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/m³ 2nd Maximum Monthly Mean		Final NAAQS: 0.15 μg/m³ 2nd Maximum Monthly Mean		Alternative Standard: 0.10 μg/m³ 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/m³ 2nd Maximum Monthly Mean		Final NAAQS: 0.15 μg/m³ 2nd Maximum Monthly Mean		Alternative Standard: 0.10 μg/m³ 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**

<u>Discussion of Uncertainties and Limitations</u>

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.