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Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule

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Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Program

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Abbreviations and Acronyms

b_{ext} - Total light extinction

CAA – Clean Air Act

CAAA – 1990 Clean Air Act Amendments

CASTNet - Clean Air Status and Trends Network

CM - Coarse mass

EPA – United States Environmental Protection Agency

f(RH) – Relative humidity adjustment factor

IMPROVE – Interagency Monitoring of protected Visual Environments

LAC - Light absorbing carbon

Mm^{-1} - Inverse megameter (10^{-6} m^{-1})

NAAQS – National Ambient Air Quality Standards

NWS - National Weather Service

OC - Organic carbon

OMC - Organic carbon mass

OP - Pyrolized organics

PM – Particulate matter

$PM_{2.5}$ – Particulate matter with an aerodynamic diameter less than 2.5 microns

PM_{10} – Particulate matter with an aerodynamic diameter less than 10 microns

RH - Relative humidity

SIP – State Implementation Plan

TOR - Thermal optical reflectance

Glossary of Terms

Aerosols – Suspensions of tiny liquid and/or solid particles in the air.

Coarse mass – Mass of particulate matter with an aerodynamic diameter greater than 2.5 microns but less than 10 microns.

Deciview (dv) - The unit of measurement of haze, as in the haze index (HI) defined below.

Default approach - The basic approach recommended by EPA to estimate the natural visibility conditions. States may choose to adopt the default values for natural visibility conditions or, with sufficient technical justification, propose alternatives to the basic approach or generate refined estimates. EPA believes that the default values that are provided in this document are adequately justified and believes that it can propose for approval States' use of them. However, EPA may not guarantee approval prior to receiving and fully considering public comment on any proposed actions.

Default values - the values obtained from adopting the default approach to estimating natural visibility conditions.

Fine particulate matter – particulate matter with an aerodynamic diameter less than 2.5 microns ($PM_{2.5}$).

Fine soil – Particulate matter composed of material from the Earth's soil, with an aerodynamic diameter less than 2.5 microns. The fine soil mass is calculated from chemical mass measurements of fine aluminum, fine silicon, fine calcium, fine iron, and fine titanium as well as their associated oxides.

Haze index (HI) – A measure of visibility derived from calculated light extinction measurements, that is designed so that uniform changes in the haze index correspond to approximately uniform incremental changes in visual perception, across the entire range of conditions from pristine to highly impaired. The haze index [in units of deciviews (dv)] is calculated directly from the total light extinction [b_{ext} expressed in inverse megameters (Mm^{-1})] as follows:

$$HI = 10 \ln (b_{ext}/10)$$

Least-impaired days – The clearest, or least hazy, days.

Light absorbing carbon - Carbon particles in the atmosphere that absorb light; sometimes reported as elemental carbon.

Light extinction – A measure of how much light is absorbed or scattered as it passes through a medium, such as the atmosphere. The aerosol light extinction coefficient refers to the absorption and scattering by aerosols, and the total light extinction coefficient refers to the sum of the aerosol light extinction coefficient, the absorption coefficient of gases (such as NO_2), and the atmospheric light extinction coefficient due to molecular light scattering (Rayleigh scattering).

Mandatory Federal Class I areas – Certain National Parks (over 6,000 acres), wilderness areas (over 5,000 acres), national memorial parks (over 5,000 acres), and international parks that were in existence as of August 1977. Appendix A lists the mandatory Federal Class I areas.

Most impaired days – the dirtiest, or haziest, days.

Nitrate – Solid or liquid particulate matter containing ammonium nitrate [NH_4NO_3] or other nitrate salts. Atmospheric nitrate aerosols are often formed from the atmospheric oxidation of oxides of nitrogen (NO_x).

Organic carbon – Aerosols composed of organic compounds, which may result from emissions from incomplete combustion processes, solvent evaporation followed by atmospheric condensation, or the oxidation of some vegetative emissions.

Particulate matter – Material that is carried by liquid or solid aerosol particles with aerodynamic diameters less than 10 microns (in the discussions of this report). The term is used for both the in situ atmospheric suspension and the sample collected by filtration or other means.

Rayleigh scattering – Light scattering by gases in the atmosphere. At an elevation of 1.8 kilometers, the light extinction from Rayleigh scattering is approximately 10 inverse megameters (Mm^{-1}).

Relative humidity – The partial pressure of water vapor at the existing atmospheric temperature divided by the saturated vapor pressure of water at that temperature, expressed as a percentage.

Sulfate – Solid or liquid particulate matter composed of sulfuric acid [H_2SO_4], ammonium bisulfate [NH_4HSO_4], or ammonium sulfate [$(NH_4)_2SO_4$], or other sulfate salts. Atmospheric sulfate aerosols are often formed from the atmospheric oxidation of sulfur dioxide.

Total carbon – Sum of the light absorbing carbon and organic carbon.

Visibility impairment – Any humanly perceptible change in visibility (light extinction, visual range, contrast, coloration) from that which would have existed under natural conditions. This change in atmospheric transparency results from added particulate matter or trace gases.

1. INTRODUCTION

1.1 What is regional haze?

Regional haze is visibility impairment caused by the cumulative air pollutant emissions from numerous sources over a wide geographic area. Visibility impairment is caused by particles and gases in the atmosphere. Some particles and gases scatter light while others absorb light. The net effect is called "light extinction." The result of the scattering and absorption processes is a reduction of the amount of light from a scene that is returned to the observer, and scattering of other light into the sight path, creating a hazy condition.

The primary cause of regional haze in many parts of the country is light scattering resulting from fine particles (i.e., particulate matter less than 2.5 microns in diameter, referred to as $PM_{2.5}$) in the atmosphere. These fine particles can contain a variety of chemical species including carbonaceous species (i.e., organics and elemental carbon), as well as ammonium nitrate, sulfates, and soil. Additionally, coarse particles between 2.5 and 10 microns in diameter can contribute to light extinction. Each of these components can be naturally occurring or the result of human activity. The natural levels of these species result in some level of visibility impairment, in the absence of any human influences, and will vary with season, daily meteorology, and geography.

1.2 What is meant by the term "natural visibility conditions?"

The term "natural visibility conditions" represents the ultimate goal of the regional haze program, consistent with the national visibility goal set forth in section 169A of the Clean Air Act (CAA). The national visibility goal is to remedy existing and prevent future human-caused impairment of visibility in mandatory Federal Class I areas. Regional haze strategies are to make reasonable progress towards this goal.

Natural visibility conditions represent the long-term degree of visibility that is estimated to exist in a given mandatory Federal Class I area in the absence of human-caused impairment. It is recognized that natural visibility conditions are not constant, but rather they vary with changing natural processes (e.g., windblown dust, fire, volcanic activity, biogenic emissions). Specific natural events can lead to high short-term concentrations of particulate matter and its precursors. However, for the purpose of this guidance and implementation of the regional haze program, natural visibility conditions represents a long-term average condition analogous to the 5-year average best-and worst-day conditions that are tracked under the regional haze program.

1.3 What is the purpose of the Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule?

The purpose of this document is to provide guidance to the States in implementing the regional haze program under the Clean Air Act. The regional haze regulations were published by EPA in 1999.[1] They are designed to protect visual air quality in 156 National Parks and wilderness areas (known as "mandatory Federal Class I areas"), across the country. As part of the program, States will develop goals and implement strategies for improving visibility in each mandatory Federal Class I area. Estimates of natural visibility conditions are needed by the States for the goal development process. This guidance document describes "default"[2] and "refined" approaches for estimating natural conditions. The EPA believes that natural conditions estimates developed using the default approach will be adequate to satisfy the requirements of the regional haze rule for the initial State implementation plan (SIP) submittals due no later than 2008.

This document provides guidance to EPA Regional, State, and Tribal air quality management authorities and the general public, on how EPA intends to exercise its discretion in implementing Clean Air Act provisions and EPA regulations, concerning the estimation of natural conditions under the regional haze program. The guidance is designed to implement national policy on these issues. Sections 169A and 169B of the Clean Air Act (42) U.S.C. § § 7491,7492 and implementing regulations at 40 CFR 51.308 and 51.309 contain legally binding requirements. This document does not substitute for those provisions or regulations, nor is it a regulation itself. Thus, it does not impose binding, enforceable requirements on any party, nor does it assure that EPA may approve all instances of its application, and thus the guidance may not apply to a particular situation based upon the circumstances. The EPA and State decision makers retain the discretion to adopt approaches on a case-by-case basis that differ from this guidance where appropriate. Any decisions by EPA regarding a particular SIP demonstration will only be made based on the statute and regulations, and will only be made following notice and opportunity for public review and comment. Therefore, interested parties are free to raise questions and objections about the appropriateness of the application of this guidance to a particular situation; EPA will, and States should, consider whether or not the recommendations in this guidance are appropriate in that situation. This guidance is a living document and may be

[1]64 Federal Register 35769, July 1, 1999.

[2] In the context of this guidance, the term "default" refers to the basic approach recommended by EPA to estimate the natural visibility conditions and the values obtained from adopting this approach. States are welcome to adopt the default values for natural visibility conditions or, with sufficient technical justification, to propose alternatives to the basic approach or to generate refined estimates. In theabsence of refinement, EPA recommends that the default values provided in this document be adopted.

revised periodically without public notice. The EPA welcomes public comments on this document at any time and will consider those comments in any future revision of this guidance document.

Readers of this document are cautioned not to regard statements recommending the use of certain procedures or defaults as either precluding other procedures or information or providing guarantees that using these procedures or defaults will result in actions that are fully approvable. As noted above, EPA cannot assure that actions based upon this guidance will be fully approvable in all instances, and all final actions may only be taken following notice and opportunity for public comment.

1.4 Does this guidance document apply to Tribal Class I areas as well as mandatory Federal Class I areas?

Not directly, although the procedures for estimating natural conditions that are described in this guidance can be used by Tribes if desired. The CAA and the regional haze rule call for the protection of visibility in 156 "mandatory Federal Class I areas."[3] Tribes can establish Class I areas for the purposes of the prevention of significant deterioration (PSD) program, but the CAA does not provide for the inclusion of Tribal areas as mandatory Federal Class I areas subject to section 169A and 169B of the CAA. For this reason, progress goals and natural conditions estimates do not have to be established for Tribal Class I areas.

However, Tribes may find it advantageous for a number of reasons to participate in regional planning organizations (RPO) for regional haze and to develop regional haze tribal implementation plans (TIPs). Participation in an RPO may allow some Tribes to build capacity and enhance their air quality management capabilities. Under the Tribal Air Rule, Tribal governments may elect to implement air programs in much the same way as States, including development of Tribal implementation plans.[4] In this way, Tribes can work with other States and

[3] Areas designated as mandatory Class I areas are those National Parks exceeding 6,000 acres, wilderness areas and national memorial parks exceeding 5,000 areas, and all international parks which were in existence on August 7, 1977. Visibility has been identified as an important value in 156 of these areas. See 40 CFR part 81, subpart D. The extent of a Class I area includes subsequent changes in boundaries, such as park expansions. (CAA section 162(a)). States and tribes may designate additional areas as Class I, but the requirements of the visibility program under section 169A of the CAA apply only to "mandatory Class I areas," and do not affect these additional areas. For the purpose of this guidance document, the term "Class I area" will be used interchangeably with "mandatory Federal Class I area."

[4] See 63 Federal Register 7254 (February 12, 1998), and 40 CFR Part 49.

Tribes on the development and adoption of specific emissions reduction strategies designed to protect air quality across a broad region including Tribal and State lands.

1.5 What is the statutory and regulatory background for the regional haze program?

In section 169A of the 1977 Amendments of the Clean Air Act, Congress established a national visibility goal as the "prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Federal Class I areas which impairment results from manmade air pollution." States are required to develop implementation plans that make "reasonable progress" toward this goal.

The EPA issued initial visibility regulations in 1980[5] that addressed visibility impairment in a specific mandatory Federal Class I area that is determined to be "reasonably attributable" to a single source or small group of sources. Regulations to address regional haze were deferred until improved techniques could be developed in monitoring, modeling, and in understanding the effects of specific pollutants on visibility impairment. The 1990 Clean Air Act Amendments included language in Section 169B to focus attention on regional haze issues. That section called for EPA to establish the Grand Canyon Visibility Transport Commission, and to issue regional haze rules within 18 months of receipt of a final report from the Commission. The EPA issued regional haze regulations in 1999.[6]

As noted in question 1.2 above, estimates of "natural visibility conditions," which are the national visibility goal of the Clean Air Act, are needed as part of the implementation process for the regional haze program.

1.6 What visibility metric will be used for estimating natural conditions, setting goals, and tracking progress?

According to the Regional Haze Rule, baseline visibility conditions, progress goals, and changes in natural visibility conditions must be expressed in terms of deciview (*dv*) units. The deciview is a unit of measurement of haze, implemented in a haze index (HI) that is derived from calculated light extinction, and that is designed so that uniform changes in haziness correspond approximately to uniform incremental changes in perception, across the entire range of conditions, from pristine to highly impaired. The HI is expressed by the following formula:

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[5] See 45 Federal Register 80084 (December 2, 1980).

[6] See 64 Federal Register 35713 (July 1, 1999). See also 40 CFR 51.300-309.

$$HI = 10\ ln(b_{ext}/10)$$

where

b_{ext} represents total light extinction expressed in inverse megameters (i.e., $Mm^{-1} = 10^{-6}\ m^{-1}$).

1.7 What are the key requirements and milestones for State implementation plans, pertaining to the estimation of natural visibility conditions under the regional haze rule?

The regional haze rule requires States to develop SIPs that include 1) reasonable progress goals for improving visibility in each mandatory Federal Class I area, and 2) a set of emission reduction measures to meet these goals. A State that does not have any Class I areas will not establish any progress goals in its SIP, but it is required to consult with nearby States having Class I areas that may be impacted by emissions from the State. A State without any Class I areas will also need to adopt emission reduction strategies to address its contribution to visibility impairment problems in Class I areas located in other States.

Specifically, a State is required to set progress goals for each Class I area in the State that:

- provide for an improvement in visibility for the 20% most impaired (i.e., worst visibility) days over the period of the implementation plan, and

- ensure no degradation in visibility for the 20% least impaired (i.e., best visibility) days over the same period.

Baseline visibility conditions for the 20% worst and 20% best days are to be determined using monitoring data collected during calendar years 2000-2004. Baseline conditions for 2000-2004, progress goals, and tracking changes over time are to be expressed in deciview units *via* the haze index.

Most States (and Tribes as appropriate) participating in regional planning organizations will submit regional haze implementation plans, including estimates of natural conditions and proposed progress goals, in the 2007-2008 time frame[7]. In developing any progress goal, the

[7] Note that in the May 2002 American Corn Growers decision, the DC circuit court of appeals raised concerns with some of the deadlines for regional haze SIPs in the 1999 regional haze rule. While these issues are not fully resolved, EPA intends to seek solutions that will ensure that the schedule for regional haze implementation

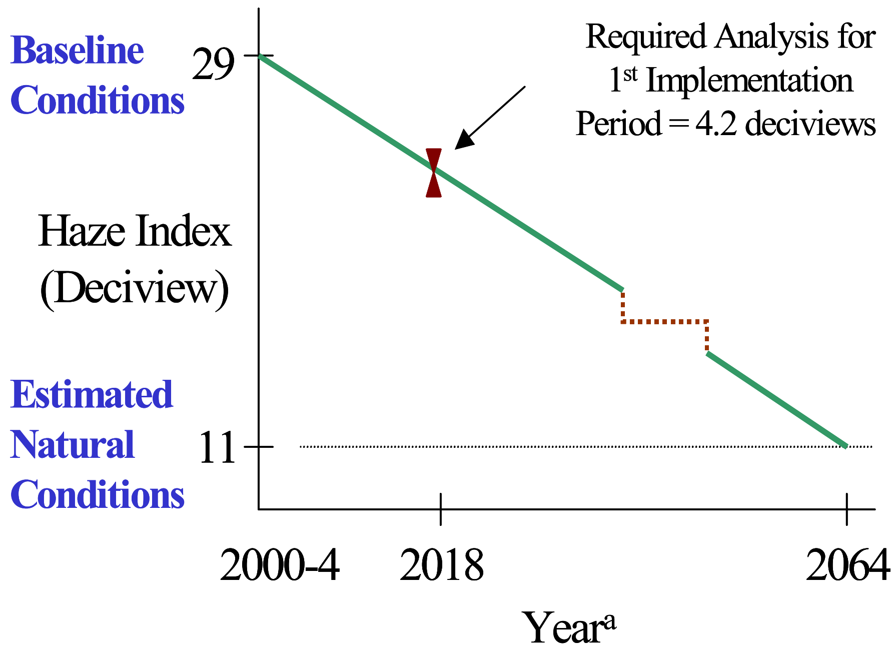

Figure 1-1 **Example of method for determining mandatory Federal Class I area rate of progress to be analyzed in SIP development process. ([a] HI values for 2004 are based on 2000-2004 data, etc.)**

State will need to analyze and consider in its set of options the rate of improvement between 2004 (when 2000-2004 baseline conditions are set) and 2018 that, if maintained in subsequent implementation periods, would result in achieving estimated natural conditions in 2064. In the example in Figure 1-1, baseline conditions for the 20% worst days exceed estimated natural conditions by 18 deciviews. The rate the State must analyze and consider for the 2018 progress goal is equal to 18 divided by 60 years = 0.3 deciviews per year x 14 years (2004 to 2018) = 4.2 deciviews. The State must demonstrate in the SIP whether it finds that this rate is reasonable or not, taking into consideration the relevant statutory factors. If it finds that this first rate is not reasonable, the State shall include a demonstration supporting its finding that an alternate rate is reasonable.

In order to determine the 2004-2018 progress rate for this analysis, the State should calculate baseline conditions in accordance with EPA guidance on tracking progress and use this guidance document for estimating natural conditions.

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plans is fully harmonized with the schedule for implementation plans addressing $PM_{2.5}$ nonattainment.

1.8 What other factors should be considered in developing progress goals?

Other important issues to be considered in developing mandatory Federal Class I area progress goals include the reasonable progress factors in the CAA, consultation with Tribes and other States, and emission reductions due to other Clean Air Act programs. The reasonable progress factors[8] to consider in developing any progress goal are:

- the costs of compliance;
- the time necessary for compliance;
- the energy and non-air quality environmental impacts of compliance; and
- the remaining useful life of any existing source subject to such requirements.

The EPA plans to develop additional guidance on how to address these factors in the goal setting process.

Because visibility impairment results from human activities and their emissions transported over long distances - hundreds of miles in many cases - addressing impairment can be effective only through efforts among multiple States. For this reason, States are required to consult with other States (and Tribes, as appropriate) in developing mandatory Federal Class I area progress goals and long-term strategies to meet these goals. If a State is reasonably anticipated to cause or contribute to impairment in a mandatory Federal Class I area in another State, it is required to consult with that State on the development of that State's progress goals, and it must include strategies in its SIP that address its contribution to the haze in that State's mandatory Federal Class I area. Emissions reductions from other States may likewise be taken into account in setting mandatory Federal Class I area goals. The EPA supports the regional planning organization process currently under way as the most effective means to address the requirements of the regional haze program, and it is expected that much of the consultation, apportionment demonstrations, and technical documentation needed for SIPs will be facilitated and developed by the regional planning organizations.

Progress goals should also take into account any emission reduction strategies in place or on the way in order to meet other Clean Air Act requirements. For example, emission reduction strategies implemented to attain the $PM_{2.5}$ and ozone NAAQS, and national mobile source measures such as the Tier II or heavy duty diesel regulations, should be taken into account in

[8] See CAA section 169A(g).

developing mandatory Federal Class I area progress goals for regional haze. Thus, EPA does not expect any progress goals for regional haze to be less ambitious than the level of visibility improvement expected from other programs.[9]

1.9 What progress reviews and future SIP revisions are required under the regional haze rule?

After the initial SIPs are approved, States will conduct formal progress reviews (in the form of a SIP revision) every 5 years from the date of SIP submittal (e.g., in 2013 if the initial SIP is submitted in 2008). Progress will be reviewed in terms of changes in visibility based on monitoring data, and in terms of the implementation of emission reduction measures contained in the plan. If progress is not consistent with the visibility and emission reduction goals established in the original SIP, the State must evaluate the reason for lack of progress and take any appropriate further action. If the lack of progress is primarily due to emissions from within the State, then the State must revise its implementation plan within 1 year to include additional measures to make progress. If the lack of progress is primarily due to emissions from other States, then the State must reinitiate the regional planning process to address this problem in the next major SIP revision (e.g., in 2018). If the State finds that international emissions sources are responsible for a substantial increase in emissions in any Class I area or causing a deficiency in visibility progress, the State must submit a technical demonstration to EPA in support of its finding. Similarly, the State should submit a technical demonstration if the State finds that unusual events (e.g., large wildfires), have affected visibility progress during the 5-year period.[10] Given that progress is determined based upon long-term averaging, the EPA believes that it is unlikely that such events will have a significant effect in most cases. See Section 1.14 for additional information about consideration of natural emissions from fire.

States will be required to conduct a comprehensive SIP revision in 2018 and every 10 years thereafter. This process will involve re-evaluating rates of progress for each mandatory Federal Class I area within the State as noted above and establishing new visibility improvement goals for these areas. The revised SIP should also include any revised emission reduction measures needed to meet the new mandatory Federal Class I area progress goals.

1.10 Should estimates of natural visibility conditions reflect contemporary conditions and

[9] See regional haze rule, 40 CFR Section 51.308(d) (1) (vi).

[10] 64 Federal Register 35747 (Thursday, July 1, 1999).

land use patterns, or historic conditions?

For the purposes of this guidance, estimates of natural visibility conditions should reflect contemporary conditions and land use patterns. That is, estimates should attempt to calculate the degree of visibility impairment that exists today, given current vegetative landscapes, when human emissions contributions are removed. We believe that this is a more practical approach than attempting to speculate about what visibility conditions would have existed under the vegetative landscapes that existed 3 or 4 centuries ago, i.e., prior to the arrival of European settlers.

1.11 What estimates of natural conditions are referenced in the regional haze rule and preamble?

Section 308(d)(2)(iii) of the regional haze rule states that "[natural visibility conditions must be calculated by estimating the degree of visibility impairment existing under natural conditions for the most impaired and least impaired days, based on available monitoring information and appropriate data analysis techniques.]" In the preamble to the regional haze rule, EPA states that "it will be appropriate to derive regional estimates of natural visibility conditions by using estimates of natural levels of visibility-impairing pollutants in conjunction with the IMPROVE methodology for calculating light extinction from measurements of the five main components of fine particle mass (sulfate, nitrate, organic carbon, elemental carbon, and crustal material)." As described elsewhere in this document, in addition to the five main components of fine particle mass, terms for coarse particle mass and Rayleigh scattering are also included in the calculation of light extinction.

The 1991 peer-reviewed report of the National Acid Precipitation Assessment Program (NAPAP) provides annual average estimates of natural concentrations for these six main components of PM for the eastern and western regions of the country.[11] By applying assumptions for average extinction efficiencies for each PM component and for the effect of humidity, the NAPAP report also included estimates of natural visibility conditions on an annual average basis. Those estimates are equivalent to about 9.6 deciviews in the eastern region and 5.3 deciviews in the western region of the United States.

In the regional haze preamble, EPA used the NAPAP estimates for natural concentrations of PM mass components, but used assumptions for average extinction efficiencies and annual

[11] National Acid Precipitation Assessment Program, 1991. Acid Deposition: State of Science and Technology. Report 24. Visibility: Existing and Historical Conditions – Causes and Effects. Table 24-6, Washington, DC.

average humidity, based on updated methodologies developed under the IMPROVE program. Using this approach, EPA found that an appropriate estimate for natural conditions for the 20% worst days would be approximately 11-12 deciviews in the east and 8 deciviews in the west.

The preamble further stated that "with each subsequent SIP revision, the estimates of natural conditions for each mandatory Federal Class I area may be reviewed and revised as appropriate as the technical basis for estimates of natural conditions improve." Possible approaches for refining natural conditions estimates are discussed later in this document.

1.12 How are the natural visibility conditions at a mandatory Federal Class I area determined?

The general approach to estimating natural visibility conditions is based on the IMPROVE methodology for calculating visibility extinction. Using estimates of the natural concentrations of the primary components of particulate matter, along with estimates of the extinction efficiencies of these species, and site-specific factors to account for the effects of relative humidity on light scattering by particles, values for the annual average light extinction at each mandatory Federal Class I area are calculated. Figure 1-2 summarizes the approach to estimating natural visibility conditions.

1.13 What approaches for estimating natural conditions are discussed in this guidance document?

Chapter 2 of this guidance document describes the default approach for estimating natural visibility conditions for each mandatory Federal Class I area. This approach (see Figure 1-2) relies on the NAPAP estimates for PM mass components and the IMPROVE methodology for calculating light extinction. Important enhancements incorporated in this approach include the use of 10-year average relative humidity data from more than 300 weather stations, for development of appropriate relative humidity adjustment factors (*f(RH)*), and statistical techniques for estimating values for the 20% most impaired and 20% least impaired days. The EPA believes that this approach provides an adequate estimate of natural conditions for the purpose of developing initial visibility improvement goals and expects to be able to propose to approve goals in SIP submissions relying on this approach.

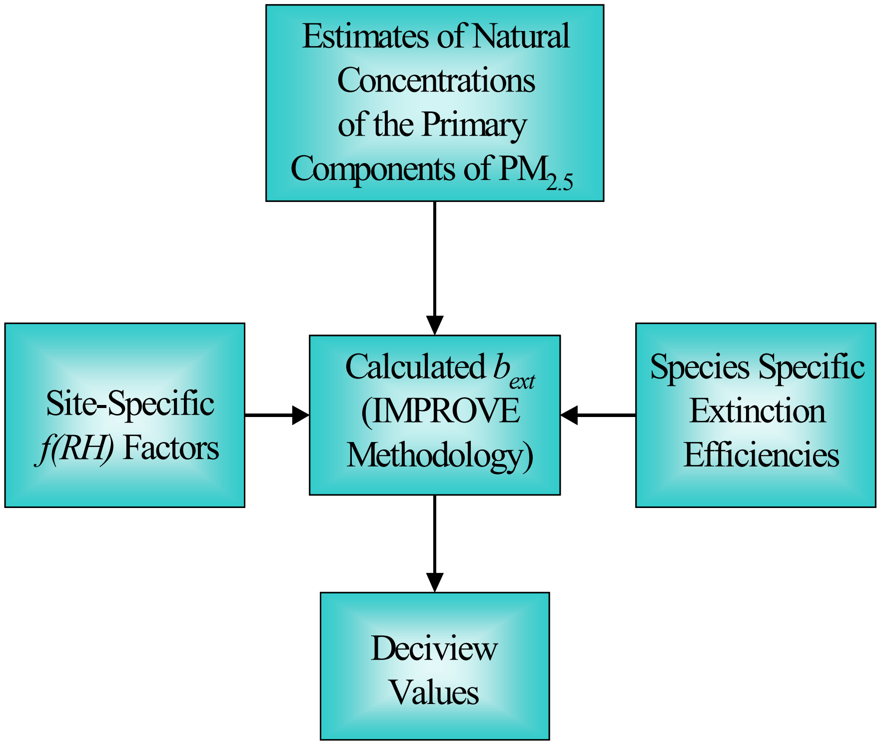

Figure 1-2 Types of Data Used in Approach for Estimating Natural Visibility Conditions

Chapter 3 of this guidance describes some alternative approaches by which States may refine their natural conditions estimates based on additional data and analyses. For example, one possible refined approach would involve updating the estimates of natural PM mass concentrations for each PM component, based on recent peer-reviewed literature, rather than using the NAPAP default values. These methods do not represent an exhaustive list and States are free to develop alternative approaches that will provide natural visibility conditions estimates that are technically and scientifically supportable. Any refined approach should be based on accurate, complete, and unbiased information and should be developed using a high degree of scientific rigor.

1.14 How are natural emissions from fire taken into account in estimates of natural PM and visibility levels?

Because some of the fires producing particulate emissions are naturally occurring, and would occur in the absence of human activities, the estimate of natural visibility conditions must take fire into account.

Appendix A of the NAPAP report discusses the approach used to estimate natural mass levels for each PM component. The estimates are based on compilations of natural versus man-made emission levels, ambient measurements in remote areas, and regression studies using man-made and/or natural tracers. Uncertainties are recognized in the estimates of each PM component. The report recognizes that estimated natural levels of both organic carbon and elemental carbon include contributions from fire emissions. The NAPAP report includes organic carbon as the most significant natural PM component by mass in both the eastern and western regions. Because most of the studies cited in the NAPAP Appendix were conducted in relatively remote areas, it is reasonable to assume that the contribution of fire to PM mass in the NAPAP estimates represents the natural regional contribution by fire. The NAPAP estimates included contributions from smoke but no distinction was made at the time between natural and man-made fire. Nonetheless, these are the best estimates available in the literature for current contributions from natural sources. Since the estimate of natural visibility conditions is a long-term (5-year) average, and because we expect to be able to further refine estimates over time based on improved information and methods, a regional contribution by fire emissions to overall natural visibility conditions should be adequate for the purpose of developing initial progress goals.

Data should be available for EPA and States to develop improved estimates of the contribution of fire emissions to natural visibility conditions in mandatory Federal Class I areas over time. Information from a number of additional activities and technical tools should be available over the coming years, including:

- implementation of a coordinated fire data system or fire tracking system;
- the collection of multiple years of speciated PM data in mandatory Federal Class I areas, and the assessment of potential contributions by natural fire events using data from the fire tracking system;
- development of chemical analysis techniques to identify carbon attributed to fire versus other sources;
- development of improved emissions factors and tracking of fire activity levels; and

- improved regional scale fire modeling, or remote sensing tools to retrospectively determine whether smoke from a fire impacted a Class I airshed.

1.15 How does the need to consider the fire component for natural visibility conditions interface with EPA's general policies regarding fire emissions?

The purpose of this document is to address the identification of methodologies for States to use in estimating natural visibility conditions, including the contribution from fire. This document is not intended to identify or dictate potential emission sources and control requirements.

The EPA acknowledges the need to allow the use of fire as an efficient and economical land management tool. The use of fire has proven benefits in maintaining the health of fire-tolerant and fire-dependent plant and animal ecosystems. In some cases, fire may be the only viable alternative to maintaining species diversity, enhancing productivity, or eliminating the threat of disease or catastrophic wildfires. The EPA, in partnership with the U.S. Department of Agriculture (USDA), and the Department of the Interior (DOI), will work with Federal and private land managers to develop alternatives to fire where applicable but will allow fire as a viable option in the maintenance of forest land and agricultural (cropland, rangeland, pastureland) ecosystems. The EPA has participated in the review of the USDA/DOI Wildland Fire Management Policies (1995 and 2001) and in the development of the 10-Year Comprehensive Strategy which establishes fire management priorities. The EPA is also actively involved with USDA and their Agricultural Air Quality Task force in addressing fire as a management tool for crop production and rangeland management. The EPA expects to amend the 1998 Interim Air Quality Policy on Wildland and Prescribed Fires to incorporate the final policy on burning for agricultural crop production and rangeland management. The EPA’s overall policy approach encourages the use of smoke management plans to minimize the impacts of burning activities on air quality and visibility impairment and provide some flexibility to areas with certified smoke management programs if it is determined that emissions from these fires contribute significantly to the National Ambient Air Quality Standards (NAAQS) violations.

States/tribes are aware of their responsibility to meet air quality standards and develop plans on how they will meet the standards. It is EPA’s view that smoke management plans are best negotiated and implemented at the local level, taking into account regional impacts, and that sources of emissions from burning are treated in an equitable manner. Recognizing the State’s responsibility to meet air quality standards, EPA encourages flexibility for local decisions on smoke management by States, locals, or tribal authorities. To address the NAAQS, reduce human health risk or exposure, or improve visibility in Class I areas, EPA encourages State and local air regulatory authorities to include their respective State/local agriculture, forestry, and park management agencies in stakeholder discussions and decisions, to ensure equitable and appropriate viable options for maintaining cropland, rangeland, pastureland, and forest land ecosystems while meeting air quality goals and standards.

The EPA understands the benefits of a tracking system to keep accurate accounting of fire emissions for emissions inventory, modeling, and attainment demonstrations and for the purposes of making sound decisions regarding burn and no burn days. The EPA is currently working with USDA and USDOI to develop a shared data system that would allow access to information useful to Federal, State, and local agencies. Some States or regional organizations have already started to develop their own tracking system for the area. The EPA is not endorsing any particular tracking system and will work with the States and regional planning organizations to make sure their tracking systems will interface with the Federal Tracking System to be developed.

In some cases, regional organizations have found it useful to classify fire emissions into two categories, natural and man-made, for the purposes of estimating natural visibility conditions. While EPA is not expressing an opinion on the importance of classifying fires, it supports those organizations who wish to do so for the purposes of estimating visibility conditions. However, the EPA does not require the distinction between natural and man-made fires. The EPA believes that it is important to recognize that any such classification of fire should not be construed to suggest any classification of emission sources for purposes of identifying those that are subject to control requirements. The criteria used to classify fires may or may not be the same criteria used to determine culpable sources and potential control requirements. Identifying culpable sources and potential control requirements to meet SIP requirements is beyond the scope and purpose of this document.

1.16 Can a State delay submittal of its control strategy SIP and associated mandatory Federal Class I area progress goals until it has developed a "refined" estimate of natural conditions?

No, States cannot use the development of a refined estimate of natural visibility conditions as a reason for delaying the submittal of regional haze control strategy SIPs required by statute and regulation. The EPA believes that the 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. In addition, the timeline for implementing the regional haze program already includes a significant amount of lead time for developing these SIPs, and EPA does not believe that SIP due dates may be extended beyond the existing regulatory requirements. The EPA expects that States will need to begin assessing progress goals and emission reduction strategies beginning in the 2004-2005 time frame, in order to leave adequate time for air quality modeling, analysis of the statutory factors, consultation with other States or Tribes, development of regional recommendations, and adoption of individual State regulations by 2007-8. Because the process of planning and implementing strategies and evaluating progress is an iterative one, there will be future opportunities to refine progress goals based on new information about natural visibility conditions, rates of growth and development, and the effectiveness of controls.

2. DEFAULT APPROACH TO ESTIMATING NATURAL VISIBILITY CONDITIONS

This section of the guidance document presents the default approach to be used in estimating the natural visibility conditions for both the 20% most and 20% least impaired days.

2.1 What are the default estimates of the natural concentrations for the $PM_{2.5}$ components?

The estimates of the annual averages for the natural levels of fine particle constituents and of coarse particles are drawn from the 1990 report of NAPAP.[12] That report draws published data from a variety of sources and presents estimates for the natural levels of sulfates, organics, light absorbing carbon (also referred to as elemental carbon), ammonium nitrate, soil dust, and coarse particles for the eastern and western regions of the United States. The estimates presented in that report include significant uncertainties which indicate that the actual natural levels for these species are likely to fall within a range around the values reported. However, with minor adjustments, these estimates provide the starting point for calculating natural visibility conditions in the mandatory Federal Class I areas.

The approach to estimating natural conditions presented in the NAPAP report defines two separate regions of the United States: (1) the East, which consists of all the States east of the Mississippi River, and up to one tier of States west of the Mississippi; and (2) the West, including the desert/mountain regions of the Mountain and Pacific time zones. Geographically, these two subregions show strong differences in haze sources, vegetation, relative humidity, and regional haze levels. Within these two subregions, spatial variations in the natural aerosol levels would be expected. As a result, States near the boundary between East and West should choose which set of NAPAP estimates are most appropriate and adopt those values.

Table 2-1 presents the default estimated natural concentrations of the particulate species for the East and the West along with estimates of the dry extinction efficiencies for each species. These concentration estimates are used with the respective estimates of the dry extinction efficiencies to establish the light extinction attributed to natural sources in the East and West. As Table 2-1 shows, the natural concentration estimates differ between the East and West only in the concentrations of sulfate and organic species.

[12] Trijonis, J.C., NAPAP State of Science & Technology, Vol. III, 1990.

Table 2-1 Average Natural Levels of Aerosol Components[a]

	Average Natural Concentration		Error Factor	Dry Extinction Efficiency (m^2/g)
	West ($\mu g/m^3$)	East ($\mu g/m^3$)		
Ammonium sulfate [b]	0.12	0.23	2	3
Ammonium nitrate	0.10	0.10	2	3
Organic carbon mass [c]	0.47	1.40	2	4
Elemental carbon	0.02	0.02	2-3	10
Soil	0.50	0.50	1½ - 2	1
Coarse Mass	3.0	3.0	1½ - 2	0.6

a: After Trijonis, see footnote 12
b: Values adjusted to represent chemical species in current IMPROVE light extinction algorithm; Trijonis estimates were 0.1 $\mu g/m^3$ and 0.2 $\mu g/m^3$ of ammonium bisulfate.
c: Values adjusted to represent chemical species in current IMPROVE light extinction algorithm; Trijonis estimates were 0.5 $\mu g/m^3$ and 1.5 $\mu g/m^3$ of organic compounds.

2.2 What should be done if the default estimate for any naturally contributed species exceeds the corresponding measured concentrations?

Contributions by natural sources to haze are defined as "those not from man-made sources," accordingly, neither natural nor man-made contributions to haze can exceed the total haze levels over any period of time. The default natural concentration estimates are for long-term average conditions, and so may be larger than the measured current concentrations for short periods, but should not exceed the average concentration over several annual cycles. If the average measured level of any of the six particle species (for the baseline period, or for any other 5-year period), is smaller than the corresponding default natural values, then the default values should be replaced by values that are equal to or less than the measured values. This would constitute a refinement of the default as discussed in Section 3.

2.3 How are the long-term relative humidity data used to determine f(RH) values?

The U.S. EPA recently sponsored a project to examine measured hourly relative humidity data over a 10-year period (1988-1997) within the United States, to derive month-specific climatological mean humidity correction factors for each mandatory Federal Class I area.[13] These relative humidity (RH) factors were calculated from available hourly relative humidity data from 292 National Weather Service (NWS) stations across the 50 States and the District of Columbia, as well as from 29 IMPROVE and IMPROVE protocol monitoring sites, 48 Clean Air Status and Trends Network (CASTNet) sites, and 13 additional sites administered by the National Park Service.

The hourly RH measurements from each site were converted to hourly *f(RH)* values using a non-linear weighting factor curve, based on a modified ammonium sulfate growth curve (see Appendix A), applied to the 10 years of surface relative humidity data.

The annual average *f(RH)* values for all mandatory Federal Class I areas are tabulated in Appendix A of this document. Those values are used in the default approach to establishing natural visibility conditions. The 12 monthly averaged *f(RH)* values for each of these Class I areas are also tabulated in Appendix A. In most regions there is a seasonal cycle of relative humidity, which is evident in the appropriate monthly *f(RH)* values. The monthly *f(RH)* values may be used in refined estimates of the natural visibility conditions (Chapter 3). Note that Table A-2 and supplementary Table A-3 only includes f(RH) values for the designated mandatory Federal Class I areas. However, the software program needed to calculate *f(RH)* values for other sites is available for use by States, Tribes, and other agencies or interested parties, upon request to EPA.

[13] U.S. EPA, Interpolating Relative Humidity Weighting Factors to Calculate Visibility Impairment and the Effects of IMPROVE Monitor Outliers, prepared by Science Applications International Corporation, Raleigh, NC, EPA Contract No. 68-D-98-113, August 30, 2001.

2.4 How is the default natural light extinction at a mandatory Federal Class I area calculated?

The calculation of natural light extinction is based on the IMPROVE methodology. Using the values in Table 2-1, the natural light extinction can be calculated from Equation 1:

$$
\begin{aligned}
b_{ext} = {} & (3)f(RH)[SULFATE] + \\
& (3)f(RH)[NITRATE] \\
& +(4)[OMC] \\
& +(10)[LAC] \\
& +(1)[SOIL] \\
& +(0.6)[CM] \\
& +10
\end{aligned}
\tag{1}
$$

where b_{ext} is the calculated total light extinction in inverse megameters. (Note: A value of 10 Mm^{-1} is used for all mandatory Federal Class I areas as an estimate of the light extinction caused by the light scattering from gas molecules, i.e., Rayleigh scattering). Relative humidity correction factors, *f(RH)*, are included for the sulfate and nitrate species as these are hygroscopic (i.e., absorb water) and their extinction efficiencies change with relative humidity. Annual average site-specific *f(RH)* values for 154 of the 156 mandatory Federal Class I areas (Appendix A) have been determined from historical data and are used in the default approach to establish site-specific natural visibility conditions.

Example calculations with Equation 1 will illustrate the use of the default approach. Looking at two examples in the East, and referring to Table 2-1 for default concentrations and Appendix A for annual *f(RH)* values, we see that the natural total light extinction for the Acadia National Park (Maine) is:

$$
\begin{aligned}
b_{ext} &= 3(3.4)[0.23] + 3(3.4)[0.1] + 4[1.4] + 10[0.02] + 1[0.5] + 0.6[3.0] + 10 \\
&= 21.5\,Mm^{-1}
\end{aligned}
$$

Similarly, for the Everglades National Park (Florida) b_{ext} is:

$$
\begin{aligned}
b_{ext} &= 3(2.7)[0.23] + 3(2.7)[0.1] + 4[1.4] + 10[0.02] + 1[0.5] + 0.6[3.0] + 10 \\
&= 20.8\,Mm^{-1}
\end{aligned}
$$

In the West, we see that Bandelier National Monument (New Mexico) has a default natural light extinction of:

$$\begin{aligned} b_{ext} &= 3(1.9)[0.12] + 3(1.9)[0.1] + 4[0.47] + 10[0.02] + 1[0.5] + 0.6[3.0] + 10 \\ &= 15.6\,Mm^{-1} \end{aligned}$$

and Yellowstone National Park (Wyoming) has a default b_{ext} of:

$$\begin{aligned} b_{ext} &= 3(2.1)[0.12] + 3(2.1)[0.1] + 4[0.47] + 10[0.02] + 1[0.5] + 0.6[3.0] + 10 \\ &= 15.8\,Mm^{-1} \end{aligned}$$

The default natural light extinction values have been calculated by this approach for 154 of the 156 mandatory Federal Class I areas and are listed in Appendix B.

2.5 How are the default b_{ext} values used to estimate natural visibility in deciview units?

The default light extinction values are used to calculate estimates for the annual average HI values (in *dv* units) at each mandatory Federal Class I area. These default HI values are determined from Equation 2:

$$HI = 10\ln(b_{ext} / 10) \qquad \textbf{(2)}$$

where b_{ext} is the default total light extinction in Mm^{-1} as calculated by Equation 1. From the examples above, the default annual average HI value for Acadia National Park is:

$$\begin{aligned} HI &= 10\ln(21.5 / 10) \\ &= 7.7\ dv. \end{aligned}$$

For the Everglades National Park, the default HI value is:

$$\begin{aligned} HI &= 10\ln(20.8 / 10) \\ &= 7.3\ dv. \end{aligned}$$

The default HI value for Bandelier National Monument is:

$$
\begin{aligned}
HI &= 10\ln(15.6/10) \\
&= 4.4\ dv.
\end{aligned}
$$

and for Yellowstone National Park the default HI is:

$$
\begin{aligned}
HI &= 10\ln(15.8/10) \\
&= 4.6\ dv.
\end{aligned}
$$

The calculated annual average HI values for each mandatory Federal Class I area are presented in Appendix B along with the default total light extinction (b_{ext})values.

2.6 How are the 20% best visibility days and the 20% worst visibility days determined in the default approach?

The calculated HI value represents an estimate of the annual average of daily natural visibility in *dv* units. If daily HI values for the natural background visibility in *dv* units were available, those values could be arranged in order, and the averages of the best 20% and the worst 20% of the values could be calculated to establish the regional haze rule goals for each mandatory Federal Class I area. However, since daily natural visibility *HI* values are not available, the default approach provides only an estimate of the annual average natural background visibility, and the averages for the best and worst 20% must be estimated.

Ames and Malm[14] have shown that the frequency distributions of daily calculated *HI* values for sites in the East and in the West, can each be well represented by normal distributions. Consequently, the average *HI* values for the 20% best visibility days and the 20% worst visibility days can be estimated from 10th and 90th percentile *HI* values, respectively. That is,

[14]Rodger Ames and William Malm, Recommendations for Natural Condition Deciview Variability: An Examination of IMPROVE Data Frequency Distributions, Proceedings of "Regional Haze and Global Radiation Balance - Aerosol Measurements and Models: Closure Reconciliation and Evaluation," October 2-5, 2002, Bend, Oregon.

since the frequency distributions appear to behave normally, the 10th and 90th percentile *HI* values (*p*10 and *p*90, respectively) for a mandatory Federal Class I area can be estimated from the following equations:

$$p10 = \overline{HI} - 1.28sd \quad (3)$$

and,

$$p90 = \overline{HI} + 1.28sd \quad (4)$$

where *sd* represents the standard deviation (in *dv* units) of the daily *HI* values for that area, and $\overline{HI}$ is the annual average of the *HI* values. Estimates of *sd* for current visibility conditions for eastern and western sites were derived from a database of current visibility conditions. At each site, daily *HI* values were calculated from the calculated light extinction values, and the mean and standard deviation of the daily *HI* values were determined. Comparison of sites within the same region showed that, in the East, the current visibility conditions have on average an *HI* value of approximately 18 *dv,* with an average *sd* of approximately 5 *dv*. In the West, the current visibility conditions showed an average *HI* of approximately 8 *dv* and an average *sd* of approximately 2.4 *dv*. More important in the present context, by inspection of the relationships between *sd* and *HI*, Ames and Malm[14] inferred best estimates of the *sd* values for natural

visibility in both the West and East. In the West this best estimate of the natural visibility *sd* is 2 *dv*, whereas in the East the best estimate of the natural visibility *sd* is 3 *dv.*

These estimates of the standard deviation of natural contributions to visibility impairment can be used in Equations 3 and 4 above, along with the default natural *HI* values, to estimate the averages of the 20% best and 20% worst natural visibility contributions.

For example, the calculated 10th and 90th percentile natural *HI* values for Acadia National Park are:

$$p10 = 7.7 - 1.28(3) = 3.8$$
$$p90 = 7.7 + 1.28(3) = 11.5$$

Appendix B provides the default 10th and 90th percentile natural visibility *HI* values in *dv* units for each of the 156 mandatory Federal Class I areas. Figure 2-1 is a map of the 10th percentile default *HI* at mandatory Federal Class I areas across the United States, indicating a range from approximately 2 *dv* in the West to 4 *dv* in the East. Figure 2-2 is a map of the 90th percentile *HI*, which ranges from approximately 7 *dv* in the west to 11 dv in the East. Note that different color scales apply to the East and West portions of Figures 2-1 and 2-2, as indicated in the figures. Higher natural *HI* values in the northwest than the southwest United States are due to higher RH in the northwest. Higher natural condition organic carbon mass concentrations in the East are primarily responsible for higher default 10^{th} and 90^{th} percentile natural *HI* values in the East relative to the western United States. As noted in Section 2.1, States near the boundary between East and West have the option of choosing which set of default natural background conditions to use.

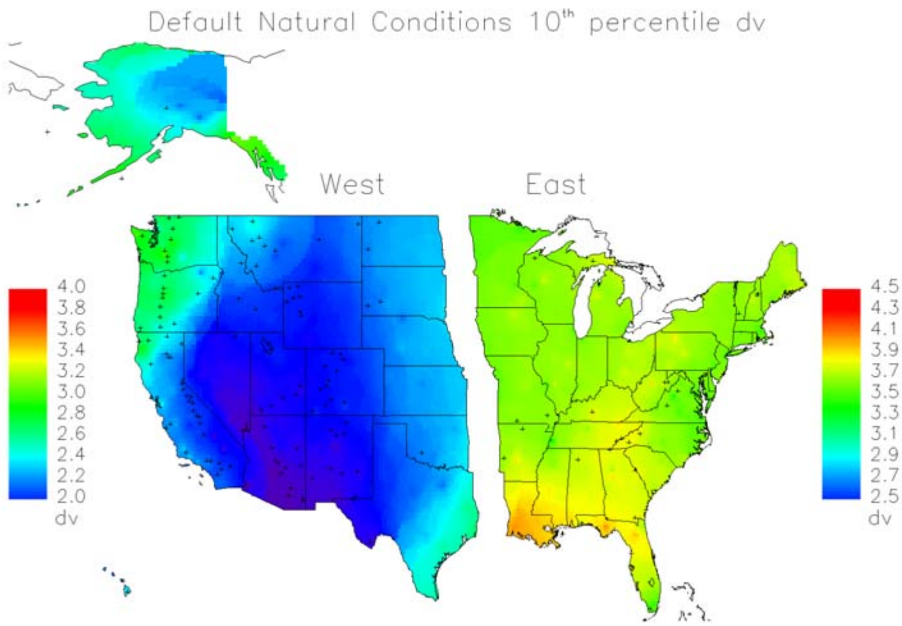

Figure 2-1 Estimates of the Default 10% Natural Haze Index Values (in *dv*)
(Note different color scales for the two parts of the figure)

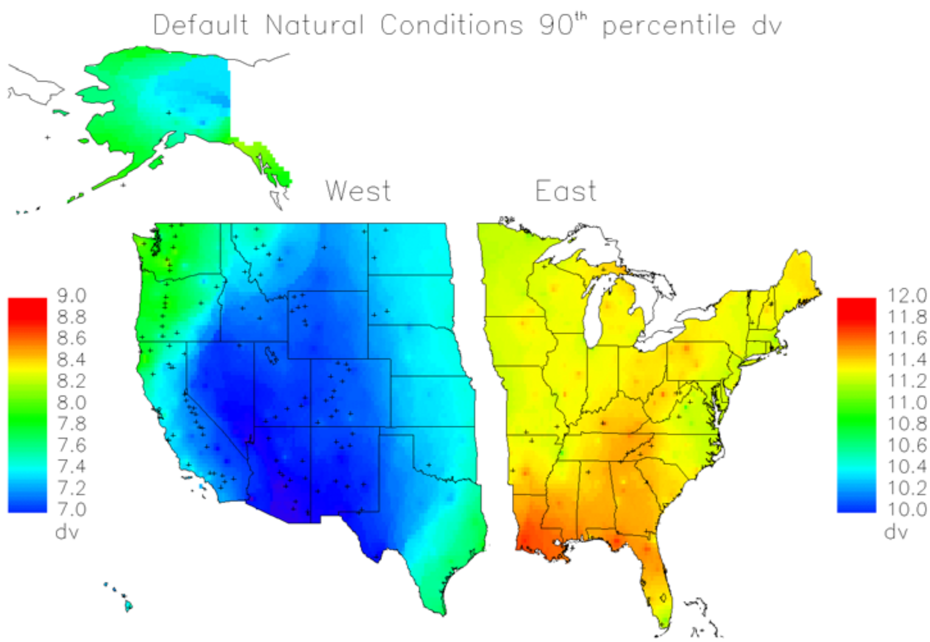

Figure 2-2 Estimates of the Default 90% Natural Haze Index Values (in *dv*)
(Note different color scales for the two parts of the figure)

3. Refined Estimation Approaches Regional & Site-Specific Application

3.1 Why might States want to use a refined approach to estimate natural visibility conditions?

There are a variety of circumstances under which States might wish to adopt a refined approach to estimating natural visibility conditions. For example, if the default estimates of the natural background conditions are close to the current visibility conditions, small uncertainties can have significant impacts on States' ability to meet SIP goals. In some regions, natural sources are known to exhibit predictable seasonal influences on visibility. Therefore, States might wish to use refined estimates of natural visibility conditions to account for these influences. Also, States which receive significant visibility impacts from biomass smoke might wish to distinguish more explicitly between man-made and natural sources. These examples are non-exhaustive, and there may be many other circumstances under which States find it desirable to develop more refined estimates. In all such cases, they should be prepared to support alternative approaches with sufficient information so that EPA and the reviewing public can verify their accuracy and validity.

3.2 What are some of the approaches that could be used by States to refine the default natural visibility estimates?

A refined approach is essentially one that uses species concentration estimates that differ from the NAPAP default values given in Table 2-1. Several possible refined approaches which can be adopted are described in this document, and States may identify others that are more appropriate for their own situations.

One possible refined approach is to revise the NAPAP default estimates of the natural concentrations of one or more of the composite components, and repeat the calculations with the refined concentrations. This approach might be adopted where there is an offset between the regional natural concentrations and the NAPAP default estimates. In this approach, the visibility calculations (i.e., Equations 1-4) would be carried out using refined annual average concentration estimates and the default annual average *f(RH)* values. Note that any refined natural concentration estimates must retain the distinction between natural and anthropogenic components. For example, the natural concentration estimate for a species can never exceed the actual measured concentration of that species over a 5-year period.

In cases where constant values for natural species concentrations may not be appropriate, a second possible approach could estimate natural visibility using species concentrations that vary (e.g., seasonally, monthly, or climatologically). This approach might adopt the NAPAP default estimates for some species, and temporally varying estimates for others. Alternatively, the NAPAP estimates might be used for some seasons or time periods and other technically justified estimates or measurements for the remaining time periods. This approach would use the refined concentration estimates and if the time-varying species is hygroscopic (i.e., sulfate or nitrate), it would also use the appropriate monthly average *f(RH)* values (Appendix A).

Finally, a refined approach might account for infrequent natural events, such as forest fires or wind-blown dust, as major influences on visibility. Such an approach would require estimating the frequency and magnitude of the natural contribution to particle concentrations during the events.

3.3 Which refined approach is most appropriate for States to use?

To determine which approach is most appropriate, States should first identify whether any of the particle species concentrations are thought to deviate significantly from the NAPAP default values. Once identified, States should classify the deviations as either a constant offset (e.g., NAPAP sulfate values are too low near the sea coast), a systematic temporal variation (e.g., natural organics are seasonally higher in the summer), or an infrequent natural variation (e.g., dust produced by a natural sand dune area during wind events). The refinement of particle species concentrations could follow a range of different approaches, from using different annual average species concentrations, to using seasonal or monthly concentrations, to using different natural concentrations for individual sample events. Such refined approaches may require alternative methods to predict the 10^{th} and 90^{th} percentile natural condition *HI* values. The EPA encourages flexibility in the approaches used so that default and refined annual average, seasonal, monthly, and event-specific species concentrations may be intermingled to provide the best estimates of natural visibility for each of the mandatory Federal Class I areas.

3.4 What should States do if they want to use a refined approach, rather than the default approach to estimate natural visibility conditions?

States wishing to employ a refined approach should supply demonstrations that the refined approach is technically sound and provides regionally representative estimates of natural visibility conditions. The proposed refined approach must be based upon particle species classification into natural and man-made components (i.e., in any given time period, the natural particle species concentration cannot exceed the measured concentration), and should be submitted to EPA for approval prior to implementation.

States wishing to adopt a refined approach based on a constant offset of the natural concentrations of the particle species should provide technical justification for revising the NAPAP default concentrations. Using the refined concentrations, the natural visibility condition should then be calculated based on an approach that is consistent with the methodology that is used to track trends, such as the default approach.

States wishing to adopt a refined approach based on estimates of annually varying (seasonally, monthly, climatologically, etc.) natural particle concentrations should also provide technical justification for the estimates of the natural particle species concentrations. For example, if seasonal variations in particle species are the basis for the refined approach, then estimates should be provided of natural concentrations in every season for every pertinent species. Those particle species components that do not vary significantly should be treated using a constant estimate of the natural concentrations (e.g., use NAPAP value for each season).

In any case, the appropriate mechanism for putting a refined estimation approach in place is to incorporate the approach in a new or revised SIP. The justification for the proposed refined approach will thereby be considered as part of the normal SIP review process.

3.5 How might an infrequent natural impact be quantified?

Infrequent events affecting the visibility at specific mandatory Federal Class I areas could be addressed by using a constant or temporally varying value for species affected by the event during all non-event periods, and a different value for those same species for sampling periods during the event. For example, consider a forest fire, which affects particulate organic and elemental carbon. The contribution of the fire event to the natural levels of those species during the fire might be estimated by assuming all of the observed increment above the mean of the sample periods immediately pre- and post-fire event was the result of the fire. Multiple pre- and post-event sample periods could be used to strengthen the comparison. Alternatively, an air quality model might be used to estimate the impact of the smoke plume on particle carbon levels, or other air quality measurements might be used to estimate the impact of the event.

3.6 Can natural visibility estimates be made on a sample-period-by-sample-period basis?

Yes, such calculations can be done, but refined concentration estimates should be justified to support such an approach. In that case, the calculation of the current b_{ext} would first be done for each sample day, using Equation 1, the appropriate monthly *f(RH)* values, and the daily monitoring data for each species. The resulting daily b_{ext} values would then be converted to an *HI* value in *dv* units by Equation 2. Those *HI* values would then be sorted, and the highest 20% and lowest 20% identified, indicating the days with the most and the least visibility impairment, respectively. (This procedure is described in detail in a separate guidance document for tracking progress). For each of the days in these two groups, the natural contribution to light extinction would then be estimated. The average of each of these two groups of natural contributions would then be calculated.

As noted above, in any given time period the natural concentration of a species estimated by this calculation cannot exceed the actual measured concentration. Furthermore, if this approach is taken, natural visibility conditions (i.e., the averages of the 20% worst and 20% best natural *HI* values) should be estimated for as many years as possible to ensure that the average results are more representative of the long-term conditions.

Appendix A

Annual Average *f(RH)* and Monthly Average *f(RH)* Values at All Mandatory Federal Class I Areas

Appendix A
Origin of Relative Humidity and f(RH) Values

In terms of visibility reduction caused by fine particles, it is appropriate to treat relative humidity differently for different objectives. If the objective is the most reliable short-term estimate of visibility, then the measured or estimated relative humidity for the specific time and location of the aerosol speciation data is most appropriate. If the objective is to assess the long-term changes in man-made visibility impairment, it is appropriate to use relative humidity that is the same for the baseline period and future periods. In other words, it is more appropriate to eliminate the confounding effects of varying relative humidity, if the purpose is to track the visibility effects of air pollution emissions over extended time periods.

A number of approaches were considered to prevent variations in the relative humidity adjustment factor from confounding efforts to track progress related to emission controls. The simplest approach would use the same typical or overall average adjustment factor for all Class I areas at all times. However, this would enhance the contributions of hygroscopic particle species in dry locations and during typically dry seasons above what they truly should be while reducing their contributions in moist locations and seasons. Such distortions of the contributions to haze by hygroscopic particle species are unnecessary if a set of Class I area-specific adjustment factors are used that reflect seasonal changes in relative humidity.

A second approach would be to review relative humidity data over a long period of time to derive climatological estimates for relative humidity adjustment factors. These climatological estimates would then be used to estimate visibility extinction coefficients. These estimates are more likely to reflect "typical" relative humidity at the different mandatory Federal Class I areas during different times of year and, thus, are more likely to be more appropriate for establishing trends in visibility at the mandatory Federal Class I areas.

Recently, the U.S. EPA sponsored a project to examine measured hourly relative humidity data over a 10-year period within the United States, to derive month-specific climatological mean humidity correction factors for each mandatory Federal Class I area.[15] The results of that work are presented in the table below and the draft report is available at:

http://www.epa.gov/ttn/naaqs/pm/pm25_tech.html

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[15] U.S. EPA, Interpolating Relative Humidity Weighting Factors to Calculate Visibility Impairment and the Effects of IMPROVE Monitor Outliers, prepared by Science Applications International Corporation, Raleigh, NC, EPA Contract No. 68-D-98-113, August 30, 2001.

These relative humidity factors have been calculated from available hourly relative humidity data from 292 National Weather Service stations across the 50 States and District of Columbia as well as from 29 IMPROVE and IMPROVE protocol monitor sites, 48 CASTNet sites, and 13 additional sites administered by the National Park Service.

The hourly RH measurements from each site were converted to *f(RH)* values using a non-linear weighting factor curve, based on a modified ammonium sulfate growth curve. Values above 95% RH were set equal to the *f(RH)* corresponding to 95% RH. For days in which at least 16 hours of valid RH data were available, daily averages were determined from these hourly *f(RH)* values at each site. Monthly averages were then calculated from the daily *f(RH)* averages at each site.

The monthly average *f(RH)* values were interpolated at 1/4-degree increments using the inverse distance weighting technique (with a distance interpolation exponent of 1):

$$f(RH)_g = \frac{\sum f(RH)_w / x_{wg}}{\sum 1 / x_{wg}}$$

where the monthly $f(RH)_g$ of the grid cell is calculated from $f(RH)_w$ at the weather station, and the horizontal distance between the grid cell center and the weather station, x_{wg}, summed over all the weather stations within a 250-mile radius with valid *f(RH)* values for that month.

In most regions there is a seasonal cycle of relative humidity which is accounted for by this process of appropriate *f(RH)* values for each month of the year from the daily-averaged values. Thus, the 12 monthly-averaged *f(RH)* values determined in this way for each Class I area should be used for all aerosol speciation data or model predictions for that location. However, a more complicated approach has also been investigated, as described below.

The regional haze regulation requires separate tracking of visibility changes for the worst 20% and best 20% of visibility days. If there is a significant correlation in any month at any site between daily relative humidity and the sulfate or nitrate concentrations, then use of the monthly-averaged *f(RH)* will systematically over- or under-predict the contribution to visibility impairment of the aerosol species. Fortunately, this concern can be tested at a number of locations in all regions of the country using the IMPROVE database. If the use of monthly-averaged values were found to cause large systematic biases in any region of the country, the Class I areas in those regions would require two *f(RH)* values for each month. One value would be the average *f(RH)* associated with relative humidity conditions that correspond to the worst 20% and the other value associated with relative humidity conditions that correspond to the best

20% of the light extinction values. Therefore there is the potential that some Class I area locations could require up to 24 *f(RH)* values for use in calculating extinction for aerosol data.

The U.S. National Park Service has tested this possibility, by examining data for each of the 12 months from 20 mandatory Federal Class I areas where relative humidity measurements are made. In nearly all cases, no statistically significant correlations were found between measured concentrations of SO_4^{2-}, NO_3^- and [SO_4^{2-} + NO_3^-] vs. daily values of relative humidity in a large majority of months. Furthermore, deciview calculations were made using day-specific vs. climatological values for the relative humidity adjustment factor for each of 10 years in 15 mandatory Federal Class I areas. In 14 of the 15 areas, little if any difference was observed in the year to year calculations for the mean deciview values for the 20% worst and 20% best days, nor was there any difference in the trends. Some difference in the mean deciview value for the worst 20% days was observed in one mandatory Federal Class I area. However, the overall trend in the mean worst and best deciview values for this site was similar using the two types of *f(RH)* values. These results suggest there is a relatively weak correlation between hygroscopic components of PM and relative humidity and that the choice of a "climatological" vs. "day-specific" method for computing *f(RH)* has little apparent effect on observed trends in visibility. Consequently, the simpler climatological approach is used in regional haze calculations.

Table A-1 Values for f(RH) determined from the growth of ammonium sulfate

RH	f(RH)	RH	f(RH)	RH	f(RH)
1	1.00	34	1.00	67	2.03
2	1.00	35	1.00	68	2.08
3	1.00	36	1.00	69	2.14
4	1.00	37	1.02	70	2.19
5	1.00	38	1.04	71	2.25
6	1.00	39	1.06	72	2.31
7	1.00	40	1.08	73	2.37
8	1.00	41	1.10	74	2.43
9	1.00	42	1.13	75	2.50
10	1.00	43	1.15	76	2.56
11	1.00	44	1.18	77	2.63
12	1.00	45	1.20	78	2.70
13	1.00	46	1.23	79	2.78
14	1.00	47	1.26	80	2.86
15	1.00	48	1.28	81	2.94
16	1.00	49	1.31	82	3.03
17	1.00	50	1.34	83	3.12
18	1.00	51	1.37	84	3.22
19	1.00	52	1.41	85	3.33
20	1.00	53	1.44	86	3.45
21	1.00	54	1.47	87	3.58
22	1.00	55	1.51	88	3.74
23	1.00	56	1.54	89	3.93
24	1.00	57	1.58	90	4.16
25	1.00	58	1.62	91	4.45
26	1.00	59	1.66	92	4.84
27	1.00	60	1.70	93	5.37
28	1.00	61	1.74	94	6.16
29	1.00	62	1.79	95	7.40
30	1.00	63	1.83	96	9.59
31	1.00	64	1.88	97	14.1
32	1.00	65	1.93	98	26.4
33	1.00	66	1.98		

Table A-2 Recommended Monthly Site-Specific f(RH) Values for Each Mandatory Federal Class I Area, Based on the Representative IMPROVE Site Location

Class I Area	Site Name		Code	Site St	LAT	LONG	Jan f(RH)	Feb f(RH)	Mar f(RH)	Apr f(RH)	May f(RH)	Jun f(RH)	Jul f(RH)	Aug f(RH)	Sep f(RH)	Oct f(RH)	Nov f(RH)	Dec f(RH)
Acadia	Acadia	1	ACAD1	ME	44.38	-68.37	3.2	2.8	2.8	3.2	3.2	3.3	3.7	3.7	3.9	3.5	3.4	3.5
Agua Tibia	Agua Tibia	100	AGTI1	CA	33.38	-116.87	2.4	2.3	2.4	2.2	2.2	2.2	2.2	2.3	2.3	2.2	2.1	2.2
Alpine Lakes	Snoqualmie Pass	80	SNPA1	WA	47.38	-121.37	5.3	5.0	3.7	3.6	4.2	3.1	3.5	3.4	3.8	4.9	5.5	5.3
Anaconda - Pintler	Sula	71	SULA1	MT	45.88	-114.12	3.4	3.0	2.6	2.3	2.3	2.2	1.9	1.8	2.0	2.5	3.3	3.4
Ansel Adams	Kaiser	110	KAIS1	CA	37.13	-119.12	3.0	2.7	2.5	2.1	2.0	1.7	1.7	1.7	1.8	1.9	2.3	2.7
Arches	Canyonlands	50	CANY1	UT	38.38	-109.87	2.6	2.3	1.8	1.6	1.5	1.2	1.3	1.5	1.5	1.6	2.0	2.3
Badlands	Badlands	59	BADL1	SD	43.63	-101.87	2.8	2.8	2.8	2.6	2.8	2.7	2.4	2.4	2.3	2.3	2.9	2.8
Bandelier	Bandelier	33	BAND1	NM	35.88	-106.37	2.3	2.1	1.8	1.6	1.6	1.4	1.7	2.0	1.9	1.7	2.0	2.3
Bering Sea (a)																		
Big Bend	Big Bend	31	BIBE1	TX	29.38	-103.12	1.8	1.7	1.5	1.4	1.5	1.5	1.6	1.8	1.9	1.7	1.7	1.7
Black Canyon of the Gunnison	Weminuche	55	WEMI1	CO	37.63	-107.87	2.5	2.3	2.0	1.7	1.7	1.5	1.7	2.0	1.9	1.7	2.2	2.4
Bob Marshall	Monture	73	MONT1	MT	47.13	-113.12	3.3	2.9	2.6	2.4	2.4	2.4	2.1	2.0	2.3	2.7	3.2	3.3
Bosque del Apache	Bosque del Apache	38	BOAP1	NM	33.88	-106.87	2.2	2.0	1.6	1.4	1.4	1.3	1.7	1.9	1.9	1.6	1.8	2.2
Boundary Waters Canoe Area	Boundary Waters	23	BOWA1	MN	47.88	-91.62	2.9	2.6	2.6	2.3	2.5	2.8	3.0	3.1	3.2	2.7	3.1	3.1
Breton	Breton	20	BRET1	LA	29.13	-89.12	3.5	3.3	3.3	3.3	3.4	3.6	3.8	3.8	3.6	3.4	3.4	3.5
Bridger	Bridger	65	BRID1	WY	42.88	-109.87	2.5	2.3	2.3	2.1	2.1	1.8	1.5	1.5	1.8	2.0	2.5	2.4
Brigantine	Brigantine	5	BRIG1	NJ	39.38	-74.37	2.9	2.6	2.7	2.6	2.9	3.0	3.2	3.4	3.4	3.2	2.8	2.9
Bryce Canyon	Bryce Canyon	49	BRCA1	UT	37.63	-112.12	2.6	2.4	2.0	1.6	1.5	1.3	1.3	1.5	1.5	1.6	2.0	2.4
Cabinet Mountains	Cabinet Mountains	75	CABI1	MT	47.88	-115.62	3.7	3.2	2.8	2.5	2.5	2.4	2.1	2.1	2.4	2.9	3.6	3.8
Caney Creek	Caney Creek	29	CACR1	AR	34.38	-94.12	3.3	3.0	2.7	2.8	3.2	3.2	3.0	3.0	3.2	3.2	3.1	3.3
Canyonlands	Canyonlands	50	CANY1	UT	38.38	-109.87	2.6	2.3	1.8	1.6	1.5	1.2	1.3	1.5	1.5	1.6	2.0	2.3
Cape Romain	Cape Romain	15	ROMA1	SC	32.88	-79.62	3.2	2.9	2.8	2.7	2.9	3.3	3.3	3.6	3.5	3.4	3.1	3.1
Capitol Reef	Capitol Reef	52	CAPI1	UT	38.38	-111.37	2.7	2.5	2.0	1.7	1.6	1.4	1.4	1.6	1.6	1.7	2.1	2.5
Caribou	Lassen Volcanic	90	LAVO1	CA	40.63	-121.62	3.7	3.1	2.8	2.4	2.3	2.1	2.0	2.0	2.1	2.3	3.1	3.5
Carlsbad Caverns	Guadalupe Mountains	32	GUMO1	TX	31.88	-104.87	2.4	2.0	1.6	1.4	1.6	1.5	1.9	2.2	2.4	1.7	1.9	2.3
Chassahowitzka	Chassahowitzka	18	CHAS1	FL	28.63	-82.62	3.5	3.2	3.1	3.0	3.0	3.5	3.5	3.7	3.7	3.5	3.4	3.6
Chiricahua NM	Chiricahua	39	CHIR1	AZ	32.13	-109.37	2.0	1.9	1.6	1.2	1.2	1.1	1.7	2.0	1.7	1.5	1.6	2.1
Chiricahua W	Chiricahua	39	CHIR1	AZ	32.13	-109.37	2.0	1.9	1.6	1.2	1.2	1.1	1.7	2.0	1.7	1.5	1.6	2.1
Cohutta	Cohutta	12	COHU1	GA	34.88	-84.62	3.4	3.1	2.9	2.7	3.2	3.6	3.6	3.7	3.7	3.5	3.2	3.4
Crater Lake	Crater Lake	86	CRLA1	OR	42.88	-122.12	4.6	4.0	3.7	3.5	3.2	2.9	2.6	2.7	2.9	3.6	4.6	4.7
Craters of the Moon	Craters of the Moon	69	CRMO1	ID	43.38	-113.62	3.1	2.7	2.3	2.0	2.0	1.8	1.4	1.4	1.6	2.0	2.7	3.0
Cucamonga	San Gabriel	93	SAGA1	CA	34.38	-118.12	2.6	2.5	2.5	2.2	2.2	2.1	2.2	2.2	2.3	2.2	2.2	2.3
Denali	Denali	102	DENA1	AK	63.75	-148.75	2.5	2.3	2.1	1.9	1.8	2.1	2.5	2.9	2.8	3.0	2.9	3.0
Desolation	Bliss	95	BLIS1	CA	38.88	-120.12	3.2	2.8	2.5	2.0	1.9	1.6	1.5	1.5	1.7	1.8	2.4	3.0
Diamond Peak	Crater Lake	86	CRLA1	OR	42.88	-122.12	4.6	4.0	3.7	3.5	3.2	2.9	2.6	2.7	2.9	3.6	4.6	4.7
Dolly Sods	Dolly Sods	8	DOSO1	WV	39.13	-79.37	3.0	2.7	2.7	2.5	3.5	3.1	3.2	3.5	3.5	3.1	2.8	3.1
Dome Land	Dome Land	109	DOME1	CA	35.63	-118.12	2.6	2.3	2.2	1.9	1.9	1.8	1.8	1.8	1.9	1.9	2.0	2.2
Eagle Cap	Starkey	76	STAR1	OR	45.13	-118.62	4.3	3.8	3.2	2.9	2.7	2.4	2.0	2.1	2.4	3.3	4.2	4.5
Eagles Nest	White River	56	WHRI1	CO	39.13	-106.87	2.2	2.2	2.0	2.0	2.0	1.7	1.8	2.1	2.1	1.8	2.1	2.1
Emigrant	Yosemite	96	YOSE1	CA	37.63	-119.62	3.0	2.9	2.7	2.2	2.1	1.7	1.5	1.5	1.6	1.8	2.3	2.7
Everglades	Everglades	19	EVER1	FL	25.38	-80.62	2.6	2.5	2.5	2.3	2.3	2.6	2.5	2.8	2.9	2.7	2.5	2.6
Fitzpatrick	Bridger	65	BRID1	WY	42.88	-109.87	2.5	2.3	2.3	2.1	2.1	1.8	1.5	1.5	1.8	2.0	2.5	2.4
Flat Tops	White River	56	WHRI1	CO	39.13	-106.87	2.2	2.2	2.0	2.0	2.0	1.7	1.8	2.1	2.1	1.8	2.1	2.1

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Galiuro	Chiricahua	39	CHIR1	AZ	32.13	-109.37	2.0	1.9	1.6	1.2	1.2	1.1	1.7	2.0	1.7	1.5	1.6	2.1
Gates of the Mountains	Gates of the Mountains	74	GAMO1	MT	46.88	-111.62	2.8	2.5	2.4	2.3	2.3	2.2	2.0	1.9	2.1	2.4	2.7	2.7
Gearhart Mountain	Crater Lake	86	CRLA1	OR	42.88	-122.12	4.6	4.0	3.7	3.5	3.2	2.9	2.6	2.7	2.9	3.6	4.6	4.7
Gila	Gila Cliffs	42	GICL1	NM	33.13	-108.12	2.1	1.9	1.6	1.3	1.3	1.2	1.9	1.9	1.8	1.6	1.8	2.2
Glacier	Glacier	72	GLAC1	MT	48.63	-114.12	3.9	3.4	3.1	2.9	3.0	3.0	2.5	2.5	3.0	3.3	3.7	3.8
Glacier Peak	North Cascades	81	NOCA1	WA	48.63	-121.12	4.5	4.1	3.6	3.4	3.3	3.0	2.9	3.1	3.5	4.2	4.7	4.7
Goat Rocks	White Pass	79	WHPA1	WA	46.63	-121.37	4.8	4.2	3.8	3.6	3.4	3.1	2.9	3.0	3.5	4.3	4.9	5.0
Grand Canyon	Grand Canyon, Hance	48	GRCA2	AZ	35.88	-111.87	2.5	2.4	2.0	1.6	1.4	1.2	1.4	1.7	1.7	1.7	2.0	2.3
Grand Teton	Yellowstone	66	YELL2	WY	44.63	-110.37	2.5	2.3	2.2	2.1	2.1	1.9	1.7	1.6	1.8	2.1	2.4	2.5
Great Gulf	Great Gulf	4	GRGU1	NH	44.38	-71.12	2.8	2.6	2.6	2.8	2.9	3.0	3.3	3.5	3.6	3.2	3.0	2.9
Great Sand Dunes	Great Sand Dunes	53	GRSA1	CO	37.63	-105.62	2.4	2.3	2.0	1.9	1.9	1.7	1.9	2.3	2.2	1.9	2.3	2.4
Great Smoky Mountains	Great Smoky Mountains	10	GRSM1	TN	35.63	-83.87	3.6	3.0	3.0	2.8	3.2	3.6	3.6	3.6	3.7	3.4	3.3	3.5
Guadalupe Mountains	Guadalupe Mountains	32	GUMO1	TX	31.88	-104.87	2.4	2.0	1.6	1.4	1.6	1.5	1.9	2.2	2.4	1.7	1.9	2.3
Haleakala	Haleakala	108	HALE1	HI	20.75	-156.25	2.7	2.6	2.5	2.5	2.4	2.3	2.4	2.4	2.3	2.5	2.7	2.6
Hawaii Volcanoes	Hawaii Volcanoes	107	HAVO1	HI	19.25	-155.25	3.0	2.9	2.9	2.9	2.9	2.9	3.0	3.0	3.0	3.0	3.3	3.0
Hells Canyon	Hells Canyon	77	HECA1	OR	44.88	-116.87	3.7	3.1	2.4	2.1	2.0	1.8	1.5	1.4	1.6	2.2	3.4	3.8
Hercules - Glade	Hercules - Glade	28	HEGL1	MO	36.63	-92.87	3.2	2.9	2.6	2.6	3.0	3.0	3.0	3.0	3.2	2.9	3.0	3.2
Hoover	Hoover	97	HOOV1	CA	38.13	-119.12	3.1	2.7	2.5	2.0	1.9	1.6	1.5	1.5	1.6	1.8	2.3	2.8
Isle Royale	Isle Royale	25	ISLE1	MI	47.38	-88.12	3.1	2.6	2.7	2.5	2.4	2.9	3.2	3.4	3.5	2.9	3.3	3.3
James River Face	James River Face	7	JARI1	VA	37.63	-79.62	2.9	2.7	2.6	2.4	2.9	3.1	3.2	3.3	3.4	3.0	2.7	3.0
Jarbidge	Jarbidge	68	JARB1	NV	41.88	-115.37	2.9	2.6	2.1	2.1	2.2	2.0	1.6	1.4	1.4	1.6	2.4	2.8
John Muir	Kaiser	110	KAIS1	CA	37.13	-119.12	3.0	2.7	2.5	2.1	2.0	1.7	1.7	1.7	1.8	1.9	2.3	2.7
Joshua Tree	Joshua Tree	101	JOSH1	CA	34.13	-116.37	2.4	2.3	2.3	2.0	2.0	1.9	1.5	2.0	2.0	2.0	1.9	2.1
Joyce Kilmer - Slickrock	Great Smoky Mountains	10	GRSM1	TN	35.63	-83.87	3.6	3.0	3.0	2.8	3.2	3.6	3.6	3.6	3.7	3.4	3.3	3.5
Kaiser	Kaiser	110	KAIS1	CA	37.13	-119.12	3.0	2.7	2.5	2.1	2.0	1.7	1.7	1.7	1.8	1.9	2.3	2.7
Kalmiopsis	Kalmiopsis	89	KALM1	OR	42.63	-124.12	4.5	3.9	3.7	3.5	3.3	3.1	2.9	3.0	3.1	3.6	4.4	4.4
Kings Canyon	Sequoia	98	SEQU1	CA	36.38	-118.87	2.9	2.6	2.5	2.2	2.1	1.8	1.7	1.7	1.8	1.9	2.3	2.5
La Garita	Weminuche	55	WEMI1	CO	37.63	-107.87	2.5	2.3	2.0	1.7	1.7	1.5	1.7	2.0	1.9	1.7	2.2	2.4
Lassen Volcanic	Lassen Volcanic	90	LAVO1	CA	40.63	-121.62	3.7	3.1	2.8	2.4	2.3	2.1	2.0	2.0	2.1	2.3	3.1	3.5
Lava Beds	Lava Beds	87	LABE1	CA	41.63	-121.62	4.0	3.4	3.1	2.8	2.6	2.4	2.2	2.2	2.4	2.8	3.6	4.0
Linville Gorge	Linville Gorge	13	LIGO1	NC	35.88	-81.87	3.2	3.0	2.9	2.7	3.2	3.6	3.6	3.9	3.9	3.4	3.1	3.2
Lostwood	Lostwood	62	LOST1	ND	48.63	-102.37	3.0	2.9	3.0	2.3	2.2	2.5	2.5	2.3	2.2	2.4	3.2	3.2
Lye Brook	Lye Brook	3	LYBR1	VT	43.13	-73.12	2.8	2.6	2.7	2.6	2.8	2.9	3.1	3.3	3.4	3.2	2.9	2.9
Mammoth Cave	Mammoth Cave	9	MACA1	KY	37.13	-86.12	3.3	3.0	2.9	3.0	4.1	4.7	4.6	3.5	3.5	3.2	3.1	3.4
Marble Mountain	Trinity	104	TRIN1	CA	40.88	-122.87	4.0	3.4	3.2	2.9	2.8	2.6	2.5	2.6	2.7	2.9	3.6	3.9
Maroon Bells - Snowmass	White River	56	WHRI1	CO	39.13	-106.87	2.2	2.2	2.0	2.0	2.0	1.7	1.8	2.1	2.1	1.8	2.1	2.1
Mazatzal	Ike's Backbone	46	IKBA1	AZ	34.38	-111.62	2.2	2.0	1.8	1.4	1.3	1.2	1.4	1.7	1.6	1.5	1.8	2.1
Medicine Lake	Medicine Lake	63	MELA1	MT	48.38	-104.37	3.0	2.9	2.9	2.2	2.2	2.4	2.4	2.1	2.2	2.3	3.1	3.1
Mesa Verde	Mesa Verde	54	MEVE1	CO	37.13	-108.37	2.8	2.6	2.2	1.7	1.7	1.3	1.7	2.0	1.9	1.8	2.2	2.6
Mingo	Mingo	26	MING1	MO	36.88	-90.12	3.2	2.9	2.7	2.6	2.9	3.0	3.1	3.1	3.2	2.9	3.0	3.2
Mission Mountains	Monture	73	MONT1	MT	47.13	-113.12	3.3	2.9	2.6	2.4	2.4	2.4	2.1	2.0	2.3	2.7	3.2	3.3
Mokelumne	Bliss	95	BLIS1	CA	38.88	-120.12	3.2	2.8	2.5	2.0	1.9	1.6	1.5	1.5	1.7	1.8	2.4	3.0
Moosehorn	Moosehorn	2	MOOS1	ME	45.13	-67.37	3.0	2.7	2.7	2.9	2.9	3.1	3.5	3.6	3.8	3.3	3.2	3.2

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Mount Adams	White Pass	79	WHPA1	WA	46.63	-121.37	4.8	4.2	3.8	3.6	3.4	3.1	2.9	3.0	3.5	4.3	4.9	5.0
Mount Baldy	Mount Baldy	43	BALD1	AZ	34.13	-109.37	2.2	2.1	1.7	1.4	1.3	1.2	1.6	1.9	1.7	1.6	1.9	2.3
Mount Hood	Mount Hood	85	MOHO1	OR	45.38	-121.87	4.6	4.1	3.7	3.6	3.2	3.0	2.7	2.8	3.2	4.1	4.8	4.8
Mount Jefferson	Three Sisters	84	THSI1	OR	44.38	-122.12	5.3	4.6	4.4	4.3	3.8	3.4	2.7	2.7	3.1	4.3	5.2	5.3
Mount Rainier	Mount Rainier	78	MORA1	WA	46.88	-122.12	5.3	4.7	4.4	4.3	3.9	3.7	3.4	3.6	4.2	5.1	5.5	5.6
Mount Washington	Three Sisters	84	THSI1	OR	44.38	-122.12	5.3	4.6	4.4	4.3	3.8	3.4	2.7	2.7	3.1	4.3	5.2	5.3
Mount Zirkel	Mount Zirkel	58	MOZI1	CO	40.63	-106.62	2.2	2.2	2.0	2.1	2.2	1.8	1.7	1.8	2.0	1.9	2.1	2.1
Mountain Lakes	Crater Lake	86	CRLA1	OR	42.88	-122.12	4.6	4.0	3.7	3.5	3.2	2.9	2.6	2.7	2.9	3.6	4.6	4.7
North Absaroka	North Absoraka	67	NOAB1	WY	44.63	-109.37	2.4	2.2	2.2	2.1	2.1	1.9	1.6	1.5	1.8	2.0	2.3	2.4
North Cascades	North Cascades	81	NOCA1	WA	48.63	-121.12	4.5	4.1	3.6	3.4	3.3	3.0	2.9	3.1	3.5	4.2	4.7	4.7
Okefenokee	Okefenokee	16	OKEF1	GA	30.63	-82.12	3.3	3.0	3.2	3.0	3.2	3.8	3.4	3.6	3.6	3.4	3.3	3.4
Olympic	Olympic	83	OLYM1	WA	48.13	-122.87	4.2	3.9	3.6	3.5	2.9	3.2	2.7	3.3	3.8	4.3	4.5	4.4
Otter Creek	Dolly Sods	8	DOSO1	WV	39.13	-79.37	3.0	2.7	2.7	2.5	3.5	3.1	3.2	3.5	3.5	3.1	2.8	3.1
Pasayten	Pasayten	82	PASA1	WA	48.38	-119.87	4.6	4.1	3.5	3.3	3.2	2.9	2.8	2.9	3.4	4.1	4.7	4.8
Pecos	Wheeler Peak	35	WHPE1	NM	36.63	-105.37	2.4	2.2	1.9	1.8	1.8	1.6	1.8	2.1	2.1	1.8	2.2	2.4
Petrified Forest	Petrified Forest	41	PEFO1	AZ	35.13	-109.87	2.4	2.1	1.7	1.4	1.3	1.2	1.5	1.8	1.6	1.6	2.0	2.3
Pine Mountain	Ike's Backbone	46	IKBA1	AZ	34.38	-111.62	2.2	2.0	1.8	1.4	1.3	1.2	1.4	1.7	1.6	1.5	1.8	2.1
Pinnacles	Pinnacles	92	PINN1	CA	36.38	-121.12	3.4	3.4	3.5	2.6	2.4	2.2	2.1	2.2	2.2	2.4	2.4	2.9
Point Reyes	Point Reyes	91	PORE1	CA	38.13	-122.87	3.6	3.2	3.1	2.6	2.5	2.3	2.4	2.4	2.5	2.5	2.9	3.3
Presidential Range - Dry River	Great Gulf	4	GRGU1	NH	44.38	-71.12	2.8	2.6	2.6	2.8	2.9	3.0	3.3	3.5	3.6	3.2	3.0	2.9
Rawah	Mount Zirkel	58	MOZI1	CO	40.63	-106.62	2.2	2.2	2.0	2.1	2.2	1.8	1.7	1.8	2.0	1.9	2.1	2.1
Red Rock Lakes	Yellowstone	66	YELL2	WY	44.63	-110.37	2.5	2.3	2.2	2.1	2.1	1.9	1.7	1.6	1.8	2.1	2.4	2.5
Redwood	Redwood	88	REDW1	CA	41.63	-124.12	3.8	3.6	3.8	3.6	3.8	3.9	4.2	4.2	3.7	3.4	3.6	3.4
Rocky Mountain	Rocky Mountain	57	ROMO1	CO	40.38	-105.62	1.9	2.0	2.0	2.1	2.3	2.0	1.9	1.9	2.0	1.8	2.0	1.9
Roosevelt Campobello	Moosehorn	2	MOOS1	ME	45.13	-67.37	3.0	2.7	2.7	2.9	2.9	3.1	3.5	3.6	3.8	3.3	3.2	3.2
Saguaro	Saguaro	40	SAGU1	AZ	32.13	-110.62	1.8	1.6	1.4	1.1	1.1	1.0	1.4	1.7	1.5	1.4	1.5	2.0
Saint Marks	Saint Marks	17	SAMA1	FL	30.13	-84.12	3.5	3.3	3.2	3.1	3.2	3.6	3.8	3.8	3.7	3.5	3.4	3.6
Salt Creek	Salt Creek	36	SACR1	NM	33.38	-104.37	2.2	1.9	1.5	1.5	1.6	1.5	1.7	1.9	2.0	1.7	1.8	2.0
San Gabriel	San Gabriel	93	SAGA1	CA	34.38	-118.12	2.6	2.5	2.5	2.2	2.2	2.1	2.2	2.2	2.3	2.2	2.2	2.3
San Gorgonio	San Gorgonio	99	SAGO1	CA	34.13	-116.87	2.5	2.6	2.4	2.1	2.1	1.8	1.7	1.8	1.9	1.8	1.9	2.1
San Jacinto	San Gorgonio	99	SAGO1	CA	34.13	-116.87	2.5	2.6	2.4	2.1	2.1	1.8	1.7	1.8	1.9	1.8	1.9	2.1
San Pedro Parks	San Pedro Parks	34	SAPE1	NM	36.13	-106.87	2.4	2.2	1.9	1.6	1.6	1.4	1.7	2.0	1.9	1.7	2.1	2.3
San Rafael	San Rafael	94	RAFA1	CA	34.63	-120.12	3.0	2.8	2.8	2.5	2.5	2.4	2.5	2.6	2.7	2.6	2.4	2.6
Sawtooth	Sawtooth	70	SAWT1	ID	44.13	-114.87	3.3	2.8	2.3	2.0	2.0	1.8	1.4	1.4	1.5	2.0	2.9	3.3
Scapegoat	Monture	73	MONT1	MT	47.13	-113.12	3.3	2.9	2.6	2.4	2.4	2.4	2.1	2.0	2.3	2.7	3.2	3.3
Selway - Bitterroot	Sula	71	SULA1	MT	45.88	-114.12	3.4	3.0	2.6	2.3	2.3	2.2	1.9	1.8	2.0	2.5	3.3	3.4
Seney	Seney	22	SENE1	MI	46.38	-85.87	3.3	2.8	2.9	2.7	2.6	3.0	3.3	3.6	3.7	3.3	3.5	3.4
Sequoia	Sequoia	98	SEQU1	CA	36.38	-118.87	2.9	2.6	2.5	2.2	2.1	1.8	1.7	1.7	1.8	1.9	2.3	2.5
Shenandoah	Shenandoah	6	SHEN1	VA	38.63	-78.37	2.9	2.6	2.7	2.4	2.9	3.1	3.2	3.5	3.5	3.0	2.7	2.9
Shining Rock	Shining Rock	11	SHRO1	NC	35.38	-82.87	3.3	3.0	2.9	2.7	3.2	3.6	3.6	3.9	3.9	3.5	3.2	3.3
Sierra Ancha	Sierra Ancha	45	SIAN1	AZ	34.13	-110.87	2.2	2.0	1.7	1.4	1.3	1.1	1.5	1.8	1.6	1.5	1.8	2.2
Simeonof	Simeonof	105	SIME1	AK	55.25	-160.75	4.2	4.2	3.8	4.0	4.2	4.6	5.0	5.2	4.5	3.7	3.9	4.2
Sipsey	Sipsey	21	SIPS1	AL	34.38	-87.37	3.3	3.0	2.8	2.7	3.1	3.4	3.5	3.5	3.5	3.3	3.1	3.3

Table A-2 Recommended Monthly Site-Specific f(RH) Values for Each Mandatory Federal Class I Area, Based on the Representative IMPROVE Site Location

Class I Area	Site Name		Code	Site St	LAT	LONG	Jan f(RH)	Feb f(RH)	Mar f(RH)	Apr f(RH)	May f(RH)	Jun f(RH)	Jul f(RH)	Aug f(RH)	Sep f(RH)	Oct f(RH)	Nov f(RH)	Dec f(RH)
South Warner	Lava Beds	87	LABE1	CA	41.63	-121.62	4.0	3.4	3.1	2.8	2.6	2.4	2.2	2.2	2.4	2.8	3.6	4.0
Strawberry Mountain	Starkey	76	STAR1	OR	45.13	-118.62	4.3	3.8	3.2	2.9	2.7	2.4	2.0	2.1	2.4	3.3	4.2	4.5
Superstition	Tonto	44	TONT1	AZ	33.63	-111.12	2.1	1.9	1.6	1.3	1.2	1.1	1.4	1.7	1.6	1.5	1.7	2.1
Swanquarter	Swanquarter	14	SWAN1	NC	35.38	-76.12	2.9	2.7	2.6	2.4	2.7	3.0	3.1	3.2	3.1	3.0	2.7	2.9
Sycamore Canyon	Sycamore Canyon	47	SYCA1	AZ	35.13	-111.87	2.4	2.4	2.0	1.6	1.5	1.2	1.5	2.0	1.9	1.8	2.0	2.3
Teton	Yellowstone	66	YELL2	WY	44.63	-110.37	2.5	2.3	2.2	2.1	2.1	1.9	1.7	1.6	1.8	2.1	2.4	2.5
Theodore Roosevelt	Theodore Roosevelt	61	THRO1	ND	46.88	-103.37	2.9	2.8	2.8	2.4	2.4	2.5	2.4	2.2	2.2	2.3	3.0	3.0
Thousand Lakes	Lassen Volcanic	90	LAVO1	CA	40.63	-121.62	3.7	3.1	2.8	2.4	2.3	2.1	2.0	2.0	2.1	2.3	3.1	3.5
Three Sisters	Three Sisters	84	THSI1	OR	44.38	-122.12	5.3	4.6	4.4	4.3	3.8	3.4	2.7	2.7	3.1	4.3	5.2	5.3
Tuxedni	Tuxedni	103	TUXE1	AK	59.75	-152.75	3.6	3.4	2.9	2.8	2.8	2.9	3.6	3.9	3.8	3.4	3.5	3.7
UL Bend	UL Bend	64	ULBE1	MT	47.63	-108.62	2.6	2.4	2.4	2.3	2.2	2.1	1.9	1.8	1.9	2.2	2.6	2.6
Upper Buffalo	Upper Buffalo	27	UPBU1	AR	35.88	-93.12	3.2	2.9	2.6	2.7	3.1	3.1	3.0	3.0	3.2	3.0	3.0	3.2
Ventana	Pinnacles	92	PINN1	CA	36.38	-121.12	3.4	3.4	3.5	2.6	2.4	2.2	2.1	2.2	2.2	2.4	2.4	2.9
Virgin Islands (b)	Virgin Islands	106	VIIS1	VI	18.75	-155.75												
Voyageurs	Voyageurs	24	VOYA2	MN	48.38	-92.87	2.7	2.4	2.3	2.2	2.2	2.8	2.5	2.7	2.9	2.5	2.8	2.7
Washakie	North Absoraka	67	NOAB1	WY	44.63	-109.37	2.4	2.2	2.2	2.1	2.1	1.9	1.6	1.5	1.8	2.0	2.3	2.4
Weminuche	Weminuche	55	WEMI1	CO	37.63	-107.87	2.5	2.3	2.0	1.7	1.7	1.5	1.7	2.0	1.9	1.7	2.2	2.4
West Elk	White River	56	WHRI1	CO	39.13	-106.87	2.2	2.2	2.0	2.0	2.0	1.7	1.8	2.1	2.1	1.8	2.1	2.1
Wheeler Peak	Wheeler Peak	35	WHPE1	NM	36.63	-105.37	2.4	2.2	1.9	1.8	1.8	1.6	1.8	2.1	2.1	1.8	2.2	2.4
White Mountain	White Mountain	37	WHIT1	NM	33.38	-105.62	2.2	1.9	1.6	1.5	1.5	1.4	1.7	1.9	2.0	1.7	1.8	2.1
Wichita Mountains	Wichita Mountains	30	WIMO1	OK	34.63	-98.62	2.8	2.6	2.4	2.4	2.7	2.5	2.2	2.4	2.7	2.5	2.6	2.8
Wind Cave	Wind Cave	60	WICA1	SD	43.63	-103.37	2.5	2.5	2.5	2.5	2.6	2.5	2.2	2.2	2.1	2.2	2.6	2.5
Wolf Island	Okefenokee	16	OKEF1	GA	30.63	-82.12	3.3	3.0	3.2	3.0	3.2	3.8	3.4	3.6	3.6	3.4	3.3	3.4
Yellowstone	Yellowstone	66	YELL2	WY	44.63	-110.37	2.5	2.3	2.2	2.1	2.1	1.9	1.7	1.6	1.8	2.1	2.4	2.5
Yolla Bolly - Middle Eel	Trinity	104	TRIN1	CA	40.88	-122.87	4.0	3.4	3.2	2.9	2.8	2.6	2.5	2.6	2.7	2.9	3.6	3.9
Yosemite	Yosemite	96	YOSE1	CA	37.63	-119.62	3.0	2.9	2.7	2.2	2.1	1.7	1.5	1.5	1.6	1.8	2.3	2.7

a: No particulate matter sampling or visibility monitoring is conducted in the Bering Sea Wilderness.

b**:** *f(RH)* values for Virgin Islands National Park were not calculated because of the limited RH data available.

Table A-3 Monthly Site-Specific f(RH) Values for Each Mandatory Federal Class I Area, Based on the Centroid of the Area (Supplemental Information)

Class I Area	Site Name	Map ID	Code	Site St	LAT	LONG	Jan f(RH)	Feb f(RH)	Mar f(RH)	Apr f(RH)	May f(RH)	Jun f(RH)	Jul f(RH)	Aug f(RH)	Sep f(RH)	Oct f(RH)	Nov f(RH)	Dec f(RH)
Acadia	Acadia	1	ACAD1	ME	44.37	68.26	3.3	2.9	2.8	3.4	3.1	3.0	3.4	3.8	4.0	3.8	3.6	3.5
Agua Tibia	Agua Tibia	100	AGTI1	CA	33.41	116.98	2.4	2.4	2.4	2.2	2.2	2.2	2.3	2.3	2.3	2.3	2.1	2.2
Alpine Lakes	Snoqualmie Pass	80	SNPA1	WA	47.42	121.42	4.3	3.8	3.5	3.9	2.9	3.2	2.9	3.1	3.3	3.9	4.5	4.5
Anaconda - Pintler	Sula	71	SULA1	MT	45.98	113.42	3.3	2.9	2.5	2.4	2.4	2.3	2.0	1.9	2.1	2.5	3.2	3.3
Ansel Adams	Kaiser	110	KAIS1	CA	37.65	119.20	3.0	2.7	2.4	2.1	1.9	1.7	1.6	1.6	1.6	1.8	2.3	2.7
Arches	Canyonlands	50	CANY1	UT	38.64	109.58	2.6	2.3	1.8	1.6	1.6	1.3	1.4	1.5	1.6	1.6	2.0	2.3
Badlands	Badlands	59	BADL1	SD	43.74	101.94	2.6	2.7	2.6	2.4	2.8	2.7	2.5	2.4	2.2	2.3	2.7	2.7
Bandelier	Bandelier	33	BAND1	NM	35.78	106.27	2.2	2.1	1.8	1.6	1.6	1.4	1.7	2.1	1.9	1.7	2.0	2.2
Bering Sea (a)					60.45	172.79												
Big Bend	Big Bend	31	BIBE1	TX	29.31	103.19	2.0	1.9	1.6	1.5	1.6	1.6	1.7	2.0	2.1	1.9	1.8	1.9
Black Canyon of the Gunnison	Weminuche	55	WEMI1	CO	38.58	107.70	2.4	2.2	1.9	1.9	1.9	1.6	1.7	1.9	2.0	1.8	2.1	2.3
Bob Marshall	Monture	73	MONT1	MT	47.75	113.38	3.6	3.1	2.8	2.6	2.7	2.7	2.3	2.2	2.6	2.9	3.5	3.5
Bosque del Apache	Bosque del Apache	38	BOAP1	NM	33.79	106.83	2.1	1.9	1.6	1.4	1.4	1.3	1.8	2.0	1.9	1.6	1.8	2.2
Boundary Waters Canoe Area	Boundary Waters	23	BOWA1	MN	47.95	91.50	3.0	2.6	2.7	2.4	2.3	2.9	3.1	3.4	3.5	2.8	3.2	3.2
Breton	Breton	20	BRET1	LA	29.73	88.88	3.7	3.5	3.7	3.6	3.8	4.0	4.3	4.3	4.2	3.7	3.7	3.7
Bridger	Bridger	65	BRID1	WY	42.98	109.76	2.5	2.4	2.3	2.2	2.1	1.8	1.5	1.5	1.7	2.0	2.4	2.4
Brigantine	Brigantine	5	BRIG1	NJ	39.46	74.45	2.8	2.6	2.7	2.6	3.0	3.2	3.4	3.7	3.6	3.3	2.9	2.8
Bryce Canyon	Bryce Canyon	49	BRCA1	UT	37.62	112.17	2.6	2.4	1.9	1.6	1.5	1.3	1.3	1.5	1.5	1.6	2.0	2.4
Cabinet Mountains	Cabinet Mountains	75	CABI1	MT	48.21	115.71	3.8	3.3	2.9	2.6	2.7	2.7	2.3	2.2	2.6	3.0	3.7	3.9
Caney Creek	Caney Creek	29	CACR1	AR	34.41	94.08	3.4	3.1	2.9	3.0	3.6	3.6	3.4	3.4	3.6	3.5	3.4	3.5
Canyonlands	Canyonlands	50	CANY1	UT	38.46	109.82	2.6	2.3	1.7	1.6	1.5	1.2	1.3	1.5	1.6	1.6	2.0	2.3
Cape Romain	Cape Romain	15	ROMA1	SC	32.94	79.66	3.3	3.0	2.9	2.8	3.2	3.7	3.6	4.1	4.0	3.7	3.4	3.2
Capitol Reef	Capitol Reef	52	CAPI1	UT	38.36	111.05	2.7	2.4	2.0	1.7	1.6	1.4	1.4	1.6	1.6	1.7	2.1	2.5
Caribou	Lassen Volcanic	90	LAVO1	CA	40.50	121.18	3.7	3.1	2.8	2.5	2.4	2.2	2.1	2.1	2.2	2.4	3.0	3.4
Carlsbad Caverns	Guadalupe Mountains	32	GUMO1	TX	32.14	104.48	2.1	2.0	1.6	1.5	1.6	1.6	1.8	2.1	2.2	1.8	1.9	2.1
Chassahowitzka	Chassahowitzka	18	CHAS1	FL	28.75	82.55	3.8	3.5	3.4	3.2	3.3	3.9	3.9	4.2	4.1	3.9	3.7	3.9
Chiricahua NM	Chiricahua	39	CHIR1	AZ	32.01	109.39	2.0	2.0	1.6	1.3	1.3	1.1	1.8	2.1	1.8	1.5	1.6	2.2
Chiricahua W	Chiricahua	39	CHIR1	AZ	31.84	109.27	2.0	1.9	1.6	1.2	1.3	1.1	1.8	2.1	1.8	1.5	1.6	2.2
Cohutta	Cohutta	12	COHU1	GA	34.92	84.58	3.3	3.1	3.0	2.8	3.4	3.8	4.0	4.2	4.2	3.8	3.4	3.5
Crater Lake	Crater Lake	86	CRLA1	OR	42.90	122.13	4.6	3.9	3.7	3.4	3.2	3.0	2.8	2.9	3.1	3.6	4.6	4.6
Craters of the Moon	Craters of the Moon	69	CRMO1	ID	43.47	113.55	3.1	2.7	2.3	2.0	2.0	1.8	1.4	1.4	1.6	2.0	2.8	3.0
Cucamonga	San Gabriel	93	SAGA1	CA	34.25	117.57	2.5	2.4	2.4	2.2	2.1	2.1	2.1	2.2	2.2	2.2	2.1	2.2
Denali	Denali	102	DENA1	AK	63.72	148.97	2.5	2.3	2.1	1.9	1.9	2.2	2.5	3.0	2.8	2.9	3.0	3.1
Desolation	Bliss	95	BLIS1	CA	38.98	120.12	3.2	2.8	2.4	2.0	1.8	1.6	1.5	1.6	1.7	1.9	2.4	3.0
Diamond Peak	Crater Lake	86	CRLA1	OR	43.53	122.10	4.5	4.0	3.6	3.7	3.2	3.1	2.9	2.9	3.1	3.7	4.6	4.6
Dolly Sods	Dolly Sods	8	DOSO1	WV	39.11	79.43	3.0	2.8	2.8	2.6	3.1	3.4	3.5	3.9	3.9	3.3	3.0	3.1
Dome Land	Dome Land	109	DOME1	CA	35.70	118.19	2.5	2.3	2.2	1.9	1.8	1.8	1.8	1.8	1.8	1.9	2.0	2.2
Eagle Cap	Starkey	76	STAR1	OR	45.10	117.29	3.8	3.2	2.5	2.1	2.0	1.9	1.6	1.6	1.6	2.3	3.4	4.0
Eagles Nest	White River	56	WHRI1	CO	39.69	106.25	2.2	2.2	2.0	2.0	2.1	1.9	1.8	2.0	2.0	1.9	2.1	2.1

Table A-3 Monthly Site-Specific f(RH) Values for Each Mandatory Federal Class I Area, Based on the Centroid of the Area (Supplemental Information)

Class I Area	Site Name	Map ID	Code	Site St	LAT	LONG	Jan f(RH)	Feb f(RH)	Mar f(RH)	Apr f(RH)	May f(RH)	Jun f(RH)	Jul f(RH)	Aug f(RH)	Sep f(RH)	Oct f(RH)	Nov f(RH)	Dec f(RH)
Emigrant	Yosemite	96	YOSE1	CA	38.20	119.75	3.2	2.8	2.5	2.1	1.9	1.7	1.5	1.6	1.6	1.9	2.4	2.9
Everglades	Everglades	19	EVER1	FL	25.39	80.68	2.7	2.6	2.6	2.4	2.4	2.7	2.6	2.9	3.0	2.8	2.6	2.7
Fitzpatrick	Bridger	65	BRID1	WY	43.27	109.57	2.5	2.3	2.2	2.1	2.1	1.8	1.5	1.5	1.7	2.0	2.4	2.4
Flat Tops	White River	56	WHRI1	CO	39.97	107.25	2.3	2.2	2.0	2.0	2.0	1.8	1.7	1.9	1.9	1.8	2.2	2.2
Galiuro	Chiricahua	39	CHIR1	AZ	32.56	110.32	2.0	1.8	1.5	1.2	1.2	1.1	1.5	1.8	1.6	1.5	1.6	2.1
Gates of the Mountains	Gates of the Mountains	74	GAMO1	MT	46.87	111.81	2.9	2.6	2.4	2.3	2.3	2.3	2.0	1.9	2.1	2.4	2.8	2.8
Gearhart Mountain	Crater Lake	86	CRLA1	OR	42.49	120.85	4.0	3.4	3.1	2.8	2.7	2.5	2.3	2.3	2.4	2.8	3.7	3.8
Gila	Gila Cliffs	42	GICL1	NM	33.22	108.25	2.1	1.9	1.6	1.3	1.4	1.2	2.1	2.0	1.8	1.6	1.8	2.2
Glacier	Glacier	72	GLAC1	MT	48.51	114.00	4.0	3.5	3.2	3.1	3.2	3.4	2.8	2.6	3.2	3.5	3.8	3.9
Glacier Peak	North Cascades	81	NOCA1	WA	48.21	121.04	4.2	3.7	3.4	3.8	2.9	3.2	2.9	3.1	3.3	3.9	4.4	4.4
Goat Rocks	White Pass	79	WHPA1	WA	46.54	121.48	4.3	3.8	3.4	4.2	2.8	3.4	3.0	3.2	3.1	3.8	4.4	4.6
Grand Canyon	Grand Canyon, Hance	48	GRCA2	AZ	35.97	111.98	2.4	2.3	1.9	1.5	1.4	1.2	1.4	1.7	1.6	1.6	1.9	2.3
Grand Teton	Yellowstone	66	YELL2	WY	43.68	110.73	2.6	2.4	2.2	2.1	2.1	1.8	1.5	1.5	1.7	2.0	2.4	2.6
Great Gulf	Great Gulf	4	GRGU1	NH	44.31	71.22	2.8	2.6	2.6	2.8	2.9	3.2	3.5	3.8	4.0	3.4	3.1	2.9
Great Sand Dunes	Great Sand Dunes	53	GRSA1	CO	37.73	105.52	2.4	2.3	2.0	1.9	1.9	1.8	1.9	2.3	2.2	1.9	2.4	2.4
Great Smoky Mountains	Great Smoky Mountains	10	GRSM1	TN	35.63	83.94	3.3	3.0	2.9	2.7	3.2	3.9	3.8	4.0	4.2	3.8	3.3	3.4
Guadalupe Mountains	Guadalupe Mountains	32	GUMO1	TX	31.83	104.80	2.0	2.0	1.6	1.5	1.6	1.5	1.9	2.2	2.2	1.8	1.9	2.2
Haleakala	Haleakala	108	HALE1	HI	20.81	156.28	2.7	2.6	2.6	2.5	2.4	2.3	2.5	2.4	2.4	2.5	2.8	2.7
Hawaii Volcanoes	Hawaii Volcanoes	107	HAVO1	HI	19.43	155.27	3.2	2.9	3.0	3.0	3.0	2.9	3.1	3.2	3.2	3.2	3.7	3.2
Hells Canyon	Hells Canyon	77	HECA1	OR	45.34	116.57	3.7	3.1	2.5	2.2	2.1	2.0	1.6	1.6	1.8	2.4	3.5	3.9
Hercules - Glade	Hercules - Glade	28	HEGL1	MO	36.69	92.90	3.2	2.9	2.7	2.7	3.3	3.3	3.3	3.3	3.4	3.1	3.1	3.3
Hoover	Hoover	97	HOOV1	CA	38.14	119.45	3.1	2.8	2.5	2.1	1.9	1.6	1.5	1.5	1.6	1.8	2.3	2.8
Isle Royale	Isle Royale	25	ISLE1	MI	47.99	88.83	3.1	2.5	2.7	2.4	2.2	2.6	3.0	3.2	3.8	2.7	3.3	3.3
James River Face	James River Face	7	JARI1	VA	37.62	79.48	2.8	2.6	2.7	2.4	3.0	3.3	3.4	3.7	3.6	3.2	2.8	3.0
Jarbidge	Jarbidge	68	JARB1	NV	41.89	115.43	3.0	2.6	2.1	2.1	2.2	2.2	1.6	1.4	1.4	1.6	2.4	2.8
John Muir	Kaiser	110	KAIS1	CA	37.39	118.84	2.9	2.6	2.4	2.1	1.9	1.7	1.7	1.7	1.7	1.9	2.2	2.6
Joshua Tree	Joshua Tree	101	JOSH1	CA	34.03	116.18	2.4	2.3	2.2	2.0	2.0	1.9	2.0	2.0	2.0	2.0	1.9	2.0
Joyce Kilmer - Slickrock	Great Smoky Mountains	10	GRSM1	TN	35.43	84.00	3.3	3.1	2.9	2.7	3.3	3.8	4.0	4.2	4.2	3.8	3.3	3.5
Kaiser	Kaiser	110	KAIS1	CA	37.28	119.18	3.0	2.7	2.5	2.1	1.9	1.7	1.6	1.7	1.7	1.9	2.3	2.7
Kalmiopsis	Kalmiopsis	89	KALM1	OR	42.27	123.93	4.5	3.9	3.8	3.5	3.5	3.3	3.2	3.2	3.3	3.6	4.4	4.3
Kings Canyon	Sequoia	98	SEQU1	CA	36.82	118.76	2.8	2.6	2.4	2.1	1.9	1.8	1.7	1.7	1.8	1.9	2.3	2.5
La Garita	Weminuche	55	WEMI1	CO	37.96	106.81	2.3	2.2	1.9	1.8	1.8	1.6	1.7	2.1	2.0	1.8	2.2	2.3
Lassen Volcanic	Lassen Volcanic	90	LAVO1	CA	40.54	121.57	3.8	3.2	2.9	2.5	2.4	2.2	2.1	2.1	2.2	2.4	3.1	3.5
Lava Beds	Lava Beds	87	LABE1	CA	41.71	121.34	4.0	3.4	3.1	2.7	2.6	2.4	2.3	2.3	2.4	2.7	3.5	3.8
Linville Gorge	Linville Gorge	13	LIGO1	NC	35.89	81.89	3.3	3.0	3.0	2.7	3.3	3.9	4.1	4.5	4.4	3.7	3.2	3.4
Lostwood	Lostwood	62	LOST1	ND	48.60	102.48	3.0	2.9	2.9	2.3	2.3	2.6	2.7	2.4	2.3	2.4	3.2	3.2
Lye Brook	Lye Brook	3	LYBR1	VT	43.15	73.12	2.7	2.6	2.6	2.6	2.8	3.0	3.3	3.6	3.7	3.3	2.9	2.8
Mammoth Cave	Mammoth Cave	9	MACA1	KY	37.22	86.07	3.4	3.1	2.9	2.6	3.2	3.5	3.7	3.9	3.9	3.4	3.2	3.5
Marble Mountain	Trinity	104	TRIN1	CA	41.52	123.21	4.4	3.8	3.7	3.3	3.4	3.2	3.2	3.2	3.2	3.4	4.1	4.2
Maroon Bells - Snowmass	White River	56	WHRI1	CO	39.15	106.82	2.2	2.1	2.0	2.0	2.1	1.7	1.9	2.2	2.1	1.8	2.1	2.1

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Class I Area	Site Name	Map ID	Code	Site St	LAT	LONG	Jan f(RH)	Feb f(RH)	Mar f(RH)	Apr f(RH)	May f(RH)	Jun f(RH)	Jul f(RH)	Aug f(RH)	Sep f(RH)	Oct f(RH)	Nov f(RH)	Dec f(RH)
Mazatzal	Ike's Backbone	46	IKBA1	AZ	33.92	111.43	2.1	1.9	1.7	1.3	1.3	1.1	1.5	1.7	1.6	1.5	1.7	2.1
Medicine Lake	Medicine Lake	63	MELA1	MT	48.50	104.29	3.0	2.9	2.9	2.3	2.2	2.5	2.5	2.2	2.2	2.4	3.2	3.2
Mesa Verde	Mesa Verde	54	MEVE1	CO	37.20	108.49	2.5	2.3	1.9	1.5	1.5	1.3	1.6	2.0	1.9	1.7	2.1	2.3
Mingo	Mingo	26	MING1	MO	36.98	90.20	3.3	3.0	2.8	2.6	3.0	3.2	3.3	3.5	3.5	3.1	3.1	3.3
Mission Mountains	Monture	73	MONT1	MT	47.40	113.85	3.6	3.1	2.7	2.5	2.6	2.6	2.3	2.2	2.5	2.9	3.5	3.6
Mokelumne	Bliss	95	BLIS1	CA	38.58	120.03	3.2	2.8	2.4	2.0	1.9	1.6	1.5	1.6	1.7	1.9	2.4	2.9
Moosehorn	Moosehorn	2	MOOS1	ME	45.12	67.26	3.0	2.7	2.7	3.0	3.0	3.1	3.4	3.8	3.9	3.5	3.2	3.2
Mount Adams	White Pass	79	WHPA1	WA	46.19	121.50	4.3	3.8	3.4	4.4	2.9	3.5	3.1	3.3	3.1	3.9	4.5	4.6
Mount Baldy	Mount Baldy	43	BALD1	AZ	34.12	109.57	2.2	2.0	1.7	1.4	1.3	1.2	1.6	1.9	1.7	1.6	1.8	2.2
Mount Hood	Mount Hood	85	MOHO1	OR	45.38	121.69	4.3	3.8	3.5	3.9	3.0	3.2	2.9	3.0	3.1	3.9	4.5	4.6
Mount Jefferson	Three Sisters	84	THSI1	OR	44.55	121.83	4.4	3.9	3.6	3.7	3.1	3.1	2.9	2.9	3.0	3.8	4.6	4.5
Mount Rainier	Mount Rainier	78	MORA1	WA	46.76	122.12	4.4	4.0	3.6	4.7	3.1	3.7	3.3	3.5	3.4	4.1	4.7	4.7
Mount Washington	Three Sisters	84	THSI1	OR	44.30	121.87	4.4	3.9	3.6	3.7	3.1	3.1	3.0	2.9	3.0	3.8	4.6	4.6
Mount Zirkel	Mount Zirkel	58	MOZI1	CO	40.55	106.70	2.2	2.2	2.0	2.1	2.2	1.9	1.7	1.9	2.0	1.9	2.1	2.1
Mountain Lakes	Crater Lake	86	CRLA1	OR	42.34	122.11	4.3	3.6	3.3	3.0	2.9	2.6	2.5	2.5	2.6	3.1	4.1	4.3
North Absaroka	North Absoraka	67	NOAB1	WY	44.77	109.78	2.4	2.3	2.2	2.2	2.1	1.9	1.7	1.6	1.8	2.0	2.4	2.4
North Cascades	North Cascades	81	NOCA1	WA	48.54	121.44	4.1	3.7	3.4	3.7	2.9	3.2	2.9	3.2	3.5	3.9	4.4	4.4
Okefenokee	Okefenokee	16	OKEF1	GA	30.74	82.13	3.5	3.2	3.1	3.0	3.6	3.7	3.7	4.1	4.0	3.8	3.5	3.6
Olympic	Olympic	83	OLYM1	WA	47.32	123.35	4.5	4.1	3.8	4.1	3.2	3.5	3.1	3.5	3.7	4.4	4.8	4.8
Otter Creek	Dolly Sods	8	DOSO1	WV	39.00	79.65	3.0	2.8	2.8	2.6	3.2	3.5	3.7	4.1	4.0	3.3	3.0	3.1
Pasayten	Pasayten	82	PASA1	WA	48.85	120.52	4.2	3.7	3.4	3.7	2.9	3.2	2.9	3.2	3.3	3.9	4.4	4.5
Pecos	Wheeler Peak	35	WHPE1	NM	35.93	105.64	2.3	2.1	1.8	1.7	1.7	1.5	1.8	2.1	2.0	1.7	2.0	2.2
Petrified Forest	Petrified Forest	41	PEFO1	AZ	35.08	109.77	2.4	2.2	1.7	1.4	1.3	1.2	1.5	1.8	1.7	1.6	1.9	2.3
Pine Mountain	Ike's Backbone	46	IKBA1	AZ	34.31	111.80	2.2	2.0	1.7	1.4	1.3	1.1	1.4	1.8	1.6	1.5	1.7	2.1
Pinnacles	Pinnacles	92	PINN1	CA	36.49	121.16	3.2	2.8	2.6	2.4	2.3	2.0	2.0	2.1	2.1	2.3	2.5	2.9
Point Reyes	Point Reyes	91	PORE1	CA	38.12	122.90	3.6	3.3	3.1	2.7	2.5	2.3	2.5	2.6	2.6	2.7	2.9	3.3
Presidential Range - Dry River	Great Gulf	4	GRGU1	NH	44.21	71.35	2.8	2.6	2.6	2.8	3.0	3.4	3.7	4.0	4.3	3.5	3.1	3.0
Rawah	Mount Zirkel	58	MOZI1	CO	40.70	105.94	2.1	2.1	2.0	2.1	2.3	2.0	1.8	2.0	2.0	1.9	2.1	2.0
Red Rock Lakes	Yellowstone	66	YELL2	WY	44.67	111.70	2.7	2.5	2.3	2.1	2.1	1.9	1.7	1.6	1.8	2.1	2.6	2.7
Redwood	Redwood	88	REDW1	CA	41.56	124.08	4.4	3.9	4.6	3.9	4.5	4.7	4.9	4.7	4.3	3.7	3.8	3.4
Rocky Mountain	Rocky Mountain	57	ROMO1	CO	40.28	105.55	1.7	1.9	1.9	2.1	2.3	2.0	1.8	2.0	1.9	1.8	1.8	1.7
Roosevelt Campobello	Moosehorn	2	MOOS1	ME	44.88	66.95	3.0	2.7	2.7	3.0	3.0	3.1	3.4	3.8	3.9	3.5	3.3	3.2
Saguaro	Saguaro	40	SAGU1	AZ	32.25	110.73	1.8	1.6	1.4	1.1	1.1	1.1	1.4	1.8	1.6	1.4	1.6	2.1
Saint Marks	Saint Marks	17	SAMA1	FL	30.12	84.08	3.7	3.4	3.4	3.4	3.5	4.0	4.1	4.4	4.2	3.8	3.7	3.8
Salt Creek	Salt Creek	36	SACR1	NM	33.61	104.37	2.1	1.9	1.5	1.5	1.7	1.6	1.8	2.0	2.1	1.8	1.8	2.1
San Gabriel	San Gabriel	93	SAGA1	CA	34.27	117.94	2.5	2.5	2.4	2.2	2.2	2.1	2.2	2.2	2.2	2.3	2.1	2.2
San Gorgonio	San Gorgonio	99	SAGO1	CA	34.18	116.90	2.7	2.8	2.6	2.3	2.2	1.9	1.8	1.9	1.9	1.9	1.9	2.2
San Jacinto	San Gorgonio	99	SAGO1	CA	33.75	116.65	2.5	2.4	2.4	2.2	2.1	2.0	2.1	2.1	2.1	2.1	2.0	2.1
San Pedro Parks	San Pedro Parks	34	SAPE1	NM	36.11	106.81	2.3	2.1	1.8	1.6	1.6	1.4	1.7	2.0	1.9	1.7	2.1	2.2
San Rafael	San Rafael	94	RAFA1	CA	34.78	119.83	2.8	2.7	2.7	2.4	2.3	2.3	2.5	2.5	2.4	2.5	2.3	2.5

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Sawtooth	Sawtooth	70	SAWT1	ID	44.18	114.93	3.3	2.9	2.3	2.0	2.0	1.8	1.4	1.4	1.5	2.0	2.9	3.3
Scapegoat	Monture	73	MONT1	MT	47.17	112.73	3.2	2.8	2.6	2.4	2.5	2.4	2.1	2.0	2.3	2.6	3.1	3.1
Selway - Bitterroot	Sula	71	SULA1	MT	45.86	114.00	3.5	3.0	2.6	2.3	2.4	2.3	1.9	1.9	2.1	2.6	3.3	3.5
Seney	Seney	22	SENE1	MI	46.26	86.03	3.3	2.8	2.9	2.7	2.6	3.1	3.6	4.0	4.1	3.4	3.6	3.5
Sequoia	Sequoia	98	SEQU1	CA	36.50	118.82	2.5	2.4	2.4	2.2	1.9	1.8	1.7	1.6	1.8	1.9	2.3	2.3
Shenandoah	Shenandoah	6	SHEN1	VA	38.52	78.44	3.1	2.8	2.8	2.5	3.1	3.4	3.5	3.9	3.9	3.2	3.0	3.1
Shining Rock	Shining Rock	11	SHRO1	NC	35.39	82.78	3.3	3.0	2.9	2.7	3.4	3.9	4.1	4.5	4.4	3.8	3.3	3.4
Sierra Ancha	Sierra Ancha	45	SIAN1	AZ	33.82	110.88	2.1	2.0	1.7	1.3	1.3	1.1	1.5	1.8	1.6	1.5	1.7	2.1
Simeonof	Simeonof	105	SIME1	AK	54.92	159.28	4.3	4.1	3.6	3.9	3.9	4.3	5.0	5.2	4.5	3.8	4.0	4.3
Sipsey	Sipsey	21	SIPS1	AL	34.34	87.34	3.4	3.1	2.9	2.8	3.3	3.7	3.9	3.9	3.9	3.6	3.3	3.4
South Warner	Lava Beds	87	LABE1	CA	41.33	120.20	3.6	3.1	2.7	2.4	2.3	2.1	1.9	1.9	2.0	2.3	3.1	3.4
Strawberry Mountain	Starkey	76	STAR1	OR	44.30	118.73	3.9	3.3	2.8	2.9	2.3	2.4	2.0	2.0	1.9	2.6	3.7	4.1
Superstition	Tonto	44	TONT1	AZ	33.63	111.10	2.1	1.9	1.6	1.3	1.3	1.1	1.5	1.7	1.6	1.5	1.7	2.1
Swanquarter	Swanquarter	14	SWAN1	NC	35.31	76.28	2.9	2.7	2.6	2.5	2.9	3.2	3.4	3.5	3.4	3.1	2.8	2.9
Sycamore Canyon	Sycamore Canyon	47	SYCA1	AZ	34.03	116.18	2.4	2.3	2.2	2.0	2.0	1.9	2.0	2.0	2.0	2.0	1.9	2.0
Teton	Yellowstone	66	YELL2	WY	44.09	110.18	2.5	2.4	2.2	2.1	2.1	1.9	1.6	1.5	1.7	2.0	2.4	2.5
Theodore Roosevelt	Theodore Roosevelt	61	THRO1	ND	47.30	104.00	2.9	2.8	2.8	2.3	2.3	2.5	2.4	2.2	2.2	2.3	3.0	3.0
Thousand Lakes	Lassen Volcanic	90	LAVO1	CA	40.70	121.58	3.8	3.2	2.9	2.5	2.4	2.2	2.1	2.1	2.2	2.4	3.1	3.5
Three Sisters	Three Sisters	84	THSI1	OR	44.29	122.04	4.5	4.0	3.6	3.7	3.1	3.1	3.0	2.9	3.0	3.8	4.6	4.6
Tuxedni	Tuxedni	103	TUXE1	AK	60.15	152.60	3.5	3.3	2.9	2.7	2.7	2.9	3.6	4.0	3.9	3.5	3.5	3.7
UL Bend	UL Bend	64	ULBE1	MT	47.55	107.87	2.7	2.5	2.5	2.3	2.2	2.2	2.0	1.8	1.9	2.2	2.7	2.7
Upper Buffalo	Upper Buffalo	27	UPBU1	AR	35.83	93.21	3.3	3.0	2.7	2.8	3.4	3.4	3.4	3.4	3.6	3.3	3.2	3.3
Ventana	Pinnacles	92	PINN1	CA	36.22	121.59	3.2	2.9	2.8	2.4	2.3	2.1	2.2	2.3	2.2	2.4	2.5	2.9
Virgin Islands (b)	Virgin Islands	106	VIIS1	VI	18.33	64.79												
Voyageurs	Voyageurs	24	VOYA2	MN	48.59	93.17	2.8	2.4	2.4	2.3	2.3	3.1	2.7	3.0	3.2	2.6	2.9	2.8
Washakie	North Absoraka	67	NOAB1	WY	43.95	109.59	2.5	2.3	2.2	2.1	2.1	1.8	1.6	1.5	1.8	2.0	2.4	2.5
Weminuche	Weminuche	55	WEMI1	CO	37.65	107.80	2.4	2.2	1.9	1.7	1.7	1.5	1.6	2.0	1.9	1.7	2.1	2.3
West Elk	White River	56	WHRI1	CO	38.69	107.19	2.3	2.2	1.9	1.9	1.9	1.7	1.8	2.1	2.0	1.8	2.1	2.2
Wheeler Peak	Wheeler Peak	35	WHPE1	NM	36.57	105.42	2.3	2.2	1.9	1.8	1.8	1.6	1.8	2.2	2.1	1.8	2.2	2.3
White Mountain	White Mountain	37	WHIT1	NM	33.49	105.83	2.1	1.9	1.6	1.5	1.5	1.4	1.8	2.0	2.0	1.7	1.8	2.1
Wichita Mountains	Wichita Mountains	30	WIMO1	OK	34.74	98.59	2.7	2.6	2.4	2.4	3.0	2.7	2.3	2.5	2.9	2.6	2.7	2.8
Wind Cave	Wind Cave	60	WICA1	SD	43.55	103.48	2.5	2.5	2.5	2.5	2.7	2.5	2.3	2.3	2.2	2.2	2.6	2.6
Wolf Island	Okefenokee	16	OKEF1	GA	31.31	81.30	3.4	3.1	3.1	3.0	3.3	3.7	3.7	4.1	4.0	3.7	3.5	3.5
Yellowstone	Yellowstone	66	YELL2	WY	44.55	110.40	2.5	2.4	2.3	2.2	2.2	1.9	1.7	1.6	1.8	2.1	2.5	2.5
Yolla Bolly - Middle Eel	Trinity	104	TRIN1	CA	40.11	122.96	4.0	3.4	3.1	2.8	2.7	2.5	2.4	2.5	2.6	2.7	3.3	3.6
Yosemite	Yosemite	96	YOSE1	CA	37.71	119.70	3.3	3.0	2.8	2.3	2.1	1.8	1.5	1.5	1.5	1.8	2.4	2.8
Zion	Zion	51	ZION1	UT	37.25	113.01	2.7	2.4	2.0	1.6	1.5	1.3	1.2	1.4	1.4	1.6	2.0	2.4

a: No particulate matter sampling or visibility monitoring is conducted in the Bering Sea Wilderness.
b**:** *f(RH)* values for Virgin Islands National Park were not calculated because of the limited RH data available.

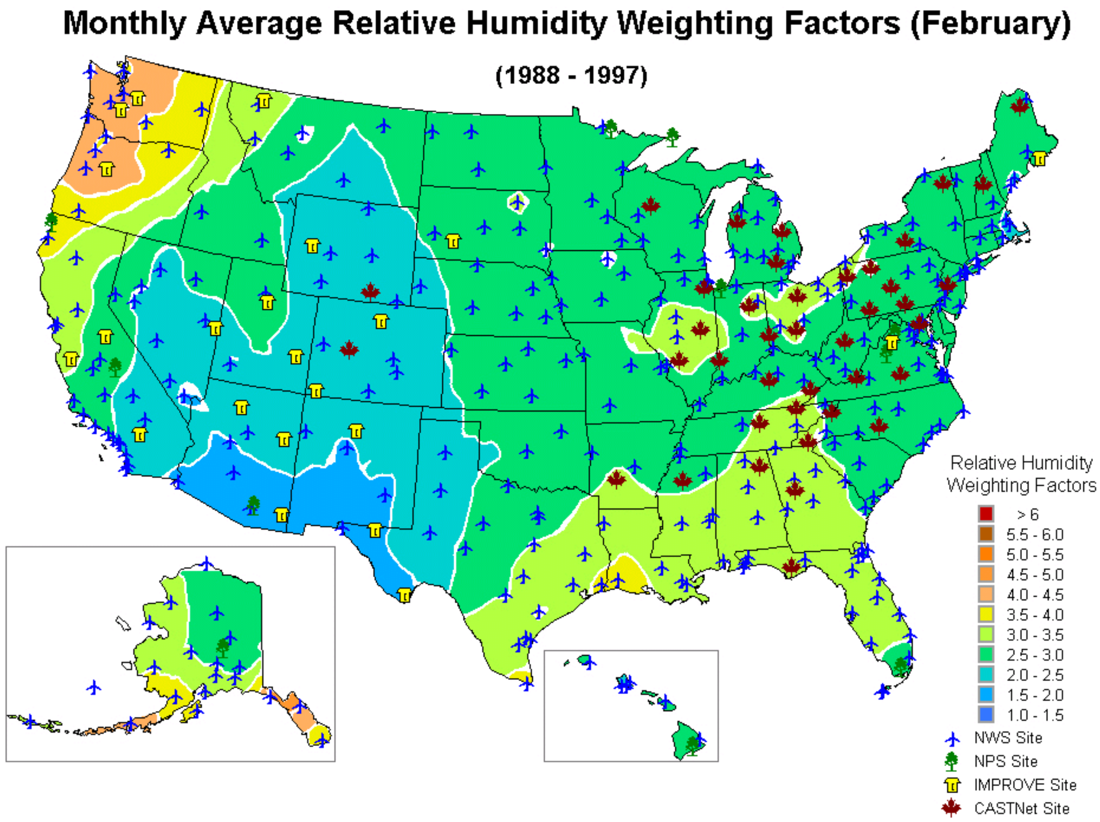

Figure A-1 Monthly Average f(RH) Values for February (all weather stations shown)

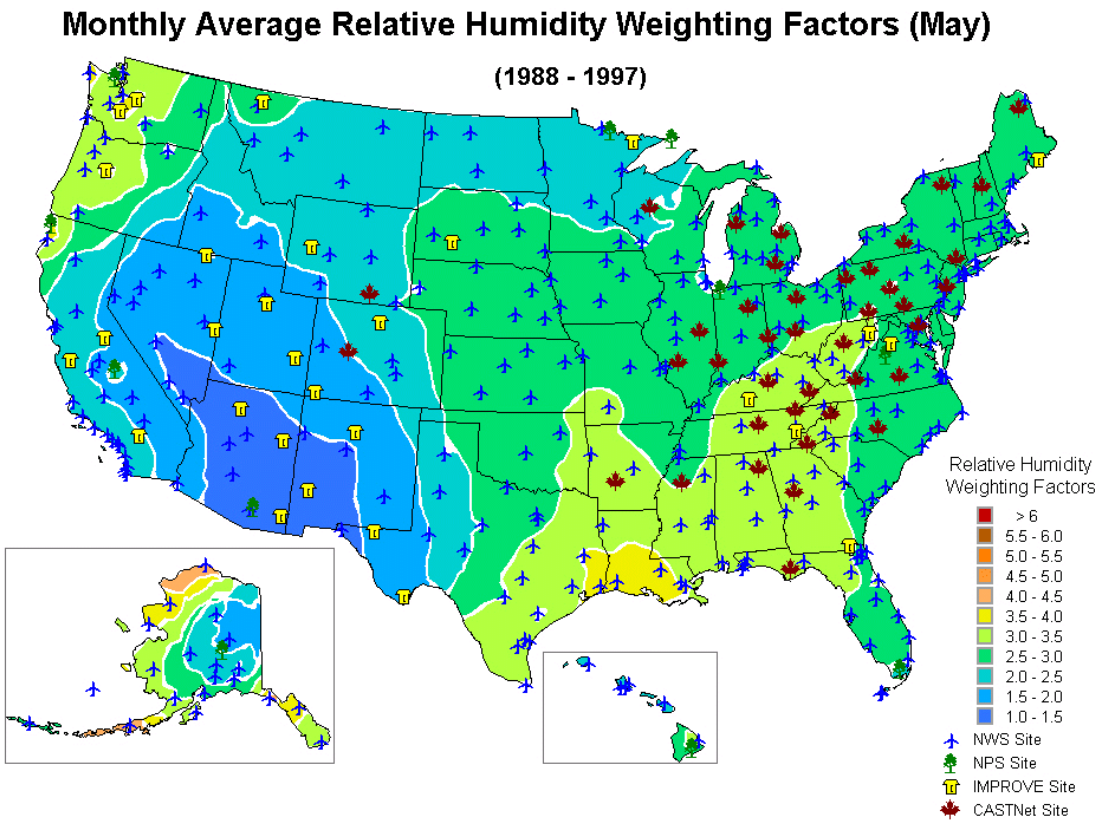

Figure A-2 Monthly Average f(RH) Values for May
(all weather stations shown)

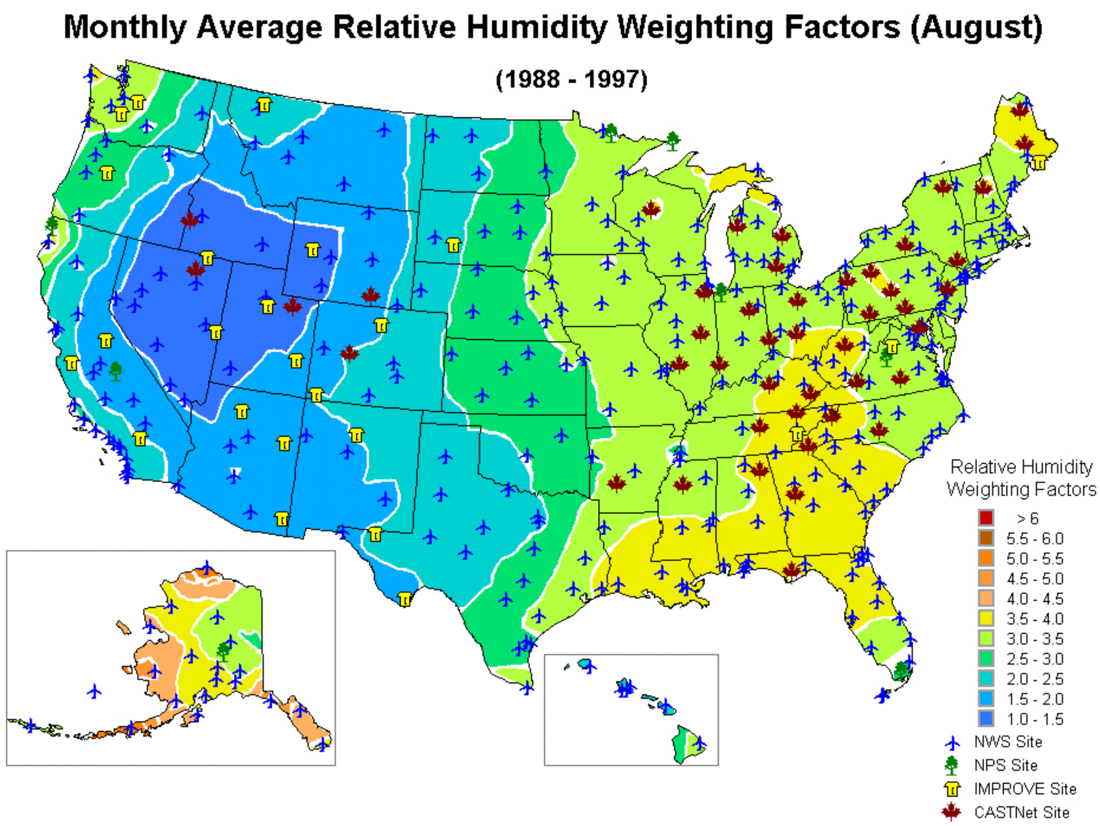

Figure A-3 Monthly Average f(RH) Values for August
(all weather stations shown)

Appendix B

Default Natural b_{ext}, *dv*, and 10th and 90th Percentile *dv* Values at All Mandatory Federal Class I Areas

Appendix B
Default Natural b_{ext}, dv, and 10th and 90th Percentile dv Values at All Mandatory Federal Class I Areas

Mandatory Federal Class I Area	State	Lat.	Lon.	bext (Mm-1)	Ann. Avg. (dv)	Best Days (dv) [(a)]	Worst Days (dv) [(a)]
Acadia NP	ME	44.35	-68.24	21.40	7.61	3.77	11.45
Agua Tibia Wilderness	CA	33.42	-116.99	15.86	4.61	2.05	7.17
Alpine Lake Wilderness	WA	47.55	-121.16	16.99	5.30	2.74	7.86
Anaconda-Pintler Wilderness	MT	45.95	-113.5	16.03	4.72	2.16	7.28
Arches NP	UT	38.73	-109.58	15.58	4.43	1.87	6.99
Badlands NP	SD	43.81	-102.36	16.06	4.74	2.18	7.30
Bandelier NM	NM	35.79	-106.34	15.62	4.46	1.90	7.02
Bering Sea	AK	60.46	-172.75				
Big Bend NP	TX	29.33	-103.31	15.48	4.37	1.81	6.93
Black Canyon of the Gunnison NM	CO	38.57	-107.75	15.68	4.50	1.94	7.06
Bob Marshall Wilderness	MT	47.68	-113.23	16.17	4.80	2.24	7.36
Bosque del Apache	NM	33.79	-106.85	15.54	4.41	1.85	6.97
Boundary Waters Canoe Area	MN	48.06	-91.43	20.89	7.37	3.53	11.21
Breton	LA	29.87	-88.82	21.57	7.69	3.85	11.53
Bridger Wilderness	WY	42.99	-109.49	15.71	4.52	1.96	7.08
Brigantine	NJ	39.49	-74.39	21.05	7.44	3.60	11.28
Bryce Canyon NP	UT	37.57	-112.17	15.58	4.43	1.87	6.99
Cabinet Mountains Wilderness	MT	48.18	-115.68	16.27	4.87	2.31	7.43
Caney Creek Wilderness	AR	34.41	-94.08	21.14	7.49	3.65	11.33
Canyonlands NP	UT	38.23	-109.91	15.60	4.45	1.89	7.01
Cape Romain	SC	32.99	-79.49	21.22	7.52	3.68	11.36
Capitol Reef NP	UT	38.06	-111.15	15.63	4.47	1.91	7.03
Caribou Wilderness	CA	40.49	-121.21	16.05	4.73	2.17	7.29
Carlsbad Caverns NP	NM	32.12	-104.59	15.61	4.46	1.90	7.02
Chassahowitzka	FL	28.69	-82.66	21.46	7.63	3.79	11.47
Chiricahua NM	AZ	32.01	-109.34	15.47	4.36	1.80	6.92
Chiricahua Wilderness	AZ	31.86	-109.28	15.45	4.35	1.79	6.91
Cohutta Wilderness	GA	34.93	-84.57	21.39	7.60	3.76	11.44
Crater Lake NP	OR	42.92	-122.13	16.74	5.15	2.59	7.71
Craters of the Moon NM	ID	43.39	-113.54	15.80	4.57	2.01	7.13
Cucamonga Wilderness	CA	34.24	-117.59	15.85	4.61	2.05	7.17
Denali Preserve NP	AK	63.31	-151.19	16.27	4.86	2.30	7.42
Desolation Wilderness	CA	38.9	-120.17	15.80	4.57	2.01	7.13
Diamond Peak Wilderness	OR	43.53	-122.1	16.84	5.21	2.65	7.77
Dolly Sods Wilderness	WV	39	-79.37	21.13	7.48	3.64	11.32
Dome Land Wilderness	CA	35.84	-118.23	15.70	4.51	1.95	7.07
Eagle Cap Wilderness	OR	45.22	-117.37	16.12	4.78	2.22	7.34

Appendix B
Default Natural b_{ext}, *dv*, and 10th and 90th Percentile *dv* Values at All Mandatory Federal Class I Areas

Mandatory Federal Class I Area	State	Lat.	Lon.	bext (Mm-1)	Ann. Avg. (dv)	Best Days (dv) [(a)]	Worst Days (dv) [(a)]
Eagles Nest Wilderness	CO	39.67	-106.29	15.72	4.52	1.96	7.08
Emigrant Wilderness	CA	38.18	-119.77	15.81	4.58	2.02	7.14
Everglades NP	FL	25.35	-80.98	20.77	7.31	3.47	11.15
Fitzpatrick Wilderness	WY	43.24	-109.6	15.73	4.53	1.97	7.09
Flat Tops Wilderness	CO	39.95	-107.3	15.70	4.51	1.95	7.07
Galiuro Wilderness	AZ	32.6	-110.39	15.40	4.32	1.76	6.88
Gates of the Mountains Wilderness	MT	46.86	-111.82	15.93	4.66	2.10	7.22
Gearhart Mountain Wilderness	OR	42.51	-120.86	16.33	4.90	2.34	7.46
Gila Wilderness	NM	33.21	-108.47	15.51	4.39	1.83	6.95
Glacier NP	MT	48.64	-113.84	16.48	5.00	2.44	7.56
Glacier Peak Wilderness	WA	48.21	-121	16.88	5.24	2.68	7.80
Goat Rocks Wilderness	WA	46.52	-121.47	16.93	5.26	2.70	7.82
Grand Canyon NP	AZ	36.3	-112.79	15.51	4.39	1.83	6.95
Grand Teton NP	WY	43.82	-110.71	15.74	4.53	1.97	7.09
Great Gulf Wilderness	NH	44.3	-71.28	21.10	7.47	3.63	11.31
Great Sand Dunes NM	CO	37.77	-105.57	15.74	4.54	1.98	7.10
Great Smoky Mountains NP	TN	35.6	-83.52	21.39	7.60	3.76	11.44
Guadalupe Mountains NP	TX	31.91	-104.85	15.64	4.47	1.91	7.03
Haleakala NP	HI	20.71	-156.16	16.02	4.71	2.15	7.27
Hawaii Volcanoes NP	HI	19.41	-155.34	16.33	4.91	2.35	7.47
Hells Canyon Wilderness	OR	45.54	-116.59	16.09	4.76	2.20	7.32
Hercules-Glades Wilderness	MO	36.68	-92.9	21.03	7.43	3.59	11.27
Hoover Wilderness	CA	38.11	-119.37	15.78	4.56	2.00	7.12
Isle Royale NP	MI	48.01	-88.83	20.91	7.38	3.54	11.22
James River Face Wilderness	VA	37.59	-79.44	20.96	7.40	3.56	11.24
Jarbidge Wilderness	NV	41.77	-115.35	15.75	4.54	1.98	7.10
John Muir Wilderness	CA	36.97	-118.88	15.80	4.58	2.02	7.14
Joshua Tree NM	CA	33.92	-115.88	15.72	4.52	1.96	7.08
Joyce-Kilmer-Slickrock Wilderness	TN	35.44	-83.99	21.40	7.61	3.77	11.45
Kaiser Wilderness	CA	37.28	-119.17	15.80	4.57	2.01	7.13
Kalmiopsis Wilderness	OR	42.26	-123.92	16.74	5.15	2.59	7.71
Kings Canyon NP	CA	36.92	-118.61	15.79	4.57	2.01	7.13
La Garita Wilderness	CO	37.95	-106.83	15.69	4.50	1.94	7.06
Lassen Volcanic NP	CA	40.49	-121.41	16.08	4.75	2.19	7.31
Lava Beds NM	CA	41.76	-121.52	16.37	4.93	2.37	7.49
Linville Gorge Wilderness	NC	35.88	-81.9	21.36	7.59	3.75	11.43
Lostwood	ND	48.59	-102.46	16.11	4.77	2.21	7.33

Appendix B
Default Natural b_{ext}, *dv*, and 10th and 90th Percentile *dv* Values at All Mandatory Federal Class I Areas

Mandatory Federal Class I Area	State	Lat.	Lon.	bext (Mm-1)	Ann. Avg. (dv)	Best Days (dv) [(a)]	Worst Days (dv) [(a)]
Lye Brook Wilderness	VT	43.13	-73.02	20.99	7.41	3.57	11.25
Mammoth Cave NP	KY	37.2	-86.15	21.58	7.69	3.85	11.53
Marble Mountain Wilderness	CA	41.51	-123.21	16.65	5.10	2.54	7.66
Maroon Bells-Snowmass Wilderness	CO	39.1	-107.02	15.70	4.51	1.95	7.07
Mazatzal Wilderness	AZ	34.13	-111.56	15.44	4.35	1.79	6.91
Medicine Lake	MT	48.49	-104.35	16.07	4.74	2.18	7.30
Mesa Verde NP	CO	37.25	-108.45	15.73	4.53	1.97	7.09
Minarets Wilderness	CA	37.74	-119.19	15.78	4.56	2.00	7.12
Mingo	MO	37	-90.19	21.03	7.43	3.59	11.27
Mission Mountains Wilderness	MT	47.48	-113.87	16.21	4.83	2.27	7.39
Mokelumne Wilderness	CA	38.57	-120.06	15.80	4.58	2.02	7.14
Moosehorn	ME	45.09	-67.29	21.22	7.52	3.68	11.36
Mount Adams Wilderness	WA	46.2	-121.49	16.86	5.22	2.66	7.78
Mount Baldy Wilderness	AZ	33.95	-109.54	15.51	4.39	1.83	6.95
Mount Hood Wilderness	OR	45.37	-121.73	16.83	5.21	2.65	7.77
Mount Jefferson Wilderness	OR	44.61	-121.84	16.91	5.25	2.69	7.81
Mount Rainier NP	WA	46.86	-121.72	17.05	5.34	2.78	7.90
Mount Washington Wilderness	OR	44.3	-121.88	17.03	5.33	2.77	7.89
Mount Zirkel Wilderness	CO	40.75	-106.68	15.71	4.52	1.96	7.08
Mountain Lakes Wilderness	OR	42.33	-122.11	16.50	5.01	2.45	7.57
North Absaroka Wilderness	WY	44.74	-109.8	15.74	4.53	1.97	7.09
North Cascades NP	WA	48.83	-121.35	16.86	5.22	2.66	7.78
Okefenokee	GA	30.82	-82.33	21.41	7.61	3.77	11.45
Olympic NP	WA	47.77	-123.74	17.02	5.32	2.76	7.88
Otter Creek Wilderness	WV	38.99	-79.65	21.14	7.49	3.65	11.33
Pasayten Wilderness	WA	48.89	-120.44	16.84	5.21	2.65	7.77
Pecos Wilderness	NM	35.9	-105.62	15.65	4.48	1.92	7.04
Petrified Forest NP	AZ	34.99	-109.79	15.54	4.41	1.85	6.97
Pine Mountain Wilderness	AZ	34.31	-111.8	15.47	4.36	1.80	6.92
Pinnacles NM	CA	36.48	-121.19	16.12	4.78	2.22	7.34
Point Reyes NS	CA	38.06	-122.9	16.20	4.83	2.27	7.39
Presidential Range-Dry River Wilderness	NH	44.2	-71.34	21.15	7.49	3.65	11.33
Rainbow Lake Wilderness	WI	46.42	-91.31	20.99	7.42	3.58	11.26
Rawah Wilderness	CO	40.69	-105.95	15.72	4.52	1.96	7.08
Red Rock Lakes	MT	44.64	-111.78	15.81	4.58	2.02	7.14
Redwood NP	CA	41.44	-124.03	16.90	5.25	2.69	7.81
Rocky Mountain NP	CO	40.35	-105.7	15.67	4.49	1.93	7.05

Appendix B
Default Natural b_{ext}, *dv*, and 10th and 90th Percentile *dv* Values at All Mandatory Federal Class I Areas

Mandatory Federal Class I Area	State	Lat.	Lon.	bext (Mm-1)	Ann. Avg. (dv)	Best Days (dv) [(a)]	Worst Days (dv) [(a)]
Roosevelt Campobello International Park	ME	44.85	-66.94	21.22	7.52	3.68	11.36
Saguaro NM	AZ	32.17	-110.61	15.35	4.28	1.72	6.84
Salt Creek	NM	33.6	-104.41	15.58	4.43	1.87	6.99
San Gabriel Wilderness	CA	34.27	-117.94	15.86	4.61	2.05	7.17
San Gorgonio Wilderness	CA	34.12	-116.84	15.74	4.54	1.98	7.10
San Jacinto Wilderness	CA	33.75	-116.64	15.78	4.56	2.00	7.12
San Pedro Parks Wilderness	NM	36.11	-106.81	15.63	4.47	1.91	7.03
San Rafael Wilderness	CA	34.76	-119.81	16.03	4.72	2.16	7.28
Sawtooth Wilderness	ID	43.99	-115.06	15.82	4.59	2.03	7.15
Scapegoat Wilderness	MT	47.16	-112.74	16.05	4.73	2.17	7.29
Selway-Bitterroot Wilderness	ID	46.12	-114.86	16.09	4.76	2.20	7.32
Seney	MI	46.25	-86.09	21.23	7.53	3.69	11.37
Sequoia NP	CA	36.51	-118.56	15.79	4.57	2.01	7.13
Shenandoah NP	VA	38.47	-78.49	20.98	7.41	3.57	11.25
Shining Rock Wilderness	NC	35.38	-82.85	21.40	7.61	3.77	11.45
Sierra Ancha Wilderness	AZ	33.85	-110.9	15.46	4.36	1.80	6.92
Simeonof	AK	54.91	-159.28	17.21	5.43	2.87	7.99
Sipsey Wilderness	AL	34.32	-87.44	21.28	7.55	3.71	11.39
South Warner Wilderness	CA	41.31	-120.2	16.09	4.76	2.20	7.32
St. Marks	FL	30.11	-84.15	21.54	7.67	3.83	11.51
Strawberry Mountain Wilderness	OR	44.29	-118.74	16.37	4.93	2.37	7.49
Superstition Wilderness	AZ	33.5	-111.27	15.40	4.32	1.76	6.88
Swanquarter	NC	35.39	-76.39	20.91	7.38	3.54	11.22
Sycamore Canyon Wilderness	AZ	35.01	-112.09	15.53	4.40	1.84	6.96
Teton Wilderness	WY	44.04	-110.17	15.74	4.53	1.97	7.09
Theodore Roosevelt NP	ND	46.96	-103.46	16.08	4.75	2.19	7.31
Thousand Lakes Wilderness	CA	40.7	-121.58	16.10	4.76	2.20	7.32
Three Sisters Wilderness	OR	44.04	-121.91	17.01	5.31	2.75	7.87
Tuxedni	AK	60.14	-152.61	16.58	5.06	2.50	7.62
UL Bend	MT	47.54	-107.89	15.87	4.62	2.06	7.18
Upper Buffalo Wilderness	AR	36.17	-92.41	21.04	7.44	3.60	11.28
Ventana Wilderness	CA	36.21	-121.6	16.09	4.76	2.20	7.32
Virgin Islands NP **(b)**	VI	18.35	-64.74				
Voyageurs NP	MN	48.47	-92.8	20.64	7.25	3.41	11.09
Washakie Wilderness	WY	44.1	-109.57	15.73	4.53	1.97	7.09
Weminuche Wilderness	CO	37.61	-107.25	15.68	4.50	1.94	7.06
West Elk Wilderness	CO	38.75	-107.21	15.71	4.51	1.95	7.07

Appendix B
Default Natural b_{ext}, *dv*, and 10th and 90th Percentile *dv* Values at All Mandatory Federal Class I Areas

Mandatory Federal Class I Area	State	Lat.	Lon.	bext (Mm-1)	Ann. Avg. (dv)	Best Days (dv) [(a)]	Worst Days (dv) [(a)]
Wheeler Peak Wilderness	NM	36.57	-105.4	15.70	4.51	1.95	7.07
White Mountain Wilderness	NM	33.48	-105.85	15.56	4.42	1.86	6.98
Wichita Mountains	OK	34.75	-98.65	20.60	7.23	3.39	11.07
Wind Cave NP	SD	43.58	-103.47	15.97	4.68	2.12	7.24
Wolf Island	GA	31.33	-81.3	21.33	7.58	3.74	11.42
Yellowstone NP	WY	44.63	-110.51	15.77	4.56	2.00	7.12
Yolla Bolly Middle Eel Wilderness	CA	40.09	-122.96	16.25	4.85	2.29	7.41
Yosemite NP	CA	37.85	-119.54	15.81	4.58	2.02	7.14
Zion NP	UT	37.32	-113.04	15.56	4.42	1.86	6.98

(a) Values for the best and worst days are estimated from a statistical approach described in Section 2.6 of this document.
(b) *f(RH)* values for Virgin Islands National Park were not calculated because of the limited RH data available. As such no estimates for Natural Visibility Conditions are presented at this time.

TECHNICAL REPORT DATA

(Please read Instructions on reverse before completing)

1. REPORT NO. EPA-454/B-03-005	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Program		5. REPORT DATE September 2003 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) U.S. EPA/OAR/OAQPS/EMAD/AQTAG		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Air Quality Planning and Standards Emissions, Monitoring and Analysis Division U.S. Environmental Protection Agency Research Triangle Park, NC 27711		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO. 68-D-02-0261 Work Order No. 1-06
12. SPONSORING AGENCY NAME AND ADDRESS Director Office of Air Quality Planning and Standards U.S. Environmental Protection Agency Research Triangle Park, NC 27711		13. TYPE OF REPORT AND PERIOD COVERED Guidance document 14. SPONSORING AGENCY CODE EPA/200/04

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The purpose of this document is to provide guidance to the States in implementing the regional haze program under the Clean Air Act. As part of the program, States will develop goals and implement strategies for improving visibility in each mandatory Federal Class I area. Estimates of natural visibility conditions are needed by the States for the goal development process. This guidance document describes "default"[16] and "refined" approaches for estimating natural conditions. EPA believes that natural conditions estimates developed using the default approach will be adequate to satisfy the requirements of the regional haze rule for the initial SIP submittals due no later than 2008. This document provides guidance to EPA Regional, State, and Tribal air quality management authorities and the general public, on how EPA intends to exercise its discretion in implementing Clean Air Act provisions and EPA regulations, concerning the estimation of natural conditions under the regional haze program.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Regional Haze, Haze Index	Air Pollution control	

18. DISTRIBUTION STATEMENT Unlimited	19. SECURITY CLASS *(Report)* Unclassified	21. NO. OF PAGES
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United States Environmental Protection Agency	Office of Air Quality Planning and Standards Emissions, Monitoring and Analysis Division Research Triangle Park, NC	Publication No. EPA-454/B-03-005 September 2003

Postal information in this section where appropriate.