State of Rhode Island
Department of Environmental Management
Office of Air Resources

Notice of Public Hearing and Comment Period

Concerning the adoption of the proposed
"Rhode Island Regional Haze State Implementation Plan Revision"

Notice is hereby given that a public hearing regarding adoption of the proposed "Rhode Island Regional Haze State Implementation Plan (SIP) Revision." will be held in Room 300 of the Department of Environmental Management, at 235 Promenade Street, Providence, RI on Thursday, July 30, 2009 at 10:00 AM, at which time interested parties will be heard.

This SIP Revision addresses Environmental Protection Agency (EPA) requirements that states that contribute to visibility impairment in one or more Federal Class I Areas (national parks and wilderness areas) prepare plans consistent with the national goal of restoring visibility in those areas to natural conditions. Although Rhode Island does not have any Class I Areas, the EPA has determined that emissions from sources in the State contribute to visibility impairment in Class I areas in nearby states.

As required by the EPA rule (40 CFR 51.300-309), the proposed SIP revision includes a long-term strategy with emissions control measures that constitute Rhode Island's share of the emission reductions needed to meet visibility goals in the region. The measures included in Rhode Island's strategy include participation in a regional low-sulfur fuel oil program.

Copies of the proposed plan are available from the Office of Air Resources, 235 Promenade Street, Providence, RI, between 8:30 am and 4:00 PM and from the Air Resources section of the Department's web site at http://www.dem.ri.gov/. For more information, or copies of the supporting appendices, contact Barbara Morin at (401) 222-2808, ext. 7012, TCDD (401) 222-6800.

Written comments may be sent to the Office of Air Resources at the above address or emailed to Barbara Morin at barbara.morin@dem.ri.gov until 4:00 PM on Thursday, July 30, 2009, at which time the comment period will end, unless extended by the hearing officer. It is requested that persons who wish to make comments during the public hearing submit a copy of their statement for the record. Members of the Office of Air Resources may question commenters concerning their remarks.

The Department of Environmental Management building is accessible to those with disabilities. Persons with disabilities requiring accommodation should contact the Office of Air Resources at TCDD (401) 222-6800, or (401) 222-2808 at least three business days prior to the hearing.

Signed this 24th day of June 2009

Douglas McVay, Acting Chief
Office of Air Resources

Rhode Island Regional Haze State Implementation Plan Revision

Rhode Island Department of Environmental Management
Office of Air Resources

Posted for Public Comment: June 30, 2009

Prepared by

Rhode Island Department of Environmental Management

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1.0 THE REGIONAL HAZE ISSUE

In 1999, the Environmental Protection Agency (EPA) issued regulations designed to improve visibility in the 156 national parks and wilderness areas across the United States known as federal "Class I" areas. The affected areas include the Grand Canyon, Yosemite, Yellowstone, Mount Rainier, Shenandoah, the Great Smokies, and the Everglades. New England contains six federally-designated Class I areas: Acadia National Park (Maine), Great Gulf Wilderness Area (New Hampshire), Lye Brook Wilderness Area (Vermont), Moosehorn Wildlife Refuge (Maine), Presidential Range-Dry River Wilderness Area (New Hampshire), and Roosevelt Campobello International Park (Maine/Canada). There are no Class I areas in Rhode Island.

The EPA regulations address visibility impairment in the form of regional haze. Haze is an atmospheric phenomenon that obscures the clarity, color, texture, and form of what we see. It is caused primarily by anthropogenic (manmade) pollutants but can also be caused by a number of natural phenomena, including forest fires, dust storms, and sea spray. Some haze-causing pollutants are emitted directly to the atmosphere by anthropogenic emission sources such as electric power plants, factories, automobiles, construction activities, and agricultural burning. Others occur when gases emitted to the air (haze precursors) interact to form new particles.

Emissions from these activities generally span broad geographic areas and the resulting atmospheric particulate matter can be transported hundreds or thousands of miles. Consequently, every state in the nation contributes to regional haze in one or more Class I areas. Emissions from Rhode Island sources contribute to regional haze in Class I areas in nearby states, although that contribution has been determined to be relatively small. Because of the regional nature of haze, EPA's regulations require states to consult with each other toward the national goal of improving visibility at the 156 parks and wilderness areas designated under the Clean Air Act as mandatory Class I Federal Areas.

The Regional Haze Rule calls for each state to formulate a long-term strategy for meeting visibility goals. These requirements apply to any state having a Class I area as well as any state that contributes to visibility impairment at any (downwind) Class I area. The visibility goals must be designed both to improve visibility on the haziest days and to ensure that there is no degradation to visibility on the clearest days.

A state's long-term strategy must include enforceable emission reduction measures designed to meet reasonable progress goals. The first long-term strategy covers the 10-15-year period ending in 2018 and subsequent revisions are to be issued every 10 years thereafter. In identifying the emission reduction measures to be included in the long-term strategy, states must address all types of anthropogenic emissions sources that contribute to visibility degradation in Class I areas, including mobile sources, large stationary point sources such as factories and power plants, smaller stationary area sources such as residential wood stoves and small boilers, and prescribed fires.

In developing their plans, states can take into account emission reductions that will occur as a result of ongoing air pollution control programs at the state, regional, or national levels. For most states and regions of the country, however, additional emission control measures beyond those already on the books will be necessary if national visibility goals are to be achieved. In addition, the Regional Haze Rule mandates that control measures be implemented for certain existing sources placed into operation between 1962 and 1977. This portion of the rule is known as Best Available Retrofit Technology (BART). There are no BART-eligible sources in Rhode Island.

Each state's plan for addressing regional haze will take the form of a State Implementation Plan (SIP) or SIP revision. Rhode Island's SIP, presented here, was developed after extensive consultations with other states and regional planning organizations (RPOs). Rhode Island participated in a regional planning process to reduce haze in Class I areas as a member of the Mid-Atlantic/Northeast Visibility Union (MANE-VU). This RPO established baseline and natural visibility conditions, determined the primary contributors to regional haze, and facilitated a consultation process with states, other RPOs, and federal land managers. Rhode Island, as a MANE-VU member state, adopted the "*Statement of MANE-VU Concerning a Request for a Course of Action by States Within MANE-VU Toward Assuring Reasonable Progress*" (the Ask) at the MANE-VU Board meeting on June 7, 2007. This document outlines a strategy for reducing haze at MANE-VU Class I areas. This strategy takes into account the following four factors to determine which additional emission control measures are needed to make reasonable progress in improving visibility: 1) costs of compliance, 2) time necessary for compliance, 3) energy and non-air quality environmental impacts of compliance, and 4) remaining useful life of any existing source subject to such requirements.

The control measures included in this SIP revision represent Rhode Island's fair share contribution towards achieving the reasonable progress goals of Class I states by 2018. These measures include a two-phased reduction in the sulfur content of fuel oil, as specified in the Ask, and, pending legislative approval, controls on outdoor wood boilers, in addition to control measures that have been adopted pursuant to other programs. Rhode Island is also committing to continue to work with other states to identify appropriate further control measures. Other emission reduction strategies identified in the Ask are not applicable to Rhode Island sources. Modeling conducted by MANE-VU demonstrates that Rhode Island's long-term strategy, when coordinated with other states' strategies as defined by the MANE-VU statement, is sufficient to meet these reasonable progress goals. All MANE-VU Class I sites are projected to meet or exceed the uniform rate of progress by 2018.

1.1 The Basics of Haze

Small particles and certain gaseous molecules in the atmosphere scatter and absorb light, reducing the amount of visual information about distant objects that reaches an observer and, thereby, reducing visibility. Some light scattering by air molecules and naturally occurring aerosols occurs even under natural conditions.[1]

The distribution of particles in the atmosphere depends on meteorological conditions and leads to various forms of visibility impairment. When high concentrations of pollutants are well mixed in the atmosphere, they form a uniform haze. When temperature inversions trap pollutants near the surface, the result can be a sharply demarcated layer of haze. Plume blight –

[1] The fact that air molecules scatter more short-wavelength (blue) light accounts for the blue color of the sky. The term "aerosol" is defined as a suspension of particles in a gas. In this report, the term refers to particles suspended in the atmosphere.

a distinct, frequently brownish plume of pollution from a particular emissions source – occurs under stable atmospheric conditions, where pollutants take a long time to disperse.

Visibility impairment can be quantified using three different, but mathematically related measures: light extinction per unit distance (e.g., Mm^{-1})[2]; visual range (i.e., how far one can see); and deciviews (dv), a useful metric for measuring increments of visibility change that are just perceptible to the human eye. Each can be estimated from the ambient concentrations of individual particle constituents, taking into account their unique light-scattering (or absorbing) properties and making appropriate adjustments for relative humidity. Under natural conditions, visibility in the Northeast and Mid-Atlantic is estimated to be about 23 Mm^{-1}, which corresponds to a visual range of about 106 miles or 8 dv. Under current polluted conditions in the region, average visibility ranges from 103 Mm^{-1} in the south to 55 Mm^{-1} in the north; these values correspond to a visual range of 24 to 44 miles or 23 to 17 dv, respectively. On the worst 20 percent of days, visibility impairment in Northeast and Mid-Atlantic Class I areas ranges from about 25 to 30 dv, for a visual range of 20 to 12 miles.

The small particles that commonly cause hazy conditions in the East are primarily composed of sulfate, nitrate, organic carbon, elemental carbon (soot), and crustal material (e.g., soil dust, sea salt, etc.). Of these constituents, only elemental carbon impairs visibility by absorbing visible light; the others scatter light. Sulfate, nitrate, and organic carbon[3] are secondary pollutants that form in the atmosphere from precursor pollutants, primarily sulfur dioxide (SO_2), oxides of nitrogen (NO_X), and volatile organic compounds (VOCs), respectively. By contrast, soot and crustal material and some organic carbon particles are released directly to the atmosphere. Particle constituents also differ in their relative effectiveness at reducing visibility. Sulfates and nitrates, for example, contribute disproportionately to haze because of their chemical affinity for water. This property allows them to grow rapidly, in the presence of moisture, to the optimal particle size for scattering light, 0.1 to 1 micrometer.

1.2 Anatomy of Regional Haze

Monitoring data collected over the last decade show that fine particle[4] concentrations, and hence visibility impairment, in the Northeast and Mid-Atlantic are generally highest near industrial and highly populated areas. Particle concentrations are lower, and visibility conditions are better, at the more northerly Class I sites, where visibility on the 20 percent best days[5] is close to natural, unpolluted conditions. By contrast, visibility at the more southerly Brigantine site in New Jersey is substantially impaired even on the 20 percent clearest days. On the 20 percent haziest days, visibility impairment is substantial throughout the region.

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[2] In units of inverse length. An inverse megameter (Mm^{-1}) is equal to one over one thousand kilometers.

[3] The term "organic carbon" encompasses a large number of hydrogen and carbon containing molecules. Light scattering secondary organic aerosols result from the oxidation of hydrocarbons that are emitted from many different sources, ranging from automobiles to solvents, to natural vegetation. Organic carbon can be emitted as a primary particle from sources such as wood burning, meat cooking, automobiles, and paved road dust.

[4] "Fine particles" refers throughout this study to particles less than or equal to 2.5 micrometers in diameter, consistent with US EPA's recently proposed fine particle National Ambient Air Quality Standard (NAAQS).

[5] "20 percent best visibility conditions" are defined throughout this report as the simple average of the lower 20th percentile of a cumulative frequency distribution of available data (expressed in deciviews). Similarly, "20 percent worst visibility conditions" represent the upper 20th percentile of the same distribution of available data.

Sulfate is the dominant contributor to fine particle pollution throughout the eastern U.S. On the haziest 20 percent of days, sulfate accounts for one-half to two-thirds of total fine particle mass and is responsible for about three-quarters of total light extinction at Class I sites in the Northeast and Mid-Atlantic. Even on the clearest 20 percent of days, sulfate typically constitutes 40 percent or more of total fine particle mass in the region. Moreover, sulfate accounts for 60 to 80 percent of the difference in fine particle mass concentrations on hazy versus clear days.

Organic carbon consistently accounts for the next largest fraction of total fine particle mass; its contribution typically ranges from 20 to 30 percent on the haziest days. Notably, organic carbon accounts for as much as 40 to 50 percent of total mass on the clearest days, indicating that biogenic hydrocarbon sources (i.e. vegetation) are important at Class I areas in the region.

The relative contributions of nitrate, elemental carbon, and fine soil are smaller than those of sulfate and organic carbon – typically less than 10 percent of total mass and varying with location. However, in some settings such as a monitoring site in Washington, DC,[6] nitrate plays a considerably larger role, pointing to the importance of local NO_X sources to fine-particle pollution in urban environments.

About half of the worst visibility days in the New England's Class I Areas occur in the summer when meteorological conditions are more conducive to the formation of sulfate from SO_2 and to the oxidation of organic aerosols. The remaining worst visibility days are divided nearly equally among spring, winter, and fall. In addition, winter and summer transport patterns are different, possibly leading to different contributions from upwind pollutant source regions. In contrast to sulfate and organic carbon, the nitrate contribution is typically higher in the winter months[7]. The crustal and elemental carbon fractions do not show a clear pattern of seasonal variation.

The basis for EPA's regional haze regulations is recognition that visibility impairment is fundamentally a regional phenomenon. Emissions from numerous sources over a broad geographic area commonly create hazy conditions across large portions of the eastern U.S. as a result of the long-range transport of airborne particles and precursor pollutants in the atmosphere. The key sulfate precursor, SO_2, for example, has an atmospheric lifetime of several days and is known to be subject to transport distances of hundreds of miles. NO_X and some organic carbon species are also subject to long-range transport, as are small particles of soot and crustal material.

The importance of transport dynamics is well illustrated by a particularly severe haze episode that occurred in mid-July of 1999. During this episode, unusually hot and humid conditions coincided with the development of a high-pressure system over the Mid-Atlantic States that produced atmospheric stagnation over the heavily urbanized, southern portion of the MANE-VU region (i.e., Philadelphia - DC - southern New Jersey). At the same time, wind patterns above the area of stagnation brought a steady flow of air from the Midwest into the New England states. This set of conditions resulted in several days of unusually high

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[6] The Washington, DC, site is part of the IMPROVE nationwide monitoring network and is mentioned here for the purposes of comparison.

[7] This is largely due to the fact that the ammonium nitrate bond is more stable at lower temperatures. The role of ammonia in combination with both sulfate and nitrate is discussed further in later sections.

concentrations of fine-particle pollution throughout the region. On July 17, 1999, ambient sulfate concentrations at Acadia National Park were 40 percent higher than any previous measurement at that site since the late 1980s. On the same day, visibility at the Burlington, Vermont, airport was limited to just 3 miles. As is often the case, high concentrations of ground-level ozone accompanied these severe haze conditions. These coinciding conditions occur because haze and ground-level ozone – although they are fundamentally different phenomena – tend to form and accumulate under similar meteorological conditions.

1.3 Regulatory Framework

In amendments to the Clean Air Act (CAA) in 1977, Congress added Section 169 (42 U.S.C. 7491), setting forth the following national visibility goal:

> "Congress hereby declares as a national goal the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas which impairment results from manmade air pollution."

The "Class I" designation was given to each of 158 areas in existence as of August 1977 that met the following criteria:

- all national parks greater than 6000 acres
- all national wilderness areas and national memorial parks greater than 5000 acres
- one international park

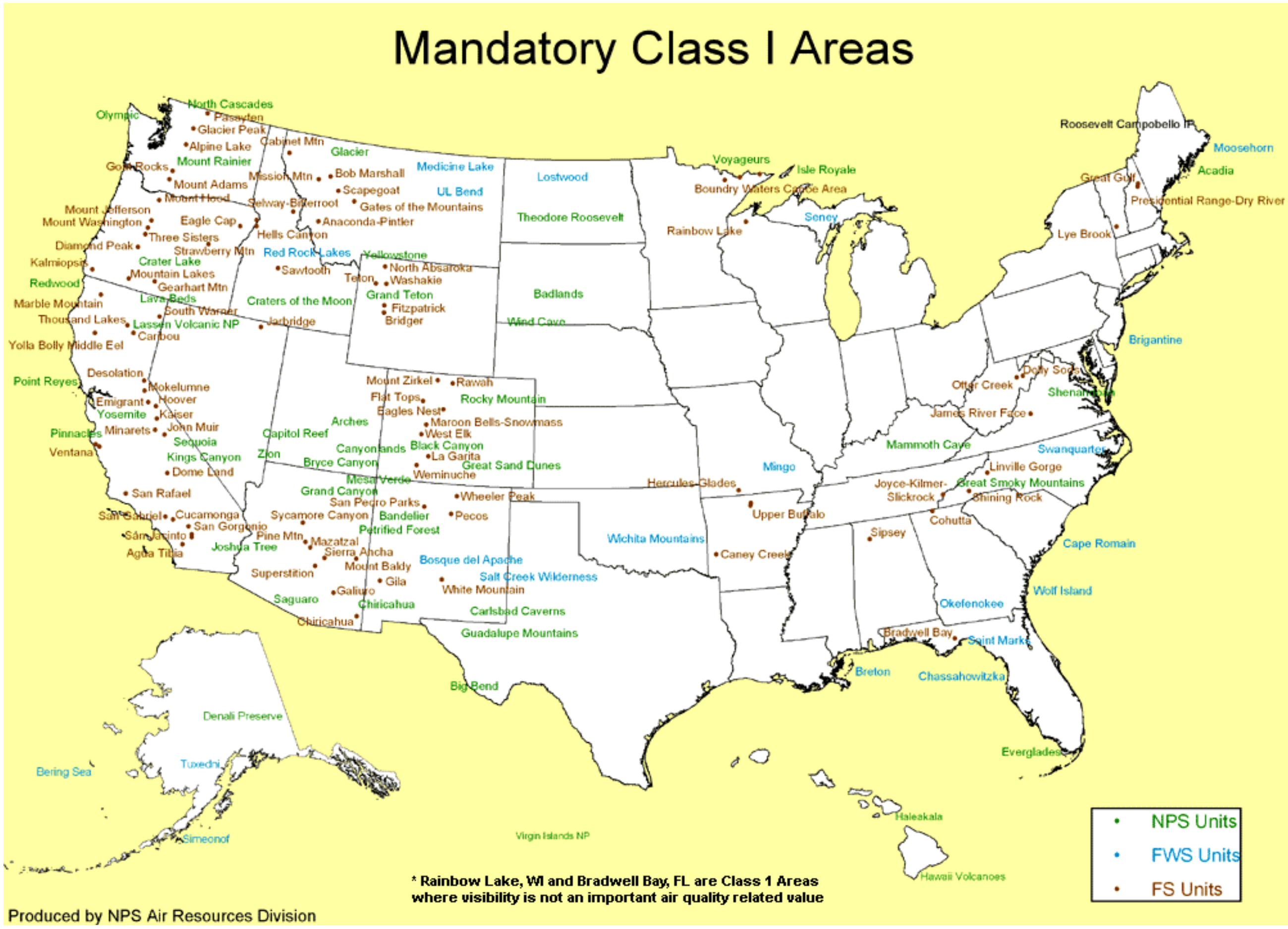
In 1980, the Bradwell Bay, Florida, and Rainbow Lake, Wisconsin Class I areas, were excluded from visibility protection requirements. Today, 156 national park and wilderness areas remain as Class I visibility protection areas (Figure 1.1).

Over the following years, modest steps were taken to address the visibility problems in Class I areas. The control measures taken mainly addressed plume blight from specific pollution sources, a localized phenomenon, and did little to address regional haze issues in the Eastern United States.

When the Clean Air Act was amended, again, in 1990, Congress added Section 169B (42 U.S.C. 7492), authorizing further research and regular assessments of progress made in visibility. In 1993, the National Academy of Sciences concluded that "current scientific knowledge is adequate and control technologies are available for taking regulatory action to improve and protect visibility."

In addition to authorizing creation of visibility transport commissions and setting forth their duties, Section 169B(f) of the CAA mandated creation of the Grand Canyon Visibility Transport Commission (GCVTC) to make recommendations to EPA for the region affecting the visibility of the Grand Canyon National Park. GCVTC submitted its report to EPA in June 1996, following four years of research and policy development. This report, as well as the many research reports prepared by the GCVTC, contributed invaluable information to EPA in its development of regulations for visibility improvement.

Figure 1.1: Locations of Federally Protected Mandatory Class I Areas



1.3.1 The Regional Haze Rule

The federal requirements that states must meet to achieve national visibility goals are contained in Title 40: Protection of Environment, Part 51 – Requirements for Preparation, Adoption, and Submittal Of Implementation Plans, Subpart P – Protection of Visibility (40 CFR 51.300-309). Known more simply as the Regional Haze Rule, these regulations were adopted on July 1, 1999, and went into effect on August 30, 1999. The rule seeks to address the combined visibility effects of various pollution sources over a large geographic region. This wide-reaching pollution net means that many states – even those without Class I Areas – are required to participate in haze reduction efforts. The specific requirements for states' regional haze SIPs are set forth in 40 CFR 51.308, Regional Haze Program Requirements.

In consultation with the states and tribes, EPA designated five Regional Planning Organizations (RPOs to assist with the coordination and cooperation needed to address the regional haze issue. The Mid-Atlantic and Northeast states, joined by the District of Columbia and tribes in the Northeast, formed the Mid-Atlantic / Northeast Visibility Union (MANE-VU).[8]

[8] MANE-VU includes the following member states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and the District of Columbia. A more complete description of MANE-VU appears in Section 3.0 of this SIP.

EPA's adoption of the Regional Haze Rule was not without controversy and legal challenges. On May 24, 2002, the U.S. Court of Appeals for the District of Columbia Circuit ruled on the challenge brought by the American Corn Growers Association against the Regional Haze Rule. The Court remanded the BART provisions of the rule to EPA and denied industry's challenge to the haze rule goals of achieving natural visibility levels and zero degradation. On June 15, 2005, EPA finalized a rule addressing the court's remand.

On February 18, 2005, the U.S. Court of Appeals for the D.C. Circuit issued another ruling vacating the Regional Haze Rule in part and sustaining it in part. For more information see *Center for Energy and Economic Development v. EPA*, no. 03-1222, (D.C. Cir. Feb. 18, 2005) ("*CEED* v. EPA"). In this case, the court granted a petition challenging provisions of the Regional Haze Rule governing the optional emissions trading program for certain Western States and Tribes (the WRAP Annex Rule).

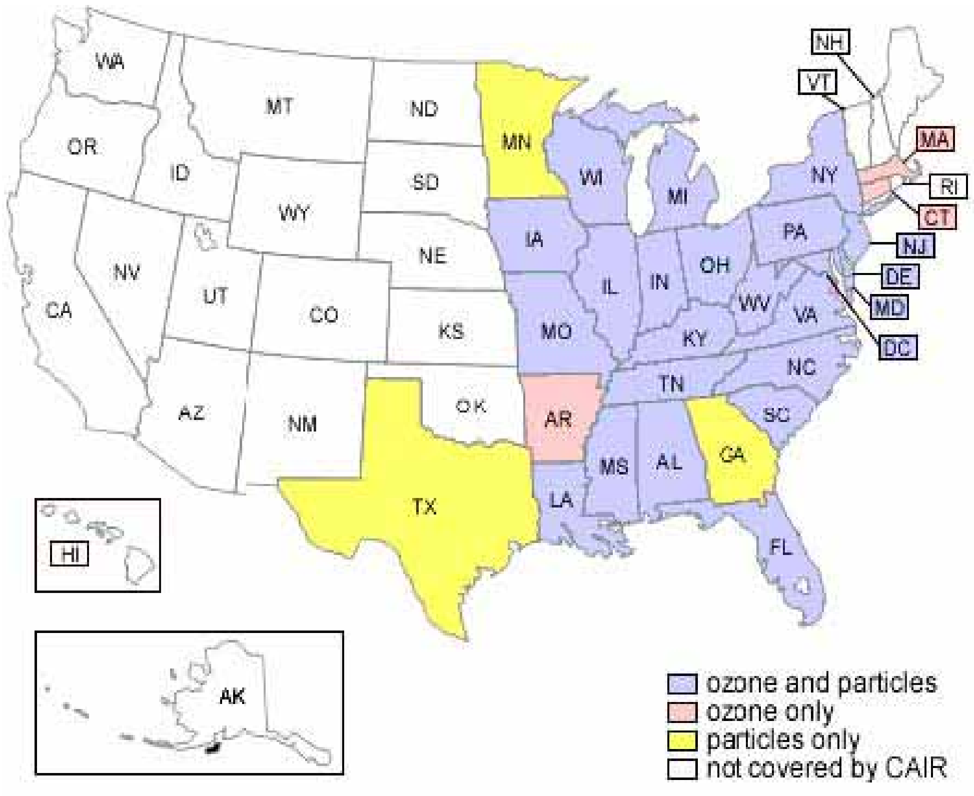
In the aftermath of these decisions, EPA's final rulemaking incorporated the following changes to the Regional Haze Rule:

- Revised the regulatory text in 40 CFR 51.308(e)(2)(i) in response to the *CEED* court's remand, to
    - Remove the requirement that the determination of BART be based on cumulative visibility analyses, and
    - Clarify the process for making such determinations, including the application of BART presumptions for electric generating units (EGUs) as contained in 40 CFR 51, Appendix Y;
- Added new regulatory text in 40 CFR 51.308(e)(2)(vi) to provide minimum elements for cap-and-trade programs in lieu of BART; and
- Revised regulatory text in 40 CFR 51.309 to reconcile the optional framework for certain Western states and tribes to implement the recommendations of the GCVTC with the *CEED* decision.

1.3.2 Regional Haze Planning after the Remand of CAIR

On March 10, 2005, EPA issued the Clean Air Interstate Rule (CAIR). This rule was designed to achieve major permanent reductions in SO_2 and NOx emissions in the eastern United States through a cap-and-trade system using emission allowances. As promulgated, CAIR permanently caps emissions originating in 28 eastern states and the District of Columbia (Figure 1.2). Although Rhode Island was not designated as a participating CAIR state, emissions reductions due to CAIR in upwind states would reduce ozone levels in Rhode Island

Figure 1.2: CAIR States



http://www.epa.gov/cair/

According to EPA's CAIR website, full implementation of CAIR would reduce SO_2 emissions in the affected states by more than 70% and NOx emissions by more than 60% from 2003 levels (see http://www.epa.gov/cair/).

However, on July 11, 2008, the U.S. Court of Appeals for the District of Columbia Circuit found that CAIR violated basic provisions of the Clean Air Act and vacated CAIR in its entirety and remanded it to EPA to promulgate a new rule consistent with the court's opinion. On September 24, 2008, EPA petitioned the D.C. Circuit for a rehearing or rehearing *en banc* on the vacatur of CAIR. Thereafter, the D.C. Circuit issued an order requesting briefs on the issue of whether any party is seeking vacatur of CAIR and whether the court should stay its vacatur until EPA promulgates a revised rule. Rhode Island, along with more than 20 other states, filed an *amicus* brief in support of staying the court decision vacating CAIR while EPA promulgates a revised rule that complies with the court's decision. The states argued that because they "reasonably relied on CAIR in formulating long-term plans for improving air quality, in the short term even a flawed rule is better than no rule at all."

The vacatur of CAIR presented a major difficulty for the individual states in attempting to comply with the Regional Haze Rule because CAIR formed the regulatory underpinnings for most of the emission reductions that would produce visibility improvements in mandatory Class I areas. While all states depended in varying degree on CAIR in the preparation of their regional haze SIPs, some Southeast states relied almost entirely on CAIR to demonstrate compliance with the rule. As a major ramification, the vacatur of CAIR invalidated EPA's determination that CAIR satisfies the requirements of BART. The vacatur of CAIR also called into question the validity of MANE-VU's (and other RPOs') emission inventories and air quality modeling studies already completed for the member states' regional haze SIPs.

However, on December 23, 2008, the D.C. Circuit decided that "a remand without vacatur is appropriate in this case" because "notwithstanding the relative flaws of CAIR, allowing CAIR to remain in effect until it is replaced by a rule consistent with our opinion would at least temporarily preserve the environmental values covered by CAIR." *State of North Carolina v. EPA*, No. 05-1244, slip op. at 3 (D.C. Cir. Dec. 23, 2008).

In light of this decision, Rhode Island believes that future emissions and air quality levels will not be vastly different from values predicted by MANE-VU's completed modeling, even though that modeling was based on implementation of CAIR and did not take into account the remand of CAIR to EPA. Consequently, the reasonable progress goals and long-term strategy developed for the MANE-VU regional haze SIPs still represent a defensible position from which to go forward with measures to improve visibility in MANE-VU's Class I Areas.

Further, Rhode Island and the other MANE-VU states have maintained all along that the regional haze SIPs should look beyond the provisions of CAIR to identify additional emission control measures that could be effectively employed to mitigate regional haze. The remand of CAIR without vacatur is a complicating factor for the long term plan because of the uncertainty involved, but does not present impediment to making visibility progress in the near term. The salient points to consider are as follows:

- Because Rhode Island is not a CAIR state, CAIR does not directly affect any of Rhode Island's proposed in-state control strategies for visibility improvement. Note that emissions from Rhode Island Electric Generating Units (EGUs) are limited to levels below those that were the basis of the CAIR allowances..
- Rhode Island will meet its "fair share" of emissions in comparison with other MANE-VU states and the original CAIR states, as Rhode Island's long-term strategy demonstrates (see Section 11.9).
- Rhode Island does not have any BART sources and so the issues of whether CAIR is equal to BART is not relevant in the State.
- Rhode Island does not have any Class I areas that would be affected by the remand of the CAIR program in upwind states.
- The remand without vacatur keeps the first phase of the CAIR rule in place, so emissions reductions associated with those limitations will be realized;
- By the time of the first regional haze SIP progress report, the CAIR-replacement regulatory framework should be clearer and new modeling results should be available. It should then be possible to fine-tune regional haze plans to take into account any rule that EPA has promulgated to replace CAIR. Rhode Island is committed to reviewing and updating its regional haze SIP as new information becomes available.
- Given the D.C. Circuit's remand without vacatur of CAIR, Rhode Island has chosen to retain appropriate references to CAIR in the remainder of this document, which will help to maintain continuity with the large body of completed work – much of it based on CAIR – that serves as the foundation for regional haze planning in the MANE-VU states to date.

1.3.3 State Implementation Plan

EPA prepared a checklist summarizing the requirements of the final Regional Haze Rule to be addressed in Regional Haze State Implementation Plans (SIPs). ~~Attachment~~ _A contains a copy of that checklist with cross-references to sections of Rhode Island's Regional Haze SIP showing how the requirements have been met.

In accordance with 40 CFR 51.308(a) and (b), Rhode Island is submitting this SIP to meet the requirements of EPA's Regional Haze Rule. This SIP addresses the core requirements of 40 CFR 51.308(d) and the BART components of 40 CFR 50.308(e). In addition, this SIP addresses requirements pertaining to regional planning, and state/tribe and Federal Land Manager (FLM) coordination and consultation.

40 CFR 51.308(f) requires the Rhode Island Department of Environmental Management (RI DEM) to submit periodic revisions to its Regional Haze SIP by July 31, 2018, and every ten years thereafter. **RI DEM acknowledges and will comply with this schedule.**

40 CFR 51.308(g) requires RI DEM to submit a report to EPA every 5 years that evaluates progress toward the reasonable progress goal for each mandatory Class I area located within the State and each mandatory Class I area located outside the State that may be affected by emissions from within the State. **RI DEM will submit the first progress report, in the form of a SIP revision, within 5 years from submittal of the initial State Implementation Plan.**

Pursuant to 40 CFR 51.308(d)(4)(v), **RI DEM will also make periodic updates to the Rhode Island's emissions inventory** (see Section 6.0, Emissions Inventory). RI DEM proposes to complete these updates to coincide with the progress reports. Actual emissions will be compared to projected modeled emissions in the progress reports.

Lastly, pursuant to 40 CFR 51.308(h), **RI DEM will submit a determination of adequacy of its regional haze SIP revision whenever a progress report is submitted.** Depending on the findings of its five-year review, Rhode Island will take one or more of the following actions at that time, whichever actions are appropriate or necessary:

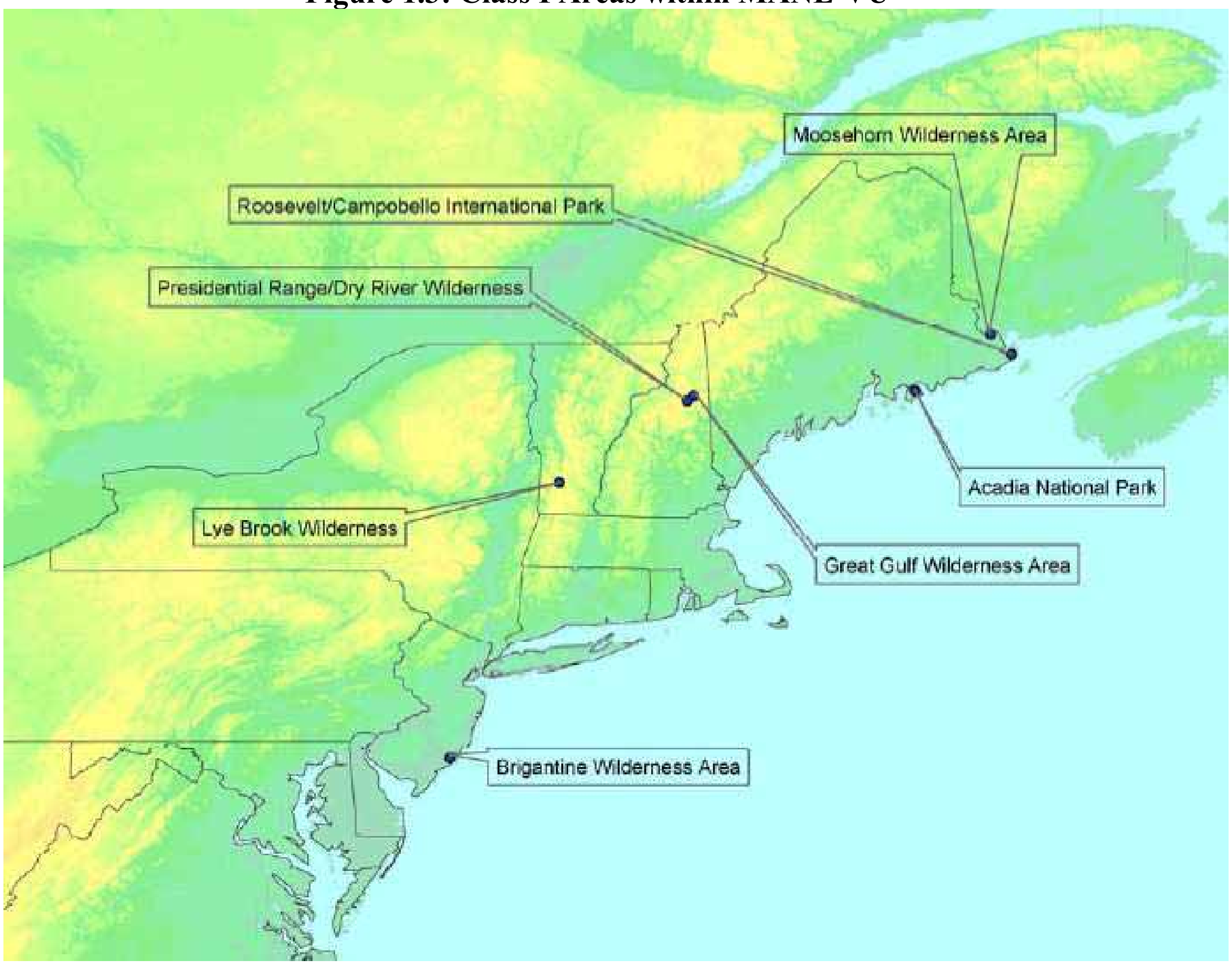
- If Rhode Island determines that the existing State Implementation Plan requires no further substantive revision in order to achieve established goals for visibility improvement and emissions reductions, RI DEM will provide to the EPA Administrator a negative declaration that further revision of the existing plan is not needed.
- If Rhode Island determines that its implementation plan is or may be inadequate to ensure reasonable progress as a result of emissions from sources in one or more other state(s) which participated in the regional planning process, Rhode Island will provide notification to the EPA Administrator and to those other state(s). Rhode Island will also collaborate with the other state(s) through the regional planning process for the purpose of developing additional strategies to address any such deficiencies in Rhode Island's plan.
- If Rhode Island determines that its implementation plan is or may be inadequate to ensure reasonable progress as a result of emissions from sources in another country, Rhode Island will provide notification, along with available information, to the EPA Administrator.

- If Rhode Island determines that the implementation plan is or may be inadequate to ensure reasonable progress as a result of emissions from sources within the state, Rhode Island will revise its implementation plan to address the plan's deficiencies within one year from this determination.

1.4. Class I Areas Within MANE-VU

The MANE-VU RPO contains seven Class I areas in four states (see Figure 1.3). Rhode Island does not have any Federal Class I areas.

Figure 1.3: Class I Areas within MANE-VU



2.0 AREAS CONTRIBUTING TO REGIONAL HAZE

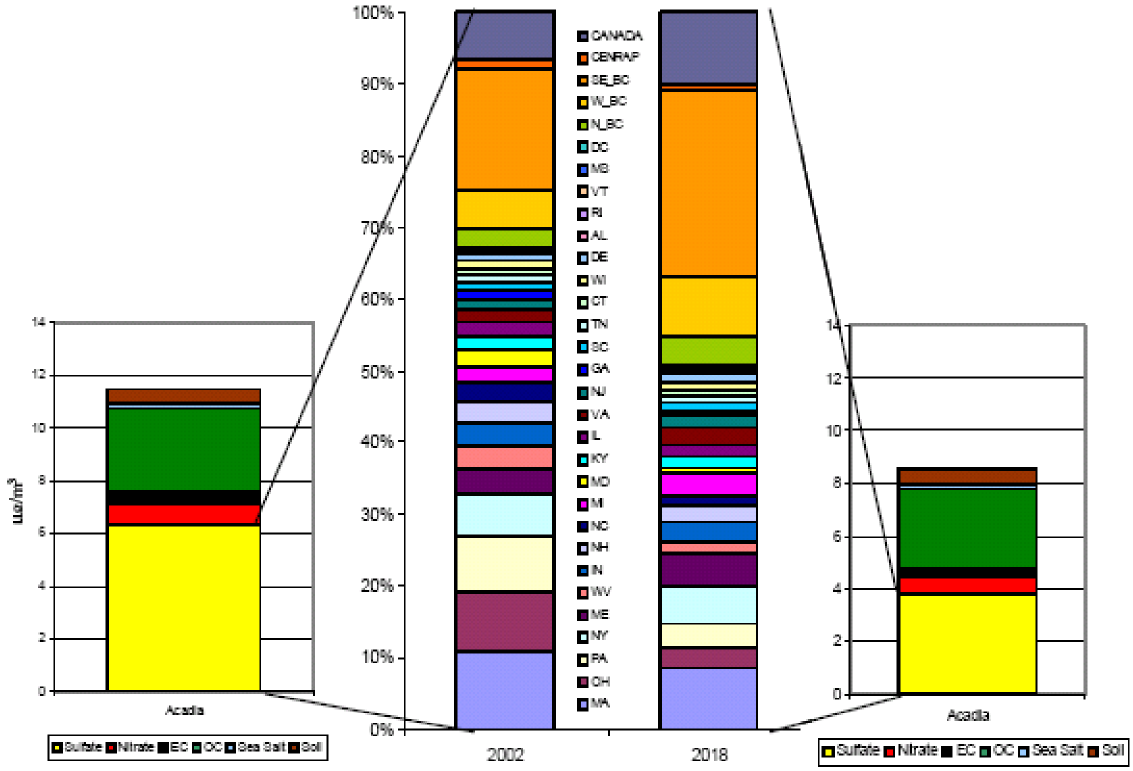
40 CFR 51.308I(3) of the Regional Haze Rule requires states to determine their contributions to visibility impairment at mandatory Class I areas. Through source apportionment modeling (more fully described in Section 8.0, "Understanding the Sources of Visibility-Impairing Pollutants"), MANE-VU has identified and evaluated the major contributors to regional haze at MANE-VU Class I Areas as well as Class I areas in nearby RPOs. The complete findings are contained in a report produced by the Northeast States for Coordinated Air Quality Management (NESCAUM) entitled "Contributions to Regional Haze in the Northeast and Mid-Atlantic United States," August 2006, otherwise known as the Contribution Assessment (Attachment B).

The regional modeling performed by MANE-VU used a pollutant tagging scheme to produce a comprehensive assessment of the individual contributions from 28 nearby states to visibility impairment in Class I areas. The modeling also provided a partial accounting of the contributions from several states along the western and southern edges of the modeling domain (i.e., boundary conditions) where only a portion of the states' emissions were tracked. Modeling was conducted for the base year 2002 and then projected to year 2018, when currently anticipated emission control programs would be in place.

Modeling results indicate that the relative contributions of states within the modeling domain will decrease significantly by 2018 as a result of anticipated SO_2 emission reductions from implementation of existing state programs, the federal Clean Air Interstate Rule (CAIR), and additional state and federal control measures described in following sections of this document. At the same time, there will be large increases in the relative contributions from Canada and the boundary areas. These predicted increases are due simply to the fact that contributions from outside the modeling domain will represent a larger share of the total after the various emission control programs have reduced contributions from within the domain.

Figure 2.1 shows the magnitude of the 2002 (measured) and 2018 (projected) sulfate concentrations at Acadia National Park, as well as the relative mass contributions of each state, on the 20 percent worst visibility days. Similar findings apply to the other Class I areas (graphical figures for these other sites are available in the Contribution Assessment but, for brevity, are not repeated here). Note that, according to the source attribution modeling discussed below, the impact of Rhode Island emissions, relative to those from other states, is higher at Acadia than at other Class I areas

Figure 2.1: Measured and Projected Mass Contributions in 2002 and 2018 at Acadia National Park on 20 Percent Worst Visibility Days



IMPROVE mass 00-04 **REMSAD Contribution to Sulfate** **CMAQ RRF-Based 2018 Mass**

2.1 Class I Areas Affected by Rhode Island's Emission Sources

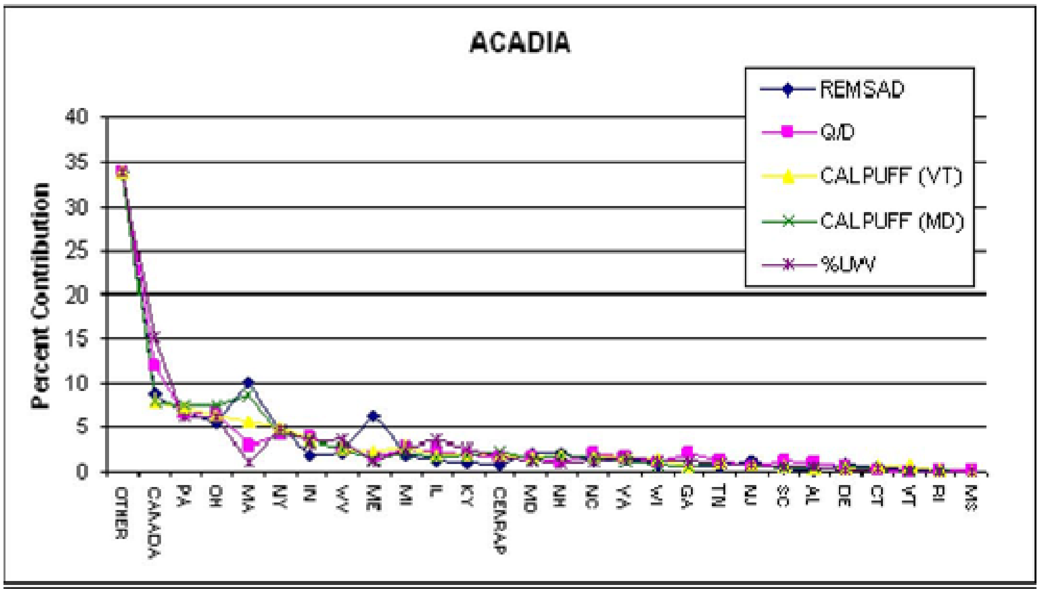
Emission sources within Rhode Island have minimal impacts on visibility at Class I areas. Table 2.1 lists the affected Class I areas and Rhode Island's percent contribution to total annual sulfate at each area in the 2002 baseline year, as determined using five different techniques for assessing state contribution. Despite the fact that those assessment techniques, which are described in Section 8 and, in more detail, in MANE-VU's Contribution Assessment (Attachment B) are based on the application of disparate chemical, meteorological and physical principles, the contribution of Rhode Island emissions to total sulfate was consistently determined to be no more than 0.31% of total sulfate at any of the Class I areas. Together, these findings create a strong weight-of-evidence case for the determination that Rhode Island emissions contribute minimally to visibility impairment in MANE-VU Class I areas.

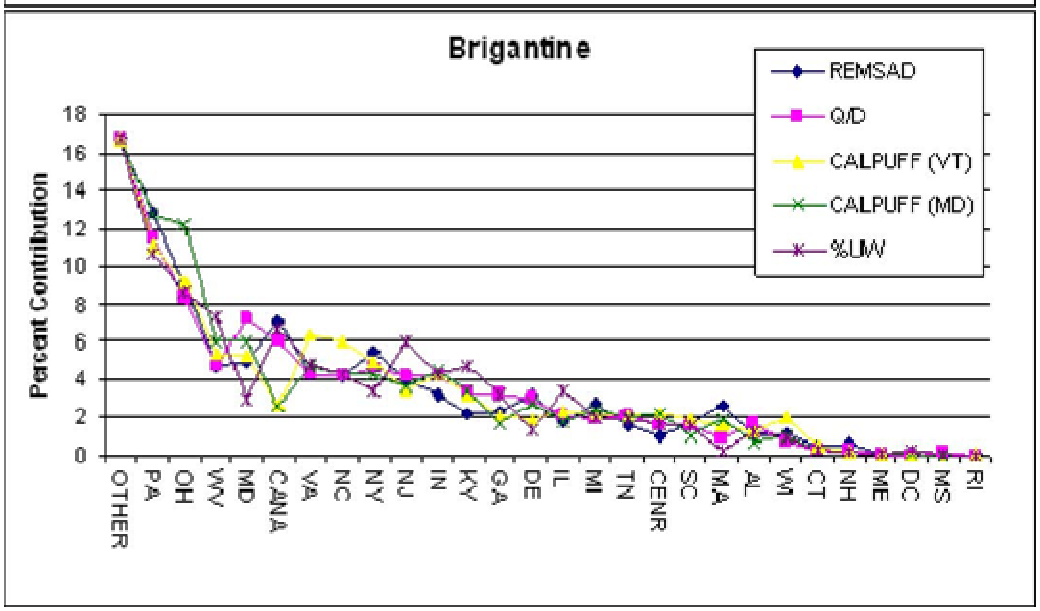
**Table 2.1: Rhode Island's Percent Contribution to Total Annual Average Sulfate Impact (Mass Basis) at Eastern Class I Areas in 2002
Calculated Using Five Different Modeling Techniques**

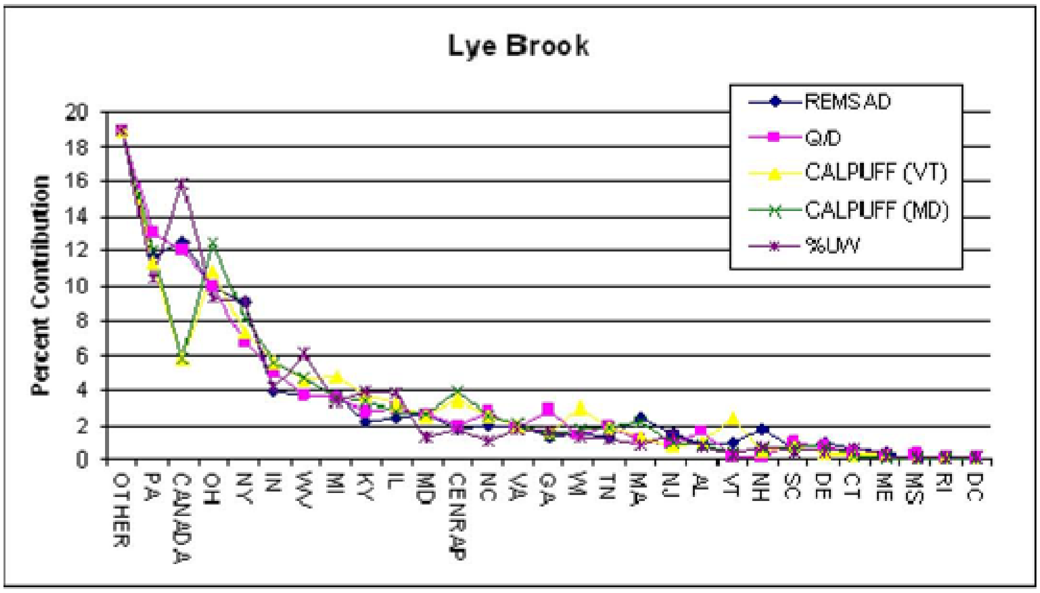
Class I Area	Modeling Technique				
	REMSAD	Q/D	CALPUFF (NWS)	CALPUFF (MM5)	% Upwind Method
Acadia National Park, ME	0.28	0.12	0.31	0.14	0.11
Moosehorn Wilderness & Roosevelt Campobello International Park, ME	0.19	0.06	0.22		0.09
Great Gulf Wilderness & Presidential Range - Dry River Wilderness, NH	0.11	0.08	0.08		0.08
Lye Brook Wilderness, VT	0.06	0.04	0.06	0.04	0.08
Brigantine Wilderness, NJ	0.1	0.05	0.14	0.04	0.05
Shenandoah National Park, VA	0.01	0.06	0.01	0.00	0.02
Dolly Sods Wilderness, WV	0.01	0.02	0.01		

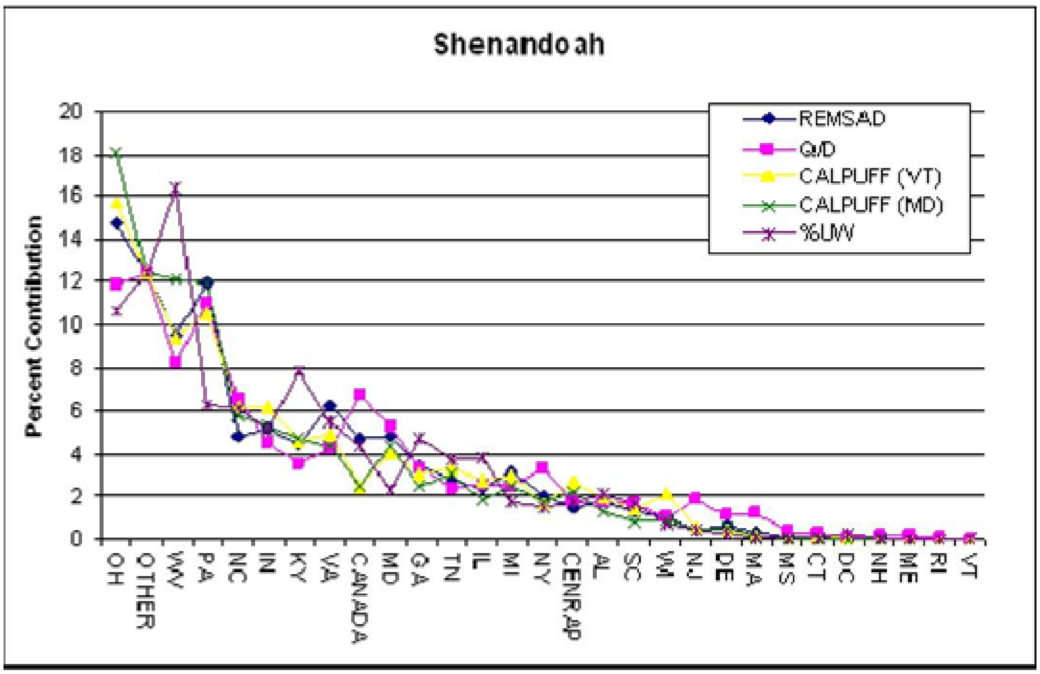
Figures 2.2 (a-d) show the ranking of the contributions of states to sulfate levels at four of the eastern Class I areas, including Acadia, using the five modeling techniques. In all cases, Rhode Island ranked last or next to last in contribution to sulfate levels at those areas, as compared to the other states.

Figure 2.2 (a-d): Comparison of normalized (percent contribution) results using different techniques for ranking state contributions to sulfate levels at the MANE-VU Class I sites(a) Acadia National Park, ME, (b) Brigantine Wilderness Area, NJ, (c)Lye Brook Wilderness Area, VT, and (d) Shenandoah National Park, VA.





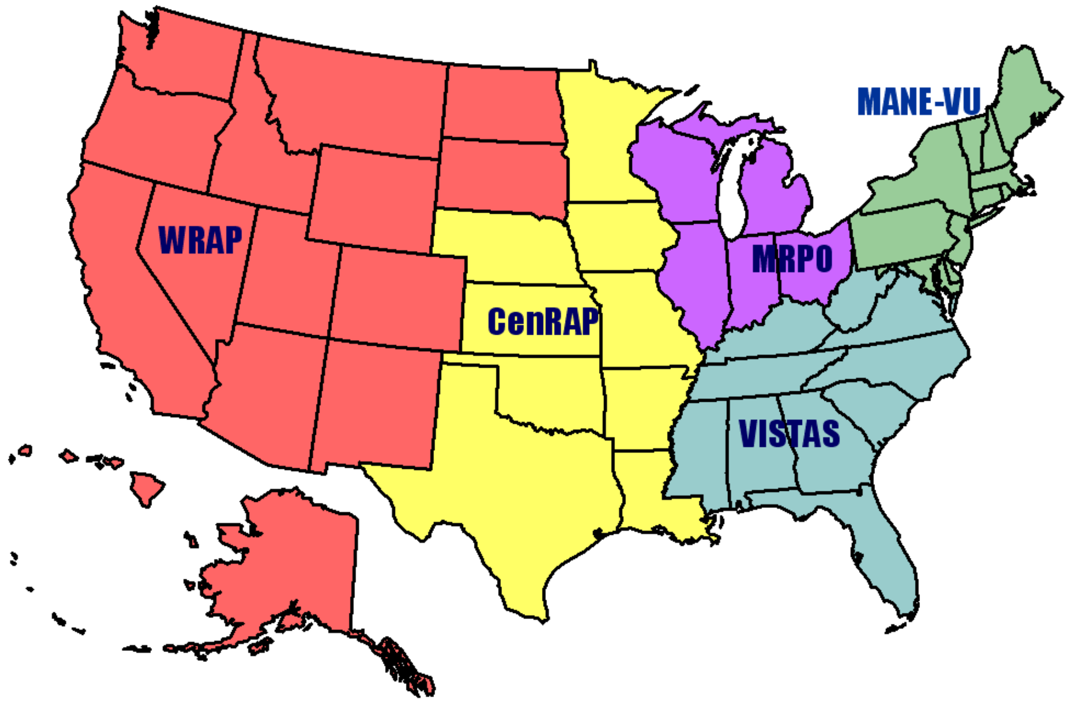




3.0 REGIONAL PLANNING AND CONSULTATION

In 1999, EPA and affected states/tribes agreed to create five RPOs to facilitate interstate coordination on Regional Haze SIPs.. The RPOs, and states/tribes within each RPO, are required to consult on emission management strategies toward visibility improvement in affected Class I areas. As shown in Figure 3.1, the five RPOs are MANE-VU (Mid-Atlantic/Northeast Visibility Union), VISTAS (Visibility Improvement State and Tribal Association of the Southeast), MRPO (Midwest Regional Planning Organization), CenRAP (Central Regional Air Planning Association), and WRAP (Western Regional Air Partnership). Rhode Island is a member of MANE-VU.

Figure 3.1: EPA-Designated Regional Planning Organizations (RPOs).



3.1 Mid-Atlantic / Northeast Visibility Union (MANE-VU)

MANE-VU's work is managed by the Ozone Transport Commission (OTC) and carried out by the OTC, the Mid-Atlantic Regional Air Management Association (MARAMA), and the Northeast States for Coordinated Air Use Management (NESCAUM). The states, tribes, and federal agencies comprising MANE-VU are listed in Table 3.1. Individuals from the member states, tribes, and agencies, along with professional staff from OTC, MARAMA, and NESCAUM, make up the various committees and workgroups. MANE-VU also established a Policy Advisory Group (PAG) to provide advice to decision-makers on policy questions. EPA, Federal Land Managers, states, and tribes are represented on the PAG, which meets on an as-needed basis.

Table 3.1: MANE-VU Members

Connecticut	Rhode Island
Delaware	Vermont
Maine	District of Columbia
Maryland	Penobscot Nation
Massachusetts	St. Regis Mohawk Tribe
New Hampshire	U.S. Environmental Protection Agency*
New Jersey	U.S. Fish and Wildlife Service*
New York	U.S. Forest Service*
Pennsylvania	U.S. National Park Service*

*Non-voting member

Since its inception on July 24, 2001, MANE-VU has created an active committee structure to address both technical and non-technical issues related to regional haze. The primary committees are the Technical Support Committee (TSC) and the Communications Committee, While the work of these committees are instrumental to policies and programs, all policy decisions reside with and are made by the MANE-VU Board.

The TSC is charged with assessing the nature and magnitude of the regional haze problem within MANE-VU, interpreting the results of technical work, and reporting on such work to the MANE-VU Board. This committee has evolved to function as a valuable resource on all technical projects and issues for MANE-VU. The TSC has established a process to ensure that important regional-haze-related projects are completed in a timely fashion, and members are kept informed of all MANE-VU tasks and duties. In addition to the formal working committees, there are three standing workgroups of the TSC assigned by topic area: the Emissions Inventory Workgroup, the Modeling Workgroup, and the Monitoring/Data Analysis Workgroup.

The Communications Committee is charged with developing approaches to inform the public about the regional haze problem and making recommendations to the MANE-VU Board to facilitate that goal. This committee oversees the production of MANE-VU's newsletter and outreach tools, both for stakeholders and the public, regarding regional issues affecting MANE-VU's members.

3.2 Regional Consultation and the Ask

On May 10, 2006, MANE-VU adopted the Inter-RPO State/Tribal and FLM Consultation Framework (Attachment C). That document set forth the principles presented in Table 3.2. The MANE-VU states and tribes applied these principles to the regional haze consultation and SIP development process. Issues addressed included regional haze baseline assessments, natural background levels, and development of reasonable progress goals – described at length in later sections of this SIP.

Table 3.2: MANE-VU Consultation Principles for Regional Haze Planning

1. All State, Tribal, RPO, and Federal participants are committed to continuing dialogue and information sharing in order to create understanding of the respective concerns and needs of the parties.
2. Continuous documentation of all communications is necessary to develop a record for inclusion in the SIP submittal to EPA.
3. States alone have the authority to undertake specific measures under their SIP. This inter-RPO framework is designed solely to facilitate needed communication, coordination and cooperation among jurisdictions but does not establish binding obligation on the part of participating agencies.
4. There are two areas which require State-to-State and/or State-to-Tribal consultations ("formal" consultations): (i) development of the reasonable progress goal for a Class I area, and (ii) development of long-term strategies. While it is anticipated that the formal consultation will cover the technical components that make up each of these policy decision areas, there may be a need for the RPOs, in coordination with their State and Tribal members, to have informal consultations on these technical considerations.
5. During both the formal and informal inter-RPO consultations, it is anticipated that the States and Tribes will work collectively to facilitate the consultation process through their respective RPOs, when feasible.
6. Technical analyses will be transparent, when possible, and will reflect the most up-to-date information and best scientific methods for the decision needed within the resources available.
7. The State with the Class I area retains the responsibility to establish reasonable progress goals. The RPOs will make reasonable efforts to facilitate the development of a consensus among the State with a Class I area and other States affecting that area. In instances where the State with the Class I area can not agree with such other States that the goal provides for reasonable progress, actions taken to resolve the disagreement must be included in the State's regional haze implementation plan (or plan revisions) submitted to the EPA Administrator as required under 40 CFR §51.308(d)(1)(iv).
8. All States whose emissions are reasonably anticipated to contribute to visibility impairment in a Class I area must provide the Federal Land Manager ("FLM") agency for that Class I area with an opportunity for consultation, in person, on their regional haze implementation plans. The States/Tribes will pursue the development of a memorandum of understanding to expedite the submission and consideration of the FLMs' comments on the reasonable progress goals and related implementation plans. As required under 40 CFR §51.308(i)(3), the plan or plan revision must include a description of how the State addressed any FLM comments. (Attachment I)
9. States/Tribes will consult with the affected FLMs to protect the air resources of the State/Tribe and Class I areas in accordance with the FLM coordination requirements specified in 40 CFR §51.308(i) and other consultation procedures developed by consensus.
10. The consultation process is designed to share information, define and document issues, develop a range of options, solicit feedback on options, develop consensus advice if possible, and facilitate informed decisions by the Class I States.
11. The collaborators, including States, Tribes and affected FLMs, will promptly respond to other RPOs'/States'/Tribes' requests for comments.

The following points offer a snapshot of several important ways in which MANE-VU member states and tribes have cooperatively addressed regional haze:

- *Prioritization*: MANE-VU developed a process to coordinate MARAMA, OTC, and NESCAUM staff in developing budget priorities, project rankings, and the eventual federal grant requests.
- *Issue Coordination*: MANE-VU established a conference call and meeting schedule for each of its committees and workgroups. In addition, its MANE-VU directors regularly discussed pertinent issues.
- *SIP Policy and Planning*: MANE-VU states/tribes collaborated on the development of a regional haze SIP template and the technical aspects of the SIP development process.
- *Capacity Building*: To educate its staff and members, MANE-VU included technical presentations on conference calls and organized workshops with nationally recognized experts. Presentations on data analysis, Best Available Retrofit Technology (BART) applicability, inventory topics, modeling, and control measures were effective education and coordination tools.
- *Routine Operations*: MANE-VU staff at OTC, MARAMA, and NESCAUM established a coordinated approach to budget tracking, project deliverables and due dates, workgroup meetings, inter-RPO consultations, etc.

Both formal and informal consultations within MANE-VU have been ongoing since the organization's establishment in 2001; but the bulk of formal consultation took place in 2007, as outlined in Table 3.3. Further documentation of consultation meetings and calls is included in Attachment D.

Table 3.3: Summary of MANE-VU's Consultations on Regional Haze Planning

MANE-VU Intra-Regional Consultation Meeting, March 1, 2007:

MANE-VU members reviewed the requirements for regional haze plans, preliminary modeling results, the work being done to prepare the MANE-VU report on reasonable progress factors, and control strategy options under review.

MANE-VU Intra-State Consultation Meeting, June 7, 2007:

The MANE-VU Class I states adopted a statement of principles, and all MANE-VU members discussed draft statements concerning reasonable controls within and outside of MANE-VU. Federal Land Managers also attended the meeting, which was open to stakeholders.

MANE-VU Conference Call, June 20, 2007:

The MANE-VU states concluded discussions of statements concerning reasonable controls within and outside MANE-VU and agreed on the statements called the MANE-VU Ask (see Part 3.2.2 of this SIP), including a statement concerning controls within MANE-VU, a statement concerning controls outside MANE-VU, and a statement requesting a course of action by the U.S. EPA. Federal Land Managers also participated in the call. Upon approval, all statements as well as the statement of principles adopted on June 7 were posted and publicly available on the MANE-VU website. The MANE-VU Ask was determined to represent New Hampshire's needs for meeting Regional Haze rule requirements and was thus adopted as the New Hampshire Ask.

MANE-VU Class I States' Consultation Open Technical Call, July 19, 2007:

The MANE-VU/New Hampshire Ask was presented to states in other RPOs, RPO staff, and Federal Land Managers; and an opportunity was provided to request further information. This call was intended to provide information to facilitate informed discussion at follow-up meetings.

MANE-VU Consultation Meeting with MRPO, August 6, 2007:

This meeting, held at LADCO offices in Chicago, was attended by representatives of MANE-VU and MRPO states as well as staff. The meeting provided an opportunity to formally present the MANE-VU/ New Hampshire Ask to MRPO states and to consult with them on the reasonableness of the requested controls. Federal Land Manager agencies also attended the meeting.

MANE-VU Consultation Meeting with VISTAS, August 20, 2007:

This meeting, held at State of Georgia offices in Atlanta, was attended by representatives of MANE-VU and VISTAS states. The meeting provided an opportunity to formally present the MANE-VU/New Hampshire Ask to VISTAS states and to consult with them on the reasonableness of the requested controls. Federal Land Manager agencies also attended the meeting.

MANE-VU / MRPO Consultation Conference Call, September 13, 2007:

As a follow-up to the meeting held on August 6 in Chicago, this call provided an opportunity for MANE-VU to clarify further what was being asked of the MRPO states. The flexibility in the Ask was explained. MRPO and MANE-VU staff agreed to work together to facilitate discussion of further controls on ICI boilers and EGUs.

MANE-VU Air Directors' Consultation Conference Call, September 26, 2007:

MANE-VU members clarified their understanding of the Ask and provided direction to modeling staff regarding interpretation of the Ask for purposes of estimating visibility impacts of the requested controls.

3.2.1 The MANE-VU Ask

In addition to having a set of guiding principles for consultation (as described in Table 3.2, above), MANE-VU needed a consistent technical basis for emission control strategies to combat regional haze. After much research and analysis, on June 20, 2007, MANE-VU adopted the following pair of documents (available in Attachment E), which provide the technical basis for consultation among the interested parties and define the basic strategies for controlling pollutants that cause visibility impairment at Class I areas in the eastern U.S. Together, these documents are known as the MANE-VU Ask.:

- "Statement of the Mid-Atlantic / Northeast Visibility Union (MANE-VU) Concerning a Course of Action within MANE-VU toward Assuring Reasonable Progress," and
- "Statement of the Mid-Atlantic / Northeast Visibility Union (MANE-VU) Concerning a Request for a Course of Action by States outside of MANE-VU toward Assuring Reasonable Progress."

3.2.1.1 Meeting the Ask – MANE-VU States

The member states of MANE-VU have stated their intention to meet the terms of the Ask in their individual State Implementation Plans. The Ask for member states promises that each state will pursue the adoption and implementation of the following emission management strategies, as appropriate and necessary:

- ***Timely implementation of BART requirements***, in accordance with 40 CFR 51.308(e).
- ***A low-sulfur fuel oil strategy in the inner zone states*** (New Jersey, New York, Delaware and Pennsylvania, or portions thereof) to reduce the sulfur content of: distillate oil to 0.05% sulfur by weight (500 ppm) by no later than 2012, of #4 residual oil to 0.25% sulfur by weight by no later than 2012, of #6 residual oil to 0.3-0.5% sulfur by weight by no later than 2012, and to reduce the sulfur content of distillate oil further to 15 ppm by 2016;
- ***A low-sulfur fuel oil strategy in the outer zone states*** (the remainder of the MANE-VU region) to reduce the sulfur content of distillate oil to 0.05% sulfur by weight (500 ppm) by no later than 2014, of #4 residual oil to 0.25-0.5% sulfur by weight by no later than 2018, and of #6 residual oil to no greater than 0.5 % sulfur by weight by no later than 2018, and to reduce the sulfur content of distillate oil further to 15 ppm by 2018, depending on supply availability;
- ***A targeted EGU strategy*** for the top 100 electric generating unit (EGU) emission points, or stacks, identified by MANE-VU as contributing to visibility impairment at each mandatory Class I area in the MANE-VU region. (The combined list for all seven MANE-VU Class I Areas contains 167 distinct emission points. Consequently, this strategy is sometimes referred to as the 167-stack strategy.) The targeted EGU strategy calls for a ninety percent or greater reduction in sulfur dioxide (SO_2) emissions

from all identified units. If it is infeasible to achieve that level of reduction from specific units, equivalent alternative measures will be pursued in such state; and

- ***Continued evaluation of other control measures***, including improvements in energy efficiency, use of alternative (clean) fuels, further control measures to reduce SO_2 and nitrogen oxide (NO_X) emissions from all coal-burning facilities by 2018, and new source performance standards for wood combustion. These and other measures will be evaluated during the consultation process to determine whether they are reasonable strategies to pursue.

⇨ **RIDEM supports the SIPs of each of its fellow MANE-VU states, provided that these commitments are incorporated into approvable State Implementation Plans.**

3.2.1.2 Meeting the Ask – Rhode Island

Rhode Island, being a MANE-VU member state, adopted the Ask at the MANE-VU Board meeting on June 7, 2007. Rhode Island will meet those commitments as follows:

- ***Implementation of BART requirements:*** RI DEM performed an analysis of sources in the State and determined that there are no BART-eligible Rhode Island sources.
- ***Low-sulfur fuel oil strategy in the outer zone states***: RI DEM is committed to adopting enforceable requirements limiting the sulfur content of distillate oil to 0.05% sulfur by weight (500 ppm) by no later than 2014, of #4 residual oil to 0.25-0.5% sulfur by weight by no later than 2018, and of #6 residual oil to no greater than 0.5 % sulfur by weight by no later than 2018, and to further reduce the sulfur content of distillate oil further to 15 ppm by 2018, if MANE-VU verifies that these measures are feasible by those dates, considering supply availability; These requirements will apply to EGUs, Industrial, Commercial and Institutional (ICI) boilers and home heating units.
- ***Targeted EGU strategy:*** None of the 167 EGU emission points identified in this strategy are located in Rhode Island.
- ***Continued evaluation of other control measures:*** Rhode Island will continue to work in consultation with Class I states to identify additional reasonable and cost-effective control measures as needed. The General Assembly in Rhode Island has under consideration, in the 2009 session, legislation that would impose requirements on the sale, use and installation of outdoor wood boilers. If enacted in its present form, this legislation would require RI DEM to promulgate regulations to restrict the sale of outdoor wood boilers equipment that has been certified to meet EPA's Phase II requirements, effective July 1, 2010. Other requirements of the legislation would be administered by cities and towns.

3.2.1.3 Meeting the Ask – States outside MANE-VU

Rhode Island agrees with the MANE-VU Ask for consulting states outside the MANE-VU region. This Ask requests the affected states to pursue adoption and implementation of the following control strategies, as appropriate and necessary:

- ***Timely implementation of BART requirements***, as described for the MANE-VU states;
- ***A targeted EGU strategy***, as described for the MANE-VU states, for the top 167 EGU stacks contributing the most to visibility impairment at mandatory Class I areas in the MANE-VU region, or an equivalent SO_2 emission reduction within each state;
- ***Installation of reasonable control measures on non-EGU sources*** by 2018 to achieve an additional 28 percent reduction in non-EGU SO_2 emissions beyond current on-the-books/on-the-way (OTB/OTW) measures, resulting in an emission reduction that is equivalent to that from MANE-VU's low-sulfur fuel oil strategy (see Section 11.0, Long-Term Strategy);
- ***Continued evaluation of other control measures***, including additional reductions in SO_2 and NO_X emissions from all coal-burning facilities by 2018 and promulgation of new source performance standards for wood combustion. These and other measures will be evaluated during the consultation process to determine whether they are reasonable strategies to pursue.

There is concern within MANE-VU that non-MANE-VU states may not adopt MANE-VU's Ask because of the associated costs, potential conflicts, and relative lack of perceived benefits within their jurisdictions. On the basis of consultations held, MANE-VU members believe that some non-MANE-VU states will choose not to pursue reductions beyond CAIR controls and other measures pertaining to BART requirements. Rhode Island understands that, among non-MANE-VU states that have already submitted their regional haze SIPs to EPA, a number of the affected states have decided not to address major elements of the MANE-VU Ask in their plans.

There are some positive developments, however. Many states of the MRPO are working with MANE-VU states to investigate the potential for widespread use of low-sulfur fuel oil and installation of emission controls on ICI boilers within their region. The Midwest states would be more likely than Southeast states to adopt a low-sulfur oil strategy because the VISTAS states do not have the same extent of fuel oil usage and lack the inventory infrastructure found in more northerly states. Both MRPO and VISTAS claim that a substantial portion of the top 167 contributing EGU stacks will be controlled. However, instead of taking concrete actions on uncontrolled or under-controlled facilities, many of these states appear to be satisfied with meeting CAIR-equivalent requirements and not looking beyond this level of emission controls for additional emission reductions. Further discussion of these issues is provided in Part 3.2.3, below.

3.2.2 Technical Ramifications of Differing Approaches

MANE-VU states intended to develop a modeling platform that was common in terms of meteorology and emissions with each of the other nearby RPOs. The RPOs worked hard to form a common set of emissions with similar developmental assumptions. Even with the best of intentions, however, it became difficult to keep up with each RPO's updates and corrections. Each iteration of the emissions inventory improved its quality, but each update to one RPO's emissions required the other RPOs to adopt the updates. With each iteration, the revised emissions had to be re-blended with the full set of emission files for all associated RPOs in the modeling domain. Because each rendition put previous modeling efforts out of date, and a single modeling run could take more than a month to complete, inventory updates have contributed to SIP delays. The emission inventory conflicts have been excessively time-consuming.

The RPOs also took differing perspectives on which version of the EGU dispatching model to use. At the beginning of the process, International's Integrated Planning Model (IPM) version 2.1.9 was available, and EPA agreed to its use for emissions preparation. Subsequently, IPM version 3.0 became available and was preferred by some users because of its updated fuel costs. MRPO adopted IPM v3.0 for its use, but VISTAS stayed with IPM v2.1.9. Rather than develop non-comparative datasets for its previous IPM analyses, MANE-VU opted also to remain with IPM v2.1.9. Therefore, for the three eastern RPOs, differing emissions assumptions eventually worked their way into the final set of modeling assumptions.

MANE-VU's most recent visibility projections take into account on-the-books/on-the-way (OTB/OTW) emissions control programs for 2018, and go further by including additional reasonable controls in the region, as developed through the MANE-VU Ask. It should be noted that other RPOs may not have included such measures in their final modeling and, as a result, may have been able to complete their analyses ahead of those for the MANE-VU states. Where that is the case, those states' modeling results will be inconsistent with meeting the terms of the Ask – a situation that may not be adequately addressed in their individual SIPs.

3.2.3 State/Tribe and Federal Land Manager Coordination

Rhode Island will continue to coordinate and consult with the Federal Land Managers (FLMs) during the development of future progress reports and plan revisions, as well as during the implementation of programs having the potential to contribute to visibility impairment in the mandatory Class I areas.

40 CFR 51.308(i) of the Regional Haze Rule requires coordination between states/tribes and the FLMs. Opportunities have been provided by MANE-VU for FLMs to review and comment on each of the technical documents developed by MANE-VU and included in this SIP. Rhode Island has identified agency contacts to the FLMs as required under 40 CFR 51.308(i)(1). Rhode Island has consulted with the FLMs in the development of this plan and, in accordance with 40 CFR 51.308(i)(2), has provided the FLMs an opportunity for consultation, in person, at least 60 days prior to holding any public hearing on the SIP. This SIP was submitted to the FLMs on January 26, 2009 for review and comment.

40 CFR 51.308(i)(4) requires procedures for continuing consultation between the states/tribes and FLMs on the implementation of the visibility protection program. In particular, Rhode Island will consult with the designated visibility protection program coordinators for the National Park Service, U. S. Fish and Wildlife Service, and U.S. Forest Service, periodically and as circumstances require, on the following implementation items:

1. Status of emissions strategies identified in the SIP as contributing to improvements in the worst-day visibility;
2. Summary of major new source permits issued;
3. Status of Rhode Island's actions toward completing any future assessments or

rulemakings on sources identified as probable contributors to visibility impairment, but not directly addressed in the most recent SIP revision;

4. Any changes to the monitoring strategy or status of monitoring stations that might affect tracking of reasonable progress;
5. Work underway for preparing the 5-year SIP review and/or 10-year SIP revision, including any items where the FLMs' consideration or support is requested; and
6. Summary of topics discussed in ongoing communications (e.g., meetings, emails, etc.) between Rhode Island and the FLMs regarding implementation of the visibility improvement program.

4.0 ASSESSMENT OF BASELINE AND NATURAL VISIBILITY CONDITIONS

Pursuant to 40 CFR 51.308(d)(2) of the Regional Haze Rule, states must determine baseline and natural visibility conditions for each Class I area within their jurisdictions. This information allows states to assess current levels of visibility degradation and provides a basis for setting reasonable progress goals toward restoration of natural visibility conditions in Class I areas. As discussed previously, there are no Class I areas in Rhode Island; however, an assessment of baseline and natural visibility conditions in the Class I areas in the MANE-VU region is presented here for informational purposes.

The Interagency Monitoring of Protected Visual Environments (IMPROVE) program was established in 1985 to provide the data necessary to support the creation of Federal and State implementation plans for the protection of visibility in Class I areas. IMPROVE has made it possible to assess current visibility conditions, track changes in visibility, and identify the chemical species and emission sources responsible for visibility impairment. In particular, IMPROVE data were used to calculate baseline and natural conditions for MANE-VU Class I Areas.

The IMPROVE monitors listed in Table 4.1 provide data representative of Class I Areas in the MANE-VU region.

Table 4.1: IMPROVE Monitors for MANE-VU Class I Areas

IMPROVE Site / Location	Class I Area(s) Served	Latitude, Longitude	State
ACAD1 Acadia National Park	Acadia National Park	44.38, -68.26	Maine
MOOS1 Moosehorn Wilderness	Moosehorn Wilderness; Roosevelt Campobello International Park	45.13, -67.27	Maine
GRGU1 Great Gulf Wilderness	Great Gulf Wilderness; Presidential Range - Dry River Wilderness	44.31, -71.22	New Hampshire
LYBR1 Lye Brook Wilderness	Lye Brook Wilderness	43.15, -73.13	Vermont
BRIG1 Brigantine National Wildlife Refuge	Brigantine National Wildlife Refuge	39.47, -74.45	New Jersey

http://www.vista.circa.colostate.edu/views/; http://vista.cira.colostate.edu/improve/

4.1 Calculation Methodology

In September 2003, EPA issued guidance for the calculation of natural background and baseline visibility conditions. The guidance provided a default method and described certain refinements that states might consider in order to tailor their estimates to any Class I areas not adequately represented by the default method. At that time, MANE-VU calculated natural visibility for each of the MANE-VU Class I Areas using the default method for the 20 percent best and 20 percent worst visibility days. MANE-VU also evaluated ways to refine those estimates. Potential refinements included 1) increasing the multiplier used to calculate impairment attributed to carbon, 2) adjusting the formula used to calculate the 20 percent best and worst visibility days, and 3) accounting for visibility impairment caused by sea salt at coastal sites. However, MANE-VU found that these refinements did not significantly improve the accuracy of the estimates, and MANE-VU states desired a consistent approach to visibility assessment. Therefore, default estimates were used with the understanding that this methodology would be reconsidered upon demonstrated improvements in the science.

Once the technical analysis of visibility conditions was complete, MANE-VU provided an opportunity to comment to federal agencies and stakeholders. The proposed approach to visibility assessment was posted on the MANE-VU website on March 17, 2004, and a stakeholder briefing was held on the same day. Comments were received from the Electric Power Research Institute (EPRI), the Midwest Ozone Group (MOG), the Appalachian Mountain Club, the National Parks Conservation Association, the National Park Service, and the US Forest Service.

Several comments supported the proposed approach in general; other comments were divided among four main topics: 1) the equation used to calculate visibility, 2) the statistical technique used to estimate the 20 percent best and worst visibility days, 3) the inclusion of transboundary effects and fires, and 4) the timing as to when new information should be included. All comments were reviewed and summarized by MANE-VU; and air directors were briefed on comments, proposed response options, and implications. Attachment J provides a compilation of comments received and a summary of stakeholders' comments.

MANE-VU's position on natural background conditions was presented in a report issued in June 2004 (see Attachment K, "Natural Background Visibility Conditions: Considerations and Proposed Approach to the Calculation of Natural Background Visibility Conditions at MANE-VU Class I Areas," June 10, 2004). The report stated, "Refinements to other aspects of the default method (e.g., refinements to the assumed distribution or treatment of Rayleigh extinction, inclusion of sea salt, and improved assumptions about the chemical composition of the organic fraction) may be warranted prior to submission of SIPs depending on the degree to which scientific consensus is formed around a specific approach…"

In 2006, the IMPROVE Steering Committee adopted an alternative reconstructed extinction equation to revise certain aspects of the default method. The scientific basis for these revisions was well understood, and the Committee determined that the revisions improved the performance of the equation at reproducing observed visibility at Class I sites.

In 2006, MANE-VU conducted an assessment of the default and alternative approaches for calculation of baseline and natural background conditions at MANE-VU Class I Areas. Based on that assessment, in December 2006, MANE-VU recommended adoption of the alternative reconstructed extinction equation for use in the regional haze SIPs. (See Attachment L, "Baseline and Natural Background Visibility Conditions: Considerations and Proposed Approach to the Calculation of Baseline and Natural Background Visibility Conditions at MANE-VU Class I Areas," December 2006.) MANE-VU will continue to participate in further research efforts on this topic and will reconsider the calculation methodology as scientific understanding evolves.

4.2 MANE-VU Baseline Visibility

The IMPROVE program has calculated the 20 percent best and 20 percent worst baseline (2000-2004) and natural visibility conditions using the EPA-approved alternative method described above for each MANE-VU Class I Area. The data are posted on the Visibility Information Exchange Web System (VIEWS) operated by the regional planning organizations. The information can be accessed at http://vista.cira.colostate.edu/views/) and is summarized in Table 4.2 below. Displayed are the five-year average baseline visibility values for the period 2000-2004, natural visibility levels, and the difference between baseline and natural visibility values for each of the MANE-VU Class I Areas. The difference columns (best and worst) are of particular interest because they describe the magnitude of visibility impairment attributable to manmade emissions, which are the focus of the Regional Haze Rule.

The five-year averages for 20 percent best and worst visibility were calculated in accordance with 40 CFR 51.308(d)(2), as detailed in NESCAUM's Baseline and Natural Background document found in Attachment L.

Table 4.2: Summary of Baseline Visibility and Natural Visibility Conditions for the 20 Percent Best and 20 Percent Worst Visibility Days at MANE-VU Class I Areas

Class I Area(s)	2000-2004 Baseline (deciviews)		Natural Conditions (deciviews)		Difference (deciviews)	
	Best 20%	Worst 20%	Best 20%	Worst 20%	Best 20%	Worst 20%
Acadia National Park	8.8	22.9	4.7	12.4	4.1	10.5
Moosehorn Wilderness and Roosevelt Campobello International Park	9.2	21.7	5.0	12.0	4.1	9.7
Great Gulf Wilderness and Presidential Range - Dry River Wilderness [9]	7.7	22.8	3.7	12.0	3.9	10.8
Lye Brook Wilderness	6.4	24.5	2.8	11.7	3.6	12.7
Brigantine Wilderness	14.3	29.0	5.5	12.2	8.8	16.8

Source: VIEWS (http://vista.circa.colostate.edu/views/), prepared on 6/22/2007

[9] Based on 4-year average for 2001-2004 (data collection in 2000 was for summer only).

5.0 AIR MONITORING STRATEGY

In the mid-1980's, the Interagency Monitoring of Protected Visual Environments (IMPROVE) program was established to measure visibility impairment in mandatory Class I areas throughout the United States. The monitoring sites are operated and maintained through a formal cooperative relationship between the U.S. EPA, National Park Service, U.S. Fish and Wildlife Service, Bureau of Land Management, and U.S. Forest Service. In 1991, several additional organizations joined the effort: State and Territorial Air Pollution Program Administrators and the Association of Local Air Pollution Control Officials (which have since merged under the name National Association of Clean Air Agencies), Western States Air Resources Council, Mid-Atlantic Regional Air Management Association, and Northeast States for Coordinated Air Use Management.

Although no IMPROVE sites are located in the State of Rhode Island, RI DEM supports the continued operation of that network. RI DEM agrees that the IMPROVE network is an appropriate monitoring network to track Regional Haze progress and agrees to work with neighboring states and FLMs in meeting the goals of the IMPROVE program.

5.1 IMPROVE Program Objectives

The IMPROVE program provides scientific documentation of the visual air quality of America's wilderness areas and national parks. Many individuals and organizations – land managers; industry planners; scientists, including university researchers; public interest groups; and air quality regulators – use the data collected at IMPROVE sites to understand and protect the visual air quality resource in Class I areas. Major objectives of the IMPROVE program include the following:

- Establish current visibility and aerosol conditions in mandatory Class I areas;
- Identify chemical species and emission sources responsible for existing anthropogenic visibility impairment;
- Document long-term trends for assessing progress towards the national visibility goals;
- Provide regional haze monitoring for all visibility-protected federal Class I areas where practical, as required by EPA's Regional Haze Rule.

5.2. Monitoring Information for Rhode Island

Section 51.308(d)(4)(iii) of EPA's Regional Haze Rule requires the inclusion of procedures by which monitoring data and other information are used in determining the contribution of emissions from within the State to regional haze visibility impairment at mandatory Class I areas both within and outside the State. MANE-VU and Rhode Island accept the contribution assessment analysis completed by NESCAUM entitled, Contributions to Regional Haze in the Northeast and Mid-Atlantic States (Appendix A). The methods of visibility and emissions data analysis used in preparing the Contribution Assessment include source apportionment analysis, trajectory analysis, emissions divided by distance, emissions times upwind probability, chemical transport models, and Lagrangian dispersion modeling. The many techniques used provided a stronger weight of evidence for the assessment of contribution by source types and regions.

Rhode Island agrees that NESCAUM is providing quality technical information by using the IMPROVE program data and the VIEWS site. Information about the use of the default and alternative approaches to the calculation of baseline and natural background conditions can be found in Section 3 of this SIP.

Rhode Island does not contain any Class I Areas; therefore no monitoring plan is required under Section 51.308(d)(4) or Section 51.305 of EPA's Regional Haze rule. The following information is for monitoring within Class I areas determined to be impacted by Rhode Island sources by the Contribution Assessment contained in Appendix B.

5.3 Monitoring Sites for MANE-VU Class I Areas

IMPROVE monitoring sites have been established for each of the Class I areas in the region. The Great Gulf Wilderness and Presidential Range - Dry River Wilderness share a single monitoring site. Similarly, Moosehorn Wilderness and Roosevelt Campobello International Park share a monitoring site. Each of the other MANE-VU Class I Areas has its own monitoring site.

5.3.1 Acadia National Park, Maine

The IMPROVE monitor for Acadia National Park (ACAD1) is located at park headquarters, near Bar Harbor, Maine, at elevation 157 meters, latitude 44.38˚, and longitude -68.26˚. This monitor is operated and maintained by the National Park Service. Rhode Island considers the ACAD1 site as adequate for assessing reasonable progress toward visibility goals at Acadia National Park, and no additional monitoring sites or equipment are necessary at this time.

Figure 5.1: Map of Acadia National Park Showing Location of IMPROVE Monitor

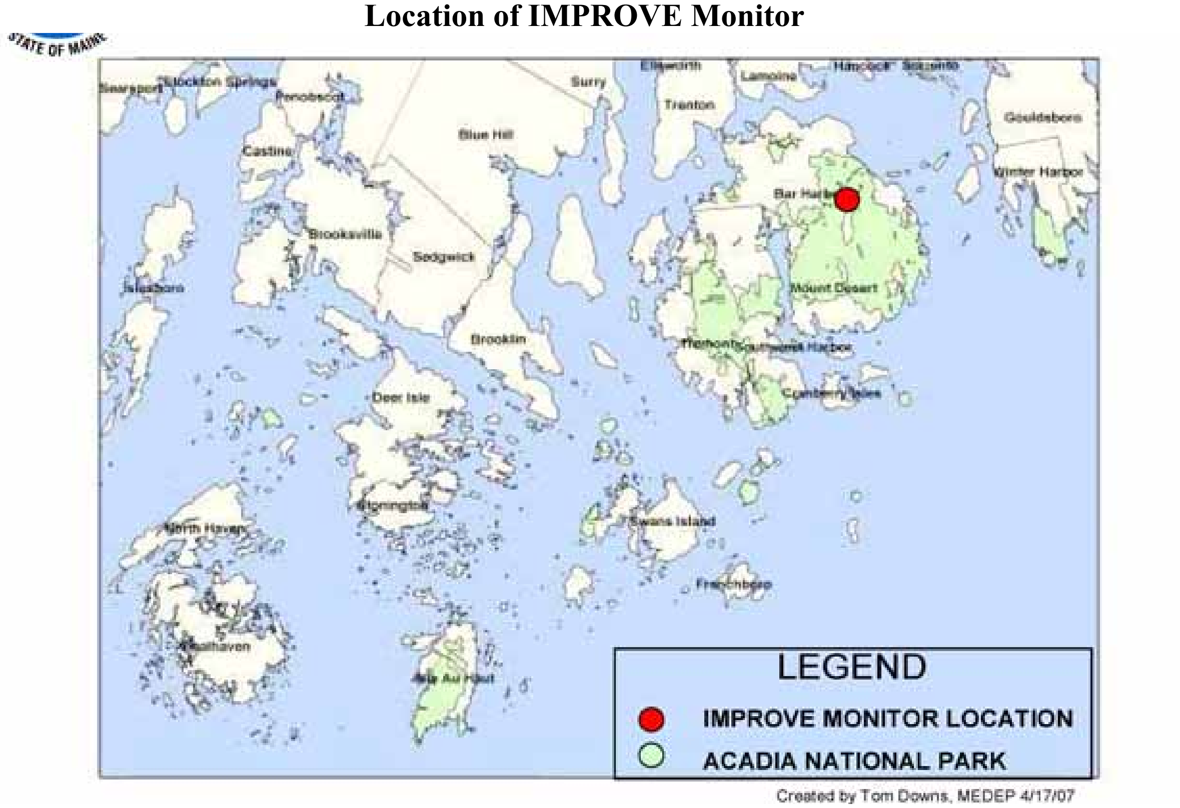


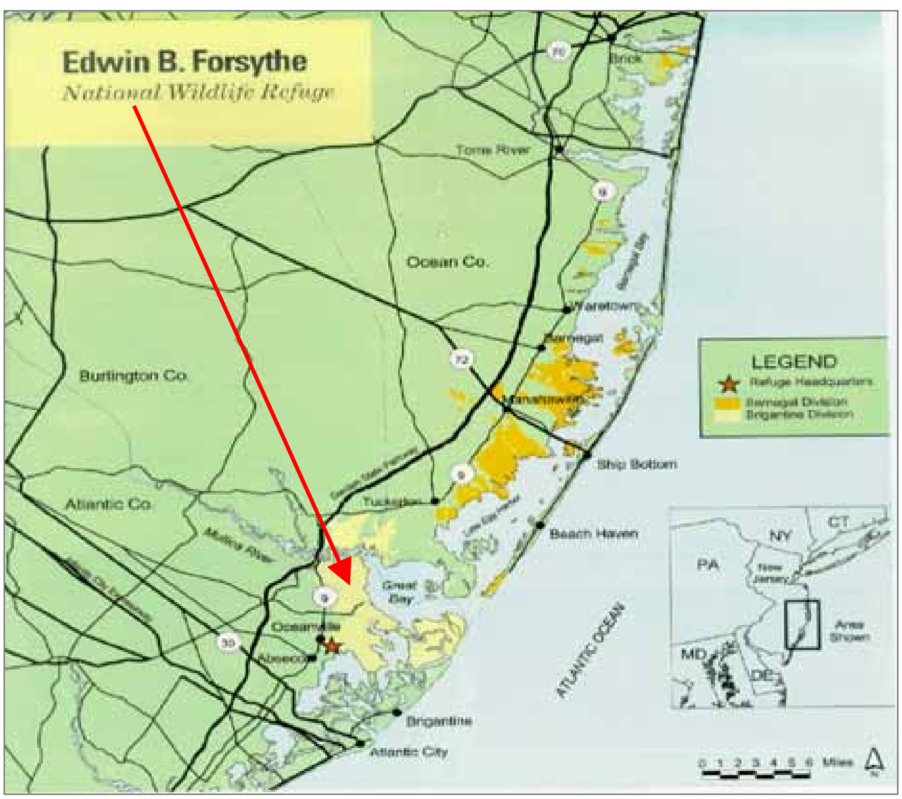
Figure 5.2: Acadia National Park on Clear and Hazy Days

http://www.hazecam.net/class1/acadia.html

5.3.2 Brigantine Wilderness, New Jersey

The IMPROVE monitor for the Brigantine Wilderness (BRIG1) is located at the Edwin B. Forsythe National Wildlife Refuge Headquarters in Oceanville, New Jersey, at elevation 5 meters, latitude 39.47˚, and longitude -74.45˚. This monitor is operated and maintained by the U.S. Fish & Wildlife Service. Rhode Island considers the BRIG1 site as adequate for assessing reasonable progress toward visibility goals at the Brigantine Wilderness, and no additional monitoring sites or equipment are necessary at this time.

Figure 5.3: Map of Edwin B. Forsythe National Wildlife Refuge



http://www.fws.gov/northeast/forsythe/MAP.htm

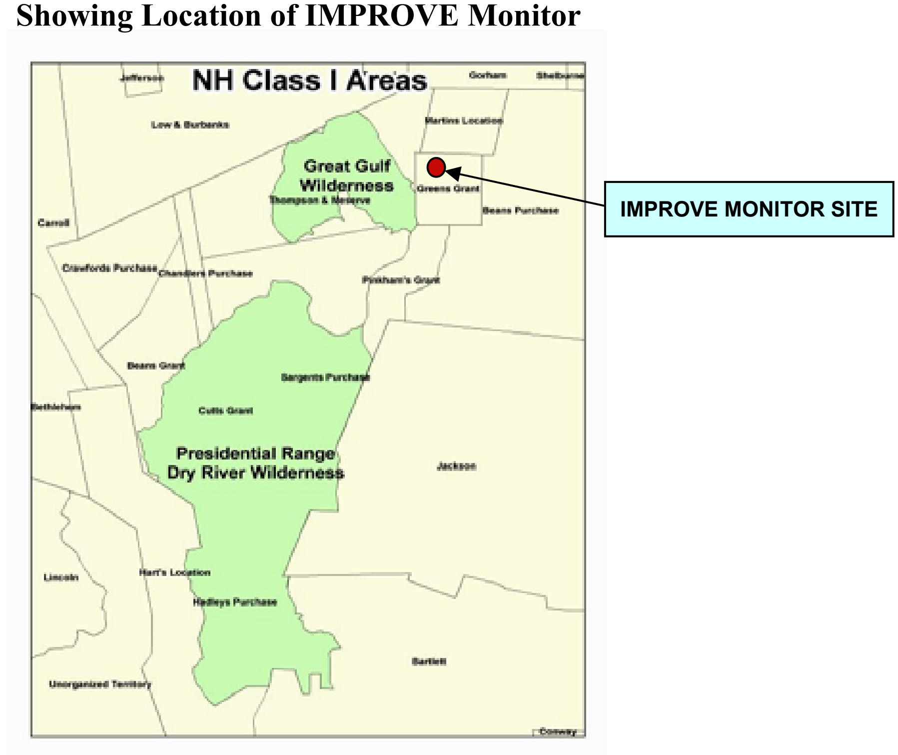
Figure 5.4: Brigantine Wilderness on Clear and Hazy Days

http://www.hazecam.net/class1/brigantine.html

5.3.3 Great Gulf Wilderness, New Hampshire

The IMPROVE monitor for the Great Gulf Wilderness (GRGU1) is located at Camp Dodge, in the mid-northern area of Greens Grant in the White Mountain National Forest. The monitor site lies just east and south of where Route 16 crosses the Greens Grant / Martins Location boundary, south of Gorham, New Hampshire, at elevation 454 meters, latitude 44.31˚, and longitude of -71.22˚. This monitor, which also represents the Presidential Range - Dry River Wilderness (see 5.3.4 below), is operated and maintained by the U.S. Forest Service. Rhode Island considers the GRGU1 site as adequate for assessing reasonable progress toward visibility goals at the Great Gulf Wilderness, and no additional monitoring sites or equipment are necessary at this time.

Figure 5.5: Map of Great Gulf and Presidential Range - Dry River Wilderness Areas Showing Location of IMPROVE Monitor



http://www.maine.gov/dep/air/meteorology/images/NHclass1.jpg

Figure 5.6: Great Gulf Wilderness on Clear and Hazy Days

http://www.wilderness.net

5.3.4 Presidential Range - Dry River Wilderness, New Hampshire

The IMPROVE monitor for the Presidential Range - Dry River Wilderness is also the monitor for Great Gulf Wilderness (GRGU1), as described above. Rhode Island considers the GRGU1 site as adequate for assessing reasonable progress toward visibility goals at the Presidential Range - Dry River Wilderness, and no additional monitoring sites or equipment are necessary at this time.

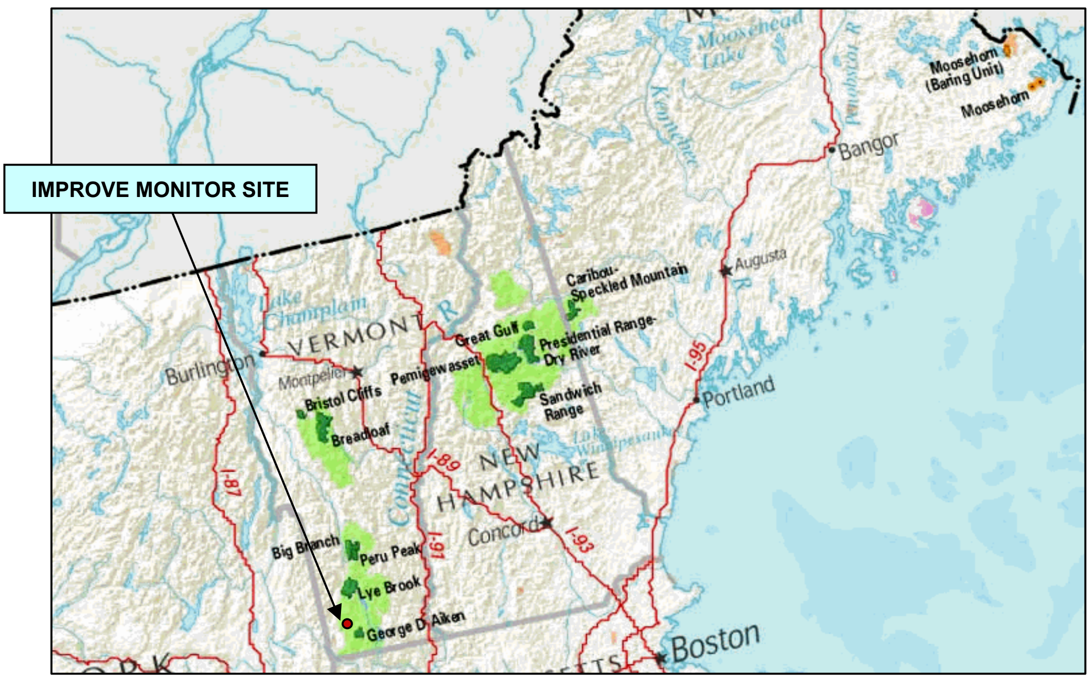
Figure 5.7: Presidential Range - Dry River Wilderness in Autumn

http://www.wilderness.net

5.3.5 Lye Brook Wilderness, Vermont

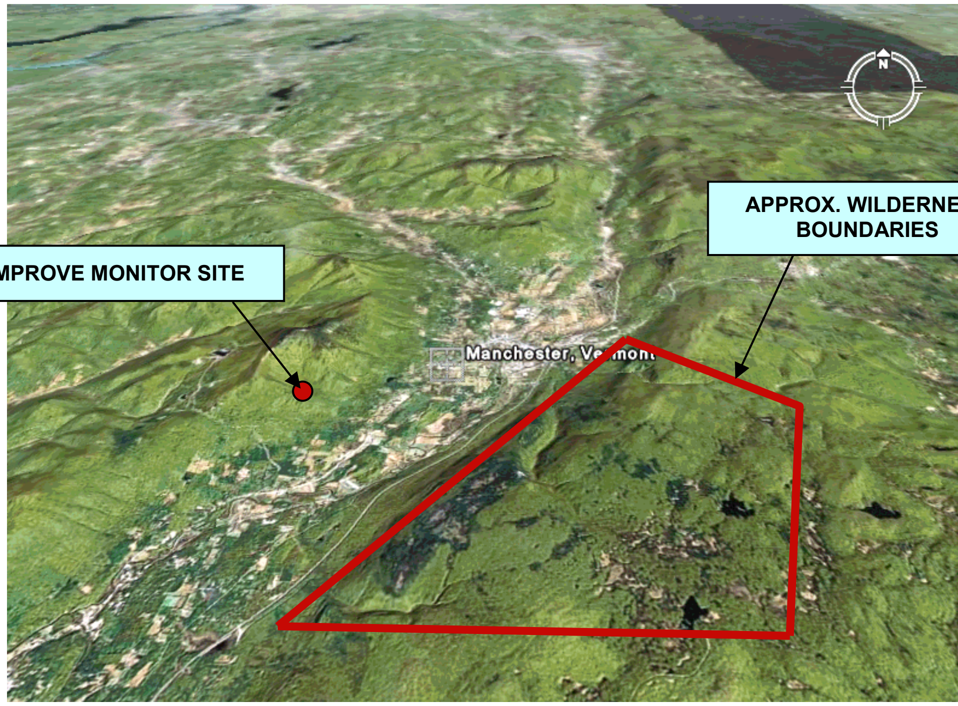
The IMPROVE monitor for the Lye Brook Wilderness (LYBR1) is located on Mount Equinox at the windmills in Manchester, Vermont, at elevation 1015 meters, latitude 43.15˚, and longitude of -73.13˚. The monitor does not lie within the wilderness area but is situated on a mountain peak across the valley to the west of the wilderness area. The IMPROVE site and the Lye Brook Wilderness are at similar elevations. The monitor is operated and maintained by the U.S. Forest Service. Rhode Island considers the LYBR1 site as adequate for assessing reasonable progress toward visibility goals at the Lye Brook Wilderness, and no additional monitoring sites or equipment are necessary at this time.

Figure 5.8: Location of Lye Brook Wilderness IMPROVE Monitor



http://www.wilderness.net/index.cfm?fuse=NWPS&sec=stateView&state=NH&map=menhvt

Figure 5.9: Aerial View of Lye Brook Wilderness IMPROVE Monitoring Site



sources: GoogleEarth; and Paul Wishinski, Vermont DEC, Air Pollution Control Division

Figure 5.10: Lye Brook Wilderness on Clear and Hazy Days

http://www.hazecam.net/class1/lye.html

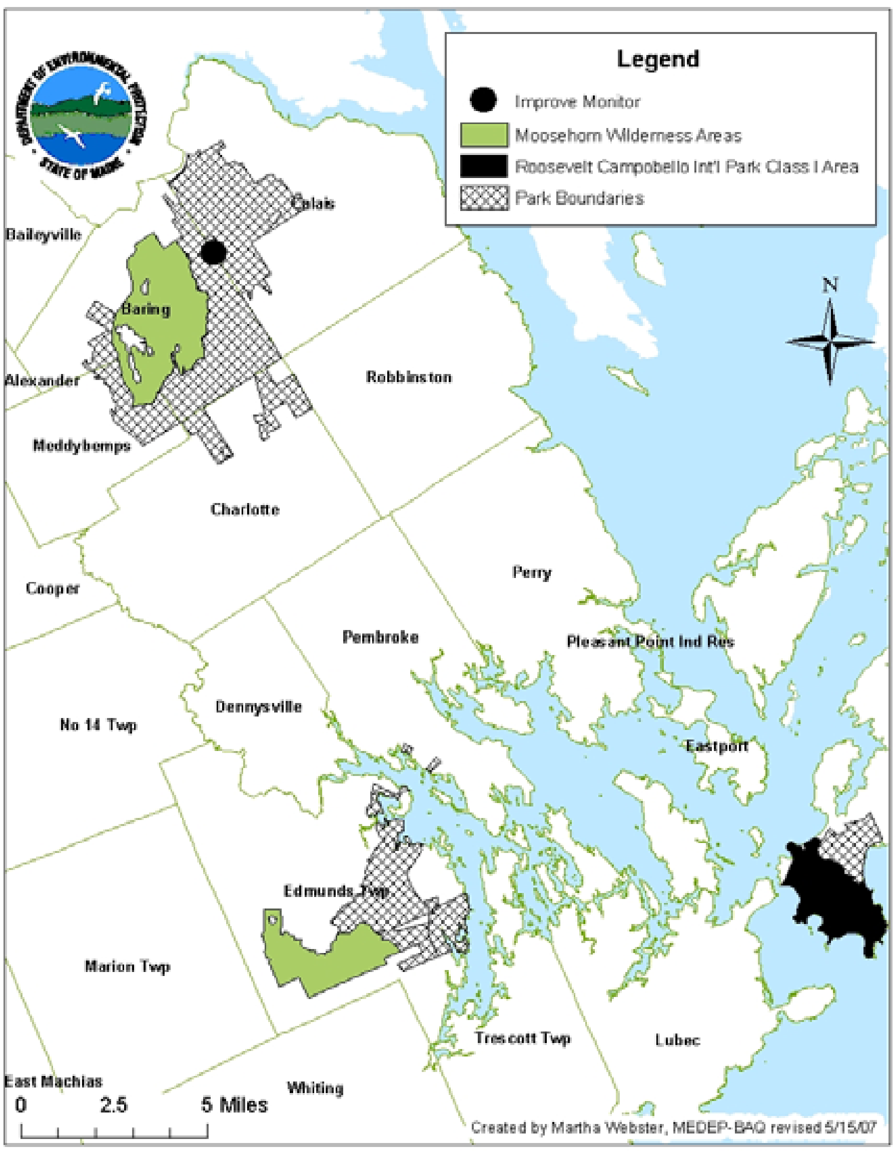
5.3.6 Moosehorn Wilderness, Maine

The IMPROVE monitor for the Moosehorn Wilderness (MOOS1) is located near McConvey Road, about one mile northeast of the National Wildlife Refuge Baring (ME) Unit Headquarters, at elevation 78 meters, latitude 45.13˚, and longitude -67.27˚. This monitor also represents the Roosevelt Campobello International Park in New Brunswick, Canada. The monitor is operated and maintained by the U.S. Fish & Wildlife Service. Rhode Island considers the MOOS1 site as adequate for assessing reasonable progress toward visibility goals at the Moosehorn Wilderness, and no additional monitoring sites or equipment are necessary at this time.

Figure 5.11: Moosehorn Wilderness on Clear and Hazy Days

http://www.hazecam.net/moosehorn.html

Figure 5.12: Map of the Baring and Edmunds Divisions of the Moosehorn National Wildlife Refuge Showing Location of IMPROVE Monitor



5.3.7 Roosevelt Campobello International Park, New Brunswick, Canada

The IMPROVE monitor for Roosevelt Campobello International Park is also the monitor for the Moosehorn Wilderness (MOOS1), as described above. Rhode Island considers the MOOS1 site as adequate for assessing reasonable progress toward visibility goals at Roosevelt Campobello International Park, and no additional monitoring sites or equipment are necessary at this time.

Figure 5.13: Map of Roosevelt Campobello International Park

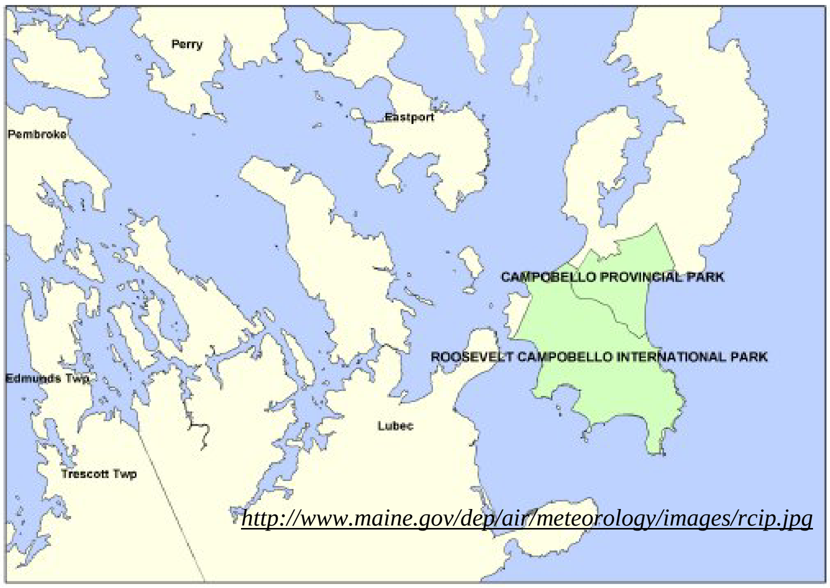


Figure 5.14: Roosevelt Campobello International Park on Clear and Hazy Days

source: Chessie Johnson

6.0 EMISSIONS INVENTORY

40 CFR 51.308(d)(4)(v) of EPA's Regional Haze Rule requires a statewide emissions inventory of pollutants that are reasonably anticipated to cause or contribute to visibility impairment in any mandatory Class I area. The inventory must include emissions for a baseline year, a future (projected) year, and the most recent year for which data are available. Rhode Island's baseline year, 2002, is also the most recent year for which data are available. The pollutants inventoried by Rhode Island include nitrogen oxides (NO_X), sulfur dioxide (SO_2), volatile organic compounds (VOCs), fine particles (particulate matter less than 2.5 micrometers in diameter, or $PM_{2.5}$), coarse particles (particulate matter less than 10 micrometers in diameter, or PM_{10}), and ammonia (NH_3). The following source categories were included in Rhode Island's emissions inventory: stationary point sources, stationary area sources, on-road mobile sources, non-road mobile sources, and biogenic sources. These emissions categories are discussed further in Subsection 7.3, Model Platforms.

6.1 Baseline and Future-Year Emissions Inventories for Modeling

40 CFR 51.308(d) (3) (iii) of EPA's Regional Haze Rule requires the State of Rhode Island to identify the baseline emissions inventory used to evaluate emission control strategies. The baseline inventory is intended to be used for assessing progress in making emission reductions. In accordance with EPA's guidance memorandum "2002 Base Year Emission Inventory SIP Planning: 8-hour Ozone, $PM_{2.5}$, and Regional Haze Programs," November 18, 2002, all of the MANE-VU states are using 2002 as the baseline year for regional haze.

Previously, Rhode Island submitted its 2002 baseline inventory to EPA to meet its implementation planning obligations under the 8-hour ozone program. It should be noted, however, that emissions inventories are not static documents, but are constantly revised and updated to reflect the input of better emissions estimates as they become available. With contractor assistance, MARAMA developed a 2002 baseline modeling inventory using the inventories that Rhode Island and other states submitted to EPA to meet their SIP obligations and the requirements of the Consolidated Emissions Reporting Rule (CERR). To create the 2002 baseline inventory for modeling, MARAMA and its contractor quality-assured and augmented states' inventories and generated the necessary input files for the emissions processing model. As described in Part 6.1.1 below, several iterations of this inventory were generated. Therefore, the 2002 baseline emissions summarized in this document may differ slightly from Rhode Island's original 2002 baseline inventory submittal.

Future-year inventories for 2009, 2012, and 2018 were projected from the 2002 base year. These future-year emissions inventories include emissions growth due to projected increases in economic activity as well as emissions reductions expected from the implementation of control measures. While the 2009 and 2012 emissions projections were originally developed in support of Rhode Island's and other states' ozone attainment demonstrations, the inventory for 2018 (the year targeted by the Regional Haze Rule) was developed for the specific purposes of regional haze SIP planning. Therefore, although the 2009 and 2012 projected inventories are mentioned in subsequent sections, only the 2002 baseline inventory and 2018 projected inventory are described below in Subsection 6.4, Summary of Emissions Inventories.

Accurate baseline and future-year emissions inventories are crucial to the analyses required for the regional haze SIP process. These emissions inventories were used to drive the air quality modeling simulations undertaken to assess the visibility improvements that would result from possible control measures. Air quality modeling was also used to perform a pollution apportionment, which evaluates the contribution to visibility impairment by geographic region and emission source sector.

To be compatible with the air quality modeling simulations, the baseline and future-year emissions inventories were processed with the Sparse Matrix Operator Kernel Emissions (SMOKE) emissions pre-processor for subsequent input into the CMAQ and REMSAD air quality models described in Subsection 7.3. Further description of the base and future-year emissions inventories is provided below.

Although the RPOs worked to try to make the methodologies and assumptions used to develop emissions inventories for use in modeling platforms as consistent as possible, they were not able to eliminate all differences. Those differences, along with the technical ramifications of those differences, are explained above in Section 3.2.2.

6.1.1 Baseline Inventory (2002)

The starting point for the 2002 baseline emissions inventory was the 2002 inventory submittals that were made to EPA by state and local agencies as part of the Consolidated Emissions Reporting Rule (CERR). With contractor assistance (E.H. Pechan & Associates, Inc.,), MANE-VU then coordinated and quality-assured the 2002 inventory data and prepared it for input into the SMOKE emissions model. The 2002 emissions from non-MANE-VU areas within the modeling domain were obtained from other RPOs for their corresponding areas. These RPOs included VISTAS, MRPO, and CenRAP.

The 2002 baseline inventory went through several iterations. Work on Version 1 of the 2002 MANE-VU inventory began in April 2004, and the final inventory and SMOKE input files were completed during January 2005. Work on Version 2 (covering the period of April through September 2005) involved incorporating revisions requested by some MANE-VU state/local agencies on the point, area, and on-road categories. Work on Version 3 (covering the period from December 2005 through April 2006) included additional revisions to the point, area, and on-road categories as requested by some states. Thus, the Version 3 inventory for point, area, and on-road sources was built upon Versions 1 and 2. This work also included development of the biogenic inventory. In Version 3, the non-road inventory was completely redone because of changes that EPA made to the NONROAD2005 non-road mobile emissions model.

Version 3 of the MANE-VU 2002 baseline emissions inventory was used in the regional air quality modeling simulations. Further description of the data sources, methods, and results for this version of the 2002 baseline inventory is presented in E.H. Pechan & Associates, Inc., “Technical Support Document for 2002 MANE-VU SIP Modeling Inventories, Version 3, November 20, 2006, also known as the Baseline Emissions Report (Attachment M). Emissions inventory data files are available on the MARAMA website at: http://www.marama.org/visibility/EI_Projects/index.html.

6.1.2 Future-Year Emissions Inventories

Future-year emissions inventories are provided in MACTEC's technical support document, "Development of Emissions Projections for 2009, 2012, and 2018 for NonEGU Point, Area, and Nonroad Sources in the MANE-VU Region," Final Report, February 28, 2007, also known as the Emission Projections Report (Attachment N). This document describes the data sources, methods, and modeling results for three future years, five emission source sectors, two emission control scenarios, seven pollutants, and eleven states plus the District of Columbia. The following summarizes the basic framework of the future-year inventories that were developed:

- ***Projection years*:** 2009, 2012, and 2018;
- ***Emission source sectors*:** point-source electric generating units (EGUs), point-source non-electric generating units (non-EGUs), area sources, non-road mobile sources, and on-road mobile sources.
- ***Emission control scenarios*:**
  - A combined on-the-books/on-the-way (OTB/OTW) control strategy accounting for emission control regulations already in place as of June 15, 2005, as well as some emission control regulations that are not yet finalized but are expected to achieve additional emission reductions by 2009; and
  - A beyond-on-the-way (BOTW) scenario to account for controls from potential new regulations that may be necessary to meet attainment and other regional air quality goals, mainly for ozone. This scenario also included, for certain states, including Rhode Island, the adoption of a 500 ppm sulfur limit for distillate fuel oil.
  - An updated scenario (sometimes referred to as "Best-and-Final") to account for additional potentially reasonable control measures. For the MANE-VU region, these include: SO_2 reductions at a set of 167 EGUs which were identified as contributing to visibility impairment at northeast Class I areas; implementation of a low-sulfur fuel strategy for non-EGU sources; and implementation of a Best Available Retrofit Technology (BART) strategy for BART-eligible sources not controlled under other programs. Since Rhode Island does not have BART-eligible or targeted EGU sources, the emissions reductions for Rhode Island in this scenario, relative to the BOTW scenario, is derived from adoption of the low-sulfur fuel limits for residual oil and the Phase II sulfur limits for distillate oil in the Ask strategy.

  (Note: Refer to Section 11.0, Long-Term Strategy, for detailed descriptions of specific control strategies.)
- ***Pollutants*:** ammonia, carbon monoxide (CO), oxides of nitrogen (NO_X), sulfur dioxide (SO_2), volatile organic compounds (VOCs), fine particulate matter ($PM_{2.5}$, sum of filterable and condensable components), and coarse particulate matter (PM_{10}, sum of filterable and condensable components).
- ***States*:** Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont, plus the District of Columbia (all members of the MANE-VU region).

6.2 Emission Processor Selection and Configuration

The Sparse Matrix Operator Kernel Emissions (SMOKE) model was used to format the emissions inventories for use with the air quality models that are discussed in Subsection 7.3. SMOKE is primarily an emissions processing system, as opposed to a true emissions inventory preparation system, in which emissions estimates are simulated from "first principles." This means that, with the exception of mobile and biogenic sources, SMOKE's purpose is to provide an efficient, modern tool for converting emissions inventory data into the formatted emissions files required for a photochemical air quality model. The SMOKE emissions processing that was performed in support of the air quality modeling for regional haze is described further in Subsection 7.2.

6.3 Inventories for Specific Source Categories

There are five emission source classifications in the emissions inventory, as follows:

- Stationary point,
- Stationary area,
- Non-road mobile,
- On-road mobile, and
- Biogenic.

Stationary point sources are large sources that emit greater than a specified tonnage per year, as described below. ***Stationary area sources*** are those sources whose individual emissions are relatively small (i.e., dry cleaners, service stations, agricultural areas, fires, etc.), but because of the large number of these sources, their collective emissions are significant. ***Non-road mobile sources*** are equipment that can move but do not use the roadways (i.e., lawn mowers, construction equipment, railroad locomotives, marine vessels, aircraft, etc.). ***On-road mobile sources*** include automobiles, trucks, buses, and motorcycles that use the roadway system. ***Biogenic sources*** include natural sources such as trees, crops, grasses, and natural decay of plants.

The subsections below give an overview of each of the source categories and the methods that were used to develop their corresponding baseline and future-year emissions estimates. All emissions data were prepared for modeling in accordance with EPA guidance.

6.3.1 Stationary Point Sources

Point source emissions are emissions from large individual sources. Generally, point sources have permits to operate, and their emissions are individually calculated based on source-specific parameters. Emissions estimates for point sources are made on a regular basis, and the largest point sources submit annual emissions statements. Sources with emissions greater than or equal to 10 tons per year (tpy) of VOC or 25 tpy of NOx are considered point sources in Rhode Island. Emissions from smaller point sources are also calculated individually. Point sources are further subdivided into EGUs and non-EGUs.

6.3.1.1 Electric Generating Units (EGUs)

The base-year inventory for EGU sources was based on 2002 continuous emissions monitoring (CEM) data reported to EPA in compliance with the Acid Rain Program or 2002 state emissions inventory data. The CEM data provided actual hourly emission values used in the modeling of SO_2 and NO_X emissions from these large sources. See Chapter II, Section A.2.a.i of the "Technical Support Document for 2002 MANE-VU SIP Modeling Inventories," Version 3 (Attachment M) for a discussion of the quality assurance steps performed on the CEM data that were included in the 2002 baseline modeling inventory. Emissions of other pollutants (e.g., VOCs, CO, NH_3, and $PM_{2.5}$) were provided by the states in most instances. Future-year inventories of EGU emissions for 2009, 2012 and 2018 were developed using ICF International's Integrated Planning Model (IPM) to forecast growth in electric demand and replacement of older, less efficient and more polluting power plants with newer, more efficient and cleaner units. This effort was undertaken by an inter-RPO workgroup. While the output of the IPM model predicts that a certain number of older plants will be replaced by newer units to meet future electric growth and state-specific NO_X and SO_2 caps, Rhode Island did not directly rely on the closure of any particular plant in establishing the 2018 inventory upon which the reasonable progress goals were set.

The IPM model results do not provide a reliable basis upon which to predict EGU closures. Specific plant closures in Rhode Island are addressed in Section 11.0, Reasonable Progress Goals. Preliminary modeling was performed with unchanged IPM 2.1.9 model results. However, prior to the most recent modeling, future-year EGU inventories were adjusted as follows:

- First, IPM predictions were reviewed by permitting and enforcement staff of the MANE-VU states. In many cases, staff believed that the IPM shutdown predictions were unlikely to occur. In particular, many oil-fired EGUs in urban areas were predicted to be shut down by IPM. Similar source information was solicited from states in both VISTAS and MRPO. As a result of this model validation, the IPM modeling output was adjusted before the most recent modeling to reflect staff knowledge of specific plant status in MANE-VU, VISTAS, and MRPO states. Where expected EGU operating status was contrary to what was predicted by IPM modeling, the future-year emissions inventory was adjusted to reflect the expected operation of those plants.

- Second, as a result of inter- and intra-RPO consultations, MANE-VU agreed to pursue certain emission control measures (see Section 3.0, Regional Planning). For EGUs, the agreed-upon approach was to pursue emission reductions from each of the top 167 stacks located in MANE-VU, MRPO, and VISTAS that contributed the most to visibility impairment at any Class I area in the MANE-VU region. This approach, known as the targeted EGU strategy, is further described in Section 11.0 of this SIP.

6.3.1.2 Non-EGU Point Sources

The primary basis for the 2002 baseline non-EGU emissions inventory was data reported by state and local agencies for the CERR. As described in Part 6.1.1, MANE-VU's contractor, E.H. Pechan & Associates (Pechan), coordinated the quality assurance of the inventory and prepared the necessary files for input into the SMOKE emissions model. Further information on the preparation of the MANE-VU 2002 baseline point source modeling emissions inventory can be found in Chapter II of the Baseline Emissions Report (Attachment M).

Projected non-EGU point source emissions were developed for the MANE-VU region by MACTEC Federal Programs, Inc. under contract to Mid-Atlantic Regional Air Management Association (MARAMA). The specific methodologies that were employed are described in Section 2 of the Emission Projections Report (Attachment N). MACTEC used state-supplied growth factor data, where available, to project future-year emissions. Where state-supplied data were not available, MACTEC used EPA's Economic Growth and Analysis System, Version 5.0 (EGAS 5.0) to develop applicable growth factors for the non-EGU component. Rhode Island supplied MACTEC with applicable employment data for 2002 and 2012 from the Rhode Island Department of Labor and Training. Those data were used to develop 2002-2012 growth factors and were interpolated to derive 2009-2018 growth factors.

MACTEC also incorporated the applicable federal and state emissions control programs to account for the expected emissions reductions that will take place under the OTB/OTW and BOTW scenarios.

6.3.2 Stationary Area Sources

Stationary area sources include sources whose individual emissions are relatively small but, because the number of sources is large, their collective emissions are significant. Some examples include dry cleaners, service stations, and residential heating. For each area source, emissions are estimated by multiplying an appropriate emission factor by some known indicator of collective activity, such as fuel usage, number of households, or population.

The area source emissions inventory submittals made for the CERR became the basis for the area source portion of the 2002 baseline inventory. MANE-VU's consultant, Pechan, prepared the area source modeling inventory using the CERR submittals as a starting point. Pechan quality-assured the inventory and augmented it with additional data, including MANE-VU-sponsored inventories for categories such as residential wood combustion and open burning. Details on the preparation of MANE-VU's 2002 baseline area source emissions inventory can be found in Chapter III of the Baseline Emissions Report (Attachment M).

In similar fashion, MACTEC prepared future-year area source emission projections for the MANE-VU region. The specific methodologies employed are described in Section 3 of the Emission Projections Report (Attachment N). MACTEC applied growth factors to the 2002 baseline area source inventory using state-supplied data, where available, or using the EGAS 5.0 growth factor model. MACTEC also accounted for the appropriate control strategies in the future year projections.

RI DEM supplied MACTEC with county level population projections for 2002, 2010, 2015 and 2020 which were interpolated to 2002, 2009, 2012 and 2018 and used to project future year inventories for sectors that are population-based. RI DEM also supplied employment data for 2002 and 2012 from the RI Department of Employment and Training by 3-digit NAICS code. Those data were interpolated to 2009 and 2018 and matched to SCC codes for specific area source categories. RI DEM agreed to the use of the AEO2005 growth factors from the US Department of Energy for projecting fuel use in future years.

6.3.3 Non-Road Mobile Sources

Non-road mobile sources are equipment that can move but do not use the roadways, such as construction equipment, aircraft, railroad locomotives, and lawn & garden equipment. For the majority of non-road mobile sources, emissions are estimated using the EPA's NONROAD model. Aircraft, railroad locomotives, and commercial marine vessels are not included in the NONROAD model; and their emissions are estimated using applicable references and methodologies. Again, Pechan prepared the 2002 baseline modeling inventory using the state and local CERR submittals as a starting point. Details on the preparation of the 2002 baseline non-road inventory are described in Chapter IV of the Baseline Emissions Report (Attachment M).

Future-year non-road mobile source emissions were projected for the MANE-VU region by MACTEC. The methodologies employed are discussed in Section 4 of the Emission Projections Report (Attachment N). MACTEC used EPA's NONROAD2005 non-road vehicle emissions model as contained in EPA's National Mobile Inventory Model (NMIM). Since the calendar year is an explicit input into the NONROAD model, future-year emissions for non-road vehicles could be calculated directly for the applicable projection years. For the non-road vehicle types that are not included in the NONROAD model (i.e. aircraft, locomotives, and commercial marine vessels), MACTEC used the 2002 baseline inventory and the projected inventories that EPA developed for these categories for the Clean Air Interstate Rule (CAIR) to develop emission ratios and subsequent combined growth and control factors. Since the future years for the CAIR projections did not precisely match those required for the purposes of ozone, particulate matter, and regional haze analyses (i.e. 2009, 2012, and 2018), MACTEC used linear interpolation to develop factors for the required future years.

6.3.4 On-Road Mobile Sources

The on-road emissions source category consists of vehicles that are meant to travel on public roadways, including cars, trucks, buses, and motorcycles. The basic methodology used for on-road mobile source calculations is to multiply vehicle-miles-traveled (VMT) by emission factors developed using the EPA's MOBILE6 motor vehicle emission factors model. The on-road mobile category requires that SMOKE model inputs be prepared instead of the SMOKE/IDA emissions data format that is required by the other emission source categories. Therefore, for the 2002 baseline inventory, Pechan prepared the necessary VMT and MOBILE6 inputs in SMOKE format.

Projected on-road mobile source inventories were developed by NESCAUM for the MANE-VU region for ozone, particulate matter, and regional haze SIP purposes. As with the other emissions source categories, projected on-road mobile inventories were developed for calendar years 2009, 2012, and 2018. As part of this effort, MANE-VU member states were asked to provide VMT data and MOBILE6 model inputs for the applicable calendar years. Using the inputs supplied by the MANE-VU member states, NESCAUM compiled and generated the required SMOKE/MOBILE6 emissions model inputs. Further details regarding the on-road mobile source projections can be found in NESCAUM's "Technical Memorandum, Development of MANE-VU Mobile Source Projection Inventories for SMOKE/MOBILE6 Application," June 2006 (Attachment O).

6.3.5 Biogenic Emission Sources

For the purposes of the 2002 baseline modeling emissions inventory, biogenic emissions were calculated for the modeling domain by the New York State Department of Environmental Conservation (NYSDEC). NYSDEC used the Biogenic Emissions Inventory System (BEIS) Version 3.12 as contained within the SMOKE emissions processing model. Biogenic emissions estimates were made for CO, nitrous oxide (NO) and VOCs. Further details about the biogenic emissions processing can be found in NYSDEC's technical support document

TSD-1c, "Emission Processing for the Revised 2002 OTC Regional and Urban 12 km Base Case Simulations," September 19, 2006 (Appendix P), and in Chapter VI of Pechan's "Technical Support Document for 2002 MANE-VU SIP Modeling Inventories," Version 3, November 20, 2006 (Appendix M). Biogenic emissions were assumed to remain constant for the future-years analysis – a reasonable approximation reflecting the expectation that most of the region will remain heavily forested for the duration of the planning period.

6.4 Summary of Emissions Inventories

Rhode Island's baseline and future-year emissions inventories are summarized in Tables 6.1 through 6.4, below. All values are reported in tons per year (tpy). SO_2 area source emissions increased, relative to the 2002 inventory, in the 2018 OTB/OTW inventory, using growth factors derived as discussed above. However, the area source SO_2 emissions in the BOTW inventory were 70% lower and in the Best and Final emissions 99% lower than in the 2002 inventory. These emissions reductions are due to the application of a 500 ppm limit on the sulfur content of distillate fuel oil in the BOTW strategy and inclusion of all Phase I and Phase II limits in the Ask for fuel oil (15 ppm sulfur limit for distillate oil, 2,500-5,000 for residual oil) in the Best and Final inventory.

$PM_{2.5}$ and PM_{10} emissions from area sources in the BOTW inventory were slightly lower than in the OTB/OTW, but were still greater than in the 2002 baseline. However, in the Best and Final Inventory, those emissions were 24% and 49% lower, respectively, than in the 2002 baseline, due to the inclusion of the low-sulfur fuel oil strategy. PM emissions for oil burning sources are influenced by sulfur content of the fuel. Unlike SO_2 emissions, however, PM emissions are not directly proportional to the sulfur content in fuel and, therefore, show a less dramatic decrease when the sulfur content is reduced.

Point source SO_2 emissions in the BOTW inventory were also somewhat lower than in the OTB/OTW projections but higher than in the 2002 base. This is because many of the point sources in the State burn natural gas and/or residual oil, neither of which was controlled in the BOTW inventory. In addition, some of the large point sources that burn distillate oil are already limited by permit to using oil that is at or below the 500 ppm sulfur limit assumed in the BOTW inventory; this is the case for two of the three EGUs in the State that have oil-burning capability (see Section 11.3.1). In the Best and Final Inventory, which included the Phase II limit for distillate and the residual oil limit, however, point source SO_2 emissions were 43% lower than in 2002.

Table 6.1: 2002 Emissions Inventory Summary for Rhode island (tpy)

Emission Sector	VOC	NO_X	$PM_{2.5}$	PM_{10}	NH_3	SO_2
Point	1928	2,764	183	300	58	2,666
Area	31,402	3,886	2,064	8,295	883	4,557
Mobile	12,538	16,677	211	345	853	425
Non-Road Mobile	7,780	5,001	443	500	4	377
Biogenic	19,233	211	--	--	--	--
TOTAL	72,881	28,540	2,901	9,440	1,,797	8026

Table 6.2: 2018 OTB/OTW Emissions Inventory Summary for Rhode Island (tpy)

Emission Sector	VOC	NO_X	$PM_{2.5}$	PM_{10}	NH_3	SO_2
Point	1,854	3,018	350	487	195	3,219
Area	23,561	4,397	2,316	9,797	1,025	5,398
Mobile	6,305	5,351	148	168	1,200	100
Non-Road Mobile	5,389	2,723	303	348	5	42
Biogenic	19,233	211	--	--	--	--
TOTAL	56,342	15,701	3,118	10,801	2,425	8,759

Table 6.3: 2018 BOTW Emissions Inventory Summary for Rhode Island (tpy)

Emission Sector	VOC	NO_X	$PM_{2.5}$	PM_{10}	NH_3	SO_2
Point	1,841	3,018	340	473	195	3,055
Area	23,305	4,249	2,069	9,514	1,025	1,368
Mobile	6,305	5,351	148	168	1,200	100
Non-Road Mobile	5,389	2,723	303	348	5	42
Biogenic	19,233	211	--	--	--	--
TOTAL	56,073	15,553	2,860	10,504	2,425	4,565

Table 6.4: 2018 Best and Final Emissions Inventory Summary for Rhode Island (tpy)

Emission Sector	VOC	NO_X	$PM_{2.5}$	PM_{10}	NH_3	SO_2
Point	1,841	3,018	340	473	195	1,509
Area	23,305	4,249	1,570	4,269	1,025	52
Mobile	6,305	5,351	148	168	1,200	100
Non-Road Mobile	5,389	2,723	303	348	5	42
Biogenic	19,233	211	--	--	--	--
TOTAL	56,073	15,553	2,362	5,260[10]	2,425	1,703

[10] An adjustment factor was applied during the processing of emissions data to restate fugitive particulate matter emissions. Grid models have been found to overestimate fugitive dust impacts when compared with ambient samples; therefore, an adjustment is typically applied to account for the removal of particles by vegetation and other terrain features. The summary emissions for PM_{10} in Table 6.4 reflect this adjustment. Comparable adjustments were not made to PM_{10} values listed in Tables 6.1 through 6.3.

7.0 AIR QUALITY MODELING

Air quality modeling to assess regional haze has been performed cooperatively between Rhode Island and MANE-VU, with major modeling being conducted by NESCAUM. These modeling efforts include emissions processing, meteorological input analysis, and chemical transport modeling to perform regional air quality simulations for calendar year 2002 and several future periods, including the primary target date, 2018, for this SIP. The modeling assessed the contributions of Rhode Island and other upwind states to visibility impairment in Class I areas in downwind states. Further, the modeling evaluated visibility benefits of specific control measures being considered to achieve reasonable progress goals and establish a long-term emissions management strategy for MANE-VU Class I Areas.

Several modeling tools were utilized for these analyses:

- The Fifth-Generation Pennsylvania State University/National Center for Atmospheric Research (NCAR) Mesoscale Model (MM5) was used to derive the required meteorological inputs for the air quality simulations.
- The Sparse Matrix Operator Kernel Emissions (SMOKE) emissions modeling system was used to process and format the emissions inventories for input into the air quality models.
- The Community Mesoscale Air Quality model (CMAQ) was used for the primary SIP modeling.
- The Regional Model for Aerosols and Deposition (REMSAD) was used during contribution apportionment.
- The California Puff Model (CALPUFF) was used to assess the contribution of individual states' emissions to sulfate levels at selected Class I receptor sites.

Each of these tools has been evaluated and found to perform adequately. The SIP-pertinent modeling underwent full performance testing, and the results were found to meet the specifications of EPA modeling guidance.

For more details on the regional haze modeling, refer to the NESCAUM report, "MANE-VU Modeling for Reasonable Progress Goals: Model Performance Evaluation, Pollution Apportionment, and Control Measure Benefits," February 7, 2008 (Attachment G). The detailed modeling approach for the most recent 2018 projections can be found in NESCAUM's "2018 Visibility Projections," May 13, 2008 (Attachment Q).

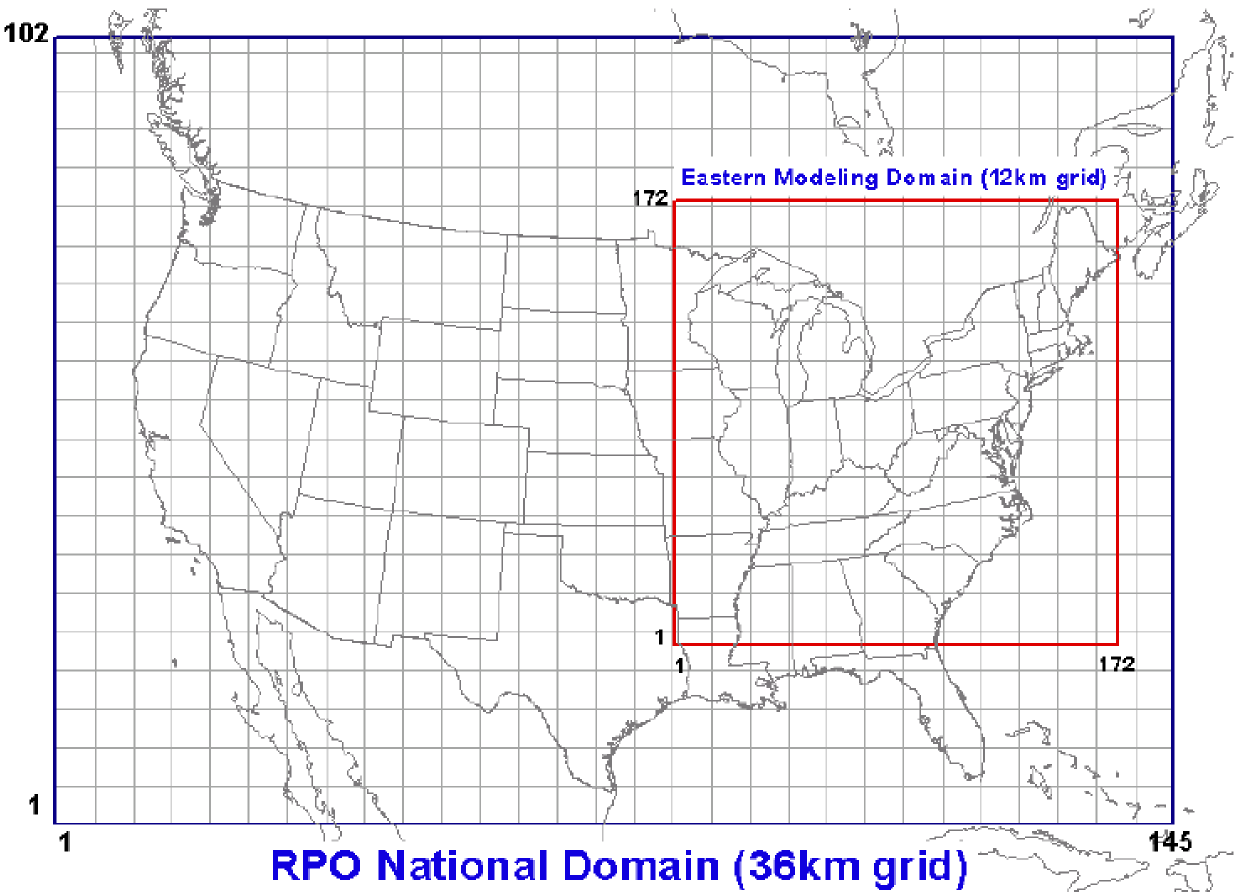
7.1 Meteorology

The meteorological inputs for the air quality simulations were developed by the University of Maryland (UMD) using the MM5 meteorological modeling system. Meteorological inputs were generated for 2002 to correspond with the baseline emissions inventory and analysis year. The MM5 simulations were performed on a nested grid (Figure 7.1). The modeling domain is composed of a 36-km, 145 x 102 continental grid and a nested 12-km, 172 x 172 grid encompassing the eastern United States and parts of Canada. In cooperation with the New York State Department of Conservation (NYSDEC), an assessment was made for the period of May-September 2002 to compare the MM5 predictions with observations from a variety of data sources, including:

- Surface observations from the National Weather Service and the Clean Air Status and Trends Network (CASTNET),
- Wind-profiler measurements from the Cooperative Agency Profilers (CAP) network,
- Satellite cloud image data from the UMD Department of Atmospheric and Oceanic Science, and
- Precipitation data from the Earth Observing Laboratory at NCAR.

Further details regarding the MM5 meteorological processing and the modeling domain can be found in NYSDEC's technical support document TSD-1a, "Meteorological Modeling Using Penn State/NCAR 5th Generation Mesoscale Model (MM5)," February 1, 2006 (Attachment R), and in the NESCAUM report, "MANE-VU Modeling for Reasonable Progress Goals, Model Performance Evaluation, Pollution Apportionment, and Control Measure Benefits," November 27, 2007 (Attachment G).

Figure 7.1: Modeling Domains Used in MANE-VU Air Quality Modeling Studies with CMAQ



Note: Outer (blue) domain is 36-km grid. Inner (red) domain is 12-km grid. Gridlines are shown at 180-km intervals (5×5 36-km cells and 15×5 12-km cells).

7.2 Data Preparations

Emissions data were prepared for input into the CMAQ and REMSAD air quality models using the SMOKE emissions modeling system. SMOKE supports point, area, mobile (both on-road and non-road), and biogenic emissions. The SMOKE emissions modeling system uses flexible processing to apply chemical speciation as well as temporal and spatial allocation to the emissions inventories. SMOKE incorporates the Biogenic Emission Inventory System (BEIS) and EPA's MOBILE6 motor vehicle emission factor model to process biogenic and on-road mobile emissions, respectively. Vector-matrix multiplication is used during the final processing step to merge the various emissions components into a single model-ready emissions file. Examples of processed emissions outputs are shown in Figure 7.2.

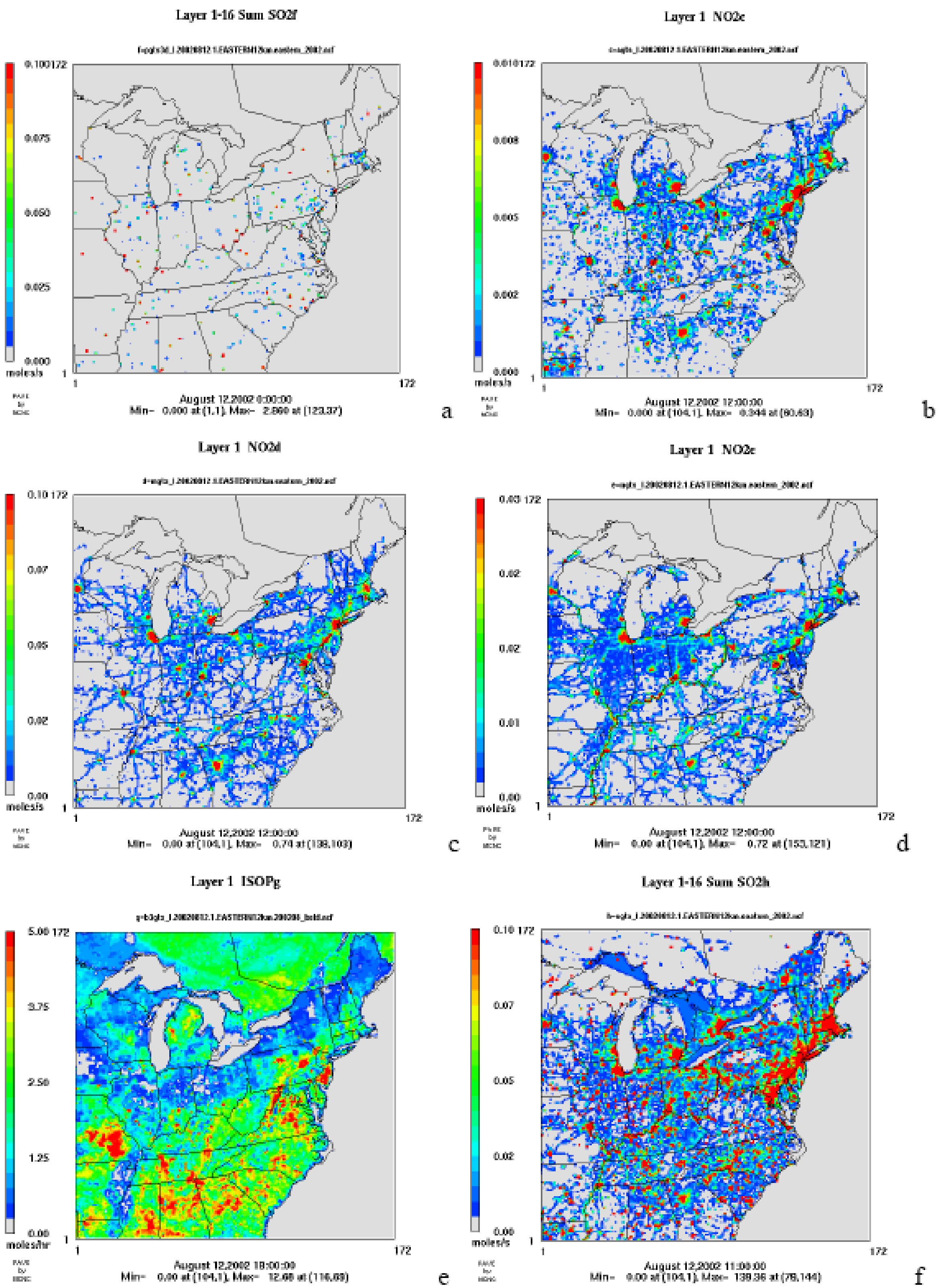
Further details on the SMOKE processing conducted in support of the air quality simulations is provided in NYSDEC's technical support document TSD-1c, "Emission Processing for the Revised 2002 OTC Regional and Urban 12 km Base Case Simulations," September 19, 2006 (Attachment P), and in NESCAUM's report, "MANE-VU Modeling for Reasonable Progress Goals, Model Performance Evaluation, Pollution Apportionment, and Control Measure Benefits," February 7, 2008 (Attachment G). Additional details on the emissions inventory preparation can be found in Section 6.0 of this report.

7.3 Model Platforms

Two regional-scale air quality models, CMAQ and REMSAD, were used for the air quality simulations that directly supported the regional haze SIP effort. CMAQ was developed by EPA and was used to perform the primary SIP-related modeling. The CMAQ modeling simulations were also an important tool for the 8-hour ozone SIP process. REMSAD was developed by ICF Consulting/Systems Applications International with support from EPA. REMSAD was used by NESCAUM to perform a source apportionment (contribution assessment) analysis. All of the air quality simulations that were used in the SIP efforts were performed on the 12-km eastern modeling domain shown in Figure 7.1 above.

NYSDEC performed an extensive model performance analysis to evaluate CMAQ model predictions against observations of ozone, $PM_{2.5}$, and other pollutant species. This model performance evaluation is described in detail in NYSDEC's technical support document TSD-1e, "CMAQ Model Performance and Assessment, 8-Hr OTC Ozone Modeling," February 23, 2006 (Attachment S). A model performance evaluation for $PM_{2.5}$ species, aerosol extinction coefficient, and the haze index is provided in NESCAUM's report, "MANE-VU Modeling for Reasonable Progress Goals, Model Performance Evaluation, Pollution Apportionment, and Control Measure Benefits," February 7, 2008 (Attachment G).

Figure 7.2: Examples of Processed Model-Ready Emissions: (a) SO_2 from Point, (b) NO_2 from Area, (c) NO_2 from On-Road, (d) NO_2 from Non-Road, (e) ISOP from Biogenic, and (f) SO_2 from all Source Categories



7.3.1 CMAQ

The CMAQ air quality simulations were performed cooperatively among five modeling centers: NYSDEC, the New Jersey Department of Environmental Protection (NJDEP) in association with Rutgers University, the Virginia Department of Environmental Quality (VADEQ), UMD, and NESCAUM. NYSDEC also performed an annual 2002 CMAQ simulation on the 36-km domain shown in Figure 7.1; this simulation was used to derive the boundary conditions for the inner 12-km eastern modeling domain. Boundary conditions for the 36-km simulations were obtained from a run of the GEOS-Chem (Goddard Earth Observing System) global chemistry transport model that was performed by researchers at Harvard University. The technical options that were used in performing the CMAQ simulations are described in detail in NYSDEC's technical support document TSD-1d, "8hr Ozone Modeling Using the SMOKE/CMAQ System," February 1, 2006 (Attachment T). Further technical details regarding the CMAQ model and its execution are also provided in NESCAUM's report, "MANE-VU Modeling for Reasonable Progress Goals, Model Performance Evaluation, Pollution Apportionment, and Control Measure Benefits," February 7, 2008 (Attachment G).

7.3.2 REMSAD

The REMSAD modeling simulations were used to produce the contribution assessment required by the Regional Haze Rule. REMSAD's species tagging capability makes it an important tool for this purpose. The REMSAD model simulations were performed on the same 12-km eastern modeling domain as shown in Figure 7.1. NESCAUM's report, "MANE-VU Modeling for Reasonable Progress Goals, Model Performance Evaluation, Pollution Apportionment, and Control Measure Benefits," February 7, 2008 (Attachment G), further describes the REMSAD model and its application to the regional haze SIP efforts.

7.3.3 CALGRID

In addition to the SIP-quality modeling platforms described above, another modeling platform was developed for use as a screening tool to evaluate additional control strategies or to perform sensitivity analyses. The CALGRID model was selected as the basis for this platform. CALGRID is a grid-based photochemical air quality model that is designed to be run in a Windows environment. In order to make the CALGRID model the best possible tool to supplement the SIP-quality CMAQ and REMSAD modeling, the current version of the CALGRID platform was set up to be run with the same set of inputs as the SIP-quality models. The CALGRID air quality simulations were run on the same 12-km eastern modeling domain that was used for CMAQ and REMSAD. This model's performance was comparable to the performance of the already evaluated CMAQ and REMSAD models and was thus determined to perform adequately.

Conversion utilities were developed to reformat the meteorological inputs, the boundary conditions, and the emissions data for use with the CALGRID modeling platform. Pre-merged SMOKE emissions files were obtained from the modeling centers and reformatted for input into EMSPROC6, the emissions pre-processor for the CALGRID modeling system. EMSPROC6 allows the CALGRID user to adjust emissions temporally, geographically, and by emissions category for control strategy analysis. The pre-merged SMOKE files that were obtained from the modeling centers were broken down into the biogenic, point, area, non-road, and on-road emissions categories. These files by component were then converted for use with EMSPROC6, thus giving CALGRID users the flexibility to analyze a wide variety of emissions control strategies. Additional information on the CALGRID modeling platform can be found in NHDES' "Modeling Protocol for the OTC CALGRID Screening-Level Modeling Platform for the Evaluation of Ozone," May 23, 2007 (Attachment U).

7.3.4 CALPUFF

CALPUFF is a non-steady-state Lagrangian puff model that simulates the dispersion, transport, and chemical transformation of atmospheric pollutants. Two parallel CALPUFF modeling platforms were developed by the Vermont Department of Environmental Conservation (VTDEC) and the Maryland Department of the Environment (MDE). The VTDEC CALPUFF modeling platform utilized meteorological observation data from the National Weather Service (NWS) to drive the CALMET meteorological model. The MDE platform utilized the same MM5 meteorological inputs that were used in the modeling done in support of the ozone and regional haze SIPs. These two platforms were run in parallel to evaluate individual states' contributions to sulfate levels at Northeast and Mid-Atlantic Class I areas. The CALPUFF modeling effort is described in detail in NESCAUM's report, "Contributions to Regional Haze in the Northeast and Mid-Atlantic United States," August 2006 (Attachment B).

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8.0 UNDERSTANDING THE SOURCES OF HAZE-CAUSING POLLUTANTS

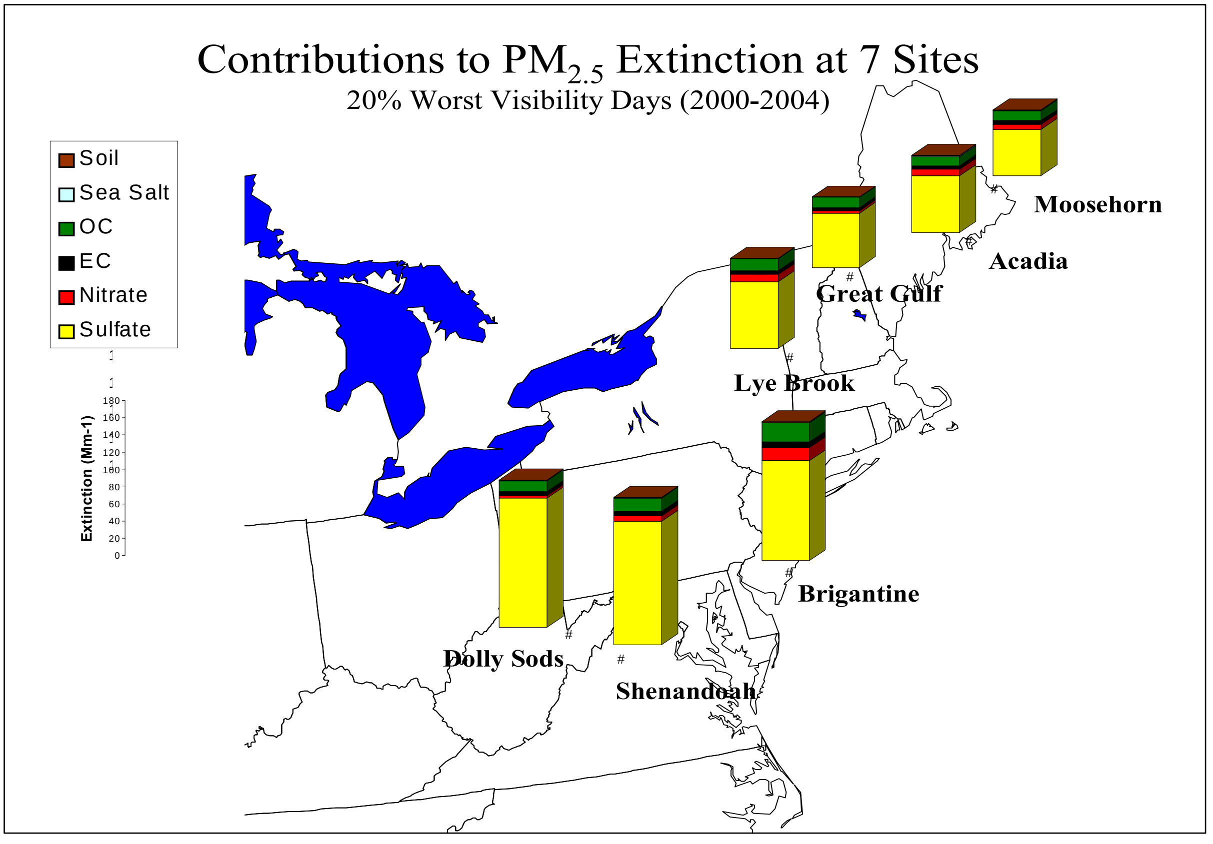
This section explores the origins, quantities, and roles of visibility-impairing pollutants emitted in the eastern United States and Canada that contribute significantly to regional haze at MANE-VU's mandatory Class I areas.

8.1 Fine-Particle Pollutants

The pollutants primarily responsible for fine particle formation, and thus contributing to regional haze, include SO_2, NO_X, VOCs, NH_3, PM_{10}, and $PM_{2.5}$. The MANE-VU Contribution Assessment (Attachment B), finalized in August 2006, reflects a conceptual model in which sulfate emerges as the most important single constituent of haze-forming fine particle pollution and the principle cause of visibility impairment across the Northeast region. Sulfate alone accounts for anywhere from ½ to ⅔ of total fine particle mass on the 20 percent haziest days at MANE-VU Class I Areas. This translates to about ⅔ to ¾ of visibility extinction on those days.

Visibility extinction is a measure of the ability of particles to scatter and absorb light. Extinction is expressed in units of inverse mega-meters (Mm^{-1}). Figure 8.1 shows the dominance of sulfate in visibility extinction calculated from 2000-2004 baseline data for seven Northeast Class I Areas.

Figure 8.1: Contributions to $PM_{2.5}$ Extinction at Seven Class I Areas



Given the dominant role of sulfate in the formation of regional haze in the Northeast and Mid-Atlantic Regions, MANE-VU concluded that an effective emissions management approach would rely heavily on broad-based regional SO_2 control measures in the eastern United States. The focus on SO_2 as MANE-VU's first priority makes sense not only because of its dominant role in regional haze but also because its emission sources are well understood. Moreover, the control measures needed for SO_2 emission reductions are readily available, cost-effective, and could be implemented quickly. On the basis of the scientific evidence, it is apparent that the bulk of haze-causing pollution can be eliminated by pursuing SO_2 emission controls.

Organic carbon was found to be the next largest contributor to haze after sulfate. In comparison with sulfate, the emission sources of organic carbon are diverse, variable, more diffuse, and less well understood; and the problem of controlling organic carbon emissions is exceedingly complex. For these reasons, MANE-VU considered organic carbon to be the subject of possible future control measures but not a specific target pollutant in the initial strategy to mitigate regional haze. This issue will be discussed further in the first progress report.

8.2 Contributing States and Regions

The MANE-VU Contribution Assessment used various modeling techniques, air quality data analysis, and emissions inventory analysis to identify source categories and states that contribute to visibility impairment in MANE-VU and nearby Class I areas. With respect to sulfate, the Contribution Assessment estimated emissions from within MANE-VU in 2002 were responsible for about 25-30 percent of the sulfate at MANE-VU and nearby Class I areas. (Emissions from other regions, Canada, and outside the modeling domain were also important).

It should be pointed out that the listed values for VISTAS, CenRAP, and Canada understate the actual percentage contributions from those regions because they count only emissions originating within the modeling domain (see Figure 7.1). Actual contributions, especially in the case of CenRAP, would be considerably higher than stated. Differences between actual and stated values are lumped into "Other."

These findings highlight the importance of emissions from outside MANE-VU to visibility impairment inside the region. Note that, although there is some variation in the contribution estimates among the different assessment methods employed, there is a general consistency of results from one method to another.

Table 8.1 displays the results of just one of the methods used (the REMSAD model) to assess state-by-state and regional contributions to annual sulfate impacts in nine Class I areas.

Table 8.1: Percent Contributions (Mass Basis) of Individual States and Regions to Total Annual Sulfate Impacts at Northeast Class I Areas (REMSAD)

Contributing State or Region	Mandatory Class I Area						
	Acadia ME	Brigantine NJ	Dolly Sods WV	Great Gulf & Presidential Range - Dry River, NH	Lye Brook VT	Moosehorn & Roosevelt Campobello ME	Shenandoah VA
Connecticut	0.76	0.53	0.04	0.48	0.55	0.56	0.08
Delaware	0.96	3.20	0.30	0.63	0.93	0.71	0.61
District of Columbia	0.01	0.04	0.01	0.01	0.02	0.01	0.04
Maine	6.54	0.16	0.01	2.33	0.31	8.01	0.02
Maryland	2.20	4.98	2.39	1.92	2.66	1.60	4.84
Massachusetts	10.11	2.73	0.18	3.11	2.45	6.78	0.35
New Hampshire	2.25	0.60	0.04	3.95	1.68	1.74	0.08
New Jersey	1.40	4.04	0.27	0.89	1.44	1.03	0.48
New York	4.74	5.57	1.32	5.68	9.00	3.83	2.03
Pennsylvania	6.81	12.84	10.23	8.30	11.72	5.53	12.05
Rhode Island	0.28	0.10	0.01	0.11	0.06	0.19	0.01
Vermont	0.13	0.06	0.00	0.41	0.95	0.09	0.01
MANE-VU	36.17	34.83	14.81	27.83	31.78	30.08	20.59
MRPO	11.98	18.16	30.26	20.10	21.48	10.40	26.84
VISTAS	8.49	21.99	36.75	12.04	13.65	6.69	33.86
CenRAP	0.88	1.12	1.58	1.65	1.67	0.82	1.48
Canada	8.69	7.11	3.90	14.84	12.43	7.85	4.75
Other	33.79	16.78	12.70	23.54	18.99	44.17	12.48

Note: Indicated percent contributions from, VISTAS, CenRAP, and Canada apply only to those portions lying within the modeling domain (see Figure 7.1). Actual contributions, especially from CenRAP, would be higher than stated.

Source: Table 8-1 of the MANE-VU Contribution Assessment

Figures 8.2 and 8.3, also borrowed from the Contribution Assessment, illustrate another method for identifying and ranking states' contributions to sulfate at Class I areas using the 2002 data. This simple technique for deducing the relative impact of emissions from specific point sources on specific receptor sites involves calculating the ratio of annual emissions (Q) to source-receptor distance (d). The ratio (Q/d) is then multiplied by a factor to account for the frequency effect of prevailing winds. The use of this technique is explained in the Contribution Assessment (see pages 4-12 to 4-17 of Attachment B).

Figure 8.2: Ranked Sulfate Contributions to Northeast Class I Receptors Based on Q/d Method (Mass Basis), by Location of Origin

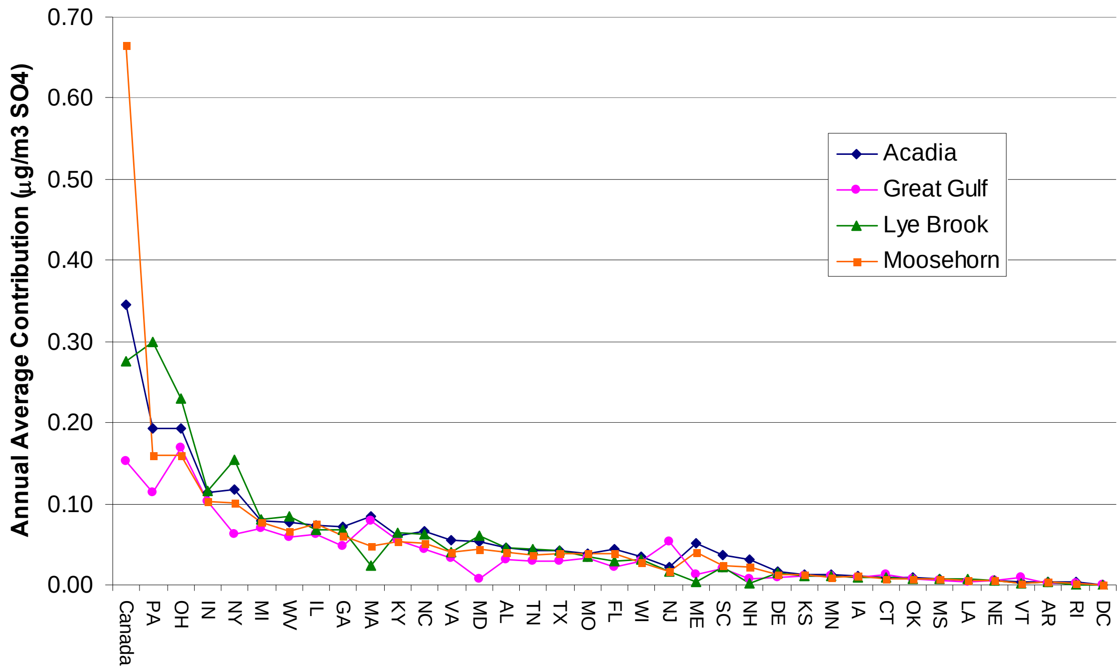
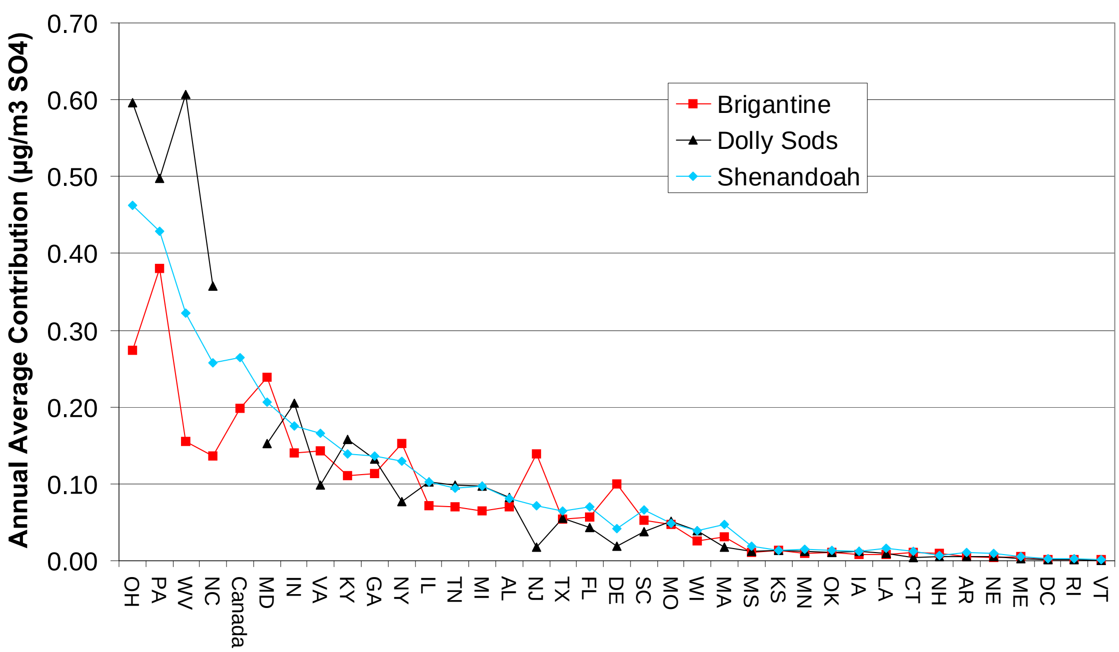


Figure 8.3: Ranked Sulfate Contributions to Mid-Atlantic Class I Receptors Based on Q/d Method (Mass Basis), by Location of Origin



The first of the Q/d plots covers the four northern Class I areas in MANE-VU. The second covers one Class I area in the southern part of MANE-VU and two neighboring Class I areas in the VISTAS region. Observe, again, the comparative importance of emissions from Canada and from states outside the MANE-VU region.

The ranking of emission contributions to visibility impairment in the MANE-VU Class I Areas by methods such as these has direct relevance to the consultation process described previously in Section 3.0, Regional Planning and Consultation. Using results from the REMSAD model, MANE-VU applied the following three criteria to identify states and regions for the purposes of consultation on regional haze:

1. Any state/region that contributed 0.1 $\mu g/m^3$ sulfate or greater on the 20 percent worst visibility days in the base year (2002),
2. Any state/region that contributed at least 2 percent of total sulfate observed on the 20 percent worst visibility days in 2002, and
3. Any state/region among the top ten contributors on the 20 percent worst visibility days in 2002.

For the purposes of deciding how broadly to consult, the MANE-VU States settled on the second of the three criteria: any state/region that contributed at least 2 percent of total sulfate observed on the 20 percent worst visibility days in 2002.

In Figures 8.4 through 8.10, below, states and regions meeting the three listed criteria are identified graphically for seven Class I areas: Shenandoah and Dolly Sods are Class I areas in the VISTAS region that are impacted by emissions from MANE-VU states; the other five Class I areas are in MANE-VU. Note that the IMPROVE monitor at Great Gulf also represents the Presidential Range - Dry River Wilderness, and the IMPROVE monitor at Moosehorn also represents Roosevelt Campobello International Park.

Each figure has the following components:

- On the left is a single bar graph of the IMPROVE-monitored $PM_{2.5}$ mass concentration ($\mu g/m^3$) by constituent species for the baseline years 2000-2004. The yellow, bottom portion of the bar represents the measured sulfate concentration.
- The middle component of each figure provides a bar graph of the 2002 total sulfate contribution of each state or region as estimated by REMSAD.
- Finally, the right segment contains three maps showing which states meet the criteria described above.

Connecticut, Rhode Island, Vermont, and the District of Columbia were not identified as being among the political or regional units contributing at least 2 percent of sulfate at any of the seven Class I areas. However, as participants in MANE-VU, those entities have agreed to pursue adoption of regional control measures aimed at visibility improvement on the haziest days and prevention of visibility degradation on the clearest days, as identified by MANE-VU..

Figure 8.4: Modeled 2002 Contributions to Sulfate at Great Gulf, by State

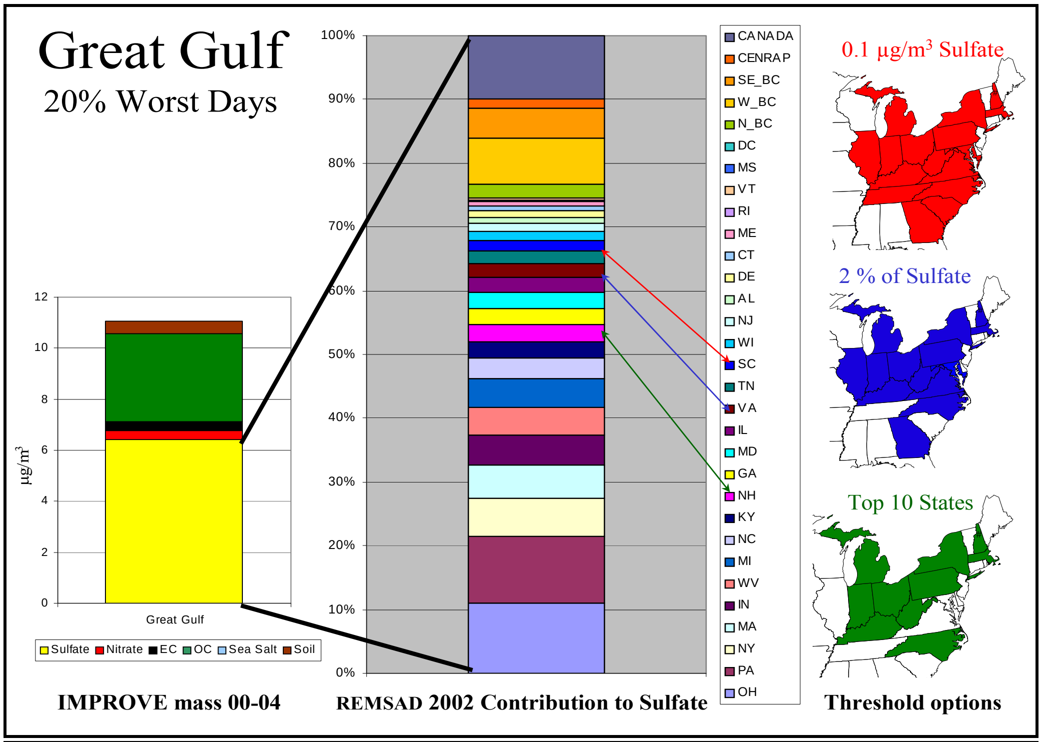


Figure 8.5: Modeled 2002 Contributions to Sulfate at Brigantine, by State

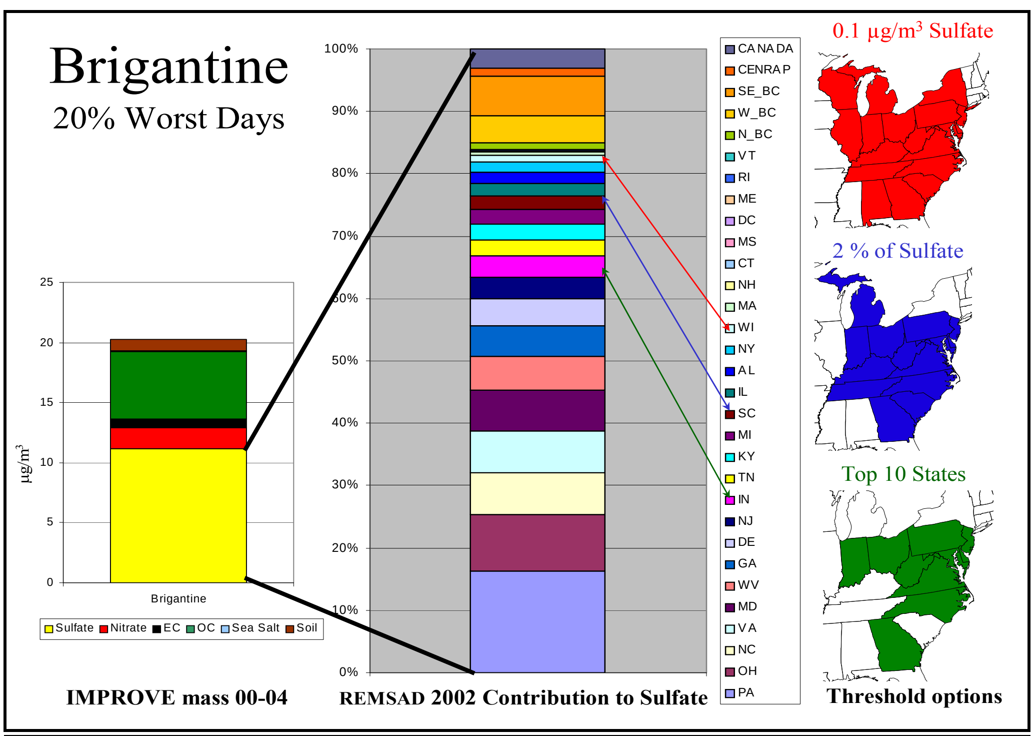


Figure 8.6: Modeled 2002 Contributions to Sulfate at Lye Brook, by State

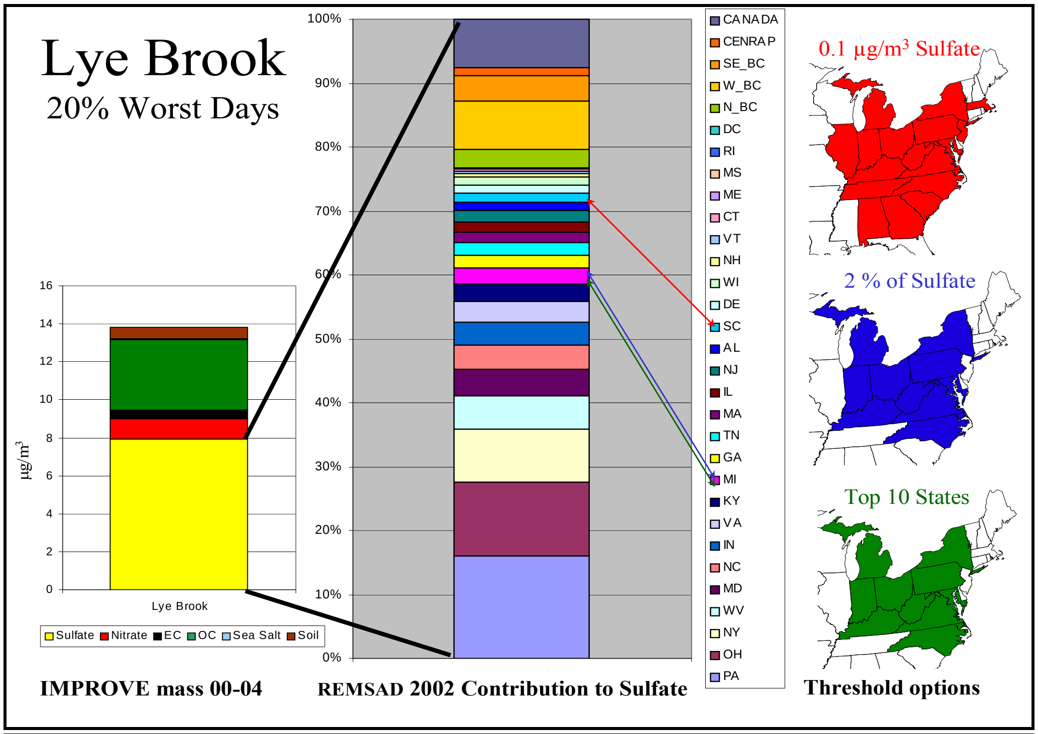


Figure 8.7: Modeled 2002 Contributions to Sulfate at Acadia, by State

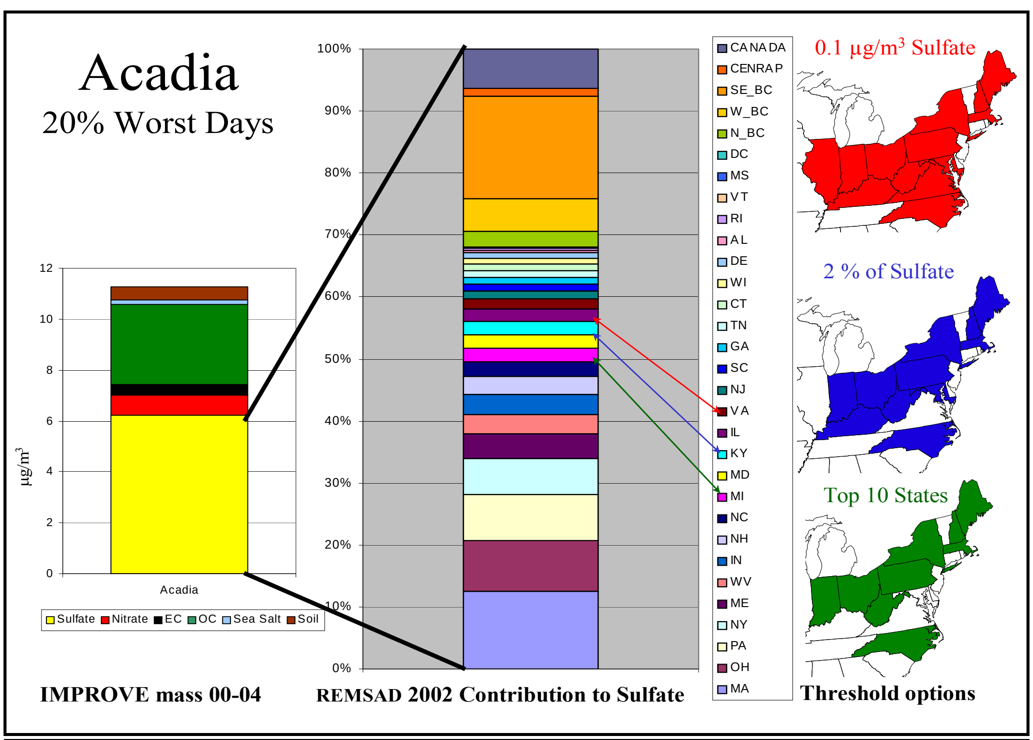


Figure 8.8: Modeled 2002 Contributions to Sulfate at Moosehorn, by State

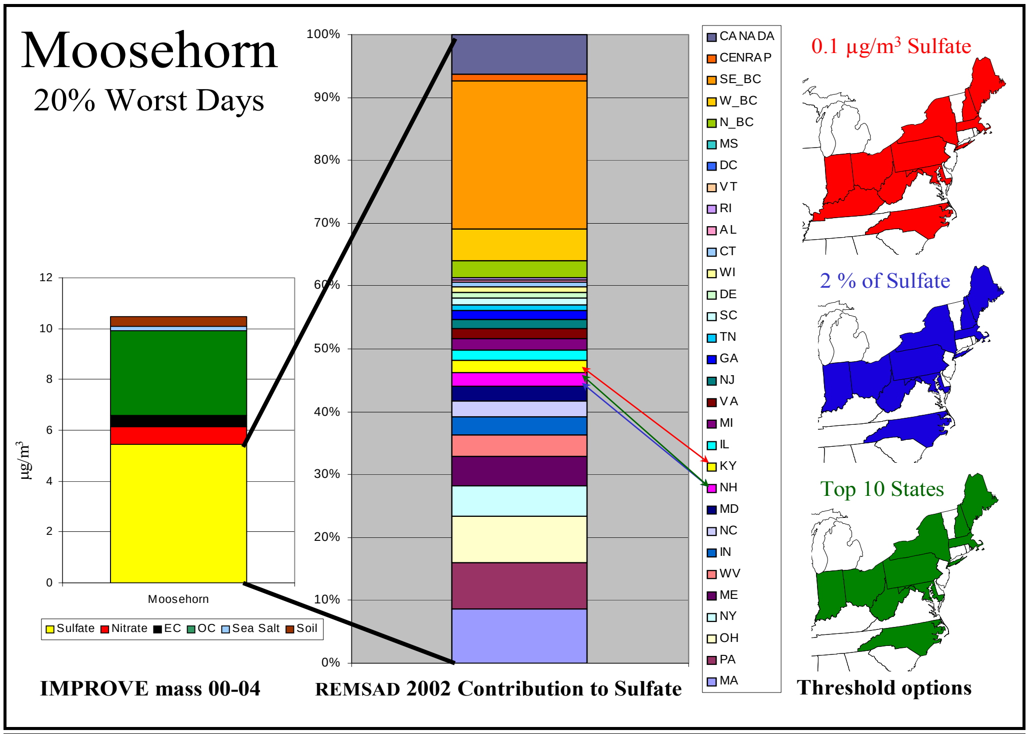


Figure 8.9: Modeled 2002 Contributions to Sulfate at Shenandoah, by State

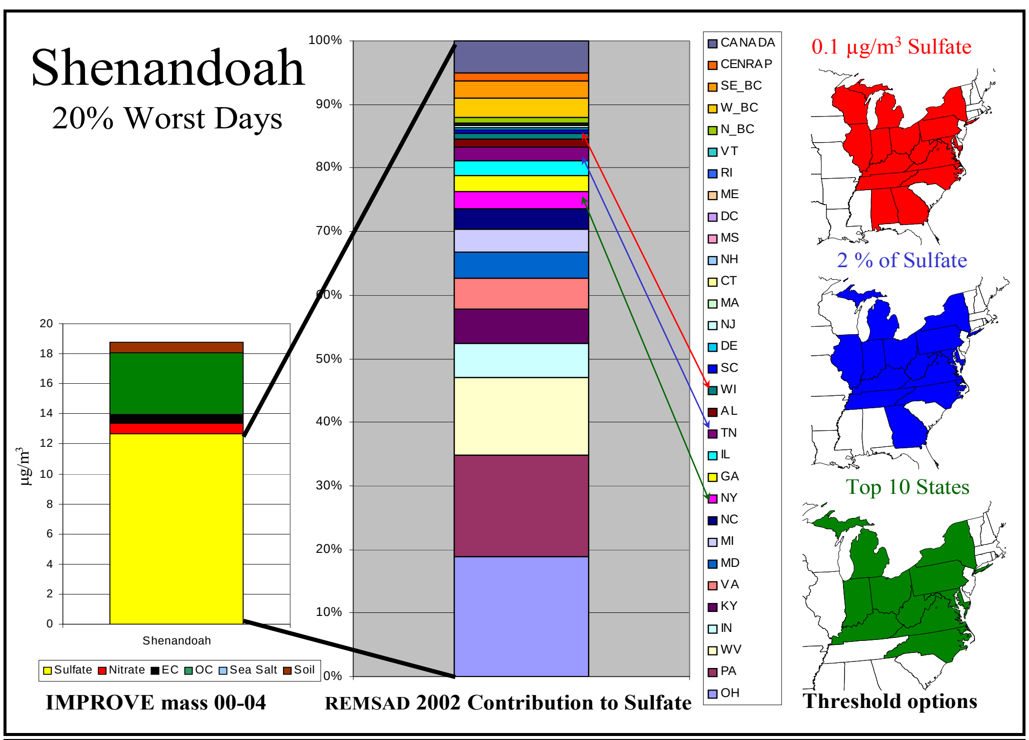
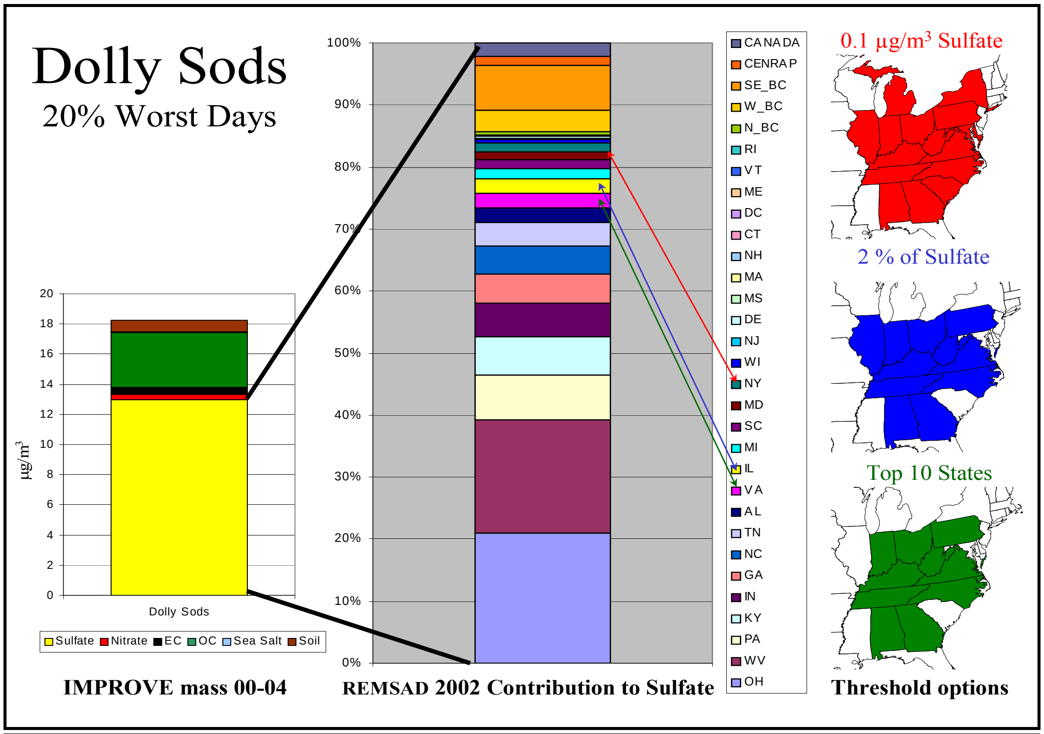


Figure 8.10: Modeled 2002 Contributions to Sulfate at Dolly Sods, by State



8.3 Emission Sources and Characteristics

As previously mentioned, the major pollutants responsible for regional haze are SO_2, NO_X, VOCs, NH_3, PM_{10}, and $PM_{2.5}$. The following is a description of the sources (e.g., point, area, and mobile) and characteristics of pollutant emissions contributing to haze in the eastern United States. Emissions data and graphics presented for the purposes of this section are taken from the MANE-VU 2002 Baseline Emissions Inventory, Version 2.0 (note that the more recent MANE-VU 2002 Baseline Emissions Inventory, Version 3.0, released in April 2006, has superseded Version 2.0 for modeling purposes). Although the emissions inventory database also includes carbon monoxide (CO), this primary pollutant is not considered here because it does not contribute to regional haze.

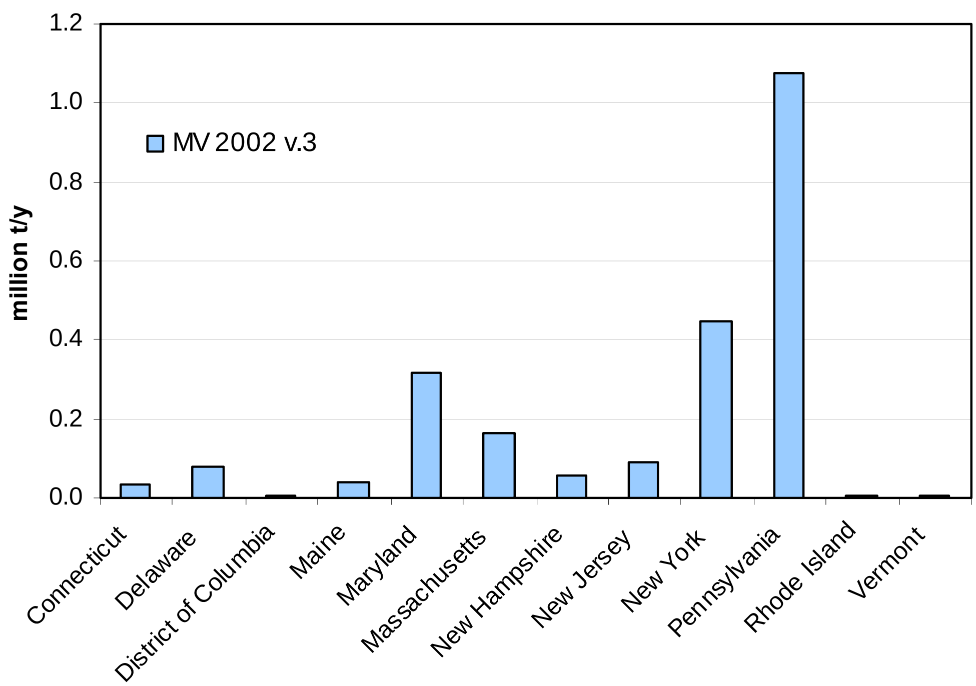
8.3.1 Sulfur Dioxide (SO_2)

SO_2 is the primary precursor pollutant for sulfate particles. Sulfate particles commonly account for more than 50 percent of particle-related light extinction at northeastern Class I areas on the clearest days and for as much as 80 percent or more on the haziest days. Hence, SO_2 emissions are an obvious target of opportunity for reducing regional haze in the eastern United States. Combustion of coal and, to a lesser extent, of certain petroleum products accounts for most anthropogenic SO_2 emissions. In fact, in 1998, a single source category – coal-burning power plants – was responsible for two-thirds of total SO_2 emissions nationwide (NESCAUM, 2001a).

Figure 8.11 shows SO_2 emissions in the MANE-VU states as extracted from the 2002 MANE-VU inventory (http://www.marama.org/visibility/Inventory%20Summary/2002EI-Ver3Sum.html). Most states in the region showed declines in annual SO_2 emissions through 2002 compared with those from previous inventories.

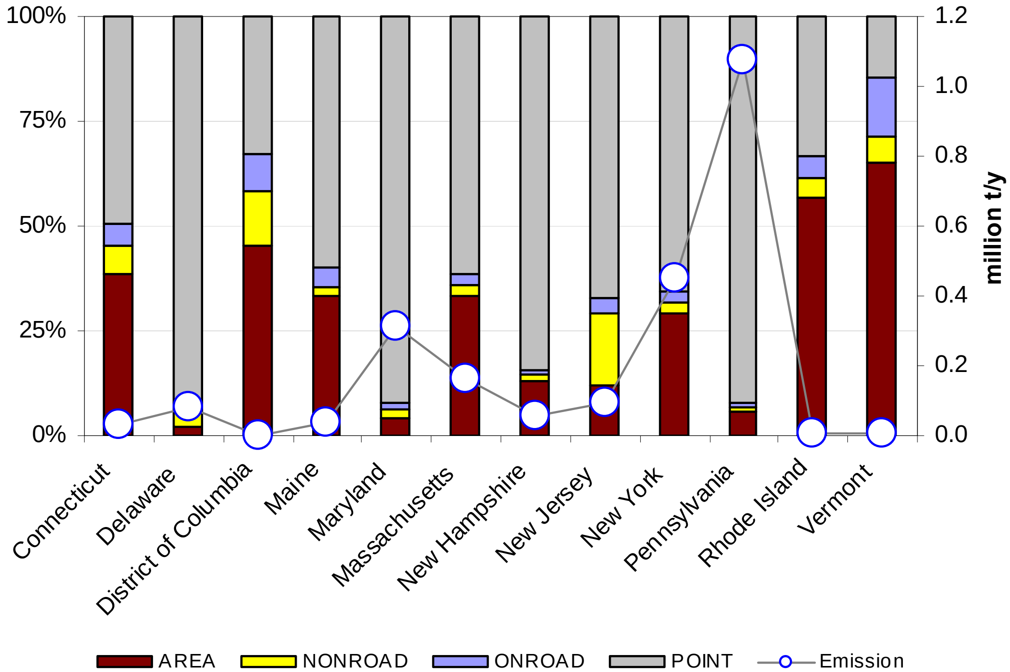
This decline can be attributed in part to implementation of Phase 2 of the Acid Rain Program, which in 2000 further reduced allowable emissions below Phase 1 levels and extended emission limits to a greater number of power plants.

Figure 8.11: Annual Sulfur Dioxide (SO_2) Emissions, by State



The bar graph in Figure 8.12 displays the percentage contributions from different emission source categories to annual SO_2 emissions in the MANE-VU states in 2002, as detailed on the MARAMA Regional Haze website at http://www.marama.org/visibility/Inventory%20Summary/2002EI-Ver3Sum.html. The chart shows that point sources – consisting mainly of stationary combustion sources for generating electricity, industrial power, and heat – dominate SO_2 emissions in the region. Smaller stationary combustion sources, referred to collectively as areas sources, are another important source category in the MANE-VU states. These include smaller industrial, commercial, and institutional boilers as well as residential heating sources. By contrast, on-road and non-road mobile sources make a relatively minor contribution to overall SO_2 emissions in the region (NESCAUM, 2001a).

Figure 8.12: 2002 Sulfur Dioxide (SO_2) Emissions, by State
Bar Graph = Percentage Fractions of Four Source Categories
Line Graph = Total Annual Emissions (10^6 tpy)



8.3.2 Volatile Organic Compounds (VOC)

Existing emissions inventories generally refer to volatile organic compounds (VOCs) as hydrocarbons whose volatility in the atmosphere makes them particularly important to ozone formation. From a regional haze perspective, there is less concern with the volatile organic gases emitted directly to the atmosphere than with the secondary organic aerosols (SOAs) that VOCs form after undergoing condensation and oxidation. Thus the VOC inventory category is of interest primarily because of the organic carbon component of $PM_{2.5}$.

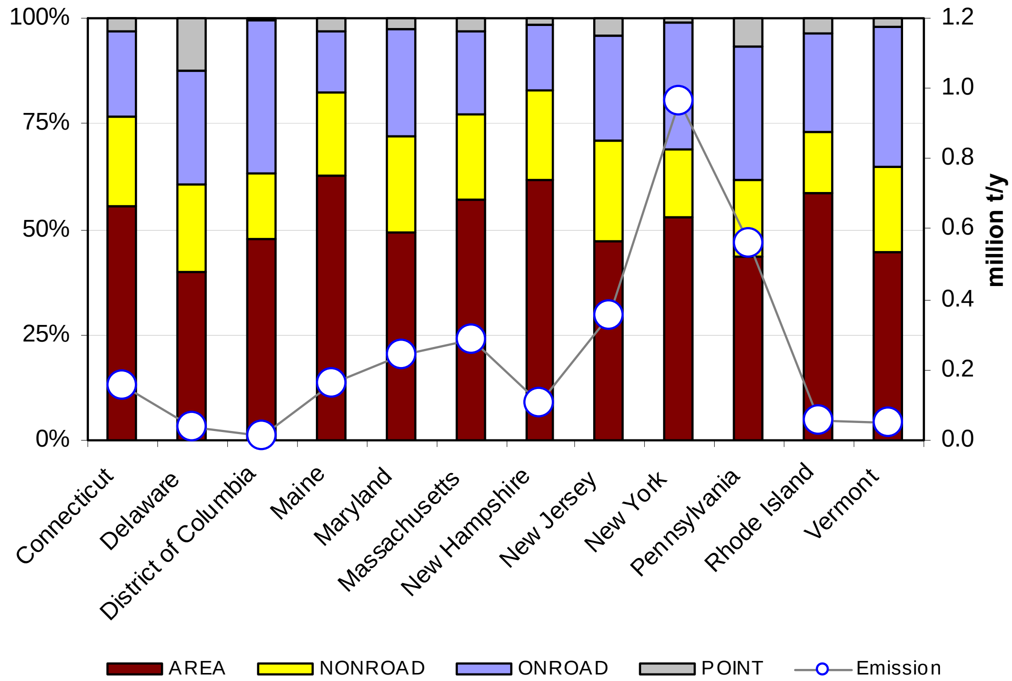
After sulfate, organic carbon generally accounts for the next largest share of fine particle mass and particle-related light extinction at northeastern Class I sites. The term organic carbon encompasses a large number and variety of chemical compounds that may be emitted directly from emission sources as components of primary PM or that may form in the atmosphere as secondary pollutants. The organic carbon present at Class I areas includes a mix of species, including pollutants originating from anthropogenic (i.e., manmade) sources as well as biogenic hydrocarbons emitted by vegetation. Recent efforts to cut back on manmade organic carbon emissions have been undertaken mainly for the purpose of reducing summertime ozone formation in urban centers. Future efforts to make further reductions in organic carbon emissions may be driven by programs that address fine particles and visibility.

Understanding the source regions and transport dynamics for organic carbon in MANE-VU and nearby Class I areas is likely to be more complex than for sulfate. This complexity derives from the large number and diversity of organic carbon species, the wide variation in their transport characteristics, and the fact that a given species may undergo numerous complex chemical reactions in the atmosphere. Thus, the organic carbon contribution to visibility impairment at most Class I areas in the region is likely to include manmade pollution from nearby sources, manmade pollution transported from a distance, and biogenic emissions – especially terpenes from coniferous forests.

As shown in Figure 8.13, the VOC inventory is dominated by mobile and area sources. On-road mobile sources of VOCs include evaporative emissions from transportation fuels and exhaust emissions from gasoline passenger vehicles and diesel-powered, heavy-duty vehicles. VOC emissions may also originate from a variety of area sources (including those that use organic solvents, architectural coatings, and dry cleaning fluids) as well as from some point sources (e.g., industrial facilities and petroleum refineries).

Biogenic VOCs (not included in Figure 8.13) may play an important role within the rural settings typical of Class I areas. The oxidation of hydrocarbon molecules containing seven or more carbon atoms is generally the most significant pathway for the formation of light-scattering organic aerosol particles (Odum et al., 1997). Smaller reactive hydrocarbons that may contribute significantly to urban smog (ozone) are less likely to play a role in organic aerosol formation, although it is noted that high ozone levels can have an indirect effect on visibility by promoting the oxidation of other available hydrocarbons, including biogenic emissions (NESCAUM, 2001a). In short, further work is needed to characterize the organic carbon contribution to regional haze in the MANE-VU states and to develop emissions inventories that will be of greater value for visibility planning purposes. As pointed out in Subsection 8.1, above, organic carbon could be the subject of future control measures to mitigate regional haze but is not the focus of initial planning. This issue will be discussed further in the first progress report.

Figure 8.13: 2002 Volatile Organic Carbon (VOC) Emissions, by State
Bar Graph = Percentage Fractions of Four Source Categories
Line Graph = Total Annual Emissions (10^6 tpy)



8.3.3 Oxides of Nitrogen (NO_X)

NO_X emissions contribute to visibility impairment in the eastern U.S. by forming light-scattering nitrate particles. Nitrate generally accounts for a substantially smaller fraction of fine particle mass and related light extinction than sulfate and organic carbon at northeastern Class I areas. Notably, nitrate may play a more important role in urban settings and in the wintertime. In addition, NO_X may have an indirect effect on summertime visibility by virtue of its role in the formation of ozone, which in turn promotes the formation of secondary organic aerosols (NESCAUM, 2001a).

Since 1980, nationwide emissions of NO_X from all sources have shown little change. Emissions increased by 2 percent between 1989 and 1998 (EPA, 2000a). To a large extent, increases from the industrial and transportation sectors have been offset by emission reductions from power plant combustion sources implemented during the same time period. Figure 8.14 shows NO_X emissions in 2002 for each state in the MANE-VU region. In the several years just prior to 2002, most MANE-VU states experienced declining NO_X emissions.

Power plants and mobile sources generally dominate state and national NO_X emissions inventories. Nationally, power plants account for more than one-quarter of all NO_X emissions, amounting to over six million tons annually. The electric sector plays an even larger role in parts of the industrial Midwest, where power plants contribute significantly to NO_X emissions. By contrast, mobile sources dominate the NO_X inventories for more urbanized MANE-VU states, as shown in Figure 8.15. In these states, on-road mobile sources (i.e., highway vehicles) represent the largest NO_X source category. Emissions from non-road (i.e., off-highway) mobile sources, primarily diesel-powered engines, also make up a substantial fraction of the inventory.

Figure 8.14: Annual Nitrogen Oxide (NO_X) Emissions, by State

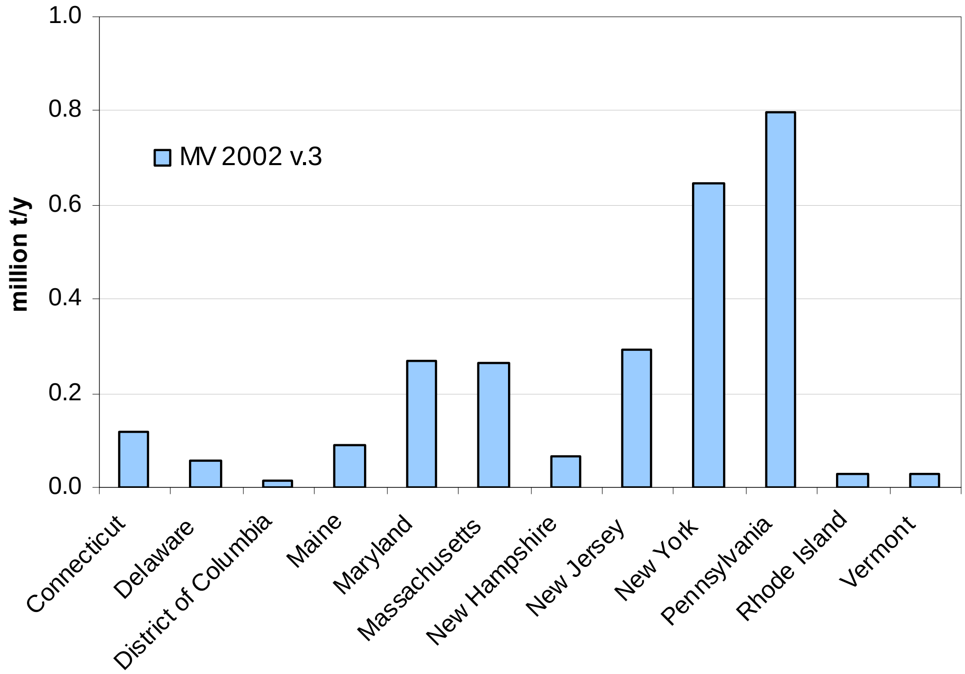
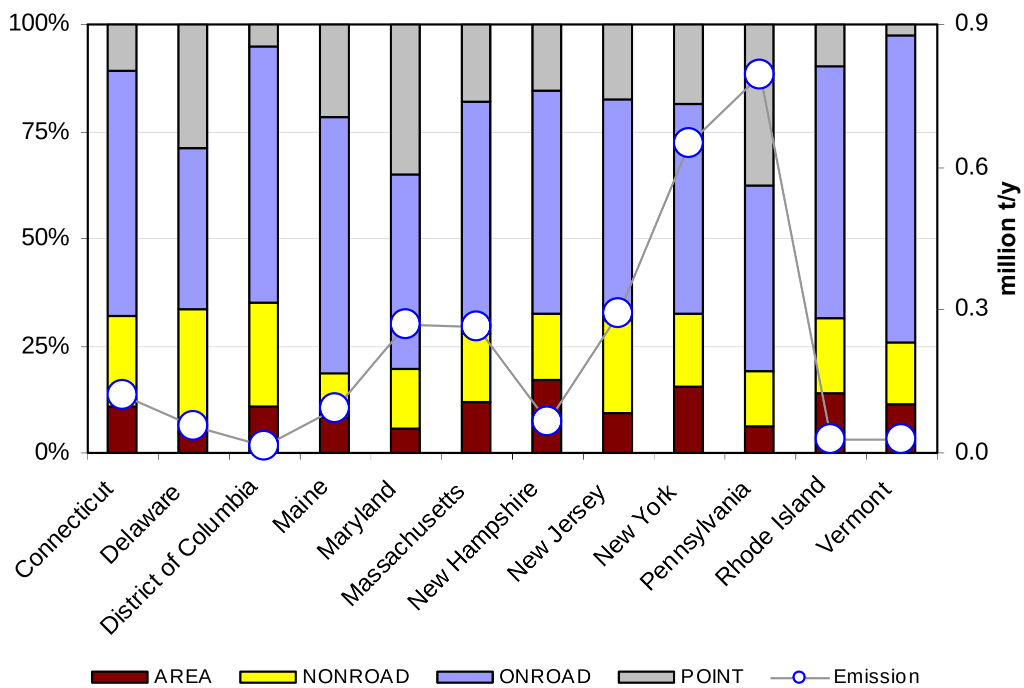


Figure 8.15: 2002 Nitrogen Oxide (NO_X) Emissions, by State
Bar Graph = Percentage Fractions of Four Source Categories
Line Graph = Total Annual Emissions (10^6 tpy)



8.3.4 Primary Particulate Matter (PM_{10} and $PM_{2.5}$)

Directly emitted, or "primary," particles (as distinct from secondary particles that form in the atmosphere through chemical reactions involving precursor pollutants such as SO_2 and NO_X) can also contribute to regional haze. For regulatory purposes, a distinction is made between particulate matter (PM) with an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}) and smaller particles with an aerodynamic diameter less than or equal to 2.5 micrometers ($PM_{2.5}$). Figures 8.16 and 8.17 show PM_{10} and $PM_{2.5}$ emissions, respectively, for the MANE-VU states as reported for the 2002 base year.

Crustal sources are significant contributors of primary PM emissions. This category includes fugitive dust emissions from construction activities, paved and unpaved roads, and agricultural tilling. Typically, monitors estimate PM_{10} emissions from these types of sources by measuring the horizontal flux of particulate mass at a fixed downwind sampling location within perhaps 10 meters of a road or field. Comparisons between estimated emission rates for fine particles using these types of measurement techniques and observed concentrations of crustal matter in the ambient air at downwind receptor sites suggest that physical or chemical processes remove a significant fraction of crustal material relatively quickly. As a result, it rarely entrains into layers of the atmosphere where it can be transported to downwind receptor locations. Because of this discrepancy between estimated emissions and observed ambient concentrations, modelers typically reduce estimates of total $PM_{2.5}$ emissions from all crustal sources by applying a factor of 0.15 to 0.25 to the total $PM_{2.5}$ emissions before including them in modeling analyses.

Figure 8.16: Primary Coarse Particle (PM_{10}) Emissions, by State

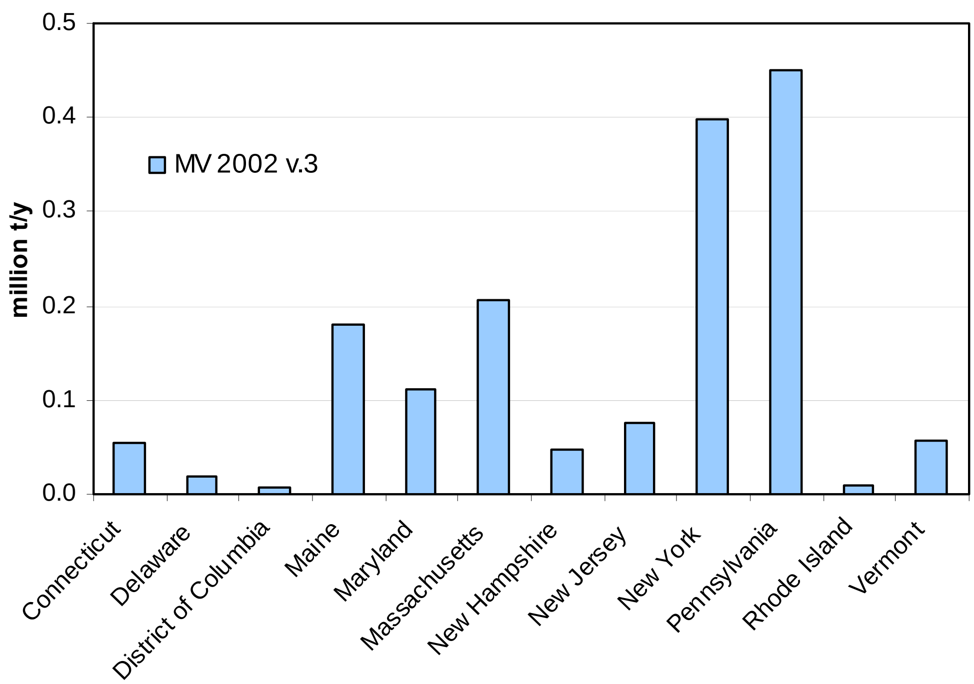
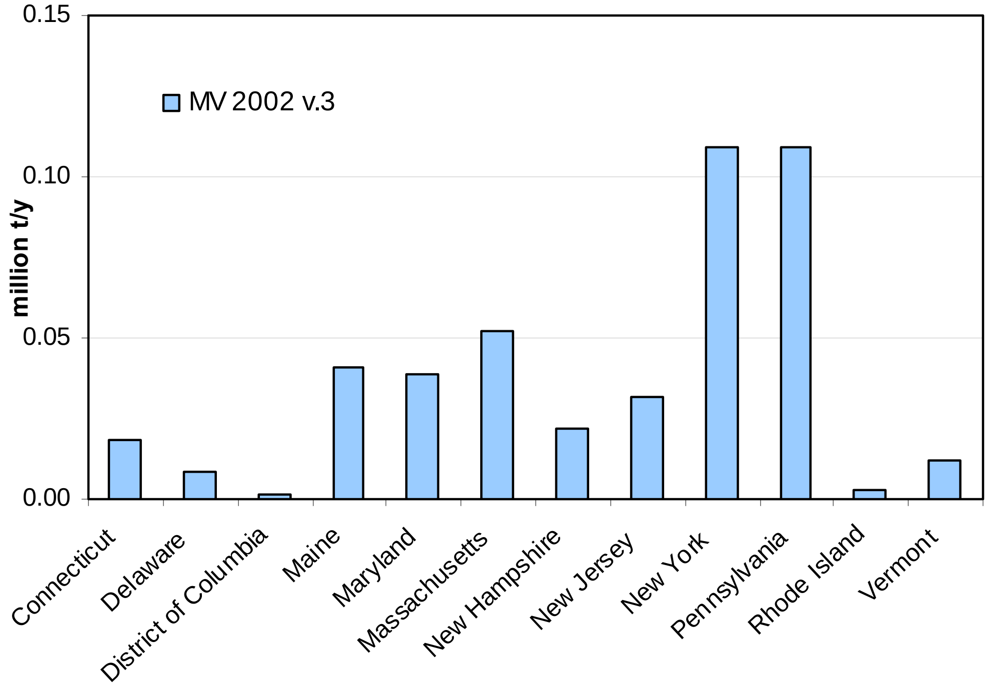


Figure 8.17: Primary Fine Particle ($PM_{2.5}$) Emissions, by State



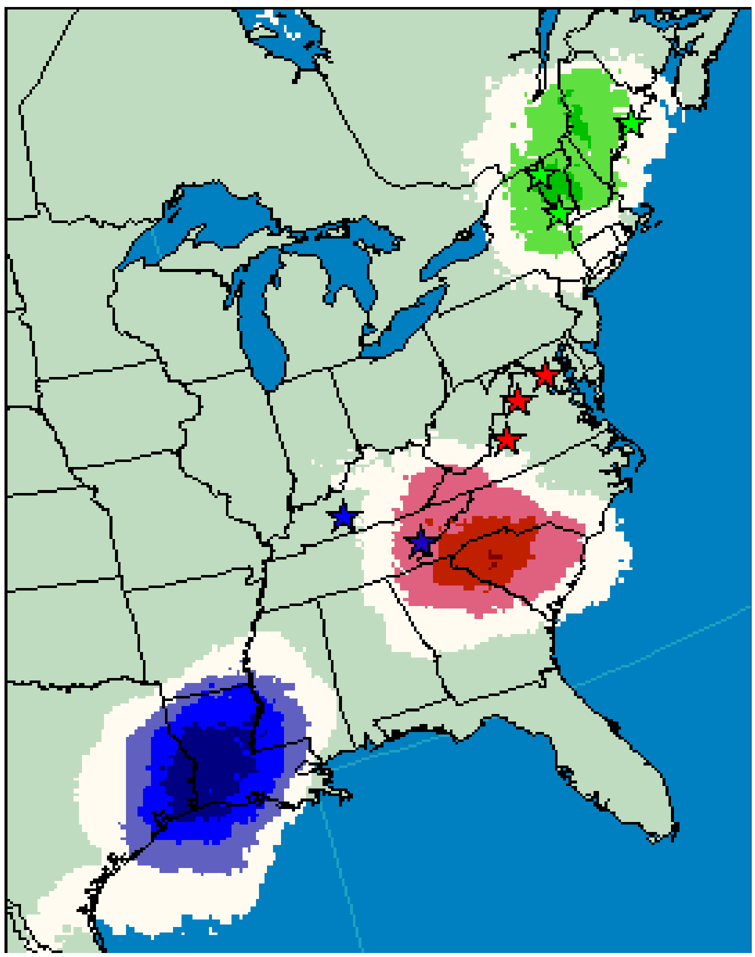
From a regional haze perspective, crustal material generally does not play a major role. On the 20 percent best visibility days during the baseline period (2000-2004), crustal PM accounted for six to eleven percent of particle-related light extinction at MANE-VU Class I sites. On the 20 percent worst visibility days, however, crustal material generally plays a much smaller role, ranging from two to three percent visibility extinction, than other haze-forming pollutants. Moreover, the crustal fraction includes materials of natural origin, such as soil or sea salt, that is not targeted under the Regional Haze Rule. Of course, the crustal fraction can be influenced by construction, agricultural practices, and road maintenance (including wintertime salting). Thus, to the extent that these types of activities are found to affect visibility at Northeastern Class I areas, control measures to reduce coarse and fine particulate matter deriving from crustal material may prove beneficial and are within the purview of EPA or state agencies.

Experience from the western United States, where the crustal component has played a more significant role in overall particulate levels, may be applicable to the extent that it is relevant to the situation in the eastern states. In addition, a few areas in the Northeast, such as New Haven, Connecticut, and Presque Isle, Maine, have had some experience with the control of dust and road-salt stemming from regulatory obligations related to their past non-attainment status with respect to the NAAQS for PM_{10}.

Current emissions inventories for the entire MANE-VU area indicate that residential wood combustion represents 25 percent of primary fine particle emissions in the region. This finding implies that rural sources, as well as contributions from the region's many populous urban areas, can play an important role. An important consideration in this regard is that residential wood combustion occurs mainly in the winter months, while managed or prescribed burning activities occur largely in other seasons. The latter category includes agricultural field-burning, prescribed burning of forested areas, and miscellaneous burning activities such as construction waste burning. Particulate emissions from many of these sources can be managed by limiting allowed burning activities to times when favorable meteorological conditions can efficiently disperse the emissions.

Figure 8.18, taken from Appendix B of the MANE-VU Contribution Assessment, represents the results of source apportionment and trajectory analyses on wood smoke in the area extending from the Gulf States to the Northeast. The green-highlighted portion of the map depicts the wood smoke source region in the Northeast states. The stars on the map represent air monitor sites (including those at several Class I areas) whose data sets were determined to be useful to the modeling analysis.

Figure 8.18: Wood Smoke Source Regional Aggregations



Northeast: ACAD, PMRC, LYBR
Mid-Atlantic: WASH, SHEN, JARI
Southeast: GRSM, MACA

MANE-VU's "Technical Support Document on Agricultural and Forestry Smoke Management in the MANE-VU Region," September 1, 2006 (Attachment V), concluded that fire from land management activities was not a major contributor to regional haze in MANE-VU Class I Areas, and that the majority of emissions from fires were from residential wood combustion.

Figures 8.19 and 8.20 show that area sources dominate primary PM emissions. (EPA's National Emissions Inventory categorizes residential wood combustion and some other combustion sources as area sources.) The relative contribution of point sources is larger in the primary $PM_{2.5}$ inventory than in the primary PM_{10} inventory because the crustal component of particulate emissions (consisting mainly of larger, or coarse, particles) contributes more to overall PM_{10} levels than to $PM_{2.5}$ levels. At the same time, pollution control equipment commonly installed at large point sources is usually more efficient at capturing coarse particle emissions.

Figure 8.19: 2002 Primary Coarse Particle (PM_{10}) Emissions, by State
Bar Graph = Percentage Fractions of Four Source Categories
Line Graph = Total Annual Emissions (10^6 tpy)

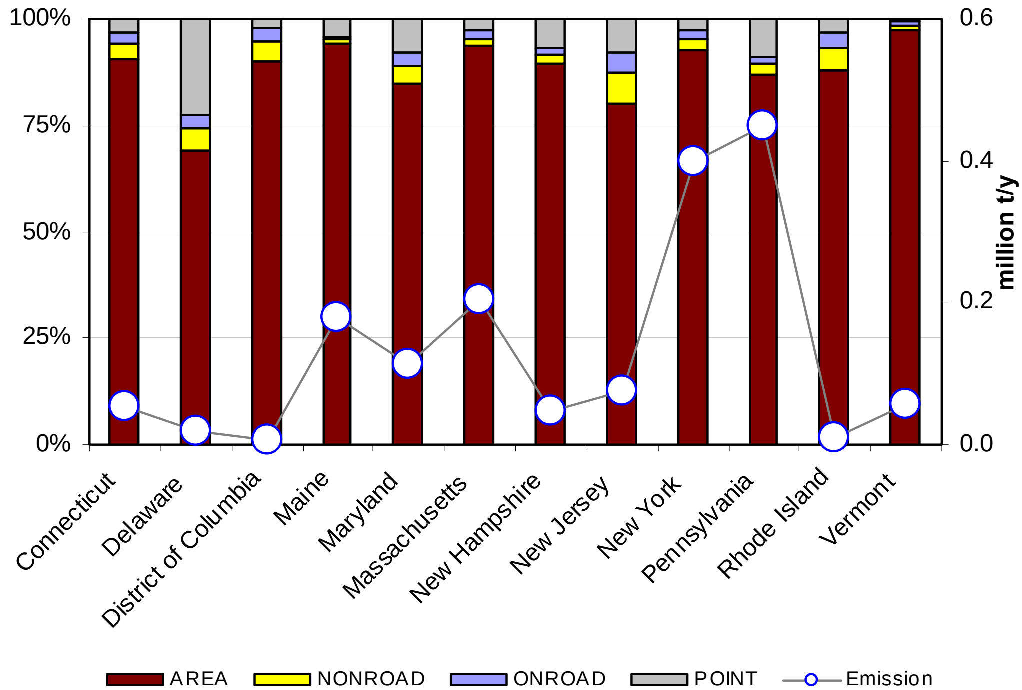
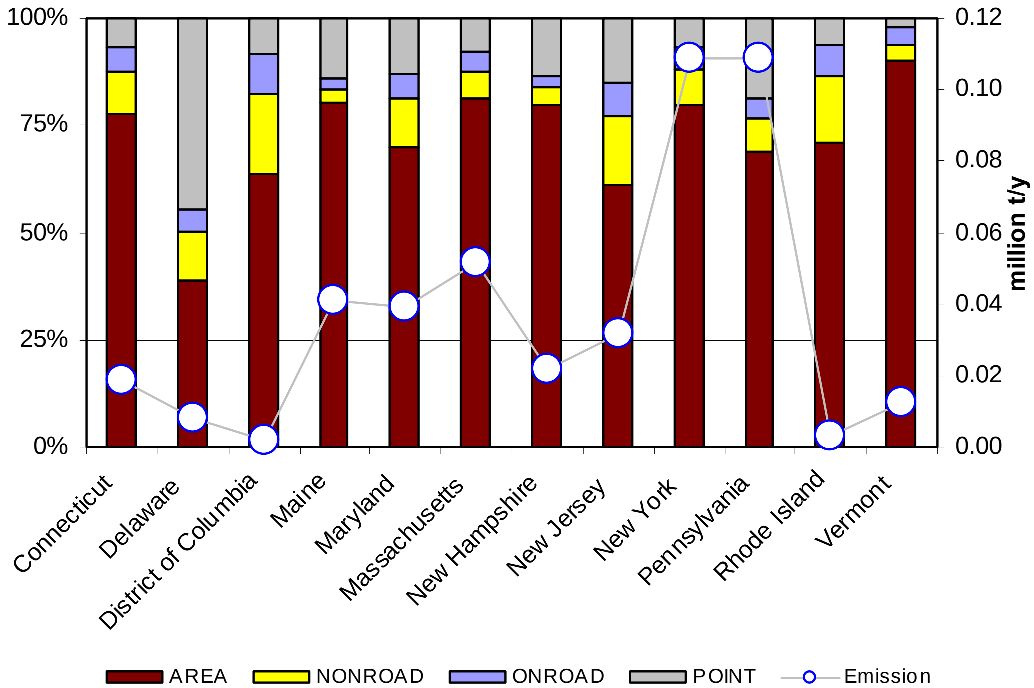


Figure 8.20: 2002 Primary Fine Particle ($PM_{2.5}$) Emissions, by State
Bar Graph = Percentage Fractions of Four Source Categories
Line Graph = Total Annual Emissions (10^6 tpy)



8.3.5 Ammonia Emissions (NH_3)

Because ammonium sulfate ($(NH_3)_2SO_4$) and ammonium nitrate (NH_3NO_3) are significant contributors to atmospheric light scattering and fine particle mass, knowledge of ammonia emission sources is important to the development of effective regional haze reduction strategies. According to 1998 estimates, livestock agriculture and fertilizer use accounted for approximately 86 percent of all ammonia emissions to the atmosphere (EPA, 2000b). However, improved ammonia inventory data are needed as inputs to the photochemical models used to simulate fine particle formation and transport in the eastern United States. States were not required to include ammonia in their emissions data collection efforts until fairly recently (see the Consolidated Emissions Reporting Rule, 67 CFR 39602, June 10, 2002). Therefore, emissions data for ammonia do not exist at the same level of detail or reliability as exists for other pollutants.

Ammonium ion (formed from ammonia emissions to the atmosphere) is an important constituent of airborne particulate matter, typically accounting for 10–20 percent of total fine particle mass. Reductions in ammonium ion concentrations can be instrumental to controlling regional haze because such reductions yield proportionately greater reductions in fine particle mass. Ansari and Pandis (1998) showed that a one $\mu g/m^3$ reduction in ammonium ion could result in up to a four $\mu g/m^3$ reduction in fine particulate matter. Decision makers, however, must weigh the benefits of ammonia reduction against the significant role it plays in neutralizing acidic aerosol.[11]

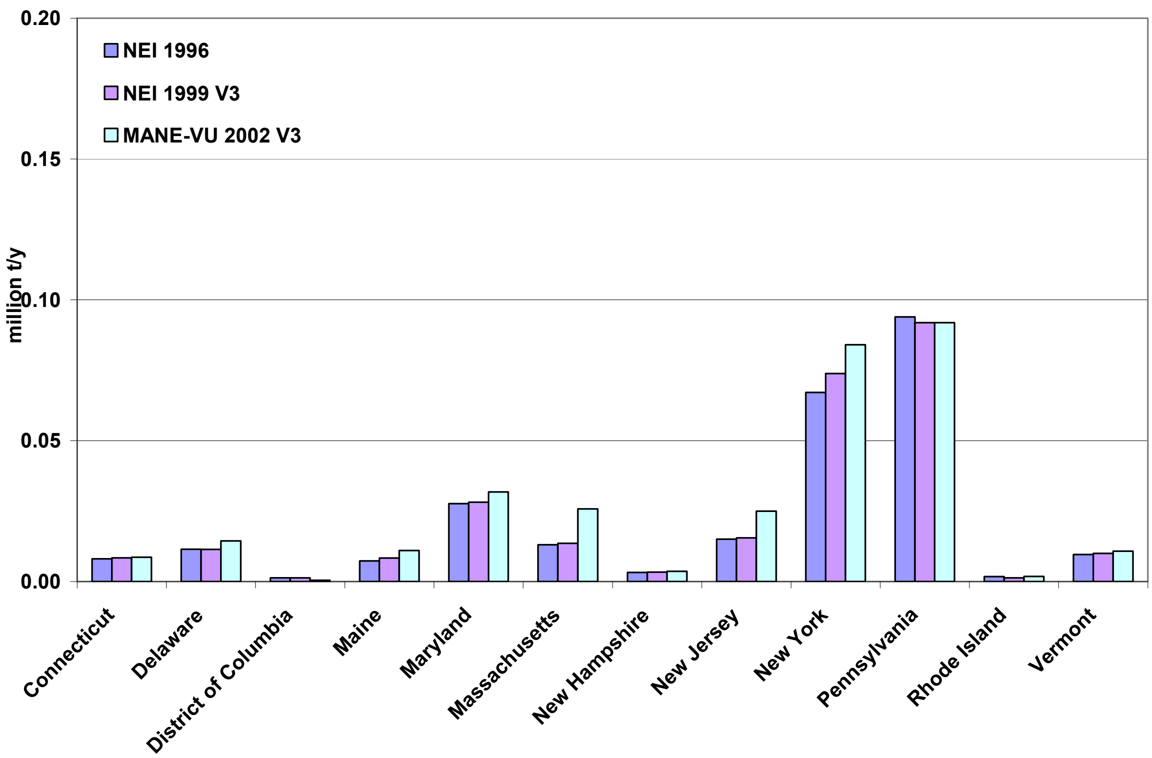
[11] SO_2 reacts in the atmosphere to form sulfuric acid (H_2SO_4). Ammonia can partially or fully neutralize this strong acid to form ammonium bisulfate or ammonium sulfate. If planners focus future control strategies on ammonia and do not

To address the need for improved ammonia inventories, MARAMA, NESCAUM, and EPA funded researchers at Carnegie Mellon University (CMU) in Pittsburgh to develop a regional ammonia inventory (Davidson et al., 1999). This study focused on three issues with respect to current emission estimates: 1) a wide range of ammonia emission factors, 2) inadequate temporal and spatial resolution of ammonia emissions estimates, and 3) a lack of standardized ammonia source categories.

The CMU project established an inventory framework with source categories, emission factors, and activity data that are readily accessible to the user. With this framework, users can obtain data in a variety of formats[12] and can make updates easily, allowing additional ammonia sources to be added or emission factors to be replaced as better information becomes available (Strader et al., 2000; NESCAUM, 2001b).

Figures 8.21 and 8.22 show estimated ammonia emissions for the MANE-VU states in 2002. Area and on-road mobile sources dominate the ammonia inventory data. Specifically, emissions from agricultural sources and livestock production account for the largest share of estimated ammonia emissions in the MANE-VU region, except in the District of Columbia. The two other sources contributing significant emissions are wastewater treatment systems and gasoline exhaust from highway vehicles.

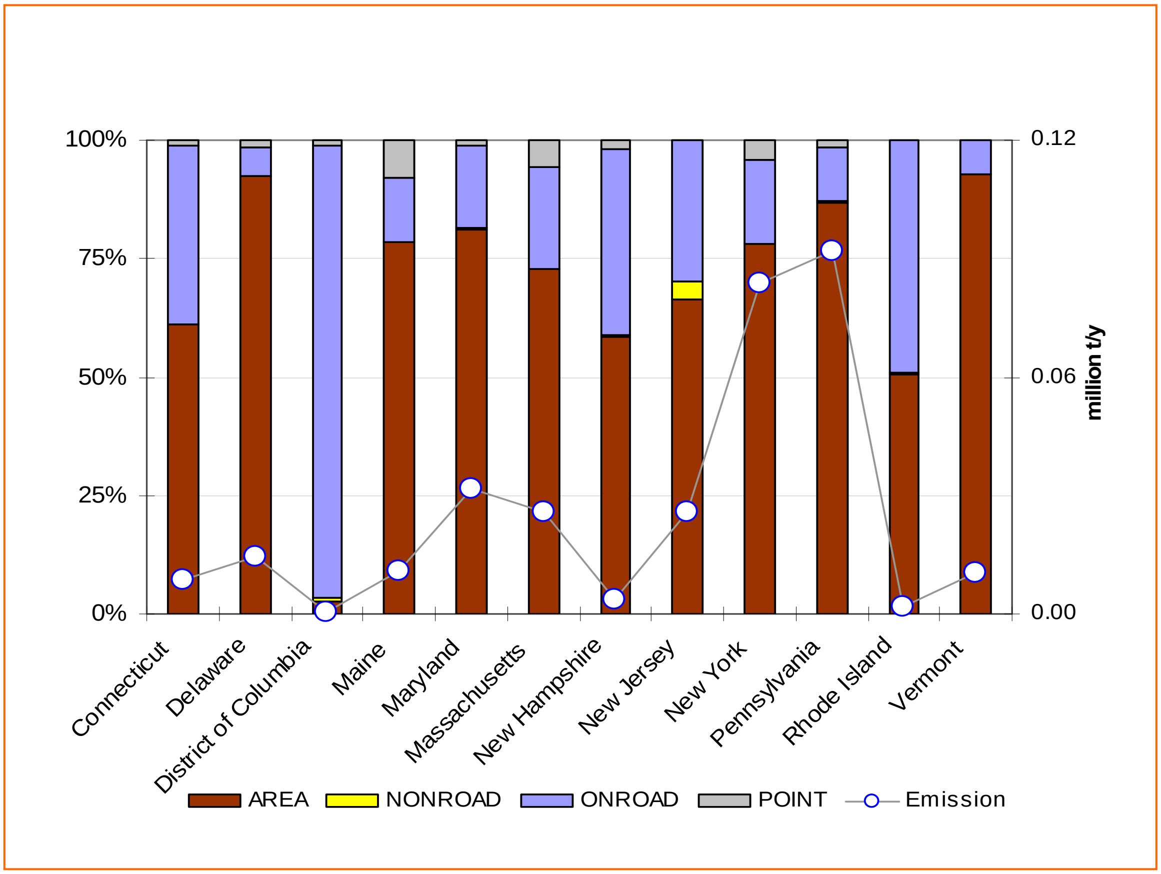
Figure 8.21: Ammonia (NH_3) Emissions, by State



achieve corresponding SO_2 reductions, fine particles formed in the atmosphere will be substantially more acidic than those presently observed.

[12] For example, the user will have the flexibility to choose the temporal resolution of the output emissions data or to spatially attribute emissions based on land-use data.

Figure 8-22 NH_3 (Bar graph: Percentage fraction of four source categories, Circle: Annual emissions amount in 10^6 tons per year)



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Duyzer, J., "Dry Deposition of Ammonia and Ammonium Aerosols over Heathland," *J. Geophys. Res.,* 99(D9):18,757 – 18,763, 1994.

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NESCAUM, "Development of an Improved Ammonia Emissions Inventory for the United States," December 2001b.

Odum, J.R., Jungkamp, T.P.W., Griffin, R.J., Flagan, R.C., and Seinfeld, J.H., "The Atmospheric Aerosol-forming Potential of Whole Gasoline Vapor," *Science*, 276, 96-99, 1997.

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EPA, *National Air Quality and Emission Trends Report, 1998*, EPA 454/R-00-003, available online: http://www.epa.gov/oar/aqtrnd98/, 2000a.

EPA, *National Air Pollutant Trends, 1900 – 1998*, EPA 454/R-00-002, available online: http://www.epa.gov/ttn/chief/trends/trends98/trends98.pdf, 2000b.

EPA 2005, http://www.epa.gov/ttn/chief/eiinformation.html.

9.0 BEST AVAILABLE RETROFIT TECHNOLOGY (BART)

In the Regional Haze Rule, EPA included provisions designed specifically to reduce emissions of visibility-impairing pollutants from large sources that, because of their age, were exempted from new source performance standards (NSPS) established under the Clean Air Act. These provisions, known as Best Available Retrofit Technology, or BART, are located at 40 CFR 51.308(e).

BART requirements pertain to 26 specified major point source categories, including power plants, industrial boilers, paper and pulp plants, cement kilns, and other large stationary sources. To be considered BART-eligible, sources from these specified categories must have the potential to emit at least 250 tons per year of any haze-forming pollutant and must have commenced operation or come into existence in the 15-year period prior to August 7, 1977 (the date of passage of the 1977 Clean Air Act Amendments, which first required new source performance standards).

RI DEM evaluated the major point sources in the State and determined that none meet the criteria to be considered BART- eligible.

10. REASONABLE PROGRESS GOALS

For each Class I area within a State/Tribe, 40 CFR Section 51.308 (d)(1) requires that State/Tribe to establish reasonable progress goals (RPGs), expressed in deciviews, that provide for reasonable progress towards achieving natural visibility. EPA released guidance on June 7, 2007 for setting RPGs. The goals must provide improvement in visibility for the most impaired days and ensure no degradation in visibility for the least impaired days over the SIP period. The State/Tribe must also provide an assessment of the number of years it would take to attain natural visibility conditions if improvement continues at the rate represented by the RPGs.

Under 40 CFR Section 51.308 (d)(1)(iv), consultation is required in developing RPG. The rule states:

> *In developing each reasonable progress goal, the State must consult with those States which may reasonably be anticipated to cause or contribute to visibility impairment in the mandatory Class I Federal area. In any situation in which the State cannot agree with another such State or group of States that a goal provides for reasonable progress, the State must describe in its submittal the actions taken to resolve the disagreement. In reviewing the State's implementation plan submittal, the Administrator will take this information into account in determining whether the State's goal for visibility improvement provides for reasonable progress towards natural visibility conditions.*

In developing the RPGs, the Class I State/Tribe must also consider four factors (cost of compliance, time needed for compliance, energy and non-air quality environmental impacts, and remaining useful life of any affected source). The State/Tribe also must show that it considered the uniform rate of improvement and the emission reduction measures needed to achieve reasonable progress for the period covered by the implementation plan, and if the state proposes a rate of progress slower than the uniform rate of progress, assess the number of years it would take to attain natural conditions if visibility improvement continues at the rate proposed.

Because Rhode Island does not contain any Class I areas, it did not determine RPGs, but, as required, consulted with states with Class I areas that are potentially impacted by emissions from Rhode Island sources. Rhode Island consulted with the following states having Class I areas as those states established RPGs for their Class I areas:

- Maine
- New Hampshire
- Vermont
- New Jersey

Rhode Island agrees with the RPGs established by the above states for their Class I areas, as described below.

10.1 Calculation of Uniform Rate of Progress

As a benchmark to aid in developing RPGs, MANE-VU compared baseline visibility conditions to natural visibility conditions at each MANE-VU Class I area. The difference between baseline and natural visibility conditions for the 20 percent worst days was used to determine the uniform rate of progress that would be needed during each implementation period in order to attain natural visibility conditions by 2064. Table 10.1 presents baseline visibility, natural visibility, and required uniform rate of progress for each MANE-VU Class I area. Visibility values are expressed in deciviews (dv), where each single-unit deciview decrease would represent a barely perceptible improvement in visibility.

Table 10.1 Uniform Rate of Progress Calculation (all values in deciviews)

Class I Area	2000-2004 Baseline Visibility (20% Worst Days)	Natural Visibility (20% Worst Days)	Total Improvement Needed by 2018	Total Improvement Needed by 2064	Uniform Annual Rate of Improvement
Acadia National Park	22.9	12.4	2.4	10.5	0.174
Moosehorn Wilderness and Roosevelt Campobello International Park	21.7	12.0	2.3	9.7	0.162
Great Gulf Wilderness and Presidential Range - Dry River Wilderness	22.8	12.0	2.5	10.8	0.180
Lye Brook Wilderness	24.5	11.7	3.0	12.8	0.212
Brigantine Wilderness	29.0	12.2	3.9	16.8	0.280

Note: Both natural conditions and baseline visibility for the 5-year period from 2000 through 2004 were calculated in conformance with an alternative method recommended by the IMPROVE Steering Committee. ("Baseline and Natural Visibility Conditions, Considerations and Proposed Approach to the Calculation of Baseline and Natural Visibility Conditions at MANE-VU Class I Areas," NESCAUM, December 2006.).

The reasonable progress goals established for MANE-VU's Class I Areas, described in Subsection 10.3, are expected to provide visibility improvements in excess of the uniform rates of progress shown above.

10.2 Identification of (Additional) Reasonable Control Measures

The MANE-VU states have identified specific emission control measures – beyond those which individual states or RPOs had already made commitments to implement – that would be reasonable to undertake as part of a concerted strategy to mitigate regional haze. The proposed additional control measures were incorporated into the regional strategy adopted by MANE-VU on June 20, 2007, to meet the reasonable progress goals established in this SIP. The basic elements of this strategy are described in the MANE-VU Ask (see Section 3.0. States targeted for coordinated actions toward achieving these goals include all of the MANE-VU states plus Georgia, Illinois, Indiana, Kentucky, Michigan, North Carolina, Ohio, South Carolina, Tennessee, Virginia, and West Virginia.

In addition to including proposed emission controls in the eastern United States, MANE-VU determined that it was reasonable to include anticipated emission reductions in Canada in the modeling used to set reasonable progress goals. This determination was based on evaluations conducted before and during the consultation process (see description of relevant consultations in Part 3.2.1). Specifically, the modeling accounts for six coal-burning electric generating units (EGUs) in Canada having a combined output of 6,500 MW that are scheduled to be shut down and replaced by nine natural gas turbine units equipped with selective catalytic reduction (SCR) by 2018.

The process of identifying reasonable measures and setting reasonable progress goals is described in the subsections which follow. Further elaboration on the reasonable measures which make up the Rhode Island/MANE-VU long-term strategy is provided in Section 11.0 of this SIP. Under this plan, the affected states will have a maximum of 10 years to implement reasonable and cost-effective control measures to reduce primarily SO_2 and NO_X emissions. For a description of how proposed emission control measures were modeled to estimate resulting visibility improvements, see Subsection 10.4, Visibility Effects of (Additional) Reasonable Control Measures.

10.2.1 Rationale for Determining Reasonable Controls

40 CFR 51.308(d)(1)(i)(A) of EPA's Regional Haze Rule requires that, in establishing reasonable progress goals for each Class I area, the state must consider 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 potentially affected sources. The SIP must include a demonstration showing how these factors were taken into consideration in setting the RPGs. These factors are sometimes termed the "four statutory factors," since their consideration is required by the Clean Air Act.

Focus on SO_2: MANE-VU conducted a Contribution Assessment (Attachment B) and developed a conceptual model that showed the dominant contributor to visibility impairment at all MANE-VU Class I areas during all seasons in the base year was particulate sulfate formed from emissions of SO_2. While other pollutants, including organic carbon, will need to be addressed in order to achieve the national visibility goals, MANE-VU's contribution assessment suggested that an early emphasis on SO_2 would yield the greatest near-term benefit. Therefore, it is reasonable to conclude that the additional measures considered in setting reasonable progress goals require reductions in SO_2 emissions.

Contributing Sources: The MANE-VU Contribution Assessment indicates that, in 2002, emissions from within MANE-VU were responsible for approximately 25 percent of the sulfate at MANE-VU Class I Areas. Sources in the Midwest and Southeast regions were responsible for about 15 to 25 percent each. Point sources dominated the inventory of SO_2 emissions. Therefore, MANE-VU's long-term strategy includes additional measures to control sources of SO_2 both within the MANE-VU region and in other states that were determined to contribute to regional haze at MANE-VU Class I Areas.

The Contribution Assessment documented the source categories most responsible for visibility degradation at MANE-VU Class I Areas. As described in Section 11, Long-Term Strategy, MANE-VU and the OTC collaborated to evaluate a large number of potential control measures. Several measures that would reduce SO_2 emissions were identified for further study.

These efforts led to production of the MANE-VU report by MACTEC Federal Programs, Inc., "Assessment of Reasonable Progress for Regional Haze in MANE-VU Class I Areas," Final, July 9, 2007, otherwise known as the Reasonable Progress Report (Attachment Y). This report provides an analysis of the four statutory factors for five major source categories: electrical generating units (EGUs); industrial, commercial, and institutional (ICI) boilers; cement and lime kilns; heating oil combustion; and residential wood combustion. Table 10.2 summarizes the results of MANE-VU's four-factor analysis for the source categories considered.

Table 10.2 Summary of Results from Four-Factor Analysis of Different Source Categories

Source Category	Primary Regional Haze Pollutant	Control Measure(s)	Average Cost in 2006 dollars (per ton of pollutant reduction)	Compliance Timeframe	Energy and Non-Air Quality Environmental Impacts	Remaining Useful Life
Electric Generating Units	SO_2	Switch to a low-sulfur coal (generally <1% sulfur); switch to natural gas (virtually 0% sulfur); coal cleaning; flue gas desulfurization (FGD), including wet, spray-dry, or dry.	$775-$1,690 based on IPM® v.2.1.9 * $170-$5,700 based on available literature	2-3 years following SIP submittal	Fuel supply issues, possible permitting issues, reduced electricity production capacity, wastewater issues	50 years or more
Industrial, Commercial, Institutional Boilers	SO_2	Switch to a low-sulfur coal (generally <1% sulfur); switch to natural gas (virtually 0% sulfur); switch to a lower-sulfur oil; coal cleaning; combustion controls; flue gas desulfurization (FGD), including wet, spray-dry, or dry.	$130-$11,000 based on available literature; dependent on size.	2-3 years following SIP submittal	Fuel supply issues, potential permitting issues, control device energy requirements, wastewater issues	10-30 years
Cement and Lime Kilns	SO_2	Fuel switching; flue gas desulfurization (FGD), including wet, spray-dry, or dry; advanced flue gas desulfurization (FGD).	$1,900-$73,000 based on available literature; dependent on size.	2-3 years following SIP submittal	Control device energy requirements, wastewater issues	10-30 years
Heating Oil	SO_2	Switch to lower-sulfur fuel (varies by state)	$550-$750 based on available literature; high degree of uncertainty with this cost estimate	Currently feasible; capacity issues may influence timeframe for implementation of new fuel standards	Increased furnace/boiler efficiency, reduced furnace/boiler maintenance requirements	18-25 years
Residential Wood Combustion	PM	State implementation of NSPS, ban on resale of uncertified devices, installer training certification or inspection program, pellet stoves, EPA Phase II certified RWC devices, retrofit requirement, accelerated changeover requirement or inducement	$0-$10,000 based on available literature	Several years, depending on mechanism for emission reductions	Increased efficiency of combustion device, reduced greenhouse gas emissions	10-15 years

* Integrated Planning Model® CAIR versus CAIR plus analysis conducted for MARAMA/MANE-VU by ICF Consulting, L.L.C.

The MANE-VU states reviewed the four-factor analyses presented in the Reasonable Progress Report, consulted with one another about possible control measures, and concluded by adopting the statements known as the MANE-VU Ask. These statements identify the control measures that would be pursued toward improving visibility in the region. The following discussions focus on the four basic control strategies chosen by MANE-VU and included in the modeling to establish the reasonable progress goals:

1 Best Available Retrofit Technology (BART),
2 Low-sulfur fuel oil requirements,
3 Emission reductions from specific EGUs, and
4 Additional measures determined to be reasonable.

10.2.2 Best Available Retrofit Technology Controls

The MANE-VU states identified approximately 100 BART-eligible sources in the region. Most of these facilities are already controlling emissions in response to other federal or state air programs or are likely to install emission controls under new programs. A complete compilation of BART-eligible sources in the MANEVU region is available in Appendix A of MANE-VU's "Assessment of Control Technology Options for BART-Eligible Sources," March 2005, also known as the BART Report (Attachment Z).

To assess the benefits of implementing BART in the MANE-VU region, NESCAUM estimated emission reductions for twelve BART-eligible sources in MANE-VU states that would probably be controlled as a result of BART requirements alone. These sources include one EGU and eleven non-EGUs. The affected sources were identified by a survey of states' staff members, who furnished data on the potential control technologies and expected control levels for these sources under BART implementation. The twelve sources are listed in Table 10.3 along with their 2002 baseline and 2018 estimated emissions. Information on these sources was incorporated into the 2018 emissions inventory projections that were used in the modeling to set reasonable progress goals.

***Best Available Retrofit Technology is Reasonable*:** BART controls are part of the strategy for improving visibility at MANE-VU Class I Areas. MANE-VU prepared reports to provide states with information about available control technologies (e.g., MANE-VU's BART Report referenced above), estimated cost ranges, and other factors associated with those controls. The reasonable progress goals established in this regional haze SIP assume that states whose emissions affect Class I areas in MANE-VU will make determinations demonstrating the reasonableness of BART controls for sources in their states. As discussed previously, there are no BART-eligible sources in Rhode Island.

Table 10.3 Estimated Emissions from BART-Eligible Facilities in MANE-VU States (Facilities Likely to be Controlled as a Result of BART Alone

State	Facility Name	Unit Name	SCC Code	Plant ID (MANE-VU Inventory)	Point ID (MANE-VU Inventory)	Facility Type	2002 SO_2 Emissions (tons)	2018 SO_2 Emissions (tons)
MD	EastAlco Aluminum	28	30300101	021-0005	28	Metal Production	1,506	1,356
MD	Eastalco Aluminum	29	30300101	021-0005	29	Metal Production	1,506	1,356
MD	Lehigh Portland Cement	39	30500606	013-0012	39	Portland Cement	9	8
MD	Lehigh Portland Cement	16	30500915	021-0003	16	Portland Cement	1,321	1,189
MD	Lehigh Portland Cement	17	30500915	021-0003	17	Portland Cement	9,76	8,78
MD	Westvaco Fine Papers	2	10200212	001-0011	2	Paper and Pulp	8,923	1,338
ME	Wyman Station	Boiler 3	10100401	2300500135	004	EGU	616	308
ME	SAPPI Somerset	Power Boiler 1	10200799	2302500027	001	Paper and Pulp	2,884	1,442
ME	Verso Androscoggin LLC	Power Boiler 1	10200401	2300700021	001	Paper and Pulp	2,964*	1,482
ME	Verso Androscoggin LLC	Power Boiler 2	10200401	2300700021	002	Paper and Pulp	3,086*	1,543
NY	Kodak Park Division	U00015	10200203	8261400205	U00015	Chemical Manufacturer	2,3798	1,4216
NY	Lafarge Building Materials, Inc	41000	30500706	4012400001	041000	Portland Cement	14,800	4,440

Note: Many additional sources in MANE-VU are BART-eligible but are expected to be controlled as a result of other emission reduction programs (e.g., state-specific multi-pollutant programs, CAIR-successor legislation, etc.).

*Data for 1999 baseline year.

10.2.3 Low-Sulfur Fuel Strategy

The MANE-VU region, especially the Northeast, is heavily reliant on distillate oil for home space heating, with more than 4 million gallons used, according to 2006 estimates from the Energy Information Administration[13.] Likewise, the heavier residual oils are widely used by non-EGU sources and, to a lesser extent, the EGU sector. The sulfur content of distillate fuels currently averages above 2,000 ppm (0.2 percent). Although the sulfur content of residual

[13] U.S. Department of Energy, EIA, Table F3a, at http://www.eia.doe.gov/emeu/states/sep_fuel/html/fuel_use_df.html

oils varies by source and region, it can exceed 2.0 percent. Combustion of distillate and residual fuel in the MANE-VU states resulted in SO_2 emissions totaling approximately 380,000 tons in 2002.

As the second component of MANE-VU's long-term strategy, the member states agreed to pursue measures that would require the sale and use of fuel oils having reduced sulfur content. This strategy would be implemented in two phases:

- Phase 1 would reduce the sulfur content in distillate (#1 and # 2) fuel oils from current levels of 2,000 to 2,300 ppm (0.20 to 0.23 percent) to a maximum of 500 ppm (0.05 percent) by weight. It would also restrict the sale of heavier blends of residual (# 4, #5, and # 6) fuel oils that have sulfur content greater than 2,500 ppm (0.25 percent) and 5,000 ppm (0.5 percent) by weight, respectively.

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- Phase 2 would further reduce the sulfur content of the distillate fraction from 500 ppm (0.05 percent) to 15 ppm (0.015 percent); the sulfur limits on residual oils would be at first-phase levels.

The two phases are to be introduced in sequence with slightly different timing for an inner zone of MANE-VU states, including New Jersey, Delaware, New York City, and possibly portions of eastern Pennsylvania, and the remainder of MANE-VU states. While all MANE-VU states have agreed to pursue implementation of both phases to full effect by the end of 2018, not every state can make a firm commitment to these measures at this time. States are expected to review the situation by the time of the first regional haze SIP progress report in 2012 and to seek alternate, equivalent reductions if necessary.

Reductions in sulfur dioxide emissions will occur as a direct consequence of the low-sulfur fuel strategy. For both phases combined, it is estimated that SO_2 emissions in the MANE-VU region will decline from 2002 levels by 168,222 tons per year for combustion of light distillates and by 42,875 tons per year for combustion of the heavier fuels. Together, these reductions represent a 35 percent decrease in the projected 2018 SO_2 emissions inventory for non-EGU sources in the region.

NESCAUM analyzed the two program phases separately for MANE-VU, but it is the combined benefit of implementing both phases that is relevant to the question of visibility improvement by 2018. To estimate the effects of the low-sulfur fuel strategy, MANE-VU applied the expected sulfur dioxide emission reductions to all non-EGU sources burning #1, #2, #4, #5, or #6 fuel oil. These emission reductions would result directly from the lowering of fuel sulfur content from original levels to 0.015 percent for #1 and #2 oil, to 0.25 percent for #4 oil, and to 0.5 percent for #5 and #6 oil.

The reduction in SO_2 emissions by 2018 will yield corresponding reductions in sulfate aerosol, the main culprit in fine-particle pollution and regional haze. The full benefit of MANE-VU's low-sulfur fuel strategy is represented in Figure 10.1, which displays the estimated average reductions in 24-hr $PM_{2.5}$ concentration as calculated by the CMAQ model for the combined first and second phases of the program.

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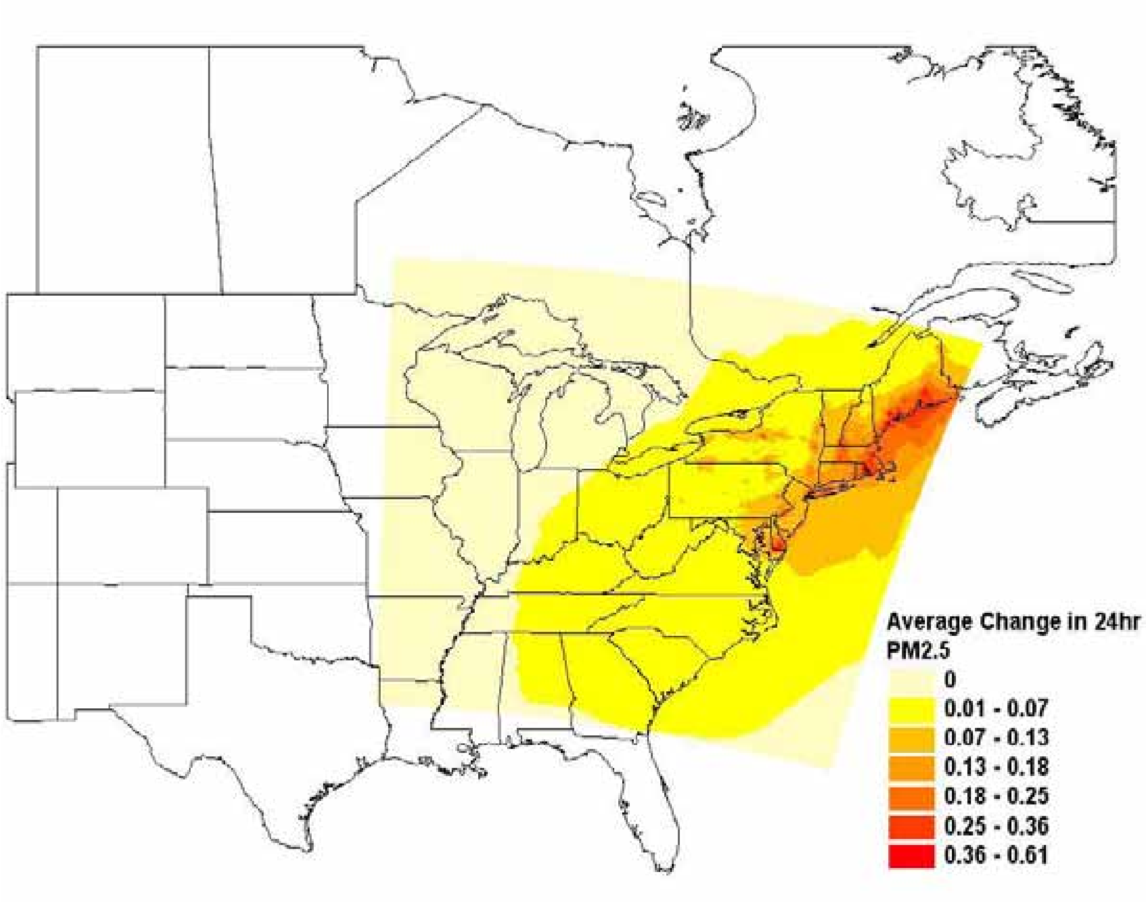
Figure 10.1 Average Change in 24-hr $PM_{2.5}$ Due to Low-Sulfur Fuel Strategy (Phases I and 2 Combined) Relative to OTB/OTW (values in µg/m^3)



Low-Sulfur Fuel Oil Requirements are Reasonable: The MANE-VU Contribution Assessment documented source apportionment analyses that linked visibility impairment in MANE-VU Class I Areas with SO_2 emissions from sources burning fuel oil. The reasonable assumption underlying the low-sulfur fuel oil strategy is that refiners can, by 2018, produce home heating and fuel oils that contain 50 percent less sulfur for the heavier grades (#4 and #6 residual oil), and 75 to 99.25 percent less sulfur in #2 fuel oil (also known as home heating oil, distillate, or diesel fuel) at an acceptably small increase in price to the consumer.

***Four-Factor Analysis – Low-Sulfur Fuel Oil Strategy*:** The MANE-VU Reasonable Progress Report discussed the four factors as they apply to low-sulfur fuel use for ICI boilers and residential heating systems. MANE-VU's Reasonable Progress Report identified switching to a lower-sulfur fuel oil as an available SO_2 control option that would achieve 50 to 90 percent reductions in SO_2 emissions from ICI Boilers. The report also noted that home heating oil use generates an estimated 100,000 tons of SO_2 emissions in the Northeast each year and that SO_2 emissions would decline in proportion to reductions in fuel sulfur content. The following discussion summarizes information concerning the four factors for the low-sulfur fuel strategy.

***1) Low-Sulfur Fuel Oil Strategy – Costs of Compliance*:** The MANE-VU Reasonable Progress report noted that, because of requirements for motor vehicle fuels, refineries have already made the capital investments required for the production of low-sulfur diesel (LSD) and ultra-low sulfur diesel (ULSD). The report estimated the cost of SO_2 removal by switching to lower-sulfur fuel would range from $554 to $734 per ton (converted from 2001 to 2006 dollars using a conversion factor of 1.1383). In some seasons and some locations, low-sulfur diesel is actually cheaper than regular diesel fuel. (See Chapter 8 of the MANE-VU Reasonable Progress Report.)

The sulfur content of #4 and #6 fuels can also be cost-effectively reduced. Residual oil is essentially a byproduct of the refining process and is produced in several grades that can be blended to meet a specified fuel sulfur content limit. New York Harbor residual fuel prices for the week ending March 21, 2008 ranged from a low of $71.38 a barrel for 2.0 and 2.2 percent sulfur fuel to a high of $91.38 per barrel for 0.3 percent sulfur fuel. During this same period, low-pour (low-temperature, reduced viscosity) residual fuel oil with a 0.5 percent sulfur content sold for $80.83 per barrel. Residual oil with a fuel sulfur content limit of 0.7 percent and 1.0 percent traded at $75.13 and $72.63, respectively.

While the costs of achieving the projected emissions reductions with the low-sulfur fuel strategy are somewhat uncertain, they appear to be reasonable in comparison with the costs of controlling other sectors. Some MANE-VU states are proceeding with low-sulfur oil requirements much sooner than 2018; however, all of the MANE-VU states concur that a low-sulfur oil strategy is both reasonable and achievable within the MANE-VU region by no later than 2018. MANE-VU has concluded that the cost of requiring the use of lower-sulfur fuels is reasonable.

2) Low-Sulfur Fuel Oil Strategy – Time Necessary for Compliance: MANE-VU's Reasonable Progress Report indicated that furnaces and boilers would not have to be retrofit with process or control equipment to burn ULSD distillate fuel oil. Therefore, the time necessary for compliance would be determined by the availability of the fuel.

The MANE-VU Reasonable Progress Report notes that, on a national scale, more ULSD is produced than both LSD and high-sulfur fuel, and concludes that the United States has the infrastructure to produce adequate stocks of these fuels. NESCAUM's report, "Low Sulfur Heating Oil in the Northeast States: An Overview of Benefits, Costs, and Implementation Issues," December 2005 (Attachment AA) observes that the federal rules for heavy duty highway diesel fuel are flexible, so that if there is a shortage of 15 ppm fuel, the 15 to 500 ppm fuel could be used to relieve the shortage. With this flexibility, the report concludes that the likelihood of a fuel shortage in the short term due to use of ULSD for heating oil is diminished. The volatile nature of heating supply and demand presents unique challenges to the fuel oil industry. The success of a low-sulfur fuel oil program is predicated on meeting these challenges. The Northeast states are assessing a variety of business strategies and regulatory approaches that could be used to minimize any potential adverse supply and price impacts that could result from a regional 500 ppm sulfur standard for heating oil. Suppliers can increase pre-season reserves of low-sulfur product. Blending domestically produced biodiesel into heating oil offers opportunity to reduce imports, stabilize supplies and minimize supply-related price spikes.

Potential supply disruptions and price spikes for residual fuels are a particular concern for several northern MANE-VU states. Maine, New Hampshire, and Massachusetts receive a significant percentage of their residual fuel supplies from offshore sources during the winter months, when barge traffic from New York Harbor is interrupted because of severe weather. At these times, residual oil is often imported directly from foreign sources (e.g., Venezuela and Russia), and stakeholders have expressed concerns that the supply of low-sulfur residual fuels may be insufficient to satisfy demand during these periods. While the potential for disruptions in the supply of residual fuels is greater than that for distillate oil, these disruptions would affect only a limited number of states during extreme weather events.

MANE-VU has identified several mechanisms that could be implemented to address disruptions, including seasonal averaging and emergency waivers. A seasonal averaging approach would reduce potential supply constraints by allowing the use of higher-sulfur fuel during periods of peak demand (and limited supply), and then requiring the increased sulfur content of these fuels to be offset through the use of a lower-sulfur fuel at other times. This approach would provide regulatory certainty and greater flexibility during the winter months when fuel supplies may be subject to weather-related disruptions, but at a cost of increased recordkeeping and compliance monitoring. Since many states already have statutory authority to waive fuel sulfur limits in an emergency, states could also utilize their discretionary powers to address short-term supply disruptions.

The strategy adopted by Rhode Island and the other MANE-VU states proposes to phase in the required use of lower-sulfur fuels over the next 10 years, providing adequate time for full implementation.

***3) Low-Sulfur Fuel Oil Strategy – Energy and Non-Air Quality Environmental Impacts of Compliance*:** According to MANE-VU's Reasonable Progress Report, reducing the sulfur content of fuel oil would have a variety of beneficial consequences for boilers and furnaces using this fuel. Low-sulfur distillate fuel is cleaner burning and emits less particulate matter, thereby reducing the rate of fouling of heating units and allowing longer time intervals between cleanings. The MANE-VU report cites a study by the New York State Energy Research and Development Authority (NYSERDA) that showed that boiler deposits are reduced by a factor of two by lowering the fuel sulfur content from 1,400 ppm to 500 ppm. The use of low-sulfur oil could extend the useful life of a source by reducing the maintenance required because low-sulfur oil is less damaging to the combustion equipment. The report also notes that decreasing sulfur levels in fuel would enable manufacturers to develop more efficient furnaces and boilers by using more advanced condensing equipment that recovers energy normally lost to the heating of water vapor in the exhaust gases.

Furthermore, SO_2 controls would have beneficial environmental impacts by reducing acid deposition and helping to decrease ambient concentrations of $PM_{2.5}$. Reductions in $PM_{2.5}$ resulting from use of low-sulfur fuels could help nonattainment areas meet health-based National Ambient Air Quality Standards.

***4) Low-Sulfur Fuel Oil Strategy – Remaining Useful Life of Any Potentially Affected Sources*:** Residential furnaces and boilers have finite life spans, but they do not need to be replaced to burn low- or ultra-low-sulfur fuel oil. The Energy Research Center estimates that the average life expectancy of a residential heating oil boiler is 20-25 years. As noted above, use of low-sulfur fuel is less damaging to equipment and could therefore extend the useful life of an oil-fired residential furnace or boiler.

Available information on the remaining useful life of ICI boilers indicates a wide range of life expectancies, depending on unit size, capacity factor, and level of maintenance performed. (Capacity factor is defined as the actual amount of energy a boiler generates in one year divided by the total amount it could generate if it ran full time at full capacity.) The typical life expectancy of an ICI boiler ranges from 10 years to more than 30 years. As in the case of residential units, use of lower-sulfur fuels could extend the life span of an ICI boiler.

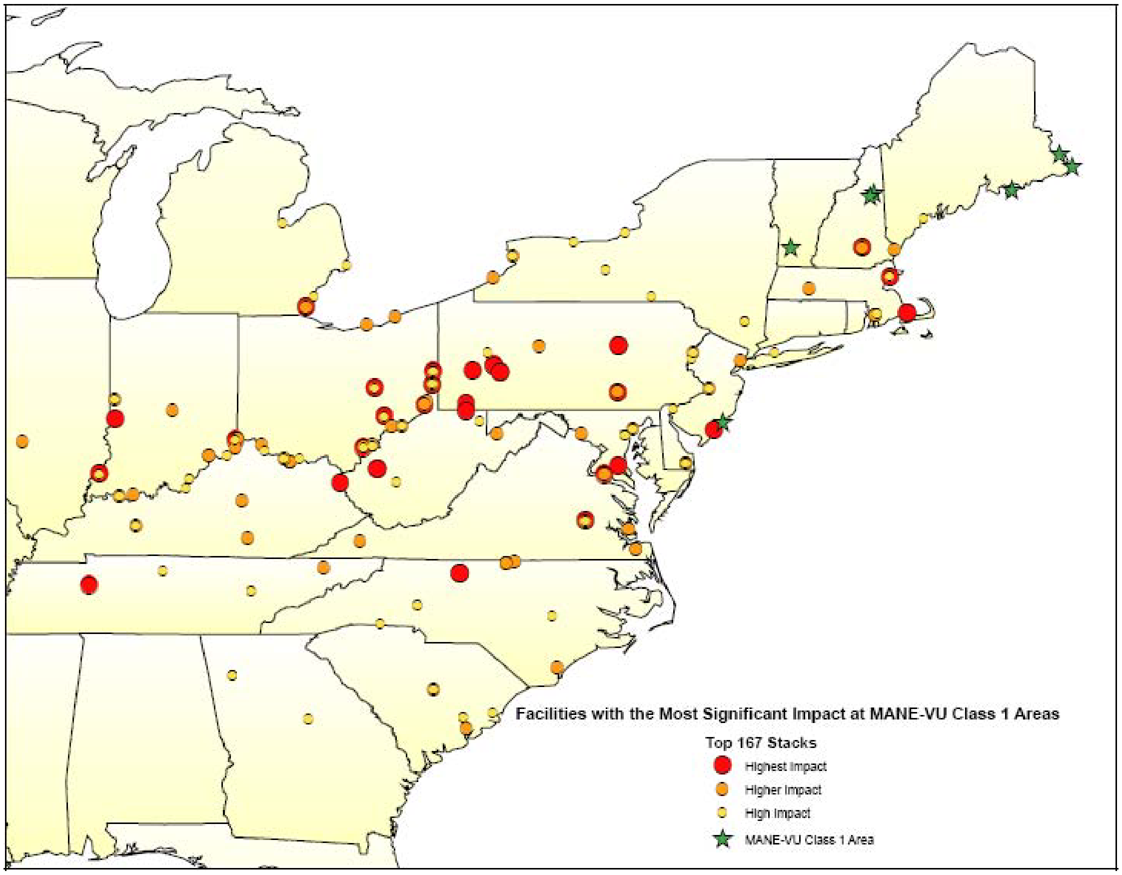
10.2.4 Targeted EGU Strategy for SO_2 Reduction

Electrical generating units (EGUs) are the single largest sector contributing to visibility impairment at MANE-VU's Class I Areas. SO_2 emissions from power plants continue to dominate the emissions inventory. Sulfate formed through atmospheric processes from SO_2 emissions are responsible for over half the mass and approximately 70-80 percent of visibility extinction on the days of worst visibility (see NESCAUM's Contribution Assessment, Attachment B).

To ensure that EGU control measures are targeted at those units having the greatest impact on visibility at MANE-VU Class I Areas, a modeling analysis was conducted to identify the individual sources responsible for the highest contributions to visibility degradation. Accordingly, MANE-VU developed lists of the 100 EGU emission points (stacks) having the largest impacts at each MANE-VU Class I Area during 2002. The combined list for all seven MANE-VU Class I Areas identified a total of 167 distinct emission points. These 167 stacks are spread across the Northeast, Southeast, and Midwest (Figure 10.2). None of the identified EGU units are located in Rhode Island.

After consultations with its member states and with other RPOs, MANE-VU requested a 90-percent reduction in SO_2 emissions from the top 167 stacks by no later than 2018 (see the MANE-VU Ask). NESCAUM's preliminary modeling for MANE-VU showed that SO_2 emission reductions of this magnitude from the targeted facilities would produce substantial improvements in ambient 24-hour $PM_{2.5}$ concentrations. Assuming a control level equal to 10 percent of the 2002 baseline emissions (i.e., 90-percent emission reduction), NESCAUM used CMAQ to model sulfate concentrations in 2018 after implementation of controls. The modeled sulfate values were then converted to estimates of $PM_{2.5}$ concentration. Figure 10.3 displays the predicted average change in 24-hr $PM_{2.5}$.

Figure 10.2 Location of 167 EGU Stacks Contributing the Most to Visibility Impairment at MANE-VU Class I Areas

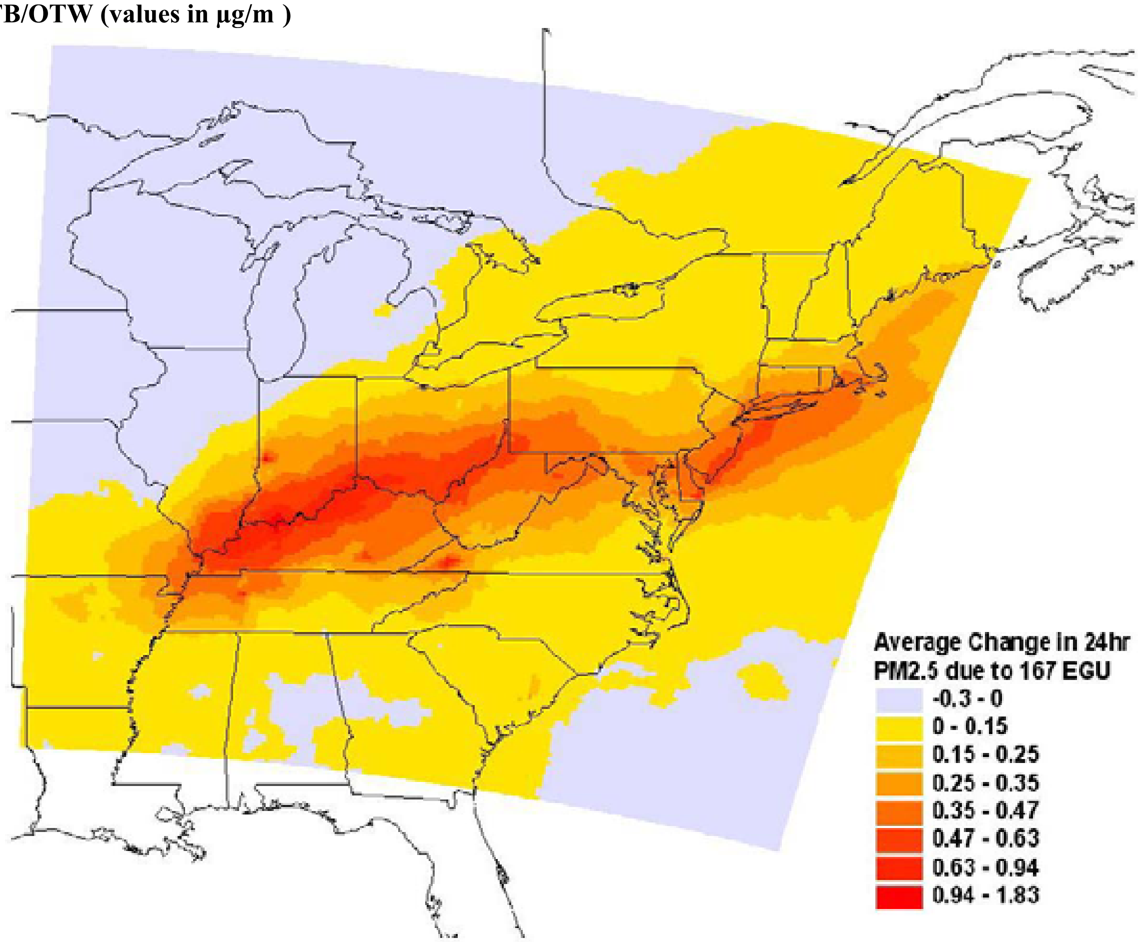


Note: Some facilities have more than one stack.

Figure 10.3 shows the reductions in fine-particle pollution in the Eastern U.S. that would result from implementation of the targeted EGU strategy for SO_2. Improvements in $PM_{2.5}$ levels would occur throughout the MANE-VU region and portions of the VISTAS and MRPO regions, especially along the Ohio River Valley.

Although the reductions would be both advantageous and potentially large, MANE-VU determined, after further consultation with affected states, that it was unreasonable to expect that the full 90-percent reduction in SO_2 emissions would be achieved by 2018. Therefore, additional modeling was conducted to assess the more realistic scenario in which emissions would be controlled by the individual facilities and/or states to levels already projected to take place by that date. At some facilities, the actual emission reductions are anticipated to be greater or less than the 90 percent benchmark. For details, see Alpine Geophysics' report for MARAMA entitled, "Documentation of 2018 Emissions from Electric Generating Units in the Eastern United States for MANE-VU's Regional Haze Modeling, Revised Final Draft," April 28, 2008 (Attachment H).

Figure 10.3 Average Change in 24-hr PM2.5 Due to 167 Stack EGU Control Strategy Relative to OTB/OTW (values in µg/m^3)



***Targeted EGU SO_2 Reduction Strategy Controls are Reasonable*:** MANE-VU identified specific EGU stacks that were significant contributors to visibility degradation at MANE-VU Class I Areas in 2002 based on CALPUFF modeling analyses documented in the Contribution Assessment. MANE-VU obtained information about existing and planned controls on emissions from those stacks. These analyses and information on proposed EGU controls are presented in MANE-VU's Reasonable Progress Report and the Contribution Assessment as well as in Section 6.0, Emissions Inventory, and Section 11.0, Long-Term Strategy section of this SIP.

Based on information gathered from the states and regional planning organizations, MANE-VU anticipated that emissions from many of the targeted EGU stacks will be subject to EPA's Clean Air Interstate Rule (CAIR). However, because CAIR is a cap-and-trade program that has been remanded to EPA, it is not possible to predict with certainty which of the 167 stacks will be controlled under CAIR (or its replacement) in 2018.

***Four-Factor Analysis – Targeted EGU SO_2 Reduction Strategy*:** The following discussion addresses each of the four factors with respect to the strategy of controlling specific EGUs. Information is taken primarily from the MANE-VU Reasonable Progress Report (Attachment Y) and MANE-VU BART Report (Attachment W).

***1) Targeted EGU SO_2 Reduction Strategy – Costs of Compliance*:** Technologies to control the precursors of regional haze are commercially available today. Because EGUs are the most significant stationary source of SO_2, NO_X, and PM, they have been subject to extensive federal and state regulations to control all three pollutants. The technical feasibility of control technologies has been successfully proven for a substantial number of small (e.g., 100 MW) to very large (over 1,000 MW) boilers burning different types of coal. Over the last few years, the cost data clearly indicate that many technologies provide substantial and cost-effective emission reductions.

Both wet and dry scrubbers are in wide commercial use in the U.S. for controlling SO_2 emissions from coal-fired power plants. The capital costs for new or retrofit wet or dry scrubbers are higher than the capital costs for NO_X and PM controls. Capital costs for scrubbers ranged from $180/kW for large units (greater than 600 MW) to as high as $350/kW for small units (200 to 300 MW). (See pages 2-22 through 2-25 of the BART Report, Attachment Z). However, the last few years have seen a general trend of declining capital costs attributable to vendor competition and technology maturation. Also, the cost-effectiveness (in dollars per ton of emissions removed) is very attractive because the high sulfur content of the coal burned results in very large amounts of SO_2 removed by the control devices. The typical cost is in the range of 200 to 500 dollars per ton of SO_2 removed, although the cost rises steeply for small units burning lower-sulfur coal and operating at low capacity factors. For any plant, overall cost-effectiveness depends mainly on the baseline pre-controlled SO_2 emission rate (or fuel sulfur content), size and capacity factor of the unit, and capital costs of flue gas desulfurization (generally ranging from $150 to $200/kW).

The MANE-VU Reasonable Progress Report reviewed options for controlling coal-fired EGU boilers, including switching to lower-sulfur coal, switching to natural gas, coal cleaning, and flue gas desulfurization (FGD). The most effective control option (but not necessarily appropriate for all installations) is FGD, which can achieve up to 95 percent reduction in SO_2 emissions. The costs of different technologies vary considerably among units and were estimated to range from as low as $170/ton to as high as $5,700/ton. Table 10.4 summarizes the estimated costs of controlling SO_2 emissions, expressed in dollars per ton of SO_2 removed. Note that there are no coal-fired power plants in Rhode Island.

To predict future emissions and further evaluate the costs of emission controls for electric generating units, MANE-VU and other RPOs have followed the example of the EPA in using the Integrated Planning Model (IPM®), an integrated economic and emissions model for EGUs. This model projects electricity supplies based on various assumptions while at the same time developing least-cost solutions to electrical generating needs within specified emissions targets. IPM also provides estimates of the costs of complying with various policy requirements.

Table 10.4 Estimated Cost Ranges for SO2 Control Options for Coal-Fired EGU Boilers (2006 dollars per ton of SO_2 removed)

Technology	Description	Performance	Cost Range (2006 dollars/ton of SO_2 Reduced)
Switch to a Low Sulfur Coal (generally <1% sulfur)	Replace high-sulfur bituminous coal combustion with lower-sulfur coal	50-80% reduction in SO_2 emissions by switching to a lower-sulfur coal	Potential reduction in coal costs, but possibly offset by expensive retrofits and loss of boiler efficiency
Switch to natural gas (virtually 0% sulfur)	Replace coal combustion with natural gas	Virtually eliminate SO_2 emissions by switching to natural gas	Unknown – cost of switch is currently uneconomical due to price of natural gas
Coal Cleaning	Coal is washed to remove some of the sulfur and ash prior to combustion	20-25% reduction in SO_2 emissions	2-15% increase in fuel costs based on current prices of coal
Flue Gas Desulfurization (FGD) – Wet	SO_2 is removed from flue gas by dissolving it in a lime or limestone slurry. (Other alkaline chemicals are sometimes used)	30-95%+ reduction in SO_2 emissions	\$570-\$5,700 for EGUs <1,200 MW \$330-\$570 for EGUs >1,200 MW
Flue Gas Desulfurization (FGD) – Spray Dry	A fine mist containing lime or other suitable sorbent is injected directly into flue gas	60-95%+ reduction in SO_2 emissions	\$570-\$4,550 for EGUs <600 MW \$170-\$340 for EGUs >600 MW
Flue Gas Desulfurization (FGD) –Dry	Powdered lime or other suitable sorbent is injected directly into flue gas	40-60% reduction in SO_2 emissions	\$250-\$850 for EGUs ~300 MW

Table references:
1. EIA website accessed on 2/20/07: http://www.eia.doe.gov/cneaf/coal/page/coalnews/coalmar.html
2. EIA website accessed on 2/20/07: http://www.eia.doe.gov/cneaf/coal/page/acr/table31.html
3. STAPPA-ALAPCO. *Controlling Fine Particulate Matter Under the Clean Air Act: A Menu of Options*, March 2006.

EPA developed IPM version 2.1.9 and used this model to evaluate the impacts of CAIR and the now-vacated Clean Air Mercury Rule (CAMR). Recently, EPA updated their input data and developed IPM v.3.0. However, because of time constraints, all MANE-VU runs were based on EPA IPM v.2.1.9 with changes made to the input assumptions.

The RPOs collaborated with one another to update the inputs to IPM v.2.1.9 using more current data on the EGUs and more realistic fuel prices. The resulting IPM run is called VISTAS PC_1f. This IPM run serves as the basis for regional air quality modeling for ozone and haze SIPs in MANE-VU and the OTC.

MANE-VU, through MARAMA, contracted with the consulting firm ICF Resources, L.L.C. to prepare two new IPM runs, as documented in "Comparison of CAIR and CAIR Plus Proposal using the Integrated Planning Model (IPM®)," Final Draft Report, May 30, 2007 (Attachment BB). The first run, known as the MARAMA CAIR Base Case run (also known as MARAMA_5c), was based on the VISTAS PC 1f run and underlying EPA IPM v.2.1.9 with some updated information on fuel prices, control constraints, etc. The second run, called the MARAMA CAIR Plus run (also known as MARAMA_4c), was similarly based on VISTAS PC_1f run and the underlying EPA IPM v.2.1.9. The MARAMA CAIR Plus run included updated information used in the VISTAS run but assumed lower NOx emission caps and higher SO_2 retirement ratios.

Based on the modeling results, MANE-VU estimates that the marginal cost of SO_2 emission reductions (the cost of reducing one additional ton of emissions) ranges from $640/ton in 2008 to $1,392/ton in 2018 (see Table 6, "Allowance Prices (Marginal Costs) of Emissions Reductions…," in Attachment BB).

Costs will vary for individual plants to reduce emissions by 90 percent, as recommended in the MANE-VU Ask. However, this strategy provides states with flexibility to pursue controls on specific sources as appropriate and to control emissions from alternative sources, if necessary, to meet the 90 percent target established in the Ask.

Given the importance of SO_2 emissions from specific EGUs to visibility impairment in MANE-VU Class I Areas, the MANE-VU Commissioners, after weighing all factors – the availability of technology to reduce emissions, the estimated costs of controls, the costs of alternative measures, the flexibility to achieve alternative reductions if necessary, etc. – concluded that the costs of the targeted EGU strategy are reasonable. Rhode Island agrees with this conclusion.

2) Targeted EGU SO_2 Reduction Strategy – Time Necessary for Compliance**:** MANE-VU's Reasonable Progress Report indicates that, generally, sources are given a 2- to 4-year phase-in period to comply with new rules. Under Phase I of the NO_X SIP call, EPA provided a compliance date of about 3½ years from the SIP submittal date. Most MACT standards allow a 3-year compliance period. Under Phase II of the NO_X SIP Call, EPA provided for 2-year compliance period from the SIP submittal date. Therefore, Rhode Island concludes that there is more than sufficient time between 2008 and 2018 for affected states to adopt requirements and for affected sources to install necessary controls.

3) Targeted EGU SO_2 Reduction Strategy – Energy and Non-Air Quality Environmental Impacts of Compliance**:** The MANE-VU Reasonable Progress Report identified several energy and non-air quality impacts from additional EGU controls. Large-scale fuel switching could potentially impact fuel supplies. Flue gas desulfurization systems may generate wastewater and sludge (which is sometimes recycled as a useful byproduct). On the other hand, SO_2, NO_X, and ammonia controls would have beneficial environmental impacts by reducing acid deposition and nitrogen deposition to water bodies and natural land areas. Emission reductions for these pollutants would also produce decreases in ambient levels of $PM_{2.5}$ and result in corresponding health benefits. Similarly, mercury emissions may be reduced by the addition of controls for other pollutants. Rhode Island concludes that the energy and non-air quality impacts of additional EGU controls are reasonable.

4) Targeted EGU SO_2 Reduction Strategy – Remaining Useful Life of Any Potentially Affected Sources**:** As noted in the MANE-VU Reasonable Progress Report, remaining useful life estimates of EGU boilers indicate a wide range of operating lifetimes, depending on unit size, capacity factor, and level of maintenance performed. Typical life expectancies range to 50 years or more. Additionally, implementation of air pollution regulations over the years has necessitated emission control retrofits that have increased the expected life spans of many EGUs. The lifetime of an EGU may be extended through repair, re-powering, or other strategies if the unit is more economical to run than to replace with power from other sources. Extending facility lifetime may be particularly likely for a unit serving an area with limited transmission capacity to bring in other power.

10.2.5 Non-EGU SO_2 Emissions Reduction Strategy for Non-MANE-VU States

In addition to the measures described above (i.e., BART, low-sulfur fuel, and targeted EGU controls), MANE-VU states with Class I Areas asked states in neighboring regional planning organizations to consider further non-EGU emission reductions comparable to those achieved by MANE-VU states through application of MANE-VU's low-sulfur fuel strategy. Previous modeling indicated that the MANE-VU low-sulfur fuel strategy would achieve a greater than 28- percent reduction in non-EGU SO_2 emissions by 2018. After consultation with other states and consideration of comments received, MANE-VU decided to include, in the latest modeling for the VISTAS and MRPO regions, implementation of control measures capable of achieving SO_2 emission reductions equivalent to MANE-VU's 28-percent reduction in non-EGU SO_2 emissions in 2018.

To model the effects of this strategy on visibility at MANE-VU Class I Areas, MANE-VU had to make reasonable assumptions about where the requested emission reductions would occur in the VISTAS and MRPO states without knowing precisely how those reductions would be realized. As a way to represent approximately a 28-percent reduction in non-EGU SO2 emissions, the following reductions were modeled:

- For control measures in VISTAS and MRPO states: − Coal-fired ICI boilers: SO_2 emissions were reduced by 60 percent. − Oil-fired ICI boilers: SO_2 emissions were reduced by 75 percent. − ICI boilers lacking fuel specification: SO_2 emissions were reduced by 50 percent.

- For additional controls *only* in the VISTAS states: SO_2 emissions from other oil-fired area sources were reduced by 75 percent (based on the same SCCs identified in MANE-VU's oil strategies list).

This modeling scenario represents just one example of realistic strategies that states outside of MANE-VU could employ to meet the non-EGU SO_2 emissions reductions requested by MANE-VU.

A number of non-MANE-VU states have not included, or may not include, the requested 28-percent reduction in non-EGU SO_2 emissions in their State Implementation Plans at the present time. Future revisions of Rhode Island's regional haze SIP will reflect other states' commitments to these reductions

***Non-EGU SO_2 Emission Reduction Measures Outside MANE-VU are Reasonable*:** After EGUs, ICI boilers are the next largest class of SO_2 emitters. ICI boilers are thus a logical choice among non-EGU sources for consideration of additional SO_2 control measures.

***ICI Boiler Control Options*:** Air pollution reduction and control technologies for ICI boilers have advanced substantially over the past 25 years. However, according to a 1998 survey of industrial boilers by EPA (2004), only 2 percent of gas-fired boilers and 3 percent of oil-fired boilers had installed any kind of air pollution control device. A larger percentage of coal-fired boilers had installed air pollution controls: specifically, 47 percent had installed some type of control device, mainly to control particulate matter (PM). Post-combustion SO_2 controls were used by less than one percent of industrial boilers in 1998, with the exception of boilers firing petroleum coke (2 percent of boilers using this fuel had acid scrubbers). A small percentage of industrial boilers had combustion controls in place in 1998, although additional low-NO_X firing systems may have been installed since that date.

Almost all SO_2 emission control technologies fall into the category of reducing SO_2 after its formation as opposed to minimizing its formation during combustion. The method of SO_2 control appropriate for any individual ICI boiler is dependent upon the type of boiler, type of fuel, capacity utilization, and the types and staging of other air pollution control devices. However, cost-effective emission reduction technologies for SO_2 are available and are effective in reducing emissions from the exhaust gas stream of ICI boilers. Post-combustion SO_2 control is accomplished by reacting the SO_2 in the gas with a reagent (usually calcium- or sodium-based) and removing the resulting product (a sulfate/sulfite) for disposal or commercial use, depending on the particular technology. SO_2 reduction technologies are commonly referred to as flue gas desulfurization (FGD) and are usually described in terms of the process conditions (wet versus dry), byproduct utilization (throwaway versus saleable) and reagent utilization (once-through versus regenerable).

The exceptions to the nearly universal use of post-combustion controls are found in fuel switching, coal cleaning, and fluidized bed boilers, in which limestone is added to the fuel in the combustion chamber. Both pre- and post-combustion SO_2 emission control alternatives for ICI boilers are outlined in Table 10.5. Further description of these technology options is available in Chapter 4 of the MANE-VU Reasonable Progress Report (Attachment Y).

The SO_2 removal efficiency of these controls varies from 20 to 99+ percent depending on the fuel type and control technology. For coal-fired boilers, options include switching to low-sulfur coal, coal cleaning, wet FGD, dry FGD, and spray dryers. The overall SO_2 reductions vary from a low of 20 to 25 percent for fuel switching to a high of 60 to 95 percent for wet FGD and spray dry FGD. The majority of control strategies, however, are capable of achieving a 60 percent or greater reduction. Thus, assuming that coal-fired ICI boilers adopt varying levels of controls, with most choosing a 50- to 70- percent reduction strategy and fewer choosing either the 20-percent or the 90-percent reduction strategy, the region-wide average would be likely to fall in the vicinity of a 60- percent reduction in SO_2 emissions. This assumption is validated by data showing that wet FGD systems represent 85 percent of the FGD systems in use in the United States and that these systems have an average SO_2 removal efficiency of 78 percent. MANE-VU's modeling of a 60-percent reduction in SO_2 emission from coal-fired ICI boilers is therefore reasonable.

For oil-fired boilers, options include switching to a lower-sulfur fuel (e.g., oil or natural gas), dry FGD, and spray dryers. The overall SO_2 reductions vary from a low of 40 to 60 percent for dry FGD to a high of 60 to 95 percent for spray dry FGD. For comparison, the MANEVU low-sulfur fuel strategy assumes a 50- to 90- percent reduction in SO_2 emissions from oil-fired ICI boilers. Assuming a normal distribution of control strategies chosen by the sources, MANE-VU's modeling of an average 75-percent reduction in SO_2 emission from oil-fired ICI boilers is reasonable.

Table 10.5 Available SO_2 Control Options for ICI Boilers

Technology	Description	Applicability	Performance
Switch to a Low Sulfur Coal (generally <1% sulfur)	Replace high-sulfur bituminous coal combustion with lower-sulfur coal	Potential control measure for all coal-fired ICIs currently using coal with high sulfur content	50-80% reduction in SO_2 emissions by switching to a lower-sulfur coal
Switch to Natural Gas (virtually 0% sulfur)	Replace coal combustion with natural gas	Potential control measure for all coal-fired ICIs	Virtually eliminate SO_2 emissions by switching to natural gas
Switch to a Lower Sulfur Oil	Replace higher-sulfur residual oil with lower-sulfur distillate oil. Alternatively, replace medium sulfur distillate oil with ultra-low sulfur distillate oil	Potential control measure for all oil-fired ICIs currently using higher sulfur content residual or distillate oils	50-80% reduction in SO_2 emissions by switching to a lower-sulfur oil
Coal Cleaning	Coal is washed to remove some of the sulfur and ash prior to combustion	Potential control measure for all coal-fired ICI boilers	20-25% reduction in SO_2 emissions
Combustion Control	A reactive material, such as limestone or bi-carbonate, is introduced into the combustion chamber along with the fuel	Applicable to pulverized coal-fired boilers and circulating fluidized bed boilers	40%-85% reductions in SO_2 emissions
Flue Gas Desulfurization (FGD) - Wet	SO_2 is removed from flue gas by dissolving it in a lime or limestone slurry. (Other alkaline chemical are sometimes used)	Applicable to all coal-fired ICI boilers	30-95%+ reduction in SO_2 emissions
Flue Gas Desulfurization (FGD) - Spray Dry	A fine mist containing lime or other suitable sorbent is injected directly into flue gas	Applicable primarily for boilers currently firing low to medium sulfur fuels	60-95%+ reduction in SO_2 emissions
Flue Gas Desulfurization (FGD) - Dry	Powdered lime or other suitable sorbent is injected directly into flue gas	Applicable primarily for boilers currently firing low to medium sulfur fuels	40-60% reduction in SO_2 emissions

For ICI boilers in which a fuel was not specified, a 50-percent reduction in SO_2 emissions was assumed. ICI boilers in this category include those outside the MANE-VU region for which the current inventory did not specify the type of fuel burned. Because a response from the MRPO was not received, this assumption also encompasses some of the uncertainty regarding the implementation of MANE-VU's non-EGU Ask. Given the paucity of data, a lower reduction in SO_2 emissions (50 percent) was assumed for this category than for coal- or oil-fired ICI boilers. Implementation of one or more of the suggested SO_2 control options to achieve, on average, a 50-percent reduction in SO_2 emissions at these sources is a reasonable assumption.

For emissions from other area oil-combustion sources in the VISTAS region, an SO_2 reduction of 75 percent was assumed. This reduction is equal to the reduction that would result from implementing the MANE-VU low-sulfur fuel strategy for this sector. The four-factor analysis for the low-sulfur fuel strategy was described in Part 10.2.3 of this section.

***Four-Factor Analysis – Non-EGU SO_2 Emission Reduction Measures Outside MANE-VU*:**
Based on the survey of available technologies outlined above and the four-factor analyses summarized below, MANE-VU concludes that each of the strategies assumed for modeling purposes to meet the MANE-VU Ask of a 28-percent reduction in non-EGU SO_2 emissions is reasonable. States should have no difficulty in meeting this benchmark in light of the control efficiencies that are attainable at reasonable costs with retrofit technologies that are available for ICI boilers today.

***1) Non-EGU SO_2 Emission Reduction Measures outside MANE-VU – Costs of Compliance*:** Industrial boilers have a wider range of sizes than EGUs and often operate over a wider range of capacities. Thus, cost estimates for the same technologies will generally span a relatively larger range, and costs for an individual boiler will depend on the capacity of the boiler and typical operating conditions. In general, cost-effectiveness improves as boiler size and capacity factor (a measure of boiler utilization) increases.

MANE-VU's Reasonable Progress Report (Attachment Y) provides emission control cost estimates for ICI boilers in the range of $130 to $11,000 per ton of SO_2 removed, a very wide spread due to the variability of sources and control options in this category. All costs presented below for emission controls on ICI boilers are borrowed from this report. Dollar amounts originated from EPA publications cited in the report and are restated in 2006 dollars using appropriate adjustment factors found at www.inflationdata.com.

◊ ***Cost of Fuel Switching*:** Although fuel switching can be a very effective means of controlling SO_2 emissions (reductions of 50 to 99.9 percent are possible), burning low-sulfur fuel may not be technically feasible or economically practical as an SO_2 control option for every coal-fired boiler. Factors impacting applicability include the characteristics of the plant and the particular type of fuel change being considered. Additionally, switching to a lower-sulfur coal can affect fuel handling systems, boiler performance, PM control effectiveness, and ash handling systems. Oil-fired boilers switching to a lower-sulfur fuel of the same grade (e.g., switching from #6 fuel oil at 2.0% S to #6 fuel oil at 0.5% S) do not typically encounter these issues. (See Part 10.2.3 for a discussion of the costs and issues associated with switching to low-sulfur fuel oil.)

The costs of coal fuel switching, including substitution or blending with a low-sulfur coal, can be attributed to two main factors: the cost of low-sulfur coal compared to higher-sulfur coal (including consideration of the coal's heating value), and the cost of necessary boiler or coal handling equipment modifications. Many plants will be able to switch from high-sulfur to low-sulfur bituminous coal without serious difficulty, but switching from bituminous to sub bituminous coal may require potentially significant investments and modifications to an existing plant. Even if a lower-sulfur fuel is available, it may not be cost competitive if it must be supplied in small quantities or transported long distances from the supplier. It also may be more cost-effective to burn a higher-sulfur fuel supplied by nearby suppliers and to use a post-combustion control device.

Switching from coal combustion to natural gas combustion virtually eliminates SO_2 emissions. It is technically feasible to switch from coal to natural gas, but it is currently uneconomical to consider this option for large ICI boilers because of the fuel quantity necessary and the price of natural gas. Natural gas is roughly seven times the price of coal in terms of heating value (price per million Btus).

- ***Cost of Coal Cleaning***: The World Bank, an organization which assists with economic and technological needs in developing countries, reports that the cost of physically cleaning coal varies from $1 to $10 per ton of coal cleaned, depending on the coal quality, the cleaning process used, and the degree of cleaning desired. In most cases, the costs were found to be between $1 and $5 per ton of coal cleaned. Coal cleaning typically results in a 20-to 25-percent reduction in SO2 emissions and increases the heating value of the fuel by a small amount.

- ***Cost of Combustion Controls***: Dry sorbent injection (DSI) systems have lower capital and operation costs than post-combustion FGD systems because of the simplicity of the DSI design, lower water use needs, and smaller land area requirements. Table 10.6 presents the estimated costs of adding DSI-based SO2 emission controls to ICI boilers for different boiler sizes, fuel types, and capacity factors.

Table 10.6 Estimated Costs of Dry Sorbent Injection (DSI) for ICI Boilers (2006 dollars)

Fuel	SO_2 Reduction (%)	Capacity Factor (%)	Cost-Effectiveness ($/ton of SO_2 removed)		
			100 MMBtu/hr	250 MMBTU/hr	1,000 MMBTU/hr
2%-Sulfur Coal	40	14	4,686	3,793	2,979
		50	1,312	1,062	834
		83	772	624	490
3.43%-Sulfur Coal	40	14	2,732	2,212	1,737
		50	765	619	486
		83	450	364	286
2%-Sulfur Coal	85	14	2,205	1,786	1,402
		50	617	500	392
		83	363	294	231
3.43%-Sulfur Coal	40	14	1,286	1,040	818
		50	360	291	229
		83	212	171	134

Cost of FGD: Installation of post-combustion SO_2 controls in the form of FGD has several impacts on facility operations, maintenance, and waste handling procedures. FGD systems generally require substantial land area for construction of the absorber towers, sorbent tanks, and waste handling equipment. Facility costs therefore depend on cost and availability of space for construction of the FGD system. In addition, significant quantities of waste material may be generated that require disposal. The costs may be mitigated, however, by utilization of a forced oxidation FGD process that produces commercial-grade gypsum, which may be sold as a raw material for other commercial processes.

Table 10.7 presents the total estimated cost-per-ton of adding FGD-based SO_2 emission controls to ICI boilers for different boiler sizes, fuel types, and capacity factors. There is no indication that these cost data include possible revenues from gypsum sales, which would partially offset the costs of FGD controls. Carbon dioxide is also emitted as a byproduct of FGD; therefore, the impacts of increased carbon emissions associated with this technology would need to be considered. CO_2 emissions will become more of an issue in the future if they are limited under climate change mitigation strategies. Given the uncertainty of such future strategies, costs related to increased carbon emissions from FGD cannot yet be assessed.

MANE-VU's request for a 28-percent reduction in non-EGU SO_2 emissions allows states flexibility in determining which sources to control, so that the most cost-effective control measures can be adopted and implemented over the next 10 years. Given the wide range of control options and costs available for this purpose, MANE-VU has concluded that the request for a 28-percent reduction in non-EGU SO_2 emissions is reasonable. Rhode Island concurs with this conclusion.

Table 10.7 Estimated Costs of Flue Gas Desulfurization for ICI Boilers (2006 dollars)

Fuel	Technology	SO_2 Reduction (%)	CapacityFactor (%)	Cost-Effectiveness ($/ton of SO_2 removed)		
				100 MMBtu/hr	250 MMBTU/hr	1,000 MMBTU/hr
High-Sulfur Coal	FGD (dry)	40	14	3,781	2,637	1,817
			50	1,379	1,059	828
			83	1,006	814	676
Lower-Sulfur Coal	FGD (dry)	40	14	4,571	3,150	2,119
			50	1,605	1,207	928
			83	1,147	906	744
Coal	FGD (spray dry)	85	14	4,183	2,786	1,601
			50	1,290	899	567
			83	843	607	407
High-Sulfur Coal	FGD (spray dry)	85	14	3,642	2,890	1,909
			50	1,116	875	601
			83	709	563	398
Lower-Sulfur Coal	FGD (wet)	40	14	4,797	3,693	2,426
			50	1,415	1,106	751
			83	892	705	492
Oil	FGD (wet)	40	14	10,843	8,325	5,424
			50	2,269	1,765	1,184
			83	1,371	1,079	740

2) Non-EGU SO_2 Emission Reduction Measures outside MANE-VU – Time Necessary for Compliance: For pre- and post-combustion SO_2 emission controls, engineering and construction lead times will vary between 2 and 5 years, depending on the size of the facility and specific control technology selected. Generally, sources are given a 2- to 4- year phase-in period to comply with new rules, as previously described, and states generally have a 2-year period for compliance with RACT rules.

For the purposes of this review, it is assumed that a 2-year period after SIP submittal is adequate for pre-combustion controls (fuel switching or cleaning), and a 3-year period is adequate for the installation of post-combustion controls. MANE-VU has therefore concluded that there is sufficient time between 2008 and 2018 for affected states to adopt emission control requirements and for affected sources to install the necessary controls to meet MANE-VU's requested SO_2 emission reductions from non-EGU sources. Rhode Island concurs with this conclusion.

***3) Non-EGU SO_2 Emission Reduction Measures Outside MANE-VU – Energy and Non-Air Quality Environmental Impacts of Compliance*:** The primary energy impact of pre- or post-combustion control alternatives is a potential increase in electricity usage. Fuel switching and cleaning do not significantly affect the efficiency of the boiler itself, but require additional energy to clean or blend coal. FGD systems typically operate with high-pressure drops across the control equipment and therefore consume significant amounts of electricity to operate blowers and circulation pumps. In addition, some combinations of FGD technology and plant configuration may require flue gas reheating to prevent physical damage to equipment, resulting in higher fuel usage.

The primary non-air environmental impacts of fuel switching derive from transportation of the fuel. Secondary environmental impacts derive from waste disposal and material handling operations (e.g. fugitive dust). For FGD systems, the generation of wastewater and sludge from the SO_2 removal process is a consideration. Wastewater from the FGD systems will increase sulfate, metals, and solids loading at the receiving wastewater treatment facility, resulting in potential impacts to operating cost, energy requirements, and effluent water quality. Processing of the wastewater sludge can require energy for stabilization and/or dewatering, and transporting the dewatered sludge to a landfill has additional environmental implications.

Fuel switching to a low-sulfur distillate fuel oil has a variety of beneficial consequences for ICI boilers. Low-sulfur distillate fuel is cleaner burning and emits less particulate matter, which reduces the rate of fouling of heating units substantially and permits longer time intervals between cleanings. According to a study conducted by NYSERDA (reference 10 in Attachment AA), boiler deposits are reduced by a factor of two by lowering the fuel sulfur content from 1,400 ppm to 500 ppm. These reductions in buildup of deposits result in longer service intervals between cleanings.

Reducing SO_2 emissions from ICI boilers would have positive environmental and health impacts. SO_2 controls would reduce acid deposition, helping to preserve aquatic life, forests, and crops as well as buildings and sculptures made of acid-sensitive materials. These emission reductions would also help to decrease ambient levels of $PM_{2.5}$, a significant contributor to premature morbidity and illness in individuals with heart or lung conditions.

MANE-VU has concluded that the energy and non-air environmental impacts of controlling SO_2 emissions from ICI boilers are justified in light of the beneficial impacts on regional haze, fine particulate air pollution, acid rain, and equipment operation, as described above. Rhode Island concurs with this conclusion.

***4) Non-EGU SO_2 Emission Reduction Measures Outside MANE-VU – Remaining Useful Life of Any Potentially Affected Sources*:** Available information for remaining useful life estimates of ICI boilers indicates a wide range of life expectancies, depending on unit size, capacity factor, and level of maintenance performed. Typical life spans range from about 10 years to over 30 years. However, the remaining useful life of a specific source is highly variable; and older units are not likely to be retrofitted with expensive emission controls. Given the typical range of life expectancies of ICI boilers, the technical options available, and the flexibility that non-MANE-VU states would have to meet the Ask, MANE-VU has concluded that a 28-percent reduction in non-EGU SO_2 emissions is reasonable. Rhode Island concurs with this conclusion.

10.3 Reasonable Progress Goals for Class I Areas in the State

Since Rhode Island does not have any Class I Areas, RPGs were not established by the State. Rhode Island concurs with the RPGs established by the MANE-VU states that have Class I Areas, as required under 40 CFR 51.308(d)(1). Those RPGs were determined from modeling based on implementation of the proposed reasonable measures included in MANE-VU's long-term strategy.

The MANE-VU Class I states calculated natural conditions and baseline visibility for the 5-year period from 2000 through 2004 in conformance with an alternative method recommended by the IMPROVE Steering Committee. (See Attachment L, "Baseline and Natural Visibility Conditions: Considerations and Proposed Approach to the Calculation of Baseline and Natural Visibility Conditions at MANE-VU Class I Areas," December 2006.) Future progress toward the 2018 visibility target will be calculated in a nationally consistent manner based on 5-year averages in accordance with EPA's "Guidance for Tracking Progress Under the Regional Haze Rule" (EPA-454/B-03-004, September 2003) with adjustments for the alternative method as recommended by the IMPROVE Steering Committee.

40 CFR 51.308(d)(1)(vi) requires that reasonable progress goals represent at least the visibility improvement expected from implementation of other Clean Air Act programs during the applicable planning period. The modeling that formed the basis for reasonable progress goals for MANE-VU Class I Areas included estimation of the effects of all other programs required by the Clean Air Act. MANE-VU's modeling also included the specific control measure assumptions described previously in Subsection 10.2. Additional information may be found in Section 6.0, Emissions Inventory, and Section 11.0, Long-Term Strategy, as well as in the documentation for the MANE-VU modeling.

In setting the RPGs, MANE-VU states with Class I Areas recognized that contributing states have the flexibility to submit SIP revisions and implement various control measures to meet these goals between now and 2018. The overall approach to reducing and preventing emissions that contribute to regional haze allows each state up to 10 years to implement reasonable SO_2 and NO_X control measures as appropriate and necessary.

10.4 Visibility Effects of (Additional) Reasonable Control Measures

MANE-VU's evaluations included modeling to estimate the effects on visibility of the MANE-VU Ask. The results of this work are summarized below.

NESCAUM performed preliminary modeling as described in the report entitled "MANE-VU Modeling for Reasonable Progress Goals, Model Performance Evaluation, Pollution Apportionment, and Control Measure Benefits," February 7, 2008 (Attachment G).

NESCAUM also conducted more recent, revised modeling to assess the effects of all haze reduction strategies combined. The latter modeling is described in NESCAUM's "2018 Visibility Projections," May 13, 2008 (Attachment Q).

The NESCAUM modeling demonstrates that significant visibility benefits will accrue from implementation of the additional reasonable control measures described in Subsection 10.2, above. Figures 10.4 and 10.5 describe the results of this modeling. In the first of the two figures, the light yellow bars represent expected visibility at MANE-VU Class I Areas in 2018. Comparison of these values with the 2018 "glide slope" values (the plum-colored bars) shows that all areas are expected to experience visibility improvements that meet or exceed the uniform rate of progress calculated for each area. The second figure shows that, for the 20 percent of days having best visibility, expected visibility in 2018 will be better than it is today at all locations.

In conclusion, the reasonable control measures proposed by the MANE-VU states with Class I areas are found to be consistent with the stated national goals of preventing further visibility degradation while making measurable progress toward achieving natural visibility conditions in wilderness areas by 2064.

Figure 10.4 Demonstration of Required and Reasonable Visibility Progress for 20 Percent Worst Visibility Days

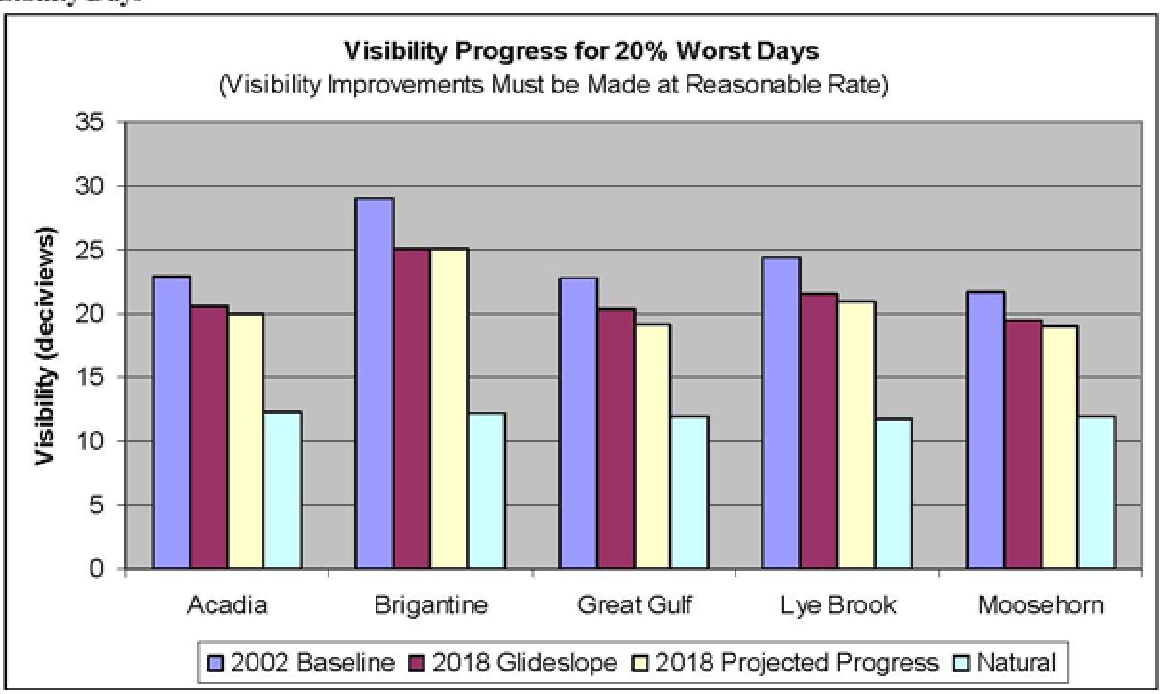
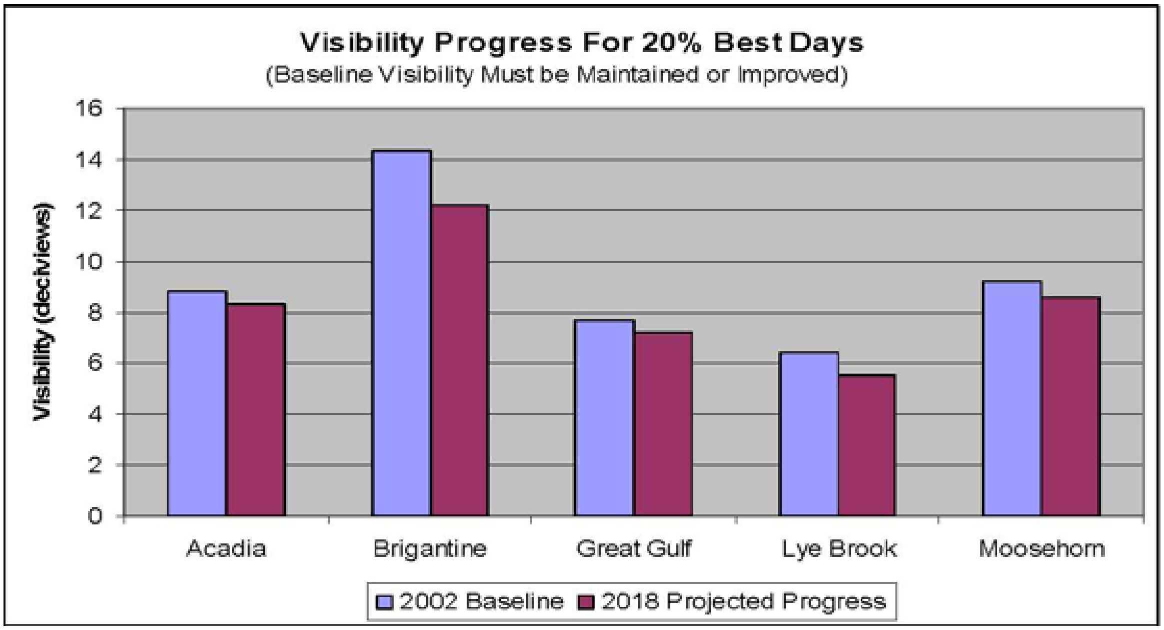


Figure 10.5 Demonstration of Required Maintenance or Improvement of Visibility for 20 Percent Best Visibility Days



10.5 References for Section 10

U.S. Environmental Protection Agency, *National Emission Standards for Hazardous Air Pollutants for Industrial/ Commercial/Institutional Boilers and Process Heaters*, http://cascade.epa.gov/RightSite/dk_public_collection_detail.htm?ObjectType=dk_docket_collection&cid=OAR-2002-0058&ShowList=items&Action=view (Accessed Feb. 25, 2004)

11.0 LONG-TERM STRATEGY

40 CFR Section 51.308(d)(3) requires Rhode Island to submit a long-term strategy that addresses regional haze visibility impairment for each mandatory Class I Federal area which may be affected by emissions from the state. The long-term strategy must include enforceable emissions limitations, compliance schedules, and other measures necessary to achieve the RPGs established by states where the Class I areas are located. Consultation between states affecting and/or containing Class I areas must be performed to develop coordinated emission management strategies. The state must demonstrate that it has included all measures necessary to obtain its share of the emission reductions needed to meet the progress goal for the area. If the state has participated in a regional planning process, the state must include measures needed to achieve its obligations agreed upon through that process.

This section describes the long-term strategy that Rhode Island will pursue to address visibility impairment for each of the following Class I areas: Acadia National Park, Great Gulf Wilderness, Lye Brook Wilderness, Presidential Range/Dry River Wilderness, Moosehorn Wilderness, and Roosevelt/Campobello International Park. Note that, as discussed in Section 8.2, MANE-VU's analysis determined that Rhode Island, along with Connecticut, Vermont, and the District of Columbia, contribute less than 2 percent of the sulfate at any of the Class I areas. However, as a participant in MANE-VU, Rhode Island has agreed to pursue adoption of regional control measures aimed at visibility improvement on the haziest days and prevention of visibility degradation on the clearest days.

The long-term strategy described below includes enforceable emissions limitations, compliance schedules, and other measures necessary to achieve the RPGs established for the Class I areas. To the extent that it is reasonable, Rhode Island commits to adopting these measures before submitting a report on reasonable progress to EPA five years following the initial submittal of this SIP. Additional measures may be reasonable to adopt at a later date after further consideration and review.

11.1 Overview of Strategy Development Process

The regional strategy development process identified reasonable measures that would reduce emissions contributing to visibility impairment at Class I areas by 2018 or earlier. The process of identifying potential emission reduction measures and the technical basis for the long-term strategy are discussed in this section. As a MANE-VU member and participant, Rhode Island supported several technical analyses undertaken to assist the MANE-VU states in deciding which regional haze control measures to pursue. These analyses are documented in the following reports:

- NESCAUM, "Contributions to Regional Haze in the Northeast and Mid-Atlantic United States," August 2006, otherwise known as the Contribution Assessment (Attachment B).
- ICF Resources, L.L.C., "Comparison of CAIR and CAIR Plus Proposal Using the Integrated Planning Model®," Final Draft Report, May 30, 2007, otherwise known as the CAIR Plus Report (Attachment BB);
- MACTEC Federal Programs, Inc., "Assessment of Reasonable Progress for Regional Haze in MANE-VU Class I Areas," Final, July 9, 2007, otherwise known as the Reasonable Progress Report (Attachment Y);
- NESCAUM, "Five-Factor Analysis of BART-Eligible Sources: Survey of Options for Conducting BART Determinations," June 1, 2007 (Attachment W); and
- NESCAUM, "Assessment of Control Technology Options for BART-Eligible Sources: Steam Electric Boilers, Industrial Boilers, Cement Plants and Paper and Pulp Facilities," March 2005, otherwise known as the BART Report (Attachment Z).

MANE-VU reviewed a wide range of potential control measures aimed at reducing regional haze by the 2018 milestone. The process of choosing a set of control measures started in late 2005. OTC selected a contracting firm to assist with the analysis of ozone and regional haze control measure options and provided the contractor with a master list of some 900 potential control measures based on experience and previous state implementation plan work. With the help of an internal OTC Control Measures Workgroup, the contractor narrowed the list of regional haze control measures for further consideration by MANE-VU.

MANE-VU then developed an interim short list of possible control measures for regional haze. The identified control measures can be divided into three general categories:

- Beyond-CAIR sulfate reductions and related control measures targeted at specific electrical generating units (EGUs) in the eastern United States,
- Low-sulfur heating oil for industrial, commercial, institutional (ICI) boilers and residential sources (i.e., boilers and furnaces), and
- Emission controls on ICI boilers (both coal- and oil-fired); lime and cement kilns; residential wood stoves; and outdoor burning (including outdoor wood boilers).

The next step was to further refine this list, with the aid of several of the reports named above. The CAIR Plus Report documents MANE-VU's assessment of the costs of CAIR and provides a cost analysis for additional SO_2 and NO_X controls at EGUs in the eastern United States. The Reasonable Progress Report documents the assessment of control measures for EGUs and the other source categories selected for analysis. Further analysis is provided in the second of the two NESCAUM documents referenced above pertaining to Best Available Retrofit Technology (BART) controls.

The beyond-CAIR strategy for EGUs rose to the top of the list because the Contribution Assessment showed that EGU sulfate emissions have, by far, the largest impact on visibility in the MANE-VU Class I Areas. Similarly, a low-sulfur oil strategy gained traction after a NESCAUM-initiated conference with refiners and fuel-oil suppliers concluded that such a strategy could realistically be implemented within the next 10 years. Thus, the low-sulfur heating oil option for the residential and commercial sectors and the control measures option for the oil-fired ICI boiler sector merged into an overall strategy requiring the use of low-sulfur oil. Under this strategy, low-sulfur oil would be required for all residential and commercial heating units and all ICI boilers burning #2, #4, or #6 fuel oils.

During MANE-VU's internal consultation meeting in March 2007, member states reviewed the interim list of control measures to make additional refinements. States determined, for example, that there may be too few coal-fired ICI boilers in MANE-VU for these sources to be included in a regional strategy, but that they could be covered in programs adopted by individual states. The member states also decided that lime and cement kilns, of which there are few in the MANE-VU region, are most likely to be handled via the BART determination process. Residential wood burning and outdoor wood boilers remained on the list for those states where localized visibility impacts are a consideration even though emissions from these sources are primarily organic carbon and direct particulate matter. Finally, it was decided that the issue of outdoor wood burning should be examined further on a state-by-state basis because of concerns related to enforcement and penetration of existing state regulations.

11.2 Technical Basis for Strategy Development

40 CFR 51.308(d)(3)(iii) requires Rhode Island to document the technical basis for the state's apportionment of emission reductions necessary to meet RPGs in each Class I area affected by Rhode Island's emissions. Rhode Island relied on technical analyses developed by MANE-VU to demonstrate that Rhode Island's emission reductions, when coordinated with those of other states and tribes, are sufficient to achieve reasonable progress goals in Class I areas affected by emissions originating in Rhode Island.

The emission reductions necessary to meet reasonable progress goals in Class I areas affected by Rhode Island are described in the following documents:

- NESCAUM, "Baseline and Natural Background Visibility Conditions: Considerations and Proposed Approach to the Calculation of Baseline and Natural Background Visibility Conditions at MANE-VU Class I Areas," December 2006 (Attachment L);
- NESCAUM, "The Nature of the Fine Particle and Regional Haze Air Quality Problems in the MANE-VU Region: A Conceptual Description," Final, November 2, 2006 (Attachment CC);
- NESCAUM, "Contributions to Regional Haze in the Northeast and Mid-Atlantic United States," August 2006, otherwise known as the Contribution Assessment (Attachment B).
- ICF Resources, L.L.C., "Comparison of CAIR and CAIR Plus Proposal Using the Integrated Planning Model®," Final Draft Report, May 30, 2007, otherwise known as the CAIR Plus Report (Attachment BB);
- MACTEC Federal Programs, Inc., "Assessment of Reasonable Progress for Regional Haze in MANE-VU Class I Areas," Final, July 9, 2007, otherwise known as the Reasonable Progress Report (Attachment Y);
- NESCAUM, "Five-Factor Analysis of BART-Eligible Sources: Survey of Options for Conducting BART Determinations," June 1, 2007 (Attachment W);
- NESCAUM, "Assessment of Control Technology Options for BART-Eligible Sources: Steam Electric Boilers, Industrial Boilers, Cement Plants and Paper and Pulp Facilities," March 2005, otherwise known as the BART Report (Attachment Z);
- NESCAUM, "MANE-VU Modeling for Reasonable Progress Goals: Model Performance Evaluation, Pollution Apportionment, and Control Measure Benefits," February 7, 2008 (Attachment G); and
- NESCAUM, "2018 Visibility Projections," May 13, 2008 (Attachment Q).

As described in Subsection 11.1, above, Rhode Island worked with other members of the Ozone Transport Commission and MANE-VU to evaluate a large number of potential emission reduction strategies covering a wide range of sources of SO_2 and other pollutants contributing to regional haze. 40 CFR 51.308(d)(3)(v) requires states to consider several factors in developing their long-term strategies. Operating within this framework and using available information about emissions and potential impacts, the MANE-VU Reasonable Progress Workgroup selected the following source categories for detailed analysis:

- Coal and oil-fired electric generating units (EGUs);
- Point and area source ICI boilers;
- Cement kilns and lime kilns;
- Sources capable of using low-sulfur heating oil; and
- Residential wood combustion and open burning.

These efforts led to the selection of the emission reduction strategies presented in this SIP.

11.3 Existing Commitments to Reduce Emissions

40 CFR Section 51.308(d)(3)(v)(A) requires states to consider emission reductions from ongoing pollution control programs. In developing its long-term strategy, Rhode Island considered air pollution programs being implemented between the 2002 baseline year and 2018. The emission reduction programs described in Parts 11.3.1, 11.3.2, and 11.3.3, below, represent commitments already made by Rhode Island and other states to implement air pollution control measures for EGU point sources, non-EGU point sources, and area sources, respectively. These control measures are the same measures that were included in the 2018 emissions inventory and used in the modeling. While these control measures were not designed expressly for the purpose of improving visibility, the pollutants they control include those that contribute to visibility impairment in MANE-VU Class I Areas.

MANE-VU's 2018 beyond-on-the-way (BOTW) emissions inventory accounts for emission controls already in place as well as emission controls that are not yet finalized but are likely to achieve additional emission reductions by 2018. The BOTW inventory was developed based on the MANE-VU 2002 Version 3.0 inventory and the MANE-VU 2018 on-the-books/on-the-way (OTB/OTW) inventory. Inventories used for other RPOs reflect anticipated emissions controls that will be in place by 2018. The inventory is termed BOTW because it includes control measures that were developed for ozone SIPs that were not yet on the books in some states. For some states, BOTW also included controls that were under consideration for regional haze SIPs that have not yet been adopted. More information may be found in the following documents:

- MACTEC Federal Programs, Inc., "Development of Emissions Projections for 2009, 2012, and 2018 for NonEGU Point, Area, and Nonroad Sources in the MANE-VU Region," Final Report, February 28, 2007, otherwise known as the Emission Projections Report (Attachment N);
- Alpine Geophysics, LLC, "Documentation of 2018 Emissions from Electric Generating Units in the Eastern United States for MANE-VU's Regional Haze Modeling, Revised Final Draft, April 28, 2008 (Attachment H);
- NESCAUM, "MANE-VU Modeling for Reasonable Progress Goals: Model Performance Evaluation, Pollution Apportionment, and Control Measure Benefits," February 7, 2008 (Attachment G); and
- NESCAUM, "2018 Visibility Projections," May 13, 2008 (Attachment Q).

11.3.1 Controls on EGUs Expected by 2018

The following EGU emission reduction programs were included in the modeling used to develop the reasonable progress goals. These programs represent the greatest opportunities for reducing SO_2 emissions at Class I areas in the MANE-VU region and serve as the starting point for MANE-VU's long-term strategy to mitigate regional haze.

Clean Air Interstate Rule (CAIR): This major federal rule imposes permanent emissions caps on sulfur dioxide (SO_2) and nitrogen oxides (NO_X) in the eastern United States by 2015. When fully effective, CAIR would reduce SO_2 emissions in the CAIR region by up to 70 percent. Note that Rhode Island is not covered by the CAIR rule; however, emissions from all EGUs in Rhode Island are regulated under Rhode Island's NOx SIP regulation and restricted by permit, as discussed below. To predict future emissions from EGUs after implementation of CAIR, MANE-VU used the Integrated Planning Model (IPM)[14]. Adjustments to the IPM output were made to provide a more accurate representation of anticipated controls at specific EGU sources as documented in the Alpine Geophysics report listed above. In making these adjustments, emission controls originating from the following state and regional programs were considered:

***Rhode Island EGU Permit Restrictions*:** Three of the EGUs in Rhode Island have dual fuel capability and burn both natural gas and distillate fuel oil. The remaining EGUs burn only natural gas. SO_2 emission limits, which are all incorporated in state and federally enforceable preconstruction and operating permits, for the three EGUs that burn fuel oil are as follows::

- *Dominion Energy Manchester Street, Providence:* fuel oil content sulfur limited to 500 ppm (0.05%), which corresponds to an SO_2 emission rate of 0.055 lb/MMBtu;
- *Ocean State Power, Harrisville*, fuel oil sulfur content limited to 15 ppm (0.0015%), which corresponds to an SO_2 emission rate of 0.00165 lb/MMBtu;
- *Pawtucket Power, Pawtucket*, fuel oil sulfur content limited to 2,000 ppm (0.2%), which corresponds to an SO_2 emission rate of 0.22 lb/MMBtu;

***Connecticut EGU Regulations*:** Connecticut adopted the following regulations governing EGU emissions:

- *Regulations of Connecticut State Agencies (RCSA), section 22a-174-19a*, limiting the SO_2 emission rate to 0.33 lb/MMBtu for fossil-fuel-fired EGUs greater than 15 MW that are also Title IV sources (effective, 2007).
- *RCSA, section 22a-174-22*, limiting the non-ozone seasonal NO_X emission rate to 0.15 lb/MMBtu for fossil-fuel-fired EGUs greater than 15 MW (effective, 2007).
- *RCSA, section 22a-199*, limiting the mercury (Hg) emission rate to 0.0000006 lb/MMBtu for all coal-fired EGUs or alternatively coal-fired EGUs can meet a 90% Hg emission reduction (effective, 2008).

***Delaware EGU Regulations*:** Delaware adopted the following regulations governing EGU emissions:

- *Reg. 1144, Control of Stationary Generator Emissions*, requiring emission controls for SO_2, PM, VOC, and NO_X state-wide, effective January 2006.

[14] The IPM model runs also anticipated the implementation of EPA's Clean Air Mercury Rule (CAMR), which was recently vacated by the courts. However, MANE-VU believes that the adjustments made to the predicted SO_2 emissions from electric generating units (EGUs) will have a larger effect on the air quality modeling analysis conducted for this SIP than will the vacatur of the CAMR rule. The emission adjustments were based on states' comments on the actual levels of SO_2 controls expected to be installed in response to state-specific regulations and EPA's CAIR rule. MANE-VU believes these adjustments improve the reliability of both the emissions inventory and modeling results.

- *Reg. 1146, Electric Generating Unit (EGU) Multi-Pollutant Regulation,* requiring SO_2 and NO_X emission controls state-wide, effective December 2007. SO_2 reductions will be more than regulation specifies

- *Reg. 1148, Control of Stationary Combustion Turbine Electric Generating Unit Emissions*, requiring SO_2, NO_X, and $PM_{2.5}$ emission controls state-wide, effective January 2007.

Delaware estimates that these regulations will result in the following emission reductions for affected units: SO_2 emissions of 32,630 tons in 2002 will decline to 8,137 tons in 2018 (a 75-percent reduction); NO_X emissions of 8,735 tons in 2002 will decline to 3,740 tons in 2018 (a 57-percent reduction).

Also, Delaware anticipates the following reductions resulting from the consent decree with Valero Refinery Delaware City, DE (formerly Motiva, Valero Enterprises): SO_2 emissions of 29,747 tons in 2002 will decline to 608 tons in 2018 (a 98-percent reduction); NO_X emissions in 1,022 in 2002 will decline to 102 tons in 2018 (a 90-percent reduction).

Maine EGU Regulations**:** *Chapter 145, NO_X Control Program*, limits the NO_X emission rate to 0.22 lb/MMBtu for fossil-fuel-fired units greater than 25 MW built before 1995 with a heat input capacity between 250 and 750 MMBtu/hr, and also limits the NO_X emission rate to 0.15 lb/MMBtu for fossil-fuel-fired units greater than 25 MW built before 1995 with a heat input capacity greater than 750 MMBtu/hr (effective, 2007).

Massachusetts EGU Regulations**:** Based on the Massachusetts Department of Environmental Protection's 310 CMR 7.29, *Emissions Standards for Power Plants,* adopted in 2001, six of the largest fossil-fuel-fired power plants in Massachusetts must comply with emissions limitations for NO_X, SO_2, Hg, and CO_2. These regulations will achieve an approximately 50-percent reduction in NO_X emissions and a 50- to 75-percent reduction in SO_2 emissions. Depending on the compliance paths selected, the affected facilities will meet the output-based NO_X and SO_2 standards between 2004 and 2008. This regulation also limits the six grandfathered EGUs to a CO_2 emission rate of 1,800 lb/MWh.

New Hampshire EGU Regulations**:** New Hampshire adopted the following regulations governing EGU emissions:

- *Chapter Env-A 2900, Multiple Pollutant Annual Budget Trading and Banking Program*, capping NO_X emissions at 3,644 tons per year, SO_2 emissions at 7,289 tons per year, and CO_2 emissions at 5,425,866 tons CO_2 per year for all existing fossil-fuel-fired steam units by December 31, 2006.

- *Chapter Env-A 3200*, *NO_X Budget Trading Program*, limiting ozone season NO_X emissions on all fossil-fuel-fired EGUs greater than 15 MW to 0.15 lb/MMBtu, effective November 2, 2007.

New Jersey New Source Review Settlement Agreements**:** The New Jersey settlement agreement with PSEG required the following actions for specific EGUs:

- *Bergen Unit #2*: Repower to combined cycle by December 31, 2002.

- *Hudson Unit #2*: Install dry FGD or approved alternative technology by Dec. 31, 2006, to control SO_2 emissions and operate the control technology at all times the unit operates to limit SO_2 emissions to 0.15 lb/MMBtu; install SCR or approved alternative technology by May 1, 2007, to control NO_X emissions and operate the control technology year-round to limit NO_X emissions to 0.1 lb/MMBtu; and install a baghouse or approved alternative technology by May 1, 2007, to control and limit PM emissions to 0.015 lb PM/MMBtu.

- *Mercer Unit #1*: Install dry FGD or approved alternative technology by Dec. 31, 2010, to control SO_2 emissions and operate the control technology at all times the unit operates to limit SO_2 emissions to 0.15 lb/MMBtu; and install SCR or approved alternative technology by 2005 to control NO_X emissions and operate the control technology during ozone season only in 2005 and year-round by May 1, 2006, to limit NO_X emissions to 0.13 lb/MMBtu.
- *Mercer Unit #2*: Install dry FGD or approved alternative technology by Dec. 31, 2012, to control SO_2 emissions and operate the control technology at all times the unit operates to limit SO_2 emissions to 0.15 lb/MMBtu; and install SCR or approved alternative technology by 2004 to control NO_X emissions and operate the control technology during ozone season only in 2004 and year-round by May 1, 2006, to limit NO_X emissions to 0.13 lb/MMBtu.

The New Jersey settlement also requires that units operating an FGD use coal having a monthly average sulfur content no greater than 2 percent.

***New York EGU Regulations*:** New York adopted the following regulations governing EGU emissions:

- *Title 6 NYCRR Parts 237, Acid Deposition Reduction NO_X Budget Trading Program*, limits NO_X emissions on all fossil-fuel-fired EGUs greater than 25 MW to a non-ozone season cap of 39,908 tons in 2007.
- *Title 6 NYCRR Parts 238, Acid Deposition Reduction SO_2 Budget Trading Program*, limits SO_2 emissions from all fossil-fuel-fired EGUs greater than 25 MW to an annual cap of 197,046 tons per year starting in 2007 and an annual cap of 131,364 tons per year starting in 2008.

***North Carolina Clean Smokestacks Act*:** Enacted in 2002, this legislation requires that coal-fired EGUs achieve a 77-percent cut in NO_X emissions by 2009 and a 73-percent cut in sulfur dioxide SO_2 emissions by 2013. This act also established annual caps on both SO_2 and NO_X emissions for the two primary utility companies in North Carolina, Duke Energy and Progress Energy. These reductions must be made in North Carolina, and allowances are not saleable.

***Consent Agreements in the VISTAS region*:** The effects of the following consent agreements in the VISTAS states were reflected in the emissions inventories used for those states:

- *Santee Cooper*: A 2004 consent agreement calls for Santee Cooper in South Carolina to install and commence operation of continuous emission control equipment for $PM/SO_2/NO_X$ emissions; comply with system-wide annual $PM/SO_2/NO_X$ emissions limits; agree not to buy, sell, or trade SO_2/NO_X allowances allocated to Santee Cooper System as a result of this agreement; and to comply with emission unit limits of this agreement.

- *TECO*: Under a settlement agreement, by 2008, Tampa Electric in the state of Florida will install permanent emission control equipment to meet stringent pollution limits; implement a series of interim pollution reduction measures to reduce emissions while the permanent controls are designed and installed; and retire pollution emission allowances that Tampa Electric or others could use, or sell to others, to emit additional NO_X, SO_2, and PM.
- *VEPCO*: Virginia Electric and Power Co. agreed to spend $1.2 billion by 2013 to eliminate 237,000 tons of SO_2 and NO_X emissions each year from eight coal-fired electricity generating plants in Virginia and West Virginia.
- *Gulf Power 7*: A 2002 agreement calls for Gulf Power to upgrade its operation to cut NO_X emission rates by 61 percent at its Crist 7 generating plant by 2007 with major reductions beginning in early 2005. The Crist plant is a significant source of NO_X emissions in the Pensacola, Florida, area.

11.3.2 Controls on Non-EGU Point Sources Expected by 2018

Rhode Island used MANE-VU's Version 3.0 Emission Inventory for 2002 to identify non-EGU point sources in the State. MACTEC conducted an analysis of control measures, as documented in the Emission Projections Report (Attachment N). Control factors were applied to the 2018 MANE-VU inventory for non-EGUs to represent the following national, regional, or state control measures:

- NO_X SIP Call Phase I (NO_X Budget Trading Program) (except ME, NH, VT);
- NO_X SIP Call Phase II (except ME, NH, VT);
- NO_X RACT in 1-hour Ozone SIPs (already included in the 2002 inventory);
- NO_X OTC 2001 Model Rule for ICI Boilers;
- 2-, 4-, 7-, and 10-year MACT Standards;
- Combustion Turbine and RICE MACT (NO_X co-benefits were not included and assumed to be small);
- Industrial Boiler/Process Heater MACT[15]; and
- Refinery Enforcement Initiative (Fluid catalytic cracking units and fluid coking units, process heaters and boilers, flare gas recovery, leak detection and repair, and benzene (wastewater)).

In addition, states provided control measure information about specific non-EGU sources or regulatory programs in their states. MANE-VU used the state-specific data to the extent it was available. For example, several states developed additional control measures in the course of their planning efforts to reduce ozone within the Ozone Transport Region (OTR). These control measures were included by MANE-VU in the inventories used for regional haze modeling. (The affected states may or may not have committed to adopting these measures in their ozone SIPs.) For specific states, the ozone-reduction strategies included in the modeling would reduce NO_X emissions from the following non-EGU point sources:

[15] The inventory was prepared before the MACT for Industrial Boilers and Process Heaters was vacated. Control efficiency was assumed to be 4 percent for SO_2 and 40 percent for PM. The overall effects of including these reductions in the inventory are estimated to be minimal.

- Asphalt production plants in Connecticut, New Jersey, New York, and the District of Columbia;
- Cement kilns in Maine, Maryland, New York, and Pennsylvania; and
- Glass and fiberglass furnaces in Maryland, Massachusetts, New Jersey, New York, and Pennsylvania.

For other regions, MANE-VU used emission inventory data developed by the RPOs for those regions, including VISTAS's Base G2, MRPO's Base K, and CenRAP's emissions inventory. Non-EGU source controls incorporated into the modeling include those required under the following consent agreements as reflected in the VISTAS inventory:

- *Dupont*: A 2007 agreement calls for E. I. Dupont Nemours & Co.'s James River plant to install dual absorption pollution control equipment by September 1, 2009, resulting in SO_2 emission reductions of approximately 1,000 tons annually. The James River plant is a non-EGU located in the state of Virginia.
- *Stone Container*: A 2004 agreement calls for the West Point Paper Mill in Virginia owned by Smurfit/Stone Container to control SO_2 emissions from its #8 Power Boiler by using a wet scrubber. This control device should result in reductions of over 3,500 tons of SO_2 in 2018.

11.3.3 Controls on Area Sources Expected by 2018

Rhode Island used MANE-VU's Version 3.0 Emissions Inventory for 2002 to characterize area source emissions. In general, MANE-VU developed the 2018 inventory for area sources by applying growth and control factors to the 2002 Version 3.0 inventory. Growth factor development is discussed above in Section 6.3.2. Area source control factors were developed for the following national or regional control measures:

- The OTC's VOC Model Rules for consumer products, architectural and industrial maintenance coatings, portable fuel containers, mobile equipment repair and refinishing, and solvent cleaning; Rhode Island has adopted the OTC rules for consumer products, architectural and industrial maintenance coatings and solvent cleaning (APC Regulations Nos. 31, 33 and 36, respectively) and has a similar rule on the books for mobile equipment repair and refinishing (APC Regulation No. 30). The EPA adopted portable fuel container requirements in its Mobile Source Air Toxics rule, obviating the need for individual states to adopt similar requirements.
- Federal On-board Vapor Recovery
- New Jersey post-2002 area source controls; and
- Residential woodstove NSPS.

The following additional control measures were included in the 2018 analysis to reduce NO_X and VOC emissions for the following area source categories for some (identified) states:

- NO_X control measures for combustion of coal; natural gas; and #2, #4, and #6 fuel oils (CT, NJ, and NY only);

- VOC control measures for adhesives and sealants (all MANE-VU states except New Jersey[16] and VT). Rhode Island has adopted the OTC requirements for adhesives and sealants (APC Regulation No. 44);
- VOC control measures for emulsified and cutback asphalt paving (all MANE-VU states except ME and VT). Rhode Island has gone through the public hearing process with modifications to its asphalt paving regulation to be consistent with OTC recommended controls and will file the amended regulation in October 2009 to be effective May 2010 (APC Regulation No. 25);
- VOC control measures for consumer products (all MANE-VU states except VT). These measures have been adopted in Rhode Island (Regulation No. 31); and
- VOC control measures for portable fuel containers (all MANE-VU states except VT).

As noted above, inventory data for other regions were obtained from those regions' RPOs. Some of the area-source control measures listed above may have been developed by states for the primary purpose of reducing ozone within the Ozone Transport Region (OTR) – see Part 11.3.2 for information on other measures included in states' ozone SIPs.

11.3.4 Controls on Mobile Sources Expected by 2018

For the on-road mobile source emission inventory, Rhode Island relied on MANE-VU's Version 3.0 emission inventory, which included the following emission control measures for Rhode Island:

- Use of reformulated gasoline;
- An enhanced safety inspection program, including an anti-tampering inspection for motor vehicles less than 20 years old;
- On-board diagnostics testing for 1996 and newer vehicles in lieu of the anti-tampering inspection;
- Federal On-Board Refueling Vapor Recovery (ORVR) Rule;
- Federal Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Requirements;
- Federal Heavy-Duty Diesel Engine Emission Standards for Trucks and Buses; and
- Federal Emission Standards for Large Industrial Spark-Ignition Engines and Recreational Vehicles

Similar programs in other MANE-VU states were included in the on-road mobile source emission inventory, where applicable. The last four items listed above are federal programs, briefly described here:

***On-Board Refueling Vapor Recovery (ORVR) Rule*:** The 1990 Clean Air Act (CAA) Amendments contain provisions that require passenger cars to capture refueling emissions. In 1994, EPA published the ORVR Rule establishing standards for refueling emissions controls

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[16] New Jersey's emission reductions from control measures for adhesives and sealants apply only to area sources. No reductions for point sources (SCC 4-02-0007-xx) were included to avoid inventory double-counting.

for passenger cars and light trucks. The onboard controls were required to be phased in for all new car production by 2000 and for all light trucks by 2006. The rule established a refueling emission standard of 0.20 grams per gallon of dispensed fuel, which was expected to yield a 95 percent reduction of VOC emissions over uncontrolled levels. The CAA authorizes EPA to allow state and local agencies to phase out Stage II programs, even in the worst nonattainment areas, once EPA has determined that onboard systems are in widespread use.

Tier 2 Motor Vehicle Emissions Standards: Tier 2 is a fleet-averaging program modeled after the California LEV II standards. Manufacturers can produce vehicles with emissions ranging from relatively dirty to zero, but the mix of vehicles a manufacturer sells each year must have average NO_X emissions below a specified value. The Tier 2 regulations also require reduced gasoline sulfur levels. The reduction in sulfur levels contributes directly to cleaner air and has additional beneficial effects on vehicle emission control systems. The Tier 2 standards became effective in the 2005 model year and are included in the assumptions used for calculating mobile source emissions inventories used for 2018.

***Heavy-Duty Diesel Engine Emission Standards for Trucks and Buses*:** EPA set a PM emissions standard of 0.01 grams per brake-horsepower-hour (g/bhp-hr) for new heavy-duty diesel engines in trucks and buses, to take full effect in the 2007 model year. This rule also includes standards for NO_X and non-methane hydrocarbons (NMHC) of 0.20 g/bhp-hr and 0.14 g/bhp-hr, respectively. These NO_X and NMHC standards will be phased in together between 2007 and 2010. Sulfur in diesel fuel must be lowered to enable modern pollution-control technology to be effective on the trucks and buses that use this fuel. EPA will require a 97-percent reduction in the sulfur content of highway diesel fuel from its current level of 500 parts per million (low-sulfur diesel) to 15 parts per million (ultra-low sulfur diesel).

***Emission Standards for Large Industrial Spark-Ignition Engines and Recreational Vehicles*:** EPA has adopted new standards for emissions of NO_X, hydrocarbons (HC), and carbon monoxide (CO) from several groups of previously unregulated non-road engines. Included are large industrial spark-ignition engines and recreational vehicles. The affected spark-ignition engines are those powered by gasoline, liquid propane, or compressed natural gas rated over 19 kilowatts (kW) (25 horsepower). These engines are used in commercial and industrial applications, including forklifts, electric generators, airport baggage transport vehicles, and a variety of farm and construction applications. Non-road recreational vehicles include snowmobiles, off-highway motorcycles, and all-terrain vehicles. These rules were initially effective in 2004 and will be fully phased-in by 2012.

11.3.5 Controls on Non-Road Sources Expected by 2018

For non-road emission sources, Rhode Island used Version 3.0 of the MANE-VU 2002 Emissions Inventory. Because the NONROAD Model used to develop the non-road source emissions did not include aircraft, commercial marine vessels, and locomotives, MANE-VU's contractor, MACTEC, developed the inventory for these sources. Non-road mobile source emissions for the 2018 emission inventory were calculated with EPA's NONROAD2005 emissions model as incorporated into the NMIM2005 (National Mobile Inventory Model) database. The NONROAD model accounts for emissions benefits associated with federal non-road emission control requirements such as the following:

- "Control of Air Pollution: Determination of Significance for Nonroad Sources and Emissions Standards for New Nonroad Compression Ignition Engines at or above 37 Kilowatts," 59 FR 31306, June 17, 1994.
- "Control of Emissions of Air Pollution from Nonroad Diesel Engines," 63 FR 56967, October 23, 1998.
- "Control of Emissions from Nonroad Large Spark-Ignition Engines and Recreational Engines (Marine and Land-Based)," Final Rule, 67 FR 68241, November 8, 2002.
- "Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel," Final Rule, April, 2004.

As noted above, inventory data for other regions were obtained from those regions' RPOs.

11.4 Additional Reasonable Measures

As required under 40 CFR 51.308(d)(1)(i)(A), the MANE-VU states applied a four-factor analysis to potential control measures for the purpose of establishing reasonable progress goals. Reasonable measures include those that the affected states have already committed themselves to implementing, as described in Subsection 11.3, above. In addition, the MANE-VU states have identified other control measures that were found to be reasonable and were included in the modeling that was used to set reasonable progress goals. (These additional measures surpass the "beyond-on-the-way" emission controls and inventories.) All of the control measures – those embodied in the states' commitments to existing or planned programs and the additional reasonable control measures described below – comprise the long-term strategy for improving visibility at MANE-VU Class I Areas.

Specifically, the Rhode Island/MANE-VU long-term strategy includes the following additional measures to reduce pollutants that cause regional haze.

- Timely implementation of BART requirements (note that no BART-eligible sources are located in Rhode Island).
- A low-sulfur fuel oil strategy in the inner-zone states (New Jersey, New York, Delaware, and Pennsylvania, or portions thereof) to reduce the sulfur content of:
  - #2 distillate oil to 0.05 percent (500 ppm) sulfur, by weight, by no later than 2012;
  - #4 residual oil to 0.25 percent sulfur, by weight, by no later than 2012;
  - #6 residual oil to 0.3-0.5 percent sulfur, by weight, by no later than 2012;
  - Further reduction of the sulfur content of distillate oil to 15 ppm by 2016.
- A low-sulfur fuel oil strategy in the outer-zone states (the remainder of the MANE-VU region) to reduce the sulfur content of:
  - #2 distillate oil to 0.05 percent (500 ppm) sulfur, by weight, by no later than 2014;
  - #4 residual oil to 0.25-0.50 percent sulfur, by weight, by no later than 2018;
  - #6 residual oil to 0.5 percent sulfur or less, by weight, by no later than 2018;
  - Further reduction of the sulfur content of distillate oil to 15 ppm by 2018, contingent on supply and availability.

- A 90-percent or greater reduction in sulfur dioxide (SO_2) emissions from each of the EGUs identified by MANE-VU as reasonably anticipated to cause or contribute to impairment of visibility in each mandatory Class I area in the MANE-VU region. (This requirement affects 167 point sources, or stacks, at EGU facilities in the eastern United States.) If it is infeasible to achieve this level of SO_2 reductions from specific EGUs, equivalent alternative measures will be pursued in the affected states.

- Continued evaluation of other control measures, including energy efficiency, alternative clean fuels, other measures to reduce SO_2 and nitrogen oxide (NO_X) emissions from all coal-burning facilities by 2018, and new source performance standards for wood combustion.

This suite of additional control measures are those that the MANE-VU states have agreed to pursue for the purpose of mitigating regional haze. The MANE-VU Class I states (Maine, New Hampshire, Vermont, and New Jersey) also are asking states outside the MANE-VU region that contribute to visibility impairment inside the region to pursue similar measures. The control measures that non-MANE-VU states choose to pursue may be directed toward the same emission source sectors identified by MANE-VU for its own emission reductions, or they may be equivalent measures targeting other source sectors. Under MANE-VU's long-term strategy, states will be allowed up to ten years to pursue adoption and implementation of proposed control measures. While some measures that states pursue may not represent enforceable commitments immediately, they may become enforceable in the future as new laws are passed, rules are written, and facility permits are issued.

11.4.1 BART

BART controls are among the reasonable strategies included in this SIP. EPA has determined that CAIR fulfills the BART requirement for EGUs in the annual CAIR program. To assess the impacts of MANE-VU states' implementation of the BART provisions of the Regional Haze Rule for other facilities, NESCAUM included estimated reductions anticipated for BART-eligible facilities in the MANE-VU region in the final 2018 CMAQ modeling analysis. A survey of state staff indicated that eight non-CAIR facilities in MANE-VU would likely be controlled under BART alone. These states provided potential control technologies and levels of control, which were in turn incorporated into the 2018 emission inventory projections. Updates to this preliminary assessment were incorporated into the most recent modeling run completed in March, 2008. Table 11.1 lists affected facilities and emissions assumptions used in the modeling.

Additional visibility benefits are likely to result from installation of controls at other non-CAIR BART-eligible facilities located in adjacent RPOs. These benefits were not accounted for in the MANE-VU modeling, since information about final BART determinations was not available.

Since Rhode Island has no BART sources, none of the eight facilities controlled by BART in the modeling listed in Table 11.1 are located in Rhode Island.

Table 11.1: Estimated Emissions from Non-EGU BART-Eligible Facilities Located in MANE-VU Used in Final Modeling

	Facility Name	Unit Name	SCC Code	Plant ID (from the MANE-VU inventory)	Point ID (from the MANE-VU inventory)	Facility Type	Fuel	2002 Emissions (tons)	2018 Emissions (tons)
MD	EASTALCO Aluminum	28	30300101	021-0005	28	Metal Production		1506	1356
MD	EASTALCO Aluminum	29	30300101	021-0005	29	Metal Production		1506	1356
MD	Lehigh Portland Cement	39	30500606	013-0012	39	Portland Cement		9	8
MD	Lehigh Portland Cement	16	30500915	021-0003	16	Portland Cement		1321	1,189
MD	Lehigh Portland Cement	17	30500915	021-0003	17	Portland Cement		976	878
MD	WESTVACO Fine Papers	2	10200212	001-0011	2	Paper and Pulp		8923	1338
ME	Wyman Station	Boiler 3	10100401	2300500135	004	EGU	Oil	616	308
ME	SAPPI Somerset	Power Boiler #1	10200799	2302500027	001	Paper and Pulp	Oil/Wood Bark/ Process Gas	2884	1442
ME	IP Jay	Power Boiler #2	10200401	2300700021	002	Paper and Pulp	Oil	3086	1543
ME	IP Jay	Power Boiler #1	10200401	2300700021	001	Paper and Pulp	Oil	2964	1482
NY	KODAK Park Division	U00015	10200203	8261400205	U00015	Chemical Manufacturer		23798	14216
NY	LAFARGE Building Materials, Inc	41000	30500706	4012400001	041000	Portland Cement		14800	4440

11.4.2 Low-Sulfur Oil Strategy

The important assumption underlying MANE-VU's low-sulfur fuel oil strategy is that refiners can, by 2018, produce sufficient quantities of home heating and other fuel oils with lower sulfur content than current fuel supplies at only a small increase in price to the end user. The expected reductions in sulfur content range from 50 percent for the heavier grades (#4 and #6 residual) to a minimum of 75 percent and maximum of 99.25 percent for #2 fuel oil (also known as home heating oil, distillate, or diesel fuel). As much as three-fourths of the total sulfur reductions achieved by this strategy will come from using low-sulfur #2 distillate for space heating in the residential and commercial sectors. The costs of these emissions reductions are estimated at $550 to $750 per ton, as documented in the MANE-VU Reasonable Progress Report. While the costs of the low-sulfur fuel oil strategy remain somewhat uncertain, they appear to be reasonable when measured against the costs of controlling other sectors.

The MANE-VU states agree that a low-sulfur oil strategy is reasonable to pursue in the next ten years. RI DEM commits to adopting regulations limiting fuel sulfur content consistent with the specifications for outer-zone MANE-VU states in the Ask, as specified in Section 11.4, above.

11.4.3 Targeted EGU Strategy

MANE-VU has identified emissions from the top 167 EGU emission points that contribute the most to visibility impairment at MANE-VU Class I Areas (see Figure 10.2). Controlling emissions from these contributing facilities is crucial to mitigating haze pollution in wilderness areas and national parks of the Northeast states.

MANE-VU's agreed regional approach for the EGU source sector is to pursue a 90-percent control level on SO_2 emissions from the 167 identified stacks by 2018. MANE-VU has concluded that pursuing this level of sulfur reduction is both reasonable and cost-effective. Even though current wet scrubber technology can achieve sulfur reductions greater than 95 percent, an overall 90-percent sulfur reduction level would include the effects of lower average reduction rates from dry scrubbing technology, consistent with historical experience. The costs of SO_2 emission reductions will vary by unit. MANE-VU's Reasonable Progress Report (Attachment Y) summarizes the available control methods and costs, which range from $170 to $5,700 per ton (2006 dollars), depending on site-specific factors such as size of unit, combustion technology used, and type of fuel burned.

Several other states within and outside the MANE-VU region have implemented state-specific EGU emission reduction programs that will help MANE-VU meet visibility improvement goals. Many of the state programs that will contribute to meeting the targeted EGU strategy are identified in Part 11.3.1 of this section. Listed below are other state programs not previously identified that will also contribute to meeting this strategy. These other programs may yield additional benefits by controlling emissions at certain EGUs not listed among the top 167 EGU stacks. The listed programs represent existing commitments by the states and, as such, were included in MANE-VU's most recent modeling.

***Maryland Healthy Air Act*:** Maryland adopted the following requirements governing EGU emissions:

- For NO_X:

  - Phase I (2009) sets unit-specific annual caps totaling 20,216 tons and ozone-season caps totaling 8,900 tons.
  - Phase II (2012) sets unit-specific annual caps totaling 16,667 tons and ozone-season caps totaling 7,337 tons.
- For SO_2:
  - Phase I (2010) sets unit-specific annual caps totaling 48,818 tons.
  - Phase II (2013) sets unit-specific annual caps totaling 37,235 tons.
- For mercury:
  - Phase I (2010) requires a 12-month-rolling-average minimum removal efficiency of 80 percent.
  - Phase II (2013) requires a 12-month-rolling-average minimum removal efficiency of 90 percent.

The specific EGUs included are: Brandon Shores (Units 1 and 2), C.P.Crane (Units 1 and 2), Chalk Point (Units 1, and 2), Dickerson (Units 1, 2, and 3), H.A. Wagner (Units 2 and 3) Morgantown (Units 1 and 2), and R. Paul Smith (Units 3 and 4). No out-of-state trading of emission allowances, no inter-company trading of allowances, and no banking of allowances from year to year were included in the analyses.

***New Jersey Mercury MACT Rule*:** Under this rule all coal-fired EGUs in New Jersey will have a mercury removal efficiency of 90 percent. (Some SO_2 reductions may occur as a co-benefit of mercury emission controls.)

***Consent Agreements in the VISTAS region*:** The following consent agreements in the VISTAS states were reflected in the emissions inventories used for those states:

- *East Kentucky Power Cooperative*: A July 2, 2007, consent agreement between EPA and East Kentucky Power Cooperative (EKPC) requires the utility to reduce its SO_2 emissions by 54,000 tons per year and its NO_X emissions by 8,000 tons per year, by installing and operating selective catalytic reduction (SCR) technology; low-NO_X burners, and PM and mercury continuous emissions monitors at the utility's Spurlock, Dale, and Cooper Plants. According to the EPA, total emissions from the plants will decrease between 50 and 75 percent from 2005 levels. As with all federal consent decrees, EKPC is precluded from using reductions required under other programs such as CAIR to meet the reduction requirements of the consent decree. EKPC is expected to spend $654 million to install pollution controls.

- *American Electric Power*: Under this agreement, American Electric Power (AEP) will spend $4.6 billion dollars for emission controls at sixteen plants located in Indiana, Kentucky, Ohio, Virginia, and West Virginia. These control measures will eliminate 72,000 tons of NO_X emissions each year by 2016 and 174,000 tons of SO_2 emissions each year by 2018 from the affected facilities.

11.5 Source Retirement and Replacement Schedules

40 CFR Section 51.308(d)(3)(v)(D) of the Regional Haze Rule requires Rhode Island to consider source retirement and replacement schedules in developing reasonable progress goals. Source retirement and replacement were considered in developing the 2018 emissions

inventory described previously in Subsection 10.3, Reasonable Progress Goals for Class I Areas in the State. See also Table B-5 in the Emission Projections Report (Attachment N).

The sources in Rhode Island that were shut down after the 2002 base year and therefore were not included in the 2018 inventory are listed in Table 11.2

Table 11.2: Rhode Island Sources Closed After 2002

STATE	FIPS	SITE ID	FACILTY NAME
44	001	AIR3625	Albin
44	001	AIR3753	Display World
44	003	AIR684	Clariant
44	003	AIR876	Leviton
44	007	AIR1177	CCL Manufacturing
44	007	AIR447	Eastern Butcher Block
44	007	AIR	Fiber Mark
44	007	AIR2682	Metals Recycling
44	007	AIR1395	Slater Pawtucket
44	007	AIR3315	Slater Cumberland
44	009	AIR248	Charbert

11.6 Measures to Mitigate the Impacts of Construction Activities

40 CFR 51.308(d)(3)(v)(B) of the Regional Haze Rule requires Rhode Island to consider measures to mitigate the impacts of construction activities on regional haze. MANE-VU's consideration of control measures for construction activities is documented in "Technical Support Document on Measures to Mitigate the Visibility Impacts of Construction Activities in the MANE-VU Region," Draft, October 20, 2006," (Attachment DD).

The construction industry is already subject to requirements for controlling pollutants that contribute to visibility impairment. For example, federal regulations require the reduction of SO_2 emissions from construction vehicles. At the state level, Rhode Island Air Pollution Control Regulation Number 5, "Fugitive Dust" regulates dust from construction and demolition activities. Section 5.3 of that regulation states, "No person shall cause or permit any materials, including but not limited to sand, gravel, soil, aggregate and any other organic or inorganic solid matter capable of releasing dust, to be handled, transported, mined, quarried, stored or otherwise utilized in any way so as to cause airborne particulate matter to travel beyond the property line of the emission source without taking adequate precautions to prevent particulate matter from becoming airborne."

MANE-VU's Contribution Assessment (Attachment B) found that, from a regional haze perspective, crustal material generally does not play a major role. On the 20 percent best-visibility days during the 2000-2004 baseline period, crustal material accounted for 6 to 11 percent of particle-related light extinction at MANE-VU Class I Areas. On the 20 percent worst-visibility days, however, the ratio was reduced to 2 to 3 percent. Furthermore, the crustal fraction is largely made up of pollutants of natural origin (e.g., soil or sea salt) that are not targeted under the Regional Haze Rule. Nevertheless, the crustal fraction at any given location can be heavily influenced by the proximity of construction activities; and construction activities occurring in the immediate vicinity of MANE-VU Class I Areas could have a noticeable effect on visibility.

For this regional haze SIP, Rhode Island concluded that its regulations are currently sufficient to mitigate the impacts of construction activities. Any future deliberations on potential control measures for construction activities and their possible implementation will be documented in the first regional haze SIP progress report in 2012.

11.7 Agricultural and Forestry Smoke Management

40 CFR 51.308(d)(3)(v)(E) requires states to consider smoke management techniques related to agricultural and forestry management in developing the long-term strategy. MANE-VU's analysis of smoke management in the context of regional haze is documented in "Technical Support Document on Agricultural and Forestry Smoke Management in the MANE-VU Region, September 1, 2006," (Attachment V).

Rhode Island does not currently have a Smoke Management Program (SMP). However, SMPs are required only when smoke impacts from fires managed for resource benefits contribute significantly to regional haze. The emissions inventory presented in the above-cited document indicates that agricultural, managed and prescribed burning emissions are very minor; the inventory estimates that, in Rhode Island, those emissions from those source categories totaled 7.8 tons of PM_{10}, 6.7 tons of $PM_{2.5}$ and 0.5 tons of SO_2 in 2002, which constitute 0.08%, 0.2% and0.006% of the total inventory for those pollutants, respectively.

Source apportionment results show that wood smoke is a moderate contributor to visibility impairment at some Class I areas in the MANE-VU region; however, smoke is not a large contributor to haze in MANE-VU Class I areas on either the 20% best or 20% worst visibility days. Moreover, most of wood smoke is attributable to residential wood combustion. Therefore, it is unlikely that fires for agricultural or forestry management cause large impacts on visibility in any of the Class I areas in the MANE-VU region. On rare occasions, smoke from major fires degrades the air quality and visibility in the MANE-VU area. However, these fires are generally unwanted wildfires that are not subject to SMPs. Therefore, a SMP is not required for Rhode Island. RI DEM commits to including this source category in future emissions inventories used to track regional haze reduction progress.

11.8 Estimated Effects of Long-Term Strategy on Visibility

40 CFR 51.308(d)(3)(v)(G) requires Rhode Island to consider, in developing its long-term strategy, the anticipated net effect on visibility due to projected changes in point, area, and mobile source emissions over the period addressed by the long-term strategy. NESCAUM conducted modeling to evaluate the expected improvements to visibility at affected Class I areas by 2018 as a consequence of implementing MANE-VU's long-term strategy. Those

visibility improvements will result, in part, from the efforts identified in this SIP to reduce emissions that originate in Rhode Island.

All Class I states affected by emissions originating in Rhode Island have (or will have) established reasonable progress goals for 2018 for each of their Class I areas. The control measures included in this SIP represent the reasonable efforts of Rhode Island, in conjunction with the efforts of other MANE-VU states, toward achieving the reasonable progress goals established by the affected states.

Based on the most recent MANE-VU modeling, the proposed control measures will reduce sulfate levels at affected Class I areas by about one-third on the worst visibility days and by 6 to 31 percent on the best visibility days by 2018. Nitrate and elemental carbon levels will also show substantial reductions across all areas for both best and worst days, while smaller reductions in organic carbon levels will occur. Small increases are predicted for the fine soil component of regional haze. There is a possibility that the predicted increases in this component are not real but, rather, related to structural differences in the data sets used in the modeling for the baseline and future years. (Specifically, the fire emissions inventory used in VISTAS for the base year relied on an earlier version of fire emissions data than the one used for the 2018 inventory.) No changes are predicted for sea salt because the model does not track this component.

The 2000-2004 visibility readings at affected Class I areas provide the baseline against which future visibility readings will be measured to assess progress deriving from implementation of Rhode Island's regional haze SIP and those of the other MANE-VU states. To determine baseline visibility for affected Class I areas, the 2000-2004 IMPROVE monitoring data were used to calculate the average deciview values for the 20 percent best visibility days and the 20 percent worst visibility days over that period. Thus, the 20 percent best day and 20 percent worst day values represent average visibility conditions for the top and bottom quintiles.

To create the series of visibility graphs which follow, 2018 visibility estimates were made in accordance with EPA modeling guidance. First, 2002 daily average baseline concentrations were multiplied by their corresponding relative reduction factors to obtain 2018 projected concentrations for each day. The 2018 projected concentrations were then used to derive daily visibility in deciviews. As a final step, the deciview values for the 20 percent of days having best visibility were averaged, and the process repeated for the 20 percent of days having worst visibility. The resulting averages represent the projected upper and lower quintiles of visibility in 2018.

The following is provided to assist with interpretation of the line graphs in Figures 11.1 and Figures 11.3 through 11.6. Note that lower deciview values indicate better visibility.

- The irregular blue line (~) represents the 20 percent best visibility average value as determined from monitoring data for each year of the period 2001-2005.
- The irregular red line (~) represents the 20 percent worst visibility average value as determined from monitoring data for each year of the period 2001-2005.
- The straight orange line (—) represents the 20 percent best visibility average value as determined from monitoring data for the 5-year period of 2000-2004. (This line represents the *20 percent best visibility baseline condition*.)
- The straight blue line (—) represents the 20 percent worst visibility average value as

determined from monitoring data for the 5-year period of 2000-2004. (This line represents the *20 percent worst visibility baseline condition*.)

- The straight broken line (▪▪▪) is a continuation of the 20 percent best visibility baseline, representing the 20 percent best visibility condition as it would be with no further degradation or improvement.
- The straight green line (**—**) represents the 20 percent worst visibility values that establish the uniform rate of progress for the period 2004-2064. (This line is sometimes referred to as the *uniform progress line*, or *"glide slope."* It was created by linear interpolation between the 20 percent worst visibility baseline value in 2004 and the 20 percent worst visibility value under natural conditions in 2064. If visibility improvements match this rate of progress, actual visibility will return to natural conditions in 2064.)
- The light-green dash (**–**) shown at 2064 represents the theoretical 20 percent best visibility value under natural conditions (i.e., no anthropogenic emissions).
- The purple star (✳) represents the 20 percent best visibility value in 2018 after implementation of MANE-VU's long-term strategy, as predicted by the CMAQ model. (This value is a *reasonable progress goal*.)
- The blue star (✳) represents the 20 percent worst visibility value in 2018 after implementation of MANE-VU's long-term strategy, as predicted by the CMAQ model. (This value is a *reasonable progress goal*.)

Figures 11.1 through 11.5 are line graphs showing anticipated visibility improvements for the other MANE-VU Class I Areas. All locations are projected to meet or exceed their uniform-rate-of-progress goals for 2018. In addition, all areas are expected to see improvements in best-day visibility relative to baseline values.

Figure 11.1: Expected Visibility Improvement at Great Gulf Wilderness Based on Most Recent Projections [17]

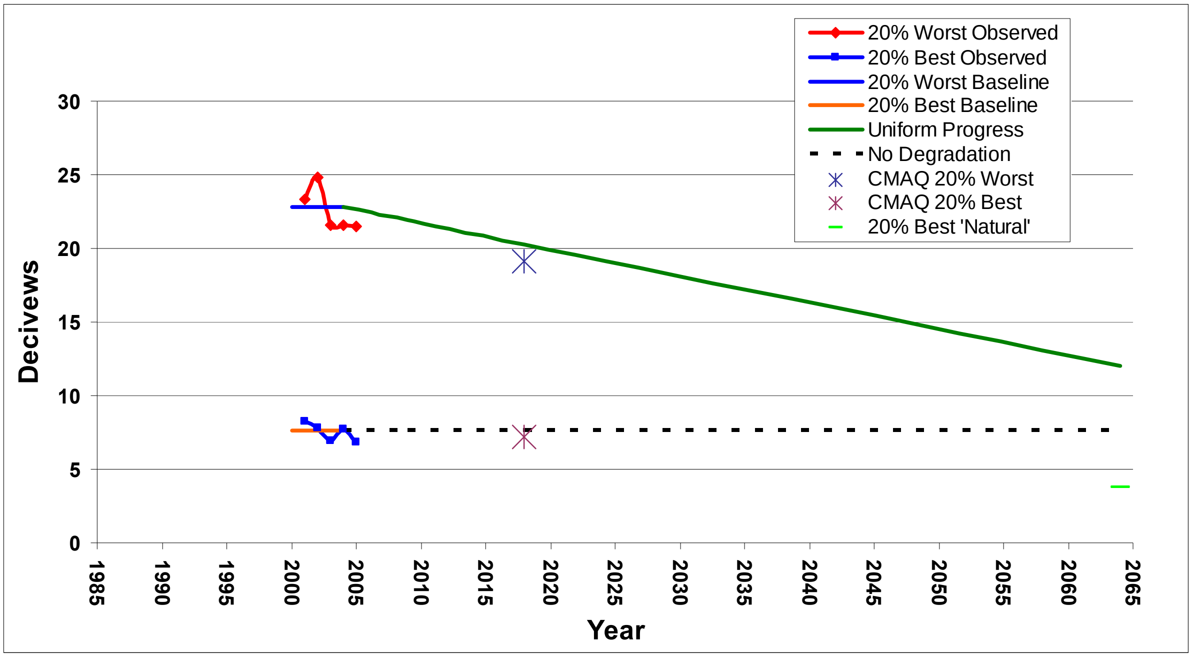
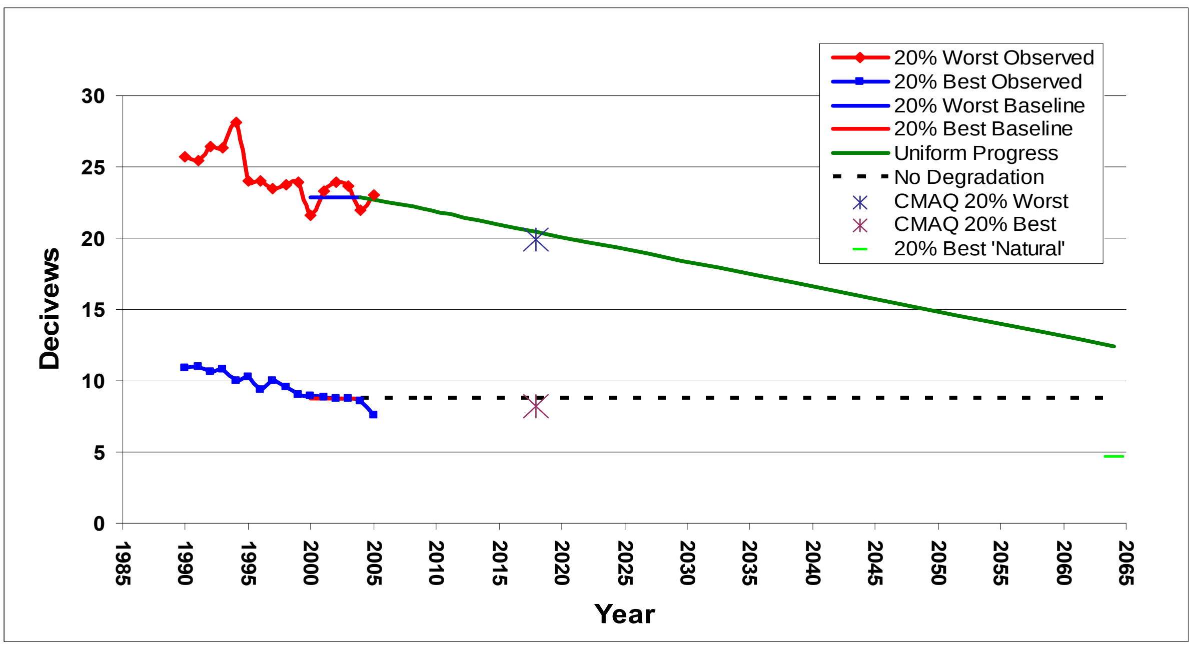


Figure 11.2: Expected Visibility Improvement at Acadia National Park Based on Most Recent Projections



[17] The visibility improvement estimate for Great Gulf Wilderness also serves as an estimate for Presidential Range - Dry River Wilderness.

Figure 11.3: Expected Visibility Improvement at Brigantine National Wildlife Refuge Based on Most Recent Projections

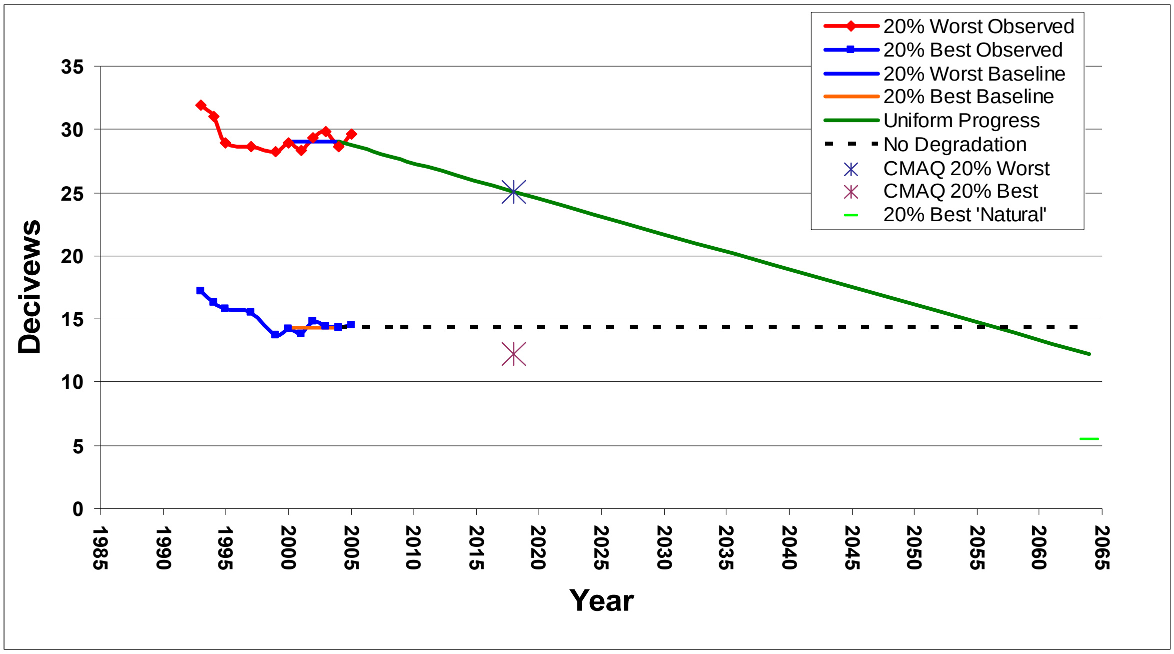


Figure 11.4: Expected Visibility Improvement at Lye Brook Wilderness Based on Most Recent Projections

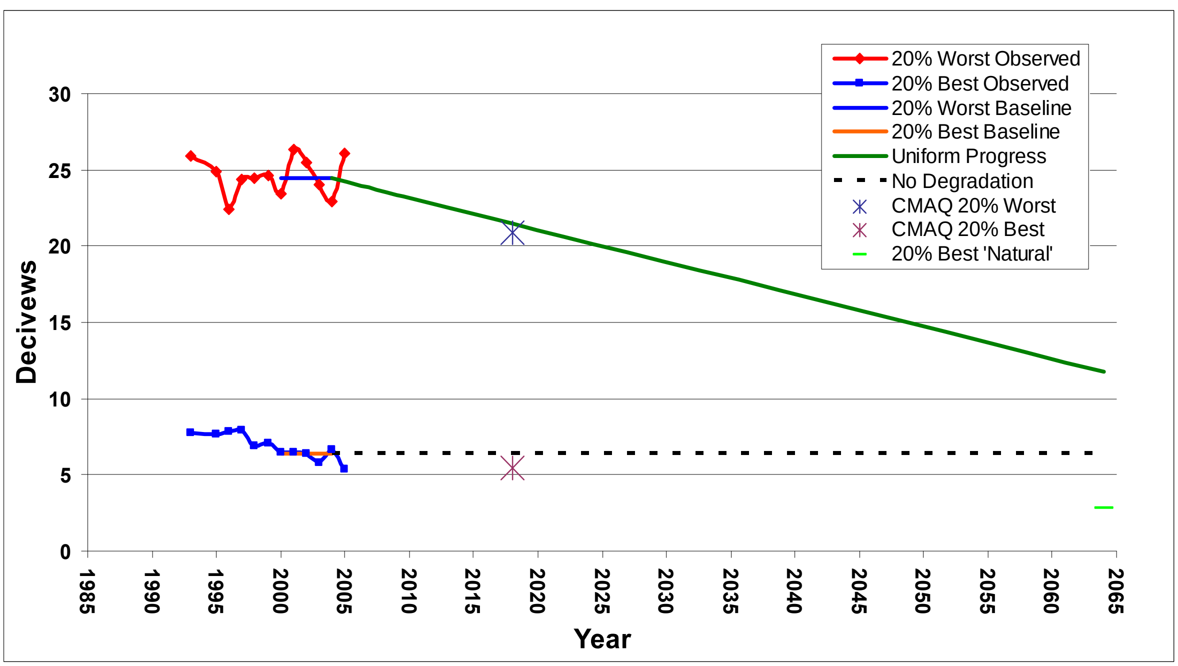
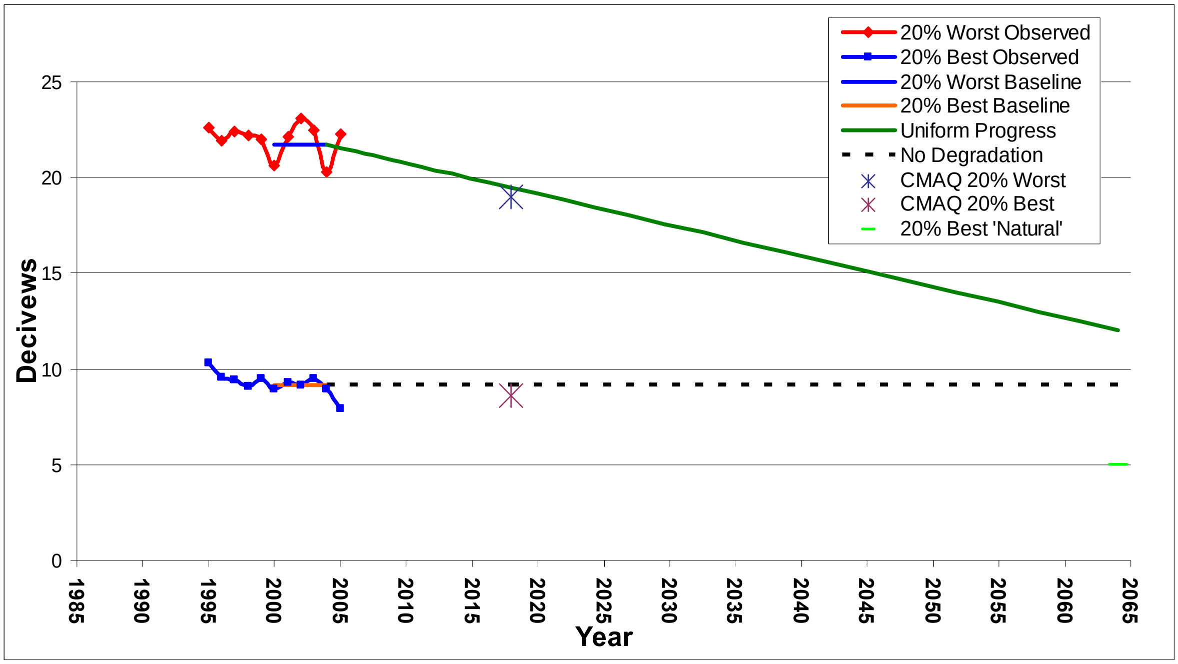


Figure 11.5: Expected Visibility Improvement at Moosehorn National Wildlife Refuge Based on Most Recent Projections [18]



11.9 Rhode Island's Share of Emission Reductions

40 CFR 51.308(d)(3)(ii) of the Regional Haze Rule requires Rhode Island to demonstrate that its implementation plan includes all measures necessary to obtain its share of emission reductions needed to meet the reasonable progress goals. The modeling analyses referenced in Subsection 11.8, above, demonstrate that the Rhode Island/MANE-VU long-term strategy is sufficient to meet these visibility goals.

The basis for the long-term strategy is a statement adopted by MANE-VU on June 20, 2007 (see Part 3.3.3, The MANE-VU Ask). This document provides that each state will have up to 10 years to pursue adoption and implementation of reasonable control measures for NO_X and SO_2 emission reductions. Rhode Island's regional haze SIP is wholly consistent with this long-term strategy. To meet its obligation, Rhode Island agrees to pursue the following emission reduction measures:

- Participation in a regional low-sulfur fuel oil strategy according to the limits and dates specified in the Ask for outer-zone MANE-VU states.. This will result in SO_2 emission reductions from two oil-fired EGUs, Pawtucket Power Associates in Pawtucket (both phases of the low-sulfur fuel oil strategy) and the Dominion Energy Manchester Street (second phase only), as well as from ICI boilers and residential heating units across the State;

[18] The visibility improvement estimate for Moosehorn Wilderness also serves as an estimate for Roosevelt/Campobello International Park.

- The adoption of controls on outdoor wood boilers, if legislation concerning this source category currently under consideration in the Rhode Island General Assembly is approved. The legislation would impose requirements on the sale, use and installation of outdoor wood boilers. If enacted in its present form, the legislation requires RI DEM to promulgate regulations to restrict the sale of outdoor wood boilers to equipment that has been certified to meet EPA's Phase II requirements effective July 1, 2010.
- Continued evaluation of other possible control measures that would reduce haze-causing emissions in consultation with other MANE-VU states. Any such evaluations will be discussed in the first progress report...

Note that, since Rhode Island does not have any BART-eligible or targeted EGU sources, no action is required from the State in those areas to be consistent with the Ask.

Implementation of the long-term strategy will produce significant changes in Rhode Island's emissions inventory by the end of the first planning period, 2018. Changes to the emissions inventory will also occur as a result of population growth; changes in land use and transportation; development of industrial, energy, and natural resources; and other air pollution control measures not directly related to regional haze. However, it is the expected reductions in SO_2 emissions that will have the greatest effect on visibility improvement at MANE-VU Class I Areas; and those reductions will be largely due to implementation of the control measures developed for this SIP. (As a precursor to sulfate, SO_2 emissions are responsible for most of the fine-particle mass on the haziest days at MANE-VU Class I Areas. See Section 8.0, Understanding the Sources of Haze-Causing Pollutants.)

Current and projected SO_2 emissions for the various source categories in Rhode Island and, for comparison, all of MANE-VU are summarized in Tables 11.2 and 11.3. These emissions represent the majority of all haze-causing pollutants originating within the state and region. The projected sharp decrease in point and area source SO_2 emissions is largely due to implementation of the low-sulfur fuel oil strategy. Further information on Rhode Island's emissions inventory, including other pollutants that contribute to visibility impairment, is available in Section 6.0, Emissions Inventory.

Table 11.3: SO_2 Emissions from Point, Area, and Mobile Sources in Rhode Island (tpy)

Source Category	Baseline 2002	Projected 2018	% Reduction 2002-2018
Area	4557	52	98.9
Point	2666	1509	43.3
On-Road Mobile	425	100	76.4
Non-Road Mobile	357	42	88.2
TOTAL	8026	1703	78.9

Table 11.4: SO_2 Emission from Point, Area, and Mobile Sources in all of MANE-VU (tpy)

Source Category	Baseline 2002	Projected 2018	% Reduction 2002-2018
Area	286,921	129,656	54.8
Point	1,907,634	460,155	75.8
On-Road Mobile	40,090	8,757	78.2
Non-Road Mobile	57,257	8,643	84.9
TOTAL	2,291,902	607,211	73.5

The projected overall reduction of 78.9 percent for SO_2 emissions originating in Rhode Island exceeds the projected average reduction of 73.5 for all of MANE-VU. This comparison indicates that Rhode Island will meet its share of anticipated SO_2 emission reductions within the region by 2018.

11.10 Enforceability of Emission Limitations and Control Measures

40 CFR 51.308(d)(3)(v)(C) requires states to establish emission limitations and compliance schedules to meet reasonable progress goals. Emission limitations and compliance schedules are already in place for the Rhode Island programs outlined in Subsection 11.3 of this section. For the additional reasonable control measures described in Subsection 11.4, certain emission limitations and compliance schedules may need to be established in Rhode Island Air Pollution Control Regulations. These additional measures include:

1. Low-sulfur fuel oil requirements,
2. Controls on outdoor wood boilers, if approved by the 2009 General Assembly of Rhode Island; and
3. Additional measures determined to be reasonable after consultation with other MANE-VU states.

RI DEM intends to adopt the low-sulfur fuel oil requirements by January 1, 2012 and will have a compliance date of 2014 for Phase I and 2018 for Phase II. If the Rhode Island General Assembly approves the pending outdoor wood boiler legislation, a regulation for that source type will be adopted that includes a restriction on the sale of outdoor wood boilers to equipment that has been certified to meet EPA's Phase II requirements, effective July 1, 2010, as specified in that legislation.

RI DEM will continue to evaluate additional measures to ascertain whether they are reasonable for Rhode Island to implement by 2018 and will formalize that determination in the first regional haze SIP progress report, which is due in 2012. **Rhode Island intends to adopt all reasonable control measures as expeditiously as practicable, in a manner consistent with state law, so that they may be in place by the end of the ten-year planning period.**

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11.11 Prevention of Significant Deterioration

Rhode Island Air Pollution Control Regulation No. 9, "Air Pollution Control Permits," includes Prevention of Significant Deterioration (PSD) requirements for the State. PSD is applicable to all major sources and major modifications of existing major sources in an area that is in attainment with respect to the National Ambient Air Quality Standards for a pollutant. A major source is, in Rhode Island, defined as an emissions source that has the potential to emit more than 100 tons per year or more of any air pollutant and is in one of 28 listed source categories or 250 tons per year or more of any air pollutant if the source is not one of the 28 listed source categories. One of the intentions of the PSD program is to protect air quality in national parks, wilderness areas, and other areas of special natural, scenic, or historic value. The PSD permitting process requires a technical air quality analysis and additional analyses to assess the potential impacts on soils, vegetation and visibility as well as air quality.

PSD permit applicants are required to provide an analysis of the impairment to visibility, soils and vegetation that would occur as a result of a project by following certain prescribed procedures. Regulation No. 9 references a RI DEM document that specifies procedures for evaluating these impacts; the document is entitled "Guidelines for Assessing the Welfare Impacts of Proposed Air Pollution Facilities"." To assess impairment to visibility, applicants are required to apply the procedure and comply with the criteria in the Workbook for Plume Visual Impact Screening and Analysis (EPA-450/4-88-015, September 1988). Typically, a Level 1 visibility assessment is performed for the nearest Class I area using USEPA's VISCREEN model. This analysis and the additional analyses required by the PSD regulations assures that new major sources and major modifications to existing major sources are constructed and operated in a manner that does not degrade air quality or visibility. The PSD permitting program, as set for under Regulation No. 9, is an integral part of Rhode Island's long-term strategy for assuring that the State does its share in meeting regional haze goals.