Attachment A:
Duke Energy
Belews Creek Generating Station

Modeling Report
For 1-hour SO_2 National Ambient Air Quality Standard (NAAQS)

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1.0 Executive Summary

Duke Energy is submitting this SO_2 modeling report performed for Duke Energy's Belews Creek Generating Station (Belews Creek) and the surrounding area. This work was undertaken in support of the North Carolina Division for Air Quality (NCDAQ) request regarding modeling for the 1-hour SO_2 National Ambient Air Quality Standard (NAAQS). Belews Generating Station has been identified by the NCDAQ as a source meeting the applicability criteria in the Data Requirements Rule (DDR)[1] for the 2nd round of SO_2 attainment designations. The DRR requires all sources of SO_2 greater than 2,000 tons/year to characterize the SO_2 concentrations where the sources are located using either a modeling or monitoring approach. Duke Energy's Belews Generating Station is demonstrating compliance with the 1-hour SO_2 NAAQS based on a modeling approach.

The dispersion modeling was conducted following the SO_2 NAAQS Designation Source Oriented Modeling Technical Assistance Document (TAD).[2] As allowed by this document, the actual hourly SO_2 emissions, stack temperature and exit velocity were used for the modeling Belews Creek utility boilers. The actual stack height was using in the modeling.

Sources located within 50 km of Belews Creek, were evaluated to determine if these sources need to be included in the modeling. Sources which are expected to cause a significant concentration gradient in the vicinity of Belews Creek were included in the modeling. Those sources that do not cause significant concentration gradients in the vicinity of Belews Creek were accounted for in the background concentrations. Based on this screening, Pine Hall Brick Co., Inc. and Wieland Copper Products, LLC were included in the modeling.

The background concentrations used in the modeling was obtained from the Forsyth County SO_2 monitor located 23 km southwest of Belews Creek. A conservative Tier 1 approach using the 2013-2015 design value from the Forsyth County SO_2 monitor was used in the modeling.

Based on this strategy, a modeling analysis was performed to characterize the hourly ambient SO_2 concentrations in the area surrounding Belews Creek Generating Station. The 1-hour SO_2 NAAQS is 196 $\mu g/m^3$ (75 ppb) based on the 99th percentile of the daily maximum 1-hour concentration averaged over three years. The modeling analysis showed the maximum 99th percentile of the daily 1-hour concentration averaged over 3 years, including background, to be

[1] *Data Requirements Rule for the 1-Hour Sulfur Dioxide (SO2) Primary National Ambient Air Quality Standards (NAAQS): Final Rule,* Federal Register Vol. 90 No. 162, pages 51052-51088, August 21, 2015.

[2] SO2 NAAQS Designations Source-Oriented Modeling Technical Assistance Document, draft, U.S. Environmental Protection Agency, Research Triangle Park, NC, August 2016.

98.5 μg/m^3. Therefore, this modeling demonstrates that the area surrounding Belews Creek should be designated as attainment for the 1-hour SO_2 NAAQS.

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 (ES01 and ES02). 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 vent out separate stacks and 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 January 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.

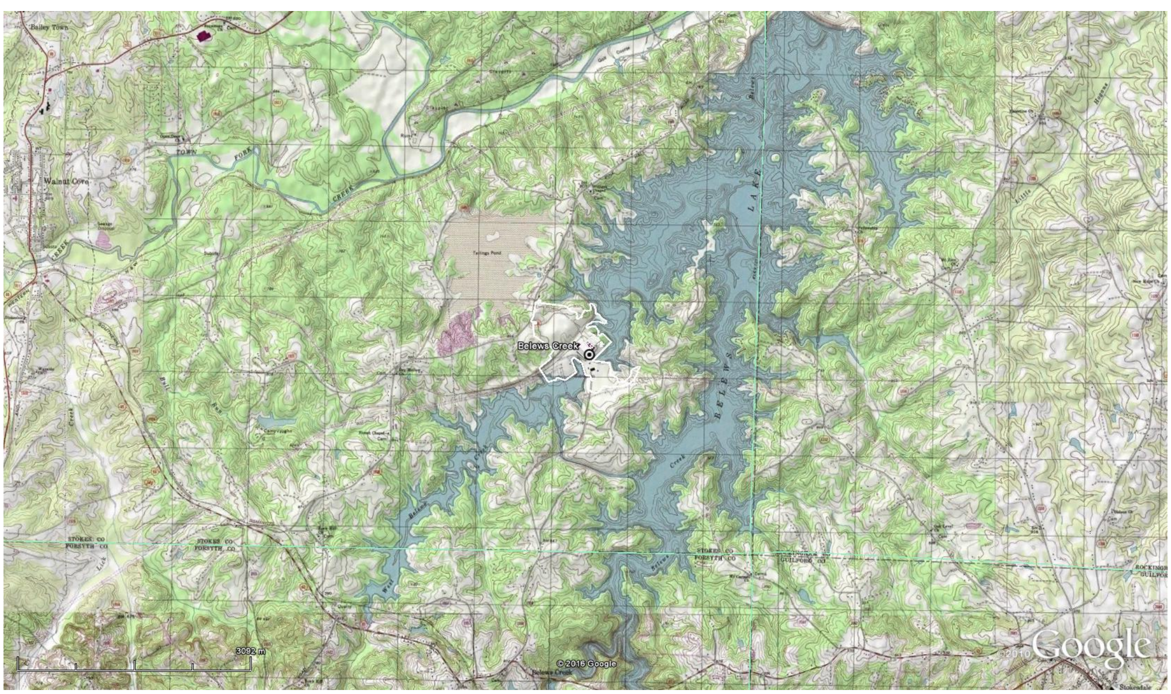

Figure 1. Topographic Map

Figure 2. Aerial Photo Showing Modeled Structures and Fenceline

3.0 Basis for Analysis

Under the DRR, NCDAQ has the option of installing an SO_2 monitor network or performing dispersion modeling to characterize the air quality around Belews Creek for the 1-hour SO_2 NAAQS. We are submitting this modeling report to assist in the designation process. This modeling analysis follows the methodology and guidance from the EPA's SO_2 NAAQS designation modeling guidance TAD and DRR. We believe that AERMOD modeling provides a conservative estimate of the actual ambient SO_2 concentrations.

As recommended this modeling analysis used the preferred model AERMOD.[3] In addition, to allow for a more accurate representation of actual ambient SO_2 concentrations, the modeling analysis was conducted as follows:

[3] http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod

- 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 and the GEP stack height when using allowable emissions.

The following sections provide an overview of the modeling procedures used for Belews Creek.

4.0 Model Selection

The modeling analysis for the 1-hour SO_2 analysis was performed using AERMOD (version 15181), and pre-processing program, AERMAP (version 11130). The modeling analysis accounted for building down wash using BPIPPRIME (version 04274). The regulatory default options were used in the modeling analysis. The pollutant identification was set to “SO_2”in AERMOD, enabling the output options to properly calculate an SO_2 design value based on the 3-year average of the 99^{th} percentile of the annual distribution of the daily maximum 1-hour concentrations for comparison with the 1-hour SO_2 NAAQS of 75 ppb (196 µg/m3).

5.0 Rural or Urban Dispersion

Duke Energy has determined that modeling for this area would most appropriately use the model in rural mode. The land use 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. The results of this analysis shows that the area is clearly rural.

6.0 Meteorological Data

For the purpose of modeling for attainment designation, 3 years of National Weather Service (NWS) data were used. The years used in the analysis were 2013-2015. The NWS sites used in the analysis are spatially and climatologically representative of Belews Creek.

As noted in the Modeling TAD, the selection of meteorological data was based on spatial and climatological (temporal) representativeness. More specifically, the representativeness of the data is based on: 1) the proximity of the meteorological monitoring site to the area under consideration, 2) the complexity of terrain, 3) the exposure of the meteorological site, and 4) the period of time during which data are collected. Representativeness was also based on availability of data meeting modeling application quality objectives and completeness criteria as specified by EPA guidance.[4]

There are two NWS surface monitoring sites located within 30 km of Belews Creek. The NWS site at the Greensboro Airport (KGSO) is located 23 km SE of Belews Creek, and the NWS site located at Winston-Salem Airport (KINT) is located 21 km SW of Belews Creek. Both sites have similar terrain, are located within the same vicinity of the station, have similar exposure, and therefore, are climatologically representative of Belews Creek. Spatial representativeness was analyzed in terms of land use representativeness, and is discussed in the following section. Note: The Greensboro site data is preferable in terms of higher data availability and proximity to the upper air site located at the Greensboro Airport. However, as discussed in the next section, AERMOD concentrations are relatively more sensitive to land use, and thus, determination of representativeness was based primarily on influences of land use on dispersion modeling parameters applied at Belews Creek.

6.1 Land Use Analysis

AERMET requires land use parameters to derive wind and temperature vertical profiles that directly influence the dispersive capacity of the atmosphere and resultant model concentrations. These land use parameters include surface roughness, Bowen ratio, and albedo. Surface roughness is more important to characterization of mechanical turbulence under stable atmospheric conditions (e.g., calm winds during daytime or nighttime), whereas Bowen ratio and albedo are more important to characterization of convective turbulence under neutral and/or unstable atmospheric conditions (e.g., windy, daytime). In general, AERMOD is formulated to predict higher concentrations under stable atmospheric conditions, and thus, surface roughness is generally the most important of the three land use parameters in terms of determining the highest hourly concentrations.

The methodology outlined in Section 3.1.2 and 3.1.3 of the AERMOD Implementation Guide (AIG)[5] was applied using AERSURFACE (version 13016)[6] to determine surface roughness, Bowen ratio and albedo. AERSURFACE reads digital land cover data obtained from the USGS. USGS land cover data inputs to AERSURFACE were taken from the National Land Cover Dataset 1992 (NLCD92). AERSURFACE converts this data to the surface parameters listed above. These surface parameters are ultimately used by AERMET and AERMOD in calculation

[4] U.S. Environmental Protection Agency. 2000. "Meteorological Monitoring Guidance for Regulatory Modeling Applications." EPA-454/R-99-005, February 2000.
[5] US Environmental Protection Agency. 2015 "AERMOD Implementation Guide" revised August 3,2015. Available online https://www3.epa.gov/ttn/scram/7thconf/aermod/aermod_implmtn_guide_3August2015.pdf
[6] 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

of hourly vertical wind and temperature profiles that are needed for calculation of hourly ambient concentrations at each receptor.

AERSURFACE processed NLCD land use data at three locations for comparison purposes: Belews Creek, Greensboro Airport, and Winston-Salem Airport. Each location was analyzed by AERSURFACE using the following options: seasonal defaults, 12 flow sectors of 30 degrees each, and airport location characterization for the Greensboro and Winston-Salem airport sites. Surface roughness was analyzed for each of the 12 flow sectors within a 1 km radius circular land use area. Albedo and Bowen ratio were analyzed based on a 10 km by 10 km square land use area centered on the surface site location. The surface moisture at the surface sites were classified as "average" based on comparison of the model period (2013-2015) monthly precipitation totals to the statistical distribution of 30-year precipitation data. The surface moisture classification is used to adjust the seasonal Bowen ratios estimated by AERSURFACE.

Some land use surface characteristics found at the selected airport meteorological stations are different than those found surrounding the model application site (Belews Creek Generating Station). Land use characteristics at the Greensboro site, Winston-Salem site, and facility are shown in Figures 3, 4, and 5, respectively, and highlight differences and similarities between the airport sites and Belews Creek. The EPA recommends that these differences be evaluated to determine representativeness of the surface characteristics and to determine influences of surface characteristics on model concentrations.[7] The EPA further recommends that consideration of surface roughness is most important due to model sensitivities to that particular parameter under stable atmospheric conditions. Differences between albedo and Bowen ratio are less significant than surface roughness in terms of influencing the highest hourly model concentrations due to the intrinsic role of albedo and Bowen ratio characterizing dispersion under neutral and/or unstable atmospheric conditions, when hourly model concentrations are expected to be relatively lower.

Differences in surface characteristics at the two airport sites and modeling application site were reviewed and compared to evaluate representativeness of the surface characteristics values. Seasonal albedo, Bowen ratio, and surface roughness values calculated by AERSURFACE at the Greensboro airport and facility for each flow sector are provided in Table 4. Table 5 shows similar information as calculated by AERSURFACE at the Winston-Salem airport and facility. As shown, the seasonal albedo and Bowen ratio values are similar across both airports and at the facility, and therefore, are not expected to bias model predictions during unstable and/or neutral atmospheric conditions. Therefore, albedo and Bowen ratio values taken from either airport land use dataset were expected to be representative at the facility. By contrast, dissimilar surface roughness values at both airports and at the facility were expected to play a more prominent role

[7] https://www3.epa.gov/ttn/scram/7thconf/aermod/aermod_implmtn_guide_3Aµgust2015.pdf, Section 3.1.

in determining representativeness, and ultimately, prediction of hourly concentrations from AERMOD during stable conditions.

The overall average surface roughness values at the Greensboro airport are lower than those at the facility. The surface roughness values at the Winston-Salem airport are higher than those found at the facility. The lower surface roughness values at the Greensboro airport are expected to influence decreased dispersion and higher model concentrations, based on AERMOD conservative formulations applied under stable atmospheric conditions. Thus, lower surface roughness values at the Greensboro airport introduce a degree of conservatism to the modeled concentrations predicted under stable atmospheric conditions whereas the higher values at the Winston-Salem airport would tend to increase dispersion and decrease hourly concentrations under similar meteorological conditions. Figures 6, 7, and 8 show surface roughness values at the Greensboro airport, Winston-Salem airport, and facility, respectively, for summertime when differences in surface roughness are greatest. The largest differences in surface roughness at the Greensboro airport compared to the facility occur in the northeastern and southwestern quadrants where there is notable disparity in the spatial distribution of land and water. The surface roughness values at Greensboro are generally lower than those found at Winston-Salem and the facility. These lower surface roughness values influence higher predicted concentrations during stable nighttime conditions, and therefore, demonstrated Greensboro surface data was conservatively representative of the upper distribution of hourly SO_2 concentrations needed for comparison to the 1-hour SO_2 NAAQS under DRR.

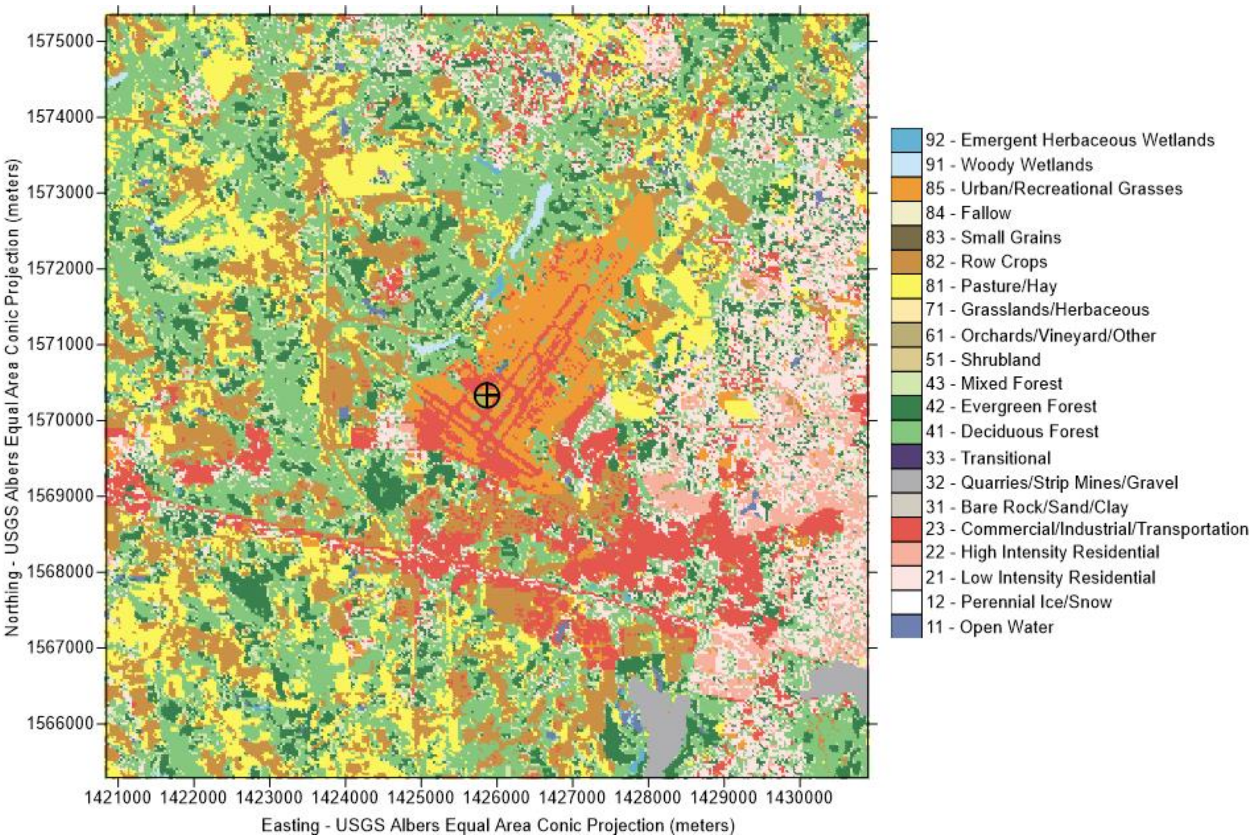

Figure 3. Greensboro Airport Land Use (10km x 10km Area)

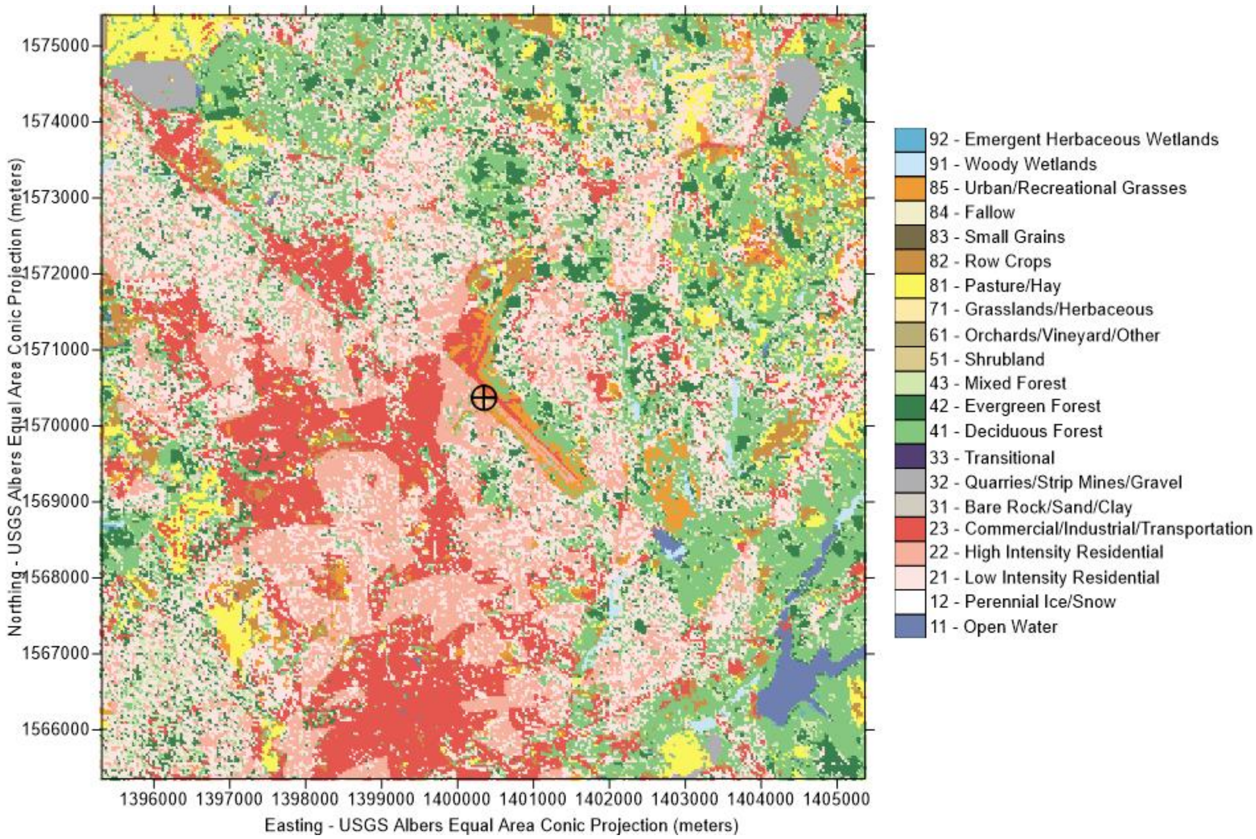

Figure 4. Winston-Salem Airport Land Use (10km x 10km Area)

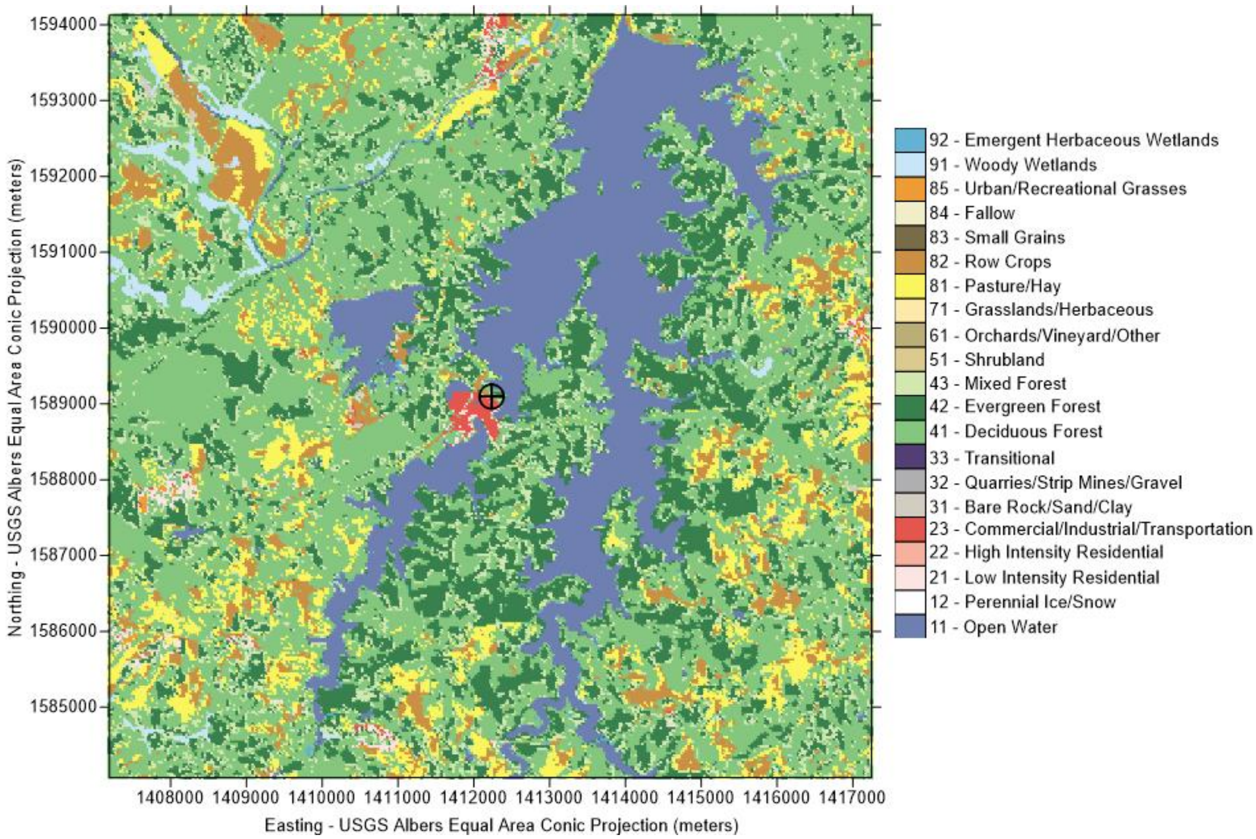

Figure 5. Belews Creek Land Use (10km x 10km Area)

Table 1. Greensboro Airport Surface Characteristics Comparison and Evaluation

		Greensboro Airport			Belews Creek Station		
Season	**Flow Sector**	**Albedo**	**Bowen Ratio**	**Surface Roughness (m)**	**Albedo**	**Bowen Ratio**	**Surface Roughness (m)**
Winter	(0 - 30)	0.17	0.89	0.023	0.15	0.63	0.005
Winter	(30 - 60)	0.17	0.89	0.024	0.15	0.63	0.006
Winter	(60 - 90)	0.17	0.89	0.023	0.15	0.63	0.075
Winter	(90 - 120)	0.17	0.89	0.024	0.15	0.63	0.202
Winter	(120 - 150)	0.17	0.89	0.034	0.15	0.63	0.113
Winter	(150 - 180)	0.17	0.89	0.040	0.15	0.63	0.392
Winter	(180 - 210)	0.17	0.89	0.061	0.15	0.63	0.130
Winter	(210 - 240)	0.17	0.89	0.043	0.15	0.63	0.082
Winter	(240 - 270)	0.17	0.89	0.034	0.15	0.63	0.564
Winter	(270 - 300)	0.17	0.89	0.031	0.15	0.63	0.322
Winter	(300 - 330)	0.17	0.89	0.134	0.15	0.63	0.200
Winter	(330 - 360)	0.17	0.89	0.121	0.15	0.63	0.087
Spring	(0 - 30)	0.15	0.58	0.031	0.14	0.46	0.006

Table 1. Greensboro Airport Surface Characteristics Comparison and Evaluation							
		Greensboro Airport			Belews Creek Station		
Season	Flow Sector	Albedo	Bowen Ratio	Surface Roughness (m)	Albedo	Bowen Ratio	Surface Roughness (m)
Spring	(30 - 60)	0.15	0.58	0.032	0.14	0.46	0.006
Spring	(60 - 90)	0.15	0.58	0.030	0.14	0.46	0.091
Spring	(90 - 120)	0.15	0.58	0.031	0.14	0.46	0.233
Spring	(120 - 150)	0.15	0.58	0.046	0.14	0.46	0.138
Spring	(150 - 180)	0.15	0.58	0.052	0.14	0.46	0.460
Spring	(180 - 210)	0.15	0.58	0.075	0.14	0.46	0.144
Spring	(210 - 240)	0.15	0.58	0.055	0.14	0.46	0.091
Spring	(240 - 270)	0.15	0.58	0.041	0.14	0.46	0.647
Spring	(270 - 300)	0.15	0.58	0.043	0.14	0.46	0.359
Spring	(300 - 330)	0.15	0.58	0.173	0.14	0.46	0.263
Spring	(330 - 360)	0.15	0.58	0.160	0.14	0.46	0.109
Summer	(0 - 30)	0.17	0.48	0.041	0.15	0.28	0.006
Summer	(30 - 60)	0.17	0.48	0.039	0.15	0.28	0.007
Summer	(60 - 90)	0.17	0.48	0.036	0.15	0.28	0.100
Summer	(90 - 120)	0.17	0.48	0.037	0.15	0.28	0.252
Summer	(120 - 150)	0.17	0.48	0.056	0.15	0.28	0.168
Summer	(150 - 180)	0.17	0.48	0.062	0.15	0.28	0.513
Summer	(180 - 210)	0.17	0.48	0.085	0.15	0.28	0.152
Summer	(210 - 240)	0.17	0.48	0.065	0.15	0.28	0.095
Summer	(240 - 270)	0.17	0.48	0.047	0.15	0.28	0.714
Summer	(270 - 300)	0.17	0.48	0.055	0.15	0.28	0.382
Summer	(300 - 330)	0.17	0.48	0.200	0.15	0.28	0.459
Summer	(330 - 360)	0.17	0.48	0.205	0.15	0.28	0.168
Fall	(0 - 30)	0.17	0.89	0.035	0.15	0.63	0.006
Fall	(30 - 60)	0.17	0.89	0.033	0.15	0.63	0.007
Fall	(60 - 90)	0.17	0.89	0.031	0.15	0.63	0.100
Fall	(90 - 120)	0.17	0.89	0.031	0.15	0.63	0.252
Fall	(120 - 150)	0.17	0.89	0.048	0.15	0.63	0.168
Fall	(150 - 180)	0.17	0.89	0.054	0.15	0.63	0.513
Fall	(180 - 210)	0.17	0.89	0.079	0.15	0.63	0.152
Fall	(210 - 240)	0.17	0.89	0.057	0.15	0.63	0.095
Fall	(240 - 270)	0.17	0.89	0.042	0.15	0.63	0.714
Fall	(270 - 300)	0.17	0.89	0.046	0.15	0.63	0.382
Fall	(300 - 330)	0.17	0.89	0.188	0.15	0.63	0.459
Fall	(330 - 360)	0.17	0.89	0.191	0.15	0.63	0.168
Average:		**0.17**	**0.71**	**0.065**	**0.15**	**0.50**	**0.224**

Table 2. Winston-Salem Airport Surface Characteristics Comparison and Evaluation							
		Winston-Salem Airport			Belews Creek Station		
Season	Flow Sector	Albedo	Bowen Ratio	Surface Roughness (m)	Albedo	Bowen Ratio	Surface Roughness (m)
Winter	(0 - 30)	0.17	1.02	0.055	0.15	0.63	0.005
Winter	(30 - 60)	0.17	1.02	0.218	0.15	0.63	0.006
Winter	(60 - 90)	0.17	1.02	0.285	0.15	0.63	0.075
Winter	(90 - 120)	0.17	1.02	0.189	0.15	0.63	0.202
Winter	(120 - 150)	0.17	1.02	0.108	0.15	0.63	0.113
Winter	(150 - 180)	0.17	1.02	0.288	0.15	0.63	0.392
Winter	(180 - 210)	0.17	1.02	0.579	0.15	0.63	0.130
Winter	(210 - 240)	0.17	1.02	0.292	0.15	0.63	0.082
Winter	(240 - 270)	0.17	1.02	0.293	0.15	0.63	0.564
Winter	(270 - 300)	0.17	1.02	0.193	0.15	0.63	0.322
Winter	(300 - 330)	0.17	1.02	0.518	0.15	0.63	0.200
Winter	(330 - 360)	0.17	1.02	0.088	0.15	0.63	0.087
Spring	(0 - 30)	0.16	0.79	0.074	0.14	0.46	0.006
Spring	(30 - 60)	0.16	0.79	0.286	0.14	0.46	0.006
Spring	(60 - 90)	0.16	0.79	0.358	0.14	0.46	0.091
Spring	(90 - 120)	0.16	0.79	0.246	0.14	0.46	0.233
Spring	(120 - 150)	0.16	0.79	0.136	0.14	0.46	0.138
Spring	(150 - 180)	0.16	0.79	0.357	0.14	0.46	0.460
Spring	(180 - 210)	0.16	0.79	0.662	0.14	0.46	0.144
Spring	(210 - 240)	0.16	0.79	0.350	0.14	0.46	0.091
Spring	(240 - 270)	0.16	0.79	0.320	0.14	0.46	0.647
Spring	(270 - 300)	0.16	0.79	0.205	0.14	0.46	0.359
Spring	(300 - 330)	0.16	0.79	0.540	0.14	0.46	0.263
Spring	(330 - 360)	0.16	0.79	0.097	0.14	0.46	0.109
Summer	(0 - 30)	0.16	0.62	0.088	0.15	0.28	0.006
Summer	(30 - 60)	0.16	0.62	0.320	0.15	0.28	0.007
Summer	(60 - 90)	0.16	0.62	0.395	0.15	0.28	0.100
Summer	(90 - 120)	0.16	0.62	0.291	0.15	0.28	0.252
Summer	(120 - 150)	0.16	0.62	0.177	0.15	0.28	0.168
Summer	(150 - 180)	0.16	0.62	0.463	0.15	0.28	0.513
Summer	(180 - 210)	0.16	0.62	0.751	0.15	0.28	0.152
Summer	(210 - 240)	0.16	0.62	0.425	0.15	0.28	0.095
Summer	(240 - 270)	0.16	0.62	0.365	0.15	0.28	0.714
Summer	(270 - 300)	0.16	0.62	0.248	0.15	0.28	0.382
Summer	(300 - 330)	0.16	0.62	0.547	0.15	0.28	0.459

Table 2. Winston-Salem Airport Surface Characteristics Comparison and Evaluation							
		Winston-Salem Airport			**Belews Creek Station**		
Season	**Flow Sector**	**Albedo**	**Bowen Ratio**	**Surface Roughness (m)**	**Albedo**	**Bowen Ratio**	**Surface Roughness (m)**
Summer	(330 - 360)	0.16	0.62	0.108	0.15	0.28	0.168
Fall	(0 - 30)	0.16	1.02	0.077	0.15	0.63	0.006
Fall	(30 - 60)	0.16	1.02	0.304	0.15	0.63	0.007
Fall	(60 - 90)	0.16	1.02	0.379	0.15	0.63	0.100
Fall	(90 - 120)	0.16	1.02	0.274	0.15	0.63	0.252
Fall	(120 - 150)	0.16	1.02	0.160	0.15	0.63	0.168
Fall	(150 - 180)	0.16	1.02	0.452	0.15	0.63	0.513
Fall	(180 - 210)	0.16	1.02	0.749	0.15	0.63	0.152
Fall	(210 - 240)	0.16	1.02	0.415	0.15	0.63	0.095
Fall	(240 - 270)	0.16	1.02	0.365	0.15	0.63	0.714
Fall	(270 - 300)	0.16	1.02	0.248	0.15	0.63	0.382
Fall	(300 - 330)	0.16	1.02	0.546	0.15	0.63	0.459
Fall	(330 - 360)	0.16	1.02	0.102	0.15	0.63	0.168
Average:		**0.16**	**0.86**	**0.312**	**0.15**	**0.50**	**0.224**

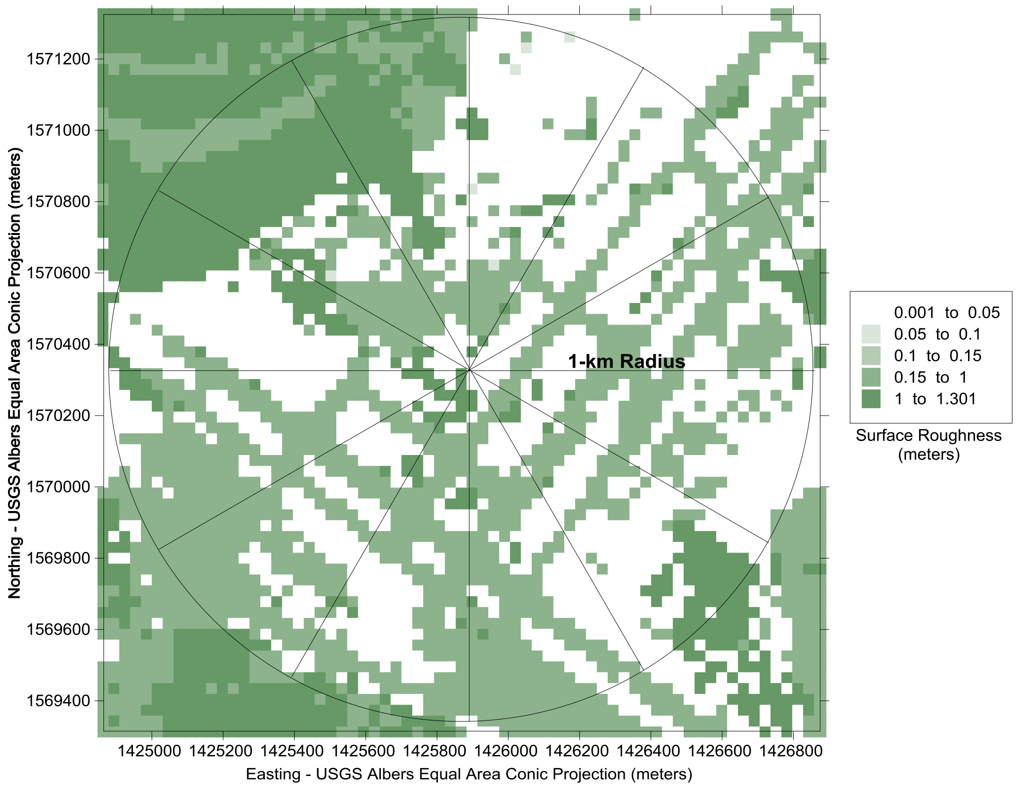

Figure 6. Greensboro Airport Summertime Surface Roughness Analysis Area

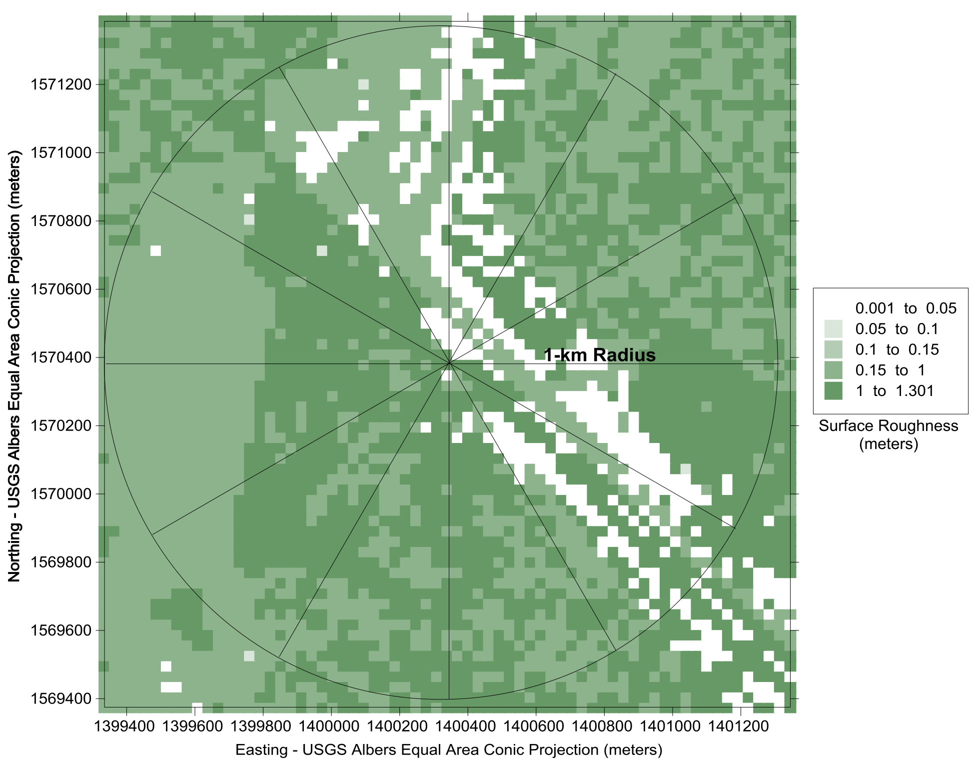

Figure 7. Winston-Salem Airport Summertime Surface Roughness Analysis Area

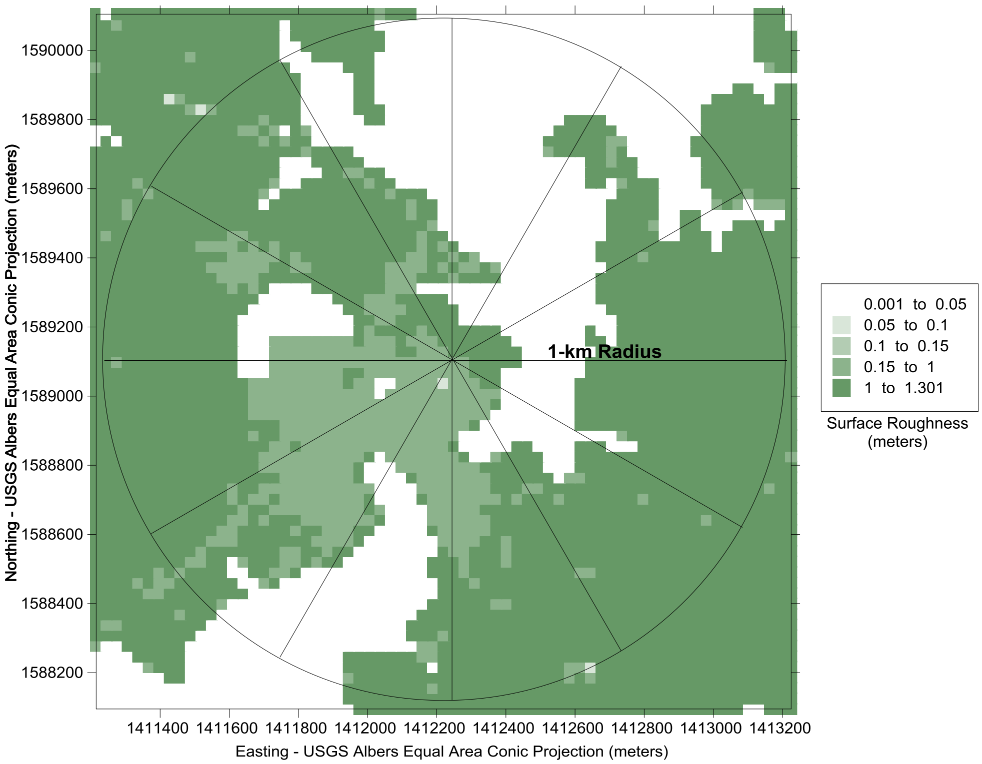

Figure 8. Belews Creek Summertime Surface Roughness Analysis Area

6.2 Surface Data

Hourly surface meteorological data was obtained from the U.S. National Climatic Data Center (NCDC) for the Greensboro Airport (KGSO) for 2013-2015 in the standard integrated surface hourly data (ISHD) format.[8] The hourly data was supplemented, as recommended by EPA with TD-6405 format (so-called “1-minute”) wind data also from the KGSO archives[9] 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 KGSO since 6/30/2009.

6.3 Upper Air Data

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 Greensboro, North Carolina (WBAN No. 13723) was obtained from the National Oceanic and Atmospheric Administration (NOAA) in Forecast Systems Laboratory (FSL) format.[10]

[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/

7.0 AERSURFACE

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] was used with AERSURFACE (version 13016)[12] to determine the surface roughness length, Bowen ratio and albedo. AERSURFACE reads land cover data obtained from the USGS and converts this data to the surface parameters listed above. AERSURFACE was set using the location coordinates for the NWS site (KGSO), month delineation, seasonal defaults, 12 sectors of 30 degrees each, and for an airport location.

To calculate the Bowen ratio, AERSURFACE was run with the above setting using the wet, dry and average surface moisture. Next, the monthly surface moisture at the NWS site was classified each month as wet, dry or average based on a comparison with the historic 30-year monthly average precipitation data. If the monthly precipitation total is less than or equal to the 30th percentile of the historic precipitation data, then dry Bowen ratio was used. If the monthly precipitation total is between the 30th and 70th percentile of the historic precipitation data, then the average Bowen ratio was used. If the monthly precipitation total is equal to or greater than the 70th percentile of the historic precipitation data, then the wet Bowen ratio was used. Table 3 shows the monthly precipitation totals for 2013, 2014 and 2015. Table 4 shows the 30th and 70th percentile from the historic precipitation data from the past 30 years by month. Table 5 shows the moisture category (wet, dry or average) associated with each year by month. Bowen ratio is used in calculating convective mixing heights used in AERMOD.

Table 3. 2013-2015 Greensboro Precipitation Data

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2013	5.47	3.2	2.85	3.75	3.08	8.37	6.02	5.65	2.13	1.11	3.61	5.19
2014	3.98	2.24	4.36	4.3	2.61	3	2.73	2.66	2.93	2.01	3.33	2.21
2015	2.04	2.64	2.72	2.5	3.06	2.06	3.34	6.85	5.6	4.24	6.79	6.65

Table 4. Greensboro 70th and 30th Percentile of Precipitation

Period	% ile	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2015-1986	30th	3.83	3.07	4.36	4.62	3.67	3.92	4.57	5.33	6.28	3.98	3.62	3.55
	70th	2.35	2.17	2.82	2.52	2.26	2.44	3.08	2.56	2.68	1.79	1.94	2.21

[11] US Environmental Protection Agency. 2015 "AERMOD Implementation Guide" revised August 3,2015. Available online https://www3.epa.gov/ttn/scram/7thconf/aermod/aermod_implmtn_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

Table 5. Greensboro Monthly Moisture 2013-2015												
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2013	WET	AVG	AVG	AVG	AVG	WET	WET	WET	DRY	DRY	AVG	WET
2014	AVG	AVG	AVG	AVG	AVG	AVG	DRY	AVG	AVG	AVG	AVG	AVG
2015	DRY	AVG	DRY	DRY	AVG	DRY	AVG	WET	AVG	WET	WET	WET

8.0 Coordinate System

In all modeling input and output files, the locations of emission sources, structures, and receptors are represented in the appropriate Zone of the Universal Transverse Mercator (UTM) coordinate system using the North American Datum 1983 (NAD83). Belews Creek and the surrounding area lie within Zone 17.

9.0 Receptor Grid

The size, spacing, and location of the receptor grid is unique to the modeling analysis. The receptor grid takes 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 no receptors were placed on Belews Lake. Figures 9 and 10 show the receptors on a satellite view and a map of counties and townships, respectively.

Receptor density was 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 National Elevation Data[13] (NED) processed with AERMAP[14] (version 11130). Flagpole receptor height for this analysis was 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
- 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

[13] http://www.mrlc.gov/viewerjs/
[14] https://www3.epa.gov/scram001/dispersion_related.htm

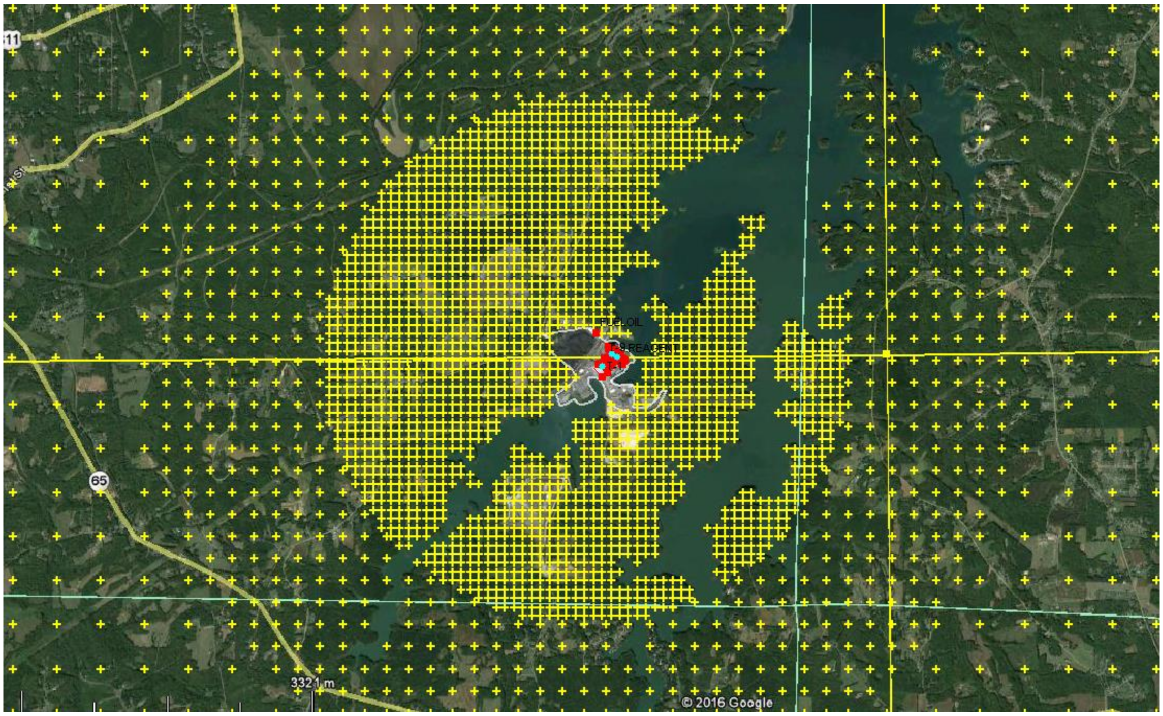

Figure 9. Receptor Grid Shown Over a Satellite Image

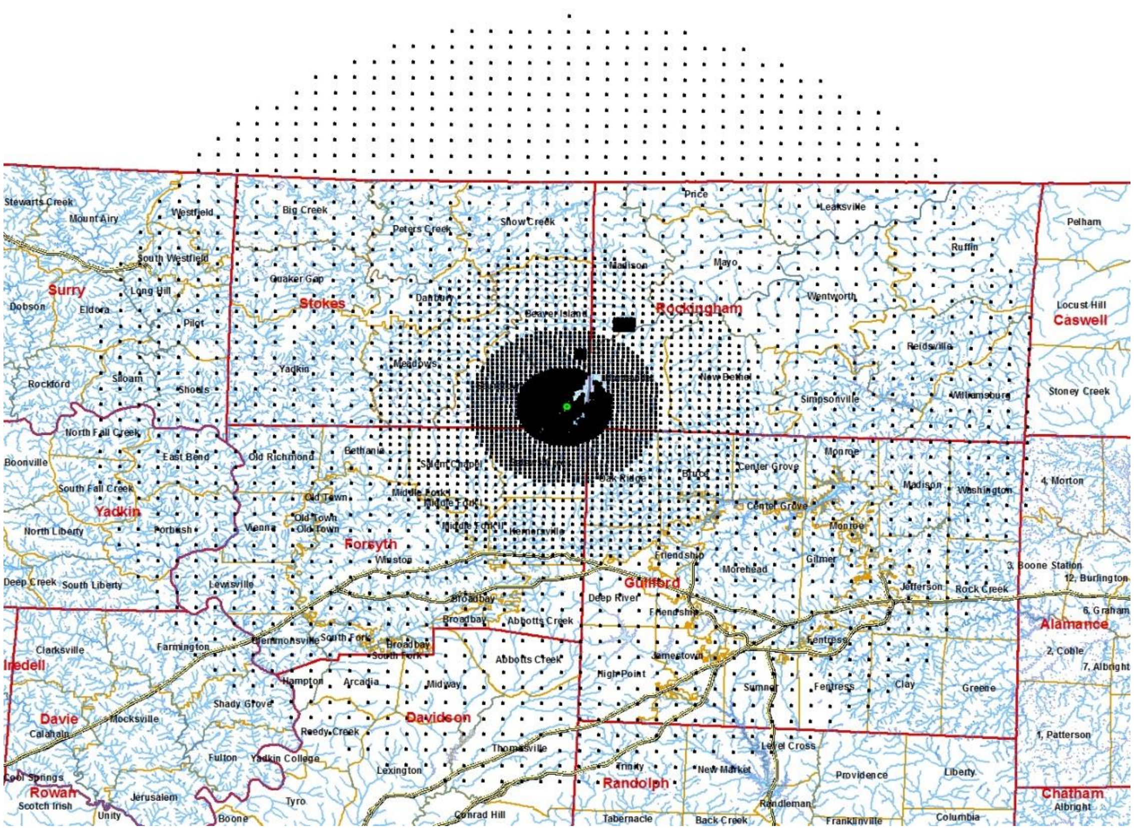

Figure 10. Receptor Grid Shown Over a Map of Counties and Townships

10.0 Terrain Elevation

The terrain elevation for each receptor, building, and emission source was determined using USGS 7.5-minute National Elevation Data (NED). Using the AERMOD terrain processor, AERMAP (version 11103), the terrain height for each receptor, and outlying buildings included in the model was determined by assigning the interpolated height from the digital terrain elevations surrounding each source. The elevation data was used in the AERMOD modeling analysis.

11.0 Belews Creek Emission Sources

Belews Creek includes the following sources of SO_2 emissions: two coal fired utility boilers, two oil fired auxiliary boilers and eight emergency engines. The four boilers are included in the modeling. The engines are considered intermittent units and were not included in the modeling. The annual emissions for 2013-2015 for the boilers and engines are listed in Tables 6 and 7 respectively.

Table 6. Boiler Annual SO_2 Emissions

Source ID #	Emissions Source	Capacity		2013 SO_2 (tons)	2014 SO_2 (tons)	2015 SO_2 (tons)
		Rating	Units			
ES-3 (AuxB1)	Auxiliary Boiler #1, Oil Fired	172	MMBtu/hr	1.76*	5.67*	0.021*
ES-4 (AuxB2)	Auxiliary Boiler #2, Oil Fired	172	MMBtu/hr	3.08*	6.64*	0.016*
ES-1	Electric Utility Boiler, Coal Fired	1200	MMBtu/hr	2472	4092	3230
ES-2	Electric Utility Boiler, Coal Fired	1200	MMBtu/hr	2603	2940	3564

* Emissions Inventory Reports for 2013 and 2014 assumed 0.5% sulfur oil for aux boilers. Current fuel supply is limited to 15 ppm sulfur based on commercially available ULSD fuel.

11.1 Intermittent Sources

Belews Creek operates eight emergency engines. These engines operate during emergencies and for readiness/maintenance checks. In addition, these engines are limited to operating no more than 100 hours per year for readiness/maintenance checks and combust ultra-low sulfur fuel oil. Table 7 below shows the maximum hourly and annual SO_2 emissions for the engines for 2013-2015. According to the Modeling TAD, Section 5.4, EPA states that it is most appropriate to include sources of emissions which operate continuously or frequent enough to contributed to the annual distribution of the daily maximum concentrations. The emergency engines do not operate enough or have large enough emissions of SO_2 to contribute to the annual distribution of daily maximum 1-hour SO_2 concentrations, consequently these engines were considered intermittent sources and excluded from the dispersion modeling analysis.

Table 7. Emergency Engine SO_2 Emissions							
Source ID #	Emissions Source	Capacity		Max SO_2 (lbs/hr)	2013 SO_2 (tons)	2014 SO_2 (tons)	2015 SO_2 (tons)
		Rating	Units				
ES-4a (EmGen)	Emergency Blackout protection generator	2000	kw	4.00E-02	3.70E-05	3.70E-05	1.02E-04
ES-5 (AC)	Emergency Air Compressor	525	hp	6.40E-03	8.60E-05	2.23E-05	6.69E-05
ES-23 (EQWP)	Emergency Quench Water Pump	1610	hp	1.95E-02	2.18E-04	4.50E-02	1.13E-04
ES-34	Backup emergency generator	37.1	hp	5.00E-04	0.00E+00	0.00E+00	5.40E-07
ES-35	Backup emergency generator	364	hp	4.40E-03	0.00E+00	0.00E+00	7.73E-06
ES-37	Emergency fire pump	440	hp	5.30E-03	1.28E-04	5.69E-05	4.30E-05
IS-86	Emergency Water Pump (Landfill)	36	hp	4.00E-04	2.49E-05	0.00E+00	0.00E+00
IS-87	Emergency Water Pump (Landfill)	36	hp	4.00E-04	1.00E-04	1.10E-01	0.00E+00

11.2 Utility Boiler Modeled Emissions Rates

Section 5.2 of the Modeling TAD recommends using hourly emissions from Continuous Emissions Monitoring Systems (CEMS) data, where available. The CEMS-derived, hour-by-hour datasets provides the most accurate representation of the actual operating history of the source for the relevant time period considered in the modeling.

The Utility Boilers, identified as ES-1 and ES-2, vent out separate stacks, which are equipped with CEMS. The CEMS monitor and record hourly SO_2, flow and stack gas temperature data. The hourly CEMS Data was converted into a AERMOD ready format as follows:

- The hourly SO_2 pounds per hour emissions data were converted to units of grams per second and inputted into the AERMOD. All the SO_2 emissions (lbs/hr) data was quality assured and missing data substituted using the Part 75 data procedures.

- The hourly stack temperature data from CEMS were used in the modeling analysis. For periods when the stack temperature data was missing or invalid the average stack temperature data was used. The average stack temperature from CEMS is relatively constant at 120 degrees F.

- The hourly stack exit velocity data calculated from CEMS was used in the modeling analysis. The hourly exit velocity was calculated from the hourly flow and stack temperature data. The hourly flow in units of standard cubic feet per hour (scfh) was converted to actual cubic feet per hour (acfh) using the actual stack gas temperature.

Next, the actual flow (acfh) was converted to cubic meters per second (m^3/s) and divided by the stack area in square meters (m^2) to get the stack exit velocity in meters per second (m/s). All the flow (scfh) data was quality assured and missing data substituted using the Part 75 data procedures.

11.3 Auxillary Boiler Modeled Emissions Rates

The Auxillary Boilers, identified as ES-3 and ES-4, are operated during startup of the Uitlity Boilers and to supply building heat when the temperature is cold and the Utility Boilers are not available. During the period from 2013 to 2015, the maximum annual hours of operation were less than 160 hours per year per boiler. In addition starting in 2015, the commercially available fuel oil is limited to Ultra Low Sulfur Fuel (ULSF) oil. During 2015 the maximum hourly SO_2 emissions rate was 0.57 lbs/hr for both boilers. Prior to 2015 these boilers combusted fuel oil with a sulfur content of 0.05% and had the maximum hourly SO_2 emissions rate of 176 lbs/hr for both boilers.

The auxilary boilers vent to a common stack and were assumed to operate at the same time. These boilers operate infrequently on a random basis, during periods when the coal fire utility boilers are typically not operating. In addition these boilers combusted ULSF starting in 2015. Given these factors, modeling using the maximum hourly emissions rate of 176 pounds per hour for every hour during the modeling period, coupled with the statistical nature of the standard, is overly conservative. The EPA's March 1, 2011 guidance allows intermittently operated sources to be modeled using the average hourly emission rate rather than the maximum emissions rate. The average hourly emissions rate was conservatively estimated by multipling the maximum hourly emissions rate of 176 pounds per hour by the 500/8760. The 500 hours is well above the highest hours of operation during 2013-2015. The average emissions rate from the auxillary boiler is 10.04 pounds per hour or 1.267 grams per second. The stack temperature and exit velocity reflect conditions at maximum load and were held constant over the modeling period. The stack parameters are provided in Table 8.

11.4 Stack Parameters for Belews Creek

Table 8 below summarizes the stack parameters that were used in this modeling analysis. For the Utility Boilers, the actual hourly SO_2 emissions, stack exit velocities and stack temperature data were used. The hourly data coincides with the meteorological data for the period January 1, 2013 through December 31, 2015. The hourly data was inputted into AERMOD using the HOUREMIS keyword in the source pathway of the AERMOD control file (AERMOD.INP).

Table 8. Stack Parameters for Belews Creek Boilers									
ID	Description	UTM East (meters)	UTM North (meters)	Elevation (m)	SO_2 Emission Rate (g/s)	Stack Height (m)	Stack Temp (K)	Stack Dia. (m)	Stack Exit Vel (m/s)
BC1	ES-1	584,525	4,015,728	225.6	Varying	152.4	Varying	15.0	Varying
BC2	ES-2	584,584	4,015,681	225.6	Varying	152.4	Varying	15.0	Varying
AUX	ES-3, ES-4	584,415	4,015,579	225.6	1.267	81.7	550	3.2	5.83

12.0 Building Downwash

The EPA's Building Profile Input Program (BPIP) with the Plume Rise Model Enhancements (PRIME) (version 04274), was used to account for building downwash influences on the boiler stacks. Building downwash analysis is used to determine if the stack 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.

13.0 Nearby Emissions Sources

Section 4.1 of the TAD recommends sources which are expected to cause a significant concentration gradient in the vicinity of the source of interest be explicitly modeled. Those sources not causing significant concentration gradients in the vicinity of the source of interest, should be accounted for in the monitored background concentrations as described later in Section 8 of this TAD.

Emissions inventory from NCDAQ and the Forsyth County Office of Environmental Assistance & Protection were used to identify nearby sources. The NCDAQ inventory includes all sources of SO_2 except for those located in Forsyth County. We used the following criteria to identify sources to be evaluated for inclusion in the SO_2 modeling analysis:

- All sources of SO_2 located within 25 km which had actual emissions greater than 1 ton per year were evaluated; and

- Sources located between 25 and 50 km from Belews Creek with actual emissions greater than 50 tons per year were also evaluated.

The SO_2 emissions are based on the most recent data available from the NCDAQ's and Forsyth County emissions inventories. Table 9 below lists all the sources which meet the criteria listed above. We believe the criteria is conservative enough to ensure that all sources which could potentially cause a significant concentration gradient in the vicinity of Belews Creek are evaluated.

An isopleth map of the 4th high modeled SO_2 concentration for Belews Creek using 2013-2015 actual data is shown in Figure 11. The nearby sources of SO_2 identified in Table 9 were included in the figure. The isopleth map indicates that the concentration gradient from Belews Creek drops of significantly 15 km from the station.

Table 9. SO_2 Sources Located Near Belews Creek

Facility ID	Facility Name	UTM E (meters)	UTM N (meters)	Distance (km)	Inventory Year	SO2 (tons)	Q/d
3400732	Ingredion Incorporated - Winston-Salem	569,534	3,988,020	31.4	2014	230.9	7.4
3400131	HANES DYE AND FINISHING CO.	567,231	3,995,875	26.2	2014	54.7	2.1
3400464	Larco Construction	569,274	4,000,434	21.5	2010	8.9	0.4
3403997	R.J. Reynolds Tobacco Company (Whitaker Park)	567,042	3,999,345	23.9	2014	6.6	0.3
3400004	Wieland Copper Products, LLC	586,692	4,021,804	6.6	2015	6.4	1.0
3400884	TIMCO, dba HAECO Americas Airframe Services	595,947	3,994,678	23.9	2014	5.6	0.2
3400914	Pine Hall Brick Co., Inc.	590,456	4,025,980	12.0	2014	4.0	0.3
3400003	Sharpe Bros., a Div. of Vecellio & Grogan, Inc.-Lebanon Rd.	593,278	3,995,814	21.7	2012	3.2	0.1
4100042	Winston Weaver Co., Inc.	566,022	4,000,844	23.6	2011	2.6	0.1
4101176	Salem Energy Systems, L.L.C.	563,720	4,005,372	23.2	2014	2.0	0.1
3400339	Piedmont Landfill and Recycling Center	586,536	4,006,047	9.8	2014	1.7	0.2
7900156	Duke Energy Carolinas, LLC-Rockingham Co Comb. Turb.	605,145	4,021,067	21.4	2014	1.6	0.1
8500028	Wake Forest University	575,418	3,992,656	24.7	2010	0.8	0.03

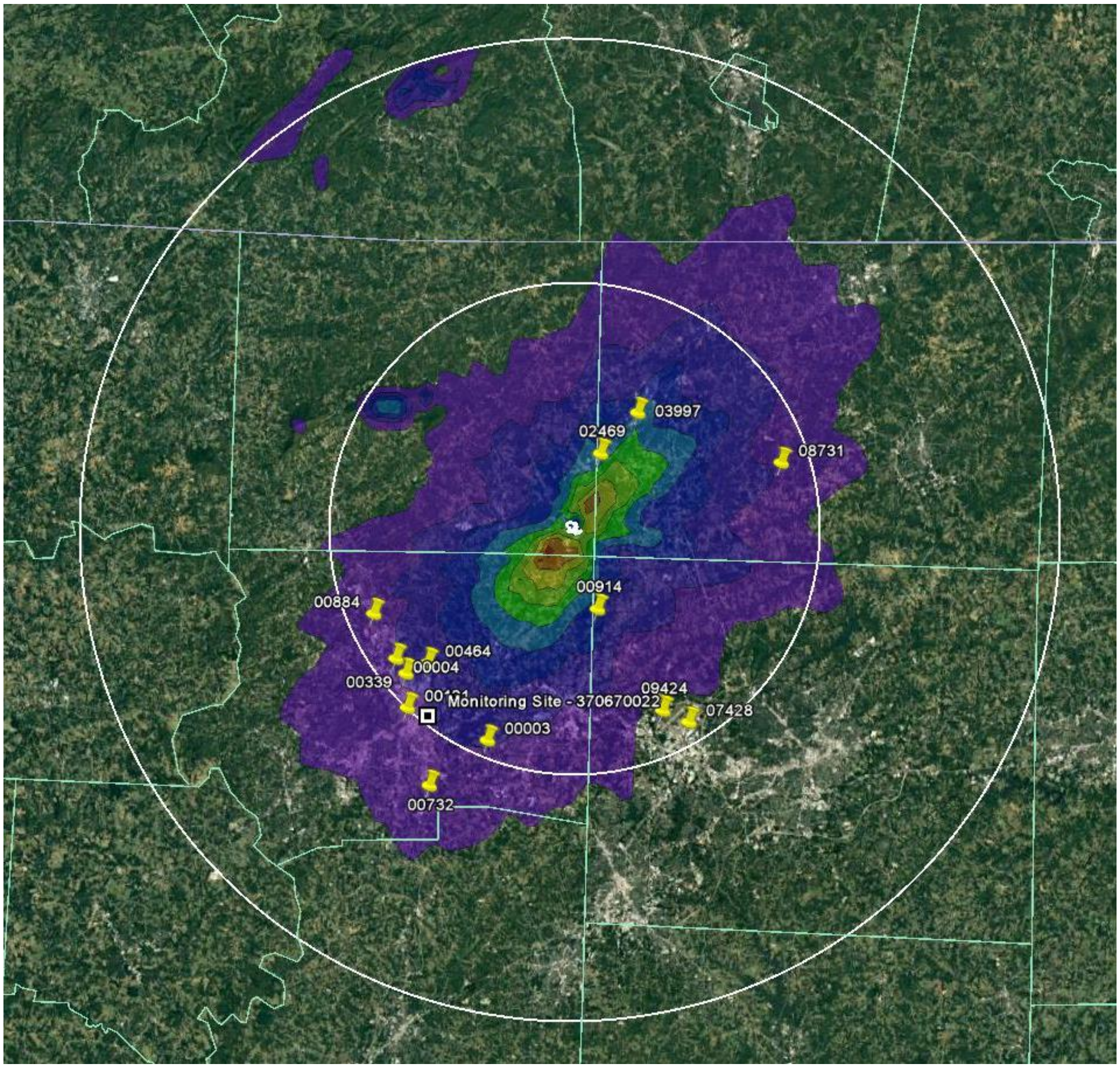

Figure 11. Isopleth Map

Sources of SO_2 greater than 1 ton per year, located within 25 km of Belews Creek were evaluated as follows:

- Pine Hall Brick Co., Inc. and Wieland Copper Products, LLC are located within 15 km from Belews Creek and have annual actual SO_2 emissions of 4 and 6.4 tons per year respectively. Due to the close proximity to Belews Creek these sources were included in the modeling.

- All other sources located within 25 km of Belews Creek have actual SO_2 emissions less than 10 tons/yr. For these sources the 20D method was used to further screen which units should be included in the modeling analysis. The 20D method uses the ratio of the emissions (Q) to the distance between sources (d) to determine if a source needs to be included in the modeling analysis. If Q/d is less than 20, a source does not need to be included in the modeling. The specification of the variables in the 20D analysis include:

Q = Annual actual/potential emissions in tons/year
d = Distance from the target source in kilometers to the Belews Creek

All of these sources have a Q/d value less than 20 and were not included in the modeling The Q/d values are included in Table 9.

Sources of SO_2 greater than 50 tons per year of actual emissions located between 25 and 50 km from Belews Creek were identified and evaluated to determine if these sources should be included in the modeling analysis. The following sources meeting the criteria were evaluated;

- Ingredion Incorporated is located 31 km from Belews Creek and operates corn milling operation. This facility has a number of sources of SO_2 and emitted 231 tons per year of SO_2 emissions in 2014. An AERMOD modeling analysis was run using the stack parameters provided by the Forsyth County with the AERMET files used to model Belews Creek. An isopleth map was generated for the 4th high value for 2013-2015. The results of the modeling analysis show that the concentration gradient in the vicinity of Belews Creek leveled off at 1 μg/m^3, consequently this source was not included in the final modeling analysis.

- Hanes Dye and Finishing Company is located 26 km from Belews Creek. This source operates a boiler which emitted 54 tons of SO_2 in 2014. An AERMOD modeling analysis was run using the stack parameters provided by Forsyth County with the AERMET files used to Model Belews Creek. An isopleth map was generated for the 4th high value for 2013-2015. The results of the modeling analysis show that the concentration gradient in the vicinity of Belews Creek leveled off to 1 μg/m^3, consequently this source was not included in the final modeling analysis.

Miller Coors Brewery LLC Eden Brewery is located 41 km from Belews Creek and had 4 coal fired boilers which emitted 371.1 tons of SO_2 emissions in 2014. These coal fired boilers were removed from the permit on 3/9/2015. The EPA guidance allow sources which have been permanently shut down prior to 1/1/2017 to be excluded from the modeling analysis.

13.1 Stack Parameters for Nearby Sources

The stack parameters for the nearby sources included in the modeling analysis are listed in Tables 10 and 11 below. The SO_2 emission rates were based on the maximum annual emissions over 2013-2015 and assume continuous hours of operation. The melting furnaces, casting furnaces, and arc furnace emissions emit out of a series of building roof monitors and were modeled as volumes sources. The initial vertical dimension was calculated by dividing the building height of 10 meters by 2.15. The initial lateral dimension was calculated by dividing the building length of 300 meters by 2.14.

Table 10. Stack Parameters for Nearby Point Sources

ID	Description	UTM East (meters)	UTM North (meters)	Elev. (me)	Emiss. Rate (g/s)	Stack Height (m)	Stack Temp (K)	Stack Exit Vel (m/s)	Stack Dia (m)
Wieland Copper Products, LLC									
WP_EAF1	Electric arc furnace bagfitler stack	585,8010	4,022,429	191	0.025	45	102	16.764	1.3716
Pine Hall Brick Co., Inc.									
BH_EP4	Brick Kilns	590,469	4,026,196	181	0.061	110	292	10.00	1.194
BP_EP51	Brick Kiln	590,080	4,026,182	181	0.030	30	250	11.765	1.216
BP_EP52	Brick Kiln	590,080	4,026,182	181	0.022	30	250	11.765	1.216

Table 11. Release Parameters for Nearby Volume Sources

ID	Description	UTM East (meters)	UTM North (meters)	Elev (m)	Emiss. Rate (g/s)	Release Height (m)	Initial Lateral Dimension (m)	Initial Vertical Dimension (m)
Wieland Copper Products, LLC								
WP_CF1	Casting Furnace	585,810	4,022,430	191	0.057	10	137.67	4.65
WP_MF1	Melting Furnace (ES-MF-1)	585,810	4,022,430	191	0.029	10	137.67	4.65
WP_MF2	Melting Furnace (ES-MF-2)	585,810	4,022,430	191	0.029	10	137.67	4.65
WP_EAF2	arc furnace roof vent	585,810	4,022,430	191	0.025	10	137.67	4.65

14.0 Background Concentration

Section 8 of the Modeling TAD describes the significance of background concentration in estimating the cumulative impacts from sources not included in the model. The Modeling TAD recommends a 1st tier approach (i.e., the most conservative) based on the monitored design value for the most recent three-year period. If this approach is too conservative, the TAD also allows a 2nd tier approach, which uses the background concentration based on the 99th percentile on an hour of day and season of year basis. Finally, this guidance allows for the exclusion of upwind source impacts under certain circumstances.

The closest 2013-2015 SO_2 monitoring site is the Forsyth County monitor which is located 23 km south west of Belews Creek. The most conservative, tier 1 approach was used to determine the back ground concentration. The SO_2 design value for the Forsyth SO_2 monitor of 23 µg/m^3 was used in the analysis.

15.0 Comparison to Standard

The model was set to output the annual 4th high daily maximum concentrations at each receptor using the MXDYBYR output option. The design value at each receptor was calculated by averaging the annual 4th high daily maximum concentrations over the period from 2013-2015. The design values were compared to the SO_2 standard of 196 µg/m^3. The modeling results are shown in the Table 12 below. The receptor identified below with the highest modeled design value is within the modeled area where the receptor grid spacing is finest (100 meter spacing as shown in Figure 9).

Table 12. Model Results

Averaging Period	Years Met Data	Modeled Design (µg/m^3)	Background Conc. (µg/m^3)	NAAQS (µg/m^3)	% NAAQS	UTM East (meters)	UTM North (meters)	NAAQS Exceeded
1-hr	2013-15	98.5	23	196	62 %	582,407	4,013,755.5	No

The NCDAQ will provide EPA with all modeling files including the input/out files necessary to validate the results of the modeling analysis.