APPENDIX H

VISTAS Area of Influence Analyses

Based on “VISTAS Area of Influence Analyses for Sulfur Dioxide” by Archuleta, Adhloch, Mansell, Stella and Brewer (February 28, 2007) and “Procedures for Developing and Displaying AoI Back-trajectories Residence Time GIS Data by Mansell (August 29, 2007)

H.1 Introduction

The objective of the VISTAS Area of Influence analysis is to identify the geographic source regions that are contributing to visibility impairment at the Class I areas on the worst 20 percent visibility days. This information is being used by the VISTAS states as part of the evaluation and demonstration of reasonable progress toward visibility improvement in Class I areas.

VISTAS' contribution assessment based on IMPROVE monitoring data (Brewer and Adhloch, 2005) that demonstrated ammonium sulfate is the major contributor to $PM_{2.5}$ mass and visibility impairment at Class I areas in the VISTAS and neighboring states. As illustrated in Figure H-1, on the worst 20 percent visibility days during the 2000-2004 5-year Baseline, ammonium sulfate accounted for greater than 70% of the calculated light extinction at Class I areas in the Southern Appalachians and greater than 60% of the calculated light extinction for coastal sites in the VISTAS states (excepting Everglades). In contrast, ammonium nitrate contributed less than 5% of the calculated light extinction at VISTAS Class I areas on the worst 20 percent visibility days. (Nitrate has a somewhat larger contribution on the worst 20 percent days at Class I areas in neighboring states.) Particulate organic matter carbon (OMC) accounted for 10-20% of light extinction on the worst 20 percent visibility days (except Everglades where organic carbon accounted for 40%).

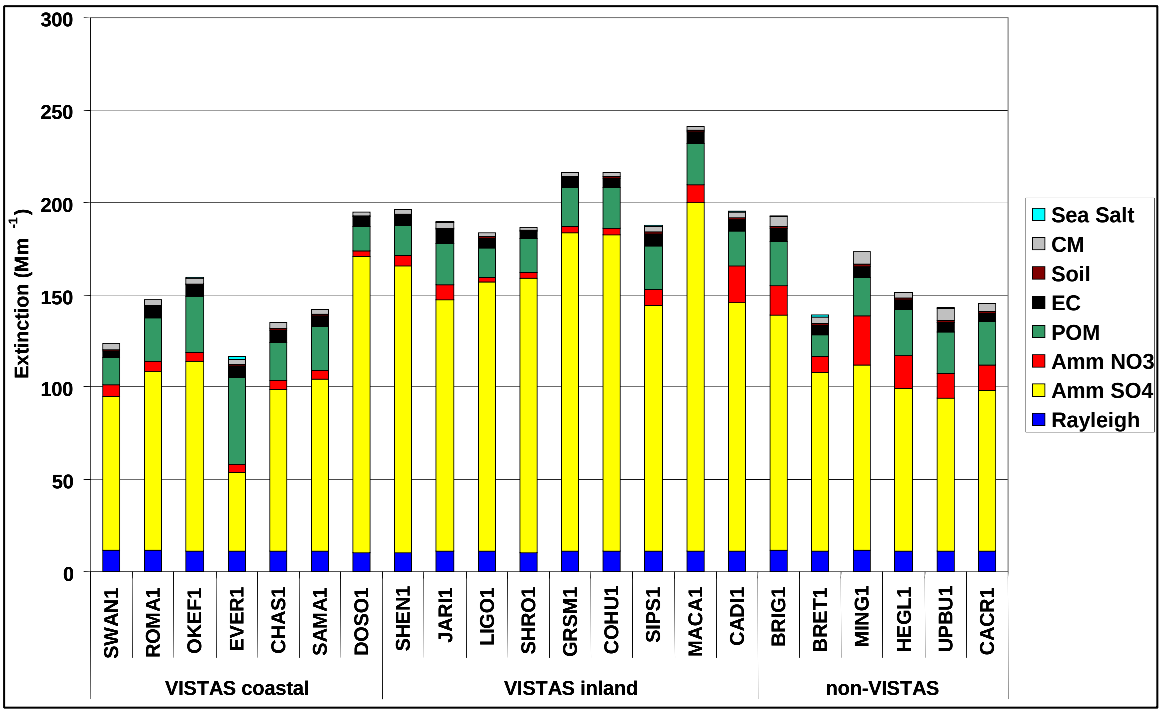

Figure H-1. Average extinction for the worst 20 percent visibility days in 2000-2004 using the new IMPROVE equation (data from VIEWS September 2006).

VISTAS emissions sensitivity analyses using the CMAQ regional air quality model project that reductions in SO2 emissions from Electric Generating Utilities (EGU) and non-EGU industrial point sources will result in the greatest improvements in visibility at VISTAS Class I areas. EGU and non-EGU industrial point sources comprise 95+% of the SO2 emissions inventory in the VISTAS states. The emissions sensitivity analyses also indicate that improvements in visibility from reductions in NOx or primary carbon emissions from ground- level sources or point sources would be small. Based on these analyses, VISTAS states chose to focus their reasonable progress evaluation on potential controls of SO2 emissions from EGU and non-EGU point sources. To select the specific point sources that would be considered for each Class I area, VISTAS first identified the geographic area that was most likely to influence visibility in each Class I area and then identified the major SO2 point sources in that geographic area.

H.2 Back Trajectory Analyses

In support of VISTAS's Area of Influence (AoI) analysis, Air Resource Specialists (ARS) generated meteorological back trajectories for IMPROVE sites in VISTAS and neighboring states. Back trajectory analyses use interpolated measured or modeled meteorological fields to estimate the most likely central path of air masses that arrive at a receptor at a given time. The method essentially follows a parcel of air backward in hourly steps for a specified length of time. Back trajectories account for the impact of wind direction and wind speed on delivery of emissions to the receptor, but do not account for chemical transformation and dispersion of emissions.

Trajectories were generated using the Hybrid-Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model developed by the National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory (ARL). HYSPLIT uses archived 3-dimensional meteorological fields generated from observations and short-term forecasts. HYSPLIT can be run to generate forward or backward trajectories using several available meteorological data archives.

The data archives used in this analysis were the National Weather Service's National Centers for Environmental Prediction Eta Data Assimilation System (EDAS). The EDAS fields are archived by the ARL across the continental U.S., including a buffer zone, at a horizontal resolution of 80 km before 2004, and at a horizontal resolution of 40 km starting in 2004. Detailed information regarding the trajectory model and these data sets can be found on NOAA's Web site (http://www.arl.noaa.gov/ready/hysplit4.html).

The major model parameters selected for this analysis include those listed in Table H-1.

Table H-1. Back Trajectory Model Parameters Selected for VISTAS AoI Analysis.

Model Parameter	Value
Trajectory duration	72 hours backward in time
Top of model domain	14,000 meters
Vertical motion option	used model data
Meteorological Field	EDAS
End Times	0600, 1200, 1800 and 2400 EST
End Heights	100 and 500 m

The choice of these parameters affects the trajectories generated and the final attribution analyses. In particular, trajectories tend to become increasingly uncertain the further back in time they are used. Vertical motion in the model is sometimes best represented by following actual vertical motion measurements (represented by model data), surfaces of constant entropy, or surfaces of constant pressure, depending on the meteorological conditions at a given location and time. The impact of receptor height (or end height) on an individual trajectory is also important. Low-ending trajectories represent air parcels nearer to ground level and high-ending trajectories may represent more accurate boundary layer flow above the local terrain.

For the years 2000 through 2004, back trajectories were computed for the following 22 IMPROVE sampling sites in and around the VISTAS region:

1. Breton, LA (BRET1)
2. Brigantine NWR, NJ (BRIG1)
3. Cadiz, KY (CADI1)
4. Caney Creek, AR (CACR1)
5. Cape Romain NWR, SC (ROMA1)
6. Chassahowitzka NWR, FL (CHAS1)
7. Cohutta, GA (COHU1)
8. Dolly Sods Wilderness, WV (DOSO1)
9. Everglades NP, FL (EVER1)
10. Great Smoky Mountains NP, TN (GRSM1)
11. Hercules-Glades, MO (HEGL1)
12. James River Face Wilderness, VA (JARI1)
13. Linville Gorge, NC (LIGO1)
14. Mammoth Cave NP, KY (MACA1)
15. Mingo, MO (MING1)
16. Okefenokee NWR, GA (OKEF1)
17. Shenandoah NP, VA (SHEN1)
18. Shining Rock Wilderness, NC (SHRO1)
19. Sipsy Wilderness, AL (SIPS1)
20. St. Marks, FL (SAMA1)
21. Swanquarter, NC (SWAN1)
22. Upper Buffalo Wilderness, AR (UPBU1)

Based on the five years of individual back trajectories, ARS generated extinction-weighted residence time data for each IMPROVE site. Each hourly trajectory point was tagged with its associated sample (or end) date. Back trajectories with end dates corresponding to the worst 20 percent visibility days were weighted with calculated extinction values and summed into 1 degree horizontal grid cells of latitude and longitude.

Extinction data is based on the IMPROVE Regional Haze Rule dataset, as available from the VIEWS website (http://vista.cira.colostate.edu/views/Web/IMPROVE/SummaryData.aspx) in November 2005 and is calculated based on the original IMPROVE algorithm. For sites with less than three complete years of data, ARS developed and applied a data substitution protocol to fill missing data. Organic carbon and elemental carbon values were filled based on correlations to hydrogen and sulfate values for the same site. Other components were filled based on data from nearby sites.

Trajectory data were weighted by total extinction, and by extinction components including ammonium sulfate (AmmSO4), ammonium nitrate (AmmNO3), organic matter carbon (OMC), Light Absorbing Carbon (LAC or EC), Soil, and Coarse Mass (CM). Weighting trajectories for the worst 20 percent days by sulfate extinction gave greater importance to days influenced by SO2 emissions and lesser importance to days influenced by organic carbon emissions. This allowed a geographic area of influence to be identified based on sulfate contributions and not skewed by contributions from fire.

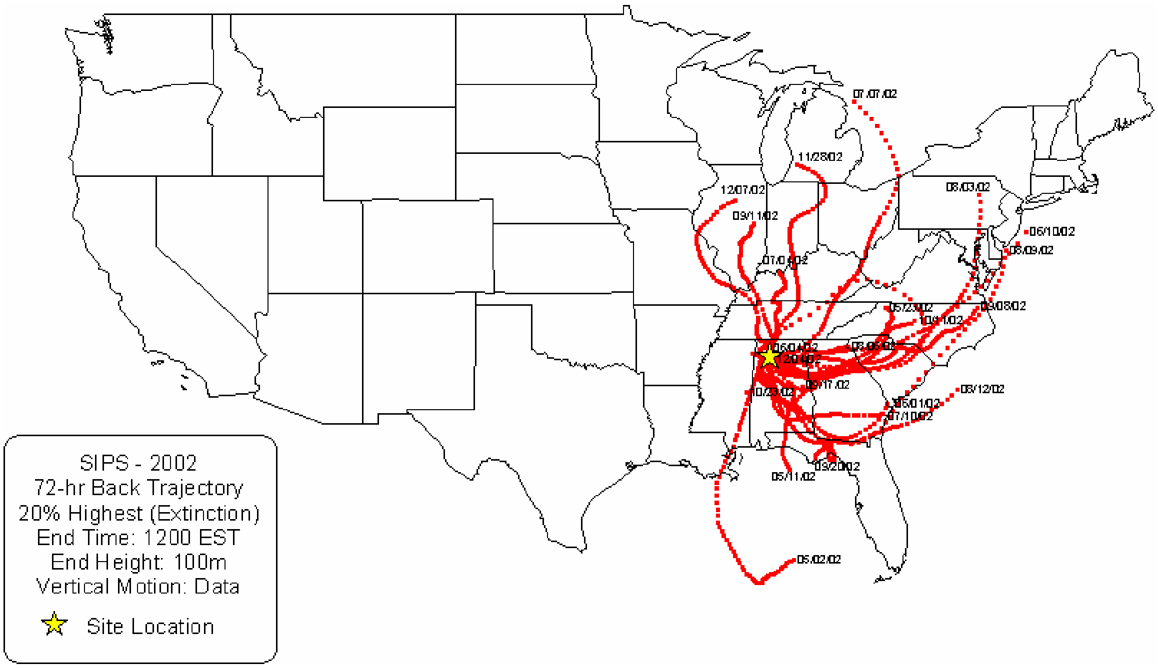

Figure H-2. Example Back trajectories for 20% worst visibility days in 2002 for Sipsey Wilderness Area.

These data files were provided to ENVIRON. ENVIRON was charged with developing residence time plots to define the geographic area with highest probability of influencing the receptor on the worst 20 percent days dominated by sulfate. Residence time over an area is indicative of general flow patterns, but since it does not account for emissions and removal processes, it does not necessarily imply specific areas contributed significantly to haze compounds at a receptor site.

H.3 Area of Influence Data and Displays

The primary objective of the Area of Influence (AOI) displays and data sets are to assist the States in focusing their reasonable progress analysis on those geographic regions and source categories which most impact a particular Class I Area. The sources of data used in these analyses include back-trajectory residence time data, provided by ARS and described above, and the VISTAS 2002 and 2018 36-km gridded emissions data (Base G, August 2006 inventory version).

Extinction weighted back-trajectory residence time plots were provided by ARS for all Class I Areas in the VISTAS region as well as for the surrounding neighboring states. These trajectories were processed on an un-projected (i.e., geodetic lat/lon 1 degree by 1 degree) grid and transferred to ENVIRON for further GIS processing and analysis. Back-trajectories were run for 100-meter and 500-meter start heights. Because the back-trajectories were to be combined with gridded emissions data, the first step in the analysis and GIS processing involved re-projecting these data to the 36 km Inter-RPO Unified Lambert Conformal Projection domain. Once the data were re-projected, the data were mapped to the 36 km grid cells in the RPO projection using an area-weighted mapping routine. The re-projected extinction weighted back-trajectory residence times were then plotted on the VISTAS 12 km modeling domain. As sulfate is the primary visibility impairing component of the total extinction in the Southeast, the SO4-weighted residence time trajectories were chosen as the basic data set for display. For clarity, these data are scaled by the maximum value of the total extinction-weighted residence time within the modeling domain. Figure H-3 displays an example of the back-trajectory residence time plot for Sipsey, Alabama.

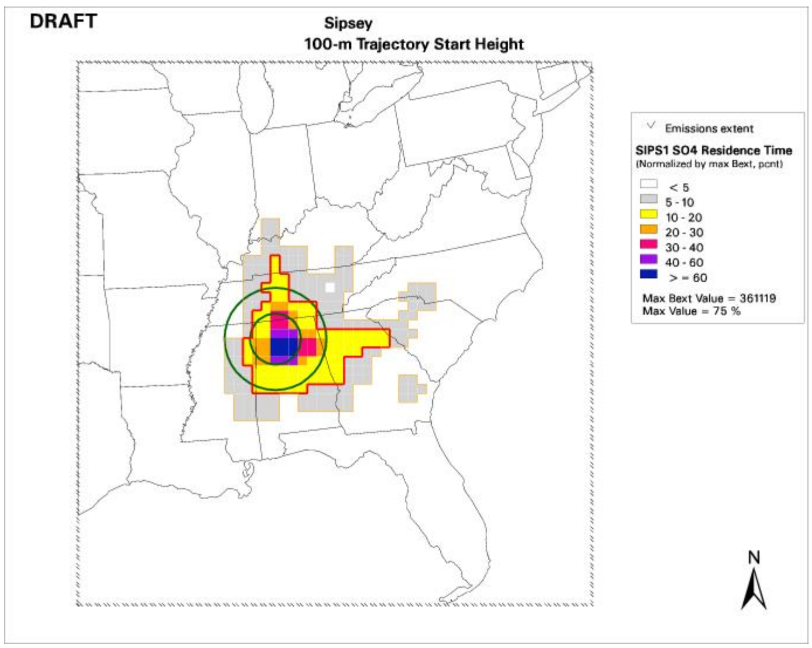

Figure H-3. Sulfate-weighted back-trajectory residence time (RT) displays for Sipsey, AL. (Red outline delineates the region with RT > 10%; orange outline (grey cells) delineates regions with RT > 5%).

As an aid to the analysis, all regions with scaled residence time values greater than 5% and greater than 10% were noted on the displays as shown in Figure H-3. Finally, county boundaries were overlaid to identify those counties and 36 km modeling grid cells for which the extinction-weighted residence time back-trajectories exceeded 5% and 10%. These data were then exported as comma-delimited ASCII data files for further analyses. These residence time displays are used primarily to determine the regions (counties and/or grid cells) impacting each Class I Area. The next step in the analysis is to determine the potential impact from emission sources within the regions identified from the extinction-weighted back-trajectory residence time displays and analyses.

Previous VISTAS contribution assessment, emissions sensitivity modeling, and inventory analyses have indicated that SO4 is the largest contributor to haze on the worst 20 percent visibility days and that Electric Generating Utilities and industrial point sources are the largest contributors to SO4 levels at the Class I areas. These two source categories make up 95% of the VISTAS SO2 inventory. Therefore these two source categories were identified as the highest priority for evaluation of reasonable progress in 2018 at the Class I areas.

The potential impacts of SO2 point source emissions for each Class I Area are determined by combining gridded emissions data and weighted back-trajectory residence times for the 36 km grid cells. The analysis was carried out with both the 2002 and 2018 base year emission inventories. Figures H-4 and H-5 display the gridded point source SO2 emissions from the VISTAS modeling databases, for 2002 and 2018, respectively. These data were processed by summing all vertical layers for each grid column and then summing across all days to obtain annual emission totals for each grid cell.

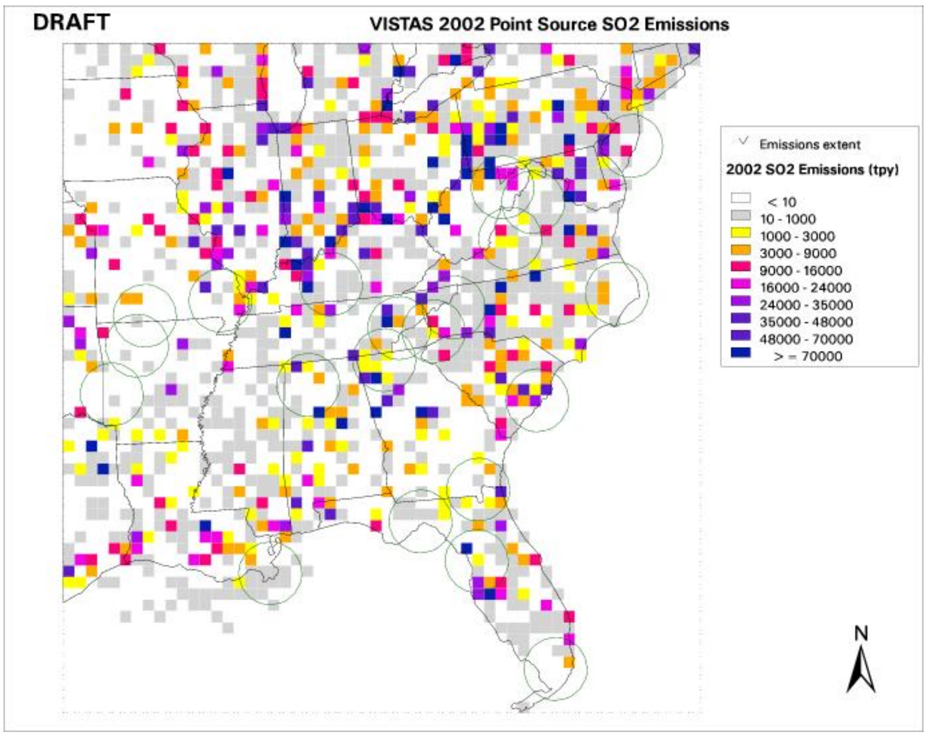

Figure H-4. Annual point source SO2 emissions for the VISTAS region for 2002 in tons/year. (2002 BaseG).

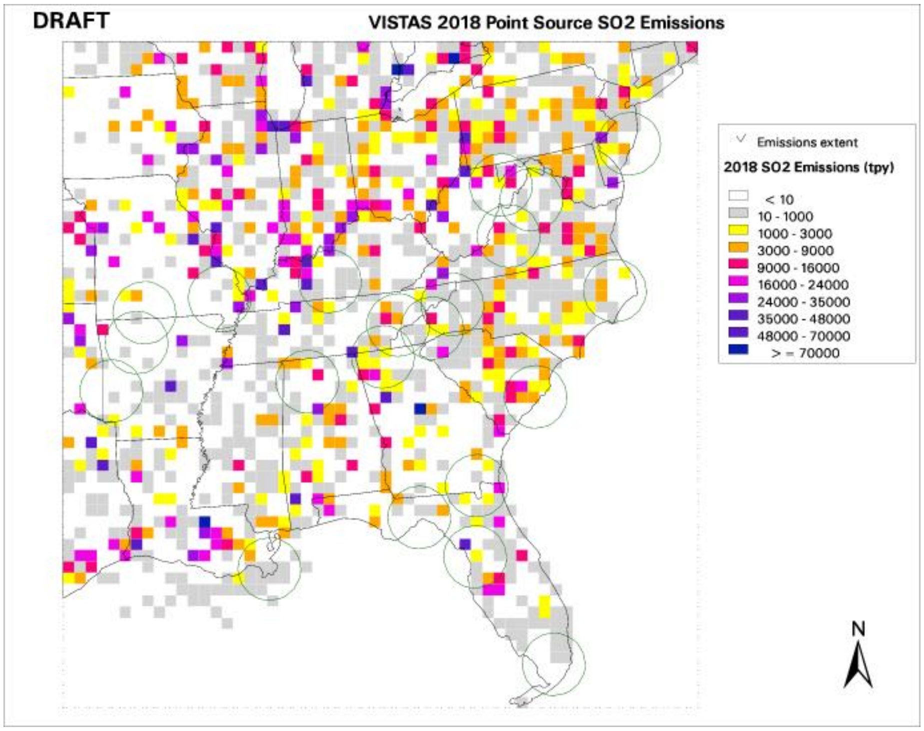

Figure H-5. Annual point source SO2 emissions for the VISTAS region for 2018 in tons/year. (2018 BaseG).

As a way of incorporating the effects of transport, dispersion, deposition, and chemical transformation of point source emissions along the path of the trajectories, these data were weighted by 1/d, where d was calculated as the distance between the 36 km grid cell centers for the source and the Class I area monitor, in kilometers. For the grid cell containing the Class I Area monitor, a weighting of 1/9 was applied. The distance-weighted point source SO2 emissions are then combined with the gridded extinction-weighted back-trajectory residence times at a spatial resolution of 36 km.

The final step in the development of the displays and datasets involve the combination of the residence times and gridded emission data. The distance weighted (1/d) gridded point source SO2 emissions are multiplied by the total extinction-weighted back-trajectory residence times (SO2 * Bext-weighted RT * (1/d)) on a grid cell by grid cell basis. These results are then normalized by the domain-wide total and displayed as a percentage. The analysis is carried out for both the 2002 and 2018 base year inventories. Figures H-6 and H-7 display the result of this final analysis step. Note that the outlined regions (in red and light orange) represent the extent of the >10% and >5% sulfate extinction-weighted residence times, determined from the first step in the analysis (see Figure H-3). As with the residence time analysis, the results of the combined distance-weighted SO2 emissions and extinction-weighted residence times are overlaid with county boundaries and exported to comma-delimited ASCII data files for further analyses of emissions and control options for specific sources.

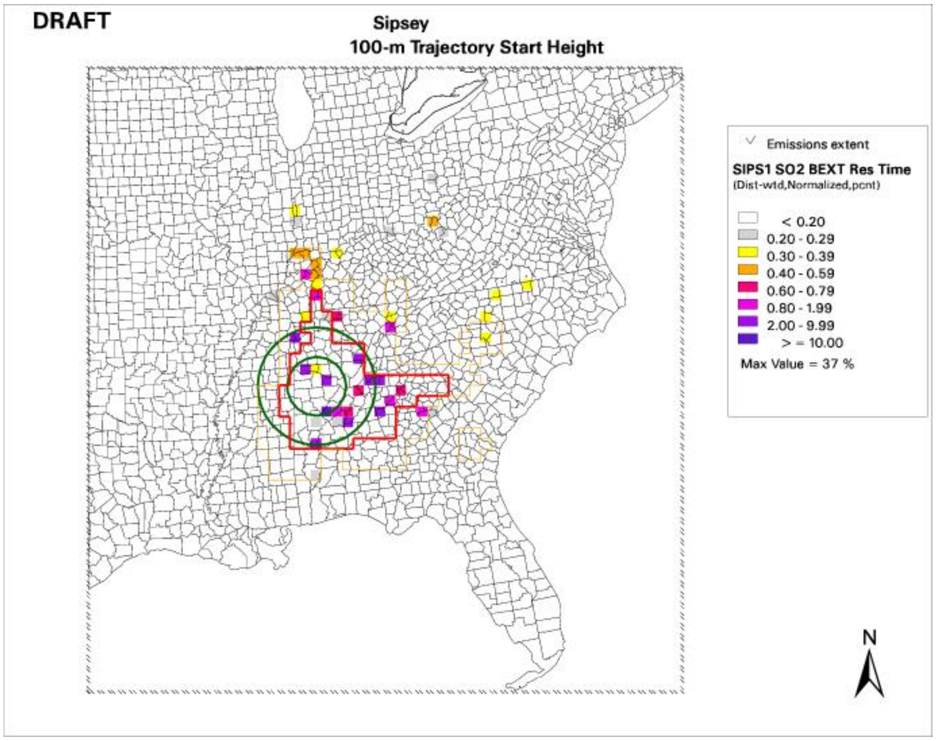

Figure H-6. Normalized 2002 SO2 point source emissions times distance-weighted residence time display for Sipsey, AL. (Red outline delineates the region with RT > 10%; orange outline delineates regions with RT > 5%).

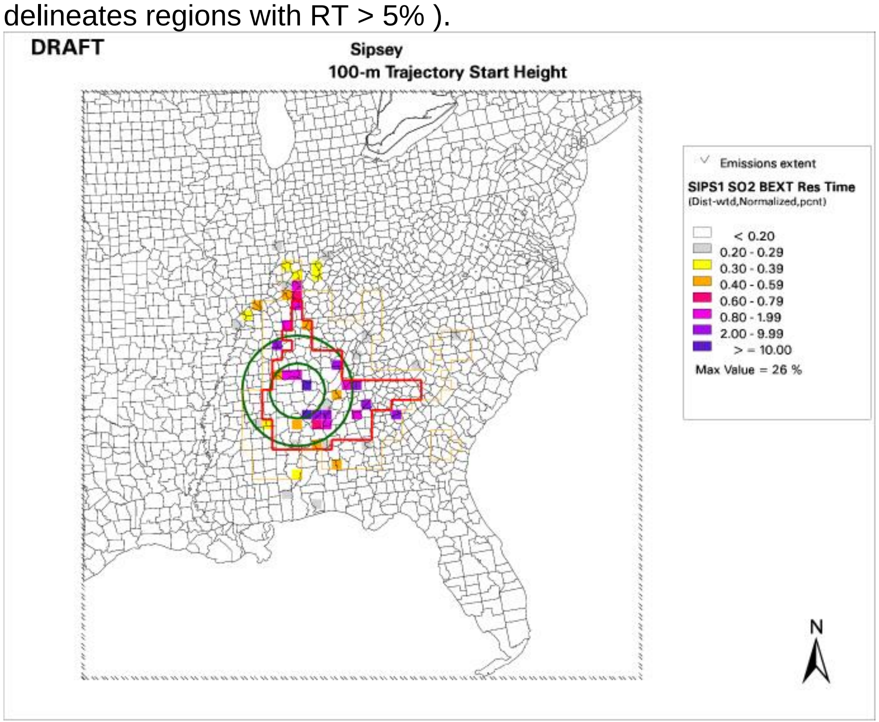

Figure H-7. Normalized 2018 SO2 point source emissions times distance-weighted residence time display for Sipsey, AL. (Red outline delineates the region with RT > 10%; orange outline delineates regions with RT > 5%).

VISTAS states evaluated these plots of residence time weighted by sulfate extinction plots of gridded SO2 emissions and defined the SO2 Areas of Influence as those areas with residence time greater than 10%, based on trajectories with start height of 100m and 4 start times per day.

H.4 Summary of Emission Inventories Used in Cost Curve Analysis

A necessary component of control strategy design is a thorough review of the emission inventories that are used in the modeling of the future year base case. These inventories can shed light on the residual emissions from sources or source categories defined to be within areas of transport or impact of a Class I area. We used the Base G (fall 2006) version of the VISTAS 2018 base case and 2002 base year emissions to conduct this cost curve analysis.

The NIF formatted and SMOKE-ready modeling files for both 2002 and 2018 base year and base cases were obtained from VISTAS emissions development and modeling contractors and converted to annual emissions and summed for the geography and domain of interest.

Tables H-2 and H-3 present the State breakdown of these emissions for the entire VISTAS domain. Because the SMOKE-ready files were used in this analysis, the fugitive dust transport factor (FDTF) is included in the PM emission summaries. This factor is applied to account for the removal of a substantial portion of fugitive dust emissions near a source by surrounding vegetation and structures when such emissions are used in regional scale modeling analyses.

Table H-2. VISTAS 2002 Base Year Annual Emissions Summary.

	BaseG Annual Emissions - 2002 Typical (Tons)						
State	**VOC**	**NOx**	**CO**	**SO2**	**PM-10**	**PM-2.5**	**NH3**
AL	445,497	459,880	2,534,778	584,665	232,229	105,341	67,970
FL	1,291,562	930,086	7,710,376	589,069	408,902	205,450	61,643
GA	765,063	623,645	5,013,024	653,362	408,736	195,654	100,134
KY	286,752	466,403	1,730,622	580,341	148,290	50,981	57,220
MS	302,374	239,547	1,203,899	103,679	180,816	43,533	63,765
NC	655,950	616,583	4,097,444	546,429	179,242	84,513	172,976
SC	382,836	323,976	2,064,423	286,781	165,699	78,356	35,400
TN	473,244	511,151	2,601,059	442,589	165,095	75,458	42,738
VA	448,205	461,628	3,034,414	416,190	109,848	47,004	55,057
WV	135,819	348,576	802,262	569,373	48,423	27,807	12,341
VISTAS	**5,187,303**	**4,981,474**	**30,792,301**	**4,772,477**	**2,047,281**	**914,096**	**669,243**

Table H-3. 2018 Base Case Annual Emissions Summary.

	BaseG Annual Emissions - 2018 Base Case (Tons)						
State	**VOC**	**NOx**	**CO**	**SO2**	**PM-10**	**PM-2.5**	**NH3**
AL	327,850	268,067	1,994,607	305,938	258,179	114,681	84,513
FL	990,629	448,443	6,099,425	260,963	483,328	226,529	73,455
GA	585,528	357,169	3,820,095	358,570	472,376	211,406	124,237
KY	236,983	277,271	1,356,496	320,525	166,918	58,559	63,959
MS	247,932	173,893	850,056	62,627	205,761	54,912	76,040
NC	421,965	275,907	2,702,315	164,067	208,015	100,253	196,577
SC	300,291	193,247	1,527,341	163,491	189,358	88,891	42,883
TN	374,093	247,827	1,692,551	228,035	187,066	84,117	46,984
VA	311,835	276,525	2,001,939	294,209	131,708	57,993	64,276
WV	107,675	150,777	576,198	190,683	54,736	31,678	14,400
VISTAS	**3,904,780**	**2,669,125**	**22,621,023**	**2,349,107**	**2,357,445**	**1,029,017**	**787,325**

Our review was conducted in a top down fashion starting with an analysis of the major source categories in the domains of interest to determine which major categories had the highest residual contribution to the area. Once the highest source types were identified, subcategories within those source types were reviewed. Again, a ranking of the highest residual sub source types was performed and additional analyses on these categories were conducted. These analyses are illustrated for sources in the SO2 Area of Influence for Sipsey in Tables H-4 through H-8.

For purposes of listing sources within the Area of Influence, data were provided for all sources with emissions over distance (Q/d) greater than 5 and maximum residence time (RTmax) greater than 5. States independently defined the criteria for selecting which sources from this list would be considered for reasonable control measures. RTmax greater than 10 was used to define emissions included in Tables H-4 through H-8.

Table H-4. 2018 Base G2 Annual Emissions (Tons) by Source Category in SO2 Area of Influence for Sipsey Wilderness Area.

	Annual 2018 BaseG2 Emissions (Tons)						
Tier	**VOC**	**NOX**	**CO**	**SO2**	**PM-10**	**PM-2.5**	**NH3**
Fuel Comb. Elec. Util.	7,237	236,192	82,293	542,524	74,612	56,145	3,916
Fuel Comb. Industrial	14,210	181,413	168,051	198,033	29,686	19,351	592
Fuel Comb. Other	61,635	55,145	178,412	57,140	27,763	25,516	873
Chemical & Allied Product Mfg	19,707	6,225	61,613	16,315	6,046	4,038	1,643
Metals Processing	12,069	8,866	235,955	48,889	23,309	19,855	778.78
Petroleum & Related Industries	2,372	1,689	3,353	5,709	998	643	0.02
Other Industrial Processes	112,629	59,626	94,469	42,121	77,815	36,776	3,133
Solvent Utilization	583,810	969	574.93	12.87	2,387	1,935	105.74
Storage & Transport	84,177	462	422.07	122.1	4,637	2,668	3.59
Waste Disposal & Recycling	46,900	14,606	310,604	2,438	53,825	50,254	169
Highway Vehicles	231,426	220,157	3,159,968	3,315	10,934	5,399	33,044
Off-highway	151,510	186,975	2,304,372	7,789	13,846	13,083	204.24
Miscellaneous	39,733	13,403	642,523	3,640	580,930	117,566	308,848
VISTAS Total	**1,367,414**	**985,728**	**7,242,611**	**928,046**	**906,789**	**353,229**	**353,311**

Table H-5. 2018 Base G2 Annual Emissions (Percentage) by Source Category in SO2 Area of Influence for Sipsey Wilderness Area.

	Annual 2018 BaseG2 Emissions (%)						
Tier	**VOC**	**NOX**	**CO**	**SO2**	**PM-10**	**PM-2.5**	**NH3**
Fuel Comb. Elec. Util.	1%	24%	1%	58%	8%	16%	1%
Fuel Comb. Industrial	1%	18%	2%	21%	3%	5%	0%
Fuel Comb. Other	5%	6%	2%	6%	3%	7%	0%
Chemical & Allied Product Mfg	1%	1%	1%	2%	1%	1%	0%
Metals Processing	1%	1%	3%	5%	3%	6%	0%
Petroleum & Related Industries	0%	0%	0%	1%	0%	0%	0%
Other Industrial Processes	8%	6%	1%	5%	9%	10%	1%
Solvent Utilization	43%	0%	0%	0%	0%	1%	0%
Storage & Transport	6%	0%	0%	0%	1%	1%	0%
Waste Disposal & Recycling	3%	1%	4%	0%	6%	14%	0%
Highway Vehicles	17%	22%	44%	0%	1%	2%	9%
Off-highway	11%	19%	32%	1%	2%	4%	0%
Miscellaneous	3%	1%	9%	0%	64%	33%	87%
VISTAS Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table H-6. 2018 Base G2 Annual Emissions (Tons) for Top Three Source Categories in SO2 Area of Influence for Sipsey Wilderness Area.

	Annual 2018 BaseG2 Emissions (Tons)						
Tier	**VOC**	**NOX**	**CO**	**SO2**	**PM-10**	**PM-2.5**	**NH3**
Fuel Comb. Elec. Util.-Coal	5,838	222,105	43,332	538,424	70,940	52,634	988
Fuel Comb. Elec. Util.-Oil	65	548	9	52	2	1	0
Fuel Comb. Elec. Util.-Gas	66	1,598	609	3,782	323	216	113
Fuel Comb. Elec. Util.-Other	16	235	101	6	76	46	0
Fuel Comb. Elec. Util.-Internal	1,252	11,706	38,242	260	3,272	3,248	2,815
Fuel Comb. Industrial-Coal	1,884	41,177	29,545	135,360	13,952	6,177	13
Fuel Comb. Industrial-Oil	231	12,471	4,455	36,115	2,138	1,305	97
Fuel Comb. Industrial-Gas	6,001	56,185	74,037	17,184	7,836	7,381	482
Fuel Comb. Industrial-Other	3,377	18,346	48,181	9,188	5,149	3,902	0
Fuel Comb. Industrial-Internal	2,717	53,233	11,833	185	611	587	0
Fuel Comb. Other-	302	5,437	1,005	18,786	440	295	0
Fuel Comb. Other-	131	3,076	1,193	32,056	1,602	968	149
Fuel Comb. Other-	658	11,045	7,131	946	962	898	23
Fuel Comb. Other-Misc. Fuel Comb.	1,145	3,811	21,618	1,649	958	689	3
Fuel Comb. Other-Residential Wood	57,645	3,034	129,215	431	21,242	20,345	304
Fuel Comb. Other-Residential Other	1,753	28,742	18,249	3,272	2,560	2,323	395
Top Tier Total	**83,082**	**472,750**	**428,756**	**797,697**	**132,061**	**101,013**	**5,381**

Table H-7. 2018 Base G2 Annual Emissions (Percentage) for Top Three Source Category in SO2 Area of Influence for Sipsey Wilderness Area.

	Annual 2018 BaseG2 Emissions (%)						
Tier	**VOC**	**NOX**	**CO**	**SO2**	**PM-10**	**PM-2.5**	**NH3**
Fuel Comb. Elec. Util.-Coal	0%	23%	1%	58%	8%	15%	0%
Fuel Comb. Elec. Util.-Oil	0%	0%	0%	0%	0%	0%	0%
Fuel Comb. Elec. Util.-Gas	0%	0%	0%	0%	0%	0%	0%
Fuel Comb. Elec. Util.-Other	0%	0%	0%	0%	0%	0%	0%
Fuel Comb. Elec. Util.-Internal	0%	1%	1%	0%	0%	1%	1%
Fuel Comb. Industrial-Coal	0%	4%	0%	15%	2%	2%	0%
Fuel Comb. Industrial-Oil	0%	1%	0%	4%	0%	0%	0%
Fuel Comb. Industrial-Gas	0%	6%	1%	2%	1%	2%	0%
Fuel Comb. Industrial-Other	0%	2%	1%	1%	1%	1%	0%
Fuel Comb. Industrial-Internal	0%	5%	0%	0%	0%	0%	0%
Fuel Comb. Other-	0%	1%	0%	2%	0%	0%	0%
Fuel Comb. Other-	0%	0%	0%	3%	0%	0%	0%
Fuel Comb. Other-	0%	1%	0%	0%	0%	0%	0%
Fuel Comb. Other-Misc. Fuel Comb.	0%	0%	0%	0%	0%	0%	0%
Fuel Comb. Other-Residential Wood	4%	0%	2%	0%	2%	6%	0%
Fuel Comb. Other-Residential Other	0%	3%	0%	0%	0%	1%	0%
Top Tier Total	**4%**	**47%**	**6%**	**85%**	**14%**	**28%**	**1%**

In addition to reviewing the residual emission categories in the future year base, it was important to identify reductions that had already occurred within each category or at specific units. This allowed VISTAS States to determine if certain source categories that had yet to be controlled under the future year base case had the potential for reduction or if source types already reduced have reached the full cost-effective emission reduction potential.

Finally, once each subcategory was identified, unit level tables of emission comparisons from 2002 to 2018 were developed allowing VISTAS States to review existing emission reductions and providing the ability to assign new cost-effective controls to units using the best control for the scenario. These tables presented comparisons of 2002 and 2018 emission levels, for SO2, and future year control technology assignment (by IPM forecasting and State modification) for point sources. Non-EGU unit-specific technology assignments were identified using the control efficiency tables provided by the VISTAS emissions inventory contractor, MACTEC.

Using these emission reviews and summaries like those presented in Figure H-8, VISTAS states made a decision to further evaluate reasonable measures for SO2 emissions controls beyond the On-The-Books scenario in 2018 for EGU and non-EGU point sources only. Ultimately, the long-term strategy will include emissions controls on the BART applicable sources. However, determinations of BART controls were not available for this analysis.

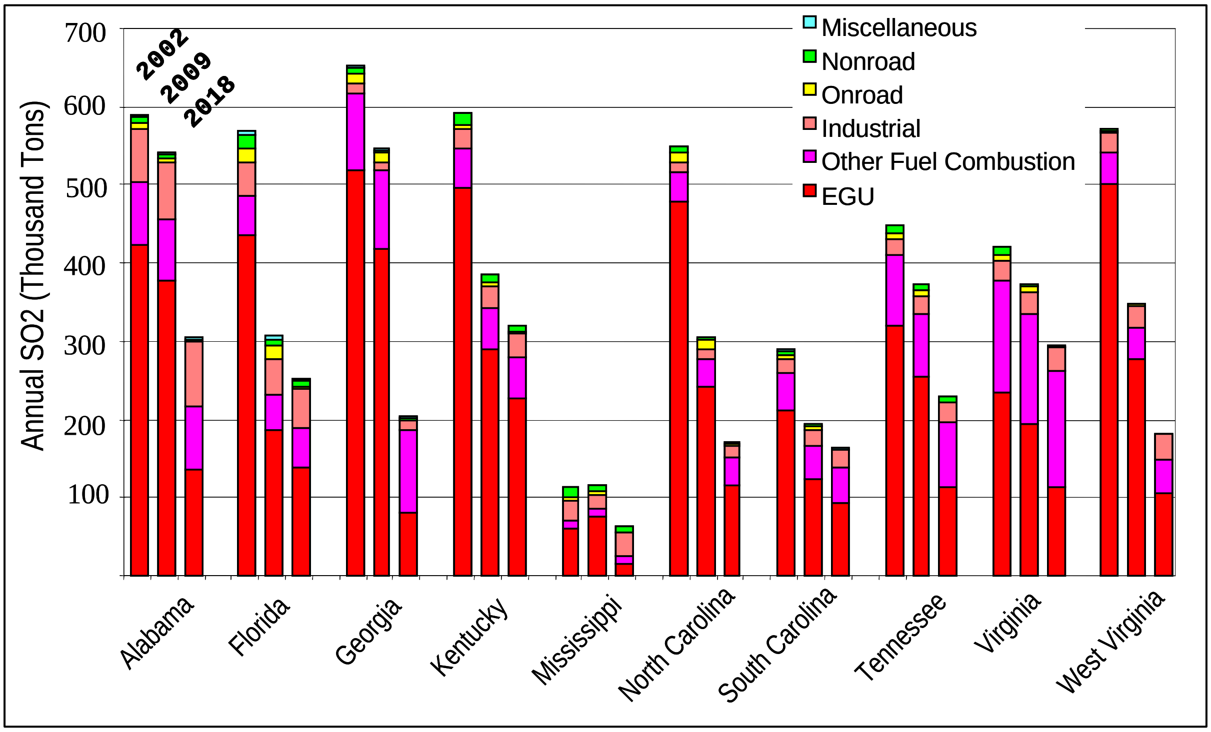

Figure H-8. VISTAS Base G2 SO2 Emissions Contributions by Major Source Sector.

H.5 Process in Preparing Files for Cost Effectiveness Curve Development

The 2018 IPM file used by VISTAS for EGU sources (RPO IPM version 2.1.9) was obtained and matched to the 2018 base case inventory of EGU sources. This step was conducted to ensure that incremental controls assigned to these source types did not duplicate existing base case assumptions. Because IPM does not assign a control efficiency with each control device applied to SO_2 and NO_X, we made some assumptions, based on IPM documentation, as to what pollutant specific level of reduction was applied in the future year base case runs. These assumptions, by primary and secondary control device code combinations for $SO_{2,}$ are presented in Table H-8.

Since many of the control technology control cost equations within AirControlNET require additional unit-level characteristic data, we also made matches of the SMOKE IDA files to VISTAS NIF, EPA NEI, or EPA CAMD CEM data sets to obtain these variables when missing. Unit level boiler capacity (MMBtu/hr) or NETDC (MW) values are required for capital and operating and maintenance cost calculations for many of the SO2 applied technologies. In cases where these nameplate capacity values could not be identified, emission weighted (based on the final EPA 2002 NEI) were assigned to boilers using a primary (highest emitting) SCC. Table H-9 presents these weighted capacities. Additionally, stack flow, sulfur content, and primary SCC assignment were necessary to cross-reference available incremental control technologies to the base case emissions inventory data. These variables were obtained where matches could be found, in priority order of VISTAS, CAMD, and other EPA datasets, respectively.

Table H-8. IPM Post Processing Assigned Device Codes and Applied SO_2 Control Efficiencies.

Primary Device Code	Secondary Device Code	Description	CE	RE
0	0	No Control	0	0
119	0	Dry Scrubber	90	100
141	0	Wet Scrubber	90	100

H.6 Application of AirControlNET Technologies

AirControlNET is a control technology analysis tool developed to support the U.S. EPA in its analyses of air pollution policies and regulations (Pechan, 2005). The tool provides data on emission sources, potential pollution control measures and emission reductions, and the costs of implementing those controls.

The core of AirControlNET is a relational database system in which control technologies are linked to sources within EPA emissions inventories. The system contains a database of control measure applicability, efficiency, and cost information for reducing the emissions contributing to ambient concentrations of ozone, PM_{10}, $PM_{2.5}$, SO_2, NO_X, as well as visibility impairment (regional haze) from point, area, and mobile sources. PM_{10} and $PM_{2.5}$ as included in AirControlNET represent primary emissions of PM. The control measure data file in AirControlNET includes not only the technology's control efficiency, and calculated emission reductions for that source, but also estimates the costs (annual and capital) for application of the control measure.

Since available versions of AirControlNET contain the preprocessed application of control technologies to a predetermined set of EPA emission inventories, direct use of the model in this analysis was not possible. However, VISTAS received approval from EPA’s Innovative Strategies and Economics Group (ISEG) to modify the AirControlNET version 4.1 source code and data tables in order to make it useful to this study (Sorrels, 2006). The results of the application of this modified version of the code still retain the applicability, efficiency, and cost information from the unmodified version of the source code, but were applied to the VISTAS modeling inventories with updated price index scalars to reflect control costs in 2005-dollars.

Using the modified inventories identified above, we ran every available SO2 control strategy in AirControlNET against the EGU and non-EGU point source inventories to develop a master list of available, *incremental* control strategies for the entire VISTAS 36 km domain necessary for VISTAS States to design command-and-control or cost-effectiveness based control strategies by source or domain.

Table H-9. Emissions Weighted NETDC (MW) Association.

SCC	Description	NETDC (MW)
10100201	External Combustion Boilers; Electric Generation; Bituminous/Subbituminous Coal; Pulverized Coal: Wet Bottom (Bituminous Coal)	200
10100202	External Combustion Boilers; Electric Generation; Bituminous/Subbituminous Coal; Pulverized Coal: Dry Bottom (Bituminous Coal)	500
10100203	External Combustion Boilers; Electric Generation; Bituminous/Subbituminous Coal; Cyclone Furnace (Bituminous Coal)	200
10100212	External Combustion Boilers; Electric Generation; Bituminous/Subbituminous Coal; Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	500
10100215	External Combustion Boilers; Electric Generation; Bituminous/Subbituminous Coal; Cell Burner (Bituminous Coal)	1300
10100218	External Combustion Boilers; Electric Generation; Bituminous/Subbituminous Coal; Atmospheric Fluidized Bed Combustion: Circulating Bed (Bitum. Coal)	200
10100222	External Combustion Boilers; Electric Generation; Bituminous/Subbituminous Coal; Pulverized Coal: Dry Bottom (Subbituminous Coal)	400
10100223	External Combustion Boilers; Electric Generation; Bituminous/Subbituminous Coal; Cyclone Furnace (Subbituminous Coal)	400
10100226	External Combustion Boilers; Electric Generation; Bituminous/Subbituminous Coal; Pulverized Coal: Dry Bottom Tangential (Subbituminous Coal)	500
10100401	External Combustion Boilers; Electric Generation; Residual Oil; Grade 6 Oil: Normal Firing	400
10100404	External Combustion Boilers; Electric Generation; Residual Oil; Grade 6 Oil: Tangential Firing	500
10100501	External Combustion Boilers; Electric Generation; Distillate Oil; Grades 1 and 2 Oil	400
10100601	External Combustion Boilers; Electric Generation; Natural Gas; Boilers > 100 Million Btu/hr except Tangential	400
10100701	External Combustion Boilers; Electric Generation; Process Gas; Boilers > 100 Million Btu/hr	200
10100801	External Combustion Boilers; Electric Generation; Petroleum Coke; All Boiler Sizes	600
10101204	External Combustion Boilers; Electric Generation; Solid Waste; Tire Derived Fuel : Shredded	200
10300811	External Combustion Boilers; Commercial/Institutional; Landfill Gas; Landfill Gas	200
20100101	Internal Combustion Engines; Electric Generation; Distillate Oil (Diesel); Turbine	200
20100109	Internal Combustion Engines; Electric Generation; Distillate Oil (Diesel); Turbine: Exhaust	200
20100201	Internal Combustion Engines; Electric Generation; Natural Gas; Turbine	200
	All other boilers	100

H.7 Development of AOI-Based Cost Curves

Each Class I area in the VISTAS modeling domain had an associated AOIs. In order to best determine where emission reduction has the greatest benefit, this geography was designed to limit the available source type list from including all sources within the entire domain.

These marginal cost curves include the application of all available control measures to all applicable point sources within the AOI. The curves allow VISTAS States to determine if emission controls, based on the generic application of SO2 control technologies from the associations originally developed in AirControlNET and improved upon with stakeholder input, will help attain reasonable further progress objectives while presumably minimizing the number and type of controlled sources in each AOI.

Using a geocoded county list from these AOIs, we parsed the master list of incremental control measures from all point sources located within the boundaries of the AOIs. This parsed list was then sorted on in incremental cost-effectiveness (marginal cost) basis to determine the most cost effective control suite available to attain emission reduction targets for SO2 within each AOI. Each individual source had its own cost effectiveness curve generated.

In aggregate, the results of these applications are SO2 emission cost curves for all EGU and non-EGU point source within the geographic domain of the AOI. Incremental controls on area and mobile sources were not considered in this analysis.

With each AOI's cost curve, additional metrics calculated for the distance from the emission release point to the Class I area IMPROVE monitor (in km), the 2018 residual emissions and distance (Q/d) or squared distance (Q/d^2), and the normalized 2018 SO2 point source emissions times distance-weighted residence time (RTMax) values for the county in which the emission release point was located were calculated for incremental review and consideration. States can use these values to further determine control strategy development for individual Class I areas.