

# **Comments on EPA's "Draft Integrated Review Plan for the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur"**

**Prepared for the  
Alliance of Automobile Manufacturers**

**George T. Wolff, Ph.D  
Jon M. Heuss  
Dennis F. Kahlbaum  
Air Improvement Resource, Inc.  
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## **Executive Summary**

With the release of the draft integrated review plan, the U.S. EPA has begun their periodic review on the adequacy of the secondary National Ambient Air Quality Standards (NAAQS) for oxides of nitrogen (NO<sub>x</sub>) and oxides of sulfur (SO<sub>x</sub>) in protecting welfare. The last review, completed in 2012, concluded that the existing secondary standards were adequate to protect vegetation from the direct exposures to ambient concentrations of nitrogen dioxide (NO<sub>2</sub>) and sulfur dioxide (SO<sub>2</sub>), but that they were not adequate to protect against adverse effects due to the acidification of aquatic ecosystems from the combined deposition of sulfur (S) and nitrogen (N) species. However, EPA did not create a new NAAQS in 2012 for deposition because of many uncertainties that existed at that time. In the present review, EPA plans to revisit the aquatic ecosystem issue as well as to include the issues of terrestrial acidification, aquatic and terrestrial eutrophication, loss of terrestrial plant diversity and mercury methylation.

### **Deposition Is Declining**

The first question that EPA needs to address in this review is whether current and committed emission control programs will reduce acidification, eutrophication and the other effects sufficiently so that an additional secondary standard(s) would be superfluous by the time it (they) could be promulgated and then implemented. In recent years, EPA has promulgated a dozen or so new regulations that have reduced US emissions of both NO<sub>x</sub> and SO<sub>x</sub> and will continue to ensure the decline of their ambient concentrations for the foreseeable future. From 1970 to 2014, US NO<sub>x</sub> emissions have decreased 54% while SO<sub>2</sub> emissions have decreased 84%. EPA's projected inventories show additional declines in the emissions of NO<sub>x</sub> of 34% and SO<sub>2</sub> of 46% from 2014 to 2025. As a result of these emissions decreases, the ambient air concentrations of NO<sub>2</sub> and SO<sub>2</sub> have shown similar declines. Further, proportional declines in total N and S deposition have been observed.

## **Large Uncertainties Associated With Complex Form Of NAAQS**

To address the deposition issues, EPA is planning to use the concept of critical loads, which is a quantitative estimate of exposure to one or more pollutants, below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge. EPA will choose an indicator based on the critical load concept for N and/or S species for each effect and ecosystem type (acidification of aquatic ecosystems, eutrophication of terrestrial ecosystems etc.) and establish a single, national indicator value that cannot be exceeded. To insure that the indicator is not exceeded, EPA will calculate the maximum allowable deposition of S and N species that an ecoregion could assimilate without exceeding the indicator level. This amount would vary from ecoregion to ecoregion depending upon a variety of local conditions. EPA would then relate the maximum allowable deposition to a corresponding sum of the ambient air concentration of SO<sub>x</sub> and total oxidized nitrogen species that could be present.

In the last review, EPA considered such a NAAQS as described in the preceding paragraph for aquatic ecosystem acidification based on an Aquatic Acidification Index (AAI). They considered establishing a single AAI NAAQS, which would apply to some 83 different ecoregions in the US. However, extrapolating from an AAI to allowable ambient air concentrations requires the use of watershed and ambient air modeling involving highly uncertain inputs. The error in the allowable ambient concentrations was over  $\pm 200\%$  at times. With such uncertainties, the Administrator decided not to adopt such a NAAQS at the time, but revisit it in the next review, which has just begun. Because EPA's draft plan contains insufficient details to understand the specific approaches that they will employ to assess the critical loads for each of the ecosystem types they plan to protect, it is difficult to provide specific comments on each. However, it is likely that the approaches the Agency takes will be similar to the AAI approach. Consequently, we expect them to suffer from the same types of uncertainties and rely on unverified modeling. Since we are unaware of anything that has reduced these uncertainties since the previous review, EPA needs to address these uncertainties in the upcoming Integrated Science Assessment (ISA) document.

## **Implementation Issues**

When EPA was considering the AAI NAAQS in the last review a number of implementation issues arose that EPA failed to address. These include:

1. What are the appropriate monitoring network density and siting requirements to support a compliance system based on ecoregions?
2. Given the unique spatial nature of the secondary standard (e.g., ecoregions), what are the appropriate parameters for establishing nonattainment areas?
3. How can new or modified major sources of oxides of nitrogen and oxides of sulfur emissions assess their ambient impacts on the standard and demonstrate that they are not causing or contributing to a violation of the NAAQS for preconstruction permitting?
4. To what extent does the fact that a single source may be impacting multiple areas with different acid sensitivities and variable levels of NO<sub>y</sub> and SO<sub>x</sub> concentrations that would be necessary to achieve a national ANC target, complicate this assessment? How can

these additional complexities best be addressed?

5. What additional tools, information, and planning structures are needed to assist states with SIP development, including the assessment of interstate pollutant transport and deposition?
6. Would transportation conformity apply in nonattainment and maintenance areas for this secondary standard, and, if it does, would satisfying requirements that apply for related primary standards (e.g., ozone, PM<sub>2.5</sub>, and NO<sub>2</sub>) be demonstrated to satisfy requirements for this secondary standard?

These questions need to be addressed in this review if EPA plans to resurrect an AAI standard or something similar.

### **Other Approaches Must Be Considered**

In previous reviews, EPA decided the secondary national air quality standards were not an appropriate approach to address deposition effects. Instead both EPA and Congress have regulated deposition through Title IV of the Clean Air Act. Nothing has changed to alter the fundamental limitations that led to those decisions. The draft plan glosses over or omits the reasons given in past reviews as to why secondary NAAQS cannot adequately address deposition issues.

As EPA establishes the Integrated Review Plan, we urge the Agency to broaden the scope of alternatives considered in the upcoming rulemaking. EPA concluded some years ago that it is prudent to consider the results of studies and research, including those assessing the comparative merits of secondary standards, acidic deposition standards and other approaches to control of acidic deposition and related effects.

As a first step, it is necessary to establish the impact of current and committed controls and identify any residual impacts expected in the time frame a national secondary NO<sub>x</sub>/SO<sub>x</sub> standard could be implemented. Depending on the location and extent of residual impacts, alternative approaches to addressing these impacts should be identified and evaluated. The alternatives considered may include national secondary standards but they should also include national or regional deposition standards or other creative approaches to efficiently address the residual impacts.

## I. Introduction

The Clean Air Act (CAA) requires EPA to assess the scientific basis of the National Ambient Air Quality Standards (NAAQS) for the Criteria Air Pollutants<sup>1</sup> every five years and to either reaffirm the existing standards or recommend revised standards. The October release of EPA's draft review plan<sup>2</sup> for the secondary standards for the oxides of nitrogen (NO<sub>x</sub>) and the oxides of sulfur (SO<sub>x</sub>) for public and CASAC review marks the beginning of the review process for these pollutants. Secondary standards are set to protect against adverse welfare effects of air pollutants. EPA is planning to release a draft of the first of several assessment documents in July 2016 and hopes to complete the rulemaking process by April 2020.

## II. History of Secondary NO<sub>x</sub> and SO<sub>x</sub> NAAQS

The current secondary NAAQS for NO<sub>x</sub> (annual arithmetic average NO<sub>2</sub> of 0.053 ppm) and SO<sub>x</sub> (3-hour SO<sub>2</sub> concentration of 0.5 ppm, not to be exceeded more than once a year) were established in 1971 and reaffirmed in subsequent reviews including the most recent in 2012. The form, level and averaging time of these NAAQS were chosen to protect vegetation from the direct exposure to these gaseous compounds. In 2012, the final rule stated:

Additional research on acute foliar injury has been limited and there is no evidence to suggest foliar injury below the levels of the current secondary standards. Based on information in the ISA, the PA concludes that there is sufficient evidence to suggest that the levels of the current standards are likely adequate to protect against phytotoxic effects caused by direct gas-phase exposure.<sup>3</sup>

In the last review, EPA also considered setting a separate joint NO<sub>x</sub>/SO<sub>x</sub> NAAQS to protect aquatic ecosystems from the acidifying effects of the atmospheric deposition of NO<sub>x</sub> and SO<sub>x</sub> species using the concept of critical loads.<sup>4</sup> The standard considered was in the form of an Aquatic Acidification Index (AAI),<sup>5</sup> which will be discussed in detail later in this report. In the proposed<sup>6</sup> and final rules, however, the Administrator did not feel confident in promulgating such a standard because of large uncertainties. The final rule states:

Based on the above considerations, the Administrator provisionally concluded that it is premature to set a new, multi-pollutant secondary standard for oxides of nitrogen and sulfur at this time, and as such she proposed not to set such a new secondary standard.

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<sup>1</sup> Oxides of nitrogen and sulfur, ozone, particulate matter (PM), carbon monoxide and lead.

<sup>2</sup> EPA, 2015. "Draft Integrated Review Plan for the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur". October, 2015.

<sup>3</sup> 77 Federal Register 20218, April 3, 2012.

<sup>4</sup> Critical load is a quantitative estimate of exposure to one or more pollutants, below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge.

<sup>5</sup> EPA, 2011. "Policy Assessment for the Review of the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur." EPA-452/R-11-005a, February, 2011.

<sup>6</sup> 76 Federal Register 46084, August 1, 2011.

Instead, in the proposed rule, she recommended that the relatively new primary 1-hour NO<sub>2</sub> and SO<sub>2</sub> NAAQS also be adopted as secondary NAAQS. However, in the final rule, she decided that 1-hour NAAQS were inappropriate in protecting the acidification of aquatic ecosystems that occur on much longer time frames.

However, the Administrator realized that the Agency would revisit an AAI based NAAQS in the next review, so she wanted to set in motion research to reduce the uncertainties in the AAI approach. The final rule states:

Nonetheless, while the Administrator concluded that it is premature to set such a multi-pollutant standard at this time, she determined that the Agency should undertake a field pilot program to gather additional data (discussed below in section IV). She concluded that it is appropriate that such a program be undertaken before, rather than after, reaching a decision to set such a standard.

### **III. Scope of Current Review**

While the previous review primarily focused on direct effects of the gaseous effects on vegetation and the indirect effects of acid deposition on aquatic ecosystem, the current plan is much more ambitious. The current plan also intends to use critical loads to include:

- terrestrial acidification
- aquatic eutrophication
- terrestrial eutrophication
- loss of terrestrial plant biodiversity
- mercury methylation.

Because EPA's draft plan contains insufficient details to understand the specific approaches that they will employ to assess the critical loads for each of the above processes, it is difficult to provide specific comments. However, it is likely that the approaches the Agency takes will be similar to the approach they used in the last review in trying to formulate an AAI standard for aquatic ecosystems. In this approach, both the effects of NO<sub>x</sub> and SO<sub>x</sub> species were considered. It is likely, a similar approach will be used to assess the critical loads affecting terrestrial acidification since there will be contribution from both species. However, for eutrophication,<sup>7</sup> the focus will be on a nitrogen critical load. EPA states in the plan: "A causal relationship was also inferred between N deposition and the alteration of species richness, species composition and biodiversity in terrestrial ecosystems." Consequently, nitrogen species will be the focus of the loss of terrestrial plant biodiversity. For the mercury methylation, the focus will be SO<sub>x</sub> deposition as EPA has inferred a causal relationship between the two.

It should be noted that in protecting vegetation from the phytotoxic effect of SO<sub>x</sub> and NO<sub>x</sub> species, EPA has always focused on SO<sub>2</sub> and NO<sub>2</sub> that produce the effects. To protect against

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<sup>7</sup> Eutrophication is the process by which nitrogen additions stimulate the growth of autotrophic biota, usually resulting in the depletion of dissolved oxygen.

aquatic and terrestrial acidification, other SO<sub>x</sub>, NO<sub>x</sub> and N species play a role and must be considered. For SO<sub>x</sub>, the atmospheric oxidation product of SO<sub>2</sub>, particulate sulfate (SO<sub>4</sub><sup>-2</sup>), must also be included. For NO<sub>x</sub>, all the total reactive nitrogen species must be considered because they all can lead to acidification. These include all biologically, chemically, and radiatively active nitrogen compounds in the atmosphere and biosphere, such as NH<sub>3</sub>, NH<sub>4</sub><sup>+</sup>, NO, NO<sub>2</sub>, HNO<sub>3</sub>, N<sub>2</sub>O, NO<sub>3</sub><sup>-</sup>, and organic compounds (e.g., urea, amines, nucleic acids). It should be noted that the reduced N compounds such as NH<sub>3</sub> and NH<sub>4</sub><sup>+</sup> are not NO<sub>x</sub> compounds or reaction products. Consequently, they cannot be regulated under a NO<sub>x</sub> NAAQS.

To protect against eutrophication and loss of terrestrial plant biodiversity, EPA's focus will be on the same N species that are targeted for the acidification. For the mercury methylation, EPA will focus on the total deposition of both of the SO<sub>x</sub> species.

#### **IV. Comments on the Draft Plan**

##### **A. Existing EPA Regulations Are Reducing S and N Deposition**

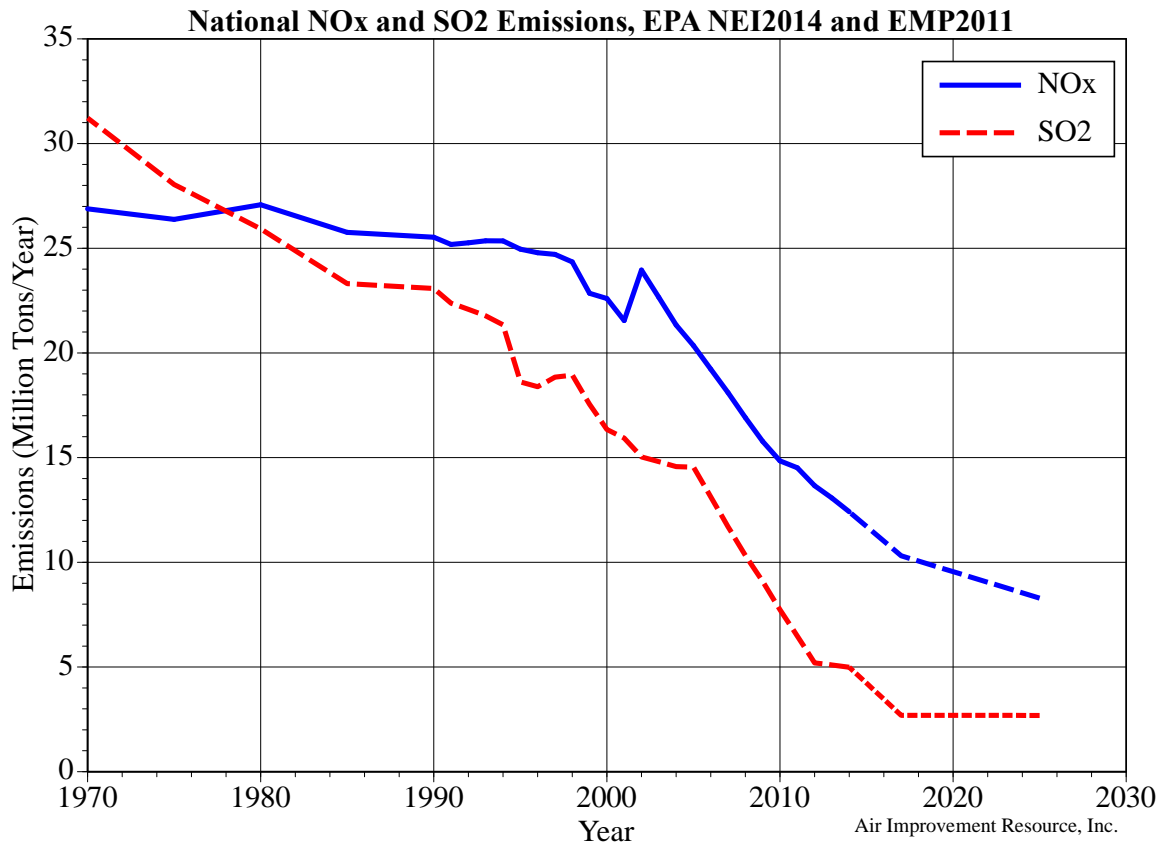
Since the passage of the CAA, numerous control programs have been put in place to lower the emission of anthropogenic NO<sub>x</sub> and SO<sub>x</sub> emissions. Since 1998, numerous additional emission reduction programs have been added and will continue to reduce emissions for the foreseeable future. These include: 1) 1998 NO<sub>x</sub>-SIP Call, 2) the OTC NO<sub>x</sub> Budget Trading Program, 3) Tier 2 vehicle regulations which will continue to reduce NO<sub>x</sub> emissions as new vehicles replace older ones, 4) the Tier 3 and California LEV III vehicle regulations which will reduce NO<sub>x</sub> emissions to near unmeasurable levels, 5) the diesel tailpipe and fuel-sulfur regulations, 6) the off-road vehicle emissions rule, 7) the State Implementation Plans developed to meet the PM, SO<sub>2</sub> and ozone NAAQS, 8&9) the NO<sub>x</sub> and SO<sub>x</sub> reductions mandated by the Clean Air Interstate and Cross-State Air Pollution Rules and the, 10) the Utility Mercury Standard, 11) the Utility Air Toxics Standards, and 12) the Clean Power Plan Rule. While the last three rules do not specifically target NO<sub>x</sub> or SO<sub>x</sub> emissions, they will be reduced due to co-benefits of the required emissions reduction technologies or by the retirement of coal-fired electrical generating units.

The results of these programs are reflected in the trends of US NO<sub>x</sub> and SO<sub>x</sub> emissions from 1970 to 2014,<sup>8</sup> which are shown in Figure 1. Since 1970, US NO<sub>x</sub> emissions have decreased 54% while SO<sub>2</sub> emissions have decreased 84%. Most of the decrease in NO<sub>x</sub> emissions has occurred since 2002. The SO<sub>2</sub> emissions reductions have been more constant over the period. Also shown in Figure 1 are the EPA's projected inventories for 2017 and 2025.<sup>9</sup> The projected inventories show additional declines in the emissions of NO<sub>x</sub> of 34% and SO<sub>2</sub> of 46% from 2014 to 2025.

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<sup>8</sup> EPA, 2015. National Emissions Inventory (NEI) Air Pollutant Emissions Trends Data, available at <http://www.epa.gov/ttn/chief/trends/index.html> (accessed November 27, 2015).

<sup>9</sup> EPA, 2015. "Technical Support Document (TSD) Preparation of Emissions Inventory for the Version 6.2, 2011 Emissions Modeling Platform," [http://www3.epa.gov/ttn/chief/emch/2011v6/2011v6\\_2\\_2017\\_2025\\_EmisMod\\_TSD\\_aug2015.pdf](http://www3.epa.gov/ttn/chief/emch/2011v6/2011v6_2_2017_2025_EmisMod_TSD_aug2015.pdf) (accessed December 7, 2015).



**Figure 1:** Nationwide US emissions of NO<sub>x</sub> and SO<sub>2</sub>.

In response to the emission reductions, the concentrations of NO<sub>2</sub> and SO<sub>2</sub> have experienced similar reductions. Since the focus of the secondary standard is primarily on rural areas of the country, monitoring data from EPA's Clean Air Status and Trends Network (CASTNET)<sup>10</sup> are the most appropriate to examine. Unfortunately, CASTNET trend data are not available for NO<sub>2</sub>, so the only data available are from EPA's nationwide network,<sup>11</sup> which includes urban sites. That data, shown in Figure 2, indicates that from 1980 to 2014, NO<sub>2</sub> concentrations declined 57%. The SO<sub>2</sub> trends from the CASTNET sites<sup>12</sup> are shown in Figures 3a&b. In the eastern US, where the bulk of the emissions occur, concentrations experienced the same decline (84%) as the emissions.

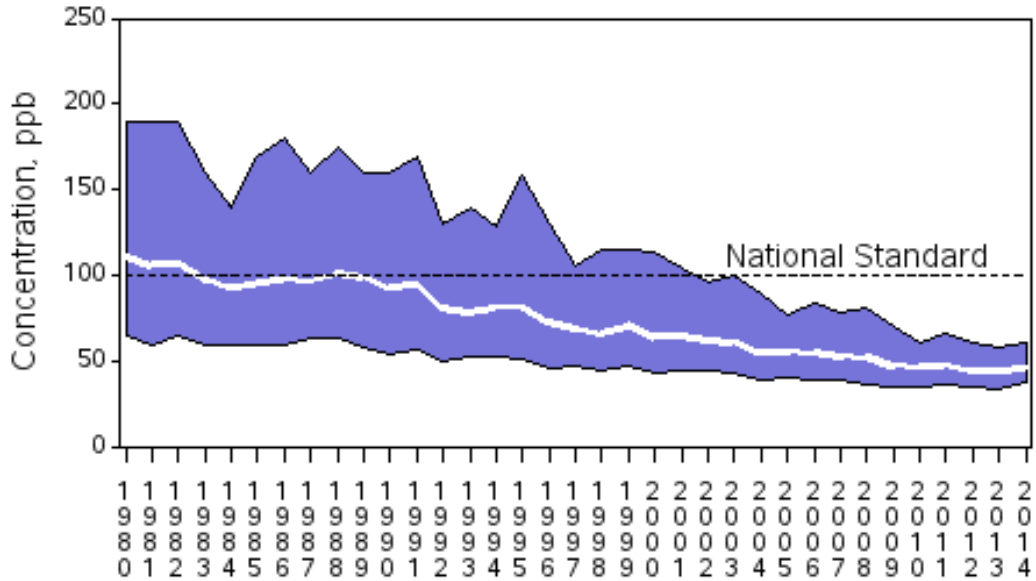
<sup>10</sup> EPA, 2015. CASTNET Annual Report 2013, <http://www3.epa.gov/castnet/docs/CASTNET/AR2013-main.htm> (accessed November 23, 2015).

<sup>11</sup> EPA, 2015. National Trends in Nitrogen Dioxide Levels, <http://www3.epa.gov/airtrends/nitrogen.html> (accessed December 1, 2015).

<sup>12</sup> EPA, 2015. Clean Air Status and Trends Network (CASTNET), available at: <http://www2.epa.gov/castnet> (accessed November 27, 2015).

## NO<sub>2</sub> Air Quality, 1980 - 2014

(Annual 98th Percentile of Daily Max 1-Hour Average)  
National Trend based on 24 Sites

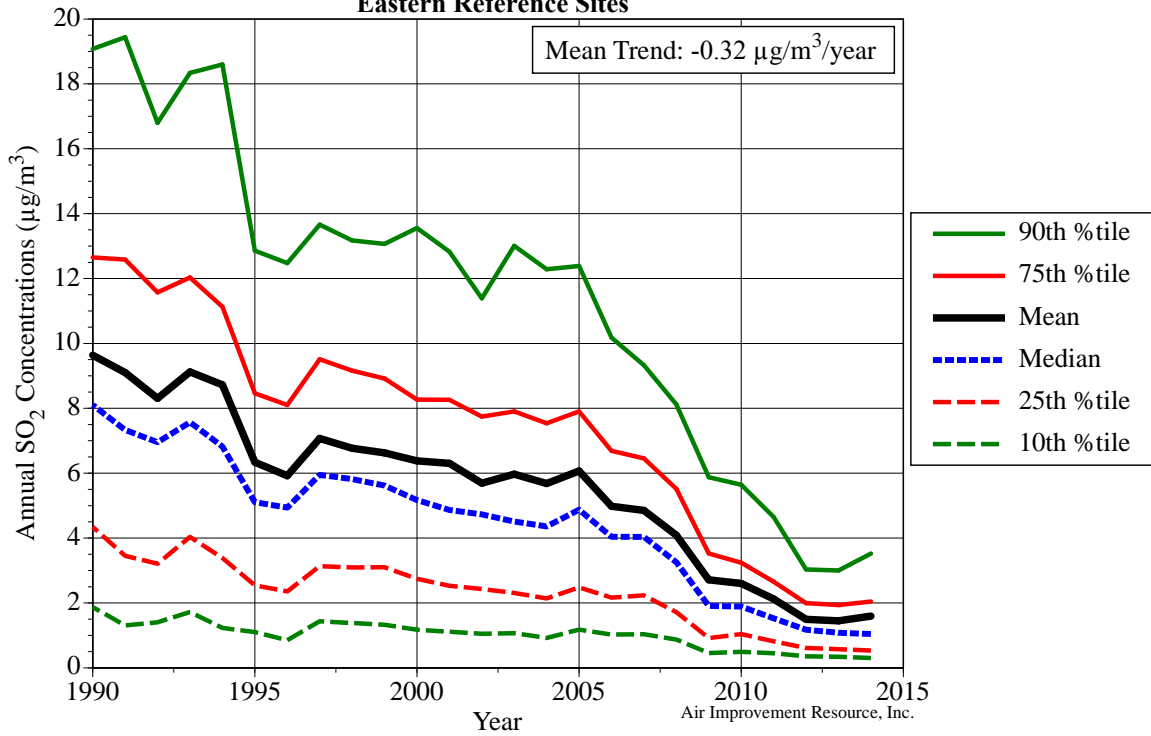


**Figure 2:** Time-series of national average NO<sub>2</sub> concentrations. The blue band shows the distribution of air pollution levels among the trend sites, displaying the middle 80 percent. The white line represents the average among all the trend sites.

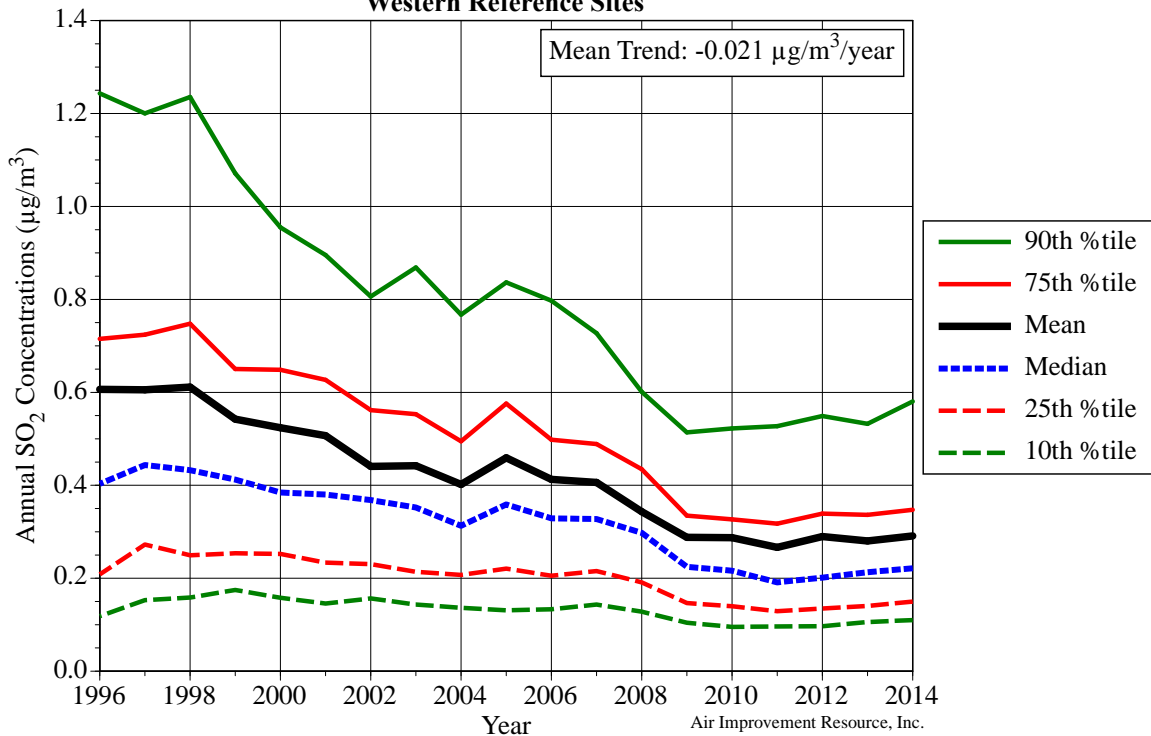
Figures 4 - 6 show the trends associated with airborne SO<sub>4</sub>, NO<sub>3</sub> and NH<sub>4</sub>, which are all associated with the particulate SO<sub>x</sub> and NO<sub>x</sub> species. Significant decreasing trends are again observed for all species with the greatest trends in the east. The eastern decreases are SO<sub>4</sub> = 69%, NO<sub>3</sub> = 50% and NH<sub>4</sub> = 56%. In the west, the respective decreases are 32, 46 and 29%. Since NH<sub>3</sub> emissions are not regulated, there is no reason to suspect that their emissions decreased over the period despite decreases in the NH<sub>4</sub> concentrations. The NH<sub>4</sub> decreases merely reflect the decreasing availability of SO<sub>4</sub> and NO<sub>3</sub> ions.



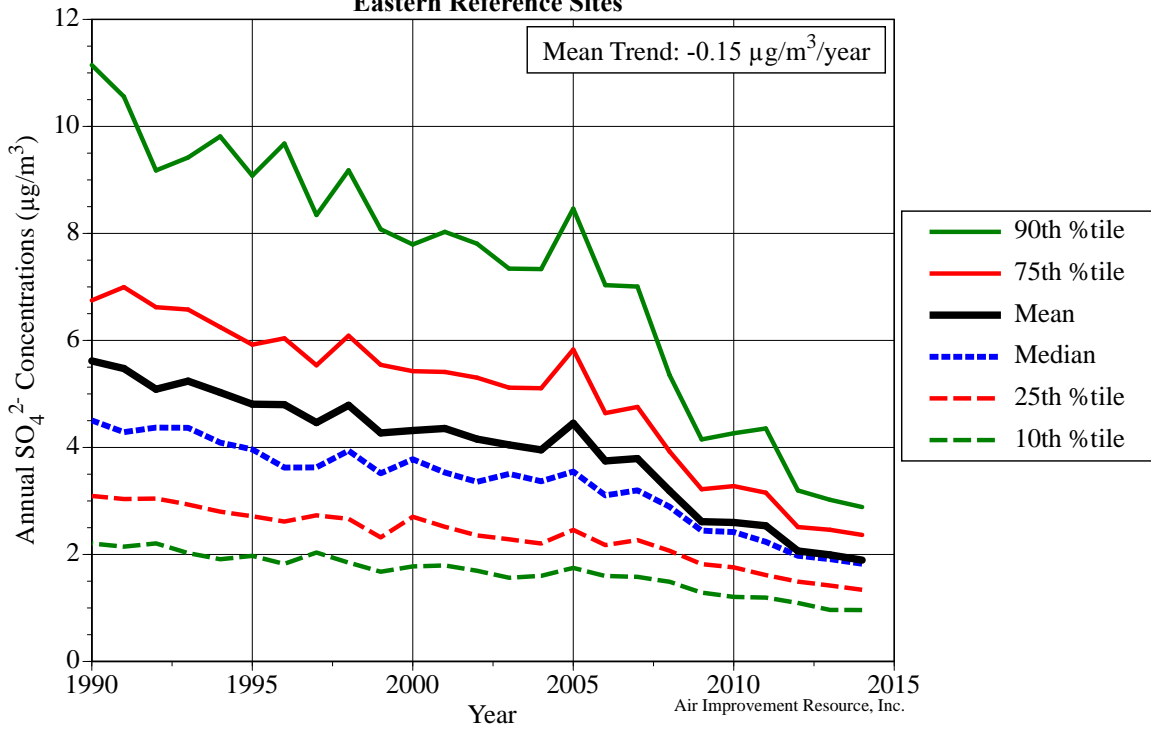
**Figure 3A**  
**Trend in Annual SO<sub>2</sub> Concentrations**  
**Eastern Reference Sites**



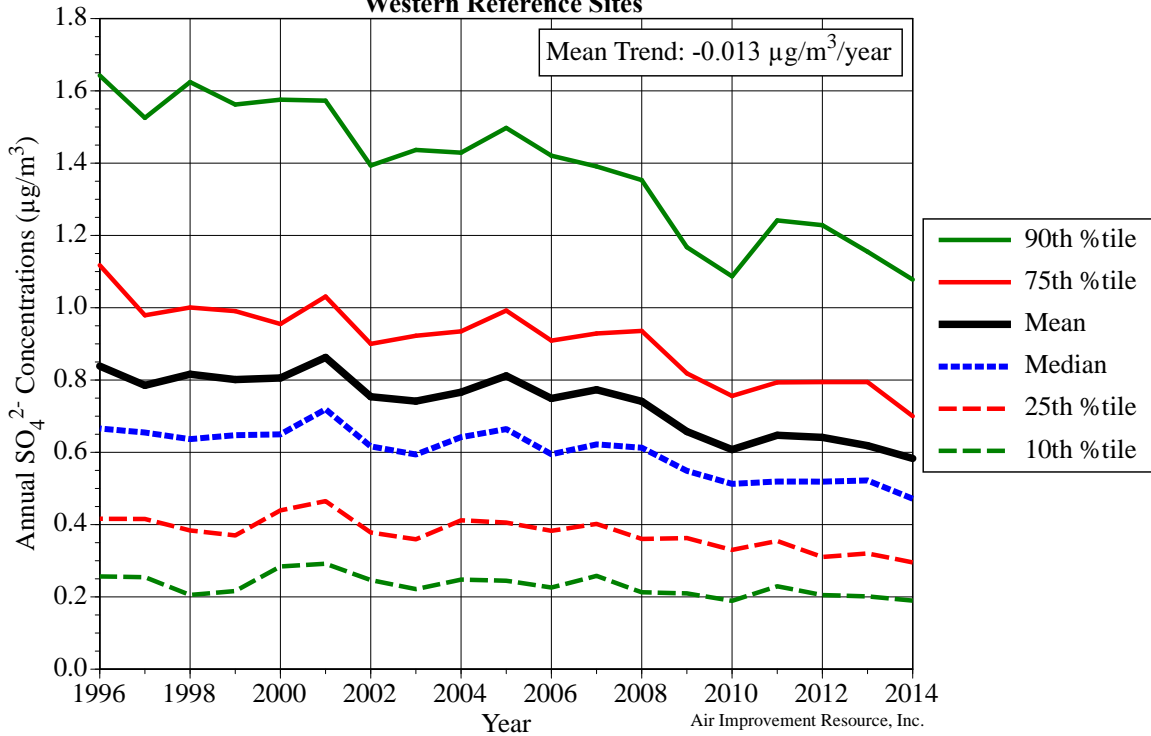
**Figure 3B**  
**Trend in Annual SO<sub>2</sub> Concentrations**  
**Western Reference Sites**



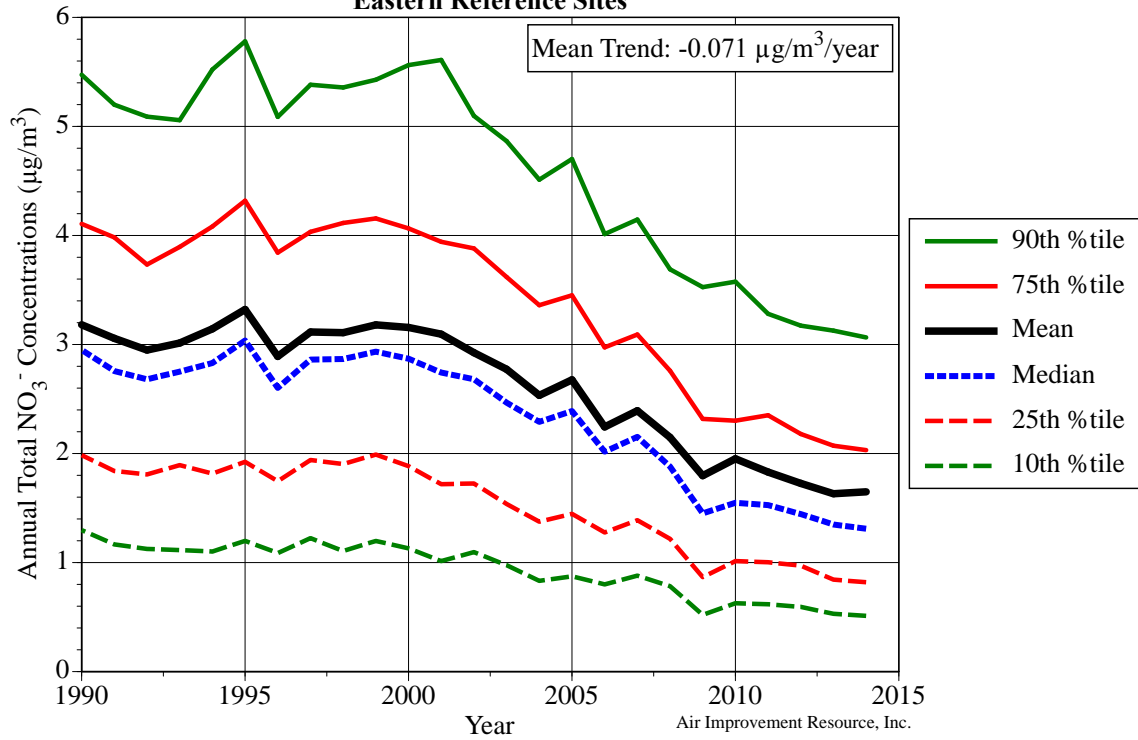
**Table 4A**  
**Trend in Annual SO<sub>4</sub><sup>2-</sup> Concentrations**  
**Eastern Reference Sites**



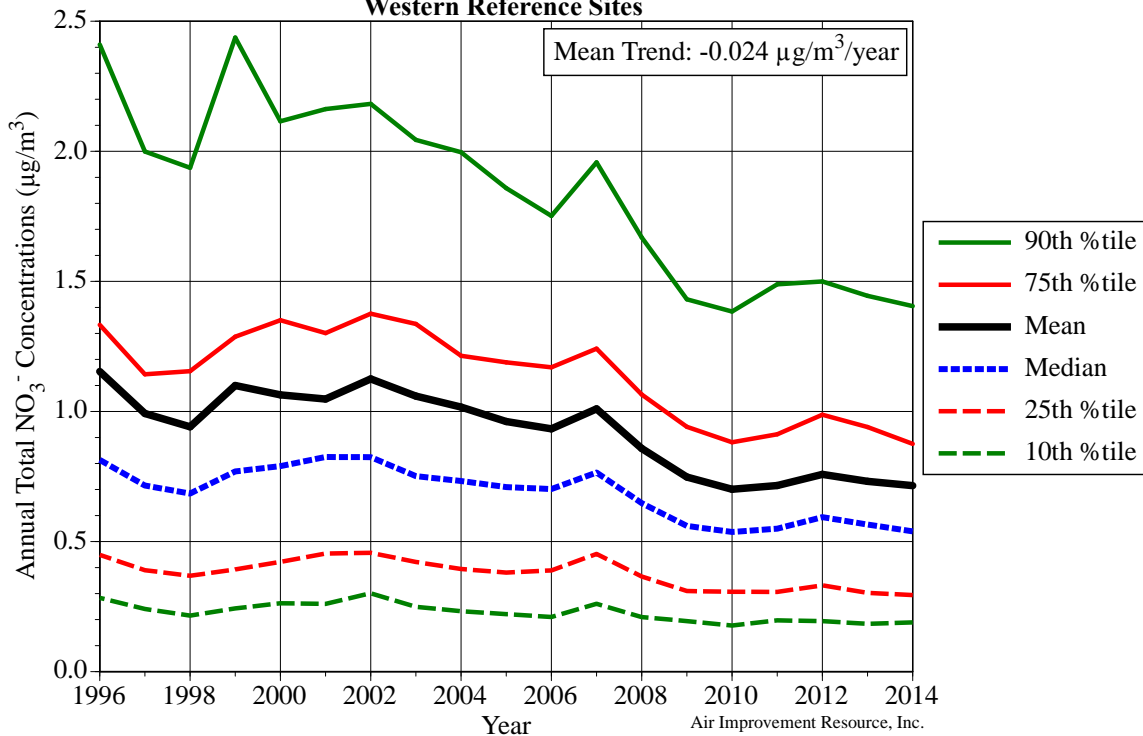
**Table 4B**  
**Trend in Annual SO<sub>4</sub><sup>2-</sup> Concentrations**  
**Western Reference Sites**



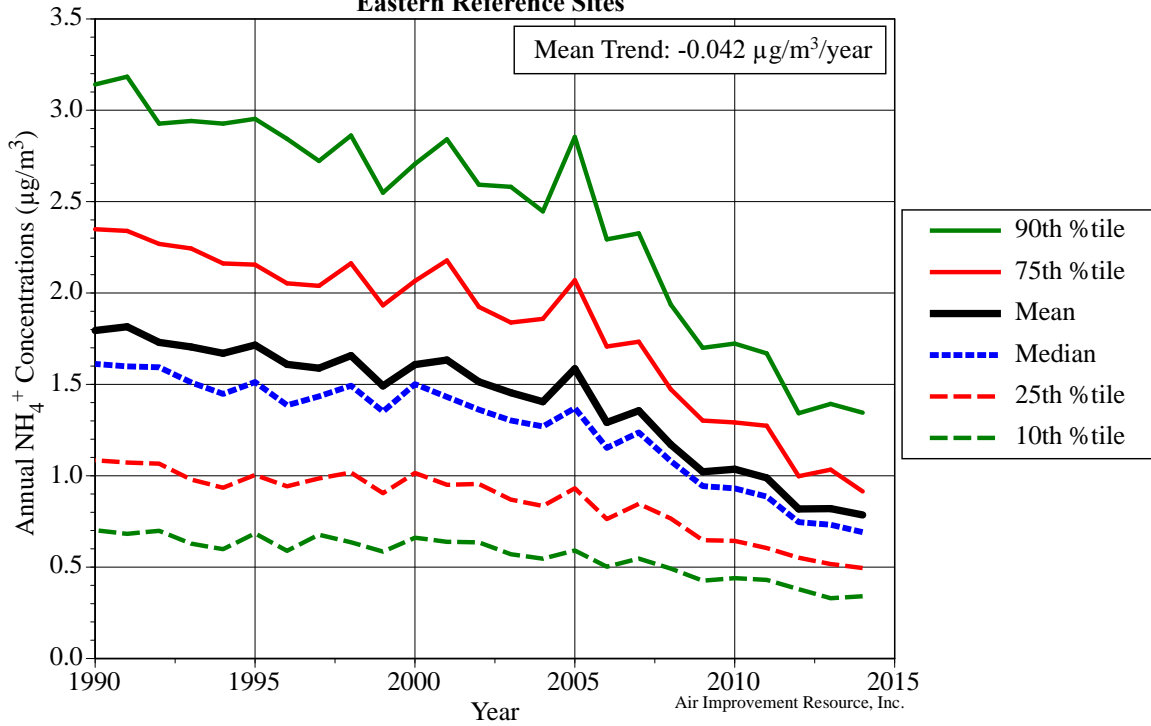
**Figure 5A**  
**Trend in Annual Total NO<sub>3</sub><sup>-</sup> Concentrations**  
**Eastern Reference Sites**



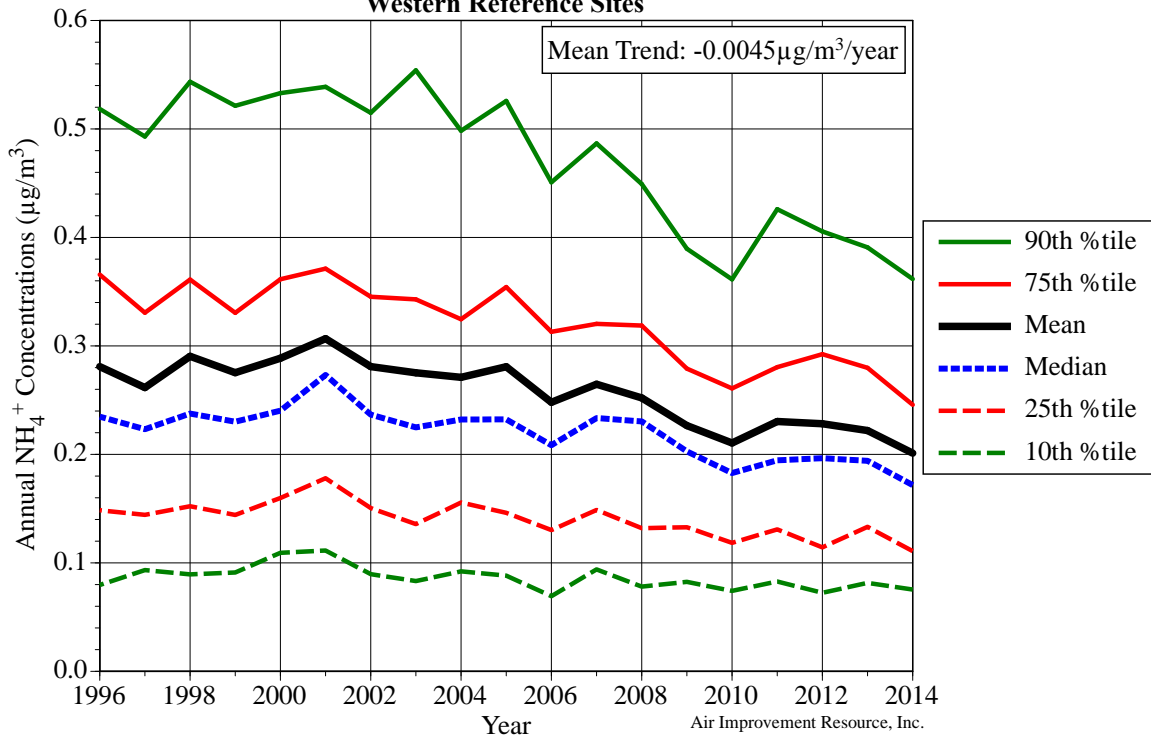
**Figure 5B**  
**Trend in Annual Total NO<sub>3</sub><sup>-</sup> Concentrations**  
**Western Reference Sites**



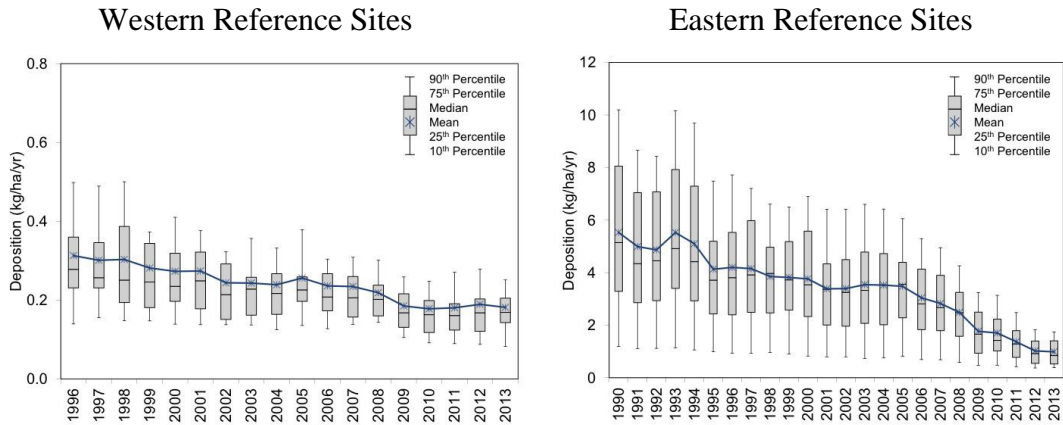
**Figure 6A**  
**Trend in Annual NH<sub>4</sub><sup>+</sup> Concentrations**  
**Eastern Reference Sites**



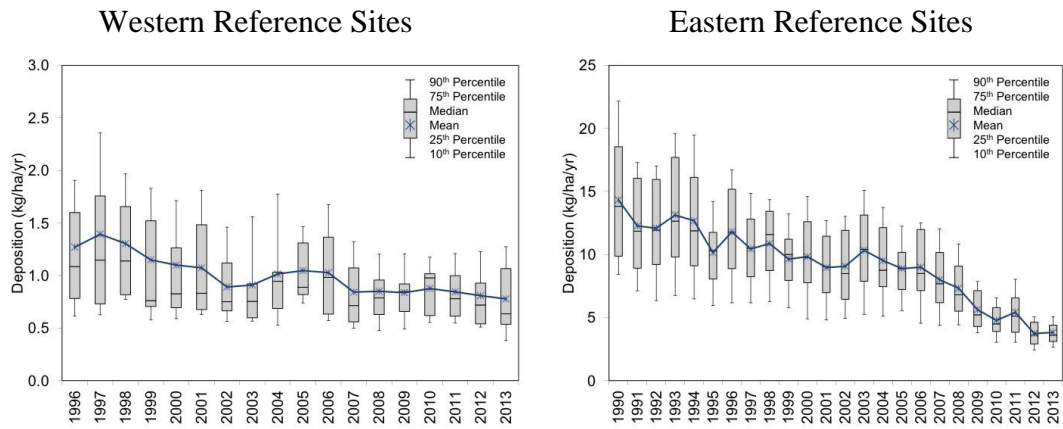
**Figure 6B**  
**Trend in Annual NH<sub>4</sub><sup>+</sup> Concentrations**  
**Western Reference Sites**



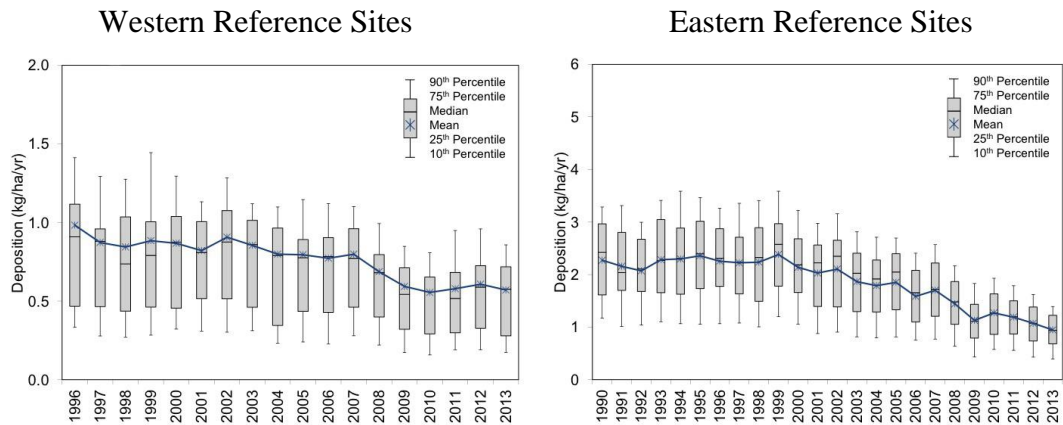
CASTNET also produces trend estimates for S and N deposition and these are shown in Figures 7 and 8. For S deposition, total and dry deposition decreased 66% and 78% in the east from 1990 to 2013; while in the west the decreases were 39% and 40%. For N, total and dry deposition decreased 24% and 51% in the east and 18% and 35%, respectively, in the west.



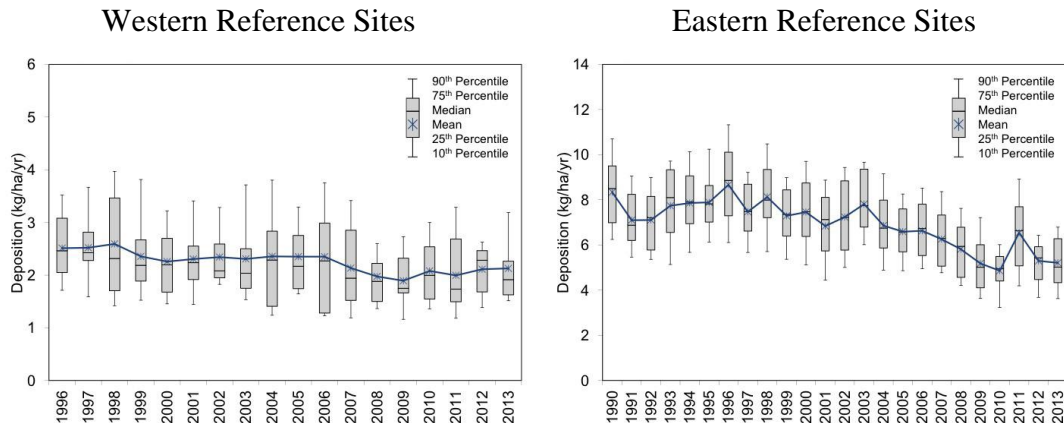
**Figure 7a:** Trends in dry S deposition.



**Figure 7b:** Trends in total S deposition.



**Figure 8a:** Trends in dry N deposition.



**Figure 8b:** Trends in total N deposition.

Because emissions, atmospheric concentrations and deposition have been and will continue to decrease for the foreseeable future, it raises an important question. Would a secondary standard based on AAI be superfluous by the time it could be promulgated and then implemented because of current emission reduction programs? EPA needs to address this question in the upcoming ISA.

### **B. Uncertainties Render The AAI Framework Impractical As A Secondary NAAQS**

In the last review, EPA staff recommended that a new multi-pollutant secondary NAAQS be established in the form of an Aquatic Acidification Index (AAI).<sup>13</sup> EPA described the AAI:

Staff has developed such a form, termed an aquatic acidification index (AAI), using a simple equation to calculate an AAI value in terms of the ambient air indicators  $\text{NO}_y$  and  $\text{SO}_x$  and the relevant ecological and atmospheric factors that modify the relationships between the ambient air indicators and ANC. This AAI reflects the difference between the natural acid neutralizing capability of a region and acidifying deposition inputs from  $\text{NO}_y$  and  $\text{SO}_x$  in the ambient air. Recognizing the spatial variability of such factors across the U.S., we conclude it is appropriate to divide the country into ecologically relevant regions, characterized as acid sensitive or relatively non-acid sensitive, and specify the value of each of the factors in the AAI equation for each such region.

With regard to approaches to defining such ecologically relevant regions, staff concludes that consideration should be given to using Omernik Ecoregions, level III, as the appropriate set of regions over which to define the AAI. There are 84 such level III ecoregions that cover the continental U.S. This set of ecoregions is based on grouping a variety of vegetation,

<sup>13</sup> EPA, 2011. "Policy Assessment for the Review of the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur." EPA-452/R-11-005a, February, 2011.

geological, and hydrological attributes that are directly relevant to aquatic acidification assessments and that allow for a practical application of an aquatic acidification standard on a national scale. The figure below illustrates the Omernik ecoregions with the level III delineations defined by the different colored areas within each level II group.<sup>14</sup>

The "simple equation" that EPA refers to is:

$$AAI = F1 - F2 - F3[NO_y] - F4[SO_x]. \quad (1)$$

F1 represents the pristine acid neutralizing capacity (ANC) of the watershed before an industrialized society existed. EPA states, "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 such criteria, is requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of [the] pollutant in the ambient air.'"<sup>15</sup> It is unrealistic to assume that a "pre-industrialized" state is requisite to protect public welfare. Furthermore, we agree with EPA that "relatively large uncertainties are introduced by a lack of data with regard to pre-industrial environmental conditions and other parameters that are necessary inputs to critical load models that are the basis for factor F1 in the AAI equation."<sup>16</sup> Consequently, we do not think there is an adequate scientific basis for the establishment of realistic F1 values nor do we think that such a pristine state is requisite to protect welfare.

F2 is the contribution of ammonia and ammonium compounds to the net acidification of the watershed. Since these substances are not routinely measured, EPA intends to rely on estimated concentrations using a complex atmospheric model that has had an inadequate performance evaluation. EPA admits "observational data are not generally available to evaluate the modeled relationships between nitrogen and sulfur in the ambient air and associated deposition, which are the basis for the other factors (*i.e.*, F2, F3, and F4) in the AAI equation."<sup>17</sup> We do not think it is appropriate to base a NAAQS on a calculation that cannot have a reality check.

F3 and F4 are the transference ratios that convert the measured ambient concentrations of NO<sub>y</sub> and SO<sub>x</sub> into annual deposition rates. As stated above, these too suffer from the fact that there are insufficient data to conduct an adequate model performance evaluation on the estimates of these important functions. In addition, as we have documented in previous comments,<sup>18</sup> most of the deposition over most of the US occurs from wet deposition that is a function of the NO<sub>y</sub> and SO<sub>x</sub> concentrations at cloud level and not at ground level where these species will be measured.

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<sup>14</sup> Ibid, p. ES-7.

<sup>15</sup> Federal Register, *supra* note 6 at 46084.

<sup>16</sup> Ibid., at p. 46134.

<sup>17</sup> Ibid.

<sup>18</sup> Heuss, J.M. 2008, "Comments on First External Review Draft of 'Integrated Science Assessment for Oxides of Nitrogen and Sulfur: Ecological Criteria,'" Prepared for the Alliance of Automobile Manufacturers, March 17, 2008; Heuss, J. M. and Wolff, G.T. 2010. "Comments on EPA's Second External Review Draft 'Policy Assessment for the Review of the Secondary National Ambient Air Quality Standards for NO<sub>x</sub> and SO<sub>x</sub>,'" Prepared for the Alliance of Automobile Manufacturers, November 5, 2010.

Again, the absence of reality checks should preclude using this approach to determine attainment/nonattainment of a NAAQS.

Our concern over the large uncertainties associated with quantifying the F values is shared by EPA.<sup>19</sup> They state:

The EPA believes that for many areas there is a strong basis for determining whether an ecoregion is acid sensitive or not acid sensitive, while recognizing there is some uncertainty in some areas as to which category the area should fall in. The EPA's decision not to adopt an AAI-based standard at this time is not driven by uncertainty in these elements of the AAI, but instead in the elements needed to derive the quantified F factors for ecoregions across the country and our ability to evaluate the representativeness of those F factors for an entire ecoregion. The greatest uncertainties concern the F1 and F2 factors, which relate to development of a single critical load to represent a specified percentile of all of the waterbodies in an ecoregion and development of the value for deposition of reduced nitrogen. In addition, there are also important uncertainties related to development of the F3 and F4 factors, which concern the quantified relationship between ambient levels of NO<sub>y</sub> and SO<sub>x</sub> and deposition rates of nitrogen and sulfur.<sup>20</sup>

They further note our concerns about the transference ratios:

With regard to the transference ratios used in the AAI, some commenters expressed concerns that there is no unique link between ground-level NO<sub>x</sub> and SO<sub>x</sub> concentrations and the deposition that may lead to effects. In their view, there is a lack of deposition data and the models are inadequate for deposition predictions. They expressed concerns with the transference ratio as a method to link ambient air concentrations to deposition.<sup>21</sup>

They conclude that these uncertainties will be "appropriately considered in the next review:"

Response: The EPA has carefully considered these technical comments and analyses and believes that the issues raised in the comments are appropriately considered in the next review. The information presented in these comment will help inform EPA's consideration of the scientific aspects of developing an ecologically relevant, multi-pollutant standard in the next review.<sup>22</sup>

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<sup>19</sup> EPA. 2012, "Responses to Significant Comments on the 2011 Proposed Rule on the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur," March 20, 2012, <http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2007-1145-0203> (accessed 12/4/2015).

<sup>20</sup> Ibid., p. 15.

<sup>21</sup> Ibid., p. 25.

<sup>22</sup> Ibid.



Since the last review, EPA has conducted additional monitoring and modeling studies on the development of the transference ratios for both SO<sub>x</sub> and NO<sub>y</sub>. Sickles and Shadwick, 2013<sup>23</sup> used monitoring data from 15 years from 12 sites to determine the variability of the transference ratios. They found the following variability: weekly, ±235%, seasonal, ±94%, and annual, ±35%. These represent the 95% confidence intervals of the variability. When site-specific transference ratios were only considered, the variability was reduced to ±25% on an annual basis.

The ±235% variability on a weekly basis confirms our statement that total deposition of S and N, which is predominantly wet deposition at most sites, has no relationship to the concentrations of S and N species measured at ground level. Even when site-specific transference ratios are used on a yearly basis, an uncertainty of ±25% remains for each of the S and N transference terms. Such large uncertainties should preclude the consideration of AAI as a secondary NAAQS.

In addition, Sickles et al., 2013<sup>24</sup> found that the relative differences between model-based and monitoring-based transference ratios were large with the modeling results significantly higher. The model-based values for S were -14% to +134% and for N were -37% to +64% of the monitoring-based values.

Since very few of the 84 ecoregions that EPA plans to designate will have monitoring sites, most of the US will be relying on modeled concentrations to determine compliance with a secondary NAAQS based on an AAI. The results from Sickles and Shadwick and Sickles et al. suggest that the uncertainties associated with an AAI are too large to make this a viable approach for determining compliance with a secondary NAAQS. EPA needs to discuss this in the ISA.

As mentioned earlier to reduce these and other uncertainties for the next NAAQS review, EPA proposed to conduct a pilot field program that would test the models against actual ambient measurements. EPA needs to demonstrate in the upcoming ISA that the uncertainties have been drastically reduced.

As stated earlier, because EPA's draft plan contains insufficient details to understand the specific approaches that they will employ to assess the critical loads for each of the ecosystem types they plan to protect, it is difficult to provide specific comments. However, it is likely that the approaches the Agency takes will be similar to the AAI approach. Consequently, we expect them to suffer from the same types of uncertainties and rely on unverified modeling. EPA needs to address these issues as well in the upcoming ISA.

### **C. Many Implementation Issues Need To Be Resolved**

The 2014 publication by Scheffe et al.<sup>25</sup> provides the latest thinking of EPA staff regarding the AAI approach. Scheffe et al. point out:

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<sup>23</sup> Sickles, J.E. and Shadwick, D.S. 2013, "Transference ratios" to predict total oxidized sulfur and nitrogen deposition - Part I, monitoring results, *Atmos. Environ.*, 77:1060-1069.

<sup>24</sup> Sickles, J.E., Shadwick, D.S., Vasu Kilaru, J. and Wyat Appel, K. 2013, "Transference ratios" to predict total oxidized sulfur and nitrogen deposition - Part II, modeling results, *Atmos. Environ.*, 77:1070-1062.

<sup>25</sup> Scheffe, R.D., Lynch, J.A., Reff, A., Kelly, J.T., Hubbell B., Greaver, T.L. and Smith, J.T. 2014, The Aquatic Acidification Index: a new regulatory metric linking atmospheric and biogeochemical models to assess potential aquatic ecosystem recovery, *Water Air Soil Pollut.* 225:1838-1853. DOI 10.1007/s11270-013-1838-0.

A NAAQS structure (Bachmann 2007) relies on air concentrations to judge compliance relative to a target level and also considers levels of protection that are adequate but not “over requisite”. The reliance on air concentrations prohibits the direct use of critical loads (CLs) in a NAAQS setting process.

and also point out:

We acknowledge that the AAI approach is an extension of CL exceedances (Henriksen et al. 2002; Posch et al. 2001), borne out of a need to isolate the role of ambient air concentrations as required by the NAAQS. Transference ratios for NO<sub>y</sub> and SO<sub>x</sub>, which enable this focus on ambient air concentrations, are a new model construct (section 4, supporting materials) that has undergone limited assessment.

Thus, the AAI approach is acknowledged as a convoluted way of implementing a critical loads-based solution to the issue of how to address aquatic acidification. However, as noted above in Section B, ground-based ambient measurements are a very poor surrogate for actual deposition loads. This is a fundamental limitation to the AAI approach.

Scheffe et al. (2014) include a “national level application” of the AAI methodology to show that the planned emission reductions by 2016 reduce the deposition rates from 2005 levels and commensurately improve water quality. This raises the question of whether current and committed emission control programs will reduce aquatic acidification sufficiently so that a secondary standard based on AAI would be superfluous by the time it could be promulgated and then implemented. As documented in Section A above, the emissions of SO<sub>x</sub> and NO<sub>x</sub> have been reduced dramatically in recent decades and that progress will continue.

The ISA and other parts of the current review should carefully document these trends and projections and document the changes in receiving waters from the controls already implemented.

Although Scheffe et al. carried out a “national level application,” they did not use the AAI as it would be used in State Implementation Plans if such a standard were promulgated. EPA acknowledges that there are major issues involved in implementing an AAI standard under the Clean Air Act. For example, the proposed rule and the final rule in 2012 acknowledged that

“... the Administrator also recognizes that a new, innovative AAI-based standard would raise significant implementation issues that would need to be addressed consistent with the CAA requirements for implementation-related actions following the setting of a new NAAQS.”<sup>26</sup>

The final rule lists some of these issues and indicates that while the field study collects data, “the

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<sup>26</sup> Federal Register, supra note 6 at 46135 and Federal Register, supra note 3 at 20263.

implementing agencies and other stakeholders have an opportunity to discuss and thoroughly understand how such a standard would work.” It is unfortunate that the AAI approach would have been developed and considered without thoroughly evaluating the issues EPA lists, since any one of the issues could provide either an insurmountable obstacle to its implementation or result in a substantial delay in the development of implementation plans. In the following, each of the implementation issues identified and listed by EPA is discussed.

1. What are the appropriate monitoring network density and siting requirements to support a compliance system based on ecoregions?

This is an important question that EPA to date has failed to fully address. Is compliance to be measured at a single site or at a suite of sites? The PA indicates that:

“... an aquatic acidification standard would be interpreted as follows: the standard would be met at a monitoring site when the measured annual-average concentrations of NO<sub>y</sub> and SO<sub>2</sub> are such that the value of the annual AAI, averaged over 3 to 5 years, is equal to or greater than the level of the standard, when using the region-specific values of factors F1 through F4 for the ecoregion in which the monitor is located.”<sup>27</sup>

The above statement implies that compliance would be required for each monitoring site. However, the pollution of interest that is the proximate cause of any effects is the deposition of N and S spatially averaged over some as yet undefined area that influences the sensitive aquatic resources of concern. The question of spatial averaging is left unanswered in the EPA documents to date. Since the ecoregions discussed in the PA and the proposed rule include urban and rural areas, road networks, and both managed and unmanaged ecosystems, choosing one or more appropriate sites will be difficult. It is also not clear what measurements should be made at a site since ground-level NO<sub>y</sub> is an inappropriate measure for either wet or dry deposition. Given these concerns, the development and application of actual measurements of dry and wet deposition would be a far preferable approach compared to the AAI approach to deal with acid deposition. The ISA should document what is known about the spatial and temporal variation in S and N deposition. It should also document the state of the art of measurements for various candidate S and N indicators, with consideration of whether a given method is suitable for use in a monitoring network primarily located in rural, remote, or pristine areas.

2. Given the unique spatial nature of the secondary standard (e.g., ecoregions), what are the appropriate parameters for establishing nonattainment areas?

This is also an important question that EPA has yet to address, given that states are required to recommend designations of nonattainment areas within a year after a new NAAQS is promulgated under the Clean Air Act. Given the irregular shapes of the ecoregions, their lack of correspondence with state and county boundaries, the variable locations of the small portion of sensitive resources within those ecoregions, and the limited information on the area of deposition influence of various ground-level and elevated sources, establishing relevant nonattainment areas would require extensive study.

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<sup>27</sup> PA at page ES-9.

3. How can new or modified major sources of oxides of nitrogen and oxides of sulfur emissions assess their ambient impacts on the standard and demonstrate that they are not causing or contributing to a violation of the NAAQS for preconstruction permitting? To what extent does the fact that a single source may be impacting multiple areas, with different acid sensitivities and variable levels of NO<sub>y</sub> and SO<sub>x</sub> concentrations that would be necessary to achieve a national ANC target, complicate this assessment and how can these additional complexities best be addressed?

These questions pose what may be an intractable problem. The prevention of significant deterioration requirements for major new or modified sources under section 165 of the Clean Air Act were not established with consideration of as complex an issue as the AAI methodology in mind. How would the owner of such a source demonstrate it would not cause or contribute to a violation of the new NAAQS given the spatial issues noted in the question and given that there may be a significant lag between reduction in deposition and improvement in water quality? The unintended consequences of establishing an AAI standard could be the shutting down of new or modified sources and loss of jobs therefore due to prolonged legal battles over section 165 requirements. Before an AAI or related standard would be promulgated, this issue needs to be fully vetted.

4. What additional tools, information, and planning structures are needed to assist states with SIP development, including the assessment of interstate pollutant transport and deposition?

A threshold question that EPA has not addressed is whether the expected emission reductions over the next several decades will make adoption of any deposition-specific regulations superfluous. The REA evaluated the continuation of current emissions out to the year 2050 as one of the scenarios. This is clearly not relevant. Appendix D of the PA evaluated further reductions of 42 and 48% for SO<sub>x</sub> and NO<sub>y</sub> from a 2005 base case and showed major improvements (increase) in ANC. The PA and the proposed rule indicate that “expected emission changes over the next two decades should be far greater than the 42 and 48% SO<sub>x</sub> and NO<sub>y</sub> reductions used in this analysis, with a consequent further reduction in ecoregions that would likely not meet alternative standards.”<sup>28</sup> EPA should not consider expanding its bureaucracy and adding unfunded mandates for the states until the full impact of current regulations is evaluated.

5. Would transportation conformity apply in nonattainment and maintenance areas for this secondary standard, and, if it does, would satisfying requirements that apply for related primary standards (e.g., ozone, PM<sub>2.5</sub>, and NO<sub>2</sub>) be demonstrated to satisfy requirements for this secondary standard?

This is another CAA requirement that EPA has not considered in detail.

In summary, EPA identified and acknowledged a number of key implementation issues that need to be addressed if an AAI standard is given consideration in the current review. It is clear that, to date, EPA has not thought through all the ramifications of the AAI approach. This is unfortunate

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<sup>28</sup> EPA 2011, supra note 13 at 46129.

since the section 404 study requested by Congress in 1990 specifically asked EPA to consider and evaluate the impediments to implementation of various possible approaches for dealing with acid deposition.

In addition to the implementation issues that EPA acknowledges in the final rule, there are additional issues concerning the formulation and its implementation that States and public comments have identified.

For example, there is no recognition in the AAI formulation that in many instances deposition of NO<sub>x</sub> has beneficial effects. By law, beneficial effects of a criteria pollutant in the ambient air are relevant and must be considered in comparison to any adverse effects.<sup>29</sup> EPA acknowledges that it must assess the net impact on public health and/or welfare of a pollutant.<sup>30</sup> If a secondary NAAQS is proposed to address deposition effects, EPA must provide a framework within which the net impacts of N deposition can be evaluated. In addition, there is no recognition of base cation deposition in the AAI formulation.

While EPA recognizes there are issues concerning the potential monitoring network, the time required to develop and approve new Federal Reference methods is not factored into the discussion. In addition, how an area designated nonattainment would demonstrate that it had attained the standard is not sufficiently discussed, given that there may be a significant lag between reduction in deposition and improvement in water quality.

#### **D. Both EPA And Congress Have Historically Decided That Secondary NAAQS Are Not An Appropriate Approach To Address Regionally Variable Welfare Effects**

In previous reviews, EPA decided the secondary national air quality standards were not an appropriate approach to address deposition effects. Instead both EPA and Congress have regulated deposition through Title IV of the Clean Air Act. Nothing has changed to alter the fundamental limitations that led to those decisions. The draft plan glosses over or omits the reasons given in past reviews as to why secondary NAAQS cannot adequately address deposition issues.

The basic understanding of the causes and effects of acidic deposition and eutrophication has been available to legislative and regulatory bodies for many years. Over those years, the appropriate mechanisms and approaches to address the concern that the draft plan focuses on – the acidifying effects of NO<sub>x</sub> and SO<sub>x</sub> – have been debated and decided several times by EPA, Congress, and the States. The draft plan summarizes some of this history but leaves out important relevant material. For example, when EPA decided the secondary SO<sub>x</sub> standard in 1993, the Administrator indicated:

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<sup>29</sup> See March 6, 2008 Office of Management and Budget memo from Susan Dudley to Administrator Johnson at footnote 1, quoting the Court's decision in *American Trucking Association v. EPA* that legally EPA must consider positive identifiable effects of a pollutants presence in ambient air in formulating air quality criteria under section 108 and NAAQS under section 109 of the Clean Air Act.

<sup>30</sup> See March 7, 2008 U. S EPA memo from Marcus Peacock to Susan Dudley of OMB at page 2, indicating that EPA agrees that it must consider the beneficial effects of an air pollutant as well as its adverse effects, and that it must assess the net impact of a pollutant.

The 1990 Amendments and the legislative history indicate, however, that Congress *reserved judgment* as to whether further action might be necessary or appropriate in the longer term and, if so, what form it should take. *Congress seems to have viewed these as questions it would itself address in the future*, based on further studies and research to be conducted by the EPA and other agencies. Consistent with the 1988 proposal notice, *Congress does not seem to have expected that the EPA would set a secondary standard for acidic deposition .... in the interim*. To the contrary, in section 404 of the 1990 Amendments, Congress specifically required the EPA to conduct a study of the feasibility and effectiveness of an acid deposition standard or standards, and to report to Congress by November 15, 1993 on the role that a deposition standard might play in supplementing the acidic deposition control program adopted in title IV, and what measures would be needed to integrate it with that program.<sup>31</sup>

The draft plan also leaves out relevant material from the Clean Air Act charge to EPA to conduct the section 404 Study noted above and the results of the study that were transmitted to Congress in 1995.<sup>32</sup> The Section 404 Study was required to report on the feasibility and effectiveness of an acid deposition standard or standards to protect sensitive and critically sensitive aquatic and terrestrial resources. Protecting those resources is essentially what EPA is seeking to do through the secondary NAAQS process. The study was to include (1) identification of the sensitive aquatic and terrestrial resources in the United States which may be affected by the deposition of acidic compounds, (2) describe the nature and numerical value of a deposition standard or standards that would be sufficient to protect such resources, (3) describe the measures that would need to be taken to integrate such standard or standards with the control program required by Title IV of the Clean Air Act, and (4) describe the cost-effectiveness of deposition standards compared to other control strategies including ambient air quality standards, new source performance standards and the requirements of Title IV of the Clean Air Act.

Both the way Congress set up the requirements of the section 404 study and the study report itself presume that deposition standards would be carried out under Title IV and that EPA's existing authority under Title I was not well-suited to the issue. The study evaluated a regional target approach and a national emission reduction approach for establishing deposition standards (in likely units of kg/hectare). In both cases, the report discusses the need for further legislative action by Congress. The report recommended against setting acid deposition standards at the time because of uncertainties, with the uncertainty in the rate of nitrogen effects on the watershed the most important impediment. The report also concluded that setting a uniform national deposition standard would not be appropriate. The CASAC Panel and EPA should draw on the section 404 report as it informs the decisions in the current review.

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<sup>31</sup> 58 FR 21356; April, 21, 1993 (emphasis added).

<sup>32</sup> U.S. EPA, Acid Deposition Standard Feasibility Study: Report to Congress, EPA 430-R-95-001a, October 1995.

A previous review of the secondary NO<sub>x</sub> standard<sup>33</sup> also provides an important perspective that must be included in the current review. In the 1996 final rule the Administrator acknowledged the concerns about acid deposition (particularly in the Adirondacks) and eutrophication (particularly in the Chesapeake Bay). With regard to acidification, the Administrator referred to one commenter who “recognized EPA's concern that revision of the secondary NAAQS may not be the best mechanism for addressing the effects of acid rain and supported regionally-targeted regulatory efforts.” The final rule also refers to the section 404 report concerning deposition standards and indicates that the Agency will continue, as appropriate, to assess the feasibility of developing regionally-targeted tools and policy initiatives.

With regard to eutrophication, the rule indicated:

Given the complexities associated with estimating the contribution of nitrogen deposition to the eutrophication of estuarine and coastal waters and the limited data currently available, the Administrator again concludes that there is not sufficient quantitative information to establish a national secondary standard to protect sensitive ecosystems from the eutrophication effects caused by nitrogen deposition. The Administrator also concludes that regional control strategies which consider all of the factors contributing to eutrophication are more likely to be effective in mitigating this problem than a national standard which addresses only atmospheric deposition of nitrogen compounds.

The rule concludes:

Given the multiple causes and regional character of these problems, the Administrator also concludes that adoption of a nationally-uniform secondary standard would not be an effective approach to addressing them. Therefore, the Administrator has determined, pursuant to section 109(d)(1) of the Act, as amended, that it is not appropriate to revise the current secondary standard for NO<sub>x</sub> to protect against welfare effects at this time.

The final rule went on to indicate that, in the interim, the EPA and the States are in the process of achieving significant reductions in NO<sub>x</sub> emissions from both mobile and stationary sources in response to the Act's 1990 Amendments and local or regional initiatives. The Administrator pointed out that the NO<sub>x</sub> emissions reductions achieved through these actions will provide additional protection against the environmental impacts associated with various pollution issues including eutrophication and acid deposition. Indeed, dramatic reductions in NO<sub>x</sub> emissions have occurred since 1996 and, as documented above in Section IV-A, will continue to occur due to current and committed regulations.

A Panel of the National Research Council (NRC) has also addressed the issue of regionally different welfare standards. The August, 2011 proposed rule noted<sup>34</sup> that the NRC Panel

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<sup>33</sup> 61 FR 52852, October 8, 1996.

<sup>34</sup> 76 Federal Register 46089, August 1, 2011.

recommended that EPA consider multiple pollutants, as appropriate, in forming the scientific basis for the NAAQS.<sup>35</sup> However, the Panel also acknowledged that concentration-based standards are inappropriate for some resources at risk, such as soils, groundwater, forests, surface water, and coastal eco-systems from air pollutants, such as sulfur and nitrogen.<sup>36</sup> For such resources, the Panel indicated that deposition-based standards would be more appropriate. The Panel also indicated that if acceptable exposure levels vary significantly from one region of the nation to another, consideration should be given to the promulgation of regionally distinct secondary standards. But the Panel noted that a move to regional secondary standards might require an amendment of the Clean Air Act.

The EPA, in one of series of reports on the Acid Rain Program established under Title IV, recognized that, “In the United States, the critical loads approach is not an officially accepted approach to ecosystem protection,”<sup>37</sup> noting that language specifically requiring a critical loads approach does not exist in the Clean Air Act.

In discussing the regulatory history, the draft plan acknowledges that, in a prior SO<sub>2</sub> review, the Agency indicated:<sup>38</sup>

While recognizing that further action might be needed to address acidic deposition in the longer term, the EPA judged it prudent to await the results of the studies and research programs then underway, including those assessing the comparative merits of secondary standards, acidic deposition standards and other approaches to control of acidic deposition and related effects, and then to determine whether additional control measures should be adopted or recommended to Congress (58 FR 21358).

The relevant history discussed above must be included and considered in the upcoming review and in the Administrator’s decisions. An argument can be made, based on the various previous findings, that any decision on additional national regulatory action to address acid deposition is reserved to the Congress. Such a conclusion is based on Congress’s prior actions, the legislative history of the relevant statutes, and EPA’s own prior findings.

As documented in Sections IV-B and C above, there are major uncertainties and inherent limitations to the AAI approach. By focusing on how to fit regionally-specific deposition controls under the umbrella of a national secondary standard, EPA is forcing the proverbial square peg in a round hole.

If an extension of the AAI approach is considered for eutrophication, the issues and uncertainties will be magnified. Although only N species would be considered, atmospheric deposition is only one source of the species of concern and agricultural and urban run-of are major contributors that any formulation needs to account for. There is also the issue of whether a given water body is

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<sup>35</sup> National Research Council. 2004. *Air Quality Management in the United States*. National Academies Press, Washington, D.C.

<sup>36</sup> *Ibid.* at page 312.

<sup>37</sup> U. S. EPA report “Acid Rain and Related Programs: 2008 Environmental Results,” 2009, at page 13.

<sup>38</sup> Draft Integrated Review Plan, *supra* note 2, at page 1-10.



phosphorus-limited or reduced nitrogen-limited. All these complexities and issues will render a national secondary standard approach for eutrophication intractable.

As EPA establishes the Integrated Review Plan, we urge the Agency to broaden the scope of alternatives considered in the upcoming rulemaking. EPA concluded some years ago that it is prudent to consider the results of studies and research, including those assessing the comparative merits of secondary standards, acidic deposition standards and other approaches to control of acidic deposition and related effects.<sup>39</sup>

There are examples of effective regional approaches to deposition impacts that can inform the policy considerations of the Agency. For example, Mast et al. (2014)<sup>40</sup> report that stream nitrate concentrations have declined over 40 percent since the mid-2000s in a high-elevation watershed in the Colorado Front Range. Mast et al. explain the regional efforts:

These results are important in light of recent policy efforts to reduce N deposition in the Front Range. Published evidence of ecosystem changes in response to elevated N deposition in Rocky Mountain National Park led to enactment of policy in 2007 titled the Nitrogen Deposition Reduction Plan (<http://www.colorado.gov/cs/Satellite/CDPHE-AP/CBON/1251594862555>). As part of the Nitrogen Deposition Reduction Plan, the Colorado Department of Public Health and Environment, the National Park Service, and the U.S. Environmental Protection Agency agreed on a resource management goal of reducing wet N deposition at CO98 in LV to 1.5 kg ha<sup>-1</sup> yr<sup>-1</sup> by 2035. Our results suggest that reductions in N emissions and deposition on a regional scale should result in fairly immediate declines in stream nitrate concentrations in LV and in other high-elevation watersheds in the Colorado Front Range (citations omitted).

In summary, as a first step, it is necessary to establish the impact of current and committed controls and identify any residual impacts expected in the time frame a national secondary NO<sub>x</sub>/SO<sub>x</sub> standard could be implemented. Depending on the location and extent of residual impacts, alternative approaches to addressing these impacts should be identified and evaluated. The alternatives considered may include national secondary standards but they should also include national or regional deposition standards or other creative approaches to efficiently address the residual impacts.

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<sup>39</sup> Ibid.

<sup>40</sup> Mast, M.A., Clow, D.W., Baron, J.S. and Wetherbee, G.A. 2014, Links between N deposition and nitrate export from a high-elevation watershed in the Colorado Front Range, *Environ. Sci. Technol.*48:14258–14265. [dx.doi.org/10.1021/es502461k](https://doi.org/10.1021/es502461k).