Regional Haze State Implementation Plan

for
North Carolina Class I Areas

Prepared by

North Carolina Department of Environment and Natural Resources

Division of Air Quality

December 17, 2007

Preface: This document contains summaries of the technical analyses that will be used by North Carolina's Division of Air Quality to support the regional haze state implementation plan pursuant to §§107(d)(3)(D) and (E) of the Clean Air Act, as amended.

EXECUTIVE SUMMARY

Introduction

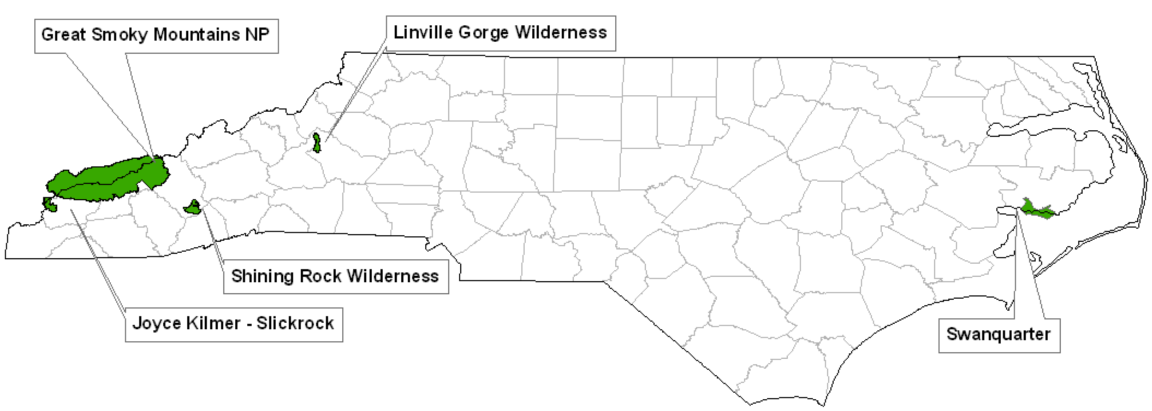
Regional haze is pollution that impairs visibility over a large region, including national parks, forests, and wilderness areas (many termed "Class I" areas). Regional haze is caused by sources and activities emitting fine particles and their precursors, often transported over large regions. Particles affect visibility through the scattering and absorption of light. Reducing fine particles in the atmosphere is an effective method of improving visibility. In the southeast, the most important sources of haze-forming emissions are coal-fired power plants, industrial boilers and other combustion sources, but also include mobile source emissions, area sources, fires, and wind blown dust.

An easily understood measure of visibility to most people is visual range. Visual range is the greatest distance, in kilometers or miles, at which a dark object can be viewed against the sky. However, the most useful measure of visibility impairment is light extinction, which affects the clarity and color of objects being viewed. The measure used by the regional haze rule is the deciview (dv), calculated directly from light extinction using a logarithmic scale.

The regional haze rule requires states to demonstrate reasonable progress toward meeting the national goal of a return to natural visibility conditions by 2064. The rule directs states to graphically show what would be a "uniform rate of progress", also known as the "glide path", toward natural conditions for each Class I area within the State and certain ones outside the State.

North Carolina's Class I areas

North Carolina has five Class I areas within its borders: Great Smoky Mountains National Park, Joyce Kilmer-Slickrock Wilderness Area, Linville Gorge Wilderness Area, Shining Rock Wilderness Area, and Swanquarter Wildlife Refuge. Both the Great Smoky Mountains National Park and Joyce Kilmer-Slickrock Wilderness Area are located in both North Carolina and Tennessee. The figure below illustrates the location of these Class I areas.



Visibility on the worst days at the mountain sites is generally between 28 and 30 dv, and visibility at Swanquarter is 25 dv. Natural background visibility on the worst days is between 11 and 12 dv.

State Implementation Plan Requirements

States are required to submit state implementation plans (SIPs) to the United States Environmental Protection Agency that set out each states' plan for meeting the national goal of a return to natural visibility conditions by 2064. The plan includes the states' reasonable progress goals, expressed in deciviews, for visibility improvement at each affected Class I area for each 10-year period until 2064.

SIPs must include determinations of the baseline visibility conditions (expressed in deciviews) for the most impaired and least impaired days. In addition, states must include a monitoring strategy for measuring, characterizing, and reporting of regional haze visibility impairment. The long-term strategy includes enforceable emissions limitations, compliance schedules, and other measures as necessary to achieve the reasonable progress goals. States must also consider ongoing control programs, measures to mitigate construction activities, source retirement and replacement schedules, smoke management techniques for agriculture and forestry, and enforceability of specific measures.

The SIPs for the first review period are due December 17, 2007. These plans will cover long-term strategies for visibility improvement between baseline conditions in 2000-2004 and 2018. States are required to evaluate progress toward reasonable progress goals every 5 years to assure that installed emissions controls are on track with emissions reduction forecasts in each SIP.

Federal and State Control Requirements

There are significant control programs being implemented between the baseline period and 2018. These programs will all reduce the particulate precursor emissions that affect visibility in the Class I areas, and include: the Clean Air Interstate Rule (CAIR), the NO_x SIP Call, the North Carolina Clean Smokestacks Act, Georgia Multi-Pollutant Rule, consent agreements with Tampa Electric, Virginia Electric and Power Company, Gulf Power and American Electric Power, one-hour ozone SIPs submitted by Atlanta, Birmingham, and Northern Kentucky, NOx RACT in 8-hour nonattainment area SIPs, heavy duty diesel (2007) engine standard (for on-road trucks and buses), Tier 2 tailpipe standards for on-road vehicles, large spark ignition and recreational vehicle rule, nonroad diesel rule, and various Federal Maximum Achievable Control Technology regulations.

The regional haze rule also requires states to determine best available retrofit technology (BART) for certain facilities. Fifteen of North Carolina's seventeen BART-eligible sources were able to demonstrate that they did not cause or contribute to visibility impairment. Further BART analysis of two other sources, PCS Phosphate in Aurora, North Carolina and Blue Ridge Paper in Canton, North Carolina, demonstrated that no additional controls were required at this time at either facility.

Conclusion

At all five Class I areas in North Carolina, visibility improvements on the worst days are expected to be better than the uniform rate of progress glidepath by 2018 based solely on reductions from existing and planned emissions controls. Additionally, the visibility is expected to improve for the best days for all of the North Carolina Class I areas. The table below displays the 2018 reasonable progress goals for the North Carolina Class I areas.

Class I Area	Baseline Visibility Worst Days	Reasonable Progress Goal - Worst Days	Baseline Visibility Best Days	Reasonable Progress Goal - Best Days
Great Smoky Mountains National Park	30.3	23.7	13.6	12.2
Joyce Kilmer-Slickrock Wilderness Area	30.3	23.7	13.6	12.2
Linville Gorge Wilderness Area	28.8	22.0	11.1	9.6
Shining Rock Wilderness Area	28.5	22.1	7.7	6.9
Swanquarter Wildlife Refuge	24.7	20.4	12.0	11.0

ACKNOWLEDGEMENTS

This regional haze plan has been primarily produced by the Planning Section of the North Carolina Division of Air Quality (NCDAQ), with significant help from the VISTAS (Visibility Improvement – State and Tribal Association of the Southeast) technical coordinator. Additionally, the NCDAQ was lucky to have, on Interagency Personnel Agreements, a couple of U. S. Environmental Protection Agency (USEPA) staff that also contributed to the process. Below are the names of the staff involved in this process.

NCDAQ Staff:

Planning Section

Michael Abraczinskas

Pat Bello

George Bridgers

Joelle Burleson

Victoria Chandler

Chris Misenis

Bebhinn Do

Janice Godfrey

Phyllis Jones

Matt Mahler

Donnie Redmond

Nick Witcraft

Bob Wooten

Ming Xie

Kathy Kaufman, on rotation from USEPA

Rosalina Rodriguez, on rotation from USEPA

Thom Allen, Rules Development Branch Supervisor

Laura Boothe, Attainment Planning Branch Supervisor

Sheila Holman, Planning Section Chief

Permits Section

Tom Anderson

Chuck Buckler

Jerry Freeman

Fern Patterson

Wallace Pitts

Mark Yoder

VISTAS Staff:

Pat Brewer, VISTAS Technical Coordinator

Additionally, there were a number of NCDAQ staff and other agencies that provided support during the development of the regional haze plan. These staff are acknowledge below:

IT Support
Holly Groce, NCDAQ, Business Office
George Halsey, NCDAQ, Business Office

Regional Office Support
Brendan Davey, Asheville Regional Office
Robert Fisher, Washington Regional Office Supervisor, Hearing Officer
Paul Muller, Asheville Regional Office Supervisor, Hearing Officer
Brad Newland, Wilmington Regional Office

Local Program Support
Ashley Featherstone, Western North Carolina Regional Air Quality Agency

Office Assistant Support
Mildred Mitchell, NCDAQ, Planning Section
Angela Terry, NCDAQ, Planning Section

Management Support
Brock Nicholson, NCDAQ, Deputy Director
Keith Overcash, NCDAQ, Director
John Hornback, VISTAS, Executive Director

The NCDAQ worked closely with those states in the VISTAS region through technical coordination, technical discussions and technical support. This regional haze plan could not have been completed on time without the combined efforts of the staff from these state agencies:

VISTAS State Agencies:

Alabama Department of Environmental Management
Florida Department of Environmental Protection
Georgia Department of Natural Protection
Kentucky Department of Environmental Protection
Mississippi Department of Environmental Quality
South Carolina Department of Health and Environmental Control
Tennessee Department of Environmental Conservation
Virginia Department of Environmental Quality
West Virginia Department of Environmental Protection

Finally, this could not have been completed without the expertise and dedication of the VISTAS contractors that performed the technical work.

Contractors:

Air Resource Specialists: Monitoring Data Analysis

Alpine Geophysics: Emissions and Air Quality Modeling, Technical Advisor for Emissions Inventory

Atmospheric Research and Analysis, Inc.: Operation of continuous monitors at Millbrook, NC

Baron Applied Meteorology: Meteorological Modeling

Desert Research Institute: Carbon Source Attribution including sample filter preparation, sample analysis using Gas Chromatography and Mass Spectrometry, source attribution using Chemical Mass Balance analyses and Positive Matrix Factorization

Earth Tech, Inc: BART Modeling, CALPUFF Training

ENVIRON: Emissions and Air Quality Modeling

Georgia Institute of Technology: Emissions and Air Quality modeling sensitivities

Harvard University: GEOS-Chem global model

Ivar Tombach, Environmental Consultant

ICF Consulting: Integrated Planning Model for future electric utility generation

MACTEC: 2002, 2009, and 2018 Emissions Inventory and Projections, CALPUFF training

E.H. Pechan and Associates: 2002 Mobile Inventory

Research Triangle Institute: Chemical Analysis of Monitoring Samples

System Applications International: Meteorological Characterization

Tennessee Valley Authority: Operation of continuous monitors at Great Smoky Mountain National Park and preparation of final project report and draft manuscript

TRC, Inc: BART Modeling

University of California, Riverside: Emissions and Air Quality Modeling

Woods Hole: Analysis of Carbon 14 isotope in carbon samples as part of carbon source attribution project

TABLE OF CONTENTS

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 What is regional haze?

Regional haze is pollution from disparate sources that impairs visibility over a large region, including national parks, forests, and wilderness areas (156 of which are termed mandatory Federal "Class I" areas). Regional haze is caused by sources and activities emitting fine particles and their precursors. Those emissions are often transported over large regions.

Particles affect visibility through the scattering and absorption of light, and fine particles – particles similar in size to the wavelength of light – are most efficient, per unit of mass, at reducing visibility. Fine particles may either be emitted directly or formed from emissions of precursors, the most important of which are sulfur dioxides (SO2) and nitrogen oxides (NOx). Reducing fine particles in the atmosphere is generally considered to be an effective method of reducing regional haze, and thus improving visibility. Fine particles also adversely impact human health, especially respiratory and cardiovascular systems. The United States Environmental Protection Agency (USEPA) has set national ambient air quality standards for daily and annual levels of fine particles with diameter smaller than 2.5 μm (PM2.5). In the southeast, the most important sources of PM2.5 and its precursors are coal-fired power plants, industrial boilers and other combustion sources. Other significant contributors to PM2.5 and visibility impairment include mobile source emissions, area sources, fires, and wind blown dust.

1.2 What are the requirements under the Clean Air Act for addressing regional haze?

In Section 169A of the 1977 Amendments to the Clean Air Act (CAA), Congress set forth a program for protecting visibility in Class I areas which calls for 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." Congress adopted the visibility provisions to protect visibility in these 156 national parks, forests and wilderness areas. On December 2, 1980, the USEPA promulgated regulations to address visibility impairment (45 FR 80084). The 1980 regulations were developed to address visibility impairment that is "reasonably attributable" to a single source or small group of sources. These regulations represented the first phase in addressing visibility impairment and deferred action on regional haze that emanates from a variety of sources until monitoring, modeling and scientific knowledge about the relationships between pollutants and visibility impairment improved.

In the 1990 Amendments to the CAA, Congress added section 169B and called on the USEPA to issue regional haze rules. The regional haze rule that the USEPA promulgated on July 1, 1999 (64 FR 35713), revised the existing visibility regulations in order to integrate provisions addressing regional haze impairment and establish a comprehensive visibility protection program for Class I Federal areas. States are required to submit state implementation plans (SIPs) to the USEPA that set out each states' plan for complying with the regional haze rule, including consultation and coordination with other states and with Federal Land Managers (FLMs). The timing of SIP submittal is tied to the USEPA's promulgation of designations for the National Ambient Air Quality Standard (NAAQS) for fine particulate matter. States must submit a regional haze implementation plan to the USEPA within three years after the date of designation. Because the USEPA promulgated designation dates on December 17, 2004, regional haze SIPs must be submitted by December 17, 2007.

The regional haze rule addressed the combined visibility effects of various pollution sources over a wide geographic region. This wide reaching pollution net meant that many states – even those without Class I areas – would be required to participate in haze reduction efforts. The USEPA designated five Regional Planning Organizations (RPOs) to assist with the coordination and cooperation needed to address the visibility issue. The RPO that makes up the southeastern portion of the contiguous United States is known as VISTAS (Visibility Improvement – State and Tribal Association of the Southeast), and include the following states: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia.

Figure 1.2-1. Geographical Areas of Regional Planning Organizations

1.3 General overview of regional haze SIP requirements

The regional haze rule at 40 CFR 51.308(d) requires states to demonstrate reasonable progress toward meeting the national goal of a return to natural visibility conditions by 2064. As a guide for reasonable progress, the regional haze rule directs states to graphically show what would be a "uniform rate of progress" toward natural conditions for each mandatory Class I Federal area within the State and/or for each mandatory Class I Federal area located outside the State, which may be affected by emissions from sources within the State. States are to establish baseline visibility conditions for 2000-2004, natural background visibility conditions in 2064, and the rate of uniform progress between baseline and background conditions. The uniform rate of progress is also known as the "glidepath."

The regional haze rule then requires states to establish reasonable progress goals, expressed in deciviews, for visibility improvement at each affected Class I area covering each (approximately) 10-year period until 2064. The goals must provide for reasonable progress towards achieving natural visibility conditions, provide for improvement in visibility for the most impaired days over the period of the implementation plan, and ensure no degradation in visibility for the least impaired days over the same period (see 40 CFR 51.308(d)(1)).

In order to ensure that visibility goals are properly met and set, SIPs plans must include determinations, for each Class I area, of the baseline visibility conditions (expressed in deciviews) for the most impaired and least impaired days. SIPs must also contain supporting documentation for all required analyses used to calculate the degree of visibility impairment under natural visibility conditions for the most impaired and least impaired days (see 40 CFR 51.308(d)(2)). In addition, states must include a monitoring strategy for measuring, characterizing, and reporting of regional haze visibility impairment that is representative of all mandatory Class I Federal areas within the state (see 40 CFR 51.308(d)(4)).

This first set of reasonable progress goals must be met through measures contained in the state's long-term strategy covering the period from the present until 2018. The long-term strategy includes enforceable emissions limitations, compliance schedules, and other measures as necessary to achieve the reasonable progress goals, including all controls required or expected under all federal and state regulations by 2009 and by 2018. During development of the long-term strategy, states are also required to consider specific factors such as the above mentioned ongoing control programs, measures to mitigate construction activities, source retirement and replacement schedules, smoke management techniques for agriculture and forestry, and enforceability of specific measures (see 40 CFR 51.308(d)(3)).

In addition, a specific component of each state's first long-term strategy is dictated by the specific best available retrofit technology (BART) requirements in 40 CFR 51.308(e) of the regional haze rule. The regional haze rule at 40 CFR 51.308(e) requires states to include a determination of BART for each BART-eligible source in the State that emits any air pollutant, which may reasonably be anticipated to cause or contribute to any impairment of visibility in any mandatory Class I Federal area. The Clean Air Act section 169A(b) defines BART-eligible sources as sources in 26 specific source categories, in operation within a 15-year period prior to enactment of the 1977 Clean Air Act Amendments. States must determine BART according to five factors set out in section 169A(g)(7) of the Clean Air Act. Emission limitations representing BART and schedules for compliance with BART for each source subject to BART must be included in the long-term strategy.

The SIPs for the first review period are due December 17, 2007. These plans will cover long-term strategies for visibility improvement between baseline conditions in 2000-2004 and 2018. States are required to evaluate progress toward reasonable progress goals every 5 years to assure that installed emissions controls are on track with emissions reduction forecasts in each SIP. The first interim review would be due to the USEPA in December 2012. If emissions controls are not on track to meet SIP forecasts, then states would need to take action to assure emissions controls by 2018 will be consistent with the SIP or to revise the SIP to be consistent with the revised emissions forecast.

The USEPA provided several guidance documents listed below to assist the states in implementation of the regional haze rule requirements. NC followed these guidance documents in developing the technical analyses reported in this plan.

- Guidance for Tracking Progress Under the Regional Haze Rule (EPA-454/B-03-004, September 2003).
- Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule (EPA-454/B-03-005, September 2003).
- Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5 and Regional Haze (EPA, 2007).
- Guidance for Setting Reasonable Progress Goals Under the Regional Haze Program (EPA, June 2007).

1.4 Class I areas in North Carolina

North Carolina has five Class I areas within its borders: Great Smoky Mountains National Park, Joyce Kilmer-Slickrock Wilderness Area, Linville Gorge Wilderness Area, Shining Rock Wilderness Area, and Swanquarter Wildlife Refuge. The North Carolina Division of Air Quality (NCDAQ) in the North Carolina Department of Environment and Natural Resources is responsible for developing the Regional Haze SIP. This SIP establishes reasonable progress goals for visibility improvement at each of these Class I areas, and a long-term strategy that will achieve those reasonable progress goals within the first regional haze planning period. The Great Smoky Mountains and Joyce Kilmer-Slickrock are located in both Tennessee and North Carolina. For the Great Smoky Mountains, both states are sharing the lead for setting goals and for Joyce Kilmer-Slickrock, North Carolina is the lead.

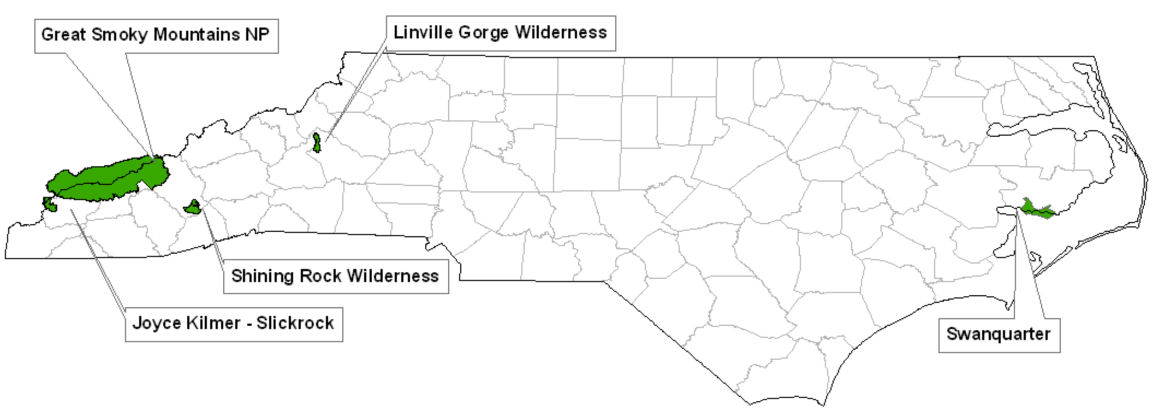


Figure 1.4-1. North Carolina's Class I areas

In developing this SIP, the NCDAQ has also considered that emission sources outside of North Carolina may affect visibility at these North Carolina Class I areas, and that emission sources within North Carolina may affect visibility at Class I areas in neighboring states. Through VISTAS, the southeastern states have worked together to assess state-by-state contributions to visibility impairment in specific Class I areas, including those in North Carolina and those affected by emissions from North Carolina. This technical work is discussed further in Sections 5, 6, and 7. Consultations to date between North Carolina and other states and the FLMs are summarized in Section 10; consultations are ongoing.

Prior to VISTAS, the southern states cooperated in a voluntary regional partnership to identify and recommend reasonable measures to remedy existing and prevent future adverse effects from human-induced air pollution on the air quality related values of the Southern Appalachian Mountains. States cooperated with the FLMs, the USEPA, industry, environmental organizations and academia to complete a technical assessment of the impacts of acid deposition, ozone, and fine particles on sensitive resources in the Southern Appalachians. The (Southern Appalachian Mountain Initiative) SAMI Final Report was delivered in August 2002. The SAMI Assessment concluded that ammonium sulfate is the major contributor to visibility impairment in the Southern Appalachian Mountains and to improve visibility, it is most important to reduce SO2 emissions. SAMI also concluded that reducing ammonia emissions would be helpful to reduce ammonium nitrate contributions to visibility impairment. Emissions controls for organic carbon, elemental carbon, and soil were expected to be less important for improving visibility. The SAMI modeling found that on the haziest days, much of the benefit of emissions reductions would occur in the state where emissions reductions were made. Emissions in surrounding the SAMI states and states outside the SAMI region also contribute to air quality in the SAMI Class I areas. The SAMI states supported strong national multi-pollutant legislation to accomplish its mission. Emissions reductions to meet national health standards for ozone and fine particles were expected to also improve air quality in the Southern Appalachian Mountains. The SAMI states committed to consider air quality benefits in the Southern Appalachians as they developed SIPs for the health standards.

In 2002, the North Carolina legislation passed the North Carolina Clean Smokestack Act (CSA) that requires North Carolina utilities to reduce emissions of SO2 and NOx. The SAMI analyses and recommendations supported development of the North Carolina CSA. Congress considered several legislative bills to reduce SO2 and NOx from electric generating utilities. In 2004, the USEPA promulgated the Clean Air Interstate Rule (CAIR) to require emissions reductions for SO2 and NOx from electric generating utilities in 26 eastern states. The CAIR rule allows for interstate trading of emissions to find cost effective reductions. These reductions will improve visibility in Class I areas in North Carolina.

1.5 State and Federal Land Manager coordination

As required by 40 CFR §51.308(i), the regional haze SIP must include procedures for continuing consultation between the States and FLMs on the implementation of the visibility protection program, including development and review of implementation plan revisions and 5-year progress reports, and on the implementation of other programs having the potential to contribute to impairment of visibility in any mandatory Class I Federal area within the State. The three

FLMs are the United States Department of Interior's (USDI's) Fish and Wildlife Service (FWS) and National Park Service (NPS) and the United States Department of Agriculture's (USDA's) Forest Service (FS).

Successful implementation of a regional haze program will involve long-term regional coordination among States. VISTAS was formed in 2001 to address regional haze and visibility problems in the southeastern United States. Jurisdictions represented by VISTAS members include the Eastern Band of Cherokee Indians; the States of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia; and the local air pollution control programs located in these States. A copy of the VISTAS Memorandum of Agreement and Bylaws is enclosed as Appendix A.

The objectives of the VISTAS project are to establish natural background visibility conditions across the mandatory Class I Federal areas, identify current visibility impairment levels, analyze emission control levels that will achieve interim visibility goals, and provide adequate documentation to member agencies so that they can develop their regional haze State/Tribal Implementation Plans (SIP/TIP). Figure 1.5-1 shows the 18 mandatory Class I Federal areas in the VISTAS Region, where visibility is an important value. Table 1.5-1 lists these Class I areas and the reported acreage associated with the Class I areas.

Figure 1.5-1. Class I Areas in the VISTAS Region

Table 1.5-1 Mandatory Class I Federal Areas in the VISTAS Region

State	Area Name	Acreage	Federal Land Manager
Alabama	Sipsey Wilderness	24,922	USDA-FS
Florida	Chassahowitzka Wilderness	23,579	USDI-FWS
	Everglades National Park	1,397,429	USDI-NPS
	St. Marks Wilderness	17,350	USDI-FWS
Georgia	Cohutta Wilderness	36,977	USDA-FS
	Okefenokee Wilderness	353,981	USDI-FWS
	Wolf Island Wilderness	5,126	USDI-FWS
Kentucky	Mammoth Cave National Park	51,303	USDI-NPS
North Carolina	Great Smoky Mountains National Park	273,551	USDI-NPS
	Joyce Kilmer-Slickrock Wilderness	13,562	USDA-FS
	Linville Gorge Wilderness	11,786	USDA-FS
	Shining Rock Wilderness	18,483	USDA-FS
	Swanquarter Wilderness	8,785	USDI-FWS
South Carolina	Cape Romain Wilderness	29,000	USDI-FWS
Tennessee	Great Smoky Mountains National Park	241,207	USDI-NPS
	Joyce Kilmer-Slickrock Wilderness	3,832	USDA-FS
Virginia	James River Face Wilderness	8,886	USDA-FS
	Shenandoah National Park	190,535	USDI-NPS
West Virginia	Dolly Sods Wilderness	10,215	USDA-FS
	Otter Creek Wilderness	20,000	USDA-FS

2.0 ASSESSMENT OF BASELINE AND CURRENT CONDITIONS AND ESTIMATE OF NATURAL BACKGROUND CONDITIONS IN CLASS I AREAS

The goal of the regional haze rule is to restore natural visibility conditions to the 156 Class I areas identified in the 1977 Clean Air Act Amendments. 40 CFR 51.301(q) defines natural conditions: "Natural conditions include naturally occurring phenomena that reduce visibility as measured in terms of light extinction, visual range, contrast, or coloration." The regional haze SIPs must contain measures that make "reasonable progress" toward this goal by reducing anthropogenic, i.e., manmade, emissions that cause haze.

An easily understood measure of visibility to most people is visual range. Visual range is the greatest distance, in kilometers or miles, at which a dark object can be viewed against the sky.

For evaluating the relative contributions of pollutants to visibility impairment, however, the most useful measure of visibility impairment is light extinction, which is usually expressed in units of inverse megameters (Mm^{-1}). Light extinction affects the clarity and color of objects being viewed.

The measure used by the regional haze rule is the deciview (dv). Deciviews are calculated directly from light extinction using a logarithmic scale. The deciview is a useful measure for tracking progress in improving visibility, because each deciview change is an equal incremental change in visibility perceived by the human eye. Most people can detect a change in visibility at one deciview.

For each Class I area, there are three metrics of visibility that are part of the determination of reasonable progress:

1) natural conditions,
2) baseline conditions, and
3) current conditions.

Each of the three metrics includes the concentration data of the visibility pollutants as different terms in the light extinction algorithm, with respective extinction coefficients and relative humidity factors. Total light extinction when converted to deciviews (dv) is calculated for the average of the 20% best and 20% worst visibility days.

"Natural" visibility is determined by estimating the natural concentrations of visibility pollutants and then calculating total light extinction. "Baseline" visibility is the starting point for the improvement of visibility conditions. It is the average of the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring data for 2000 through 2004 and is equivalent to "current" visibility conditions for this initial review period. The comparison of initial baseline conditions to natural visibility conditions indicates the amount of improvement necessary to attain natural visibility by 2064. Each state must estimate natural visibility levels for Class I areas within its borders in consultation with FLMs and other states (40 CFR 51.308(d)(2)). "Current conditions" are assessed every five years as part of the SIP review where actual progress in reducing visibility impairment is compared to the reductions committed to in the SIP.

2.1 Estimating Natural Conditions for North Carolina Class I Areas

Natural background visibility, as defined in *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Program*, EPA-454/B-03-005, September 2003, is based on annual average concentrations of fine particle components. The same annual average natural background visibility is assumed for all Class I areas in the eastern United States (separate values are estimated for the western United States). Natural background visibility for the 20% worst days is estimated by assuming that fine particle concentrations for natural background are normally distributed and the 90^{th} percentile of the annual distribution represents natural background visibility on the 20% worst days.

In the 2003 guidance, the USEPA also provided that states may use a "refined approach" to estimate the values that characterize the natural visibility conditions of the Class I areas. The purpose of such a refinement would be to provide more accurate estimates with changes to the extinction algorithm that may include the concentration values, factors to calculate extinction from a measured particular species and particle size, the extinction coefficients for certain compounds, geographical variation (by altitude) of a fixed value, and the addition of visibility pollutants.

In 2005, the IMPROVE Steering Committee made recommendations for a refined equation that modifies the terms of the original equation to account for the most recent data. The choice between use of the old or the new equation for calculating the visibility metrics for each Class I area is made by the state in which the Class I area is located.

The new IMPROVE equation accounts for the effect of particle size distribution on light extinction efficiency of sulfate, nitrate, and organic carbon. The mass multiplier for organic carbon (particulate organic matter) is increased from 1.4 to 1.8. New terms are added to the equation to account for light extinction by sea salt and light absorption by gaseous nitrogen dioxide. Site-specific values are used for Rayleigh scattering to account for the site-specific effects of elevation and temperature. Separate relative humidity enhancement factors are used for small and large size distributions of ammonium sulfate and ammonium nitrate and for sea salt. The elemental carbon (light-absorbing carbon), fine soil, and coarse mass terms do not change between the original and new IMPROVE equation.

Natural background conditions using the new IMPROVE equation are calculated separately for each Class I area. The calculation starts with the annual average values for natural background for each component of PM2.5 mass from the EPA 2003 guidance (default values). The annual frequency distribution of values of each PM2.5 component for current conditions (2000-2004) is then defined. This species-specific frequency distribution is applied to the default annual average values for that PM2.5 component to calculate natural conditions on the 20% worst days. The current variability in each component is retained while also retaining the same annual average background condition for that component as defined in the 2003 guidance. The new calculation of natural background allows Rayleigh scattering to vary with elevation. Current sea salt values are used for natural background levels of sea salt.

The VISTAS states chose to use the new IMPROVE equation as the basis for the conceptual description because it takes into account the most recent review of the science and because it is recommended by the IMPROVE Steering Committee. For more detailed discussion of the two IMPROVE equations, see Appendix B.

2.2 Estimating Baseline Conditions for North Carolina Class I Areas

Baseline visibility conditions at each North Carolina Class I area are estimated using sampling data collected at IMPROVE monitoring sites at four of the five Class I areas in North Carolina. A five-year average (2000 to 2004) was calculated for each of the 20% worst and 20% best visibility days in accordance with 40 CFR 51.308(d)(2) and *Guidance for Tracking Progress Under the Regional Haze Rule*, EPA-454-03-004, September, 2003. IMPROVE data records for

Great Smoky Mountains and Linville Gorge for the period 2000 to 2004 meet the USEPA requirements for data completeness (75 percent for the year and 50 percent for each quarter). Shining Rock and Swanquarter had missing data in more than one year between 2000 to 2004. Data records for these sites were filled using data substitution procedures outlined in Appendix B. IMPROVE does not operate a monitor at Joyce Kilmer Wilderness and considers the IMPROVE monitor at Great Smoky Mountains to be representative of visibility in the Joyce Kilmer area. The light extinction and deciview visibility values for the 20% worst and 20% best visibility days at the Class I areas are based on data and calculations included in Appendix B of this SIP.

2.3 Summary of Natural Background and Baseline Conditions for North Carolina Class I Areas

Table 2.3-1 presents estimated natural background and baseline visibility metrics for North Carolina Class I areas. Note that North Carolina is not considering international emissions to be a component of natural background. Baseline visibility on the 20% worst days at the southern Appalachian Class I area monitoring sites, including Great Smoky Mountains, Linville Gorge, and Shining Rock, is generally between 28 and 30 dv, and baseline visibility at Swanquarter is 25 dv. Natural background visibility at all four sites is predicted to be between 11 and 12 dv. The Class I area with the worst visibility impairment is Great Smoky Mountains, at greater than 30 dv on the 20% worst days. Swanquarter experiences somewhat less visibility impairment on the 20% worst days than the mountain monitoring sites.

Table 2.3-1 Natural Background and Baseline Conditions for North Carolina Class I Areas

Class 1 area	Average for 20% Worst Days (deciviews)	Average for 20% Best Days (deciviews)	Average for 20% Worst Days Bext (Mm-1)	Average for 20% Best Days Bext (Mm-1)
Natural Background Conditions				
Great Smoky Mountains	11.1	4.5	30.8	15.8
Joyce Kilmer-Slickrock	11.1	4.5	30.8	15.8
Linville Gorge	11.2	4.1	30.9	15.1
Shining Rock	11.5	2.5	34.9	12.1
Swanquarter	11.5	5.5	32.6	17.3
Baseline Visibility Conditions (2000 – 2004)				
Great Smoky Mountains	30.3	13.6	216.3	40.2
Joyce Kilmer-Slickrock	30.3	13.6	216.3	40.2
Linville Gorge	28.8	11.1	183.6	31.2
Shining Rock	28.5	7.7	182.2	22.3
Swanquarter	24.7	12.0	123.9	33.7

2.4 Pollutant Contributions to Visibility Impairment (2000-2004 Baseline Data)

The 20% worst visibility days at the Southern Appalachian sites (in North Carolina: Great Smoky Mountains, Joyce Kilmer, Linville Gorge, and Shining Rock) generally occur in the period April to September, with sulfate being the largest component. To illustrate this, Figure 2.4-1 displays the 2000 – 2004 reconstructed extinction, using the new IMPROVE equation, for the 20% worst days for the Great Smoky Mountains National Park. Similar plots for the other North Carolina Class I areas can be found in Appendix B. The peak hazy days occur in the summer under stagnant weather conditions with high relative humidity, high temperatures, and low wind speeds. The 20% best visibility days at the Southern Appalachian sites can occur at any time of year. At Swanquarter and other coastal sites, the 20% worst and best visibility days are distributed throughout the year. Figures 2.4-2 and 2.4-3 displays the average light extinction for the 20% haziest days and 20% clearest days, respectively.

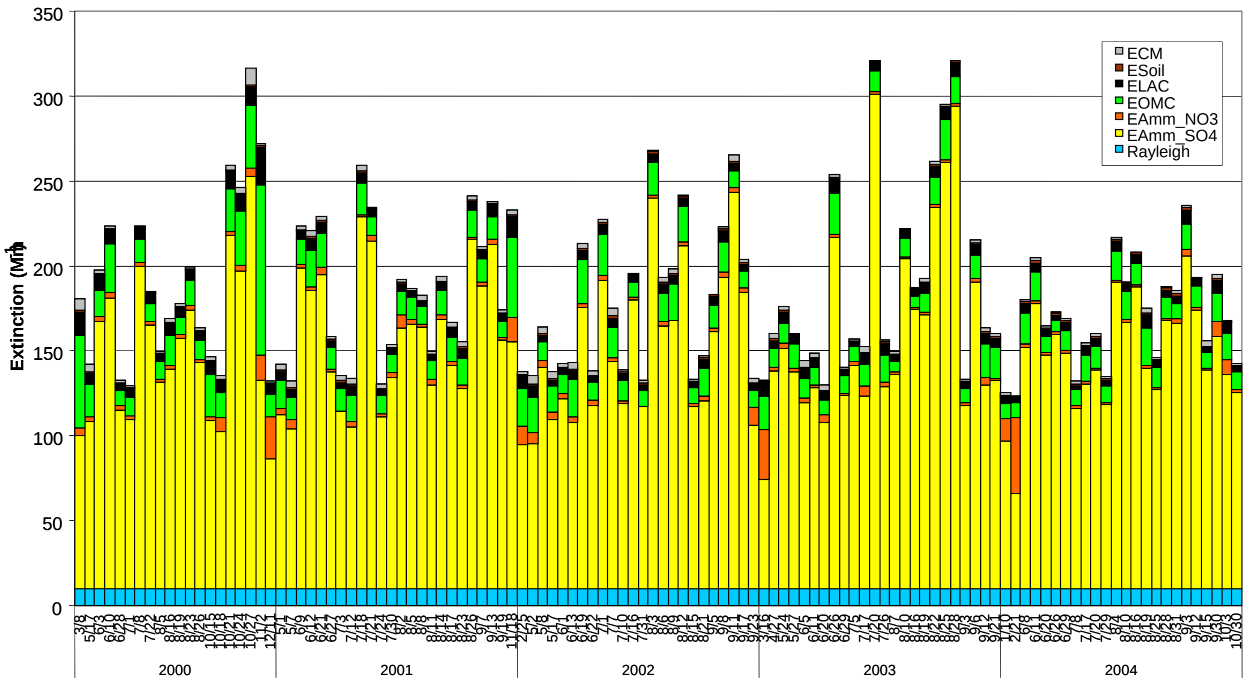


Figure 2.4-1. The 2000 – 2004 reconstructed extinction, using the new IMPROVE equation, for the 20% worst days at the Great Smoky Mountains National Park.

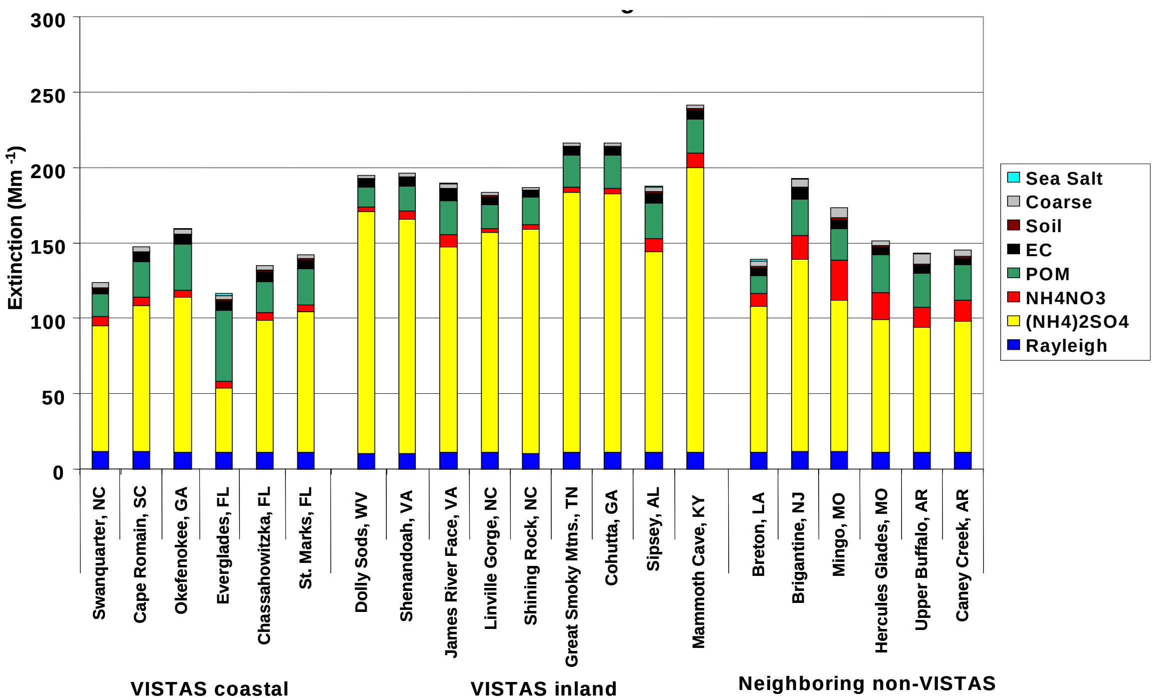


Figure 2.4-2. Average light extinction for the 20% Haziest Days in 2000-2004 at VISTAS and neighboring Class I areas using new IMPROVE equation

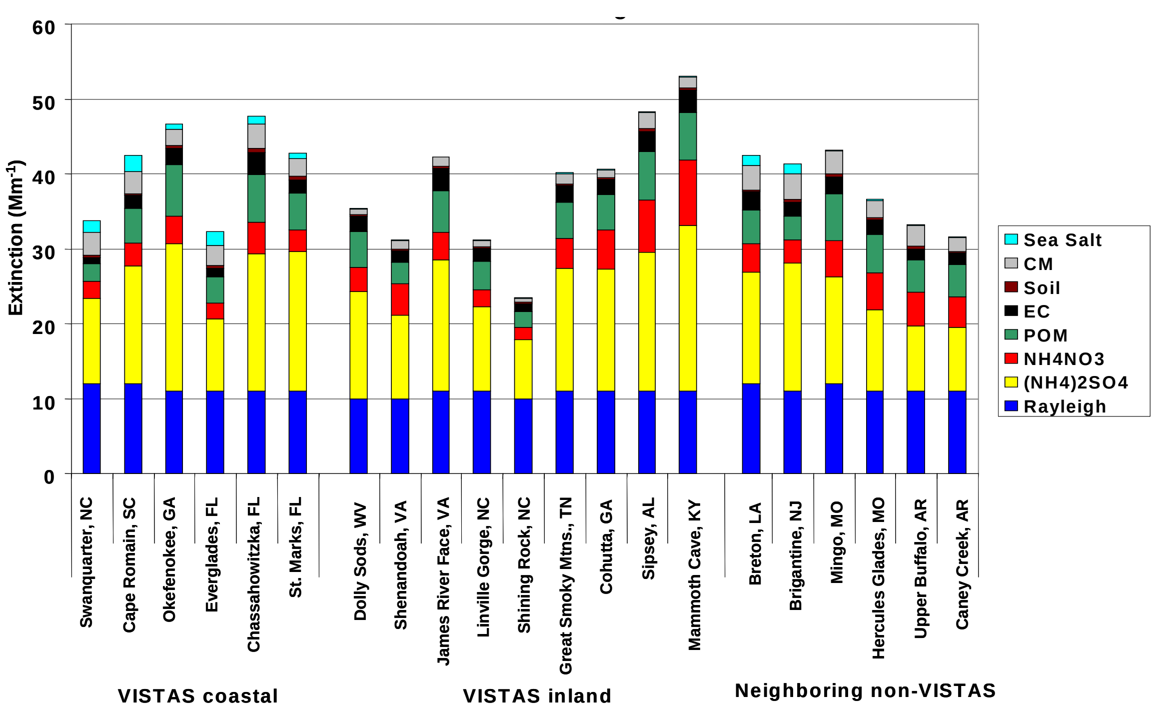


Figure 2.4-3. Average light extinction for the 20% Clearest Days in 2000-2004 at VISTAS and neighboring Class I areas using new IMPROVE equation

Ammonium sulfate, $(NH_4)_2SO_4$, is the most important contributor to visibility impairment and fine particle mass on the 20% worst and 20% best visibility days at all the North Carolina Class I areas. Sulfate levels on the 20% worst days account for 60-70 percent of the visibility impairment. Across the VISTAS region, sulfate levels are higher at the Southern Appalachian sites than at the coastal sites (Figure 2.4-1). On the 20% clearest days, sulfate levels are more uniform across the region (Figure 2.4-2). [Note that in these two figures, levels at Great Smoky Mountains National Park should be considered to be representative of levels at Joyce Kilmer-Slickrock Wilderness.]

The best average visibility and lowest sulfate values on the clearest days occurred at Shining Rock. Shining Rock, at 1621 meters elevation, is likely influenced on the clearest days by regional transport of air masses above the boundary layer. Sulfate particles are formed in the atmosphere from SO2 emissions. Sulfate particles occur as hydrogen sulfate, $H_2(SO_4)$, ammonium bisulfate HNH_4SO_4, and ammonium sulfate, $(NH_4)_2SO_4$, depending on the availability of ammonia, NH3, in the atmosphere.

Particulate Organic Matter (POM) is the second most important contributor to fine particle mass and light extinction on the 20% haziest and the 20% clearest days at the North Carolina Class I areas. Elevated levels of POM and Elemental Carbon, EC, indicate impact from wildfires or prescribed fire. Significant fire impacts are infrequent at Class I areas in North Carolina. VISTAS collected additional samples of carbon at five sites, including Great Smoky Mountains and Millbrook located in Raleigh, North Carolina, to better understand sources contributing to carbon in rural and urban areas. Samples were analyzed to define the amount of carbon-14 isotope as an indicator of the amount of carbon from modern sources (vegetative emissions, fires) and the amount of carbon from fossil sources (gasoline, diesel, oil). For most samples, the ratio of modern carbon to fossil carbon was greater than 0.60 throughout the year. In the fall, winter, and spring, more of the modern carbon is attributable to wood burning while in the summer months more of the modern carbon mass is attributable to biogenic emissions from vegetation. On some days greater than 90% of the carbon at Great Smoky Mountains is attributable to modern sources of carbon. Biogenic carbon emissions at Cape Romain, South Carolina, a coastal site similar to Swanquarter, were lower than emissions at the forested mountain sites. Carbon from gasoline and diesel engines is a relatively small contribution at the rural sites. At Millbrook, carbon from fossil fuel combustion is a larger percentage contribution than at the rural sites, but still less than 50% of total carbon measured. These results suggest that controlling anthropogenic sources of carbon will have little benefit in improving visibility in Class I areas since the majority of the POM comes from natural, i.e., biogenic, sources. Controlling anthropogenic sources of carbon will likely be more effective to reduce levels of PM2.5 in urban areas.

Ammonium nitrate, NH_4NO_3, is formed in the atmosphere by reaction of NH3 and NOx. In the VISTAS region, nitrate formation is limited by availability of NH3 and by temperature. Ammonia preferentially reacts with SO2 and sulfate before reacting with NOx. Particle nitrate is formed at lower temperatures; at elevated temperatures nitric acid remains in gaseous form. For this reason, particle nitrate levels are very low in the summer and a minor contributor to visibility impairment. Particle nitrate concentrations are higher on winter days and are more important for the coastal sites where 20% worst days can occur on winter days. Nitrogen oxides are emitted by fossil fuel combustion by point, area, on-road, and off-road mobile sources. Modeling data (see Section 7) indicate that in the VISTAS region ammonium nitrate formation is limited by NH3 concentrations and suggest that for winter days, controls of NH3 sources would be more effective in reducing ammonium nitrate levels than controls of NOx.

Elemental Carbon, EC, is a comparatively minor contributor to visibility impairment. Sources include agriculture, prescribed, wildland, and wild fires and incomplete combustion of fossil fuels. EC levels are higher at urban monitors than at the Class I areas and suggest controls of fossil fuel combustion sources would be more effective to reduce PM2.5 in urban areas than to improve visibility in Class I areas.

Soil fine particles are minor contributors to visibility impairment at most southeastern sites on most days. Occasional episodes of elevated fine soil can be attributed to Saharan dust episodes, particularly at Everglades, Florida, but rarely are seen at the North Carolina Class I areas. No control strategies are indicated for fine soil.

Sea salt, NaCl, is observed at the coastal sites. Sea salt contributions to visibility impairment are most important on the 20% clearest days when sulfate and POM levels are low. Sea salt levels do not contribute significantly to visibility on the 20% worst visibility days. The new IMPROVE equation uses Chloride ion, Cl^-, from routine IMPROVE measurements to calculate sea salt levels. VISTAS used Cl^- to calculate sea salt contributions to visibility following IMPROVE guidance.

Coarse particle mass (particles with diameters between 2.5 and 10 microns) has a relatively small contribution to visibility impairment because the light extinction efficiency of coarse mass is very low compared to the extinction efficiency for sulfate, nitrate, and carbon.

An *unidentified* component is reported by IMPROVE as the difference between the total PM2.5 mass measured on the filter and the sum of the measured components. This unidentified mass may be positive or negative and is attributable to water and/or the factors used to calculate molecular weights of the other components.

The new IMPROVE equation generally results in higher calculated light extinction on days with higher mass and lower light extinction on days with lower mass. This tends to increase calculated light extinction for current conditions and to decrease calculated light extinction for natural visibility conditions. Adding sea salt to the new IMPROVE equation increases light extinction for both current and natural visibility conditions. Increasing the mass multiplier for POM in the new IMPROVE equation increases light extinction for current conditions more than for natural conditions. The new algorithm does not change the conclusion that in the VISTAS region, and in North Carolina, the most effective means to improve visibility is to reduce sulfate concentrations.

PM2.5 trends in urban and Class I areas: IMPROVE data were compared to monitoring data from the Speciated Trends Network (STN) in nearby urban areas to understand the similarities and differences in composition of fine particle mass. Several PM2.5 nonattainment areas are in close proximity to the Class I areas in the southeastern United States, including Atlanta, GA;

Birmingham, AL; Charleston, WV; Chattanooga, TN; Knoxville, TN; and Louisville, KY. Ammonium sulfate concentrations are comparable between urban and nearby Class I areas, while organic carbon, elemental carbon, and nitrate concentration are generally higher in urban areas than the Class I areas. These results suggest that sulfate is widely distributed regionally while urban areas see an additional incremental pollutant loading from local emissions sources.

Role of meteorology in determining visibility conditions: Classification and Regression Tree (CART) Analyses were used to characterize the relationship between meteorological conditions and visibility conditions at the Class I areas. Days were assigned to one of five visibility classes ranging from poor to good visibility. Days were then assigned to bins based on meteorological conditions. For the North Carolina Class I areas, poor visibility days were most likely to occur on days with high temperatures, high relative humidity, low wind speeds, and elevated PM2.5 mass at upwind urban areas. Precipitation was not a good predictor of visibility condition. Weights were assigned to days based on frequency of occurrence of days with similar meteorological conditions.

The above analyses are further discussed in Appendix B.

3.0 GLIDEPATHS TO NATURAL CONDITIONS IN 2064

As stated in Section 1.3, the regional haze rule directs states to graphically show what would be a "uniform rate of progress" toward natural conditions for each mandatory Class I Federal area within the State as well as for each mandatory Class I Federal area located outside the State, which may be affected by emissions from sources within the State. The uniform rate of progress is also known as the "glidepath." The glidepath is simply a straight graphical line drawn from the baseline level of visibility impairment for 2000-2004 to the level representing no manmade impairment in 2064.

Each state must set goals for each Class I area that provide for reasonable progress towards achieving natural visibility conditions by 2064. Section 51.308(d)(1) of the regional haze rule requires that reasonable progress goals must both:

(1) provide for improvement in visibility for the most impaired days over the period of the implementation plan; and
(2) ensure no degradation in visibility for the least impaired days over the same period.

Uniform rate of progress graphs (glidepaths), were developed for each Class I area in the VISTAS region. The glidepaths were developed in accordance with the USEPA's guidance for tracking progress and used data collected from the IMPROVE monitoring sites as described in Section 2 of this document. The glidepath is one of the indicators used in setting reasonable progress goals.

3.1 Glidepaths for Class I Areas in North Carolina

The following are glidepaths for the 20% most impaired days for Great Smoky Mountains National Park, Joyce Kilmer-Slickrock Wilderness Area, Linville Gorge Wilderness Area, Shining Rock Wilderness Area, and Swanquarter Wildlife Refuge, assuming uniform rate of progress toward regional haze goals. Natural background visibility at all four sites is predicted to be between 11 and 12 dv. The Class I areas with the steepest slope from baseline to natural background conditions are Great Smoky Mountains and Joyce Kilmer-Slickrock, while Swanquarter currently has the shortest path from the baseline level of visibility impairment to natural conditions.

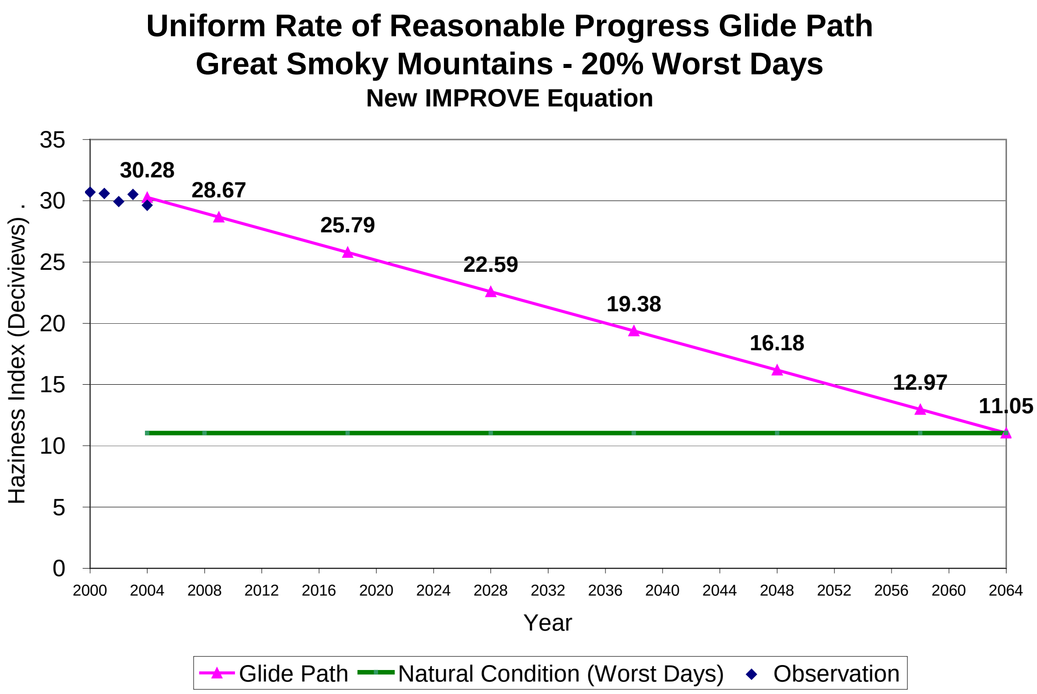


Figure 3.1-1. Uniform Rate of Progress Glidepath for 20% worst days at Great Smoky Mountains National Park.

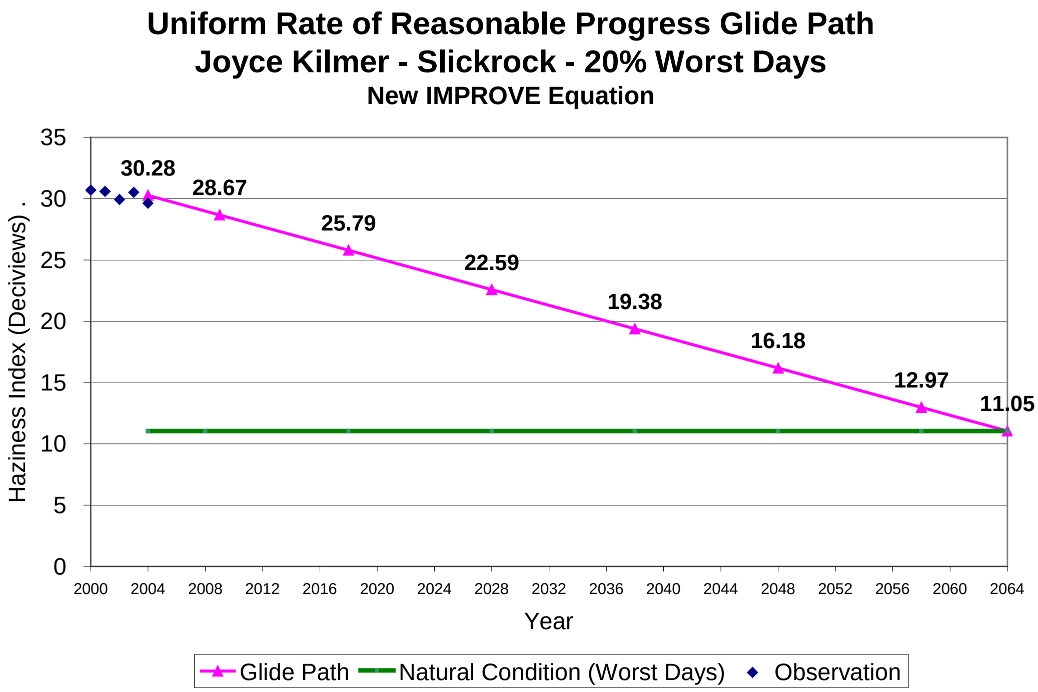


Figure 3.1-2. Uniform Rate of Progress Glidepath for 20% worst days at Joyce Kilmer-Slickrock Wilderness Area.

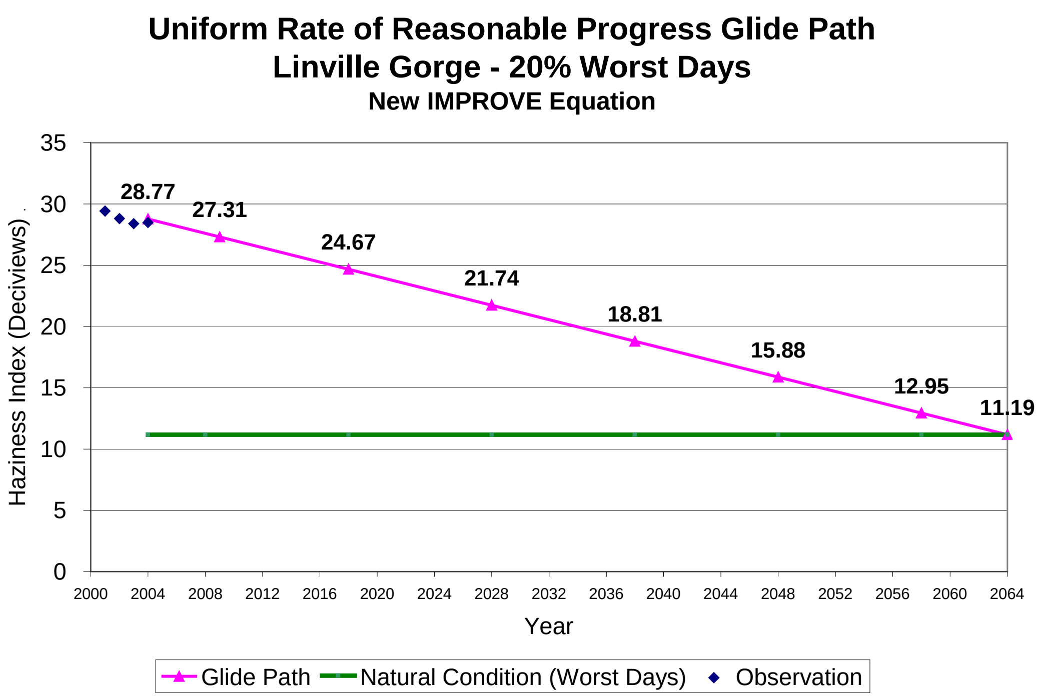


Figure 3.1-3. Uniform Rate of Progress Glidepath for 20% worst days at Linville Gorge Wilderness Area.

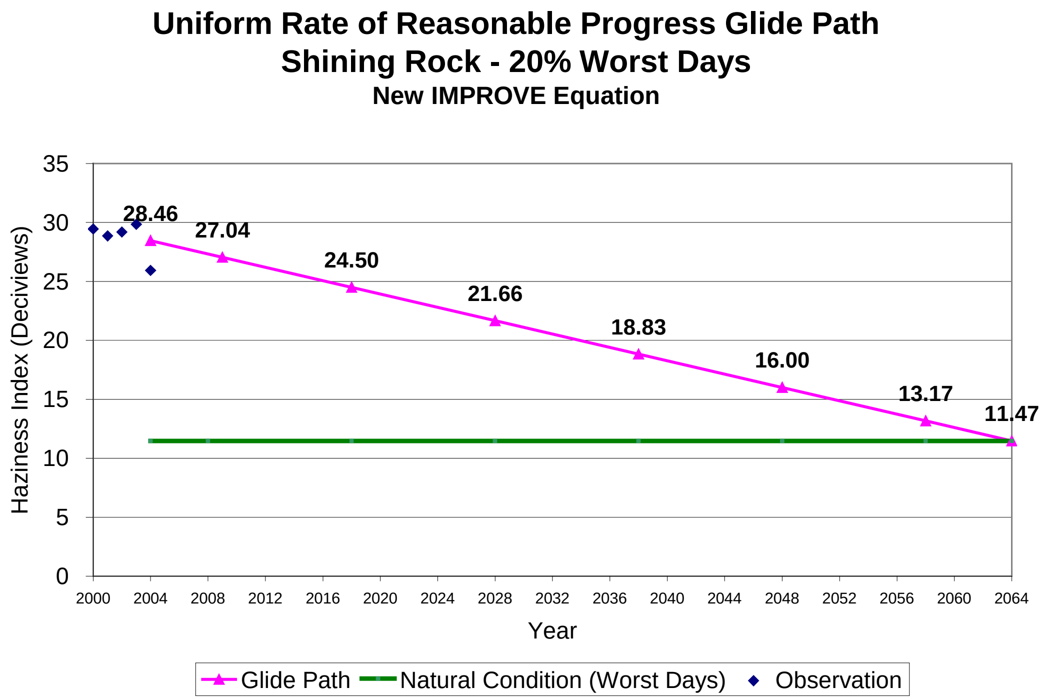


Figure 3.1-4. Uniform Rate of Progress Glidepath for 20% worst days at Shining Rock Wilderness Area.

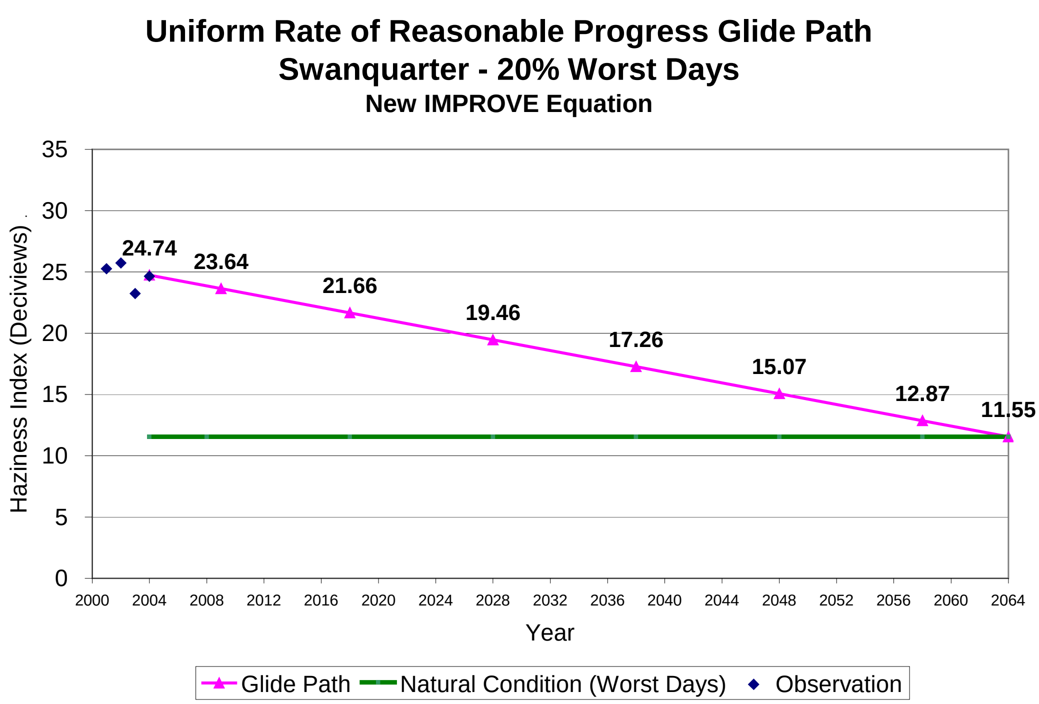


Figure 3.1-5. Uniform Rate of Progress Glidepath for 20% worst days at Swanquarter Wildlife Refuge.

4.0 TYPES OF EMISSIONS IMPACTING VISIBILITY IMPAIRMENT IN NORTH CAROLINA CLASS I AREAS

4.1 Baseline Emissions Inventory

The regional haze rule at 51.308(d)(4)(v) requires a statewide emissions inventory of pollutants that are reasonably anticipated to cause or contribute to visibility impairment in any mandatory Class I area. An inventory was developed for the baseline year 2002 and projected to 2009 and 2018. The pollutants inventoried include VOCs, NOx, PM2.5, coarse particulate (PM10), NH3 and SO2. The baseline emissions inventory for 2002 was developed for North Carolina following the methods described in Appendix D.

There are five different emission inventory source classifications: stationary point and area sources, off-road and on-road mobile sources, and biogenic sources. Stationary point sources are those sources that emit greater than a specified tonnage per year, with data provided at the facility level. Electric generating utilities and industrial sources are the major categories for stationary point sources. Stationary area sources are those sources whose individual emissions are relatively small, but due to the large number of these sources, the collective emissions from the source category could be significant (i.e., dry cleaners, service stations, agricultural sources, fire emissions, etc.). These types of emissions are estimated on a countywide level. Off-road (or non-road) mobile sources are equipment that can move but do not use the roadways, i.e., lawn mowers, construction equipment, railroad locomotives, aircraft, etc. The emissions from these sources, like stationary area sources, are estimated on a countywide level. On-road mobile sources are automobiles, trucks, and motorcycles that use the roadway system. The emissions from these sources are estimated by vehicle type and road type and are summed to the countywide level. Biogenic sources are the natural sources like trees, crops, grasses and natural decay of plants. The emissions from these sources are estimated on a countywide level.

In addition to the various source classifications, there are also various types of emission inventories. The first is the actual base year inventory. This inventory is the base year emissions that correspond to the meteorological data used, which for this modeling effort is data from 2002. These emissions are used for evaluating the air quality model performance.

The second type of inventory is the typical base year inventory. This inventory is similar to the actual base year inventory, except that for sources whose emissions change significantly from year to year, a more typical emission value is used. In this modeling effort, typical emissions were developed for the electric generating units (EGUs) and the wildland fire emissions. The air quality modeling is run using the typical base year inventory and the future year inventory. The results from these two runs are then used to calculate relative reduction factors. These relative reduction factors are used to estimate the future year visibility estimates that are used to demonstrate reasonable progress toward visibility goals.

Below is an overview of the inventories used for each source classification. More detailed discussion of the emissions inventory development is contained in Appendix D.

4.1.1 Stationary Point Sources

Point source emissions are emissions from individual sources having a fixed location. Generally, these sources must have permits to operate, and their emissions are inventoried on a regular schedule. Large sources emitting at least 100 tons per year (tpy) of a criteria pollutant, 10 tpy of a single hazardous air pollutant (HAP), or 25 tpy total HAP are inventoried annually. Smaller sources have been inventoried less frequently. The point source emissions data can be grouped as EGU sources and other industrial point sources, also called non-EGUs.

Electric Generating Units

The actual base year inventory for the EGU sources used 2002 continuous emissions monitoring (CEM) data reported to the USEPA's Acid Rain program or 2002 hourly emissions data provided by stakeholders. These data provide hourly emissions profiles for SO2 and NOx that can be used in air quality modeling. Emissions profiles are used to estimate emissions of other pollutants (VOCs, carbon monoxide, NH3, PM2.5) based on measured emissions of SO2 and NOx.

Emissions from EGU vary daily and seasonally as a function of variability in energy demand and utilization and outage schedules. To avoid anomalies in future year emissions created by relying on 2002 operations to represent future operations, a typical base year emissions inventory was developed for EGUs. This approach is consistent with the USEPA's 2007 modeling guidance. To develop a typical year 2002 emissions inventory for EGU sources, each unit's average CEM heat input for 2000 through 2004 was divided by the 2002 actual heat input to generate a unit specific normalizing factor. This normalizing factor was then multiplied by the 2002 actual emissions. The heat inputs for the period 2000 through 2004 were used because the modeling current conditions use monitored data from this same 5-year period. If a unit was shut down for an entire year during the 2000 through 2004 period, the average of the years the unit was operational was used. If a unit was shut down in 2002, but not permanently shutdown, the emissions and heat inputs from 2001 (or 2000) were used in the normalizing calculations.

As part of the VISTAS air quality modeling, VISTAS, in cooperation with the other eastern RPOs, contracted with ICF Resources, L.L.C., to generate future year emission inventories for the electric generating sector of the contiguous United States using the Integrated Planning Model (IPM) version 2.1.9 updated with state-specific information. IPM is a dynamic linear optimization model that can be used to examine air pollution control policies for various pollutants throughout the contiguous United States for the entire electric power system. The dynamic nature of IPM enables projection of the behavior of the power system over a specified future period. Optimization logic in IPM determines the least-cost means of meeting electric generation and capacity requirements while complying with specified constraints including air pollution regulations, transmission bottlenecks, and plant-specific operational constraints. The versatility of IPM allows users to specify which constraints to exercise, and to populate IPM with their own datasets.

The IPM modeling runs took into consideration both CAIR implementation and North Carolina's CSA requirements for Duke Energy and Progress Energy.

Other Industrial Point Sources

For the non-EGU sources, the same inventory is used for both the actual and typical base year emissions inventories. The non-EGU category uses annual emissions as reported under the Consolidated Emissions Reporting Rule (CERR) for the year 2002. These emissions are temporally allocated to month, day, and hour using source category code (SCC)-based allocation factors.

The general approach for assembling future year data was to use recently updated growth and control data consistent with the USEPA's CAIR analyses. This data was supplemented with state-specific growth factors and stakeholder input on growth assumptions.

4.1.2 Stationary Area Sources

Stationary area sources are sources whose individual emissions are relatively small, but due to the large number of these sources, the collective emissions could be significant (i.e., combustion of fuels for heating, structure fires, service stations, etc.). Emissions are estimated by multiplying an emission factor by some known indicator of collective activity, such as fuel usage, number of households, or population. Stationary area source emissions are estimated at the countywide level.

A portion of the area source 2002 base year inventory for North Carolina was developed by the NCDAQ and provided to the VISTAS contractor. The VISTAS contractor calculated the remaining portion of the area source inventory. The sources estimated by the contractor include emissions from animal husbandry, wildland fires, and particulate matter from paved and unpaved roads. For the other states within the modeling domain, either state-supplied data or data reported under CERR for 2002 was used.

The actual base year inventory will serve as the typical base year inventory for all area source categories except for wildland fires. For wildland fires, a typical year inventory was used to avoid anomalies in wildfire activity in 2002 compared to longer term averages. Development of a typical year wildfire inventory provided the capability of using a comparable data set for both the base year and future years. Thus, fire emissions remain the same for air quality modeling in both the base and any future years. The VISTAS Fire Special Interest Work Group used State records to ratio the number of acres burned over a longer term period (three or more years, as available from state records) to 2002. Based on these ratios, the 2002 acreage was then scaled up or down to develop a typical year inventory.

The VISTAS contractor generated future year emissions inventories for 2009 and 2018 for the regional haze modeling. Growth factors, supplied either by states or taken from the CAIR emission projections, were applied to project the controlled emissions. If no growth factor was available from either the state or the CAIR growth factor files, then the USEPA's Economic Growth and Analysis System Version 5 growth factors were used.

4.1.3 Off-Road Mobile Sources

Off-road mobile sources are equipment that can move but do not use the roadways, such as construction equipment, aircraft, railroad locomotives, lawn and garden equipment, etc. For the majority of the off-road mobile sources, the emissions for 2002 were estimated using the USEPA's NONROAD2005c model. For the three source categories not included in the NONROAD model, i.e., aircraft engines, railroad locomotives and commercial marine, more traditional methods of estimating the emissions were used. The same inventory is used for both the actual and typical base year emissions inventories.

For the source categories estimated using the USEPA's NONROAD model, the model growth assumptions were used to create the 2009 and 2018 future year inventories. The NONROAD model takes into consideration regulations affecting emissions from these source categories. For the four largest airports in North Carolina, the Federal Aviation Administration's Terminal Area Forecast was used to project growth in aircraft emissions. For the commercial marine, railroad locomotives and the remaining airport emissions, the VISTAS contractor calculated the future growth in emissions using detailed inventory data (both before and after controls) for 1996 and 2010, obtained from the CAIR Technical Support Document. When available, state-specific growth factors were used.

4.1.4 Highway Mobile Sources

For on-road vehicles, the newest version of the MOBILE model, MOBILE6.2, was used. Key inputs for MOBILE include information on the age of vehicles on the roads, the average speeds on the roads, the mix of vehicles on the roads, any programs in place in an area to reduce emissions for motor vehicles (e.g., emissions inspection programs), and temperature.

The MOBILE model takes into consideration regulations that affect emissions from this source sector. The same MOBILE run is used to represent the actual and typical year emissions for on-road vehicles using input data reflective of 2002. The MOBILE model then is run for 2018 inventory using input data reflective of that year. The 2002 vehicle miles traveled (VMT), speeds, vehicle age and vehicle mix data were obtained from the North Carolina Department of Transportation (NCDOT). For urban areas in North Carolina that run travel demand models (TDMs), VMT and speed data from TDMs were used.

4.1.5 Biogenic Emission Sources

Biogenic emissions were prepared with the SMOKE-BEIS3 (Biogenic Emission Inventory System 3 version 0.9) preprocessor. SMOKE-BEIS3 is a modified version of the Urban Airshed Model (UAM)-BEIS3 model. Modifications include use of MM5 data, gridded land use data, and improved emissions characterization. The emission factors that are used in SMOKE-BEIS3 are the same as the emission factors as in UAM-BEIS3. The basis for the gridded land use data used by BEIS3 is the county land use data in the Biogenic Emissions Landcover Database version 3 (BELD3) provided by the USEPA. A separate land classification scheme, based upon satellite (AVHRR, 1 km spatial resolution) and census information, aided in defining the forest, agriculture and urban portions of each county.

4.1.6 Summary 2002 Baseline Emissions Inventory for North Carolina

Table 4.1.6-1 is a summary of the 2002 baseline emission inventory for North Carolina. The complete inventory and discussion of the methodology is contained in Appendix D. The emissions summaries for other VISTAS states can also be found in Appendix D.

Table 4.1.6-1 2002 Emissions Inventory Summary for North Carolina (tons/year)

	VOC	NOx	PM2.5	PM10	NH3	SO2
Point	61,484	196,731	26,953	36,539	1,233	522,093
Area	250,044	41,517	83,520	300,838	162,183	5,815
On-Road Mobile	263,766	327,329	4,623	6,579	9,702	12,420
Off-Road Mobile	94,480	84,284	7,348	7,348	65	7,693
Biogenics	1,213,819	17,888	0	0	0	0
TOTAL	1,883,593	667,749	122,444	351,304	173,183	548,021

4.1.7 Model Performance Improvements through Emissions Inventory Improvements

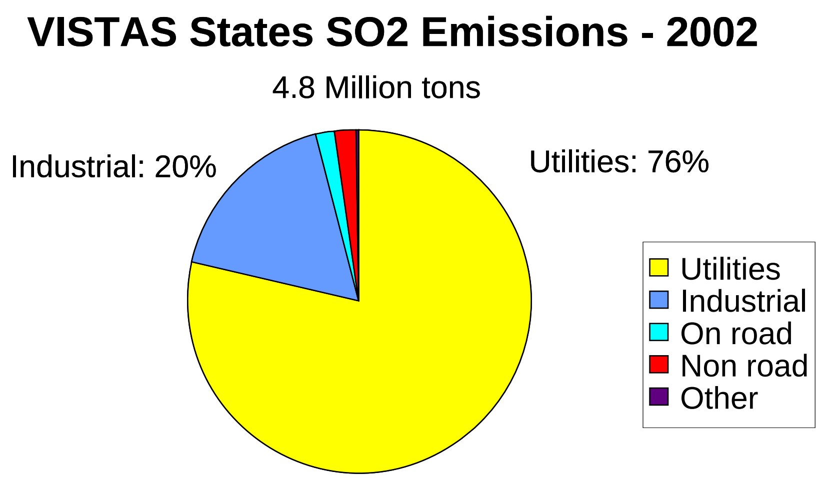
Since the initial model performance evaluation, VISTAS has made several improvements to the emissions inventory, which in turn improved model performance. These inventory improvements are detailed in the VISTAS emissions inventory report and Appendix D, and are summarized here:

- For electric generating utilities, the Integrated Planning Model (IPM) was used to provide estimates of future year utility production and emissions. Continuous Emissions Monitoring data was used to define seasonal variability in production and emissions. The states updated IPM model projections from with control data provided by utility companies in late 2006 through early 2007.
- For on-road vehicle emissions, states and local agencies provided updated MOBILE model input and vehicle-miles-traveled data.
- For ammonia emissions from agricultural sources, the Carnegie Mellon University ammonia model was used to improve annual and monthly estimates.
- For fires, the VISTAS states provided fire activity data for 2002 for wildfires, prescribed fire, land clearing and agricultural burning to develop a 2002 fire inventory. Where data allowed, large fire events were modeled as point sources. In 2006, United States Forest Service and Fish and Wildlife Service provided projections of increased prescribed burning in 2009 and 2018; these data were incorporated in the inventory for all states except Florida. Because current prescribed fire activity already reflects the use of fire as a forest management technique, Florida believed that there is too much uncertainty to project how future total fire activity (prescribed plus wildfire) will change. In Florida, prescribed fire in the future years is the same as 2002 typical for prescribed fire.
- For non-road engines, the updated USEPA NONROAD2005 emissions model was used.
- For commercial marine emissions in shipping lanes in the Gulf of Mexico and Atlantic Oceans, gridded emissions for the VISTAS modeling domain was created using inventory data newly developed for the USEPA by Dr. Corbett at the University of Delaware. These emissions were incorporated in the modeling.

- Updated inventories from the neighboring RPOs, Mexico, and Canada were incorporated as available.

4.2 Assessment of Relative Contributions from Specific Pollutants and Sources Categories

Ammonium sulfate is the largest contributor to visibility impairment at the North Carolina Class I areas, and reduction of SO2 emissions would be the most effective means of reducing ammonium sulfate. As illustrated in Figure 4.2-1, 96% of 2002 SO2 emissions in the VISTAS states are attributable to electric generating facilities and industrial point sources. Similarly, in



North Carolina the stationary point sources, consisting of electric generating facilities and industrial point sources, contribute 95% of SO2 emissions in the State (see Table 4.2-1).

Figure 4.2-1. 2002 SO2 emissions in the VISTAS States.

Table 4.2-1 2002 SO2 Emissions for North Carolina (tons/year)

	SO2	Percent
Point	522,093	95.3%
Area	5,815	1.1%
On-Road Mobile	12,420	2.2%
Off-Road Mobile	7,693	1.4%
Biogenics	0	0%
TOTAL	548,021	

Since the largest source of SO2 emissions comes from the stationary point sources, the focus of potential controls and the impacts for those controls was on this source sector. In North Carolina, the types of sources emitting SO2, and thus contributing to the visibility impairment of the Class I areas, were predominately coal fired utility and industrial boilers.

5.0 REGIONAL HAZE MODELING METHODS AND INPUTS

Modeling for regional haze was performed by VISTAS for the ten southeastern states, including North Carolina. The sections below outline the methods and inputs used by VISTAS for the regional modeling. Additional details are provided in Appendices C, D and M.

5.1 Analysis Method

The modeling analysis is a complex technical evaluation that begins by selection of the modeling system. VISTAS decided to use the following modeling system:

- Meteorological Model: The Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) Mesoscale Meteorological Model (MM5) is a nonhydrostatic, prognostic meteorological model routinely used for urban- and regional-scale photochemical, fine particulate matter, and regional haze regulatory modeling studies.
- Emissions Model: The Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system is an emissions modeling system that generates hourly gridded speciated emission inputs of mobile, nonroad mobile, area, point, fire and biogenic emission sources for photochemical grid models.
- Air Quality Model: The USEPA's Models-3/ Community Multiscale Air Quality (CMAQ) modeling system is an 'One-Atmosphere' photochemical grid model capable of addressing ozone, particulate matter (PM), visibility and acid deposition at regional scale.

The USEPA's 2007 modeling guidance recommends modeling an entire year or at a minimum several days in each quarter of a year to adequately represent the range of meteorological conditions that contribute to elevated levels of fine particulate matter. The year 2002 was selected by VISTAS as the modeling year for this demonstration. Meteorological inputs were developed for 2002 using the meteorological model. Emission inventories were also developed for 2002 and processed through the emissions model. These inputs were used in the air quality model to predict fine particle mass and visibility. The model results for 2002 were compared with observed meteorological and air quality data to evaluate model performance. Several configurations of the meteorological and air quality model were evaluated to select a configuration that gave the best overall performance for the VISTAS region.

Once model performance was deemed adequate, the current and future year emissions were processed through the emissions model. The air quality modeling results are used to determine a relative reduction in future visibility impairment, which is used to determine reasonable progress.

The complete modeling protocol used for this analysis can be found in Appendix C.

5.2 Model Selection

To ensure that a modeling study is defensible, care must be taken in the selection of the models to be used. The models selected must be scientifically appropriate for the intended application and be freely accessible to all stakeholders. Scientifically appropriate means that the models address important physical and chemical phenomena in sufficient detail, using peer-reviewed methods. Freely accessible means that model formulations and coding are freely available for review and that the models are available to stakeholders, and their consultants, for execution and verification at no or low cost.

The following sections outline the criteria for selecting a modeling system that is both defensible and capable of meeting the study's goals. These criteria were used in selecting the modeling system used for this modeling demonstration.

5.2.1 Selection of Photochemical Grid Model

Criteria

For a photochemical grid model to qualify as a candidate for use in a regional haze SIP, a State needs to show that it meets the same several general criteria as a model for an attainment demonstration for a NAAQS:

- The model has received a scientific peer review
- The model can be demonstrated applicable to the problem on a theoretical basis
- Data bases needed to perform the analysis are available and adequate
- Available past appropriate performance evaluations have shown the model is not biased toward underestimates or overestimates
- A protocol on methods and procedures to be followed has been established
- The developer of the model must be willing to make the source code available to users for free or for a reasonable cost, and the model cannot otherwise be proprietary.

Overview of CMAQ

The photochemical model selected for this study was CMAQ version 4.5. For more than a decade, the USEPA has been developing the Models-3 CMAQ modeling system with the overarching aim of producing a 'One-Atmosphere' air quality modeling system capable of addressing ozone, fine particulate matter, visibility and acid deposition within a common platform. The original justification for the Models-3 development emerged from the challenges posed by the 1990 CAAA and the USEPA's desire to develop an advanced modeling framework for 'holistic' environmental modeling utilizing state-of-science representations of atmospheric processes in a high performance computing environment. The USEPA completed the initial stage of development with Models-3 and released the CMAQ model in mid-1999 as the initial operating science model under the Models-3 framework. The most recent rendition is CMAQ version 4.5, which was released in September 2005.

An advantage of choosing CMAQ as the atmospheric model is the ability to do one-atmospheric modeling. The same model configuration is being applied for the ozone and PM2.5 attainment demonstrations SIPs, as well as the regional haze SIP. A number of features in CMAQ's theoretical formulation and technical implementation make the model well suited for annual PM modeling.

The configuration used for this modeling demonstration, as well as a more detailed description of the CMAQ model, can be found in the Modeling Protocol (Appendix C).

5.2.2 Selection of Meteorological Model

Criteria

Meteorological models, whether through objective, diagnostic, or prognostic analysis, extend available information about the state of the atmosphere to the grid upon which photochemical grid modeling is to be carried out. The criteria for selecting a meteorological model are based on both the models ability to accurately replicate important meteorological phenomena in the region of study, and the model's ability to interface with the rest of the modeling systems -- particularly the photochemical grid model. With these issues in mind, the following criteria were established for the meteorological model to be used in this study:

- Non-Hydrostatic Formulation
- Reasonably current, peer reviewed formulation
- Simulates Cloud Physics
- Publicly available at no or low cost
- Output available in I/O API format
- Supports Four Dimensional Data Assimilation (FDDA)
- Enhanced treatment of Planetary Boundary Layer heights for AQ modeling

Overview of MM5

The non-hydrostatic MM5 model is a three-dimensional, limited-area, primitive equation, prognostic model that has been used widely in regional air quality model applications. The basic model has been under continuous development, improvement, testing and open peer-review for more than 20 years and has been used worldwide by hundreds of scientists for a variety of mesoscale studies.

MM5 uses a terrain-following non-dimensionalized pressure, or "sigma", vertical coordinate similar to that used in many operational and research models. In the non-hydrostatic MM5, the sigma levels are defined according to the initial hydrostatically-balanced reference state so that the sigma levels are also time-invariant. The gridded meteorological fields produced by MM5 are directly compatible with the input requirements of 'one atmosphere' air-quality models using this coordinate. MM5 fields can be easily used in other regional air quality models with different coordinate systems by performing a vertical interpolation, followed by a mass-conservation re-adjustment.

Distinct planetary boundary layer parameterizations are available for air-quality applications, both of which represent sub-grid-scale turbulent fluxes of heat, moisture and momentum. One scheme uses a first-order eddy diffusivity formulation for stable and neutral environments and a modified first-order scheme for unstable regimes. The other scheme uses a prognostic equation for the second-order turbulent kinetic energy, while diagnosing the other key boundary layer terms.

Initial and lateral boundary conditions are specified for real-data cases from mesoscale three-dimensional analyses performed at 12-hour intervals on the outermost grid mesh selected by the user. Surface fields are analyzed at three-hour intervals. A Cressman-based technique is used to analyze standard surface and radiosonde observations, using the National Meteorological Center's spectral analysis, as a first guess. The lateral boundary data are introduced using a relaxation technique applied in the outermost five rows and columns of the coarsest grid domain.

MM5 modeling system in regulatory air quality application studies have been widely reported in the literature (e.g., Emery et al., 1999; Tesche et al., 2000, 2003) and many have involved comparisons with other prognostic models such as the Regional Atmospheric Modeling System (RAMS) and the Systems Application International Mesoscale Model. The MM5 enjoys a far richer application history in regulatory modeling studies compared with RAMS or other models. Furthermore, in evaluations of these models in over 60 recent regional scale air quality application studies since 1995, it has generally been found that the MM5 model tends to produce somewhat better photochemical model inputs than alternative models.

The configuration used for this modeling demonstration, as well as a more detailed description of the MM5 model, can be found in the meteorological modeling protocol (Appendix E).

5.2.3 Selection of Emissions Processing System

<u>Criteria</u>

The principal criterion for an emissions processing system is that it accurately prepares emissions files in a format suitable for the photochemical grid model being used. The following list includes clarification of this criterion and additional desirable criteria for effective use of the system.

- File System Compatibility with the I/O API
- File Portability
- Ability to grid emissions on a Lambert Conformal projection
- Report Capability
- Graphical Analysis Capability
- MOBILE6 Mobile Source Emissions
- Biogenic Emissions Inventory System version 3 (BEIS-3)
- Ability to process emissions for the proposed domain in a reasonable amount of time.

- Ability to process control strategies
- No or low cost for acquisition and maintenance
- Expandable to support other species and mechanisms

Overview of SMOKE

The SMOKE Emissions Processing System Prototype was originally developed at the Micro-computing Center of North Carolina. As with most 'emissions models', SMOKE is principally an emission processing system and not a true emissions modeling system in which emissions estimates are simulated from 'first principles'. This means that, with the exception of mobile and biogenic sources, its purpose is to provide an efficient, modern tool for converting emissions inventory data into the formatted emission files required by an air quality simulation model. For mobile sources, SMOKE actually estimates emissions based on input mobile-source activity data, emission factors and outputs from transportation travel-demand models.

SMOKE was originally designed to allow emissions data processing methods to utilize emergent high-performance-computing as applied to sparse-matrix algorithms. Indeed, SMOKE is the fastest emissions processing tool currently available to the air quality modeling community. The sparse matrix approach utilized throughout SMOKE permits both rapid and flexible processing of emissions data. The processing is rapid because SMOKE utilizes a series of matrix calculations instead of less efficient algorithms used in previous systems. The processing is flexible because the processing steps of temporal projection, controls, chemical speciation, temporal allocation, and spatial allocation have been separated into independent operations wherever possible. The results from these steps are merged together at a final stage of processing.

SMOKE contains a number of major features that make it an attractive component of the modeling system. The model supports a variety of input formats from other emissions processing systems and models. It supports both gridded and county total land use schemes for biogenic emissions modeling. SMOKE can accommodate emissions files from up to 10 countries and any pollutant can be processed by the system. For additional information about the SMOKE model please refer to Modeling Protocol (Appendix C).

5.3 Selection of the Modeling Year

A crucial step to SIP modeling is the selection of the period of time to model to represent current air quality conditions and to project changes in air quality in response to changes in emissions. The year 2002 was selected as the base year for several reasons.

The USEPA's April 2007 *Guidance on the use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze* identifies specific goals to consider when selecting one or more episodes for use in demonstrating reasonable progress in attaining the regional haze air quality goals. The USEPA recommends that episode selection derive from four principal criteria:

- Simulate a variety of meteorological conditions;

- Model time periods in which observed concentrations are close to the appropriate baseline design value or visibility impairment;
- Model periods for which extensive air quality/meteorological data bases exist; and
- Model a sufficient number of days so that the modeled attainment test applied at each monitor violating the NAAQS is based on multiple days.

For regional haze modeling, the guidance goes further by suggesting that the preferred approach is to model a full, representative year. Moreover, the required relative reduction factor values should be based on model results averaged over the 20% worst and 20% best visibility days determined for each Class I are based on monitoring data from the 2000 – 2004 baseline period.

The USEPA also lists several other considerations to bear in mind when choosing potential regional haze episodes including: (a) choose periods which have already been modeled, (b) choose periods which are drawn from the years upon which the current design values are based, (c) include weekend days among those chosen, and (d) choose modeling periods that meet as many episode selection criteria as possible in the maximum number of nonattainment or Class I areas as possible. Finally, the USEPA explicitly recommended in its 2007 modeling guidance to use 2002 as the baseline inventory year.

VISTAS adopted a logical, stepwise approach in implementing the USEPA's 2007 modeling guidance in order to identify the most preferable, representative year for regional haze modeling. These steps include the following:

> Representativeness of Meteorological Conditions: The VISTAS meteorological contractor (BAMS) identified important meteorological characteristics and data sets in the VISTAS region directly relevant to the evaluation of candidate annual modeling episodes.
>
> Initial Episode Typing: At the time of selection in 2003, meteorological and air quality data were available for 2002 for model inputs and model performance evaluation. VISTAS used CART analyses to evaluate visibility conditions for 2000, 2001, and 2002, the candidate modeling years. The year 2002 was found to be representative of conditions in the other two years. Subsequently, these analyses were repeated with the meteorological and air quality monitoring data for 2000 to 2004 to evaluate how well the 2002 modeling year represented the full 2000-2004 baseline period. This analysis confirmed that visibility and PM2.5 mass in 2002 were representative of the five-year baseline period for the VISTAS Class I areas. This analysis is discussed in more detail in the project report in Appendix B.
>
> Data Availability: In parallel with the CART analyses, episode characterization analyses, collaborative investigations by VISTAS states (e.g., NCDAQ, Georgia Department of Natural Resources, Florida Department of Environmental Protection) intensively studied the availability of PM2.5, meteorological, and emissions data and representativeness of alternative baseline modeling periods from a regulatory standpoint. Additionally, 2002 was the year that the USEPA was requiring states to provide emissions inventory data for

the Comprehensive Emissions Reporting Rule, it made sense to use 2002 as the modeling year to take advantage of the 2002 inventory.

Years to be used by other RPOs: VISTAS also considered what years other RPO would be modeling, and several had already chosen calendar year 2002 as the modeling year.

After a lengthy process of integrated studies, the episode selection process culminated in the selection of calendar year 2002 (1 January through 31 December) as the most current, representative, and pragmatic choice for VISTAS regional haze modeling. All of the USEPA criteria for regional haze episode selection were directly considered in this process together with many other considerations (e.g., timing of new emissions or aerometric data deliveries by the USEPA or the states to the modeling teams).

5.4 Modeling Domains

5.4.1 Horizontal Modeling Domain

The USEPA's 2007 modeling guidance recommends a 12-km modeling grid resolution for PM2.5 modeling while a 36-km grid is considered acceptable for regional haze. For the VISTAS modeling, a coarse 36-km grid resolution was used for modeling the entire contential United States and a finer 12-km grid was used to model the eastern United States.

The CMAQ model was run in one-way nested grid mode. This allowed the larger outer domains to feed concentration data to the inner nested domain. Two-way nesting was not considered due to numerical and computational uncertainty associated with the technique.

The horizontal coarse grid modeling domain boundaries were determined through a national effort to develop a common grid projection and boundary. A smaller 12-km grid, modeling domain was selected in an attempt to balance location of areas of interest, such as ozone and fine particulate matter nonattainment areas, as well as Class 1 areas for regional haze. Processing time was also a factor in choosing a smaller 12-km grid, modeling domain.

The coarse 36-km horizontal grid domain covers the continental United States. This domain was used as the outer grid domain for MM5 modeling with the CMAQ domain nested within the MM5 domain. Figure 5.4.1-1 shows the MM5 horizontal domain as the outer most, blue grid with the CMAQ 36-km domain nested in the MM5 domain.

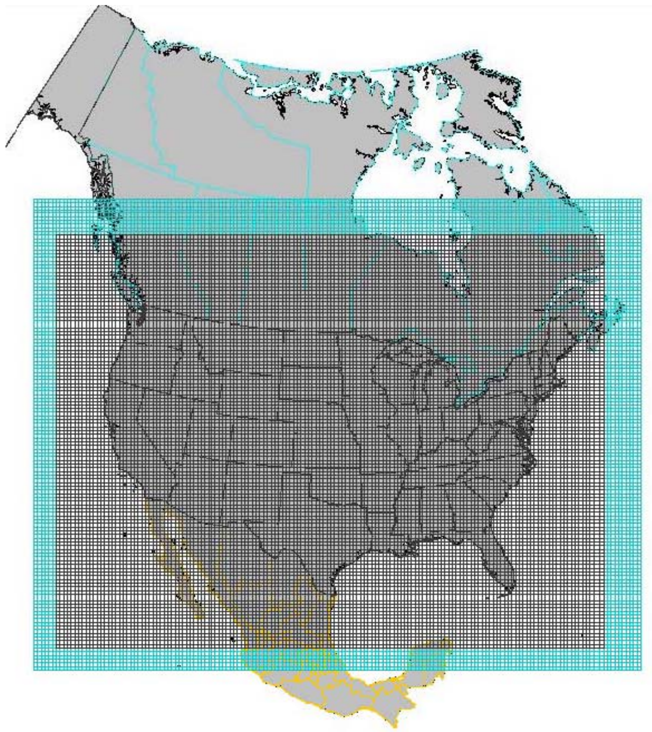


Figure 5.4.1-1. The MM5 horizontal domain is the outer most, blue grid, with the CMAQ 36-km domain nested in the MM5 domain.

To achieve finer spatial resolution in the VISTAS states, a one-way nested high resolution (12-km grid resolution) was used. Figure 5.4.1-2 shows the 12-km grid, modeling domain for the VISTAS region. The modeling results from this modeling domain are which the reasonable progress goals will be assessed.

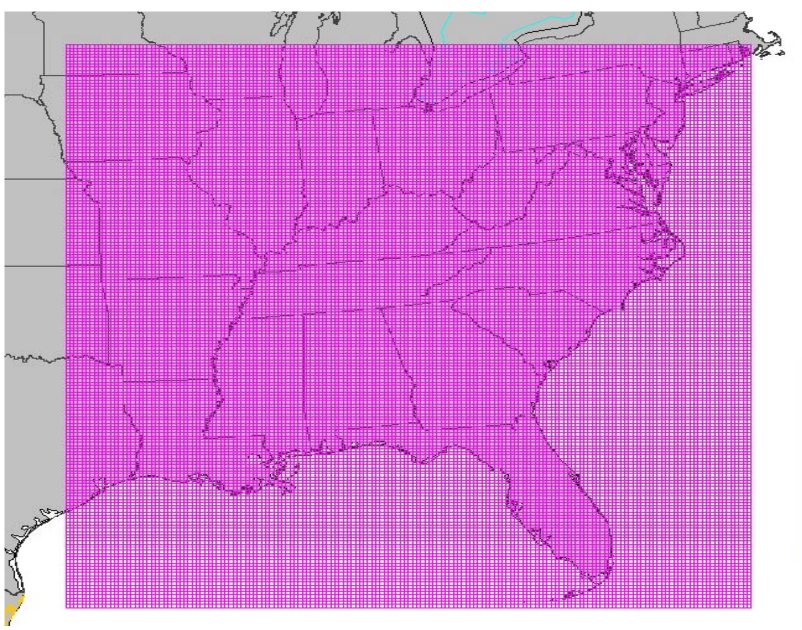


Figure 5.4.1-2. A more detailed view of the 12-km grid over the VISTAS region.

5.4.2 Vertical Modeling Domain

The CMAQ vertical structure is primarily defined by the vertical grid used in the MM5 modeling. The MM5 model employed a terrain following coordinate system defined by pressure, using 34 layers that extend from the surface to the 100 mb. A layer-averaging scheme was used to generate 19 vertical layers for CMAQ to reduce the computational cost of the CMAQ simulations. The effects of layer averaging were evaluated in conjunction with the VISTAS modeling effort and was found to have a relatively minor effect on the model performance metrics when both the 34-layer and a 19-layer CMAQ models were compared to ambient monitoring data.

6.0 MODEL PERFORMANCE EVALUATION

The initial modeling effort focused on evaluating previous regional air quality modeling applications and testing candidate model configurations for the SMOKE emissions and CMAQ model for the VISTAS 36-km and 12-km modeling domains. This effort resulted in a report recommending the model configuration for the annual emissions and air quality modeling, which is included as part of the VISTAS Emissions and Air Quality Modeling Protocol. The evaluation of the meteorological modeling configuration can be found in Appendix F.1, with a summary of the final meteorological and air quality modeling configuration in the modeling protocol contained in Appendix E and Appendix C, respectively.

Air quality model performance for the 2002 modeling year was initially tested in 2004 using an early version of the VISTAS emissions inventory. In keeping with the one-atmosphere objective of the CMAQ modeling platform, model performance was evaluated based on measured ozone, fine particles, and acid deposition in the Air Quality System (AQS), IMPROVE, Speciated Trends Network (STN), Southeastern Aerosol Research and Characterization (SEARCH), National Acid Deposition Program (NADP) and Clean Air Status and Trends Network (CASTNet) monitoring networks (Figure 6.0-1). A detailed examination of the results was published in 2005 in the Journal of Air and Waste Management (see Appendix B.3) as well as being summarized in Appendix B.1.

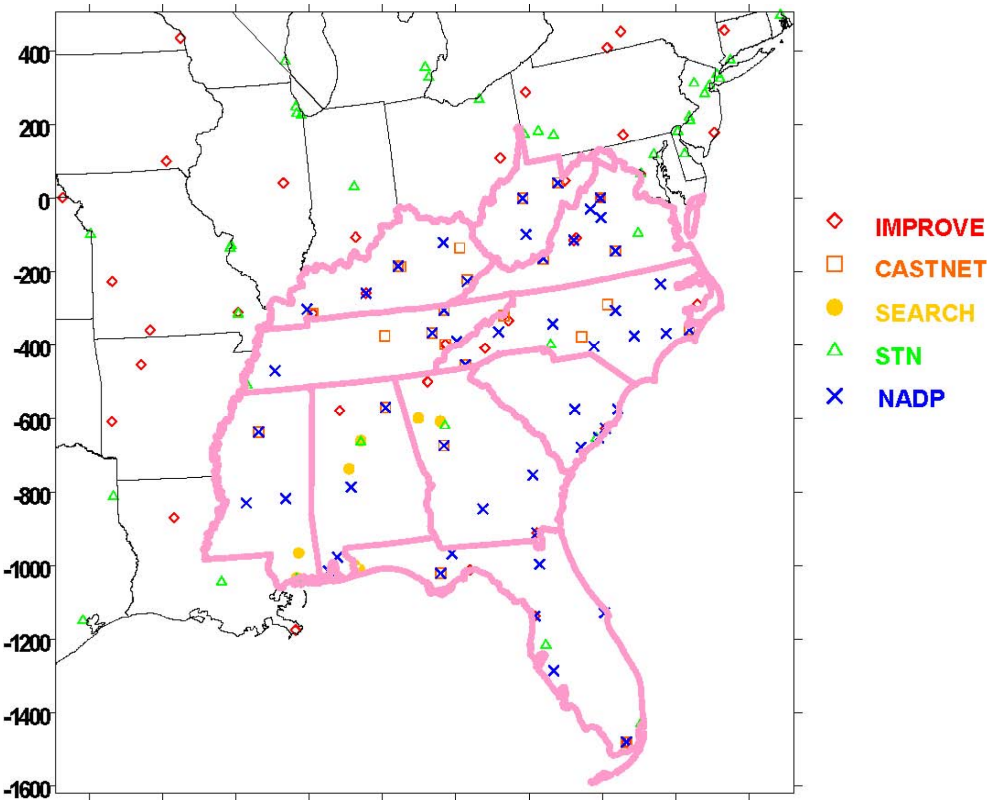


Figure 6.0-1: Monitoring Networks used for VISTAS 2002 model performance evaluation, and their location within the VISTAS 12km domain.

6.1 Modeling Performance Goals, and Criteria

In 2004, VISTAS established model performance goals and criteria for components of fine particle mass (Table 6.1-1) based on previous model performance for ozone and fine particles. The USEPA's 2007 modeling guidance for fine particulate matter at the time noted that PM models might not be able to achieve the same level of performance as ozone models. VISTAS's evaluation considered several statistical performance measures and displays. Fractional bias and mean fractional error were selected as the most appropriate metrics to summarize model performance; other metrics were also calculated and are included for IMPROVE monitors in the full model performance evaluation (Appendix F.2).

Table 6.1-1: Established model performance goals and criteria for the component species of fine particle mass.

Fractional Bias	Mean Fractional Error	Comment
≤15%	≤35%	Goal for PM model performance based on ozone model performance, considered excellent performance
≤30%	≤50%	Goal for PM model performance, considered good performance
≤60%	≤75%	Criteria for PM model performance, considered average performance. Exceeding this level of performance indicates fundamental concerns with the modeling system and triggers diagnostic evaluation.

Several graphic displays of model performance were prepared including:

1. Scatter plots of predicted and observed concentrations and deposition by species, monitoring network, and month
2. Time series plots of predicted and observed concentrations and deposition by species, monitoring site, and month
3. Spatially average time series plots
4. Time series plots of monthly fractional bias and error for a species, region, and network
5. Performance goal plots ("soccer plots") that summarize model performance by species, region, season
6. Concentration performance plots ("bugle plots") that display fractional bias or error as a function of concentration by species, region, monitoring network, and month

The "soccer plots" and "bugle plots" are relatively new tools in model performance evaluations, and have recently been included as model performance evaluation displays in the USEPA's 2007 modeling guidance for ozone, PM2.5, and regional haze. Both "soccer plots" and "bugle plots" allow for convenient way to examine model performance with respect to set goals and criteria. The bugle plots have the added benefit of adjusting the goals and criteria to consider the concentration of the species. Analysis of "bugle plots" generally suggests that greater emphasis should be placed on performance of those components with the greatest contribution to PM mass and visibility impairment (e.g. sulfate and organic carbon) and that greater bias and error could be accepted for components with smaller contributions to total PM mass (e.g. elemental carbon, nitrate, and soil).

6.2 VISTAS Domain-Wide Performance

Further discussion of model performance in this document will focus on the comparison of observational data from the IMPROVE monitors and model output data from the VISTAS 2002 actual annual air quality modeling. Focus is limited to the IMPROVE monitoring network as these sites are the locations used in projecting visibility improvement goals in the Class I areas.

The evaluation will primarily focus on the air quality model's performance with respect to individual components of PM2.5, as good model performance of the component species will dictate good model performance of total or reconstituted PM2.5. Model performance of the total

PM2.5 and the resulting total light extinction will also be provided as a means to discuss the overall model performance for this SIP.

In the analyses, mean fractional bias (error) is used in lieu of mean bias (error), to prevent low observations and model predictions from skewing the metrics. A full list of model performance statistics is found in Appendix F.2. The soccer and bugle plots for the all of the VISTAS IMPROVE monitors are included here for summary purposes. The goal and criteria levels used for regional haze model performance were 30% and 60%, respectively, for mean fractional bias and 50% and 75%, respectively, for mean fractional error. Plots have been developed for the average monthly concentrations and the performance statistics for all of the most significant light scattering component species (Sulfate, Nitrate, and Organic Carbon) for the 20% best days and 20% worst days. Plots for individual IMPROVE monitors associated with North Carolina Class I areas are included in Appendix F.2.

The soccer plots of monthly concentrations (Figures. 6.2-1 and 6.2-2) show that values for nitrate generally fall outside of criteria performance thresholds (red box). Sulfates and organic carbon generally fall within goal thresholds (green box), with a couple of months falling just outside the goal thresholds but well within the criteria thresholds. In these figures, each point represents a month. Figure 6.2-3 contains separate soccer plots for each season. The seasonal plots emphasize poorer nitrate performance in the summer, when observed nitrate is quite low and predicted nitrate is even lower. When concentration is factored into performance criteria, nitrate performance improves with respect to mean fractional bias and mean fractional error (Figures 6.2-4 and 6.2-5).

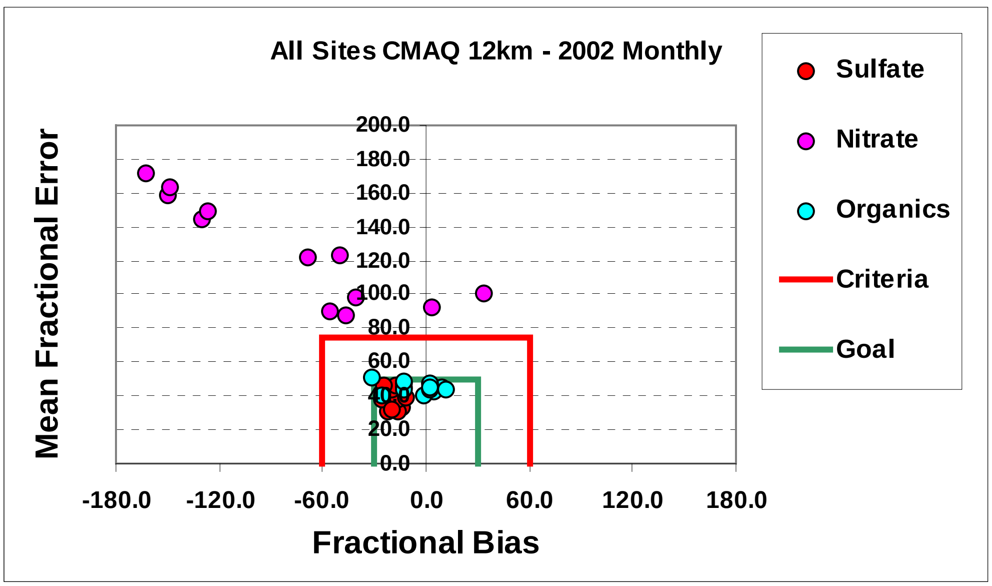


Figure 6.2-1: Soccer plot depicting both the mean fractional error and fractional bias for component concentration for all VISTAS sites.

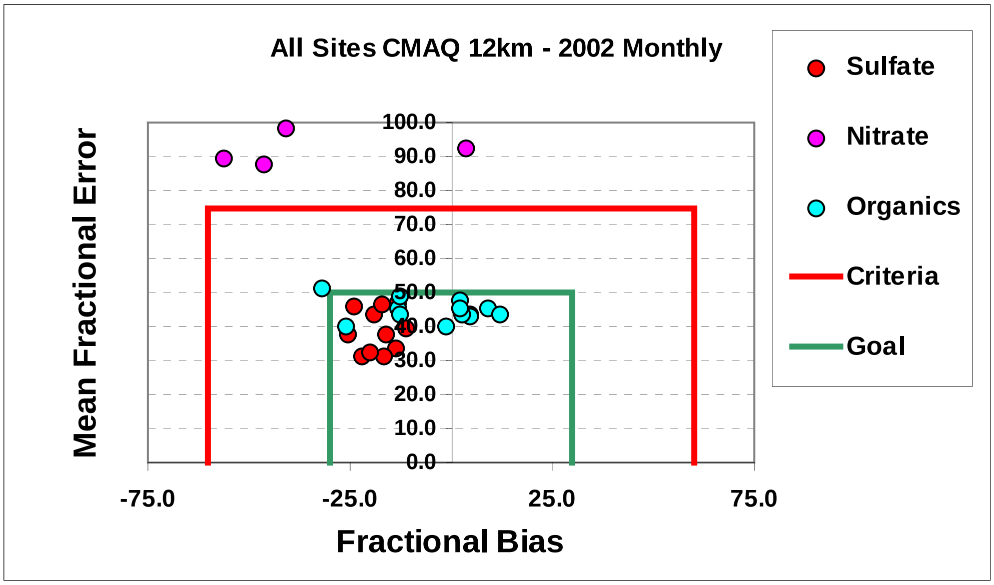


Figure 6.2-2: A zoomed view of the soccer plot depicting both the mean fractional error and fractional bias for component concentration for all VISTAS sites.

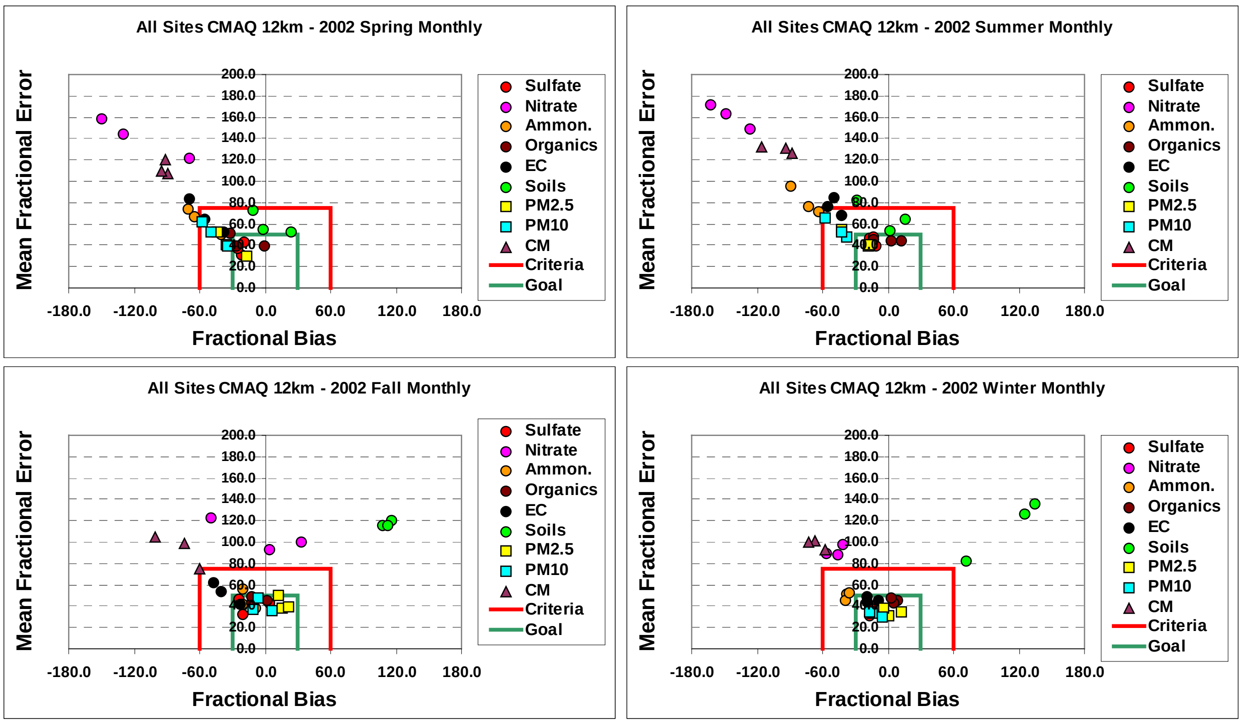


Figure 6.2-3: Seasonal soccer plots for all VISTAS IMPROVE monitors.

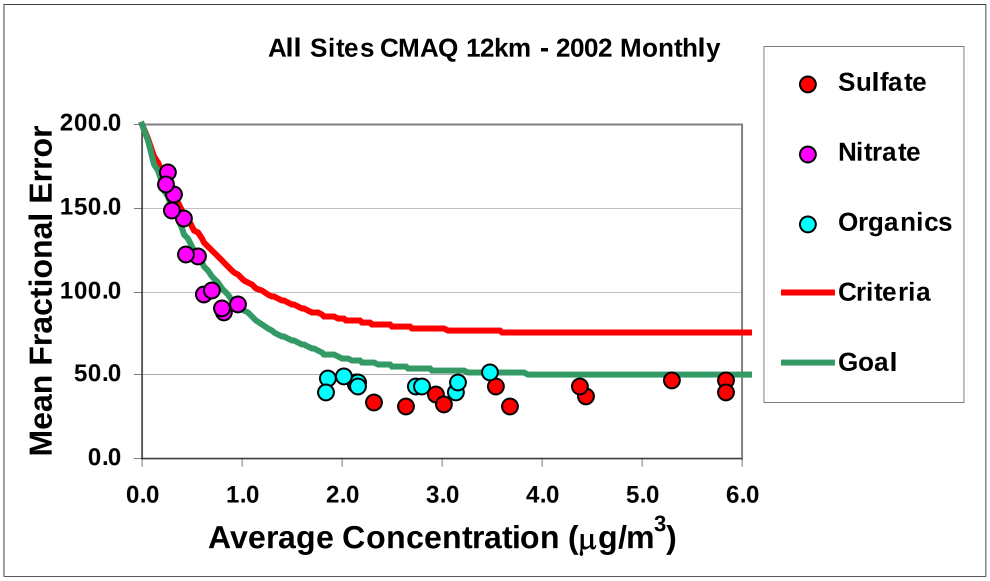


Figure 6.2-4: Bugle plot of the mean fraction bias for particulate matter and its component concentrations for all VISTAS sites.

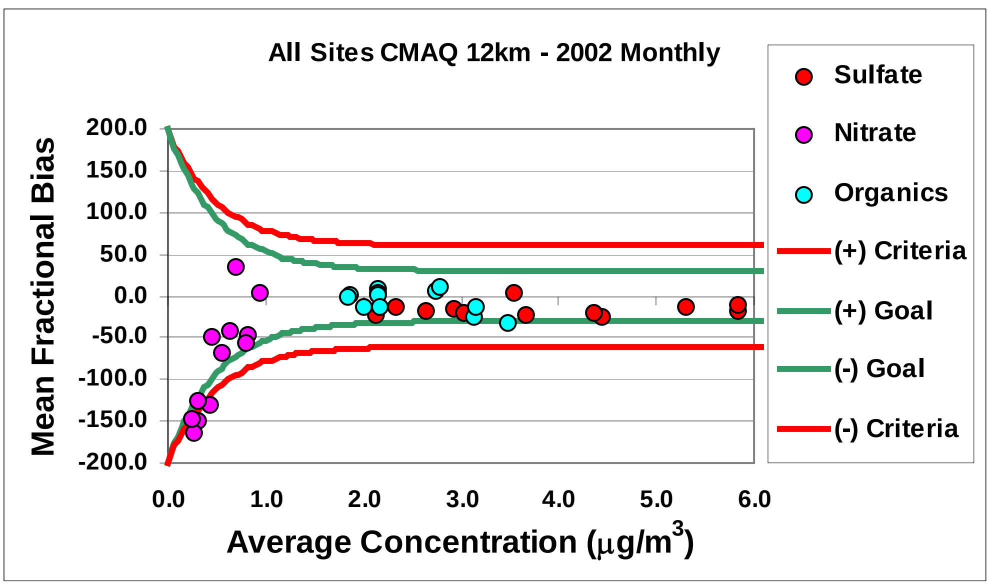


Figure 6.2-5: Bugle plot of mean fraction error for particulate matter and its component species for all VISTAS sites.

Additionally, performance assessed at the "one atmosphere" level was also deemed acceptable for ozone and particulate matter at various monitoring sites (STN, FRM, CASTNet, etc.). Overall, VISTAS found the modeling results to be representative and acceptable for use in modeling projection for ozone, particulate matter, and regional haze.

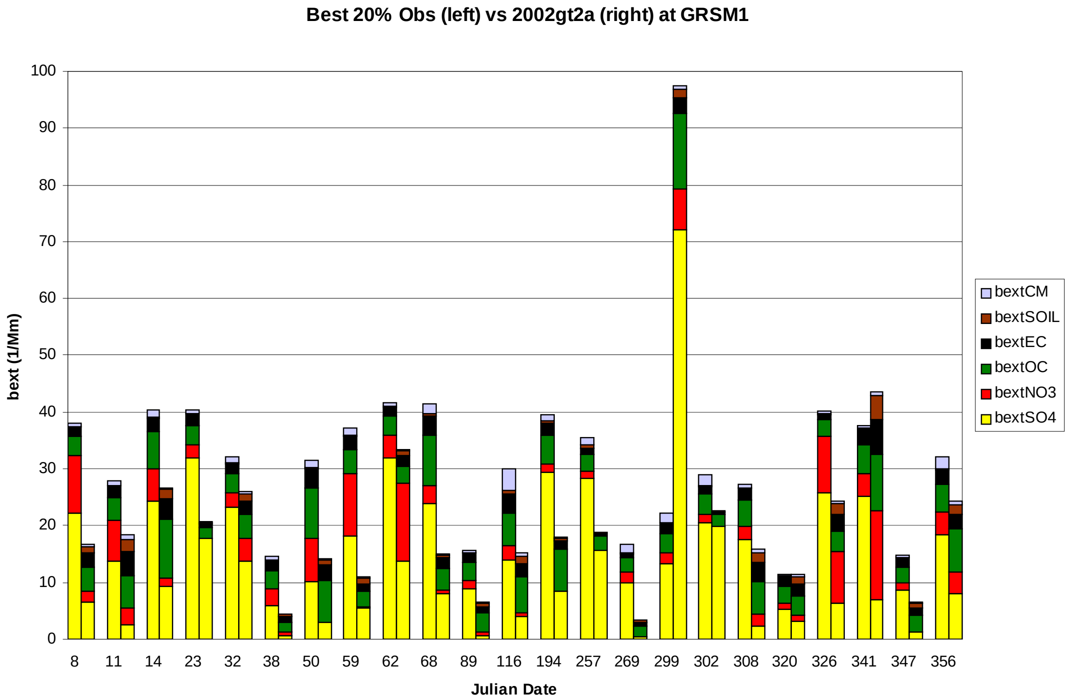
6.3 North Carolina Class 1 Areas Performance

The following section provides stack bar charts comparing observed PM2.5 composition and modeled PM2.5 composition. The charts have been split into two charts, with the first displaying the 20% best days followed by the chart for the 20% worst days. Stacked bar charts have been developed for each of the four IMPROVE monitoring sites relevant to North Carolina: Great Smoky Mountains National Park, Linville Gorge Wilderness Area, Shining Rock Wilderness Area, and Swanquarter Wildlife Refuge (for the location of these areas see Figure 1.4-1). The Great Smoky Mountains National Park IMPROVE monitor is used to represent the Joyce Kilmer-Slickrock Wilderness Area.

The stacked bar chart allows a side-by-side comparison of the each day's observed and modeled compositional and total light extinction. Within each bar the color codes are:

- Yellow = light extinction due to sulfates (bextSO4)
- Red = light extinction due to nitrates (bextNO3)
- Green = light extinction due to organic carbon (bextOC)
- Black = light extinction due to elemental (bextEC)
- Brown = light extinction due to soil (bextSoil)
- Grey = light extinction due to coarse mass (bextCM)

The components are presented in the same order for both the observed (left hand bar) and modeled bar (right hand bar), so it easy to identify days when the prediction light extinction for the component differs from the observed. The total height of the bar provides the total reconstructed particulate matter light extinction value.



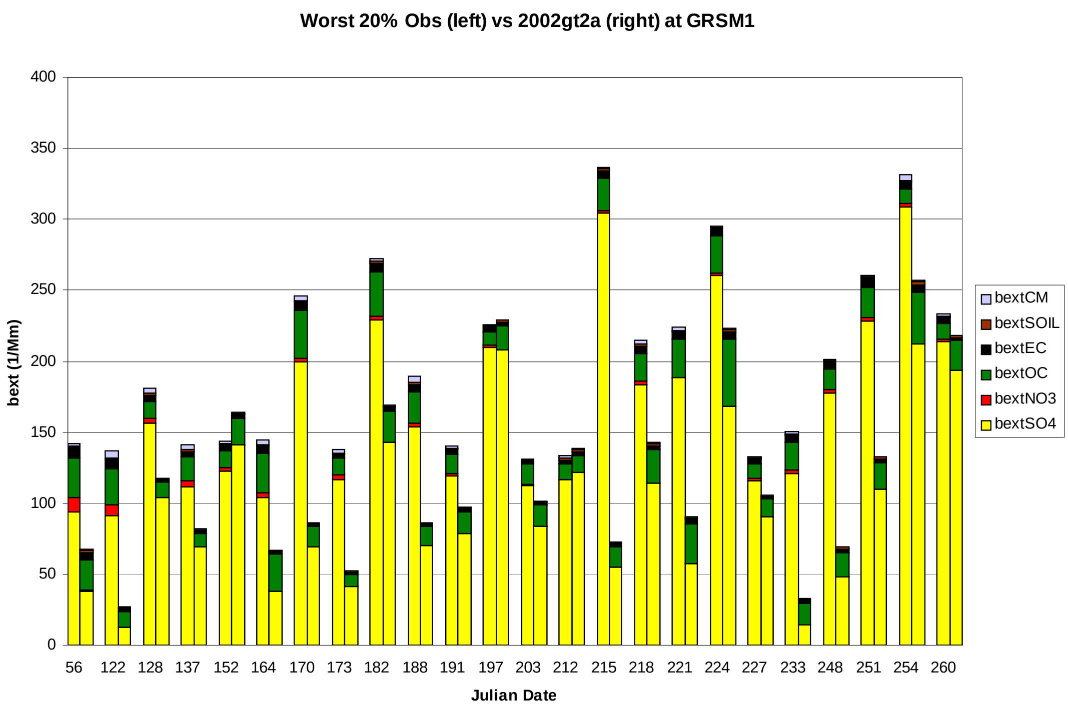
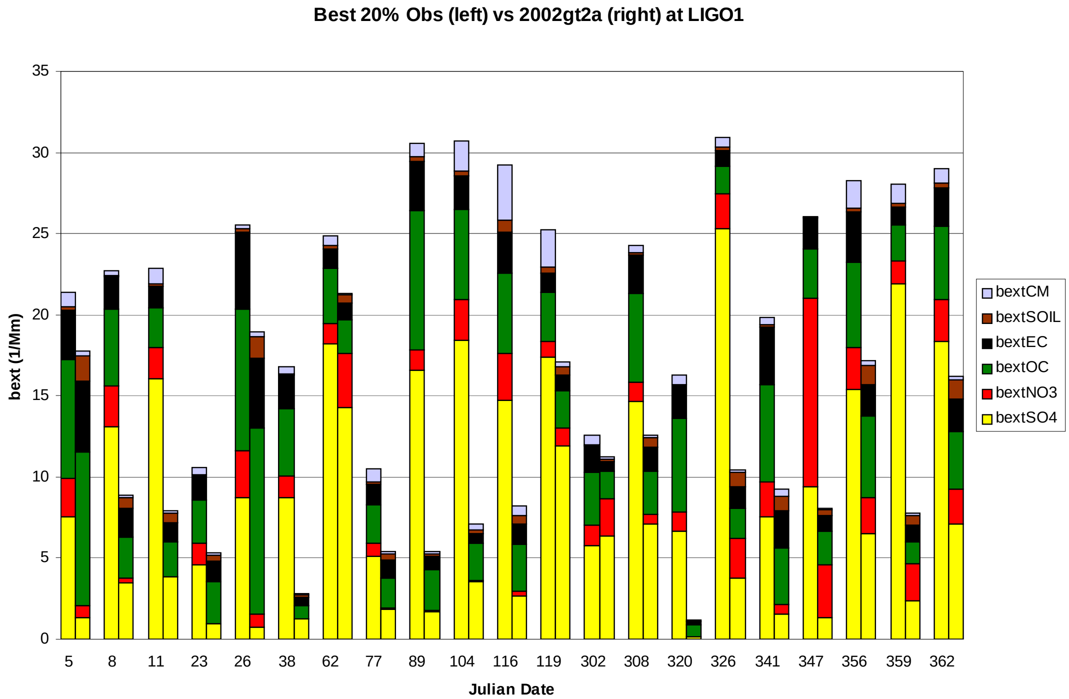


Figure 6.3-1: Stacked bar chart for Great Smoky Mountains National Park on the 20% best days (top) and 20% worst days (bottom). Observed composition is presented in the left hand bar, with modeled composition represented by the right hand bar.



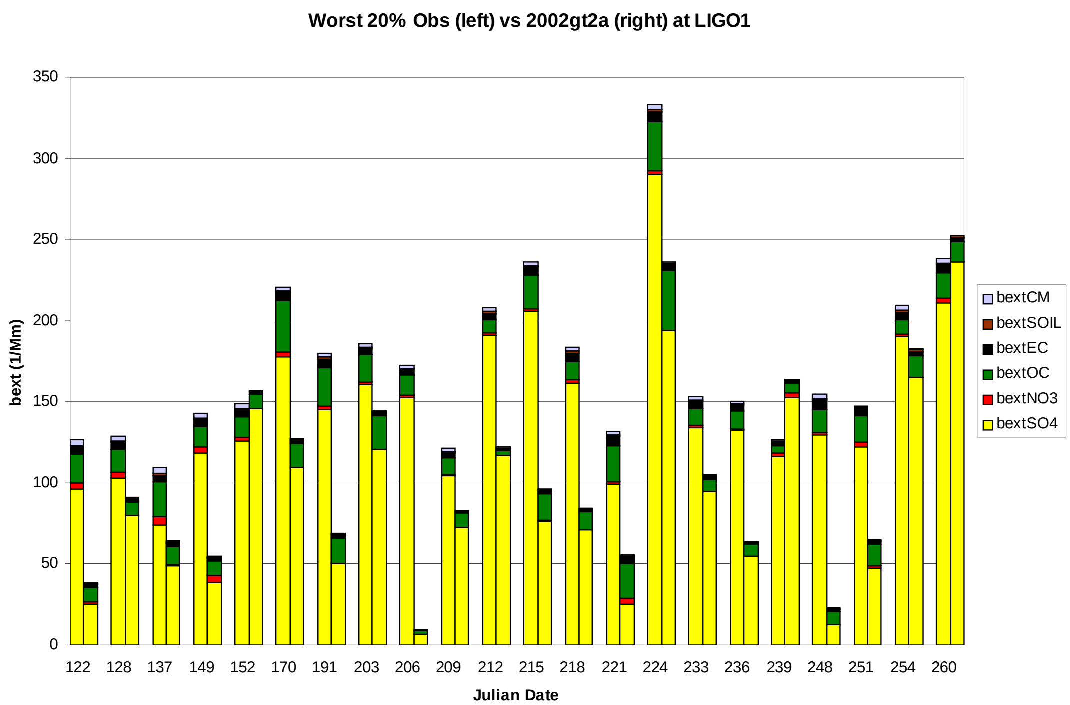
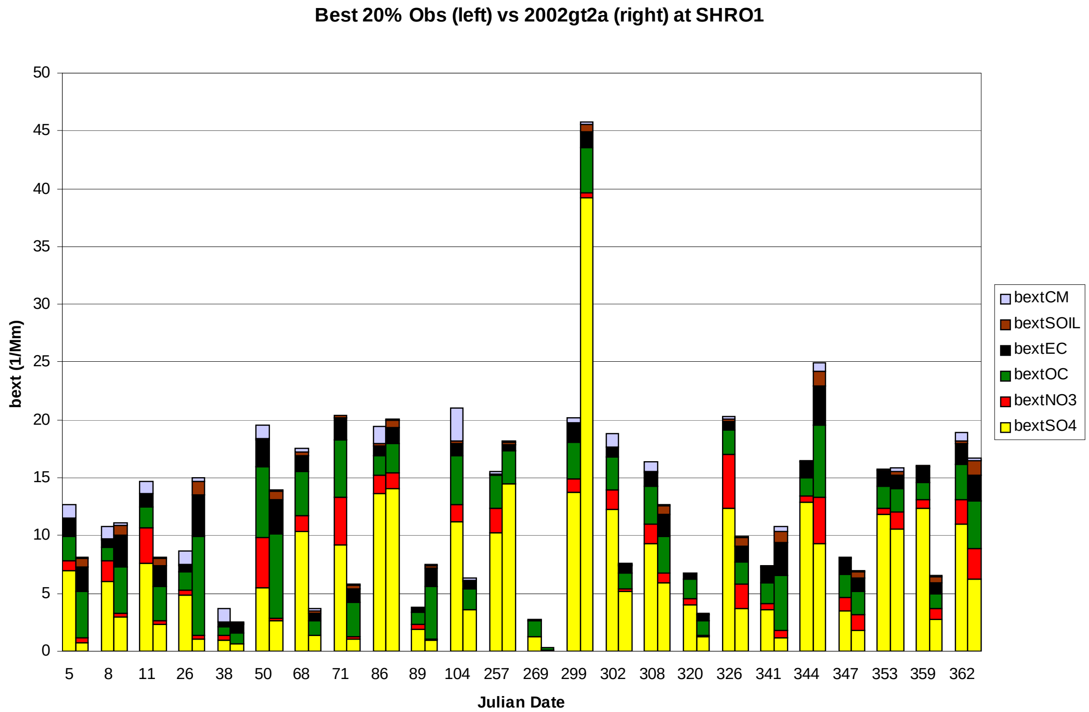


Figure 6.3-2: Stacked bar chart for Linville Gorge Wilderness Area on the 20% best days (top) and 20% worst days (bottom). Observed composition is presented in the left hand bar, with modeled composition represented by the right hand bar.



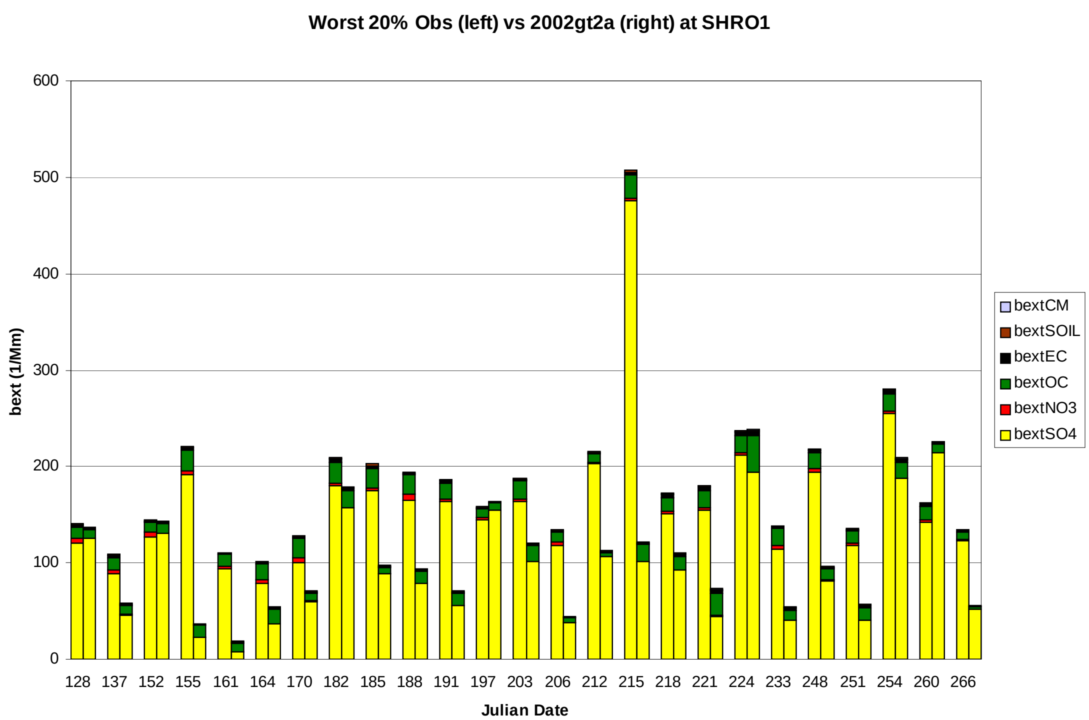
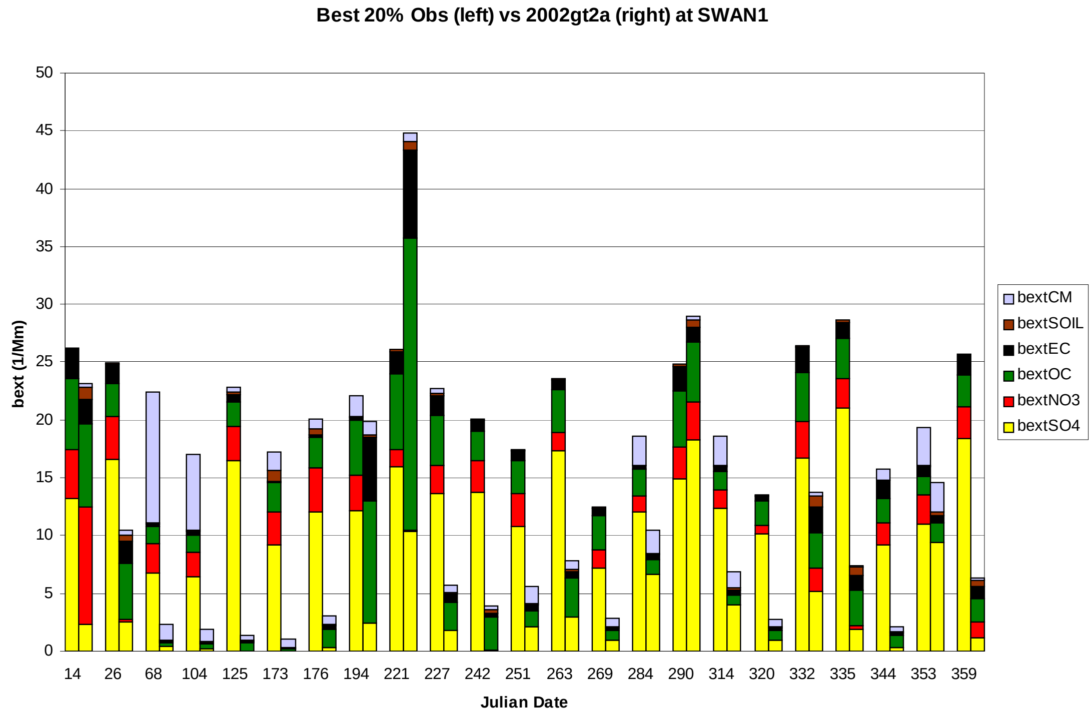


Figure 6.3-3: Stacked bar chart for Shining Rock Wilderness Area on the 20% best days (top) and 20% worst days (bottom). Observed composition is presented in the left hand bar, with modeled composition represented by the right hand bar.



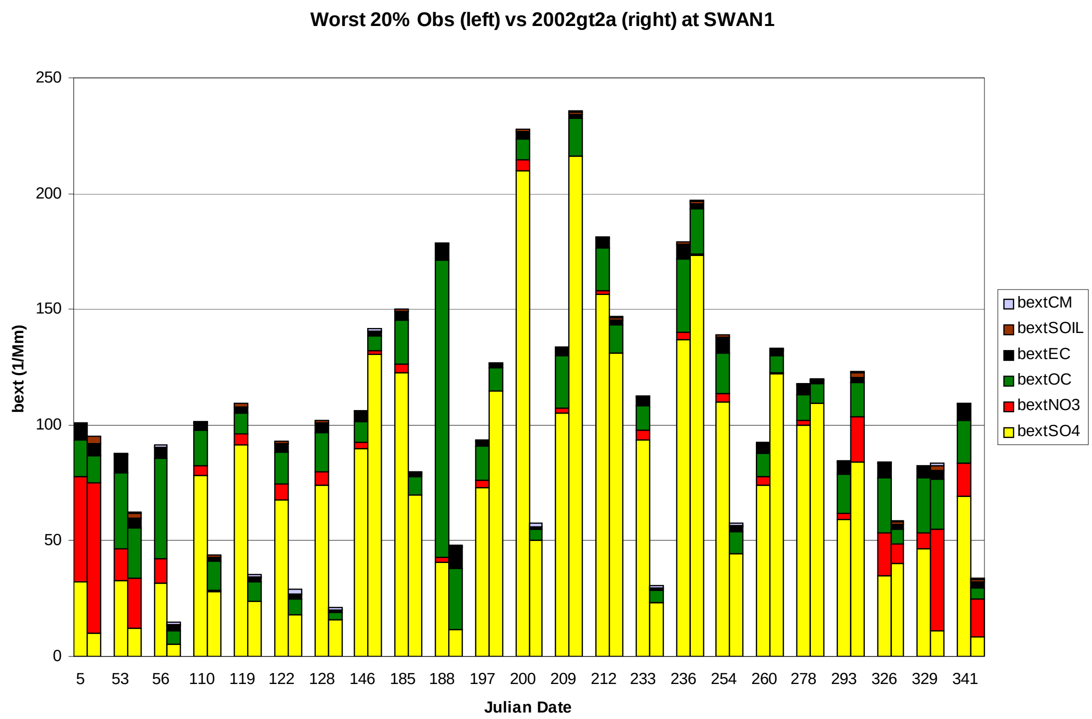


Figure 6.3-4: Stacked bar chart for Swanquarter Wildlife Refuge on the 20% best days (top) and 20% worst days (bottom). Observed composition is presented in the left hand bar, with modeled composition represented by the right hand bar.

A cursory view of the stacked bars charts reiterates that sulfates are a large contributor to light extinction in the North Carolina Class I areas on both the 20% best days and the 20% worst days. The bar charts also suggest that organic carbon and nitrates are important on the 20% best days at the four IMPROVE sites of interest for North Carolina. The bar charts for the 20% best reiterate the general under prediction seen in previous sections. Model performance at Linville Gorge and Shining Rock Wilderness areas are arguably better than both the Great Smoky Mountains National Park and Swanquarter Wildlife Refuge for the 20% best days. The under prediction of sulfate on most of the 20% best days appears to be the reason for poor model performance, with the under prediction of nitrate observed on some days. On most 20% best days there is a small under-prediction of sulfate and on some days there is a large nitrate under prediction.

Comparing the 20% best day charts to the 20% worst days charts, one notices that the various components of particle pollution play a more prominent role in the 20% best days than with the 20% worst days. Also, the species make up on the 20% best days varies more widely compared to the 20% worst days. This suggests accurately modeling each species is especially important on the 20% best days. Note the differences in scale of the two charts; on the 20% best days modeled extinction is generally less than 20 Mm-1 different from measured values. For 20% worst days total differences between modeled and measured extinction varies from near zero to greater than 200 Mm-1.

With the bar chart for the 20% worst days, you can see model performance does improve across the sites. Light extinction due to sulfate prediction is better, but still falls short on some days. Light extinction due to organic carbon also become more important to total light extinction. Much like the sulfate component, the organic carbon component accuracy has improved performance over the 20% best day series, thought some days are still under predicted. Overall, the NCDAQ found model performance to fall within acceptable limits for model performance. The NCDAQ further asserts the one-atmosphere modeling performed by the VISTAS contractors is representative of conditions in the southeastern states and is applicable for use in setting reasonable progress goals for the Class I areas.

7.0 LONG-TERM STRATEGY FOR NORTH CAROLINA CLASS I AREAS

As stated in Section 1.3, the regional haze rule requires a State to establish reasonable progress goals for Class I areas within the State, expressed in deciviews, that provide for reasonable progress toward achieving natural visibility conditions by 2064. This first set of reasonable progress goals must be met through measures contained in the State's long-term strategy covering the period from the baseline through 2018. States are also to evaluate the effects of emissions from their State on Class I areas in other states. This section discusses development of North Carolina's long-term strategy.

7.1 Overview of the Long-Term Strategy Development Process

The process NCDAQ's used to develop its long-term strategy was to address the following set of questions:

a. Assuming implementation of existing federal and state air regulatory requirements, how much visibility improvement would be expected at each Class I areas in North Carolina between now and 2018 compared to the area's uniform rate of progress?

b. What additional emission controls represent BART in North Carolina?

c. If additional emission reductions were needed, from what pollutants and source categories would the greatest visibility benefits be realized between the baseline and 2018?

d. Based on the pollutants identified in (c) above, determine the geographic locations (i.e., area of influence) for each Class I area where these emissions having the greatest impact on visibility are found?

e. What types of emissions sources do we find in those areas of influence?

f. Which specific individual sources in those areas of influence have the greatest visibility impacts at a given Class I area?

g. What additional emission controls represent reasonable control measures for those sources identified in (f) above?

h. Given the additional emission reductions from BART and reasonable control measures identified, how much visibility improvement, compared to the glidepath, is expected at Class I areas in North Carolina between the baseline and 2018?

7.2 Expected Visibility Results in 2018 for North Carolina Class I Areas under existing and planned emissions controls

There are significant control programs being implemented between the baseline period and 2018. Emission reductions from these control programs are projected to achieve substantial visibility improvement by 2018 in the North Carolina Class I areas. These programs are described in more detail below.

7.2.1 Federal and State Control Requirements

<u>CAIR</u>**.** CAIR will permanently cap emissions of SO2 and NOx from EGUs in the eastern United States by 2015. When fully implemented, CAIR will reduce SO2 emissions from EGUs in these states by more than 70%, and NOx emissions by more than 60%, from 2003 levels.

<u>NOx SIP Call</u>. Phase I of the NO_X SIP call applies to certain EGUs and large non-EGUs, including large industrial boilers and turbines, and cement kilns. Those states affected by the NOx SIP call in the VISTAS region have developed rules for the control of NOx emissions that have been approved by the USEPA. The NOx SIP Call has resulted in a 68% reduction in summertime NOx emissions from large stationary combustion sources in North Carolina. For

this analysis, we capped the emissions for NOx SIP call-affected sources at 2007 levels, and carried forward the capped levels for the 2009 and 2018 future year inventories.

North Carolina CSA. Under the CSA, enacted in 2002, coal-fired power plants in North Carolina must achieve a 77-percent cut in NOx emissions by 2009 and a 73-percent cut in SO2 emissions by 2013. This legislation establishes annual caps on both SO2 and NOx 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 cannot be sold.

Georgia Multi-pollutant Bill. Georgia enacted regulations in summer 2007 to require coal fired power plants in Georgia to reduce SO2 by approximately 90%, NOx by approximately 50%, and mercury by an estimated 75-85% by 2015. Reductions will affect 21 units at seven facilities. The rule requires specific controls on specific units according to a specific schedule. This is not a cap and trade rule, thus there are no allowances to be banked, sold or traded.

Consent Agreements. Under a settlement agreement, by 2008, Tampa Electric will install permanent emissions-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 NOx, SO2, and PM.

Virginia Electric and Power Company agreed to spend $1.2 billion by 2013 to eliminate 237,000 tons of SO2 and NOx emissions each year from eight coal-fired electric generating plants in Virginia and West Virginia.

A 2002 agreement calls for Gulf Power to upgrade its operation to cut NOx emission rates by 61% at its Crist generating plant by 2007, with major reductions beginning in early 2005. The Crist plant is a significant source of NOx emissions in the Pensacola area.

In October 2007, American Electric Power agreed to spend $4.6 billion dollars to eliminate 72,000 tons of NOx emissions each year by 2016 and 174,000 tons of SO2 emissions each year by 2018 from sixteen coal-fired power plants located in Indiana, Kentucky, Ohio, Virginia and West Virginia.

One-hour ozone SIPs (Atlanta / Birmingham / Northern Kentucky). New SIPs have been submitted to the USEPA to demonstrate attainment of the one-hour ozone NAAQS. These SIPs require NOx reductions from specific coal fired power plants and address transportation plans in these cities.

NOx RACT in 8-hour Nonattainment Area SIPs. The NCDAQ's SIP for the Charlotte/Gastonia/ Rock Hill nonattainment area includes Reasonable Achievable Control Technology (RACT) for NOx for two facilities located in the nonattainment area: Philip Morris USA and Norandal USA. These controls were also modeled in 2018. Additional RACT controls may be realized as other companies subject to RACT complete the determination, but RACT-level controls were assumed for just these two sources.

Heavy Duty Diesel (2007) Engine Standard (for on-road trucks and buses). The USEPA set a PM emissions standard for new heavy-duty engines of 0.01 grams per brake-horsepower-hour (g/bhp-hr), to take full effect for diesel engines in the 2007 model year. This rule also includes standards for NOx and non-methane hydrocarbons (NMHC) of 0.20 g/bhp-hr and 0.14 g/ bhp-hr, respectively. These NOx and NMHC standards will be phased in together between 2007 and 2010, for diesel engines. Sulfur in diesel fuel must be lowered to enable modern pollution-control technology to be effective on these trucks and buses. The USEPA 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, or LSD) to 15 parts per million (ultra-low sulfur diesel, or ULSD).

Tier 2 Tailpipe (On-road vehicles). The USEPA mobile source rules include the Tier 2 fleet averaging program, modeled after the California LEV II standards. Manufacturers can produce vehicles with emissions ranging from relatively dirty to zero emissions, but the mix of vehicles a manufacturer sells each year must have average NOx emissions below a specified value. Tier 2 standards became effective in the 2005 model year.

Large Spark Ignition and Recreational Vehicle Rule. The USEPA has adopted new standards for emissions of NOx, hydrocarbons, and carbon monoxide from several groups of previously unregulated nonroad engines. Included in these are large industrial spark-ignition engines and recreational vehicles. Nonroad spark-ignition engines are those powered by gasoline, liquid propane gas, 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. Nonroad 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.

Nonroad Diesel Rule. This rule sets standards that will reduce emissions by more than 90 percent from nonroad diesel equipment, and reduce sulfur levels by 99 percent from current levels in nonroad diesel fuel starting in 2007. This step will apply to most nonroad diesel fuel in 2010 and to fuel used in locomotives and marine vessels in 2012.

Industrial Boiler/Process Heater MACTs. The USEPA issued final rules to substantially reduce emissions of toxic air pollutants from industrial, commercial and institutional boilers and process heaters. These rules reduce emissions of a number of toxic air pollutants, including hydrogen chloride, manganese, lead, arsenic and mercury by 2009. This rule also reduces emissions of SO2 and PM in conjunction with the toxic air pollutant reductions. The applied Maximum Achievable Control Technology (MACT) control efficiencies were 4 percent for SO_2 and 40 percent for PM10 and PM2.5. The USEPA's industrial boiler MACT rules were vacated on June 8, 2007. The VISTAS states decided to leave these controls in the modeling since it is believed that by 2018 the USEPA will have re-promulgated a boiler MACT rule or states will have addressed the issue through state rule making.

Combustion Turbine and Reciprocating Internal Combustion Engines MACTs. The projection inventories do not include the NOx co-benefit effects of the MACT regulations for Gas Turbines or stationary Reciprocating Internal Combustion Engines, which the USEPA estimates to be small compared to the overall inventory.

VOC 2-, 4-, 7-, and 10-year MACT Standards. Various point source MACTs and associated emission reductions were implemented. Reductions occurring before 2002 were assumed to be accounted for in the 2002 base year inventory.

7.2.2 Additional State programs to reduce emissions

In addition to accounting for specific emission reductions due to ongoing air pollution programs as required under the regional haze rule section 308 (d)(3)(v)(A), states are also required to consider the air quality benefits of measures to mitigate the impacts of construction activities [section 308(d)(3)(v)(B)] and agricultural and forestry smoke management techniques [section 308(d)(3)(v)(E)]. These state measures are discussed in more detail in Appendix H.

7.2.3 Projected 2009 and 2018 Emissions Inventories

The inventories for 2009 and 2018 account for post-2002 emission reductions from promulgated and proposed federal, state, local, and site-specific control programs as of July 1, 2004. In general, emissions inventories were developed for 2009 and 2018 using current control information in North Carolina.

For EGUs, IPM results were adjusted based on state and local air agencies knowledge of planned emission controls at specific EGUs. These updates are documented in the MACTEC emissions inventory report "Documentation of the 2002 Base Year and 2009 and 2018 Projection Year Emission Inventories for VISTAS" dated February 2007 (Appendix D).

For non-EGUs, VISTAS used recently updated growth and control data consistent with the data used in the USEPA's CAIR analyses (Clean Air Interstate Rule Emissions Inventory Technical Support Document, March 2005) supplemented by state and local air agencies data and updated forecasts from the Department of Energy (DOE).

Area source controls were estimated using known state level Stage I controls on gasoline dispensing facilities and open burning estimates, as well as controls used to project emissions for the USEPA's Heavy Duty Diesel rulemaking and for the CAIR rulemaking.

Mobile source controls included local controls underlying the 2002 baseline inventory (vehicle emission inspection, Stage II vapor recovery, anti-tampering, etc.) with changes based on specific State input. The future year inventories were developed by running the MOBILE6.2 model for each year modeled. The future year emissions for the off-road mobile sources included in the USEPA NONROAD model were estimated by running the model for each future year. For the other off-road mobile source categories control data and projections for 1996, 2010, 2015, and 2020 were obtained from the USEPA's CAIR Technical Support Document, and straight-line projections were used to estimate 2009 and 2018 levels.

The following bar charts show expected decreases in emissions of SO2 and NOx across the VISTAS states from 2002 through 2018. (Similar charts for other visibility impairing pollutants are contained in Appendix H). Note that for SO2 emissions in particular, which are the largest contributors to haze, emissions from electric generating facilities are expected to decrease dramatically (70%) between 2002 and 2018. However, even after implementation of CAIR, EGU emissions are projected to remain the largest contributor to haze, comprising more than half of remaining SO2 emissions in most states.

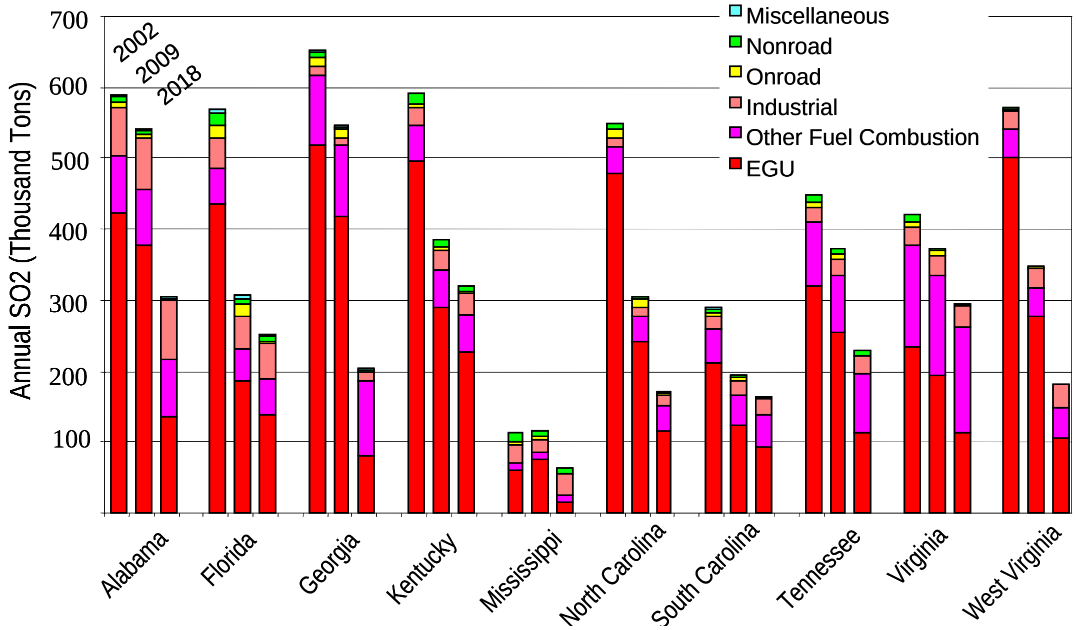


Figure 7.2.3-1. Annual SO2 emissions for 2002, 2009, and 2018 in the VISTAS states.

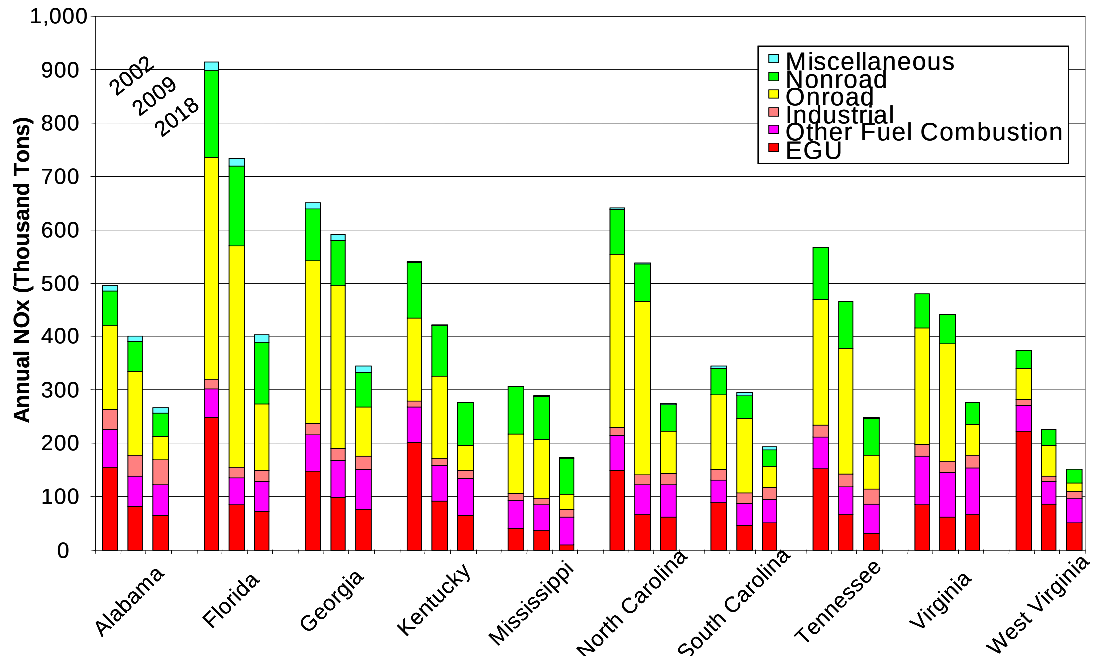


Figure 7.2.3-2. Annual NOx emissions in 2002, 2009, and 2018 in the VISTAS States.

<u>Summary of Emissions Inventories for 2009 and 2018</u>

Tables 7.2.3-1 and 7.2.3-2 are summaries of the 2009 and 2018emission inventory, respectively. The complete inventory and discussion of the methodology is contained in Appendix D.

Table 7.2.3-1. 2009 Emissions Inventory Summary for North Carolina.

	VOC	NOx	PM2.5	PM10	NH3	SO2
Point	62,161	101,236	26,360	36,007	1,730	284,802
Area	200,873	45,382	90,729	315,004	170,734	6,281
On-Road Mobile	168,676	201,609	3,493	5,572	11,825	1,503
Non-Road Mobile	74,056	70,997	5,760	6,055	72	1,892
Biogenics	1,213,819	17,888	NA	NA	NA	NA
TOTAL	1,719,585	437,112	126,342	362,638	184,361	294,478

Table 7.2.3-2. 2018 Emissions Inventory Summary for NC.

	VOC	NOx	PM2.5	PM10	NH3	SO2
Point	71,247	94,276	37,789	48,354	2,073	148,972
Area	203,132	49,514	93,406	338,872	181,333	6,674
On-Road Mobile	101,099	87,791	2,123	4,392	14,065	1,481
Non-Road Mobile	61,327	49,046	4,069	4,298	83	905
Biogenics	1,213,819	17,888	NA	NA	NA	NA
TOTAL	1,650,624	298,515	137,387	395,916	197,554	158,032

7.2.4 Model Results for the 2018 Inventory Compared to the Uniform Rate of Progress Glidepaths for North Carolina Class I Areas

Using 2000 - 2004 IMPROVE monitoring data, the deciview values for the 20% best days in each year are averaged together, producing a single average deciview value for the best days. Similarly, the deciview values for the 20% worst days in each year are averaged together, producing a single average deciview value for the worst days. The average values represent the current visibility conditions.

The predicted visibility improvement is calculated by comparing the 2002 typical year modeling results for the 12-km grid to the 2018 12-km modeling results to develop a relative reduction factor. This factor is then applied to the current visibility condition values to estimate the future visibility. Detailed discussions about how the relative reduction factors are calculated can be found in Appendix G.

For the 20% worst days in the North Carolina Class I areas, Figures 7.2.4-1 through 7.2.4-5 graphically compare the visibility which would result with each area’s uniform rate of progress (red line) to the predicted visibility from 2004 to 2018 due to modeled emission reductions expected by federal and state control programs (purple line). Similarly, for the 20% best days in each area, Figures 7.2.4-6 through 7.2.4-10 graphically compare visibility with no degradation over the first planning period (red line) to the predicted visibility from 2004 to 2018 due to modeled emission reductions expected by federal and state control programs (purple line).

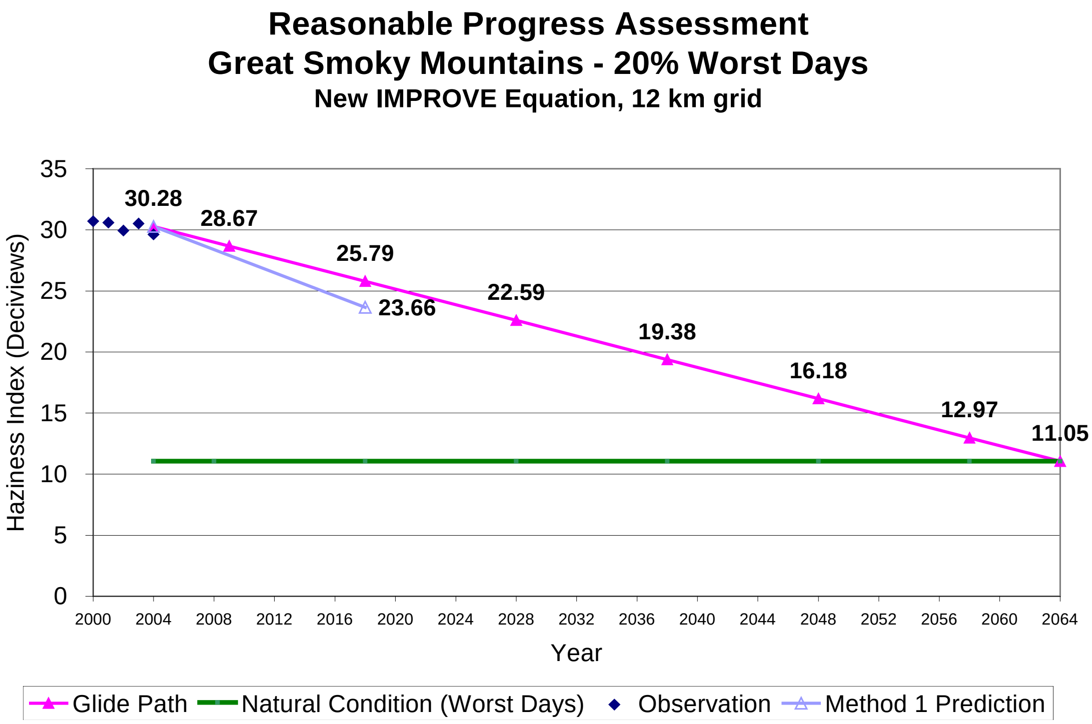


Figure 7.2.4-1. Reasonable progress assessment compared to Uniform Rate of Progress for 20% worst days at Great Smoky Mountains National Park.

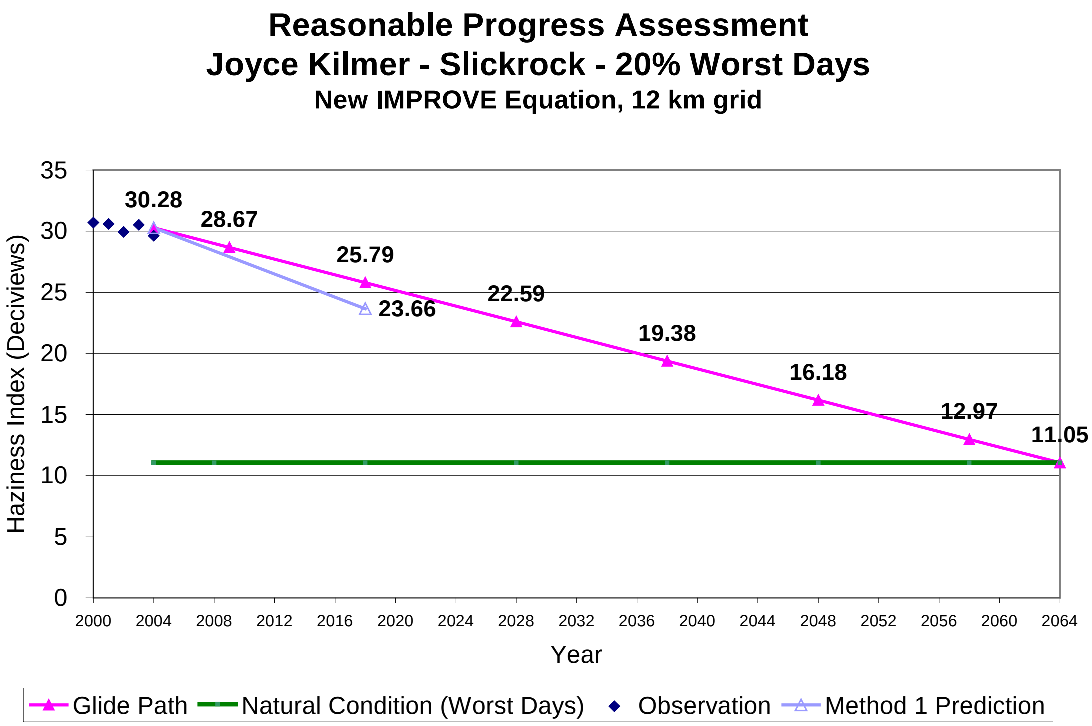


Figure 7.2.4-2. Reasonable progress assessment compared to Uniform Rate of Progress for 20% worst days at Joyce Kilmer-Slickrock Wilderness Area.

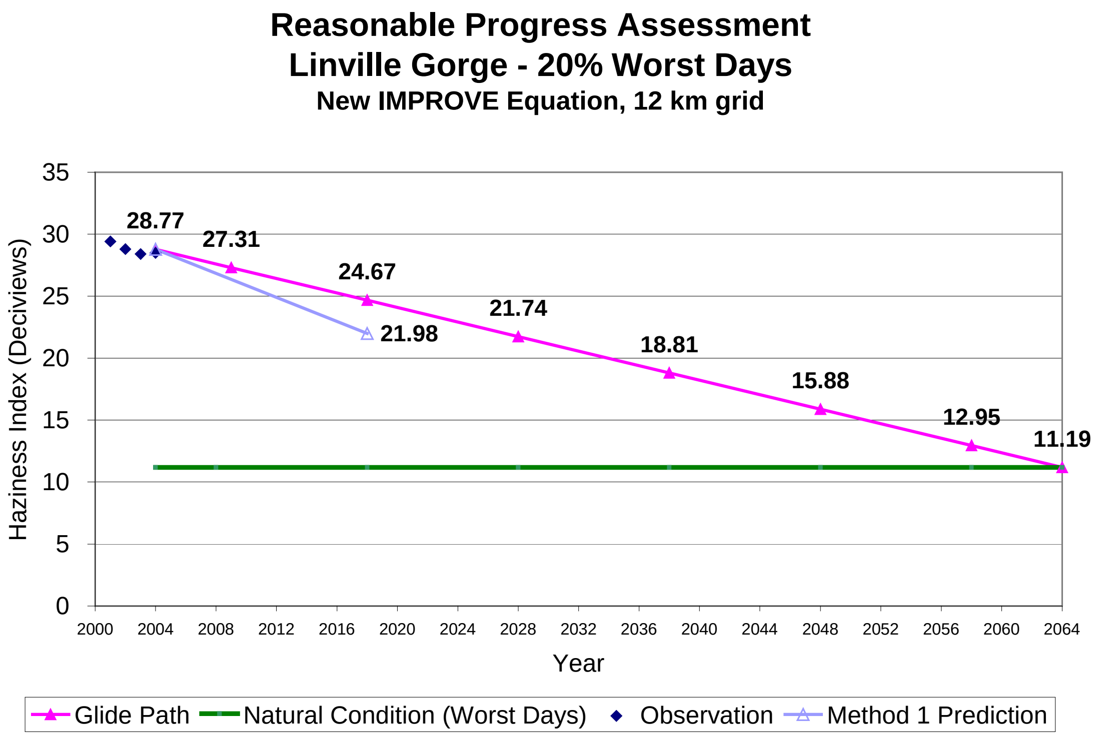


Figure 7.2.4-3. Reasonable progress assessment compared to Uniform Rate of Progress for 20% worst days at Linville Gorge Wilderness Area.

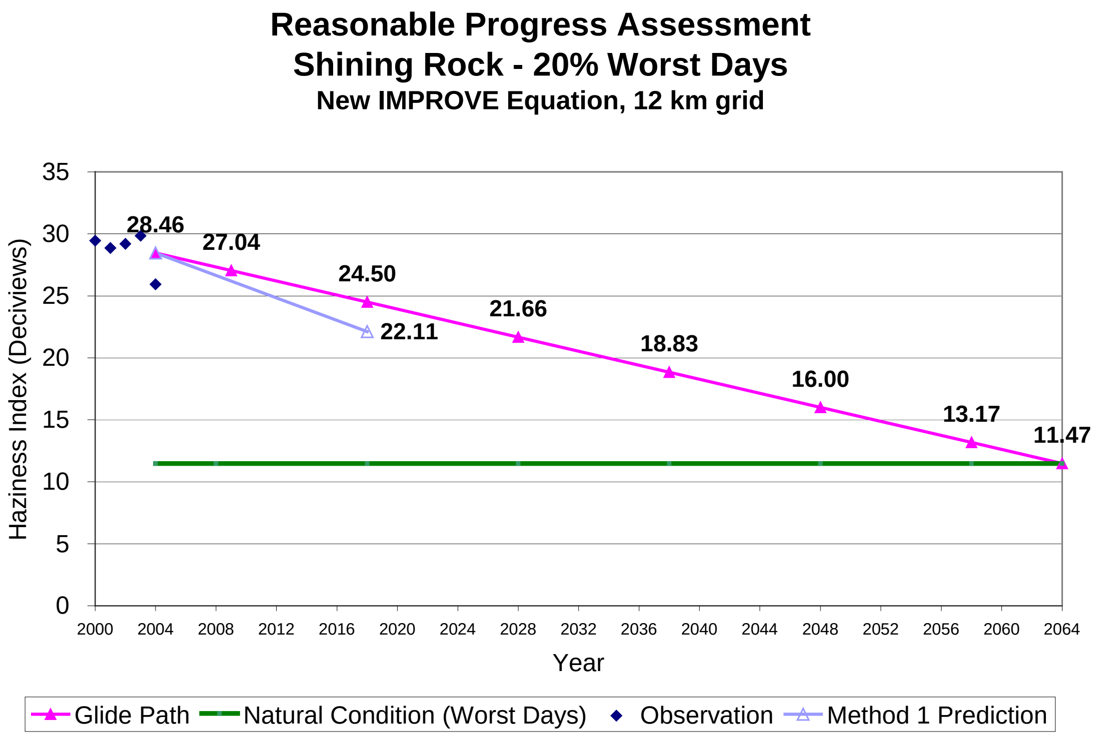


Figure 7.2.4-4. Reasonable progress assessment compared to Uniform Rate of Progress for 20% worst days at Shining Rock Wilderness Area.

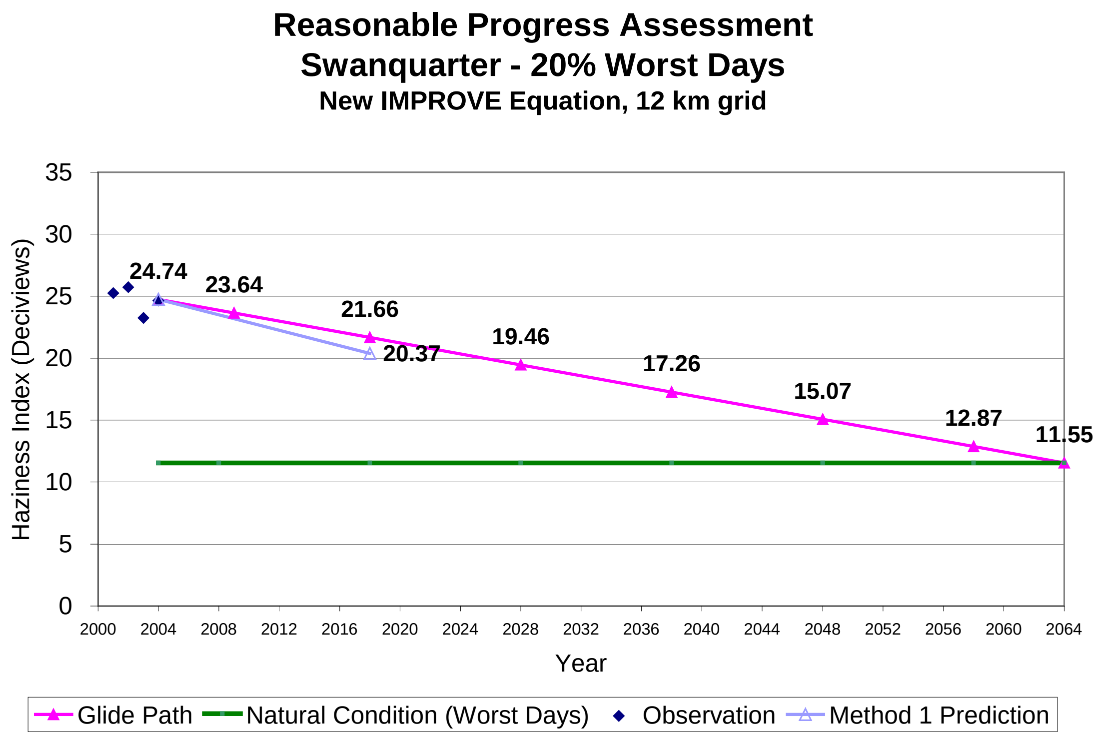


Figure 7.2.4-5. Reasonable progress assessment compared to Uniform Rate of Progress for 20% worst days at Swanquarter Wildlife Refuge.

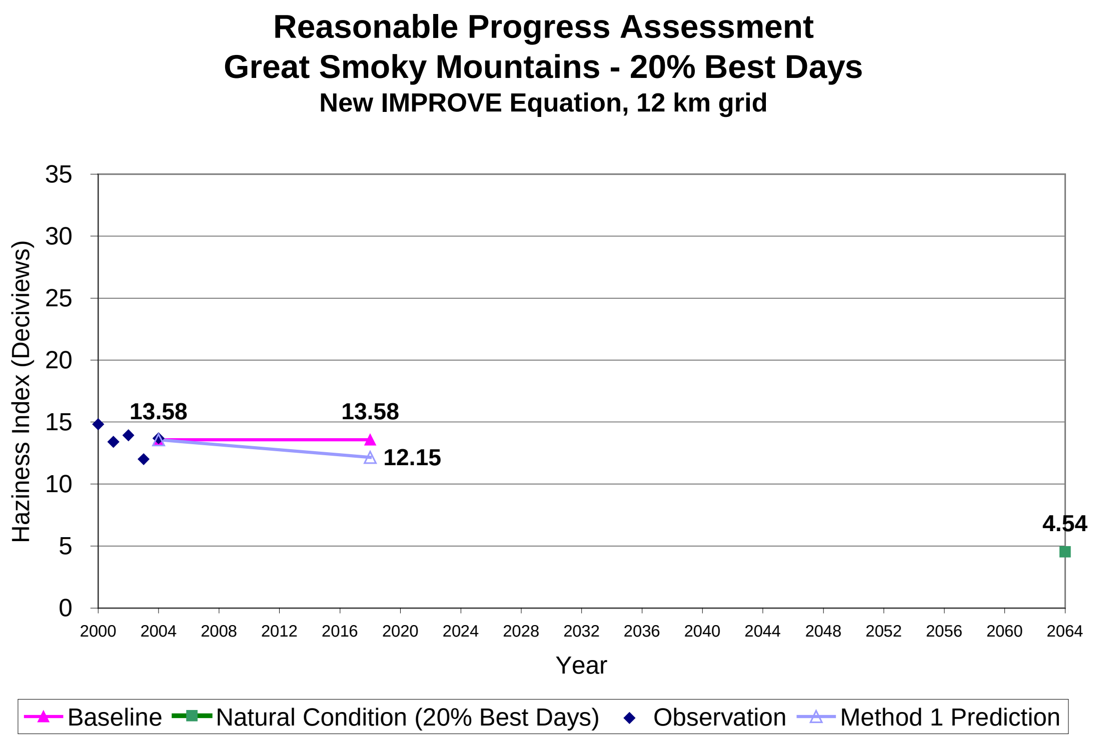


Figure 7.2.4-6 Reasonable progress assessment for 20% best days at Great Smoky Mountains National Park.

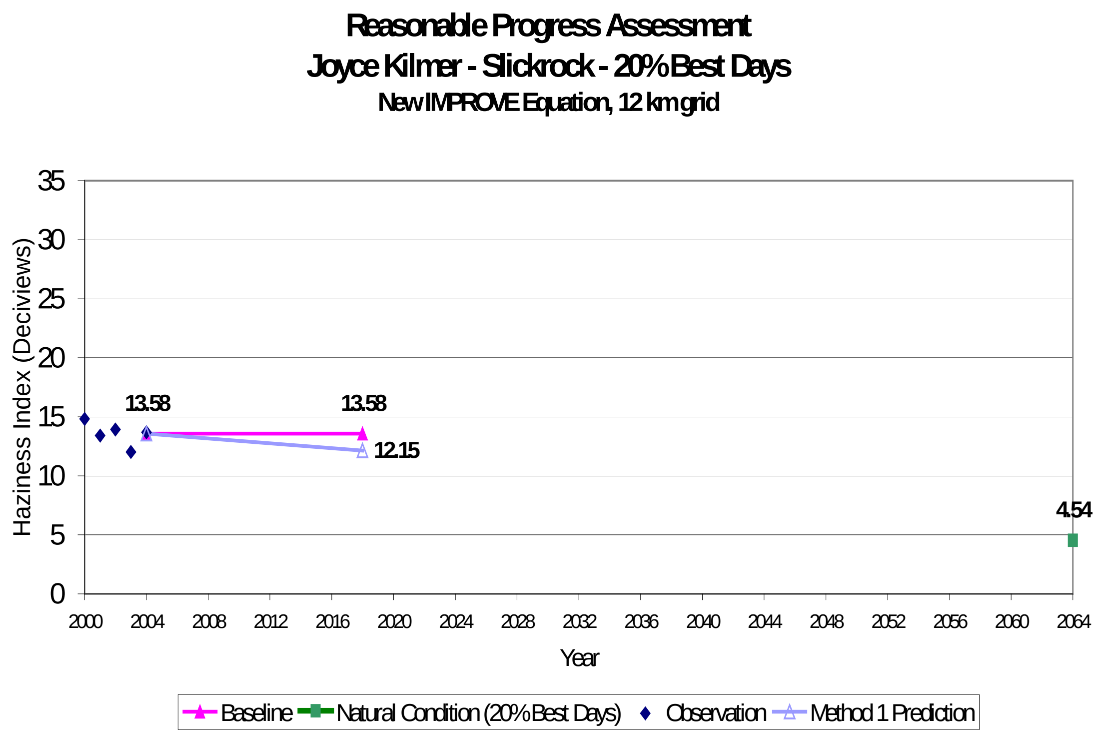


Figure 7.2.4-7 Reasonable progress assessment for 20% best days at Joyce Kilmer-Slickrock Wilderness Area

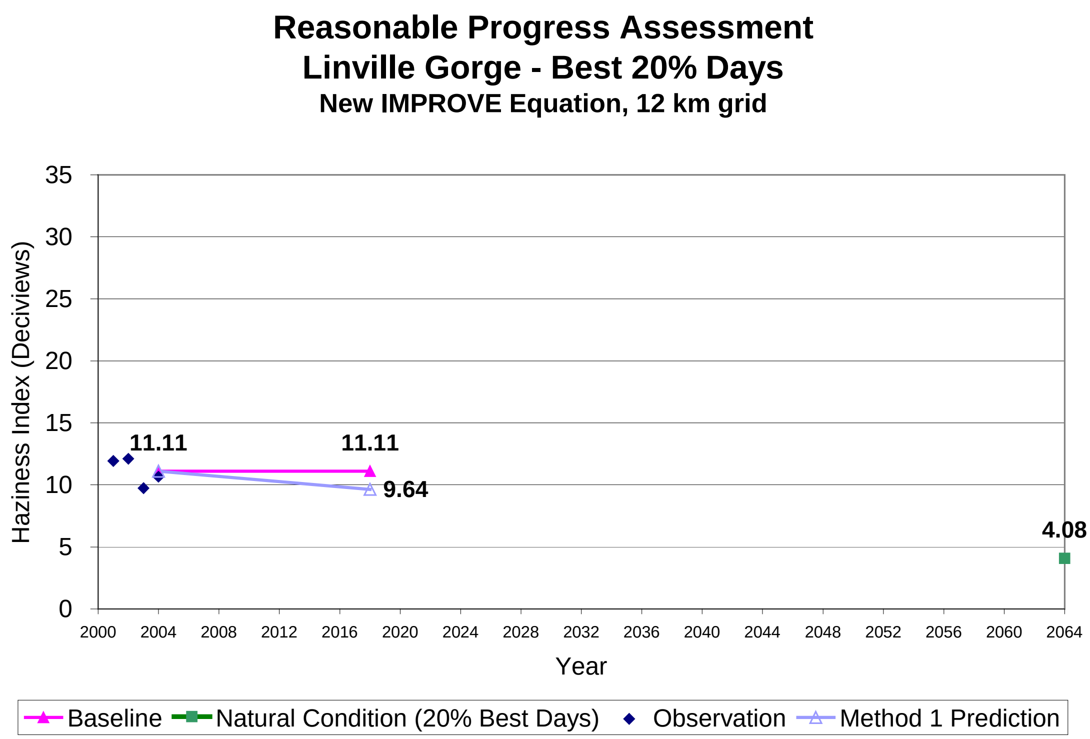


Figure 7.2.4-8 Reasonable progress assessment for 20% best days at Linville Gorge Wilderness Area.

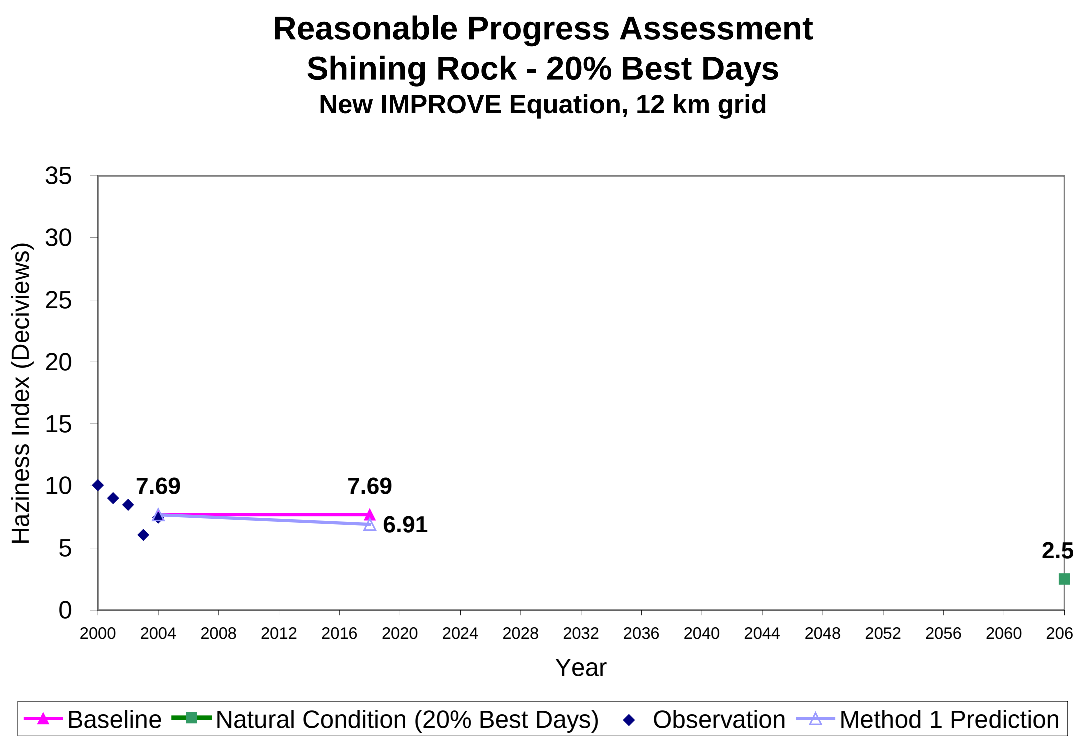


Figure 7.2.4-9 Reasonable progress assessment for 20% best days at Shining Rock Wilderness Area.

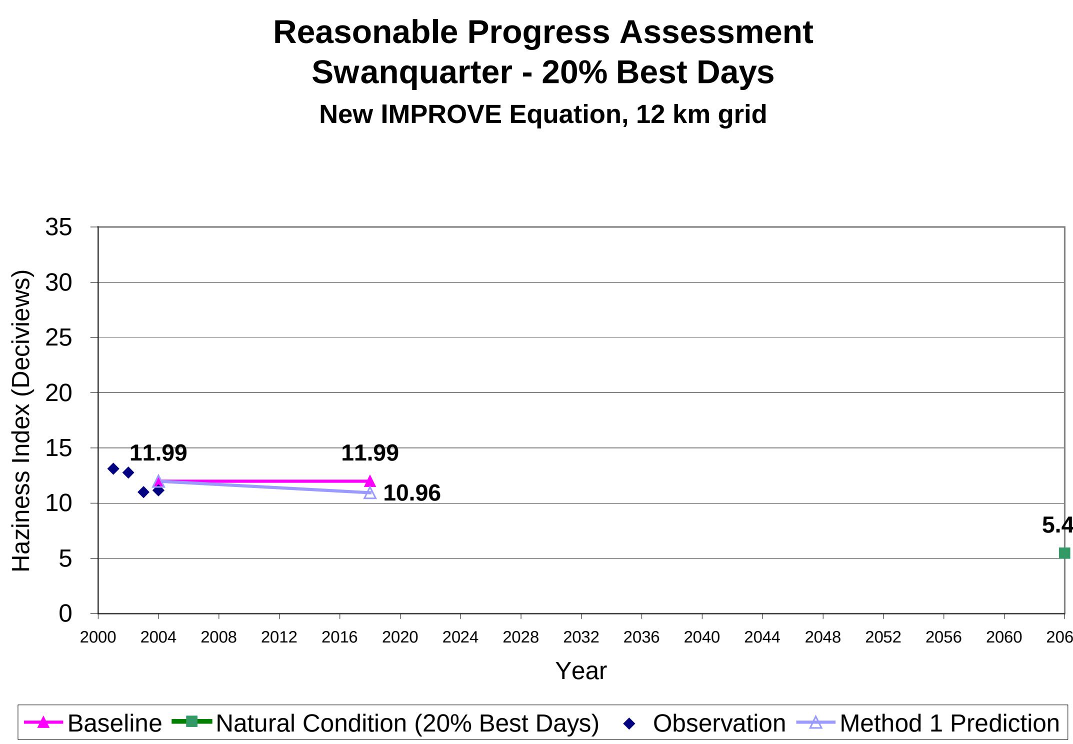


Figure 7.2.4-10 Reasonable progress assessment for 20% best days at Swanquarter Wildlife Refuge.

Note that at all five Class I areas in North Carolina, visibility improvements on the 20% worst days are expected to be better than the uniform rate of progress by 2018 based solely on reductions from existing and planned emissions controls. For example, at Great Smoky Mountains, a 4.5 dv improvement in visibility would meet uniform rate of progress in 2018; expected emissions reductions by 2018 are projected to achieve a 6.6 dv improvement. In fact, as illustrated in Figure 7.2.4-11, visibility improvements at all the VISTAS mountain Class I areas and most of the coastal Class I areas are projected to be better than the uniform rate of progress. In Figure 7.2.4-11, the predicted percentage of the target reduction achieved for the North Carolina Class I areas, using the new IMPROVE equation, is between 140% and 180%. This means that the amount of visibility improvement expected from the modeled control programs is 40% to 80% more than what the uniform rate of progress would be for 2018.

In addition to improving visibility on the 20% worst visibility days, states are also required to protect visibility on the 20% best days at the Class I areas. As illustrated in Figure 7.2.4-12, visibility on the 20% best days is projected to improve in 2018 at all VISTAS Class I areas as a result of the emissions reductions expected from federal and state control programs. In Figure 7.2.4-12, the percentage of the target achieved for the North Carolina Class I areas is about -10%. Zero percent change would mean no change in visibility; -10% means that visibility is better than no change, or a 10% improvement (values lower than current conditions).

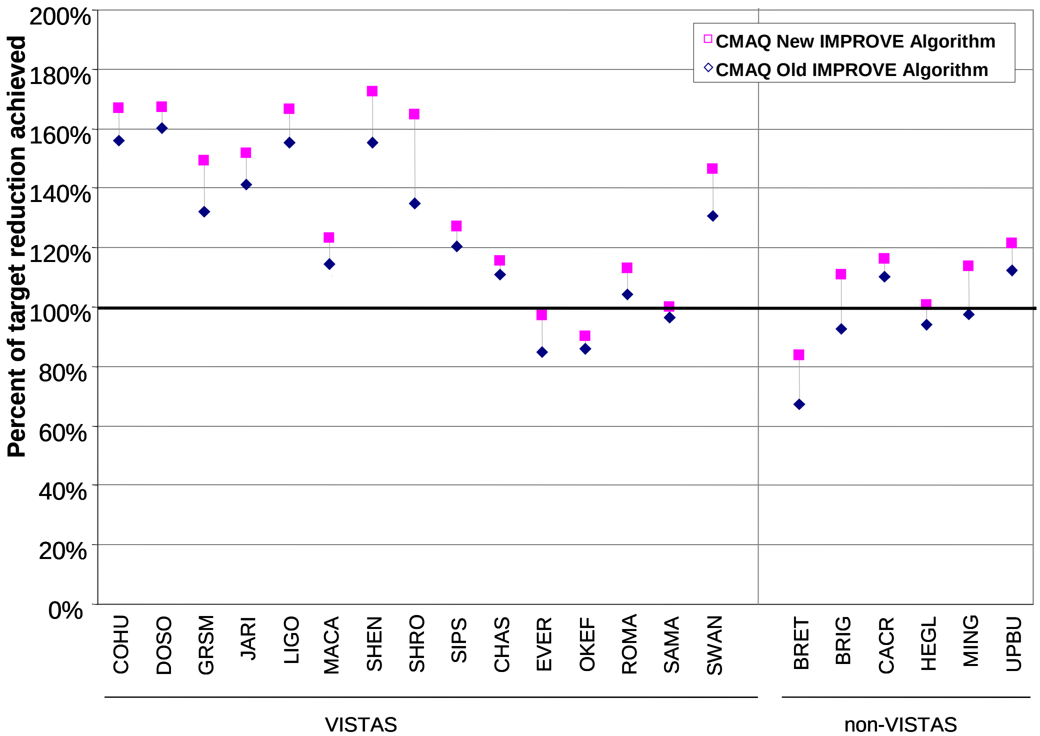


Figure 7.2.4-11. Projected visibility improvement on 20% worst visibility days at VISTAS and neighboring Class I areas for the 2018 (12 km grid)

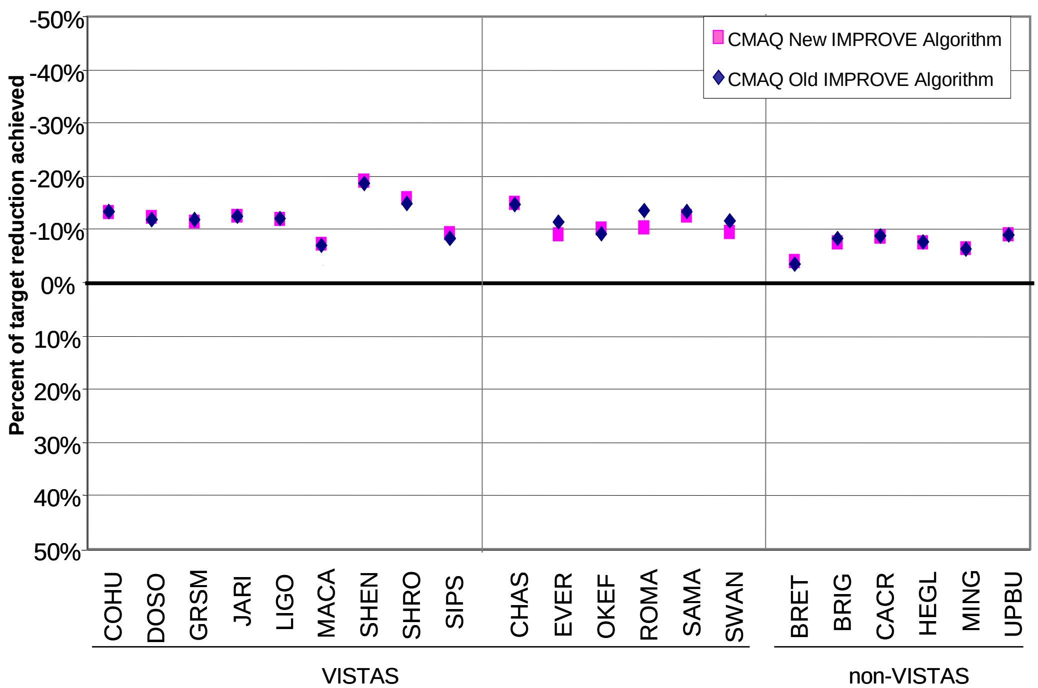


Figure 7.2.4-12. Projected visibility improvement on 20% best visibility days at VISTAS and neighboring Class I areas for the 2018 Base G2a CMAQ run

The expected change in visibility at Great Smoky Mountains between 2000-2004 baseline conditions on the 20% worst days and 2018 projections is illustrated in Figure 7.2.4-13 (upper picture). In contrast, natural background visibility conditions for the 20% worst days are illustrated in the bottom picture in Figure 7.2.4-13. These images were generated using WINHAZE, a photographic imaging tool that accounts for the effect of concentrations of fine particle components and relative humidity on visibility. These images illustrate that notable improvements in visibility are expected by 2018 and that significantly greater improvements are needed to reach natural background conditions.

Figure 7.2.4-13. Visibility improvement on 20 % haziest days at Great Smoky Mountains between 2000-2004 baseline conditions (upper left) and 2018 projected visibility (upper right). Projected visibility on 20 % haziest days for natural background (bottom).

7.3 Relative Contribution from International Emissions to Visibility Impairment in 2018 at VISTAS Class I areas

Emissions from Mexico, Canada, Central America, Asia, and Africa contribute to PM2.5 loadings and visibility impairment at Class I areas in the continental United States. To evaluate the relative contribution of international emissions to visibility at Class I areas in the southeastern United States, VISTAS used a combination of modeling results from the global three-dimensional chemical transport model (GEOS-Chem) and CMAQ. VISTAS used the GEOS-Chem global model to generate initial and boundary conditions for the CMAQ modeling domain. GEOS-Chem was run for the 2002 modeling year using a 4 x 5 degree horizontal grid resolution and a 3-hour temporal resolution. Because emissions were based on monthly averages, the model does not capture the episodic variability in emissions. The GEOS-Chem outputs were used to calculate initial and boundary conditions for the national CMAQ modeling domain. The national CMAQ domain included portions of Canada and Mexico, so emissions for these countries were included within the national CMAQ modeling domain or as part of the boundary conditions outside the national modeling domain, as appropriate.

Two complementary methods were used to calculate the impact of international emissions at Class I areas. Since the international emissions inventory used in the GEOS-CHEM model did not distinguish between wildfires and anthropogenic fires, all international fire emissions were treated as wildfire. This treatment of the international fire emissions would therefore underestimate the impact international anthropogenic emissions have, since the anthropogenic international fire emissions are not included.

1) International emissions are represented by the difference between two GEOS-Chem runs. In the first run United States anthropogenic emissions were removed, and in the second run both United States and international anthropogenic emissions were removed. The difference represents international anthropogenic emissions, in the absence of United States anthropogenic emissions (e.g. compared to 2064 levels). Harvard University provided GEOS-Chem results to VISTAS for 2002 international contribution on 4 x 5 degree grid. Concurrently Harvard modeling for the Electric Power Research Institute (EPRI) provided GEOS-Chem results for 2001 international contribution on a 1 x 1 degree grid scale.

2) International emissions are represented by the difference between two CMAQ 36-km simulations, both using an earlier version of the 2018 emissions and boundary conditions from GEOS-Chem. In the first CMAQ run, all global natural and anthropogenic emissions in 2018 are active. In the second CMAQ run, only global (United States and international) natural emissions are active. Here the impacts of international emissions are compared against 2018 conditions rather than natural background conditions.

VISTAS has compared its results to results from other RPOs on the impact of international emissions and boundary conditions on visibility at Class I areas in 2002; the results were similar.

As illustrated in Figure 7.3-1 for annual average contributions to sulfate at VISTAS and neighboring Class I areas, the estimated international contributions are higher at Class I areas near the Canadian and Mexican borders and along the eastern coast. The estimated international contribution is higher using CMAQ than in the GEOS-Chem runs because the grid scale is finer (more accurate dispersion of emissions) and because the background atmosphere includes loadings from current United States anthropogenic emissions (greater photochemical activity). Similar charts for nitrate and organic carbon mass, for impacts on 20% worst visibility days, and for impacts of international emissions on calculated light extinction are included in Appendix H.

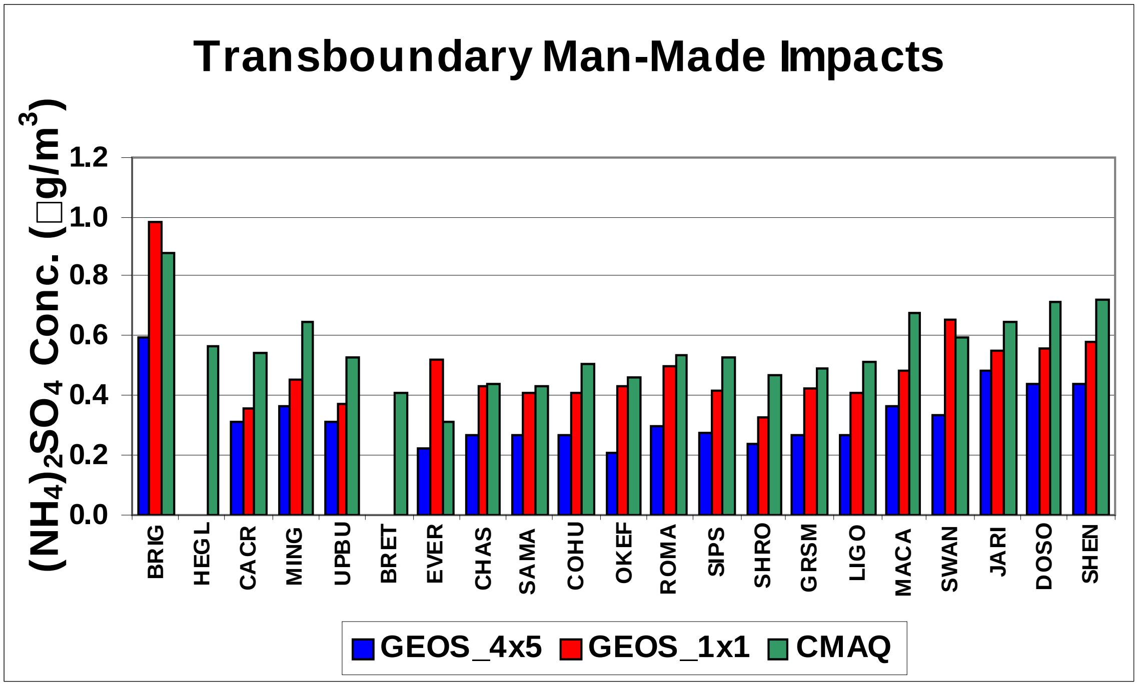


Figure 7.3-1. Estimated international emissions contributions to sulfate at VISTAS and neighboring Class I areas.

In Figure 7.3-2, CMAQ projections of contributions from international emissions to PM mass on 20% worst visibility days in 2002 at Swanquarter, North Carolina are compared to United States domestic contributions to PM components at the site on those days.

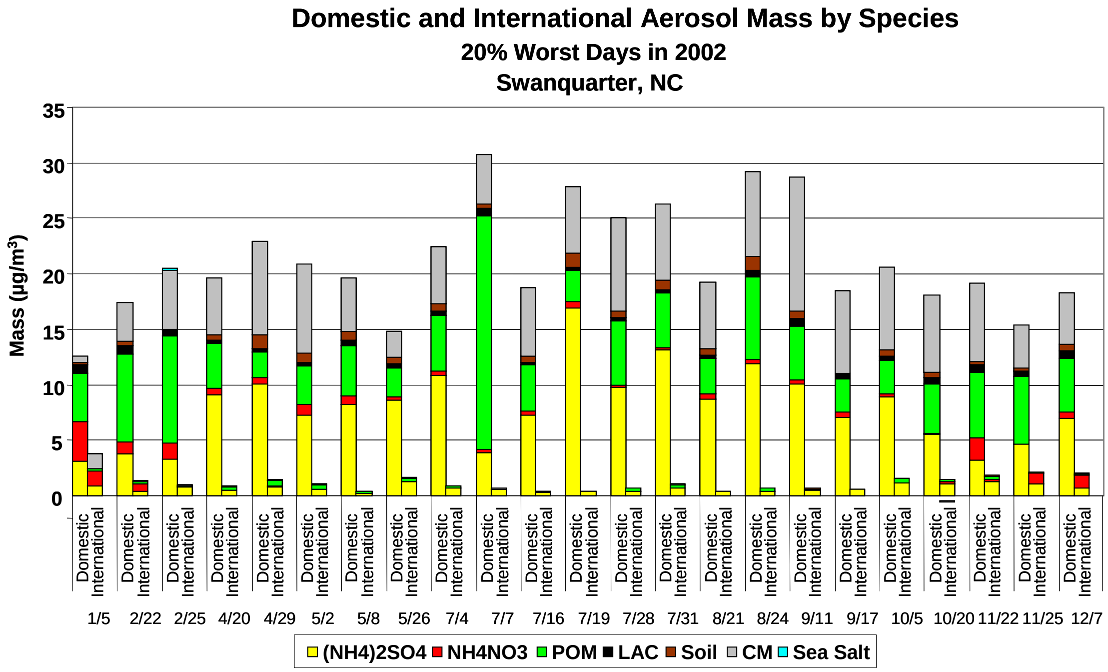


Figure 7.3-2. PM component concentrations from US domestic sources on 20% worst visibility days in 2002 (left bars) and CMAQ-simulated international contributions (right bars) at Swanquarter, North Carolina.

Although VISTAS assessed impacts from international emissions at the Class I areas, these modeling runs were to provide information to the states to understand what the potential impacts may be at their Class I areas. The modeling showed that for the North Carolina Class I areas the impacts from international emissions were between 1.3 and 1.5 dv of the current conditions. Since good projected emissions for areas outside of the continental United States are not readily available, there is no real way to assess what the impacts from international emissions would be for 2018, other than to assume that it would be approximately same amount as for the baseline current conditions. Therefore, the NCDAQ will not be accounting for international emissions in setting the 2018 reasonable progress goals for its Class I areas.

Nevertheless, as the atmosphere becomes closer to natural background conditions in the future, the incremental contribution from international emissions will become more important. The information is included in this SIP documentation to provide reference for future assessments of reasonable progress.

7.4 Relative Contributions to Visibility Impairment: Pollutants, Source Categories, and Geographic Areas

An important step toward identifying potential reasonable control measures is to identify the key pollutants contributing to visibility impairment at each Class I area. To understand the relative benefit of further reducing emissions from different pollutants, source sectors, and geographic areas, VISTAS engaged the Georgia Institute of Technology to perform emission sensitivity model runs using CMAQ. Emissions sensitivities were initially performed for three episodes representing winter and summer conditions: Jan 2002, July 2001, and July 2002. These runs used the initial 2018 projections inventory and considered 30% reductions from specific pollutants, source categories, and geographic areas. As part of a separate effort, emissions sensitivities were performed using a preliminary 2009 projection inventory and two, month-long episodes from 2002: Jun 1 – Jul 10 and Nov 19 – Dec 19. The emissions in 2009 were reduced by 30% for each pollutant sensitivity run. The pollutant contributions that were evaluated were:

- SO2 from EGU sources in each VISTAS state, other RPOs in the VISTAS 12 km grid, and Boundary Conditions from outside the 12 km domain.
- SO2 from non-EGU point sources in each VISTAS state, other RPOs, and Boundary Conditions
- NOx from ground level sources (on-road plus off-road plus area) in each VISTAS state and other RPOs. In the VISTAS states, these reductions were only applied to specific counties that were of concern for 8-hour ozone nonattainment.
- NOx from point (EGU plus non-EGU) sources in each VISTAS state and other RPOs
- NH3 from all sources in VISTAS and other RPOs
- Volatile Organic Compounds from anthropogenic and biogenic sources in the 12 km modeling domain
- Primary Carbon from all ground level sources in each VISTAS state and other RPOs. In the VISTAS states, these reductions were only applied to specific counties that were of concern for PM2.5 nonattainment.
- Primary Carbon from all point sources in each VISTAS state and other RPOs
- Primary Carbon from all fires in each VISTAS state and other RPOs

While the 2009 sensitivity analyses cannot be used to judge absolute contributions from each state or source sector, the results do indicate relative level of response among pollutants, sectors, and geographic areas. The NCDAQ decided to use the 2009 sensitivities to assess relative contribution to visibility impairment from various source sectors and believes this is an appropriate use of this data since the use of the emissions sensitivities is to qualitatively understand how reductions in emissions from various source sectors would impact visibility at the Class I areas.

Results are shown in Figures 7.4-1 through 7.4-4 below for the average of the 20% worst visibility days for each of four North Carolina Class I areas. Responses for 20% worst days were calculated by averaging the responses of the 20% worst days that were modeled in the two episodes. For the North Carolina sites, responses on five to six of the 20% worst visibility days were included in these graphics.

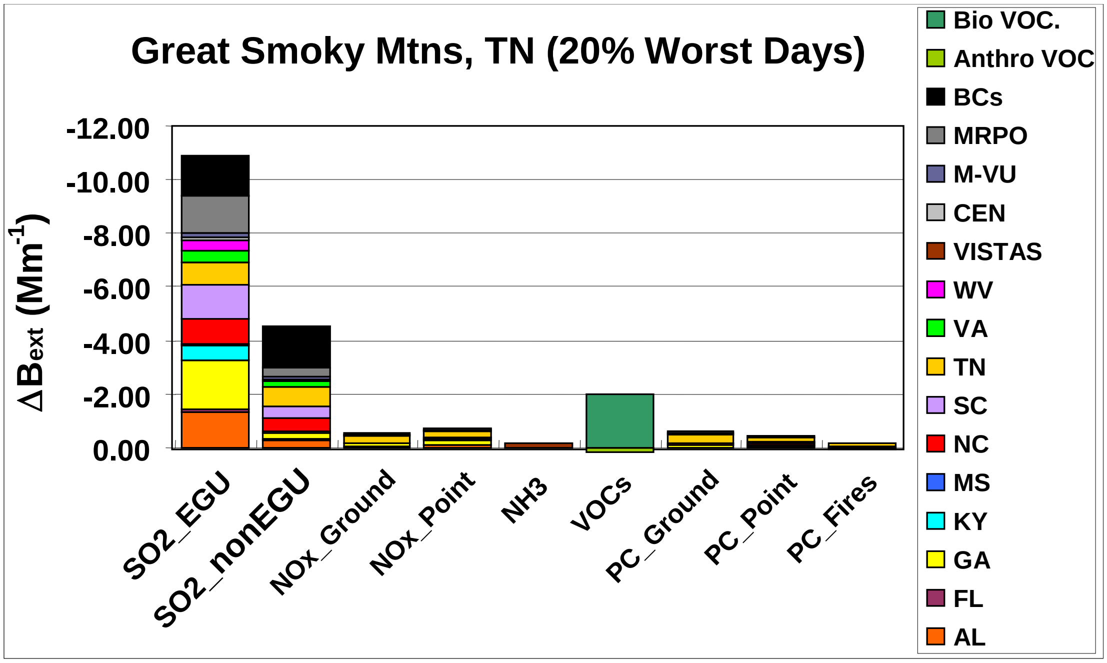


Figure 7.4-1. CMAQ projections of visibility responses on 20% worst days at Great Smoky Mountains to 30 % reductions from a 2009 inventory for visibility-reducing pollutants in different source categories and geographic areas.

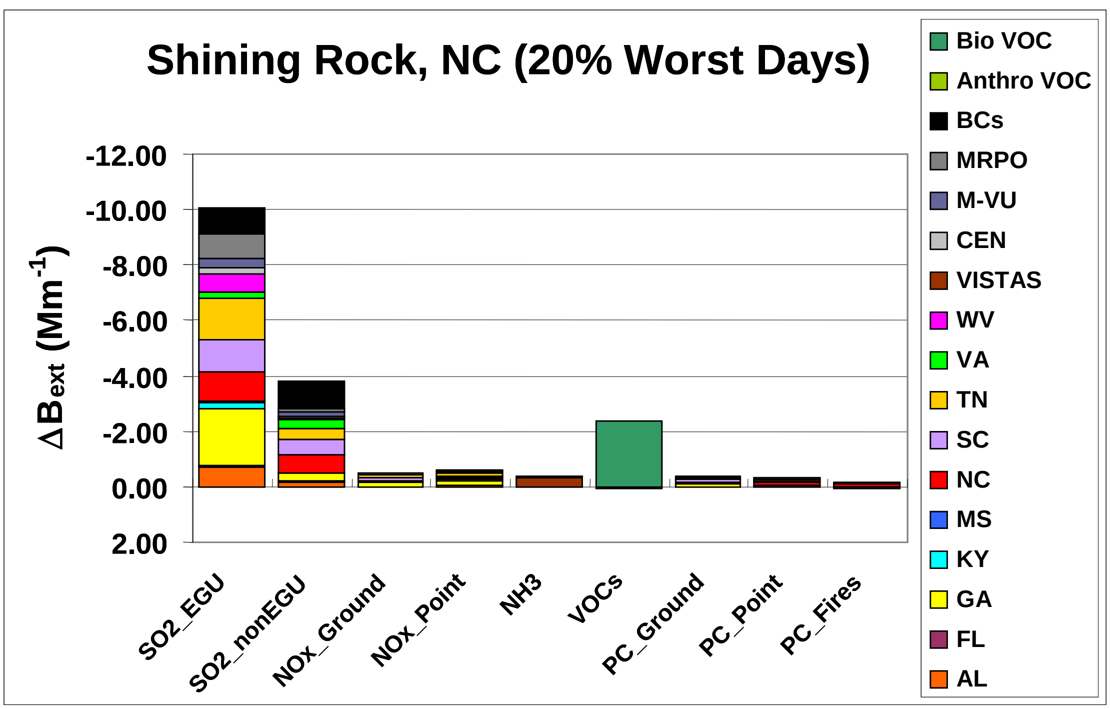


Figure 7.4-2. CMAQ projections of visibility responses on 20% worst days at Shining Rock to 30% reductions from a 2009 inventory for visibility-reducing pollutants in different source categories and geographic areas.

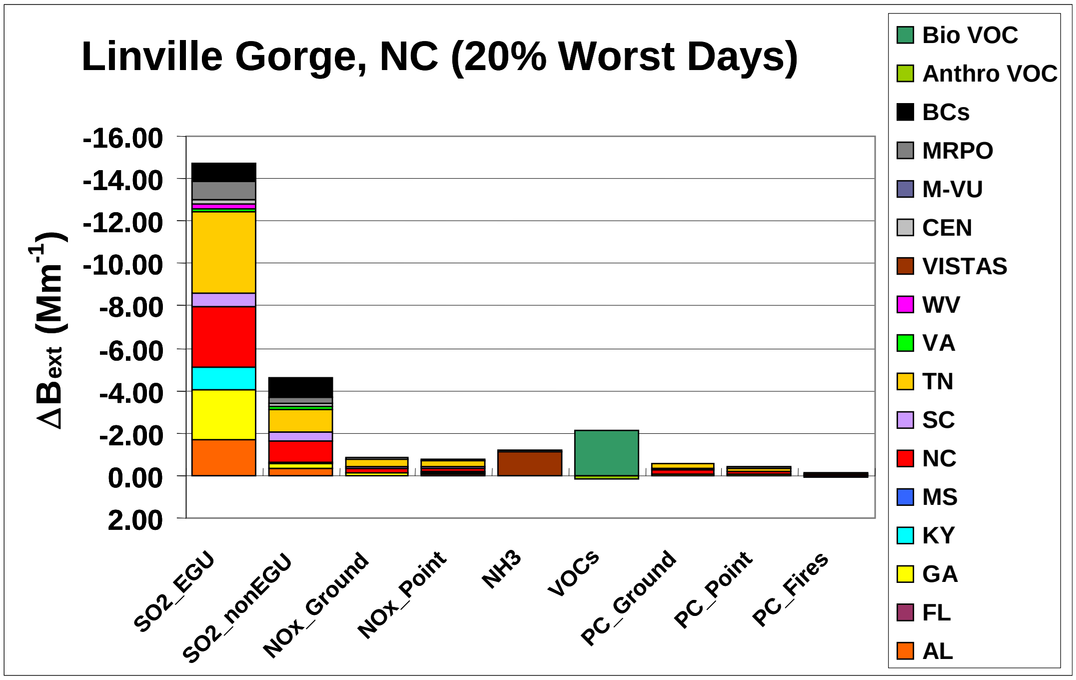


Figure 7.4-3. CMAQ projections of visibility responses on 20% worst days at Linville Gorge to 30% reductions from a 2009 inventory for visibility-reducing pollutants in different source categories and geographic areas.

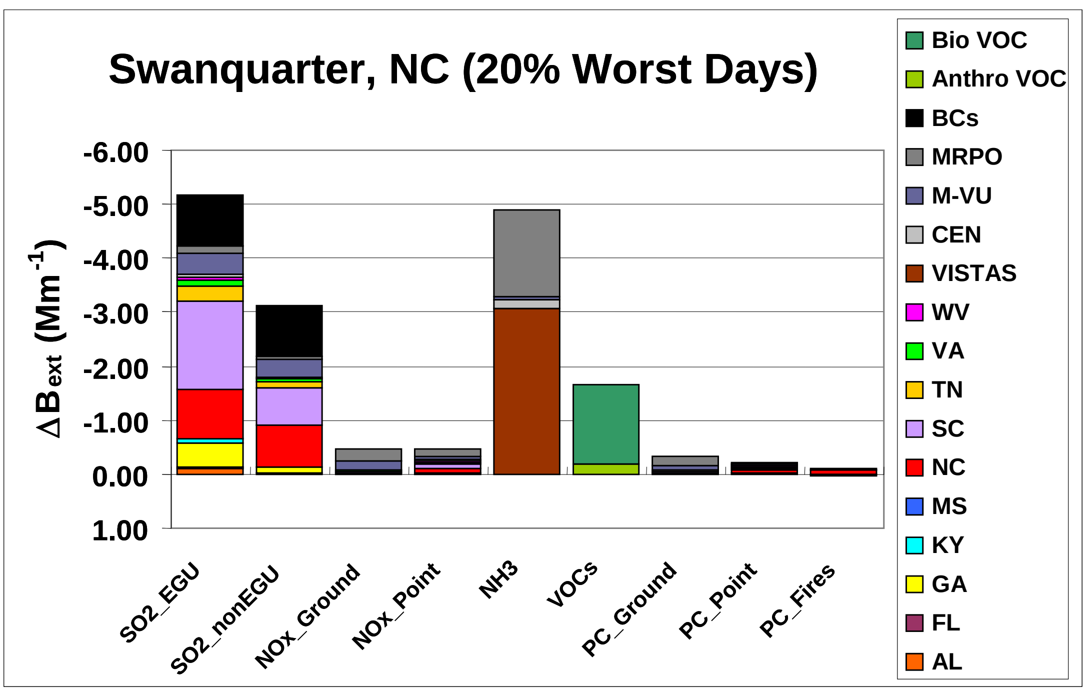


Figure 7.4-4. CMAQ projections of visibility responses on 20% worst days at Swanquarter to 30% reductions from a 2009 inventory for visibility-reducing pollutants in different source categories and geographic areas.

As Figures 7.4-1 through 7.4-4 illustrate, the greatest visibility benefits on the 20% worst days for the North Carolina Class I areas are projected to result from further reducing SO2 from EGUs. At the mountain Class I areas, benefits are projected from SO2 reductions from EGUs in several VISTAS states including Alabama, Georgia, Kentucky, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. Contributions from other RPOs and from the boundary conditions are comparatively small and the greatest benefits would likely be from further EGU reductions within the VISTAS states. In contrast, at Swanquarter, reductions from EGUs in North Carolina and South Carolina would have the greatest benefits and the contributions from other VISTAS states are comparatively small. MANE-VU states also contribute, as do SO2 and SO4 coming into the modeling domain from outside the boundary (e.g. Atlantic Ocean). Additional, smaller benefits are projected from additional SO2 emission reductions from non-utility, industrial point sources. The pattern of relative SO2 contributions from non-EGUs among the various VISTAS states is similar to the pattern of relative SO2 contributions from EGUs.

Because ammonium nitrate is a small contributor to PM2.5 mass and visibility impairment on the 20% worst days at the mountain Class I areas, the benefits of reducing NOx and NH3 emissions at these sites are small. Some of the 20% worst days at Swanquarter, and other coastal sites in the VISTAS states, occur in the winter when ammonium nitrate has a somewhat larger contribution to visibility impairment. As shown in Figure 7.4-4, reducing ammonia emissions would be more beneficial for reducing ammonium nitrate contributions to visibility impairment in wintertime than further reducing nitrogen oxide emissions from either ground or point sources. For Swanquarter, the numerous hog farms in eastern North Carolina are the likely primary emission sources for ammonia.

VOC emissions do contribute to visibility impairment, but as shown in the charts above, this contribution is from biogenic sources such as vegetative emissions. Controlling anthropogenic sources of VOC emissions has little if any visibility benefit at the Class I areas. Reducing primary carbon from point sources, ground level sources or fires are projected to have small to no visibility benefit. This is consistent with the monitoring data that shows that most of measured organic carbon is secondary in origin and primary carbon is only a small fraction of the total measured carbon (Appendix B). The sensitivities were not useful in analyzing reductions carbon from fires because there was little fire activity at these sites on the days modeled. However, looking at the 2000 – 2004 reconstructed extinction, using the new IMPROVE equation, for the 20% worst days it is clear that the number of days where fires played a role in visibility impairment was approximately 2% to 3% of the days in the entire baseline period (see Appendix B). Therefore, although the emission reduction sensitivities did not include many days influenced by fires, this should not impact the ultimate results of the sensitivities.

Note that these results from the emission sensitivity runs are consistent with the conclusions drawn from the 2000-2004 baseline monitoring data (see Section 2.4). The results indicate that sulfate is the dominant contributor to visibility impairment on the 20% worst days at all sites, and that ammonium nitrate may be important for sites where the 20% worst days occur in the winter. The NCDAQ concluded that reducing SO2 emissions from EGU and non-EGU point sources in the VISTAS states would have the greatest visibility benefits for the North Carolina Class I areas. Contributions from the Midwest RPO and MANE-VU are greater at the Class I areas bordering these RPOs. Contributions from outside the VISTAS 12-km modeling domain are more important for the coastal Class I areas. These results are consistent with the CMAQ model results indicating that contributions from international emissions to visibility impairment at VISTAS Class I areas are greater closer to the boundaries of the modeling domain (see summary in Section 7.3 and further discussion in Appendix H).

7.5 What Control Determinations Represent Best Available Retrofit Technology for Individual Sources?

Section 169A of the CAA directs States to assess certain large emission sources for additional controls in order to address visibility impacts. States are directed to conduct BART determinations for such sources in specific source categories, and which contribute to visibility impairment in Class I areas. The 1999 regional haze rule includes the BART requirement, and directs States to include BART in their regional haze SIPs. On July 6, 2005, the USEPA published a revised final rule, including Appendix Y to 40 CFR Part 51, the *Guidelines for BART Determinations Under the Regional Haze Rule* (hereinafter referred to as the "BART Guidelines") that provides guidance to states on determining which of these sources should be subject to BART, and how to determine BART for each source.

A BART-eligible source is one which has the potential to emit 250 tons or more of a visibility-impairing air pollutant, was put in place between August 7, 1962 and August 7, 1977, and whose operations fall within one or more of 26 specifically listed source categories. Under the CAA, a BART determination is required for any BART-eligible source that a State determines ‘‘emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility in any such area.’’

For those sources subject to BART, Section 169A(g)(7) of the CAA requires that States must consider the following factors in making BART determinations: (1) the costs of compliance, (2) the energy and non-air quality environmental impacts of compliance, (3) any existing pollution control technology in use at the source, (4) the remaining useful life of the source, and (5) the degree of improvement in visibility which may reasonably be anticipated to result from the use of such technology.

7.5.1 BART-Eligible Sources in North Carolina

The following is a list of facilities with BART-eligible sources in North Carolina. See Appendix L for a detailed description of each BART-eligible emission unit:

- Alcoa, Inc.-Badin Works
- Blue Ridge Paper Products – Canton Mill
- DAK Americas – Cape Fear
- DAK Americas – Cedar Creek
- Duke Energy – Belews Creek Steam Station
- Duke Energy – Cliffside Steam Station
- Duke Energy – Marshall Steam Station
- Elementis Chromium
- International Paper – Riegelwood Mill

- International Paper – Roanoke Rapids
- Invista, S.A.R.L.
- PCS Phosphate Company Inc. – Aurora
- Progress Energy – Asheville Plant
- Progress Energy – Roxboro Steam Electric Plant
- Progress Energy – Sutton Plant
- Weyerhaeuser Company – Plymouth
- Weyerhaeuser Company – New Bern

The BART-eligible sources were identified using the methodology in the BART Guidelines.

- One or more emissions units at the facility fit within one of the 26 categories listed in the BART Guidelines;
- The emission unit(s) were in existence on August 7, 1977 and began operation at some point on or after August 7, 1962; and
- The potential emissions considering enforceable limits from all emission units identified in the previous two bullets emission units were 250 tons or more per year of any of these visibility-impairing pollutants: SO2, NOx, and PM10.

The BART Guidelines recommend addressing these visibility-impairing pollutants: SO2, NOx, and particulate matter, and suggest that States use their best judgment in determining whether to address VOC or ammonia emissions. The NCDAQ addressed SO2 and NOx, and used particulate matter less than 10 microns in diameter (PM10) as an indicator for particulate matter to identify BART-eligible units, as the BART Guidelines recommend. As discussed in detail in Appendix L, VISTAS modeling demonstrated that VOCs and ammonia from point sources are not visibility-impairing pollutants. For this reason, the NCDAQ did not evaluate emissions of VOCs and ammonia in BART determinations.

7.5.2 Determination of Sources Subject to BART in North Carolina

Under the BART Guidelines, the NCDAQ may consider exempting some sources from BART if it is determined that they do not cause or contribute to visibility impairment in a Class I area. In accordance with the BART guidelines, the NCDAQ chose to perform source-specific analyses to determine which sources cause or contribute to visibility impairment using the CALPUFF model. The CALPUFF modeling protocol used for determining which facilities are subject to BART is included in Appendix L. In accordance with the Guidelines, a contribution threshold of 0.5 dv was used for determining which sources were subject to BART. Detailed discussions about how a threshold of 0.5 dv meets the USEPA's BART guidelines can be found in Appendix L.

All of North Carolina's BART-eligible sources submitted exemption-modeling demonstrations. Fifteen of the seventeen sources were able to demonstrate exemption. Results of these demonstrations are summarized in Tables 7.5.2-1 through 7.5.2-3 below. Additional details are available in Appendix L. Facilities found to be subject to BART must complete a BART analysis.

Table 7.5.2-1 represents the facilities that were able to demonstrate exemption from BART based on CALPUFF modeling conducted using the VISTAS modeling protocol and the old IMPROVE equation. Table 7.5.2-2 represents the facilities that were able to demonstrate exemption from BART based on CALPUFF modeling conducted using the VISTAS modeling protocol and the new IMPROVE equation. Refer to Appendix B for a discussion on the old and new IMPROVE equations. The NCDAQ has proposed to exempt all of the units listed in these two tables and no significant adverse comments were received during the public comment periods. For further details about the BART exemption modeling, please refer to Appendix L.

Table 7.5.2-1. BART Exemption Modeling Results for Sources using Old IMPROVE Equation

Facility	Class 1 Areas	Distance To Class I Area (km)	Impact (Change in dv)
ALCOA – Badin (for SO2, NOx and PM10)	Linville Gorge	164	0.260
	James River Face	242	0.175
	Cape Romain	265	0.135
	Great Smoky Mountains	264	0.113
	Shining Rock	241	0.109
DAK Americas - Cape Fear (for SO2, NOx and PM10)	Swanquarter	187	0.19
	Cape Romain	182	0.16
DAK Americas - Cedar Creek (for SO2, NOx and PM10)	Swanquarter	219	0.08
	Cape Romain	216	0.06
	Linville Gorge	295	0.05
	James River Face	291	0.04
Elementis Chromium (for SO2, NOx and PM10)	Swanquarter	170	0.185
	Cape Romain	200	0.129
International Paper - Riegelwood (for SO2, NOx and PM10)	Swanquarter	210	0.112
	Cape Romain	150	0.109
International Paper - Roanoke Rapids (for SO2, NOx and PM10)	Swanquarter	164	0.305
	Shenandoah	204	0.248
	James River Face	200	0.234
Invista, S.A.R.L. (for SO2, NOx and PM10)	Swanquarter	184	0.286
	Cape Romain	187	0.215
Progress Energy – Asheville (for PM10)	Shining Rock	26	0.372
	Great Smoky Mountains	50	0.265
	Linville Gorge	68	0.143
	Joyce Kilmer-Slickrock	125	0.042
	Cohutta	185	0.031
Progress Energy – Sutton (for PM10)	Swanquarter	185	0.156
	Cape Romain	183	0.148
Weyerhaeuser – Plymouth (for SO2, NOx and PM10)	Swanquarter	73	0.336
	Shenandoah	300	0.087
	James River Face	300	0.068

Table 7.5.2-2. BART Exemption Modeling Results for Sources using New IMPROVE Equation

Facility	Class 1 Areas	Distance To Class I Area (km)	Impact (Change in dv)
Duke Energy Belews Creek (for PM10)	Linville Gorge	180	0.26
	James River Face	140	0.24
	Shenandoah	215	0.20
	Great Smoky Mountains	290	0.09
	Shining Rock	280	0.09
	Otter Creek	290	0.06
Duke Energy Cliffside (for PM10)	Linville Gorge	60	0.25
	Shining Rock	105	0.13
	Great Smoky Mountains	130	0.09
	Cohutta	265	0.05
	Joyce Kilmer-Slickrock	205	0.05
Duke Energy Marshall (for PM10)	Linville Gorge	95	0.46
	James River Face	240	0.15
	Shining Rock	180	0.15
	Great Smoky Mountains	200	0.11
	Joyce Kilmer-Slickrock	280	0.07
Progress Energy – Roxboro (for PM10)	James River Face	113	0.483
	Shenandoah	168	0.304
	Linville Gorge	257	0.214
	Swanquarter	264	0.152
	Dolly Sodds	265	0.069
	Otter Creek	262	0.066
Weyerhaeuser – New Bern (for SO2, NOx and PM10)	Swanquarter	65	0.367[1]

[1]Initial modeling showed an impact of 0.722 dv at Swanquarter. Initial modeling showed an impact of 0.211 dv at Cape Romain (300 km from facility). Since the initial modeling result was below the 0.5 dv contribution threshold, Cape Romain was not evaluated in Weyerhaeuser's revised modeling.

There were two sources that failed to model below the 0.5 dv threshold for exemption. These facilities were PCS Phosphate and Blue Ridge Paper. The exemption modeling results are listed in Table 7.5.2-3. For the exemption modeling, both sources were required to model for SO2, NOx and PM10. PCS Phosphate used the new IMPROVE equation for their modeling; whereas Blue Ridge Paper used the old IMPROVE equation.

Table 7.5.2-3. Exemption Modeling Results for BART-Subject Sources.

Facility	Class 1 Areas	Distance To Class I Area (km)	Impact (Change in dv)
PCS Phosphate	Swanquarter	32	1.319
Blue Ridge Paper	Shining Rock	11	2.887
	Great Smoky Mountains	22	0.764
	Linville Gorge	89	0.155
	Joyce Kilmer-Slickrock	99	0.134
	Cohutta	161	0.095

Six of North Carolina's BART-eligible sources are EGUs subject to the North Carolina CSA. Under the Act, Duke Energy and Progress Energy must reduce their NOx emissions by 77 percent by 2009 and SO2 emissions by 73 percent by 2013. These sources have already installed or are installing scrubbers to reduce SO2 emissions and to reduce NOx emissions Selective Catalytic Reduction (SCR) and Selective Non-Catalytic Reduction (SNCR). The EGUs are required by the statute to submit annual update to their compliance plans to meet these requirements. The Duke Energy and Progress Energy compliance plans from the June 1, 2007 report *Implementation of the Clean Smokestacks Act* summarize the status of control on these EGUs and are attached to Appendix L.

The USEPA has determined that, as a whole, the CAIR cap-and-trade program improves visibility more than implementing BART for individual sources in states affected by CAIR. A State that opts to participate in the CAIR program under 40 CFR 96.201-.224 (Subpart AAA through EEE) need not require BART-eligible EGUs subject to CAIR to install, operate, and maintain BART for SO2 or NOx emissions. Given that all BART-eligible units are installing scrubbers and NOx controls, and since North Carolina is participating in CAIR and accepts the USEPA's overall finding that CAIR "substitutes" for BART for NOx and SO2, North Carolina's EGUs were allowed to submit BART exemption modeling demonstrations for PM emissions only. All six EGUs demonstrated that they do not contribute to visibility impairment in any Class I area.

In total, fifteen of North Carolina's seventeen BART-eligible sources were able to demonstrate that they did not cause or contribute to visibility impairment in any Class I area within 300 km of the source. Six sources used the new IMPROVE equation in efforts to demonstrate exemption.

7.5.3 Determination of BART Requirements for Subject-to-BART Sources

Two sources, PCS Phosphate in Aurora, North Carolina and Blue Ridge Paper in Canton, North Carolina, were unable to demonstrate a contribution of less than 0.5 dv at all Class I areas within 300 km from their BART-eligible sources. These two facilities are considered to be "subject to BART" and were required to submit permit applications containing their evaluation of potential BART options and proposed BART determinations. These facilities submitted permit applications including their proposed BART determinations in the Fall of 2006. The proposed BART determinations have been reviewed by the NCDAQ and it was determined that BART is no additional controls at either facility. The BART determinations will be taken to public hearing concurrent with the public hearing on the Regional Haze SIP. Permit issuance is targeted for the fall of 2007. For a more detailed discussion of the BART determinations, please see Appendix L.

7.6 Relative Contributions to Visibility Impairment: Geographic Areas of Influence for North Carolina Class I Areas

Once it was determined that SO2 emission reductions from EGU and non-EGU point sources in the VISTAS states would be the most effective sources to control to improve visibility at the North Carolina Class I areas, the next step was to identify the specific geographic areas that most likely influence visibility in each Class I area, and then to identify the major SO2 point sources located in those geographic areas. An SO2 Area of Influence was defined for each Class I area to represent the geographic area containing sources that would likely have the greatest impact on visibility at that Class I area. All SO2 point sources within these Areas of Influence were identified and ranked by their 2018 emissions. The following sections contain a broad overview of the steps in the Area of Influence analyses. See Appendix H for a more detailed discussion of these analyses and plots for additional Class I areas.

7.6.1 Back Trajectory Analyses

The first step was to generate meteorological back trajectories for IMPROVE monitoring sites in North Carolina and neighboring Class I areas for the 2000-2004 20% worst days baseline period. Back trajectory analyses use interpolated measured or modeled meteorological fields to estimate the most likely central path of air masses that arrive at a receptor at a given time. The method essentially follows a parcel of air backward in hourly steps for a specified length of time. Figure 7.6.1 is an example of a back trajectory analysis for Great Smoky Mountains National Park for the 20% worst days in 2002.

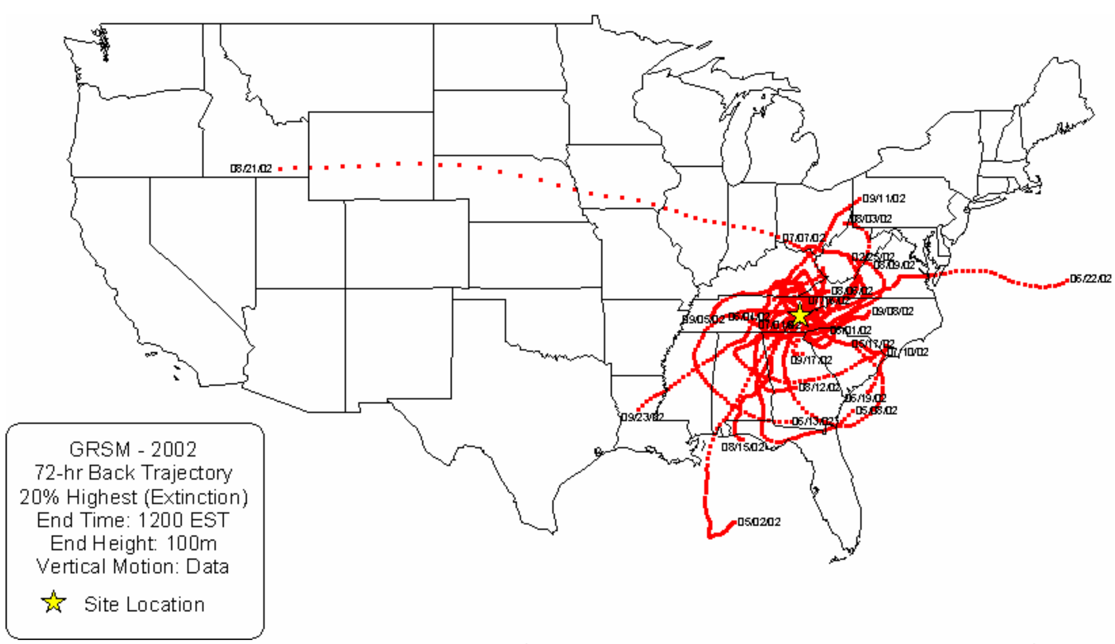


Figure 7.6.1. Example back trajectories for 20% worst visibility days in 2002 for Great Smoky Mountains.

Trajectories were started at 100 meters and 500 meters above the surface and run backward from the site for 72-hours. These individual back trajectories for 20% worst days in 2002 were also useful in evaluating model performance for individual days at the Class I areas.

7.6.2 Residence Time Plots

The next step was to plot residence time for each Class I area using five years of back trajectories for the 20% worst visibility days in 2000-2004. Residence time is the frequency that winds pass over a specific geographic area on the path to a Class I area. Separate residence time plots were generated using trajectories with 100m and 500m start heights. As illustrated in Figure 7.6.2-1, winds influencing Great Smoky Mountains on the 20% worst days come from all directions and there is no single predominant wind direction influencing the 20% worst visibility days. In contrast, at Swanquarter, the residence time plot indicates a clear north-south gradient of influence along the eastern coast of the United States (Figure 7.6.2-2). The residence time plots for the other Class I areas can be found in Appendix B.

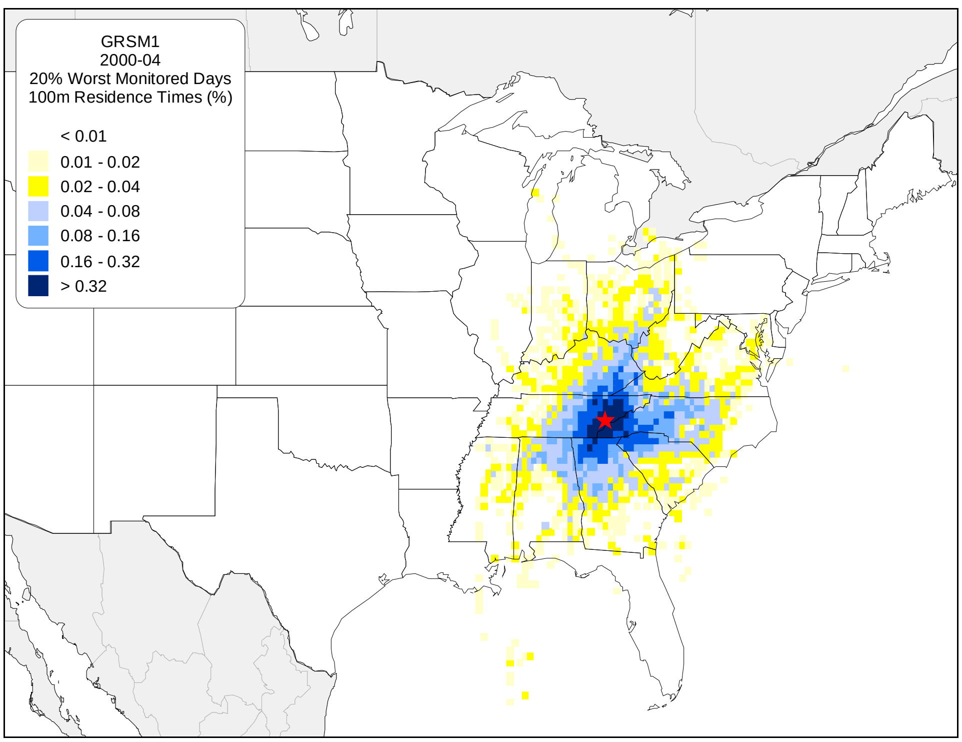


Figure 7.6.2-1. Example residence time plot for 20% worst visibility days in 2000-2004 for Great Smoky Mountains based on trajectories with 100m start height.

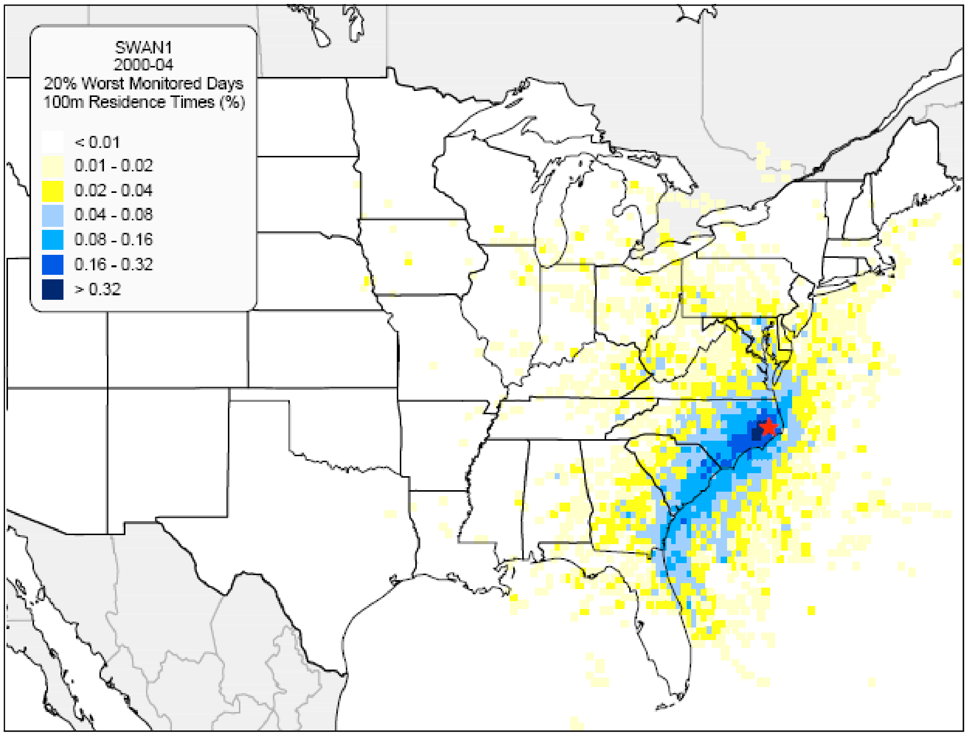


Figure 7.6.2-2. Example residence time plot for 20% worst visibility days in 2000-2004 for Swanquarter based on trajectories with 100m start height.

7.6.3 SO2 Areas of Influence

As discussed earlier, the NCDAQ has determined that reductions in SO2 emissions would have the greatest visibility impact. Therefore, sulfate extinction-weighted residence time plots were developed to define the geographic area with highest probability of influencing the receptor on the 20% worst days in the 2000-2004 baseline period that were dominated by sulfate. Each back trajectory was weighted by sulfate extinction for that day. This allows the focus to be on the 20% worst days that are influenced by sulfate and places less importance on days influenced by organic carbon from fires. Sulfate-weighted back trajectories for the 20% worst days were combined for 5 years of data. The resulting sulfate extinction-weighted residence time plots were used to define the geographic Area of Influence for sources of SO2 emissions. In Figure 7.6.3-1 the area representing 10% or greater residence time is outlined in red and the area representing 5% or greater residence time is outlined in gray.

The VISTAS states discussed various options as to what percentage of sulfate extinction-weighted area of influence should be assessed. It was determined that for this planning period that the area of influence defined by 5% or greater sulfate extinction-weighted residence time provided a reasonable universe of sources that may cause visibility impairment at a Class I area. The VISTAS states recognized that this did not represent 100% of the sources contributing to visibility impairment at Class I areas, but rather a reasonable universe of sources to consider during the first planning period.

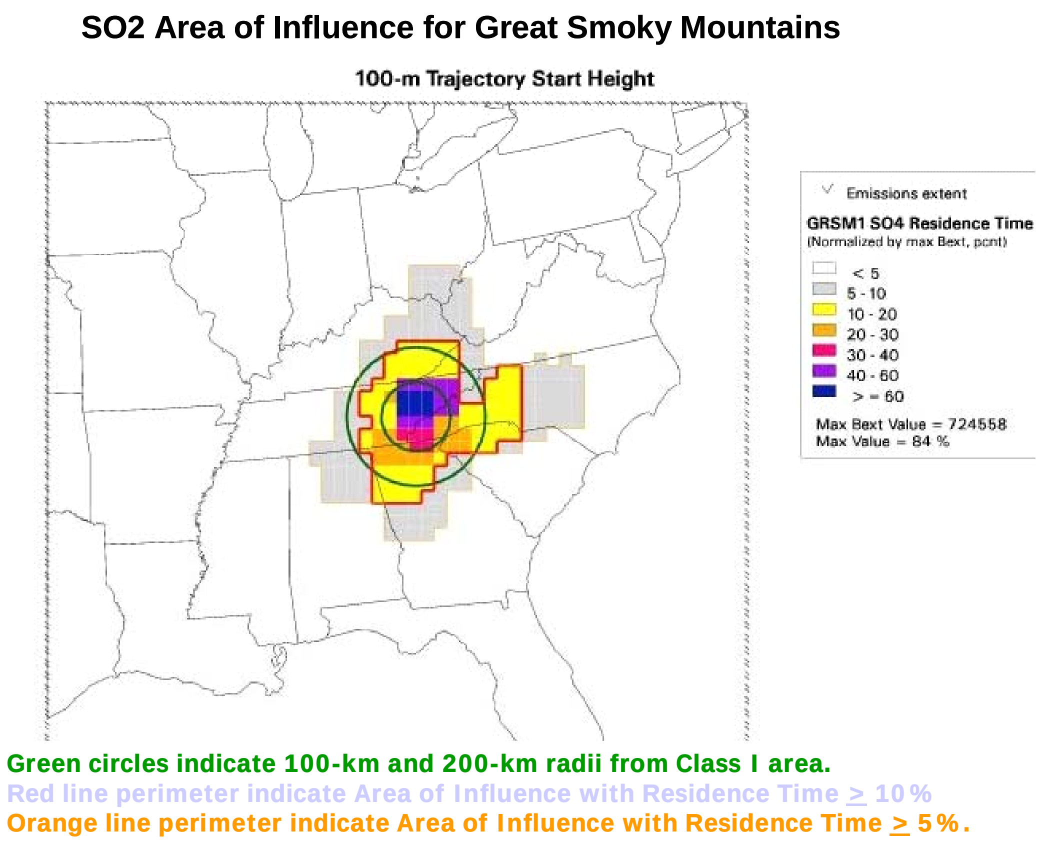


Figure 7.6.3-1. Example SO2 Area of Influence plot for sulfate extinction weighted residence time for 20% worst visibility days in 2000-2004 for Great Smoky Mountains based on trajectories with 100m start height.

7.6.4 Emissions Sources within SO2 Areas of Influence

Residence time plots were then combined with geographically-gridded emission data based on the 2002 baseline and 2018 emissions inventories. Plots were generated for the Areas of Influence defined by trajectories with 100m and 500 m start heights. As a way of incorporating the effects of transport, deposition, and chemical transformation of point source emissions along the path of the trajectories, these data were weighted by 1/d, where d was calculated as the distance, in kilometers, between the center of the grid cell in which a source is located and the center of the grid cell in which the IMPROVE monitor is located. The distance-weighted point source SO2 emissions are then combined with the gridded sulfate extinction-weighted residence times at a spatial resolution of 36-km.

The final step was to combine the residence times and gridded emissions data in plots and data sets. The distance weighted (1/d) gridded point source SO2 emissions were multiplied by the total sulfate extinction-weighted back-trajectory residence times on a grid cell by grid cell basis. These results were then normalized by the domain-wide total and displayed as a percentage. The analysis was done using both the 2002 and 2018 emissions inventories.

Figures 7.6.4-1 illustrates the 2002 and 2018 distance weighted gridded emissions multiplied by sulfate extinction-weighted residence time for Great Smoky Mountains National Park. These maps help visualize where the emissions reductions will be occurring between 2002 and 2018. The change in SO2 emissions between 2002 and 2018 can be seen by comparing emissions source strengths in the two plots. Note the emissions from each source are normalized by the total emissions in the domain. Sources that reduce SO2 emissions by 2018 will show a lower contribution to emissions in the domain. On the 2018, map the grid cells with these sources will show a lighter color gradient than on the 2002 map. For example, SO2 reductions from EGU in western and central North Carolina under the North Carolina CSA can be seen by comparing the 2002 and 2018 maps. Because the total emissions in the domain are smaller in 2018, a source that does not change emissions between 2002 and 2018 may actually appear to increase in importance in 2018 compared to 2002.

Although the sulfate extinction-weighted residence times were developed using the 2002 emissions, the 2018 emissions weighted by residence time plots still provides useful information. The NCDAQ does not believe that the area of influence would have changed significantly if sulfate extinction-weighted residence times were developed using the 2018 emissions. However, if the area of influence would have been smaller using the 2018 emissions due to reductions expected in the EGU source sector, then the area developed to identify potential sources would be considered conservative.

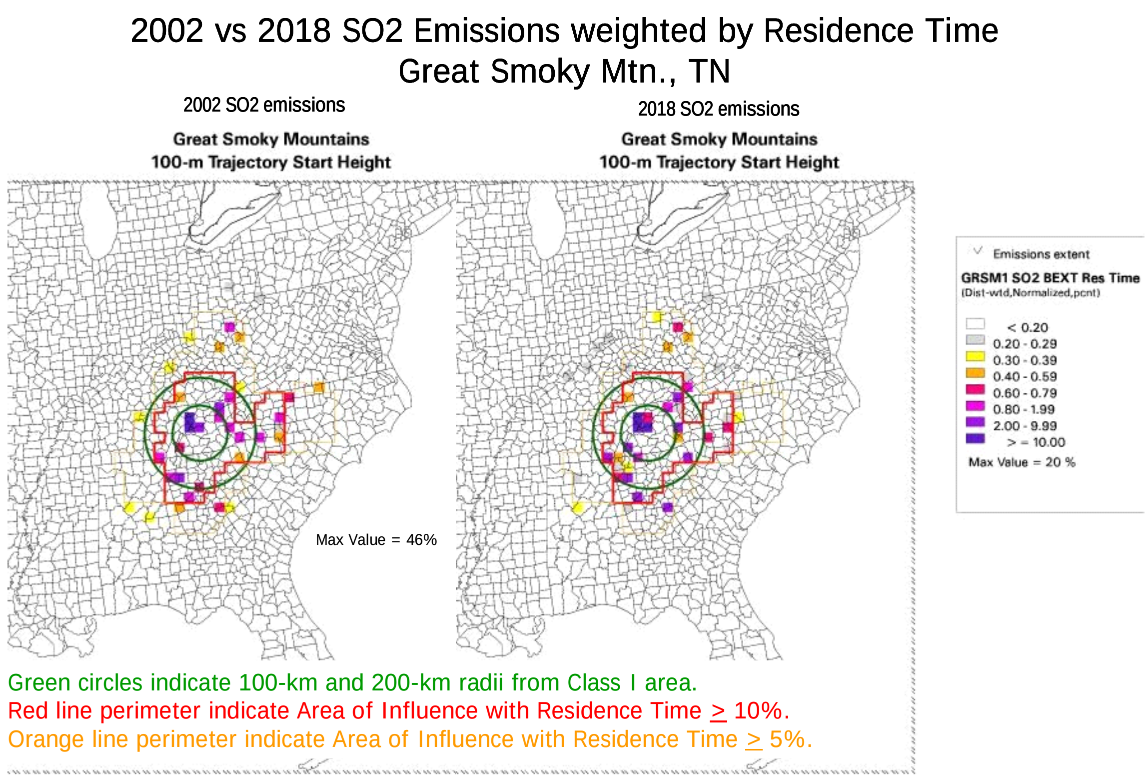


Figure 7.6.4-1. Great Smoky Mountains 2002 (left) and 2018 (right) SO2 distance weighted emissions times SO4 extinction-weighted residence time plots.

Figures 7.6.4-2 through 7.6.4.4 illustrate similar plots for 2018 for Linville Gorge, Shining Rock, and Swanquarter. Since Joyce Kilmer-Slickrock Wilderness Area does not have its own monitor, the plot for Great Smoky Mountains National Park is considered to represent this area. These plots illustrate the relative importance of North Carolina sources of SO2 compared to sources in neighboring states. Additional analyses, including 2002 and 2018 distance weighted emissions times residence-time plots for the Class I areas in North Carolina and neighboring states are contained in Appendix H. These analyses are serving as the basis for consultation among the VISTAS states.

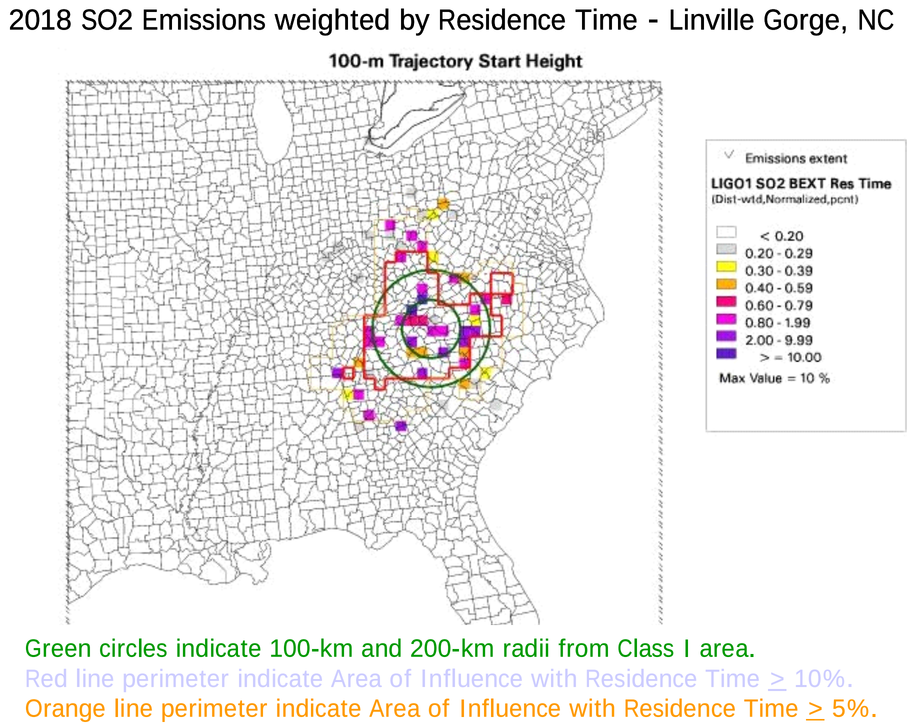


Figure 7.6.4-2. Linville Gorge 2018 SO2 distance weighted emissions times SO4 extinction-weighted residence time plot.

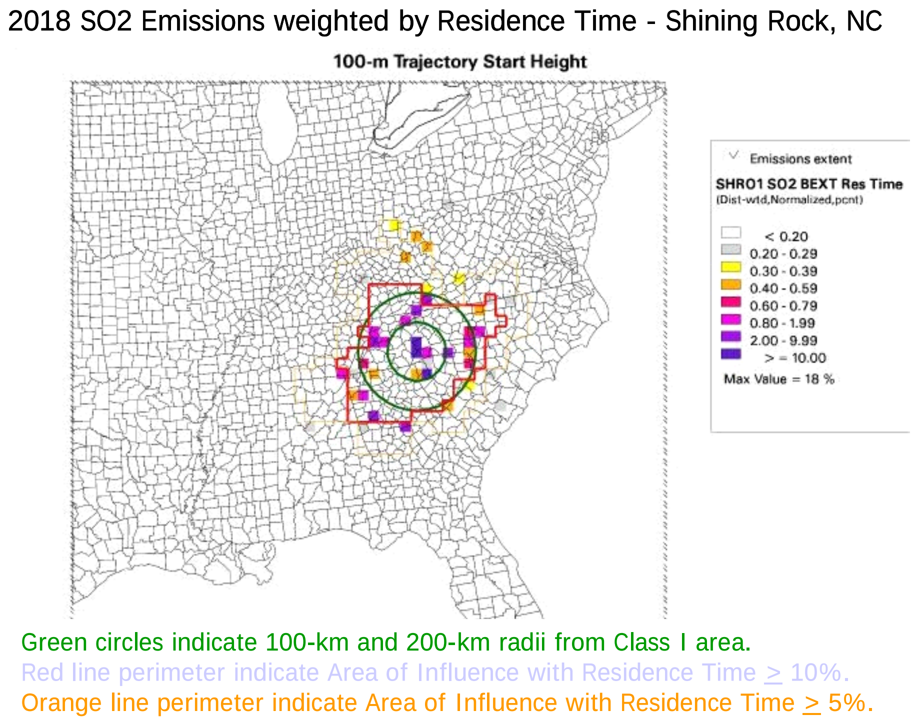


Figure 7.6.4-3. Shining Rock 2018 SO2 distance weighted emissions times SO4 extinction-weighted residence time plot.

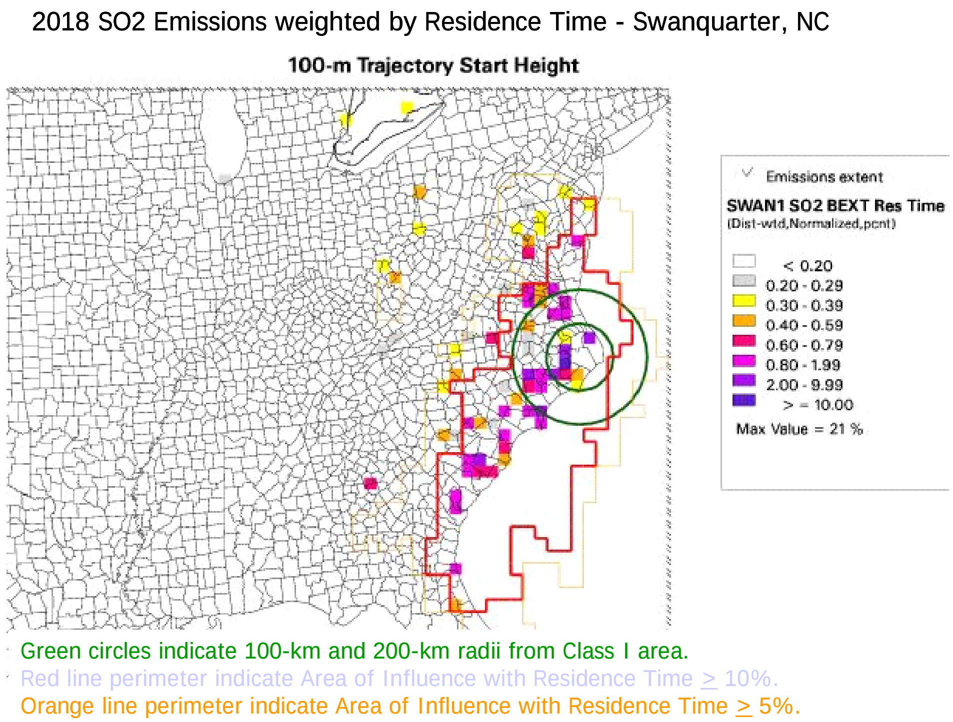


Figure 7.6.4-4. Swanquarter 2018 SO2 distance weighted emissions times SO4 extinction-weighted residence time plot.

Finally, Table 7.6.4-1 shows, in tabular form, the relative contributions of point source SO2 emissions from nearby states to North Carolina Class I areas. These percentages were estimated by multiplying the maximum residence time to the emissions over distance.

Table 7.6.4-1 2018 Point Source SO2 Contribution to NC Class I Areas by State

	North Carolina Class I Area				
State	GRSM	SHRO	LIGO	SWAN	JOKI
Alabama	3.1%	1.84%	1.35%		6.53%
Delaware				2.83%	
Florida				2.35%	
Georgia	7.7%	7.22%	1.98%	3.34%	20.46%
Kentucky	1.0%	0.81%	0.90%	0.10%	1.38%
Maryland				1.34%	
New Jersey				1.10%	
North Carolina	7.4%	**58.84%**	**34.75%**	**58.69%**	9.08%
Ohio	0.9%	0.64%	1.76%		
Pennsylvania				0.50%	
South Carolina	2.4%	14.89%	3.93%	15.35%	5.14%
Tennessee	**74.5%**	12.19%	**36.28%**		**55.87%**
Virginia	2.3%	2.95%	16.52%	13.78%	1.53%
West Virginia	0.5%	0.63%	2.52%	0.63%	
Total	100.0%	100.0%	100.0%	100.0%	100.0%

7.6.5 Specific Source Types in the Areas of Influence for North Carolina Class I Areas

The next step in the analysis was to review the emissions inventories to determine the source categories, as well as specific sources, found to have the greatest impact on visibility in North Carolina Class I areas. Lists of SO2 point sources within the Areas of Influence for each Class I areas were developed using the VISTAS 2002 base year and 2018 future year emissions. For this purpose, the Area of Influence was defined as the counties with maximum sulfate extinction weighted residence time greater than five. For SO2 sources within each Area of Influence, the following attributes were defined for each individual unit:

- State, county, and source (plant), and industry identification codes
- SO2 emissions for 2002 and 2018
- 2018 control efficiency
- Distance to Class I areas (defined by distance to the monitor at the Class I area)
- Emissions divided by distance (Q/d), a metric that accounts for the dispersion of emissions over distance
- Maximum sulfate extinction weighted residence time (RTmax)

Our review was conducted in a top down fashion starting with an analysis of the major source categories in each SO2 Area of Influence to determine which major categories had the highest residual contribution to the area in 2018. It was also important to identify reductions that are projected to occur between 2002 and 2018 within each category or at specific units. This allowed VISTAS States to determine if certain source categories or units that had yet to be controlled under the future year base case had the potential for reduction. Once the highest source types were identified, subcategories within those source types were reviewed. The contributions from major source categories to the 2018 inventory for the SO2 Areas of Influence for the North Carolina Class I areas are listed in Tables 7.6.5-1 through 7.6.5-5. In these tables, the source categories are broken out by the USEPA's Tier 1 report categories and are defined below:

• Fuel Comb Elec Utility	Emissions from all fuel combustions at utility boilers
• Fuel Comb Industrial	Emissions from all fuel combustions at industrial boilers
• Fuel Comb Other	Emissions from all fuel combustions from commercial/institutional and residential sources (i.e., fireplaces, natural gas stoves, oil heaters, etc.)
• Chemical & Allied Product Mfg	Emissions from chemical manufacturing processes
• Metal Processing	Emissions from metal processing operations
• Petroleum & Related Industries	Emissions from petroleum refineries & related industries
• Other Industrial Processes	All other industrial processing not previously mentioned
• Solvent Utilization	Emissions from solvent utilization such as degreasing operations, surface coating operations, etc.
• Storage & Transport	Emissions from storage and transport of petroleum, organic and inorganic products
• Waste Disposal & Recycling	Emissions from open burning, incineration, landfills, publicly owned treatment works, treatment storage and/or disposal facilities, wastewater treatment facilities
• Highway Vehicles	Emissions from on-road mobile sources
• Off-highway	Emissions from off-road mobile sources
• Miscellaneous (Ag, Fires)	Emissions from agricultural operations, wildland fires, and other emissions sources not previously mentioned

Table 7.6.5-1. 2018 Emissions Contributions from Major Source Categories in the Area of Influence for Great Smoky Mountains.

Tier	VOC	NOX	CO	SO2	PM-10	PM-2.5	NH3
Fuel Comb. Elec. Util.	0%	**22%**	1%	**54%**	11%	21%	1%
Fuel Comb. Industrial	1%	**18%**	2%	**30%**	3%	5%	0%
Fuel Comb. Other	5%	6%	3%	**6%**	5%	12%	1%
Chemical & Allied Product Mfg	2%	0%	0%	2%	1%	1%	0%
Metals Processing	1%	1%	2%	3%	2%	5%	0%
Petroleum & Related Industries	0%	0%	0%	1%	0%	0%	0%
Other Industrial Processes	6%	5%	1%	3%	8%	11%	0%
Solvent Utilization	44%	1%	0%	0%	0%	1%	0%
Storage & Transport	6%	0%	0%	0%	0%	1%	0%
Waste Disposal & Recycling	4%	2%	3%	0%	5%	11%	0%
Highway Vehicles	18%	**25%**	48%	0%	2%	2%	11%
Off-highway	11%	**18%**	35%	1%	2%	4%	0%
Miscellaneous (Ag, Fires)	1%	1%	5%	0%	**59%**	**26%**	**86%**

Table 7.6.5-2. 2018 Emissions Contributions from Major Source Categories in the Area of Influence for Joyce Kilmer, North Carolina.

Tier	VOC	NOX	CO	SO2	PM-10	PM-2.5	NH3
Fuel Comb. Elec. Util.	0%	**21%**	1%	**51%**	9%	17%	1%
Fuel Comb. Industrial	1%	**18%**	2%	**30%**	3%	5%	0%
Fuel Comb. Other	5%	6%	3%	**7%**	5%	12%	1%
Chemical & Allied Product Mfg	2%	0%	0%	3%	1%	1%	0%
Metals Processing	1%	1%	1%	3%	2%	5%	0%
Petroleum & Related Industries	0%	0%	0%	1%	0%	0%	0%
Other Industrial Processes	6%	5%	1%	3%	9%	11%	1%
Solvent Utilization	44%	1%	0%	0%	0%	1%	0%
Storage & Transport	6%	0%	0%	0%	0%	1%	0%
Waste Disposal & Recycling	4%	2%	4%	1%	5%	12%	0%
Highway Vehicles	18%	**26%**	48%	1%	2%	2%	12%
Off-highway	11%	**18%**	35%	1%	2%	4%	0%
Miscellaneous (Ag, Fires)	1%	1%	5%	0%	**61%**	**28%**	**85%**

Table 7.6.5-3. 2018 Emissions Contributions from Major Source Categories in the Area of Influence for Linville Gorge, North Carolina.

Tier	VOC	NOX	CO	SO2	PM-10	PM-2.5	NH3
Fuel Comb. Elec. Util.	0%	**20%**	1%	**54%**	13%	23%	1%
Fuel Comb. Industrial	1%	**19%**	2%	**31%**	4%	6%	0%
Fuel Comb. Other	6%	7%	4%	**5%**	6%	13%	1%
Chemical & Allied Product Mfg	2%	0%	0%	1%	1%	1%	0%
Metals Processing	1%	1%	1%	3%	1%	3%	0%
Petroleum & Related Industries	0%	0%	0%	1%	0%	0%	0%
Other Industrial Processes	5%	5%	0%	**4%**	9%	11%	1%
Solvent Utilization	44%	1%	0%	0%	0%	1%	0%
Storage & Transport	6%	0%	0%	0%	1%	1%	0%
Waste Disposal & Recycling	4%	2%	3%	0%	5%	10%	0%
Highway Vehicles	19%	**26%**	49%	0%	2%	2%	11%
Off-highway	11%	**19%**	36%	0%	2%	5%	0%
Miscellaneous (Ag, Fires)	1%	1%	4%	0%	**57%**	**24%**	**85%**

Table 7.6.5-4. 2018 Emissions Contributions from Major Source Categories in the Area of Influence for Shining Rock, North Carolina.

Tier	VOC	NOX	CO	SO2	PM-10	PM-2.5	NH3
Fuel Comb. Elec. Util.	0%	**21%**	1%	**52%**	10%	19%	1%
Fuel Comb. Industrial	1%	**19%**	2%	**31%**	3%	6%	0%
Fuel Comb. Other	5%	6%	3%	**5%**	5%	11%	1%
Chemical & Allied Product Mfg	2%	1%	0%	2%	1%	1%	1%
Metals Processing	1%	1%	2%	3%	2%	5%	0%
Petroleum & Related Industries	0%	0%	0%	1%	0%	0%	0%
Other Industrial Processes	6%	6%	1%	4%	9%	11%	1%
Solvent Utilization	43%	1%	0%	0%	0%	1%	0%
Storage & Transport	6%	0%	0%	0%	1%	1%	0%
Waste Disposal & Recycling	4%	2%	3%	0%	5%	11%	0%
Highway Vehicles	18%	**25%**	48%	0%	2%	2%	11%
Off-highway	11%	**18%**	34%	1%	2%	4%	0%
Miscellaneous (Ag, Fires)	1%	1%	5%	0%	**60%**	**28%**	**85%**

Table 7.6.5-5. 2018 Emissions Contributions from Major Source Categories in the Area of Influence for Swanquarter, North Carolina.

Tier	VOC	NOX	CO	SO2	PM-10	PM-2.5	NH3
Fuel Comb. Elec. Util.	0%	**21%**	1%	**50%**	10%	19%	1%
Fuel Comb. Industrial	1%	**16%**	2%	**29%**	4%	5%	0%
Fuel Comb. Other	5%	7%	3%	**7%**	5%	10%	1%
Chemical & Allied Product Mfg	1%	1%	0%	2%	0%	1%	1%
Metals Processing	0%	1%	2%	3%	1%	1%	0%
Petroleum & Related Industries	0%	0%	0%	0%	0%	0%	0%
Other Industrial Processes	5%	6%	1%	**5%**	8%	10%	1%
Solvent Utilization	38%	0%	0%	0%	0%	0%	0%
Storage & Transport	7%	0%	0%	0%	1%	1%	0%
Waste Disposal & Recycling	4%	3%	5%	1%	6%	13%	0%
Highway Vehicles	19%	**23%**	43%	1%	2%	2%	11%
Off-highway	16%	**20%**	37%	1%	3%	6%	0%
Miscellaneous (Ag, Fires)	2%	1%	7%	0%	**61%**	**32%**	**85%**

These tables indicate that for all North Carolina Class I areas, EGUs and industrial boilers are the two major sources categories contributing to 2018 SO2 emissions in the Areas of Influence, even after implementation of the CSA and CAIR. Together these two source categories contribute 79-85 percent of the 2018 SO2 emissions for the Areas of Influence for the North Carolina Class I areas. Other fuel combustion and other industrial processes comprise another 9-12 percent of the 2018 SO2 emissions.

These tables can also be used to evaluate the major source categories contributing to emissions of NOx, NH3, and PM emissions in 2018. For instance, highway vehicles and off road vehicles are major sources of NOx emissions, in addition to electric utilities and industrial boilers. The source category "miscellaneous" (which includes agricultural sources and fires) is the major contributor to NH3 and primary PM. However, based upon the 2000 – 2004 reconstructed extinction for the 20% worst visibility days (Appendix B), these pollutants are not significant contributors to visibility impairment on most days in the baseline period. Additionally, the emissions sensitivities discussed in Section 7.4 indicated very small benefits of controlling NOx, NH3, and primary PM emissions at the North Carolina Class I areas, but if these emissions were of concern, different source categories would need to be addressed.

The contributions to SO2 emissions in 2018 from the three highest source categories, electric utilities, industrial boilers, and other fuel combustion have been further broken out into subcategories. Table 7.6.5-6 indicates subcategories for the Areas of Influence for the North Carolina Class I areas. Within electric utilities, all the SO2 emissions are attributable to coal-fired power plants. Within industrial boilers, most emissions are attributable to coal-fired boilers with lesser contributions from oil and gas boilers. Commercial and institutional coal and oil boilers have smaller contributions.

Table 7.6.5-6. 2018 Emissions Contributions from Major Source Categories in the Area of Influence for Swanquarter North Carolina.

Tier	GRSM	SHRO	LIGO	JOKI	SWAN
Fuel Comb. Elec. Util.-Coal	**54%**	**52%**	**53%**	**51%**	**47%**
Fuel Comb. Elec. Util.-Oil	0%	0%	0%	0%	1%
Fuel Comb. Elec. Util.-Gas	0%	0%	0%	0%	0%
Fuel Comb. Elec. Util.-Other	0%	0%	0%	0%	1%
Fuel Comb. Elec. Util.-Internal Combustion	0%	0%	0%	0%	1%
Fuel Comb. Industrial-Coal	**22%**	**24%**	**25%**	**21%**	**18%**
Fuel Comb. Industrial-Oil	**5%**	**5%**	**4%**	**6%**	**7%**
Fuel Comb. Industrial-Gas	2%	2%	2%	2%	2%
Fuel Comb. Industrial-Other	1%	1%	1%	1%	2%
Fuel Comb. Industrial-Internal Combustion	0%	0%	0%	0%	0%
Fuel Comb. Other-Comm/Institutional Coal	2%	2%	2%	2%	2%
Fuel Comb. Other-Comm/Institutional Oil	3%	3%	2%	3%	3%
Fuel Comb. Other-Comm/Institutional Gas	0%	0%	0%	0%	0%
Fuel Comb. Other-Misc. (Except Residential)	0%	0%	0%	0%	0%
Fuel Comb. Other-Residential Wood	0%	0%	0%	0%	0%
Fuel Comb. Other-Residential Other	1%	1%	1%	1%	2%

From these analyses, the NCDAQ considered what additional control measures for electric utilities and industrial boilers are reasonable. The lists of individual sources are also being used to determine if individual sources in other sources categories are major contributors to SO2 emissions in the Areas of Influence.

7.7 Evaluating the Four Statutory Factors for Specific SO2 Emissions Sources in Each Area of Influence

The next step was to identify emission reductions that have already occurred within each source category and at specific units. A list of emission units located within the area of influence for each Class I area was compiled using the modeling emissions inventories. Unit level tables of emission comparisons from 2002 to 2018 were developed, allowing VISTAS States to review existing emission reductions. These tables assigned future year control technology from IPM forecasting and State modification for EGU and from control efficiency tables for non-EGU point sources. These tables can be found in Appendix H.

Once emission control profiles for specific units were defined, the next step is to determine what, if any, additional control measures would be technically feasible, and to assign costs to those control measures. For EGUs, the 2018 IPM file used by VISTAS was obtained and matched to the 2018 base case inventory of EGU sources. This step was conducted to ensure that incremental controls assigned to these source types did not duplicate existing base case assumptions.

VISTAS used the USEPA's AirControlNET database, modified for the VISTAS emission inventories, for the non-EGUs. The core of AirControlNET is a relational database system in which control technologies are linked to sources within the USEPA emissions inventories. The system contains a database of control measure applicability, efficiency, and cost information for reducing emissions. The control measure data file in AirControlNET includes not only the technology's control efficiency, and calculated emission reductions for that source, but also estimates the costs (annual and capital) for application of the control measure.

Using the modified inventories identified above, VISTAS ran every available SO2 control strategy in AirControlNET against the EGU and non-EGU point source inventories to develop a master list of incremental control strategies for each unit in the VISTAS 36 km domain.

For the sources within the Area of Influences for each North Carolina Class I area, the master list of incremental control measures was sorted to determine the costs of incremental control measures. These data were combined in a master spreadsheet with the distance from the emission release point to the Class I area IMPROVE monitor (in km), the 2018 residual emissions and distance (Q/d) or squared distance (Q/d^2), and the normalized 2018 SO2 point source emissions times distance-weighted residence time (RTMax) values for the county in which the emission release point was located. North Carolina evaluated these control measures and costs as part of their review of the statutory factors for reasonable further progress.

The regional haze rule requires that states consider the following factors and demonstrate how these factors were taken into consideration in selecting the reasonable progress goal:

- 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.

Cost of Compliance:
As defined in Section 7.6.5, coal-fired electric utilities and coal-fired industrial boilers were the largest source categories contributing to SO2 in 2018 in the Areas of Influence defined for the North Carolina Class I areas. Industrial boilers using oil and commercial and institutional boilers using coal or oil had small contributions to SO2 in 2018.

Sulfur dioxide emissions from utility, industrial, commercial, or institutional boilers can be controlled either by switching the fuel source to a lower sulfur fuel content or by installing post-combustion controls. Costs vary by fuel source, boiler type and boiler size and require source specific analyses for accuracy.

Bituminous coal is commonly burned in boilers in the eastern US. Switching to another bituminous coal with lower sulfur content or blending bituminous coals can reduce SO2 emissions with least impact to boiler performance. While sub-bituminous coal has a lower sulfur content than bituminous coal, it also has a lower heat content and so more coal has to be burned to generate the same energy output. For boilers that are designed for bituminous coal, only a small fraction of the fuel can be switched to low sulfur sub-bituminous coal without adversely affecting boiler operations. Boiler modifications to accommodate low sulfur sub-bituminous coal may not be cost-effective. Contract initiation and termination costs, differential fuel prices and heat contents, transportation costs, and modification to boiler operations, fuel handling and waste handling systems will have to be considered specific to each source.

Flue-gas desulfurization is the common post-combustion control for coal-fired boilers. Flue gas is passed through an absorbent for sulfur dioxide (generally limestone or lime) in either a wet scrubber, dry scrubber, or spray dryer. A calcium sulfate by-product is produced that may be further processed to produce gypsum as a commercial byproduct. Costs of flue-gas desulfurization include initial capital costs and ongoing operational and maintenance costs for the absorber tower, sorbent handling, and waste product handling facilities. Costs per ton of SO2 removed vary with boiler size, type, and available space for retrofit control devices.

For oil-fired boilers, lower sulfur oil may be an option. Costs need to consider differential fuel prices and heat content, boiler modifications, fuel handling costs, and maintenance costs. Conceptually, post-combustion controls can be used for oil boilers, but there is little precedence for such installations.

Time Necessary for Compliance:
For fuel switching, the time necessary to terminate existing fuel contracts and initiate new contracts needs to be considered. Generally two to three years may be required. Installation of post-combustion controls will require 3 or more years depending on market availability of labor and materials and utility system-wide priorities. Time necessary for compliance will need to be refined for specific sources.

Energy and Non-Air Environmental Impacts:
Switching to lower sulfur fuel or installing post-combustion controls may reduce boiler heat rate and energy output. Scrubbers and spray dryers will require additional safeguards for fuel handling and waste handling systems to avoid additional non-air environmental impacts such as increased effluents in waste water discharges and storm water runoff. These factors will need to be considered specific to individual sources. Carbon dioxide is emitted as a by-product of flue gas desulfurization, therefore impacts of increased carbon emissions will need to be considered, particularly if carbon emissions are limited in the future under climate change mitigation strategies.

Remaining Useful Life:
The useful remaining life is specific to the unit for which controls are considered.

7.8 Which Control Measures Represent Reasonable Progress for Individual Sources?

The following summarizes the process for determining reasonable progress for North Carolina sources. For a detailed discussion of the reasonable progress assessments for all units with a contribution of greater than one percent to visibility impairment at any Class I area in North Carolina or in neighboring states, please see Appendix H.

Step 1: Determine pollutants of concern.

VISTAS evaluated the species contribution on the 20% worst visibility days in the baseline period and concluded that sulfate accounted for greater than 70% of the visibility impairing pollution. The VISTAS States concluded that controlling SO2 emissions was the appropriate step in addressing the reasonable progress assessment for 2018. The VISTAS findings were consistent with the findings of SAMI. As you recall, SAMI confirmed that sulfate particles account for the greatest portion of the haze affecting Class I areas in the Southern Appalachian region and that these sulfates were produced in large part from SO2 emissions from coal combustion.

Step 2: Determine which source sectors should be evaluated for reasonable progress.

Since the pollutant of primary concern was determined to be SO2, the emissions inventory was assessed to determine the source categories that contribute the most SO2 emissions. Point source emissions in 2018 are projected to represent greater than 95% of the total SO2 emissions inventory, the VISTAS States concluded that the focus should be on electric generating unit (EGU) and non-EGU point sources of SO2 emissions.

Step 3: Determine if the Clean Air Interstate Rule is sufficient for reasonable progress for subject EGUs.

The NCDAQ evaluated the amount of SO2 reduction from the EGU sector resulting from the implementation of the North Carolina Clean Smokestacks Act (CSA) and CAIR. The EGUs in North Carolina are expected to reduce their SO2 emissions by greater than 80% between 2002 and 2018. Much of that reduction is the result of CSA requirements which are directly enforceable and which must be satisfied by actual emission reductions as opposed to buying banked Title IV allowances to meet the system-wide emissions caps. In contrast, the SO2 emission reductions beyond CSA that are predicted by the IPM to meet the CAIR requirements are not as certain due to that rule’s provision for regional emissions trading and the use of banked Title IV allowances.

To further support EGUs subject to CAIR is sufficient for reasonable progress, a discussion in the CAIR rule highlighted below (70 FR 25197) addresses the reasonable progress factors of cost and time necessary for compliance for these EGUs, and provide the necessary support for a State's four factor reasonable progress analysis that must accompany a State’s assertion that CAIR is sufficient for reasonable progress for subject EGU’s during the first planning period.

> *From past experience in examining multi-pollutant emissions trading programs for SO2 and NOX, EPA recognized that the air pollution control retrofits that result from a program to achieve highly cost-effective reductions are quite significant and can not be immediately installed. Such retrofits require a large pool of specialized labor resources, in particular, boilermakers, the availability of which will be a major limiting factor in the amount and timing of reductions.*

> *Also, EPA recognized that the regulated industry will need to secure large amounts of capital to meet the control requirements while managing an already large debt load, and is facing other large capital requirements to improve the transmission system. Furthermore, allowing pollution control retrofits to be installed over time enables the industry to take advantage of planned outages at power plants (unplanned outages can lead to lost revenue) and to enable project management to learn from early installations how to deal with some of the engineering challenges that will exist, especially for the smaller units that often present space limitations.*
>
> *Based on these and other considerations, EPA determined in the NPR that the earliest reasonable deadline for compliance with the final highly cost-effective control levels for reducing emissions was 2015 (taking into consideration the existing bank of title IV SO2 allowances). First, the Agency confirmed that the levels of SO2 and NOX emissions it believed were reasonable to set as annual emissions caps for 2015 lead to highly cost-effective controls for the CAIR region.*
>
> *Once EPA determined the 2015 emissions reductions levels, the Agency determined a proposed first (interim) phase control level that would commence January 1, 2010, the earliest the Agency believed initial pollution controls could be fully operational (in today's final action, the first NOX control phase commences in 2009 instead of in 2010, as explained in detail in section IV.C). The first phase would be the initial step on the slope of emissions reductions (the glide-path) leading to the final (second) control phase to commence in 2015. The EPA determined the first phase based on the feasibility of installing the necessary emission control retrofits, as described in section IV.C.*
>
> *Although EPA's primary cost-effectiveness determination is for the 2015 emissions reductions levels, the Agency also evaluated the cost effectiveness of the first phase control levels to ensure that they were also highly cost effective. Throughout this preamble section, EPA reports both the 2015 and 2010 (and 2009 for NOX) cost-effectiveness results, although the first phase levels were determined based on feasibility rather than cost effectiveness. The 2015 emissions reductions include the 2010 (and 2009 for NOX) emissions reductions as a subset of the more stringent requirements that EPA is imposing in the second phase.*

The NCDAQ intends to re-evaluate the IPM predictions of SO2 reductions for CAIR at the time of our next periodic report in 2012 to ensure that the reductions are in fact taking place where they were predicted. Based on the controls required by CSA, and predicted by IPM under CAIR, the NCDAQ has concluded that at this time these existing regulatory programs constitute reasonable control measures for North Carolina EGUs during this first assessment period (between baseline and 2018).

<u>Step 4: Determine which emission units would be evaluated based on impact.</u>

The NCDAQ calculated the fractional contribution from all emission units within the SO2 Area of Influence for a given Class I area and identified those emission units with a contribution of one percent or more to the visibility impairment at that Class I area. A full description of this process and a list of sources considered in the reasonable progress evaluation can be found in Appendix H.

Step 5: Evaluate the four factors.

Each emission unit identified in Step 4 above was evaluated using the statutory and regulatory factors of 1) cost of compliance, 2) time necessary for compliance, 3) the energy and non-air quality environmental impacts of compliance, and 4) the remaining useful life of the emissions unit. If any control measure for an emission unit was found reasonable after assessing the four factors, modeling would be performed to determine if the controls would result in a visibility improvement at any Class I area.

For the limited purpose of evaluating the cost for the reasonable progress assessment in this first regional haze SIP, the NCDAQ believes it is not equitable to require non-EGUs to bear a greater economic burden than EGUs for a given control strategy. The NCDAQ used the capital and operating costs provide by Duke Energy and Progress Energy for the CSA compliance plans to establish a cost/ton of SO2 removed threshold. During the current reasonable progress assessment, no units in North Carolina were identified for additional control since no measures were found to be below the cost threshold. Below is a summary of the analysis. The detailed analysis is included in Appendix H.

Results of four-factor analysis.

The following is a brief summary of the four-factor analysis. More detail is included in Appendix H. The NCDAQ used the cost of compliance as a screening tool to determine the universe of sources to perform the full four-factor evaluation. Therefore, the summary is focused on the cost of control. The dollar per ton of SO2 removed that the NCDAQ used to determine if the cost was reasonable was based on the facility-by-facility and system wide EGU costs for implementing CSA and are included as Attachment 2 to Appendix H. The facility-by-facility costs ranged from 912 to 1,922 dollars per ton of SO2 removed, and the average costs per system ranged from 1,231 to 1,375 dollars per ton of SO2 removed. The CSA controls will reduce SO2 emissions at North Carolina EGUs by more than 80 percent between 2002 and 2018.

For non-EGUs, the NCDAQ found that emissions from the following facilities contributed one percent or more to visibility impairment in a Class I area, and therefore focused the reasonable progress assessments on specific units at these facilities:

Blue Ridge Paper Products

PCS Phosphate

Weyerhaeuser Plymouth

Weyerhaeuser New Bern

Congentrix Kenansville

Additionally, two units at Ecusta Business Development Center contributed more than one percent to visibility impairment at Shining Rock Wilderness Area. However, this facility has since closed and therefore was not evaluated for reasonable progress.

The NCDAQ also looked at what sources in North Carolina may be impacting Class I areas located outside of the State, as well as what sources located outside of North Carolina may be impacting the North Carolina Class I areas. Letters were sent to the states (see Appendix J) identifying which sources in North Carolina may impact their Class I areas and what the NCDAQ had deemed as reasonable control measures. Additionally, the letters requested information on what each state had deemed as reasonable control measures for their sources impacting North Carolina's Class I areas. The only North Carolina source that was identified, outside of facilities listed above, was the Duke Power Dan River facility, which may impact James River Face Wilderness in Virginia. Since this facility is subject to CAIR, the NCDAQ had deemed no additional controls would be required.

Blue Ridge Paper Products

Some of the units at Blue Ridge Paper Products were subject to BART. These units were analyzed for BART and are addressed in Appendix L. Since the BART a determination takes into consideration many of the same factors as for reasonable progress, the BART subject units were not re-evaluated in the reasonable progress review.

The NCDAQ evaluated switching to lower sulfur content coals. Currently, the company is using 0.75% sulfur coal in one boiler regulated by NSPS. The NCDAQ did cost calculations for the following scenario: if 0.75 percent sulfur content coal was required across the mill for the boilers that currently use about one percent sulfur coal. This measure could result in 1400 tons SO2 per year reduced.

Based on information from the company, the lower sulfur coal is $75-90 per ton and the other coal (one percent sulfur) on site is $65 per ton. The cost is $10-25 per ton difference. The company burned 277,214 tons of one percent sulfur coal in 2005; switching to lower sulfur coal (0.75%) would cost ~ $2,772,140 - $6,930,350 extra per year. If 1400 tons of SO2 were reduced, costs would be in the range of $1980 - $4950 per ton, with an average cost of $3,465 per ton.

Add-on control technology for these units cost in the range of $12,055 to $100,961 per ton of SO2 removed. The NCDAQ concludes that there are no cost-effective controls available for these units at this time within the cost threshold established for this reasonable progress assessment. Although the NCDAQ has concluded that for this reasonable progress period there are no cost-effective controls, the agency acknowledges that the emissions from Blue Ridge Paper Products do have impacts on the Class I areas located in the mountains. The NCDAQ has notified the company that although additional controls are not being required this planning period, future-planning periods may require controls to be installed. The NCDAQ is committed to work with this company over the next review period and to encourage the company to modernize some of its processes with more efficient, less polluting equipment.

PCS Phosphate

Some of the units at PCS Phosphate were subject to BART. These units were analyzed for BART and are addressed in Appendix L. Since the BART determination takes into consideration many of the same factors as for reasonable progress, the BART subject units were not re-evaluated in the reasonable progress review.

No control options were listed in the VISTAS's control cost spreadsheet for any of the four units at this facility. The two PCS Phosphate units not subject to BART currently utilize dual absorption systems with a vanadium catalyst. Other technologies reviewed included sodium bisulfite scrubbing, molecular sieve, ammonia scrubbing, and dual absorption process with cesium-promoted catalyst. The first 3 options were rejected because they have not been commercially demonstrated to reliably meet current NSPS and state permit limits. The fourth was found to cost $3,433/ton to $3,457/ton SO2 reduced based on a reduction of sulfur emissions from 3.8 to 3.5 lb SO2/ton sulfuric acid. Therefore, the NCDAQ concludes that there are no cost-effective controls available for these units at this time within the cost threshold established for this reasonable progress assessment. The NCDAQ has notified the company that although additional controls are not being required this planning period, future-planning periods may require controls to be installed.

In addition, PCS Phosphate has submitted a Prevention of Significant Deterioration application to the NCDAQ. The company plans to shut down the two sulfuric acid plants subject to BART and build one new plant. Preliminary review of the application indicates that the total facility SO2 emissions may decrease with these changes.

Weyerhaeuser Plymouth
Weyerhauser Plymouth contains two boilers burning a combination of fuels. There were no controls suggested for the Boiler 1 or 2 in the VISTAS Control Cost Spreadsheet. For the Riley Boiler, the control suggested by VISTAS Control Cost Spreadsheet is an FGD at a cost of $20,460 per ton of SO2 removed. Therefore, the NCDAQ concludes that there are no cost-effective controls available for these units at this time within the cost threshold established for this reasonable progress assessment.

Weyerhaeuser New Bern
Weyerhaeuser New Bern contains one residual oil-fired boiler. The control suggested by VISTAS Control Cost Spreadsheet is an FGD at a cost of $17,317 per ton of SO2 removed. Therefore, the NCDAQ concludes that there are no cost-effective controls available for these units at this time within the cost threshold established for this reasonable progress assessment.

Cogentrix Kenansville
Congentrix Kenansville is currently burning unadulterated wood (pure wood with up to 5% impurities). The company retains coal as a permitted fuel on the permit, with no immediate plans to use it. They are currently burning wood and their new business plan is to continue just burning wood as part of the "green power" movement here in North Carolina.
The 2005 actual SO2 emissions for this unit were 23.25 tons, whereas the projected 2018 SO2 emissions were 1,833.8 tons based on using coal. The NCDAQ is sending the company a letter indicating that they are currently on the list of sources contributing greater than one percent contribution to visibility impairment at Swanquarter Wildlife Refuge based on the estimated emissions from burning coal. The letter will suggest that they change their permit to remove coal as a possible fuel source for this unit.

Summary:
During the current reasonable progress assessment no units in North Carolina were identified for additional control since no measures were found to be below the cost threshold discussed in Step 5. In addition to costs, the statutory factors include time necessary for compliance, remaining useful life of the facility, and energy and non-air environmental impacts of the control installation. However, since no cost effective control measures were identified for the specific sources with contributions to North Carolina or neighboring States' Class I areas, the NCDAQ did not invest in an exhaustive review of the remaining three factors beyond that described in Section 6.4 for control options for major SO2 source sectors. Neither the time necessary for compliance nor the energy and non-air quality environmental impacts of compliance appear to be out of the ordinary for any of these facilities. A likely short remaining useful life for two units was noted in one case, but a longer remaining useful life would not alter that particular determination.

It should be noted that, in order to show continued progress past 2018, the criteria will likely be different in the next reasonable progress assessment in order to maintain a continuous downward glidepath toward natural background conditions by 2064. The facilities in North Carolina that have units that contribute at least one percent to visibility impairment at any Class I area in the State, or in neighboring States, were sent letters from the NCDAQ indicating that while no additional controls were identified during this reasonable progress assessment, the sources should be evaluating possible SO2 reduction strategies for the next round of regional haze SIP development. Those letters are contained in Appendix H.3.

7.9 What Additional Emissions Controls Were Considered as part of the Long-Term Strategy for Visibility Improvement by 2018?

Section 308(d)(3)(v) of the regional haze rule lists several factors that must be addressed in each SIP. These factors include the role of fire at Class I areas and status of state planning for smoke management, the role of dust and fine soil at Class I areas and status of state plans to mitigate emissions from construction activities, and the role of NH3 and potential benefits if emissions from agricultural sources were mitigated.

As discussed in Section 2.4 and demonstrated in Figures 2.4-1 and 2.4-2, elemental carbon (sources include agricultural burning, prescribed wildland fires, and wildfires) is a relatively minor contributor to visibility impairment at the Class I areas in North Carolina. However, the NCDAQ is currently working with the North Carolina Division of Forest Resources to develop a smoke management program that utilizes basic smoke management practices and addresses the issues laid out in the USEPA's 1998 Interim Air Quality Policy on Wildland and Prescribed Fires. Additionally, the NCDAQ is working with the North Carolina Department of Agriculture to develop a Memorandum of Understanding regarding agricultural burning. The NCDAQ anticipates that the resulting smoke management program and Memorandum of Understanding should be sufficient to satisfy the directive in 40 CFR 51.308(d)(3)(v)(E).

Also as discussed in Section 2.4 and demonstrated in Figures 2.4-1 and 2.4-2, fine soils are a relatively minor contributor to visibility impairment at the Class I areas in North Carolina. Nevertheless, in regard to construction activities, the NCDOT Division of Highways has issued regulations addressing control of erosion, siltation, and pollution from construction activities. Section 107-13(E) of the Division of Highways General Contract Specifications, Division 1 General Requirements, reads as follows:

> (E) Dust Control
> The Contractor shall control dust throughout the life of the project within the project area and at all other areas affected by the construction of the project, including, but not specifically limited to, unpaved secondary roads, haul roads, access roads, disposal sites, borrow and material sources, and production sites. Dust control shall not be considered effective where the amount of dust creates a potential or actual unsafe condition, public nuisance, or condition endangering the value, utility, or appearance of any property. The Contractor will not be directed compensated for any dust control measures necessary, as this work will be considered incidental to the work covered by the various contract items.

In addition, the NCDAQ has recently promulgated a new rule, effective on September 1, 2007, intended to control particulates from fugitive dust emission sources generated within plant boundaries from activities such as "unloading and loading areas, process areas, stockpiles, stock pile working, plant parking lots, and plant roads (including access roads and haul roads)."

Note that benefits from neither the new rule nor the NCDOT dust ordinance have been included in the VISTAS modeling runs. Copies of the dust ordinance and the NCDAQ rule are attached to Appendix H.

In regard to agricultural ammonia, the NCDAQ, as a continuation of the CSA, initiated the Climate Action Planning Advisory Group (CAPAG) to develop widespread and specific options for the reduction of greenhouse gas emissions in North Carolina. The CAPAG is comprised of leaders from agricultural, industrial, local and state governmental, and environmental sectors in North Carolina. This collaborative effort developed mitigation options through a consensus process to simultaneously address the goal of reducing green house gas emissions and improve the quality of life in North Carolina. Agriculture and waste in North Carolina is one of the major areas being developed to reduce greenhouse gases. Since North Carolina is second in the nation in production of pork, one of the options being developed promotes increased use of the energy content of hog and cattle waste through the expansion of biodigesters.

To accomplish the expanded utilization of methane (a greenhouse gas) from hog/cattle waste for energy, the report supports expanded research, regulatory actions, and grant guarantees as key implementation tools. Inherent to the success are improved waste management practices. With increased support and improved management a co-benefit will be the reduction of ammonia emissions from animal waste. As less ammonia will be applied to soils, lower direct emissions of ammonia will occur and lower emissions of nitrous oxide (N2O), a potent greenhouse gas, from soils will occur. The exact benefits from the reduction in ammonia emissions have not been quantified.

In addition, the North Carolina Legislature approved a bill on July 26, 2007 that permanently bans new hog lagoons and orders state regulators to set environmental standards for new waste systems. The new legislation creates a phase-out of waste lagoons used by hog farmers, replacing them with more environmentally friendly systems paid for in part by taxpayer-funded grants. The bill is included as an attachment to Appendix H.

VISTAS is working on a modeling run that will include the cumulative benefits from the emission controls discussed in Section 7.2.1, any controls resulting from BART determinations within the other VISTAS states and any controls resulting from the other states within VISTAS to address reasonable control measures. These modeling results were not completed in time to be included with this Regional Haze SIP. Additionally, not all states within VISTAS have completed their reasonable control measures analysis and the modeling does not include controls resulting from BART determinations or reasonable control measures from states located outside the VISTAS region. Since it may take a significant amount of time to have a modeling run completed that incorporates all of these measures, the NCDAQ has decided that it will incorporate these types of results in the first periodic review in 2012.

8.0 REASONABLE PROGRESS GOALS

The regional haze rule at 40 CFR 51.308(d)(1) requires a State to establish reasonable progress goals for each Class I area within the State (expressed in deciviews) that provide for reasonable progress towards achieving natural visibility conditions by 2064. In addition, the USEPA released guidance on June 7, 2007 to use in setting reasonable progress goals. 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.

In accordance with the requirements of 40 CFR 51.308(d)(1), this Regional Haze SIP establishes the uniform rate of progress for each Class I area in North Carolina. The NCDAQ compared baseline visibility conditions to natural visibility conditions in each Class I area to determine the uniform rate of visibility improvement (in deciviews) that would need to be maintained during each implementation period in order to attain natural visibility conditions by 2064.

Through the VISTAS modeling, the NCDAQ has estimated the expected visibility improvements by 2018 in each Class I area resulting from existing federal and state regulations. As stated earlier, VISTAS is in the process of modeling additional control measures found to be reasonable to implement in this review period by the other VISTAS states, as well as the results of other VISTAS states' BART determinations. These modeling results were completed in time to be included with this Regional Haze SIP. The VISTAS baseline modeling has already demonstrated that the 2018 base control scenario provides for an improvement in visibility better than the uniform rate of progress for all North Carolina Class I areas for the most impaired days over the period of the implementation plan and ensures no degradation in visibility for the least impaired days over the same period.

North Carolina and Tennessee are sharing the lead for the Great Smoky Mountains National Park since it is located in both states. The NCDAQ and the Tennessee Division of Air Pollution Control have agreed to work together in setting reasonable progress goals and both agencies have been working together, through VISTAS, throughout the regional haze SIP planning process.

Table 8.0-1 contains the reasonable progress goals for this planning period for each of the North Carolina Class I areas. For the 20% worst days, the reasonable progress goal for each area provides for greater visibility improvement by 2018 than the area's uniform rate of progress. For the 20% best days, the reasonable progress goal for each area indicates an improvement of visibility by 2018 than current best day conditions. These goals are based on the modeling results discussed in Section 7.2.4. The model performance for the 20% best days is not as good as for the 20% worst days because the model has greater difficulty accurately projecting small concentrations. On the 20% best days, the model does not meet VISTAS model performance goals or criteria for sulfate, nitrate, and coarse mass (under predicted) and soil (over predicted), however, the organic carbon and elemental carbon do meet performance goals on the 20% best days. Given the larger percent errors of the fractional bias on the 20% best days, the NCDAQ has less confidence in the absolute values projected for these reasonable progress goals, however, the NCDAQ does expect that visibility on these days will be better than the current conditions 20% best days.

Table 8.0-1. North Carolina 2018 Reasonable Progress Goals (in deciviews)

Class I Area	Baseline Visibility for 20% Worst Days	Reasonable Progress Goal - 20% Worst Days (Improvement)	Baseline Visibility for 20% Best Days	Reasonable Progress Goal - 20% Best Days (Improvement)
Great Smoky Mountains National Park	30.3	23.7 (6.6)	13.6	12.2 (1.4)
Joyce Kilmer-Slickrock Wilderness Area	30.3	23.7 (6.6)	13.6	12.2 (1.4)
Linville Gorge Wilderness Area	28.8	22.0 (6.8)	11.1	9.6 (1.5)
Shining Rock Wilderness Area	28.5	22.1 (6.4)	7.7	6.9 (0.8)
Swanquarter Wildlife Refuge	24.7	20.4 (4.3)	12.0	11.0 (1.0)

9.0 MONITORING STRATEGY

The Regional Haze SIP is to be accompanied by a strategy for monitoring regional haze visibility impairment. Specifically, the regional haze rule states at 40 CFR 51.308(d)(4):

"(4) *Monitoring strategy and other implementation plan requirements.* The State must submit with the implementation plan a monitoring strategy for measuring, characterizing, and reporting of regional haze visibility impairment that is representative of all mandatory Class I Federal areas within the State. This monitoring strategy must be coordinated with the monitoring strategy required in §51.305 for reasonably attributable visibility impairment. Compliance with this requirement may be met through participation in the IMPROVE network. The implementation plan must also provide for the following:

(i) The establishment of any additional monitoring sites or equipment needed to assess whether reasonable progress goals to address regional haze for all mandatory Class I Federal areas within the State are being achieved.

(ii)-(vi) [Other implementation plan requirements that pertain to reporting and use of monitoring data and an emission inventory.]"

Such monitoring is intended to provide the data needed to satisfy four objectives:

1. Track the expected visibility improvements resulting from emissions reductions identified in this SIP.
2. Better understand the atmospheric processes of importance to haze
3. Identify chemical species in the ambient particulate matter and relate them to emissions from sources
4. Evaluate regional air quality models for haze and construct relative response factors for using those models

The primary monitoring network for regional haze, both nationwide and in North Carolina, is the IMPROVE network. Given that IMPROVE monitoring data from 2000-2004 serves as the baseline for the regional haze program, the future regional haze monitoring strategy must necessarily be based on, or directly comparable to, IMPROVE. The IMPROVE measurements provide the only long-term record available for tracking visibility improvement or degradation and therefore North Carolina intends to rely on the IMPROVE network for complying with the regional haze monitoring requirement in the Regional Haze Rule.

There are currently 3 IMPROVE sites in North Carolina (2 at distinctly different locations in the mountains and one on the coast). In addition, as Table 9.0-1 shows, an IMPROVE site just across the border in Tennessee serves as the monitoring site for both the Great Smoky Mountains National Park and Joyce Kilmer-Slickrock Wilderness Area, both of which lie partly in Tennessee and partly in North Carolina.

Table 9.0-1. North Carolina Class I Areas and Representative IMPROVE Monitor

Class I Area	IMPROVE Site Designation
Great Smoky Mountains National Park	GRSM1 (TN)
Joyce Kilmer-Slickrock Wilderness Area	GRSM1 (TN)
Linville Gorge Wilderness Area	LIGO1 (NC)
Shining Rock Wilderness Area	SHRO1 (NC)
Swanquarter Wildlife Refuge	SWAN1 (NC)

In addition to the IMPROVE measurements, some ongoing long-term limited monitoring supported by Federal Land Managers provides additional insight into progress toward regional haze goals. North Carolina benefits from the data from these measurements, but is not responsible for the funding decisions to maintain these measurements into the future. Such measurements include:

- Web cameras operated by the National Park Service at Look Rock, Tennessee and Purchase Knob, North Carolina in Great Smoky Mountains National Park and by the United States Forest Service at Frying Pan Mountain in the Shining Rock Wilderness Area.
- An integrating nephelometer for continuously measuring light scattering, operated by the National Park Service at Look Rock, Tennessee.
- A Tapered Element Oscillating Microbalance (TEOM) for continuously measuring PM2.5 mass concentration, operated by the National Park Service at Look Rock, Tennessee.

Additional haze-related measurements were made in North Carolina in 2002-2005 as part of special monitoring studies by the VISTAS regional planning organization. These studies were intended to better understand source contributions to PM2.5 mass and visibility. They included continuous monitoring of sulfate, nitrate, and carbon to better understand daily trends in PM2.5, detailed analyses of carbon collected on filters to identify source contributions to carbon, and additional analyses of sodium and ammonium on IMPROVE filter samples. Funding does not exist to continue these special studies, however, the equipment has been transferred to the NCDAQ.

The continuous nitrate monitor continues to operate at the Millbrook site in Raleigh and the NCDAQ intends to operate this monitor as long as funds allow. Additionally, a second continuous nitrate monitor is in operation at the Rockwell monitoring site in Rowan County. Again, the NCDAQ plans to operate this monitor indefinitely as long as funds allow. The NCDAQ began operating a continuous sulfate monitor at the Millbrook in August 2007, and expect to have one at the Rockwell sites in January 2008. The NCDAQ is also operating a 5400 R&P monitor for organic, total, and elemental carbon at the Millbrook site. The 5400 R&P monitor is near the end of its lifecycle, but the NCDAQ plans to operate it as long as it can be kept functional or until money is available to purchase a better technology should such a technology become available. VISTAS also transferred a 5400 R&P monitor from the Look Rock special studies location, but the unit is inoperable. The NCDAQ used it for parts for the Millbrook unit, thus, a 5400 R&P unit is not available for the Rockwell site. At this time, the NCDAQ does intend to purchase one to place there due to the short lifecycle of the unit and the various operating issues.

In February 2008, the NCDAQ will finish a year-long black carbon study in Hickory with the aethalometer that was used at the Millbrook site. Depending on the results of the study, this monitor may remain at the Hickory site, return to the Millbrook site, or go to the Rockwell site.

The NCDAQ will use the continuous speciation data from the sites discussed above to further the understanding of both PM2.5 and visibility formation and trends in North Carolina. The NCDAQ will operate the units discussed above as long as funds allow.

In addition, the NCDAQ and the local air agencies in the State operate a fairly comprehensive PM2.5 network of the filter based Federal reference method monitors, continuous mass monitors (TEOMs), filter based speciated monitors and the continuous speciated monitors described above. A map of the various locations around the State is included in Figure 9.0-1. These PM2.5 measurements help the NCDAQ characterize air pollution levels in areas across the state, and therefore aid in the analysis of visibility improvement in and near the Class I areas.

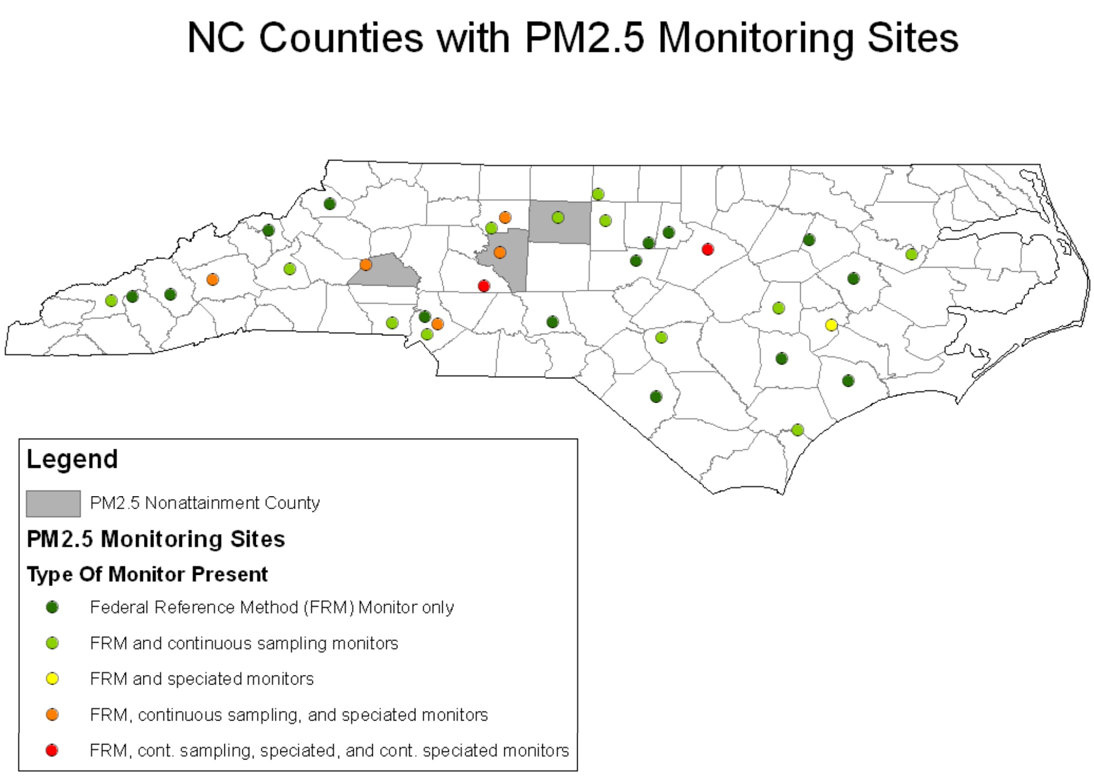


Figure 9.0-1 PM2.5 Monitoring Network in North Carolina

The IMPROVE measurements are central to North Carolina's regional haze monitoring strategy, and it is difficult to visualize how the objectives listed above could be met without the monitoring provided by IMPROVE. Any reduction in the scope of the IMPROVE network in North Carolina would jeopardize the State's ability to demonstrate reasonable progress toward visibility improvement in some of its Class I areas. In particular, North Carolina's regional haze strategy relies on emission reductions that will result from the CAIR and the CSA, which occur on different time scales and will most likely not be spatially uniform. Monitoring at every Class I area is important to document the different air quality responses to the emissions reductions.

Because each of the current IMPROVE monitors in North Carolina represents a different airshed, reduction of the IMPROVE network by shutting down one of these monitoring sites impedes tracking progress at reducing haze at the affected Class I area. In the event this occurs, North Carolina, in consultation with the USEPA and relevant Federal Land Managers, will develop an alternative approach for meeting the tracking goal, perhaps by seeking contingency funding to carry out limited monitoring or by relying on data from nearby urban monitoring sites to demonstrate trends in speciated $PM_{2.5}$ mass.

Data produced by the IMPROVE monitoring network will be used nearly continuously for preparing the 5-year progress reports and the 10-year SIP revisions, each of which relies on analysis of the preceding five years of data. Consequently, the monitoring data from the IMPROVE sites needs to be readily accessible and to be kept up to date. Presumably, IMPROVE will continue to process information from its own measurements at about the same pace and with the same attention to quality as it has shown in the recent past. The VIEWS web site has been maintained by VISTAS and the other Regional Planning Organizations to provide ready access to the IMPROVE data and data analysis tools. North Carolina is encouraging VISTAS and the other RPOs to maintain VIEWS or a similar data management system to facilitate analysis of the IMPROVE data.

10.0 CONSULTATION PROCESS

The VISTAS states have jointly developed the technical analyses to define the visibility improvement by 2018 under existing federal and state regulations compared to the uniform rate of progress, SO2 Areas of Influence for each Class I area, and methods to prioritize contributions from individual sources within the Areas of Influence. The states collectively accept the conclusions of these analyses.

In December 2006, the VISTAS State Air Directors held their first formal consultation meeting to review the modeling results and the SO2 Areas of Influence analyses. The Air Directors agreed to look at reasonable control measures for sources on the lists for the SO2 Areas of Influence. Each state would consider sources within their state and would identify sources in neighboring states that they would like to have that neighboring state consider. States acknowledged that the review process would differ among states since some Class I areas are projected to see visibility improvements near the uniform rate of progress while most Class I areas are projected to have greater improvements than uniform rate of progress.

In May 2007, the VISTAS State Air Directors met for their second formal interstate consultation. States shared their lists of sources in their state and neighboring states for each Class I area.

They also shared their criteria for listing sources and their plans for further interstate consultation. A summary of this meeting is included in Appendix J.

The NCDAQ has evaluated the impact of North Carolina sources on Class I areas in neighboring states and determined that there are no additional reasonable control measures that should be implemented to mitigate impacts in Class I areas in neighboring states. The NCDAQ has consulted with the responsible states regarding its evaluation showing no cost-effective controls available for those units contributing at least one percent to visibility impairment at Class I areas. Analyses of impacts from North Carolina sources and potential controls are discussed in greater detail in Appendix H. Copies of the consultation letters may be found in Appendix J.

Additionally, the NCDAQ sent letters to states where sources outside of North Carolina were determined to contribute one percent or higher to a North Carolina Class I area. Four states have responded to the consultation letters that were sent out: Delaware, Georgia, South Carolina and Virginia. Delaware sent information about their multi-pollutant rule and the expected emissions for the identified source. With the new emissions included in the analysis, the Delaware source no longer contributed one percent or greater to Swanquarter Wilderness Area. Georgia has determined that CAIR is sufficient for the EGUs and summarized their expected controls due to their recently passed rule controlling EGUs. Georgia also identified another source that contributes 0.5 percent to the Joyce Kilmer-Slickrock Wilderness Area and is in the process of reviewing a four factor analysis received from this facility. South Carolina has also determined that CAIR is sufficient for EGUs and no additional controls are required. Virginia provided their reasonable progress analysis for the facility identified to impact Swanquarter Wildlife Refuge. Their analysis showed that the source is currently controlled and that no additional reasonable controls were available for the identified source. Copies of the consultation letters may be found in Appendix J.

The MANE-VU states of Maine, New Jersey, New Hampshire, and Vermont sent letters to North Carolina in the spring of 2007 stating that based on 2002 emissions, North Carolina contributed to visibility impairment to Class I areas in those states. MANE-VU states asked the NCDAQ to participate in further consultation with these states, and a meeting was held in August 2007, in Atlanta, Georgia.

The MANE-VU states identified 12 EGUs in North Carolina that they would like to see controlled to 90% efficiency. They also requested a control strategy to provide a 28% reduction in SO2 emissions from sources other than EGUs that would be equivalent to their low sulfur fuel oil strategy. North Carolina has controlled or is expecting to control under CSA 11 of the 12 identified EGUs. Additionally, scrubbers are expected on three EGUs that were not identified by MANE-VU. The NCDAQ believes that these reductions satisfy MANE-VU's request. The letters from these states, the responses from the NCDAQ, and the meeting notes are included in Appendix J.

In September 2007, the NCDAQ had consultation meetings with the FLMs regarding the initial pre-hearing draft Regional Haze SIP shared with them in August 2007. In these meetings the FLMs provided feedback to the NCDAQ of changes or clarifications they would like to see in the SIP. All three FLMs (FS, NPS and FWS) expressed their concerns about Blue Ridge Paper

Products located in Canton, North Carolina and its impacts on the mountain Class I areas. The NPS and FWS also expressed concern about PCS Phosphate, located in Aurora, North Carolina and its impacts on Swanquarter Wildlife Refuge. The NCDAQ explained the process it went through to determine reasonable, cost-effective control measures and stated that the NCDAQ has notified the company that although additional controls are not being required this planning period, future planning periods may require controls to be installed. The NCDAQ intends to have discussions with Blue Ridge Paper Products over the next review period and to encourage the company to modernize some of its processes with more efficient, less polluting equipment.

On October 2, 2007, and October 9, 2007, the NCDAQ received official comment letters from the U. S. Department of Interior and the USFS, respectively, on the pre-draft version of the Regional Haze SIP. Copies of these comments, as well as the NCDAQ's response to comments are included in Appendix J, satisfying the requirements of 51.308(i)(3) of the regional haze rule.

11.0 COMPREHENSIVE PERIODIC IMPLEMENTATION PLAN REVISIONS

40 CFR 51.308(f) requires the NCDAQ to revise its regional haze implementation plan and submit a plan revision to the USEPA by July 31, 2018 and every ten years thereafter. In accordance with the requirements listed in Section 51.308(f) of the federal rule for regional haze, North Carolina commits to revising and submitting this regional haze implementation plan by July 31, 2018 and every ten years thereafter.

In addition, 51.308(g) requires periodic reports evaluating progress towards the reasonable progress goals established for each mandatory Class I area. In accordance with the requirements listed in 51.308(g) of the federal rule for regional haze, the NCDAQ commits to submitting a report on reasonable progress to the USEPA every five years following the initial submittal of the SIP. The report will be in the form of a SIP revision. The reasonable progress report will evaluate the progress made towards the reasonable progress goal for each mandatory Class I area located within North Carolina and in each mandatory Class I area located outside North Carolina which may be affected by emissions from within North Carolina**.**

The requirements listed in 51.308(g) include the following:

1. Description of the status of implementation;
2. Summary of emission reductions achieved thus far, including especially the status of implementation of the CAIR compliance plans for EGUs compared to the control assumed in the modeling.
3. Assessment of changes in visibility conditions at each Class I area (current vs. baseline), expressed as 5-year averages of annual values for 20% best and worst days;
4. Analysis of emission changes over the 5-year period, identified by source or activity,
5. Analysis of any significant changes in or out of the State which have impeded progress;
6. Assessment of the sufficiency of the implementation plan to meet Reasonable progress goals;
7. Review and any modifications to our visibility monitoring plan.

All requirements listed in 51.308(g) shall be addressed in the SIP revision for reasonable progress. In particular, the NCDAQ recognizes that the 2018 projections of EGU controls from the IPM runs represent one solution to how the CAIR requirements will be met. By the time of the first periodic report, the NCDAQ anticipates that the actual compliance strategy for the various utility companies will be much more defined. An assessment of those actual compliance plans will be done for the first periodic report.

The NCDAQ believes that its New Source Review regulations for both nonattainment areas as well as the prevention of significant deterioration will address emissions from new sources that may located near a Class I area, or increased emissions from major modifications to existing sources. In addition to the NCDAQ regulations that would govern these sources, consultation with the FLMs is also required for sources that are subject to the new source review regulations.

The NCDAQ also commits to ongoing consultation with the FLMs throughout the implementation process, including annual discussion of the implementation process and the most recent IMPROVE monitoring data and VIEWS data.

There are several technical improvements that are recommended in the emissions inventory and air quality models that are used to support regulatory decisions for regional haze. These recommended improvements, as funding is available, can support the next long term strategy. The following is an overall summary; Appendix K contains a more detailed discussion of possible technical improvements.

First and foremost, continued improvements are needed in the integrated one-atmosphere air quality models that are used to project air quality responses to emissions reductions. As our understanding of partitioning between gaseous and aerosol phases improves, this understanding needs to be reflected in the models. Improvements can also be made in how the models handle individual pollutants. Sulfate performance for the CMAQ regional air quality model is good overall. However sulfate deposition is frequently overestimated in the models, particularly in the summer months. At the coastal sites, when winds are blowing from the Gulf of Mexico or Atlantic Ocean, CMAQ underestimates measured sulfate at the monitors. CMAQ's processes also should be reviewed for sulfate formation over water. Nitrate is overestimated by the model in the winter and underestimated in the summer, although summer monitored values of nitrate are very low. Additional improvements in seasonal allocation of ammonia emissions would improve model estimates of ammonium nitrate formation. Organic carbon is generally underestimated in the summer months. Improvements are needed in the characterization of both primary carbon emissions and formation of secondary organic carbon.

Other improvements needed include better tools for organic carbon source apportionment, and more consistent measurement techniques between rural and urban monitoring networks. To improve our understanding of the contribution of fire from natural forest fires, prescribed burning, land clearing, and agricultural burning, states need improved record keeping. Additional improvements to international emissions inventory are also needed to improve our understanding of boundary conditions for our modeling domain and of the contributions from international emissions to pollutant concentrations at the VISTAS Class I areas.

12.0 DETERMINATION OF ADEQUACY OF THE EXISTING PLAN

Depending on the findings of the five-year progress report, North Carolina commits to taking one of the actions listed in 40 CFR 51.308(h). The findings of the five-year progress report will determine which action is appropriate and necessary.

List of Possible Actions – adapted from 40 CFR 51.308(h)

1) The NCDAQ determines that the existing SIP requires no further substantive revision in order to achieve established goals. The NCDAQ provides to the Administrator a negative declaration that further revision of the SIP is not needed at this time.
2) The NCDAQ determines that the existing SIP may be inadequate to ensure reasonable progress due to emissions from other states, which participated in the regional planning process. The NCDAQ provides notification to the Administrator and the states that participated in regional planning. The NCDAQ collaborates with states and FLMs through the regional planning process to address the SIP's deficiencies.
3) The NCDAQ determines that the current SIP may be inadequate to ensure reasonable progress due to emissions from another country. The NCDAQ provides notification, along with available information, to the Administrator.
4) The NCDAQ determines that the existing SIP is inadequate to ensure reasonable progress due to emissions within the state. The NCDAQ will consult with FLMs and revise its SIP to address the plan's deficiencies within one year.