Appendix E

Modeling Protocol: Dispersion Modeling to Demonstrate Attainment of the 2010 SO2 NAAQS

Purpose

Dispersion modeling is necessary to demonstrate attainment of the 2010 National Ambient Air Quality Standard (NAAQS) for sulfur dioxide (SO2). U.S. EPA recommends the use of the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) modeling system. The purpose of this document is to detail the procedures followed by Ohio EPA in conducting air quality modeling for nonattainment areas to develop attainment plans for the SO2 standard.

Guidance on Air Quality Models

To assist states in conducting modeling with respect to the SO2 standard, U.S. EPA has provided several guidance documents:

- Applicability of Appendix W Modeling Guidance for the 1-hour SO2 NAAQS
- Guideline on Air Quality Models, 40 CFR Part 51, Appendix W
- Additional Clarification Regarding Applicability of Appendix W Modeling Guidance for the 1-hour NO2 NAAQS
- Guidance for 1-Hour SO2 Nonattainment Area SIP Submissions

The preamble to the final rule for the SO2 standard states that any guidance released with respect to the SO2 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 modeled attainment demonstrations.

Model Selection

EPA guidance, including Appendix W and *Guidance for 1-Hour SO2 Nonattainment Area SIP Submissions* (herein referred to as "Nonattainment SIP Guidance") recommend the use of AERMOD for the majority of modeling demonstrations.

U.S. EPA recently released a new version of AERMOD (Version 14134), which included multiple enhancements to support the form of the 1-hour SO2 standard. Ohio EPA utilized this version of AERMOD for all modeling analyses performed in support of the SIP. The most up-to-date versions of the regulatory components of AERMOD were also used; AERMET version 14134, 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 14237

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 SO2 in urban areas.

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 attainment strategies.

Modeling Framework

U.S. EPA describes a stepwise approach to a SIP modeling framework in Appendix A of the Nonattainment SIP Guidance document. Ohio EPA has followed this framework with little modification, as detailed below.

1. *Gather information about SO2 sources in the nonattainment areas.*

   Ohio EPA conducted two phases of facility outreach in 2011 and 2013, wherein Ohio EPA supplied facilities located in nonattainment areas 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, for those facilities that do not report hourly emissions to the U.S. EPA Clean Air Markets Database, Ohio EPA requested actual hourly emissions for the 2010-2012 period.

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 SO2 sources impacting the nonattainment areas using emissions reports, meteorology patterns, and other engineering judgment in selecting sources to explicitly model. Via this approach, Ohio EPA chose facilities to explicitly model representing greater than 99% of SO2 emissions in each nonattainment area using 2008 National Emissions Inventory data. 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. *Beginning with maximum allowable emissions or federally enforceable emission limits, apply control strategies that may be employed from enforceable rules.*

   Via facility outreach and current facility permits, Ohio EPA obtained maximum allowable emission limits for relevant facilities, inclusive of any nationally enforceable rules. The Nonattainment SIP Guidance states that "*in the absence of allowable emissions or federally enforceable permit limits, potential to emit emissions should be used*". U.S. EPA states in the Nonattainment SIP Guidance that for a short-term (i.e., 1-hour) standard, they believe that dispersion modeling, using appropriate allowable emissions and addressing station sources in the affected area is technically appropriate. Ohio EPA has taken this into consideration, and used allowable (or potential to emit) emissions as part of our analyses, where appropriate.

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

5-8. *Steps 5-8 of the modeling framework concern the application of control strategies with respect to exceedances of the NAAQS and demonstration of attainment.*

Ohio EPA followed the recommendations of the guidance for steps 4-8, using permitted or potential emission rates to establish baseline levels for use in developing control scenarios. The five-year design values were obtained for multiple ranks, and used to determine facility and unit specific contributions to modeled exceedances of the standard, as per the guidance. However, Ohio EPA included additional steps to determine facility specific impacts, allocation of required reductions, and to assess model performance. These additional steps were deemed necessary given the wide variation in annual emissions from sources explicitly modeled, the substantial number of sources explicitly modeled in each nonattainment area, and to avoid over-control of facilities not contributing significantly to the non-attaining monitor(s). Ohio EPA's modeling framework is detailed below.

Ohio EPA's modeling framework expands on U.S. EPA's recommended approach for steps 4-8. Although Ohio did consider maximum allowable or potential to emit rates as part of the attainment demonstration, additional modeling analyses were necessary. The framework followed by Ohio EPA is as follows.

1. *Base case modeling scenario using variable, actual emissions.*

Ohio EPA included a base case scenario for each modeling domain to assess both model performance and the relative contribution of each source to modeled exceedances at the monitor location only. Each base case included only receptors located at the location of ambient SO2 monitors. Variable, actual emissions from each source included in the modeling domain were modeled for the 2010-2012 period. This enabled a direct comparison of modeled and monitored three year design values and provided a means to assess model performance and the chosen background concentration for each area. Further, the contribution of each source to modeled exceedances at the model location was used to inform control scenarios.

2. *Individual facilities modeled at permitted or potential to emit rates*

Ohio EPA assessed the individual impact of each facility included in the modeling domain when modeled alone at permitted or potential to emit rates. This modeling was conducted using the full receptor grid, created using the procedures detailed below. In situations where National Weather Service

(NWS) meteorological data were used, a full five years (2008-2012) were modeled. In situations where on-site meteorological was available, Ohio EPA modeled at least one full year of meteorological data. The objective of this modeling analysis was to identify those sources which cause modeled exceedances of the standard individually, and to identify initial control strategies to eliminate any facility-specific exceedances of the standard. The rates determined from this step are referred to herein as “ceiling rates”.

3. *Interactive modeling of all facilities at ceiling rates*

Ohio EPA assessed the combined impact of each facility included in the modeling domain when modeled at the ceiling rate established above. This modeling was conducted using the full receptor grid, created using the procedures detailed below. In situations where National Weather Service (NWS) meteorological data were used, a full five years (2008-2012) were modeled. In situations where on-site meteorological was available, Ohio EPA modeled at least one full year of meteorological data. The objective of this modeling analysis was to identify any further modeled exceedances of the standard when all sources were combined, assess the contribution of each facility to modeled exceedances, and to determine a final attainment strategy. The final attainment strategy for each area was informed by the results of the base case analysis and the contribution of each facility with respect to modeled exceedances when modeled at the ceiling rate. From this analysis, Ohio EPA determined final attainment strategies for each facility, where necessary.

4. *Interactive attainment modeling of all facilities using final attainment strategies*

Ohio EPA assessed the combined impact of each facility included in the modeling domain when modeled at final attainment rates, inclusive of all control strategies. This modeling was conducted using the full receptor grid, created using the procedures detailed below. In situations where National Weather Service (NWS) meteorological data were used, a full five years (2008-2012) were modeled. In situations where on-site meteorological was available, Ohio EPA modeled at least one full year of meteorological data. The objective of this modeling analysis was to demonstrate attainment of the standard.

Ohio EPA’s modeling framework provides for a logical approach to an attainment strategy for each nonattainment area. By eliminating facility-specific impacts first via the establishment of ceiling rates, the over-control of any one facility is avoided. Further interactive modeling at these ceiling rates limits the number of receptors exceeding the standard, and allows for the results of the base case analysis to inform the allocation of further reductions or additional control.

Modeling Domain

For all relevant nonattainment areas, Ohio EPA followed the Nonattainment SIP Guidance when developing modeling domains. According to that guidance, the modeling domain should "encompass the nonattainment area and include the sources thought most likely to cause or contribute to NAAQS violations in and around the nonattainment area". Further, the Nonattainment SIP Guidance 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.

Determining Sources to Explicitly Model

All sources within the nonattainment 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 chose facilities to explicitly model representing greater than 99% of SO2 emissions in each nonattainment area using 2008 National Emissions Inventory data. 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.

Receptor Grid

The Nonattainment SIP Guidance document recommends that receptors be placed in areas considered ambient air and placed throughout the nonattainment area, and that receptors should be placed with sufficient density to detect significant concentration gradients. Further, that guidance states that "*states may already have existing receptor placement strategies in place for regulatory dispersion modeling*" and that if such a strategy is deemed "*adequate for the implementation modeling, states should continue with their respective receptor placement strategies*". 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.

Ohio EPA utilized this facility-centered approach in all nonattainment 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 nonattainment area, including placing receptors at the location of air quality monitors. A prescriptive placement strategy was not developed, to allow for flexibility within each nonattainment area. The specific receptor placement

strategy used in the individual nonattainment areas are described in the area-specific protocols included in this document.

Source Inputs

Baseline Emissions Including Federal Rules and Modeling of Additional Controls

The Nonattainment SIP Guidance recommends the use of maximum short term allowable emission limits, and states that since short-term SO2 standards have been in place for many years, such rates should be readily available. For the majority of sources explicitly modeled for the purposes of this SIP submittal, short term emission limits were available. For those sources for which short-term emission limits were not available, Ohio EPA utilized available permitted limits and in some instances limits based on potential to emit. In either case, Ohio EPA accounted for this via the modeling framework detailed above. By following this framework, whereby sources are modeled individually at maximum allowable rates to determine and eliminate facility specific exceedances first, all subsequent emission limits established at each step in the framework are assumed to represent hourly emission limits. As the objective of the modeled attainment demonstration is to establish those short term emission limits that will demonstrate modeled attainment at all receptors in the nonattainment area, Ohio EPA's modeling framework accomplishes this while at the same time obviating the need for unnecessary initial permitted rate modeling.

Ohio EPA analyzed whether baseline allowable emissions should be adjusted based on factors such as permanent shut down of sources or future national rules that will require SO2 reductions. Where those adjustments were warranted, they were included as part of Ohio's modeling analysis and are discussed elsewhere in this submittal.

Good Engineering Practice Stack Height

Ohio EPA, in accordance with Appendix W and the Nonattainment SIP Guidance, modeled all sources at or below GEP stack height.

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

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 SO2 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

Ohio EPA modeled all stacks at GEP stack height or below. As described in the Steubenville, OH-WV protocol portion of this document, Ohio EPA modeled Cardinal Unit 3 as having a variable exit velocity and plume height based on ambient conditions. This is the result of the installation of controls and the venting of emissions through a cooling tower. Further, Ohio EPA modeled the fugitive emissions from the coke oven batteries at Mountain State Carbon (a less than 5,000 TPY facility) as buoyant volume sources with variable release heights, as determined using the BLP modeling platform. These special considerations are presented in greater detail in the Steubenville, OH-WV-specific protocol portion of this document.

Source Configurations and Source Types

The Nonattainment SIP Guidance 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 in 2011 and 2013, 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 nonattainment areas were traditional stack-type release points characterized as point sources. Under no circumstances did Ohio EPA have to account for capped stacks, horizontal releases, area sources, or other release point characterizations. Those sources which required an alternative characterization and the methodology to do so are described in the area-specific protocol portions of this document.

Urban/Rural Determination

Ohio EPA, in accordance with the Nonattainment SIP Guidance, carefully considered the URBAN vs. RURAL characterization of each source explicitly modeled in each nonattainment area. 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 nonattainment areas modeled as part of this submittal, which was also considered. The full URBAN/RURAL determination for those sources in question are described in the area-specific protocol portions of this document.

Source Groups

Ohio EPA utilized the source group options available in AERMOD extensively in the modeled attainment demonstration process, both to assess the total impacts of a facility, the individual impacts of specific units, and to demonstrate modeled attainment of the standard. Ohio EPA also utilized various source groups, in conjunction with the MAXDCONT output option, to assess the effectiveness of control strategies. Final modeled attainment demonstrations utilized, as per the Nonattainment SIP Guidance, the source group ALL to show the full combined impact of all facilities explicitly modeled in the nonattainment 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. In the Steubenville, OH-WV nonattainment area, multiple on-site meteorological datasets were available. These are described in the Steubenville, OH-WV protocol section of this document. Ohio EPA determined surface 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 and per the Nonattainment SIP Guidance document. Surface characteristics were calculated for 12 sectors and four seasons.

In all circumstances, Ohio EPA followed Ohio Engineering Guide #69 with respect to selecting representative upper air sounding data for each nonattainment area.

Meteorological Inputs

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

Per the Nonattainment SIP Guidance and Appendix W, Ohio EPA used five 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 used at least one full year 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. This methodology was used for portions of the modeling analysis of the Steubenville, OH-WV nonattainment area, and is described in greater detail in that area-specific protocol portion of this document.

Background Concentrations

Ohio EPA considered background concentrations of SO2 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 SO2 monitoring network is extensive, there are few SO2 monitors not sited specifically to monitor facility-specific impacts. This is especially true in the nonattainment areas modeled for this submittal.

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 representative of the nonattainment areas, 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. Ohio EPA did not consider the use of temporally varying backgrounds, but instead added background

concentration directly to modeled design values. Given the varied terrain, sources, and meteorological conditions amongst the nonattainment areas, the specific background determination for each area is detailed in the area-specific protocol portions of this document.

Determining Design Value Metrics

The Nonattainment SIP Guidance indicates that refined dispersion modeling for SIPs should provide design values at all receptors and inclusive of all sources in the modeling domain, including background. For the 2010 SO2 NAAQS, the modeled design value for each receptor is to be calculated as the 99th 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 the SIP.

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 nonattainment area.

The Nonattainment SIP Guidance 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”. Ohio EPA applied this recommendation to the Steubenville, OH-WV nonattainment area, as detailed in the Steubenville, OH-WV protocol portion of this document.

Documentation

Ohio EPA is providing as part of this SIP submittal all necessary information, including the following elements specifically enumerated in the Nonattainment SIP Guidance.

- Characterization of the nonattainment problem or characterization of the modeled area in absence of a violating monitor.
- An emissions analysis around the violating monitor or area under consideration for the attainment and maintenance demonstration in absence of a violating monitor.
- Description of any other supplemental analyses (in addition to the characterization and emissions analyses noted above) intended to strengthen the attainment demonstration.
- Methodology for preparing air quality and meteorology inputs including choice of meteorological data and representativeness of the data.
- Summary and analysis of modeling results.

- Modeling data inputs and outputs in electronic form.
- Results of any supplemental analyses.

Supplemental Analysis

The Nonattainment SIP Guidance indicates states may choose to include additional analyses that examine monitoring data, meteorological data, and other datasets relevant to the nonattainment area to supplement modeling analyses and to assess control strategies in their SIP submittal. Ohio EPA has incorporated multiple analyses of such data to support and/or supplement modeling analyses in this SIP submittal based on this guidance.

Modeling Protocol: Dispersion Modeling to Demonstrate Attainment of the 2010 SO2 NAAQS: Lake County, Ohio

Purpose

Dispersion modeling is necessary to demonstrate attainment of the 2010 National Ambient Air Quality Standard (NAAQS) for sulfur dioxide (SO2) in the Lake County nonattainment area. U.S. EPA recommends the use of the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) modeling system. The purpose of this section of the document is to detail the procedures which differ from the general protocol section of this document or require further description of procedures followed by Ohio EPA in conducting air quality modeling to develop the attainment plan for the SO2 standard in Lake County, Ohio.

Guidance on Air Quality Models

Refer to the General Modeling Protocol.

Model Selection

Refer to the General Modeling Protocol.

Modeling Framework

Refer to the General Modeling Protocol.

Ohio EPA followed the modeling framework as described in the General Modeling Protocol document for all modeling analyses conducted for the Lake County nonattainment area.

Modeling Domain

Refer to the General Modeling Protocol.

Ohio EPA utilized a receptor grid encompassing the entirety of the Lake County nonattainment area, as described in the Lake County Dispersion Modeling Analysis portion of this submittal. This nonattainment area was based on U.S. EPA's technical support document entitled *Ohio Area Designations For the 2010 SO2 Primary National Ambient Air Quality Standard,* submitted to the State of Ohio on July 25, 2013.

Determining Sources to Explicitly Model

Refer to the General Modeling Protocol.

Utilizing the procedures described in the General Modeling Protocol document of this submittal, Ohio EPA determined that the following sources were to be explicitly modeled in the Lake County nonattainment area.

	Source ID	Easting (X)	Northing (Y)	SO2
		(m)	(m)	2011 TPY
Eastlake Power Plant	B001_EL	463125	4613288	48,303.10
	B002_EL	463125	4613288	
	B003_EL	463125	4613288	
	B004_EL	463125	4613288	
	B005_EL	462979	4613348	
Painesville Municipal	B001_PV	478879.3	4619419.7	2,745.29
	B003_PV	478858.9	4619428.82	
	B004_PV	478858.9	4619428.82	
Carmeuse Lime	P001_CL	476497.02	4622159.11	890.60
	P002_CL	476497.02	4622159.11	

These sources account for 99% of 2011 SO2 emissions in the nonattainment area.

Receptor Grid

Refer to the General Modeling Protocol.

Ohio EPA utilized established methodologies in designing the receptor grid for the Lake County nonattainment area. A total of 14,680 receptors were included in the modeling domain. 50 meters spacing within a 1 km radius of each facility was used. 100 meters spacing was used within 2.5 km of each facility, 250 meters spacing was used within a radius of 5 km from each facility, and a 500 meters spacing was used within a 10 km radius of each facility. Beyond 10 km, 1000 meters spacing was used. A discrete receptor was also included at the location of the monitor, as was done in the base case scenario. Ohio EPA determined that, given the significant degree of overlap from the dense near-source grids, there was sufficient receptor density to capture significant concentration gradients in the nonattainment area.

Source Inputs

Refer to the General Modeling Protocol.

Urban/Rural Determination

The determination of the appropriate classification (URBAN or RURAL) for the three sources (Eastlake Power Plant, Painesville Municipal, and Carmeuse Lime) in the Lake County nonattainment area is complicated by the proximity of these sources to Lake Erie. As such, Ohio EPA performed multiple analyses to assess the appropriate classification of each of these facilities.

Firstly, Ohio EPA collected 2010 census data maps from the TIGER/Line® shapefile repository (https://www.census.gov/geo/maps-data/data/tiger-data.html). 1992 land cover data was obtained from the National Land Cover Dataset 1992 (NLCD 1992) **(**http://landcover.usgs.gov/natlandcover.php), and 2011 land cover data was obtained

from the National Land Cover Database 2011 (NLCD 2011) **(**www.mrlc.gov/nlcd2011.php**)**.

The Lake County source classifications were evaluated using both the Land Use Procedure and Population Density Procedure as described in US EPA's 7.2.3 Dispersion Coefficients guidance published in the Federal Register, 70 FR 68239 (Nov. 9, 2005). Both procedures recommend evaluation of a circular 3 km buffer around the source. The buffer in these analyses was extended from the approximate center of each source.

For the Land Use Procedure method, URBAN or RURAL classification is determined using the Auer land use classification system. If Auer categories I1,I2,C1,R2,R3 (Figure 1) cumulatively exceed 50% then the source is classified as URBAN, otherwise it is classified as RURAL. The guidance does not specify the method of assigning the Auer categories or the appropriate segmentation of the circular buffer. For this analysis, Ohio EPA related the National Land Cover Database information to Auer classifications. The classification assignment was performed on a pixel-by-pixel basis using the National Land Cover Dataset, and then subsequently converted to Auer classification categories. The specific GIS analysis steps performed were as follows:

1) Construct a circular 3 km buffer around the source using the source's coordinates.
2) Convert National Land Cover Dataset geotiff to ArcGIS grid format.
3) Clip the converted National Land Cover Database grid to the buffer.
4) Use the Zonal Histogram tool to produce a table of counts for each classification type.

For the Population Density Procedure, the same 3 km buffer was used but 2010 census data replaced the NLCD. Per U.S. EPA guidance, source-centered buffers with population densities greater than 750 people/km^2 could potentially be classified as URBAN. The specific GIS analysis steps performed were as follows:

1) Construct a circular 3 km buffer around the source using the source's coordinates.
2) Clip census TIGER/Line® shapefile to the buffer.
3) Calculate area of buffer using the ArcGIS built-in geometric calculation tool.
4) Obtain population counts from the clipped shapefile.

U.S. EPA guidance does not provide recommendations on how to treat large bodies of water with respect to URBAN/RURAL source classifications. For both the Carmeuse Lime and Eastlake Power Plant, Lake Erie comprises a significant portion of the buffer area. For comparative purposes, classifications were determined both with and without Lake Erie. With respect to the Land Use Procedure, water pixels were simply removed from the percentage calculations. For the Population Density Procedure, an area equal to the water pixels was removed in the density calculation.

With respect to the Land Use Procedure, none of the three facilities (Eastlake Power Plant, Painesville Municipal, and Carmeuse Lime) could be classified as URBAN using

the 1992 NLCD (Table 1) or 2011 NLCD (Table 2). Furthermore, removing Lake Erie from the buffers did not alter the classification results. All three facilities had Auer classifications well below the 50% threshold recommended for classification as URBAN sources.

LAND USE PROCEDURE - 1992 NLCD								
	Land Cover ID	Land Cover Description	Auer Category Best Fit	Count	Percent	Without Water %		
Eastlake Electric	11	Open Water	A5	16283	51.80%		Auer Urban Including Water: I1,I2,C1,R2,R3 > 50%	Auer Urban Without Water: I1,I2,C1,R2,R3 > 50%
	21	Low Intensity Residential	R1	8610	27.39%	56.82%		
	22	High Intensity Residential	R2,R3	1001	3.18%	6.61%		
	23	Commercial/Industrial/Transportation	I1, I2, C1	879	2.80%	5.80%		
	41	Deciduous Forest	A4	1992	6.34%	13.15%		
	42	Evergreen Forest	A4	117	0.37%	0.77%		
	43	Mixed Forest	A4	85	0.27%	0.56%		
	81	Pasture/Hay	A2	588	1.87%	3.88%		
	82	Row Crops	A2	91	0.29%	0.60%		
	85	Urban/Recreational Grasses	A1	868	2.76%	5.73%		
	91	Woody Wetlands	A3	764	2.43%	5.04%		
	92	Emergent Herbaceous Wetlands	A3	158	0.50%	1.04%		
		Total Pixel Count		31436		15153	5.98%	12.41%
Painesville Electric	11	Open Water	A5	1208	3.84%		Auer Urban Including Water: I1,I2,C1,R2,R3 > 50%	
	21	Low Intensity Residential	R1	8251	26.24%			
	22	High Intensity Residential	R2,R3	565	1.80%			
	23	Commercial/Industrial/Transportation	I1,I2,C1	6434	20.47%			
	33	Transitional	?	29	0.09%			
	41	Deciduous Forest	A4	5622	17.88%			
	42	Evergreen Forest	A4	247	0.79%			
	43	Mixed Forest	A4	148	0.47%			
	71	Grasslands/Herbaceous	A3	1324	4.21%			
	81	Pasture/Hay	A2	907	2.88%			
	82	Row Crops	A2	2139	6.80%			
	85	Urban/Recreational Grasses	A1	1716	5.46%			
	91	Woody Wetlands	A3	1794	5.71%			
	92	Emergent Herbaceous Wetlands	A3	1055	3.36%			
		Total Pixel Count		31439			22.26%	
Carmeuse Lime	11	Open Water	A5	13142	41.80%		Auer Urban Including Water: I1,I2,C1,R2,R3 > 50%	Auer Urban Without Water: I1,I2,C1,R2,R3 > 50%
	21	Low Intensity Residential	R1	3470	11.04%	18.96%		
	22	High Intensity Residential	R2,R3	311	0.99%	1.70%		
	23	Commercial/Industrial/Transportation	I1,I2,C1	3653	11.62%	19.97%		
	33	Transitional	?	671	2.13%	3.67%		
	41	Deciduous Forest	A4	2741	8.72%	14.98%		
	42	Evergreen Forest	A4	100	0.32%	0.55%		
	43	Mixed Forest	A4	51	0.16%	0.28%		
	71	Grasslands/Herbaceous	A3	1244	3.96%	6.80%		
	81	Pasture/Hay	A2	599	1.91%	3.27%		
	82	Row Crops	A2	1001	3.18%	5.47%		
	85	Urban/Recreational Grasses	A1	206	0.66%	1.13%		
	91	Woody Wetlands	A3	1961	6.24%	10.72%		
	92	Emergent Herbaceous Wetlands	A3	2289	7.28%	12.51%		
		Total Pixel Count		31439		18297	12.61%	21.66%

Table 1: NLCD 1992 land use classification results.

LAND USE PROCEDURE - 2011 NLCD								
	Land Cover ID	Land Cover Description	Auer Category Best Fit	Count	Percent	Without Water %		
Eastlake Electric	11	Open Water	A5	15915	50.63%			
	21	Developed, Open Space	R4,A1	3449	10.97%	22.22%		
	22	Developed, Low Intensity	R1	8829	28.09%	56.88%	**Auer Urban Including Water: I1,I2,C1,R2,R3 > 50%**	**Auer Urban Without Water: I1,I2,C1,R2,R3 > 50%**
	23	Developed, Medium Intensity	R2,R3	1110	3.53%	7.15%		
	24	Developed, High Intensity	I1,I2,C1	327	1.04%	2.11%		
	31	Barren Land	?	105	0.33%	0.68%		
	41	Deciduous Forest	A4	1235	3.93%	7.96%		
	71	Grassland/Herbaceous	A3	466	1.48%	3.00%		
		Total Pixel Count		31436		15521	**4.57%**	**9.26%**
Painesville Electric	11	Open Water	A5	817	2.60%			
	21	Developed, Open Space	R4,A1	6658	21.18%			
	22	Developed, Low Intensity	R1	11595	36.88%			
	23	Developed, Medium Intensity	R2,R3	3517	11.19%			
	24	Developed, High Intensity	I1,I2,C1	946	3.01%			
	31	Barren Land	?	137	0.44%		**Auer Urban Including Water: I1,I2,C1,R2,R3 > 50%**	
	41	Deciduous Forest	A4	3798	12.08%			
	42	Evergreen Forest	A4	27	0.09%			
	52	Shrub/Scrub	A3	362	1.15%			
	71	Grassland/Herbaceous	A3	1768	5.62%			
	81	Pasture/Hay	A2	915	2.91%			
	82	Cultivated Crops	A2	864	2.75%			
	90	Woody Wetlands	A4	35	0.11%			
		Total Pixel Count		31439			**14.20%**	
Carmeuse Lime	11	Open Water	A5	12625	40.16%			
	21	Developed, Open Space	R4,A1	2737	8.71%	14.55%		
	22	Developed, Low Intensity	R1	5589	17.78%	29.71%		
	23	Developed, Medium Intensity	R2,R3	1637	5.21%	8.70%		
	24	Developed, High Intensity	I1,I2,C1	351	1.12%	1.87%		
	31	Barren Land	?	629	2.00%	3.34%	**Auer Urban Including Water: I1,I2,C1,R2,R3 > 50%**	**Auer Urban Without Water: I1,I2,C1,R2,R3 > 50%**
	41	Deciduous Forest	A4	3832	12.19%	20.37%		
	43	Mixed Forest	A4	6	0.02%	0.03%		
	52	Shrub/Scrub	A3	161	0.51%	0.86%		
	71	Grassland/Herbaceous	A3	2573	8.18%	13.68%		
	81	Pasture/Hay	A2	328	1.04%	1.74%		
	82	Cultivated Crops	A2	609	1.94%	3.24%		
	90	Woody Wetlands	A4	334	1.06%	1.78%		
	95	Emergent Herbaceous Wetlands	A3	28	0.09%	0.15%		
		Total Pixel Count		31439		18814	**6.32%**	**10.57%**

Table 2: NLCD 2011 land use classification results.

The Population Density Procedure produced different classification results for Eastlake Power Plant and Painesville Municipal. Eastlake Power Plant, with respect to the 2010 census, had a population density of 765 people per square kilometer and Painesville Municipal a population density of 983 people per square kilometer. Both sources

exceed the EPA guidance threshold of 750 people per square kilometer recommended for URBAN classification.

U.S. EPA guidance indicates that the preferred method for URBAN/RUAL classification of sources is the Land Use Procedure. Oho EPA prefers this method for use in other modeling applications, and will maintain that preference here. Further, preliminary model performance runs, using actual, variable emissions indicate that the RURAL classification of all sources demonstrated the most accurate comparison to monitor data over the same period.

Source Groups

Refer to the General Modeling Protocol.

Meteorological Data

Refer to the General Modeling Protocol.

Ohio EPA has extensive background and expertise in the selection of meteorological data for modeling purposes. Ohio Engineering Guide #69[2], a document created to provide guidance to consultants, facilities with respect to modeling, provides a recommended meteorological station for each county in Ohio. For the Lake County nonattainment area, Ohio EPA utilized five years of NWS data from 2008 through 2012 from the Cleveland, OH surface station (Station # 14820) located at the Cleveland Hopkins International Airport and the Buffalo, NY upper air station (Station # 14733) located at the Buffalo Niagara International Airport. These sites were determined to be representative of Lake County. AERSURFACE was run using twelve sectors and four seasons. Further, Ohio EPA utilized the AERMINUTE module to reduce the number of missing hours present in the .SFC file.

Background Concentrations

Ohio EPA conducted a rigorous analysis to determine appropriate and conservative background concentrations. Ohio EPA established two background concentrations for the Lake County nonattainment area. The first was established for the 2010 to 2012 period, and is representative of those sources thought to contribute to current and historical monitored concentrations, but not included in, the modeling domain. The sources included in the background modeling domain are Eastlake Power Plant, Carmeuse Lime and Painesville Municipal Power Plant. This background was used for base case modeling using variable actual emissions for the 2010 to 2012 period to determine monitor-specific impacts.

A second background was established building from the background analysis for base case modeling. This second background is intended to represent the future case and accounts for the substantial decrease in SO2 emissions expected from the shutdown or natural gas (NG) conversion of large SO2 sources in Lorain and Cuyahoga Counties.

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

These larger sources contributed to background concentrations in the base case analysis but will not be operating in a manner to contribute to those concentrations in the future. Therefore, as will be seen in our analysis, the future case background would have been overly conservative without further adjustment.

In both cases, background was determined using data collected at ambient air quality monitor 39-085-0003 (Eastlake Monitor), located in Eastlake, Ohio. This monitor was selected for the background determination because it is currently monitoring attainment of the SO2 standard and is located upwind of the violating monitor. This monitor is likely impacted by those sources upwind of, but not included in, the modeling domain. While Eastlake Power Plant is located upwind of the background monitor, impacts from the Eastlake Power Plant at the monitor are easily identifiable and can be isolated from the background determination to avoid double counting.

Base Case Background Determination

Data Description:

Hourly ambient SO2 concentrations recorded at the Eastlake Monitor, years 2008-2012, were compiled from U.S. EPA's Technology Transfer Network, Air Quality System (AQS). Likewise, hourly climate data for the same time period was acquired from the National Climatic Data Center (http://www.ncdc.noaa.gov/) for Cleveland Hopkins Airport (KCLE), Burke Lakefront Airport (KBKL), Ashtabula County Airport (KHZY) and Portage County Airport (KPOV). Additional hourly climate data was acquired from the National Data Buoy Center (http://www.ndbc.noaa.gov/) for Geneva on the Lake (GELO1) and Fairport (FAIO). Figure 1 shows the location of the Eastlake Monitor, the Painesville Monitor, all facilities included in the modeling domain, and the meteorological stations included in this analysis.

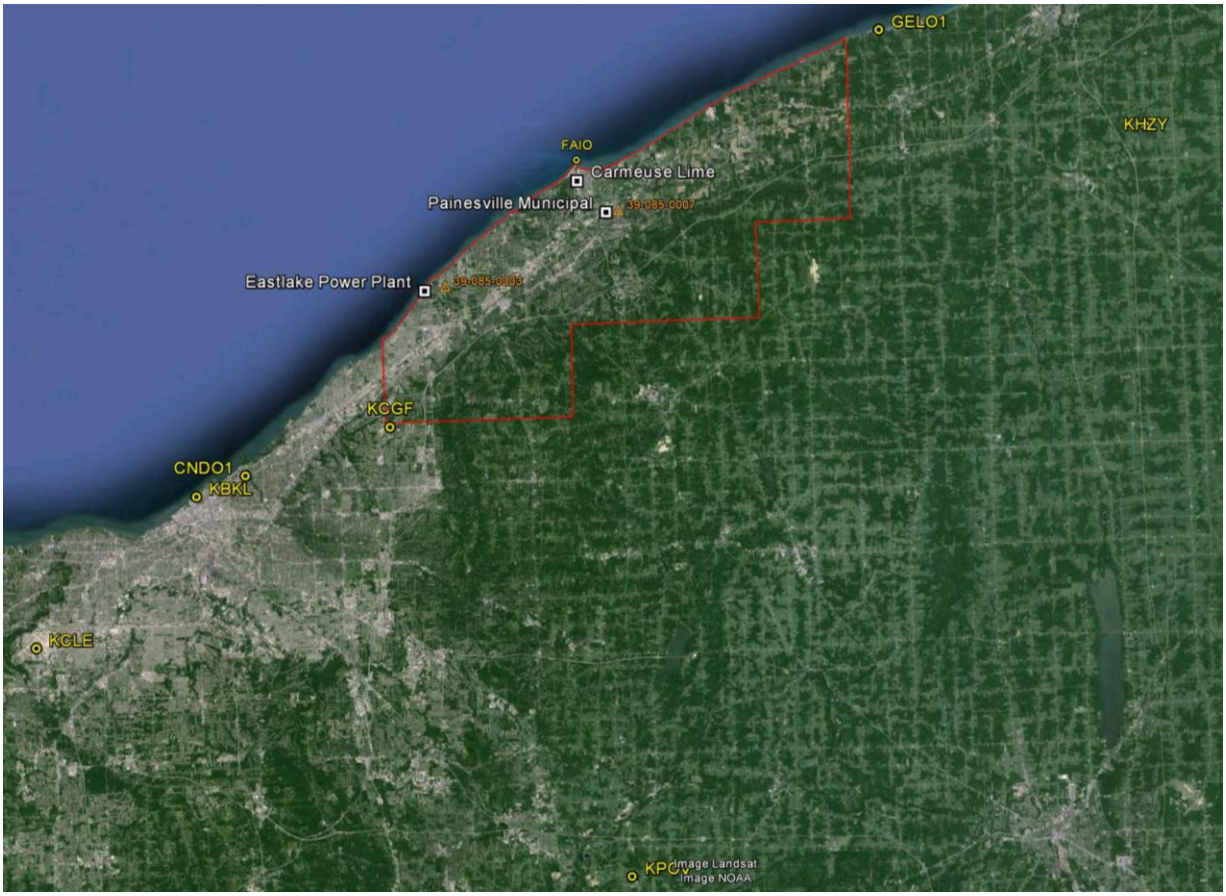

Figure 1: Emission sources, monitor locations, and meteorological stations.

Methodology:

The meteorology of the Lake County area is complex, as it is influenced by both maritime and continental wind conditions. Given this complexity, multiple analyses were performed to characterize the regional meteorological system, to identify correlations between meteorological conditions and monitor values, and to isolate the potential impacts of sources included in the modeling domain on monitored values. Firstly, hourly monitor and wind direction data were co-plotted to evaluate over-arching trends. Secondly, a correlation analysis was performed between wind direction data collected at all representative meteorological stations and ambient SO2 data to determine which meteorological station(s) were the most predictive of ambient SO2 concentrations at the Eastlake Monitor. This information was then subsequently used to derive a base case background SO2 concentration.

Analysis and Results:

The initial data analysis was conducted using a limited meteorological data set from the KCLE, KBKL, KHZY, GELO1 stations and the hourly ambient SO2 data from the Eastlake Monitor, years 2008-2012. These stations were selected, as they represent stations located to both the East and West of the monitor, as seen in Figure 1, above.

Scatterplots of hourly SO2 concentrations recorded at the Eastlake Monitor versus wind direction at each of the four meteorological stations were generated. These scatterplots revealed a general clustering of elevated SO2 readings for wind directions between approximately 40-60°, 140-180° and 250-270°. Based on these wind directions and the location of those facilities included in the modeling domain (Figure 1), it is likely that the majority of the elevated monitor values represent the impacts of those facilities in the modeling domain. However, for monitored values greater than 20 ppb, significantly more variability was observed in the associated wind directions. It is reasonable to assume that these readings (above 20 ppb and not associated with those facilities included in the modeling domain) are the result of sources not included in the modeling domain that impact the nonattainment area. To maintain conservatism in the background and to ensure that sources outside of modeling domain are adequately represented, Ohio EPA isolated these elevated values for further analysis.

For each of the five years included in the analysis, Ohio EPA determined that the highest 1% of SO2 values recorded at the Eastlake Monitor were adequately representative of those meteorological conditions generally associated with sources not included in the modeling domain. Table 3 below indicates the threshold values for the highest 1% SO2 concentrations for each of the five years analyzed.

Year	Total Hours	Hours at or above 1%	1% SO_2 Threshold Concentration (ppb)
2008	8784	93	21
2009	8760	104	17
2010	8760	89	17
2011	8760	109	15
2012	8784	92	17

Table 3: Highest 1% monitored SO2 concentrations (parts per billion).

Based on these results, all years of data were combined and binned for different SO2 thresholds (>= 30 ppb, >= 27 ppb, >= 24 ppb, >= 21 ppb, < 21 ppb and < 15 ppb). Likewise, 8 binned categories were created for wind directions (0-45°, 45-90°, 90-135°, 135-180°, 180-225°, 225-270°, 270-315°, 315-360°) at each of the six representative meteorological sites. A summary of data availability by station for each SO2 category is provided in Table 4. Data availability statistics indicate when both wind speed and wind direction were reported for a given SO2 concentration. KCLE, KBKL, KHZY and GELO1 stations had data availabilities above 95%. FAIO and KPOV had lower availabilities at around 40-60%. The lower availability at the FAIO and KPOV stations was the result of both data records not starting until the middle of 2009. However, even when this shorter period of record is accounted for, data continuity and availability for FAIO and KPOV was significantly lower than the other stations.

Total Hour Counts - Divided by SO_2 Bins (Wind Speed and Direction are Reported for Same SO_2 Measurement Time)													
SO_2 Category	Total	KCLE		KBKL		KHZY		KPOV		GELO1		FAIO	
	Hours	Num	%	Num	%	Num	%	Num	%	Num	%	Num	%
At or Above 30	55	53	96%	52	95%	52	95%	24	44%	53	96%	30	55%
At or Above 27	86	83	97%	82	95%	82	95%	32	37%	84	98%	40	47%
At or Above 24	142	138	97%	137	96%	134	94%	54	38%	139	98%	64	45%
At or Above 21 (~1% limit)	253	247	98%	247	98%	239	94%	100	40%	249	98%	126	50%
Below 21	43209	42742	99%	42745	99%	41798	97%	23363	54%	42729	99%	28989	67%
Below 15	42664	42202	99%	42210	99%	41268	97%	23123	54%	42194	99%	28699	67%

Table 4: Meteorological data availability for binned SO2 categories.

Using the binned data for both ambient SO2 concentrations and wind direction, correlation and multiple correlation values were calculated for binned wind directions, wind speeds, and SO2 concentrations for the six different climate stations to assess the linear relationships between parameters. Ohio EPA used the built-in EXCEL "CORREL" function, which determines the Pearson product-moment correlation coefficient between data sets. This statistical measurement reflects the positive or negative linear association between data sets. Results from both the simple correlation analyses (between station wind directions and recorded SO2 concentrations) and multiple correlations (combinations of station directions and SO2) demonstrate that correlations were moderate at best (~ .3 - ~ .6). The results of the simple correlation analysis are shown in Table 5.

Pearson Correlation Coefficients: Wind Direction and SO2 Bins					
	SO2 Category				
Station ID	**>30**	**>27**	**>24**	**>21**	**<21**
KCLE	0.172	0.169	0.108	0.071	0.014
KBKL	0.112	0.080	0.061	0.032	-0.002
KHZY	0.512	0.356	0.213	0.145	0.016
KPOV	0.568	0.466	0.304	0.213	-0.052
FAIO	0.239	0.174	0.144	0.057	-0.001
GELO1	0.457	0.309	0.202	0.125	-0.035

Table 5: Correlation coefficients for wind direction and SO2 category, by met station.

The relatively low degree of correlation indicates that the relationship between SO2 values recorded at the Eastlake Monitor and wind direction is complicated for this region, and indicates to a degree that sources of SO2 not included in the modeling domain do contribute to the monitored SO2 concentrations. This is particularly true for the higher SO2 concentration bins. Both weather stations west of the Eastlake Air Monitor (KBKL and KCLE) exhibited the lowest correlations. The KHZY and GELO1 stations demonstrated correlations approximately three times higher than those determined for KBKL and KCLE stations. This suggests KHZY and GELO1 wind directions will serve as the most reliable predictor of SO2 concentrations at the monitor. The KHZY station demonstrated slightly better correlation than the GELO1 station for all bins. For this reason, wind direction data from the KHZY monitor was used for all subsequent background analyses.

To determine an appropriate range of wind directions to base the background concentration on, Ohio EPA compiled the binned wind directions recorded at the KHZY meteorological station and SO2 concentrations bins, and calculated the percent contribution of each wind direction bin to each SO2 concentration bin. This data is presented in Table 6, below.

KHZY Wind Direction Contributions for SO2 bins (Eastlake Sector 250-270° in Parenthesis)													
		SO2 Monitor Levels							SO2 Monitor Levels				
Station	Direction	> 30	> 27	> 24	> 21	< 21	Station	Direction	> 30	> 27	> 24	> 21	< 21
KHZY	315-360	7%	6%	6%	4%	10%	KHZY	0-45	27%	26%	22%	20%	20%
		SO2 Monitor Levels							SO2 Monitor Levels				
Station	Direction	> 30	> 27	> 24	> 21	< 21	Station	Direction	> 30	> 27	> 24	> 21	< 21
KHZY	270-315	9%	8%	9%	6%	14%	KHZY	45-90	20%	19%	15%	13%	3%
		SO2 Monitor Levels							SO2 Monitor Levels				
Station	Direction	> 30	> 27	> 24	> 21	< 21	Station	Direction	> 30	> 27	> 24	> 21	< 21
KHZY	225-270	7% (1.8)	8% (4.7)	8% (7.0)	10% (7.1)	10% (7.1)	KHZY	90-135	9%	7%	7%	8%	6%
		SO2 Monitor Levels							SO2 Monitor Levels				
Station	Direction	> 30	> 27	> 24	> 21	< 21	Station	Direction	> 30	> 27	> 24	> 21	< 21
KHZY	180-225	7%	8%	8%	12%	19%	KHZY	135-180	9%	15%	20%	22%	12%

Table 6: Percent contribution of wind directions with respect to SO2 concentration categories, KHZY station.

Table 6 shows that there is a substantial portion of elevated monitor values resultant from wind directions from both the 0-45° and 45-90° wind sectors. Based on the location of the Carmeuse Lime facility and the Painesville Municipal Power Plant relative to the Eastlake Monitor, Ohio EPA eliminated these wind sectors from further analysis, as they likely represent monitor impacts from these facilities and would potentially double count their impacts in the modeling if included. Elevated SO2 concentrations are observed for wind sectors 135-180°, 180-225°, 225-270°, and 270-315°, and decrease for the 315-360° sector, as shown in Table 6. Based on these results, Ohio EPA compiled paired hourly SO2 monitor data from the Eastlake Monitor with hourly wind direction data from the KHZY station for all wind directions between 130° and 320°. As can be seen in Figure 2 monitoring data from this relatively large wind sector would capture the contribution of down wind sources not included in the monitoring domain as well as the contribution of the Cleveland metropolitan area and signficant sources from eastern Lorain County (e.g., Avon Lake Power Plant).

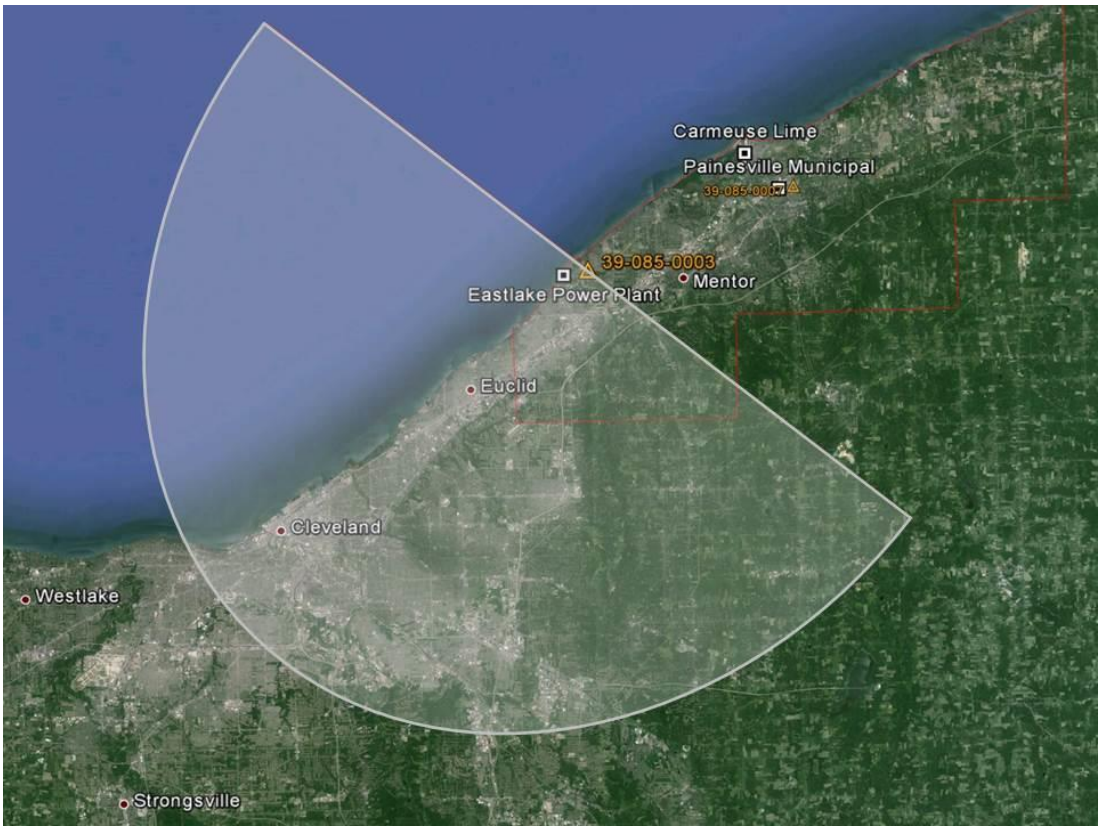

Figure 2: 130° to 320° wind sector used for base case background determination.

To eliminate the impact of the Eastlake Power Plant, a narrow sector (250° - 270°) was isolated from within the 130-320° wind sector. This narrow sector was selected by finding the centerline heading between the power plant and the monitor (262°). As can be seen from Figure 2, elimination of this small sector from the background determination would have little effect on the overall area considered. All monitor data recorded for this sector was excluded from further analysis to avoid double counting of the Eastlake Power Plant. The resultant monitored values from the 130-320° wind sector, less concentrations associated with the 250° - 270° sector, were compiled for each year of the 2008-2012 period and subsequently sorted. Conservatively, Ohio EPA calculated the average of the highest 1% of monitor values for each year of the 2008-2012 period. This analysis yielded a range of background concentrations from 21 to 27 ppb. Ohio EPA chose the 27 ppb value as the base case background concentration. The results of the above analysis are shown in Table 7, below.

Annual Average of Highest 1% of Monitored SO2 Concentrations, 2008-2012					
	2008	**2009**	**2010**	**2011**	**2012**
Background SO2 (ppb)	27	22	21	21	24

Table 7: Annual average of highest 1% SO2 concentrations for select wind directions, Eastlake Monitor.

Future Case Background Determination

Ohio EPA believes the 27 ppb base case background is overly conservative and not appropriate for use in the future case scenario. Future case modeling determines the impact of sources in operation when attainment of the SO2 standard is to be achieved. Two sources, the Lake Shore Power Plant in Cuyahoga County and the Avon Lake Power Plant in Lorain County will eliminate their SO2 emissions in the near future. Lake Shore Power Plant will be shutting down operations no later than June 2016 and Avon Lake Power Plant will either be shutting down or converting to NG by the same date. As will be seen below, these two sources by far contribute the majority of SO2 emissions (tons per year (TPY)) that comprise the background concentration established in the base case scenario.

Data Description:

As with the base case background, Ohio EPA compiled hourly ambient SO2 concentrations recorded at the Eastlake Monitor, years 2008-2012, from U.S. EPA's Technology Transfer Network, Air Quality System (AQS). Additionally, annual SO2 emissions data for sources likely impacting the Lake County nonattainment area were compiled from Ohio EPA's Emissions Inventory System (EIS).

Methodology:

Using the base case background of 27 ppb as a starting point, Ohio EPA assessed the impact of the future shutdown or NG conversion of several major SO2 sources likely impacting the nonattainment area to derive a representative future case SO2 background. Ohio EPA recognized that a reasonable and conservative future-case background concentration for the Lake County non-attainment area would consist of both rural and urban components. As such, Ohio EPA applied the impact of future SO2 reductions to only the assumed urban component to maintain a level of conservatism in the future case background.

Results and Analysis:

Lake Shore Power Plant will be shutting down operations no later than June 2016, and Avon Lake Power Plant will either be shutting down or converting to NG by the same date. SO2 emissions from these two facilities (2010-2012) are summarized in Table 8 below.

SO2 Emission Reductions from Known Shutdown/NG Conversion Facilities					
Facility ID	**Facility Name**	**County**	**2010 Total Emissions (TPY)**	**2011 Total Emissions (TPY)**	**2012 Total Emissions (TPY)**
0247030013	Avon Lake Power Plant	Lorain	35,488.18	32,040.47	38,307.51
1318000245	Lake Shore Power Plant	Cuyahoga	3,067.7	1,941.90	747.70

Table 8: Annual SO2 emissions, Avon Lake Power Plant and Lake Shore Power Plant

As can be seen from Table 8, these two sources would contribute substantially to the base case background concentration previously established. The reduction/elimination of the SO2 emissions from these two sources will undoubtedly affect the background SO2 concentration for this area in the future.

Ohio EPA determined, for years 2010-2012, the percent contribution of these sources with respect to all sources impacting the nonattainment area, excluding those included in the modeling domain. Table 9 below shows that these two sources contributed over 85% of the background emissions for this area over the 2010-2012 period.

Emissions and Percentage of Change in Total SO_2 Emissions			
Year	**2010 (TPY)**	**2011 (TPY)**	**2012 (TPY)**
A. All sources in Lake County excluding Painesville, Eastlake and Carmeuse	30.86	28.32	33.56
B. All sources in Cuyahoga County	7,391.59	6,428.01	5,172.67
C. All sources in Lorain County	35,882.39	32,915.81	38,584.68
D. Total Background Emissions (A + B + C)	43,304.84	39,372.13	43,790.91
E. Future Shutdown Emissions from Cuyahoga and Lorain Counties	38,555.88	33,982.37	39,055.21
F. Remaining Background Emissions (D – E)	4,748.96	5,389.76	4,735.70
G. Percent Reduction in Background from Shutdown/NG Conversions (1-(F/D))	89%	86%	89%

Table 9: Anticipated SO2 emission reductions, Lake, Lorain, and Cuyahoga Counties

As stated previously, Ohio EPA recognizes that the background SO2 concentration in the Lake County nonattainment area will have both a rural and urban component. With respect to the rural component, Ohio EPA is relying on an analysis conducted by the Lake Michigan Air Directors Consortium (LADCO) in conjunction with the U.S. EPA Region 5 states contained in the "Modeling Protocol: Dispersion Modeling to Demonstrate Attainment of SO2 Primary NAAQS", July 25, 2011. An analysis of background options was explored in this document and ultimately LADCO recommended a default regional background concentration of 8 ppb using a weight-of-evidence approach. Ohio EPA is using LADCO's suggested 8 ppb regional SO2 background recommendation as the rural component for this analysis.

The urban component is assumed to account for the SO_2 emissions from the industries in the Lake County non-attainment area (Painesville, Eastlake and Carmeuse excluded since they are included in the modeling domain), as well as those SO2 sources downwind of nonattainment area in Cuyahoga and Lorain Counties. Thus, the shutdown of the Lake Shore Power Plant and shutdown or NG conversion of the Avon Lake Power Plant will lead to a significant reduction of the urban component of background concentration.

Several steps were taken to determine the urban component of the background after the shutdown/NG conversion of two large SO2 emission sources.

Subtracting the rural background concentration of 8 ppb from the previously established base case background concentration of 27 ppb, the remaining portion of 19 ppb is attributed to the urban background concentration when all SO2 sources downwind of the violating monitor are operating as they historically did. The remaining 19 ppb urban component was then adjusted to account for the significant amount of future shutdown/NG conversions by subtracting the background percentage attributable to the Avon Lake and Lake Shore Power Plants from the 19 ppb base case urban component. This adjusted urban background concentration was then added to the rural background concentration of 8 ppb and a new background concentration for the future case was determined to be in the range of 10.09 to 10.66 ppb (Table 10). To be conservative, the three-year average of the new background concentration was calculated at 10.25 ppb and is being used as the background concentration for the future scenario analysis for this area.

Year	**2010**	**2011**	**2012**
A. Base Case Calculated Background (ppb)	27	27	27
B. Base Case Urban Background Component (ppb) (A - 8 ppb LADCO Rural Background)	19	19	19
C. Percent Reduction in Urban Component from Shutdown/NG Conversions (Table 7)	89%	86%	89%
D. Future Case Urban Component of Background (ppb) (100%-C) x B)	2.09	2.66	2.09
E. LADCO Rural Background (ppb)	8	8	8
New Background Total (ppb)	10.09	10.66	10.09
Average (ppb)		**10.28**	

Table 10: Adjusted Future Case Background Concentration

In summary, based on the above analysis, a future case background concentration for the Lake County nonattainment area is conservatively estimated at 10.3 ppb, accounting for the shutdown (or possible NG conversion of Avon Lake) of two major SO2 emission sources. Ohio EPA believes that a value of 10.3 ppb, based initially on a conservative background of 27 ppb and adjusted only in the urban component, is adequately conservative for future case modeling scenarios.

Determining Design Value Metrics

Refer to the General Modeling Protocol.

Documentation

Ohio EPA is providing as part of this SIP submittal all necessary information, including the following elements specifically enumerated in the Nonattainment SIP Guidance.

- Characterization of the nonattainment problem or characterization of the modeled area in absence of a violating monitor.
- An emissions analysis around the violating monitor or area under consideration for the attainment and maintenance demonstration in absence of a violating monitor.
- Description of any other supplemental analyses (in addition to the characterization and emissions analyses noted above) intended to strengthen the attainment demonstration.
- Methodology for preparing air quality and meteorology inputs including choice of meteorological data and representativeness of the data.
- Summary and analysis of modeling results.
- Modeling data inputs and outputs in electronic form.
- Results of any supplemental analyses.

Supplemental Analysis

Refer to the General Modeling Protocol.

Modeling Protocol: Dispersion Modeling to Demonstrate Attainment of the 2010 SO2 NAAQS: Steubenville, OH-WV

Purpose

Dispersion modeling is necessary to demonstrate attainment of the 2010 National Ambient Air Quality Standard (NAAQS) for sulfur dioxide (SO2) in the Steubenville, OH-WV nonattainment area. U.S. EPA recommends the use of the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) modeling system. The purpose of this section of the document is to detail the procedures which differ from the general protocol section of this document or require further description of procedures followed by Ohio EPA in conducting air quality modeling to develop the attainment plan for the SO2 standard in the Steubenville, OH-WV nonattainment area.

Guidance on Air Quality Models

Refer to the General Modeling Protocol.

Model Selection

Refer to the General Modeling Protocol.

Modeling Framework

Refer to the General Modeling Protocol.

The majority of the modeling analyses performed for the Steubenville, OH-WV followed Ohio EPA's modeling framework, referenced above. However, special consideration was required due to the unusual nature of the Cardinal Unit 3 release point, as described in greater detail in the *Source Configurations and Source Types* section of this document. In addition, Ohio EPA used a weight-of-evidence approach considering other factors in addition to modeling, such as a newly available monitoring network, in determining our approach for showing attainment in this area. The weight-of-evidence approach is fully discussed in the Steubenville, OH-WV Nonattainment Area Modeling Results section of this State Implementation Plan (SIP) submittal.

Modeling Domain

Refer to the General Modeling Protocol.

Ohio EPA utilized a receptor grid encompassing the entirety of the Steubenville, OH-WV nonattainment area, as described in the Steubenville, OH-WV Dispersion Modeling Analysis portion of this submittal. This nonattainment area was based on U.S. EPA's technical support document entitled *Ohio Area Designations For the 2010 SO2 Primary National Ambient Air Quality Standard,* submitted to the State of Ohio on July 25, 2013.

Determining Sources to Explicitly Model

Refer to the General Modeling Protocol.

Utilizing the procedures described in the General Modeling Protocol document of this submittal, Ohio EPA determined that the following sources were to be explicitly modeled in the Steubenville, OH-WV nonattainment area.

Facility ID	SO2
	2011 TPY
Cardinal Power Plant	25,122.43
Mingo Junction Energy Center	82.37 (2008)
Mingo Junction Steel Works	699.99 (2008)
Mountain State Carbon	696.79

These sources (Cardinal Power Plant and Mountain State Carbon) account for 99% of 2011 SO2 emissions in the nonattainment area. Note that Ohio EPA included in the final attainment strategy a future case control strategy for Mingo Junction Energy Center and Mingo Junction Steel Works. These facilities were not in operation in 2011, but were included in the final attainment plan based on facility outreach and potential future operations of these facilities. Further, it should be noted that in 2012, Cardinal began operation of advanced flue gas desulfurization (FGD) control equipment on Unit 3. Cardinal Units 1 and 2 have FGD equipment installed prior to 2011.

Receptor Grid

Refer to the General Modeling Protocol.

A total of 21,186 receptors were included in the modeling domain. Fenceline receptors were placed with 25 meters spacing. 50 meters spacing within a 1 km radius of each facility was used. 100 meters spacing was used within 2.5 km of each facility, 250 meters spacing was used within a radius of 5 km from each facility, and a 500 meters spacing was used if further receptors were needed. Given the number of sources in the nonattainment area, there is substantial receptor density in a majority of the area. Discrete receptors were also included at the locations of the eight ambient air quality monitors, as was done in the base case scenario. Given the complex terrain of the area, Ohio EPA utilized the higher-resolution 1/3 arc-second National Elevation Dataset within the AERMAP preprocessing module to determine the elevation of all receptors, sources, and buildings included in the nonattainment area.

Source Inputs

Baseline Emissions Including Federal Rules and Modeling of Additional Controls

Refer to the General Modeling Protocol.

Good Engineering Practice Stack Height

Ohio EPA, in accordance with Appendix W and the Nonattainment SIP Guidance modeled all sources at or below GEP stack height.

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

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 SO2 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

Ohio EPA modeled Cardinal Unit 3 as having a variable exit velocity and plume height based on ambient conditions. This is the result of the installation of controls and the venting of emissions through a cooling tower, and the methodology and rationale for this treatment is described in the *Source Configurations and Source Types* section of this document, below. Additionally, Ohio EPA modeled the fugitive emissions from the coke oven batteries at Mountain State Carbon (a less than 5,000 TPY facility) as buoyant volume sources with variable release heights, as determined using the BLP modeling platform and described in the *Source Configurations and Source Types* section of this document, below.

Source Configurations and Source Types

The Buoyant Line and Point Source (BLP) dispersion model was used in this analysis to provide more reasonable release parameters for input to AERMOD for the coke battery sources at Mountain State Carbon. This same approach was used historically to model these sources in support of PM10 modeling for Jefferson County. The BLP dispersion model was developed by Environmental Research and Technology Inc. (ERT) to address the unique transport, including the unique plume rise, and diffusion of emissions from buoyant line sources (e.g., coke battery roof vents). BLP is a preferred/recommended model for representing buoyant line sources per Appendix W.

BLP can simulate dispersion from line sources either using a single day of user supplied meteorological data or a full year of data prepared using the preprocessing utilities PCRAMMET or MPRM.

Modeling line sources in BLP requires the user to input the following parameters to assist in calculating dispersion: the average length, width and height of the building containing the line source, the line source width, the average separation between buildings containing the sources, and the average buoyancy parameter (which is a function of building length, line source width, exit velocity, and ambient and exit temperatures). In addition to these fixed parameters, the user must also specify the location (beginning and ending coordinates), the release height, the emission rate, and the base elevation of each line source modeled. BLP input parameters used in this analysis were consistent with those used for Batteries 1, 2, 3, and 8 at the Mountain State Carbon facility in the March 2007 PM10 SIP Modeling Report. As was the case in the previous PM10 modeling analysis, the default BLP code was modified to generate an output file containing information on hourly plume rise for each battery for use in developing input parameters to AERMOD.

One update made to the previous PM10 modeling analysis was to use more recent meteorological data in BLP, with a time period consistent with that used in the current AERMOD analysis (2007-2009 and July 2013 to June 2014). Meteorological data gathered at a site-specific tower (the same data set used in AERMET to generate inputs for AERMOD for the northern portion of the nonattainment area) were supplemented by hourly surface data collected at the Pittsburgh National Weather Service (NWS) station for use in the Meteorological Processor for Regulatory Models (MPRM) utility.[3] Daily mixing height data were generated for input to MPRM using EPA's Mixing Height Program with NWS surface and upper air data gathered at Pittsburgh. The site-specific meteorological data file was missing data on the following 10 hours: 10/6/2013 from 0900 to 1200 (4 hours); and 4/26/2014 from 1000 to 1500 (6 hours).

To ensure that a complete set of hourly plume rise values was available for use in AERMOD, a second set of meteorological data were generated using Pittsburgh surface and upper air data as input to PCRAMMET. These meteorological data were then used as input to BLP, using all other inputs identical to those used in the BLP runs using site-specific data. Plume rise values from these NWS meteorological data runs were then substituted into the final plume rise data set for those few hours missing site-specific meteorological data. The hourly plume rise values output by BLP using on-site meteorological data were used to generate an HOUREMIS file for input to AERMOD. The following outlines the characterization of the fugitive emissions from Batteries 1, 2, 3 and 8.

Battery 1, 2 and 3 Fugitives

Fugitive emissions from batteries 1, 2, and 3 were represented in AERMOD as five volume sources each, situated in series along each battery roof vent. The hourly-

[3] MPRM was used rather than PCRAMMET because MPRM has the ability to process non-airport meteorological data, such as that available in this case, while PCRAMMET does not.

varying release height for each volume source representing Batteries 1, 2, and 3 was calculated by adding 16.76 meters to the battery-specific plume rise output by BLP for each hour. This value is derived based on the height of the coal side car shed for Batteries 1, 2 and 3. The initial vertical dimension of each volume source was calculated by dividing the release height by 2.15, treating each volume source as an elevated source adjacent to a building (i.e., the coke battery structures). The initial lateral dimension of each Battery 1, 2, and 3 volume source was set at 5.33 meters, the distance between each volume source divided by 2.15.

Battery 8 Fugitives

Battery 8 fugitive emissions were represented in AERMOD as seven volume sources situated in series along the Battery 8 roof vent. The hourly-varying release height for each volume source representing the Battery was calculated by adding 13.72 meters, the approximate height of the Battery 8 structure, to the battery-specific plume rise output by BLP for each hour. The initial vertical dimension of each volume source was calculated by dividing the release height by 2.15, treating each volume source as an elevated source adjacent to a building (i.e., the coke battery structures). The initial lateral dimension of each Battery 8 volume source was 6.84 meters, the approximate distance between each volume source divided by 2.15.

On a March 16, 2015 call with Ohio EPA, representatives from U.S. EPA Region 5 indicated that the above methodology for the treatment of sources of this type was generally acceptable for inclusion in a SIP submittal. Further, these sources, in total, have an allowable emission rate of 34.25 tons SO2 per year and are, therefore, highly unlikely to impact modeled design values in a significant manner.

Ohio EPA worked closely with modelers and engineers at Cardinal Power Plant to characterize the release point of Unit 3. This is partially a translation of the previous CALPUFF parameterization for this unit performed for the Permit to Install modeling of Flue Gas Desulfurization (FGD) equipment to AERMOD. However, the parameterization was updated significantly using new engineering data that was not available prior to the operation of the Unit 3 FGD/cooling tower release point. The details of the parameterization of Cardinal Unit 3 for AERMOD modeling is provided as Appendix A of this modeling protocol.

Urban/Rural Determination

Ohio EPA classified all sources in the Steubenville, OH-WV nonattainment area with respect to URBAN or RURAL settings based on engineering judgment and several other factors. Firstly, recent modeling performed in support of PM10 analysis treated all sources in the area as RURAL sources. 2010 census data indicates that the overall population density for the Steubenville-Weirton area is 683 people/km^2, and the population is projected to decrease by approximately 1 to 1.2% by 2012. It is, therefore, highly unlikely, given the location of those sources explicitly modeled in industrialized areas, to have a population density of 750 people/km^2 or greater. For these reasons,

Ohio EPA determined that the sources explicitly modeled in the Steubenville, OH-WV nonattainment area represent RURAL sources.

Source Groups

Refer to the General Modeling Protocol.

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[4], a document created to provide guidance to consultants, facilities with respect to modeling, provides a recommended meteorological station for each county in Ohio. Further this guidance indicates that on-site meteorological data, when available, is preferred to NWS data. Multiple datasets of on-site meteorological data were available for sources explicitly modeled in the Steubenville, OH-WV nonattainment area. Three years of on-site data collected at Mountain State Carbon for the 2007-2009 period were available, as well as a one-year period from July 1, 2013-June 30, 2014 (herein referred to as the "split year"). Additionally, Cardinal maintains and operates three meteorological stations. These stations did not begin operation until 2011. Further, the meteorological station located at Mountain State Carbon was not in operation for an extended period of time between 2009 and 2013. Thus, a split year time period was utilized for a majority of the modeling analyses in this area, as it represents a common period when both Cardinal and Mountain State Carbon were collecting meteorological data. This use of separate meteorological data sets is necessary given the unique discharge and parameterization associated with the Cardinal Unit 3 cooling tower emissions, described in this document. The use of a split year meteorological dataset, and the use of separate site-specific meteorological data, is consistent with both the Nonattainment SIP Guidance and Appendix W. The following describes the specific details used to collect, process, and use the various on-site meteorological datasets available for this area.
Multi-level tower and SODAR (Sonic Detection and Ranging) measurements from Mountain State Carbon's Follansbee, WV facility were utilized to develop AERMOD-ready meteorological data to be used in the dispersion modeling analysis for the northern extent of the nonattainment area. The raw observational data consisted of on-site tower measurements, on-site SODAR measurements, surface and upper air data from the Pittsburgh, PA National Weather Service (NWS) site and precipitation data from the Steubenville, OH station over the period from 7/1/2013 through 6/30/2014. The data were processed through the latest versions of the meteorological pre-processor, AERMET (v14134) and its various components (AERSURFACE v13016 and AERMINUTE v14337). The procedures utilized in the data processing of this split year meteorological dataset were generally performed using the following U.S. EPA guidance documents:

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

- U.S. EPA's *AERMET User's Guide Addendum* (Updated May 6, 2014)
- U.S. EPA's *AERMINUTE User's Guide* (Revised December 3, 2014)

On-site measurements from a tower and SODAR located near Mountain State Carbon's facility formed the basis for the surface data processing and were provided by Mountain State Carbon. The tower collects temperature, wind and solar radiation measurements at levels ranging from 2 meters (m) to 50 m above ground level. The SODAR collects wind measurements at levels ranging from 80 m to 260 m above ground level. As discussed in the *AERMET User's Guide Addendum*, AERMET preferentially utilizes the on-site measurements wherever available. If all of the on-site measurements are missing for a given hour, AERMET then looks for surface observations from a user-specified NWS/FAA surface station location; Pittsburgh, PA (WBAN ID: 94823) in this case. Per the guidance, surface stations with 1-minute ASOS wind data are preferred for this process to alleviate numerous calm and/or variable wind observations present in the routine hourly observations. In the absence of on-site wind data for a given hour, the routine processed ASOS hourly observations from the surface station are then utilized.

To complete the surface data processing, the formatted on-site tower data file along with the 1-minute ASOS data and hourly surface data from Pittsburgh, PA were utilized. The 1-minute ASOS data from Pittsburgh were then processed through AERMINUTE. In order for AERMINUTE to interpret observations from ice-free wind sensors, an installation date of July 28, 2009 was included in the AERMINUTE processing. Once the AERMINUTE processing was completed, the Stage 1 AERMET processing was performed for the on-site and hourly surface data observations. Stage 2 processing was then completed to assimilate the 1-minute ASOS data and merge all of the records together.

Upper air radiosonde data from the same data period (7/1/2013-6/30/2014) taken from the Pittsburgh, PA radiosonde site were input during the Stage 1 AERMET processing and then the merged in Stage 2 of AERMET processing.

Stage 3 processing in AERMET requires the user to input surface characteristics (albedo, Bowen ratio, and surface roughness) which are a function of land use and precipitation. The AERSURFACE program currently uses gridded land use data from the 1992 version of the National Land Cover Database (NLCD 92)[5] in order to determine appropriate land use characteristics for the area surrounding the surface station location(s). In cases where on-site tower observations are used, AERSURFACE is run for the tower location. As previously discussed, when all the on-site observations are missing for a given hour, the NWS surface data are substituted in the processing. As such, AERSURFACE must also be run for that station location, so that the appropriate land use characteristics are paired with the correct surface observation. In the case of the 7/1/2013-6/30/2014 data period, there were only 4 hours where the on-site data were all missing, each of which had 1-minute ASOS wind observations.

[5] Data obtained from online data viewer: http://www.mrlc.gov/viewerjs/

U.S. EPA default settings in the AERSURFACE data processing were used to generate surface characteristics for both the Follansbee tower location (40.338N, 80.599W) and Pittsburgh surface station (40.485N, 80.214W) to input in Stage 3 of the AERMET processing. Those settings pertain to both the seasonal distribution of land use data as well as the wind direction sectors over which land use categories are evaluated. The default settings are for the seasons to correspond to their calendar months and for twelve wind sectors, consistent with Ohio EPA precedence and the General Modeling Protocol. In order to estimate the Bowen ratio, actual monthly precipitation totals from the Steubenville, OH observation site (GHCND: USC00338025), which is near to and representative of the Steubenville, OH-WV nonattainment area, were utilized. Those actual monthly precipitation totals were then compared to their 30 year climatological norms in order to determine if a given month was relatively dry, average or wet from a precipitation standpoint. AERSURFACE was run 3 separate times to generate land use characteristics for each precipitation condition, so that the combined AERMOD-ready file would contain the appropriate Bowen ratios for each month of data.

On-site meteorological data were also available for the 2007-2009 period. This data was made available by Mountain State Carbon. During this time period, SODAR measurements were not available. This data was processed using the procedures described above. However, data completeness was well over 90% for each of the three years, and no substitutions from the Pittsburgh surface station were deemed necessary.

On-site meteorological data collected at the Cardinal Power Plant was supplied to Ohio EPA by American Electric Power. The processing of this meteorological data for use as input to AERMOD is described below.

The surface meteorological data selected for this study was taken from a combination of monitor site number 39-081-002 from Cardinal Power Plant's approved monitoring network, also known as the Dam Site, and the Wheeling Ohio County Airport for the period July 1, 2013 to June 30 2014. The Dam Site provided a complete data set for the 2m and 10m temperature, wind direction, wind speed, and solar radiation. The cloud cover, pressure, and relative humidity data were obtained from the National Climatological Data Center (NCDC)[6] for Wheeling Ohio County Airport. Data was also obtained from NCDC for the Greater Pittsburgh International Airport meteorological site for use in data substitution should the Dam and Wheeling Airport sites both have missing data for a given hour. These sites were chosen as the most climatologically representative surface locations for Cardinal Power Plant.

Missing data substitution was performed following a step-wise procedure for the Dam Site. If a parameter was missing, the Wheeling Ohio County Airport data was examined to determine if the parameter was present for the missing hour. If it was, that value was substituted. If this did not result in obtaining valid data for the missing parameter, the Greater Pittsburgh International data was examined to determine if valid data was

[6] ftp://ftp.ncdc.noaa.gov/pub/data/noaa

present. If this step did not result in valid data being available, the U.S. EPA Guidance[7] method for the substitution of missing data was followed. Missing data for parameters sourced from the Wheeling Ohio County Airport followed the process starting with the Greater Pittsburgh International Airport step. Once the data substitution steps were completed, the overall surface data set was placed into a comma-separated values (csv) format file ready for input into the AERMET module.

One-minute data was obtained from the NCDC[8] for Wheeling Ohio County Airport for the months of June 2013 through July 2014. This data was processed into a single file suitable for use in AERMET using AERMINUTE version 14237. Upper Air data was obtained for the same time period as the surface data from the NOAA/ERSL Radiosonde Database[9] for the Greater Pittsburgh International Airport site. This data set had limited missing data that required substitution. Table 11 shows the dates and substitutions made in this data set.

Date/Time and Missing Elements	Substitution
08/03/13 @ 1200 UTC – 500 mb data missing	Professional judgment based on previous two and following two readings
08/16/13 @ 1200 UTC – 500 mb Wind Speed and Wind Direction missing	Professional judgment based on previous two and following two readings
12/13/13 @ 1200 UTC – No Data reported	Professional judgment based on previous two and following two readings for critical levels only
12/16/13 @ 0000 UTC – No Data reported	Professional judgment based on previous two and following two readings for critical levels only
12/18/13 @ 1200 UTC – No Data reported	Professional judgment based on previous two and following two readings for critical levels only
12/25/13 @ 1200 UTC – No Data reported	Relatively consistent conditions allowed use of reading before and reading after data to generate data for the critical levels

Table 11: Data Substitutions made to the Greater Pittsburgh International Airport Radiosonde Data.

No further processing beyond the filling of the missing data was required to prepare the data for use in AERMET.

This data was ultimately processed into model-ready form using AERMET version 14134. The surface data was entered into Stage 1 of AERMET in free form in order to accommodate the on-site data. The 1-minute data was utilized in Stage 2 to backfill the surface data during times of calm winds. The surface parameters used in the Stage 3 processing of AERMET were developed for the Dam Site and Wheeling Airport surface sites using the AERSURFACE preprocessor over a 1 kilometer radius divided into 4

[7] Atkinson, Dennis and Lee, Russell, Procedures for Substituting Values for Missing NWS Meteorological Data for Use in Regulatory Air Quality Models, USEPA, Research Triangle Park, NC, 1992.
[8] ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin/
[9] http://esrl.noaa.gov/raobs/

manually selected sectors for both locations. The sectors were chosen based on manual inspection of the land use within 1 kilometer of the monitoring location. Precipitation data used to determine the dry, average, or wet classification for the specific month was obtained from the PRISM CoCoRaHS Climate Portal[10] based on the Dam Site, since it is the primary site being used to supply the meteorological data and is the closest site to the Cardinal Plant. Wet surface values were used anytime the monthly precipitation values were greater than 20% of the 30 year average precipitation and dry values were used for months where the monthly precipitation values were less than 20% of the 30 year average precipitation. Table 12 shows the data used in making this determination.

Month	30 Yr Average	Monthly Precipitation	Classification
July 2013	4.22	5.86	Wet
Aug 2013	3.48	1.81	Dry
Sept 2013	3.34	2.07	Dry
Oct 2013	2.73	2.42	Avg
Nov 2013	3.30	3.46	Avg
Dec 2013	2.85	3.59	Wet
Jan 2014	2.81	2.08	Dry
Feb 2014	2.29	2.65	Avg
Mar 2014	3.02	2.01	Dry
Apr 2014	3.44	4.02	Avg
May 2014	4.17	4.70	Avg
June 2014	4.22	4.53	Avg

Table 12: Precipitation data used in determining monthly moisture classification for AERMET.

Background Concentrations

Ohio EPA considered background concentrations of SO2 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 SO2 monitoring network is extensive, there are few SO2 monitors not sited specifically to monitor

[10] http://cocorahs.nacse.org/index.php?&, last checked April 1, 2015.

facility-specific impacts. This is especially true in the nonattainment areas modeled for this submittal.

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 representative of the nonattainment area, Ohio EPA considered and applied multiple approaches, including the elimination of readily identifiable source-specific impacts, statistical analysis of available monitoring data to determine conservative and appropriate background concentrations. Ohio EPA did not consider the use of temporally varying backgrounds, but instead added background concentration directly to modeled design values.

Source-oriented impacts and the lack of a regional background monitor are major obstacles in determining a background concentration for the Steubenville, OH-WV nonattainment area. This is further complicated by the large number of facilities shutting down entirely, installing controls, or sharply curtailing operations. Ohio EPA estimates that between 2008 and 2013, actual emissions from sources not explicitly included in Ohio's modeling located the surrounding counties of Jefferson, Harrison, and Belmont Counties in Ohio and Marshall, Ohio, and Brooke Counties in West Virginia decreased by a factor of approximately 7 (152,824 TPY in 2008, 21,904 in 2013). This sharp decrease in emissions has undoubtedly reduced background concentrations contributing to the nonattainment area monitors and should be reflected in the background determination for the Steubenville, OH-WV nonattainment area.

Ohio EPA established a background concentration for the Steubenville, OH-WV nonattainment area using ambient air quality data collected at the four AQS monitors in the area. No regional monitors were available for this area, and data collected at each of these monitors demonstrate strong and readily identifiable source-oriented impacts. Following Appendix W and the Nonattainment SIP Guidance, Ohio EPA conducted a background analysis using the following methodology, for years 2007-2009 and 2010-2012.

1. Hourly monitoring data were collected for each monitor from AQS.

2. Representative meteorological data for the same time period was collected.
3. Using a 90° sector centered on each monitor and the closest facility, concentrations recorded during hours when wind directions originate from this sector were eliminated.
4. The average concentration at each monitor from these abbreviated datasets were determined.

The results of this analysis are shown in Table 13, below.

Monitor ID	2007-2009 Average SO2 (ppb)	2010-2012 Average SO2 (ppb)
54-009-0005	8.2	4.8
39-081-0017	3.4	3.5
54-009-0007	8.6	5.2
54-009-0011	8.4	5.1

Table 13: Average monitor values corrected for facility impacts, 2007-2009 and 2010-2012.

Ohio EPA conservatively chose to eliminate from further background analysis the results obtained for the 2010-2012 period to maintain conservatism in the background determination.

In addition to the four AQS monitors located in the northern portion of the nonattainment area, a network of four monitors is maintained by the Cardinal Power Plant. These monitors began collecting data in 2011 as part the Permit-to-Install process for the scrubber/cooling tower configuration at Cardinal Unit 3. These monitors are located in the southern portion of the nonattainment area, and should represent sources not explicitly modeled but potentially impacting the nonattainment area. In consultation with American Electric Power, Ohio EPA very conservatively represented the 95th percentile of maximum daily values at the Cardinal monitoring network as representative of periods when emissions from Cardinal are not impacting the monitors. Given that these monitors were sited specifically to monitor emissions from Cardinal, it is highly unlikely that the 95th percentile is reflective of periods when Cardinal is not impacting these monitors to some degree, and as such, this is considered by Ohio EPA to represent an additional measure of conservatism in the background determination. Table 14 below shows the 95th percentile for years 2011-2014 at each of the four Cardinal network monitors.

Monitor ID	2011 95th Pctile (ppb)	2012 95th Pctile (ppb)	2013 95th Pctile (ppb)	2014 95th Pctile (ppb)
54-009-6000	9	5	3	6
39-081-0020	9	7	6	6
39-081-0018	11	10	9	9
Unit 3 Monitor	10	8	7	4

Table 14: 95th percentile values, Cardinal monitoring network, 2011-2014.

To derive a final background concentration that is both conservative and reflective of the large decrease in emissions in the nonattainment area and surrounding Counties, Ohio

EPA averaged the 2007 to 2009 average SO2 concentrations (less facility specific impacts) for monitors 54-009-0005, 54-009-0007, and 54-009-0011 (excluding monitor 39-081-0017 to maintain conservatism), with the 2011 and 2012 95th percentile values from the Cardinal monitor network. Ohio EPA excluded the 2013 and 2014 data from the Cardinal network to maintain conservatism. The resultant background of 8.1 ppb is similar to those values observed in the 2007-2009 period at the AQS monitors, and well above those observed at these monitors for the 2010-2012 period. Further, this value is well in line with conservative 95th percentile values at the Cardinal monitors. Ohio EPA concludes that this background is both conservative with respect to observed monitor data and is reflective of the large decrease in emissions from the nonattainment area and surrounding Counties.

Determining Design Value Metrics

Refer to the General Modeling Protocol.

The Nonattainment SIP Guidance allows for the flexibility to perform separate AERMOD runs in situations where the simultaneous modeling of all explicitly modeled sources is not possible, as was the case in the Steubenville, OH-WV nonattainment area. 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”. Ohio EPA applied this recommendation for specific modeling analyses. In these situations, Ohio EPA includes those POSTFILES with the relevant modeling input and output files.

Documentation

Ohio EPA is providing as part of this SIP submittal all necessary information, including the following elements specifically enumerated in the Nonattainment SIP Guidance.

- Characterization of the nonattainment problem or characterization of the modeled area in absence of a violating monitor.
- An emissions analysis around the violating monitor or area under consideration for the attainment and maintenance demonstration in absence of a violating monitor.
- Description of any other supplemental analyses (in addition to the characterization and emissions analyses noted above) intended to strengthen the attainment demonstration.
- Methodology for preparing air quality and meteorology inputs including choice of meteorological data and representativeness of the data.
- Summary and analysis of modeling results.
- Modeling data inputs and outputs in electronic form.
- Results of any supplemental analyses.

Supplemental Analysis

The Nonattainment SIP Guidance indicates states may choose to include additional analyses that examine monitoring data, meteorological data, and other datasets relevant to the nonattainment area to supplement modeling analyses and to assess control strategies in their SIP submittal. Ohio EPA has incorporated multiple analyses of such data to support and/or supplement modeling analyses in the Steubenville, OH-WV nonattainment area based on this guidance. The details and results of these supplemental analyses are presented in the Steubenville, OH-WV Dispersion Modeling Analysis portion of this submittal.