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United States Environmental Protection Agency
Office of Air Quality Planning and Standards • Air Quality Strategies and Standards Division (MD-15) • Research Triangle Park, North Carolina 27711

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Phone No: **(919) 541-5310**
Facsimile No: **(919) 541-0839**

Message:

Attached are EPA's latest revisions to Volume 2 of the NOx SIP Call RIA (Health and Welfare Benefits) based on comments received from you on December 4, 1998. The revisions are high-lighted. We have attempted to address all of your residual concerns. We had not anticipated any new comments from you, such as the new comment from CEA on passive fertilization. None-theless we have attempted to provide additional language to address the issues you raised. However, we are not prepared to provide any additional analysis of this issue. Please review the material as soon as possible so we can finalize the report. Thanks.

cc: Ron Evans
Bryan Hubbell
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1.5 Statement of Need for the NOx SIP Call

The following sections discuss the statutory authority and legislative requirements of the NOx SIP call, health and welfare effects of NOx emissions, and the basis for the regulatory actions of the NOx SIP call.

1.5.1 Statutory Authority and Legislative Requirements

Section 110(a)(2)(D) provides that a SIP must contain provisions preventing its sources from contributing significantly to nonattainment or interfering with maintenance of the NAAQS in a downwind State. This section applies to all pollutants covered by NAAQS and all areas regardless of their attainment designation. Section 110(k)(5) authorizes EPA to find that a SIP is substantially inadequate to meet any CAA requirement, as well as being inadequate to mitigate interstate transport as described in Sections 184 and 176A. Such a finding would require States to submit a SIP revision to correct the inadequacy within a specified period of time.

1.5.2 Health and Welfare Effects of NOx Emissions[16]

NOx emissions contribute to the formation of ozone during the summer season. Ozone is a major component of smog and is harmful to both human health and the environment. Research has shown the following health effects of ozone:

- Exposure to ambient ozone concentrations has been linked to increased hospital admissions for respiratory ailments, such as asthma. Repeated exposure to ozone can make people more susceptible to respiratory infection and lung inflammation, and can aggravate preexisting respiratory diseases.
- Children are at risk for the effects of ozone because they are active outside during the summer months when ozone levels are at their highest. Adults who are outdoors and moderately active during the summer months are also at risk. These individuals can experience a reduction in lung function and increased respiratory symptoms, such as chest pain and cough, when exposed to relatively low ozone levels during periods of moderate exertion.
- Long-term exposures to ozone can cause repeated inflammation of the lung, impairment of lung defense mechanisms, and irreversible changes in lung structure, which could lead to premature aging of the lungs and/or chronic respiratory illnesses such as emphysema and chronic bronchitis.
- Several peer reviewed epidemiology studies recently published suggest a possible association between ozone exposure and mortality, though several other studies find no significant association.

Ozone has also been shown to adversely affect vegetation, including reductions in agricultural and commercial forest yields, reduced growth and decreased survivability of tree seedlings, and increased tree and plant susceptibility to disease, pests and other environmental stresses.

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[16] A comprehensive discussion of health and environmental issues related to NOx appears in EPA, 1997d.

Chapter 4. BENEFITS OF REGIONAL NOx REDUCTIONS

The changes in ozone and PM ambient concentrations described in Chapter 3 will result in changes in the physical damages associated with elevated ambient concentrations of these pollutants. The damages include changes in both human health and welfare effects categories.

This chapter presents the methods used to estimate the physical and monetary benefits of the modeled NOx and SO_2 emissions changes from implementing the revised SIPs, the estimates of the avoided physical damages (e.g., incidence reductions), and the results of the benefits analysis for a range of regulatory alternatives considered for the SIP call. EPA decided to analyze the benefits of the most significant alternatives that it considered for determining state NOx budgets for the electric power industry and other stationary sources. The five alternatives are described in Table 2-3 in Chapter 2 of Volume 2 of the RIA. In order to conserve analytical resources, the benefits of Regionality 2 are not analyzed. Regionality 2 achieves emission reductions and air quality improvements that are similar, though not identical, to Regionality 1 and 0.15 Trading. It is likely that total benefits for Regionality 2 would fall somewhere in between the benefits estimates for Regionality 1 and 0.15 Trading.

The remainder of this chapter is laid out as follows. Section 4.1 provides an overview of the benefits methodology. Section 4.2 discusses issues in estimating health effects. Sections 4.3 discusses methods and provides estimated values for avoided incidences and monetary benefits for ozone and PM related health effects. Section 4.4 discusses methods and provides estimated values for ozone and PM related welfare effects. Section 4.5 provides estimates of total health and welfare benefits associated with alternative NOx emission limit policies. Finally, Section 4.6 discusses potential benefit categories that are not quantified due to data and/or methodological limitations, and provides a list of analytical uncertainties, limitations, and biases.

4.1 Overview of Benefits Estimation

Most of the specific methods and information used in this benefit analysis are similar to those used in the §812 Retrospective of the Benefits and Costs of the Clean Air Act and forthcoming §812 Prospective EPA Reports to Congress, which were reviewed by EPA's Science Advisory Board (EPA, 1997c),as well as the approach used by EPA in support of revising the ozone and PM NAAQS in 1997 (EPA, 1997a and 1997b).

Prior to describing the details of the approach for the benefits analysis, it is useful to provide an overview of the approach. The overview is intended to help the reader better identify the role of each issue described later in this chapter.

The general term "benefits" refers to any and all outcomes of the regulation that are considered positive; that is, that contribute to an enhanced level of social welfare. The economist's meaning of "benefits" refers to the dollar value associated with all the expected positive impacts of the regulation; that is, all regulatory outcomes that lead to higher social welfare. If the benefits are associated with market goods and services, the monetary value of the benefits is approximated by the sum of the predicted changes in "consumer (and producer) surplus." These "surplus" measures are standard and widely accepted measures in the field of applied welfare economics, and reflect the degree of well being enjoyed by people given different levels of goods and prices. If the benefits are non-market benefits (such as the risk reductions associated with

The next two sections provide details on the measurement and valuation of changes in incidences of premature mortality associated with changes in ozone and PM arising from implementation of the NOx SIP call.

Ozone-related Mortality

The literature on the possible relationship between exposure to ambient ozone and premature mortality has been evolving rapidly. Of the 28 time-series epidemiology studies identified in the literature that report results on a possible association between daily ozone concentrations and daily mortality (see EPA, 1997a, Appendix J), 21 were published or presented since 1995. In particular, a series of studies published in 1995 through 1997 (after closure on the ozone Criteria Document) from multiple cities in western Europe has significantly increased the body of studies finding a positive association. Fifteen of the 28 studies report a statistically significant relationship between ozone and mortality, with the more recent studies tending to find statistical significance more often than the earlier studies. The ozone-mortality datasets have also tended to become larger in more recent studies as longer series of air quality monitoring data have become available over time. This suggests that it may take many years of data before the ozone effect can be separated from the daily weather and seasonal patterns with which it tends to be correlated.

In 1997, as a part of the ozone NAAQS promulgation RIA, EPA staff reviewed this recent literature. They identified 9 studies that met a defined set of selection criteria, and conducted a meta-analysis of the results of the 9 studies. The result of this work was included as Appendix J in the NAAQS RIA, "Assessment and Synthesis of Available Epidemiological Evidence of Mortality Associated with Ambient Ozone from Daily Time-series Analyses" (EPA, 1997a).

The NOx SIP call related benefits analysis implements the same basic meta-analysis approach to quantifying ozone mortality as the NAAQS RIA, with the exception that a subset of 4 of the 9 studies is used, representing only U.S. based analyses. In a post-NAAQS RIA review of the methodology for assessing ozone mortality effects, it was determined that the relationships between ambient ozone and mortality in the non-U.S. study locations included in the original NAAQS-related meta-analysis may not be representative of the range of ozone-mortality concentration-response relationships in the United States. Although ozone is the same everywhere (in contrast to PM), its effects on mortality may depend on its interactions with other pollutants and with meteorological variables. In addition, there are population and societal differences (air conditioning incidence, building construction, human activity patterns, etc.) across locations that could affect the relationship between ambient ozone levels and mortality. To reduce the potential for applying inappropriate concentration-response functions in analysis of the ozone mortality benefits from the NOx SIP call, only U.S. studies are included, based on the assumption that demographic and environmental conditions on average would be more similar between the study and policy sites. However, the full body of peer-reviewed ozone mortality studies should be considered when evaluating the weight of evidence regarding the presence of an association between ambient ozone concentrations and premature mortality.

Because of differences in the averaging times used in the underlying studies (some use daily average ozone levels, while others use 1-hour daily maximum values), it is not possible to conduct a meaningful meta-analysis directly on the coefficients of the C-R functions. Instead, for each pair of air quality modeling results (for the baseline and a given regulatory alternative) for the NOx SIP call, each C-R function is translated into a set of predicted mortality incidence changes that would be estimated by that C-R function, given the set of air quality changes. The meta-analysis approach is then applied to the predicted mortality incidence changes that would be estimated by each of the studies. Additional details of the approach are described in the technical support document for the NOx SIP call (Abt Associates, 1998a).

Table 4-8 presents the range of estimates of avoided incidences of ozone-related mortality and monetary benefits associated with five regulatory alternatives for the NOx SIP call. Note that the lower estimate for this endpoint is zero to reflect both the number of peer-reviewed studies finding no significant relationship between ozone and premature mortality and the lack of a directly established biological mechanism linking ozone and premature mortality. In its review of the epidemiological ozone-mortality literature, EPA has determined that there is a reasonable probability that increased ozone concentrations are associated with incidences of premature mortality. In Table 4-8 the higher estimate allows for the existence of an ozone-mortality relationship, but assumes there is some probability that for any specific location within the SIP call region that the effect of ozone on premature mortality is zero. This probability is embedded in the previously discussed meta-analysis approach, which includes studies both with and without findings of a statistically significant relationship between ozone concentrations and premature mortality.

Table 4-8

Range of Avoided Ozone-related Mortality Incidences and Monetary Benefits Associated with the NOx SIP Call[a]

Regulatory Alternative	Avoided Incidences (cases/year)		Monetary Benefits (millions 1990$)	
	Low	High	Low	High
0.12 Trading	0	315	$0	$1,496
0.15 Trading	0	279	$0	$1,326
Regionality 1	0	251	$0	$1,191
0.20 Trading	0	234	$0	$1,108
0.25 Trading	0	174	$0	$824

[a] Annual baseline incidence for non-accidental deaths in the general population for all ages is 803/100,000. Total annual baseline incidence for the NOx SIP call region is 1,768,014 non-accidental deaths.

Table 4-9 shows the results of a sensitivity analysis based on the opposite of the assumption driving the low-end estimate presented in Table 4-8. The results in Table 4-9 are based on the assumption that there is a positive relationship between ozone exposure and premature mortality, and that this relationship is captured by studies that find a statistically significant relationship between ozone concentrations and premature mortality. This assumption might be the preferred approach if there were strong clinical data suggesting a relationship, but, due to data and statistical limitations, epidemiological studies have had difficulty isolating an effect. The practical implication of this assumption is that one of the four studies used in the meta-analysis in Table 4-8 is dropped from the analysis in Table 4-9. This approach generates an upper-end estimate of potential avoided ozone-related premature mortality incidences and associated monetary benefits. This upper-end is presented only as a sensitivity analysis and is not included in the calculation of the high-end estimate of total ozone-related benefits in Tables 4-30 through 4-34. The monetary benefits for this sensivity analysis shown in Table 4-9 are about 45 percent higher than those shown in the primary mortality analysis.

Table 4-9

Sensitivity Analysis: Avoided Ozone-related Mortality Incidences and Monetary Benefits Associated with the NOx SIP Call -- Significant Studies Only[a]

Regulatory Alternative	Avoided Incidences (cases/year)	Monetary Benefits (millions 1990$)
0.12 Trading	460	$2,195
0.15 Trading	408	$1,947
Regionality 1	365	$1,725
0.20 Trading	341	$1,627
0.25 Trading	254	$1,211

[a] Annual baseline incidence for non-accidental deaths in the general population for all ages is 803/100,000. Total annual baseline incidence for the NOx SIP call region is 1,768,014 non-accidental deaths.

PM-related Mortality

PM-associated mortality in the benefits analysis is estimated using the $PM_{2.5}$ relationship from Pope et al., 1995. This decision reflects the Science Advisory Board's explicit recommendation for modeling the mortality effects of PM in both the completed §812 Retrospective Report to Congress and the ongoing §812 Prospective Study. The Pope study estimates the association between long-term (chronic) exposure to $PM_{2.5}$ and the survival of members of a large study population. This relationship is selected for use in the benefits analysis instead of short-term (daily pollution) studies for a number of reasons.

The Pope long-term study is selected as providing the best available estimate of the relationship between PM and mortality. It is used alone, rather than considering the total effect to be the sum of estimated short-term and long-term effects, because summing creates the possibility of double-counting a portion of total mortality. The Pope study is selected in preference to other available long-term studies because it uses the best methods (i.e., a prospective cohort method with a Cox proportional hazard model),

4.4.1 Commodity Agricultural Crops

The economic value associated with varying levels of yield loss for ozone-sensitive commodity crops is analyzed using a revised and updated Regional Model Farm (RMF) agricultural benefits model (Mathtech, 1998a). The RMF is an agricultural benefits model for commodity crops that account for about 75 percent of all U.S. sales of agricultural crops. The RMF explicitly incorporates exposure-response functions into microeconomic models of agricultural producer behavior. The model uses the theory of applied welfare economics to value changes in ambient ozone concentrations brought about by particular policy actions such as the NOx SIP call.

The measure of benefits calculated by the model is the net change in consumers' and producers' surplus from baseline ozone concentrations to the ozone concentrations resulting from attainment of alternative standards. Using the baseline and post-control equilibria, the model calculates the change in net consumers' and producers' surplus on a crop-by-crop basis[3]. Dollar values are aggregated across crops for each standard. The total dollar value represents a measure of the change in social welfare associated with the regulatory alternative. Although the model calculates benefits under three alternative welfare measures (perfect competition, price supports, and modified agricultural policy), results presented here are based on the "perfect competition" measure to reflect recent changes in agricultural subsidy programs. Under the recently revised 1996 Farm Bill , most eligible farmers have enrolled in the program to phase out government crop price supports for the RMF-relevant crops: wheat, corn, sorghum, and cotton.

For the purpose of this analysis, the six most economically significant crops are analyzed: corn, cotton, peanuts, sorghum, soybean, and winter wheat. In the 37-state region modeled in this analysis, these crops were valued at over $70 billion in 1997. The model employs biological exposure-response information derived from controlled experiments conducted by the National Crop Loss Assessment Network (NCLAN) (Lee et al., 1996). Four main areas of the RMF have been updated to reflect the 1996 Farm Bill and USDA data projections to 2005 (the year farthest into the future for which projections are available). These four areas are yield per acre, acres harvested, production costs, and model farms. Documentation outlining the 2005 update is provided in EPA, 1997a.

Table 4-22 presents estimates of monetary benefits due to changes in the production of all six commodity crops associated with five regulatory alternatives for the NOx SIP call. Estimates for both most and least ozone sensitive crops are presented in Table 4-22. The highest benefit estimate of $415 million (assuming relatively sensitive cultivars for the 0.12 Trading alternative) is a relatively small 0.6% of the total 1997 crop value. This suggests that individual farmers are not likely to identify ozone sensitivity as a major factor in observed yield changes in the presence of other more obvious factors, such as meterology, fertilization, and pest resistance. Likewise, given the relative importance of other yield enhancing crop traits, such as pest resistence, it is unlikely that seed developers will focus on development of ozone tolerant varieties. Nonetheless, to the extent that ozone resistant cultivars are available and farmers respond to increased ozone levels by subtituting towards more ozone resistant cultivars, crop losses will be reduced.

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[3] Agricultural benefits differ from other health and welfare endpoints in the length of the assumed ozone season. For agriculture, the ozone season is assumed to extend from April to September. This assumption is made to ensure proper calculation of the ozone statistic used in the exposure-response functions. The only crop affected by changes in ozone during April is winter wheat.

Table 4-24 presents estimates of monetary benefits of yield changes of commercial forests associated with the five policy alternatives for the NOx SIP call. EPA did not estimate monetary benefits for all policy alternatives. Benefits for excluded alternatives can be easily estimated using a ratio of estimated benefits to a similar benefit category, such as commodity crops. Benefits for the 0.25 trading and Regionality 1 alternatives are estimated by applying the ratio of forestry to agricultural benefits for the 0.15 trading alternative, equal to 0.59, to the agricultural benefits for these two alternatives.

Because of the long harvesting cycle of commercial forests and the cumulative effects of higher growth rates, the benefits to the future economy will be much larger than the estimates reported in Table 4-24. For example, the 0.12 trading policy alternative would result in about $8.0 billion additional forest inventories by 2040. The estimated annualized benefits for this alternative, $233 million, are much lower because of smaller benefits in earlier years (i.e., the 2010 and 2020 decades) and because the higher benefits realized in later years are heavily discounted.

Table 4-24

Commercial Forest Monetary Benefits Associated with the NOx SIP Call

Regulatory Alternative	Monetary Benefits (millions 1990$)
0.12 Trading	$233
0.15 Trading	$213
Regionality 1	$188
0.20 Trading	$185
0.25 Trading	$143

4.4.3 Nitrogen Deposition

Excess nutrient loads, especially that of nitrogen, are responsible for a variety of adverse consequences to the health of estuarine and coastal waters. These effects include toxic and/or noxious algal blooms such as brown and red tides, low (hypoxic) or zero (anoxic) concentrations of dissolved oxygen in bottom waters, the loss of submerged aquatic vegetation due to the light-filtering effect of thick algal mats, and fundamental shifts in phytoplankton community structure. Direct concentration-response functions relating deposited nitrogen and reductions in estuarine benefits are not available. The preferred willingness-to-pay based measure of benefits depends on the availability of these concentration-response functions and on estimates of the value of environmental responses. Because neither appropriate concentration-response functions nor sufficient information to estimate the marginal value of changes in water quality exist at present, an avoided cost approach is used instead of willingness-to-pay to generate estuary related benefits of the NOx SIP call.

The benefits to surrounding communities of reduced nitrogen loadings resulting from various control strategies for atmospheric NOx emissions are calculated for 10 East and 2 Gulf Coast case study estuaries, and extrapolated to all 43 Eastern U.S. estuaries. The 10 East Coast case study estuaries represent approximately half of the estuarine watershed area in square miles along the East Coast. The 12 case study estuaries are chosen because of the availability of necessary data and their potential representativeness. This analysis uses the following data for each estuary: (1) total nitrogen load from all sources; (2) direct nitrogen load from atmospheric deposition to the estuary surface; (3) indirect nitrogen load from atmospheric deposition to the estuary watershed and subsequent pass-through to the estuary itself; (4) established nitrogen thresholds and reduction goals adopted by the community; and (5) costs associated with using agreed upon non-point water pollution control technologies.

Atmospheric nitrogen reductions are valued in this analysis on the basis of avoided costs associated with agreed upon controls of nonpoint water pollution sources. Benefits are estimated using an average, locally-based cost for nitrogen removal from water pollution (EPA, 1998). Valuation reflects water pollution control cost avoidance based on average cost/pound of current non-point source water pollution controls for nitrogen in three case study estuaries: Albemarle/Pamlico Sounds, Chesapeake Bay, and Tampa Bay. Taking the weighted cost/pound of these available controls assumes States will combine low cost and high cost controls, which could inflate avoided cost estimates.

In a recent advisory statement, the EPA's Science Advisory Board (SAB), charged with reviewing the benefits methodology for the §812 Prospective report on the benefits and costs of the Clean Air Act Amendments, raised concerns about the use of the avoided cost approach to value reduced ecosystem damages. Specifically, they identified a key requirement which should be met in order for avoided costs to approximate environmental benefits. This requirement is that there is a direct link between implementation of the air pollution regulation and the abandonment of a separate costly regulatory program by some other agency, i.e. a state environmental agency. Reductions in nitrogen deposition from the NOx SIP call are expected to impact estuaries all along the eastern seaboard and the Gulf Coast. Many of the estuaries in these areas are currently being targeted by nitrogen reduction programs due to current impairment of estuarine water quality by excess nutrients. Some of the largest of these estuaries, including the Chesapeake Bay, have established goals for nitrogen reduction and target dates by which these goals should be achieved. Using the best and most easily implemented existing technologies, many of the estuaries will not be able to achieve the stated goals by the target dates. For example, the Chesapeake Bay needs an additional 9,000 tons of nitrogen reductions per year and Long Island Sound needs an additional 3,500 tons of reductions per year. Meeting these additional reductions will require development of new technologies, implementation of costly existing technologies (such as stormwater controls), or use of technologies with significant implementation difficulties, such as agricultural best management practices (BMPs). Reductions in nitrogen deposition from the atmosphere due to the NOx SIP call will directly reduce the need for these additional costly controls. Thus while the NOx SIP call does not eliminate the need for nutrient management programs already in place, it may substitute for some of the incremental costs and programs (such as an agricultural BMP program) necessary to meet the nutrient reduction goals for each estuary. This then meets the SAB requirement since the NOx SIP call will directly reduce the need for elements of separate costly reduction actions.

EPA believes that the use of an avoided cost approach in this RIA is consistent with the SAB advice for appropriate use of avoided costs. The SAB did not provide direct guidance on alternative approaches to measuring the benefits of reduced nitrogen deposition to estuaries. However, EPA recognizes the fact that avoided costs do not directly measure the benefits of reduced ecological impacts due to nitrogen deposition.

Thus, while avoided cost is only a proxy for benefits, and should be viewed as inferior to willingness-to-pay based measures, it is preferred to excluding any quantitative estimate of benefits for this category. Current research is underway to develop other approaches for valuing estuarine benefits, including contingent valuation and hedonic property studies. However, this research is still sparse, and does not contain sufficient information on the marginal willingness-to-pay for changes in concentrations of nitrogen (or changes in water quality or water resources as a result of changes in nitrogen concentrations). As more studies become available, more complete estimates of the commercial and ecological benefits of reduced atmospheric deposition of nitrogen can be incorporated into regulatory analyses.

The fixed capital costs for non-point controls in the case study estuaries is ranged from $0.61 to $45.27 per pound for agricultural and other rural best management practices and from $35 to $142.64 per pound for urban nonpoint source controls (stormwater controls, reservoir management, onsite disposal system changes, onsite BMPs). Using these as a base, the total fixed capital cost per pound (weighted on the basis of fractional relationship of nitrogen load controlled for the estuary goal) is calculated for each of the case-study estuaries and applied in the valuation of their avoided nitrogen load controlled. The weighted capital costs per pound for the case-study estuaries are $32.88 for Albemarle-Pamlico Sounds, $22.31 for Chesapeake Bay, and $88.25 for Tampa Bay[4]. For the purposes of this analysis, EPA assumes that estuaries that have not yet established nutrient reduction goals will utilize the same types of nutrient management programs as projected for the case study estuaries. For the other nine estuaries, an average capital cost per pound of nitrogen (from the three case-estuaries) of $47.65/lb ($105/kg) is calculated and applied; this cost may understate or overstate the costs associated with reductions in these other estuaries. The other nine estuaries generally represent smaller, more urban estuaries (like Tampa Bay), which typically have fewer technical and financial options available to control nitrogen loadings from nonpoint sources. This may result in higher control costs more similar to the Tampa Bay case. On the other hand, these estuaries may have opportunities to achieve additional point source controls at a lower costs. Also, increased public awareness of nutrification issues and technological innovation may, in the future, result in States finding lower cost solutions to nitrogen removal.

The 12 estuaries directly analyzed represent approximately 48% of the estuarine watershed area along the East Coast (there are 43 East Coast estuaries of which 10 were in the sample, and 31 Gulf of Mexico estuaries of which 2 are in the sample). Because NOAA data indicate that approximately 89% (92.6% by watershed area plus surface area) of East Coast estuaries are highly or moderately nutrient sensitive, it is reasonable to expect that estuaries not included in this analysis would also benefit from reduced deposition of atmospheric nitrogen. Total benefits from the 12 representative estuaries are scaled-up to include the remainder of the nutrient sensitive estuaries along the East Coast (92.6% of all East Coast estuaries) on the basis of estuary watershed plus water surface area. Since the 12 representative estuaries account for 48 percent of total eastern estuarine area, estimates are scaled up by multiplying the estimate for the 12 estuaries by 2.083 and then taking 92.6 percent of this estimate to adjust for nutrient sensitivity.

All capital cost estimates are then annualized based on a 7% discount rate and a typical implementation horizon for control strategies. Based on information from the three case study estuaries, this typically ranges from 5 to 10 years. EPA has used the midpoint of 7.5 years for annualization, which yields

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[4] The value for Tampa Bay is not a true weighted cost per pound, but a midpoint of a range of $58.54 to $117.65 developed by Apogee Research for the control possibilities (mostly urban BMPs) in the Tampa Bay estuary.

an annualization factor of 0.1759. Non-capital installation costs and annual operating and maintenance costs are not included in these annual cost estimates. Depending upon the control strategy, these costs can be significant. Reports on the Albemarle-Pamlico Sounds indicate, for instance, that planning costs associated with control measures comprises approximately 15% of capital costs. Information received from the Association of National Estuary Programs indicates that operating and maintenance costs are about 30% of capital costs, and that permitting, monitoring, and inspections costs are about 1 to 2% of capital costs. For these reasons, the annual cost estimates may be understated.

Table 4-25 presents estimates of monetary benefits arising from the avoided costs of nitrogen removal for the 12 estuaries with directly modeled nitrogen deposition changes and for the full set of 43 East Coast estuaries including extrapolated benefits associated with five regulatory alternatives for the NOx SIP call. Estimates in Table 4-25 assume that 10 percent of nitrogen deposited over the watershed reaches the estuary, costs for non-study estuaries are equal to the average of the costs for the three case studies, and benefits are applied only to nutrient-sensitive estuaries.

Table 4-25
Monetary Benefits Associated with the NOx SIP Call from Avoided Costs of Nitrogen Removal in Eastern Estuaries

Regulatory Alternative	Monetary Benefits (millions 1990$)	
	12 Modeled Eastern Estuaries	Extrapolation to 43 Eastern Estuaries
0.12 Trading	$129	$248
0.15 Trading	$123	$238
Regionality 1	$115	$221
0.20 Trading	$109	$210
0.25 Trading	$79	$152

4.4.4 Household Soiling Damage

Welfare benefits also accrue from avoided air pollution damage, both aesthetic and structural, to architectural materials and to culturally important articles. At this time, data limitations preclude the ability to quantify benefits for all materials whose deterioration may be promoted and accelerated by air pollution exposure. However, this analysis addresses one small effect in this category, the soiling of households by particulate matter.

Assumptions regarding the air quality indicator are necessary to evaluate the concentration-response function. PM_{10} and $PM_{2.5}$ are both components of TSP. However, it is not clear which components of TSP

Brown Clouds

NOx emissions, especially gaseous NO_2 and NOx aerosols, can cause a brownish color to appear in the air (EPA, 1996c). In higher elevation western cities where wintertime temperature inversions frequently trap air pollutants in atmospheric layers close to the ground, this can result in distinct brown layers. In the eastern U.S., a layered look is not as common, but the ubiquitous haze sometimes takes on a brownish hue. To date, economic valuation studies concerning visual air quality have focused primarily on the clarity of the air, and have not addressed the question of how the color of the haze might be related to aesthetic degradation. It may be reasonable to presume that brown haze is likely to be perceived as dirty air and is more likely to be associated with air pollution in people's minds. It has not, however, been established that the public would have a greater value for reducing brown haze than for a neutral colored haze. Results of economic valuation studies of visibility aesthetics conducted in Denver and in the eastern U.S. (McClelland et al., 1991) are not directly comparable because changes in visibility conditions are not defined in the same units of measure. However, the WTP estimates for improvements in visibility conditions presented in this assessment are based on estimates of changes in clarity of the air (measured as deciview) and do not take into account any change in color that may occur. It is possible that there may be some additional value for reductions in brownish color that may also occur when NOx emissions are reduced.

Other Unquantifiable Benefits Categories

There are other welfare benefits categories for which there is incomplete information to permit a quantitative assessment for this analysis. For some endpoints, gaps exist in the scientific literature or key analytical components and thus do not support an estimation of incidence. In other cases, there is insufficient economic information to allow estimation of the economic value of adverse effects. Potentially significant, but unquantified welfare benefits categories include: existence and user values related to the protection of Class I areas (e.g., Shenendoah National Park), damage to tree seedlings of more than 10 sensitive species (e.g., black cherry, aspen, ponderosa pine), non-commercial forests, ecosystems, materials damage, and reduced sulfate deposition to aquatic and terrestrial ecosystems. Although scientific and economic data are not available to allow quantification of the effect of ozone in these categories, the expectation is that, if quantified, each of these categories would lead to an increase in the monetized benefits presented in this RIA.

4.6.3 Potential Disbenefits

In this discussion of unquantified benefits, a discussion of potential disbenefits must also be mentioned. Several of these disbenefit categories are related to nitrogen deposition while one category is related to the issue of ultraviolet light.

Passive Fertilization

Several disbenefit categories are related to nitrogen deposition. Nutrients deposited on crops from atmospheric sources are often referred to as passive fertilization. Nitrogen is a fundamental nutrient for primary production in both managed and unmanaged ecosystems. Most productive agricultural systems require external sources of nitrogen in order to satisfy nutrient requirements. Nitrogen uptake by crops varies, but typical requirements for wheat and corn are approximately 150 kg/ha/yr and 300 kg/ha/yr, respectively (NAPAP, 1990). These rates compare to estimated rates of passive nitrogen fertilization in the range of 0 to 5.5 kg/ha/yr (NAPAP, 1991). So, for these crops, deposited nitrogen could account for as much as 2 to 4 percent of nitrogen needs. Holding all other factors constant, farmers' use of purchased fertilizers or manure may increase as deposited nitrogen is reduced. EPA has not estimated the potential value of this possible increase in the use of purchased fertilizers, but a qualitative assessment of several factors suggests that the overall value is very small relative to the value of other health and welfare endpoints presented in this analysis. First, reductions in NOx emissions affect only a fraction of total nitrogen deposition. Approximately 70 to 80 percent of nitrogen deposition is in the form of nitrates (and thus can be traced to NOx emissions) while most of the remainder is due to ammonia emissions (personal communication with Robin Dennis, NOAA Atmospheric Research Lab, 1997). Table 3-4 in Chapter 3 indicates the annual average change in nitrogen deposition attributable to the 0.15 Trading alternative of the NOx SIP call is about 11 percent of baseline levels, suggesting a relatively small potential change in passive fertilization. Second, some sources of nitrogen, such as animal manure, are available at no cost or at a much lower cost than purchased nitrogen. In addition, in certain areas nitrogen is currently applied at rates which exceed crop uptake rates, usually due to an overabundance of available nutrients from animal waste. Small reductions in passive fertilization in these areas is not likely to have any consequence to fertilizer application. The combination of these factors suggests that the cost associated with compensating for reductions in passive fertilization is relatively minor.

Information on the effects of changes in passive nitrogen deposition on forestlands and other terrestrial ecosystems is very limited. The multiplicity of factors affecting forests, including other potential stressors such as ozone, and limiting factors such as moisture and other nutrients, confound assessments of marginal changes in any one stressor or nutrient in forest ecosystems. However, reductions in deposition of nitrogen could have negative effects on forest and vegetation growth in ecosystems where nitrogen is a limiting factor (EPA, 1993).

On the other hand, there is evidence that forest ecosystems in some areas of the United States are nitrogen saturated (EPA, 1993). Once saturation is reached, adverse effects of additional nitrogen begin to occur such as soil acidification which can lead to leaching of nutrients needed for plant growth and mobilization of harmful elements such as aluminum. Increased soil acidification is also linked to higher amounts of acidic runoff to streams and lakes and leaching of harmful elements into aquatic ecosystems.

Ultraviolet Light

A reduction of tropospheric ozone is likely to increase the penetration of ultraviolet light, specifically UV-B, to ground level. UV-B is an issue of concern because depletion of the stratospheric ozone layer (i.e., ozone in the upper atmosphere) due to chlorofluorocarbons and other ozone-depleting chemicals is associated with increased skin cancer and cataract rates. Currently, EPA is not able to adequately quantify these effects for the purpose of valuing benefits for this policy.

Other EPA programs exist to address the risks posed by changes in UV-B associated with changes in total column ozone. As presented in the Stratospheric Ozone RIA (EPA, 1992), stratospheric ozone levels are expected to significantly improve over the next century as the major ozone depleting substances are