NACAA
national association of clean air agencies

$PM_{2.5}$ Modeling Implementation for Projects Subject to National Ambient Air Quality Demonstration Requirements Pursuant to New Source Review

Report from NACAA $PM_{2.5}$ Modeling Implementation Workgroup

January 7, 2011

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Executive Summary

This report reflects the analysis and recommendations of the National Association of Clean Air Agencies (NACAA) $PM_{2.5}$ Modeling Implementation Workgroup. The workgroup was formed at the request of the U.S. Environmental Protection Agency (EPA) with the objective of providing technical recommendations to the agency to aid in its development of guidance for fine particulate matter ($PM_{2.5}$) modeling under the New Source Review (NSR) program. NACAA is the national association of air pollution control agencies in 52 states and territories and over 165 metropolitan areas across the country.

The workgroup addressed three specific issues regarding $PM_{2.5}$ modeling implementation: 1) Emissions Inventories; 2) Secondary Formation from Project Source; and 3) Representative Background Concentrations. Section 1 of this report contains technical input and recommendations regarding development of $PM_{2.5}$ emissions inventories for permit modeling, responding to four aspects of emission inventories: 1) current basis and approach for developing source estimates; 2) identification of data gaps and information needs; 3) recommended process or approach for more consistent and transparent efforts across state/local agencies; and 4) emission inventory needs for permit modeling.

Section 2 of this report contains technical analysis and recommendations regarding secondary formation from project sources. The workgroup identified a 4-tiered approach for conducting air quality analyses (up to 50 km) to address the significant impact levels (SILs), National Ambient Air Quality Standard (NAAQS), and Prevention of Significant Deterioration (PSD) increments for $PM_{2.5,}$ building upon long-standing procedures that have been developed and successfully applied for conducting air quality analyses of new project sources. Section 3 provides technical analysis and recommendations for determining the representative background concentrations to be used in $PM_{2.5}$ NAAQS modeling, and addressee the following issues: 1) possible approaches; 2) analysis of $PM_{2.5}$ background options; and 3) using Paired Sums. Finally, the report contains a number of appendices containing references, supplemental information, and relevant case studies.

Two overarching concerns that should be noted are the uncertainty in the data (e.g., emissions, background values, etc.) and the relative lack of experience with the recommended modeling approaches. Given these concerns, EPA should continue to work with state and local agencies to review, and, as necessary, improve the guidance. Such improvements could include, for example, adding comprehensive chemistry to AERMOD, so it can be used to support modeling for both primary and secondary impacts.

The workgroup provides the following recommendations:

1) Section 1, Emissions Inventories

- Emphasize the development of reliable $PM_{2.5}$ emission factors.
- Until new emission factors are developed, quality assured, and are available for use, the workgroup recommends utilization of existing state programmatic work, most significantly that of the California Air Resource Board (CARB).
- Provide guidance as to what types of emissions sources are required to include secondary formation in their modeling analyses (e.g., only combustion sources).

2) Section 2, Secondary Formation from Project Source

- Establish a 4-tiered modeling approach for conducting air quality analyses to address compliance with the PSD increment and NAAQS.

- Reconsider use of maximum modeled values for comparison to the 24-hour NAAQS. Also, review and, if necessary, revise guidance for addressing NAAQS and PSD increments for other criteria pollutants.
- Develop offset ratios which reflect geographic and seasonal variation for the purpose of single-source permitting.
- Complete evaluation of plume models and, as necessary, clarify the guidance for the Tier III modeling approach.
- Consider adding comprehensive chemistry to AERMOD. Note that if this were done, then the recommended 4-tiered modeling approach would need to be revisited.
- For use of photochemical grid models (i.e., Tier IV), the following issues need to be addressed: a) how to best apply the model (e.g., difference method, source apportionment, or sub-grid plume sampling); b) whether it is better to use plume-in-gird for the new source (with sub-grid sampling) or ensure small spatial grid spacing in the vicinity of the source (e.g., 1 km or less); c) whether to use absolute or relative model results; and d) whether to use the photochemical model for primary and secondary impacts or just secondary impacts.

3) Section 3, Representative Background Concentrations

- Include the “Paired-Sums” approach using continuous $PM_{2.5}$ monitoring data with or without inverse-distance (1/R) interpolation.
- Include the "Paired-Sums" approach even where only 1:3 day $PM_{2.5}$ monitoring data are available.
- Develop an analysis technique that will help determine whether one or more monitoring sites can be used to estimate the daily background concentration.
- Investigate fusion of model predictions with observations across a region as a way to produce a gridded estimate of background concentrations.
- Modify AERMOD to read in an hourly background $PM_{2.5}$ concentration file and then add the hourly background values to the hourly model source impacts to allow pairing in time (hour-by-hour basis).
- Modify 40 CFR 51 Appendix W to accommodate the above recommendations.

Preface

NACAA $PM_{2.5}$ Modeling Implementation Workgroup

In mid 2009, Tyler Fox, from EPA's Office of Air Quality Planning and Standards (OAPQS), Air Quality Modeling Group, approached NACAA to provide technical recommendations to the agency to aid its development of guidance for fine particulate matter ($PM_{2.5}$) modeling under the New Source Review (NSR) program. EPA will be developing this guidance over time, with an expected final version in the fall of 2011. The workgroup held a kick off call in January 2010, and then worked to organize into three subgroups and define the charter for each. During this period, two EPA memos were released that established policy for $PM_{2.5}$ modeling: the February 26, 2010 Tyler Fox Memo[1] and the March 23, 2010 Steve Page memo.[2]

This report provides a compilation of efforts to achieve this objective within the following three subgroups: 1) Emissions Inventories; 2) Secondary Formation from Project Source; and 3) Representative Background Concentrations. Of the approximately 20 modeling issues initially identified by EPA, the agency determined that the following technical issues are in need of input and recommendations from NACAA.

1) Emissions Inventories

Background: Emissions inventories for directly emitted $PM_{2.5}$ from existing sources have not been formally developed and established by state and local agencies for purposes of permit modeling as part of cumulative impact analysis.

Charge: Provide technical input and recommendations to EPA on development of $PM_{2.5}$ emissions inventories for permit modeling, including current basis and approach for developing source estimates, identification of data gaps and information needs, and recommended process or approach for more consistent and transparent efforts across state/local agencies.

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[1] Available at: http://www.epa.gov/ttn/scram/guidance/mch/new_mch/MCmemo_Region6_PM25_NAAQS_Compliance.pdf.

[2] Available at: http://www.epa.gov/ttn/scram/Official%20Signed%20Modeling%20Proc%20for%20Demo%20Compli%20w%20PM2.5.pdf.

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2) Secondary Formation from Project Source

Background: The current preferred dispersion model for near-field $PM_{2.5}$ modeling, AERMOD, does not account for secondary formation of $PM_{2.5}$. Therefore, any secondary contribution of the facility's or other modeled source's emissions is not explicitly accounted for. While representative background monitoring data for $PM_{2.5}$ should adequately account for secondary contribution from background sources in most cases, if the facility emits significant quantities of $PM_{2.5}$ precursors, some assessment of their potential contribution to cumulative impacts as secondary $PM_{2.5}$ may be necessary. In determining whether such contributions may be important, keep in mind that peak impacts due to facility primary and secondary $PM_{2.5}$ are not likely to be well-correlated in space or time, and these relationships may vary for different precursors.

Charge: Provide technical input and recommendations to EPA on more detailed guidance on need for and approaches to account for secondary $PM_{2.5}$ formation from a project's precursor emissions, including suggested emissions thresholds and basis for when to include in both significant impact analysis and cumulative impact analysis, critique of available options/approaches for accounting for project's secondary contributions, and identification of data gaps and information needs.

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3) Representative Background Concentrations

Background: The determination of representative background monitored concentrations of $PM_{2.5}$ to include in the $PM_{2.5}$ cumulative impact assessment will entail different considerations from those for other criteria pollutants. An important aspect of the monitored background concentration for $PM_{2.5}$ is that the monitored data should account for the contribution of secondary $PM_{2.5}$ formation representative of the modeling domain. As with other criteria pollutants, consideration should also be given to the potential for some double-counting of the impacts from modeled emissions that may be reflected in the background monitoring, but this should generally be of less importance for $PM_{2.5}$ than the representativeness of the monitor for secondary contributions. Also, due to the important role of secondary $PM_{2.5}$, background monitored concentrations of $PM_{2.5}$ are likely to be more homogeneous across the modeling domain in most cases, compared to other pollutants.

Charge: Provide technical input and recommendations to EPA on more detailed guidance on the determination of representative background concentrations for $PM_{2.5,}$ including survey and critique of available options/approaches using ambient and modeled data, potential criteria for determining what is "representative," and identification of data gaps and information needs.

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Section 1
Developing Emissions Inventories for Permit Modeling

The NACAA $PM_{2.5}$ Modeling Implementation workgroup was invited by EPA to provide technical input and recommendations regarding development of $PM_{2.5}$ emissions inventories for permit modeling. Specifically, this section addresses emissions inventories of directly emitted $PM_{2.5}$ from existing sources where they have not yet been formally developed and established by state and local agencies for purposes of permit modeling as part of cumulative impact analysis. This section provides a response to four aspects of emission inventories:

1. Current basis and approach for developing source estimates;
2. Identification of data gaps and information needs;
3. Recommended process or approach for more consistent and transparent efforts across state/local agencies; and
4. Emission inventory needs for permit modeling.

Introduction

As we implement new $PM_{2.5}$ programs and policies, NACAA members recognize that state and local permit writers and air dispersion modelers are going to be in a data–poor environment for high quality emission rates for several years. While we cannot correct this deficiency immediately, the duration of this data gap can be significantly shortened through good planning and execution. We recognize that we have experience with other "transition periods" (e.g. developing inventories for PM_{10} modeling requirements perhaps being most similar) and that the desired outcome can be successfully reached. It is therefore critical that we generate an equally concentrated effort on data collection and emission estimates by federal, state, and local agencies.

Current Basis and Approach for Developing Source Estimates

The workgroup reviewed draft guidance provided by EPA on several topics, including the document titled, "Draft - Background for 24-hour $PM_{2.5}$ NAAQS: How to Construct Model Emission Inventory for Permit Modeling," (Appendix A) and provides the following feedback.

Calculating $PM_{2.5}$ from PM and PM_{10} Data

The workgroup recognizes that capture and control efficiencies may not be the same for $PM_{2.5}$ as they are for coarse particulate matter (PM_{10}). Many state air quality agencies have developed "capture and control efficiency default values" for other pollutants. This approach is most heavily used during Title V permitting but can also be used in minor source construction permitting as well. When developing an emission inventory of existing sources for National Ambient Air Quality Standard (NAAQS) modeling, such presumptive capture and control values may be needed to calculate controlled, uncontrolled, and fugitive $PM_{2.5}$ emissions. We provide the following comments based on our experience with this approach for other pollutants.

1. The methodology to calculate $PM_{2.5}$ emissions from a controlled PM_{10} presented in the EPA Background Document for 24-hour $PM_{2.5}$ NAAQS (Appendix A) is well understood as an acceptable practice. The ability to perform these calculations, though, is based on the availability and reliability of some key data that may not always be readily available, including:
    - Uncontrolled $PM_{2.5}$ emission factors;
    - Established $PM_{2.5}$ control efficiencies for pollution control equipment; and
    - Established $PM_{2.5}$ capture efficiencies.

Most performance testing required by state and local agencies is done at the outlet of the source, which is the point of compliance. When the controlled emission rate is the only available data, the determination of uncontrolled and fugitive emissions would have to be derived from an assumed capture and control efficiency. In the example provided in the EPA Background Document, vendor data were relied upon for capture and control efficiencies. It is our experience that "vendor data" are conservative and therefore relying on this information to calculate allowable emissions may result in significant overestimation of emissions. For example a difference of a fraction of percent (e.g. 99% versus 99.5%) could double the emissions estimate. Furthermore, emission calculations can create absurd results when back calculating emissions from PM, PM_{10}, and $PM_{2.5}$ as the control and capture efficiency estimate can often be inconsistent due to variability in data collection and system performance. This is due to the differences in presumed control efficiencies for PM, PM_{10}, and $PM_{2.5}$

2. In addition to the work in collecting $PM_{2.5}$ emission data, the amount of work to make the individual PM to $PM_{2.5}$ conversion calculations for each source located within a significant impact area will be onerous. While the burden may be on the source to perform the calculations, the collection of the additional data and the verification of the approach will fall upon the agency.

3. Major source emission inventory data is collected by state and local agencies through annual Title V Emission Inventory Questionnaires. Some state and local agencies that collect inventory data may need to change their Title V forms and collection programs (e.g. software) to reflect data needs for developing $PM_{2.5}$ emission factors. Approval by EPA Regional Office is usually required when changing Title V forms. This modification and approval process can be lengthy, taking months and sometimes years to complete making advanced planning critical.

4. The EPA Background Document for 24-hour $PM_{2.5}$ NAAQS lists the following hierarchy emission data sources:

   I. Source test data from facility or similar sources;
   II. Vendor supplied emission factor data; and
   III. AP-42 Emission Factor Data.

   The workgroup believes that this hierarchy can be expanded upon to provide additional clarification allowing the appropriate use of the emission factor.

   a. Source test data should be further qualified based on source test methodology. The highest quality data will come from the recently finalized $PM_{2.5}$ test method.[3] Non-standard test methods should be qualified and placed lower in the hierarchy. Some states, such as California, have their own state approved test method, which may be ranked below the federally-approved test method. State test methods which have been relied upon in a SIP should be ranked above those state test methods which have not.
   b. Vendor supplied emission factor data, including performance data for emission control equipment, also vary. Data supplied as a "guarantee" may not accurately reflect actual performance. Guarantee's for Best Available Control Technology (BACT) tend to be conservative while older equipment may no longer be able to perform at that level.

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[3] Methods for Measurement of Filterable PM_{10} and $PM_{2.5}$ and Measurement of Condensable PM Emissions from Stationary Sources; Final Rule, 75 *Fed. Reg.* 80118 (December 21, 2010).

5. Existing data in AP-42, including AP-42 Appendix D, will vary with current $PM_{2.5}$ testing methodologies and emission factors based on the newly federally approved $PM_{2.5}$ test method and should be qualified with the specific $PM_{2.5}$ emission factor developed from the federally approved $PM_{2.5}$ test method. Emission factors based on data generated prior to the federal approval date of the $PM_{2.5}$ stack test method should receive a lower rank for quality.

Identification of Data Gaps and Information Needs

While some of these issues were identified in the previous section, the workgroup highlights some key data gaps and information needs for additional consideration.

Use of AP-42 Emission Factors

A workgroup member provided the following analysis of AP-42 emission factors for $PM_{2.5}$.

- As of May 2010, WebFIRE contained $PM_{2.5}$ emission factor values or formulas for over 850 processes.
- Roughly 80% of the $PM_{2.5}$ emission factors in WebFIRE estimate emissions from combustion processes.
- The remaining 20% of the emission factors are used to estimate processes from chemical manufacturing, food and agriculture, primary and secondary metal production, mineral products, pulp-paper-wood products, and solid waste disposal.
- Of the $PM_{2.5}$ emissions factors in AP-42, there are no A-rated factors and only 2.7% of the factors are B-rated.

"A-rated" $PM_{2.5}$ emission factors in WebFIRE = 0%
"B-rated" $PM_{2.5}$ emission factors in WebFIRE = 2.7%
"C-rated" $PM_{2.5}$ emission factors in WebFIRE = 11.8%
"D-rated" $PM_{2.5}$ emission factors in WebFIRE = 29.6%
"E-rated" $PM_{2.5}$ emission factors in WebFIRE = 43.0%
"U-rated" $PM_{2.5}$ emission factors in WebFIRE = 12.9%

Two gaps are readily apparent from this analysis:

1. There is an immediate gap with existing $PM_{2.5}$ emission factors for non-combustion sources; and
2. There is a significant limitation in the quality of nearly all $PM_{2.5}$ emission factors, and a robust effort to develop a new set of emission factors is needed in the long-term.

Use of the National Emission Inventory

The National Emission Inventory (NEI) contains data on actual historical emissions only, which is insufficient information for Prevention of Significant Deterioration (PSD) NAAQS determinations because potential, rather than actual, $PM_{2.5}$ emissions must be used for such analyses. It is our experience that much of the reported point source $PM_{2.5}$ emissions in the NEI are PM_{10} emission rates with an applied factor from the EPA $PM_{2.5}$ calculator or AP-42 Appendix D and do not represent actual measured emissions.

To the extent that the NEI or the Emission Inventory System (EIS) can be updated to support potential emissions as well as actual emissions, the NEI would become a more useful source of information for $PM_{2.5}$ permitting purposes. In addition, building a new EIS component that supports compliance testing, other stack test results, and other source-specific emission factors would be beneficial as a central source of such information, in particular once data are available for $PM_{2.5}$ emissions rates based on the expected new test method. Therefore, EPA is encouraged to take actions that would capture this information and make it accessible to users either through the EIS or another web-based tool that can be integrated with this information.

Transition for Permitting of $PM_{2.5}$

It is unclear how long it will take to build a sufficient accurate $PM_{2.5}$ inventory for PSD modeling. Therefore cautionary statements in permits and compliance documentation will be necessary to provide for the free flow of data, and the flexibility to change determinations as the knowledge base grows. EPA input and development of updated guidance for permitting $PM_{2.5}$ for at the least the short term would aid state and local agencies.

At the inception of this workgroup, we were referred by OAPQS to an EPA memo dated July 5, 1998 from Gerald Emison, former Director of OAPQS. This memo provides information on how to interpret dispersion modeling results to determine whether a source will cause or contribute to a new or existing NAAQS violation. We understand that this memo may be affirmed with elaboration on application to $PM_{2.5}$. Workgroup members expressed varying difficulties with implementing corrective action of culpable sources not associated with the facility that applied for the permit. The memo guidance states that, "[t]he EPA Regional Offices' role in this process should be to establish with the State agency a timetable for further analysis and/or corrective action leading to a SIP revision, where necessary." This recommendation will be difficult to implement in a data poor environment. Members of the NACAA workgroup report that some states have historically been challenged to demonstrate legal authority to re-open permits and this would be particularly challenging if the analysis supporting such a determination is based on poor data. An approach that targets the largest contributors first and works with culpable sources to make modifications on a mutual and voluntary approach for corrective measures may result in a faster and less litigious remedy.

Recommended Process or Approach for More Consistent and Transparent Efforts across State/Local Agencies

The workgroup recommends that EPA emphasize the development of reliable $PM_{2.5}$ emission factors. There will be rapid activity early in $PM_{2.5}$ implementation, following the recent issuance of an approved stack test method. This is valuable information that needs to be collected with the necessary quality assurance procedures in place. Until new emission factors are developed, quality assured, and are available for use, the workgroup recommends utilization of existing state programmatic work, most significantly that of the California Air Resource Board (CARB).

Emission Factor Improvement Program

NACAA provided a written response to EPA's Advanced Notice of Proposed Rulemaking for the Emissions Factors Program Improvements, published in the *Federal Register* on October 14, 2009 (74 *Federal Register* 52723, Docket ID No. EPA-HQ-OAR-2009-0174) (Appendix B). NACAA supports the development of a self-sustaining emission factors program and was pleased that EPA sought input on this important issue. We would like to reiterate our key points submitted in response to the ANPR:

1. An emission reporting tool based on a web-enabled technology platform should be used to collect $PM_{2.5}$ test data. Such a tool would be most effective if integrated with the recently reengineered Emission Inventory System (EIS) Development Project and Gateway. This approach would provide for a real-time repository of emission data more easily accessible and useable by all stakeholders. Any effort to improve the emission factor program must meet these criteria first if it is to be successful. The ANPR solicited input on the use of an existing Emissions Reporting Tool (ERT). We have reviewed this approach and find that it is not based on current technology and

would be an ineffective platform on which to build a national emission factor program. [Note: Our exposure to this technology in the ICR for the ICI Boiler NESHAP confirmed our December 2009 assessment that the MS Access based ERT is cumbersome and does not meet the needs of all users.]

2. NACAA strongly believes that data quality is a critical component of an emission factor program. Minimum threshold criteria should be used to identify acceptable data to be entered into the database. Once the minimum requirements are met for data entry, additional criteria could be used to further evaluate the quality of the data by the State, Local, and Tribal authorities depending on its intended use. The existing system, accessible through AP-42 and WebFIRE, lacks the necessary quantitative measures for assessing data quality and should be improved upon.

3. NACAA supports the development of a new data quality rating approach. The current system that uses categorical qualifiers remains subjective. A new system that includes statistical quantitative measures would be more useful to determine the appropriateness of an emission factor to a specific application. A variety of statistical information such as population, variability, median, mode, confidence intervals could be provided in tabular form and a graphical output would add additional value when assessing data distribution. However, a preferred platform would provide for the user the ability to download data from the emission inventory gateway (such as an upgraded WebFIRE) and perform statistical analysis using other third party software that has more robust statistical analytic capabilities.

4. NACAA generally supports the use of all available performance test data subject to the data quality objectives established for the emission factor program. Minimum threshold criteria should be used to be entered into the database. Once the minimum requirements are met additional criteria could be used to further evaluate the data quality including, but not limited to:
    a. the source's position in the industry, defined by the percentage of the national total that the source manufactures of a given product;
    b. the age of the equipment in use at the plant for the process tested;
    c. professional certifications of the stack testers;
    d. definition of representative operating conditions for the facility;
    e. control equipment in use for process;
    f. pollutants measured; and
    g. QA/QC flags.

5. Determining the appropriateness of using emission factors should be evaluated in the context in which they are applied. Such decisions should be left to the S/L/T agency on a case-by-case basis. Quantifying and qualifying the quality of the data (such as emission factor ratings) enables the data user to make more informed decisions regarding the emission factors and potentially expands their use. However, existing emission factor databases (primarily WebFIRE), are woefully incomplete for $PM_{2.5}$. NACAA members observe that current available emission factors are lacking in a variety of areas including data by major industrial groupings, both controlled and uncontrolled, and the vintage of the emission factor. Therefore, NACAA supports an effort to provide better quality data that includes better data quality characterization and data completeness.

California Air Resource Board $PM_{2.5}$ Technical Resources

While conducting an extensive study of state and local program efforts to provide $PM_{2.5}$ technical support, the workgroup identified a lead area of practice by the California Air Resource Board (CARB), which has developed speciation profiles for sources of PM_{10} to define $PM_{2.5}$. We believe that this can be an interim resource or a launching point for additional $PM_{2.5}$ emission inventory development. This information is accessible through the internet at:

Main Page
http://www.arb.ca.gov/ei/speciate/speciate.htm

Quick Links
How to Use the Speciation profile Data
http://www.arb.ca.gov/ei/speciate/usingdat.htm

2010 Profile page
http://arb.ca.gov/ei/speciate/profphp10/pmprof_list.php
By clicking on the number under the "reflink1" column(s) a new window will open to display the documents used to develop the PM, PM_{10}, $PM_{2.5}$ speciation profiles.

Some key points in the CARB approach include:

1. $PM_{2.5}$ data is based on a California approved test method, which may be different than the final $PM_{2.5}$ test method recently issued by EPA.
2. The speciation profiles for sources of PM are Source Classification Codes (SCC) based with some additional segmentation. These profiles may be based on test data or national data. This resource has been established and maintained by California for two years.
3. Permit limits for $PM_{2.5}$ are contained in permits and then tested for $PM_{2.5}$ using the California approved test method to validate that the source can meet limits. Annual testing may also be required, but primarily major sources are required to perform one-time testing at the commencement of operations. This is an interim approach until sufficient source test or Continuous Emission Monitor (CEM) data can be generated to formulate emission factors.
4. According to California local agency workgroup members, use of the California $PM_{2.5}$ speciation profile has been used for California State Implementation Plans (SIPs) that have been approved EPA, thereby making this $PM_{2.5}$ methodology a federally approved approach.

Emissions Inventory Needs for Permit Modeling

The source emissions data are a key input for all modeling analyses. Section 8.1 of the “Guideline on Air Quality Models” provides guidance regarding source emission input data for dispersion modeling. Two specific issues relevant to modeling of $PM_{2.5}$ secondary formation should be noted.

First, it is assumed that secondarily-formed $PM_{2.5}$ is associated principally with combustion-related emissions of sulfur dioxide (SO_2) and oxides of nitrogen (NOx) sources emitted from stacks. The portion of particulate emitted from mechanical processes is assumed to be directly emitted as primary $PM_{2.5}$. The workgroup recommends that EPA provide guidance as to what types of emissions sources are required to include secondary formation in their modeling analyses (e.g., only combustion sources).

Second, EPA’s final regulations for the “Implementation of the New Source Review (NSR) Program for Particulate Matter Less than 2.5 Micrometers ($PM_{2.5}$)” (73 FR 28321, May 16, 2008), make the following assumptions on which precursor pollutants should be considered:

SO_2 – “required”	NO_X – “presumed in”
NH_3 – “presumed out”	VOC – “presumed out”

It is recommended that any new project source with SO_2 or NO_X emissions in excess of the significant emissions threshold (i.e., 40 TPY) be required to conduct at least a screening analysis (i.e., Tier I). Very large emission sources will produce impacts well in excess of the SILs and, as such, will need to pursue a more refined analysis (e.g., Tier II, III, or IV).

EPA's NSR implementation rule for $PM_{2.5}$ does not set a significant emissions threshold for NH3, but rather requires states to establish this threshold if their SIP requires control of ammonia as part of its $PM_{2.5}$ control strategy. Consistent with this approach, it is left up to each state to determine whether a new project source should include its NH3 emissions in addressing the NAAQS or PSD increments for $PM_{2.5}$. The implementation rule also states that "the modeling available at this time does not provide sufficient information to estimate impacts of emissions from individual sources of ammonia and VOC on ambient $PM_{2.5}$ concentrations." Consequently, it is appropriate to maintain EPA's "presumed out" assumption for ammonia and VOC, unless, as noted above, a state believes that ammonia control is needed for $PM_{2.5}$ compliance.

Section 2

$PM_{2.5}$ Secondary Formation from Project Sources

This section presents recommendations by the NACAA $PM_{2.5}$ Modeling Implementation Workgroup on secondary formation from project sources. The Workgroup has identified a 4-tiered approach for conducting air quality analyses (up to 50 km) to address the significant impact levels (SILs), NAAQS, and PSD increments for $PM_{2.5}$[4]. The recommendations build upon long-standing procedures that have been developed and successfully applied for conducting air quality analyses of new project sources, and provide multiple levels of technically defensible methods for quantifying secondarily formed $PM_{2.5}$. In brief, the recommended approach consists of a screening analysis of the new project source to compare with SILs (Tier I), followed by, if necessary, more refined analyses of the new source and other appropriate sources, plus background, to compare with the NAAQS and PSD increments (Tiers II-IV). A summary of the tiers is provided in Table 2-1.

Table 2-1 - Recommended Approach for Assessing Secondarily Formed $PM_{2.5}$ from New (Project) Sources

Model Requirement	Tier	Approach
Single-source screening analysis to compare with SILs	Tier I	**Primary & Secondary:** AERMOD with region- (or state-) specific offset ratios
Cumulative-source analysis to compare with NAAQS and PSD increments	Tier II	**Primary & Secondary:** AERMOD with region- (or state-) specific offset ratios
	Tier III	**Primary:** AERMOD **Secondary:** Use of a chemistry plume model (e.g., SCICHEM)
	Tier IV	**Primary**: AERMOD **Secondary**: CAMx (or CMAQ) with fine grid and PiG for new source

It is recommended that EPA consider adding the approaches in this memo to future EPA modeling guidance (e.g., a supplement to the March 23, 2010, memorandum "Modeling Procedures for Demonstrating Compliance with $PM_{2.5}$ NAAQS") and revisions to Appendix W of 40 CFR Part 51.

Background

EPA's modeling guidelines recommend procedures and approaches for assessing the air quality impact of facility point source emissions. (Appendix W to Part 51 - Guideline on Air Quality Models, November 9, 2005). Specifically, the guidelines recommend the use of AERMOD for a wide variety of near-field stationary source applications, including new project sources.[5] In recent guidance ("Modeling Procedures for Demonstrating Compliance with $PM_{2.5}$ NAAQS", March 23, 2010), EPA noted that use of AERMOD for new source analyses is limited to modeling only the primary or direct $PM_{2.5}$ emissions from the

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[4] EPA published its notice of final rulemaking on SILs, PSD increments, and significant monitoring concentrations (SMCs) for $PM_{2.5}$ on October 20, 2010 (Prevention of Significant Deterioration (PSD) for Particulate Matter Less Than 2.5 Micrometers (PM2.5) – Increments, Significant Impact Levels (SILs) and Significant Monitoring Concentration (SMC), 75 *Fed. Reg*. 64864).

[5] AERMOD is recommended for regulatory use for transport distances up to 50 km. Other methods should be considered to assess impacts at longer distances.

facility. Given the importance of $PM_{2.5}$ secondary components (e.g., ammonium sulfate, ammonium nitrate, and secondary organic aerosols), additional or alternative methods must be used to provide a complete assessment of the $PM_{2.5}$ impact from a new project source.

Current modeling practice generally consists of an initial screening analysis to provide a conservative estimate of the impact of the new source. When comparing a new source's ambient impact with the SILs, maximum modeled values are typically used[6]. If the new source's impact is less than the SILs, then no further air quality analysis is needed. If the new source's impact is greater than the SILs, then a full modeling analysis, which involves accounting for emissions from the rest of the facility, nearby sources, and background, and comparing the results to the NAAQS and PSD increments, is necessary.

Tiered Approach to Assessing $PM_{2.5}$ Secondary Formation

Based on consideration of a range of possible modeling methods to account for $PM_{2.5}$ secondary formation from a facility that emits $PM_{2.5}$ precursors, the workgroup recommends a 4-tiered approach to screen projects for comparison with the SILs and to conduct full dispersion modeling for comparison with the NAAQS and PSD Increments. The recommended approach is outlined in Table 2-1 and discussed further below.

Tier I (Screening Analysis) and Tier II (Full Modeling Analysis)

The methodology for Tier I and Tier II are similar. The AERMOD model is prominent in these tiers because of its ease of use and wide-spread application in new source project modeling.

In the Tier I screening analysis, only the proposed project source is modeled. The purpose of this analysis is to provide a single source analysis to identify those sources which will clearly pose no threat to the $PM_{2.5}$ NAAQS and PSD increments and, therefore, can be eliminated from further air quality modeling.

In the Tier II full-dispersion modeling analysis, the proposed project source is modeled along with other nearby existing sources and background. The purpose of this analysis is to provide a cumulative source analysis to compare ambient air quality impacts with the $PM_{2.5}$ NAAQS and PSD Increments.

According to the "Guideline on Air Quality Models", at least 5 consecutive years of National Weather Service (NWS) or 1 year of on-site meteorological data are to be used in the modeling.
For comparison with the SILs and the NAAQS, the March 23, 2010, memorandum recommended:

- Annual: highest average of the modeled annual averages across 5 years of NWS data or the highest modeled annual average for 1 year of on-site data; and

- 24-hour: highest average of the maximum 24-hour average across 5 years of NWS data or the highest modeled 24-hour average for 1 year of on-site data.

The March 23, 2010, memorandum did not address how to use modeled values for comparison with PSD increments. In its October 20, 2010, final PSD rule for $PM_{2.5}$, EPA recommended that compliance with the PSD increments should be based on:

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[6] Further discussion on the appropriate modeled concentrations to use for comparison with SILs, NAAQS, and PSD increments is provided below.

- Annual: highest average of the modeled annual averages across 5 years of NWS data or the highest modeled annual average for 1 year of on-site data; and

- 24-hour: highest value of the second-highest modeled concentration.

The workgroup recommends that EPA reconsider the use of maximum values for comparison with the 24-hour NAAQS. Consistent with recent guidance for SO_2 and NO_2, use of 98th percentile modeled daily values, in particular, may be more appropriate.

Secondarily-formed $PM_{2.5}$ can be estimated by applying interpollutant "offset ratios", such as those in EPA's NSR implementation rule for $PM_{2.5}$ (73 FR 28321, May 16, 2008).[7]

Nationwide SO_2 to Primary $PM_{2.5}$ offset ratio: 40:1
Eastern U.S. NO_X to Primary $PM_{2.5}$ offset ratio: 200:1
Western U.S. NO_X to Primary $PM_{2.5}$ offset ratio: 100:1

It should be noted that these offset ratios were developed by EPA with a "response surface modeling (RSM)" approach based on full-chemistry modeling using the Community Multi-Scale Air Quality (CMAQ) model at 36 km grid resolution for the purposes of $PM_{2.5}$ offsets, not single-source permitting analyses. In lieu of any other readily available information, these offset ratios were assumed here and were used in limited case study analyses by Workgroup members.

Using the offset ratios, the equivalent amount of primary $PM_{2.5}$ emissions associated with SO_2 and NO_X emissions is calculated as follows:

SO_2: [SO_2 TPY]/40
NO_X: [NO_X TPY]/200 (eastern U.S.) or 100 (western U.S.)

The total equivalent primary $PM_{2.5}$ emissions are then:

Total Equivalent Primary $PM_{2.5}$ [TPY] =
Primary $PM_{2.5}$ [TPY] + [SO_2 TPY]/40 + [NO_X TPY]/200 or 100

The total (primary + secondary) $PM_{2.5}$ concentration can then be estimated by multiplying the maximum AERMOD concentration for primary $PM_{2.5}$ by the emissions ratio:

Total $PM_{2.5}$ ($\mu g/m^3$) =
Primary $PM_{2.5}$ ($\mu g/m^3$) * (Total Equivalent Primary $PM_{2.5}$ [TPY]/Primary $PM_{2.5}$ [TPY])

Our case studies indicate that the EPA offset ratios may either be inappropriately high or not responsive to regional variations (see Appendix C). The workgroup recommends that EPA develop offset ratios which reflect geographic and, perhaps, seasonal variation for the purpose of single-source permitting analyses. Note that it may be sufficiently conservative to not vary the offset ratios by season and to simply use the worst-case seasonal values. EPA may wish to consider the results of their existing RSM-based modeling, in addition to conducting new modeling, in developing these offset ratios.

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[7] An alternative approach for estimating secondarily-formed PM2.5 was considered by the Workgroup, but would require significant additional work by EPA to develop it for national application. This other approach (nonlinear regression model) is discussed further in Appendix D.

A key assumption in this method is the spatial pairing of primary and secondary impacts. Our case studies indicate that primary impacts generally occur close in (near fenceline) and decrease with downwind distance, whereas secondary impact generally occur farther downwind (well beyond fenceline). Assuming the primary and secondary impacts occur at the same (close in) location will, generally, result in a more conservative concentration estimate for near-field applications (i.e., within 50 km) than if the actual spatial locations of the primary and secondary impacts were taken into account. This assumption may not be conservative if considering impacts at more distant receptors – e.g., Class I area analyses. Appendix C contains a case study with a description, results and conclusions that support the final Tier I and Tier II recommendation. Case study analyses of initial considerations and alternative approaches, in the form of Power Point presentations, are listed in the references at the end of this section. These presentations are available upon request to the subgroup chair.

Under Tier I, if the combined (primary plus secondary) concentration estimate from the new source is less than the $PM_{2.5}$ SILs, then the air quality assessment is passed and no further analysis is necessary. If the combined concentration estimate is greater than the SILs, however, then a cumulative source analysis (as outlined in Tiers II-IV) is needed to address compliance with the $PM_{2.5}$ NAAQS and PSD increments.

Under Tier II, it is necessary to account for emissions from the rest of the facility, other nearby sources, and background. Procedures for determining which other nearby sources to model are addressed in the March 23, 2010 memorandum "Modeling Procedures for Demonstrating Compliance with the $PM_{2.5}$ NAAQS," as well as Appendix W to Part 51-Guideline on Air Quality Models (November 9, 2005; see, in particular, section 8.2). Procedures for determining appropriate background concentrations will be identified in section 3 of this document.

It is worth noting that the workgroup considered, but rejected, other methods for assessing secondary $PM_{2.5}$ impacts, including use of a simple emissions divided distance (Q/D) metric and use of AERMOD with 100% conversion of SO_2 and NO_X concentrations to $(NH_4)_2SO_4$ and $(NH_4)NO_3$. Further discussion of these methods, and the reason for not recommending them, is provided in Appendix E.

Tier III (Full Modeling Analysis) - Plume Modeling

Plume models can also be used to quantify secondary impacts from the new project source and other nearby sources. Consistent with Tiers I and II, AERMOD should be used to model the impact of primary emissions from the new project source and other nearby sources. Candidate plume models include CALPUFF and SCICHEM, but there are reservations with these models.

CALPUFF is recommended in EPA's Guideline on Air Quality Models for use in long-range transport applications (e.g., Class I area analyses at distances greater than 50 km), and in EPA's BART rule to determine if an individual source is reasonably anticipated to cause or contribute to visibility impairment in Class I areas (and to predict the degree of visibility improvement reasonably anticipated to result from the use of retrofit technology at an individual sources). This model, however, suffers from very limited chemistry and has had only limited evaluation for near-field applications (i.e., within 50 km).

SCICHEM is a Lagrangian transport and diffusion model developed by the Electric Power Research Institute. The model employs a Gaussian puff method, in which a collection of three-dimensional puffs is used to represent an arbitrary time-dependent concentration field, and second-order turbulence closure theories to represent turbulent diffusion parameterization. Although the model has comprehensive chemistry, it is not included, or referenced, in EPA's modeling guidelines and is not available in the public domain.

It is our understanding that EPA is currently evaluating these, and other, plume models. Pending the results of this work, no specific recommendation is offered at this time for a Tier III modeling approach.

Another option which EPA may wish to consider is to include a comprehensive chemical mechanism in AERMOD. If this was done, then this enhanced, full chemistry version of AERMOD could be used to estimate the total (primary + secondary) $PM_{2.5}$ concentration from the new (project) source and other nearby sources.

Tier IV (Full Modeling Analysis) - Photochemical Modeling

Photochemical grid models provide a complete characterization of emissions, meteorology, chemistry, and other effects. EPA's modeling guidelines identify CMAQ and CAMx for use in modeling $PM_{2.5}$, given their ability to treat secondary components of $PM_{2.5}$. Two concerns with using such models for single-source analyses should be noted. First, it is recognized that photochemical grid models can be resource intensive and require special expertise. As such, it is anticipated that this method will be used mostly for large emitting sources. Advancements made as part of the Regional Planning Organization process in recent years, however, has provided many states with both a modeling framework and organizational support for such modeling.

Second, in the preamble to its final BART rule, EPA noted that regional scale photochemical models "have been designed to assess cumulative impacts, not impacts from individual sources" and "regional models have not been evaluated for single source applications". (70 FR 39123, July 6, 2005). With recent improvements in the ability of the models to treat individual sources (e.g., two-way interactive grid nesting, flexi-nesting, full chemistry plume-in-grid (PiG) modules, source apportionment algorithms, and computational advances), the Workgroup believes that single source applications are possible. To avoid improper dilution of emissions from the new source (and better characterize impacts near the source), EPA should evaluate whether it is better to use PiG for the new source (with sub-grid sampling) or ensure small spatial grid spacing in the vicinity of the source (e.g., 1 km or less).

According to EPA's "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze" (April 2007), only one full year of meteorological data are required for photochemical modeling to address the annual and daily $PM_{2.5}$ standards. This same approach is recommended here for Tier IV analyses (i.e., use at least one year of meteorological data).

The photochemical grid models can provide concentration estimates in several ways:

- Difference Method: Under this method, the model is run twice, once with all existing sources and again with all existing sources and the new source. The difference in concentration estimates between these two runs represents the impact of the new source.

- Source Apportionment: The $PM_{2.5}$ source apportionment tool (PSAT) in CAMx, for example, can be used to track the contribution from individual sources.

- Sub-Grid Plume Sampling: CAMx can sample specific point-source plumes passing through a given grid cell at a higher resolution than the grid cell (e.g., 100 m spaced receptors within a 12 km grid cell).

It should be noted that these methods represent fundamentally different approaches (source sensitivity (difference method) v. source apportionment). The first two methods yield identical results for primary PM species, but may differ for secondary PM species depending on non-linear chemical processes. An analysis of the sulfate impacts from the two methods using CAMx showed generally similar results, but some model "noise" problems with the difference method for smaller SO_2 sources (ENVIRON, 2005). The third method includes the non-linear chemical processes, but can tease out the concentrations of the plume(s), rather than concentrations of the grid cell. The chemistry with the plume interacts with chemistry processes occurring outside the plume. This approach can be advantageous for examining smaller sources whose highest impacts are within the grid. The third method was used in the Case Study to evaluate the final Tier I and Tier II recommendation, and is described in Appendix C.

In comparing the photochemical model concentrations with the NAAQS and PSD increments, either absolute or relative model results from the two methods can be used. The "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze" (April 2007) encourages use of photochemical model results in a relative sense in concert with observed air quality data. As such, relative reduction factors (RRFs) could be derived and used to adjust the absolute photochemical model results. Because RRFs are applied to observed design values, EPA's MATS software could be used to evaluate the impacts in unmonitored areas.

Another decision to be made in applying photochemical grid models is how to best account for primary and secondary impacts. One approach is to continue to use AERMOD for estimating the primary impacts from the new (project) sources, the rest of the facility, and other nearby sources, and to use the photochemical model for estimating the secondary impacts. Another approach is to use the photochemical model for quantifying both primary and secondary impacts to address compliance with the NAAQS and PSD increments. AERMOD can accommodate building downwash, which can be very important in evaluating near-field concentrations, while the photochemical grid models cannot. The Workgroup prefers using AERMOD to estimate the primary impacts, but recognizes that EPA may need to conduct further analyses before making a decision on which approach to include in its final guidance.

References

Supporting the MRPO's PM and Visibility Modeling: CAMx Evaluation and Improvements", Final Report, ENVIRON, March 2005 http://www.ladco.org/reports/rpo/modeling/camx_summary.pdf

"CAMx Photochemical Modeling Review; Plant Washington, Washington County", memorandum from Byeong-Uk Kim, Georgia EPD, August 12, 2009

"Potential Methods for Addressing $PM_{2.5}$ Impacts from New Sources: Primary and Secondary Impacts", May 28, 2010

"Secondary $PM_{2.5}$ Impacts from Plant Washington", PowerPoint presentation by Jim Boylan and Byeong-Uk Kim, Georgia EPD, June 28, 2010

"$PM_{2.5}$ Individual Sources Impacts: A Simple Tool to Estimate $PM_{2.5}$ Concentrations in relation to Emissions and Distance in Minnesota", PowerPoint presentation by Margaret McCourtney, Minnesota PCA, July 27, 2010

"$PM_{2.5}$ Secondary Formation from Project Sources", PowerPoint presentation by Jim Boylan and Byeong-Uk Kim, Georgia EPD, October 7, 2010

"$PM_{2.5}$ Secondary Formation from Project Sources: Minnesota Case Study, Draft Approaches, Tier I, II and IV", PowerPoint presentation by Margaret McCourtney, Minnesota PCA, October 7, 2010.
"Summary of Minnesota Case Studies", prepared by Margaret McCourtney, Minnesota PCA, November 23, 2010.

Section 3

Background Concentrations: $PM_{2.5}$ NAAQS Modeling, Modeling Tiers and Background Options

Introduction

This section provides analysis and recommendations from the NACAA $PM_{2.5}$ Modeling Implementation Workgroup for determining the representative background concentrations to be used in $PM_{2.5}$ NAAQS modeling. During the course of its work, the workgroup considered available guidance as found in the Guideline on Air Quality Models (EPA, 2005) and in the recently released OTAQ Hot Spot Guidance (EPA, 2010) as well as state/local experiences (See Appendix F and Appendix G). The workgroup considered possible methods for defining background concentrations and, where possible, analyzed each method. As only limited data were available for analyses, any technique that failed to show promise was dropped in favor of those that demonstrated ability.

This section addresses the following issues relevant to determining representative background concentrations:

1) Possible approaches;
2) Analysis of $PM_{2.5}$ background options; and
3) Using Paired Sums.

The workgroup provides the following recommendations in this section:

- Include the “Paired-Sums” approach using continuous $PM_{2.5}$ monitoring data with or without inverse-distance (1/R) interpolation.
- Include the "Paired-Sums" approach even where only 1:3 day $PM_{2.5}$ monitoring data are available.
- Develop an analysis technique that will help determine whether one or more monitoring sites can be used to estimate the daily background concentration.
- Investigate fusion of model predictions with observations across a region as a way to produce a gridded estimate of background concentrations.
- Modify AERMOD to read in an hourly background $PM_{2.5}$ concentration file and then add the hourly background values to the hourly model source impacts to allow pairing in time (hour-by-hour basis).
- Modify 40 CFR 51 Appendix W to accommodate the above recommendations.

What is “background”?

For modeling purposes, “background” is the ambient concentration produced by emissions from sources such as local residences, unidentified sources, and natural background that are not modeled explicitly. The background is conceptualized as varying slowly in space and time.

Background concentrations may be defined in several ways depending on the available resources. Conceptually, the most complete approach is to use a model such as MOZART or GEOS-Chem fused with satellite-derived concentration estimates to compute the global component. That global component is then used to specify the boundary conditions of a regional model such as CAMx or CMAQ, following which the regional model output is fused with available monitored concentrations to provide an estimate of the background concentration for the NAAQS analysis. The NAAQS analysis could use a steady-state plume model such as AERMOD to model only those sources responsible for the sub-grid scale variability in the vicinity of the source being permitted. Double counting of existing sources could be avoided by subtracting their spatial mean contribution within each grid cell from the AERMOD modeled concentrations. However, generally resources are not yet available, nor have the requisite models been sufficiently evaluated, to recommend this approach at this time.

The simplest approach to defining background concentrations is to use one or more representative monitoring sites. Using this approach depends on determining that at least one existing monitoring site qualifies as representative. During this process, an analysis needs to be undertaken to assess the contribution of existing sources at the monitoring site(s) and avoid double counting those existing sources. An important factor in assessing the representativeness of the monitoring site(s) is a comparison of surroundings (emission data, land use, traffic, population, topography) at the facility and the monitoring site(s).

Possible Approaches

$PM_{2.5}$ NAAQS modeling uses two modeling tiers (screening and refined), as well as background options (monitor data with/without photochemical model considerations or chemical transport model (CTM) considerations). The workgroup provides suggestions for five background options, along with possible approaches for combining modeling and background data.

Background Options

I. Non-continuous monitor data; no photochemical model considerations
II. Non-continuous monitor data with photochemical modeling
III. Continuous monitor data; no photochemical model considerations
IV. Continuous monitor data with photochemical model considered qualitatively
V. Continuous monitor data and photochemical model output fused/paired

We recommend that the modeling values (as discussed in Section 2) and the background values discussed in this section be combined in one of the following ways.

AERMOD + Background (Unpaired; Screening; Constant to Time-Varying)

Level 1a (Maximum AERMOD + 98th percentile monitor)
Level 1b (98th percentile AERMOD + maximum monitor)
Level 1c (98th percentile AERMOD + 98th percentile monitor and photochemical model fused) [WA]
Level 1d (98th percentile AERMOD + quarterly monitoring data)
Level 1e (98th percentile AERMOD + monthly monitoring data)

AERMOD + Background (Daily Paired Sums; Refined; Monitoring only to Fused model/monitor data) (See Appendix H, Technical Note No. 1)

Level 2a (Paired Sums w/daily monitoring data; no photochemical model considerations)
Level 2b (Paired Sums w/daily monitoring data and photochemical model considerations) [MN]
Level 2c (Paired Sums w/daily monitoring data and photochemical model fused)

AERMOD + Background (Hourly Paired Sums; Refined; Future Work)

Level 3a (Paired Sums w/hourly monitoring data; no photochemical model considerations)

Level 3b (Paired Sums w/hourly monitoring data and photochemical model considerations)
Level 3c (Paired Sums w/hourly monitoring data and photochemical model fused)

Note that using continuous monitor data such as beta-attenuation monitor (BAM) or tapered element oscillating microbalance (TEOM) data and concurrent meteorological data is much more advantageous for high impact situations than using non-continuous monitor data such as Federal Reference Method (FRM) data.

Analysis of $PM_{2.5}$ Background Options

$PM_{2.5}$ Background – Quick Reference Guide

Background Option ID	$PM_{2.5}$ Monitor Data (and Type)	Qualitative Component	Paired Sums Friendly?
I	Non-continuous (generally FRM)	None	Yes – modeling protocol is required.
II	Non-continuous (generally FRM)	CTM Models (CAMx, CMAQ)	Yes – modeling protocol is required.
III	Continuous Level 3 (AERMOD + Background paired sums w/hourly information) (BAM in MN)	None	Yes – modeling protocol is required.
IV	Continuous (BAM in MN)	CTM Models (CAMx, CMAQ)	Yes – modeling protocol is required.
V	Continuous $PM_{2.5}$ Monitor Data and CTM Model Fused	-	Yes?

Considerations

Any selected background $PM_{2.5}$ option depends on a balance of AERMOD sources versus monitor data on a sliding scale. Extreme examples include:

1) Where a project involves modeling just the subject source, a relatively more conservative (“higher”) background may be prescribed;
2) Where a project involves modeling the subject source and “all” nearby/regional sources, a relatively less conservative (“lower”) background might be prescribed.

On the other hand, a situation where a facility is located in an isolated rural area with no significant sources nearby might reasonably call for a coupling with a relatively low, or even pristine, background. Again, good professional judgment will be a necessary component of any background determination.

For Level-of-Effort Considerations (which sources/facilities to model explicitly via AERMOD):

1) Determine which sources to model ("key" source tests)[8]
   - The 20D test (or N*D test), which is simpler.
   - The SIL test, which is more robust,.
2) Simple/screening considerations (background). What background should I consider?
   - If modeling just the subject source, 100% of conservative background.
   - If modeling nearby sources within ~3km, 95% of conservative background.
3) Robust/refined considerations (background). See next section for detailed steps.

Steps

1. Determine facility setting (**X** = pristine [national park], rural, suburban, urban).
2. Determine background option and background setting.
3. Perform analysis (modeling by level-of-effort, facility location, and background location).

Background $PM_{2.5}$ Options I-IV (Detailed Steps)

1. Determine facility surroundings.

a) Determine type of facility location (**X** = national park, national forest, rural, suburban, urban)
b) Evaluate other considerations (e.g., proximity and size of important nearby mobile and point sources and topographical features)

2) Determine background.

a) Determine background type (**X** = pristine [national park], rural, suburban, urban)
b) Determine background option
   i) Option I is simple, conservative (no additional qualitative support) – determine background monitor site from non-continuous (e.g., FRM) sites.
   ii) Option II is simple, conservative (w/additional qualitative support) – determine background monitor site from non-continuous (e.g., FRM) sites; qualitatively use photochemical model or CTM; or determine 98th percentile from monitoring fused with photochemical modeling. (See Appendix I, "Technical Note No. 2")
   iii) Option III is more refined, representative (no additional qualitative support) – determine background monitor sites from continuous (e.g., BAM or TEOM) sites. Determine site hierarchy.[9]
   iv) Option IV is more refined, representative (w/additional qualitative support) – determine background monitor sites from continuous (e.g., BAM or TEOM) sites; qualitatively use photochemical model or CTM. Determine site hierarchy.[10]

3) Perform analysis (modeling by level-of-effort, facility location, and background location).

a) If modeling just subject source/facility, use a conservative "**X** or a higher" background site.[11]
b) If modeling includes "key" nearby sources, use a typical "**X** or a higher" background site.[12]
c) If modeling includes "all" nearby sources, use the cleanest "**X** or a higher" background site.[13]

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[8] For further guidance, see the March 23, 2010 memorandum "Modeling Procedures for Demonstrating Compliance with the $PM_{2.5}$ NAAQS," and Appendix W to Part 51-Guideline on Air Quality Models (November 9, 2005; see, in particular, section 8.2).

[9] In many situations, the inverse-distance (1/R) weighted average will provide a reasonable approximation of background concentrations of other sources.

[10] *Id.*

[11] *Id.*

[12] *Id.*

[13] *Id.*

Background $PM_{2.5}$ Option V (continuous monitor data and photochemical model fused/paired)

This option depends on a balance of AERMOD sources versus monitor data and concurrent photochemical model output. This option is exploratory and needs more work. A good Rule-of-Thumb is to run subject source and key nearby sources via AERMOD, run distant/regional sources via CAMx, and add background pristine monitor site via "Paired Sums". The following conceptual procedure should be used:

1. Determine which sources/facilities to model explicitly via AERMOD.
   a) Subject Source
   b) Nearby Sources (facilities)
2. Local Mobile Sources (roads, ships, trains, planes)
3. Acquire CAMx regional emission inventory.
4. Acquire continuous background monitor data for a pristine setting (e.g. national park).
5. Run AERMOD.
6. Run CAMx with full emission inventory less AERMOD sources.
7. Add AERMOD results and CAMx results and pristine background via "Paired Sums".

Using Paired Sums

While unpaired sums may work for simple situations, challenging situations may require detailed temporal pairing (e.g., "Paired Sums"). The workgroup recommends seeing EPA guidance for traditional "unpaired sums" approaches or possible simplistic temporal pairing (e.g., seasonal).

Paired Sums with Continuous $PM_{2.5}$ Monitoring Data

The subgroup recommends two options for areas needing more refined $PM_{2.5}$ NAAQS modeling. The first is a Paired Sums approach using continuous $PM_{2.5}$ monitoring data from a single monitor site. The second is a Paired Sums approach using multiple continuous $PM_{2.5}$ monitoring sites with inverse-distance (1/R) monitor interpolation. Site selection depends on urban/rural considerations, terrain considerations, and other considerations addressed below.

Advantages and Disadvantages of Continuous $PM_{2.5}$ Monitoring Data (e.g., BAM or TEOM data)

The obvious advantage is that it is continuous and thus can be processed into 1-hour averages or 24-hour averages for use with a "Paired Sums" post-processor, and possibly future versions of AERMOD. The main disadvantage is that it is not traditional FRM data. However federal equivalent method (FEM) data is becoming more common; various studies comparing continuous versus FRM data may also help determine appropriate adjustments [monitor-specific correction factors] to better inform use of continuous $PM_{2.5}$ data in the near future.

Urban/Rural Considerations

The spatial representativeness of $PM_{2.5}$ background monitoring data may span many kilometers in urban and semi-urban areas and tens of kilometers or hundreds of kilometers in rural areas. Although urban monitor sites tend to have higher $PM_{2.5}$ concentrations than rural monitor sites, a review of data across much of the country indicates urban/rural differences are surprisingly small. This is probably due to the overwhelming secondary formation on a regional scale, and to a lesser extent, relatively benign terrain influences in non-mountainous regions (e.g., Southeast, Midwest, and Great Plains).

Terrain Considerations

The spatial extent of representativeness in mountainous regions may be less than in non-mountainous regions. (See Appendix J, Technical Note No. 3).

Other Considerations

Chemical transport models (CTM) such as CAMx or CMAQ may provide additional qualitative support.

Recommendations for Application of the Paired Sums Approach for Continuous $PM_{2.5}$ Monitoring Data

The Paired Sums approach using continuous $PM_{2.5}$ monitoring data with or without inverse-distance (1/r) monitor interpolation is recommended for areas needing more refined $PM_{2.5}$ NAAQS modeling. A state/region-specific analysis should be performed to determine whether it is appropriate to use non-FEM data without adjustment (as is) or whether a scaling or linear regression adjustment (or some other statistical adjustment) on the data before addition to the modeled concentrations is warranted. Such analysis should involve statistical comparison of co-located continuous and FRM data at various locations to insure adequate representation of various background locations and emission profiles.

Paired Sums with Discrete (FRM) $PM_{2.5}$ Data

An additional option to the Paired Sums approach with continuous $PM_{2.5}$ monitoring data is to use discrete FRM data. The monitor site selection will depend on the same urban/rural and terrain considerations as noted above for continuous monitors.

Advantages and Disadvantages of the Paired Sums Approach using Discrete (FRM) Data

FRM data is widely available and has been used for calculating attainment since the outset of the $PM_{2.5}$ program. Continuous $PM_{2.5}$ monitors have only recently been cleared by EPA for NAAQS comparisons, and comparability of continuous $PM_{2.5}$ data with FRM data is still problematic in certain parts of the country.[14] Continuous $PM_{2.5}$ data are typically available as hourly values, which correspond nicely with hourly meteorological data sets used for modeling; however $PM_{2.5}$ FRM data values are only available as integrated 24-hour values.

FRM data is taken on a schedule of one sample every day, one sample every third day or one sample every sixth day, so a disadvantage of the Paired Sums approach using FRM data is that that the modeling results on days where there is no monitoring data available are discarded in the ambient impact analysis. EPA computes design values from monitoring data collected at any of these three frequencies (1-in-3 FRM monitoring data is most prevalent in the national $PM_{2.5}$ network).[15] While a number of days are removed from the meteorological datasets, statistical tests of data sets from various locations throughout the country indicate that using modeling results generated on a 1-in-3 or a 1-in-6 day schedule to correspond with the monitoring data should not cause unacceptable variability in the design values resulting from the modeling analysis (See Appendix I).

In certain areas of the country, $PM_{2.5}$ levels are comparable to the NAAQS during regional episodes. In these areas, it is particularly important that the modeling procedures are faithful to the monitoring data, in the sense that when the $PM_{2.5}$ emissions are set to zero in the model, the 24-hour design value across the modeling domain reduces to the design value associated with the (background) monitoring data. The Paired Sums approach for FRM data described below has this advantage.

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[14] See for example: http://www.4cleanair.org/Documents/BetaAttenuationMonitorsFeltonFineHeindorfKelley.pdf

[15] See: http://www.epa.gov/airtrends/pdfs/dv_pm25_2005_2007.xls

Additionally, the use of FRM data provides continuity among various regulatory activities given the dependencies associated with the FRM data, such as their role in designation and attainment demonstration processes. Increased continuity among intrastate and interstate modeling practices are enhanced with use of common and familiar datasets.

Recommended Procedure for Application of the Paired Sums Approach to FRM Data

Use of the Paired Sums approach requires at least three years of consecutive monitoring data from the most recent period for which data is available. The monitoring data must meet the minimum requirements for quality and completeness. The first step of the procedure is to compute 24-hour $PM_{2.5}$ concentrations over the modeling grid for each day of a given year. Next, for each day of the year where monitoring data is available, the monitored concentration from the representative/conservative site is added to the maximum modeled concentration for that same day. Then, the annual 98th percentile value is computed as the nth highest (modeled + monitored) concentration in the year, where n depends on the number of monitored values in the year as shown in Table 3-1:

Table 3-1, Computed 98th Percentile Value for the nth Highest Concentration

Number of Observations	98th Percentile Value
0 - 50	1
51 - 100	2
101 - 150	3
151 - 200	4
201 - 250	5
251 - 300	6
301 - 350	7
351 - 366	8

This analysis is repeated for each year of monitoring data, resulting in an annual 98th percentile value for each year of modeling. Finally, the average of these annual 98th percentile concentrations is computed to obtain the design value for comparison with the 24-hour NAAQS. The concentrations must be 35 $\mu g/m^3$ or less to show NAAQS compliance over the modeling period. NAAQS comparisons may be performed in this way for any consecutive three plus year period where monitoring data is available. To pass the ambient impact analysis, the data would be required to show compliance for the modeling period chosen.

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Appendix A

Draft - Background for 24-hour PM2.5 NAAQS: How to Construct Model Emission Inventory for Permit Modeling, Tyler Fox EPA OAPQS

Model Emission Inventory for $PM_{2.5}$ Modeling

For permit modeling under the PSD program, the owner or operator of the source is required to conduct modeling to demonstrate that the source does not cause or contribute to a violation of a NAAQS (40 CFR 51.166 (k)(1) and 40 CFR 52.21 (k)(1)) and/or PSD increments (40 CFR 51.166 (k)(2) and 40 CFR 52.21 (k)(2)). Thus the burden of compiling the modeling inventory rests with the applicant, not the permitting authority. Historically, it was not a typical practice for an applicant to use the national emission inventory (NEI) as the primary source for compiling the permit modeling inventory. For short term NAAQS such as the new 24-hour PM2.5 NAAQS, emission rates for permit modeling are computed in accordance with Section 8.1 of Appendix W to 40 CFR Part 51. Under Tables 8-1 and 8-2, the maximum allowable (SIP approved process weight rate limits) or federally enforceable permit limit emission rates assuming design capacity or federally enforceable capacity limitation is used to compute hourly emissions for dispersion modeling against short term NAAQS such as the new 24-hour $PM_{2.5}$ NAAQS, not annual emissions totals as is reported in the NEI. Additional information regarding stack parameters and operating rates may not be available from the NEI. While records exist in the NEI for reporting stack data (stack coordinates, heights, temperatures, velocities) necessary for point source modeling, some states do not report such information to the NEI, or there are errors in the location data submitted to the NEI. Under such conditions, default stack information based upon SIC is substituted and thus represents a major problem accurate for near-field modeling using such a data source.

The normal procedure for compiling the necessary information to construct a permit modeling inventory is relatively straightforward. The applicant completes initial modeling of the proposed project that results in a net emissions increase (40 CFR 52.21 (b)(3)(i)) that is significant (40 CFR 52.21 (b)(23)(i)) and determines the radii of impact (ROI) for each pollutant and averaging period. Typically, the largest ROI is selected and then list of potential sources within the ROI plus a screening distance beyond the ROI are compiled by the permitting authority and supplied to the applicant. The applicant typically requests permit applications or EIQ submittals from the records department of the permitting authority to gather stack data and source operating data necessary to compute emissions for the model inventory. Once the applicant has gathered the relevant data from the permitting authorities, model emission rates are calculated. The EPA preferred near-field dispersion model AERMOD requires input of an hourly emission rate.

As mentioned previously, model emission rates for short term NAAQS are computed consistent with the requirements of Section 8.1 of Appendix W to 40 CFR Part 51, Tables 8-1 and 8-2. The maximum allowable (SIP approved process weight rate limits) or federally enforceable permit limit emission rates assuming design capacity or federally enforceable capacity limitation are used to compute hourly emissions for dispersion modeling against short term NAAQS such as the new 24-hour $PM_{2.5}$ NAAQS. If a source assumes a limit on the hourly firing capacity of a boiler, this is reflected in the calculations. Otherwise, the design capacity of the source is used to compute the model emission rate.

Given a general paucity of $PM_{2.5}$ emission factors for many source categories, a hierarchy of data sources is recommended to establish the $PM_{2.5}$ model inventory. The best quality information is derived from source test data from the same facility or similar sources. The next highest quality emission factor data is vendor supplied data, typically available for point source categories in well-established industries. The next level is the traditional AP-42 emission factor data. Unfortunately, a number of source categories in AP-42 only have emission factor information for filterable PM and PM_{10}. For these source categories, it is necessary to extrapolate a $PM_{2.5}$ emission factor from either the total particulate matter emission factor using general particle size distribution data from Appendix B.1 and Appendix B.2 of AP-42.

Hierarchy of Emission Data Sources

1. Source test data from facility or similar
2. Vendor supplied emission factor data
3. AP-42 Emission Factor Data

Calculating Uncontrolled Emissions

The first step in extrapolating $PM_{2.5}$ emission factors is to calculate uncontrolled emissions. This is accomplished by multiplying the cumulative percentage of the aerodynamic particle diameter (μm) in the 0 – 2.5 range by the total particulate emission factor.

For example, it is necessary to calculate $PM_{2.5}$ emissions from the grain conveying operations at an ethanol facility. Using data from AP-42, Section 9.9.1 (Feed and Grain Mills and Elevators), the $PM_{2.5}$ emission factor would be established as follows:

Uncontrolled $EF_{PM2.5}$ = Total PM Emission Factor x Mean Cumulative Percentage in the 0 – 2.5 μm diameter range.

Uncontrolled $EF_{PM2.5}$ = 0.5 kg/Mg of grain conveyed (AP-42, Section 9.9.1) x 0.168 (Appendix B.1, Section 9.9.1(16.8%)) = 0.084 g $PM_{2.5}$/Mg of grain conveyed.

To calculate the uncontrolled model emission rate, the uncontrolled emission factor for $PM_{2.5}$ is then multiplied by the hourly throughput of the conveyer system. For this example, we assume 1,000 Mg/hr of grain is conveyed across a particular transfer point.

Uncontrolled hourly $PM_{2.5}$ = 0.084 g $PM_{2.5}$/Mg x 1,000 Mg/hr or 84 g/hr of uncontrolled $PM_{2.5}$ from grain conveying.

Calculating Controlled Emissions

If $PM_{2.5}$ emissions are controlled by a control device such as a baghouse or scrubber, two additional calculations are necessary to calculate controlled hourly $PM_{2.5}$ values that would be used as input into a dispersion model.

The first step is to determine the collection efficiency of a particular control device. The collection efficiency is the percentage of uncontrolled emissions that are captured and presented to the particulate control device. The remainder of the emissions that are not captured by the control device are considered uncontrolled and simulated as a fugitive release in the model.

In the second step, the uncontrolled hourly $PM_{2.5}$ captured by the control device collection system is then multiplied by the control efficiency of the control device.

In the example above, emissions from a conveyer transfer point are being calculated. The conveyer transfer point is controlled by a baghouse. The uncontrolled particulate matter is captured by a collection hood. The baghouse vendor estimates that 97% of uncontrolled particulate matter is captured by the collection hood. The vendor further estimates that the baghouse is 99.5% efficient for particulate matter in the 0 – 2.5 µm diameter range.

Controlled hourly $PM_{2.5}$ = Uncontrolled hourly $PM_{2.5}$ x Control Device Collection Efficiency x Control Device Efficiency

Controlled hourly $PM_{2.5}$ = 84 g/hr $PM_{2.5}$ x 0.97 (collection efficiency) x 0.005 (control efficiency) = 0.407 g/hr controlled $PM_{2.5}$

The uncontrolled fugitive emissions are calculated as follows:

Uncontrolled hourly $PM_{2.5}$ = 84 g/hr PM2.5 x (1 – 0.97) = 2.52 g/hr uncontrolled $PM_{2.5}$

In this example, the model emission rate for the baghouse stack servicing the conveyer transfer point would be 0.407 g/hr $PM_{2.5}$. The model emission rate for fugitives from grain handling would be 2.52 g/hr $PM_{2.5}$.

Appendix B
NACAA Comments on EPA ANPR for Emissions Factors Program Improvements

This letter was submitted by NACAA to Docket ID No. EPA-HQ-OAR-2009-0174, Air and Radiation Docket, December 14, 2009, in response to the Advanced Notice of Proposed Rulemaking (ANPR) Published in the *Federal Register* on October 14, 2009 (74 *Federal Register* 52723).

NACAA
national association of clean air agencies

December 14, 2009

U. S. Environmental Protection Agency
EPA Docket Center
Attention Docket ID No. EPA-HQ-OAR-2009-0174
Air and Radiation Docket
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460

Dear Sir/Madam:

On behalf of the National Association of Clean Air Agencies (NACAA), thank you for the opportunity to comment on the Advanced Notice of Proposed Rulemaking (ANPR) for the Emissions Factors Program Improvements, published in the *Federal Register* on October 14, 2009 (74 *Federal Register* 52723). NACAA is the national association of air pollution control agencies in 53 states and territories and over 165 major metropolitan areas throughout the United States.

NACAA supports the development of a self-sustaining emission factors program and is pleased that EPA is seeking input on this important issue. Although we do not believe that amending federal regulation is necessary for improving development of emission factors and their use, NACAA does offer to work with EPA to achieve the goals of the improvement effort outlined by EPA in the ANPR. We begin by providing input on several key components.

Most notably, NACAA is concerned that the existing Emissions Reporting Tool (ERT) is not based on current technology and would not be an effective platform on which to build a national emission factor program. Rather, a web-enabled technology platform should be used, as has been accomplished with the Emission Inventory System (EIS) Development Project and Gateway. Such an approach would provide for a real-time repository of emission data more easily accessible and useable by all stakeholders. Any effort to improve the emission factor program must meet these criteria first if it is to be successful.

Because emission factors are used for many purposes, a successful emission factor program should be inclusive of a large variety of emissions data. This may include data collected by continuous emission monitoring, non-reference methods, and from both controlled and uncontrolled sources, the latter being most important for emission inventory development. A system that includes access to raw emission data also provides much needed transparency to state and local air agencies. Determining the appropriateness of using emission factors should be evaluated in the context in which they are applied. Such decisions should be left to the state or local agency on a case-by-case basis.

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NACAA strongly believes that data quality is a critical component of an emission factor program. Minimum threshold criteria should be used to be entered into the database. Once the minimum requirements are met for data entry, additional criteria could be used to further evaluate the quality of the data by the state or local agency, depending on its intended use. The existing system, accessible through AP-42 and WebFIRE, lacks the necessary quantitative measures for assessing data quality and should be improved upon.

The following are NACAA's comments on the 14 specific issues on which EPA requested input in the ANPR:

1. **Is it appropriate to amend the reporting provisions of the 40 CFR parts 60, 61, and 63 General Provisions to require electronic submittal of performance tests that are already required by standards in these parts?**

NACAA supports EPA's goal to develop a self-sustaining emissions factors program that produces high quality, timely emissions factors, better indicates the precision and accuracy of emissions factors, encourages the appropriate use of emissions factors, and ultimately improves emissions quantification. However, NACAA does not believe that it is appropriate at this time to require electronic submittal of performance test results pursuant to 40 CFR Parts 60, 61, and 63 General Provisions. We believe that there are steps that must first be taken to ensure that mandatory electronic reporting is practicable.

- As noted by EPA in the ANPR, emission factors were initially developed for emissions inventory purposes but have since expanded to a variety of air pollution control activities and emission source types. It is unclear how requiring submittal of performance test results for this small subset of sources will support the goals of the emission factor programs envisioned by EPA and NACAA. If this is to be a comprehensive program, NACAA suggests additional consideration of other regulatory programs that produce qualified emissions data.
- The current EPA Emission Reporting Tool (ERT) platform does not appear to be current with the data collection and security standards employed by many of the state and local agencies. It also remains unclear how the implementation of the ERT would comply with the Cross-Media Electronic Reporting Regulation (CROMERR). Therefore, NACAA members remain concerned that a regulatory mandate to use this technology platform would be problematic. Accordingly, NACAA recommends that EPA invest in the development of a web-based database platform similar to the efforts with updating the Emission Inventory System Gateway.
- It is unclear from the ANPR how the electronic reporting system would be implemented. While NACAA recognizes that EPA may lead the development of the electronic database tool, a complete impact assessment of time, cost, and technology investments required for the state and local agencies to comply with the regulatory aspects of the proposal is necessary.

2. **As acknowledged earlier, emissions factors are used for many air pollution control activities that were not envisioned when this program was established. We are**

seeking comment on the appropriateness of using emission factors for these other purposes and, if they are to be used for other purposes, should there be any other requirements for these emission factors (such as using only highly rated emission factors for permitting) or more information required for these emission factors (such as greater precision and accuracy)?

NACAA agrees that emission factors are used for many purposes. Determining the appropriateness of using emission factors should be evaluated in the context in which they are applied. Such decisions should be left to the state or local agency on a case-by-case basis. Quantifying and qualifying the quality of the data (such as emission factor ratings) enables the data user to make more informed decisions regarding the emission factors and potentially expands their use. However, existing emission factor databases (primarily WebFIRE), are woefully incomplete. NACAA members observe that currently available emission factors are lacking in a variety of areas including data by major industrial groupings, both controlled or uncontrolled, and the vintage of the emission factor. Therefore, NACAA supports an effort to provide better quality data that includes better data quality characterization and data completeness.

3. **Are third party reviews of performance tests needed and, if so, then how could we encourage third party reviews of test reports and what weight should we give reviews in assigning a quality rating?**

While third-party reviews can provide a less biased assessment of performance tests, NACAA recognizes that such reviews are time consuming and are only necessary in specific instances. NACAA believes that a dynamic database emission factor tool could greatly aide in determining when a third-party review is needed, if at all. Many tests are commonplace and procedurally well established and therefore do not require a third-party review.

4. **Should we require electronic submittal of performance tests via the ERT or some similar electronic submittal software (such as existing S/L/T submittal software)? What is the availability of other electronic formats that currently may be used by sources to report source test information to their S/L/Ts? Could these formats be used or adapted to fit into our proposed process?**

As previously mentioned, NACAA believes that the technology platform for the current Electronic Reporting Tool cannot adequately support the emission factor program goals. Nor will it adequately meet the needs of the users providing the emission factor data. Rather, EPA should invest in a web-based platform as has been done with the Emission Inventory System. Such effort would likely need to be developed for the purposes of the emission factor program, as NACAA members are unaware of any available electronic state or local agency software that could be scaled to a nationwide application.

5. **Would a different format for the ratings of test data be useful? For example, would a numerical system provide more information on the quality of the test rating?**

NACAA supports the development of a new data quality rating approach. The current system that uses categorical qualifiers remains subjective. A new system that includes statistical quantitative measures would be more useful to determine the appropriateness of an emission factor to a specific application.

6. **If needed, should additional information be required as part of ERT to enhance the emission factors development process? Should we obtain continuous emissions monitoring data in a fashion that could be used for emissions factors development in the next versions of ERT and WebFIRE?**

NACAA supports the inclusion of CEM data into the development of emission factors. CEM data is more representative of actual emissions than a limited series of performance tests and therefore would make an emission factor more representative of the source.

7. **We plan to build into WebFIRE decision criteria that would be used to select the test data to be used in an emissions factor update. For example, we may have four performance tests conducted in 1979 and four performance tests conducted in 1995 where the source made a slightly different product. What tests should we use to develop the emissions factors and what criteria should we consider to select the performance tests?**

NACAA generally supports the use of all available performance test data subject to the data-quality objectives established for the emission factor program. Minimum threshold criteria should be used to be entered into the database. Once the minimum requirements are met additional criteria could be used to further evaluate the data quality including, but not limited to:

- the source's position in the industry, defined by the percentage of the national total that the source manufactures of a given product;
- the age of the equipment in use at the plant for the process tested;
- professional certifications of the stack testers;
- definition of representative operating conditions for the facility;
- control equipment in use for process;
- pollutants measured; and
- QA/QC flags.

8. **How should emissions data be grouped into related clusters for which the average emissions factors will be developed? Examples of some of the criteria we consider in the present system include the source category, process type, representatives of source, emission source, equipment design, operating conditions, raw material or fuel characteristics, control devices, and test method used.**

NACAA supports the continued use of Source Classification Codes (SCC) for grouping emission factors and the appropriate use of additional clusters where there is sufficient data to provide representative emission factors. NACAA is aware of several proposals to provide additional clusters within an SCC classification, such as "Applicability of FIRE Emissions factors in State-Wide Emission Inventories" presented at the 101st Annual Meeting of the A&WMA, Portland, OR, June 24-26, 2008."

9. **How should WebFIRE assess data collected by non-EPA reference methods (such as those developed by the California Air Resources Board) or data from two different methods that are averaged to develop an emissions factor? How might the quality rating be adjusted to account for methods that are less easy to compare directly?**

NACAA believes that collecting and warehousing emission data collected from non-EPA reference methods may be useful. However, any such data collected should be easily separated or filtered from data collected by EPA reference methods. Data that may be used as a regulatory basis should be based on EPA reference test methods.

10. **At what frequency or schedule should emissions factors in WebFIRE be updated?**

In general, NACAA supports the annual update of emission factors for point sources. Some non-point emission factor data are used less frequently, such as for the triennial emission inventories submitted by state and local agencies to EPA. A dynamic database with appropriate quality assurance measures may be capable of updating emission factors continually.

11. **There are several data handling criteria associated with preparing draft emission factors. These criteria include data averaging, rounding, outliers, detection limits, use of blanks, and format and unit of measure of the factor. How should we account for these potential variables in emissions factors?**

NACAA proposes that raw data required by the reference test method be reported with the electronic submittal of the test report, provided that the emission factor database is designed to effectively receive this input. This is consistent with EPA's approach to the ERT. As such, all emission factor computations could become transparent to the public. Without raw data entry, emission factor data will need to be reduced, clouding the ability of users to evaluate the quality of the basis data.

Emission factor data must be normalized to provide effective application across multiple sources. However, NACAA recognizes that reduction to a normalized value introduces uncertainty. NACAA believes that differentiation should be provided where sufficient data is available. For example, efforts to differentiate fuel types should continue (e.g., coal can continue to be discernable by type and region and other source and process characteristics). Additional value to an emission factor program could be provided where multiple process variables are available (e.g., ton of coal fired, heat input provided, or pounds of steam produced).

12. **Besides calculating the arithmetic mean to be used as the traditional emissions factor, what other statistical characteristics should additional features such as calculations of median and mode factors or other information from the data sets also be provided and in what format, i.e., tabular or graphical, should they be provided?**

A variety of statistical information such as population, variability, median, mode, confidence intervals could be provided in tabular form and a graphical output would add additional value when assessing data distribution. However, a preferred platform would provide for the user the ability to download data from the emission inventory gateway (such as an upgraded WebFIRE) and perform statistical analysis using other third party software that has more robust statistical analytic capabilities.

13. **Should there be a process to limit the number of performance test reports from a particular source category submitted to EPA? For example, should we establish a threshold in the submittal requirement after 50 or 100 performance tests have been submitted? If so, then how would EPA know when source categories significantly change process or controls, such that additional performance tests for emission factors revisions?**

As previously stated, NACAA suggests that all validated data be included in the emission factor development program. NACAA agrees that sources providing a preponderance of data should be attenuated, particularly if the source is not representative of the Source Classification Code for the source. NACAA understands that statistical tools can be employed to ensure proper representation to determine whether submitted test data is significantly different from the total population of data. NACAA encourages EPA to include these techniques in the development of the program.

14. **What steps could enhance public review of the emissions factors development process and outcome and contribute to the timely development of new and revised factors?**

NACAA proposes that an explicit protocol for emission test data review and factor development be prepared with the input from an advisory group that includes the primary affected stakeholders, such as EPA; state, local and tribal agencies; regulated sources; and non-government organizations. Such a protocol should include a specified review period by which the process is kept current with changing regulations and technology.

NACAA appreciates the opportunity to comment on EPA's Advanced Notice of Proposed Rulemaking for the Emissions Factors Program Improvements. We look forward to working with EPA to advance the proposal of an improved emission factor program. Please do not hesitate to contact us if you have any questions or require additional information.

Sincerely,

James D Hodina

David Thornton
Minnesota
Co-Chair
Emissions & Modeling Committee

James Hodina
Cedar Rapids, Iowa
Co-Chair
Emissions & Modeling Committee

Appendix C
Case Study for NACAA $PM_{2.5}$ Workgroup Final Recommendations on Secondary Formation from Project Sources

A limited case study was conducted implementing the NACAA $PM_{2.5}$ Modeling Implementation Workgroup recommendations on secondary formation from project sources. Specifically reviewed was Tier I and Tier II "AERMOD with region- (or state-) specific offset ratios." Focus was on the 24-hour average, as opposed to the annual average, because shorter-term averaging times are more sensitive to adjustments to modeled concentrations. This limited case study indicates that using AERMOD with adjustments to primary $PM_{2.5}$ concentrations to reflect secondary formation promises to be a viable approach to approximate maximum concentrations of $PM_{2.5}$ from project sources to compare with the NAAQS.

The recommended approach:

1. Multiply project source SO_2 emissions by an offset ratio of Primary $PM_{2.5}$: SO_2 in tons per year;
2. Multiply project source NO_X emissions by an offset ratio of Primary $PM_{2.5}$: NO_X in tons per year;
3. Add project source primary $PM_{2.5}$, offset SO_2 and offset NO_X emissions to obtain "Total Equivalent Primary $PM_{2.5}$" emissions;
4. Model Primary $PM_{2.5}$ emissions using AERMOD;
5. Multiply Primary $PM_{2.5}$ modeled concentration by the ratio of Total Equivalent Primary $PM_{2.5}$ emissions: Primary $PM_{2.5}$ emissions.

As discussed in the workgroup recommendation and in this Case Study, the offset ratios applied are the inter-pollutant offset ratios in EPA's final regulations for the "Implementation of the New Source Review (NSR) Program for Particulate Matter Less than $_{2.5}$ Micrometers ($PM_{2.5}$)," 73 FR 28321. These ratios are as follows:

Nationwide SO_2 to Primary $PM_{2.5}$ offset ratio: 40:1
Eastern U.S. NO_X to Primary $PM_{2.5}$ offset ratio: 200:1
Western U.S. NO_X to Primary $PM_{2.5}$ offset ratio: 100:1

The EPA regulation places Minnesota in the Western U.S. Therefore, in this Case Study:

Total Equivalent Primary $PM_{2.5}$ [TPY] = Primary $PM_{2.5}$ [TPY] + [SO_2 TPY]/40 + [NO_x TPY]/100; and

Total $PM_{2.5}$ ($\mu g/m^3$) = Primary $PM_{2.5}$ ($\mu g/m^3$) * (Total Equivalent Primary $PM_{2.5}$ [TPY]/Primary $PM_{2.5}$ [TPY])

Case Study Subjects

Four stacks in Minnesota were evaluated; these are detailed in Table C-1. To simplify the case study, only 1 stack was chosen from any particular facility. All case studies are combustion sources. Individual stacks were chosen to reflect varying conditions.

- Case 1 is a significant emitter of NO_X and SO_2. It also has one of the tallest stack heights—and other parameters that foster good dispersion—in the State. This stack is located in the metropolitan area.
- Case 2 emits significantly less NO_X and SO_2 than Case 1. It was chosen because it is located in the southern part of the state where there is a significant amount of available ammonia to form

ammonium sulfate and ammonium nitrate, due to the proximity of agricultural livestock and fertilizer application sources.

- Case 3 emits lower, but also a significant amount, of NO_X and SO_2 than Case 1. It has a lower stack height and potentially less dispersion. This stack is located in the metropolitan area.
- Case 4 was chosen because it has more equitable emissions of NO_X, SO_2 and primary $PM_{2.5}$ emissions than the other sources. This stack is located in the Northeastern part of the state, where there is the least amount of available ammonia.

Table C-1 Minnesota Case Study Subjects

	Emissions (tons/year)				Stack Parameters			
Case	NO_X	SO_2	NH_3	Primary PM_{25}	Height (m)	Diameter (m)	Temp(K)	Exit Velocity (m/hr)
1	13,273	14,954	1.8	28	198	9.9	350	114,635
2	401	532		17	61	2.0	433	57,221
3	4,475	2,257	0.3	8	74	3.7	422	54,979
4	1,488	472		356	35	3.0	386	74,978

Estimation of Secondary Formation

The Comprehensive Air Quality Model with Extensions (CAMx) version 5.20.1, developed by ENVIRON, was used to simulate secondary formation of $PM_{2.5}$ in the form of particulate sulfate and particulate nitrate. These concentrations were assumed to be fully neutralized by ammonia. Thus, particulate sulfate was multiplied by 1.375 to estimate ammonium sulfate ($[NH_4]_2SO_4$) and particulate nitrate was multiplied by 1.290 to estimate ammonium nitrate (NH_4NO_3).

CAMx simulates atmospheric and surface processes affecting the transport, chemical transformation and deposition of air pollutants and their precursors. CAMx is an Eulerian model that computes a numerical solution on a fixed grid. CAMx also has a Lagrangian Plume-in-Grid (PiG) module to treat the early dispersion and chemistry of point source plumes. Chemistry within the PiG'd plume interacts with chemistry processes occurring outside the plume. For example, formation of nitrate within the plume will be produced from ammonia available within the plume and the grid cell. Likewise, grid cell ozone and peroxide is available to form sulfate. CAMx has an option to output concentrations of point source plumes passing through a given grid cell at a higher resolution than the grid cell, termed sub-grid sampling.

The Minnesota Case Study utilized the PiG module for each Case Study subject. The CAMx simulation used the CB05 gas-phase chemical mechanism 6—which contains 156 reactions and up to 89 species—and the CF aerosol chemistry option.[16]

In the Minnesota case study, the CAMx simulation included emissions of SO_2, NO_X, ammonia, primary $PM_{2.5}$ and Volatile Organic compounds from point, mobile on-road, non-road, area and biogenic sources, and meteorology, at a 36-km grid cell resolution for most of the United States and Canada, a 12-km grid cell resolution covering the state of Minnesota and portions of neighboring states, and PiG and sub-grid sampling at 200-m intervals over a 72x72 km area encompassing each of the four Case Study subjects. An example of a point source and the sub-grid sampling area for Case 1 is shown in Figure C-1.

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[16] ENVIRON (2010).

The emissions and meteorology were obtained from the Lake Michigan Air Directors Consortium (LADCO) for the year 2005, version BaseM. The meteorology was processed by Alpine Geophysics using the Pennsylvania State University/National Center for Atmospheric Research Mesoscale Model (MM5) version 3.7 and emissions were processed by LADCO and ENVIRON with a combination of the Emissions Modeling System (EMS-2003) and the Consolidated Community Emissions Processing Tool (CONCEPT).

The 24-hour average 98th-percentile concentration was extracted from CAMx output for each primary and secondary-formed (i.e. nitrate and sulfate) $PM_{2.5}$ species. The 98th-percentile concentrations for each species were summed to obtain the 98th-percentile concentration of total $PM_{2.5}$.

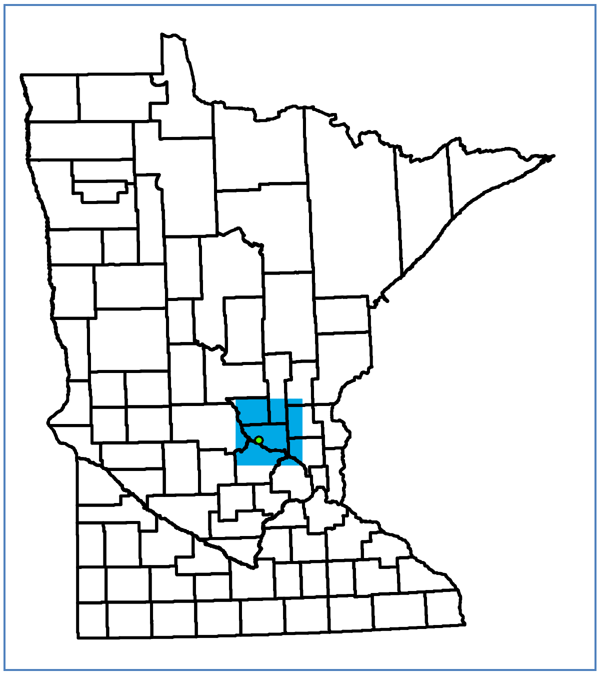

Figure C-1 CAMx Sub-Grid Sampling at 200 meter Intervals for Case 1

<u>CAMx Case Study Results</u>

In order to eliminate the inherent differences in the AERMOD and CAMx model, initially all primary and secondary formed $PM_{2.5}$ species were modeled using only CAMx. The modeled CAMx primary + secondary $PM_{2.5}$ (Modeled 1^0 & 2^0) was compared to the Tier I, Tier II approaches calculated from CAMx-estimated primary $PM_{2.5}$ concentrations (Modeled 1^0 * offset ratio). Table C-2 shows the maximum 24-hour average 98th-percentile concentrations of total $PM_{2.5}$ in micrograms per cubic meter ($\mu g/m^3$) for each Case Study subject. The table also contains the concentration of the individual species that make up the total. The modeled and the offset ratio results are within the same order of magnitude and are within approximately a factor of two. In all cases, secondary formation accounts for less than or equal to 1 $\mu g/m^3$ $PM_{2.5}$.

Table C-2 CAMx Modeled Primary and Secondary $PM_{2.5}$ Concentrations and Tier I, II Estimated $PM_{2.5}$ Concentrations

Case Study	Method	Maximum Concentration (µg/m^3)			
		$(NH_4)_2SO_4$	NH_4NO_3	Primary $PM_{2.5}$	Total $PM_{2.5}$
1	Modeled 1^o & 2^o	0.207	0.002	0.006	0.216
	Modeled 1^o * offset ratio	0.090	0.032	0.007	0.129
2	Modeled 1^o & 2^o	0.055	0.002	0.325	0.383
	Modeled 1^o * offset ratio	0.267	0.081	0.325	0.673
3	Modeled 1^o & 2^o	0.248	0.000	0.028	0.276
	Modeled 1^o * offset ratio	0.336	0.267	0.047	0.650
4	Modeled 1^o & 2^o	0.630	0.393	6.518	7.541
	Modeled 1^o * offset ratio	0.241	0.304	6.518	7.064

Figures 2 through 9[17] illustrate the results of the modeled approach and the offset ratio approach based on distance from the project source. The offset ratio approach forces the maximum total $PM_{2.5}$ concentration to occur at the location of the maximum primary $PM_{2.5}$ concentration. The modeled CAMx results indicate that the maximum primary $PM_{2.5}$ concentrations occur nearer to the stack than the maximum secondary components. Case 2 (Figures 4 and 5) most clearly illustrates the effect distance has on the difference in the estimation methods. Multiplying primary $PM_{2.5}$ by the offsets resulted in maximum values at the same distance from the stack as the primary $PM_{2.5}$ concentration. Because the secondary formed $PM_{2.5}$ from each Case Study subject is less than or equal to 1 µg/m^3, placement of the maximum at the location of maximum primary $PM_{2.5}$ concentration may be considered a conservative assumption.

The offset ratio approach appears to underestimate sulfate concentrations compared to the modeled where the maximum concentration is driven by sulfate and the maximum concentration of all species occurs at a greater distance from the project source. Case Study #1 (Figures 2 and 3) illustrates this, where the maximum concentration occurs at about 9-km from the project source. The offset ratio approach also appears to underestimate sulfate concentration compared to the modeled where the total maximum concentration occurs nearer to the project source, at 100-m[18], and is predominantly primary $PM_{2.5}$. This is illustrated with Case Study #4 (Figures 8 and 9). The offset ratio approach appears to be conservative estimating sulfate when both sulfate and primary $PM_{2.5}$ are more prominent factors in the total $PM_{2.5}$ concentration and where total maximum concentration occur from about 900-m to 4-km from the Case Study subject. This is illustrated with Case Study subjects #2 and #3 (Figure 4 – 7).

The offset ratio approach appears to be conservative estimating nitrate concentrations compared to modeled when nitrate concentrations are very low (~1/2000th µg/m^{3}or less), as illustrated in Case Study subjects #1 through #3 (Figures 2 – 7). The offset ratio approach also appears to be conservative beyond distances of about 3.0-km from the project source. The offset ratio approach underestimates nitrate concentrations compared to the modeled when both nitrate and primary $PM_{2.5}$ become more predominant

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[17] Jagged appearance of plots due to the fact that the receptors in the CAMx sub-grid sampling are on a gridded basis rather than on a polar grid with the Case Study subject located at the center of the polar grid. Distance is based on grid cell centroid from the Case Study subject, placed in 100 meter bins. The maximum 98th-percentile concentration is plotted from each bin. Thus, first maximum is extracted from the set of grid cell centroids located 50-150 meters from the Case Study subject.

[18] The closest receptor in the CAMx modeling to Case Study subject #4 is approximately 100 meters.

factors and the nitrate concentrations are highest near the Case Study subject (less than about 3.0-km). Case Study subject #4 (Figures 8 and 9) illustrates this.

Because the Tier I and II recommended approaches are intended to be conservative, this limited case study would indicate that appropriate offset ratios, covering all distances from all four Case Study subjects, would be:

SO_2 to Primary $PM_{2.5}$: ~~40:1~~ 15:1
NO_X to Primary $PM_{2.5}$: ~~100:1~~ 77:1

Table C-3 shows the resulting maximum concentrations using the Case Study generated offset ratios. The conservative assumption in offset ratios still results in total $PM_{2.5}$ concentrations within the same order of magnitude of the modeled concentrations. However, Case Study Subjects #2 and #3 offset ratio concentrations are 3-5 times higher than modeled concentrations. For all Case Study subjects, the secondary-formed $PM_{2.5}$ components still total less than or equal to 1 µg/m^3.

Table C-3. CAMx Modeled Primary and Secondary $PM_{2.5}$ Concentrations and Tier I, II Estimated $PM_{2.5}$ Concentrations with Case Study Derived Conservative Offset Ratios.

Case Study	Method	Maximum Concentration (µg/m^3)			
		$(NH_4)_2SO_4$	NH_4NO_3	Primary $PM_{2.5}$	Total $PM_{2.5}$
1	Modeled 1^o & 2^o	0.207	0.002	0.006	0.216
	Modeled 1^o * offset ratio	0.240	0.042	0.007	0.289
2	Modeled 1^o & 2^o	0.055	0.002	0.325	0.383
	Modeled 1^o * offset ratio	0.713	0.105	0.325	1.143
3	Modeled 1^o & 2^o	0.248	0.000	0.028	0.276
	Modeled 1^o * offset ratio	0.897	0.346	0.047	1.290
4	Modeled 1^o & 2^o	0.630	0.393	6.518	7.541
	Modeled 1^o * offset ratio	0.644	0.395	6.518	7.557

AERMOD Application of Tier I , II methodology

AERMOD version 09292 was used to simulate the primary $PM_{2.5}$ concentration for each Case Study subject. The Tier I, II recommended approach with EPA offset ratios was applied to the AERMOD primary $PM_{2.5}$ concentrations. The model setup included no building downwash, no deposition, and rural (more conservative) dispersion. Integrated Surface Hourly Data (ISHD) formatted meteorological data, obtained from the National Climatic Data Center for the Minneapolis/St. Paul Airport was used. A polar grid was developed with receptors from 10-5,000 meters from each Case Study stack. The AERMOD maximum concentration is captured within 5-km from each Case Study stack. AERMOD has no chemistry modules.

AERMOD Case Study Results

As with the CAMx results, the modeled and the EPA offset ratio results are within the same order of magnitude and are within approximately a factor of two. Table C-4 shows these results.

Table C-4 AERMOD Tier I, II Estimated Maximum 98th Percentile 24-hour Average $PM_{2.5}$ Concentrations with EPA Offset Ratios.

Case Study	Maximum Concentration (µg/m³)		
	CAMx		AERMOD
	1° & 2°	1° * offset ratio	1° * offset ratio
1	0.216	0.129	0.166
2	0.383	0.673	0.309
3	0.276	0.650	0.459
4	7.541	7.064	3.851

Figures J-10 through J-3 show the maximum 98th-percentile 24-hour average $PM_{2.5}$ concentrations estimated with AERMOD along with the associated components, sulfate, nitrate and primary particulate. As expected, the relative concentration of component species to total $PM_{2.5}$ with AERMOD is the same as that with the offset ratio applied to CAMx primary concentrations (Figures I-3, I-5, I-7 and I-9).

Except in Case Study #1, where maximum primary $PM_{2.5}$ concentrations occur further from the project source—approximately 9-km—and are low—less than 1/100th of a microgram per cubic meter—CAMx overall predicts higher maximum primary $PM_{2.5}$ concentrations than AERMOD. This is clearly illustrated in Figures I-14 through I-17, and may be at least in part due to the fact that wind speeds based on MM5 used in CAMx can be very low, while wind speeds less than 3 knots (1.5 meters per second) are assigned a value of 0 knots in the ISHD data and are not processed in AERMOD[19].

The difference between secondary-formed $PM_{2.5}$ species modeled with CAMx compared to the AERMOD—offset ratios approach (based on AERMOD estimated primary $PM_{2.5}$) is shown in Table C-5. CAMx estimated about a ½-µg/m³ more ammonium sulfate and about a ¼-µg/m³ more ammonium nitrate than the AERMOD—offset ratio approach for Case #4, where primary $PM_{2.5}$ concentrations dominate the maximum total $PM_{2.5}$ concentration.

Table C-5. Difference of AERMOD and CAMx Estimated Secondary-Formed Species of Maximum 98th Percentile 24-hour Average $PM_{2.5}$ Concentrations

Species	Case Study	AERMOD Offset	CAMx Modeled	Difference (CAMx - AERMOD)
Sulfate	#1	0.116	0.208	0.091
	#2	0.120	0.137	0.017
	#3	0.237	0.248	0.010
	#4	0.119	0.630	0.511
Nitrate	#1	0.041	0.007	-0.035
	#2	0.036	0.003	-0.033
	#3	0.188	0.000	-0.188
	#4	0.150	0.393	0.243

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[19] EPA (2005)

Additional Considerations

i. Seasonality of Secondary $PM_{2.5}$ components. Secondary $PM_{2.5}$ in the form of sulfate, or ammonium sulfate, is highest during the summer months when more of the by-products of photochemistry are available. Secondary $PM_{2.5}$ in the form of ammonium nitrate favors low temperatures and high humidity, and forms after ammonia preferentially forms ammonium sulfate. In Minnesota, overall monitored 24-hour average $PM_{2.5}$ concentrations are highest during the cooler months, when ammonium nitrate is the primary component.

The above section "Estimation of Secondary Formation", states that the 24-hour average 98th-percentile concentration was extracted from CAMx output for each primary and secondary-formed (i.e. nitrate and sulfate) $PM_{2.5}$ species. The 98th-percentile concentrations for each species were summed to obtain the 98th-percentile concentration of total $PM_{2.5}$. This approach accounts for the seasonality of each component. None of the Case Study subjects formed nitrate to levels that predominate over sulfate formation.

ii. Averaging Time to Compare with $PM_{2.5}$ NAAQS. In some circumstances, the modeled secondary formation of sulfate can be very sensitive to the averaging time chosen for estimating total $PM_{2.5}$ concentration. This is illustrated for Case #2, Figure 26. This Figure shows the 24-hour average maximum, 2nd-high, 4th-high and 98th-percentile (8th-high) sulfate concentration. For this case only, the maximum sulfate concentration is an order of magnitude higher than the 98th-percentile concentration. Although not substantiated in this Case Study analysis, a hypothesis is that the high maximum sulfate concentration may be due to the role of heterogeneous sulfate chemistry[20,21] in the model.

As stated in the above section "Estimation of Secondary Formation", as project source PiG puffs evolve, they are fully interactive with the grid cell. Thus, SO_2 from the PiG puffs, dissolved in water, can react with grid cell ozone and peroxide to form sulfate. Ammonia from the grid cell could make the pH of the droplets more basic, which also influences the heterogeneous sulfate chemistry. It appears the modeled level of maximum sulfate produced for Case #2 may happen under infrequent circumstances. This supports an averaging time such as the 4th-high or 98th-percentile as more appropriate than the maximum sulfate concentration.

Conclusions of Case Study

This limited case study indicates that using AERMOD with adjustments to primary $PM_{2.5}$ concentrations to reflect secondary formation promises to be a viable approach to approximate maximum concentrations of $PM_{2.5}$ from project sources to compare with the NAAQS. The results of this Case Study indicate that more conservative offset ratios than EPA offset ratios would be more likely to ensure compliance with the NAAQS. However, in all cases the 98th percentile 24-hour average secondary formation of $PM_{2.5}$ (i.e. sulfate and nitrate) from individual point source stacks accounted for less than or equal to 1 μg/m3. Emissions from the Case Study subjects ranged from 400 TPY – 13,000 TPY NO_X and 500 TPY – 15,000 TPY SO_2 (with properly designed stacks). Additional case studies would be useful to substantiate this conclusion.

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[20] Hoffmann M.R. and Calvert J.G. (1985).

[21] Seinfeld J.H. (1986).

References

ENVIRON (2010), "Comprehensive Air Quality Model with Extensions, CAMx User's Guide", version 5.20.

EPA (2005), "Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule", 70 FR 68218.

Hoffmann M.R. and Calvert J.G. (1985), "Chemical Transformation Modules for Eulerian Acid Deposition Models. Volume II. The Aqueous-Phase Chemistry", National Center for Atmospheric Research, Boulder, CO.

Seinfeld J.H. (1986), "Reaction Kinetics of Aqueous Sulfur Chemistry", Atmospheric Chemistry and Physics of Air Pollution, pp 218-229, John Wiley & Sons. Inc, New York.

Figures for Appendix C

CASE 1: CAMx 24-hour Average 98th percentile $PM_{2.5}$ Concentration in micrograms per cubic meter by distance.

Figure C-2. Modeled 1□ & 2□

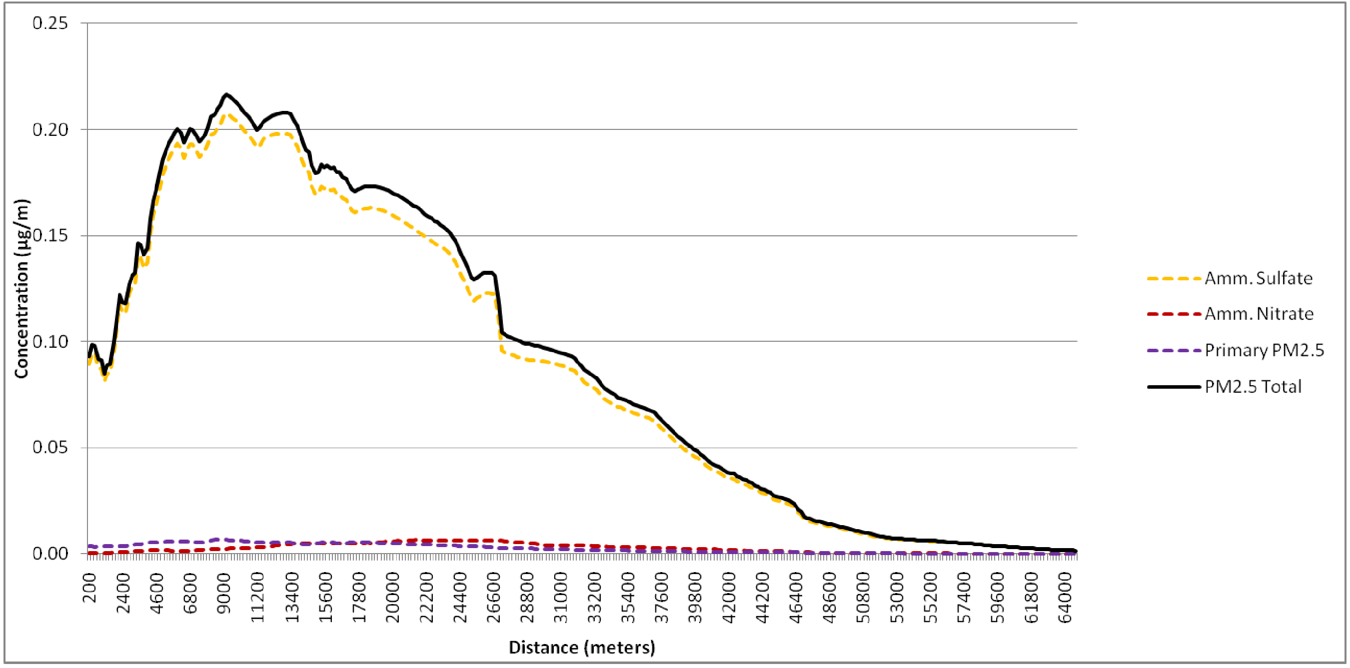
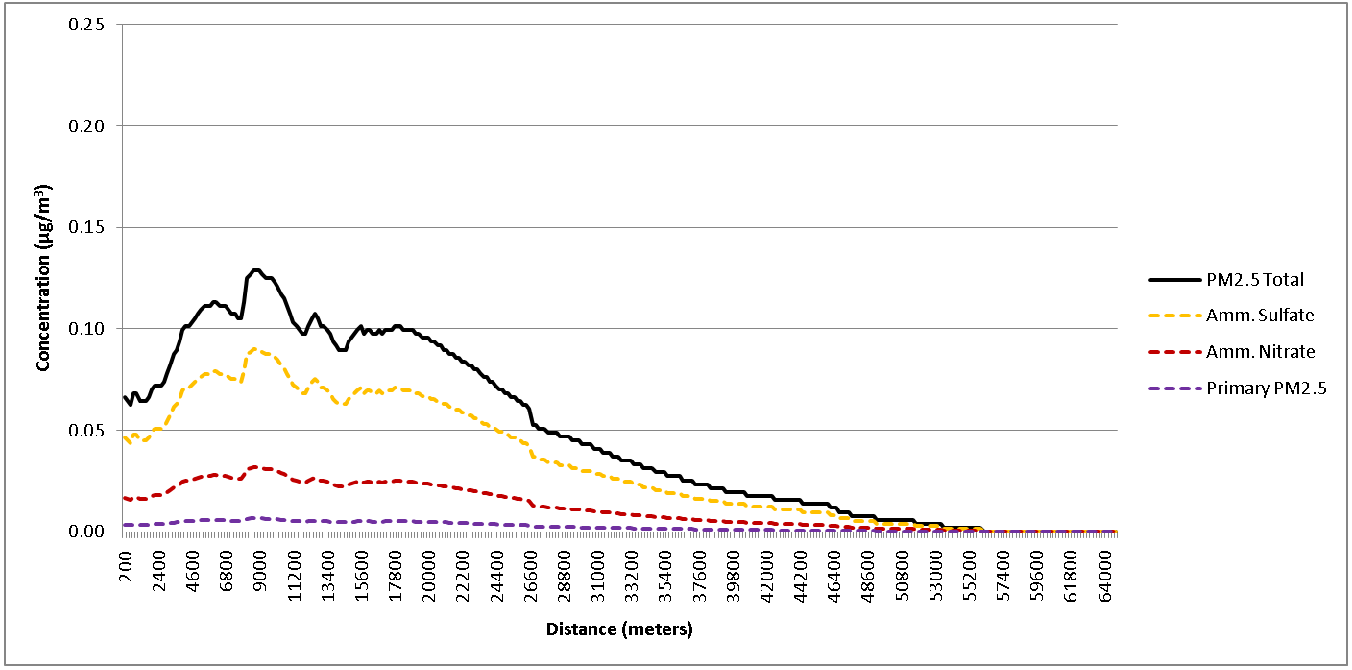


Figure C-3. Modeled 1□ * offset ratio



<u>CASE 2</u>: CAMx 24-hour Average 98th percentile $PM_{2.5}$ Concentration in micrograms per cubic meter by distance

Figure C-4. Modeled 1□ & 2□

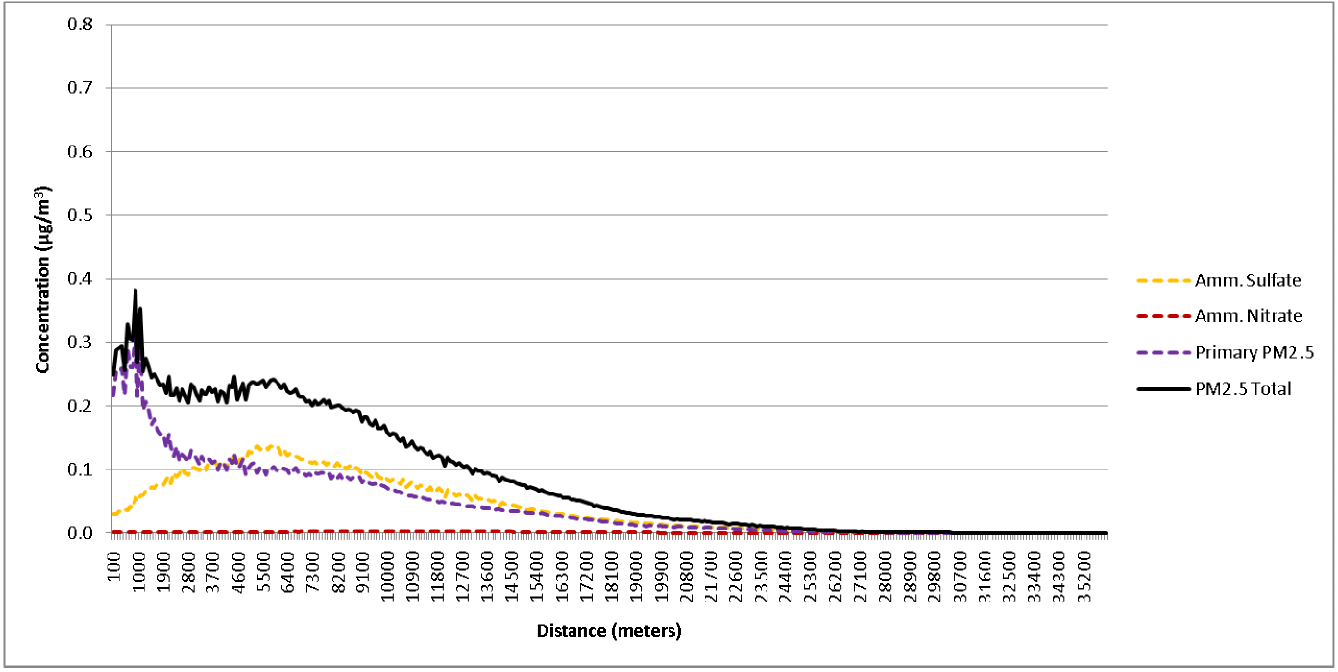
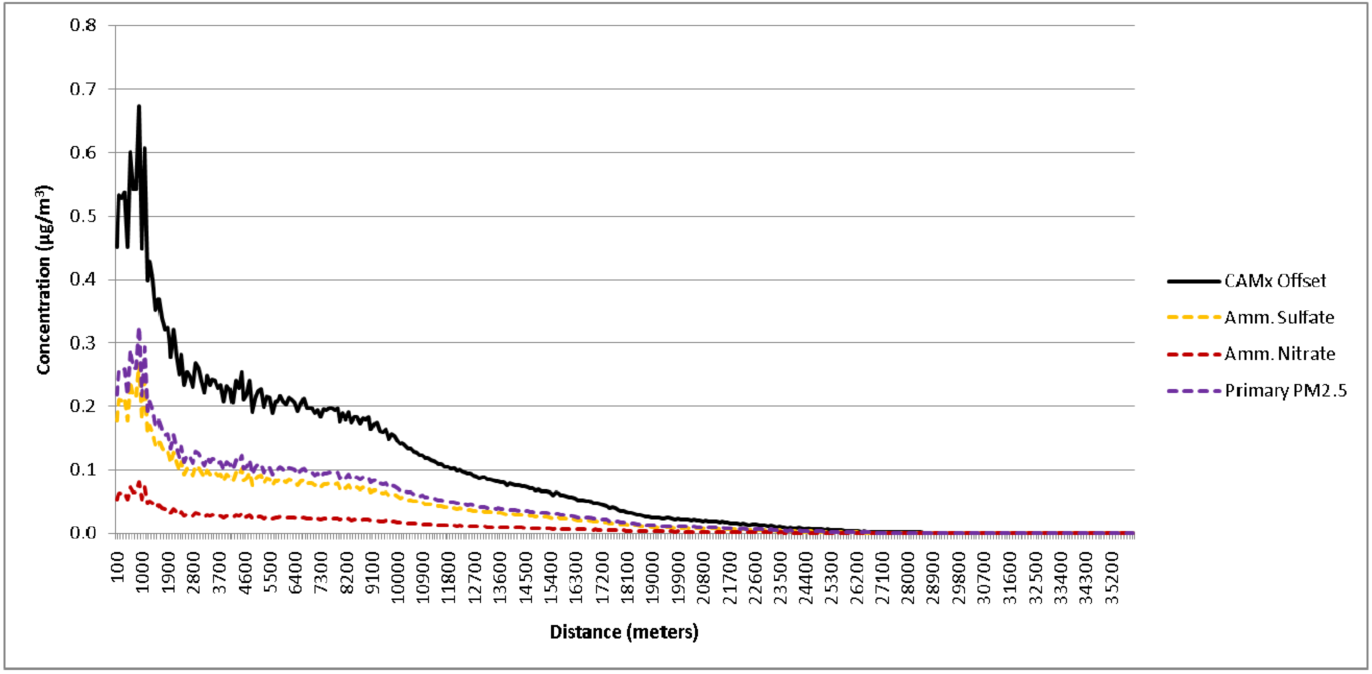


Figure C-5. Modeled 1□ * offset ratio



CASE 3: CAMx 24-hour Average 98th percentile $PM_{2.5}$ Concentration in micrograms per cubic meter by distance

Figure C-6. Modeled 1° & 2°

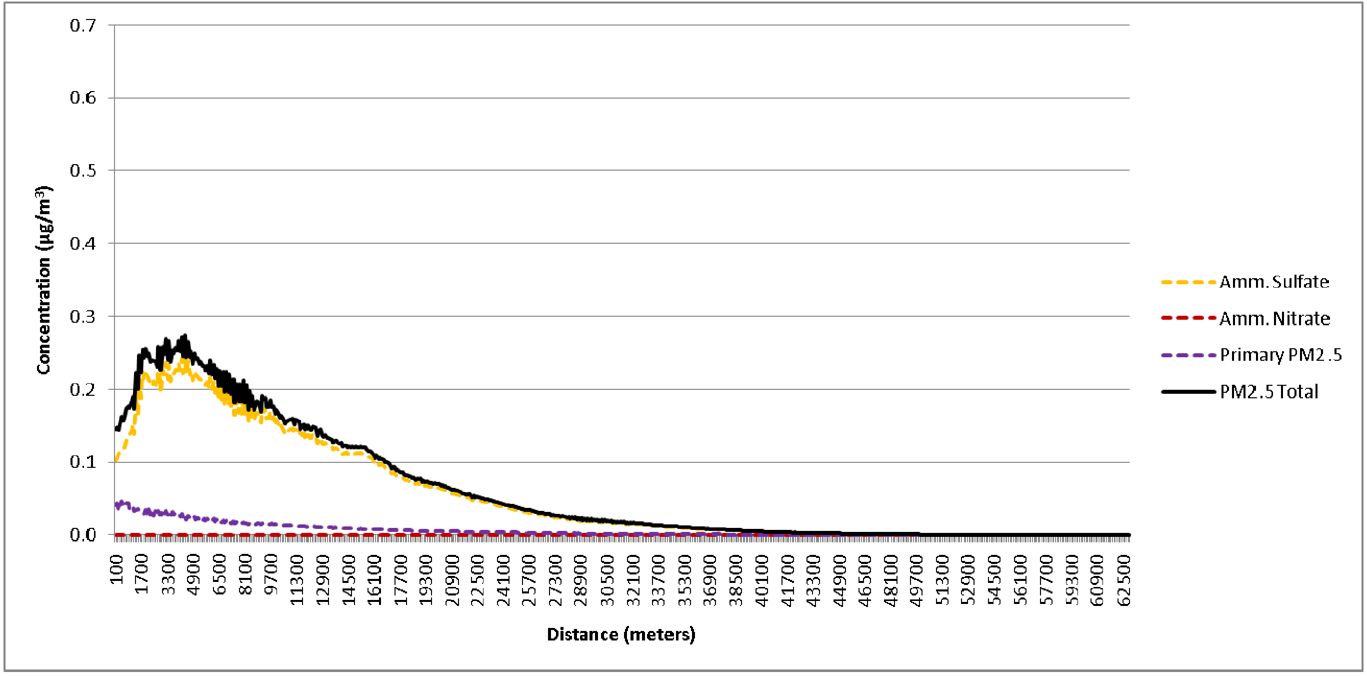
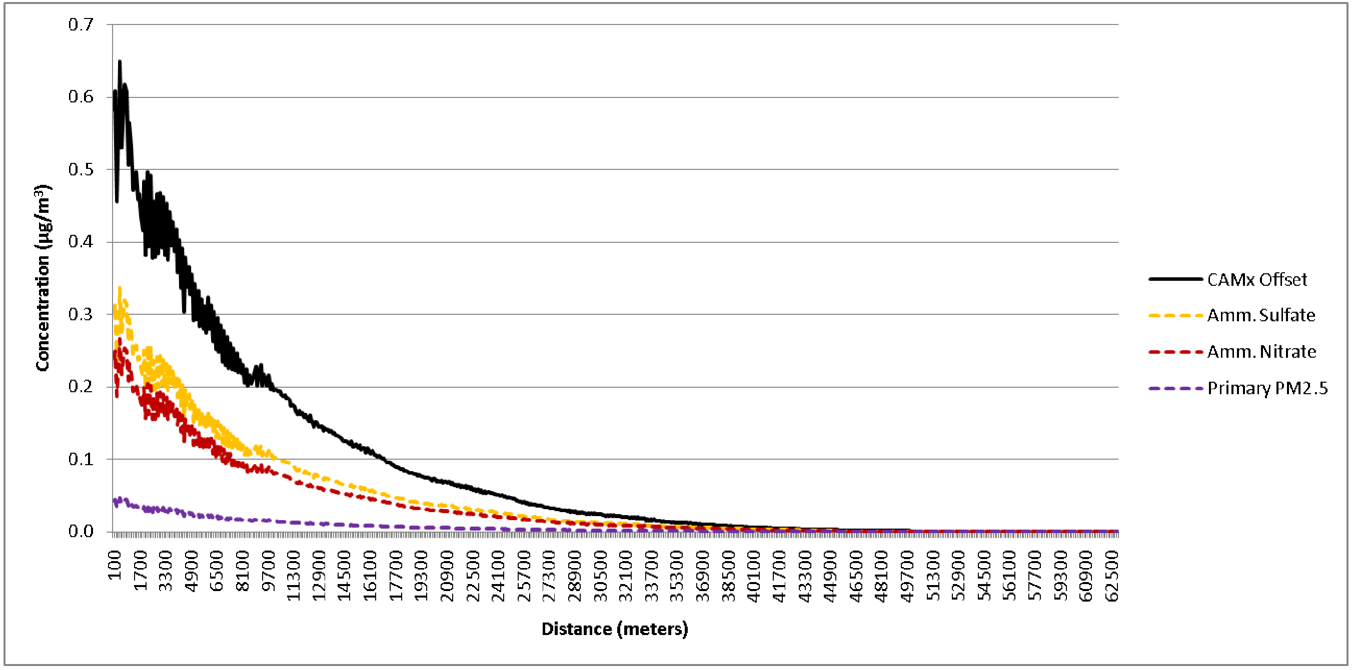


Figure C-7. Modeled 1° * offset ratio



<u>CASE 4</u>: CAMx 24-hour Average 98th percentile $PM_{2.5}$ Concentration in micrograms per cubic meter by distance

Figure C-8. Modeled 1□ & 2□

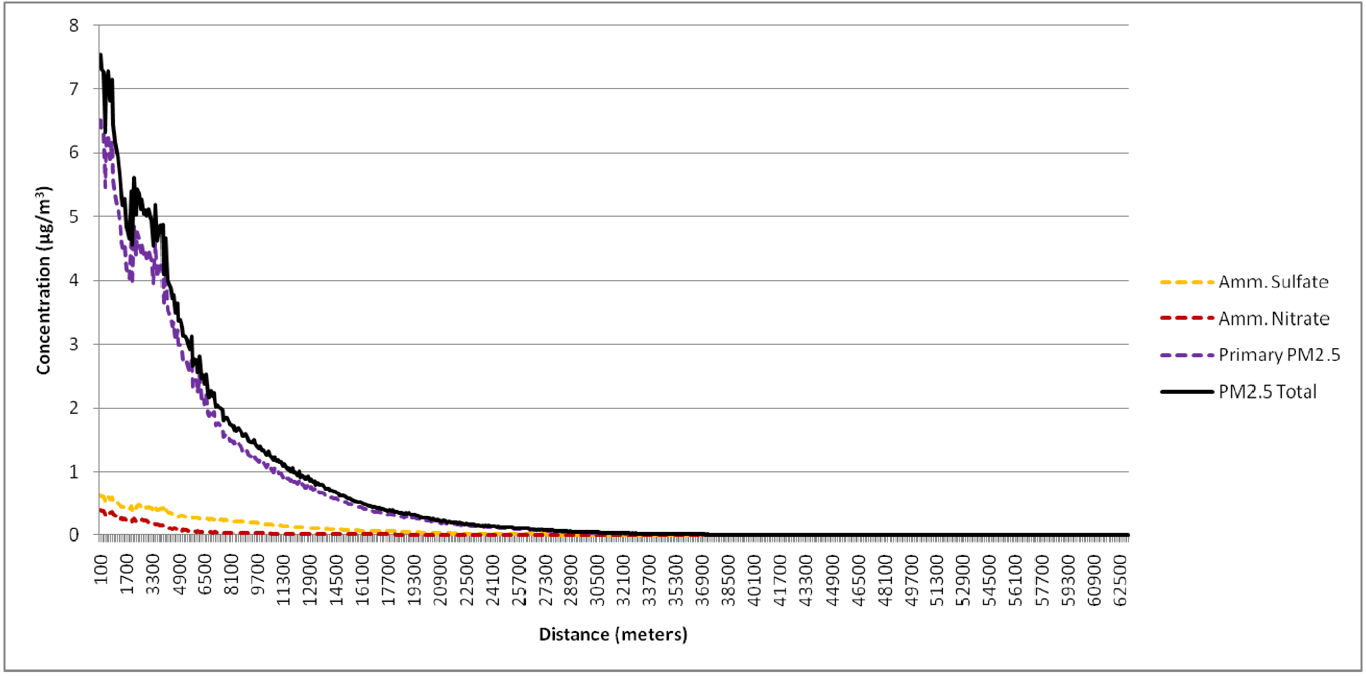
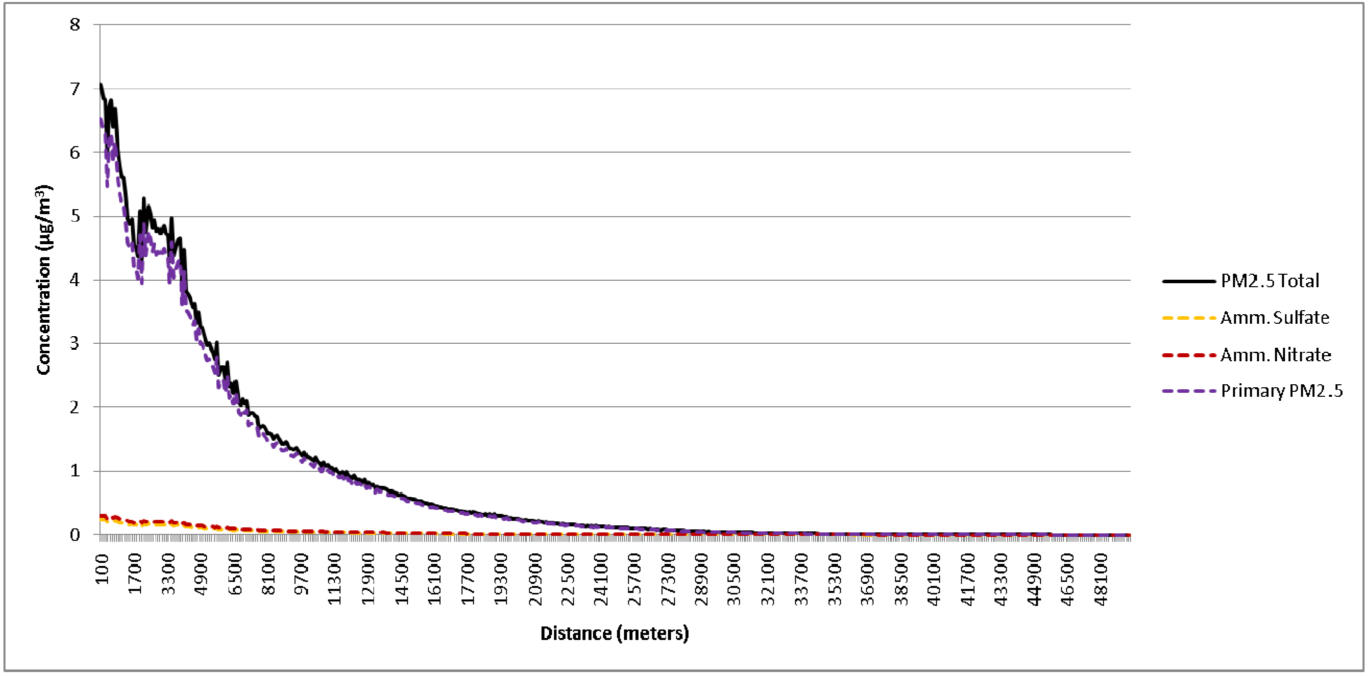
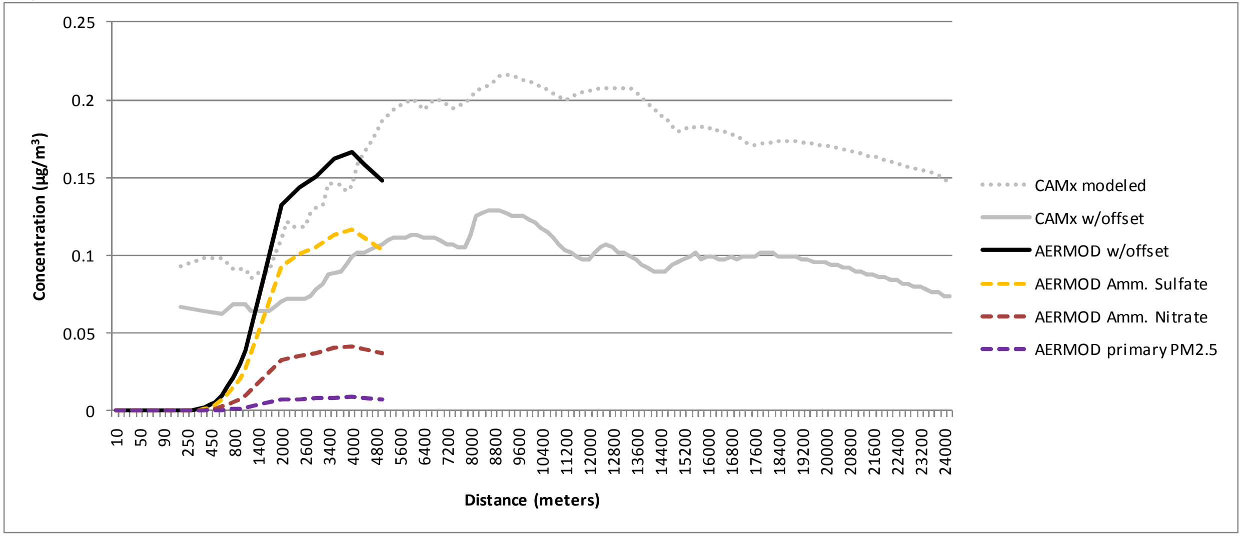


Figure C-9. Modeled 1□ * offset ratio



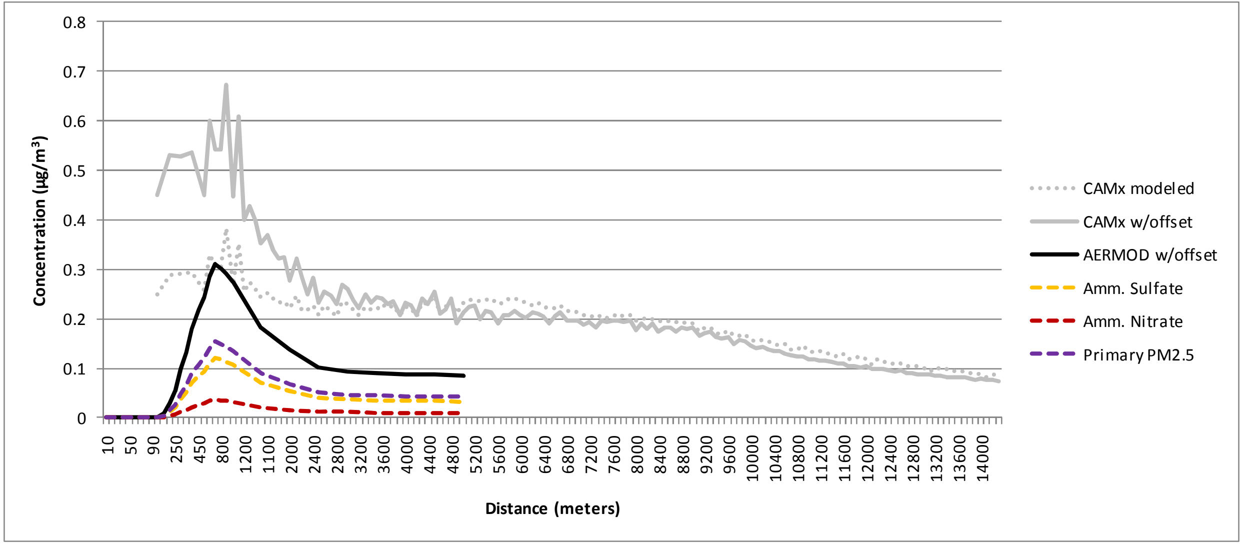
<u>CASE 1</u>: CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio 24-hour Average 98th percentile $PM_{2.5}$ Concentration in micrograms per cubic meter by distance.

Figure C-10.



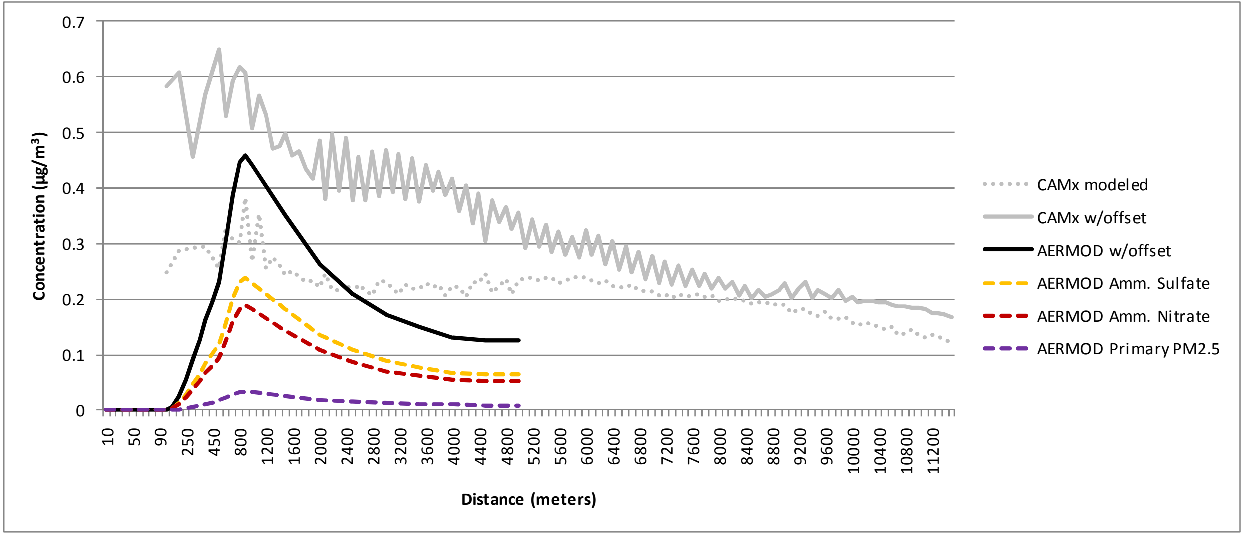
<u>CASE 2</u>: CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio 24-hour Average 98th percentile $PM_{2.5}$ Concentration in micrograms per cubic meter by distance.

Figure C-11.



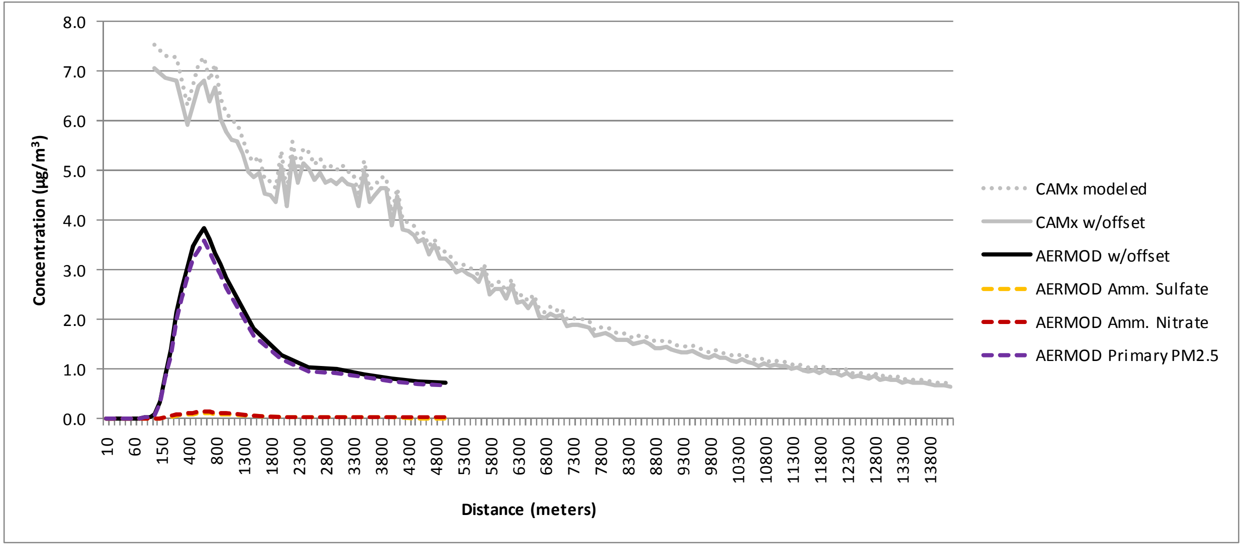
CASE 3: CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio 24-hour Average 98th percentile $PM_{2.5}$ Concentration in micrograms per cubic meter by distance.

Figure C-12.



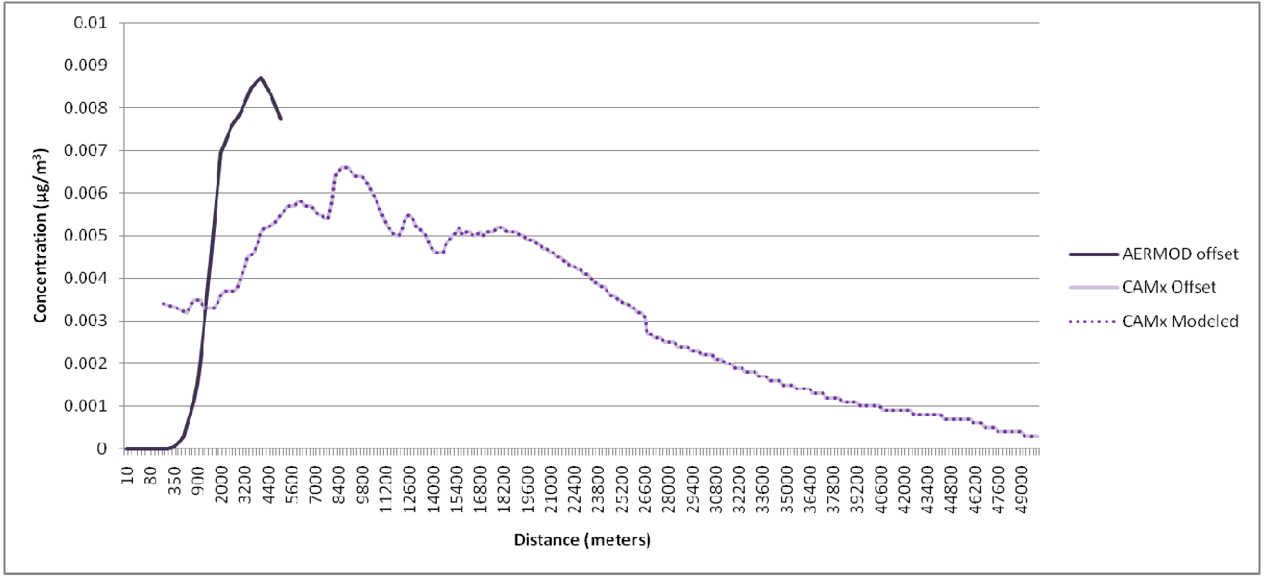
CASE 4: CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio 24-hour Average 98th percentile $PM_{2.5}$ Concentration in micrograms per cubic meter by distance.

Figure C-13.



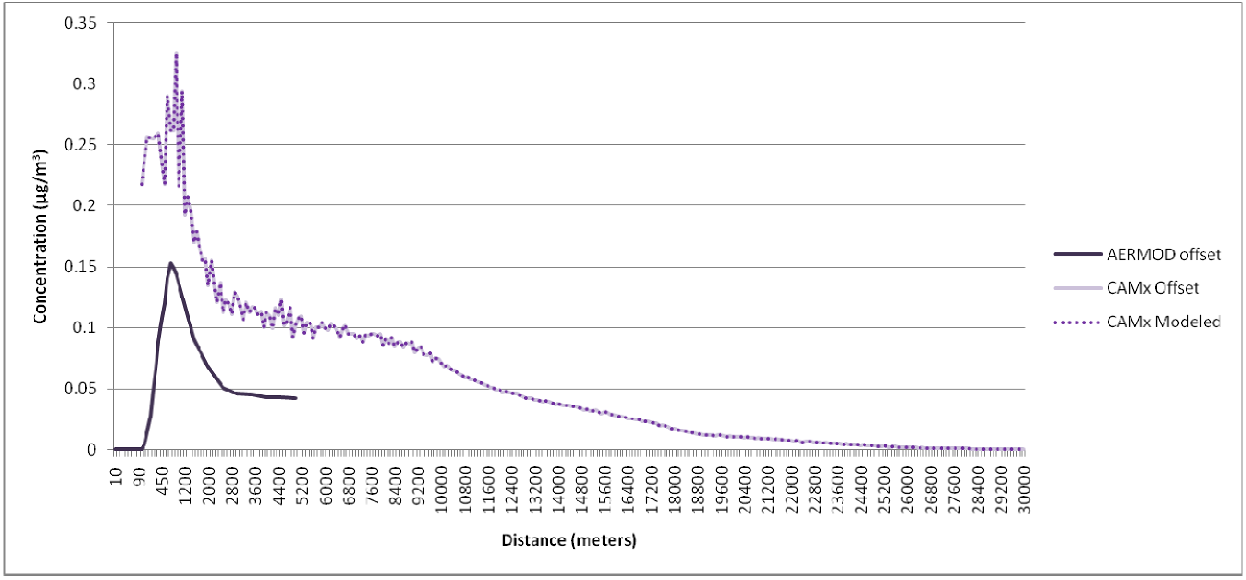
CASE 1: Primary $PM_{2.5}$
CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio 24-hour Average 98th percentile Concentration in micrograms per cubic meter by distance.

Figure C-14.



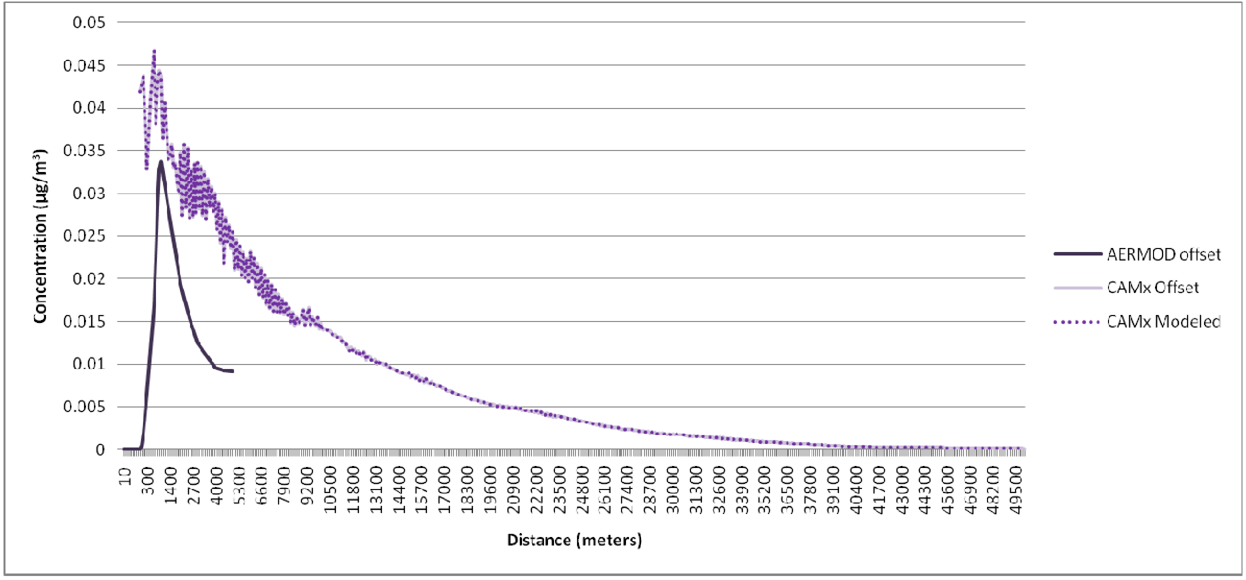
CASE 2: Primary $PM_{2.5}$
CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio 24-hour Average 98th percentile Concentration in micrograms per cubic meter by distance.

Figure C-15.



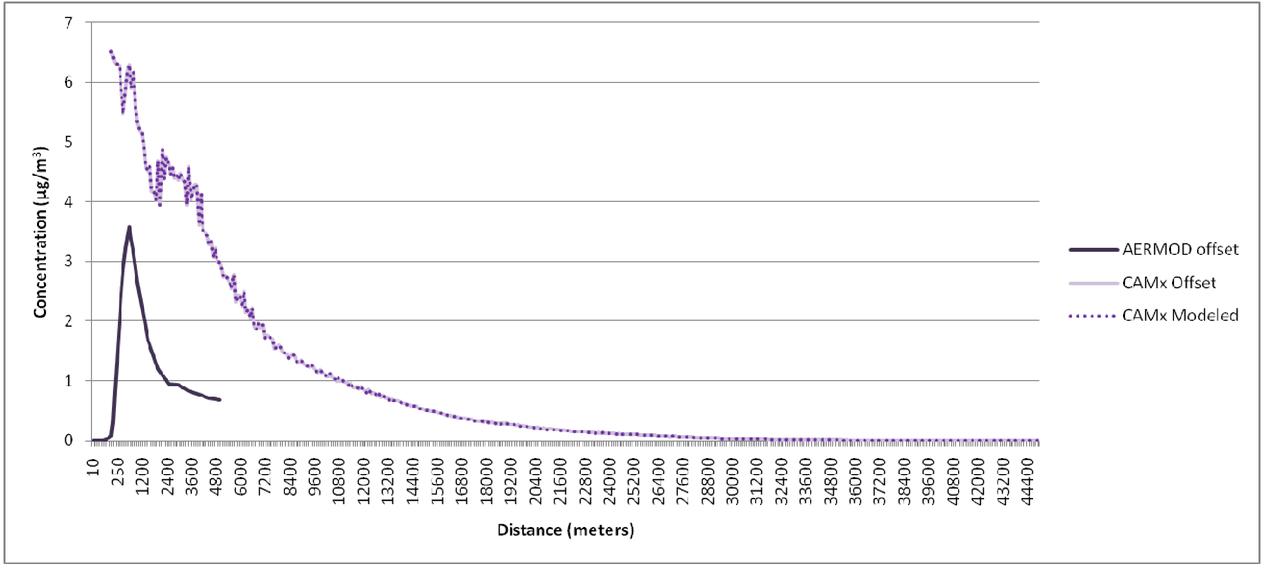
CASE 3: Primary $PM_{2.5}$
CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio 24-hour Average 98th percentile Concentration in micrograms per cubic meter by distance.

Figure C-16.



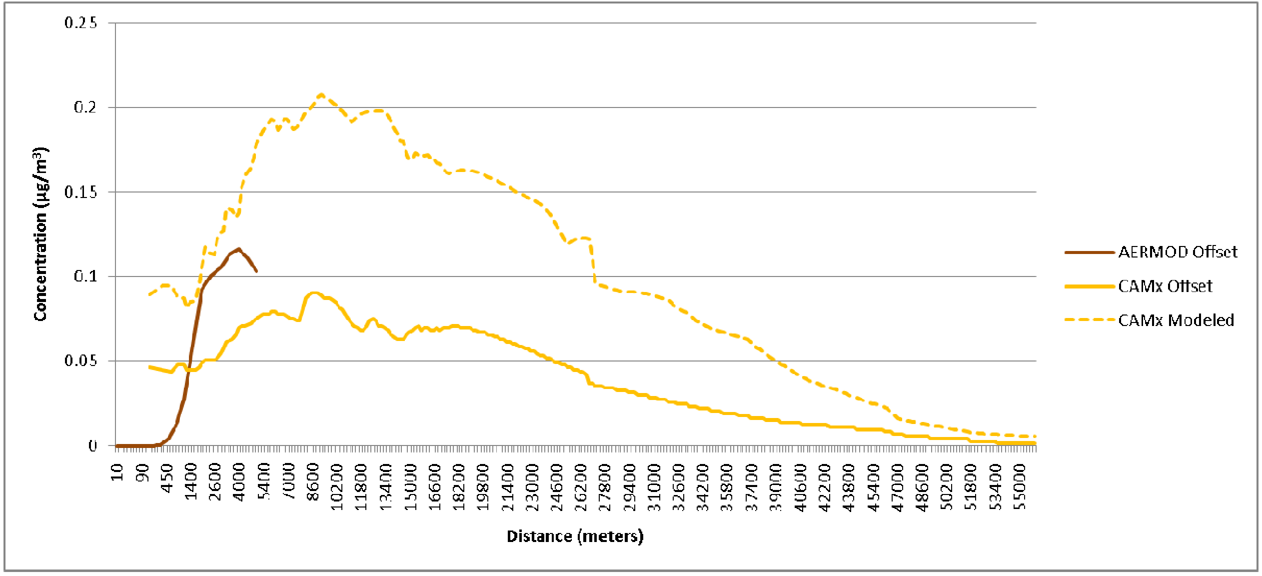
CASE 4: Primary $PM_{2.5}$
CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio 24-hour Average 98th percentile Concentration in micrograms per cubic meter by distance.

Figure C-17.



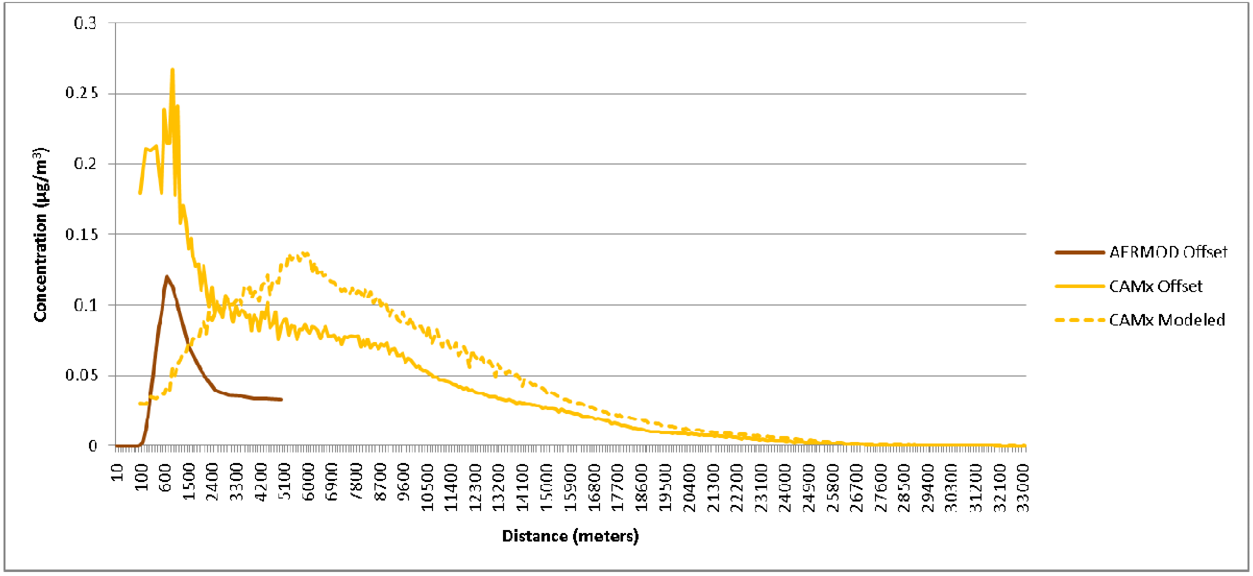
<u>CASE 1</u>: Sulfate
CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio 24-hour Average 98th percentile Concentration in micrograms per cubic meter by distance.

Figure C-18.



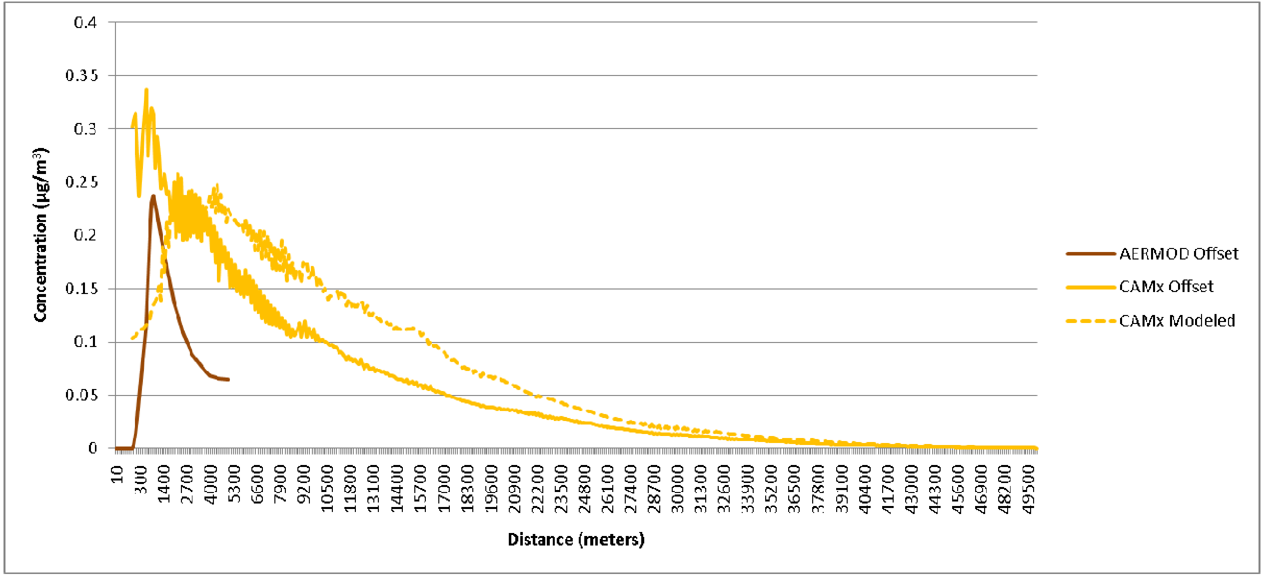
<u>CASE 2</u>: Sulfate
CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio 24-hour Average 98th percentile Concentration in micrograms per cubic meter by distance.

Figure C-19.



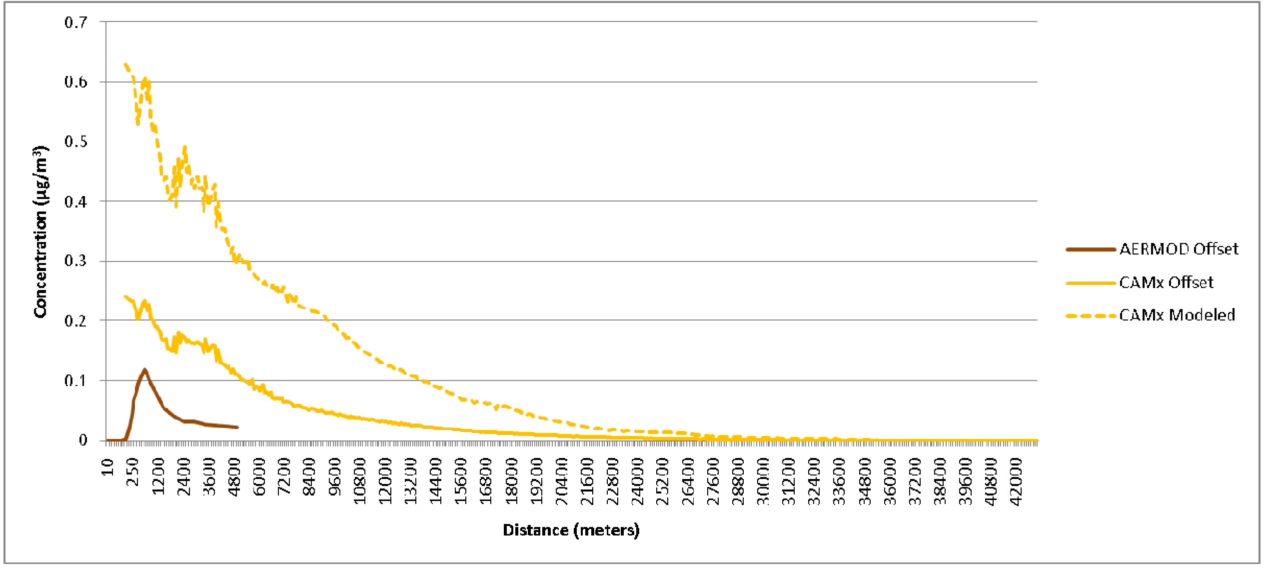
CASE 3: Sulfate
CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio 24-hour Average 98th percentile Concentration in micrograms per cubic meter by distance.

Figure C-20.



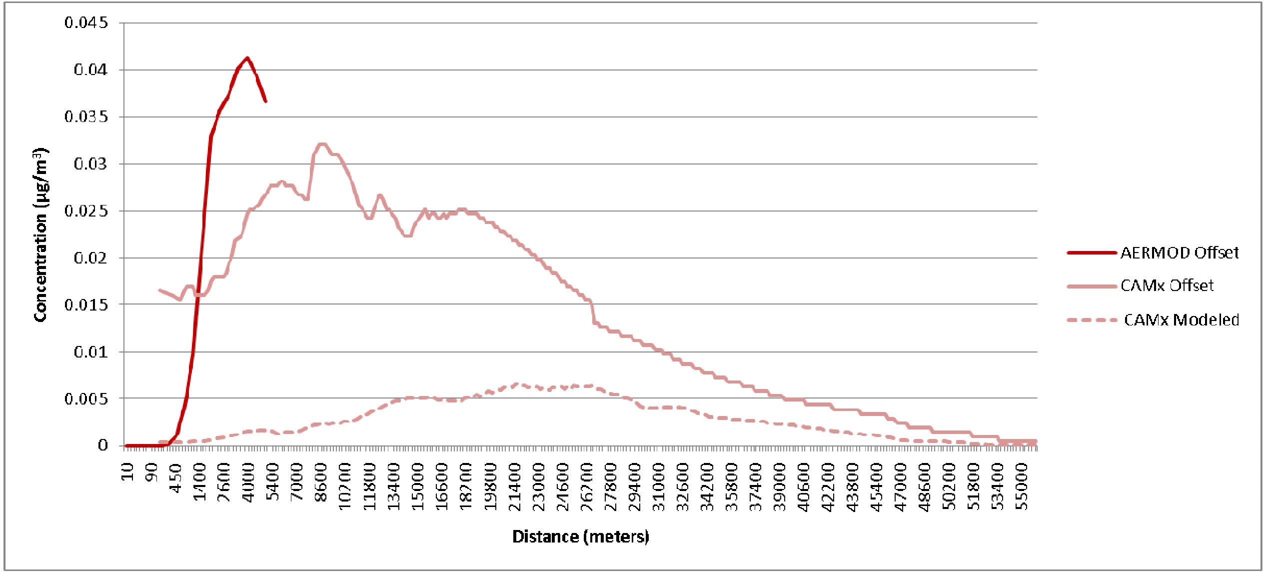
CASE 4: Sulfate
CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio 24-hour Average 98th percentile Concentration in micrograms per cubic meter by distance.

Figure C-21.



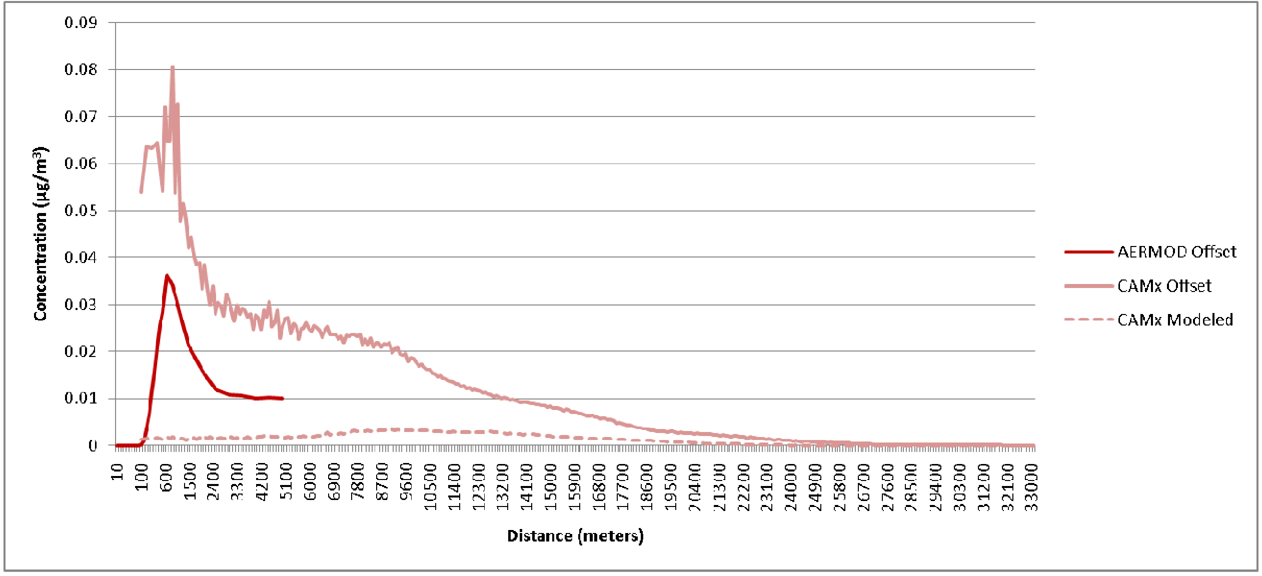
CASE 1: Nitrate
CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio
24-hour Average 98th percentile Concentration in
micrograms per cubic meter by distance.

Figure C-22.



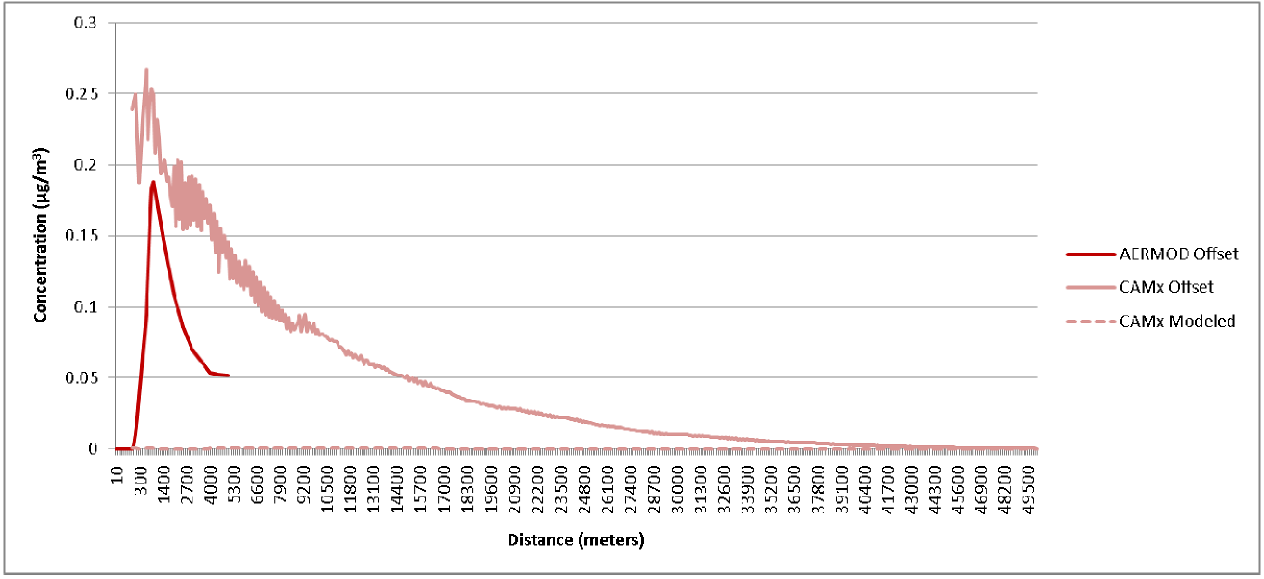
CASE 2: Nitrate
CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio
24-hour Average 98th percentile Concentration in
micrograms per cubic meter by distance.

Figure C-23.



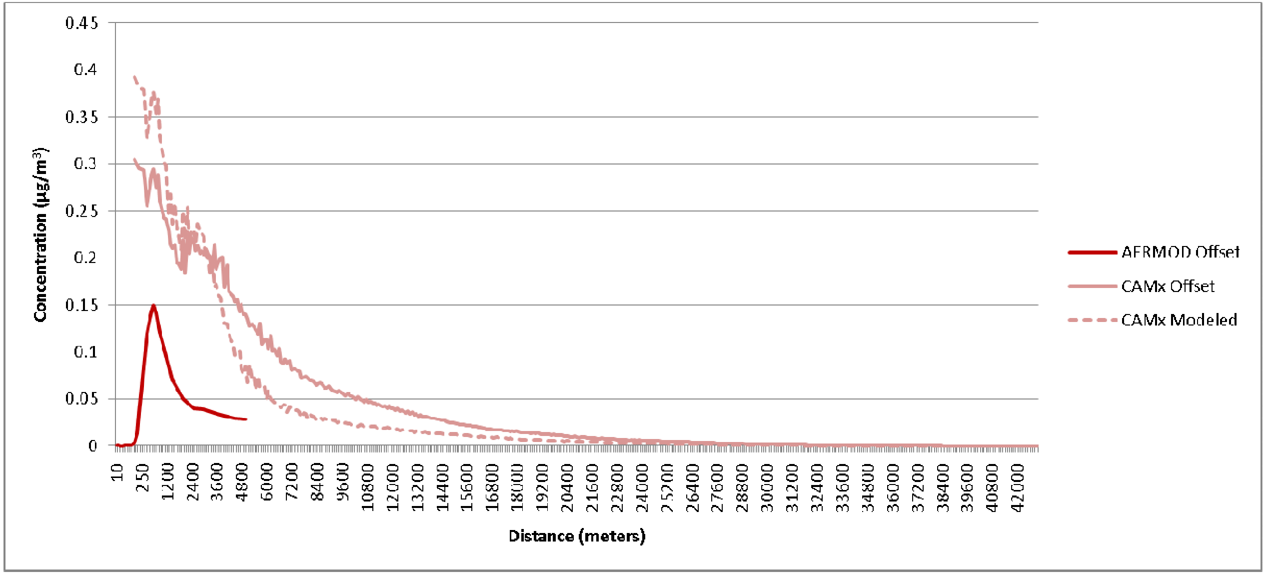
CASE 3: Nitrate
CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio
24-hour Average 98th percentile Concentration in
micrograms per cubic meter by distance.

Figure C-24.



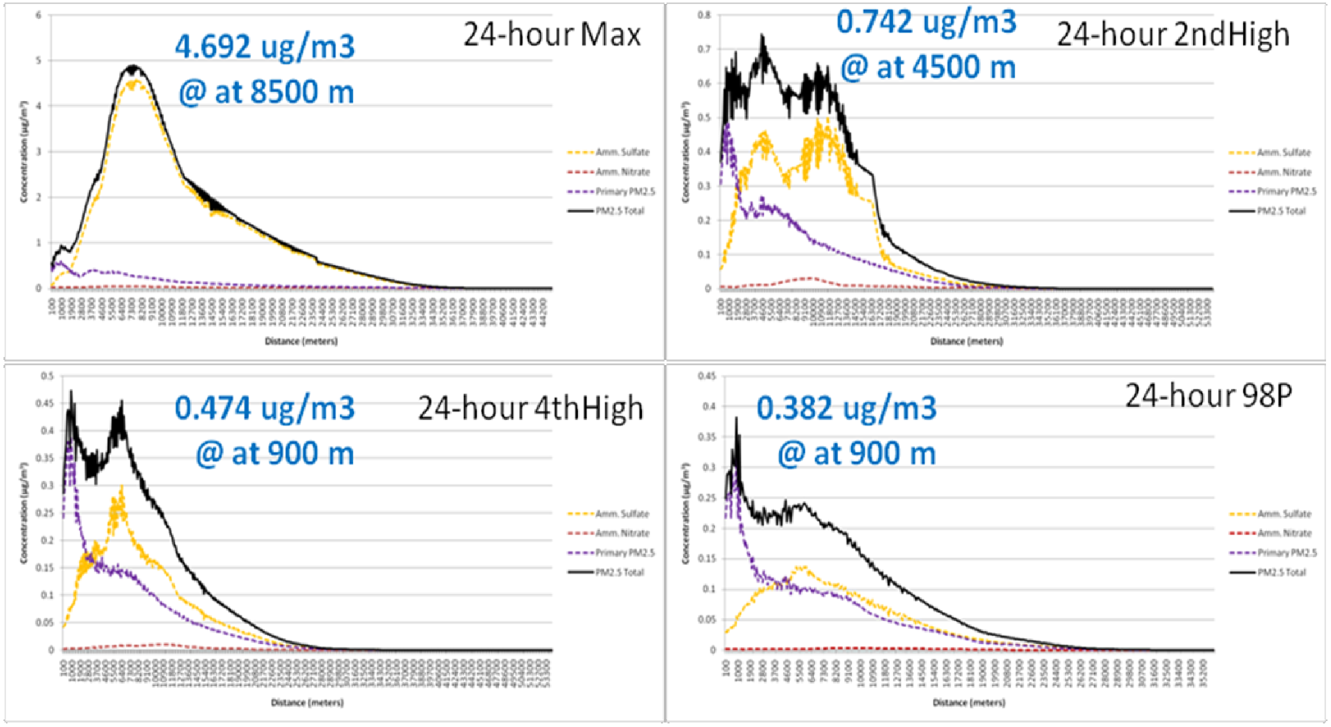
CASE 4: Nitrate
CAMx Modeled, CAMx with Offset Ratio and AERMOD with Offset Ratio
24-hour Average 98th percentile Concentration in
micrograms per cubic meter by distance.

Figure C-25.



<u>CASE 2</u>: CAMx Modeled Sulfate Sensitivity to Averaging Time.

Figure C-26.



Appendix D
An Alternative Method for Addressing Secondary Formation

A nonlinear regression model based on fine grid photochemical modeling with plume-in-grid (PiG) and sub-grid sampling is a viable approach for quantifying secondarily-formed $PM_{2.5}$. One such example of this model is an "emissions-distance" (Q-D) tool developed by the state of Minnesota (with assistance from EPA) to estimate secondarily-formed $PM_{2.5}$ from sources in the state. The tool consists of an Excel spreadsheet with two simple sets of inputs: (1) annual emissions of SO_2, NO_X, and primary $PM_{2.5}$, and (2) distance from the source to key receptors.

The Minnesota tool was developed using CAMx with PiG treatment and the PSAT algorithm for 30 large facilities in the State with emissions and meteorology for two years (2002 and 2005). This modeling produced a large amount of data on $PM_{2.5}$ concentrations as a function of emissions and distance. The data were used to derive Minnesota-specific beta-coefficients (B1 and B2) for the following equation:

$$\text{Concentration} = \text{B1} * \text{Emissions}/(1+\exp(\text{Distance})^{\text{B2}})$$

Beta-coefficients were derived for sulfate, nitrate, and primary $PM_{2.5}$ for both annual average and 24-hour (98th percentile) concentrations.

While technically credible, development of the tool for national application will take significant additional work by EPA. At a minimum, analyses along the lines of the approach followed by EPA in "Details on Technical Assessment to Develop Interpollutant Trading Ratios for $PM_{2.5}$ Offsets", July 23, 2007, would be necessary. Specifically, this modeling should consider at least nine urban areas: NY/Philadelphia, Chicago, Atlanta, Dallas, San Joaquin, Salt Lake City, Phoenix, Seattle, and Denver.

The resulting beta-coefficients for sulfate, nitrate, and primary $PM_{2.5}$ (annual and 24-hour) for each area should be compared to assess variability due to differences in emissions and meteorology. In particular, the results should be reviewed to determine if the beta-coefficients are similar enough to establish one (or more) sets of beta-coefficients with national applicability, or if the beta-coefficients are different enough to warrant more modeling to derive additional sets of beta-coefficients necessary to provide for national applicability. Depending on the outcome of this initial modeling, additional modeling may be necessary. Further work may also be needed to determine an appropriate equation for relating concentration to emissions and distance.

Appendix E
Other Methods for Addressing Secondary Formation

The workgroup considered several other methods for assessing the secondary $PM_{2.5}$ impacts from new (project) sources, including use of a simple emissions divided distance (Q/D) metric, and use of AERMOD with 100% conversion of SO2 and NOx concentrations to $(NH_4)_2SO_4$ and NH_4NO_3. A brief discussion of these methods and the reason for not including them in the final recommendation is provided below.

Q/D: Under this simple approach, a non-modeling test is used based on annual allowable emissions (Q) and distance to key receptors (D). If the Q/D ratio is less than a certain value, then the source is exempt from further air quality assessment. Groups considering (or addressing) this approach include:

- "Federal Land Managers' Air Quality Related values Workgroup (FLAG), Phase I Report - Revised", June 27, 2008 Draft
- Regional Haze Regulations for Best Available Retrofit Technology (BART) Determinations: Proposed Rule - May 5, 2004, 69 FR 25184; and "Summary of Alternative Approaches for Individual Source BART Exemptions", EPA OAQPS, March 12, 2004
- "Screening Threshold Method for PSD Modeling", North Carolina AQS, September 12, 1985

Although simple to apply, there are many limitations with approach which preclude its use. In particular, Q/D does not result in a concentration that can be compared against the SILs. Also, Q/D may be appropriate primary $PM_{2.5}$ that is being dispersed in the atmosphere, but it does not account for the formation of $PM_{2.5}$ through chemical reactions as a function of distance.

100% Conversion: Under this approach, all modeled SO2 and NO2 concentrations are assumed to be converted to $(NH_4)_2SO_4$ and $(NH_4)NO_3$, as shown below:

$$(NH_4)_2SO_4\ (\mu g/m^3) = SO_2\ (\mu g/m^3) * (MW_{SO4}/MW_{SO2}) * (MW_{(NH4)2SO4})/(MW_{SO4})$$
$$(NH_4)_2SO_4\ (\mu g/m^3) = SO_2\ (\mu g/m^3) * (96/64) * (132/96)$$
$$(NH_4)_2SO_4\ (\mu g/m^3) = SO_2\ (\mu g/m^3) * 2.0625$$

$$(NH_4)NO_3\ (\mu g/m^3) = NO_2\ (\mu g/m^3) * (MW_{NO3}/MW_{NO2}) * (MW_{(NH4)NO3})/(MW_{NO3})$$
$$(NH_4)NO_3\ (\mu g/m^3) = NO_2\ (\mu g/m^3) * (62/46) * (80/62)$$
$$(NH_4)NO_3\ (\mu g/m^3) = NO_2\ (\mu g/m^3) * 1.7391$$

The resulting secondary $PM_{2.5}$ is calculated as follows:

$$\text{Secondary } PM_{2.5}\ (\mu g/m^3) = (NH_4)_2SO_4\ (\mu g/m^3) + (NH_4)NO_3\ (\mu g/m^3)$$

The total $PM_{2.5}$ concentration is the sum of the primary $PM_{2.5}$, $(NH_4)_2SO_4$ and NH_4NO_3.

$$\text{TOTAL } PM_{2.5}\ (\mu g/m^3) = \text{Secondary } PM_{2.5}\ (\mu g/m^3) + \text{Primary } PM_{2.5}\ (\mu g/m^3)$$

Limited case studies conducted by Workgroup members indicate that this approach produced excessively high modeled concentrations compared to other methods and, as such, was not a viable method (see Georgia EPD, October 7, 2010, and Minnesota PCA, October 7, 2010).

Appendix F
Background, Charge, and Initial Clarifying Discussions from Background Concentrations Subgroup

Background: The determination of representative background monitored concentrations of $PM_{2.5}$ to include in the $PM_{2.5}$ cumulative impact assessment will entail different considerations from those for other criteria pollutants. An important aspect of the monitored background concentration for $PM_{2.5}$ is that the monitored data should account for the contribution of secondary $PM_{2.5}$ formation representative of the modeling domain. As with other criteria pollutants, consideration should also be given to the potential for some double-counting of the impacts from modeled emissions that may be reflected in the background monitoring, but this should generally be of less importance for $PM_{2.5}$ than the representativeness of the monitoring data for secondary contributions. Also, due to the important role of secondary $PM_{2.5}$, background monitored concentrations of $PM_{2.5}$ are likely to be more homogeneous across the modeling domain in most cases, compared to other pollutants. Another problem will be the proper accounting for the effects of wildfires.

Charge: Provide technical input and recommendations to EPA on more detailed guidance on the determination of representative background concentrations for $PM_{2.5,}$ including survey and critique of available options/approaches using ambient and modeled data, potential criteria for determining what is representative, and identification of data gaps and information needs.

Glenn Reed, *Glenn.Reed@valleyair.org*

The one area that I think is lacking in your outline is the role of modeling background sources. If there are large background sources in the area, they should be modeled. It may be possible that the selection of a representative monitoring site for background concentrations would be affected by the extent of the background sources modeled. For example, assume that the source being permitted is located in a rural area where there are several other sources but no significant non-stationary sources such as a major freeway. If all these background sources are modeled, it may be appropriate to choose a remote monitoring site that is affected only by regional concentrations as the representative site for determining the background concentration. So, tiers might be defined in terms of the extent to which nearby sources are included in the modeling.

$PM_{2.5}$ concentrations in the vicinity of a source being permitted will consist of the following:

1) *the air quality impact of the source being permitted;*
2) *the impact of background sources modeled;*
3) *the product of secondary formation of $PM_{2.5}$ from precursor emissions from the sources modeled;*
4) *the impact of background sources that are not modeled; and*
5) *Secondary $PM_{2.5}$ formed from emissions from other background sources that are not modeled. To determine a proper background concentration to be added to air quality impacts modeled and to the $PM_{2.5}$ produced by secondary formation from precursors emitted by the sources modeled, the monitoring site must be representative of conditions near the source being permitted.*

The representativeness of the monitoring site will depend upon the following factors:

1. *Proximity to the source(s) modeled. In general, the nearest monitoring site is preferable. A monitoring site that is far from the source(s) modeled may be affected by the secondary formation of* $PM_{2.5}$ *from precursors that are emitted under much different circumstances.*
2. *Similarity of surrounding source(s). Sources in the vicinity of the monitor should be similar to those near the source(s) modeled. The background concentration should not be affected by major point sources that would not affect receptors in the vicinity of the source being permitted. But, the concentrations at a monitoring site that is impacted by suburban or industrial sources might be representative of the background in an area that has similar sources.*
3. *Conservativeness of the background concentrations. The intent of any analysis is to ensure that it is "conservative" (i.e., ambient concentrations are overestimated). Thus, an effort should be made to select a background monitoring site where the measured concentrations are equal to or greater than those that would be measured were a monitor to be located in the vicinity of the source(s) to be modeled.*

It is unlikely that any monitoring site not co-located where the source being permitted will be completely representative. The task is to reduce the compromises that must be made to account for all the impacts that must be considered.

Tyler Fox, Fox.Tyler@epamail.epa.gov, **Additional Comments**

1. It would be extremely helpful to get basic thoughts on what constitutes "representative" for background. And as Glenn noted that definition will depend on the location of source (rural, suburban, urban) and what nearby sources will be accounted for or not via explicit modeling.

2. Developing some "conceptual" models of areas that typify the areas that folks will encounter might provide useful and insightful examples, e.g., rural with no nearby source so remote monitor used (or CMAQ or spatial surface), more urban area with some but not a lot of nearby sources , highly urbanized area with multiple nearby sources, etc. Perhaps members could bring recent permit examples that illustrate potential areas and work through what monitors are available and back out criteria from analysis.

3. Assess these examples based on Dennis' tool to see the implications and also test criteria by which nearby sources should be included based on App W that there should be few and should contribute significant concentration gradient.

Different tools or approaches to provide those background data could also be assessed.

Peter Courtney, *Peter.Courtney@dnr.state.ga.us*

I agree with both Mike and Leigh. I think we should focus on methodologies with near-term potential (Leigh) and leave the door open (Mike) for other (seemingly resource intensive and/or not-presently-viable) methodologies to be developed in the future as more experience is gained with (anticipated) EPA guidance as well as with the Bayesian and other sophisticated procedures. I think this follows the Steve Page memo intent of allowing alternative approaches other than those which may be foreseeable at this point. Maybe Mike has some alternative $PM_{2.5}$ *modeling methods submitted by consultants we could discuss?*

I would also, in the interests of progress, like to postpone further effort on the Minnesota Tier 7 (with the hourly focus) as this appears to be more applicable to SO_2 *and* NO_2*, not the 24-hr and annual average* $PM_{2.5}$ *standards.* SO_2 *and* NO_2 *should have their own issues, but do not appear to be critical until EPA* *issues NO_2 (OLM/PVMRM) guidance and a post-processing AERMOD (March, April, May, June, etc.). Of course, it might be nice to see the SILs, SMCs, and Increments finalized for $PM_{2.5}$.*

Perhaps (in the interests of progress) on the next call, we could focus on understanding the potential applications of Minnesota Tiers 4 & 5. What could constitute an adequate demonstration that a quarterly (monthly) high/low background can be expected to be limited to occurring in that single quarter (month)?

Tyler Fox, Fox.Tyler@epamail.epa.gov , Additional Comments

Sorry that I was unable to participate but would like to strongly echo the suggestions of Peter, Leigh and Mike. They have it right in terms of focus and near-term recommendations to EPA per $PM_{2.5}$ permit modeling. I am currently digesting the materials and will follow up with some additional thoughts and reiterate what I sent previously in terms of "guidance" which will take the form similar to the attached section on background from OTAQ's draft guidance on $PM_{2.5}$ hot spot modeling for conformity. We envision taking some of this same language and using it as starting point for the draft $PM_{2.5}$ permit modeling guidance that we are seeking your input on here. Having information on techniques and the like is great but this guidance will not be prescriptive nor exclude approaches from being considered. This is the starting point to help inform folks on what is available to develop 'background', what criteria or process to consider in developing "representative" background, and what implications there are on what 'nearby' sources to include.

I'll refer back to the presentation at the workshop where the "Becker tool" was seen as a useful vehicle to inform the community and EPA with various situational data to illustrate situations and what that might mean in terms of how to develop representative background and also show implications of methods for combining. Please note that those "methods for combining" must have a rational or conceptual basis to be useful such that the situations that will be encountered can have something to build from. Please consider taking some situations that perhaps state/locals can identify now as illustrative of what we'll see for permit actions--based on recent or past experience--then ask how would we have developed "representative background" in this scenario and assess the options to gain some insights and knowledge. Simply having a tool that allows one to combine in infinite manners inside or outside of AERMOD or efforts that digs into the ugly details of FRM monitoring data really aren't going to be as useful either as input for our guidance development nor your use of that information.

Appendix G
Summary of Initial Survey from Background Concentrations Subgroup

A survey of subgroup members is summarized in Table G-1 below. The survey contained the following four questions:

1. The **basis**(es) for most $PM_{2.5}$ monitors in their states?
2. What their state's **approach** is to $PM_{2.5}$ ambient background now (regional/local, ie., what they're asking applicants to submit)?
3. Any other **options** they're considering to address ambient $PM_{2.5}$ background?
4. Techniques for removing major source contributions from monitored data (**adjustments**)?

The responses are shown in Table G-1

Table G-1 – Summary of Workgroup Responses

State	Basis[1]	Approach[2]	Options[3]	Adjustments[4]
GA	Metro areas w/one 'background'	Are filtering prescribed /wild fire impacts	Consider population and source emissions	No experience.
IA	Meeting the minimum federal monitoring requirements, public data reporting, air quality mapping, compliance and understanding $PM_{2.5}$ related atmospheric processes	Transitioning from PM10 surrogate policy to modeling $PM_{2.5}$. Careful examination of observations to eliminate anomalous data and include regional events.	Have established stakeholder workgroup	No adjustments to $PM_{2.5}$ observations
LA		Limited experience—used a local monitor	None yet	None yet
MN	Metro areas	Paired-Sums	Observations with CAMx	To be determined
SC	Neighborhood scale with some background and transport sites	Proximity, urban/rural, upwind/downwind, data substitution are possible	Considering seasonal values	As described in Appendix W
SJV AQMD	Neighborhood scale plus two rural	No experience w/$PM_{2.5}$, extensive experience w/PM10 and NO2	Interested in numerical modeling	None except for high winds
VA	Population exposure plus background plus transport sites	Looking for technically defensible methods	None yet	No experience
WA	Woodsmoke and agricultural burning	Model-Observation fusion, 98th percentile	Exploring approaches for time varying	Large grid size (12 km) smooths out effect of individual sources
WI	Metro areas, some target mobile sources, some agricultural sources	Developing methods to define background	No experience	None

State	Basis[1]	Approach[2]	Options[3]	Adjustments[4]
WV	MSAs and pair of background sites	N/A but did use a local monitor for non-PSD	None yet	Filter by wind direction or speciated data
WY	Metro areas, Powder River Basin, and IMPROVE sites for Class I Areas	Transitioning from PM10 surrogate policy to actively modeling $PM_{2.5}$	None yet	Have used observed values

Appendix H

Why Consider "Paired-Sums" When Evaluating 24-Hour Average $PM_{2.5}$ Impacts?

(Background Concentrations Subgroup Technical Note No. 1)

On the face of it, adding the maximum modeled impacts to the maximum concentration observed at a representative (background) monitoring site seems to be a sensible approach in assessing whether new emissions will contribute to or cause an exceedance of an air quality standard. However, there are areas in the country where the prevailing background concentrations are sufficiently high that few projects could qualify. Also, the ambient air quality standard is defined statistically and allows a limited number of days when the ambient concentration may exceed the standard. But, even at a level less than the maximum, say the 98th percentile, the resulting background concentrations are quite high over a large portion of the country.

In the face of high background concentrations, it seems reasonable to ask whether the maximum impact from new emissions will occur under the same conditions that the maximum background concentrations do. The information, gathered as part of the Background Concentrations Subgroup's efforts, included both extensive modeling files and the concurrent observations of $PM_{2.5}$ concentrations. Daily observations between 20010101 and 20081231 from 16 sites were available. The maximum observed concentration for each day characterized the observed concentration. In general, the monitor with the highest concentration tracked closely with several other locations indicating that the $PM_{2.5}$ concentration was similar over a large area. The AERMOD modeling of the Granite Falls Energy facility predicted concentrations at 87 receptors and, again, the maximum characterized the predictions.

A number of individual emission points with varying stack parameters were used in the AERMOD modeling. The Figure H-1 shows the paired normalized observation-normalized prediction for three cases, all sources at the Granite Falls Energy facility with the stack parameters in the Table H-1 below.

Table H-1 Granite Falls Energy Facility

Source	Stack Height [m]	Exit Temperature [K]	Exit Velocity [m/s]	Exit Diameter [m]
'001	40	378	16	1.8
'003	12	293	16	0.8
'005	11	1255	9.5	1

Note: *Source 003 was included with sources 001 and 005 and several others not listed to produce the "all" plot in Figure H-1.*

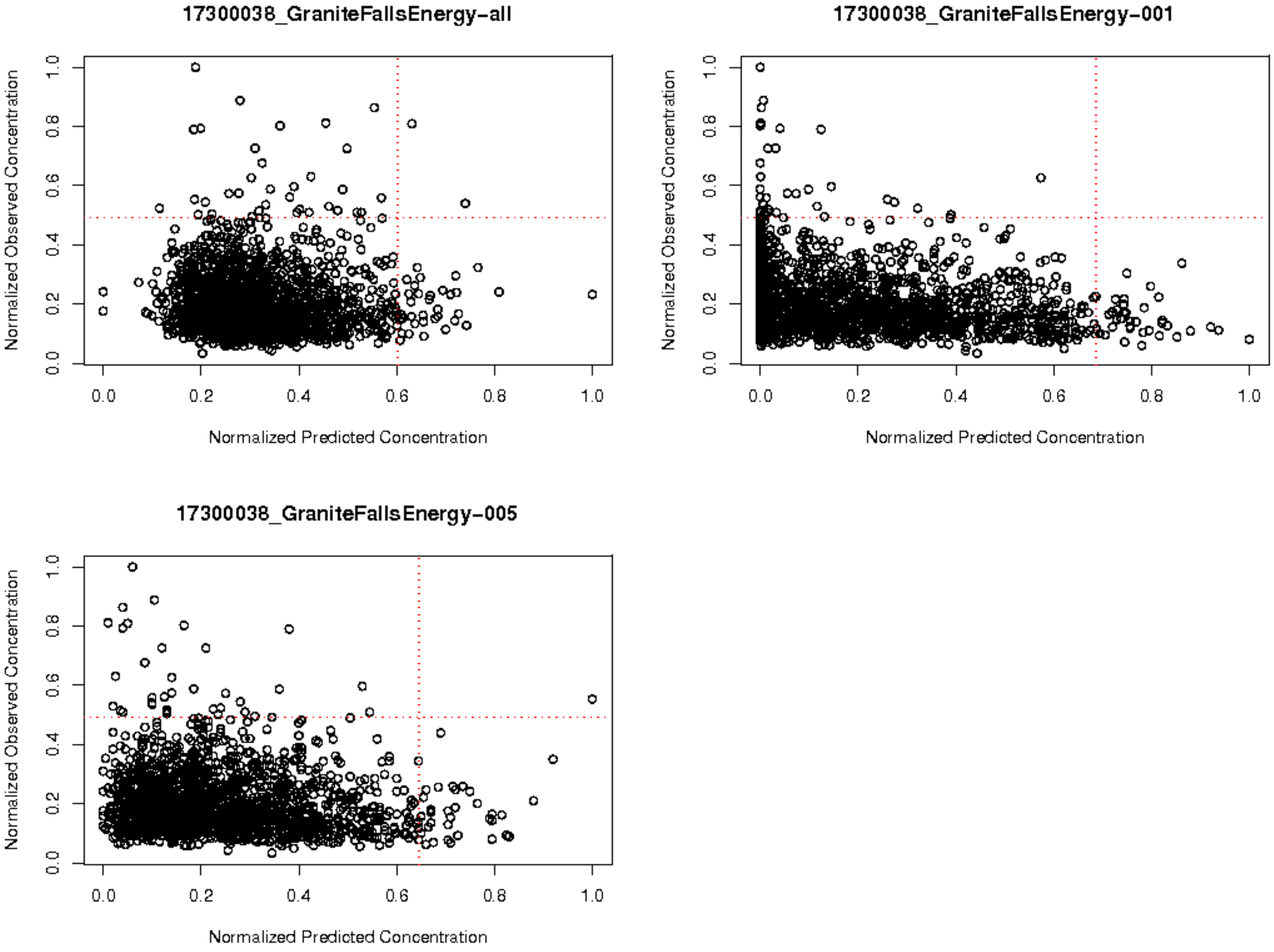


Figure H-1 Paired Normalized Observation-Normalized Prediction for Three Cases: All Emission Points, A Tall, Warm Stack (001), and A Short, Hot Stack (005).

These sources are continuously emitting. The red dotted lines show the normalized 98th percentile for the observations and predictions. It can be seen that with few exceptions the upper tails of the distributions are not paired; indeed, for the tall stack (source 001) there are virtually no times that the observations are in the upper two percent of the distribution (above the red dotted line) when the predicted concentration is greater than 40 percent of the maximum predicted concentration. It can be seen that the paired-sums method will allow permitting larger sources than using a constant background concentration.

This analysis paired daily observations with daily predictions but many areas have only every third day observations. It would be natural to try to develop a predictive relationship based on meteorological parameters to estimate the missing observations. However, an analysis of the meteorological conditions as characterized by six of our favorite boundary layer parameters used in AERMOD (u-star, w-star, boundary layer height, Monin-Obukhov length, temperature, and relative humidity) failed to find useful associations to estimate the missing observations and another technique to deal with the missing observations must be developed.

Appendix I

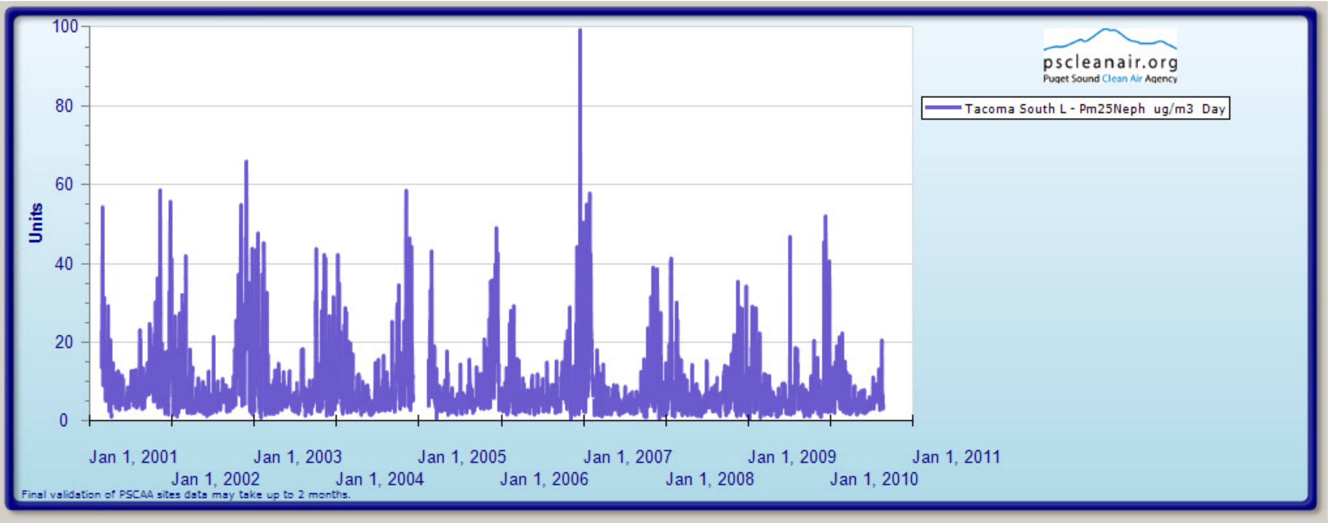
Effect of Sampling Rate on 98th Percentile Value

(Background Concentrations Subgroup Technical Note No. 2)

There seems to be uncertainty regarding the effect of various sampling rates on the computed 98th percentile of a distribution. This note examines the effect of varying the sampling rate from every day to a one in six day rate on the computed 98th percentile of the daily $PM_{2.5}$ concentration. Both observed and model predicted daily averages are analyzed.

The initial investigation used 3345 valid observations of the 3469 possible daily $PM_{2.5}$ concentrations between 2001-02-23 and 2010-08-23 from the Tacoma South L Street $PM_{2.5}$ monitor. Except for an obvious gap around the beginning of 2005 (Figure I-1), the missing days were assumed to be missing completely at random. The length of the data set will reduce the effect that the gap, which occurred at the time of year most likely to have high $PM_{2.5}$ concentrations, will have on the analysis.

Figure I-1. *Daily $PM_{2.5}$ concentrations used in the analysis.*



The analysis proceeded in two stages. First the 98th percentile was computed for the entire data set—that is 38.2 µg/m^3. Then the data were re-sampled, pulling out fewer observations corresponding to one in two through one in six sampling rates. The re-sampling was done without replacement. For each sampling rate, the re-sampling was done 1000 times to produce a distribution of computed 98th percentiles which is plotted in Figure I-2.

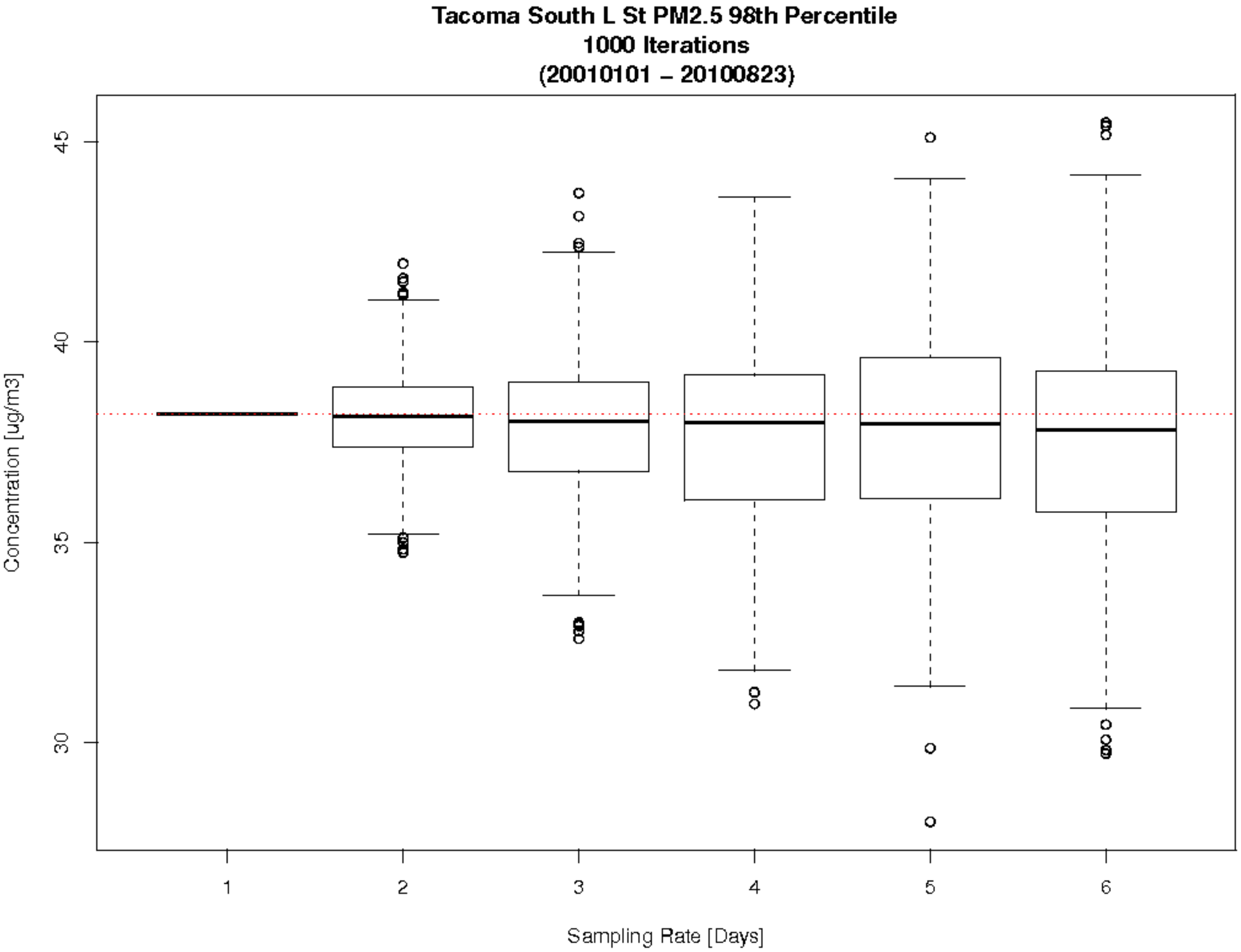


Figure I-2, Effect of Sampling Rate on the Variability of the Estimated 98th Percentile. Red Dotted Line is the 98th Percentile of the Entire Data Set.

It can easily be seen that although the median 98th percentile of the 1000 re-samplings remains close to the actual 98th percentile of the entire data set for all rates between one every two days through one in every six, the range of computed 98th percentiles increases with a decreased sampling rate. When the sampling rate is decreased to one in five, almost half of the computed 98th percentiles will be more than two micrograms per cubic meter away from the true 98th percentile. At a one in six sampling rate the computed 98th percentiles range from 30 μg/m^3 to 45 μg/m^3.

There are two additional questions that need to be answered. First, would a similar variability in the computed 98th percentile with reduced sampling rates be observed with observational data sets from other locations, especially ones where background concentrations are dominated by secondary particulate matter. The second question addresses the representativeness of the statistical approach of re-sampling to the usual uniformly spaced observations. EPA has established a protocol for reduced sampling rates, which requires that a regular schedule be followed that maintains a uniform number of days between samples. Thanks to the generosity of members of the Background Concentration Subgroup, sufficient monitoring data from across the country were available to begin to answer these two questions.

Daily monitoring records of two to almost ten years long were available from nine monitoring sites in Iowa, South Carolina, Washington, and Wisconsin to explore the variability. Figure I-3 shows the effect of reduced sampling rates on the computed 98th percentiles. Also plotted in Figure I-3 are the 98th percentiles computed from the one to six possible uniformly spaced observations for the 1:1 to 1:6 observing schedules. Because actual concentrations at each monitoring site differ, the concentration has been normalized by the 98th percentile concentration for that site.

Generally, the observations made for the South Tacoma site shown in Figure I-2 continue to hold for the other eight sites. Some sites show greater or lesser variability but the expected trend of increasing variability with a decreased sampling rate shows clearly at all sites. Except for one of the Wisconsin sites, the 1:3 sampling rate may be expected to determine the 98th percentile within ten percent of the true value.

Continued next page

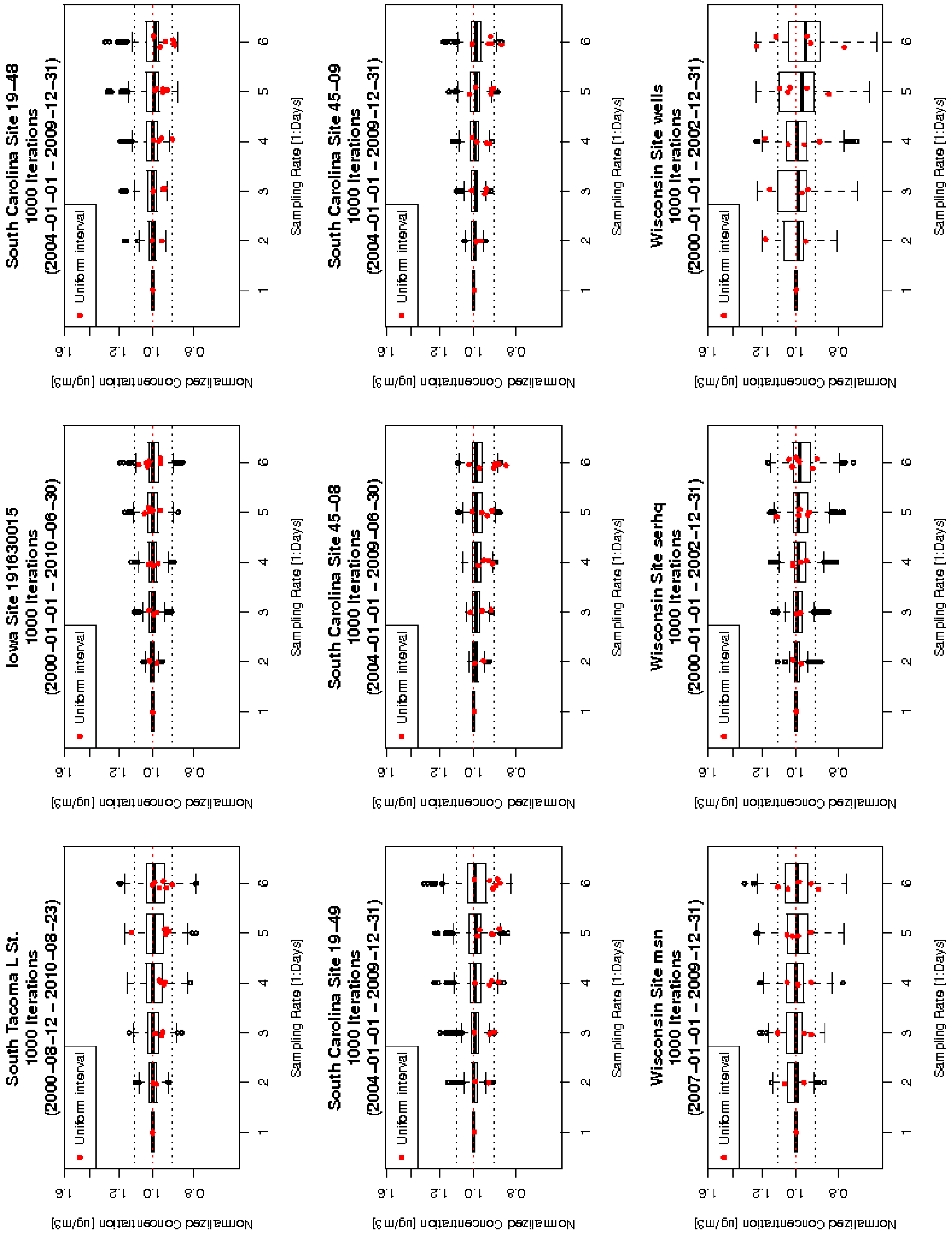


Figure I-3, *The relative effect of decreased sampling rate on the calculated 98th percentile. The red dotted line is the 98th percentile, the black dotted lines are ten percent above and below the 98th percentile. The red dots show the possible 98th percentiles computed using the uniformly spaced samples.*

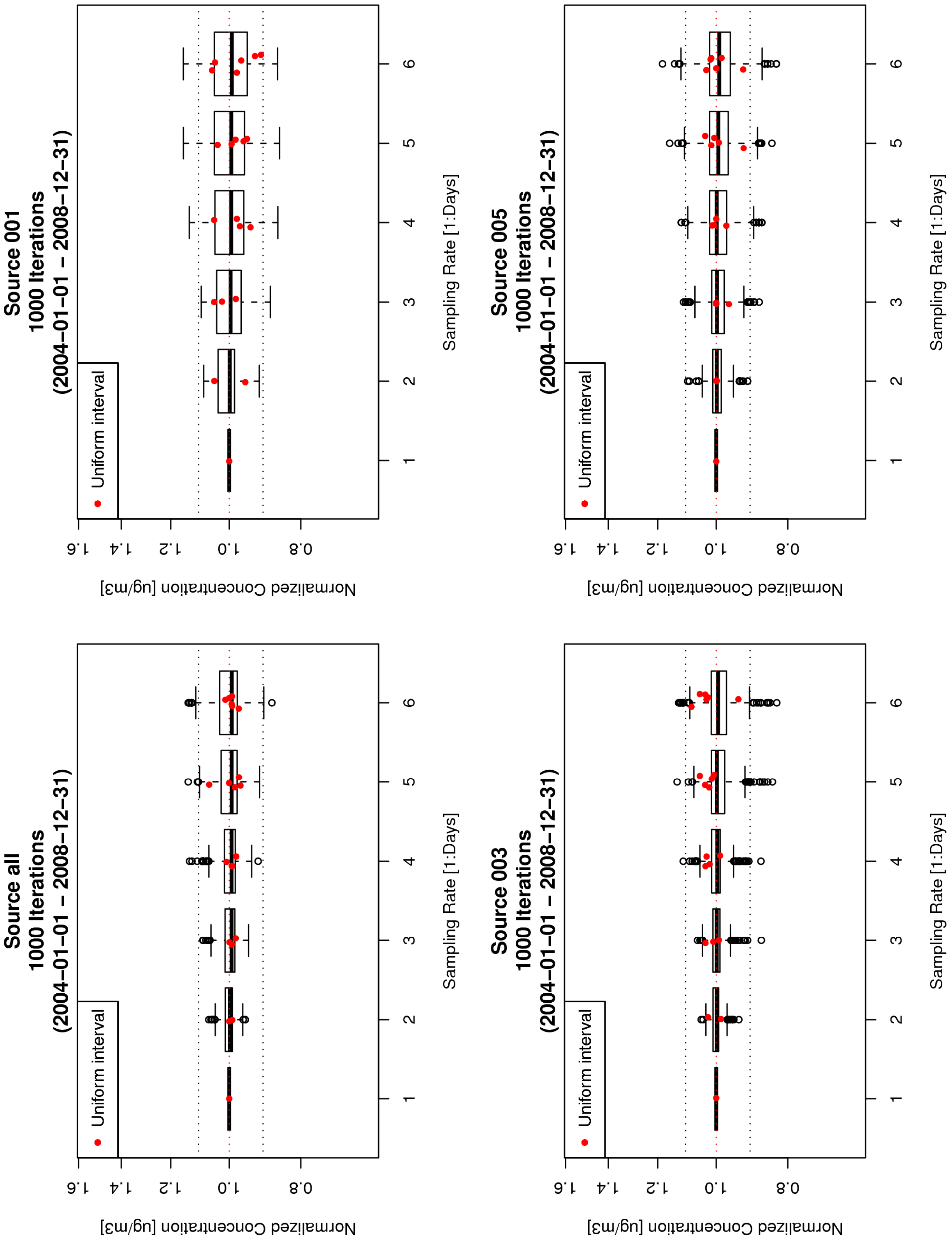


Figure I-4. *The relative effect of decreased sampling rate on the predicted 98th percentile from several combinations of sources.*

It seems natural to ask whether modeling shows the same characteristics, especially because a concept called “Paired Sums” has been advanced for use in permitting facilities. The Paired Sums approach seeks to use a background concentration that is representative of the specific day being modeled. The question of model performance in a 1:N day analysis must be answered because many locations do not have access to observations more frequently than 1:3.

Thanks to the generosity of Minnesota, predicted daily $PM_{2.5}$ concentrations at 87 receptor locations for five years were available for an analysis similar to that done with the observations. The facility had a mix of short and tall stacks and the output was grouped to permit separate analysis of the source types. Figure I-4 shows the relative effect of decreased sampling rate on the calculated 98th percentile based on modeled concentrations. Stack physical parameters used develop the plot shown in Figure I-4 are in the Table I-2 below.

Table I-2: Stack Physical Parameters for Figure I-4: The Relative Effect of Decreased Sampling Rate on the Predicted 98th Percentile

Source	Stack Height [m]	Exit Temperature [K]	Exit Velocity [m/s]	Exit Diameter [m]
'001	40	378	16	1.8
'003	12	293	16	0.8
'005	11	1255	9.5	1

Qualitatively, there is no difference between Figure I-4 and Figure I-3. The estimate of the 98th percentile concentration degrades with decreasing sample rate in the same way that it does for the observations—the reduced rate of 1:3 still remains within the ten percent limits for most of the source types analyzed.

It is obvious that additional analysis is required before accepting 1:3 day modeling but an approach has been developed that can be applied to assure the acceptability of modeling. Write out daily averages to a post file and apply the analysis used here. R code has been developed and can be shared to do the analysis.

In conclusion the acceptance of every third day model results from a five year model run will produce an estimate of the predicted 98th percentile concentration that is just as accurate as 1:3 sampling does for the observed ambient concentration.

Appendix J

Background $PM_{2.5}$ Effects of Topography Fusion of Continuous Monitor Data and Photochemical Model

(Background Concentrations Subgroup Technical Note No. 3)

Regions of topographic complexity are characterized by multiple air sheds separated by features that tend to isolate and restrict the inter-air shed transfer of pollutants. These same topographic features also tend to separate the sources of pollution into definable clusters of industrial development around population centers. The photochemical transport model, CMAQ, has been used for the past seven years to predict $PM_{2.5}$ concentrations across a large portion of the Pacific Northwest. The following figures from these operational forecast runs are examples of the output. Figure J-1 shows the high variability in $PM_{2.5}$ concentrations across the model domain.

Figure J-1*. Example of 1-hour ground-level $PM_{2.5}$ concentration showing the large gradients near populated areas and the nearly featureless, low concentrations elsewhere.*

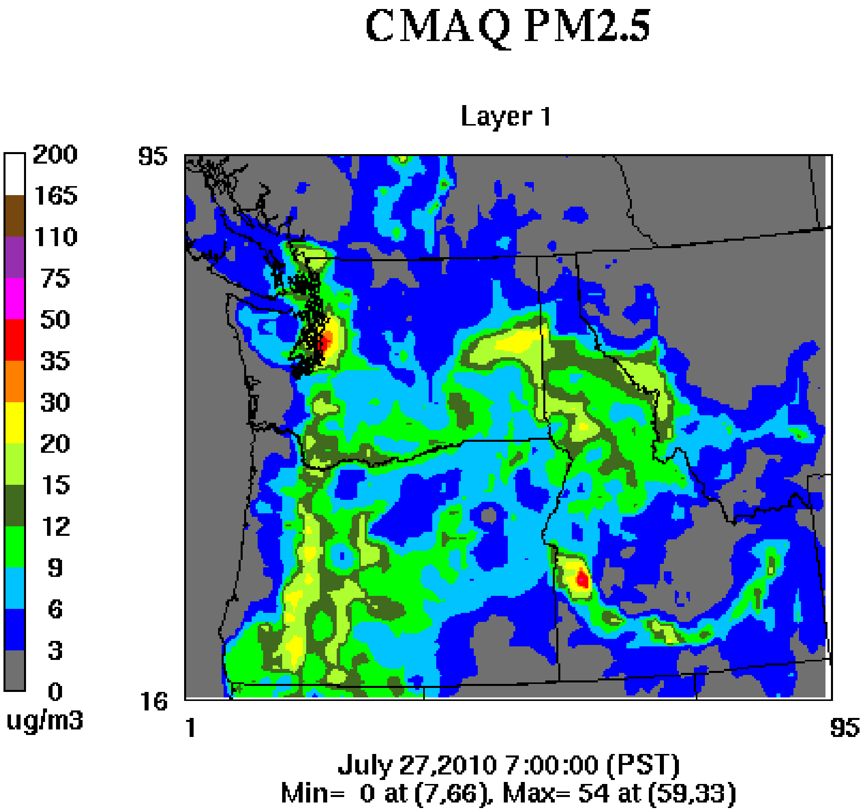


Figure J-6 shows the topography across the same domain. Although the long-range transport of pollution does occur in topographically complex regions, the concentrations of individual species is low by air quality standards and are generally of concern only when deposition or visibility in Class I Areas is addressed.

A comparison of Figures J-2 and J-3 with Figure J-1 shows that the contribution of secondary particulate matter can be nearly one-third in Puget Sound for individual hours. Animation of the model output shows that the patch of sulfate (small patch of yellow) along the Columbia River in Eastern Washington/Eastern Oregon came from Portland, OR. Obviously a 24-hour average will smear out the pattern seen in these snapshots but as can be seen in Figure J-4, the populated areas continue to have the highest $PM_{2.5}$ concentrations throughout the day.

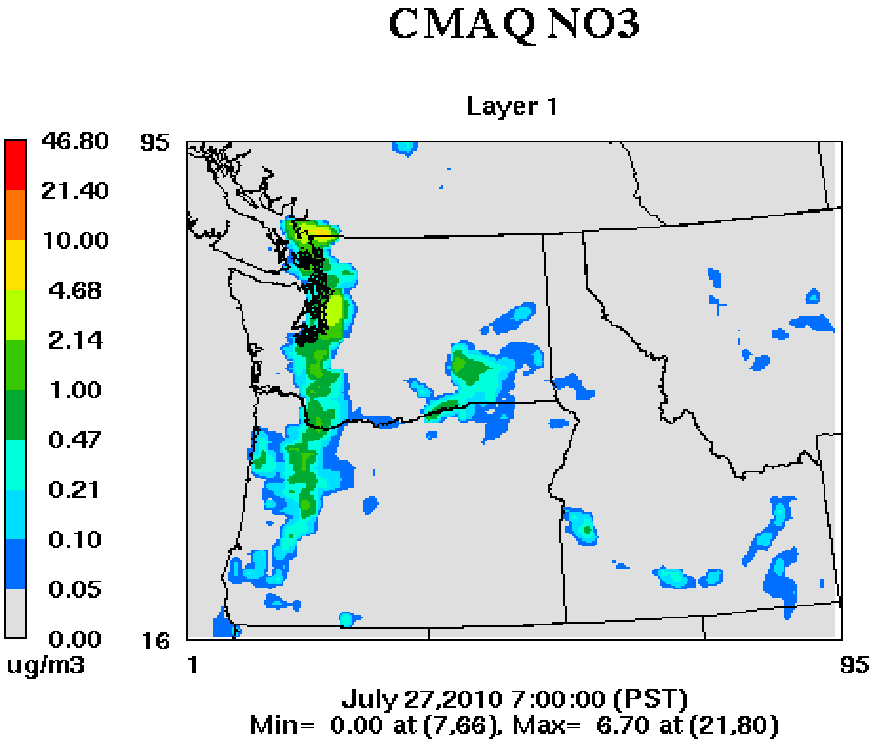


Figure J-2: *Example of 1-hour ground-level NO_3 concentration showing the association of high concentrations with the I-5 transportation corridor.*

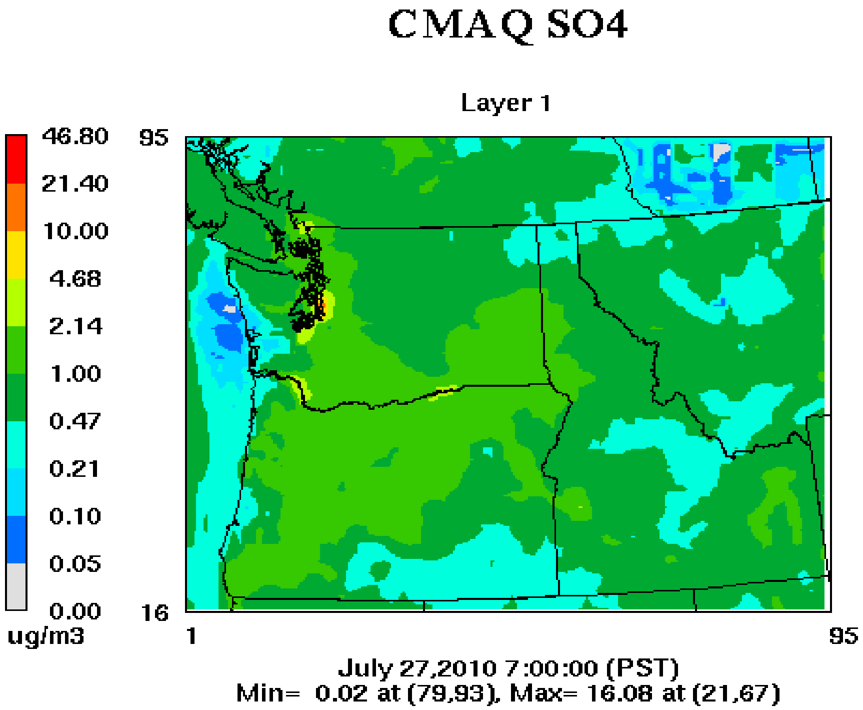


Figure J-3: *Example of 1-hour ground-level* SO_4 *concentration showing the relatively uniform concentration across the entire domain except in the industrialized Puget Sound.*

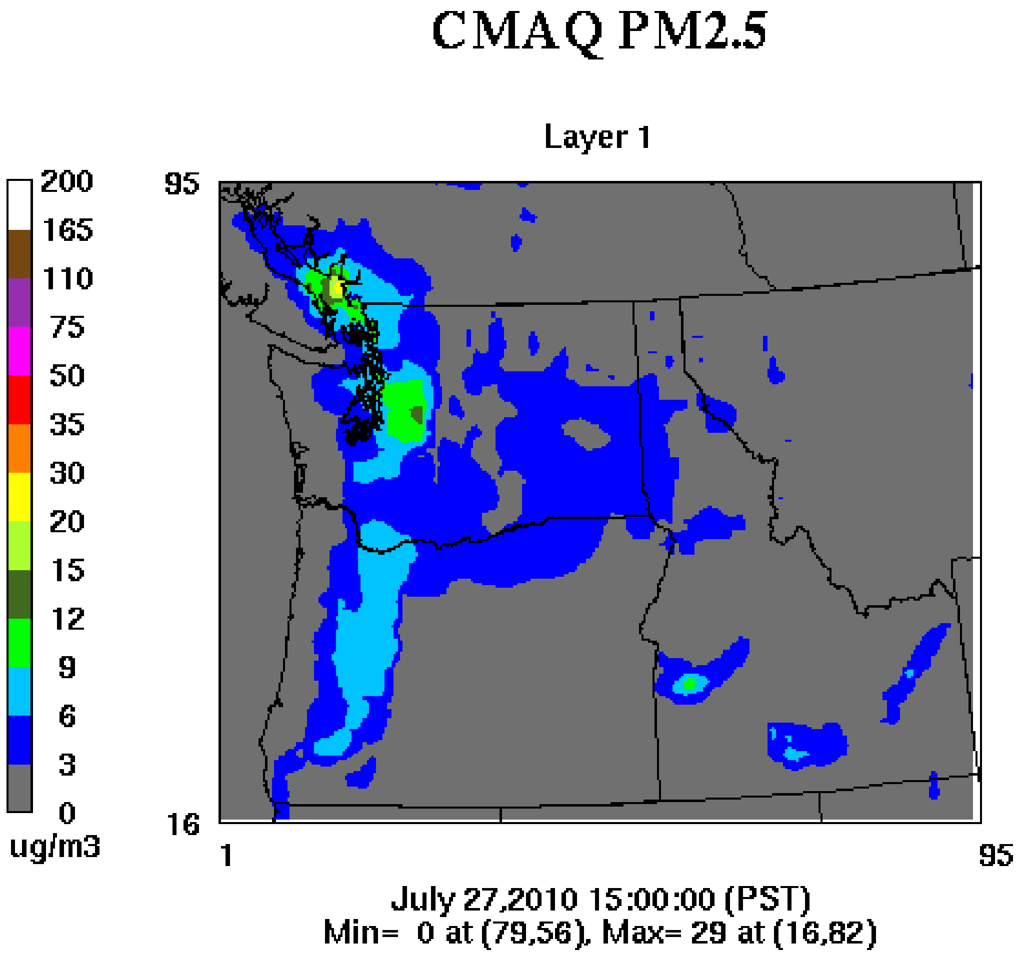


Figure J-4: *1-hour $PM_{2.5}$ concentration at 1500 on the same day as Figure J-1. The populated areas of the Lower Fraser Valley in British Columbia, Puget Sound, the Willamette River in Oregon, and the Snake River in Idaho continue to stand out. In spite of the low concentrations, the gradients are generally still quite sharp*

The difference between the spatial behaviors of the NO_3 and the SO_4 figures is a reflection of the effective release height of the precursors, NO_X and SO_2. Most of the NOx is released at ground level and comes from mobile emissions. Most of the SO_2 is released from industrial stacks and has a relatively high effective release height. The high effective release height allows the SO2->SO4 concentration to spread out becoming more uniform spatially. The mobile emissions occur in the lowest model layers and therefore remain near their sources.

With seven years of modeling and monitoring of $PM_{2.5}$ concentrations, we've had the opportunity to evaluate the performance of CMAQ and develop confidence in the model's ability to describe the spatial variation of $PM_{2.5.}$ Therefore we embraced the technique of model/observation fusion, as implemented in the BenMAP program, as a way of interpolating between monitoring locations to provide estimates of both the annual mean and the 98th percentile 24-hour average concentrations. Figure J-5 shows the current values using a 12 km grid.

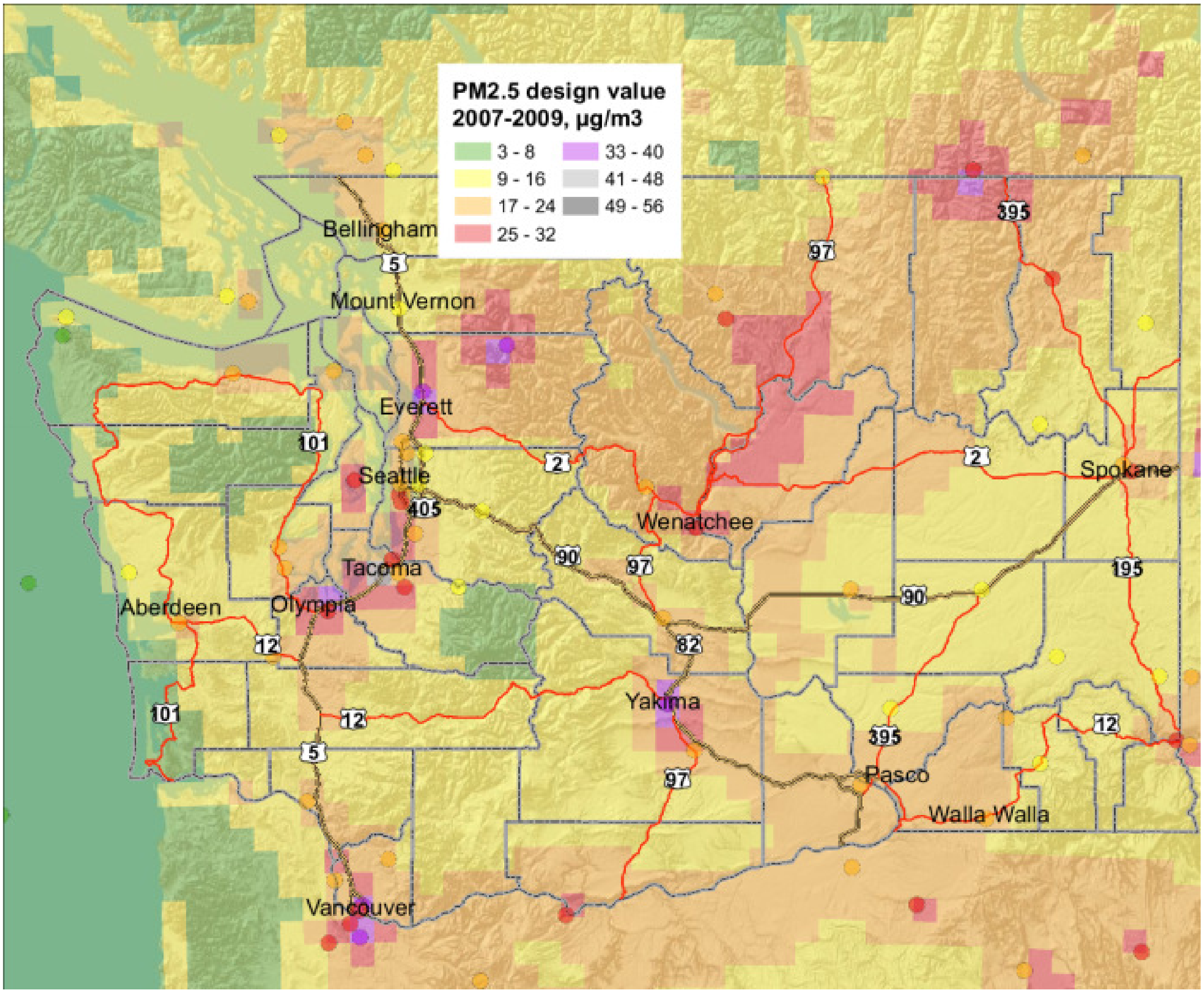


***Figure J-5**: Map of $PM_{2.5}$ design values produced by combining observed and modeled data with the BenMAP program. The corresponding observed design values are shown by colored disks.*

It can be seen that nearly all of the monitors are in or near population and industrial centers but there are some smaller communities that don't have monitors that are reflected in the spatial pattern. The fusion makes generous use of observations from Oregon, Idaho, and British Columbia. Also, because long stretches of the Pacific coast do not have monitors, several representative pseudo-observations were placed over the ocean to rein in instabilities that develop at the edges of the interpolation. Emissions from major wildfires are added to the model to help predict areas of poor air quality. The area of relatively high design values northeast of Wenatchee is larger than would be expected because of the effects of wildfires that affected both the observations and the modeled concentration during the years used to construct Figure J-5.

This first foray into model-observation fusion will impose stronger restrictions because there is no seasonality but as techniques are improved and additional years of both observations and model output become available, similar figures for either seasonal or monthly background concentrations may be confidently produced.

Using these gridded design values allows the applicant to model only a few nearby sources that would be expected to have impacts not resolved with a 12 km grid.

Figure J-6*: Topography of the Airpact domain.*