

Selection of States for MANE-VU Regional Haze Consultation (2018)

MANE-VU Technical Support Committee

5/4/2017

Introduction

Under the Regional Haze Rule¹, States with Class I areas are to consult with states contributing to visibility degradation regarding reasonable measures that can be pursued to improve visibility. The purpose of this paper is to review the process used to determine the selection of states for MANE-VU Class I Area state consultation. Consultation does not mean that selected states have not addressed their visibility impairing emissions, but rather technical analysis suggests that their location, historical emissions and prevailing weather patterns create enough possibility for visibility impact on MANE-VU's Class I areas that they should be included in the discussion of "reasonable" measures to include in the Regional Haze SIP's.

In order to determine which states should be consulted an analysis must be conducted to define what States, sources, or sectors reasonably contribute to visibility impairment. EPA's draft guidance document calls for a process for determining which sources or source sectors should be considered.² It begins with analyzing monitored emissions data on the 20% worst days to determine what pollution is leading to anthropogenic visibility impacts. This is followed by screening for sources or source sectors that are leading to a majority of that impact. The results of this analysis will lead to what source or sectors need a four-factor analysis and which states should be consulted with.

Firstly, MANE-VU concluded, after developing a conceptual model, that the sulfates from SO₂ emissions were still the primary driver behind visibility impairment in the region, though nitrates from NO_x emission sources do play a more significant role than they had in the first planning period.³ Because of this, MANE-VU chose an approach to contribution assessments that focused on sulfates and included nitrates when they could be included in a technically sound fashion.

Secondly, MANE-VU examined annual inventories of emissions to find sectors that should be considered for further analysis.⁴ EGUs emitting SO₂ and NO_x and industrial point sources emitting SO₂ were found to be point source sectors of high emissions that warranted further scrutiny. Mobile sources were not considered in this analysis because any issues concerning mobile sources would be raised to EPA and not during the intra-RPO and inter-RPO consultation process.

After this initial work, MANE-VU initiated a process of screening states and sectors for contribution using two tools, Q/d and CALPUFF. Support for these tools for screening purposes follows in the next section.

¹ US EPA, "Protection of Visibility: Amendments to Requirements for State Plans."

² US EPA, "Draft Guidance on Progress Tracking Metrics, Long-Term Strategies, Reasonable Progress Goals and Other Requirements for Regional Haze State Implementation Plans for the Second Implementation Period."

³ Downs et al., *The Nature of the Fine Particle and Regional Haze Air Quality Problems in the MANE-VU Region: A Conceptual Description*.

⁴ Mid-Atlantic Northeast Visibility Union, "Contribution Assessment Preliminary Inventory Analysis."

MANE-VU wanted to limit this work to only these two analyses for screening purposes because of the lack of resources within the States and visibility impacts are not one of the so called four-factors for determining if a future air pollution control is “reasonable” for a state to undertake. The four factors to be considered are:

1. Costs of compliance;
2. Time necessary for compliance;
3. Energy and non-air quality environmental impacts; and
4. Remaining useful life of affected sources (40 CFR 51.308(d)(1)(i))

If visibility impacts were specifically determined, this information would not be useful in determining if a control is “reasonable” and would not advance the Clean Air Act mandate of the eventual elimination of all manmade visibility impacts on Class I areas. As a result, the screening work only goes as far as to develop weighted concentration data for use in determining what States have a high likelihood of effecting visibility levels in MANE-VU’s Class I areas.

Support for Use of Q/d and CALPUFF for Screening

Q/d is largely accepted as a screening tool and continues to be as was the conclusion of a July 2015 report by an interagency air quality modeling work group.⁵ This conclusion was supported by EPA due to Q/d being a highly conservative screening tool as found in a report by NACAA when assuming 100% conversion of SO₂ gas to the particulate form (NH₃SO₄) that effects visibility⁶ EPA has also found that Q/d is well suited for determining the relative impacts for comparison purposes.⁷ This means that Q/d lends itself well to determining which states, sectors, or sources have a larger relative impact and warrant further scrutiny.

The FLMs, through the FLAG processes, suggest that using the Q/d test is an appropriate initial test⁸ when evaluating emissions from new sources “greater than 50 km from a Class I area to determine whether or not any further visibility analysis is necessary”. Given that many of the sources being examined are well over 50 km from any of the MANE-VU Class I areas, the use of Q/d would appear to be supported.

A review of contribution analyses conducted by MANE-VU, including the previous two NESCAUM Q/d studies (CALPUFF analyses and REMSAD analysis) found similar results regardless of the method.⁹ This is

⁵ US EPA, *Interagency Work Group on Air Quality Modeling Phase 3 Summary Report: Near-Field Single Source Secondary Impacts*.

⁶ National Association of Clean Air Agencies, *PM2.5 Modeling Implementation for Projects Subject to National Ambient Air Quality Demonstration Requirements Pursuant to New Source Review*.

⁷ Baker and Foley, “A Nonlinear Regression Model Estimating Single Source Concentrations of Primary and Secondarily Formed PM2.5.”

⁸ US Forest Service, *Federal Land Managers’ Air Quality Related Values Workgroup (FLAG) Phase I Report--Revised*.

⁹ NESCAUM, *Contributions to Regional Haze in the Northeast and Mid-Atlantic United States*.

demonstrated in the correlation matrix in Table 1 where the ideal result would be that all of the tools produced the exact same results resulting in a correlation coefficient of 100%.

Table 1: Correlation coefficients obtain from comparing sulfate concentration results from four techniques¹⁰

	Q/d	REMSAD	CALPUFF (NWS)	CALPUFF (MM5)
Q/d	100%	93.01%	92.83%	91.86%
REMSAD		100%	95.12%	94.16%
CALPUFF (NWS)			100%	97.82%
CALPUFF (MM5)				100%

In the FLAG report, the FLM’s stated that “CALPUFF is still the preferred first-level air quality model for calculating pollutant concentrations,” with the first-level analysis being able to determine a relative change in light extinction.¹¹ In particular, the FLAG report recommends running 3 years of meteorology as was done as part of this work. As was demonstrated in Table 1, CALPUFF produces similar results to REMSTAD and Q/d as well.

Although these methods are intended as screening tools, these previous analyses provide a precedence for using them as such.

Modeling Analysis

MANE-VU conducted two contribution analyses including a state modified Q/d analysis¹² and a CALPUFF dispersion modeling analysis.¹³ Each is summarized in detail in separate reports.

The Q/d analysis considered several approaches to determining impact. Some of these used specific point source locations and some state centroids, some looked at both NO_x and SO₂ emissions and some only SO₂ emissions, some looked at 2011 emissions and some looked at 2018. The specific analysis taken forward is the analysis of point source specific 2011 SO₂ emissions emanating from the location of the point source. The study uses dispersion factors developed during a similar analysis conducted by MANE-VU for the 2008 regional haze SIP process. The results of this Q/d analysis are presented in Table 2.

The CALPUFF analyses considered 500 EGU and 121 ICI units throughout the eastern United States. Ninety-fifth percentile NO_x and SO₂ emissions for 2011 were modeled with three different years of meteorology (2002, 2011, and 2015). The full set of state summarized contribution is in Table 3.

¹⁰ Ibid.

¹¹ US Forest Service, *Federal Land Managers’ Air Quality Related Values Workgroup (FLAG) Phase I Report--Revised*.

¹² Mid-Atlantic Northeast Visibility Union, *MANE-VU Updated Q/d*C Contribution Assessment*.

¹³ Mid-Atlantic Northeast Visibility Union, *2016 MANE-VU Source Contribution Modeling Report*.

Table 2: Summary of state level impacts from 2011 SO₂ point source emissions using Q/d

	Acadia			Brigantine			Great Gulf			Lye Brook			Moosehorn		
	Total	%	Rank	Total	%	Rank	Total	%	Rank	Total	%	Rank	Total	%	Rank
2011															
AL	0.0193	2.14%	10	0.0297	2.30%	12	0.0132	1.97%	11	0.0217	2.25%	11	0.0142	1.88%	11
AR	0.0062	0.69%	24	0.0085	0.66%	23	0.0053	0.78%	22	0.0067	0.69%	21	0.0059	0.79%	23
CT	0.0005	0.05%	29	0.0004	0.03%	30	0.0001	0.01%	32	0.0003	0.03%	29	0.0003	0.04%	29
DC	0.0002	0.02%	32	0.0006	0.04%	29	0.0001	0.02%	30	0.0001	0.01%	30	0.0001	0.01%	31
DE	0.0026	0.29%	27	0.0158	1.22%	19	0.0006	0.09%	27	0.0013	0.13%	26	0.0018	0.24%	26
GA	0.0216	2.40%	9	0.0319	2.47%	8	0.0131	1.95%	12	0.0178	1.84%	12	0.0151	2.01%	10
IA	0.0129	1.43%	18	0.0104	0.80%	22	0.0106	1.58%	14	0.0113	1.17%	18	0.0094	1.25%	16
IL	0.0318	3.53%	5	0.0311	2.41%	9	0.0271	4.05%	5	0.0298	3.09%	8	0.0318	4.23%	5
IN	0.0503	5.58%	3	0.0610	4.72%	3	0.0454	6.77%	3	0.0511	5.30%	3	0.0470	6.25%	3
KY	0.0265	2.95%	7	0.0487	3.77%	4	0.0213	3.19%	7	0.0324	3.36%	6	0.0248	3.29%	8
LA	0.0118	1.31%	20	0.0163	1.26%	17	0.0079	1.19%	16	0.0127	1.32%	15	0.0087	1.16%	17
MA	0.0123	1.36%	19	0.0061	0.47%	24	0.0024	0.36%	24	0.0033	0.34%	25	0.0037	0.50%	24
MD	0.0107	1.19%	22	0.0369	2.86%	6	0.0073	1.09%	17	0.0118	1.23%	16	0.0082	1.09%	18
ME	0.0097	1.07%	23	0.0008	0.06%	28	0.0012	0.18%	25	0.0004	0.05%	28	0.0069	0.92%	21
MI	0.0423	4.69%	4	0.0301	2.33%	11	0.0353	5.26%	4	0.0446	4.62%	4	0.0381	5.06%	4
MN	0.0046	0.51%	25	0.0029	0.23%	27	0.0009	0.14%	26	0.0050	0.52%	22	0.0011	0.15%	28
MO	0.0251	2.79%	8	0.0262	2.03%	13	0.0211	3.15%	8	0.0228	2.37%	9	0.0259	3.44%	7
MS	0.0039	0.44%	26	0.0057	0.44%	25	0.0027	0.40%	23	0.0043	0.45%	24	0.0029	0.38%	25
NC	0.0140	1.56%	17	0.0245	1.90%	14	0.0064	0.95%	19	0.0094	0.98%	19	0.0076	1.01%	19
NH	0.0145	1.61%	15	0.0047	0.36%	26	0.0056	0.83%	21	0.0044	0.45%	23	0.0104	1.39%	14
NJ	0.0018	0.20%	28	0.0162	1.25%	18	0.0006	0.08%	28	0.0011	0.11%	27	0.0012	0.16%	27
NY	0.0189	2.10%	11	0.0154	1.19%	20	0.0178	2.66%	9	0.0328	3.40%	5	0.0157	2.09%	9
OH	0.0919	10.21%	1	0.1438	11.13%	1	0.0737	11.01%	1	0.1144	11.86%	1	0.0846	11.24%	1
PA	0.0650	7.22%	2	0.1272	9.84%	2	0.0524	7.83%	2	0.0984	10.20%	2	0.0539	7.17%	2
RI	0.0005	0.05%	30	0.0002	0.02%	31	0.0001	0.01%	31	0.0001	0.01%	32	0.0001	0.01%	32
SC	0.0111	1.24%	21	0.0180	1.39%	16	0.0061	0.91%	20	0.0075	0.78%	20	0.0068	0.90%	22
TN	0.0144	1.60%	16	0.0243	1.88%	15	0.0102	1.52%	15	0.0171	1.78%	13	0.0103	1.37%	15
TX	0.0302	3.35%	6	0.0386	2.98%	5	0.0221	3.31%	6	0.0310	3.21%	7	0.0293	3.90%	6
VA	0.0151	1.68%	14	0.0360	2.78%	7	0.0069	1.03%	18	0.0116	1.20%	17	0.0072	0.95%	20
VT	0.0002	0.02%	31	0.0001	0.01%	32	0.0003	0.04%	29	0.0001	0.01%	31	0.0002	0.02%	30
WI	0.0172	1.91%	12	0.0105	0.82%	21	0.0142	2.12%	10	0.0161	1.67%	14	0.0113	1.51%	13
WV	0.0157	1.74%	13	0.0306	2.37%	10	0.0118	1.77%	13	0.0218	2.26%	10	0.0139	1.85%	12

Table 3: Summary of state level impacts from 2011 SO₄ and NO₃ from large point sources modeled using CALPUFF

Contrib. State	CALPUFF SO ₄ (µg/m ³)					CALPUFF NO ₃ (µg/m ³)				
	Acadia	Brigantine	Great Gulf	Lye Brook	Moosehorn	Acadia	Brigantine	Great Gulf	Lye Brook	Moosehorn
AL	0.366	0.699	0.221	0.322	0.267	0.081	0.259	0.081	0.105	0.070
AR	0.177	0.140	0.144	0.193	0.167	0.087	0.082	0.077	0.097	0.082
CT	0.104	0.085	0.044	0.123	0.102	0.064	0.118	0.085	0.117	0.124
DE	0.090	0.117	0.107	0.122	0.130	0.012	0.019	0.010	0.008	0.019
GA	0.627	1.089	0.867	0.659	0.528	0.126	0.185	0.135	0.138	0.125
IA	0.218	0.258	0.259	0.225	0.211	0.088	0.104	0.102	0.086	0.083
IL	0.379	0.620	0.608	0.483	0.443	0.150	0.331	0.239	0.188	0.134
IN	2.091	2.842	2.229	2.657	2.059	0.537	0.746	0.917	0.958	0.518
KS	0.106	0.136	0.103	0.193	0.104	0.069	0.055	0.067	0.084	0.068
KY	0.910	1.420	0.828	0.989	0.879	0.244	0.573	0.378	0.381	0.240
MA	1.424	0.791	0.484	0.651	1.297	0.235	0.210	0.201	0.165	0.236
MD	0.761	1.758	0.489	0.753	0.674	0.279	1.416	0.335	0.432	0.213
ME	0.212	0.083	0.128	0.152	0.202	0.094	0.015	0.115	0.149	0.075
MI	1.659	2.422	1.674	1.548	1.688	0.500	0.835	0.658	0.593	0.522
MN	0.094	0.153	0.126	0.129	0.071	0.065	0.103	0.091	0.095	0.061
MO	0.369	0.453	0.473	0.530	0.352	0.109	0.115	0.122	0.140	0.121
NC	0.720	0.963	0.411	0.655	0.737	0.124	0.487	0.119	0.229	0.125
NH	1.154	0.383	0.898	1.267	0.948	0.299	0.125	0.340	0.545	0.200
NJ	0.215	1.266	0.176	0.144	0.187	0.051	0.566	0.081	0.082	0.042
NY	0.618	0.712	0.630	1.381	0.498	0.271	0.408	0.436	0.666	0.184
OH	4.915	8.287	4.566	6.447	4.293	0.843	1.893	1.543	1.501	0.864
OK	0.191	0.261	0.226	0.324	0.148	0.108	0.128	0.087	0.139	0.089
PA	3.307	4.296	2.779	3.901	2.549	0.794	2.103	0.993	1.556	0.829
SC	0.791	1.060	0.528	0.406	0.760	0.076	0.165	0.048	0.083	0.075
TN	0.617	1.080	0.408	0.552	0.628	0.057	0.224	0.068	0.097	0.054
TX	0.394	0.955	0.507	0.987	0.408	0.076	0.184	0.078	0.075	0.075

Contrib. State	CALPUFF SO ₄ (µg/m ³)					CALPUFF NO ₃ (µg/m ³)				
	Acadia	Brigantine	Great Gulf	Lye Brook	Moosehorn	Acadia	Brigantine	Great Gulf	Lye Brook	Moosehorn
VA	1.656	3.597	0.821	1.747	1.554	0.192	0.934	0.163	0.318	0.153
WI	0.226	0.323	0.432	0.391	0.219	0.047	0.112	0.109	0.082	0.046
WV	0.715	1.364	0.699	1.073	0.552	0.336	1.558	0.750	0.685	0.364
TOTAL	25.104	37.611	21.864	29.004	22.655	613	14.053	8.430	9.792	5.793

Both techniques provided estimates for potential visibility impacting masses. Rather than relying solely on one technique for identifying states to include in the MANE-VU consultation process, both techniques were included by means of a mass-weighted average calculation. Since nitrates and sulfates have similar visibility impairment for similar ambient air concentrations, they were normalized and weighted equally in the weighting calculation. Weighting for sulfate was also applied equally for the Q/d and CALPUFF analyses. Because Q/d calculations could not be completed for nitrates, the weighting calculation relied on the CALPUFF nitrate analysis. Nitrates were normalized based on ratios calculated using 2011 IMPROVE data found in Table 4 to allow the results to be directly related to the results from sulfates. No further weighting was deemed necessary since sulfates and nitrates impact light extinction equally in the IMPROVE formula. CALPUFF results for Florida, Mississippi, and Louisiana were not available and were approximated by using the values for Alabama, Arkansas, and Arkansas respectively.

Table 4: 2011 IMPROVE NO₃/SO₄ ratio (mass)

Acadia	Brigantine	Great Gulf	Lye Brook	Moosehorn
0.221	0.396	0.230	0.352	0.177

Table 5 provides normalized contributions to five MANE-VU Class I Areas. The scores for the 30 states total 100 (or 100%). States listed towards the top of the table in orange shading each are estimated to contribute 3 percent or greater of the 30 state total contributions. States in the pink shade contribute 2 to 3 percent and states listed in green contribute less than 2 percent in this ranking. Figure 1 through Figure 5 provide maps of these results for five MANE-VU Class I Areas.

Table 5: Mass-Weighted 2011 Sulfate and Nitrate Contribution for top 30 Eastern States to MANE-VU Class I.

Rank	Acadia		Brigantine		Great Gulf		Lye Brook		Moosehorn	
1	OH	17.10	OH	18.53	OH	18.71	OH	19.37	OH	17.67
2	PA	12.12	PA	13.52	PA	12.21	PA	14.66	PA	11.28
3	IN	8.41	IN	7.05	IN	10.28	IN	8.77	IN	9.21
4	MI	6.97	VA	6.87	MI	7.80	MI	6.15	MI	7.65
5	VA	4.42	MD	5.44	KY	4.32	NY	5.23	KY	4.39
6	KY	4.03	MI	5.15	IL	4.28	KY	4.19	VA	4.02
7	MA	3.86	WV	4.86	NY	3.63	WV	4.07	IL	4.00
8	NH	3.65	KY	4.66	WV	3.55	VA	3.82	TX	3.62
9	IL	3.31	TX	3.18	TX	3.37	TX	3.63	MA	3.30
10	TX	3.10	GA	3.00	GA	3.26	IL	2.98	MO	3.26
11	WV	3.01	NJ	2.87	MO	3.25	NH	2.98	NH	3.16
12	NY	2.97	NC	2.85	NH	2.82	MD	2.55	WV	2.91

Rank	Acadia		Brigantine		Great Gulf		Lye Brook		Moosehorn	
13	GA	2.95	TN	2.66	VA	2.58	MO	2.51	NY	2.71
14	MO	2.73	IL	2.62	WI	2.45	GA	2.36	GA	2.63
15	MD	2.63	AL	2.55	MD	2.15	TN	2.10	MD	2.42
16	NC	2.55	SC	2.26	TN	1.95	AL	2.08	NC	2.36
17	SC	2.38	NY	2.03	AL	1.89	NC	1.94	TN	2.29
18	TN	2.28	MO	1.94	SC	1.75	WI	1.77	SC	2.27
19	AL	2.24	MA	1.42	IA	1.73	LA (est)	1.67	AL	1.94
20	WI	1.77	LA (est)	1.29	NC	1.63	MA	1.43	WI	1.55
21	LA (est)	1.77	FL (est)	1.15	MA	1.48	OK	1.24	LA (est)	1.47
22	IA	1.50	WI	1.01	LA (est)	1.39	SC	1.22	IA	1.41
23	ME	1.26	OK	0.98	OK	1.36	IA	1.22	OK	1.34
24	OK	1.25	DE	0.93	AR	0.92	AR	0.88	ME	1.15
25	FL (est)	1.20	IA	0.92	FL (est)	0.63	MN	0.67	AR	1.00
26	AR	0.92	NH	0.80	KS	0.63	KS	0.65	KS	0.70
27	MN	0.62	AR	0.67	ME	0.53	FL (est)	0.65	NJ	0.55
28	KS	0.61	MS (est)	0.45	NJ	0.52	MS (est)	0.57	MS (est)	0.48
29	NJ	0.60	MN	0.44	MS (est)	0.47	ME	0.48	DE	0.45
30	MS (est)	0.59	KS	0.39	MN	0.46	NJ	0.41	FL (est)	0.44

Figure 1: States Contributing to 2011 Visibility Impairment at Acadia Based on Mass Weighting Analysis

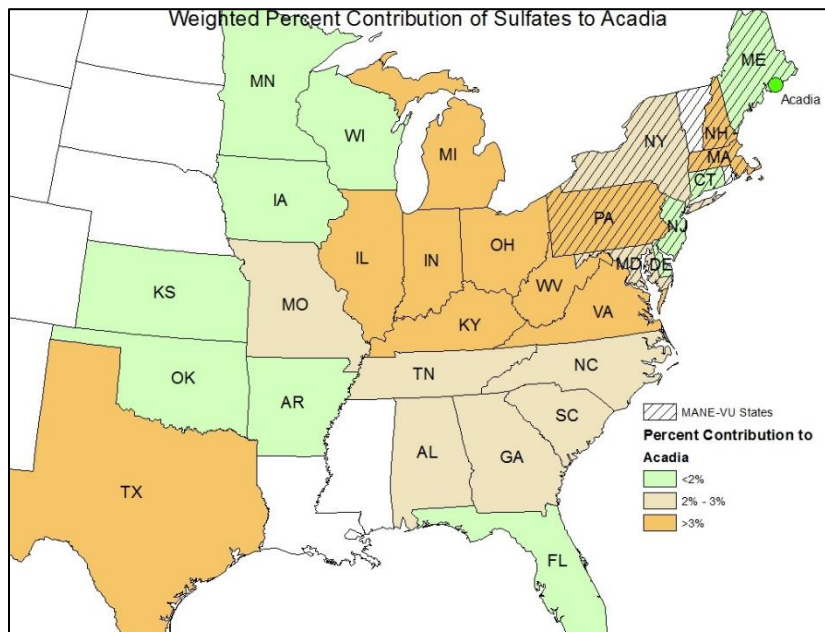


Figure 2: States Contributing to 2011 Visibility Impairment at Brigantine Based on Mass Weighting Analysis

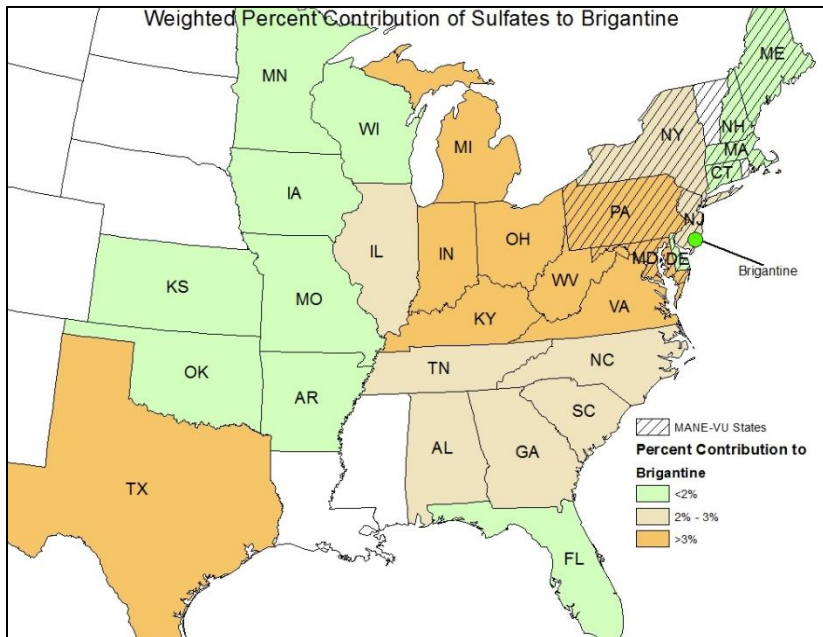


Figure 3: States Contributing to 2011 Visibility Impairment at Great Gulf Based on Mass Weighting Analysis

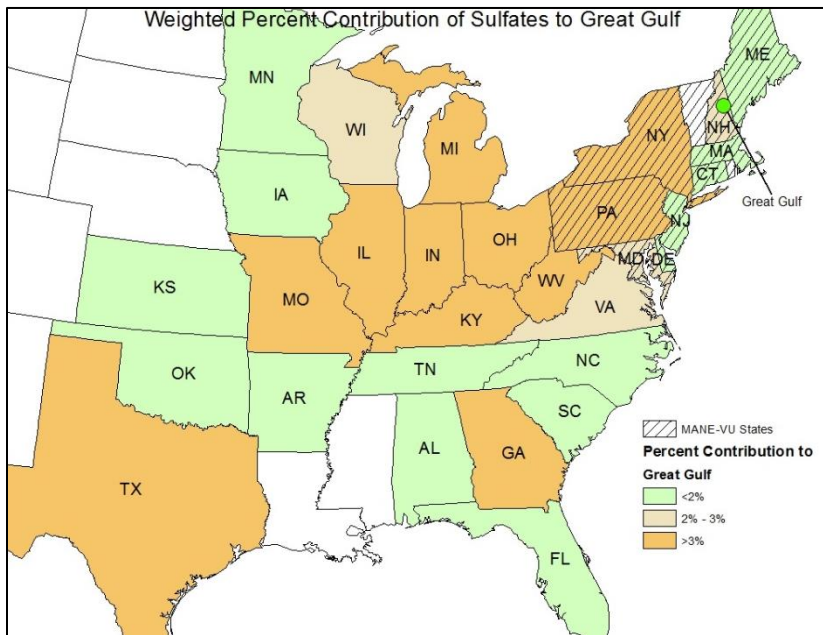


Figure 4: States Contributing to 2011 Visibility Impairment at Lye Brook Based on Mass Weighting Analysis

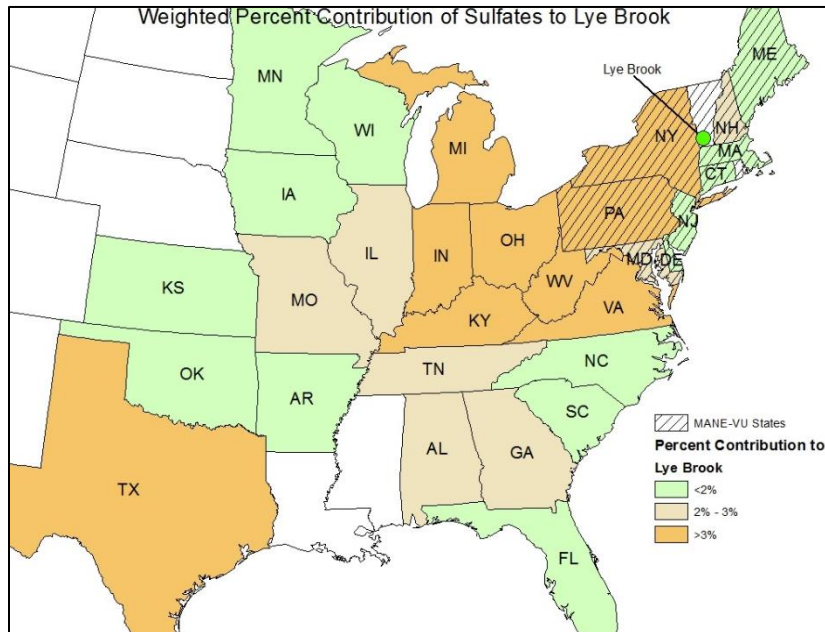


Figure 5: States Contributing to 2011 Visibility Impairment at Moosehorn Based on Mass Weighting Analysis

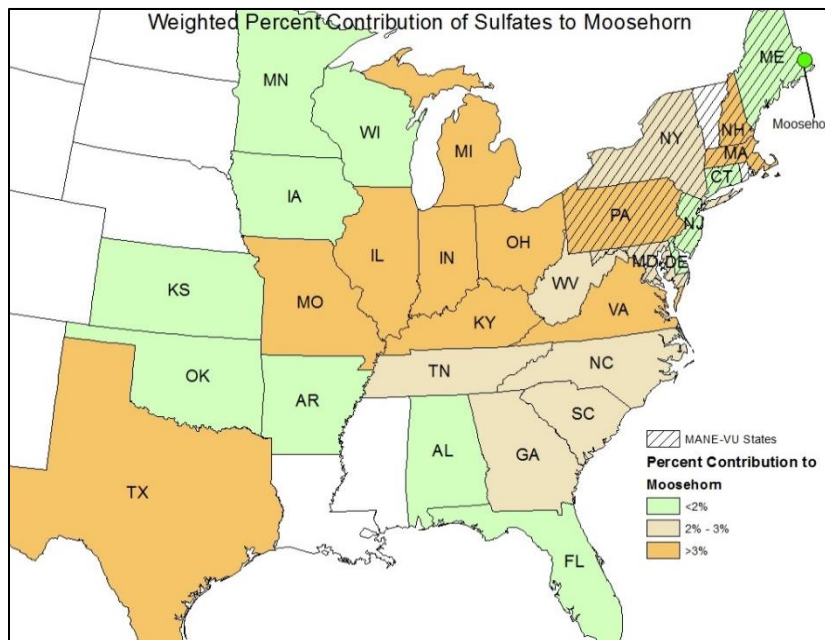
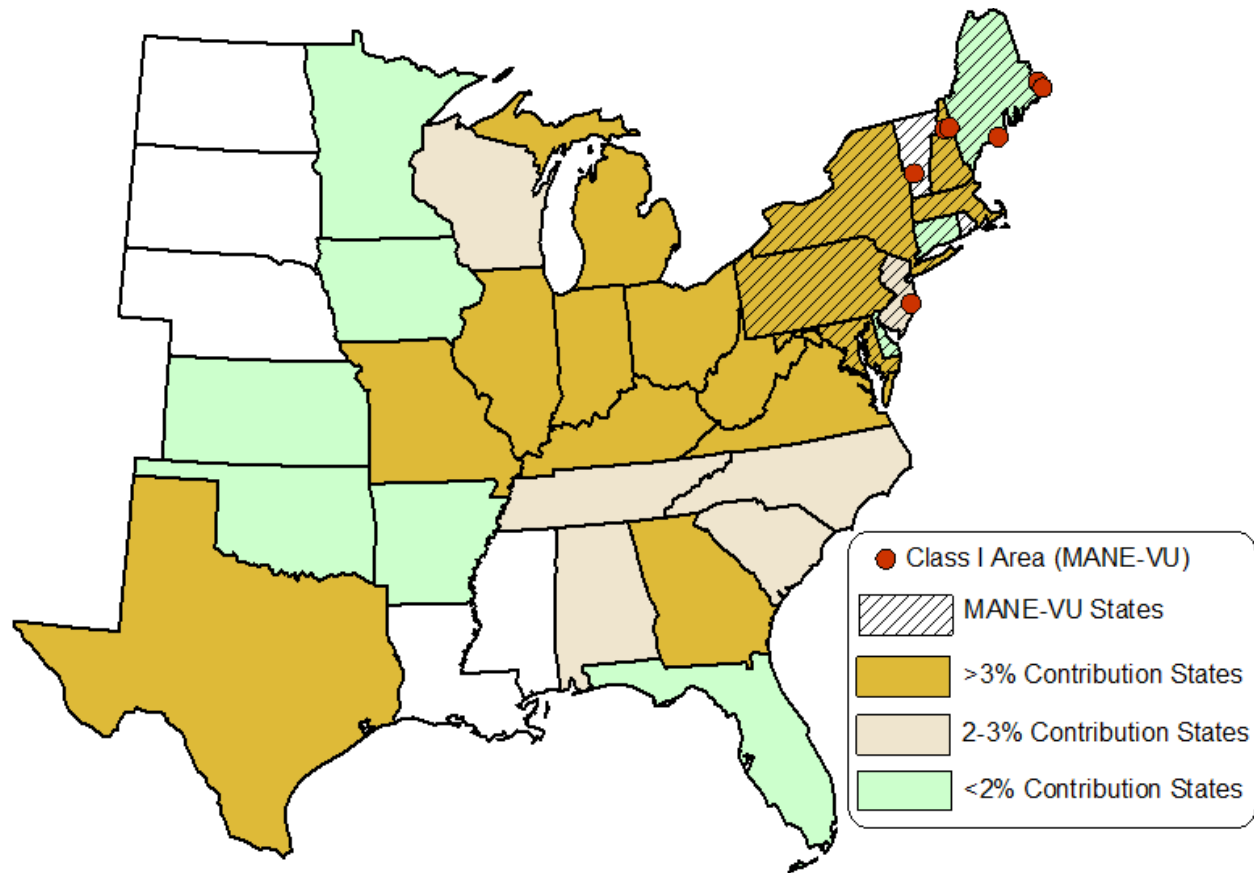


Figure 6 provides a consolidated map for the five MANE-VU Class I Areas (Acadia, Brigantine, Great Gulf, Lye Brook, and Moosehorn). If a state was estimated to contribute three percent or more at any of the five Class I Areas, it was scored as being greater than 3 percent. Likewise, if any state contributed at least 2 percent to any MANE-VU Class I Area, without exceeding 3 percent, then it was scored in the 2 to 3 percent category. States were scored as being less than two percent only if they never scored above two percent for any MANE-VU Class I Area.

Figure 6: States Contributing to 2011 Visibility Impairment at MANE-VU Class I Areas Based on Mass Weighting Analysis



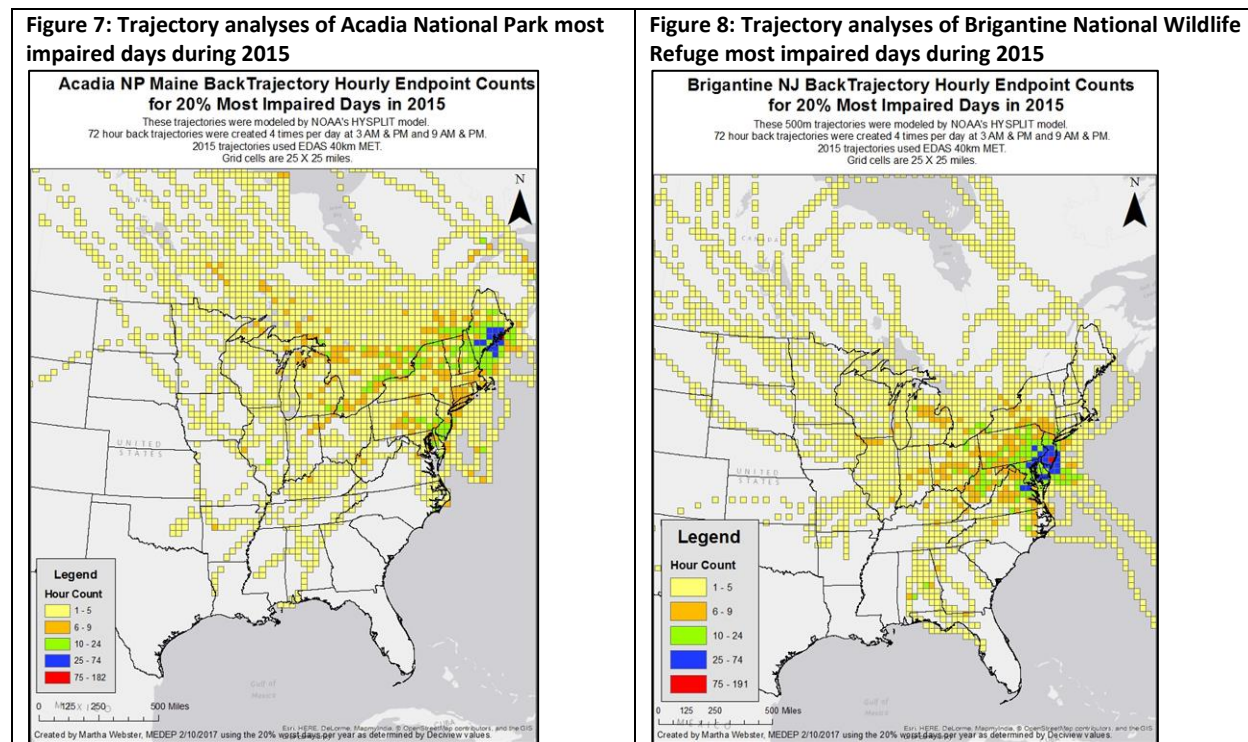
Trajectory Analysis

A trajectory analysis was also conducted by MANE-VU to better understand the source areas of the country where wind patterns transported emissions to cause the 20% most impaired visibility days in a MANE-VU Class I area. The analysis considered the 20% most impaired visibility days during 2002, 2011 and 2015 at each of the MANE-VU Class I Areas, excepting Lye Brook in 2015 where 20% most impaired days were not available so the 20% worst days were used. Details of this analysis are contained in a separate report.¹⁴ Having this analysis provides a qualitative opportunity to cross check the reasonability for including states highlighted in Figure 6 in the MANE-VU 2018 SIP consultation process.

The 500m trajectories were modeled by NOAA's HYSPLIT model. 72-hour back trajectories were created 4 times per day at 3AM & PM and 9AM and PM. 2002 trajectories used EDAS 89 km MET and 2011 and 2015 used 40 km. Grid cells are 25 x 25. Examples of the back trajectories for Acadia and Brigantine are

¹⁴ Mid-Atlantic Northeast Visibility Union, *Regional Haze Metrics Trends and HYSPLIT Trajectory Analyses*.

in Figure 7 and Figure 8. In order to determine how potential contributing states align with 72-hour back trajectories on worst visibility days, percentages of trajectories per state were calculated (Table 6).



In general, the trajectories support the results from the consolidated identification of contributing state. There is strong support for consultation with states located to the west and immediate south of the MANE-VU area. States of Indiana, Illinois, Kentucky, Maryland, Michigan, Missouri, New York, Ohio, Pennsylvania, Virginia and West Virginia were strongly tied to trajectories on 20% worst visibility days at each of the five Class I areas assessed. Trajectory analysis further suggest that Wisconsin and Iowa are frequently upwind on many 20% worst visibility days. Modeling suggests that Wisconsin had enough emissions to qualify as a 2% regional haze contributor in 2011, but Iowa did not produce enough emissions to reach the 2% contribution threshold.

Twenty percent worst visibility day trajectories to the MANE-VU Class I areas passed over the southern states less frequently than they did with states to the west and immediate south of the OTR. However in virtually all cases, at least one trajectory passed over states identified by modeling as being 2 and 3 percent contributing states.

It appears that the 20% worst visibility days at MANE-VU Class I areas are dominated by the clustering of large contributing states which offer a larger total mass of emissions than states along other trajectories. This includes most of the states identified by modeling as contributing states to MANE-VU Class I area visibility impairment. Beyond these states, modeling identified Georgia and Texas as 3 percent

contributing states, which suggests they have the potential with their actual emissions to cause notable visibility impairment. In both cases, trajectory analyses identified weaker connections on 20% worst visibility days in the MANE-VU region. Both states are relatively isolated from other states identified by modeling as being larger visibility impacting states, and thus lack a cumulative impact and frequency that a clustering of higher emitting states have in order to create 20% worst visibility days. When a 20% worst visibility day trajectory does pass over either Georgia or Texas, it also passes over at least one of the other 3% contribution states, which likely adds enough additional pollutant mass to create a 20% worst visibility day.

Table 6: Percentage of Trajectories per State

State	Acadia			Brigantine			Great Gulf			Lye Brook			Moosehorn		
	2002	2011	2015	2002	2011	2015	2002	2011	2015	2002	2011	2015	2002	2011	2015
AL	0.27%	0.45%	0.65%	0.61%	0.00%	1.44%	0.07%	0.00%	0.67%	0.71%	0.42%	0.04%	0.40%	0.31%	0.48%
AR	0.25%	0.25%	0.50%	0.83%	0.52%	0.28%	0.38%	0.52%	0.00%	0.44%	0.00%	0.34%	0.64%	0.17%	0.25%
CT	0.78%	0.61%	0.79%	0.63%	0.24%	0.25%	0.81%	1.78%	0.61%	1.55%	1.60%	2.33%	0.71%	0.57%	0.28%
DC	0.00%	0.00%	0.00%	0.03%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%	0.00%	0.00%	0.00%	0.00%
DE	0.16%	0.10%	0.29%	1.10%	1.27%	1.58%	0.06%	0.11%	0.02%	0.38%	0.29%	0.31%	0.20%	0.06%	0.29%
FL	0.37%	0.38%	0.01%	0.47%	0.00%	0.48%	0.00%	0.00%	0.00%	0.24%	0.13%	0.00%	0.25%	0.17%	0.09%
GA	0.28%	0.33%	0.07%	0.36%	0.06%	0.78%	0.33%	0.00%	0.15%	0.29%	0.41%	0.27%	0.58%	0.38%	0.06%
IA	0.59%	0.65%	0.65%	1.40%	1.57%	1.19%	0.58%	0.77%	1.05%	1.57%	0.00%	0.57%	0.52%	0.60%	0.63%
IL	1.14%	1.11%	1.66%	1.93%	3.46%	2.48%	1.72%	1.65%	1.37%	2.94%	0.44%	2.82%	1.31%	0.73%	1.35%
IN	0.82%	1.44%	1.01%	1.78%	3.63%	2.19%	1.23%	1.48%	1.15%	3.79%	0.83%	2.12%	1.07%	1.15%	1.02%
KS	0.58%	0.17%	0.07%	0.47%	0.30%	0.25%	0.13%	0.21%	0.00%	0.26%	0.00%	0.18%	0.22%	0.58%	0.52%
KY	1.01%	0.72%	1.15%	1.60%	1.36%	1.54%	1.63%	1.01%	1.53%	1.54%	1.39%	2.03%	0.89%	0.83%	0.81%
LA	0.00%	0.32%	0.06%	0.17%	0.06%	0.00%	0.01%	0.00%	0.10%	0.02%	0.11%	0.30%	0.09%	0.35%	0.00%
MA	2.27%	1.36%	0.82%	0.27%	0.37%	0.16%	1.30%	2.48%	1.56%	1.25%	2.87%	2.07%	1.69%	1.42%	0.64%
MD	0.70%	0.23%	0.84%	3.10%	2.55%	3.78%	0.32%	0.98%	0.44%	1.34%	1.94%	1.70%	0.35%	0.15%	0.95%
ME	9.23%	9.22%	9.63%	0.27%	0.03%	0.39%	1.89%	2.95%	3.05%	0.17%	0.67%	0.46%	15.72%	12.95%	11.52%
MI	2.06%	2.31%	3.96%	3.43%	5.32%	3.32%	2.24%	2.35%	3.36%	5.28%	2.09%	2.67%	1.37%	1.26%	3.38%
MN	1.17%	0.64%	1.25%	1.67%	1.02%	1.80%	1.10%	0.38%	1.88%	1.72%	0.47%	0.72%	0.35%	0.92%	0.64%
MO	1.51%	0.20%	0.28%	1.75%	0.96%	1.03%	1.14%	0.86%	0.49%	0.95%	0.00%	1.76%	0.55%	0.28%	0.65%
MS	0.38%	0.56%	0.15%	1.05%	0.34%	0.00%	0.14%	0.36%	0.21%	0.59%	0.29%	0.24%	0.45%	0.29%	0.22%
NC	0.73%	0.95%	0.55%	3.11%	1.54%	2.00%	0.77%	0.47%	0.00%	1.21%	1.08%	1.84%	0.38%	1.00%	1.22%
NE	0.00%	0.06%	0.00%	0.52%	0.43%	0.20%	0.46%	0.11%	0.31%	0.21%	0.00%	0.18%	0.03%	0.47%	0.25%
NH	2.57%	3.12%	1.92%	0.11%	0.51%	0.19%	6.97%	8.92%	8.05%	0.17%	0.42%	0.70%	2.22%	2.17%	1.09%
NJ	0.56%	0.91%	1.07%	7.19%	6.47%	8.02%	1.00%	0.73%	0.36%	2.73%	1.37%	1.87%	1.08%	0.42%	0.55%
NY	6.77%	6.82%	5.08%	3.02%	4.29%	3.51%	14.83%	14.09%	11.57%	17.45%	22.11%	19.80%	8.70%	4.20%	4.25%
OH	1.97%	2.04%	1.37%	3.90%	5.42%	4.25%	4.42%	1.97%	2.45%	3.50%	2.51%	2.79%	1.86%	1.53%	1.25%
OK	0.92%	0.26%	0.22%	0.33%	0.19%	0.09%	0.00%	1.19%	0.00%	0.26%	0.00%	0.09%	0.06%	0.36%	0.36%
PA	3.83%	3.58%	4.21%	7.25%	13.58%	9.87%	6.52%	5.38%	3.84%	11.64%	9.65%	7.07%	2.67%	2.65%	2.30%
RI	0.11%	0.14%	0.10%	0.06%	0.04%	0.06%	0.14%	0.03%	0.16%	0.17%	0.13%	0.07%	0.10%	0.07%	0.04%
SC	0.27%	0.26%	0.00%	0.57%	0.00%	0.09%	1.14%	0.00%	0.00%	0.85%	0.31%	0.60%	0.33%	0.19%	0.06%
TN	0.47%	0.25%	0.37%	0.98%	0.46%	0.70%	0.46%	1.03%	0.99%	0.47%	0.91%	0.70%	0.74%	0.32%	0.48%
TX	0.23%	0.74%	0.03%	0.00%	0.07%	0.03%	0.00%	0.05%	0.00%	0.03%	0.00%	0.00%	0.25%	0.20%	0.38%
VA	0.82%	0.68%	0.51%	5.22%	4.05%	5.51%	0.98%	1.11%	1.15%	1.34%	3.57%	2.84%	1.04%	0.25%	1.95%
VT	2.07%	2.08%	1.63%	0.13%	0.30%	0.12%	4.86%	7.60%	5.04%	2.66%	3.93%	3.94%	1.40%	0.90%	1.16%
WI	2.07%	0.61%	1.65%	4.09%	4.98%	2.06%	1.24%	0.83%	1.93%	2.75%	0.62%	0.88%	1.33%	0.60%	1.99%
WV	0.73%	0.36%	0.59%	2.47%	1.95%	3.64%	1.24%	0.62%	1.02%	0.81%	2.61%	1.45%	0.49%	0.32%	0.63%

Modeling and trajectory analyses appear to support Alabama, North Carolina, South Carolina and Tennessee as being 2% contribution states. Each has sufficient emissions to cause some degree of visibility impact in the MANE-VU area and the trajectories suggest a connection on 20% worst visibility days, even if they are not as frequent as other states.

In summary, trajectory analysis supports the list of states identified in Table 5 by the consolidated modeling effort for the purpose of initiating the regional haze consultation process.