Draft Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Ozone and PM2.5 under the PSD Permitting Program

US EPA

Office of Air Quality Planning & Standards

Webinar

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Final Revisions to Appendix W

- The final revisions to the *Guideline* were signed by the Administrator on December 20, 2016 and recently published in the Federal Register on January 17, 2017.
- These final revisions will become effective 30 days after publication so February 16, 2017 and includes a 1-year transition period under PSD program as described in the preamble to the rule.
- EPA will provide outreach to stakeholders through webinars on the final revisions to the *Guideline* that allows Q&A in addition to communications through EPA and external meetings, etc

Final Action: Single-Source Impacts on Ozone and Secondary $PM_{2.5}$

- The EPA believes photochemical grid models are generally most appropriate for addressing ozone and secondary $PM_{2.5}$, because they provide a spatially and temporally dynamic realistic chemical and physical environment for plume growth and chemical transformation.
- Lagrangian models (e.g. SCICHEM) applied with a realistic 3-dimensional field of chemical species could also be used for single source O_3 or $PM_{2.5}$ assessments.
- The EPA has finalized a two-tiered demonstration approach for addressing single-source impacts on ozone and secondary $PM_{2.5}$.
  - Tier 1 demonstrations would involves use of technically credible relationships between emissions and ambient impacts based on existing modeling studies deemed sufficient for evaluating a project source's impacts.
  - Tier 2 demonstrations would involve case-specific application of chemical transport modeling (e.g., with an Eulerian grid or Lagrangian model).

Model Emissions Rate for Precursors: O3 and Secondary $PM_{2.5}$

- EPA has provided technical guidance that will provide a framework for development of Tier 1 demonstration tools under Appendix W for PSD permitting.
  - A Modeled Emission Rate for Precursors (MERP) is a type of Tier 1 demonstration tool that would represent a level of increased precursor emissions that is not expected to contribute to levels of ozone or $PM_{2.5}$.
  - Guidance will provide a framework on how to arrive at values for MERPs based on existing relevant modeling or newly developed area specific modeling that source/states can utilize in their PSD compliance demonstrations. The guidance would not endorse a specific MERP value for each precursor.
  - Draft guidance was released on 12/2/16 for public comment, prior to App W FRM signature.

Tier 1 Demonstration Tools

- For Tier 1 assessments, EPA generally expects that applicants would use existing empirical relationships between precursors and secondary impacts based on modeling systems appropriate for this purpose.
- The use of existing credible technical information that appropriately characterize the emissions to air quality relationships will need to be determined on a case-by-case basis.
- Examples of existing relevant technical information that may be used by a permit applicant, in consultation with the appropriate permitting authority, include air quality modeling conducted for the relevant geographic area reflecting emissions changes for similar source types as part of a State Implementation Plan (SIP) demonstration, other permit action, or similar policy assessment as well air quality modeling of hypothetical industrial sources with similar source characteristics and emission rates of precursors that are located in similar atmospheric environments and for time periods that are conducive to the formation of O_3 or secondary $PM_{2.5}$.

MERPs as a Tier 1 Demonstration Tool

- In the preamble of the Appendix W NPRM, EPA discussed plans to develop a PSD compliance demonstration tool for ozone and $PM_{2.5}$ precursors called Modeled Emission Rates for Precursors (MERPs).
- MERPs can be viewed as a type of Tier 1 demonstration tool under the PSD permitting program that provides a simple way to relate maximum downwind impacts with a critical air quality threshold.
- For PSD, separate MERPs could be developed to relate:
  - volatile organic compounds (VOCs) and/or nitrogen oxides (NO_x) to O_3
  - sulfur dioxide (SO_2) and/or NO_X to secondary $PM_{2.5}$

MERPs Guidance Overview

- Provides a detailed framework that permit applicants may choose to use, in consultation with the appropriate permitting authority, to estimate single source impacts on secondary pollutants under the first tier (or Tier 1) approach.
- Presents the EPA's modeling of hypothetical single source impacts on ozone and secondary $PM_{2.5}$ to illustrate how this framework can be implemented by stakeholders.
- Based on EPA modeling to inform illustrative MERPs, these values will vary across the nation reflecting different sensitivities of an area's air quality level to precursor emissions, thereby providing an appropriate basis for evaluating the impacts of these precursors to $PM_{2.5}$ and ozone formation because they reflect the regional or local atmospheric conditions for particular situations.

Definition of MERP value

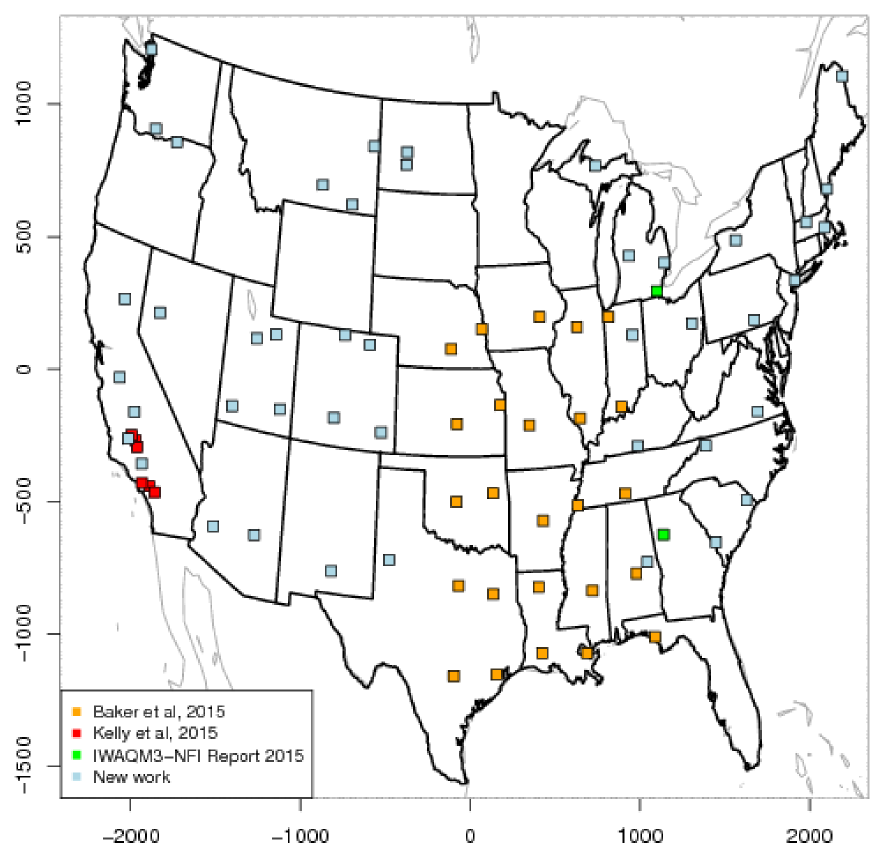
- To derive a MERP value, the model predicted relationship between precursor emissions from hypothetical sources and their downwind maximum impacts can be combined with a critical air quality threshold using the following equation:

MERP = Critical Air Quality Threshold * (Modeled emission rate from hypothetical source / Modeled air quality impact from hypothetical source)

- MERPs are expressed as an annual emissions rate in tons per year consistent with the modeled emissions rates that are input to the air quality model to predict a change in pollutant concentrations.
- The critical air quality threshold is separately defined (as discussed below) and expressed as a concentration for $PM_{2.5}$ (in µg/m^3) or O_3 (in ppb or ppm)

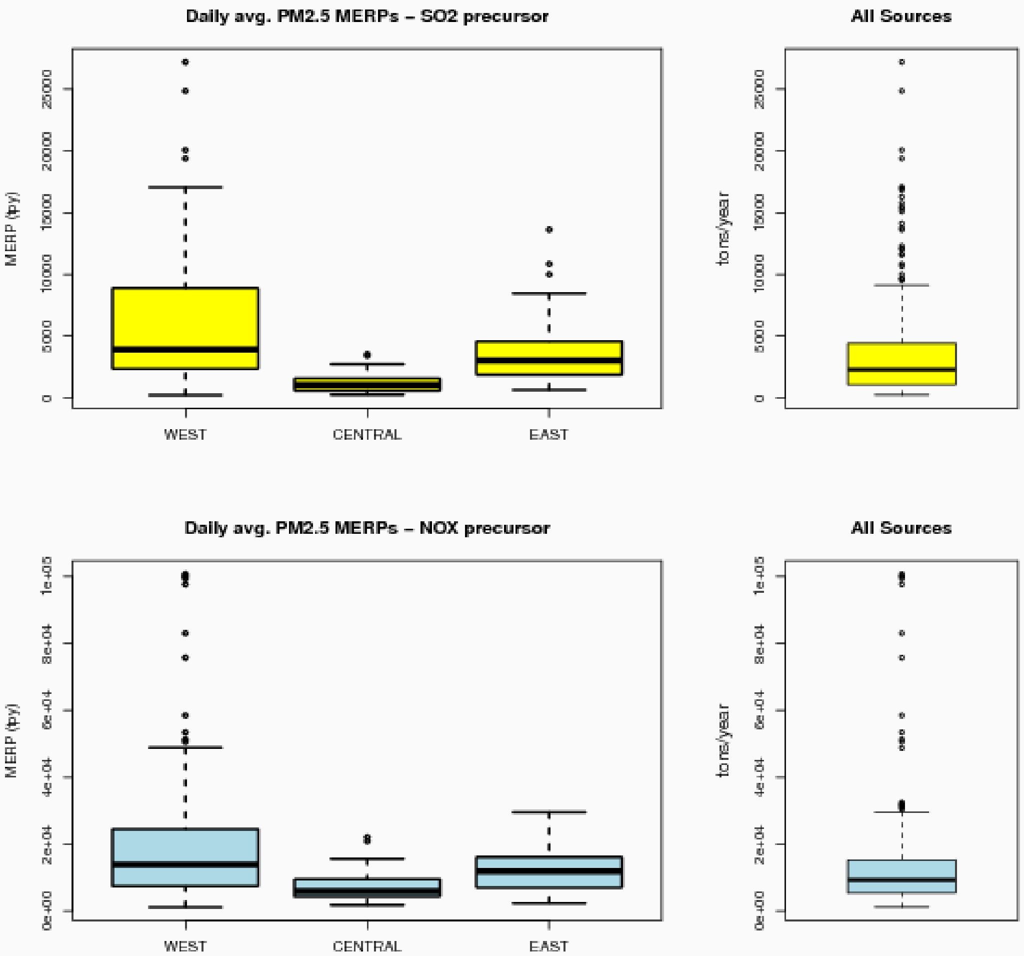
Single Source Impact Model Assessments

- Have documented and gotten peer-review for using photochemical grid models for single source secondary impacts
- We used single source modeling done to support Appendix W updates to examine the range of model estimated impacts for different sources in different areas
- Hypothetical source impact information generated with episodic and annual modeling
  - Episodic modeling for the central California the Los Angeles areas
  - Annual modeling for Detroit and Atlanta
  - Annual modeling for rural & suburban locations in the U.S. (see Figure at right)
- Important to continue this type of work to provide a robust estimate of single source secondary impacts



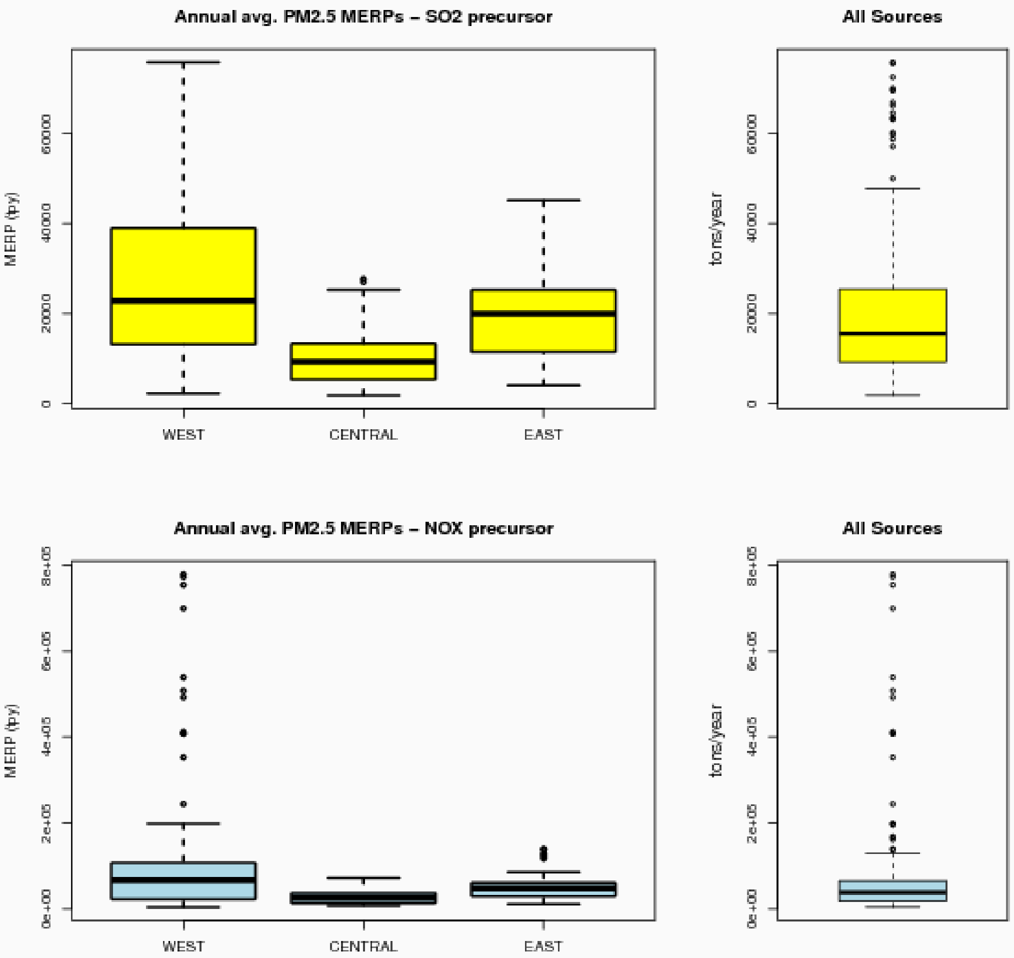
Note: The relationships provided in this guidance for these hypothetical sources are not intended to provide an exhaustive representation of all combinations of source type, chemical, and physical source environments but rather provide insightful information about secondary pollutant impacts from single sources in different parts of the U.S.

Illustrative example of Daily PM2.5 MERPs



- SO_2 (top panels) and NO_X (bottom panels) daily average $PM_{2.5}$ MERPs estimated from single source hypothetical emissions impacts on $PM_{2.5}$ nitrate ion and $PM_{2.5}$ sulfate ion respectively.
- Note: Daily $PM_{2.5}$ MERPs derived here based on critical air quality threshold of 1.2 µg/m^3 and neither $PM_{2.5}$ sulfate nor nitrate is assumed to be neutralized by ammonia.
- Shown by area and over all areas

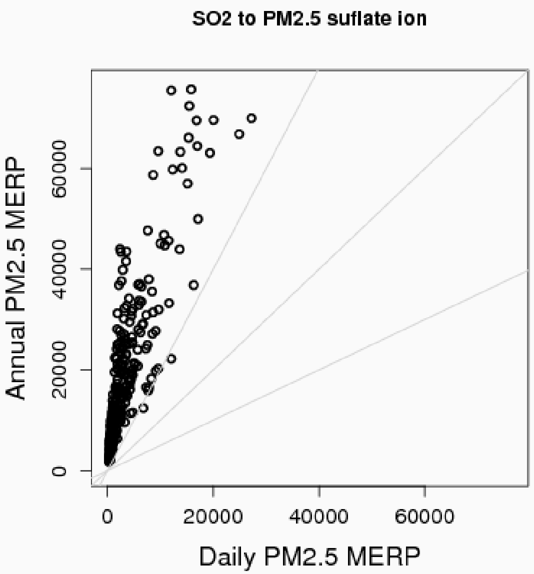
Illustrative example of Annual PM2.5 MERPs

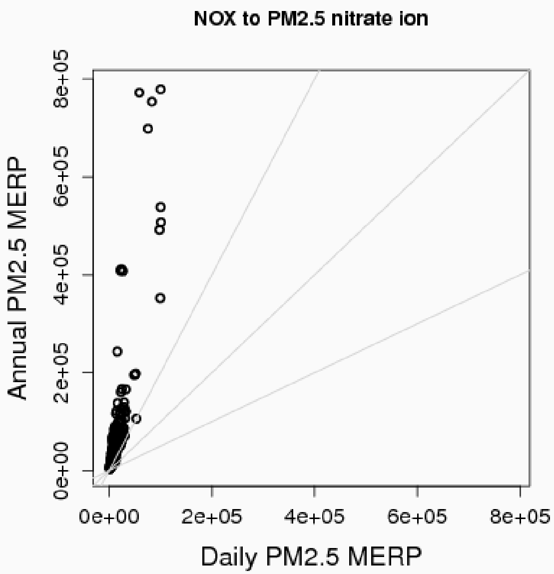


- SO_2 (top panels) and NO_X (bottom panels) annual average $PM_{2.5}$ MERPS shown by geographic region.
- Note: Annual $PM_{2.5}$ MERPs derived here based on critical air quality threshold of 0.2 $\mu g/m^3$ and neither $PM_{2.5}$ sulfate nor nitrate is assumed to be neutralized by ammonia.
- Shown by area and over all areas

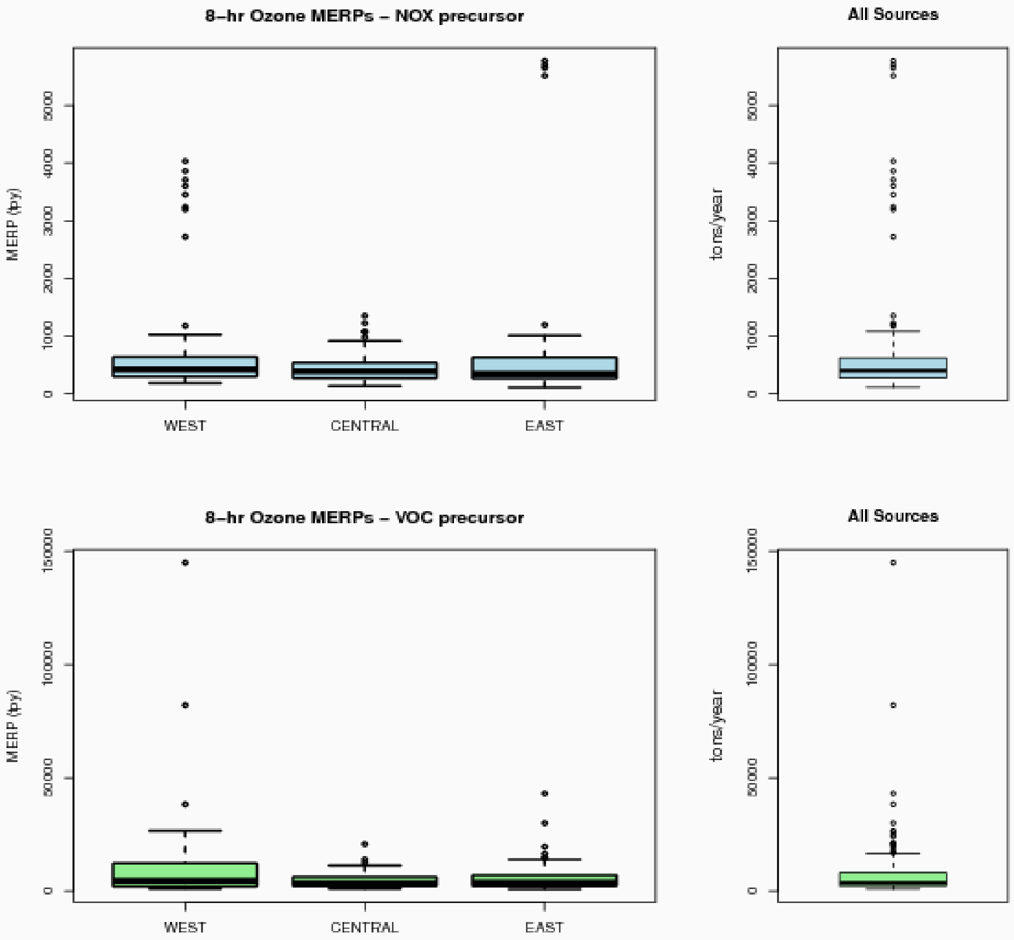
Comparing Daily and Annual PM2.5 illustrative MERPs

- Illustrative $PM_{2.5}$ MERPs for SO_2 (left panel) and NO_X (right panel) estimated from single source hypothetical emissions impacts on $PM_{2.5}$ nitrate ion and $PM_{2.5}$ sulfate ion respectively.
- Note: Daily average $PM_{2.5}$ MERPs are directly compared with annual average $PM_{2.5}$ MERPs. Neither $PM_{2.5}$ sulfate nor nitrate is assumed to be neutralized by ammonia.





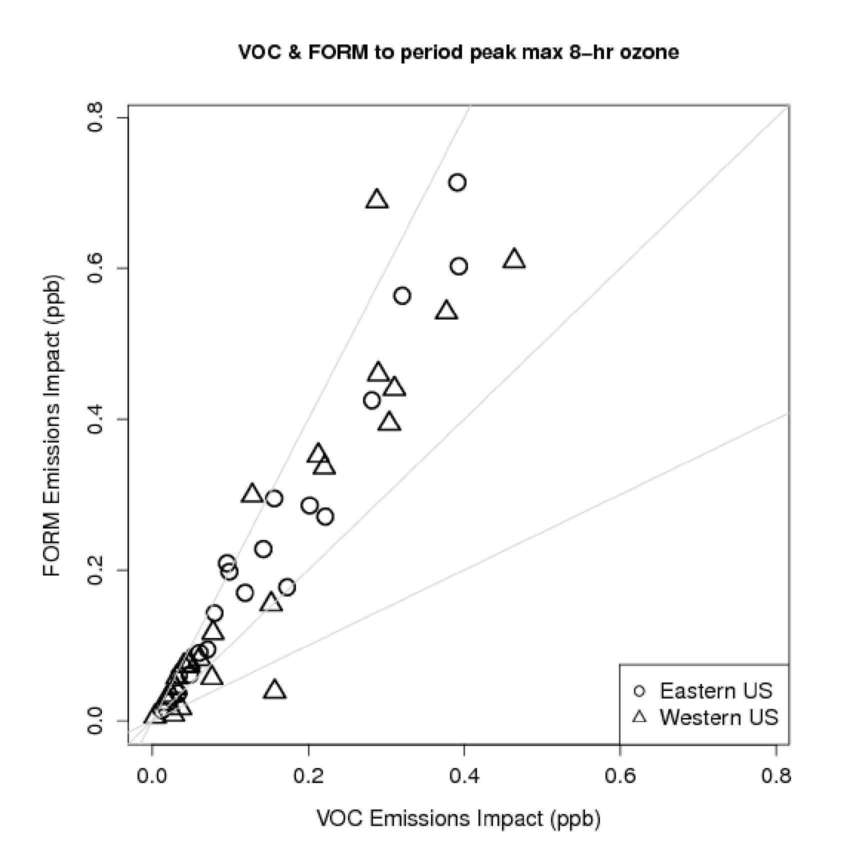
Illustrative example of 8-hr avg O3 MERPs



- NO_X (top panels) and VOC (bottom panels) MERPS estimated from single source hypothetical emissions impacts on daily maximum 8-hr O_3.
- Note: 8-hr O3 MERPs derived here based on critical air quality threshold of 1.0 ppb
- Shown by area and over all areas

VOC speciation impacts on illustrative MERPs

- Maximum 8-hr ozone impacts from 500 tpy of near-surface VOC emissions using a typical industrial VOC speciation profile and assuming all VOC emissions are formaldehyde.
- Note: these impacts are for the eastern and western U.S. hypothetical sources presented here and do not include information from any other studies.



Summary of illustrative MERPs

- **Most Conservative (Lowest) Illustrative MERP Values (tons per year) by Precursor, Pollutant and Region.** Note: illustrative MERP values are derived based on EPA modeling (as described in section 4 of guidance) and critical air quality thresholds (as described in Section 5 of guidance)

Precursor	Area	8-hr O3	Daily PM	Annual PM
NOx	Central US	126	1,820	7,427
NOx	Eastern US	169 ~~107~~	2,467	10,037
NOx	Western US	184	1,155	3,184
SO2	Central US		256	1,795
SO2	Eastern US		675	4,013
SO2	Western US		225	2,289
VOC	Central US	948		
VOC	Eastern US	814		
VOC	Western US	1,049		

Developing Area Specific MERPs

- A modeling protocol should be developed and shared with the EPA Regional office that details the planned approach for developing MERPs based on photochemical modeling to ensure a sound technical basis for development of a suitable Tier 1 demonstration tool.
  - As part of the protocol, the permit applicant should include a narrative that provides a technical justification that the existing information is relevant for their project source scenario.
- There is no minimum number of hypothetical sources to include in developing a MERPs Tier 1 demonstration tool, but the benefit of including more hypothetical sources is that more information is available for future sources to use in predicting secondary pollutant impacts from their post-construction emissions.
- Permitting authorities or permit applicants should examine the existing recent (e.g., last 5 to 10 years) permit applications in that area to determine what types of emission rates and stack characteristics (e.g., surface and elevated release) should be reflected in the hypothetical project sources included in the model simulations.
- These model simulations should include a credible representation of current or post-construction conditions in the area of the project source and key receptors.
- Pre-existing modeling conducted for an area by a source, a governmental agency, or some other entity that is deemed sufficient may be adequate for air agencies to conduct local demonstrations leading to the development of area-specific MERPs.

Developing Area Specific MERPs: 8-hr O3

- The general framework for such developmental efforts for O_3 should include the following steps:

  1) Define the geographic area(s)

  2) Conduct a series of source sensitivity simulations with appropriate air quality models to develop a database of modeled O_3 impacts associated with emissions of O_3 precursors (e.g., VOC and NO_X) from typical industrial point sources within the area of interest.

  3) Extract the highest daily 8-hr average modeled impact anywhere in the domain from the model simulation.

  4) Calculate the MERP estimate(s) using the equation provided in Section 5 of this document.

  5) Conduct quality assurance of the resulting MERP estimate(s) and evaluate the interpretation and appropriateness given the nature of O_3 precursor emissions sources and chemical formation in the area of interest. This evaluation will likely require emissions inventory data and observed ambient data for O_3 and precursors.

Developing Area Specific MERPs: Daily PM2.5

- The general framework for such developmental efforts for Daily PM2.5 should include the following steps:

    1) Define the geographic area(s)

    2) Conduct a series of source sensitivity simulations with appropriate air quality models to develop a database of modeled $PM_{2.5}$ impacts associated with emissions of $PM_{2.5}$ precursors (e.g., SO_2 and NO_X) from typical industrial point sources within the area of interest.

    3) Extract the highest daily 24-hr average modeled impact anywhere in the domain from the model simulation.

    4) Calculate the MERP estimate(s) using the equation provided in Section 5 of this document.

    5) Conduct quality assurance of the resulting MERP estimate(s) and evaluate the interpretation and appropriateness given the nature of $PM_{2.5}$ precursor emissions sources and chemical formation in the area of interest. This evaluation will likely require emissions inventory data and observed ambient data for $PM_{2.5}$ and precursors.

Developing Area Specific MERPs: Annual PM2.5

- The general framework for such developmental efforts for annual PM2.5 should include the following steps:

  1) Define the geographic area(s)

  2) Conduct a series of source sensitivity simulations with appropriate air quality models to develop a database of modeled $PM_{2.5}$ impacts associated with emissions of $PM_{2.5}$ precursors (e.g., SO_2 and NO_X) from typical industrial point sources within the area of interest.

  3) Extract the highest annual average modeled impact anywhere in the domain from the model simulation.

  4) Calculate the MERP estimate(s) using the equation provided in Section 5 of this document.

  5) Conduct quality assurance of the resulting MERP estimate(s) and evaluate the interpretation and appropriateness given the nature of $PM_{2.5}$ precursor emissions sources and chemical formation in the area of interest. This evaluation will likely require emissions inventory data and observed ambient data for $PM_{2.5}$ and precursors.

Hypothetical Examples

- The draft guidance provides 4 example scenarios using modeled hypothetical sources.
- These example scenarios are intended to illustrate how applicants could use existing information to support a demonstration.
- Further, these example scenarios are intended to help illustrate how to combine impacts from multiple precursors for a single demonstration

Scenario A: VOC and NO_X precursor assessment for $PM_{2.5}$ and additive O_3 impacts

- In this scenario, a facility with a proposed increase in emissions of 0 TPY of primary $PM_{2.5}$, 130 TPY of VOC, 72 TPY of NO_X, and 0 TPY of SO_2 located in the upper midwest region. Only VOC and NO_X emissions are above the level of the SER and therefore require a PSD compliance demonstration.
- O_3 analysis: The NO_X and VOC emissions from the project source are well below the lowest (most conservative) O_3 MERP value shown in Table 7-1 of any source modeled by EPA in the central or any other region in the continental U.S. In this case, air quality impacts of O_3 from this source would be expected to be below the critical air quality threshold.
  - However, the NO_X and VOC precursor contributions to 8-hr daily maximum O_3 are considered together to determine if the source's air quality impact would exceed the critical air quality threshold. In such a case, the proposed emissions increase can be expressed as a percent of the lowest MERP for each precursor and then summed. A value less than 100% indicates that the critical air quality threshold will not be exceeded when considering the combined impacts of these precursors on 8-hr daily maximum O_3.
  - Example calculation for additive secondary impacts on 8-hr daily maximum O_3:
  - (72 tpy NO_X from source/169 tpy NO_X 8-hr daily maximum O_3 MERP) + (130 tpy VOC from source/814 TPY VOC 8-hr daily maximum O_3 MERP) = .43 + .16 = .59 * 100 = 59%
- $PM_{2.5}$ analysis: The NO_X emissions of 72 tpy from the hypothetical project source are also well below the lowest (most conservative) $PM_{2.5}$ MERP value for the daily and annual NAAQS shown in Table 7-1 of any source modeled by EPA across the continental US. In this case, air quality impacts of $PM_{2.5}$ from this source are expected to be below the critical air quality threshold.

Scenario B: NO_X and SO_2 precursor assessment for comparable source O_3 impacts and additive secondary $PM_{2.5}$ impacts

- In this scenario, a facility with a proposed increase in emissions of 0 TPY of primary $PM_{2.5}$, 0 TPY of VOC, 310 TPY of NO_X, and 75 TPY of SO_2 located in the southeast region. Only NO_X and SO_2 emissions are above the level of the SER and therefore require a PSD compliance demonstration.
- O_3 analysis: The NO_X emissions of 310 tpy are larger than the lowest (most conservative) NO_X MERP for 8-hr O_3 in the eastern and other regions of the U.S. such that air quality impacts of O3 from this source would be expected to exceed the critical air quality threshold. A comparable hypothetical source is identified that may be representative of this source (e.g., EUS region, source 19 with elevated emissions release as shown in Appendix A) and has source derived NO_X MERPs for 8-hr O_3 ranging from 327 to 462 TPY, which are both larger than the project source's post-construction emissions. The general formula for estimating MERPs is provided in section 5. Here, the equation is used with the modeled emissions rates and air quality impact information from source 19 of the EUS region with an elevated release (as detailed in Appendix Table A-1). Since multiple hypothetical sources were modeled at this location with an elevated release the source with the lowest MERP was selected for comparison with the project source, i.e.,
  - *MERP for source 19 EUS region elevated release (tpy) = 1.0 ppb * (500 tpy / 1.52 ppb) = 329 tpy*
  - In this case, based on modeling results for a more similar hypothetical source from Appendix A, the project source emissions are less than the calculated NO_X to 8-hr O_3 MERP such that air quality impacts of O_3 from this source would be expected to be less than the critical air quality threshold.

Scenario B: NO_X and SO_2 precursor assessment for comparable source O_3 impacts and additive secondary $PM_{2.5}$ impacts (cont)

- $PM_{2.5}$ analysis: Both the NO_X and SO_2 emissions are well below the lowest (most conservative) daily and annual $PM_{2.5}$ MERP values of any source modeled in the eastern or any other region in the continental U.S. However, the NO_X and SO_2 precursor contributions to both daily average $PM_{2.5}$ are considered together to determine if the source's air quality impact of $PM_{2.5}$ would exceed the critical air quality threshold. In this case, the proposed emissions increase can be expressed as a percent of the lowest MERP for each precursor and then summed. A value less than 100% indicates that the critical air quality threshold would not be exceeded when considering the combined impacts of these precursors on daily and/or annual $PM_{2.5}$.
  - Example calculation for additive secondary impacts on daily $PM_{2.5}$:
  - (310 tpy NO_X from source/1155 tpy NO_X daily $PM_{2.5}$ MERP) + (75 tpy SO_2 from source/225 TPY SO_2 daily $PM_{2.5}$ MERP) = .27 + .33 = .60 * 100 = 60%
  - Example calculation for additive secondary impacts on annual $PM_{2.5}$:
  - (310 tpy NO_X from source/3184 tpy NO_X annual $PM_{2.5}$ MERP) + (75 tpy SO_2 from source/2289 TPY SO_2 annual $PM_{2.5}$ MERP) = .097 + .033 = .13 * 100 = 13%

Scenario C: NO_X and SO_2 precursor assessment for comparable source O_3 and $PM_{2.5}$ impacts

- In this scenario, a facility with a proposed increase in emissions of 0 TPY of primary $PM_{2.5}$, 22 TPY of VOC, 920 TPY of NO_X, and 259 TPY of SO_2 located in the western region. Only NO_X and SO_2 emissions are above the level of the SER and therefore require a PSD compliance demonstration.
- O_3 analysis: The NO_X emissions of 920 tpy are larger than the lowest (most conservative) NO_X MERP for 8-hr O_3 in the western and other regions of the U.S. such that air quality impacts of O3 from this source would be expected to exceed the critical air quality threshold. A comparable hypothetical source is identified that may be representative of this source (e.g., WUS region, source 16 elevated release as shown in Appendix A) had a range of NO_X MERPs for 8-hr O_3 of 761 to 1,020 TPY, which are all larger than the source emissions modification. The general formula for estimating MERPs is provided in section 5. Here, the equation is used with the modeled emissions rates and air quality impact information from source 19 of the EUS region with an elevated release (as detailed in Appendix Table A-1). Since multiple hypothetical sources were modeled at this location with an elevated release the source with the lowest MERP was selected for comparison with the project source, i.e.,
  - *MERP for source 16 WUS region elev. release (tpy) = 1.0 ppb * (1000 tpy / 1.31 ppb) = 763 tpy*
  - In this case, based on modeling results for a more similar hypothetical source from Appendix A, the project source emissions are still greater than the calculated NO_X to 8-hr O_3 MERP such that air quality impacts of O3 from this source are expected to exceed the critical air quality threshold.

Scenario C: NO_X and SO_2 precursor assessment for comparable source O_3 and $PM_{2.5}$ impacts (cont)

- $PM_{2.5}$ analysis: The NO_X emissions of 920 are marginally below the lowest (most conservative) daily and annual $PM_{2.5}$ MERP value of any source modeled in the continental U.S., while the SO_2 emissions of 259 tpy are comparable to the lowest daily $PM_{2.5}$ MERP value of any source modeled in the western U.S. region. A hypothetical source considered more similar (e.g., WUS region, source 16 elevated release as shown in Appendix A) has a lowest NO_X MERP for daily $PM_{2.5}$ of 16,667 TPY and SO_2 MERP for daily $PM_{2.5}$ of 5,556 TPY, which are both much larger than the increase in emissions of the project such that the source's impact on $PM_{2.5}$ would be expected to be less than the critical air quality threshold.

Scenario D: NO_X and SO_2 precursor assessment for additive secondary $PM_{2.5}$ impacts along with direct $PM_{2.5}$

- In this scenario, a facility with a proposed increase in emissions of 250 TPY of primary $PM_{2.5}$, 0 TPY of VOC, 310 TPY of NO_X, and 75 TPY of SO_2 located in the southeast region. Only NO_X and SO_2 emissions are above the level of the SER and therefore require a PSD compliance demonstration. This scenario is similar to Scenario B above, except that the primary $PM_{2.5}$ emissions must be accounted for in assessing $PM_{2.5}$ along with the secondary impacts of NO_X and SO_2 precursor emissions as part of the Tier 1 demonstration. (Ozone analysis similar to Scenario B above.)
- $PM_{2.5}$ analysis: Similar to Scenario B, when considering NO_X and SO_2 contributions to daily average $PM_{2.5}$ together, the proposed emissions increased expressed as a percent of the lowest (most conservative) MERP and summed is less than 100% indicating the critical air quality threshold would be not be exceeded when considering the additive impacts of these precursors. However, in this example, the primary $PM_{2.5}$ impacts need to be added to the secondary impacts for an appropriate account of total $PM_{2.5}$ impacts for the comparison to the air quality threshold.

Scenario D: NO_X and SO_2 precursor assessment for additive secondary $PM_{2.5}$ impacts along with direct $PM_{2.5}$ (cont)

- The primary $PM_{2.5}$ impacts should be estimated using AERMOD or an approved alternative model as outlined in the *Guideline* (U.S. Environmental Protection Agency, 2015a) and consistent with EPA guidance for combining primary and secondary impacts of $PM_{2.5}$ for permit program assessments. In this scenario, a representative secondary impact for this source is added to the appropriately estimated primary $PM_{2.5}$ impacts. The highest impact at any receptor for primary $PM_{2.5}$ should be divided by the air quality threshold to estimate the percent contribution and determine if that primary contribution exceeds the 40% remaining after secondary impacts are accounted for using MERPs demonstration tool.
- For example, a peak primary $PM_{2.5}$ impact from AERMOD is estimated to be 0.45 ug/m^3 for the scenario above. Compared with a 1.2 ug/m^3 critical air quality threshold means that the primary impact is 35% of the critical air quality threshold. When this primary impact is summed with the secondary impacts of 60% the total is 95% which is below 100% suggesting this source impact is below the critical air quality threshold.
- Alternatively, if the peak primary $PM_{2.5}$ impact from AERMOD is estimated to be 0.8 ug/m^3 for the above scenario then the percent primary contribution to the critical air quality threshold would be 62%. When summed with the secondary contribution of 60%, the total source impact exceeds 100% and therefore is greater than the critical air quality threshold.