COMMENTS OF THE UTILITY AIR REGULATORY GROUP ON THE FIRST EXTERNAL REVIEW DRAFT OF THE RISK AND EXPOSURE ASSESSMENT TO SUPPORT THE REVIEW OF THE SO_2 PRIMARY NATIONAL AMBIENT AIR QUALITY STANDARDS (JULY 2008)

DOCKET ID NO. EPA-HQ-OAR-2007-0352

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AUGUST 28, 2008

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On July 21, 2008, the United States Environmental Protection Agency ("EPA" or the "Agency") announced the release of the First External Review Draft of the Risk and Exposure Assessment to Support the Review of the SO_2 Primary National Ambient Air Quality Standards EPA-HQ-OAR-2007-0352 (July 2008) (the "REA") and requested comments from the public, to be submitted on or before August 28, 2008.[1] Based on a thorough review of the REA and both the First and Second External Review Drafts of the Integrated Science Assessment for Sulfur Oxides,[2] the Utility Air Regulatory Group ("UARG") submits the following comments.[3]

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[1] 73 Fed. Reg. 42,341 (2008). EPA's Clean Air Advisory Committee ("CASAC") reviewed the REA at a public meeting held on July 31, 2008. At that meeting, EPA presented materials that were more recent than the REA, for which no public notice has been given, and which are not available for download on the EPA webpage where the REA is located. *See* http://www.epa.gov/ttn/naaqs/standards/so2/s_so2_cr_rea.html. These materials are available at http://yosemite.epa.gov/sab/sabproduct.nsf/bf498bd32a1c7fdf85257242006dd6cb/da44325f1d9f4cf4852573ca005ff9fe!OpenDocument&Date=2008-07-31 (accessible through the hyperlink to "Agency Briefing Material: Overview of the First Draft Risk and Exposure Assessment for the SO_2 Primary NAAQS Review"). EPA has not followed the appropriate process for release of these materials, as they should have been made available for public comment. UARG does not address these recent materials in these comments, but may provide additional comments in the coming weeks.

[2] *See* Comments of the Utility Air Regulatory Group on the First External Review Draft of the Integrated Science Assessment for Sulfur Oxides - Health Criteria (November 2007) and Comments of the Utility Air Regulatory Group on the Second External Review Draft of the Integrated Science Assessment for Sulfur Oxides - Health Criteria (May 2008).

[3] UARG is a voluntary, nonprofit group of electric generating companies and organizations and four national trade associations (the Edison Electric Institute, the National Rural Electric Cooperative Association, the America Public Power Association, and the National Mining Association). UARG's purpose is to participate on behalf of its members collectively in EPA's rulemaking and other Clean Air Act proceedings that affect the interests of electric generators, and in related litigation. Since 1977, UARG has participated in virtually all key

I. Introduction and Legal Background.

Section 108(a)(1) of the Clean Air Act ("CAA" or the "Act") requires that the EPA Administrator (the "Administrator") list air pollutants for the purpose of creating national ambient air quality standards ("NAAQS") if (i) he determines that emissions of the pollutant "cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare," (ii) he determines that the presence of the pollutant in the ambient air "results from numerous or diverse mobile or stationary sources," and (iii) he intends to prepare air quality criteria for the pollutant.[4] Section 108(a)(2) of the Act requires that, for each pollutant listed, the Administrator issue air quality criteria that "accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare which may be expected from the presence of [the] pollutant in the ambient air, in varying quantities."[5] EPA has regulated sulfur dioxide ("SO_2") through the NAAQS program since 1971.[6] EPA has released two external review drafts of the Integrated Science Assessment for Sulfur Oxides, and is required to release a final assessment no later than September 12, 2008[7] (collectively, the "ISA"[8]). Under EPA's regulatory framework, the REA is required to evaluate

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Clean Air Act rulemakings affecting electric utility companies and in subsequent litigation related to those rulemakings.

[4] CAA § 108(a)(1)(A)-(B).

[5] CAA § 108(a)(2).

[6] 36 Fed. Reg. 1502 (Jan. 30, 1971); 36 Fed. Reg. 8186 (Apr. 30, 1971).

[7] Ctr. for Biological Diversity v. Stephen L. Johnson, Adm'r of EPA, Civ. No. 05-1814 (LFO) (D.C. Cir. 2007) (Consent Decree ordering EPA to issue a final ISA by September 12, 2008).

[8] Page references to the ISA herein refer to the Second External Review Draft of the Integrated Science Assessment for Sulfur Oxides -- Health Criteria, EPA/600/R-08/047 (May 2008).

the risk to public health posed by SO_2 in the ambient air, based on the findings presented in the ISA.[9] In its current form, the REA falls short of this mandate and presents information that is misleading. The REA must be revised pursuant to the comments below in order to present an assessment that is useful to the Administrator in reviewing the NAAQS for SO_2.

II. The REA's Evaluation of SO_2 Levels that Just Meet the Primary Standards Is Unwarranted.

A. The REA Should Examine Exposures and Risks at Current Ambient Air Quality.

In a memo outlining the process for reviewing NAAQS, EPA Deputy Director Marcus Peacock explained the appropriate purpose and procedure for each step in the NAAQS review process. In that memo, he stated that the REA should focus on "key results, observations and uncertainties" raised in the ISA and that the "development of methodologies to be used in the [REA] should be closely linked to the preparation of the ISA."[10] The current draft of the REA is not closely tied to the science presented in the ISA.

The ISA properly focuses on the effect of SO_2 concentrations at or near current ambient levels.[11] While the REA does consider the effect of air quality conditions as they were at the

[9] Memorandum from Marcus Peacock, Deputy Director of EPA, to George Gray, Assistant Administrator, Office of Research and Development for EPA and Bill Wehrum, Acting Assistant Administrator, Office of Air and Radiation, "Process for Reviewing National Ambient Air Quality Standards" (Dec. 7, 2006), confirmed by Memorandum from Marcus Peacock, Deputy Director of EPA, to George Gray, Assistant Administrator, Office of Research and Development for EPA and Bill Wehrum, Acting Assistant Administrator, Office of Air and Radiation, " Modifications to Process for Reviewing National Ambient Air Quality Standards" (Apr. 17, 2007) (collectively, hereinafter, the "Peacock Memo").

[10] Peacock Memo (Dec. 7, 2006) at 2.

[11] *See, e.g.*, ISA ("[Chapter 3 of the ISA - Integrated Health Effects] focuses on important new scientific studies, with emphasis on those conducted at or near current ambient concentrations." ISA at 3-4.)

time of measurement ("as is air quality"), it emphasizes simulated conditions under which air quality would just meet the primary standards ("air quality just meeting primary standards" or the "roll up").[12] EPA states that the "primary goal" of the REA is to judge whether the current SO_2 primary standards adequately protect public health, and that in order to make that judgment, it is necessary to adjust "nearly all SO_2 concentrations … upwards."[13] This is contrary to the approach to the science used in the ISA and therefore deviates from the appropriate NAAQS review process prescribed by the Peacock Memo. More importantly, given that the primary standards are very seldom "just met," there is no need to adjust the NAAQS to protect public health. Introduction of an artificial data set that projects health risks that do not currently exist is both inappropriate and misleading. This issue is discussed in greater detail below.

B. Ambient Air Quality Has Improved Substantially Since the Primary NAAQS for SO_2 Were Established, and Continues to Improve.

1. Levels of SO_2 in the Ambient Air Are Below the Current NAAQS.

Ambient levels of SO_2 in the United States have decreased steadily and significantly over the past several decades for a variety of reasons, and are currently, as a general matter, far beneath the primary SO_2 standards.[14] EPA acknowledged this in both the REA and the ISA, stating that "[a]ll areas of the U.S. currently have annual average levels [of ambient SO_2] below the current NAAQS,"[15] and "[n]ot one monitored exceedance of the SO_2 annual ambient air

[12] REA at 31.

[13] *Id.* at 47.

[14] *See* Savage T, Smith A, "Comments on the 'Risk and Exposure Assessment to Support the Review of the SO_2 Primary National Ambient Air Quality Standards: First Draft" (2008) at 2-3. (hereinafter "Savage and Smith")

[15] REA at 47.

quality standard in the lower 48 States … has been recorded since 2000."[16] According to EPA's Green Book, as of August 15, 2008, there were only seven counties in the continental United States that were designated nonattainment areas for the 24-h standard under the primary SO_2 NAAQS.[17] Both EPA's own trends data and the data of the Clean Air Status and Trends Network ("CASTNET") show substantial decreases in SO_2 concentrations in the ambient air since 1990.[18] In fact, concentration levels of SO_2 in the ambient air have decreased so much that EPA has expressed concern about instrument error in SO_2 regulatory monitors. The REA reports that, as of 2005, SO_2 concentrations were "at, or near [the SO_2 regulatory] monitors' lower limit of detection," which is approximately 0.003 ppm.[19] The fact that the data used for the exposure analysis in Chapter 7 of the REA dates from 2002[20] raises the question whether, given the continuing improvement in air quality, the analysis overstates the risk of exposure. EPA fails to mention this possibility.

2. Exposures to 5-min SO_2 Peaks Above 0.4 ppm Are Rare.

The first draft of the REA focuses on peak (5-min) SO_2 exposures, as EPA has not completed its analysis of short-term (≥ 1-h, generally 24-h) SO_2 exposure and has yet to report any risk estimates.[21] The REA uses a range of 0.4-0.6 ppm as a "benchmark" for evaluating

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[16] ISA at 2-13 - 2-14.

[17] http://www.epa.gov/oar/oaqps/greenbk/sntc.html. There were also two counties in Guam that were designated nonattainment areas as of August 15, 2008. *Id.*

[18] EPA's trends data show a 48% decrease in the national composite average SO_2 annual mean concentration between 1990 and 2005. ISA at 2-17; data trends from CASTNET are consistent with EPA's trends data. *Id.* at 2-17.

[19] REA at 12.

[20] *Id.* at 113.

[21] *Id.* at 158, 168.

these peak SO_2 exposures, because the ISA reported that this is the range in which "a substantial percentage" of exercising asthmatics experienced a moderate or greater decrease in lung function, accompanied by respiratory symptoms.[22]

Chapter 7 of the REA evaluates the number of peak (5-min) SO_2 exposures experienced in the ambient air "as is,"[23] and the number of such exposures experienced in air altered to simulate air quality just meeting the primary SO_2 standards. The analysis of SO_2 exposures to concentrations in the 0.4-0.6 ppm range in "as is air quality" shows very few exposures in this benchmark range. Of the ¾ million people simulated by EPA's APEX model, 10% of which were asthmatic, only two were estimated to have experienced one exposure to 0.4 ppm SO_2 over the course of a year while at a moderate or greater exertion level.[24] None experienced an SO_2 concentration of 0.45 ppm or above during the entire year while exercising.[25] These results show minimal exposure of potentially sensitive individuals to benchmark SO_2 levels and indicate that current ambient levels of SO_2 are not a threat to public health, including the health of asthmatics.[26]

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[22] REA at 29.

[23] Actually, as noted above, SO_2 levels have continued to decrease since 2002, the year for which "as is" exposure estimates are presented in the REA. Thus, even these exposures are likely higher than present air quality.

[24] REA at 148.

[25] *Id.* at 148.

[26] Clinical studies demonstrate that even asthmatics, while more sensitive than healthy individuals, do not experience moderate or greater lung function changes accompanied by respiratory symptoms when exposed to peak SO_2 concentrations of less than 0.4 ppm. *See, e.g.,* Linn WS, Avol EL, Peng RC, Shamoo DA, Hackney JD. (1987) Replicated Dose-Response Study of Sulfur Dioxide Effects in Normal, Atopic, and Asthmatic Volunteers. Am Rev Respir Dis 136:1127-34.

C. EPA Should Consider the Degree of Protection to be Provided by the NAAQS.

The CAA does not require that NAAQS protect 100% of the public from any response that might be considered adverse. Indeed, even the American Thoracic Society ("ATS"), a scientific organization that engages in advocacy (including NAAQS) aimed at preventing lung disease and promoting lunch health,[27] has recognized that it is "clear that some exquisitely susceptible individuals might remain outside the ambit of protection of the NAAQS."[28] ATS interprets the Act as espousing "regulations [that] should extend protection to include those with enhanced susceptibility to air pollution, recognizing that some highly susceptible individuals may still respond to low-level exposures."[29] ATS recognizes that "[r]esearch now shows that some highly susceptible individuals may respond to common exposures that are often unavoidable … [and that] by definition, susceptible individuals cannot have the same margin of safety as the nonsusceptible groups within the population."[30] EPA's past decisions demonstrate that the Agency, too, understands the impossibility of protecting 100% of people from environmental pollutants. The United States Court of Appeals for the D.C. Circuit upheld a decision by the Administrator that set a standard for lead levels in the ambient air which was intended to protect 99.5% of children under the age of five from "potentially adverse" effects (such children were judged to be a population with enhanced susceptibility to lead exposure).[31] The exposure data reported in the REA, referenced above, indicates that 99.997% of asthmatics

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[27] http://www.thoracic.org/sections/about-ats/ats-mission.html.

[28] American Thoracic Society. 2000. What Constitutes an Adverse Health Effect of Air Pollution? Am. J. Crit. Care Med. 161: 665-73 at 667.

[29] *Id.* at 669.

[30] *Id.* at 669.

[31] *Lead Indus. Assn. v. EPA*, 647 F.2d 1130 (D.C. Cir. 1980).

experienced no exposure to the lowest benchmark SO_2 concentration level over the course of a year.

D. The Analysis of Exposures If the Primary SO_2 NAAQS Were Just Met Is Unnecessary and Inappropriate.

It is both unnecessary and inappropriate under the NAAQS review procedure to amplify, or artificially increase, the existing low concentration levels of SO_2 in the ambient air to evaluate peak exposures that could occur if the primary standards were just met. The CAA requires that, for each pollutant listed under the CAA, the Administrator issue air quality criteria that "accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare *which may be expected from the presence of such pollutant in the ambient air*, in varying quantities."[32] Given that current concentrations of SO_2 in the ambient air are far below the thresholds set forth by the primary standards and have been decreasing for years,[33] it is inconceivable that the amplified SO_2 concentration levels EPA uses to represent air quality if the NAAQS were just attained will in the future ever exist in the ambient air.

The REA is to be an assessment of the air quality criteria as presented in the ISA, not an analysis of hypothetical data.[34] The NAAQS are intended to protect the public health from existing threats and those that are reasonably anticipated.[35] The REA's analysis of air adjusted to "just meet" the primary standards imagines a threat that does not exist in the United States today and is not anticipated to exist in the future, based on the overwhelming trends acknowledged by

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[32] CAA § 108(a)(2) (emphasis added).

[33] *See supra* text accompanying notes 14-19.

[34] *See supra* text accompanying note 10.

[35] CAA §108(a)(1).

EPA. This analysis is not relevant to the NAAQS review process and should be removed from the REA.

III. The REA's Representation of SO_2 Levels that Just Meet the Primary Standards is Arbitrary and Misleading.

Not only is creation of data for air that "just meets" the primary standards unwarranted under the NAAQS review process,[36] it is arbitrary and risks misrepresenting the effects of the primary standards. As explained in Section II above, SO_2 concentrations in the ambient air have been decreasing over recent decades and are currently at levels far below the primary NAAQS.[37] No reasonable observer, including EPA, would anticipate an increase in SO_2 concentrations to a level that just meets the thresholds set by the primary NAAQS. In its most recent trends report, EPA cites ongoing improvements in SO_2 concentrations and states that "[the Agency] expects the air quality to continue to improve as recent regulations are fully implemented and states work to meet [NAAQS]."[38]

Even if one were to imagine the deterioration of air quality to a level that "just meets" the primary SO_2 NAAQS, it would be impossible to know what specific factor or combination of factors would cause such an event to occur. Improvements in air quality are due to a convergence of many factors; enforcement of the primary NAAQS is only one of these many

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[36] *See supra* text accompanying note 10.

[37] *See supra* text accompanying notes 14-19.

[38] EPA. Latest Findings on National Air Quality, Status and Trends Through 2006. Jan. 2008 at 2 (hereinafter "2008 Trends Report"). Although a federal court of appeals recently vacated the Clear Air Interstate Rule, which was intended to assist in attaining NAAQS for ozone and fine particulate matter ("$PM_{2.5}$") that had been promulgated in 1997, *see* State of North Carolina v. EPA, No. 05-1244 (D.C. Cir. July 11, 2008), reduction in SO_2 emissions will still be required to meet those 1997 $PM_{2.5}$ NAAQS, *see* 72 Fed. Reg. 20586, 20589 (April 25, 2008), and even more stringent $PM_{2.5}$ NAAQS set in 2006, *see* 71 Fed. Reg. 61144 (Oct. 17, 2006).

variables. Air quality in general, and SO_2 levels in particular, are affected by improved technology, public sentiment, and a multitude of government programs. EPA attributes the decrease in SO_2 emissions to its Acid Rain Program,[39] but states that "[t]hese emission reductions resulted from a variety of control programs, from regulations at the federal, state, local and regional level to voluntary partnerships between federal, state, local, and tribal governments, academia, industrial groups, and environmental organizations."[40] EPA specifically mentions the Tier II Vehicle and Gasoline Sulfur Program, the Heavy-Duty Highway Diesel Rule, the Clean Air Nonroad Diesel Rule and the Mobile Source Air Toxics Rule as having contributed to decreases in ambient SO_2 and improvements in air quality.[41]

EPA's simulation of air quality that just meets the primary NAAQS is arbitrary in that it fails to identify any scenario that might bring about this dramatic decrease in air quality. EPA acknowledges this, stating "[w]e recognize that it is extremely unlikely that SO_2 concentrations in any of the selected areas where concentrations have been adjusted would rise to meet the current NAAQS and that there is considerable uncertainty associated with the simulation of conditions that would just meet the current standards."[42] EPA nonetheless creates and analyzes this fictitious data set,[43] although nothing in the CAA or the Peacock Memo instructs it to do so.

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[39] 2008 Trends Report at 23.

[40] *Id.* at 6.

[41] *Id.* at 2.

[42] REA at 48. Indeed, the factors used in the roll up are not credible. In order to simulate data that "just meet" the primary NAAQS, EPA increases observed 5-min max SO_2 concentrations by factors of up to 15.85. Savage and Smith at 3-4.

[43] REA at 48.

In reality, there is no way to evaluate the effect of air quality that just meets the primary SO_2 NAAQS on public health accurately because it does not exist in the United States today. Creating a scenario that allows for such an analysis is more harmful than it is helpful to the NAAQS review process; there is no benefit to be gained from the evaluation of an imagined threat. There are endless possibilities as to how and where air quality could change in coming years and what factors may cause or contribute to future changes in SO_2 concentrations. Based on recent trends, however, it is far more likely that SO_2 concentrations in the ambient air will continue to decrease than that they will increase. All of these possibilities cannot be modeled and evaluated. Selecting one unlikely scenario to analyze from among numerous possibilities is quintessentially arbitrary. For this reason, as well as those discussed in Section II above, the analysis of exposures if the primary SO_2 NAAQS were just met should be removed from the REA.

IV. The REA's Evaluation of SO_2 Levels that Just Meet the Primary Standards Improperly Ignores the Secondary NAAQS.

Although the primary and secondary SO_2 NAAQS are separate standards, they together define the acceptable level of SO_2 in the ambient air and they are often implemented in conjunction with one another. Indeed, Section 110 of the CAA requires that each state adopt a plan for implementation, maintenance and enforcement of the primary and secondary NAAQS.[44] In developing a State Implementation Plan ("SIP"), states typically address both primary and secondary standards. Therefore, separating the two and focusing on the primary standards, while ignoring the secondary standards is shortsighted. In practice, it is difficult to separate the

[44] CAA §110. Note, for example, that the Act anticipates a state's plans for implementing the primary and secondary NAAQS for a pollutant will be considered at a single public hearing. CAA §110(a)(1).

primary NAAQS from the secondary NAAQS because of the de facto relationship in enforcement between the two standards.

By simulating conditions that "just meet" the primary NAAQS, while ignoring the limit on air quality degradation imposed by the secondary NAAQS, EPA further complicates the issues described in Section III above, making the simulation even less probable than it would otherwise be. As discussed in Section III, there are so many factors that affect ambient air quality in the United States today that it is impossible to imagine or model the particular scenario that would cause SO_2 concentrations to just meet the primary NAAQS. The secondary NAAQS is just one of those factors, but it is the factor that is perhaps the most obvious. It, like the primary NAAQS, specifies a level of air quality that must be met or attained, and it could be easily taken into account. EPA uses equation 6-3 to calculate "just meets" conditions, using the lower of the daily or annual standard under the primary NAAQS.[45] EPA could easily do the same calculation using the secondary NAAQS. Although the resulting picture of air quality would still not represent a realistic scenario, this would be a less arbitrary approach than assuming that the secondary NAAQS would not be enforced.

Although the REA supports the evaluation of the primary NAAQS, the secondary NAAQS are relevant to the analysis because they also impose a specific limit on air quality and because they are implemented and enforced by the states in conjunction with the primary NAAQS. It is UARG's position that the "just meets" simulation should be removed from the REA, but if it is retained, UARG urges EPA to take into account the secondary standard.

[45] REA at 54.

V. The Presentation of Scientific Analyses in the REA is Marred by a Lack of Transparency.

A. The REA Should Provide Useful Documentation of the Data and Analyses Presented.

A substantial portion of the REA involves data manipulation. In many instances, however, it is difficult to determine both (i) what data EPA is using for its analyses and (ii) the exact methods EPA is using to manipulate that data. UARG retained CRA International ("CRA") to conduct a technical analysis of the REA, and CRA's comments are attached hereto as Appendix A.[46]

CRA was unable to match the monitoring data it obtained from EPA and from EPA's website to the data discussed in the REA. For example, the number of 5-min and 1-h monitors for which CRA was able to obtain data from EPA does not correspond to the number of monitors reportedly used for analysis in the risk assessment for peak (5-min) SO_2 exposures in Chapter 6 of the REA.[47] This lack of clarity with respect to the available monitoring data is fundamental to an understanding of the exposure assessments presented in the REA because all of these assessments are based on the relationship between the 5-min max and 1-h average SO_2 concentrations, reported by these monitors.[48] CRA was similarly unable to replicate the number of observations EPA used to calculate peak to mean ratios ("PMRs"), which makes it impossible to determine whether the PMRs are over- or understated.[49]

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[46] Savage and Smith.

[47] *Id.* at 4.

[48] *Id.* at 6.

[49] *Id.* at 7.

CRA was also unable to replicate the number of the receptors per modeling domain used in Chapter 7 of the REA to determine SO_2 concentrations as part of the exposure analyses.[50] These uncertainties may stem from a misunderstanding of the locations of stationary sources. EPA states that it manually adjusted the latitudes and longitudes of the source locations, but does not report the latitudes and longitudes used in its analysis.[51] As with discrepancies in the information on monitors, any discrepancy in the number of receptors in a given area could fundamentally alter the exposure assessment.[52]

The REA is a critical and influential component of the NAAQS review.[53] It is EPA's policy with respect to data used in developing such influential information to "ensure reproducibility according to commonly accepted scientific … or statistical standards."[54] Thus, EPA intends transparency "regarding (1) the source of the data used, (2) various assumptions employed, (3) the analytic methods applied, and (4) the statistical procedures employed."[55] EPA should provide the public with the data used in its analyses, as well as raw data, along with a description of the methods it used to manipulate that data so that it will be possible for interested parties to replicate the analyses reported in the REA. This would provide for greater transparency and would facilitate more productive pubic participation in the NAAQS review process.

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[50] *Id.* at 7-8.

[51] *Id.* at 8.

[52] *Id.* at 8.

[53] EPA, Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility and Integrity of Information Disseminated by EPA, at 20 (Oct. 2002).

[54] *Id.* at 21.

[55] *Id.* at 21.

B. EPA Should Provide an Explanation of Why it Chose to Use Peak to Mean Ratios and Coefficients of Variation in the REA Instead of More Standard Models.

The REA relies on coefficients of variation ("COVs") to assign peak to mean ratios ("PMRs") to individual 1-h monitors in order to predict 5-min max SO_2 concentrations.[56] Because COVs assume all the underlying data are normally distributed, and data on SO_2 concentrations are not normally distributed, use of COVs for this purpose adds to the uncertainty about predicted 5-min SO_2 concentrations in the REA.[57]

UARG recommends that EPA consider using instead parametric models or other statistically-based methods for predicting 5-min peak concentrations. If EPA continues to use the COV approach, UARG recommends that the Agency more fully explain its choice of that approach and the implications of that choice for the degree of confidence in the resulting exposure predictions.

VI. Conclusion and Recommendations.

The REA is intended to be an assessment of the risk to public health posed by current ambient levels of SO_2, based on the science presented in the ISA. As the REA reflects, current ambient SO_2 levels are generally far below those permitted by the current NAAQS and result in few exposures to the 5-min benchmark levels the Agency has identified. EPA's effort to estimate exposures to those benchmark levels if the NAAQS were just attained, on the other hand, runs counter to the goals set forth by the CAA and the Agency itself[58] for the NAAQS review process. Moreover, the estimates of exposures if the primary NAAQS were just attained

[56] Savage and Smith at 16.

[57] *Id.* at 16.

[58] *See* the Peacock Memo.

are also arbitrary and misleading, because they imagine a threat to public health that does not exist in the United States today and for which no realistic future scenario has been postulated. Moreover, EPA's technical approach for developing such estimates is fundamentally flawed. EPA should revise the REA to remove the analysis of exposures upon just meeting the current primary NAAQS, and to focus instead on current ambient air quality. The Agency should make its data and analyses more accessible and transparent in order to encourage more productive public participation in the NAAQS review process. Once these revisions to the REA have been made, it will be clear that it is unnecessary to alter the primary NAAQS for SO_2.

Appendix A

Comments of CRA International

[See attached.]

Comments on the "Risk and Exposure Assessment to Support the Review of the SO_2 Primary National Ambient Air Quality Standards: First Draft"

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August 28, 2008

In June 2008, the U.S. Environmental Protection Agency (EPA) released a document titled "Risk and Exposure Assessment to Support the Review of the SO_2 Primary National Ambient Air Quality Standards: First Draft" ("REA Draft 1"). We hope that EPA will take into consideration a number of technical issues that we have with the analysis presented in the REA Draft 1, in particular Chapter 6, and make appropriate modifications before it releases the next draft of the REA.

Summary of Our Comments

We make the following observations regarding REA Draft 1:

- Exceedances of the 5-minute SO_2 standards are declining and rarely observed in the data on which EPA relies.
- EPA's roll-up factors are not credible, and the approach should be abandoned.
- We cannot replicate the analyses in Chapter 6 and 7 using data obtained from EPA. EPA should produce a detailed technical appendix, published online, that contains complete monitor data and provides the computer code used to generate its analyses.
- EPA should explore standard statistical models to estimate the relationship between 1-hour average and 1-minute maximum SO_2 concentrations. Such an approach would make estimating the likelihood of an exceedance more straightforward. It would also obviate the need to rely on coefficients of variation and peak-to-mean ratios.

I. Actual 5-Minute SO_2 Exceedances Are Rare

The REA Draft 1 is a lengthy document, spanning over 300 pages of text, tables, and figures. It contains a detailed description of policy history regarding national ambient air quality standards regarding SO_2. Sections are devoted to summarizing potential human exposure to SO_2, at-risk populations, and potential adverse health effects. A large section of the REA Draft 1 describes EPA's efforts to predict 5-minute maximum SO_2 concentrations based on 1-hour average SO_2 concentrations. It also produces preliminary estimates of its exposure analysis.

The REA Draft 1 does not, however, provide the reader a simple, though important, measure: actual 5-minute SO_2 concentrations in the monitor data that is maintained by EPA and on which it relies. In passing, the REA Draft 1 notes, "… SO_2 concentrations have fallen considerably over the years (draft ISA, Figure 2-8) and are currently at, or very near these monitors' lower limit of detection (~0.003 ppm)."[1]

As a result, we believe that it is useful to examine actual 5-minute maximum SO_2 concentrations over time. Using 5-minute data obtained from EPA, Table 1A displays distributions of 5-minute maximum SO_2 concentrations by range of concentration over time.[2] (Table 1B expresses these as percentages.) It is clear that the hourly incidences of either 0.4 or 0.6 parts per million (ppm) are rare and declining over time. To be clear, these are not the number of monitors that record at least one 5-minute exceedance. These are hourly 5-minute maximum SO_2 concentrations over time by monitor. By the last two years of 5-minute data, there are only 111 hourly observations that exceed 0.4 ppm based on well over 325,531 monitor-hours of data. All of these exceedances occurred in Missouri and West Virginia.[3] By contrast, during 2006 and 2007, there are nearly 220,000 observations at or below the lower detection limit of 0.003 ppm.

[1] REA Draft 1, p.12.

[2] EPA provided the 5-minute max data directly to Southern Company, from whom we obtained them in their unaltered form. The 1-hour average data were downloaded directly from the EPA's website: http://www.epa.gov/ttn/airs/airsaqs/detaildata/downloadaqsdata.htm. The actual data files are too large to post on a website. On request to the authors, we will provide both the data and the Stata code used to generate the results in our comments. Our email addresses are tsavage@crai.com and asmith@crai.com.

[3] 104 of the hourly exceedances were in Missouri, while seven were in West Virginia. No other states in which there are 5-minute monitors report exceedances of 0.4 ppm.

Table 1A. 5-minute Maximum SO2 Concentrations (Number of Observations)

Range	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0 to < 0.1	392,227	305,440	316,571	252,619	300,256	378,933	307,075	265,591	212,249	183,623	140,865
0.1 to < 0.2	4,029	2,245	1,538	1,313	979	1,323	1,266	838	570	456	266
0.2 to < 0.3	780	518	299	294	200	248	203	82	96	83	71
0.3 to < 0.4	289	222	162	130	105	113	113	25	40	34	22
0.4 to < 0.5	181	111	109	72	85	77	74	15	16	26	22
0.5 to < 0.6	150	59	67	44	45	40	31	10	8	13	10
0.6 and above	177	105	128	88	66	58	51	10	18	25	15
Total	397,833	308,700	318,874	254,560	301,736	380,792	308,813	266,571	212,997	184,260	141,271

Table 1B. 5-minute Maximum SO2 Concentrations (Percentages)

Range	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0 to < 0.1	98.59%	98.94%	99.28%	99.24%	99.51%	99.51%	99.44%	99.63%	99.65%	99.65%	99.71%
0.1 to < 0.2	1.01%	0.73%	0.48%	0.52%	0.32%	0.35%	0.41%	0.31%	0.27%	0.25%	0.19%
0.2 to < 0.3	0.20%	0.17%	0.09%	0.12%	0.07%	0.07%	0.07%	0.03%	0.05%	0.05%	0.05%
0.3 to < 0.4	0.07%	0.07%	0.05%	0.05%	0.03%	0.03%	0.04%	0.01%	0.02%	0.02%	0.02%
0.4 to < 0.5	0.05%	0.04%	0.03%	0.03%	0.03%	0.02%	0.02%	0.01%	0.01%	0.01%	0.02%
0.5 to < 0.6	0.04%	0.02%	0.02%	0.02%	0.01%	0.01%	0.01%	0.00%	0.00%	0.01%	0.01%
0.6 and above	0.04%	0.03%	0.04%	0.03%	0.02%	0.02%	0.02%	0.00%	0.01%	0.01%	0.01%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Therefore, EPA is dealing with events—exceedances of benchmarks—that are rarely observed in the actual data on which they rely, an empirical feature that is little discussed in the REA Draft 1. But this empirical feature is central to many of the analyses that EPA undertakes. As we discuss in the remainder of our comments regarding the REA Draft 1, EPA develops an elaborate, though cumbersome, matching algorithm of peak-to-mean ratios (PMRs) based on coefficients of variation (COVs) in order to predict 5-minute maximum SO_2 concentrations from 1-hour average SO_2 concentrations. In turn, using roll-up factors that strain credibility, these 5-minute "as-is" predictions are extrapolated to a hypothetical, *much* worse air quality that "just meets" current primary air quality standards. These, in turn, are used to assess potential health effects. We propose that EPA explore alternatives to the use of its COV-based matching algorithm of PMRs. We address potential alternatives at the end of our comments.

II. EPA's Roll-Up Factors Are Not Credible and Should Be Abandoned

Following the approach in its April 2008 "Risk and Exposure Assessment to Support the Review of the NO_2 Primary National Ambient Air Quality Standards: First Draft," EPA uses a method to "roll-up" its predicted 5-minute maximum SO_2 concentrations to simulate hypothetical exposure scenarios. In comments on that NO_2 REA Draft, we noted that EPA should abandon this approach because it stretches beyond the bounds of realism. The same is true here. Simply put, EPA's approach requires it to extrapolate well outside the ranges of observed 5-minute maximum SO_2 concentrations.

The non-credibility of this approach is due to the extreme degree of extrapolation beyond the observed data. Table 2 displays distributions of the daily roll-up factors (or

multiples) by which EPA is increasing as-is concentrations to simulate just meeting current primary standards.[4] The median factor is 3.75, and the top 25 percent of factors range from 4.47 to 15.85. In other words, EPA's median daily factor nearly quadruples its predicted 5-minute maximum SO_2 concentrations. Moreover, it applies much larger factors to a considerable portion of its predictions. This underscores the absurdity of this hypothetical worsening of U.S. air quality.

Table 2: Distribution of Roll-Up Factors

Percentiles			Summary Statistics	
		Smallest		
1%	1.87	1.87		
5%	2.02	1.93	Obs	57
10%	2.29	2.02	Sum of Wgt	57
25%	2.75	2.11		
50%	3.75		Mean	3.917018
		Largest	Std. Dev.	1.960567
75%	4.47	5.67		
90%	5.29	5.69	Variance	3.843821
95%	5.69	6.83	Skewness	4.019332
99%	15.85	15.85	Kurtosis	25.21801

"Roll-ups" of this magnitude should not be performed when the supporting data are as weak and subject to uncertainty as we show them to be in these comments. If EPA does use the roll-up procedure, however, then it should at a minimum quantify the statistical uncertainty bounds of the resulting exposure and risk estimates. EPA should also carefully explain the hypothetical nature of such a worsening of air quality, and explain the range of provisions of the Clean Air Act that would make such a worsening unlikely in any future year.

III. Important Problems in Documentation and Replicability of EPA's Data

A. Air Quality Data Used in REA Draft 1 Cannot Be Independently Replicated

In our review of the REA Draft 1, we attempted to replicate several of the key air quality data analyses contained in Chapter 6. We did so because these results are central to EPA's approach to predict 5-minute maximum SO_2 concentrations for the majority of the country for which they have no such data. Using data obtained directly from EPA and following as closely as possible the narrative description of their methods, we are unable to replicate their results. In particular, the number of 5-minute and 1-hour monitors in the data obtained from EPA does not appear to match the number of monitors used for analysis in Chapter 6 of the REA Draft 1.

[4] REA Draft 1, Table 6-4, pp. 51-53.

Figure 1 reproduces Figure 6-11 of the REA Draft 1, which shows the number of 5-minute monitors from 1997 through 2000. Although it is unnoted in the REA Draft 1, there is an uneven trend in the number of such monitors between 1997 and 2002. From 2002 forward, however, there is a clear pattern in the decline in the number of 5-minute monitors. Figure 1 also shows, as a superimposed red line, the number of 5-minute monitors over time in the data we obtained from EPA. Note that the file of 5-minute data that EPA provided does not appear to contain as many monitors as EPA indicates it relied on in REA Draft 1.[5] Despite the discrepancies in the two EPA data sets, we also find an unstable pattern in the number of 5-minute monitors between 1997 and 2002, although we do not find the large peak in 2002 displayed in Figure 6-11 of the REA Draft 1. We do, however, find a steady decline in the number of such monitors since 2002. We address the lack of spatial and temporal representation in the number of 5-minute monitors in the next section of our comments.

Figure 1. Comparison of REA Draft 1 Summary of 5-Minute Monitors and Those in Data We Obtained from EPA

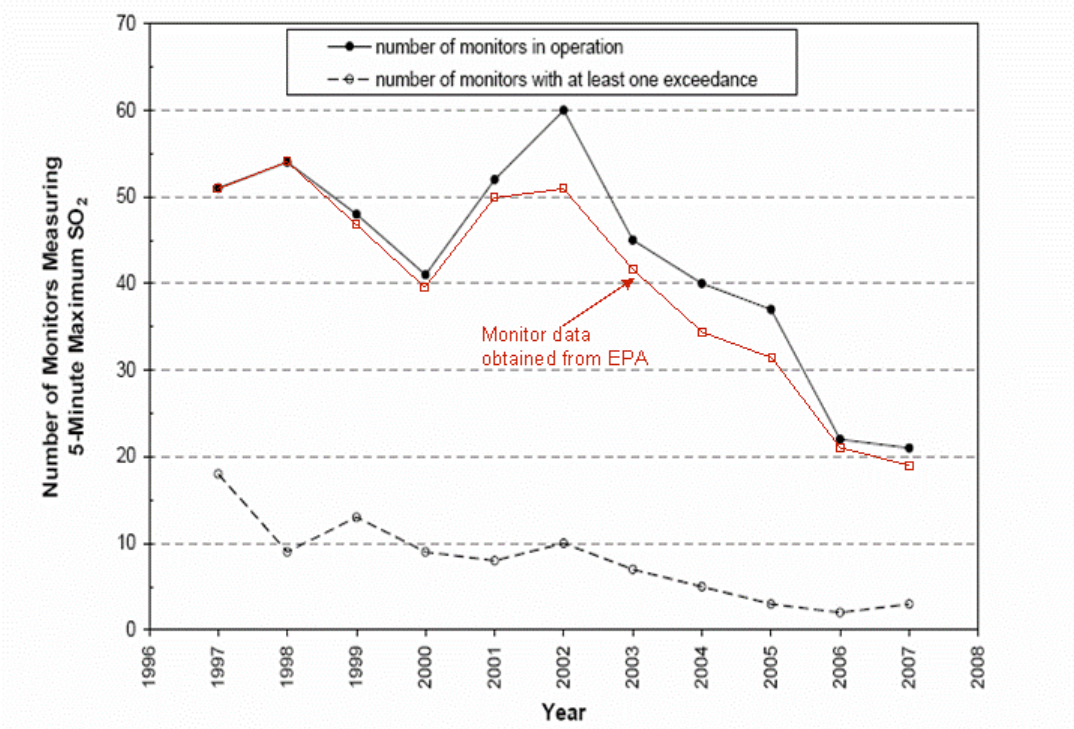
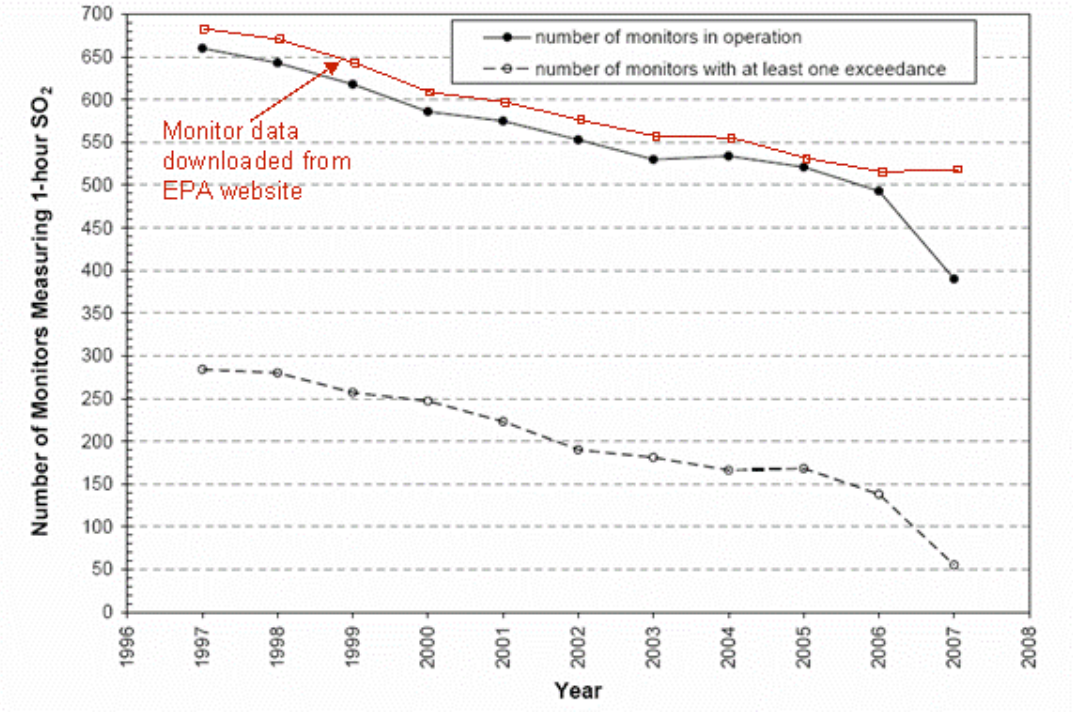


Figure 2 reproduces Figure 6-17 in the REA Draft 1 and again superimposes, as a red line, the number of 1-hour monitors in the data that we downloaded from EPA's website. It too shows a steady decline in the number of 1-hour monitors over time, which is not

[5] One possibility is that EPA supplemented the 5-minute data provided to Southern Company with additional monitor data obtained from the states. This possibility underscores the need for EPA to provide its data publicly.

discussed in the REA Draft 1. As with the 5-minute monitors, we are unable to match the number of 1-hour monitors reported by EPA. Note in particular the large difference in the number of monitors in 2007.

Figure 2. Comparison of REA Draft 1 Summary of 1-Hour Monitors and Those in Data We Obtained from EPA



The mismatches in the numbers of 5-minute and 1-hour monitors cited above are not trivial. The subsequent health-risk analyses in the REA Draft 1 follow from its analysis of the relationship between 5-minute maximum and 1-hour average SO_2 concentrations in Chapter 6. *Indeed, as EPA has acknowledged, the analyses in Chapter 6 are necessitated by the paucity of 5-minute monitor data.* As the REA Draft 1 notes, "Staff developed statistical relationships between 5-minute peak concentrations and hourly concentrations using ambient monitoring data. This was done because the averaging time for current SO_2 NAAQS (daily and annual), much of the ambient monitoring data (1-hour), and outputs from dispersion models (1-hour) were not comparable to the selected health effects averaging time of 5-minutes."[6]

Given its importance in the overall risk assessment, the actual monitor data used for analysis in Chapter 6 should be provided to independent researchers on request to EPA and/or posted on EPA's website. These data should include both the original monitor data, as well as the monitor data finally used for analysis. In fact, EPA should provide a

[6] See REA Draft 1, p. 31.

detailed technical appendix to Chapter 6 that includes the computer code used to manipulate the monitor data.

Following as closely as possible the approach to link the data from the 1-hour and 5-minute monitors described in Chapter 6, we also find that we cannot replicate the number of observations that are used by EPA in their attempts to derive their peak-to-mean ratios (PMRs).[7] The REA Draft 1 reports 2,408,420 observations for their "Final Combined Max-5 and 1-Hour" data.[8] Using the approach they describe, we find 2,999,331 observations that could be used as "combined" data.[9]

This relative difference of nearly 20 percent makes it impossible to replicate the data analyses in Chapter 6. Indeed, it is very difficult even to assess the quality of the analyses in Chapter 6, *which are central to the overall health-risk assessment*. We cannot, therefore, accurately assess whether EPA's approach systematically overstates or understates PMRs, the measurement which directly affects their 5-minute as-is predictions. If EPA overstates PMRs, this will overstate current exposures above the benchmarks. Even more importantly, any biases in the PMRs will increase the uncertainties associated with the procedure of "rolling up" their as-is predictions.

As result of data inconsistency, we are also unable to properly assess the effects of sampling variability associated with EPA's cumbersome method of generating PMRs. Despite the lack of specificity in the REA Draft 1 and the monitor data on which it relies, we think it useful to evaluate several key aspects of the data analysis in Chapter 6 using the EPA data that we have obtained, which we do in Section IV below.

B. Data Relevant to Exposure Analysis in REA Draft 1 Cannot Be Independently Replicated

The replication problems cited above are not limited to the air quality analyses. We also are unable to replicate several key aspects of the treatment of data for the exposure analysis described in Chapter 7 of the REA Draft 1.

For example, EPA defines receptors for each modeling domain as the set of all Census block centroids within 20 kilometer (km) of each point source in the domain.[10] We did a

[7] See REA Draft 1, Equation 6-1, p. 36, which describes the PMR. Simply put, it is a method to predict 5-minute maximum SO_2 concentrations from 1-hour average SO_2 concentrations where no information on 5-minute maximum SO_2 concentrations exists.
[8] See REA Draft 1, Table 6-2, p. 33.
[9] We exclude negative hourly and maximum values, as well as "duplicate measures" mentioned in the REA Draft 1, p.32. Both of the monitor datasets contain a number of other variables, which EPA may have used to restrict the ultimate sample used for analysis. There is no description in the REA Draft 1 of additional restrictions, which should be explicitly discussed in the technical appendix that we have proposed.
[10] REA Draft 1, p.118.

spot check of two of the Missouri modeling domains listed in Table 7-1 of the REA Draft 1. Specifically, these are #13995, which includes the Southwest Power Plant and the James River Power Plant, and #14938, which contains the Thomas Hill Energy Center. Table 7-1 of the REA Draft 1 reports 7,469 receptors in domain #13995. In contrast, we identified 7,367 block centroids within 20 km of the James River Power Plant and/or the Southwest Power Plant, a discrepancy of 102. Similarly, Table 7-1 reports 1,407 receptors in domain #14938. In contrast, we identified only 1,208 block centroids within 20 km of the Thomas Hill Energy Center, a discrepancy of 199.[11] Figures 3 and 4 display the Census block centroids that we identified for each domain.[12]

EPA mentions that it manually adjusted the latitude and longitude measures for the actual stack locations, but does not report the latitude and longitude that it then used for each source. Therefore, we had to develop our own estimates of source coordinates.[13] The discrepancies between our receptor list and EPA's list may be due to differences in our respective latitude and longitude estimates (but we cannot know if this is the case with the information EPA has provided in the draft). If so, this could markedly alter the population of people that AERMOD estimates to be exposed to 5-minute SO_2 concentrations exceeding benchmark levels because the populations per Census block vary dramatically.

For example, a large fraction of the Census blocks in these two domains have *no population*.[14] In contrast, other Census blocks have populations of over 1,000 individuals. We find that within one kilometer of the coordinates that we used for the two sources in domain #13995, block populations vary from 0 to 192. If most of the projected peak 5-minute concentrations were to occur within one kilometer of a plant, even slight variations in assumed plant coordinates could cause a projected 5-minute peak SO_2 concentration to result in estimated population exposures above a given benchmark that vary from zero to dozens. Seemingly small errors in plant location could create a significant difference in the apparent risk levels reported in the REA.

[11] EPA mentions on p.117 that it also included ambient monitoring locations in its modeled receptors, but there were only 20 of these in all of Missouri in 2002, indicating that this is not a likely explanation of the discrepancies.

[12] The census block data was obtained from a database of the Missouri Census Data Center located at http://mcdc2.missouri.edu/websas/geocorr2k.html. This database allows the user to filter census information by specific areas using latitude and longitude coordinates and by specifying a radius around that point. Excel files identifying and characterizing every Census block graphed in Figures 3 and 4 can be downloaded from CRA's website at: http://www.crai.com/ProfessionalStaff/AuxListingDetails.aspx?id=8262&fID=34.

[13] We did this by locating the stacks visually using Google Earth. For the James River Power Plant we estimated (37.1083, -93.2594), for Southwest Power Plant we estimated (37.1519, -93.3892), and for Thomas Hill Energy Center, we estimated (39.5538, -92.6389).

[14] 27 percent of the census blocks in domain #13995 have zero population, and 51 percent in domain #14938 have zero population in the data we downloaded from the Missouri Census website that we used.

Thus, as part of developing a comprehensive technical appendix, EPA should provide a more precise accounting of its source coordinate assumptions, as well as clearly document the specific census blocks that it considers to be a part of its domain, as we have just done. It would also be important for EPA to document the specific Census blocks in each modeling domain that account for the population exposure event that exceed key benchmark levels such as 0.4 ppm and 0.6 ppm.

Figure 3. Map of All Census Block Centroids Within 20 km of Sources in EPA Domain #13995. (Numbers show population in selected blocks)

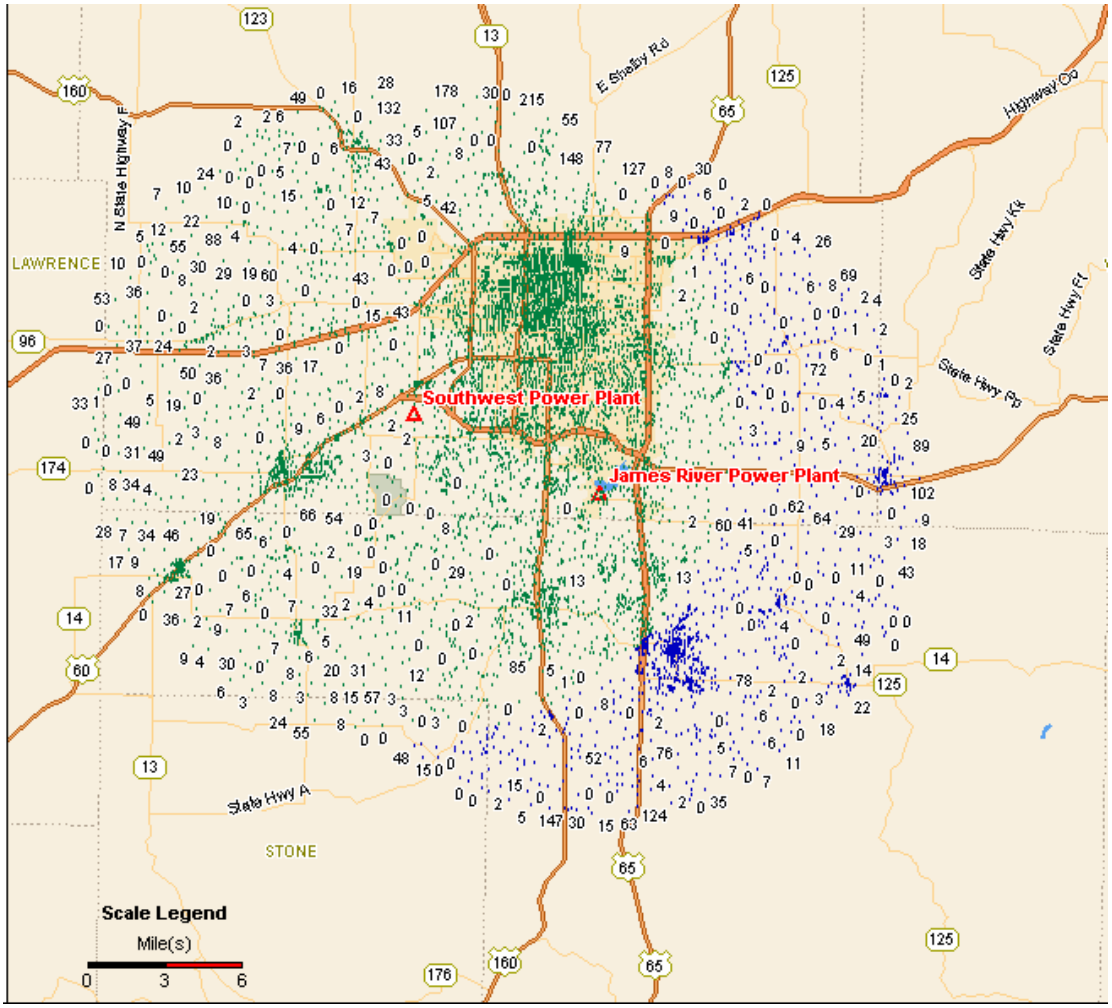
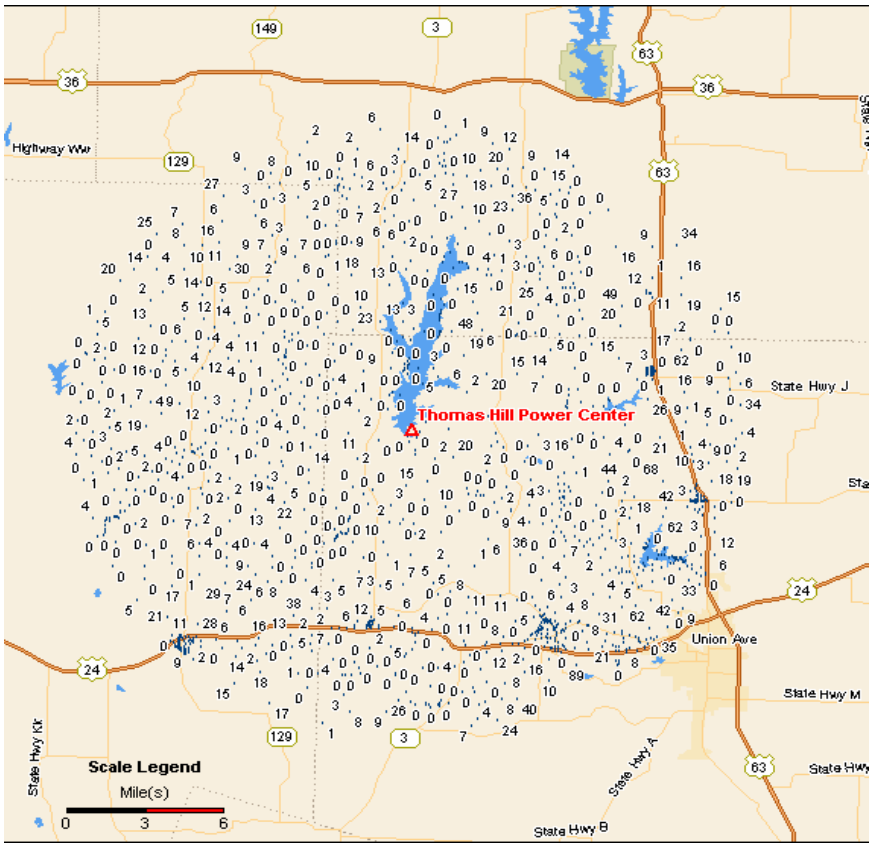


Figure 4. Map of All Census Block Centroids Within 20 km of Sources in EPA Domain #14938 (Numbers show population in selected blocks)



IV. EPA's Monitor Data Are Not Spatially or Temporally Representative

EPA's approach in Chapter 6 of the REA Draft 1 follows prior EPA research, namely Thompson (2000).[15] Like the REA Draft 1, Thompson (2000) develops a set of PMRs to map 1-hour average concentration measures to 5-minute maximum concentrations. Interestingly, Thompson (2000) acknowledges the following, "There is limited temporal and spatial coverage of the 5-minute monitors. The 83 available monitors may not be located near the sources with the most potential to cause high 5-minute concentrations or even near sources with typical or average potential."[16] Based on our review of the spatial and temporal characteristics of the monitor data, discussed below, we agree with this assessment. In particular, during the later time period used in the EPA's analyses, the

[15] Rhonda Thompson, "Preliminary Analysis of 5-Minute Maximum Ambient SO2 Concentrations," December 21, 2000, U.S. EPA. Available at http://www.epa.gov/ttn/amtic/so2data.html.
[16] Thompson (2000), unpaginated.

merged 5-minute/1-hour data become increasing dominated by observations in North Dakota.

Figure 5 displays the locations of the 5-minute monitors at three points in time between 1997 and 2007 in the data that were provided by the EPA. In 1997, there were a large number of 5-minute monitors outside of North Dakota and Missouri, in particular located in Pennsylvania. By 2002, the Pennsylvania monitors have disappeared, only to have been replaced by monitors in South Carolina.[17] However, the South Carolina monitors also disappear by 2003. *By 2007, there are only six 5-minute monitors located outside of North Dakota.*

In contrast, the 1-hour monitors display considerably more spatial and temporal stability than do the 5-minute monitors, as displayed in Figure 6. It is important to note, however, that there are a considerable number of 1-hour monitors in New England, the Midwest, and the West—*areas in which there are no 5-minute monitors*. This fact underscores the importance of the analyses in Chapter 6 of the REA Draft 1 because EPA predicts 5-minute maximum SO_2 concentrations from the 1-hour average SO_2 concentrations using PMRs. In EPA's air quality analysis on benchmarks, the projected exceedances for all of the monitors in New England and the Midwest are based on PMRs for monitors not located in those geographic areas.

[17] Table A-1 of REA Draft 1 indicates that there may still have been 6 monitors taking 5-minute maximum observations in Pennsylvania in 2002, but even in Table A-1, all but one are closed by 2003.

Figure 5. Maps of Locations of 5-Minute Monitors Over Time

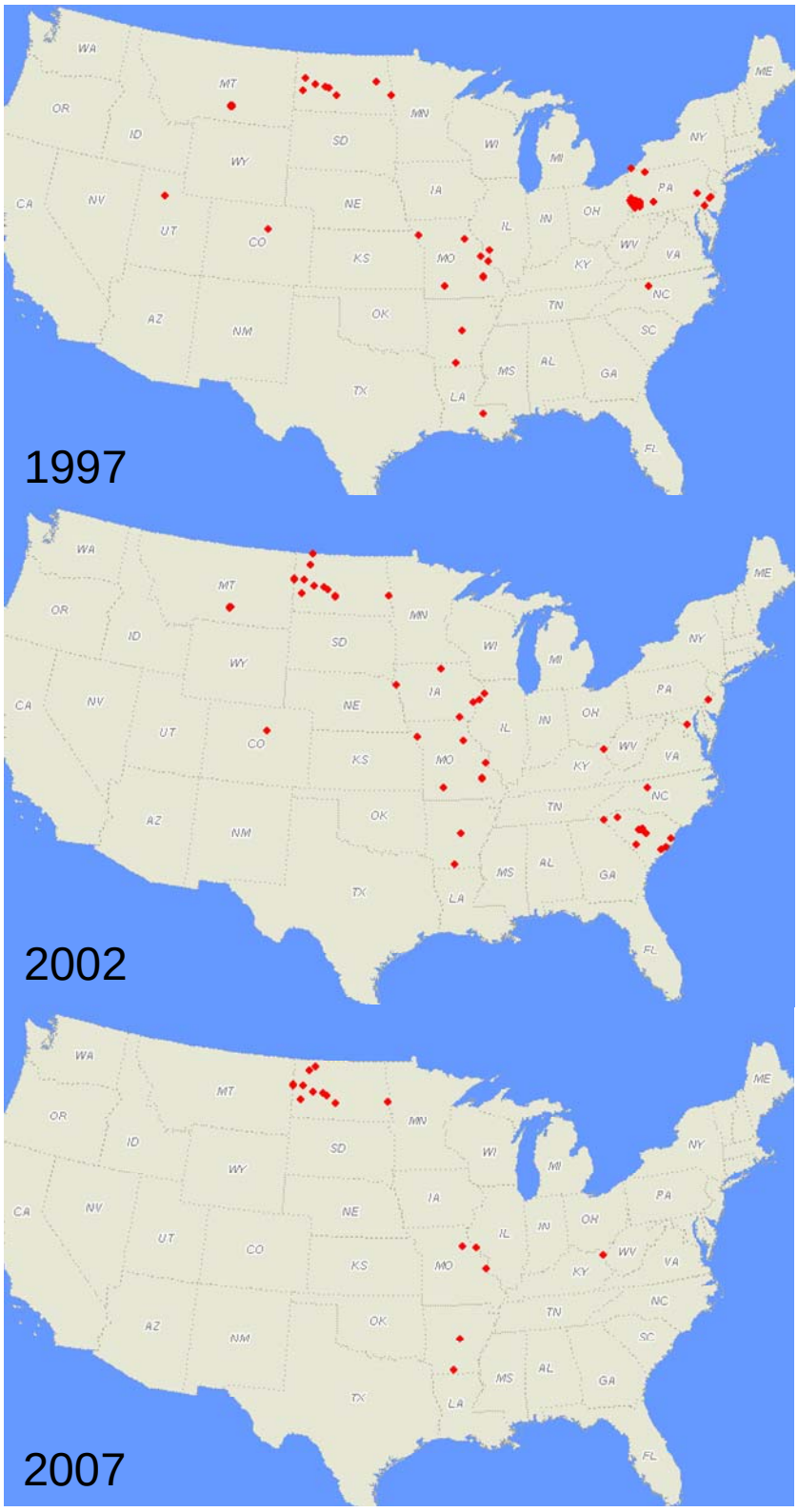
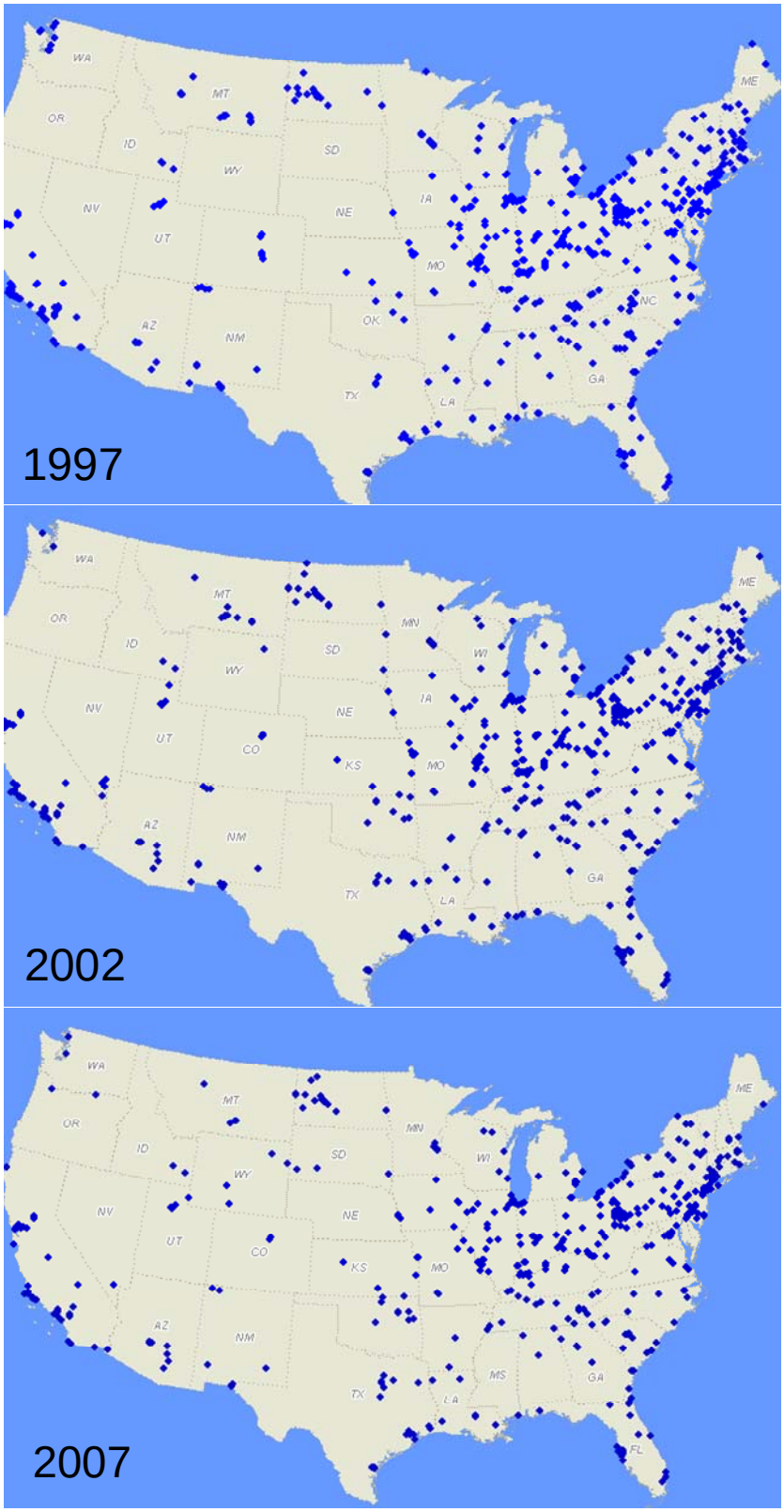


Figure 6. Maps of Locations of 1-Hour Monitors Over Time



It is also instructive to examine the spatial and temporal characteristics of the linked 5-minute/1-hour data. Table 3 displays, by year and by state, the number of observations from our attempt to replicate EPA's linked 5-minute/1-hour data. The table also displays the percentage of observations by year and by state. Over one-third of the observations are in North Dakota. Nearly two-thirds of the observations are from three states, North Dakota, Pennsylvania, and Missouri. Over half of the total observations over the entire record in Table 3 are in 2001 or before. Less than 10 percent of the observations are in the final two years of the data, even though the most recent years' data should be considered the most relevant data for assessing PMRs that will be used in a risk assessment of current or recent SO_2 conditions. *In those two years alone, however, over 65 percent of the data are from monitors in North Dakota.*

Table 3. Monitor Observations by Year and State (Linked 5-Minute/1-Hour Data)

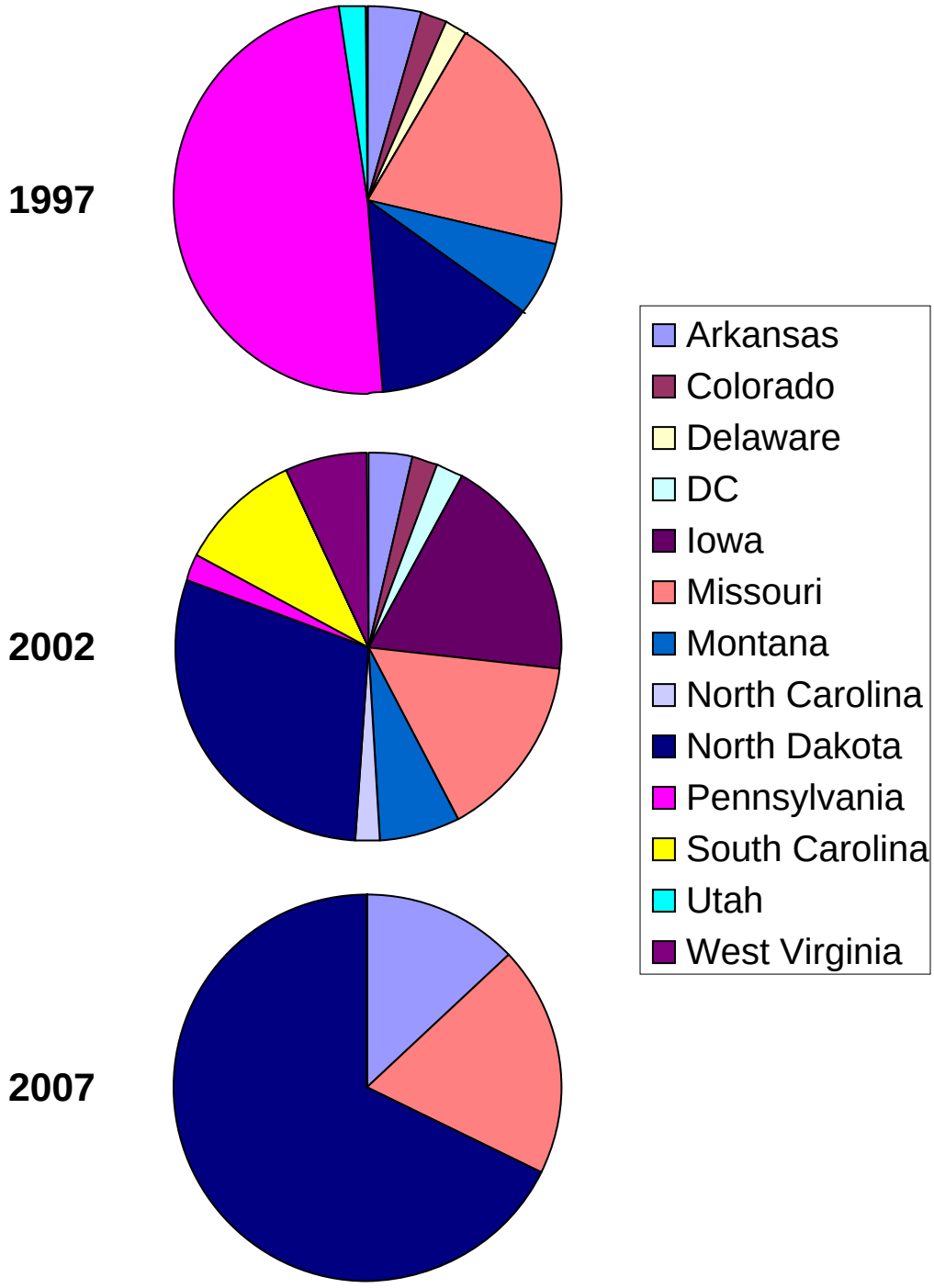
State	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total	Percent
Arkansas	16,678	14,674	12,434	16,119	16,642	14,145	16,667	16,145	14,335	16,720	16,645	171,204	5.71%
Colorado	8,343	8,214	3,552	3,030	8,051	8,200	8,223	7,674	7,768	7,914		70,969	2.37%
Delaware	7,737	6,172										13,909	0.46%
DC				3,751	8,341	8,581	4,282	2,778				27,733	0.92%
Iowa					17,076	69,938	60,590	60,343	30,116			238,063	7.94%
Missouri	74,226	82,149	78,359	77,401	62,585	59,784	51,538	21,269	25,017	25,668	24,355	582,351	19.42%
Montana	24,807	16,462	18,466	24,323	23,629	24,566	23,218	8,338	8,262	8,224		180,295	6.01%
North Carolina		8,686	8,602	6,368	8,590	8,655	8,643	6,281				55,825	1.86%
North Dakota	50,443	70,531	92,904	94,249	86,258	112,021	106,214	117,004	99,842	101,257	86,688	1,017,411	33.92%
Pennsylvania	184,863	92,651	95,037	12,653	8,608	8,464	2,761					405,037	13.50%
South Carolina				15,805	60,683	38,966						115,454	3.85%
Utah	8,093	8,375										16,468	0.55%
West Virginia						26,062	26,190	26,248	26,112			104,612	3.49%
Total	375,190	307,914	309,354	253,699	300,463	379,382	308,326	266,080	211,452	159,783	127,688	**2,999,331**	
Percent	12.51%	10.27%	10.31%	8.46%	10.02%	12.65%	10.28%	8.87%	7.05%	5.33%	4.26%		

Based on Table 3, Figure 7 displays pie charts for 1997, 2002, and 2007. In 1997, Pennsylvania monitor data dominated the sample. By 2002, however, data from Pennsylvania have all but vanished. By 2007, the sample is dominated by observations from North Dakota.

Based on the information displayed in the figures in this section and in Table 3, it is clear that the data on which EPA relies to calculate its PMRs are not spatially or temporally representative.[18] The data are disproportionately found in the earlier years of the sample and in three states. By the end of the time period covered by the data, observations are predominantly in a single state, North Dakota. EPA should explain how the spatial and temporal features of its monitor data affect the uncertainty associated with its ultimate risk assessment, in particular with respect to the types of sources and meteorological factors.

[18] This is also true for the data reported in Table 1 of Thompson (2000). To the extent that the differences between our sample and that used by EPA are random, all of the points remain valid.

Figure 7. Pie Charts Summarizing Numbers of Linked 5-minute/1-hour Observations by State



V. EPA Should Explore Standard Statistical Methods to Predict Exceedances

A. Coefficients of Variation Are Inappropriate Summary Statistics for Monitor Data

The REA Draft 1 relies on coefficients of variation (COVs) both as a tool to validate the idea of using PMRs as well as a means to assign PMRs to individual 1-hour monitors to predict their 5-minute maximum SO_2 concentrations.[19] In our experience, COVs have been used to summarize data, *particularly data that are normally distributed*. But we have never come across a study that uses them in the matter employed by EPA, which is to predict rarely observed high values from the observed mean value. Therefore, EPA should cite its authority for using its COV approach..

Because we cannot replicate EPA's linked data, we cannot at this time accurately assess the quality of their method to assign PMRs to predict 5-minute maximum SO_2 concentrations in the vast majority of the country in which they have no data on 5-minute SO_2 concentrations. Nevertheless, it is instructive to look at the distributions of COVs and the PMRs, particularly the distributions of the means and standard deviations of the 5-minute and 1-hour monitor data using the EPA data that we have obtained.

Figures 8 through 10 display histograms of the 1-hour average SO_2 concentrations by date and hour.[20] Figure 8 is a histogram of the averages, Figure 9 of the standard deviations, and Figure 10 of the COV. For each of these histograms, we overlay the image of a normal distribution.[21]

As expected, the averages of the 1-hour average SO_2 concentrations displayed in Figure 8 are not normally distributed because they are strictly positive and skewed. *It is important to note that the COV approach assumes the underlying data are normally distributed, which SO_2 concentrations data are not.*[22] The standard deviations of the 1-hour average SO_2 concentrations displayed in Figure 9 are also not normally distributed. Indeed, they are closely clustered. Finally, the COVs also are not normally distributed, and this appears to be due more to the lack of normality of the standard deviation rather than of the average. The COV measure is generally reserved for normally distributed data, which SO_2 concentrations certainly are not.

[19] For a particular data series, a COV is the ratio of the series' standard deviation to its mean.
[20] That is, the data over all years on record for each monitor have been averaged across monitors by date and hour, the approach used by EPA.
[21] We overlay normal distributions that have the same mean and variance as the data themselves.
[22] This point has been recognized in individual comments by members of the Clean Air Scientific Advisory Committee (CASAC). See, *e.g.*, Comments by Ted Russell.

Figure 8. Histogram of Averages for 1-Hour Average SO_2 Concentrations

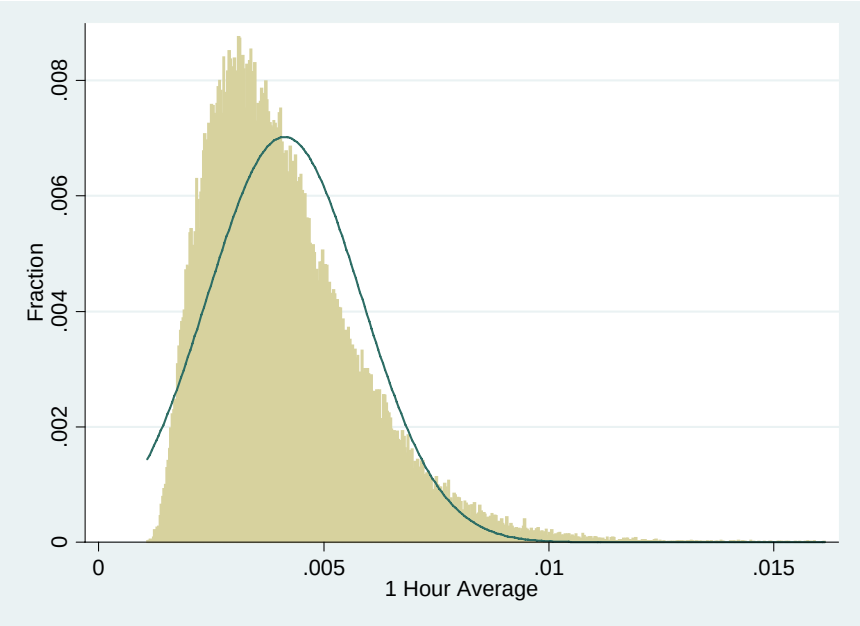


Figure 9. Histogram of Standard Deviations for 1-Hour Average SO_2 Concentrations

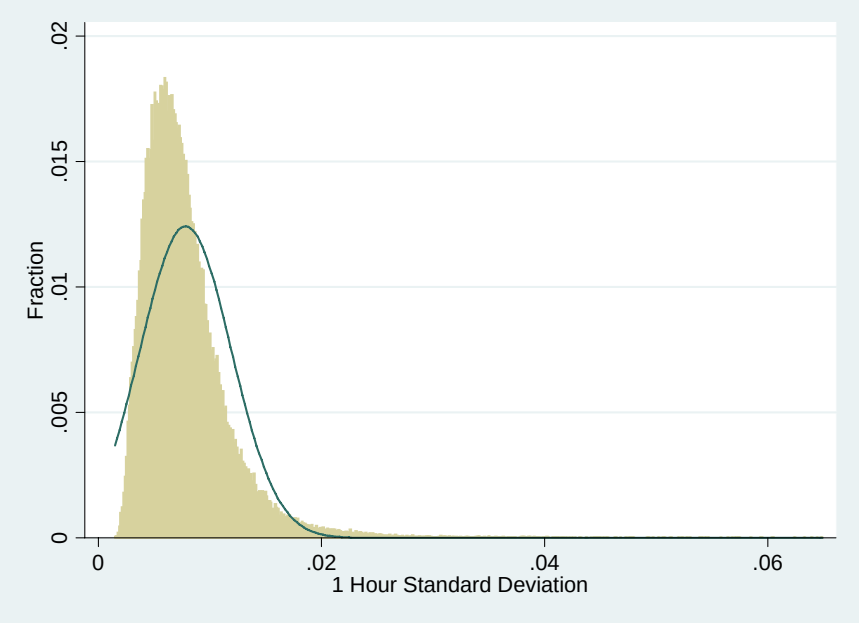
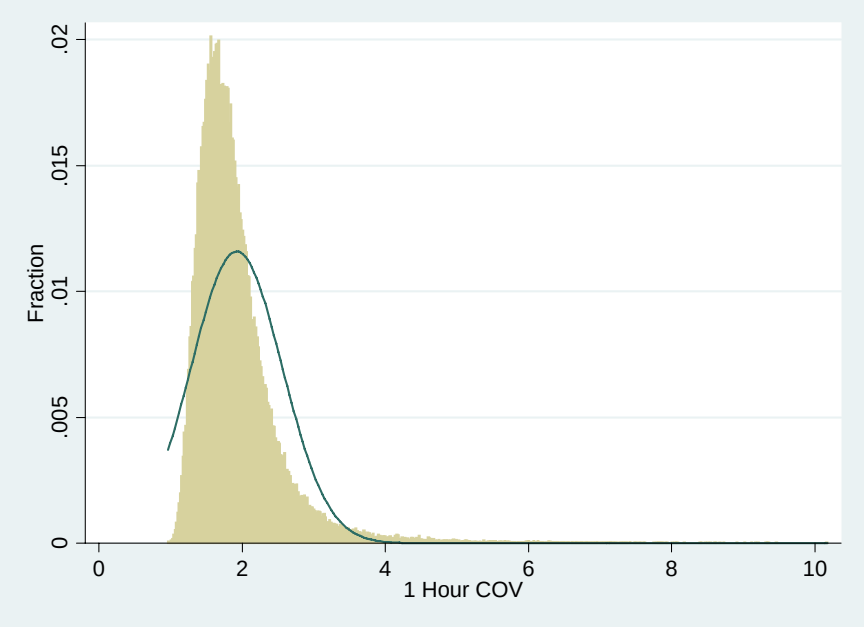


Figure 10. Histogram of COV for 1-Hour Average SO_2 Concentrations



Figures 11 through 13 display histograms for the 5-minute maximum SO_2 concentrations in a manner that is consistent with Figures 8 through 10. Again, we find that the averages do not appear to be normally distributed. These results make us skeptical about the approach adopted by EPA to assign PMRs for the purpose of predicting 5-minute maximum SO_2 concentrations, which relies on the COV.

Figure 11. Histogram of Averages for 5-Minute Maximum SO_2 Concentrations

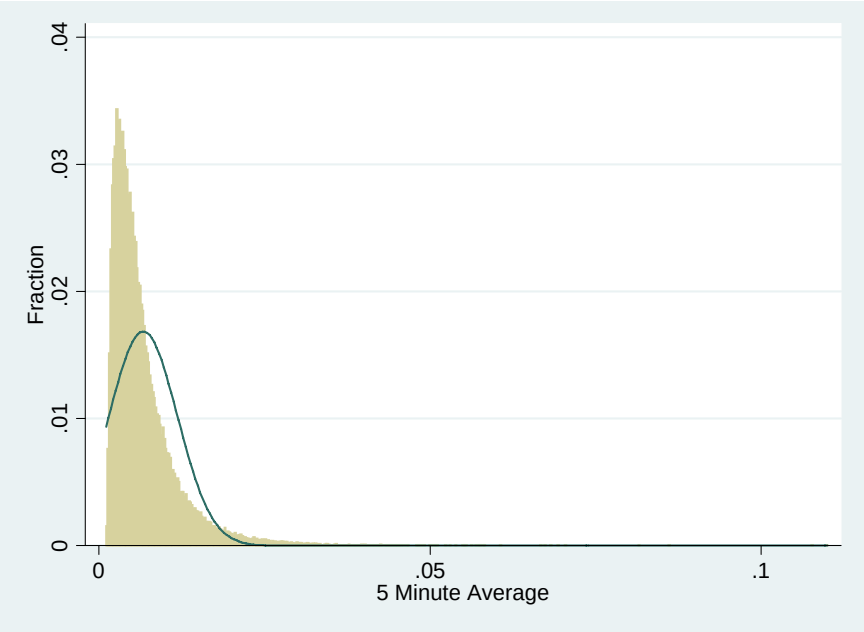


Figure 12. Histogram of Standard Deviations for 5-Minute Maximum SO_2 Concentrations

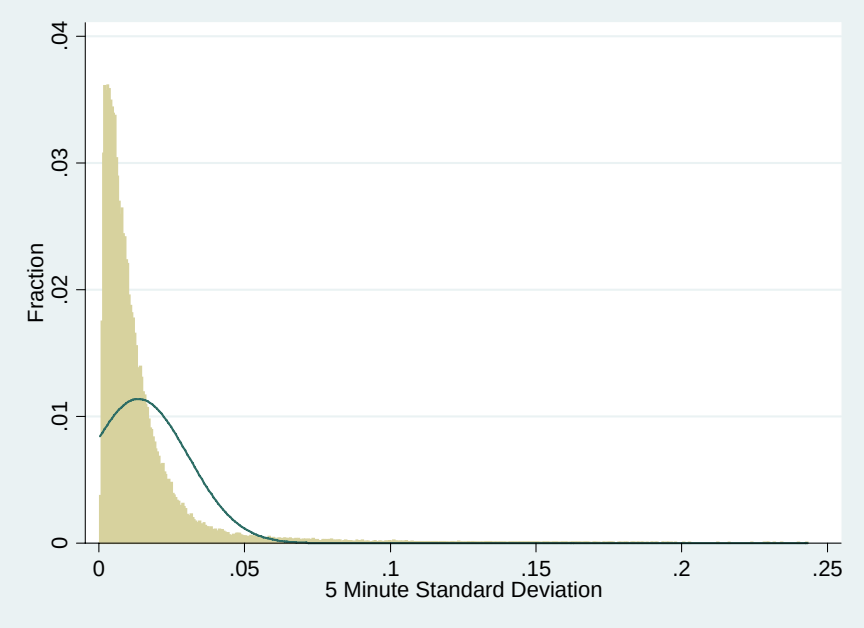
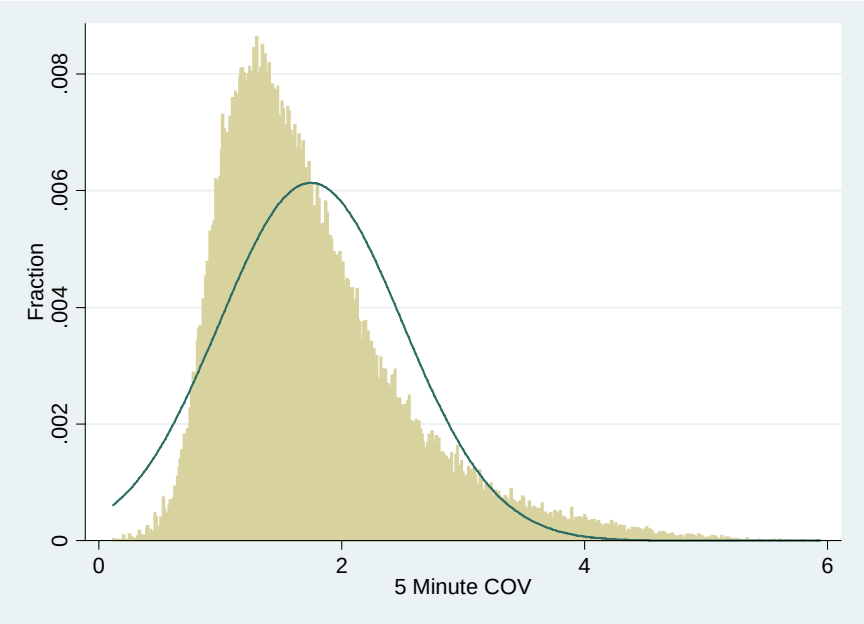


Figure 13. Histogram of COV for 5-Minute Maximum SO_2 Concentrations



B. A Considerable Portion of the Peak-to-Mean Ratios Are Invalid

EPA's PMR is the ratio of the 5-minute maximum SO_2 concentration to the 1-hour average SO_2 concentration. The peak-to-mean ratios (PMRs) used by EPA are calculated using Equation 6-1 of the REA Draft 1,[23] following analyses developed in Thompson (2000).[24] We have applied Equation 6-1 to our linked 5-minute/1-hour data to generate the PMRs. We find that nearly 30 percent of these PMRs are less than one or exceed 12.[25] Moreover, of the remaining nearly 2.1 million "valid" PMRs that we are able to calculate, over 35 percent are *exactly one*.[26]

Therefore, with the monitor data obtained from EPA, to obtain "valid" PMRs, one must exclude one-third of the observations as the result of potential monitor measurement problems. Of the remaining PMRs, one-third indicate that the 5-minute maximum and 1-hour average SO_2 concentrations are identical (i.e., they are exactly equal to one). Most of these result from concentrations at or below the lower limit of detection of

[23] REA Draft 1, p.36.
[24] REA Draft 1, p.39.
[25] Specifically, 921,217 out of 2,999,331 possible PMRs are less than one or exceed 12. Following Thompson (2000), EPA excludes all PMRs less than one or greater than 12, which results in nearly 2.4 million "valid" PMRs (REA Draft 1, p.40).
[26] Specifically, 731,848 of 2,078,114.

0.003 ppm.[27] Thompson (2000) also reports a considerable number of invalid PMRs in the earlier time period she analyzed.[28] We believe that these results raise questions regarding the reliability of PMRs.

Nevertheless, using the "valid" PMRs that it calculates, EPA then develops a cumbersome matching algorithm to assign PMRs to each 1-hour monitor that does not have a corresponding 5-minute maximum observation.[29] This algorithm is based, in part, on the COVs, which we believe are inappropriate for monitor data. First, EPA stratifies each monitor to a bin based on its hourly COV. Namely, monitors with a COV of 100 percent or less are assigned to one bin. Monitors with a COV of greater than 100 to 200 percent or less are assigned to a second. Monitors with a COV of greater than 200 are assigned to a third bin. Second, EPA stratifies the PMRs by five different concentration ranges based on their cumulative density functions (CDFs).[30] Based on these various stratifications, each monitor is assigned to one of 13 possible PMR CDFs. Using random sampling from the CDFs, a single PMR is then assigned to each 1-hour monitor that lacks a 5-minute measurement. Finally, 5-minute maximum SO_2 concentrations are predicted, by hour, based on the assigned PMR.

C. There Are Standard Statistical Methods to Predict Exceedances

EPA's method for predicting 5-minute maximum values from 1-hour values is cumbersome, however, it is also a concern that this method relies on the COVs which may be inappropriate for monitor data and PMRs that display unusual characteristics. We believe that EPA should explore other statistical methods to estimate directly the likelihood of exceedances of, for example, 0.4 ppm in 5-minute maximum SO_2 concentrations.[31] Such methods could be based on parametric relationships between 5-minute maximum and 1-hour average SO_2 concentrations.[32] Such methods would have statistical properties that are much better understood, particularly with respect to sampling variability and the potential for prediction bias. In turn, EPA could, in a straightforward manner, quantify the range of statistical uncertainty if it rolls up from as-is conditions to hypothetical conditions that just meet current standards.

[27] Specifically, for those 731,848 PMRs that are exactly one, 557,105 are at or below 0.003 ppm.
[28] Thompson (2000) unpaginated.
[29] EPA includes PMRs of exactly one in the set of "valid" PMRs.
[30] REA Draft 1, p.40. The PMR CDFs are calculated using only "valid" PMRs.
[31] Standard statistical methods have been developed under the name of "Extreme Value Theory."
[32] Parametric distributions and estimation approaches are discussed in detail in Rolf-Dieter Reiss and Michael Thomas, *Statistical Analysis of Extreme Values: with Applications to Insurance, Finance, Hydrology and Other Fields*, 2nd Edition, ISBN 978-3764364878.

VI. Conclusions

Exceedances of the 5-minute SO_2 standards are declining and are rarely observed in the data on which EPA relies. This is a feature of the data that EPA does not directly address in the REA Draft 1. EPA should review the statistics literature on estimating so-called "rare events" and explore whether the statistical techniques used in that literature are more appropriate than the methods upon which it currently relies. The statistical properties of those methods are better and more widely understood than methods that rely on coefficients of variation and peak-to-mean ratios.

Because we cannot replicate the analyses in Chapter 6 and 7 using data obtained from EPA, we also believe that EPA should produce a detailed technical appendix, published online or provided on request, which contains complete monitor data and the computer code used to generate its analyses.

Finally, EPA's roll-up factors are not credible and should be abandoned. But if EPA persists in using a roll up procedure, it should quantify the statistical uncertainty associated with exposure and risk estimates that result from that procedure. It should also describe the reasons that make such hypothetical events highly unlikely under the full body of regulations that exist under the Clean Air Act.