



# 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>

**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>**

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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 and secondary particulate matter from individual sources (either new sources or modifications to existing sources) as part of the New Source Review (NSR), Prevention of Significant Deterioration (PSD), or other programs. Sources are required to estimate both the impacts of primarily emitted and secondarily formed pollutants. AERMOD, which is a steady-state gaussian plume dispersion model, is EPA's preferred model for estimating project source impacts for primarily emitted pollutants, including primarily emitted PM<sub>2.5</sub> (U.S. Environmental Protection Agency, 2005). This guidance outlines procedures for estimating O<sub>3</sub> or secondarily formed PM<sub>2.5</sub> impacts from project sources for the purposes of permit review programs.

To date, the EPA has issued some guidance to assist sources needing to demonstrate compliance with the PM<sub>2.5</sub> NAAQS and PSD increments, including consideration of the secondarily formed components of PM<sub>2.5</sub>. In *Guidance for PM<sub>2.5</sub> Permit Modeling* (U.S. Environmental Protection Agency, 2014a), the EPA identified three different approaches for assessing the secondary PM<sub>2.5</sub> impacts: a qualitative assessment, a hybrid qualitative/quantitative assessment that utilizes existing technical work, and a full quantitative photochemical grid modeling exercise. Previously for PM<sub>2.5</sub> (and currently for ozone), the appropriate analytical technique for assessing the air quality impact of project source emissions on secondarily formed pollutants was determined on a case-by-case basis in consultation with the permitting authority.

The degree of complexity required to assess potential secondary pollutant impacts from single sources varies depending upon the nature of the source, its emissions, and the background environment. A two-tiered approach for addressing single-source impacts on ozone and secondary PM<sub>2.5</sub> has been proposed by EPA (Preamble, Appendix W NPRM, 2015) to provide permit applicants flexibility 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 more sophisticated case-specific chemical transport modeling (e.g. with an Eulerian grid or Lagrangian puff photochemical model). The appropriate tier for a given permit application should be selected in consultation with the appropriate permitting authority. This document is intended to provide more detail for applicants seeking to estimate single source impacts on secondary pollutants for purposes of comparison to a SIL or level of the NAAQS under the first (Sections 5.3.2.b and 5.4.2.b) and second (Sections 5.3.2.c and 5.4.2.c) tiers outlined in Appendix W.

The first tier screening-level approaches for estimating single source secondary impacts described in the 2015 revision to Appendix W are intended to reduce burden on sources that can rely on existing information to characterize their impacts. Additional information is provided here about the types of analysis and options that could satisfy the requirements of a first tier (Sections 5.3.2.b and 5.4.2.b) assessment under Appendix W. 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 screening approaches based on full science chemical transport modeling systems (e.g. reduced form models) could provide information to satisfy the first tier in some situations. The use of pre-existing credible technical information or a screening model 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.

Examples of existing relevant technical information include air quality modeling for sources with similar or larger emissions in similar atmospheric environments for appropriate time periods that are conducive to the formation of O<sub>3</sub> or secondary PM<sub>2.5</sub>. EPA has extensively reviewed existing published technical reports and peer-reviewed literature that provide single source impact estimates for O<sub>3</sub> and secondary PM<sub>2.5</sub> (U.S. Environmental Protection Agency, 2015). However, it is important to note that published research studies were not designed specifically for the purposes of estimating single source secondary impacts for regulatory review. Therefore these studies may not have applied models for relevant time periods or post-processed results in a way consistent with methods preferred for this purpose.

For second tier assessments (Sections 5.3.2.c and 5.4.2.c) when necessary, guidance is provided on the air quality models, inputs, run time options, receptor placement, and application approach for the purposes of estimating the impacts on ozone and secondarily formed PM<sub>2.5</sub> from single project sources. Within the second tier described in Appendix W, applicants are provided flexibility in terms of the complexity of model application for comparison to both the SIL and NAAQS. The sub-tiers of the Appendix W second tier allow for simpler approaches to be compared conservatively to the SIL and NAAQS and more sophisticated approaches could be applied to provide a more representative impact for a source.

Estimating single source impacts can be done using a Lagrangian modeling system that includes O<sub>3</sub> and PM<sub>2.5</sub> chemistry or photochemical grid models. In the simplest case, a model simulation containing the project source emitting at post-construction conditions is compared to a baseline simulation where the source is operating at pre-construction conditions or not included if the project source is new construction (See Figure 1). More details about these scenarios are provided in section 4.7.

Figure 1. Simplified representation of modeling single source secondary impacts using Lagrangian puff or photochemical grid models. This does not represent the process when a source emits both primary PM<sub>2.5</sub> and PM<sub>2.5</sub> precursor emissions (see section 6.1 for this case).

<b>Baseline Conditions Scenario (1)</b>	<b>Project Source Scenario (2)</b>	<b>Project Source Contribution Estimate (2-1)</b>
<ul style="list-style-type: none"> <li>•Model simulation with baseline conditions and the project source operating at pre-construction conditions (or not in the simulation if a new source)</li> </ul>	<ul style="list-style-type: none"> <li>•Model simulation with baseline conditions and the appropriate project source emissions adjustments</li> </ul>	<ul style="list-style-type: none"> <li>•Estimated by difference between the simulation with baseline conditions and the appropriate project source adjustments (2) and model simulation with baseline conditions only (1)</li> </ul>

Once project source contributions have been estimated as detailed through procedures outlined in this guidance document those impacts are compared to the appropriate significant impact level (SIL) and the level of the appropriate NAAQS if a cumulative assessment is necessary. A simplified schematic of this process and some illustrative examples of the flexibility afforded with each sub-tier of the significant impact analysis and cumulative impact analysis are shown in Figure 2.

Figure 2. Simplified schematic of the “second tier” process for assessing secondary pollutant impacts from source emissions with a significant impact analysis and cumulative impact analysis (if needed). This does not represent the process when a source emits both primary PM<sub>2.5</sub> and PM<sub>2.5</sub> precursor emissions (see section 6.1 for this case).

<p><b>Project Source Contribution Estimate</b></p>	<p>Estimated by difference between the simulation with baseline conditions with the appropriate project source adjustments and model simulation with baseline conditions only. See sections 5.3, 5.4, and 5.5 for NAAQS specific estimation approaches.</p>
<p><b>Significant Impact Analysis</b></p> <p>Significant Impact Analysis Level 1</p> <p>Significant Impact Analysis Level 2</p>	<p>Project source contribution estimate compared to NAAQS appropriate Significant Impact Level (SIL). Sections 6.2.1, 6.3.1, and 6.4.1 provide more details about NAAQS specific impact comparison to the SIL.</p> <p>The modeled highest impact over all receptors should be compared to the SIL. Model options include Lagrangian or photochemical transport model.</p> <p>A more refined approach than level 1. This may include the tool used for impact estimation (photochemical grid rather than Lagrangian model), configuration options for such tool (e.g. more refined grid resolution), or inclusion of additional representative episodes. After consultation with the permitting authority, a value less than the maximum impact could be used for comparison to the SIL.</p>
<p><b>Cumulative Impact Analysis</b></p> <p>Cumulative Impact Analysis Level 1</p> <p>Cumulative Impact Analysis Level 2</p>	<p>Project source contribution estimate compared to NAAQS appropriate Significant Impact Level (SIL) and also combined with an estimate of “background” for comparison to the level of the appropriate NAAQS. Sections 6.2.2, 6.3.2, and 6.4.2 provide more details about NAAQS specific cumulative impact assessments.</p> <p>The highest contribution from the project source over all receptors should be added to the highest monitored design value in the same area. Model options include Lagrangian or photochemical transport model.</p> <p>A more refined approach than level 1. This may include the tool used for impact estimation, configuration options for such tool, or inclusion of additional representative episodes. Here, the highest contribution from the project source <i>on high modeled days</i> at each receptor should be added to the monitored design value at that same receptor or an approved interpolated field of monitored design values and compared to the level of the NAAQS. After consultation with the permitting authority, a value less than the maximum impact could be used for addition to background estimates and comparison to the NAAQS.</p>

The schematic shown in Figure 2 is relevant for O<sub>3</sub> impacts and sources that do not emit primary PM<sub>2.5</sub> emissions. For project sources that emit both primary PM<sub>2.5</sub> and PM<sub>2.5</sub> precursors an alternative construct is provided. For those situations, the methods and approaches described here for estimating single source secondary PM<sub>2.5</sub> impacts are used as an input to AERMOD as an addition to the “BACKGROUND” concentration input variable and established procedures are followed for the application of AERMOD for permit source applications as described in Appendix W. This approach takes advantage of existing well known procedures for AERMOD application and community expertise with the AERMOD modeling system. It is not expected that all situations would necessitate rigorous chemical transport modeling to provide AERMOD with an estimate of secondary PM<sub>2.5</sub> from the project source. The selection of project-specific secondary PM<sub>2.5</sub> impacts should be done in consultation with the appropriate permitting authority and be consistent with EPA guidance.

This document is consistent with the recommendations for air quality modeling in the “Guideline on Air Quality Models” (Appendix W to 40 CFR Part 51), hereafter referred to as Appendix W (U.S. Environmental Protection Agency, 2005). Hereafter, references to “Appendix W” refer to both the proposed 2015 revisions and existing form. Information presented here is intended to expand upon the principles set forth in Appendix W for estimating single source impacts for permit review purposes.

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# 1 Background

Sources with proposed modifications or new sources may be required to estimate the air quality impacts of these emissions as part of the New Source Review (NSR), Prevention of Significant Deterioration (PSD), or other programs. Sources are required to estimate both the impacts of primarily emitted pollutants and secondarily formed pollutants. Steady-state Gaussian plume dispersion models such as AERMOD are used to estimate the impacts of chemically inert (primarily emitted) compounds (U.S. Environmental Protection Agency, 2005).

To date, the EPA has issued some guidance to assist sources needing to demonstrate compliance with the PM<sub>2.5</sub> NAAQS and PSD increments, including consideration of the secondarily formed components of PM<sub>2.5</sub>. In *Guidance for PM<sub>2.5</sub> Permit Modeling* (U.S. Environmental Protection Agency, 2014a), the EPA identified three different approaches for assessing secondary PM<sub>2.5</sub> impacts: a qualitative assessment, a hybrid qualitative/quantitative assessment utilizing existing technical work, and a full quantitative photochemical grid modeling exercise. Previously for PM<sub>2.5</sub> (and currently for ozone), the appropriate analytical technique for assessing the air quality impact of project source emissions on secondarily formed pollutants was determined on a case-by-case basis in consultation with the permitting authority.

For assessing secondary pollutant impacts from single sources, the degree of complexity required to assess potential impacts varies depending upon the nature of the source, its emissions, and the background environment. A two-tiered approach for addressing single-source impacts on ozone and secondary PM<sub>2.5</sub> has been proposed by EPA (preamble for 2015 Appendix W NPRM) to provide the user community flexibility in estimating these impacts. The first tier involves use of technically credible and appropriate relationships between emissions and impacts developed from previous modeling that is deemed sufficient for evaluating a source's impacts. The second tier involves application of more sophisticated case-specific photochemical modeling analyses, which is the focus of this document. The appropriate tier for a given permit application should be selected in consultation with the appropriate permitting authority and be consistent with EPA guidance. 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. Also, to further assist permit applicants, the EPA is considering undertaking a rulemaking to provide screening tools for this purpose.

This document describes the air quality models, inputs, run time options, receptor placement, and application approach for the purposes of estimating the impacts on ozone and secondarily formed PM<sub>2.5</sub> from single project sources. This document is consistent with the recommendations for air quality modeling in the "Guideline on Air Quality Models" (Appendix W to 40 CFR Part 51), hereafter referred to as Appendix W (U.S. Environmental Protection Agency, 2005). These recommendations are considered relevant for both the 2015 proposed revisions to Appendix W and existing form.

## 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. Chemical transport models treat atmospheric chemical and physical processes such as deposition and transport. There are two types of chemical transport models which are differentiated based on a fixed frame of reference

(Eulerian grid based) or a frame of reference that moves with parcels of air between the source and receptor point (Lagrangian) (McMurry et al., 2004).

A variety of Lagrangian and Eulerian modeling systems exist that could potentially be used to estimate single source impacts on secondarily formed pollution such as ozone 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 Lagrangian or Eulerian modeling system be appropriately applied for assessing the impacts of single sources on secondarily formed pollutants such as ozone and PM<sub>2.5</sub> for the purposes of permit review. This means that existing guidance for dispersion models and photochemical models developed for other purposes may not be totally applicable for this type of 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 tools that are best suited for the purpose of estimating single source secondary pollutant impacts. For a variety of regulatory programs secondary pollutant impacts such as O<sub>3</sub> and PM<sub>2.5</sub> need to be assessed near the emitting source and sometimes long-range transport to key downwind receptors. It is important that modeling systems used for these assessments be fit for this purpose and have been evaluated for skill in replicating meteorology and atmospheric chemical and physical processes that result in secondary pollutant formation and deposition.

A candidate model for use in estimating single source impacts on secondarily formed pollutants such as ozone and PM<sub>2.5</sub> for the purposes of permit review programs should meet the general criteria for an “alternative model” outlined in 40 CFR part 51, Appendix W, section 3.2 (U.S. Environmental Protection Agency, 2005). The acceptability of a particular model and approach for that model application is an EPA Regional Office responsibility that should include consultation with EPA’s Model Clearinghouse, if appropriate.

## 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> also neutralizing agents such as ammonia, as important secondary impacts happen 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., 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 estimates primary and secondary PM<sub>2.5</sub> but O<sub>3</sub> is input to the model and not estimated (Scire et al., 2000).

## 2.2 Eulerian photochemical grid models

Photochemical grid 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 are advantageous by providing a spatially and temporally dynamic realistic chemical and physical environment for plume growth and chemical transformation (Baker and Kelly, 2014; Zhou et al., 2012). Publically available and documented Eulerian 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 ozone 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 State Implementation Plans and to explore relationships between inputs and air quality impacts in 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 transport models have been shown to adequately capture single source impacts when compared with downwind in-plume measurements (Baker and Kelly, 2014; Zhou et al., 2012). Where set up appropriately for the purposes of assessing the contribution of single sources to primary and secondarily formed pollutants, photochemical grid models could be used with a variety of approaches to estimate these impacts. These approaches generally fall into the category of source sensitivity (how air quality changes due to changes in emissions) and source apportionment (the contribution of a specific source emissions to a receptor under existing ambient conditions).

The simplest source sensitivity approach (brute-force change to emissions) would be to simulate two sets of conditions, one with all emissions and one with a new source or a source of interest modified to reflect changes in operation (Cohan and Napelenok, 2011). The difference between these simulations provides an estimate of the air quality change related to the change in emissions from the project 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 tracks the sensitivity of an emissions source through all chemical and physical processes in the modeling system (Dunker et al., 2002). Sensitivity coefficients relating source emissions to air quality are estimated during the model simulation and output at the resolution of the host model.

Some photochemical models have been instrumented with source apportionment, which tracks emissions from specific sources through chemical transformation, transport, and deposition processes to estimate a contribution to predicted air quality at downwind receptors (Kwok et al., 2015; Kwok et al., 2013). Source apportionment has been used to differentiate the contribution from single sources on model predicted ozone and PM<sub>2.5</sub> (Baker and Foley, 2011; Baker and Kelly, 2014). 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) show generally similar downwind spatial gradients and impacts.

## 2.3 Elements of a model protocol

A model protocol is intended to communicate the scope of the analysis. This document generally includes the types of analysis performed, the specific steps taken in each type of analysis, the rationale for the choice of modeling system, names of organizations participating in preparing and implementing the protocol, and a complete list of model configuration options. The 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
- Identify how modeling and other analyses will be archived and documented
- Identify 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

- Identify relevant ambient data near the project source and key receptors; provide relevant performance near the project source and key receptor locations
- List evaluation procedures
- Identify possible diagnostic testing that could be used to improve model performance

### 4. Model Outputs

- Describe 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 purposes of comparison to a SIL or level of the NAAQS under the first tier outlined in Appendix W (Sections 5.3.2.b and 5.4.2.b). More refined approaches that would fall under the second tier are described in the sections subsequent to this chapter.

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 grid 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, 2015). 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> 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 or partially 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. A review has been done examining published relationships between single source precursor emissions and downwind O<sub>3</sub> and secondary PM<sub>2.5</sub> impacts (U.S. Environmental Protection Agency, 2015). Secondary impacts typically increase as precursor emissions increase. Single source secondary impacts are not always highest at the facility fence-line, but are usually highest in proximity to the source and tend to decrease as distance from the source increases (U.S. Environmental Protection Agency, 2015). Empirical relationships based on existing technical work may be relevant where the modeling system used conforms to those for estimating single source secondary impacts in Appendix W and described in this guidance for alternative models. The project source must generate a modeling protocol and describe how the existing modeling conforms to the O<sub>3</sub> or 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 demonstration tools may be adequate.

An example of using existing empirical relationships would be a hypothetical source with an additional 600 tpy of SO<sub>2</sub> emissions resulting from new construction at a 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, 2015). However, the published impacts are the result 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 PM<sub>2.5</sub> SIL, then no further technical analysis may be necessary. If a source was locating in an area where existing information does not exist, that source 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 may need to be introduced to the previously estimated downwind impacts given the additional incongruity between the existing information and actual conditions.

In all cases, additional information is needed from the project source with the existing information to corroborate the appropriateness and relevancy of the existing information for the anticipated conditions at the project source and key receptors.

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

### 4.1 Model inputs

#### 4.1.1 Project source emissions

Compliance with PSD should be demonstrated using emissions input data for the project source consistent with Appendix W (U.S. Environmental Protection Agency, 2005). Appendix W states that project sources should be “modeled using the design capacity (100 percent load).” Emissions inputs for the project source should be consistent with Tables 8.1 and 8.2 in Appendix W, meaning project source emissions should be the maximum allowable emissions or federally enforceable permit level limits (U.S. Environmental Protection Agency, 2005).

#### 4.1.2 Nearby 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 proximity 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.

#### 4.1.3 Meteorology inputs

The importance of meteorology coupled with the spatial heterogeneity of chemical reactants in a project area necessitate meteorological inputs to the air quality model that capture differences in

meteorology (i.e. 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 PM and ozone. Candidate prognostic meteorological models should be considered state of the science by the air quality modeling community, be routinely used as input for regulatory air quality modeling applications, be peer-reviewed, fully documented, freely available on the internet, and actively supported by the model developer. Currently, one of the more 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. None of the prognostic model output variables should be re-diagnosed or changed 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.

Where project source site-specific meteorology is available, the project sponsors 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 (i.e. ammonium nitrate formation under cool, humid conditions) and indirectly (i.e. warm temperatures and sunlight increase photochemistry and the availability of oxidants). Since secondary pollutant impacts are being estimated, the year(s) of meteorology selected for use in the assessment is important. A time period with generally conducive meteorology to the formation of secondary PM<sub>2.5</sub> and/or ozone is necessary. This means that time periods with elevated PM<sub>2.5</sub> and/or ozone at the source and receptors must 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 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 secondary impacts match a period used to estimate impacts of primarily emitted PM<sub>2.5</sub> when those impacts are estimated with a dispersion model such as AERMOD.

When daily PM<sub>2.5</sub> impacts from single project sources are being modeled, it is preferential to model those impacts over at least one entire time period that has been shown to be generally conducive to elevated PM<sub>2.5</sub> formation. Since PM<sub>2.5</sub> 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 they be consecutive.

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

### 4.3 Receptor placement and domain extent

Receptors are locations in the project area where an air quality model estimates pollutant concentrations. A receptor network design should emphasize resolution and location rather than match 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 concentrations. Where grid models are applied, the receptor location is the center of the surface layer grid cell.

For primarily emitted PM, the peak impacts are more likely to be near the emissions source. Secondarily formed pollutants including PM and ozone may have maximum impacts near the source or further downwind depending on meteorology, stack release characteristics, and availability of important chemical reactants. Receptors should be placed in all directions surrounding a project source to capture meteorological and chemical variability.

Receptor placement should extend from the fence-line of the project source out to a sufficient distance from the project source 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 50 km (U.S. Environmental Protection Agency, 2015) from the project source (Appendix W). Receptor placement for the purposes of estimating air quality impacts at downwind Class I areas for air quality related values should follow guidance developed by Federal land managers (U.S. Department of the Interior, 2010).

### 4.4 Vertical domain resolution

The best approach to representing the vertical atmosphere in an air quality model is to match the vertical layer structure 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 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 application up to 12 km has 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). In instances where sources may be modeled at coarser resolution or at resolutions finer than 1 km consultation with the permitting authority is appropriate.

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 ~12-15 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 be insufficient leading to unrealistic results.

If a project source is modeled using a horizontal grid resolution finer than what is typically applied for such purpose, the project source should also be modeled using a horizontal grid spacing typical of contemporary applications for similar purpose and the contribution estimates using the coarser model domain should be considered along with the finer domain impacts.

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

Where set up appropriately for the purposes of assessing the contribution of single sources to secondarily formed pollutants, photochemical grid models could be used with a variety of approaches to estimate these impacts. The simplest approach would be to simulate 2 sets of conditions, one with all emissions and one with the source of interest modified from the original “baseline” simulation (Cohan et al., 2005). The difference between these simulations provides an estimate of the air quality change due to the adjusted emissions.

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 estimating ozone source contribution (ENVIRON, 2014). The standard OSAT approach apportions contribution based on estimated NO<sub>x</sub>/VOC sensitivity while an alternative approach (APCA) diverts ozone contribution 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 review, the APCA approach is preferred.

In some instances where the source and key receptors are in very close proximity, the source and receptor may be located in the same photochemical grid model cell. Since physical and chemical processes represent a volume average, this may not represent the gradients of pollution possible between the source and receptor when they are located in such proximity. The preferred approach to better representing the spatial gradient in source-receptor relationships when they are in close proximity would be to use smaller sized grid cells. Grid resolution would be defined such that the source and receptor are no longer in the same grid cell. Ideally, there would also be several grid cells between the source and receptor to best resolve near-source pollution gradients.

In these situations of close proximity between the source and receptor, 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 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 (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 has 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 contribution 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 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 contribution in addition to sub-grid plume treatment to fully capture source contribution.

#### 4.7 Use of lagrangian models for single source impacts

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, but without realistic concentrations of oxidants and reacting pollutants the 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 data need typically necessitates the use of photochemical model concentration estimates to be used as input to a Lagrangian model.

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. Under certain conditions, this modeling approach can lead to artifacts associated with double-counting background concentrations. For instance, (Karamchandani et al., 2008) found that under certain conditions the 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. 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 just mentioned, a post-processing step known as the Ammonia Limiting Method (ALM) is sometimes applied (Escoffier-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. The approach is not necessary in 3D photochemical grid model simulations because Eulerian grid models do not allow for overlap of different air parcels. 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.

Errors similar to those just described for nitrate could potentially occur in gas-phase chemistry calculations in situations where overlapping puffs are interacting with background concentrations of oxidants that are in limited supply. 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 appropriate for assessing project source impacts on secondary pollutants.

## 4.8 Model evaluation

There are multiple components to model evaluation for the purposes of assessing single source secondary pollutant impacts for permit review programs. According to Appendix W (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 (Appendix W 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 modeling for

a permit review assessment. One of the most important questions in an evaluation concerns whether the prognostic or diagnostic meteorological fields are adequate for their intended use in supporting a variety of air quality modeling exercises.

It is important that any potential approaches for model performance for the purposes of single source assessments for PSD and NSR 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 secondary impacts of ozone and/or 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 ozone 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. 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).

## 4.9 Project-specific modeling

The different types of model simulations that are needed for different types of permit review assessments are described in this section. The necessary modeling scenarios depend on the purpose of the modeling and the type of model 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 scenario but a Lagrangian modeling system may only require a project source scenario. The credit source scenario is only needed where emissions offsets are being compared to project source impacts.

**Baseline conditions scenario.** This scenario includes all sources 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 project source operating modification will be estimated then the project source should be modeled using conditions representing pre-construction. This step may 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) a new project source or 2) a modified project source as part of the simulation. Where 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.

**Credit source scenario.** This 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.

## 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<sub>2.5</sub> is the operational definition of PM<sub>2.5</sub>. Since PM<sub>2.5</sub> 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<sub>2.5</sub>. Some modeling systems use a size sectional approach and others use a modal approach to approximate the size distribution of PM<sub>2.5</sub>. A straightforward and conservative way to estimate secondary PM<sub>2.5</sub> in modal models (e.g. CMAQ) is to sum the secondary components of the fine particle modes (the Aitken and accumulation, i.e., “i” and “j”). The fine modes largely contain particle mass in the PM<sub>2.5</sub> size range that includes particles 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<sub>2.5</sub> 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<sub>2.5</sub> attainment demonstrations estimate relative response factors at key monitors with the change in model response on the highest modeled days in the baseline period. One reason for using relative response factors 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 contribution 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.

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

The first step for estimating 8-hr O<sub>3</sub> impacts from a project source is to 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. Estimate the difference between the project scenario MDA8 and baseline scenario MDA8 for each receptor and model simulation day. This difference is the contribution from the project source. When a Lagrangian single source simulation has been completed, the absolute air quality impacts from the project scenario represent the project source impacts.

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).

#### 5.4 Estimating the annual PM2.5 impact from a project source

The first step for estimating annual PM2.5 impacts from a project source is to estimate the annual average PM2.5 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 PM2.5 at each receptor for the project scenario. Estimate the difference between the project scenario annual average PM2.5 and baseline scenario annual average PM2.5 for each receptor. This difference is the contribution 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.

If a credit scenario was modeled, calculate the annual average PM2.5 at each receptor for the credit scenario. Estimate the difference between the credit scenario annual average PM2.5 and baseline scenario annual average PM2.5 for each receptor. This difference is the impact from the credit source(s).

#### 5.5 Estimating the daily PM2.5 impact from a project source

The first step for estimating daily PM2.5 impacts from a project source is to estimate the daily 24-hour average PM2.5 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 PM2.5 at each receptor for each modeled simulation day for the project scenario. Estimate the difference between the project scenario daily average PM2.5 and baseline scenario daily average PM2.5 for each receptor and model simulation day. This difference is the contribution 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.

If a credit scenario was modeled, calculate the daily average PM2.5 at each receptor for each modeled day for the credit scenario. Estimate the difference between the credit scenario daily average PM2.5 and baseline scenario daily average PM2.5 for each receptor and model simulation day. This difference is the impact from the credit source(s).

#### 5.6 Background concentrations

Appendix W (section 8.2.1) states background concentrations are essential for determining source impacts. Concentrations are spatially and temporally variable throughout a project area due in part to differences in meteorology, terrain, landuse, and emissions. For a cumulative assessment (multi-source areas), Appendix W states that two components of background should be determined and include contributions from nearby sources and contributions from other sources. There is no single prescribed approach for characterizing the background concentration that must be added to the project source

contribution for comparison to the level of the appropriate NAAQS. An appropriate methodology for characterizing background concentrations must be chosen in consultation with the permitting authority.

Background concentrations could be based on monitored concentrations 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, monitored values are 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 State Implementation Plan (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.

## 6 Regulatory assessment: PSD

A simplified schematic of this process and the flexibility afforded each sub-tier of the significant impact analysis and cumulative impact analysis are shown in Figure 2. The schematic shown in Figure 2 is relevant for O<sub>3</sub> impacts and sources that do not emit primary PM<sub>2.5</sub> emissions. For project sources that emit both primary PM<sub>2.5</sub> and PM<sub>2.5</sub> precursors an alternative construct is provided. For these types of PM<sub>2.5</sub> assessments, the project source impacts may be estimated using different models; one for secondary and another for primary impacts. In this situation primary PM<sub>2.5</sub> emissions would be modeled using AERMOD and the secondary impacts would be estimated with a more complex modeling system that includes chemistry. The approach for estimating single source impacts described in this section are intended to be relevant for PSD permit assessments. However, these approaches may be relevant for other programs and purposes.

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

The analytical technique for estimating daily or annual average secondarily formed PM<sub>2.5</sub> impact could be from an approved reduced form (screening) approach or a refined approach. The secondary contribution impact could be input to AERMOD as an addition to the "BACKGROUND" concentration. Consequently, the impact compared to the SIL would include the AERMOD modeled primary impact and the estimate of secondary impact. In this approach of using AERMOD plus the “BACKGROUND” component including an estimate of secondary PM<sub>2.5</sub> contribution, the AERMOD output should be used according to procedures outlined in Appendix W.

### 6.2 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. A tiered approach for comparison of project source impacts to the Significant Impact Level<sup>1</sup>

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<sup>1</sup> Although there is currently no SIL for ozone, one of the screening tools suggested earlier would be to establish an ozone SIL. The EPA is considering undertaking a rulemaking to do this.

(note: currently there is no ozone SIL) and for a Cumulative Impact Assessment follows. The cumulative impact modeled ozone contribution should include the change in emissions from the project source combined with the appropriate “background” 8-hr ozone value that represents ozone impacts from all sources. This combined ozone impact should be compared to the level of the 8-hr ozone NAAQS.

### 6.2.1 Assessments of 8-hr Ozone impacts – significant impact analysis

#### *8-hr Ozone Significant Impact Analysis - First tier:*

The modeled highest daily 8-hr maximum ozone impact over all receptors should be compared to the ozone SIL. If the highest daily 8-hr maximum ozone contribution is greater than the level of the SIL then a second tier assessment is necessary. The analytical technique for estimating the ozone impact could be an approved Lagrangian or photochemical model based approach.

#### *8-hr Ozone Significant Impact Analysis - Second tier:*

The second tier differs from the first tier in that the analytical technique for estimating ozone impact 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, a value less than the maximum impact may be used for comparison to the SIL.

### 6.2.2 Assessments of 8-hr Ozone impacts – cumulative impact analysis

#### *8-hr Ozone Cumulative Impact Analysis - First tier:*

The highest daily 8-hr maximum ozone contribution from the project source over all modeled days and all receptors should be added to the highest monitored design value in the same area. If this value is below the level of the NAAQS or the source impact is below the SIL then this test has been met. If this value is greater than the level of the NAAQS and the project source contribution is greater than the SIL then a second tier assessment is necessary. The analytical technique for estimating the ozone impact could be an approved Lagrangian or photochemical model based approach.

#### *8-hr Ozone Cumulative Impact Analysis - Second tier:*

Identify each receptor on each model day that is 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, 2014b). 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.

The highest daily 8-hr maximum ozone contribution from the project source on high modeled days (or all modeled days if a single source Lagrangian model is applied) at each receptor should be added to the monitored design value at that same receptor or an approved interpolated field of monitored design values and compared to the level of the NAAQS. If this value is below the level of the NAAQS or the



source impact is below the SIL then this test has been met. 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, a value less than the maximum impact may be used for addition to background estimates and comparison to the NAAQS.

### 6.3 Assessment of sources only emitting PM2.5 precursors: annual PM2.5

The modeled annual average PM2.5 impact, for this case representing the change in emissions from the project source, should be calculated for each receptor. A tiered approach for comparison of the project source impacts to the Significant Impact Level and a Cumulative Impact Assessment follows. The cumulative impact modeled PM2.5 contribution should include the change in emissions from the project source in addition to the rest of the facility and all other “nearby” emissions sources. This combined annual PM2.5 impact should be compared to the level of the annual average PM2.5 NAAQS.

#### 6.3.1 Assessments of annual average PM2.5 impacts – significant impact analysis

*Annual Average PM2.5 Significant Impact Analysis - First tier secondary impacts only:*

The highest annual average PM2.5 impact over all receptors should be compared to the annual PM2.5 SIL. If the highest annual average secondarily formed PM2.5 impact is greater than the level of the SIL then a second tier assessment is necessary. The analytical technique for estimating the annual secondarily formed PM2.5 impact could be from an approved Lagrangian or photochemical model based approach.

*Annual Average PM2.5 Significant Impact Analysis - Second tier secondary impacts only:*

The second tier differs from the first tier in that the analytical technique for estimating the secondarily formed PM2.5 impact 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 years. After consultation with the permitting authority, a value less than the maximum impact may be used for comparison to the SIL.

#### 6.3.2 Assessments of annual average PM2.5 impacts – cumulative impact analysis

*Annual Average PM2.5 Cumulative Impact Analysis - First tier secondary impacts only:*

The highest annual average PM2.5 impact over all receptors should be added to the highest monitored design value in the same area. If this value is below the level of the NAAQS or the project source contribution is below the SIL then this test has been met. If this value is greater than the level of the NAAQS and the project source contribution is greater than the SIL then a second tier assessment is necessary. The analytical technique for estimating annual average secondary PM2.5 impact could be an approved Lagrangian or photochemical model based approach.

*Annual Average PM2.5 Cumulative Impact Analysis - Second tier secondary impacts only:*

The annual average PM2.5 impact at each receptor should be added to a monitored design value representing the receptor location. This means the monitored design value should be paired in space but not necessarily in time with receptors. If this value is below the level of the NAAQS or the project source contribution is below the SIL then this test has been met. The analytical technique for estimating the secondarily formed PM2.5 impact 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 years. After consultation with the permitting authority, a value less than the maximum impact may be used for comparison to the SIL.

## 6.4 Assessment of sources only emitting PM2.5 precursors: daily PM2.5

The modeled daily average PM2.5 impact, for this case representing the change in emissions from the project source, should be calculated for each receptor. A tiered approach for comparison of the project source impacts to the Significant Impact Level and a Cumulative Impact Assessment follows. The cumulative impact modeled PM2.5 contribution should include the change in emissions from the project source in addition to the rest of the facility and all other “nearby” emissions sources. This combined daily PM2.5 impact should be compared to the level of the daily average PM2.5 NAAQS.

### 6.4.1 Assessments of daily average PM2.5 impacts – significant impact analysis

*Daily Average PM2.5 Significant Impact Analysis - First tier secondary impacts only:*

The highest daily average PM2.5 impact over all receptors should be compared to the daily PM2.5 SIL. If the highest daily average secondarily formed PM2.5 impact is greater than the level of the SIL then the second tier assessment is necessary. The analytical technique for estimating the daily secondarily formed PM2.5 impact could be from an approved Lagrangian or photochemical model based approach.

*Daily Average PM2.5 Significant Impact Analysis - Second tier secondary impacts only:*

The second tier differs from the first tier in that the analytical technique for estimating the secondarily formed PM2.5 impact 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 years. After consultation with the permitting authority, a value less than the maximum impact may be used for comparison to the SIL.

### 6.4.2 Assessments of daily average PM2.5 impacts – cumulative impact analysis

*Daily Average PM2.5 Cumulative Impact Analysis - First tier secondary impacts only:*

The daily average PM2.5 impact over all receptors should be added to the highest monitored design value in the same area. If this value is below the level of the NAAQS or the project source contribution is below the SIL then this test has been met. If this value is greater than the level of the NAAQS and the project source contribution is greater than the SIL then a second tier assessment is necessary. The analytical technique for estimating daily average secondary PM2.5 impact could be approved Lagrangian or photochemical model based approach.

*Daily Average PM2.5 Cumulative Impact Analysis - Second tier secondary impacts only:*

Identify each receptor on each model day that is greater or equal to the value representing a “high modeled day” for the baseline scenario only. High modeled days include the top 10% of modeled total PM2.5 in each quarter of the simulation. (U.S. Environmental Protection Agency, 2014b).

The highest daily average PM2.5 contribution from the project source on high modeled days (or all modeled days if a single source Lagrangian model is applied) at each receptor should be added to the monitored design value at that same receptor or an approved interpolated field of monitored design values and compared to the level of the NAAQS. The monitored design value should be paired in space but not necessarily in time with receptors. If this value is below the level of the NAAQS or the project source contribution is below than the SIL then this test has been met. The analytical technique for estimating the secondarily formed PM2.5 impact 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 years. After consultation with the permitting authority, a value less than the maximum impact may be used for comparison to the SIL.

## 7 Regulatory assessment: nonattainment NSR

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 PM2.5 precursor emissions trading. However, these approaches may be relevant for other programs and purposes.

### 7.1 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 for each receptor and day of the simulation as described in Section 5.3.

#### *8-hr Ozone Precursor Emissions Offset Trading Analysis - First tier:*

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 - Second tier:*

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.

## 7.2 Assessments 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 and accounted for in the AERMOD simulation. 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 - First tier:*

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 - First tier:*

The modeled daily 24-hr average PM2.5 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 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.

### *Annual and 24-hr PM2.5 Precursor Emissions Offset Trading Analysis - Second tier:*

The second tier differs from the first tier in that the analytical technique for estimating PM2.5 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.

## 8 Regulatory assessment: 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. 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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