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Advisory on Plans for Emissions Estimation in the Analytical Plan for EPA's Second Prospective Analysis – Benefits and Costs of the Clean Air Act, 1990-2020; An Advisory by the Advisory Council for Clean Air Compliance Analysis

January 20, 2004

EPA-SAB-COUNCIL-ADV-04-001

The Honorable Michael O. Leavitt
Administrator
U S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Subject: Advisory on Plans for Emissions Estimation in the Analytical Plan for EPA's Second Prospective Analysis – Benefits and Costs of the Clean Air Act, 1990-2020; An Advisory by the Advisory Council for Clean Air Compliance Analysis

Dear Administrator Leavitt:

The Air Quality Modeling Subcommittee (AQMS) of the Advisory Council on Clean Air Compliance Analysis (Council) has prepared this Advisory to guide the Agency as it estimates emissions of air pollutants to be controlled as a result of implementation of the Clean Air Act. Estimating these "emission inventories" is one of the first steps in the analysis required to assess the benefits and costs of the Clean Air Act. The Council is issuing this report as the first piece of advice that the Council will provide to the Agency on the validity and reliability of the data, models, and methodologies proposed for the analysis. The Council is providing this advice, as charged by Congress under Section 812 of the Clean Air Act Amendments of 1990.

The AQMS based this Advisory on a review of the Agency document, *Benefits and Costs of the Clean Air Act 1990-2020 Revised Analytical Plan for EPA's Second Prospective Analysis* (Analytical Plan). The AQMS held a public meeting on June 12, 2003 to receive briefings from the Agency and to provide advice related to the Agency's plans to estimate emissions. The Air Quality Modeling Subcommittee further discussed this topic, and a draft report members of the AQMS developed after the June 12, 2003 meeting, at a public teleconference on July 11, 2003. The Council reviewed this report and is providing this advice to the Agency at this time because development of emissions estimates is the key first step in developing this major study.

The AQMS found that the plans for emission inventory development were generally sound and should proceed, but additional action was required in several areas. Specifically, the EPA should:

- Expand documentation to provide sufficient detail to enable a thorough review of critical emission estimation methodologies;
- Improve estimates of the emissions of particulate matter and particulate matter precursors, because the largest benefits associated with implementing the Clean Air Act will likely be due to reducing particulate matter impacts; and
- Continue to develop an uncertainty framework for emissions development and testing.

The AQMS and the Council believe that the quality of the study will benefit significantly from improved quality and transparency of data and methods in these areas.

We appreciate the opportunity to review the Analytical Plan and provide you with advice on emissions inventory development. The Council would be pleased to expand on any of the findings described in this report and we look forward to your response

Sincerely,

/Singed/	***/Singed/***
Dr. David Allen, Chair Air Quality Modeling Subcommittee	Dr Trudy Cameron, Chair Advisory Council on Clean Air Compliance Analysis

NOTICE

This report has been written as part of the activities of the EPA Advisory Council on Clean Air Compliance Analysis (Council), a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The Council is structured to provide balanced, expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency and, hence, the contents of this report do not necessarily represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names of commercial products constitute a recommendation for use.

U.S. Environmental Protection Agency
Advisory Council on Clean Air Compliance Analysis
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TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

The Air Quality Modeling Subcommittee (AQMS) of the Advisory Council on Clean Air Compliance Analysis (Council) is charged with reviewing air quality modeling components of cost benefit analyses of the 1990 Clean Air Act Amendments. Specifically, the AQMS, and the Council, are directed to address the following issues:

a) Are the input data used for each component of the analysis sufficiently valid and reliable for the intended analytical purpose?
b) Are the models, and the methodologies they employ, used for each component of the analysis sufficiently valid and reliable for the intended analytical purpose?
c) If the answer to either of the two questions above is negative, what specific alternative assumptions, data or methodologies does the Council recommend the Agency consider using for the second prospective analysis?

The AQMS and the Council will be providing commentary and guidance on EPA plans for assessing the benefits and costs of the Clean Air Act as those analyses are conducted in 2003 and 2004. One of the first steps to be undertaken in the analysis will be development of emissions inventories. To guide the Agency's initial activities in emission inventory development, the AQMS has prepared this Advisory. EPA plans for emission inventories development are described in the review document, *Benefits and Costs of the Clean Air Act 1990-2020 Revised Analytical Plan for EPA's Second Prospective Analysis* (Analytical Plan).

The AQMS found that the plans for emission inventory development were generally sound and should proceed, but additional action was required in several areas. Specifically, the EPA should:

- Expand documentation – the current analytical plan and its technical appendices do not provide sufficient detail to enable the AQMS to perform a thorough review of critical emission estimation methodologies.
- Improve the particulate matter (PM) inventory - Developing accurate estimates of the emissions of PM and PM precursors is critical because the largest benefits in the analysis will likely be due to reducing PM impacts. Among the most significant uncertainties are the composition and size distributions of primary particulate emissions, ammonia emissions, emissions from fires, fugitive dust emissions, and emissions of secondary organic aerosol (SOA) precursors.
- Continue to develop an uncertainty framework - During the first prospective analysis of costs and benefits of the Clean Air Act Amendments, the AQMS suggested to EPA that formal emissions development and testing guidelines be established and this continues to be a significant need. The AQMS commends the EPA on its responsiveness to Council specific recommendations from the first prospective analysis, which suggested comparing previous forecasted emissions with actual emissions (e.g., comparing the forecasts for 1999/2000 emissions based on 1990 data to the current emissions estimates for those years) These analyses can lead to considerable insight into the magnitude and nature of

emission forecasting uncertainties and should be performed each time that a new inventory, previously forecast, is available. In addition, to characterize uncertainties, the EPA should whenever possible use multiple and redundant sources of information in its emissions estimates. For example, state and national level on-road emission estimates can be estimated with activity-based emission models such as MOBILE6 (which employs miles traveled) and with alternative models based on fuel consumption. The use of multiple models will either provide more confidence in emission estimates or will identify areas that need improvement.

2. INTRODUCTION

2.1. Background on this Advisory

The purpose of this Advisory is to provide commentary and guidance on EPA plans for developing emissions inventories described in the May 12, 2003 review document, *Benefits and Costs of the Clean Air Act 1990-2020· Revised Analytical Plan for EPA's Second Prospective Analysis* (Analytical Plan).

The Air Quality Modeling Subcommittee (AQMS) of the Advisory Council on Clean Air Compliance Analysis (Council) held a public meeting on June 12, 2003 to receive briefings and conduct preliminary discussions of major topics related to the approach to emission inventory development described Analytical Plan. One of the members of the Advisory Council on Clean Air Compliance Analysis, Special Council Panel for the Review of the Third 812 Analysis, who was added to the Council especially to address issues associated with analysis of uncertainty, joined the meeting. In their discussions, members focused on issues related to the Agency's plan to develop emissions inventories. They prepared written comments related to the review document and responded to several charge questions from the Agency related to emissions. The charge questions are listed in Section 2.2. The AQMS held a public teleconference on July 11, 2003 to discuss its advice. The Council held a public teleconference on July 15, 2003 and September 23, 2003 to discuss this advice. On September 23, 2003, the Council accepted the report to forward to the EPA Administrator.

In its review of the analytical plan, the Council and AQMS are guided by the Council mandate, as identified in the Clean Air Act Amendments (CAA) of 1990,

a) Are the input data used for each component of the analysis sufficiently valid and reliable for the intended analytical purpose?

b) Are the models, and the methodologies they employ, used for each component of the analysis sufficiently valid and reliable for the intended analytical purpose?

c) If the answer to either of the two questions above is negative, what specific alternative assumptions, data or methodologies does the Council recommend the Agency consider using for the second prospective analysis?

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[1] Specifically, subsection (g) of CAA § 312 (as amended by Section 812 of the amendments) states "*(g) The Council shall -- (1) review the data to be used for any analysis required under this section and make recommendations to the Administrator on the use of such data, (2) review the methodology used to analyze such data and make recommendations to the Administrator on the use of such methodology, and (3) prior to issuance of a report required under subsection (d) or (e), review the findings of such report, and make recommendations to the Administrator concerning the validity and utility of such findings*"

2.2. Charge Questions Related to Emissions

EPA identified charge questions related to emissions, which are listed below. The Charge Questions are excerpted from the list of charge questions provided by the Agency on May 12, 2003 and the question numbers listed below are drawn from the May 12 document.

> Charge Question 3: Does the Council support the alternative compliance pathway estimation and comparison methodology described in chapter 2, including the specification of alternative compliance pathways which may not reflect precisely constant emissions or air quality outcomes between scenarios due (primarily) to the non-continuous nature and interaction effects of emission control options?
>
> Charge Question 4: Does the Council support the plans for estimating, evaluating, and reporting emissions changes as defined in chapter 3? If there are particular elements of these plans which the Council does not support, are there alternative data or methods the Council recommends?
>
> Charge Question 5: Chapter 3 of the analytical plan describes several alternative approaches considered by EPA for estimating non-EGU emissions growth rates. These options reflect different relative emphasis between two conflicting analytical objectives: (1) extensive refinement of the geographically-differentiated, source-specific economic activity growth estimates embedded in EGAS 4.0, and (2) maintaining the current project schedule and budget. EPA plans to use "approach #4", a compromise option which targets the most important source categories for potential refinement. Does the Council support the initial plan to use "approach #4"? If the Council does not support the use of approach #4, are there other approaches –including either the approaches described in chapter 3 or others identified by the Council– which the Council suggests EPA consider?
>
> Charge Question 6: Some state-supplied emissions data incorporated in the 1999 National Emissions Inventory (NEI) –the core emissions inventory for this analysis– incorporate different emissions factors from those used in MOBILE6, the mobile source emissions model EPA plans to use for estimating emissions changes between scenarios. Of particular importance, some of the emissions factors embedded in California's EMFAC model may be significantly different from factors used in MOBILE6 EPA considered three options for estimating emissions changes in California, which are described in chapter 3. EPA plans to implement option #3 based on the belief that the emission factors embedded by California in its EMFAC model may be more accurate for their particular state than the factors incorporated in MOBILE6. Does the Council support the plan to implement option #3? If the Council does not support the adoption of option #3, are there other options –including either the options described in chapter 3 or others identified by the Council– which the Council suggests EPA consider?

3. RESPONSES TO CHARGE QUESTIONS RELATED TO EMISSIONS

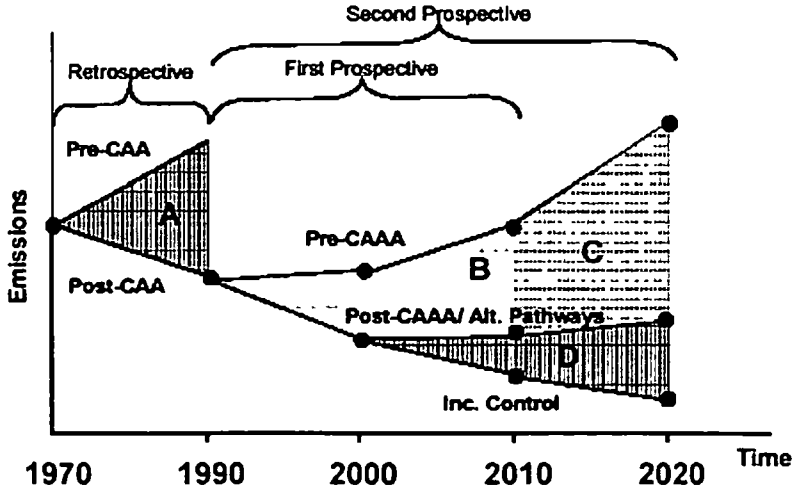
The Council's preliminary responses to the charge questions related to emissions are provided below. Development of emission inventories is one of the first steps to be undertaken in performing a cost-benefit assessment of the Clean Air Act Amendments, and the intent of the Air Quality Modeling Subcommittee and the Council in providing these responses to charge questions is to inform the Agency's initial development of emission inventories. The Subcommittee and the Council may revisit these questions as the Agency further develops emission inventories and as the Subcommittee and Council consider additional charge questions.

Responses to charge question 3 focus on the development of emission scenarios; responses to question 4, 5 and 6 address the methods of emission estimation, the methods used to "grow" emission inventories for future years, and the consistency of emission inventories from multiple information sources, respectively. Methods for dealing with uncertainty are addressed in each of these areas. In addition, the Council has integrated its advice related to emissions uncertainty into a set of summary comments.

Agency Charge Question (3): Does the Council support the alternative compliance pathway estimation and comparison methodology described in chapter 2, including the specification of alternative compliance pathways which may not reflect precisely constant emissions or air quality outcomes between scenarios due (primarily) to the non-continuous nature and interaction effects of emission control options?

Response to Agency Charge Question (3): The EPA proposed to identify 3 scenarios and 5 pathways in the May 12, 2003 document describing the Second Prospective analysis. This was subsequently modified to 3 scenarios and 3 pathways in a June 26, 2003 revision. The scenarios and pathways are illustrated conceptually in Exhibit 2-7 from the Analytical Plan, which is reproduced below.

Exhibit 2-7: Comprehensive Schematic of Section 812 Scenarios and Emissions over Time



As described in the draft Analytical Plan, the three scenarios include a base scenario of controls and two types of supplemental scenarios, described as alternative pathway scenarios and increased control scenarios. For the alternative pathway analyses, EPA plans to assess a redistribution of emissions reductions across source categories. EPA also proposes to examine the costs and benefits of standards more stringent than those required by the CAAA.

The 3 pathways in the current version of the Analytical Plan represent scenarios for the redistribution of controls across source categories and are described in the June 26 modification to the Analytical Plan as follows

- **Pathway 1:** This pathway would reflect the electric generating unit cap and trade proposals included in the Clear Skies Initiative. These proposals include emissions caps of 3 million tons, 1.7 million tons, and 15 tons for sulfur dioxide (SO_2), nitrogen oxides (NO_x), and mercury respectively for the year 2018. With this pathway's emphasis on emissions caps and allowance trading, other control methods included in the post-CAAA scenario would be eased since they would not be necessary for core CAAA compliance.
- **Pathway 2:** The second pathway tightens NO_x and VOC emissions restrictions on motor vehicles while loosening CAAA regulation of other source categories. The specific control programs would include: (a) expansion of Federal reformulated gasoline to the entire Ozone Transport Assessment Group (OTAG) region, and (b) application of enhanced inspection and maintenance (I/M) in metropolitan statistical areas and consolidated metropolitan statistical areas with 2000 population greater than 500,000. EPA is also exploring options to reflect additional measures beyond expanded reformulated gasoline and enhanced I/M programs as part of this scenario.
- **Pathway 3:** This pathway combines pathways 1 and 2 and eases other controls so that emissions remain at post-CAAA levels.

The AQMS had several concerns about the development of emission inventories for these scenarios and pathways. The concerns are described below and fall into four general categories:

1. Equivalency of the scenarios
2. Emission projections
3. Temporal interpolation of emissions
4. PM composition and choice of control scenarios

Equivalency of the scenarios: The Analytical Plan suggests that EPA would ideally consider alternative pathway scenarios that lead to the same air quality benefits, but given the difficulty of identifying such scenarios, the EPA will consider scenarios that lead to the same amounts of overall emission reductions on a tonnage basis. AQMS members had multiple reservations about this approach. One set of concerns was due to variations in uncertainties in emissions and emissions projections, which depend on source category. Because of differences in uncertainties, different pathways that lead to the same nominal estimate of emissions may have significantly different uncertainties. The EPA should characterize the differences in uncertainties associated with the alternative pathways. A second set of concerns was associated with differences in composition of volatile organic compound emissions and spatial and temporal

patterns of emissions associated with different pathways. For example, mobile source emissions have very different daily patterns of emissions and different emission locations than point sources EPA should thus consider not only the uncertainties associated with differences in the costs of the various pathways, but also uncertainties associated with the differences in benefits. Different pathways may also be implemented with different schedules. The EPA should consider differences in compliance schedules associated with the alternative pathways.

Emission Projections: The AQMS expressed concern about the substantial uncertainty associated with any projection to 2020. More specifically, there was concern about how the EPA would develop assumptions regarding the controls that would be promulgated through State Implementation Plans (SIPs). Because the 812 study will be so dependent upon rules developed through SIPs and Office of Air Quality Planning and Standards (OAQPS) actions, the AQMS needs a clear understanding of the work underway at OAQPS. In general, the analytical plan relies too heavily on assertions that work or methods developed at OAQPS will be central or used in 812, without adequately presenting the methods, data sources, and quality of analysis and review of these works. Reports and appendices for the most critical OAQPS efforts need to be made available to the AQMS.

Temporal Interpolation of Emissions: AQMS members also had concerns about estimates of emissions projections. In the 812 analysis, annual cost and benefits of the CAAA for each year in the period 1990-2020 will be estimated, but emissions and air quality modeling information will be available only for the years 1990, 2000, 2010 and 2020. AQMS members noted that information on air quality benefits would need to be interpolated for years other than 1990, 2000, 2010 and 2020 and that the method of interpolation could have an impact on cost and benefit calculations. The uncertainties associated with the interpolation could be examined by performing emission and air quality analyses for additional years, however, this approach would require a substantial effort. Given the uncertainties associated with other parts of the 812 analyses, the AQMS suggests that the choice of interpolation scheme is not likely to be a dominant source of uncertainty. Nevertheless, interpolation of benefits should not be ignored as a source of uncertainty. Therefore, the AQMS suggests that, as part of the sensitivity analyses performed for the cost-benefit analysis, hypothetical alternative interpolation schemes be employed.

PM Composition and Choice of Control Scenarios: The PM NAAQS are based on total PM mass As the second prospective study evolves, EPA should recognize that different strategies for reaching the PM NAAQS lead to differences in PM composition. Evidence is growing that different PM components have different toxicities. Thus, differences in composition may lead to differences in health benefits. The EPA should consider performing sensitivity analyses associated with different assumptions about the relative distributions of toxicities of PM arising from different control strategies.

Agency Charge Question (4): Does the Council support the plans for estimating, evaluating, and reporting emissions changes as defined in chapter 3? If there are particular elements of these plans which the Council does not support, are there alternative data or methods the Council recommends?

Response to Agency Charge Question (4): Recommendations related to emission estimation methods are organized into: a) those related to ozone precursors (volatile organic compounds, VOCs and oxides of nitrogen, NOx); b) those related to PM and PM precursor emissions; and c) those related to the case study of hazardous air pollutants (HAPs). The estimation methods associated with each of these emission categories are described below.

Emission inventories for ozone precursors [volatile organic compounds (VOCs) and oxides of nitrogen (NOx)]: The method proposed for developing base year (2000) emission inventories, specifically the use of the 1999 National Emission Inventory (NEI99) scaled to represent the year 2000, is generally sound Use of the most recent version of the NEI99, Version 3 (v3), is proposed, however, depending on when the emission inventory is developed, it may be more appropriate to use the NEI99 v2 inventory. As of mid-2003, only the first submission of the NEI99 v3 is available and this version has not undergone quality assurance by EPA and revisions by the states to address EPA's quality assurance concerns. In contrast, the NEI99 v2 has undergone quality assurance processes.

Regardless of which version of the NEI is used, additional issues will arise. One issue, not addressed in the analytical plan, is how the methods used to estimate emissions for Canada and Mexico compare to those used in the NEI. Another issue will be the assignment of specific compounds to point source VOC emissions reported in the NEI. The states have expended considerable effort in characterizing composition profiles, and therefore the overall reactivity, of point source emissions, and these profiles are in some cases considerably different from EPA's national average profiles. While the effort required to employ all state generated point source profiles is likely beyond the scope of the current cost-benefit (812) assessment, the EPA should consider performing sensitivity analyses using inventories of point source emissions generated by individual states. Texas should be one of the states used to explore the differences between state estimated emission compositions and national average values because these differences are known to be large in Houston, because exceptional effort was expended by the state to develop robust emissions estimates, and because the Houston inventory will be examined in detail for the case study of benzene emissions.

While use of the NEI99, scaled to 2000, is recommended as the primary source of emissions data, specific emission source categories may require additional attention For on-road mobile source emissions, the use of the MOBILE6 model, as described in the draft analytical plan, is appropriate for estimating on-road mobile source emissions outside of California However, the EPA should recognize that a number of recent analyses have suggested that MOBILE6 estimates of ozone precursor emissions are inconsistent with data collected in tunnels or in aircraft overflights of highways. Therefore, it may be appropriate to conduct sensitivity analyses that specifically address this uncertainty. For non-road mobile sources, the new EPA NONROAD model is the most appropriate model for estimating non-road mobile source emissions outside of California, as suggested in the draft analytical plan. However, recent studies by states have suggested that activity factors for construction vehicles may differ substantially from the values assumed in the models. Again, it may be appropriate to conduct sensitivity analyses that specifically address this uncertainty. The procedures described in the draft analytical plan for estimating non-road source emissions for the three subcategories not in the NONROAD model (i.e., locomotives, aircraft and commercial marine) also seem appropriate.

The EPA should note that, in California, the ARB OFFROAD non-road mobile source model is used to estimate emissions, and these can be different from the NONROAD model. The EPA should pursue discussions with the California Air Resources Board (ARB) about obtaining emission estimates for the non-road mobile source sector in California.

For biogenic emissions, which will drive atmospheric reactivity in much of the United States, the use of the latest version of the biogenic emission inventory system (BEIS3), as described in the draft plan, should improve biogenic emissions including the specification of many more biogenic VOC components.

Emission inventories for PM and PM precursors: Developing accurate estimates of the emissions of PM and PM precursors is critical for this cost-benefit (812) assessment because the largest health effects in the 812 analysis will likely come from the PM impacts. The most important components of PM in the eastern US are sulfate, organic carbon (OC), elemental carbon, nitrate and ammonium. In the west, nitrate concentrations are higher than in the east. Therefore, inventories of the emissions of these components of PM, and their precursors, deserve significant attention, however, significant uncertainties remain in many of these inventories. Among the most significant uncertainties are those associated with the composition and size distributions of primary particulate emissions, ammonia emissions, emissions from fires, fugitive dust emissions, and emissions of secondary organic aerosol (SOA) precursors.

The magnitude of PM emissions is obviously important in estimating the ambient concentrations of PM, but the importance of the composition and size distributions may be less clear. Size distributions have a significant impact on the atmospheric lifetime of particles; both size and composition also have a significant effect on the visibility impacts of the particles and may have an effect on the human health impacts of the particles. Inventories of PM emissions have relatively little information on the composition and size distributions of PM, therefore the analytical plan should describe in detail the assumptions that will be made to address this data gap.

For ammonia, recent studies indicate that the ammonia emissions in the NEI99 and the procedures used to spatially and temporally distribute those emissions in air quality models are incorrect. Available ammonia emission inventory development and improvement studies should be considered in developing the plan for estimating ammonia emissions and more information on how ammonia emissions will be modeled should be incorporated into the analytical plan.

Emissions from fires are highly uncertain. Agricultural burns, prescribed burns and wildfires will locally dominate PM emissions when they occur. Because wildfires have been suppressed over the last century, there has been a build up of biomass that would have normally been cleaned out with regular fires. This has led to an increase in larger wildfires in recent years (e.g., 2000 and 2002) and the development of fire management plans to perform more off-season prescribed burns to prevent catastrophic wildfires. The draft analytical plan does not document how fire emissions will be estimated for 1990 and 2000, but implies that actual emission estimates may be used. Given the year-to-year variability in wildfire emissions and the overall goal of the 812 analysis (documentation of long-term costs and benefits of the Clean Air Act Amendments), it may be more appropriate to use long term average emissions, rather than emissions from any one year that may be atypically high or low.

For fugitive dust emissions from paved and unpaved roads, the draft analytical plan states that emissions estimates will be multiplied by 0.25, which assumes that 75% percent of the emissions are not transported beyond the immediate vicinity of the roadway. The justification for this number is not provided. Some rationalization for the choice of transportable fraction should be provided. Methods for estimating fugitive dust from agricultural operations are described in the draft analytical plan, but the draft analytical plan is silent on the methods to be used for all other wind-blown, fugitive dust sources. These sources can be important locally, and can be important regional sources in the arid southwest. Methods for estimating the strength of these sources should be described in the analytical plan.

There is an increasing body of evidence suggesting that biogenic hydrocarbons may be important PM precursors in many parts of the United States. To accurately predict organic PM formation due to the reactions of biogenic emissions (biogenic secondary organic aerosol, biogenic SOA), it is necessary to know both the magnitude and composition of the emissions In addition, the characterization of the composition of the biogenic emissions provided by the emission model must be compatible with the chemistry module used in the air quality model The use of the BEIS3 emission inventory estimation methods, as described in the draft analytical plan, should improve estimates of the magnitude and composition of biogenic emissions. However, no documentation is provided on how the PM air quality model (REMSAD Version 7.06) will treat SOA. The reference to documentation provided in the draft analytical plan on REMSAD in Appendix B is for a previous version of the model (Version 7.03). This is a deficiency in the analytical plan that should be corrected. The AQMS will review modeling of SOA formation when it receives documentation on modeling protocols, and a focus of the review will be the extent to which emission composition information is used in models of SOA formation.

While biogenic emissions are expected to be important SOA precursors in many parts of the US, anthropogenic emissions of SOA precursors (especially aromatic species) may be very important in urban areas. As with biogenic emissions, both the magnitude and composition of the anthropogenic SOA precursor emissions must be known and the characterization of the composition of the emissions must be compatible with the chemistry module used in the air quality model. These issues should be addressed in the analytical plan.

Emission inventories for the HAP case study: The draft analytical plan proposes to use the costs and benefits of benzene controls in the Houston area as a case study for assessing the costs and benefits of HAP controls. This is a sound approach and the choice of this particular case study (benzene in Houston) will allow the EPA access to a very robust set of emission estimates and ambient measurements collected by the State of Texas. The draft analytical plan does not refer to any of these sources of information, however. The EPA should work with the Texas Commission on Environmental Quality (TCEQ) to obtain the most recent data available on benzene emissions in the Houston-Galveston area, particularly for point sources. In addition, it is recommended that the EPA extend the study region beyond Harris County, which is the domain specified in the analytic plan. The county boundary does not include either the entire industrial or the entire urban region, and since detailed emissions and monitoring data are available from the TCEQ for the broader airshed, the domain for the HAP analysis should be expanded to include all of the major sources and receptor sites in the region.

Agency Charge Question (5): Chapter 3 of the analytical plan describes several alternative approaches considered by EPA for estimating non-EGU emissions growth rates. These options reflect different relative emphasis between two conflicting analytical objectives: (1) extensive refinement of the geographically-differentiated, source-specific economic activity growth estimates embedded in EGAS 4.0, and (2) maintaining the current project schedule and budget. EPA plans to use "approach #4", a compromise option which targets the most important source categories for potential refinement. Does the Council support the initial plan to use "approach #4"? If the Council does not support the use of approach #4, are there other approaches – including either the approaches described in chapter 3 or others identified by the Council– which the Council suggests EPA consider?

Response to Agency Charge Question (5): The Council has interpreted this charge question, together with charge question 4, to encompass all of the emission forecasting methods to be used in the analysis. The Council's advice on emission forecasting is given below, and includes recommendations for characterizing forecasting uncertainties.

For Electrical Generating Units (EGUs), the approach to use the Integrated Planning Model (IPM) for EGU projections appears to be the most scientifically valid approach, with the following caveat. During the Ozone Transport Assessment Group (OTAG) process, concerns were raised about the IPM being a proprietary model with restricted access. The public and stakeholders could not gain access to the model and its underlying data. No mention of whether IPM continues to be a restricted access proprietary model is made in the analytical plan. EPA is discouraged from using restricted access proprietary models for making public policy decisions such as the Section 812 analysis.

Among the non-EGU sources, the approaches outlined in the plan appear to be reasonable given the time and resource limitations associated with the 812 analysis.

The most significant comments that the AQMS had on the emission forecasting procedures documented in the draft analytical plan dealt with the estimation of uncertainty. The Subcommittee commends the EPA on their responsiveness to Council recommendations from the first prospective analysis, which suggested comparing previous forecasted emissions with emission inventory estimates compiled after the emissions took place (e g., comparing the forecasts for 1999/2000 emissions based on 1990 data to the current emissions estimates for those years). These analyses can lead to considerable insight into the magnitude and nature of emission forecasting uncertainties and should be performed each time that a new inventory, previously forecast, is available. The analysis should include assessment and documentation of the differences between current and previously forecast inventories, documentation of the reasons for observed differences, and assessment of the degree to which previous uncertainty estimates captured observed differences. This final task is particularly important. Even in fields with well established procedures for estimating uncertainties (such as measurements of elementary particle masses by physicists), it is found that traditional statistical procedures for estimating standard errors and uncertainties systematically understate actual uncertainties as later calculated by comparing improved measurements with older measurements and previously estimated uncertainties (Shlyakhter, 1994a,b; Shlyakhter and Kammen, 1994; Hattis and Burmaster, 1994). Low estimates of uncertainty prevail because traditional statistical uncertainty estimation

approaches tend to be based solely on random sampling-error uncertainties in the data, neglecting what frequently turns out to be appreciable systematic or calibration errors. Developing fair estimates of uncertainties for the CAAA benefit and cost projections will require analysts to have inputs that can be interpreted in terms of both random and systematic uncertainties. Systematic evaluation of the extent and reasons for changes in successive sets of emissions estimates will be a start toward providing invaluable inputs to the overall uncertainty analysis. EPA's uncertainty analysis would also benefit from consideration of the results from a comprehensive review of BEIS3 uncertainty contained in two reports (Hanna et al., 2002, 2003) not referenced in the Draft Analytical Plan.

Agency Charge Question (6): Some state-supplied emissions data incorporated in the 1999 National Emissions Inventory (NEI) –the core emissions inventory for these analysis– incorporate different emissions factors from those used in MOBILE6, the mobile source emissions model EPA plans to use for estimating emissions changes between scenarios. Of particular importance, some of the emissions factors embedded in California's EMFAC model may be significantly different from factors used in MOBILE6. EPA considered three options for estimating emissions changes in California, which are described in chapter 3. EPA plans to implement option #3 based on the belief that the emission factors embedded by California in its EMFAC model may be more accurate for their particular state than the factors incorporated in MOBILE6. Does the Council support the plan to implement option #3? If the Council does not support the adoption of option #3, are there other options –including either the options described in chapter 3 or others identified by the Council– which the Council suggests EPA consider?

Response to Agency Charge Question (6): The Council has interpreted this charge question, together with charge questions 4 and 5, to broadly encompass issues of consistency in emission estimation and forecasting methods to be used in the analysis. The Council's advice on consistency in emission estimation and forecasting is given below.

Emission estimates (both base case and forecast), based on a consistent application of well-documented procedures, are the foundation of the 812 analysis. By using the NEI99 as the core of the emission inventory, the EPA is emphasizing consistency in emissions estimates. This consistency must come at the expense of some accuracy since there are many cases where emission estimates more reliable than the NEI are available, but these estimates are available for only certain regions. This is particularly true for the case of California, where alternative methods for estimating emissions, particularly mobile source emissions, have been in place for some time.

Because emission estimation methodologies employed in California are significantly different from those used in all other states, the EPA should coordinate with the California's Air Resources Board to use the California-estimated mobile source emissions. If sufficient resources are available, the EPA should consider assembling inventories based on a stratified sample of several states (designed to represent the universe of states contributing information) and analyze in detail the differences that would be produced in emission inventories by the use of consistent estimating methodology.

Critical Issues and Uncertainty: As noted by a multi-national commission (NARSTO – created as the North American Research Strategy for Tropospheric Ozone), "after 20 years of effort, emission estimates continue to be one of the weakest links in the air-quality management process

and a major source of uncertainty in the development of O_3 control strategies." The significant uncertainties associated with emission inventories, coupled with the nature of emission inventory development (multiple source categories, multiple sources of information of varying quality and significance, and the need to incorporate human factors into estimates) makes quality assurance and uncertainty characterization emission estimation particularly important and difficult.

In this advisory, the AQMS has identified a variety of actions that the EPA could take to improve the emission inventories that will be used in the 812 analysis. The most critical of these actions are:

- Expand documentation – the current analytical plan and its technical appendices do not provide sufficient detail to enable the AQMS to perform a thorough review of critical emission estimation methodologies.
- Improve the PM inventory - Developing accurate estimates of the emissions of PM and PM precursors is critical because the largest benefits in the analysis will likely be due to reducing PM impacts. Among the most significant uncertainties are the composition and size distributions of primary particulate emissions, ammonia emissions, emissions from fires, fugitive dust emissions, and emissions of secondary organic aerosol (SOA) precursors.
- Continue to develop uncertainty framework - During the first prospective analysis of costs and benefits of the Clean Air Act Amendments, the AQMS suggested to EPA that formal emissions development and testing guidelines be established and this continues to be a significant need. The AQMS commends the EPA on their responsiveness to Council specific recommendations from the first prospective analysis, which suggested comparing previous forecasted emissions with emission inventory estimates compiled after the emissions took place (e.g., comparing the forecasts for 1999/2000 emissions based on 1990 data to the current emissions estimates for those years). These analyses can lead to considerable insight into the magnitude and nature of emission forecasting uncertainties and should be performed each time that a new inventory, previously forecast, is available. In addition, to characterize uncertainties, the EPA should whenever possible use multiple and redundant sources of information in their emissions estimates. For example, state and national level on-road emission estimates can be estimated with activity-based emission models such as MOBILE6 (which employs miles traveled) and with alternative models based on fuel consumption. The use of multiple models will either provide more confidence in emission estimates or will identify areas that need improvement.

Finally, the AQMS advises the Agency to employ a variety of modeling tools that will enable predicted emissions to be compared to ambient measurements. These comparisons are among the most important tests of the reasonableness and accuracy of emission inventory inputs to modeling in the 812 analysis.

REFERENCES

Hanna, S., A. Russell, and Wilkinson, J. 2002. Review of BEIS3 Formulation and Consequences Relative to Air Quality Standards: Estimation of Uncertainties in BEIS3 Emission Outputs. Technical report 1005159, Electric Power Research Institute, Palo Alto, California.

Hanna, S., A. et al. 2003. Review of BEIS3 Formulation and Consequences Relative to Air Quality Standards: Estimation of Effects of Uncertainties in BEIS3 Emission on Uncertainties in Ozone Predictions by Chemical Transport Models. Technical report 1005244, Electric Power Research Institute, Palo Alto, California.

Hattis, D. and Burmaster, D. E. 1994. "Assessment of Variability and Uncertainty Distributions for Practical Risk Analyses" Risk Analysis, 14: 713-730.

Shlyakhter, A., and Kammen, D. M. 1992. "Sea-Level Rise or Fall?" Nature, 253:25.

Shlyakhter, A. 1994 "An Improved Framework for Uncertainty Analysis: Accounting for Unsuspected Errors," Risk Analysis 14:441-447.

Shlyakhter, A. 1994. "Uncertainty Estimates in Scientific Models: Lessons from Trends in Physical Measurements, Population and Energy Projections," In Uncertainty Modeling and Analysis: Theory and Application, B. M. Ayyub and M. M. Gupta, Eds., Elseiver Science, B. V., 1994, pp. 477-496.

APPENDIX A

BIOSKETCHES FOR MEMBERS OF THE AIR QUALITY MODELING SUBCOMMITTEE

Dr. David T. Allen, University of Texas, Austin, TX

Dr. David Allen is the Gertz Professor of Chemical Engineering and the Director of the Center for Energy and Environmental Resources at the University of Texas at Austin. His research interests lie in environmental reaction engineering, particularly issues related to air quality and pollution prevention. He is the author of four books and over 125 papers in these areas. The quality of his research has been recognized by the National Science Foundation (through the Presidential Young Investigator Award), the AT&T Foundation (through an Industrial Ecology Fellowship) and the American Institute of Chemical Engineers (through the Cecil Award for contributions to environmental engineering). Dr. Allen was a lead investigator in one of the largest and most successful air quality studies ever undertaken: the Texas Air Quality Study (www.utexas.edu/research/ceer/texaqs). His current research is focused on using the results from that study to provide a sound scientific basis for air quality management in Texas. In addition, Dr Allen is actively involved in developing Green Engineering educational materials for the chemical engineering curriculum. His most recent effort is a textbook on design of chemical processes and products, jointly developed with the U.S EPA. Dr. Allen received his B.S. degree in Chemical Engineering, with distinction, from Cornell University in 1979. His M S. and Ph.D. degrees in Chemical Engineering were awarded by the California Institute of Technology in 1981 and 1983. He has held visiting faculty appointments at the California Institute of Technology, the University of California, Santa Barbara, and the Department of Energy.

Dr. David Chock, Ford Motor Company, Dearborn, MI

Dr. David P. Chock received his B.A. degree with highest Honors in Chemistry from the University of California at Santa Barbara, and his Ph.D. degree in Chemical Physics from the University of Chicago. He was a Postdoctoral Fellow at the State University of New York at Buffalo, the Free University of Brussels, and the University of Texas at Austin, conducting research in electron-phonon interactions in semiconductors, dynamics of critical phenomena and hydrodynamic stability, respectively. He joined the General Motors Research Laboratories, and subsequently, Ford Research Laboratory, where he is the Leader of the Environmental Modeling Group in the Physical and Environmental Sciences Department. He has conducted a wide range of research related to the environment and its impact. This includes pollutant dispersion near roadways, improvement of numerical methods in air quality modeling by introducing accurate and fast algorithms to solve the advection equations and the stiff differential equations, extreme-value statistics of serially correlated data, time-series analysis, ozone trend analysis, statistical characteristics of the National Ambient Air Quality Standards, use of the random walk approach to study the impact of grid resolution and subgrid assumptions on air quality model predictions of a convective system containing fast nonhomogeneous atmospheric chemistry, and ozone impact

of emissions from vehicles using alternative fuels, assessment of the benefit of an ozone-scavenging system for ambient ozone reduction. He has also conducted epidemiological studies, including the effect of confounding on results of incomplete models, the association of daily mortality and pollutant concentrations in Pittsburgh, and the impact of measurement errors on the detection of a health response threshold. More recently, he has been working on modification of the Comprehensive Air Quality Model (CAMx), application of a global chemistry transport model, and issues related to global climate change. He has published about 90 papers in refereed journals. He has also served on many EPA peer review panels, External Advisory Committees on Community Modeling and Analysis System (CMAS) and on an EPA STAR project. He was a Consultant on the AQMS panel of the Council.

Dr. Dennis Alan Hansen, Electric Power Research Institute (EPRI), Palo Alto, CA

Since 1985, Dr. Alan Hansen has been the Manager of Tropospheric Studies for the Environmental Sector of the Electric Power Research Institute (EPRI). Dr. Hansen received his Ph.D. in Chemistry from the University of California, Irvine in 1973, and his B.A. in Chemistry from Southern Illinois University in 1967. Dr. Hansen's experience in modeling began in the Army as a member of a micrometeorological research group where he developed a model of the surface-atmosphere energy balance for various land covers. It continued at Southern Illinois University where he moonlighted by writing code for quantum mechanical simulations. It picked up again while an assistant research chemist at the Statewide Air Pollution Research Center of the University of California, Riverside, where he formulated the early code that, under the development of others, culminated in the SAPRC series of gas phase chemical mechanisms, while also studying hydroxyl radical kinetics and ozone-olefin chemiluminescence. After a hiatus from modeling of several years, while at ERT, he became a member of the team reviewing the development of the Acid Deposition and Oxidant Model (ADOM) under the sponsorship of the Canadian AES, the Ontario Ministry of the Environment (OME), the German Umweltbundesamt and EPRI. After joining EPRI, he managed EPRI's involvement with ADOM development which led to his participation in the formation of the Eulerian Model Evaluation and Field Study, a joint venture between, EPRI, AES, OME, EPA and the Florida Acid Deposition Monitoring Program, a major component of which was the comprehensive evaluation of RADM and ADOM. He chaired the EMEFS Working Group for it's formative first two years. As an EPRI Project manager he also managed modeling development projects with the University of Washington (rain band modeling) and Colorado State University (LES). From the perspective Dr. Hansen gained in managing these diverse model development and evaluation studies, and the recognition that modeling assessments of multiple air quality issues would be facilitated and made mutually consistent through the integration of specialized models into a single framework and adoption of cutting edge computational techniques, he initiated a project in 1989 at EPRI with a concept paper describing a "comprehensive modeling system" (CMS). To implement this concept, he established the Consortium for Advanced Modeling of Regional Air Quality (CAMRAQ), which produced an in-depth CMS design report (Design of a Framework for the Development of a Comprehensive Modeling System for Air Pollution, EPRI TR-106852, September 1996). With the emergence of EPA's Models-3 program, Dr. Hansen disbanded CAMRAQ and advocated the policy at EPRI that new air quality modeling technology developed by EPRI would be incorporated into the Models-3 framework. Since then Dr. Hansen continues to be active in managing model development and evaluation activities at EPRI, including the development of

methods for estimating modeling uncertainty. He has served or serves on many air quality modeling review and advisory committees, including those for the tri-national Commission for Environmental Cooperation, the Texas Natural Resources Conservation Commission (now the Commission for Environmental Quality), the SESARM seasonal modeling project, NARSTO, and the Community Modeling and Analysis System. He currently is the Coordinator for NARSTO's Model Comparison and Evaluation Study, investigating the relative and absolute performance of air quality models used for ozone management assessments by EPA, Meteorological Service of Canada, Coordinating Research Council, Southern Company and others.

Dr. Harvey E. Jeffries, University of North Carolina, Chapel Hill, NC

Dr. Harvey Jeffries has been a Professor of Atmospheric Chemistry in the Department of Environmental Sciences and Engineering at the University of North Carolina at Chapel Hill since 1971. He teaches graduate courses on atmospheric chemistry and photochemical modeling, including object-oriented design and programming. His research interests focus on gas phase atmospheric chemistry, specializing in volatile organic compound photooxidation with oxides of nitrogen to produce ozone, and the mathematical modeling of urban air chemistry, specifically, the development of numerical simulation models of photochemistry that become components of large scale Eulerian models incorporating meteorological and emissions sub models. He has performed photochemical experimental and simulation research in smog chambers for 30 years and has been the lead investigator in the creation and implementation of a new photochemical reaction simulation methodology that uses morphecules (time varying, shape shifting molecules) to simulate the complex organic chemistry. Now, in collaboration with researchers from the UNC School of Medicine, he is conducting gas phase and particle experiments to test air quality effects on human lung cells. Dr. Jeffries has also been active in using these models to plan public policy for air pollution control. He is a scientific advisor to the NC state regulatory agency for the 8_ hour ozone nonattainment modeling for the NC SIP He is a scientific advisor to the Business Coalition for Clean Air Appeal Group for the Houston Texas 1_hour ozone nonattainment modeling. He is a member (since 1996) of the US EPA's Science Advisory Council, Air Quality Modeling Subcommittee, and a member of the California Air Resources Board Reactivity Scientific Advisory Board. He was a founding member (since 1998) of the Reactivity Research Working Group, a public/private research coordinating effort involving US EPA, academia, and industry. He is a member (since 1999) of the Research Advisory Committee for the Texas Air Research Center at Lamar University in Beaumont. He is a member (since 2002) of the Science Advisory Committee of the Texas Environmental Research Consortium operated by the Houston Advanced Research Center. He was a member (1995_1997) of the US EPA's FACA Subcommittee for the Implementation of New Standards for Ozone, PM, and Regional Haze; he received an Exceptional Leadership Award from the US EPA (1997) as Cochair of Science and Technical Workgroup for this FACA Subcommittee In regard to funding for his research, he has a new EPA CoOperative agreement for $1.5 Million for three years on Exposing Human Lung Cells to Photochemical Reaction gas and particle products. The other source of support is a three year project funded by the American Chemistry Council ($898,000), entitled "Innovative Experimental Techniques to Help Understand Exposure to Volatile Organic Air Toxics." The overall goal of this project is to combine , develop and demonstrate new experimental techniques and methodologies that can be used to advance and prioritize the study of atmospheric chemical reactions of realistic mixtures including volataile organic air toxics and their transformation

products, a significant subset of hazardous air pollutants (HAPS).

Dr. Paulette Middleton, Panorama Pathways, Boulder, CO

Dr. Paulette Middleton has almost 30 years experience leading programs that inform decisions and enhance understanding of the human-nature bond; building life-long, effective collaborations with organizations and individuals worldwide; and creating and using innovative communication strategies and assessment approaches. In 2002, she initiated Panorama Pathways, a consulting organization dedicated to creating steps to understanding and world peace. This past year she has developed several white papers and public information pieces on mercury in the west, impacts of pollution on visual air quality in the East, air quality impacts of oil and gas drilling operations in the West, benefits of reducing power plant emissions in Colorado, and nitrogen oxide issues in the western US. Middleton has been director of the Global Emissions Inventory Activity (GEIA) Center since GEIA's inception in 1990. For over a decade, she served and chaired a number of committees on the EPA Science Advisory Board. Middleton's professional background includes the University of Texas (PhD, Chemistry) the National Center for Atmospheric Research (staff scientist), the Atmospheric Sciences Research Center at the State University of New York at Albany (Research Faculty), Science & Policy Associates, Inc. (Vice President) and RAND (Director, RAND Environment). She has special expertise in integrated assessments, complex system modeling, strategic planning, ulti-media communication, program/project management, business development, facilitation, and education with a focus on air quality and related environmental, energy, economic and social concerns.

Mr. Ralph Morris, Environ Corp., Novato, CA

Mr. Ralph E Morris is a Principal at ENVIRON International Corporation where he directs air quality modeling and analysis, control strategy development and evaluation, and regulatory air issues projects. He has over 20 years experience in air quality issues, with particular emphasis in the development and application of advanced air quality models and the development of air quality control plans. He has directed or was one of the key developers of many of the photochemical grid models that have been used to develop ozone attainment State Implementation Plans (SIPs) in the U.S. including the UAM, UAM-V, and CAMx. He has BA and MA degrees in mathematics from the University of California and has been an air quality consultant since 1979. At ENVIRON Mr. Morris' contract support comes from EPA and other federal agencies, state agencies, local agencies, trade organizations, and industry. Mr. Morris has been instrumental to bringing state-of-the-art air quality modeling techniques to regulatory air quality planning including demonstrating the use of photochemical grid models for ozone SIP modeling in the 1980'ss as leader of the EPA Five Cities UAM Study. Since then he has led the development of the next generation of nested-grid photochemical models (e.g., UAM-V and CAMx) and is currently leading the development of a state-of-science PMCAMx model that merges research-grade PM modules from academia (CMU and CalTech) with the CAMx platform. Mr. Morris has led or been involved in the development of ozone State Implementation Plans (SIPs) for numerous areas including: Los Angeles and San Francisco, CA; Houston/Galveston, Dallas-Fort Worth, and East Texas; Lake Michigan region; and St. Louis, MO. He has also led or been involved in the modeling of several PM SIPs, including: Los Angeles, Imperial County, and Owens Lake, CA; Rogue Valley OR; and Boise ID. Mr. Morris is currently assisting the Western Regional Air Partnership (WRAP) performing regional fine

particulate and visibility modeling using the CMAQ and REMSAD models as part of the WRAP Regional Modeling Center (RMC). Mr. Morris was an original member of EPA's ozone guidance workgroup and is currently a member of EPA's fine particulate guidance workgroup. He is also currently a member of the CMAS Models-3/CMAQ External Advisory Committee (EAC) and is also a member of the Scientific, Technical, and Modeling Peer-Review Group (SMTPRAG) for the South Coast Air Quality Management District&; (SCAQMD).

Dr. James Price, Texas Commission on Environmental Quality, Austin, TX

Dr. James Price is senior scientist in the Texas Commission on Environmental Quality's (TCEQ's) Technical Analysis Division. He holds bachelor's degrees in mathematics and chemistry, a master's in biochemistry, and a doctorate in environmental engineering, all from the University of Texas at Austin. For the past twelve years his work has been primarily in the design of field research studies and air quality monitoring networks and in the analysis of the data from them to elucidate the quantitative contributions of different emission sources to observed pollutant concentrations and to identify and explain discrepancies between the results of air quality modeling of estimated emissions and measurements of actual pollutant concentrations. He led TCEQ's participation in science planning for the Texas 2000 Air Quality Study of ozone, PM2.5, and regional haze in the eastern half of Texas. The Texas 2000 Air Quality Study involved over 250 researchers from over 35 organizations including the Southern Oxidants Study, NOAA, and DOE along with the TCEQ and Texas university researchers. He also led development, selection, and contracting of $2.9 million in projects to accelerate the scientific analysis of data from the Texas 2000 Air Quality Study and resolve discrepancies between results from air quality modeling of estimated emissions and measured ambient concentrations. Except for brief work as a peer reviewer for the U.S. EPA, support of all of Dr. Price's work has come from the TCEQ, which is funded by the State of Texas with about a ten per cent contribution from the U.S. EPA. Dr. Price served on EPA's Clean Air Scientific Advisory Committee from 1994 to 1997 and on the Air Quality Modeling Subcommittee of EPA's Science Advisory Board from 1997 to 2002. He has been a member of the Air & Waste Management Association since 1977, serving as Chair of the Technical Program Steering Committee from 1991 to 1993 and as Technical Program Chairman for the association's 1988 Annual Meeting. Previously, Dr. Price initiated and led for over twelve years the development of Texas' environmental management program that assesses the health and welfare impacts of all air emissions from new and modified industrial sources of air emissions in the state.

Dr. Armistead (Ted) Russell, Georgia Institute of Technology, Atlanta, GA

Dr. Armistead G. Russell is the Georgia Power Distinguished Professor and Coordinator of Environmental Engineering at the Georgia Institute of Technology. Professor Russell arrived at Georgia Tech in 1996, from Carnegie Mellon University, and has expertise in air quality engineering, with particular emphasis in air quality modeling and analysis. He earned his M.S and Ph.D degrees in Mechanical Engineering at the California Institute of Technology in 1980 and 1985, conducting his research at Caltech's Environmental Quality Laboratory. His B.S is from Washington State University (1979). Dr. Russell has been a member of a number of the National Research Council's committees, including chairing the Committee to Review EPA's Mobile Model and chairing the committee on Carbon Monoxide Episodes in Meteorological and Topographical Problem Areas, and serving on the committee on Tropospheric Ozone Formation

and Measurement, the committee on ozone forming potential of reformulated fuels and the committee on Risk Assessment of Hazardous Air Pollutants. He was also a member of the EPA FACA Subcommittee on Ozone, PM and Regional Haze, the North American Research Strategy for Tropospheric Ozone and California's Reactivity Science Advisory Committee. Previously he was on the Office of Science, Technology and Policy's Oxygenated Fuels Program Review and various National Research Council program reviews.

Dr. Russell is a member of the Air and Waste Management Association, American Association for the Advancement of Science, American Society of Mechanical Engineering, Tau Beta Pi, Sigma Xi and the American Association for Aerosol Research. Dr. Russell has won a variety of competitions for animations he has developed that depict the dynamics of pollutants have won a variety of prizes here and abroad, and his work was selected as a finalist for the prestigious Smithsonian Award for Computing in the Environmental Sciences. Recently, Prof. Russell led a multi-institutional effort to conduct air quality modeling of ozone, PM and acid deposition to assist the Southern Appalachians Mountains Initiative to identify effective control strategies to improve air quality in Class I areas in the southern Appalachians. This work has been extended to detailed analysis of air quality strategies in Georgia, PM modeling in the Southeast and Northeast, and development of a number of advanced numerical techniques for environmental modeling. For his service to National Research Council committees, he was recently selected as a National Associate of the National Academies. His funding comes from a variety of sources, including the US EPA, DoD, various states and state organizations, and the chemical, automotive and utility industries.

Dr. Chris Walcek, State University of New York, Albany, NY

Dr. Chris Walcek is Senior Research Scientist. Atmospheric Sciences Research Center of the State University of NY Albany. Write proposals for research related to air pollution and the interactions with meteorology. Education background: PhD, MS, and in Atmospheric Sciences BS from UCLA, Physical meteorology/Cloud Physics emphasis. Area of expertise and research activities: Acid rain, ozone formation, heterogeneous chemistry, numerical methods air quality modeling, Mercury pollution, aircraft impacts. Service on advisory committees: Have served on 5-6 EPA Research Proposal and Fellowship review panels. Chaired the American Meteorological Society Atmospheric Chemistry committee 1996-2000 and organized two national meetings of that section. Recent Grant Support: Environmental Protection Agency, NY State Energy Research and Development Authority, Department of Energy, NASA