

Attachment 2

Modeling Protocol for
Duke Energy Carolinas, LLC – Belews Creek
Steam Station

Duke Energy
Belews Creek Generating Station

Modeling Protocol
For 1-hour SO₂ National Ambient Air
Quality Standard (NAAQS)

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1.0 Purpose

On June 2, 2010 USEPA issued a final rule that revised the SO₂ National Ambient Air Quality Standard ¹. The revised SO₂ standard is 75 ppb based on a three year average of the 99th percentile of the daily maximum hourly concentration. On August 21, 2015 EPA issued the Data Requirements Rule ² (DRR) to implement the new standard. The DRR requires all sources of SO₂ greater than 2,000 tons/year to characterize the SO₂ concentrations where the sources are located using either a modeling or monitoring approach. Duke Energy is requesting that the North Carolina Department of Air Quality (NCDAQ) allow Belews Creek Generating Station to demonstrate attainment for the 1 hour SO₂ NAAQS based on a modeling approach.

The NCDAQ has requested that Duke Energy submit an air quality modeling protocol for Belews Creek Generation Station to help facilitate compliance with the DRR. The modeling protocol includes procedures used to setup the modelling analysis including; model selection, receptor grid, emission dataset, nearby sources, meteorological data and background concentrations.

2.0 Plant Information

Belews Creek Generating Station is a 2200 MW coal fired power plant located in Stokes County North Carolina, which consists of two generating units (EU01 and EU02). These power generating units are pulverized coal fired boilers with a nominal maximum rated heat input capacity of 12,000 MMBtu/hr each. These coal fired boilers are equipped with multiple control devices to control the emissions of pollutants regulated under various Federal and State air pollution control programs. These controls consist of: an electrostatic precipitator, low NO_x burners, hydrated lime injection, wet flue gas desulfurization (WFGD), and selective catalytic reduction (SCR). The plant also operates two (2) fuel oil fired auxiliary boilers, emergency engines, and material (coal, ash limestone, hydrated lime) handling operations to support the coal fired boiler. All the air emitting sources at the station are covered by Title V Operating Permit 01983T29 issued 1/28/2015.

The Belews Creek Generating Station is located on Belews Lake near the town of Walnut Cove North Carolina. A topographic map and aerial map of the facility and surrounding area are provided in Figures 1 and 2. These maps show the predominant geographical features such as terrain, buildings, roads, and water bodies surrounding the plant.

¹ Primary National Ambient Air Quality Standard for Sulfur Dioxide 75 FR 35520–35603, Jun 22, 2010

² Data Requirements Rule for the 1-Hour Sulfur Dioxide (SO₂) Primary National Ambient Air Quality Standards (NAAQS): Proposed Rule, Federal Register Vol. 79 No. 92, pages 27445-27472, May 13, 2014.

Figure 1- Topographic Map

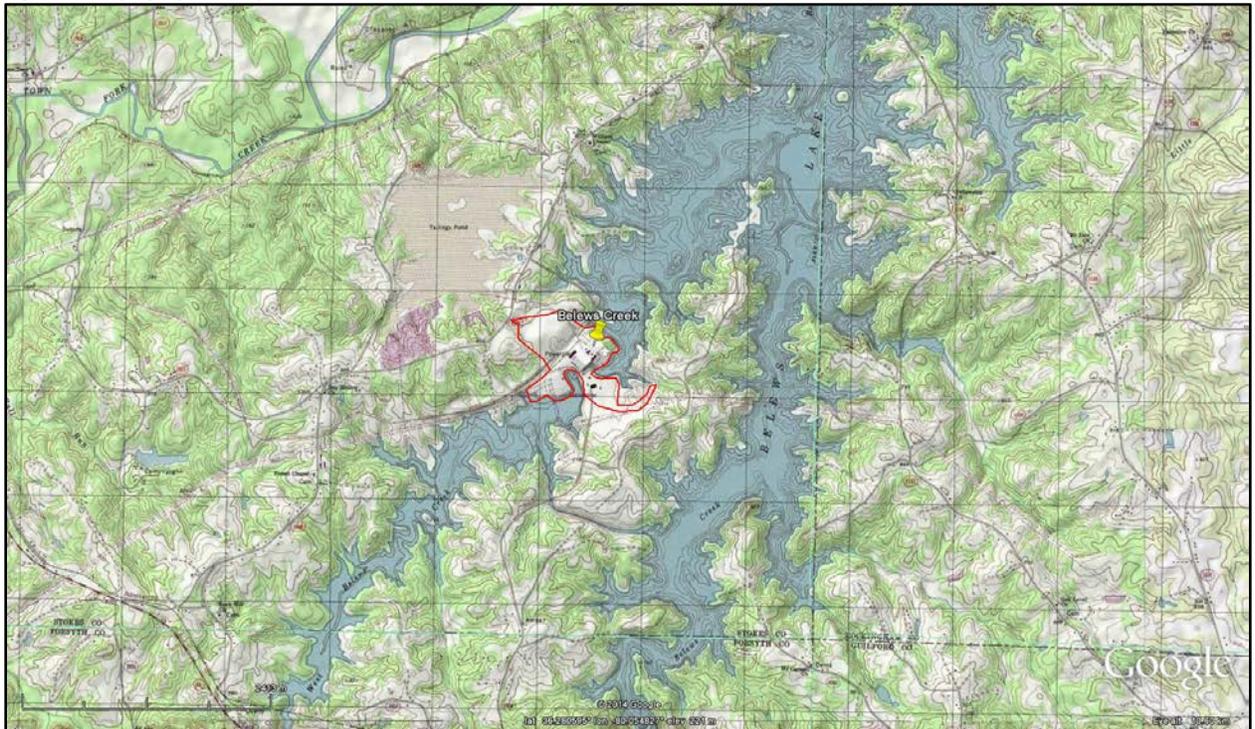


Figure 2 - Aerial Photo



3.0 Modeling Approach

The modeling analysis will follow the procedures described by the EPA in the Data Requirements Rule and modeling TAD³. The dispersion modeling analysis will be used to evaluate the attainment status of the area in the vicinity of Belews Creek Station for the 1 hour SO₂ NAAQS. The DRR allows the use of modeling rather than monitoring to make attainment designations. Air Quality Modeling provides a conservative estimate of the actual air quality within the vicinity of the plant. As recommended the modeling analysis will use the preferred model AERMOD. In addition, to allow for a more accurate representation of actual ambient SO₂ concentrations, the modeling analysis will be conducted as follows:

- Using actual emissions as an input for assessing current actual air quality;
- Using three years of modeling results to calculate a design value consistent with the 3-year monitoring period required to develop a design value for comparison to the NAAQS;
- Placing receptors for the modeling only in locations where a monitor could be placed; and
- Using actual stack heights rather than following the Good Engineering Practice (GEP) stack height policy when using actual emissions.

The following sections provides an overview of the modeling procedures to be used for Belews Creek.

4.0 Model Selection

The modeling analysis for the 1 hour SO₂ NAAQS will be performed using AERMOD version 15181, and pre-processing program, AERMAP (version 11130). The modeling analysis will account for building down wash. The BPIPPRIME (version 04274) will be used to input building parameters for AERMOD. This modeling analysis will be run using the regulatory default options. The pollutant identification was set to “SO₂”in AERMOD, to allow AERMOD to properly calculate an SO₂ design value based on the 3-year average of the 99th percentile of the annual distribution of the daily maximum 1-hour concentrations for comparison with the 1-hour SO₂ NAAQS of 75 ppb (196 ug/m³).

³ SO₂ NAAQS Designations Source-Oriented Modeling Technical Assistance Document, draft, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 2013.

5.0 Rural or Urban Dispersion

Duke Energy has determined that modeling for this area would most appropriately use the rural dispersion mode. The procedure in section 7.2.3 of Guidelines on Air Quality Models Appendix W, were used to determining if the area is rural or urban. This procedure classifies land use within an area circumscribed by a circle, centered on the source, with a radius of 3 kilometers. If Auer land use types I-1, I-2, C-1, R-2, and R-3 account for 50 percent or more of the land use within 3 kilometers of the source, then the modeling regime is considered urban.

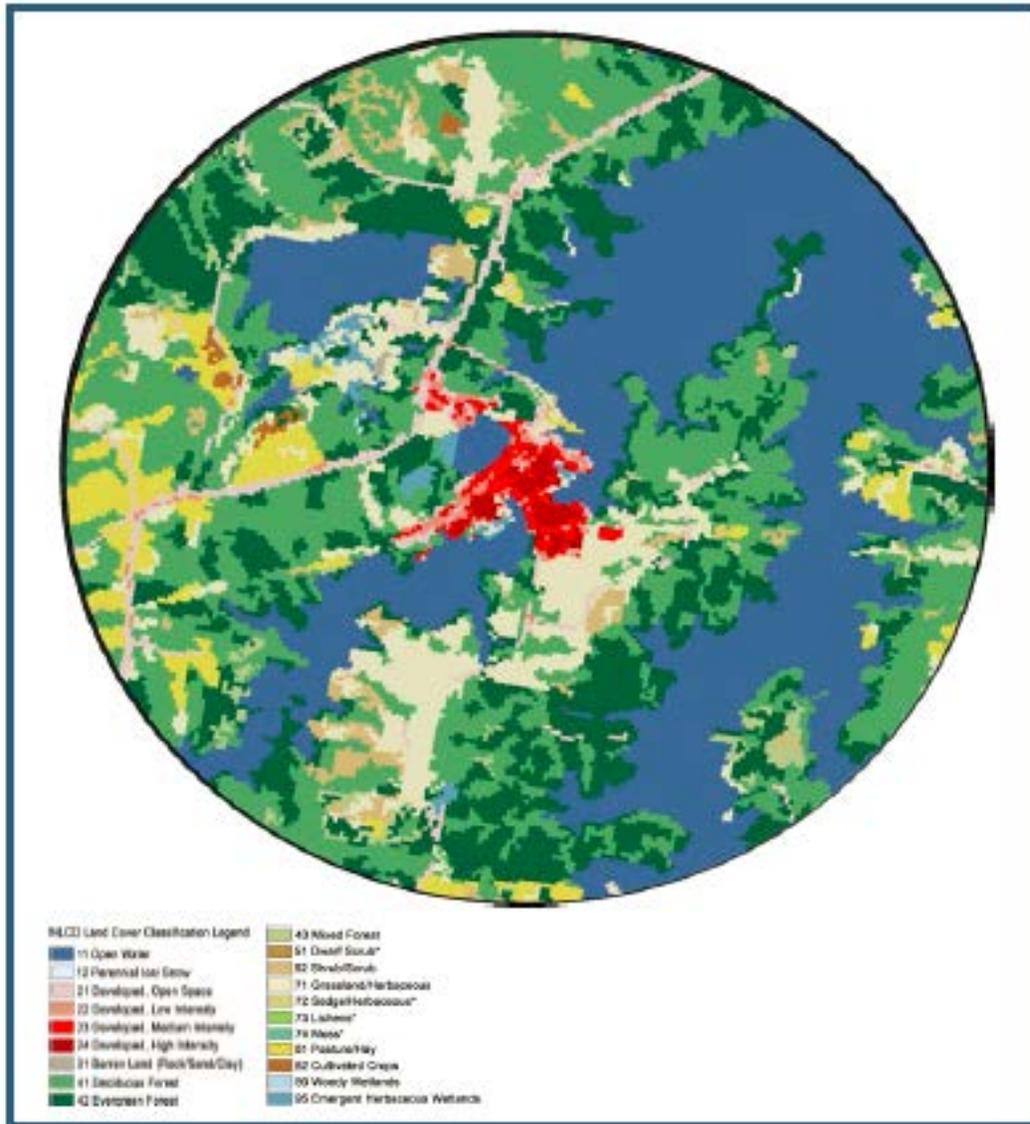
Following EPA’s guidance the 2011 land use was obtained from USGS⁴. A 3 km radius around the plant was downloaded. Table 1 shows the 2011 and corresponding AUER land cover categories. Figure 3 displays a map of 2011 land use categories within the 3 km radius of Belews Creek. This map clearly indicates that the area surrounding Belews Creek is predominately rural, consequently the rural dispersion mode will be used in the modeling analysis.

Table 1 Land Cover Classification

2011 NLCD Land Cover Classification		Auer Land-Use Classification		Modeling TAD Rural or Urban
11	Open Water	A5	Water Surfaces	rural
12	Perennial Ice/Snow	A5	Water Surfaces	rural
21	Developed, Open Space	A1	Metropolitan Natural	rural
22	Developed, Low Intensity	R1	Common Residential	rural
23	Developed, Medium Intensity	I1, I2, C1, R2, R3	Industrial/Commercial/Compact Residential	urban
24	Developed, High Intensity	I1, I2, C1, R2, R3	Industrial/Commercial/Compact Residential	urban
31	Barren Land	A3	Undeveloped (Grasses/Shrub)	rural
41	Deciduous Forest	A4	Undeveloped (Wooded)	rural
42	Evergreen Forest	A4	Undeveloped (Wooded)	rural
43	Mixed Forest	A4	Undeveloped (Wooded)	rural
52	Shrub/Scrub	A3	Undeveloped (Grasses/Shrub)	rural
71	Grassland/Herbaceous	A3	Undeveloped (Grasses/Shrub)	rural
81	Pasture/Hay	A2	Agricultural	rural
82	Cultivated Crops	A2	Agricultural	rural
90	Woody Wetlands	A1	Undeveloped (Wooded)	rural
95	Emergent Herbaceous Wetlands	A3	Undeveloped (Grasses/Shrub)	rural

⁴ <http://www.mrlc.gov/viewerjs/>

Figure 3 Belews Land Use



6.0 Building Downwash

EPA's Building Profile Input Program (BPIP) with Plume Rise Model Enhancements (PRIME) (version 04274), will be used to account for building downwash influences on the Boiler 1 and 2 plumes. Building downwash analysis is used to determine if the plume will be affected by the turbulent wake from onsite buildings or other structures. The effects of downwash on the plume can result in elevated ground-level concentrations in the near wake of a building and is required for consideration in the modeling. Building downwash will not be considered for other nearby sources included in the modeling analysis.

7.0 Belews Creek Stack Parameters

Belews Creek Generating Station operates two coal fired boilers. These coal fired boilers vent to individual stacks. Table 2 below summarizes the stack parameters that will be used in the modeling.

As recommended in the SO₂ modeling TAD, the actual hourly emissions data will be used in the modeling. The hourly emissions data will coincide with the meteorological data for the period 1/1/2012 thru 12/31/2014. The hourly SO₂ emissions measured by the continuous emissions monitoring system located on each of the boiler stacks will be used in the modeling analysis. The hourly SO₂ pounds per hour emission rate will be converted to units of grams per second. All the SO₂ emissions data was quality assured and missing data substituted using the Part 75 data procedures. The hourly data will be input into AERMOD using the HOUREMIS keyword in the source pathway of the AERMOD control file (AERMOD.INP).

Duke proposes to hold the stack exit velocity and temperature constant over the modeling period. The stack exit velocity of 15 m/s, reflects the exit velocity at maximum load and maximum SO₂ emissions rate. The stack temperature of 323.7 K reflects the normal stack temperature. The actual stack temperature remains relatively constant over the load range.

Table 2 Belews Creek Stack Parameters

Emission Unit	Description	UTM Northing (meters)	UTM Easting (meters)	Elevation (meters)	Stack Height (meters)	SO ₂ Emissions (g/s)	Stack Exit Velocity (m/s)	Stack Diameter (meters)	Stack Temp (k)
BC1	Unit 1 100% Load	584524.9	4015727.9	225.6	152.4	Varying	17.37	10.97	323.7
BC2	Unit 2 100% Load	584583.5	4015680.9	225.6	152.4	Varying	17.37	10.97	323.7

8.0 Intermittent Sources

Most other emitting sources at Belews Creek Station are associated with coal and ash handling, conveying, and transport and do not emit SO₂. The Belews Creek operates a number of emergency engines and two auxiliary boilers which operate infrequently and emit small quantities of SO₂. According to Section 5.4 of the modeling TAD, EPA states that it is most appropriate to include sources of emissions which operate continuous or frequent enough to contributed to the annual distribution of the daily maximum concentrations. Duke proposes that the emergency engines and two auxiliary boilers be considered intermittent sources and not specifically included in the modeling. The following section describe why these sources should be treated as intermittent sources.

8.1 Emergency Engines

There are a number of engines located at the stations. These engines are classified as emergency engines under the RICE MACT 40 CFR Part 63 Subpart ZZZZZ. The operation of these engines are limited to 100 hours per year for readiness checks and unlimited hours during an emergency situations such as a plant power outage, flood or fire. The actual operating hour for these engines are typically well less than the 100 hour. Table 3 shows the engines located at the station, hours of operation and the associated SO₂ emissions.

Table 3 Emergency Engines

Description	Permit ID	Fuel	hp	kW	2013 Oper. Hrs	2013 SO ₂ lbs
Emerg. Blackout generator	ES-4a	Diesel	-	2000	2	18.5
Emerg. Air compressor	ES-5(AC)	Diesel	525	-	27	47.0
Emerg. Quench pump	ES-23	Diesel	1610	-	22.3	135.0
Backup Emerg. Generator	ES-34	Diesel	37.1	-	0	0.0
Backup Emerg. Generator	ES-35	Diesel	365	-	0	0.0
Emerg. Fire Pump	ES-37	Diesel	440	-	48	41.1
Emerg. Water Pump	I-86	Diesel	36	-	114	8.4
Emerg. Water Pump	I-87	Diesel	36	-	458	33.8
Emerg. Generator	ES-36	Propane	13.7	4	28.7	0.0
Emerg. Generator	ES-EmGeLF	Propane	54	40	12	0.0

The emergency engines do not operate enough and do not have large enough emissions of SO₂ to contribute to the annual distribution of daily maximum 1-hour SO₂ concentrations, consequently Duke proposes that these sources were excluded from the dispersion modeling analysis.

8.2 Auxiliary Boilers

There are two #2 oil and propane fired auxiliary boilers located at the station. The heat input capacity for these boiler is 172 MMBtu/hr each. These boilers operate approximately 100 hours per years and are used for plant heating. The auxiliary boilers are used during startup of the coal fired boilers and on rare occasions used for plant heating when the temperature is very cold. The auxiliary boilers typically operate only when the coal fired units are offline. The emissions from the auxiliary boilers are vented to a common stack located on the boiler house building. The annual emissions and hours of operation from 2012-2014 are listed in table 4.

Table 4 Auxiliary Boiler

Year	AB3			AB4		
	SO ₂ Emission (Tons)	Fuel Oil Usage (Gal)	Operating Time (hours)	SO ₂ Emission (Tons)	Fuel Oil Usage (Gal)	Operating Time (hours)
2012	2.91	74,263	59.36	3.06	77,963	62.32
2013	1.76	44,833	35.8	3.07	78,247	62.55
2014	5.67	144,413	115.13	6.64	169,224	134.91

The Auxiliary Boilers do not operate enough and typically only operate during periods when the coal fired boilers are not in operation. Consequently the Auxiliary Boilers do not contribute to the annual distribution of daily maximum 1-hour SO₂ concentrations, and were excluded from the dispersion modeling analysis.

9.0 Nearby Emissions Sources

Other sources of SO₂ emissions in the area surrounding the Belews Creek Station will be included in the modeling as required to fully characterize the air quality in the area. The emissions inventory was obtained from NCDAQ for all sources of SO₂ in the inventory located within 25 km of Belews Creek Station.

According to the EPA March 1, 2011 Memorandum⁵ and the analysis presented at the 2011 EPA modeling workshop,⁶ selection of regional background sources should be focused on sources located within 10 kilometers from Belews Creek. According to the NCDAQ's Emissions Inventory for 2012-2014, there no other sources of SO₂ located within 10 km of the Belews Creek plant.

10.0 Receptor Grid

The size, spacing, and location of the receptor grid is unique to the modeling analysis. The receptor grid will take into account the location of the sources to be modeled, terrain features, and areas where the public generally have access. In accordance with the modeling TAD, a receptor will not be located in an area where it is not technically feasible to locate a monitor. In the case of Belews Creek Station no receptors will be placed on the Belews lake.

Receptor density will be setup to detect significant concentration gradient. Typically the receptor spacing is closer near the source and further apart farther from the source. Receptor elevations will be included in the modeling analysis. The receptor heights will be determined using 7.5 minute NEDs processed with AERMAP. Flagpole receptor height for this analysis will be set at 0 meters.

The grid receptor spacing for the area of analysis is as follows:

- Receptors along the fence line every 50 meters

⁵ http://www.epa.gov/scram001/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf

⁶ http://www.cleanairinfo.com/regionalstatelocalmodelingworkshop/archive/2011/Presentations/6-Thursday_AM/6-3_AB-3_Presentation_at_EPA_Modeling_Workshop.pdf,

- Receptors every 100 meters from fence line to 3 km
- Receptors every 250 meters from 3 km to 5 km
- Receptors every 500 meters from 5 km to 10 km
- Receptors every 1000 meter from 10 km to 20 km
- Receptors every 2000 meter from 20 km to 50 km

11.0 Meteorological Data

For the purpose of modeling for attainment designation demonstration, 3 years of National Weather Service (NWS) data will be used. The years used in the analysis will be 2012-2014. The NWS sites to be used in the analysis are spatially and climatologically representative of the Belews Creek Station. The NCDAQ has evaluated the meteorological data and recommended use Winston Salem as the surface station and Greensboro as the upper Air Station⁷.

Hourly surface meteorological data was obtained from the U.S. National Climatic Data Center (NCDC) for the Winston Salem (KINT) for 2012-2014 in the standard ISHD (integrated surface hourly data) format⁸. The hourly data was supplemented, as recommended by the U.S. EPA with TD-6405 format (so-called “1-minute”) wind data also from the KINT archives⁹ and processed using the latest version of the AERMINUTE pre-processing tool (version 14337). The “Ice-Free Winds Group” AERMINUTE option was selected for processing due to the fact that a sonic anemometer has been installed at KINT (on 6/25/2009).

In addition to surface meteorological data, AERMET requires the use of data from an upper air sounding to estimate mixing heights and other boundary layer turbulence parameters. Upper air data from the nearest U.S.NWS radiosonde equipped station was utilized in the modeling analysis. In this case, upper air data from the Greensboro (GSO, WBAN No. 13723) was obtained from the National Oceanic and Atmospheric Administration (NOAA) in FSL (Forecast Systems Laboratory) format¹⁰.

12.0 Land Use Analysis

AERMET also uses data derived for land use to calculate the surface roughness, Bowen ratio, and Albedo. The methodology outlined in Section 3.1.2 and 3.1.3 of the AERMOD Implementation Guide (AIG)¹¹ will be used with AERSURFACE (version 13016)¹² to

⁷ <http://deq.nc.gov/about/divisions/air-quality/air-quality-permits/modeling-meteorology/meteorological-data>

⁸ <ftp://ftp.ncdc.noaa.gov/pub/data/noaa/>

⁹ <ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin>

¹⁰ <http://www.esrl.noaa.gov/raobs/>

¹¹ US Environmental Protection Agency. 2015 “AERMOD Implementation Guide” revised August 3,2015.

determine Surface Roughness Length, Bowen Ratio and Albedo. AERSURFACE read land cover data obtained from the USGS and converts this data to the surface parameters listed above.

AERSURFACE setting will be set using the location coordinates for the NWS site (KINT), month delineation, seasonal defaults, 12 sectors of 30 degrees each, and airport location is checked yes. AERSURFACE will be run with the above setting for wet, dry and average surface moisture.

The monthly surface moisture at the NWS site will be classified as wet, dry or average based on a comparison of the months precipitation total to the 30 year precipitation data. This determination is used to adjust the Bowen ratio estimated by AERSURFACE. Bowen Ratio is used in calculating convective mixing heights used in AERMOD. To make the moisture conditions determination, climatological records of the annual precipitation in each modeled year (2012-2014) will be compared to the 1985-2014 climatological record.

13.0 Background Concentrations

Background concentrations in the model results are important in determining the impacts from sources of SO₂ which are not explicitly included in the model. Background concentrations will be evaluated using the EPA's March 1, 2011 memo, "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO₂ Ambient Air Quality Standard." Duke Energy will consult with NCDAQ to determine the most appropriate monitoring site to use to determine the background concentration.

14.0 Comparison to Standard

The model will be set to output the annual 4th high daily maximum concentrations at each receptor using the MXDYBYR output option. The design value at each receptor will be calculated by averaging the annual 4th high daily maximum concentrations over the period from 2012-2014. The design values will be compared to the SO₂ standard of 196 ug/m³. As needed the model will be set to output the individual source contributions to the design value using the MAXDCONT output option.

Duke will provide NCDAQ with a report which discusses the results of the modeling analysis. In addition Duke will provide NCDAQ with input/out files necessary to validate the results of the modeling analysis.

Available online https://www3.epa.gov/ttn/scram/7thconf/aermod/aermod_implmntn_guide_3August2015.pdf

¹² U.S. Environmental Protection Agency. 2013. "AERSURFACE User's Guide." EPA-454/B-08-001, Revised 01/16/2013. Available Online: http://www.epa.gov/scram001/7thconf/aermod/aersurface_userguide.pdf