UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

APR 16 2013

OFFICE OF
AIR AND RADIATION

MEMORANDUM

SUBJECT: Initial Area Designations for the 2012 Revised Primary Annual Fine Particle National Ambient Air Quality Standard

FROM: Gina McCarthy
Assistant Administrator

TO: Regional Administrators, Regions 1-10

This memorandum provides information on the schedule and process for initially designating areas for the purpose of implementing the 2012 revised primary annual fine particle ($PM_{2.5}$) national ambient air quality standard (NAAQS). In addition, this memorandum identifies important factors that the EPA intends to evaluate in making final nonattainment area boundary decisions for this standard. The EPA recommends that states and tribes also consider these factors in making their recommendations for area designations and nonattainment area boundaries. As in prior designations for the $PM_{2.5}$ NAAQS, the EPA will also consider any other relevant information for this purpose. Please share this information with state and tribal agencies in your Region.

On December 14, 2012, the EPA promulgated a revised primary annual $PM_{2.5}$ NAAQS (78 FR 3086, January 15, 2013). In that action, the EPA revised the primary annual $PM_{2.5}$ standard, strengthening it from 15.0 micrograms per cubic meter ($\mu g/m^3$) to 12.0 $\mu g/m^3$; retained the existing 24-hour $PM_{2.5}$ standard at 35 $\mu g/m^3$; retained the existing 24-hour PM_{10} (coarse particle) standard at 150 $\mu g/m^3$; and retained the current suite of secondary PM standards. The EPA revised the primary annual $PM_{2.5}$ standard based on an integrated assessment of an extensive body of new scientific evidence, which substantially strengthens our body of knowledge regarding $PM_{2.5}$-related health effects. The revised primary annual $PM_{2.5}$ standard will provide increased protection for children, older adults, persons with pre-existing heart and lung disease, and other at-risk populations against an array of $PM_{2.5}$-related adverse health effects, including premature mortality, increased hospital admissions and emergency department visits, and development and exacerbation of chronic respiratory disease.

Clean Air Act Requirements

Section 107(d) of the Clean Air Act (CAA) governs the process for initial area designations after the EPA establishes a new or revised NAAQS. Under section 107(d), states are required to submit area designation recommendations to the EPA, by a date specified by the EPA, which cannot be

sooner than 120 days after promulgation of the new or revised NAAQS and cannot be later than 1 year after the promulgation of the NAAQS. If, after careful consideration of these recommendations, the EPA believes that it is necessary to modify a state's recommendation and to promulgate a designation different from a state's recommendation, then the EPA must notify the state at least 120 days prior to promulgating the final designation and the EPA must provide the state an opportunity to comment on the potential modification. These modifications may relate either to the designation of an area or to the boundaries of an area. The CAA requires the EPA to complete the initial designation process within 2 years of promulgation of a new or revised NAAQS, unless the Administrator has insufficient information to make initial designation decisions in the 2-year time frame. In such circumstances, the EPA may take up to 1 additional year to make initial area designation decisions (i.e., no later than 3 years after promulgation of the standard). While section 107(d) of the CAA specifically addresses the designations process between the EPA and states, the EPA intends to follow the same process to the extent practicable for tribes that choose to make initial designation recommendations pursuant to section 301(d) of the CAA regarding tribal authority, and the Tribal Authority Rule (TAR) (63 FR 7254; February 12, 1998). To provide clarity and consistency, in December 2011 the EPA issued a guidance memorandum concerning collaboration between the EPA and tribes during the designations process.[1] In accordance with the TAR and the December 2011 tribal designations guidance memorandum, and in consultation with the tribes, the EPA intends to designate tribal areas on the same schedule as state designations. If a state or tribe does not submit designation recommendations, then the EPA will promulgate the initial designations that it deems appropriate.

Schedule for $PM_{2.5}$ Initial Area Designations

Consistent with the schedule in section 107(d)(1) of the CAA, as stated in the $PM_{2.5}$ NAAQS final rule, state Governors are required to submit, and tribes can choose to submit, their initial designation recommendations to the EPA for the 2012 annual $PM_{2.5}$ NAAQS to the EPA no later than 1 year following promulgation of the revised NAAQS, or by December 13, 2013. Because of the form of the 2012 annual $PM_{2.5}$ NAAQS, the EPA believes that these recommendations should be based on air quality data from the three most recent years of monitoring data available at that time, i.e., 2010 to 2012. Based upon these monitoring data, States should identify areas as attainment, nonattainment, or unclassifiable on the basis of available information.[2] If the EPA believes it is necessary to make any modifications to a state's or tribe's initial recommendations, including area boundaries, then the EPA is required to notify the state or tribe of this fact by letter no later than 120 days prior to finalizing the designation. The EPA intends to issue this "120-day

[1] Guidance to Regions for Working with Tribes during the National Ambient Air Quality Standards (NAAQS) Designations Process. Memorandum from Stephen D. Page, Director, EPA OAQPS to Regional Administrators, Regions I-X. December 20, 2011. Available at *http://www.epa.gov/ttn/oarpg/t1/memoranda/20120117naaqsguidance.pdf*

[2] For the initial PM area designations in 2005 (1997 annual $PM_{2.5}$ standard) and 2009 (2006 24-hour $PM_{2.5}$ standard), the EPA used a designation category of "unclassifiable/attainment" for areas that are monitoring attainment and for areas that do not have monitors but for which the EPA has reason to believe are likely attainment and are not contributing to nearby violations. The EPA reserved the category "unclassifiable" for areas where the EPA cannot determine based on available information whether the area is meeting or not meeting the NAAQS or where the EPA has not determined that the area contributes to a nearby violation. While states can submit recommendations identifying areas as "attainment," the EPA expects to continue to use the "unclassifiable/attainment" category for designations for the 2012 annual $PM_{2.5}$ NAAQS.

letter" no later than August 14, 2014. If a state or tribe has additional information relevant to the area that it wants the EPA to consider with respect to a designation recommendation that the EPA plans to modify, then the EPA requests that such information be submitted no later than 60 days from the date of the EPA's 120-day letter. This schedule will ensure that the EPA can fully consider any such additional information prior to issuing final designations. Also, although section 107(d) explicitly exempts the designation process from the normal public notice and comment rulemaking process, the EPA does intend to consider public input in the designation process. Accordingly, we plan to provide a 30-day public comment period immediately following issuance of the EPA's letters responding to the designation recommendations from states and tribes.[3] Attachment 1 summarizes this anticipated schedule.

Defining Nonattainment Areas

Section 107(d)(1) of the CAA directs the EPA to designate an area "nonattainment" if it is violating the NAAQS or if it is contributing to a violation of the NAAQS in a nearby area. To start the initial area designations process, states and the EPA must identify the areas that are violating the NAAQS. Thus, the first step in designating nonattainment areas is to identify air quality monitoring sites with data that show a violation of the 2012 annual $PM_{2.5}$ NAAQS. For this purpose, the EPA intends to evaluate areas using the most recent complete three consecutive calendar years of quality-assured, certified air quality data in the EPA's Air Quality System (AQS).[4] In general, violations are identified using data from Federal Reference Method (FRM), Federal Equivalent Method (FEM), and/or Approved Regional Method (ARM) monitors that are sited and operated in accordance with 40 CFR Part 58. Procedures for using the air quality data to determine whether a violation has occurred are given in 40 CFR Part 50 Appendix N, as revised by a final action published in the *Federal Register* on January 15, 2013 (78 FR 3086). We expect that in providing designation recommendations to the EPA by December 13, 2013, states and tribes will also review air quality data from 2010 to 2012. However, prior to the EPA making final designation decisions, quality-assured, certified air quality monitoring data from 2013 may be available. If so, the EPA's final designation decisions will be based on data from 2011 to 2013. States may also update their designation recommendations when these new data become available. The EPA notes that the process for evaluating areas that are not themselves violating the NAAQS, but are nearby areas contributing to the violations of the NAAQS in a violating area, is discussed in more detail below in connection with the process for determining appropriate nonattainment area boundaries.

Ambient Air Monitoring Requirements in Near-Road Environments

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[3] Section 107(d)(2) explicitly provides that designations are exempt from the notice and comment provisions of the Administrative Procedure Act (APA). Likewise, designations under section 107(d) are not among the list of actions that are subject to the notice and comment procedures of section 307(d). Thus, neither the CAA nor the APA require notice and comment rulemaking for promulgation of the designations for this or any other NAAQS. However, the EPA intends to solicit direct public comment on its responses to the initial area designation recommendations of the states and tribes because we believe this process will be useful to gather additional information and to assure that the Agency is more directly aware of issues raised by initial area designations. Despite the EPA's intention to provide a public comment period, however, the process for initial area designations under the 2012 primary annual $PM_{2.5}$ NAAQS is not an action subject to notice and comment under either CAA 307(d) or the APA.

[4] This information is available on the EPA's website at *www.epa.gov/ttn/airs/airsaqs/*.

In the final rule for the revised primary annual $PM_{2.5}$ standard, the EPA also finalized changes to the ambient air monitoring, reporting, and network design requirements applicable to the PM NAAQS, including the addition of a near-road component to the $PM_{2.5}$ monitoring network. Because the EPA is requiring placement of the first phase of near-road monitors by January 1, 2015[5], we do not anticipate having sufficient data available from any of the newly-required monitors in time for consideration in the initial designations for the 2012 annual $PM_{2.5}$ NAAQS in 2014. The EPA believes that given the form of the NAAQS, it is necessary to have three complete calendar years of quality-assured, certified air quality monitoring data from a $PM_{2.5}$ monitor for that monitor to be used for compliance purposes and in particular for designations purposes.[6] The EPA does not expect to have a complete set of $PM_{2.5}$ air quality data from these new monitors until 2018.

Exceptional Events and Designations

Exceptional events have the potential to influence regulatory decisions, including initial area designations for the 2012 annual $PM_{2.5}$ NAAQS. Air quality monitoring data affected by exceptional events may be excluded from use in identifying a violation at a monitor if the data meet the criteria for exclusion, as specified in the Final Rule on the Treatment of Data Influenced by Exceptional Events (72 FR 13560; March 22, 2007). In the 2012 PM NAAQS final rule, the EPA established schedules for air agencies to flag data influenced by exceptional events and submit related documentation specifically for PM data collected from 2010 through 2013 that will be used in the initial designations process for the 2012 annual $PM_{2.5}$ NAAQS. Although some of these deadlines are accelerated, they were promulgated to align closely with the timing of the initial designations recommendations from states and tribes in December 2013 and/or the EPA's potential issuance of 120-day letters pertaining to designations in August 2014. These schedules reflect the EPA's interest in ensuring that we can fully consider exceptional events claims, as appropriate, in the final designations decisions. The EPA regional offices are encouraged to work with states and tribes with exceptional event claims to prioritize and expedite the demonstration development and review process for those claims having the potential to influence regulatory decisions such as the initial designations process. Similarly, the EPA encourages states and tribes to contact and collaborate with the appropriate EPA regional office after identifying any exceptional event influencing ambient air quality concentrations in a way that could potentially affect compliance with the 2012 annual $PM_{2.5}$ NAAQS. The promulgated exceptional event schedules are identified in Attachment 2. The EPA has also developed interim exceptional events implementation guidance documents that air agencies can use when reviewing potential exceptional events and developing appropriate exceptional event demonstrations. Additional information and examples of exceptional event submissions and best practice components can be found at the EPA's exceptional events website located at

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[5] In the promulgated PM NAAQS (78 FR 3086), the EPA finalized a phased schedule for deployment of the $PM_{2.5}$ monitors at near-road stations and required collocating a minimum of one $PM_{2.5}$ monitor in each Core Based Statistical Area (CBSA) with a population $\geq$ 2.5 million with a near-road NO_2 monitoring station by January 1, 2015. $PM_{2.5}$ monitors at near-road stations must be collocated and operational at the remaining CBSAs (i.e., those CBSAs with populations $\geq$1 million, but less than 2.5 million) by January 1, 2017.

[6] Data completeness criteria, including data substitution methodologies, are specified in Appendix N of 40 CFR part 50.

http://www.epa.gov/ttn/analysis/exevents.htm.

Nonattainment Area Analyses and Boundary Determination

The EPA believes that the boundaries for each nonattainment area should be evaluated and determined on a case-by-case basis considering the specific facts and circumstances unique to the area. Section 107(d) explicitly requires that the EPA designate as nonattainment not only the area that is violating the standard at issue, but also those nearby areas that contribute to the violation in the violating area. After identifying each monitor or group of monitors that indicate a violation of the standard in an area, the EPA intends to begin its analysis of what areas contribute to that violating area by considering those counties in the entire metropolitan area (e.g., Core Based Statistical Area (CBSA) or Combined Statistical Area (CSA)) in which the violating monitor(s) is (are) located. The EPA also intends to evaluate any adjacent counties to the CBSA or CSA that have the potential to contribute. The EPA believes that it is appropriate to start the analysis with the relevant CBSA or CSA for the area because measured ambient $PM_{2.5}$ concentrations across urban-scale distances tend to be highly correlated and composed of direct emissions and multiple secondarily-formed pollutants attributable to a variety of sources commonly found throughout urbanized areas.[7] In other words, violations of the annual $PM_{2.5}$ NAAQS are usually the result of emissions from a broad variety of sources that are typically located across a metropolitan area, and the CBSA or CSA for that area is thus a reasonable starting point for an analysis of what nearby areas may be contributing to the violation of the NAAQS at a given monitor or monitors in a violating area. Although the CBSA or CSA, as appropriate, is the starting point for the EPA's evaluation of contribution, the EPA does not intend it to be a presumed nonattainment area boundary. The nonattainment area boundary, or multiple nonattainment area boundaries, will encompass the area(s) that violate(s) the standard and the nearby areas that contribute to the violations. In relatively urbanized areas this may include an entire metropolitan area (e.g., CBSA or CSA); in rural locations the nonattainment area boundary could include several small towns, each with a few sources that contribute to a violating monitor.[8] As described in more detail in this section and in the attachments to this memorandum, the EPA believes that the weight of evidence approach to determining area boundaries for initial nonattainment area decisions could, under proper circumstances, result in nonattainment areas consisting of single counties or partial counties.

As a framework for area-specific analyses, the EPA recommends that states and tribes base their boundary recommendations on an evaluation of information relevant to five factors: air quality

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[7] U.S. EPA (2009). Integrated Science Assessment for Particulate Matter: Final Report. National Center for Environmental Assessment-RTP Division, Office of Research and Development, Research Triangle Park, NC. EPA/600/R-08/139F. December 2009, Chapter 2, p. 2-8; Chapter 3, p. 3-4, 3-7, 3-70, 3-108. Available at *http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_2007_isa.html.*

[8] OMB adopted standards for defining metropolitan and micropolitan statistical areas on December 27, 2000 (65 FR 82229). These standards established the terms CBSAs and CSAs. In 2010, OMB adopted revised standards for delineating metropolitan and micropolitan statistical areas (75 FR 37246; June 28, 2010). OMB will use the 2010 standards when it updates the list of CBSAs and CSAs, anticipated in June 2013. The current list of CBSAs and CSAs and their geographic components is provided in a December 1, 2009 update available at *http://www.census.gov/population/metro/files/lists/2009/List1.txt* and *http://www.census.gov/population/metro/files/lists/2009/List6.txt*. The EPA intends to use the December 1, 2009 update in this designations process.

data, emissions and emissions-related data, meteorology, geography/topography, and jurisdictional boundaries. Attachment 3 describes these factors in general and provides guidance regarding analyses relevant to each of these factors that are consistent with those used in the designations process for the 1997 and 2006 $PM_{2.5}$ standards and in designations for other NAAQS.[9] Additionally, states and tribes may identify and evaluate other relevant information or circumstances specific to a particular area to support nonattainment area boundary recommendations. For cases in which states and tribes choose not to conduct a sufficient analysis justifying their boundary recommendation, the EPA will propose those boundaries that it determines to be appropriate based upon the five factor analyses and any other relevant information for a given area.

While the EPA generally believes it is appropriate to include the entirety of a violating or contributing county in a $PM_{2.5}$ nonattainment area, we recognize that, in some cases, an assessment of relevant information may support inclusion of only part of a county. For example, as has been the case in past $PM_{2.5}$ designations, there may be low elevation areas (e.g., valleys) with poor air quality in violation of the NAAQS due to restricted atmospheric dispersion where higher elevations (e.g., mountainous areas) in the same county can be shown not to have sources of emissions that contribute to the violation. Alternatively, partial county boundaries may be appropriate in situations where the sources located in a contributing county are located only in a small portion of a large county that is otherwise not contributing to the nearby violations. In such circumstances, the EPA has also previously considered designating only portions of contributing counties that are not contiguous to the violating area an acceptable approach, in appropriate circumstances. For defining partial county boundaries, the EPA recommends the use of well-defined legal jurisdictional boundaries, such as townships; tax maps; or immovable landmarks, such as major roadways; or other permanent and readily identifiable boundaries.

In addition to nearby areas with sources contributing to nonattainment, $PM_{2.5}$ concentrations in an area with a violating monitor may be affected by long-range or regional transport of $PM_{2.5}$ and its precursors (e.g., nitrogen oxides (NOx), sulfur dioxide (SO_2), volatile organic compounds (VOC), and ammonia (NH_3)).[10] Where this is the case, the CAA does not require that all contributing areas be designated nonattainment, only the contributing areas that are nearby.

As provided in CAA section 188(a), the EPA will initially classify all nonattainment areas as "Moderate" nonattainment areas when it promulgates the initial area designations for the 2012 annual $PM_{2.5}$ NAAQS.[11] In accordance with CAA section 188(c), the attainment date for each Moderate area shall be as expeditiously as practicable but no later than the end of the sixth

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[9] In the designation guidance for the 1997 $PM_{2.5}$ standards and the 2006 $PM_{2.5}$ standards, the EPA identified nine factors to consider in making designation recommendations: emissions data, air quality data, population density and degree of urbanization, traffic and commuting patterns, growth rates and patterns, meteorology, geography/topography, jurisdictional boundaries, and level of control of emission source. In April and May of 2012, when the EPA promulgated designations for the 2008 ozone standards, the EPA grouped the emissions-related factors together in the emissions and emissions-related data factor, resulting in five overall factors.

[10] The main precursor gases associated with fine particle formation are SO_2, NO_x, volatile organic compounds, and ammonia (*See* 72 FR 20586 at 20589, April 25, 2007). Unless otherwise noted, all references to $PM_{2.5}$ precursors in this memorandum and its attachments refer to at least these four gases.

[11] *Natural Resources Defense Council and Sierra Club v. EPA*, No. 08-1250 (D.C. Cir. Jan. 4, 2013).

calendar year after the designation.

This memorandum provides the EPA's preliminary views on the process for initial area designations and for boundary determinations for the 2012 annual $PM_{2.5}$ designations process. Any guidance contained herein is not binding on states, tribes, the public, or the EPA. The EPA will make the actual designations determinations and decisions concerning nonattainment area boundary issues in the final action that designates all areas for the 2012 annual $PM_{2.5}$ standard. When the EPA promulgates the initial area designations, those determinations will be binding on states, tribes, the public, and the EPA as a matter of law.

Four attachments provide additional information relevant to the initial area designations process. Attachment 1 is an anticipated time line of important milestones in the initial area designations process for the 2012 annual $PM_{2.5}$ NAAQS. Attachment 2 identifies the promulgated exceptional event schedule for initial data flagging and submission of exceptional event demonstrations. Attachment 3 identifies the five general factors that the EPA intends to consider in evaluating and making decisions on nonattainment area boundaries and provides guidance regarding analyses relevant to support each of these factors. Attachment 4 provides additional information on preparing and running a HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) modeling analysis that may be relevant to designations evaluations.

Staff in the EPA's Office of Air Quality Planning and Standards are available for assistance and consultation throughout the initial area designation process. Questions on this guidance may be directed to Beth Palma at 919-541-5432 or Martha Keating at 919-541-9407.

Attachments: 4

cc: Stephen D. Page, OAQPS
Scott Mathias, OAQPS
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ATTACHMENT 1

ANTICIPATED TIMELINE FOR 2012 ANNUAL $PM_{2.5}$ NAAQS DESIGNATION PROCESS	
Milestone	**Date**
The EPA promulgates 2012 $PM_{2.5}$ NAAQS rule	December 14, 2012
States and tribes submit recommendations for $PM_{2.5}$ designations to the EPA	No later than December 13, 2013
The EPA notifies states and tribes concerning any intended modifications to their recommendations (120-day letters)	No later than August 14, 2014 (120 days prior to final $PM_{2.5}$ area designations)
The EPA publishes public notice of state recommendations and the EPA's intended modifications, if any, and initiates 30-day public comment period	No later than August 29, 2014
End of 30-day public comment period	No later than September 29, 2014
States and tribes submit additional information, if any, to respond to the EPA's modification of a recommended designation	No later than October 29, 2014
The EPA promulgates final $PM_{2.5}$ area designations	No later than December 12, 2014

ATTACHMENT 2

Revised Schedule for Exceptional Event Flagging and Documentation Submission for Data to be Used in Initial Area Designations for the 2012 Annual $PM_{2.5}$ NAAQS

NAAQS Pollutant/ Standard/(Level)/ Promulgation Date	Air Quality Data Collected for Calendar Year	Event Flagging & Initial Description Deadline	Detailed Documentation Submission Deadline
$PM_{2.5}$/ Primary Annual Standard (12.0 µg/m^3) Promulgated December 14, 2012	2010 and 2011	July 1, 2013	December 12, 2013
	2012	July 1, 2013[a]	December 12, 2013
	2013	July 1, 2014[a]	August 1, 2014

[a] This date is provided by the general schedule in 40 CFR 50.14(c)(2)(iii).
Note: The table of revised deadlines *only* applies to data the EPA will use to establish the initial area designations for the 2012 revised primary annual $PM_{2.5}$ NAAQS. The general schedule applies for all other purposes, most notably, for data used by the EPA for redesignations to attainment.

ATTACHMENT 3

Factors the EPA Plans to Consider in Determining Nonattainment Area Boundaries in Designations for the 2012 Annual $PM_{2.5}$ NAAQS and Guidance on Analyses to Support these Factors

For initial area designations for the 2012 annual $PM_{2.5}$ NAAQS, the EPA will rely on monitoring data to identify areas to be designated nonattainment due to monitored violations of the standard. Consistent with the directives of the CAA and with previous area designation processes, the EPA will then determine the appropriate nearby areas to include within in the nonattainment area boundary for the violating area, based on emissions that contribute to these violations. For each monitor or group of monitors indicating a violation, the EPA intends to assess information related to five factors for the purpose of establishing the appropriate geographic boundaries for designated $PM_{2.5}$ nonattainment areas. The EPA will evaluate relevant information from the entire urbanized area (i.e., CBSA/CSA) containing the violating monitor(s) and any adjacent counties that have the potential to contribute. For those portions of the urbanized area where an evaluation of the available information clearly establishes that emissions sources in that portion of the area do not contribute to exceedances at the violating monitor(s), the EPA believes it would be appropriate to exclude that portion of the area from the nonattainment area. This weight of evidence approach to determining area boundaries could result in nonattainment areas consisting of the entire urbanized area, single counties, or, in cases supported by relevant evidence, partial counties, including partial counties within larger urban areas. While technical assessments can help to define the magnitude and relative magnitude of contribution from nearby areas, the EPA is not setting a threshold contribution level or bright line test for determining whether an area should be included within the boundaries of a given nonattainment area. Section 107(d) of the CAA does not require the EPA to set a threshold contribution and the EPA does not believe that such a threshold is helpful as it could be either over- or under inclusive. As a general example, a threshold contribution level would not identify contribution from sources located upwind of a nonattainment area but for which there is no downwind monitor. For these reasons and as was done in prior designations for the 1997 and 2006 $PM_{2.5}$ NAAQS, the EPA believes that the contribution determination should be made through a case-by-case evaluation of the relevant facts and circumstances in each nonattainment area.

As a framework for area-specific analyses to support nonattainment area boundary recommendations and final boundary determinations, the EPA believes it is appropriate to evaluate the following five factors:

1. air quality data
2. emissions and emissions-related data
3. meteorology
4. geography/topography
5. jurisdictional boundaries

The EPA notes that these five factors are comparable to the factors that states and tribes and the EPA have used successfully for analytical purposes in prior designations for the 1997 and 2006

$PM_{2.5}$ NAAQS. The recommendation of these factors is not intended to indicate that other relevant information should not be considered in the initial area designations process, as appropriate. The EPA will also evaluate any other relevant area-specific information not included within the five factor analysis in cases where those assessments are provided by states and tribes.

This attachment is intended to provide descriptive guidance regarding available data that states and tribes may wish to assess when evaluating these five factors. This guidance also provides insight into the EPA's subsequent review and evaluation of the state and tribal nonattainment area boundary recommendations. The guidance offers suggestions about techniques and approaches; it does not contain requirements to be strictly followed and should not be read as prescriptive with respect to the specific techniques recommended.

The EPA recognizes that some of the recommended assessments can be resource intensive. To mitigate this potential concern, the EPA intends, wherever possible, to provide the relevant data to facilitate the analyses. Table 3-1 below outlines the datasets that the EPA expects to make available to the public on the $PM_{2.5}$ designations website at *http://www.epa.gov/pmdesignations/* and the expected date of availability. The EPA may update this website during the initial area designations process as other relevant datasets are identified.

Table 3-1. Datasets the EPA will Provide via the EPA PM Designations Website

Dataset	Expected Availability Date
Current annual $PM_{2.5}$ design values	April 2013
CSN speciation data (raw and SANDWICHED)	April 2013
IMPROVE speciation data (raw and SANDWICHED)	April 2013
National Emissions Inventory (NEI) emissions summaries	April 2013
Gridded emissions*	April 2013
Urban Increments	TBD
Wind speed/direction data	April 2013
Wind roses	April 2013
HYSPLIT trajectory data	April 2013

* Provided as part of web-based mapping tool.

This guidance also offers recommendations concerning how states and tribes may wish to describe the basis for their initial designations recommendations. The EPA anticipates that states and tribes will elect to provide an articulated explanation for those recommendations in a narrative format. Thus, this guidance provides some direction regarding the content and sequence of the narrative states and tribes may wish to develop when describing the nonattainment problem in an area with monitored violations of the NAAQS. A comprehensive narrative should articulate a conceptual model of $PM_{2.5}$ nonattainment that explains the nature and causes of the $PM_{2.5}$ air quality problem in the specific area, identify the scope and scale of the air quality problem in that area, and describe all nearby emission sources that contribute to the problem. The EPA encourages regions (and states and tribes) to work collaboratively to develop a single narrative for multi-state, or multi-region, nonattainment areas. However, the EPA anticipates that states or tribes with areas contributing to potential multi-state designated nonattainment areas would

develop a conceptual model that describes only the contribution from their area to the larger nonattainment area, rather than attempting to describe the scope and scale of the air quality problem throughout the entire area and in the jurisdiction with the violating monitor. The underlying analytical framework of the recommended narrative can be summarized as follows:

- Determine violating monitoring sites and gather data that enables an assessment of potential nearby contributing areas and the sources in those areas.

- Assess and characterize air quality patterns at, and in the proximity of, the violating monitoring site. Identify the conditions that are most associated with high average concentration levels of $PM_{2.5}$ in the area by season of the year. Further, identify the spatial extent of the high $PM_{2.5}$ concentrations. This analysis will provide a basic construct from which to evaluate potential contributing sources.

- Assess and characterize the $PM_{2.5}$ species that are most prevalent over the analysis area. Determine the fractional magnitudes of total $PM_{2.5}$ by component, noting that efforts will need to be made to ensure that speciation data are adjusted to reflect FRM mass at the violating site(s). All parts of the year are important in determining contributions to the annual average concentration. However, a seasonal or episodic compositional increment analysis in combination with other factor information may provide additional insight as to which sources or factors may contribute at a greater level. This analysis can be an important first step in linking specific nearby sources of emissions to the violation.

- Assess and characterize the increase in seasonal and annual average $PM_{2.5}$ that is observed at the violating monitoring site(s) relative to monitoring sites outside the area under evaluation that reflect regional background concentrations. This "urban increment" analysis will help to differentiate the influence from more distant emission sources from the influence of closer emissions sources, and thus to identify the relative magnitude of contributions from nearby emissions sources.

- Assess and characterize the spatial and temporal differences in $PM_{2.5}$ concentrations within an urban area using FRM/FEM data as well as data from non-regulatory $PM_{2.5}$ monitoring sites.

- Once the air quality factor analyses identified in the previous bullets are compiled they can be evaluated in conjunction with emissions data and emissions-related data (e.g., vehicle miles traveled, population) to determine which source categories and source regions are most likely to contribute to the monitored violations.

- Once the emissions and air quality assessments have been evaluated, it is valuable to then assess the meteorological characteristics of air quality throughout the year in the violating area. In many locations, the weather patterns will have a large impact on the eventual determination of which source categories and source regions in the area are most likely to contribute. This analysis will further help to identify the relative magnitude of contributions from emission sources in nearby areas.

- It may be useful to assess any geographic/topographic or jurisdictional considerations that are relevant in the identification of the nonattainment area boundary.

- Finally, all of the above assessments must be aggregated or synthesized into a consistent narrative that describes the relationship between sources in the analysis area and the measured violation. This synthesis should represent a collective "weight of evidence" regarding the most appropriate boundaries for the nonattainment area.

While the general five factor framework is expected to be comprehensive and provide the foundation for each assessment of boundary areas, the extent of the analyses may vary on an area-by-area basis based on the nature, cause, and extent of the violating $PM_{2.5}$ air quality problem. This guidance suggests analyses of certain data sets that can be useful to assess which nearby areas contribute to nonattainment in a given area. In cases where more highly-resolved or newer data sets are available that are not explicitly mentioned in this guidance, states and tribes should consider their use, as appropriate. If these data are used, the EPA recommends that the states or tribes fully describe the data and its derivation in their supporting documentation for the designation recommendation.

The following sections provide more detail on the specific five factor analyses and the supplemental synthesis approaches that the EPA plans to consider when evaluating state recommendations and determining nonattainment area boundaries for the annual $PM_{2.5}$NAAQS.

1. Air Quality Data

The initial area designation process for $PM_{2.5}$ should begin with an evaluation of available ambient air quality measurements to determine the location and magnitude of violations of the standard. In addition to data from violating monitors, the air quality data from other monitors can add to the weight of evidence in assessing the contribution of sources in areas outside the violating county. Examples include the use of chemical speciation data to help characterize contributing emissions sources and the determination of nearby contributions through analyses that differentiate local and regional source contributions.

a. $PM_{2.5}$ Design Values and Intra-annual Patterns

The first step in identifying an area that must be designated "nonattainment" and to determine an appropriate nonattainment area boundary is to identify all monitored violations of the revised annual standard using the most recently available air quality data. The EPA determines NAAQS compliance by considering the "design value" for each air quality monitoring site. The design value for the 2012 annual $PM_{2.5}$ NAAQS is the 3-year average (e.g., 2010 to 2012) of the annual mean concentrations.[12] This requires calculating annual $PM_{2.5}$ design values based on ambient air

[12] The specific methodology for calculating the $PM_{2.5}$ design values, including computational formulas and data completeness requirements, is described in 40 CFR Part 50, Appendix N. For basic instructions on calculating annual mean values, see *Guideline on Data Handling Conventions for the PM NAAQS,* EPA-454/R-99-008 April 1999 located at *http://www.epa.gov/ttn/naaqs/pm/pm25_guide.html.* Design values are computed and published annually

quality data from the most recent three calendar year period (i.e., December 2013 designations recommendations should focus on data from 2010 to 2012) from all Federal Reference Method (FRM), Federal Equivalent Method (FEM), and Approved Regional Method (ARM) monitors. The EPA will designate as nonattainment all areas with one or more ambient $PM_{2.5}$ air quality monitors with a design value greater than the annual standard of 12.0 $\mu g/m^3$.

Because of the form of the NAAQS, monitored ambient $PM_{2.5}$ levels throughout the entire 3-year period, including monitored levels below the numerical level of the NAAQS, are integral to the calculation of the design value of the monitor, and hence integral to determining whether there is a violation of the NAAQS. The amount by which monitored levels exceed the NAAQS throughout the period can be an important consideration in determining appropriate boundaries for the nonattainment area because the monitored level indicates the magnitude of emissions contributions that result in such exceedance levels and whether there is a likelihood of influences from surrounding areas. Accordingly, contributions to monitored ambient $PM_{2.5}$ at a violating monitor throughout the entire 3-year period are relevant to determining the appropriate boundaries for a nonattainment area.

Only $PM_{2.5}$ measurements produced at FRM/FEM/ARM monitoring sites can be used for NAAQS comparisons. The EPA uses FRM/FEM/ARM measurement data residing in the EPA's Air Quality System (AQS) to calculate the annual $PM_{2.5}$ design values.[13] Individual measurements that the EPA determines to be "exceptional" in accordance with the Exceptional Events Rule[14] (such as days with poor air quality caused by wildfire or dust events) are not included in these calculations. State, local, and tribal monitoring agencies are required to certify data submitted to AQS on an annual basis, by May 1st of the subsequent year. The EPA typically extracts ambient data from AQS and calculates official design values for regulatory purposes shortly after that certification due date (e.g., typically by July 15th) and then posts NAAQS design values for each monitor on a public website.

In addition to identifying monitor sites where the most recent design values violate the 2012 annual $PM_{2.5}$ NAAQS, examining trends in $PM_{2.5}$ air quality values (including design values) can improve our understanding of the nature of the $PM_{2.5}$ ambient air quality problem in a violating area and thereby inform decisions regarding the sufficient size and shape of the nonattainment area boundary. Analyzing design value trends, particularly across multiple monitors in an area being evaluated, can show how $PM_{2.5}$ concentrations have changed and whether the recent design value is consistent with that trend. Additionally these trends analyses can show how frequently the design value at the 'defining' site (i.e., the monitoring site with the highest design value for the area) has occurred at other monitoring locations in the area under consideration, and whether the design value trend across the evaluation area is homogeneous. This information can help to

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by the EPA's Office of Air Quality Planning and Standards and reviewed in conjunction with the EPA regional offices. When design values are used in a regulatory action, they are based on the latest available information and valid data that support that action. Current design values and historical trend information are available at *http://www.epa.gov/airtrends/values.html*.

[13] Information from non-FRM/FEM/ARM monitors and air quality modeling, where available, may help define an appropriate boundary for areas contributing to FRM/FEM/ARM-based monitored violations, but are not valid for determining official violations of the $PM_{2.5}$ NAAQS.

[14] Final Rule on the Treatment of Data Influenced by Exceptional Events, 72 FR 13560; March 22, 2007.

identify spatial and temporal patterns in the design values and, when combined with other information from the five factor review, can help identify nearby areas with emissions sources contributing to an area with a monitored violation.

Under normal circumstances, the mere fact that a nearby area has a monitor with a design value below the level of the NAAQS would not answer the question of whether that area was contributing to violations at a monitor in another area. Such an area might contain sources releasing very large amounts of emissions that together with emissions from nearby sources combine to cause the violation at the monitor. However, there may be circumstances in which the trend in emissions at the non-violating monitor in the potentially contributing area could be relevant to the evaluation of contribution. For example, a monitor on the border of a nearby county may show a downward trend in $PM_{2.5}$ design values below the level of the standard although a neighboring county has a clearly violating monitor for the current design value period. While the county with the violating monitor will be designated as "nonattainment," the downward trend in the monitor on the border of a nearby county may, along with other evidence from the five factor analysis, support a weight of evidence conclusion to exclude the nearby county from being included as part of the nonattainment area. Similarly, an upward trending site may be indicative of growth in nearby contributing emissions sources and provide more weight toward inclusion.

In addition to evaluating trends in annual $PM_{2.5}$ values, the magnitude of quarterly or daily average $PM_{2.5}$ concentrations over the course of each year can also provide clues to the nature of the contributing emissions sources. Monthly and seasonal profiles of daily average $PM_{2.5}$ concentrations may illustrate the presence (or lack) of seasonal conditions conducive to $PM_{2.5}$ formation, and/or seasonally important emissions sources. A review of the trend in daily $PM_{2.5}$ concentrations, including speciated measurement data as elaborated on in the next section, could identify a distinct seasonal or episodic pattern of daily exceedances that is the main driver for the annual design value violation. If these seasonal episodes ultimately influence the annual design value calculation, then evaluating the emission sources and other factors described in this guidance as they relate to these episodes could help define contributing areas. For example, the occurrence of high levels of ammonium nitrate during certain winter days, when meteorological conditions enhance its formation, could contribute to annual design value exceedances in certain areas. In combination with the urban increment and emissions data analyses described below, this type of trend analysis of monitor data could provide further insight and evidence of specific contributing influences on the violating monitor sites.

b. $PM_{2.5}$ Compositional Analysis

Measurements or estimates of the components of ambient $PM_{2.5}$ can be used to determine what chemical species constitute $PM_{2.5}$ in the particular area of interest and/or at particular violating monitors. Identifying the chemical components of the $PM_{2.5}$ mass in the area (e.g., sulfate, nitrate, organic carbon mass, elemental carbon, and crustal material) can help to give insight into the types of emission sources that are contributing to the monitored $PM_{2.5}$ concentrations at the violating monitor, either through direct $PM_{2.5}$ emissions or through emissions of $PM_{2.5}$ precursor emissions. However, analysis of $PM_{2.5}$ composition at the violating monitor alone will generally not be able to distinguish between local/nearby source contributions and regional background

contributions. This assessment is therefore only one step in establishing a link between nearby emission sources to violating monitors (i.e., the source types that appear to be important to the violations in the area but not specific facilities). Determining the specific facilities and emission sources that are contributing to the violations requires the synthesis of results from an "urban increment" analysis, emissions data analysis, and an assessment of meteorological information as explained in subsequent sections.[15]

The PM speciation measurements for some locations are available from the routine urban and rural speciation monitoring networks -- the Chemical Speciation Network (CSN) and Interagency Monitoring of Protected Visual Environments (IMPROVE), respectively. There may not always be a co-located speciation monitor at the exact location of a violating monitor site; in these cases, and where there are other nearby speciation monitors available, measurement data from these nearby monitors can be considered for use in a manner (e.g., through a distance- weighted average) that best represents the conditions at the violating monitor site. Where speciation monitors are not available at all, or where supplemental coverage of speciation data is needed, additional limited measurements may be also available from analyzing FRM/FEM monitor filters. While FRM/FEM Teflon® filters normally are not chemically analyzed for $PM_{2.5}$ species; it is possible to perform certain types of chemical filter analysis. A technical report describing the Teflon® filter analysis based on previous applications related to the 2006 $PM_{2.5}$ standards provides information on general procedures and limitations of the filter analysis.[16]

Evaluating the raw speciation monitor data can provide insight into source contributions related to that monitor site, but because of differences in measurement techniques, the data must be adjusted when attempting to compare it directly to violating FRM/FEM monitor values. The FRM $PM_{2.5}$ mass measurement does not retain all ammonium nitrate and other semi-volatile materials, but it does include particle-bound water associated with sulfates, nitrates and other hygroscopic species, which result in concentrations and percent contributions to $PM_{2.5}$ mass that may be different than the measurements of ambient levels of some $PM_{2.5}$ chemical constituents. Therefore, to relate speciation data to FRM $PM_{2.5}$ concentrations, it is necessary to account for the actual $PM_{2.5}$ mass measured at the FRM monitors, which does not include all $PM_{2.5}$ chemical constituents. To address this inconsistency, speciation measurement data should be adjusted using the EPA-developed "SANDWICH" procedure to represent the chemical constituents of FRM $PM_{2.5}$ mass.[17,18] The SANDWICH technique stands for measured **S**ulfate, **A**djusted **N**itrate, **D**erived **W**ater, **I**nferred **C**arbonaceous mass **H**ybrid Material Balance Approach." A full description of

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[15] Rao, V. and N. Frank, A. Rush, F. Dimmick. Chemical Speciation of $PM_{2.5}$ in Urban and Rural Areas. Special Studies, National Air Quality and Emissions Trends Report, 2003. Available at *http://www.epa.gov/airtrends/studies.html.*

[16] Technical report on filter analysis can be found at: *http://www.epa.gov/ttn/naaqs/pm/docs/available_new_speciation_data_pm2.5_naa.pdf.*

[17] Frank, N. H., SANDWICH Material Balance Approach for PM2.5 Data Analysis, National Air Monitoring Conference, Las Vegas, Nevada, November 6-9, 2006. *http://www.epa.gov/ttn/amtic/files/2006conference/frank.pdf.*

[18] Frank, N. H., The Chemical Composition of PM2.5 to support PM Implementation, EPA State / Local / Tribal Training Workshop: PM 2.5 Final Rule Implementation and 2006 PM 2.5 Designation Process, Chicago IL, June 20-21, 2007, *http://www.epa.gov/ttn/naaqs/pm/presents/pm2.5_chemical_composition.pdf.*

the SANDWICH procedure is provided in Frank (2006).[19] The purpose of the SANDWICH technique is to provide estimates of $PM_{2.5}$ components as measured by the $PM_{2.5}$ FRM.[20] These estimates can be different than the data provided directly by the speciation measurements from the CSN network.

c. Urban Increment Analyses

$PM_{2.5}$ mass concentrations are generally higher in urban areas compared to surrounding regions. This "urban increment," also known as the "urban excess," is due to locally generated and largely directly-emitted $PM_{2.5}$ in addition to regional contributions. Among the major contributors to $PM_{2.5}$ mass, sulfate tends to originate from regional sources; organic carbon and nitrate originate from regional and local sources, while black carbon, associated soot and crustal material tend to originate from local sources.

The goal of the urban increment analysis is to estimate the local contribution to urban $PM_{2.5}$ as measured at violating FRM/FEM/ARM monitor sites and thereby provide additional evidence to consider in deciding which nearby areas with sources contributing to the monitored violations in the area to include within the boundary of the designated nonattainment area. The urban increment analysis is a key part of the air quality data factor evaluation because it can suggest spatial and temporal correlations between contributing influences and areas by integrating information from violating monitors and $PM_{2.5}$ compositional data as described in the previous sections.

An urban increment analysis can also be designed to differentiate local contributions from regional contributions as well as to differentiate *intra-urban* differences; these basic approaches are described below. Analyses of these different spatial layers (rural, urban and sub-urban) of $PM_{2.5}$ mass and components can help isolate and better explain the contributions from urban and near monitor emissions, separate from the regional background contributions.

Urban Increment Analysis to Identify Regional vs. Local Contribution

An urban increment analysis is based on the premise that rural concentrations of $PM_{2.5}$ concentrations result from a regional geographic distribution of contributing sources that result from atmospheric formation of secondary aerosols and long-range transport. Therefore, rural $PM_{2.5}$ concentrations typically do not vary as much as urban concentrations and are less impacted by local source emissions. Also, rural concentrations of the major components of $PM_{2.5}$ tend to be more spatially homogenous than the urban concentrations. Due to these attributes, the urban

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[19] Frank, N. H. *Retained Nitrate, Hydrated Sulfates, and Carbonaceous Mass in Federal Reference Method Fine Particulate Matter for Six Eastern U.S. Cities*. J. Air & Waste Manage. Assoc. 2006 56:500–511.

[20] The SANDWICH adjustment uses an FRM mass construction methodology that results in reduced nitrates (relative to the amount measured by routine speciation networks), higher mass associated with sulfates (reflecting water included in gravimetric FRM measurements) and a measure of organic carbonaceous mass derived from the difference between measured $PM_{2.5}$ and its non-carbon components. This characterization of $PM_{2.5}$ mass also reflects crustal material and other minor constituents. The resulting characterization provides a complete mass closure for the measured FRM $PM_{2.5}$ mass.

increment analysis provides a first-order indication of the type, size, and spatial patterns of nearby or local emission sources that are contributing to the nonattainment concentrations experienced at the urban monitors.[21]

The basic approach for the urban increment analysis is to calculate the difference between the ambient $PM_{2.5}$ level at an urban area monitoring site and the ambient $PM_{2.5}$ level at a nearby rural area monitoring site(s). Local contributions to $PM_{2.5}$ mass can be estimated by subtracting the rural concentration from the measured urban concentration. Assuming that the rural concentrations represent the regional background concentration, this difference is defined as the urban increment and calculated as follows:

$$\begin{aligned} Urban\ Increment_{PM2.5\ (total\ or\ species)} \\ = Urban\ Concentration_{PM2.5\ (total\ or\ species)} \\ - Regional\ Background\ Concentration_{PM2.5\ (total\ or\ species)} \end{aligned}$$

In the equation above, the 'Urban Concentration' should preferably come from the same site as the violating $PM_{2.5}$ design value monitor, a representative site, or combination of sites consistent with conditions at the violating monitor site in cases where a speciation monitor is not co-located with the violating $PM_{2.5}$ design value monitor. The calculation of the 'Regional Background Concentration' should be prepared by spatially averaging across multiple rural monitor sites, where available, in order to best represent the regional contributions to $PM_{2.5}$ mass. Monitors in nearby smaller urban areas may also be considered in assessing contributions to the upwind concentrations that are part of the regional background. The selected rural and upwind urban monitors should fall within a pre-determined radius of the violating $PM_{2.5}$ monitor site to reasonably reflect background influencing areas and must have measurement data available for days consistent with the violating monitor data being analyzed. There are several suitable averaging approaches to construct the urban increment. For example, an inverse-distance weighted average of the urban increment across the selected rural monitors can then be calculated to account for differences in the distances that separate the rural monitor sites from the violating urban monitor site. Averaging based on multiple monitors lessens any bias issues that may be associated with selecting only a singular rural/urban monitor pairing for calculating the urban increment and should be more representative of the regional influence.

As shown in the equation above, the urban increment can be estimated on either a total $PM_{2.5}$ basis, or on a $PM_{2.5}$ species component basis (i.e., comparing species of urban increments of various violating monitors in the area). This can be a powerful analytical tool for examining the influence of spatial patterns of source-specific emissions on monitor sites that are violating the 2012 annual $PM_{2.5}$ NAAQS. Linking the previously described $PM_{2.5}$ compositional assessment with the urban increment analysis can also help identify the likely contributing emission source types to the local or 'nearby' concentration increment. This is possible because different measured components of the $PM_{2.5}$ mass can be linked to specific types of emission sources. For example, large stationary sources such as electric generating units (EGUs) are predominant

[21] Rao, V. and N. Frank, A. Rush, F. Dimmick. Chemical Speciation of $PM_{2.5}$ in Urban and Rural Areas. Special Studies, National Air Quality and Emissions Trends Report, 2003. Available at *http://www.epa.gov/airtrends/studies.html.*

contributors to the sulfate component of $PM_{2.5}$. High nitrate levels (i.e., both oxides of nitrogen (NOx) and ammonia (NH_3)) often indicate the presence of localized mobile sources, local or regional fuel-combustion sources, or a regional contribution from agricultural sources, or a combination of these sources. Carbonaceous mass is typically associated with mobile sources, wood or biomass burning, and localized combustion sources. Carbonaceous mass is commonly a substantial component of urban excess. A high elemental carbon to organic carbon mass ratio can be a signature of diesel combustion source contributions, such as diesel trucks, construction engines and vehicles, ships and trains. A high organic carbon to elemental carbon ratio, on the other hand, is often a signature of biomass burning.

States and tribes with areas experiencing seasonal and episodic fluctuations in $PM_{2.5}$ concentrations may find it useful to perform a compositional analysis of the urban increments during these specific periods and compare those results to other periods of the year that experience lower or less variable $PM_{2.5}$ concentrations. While all parts of the year are important to consider to determine contributions to the annual average concentration, a seasonal or episodic compositional increment analysis in combination with other factor information may provide additional insight into contributing sources and/or contributing factors (e.g., local meteorology) influencing monitored violations. For example, residential wood combustion has a unique PM signature and can contribute appreciably to the organic fraction of winter-time $PM_{2.5}$. Likewise, a compositional analysis showing high weekday nitrate levels may be associated with increased vehicle traffic during the traditional work week. A review of both the urban increment results and the seasonal or episodic emission inventory for the area can be an important synthesis analysis to better understand what specific emission sources, and therefore areas, may be contributing to a violating monitor. Previous guidance prepared for the designations for the 2006 24-hr $PM_{2.5}$ NAAQS is relevant to these seasonal and episodic evaluations.[22] The 2006 guidance illustrates how the EPA derives fine particle composition associated with $PM_{2.5}$ mass measurements, how the typical high day and average composition varies spatially and temporally, and how these data relate to potential emission sources.

Increment Analysis to Define Intra-Urban Differences

In addition to looking at the rural versus urban gradient, an *intra*-urban analysis may be useful to understand emerging "within urban" gradients near the violating monitor site, which become more apparent as regional concentrations decline. This analysis can help further differentiate and isolate nearby contributing influences to the violating monitor site(s), particularly those that may be more evident at a refined scale such as localized plumes or suburban influences. This refined characterization of contributing emission influences within the immediate urban area may in turn help to further identify the relative importance of surrounding areas in terms of their contribution to the violating monitor. In combination, analyzing the three spatial layers (rural, urban and sub-urban) of $PM_{2.5}$ mass and components can provide a more complete understanding of the contributing urban and near monitor emissions, separate from the regional contributions. The ability to conduct an intra-urban analysis, however, is predicated on having data from multiple

[22] Frank, N. H. *The Chemical Composition of $PM_{2.5}$ to support PM Implementation,* Presentation at EPA State / Local / Tribal Training Workshop: $PM_{2.5}$ Final Rule Implementation and 2006 $PM_{2.5}$ Designation Process, June20-21, 2007. Available at: *http://www.epa.gov/ttn/naaqs/pm/pm25_2006_techinfo.html.*

monitors, preferably $PM_{2.5}$ speciation monitors, within the urban study area, which may not be feasible for some areas being evaluated.

With very few exceptions, the $PM_{2.5}$ mass concentrations have been reported to be quite uniformly distributed across urban monitoring locations.[23] However, this finding is dependent on the $PM_{2.5}$ composition in a particular metropolitan area, the season of the year, and the relative amounts of its chemical constituents that originate from regional or local emission sources. There are many possible drivers for intra-urban variability in $PM_{2.5}$ mass, including the following influences: local sources of primary PM emissions; transient emission events; topographic barriers that isolate sub-regions of the urban area; meteorological phenomena that vary on spatial scales within the urban area; differences in behavior of semi-volatile components; and measurement error.[24]

The larger the contribution of regional sources, the more uniform is the intra-urban $PM_{2.5}$. Recognizing that the amount of regional and or local contributions are expected to continue to decline in response to regional and local control programs (but perhaps at different rates), intra-urban spatial variability of $PM_{2.5}$ and its constituents may increase in the future. This potential change in intra-urban variability may be different among areas.

2. Emissions and Emissions-Related Data

The sources and levels of emissions of $PM_{2.5}$-related pollutants is an important factor in the initial area designations process. As noted above, ambient $PM_{2.5}$ is formed through complex atmospheric processes with contributions from direct emissions of particles and from secondarily-formed particles that result from multiple $PM_{2.5}$ precursors. Air quality in a nonattainment area is also typically the result of a combination of regional and local emissions. In the designations process, for each metropolitan area with a violating monitor, the EPA evaluates the emissions data from nearby counties to assess each county's contribution to $PM_{2.5}$ concentrations at the violating monitor or monitors in the area under evaluation. Because $PM_{2.5}$ components such as sulfates and nitrates are formed through atmospheric processes and can be transported many hundreds of miles, sources of emissions outside the counties comprising the metropolitan area (CBSA or CSA) may also influence the regional contribution measured at a particular site, but may not be considered in the designation determination to be "nearby" sources. Thus, the evaluation of the area is also a means to differentiate between those transported pollutants from more distant sources of emissions and those sources of emissions in nearby areas that should be part of the designated nonattainment area because they are part of the local nonattainment problem.

For initial area designations associated with the 2012 annual $PM_{2.5}$ NAAQS, we intend to examine emissions of identified sources of direct $PM_{2.5}$, the major components of direct $PM_{2.5}$

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[23] U.S. EPA. Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/139F, 2009.

[24] Turner, J.R. *A Conceptual Model for Ambient Fine Particulate Matter Over Southeast Michigan: High Concentration Days*. Version 1.0. Prepared for Southeast Michigan Council of Governments, Detroit, MI. October 1, 2008.

(organic carbon, elemental carbon, crustal material (and/or individual trace metal compounds)), primary nitrate and primary sulfate, and precursor gaseous pollutants (e.g., SO_2, NO_X, total VOC, and NH_3). Direct $PM_{2.5}$ emissions are expected to be generally local in nature and influence monitored values in a more direct fashion with little long-range transport. The gaseous precursors, on the other hand, are expected to be more regional in nature (although the EPA also expects some local NOx and VOC emissions contributions from mobile and stationary sources) and transport from neighboring areas can contribute to higher $PM_{2.5}$ levels at the violating monitors. Analyses should include reviewing data from the latest National Emissions Inventory (NEI) or other relevant sources if available. The analysis should also include examining the magnitude of relevant, county-level emissions and the geographic locations of sources of the relevant pollutants.

Analyzing the magnitude and spatial extent of emissions further informs the analysis of the urban/rural ambient relationship discussed earlier. In addition, combining these analyses (e.g., magnitude of emissions and point of release) with meteorological information can inform the evaluation of the degree of contribution from nearby areas. The EPA will also consider any additional information we receive on changes to emissions levels that are not reflected in the most recent emissions inventories. These changes may include emissions reductions due to permanent and enforceable emissions controls that will be in place before final designations are issued, and likewise may include emissions increases from new sources or increases at existing sources.

For the initial area designations for the 2012 annual $PM_{2.5}$ NAAQS, the EPA believes that it will be appropriate to use 2011 NEI version 1 data because that will be the most recent emissions inventory information available at the beginning of this designations process. The NEI represents data, generally, on an annual basis at the county level. Emissions from large stationary sources are available at a point in space; emissions from large fires are available in day-specific format. More detailed inventories (higher resolution than county estimates) are also available, although not in the NEI.[25] For the initial area designations for the 2012 annual $PM_{2.5}$ NAAQS, gridded emissions data (at 12 km grid resolution) are also available for 2007, 2009, and 2010 for the contiguous 48 states, and may potentially be useful in areas where partial counties need to be considered in nonattainment area boundary determinations. These gridded emissions data can be provided on an annual basis or for shorter time periods. The EPA does not have gridded emissions for Alaska or Hawaii, but the EPA would recommend that these states use gridded data, as appropriate, if they are available. Any data submitted in this fashion to the EPA will be reviewed against emissions estimates developed by the EPA.

Population density and degree of urbanization (including commercial development)

As noted in footnote 8, the EPA has consolidated several factors (e.g. population density, degree of urbanization, and transportation arteries) within the "Emissions and Emissions-Related Data" factor as these elements supplement and help to inform the analysis of emissions data. The EPA intends to provide these data as available although the EPA expects that states and tribes may

[25] The EPA develops gridded emissions by applying temporal (e.g., seasonal variations in emissions as reported to the NEI) and spatial (e.g., incorporates latitude and longitude location information as reported to the NEI) adjustments to the county-based NEI estimates to produce the more finely resolved gridded emissions.

have independently developed datasets to better inform these elements, which are not available to the EPA. The EPA recommends that population density analyses examine the location and trends in population growth and the patterns of residential and commercial development as potential indicators of the probable location and magnitude of emissions sources that may contribute to $PM_{2.5}$ concentrations in a given nonattainment area.

The NEI also contains county-level aggregate estimates of smaller stationary area and mobile sources emissions (gridded emissions as well as sub-annual emissions come from spatially and temporally allocating the NEI emissions). An analysis of population density, degree of urbanization, and transportation arteries may provide the location of this emission-related activity within the larger county, and thus may serve as a proxy for the spatial distribution of county-level emissions. The EPA believes that areas of dense population and commercial development are an indicator of potentially higher levels of stationary area source and mobile source emissions that may contribute to $PM_{2.5}$ formation in a given area. Rapid population growth in a county on the urban perimeter may signify increasing integration with the core urban area, which likely will be the same as the CBSA or CSA in question, and may indicate that the associated area and mobile source emissions may be appropriate to include in the nonattainment area.

Traffic and commuting patterns

As with the previous factors discussed above, these factors are also secondary in nature to the actual emissions that the EPA will provide. Traffic and commuting pattern data can help assess the influence of mobile source emissions in a given area. Analyses should examine the location of major transportation arteries and information on traffic volume and commuting in and around the area containing a violating monitor. This may include examining the number of commuters in each nearby county who drive to a county within the area that has a violating monitor, the percent of total commuters in each county who commute to other counties with violating monitors within the metropolitan area, and the total Vehicle Miles Traveled (VMT) for each county. Areas with higher VMT and commuting levels can be an indicator of the location of mobile source emissions that may contribute to $PM_{2.5}$ concentrations at the violating monitor.

The NEI is one source of the county-wide VMT data and facilitates relative comparisons of traffic and commuting patterns between counties in a larger area.[26] However, more detailed assessments provided by states or tribes could help to highlight the magnitude and location of emissions activity. If the EPA provides gridded emissions, then the EPA can also provide gridded VMT data; however, as mentioned previously, these estimates may not correspond directly with state-based VMT data to which individual areas already may have access. Table 3.1 details all the datasets that the EPA will provide for use in this process.

3. Meteorology

[26] NEI county-level VMT estimates are developed in a top down approach from Federal Highway Administration estimates of statewide VMT by road class that are allocated to counties based on surrogates. Accordingly, the NEI estimates do not always compare well to detailed area-specific studies that are developed in a more robust way (e.g., travel demand model data).

The evaluation of meteorological data helps to determine the effect on the fate and transport of emissions contributing to $PM_{2.5}$ concentrations and to identify areas potentially contributing to the monitored violations. This section of the guidance provides recommendations for summarizing meteorological data and results in support of appropriate nonattainment area boundaries. One basic type of meteorological analysis involves assessing potential source-receptor relationships in the area using summaries of emissions, wind speed, and wind direction data. A more sophisticated assessment involves modeling air parcel trajectories.

A simplified meteorological assessment may include identifying the frequency of surface level wind speed and direction on days with high observed $PM_{2.5}$ concentrations and comparing this frequency to the frequency of wind speed and direction for other meteorological periods, years or seasons, for example.

A more sophisticated meteorological assessment would employ trajectory models to help understand complex transport situations by illustrating the three-dimensional paths traveled by air parcels to violating monitor. The HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) modeling system may be useful for some areas to produce air parcel trajectories.

Attachment 4 contains additional information on conducting meaningful meteorological analyses, including HYSPLIT modeling and source apportionment modeling.

4. Geography/topography

Consideration of geography or topography can provide additional information relevant to defining nonattainment area boundaries. Analyses should examine the physical features of the land that might define the airshed and, therefore, affect the formation and distribution of $PM_{2.5}$ concentrations over an area. Mountains or other physical features may influence the fate and transport of emissions and $PM_{2.5}$ concentrations. Additional analyses may consider topographical features that cause local stagnation episodes via inversions. Valley-type features can cause local cold-air drainage patterns and vertical temperature inversions that effectively "trap" air pollution. Under these conditions emissions can accumulate leading to periods of elevated $PM_{2.5}$ concentrations. These air drainage patterns and inversions may be limited in extent and therefore may need to be separated from regions with more conventional air flow and $PM_{2.5}$ concentration patterns. Similarly, the absence of any such geographic or topographic features may also be a relevant consideration in a given nonattainment area.

5. Jurisdictional boundaries

Once the geographic extent of the area violating the $PM_{2.5}$ standard and the nearby area contributing to violations is determined, the EPA intends to consider existing jurisdictional boundaries for the purposes of providing a clearly defined legal boundary and carrying out the air quality planning and enforcement functions for nonattainment areas. Examples of jurisdictional boundaries include, but are not limited to: counties, air districts, areas of Indian country,

metropolitan planning organizations, and existing nonattainment areas. If an existing jurisdictional boundary is used to help define the nonattainment area, it must encompass all of the area that has been identified as meeting the nonattainment definition. Where existing jurisdictional boundaries are not adequate to describe the nonattainment area, other clearly defined and permanent landmarks or geographic coordinates should be used.

Synthesizing the Five Factors

In making designations recommendations for violating areas or contributing areas, and the nonattainment area boundaries for such areas, the EPA recommends that states and tribes consider the five recommended factors together and use a weight of evidence approach for this analysis. As explained above, the starting point for evaluating the factors is the air quality analysis. Of particular importance is the location(s) of the violating monitor(s) based on 2010-2012 data and the characteristics of those violations (e.g., speciation and urban increment analyses). Once the characteristics of the violations are established, one can begin to assess which nearby emissions sources or source categories and source regions may have contributed to those violations. This contribution evaluation should generally consider the location and magnitude of emissions, and the potential for these emissions to contribute to the ambient conditions at the violating monitors as informed by the meteorological and geographical/topographical analysis factors. The guiding principle for this evaluation should be to include within the boundaries of the nonattainment area, any nearby areas with emissions of $PM_{2.5}$ or $PM_{2.5}$ precursors (e.g., SO_2, NO_X, VOC, and NH_3) that have the potential to be transported to the violating monitor. The final factor, jurisdictional boundaries, should be considered to refine the nonattainment area boundary to ensure meaningful air quality planning and regulation during the NAAQS implementation phase. As in prior designations for the 1997 and 2006 $PM_{2.5}$ NAAQS, the EPA generally believes that it is appropriate to use existing legal boundaries where possible, to assure effective planning and implementation.

The EPA believes that the five factor analysis described here is generally comprehensive and intends to use a weight of evidence approach based on these five factors in establishing the nonattainment boundaries for the 2012 annual $PM_{2.5}$ NAAQS. In some cases, however, the EPA recognizes that it may also be useful to employ one of the additional analytical approaches described below to further evaluate information relevant to the factors, such as emissions data, air quality information, and meteorology in an effort to better evaluate contribution from nearby areas. The EPA does not expect to complete, nor do we expect states or tribes to complete the additional analyses in all cases. Rather, we anticipate undertaking this effort when the analysis based on the five factors would benefit from an additional analytical method to further qualitatively or quantitatively identify relative contributions from source regions to violating monitors.

The EPA also recognizes the potential value of additional analytical methods not already specified in this guidance (e.g., pollution roses) that may be used to qualitatively describe or quantify the relative contributions from contributing areas to violating monitors. By their nature, some of these supplemental methodologies may synthesize air quality, emissions, and meteorological data into quantitative estimates of the contributions from specific areas. This guidance document provides limited information regarding three specific quantitative techniques that can be used to assist any individual states or tribes choosing to employ one or more of these approaches. As noted earlier, the EPA does not require states or tribes to conduct these analyses as part of the initial area designations process for the 2012 annual $PM_{2.5}$ NAAQS.

The EPA has considered three such approaches in past designation efforts: (i) the weighted emissions score (WES); (ii) the contributing emissions score (CES); and (iii) source apportionment modeling (SAM). The EPA has used two of these techniques, the WES and CES, to support previous $PM_{2.5}$ designations. States may find them useful, with some modifications, in preparing designations recommendations for the 2012 $PM_{2.5}$ standard. Some states used the third technique, SAM, in their boundary determinations for the 2008 Ozone NAAQS. The EPA does not plan to provide WES, CES, or SAM assessments for any areas as part of the initial area designations process for the 2012 annual $PM_{2.5}$ NAAQS. Like other aspects of the factor analyses, these three aggregation techniques produce information that can help to determine potential boundaries for the area that should be designated nonattainment for the 2012 annual $PM_{2.5}$ NAAQS in a given area. The results of these synthesis approaches should be considered just one part of an overall assessment of the potential nonattainment area boundaries. The EPA also recognizes that there are particular uncertainties associated with interpreting the outputs of each of these methods; however, they can be useful techniques for comparing the relative contribution of county by county emissions of PM precursor emissions in a simplified way.

States and tribes may also want to consider the potential value of additional methods beyond those described below, such as receptor modeling techniques (e.g., Positive Matrix Factorization [PMF] and Chemical Mass Balance [CMB]) and advanced statistical analyses (e.g., non-parametric regression and cluster analyses) to better understand contributing influences to the air quality. Because of the EPA's limited experience applying such techniques to the designations factor analysis, states and tribes intending to use such methods should consult with their EPA regional office regarding their usage and intended applications.

In considering the synthesis approaches identified in this guidance document, it is important to remember that the assessment of potential nonattainment area boundaries is based on all of the information available to the Agency for all of the factors identified in the EPA's guidance. The EPA will base its final decisions on attainment and nonattainment areas on the collective assessment of the five factors.

a. Weighted Emissions Score (WES)

The WES analysis takes the urban increment compositional fractions of $PM_{2.5}$ determined through the technique described in Section 1.b and c, and applies them to each county's fraction of total emissions in the urban area for each PM species. In this manner it attempts to evaluate the level of contribution of a county's emissions to a violating monitor site by weighting each county's emissions by the fractional component observed at the violating monitor. The basic steps are as follows:

Step 1. The counties to be analyzed in relation to each urban area are first identified.

Step 2. For each analysis area, the urban increment compositional fraction of $PM_{2.5}$ mass is calculated according to the methodologies described in Section 1.b and 1.c above.

Step 3. The next step involves calculating, for each pollutant, the percentage of analysis area emissions attributable to each county (counties within and adjacent to CBSA/CSA as applicable).

Step 4. The county's percentage of analysis area emissions for each pollutant is then multiplied by the corresponding $PM_{2.5}$ component percentage of urban increment mass.

Step 5. Sum the results for each $PM_{2.5}$ species within each county to get the county WES

The WES should be regarded simply as one tool to evaluate the relative importance of multi-pollutant emissions from one county to others in the same nonattainment area. The WES score of a county in one nonattainment area is not a suitable point of comparison to the WES score of a county in another nonattainment area; the WES is only a meaningful tool to evaluate the relative contribution of counties within the same nonattainment area. The weighted emissions score combines air quality and emissions information, but does so in a less rigorous way than the contributing emissions score described below. This analysis must be considered in combination with other air quality and emissions-related information, as well as information supporting the meteorology and geography factors, to support more specific conclusions.[27]

b. Contributing Emissions Score (CES)

The CES method is intended to be a more detailed model of the actual processes that affect the contribution linkage between a monitored violation in a violating county and emission sources in a nearby potentially contributing county. The CES is a metric that takes into consideration emissions data, meteorological data, distance, and air quality monitoring information to provide a relative ranking of the contribution potential of counties in and near an area. Designed specifically for the 24-hour $PM_{2.5}$ NAAQS, it expands on the methodology for calculating the WES by adding considerations for episodic variations in emissions, meteorology, and emissions transport distances. These considerations may be relevant to designations for a 24-hour $PM_{2.5}$ NAAQS, but are not as useful for evaluating contribution for purposes of an annual $PM_{2.5}$ NAAQS for which monitored values on every monitored day are part of the calculations necessary to determine whether there is a violation of the NAAQS at a particular monitor. The CES represents the relative maximum influence that emissions in that county have on a county with a violating monitor. While the CES is a metric, it is also a general methodology for considering many of the recommended factors.

The CES[28] for each county is derived by incorporating similar information used or developed for other analyses in the five-factor analytical framework:

- Major $PM_{2.5}$ ambient components: total carbon (organic carbon (OC) and elemental carbon (EC)), sulfate, nitrate, and inorganic particles (crustal).

- Directly emitted $PM_{2.5}$ and precursor (e.g., SO_2, NO_x, VOC, and NH_3) emissions for the highest (e.g., top 5-10%) $PM_{2.5}$ ambient concentration days (herein called "high days") within each season.

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[27] For more information about the WES procedures see: *http://www.epa.gov/pmdesignations/1997standards/tech.htm.*
[28] For more information on the basic CES procedures see:
http://www.epa.gov/ttn/naaqs/pm/docs/tsd_ces_methodology.pdf.

- Meteorology on high days using the NOAA HYSPLIT model for determining trajectories of air masses for specified days.

- The "urban increment" associated with a violating monitor on high days, which is the urban $PM_{2.5}$ concentration that is in addition to a regional background $PM_{2.5}$ concentration, determined for each $PM_{2.5}$ component.

- Distance from each potentially contributing county to a county with a violating monitor.

It should be noted that the CES guidance procedures listed here were designed around a 24-hour $PM_{2.5}$ standard analysis. However, calculated annual $PM_{2.5}$ concentrations will be impacted by the trends in concentration levels throughout the year, particularly seasonal periods and days when concentrations peak during the year. The CES procedure can thus still be applied to assess these short term periods, or it can be modified to apply to broader temporal periods (e.g., the entire year) for the analysis of an annual $PM_{2.5}$ standard. Like the WES, the CES should be regarded as one tool to evaluate the relative importance of multi-pollutant emissions from one county to others in the same nonattainment area. The CES score of a county in one nonattainment area is not a suitable point of comparison to the CES score of a county in another nonattainment area; the CES is only a meaningful tool to evaluate the relative contribution of counties within the same nonattainment area.

c. Source Apportionment Modeling

Source apportionment modeling is a third aggregation technique which may be useful to assess contribution to elevated $PM_{2.5}$ levels and thereby to help identify possible areas for inclusion in the nonattainment area because of their contribution to violations in nearby areas with violating monitors. Source apportionment modeling can track the contribution of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors (e.g., SO_2, NO_x, VOC, and NH_3) at a receptor from any number of user-defined source regions. Emissions are tracked with source apportionment through $PM_{2.5}$ formation, transport, and deposition processes in the host photochemical model (Yarwood, et al., 2007). Source apportionment modeling combines into a single analysis several of the factors that the EPA believes are important for determining nonattainment area boundaries: emissions, meteorology, and geography/topography.

If a state chooses to conduct source apportionment modeling, the EPA recommends that at least one entire year be modeled to capture as many source-receptor transport patterns as possible. Further, we recommend that states and tribes follow the relevant EPA guidance for photochemical modeling attainment demonstrations (USEPA, 2007) when establishing their source apportionment modeling platform. In establishing the parameters of a source apportionment modeling exercise it would be expected that the violating monitors would establish the receptors in the analysis. The source regions should include any and all nearby contributing areas broken out into appropriate jurisdictional areas (e.g., all CBSA/CSA counties and adjacent counties associated with the violation). When summarizing the outputs from the source apportionment modeling, it is suggested that the relative contributions from nearby source regions be compared against one another. It is expected that the primary metric from the SAM modeling would be the

source region's contribution to the $PM_{2.5}$ annual mean. While it is not possible to establish an *a priori* threshold contribution level, a relative comparison of source regions should ensure capturing the majority of potential contributing sources within the nonattainment area.

ATTACHMENT 4

Preparing and Running a HYSPLIT modeling analysis for Evaluating Nonattainment Area Boundaries for the 2012 Annual $PM_{2.5}$ NAAQS Designations

a. Wind Speed and Direction Summaries/Wind Roses

A basic component of the meteorology factor is a simple assessment of the wind direction and speed for the location under examination, with the most frequently occurring wind direction and speed on days with high $PM_{2.5}$ concentrations being compared to the most frequently occurring wind direction and speed at other times. Many different combinations of monitors and data periods – season, single year, all data years – may be compared. Some comparisons may reveal clear relationships between particular wind patterns and $PM_{2.5}$ concentrations, and other comparisons may be inconclusive. The results of these comparisons may inform the multi-factor analysis in assessments associated with determining nonattainment area boundaries.

A basic wind assessment can be constructed from hourly observations of wind direction and speed. Hourly observations for many National Weather Service locations are available from the National Climate Data Center.[29] Additionally, some air quality monitoring sites have collocated meteorological sampling stations, and wind observations at these sites that may be available via AQS. (Some wind data may not be reported hourly.) In many cases, there are fewer wind observation sites than there are air quality monitors in an area.[30]

Hourly wind data may be summarized in a basic histogram or any other display of frequency distribution for direction and speed. It is not appropriate to arithmetically average wind directions to obtain a mean wind direction as representative of a general wind direction. The mode, not the mean, of wind directions is an appropriate statistic.

A common illustration of frequency of wind direction and speed is a wind rose. Most wind rose tools convert a table of hourly wind speeds and directions into a frequency distribution for speed and direction, which can be illustrated in table form or in the graphic known as a wind rose. The EPA does not recommend a specific tool for producing wind roses, and there are many such tools available. However, as with any tool used in these assessments, the results should be reproducible. The underlying data used to populate a wind rose should be made available along with any analysis that relies upon the results of the wind rose. Long-term (annual or longer) wind speed and direction in the vicinity of the violating monitor(s) can be informative, especially in the case of standards of the annual average form. However, more detailed analyses will usually be required to complete the picture of meteorology's effect on the $PM_{2.5}$ concentrations in the area.

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[29] *ftp.ncdc.noaa.gov/pub/data/noaa* or *http://gis.ncdc.noaa.gov/map/viewer/#app=cdo&cfg=cdo&theme=hourly&layers=1&node=gis* Quality assurance of the National Weather Service data is described here: *http://www1.ncdc.noaa.gov/pub/data/inventories/ish-qc.pdf*

[30] Quality assurance of the collocated meteorological data is described here: *http://www.epa.gov/air/tribal/pdfs/EPA%20QA%20Handbook%20Volume%20Version1.0%2011.01.06.pdf*

b. HYSPLIT Trajectory Modeling

Atmospheric trajectory models use meteorological data and mathematical equations to simulate three-dimensional transport in the atmosphere. Generally, the position of particles or parcels of air with time are calculated based on meteorological data such as wind speed and direction, temperature, humidity, and pressure. Model results depend on the spatial and temporal resolution of the atmospheric data used, and also on the complexity of the model itself. The HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) model[31] is frequently used to produce trajectories for assessments associated with determining nonattainment area boundaries. HYSPLIT contains models for trajectory; dispersion, and deposition, however, analyses here only use the trajectory component. The trajectory model, which uses existing meteorological forecast fields from regional or global models to compute advection (i.e., the rate of change of an atmospheric property caused by the horizontal movement of air) and stability, is designed to support a wide range of simulations related to the atmospheric transport of pollutants.

HYSPLIT trajectories may be produced for various combinations of time and locations, and those trajectories can be compared in manners similar to wind rose comparisons. When HYSPLIT trajectories are produced for specific monitor locations for days of high $PM_{2.5}$ concentrations, the results illustrate the potential source region for the air parcel that affected the monitor on the day of the high concentration.

While HYSPLIT is a useful tool for identifying meteorological patterns associated with exceedance events, HYSPLIT trajectories alone do not conclusively indicate contribution to measured high concentrations of $PM_{2.5}$. Therefore, they cannot be used in isolation to determine inclusion or exclusion of an area within a nonattainment boundary. While a HYSPLIT trajectory analysis alone cannot yield a conclusion that a particular region contributes to $PM_{2.5}$ concentrations, it may be conceivable that a set of HYSPLIT trajectories that show no wind flow from a particular region on any day with high $PM_{2.5}$ concentration measurements might support discounting that region as contributing to $PM_{2.5}$ concentrations. HYSPLIT trajectories are very useful in combination with information on the urban increment of $PM_{2.5}$, the typical species of $PM_{2.5}$ from local sources, and the magnitude and location of these emissions sources.

c. Interpreting HYSPLIT Results

A HYSPLIT backward trajectory, the most common trajectory used in assessments associated with determining nonattainment area boundaries, is usually depicted on a standard map as a single line extending in two dimensional (x,y) space from a starting point, regressing backward in time as the line extends from the starting point. An individual trajectory can have only one starting height; HYSPLIT can plot trajectories of different starting heights at the same latitude/longitude starting point on the same map, automatically using different colors for the different starting heights. HYSPLIT will also include a vertical plot of the trajectories in time, with colors corresponding to the same trajectory in the (x,y) plot. This display can be easily misinterpreted as having finer accuracy than the underlying model and data.

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[31] *http://ready.arl.noaa.gov/HYSPLIT.php*

It is important to observe the overall size of the plot, its width and length in kilometers, and consider the size of an individual grid cell in the input meteorological data set. These input grid cells are usually 40 km in width and length, so the total area of a trajectory plot may sometimes represent only a few meteorological grid cells. It is also important to understand the trajectory line itself. The line thickness is predetermined as a user option, so it does not imply coverage other than to represent the centerline of an air parcel's motion calculated to arrive at the starting location at the starting time. Uncertainties are clearly present in these results, and these uncertainties can be thought to be a range on either side of the center line in which the air parcel may be found. Further back in time along the trajectory path, that range may be assumed to increase. In other words, one should avoid concluding a region is not along a trajectory's path if that trajectory missed the region by a relatively small distance. As mentioned in the beginning of this section, the same cautions that apply to interpretation of wind roses apply to interpretation of HYSPLIT trajectories.

Detailed information for downloading, installing, and operating HYSPLIT can be found at these websites:
http://ready.arl.noaa.gov/HYSPLIT.php
http://www.arl.noaa.gov/documents/reports/hysplit_user_guide.pdf
http://www.arl.noaa.gov/documents/reports/arl-224.pdf

HYSPLIT's many setup options allow great flexibility and versatility. However, careful selection and recording of these options is necessary to provide reviewers the ability to reproduce the model results. The following paragraphs describe the options that should be recorded, at a minimum, to reproduce a HYSPLIT model run.

Model Version. If the HYSPLIT trajectory is produced via the NOAA Air Resources Laboratory (ARL) website (*http://ready.arl.noaa.gov/HYSPLIT_traj.php*), note the *"Modified:" date* in the lower-left corner of the webpage, as well as the date the trajectory was produced. If the trajectory is produced using a stand-alone version of HYSPLIT, note *the release date*, which will be displayed after exiting the main GUI screen.

Basic Trajectory Information. Note the *starting time* (YY MM DD HR), the *duration of the trajectory* in hours, and whether the trajectory is *backward or forward.* Note the *latitude and longitude*, as well as the *starting height*, for each *starting location*. Starting height is given by default in meters above ground level (AGL) unless another option is selected. Starting heights are typically no less than 100 meters AGL to avoid direct interference of terrain, and are typically no greater than 1500 meters AGL to confine the air parcel within the mixed layer. Some trajectories can escape the mixed layer, and this result would be considered in the interpretation.
Starting height and starting location will identify the three-dimensional location of the trajectory's latest endpoint in time if a backward trajectory is selected (i.e. the start of a trajectory going backward in time).

Input Meteorological Data Set. Note the *input meteorological data set* used in the HYSPLIT model run. The *original file name* provides sufficient information to identify the data set. Meteorological data fields to run the model are already available for access through the HYSPLIT menu system, or by direct FTP from ARL. The ARL web server contains several meteorological

model data sets already converted into a HYSPLIT compatible format in the public directories. Direct access via FTP to these data files is built into HYSPLIT's graphical user interface. The data files are automatically updated on the server with each new forecast cycle. Only an email address is required for the password to access the server. The ARL analysis data archive consists of output from the Global Data Analysis System (GDAS) and the NAM Data Analysis System (NDAS - previously called EDAS) covering much of North America. Both data archives are available from 1997 in semi-monthly files (SM). The EDAS was saved at 80 km resolution every 3-h through 2003, and then at 40 km resolution starting in 2004.
Detailed information on all meteorological data available for use in HYSPLIT can be found in the HYSPLIT4 Users Guide (*http://www.arl.noaa.gov/documents/reports/hysplit_user_guide.pdf*).

Vertical Motion Options. HYSPLIT can employ one of 5 different *methods for computing vertical motion.* A sixth method is to accept the vertical motion values contained within the input meteorological data set, effectively using the vertical motion method used by the meteorological model that created the data set. Note which method was selected as well as the value chosen for *the top of the model*, in meters AGL.

Trajectory Display Options. The HYSPLIT trajectory model generates a text output file of end-point positions. The end-point position file is processed by another HYSPLIT module to produce a Postscript display file or output files in other display formats. Some parameters, such as map projection and size, can be automatically computed based on the location and length of the trajectory, or they can be manually set by the user. While these display options do not directly affect the trajectory information itself, noting these options will eliminate possible misinterpretation of identical trajectories because of differing display options. An important display option is the choice of *vertical coordinate,* usually set to meters AGL for these assessments.