Appendix F

Modeling Protocol: Dispersion Modeling for 2010 SO_2 NAAQS Recommended Designations

Purpose

Dispersion modeling is an acceptable methodology for informing area designations for the 2010 National Ambient Air Quality Standard (NAAQS) for sulfur dioxide (SO_2). U.S. EPA recommends the use of the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) modeling system for this purpose. The purpose of this document is to detail the procedures followed by Ohio EPA in conducting air quality modeling for designation recommendations for the 2010 SO_2 standard.

Guidance on Air Quality Models

To assist states in conducting modeling with respect to designations under the SO_2 standard, U.S. EPA has provided several guidance documents:

- December 2013 DRAFT SO_2 NAAQS Designations Modeling Technical Assistance Document (*Modeling TAD*)
- Guideline on Air Quality Models, 40 CFR Part 51, Appendix W
- March 20, 2015 Memorandum: Updated Guidance for Area Designations for the 2010 Primary Sulfur Dioxide National Ambient Air Quality Standard (*Guidance Memorandum*)

In addition to the above guidance documents, Ohio EPA relied on information from the *Data Requirements Rule for the 1-Hour Sulfur Dioxide (SO_2) Primary National Ambient Air Quality Standards; Proposed Rule*, herein referred to as the proposed Data Requirements Rule. Additionally, U.S. EPA Region 5 provided two response documents to questions raised by Region 5 states; the first answered questions posed by the Indiana Department of Environmental Management and distributed by Region 5 to all Region 5 states, herein referred to as the Region 5 IDEM Q & A response; the second was a response to questions from the Region 5 states collectively, herein referred to as the Region 5 States Q & A response. These Q & A documents are provided as Appendices G and D to the recommended designation submittal, respectively.

The preamble to the final rule for the SO_2 standard states that any modeling guidance released with respect to the SO_2 standard will follow Appendix W "with appropriate flexibility for use in implementation". Ohio EPA has followed U.S. EPA's guidance in the preparation of this document and in the development of modeling analyses for the purposes of informing recommended designations.

Model Selection

EPA guidance, including Appendix W and the Modeling TAD recommend the use of the most recent version of AERMOD for the majority of modeling demonstrations.

U.S. EPA recently released a new version of AERMOD (Version 15181), which included multiple enhancements to support the form of the 1-hour SO_2 standard. Ohio EPA utilized this version of AERMOD for all modeling analyses performed in support of submitting recommendations for area designations. The most up-to-date versions of the regulatory components of AERMOD were also used; AERMET version 15181, and AERMAP version 11103. Further, Ohio EPA utilized the most up-to-date versions of the non-regulatory components of the AERMOD modeling system, as follows:

- AERSURFACE version 13016
- BPIPPRIME version 04274
- AERMINUTE version 14337

According to Appendix W, AERMOD is appropriate for the following applications:

- Point, volume, and area sources
- Surface, near surface, and elevated releases
- Stacks less than good engineering practice (GEP) height
- Primary pollutants and continuous releases of toxic and hazardous pollutants
- Rural or urban areas
- Simple or complex terrain
- Transport distances up to 50 km

Ohio EPA utilized the regulatory default option, which requires the use of terrain elevation data and stack-tip downwash, and assumes a four-hour half-life for SO_2 in urban areas. Deviations from regulatory practice are described in the appropriate subsections of this document and were applied according to the recommendations in the Modeling TAD and the Guidance Memorandum.

U.S. EPA guidance (Appendix W) provides for the use of alternative models and for the use of measured data in lieu of model estimates, on a case-by-case basis. Ohio EPA maintains this flexibility in this protocol. The Nonattainment SIP Guidance states that "*Appendix W allows flexibility to consider the use of alternate models on a case-by-case basis when an adequate demonstration can be made that the alternative model performs better than, or is more appropriate than, the preferred model"*.

Section 10.2.2 of Appendix W discusses the use of measured data in lieu of model estimates. It is acknowledged in Appendix W that there are some conditions where measured data may lend credence to modeling results, and that certain criteria should be considered, as follows:

1. Applicable to NAAQS demonstration for an existing source
2. Network exists for the pollutants and time periods of concern

3. Monitors sited to capture points of maximum impact
4. Monitors should meet U.S. EPA storage and quality control standards
5. Monitor should be able to capture source specific impacts
6. Full year of data available
7. Demonstrated that model results are not representative of monitor data

As such, and in accordance with the guidance above, Ohio EPA considers well-sited monitors to be an important tool in assessing the impact of facilities, assessing model performance, and the development of area designations, and maintains this flexibility for area recommendations, where appropriate.

Modeling Framework

U.S. EPA does not provide a prescriptive approach to a modeling framework for the purposes of characterizing ambient air quality in areas with significant SO_2 sources in the Modeling TAD or other guidance, as dispersion modeling is only one component of a five-factor approach to determining area designations. As such, Ohio EPA created the following general framework for designation modeling that is informed by relevant U.S. EPA guidance, the modeling framework detailed in the *Guidance for 1-Hour SO2 Nonattainment Area SIP Submissions*, and Ohio EPA's considerable modeling experience. Deviations from this framework are described in the area or source-specific modeling analysis documents, where applicable.

1. *Gather information about SO_2 sources in the source areas.*

   Ohio EPA conducted facility outreach on June 15, 2015 wherein Ohio EPA supplied identified facilities with the most up-to-date and available information with respect to stack parameters, federally enforceable emission limits, building information, coordinates, and additional pertinent modeling information, and requested that the facilities review and revise this information. Further, Ohio EPA requested actual hourly emissions for the 2012-2014 period. Per the Region 5 IDEM Q & A and Region 5 States Q & A response documents, data reported to the U.S. EPA's Clean Air Markets Database under Part 75 reporting requirements do not contain variable velocities and stack temperature data, and that is acceptable to use emissions data directly from the facility where appropriate. (Appendices G and D) The Region 5 States Q & A response document as well as the proposed Data Requirements Rule indicates that sources which will have converted to natural gas or shut down prior to the promulgation of that area's designation may be excluded from consideration under either a modeling or monitoring approach to designation.

2. *Identify sources to explicitly model and those to include as background components*

   As described in the **Modeling Domain** section of this document, Ohio EPA spent considerable effort in identifying major SO_2 sources impacting the nonattainment

areas using emissions reports, meteorology patterns, and other engineering judgment in selecting sources to explicitly model. Facilities meeting the criteria detailed in the Data Requirements Rule are presumed to be subjected to a designation based on either a modeling or monitoring approach. Other sources not meeting those criteria were screened as described above when determining whether to explicitly model some sources or account for their impacts via background. This approach is consistent with Appendix W, which recommends that all sources expected to cause a significant concentration gradient should be explicitly modeled and that the number of such sources is expected to be small except in unusual cases.

3. *Determine actual emissions and temporal variability.*

   The Data Requirements Rule, Modeling TAD, and the Guidance Memorandum provide for designations based on modeling of actual emissions data, where modeling serves as a surrogate for ambient monitoring. The Modeling TAD suggests the use of actual emissions from the most recent three years will be the best representation of emissions that would cause the impacts monitored in a three year period under most circumstances. Via facility outreach, Ohio EPA obtained variable emissions, years 2012-2014, for relevant facilities at the finest temporal scale available to that facility. Variable exit velocities and temperatures were included in the modeling analyses, where available and applicable. Inclusion of these parameters more accurately represents the emissions characteristics of the explicitly modeled sources. This is consistent with the Region 5 States Q & A response document and section 5.2 of the Modeling TAD.

   The Modeling TAD recognizes the unique and case-by-case nature of modeling analyses conducted for the purposes of designations. With respect to emissions, Section 5.2.1 of the Modeling TAD recommends that the reviewing authority work closely with each facility to determine the accuracy of emissions data. The guidance is not prescriptive with respect to substitution methodologies, but suggests averages of surrounding non-missing hours, peak emissions substitutions, use of emission factors, and others. Ohio EPA understands that data substitutions performed for the fulfillment of Part 75 monitoring and reporting requirements are in many instances conservative. To ensure that modeling presents the most accurate surrogate to monitoring for the purposes of designation, Ohio EPA intends to utilize a case-by-case approach to data substitution, including, but not limited to, Part 75 substitutions, valid hour-before hour-after averaging, mathematical interpolation across valid surrounding hours, and engineering methods.

   Lastly, U.S. EPA guidance maintains flexibility for air agencies to model allowable or potential emissions. Ohio EPA maintains this flexibility to consider these emissions where warranted and applicable.

4. *Input actual emissions along with receptors, representative meteorology, and background concentrations into the model and calculate design values based on cumulative concentrations.*

   U.S. EPA guidance is clear that designations modeling be based on three years of emissions data and representative meteorology. Thus, the form of the standard is the 99th percentile of maximum daily one-hour concentrations averaged over three years. This is a departure from Appendix W guidance, which calls for the use of five years of representative meteorological data. Ohio EPA considers background at all receptors with respect to determining design values. Background concentrations will typically be added to modeled design values external to AERMOD, although Ohio EPA maintains the flexibility to include background concentration as an additional source within AERMOD itself. Ohio EPA will fully utilize those enhancements to AERMOD, such as the MAXDCONT output option, developed for use with the new one-hour standards, where appropriate.

   Where available and appropriate, Ohio EPA will assess model performance with respect to relevant, nearby ambient air quality monitoring data. Ohio EPA understands that air quality modeling for the purposes of designations of the 2010 1-hour SO_2 standard treats receptors as surrogates for monitor data. It is therefore appropriate that the converse of this, evaluating monitor data as a surrogate for modeling data and model performance, be considered. The results of model versus model performance will be used by Ohio EPA, when warranted, as justification for alternative methodologies, selection of explicitly modeled sources, to inform background concentration, and to assess the applicability of non-default and beta model options.

5. *Evaluate the maximum modeled impacts and the distribution of modeled values across the modeling domain to inform the area designation as part of the five factor analysis.*

   The Guidance Memorandum of March 20, 2015 indicates that area designations be based on a five factor analysis approach. A five factor analysis would consist of ambient air quality data and/or dispersion modeling, emissions and emissions related data, meteorology, geography/topography, and jurisdictional boundaries. Ohio EPA intends to conduct a five factor analysis for each source area. The Guidance Memorandum also suggests that dispersion modeling accounts for multiple factors simultaneously, either in part or in full. Ohio EPA agrees fully with this assessment, but maintains the flexibility to include additional information beyond dispersion modeling analysis with respect to each of the five factors when warranted or applicable.

Ohio EPA's modeling framework provides for a logical approach to a designation modeling strategy and evaluation of model performance for each source area, and as part of a five-factor designation approach. Ohio EPA's modeling framework serves as a guideline for modeling source areas and is not prescriptive. Deviations from this framework will be detailed and justified in the area specific modeling analysis documents, where necessary and appropriate.

Modeling Domain

For all relevant source areas, Ohio EPA followed the Modeling TAD when developing modeling domains. According to that guidance, the modeling domain should be created on a case-by-case basis, considering multiple factors as described below. Of primary consideration will be how to center the modeling domain and the size of the modeling domain. Further, the Modeling TAD suggests that the selection of the modeling domain should consider the number of sources to explicitly model and the receptor network to create. Ohio EPA utilized the following approach to both the selection of sources to model and the creation of the receptor network in all modeled nonattainment areas. It should be noted that Ohio EPA utilized 1/3 arc-second NED data to determine the elevation of all receptors, buildings, and sources included in the modeling domain.

Determining Sources to Explicitly Model

All sources within 50 km of each source area were initially considered as potential sources. Sources were selected for inclusion in the modeling based upon the level of emissions, meteorology, and other engineering judgment factors. Sources that were not selected for modeling due to their insignificance were included in background concentrations used in the modeling. As noted above, Ohio EPA followed the criteria indicated in the Data Requirements Rule. In addition, Ohio EPA reviewed more recent inventory data and consulted individually with facilities to determine if any recent changes warranted inclusion or exclusion from the modeling domain beyond the 2012 and 2014 emissions inventories.

Receptor Grid

The Modeling TAD recommends that receptors be placed in areas considered ambient air and placed throughout the source area sufficient to capture any potential violation. The Modeling TAD also indicates that receptors should be placed with sufficient density to detect significant concentration gradients. Although Ohio EPA does not have a prescriptive receptor placement strategy, a general strategy has been used for all NSR and PSD modeling in Ohio. This strategy is to place fenceline receptors no more than 50 meters apart, and incorporate a closely spaced receptor grid of 50 meter spacing from the fenceline to approximately 1 km from the facility. A second, 100 meters spaced grid is then generally placed, extending from the facility to approximately 2 to 3 km, and additional, less dense grids incorporated as needed. These, again are only guidelines, and Ohio EPA utilized screening methods to ensure that the area of

maximum impact was located within the most dense (i.e. 50 meters spacing) portion of the receptor grid, where practical.

Ohio EPA utilized this facility-centered approach in all source areas, ensuring that adequate density close to those facilities included in each modeling domain was present to detect significant concentration gradients. Further, Ohio EPA placed receptors throughout each source area, including placing receptors at the location of air quality monitors, where applicable, and to encompass relevant jurisdictional boundaries. A prescriptive placement strategy was not developed, to allow for flexibility within each area. The specific receptor placement strategy used in the individual nonattainment areas are described in the area-specific modeling documents. Based on the Modeling TAD, Ohio EPA maintains the flexibility to eliminate or not place receptors based on the feasibility of monitor placement on a case-by-case basis.

Source Inputs

Emissions

Variable emissions are modeled for each source included in the modeling domain at the finest temporal scale available to the facility or source. The use of actual emissions is pursuant to U.S. EPA guidance whereby modeling can be used as a surrogate to ambient monitoring.

Ohio EPA analyzed whether actual emissions should be adjusted based on factors such as permanent shut down of sources, fuel switching, or installation of controls. Where those adjustments were warranted, they are included and justified in the appropriate modeling analysis documents for each specific source area.

Good Engineering Practice Stack Height

The Modeling TAD and Guidance Memorandum indicated that actual stack heights may be used instead of good engineering practice stack heights. Ohio EPA used actual stack heights for all stack-type egress points.

Dispersion Techniques

As stated in the Nonattainment SIP Guidance, U.S. EPA generally prohibits the use of dispersion techniques to inform or determine allowable emission rates. Such techniques include:

- Using the portion of the stack in excess of GEP
- Varying pollutant emission rates based on ambient conditions
- Selective handling of exhaust gas streams to increase plume rise

These prohibitions are generally not applicable for the purposes of designation modeling. Several exceptions to this are detailed in the above guidance, notably:

- Merging of gas streams in original design and construction, or as part of a change that includes installation of controls and a net reduction in allowable emissions affected by the change
- Utilizing techniques which increase final, exhaust' gas plume rise, provided facility-wide allowable emissions of SO_2 are less than 5,000 tons per year
- Smoke management techniques involved in agricultural or silvicultural programs
- Episodic restrictions on residential wood burning and open burning and,
- Reheating after a pollution control system

The above exceptions are likely also not applicable to designations modeling, but Ohio EPA is including them here for completeness and to maintain case-by-case flexibility for non-typical emission sources. As stated above, Ohio EPA modeled all stack-type egress points at actual stack height. Ohio EPA maintains the flexibility to consider alternate parameterizations and source characterizations, such as accounting for plume rise from volume or fugitive-type releases. Where appropriate, Ohio EPA provided the rationale and methodology for these alternative characterizations.

Source Configurations and Source Types

The Modeling TAD stresses the need for accurate source parameters, building information, coordinates, and other parameters critical with respect to refined dispersion modeling. Ohio EPA collected all necessary parameters via facility outreach, requesting each facility to be explicitly modeled provide up-to-date and accurate parameters. These parameters were cross-referenced with recent permits, past inventories, and past modeling applications. Locations of sources and buildings were confirmed using Google Earth Pro and ArcGIS mapping software. Corrections to coordinates, if necessary, were performed both manually where applicable, and using the United States Army Corps of Engineers software CORPSCON if larger datasets needed correction for improper or out of date projection information.

With few exceptions, the majority of sources explicitly modeled in the source areas were traditional stack-type release points characterized as point sources. In circumstances where Ohio EPA had to account for capped stacks, horizontal releases, area sources, or other release point characterizations, the guidance in Appendix W and Ohio's *Engineering Guide #69: Air Dispersion Modeling Guidance*. Those sources which required an alternative characterization and the methodology to do so are described in the area-specific analysis documents.

Urban/Rural Determination

Ohio EPA, in accordance with Appendix W, carefully considered the URBAN vs. RURAL characterization of each source explicitly modeled in the source areas. Appendix W recommends two methods to determine whether a source is characterized

as URBAN or RURAL. The first, and preferred, methodology is the land use method, which characterizes the land use in a 3 km radius of the source. The second, and less preferred option, classifies a source as URBAN if the population density within a 3 km radius is 750 people/km^2 or greater. As described in the Nonattainment SIP guidance, Ohio EPA also considered the impact of tall stacks on the URBAN/RURAL determination for each source. Further, Ohio EPA has extensive modeling and technical experience in the source areas modeled as part of this submittal, which was also considered. The full URBAN/RURAL determinations for those sources in question are described in the area-specific analysis documents. It should be noted that Ohio EPA's preferred approach to URBAN/RURAL determination is characterization of land use, but the flexibility to consider population density and other factors, such as the presence of a large body of water in a source area, is maintained here.

Source Groups

Ohio EPA utilized the source group options available in AERMOD extensively in the modeling designation process, to assess both the total impacts of a facility and the individual impacts of specific units. Ohio EPA also utilized various source groups, in conjunction with the MAXDCONT output option, to assess impacts. Final modeled designation results utilized the source group ALL to show the full combined impact of all facilities explicitly modeled in the source area.

Meteorological Data

Surface Characteristics and Representativeness

Ohio EPA has extensive background and expertise in the selection of meteorological data for modeling purposes. Ohio Engineering Guide #69[1], a document created to provide guidance to consultants and facilities with respect to dispersion modeling, provides a recommended and representative meteorological station and upper air station for each county in Ohio. Ohio EPA followed the recommendations of that guidance as closely as possible. While these recommendations are typically prescriptive for PSD/NSR modeling, Ohio EPA maintains the flexibility to evaluate alternate meteorological stations when it is determined that an alternate station is more representative of a source area. Ohio EPA determined the surface characteristics of each meteorological station using the AERSURFACE version 13016 module and 1992 land cover data, as described in the Model Selection portion of this document. Surface characteristics were calculated for 12 sectors on a monthly basis. Monthly Bowen ratios were determined based on a comparison of monthly precipitation recorded at the representative surface station against the most recent 30 years of precipitation recorded at the same station.

Ohio EPA attempted to follow Ohio Engineering Guide #69 with respect to selecting representative upper air sounding data for each source area, but maintains the flexibility to consider alternative upper air data sources.

[1] http://www.epa.ohio.gov/Portals/27/sip/document/2014-07-17%20FINAL%20Revised%20EG69.pdf

Meteorological Inputs

Per the Modeling TAD, Ohio EPA used three years of representative National Weather Service data, processed with the most up-to-date version of AERMET. Ohio EPA utilized the AERMINUTE module to process 2-minute ASOS data to limit missing periods in the resultant .SFC meteorological input files. In situations where on-site meteorological data were available, Ohio EPA also used three full years of meteorological data. Per the Nonattainment SIP Guidance, which states "if 1 or more years (including partial years) of site-specific data are available, those data are preferred." Ohio EPA interprets this to mean that partial years of on-site meteorological data can be used, provided that a minimum of 8760 hours of contiguous data can be assembled. The flexibility to utilize such an approach is maintained here.

Background Concentrations

Ohio EPA considered background concentrations of SO_2 in all modeling analyses performed for this submittal. U.S. EPA guidance suggests that a "first tier" approach to applying a background concentration should be considered by adding the overall highest hourly background value from a representative monitor to the modeled design value, but acknowledges that this approach may be overly conservative in many cases and could be prone to reflecting source-oriented impacts. While Ohio's SO_2 monitoring network is extensive, there are few SO_2 monitors not sited specifically to monitor facility-specific impacts.

As such, Ohio EPA considered other approaches to the determination of appropriate background concentrations. Section 8.2.2 of Appendix W provides an approach in which source specific impacts can be identified and eliminated from monitor data prior to determining a background concentration. This section of Appendix W (as paraphrased in the Nonattainment SIP Guidance) states:

> *Use air quality data collected in the vicinity of the source to determine the background concentration for the averaging times of concern. Determine the mean background concentration at each monitor by excluding values when the source in question is impacting the monitor. The mean annual background is the average of the annual concentrations so determined at each monitor. For shorter averaging periods, the meteorological conditions accompanying the concentrations of concern should be identified. Monitoring sites inside a 90° sector downwind of the source may be used to determine the area of impact.*

Based on the guidance and the lack of "regional" ambient air quality monitors in Ohio, Ohio EPA considered and applied multiple approaches, including the elimination of readily identifiable source-specific impacts, statistical analysis of available monitoring data, and engineering judgment to determine conservative and appropriate background concentrations for each source area. Ohio EPA maintains the flexibility to consider the use of temporally varying backgrounds where appropriate. Given the varied terrain,

sources, and meteorological conditions amongst the source areas and the technical detail involved, the specific background determination for each area is detailed in a separate Appendix associated with each source area.

Determining Design Value Metrics

U.S. EPA guidance indicates that refined dispersion modeling for designations should provide design values at all receptors and inclusive of all sources in the modeling domain, including background. For the 2010 SO_2 NAAQS, the modeled design value for each receptor is to be calculated as the 99^{th} percentile of the annual distribution of daily maximum 1-hour concentrations, averaged across the modeled years. Ohio EPA followed these recommendations for all modeling analyses performed in support of area designations.

Ohio EPA utilized the MAXDCONT enhancement to the AERMOD modeling system, which determines the design value at each receptor at user specified ranks, as well as the contribution of each source group included in the analysis. In areas where multiple sources were present, Ohio EPA utilized the contribution data obtained for multiple ranks of design values to determine the overall contribution of a source to receptors in the source area.

The Modeling TAD allows for the flexibility to perform separate AERMOD runs in situations where the simultaneous modeling of all explicitly modeled sources is not possible. With respect to these situations, the Nonattainment SIP Guidance states, "the use of hourly POSTFILES, which can be quite large, and external post-processing would be needed to calculate design values".

Documentation

Ohio EPA is providing as part of these designations submittal all necessary information, including the following elements specifically enumerated in the Modeling TAD:

- Characterization of the modeled area
- An emissions analysis of the source area
- Methodology for preparing air quality and meteorological inputs
- Summary and analysis of modeling results
- Provision of modeling data inputs and outputs in electronic form
- Summary of the emissions data used.

Supplemental Analysis

Ohio EPA understands that the modeling portion of the recommended designation submittals represent only part of a more extensive five-factor analysis. As such, any such supplement analysis, including but not limited to background determination, model performance evaluation, and determination of variable emissions will be included in each recommended designations submittal where relevant.