonable picture of the types of emissions controls that are currently available, the direct costs of those controls, the levels of emissions reductions that may be achieved with these controls, the air quality impact that can be expected to result from reducing emissions, and the public health benefits of reductions in ambient lead levels, as well as coincident reductions in ambient fine particulates.

Compared to recent NAAQS RIAs, however, our current knowledge of the costs and nature of lead emissions controls and the effects of changes in emissions on air quality and exposure is less robust. Lead in ambient air has not been a focus for all but a few areas of the country for the last decade or more. The proposed standards, while supported by and consistent with EPA's review of recent scientific research, represent a substantial tightening of the existing NAAQS. As a result, many of the analyses conducted for this RIA could be significantly improved through enhanced research and data in these areas. Perhaps the greatest need is for research on available pollution control technology, work practice changes, and pollution prevention options to most cost-effectively control lead emissions directly, rather than as a component of lead-bearing PM emissions.

It is important to note again that overall data limitations are very significant for this analysis, compared to other NAAQS reviews. One critical area of uncertainty is the limited TSP-Pb monitoring network (discussed in chapter 2). Because monitors are present in only 86 counties nationwide, the universe of monitors exceeding the final NAAQS level of 0.15 $\mu g/m^3$ represent only 16 counties. It is important to note that data limitations prevented us from identifying a full range of controls which would bring eight of these counties all the way to attainment of the final NAAQS. It is also important to note that because many of the highest-emitting Pb sources in the 2002 NEI do not have nearby Pb-TSP monitors (see section 2.1.7), it is likely that there may be many more potential nonattainment areas than have been analyzed in this RIA.

In addition, as discussed in chapter 3 it is not appropriate to conduct regional scale modeling for Pb similar to the regional scale modeling conducted for PM and ozone. Dispersion, or plume-based, models are recommended for compliance with the Pb NAAQS; however, dispersion models are data –intensive and more appropriate for local scale analyses of emissions from individual sources. It was not feasible to conduct such a large-scale data intensive analysis for this RIA. As a result, the simplified analysis developed for this RIA, while distance-weighting individual source contributions to ambient Pb concentrations, could not account for such locally critical variables as meteorology and source stack height. Note also that the emissions inventory has limitations for Pb sources with very low emissions.

In the remainder of this section we re-state the most important limitations and uncertainties in the cost and benefit estimates.

Uncertainties specifically related to the cost estimates include the following:

- Because limited data are available on fugitive and area source emissions, our analysis of the costs associated with the proposed and alternative lead NAAQS does not consider fugitive and area source controls that may be implemented to comply with these standards. For areas where point source controls are sufficient to reach attainment, we may have overestimated costs if more cost-effective fugitive or area source controls are likely to be available in these areas.
- To assess the cost of reducing point source lead emissions, this analysis relies upon PM control cost information from AirControlNET. EPA's database of lead-focused controls is very limited, however, and there are no lead-specific controls in AirControlNET. In addition, for several sources AirControlNET contains no information on PM controls either. Such sources represent approximately 8 percent of the point source lead emissions included in our analysis (i.e., AirControlNET contains control measure data for those lead sources that represent 92 percent of the lead emissions included in the analysis). Costs to control lead emissions from these sources may be less than or greater than costs to control emissions from other sources.
- The ambient extrapolation methodology emphasizes control costs that are the most expensive within an area, and assumes that knowledge of control costs from monitor areas that attain have no influence on the average control costs for areas that need unspecified emission reductions. It also assumes there will be no increased knowledge of sources or changed in technology between now and 2016. Lastly, most of the costs are based upon areas that make less than 1% progress towards attainment, indicating what little knowledge we have about controls in those areas.

  The cost curve methodology for unspecified emission reductions also presents a poor conceptual relationship between the costs of identified controls at a national level and the costs of control at a local level. The data underlying this curve contains data points which we believe to be invalid (presented as part of the distributional analysis in Section 6.1.3.3). The estimated curve estimates negative costs over a portion of emission reductions. In addition this approach relies heavily on the control strategy for the tightest standard alternative analyzed in this RIA, and does not account for variability in control strategies across alternative standards analyzed. Lastly, we do not believe this curve well represents the knowledge of how control costs behave over time.

Uncertainties related to the benefits estimates include the following:

- For our primary estimate of the benefits due to gains in children's IQ, we used a log-linear estimate from a recently published pooled analysis of seven studies (Lanphear et al., 2005). Using alternate estimates from other epidemiological studies examining the link between blood lead level and children's IQ has significant impact on benefits results. We found the benefits to decrease by as much as 72 percent when an alternate estimate from a paper by Schwartz (1993) is used. This is due in part to the underlying shape of the dose-response relationship assumed by each of the functions. In the Lanphear study, a log-linear relationship was found to be the best fit for the data (i.e., the natural log-transformed blood lead level is used to predict changes in IQ score). This model implies that the magnitude of changes in IQ increases with lower blood lead levels. However, in

the Schwartz (1993) and Canfield et al. (2003) studies, a single linear model is assumed (i.e., untransformed blood lead levels are used to predict changes in IQ score). The single linear model implies that the magnitude of change in IQ is constant over the entire range of blood lead levels. Therefore, at lower blood lead levels, the log-linear model predicts larger changes in IQ than the linear model. Note that CASAC, in their review of EPA's *Lead Risk Assessment* indicated that "studies show that the decrements in intellectual (cognitive) functions in children are proportionately greater at Pb concentrations <10 μg/dl" (USEPA, 2007d, page 3). However, if the true dose-response relationship is linear, than our primary estimate of benefits is an overestimation.

- Some uncertainty is involved in the estimates of maximum quarterly mean lead air concentrations used for the benefits model. We used ratios of second maximum monthly mean values to maximum quarterly mean values from lead monitoring data from 2003-2005 to convert the baseline second maximum monthly mean values in 2016 into maximum quarterly mean for the "base case" as well as to convert the alternative second maximum monthly mean NAAQS into a maximum quarterly mean for the "control scenarios." If the true ratio between the second maximum monthly means to the maximum quarterly mean is different in 2016 than in 2003-2005 because the pattern and distribution of daily values differs, then our results could be either over- or underestimated.

- The interpolation method of estimating exposure concentrations that we used for our primary estimate is associated with some uncertainty. The validity of this method is to some extent contingent upon the availability of a sufficient number of monitors to support an interpolation. In certain locations, such as Hillsborough County, FL, there are a sufficient number of lead and TSP monitors to generate an interpolation with a pronounced gradient around each monitor. The lead and TSP monitoring network in other non-attainment areas can in some cases be sparse, and the resulting interpolation does not appear to generate a meaningful gradient, such as in Delaware County, IN.

- We assumed that the IQ point effects of a change in concurrent blood lead (i.e., the effects of a change in 2016) apply to all children in our study population that were under seven years of age in 2016. If there is a critical window of exposure for IQ effects (e.g., between the ages of one and two), then we could potentially be overestimating benefits in 2016 because we would have overestimated the population affected by reduced lead exposure in that year. However, if partial or full achievement of the alternative NAAQS levels might occur earlier than 2016, the children in our 0-6 age cohort who are past any critical window in 2016 would have realized the partial or full benefits of reduced lead exposures in those earlier years. Thus, the issue of a potential critical developmental window reflects uncertainty in both the timing and size of benefits.

- The use of air:blood ratios represents a first approximation to the impact of changes in ambient air concentrations of lead on concurrent blood lead levels, applied in the absence of modeling data on lead transport and deposition and the on direct and indirect human exposures. While the values we apply match fairly well with available literature, there

are relatively few studies that report such values or provide sufficient data to calculate such ratios. Further, the lead concentrations in those studies tend to be higher than those modeled here (EPA, 2007a); thus uncertainty remains as to whether the same ratios would be expected at lower levels, or whether air exposures are more or less efficient at changing concurrent blood lead levels at these lower concentrations.

- If the air:blood ratio we apply for children or a similar value is also valid for estimating adult exposures, then our primary benefits understate the true health benefits accruing to the lead-exposed populations because they exclude impacts on morbidity and mortality impacts on adults as well as impacts on prenatal mortality. Additional research is needed to improve our understanding of the impacts of adult air exposure on adult blood lead levels.

- The earnings-based value-per-IQ-point lost that we apply in this analysis most likely represents a lower bound on the true value of a lost IQ point, because it is essentially a cost-of-illness measure, not a measure of an individual's willingness-to-pay (WTP) to avoid the loss of an IQ point. Welfare economics emphasizes WTP measures as the more complete estimate of economic value; for example, the earnings-based value does not include losses in utility due to pain and suffering, nor does it assess the costs of averting behaviors that may be undertaken by households to avoid or mitigate IQ loss from lead exposure.

- The earnings-based estimate of the value-per-IQ-point lost is based on current data on labor-force participation rates, survival probabilities, and assumptions about educational costs and real wage growth in the future. To the extent these factors diverge from these values in the future, our lifetime earnings estimate may be under- or overestimated. Another factor suggesting that our lifetime earnings estimate may be an underestimate is that it does not account for the value of productive services occurring outside the labor force (e.g., child rearing and housework).

- Because of the relatively strong relationship between $PM_{2.5}$ concentrations and premature mortality, PM co-benefits resulting from reductions in fine particulate emissions can make up a large fraction of total monetized benefits, depending on the specific PM mortality impact function used, and to a lesser extend on the relative magnitude of direct lead benefits. The lower end of the range assumes $PM_{2.5}$ benefits are based on the PM-mortality concentration-response relationship provided by Expert K; the upper end of the range assumes the relationship provided by Expert E. The relative share of co-control to primary lead benefits varies only modestly across the four alternative standards.

- Co-control benefits estimated here reflect the application of a national dollar benefit per ton estimate of the benefits of reducing directly emitted fine particulates from point sources. Because they are based on national-level analysis, the benefit-per-ton estimates used here do not reflect local meteorology, exposure, baseline health incidence rates, or other local factors that might lead to an over-estimate or under-estimate of the actual benefits of controlling directly emitted fine particulates.

Conclusions and Insights

EPA's analysis has estimated the health and welfare benefits of reductions in ambient concentrations of lead resulting from a set of illustrative control strategies to reduce emissions of lead at point sources. The results suggest there will be significant additional health and welfare benefits arising from reducing emissions from a variety of sources in and around projected nonattaining counties in 2016. While 2016 is the latest date by which states would generally need to demonstrate attainment with the revised standards, it is expected that benefits (and costs) will begin occurring earlier, as states begin implementing control measures to show progress towards attainment.

There are several important factors to consider when evaluating the relative benefits and costs of the attainment strategies for the six alternative standards assessed in this RIA:

- Benefits and costs are distributed differently across potential non-attainment counties. As presented in Chapter 5, most of the primary lead benefits of the standards are expected to be realized in a small number of areas. These are areas where the sources of lead exposure and the monitors that measure ambient lead appear to be in relatively close proximity to exposed populations. The identified control costs, on the other hand, are greatest in those areas with the largest sources of lead emissions - usually around primary or secondary lead smelters, mining operations, or battery manufacturers. PM co-control benefits tend to be distributed in better correlation to control costs. In general, PM co-control benefits tend to be highest in those areas where our attainment strategy suggests controls on combustion sources, rather than metals processing, are necessary.

- Our analysis considers controls on point source emissions only. Local areas might find that controls of area nonpoint sources would be more cost-effective or better demonstrated than the point source controls we model. In addition, at this time we have not considered whether Federal action might reduce the contribution of leaded aviation gasoline to local lead concentrations, particularly in areas where we find it difficult or impossible to reach attainment based on point sources controls alone.

CHAPTER 8. STATUTORY AND EXECUTIVE ORDER REVIEWS

A. Executive Order 12866: Regulatory Planning and Review

Under section 3(f)(1) of Executive Order (EO) 12866 (58 FR 51735, October 4, 1993), this action is an "economically significant regulatory action" because it is likely to have an annual effect on the economy of $100 million or more. Accordingly, EPA submitted this action to the Office of Management and Budget (OMB) for review under EO 12866 and any changes made in response to OMB recommendations have been documented in the docket for this action (EPA-HQ-OAR-2006-0735). In addition, EPA prepared this Regulatory Impact Analysis (RIA) of the potential costs and benefits associated with this action. However, the CAA and judicial decisions make clear that the economic and technical feasibility of attaining ambient standards are not to be considered in setting or revising NAAQS, although such factors may be considered in the development of State plans to implement the standards. Accordingly, although an RIA has been prepared, the results of the RIA have not been considered in issuing the final rule.

B. Paperwork Reduction Act

The information collection requirements in this final rule will be submitted for approval to the Office of Management and Budget (OMB) under the Paperwork Reduction Act, 44 U.S.C. 3501 et seq. The information collection requirements are not enforceable until OMB approves them.

The information collected under 40 CFR part 53 (e.g., test results, monitoring records, instruction manual, and other associated information) is needed to determine whether a candidate method intended for use in determining attainment of the National Ambient Air Quality Standards (NAAQS) in 40 CFR part 50 will meet the design, performance, and/or comparability requirements for designation as a Federal reference method (FRM) or Federal equivalent method (FEM). While this final rule amends the requirements for Pb FRM and FEM determinations, they merely provide additional flexibility in meeting the FRM/FEM determination requirements. Furthermore, we do not expect the number of FRM or FEM determinations to increase over the number that is currently used to estimate burden associated with Pb FRM/FEM determinations provided in the current ICR for 40 CFR part 53 (EPA ICR numbers 0559.12). As such, no change in the burden estimate for 40 CFR part 53 has been made as part of this rulemaking.

The information collected and reported under 40 CFR part 58 is needed to determine compliance with the NAAQS, to characterize air quality and associated health and ecosystem impacts, to develop emissions control strategies, and to measure progress for the air pollution program. The proposed amendments would revise the technical requirements for Pb monitoring sites, require the siting and operation of additional Pb ambient air monitors, and the reporting of the collected ambient Pb monitoring data to EPA's Air Quality System (AQS). We have estimated the burden based on the final

monitoring requirements of this rule. Based on these requirements, the annual average reporting burden for the collection under 40 CFR part 58 (averaged over the first 3 years of this ICR) for 150 respondents is estimated to increase by a total of 42,165 labor hours per year with an increase of $3,207,407 per year. Burden is defined at 5 CFR 1320.3(b).

C. Regulatory Flexibility Act

The Regulatory Flexibility Act (RFA) generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small organizations, and small governmental jurisdictions.

For purposes of assessing the impacts of this rule on small entities, small entity is defined as: (1) a small business that is a small industrial entity as defined by the Small Business Administration's (SBA) regulations at 13 CFR 121.201; (2) a small governmental jurisdiction that is a government of a city, county, town, school district or special district with a population of less than 50,000; and (3) a small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.

After considering the economic impacts of this final rule on small entities, the Administrator certified this action will not have a significant economic impact on a substantial number of small entities. This final rule will not impose any requirements on small entities. Rather, this rule establishes national standards for allowable concentrations of Pb in ambient air as required by section 109 of the CAA. *American Trucking Ass'ns v. EPA*, 175 F. 3d 1027, 1044-45 (D.C. cir. 1999) (NAAQS do not have significant impacts upon small entities because NAAQS themselves impose no regulations upon small entities). Similarly, the amendments to 40 CFR part 58 address the requirements for States to collect information and report compliance with the NAAQS and will not impose any requirements on small entities.

D. Unfunded Mandates Reform Act

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), Public Law 104-4, establishes requirements for Federal agencies to assess the effects of their regulatory actions on State, local, and tribal governments and the private sector. Unless otherwise prohibited by law, under section 202 of the UMRA, EPA generally must prepare a written statement, including a cost-benefit analysis, for proposed and final rules with "Federal mandates" that may result in expenditures to State, local, and tribal governments, in the aggregate, or to the private sector, of $100 million or more in any one year. Before promulgating an EPA rule for which a written statement is required under section 202, section 205 of the UMRA generally requires EPA to identify and

consider a reasonable number of regulatory alternatives and to adopt the least costly, most cost-effective or least burdensome alternative that achieves the objectives of the rule. The provisions of section 205 do not apply when they are inconsistent with applicable law. Moreover, section 205 allows EPA to adopt an alternative other than the least costly, most cost-effective or least burdensome alternative if the Administrator publishes with the final rule an explanation why that alternative was not adopted. Before EPA establishes any regulatory requirements that may significantly or uniquely affect small governments, including tribal governments, it must have developed under section 203 of the UMRA a small government agency plan. The plan must provide for notifying potentially affected small governments, enabling officials of affected small governments to have meaningful and timely input in the development of EPA regulatory proposals with significant Federal intergovernmental mandates, and informing, educating, and advising small governments on compliance with the regulatory requirements.

This action is not subject to the requirements of sections 202 and 205 of the UMRA. EPA has determined that this final rule does not contain a Federal mandate that may result in expenditures of $100 million or more for State, local, and tribal governments, in the aggregate, or the private sector in any one year. The revisions to the Pb NAAQS impose no enforceable duty on any State, local or Tribal governments or the private sector. The expected costs associated with the increased monitoring requirements are described in EPA's ICR document, but those costs are not expected to exceed $100 million in the aggregate for any year. Furthermore, as indicated previously, in setting a NAAQS EPA cannot consider the economic or technological feasibility of attaining ambient air quality standards. Because the Clean Air Act prohibits EPA from considering the types of estimates and assessments described in section 202 when setting the NAAQS, the UMRA does not require EPA to prepare a written statement under section 202 for the revisions to the Pb NAAQS.

EPA has determined that this final rule contains no regulatory requirements that might significantly or uniquely affect small governments because it imposes no enforceable duty on any small governments. Therefore, this rule is not subject to the requirements of section 203 of the UMRA.

E. Executive Order 13132: Federalism

Executive Order 13132, entitled "Federalism" (64 FR 43255, August 10, 1999), requires EPA to develop an accountable process to ensure "meaningful and timely input by State and local officials in the development of regulatory policies that have federalism implications." "Policies that have federalism implications" is defined in the Executive Order to include regulations that have "substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government."

This final rule does not have federalism implications. It will not have substantial direct effects on the States, on the relationship between the national government and the States,

or on the distribution of power and responsibilities among the various levels of government, as specified in Executive Order 13132. The rule does not alter the relationship between the Federal government and the States regarding the establishment and implementation of air quality improvement programs as codified in the CAA. Under section 109 of the CAA, EPA is mandated to establish NAAQS; however, CAA section 116 preserves the rights of States to establish more stringent requirements if deemed necessary by a State. Furthermore, under CAA section 107, the States have primary responsibility for implementation of the NAAQS. Finally, as noted in section E (above) on UMRA, this rule does not impose significant costs on State, local, or tribal governments or the private sector. Thus, Executive Order 13132 does not apply to this rule.

F. Executive Order 13175: Consultation and Coordination with Indian Tribal Governments

This action does not have tribal implications, as specified in Executive Order 13175 (65 FR 67249, November 9, 2000). It does not have a substantial direct effect on one or more Indian Tribes, since Tribes are not obligated to adopt or implement any NAAQS or monitoring requirements for NAAQS. Thus, Executive Order 13175 does not apply to this action.

G. Executive Order 13045: Protection of Children from Environmental Health & Safety Risks

This action is subject to EO 13045 (62 FR 19885, April 23, 1997) because it is an economically significant regulatory action as defined by EO 12866, and we believe that the environmental health risk addressed by this action has a disproportionate effect on children. The final rule establishes uniform national ambient air quality standards for Pb; these standards are designed to protect public health with an adequate margin of safety, as required by CAA section 109. However, the protection offered by these standards may be especially important for children because neurological effects in children are among if not the most sensitive health endpoints for Pb exposure. Because children are considered a sensitive population, we have carefully evaluated the environmental health effects of exposure to Pb pollution among children. These effects and the size of the population affected are summarized in chapters 6 and 8 of the Criteria Document and sections 3.3 and 3.4 of the Staff Paper, and the results of our evaluation of the effects of Pb pollution on children are discussed in sections II.B and II.C of the notice of proposed rulemaking, and section II.A of this preamble.

H. Executive Order 13211: Actions that Significantly Affect Energy Supply, Distribution or Use

This rule is not a "significant energy action" as defined in Executive Order 13211, "Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution,

or Use" (66 FR 28355 (May 22, 2001)) because it is not likely to have a significant adverse effect on the supply, distribution, or use of energy. The purpose of this rule is to establish revised NAAQS for Pb. The rule does not prescribe specific control strategies by which these ambient standards will be met. Such strategies will be developed by States on a case-by-case basis, and EPA cannot predict whether the control options selected by States will include regulations on energy suppliers, distributors, or users. Thus, EPA concludes that this rule is not likely to have any adverse energy effects.

H. National Technology Transfer and Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act of 1995 (NTTAA), Public Law No. 104-113, §12(d) (15 U.S.C. 272 note) directs EPA to use voluntary consensus standards in its regulatory activities unless to do so would be inconsistent with applicable law or otherwise impractical. Voluntary consensus standards are technical standards (e.g., materials specifications, test methods, sampling procedures, and business practices) that are developed or adopted by voluntary consensus standards bodies. The NTTAA directs EPA to provide Congress, through OMB, explanations when the Agency decides not to use available and applicable voluntary consensus standards.

This final rule involves technical standards. EPA has established low-volume PM_{10} samplers coupled with XRF analysis as the FRM for Pb-PM_{10} measurement. While EPA identified the ISO standard "Determination of the particulate lead content of aerosols collected on filters" (ISO 9855: 1993) as being potentially applicable, the final rule does not permit its use. EPA determined that the use of this voluntary consensus standard would be impractical because the analysis method does not provide for the method detection limits necessary to adequately characterize ambient Pb concentrations for the purpose of determining compliance with the revisions to the Pb NAAQS.

J. Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations

Executive Order 12898 (59 FR 7629; Feb. 16, 1994) establishes federal executive policy on environmental justice. Its main provision directs federal agencies, to the greatest extent practicable and permitted by law, to make environmental justice part of their mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations in the United States.

EPA has determined that this final rule will not have disproportionately high and adverse human health or environmental effects on minority or low-income populations because it increases the level of environmental protection for all affected populations without having any disproportionately high and adverse human health or environmental effects on any population, including any minority or low-income population. The final rule

establishes uniform national standards for Pb in ambient air. In the Administrator's judgment, the revised Pb NAAQS protect public health, including the health of sensitive groups, with an adequate margin of safety.

However, EPA believes that the newly strengthened Pb standards and the new requirements for ambient air monitoring for Pb will have the greatest benefit in reducing health risks associated with exposure to ambient air Pb in those areas where ambient air concentrations are currently the highest. Thus, to the extent that any population groups, including minorities or low-income populations, are currently experiencing disproportionate exposure to ambient air-related Pb, those groups can be expected to experience relatively greater air quality improvements under the revised standards. Nationwide, these revised, more stringent standards will not have adverse health impacts on any population, including any minority or low-income population.