



# Guidance on the Use of Models for Assessing the Impacts of Emissions from Single Sources on the Secondarily Formed Pollutants: Ozone and PM<sub>2.5</sub>



EPA-454/R-16-005  
December 2016

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the Secondarily Formed Pollutants: Ozone and PM<sub>2.5</sub>

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## Executive Summary

The purpose of this document is to provide guidance on how to assess the air quality impact on ozone (O<sub>3</sub>) and secondarily formed fine particulate matter (PM<sub>2.5</sub>) from individual sources (either new sources or modifications to existing sources) as part of Prevention of Significant Deterioration (PSD) compliance demonstrations under the New Source Review (NSR) program. This guidance outlines recommended procedures for estimating O<sub>3</sub> or secondarily formed PM<sub>2.5</sub> impacts from project sources. This guidance document is consistent with the recommendations for air quality modeling in the EPA's *Guideline on Air Quality Models* (published as Appendix W to 40 CFR Part 51), hereafter referred to as the *Guideline* (U.S. Environmental Protection Agency, 2016c). Information presented here is intended to expand upon the principles set forth in the *Guideline* for estimating single source impacts of ozone and secondary PM<sub>2.5</sub> for permit review purposes.

The degree of complexity required to assess potential secondary pollutant impacts from single sources varies depending upon the nature of the source, its emissions of relevant pollutants and precursors, and the background environment. A two-tiered approach for addressing single-source impacts on ozone and secondary PM<sub>2.5</sub> has been established by EPA (U.S. Environmental Protection Agency, 2016c) to provide permit applicants with both a scientifically credible and flexible approach for these assessments. The first tier involves use of appropriate and technically credible relationships between emissions and impacts developed from existing information that is deemed sufficient for evaluating a source's impacts. The second tier involves the application of more sophisticated case-specific chemical transport models (CTMs), which may include Eulerian grid or Lagrangian chemical transport models. Second tier assessments are only intended for impact assessments that are not able to be satisfied with a tier one demonstration in that pre-existing information is not available or representative of the situation such that more refined modeling is deemed necessary. This guidance document is intended to provide permit applicants and permitting authorities with more detailed procedures for applying CTMs to estimate single source impacts for chemically reactive pollutants. Such modeling may be used to either (1) inform development of an appropriate screening technique as part of a Tier 1 demonstration or (2) directly estimate the single-source impacts as part of a Tier 2 demonstration.

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# 1 Background

New and/or modifying sources may be required to estimate their air quality impacts as part of their Prevention of Significant Deterioration (PSD) permit within the New Source Review (NSR) program, or other regulatory programs. In particular, for assessing O<sub>3</sub> and secondarily formed PM<sub>2.5</sub> impacts from single sources, the degree of complexity required to make such assessment varies depending upon the nature of the source, its emissions, and the background environment. A two-tiered approach for addressing single-source impacts on O<sub>3</sub> and secondary PM<sub>2.5</sub> has been finalized by EPA (U.S. Environmental Protection Agency, 2016c) to provide the user community the necessary technical credibility and flexibility in estimating these impacts. The first tier involves use of technically credible and appropriate relationships between emissions and impacts developed from previous modeling, which is deemed representative of the source's meteorology, terrain, etc. to sufficiently evaluate a source's impacts. If the first tier analysis is not suitable, then a second tier analysis would be accomplished, which involves the application of more sophisticated case-specific air quality modeling analyses. Hence, the appropriate tier for a given permit application should be selected in consultation with the appropriate permitting authority and be consistent with the EPA's "Guideline on Air Quality Models" (published as Appendix W to 40 CFR Part 51), hereafter referred to as the *Guideline* (U.S. Environmental Protection Agency, 2016c), and associated EPA technical guidance (U.S. Environmental Protection Agency, 2016a, c). The EPA's expectation is that the first tier should be appropriate for most permit applicants; the second tier may only be necessary in special situations.

This guidance document is intended to provide more detail for applicants seeking to apply chemical transport models (CTMs) to estimate single source impacts for chemically reactive pollutants to either inform development of an appropriate screening technique as part of a Tier 1 demonstration or directly estimate the single-source impacts as part of a Tier 2 demonstration. This document is consistent with the recommendations for air quality modeling in the *Guideline* and associated technical guidance. Please note for PM<sub>2.5</sub>, sources will need to estimate the impacts of both primary PM<sub>2.5</sub> and precursor emissions that contribute to secondarily formed PM<sub>2.5</sub>. Steady-state Gaussian plume dispersion models such as AERMOD will be used to estimate the primary PM<sub>2.5</sub> impacts (U.S. Environmental Protection Agency, 2016c), while CTMs (i.e., Eulerian grid or Lagrangian chemical transport models) should be used to estimate the secondary impacts from gas-phase precursor emissions for ozone and secondarily formed PM<sub>2.5</sub>.

For the purposes of first tier approaches for estimating single source secondary impacts described in the *Guideline*, this document provides information about the types of analyses and options that could be used to satisfy the requirements of a first tier assessment. For first tier assessments, it is generally expected that applicants would use existing empirical relationships between precursors and secondary impacts based on modeling systems appropriate for this purpose as detailed in this guidance. It is also possible that screening approaches based on full science CTM (e.g., reduced form models) could provide information to satisfy the first tier in some situations. The use of pre-existing credible technical information for the purposes of estimating single source secondary impacts will be considered on a case-by-case basis and should be done in consultation with the appropriate permitting authority. One example of such a screening approach is the Model Emissions Rates for Precursors (MERPs) as detailed in EPA's draft *Guidance on the Use of Modeled Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Ozone and PM<sub>2.5</sub> under the PSD Permitting Program* (U.S. Environmental Protection Agency, 2016b).

For the purposes of second tier assessments for single source secondary pollutant impacts for permit related programs, this document describes the air quality models, inputs, run time options, receptor placement, and application approach for the purposes of directly estimating the impacts on ozone and secondarily formed PM<sub>2.5</sub> from single project sources.

## 2 Modeling systems for estimating secondary impacts

Quantifying secondary pollutant formation requires simulating chemical reactions and thermodynamic gas-particle partitioning in a realistic chemical and physical environment. CTMs treat atmospheric chemical and physical processes such as deposition and transport. There are two types of CTMs which are differentiated based on a fixed frame of reference (i.e., Eulerian grid based) or a frame of reference that moves with parcels of air between the source and receptor point (i.e., Lagrangian based) (McMurry et al., 2004).

A variety of Eulerian and Lagrangian modeling systems exist that could potentially be used to estimate single source impacts on O<sub>3</sub> and secondarily formed PM<sub>2.5</sub>. These modeling systems represent varying levels of complexity in the treatment of plume chemistry and the chemical and physical environment in which the plume exists. It is important that any Eulerian or Lagrangian modeling system be appropriately applied for assessing the impacts of single sources on secondarily formed pollutants for the purposes of permit review. This means that existing guidance for dispersion models and photochemical models developed for other purposes such as State Implementation Plans (SIPs) may not be totally applicable for this type of single-source assessment. Sound science and appropriate purpose are the fundamental basis of the approaches described for assessing single source impacts on secondarily formed pollutants.

This section describes the modeling systems that are best suited for the purpose of estimating single source secondary pollutant impacts. It is essential that any modeling system used for these types of assessments be fit for this particular purpose and evaluated for its skill in replicating meteorology and atmospheric chemical and physical processes that result in secondary pollutant formation and deposition. Therefore, a candidate model for use in estimating single source impacts on O<sub>3</sub> and secondarily formed PM<sub>2.5</sub> for the purposes of permit review programs should meet the general criteria for an “alternative model” outlined section 3.2 of 40 CFR part 51, Appendix W (U.S. Environmental Protection Agency, 2016c). The EPA is responsible for approving (1) a particular model for its acceptability and (2) the approach for that model application. Such approval includes consultation with the appropriate EPA Regional Office and concurrence with EPA’s Model Clearinghouse.

### 2.1 Lagrangian modeling systems

Lagrangian modeling systems that have been used to assess single source impacts in North America include CALPUFF, HYSPLIT, FLEXPART, SCIPUFF, and SCICHEM. Some Lagrangian models treat in-plume gas and particulate chemistry. These models require time and space varying oxidant concentrations and, in the case of PM<sub>2.5</sub>, neutralizing agents such as ammonia, in order to address important secondary impacts that occur when plume edges start to interact with the surrounding chemical environment (Baker and Kelly, 2014; ENVIRON, 2012). These oxidant and neutralizing agents are not routinely measured, but can be generated with a three dimensional photochemical transport model and subsequently input to a Lagrangian modeling system.

The Second-order Closure Integrated PUFF model with chemistry (SCICHEM) is an extension of the Second-order Closure Integrated PUFF model (SCIPUFF) and simulates in-plume chemistry and

subsequent transport and dispersion using second order closure to solve turbulent diffusion equations using spatially and temporally variant meteorological input (Sykes et al., 1998). SCICHEM is a non-steady state puff dispersion model treating both O<sub>3</sub> and PM<sub>2.5</sub> formation and their fate in the atmosphere (Chowdhury et al., 2015; Chowdhury et al., 2010). CALPUFF is a multi-specie, non-steady state puff dispersion model that treats pollutant emissions, transport, represents some chemical processes, and deposition using temporally and spatially variant meteorological inputs (Scire et al., 2000). The CALPUFF system has capabilities to estimate primary and secondary PM<sub>2.5</sub>; however, O<sub>3</sub> and other oxidants and neutralizing agents are input to the model and not internally estimated (Scire et al., 2000).

## 2.2 Eulerian grid models

Eulerian photochemical models are three-dimensional grid-based models that treat chemical and physical processes in each grid cell and use Eulerian diffusion and transport processes to move chemical species to other grid cells (McMurry et al., 2004). Photochemical models have the advantage of providing a spatially and temporally dynamic and realistic chemical and physical environment for plume growth and chemical transformation (Baker and Kelly, 2014; Zhou et al., 2012). Publically available and documented photochemical grid models such as the Comprehensive Air Quality Model with Extensions (CAMx) (ENVIRON, 2014) and the Community Multiscale Air Quality (CMAQ) (Byun and Schere, 2006) model treat emissions, chemical transformation, transport, and deposition using time and space variant meteorology. These modeling systems include primarily emitted species and secondarily formed pollutants such as O<sub>3</sub> and PM<sub>2.5</sub> (Chen et al., 2014; Civerolo et al., 2010; Russell, 2008; Tesche et al., 2006). These models have been used extensively to support SIP model demonstrations and to explore relationships between inputs and air quality impacts across the United States and beyond (Cai et al., 2011; Civerolo et al., 2010; Hogrefe et al., 2011).

Even though single source emissions are averaged into a grid volume, photochemical models have been shown to adequately capture single source impacts through comparison with downwind in-plume measurements (Baker and Kelly, 2014; Zhou et al., 2012). Where set up appropriately, for the purposes of assessing the impact of single sources to primary and secondarily formed pollutants, photochemical grid models can be used with a variety of techniques to estimate these impacts. These “instrumented” techniques generally fall into the category of source sensitivity (how air quality changes due to changes in emissions) and source apportionment (the impact of a specific source to a receptor under existing ambient conditions).

The simplest source sensitivity approach (i.e., brute-force change to emissions) would be to simulate two sets of conditions, one with all existing emissions and one with the addition of a new source or a source of interest modified to reflect changes in operation (Cohan and Napelenok, 2011). The difference between these model simulations provides an estimate of the air quality change related to the change in emissions from the new or modified source. Another source sensitivity approach to differentiate the impacts of single sources on changes in model predicted air quality is the Decoupled Direct Method (DDM), which internally tracks the sensitivity of the emissions from a source through all chemical and physical processes within the modeling system (Dunker et al., 2002). Sensitivity coefficients relating source emissions to air quality levels are estimated during the model simulation and output at the grid resolution of the host model.

Some photochemical models have been instrumented with source apportionment capability, which enables the tracking of emissions from specific sources through chemical transformation, transport, and

deposition processes to estimate a particular source's impact on predicted air quality levels (Kwok et al., 2015; Kwok et al., 2013). Source apportionment has been used to differentiate the impact from single sources on model predicted ozone and PM<sub>2.5</sub> levels (Baker and Foley, 2011; Baker and Kelly, 2014; Baker et al., 2015). DDM has also been used to estimate O<sub>3</sub> and PM<sub>2.5</sub> impacts from specific sources (Baker and Kelly, 2014; Bergin et al., 2008; Cohan et al., 2005; Cohan et al., 2006; Kelly et al., 2015) as well as the simpler brute-force sensitivity approach (Baker and Kelly, 2014; Bergin et al., 2008; Kelly et al., 2015; Zhou et al., 2012). Limited comparison of single source impacts between models (Baker et al., 2013) and approaches to differentiate single source impacts (Baker and Kelly, 2014; Cohan et al., 2006; Kelly et al., 2015) has shown generally similar downwind spatial gradients and impacts.

## 2.3 Elements of a modeling protocol

Per section 9.2.1 of the *Guideline*, the development of a modeling protocol is critical to a successful modeling assessment and that "Every effort should be made by the appropriate reviewing authority (paragraph 3.0(b)) to meet with all parties involved in either a SIP submission or revision or a PSD permit application prior to the start of any work on such a project." A modeling protocol is intended to communicate the scope of the analysis and generally includes (1) the types of analysis performed, (2) the specific steps taken in each type of analysis, (3) the rationale for the choice of modeling system, (4) names of organizations participating in preparing and implementing the protocol, and (5) a complete list of model configuration options. This protocol should detail and formalize the procedures for conducting all phases of the modeling study, such as describing the background and objectives for the study, creating a schedule and organizational structure for the study, developing the input data, conducting model performance evaluations, interpreting modeling results, describing procedures for using the model to demonstrate whether regulatory levels are met, and producing documentation to be submitted for review and approval. Protocols should include the following elements at a minimum.

### 1. Overview of Modeling/Analysis Project

- Participating organizations
- Schedule for completion of the project
- Description of the conceptual model for the project source/receptor area
- Identification of how modeling and other analyses will be archived and documented
- Identification of specific deliverables to the review authority

### 2. Model and Modeling Inputs

- Rationale for the selection of air quality, meteorological, and emissions models
- Modeling domain specifications
- Horizontal resolution, vertical resolution and vertical structure
- Episode selection and rationale for episode selection
- Description of meteorological model setup
- Description of emissions inputs
- Specification of initial and boundary conditions
- Methods used to quality assure emissions, meteorological, and other model inputs

### 3. Model Performance Evaluation

- Identification of relevant ambient data near the project source and key receptors; provide relevant performance near the project source and key receptor locations
- List evaluation procedures

- Identification of possible diagnostic testing that could be used to improve model performance

#### 4. Model Outputs

- Description of the process for extracting project source impacts including temporal aggregation and in the case of PM<sub>2.5</sub> chemical species aggregation

### 3 Relevant existing information or “First Tier” assessment of single source impacts on O<sub>3</sub> and secondary PM<sub>2.5</sub>

This section is intended to provide more detail for applicants seeking to estimate single source impacts on secondary pollutants for conducting a PSD compliance demonstration under the first tier outlined in the *Guideline* (i.e., Sections 5.3.2.b and 5.4.2.b). More refined approaches that would fall under the second tier are described in the subsequent sections. Under the first tier, existing technical information is used in combination with other supportive information and analysis for the purposes of estimating secondary impacts from a particular source. The existing technical information should provide a credible and representative estimate of the secondary impacts from the project source. In these situations, a more refined approach for estimating secondary pollutant impacts from project sources may not be necessary where agreement is reached with the permitting authority.

EPA has been compiling and reviewing screening models, screening approaches, and reduced form models that are based on technically credible tools (e.g. photochemical transport models) that relate source precursor emissions to secondary impacts. A review of existing approaches detailed in peer reviewed journal articles and non-peer reviewed forms (e.g. technical reports, conference presentations) indicates a very limited number of screening approaches have been developed and fewer still have been fully documented and tested for robust application (U.S. Environmental Protection Agency, 2016d). One example of a reduced form model is the development of a tool for the New South Wales (NSW) Greater Metropolitan Region in Australia (Yarwood et al., 2011). High O<sub>3</sub> impact days are modeled using a photochemical grid model with the higher order Decoupled Direct Method (HDDM) (Dunker et al., 2002) to calculate sensitivity coefficients for O<sub>3</sub> pertaining to additional NO<sub>x</sub> and VOC emissions from new hypothetical sources. The resulting O<sub>3</sub> sensitivity coefficients then allow O<sub>3</sub> impacts to be estimated for other NO<sub>x</sub> and/or VOC sources within the same metropolitan area. The relevancy and applicability of a given screening technique should be discussed with the permitting authority for a determination about whether that approach would fulfill a first tier assessment.

A demonstration tool could include the use of existing credible photochemical model impacts for sources deemed to be similar in terms of emission rates, release parameters, and background environment. Empirical relationships based on existing technical work may be relevant where the modeling system used conforms to those suitable for estimating single source secondary impacts as described later in this guidance and consistent with criteria for alternative models under the *Guideline*. The permit applicant should generate a modeling protocol and describe how the existing modeling conforms to the nature of O<sub>3</sub> and/or secondarily formed PM<sub>2.5</sub> that is conceptually thought to form in that particular area. Where the existing technical information is based on chemical and physical conditions less similar to the project source and key receptors, a more conservative estimate of impacts using suitable models or techniques may be appropriate. Information that could be used to describe the comparability of two different areas include average and peak temperatures, humidity, terrain, rural or urban nature of the area, nearby regional sources of pollutants (e.g. biogenics, other industry), ambient concentrations of relevant pollutants, where available.

An example of using existing empirical relationships would be a hypothetical source emitting 600 tpy of SO<sub>2</sub> emissions from a new facility in the Atlanta metropolitan area. Empirical relationships between single sources of SO<sub>2</sub> emissions in the Atlanta area and downwind impacts have been published (U.S. Environmental Protection Agency, 2016d). However, the published impacts are the result of the addition of 100 and 300 tpy emissions in that area. Impacts could be extrapolated by increasing the downwind PM<sub>2.5</sub> sulfate ion impacts from the published 300 tpy hypothetical source by a factor of 2 to estimate the post-construction impacts of source seeking a permit. If those impacts are well below the applicable air quality threshold, then the Tier 1 demonstration based on this information may be sufficient. If a source plans to locate in an area that lacks existing information, the applicant could present the most conservative estimate of impacts from sources previously modeled in areas with generally similar meteorology and air quality. However, in this case, additional conservatism would need to be introduced to the previously estimated downwind impacts given the additional incongruity between the existing information and actual conditions. In all cases, the applicant should provide detailed descriptions for the project source to corroborate the appropriateness and relevancy of the existing information for the anticipated conditions at the project source and at key receptors.

In the preamble of the 2015 proposed update to the *Guideline* (U.S. Environmental Protection Agency, 2015), EPA provided a conceptual discussion on the use of existing relationships between modeled impacts and precursor emissions that are referred to as MERPs. EPA has issued draft technical guidance that provides a framework on how air quality modeling can be used to develop relationships between precursors and maximum downwind impacts for the purposes of developing and using MERPs as a Tier 1 demonstration tool under the PSD permitting program and to present hypothetical single source impacts on O<sub>3</sub> and secondarily formed PM<sub>2.5</sub> to illustrate how this framework can be implemented by stakeholders (U.S. Environmental Protection Agency, 2016b). MERPs are the emission rates of precursors for which the modeled change in ambient concentrations likely would be less than an applicable air quality threshold for O<sub>3</sub> or PM<sub>2.5</sub>.

## 4 “Second Tier” or refined assessment of single source impacts on O<sub>3</sub> and secondary PM<sub>2.5</sub>

As described earlier, a variety of CTMs exist that could potentially be used to estimate single source impacts on O<sub>3</sub> and PM<sub>2.5</sub>. These modeling systems represent varying levels of complexity in the treatment of plume chemistry and the chemical and physical environment in which the plume exists. It is important that any CTM be appropriately applied for assessing the impacts of a single source on secondarily formed pollutants for the purposes of permit review. Therefore, this section provides recommendations concerning the emissions and meteorological model inputs, modeling episodes and domains, receptor placement, and application approach for the purposes of directly estimating the impacts on O<sub>3</sub> and secondarily formed PM<sub>2.5</sub> from a single project source.

### 4.1 Model inputs

#### 4.1.1 Project source emissions

Compliance with PSD should be demonstrated using emissions data for the project source consistent with the *Guideline* (U.S. Environmental Protection Agency, 2016c). Emissions inputs for the project

source should be consistent with Tables 8.1 and 8.2, meaning modeled project source emissions should be the maximum allowable emissions or federally enforceable permit level limits. VOC and NO<sub>x</sub> emissions should be assessed using a VOC and NO<sub>x</sub> speciation profile matching the specific project source where feasible or otherwise representative of the source type being assessed in the permit application.

#### 4.1.2 Non-project source emissions

A realistic characterization of chemistry surrounding the project source is important for estimating secondary impacts. Therefore, unlike the project source that is modeled at maximum allowable emissions, other sources in the modeled assessment should be modeled or characterized with a typical emission profile and stack characteristics for the purposes of estimating single source impacts on secondary pollutant formation. This characterization of such “nearby and other” sources in the model domain is consistent with the *Guideline* (U.S. Environmental Protection Agency, 2016c).

#### 4.1.3 Meteorology inputs

The importance of meteorology coupled with the spatial heterogeneity of chemical reactants in a project area necessitates meteorological inputs to the air quality model that capture variations in meteorology (e.g. temperature and relative humidity) over the entire spatial extent of the project area both horizontally and vertically. Prognostic meteorological model output should be used to support air quality modeling of secondary impacts of secondarily formed PM<sub>2.5</sub> and O<sub>3</sub>. Candidate prognostic meteorological models should be (1) considered state-of-the-science by the air quality modeling community, (2) routinely used as input for regulatory air quality modeling applications, (3) peer-reviewed, (4) fully documented, (5) freely available on the internet, and (6) actively supported by the model developer. Currently, one of the most widely used prognostic meteorological models in the United States is the Weather Research and Forecasting (WRF) model (Skamarock et al., 2008) available from the National Center for Atmospheric Research (<http://www.wrf-model.org/index.php>).

The prognostic meteorological model application should be configured to match the grid projection and size of the air quality model domain used to assess the single source impacts on secondary pollutants. Prognostic meteorological model applications should include the entire troposphere with the finest vertical resolution in the planetary boundary layer to appropriately capture the dynamic processes related to vertical mixing. Prognostic meteorological model output should be translated for input to the selected air quality model by making any needed adjustments to match grid structure. Prognostic model output variables should not be re-diagnosed or changed (for purposes other than grid translation) before input to the air quality model. It is important to maintain the integrity of the meteorological field to minimize dynamic inconsistencies between the air quality and meteorological models. These requirements are consistent with other applications of air quality modeling using prognostic meteorology as input, such as modeled attainment demonstrations for NAAQS (U.S. Environmental Protection Agency, 2014).

Where project source site-specific meteorology is available, applicants are encouraged to incorporate that data into the prognostic meteorological model simulation. This can be done through inclusion with other observation data as the input analysis field and through observation nudging during the model simulation.

## 4.2 Episode selection

Meteorology is an important factor in the formation of many secondarily formed pollutants, both directly (e.g., ammonium nitrate formation under cool, humid conditions) and indirectly (e.g., warm temperatures and sunlight increase photochemistry and the availability of oxidants). Since secondary pollutant impacts are being estimated, it is important to determine the appropriate year(s) of meteorology for use in the assessment. A time period with meteorology generally conducive to the formation of secondary PM<sub>2.5</sub> and/or O<sub>3</sub> is necessary. This means that time periods with elevated ambient PM<sub>2.5</sub> and/or O<sub>3</sub> at the source and receptors should be used in the analysis.

At a minimum, modeling systems applied for the purposes of characterizing secondary annual PM<sub>2.5</sub> should be applied with at least one year of meteorological inputs that vary in time and space since some components of secondarily formed PM<sub>2.5</sub> are highest in the different seasons. An entire year should be modeled to capture different formation regimes and to capture the variety of wind flows at the sources and receptors being analyzed. It may not always be necessary that the period used for estimating secondarily formed PM<sub>2.5</sub> impacts match a period used to estimate impacts of primary PM<sub>2.5</sub>.

When project sources are being modeled to characterize daily secondary PM<sub>2.5</sub> impacts, at least one entire time period that has been shown to be generally conducive to elevated secondary PM<sub>2.5</sub> formation. Since secondary PM<sub>2.5</sub> daily formation varies in a given area, multiple elevated PM<sub>2.5</sub> episodes would be appropriate for modeling the impacts of a single source on ambient PM<sub>2.5</sub> concentrations to capture the variety of wind flows and formation regimes in a given area. Where multiple-episode simulations are necessary for a single source assessment, it is not necessary for the simulations to be consecutive.

When O<sub>3</sub> impacts from a single project source are being modeled, it is preferential to include impacts that have been modeled over at least one time period that has been shown to be generally conducive to elevated O<sub>3</sub> formation. Since ozone formation varies in a given area, multiple O<sub>3</sub> seasons or multiple well characterized ozone episodes would be appropriate for modeling the impacts of a single source on ambient O<sub>3</sub> to capture the variety of wind flows and O<sub>3</sub> formation regimes in a given area. Where multiple O<sub>3</sub> episode/season simulations are necessary for a single source assessment, it is not necessary they be consecutive.

## 4.3 Modeling domain and receptor placement

Receptors are assigned locations in the area around a project where an air quality model is instructed to estimate pollutant concentrations. A receptor network design consisting of numerous receptors should emphasize resolution and location rather than achieve a minimum number of receptors. Receptors should be placed at all locations where high concentrations may occur, not just where high concentrations may be anticipated prior to the analysis. Receptor spacing near the source should be sufficient to capture expected concentration gradients around the locations of maximum modeled values. Where grid models are applied, a receptor's location is the center of the surface layer grid cell.

For primarily emitted PM<sub>2.5</sub>, the peak impacts from a particular source are more likely to occur near that source. However, peak impacts of secondarily formed PM<sub>2.5</sub> and O<sub>3</sub> may occur either near the source or further downwind depending on meteorology, stack release characteristics, and availability of important

chemical reactants. Accordingly, receptors should be placed in all directions surrounding a project source to capture meteorological and chemical variability.

Receptor placement should extend from property owned or controlled by the project source (i.e., fence line) out to a sufficient distance to account for the impacts of downwind chemical transformations and changing availability of important chemical species that may enhance secondary pollutant formation. Receptors should be placed to capture maximum concentrations of secondary impacts, which may extend out to at least 50 km from the project source (U.S. Environmental Protection Agency, 2016d). Receptor placement for Class I areas for the purpose of estimating air quality related values should follow guidance developed by Federal land managers (U.S. Department of the Interior, 2010).

#### 4.4 Vertical domain resolution

To best represent the vertical atmosphere in an air quality model, the vertical layer structure of air quality model should match that of the input prognostic meteorological model. However, it may not always be necessary in the air quality model to use the full vertical extent applied in the prognostic meteorological model and resource considerations may make vertical layer collapsing necessary at times. When vertical layer collapsing is employed, it is important to match most closely with the prognostic meteorological model the layers closest to the surface to best resolve the diurnal and seasonal variability in the mixing height. Consultation with the permitting authority is recommended for instances when modeling the entire troposphere may not be necessary and when vertical layers are not matched one-to-one between the air quality and meteorological models.

#### 4.5 Horizontal domain resolution

Photochemical grid based models have been applied for long time periods using domains covered by grid cells ranging in size from <1 to 15 square km (Couzo et al., 2012; Hogrefe et al., 2011; Jin et al., 2010; Rodriguez et al., 2011; Stroud et al., 2011). Lagrangian models have been applied using similar horizontal grid spacings (Dresser and Huizer, 2011; Levy et al., 2002). Horizontal grid spacing is important to appropriately represent the heterogeneity in pollutant concentrations between a source and receptor. This concentration gradient varies depending on a variety of factors including chemistry, available reactants, size of the particle, and terrain features among other influencing conditions.

Single source impact assessments for urban areas, where the source and receptors are in the same urban area, should be conducted at grid resolutions between ~1 km up to ~12 km. Photochemical grid model applications up to 12 km have been shown to capture similar changes in air quality due to changes in emissions from a specific source on secondary pollutants in an urban area estimated with finer grid resolution (Cohan et al., 2006).

Single source impact assessments at regional scales, where the source and receptors are hundreds of km apart should be conducted at grid resolutions no larger than ~4 to 12 km. Where resources are an important consideration, options such as 2-way nesting may be useful to reduce computation runtime. In these situations, the source and receptors would be included in 2-way nests using finer grid resolution. In regional scale assessments, using too fine grid spacing may not be appropriate as chemical

and meteorological data may not be appropriately representative and therefore lead to unrealistic model results.

#### 4.6 Use of photochemical grid models for single source impact assessments

When set up appropriately for the purposes of assessing the impact of single sources to secondarily formed pollutants, photochemical grid models can be used with a variety of approaches to credibly estimate these impacts. The simplest approach would be to simulate 2 sets of conditions (i.e., brute-force approach), one with all current emissions (“baseline” simulation) and one with the source of interest (new source or existing source with emissions modifications) added to the original “baseline” simulation (Cohan et al., 2005). The difference between these simulations provides an estimate of the air quality change due to the emissions increase from the source of interest.

An alternative approach to isolate single source impacts using photochemical grid models is source apportionment. Source apportionment has been implemented in modeling systems such as CMAQ and CAMx in the past (ENVIRON, 2014; Kwok et al., 2015; Kwok et al., 2013; Wang et al., 2009). CAMx currently includes multiple approaches to estimate ozone source attribution (ENVIRON, 2014). The standard approach of Ozone Source Apportionment Technology apportions impact based on estimated NO<sub>x</sub>/VOC sensitivity while an alternative approach of Anthropogenic Precursor Culpability Assessment (APCA) diverts ozone impact to the anthropogenic source when ozone is formed from a combination of anthropogenic and biogenic sources (most typically anthropogenic NO<sub>x</sub> and biogenic VOC). For the purposes of estimating project source impacts for permit reviews, EPA recommends the APCA approach, which is consistent with anthropogenic impact assessments done for other regulatory assessments (U.S. Environmental Protection Agency, 2011).

In some instances, where the source of interest and key receptors are in very close proximity, the source and receptors may be located in the same model grid cell. Since physical and chemical processes represent a volume average, this close proximity scenario may not adequately represent the spatial gradients of pollution possible between the source and receptors. In such cases, the preferred approach to better represent the spatial gradient for source-receptor relationships would be to use model grid cells of finer horizontal resolution for the area of the source and nearby receptors. The appropriate grid resolution could be defined such that the source and receptors are no longer in the same model grid cell. Ideally, there would be several grid cells between the source and receptors to best resolve near-source pollution gradients.

In situations of close proximity between the source and receptors, a photochemical model instrumented with sub-grid plume treatment and sampling could potentially represent these relationships. Sub-grid plume treatment extensions in photochemical models typically solve for in-plume chemistry and use a set of physical and chemical criteria for determination of when puff mass is merged back into the host model grid. A notable limitation of sub-grid plume treatments is that these implementations do not have more refined information related to meteorology or terrain than the horizontal resolution of the host grid cell. In addition to tracking puffs at sub-grid scale, the host modeling systems must be able to track and output surface layer sub-grid puff concentrations, “sub-grid plume sampling”, to best represent receptor concentrations that are in close proximity to the source (Baker et al., 2014). Another important reason sub-grid plume sampling is necessary is that inherently in this type of system (i.e., sub-grid plume treatment in a photochemical grid model) some of the source’s impacts on air quality are resolved in puffs at the sub-grid scale and some have been resolved in the 3-dimensional grid space. Just

extracting sub-grid plume information or just 3-dimensional model output would miss some of the source's impact to air quality, meaning accounting for both is necessary either with sub-grid sampling or options that integrate puffs within a grid cell with grid cell concentrations. Sub-grid plume treatments in photochemical grid models do not track grid resolved source impacts separately from other sources in the model simulation. When sub-grid treatment is applied for a project source under permit review, either source apportionment or source sensitivity is necessary to track the grid resolved source impact in addition to sub-grid plume treatment to fully capture source impact. The EPA recommends that the applicant detail the application of sub-grid plume treatment in the modeling protocol and discuss with the appropriate permitting authority before beginning such an assessment.

#### 4.7 Use of lagrangian models for single source impact assessments

Given the complex nature of chemical reactions and spatial and temporal variability in chemical reactants, it is of critical importance that when secondary impacts are estimated from single sources that they exist in a dynamic and realistic chemical and physical environment. Lagrangian models may provide adequate representation of in-plume gas, aqueous, and aerosol chemistry; however, without realistic concentrations of oxidants and reacting pollutants surrounding the plume, their estimates of secondary impacts from single sources may not be appropriately characterized. Many important oxidants are not routinely measured. Variability from the surface vertically through the troposphere is also critically important given that many sources will have plumes that do not solely exist at the surface. The use of ambient measurements is unlikely to provide the spatial (at the surface and vertically) and temporal variability in oxidants and reactants in an area. This input data need typically necessitates the use of photochemical model concentration estimates to be used as an input to a Lagrangian model. The best approach for generating three dimensional (3D) fields of chemical pollutants for a Lagrangian model would be to use photochemical grid model output that matches the Lagrangian model configuration in time and space.

Due to the existence of overlapping puffs in many Lagrangian puff models, multiple puffs can occupy the same location at a given time. These overlapping puffs interact with background concentrations independently unless special treatment of puff access to background is implemented in the model (e.g., SCICHEM). Under certain conditions, this modeling approach can lead to artifacts associated with double-counting background concentrations. For instance, it has been observed that under certain conditions the predicted concentration of nitrate in particles can greatly exceed the theoretical maximum value based on the availability of gas-phase ammonia ( $\text{NH}_3$ ) for ammonium nitrate formation (Karamchandani et al., 2008). Since each overlapping puff has access to the entire background amount of  $\text{NH}_3$ , nitrate in each puff will condense according to that amount. Under conditions where  $\text{NH}_3$  is the limiting species for ammonium nitrate formation, each overlapping puff can independently deplete the gas-phase  $\text{NH}_3$  concentration and cause over-prediction of particle nitrate when puffs overlap.

In an attempt to counteract the nitrate errors mentioned above, a post-processing step known as the Ammonia Limiting Method (ALM) is sometimes applied (Ecoffier-Czaja and Scire, 2002). This method repartitions total nitrate between nitric acid and particle nitrate with the total amount of  $\text{NH}_3$  at a given receptor with a post-processing step rather than during the model simulation. The approach is not necessary in 3D photochemical grid models and some Lagrangian models (e.g. SCICHEM) because these models estimate thermodynamic partitioning of nitrate and ammonium during runtime. Use of the ALM approach is especially problematic in long-range transport applications because the deposition velocities of nitric acid and fine-particle nitrate differ greatly, and so the extent of transport of the pollutants

depends on whether they exist in the gas or particle phase. The ALM post-processing step does not account for the differences in transport of nitric acid and particle nitrate due to their different atmospheric lifetimes, and so ALM does not correct for the flaws in the approach to modeling overlapping puffs and likely introduces new biases to the air quality model estimates.

All chemical reactions should happen dynamically and continually at run-time during model application when assessing the impacts of single sources on secondary pollutants. Post-processing changes to chemical phase or other similar techniques that occur after the model simulation has completed are not deemed appropriate for assessing project source impacts on secondary pollutants.

## 4.8 Model evaluation

There are multiple components to model performance evaluation for the purposes of assessing single source secondary pollutant impacts for permit review programs. According to the *Guideline* (Section 3.2.2.b), an alternative model should be evaluated from both a theoretical and a performance perspective before it is selected for use. Comparing modeling estimates against regional tracer experiments and against near-source in-plume measurements are examples of evaluations to satisfy the theoretical fit for use evaluation requirements and are typically only done when a modeling system has notably changed from previous testing or has never been evaluated for this purpose. The tracer experiments are useful for assessing whether a modeling system correctly captures long-range source-receptor relationships. Near-field plume transects are useful for evaluating the model system's skill in capturing primary and secondarily formed pollutant concentrations. Also, it is necessary to determine whether the inputs to the modeling system for a specific scenario are adequate (Section 3.2.2.e). This type of evaluation usually consists of operationally comparing model predictions with observation data that coincides with the episode being modeled for a permit review assessment.

It is important that any potential approaches for model performance for the purposes of single source assessments for PSD permitting purposes use a model evaluation approach that is universally applicable to any single source modeling system, which includes both photochemical grid and Lagrangian modeling systems. Regardless of the modeling system used to estimate impacts of O<sub>3</sub> and/or secondarily formed PM<sub>2.5</sub>, model estimates should be compared to observation data to generate confidence that the modeling system is representative of the local and regional air quality. For O<sub>3</sub> related projects, model estimates of ozone should be compared with observations in both time and space. For PM<sub>2.5</sub>, model estimates of speciated PM<sub>2.5</sub> components (such as sulfate ion, nitrate ion, etc.) should be matched in time and space with observation data in the model domain (Simon et al., 2012; U.S. Environmental Protection Agency, 2014). Model performance metrics comparing observations and predictions are often used to summarize model performance. These metrics include mean bias, mean error, fractional bias, fractional error, and correlation coefficient (Simon et al., 2012). There are no specific levels of any model performance metric that indicate "acceptable" model performance. Model performance metrics should be compared with model applications of similar geographic areas and time of year to assess how well the model performs (Simon et al., 2012). Model performance for chemical transport models in the context of single source impact assessments for well characterized project sources is intended to provide confidence in the chemical environment of the source and does not provide specific information about the amount or directionality of possible error in modeled source impacts.

## 4.9 Project-specific modeling

The types of model simulations needed for different types of permit review assessments are described in this section. The necessary modeling scenario in each case depends on the purpose of the modeling and the type of modeling tool used for the assessment. A photochemical model used for estimating impacts for a PSD permit review would typically require both a baseline and project source (post-construction) scenario but a Lagrangian modeling system may only require a project source scenario.

**Baseline conditions scenario.** This scenario includes all sources other than the project source in an area operating under typical (actual) conditions during the selected modeling period. Where impacts of a new project source will be estimated then the new source should not have any emissions in this simulation. Where the impacts of a proposed modification to an existing source will be estimated, the existing (project) source should be modeled using pre-modification conditions (based on actual emissions). This step should not be necessary where modeling the impacts of a new source using a Lagrangian modeling system because those modeling systems typically only output source impacts.

**Project source scenario.** This scenario is the same as the baseline scenario except it includes either 1) emissions from a new project source or 2) emissions from a modification project at an existing source as part of the simulation. Where either type of project source impacts are estimated using photochemical model source attribution techniques such as DDM or source apportionment, this step may be necessary and the baseline conditions scenario would not be necessary.

## 5 Appropriate processing of modeled estimates & background

### 5.1 Operational definition of particulate matter

An important consideration when using any modeling system for the purposes of assessing single source impacts on total  $PM_{2.5}$  is the operational definition of  $PM_{2.5}$ . Since  $PM_{2.5}$  is the sum of all particulate matter species with aerodynamic diameters less than 2.5 microns, it is important to understand how the modeling system used defines the size of  $PM_{2.5}$ . Some modeling systems use a size sectional approach and others use a modal approach to approximate the size distribution of  $PM_{2.5}$ . A straightforward and conservative way to estimate secondary  $PM_{2.5}$  in models (e.g. CMAQ) that represent particulate matter as modes rather than strict size sections is to sum the secondary components of the fine particle modes (the Aitken and accumulation, i.e., “j” and “k”). The fine modes largely contain particle mass in the  $PM_{2.5}$  size range with aerodynamic diameters less than 2.5 microns. This approach produces an estimate consistent with modeling systems that use a sectional representation of particle size distributions (e.g. CAMx) but internally assume all secondary PM is in the  $PM_{2.5}$  size range.

### 5.2 “Absolute” and “Relative” modeling approaches

For the purposes of single source impact assessments for permit review programs, the absolute modeled concentrations are compared to significance thresholds. Photochemical models used for the purposes of projecting future year design values for ozone and  $PM_{2.5}$  attainment demonstrations are processed to estimate relative response factors at key monitors with the change in model response on the highest modeled days in the baseline period (U.S. Environmental Protection Agency, 2014). One reason for using relative response factors in area attainment demonstrations is to minimize uncertainty in the different components of the emission inventory. Since project source emissions are well characterized and known, the use of the absolute impact estimate by a photochemical grid model is

appropriate in single source permit applications. Additionally, it is necessary to estimate project source impacts throughout the area impacted by a source not just at locations where monitors exist.

The relationship between photochemical model predictions of the bulk or total concentrations of O<sub>3</sub> and secondary PM<sub>2.5</sub> species and the specific impacts of a project source are not obvious and overall model performance may likely be the result of other emissions sources (e.g., not the project source which is well characterized). Therefore, conflating or deflating project source impacts so that bulk model estimates match observation data could result in unrealistic estimates of project source impacts. The emissions and emissions release characteristics of the project source should be well characterized as part of the model simulation, meaning that when placed in a realistic chemical and physical environment (e.g., chemical transport model) the downwind secondary impacts will be appropriately estimated when a source plume interacts with the surrounding environment.

### 5.3 Estimating the O<sub>3</sub> impact from a project source

There are three basic steps for estimating 8-hr O<sub>3</sub> impacts from a project source:

- First, estimate the maximum daily 8-hr O<sub>3</sub> (MDA8) at each receptor for each modeled simulation day of the baseline scenario. This step may not be necessary when using a single source Lagrangian model.
- Second, calculate the MDA8 at each receptor for each modeled simulation day of the project scenario using the same hours used to estimate MDA8 in the baseline scenario.
- Third, estimate the difference in MDA8 between the project scenario and baseline scenario for each receptor and model simulation day. This difference is the impact from the project source.

When a Lagrangian model simulation has been completed, the absolute air quality impacts from the project scenario represent the project source impacts. In this case, calculate the MDA8 at each receptor for each modeled simulation day as an estimate from the project source.

### 5.4 Estimating the annual PM<sub>2.5</sub> impact from a project source

Similarly, there are three steps for estimating annual PM<sub>2.5</sub> impacts from a project source:

- First, estimate the annual average PM<sub>2.5</sub> at each receptor for the baseline scenario. This step may not be necessary when using a single source Lagrangian model.
- Second, calculate the annual average PM<sub>2.5</sub> at each receptor for the project scenario.
- Third, estimate the difference in annual average PM<sub>2.5</sub> between the project scenario and baseline scenario for each receptor. This difference is the impact from the project source.

When a Lagrangian single source simulation has been completed, the absolute air quality impacts from this project scenario represent the project source impacts. In this case, calculate the annual average PM<sub>2.5</sub> at each receptor for each modeled year as an estimate from the project source.

## 5.5 Estimating the daily PM<sub>2.5</sub> impact from a project source

As above, there are three steps for estimating daily PM<sub>2.5</sub> impacts from a project source:

- First, estimate the daily 24-hour average PM<sub>2.5</sub> at each receptor for each modeled simulation day for the baseline scenario. This step may not be necessary when using a single source Lagrangian model.
- Second, calculate the daily average PM<sub>2.5</sub> at each receptor for each modeled simulation day for the project scenario.
- Third, estimate the difference in daily average PM<sub>2.5</sub> between the project scenario and baseline scenario for each receptor and model simulation day. This difference is the impact from the project source.

When a Lagrangian single source simulation has been completed, the absolute air quality impacts from this project scenario represent the project source impacts. In this case, calculate the daily average PM<sub>2.5</sub> at each receptor for each modeled simulation day as an estimate from the project source.

## 5.6 Background concentrations for a Cumulative Impact Analysis

Section 8.2.1 of the *Guideline* states that background concentrations are needed for determining source impacts. Concentrations are spatially and temporally variable throughout a project area due in part to differences in meteorology, terrain, land-use, and emissions. For a cumulative assessment, section 8.3 of the *Guideline* states that two components of background should be determined, thereby including impacts from nearby and other sources. Characterizing the background impact estimate that must be added to the project source impact for comparison to the level of the appropriate NAAQS should be done consistent with the *Guideline* and existing guidance (U.S. Environmental Protection Agency, 2016a) in consultation with the permitting authority.

Background concentrations could be based on either monitored values in the project area or combined observed/modeled estimates at monitored locations in the project area. Given the greater potential of secondary pollution to form downwind of a project source compared to primarily emitted PM<sub>2.5</sub>, monitored values typically provide an appropriate representation of “background” and “nearby” sources. A variety of approaches have been used to combine model surfaces with observation data; these techniques are generally referred to as “fused surfaces” (Fann et al., 2013). Any air quality modeling that includes future emissions reductions from a proposed rule or hypothetical emissions reductions that are not associated with federally enforceable SIP commitments should not be used to represent “background” or fused with observation data to represent “background.” This situation could occur when a projected future year used for a NAAQS nonattainment demonstration has past (e.g. a 2009 simulation projected from 2002) and may be thought to better reflect current air quality conditions, but includes some rules or projected facility changes that were never fully implemented.

## 6 Tier 2 Assessments for PSD Program

For tier 2 assessments (Sections 5.3.2.c and 5.4.2.c), section 5 of this guidance provided details on the air quality models, inputs, run-time options, receptor placement, and application approach for the

purposes of estimating the impacts on O<sub>3</sub> and secondarily formed PM<sub>2.5</sub> from single project sources for permit related programs. Under the *Guideline*, permit applicants are provided flexibility in terms of the complexity of model application for use in their PSD compliance demonstration. The *Guideline* allows for the flexibility to use more simple and conservative approaches where appropriate as well as more complex and sophisticated approaches that allow for a more representative impact for a source. Specifically, as noted in section 2.2 of the *Guideline*, screening models may be used to “provide conservative modeled estimates of the air quality impact of a specific source or source category based on simplified assumptions of the model inputs (e.g., preset, worst-case meteorological conditions).” In addition, the *Guideline* recognizes that refined models and approaches are available that “provide more detailed treatment of physical and chemical atmospheric processes, require more detailed and precise input data, and provide spatially and temporally resolved concentration estimates. As such, they are often more resource-intensive but provide a “more accurate estimate of source impact.”

The approaches for estimating source and cumulative impacts described in this section reflect the flexibility available for using both screening and refined level model and techniques that are suitable for PSD permit assessments.

## 6.1 Assessments of 8-hr Ozone impacts

For changes in O<sub>3</sub> precursor emissions from the project source, the modeled daily 8-hr maximum ozone impact should be calculated for each receptor and day of the simulation as described in Section 5.3 of this guidance document. The possible approaches for estimating the project source impacts of O<sub>3</sub> as part of a Tier 2 assessment are described below.

### 6.1.1 8-hr Ozone impacts: source impact analysis

#### *8-hr Ozone Single Source Analysis - Screening Level:*

Under this screening level of analysis, the model or technique would be configured at a suitable grid resolution and/or informed with more simplified and conservative modeling inputs such as ‘worst-case’ meteorological conditions for ozone formation to estimate the highest daily 8-hr maximum ozone impact over all receptors for use in the PSD compliance demonstration. The analytical technique for estimating the ozone impact could be an approved Lagrangian or photochemical model based approach. The EPA recommends that the applicant fully describe the details of this analysis in the model protocol as determined in consultation with the appropriate permit reviewing authority.

#### *8-hr Ozone Single Source Analysis - Refined Level:*

Under this refined level of analysis, the approved photochemical or Lagrangian model would be configured with a finer grid resolution and/or informed with additional representative meteorological episodes (i.e., multiple O<sub>3</sub> seasons) to estimate ozone impact over all receptors for use in the PSD compliance demonstration. Consistent with existing EPA guidance in consultation with the permitting authority, a value less than the maximum impact may be used for purposes of the PSD assessment (U.S. Environmental Protection Agency, 2016a). The EPA recommends that the applicant fully describe the details of this analysis in the model protocol as determined in consultation with the appropriate permit reviewing authority.

## 6.1.2 8-hr Ozone impacts: cumulative impact analysis

### *8-hr Ozone Cumulative Impact Analysis - Screening Level:*

Under this screening level of analysis, the highest monitored O<sub>3</sub> design value in the project source area should be added to the project source impact from above (i.e., the highest daily 8-hr maximum ozone impact over all modeled days and all receptors) to estimate the cumulative O<sub>3</sub> impact for use in the PSD compliance demonstration. The analytical technique for estimating the O<sub>3</sub> impact could be an approved Lagrangian or photochemical model based approach. The EPA recommends that the applicant fully describe the details of this analysis in the model protocol as determined in consultation with the appropriate permit reviewing authority.

### *8-hr Ozone Cumulative Impact Analysis - Refined Level:*

Under this refined level of analysis, the monitored O<sub>3</sub> design value or an appropriate interpolated field of O<sub>3</sub> design values should be added to the project source impact from above (i.e., the highest daily 8-hr maximum ozone impact at each receptor over high modeled days or all modeled days if a Lagrangian model is applied) to estimate the cumulative ozone impacts for use in the PSD compliance demonstration. The EPA recommends that the applicant fully describe the details of this analysis in the model protocol as determined in consultation with the appropriate permit reviewing authority.

High modeled days include days at each receptor where modeled 8-hr daily maximum ozone exceeds 60 ppb. If less than 5 days are greater than 60 ppb then the test is not valid for that receptor (U.S. Environmental Protection Agency, 2014). If the receptor where there are less than 5 high modeled days is considered likely to have large impacts from the project source, additional episode days will be needed to adequately represent the project source impacts at that particular receptor.

## 6.2 Assessments of PM<sub>2.5</sub> impacts

The approaches for estimating the project source impacts of PM<sub>2.5</sub> as part of a Tier 2 assessment for both annual and daily NAAQS are described below.

### 6.2.1 Sources emitting only PM<sub>2.5</sub> precursors (NO<sub>x</sub> and SO<sub>2</sub>)

For PM<sub>2.5</sub> assessments involving precursor emissions only, the project source impacts for secondary PM<sub>2.5</sub> would be estimated using a Tier 2 approach that appropriately reflects the project source and the atmospheric chemistry for that area based on the screening or refined approach detailed below. The EPA recommends that the applicant fully describe the details of such analyses in the model protocol as determined in consultation with the appropriate permit reviewing authority.

#### 6.2.1.1 Annual average PM<sub>2.5</sub> impacts: source impact analysis

##### *Annual Average PM<sub>2.5</sub> Single Source Analysis - Screening Level:*

Under this screening level of analysis, the model or technique would be configured at a suitable grid resolution and/or informed with more simplified and conservative modeling inputs such as 'worst-case' meteorological conditions to estimate the annual average PM<sub>2.5</sub> impact over all receptors for use in the

PSD assessment. The applicant may use either an approved Lagrangian or photochemical model based approach as the analytical technique for estimating the annual average PM<sub>2.5</sub> impact from precursor emissions.

*Annual Average PM<sub>2.5</sub> Single Source Analysis - Refined Level:*

Under this refined level of analysis, the approved photochemical or Lagrangian model would be configured with a finer grid resolution and/or informed with additional representative meteorological episodes (i.e., multiple years) to estimate the highest annual average PM<sub>2.5</sub> impact over all receptors for use in the PSD compliance demonstration. Consistent with existing EPA guidance (U.S. Environmental Protection Agency, 2016a) in consultation with the permitting authority, the applicant may consider using a value less than the maximum impact for purposes of the PSD assessment.

### 6.2.1.2 Annual average PM<sub>2.5</sub> impacts: cumulative impact analysis

*Annual Average PM<sub>2.5</sub> Cumulative Impact Analysis - Screening Level:*

Under this screening level of analysis, the highest monitored PM<sub>2.5</sub> design value in the project source area should be added to the project source impact from above (i.e., the highest annual average PM<sub>2.5</sub> impact over all receptors) to estimate the cumulative PM<sub>2.5</sub> impacts for use in the PSD compliance demonstration. The applicant may use either an approved Lagrangian or photochemical model based approach as the analytical technique for estimating the annual average PM<sub>2.5</sub> impact from precursor emissions.

*Annual Average PM<sub>2.5</sub> Cumulative Impact Analysis - Refined Level:*

Under this refined level of analysis, the monitored PM<sub>2.5</sub> design value in the project source area value or an appropriate interpolated field of annual PM<sub>2.5</sub> design values should be added to the project source impact from above (i.e., the annual average PM<sub>2.5</sub> impact at each receptor) to estimate the cumulative PM<sub>2.5</sub> impact at each receptor for use in the PSD compliance demonstration.

### 6.2.1.3 Daily average PM<sub>2.5</sub> impacts: source impact analysis

*Daily Average PM<sub>2.5</sub> Single Source Analysis - Screening Level:*

Under this screening level of analysis, the model or technique would be configured at a suitable coarse grid resolution and/or informed with more simplified and conservative modeling inputs such as 'worst-case' meteorological conditions to estimate the daily average PM<sub>2.5</sub> impact over all receptors and days for use in the PSD assessment. The applicant may use either an approved Lagrangian or photochemical model based approach as the analytical technique for estimating the daily average PM<sub>2.5</sub> impact from precursor emissions.

*Daily Average PM<sub>2.5</sub> Single Source Analysis - Refined Level:*

Under this refined level of analysis, the approved photochemical or Lagrangian model would be configured with a finer grid resolution and/or informed with additional representative meteorological episodes (i.e., multiple years) to estimate the highest daily average PM<sub>2.5</sub> impact over all receptor for use

in the PSD compliance demonstration. Consistent with existing EPA guidance (U.S. Environmental Protection Agency, 2016a) in consultation with the permitting authority, the applicant may consider using a value less than the maximum impact for purposes of the PSD assessment.

#### 6.2.1.4 Daily average PM<sub>2.5</sub> impacts: cumulative impact analysis

##### *Daily Average PM<sub>2.5</sub> Cumulative Impact Analysis - Screening Level:*

Under this screening level of analysis, the highest monitored daily PM<sub>2.5</sub> design value in the project source area should be added to the project source impact from above (i.e., the highest daily average PM<sub>2.5</sub> impact over all receptors and days) to estimate the cumulative PM<sub>2.5</sub> impact for use in the PSD compliance demonstration. The applicant may use either an approved Lagrangian or photochemical model based approach as the analytical technique for estimating the daily average PM<sub>2.5</sub> impact from precursor emissions.

##### *Daily Average PM<sub>2.5</sub> Cumulative Impact Analysis - Refined Level:*

Under this refined level of analysis, the applicant should add the monitored PM<sub>2.5</sub> design value in the project source area value or an appropriate interpolated field of daily PM<sub>2.5</sub> design values to the project source impact from above. That is, the monitored PM<sub>2.5</sub> design value should be added to the highest daily average PM<sub>2.5</sub> impact at each receptor from the project source on high modeled days, or all modeled days if a single source Lagrangian model is applied, to estimate the cumulative PM<sub>2.5</sub> impact at each receptor for use in the PSD compliance demonstration.

High modeled days include the top 10 percent of modeled total PM<sub>2.5</sub> in each quarter of the simulation (U.S. Environmental Protection Agency, 2014).

#### 6.2.2 Sources emitting both primarily emitted PM<sub>2.5</sub> and PM<sub>2.5</sub> precursors

For PM<sub>2.5</sub> assessments involving both primary and secondary components, the project source impacts will be estimated using different models; one model for primary and another model for secondary impacts. Consistent with the *Guideline*, primary PM<sub>2.5</sub> emissions would be modeled using AERMOD, or an approved alternative dispersion model, while the secondary impacts would be estimated using a Tier 2 approach that appropriately reflects the project source and the atmospheric chemistry for that area based on the screening or refined approach detailed above in section 6.2.1. For purposes of source impact analyses, the project source impact on total PM<sub>2.5</sub> would then reflect the combination of the estimated primary and secondary impacts at each receptor. For purposes of cumulative impact analyses the project source impact reflecting total PM<sub>2.5</sub> would then be added to the appropriate background estimate (i.e., sum of primary impacts from nearby sources modeled by AERMOD at each receptor and appropriate monitored design value reflecting other sources) to estimate the cumulative PM<sub>2.5</sub> impact at each receptor. The EPA recommends that the applicant fully describe the detail of this analysis in the model protocol as determined in consultation with the appropriate permit reviewing authority.

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## APPENDIX A. Non-PSD single source assessments

The approach for estimating single source impacts described in this section are intended to be relevant for nonattainment NSR permit assessments related to O<sub>3</sub> and PM<sub>2.5</sub> precursor emissions trading. However, these approaches may be relevant for other programs and purposes. This section is intended for the rare situations where an assessment of both project source impacts and credit source(s) impacts are desired for a specific case and is not a requirement for nonattainment new source review emissions trading.

The types of model simulations needed for different types of permit review assessments not part of the PSD program are described in this section. The necessary modeling scenarios depend on the purpose of the modeling and the type of modeling tool used for the assessment. A photochemical model used for estimating impacts for a single source impact assessment would typically require both a baseline and project source (post-construction) scenario but a Lagrangian modeling system may only require a project source scenario. An additional credit source scenario is only needed where emissions offsets are being compared to project source impacts.

A credit source scenario is only needed for situations where a new or modified source is seeking some type of emissions offset. This scenario is the same as the baseline scenario except the facility or facilities identified for emissions credit offsets are modeled with appropriate changes to operations reflective of the target emission offsets (only the targeted offset emissions are adjusted in this scenario not the entire facilities). The location of the facilities from which offsets are desired should be modeled at their actual locations (or last operating location) unless directed otherwise after consultation with the permitting authority. The simulation of credit source(s) is optional and should be done in consultation with the reviewing authority and is not a requirement for nonattainment new source review emissions trading.

Estimating air quality impacts from a project source should be consistent with the approach detailed in section 5 of this guidance document. Additional details are provided in this section about modeling the impacts of credit source(s) for situations where those impacts are needed. If a credit scenario was modeled, calculate the MDA8 at each receptor for each modeled simulation day of the credit scenario using the same hours used to estimate MDA8 in the baseline scenario. Estimate the difference between the credit scenario MDA8 and baseline scenario MDA8 for each receptor and model simulation day. This difference is the impact from the credit source(s). If a credit scenario was modeled for annual PM<sub>2.5</sub>, calculate the annual average PM<sub>2.5</sub> at each receptor for the credit scenario. Estimate the difference between the credit scenario annual average PM<sub>2.5</sub> and baseline scenario annual average PM<sub>2.5</sub> for each receptor. This difference is the impact from the credit source(s). If a credit scenario was modeled for daily PM<sub>2.5</sub>, calculate the daily average PM<sub>2.5</sub> at each receptor for each modeled day for the credit scenario. Estimate the difference between the credit scenario daily average PM<sub>2.5</sub> and baseline scenario daily average PM<sub>2.5</sub> for each receptor and model simulation day. This difference is the impact from the credit source(s).

### Assessments of 8-hr ozone impacts

The modeled daily 8-hr maximum ozone impact, for this case representing the change in emissions from the project source should be calculated for each receptor and day of the simulation as described in Section 5.3. Also, the modeled daily 8-hr maximum ozone impact should be similarly calculated from the

credit source(s) for each receptor and day of the simulation as described here. Further, it is recommended that trading ratios be based on “high modeled days”. These are modeled day that are greater or equal to the value representing a “high modeled day” for the baseline scenario only. High modeled days include days at each receptor where modeled 8-hr daily maximum ozone exceeds 60 ppb. If less than 5 days are greater than 60 ppb then the test is not valid for that receptor (U.S. Environmental Protection Agency, 2014). If the receptor where there are less than 5 high modeled days is considered likely to have large impacts from the project source, additional episode days may be needed to adequately represent the project source impacts at that particular receptor.

*8-hr Ozone Precursor Emissions Offset Trading Analysis – Screening level:*

The modeled daily 8-hr maximum ozone project source and credit source impacts should be paired in time (by episode day) for each receptor along with baseline modeled estimates (e.g. no project source or credit source modification). The analytical technique for estimating the ozone impact could be an approved Lagrangian or photochemical model based approach. Applicants should consult with the appropriate permitting authority to determine the most appropriate approach for interpreting modeled results for the purposes of establishing an emissions trade.

*8-hr Ozone Precursor Emissions Offset Trading Analysis – Refined level:*

The second tier differs from the first tier in that the analytical technique for estimating ozone impacts must be estimated with a refined approach. The refined approach may include the tool used for estimating impacts, configuration options for such tool (e.g. more refined grid resolution), or inclusion of additional representative episodes. After consultation with the permitting authority, an alternative trade ratio may be established compared to the first tier analysis. Applicants should consult with the appropriate permitting authority to determine the most appropriate approach for interpreting modeled results for the purposes of establishing an emissions trade.

*Assessment of PM2.5 impacts*

For project sources that emit both primary PM2.5 and PM2.5, the project source impacts may be estimated using different models; one for secondary and another for primary impacts. In this situation primary PM2.5 emissions would be modeled using AERMOD and the secondary impacts would be estimated with a more complex modeling system that includes chemistry. Where only secondary impacts from PM2.5 precursors are included in the assessment an appropriate chemical transport model could be used without a primary component estimated with AERMOD.

*Annual average PM2.5 Precursor Emissions Offset Trading Analysis – Screening level:*

The modeled annual average PM2.5 project source and credit source impacts should be estimated as described in Section 5.4 and paired for each receptor along with baseline modeled estimates (e.g. no project source or credit source modification). The analytical technique for estimating the PM2.5 impact could be an approved Lagrangian or photochemical model based approach. Applicants should consult with the appropriate permitting authority to determine the most appropriate approach for interpreting modeled results for the purposes of establishing an emissions trade.

*24-hr PM2.5 Precursor Emissions Offset Trading Analysis – Screening level:*

The modeled daily 24-hr average PM<sub>2.5</sub> project source and credit source impacts should be estimated as described in Section 5.5 and paired in time (by episode day) for each receptor along with baseline modeled estimates (e.g. no project source or credit source modification). The analytical technique for estimating the PM<sub>2.5</sub> impact could be an approved Lagrangian or photochemical model based approach. Applicants should consult with the appropriate permitting authority to determine the most appropriate approach for interpreting modeled results for the purposes of establishing an emissions trade.

*Annual and 24-hr PM<sub>2.5</sub> Precursor Emissions Offset Trading Analysis – Refined level:*

The second tier differs from the first tier in that the analytical technique for estimating PM<sub>2.5</sub> impacts must be estimated with a refined approach. The refined approach may include the tool used for estimating impacts, configuration options for such tool (e.g. more refined grid resolution), or inclusion of additional representative episodes. After consultation with the permitting authority, an alternative trade ratio may be established compared to the first tier analysis.

Economic Development Zones

The approach for estimating single source impacts described in this section are intended to be relevant for the purposes of air quality assessments intended to support the establishment of an Economic Development Zone (EDZ). These designations may be given to parts of areas designated as non-attainment for a NAAQS to allow for industrial growth in those areas without the administrative requirements of acquiring nonattainment NSR permits up to a certain limit of precursor emissions. Section 173(a)(1)(B) of the Clean Air Act authorizes EPA to identify, in consultation with the Secretary of Housing and Urban Development, zones within non-attainment areas which should be targeted for economic development. A new or modified major stationary source located in an EDZ is relieved of the New Source Review requirements to obtain offsets if the emissions from the new or modified stationary source do not exceed the emissions growth allowance that is identified for that EDZ in the State Implementation Plan for that nonattainment area.

Since an EDZ is essentially an “a priori” air quality credit for some part of a nonattainment area, refined modeling done to support an EDZ demonstration should generally follow the approach outlined for a nonattainment NSR credit demonstration in chapter 7 of this guidance. However, rather than modeling a specific post-construction scenario for existing facilities, the approach for this purpose involves modeling multiple hypothetical sources with varying emission rates and stack release characteristics typical of sources in the area or region. The overall approach for hypothetical source impact assessment would be generally similar to that provided for a tier 1 demonstration tool such as MERPS (U.S. Environmental Protection Agency, 2016b). Choices made for these hypothetical sources should be done in consultation with the permitting authority. The approach described here for assessing air quality impacts from potential future emissions in a proposed EDZ constitutes one aspect of a multi-component analysis for this purpose.

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United States  
Environmental Protection  
Agency

Office of Air Quality Planning and Standards  
Air Quality Assessment Division  
Research Triangle Park, NC

Publication No. EPA-454/R-16-005  
December 2016

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