BASELINE AND NATURAL BACKGROUND VISIBILITY CONDITIONS

CONSIDERATIONS AND PROPOSED APPROACH TO THE CALCULATION OF BASELINE AND NATURAL BACKGROUND VISIBILITY CONDITIONS AT MANE-VU CLASS I AREAS

Prepared by NESCAUM

December, 2006

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Considerations and Proposed Approach to the Calculation of Baseline and Natural Background Visibility Conditions at MANE-VU Class I Areas

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1. INTRODUCTION

The long-term visibility conditions that would exist in absence of human-caused impairment are referred to as *natural background* visibility conditions. Accurate assessment of these conditions is important due to their role in determining the uniform rate of progress that states must consider when setting reasonable progress goals for each mandatory Federal Class I area subject to the Regional Haze Rule. Baseline visibility conditions – based on monitored visibility during the five year baseline period (2000-2004) – and estimated natural background visibility conditions will determine the uniform rate of progress states will consider when setting reasonable progress goals for any Class I site.

In September 2001, the U.S. Environmental Protection Agency (EPA) issued draft methodological guidelines for the calculation of natural background and baseline visibility conditions as well as methods for tracking progress relative to the derived uniform rate of progress. EPA subsequently finalized this draft guidance in September 2003. The final guidance recommends a default method and allows for certain refinements that states may wish to pursue in order to make these estimates more representative of a specific Class I area if it is poorly represented by the default method.

In the spring of 2006, the IMPROVE Steering Committee adopted an alternative formulation of the reconstructed extinction equation to address certain aspects of the default calculation method. These aspects were well understood from a scientific perspective and were felt to improve the performance of the equation at reproducing observed visibility at Class I sites. This alternative formulation of the reconstructed extinction equation was not adopted as a replacement to the default method, but as an alternative to the default method for states and RPOs to consider as they proceed with the regional haze planning process. It seems likely that most, if not all, RPOs are considering this alternative formulation as the means by which they will calculate baseline conditions, natural background conditions, and track progress toward the national visibility goals under the Regional Haze Rule.

In this report, MANE-VU reviews the default and alternative approaches to the calculation of baseline and natural background conditions and presents a discussion of the principle differences between the methods. In addition, the default and alternative methods are applied to each Class I area in or near the MANE-VU region in order to establish *differences* in baseline conditions, natural background conditions, and 2018 uniform progress goals under each approach.

The prior MANE-VU position on natural background conditions was issued in June, 2004 and stated that, “Refinements to other aspects of the default method (e.g., refinements to the assumed distribution or treatment of Rayleigh extinction, inclusion of sea salt, and improved assumptions about the chemical composition of the organic fraction) may be warranted prior to submissions of SIPs depending on the degree to which scientific consensus is formed around a specific approach…” Based upon the subsequent reviews conducted by the IMPROVE Steering Committee, as well as internal Technical Steering Committee deliberations, MANE-VU is now ready to adopt the alternative reconstructed extinction algorithm for the reasons described in this report.

2. THE DEFAULT METHOD

The default method is explained in detail in *Estimating Natural Background Visibility Conditions* (U.S.EPA, 2003a) and *Guidance for Tracking Progress under the Regional Haze Rule* (U.S. EPA, 2003b). Summary information is provided here but the reader should consult the original guidance documents for any question on how to apply this method.

Estimates of natural visibility impairment due to fine and coarse particles were derived using the 1990 National Acid Precipitation Assessment Program reported average ambient concentrations of naturally present particles (Trijonis, 1990). Separate concentration values were given for the eastern and western United States; no finer spatial resolution is available. Average natural background light extinction due to particles was then calculated using the IMPROVE methodology and site specific ANNUAL f(RH) values. Worst visibility levels are derived using the work of Ames and Malm (2001), who estimated the standard deviation of visibility in deciviews in the eastern U.S. as 3 dv. By assuming a roughly normal distribution of data, the default method adds (subtracts) 1.28*(3 dv) to the average estimated natural background to calculate the 90th (10th) percentile level, which is taken by EPA to be representative of the mean of the 20 percent worst (best) conditions.

In the East, the default method for calculating best and worst natural background visibility conditions (in dv) for any area in the eastern U.S. uses the following formulae:

$$P90 = HI + 1.28\ sd$$

$$P10 = HI - 1.28\ sd$$

P90 and P10 represent the 90th and 10th percentile, respectively, the Haze Index (HI) represents annual average visibility in units of deciview, and sd is the standard deviation of daily average visibility values throughout a year, defined by the guidance as 3.0 for the eastern U.S. The Haze Index is calculated as shown:

$$HI = 10 \ln (bext/10)$$

The atmospheric extinction, bext, is given by the familiar IMPROVE equation (IMPROVE, 2000) in inverse megameters:

$$bext = (3)f(RH)[sulfate] + (3)f(RH)[nitrate] + (4)[OMC] + (10)[LAC] + (1)[SOIL] + (0.6)[CM] + 10$$

Table 2-1 below provides the default values to be applied at all eastern U.S. Class I areas. The result of using these default values in the above equation with an assumed annual average f(RH) value of 3.17 in the northeastern U.S. (the average of 11 northeastern U.S. sites) is approximately 3.6 dv on the 20 percent best days and 11.3 dv on the 20 percent worst days.

The methods for calculating baseline conditions on the 20 percent best or worst days start by repeating the calculation of the Haze Index (HI) as shown above with the individual species mass concentrations replaced by the actual monitored values for each day during the baseline period. These values should be sorted from highest to lowest for each year in the baseline period. Averages (in dv) for each year can be calculated for HI values associated with the 20 percent most impaired and 20 percent least impaired days. The average HI values for the 20 percent most impaired and 20 percent least impaired days in each year should then be averaged for the five consecutive years 2000-2004 to define baseline conditions. One important distinction between the natural conditions and baseline HI calculations is that the f(RH) values shown in Table 2-2 for natural conditions estimates are annual averages. EPA has also estimated site-specific

Table 2-1. Default parameters used in calculating natural background visibility for sites in the eastern U.S.

Parameter	**Value**	**Fractional Uncertainty**	**Reference/Comments**
[SULFATE]	0.23 µg/m^3	200%	Trijonis, 1990
[NITRATE]	0.10 µg/m^3	200%	Trijonis, 1990
[OC]	1.0 µg/m^3	200%	Trijonis, 1990
[LAC]	0.02 µg/m^3	250%	Trijonis, 1990
[SOIL]	0.50 µg/m^3	200%	Trijonis, 1990
[CM]	3.0 µg/m^3	200%	Trijonis, 1990
f(RH)	~3.2	15%	Varies by site (see Table 2-2)
Organic multiplier	1.4	50%	[OMC]=1.4*[OC]
$\sigma_{S/N}$	3.0 m^2/g	33%	Hegg, 1997; IMPROVE, 2000; Malm, 2000
σ_{OC}	4.0 m^2/g	30%	Hegg 1997; Trijonis 1990
σ_{EC}	10.0 m^2/g	40%	Malm, 1996
σ_{soil}	1.0 m^2/g	25%	Trijonis, 1990
σ_{coarse}	0.6 m^2/g	33%	IMPROVE, 2000
Rayleigh	10 Mm^{-1}	20 %	Varies with altitude/season
sd (standard deviation of daily visibility)	3.0 dv	16%	Ames and Malm, 2001
10th, 90th percentile adjustment	1.28	15%	Regulation calls for mean of top twenty percent, not 90th percentile
Parameters used in potential refinements			
[NaCl]	~0.5	50%	Varies by site, IMPROVE
σ_{NaCl}	2.5 m^2/s	16%	Haywood, 1999
f(RH)$_{NaCl}$	~3.2	33%	Assumed same as S, N

Note: The mass estimates presented above are based on estimates of fine particulate concentrations that would exist in absence of any manmade pollution (including Mexican and Canadian emissions) consistent with planning requirements of the Regional Haze Rule. MANE-VU accepts this as an appropriate planning goal and intends to consider the contribution of international transport in deciding what controls are "reasonable" under the regional haze program.

climatological mean monthly average values of f(RH) that are provided in an appendix to its guidance (EPA, 2003b) and used for the individual HI calculations for baseline conditions.

2.1. Application of the Default Methods

The Class I areas in the MANE-VU region that are subject to the requirements of the Regional Haze Rule are: Acadia National Park, Maine; Brigantine Wilderness (within the Edwin B. Forsythe National Wildlife Refuge), New Jersey; Great Gulf Wilderness, New Hampshire; Lye Brook Wilderness, Vermont; Moosehorn Wilderness (within the Moosehorn National Wildlife Refuge), Maine; Presidential Range – Dry River Wilderness, New Hampshire; and Roosevelt Campobello International Park, New Brunswick. In addition to these Class I areas, we consider several nearby Class I areas where MANE-VU states may be contributing to visibility impairment. These Class I areas include: Dolly Sods Wilderness and the Otter Creek Wilderness in West Virginia as well as Shenandoah National Park and the James River Face Wilderness in Virginia. MANE-VU understands that it is the responsibility of the appropriate VISTAS states to establish estimates of natural visibility conditions and reasonable progress goals for these areas. It is anticipated, however, that subsequent consultations will occur with those MANE-VU states that may be affecting visibility in these areas. MANE-VU has therefore calculated estimates of natural background visibility conditions at the nearby sites using MANE-VU approved methods in order to facilitate future consultations.

The only factor in the default method that varies by site is the climatological annual mean relative humidity adjustment factor. Table 2-2 lists this value for the Class I sites of interest and the resulting best 20 percent and worst 20 percent estimates of natural visibility conditions. The variation among sites using the default method is purely a function of differences in climatological annual mean relative humidity, with southern and coastal sites being more humid than inland or elevated sites.

Table 2-2. Site-specific relative humidity adjustment factors, best and worst (default) estimates of natural background visibility conditions.

MANE-VU Mandatory Federal Class I Area	f(RH)	Best Visibility (dv)	Worst Visibility (dv)
Maine			
Acadia National Park	3.34	3.77	11.45
Moosehorn Wilderness	3.15	3.68	11.36
Roosevelt Campobello International Park, New Brunswick	3.16	3.68	11.37
New Hampshire			
Great Gulf Wilderness	3.01	3.63	11.30
Presidential Range – Dry River Wilderness	3.02	3.65	11.30
New Jersey			
Brigantine Wilderness	2.97	3.60	11.28
Vermont			
Lye Brook Wilderness	2.91	3.57	11.25
Nearby Mandatory Federal Class I Area			
Virginia			
James River Face Wilderness	2.93	3.56	11.26
Shenandoah National Park	2.95	3.57	11.27
West Virginia			
Dolly Sods Wilderness	3.06	3.64	11.32
Otter Creek Wilderness	3.06	3.65	11.32

Table 2-3. Site-specific best and worst (default) estimates of baseline visibility conditions (2000-2004).

MANE-VU Mandatory Federal Class I Area	Best Visibility (dv)	Worst Visibility (dv)
Maine		
Acadia National Park	8.06	22.34
Moosehorn Wilderness	8.48	21.18
Roosevelt Campobello International Park, New Brunswick	8.48	21.18
New Hampshire		
Great Gulf Wilderness	7.50	22.25
Presidential Range – Dry River Wilderness	7.50	22.25
New Jersey		
Brigantine Wilderness	13.72	27.60
Vermont		
Lye Brook Wilderness	6.20	23.70
Nearby Mandatory Federal Class I Area		
Virginia		
James River Face Wilderness	14.35	27.72
Shenandoah National Park	11.34	27.88
West Virginia		
Dolly Sods Wilderness	12.70	27.64
Otter Creek Wilderness	12.70	27.64

3. THE ALTERNATIVE METHOD

According to EPA guidance, “[T]he default approach to estimating natural visibility conditions presented in this document is adequate for the development of progress goals for the first implementation period under the regional haze rule” (U.S. EPA, 2003a). However, the guidance does leave the door open for individual states or RPOs to adopt their own methods for calculating natural background (or baseline conditions) if they can demonstrate that the change from the default represents a significant refinement that better characterizes natural visibility (or baseline) conditions at a specific Class I site.

In response to a number of concerns raised with respect to the use of the default methods for Regional Haze Rule compliance (Lowenthal and Kumar, 2003; Ryan et al., 2005), the IMPROVE Steering Committee established a subcommittee to review the default approach and recommend refinements to address criticisms and improve the performance for tracking progress under the Haze Rule. The details presented below come from that subcommittee's summary report and a review of potential refinements by Hand and Malm (2005).

The recommended revised algorithm is shown in the equation below with revised terms in bold font. The total sulfate, nitrate, and organic carbon compound concentrations are each split into two fractions, representing small and large size distributions of those components. Although not explicitly shown in the equation, the organic mass concentration used in this new algorithm is 1.8 times the organic carbon mass concentration, which is changed from 1.4 times the carbon mass concentration as used for input in the current IMPROVE algorithm. New terms have been added for sea salt (important for coastal locations) and for absorption by NO_2 (only used where NO_2 data are available). Site-specific Rayleigh scattering is calculated for the elevation and annual average temperature of each of the IMPROVE monitoring sites.

Bext ≈ 2.2 x f_S(RH) x [Small Sulfate] + 4.8 x f_L(RH) x [Large Sulfate] +
2.4 x f_S(RH) x [Small Nitrate] + 5.1 x f_L(RH) x [Large Nitrate] +
2.8 x [Small Organic Mass] + 6.1 x [Large Organic Mass] +
10 x [Elemental Carbon Mass] + 1 x [Fine Soil Mass] +
1.7 x f_{SS}(RH) x [Sea Salt Mass] + 0.6 x [Coarse Mass] +
Rayleigh Scattering (site specific) + 0.33 x [NO_2 (ppb)]

The apportionment of the total concentration of sulfate compounds into the concentrations of the small and large size fractions is accomplished using the following equations.

$$[Large\ \ Sulfate] = \frac{[Total\ Sulfate]}{20\mu g/m^3} \times [Total\ Sulfate],\quad for\ [Total\ Sulfate] < 20\mu g/m^3$$

$$[Large\ \ Sultate] = [Total\ \ Sulfate]\quad for\ [Total\ \ Sulfate] \geq 20\ \mu g\ /\ m^3$$

$$[Small\ Sulfate] = [Total\ Sulfate] - [Large\ \ Sulfate]$$

The same equations are used to apportion total nitrate and total organic mass concentrations into the small and large size fractions.

Sea salt is calculated as 1.8 x [*Chloride*], or 1.8 x [*Chlorine*] if the chloride measurement is below detection limits, missing, or invalid. The algorithm uses three water growth adjustment terms as shown in Figure 3-1 and Table 3-1. They are for use with the small size distribution and the large size distribution sulfate and nitrate compounds and for sea salt ($f_S(RH)$, $f_L(RH)$, and $f_{SS}(RH)$, respectively).

Figure 3-1. Water growth curves for small and large size distribution sulfate and nitrate, sea salt, and the original IMPROVE algorithm sulfate and nitrate.

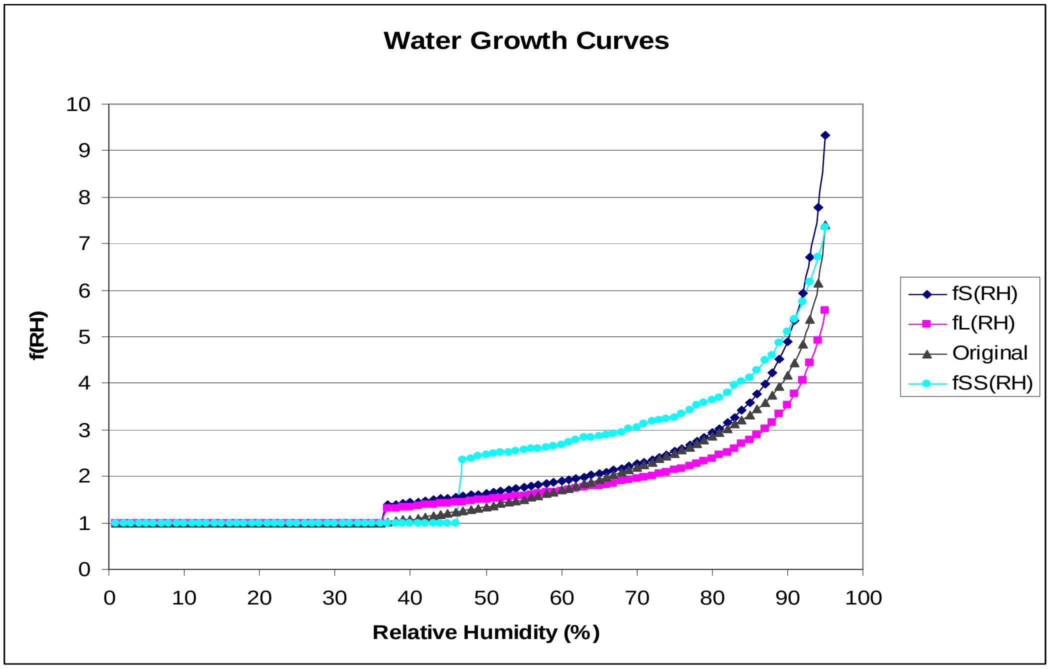

Table 3-1. f(RH) for small and large size distribution sulfate and nitrate, and sea salt.

RH (%)	f_S(RH)	f_L(RH)	f_{SS}(RH)	RH (%)	f_S(RH)	f_L(RH)	f_{SS}(RH)	RH (%)	f_S(RH)	f_L(RH)	f_{SS}(RH)
0 to 36	1.00	1.00	1.00	**56**	1.78	1.61	2.58	**76**	2.60	2.18	3.35
37	1.38	1.31	1.00	**57**	1.81	1.63	2.59	**77**	2.67	2.22	3.42
38	1.40	1.32	1.00	**58**	1.83	1.65	2.62	**78**	2.75	2.27	3.52
39	1.42	1.34	1.00	**59**	1.86	1.67	2.66	**79**	2.84	2.33	3.57
40	1.44	1.35	1.00	**60**	1.89	1.69	2.69	**80**	2.93	2.39	3.63
41	1.46	1.36	1.00	**61**	1.92	1.71	2.73	**81**	3.03	2.45	3.69
42	1.48	1.38	1.00	**62**	1.95	1.73	2.78	**82**	3.15	2.52	3.81
43	1.49	1.39	1.00	**63**	1.99	1.75	2.83	**83**	3.27	2.60	3.95
44	1.51	1.41	1.00	**64**	2.02	1.78	2.83	**84**	3.42	2.69	4.04
45	1.53	1.42	1.00	**65**	2.06	1.80	2.86	**85**	3.58	2.79	4.11
46	1.55	1.44	1.00	**66**	2.09	1.83	2.89	**86**	3.76	2.90	4.28
47	1.57	1.45	2.36	**67**	2.13	1.86	2.91	**87**	3.98	3.02	4.49
48	1.59	1.47	2.38	**68**	2.17	1.89	2.95	**88**	4.23	3.16	4.61
49	1.62	1.49	2.42	**69**	2.22	1.92	3.01	**89**	4.53	3.33	4.86
50	1.64	1.50	2.45	**70**	2.26	1.95	3.05	**90**	4.90	3.53	5.12
51	1.66	1.52	2.48	**71**	2.31	1.98	3.13	**91**	5.35	3.77	5.38
52	1.68	1.54	2.50	**72**	2.36	2.01	3.17	**92**	5.93	4.06	5.75
53	1.71	1.55	2.51	**73**	2.41	2.05	3.21	**93**	6.71	4.43	6.17
54	1.73	1.57	2.53	**74**	2.47	2.09	3.25	**94**	7.78	4.92	6.72
55	1.76	1.59	2.56	**75**	2.54	2.13	3.27	**95**	9.34	5.57	7.35

The proposed new algorithm for estimating haze reduces the biases compared to measurements at the high and low extremes. This is most apparent for the hazier eastern sites. The composition of days selected as best and worst by the current and the new algorithm are very similar, and similar to days selected by measurements. Most of the reduction of bias associated with the new algorithm is attributed to the use of the split component extinction efficiency method for sulfate, nitrate, and organic components that permitted variable extinction efficiency depending on the component mass concentration. Although not subject to explicit performance testing, the proposed new algorithm also contains specific changes from the current algorithm that reflect a better understanding of the atmosphere as reflected in the more recent scientific literature (e.g., change to 1.8 from 1.4 for organic compound mass to carbon mass ratio) and a more complete accounting for contributors to haze (e.g., sea salt and NO_2 terms), and use of site specific Rayleigh scattering terms to reduce elevation-related bias.

Unlike the default approach, which directly uses the Trijonis natural species concentration estimates to calculate natural haze levels, the Alternative Approach uses the baseline data (current species concentrations) with a multiplier applied to each species measurement in order to give the Trijonis estimate for that species. The ratio of the Trijonis estimates for each species divided by the annual mean values for the species is used to transform the entire data set to what is then assumed to be the natural species concentration levels for that site and year. This process is applied to each of the complete years of data (as defined by the EPA *tracking progress* guidance) in the baseline period (2000 through 2004). Sites with three complete years of data are treated as having sufficient data for this assessment. If any of the current annual means for any species is less than the Trijonis estimate for that species, the unadjusted species data are used. Trijonis estimates did not include sea salt, which is only significant at a few coastal sites. Estimates of current sea salt concentrations determined from Cl^- ion data (described as part of the new IMPROVE algorithm) are taken to be natural contributors to haze.

3.1. Application of the Alternative Method

Here we present a comparison of the background and natural visibility conditions calculated using the default and the alternative methods (see Table 3-2 and Table 3-3). Corresponding visibility improvement targets for 2018 using each approach are also presented (see Table 3-3). Results suggest that the alternative approach leads to very similar uniform rates of progress in New England with slightly greater visibility improvement required in the Mid-Atlantic region relative to the default approach.

Table 3-2. Comparison of default and alternative approaches for estimating the 20 percent worst natural background visibility conditions at MANE-VU and nearby sites (2000-2004).

MANE-VU Mandatory Federal Class I Area	Default Baseline dv	Alternative Baseline dv	Default Natural dv	Alternative Natural dv
Maine				
Acadia National Park	22.34	22.89	11.45	12.43
Moosehorn Wilderness	21.18	21.72	11.36	12.01
Roosevelt Campobello International Park, New Brunswick	21.18	21.72	11.37	12.01
New Hampshire				
Great Gulf Wilderness	22.25	22.82	11.30	11.99
Presidential Range – Dry River Wilderness	22.25	22.82	11.30	11.99
New Jersey				
Brigantine Wilderness	27.60	29.01	11.28	12.24
Vermont				
Lye Brook Wilderness	23.70	24.45	11.25	11.73
Nearby Mandatory Federal Class I Areas				
Virginia				
James River Face Wilderness	27.72	29.12	11.26	11.13
Shenandoah National Park	27.88	29.31	11.27	11.35
West Virginia				
Dolly Sods Wilderness	27.64	29.04	11.32	10.39
Otter Creek Wilderness	27.64	29.04	11.32	10.39

Table 3-3. Estimated uniform rates of progress (ROP) (to be considered for worst 20 percent days) and Best Day Baseline Conditions (not to be degraded on best 20 percent days) for first implementation period.

MANE-VU Mandatory Federal Class I Area	**Default ROP** Worst day (dv/14 yrs)	**Alternative ROP** Worst day (dv/14 yrs)	**Default Baseline Visibility** Best Day (dv)	**Alternative Baseline Visibility** Best Day (dv)
Maine				
Acadia National Park	2.54	2.44	8.06	8.77
Moosehorn Wilderness	2.29	2.27	8.48	9.15
Roosevelt Campobello International Park, New Brunswick	2.29	2.27	8.48	9.15
New Hampshire				
Great Gulf Wilderness[†]	2.56	2.53	7.50	7.66
Presidential Range – Dry River Wilderness[†]	2.56	2.53	7.50	7.66
New Jersey				
Brigantine Wilderness[‡]	3.81	3.91	13.72	14.33
Vermont				
Lye Brook Wilderness	2.91	2.97	6.20	6.36
Nearby Mandatory Federal Class I Area				
Virginia				
James River Face Wilderness[Π]	3.84	4.20	14.35	14.21
Shenandoah National Park[‡]	3.88	4.19	11.34	10.93
West Virginia				
Dolly Sods Wilderness	3.81	4.35	12.70	12.28
Otter Creek Wilderness	3.81	4.35	12.70	12.28

Note: The values are presented for the default and alternative approaches at MANE-VU and nearby sites (2000-2004).

The default estimates provide a sound, nationally consistent framework on which to base the regulatory structure of the Haze Rule that is justified by the current state of scientific understanding of these issues. However, an alternative approach for the calculation of reconstructed extinction under the Regional Haze Rule has been developed that provides all of the same advantages. EPA recommendations on potential refinements to the default approach (Pitchford, personal communication, 2004) suggest that, if used, any refinements should be broadly accepted by the scientific community, substantial, practical to implement, and not create arbitrary inconsistencies. The alternative approach endorsed by the IMPROVE Steering Committee for baseline and natural background conditions meet these requirements.

4. RECOMMENDATIONS

This document reviews EPA guidelines and an IMPROVE Steering Committee-endorsed alternative for calculating baseline and natural background visibility conditions under the Regional Haze Rule. It also explores how adoption of the alternative approach would affect calculated rates of progress and other regulatory drivers under the Haze Rule.

The alternative approach attempts to incorporate better science for several components of the equation to calculate reconstructed extinction that reflects the latest scientific research. MANE-VU recognizes the time and effort that has been invested in the development of this alternative. We also recognize the high likelihood that other RPOs will adopt and use the alternative approach and consider it desirable to use a similar approach to other RPOs with which MANE-VU will consult on visibility goals. Given the large uncertainties that remain in our ability to estimate the concentrations of organic carbon and other species that would be present in the absence of anthropogenic influences, we are not certain that the alternative approach significantly improves the overall accuracy of the estimated natural background conditions, but it certainly does not diminish the accuracy and is likely to improve our estimates of baseline conditions.

Finally, MANE-VU has considered the fact that the uniform rate of progress that results from these calculations is a relatively arbitrary baseline against which progress is measured. This Haze Rule requires states to consider this uniform rate, but control decisions are to be based on a four-factor analysis that is independent of the uniform rate of progress. The relatively small differences in the uniform rate that are introduced as a result of using the alternative approach further diminish the significance of this decision. Based on all of the considerations above, MANE-VU recommends adoption of the alternative approach for use in 2008 MANE-VU SIP submittals, active participation in further research efforts on this topic, and future reconsideration of natural background visibility conditions as evolving scientific understanding warrants.

References

Ames, R. B., and Malm, W. C., Recommendations for Natural Condition Deciview Variability: An Examination of IMPROVE Data Frequency Distributions. *Proceedings (CDROM) of A&WMA/AGU Specialty Conference on Regional Haze and Global Radiation Balance -- Aerosol Measurements and Models: Closure, Reconciliation and Evaluation*, Bend, Oregon, 2-5 October, 2001.

Hand, J.L. and W.C. Malm, *Review of the IMPROVE Equation for Estimating Ambient Light Extinction Coefficients*, on the IMPROVE web site at http://vista.cira.colostate.edu/improve/Publications/GrayLit/gray_literature.htm, 2005.

Haywood, Ramaswamy, and Soden, Tropospheric aerosol climate forcing in Clear-Sky Satellite Observations over the oceans, *Science*, V**283**, pg. 1299-1303, 26 February, 1999.

Hegg, Livingston, Hobbs, Novakov and Russell, Chemical Apportionment of aerosol column optical depth off the Mid-Atlantic coast of the United States, *Journal of Geophysical Research*, vol. **102,** No. D21, pg. 25,293-25,303, 1997.

IMPROVE, Malm, W. C., Principal Author, *Spatial and Seasonal Patterns and Temporal Variability of Haze and Its Constituents in the United States: Report III*, Cooperative Institute for Research in the Atmosphere, Colorado State University, Ft. Collins, CO, May, 2000.

Kumar, N. Recommendations for Natural Background Conditions and Potential Refinements, *Proceedings (CDROM) of MANE-VU/MARAMA Science Meeting on Regional Haze – Organic Aerosols and Natural Background Conditions*, MARAMA Baltimore, MD, 27-29 January, 2004.

Lowenthal, D. H., and Kumar, N. PM2.5 Mass and Light Extinction Reconstruction in IMPROVE. *Journal of the Air and Waste Management Association*, Vol. 53, pp. 1109-1120, 2003.

Malm, Molenar, Eldred and Sisler, Examining the relationship among atmospheric aerosols and light scattering and extinction in the Grand Canyon area, *Journal of Geophysical Research*, vol. **101**, No. D14, pg. 19,251-19,265, 1996.

Malm, Day, Kreidenweis, Light Scattering Characteristics of Aerosols as a function of Relative Humidity: Part 1- A comparison of Measured Scattering and Aerosol Concentrations Using the Theoretical Models, *Journal of the Air and Waste Management Association*, Vol. **50**, pg. 686-700, May 2000.

U.S. EPA, *Guidance for Estimating Natural Visibility Conditions under the Regional Haze Rule*, EPA-454/B-03-005, September, 2003a.

U.S. EPA, *Guidance for Tracking Progress under the Regional Haze Rule*, EPA-454/B-03-004, September, 2003b.

Ryan, P.A., Lowenthal, D., and Kumar, N., Improved light extinction reconstruction in Interagency Monitoring of Protected Visual Environments, *J. Air & Waste Manage. Assoc.* **55**, 1751-1759, 2005.

Trijonis, J. C., Characterization of Natural Background Aerosol Concentrations, Appendix A in *Acidic Deposition: State of Science and Technology. Report 24. Visibility: Existing and Historical Conditions* -- *Causes and Effects*, J. C. Trijonis, lead author, National Acid Precipitation Assessment Program, Washington, DC, 1990.