WESTERN REGIONAL AIR PARTERNERSHIP
REGIONAL HAZE RULE
REASONABLE PROGRESS SUMMARY REPORT

Prepared for:

Tom Moore
Western Governors' Association
WRAP Air Quality Program Manager
tmoore@westgov.org

Prepared by:

Air Resource
Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525
Phone: 970-484-7941
www.air-resource.com

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GLOSSARY OF TERMS

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

Ammonium nitrate (NH_4NO_3): Ammonium nitrate is formed in the atmosphere from reactions involving nitrogen dioxide (NO_2) emissions, which are dominated by anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.

Ammonium sulfate ($(NH_4)_2SO_4$): Ammonium sulfate is formed in the atmosphere from reactions involving sulfur dioxide (SO_2) emissions. Anthropogenic sources include coal-burning power plants and other industrial sources, such as smelters, industrial boilers, and oil refineries, and to a lesser extent, gasoline and diesel combustion.

Anthropogenic: Produced by human activities.

Area sources: Sources that are treated as being spread over a spatial extent (usually a county or air district) and that are not movable (as compared to non-road mobile and on-road mobile sources). Because it is not possible to collect the emissions at each point of emission, they are estimated over larger regions. Examples of stationary area sources are residential heating and architectural coatings. Numerous sources, such as dry cleaning facilities, may be treated either as stationary area sources or as point sources.

BART: Best Available Retrofit Technology, a process under the CAA to evaluate the need and, if warranted, install the most effective pollution controls on an already existing air pollution source.

Baseline period: The baseline period, or baseline conditions, are the basis against which improvements in worst day visibility, and lack of degradation for the best day visibility, are judged. For initial RHR implementation plan purposes, the baseline is the average visibility impairment as measured by IMPROVE monitors during the 2000-2004 5-year period.

Biogenic emissions: Biogenic emissions are based on the activity fluxes modeled from biogenic land use data, which characterizes the types of vegetation that exist in particular areas. Emissions are generally derived using modeled estimates of biogenic gas-phase pollutants from land use information, emissions factors for different plant species, and meteorology data.

Class I area (CIA): As defined in the Clean Air Act, areas that were in existence as of August 7, 1977: national parks over 6,000 acres, national wilderness areas and national memorial parks over 5,000 acres, and international parks.

Clean Air Act (CAA): The basic framework for controlling air pollutants in the United States, originally adopted in 1963, and amended in 1970, 1977, and 1990. The CAA was designed to “protect and enhance” air quality. Section 169A of the Clean Air Act (CAA), established in the 1977 Amendments, set forth a national goal for visibility which is the ‘‘prevention of any future, and the remedying of any existing, impairment of visibility in Federal Class I areas (CIAs) which impairment results from manmade air pollution.’’

Coarse mass (CM): Coarse mass refers to the mass of large particles greater than 2.5 and smaller than 10 µm in diameter.

Colorado Plateau: A high, semi-arid tableland in southeast Utah, northern Arizona, northwest New Mexico, and western Colorado.

Current conditions: For purposes of this report, current conditions represent the most recent successive 5-year average after the 2000-2004 baseline conditions, or the 2005-2009 period.

Current progress period: For purposes of this report, the current progress period, also referred to as the first progress period, represents the most recent successive 5-year average after the 2000-2004 baseline conditions, or the 2005-2009 period.

Deciview (dv): The deciview metric is used to track regional haze in the RHR. The Haze Index (measured in deciviews) was designed to be linear with respect to human perception of visibility. A one deciview change is approximately equivalent to a 10% change in extinction, whether visibility is good or poor. A one deciview change in visibility is generally considered to be the minimum change the average person can detect.

Dust: Dust emissions may have a variety of sources that could include anthropogenic sources, natural sources, and natural sources that may be influenced by anthropogenic activity. Fugitive dust includes sources such as road dust, agricultural operations, construction and mining operations and windblown dust from vacant lands. Windblown dust includes more of the natural influences such as wind erosion on natural lands.

Elemental carbon (EC): Elemental carbon, also known as light absorbing carbon (LAC), is the primary light absorbing compound in the atmosphere. These particles are emitted directly into the air from virtually all combustion activities, but are especially prevalent in diesel exhaust and smoke from wild and prescribed fires.

Environmental Protection Agency (EPA): The EPA is an agency of the U.S. federal government which was created for the purpose of protecting human health and the environment by writing and enforcing regulations based on laws passed by Congress.

Extinction (b_{ext}): Extinction is a measure of the fraction of light lost per unit length along a sight path due to scattering and absorption by gases and particles, expressed in inverse Megameters (Mm^{-1}).

Fine soil: Particulate matter composed of pollutants from the Earth’s soil that enters the air from dirt roads, fields, and other open spaces as a result of wind, traffic, and other surface mechanical disturbance activities. Fine soil includes soil particles with an aerodynamic diameter less than 2.5 microns.

Fire: Fire sources may have a mix of natural and anthropogenic influences. Natural sources include wildland fires, while anthropogenic sources can include agricultural and prescribed fires.

First progress period: For purposes of this report, the first progress period, also referred to as the current progress period, represents the most recent successive 5-year average after the 2000-2004 baseline conditions, or the 2005-2009 period.

Grand Canyon Visibility Transport Commission (GCVTC): In 1990, amendments to the Clean Air Act established the Commission to advise the EPA on strategies for protecting visual air quality on the Colorado Plateau.

Haze Index (HI): The Haze Index (measured in deciviews) is used to track regional haze in the RHR. It was designed to be linear with respect to human perception of visibility, where a one deciview change is approximately equivalent to a 10% change in extinction, whether visibility is good or poor. A one deciview change in visibility is generally considered to be the minimum change the average person can detect.

Interagency Monitoring of Protected Visual Environment (IMPROVE): A collaborative monitoring program governed by a steering committee composed of representatives from Federal and regional-state organizations to establish present visibility levels and trends, and to identify sources of man-made impairment

Inverse megameters (Mm^{-1}): A measurement unit used for light extinction, the higher the value, the hazier the air is.

Least impaired days: The least impaired, or best, days refers to the average visibility impairment (measured in deciviews) for the twenty percent of monitored days in a calendar year with the lowest amount of visibility impairment.

Light extinction: A measure of how much light is absorbed or scattered as it passes through a medium, such as the atmosphere. Aerosol light extinction refers to the absorption and scattering by aerosols. Total light extinction refers to the sum of aerosol light extinction, the absorption by gases (such as NO_2), and the atmospheric light extinction (Rayleigh scattering). Extinction is often expressed as a measure of the fraction of light lost per unit length in units of inverse Megameters (Mm^{-1}).

Mandatory Federal Class I areas: Certain national parks (over 6,000 acres), wilderness areas (over 5,000 acres), national memorial parks (over 5,000 acres), and international parks that were in existence as of August 1977.

Most impaired days: The most impaired, or worst, days refers to the average visibility impairment (measured in deciviews) for the twenty percent of monitored days in a calendar year with the highest amount of visibility impairment.

Natural background condition: Naturally occurring phenomena that reduce visibility as measured in terms of light extinction, visual range, contrast, or coloration.

Natural conditions: Natural conditions include any naturally occurring phenomena that reduce visibility as measured in terms of light extinction, visual range, contrast, or coloration.

Off-road mobile sources: Off-road mobile sources are vehicles and engines that encompass a wide variety of equipment types that either move under their own power or are capable of being moved from site to site. Examples include agricultural equipment such as tractors or combines, aircraft, locomotives and oil field equipment such as mechanical drilling engines.

Off-shore: Commercial marine emissions comprise a wide variety of vessel types and uses. Emissions can be include deep draft vessels within shore and near port using port call data, and offshore emissions generated from ship location data.

Oil and gas sources: Oil and gas sources consist of a number of different types of activities from engine sources for drill rigs and compressor engines, to sources such as condensate tanks and fugitive gas emissions. The variety of emissions types for sources specific to oil and gas activity can, in some cases, overlap with mobile, area or point sources, but these can also be extracted and treated separately.

On-road mobile sources: Vehicular sources that travel on roadways. Emissions from these sources can be computed either as being spread over a spatial extent or as being assigned to a line location (called a link). Emissions are estimated as the product of emissions factors and activity data (vehicle miles traveled (VMT). Examples of on-road mobile sources include light-duty gasoline vehicles and heavy-duty diesel vehicles.

Oxides of nitrogen (NO_X): A mixture of nitrogen dioxide and other nitrogen oxide gases. Nitrogen is the most common gas in the atmosphere. In high temperature and/or high pressure burning (as in an engine), the air's nitrogen is broken down and combined with oxygen, forming unstable or reactive NO_X gases. Nitrogen dioxide (NO_2) is yellowish brown, and thus contributes directly to haze. All the NO_X gases react in the air to form haze-causing aerosols and smog.

Particulate organic aerosol (POA): Particulate organic aerosol represents organic aerosols that are emitted directly as particles, as opposed to gases.

Particulate organic mass (POM): Particulate Organic Mass is also referred to as Particulate Organic Carbon and Organic Mass Carbon (OMC). Particulate organic mass can be emitted directly as particles, or formed through reactions involving gaseous emissions. Natural sources of organic carbon include wildfires and biogenic emissions. Man-made sources can include prescribed forest and agricultural burning, vehicle exhaust, vehicle refueling, solvent evaporation (e.g., paints), food cooking, and various commercial and industrial sources.

Point sources: These are sources that are identified by point locations, typically because they are regulated and their locations are available in regulatory reports. In addition, elevated point sources will have their emissions allocated vertically through the model layers, as opposed to being emitted into only the first model layer. Point sources can be further subdivided into electric generating unit (EGU) sources and non-EGU sources, particularly in criteria inventories in which EGUs are a primary source of NO_X and SO_2. Examples of non-EGU point sources include chemical manufacturers and furniture refinishers.

Prevention of significant deterioration (PSD): A program established by the Clean Air Act Amendments of 1977 that limits the amount of additional air pollution that is allowed in Class I and Class II areas.

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

Reasonable progress: Reasonable progress refers to progress in reducing human-caused haze in Class I areas under the national visibility goal. The Clean Air Act indicates that "reasonable" should consider the cost of reducing air pollution emissions, the time necessary, and the energy and non-air quality environmental impacts of reducing.

Reconstructed aerosol extinction: The percent of total atmospheric extinction attributed to each aerosol and gaseous component of the atmosphere.

Regional haze: Regional haze refers to visibility impairment that is caused by the emission of air pollutants from numerous sources located over a wide geographic area.

Regional Haze Rule (RHR): Federal rule that requires states to develop programs to assure reasonable progress toward meeting the national goal of preventing any future, and remedying any existing, impairment of visibility in mandatory Class I Federal areas.

Relative humidity: Partial pressure of water vapor at the atmospheric temperature divided by the vapor pressure of water at that temperature, expressed as a percentage.

Scattering efficiency: The amount of light scattered relative to the particle’s size.

Sea salt: Sea salt is a natural aerosol emitted in coastal areas. In practice, chloride ion measurements are used to represent sea salt in IMPROVE measurements, and measurements may sometimes show anthropogenic or crustal influences at inland monitors.

Sulfur dioxide (SO_2): SO_2 gas is associated with emissions from processes such as burning fuels, manufacturing paper, or smelting rock. SO_2 is converted in the air to other sulfur oxides (SO_X) or haze-causing aerosols (sulfates).

State Implementation Plans (SIPs): A detailed description of the programs a state will use to carry out its responsibilities under the Clean Air Act. State implementation plans are collections of the regulations used by a state to reduce air pollution. Plans devised by states and tribes to carry out their responsibilities under the Clean Air Act. SIPs and TIPs must be approved by the U.S. Environmental Protection Agency and include public review.

Visibility impairment: Any humanly perceptible change in visibility (light extinction, visual range, contrast, coloration) from that which would have existed under natural conditions.

Visibility: Refers to the visual quality of the view, or scene, in daylight with respect to color rendition and contrast definition.

Visual range (VR): Visual range is the greatest distance a large black object can be seen on the horizon, expressed in kilometers (km) or miles (mi).

Volatile organic compound (VOC): A carbon-containing material that evaporates, such as gasoline, some paints, solvents, dry cleaning fluids, and the like. VOCs contribute to the formation of particulate organic mass.

Western Regional Air Partnership (WRAP): A partnership of state, tribal and federal land management agencies to help coordinate implementation of the GCTVC's recommendation.

EXECUTIVE SUMMARY

The United States Environmental Protection Agency's (EPA's) 1999 Regional Haze Rule (RHR)[1] was designed to improve visibility conditions in the nation's largest National Parks and Wilderness Areas. The goal of the RHR, as stated in the Clean Air Act (CAA) 1977 Amendments, is the "prevention of any future, and the remedying of any existing, impairment of visibility."[2] The RHR mandates that states identify and implement pollution control strategies to progress towards a "natural conditions" goal, or conditions without any manmade impairment, by the year 2064. States were required to submit initial RHR implementation plans in 2007 which identified goals and strategies for visibility improvement. States are then required to revise implementation plan every 10-years, and submit progress reports at interim points between implementation plan submittals. This support document has been prepared for the Western Regional Air Partnership (WRAP), on behalf of the 15 western state members in the WRAP region, to provide technical basis for use by the western states to develop the first of their RHR progress reports, assessing progress towards goals as defined in their initial SIPs.

The visibility improvement goal, as stated in the RHR, is to ensure that visibility on the worst days improves towards a natural conditions goal, and that visibility on the best days does not get worse. To measure progress towards natural conditions, the EPA provided the concept of a linear, or uniform, rate of reasonable progress between the 2000-2004 baseline period and a default natural conditions goal year of 2064.[3] The RHR specifies that progress is determined for "current conditions", and RHR guidance released in 2003 specifies that progress be tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods (i.e. 2005-2009, 2010-2014, etc.).[4] More recent guidance, released in April, 2013, indicates that progress reports "should include the 5-year average that includes the most recent quality assured public data available at the time the state submits its 5-year progress report for public review,"[5] and suggests assessing changes using a rolling 5-year period average. Per original 2003 guidance, progress for this support document is reported as changes in monitored between baseline conditions and the first successive 5-year progress period (2005-2009) data. Additionally, for summaries here, annual average trend statistics as measured for each aerosol species during the 2000-2009 10-year period are reported to support assessments of changing conditions.

This report includes regional, state, and CIA specific summaries that characterize the difference between the baseline conditions and first successive progress period. Assessments include changes in visibility impairment as measured using aerosol data collected by the

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[1] See CFR 40 Part 51 Regional Haze Regulations; Final Rule, July 1, 1999, available online at http://www.epa.gov/airquality/visibility/actions.html.

[2] See Section 169a of the 1977 CAA Amendments.

[3] Note that "default" natural conditions as defined by the EPA are subject to revisions, and that States can extend the period of time needed to achieve natural conditions, beyond the nominal 2064 in the RHR, defining and defending new interim reasonable progress rates, and adjusting the 2064 end year as needed (see CFR Section 51.308).

[4] See page 4-2 in EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule.*

[5] See page 9 in EPA's April 2013 *General Principals for the 5-Year Regional Haze Progress reports for the Initial Regional Haze State Implementation Plans (Intended to Assist States and EPA Regional Offices in Development and Review of the Progress Reports).*

Interagency Monitoring of Protected Visual Environments (IMPROVE) network, and assessments of progress also include the differences between emissions inventories for years that represent both the baseline and progress periods. Specific regulatory questions addressed in this report include:

- What are the current visibility conditions for the most impaired (worst) and least impaired (best) days?
- What is the difference between current visibility conditions and baseline conditions for the most impaired and least impaired days?
- What is the change in emissions that occurred between the baseline period and the progress period?

The RHR also requires states to evaluate the sufficiency of current implementation plan elements and strategies to meet reasonable progress goals. Determining the status of emissions reductions and evaluation of state-selected goals are beyond the scope of this report, and will be addressed separately by individual states. Specific regulatory questions that address evaluation requirements include:

- What is the status of implementation of all measures included in the implementation plan?
- What emissions reductions have been achieved through implementation of these measures?
- What emissions from within or outside of the state have limited or impeded progress in reducing pollutant emission and improving visibility?
- Are current implementation plan elements and strategies sufficient to enable the state or other states with mandatory federal CIAs affected by the state, to meet all established reasonable progress goals?

Visibility impairment is tracked using a Haze Index (HI) in units of deciviews (dv), which is related to the cumulative sum of visibility impairment from individual aerosol species as measured by monitors in the IMPROVE Network. Emissions which affect regional haze include a wide variety of natural (e.g., wildland fires) and anthropogenic, or man-made, sources (e.g., industry sources and vehicles). Per regulatory requirements, differences between emissions inventories representing both the baseline and progress periods are presented here. Baseline emissions in most cases are represented using the 2002 inventory that was originally developed, with support from the WRAP, to represent emissions for the initial implementation plans. Current emissions are represented here by leveraging recent work by the WRAP to develop an updated and comprehensive inventory for the year 2008 for use in modeling projects. Emissions inventory comparisons in this report were complicated by the fact that a number of changes and enhancements have occurred between development of the baseline and current period inventories, such that some of the differences between inventories are more reflective of changes in inventory methodology, rather than changes in actual emissions. Characterizations here focus more on differences in the actual monitored data, which are thought to be more reflective of progress than differences between the emission inventories. Some notable results were as follows:

- Analysis of monitored data, in terms of comparisons between the 5-year average deciview metrics, showed improved visibility conditions on the best days at nearly all of the WRAP CIAs. Most sites showed improved conditions on the worst days, but some sites showed a decline in visibility conditions for the worst days.
- Looking at differences between 5-year averages for individual measured species, most sites that did not show improved deciview conditions on the worst days were affected by large particulate organic matter measurements related to wildland fire.
- Ammonium nitrate, in most cases, showed the largest decreases in 5-year averages and the largest decreasing annual trends. This was consistent with mobile source inventory comparisons which showed large decreases in oxides of nitrogen (NO_X), which are among the precursors for ammonium nitrate particulate formation. Decreasing emissions were due in large part to federal and state emissions standards that have already been implemented for mobile sources.
- In many of the plains states, the 5-year average of ammonium sulfate increased, but annual averages showed decreasing trends. Sulfur dioxide (SO_2) emissions, which are precursors for ammonium sulfate particle formation, showed decreases in most cases, especially from EGUs and other point sources. Many of the highest ammonium sulfate measurements spanned large regions. Possible contributions to measured visibility impairment from international sources were not quantified here.
- In southern Oregon and northern California, increasing ammonium sulfate trends were evident at several coastal sites. State emissions inventory comparisons did not reflect these increases, but marine vessel emissions were not quantified for summaries here.
- Also, in northeastern Montana and northwestern North Dakota, increasing ammonium sulfate trends were evident at several sites. State emissions inventory comparisons did not reflect these increases, but these sites are along the Canadian border, and possible influences from nearby international sources were not quantified here.
- In Hawaii, dramatic increases in ammonium sulfate were related to natural emissions, with increased volcanic emissions accounting for most of the SO_2 emissions inventoried.
- Coarse mass extinction trends were variable and not statistically significant in most cases, but an area represented by several IMPROVE sites in eastern Arizona and western New Mexico did show increasing coarse mass trends. Emission inventories indicated that natural windblown dust is the largest contributor to coarse mass measurements in this area, but significant changes in the development of the windblown dust inventories did not allow for definitive comparisons between 2002 and 2008 inventories for these emissions.

More detailed summaries are provided in this report on a regional, state and CIA specific basis. These summaries are also supported by interactive tools available from the online WRAP

Technical Support System (TSS).[6] Summaries presented here were developed cooperatively with representatives from each state in the WRAP region. This report and accompanying data analysis results were developed to support state development of RHR progress reports, the first of which are due in 2013, but should also serve as an important interim step informing the next round of full implementation plan revisions which come due in 2018.

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[6] The WRAP TSS, available at http://vista.cira.colostate.edu/tss/, is an online tool developed to support the air quality planning needs of western state and tribes, which has been recently updated with summaries of current IMPROVE monitoring data, and recent emissions to support development of RHR progress reports.

1.0 INTRODUCTION

The United States Environmental Protection Agency's (EPA's) 1999 Regional Haze Rule (RHR)[7] was designed to address visibility impairment in Class I areas (CIAs), where CIAs include many of the nation's largest National Parks and Wilderness Areas. The RHR mandates that each CIA progress towards a natural conditions goal, or conditions without any man-made influences, by the year 2064. Each state is required to periodically assess the rate of progress towards visibility improvement goals for each CIA in that state, and for CIAs affected by transport from that state.

The RHR requires states to develop state implementation plans (SIPs) every 10 years which identify strategies designed to meet a series of interim goals over the long term regional haze planning period. The first of these SIPs were due in 2007 and were required to identify a baseline starting point using the average of monitoring data for the 2000-2004 5-year period, and demonstrate progress towards visibility improvement that is expected to occur by the first interim goal in 2018. In addition to SIPs, the RHR requires each state to assess progress towards interim visibility improvement goals between each 10-year SIP submittal, where the first progress report addressing changes between the 2000-2004 baseline conditions and current conditions. The individual, state-submitted, progress reports for the western states are due at various times between 2013 and 2017, depending on respective approval dates for each state's initial implementation plan.

This progress report support document has been prepared by the Western Regional Air Partnership (WRAP)[8], on behalf of the 15 western state members in the WRAP region, to provide the technical basis for use by States to develop the first of their individual reasonable progress reports for the 116 Federal CIAs located in the western states. Data are presented in this report on a regional, state, and CIA specific basis that characterize the difference between 2000-2004 baseline conditions and current conditions, represented here by the most recent successive 5-year average, or the 2005-2009 period. Changes in visibility impairment are characterized using aerosol measurements from the Interagency Monitoring of Protected Visual Environments (IMPROVE) network, and the differences between emissions inventory years representing both the baseline and current progress period.

Analysis and summaries provided in this report were developed cooperatively with representatives from each state in the WRAP region, and were designed to provide western states with the technical basis necessary to support their evaluation of the current or proposed elements and strategies as outlined in their initial RHR implementation plans. Summaries here are also

[7] See CFR 40 Part 51 Regional Haze Regulations; Final Rule, July 1, 1999, available online at http://www.epa.gov/airquality/visibility/actions.html.

[8] The WRAP is a collaborative effort of tribal governments, state governments and various federal agencies representing the western states that provides technical and policy tools for the western states and tribes to comply with the EPA's RHR regulations. Detailed information regarding WRAP support of air quality management issues for western states is provided on the WRAP website (www.wrapair2.org) and data summary descriptions and tools specific to RHR support are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

supported by interactive tools available from the online WRAP Technical Support System (TSS).[9] Any questions regarding the content of this report should be addressed to:

Tom Moore, WRAP Air Quality Program Manager
Western Governors' Association
tmoore@westgov.org
970-491-8837

or

Cassie Archuleta, Primary Author
Emily Vanden Hoek, Emissions Data Analyst
Air Resource Specialists, Inc.
carchuleta@air-resource.com
evandenhoek@air-resource.com
970-484-7941

[9] The WRAP TSS, available at http://vista.cira.colostate.edu/tss/, is an online tool developed to support the air quality planning needs of western states and tribes; it has been recently updated with summaries of current IMPROVE monitoring data, and recent emissions to support development of RHR progress reports.

2.0 REGULATORY REQUIREMENTS

In regulatory context, Section 169A of the Clean Air Act (CAA), established in the 1977 Amendments, set forth a national goal for visibility which is the ‘‘prevention of any future, and the remedying of any existing, impairment of visibility in Class I areas which impairment results from manmade air pollution.”[10] In 1999, the Environmental Protection Agency’s (EPA) promulgated regulations that provided the requirements for states to develop and submit state implementation plans (SIPs) to address regional haze in Federal CIAs (40 CFR 51.308 and 51.309), where SIPs address each state’s strategy to progress towards meeting the long term natural condition visibility impairment goal by the year 2064.

The first of these SIPs were due by December 17, 2007, and were required to address a uniform rate of reasonable progress towards an interim 2018 goal. Each state is required to submit a revised implementation plan by July 31, 2018 and every 10 years thereafter (51.308(f)). Additionally, at 5-year intervals between SIP revisions, states are required to submit periodic progress reports evaluating progress towards the reasonable progress goals defined the SIPs. The first progress report is due 5 years from the approval of the initial implementation plan (51.308(g)), or, for states who submitted a SIP under 40 CFR 51.309, by December 31, 2013. To support development of Regional Haze Rule (RHR) SIPs, the EPA has released several guidance documents, including:

- EPA’s September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule*
- EPA’s September 2003 *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule*
- EPA’s April 2013 *General Principals for the 5-Year Regional Haze Progress reports for the Initial Regional Haze State Implementation Plans (Intended to Assist States and EPA Regional Offices in Development and Review of the Progress Reports)*

EPA’s September 2003 guidance specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc.[11] EPA’s more recent guidance, released in April 2013, indicates that progress reports “should include the 5-year average that includes the most recent quality assured public data available at the time the state submits its 5-year progress report for public review,”[12] and suggests assessing changes using a rolling 5-year period average. The new EPA guidance was released as this report and analysis were finalized and, per the original 2003 guidance, progress for this support document is reported as changes in monitored between baseline conditions and the most recent successive 5-year progress period, or the 2005-2009 period. Figure 2.0-1 below presents an idealized glide slope indicating linear progress in successive 5-year increments for

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[10] See section 169A of the Clean Air Act (CAA) 1977 Amendments.

[11] See page 4-2 in EPA’s September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule.*

[12] See page 9 in EPA’s April 2013 *General Principals for the 5-Year Regional Haze Progress reports for the Initial Regional Haze State Implementation Plans (Intended to Assist States and EPA Regional Offices in Development and Review of the Progress Reports)*

improvement on the worst days towards a 2064 natural conditions goal. Specific references for RHR Section 308 and 309 regulatory requirements are provided in this section.

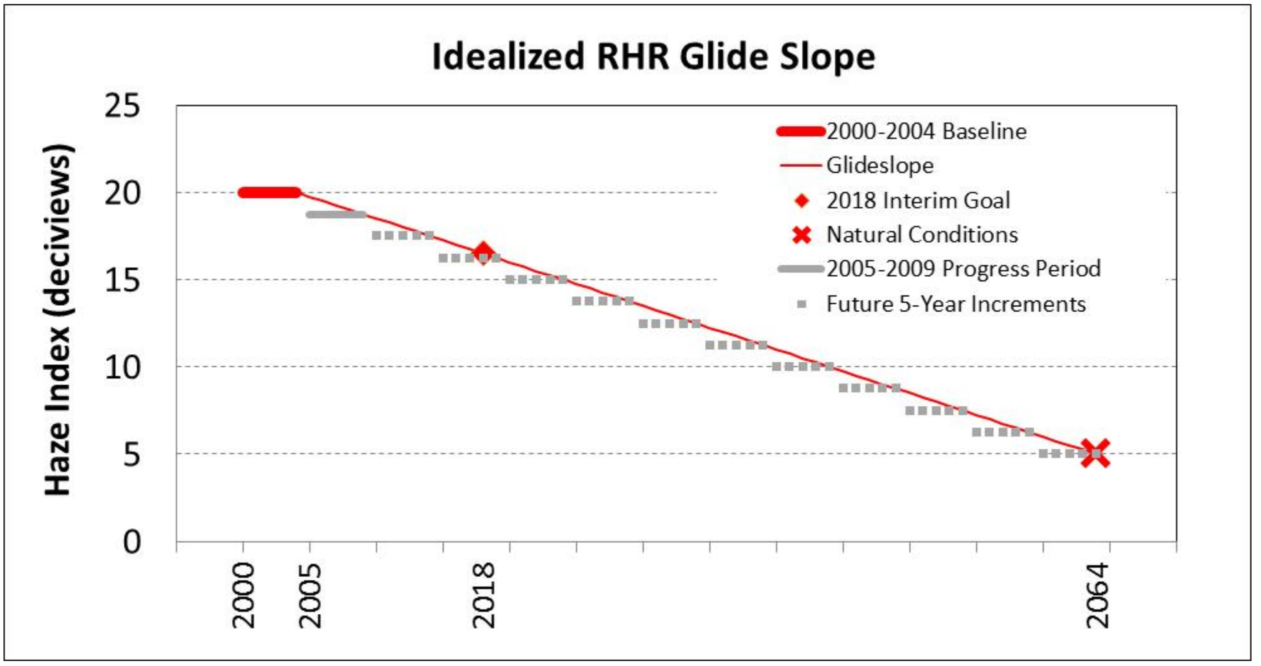

Figure 2.0-1. Idealized RHR Glide Slope Representing Linear Progress from a 2000-2004 Baseline Average to a 2064 Natural Conditions End Goal. Also Represented Are the 2018 Interim Goal and Successive 5-Year Progress Periods.

2.1 SECTION 308

Section 51.308(g) of the RHR contains the requirements for periodic progress reports. Each state is required to submit a report evaluating progress towards the reasonable progress goals outlined in its regional haze state, or in some cases federal, implementation plan (SIP or FIP).[13] These state progress reports are required to summarize recent changes in monitoring and emissions data, and evaluate the adequacy of the current SIP to meet interim progress goals. Specific regulatory text related to Section 308 progress report requirements is summarized here.

2.1.1 Monitoring and Emissions Data Summary Requirements

Sections 51.308(g)(3) and 51.308(g)(4) of the RHR contain the monitoring and emissions data summary requirements for RHR progress reports. These requirements are addressed in this report on a regional, state and Class I Area specific basis. Monitoring and emissions summary requirements for progress reports include the following:

- How has visibility changed at the CIAs in the state in the last 5 years (51.308(g)(3))? Specifically listed under this requirement are the following elements:

[13] Note that implementation plan references to SIPs in this report are also intended to include any full or partial FIPs.

- What are the current visibility conditions for the most impaired and least impaired days (51.308(g)(3)(i))?
- What is the difference between baseline visibility conditions and current visibility conditions for the most impaired and least impaired days (51.308(g)(3)(ii))?
- What is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (51.308(g)(3)(iii))?

- For pollutants that affect visibility at CIAs, how have total emissions in the state changed over the past 5 years (51.308(g)(4))?

Monitoring data summaries presented in this report include data collected by the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring network.[14] For monitoring data summaries, baseline visibility conditions are defined as the average deciview values for the 20% most impaired, or worst, and 20% least impaired, or best, days averaged over the 2000-2004 5-year period. Current visibility conditions are represented here per EPA's 2003 guidance as the most recent successive 5-year average period available, or the 2005-2009 period.[15]

Per regulatory requirements, differences between emissions inventories representing both the baseline and progress are presented here. Baseline emissions in most cases are represented using a 2002 inventory that was originally developed, with support from the WRAP, to represent emissions for the initial implementation plans. Changes in emissions are represented using differences between the baseline inventory, and more recent inventory development work sponsored by the WRAP for the year 2008.[16]

2.1.2 SIP Evaluation Requirements

The RHR progress report stipulations require individual states to determine if the current visibility monitoring strategy and existing implementation plans are sufficient, or if modifications are necessary. Evaluation of current SIPs is not within the scope of this support document, but monitoring and emissions data summaries presented here have been designed to provide the western states with the technical basis to assist with their evaluation of current or proposed implementation plan elements and strategies. Specific regulatory questions relating to SIP evaluations are listed below.

- What is the status of implementation of all measures included in each state's regional haze SIP (51.308(g)(1))?
    - Note that, for most states, 2018 projections provided by the WRAP for use in the initial SIPs were conservative estimates that did not include best available retrofit technology (BART) controls.

[14] Descriptions of IMPROVE Network monitoring data and visibility calculations are provided in Section 3.1 of this report.
[15] See page 4-2 in EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule.*
[16] See emission inventory descriptions in Section 3.2 of this report.

- What emission reductions have been achieved through implementation of regional haze SIP measurers (51.308(g)(2))?
  - Note that emissions data summaries presented in this report include a comparison of emission inventories representing both the baseline and current period, but a determination of what reductions may be related to implementation of SIP measures will be made by individual states.
- Have there been significant changes in emissions over the past 5 years from within or outside the state that have impeded progress in improving visibility at each state's Federal CIAs (51.308(g)(5))?
  - As noted previously, emissions data summaries presented in this report include a comparison of emission inventories representing both the baseline and current period, but a determination of whether specific emissions have limited or impeded progress will be made by individual states.
- Is the state's SIP sufficient to enable the state, and other states with CIAs affected by emissions from your state, to meet their reasonable progress goals (51.308(g)(6))?
- Based on these assessments, are any changes in the state's visibility monitoring plan necessary (51.308(g)(7))?
- Based on the state's assessment of the adequacy of the existing monitoring plan, the State is also required to take one of the following actions (51.308(h)):
  - Submit a declaration that the plan is adequate and further revisions are not necessary ((51.308(h)(1)); or
  - If the implementation plan is determined to be inadequate, the state must take steps to develop additional strategies to address the plans deficiencies ((51.308(h)(2), (3) and (4)).

The Regional Haze Rule also includes requirements for each state to coordinate and consult with federal land managers (FLMs) when assessing progress for current visibility conditions and SIP strategies. Specific requirements related to consultation with FLMs include:

- Has the state provided FLMs an opportunity for consultation in person 60 days prior to holding any public hearing on a regional haze SIP revision? (51.308(i)(2))
- Has the state included a description in your SIP revision on how the state addressed FLM comments? (51.308(i)(3))
- Has the state provided procedures for continuing consultation with FLMs in the regional haze SIP revisions and 5-year progress reports? (51.308(i)(4))

Development of this progress report has included regional coordination, offering opportunities for consultation with surrounding states. Also, this project has facilitated some opportunities for feedback from FLMs through summary calls and meetings.

2.2 SECTION 309

Under Section 309 of the RHR, 9 western states and tribes within those states had the option of submitting plans to reduce regional haze emissions that impair visibility at 16 CIAs on the Colorado Plateau. Five states, including Arizona, New Mexico, Oregon, Utah, and Wyoming, initially exercised this option by submitting plans to the EPA by December 31, 2003. Oregon elected to cease participation in the program in 2006 and Arizona elected to cease participation in 2010. As used in this document, Section 309 states refer to the states of New Mexico, Utah, and Wyoming and the city of Albuquerque/Bernalillo County.

Section 309 of the RHR specifically requires participating states to submit progress evaluations in 2013 (51.309(d)(10)), as opposed to the more general requirement of 5-years from initial SIP approvals, as referenced in Section 308. Specific regulatory text related to Section 309 progress report requirements is summarized here.

2.2.1 Monitoring and Emissions Data Summary Requirements

Section 51.309(d)(10) contains the monitoring and emissions data summary requirements for progress reports for Section 309 states. These requirements address the 16 CIAs on the Colorado Plateau (Grand Canyon National Park, Sycamore Canyon Wilderness, Petrified Forest National Park, Mount Baldy Wilderness, San Pedro Parks Wilderness, Mesa Verde National Park, Weminuche Wilderness, Black Canyon of the Gunnison Wilderness, West Elk Wilderness, Maroon Bells Wilderness, Flat Tops Wilderness, Arches National Park, Canyonlands National Park, Capital Reef National Park, Bryce Canyon National Park, and Zion National Park). Specific monitoring and emissions summary requirements are listed below, and are addressed in this progress report support document on a regional, state, and CIA basis.

- How has visibility changed at the CIAs in the state in the last 5 years (51.309(d)(3))? Specifically listed under this requirement are the following elements:
  - What are the current visibility conditions for the most impaired and least impaired days (51.309(d)(10)(i)(C))?
  - What is the difference between baseline visibility conditions and current visibility conditions for the most impaired and least impaired days (51.309(d)(10)(i)(C))?
  - What is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (51.309(d)(10)(i)(C))?
- For pollutants that affect visibility at CIAs, how have total emissions in the state changed over the past 5 years (51.309(d)(10)(i)(D))?

2.2.2 SIP Evaluation Requirements

Section 309 of the RHR requires that progress reports include a determination of whether the current visibility monitoring strategy and existing implementation plans are sufficient, or if modifications are necessary. Evaluation of current SIPs is not within the scope of this support document, but monitoring and emissions data summaries presented here have been designed to help states with their evaluation of current or proposed implementation plan elements and strategies. Specific regulatory requirements relating to Section 309 SIP evaluations are listed below.

- What is the status of implementation of all measures included in the implementation plan for achieving reasonable progress goals (51.309(d)(10)(i)(A))? Note that there are also some specific interim report requirements referenced separately in the RHR:
  - What is the status of mobile source emissions (51.309(d)(5)(ii))?
  - What is the status of progress towards renewable energy goals (51.309(d)(8)(vi))?
- What emission reductions have been achieved through implementation of regional haze SIP measures (51.309(d)(10)(i)(B))?
  - Note that emissions data summaries presented in this report include a comparison of emission inventories representing both the baseline and current period, but a determination of what reductions may be related to implementation of SIP measures will be made by individual states.
- Have there been significant changes in emissions over the past 5 years from within or outside the state that have impeded progress in improving visibility at your states Federal CIAs (51.309(d)(10)(i)(E))?
  - As noted previously, emissions data summaries presented in this report include a comparison of emission inventories representing both the baseline and current periods, but a determination of whether specific emissions have limited or impeded progress will be made by individual states.
- Is your state's SIP sufficient to enable your state, and other states with CIAs affected by emissions from your state, to meet their reasonable progress goals (51.309(d)(10)(i)(F)?
  - Specifically noted is a requirement to assess whether annual SO_2 emissions milestones have been met (51.309(d)(4)(i)). Note that the WRAP has supported work addressing the SO_2 milestone requirements for 309 states. These annual regional SO_2 emissions and milestone reports are located on the WRAP website at http://www.wrapair2.org/reghaze.aspx.
- Based on the state's assessment of the adequacy of the existing monitoring plan, the state is also required to take one of the following actions (51.309(d)(10)(ii)):
  - Submit a declaration that the plan is adequate and further revisions are not necessary (51.309(d)(10)(ii)(A)); or
  - If the implementation plan is determined to be inadequate, the state must take steps to develop additional strategies to address the plans deficiencies ((51.309(d)(10)(ii)(B), (C) and (D)).

2.3 2064 NATURAL CONDITIONS

The concept of "natural conditions" in regional haze represents the long term goal of improving visual conditions in our national parks and wilderness areas. EPA provided the concept of a linear, or uniform, rate of reasonable progress between the 2000-2004 baseline period and the nominal natural conditions goal year in 2064.[17] With each 10-year SIP revision The States have the opportunity to further refine natural conditions estimates. Separate from this report, the WRAP has prepared summaries of the progression and current status of natural condition estimates, including the original EPA default estimates[18] and the revised natural conditions II estimates.[19] Also included in the WRAP report are considerations and recommendations for future natural condition refinements, and some recommended adjustments to regional haze management strategies.[20]

As of 2013, the initial SIPs/FIPs have not been approved for all WRAP states, and as such, not all reasonable progress goals have been defined and/or approved at the time this support document was prepared. Through consultation with state representatives, it was determined that this progress report support document would not address state specific reasonable progress goals or natural conditions. Only summaries of the differences between baseline and current progress period aerosol measurements and emissions inventories are provided here as the technical basis for use by states to determine if they are on track to meet or exceed their individual reasonable progress goals towards natural conditions.

2.4 TRIBAL CONSIDERATIONS

Under the Tribal Air Rule, Tribal governments may elect to implement air programs in much the same way as States, including development of Tribal implementation plans (TIPs). Also, as sovereign nations, Indian tribes have the right under the Clean Air Act to have the EPA classify their lands as CIAs, but this does not provide for the inclusion of the Tribal CIAs as Federal CIAs mandated for protection under the RHR.

Even if a Tribe does not seek authority to implement an RHR TIP, it may be desirable for a Tribe to participate in the regional planning efforts to address visibility and to consult with neighboring states as they develop their regional haze SIPs. Tribes, along with states and federal agencies, are full partners in the WRAP, having equal representation on the WRAP Board as states. Several Tribal nations in the United States have been classified as CIAs, and IMPROVE visibility monitors are located in 4 tribal CIAs in the WRAP. Because these IMPROVE monitors do not represent federally mandated CIAs, summaries for these monitors are not included in this progress report support document.

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[17] Note that states can extend the period of time needed to achieve natural conditions, beyond the nominal 2064 in the RHR, defining and defending new interim amounts of reasonable progress, and adjusting the 2064 end year as needed (see Section 51.308(d)(1)(i)(B) and 501.308(d)(1)(B)(ii) of the RHR).
[18] Default natural conditions estimates are described in EPA's September 2003 *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule.*
[19] See Copeland's 2008 *Regional Haze Rule Natural Level Estimates Using the Revised IMPROVE Aerosol Reconstructed Light Extinction Algorithm*, available at http://vista.cira.colostate.edu/improve/publications/graylit/032_NaturalCondIIpaper/Copeland_etal_NaturalConditionsII_Description.pdf.
[20] WRAP's archived repository of natural conditions information, projects and references is available at http://www.wrapair.org/forums/aamrf/projects/NCB/index.html.

3.0 DATA SOURCES

This report includes summaries of monitoring and emissions data designed to support the first regional haze progress reports for the Western Regional Air Partnership (WRAP) member states. Monitoring data described here includes data collected by the Interagency Monitoring of Protected Visual Environments (IMPROVE) network, with the addition of some data substitution and baseline estimates. Emissions data summaries use inventories previously developed by the WRAP to represent baseline conditions for the initial Regional Haze Rule (RHR) implementation plans, and a more current inventory that leverages emissions estimates that have been recently collected and enhanced to support modeling work currently in progress by the WRAP. Detailed descriptions and references for these data sources as used in this report are described in this section. Also described here are recent changes to dynamic data summary tools available from the WRAP Technical Support System (TSS) website (www.vista.cira.colostate.edu/tss/), which has been updated to support development of RHR progress reports.

3.1 IMPROVE MONITORING DATA

Visibility is reduced by the absorption and scattering of light by particles and gases in the atmosphere. Light extinction, or the fraction of light lost due to scattering and absorption by gases and particles, can be estimated from measurements of speciated aerosol mass. The IMPROVE Network is a multi-agency, nation-wide visibility monitoring network which began in 1988, and expanded significantly in 2000 in support of the EPA's RHR. Each Federal Class I area (CIA) is represented by at least one IMPROVE monitor, as depicted for the WRAP region in Figure 3.1-1.

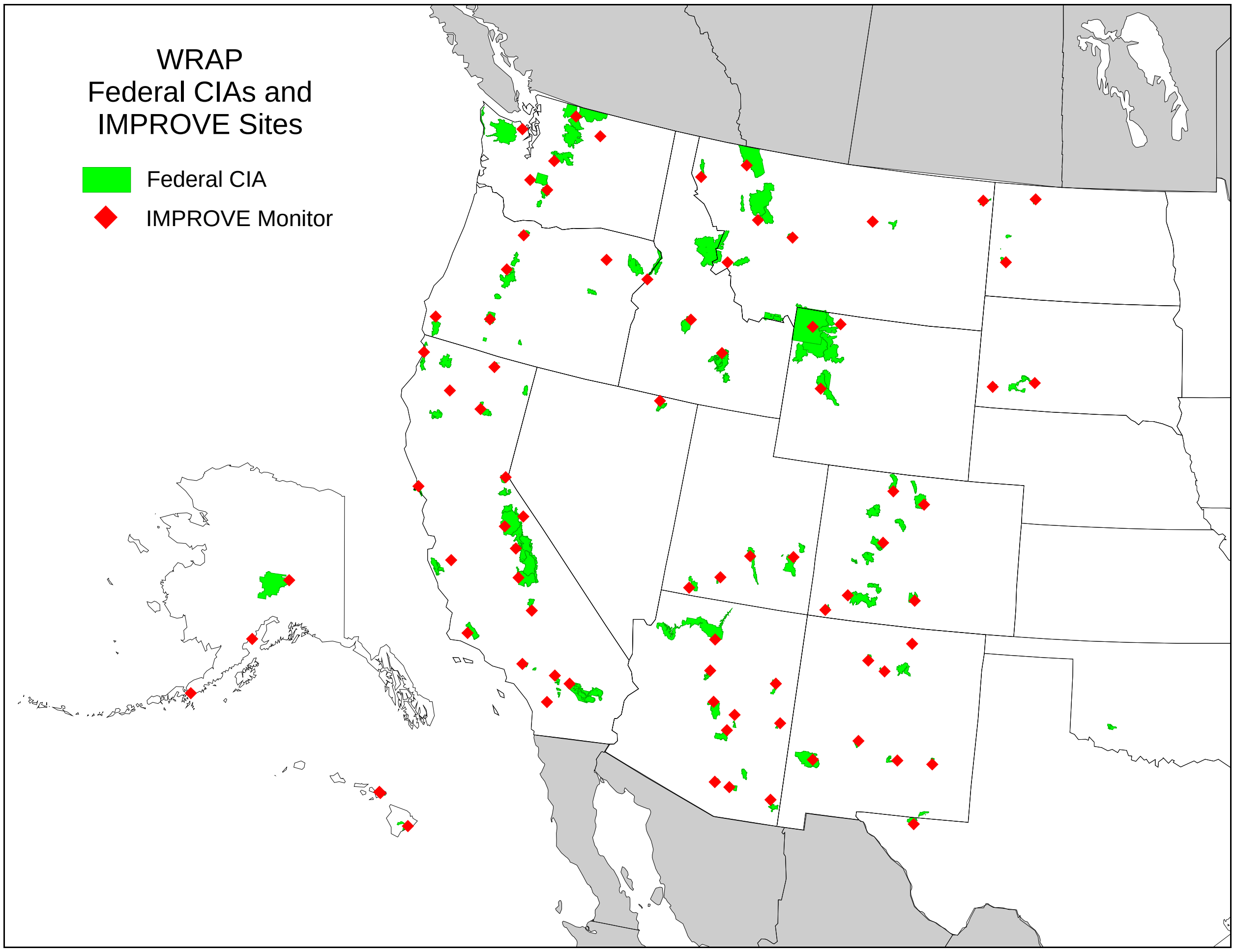

Figure 3.1-1. Map of Federal CIA IMPROVE Monitors in the WRAP Region.

IMPROVE aerosol samplers collect 24-hour integrated filter samples every third day. Each monitoring location operates four samplers (designated Module A through D) designed to quantify aerosol species that are related to visibility impairment. The aerosol species collected for regional haze purposes include:

- Ammonium Sulfate: Ammonium sulfate is formed in the atmosphere from reactions involving sulfur dioxide (SO_2) emissions. Anthropogenic sources include coal-burning power plants and other industrial sources, such as smelters, industrial boilers, and oil refineries, and to a lesser extent, gasoline and diesel combustion.
- Ammonium Nitrate: Ammonium nitrate is formed in the atmosphere from reactions involving nitrogen dioxide (NO_2) emissions, which are dominated by anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
- Particulate Organic Mass (POM): Particulate organic mass can be emitted directly as particles, or formed through reactions involving gaseous emissions. Natural sources of organic carbon include wildfires and biogenic emissions. Man-made sources can

include prescribed forest and agricultural burning, vehicle exhaust, vehicle refueling, solvent evaporation (e.g., paints), food cooking, and various commercial and industrial sources.

- Elemental Carbon (EC): Elemental carbon is the primary light absorbing compound in the atmosphere. These particles are emitted directly into the air from virtually all combustion activities, but are especially prevalent in diesel exhaust and smoke from wild and prescribed fires.
- Fine Soil: Soil, as reported by the IMPROVE Network, refers to fine soil (less than 2.5 µm in diameter) that enters the air from dirt roads, fields, and other open spaces as a result of wind, traffic, and other surface mechanical disturbance activities.
- Coarse Mass (CM): Coarse mass refers to large particles (larger than 2.5 and smaller than 10 µm in diameter), and generally includes similar sources as fine soil, but can also include coarse fraction ammonium nitrate and ammonium sulfate at some sites. Speciated coarse mass is not routinely analyzed by the IMPROVE Network.
- Sea Salt: Sea salt is a natural aerosol emitted in coastal areas. In practice, chloride ion measurements are used to represent sea salt in IMPROVE measurements, and measurements may sometimes show anthropogenic or crustal influences at inland monitors.

These different particle species scatter and absorb light in the atmosphere with different efficiencies. For example, the elemental carbon fraction of particle pollution is about ten times more efficient at absorbing light than the soil fraction is at scattering light. Some particle species, including ammonium sulfate and ammonium nitrate, will absorb water as relative humidity increases, which effectively increases the size and the light scattering efficiencies of these particles. In addition to aerosol scattering, light extinction due to natural background gases in a clean atmosphere, or Rayleigh scattering, will contribute to total light extinction. Aerosol extinction from each of these species is additive, so the sum of the individual aerosol extinction species, plus Rayleigh scattering, represents total extinction.

The IMPROVE program has developed an algorithm for estimating light extinction from speciated aerosol and relative humidity data. The original algorithm, as cited in RHR guidance, was revised in 2005.[21] IMPROVE data are available from the IMPROVE Network through the Federal Land Manager Database online repository (http://views.cira.colostate.edu/fed/) and are also reported along with data summary charts and tables specifically designed to address RHR planning efforts on the WRAP TSS (www.vista.cira.colostate.edu/tss/).

Once extinction has been calculated from speciated aerosol mass, it can be converted to other metrics that describe visibility impairment. Figure 3.1-2 presents a comparison of the most commonly used metrics, which are described below:

[21] The revised IMPROVE algorithm is described in detail in Hand's 2006 *Review of the IMPROVE Equation for Estimating Ambient Light Extinction Coefficients - Final Report* available at http://vista.cira.colostate.edu/improve/Publications/GrayLit/016_IMPROVEeqReview/IMPROVEeqReview.htm.

- Extinction (b_{ext}) – Extinction is a measure of the fraction of light lost per unit length along a sight path due to scattering and absorption by gases and particles, expressed in inverse Megameters (Mm^{-1}).
- Deciview (dv) – This is the metric used for tracking regional haze in the RHR. The Haze Index (measured in deciviews) was designed to be linear with respect to human perception of visibility. A one deciview change is approximately equivalent to a 10% change in extinction, whether visibility is good or poor. A one deciview change in visibility is generally considered to be the minimum change the average person can detect.
- Visual Range (VR) – Visual range is the greatest distance a large black object can be seen on the horizon, expressed in kilometers (km) or miles (mi).

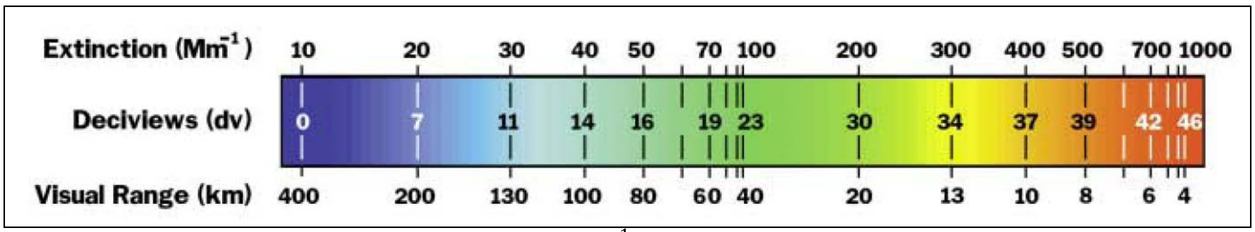

Figure 3.1-2. Comparison of Extinction (Mm^{-1}), Deciview (dv) and Visual Range (km) units.

3.1.1 Data Completeness Requirements

As described in Section 2.0, progress for the RHR is determined using 5-year average visibility conditions. EPA's 2003 *Guidance for Tracking Progress Under the Regional Haze Rule*[22] includes data completeness requirements designed to ensure that calculated averages include sufficient data to represent each daily, annual and 5-year period. EPA's 2003 Guidance specifies that the 2000-2004 baseline period, and each subsequent 5-year average progress period, meet the following conditions:

- Individual samples must contain all species required for the calculation of light extinction (ammonium sulfate, ammonium nitrate, POM, EC, soil, coarse mass, and sea salt)
- Calendar seasons must contain at least 50% of all possible daily samples
- Calendar years must contain at least 75% of all possible daily samples
- Calendar years must not contain more than 10 consecutive missing daily samples
- The 5-year baseline and each 5-year progress period averages must contain at least 3 complete years of data

[22] Data completeness requirements are listed in Section 2.2 (step 7) of EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule*.

RHR guidance specifies that if a 5-year period has less than three complete years of data, then estimates should be prepared for the missing data.[23] In the WRAP states, two data completeness issues were addressed to support progress summaries in document:

- **<u>Incomplete Progress Period Data</u>**: The 2005-2009 progress period did not have complete data available for one site in the WRAP. The SIAN1 site, representing the Sierra Ancha Wilderness Area in Arizona, did not meet RHR data completeness criteria for the years 2006, 2007, and 2008, which did not leave the 3 complete years required for a 5-year average. Data substitutions for these years were performed in a manner similar to that previously performed by the WRAP for incomplete 2000-2004 baseline years at 10 IMPROVE sites in the WRAP. Detailed methods are summarized in the Arizona state monitoring section (Section 6.2.1).
- **<u>Monitor Relocation</u>**: For two CIAs, Zion National Park in Utah and Haleakala National Park in Hawaii, it was determined that the original IMPROVE monitors sited to represent the parks did not adequately represent the CIAs. New sites were installed to better represent the parks, but because these sites were installed later, 2000-2004 baseline data averages are not available for the new locations. The RHR requires that the state establish baseline values using the most representative monitoring data for 2000-2004.[24] Detailed methodologies used to approximate baseline averages for these sites are summarized in the Hawaii and Utah monitoring sections (Sections 6.5 and 6.12, respectively).

All regional and state summaries presented in this report include the SIAN1 substituted data, and baseline estimates calculated for the ZICA1 and HACR1 sites.

3.1.2 <u>RHR Progress Period Calculation Considerations</u>

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve, and that visibility on the 20% least impaired, or best, days does not get worse, as measured in units of deciviews, calculated using data measured at IMPROVE monitoring sites. As described previously, progress for this report is measured for discreet 5-year average increments, beginning with the 2000-2004 baseline average, and proceeding with the most recently available subsequent 5-year average (2005-2009).[25] Some of the more subtle, but important, considerations for RHR calculations using IMPROVE data measurements are described below.

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[23] Section 2.2 (step 7) of the September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* states "If 3 years with complete data are not available, estimates for baseline of current conditions should be prepared in consultation with the Environmental Protection Agency's Office of Air Quality and Planning Standards (EPA/OAQPS)."

[24] Section 308(d)(2)(i) of the RHR states, "For mandatory Class I Federal areas without onsite monitoring data for 2000-2004, the State must establish baseline values using the most representative available monitoring data for 2000-2004, in consultation with the Administrator or his or her designee."

[25] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (see page 4-2 in the Guidance document).

3.1.2.1 Identification of 20% Worst Days

As described in Section 3.1, visibility impairment is the result of the cumulative effect of several different particle pollutant types. Many of these pollutants have individually consistent seasonal patterns. For example, ammonium nitrate is temperature sensitive, and formation often favored during colder winter months, while ammonium sulfate formation may be favored during warmer summer months. Other pollutants, such as particulate organic mass, may be impacted by large and variable episodic events such as wildland fires, which generally occur during the summer.

To determine the 5-year average of the 20% best and worst days, the highest and lowest 20% of days for each complete year are first selected and averaged on an annual basis, with a 5-year average calculated from these annual averages. The timing for identification of the 20% best and worst days may be significantly influenced by large episodic events (e.g., wildland fires) which may occur at different time during different years. As a result, the identification of more best or worst days during different seasons of different years may affect the averages for individual species in ways that are independent from actual increases or decreases of individual pollutants from one 5-year period to the next.

As an illustration of the effect of large episodic events on worst day averages, consider daily average aerosol extinction calculated from IMPROVE data at the CHIR1 site in Arizona. Figures 3.1-3 and 3.1-4 present daily aerosol extinction measurements for 2002 and 2008 at CHIR1, with the 20% worst days represented by an orange box with an "x" below the day. Similar daily aerosol charts depicting the 20% worst days are included for each Class I area in state specific Appendices. For 2002, large wildfire events in June and July contributed to high particulate organic mass (POM) measurements, resulting in more worst days selected during this period. In 2008, more of the worst days were selected in August and October.

As an illustration of the seasonal patterns of individual compounds, consider the monthly averages of aerosol extinction calculated from IMPROVE data at the CHIR1 site. Figure 3.1-5 presents monthly average aerosol pollution for CHIR1 measured during 2002, and Figure 3.1-6 presents monthly averages in 2008. State specific appendices included with this document present similar monthly average plots for each year at each site. The seasonal patterns for both years indicated that ammonium sulfate was generally higher between May and July than in October.

Because of the seasonal ammonium sulfate patterns, the identification of more worst days between May and July (e.g., 2002 at CHIR1) will show a higher ammonium sulfate average than a year with more worst days in October (e.g., 2008 at CHIR1), even though annual ammonium sulfate levels may not have increased. For this case, Table 3.1-1 presents the annual averages of ammonium sulfate for both the 20% worst days and all measured days. For these years, the annual average of ammonium sulfate extinction for all measured days decreases, while the 20% worst day average actually increased.

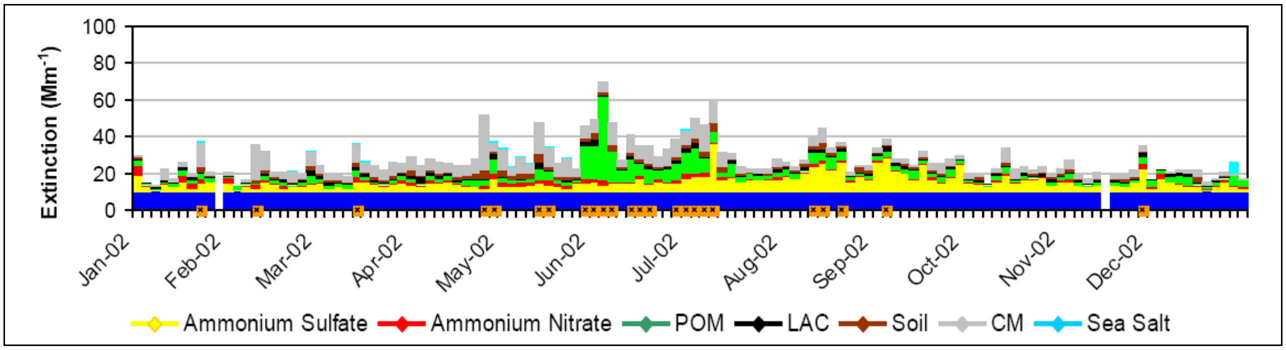

Figure 3.1-3. Daily Aerosol Extinction measured by the Chiricahua CHIR1 IMPROVE monitor during 2002.

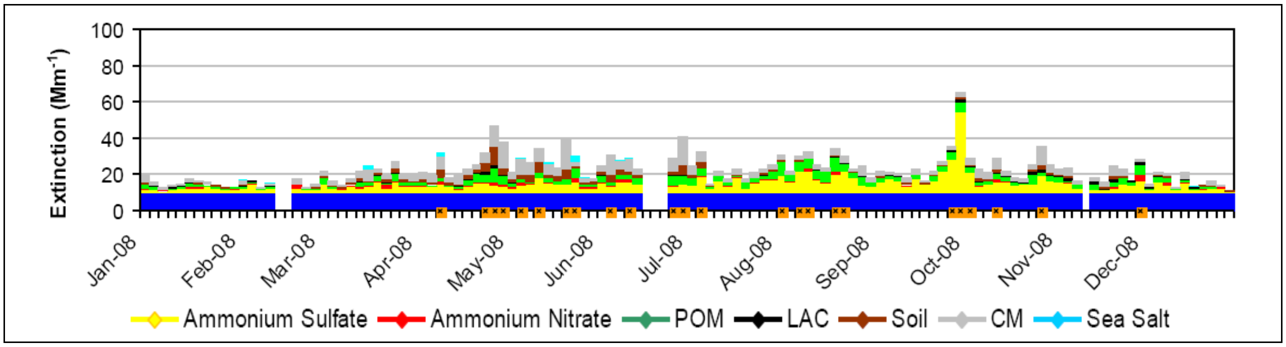

Figure 3.1-4. Daily Aerosol Extinction measured by the Chiricahua CHIR1 IMPROVE monitor during 2008.

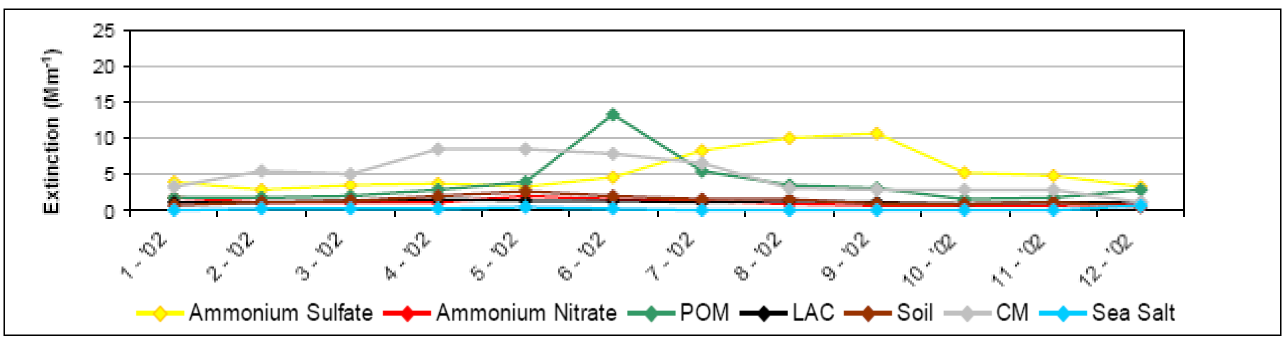

Figure 3.1-5. Monthly Average Aerosol Extinction measured by the CHIR1 IMPROVE monitor in 2002.

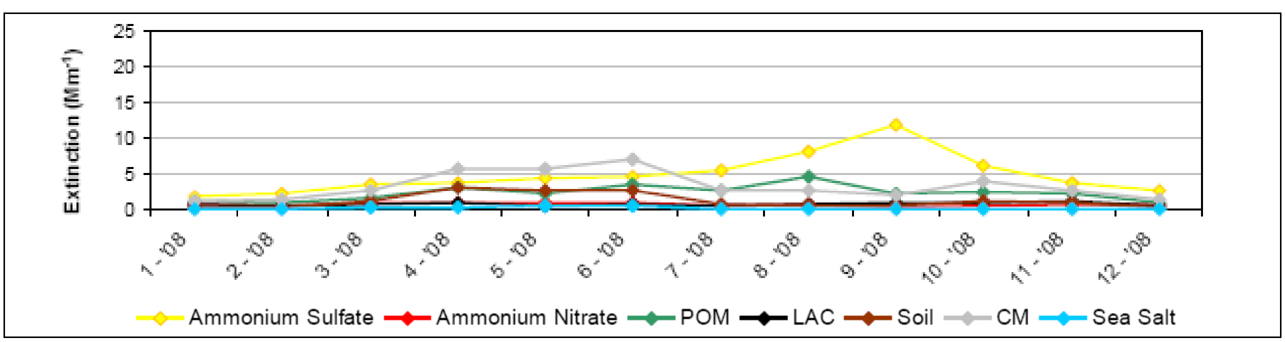

Figure 3.1-6. Monthly Average Aerosol Extinction measured by the CHIR1 IMPROVE monitor in 2008.

Table 3.1-1
CHIR IMPROVE Site
Comparison of Ammonium Sulfate Average
All Days and 20% Worst Days

Year	All Days Amm. Sulfate Average (Mm^{-1})	20% Worst Days Amm. Sulfate Average (Mm^{-1})
2002	5.3	7.8
2008	4.9	9.0
Difference	**-0.4 Mm^{-1}**	**+2.2 Mm^{-1}**

3.1.2.2 Discreet 5-Year Averages vs. Trends

The 2003 RHR Guidance prescribes that progress be measured using discreet 5-year average increments,[26] but states that determining trends for all the individual species that contribute to haze is especially helpful in tracking progress. Individual high or low years can affect the 5-year averages, while trend statistics are more resistant to extreme events and may better represent the effects of emissions controls.[27] For this reason, looking at annual trends in addition to the differences between 5-year averages can also be instructive in determining the long term behavior of pollutant measurements.

Generally, the 10-year trends are consistent with the 5-year average differences, but in some cases annual trends and differences between 5-year averages may show different characteristics. Trends for annual averages of each species at each site are presented in this report as calculated using Kendall-Theil statistics, which are often used in environmental applications because these statistics are resistant to outliers.[28] Figure 3.1-7 shows an example of an increase in the 5-year average deciview metric for ammonium sulfate measured on the 20% most impaired days at the Salt Creek Wilderness Area (SACR1) IMPROVE site (16.7 Mm^{-1} to 18.9 Mm^{-1}), but a decreasing annual deciview trend (-0.5 Mm^{-1}/year). The increase in the 5-year average was driven by uncharacteristically high average ammonium sulfate measured in 2005. For all sites included in this report, both 5-year average differences and trends is reported, and any differing characteristics are noted and described.

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[26] As noted previously, EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (see page 4-2 in the Guidance document).
[27] Section 4.7 of EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* states that "In the long-term, tracking trends of species contributions to haze provides information that can be useful in determining whether implemented emissions controls are having the expected effects."
[28] Trend statistics used in this report are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)

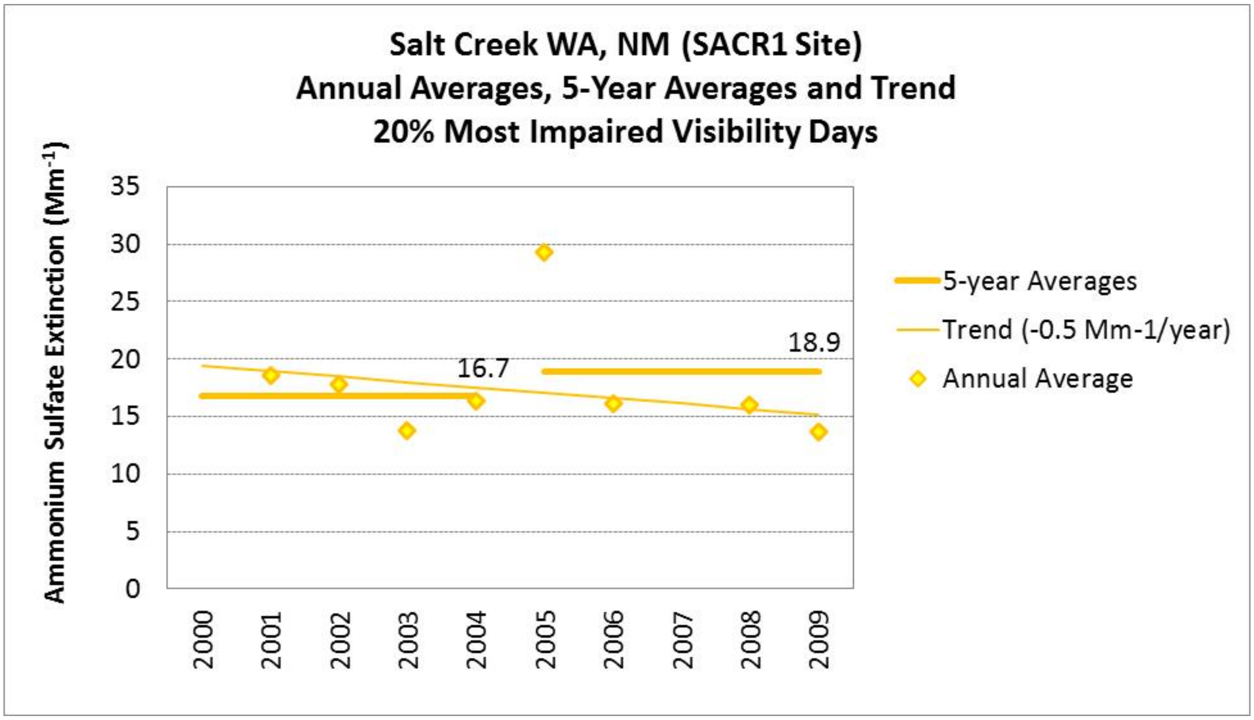

Figure 3.1-7. Annual Averages, Period Averages and Trend Statistics for Ammonium Sulfate Measured at the SACR1 IMPROVE Site in New Mexico.

3.1.2.3 Averaging Considerations for Deciview Calculations

The RHR haze index, as defined using deciviews (dv), does not provide information regarding the relative contributions of individual species to overall visibility. The deciview metric for extinction is logarithmically related to total extinction (b_{ext}), e.g. $dv=10\ln(b_{ext}/10)$, where b_{ext} is the sum of extinction as calculated from individual species mass measurements. Looking at individual species extinction is necessary for RHR considerations because each species that contributes to regional haze can have different sources and control options. For example, some species (e.g. sulfate and nitrate species) originate from largely anthropogenic sources, while others (e.g. organic species) from a mixture of both anthropogenic and natural sources. Because of the logarithmic nature of deciviews, it is not possible to separate this metric into individual species, so a representation of total extinction in units of inverse megameters (Mm^{-1}) is useful.

EPA's *Guidance for Tracking Progress Under the Regional Haze Rule* (EPA 2003) specifies that the 5-year average deciview value is calculated as an average of annual values, which are in turn calculated as averages of daily values.[29] In most cases, an increase/decrease in the deciview metric corresponds to an increase/decrease in total extinction. In some cases, because the 5-year deciview value is effectively the average of logarithmic values, the average deciviews may change in a different direction than the average of total extinction. As an

[29] Calculation of the 5-year average deciview metric is described in Section 4.3 of EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule.*

example, consider the following extinction measurements presented in Table 3.1-1 for a contrived dataset of 2 days for each of 2 periods. The table shows both daily and period average extinction, and corresponding deciview calculations. Note that the average total extinction decreases (70 to 55 Mm^{-1}), while the average deciview value increases (15.9 to 17.0 dv).

Table 3.1-1
Example Calculation
Decreasing b_{ext} Averages With Increasing deciview Averages

Averaging Periods		Extinction (Mm^{-1})	Deciviews (dv) $10\times\ln(b_{ext}/10)$
Period 1	Day 1	20	6.9
	Day 2	120	24.8
	Period 1 Average	**70**	**15.9**
Period 2	Day 1	50	16.1
	Day 2	60	17.9
	Period 2 Average	**55**	**17.0**
	Difference	**-15 Mm^{-1}**	**+1.1 dv**

For comparisons between the 2000-2004 baseline period and the 2005-2009 progress period, decreasing 5-year average deciview metrics, but increasing extinction for the 20% most impaired, or worst, days was observed at 9 WRAP Federal CIA sites, and slightly increasing deciview associated with decreasing average extinction was observed at 1 site, as listed in Table 3.1-2.

Table 3.1-2
20% Most Impaired Visibility Days
Total Extinction and Deciview Average Differences

State	Site	Extinction (Mm^{-1})			Deciviews (dv)		
		Baseline Period (2000-2004)	Progress Period (2005-2009)	Difference	Baseline Period (2000-2004)	Progress Period (2005-2009)	Difference
AZ	SYCA1	47.2	47.4	**+0.2**	15.3	15.2	**-0.1**
CA	DOME1	71.7	76.7	**+5.0**	19.4	19.2	**-0.2**
	PINN1	65.1	65.7	**+0.6**	18.5	18.4	**-0.1**
	TRIN1	68.0	91.8	**+23.8**	17.3	17.3	0.0
OR	CRLA1	47.9	47.7	**-0.2**	13.7	13.8	**+0.1**
	HECA1	69.1	71.9	**+2.8**	18.6	18.1	**-0.5**
MT	GAMO1	31.8	32.9	**+1.1**	11.3	11.2	**-0.1**
WA	WHPA1	37.1	37.9	**+0.8**	12.8	12.7	**-0.1**
WY	BRID1	31.6	31.7	**+0.1**	11.1	10.7	**-0.4**
	YELL2	34.5	36.1	**+1.6**	11.8	11.5	**-0.3**

3.2 EMISSIONS INVENTORIES

To demonstrate RHR progress, states are required to report how total emissions in the state have changed over the past 5 years (51.308(g)(4)), and to determine if there have been significant changes in emissions from the state or from other states affecting visibility at each Federal CIA which has impeded progress in improving visibility (51.308(g)(5)). Comparisons between emissions inventories in this report use the inventories that represent both baseline and current conditions. Baseline emissions in most cases are represented using the 2002 inventory that was originally developed, with support from the WRAP, to represent emissions for the initial implementation plans. Current emissions are represented here by leveraging recent work by the WRAP to develop an updated and comprehensive inventory for the year 2008 for use in modeling projects. For non-contiguous states (Alaska and Hawaii), alternate inventories representing the progress periods were obtained in consultation with the states.

Emissions inventories in this report were complicated by the fact that a number of changes and enhancements have occurred between development of the baseline and current period inventories, such that many of the differences between inventories are more reflective of changes in inventory methodology, rather that changes in actual emissions. Differences in emissions are presented for all categories in this report, but summaries focus on aspects of source categories that have been more consistently inventoried over time, while noting any changes in methodologies that may affect differences in other categories. Detailed references regarding emissions inventories are presented in this section.

3.2.1 Inventory Descriptions

Emissions related to the different particle species that affect regional haze are varied and complex, including a number of both anthropogenic and natural source possibilities. Emissions estimates vary by source category according to the different characteristics and attributes of each category, and how the emissions are modeled. A number of anthropogenic, or man-made, sources such as motor vehicles and electric generating units (EGUs) are reported by states and may be subject to controls. Natural emissions, such as fires, biogenic emissions and some categories of dust can have large regional haze impacts, but are not subject to control strategies. Source categories for both anthropogenic and natural sources are listed and described briefly below, followed by information related to inventory development and comparisons for the contiguous states, Alaska, and Hawaii.

- *Point Sources:* These are sources that are identified by point locations, typically because they are regulated and their locations are available in regulatory reports. In addition, elevated point sources will have their emissions allocated vertically through the model layers, as opposed to being emitted into only the first model layer. Point sources can be further subdivided into EGU sources and non-EGU sources, particularly in criteria inventories in which EGUs are a primary source of NO_X and SO_2. Examples of non-EGU point sources include chemical manufacturers and furniture refinishers.
- *Area Sources:* Sources that are treated as being spread over a spatial extent (usually a county or air district) and that are not movable (as compared to non-road mobile and

on-road mobile sources). Because it is not possible to collect the emissions at each point of emission, they are estimated over larger regions. Examples of stationary area sources are residential heating and architectural coatings. Numerous sources, such as dry cleaning facilities, may be treated either as stationary area sources or as point sources.

- *On-Road Mobile Sources:* These include vehicular sources that travel on roadways. Emissions from these sources can be computed either as being spread over a spatial extent or as being assigned to a line location (called a link). Emissions are estimated as the product of emissions factors and activity data, such as vehicle miles traveled (VMT). Examples of on-road mobile sources include light-duty gasoline vehicles and heavy-duty diesel vehicles.

- *Off-Road Mobile Sources:* Off-road mobile sources are vehicles and engines that encompass a wide variety of equipment types that either move under their own power or are capable of being moved from site to site. Examples include agricultural equipment such as tractors or combines, aircraft, locomotives and oil field equipment such as mechanical drilling engines. Emissions from marine vessels are included here separately as offshore emissions.

- *Off-shore:* Commercial marine emissions comprise a wide variety of vessel types and uses. Emissions can be estimated for deep draft vessels within shore and near port using port call data, and offshore emissions generated from ship location data.

- *Oil and Gas Sources:* Oil and gas sources consist of a number of different types of activities from engine sources for drill rigs and compressor engines, to sources such as condensate tanks and fugitive gas emissions. The variety of emissions types for sources specific to oil and gas activity can, in some cases, overlap with mobile, area or point sources, but these can also be extracted and treated separately.

- *Biogenic Emissions:* Biogenic emissions are based on the activity fluxes modeled from biogenic land use data, which characterizes the types of vegetation that exist in particular areas. Emissions are generally derived using modeled estimates of biogenic gas-phase pollutants from land use information, emissions factors for different plant species, and meteorology data.

- *Dust:* Dust emissions may have a variety of sources that could include anthropogenic sources, natural sources, and natural sources that may be influenced by anthropogenic activity. In order to better distinguish between the natural and anthropogenic sources, the WRAP undertook a Definitions of Dust project, with a final report available here: http://www.wrapair.org/forums/dejf/documents/defdust/index.html. For emissions summary purposes, dust is classified here as fugitive dust and windblown dust. Fugitive dust includes sources such as road dust, agricultural operations, construction and mining operations and windblown dust from vacant lands. The windblown dust category includes more of the natural influences such as wind erosion on natural lands.

- *Fire:* Fire sources are difficult to predict and control, and may have a mix of natural and anthropogenic influences. Natural sources include wildland fires, while anthropogenic sources can include agricultural and prescribed fires. In order to better distinguish between natural and anthropogenic fires, the WRAP has created an operational policy level definition of fire activity as discretely natural or anthropogenic, which included allowing certain types of prescribed fires to be treated as natural.[30]

3.2.1.1 Contiguous WRAP States

As noted previously, baseline and current period emissions are summarized here using two discreet years, where one year is used to represent baseline emissions, and other is used to represent the current progress period. For contiguous states, the baseline period inventories summarized here for comparison to current conditions is the 2002 inventory that was developed for WRAP states in support of the original SIPs, termed “plan02d” (or “plan02c” in California). Development of the plan02 inventories were a cooperative effort sponsored by the WRAP in cooperation with WRAP states. This effort built upon 2002 emissions reported by states, and included work with contractors and WRAP workgroups, in consultation with states, to enhance specific categories (e.g., point, area, on- and off-road mobile, oil and gas, fire, and dust) to better characterize regional haze implications. Detailed descriptions of inventory development are available from the WRAP Technical Support System website (http://vista.cira.colostate.edu/TSS/Results/Emissions.aspx).

The WRAP has continued to support emissions data tracking and related technical analyses focused on understanding current and evolving regional air quality issues in the western states. Methods for estimating emissions of many of the source categories that affect regional haze have continued to evolve and be refined over time. This is especially true for inventories of natural emissions categories including windblown dust and biogenic emissions, and also for rapidly evolving industries such as oil and gas exploration. To represent current conditions, this progress report support document leverages 2008 emissions data inventories which have been recently developed as part of the WRAP’s West-wide Jumpstart Air Quality Modeling Study (WestJumpAQMS) and Deterministic and Empirical Assessment of Smoke’s Contribution to Ozone (DEASCO$_3$) study, which are described briefly below:

- The WestJumpAQMS project (http://wrapair2.org/WestJumpAQMS.aspx) sponsored by the WRAP includes coordination and harmonization with the EPA 2008 National Emissions Inventory (2008 NEI v2). Among other goals, this project is intended to provide technical updates and improvements for multiple air quality issues, including regional haze, ozone, particulate pollution and nitrogen deposition.
- The DEASCO$_3$ study (http://www.wrapfets.org/deasco3.cfm) is a project sponsored by the Joint Fire Sciences Program (JFSP) that looks at impact of weather and fires on ozone formation. This project has included the development of a detailed and comprehensive 2008 fire emissions inventory, which will eventually be incorporated into the WestJumpAQMS project.

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[30] The WRAP Policy for characterizing fire emissions is available at http://www.wrapair.org/forums/fejf/documents/nbtt/firepolicy.pdf.

Because these inventories have been refined over time, there is not necessarily continuity between the 2002 and 2008 inventories, which affects data comparisons for particular source categories. Detailed references and major methodology differences for the emissions inventories compared here are summarized in Table 3.2-1. In addition to comparing baseline and progress period inventories, regional and state summary sections in this report include annual averages tracking changes in regional and state totals for SO_2 and NO_X emissions for EGU as tracked in the EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/).

Table 3.2-1
Emissions Inventory Descriptions
Contiguous WRAP States

Inventory Sector	2002 Baseline Inventory (Plan02c/Plan02d) [31]	2008 Progress Period Inventory (WRAP WestJump08) [32]	Comments
Point Sources	Most WRAP states used the Plan02d point source inventories, while California used the Plan02c inventory for their initial SIP. These inventories were generated using hourly EPA CAMD CEM data for EGUs. Other point were developed in consultation with states by the ERG contractor. Note that the WRAP also generated point source inventories for both actual reported 2002 (Base02b) EGU and all other point source data, and for a 2000-2004 average of EGU point sources (Plan02c and Plan02d). Plan02 emissions are summarized in this report because they are consistent with what was reported as baseline conditions for most initial WRAP region SIPs.	The WRAP WestJump 2008 inventories were generated using hourly EPA CAMD CEM data for EGUs. Other point sources are from the 2008 NEI v2. Note that point source oil and gas inventories were inventoried separately for WestJump08, but included in the point source totals here for comparisons with 2002 inventories.	Because point source definitions vary by state, any changes or additions for an individual state will affect comparisons of 2002 and 2008. Note that baseline conditions presented here represent a 5-year average for EGUs, while progress period conditions are represented with 2008 data. In addition to inventory changes for these two years, year-to-year variations are also presented separately for Title V Major Sources on a regional and state basis.[33]

[31] Detailed inventory descriptions for development of the WRAP Base02b, plan02c and plan02d inventories are available on the WRAP TSS website http://vista.cira.colostate.edu/TSS/Results/Emissions.aspx and archived on the original WRAP website http://www.wrapair.org/forums/ssjf/pivot.html.
[32] Detailed inventory descriptions for development of the WRAP WestJump08 inventory are available on the WRAP project page http://wrapair2.org/WestJumpAQMS.aspx.
[33] Annual EGU emissions for each state were obtained from EPA's Air Markets Program Database for permitted Title V facilities (http://ampd.epa.gov/ampd/).

Table 3.2-1
Emissions Inventory Descriptions
Contiguous WRAP States

Inventory Sector	2002 Baseline Inventory (Plan02c/Plan02d) [31]	2008 Progress Period Inventory (WRAP WestJump08) [32]	Comments
Area Sources	Most WRAP states used the Plan02d point source inventories, while California used the Plan02c inventory for their initial SIP. These inventories were developed by the ERG contractor in consultation with states.	The WRAP WestJump 2008 used state reported area source inventories from the 2008 NEI v2.[34] Note that, beginning in 2008, some source categories such as Class I and II commercial marine vessels, Class III vessels on in-land waterways and in-transit locomotive emissions, were defined as area sources (moved from off-road inventory). To reflect these changes, EPA now refers to the area source category as the "non-point" emissions.	Note that area oil and gas sources are reported separately in this report. Area source estimates represent broad areas, and include calculations which are, in part, based on population estimates and activity data. Because of this, changes in are source definitions and changes in calculation methods (which can be different from state to state and year to year), as well as changes in inputs such as population can affect differences between these inventories. One important example of methodology differences is the addition of some sources previously considered "off-road" into the area (also referenced as non-point) source category.

[34] EPA's 2008 NEI inventory estimates are available at http://www.epa.gov/ttn/chief/net/2008inventory.html.

Table 3.2-1
Emissions Inventory Descriptions
Contiguous WRAP States

Inventory Sector	2002 Baseline Inventory (Plan02c/Plan02d) [31]	2008 Progress Period Inventory (WRAP WestJump08) [32]	Comments
Area Oil and Gas	These inventories were developed for specific oil and gas basins using WRAP Phase II emissions methodologies.[35] Where WRAP Phase II emissions were not available, area source oil and gas emissions as reported by the state were used. Phase II emissions process estimated for 2002 included: • Drill Rigs • Wellhead Compressor Engines • CBM Pump Engines • Heaters • Pneumatic Devices • Condensate and oil tanks • Dehydrators • Completion Venting	These inventories were developed for specific oil and gas basins using WRAP Phase III emissions methodologies. Where WRAP Phase III emissions were not available, area source oil and gas emissions as reported by the state were used. Phase III emissions process estimated for 2008 included: These inventories used 2008 production data, which was updated with State-reported data in some cases. The following additional categories were included in addition to those listed for 2002: • Lateral compressor engines • Workover rigs • Salt-water disposal engines • Artificial lift engines • Vapor recovery units (VRUs) • Miscellaneous or exempt engines • Flaring • Fugitive emissions • Well blowdowns • Truck loading • Amine units (and gas removal) • Water tanks	Oil and gas development is a rapidly evolving industry, and significant efforts to better characterize emissions have occurred between development of the 2002 and 2008 inventories. In addition to expanded development, some notable emission inventory difference include: • Regulatory changes specific to each state may have required more sources to be reported in 2008 than were reported in 2002. • New and/or revised estimation methodologies, especially for VOC emissions rates, were used for more source categories in Phase III. • Phase III estimates included surveys which provided detailed information about specific sources (e.g. counts by device type such as low-bleed vs. high-bleed) among other improvements to activity data. These sources included small area source equipment typically not inventories by the states. Phase II did not have that information available, since no surveys were made in Phase II. • Phase III used the high-quality and complete IHS commercial database of O&G production data by well by basin. For Phase II, the state O&G Commission databases, which have been improved quite a bit over time, were used.

Table 3.2-1
Emissions Inventory Descriptions
Contiguous WRAP States

Inventory Sector	2002 Baseline Inventory (Plan02c/Plan02d) [31]	2008 Progress Period Inventory (WRAP WestJump08) [32]	Comments
On-Road Mobile	The 2002 inventory for most WRAP states used the EPA MOBILE6 model as applied by ENVIRON using inputs from states. California provided emissions separately using their EMFAC2002 model.	The 2008 on-road mobile inventory used the EPA MOVES2010 model applied to state inputs in inventory mode. The California EMFAC2011 data were downloaded in 2012 from the California ARB website.	Differences in models contribute to some differences in emissions reported, but other differences are due to a combination of VMT differences and new controls on vehicles.
Off-Road Mobile	The 2002 inventory for most WRAP states used the draft NONROAD2004 model as applied by ENVIRON using inputs from states. California provided emissions separately.	The 2008 off-road mobile inventory was obtained from the NEIv2.0 using the NONROAD model estimates within the National Mobile Inventory Model (NMIM). Note that, beginning in 2008, some source categories were removed from the off-road mobile category to the area/non-point category. These emissions included Class I and II commercial marine vessels, Class III vessels on in-land waterways and in-transit locomotive emissions. California supplied non-road emissions calculations using a California state-specific off-road model.	The off-road models include both emission factors and default county-level population and activity data. One important methodology change was the re-classification of some sources previously labeled off-road as non-point (area) sources in 2008.

[35] Additional Phase II oil and gas inventory descriptions are archived on the original WRAP website http://www.wrapair.org/forums/ogwg/documents/2007-10_Phase_II_O&G_Final)Report(v10-07%20rev.s).pdf.

Table 3.2-1
Emissions Inventory Descriptions
Contiguous WRAP States

Inventory Sector	2002 Baseline Inventory (Plan02c/Plan02d) [31]	2008 Progress Period Inventory (WRAP WestJump08) [32]	Comments
Offshore	For the baseline inventories, off-Shore emissions were treated as a region rather than a source category.	For the 2008 inventories, specific SCCs do not distinguish between regions (e.g. Atlantic, Pacific and Gulf), so these are presented as a sum of all offshore emissions.	Note that while offshore emissions are available from both datasets, comparisons are not presented in this report. These emissions were not comparable, as baseline emissions were presented as a region, and not explicitly associated with any of the coastal states for summaries here, and progress period summaries totaled all offshore emissions for the US (e.g. Atlantic, Pacific and Gulf)
Fugitive Dust and Road Dust	The WRAP 2002 inventory by ENVIRON began with inputs from states. For 2002, note that vegetative scavenging factors were applied pre-processing at the county level, as opposed to grid-level for 2008 data.	These emissions were extracted from state reported area source emissions for 2008 (NEI08v2). For the NEI08v2 inventories, the State of California notes that they have changed the way they calculate and report paved road dust. For 2008, note that vegetative scavenging factors were applied post-processing at a higher resolution grid cell level, as compared to 2002 data.	Note that fugitive dust and road dust categories were available separately in the WRAP Plan02d inventories, but are combined for summary purposes here. For the 2008 inventory, vegetative scavenging factors were applied to the combined sources; thus these source categories were not easily separated.

Table 3.2-1
Emissions Inventory Descriptions
Contiguous WRAP States

Inventory Sector	2002 Baseline Inventory (Plan02c/Plan02d) [31]	2008 Progress Period Inventory (WRAP WestJump08) [32]	Comments
Windblown Dust	Generated using WRAP Windblown Dust Model and 2002 MM5 meteorology, at 36km grid cell resolution. Vegetative scavenging factors were applied pre-processing at the county level.	Generated using WRAP Windblown Dust Model and 2008WRF meteorology, at 4km and 12km grid cell resolution for the WRAP region. Vegetative scavenging factors applied post-processing at the grid cell level.	Significant updates to enhance the accuracy of the WRAP Windblown Dust Model will affect comparisons between the 2002 and 2008 inventories. Specific differences between the inventories include: • Different meteorological models; MM5 (2002) vs. WRF (2008) met models • Higher resolution of grid cells in 2008, which led to higher average wind speeds in individual cells, and increased windblown dust emissions aggregated at the county level. • MM5 Layer 1 used 36 meter height winds vs. WRF average winds across lowest 3 layers spanning ~40 meter height. • An error in 2002 WBD model was corrected where rainfall in centimeters was treated as inches.
Biogenic	The 2002 biogenic inventory used the BEIS3.12 model with BELD3 landuse and 2002 MM5 meteorology data, at 36km grid cell resolution.	The 2008 biogenic inventory used the MEGAN2.10 with 2008 WRF meteorology data, at 4 and 12 km grid cell resolution.	Significant model changes designed to enhance the accuracy of the biogenic emissions estimates will affect comparisons between the 2002 and 2008 inventories. Specific differences between the BEIS3.12 and MEGAN2.10 model outputs include: • Different meteorological years and models (2002 MM5 vs. 2008 WRF). • Higher temporal and spatial variability of land cover and other environmental input factors. • Improved emissions factors based on better sources of data (e.g., satellites and field studies).

Table 3.2-1
Emissions Inventory Descriptions
Contiguous WRAP States

Inventory Sector	2002 Baseline Inventory (Plan02c/Plan02d) [31]	2008 Progress Period Inventory (WRAP WestJump08) [32]	Comments
Fires (Natural and Anthro-pogenic)	Baseline estimates used the WRAP Phase III fire inventory, which represent a 2000-2004 5-year average of fire activity. Inventories included both anthropogenic and natural emissions.	2008 estimates use DEASCO$_3$ fire summaries, which account for fires in 2008, and include separate reporting of anthropogenic and natural fires. [36]	Baseline conditions are represented with a 5-year average of fire, while progress period conditions are represented with 2008 data. Comparisons between these inventories are complicated by the variable and sporadic nature of wildfires. Also, differences between methodologies will affect comparisons of inventories used for 2002 and 2008 estimates.

[36] Additional details regarding fire inventory descriptions for development of the DEASCO$_3$ inventory are available on the WRAP project page at http://www.wrapfets.org/deasco3.cfm.

3.2.1.2 Alaska

Current emissions summaries for the contiguous states use inventories developed for modeling purposes, but the States of Alaska (and Hawaii) were not included in the modeling effort, so these current year inventories were not available. Baseline conditions were represented with data originally used to represent baseline emissions in the initial Alaska implementation plan. For current progress period summaries, inventories were assembled through consultation with the Alaska Department of Environmental Control (DEC). Table 3.2-2 presents data references for source categories used to represent emissions in Alaska.

Table 3.2-2
Emissions Inventory Descriptions
Alaska

<table>
<tr><th>Source Categories</th><th>2002 Inventory</th><th>2008 Inventory</th></tr>
<tr><td>Point</td><td>WRAP 2002 point source inventory[37]</td><td>Provided by Alaska DEC</td></tr>
<tr><td>Area</td><td rowspan="2">2002 emissions from the Alaska DEC “Big 3” [38] Criteria Inventories and
2005 emission from the Alaska DEC Rural Inventory[39]</td><td>2008 WestJump[40]</td></tr>
<tr><td>On-Road and Off-Road Mobile</td><td rowspan="3">NEI2008v3[41]</td></tr>
<tr><td>Aviation</td><td>WRAP 2002 Aviation Report[42]</td></tr>
<tr><td>Commercial Marine</td><td>Pechan Report[43]</td></tr>
<tr><td>Fire</td><td>WRAP 2003 Phase III Inventory[44]</td><td>Alaska Interagency Coordination Center (AICC) Incident Support Website[45]</td></tr>
</table>

3.2.1.3 Hawaii

Current emissions summaries for the contiguous states use inventories developed for modeling purposes, but the States of Hawaii (and Alaska) were not included in the modeling

[37] The WRAP 2002 point source inventory is available from http://www.wrapair.org/forums/ssjf/pivot.html.
[38] Alaska “Big 3” inventories include Anchorage, Juneau and Fairbanks.
[39] Alaska “rural” inventories refers to remaining boroughs and census areas outside of Anchorage, Juneau and Fairbanks. The 2005 Alaska rural inventory is available at http://www.epa.gov/region10/pdf/tribal/wrap_alaska_communities_final_report.pdf.
[40] WRAP 2008 WestJump inventories are available on the WRAP project page http://www.wrapfets.org/deasco3.cfm
[41] EPA’s 2008 NEI inventory estimates are available at http://www.epa.gov/ttn/chief/net/2008inventory.html. Note that only lead (Pb) emissions totals were available from the NEI2008v3 data set, so 2008 emissions are not included from this source for comparison purposes.
[42] Aviation inventories are available from the 2005 WRAP report, *Alaska Aviation Emissions Inventory Report*, developed by Sierra Research, available at http://www.wrapair.org/forums/ef/inventories/akai/.
[43] Commercial marine inventories are available from the 2005 Pechan report, *Commercial marine inventories for select Alaskan ports : final report*.
[44] The WRAP Phase III fire inventory is available at http://wrapair.org/forums/fejf/tasks/FEJFtask7Phase3-4.html.
[45] Alaska wildland fire data are available from the Alaska Interagency Coordination Center (AICC) Incident support website at http://fire.ak.blm.gov/administration/awfcg_committees.php.

effort, so these current year inventories were not available. Baseline conditions were represented the data that were used to represent baseline emissions in the initial Hawaii implementation plan. For current progress period summaries, alternate inventories were obtained through consultation with Hawaii Department of Health (DOH).

For Hawaii, summaries for the baseline period are represented with a 2005 inventory, and the current progress period is represented with a 2008 inventory. The year 2005 was selected, with EPA approval, as the baseline inventory because it was the most complete inventory available at the time technical work commenced. Categories summarized for Hawaii are listed below:

- Point
- Area
- On-road Mobile
- Off-road Mobile
- Marine
- Fire
- Biogenic
- Volcano
- Sea Spray
- Wind Blown Dust

Data summaries for both 2005 and 2008 presented in this report were obtained from the *Technical Support Document for the Proposed Action on the Federal Implementation Plan for the Regional Haze Program in the State of Hawaii*, developed by EPA Region 9,[46] except for area source SO_2 inventories, which were provided separately by the Hawaii Department of Health, Clean Air Branch (HIDOCAB). The EPA inventories were largely compiled by ENVIRON under direction from DOH. Hawaii DOH further refined the mobile inventories in conjunction with ICF International to incorporate the latest release of the MOVES model.

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[46] The May 2012 *Technical Support Document for the Proposed Action on the Federal Implementation Plan for the Regional Haze Program in the State of Hawaii* developed by the EPA Region 9 Air Quality Division is available at www.epa.gov/region9/air/actions/pdf/hi/hi-haze-tsd.pdf.

3.3 THE WRAP TSS

The WRAP Technical Support System (TSS) (http://vista.cira.colostate.edu/tss/) is an online, dynamic tool designed to provide a single portal to technical data and analytical results coordinated by the WRAP. The data, results, and methods displayed on the TSS are intended to support the air quality planning needs of western state and tribes, and were designed to be maintained and updated to support the development of RHR SIPs, progress reports, and other western air quality analysis and management needs. The TSS has recently been updated to support the first RHR progress reports, providing access, visualization, analysis, and retrieval of technical data and regional analytical results that complement the RHR progress analysis provided in this report.

The TSS integrates a number of different information resources and incorporates applicable data sets, analysis results, and documentation under one web-based umbrella. Full documentation, including tutorials and detailed descriptions of TSS tools are available directly from the website. Figure 3.3-1 shows the interactive menu options available from the "Haze Planning" section on the TSS, where each of these selection option interfaces with a variety of summary options. This section briefly describes some of these summary options that have been updated to support the development of RHR progress reports for western states.

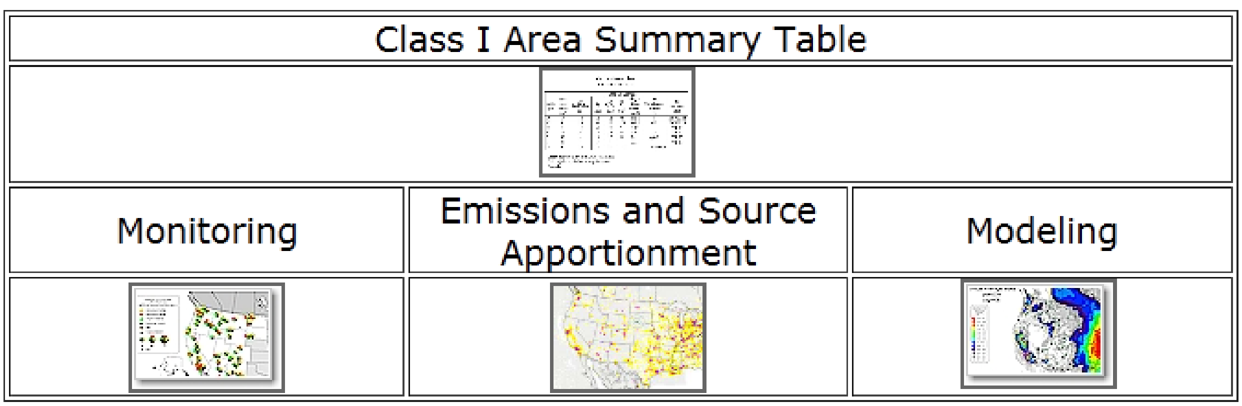

Figure 3.3-1. The WRAP TSS Summary Tools Interface.

3.3.1 Data Updates

IMPROVE data were updated through 2011, using IMPROVE data downloaded from the FED[47] database, and emissions data were updated with county and state level emission from the WestJumpAQMS 2008 inventory.[48] In addition to data updates, some of the averaging conventions were changed on the TSS, which affected some of the data summaries that may have previously been obtained from the TSS for initial SIP development. Specifically, the TSS originally reported data first rounded to 2 decimals, which were then rounded to 1 decimal. In this update, changes were made to round directly from full decimal resolution to 1 decimal.

[47] IMPROVE data are available from the IMPROVE Network through the Federal Land Manager Database online repository (http://views.cira.colostate.edu/fed/)

[48] See Emissions Inventory descriptions in Section 3.2.

While this was a small change, it did have the effect of changing the reported deciview average for the 2000-2004 progress period at a few sites by no more than 0.1 dv, which is much less than the 1 deciview change which is considered perceptible to the human eye. Figure 3.3-1 below presents a list of sites where the 5-year 2000-2004 deciview average has changed since originally published for use in initial SIPs, as reported by the TSS.

Table 3.3-1
Changes in TSS Reported Deciview Averages
2000-2004 Baseline Period

State	Class I area(s)	Site	Group	Deciview Average 2000-2004 Baseline Period		
				Extended Decimal Resolution	Previous Rounding Convention	Current Rounding Convention
AZ	Mount Baldy WA	BALD1	Worst	11.847	11.85→11.9	11.8
	Mazatzal WA Pine Mountain WA	IKBA1	Worst	13.345	13.35→12.5	12.4
CA	Lassen Volcanic NP Thousand Lakes WA Caribou WA	LAVO1	Worst	14.146	14.15→14.2	14.1
	Marble Mountain WA Yolla-Bolly-Middle-Eel WA	TRIN1	Worst	17.349	17.35→17.4	17.3
HI	Haleakala NP	HALE1	Best	4.547	4.55→4.6	4.5
MT	U L Bend WA	ULBE1	Best	4.749	4.75→4.8	4.7
NM	Guadalupe Mountains NP Carlsbad Caverns NP	GUMO1	Best	5.945	5.95→6.0	5.9
UT	Bryce Canyon NP	BRCA1	Worst	11.649	11.65→11.7	11.6
	Arches NP Canyonlands NP	CANY1	Best	3.746	3.75→3.8	3.7

3.3.2 Class I Area Summary Table

The Class I Area Summary Table calculates metrics to support regional haze analysis by species, total light extinction, and deciview, and presents a tabular display of associated values. To support progress reports, a new selection option, “Table Type: Reasonable Progress”, was added as the default summary option. Original table summary options developed to support the initial RHR SIPS are available under “Table Type: Baseline to 2018 Projections”.

The new Reasonable Progress Table presents monitoring data averages for each measured species extinction value, for total extinction and for deciview extinction. Periods represented include the 2000-2004 baseline period, the 2005-2009 next successive 5-year period, and the 2006-2010 and 2007-2011 rolling period averages. Table 3.2-2 presents an example Table for Rocky Mountain National Park (the ROMO1 IMPROVE monitor) in Colorado.

Table 3.3-1
WRAP Technical Support System Product
Example of a Class I Area Summary Table

Class I Area Summary Table

	Class I Area Visibility Summary: Rocky Mountain NP, CO Class I area **Visibility Conditions:** Worst 20% Days **Reasonable Progress Summary**			
	2000-04 Baseline Conditions (Mm-1)	2005-09 Progress Period (Mm-1)	2006-10 Progress Period (Mm-1)	2007-11 Progress Period (Mm-1)
Sulfate	7.9	7.2	6.4	6.3
Nitrate	5.3	4.0	3.7	3.4
Organic Carbon	10.5	8.9	8.4	8.0
Elemental Carbon	2.6	2.2	2.0	1.8
Fine Soil	1.4	1.5	1.5	1.5
Coarse Material	4.9	3.9	3.8	3.9
Sea Salt	0.0	0.1	0.1	0.1
Total Light Extinction	41.5	36.7	34.8	34.1
Deciview	13.8	12.6	12.0	11.8

3.3.3 Monitoring

For the “Monitoring” summary option, IMPROVE data were updated through 2011, and options were added to represent current 5-year averages. From the “Monitoring” options, two types of plots are available; “Time Series” plots and “Glide Slope” plots. For the “Time Series” plots, 5-year periods were added to the “averaging” option. The tool enables a comparison of either the 2000-2004 baseline period and the 2005-2009 most recent successive 5-year period, or the 2000-2004 period and the most recently available 2007-2011 5-year period. Options are available to display deciview averages, or any combination of species extinction and mass. Figure 3.3-2 presents an example display of 5-year period averages for the Rocky Mountain National Park ROMO1 site. The “Show Data” link below the display provides the data shown in the display in a table (this functionality is available on all TSS tools).

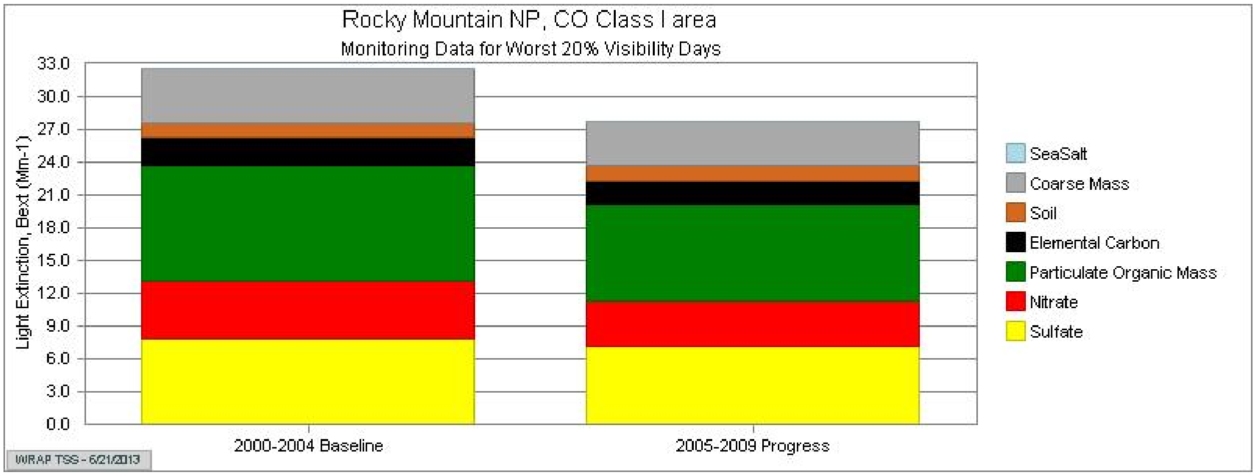

Figure 3.3-2. Example TSS Comparison of 2000-2004 and 2005-2009 period averages for Rocky Mountain National Park in CO.

For the "Glide Slope" plots, options were added to display 5-year period averages for both "successive" and "rolling" period average. As noted in Section 2.0, EPA's September 2003 guidance specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, et cetera,[49] but EPA's more recent guidance principals, released in April 2013, suggest that progress be tracked using rolling 5-year period averages. This support document assessed change using the successive periods, but rolling period averages have been made available through the TSS. Options are available to display either successive or rolling averages, with or without 2064 Natural Conditions estimates, for deciview averages and any combination of species extinction. Figure 3.3-3 presents an example of successive 5-year period averages, plotted along with annual averages, for the Rocky Mountain National Park ROMO1 site, and Figure 3.3-4 presents an example of rolling period averages.

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[49] See page 4-2 in EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule.* (http://www.epa.gov/ttnamti1/files/ambient/visible/tracking.pdf)

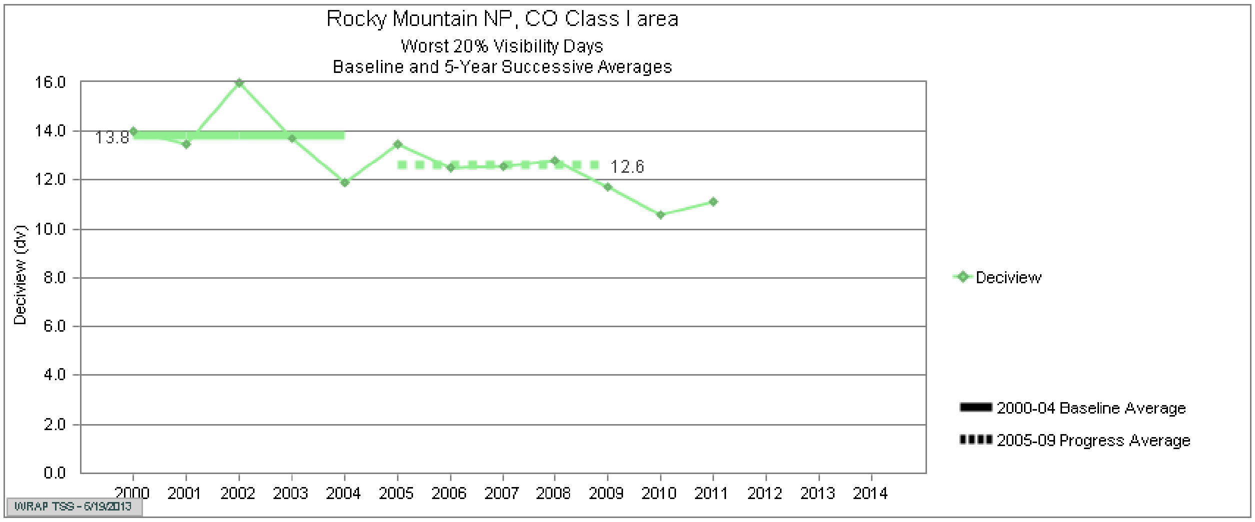

Figure 3.3-3. Example TSS Plot of 5-Year Successive Averages, Showing the 2000-2004 Baseline Average and 2005-2009 Period Averages for Rocky Mountain National Park in CO.

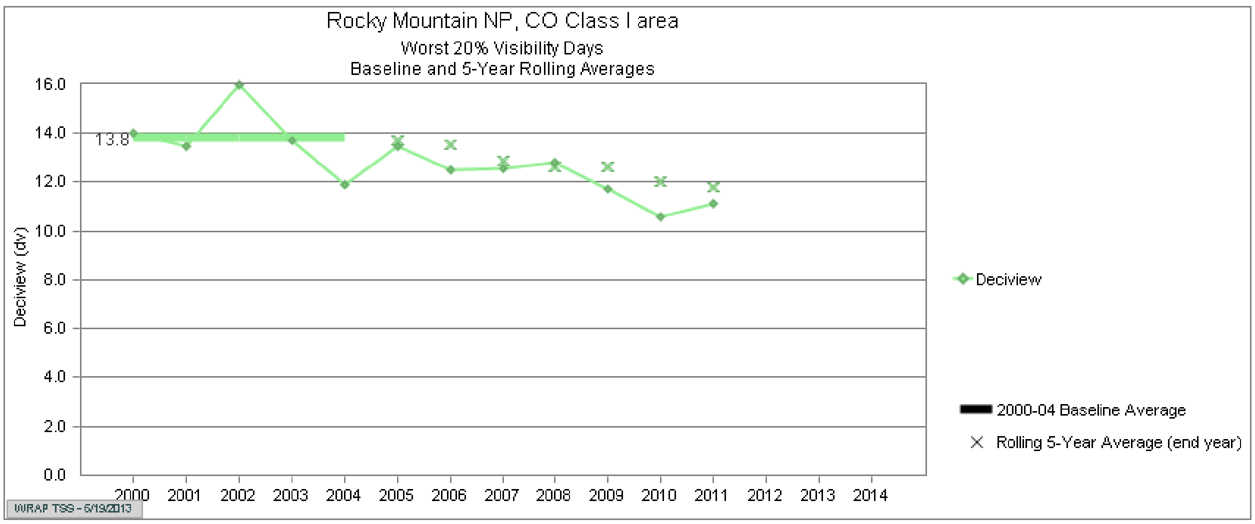

Figure 3.3-4. Example TSS Plot of 5-Year Rolling Averages, Showing the 2000-2004 Baseline Average and Rolling Averages Beginning With 2001-2005 through 2007-2011, for Rocky Mountain National Park in CO.

3.3.4 Emissions Summary Tools

For the "Emissions" summary option, the WestJumpAQMS 2008 emissions dataset was added. For display purposes, source categories were aligned with those used in the baseline planning period and display options were added for the 2008 data, including side-by-side comparisons of 2008 and 2002 data under the "Emissions Review Tool" link. Only state level summaries have been presented in this report, but county level summaries are available through the TSS. Figure 3.3-5 presents an example of a side-by-side comparison of 2002 and 2008 emissions for counties in Arizona. Note that these summaries are not available from the TSS for Alaska and Hawaii.

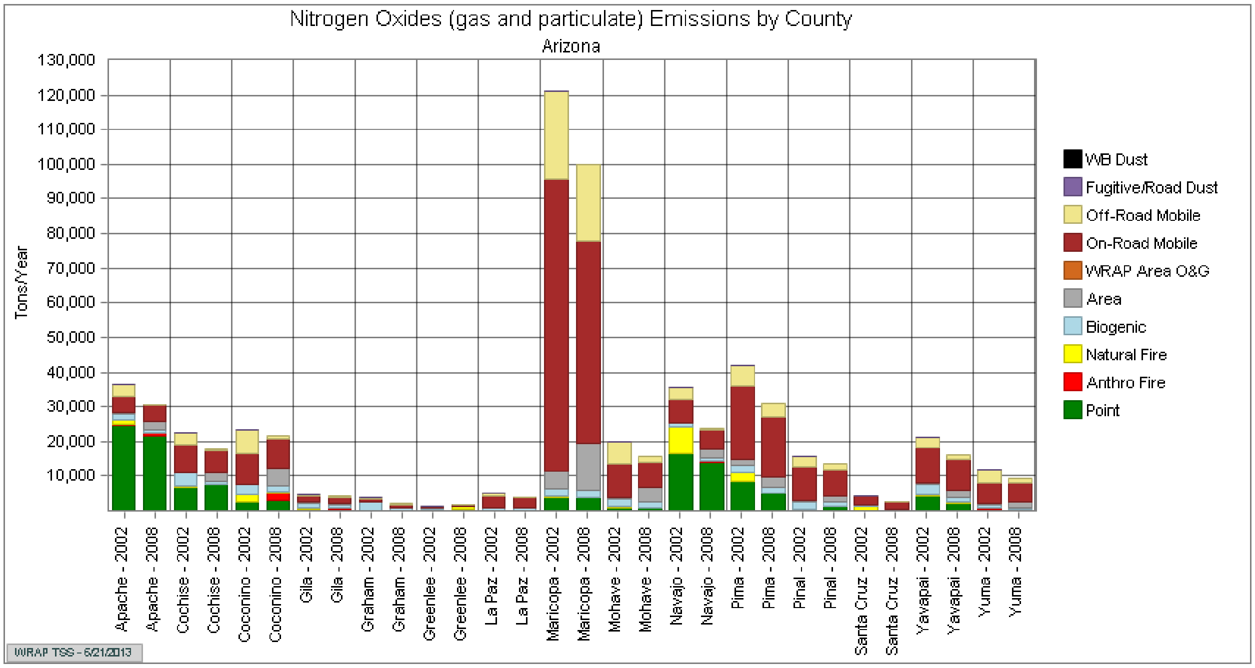

Figure 3.3-4. Example TSS Plot Showing Side-by-Side Comparisons of 2002 and 2008 Emission Inventories for Counties in Arizona.

4.0 WRAP REGIONAL SUMMARIES

As described in Section 2.0, each state is required to submit a report evaluating progress toward the reasonable progress goal, pursuant to Regional Haze Rule (RHR) 40 CFR 51.308(g). Because haze is a regional issue, summaries of monitoring and emissions data are presented here on a regional scale. These summaries are intended to support the individual State and Class I area data summaries which are presented in Section 6.0. Some general observations from these regional summaries are listed below, and described in more detail in the following sections.

- The 5-year deciview metric for the worst days decreased between the 2000-2004 baseline period and the 2005-2009 progress period at most sites, but increased at several sites. Particulate organic mass concentration was the largest contributing factor to increases in the 5-year deciview metric. The increases in particulate organic mass measurements were correlated with regions where large wildfire events occurred during the 2005-2009 progress period.
- The 5-year deciview metric for the best days decreased between the 2000-2004 baseline period and the 2005-2009 progress period did not get worse, and actually improved, at all but a few sites in Washington, Oregon, and Alaska, where small increases were measured.
- For ammonium nitrate, decreases in the 5-year average for the worst days, and decreasing annual trends, were measured at nearly all sites, with the largest decreases in northern Oregon and southern California. Emissions inventories indicate that oxides of nitrogen (NO_X) are mostly due to on-road mobile, off-road mobile, and point source emissions. Decreasing ammonium nitrate measurements were consistent with comparisons between baseline and progress period inventories, and tracking of annual averages electric generating units (EGU) emissions, which showed decreasing inventory totals for NO_X in most Western Regional Air Partnership (WRAP) states.
- A number of sites measured increases in 5-year average ammonium sulfate for the worst days, but most sites showed decreasing ammonium sulfate trends. For the 5-year average, most sites, including all sites in Utah, Colorado, Arizona, and New Mexico, were affected by anomalously high ammonium sulfate annual averages in 2005. Emissions inventories indicate that sulfur dioxide (SO_2) emissions in the western states are dominated by point sources, and comparisons between baseline and progress period inventories, and tracking of annual averages EGU emissions, show decreasing SO_2 emissions for most WRAP states.
- While most sites measured decreasing ammonium sulfate trends, increasing trends were measured in Alaska and Hawaii, at a few coastal sites in northwestern California and southwestern Oregon, and at a few sites along the Canadian border in northeastern Montana and northwestern North Dakota. Emissions inventories show that increases in Hawaii are largely due to volcanic emissions of SO_2. Increases at other WRAP sites do not appear to be reflected in the emissions inventory totals. The increases at the coastal sites may be affected by offshore emissions, which are not presented here on a state level. Increases along the Canadian border may be due to international emissions.

- For fine soil and coarse mass, measured concentrations were highest in the southern WRAP region. Soil and coarse mass extinction trends were variable and not statistically significant in most cases, but an area represented by several Interagency Monitoring of Protected Visual Environments (IMPROVE) sites in eastern Arizona and western New Mexico did show increasing coarse mass trends. Emission inventories indicated that natural windblown dust is the largest contributor to coarse mass measurements in this area, but significant changes in the development of the windblown dust inventories did not allow for definitive comparisons between 2002 and 2008 inventories for these emissions.

4.1 MONITORING DATA

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve, and that visibility on the 20% least impaired, or best, days does not get worse, as measured in units of deciviews (dv) calculated from data measured at IMPROVE monitoring sites. For purposes here, progress is measured in 5-year average increments beginning with the 2000-2004 baseline average, and proceeding with each subsequent 5-year average (e.g. 2005-2009, 2010-2014, etc.).[50] This section addresses changes as measured between the baseline period and the most recent successive progress period available, or the 2005-2009 first progress period.

Figures 4.1-1 and 4.1-2 present the difference between the 2000-2004 average baseline period and the 2005-2009 first progress period in deciviews for the 20% worst and 20% best days, respectively, for Federal Class I area (CIA) IMPROVE sites in the WRAP region. The maps indicate that 5-year average extinction on the 20% worst days decreased at most sites, but showed some increases at several sites. The map for the 20% best days indicates that best days did not get worse, and actually improved, at all but a few sites in Washington, Oregon, and Alaska, where increases were small (~0.1 dv).

[50] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (see page 4-2 in the Guidance document).

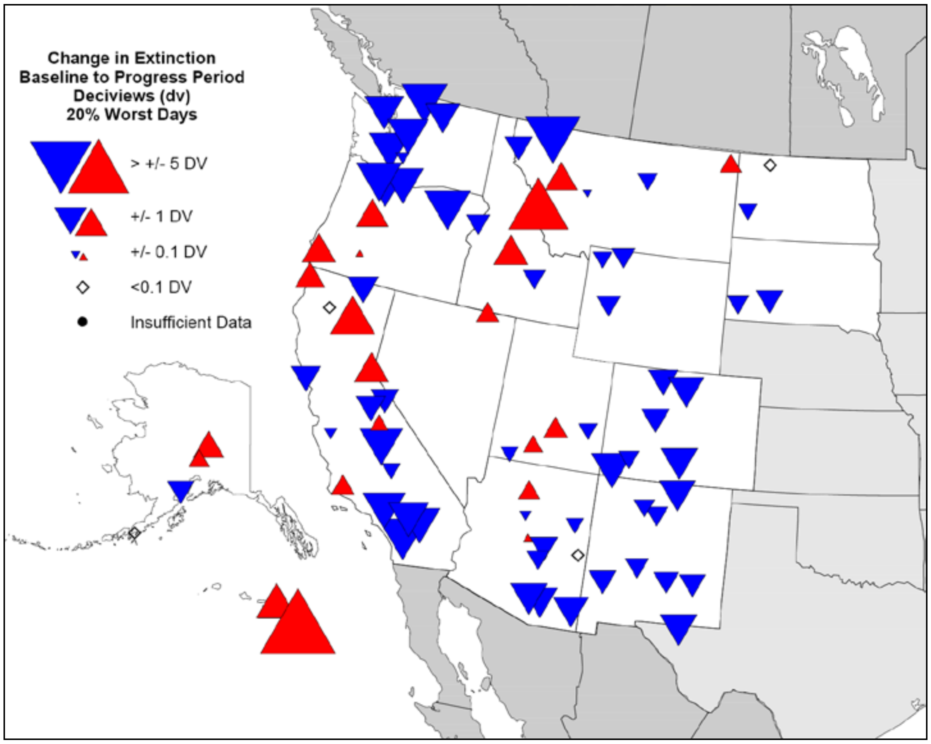

Figure 4.1-1. Change in Deciview Extinction between Baseline Period Average (2000-2004) and the First Progress Period Average (2005-2009) for the 20% Worst Visibility Days.

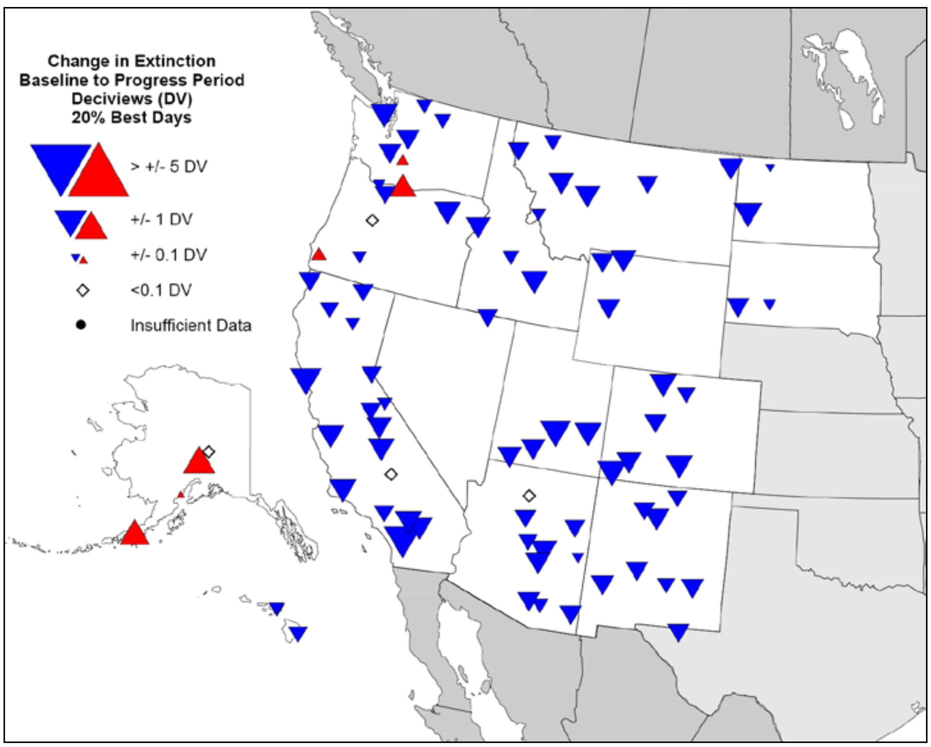

Figure 4.1-2. Change in Deciview Extinction between Baseline Period Average (2000-2004) and the First Progress Period Average (2005-2009) for the 20% Best Visibility Days.

The RHR haze index, as defined using deciview units, does not provide information regarding the relative contributions of specific pollutants to overall visibility impairment. As described in Section 3.1, calculation of visibility impairment is based on the cumulative impacts of several different species measured as measured at IMPROVE Network sites. Analyzing the behavior of each individual species has important implications for control measures, as some species originate from largely anthropogenic sources, while others may originate from a mixture of both anthropogenic and natural sources.

Figures 4.1-3 and 4.1-4 present regional maps of average aerosol extinction for the most impaired days during baseline period (2000-2004), and the first progress period average (2005-2009), respectively, for the IMPROVE monitors representing Federal CIAs in the WRAP region. The size of the pie chart is related to the magnitude of visibility impairment, and colors represent the relative contribution of the pollutants measured by the IMPROVE Network.

The maps indicate that particulate organic matter, which is often related to wildfire activity, is a large factor in visibility reduction in the west. Visibility impairment in western CIAs that are directly adjacent to more populated areas in the West is influenced more by ammonium nitrate, which is commonly associated with combustion activities, especially vehicles and industrial activities. Ammonium sulfate represents most of the visibility impairment at the Hawaii sites, and up to one third of the impairment in the contiguous United States. The largest contributor to ammonium sulfate concentrations in the contiguous United States and Alaska is generally industrial activities such as coal burning power plants, while natural volcanic activity contributes to the high measured ammonium sulfate at Hawaii sites.

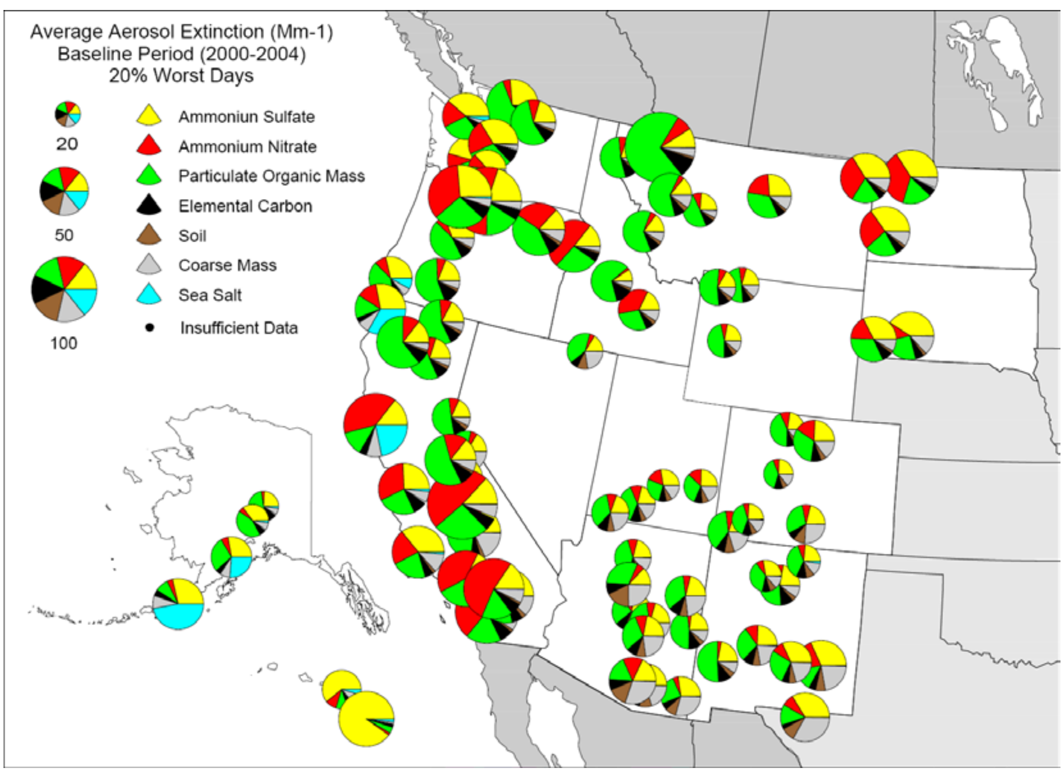

Figure 4.1-3. Regional Average of Aerosol Extinction by Pollutant for Baseline Period Average (2000-2004) for 20% Worst Days.

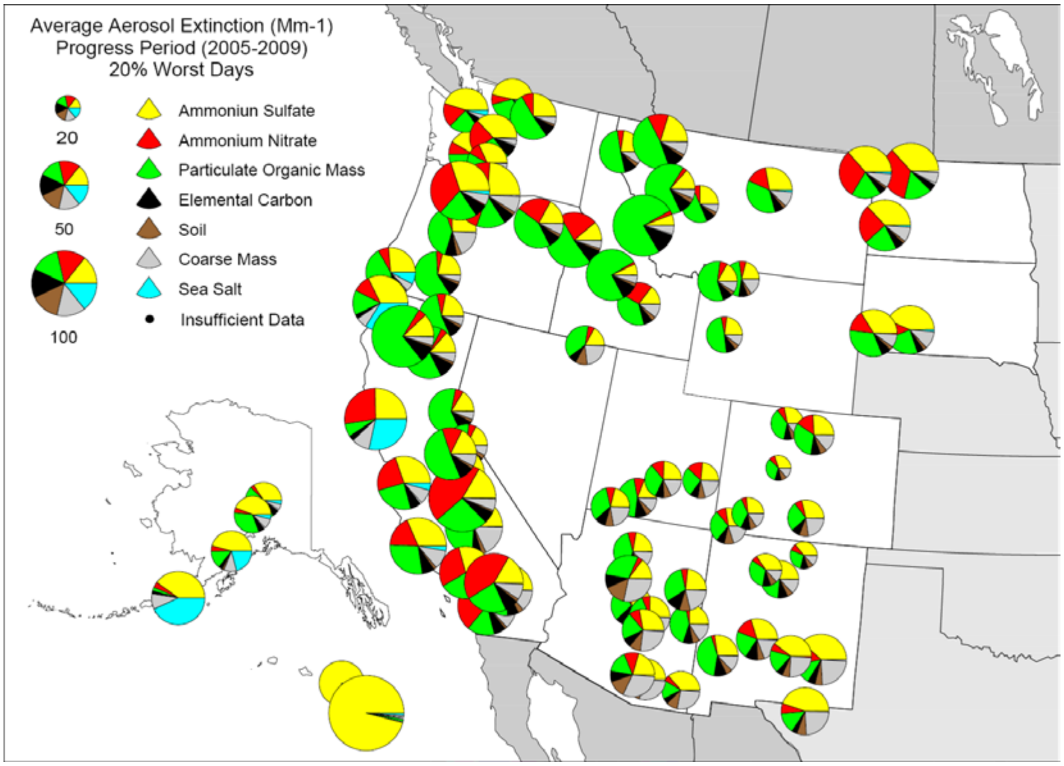

Figure 4.1-4. Regional Average of Aerosol Extinction by Pollutant for the First Progress Period Average (2005-2009) for 20% Worst Days.

The changes in deciview between the 2000-2004 baseline and 2005-2009 progress period averages, as depicted in Figure 4.1-1, is the combined effect of increases in some species and decreases in other species. To identify individual species behavior, the increasing and decreasing species are presented separately in Figures 4.1-5 and 4.1-6. Figure 4.1-5 presents the individual species of haze that have decreased between the 2000-2004 baseline period and the 2005-2009 progress period, where sites with corresponding decreases in deciview measurements are highlighted with blue circles. Figure 4.1-6 presents the individual species of haze that have increased, with corresponding deciview increases highlighted with purple circles.

As depicted in Figure 4.1-5, most of the decreases in deciviews averages values were associated with decreasing ammonium nitrate and particulate organic mass. Decreases in California, eastern Oregon, and Idaho were largely due to ammonium nitrate reductions, while decreases in northern Washington and Montana, Colorado, New Mexico, and Arizona were largely due to decreasing particulate organic mass. Some ammonium sulfate reductions were also measured in western Washington and northwestern Oregon. As depicted in Figure 4.1-6, most of the increases in deciview values were associated with increasing particulate organic mass in California, Idaho, Montana, and Utah. Ammonium sulfate increases also occurred in Alaska, Hawaii, and at a few of the sites in the contiguous states.

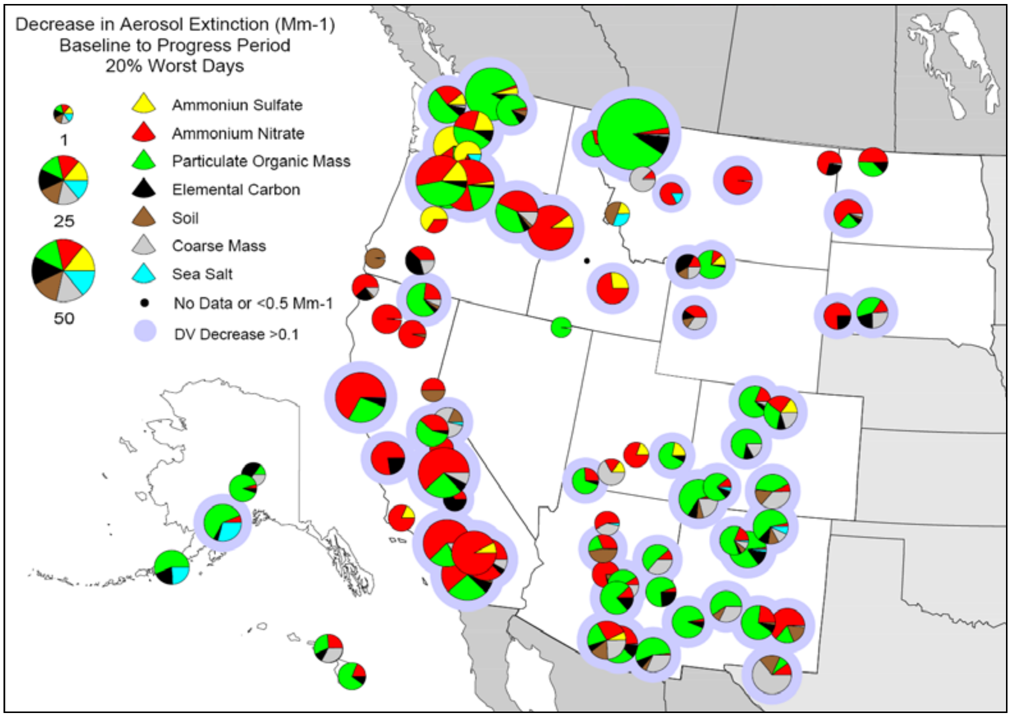

Figure 4.1-5. Magnitude of Aerosol Extinction Species That Have Decreased Between the Baseline Average (2000-2004) and the First Progress Period Average (2005-2009) for the 20% Worst Days.

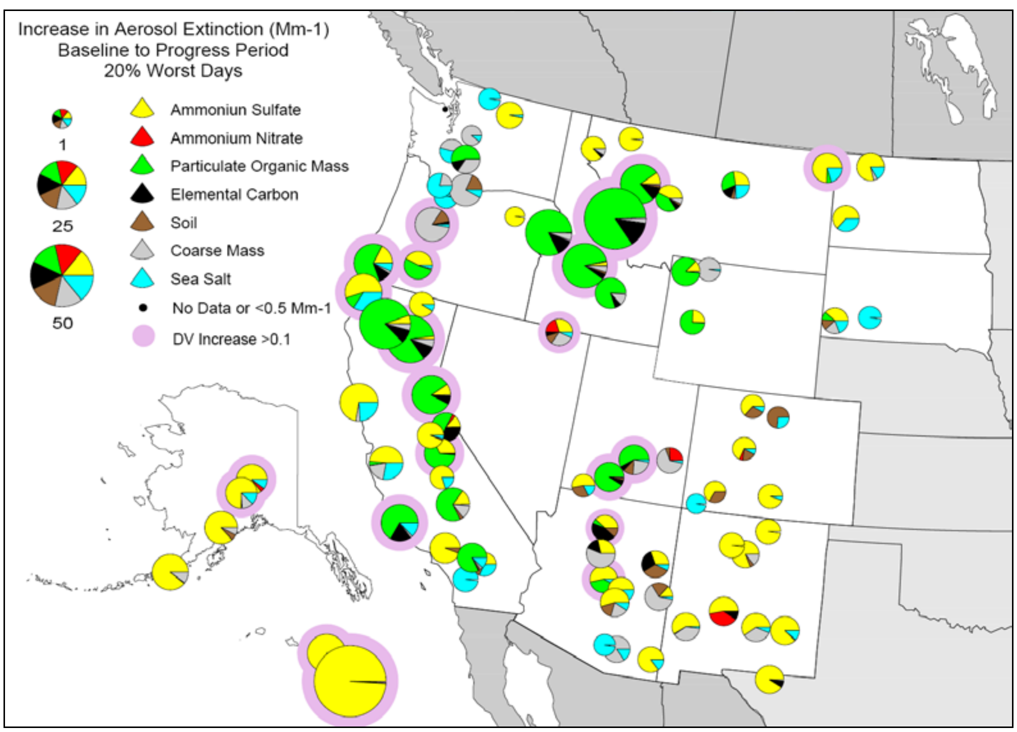

Figure 4.1-6. Magnitude of Aerosol Extinction Species That Have Increased Between the Baseline Average (2000-2004) and the First Progress Period Average (2005-2009) for the 20% Worst Days.

4.1.1 Annual Trends

In addition to looking at the 5-year averages deciview metric that is specified in regulatory text, it is useful to examine annual trends for each particle species. In the long term, annual trend statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data.

Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics, which is a nonparametric regression technique that is commonly applied to environmental data to determine statistically significant trends.[51] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes. Regional trends are presented here for aerosol species trends with p-value statistics less than 0.15 (85% confidence level). Trends for all significance levels at all sites are also included in state specific appendices provided with this report.

Figures 4.1-7 presents trends in ammonium sulfate measurements for the period 2000-2009 for the 20% most impaired or worst days at each IMPROVE Federal CIA site that had at least five years of complete data, and Figure 4.1-7 presents trends for all sampled days. Figures 4.1-9 through 4.1-20 present similar maps of ammonium nitrate, particulate organic mass, elemental carbon, soil, coarse mass, and sea salt trends. At the time this report was prepared, data were available through 2010,[52] but trends presented here include only data collected between 2000-2009 to better reflect the changes between the 2000-2004 baseline and 2005-2009 progress periods.

The RHR haze index specifically refers to the 20% most impaired and least impaired days, but trends are also presented here for the annual average of all sampled days. The 20% most impaired and least impaired days can represent different times of the year, especially when large events such as wildfires influence the worst day identification.[53] Because the annual average represents the entire year, these averages may better represent overall aerosol species trends than trends for just the 20% worst days. Consistency between worst day and all day trends adds confidence to the characterization of the trend, and differences may suggest a seasonality affect. Specific trend observations by species are listed below:

- Figures 4.1-7 and 4.1-8 indicate decreasing ammonium sulfate trends for most sites, but increasing trends were measured in Alaska and Hawaii, at a few coastal sites in northwestern California and southwestern Oregon, and at a few sites along the Canadian border in northeastern Montana and northwestern North Dakota.

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[51] Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)

[52] The 2010 IMPROVE data were not included in trend analysis, but 2010 annual averages are included for reference in states specific appendices.

[53] Seasonality effects of the identification of worst days are discussed further in Section 3.1.2.1.

- Figures 4.1-9 and 4.1-10 indicate decreasing ammonium nitrate trends at nearly all sites. Slightly increasing trends were measured at the DENA1 site in Alaska.
- Figures 4.1-11 and 4.1-12 indicate that most particulate organic mass trends are either decreasing or insignificant.
- Figures 4.1-13 and 4.1-14 indicate that elemental carbon is also generally trending down.
- Figures 4.1-15 and 4.1-16 indicate that trends in soil are mostly insignificant.
- Figures 4.1-17 and 4.1-18 indicate that trends for coarse mass were mostly decreasing, but increasing trends were apparent for a region in eastern Arizona and western New Mexico.
- Figures 4.1-19 and 4.1-20 indicate that sea salt trends are mostly insignificant, with the largest significantly increasing trends measured on the pacific coast for the worst days.

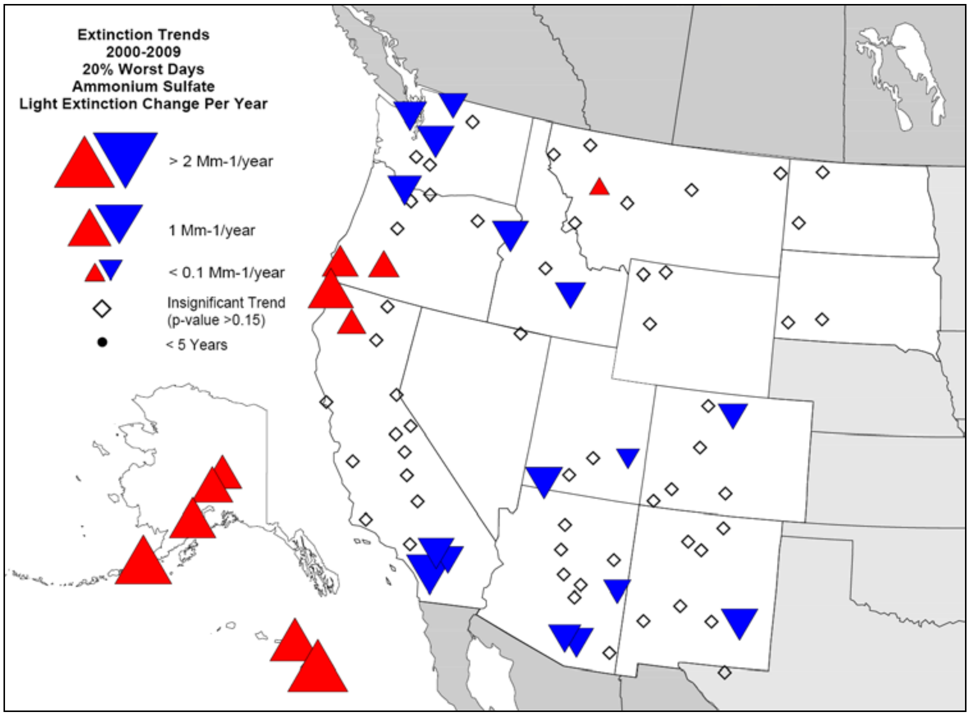

Figure 4.1-7. 10-Year Annual Average Ammonium Sulfate Extinction Trends for 20% Worst Days at CIA IMPROVE Sites in the WRAP Region.

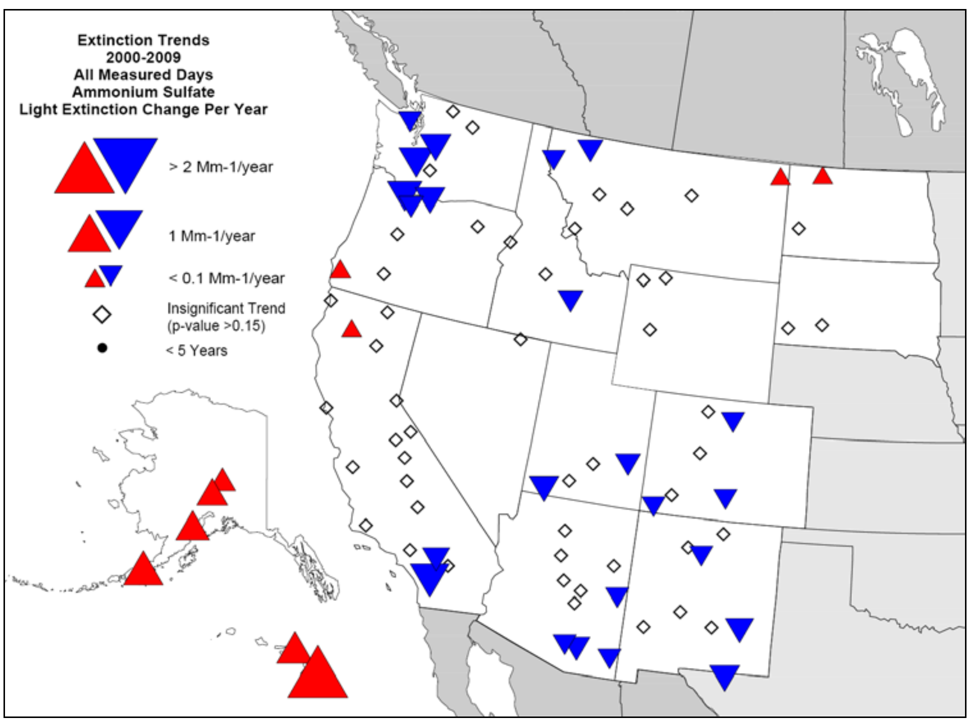

Figure 4.1-8. 10-Year Annual Average Ammonium Sulfate Extinction Trends for All Measured Days at CIA IMPROVE Sites in the WRAP Region.

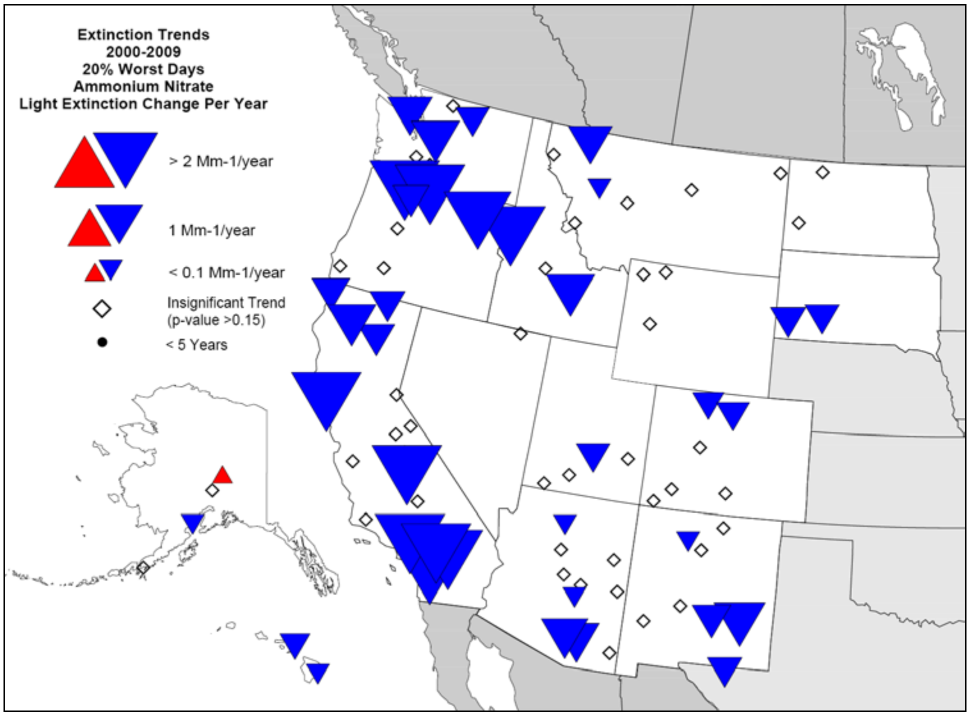

Figure 4.1-9. 10-Year Annual Average Ammonium Nitrate Extinction Trends for 20% Worst Days at CIA IMPROVE Sites in the WRAP Region.

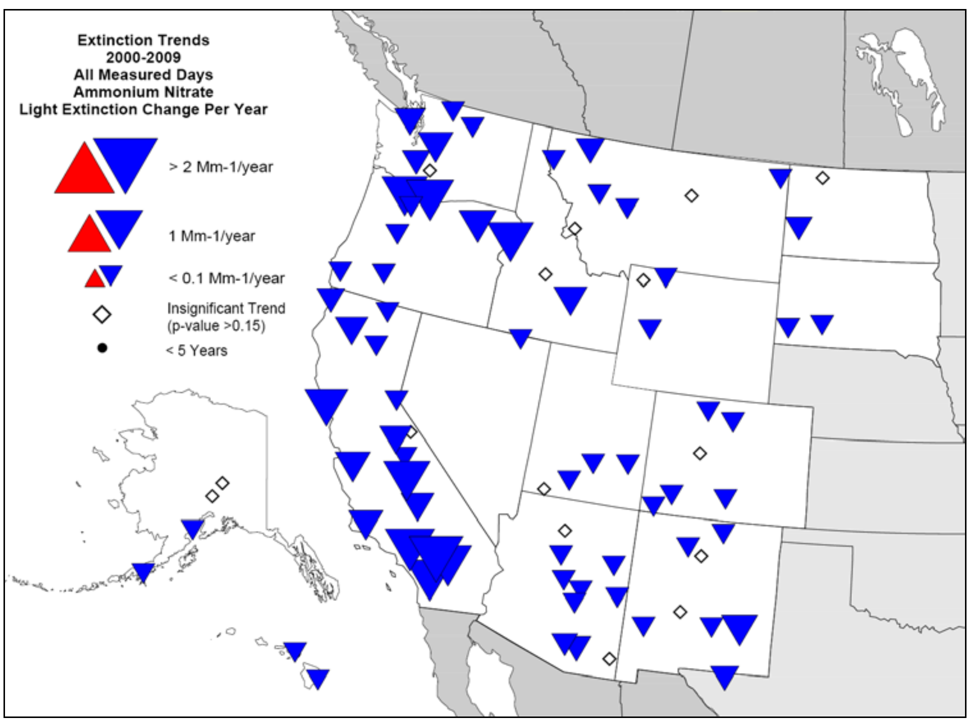

Figure 4.1-10. 10-Year Annual Average Ammonium Nitrate Extinction Trends for All Measured Days at CIA IMPROVE Sites in the WRAP Region.

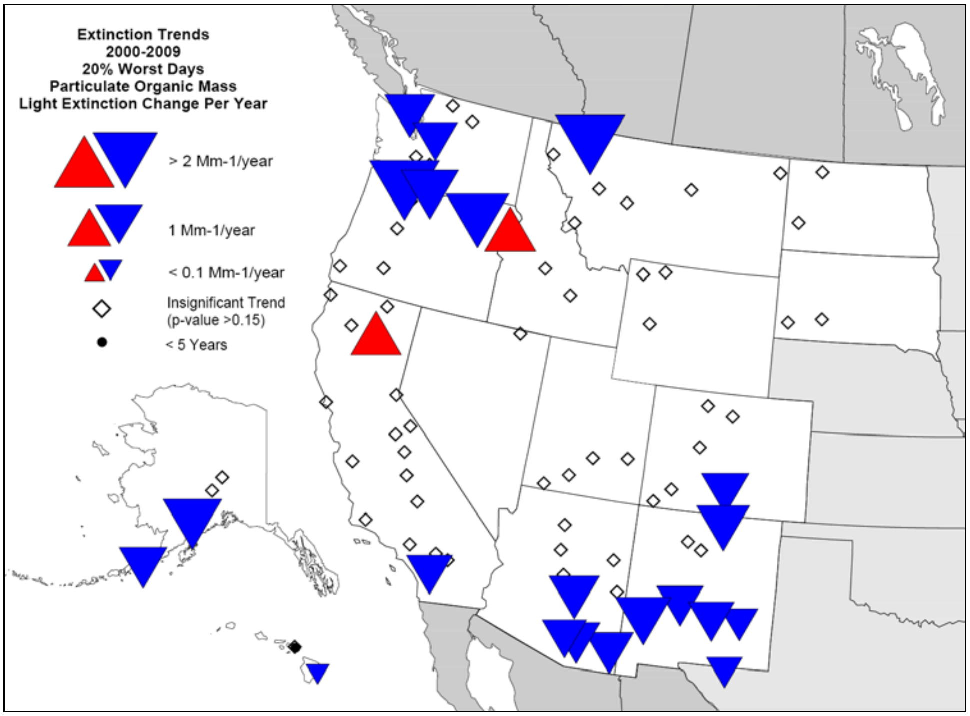

Figure 4.1-11. 10-Year Annual Average Particulate Organic Matter Extinction Trends for 20% Worst Days at CIA IMPROVE Sites in the WRAP Region.

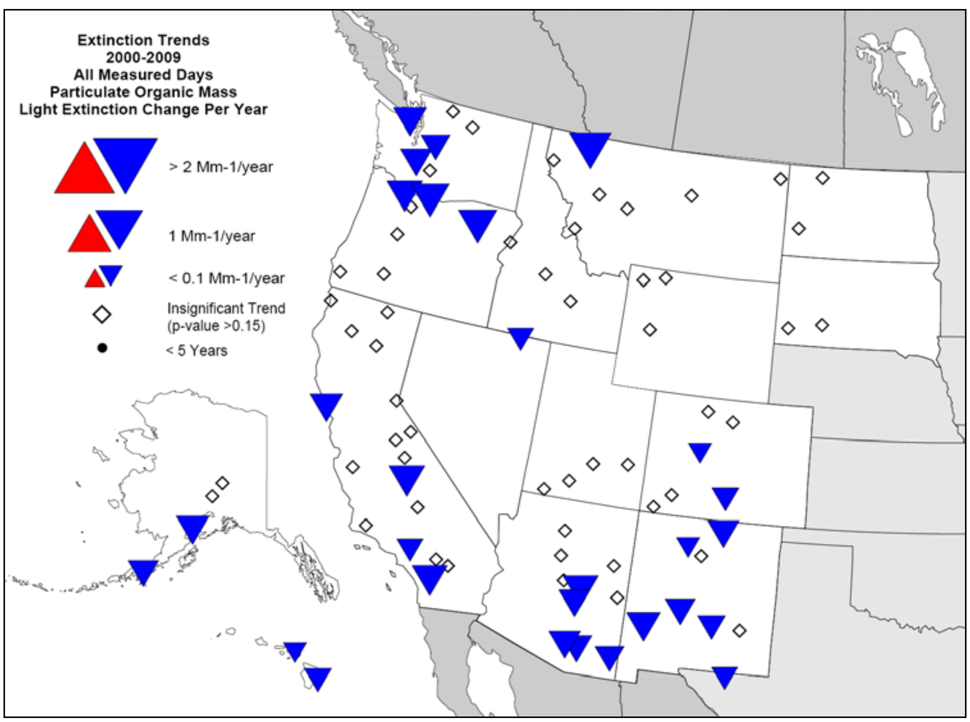

Figure 4.1-12. 10-Year Annual Average Particulate Organic Matter Extinction Trends for All Measured Days at CIA IMPROVE Sites in the WRAP Region.

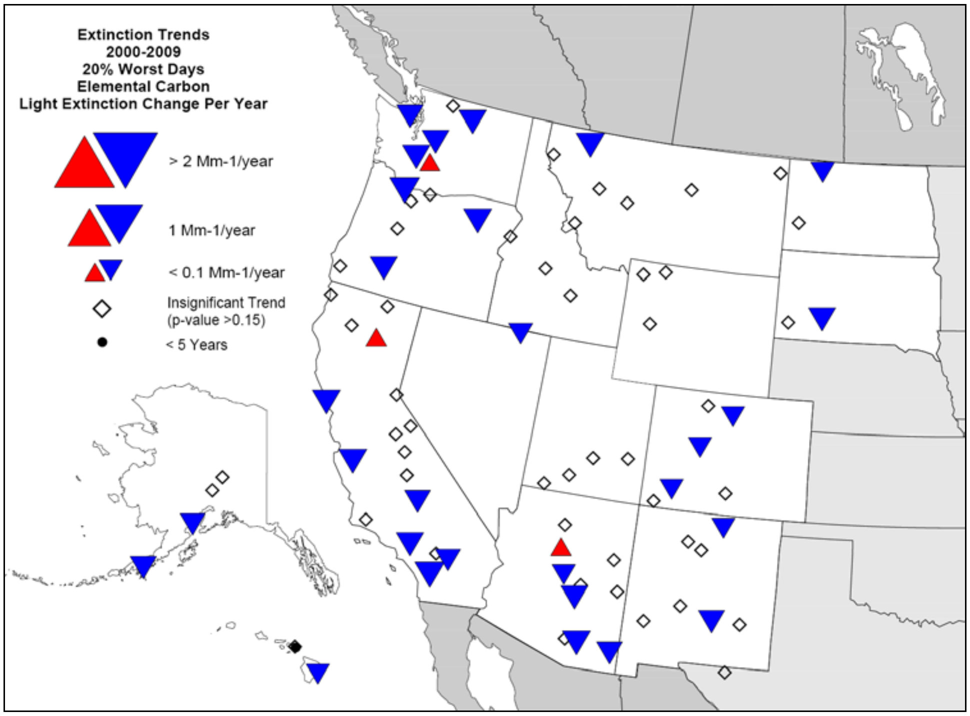

Figure 4.1-13. 10-Year Annual Average Light Absorbing Carbon Extinction Trends for 20% Worst Days at CIA IMPROVE Sites in the WRAP Region.

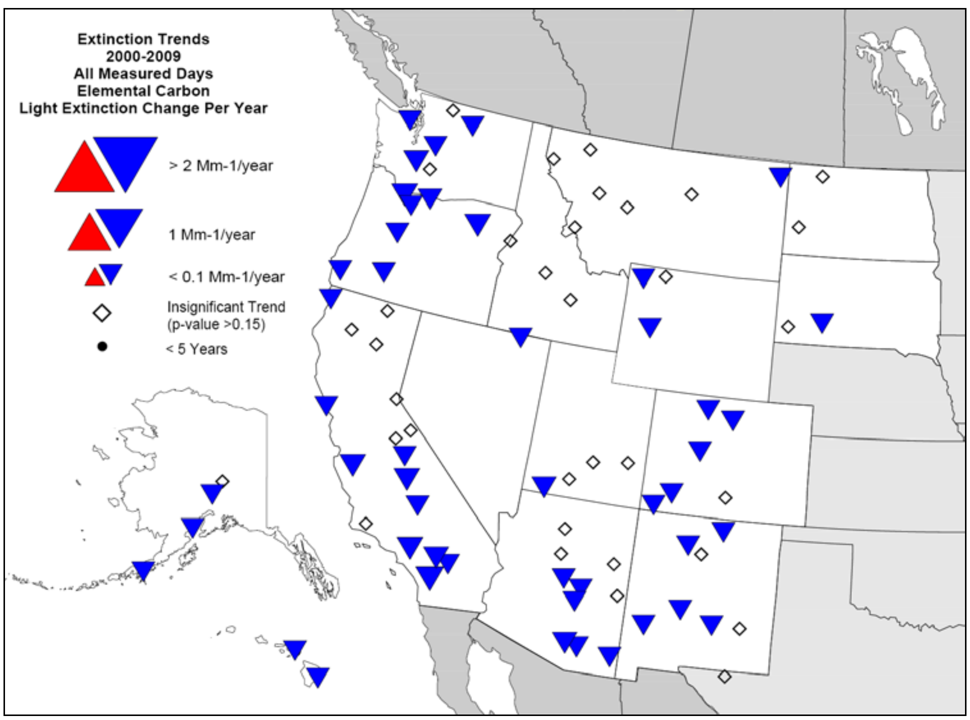

Figure 4.1-14. 10-Year Annual Average Light Absorbing Carbon Extinction Trends for All Measured Days at CIA IMPROVE Sites in the WRAP Region.

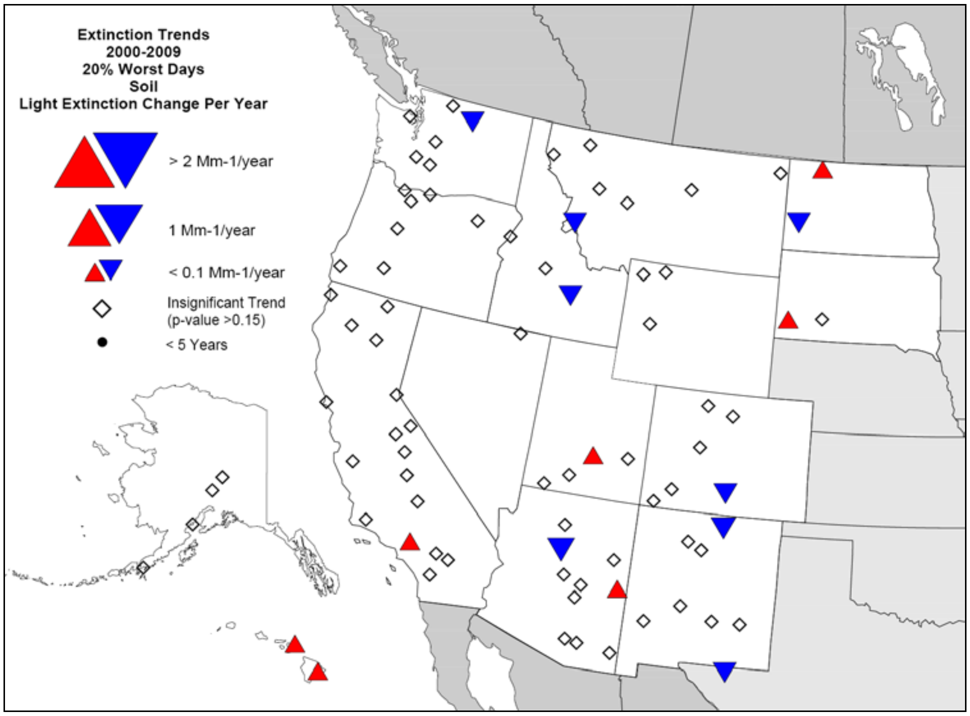

Figure 4.1-15. 10-Year Annual Average Soil Extinction Trends for 20% Worst Days at CIA IMPROVE Sites in the WRAP Region.

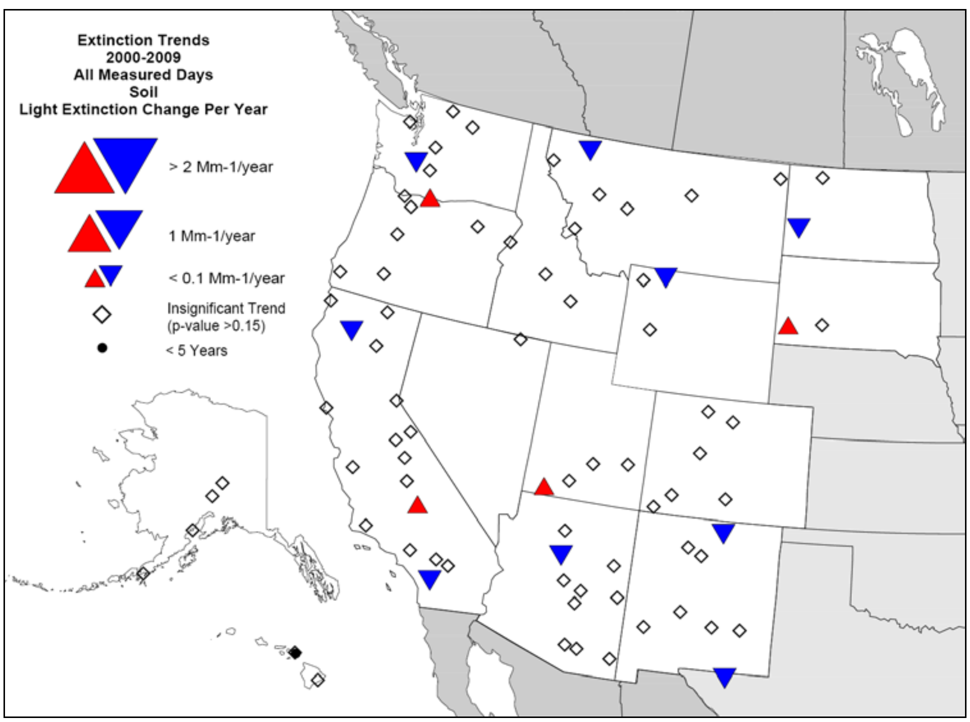

Figure 4.1-16. 10-Year Annual Average Soil Extinction Trends for All Measured Days at CIA IMPROVE Sites in the WRAP Region.

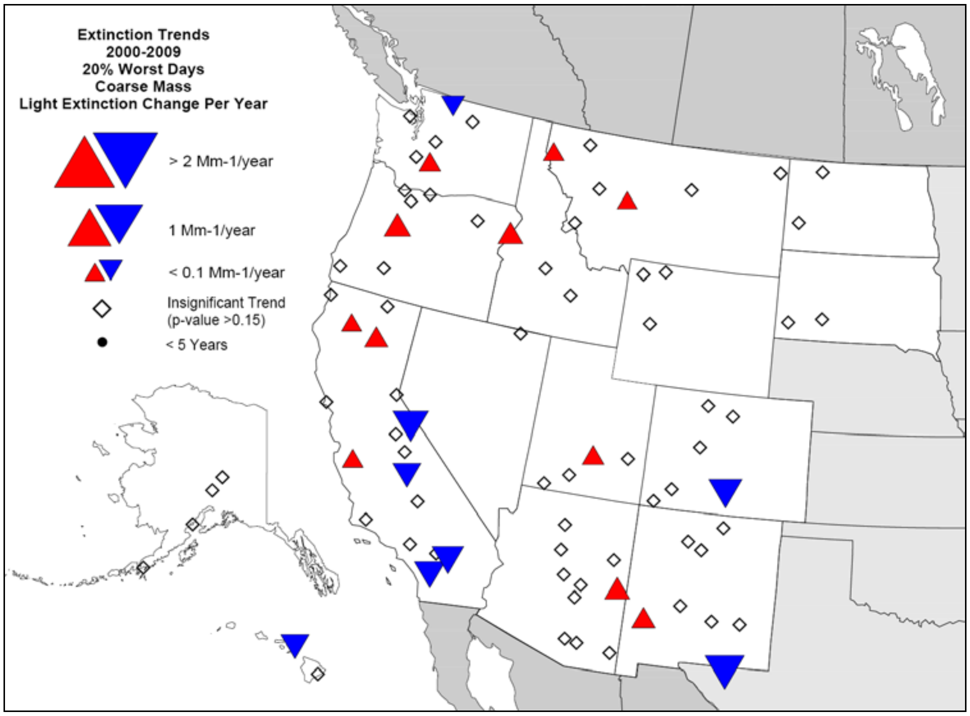

Figure 4.1-17. 10-Year Annual Average Coarse Mass Extinction Trends for 20% Worst Days at CIA IMPROVE Sites in the WRAP Region.

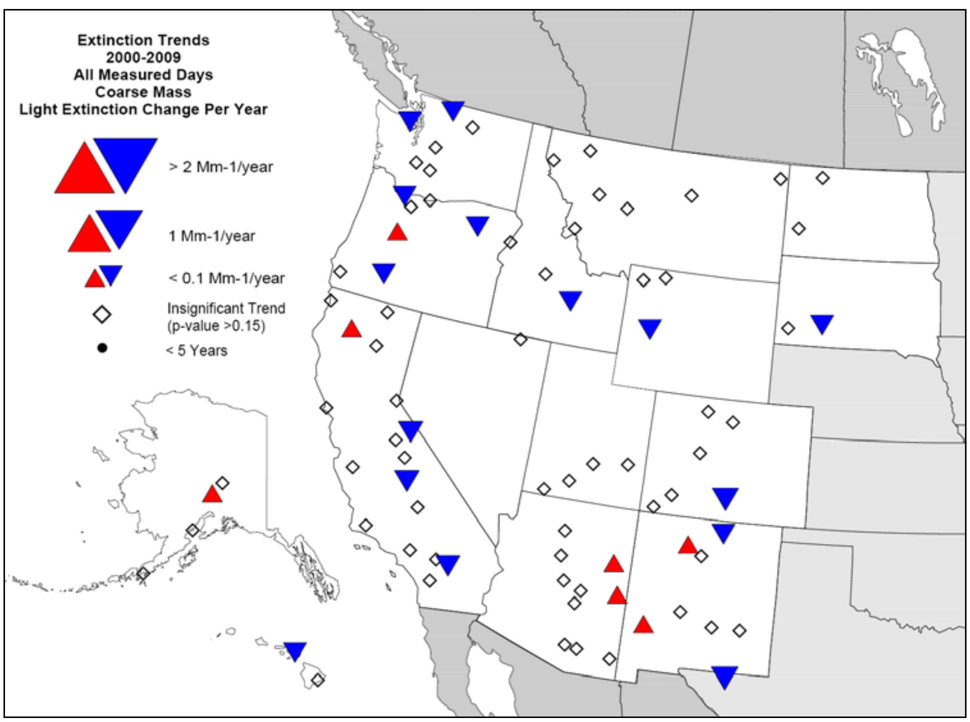

Figure 4.1-18. 10-Year Annual Average Coarse Mass Extinction Trends for All Measured Days at CIA IMPROVE Sites in the WRAP Region.

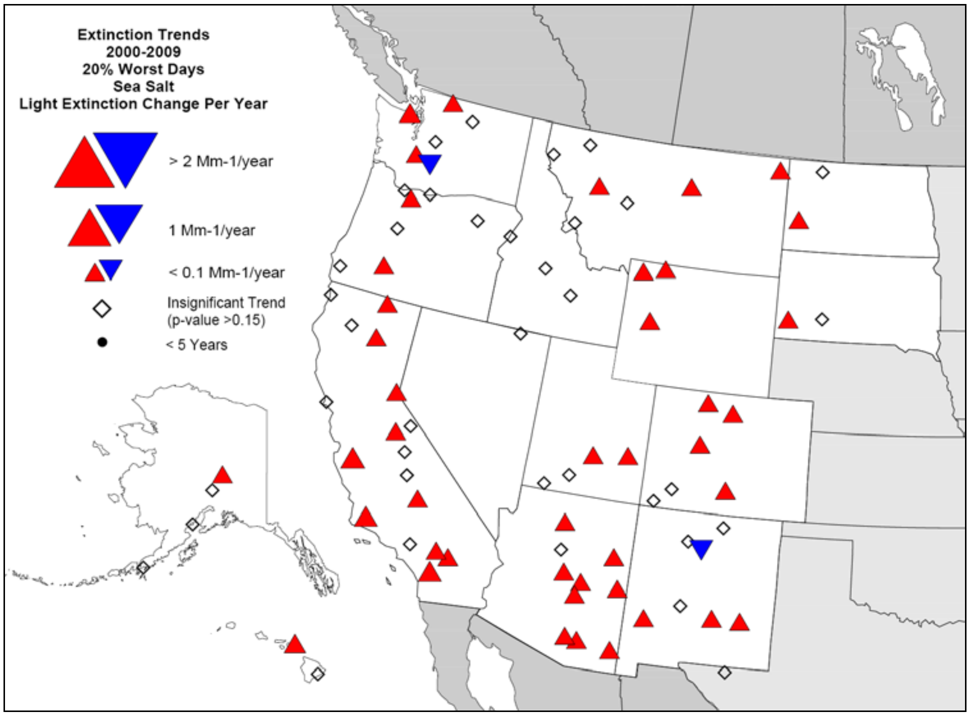

Figure 4.1-19. 10-Year Annual Average Sea Salt Extinction Trends for 20% Worst Days at CIA IMPROVE Sites in the WRAP Region.

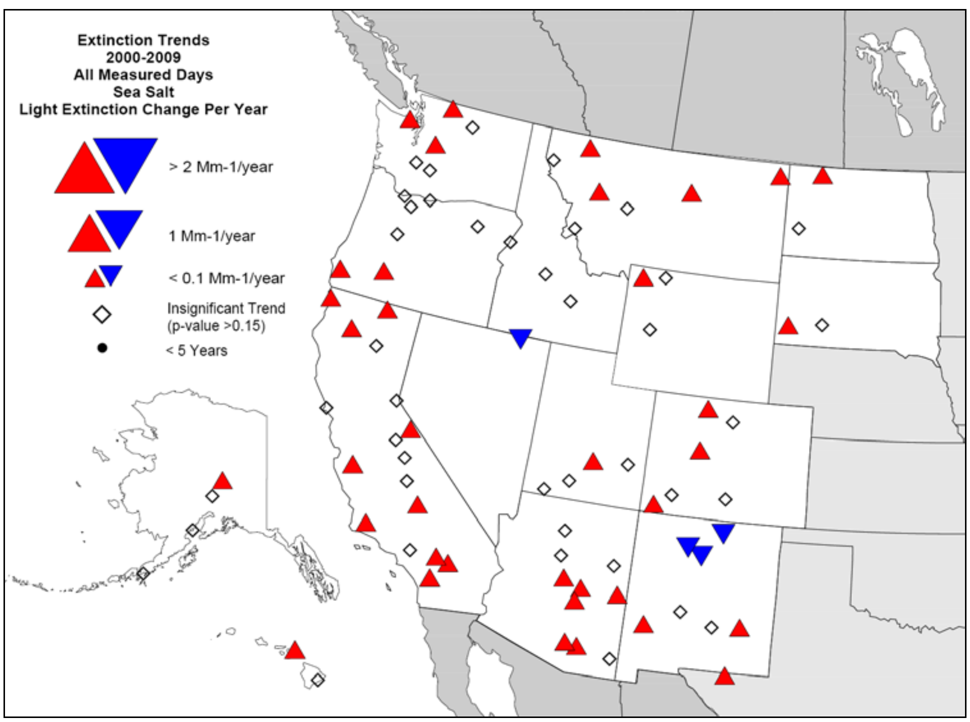

Figure 4.1-20. 10-Year Annual Average Sea Salt Extinction Trends for All Measured Days at CIA IMPROVE Sites in the WRAP Region.

4.1.2 Regional Events

The previous section presented aerosol trends, which are useful in analyzing changes in air quality data over long periods of time, but minimize the effects of large events that can affect the 5-year average metrics. Large regional episodic events can include windstorms which can transport dust from some of the desert regions in the WRAP, and even from intercontinental dust sources, as documented for several cases of Asian and African dust impacts on the United States. Other examples of large episodic regional events can include wildfires, which impact most of the western states, and volcanic emissions, which have large impacts in Hawaii. This section includes some examples showing the impact of large regional events on specific aerosol species as measured during the 2005-2009 progress period. Some effects of large events on the 5-year RHR haze indexes are discussed in for each WRAP state in Section 6.0.

Figure 4.1-21 presents an example of particulate organic mass measurements on August 4, 2007. High measurements spanned most of the state of Montana, and also some sites in Idaho, North Dakota, and Wyoming. Figure 4.1-22 presents a map from the WRAP Fire Emissions Tracking System (FETS) online tool,[54] showing fire detections between August 2 and 4, which indicates that there were a number of detections western Montana and Idaho. Largest fires in the area at the time included a fire in the Salish Mountains north of Hot Springs in Montana that began on July 31, and the Chippy Creek Fire which burned almost 100,000 acres in northwest Montana.

Figure 4.1-23 presents an example of particulate organic mass measurements on June 26, 2008, where high measurements spanned most of the state of California. Figure 4.1-24 presents a map from the WRAP FETS online tool showing fire detections on June 26, with numerous detections all along the Cascades, many of which were attributed to lightning strikes in the region.

Figures 4.1-25 and 4.1-26 present fine soil and coarse mass, respectively, as measured on May 15, 2005. For this event, high measurements spanned most of the west coast, which is consistent with what might be expected for international transport of dust from Asia. Further analysis of the chemical composition of the measured fine soil, including correlation with manganese (Mg) levels, would help elucidate whether this was an actual Asian Dust event. Figures 4.1-27 and 4.1-28 present fine soil and coarse mass as measured on June 29, 2008, representing a more typical dust event in the west, with high measurements spanning most of Arizona.

Figure 4.1-29 presents an abnormally high sea salt event that was measured on December 14, 2008 at several sites across the northern Great Plains, including sites in Montana, Wyoming, the Dakotas, and neighboring states as far south as Kansas. This event was discussed at the 2009 IMPROVE Steering Committee meeting, where it was noted that airmass characteristics and back-trajectories pointed to the Canadian arctic as the likely source of the material observed.[55]

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[54] The WRAP FETS is available online at http://www.wrapfets.org/.

[55] IMPROVE Steering committee meeting minutes are available at http://vista.cira.colostate.edu/improve/Activities/activities.htm.

Note that sea salt measurements are based on IMPROVE chloride measurements, which can also be associated with compounds not found in seawater. Figure 4.1-30 presents a more typical sea salt event, with higher measurements spanning the western coast.

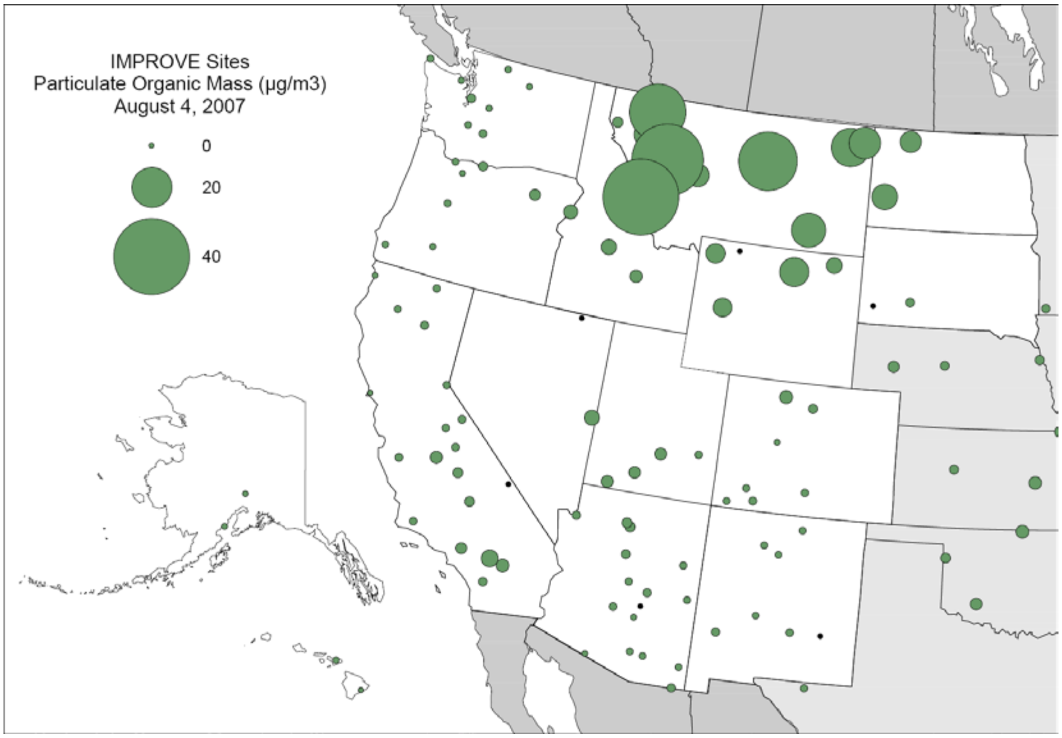

Figure 4.1-21. Particulate Organic Mass Event Measured on August 4, 2007, Affecting Most Montana IMPROVE Sites.

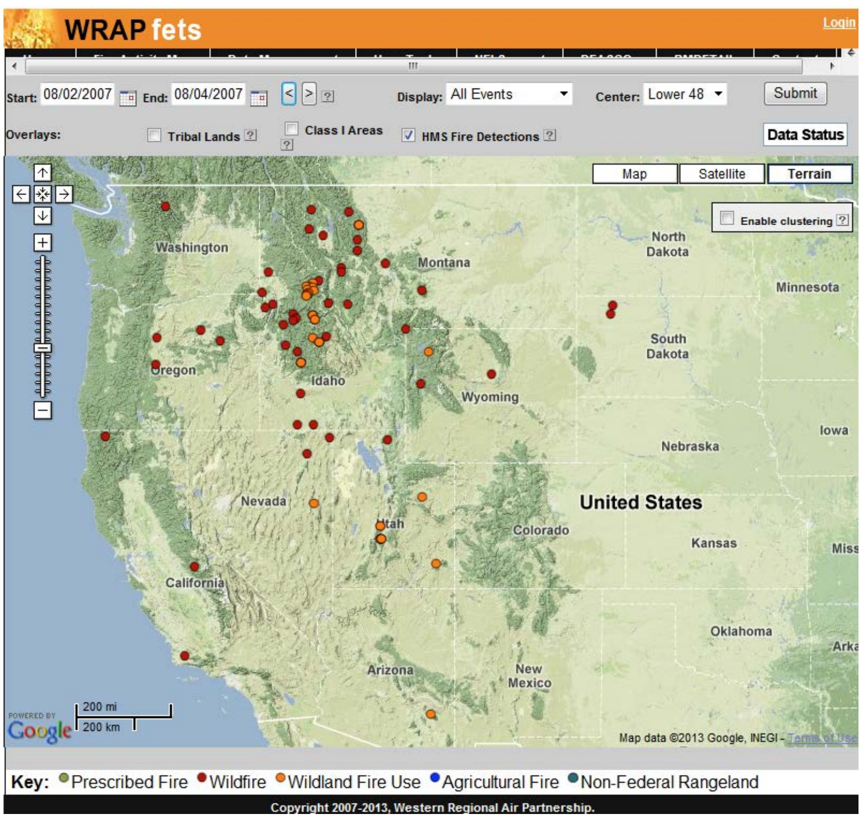

Figure 4.1-22. Map From the WRAP FETS Showing Fire Detections for the Period August 2 through August 4, 2007.

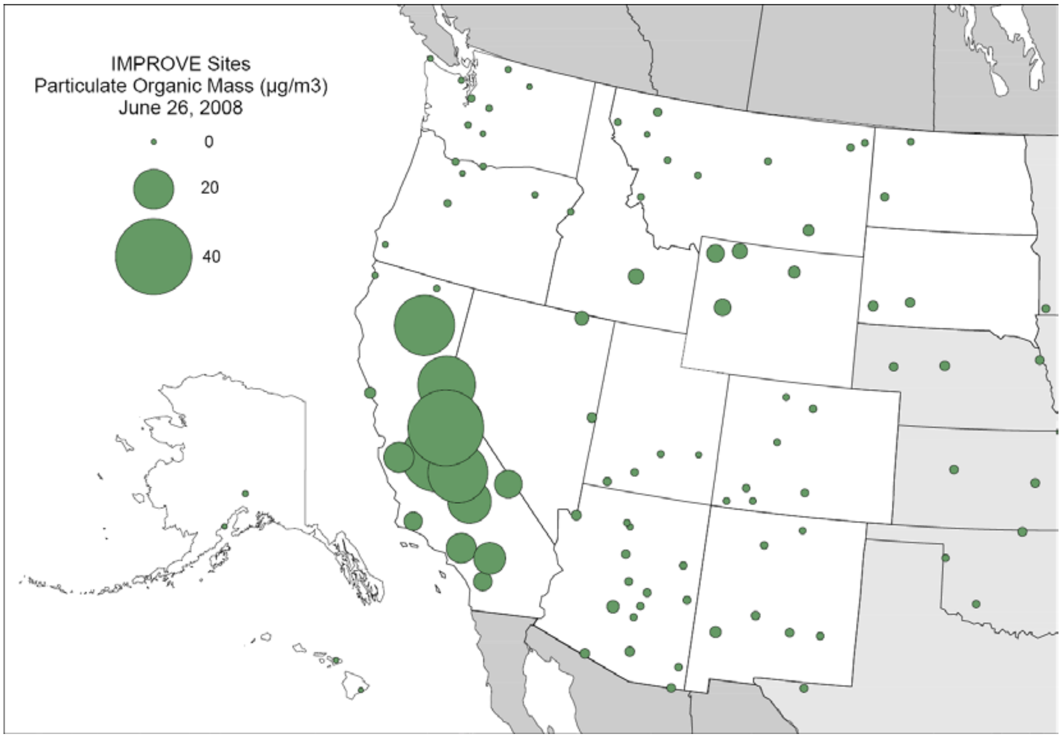

Figure 4.1-23. Particulate Organic Mass Event Measured on June 26, 2008, Affecting Most California IMPROVE Sites.

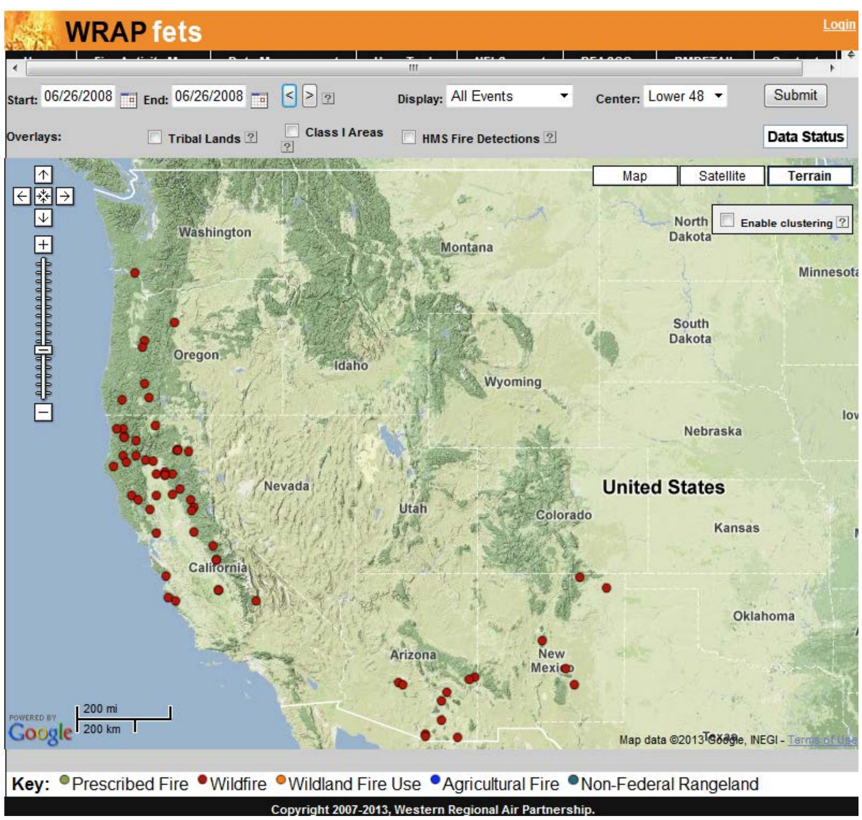

Figure 4.1-24. Map From the WRAP FETS Showing Fire Detections on June 26, 2007.

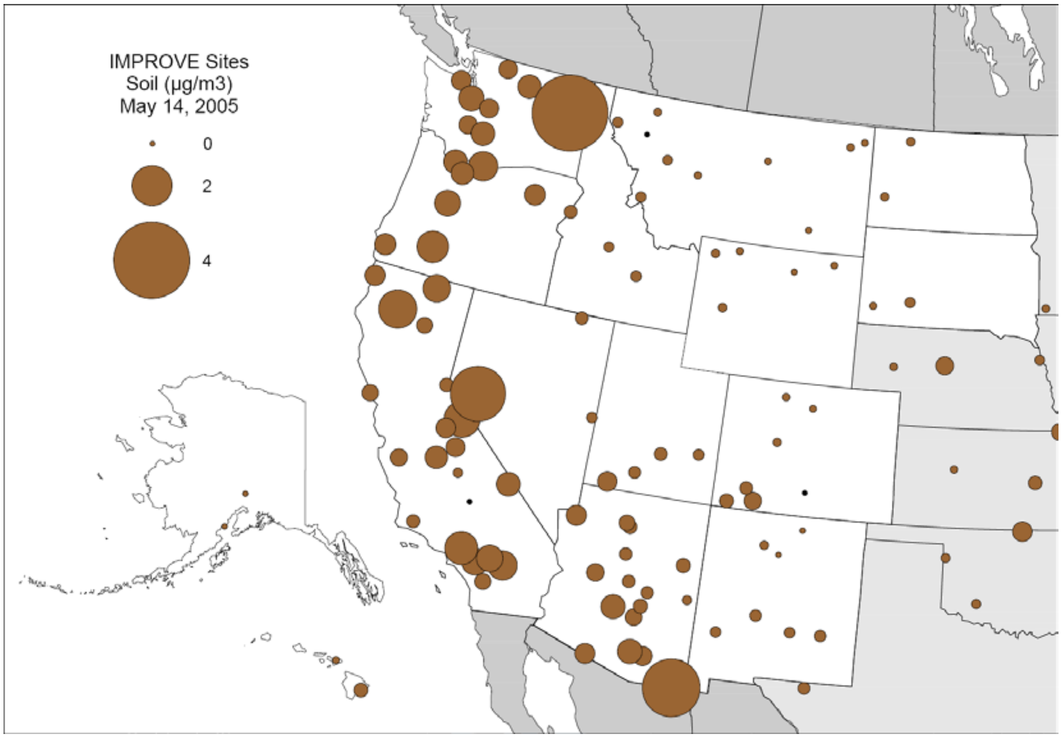

Figure 4.1-25. Soil Event Measured on March 14, 2005, Affecting Coastal IMPROVE Sites.

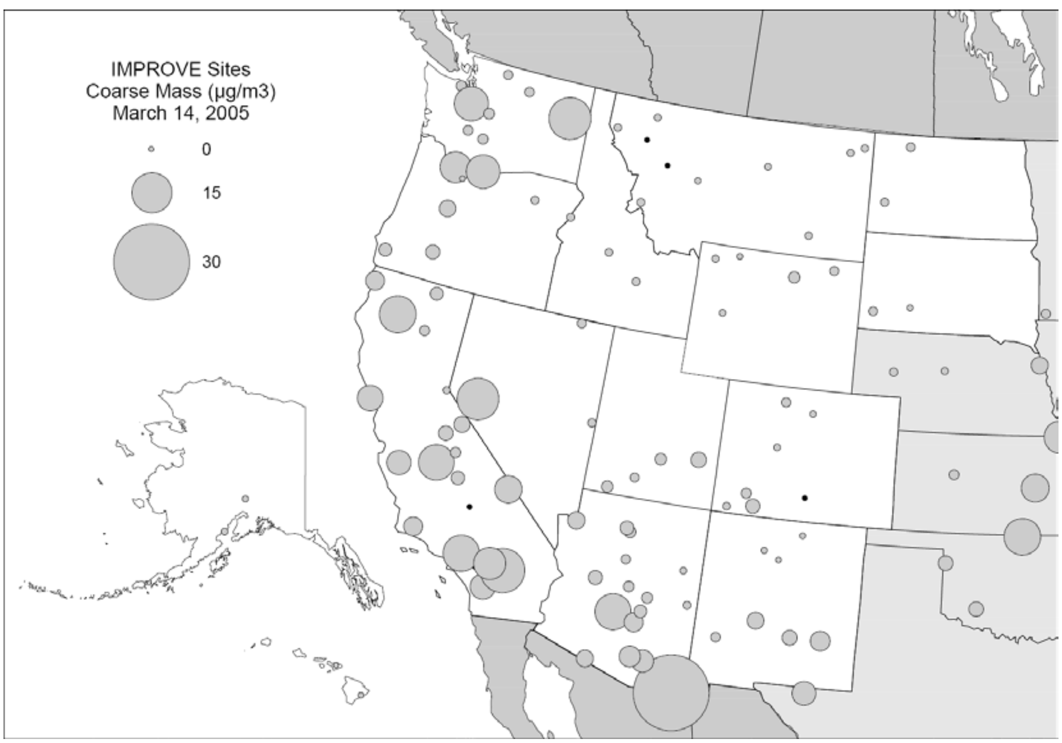

Figure 4.1-26. Coarse Mass Event Measured on March 14, 2005, Affecting Coastal IMPROVE Sites.

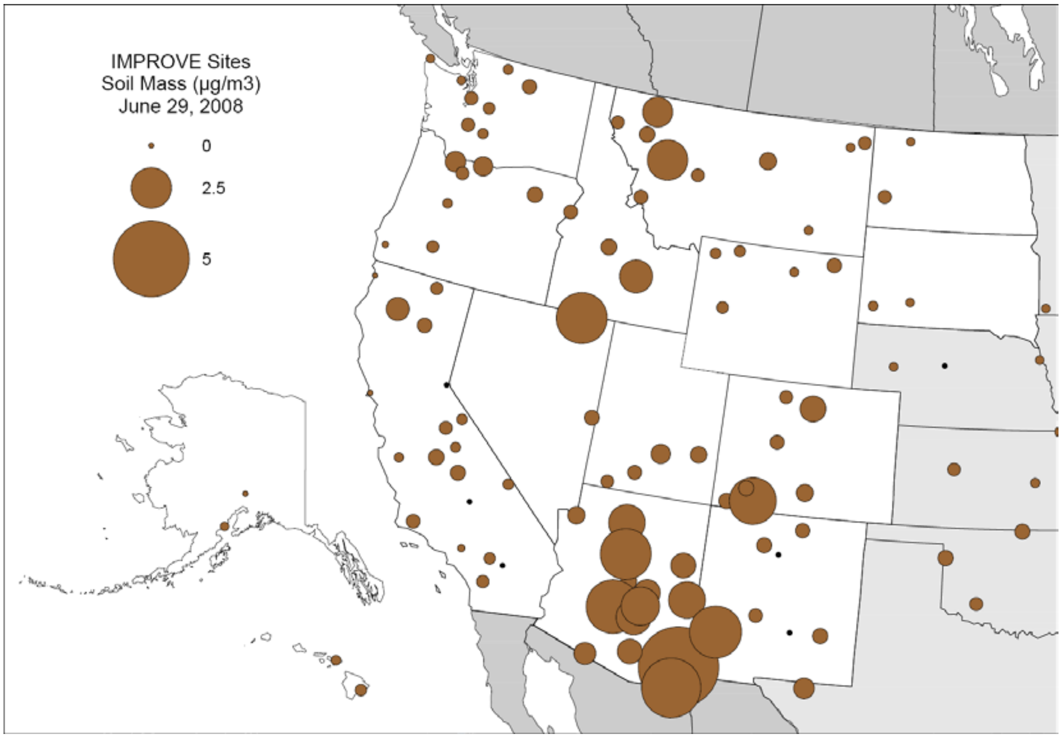

Figure 4.1-27. Soil Event Measured on June 29, 2008, Affecting Most Arizona IMPROVE Sites.

Figure 4.1-28. Coarse Mass Event Measured on June 29, 2008, Affecting Most Arizona IMPROVE Sites.

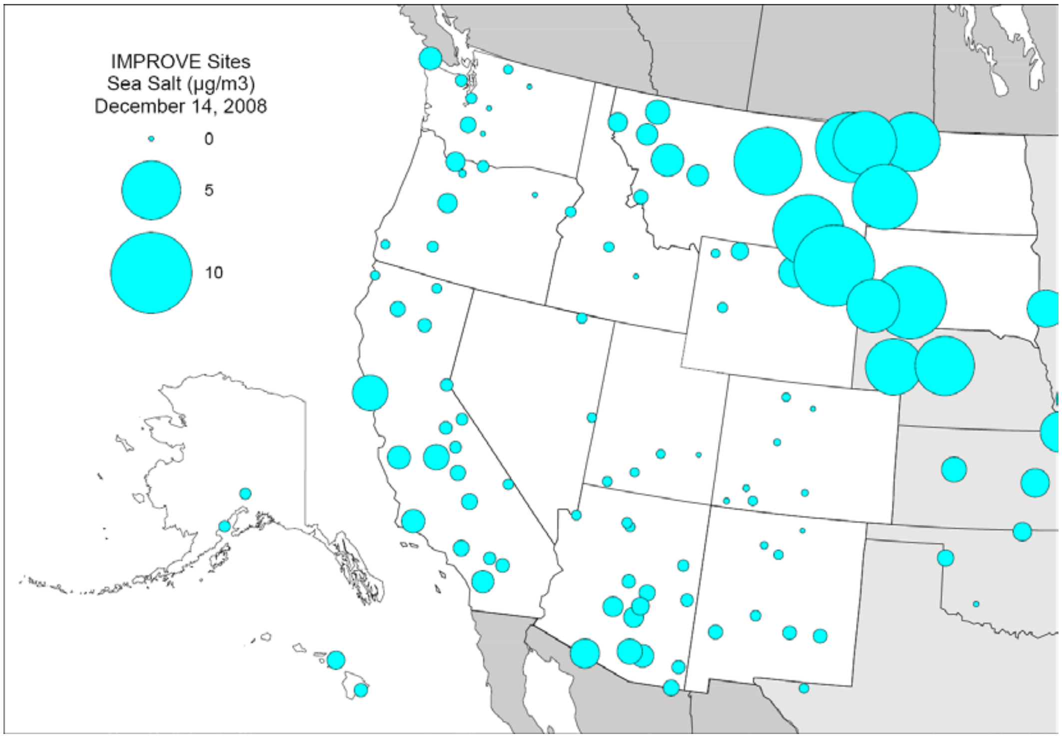

Figure 4.1-29 Sea Salt Event Measured on December 14, 2008, Affecting Inland IMPROVE Sites.

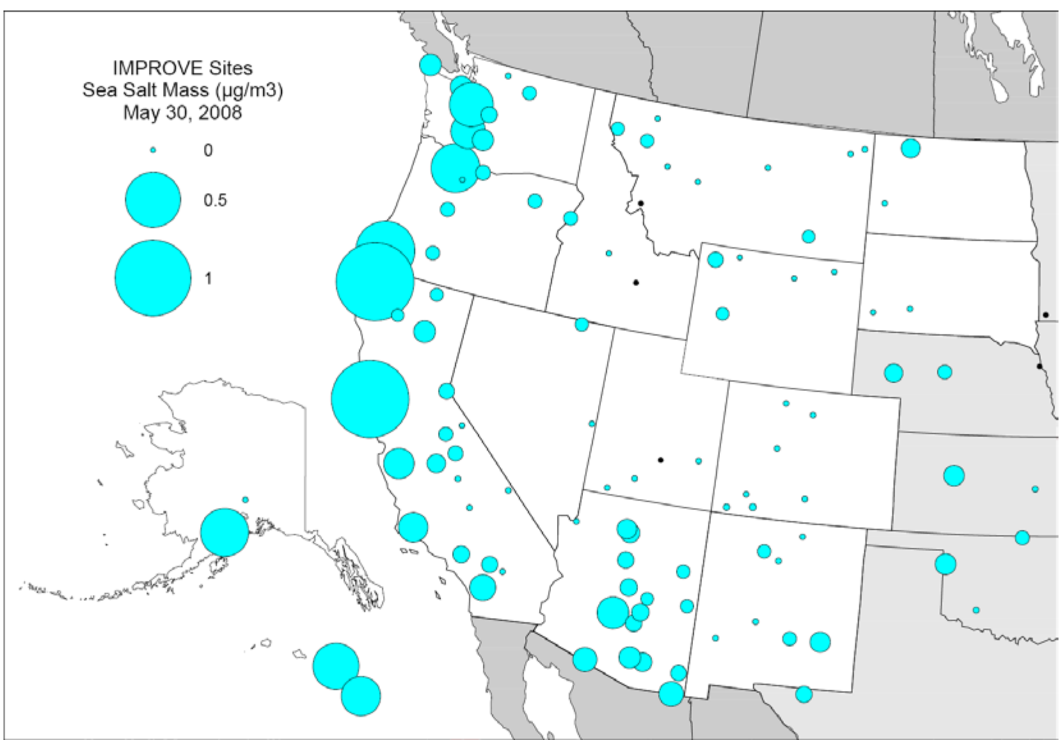

Figure 4.1-30. Sea Salt Event Measured on May 30, 2008, Affecting Coastal IMPROVE Sites.

4.2 EMISSIONS DATA

Included here are summaries depicting differences between an annual emission inventory representing the baseline period and an annual inventory representing the current progress period for the contiguous WRAP states.[56] For these summaries, emissions during the baseline years are represented using a 2002 inventory (termed plan02) which was developed with support from the WRAP for use in the original RHR SIP strategy development. Differences between inventories are represented as the difference between the 2002 inventory, and a 2008 inventory which leverages more recent inventory development work performed by the WRAP for the WestJumpAQMS and Deterministic and Empirical Assessment of Smoke's Contribution to Ozone ($DEASCO_3$) modeling projects (termed WestJump2008). Note that the comparisons of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories, as referenced in Section 3.2.1.

Growth in population has implications for the planning needs of states. Population does not directly translate into increased emissions, but population growth can affect energy use, vehicle miles traveled (VMT), and other factors that affect the emissions of visibility related species. Figure 4.2-1 presents a map comparing 2002 and 2010 census populations by county for the WRAP states.[57] Population differences are not directly related to regulatory requirements, but are provided here as reference for state planning purposes. Note that the largest population increases were observed in southern California and southern Arizona, and the largest decreases were reported for Montana, North Dakota and South Dakota.

[56] Emissions inventories used to represent Alaska and Hawaii were developed differently, so discussions for these states are not included here but are included in state specific summaries in Section 6.0.
[57] The US census is conducted every 10-years. Population data for the years 2000 and 2010 were obtained from http://www.census.gov/main/www/access.html.

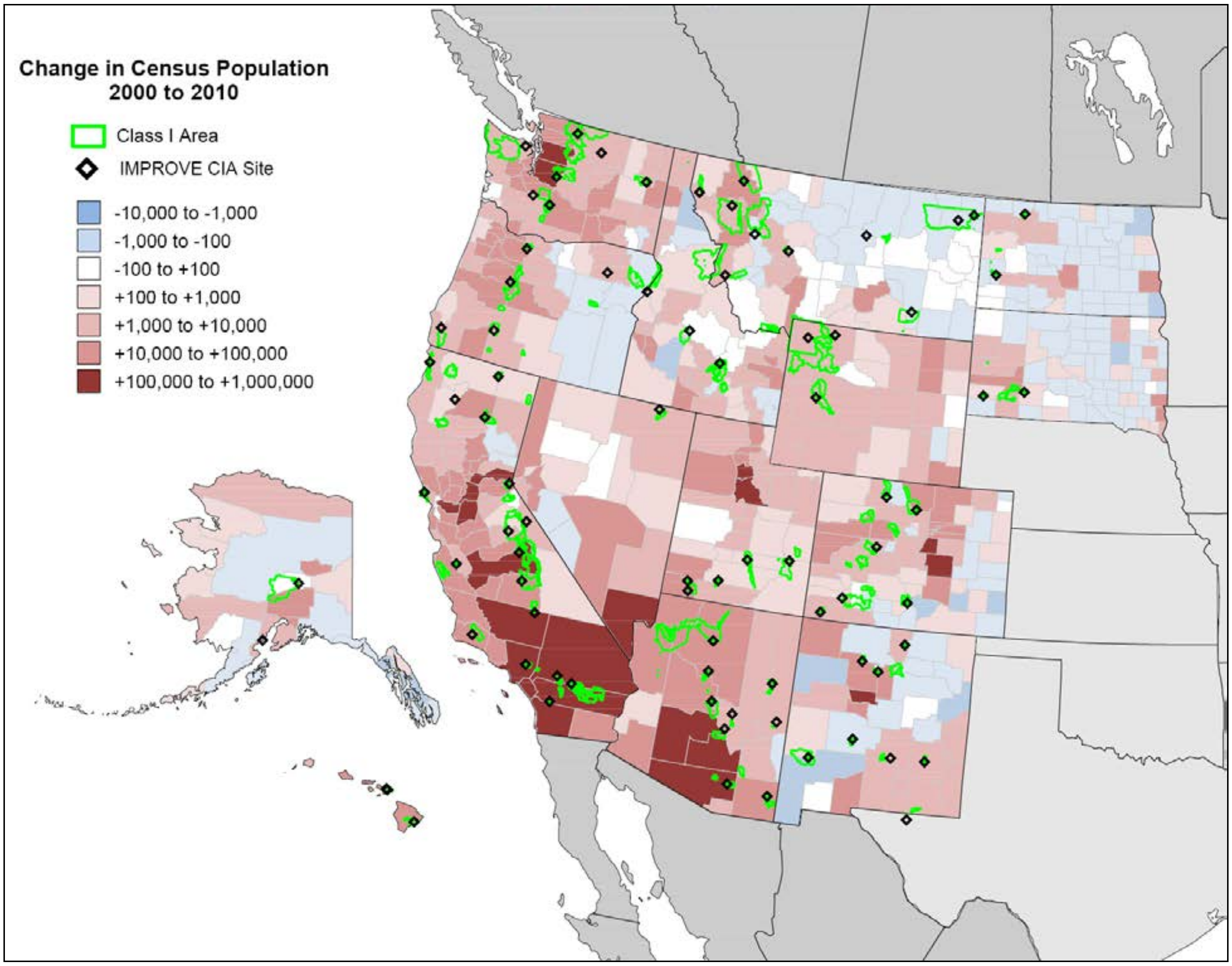

Figure 4.2-1. Difference Between 2000 and 2010 Census Population for the WRAP Region.

For regulatory purposes, State-wide inventories totals and differences for all major visibility impairing pollutants from both natural and anthropogenic source categories are presented here, and inventory totals from a county level basis are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).[58] Figure 4.2-2 presents both the 2002 and 2008 sulfur dioxide (SO_2) emission totals by source category for the contiguous and Figure 4.2-3 presents the differences for SO_2 for each category by state. Figures 4.2-4 and 4.2-5 present similar charts for oxides of nitrogen (NO_X), and subsequent figures (Figures 4.2-6 through 4.2-17) present ammonia, volatile organic compounds (VOCs), primary organic aerosol (POA), elemental carbon (EC), fine soil, and coarse particulate matter. These emissions inventory totals, including differences between inventories, are discussed for each State individually in Section 6.0. Some general regional observations are listed below.

- Inventories show that SO_2 emissions are largely due to point sources. These emissions saw decreases in most source categories for most states, with the largest decreases reported for point sources. Reductions are likely due to the implementation

[58] The WRAP TSS is described in Section 3.3.

of control strategies such as SO_2 scrubbers installed at point sources and required use of low sulfur diesel fuel.

- Inventories show that NO_X emissions are mainly due to on-road mobile, off-road mobile, and point sources. Inventories showed decreases in these categories for most states. Reductions may be to implementation of stricter emissions limits for NO_X related to combustion sources such as utility boilers and automobile engines.
- Inventories show that concentrations of VOCs are mainly due to biogenic emissions. Inventory totals comparing 2002 and 2008 emissions show large decreases in 2008, but this is likely due to enhancements in biogenic inventory methodology, as referenced in Section 3.2.1, rather than decreases of this magnitude in actual emissions.
- Inventories show that VOC, POA and EC emissions include large contributions from fire sources. Comparisons between fire inventories is not definitive as the current year inventory represent only the year 2008, as opposed to the entire 2005-2009 progress period represented in monitored data. In 2008, large fire events occurred in California, so fire emissions inventory totals increased in California, but decreased for other WRAP states.
- For fine soil and coarse mass, emissions inventories indicate that windblown and fugitive dust are the largest contributors to these haze species, with some contribution to fine soil from area and fire sources. Changes in fugitive dust and area source inventories were variable between states, and may be related to changes in population. Estimates for windblown dust inventory totals for most states in 2008 were lower than the baseline inventories, but significant methodology changes occurred with the development of the new WRAP windblown dust model, as referenced in Section 3.2.1, so differences reported here are not necessarily indicative of changes in actual source emissions between 2002 and 2008.

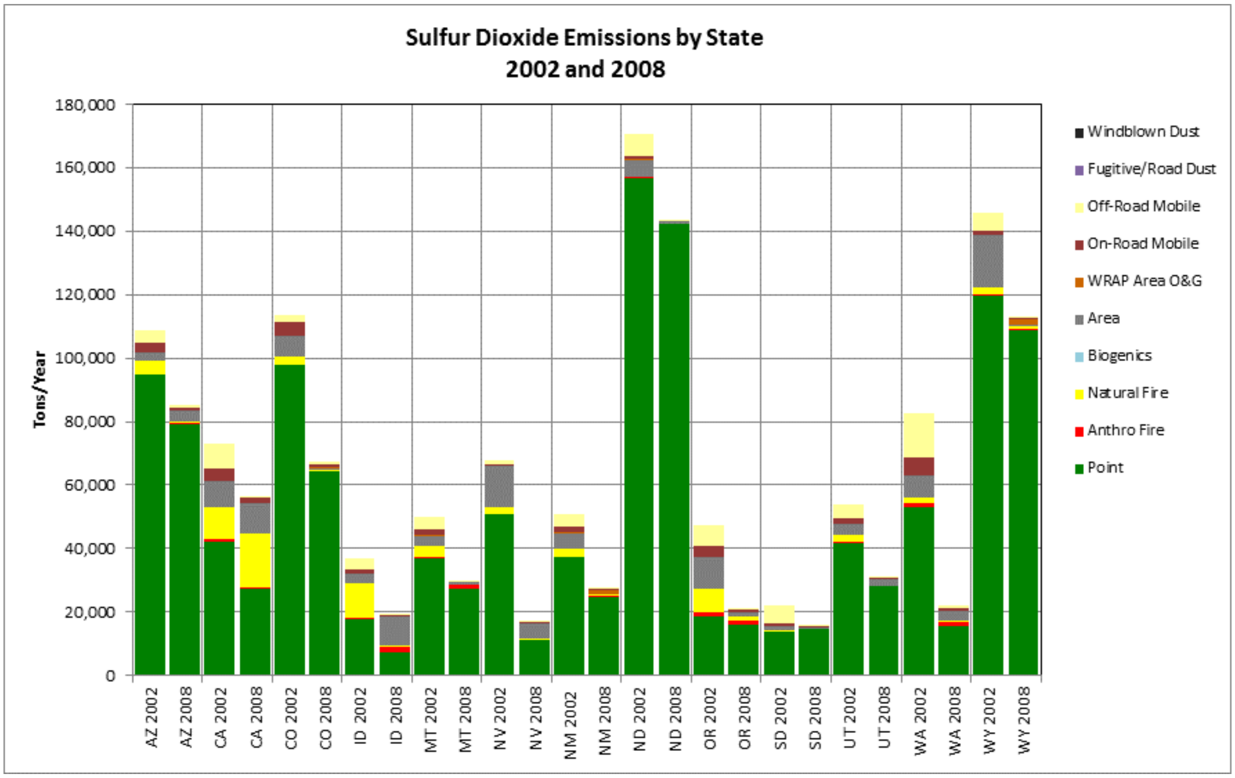

Figure 4.2-2. Comparison for 2002 and 2008 Sulfur Dioxide Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

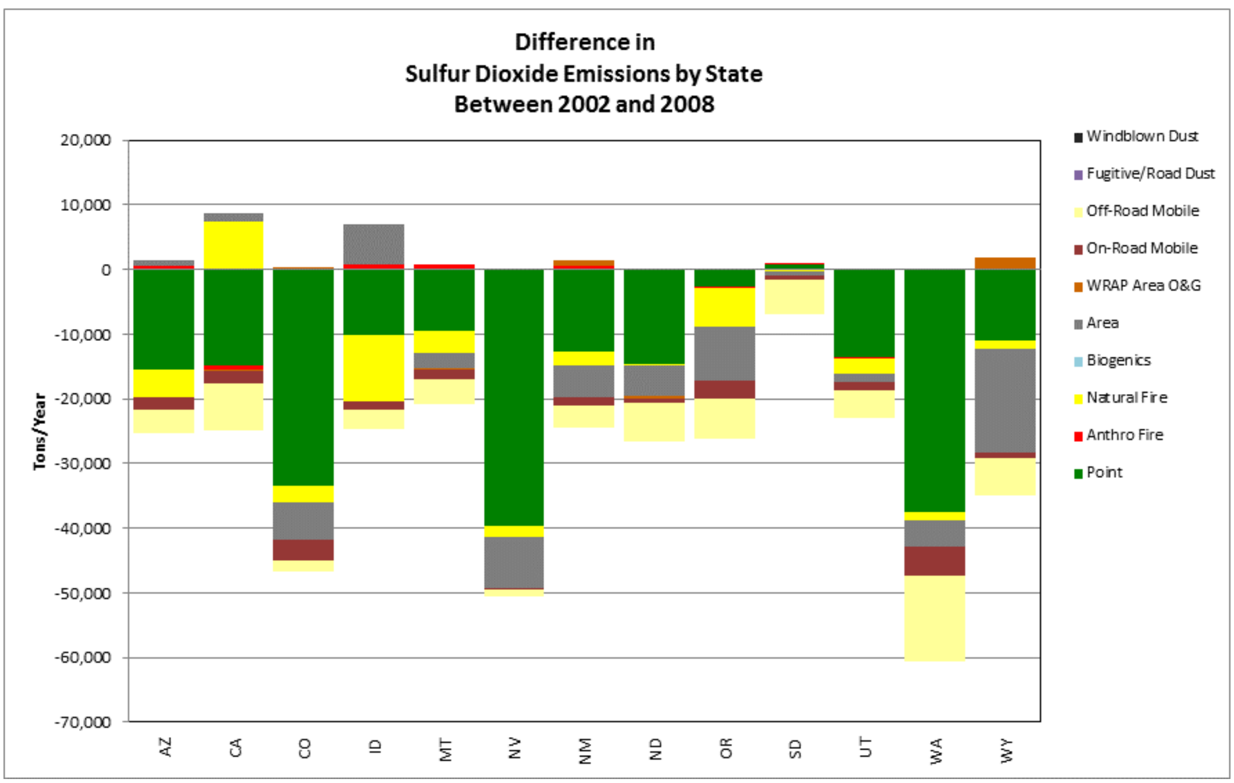

Figure 4.2-3. Differences between 2008 and 2002 Sulfur Dioxide Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

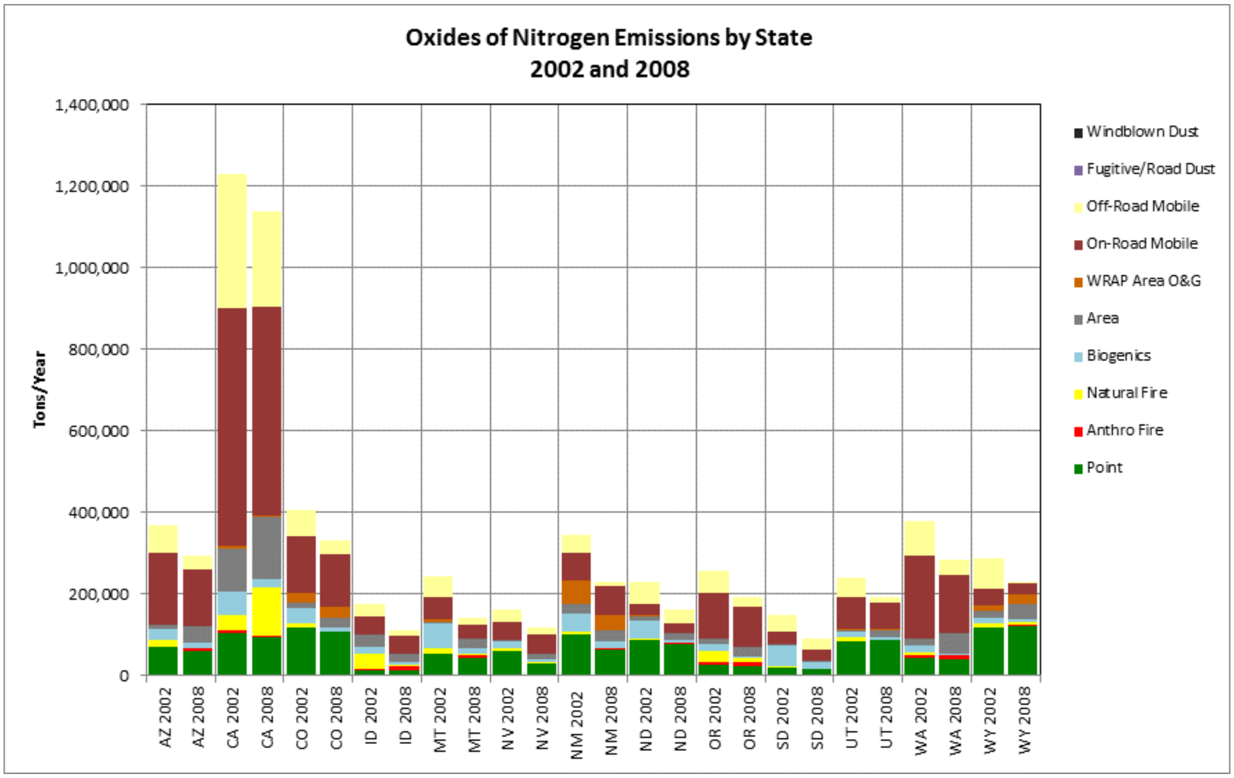

Figure 4.2-4. Comparison for 2002 and 2008 Oxides of Nitrogen Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

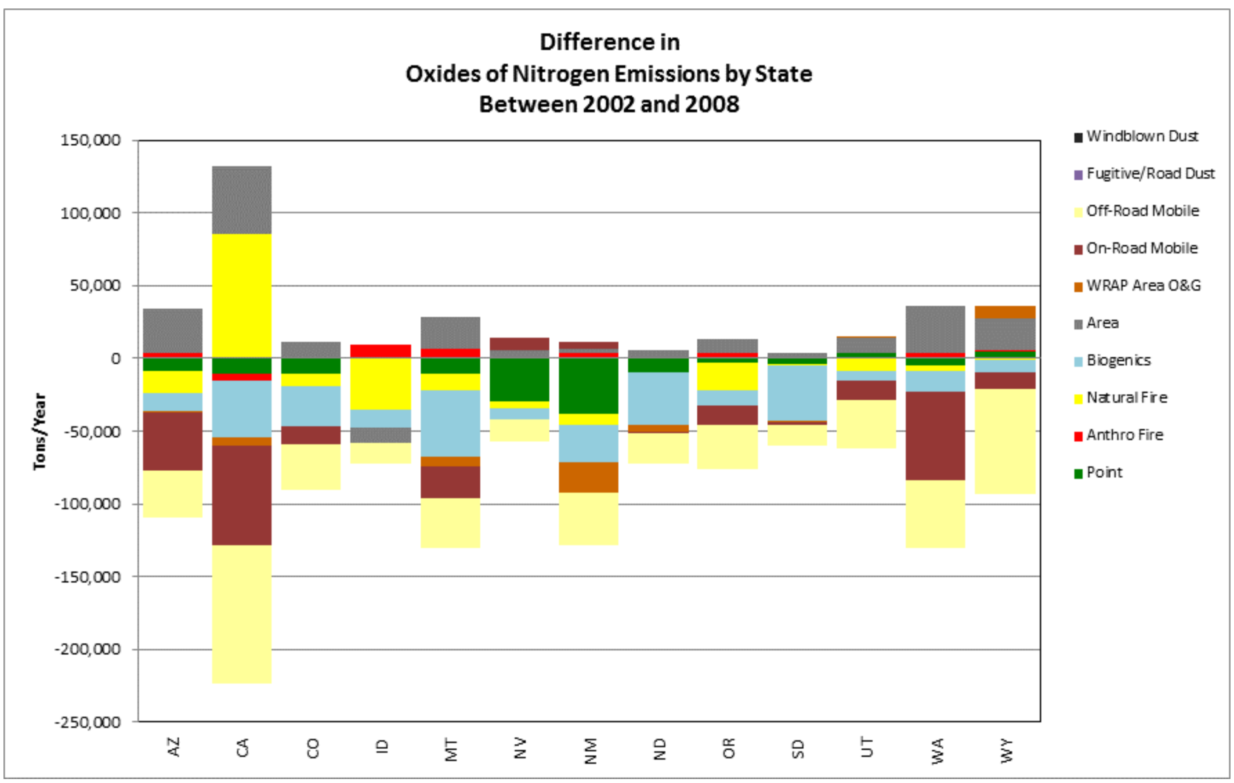

Figure 4.2-5. Differences between 2008 and 2002 Oxides of Nitrogen Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

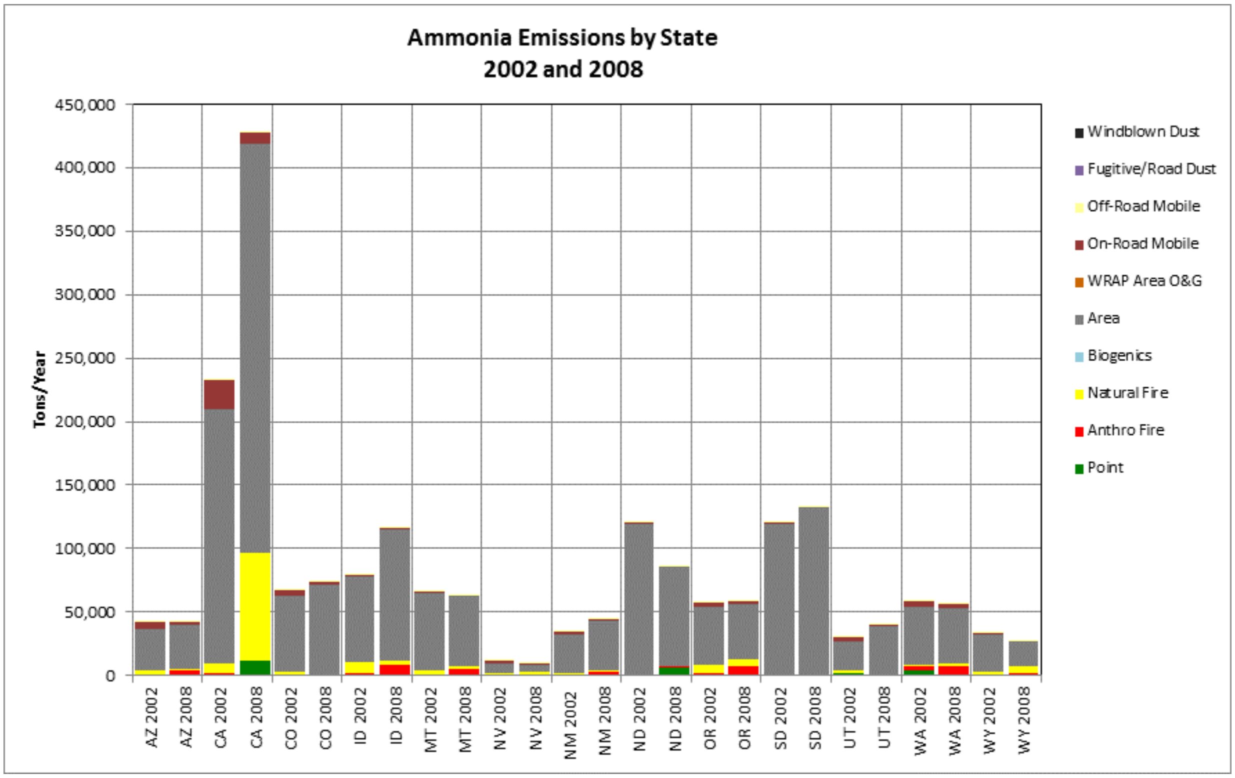

Figure 4.2-6. Comparison for 2002 and 2008 Ammonia Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

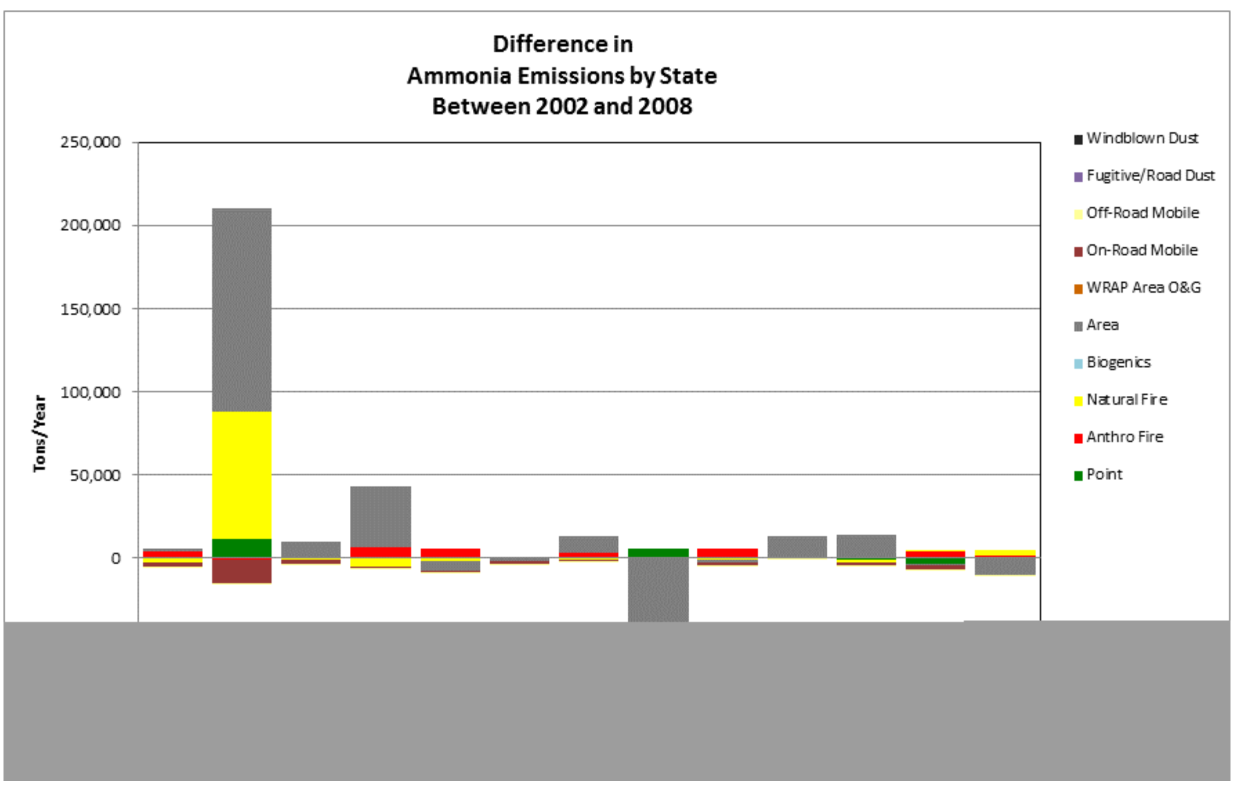

Figure 4.2-7. Differences between 2008 and 2002 Ammonia Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

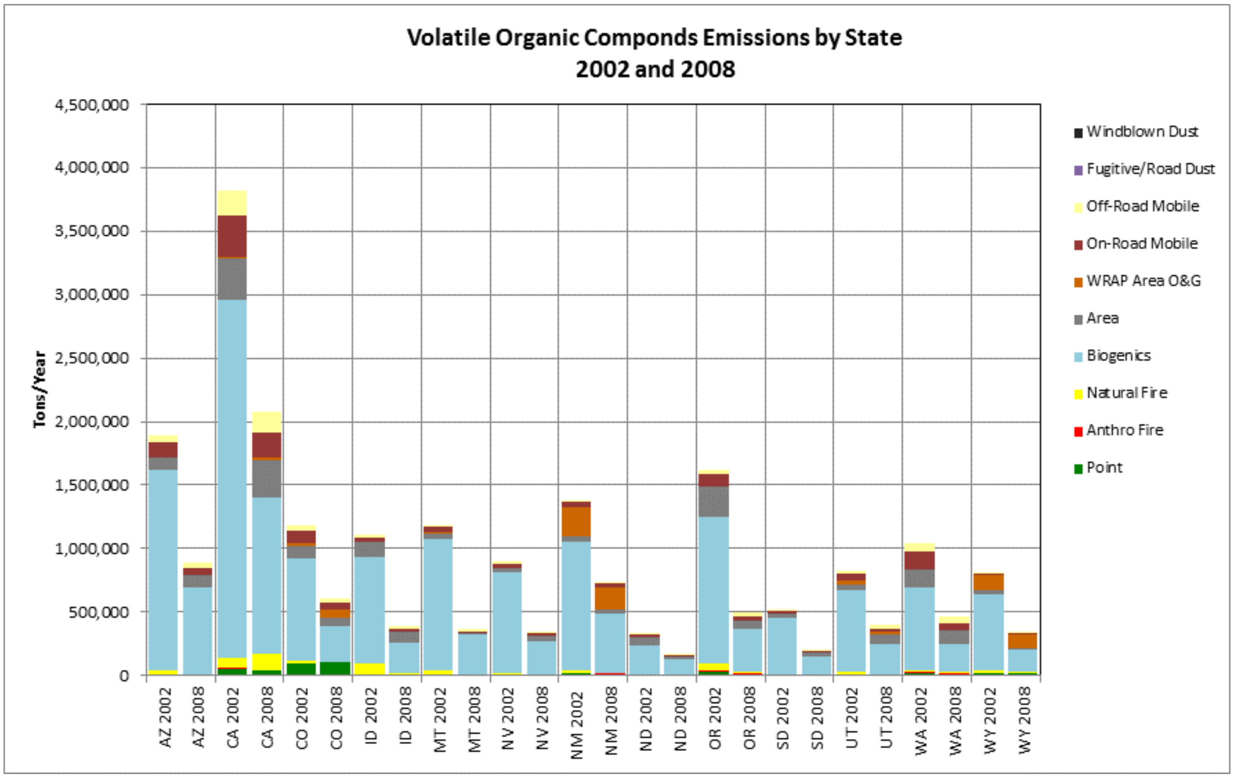

Figure 4.2-8. Comparison for 2002 and 2008 Volatile Organic Compound Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

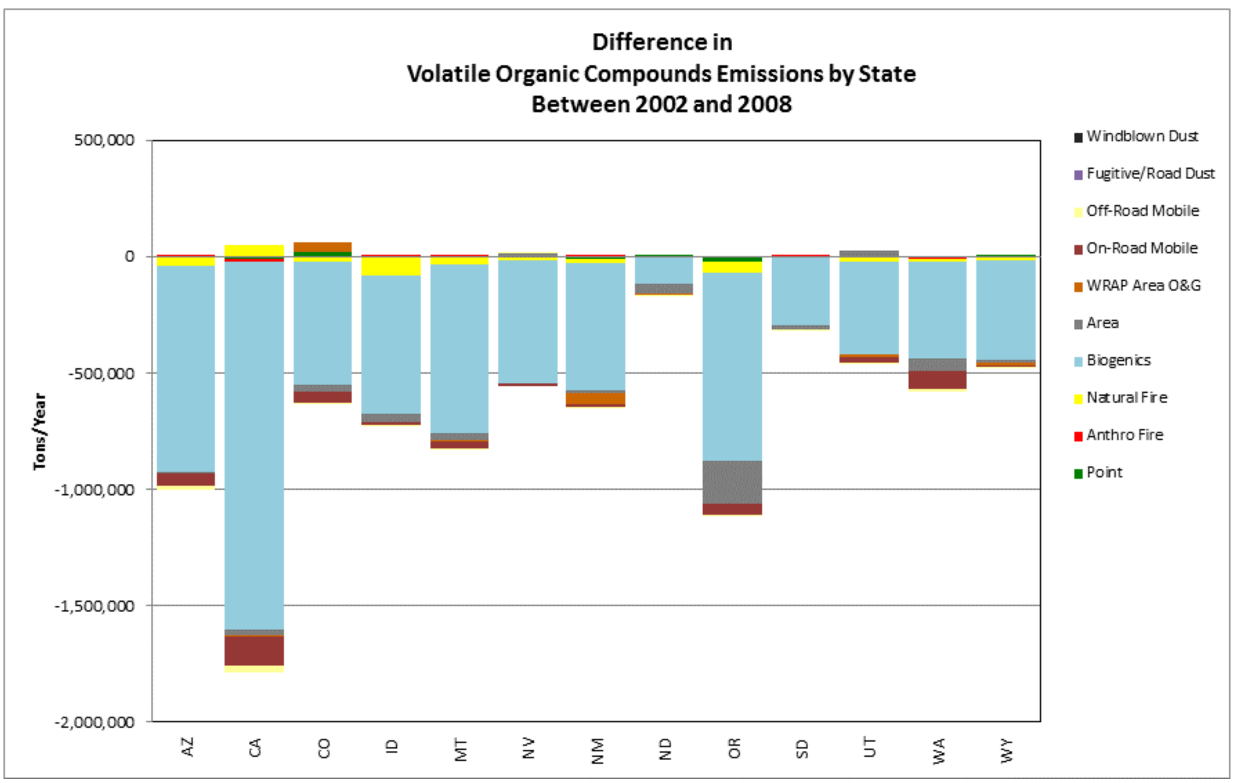

Figure 4.2-9. Differences between 2008 and 2002 Volatile Organic Compound Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

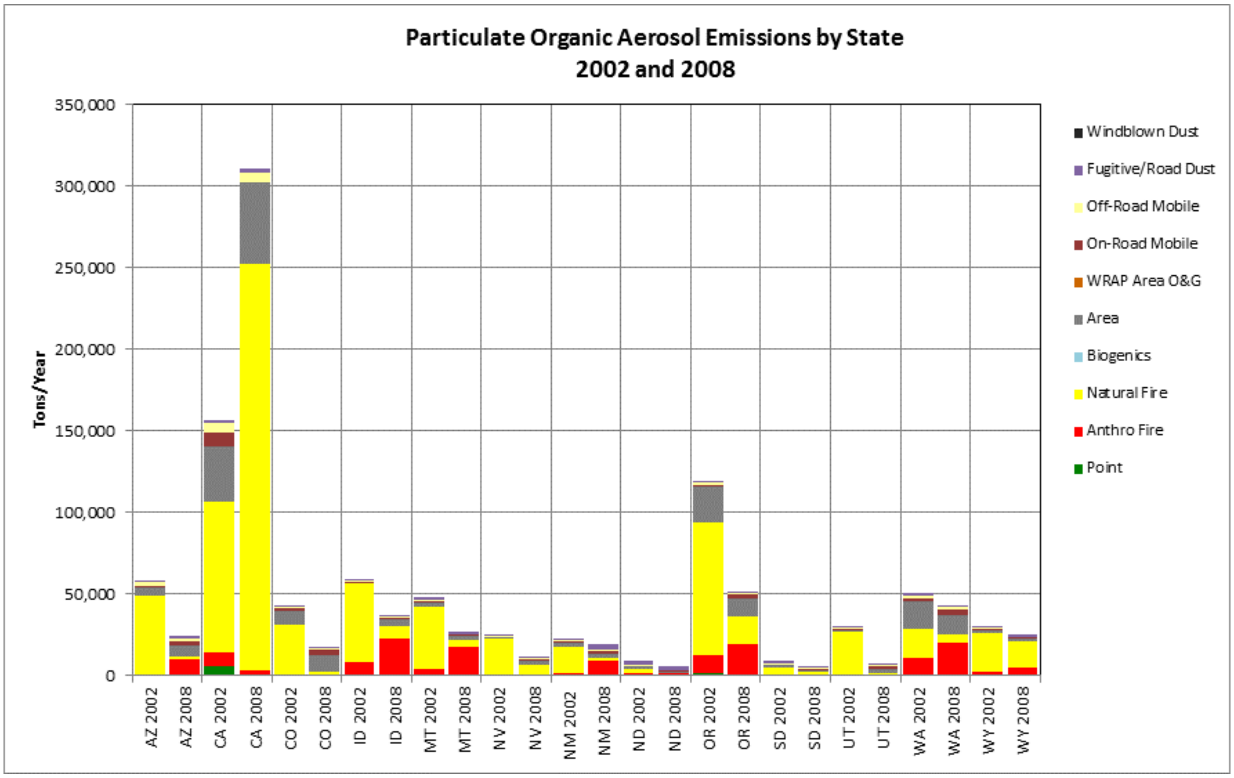

Figure 4.2-10. Comparison for 2002 and 2008 Particulate Organic Aerosol Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

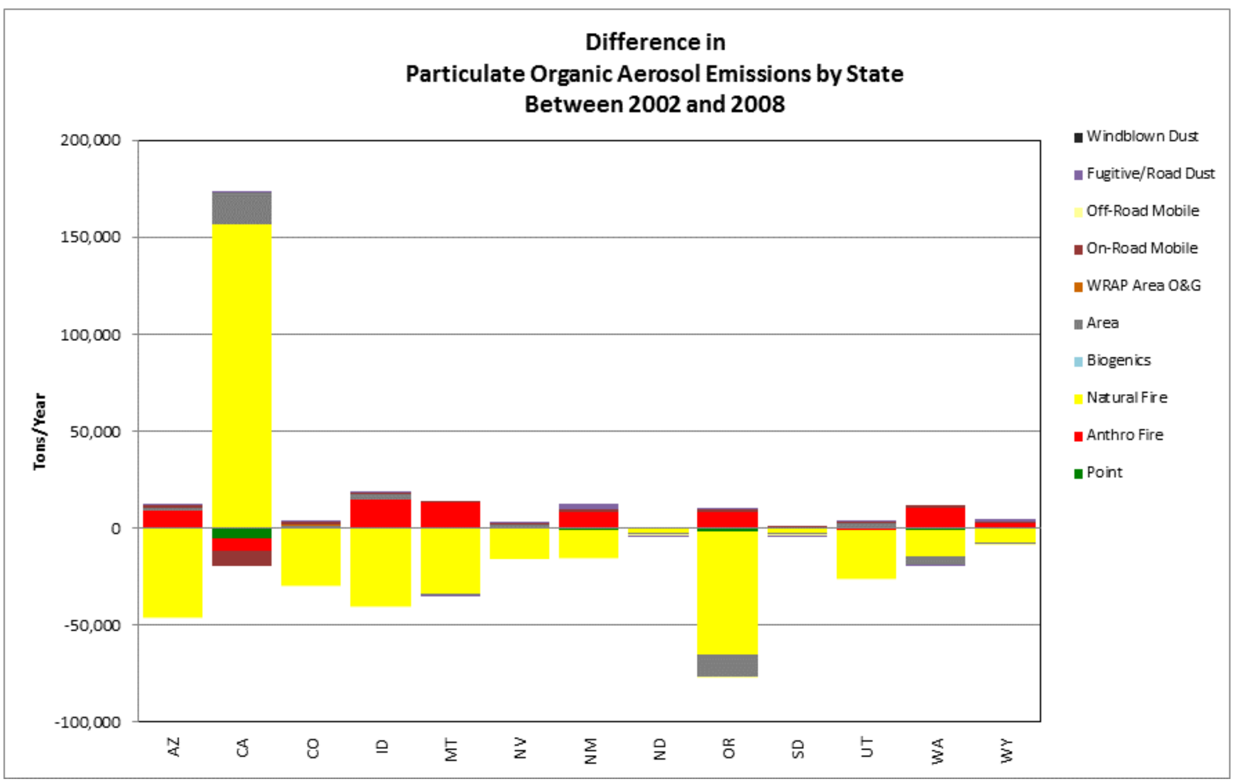

Figure 4.2-11. Differences between 2008 and 2002 Particulate Organic Aerosol Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

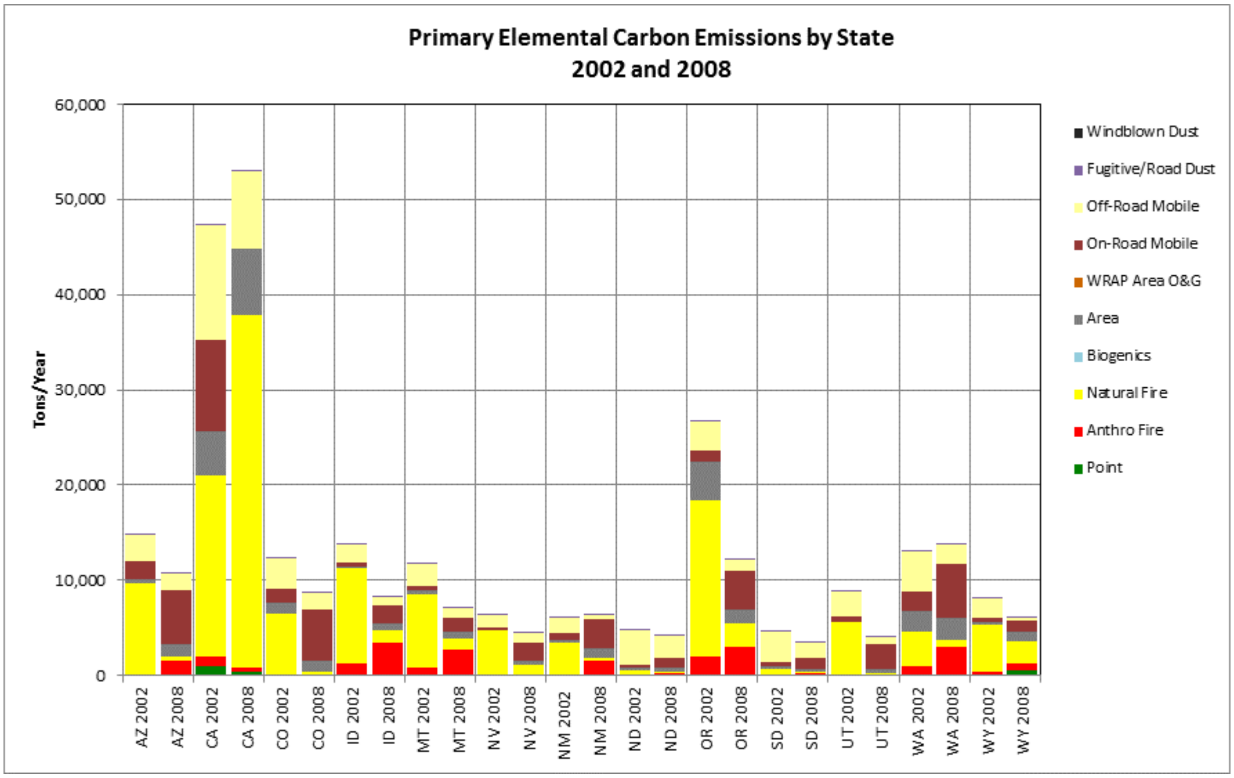

Figure 4.2-12. Comparison for 2002 and 2008 Elemental Carbon Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

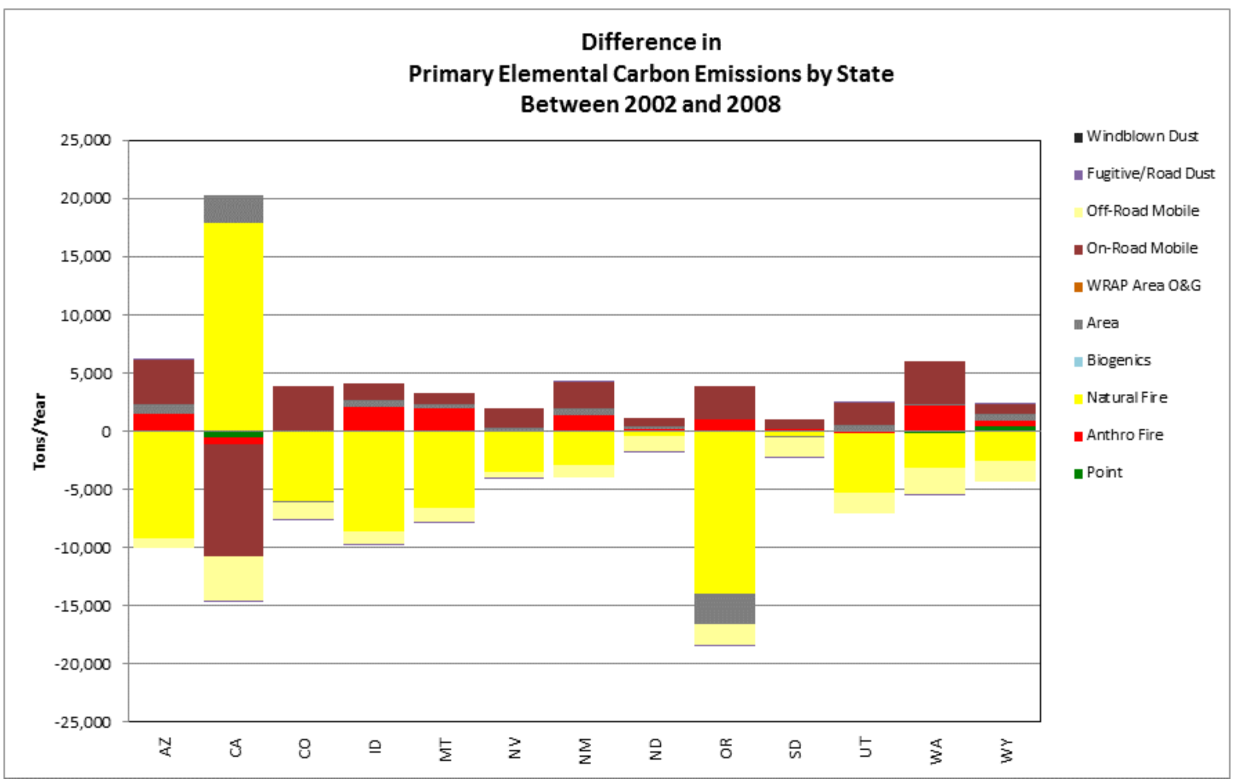

Figure 4.2-13. Differences between 2008 and 2002 Elemental Carbon Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

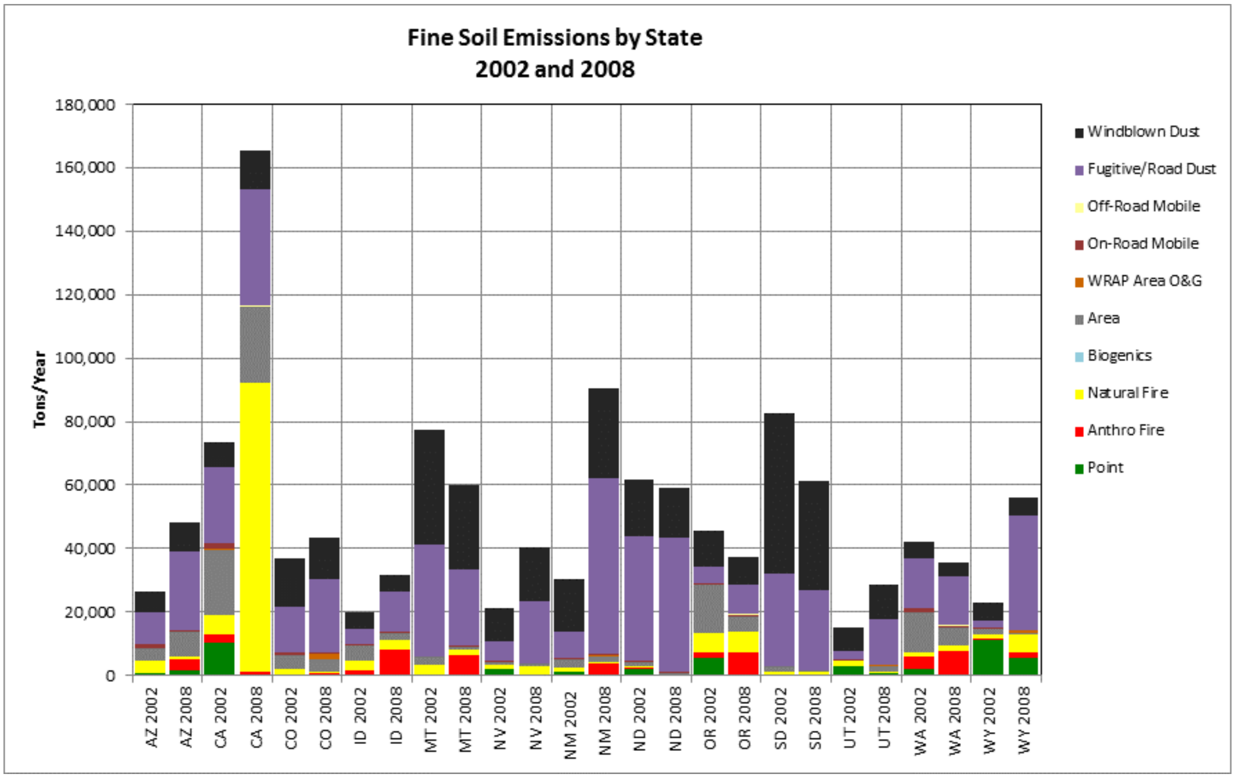

Figure 4.2-14. Comparison for 2002 and 2008 Fine Soil Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

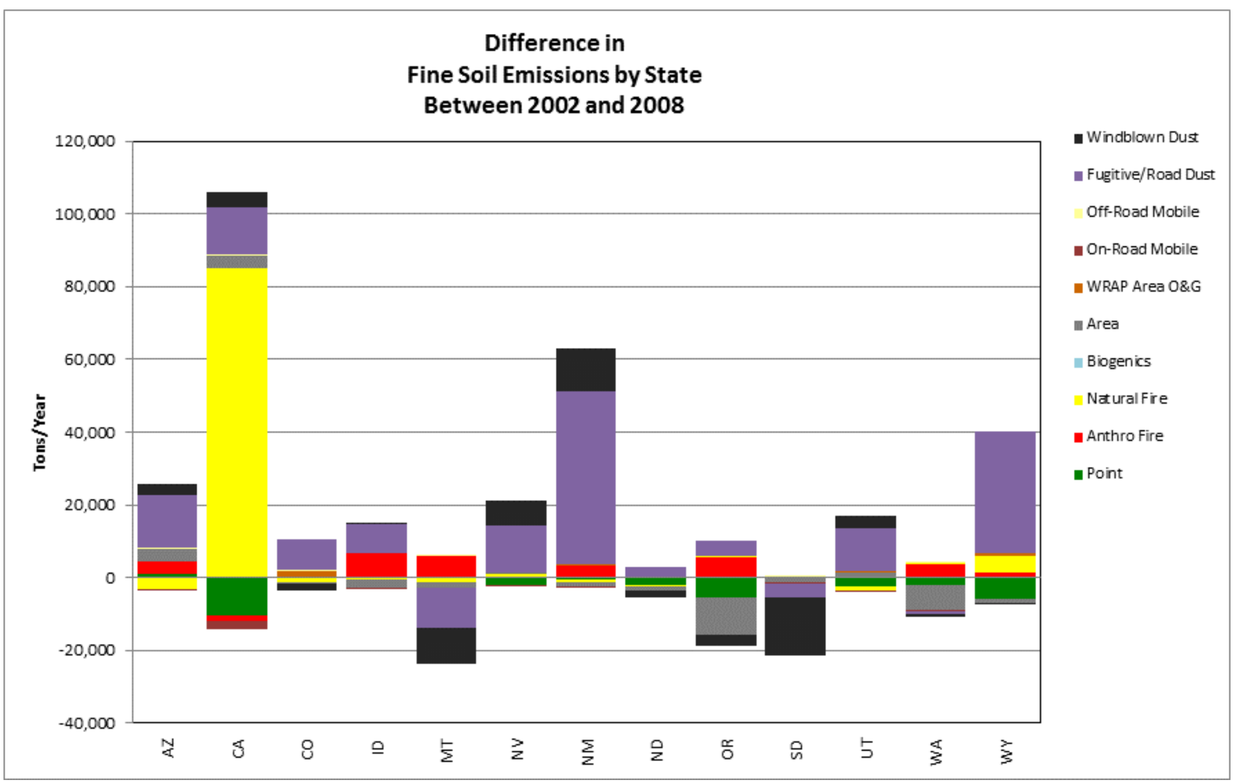

Figure 4.2-15. Differences between 2008 and 2002 Fine Soil Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

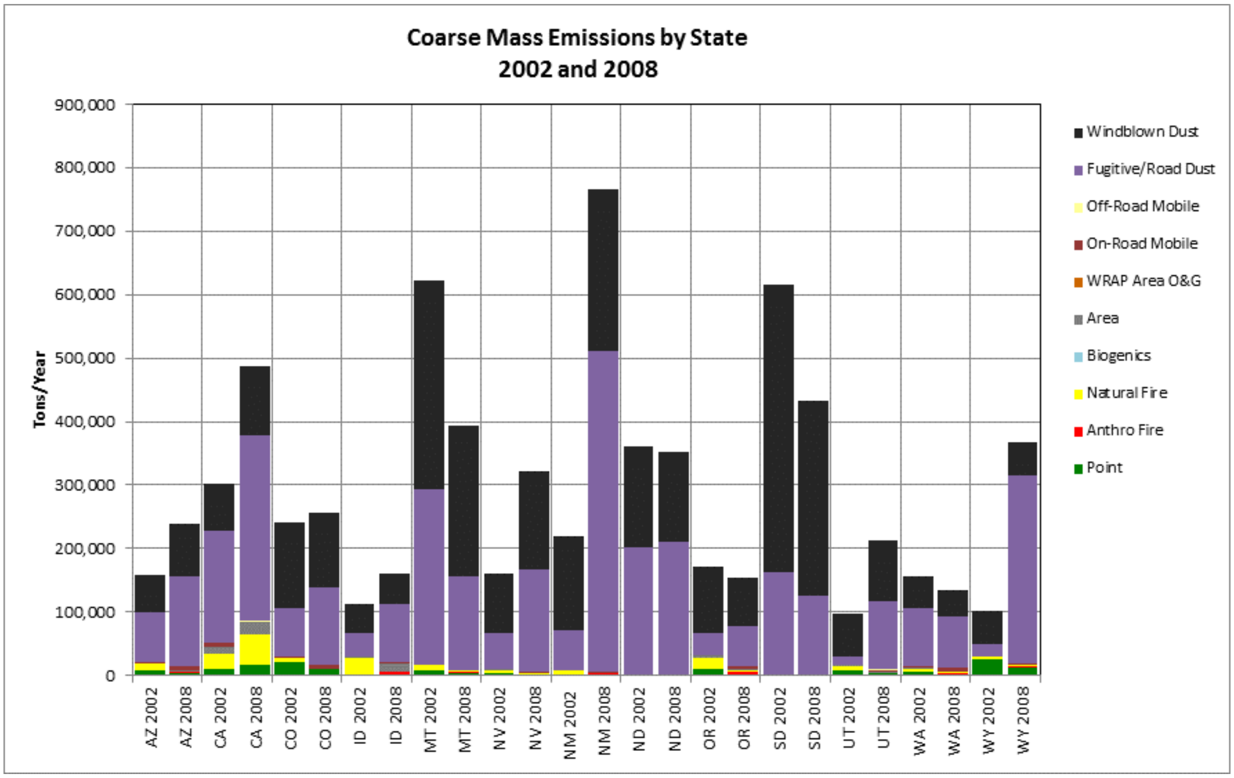

Figure 4.2-16. Comparison for 2002 and 2008 Coarse Mass Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

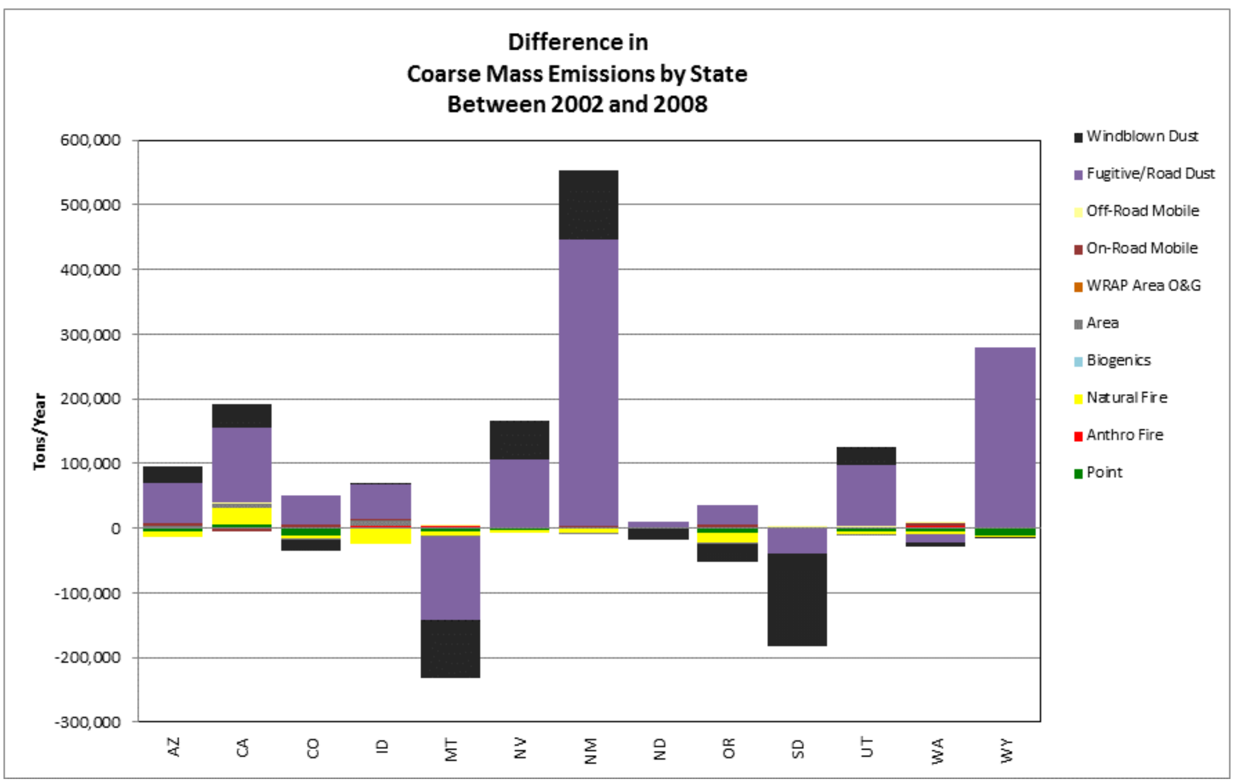

Figure 4.2-17. Differences between 2008 and 2002 Coarse Mass Emission Inventory Totals for the Contiguous WRAP States (2008 minus 2002).

4.2.1 EGU Summary

As described in previous sections, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions as numerous updates in inventory methodologies have occurred between the development of the separate inventories. Also, the 2002 baseline and 2008 progress period inventories represent only annual snapshots of emissions estimates, which may not be representative of entire 5-year monitoring periods compared. To better account for year-to-year changes in emissions, annual emission totals for electrical generating units (EGU) are presented here for the contiguous states, and for each state individually in Section 6.0. EGU emissions are some of the more consistently reported emissions, as tracked in EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/). RHR implementation plans are required to pay specific attention to certain major stationary sources, including EGUs, built between 1962 and 1977.

Figure 4.2-18 presents a sum of annual NO_X and SO_2 emissions as reported for all EGU sources in the contiguous WRAP states between 1996 and 2010. While these types of facilities are targeted for controls in state regional haze SIPs, it should be noted that many of the controls planned for EGUs in the WRAP states had not taken place yet in 2010, while other controls separate from the RHR may have been implemented. The chart shows steady declines for both SO_2 and NO_X.

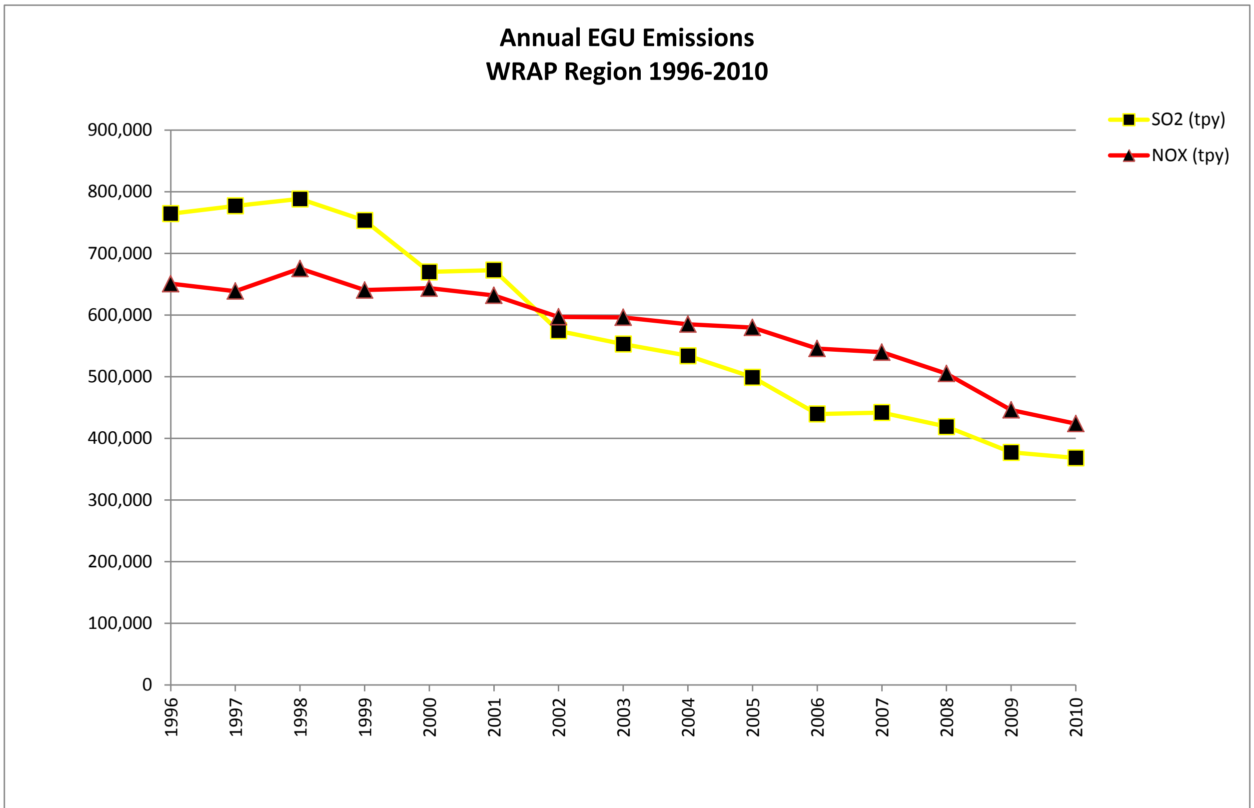

Figure 6.2-18. Sum of EGU Emissions of SO_2 and NOx Reported between 1996 and 2010 for the WRAP Region.

5.0 SECTION 309 REGIONAL SUMMARIES

As described in Section 2.2, some states in the Western Regional Air Partnership (WRAP) qualify for Section 309 requirements for submittal of Regional Haze Rule (RHR) progress reports, but have the option of compliance with Section 308 regulations. Section 309 rules were based on recommendations from the Grand Canyon Visibility Transport Commission (GCVTC) Recommendations report,[59] specific to visibility impacts at the 16 Class I areas (CIAs) on the Colorado Plateau. Of the nine western states originally eligible for Section 309 RHR implementation, only the states of New Mexico, Utah, and Wyoming and the city of Albuquerque/Bernalillo County currently exercise this option.

The 16 CIAs on the Colorado Plateau are depicted in Figure 5.0-1 and listed in Table 5.0-1. Note that the ZION1 site, which originally represented Zion Canyon National Park, has since been replaced with the ZICA1 site, as described in Section 6.13.1.1. This section presents regional progress summaries specific to monitoring and emissions data at these Colorado Plateau sites. Additionally, regional summaries for the entire WRAP region are presented in Section 4.0, and state and site specific summaries are presented in Section 6.0.

[59] The Grand Canyon Visibility Transport Commission Recommendations for Improving Western Vistas Report is archived on the WRAP website at www.wrapair.org/WRAP/reports/GCVTCFinal.PDF.

Table 5.0-1
Colorado Plateau CIAs and Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Arizona				
Grand Canyon NP	GRCA2	35.97	-111.98	2267
Mount Baldy WA	BALD1	34.06	-109.44	2508
Petrified Forest NP	PEFO1	35.08	-109.77	1766
Sycamore Canyon WA	SYCA1	35.14	-111.97	2046
Colorado				
Black Canyon of the Gunnison NP Weminuche WA	WEMI1	37.66	-107.80	2750
Flat Tops WA Maroon Bells-Snowmass WA West Elk WA	WHRI1	39.15	-106.82	3413
Mesa Verde NP	MEVE1	37.20	-108.49	2172
New Mexico				
San Pedro Parks WA	SAPE1	36.01	-106.84	2935
Utah				
Bryce Canyon NP	BRCA1	37.62	-112.17	2481
Canyonlands NP Arches NP	CANY1	38.46	-109.82	1798
Capitol Reef NP	CAPI1	38.30	-111.29	1896
Zion NP	ZICA1*	37.20	-113.15	1215

*Replaced the ZION1 monitoring site in 2003.

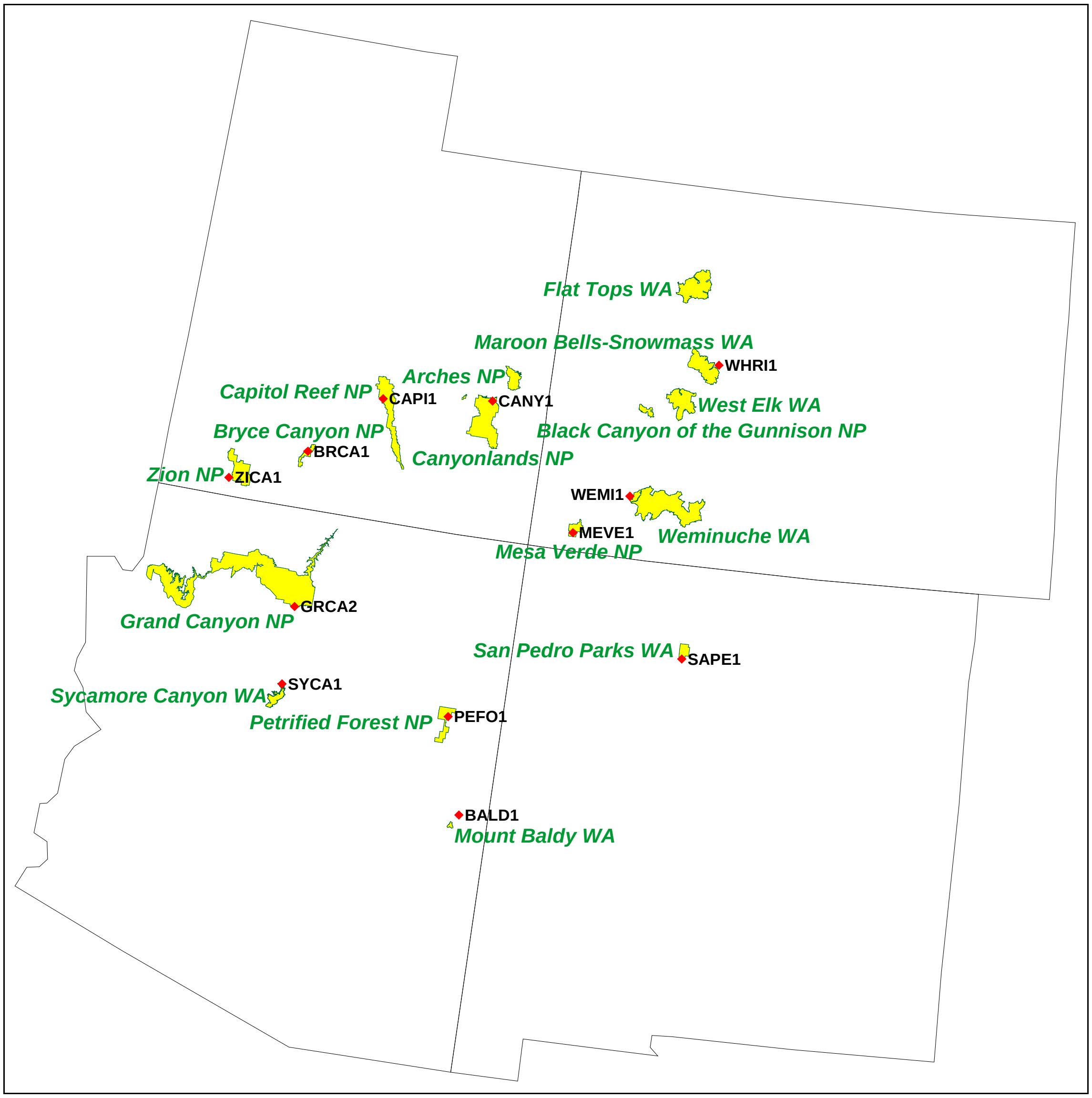

Figure 5.0-1. Map Depicting Colorado Plateau CIAs and Representative IMPROVE Monitors in Arizona, Colorado, New Mexico, and Utah.

5.1 MONITORING DATA

As described previously, the goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal CIA, and that visibility on the 20% least impaired, or best, days does not get worse. Progress is determined by comparing current monitored conditions to the baseline average, beginning with the 2000-2004 baseline, and proceeding with each subsequent 5-year average (e.g. 2005-2009, 2010-2014, etc.) [60], as measured at representative IMPROVE monitoring sites.

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[60] See page 4-2 in EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule.*

Figures 5.1-1 and 5.1-2 present the 2005-2009 visibility averages for the most impaired (20% worst) and least impaired (20% best) days, respectively, for the IMPROVE sites representing CIAs on the Colorado Plateau. The size of the pie chart is related to the magnitude of visibility impairment, and colors represent the relative contribution of the pollutants which are measured by the IMPROVE Network.

Tables 5.1-1 and 5.1-2 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the worst and best days, respectively, for each site. Tables 5.1-3 and 5.1-4 present the difference between the 2000-2004 baseline period average and the 2005-2009 first progress period average for the 20% worst and 20% best days, respectively, for the CIA sites in the Colorado Plateau region. Also, trend statistics for the years 2000-2009 for each species at each site are summarized in Table 5.1-5.[61] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[62] Some general observations for the current visibility conditions, and the difference between current and baseline conditions listed below:

- The largest contributors to aerosol extinction at the Colorado Plateau sites were particulate organic mass, ammonium sulfate, and coarse mass.
- For all sites, the 5-year average as measured in deciview metric decreased for the best days decreased between the baseline and first progress period.
- For most sites, the 5-year average as measured in deciview metric decreased for the worst days between the baseline and first progress period. Exceptions included GRCA2 and BALD1 in Arizona and BRCA1 and CAPI1 in Utah. Some contributing factors for aerosol measurements that affected increased in 5-year average deciviews are listed below.
    - The increase at GRCA2 was due to increases in ammonium sulfate, elemental carbon, particulate organic mass and soil, partially offset by decreases in ammonium nitrate and coarse mass. The particulate organic carbon increase was associated with high measurements due to fire events in June and August of 2009. No statistically significant increasing annual trends were measured for any of the species at the GRCA2 site.
    - Extinction remained relatively unchanged in terms of deciviews for the worst days measured at the BALD1 site. Increases in coarse mass, soil, and ammonium sulfate were offset by decreases in particulate organic mass, elemental carbon,

[61] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)

[62] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

and ammonium nitrate. Trend statistics showed an increasing coarse mass trend at the BALD1 and PEFO1 sites in eastern Arizona.

- At the BRCA1 and CAPI1 sites, the largest contributor to increases was particulate organic mass which, similar to GRCA2, was associated with large fires events in July and August 2009. These increases were offset by decreases in ammonium nitrate and ammonium sulfate. An increasing soil trend was measured for the worst days at the CAPI1 site.

- Increases in 5-year average ammonium sulfate were measured at many regional sites, although most sites showed decreasing annual average ammonium sulfate trends. The 5-year average was influenced by relatively high regional measurements of ammonium sulfate in 2005. Figure 5.1.3 presents a plot of the annual averages for all Colorado Plateau sites, showing the high values measured in 2005, followed by generally decreasing trends.

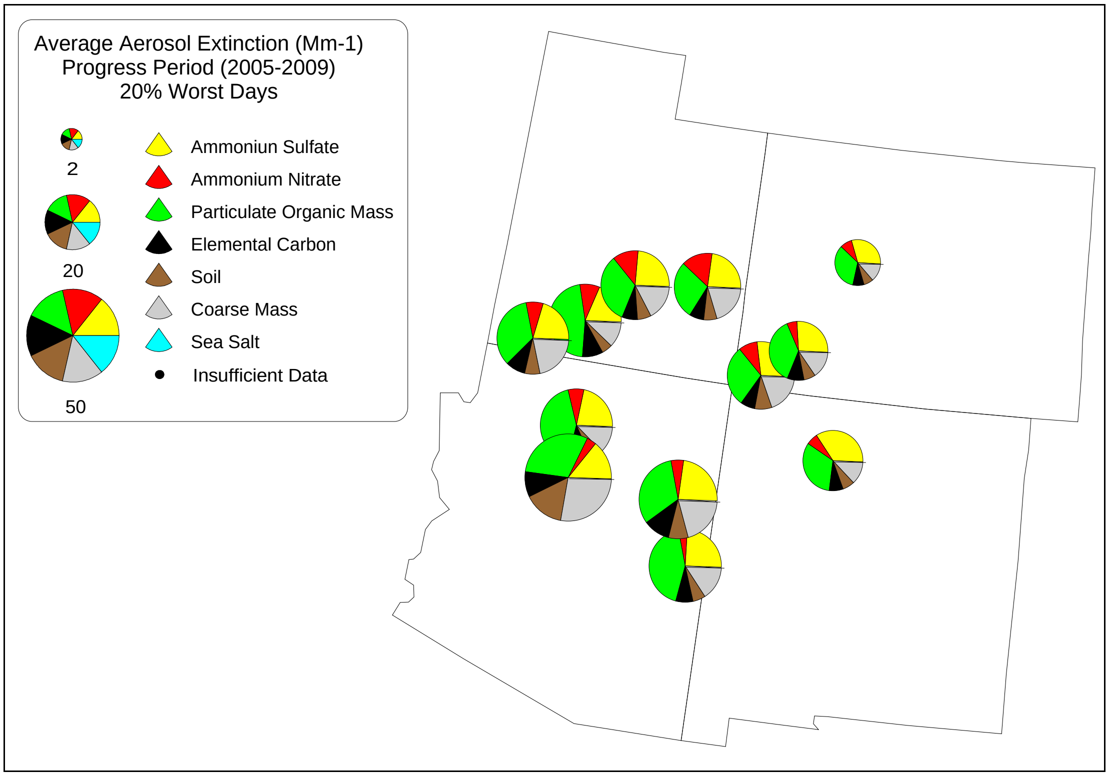

Figure 5.1-1. Regional Average of Aerosol Extinction by Pollutant for the First Progress Period Average (2005-2009) for 20% Worst Days.

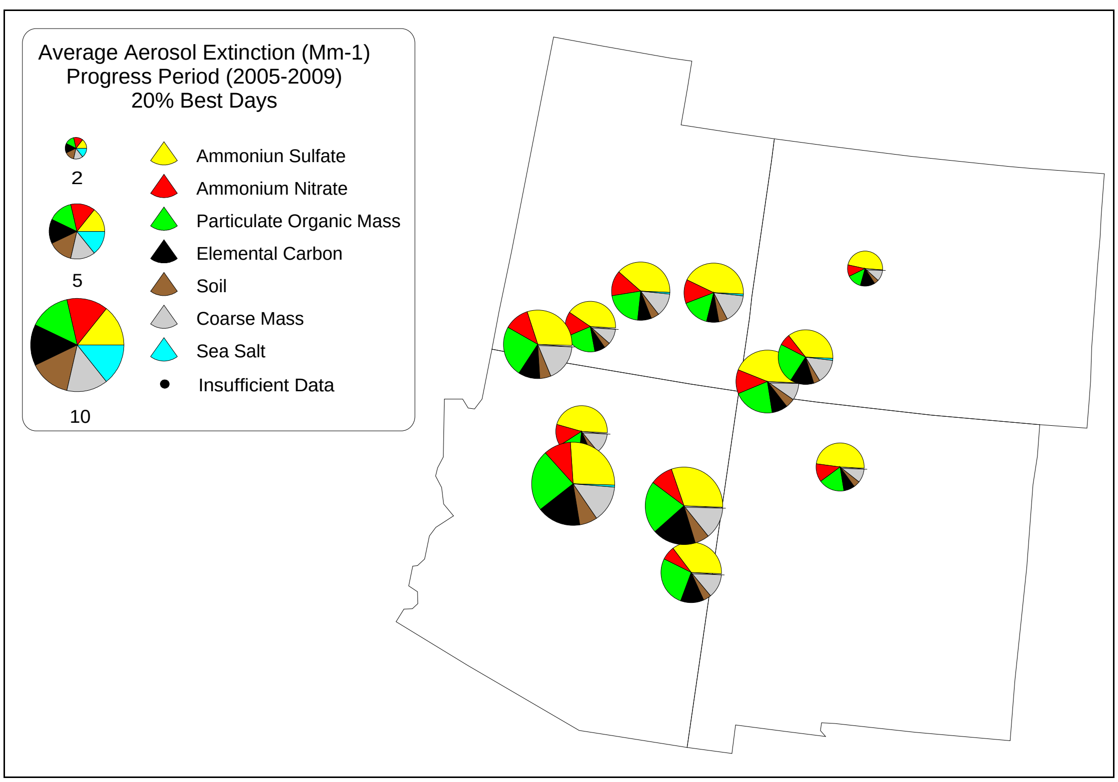

Figure 5.1-2. Regional Average of Aerosol Extinction by Pollutant for First Progress Period Average (2005-2009) for 20% Best Days.

Table 5.1-1
Colorado Plateau Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank*						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
Arizona								
GRCA2	12.0	22% (2)	7% (5)	**41% (1)**	11% (4)	6% (6)	12% (3)	0% (7)
BALD1	11.8	25% (2)	4% (6)	**42% (1)**	8% (4)	6% (5)	16% (3)	0% (7)
PEFO1	13.0	23% (2)	5% (6)	**31% (1)**	11% (4)	8% (5)	21% (3)	1% (7)
SYCA1	15.2	15% (4)	4% (6)	**29% (1)**	9% (5)	15% (3)	28% (2)	0% (7)
Colorado								
WEMI1	10.0	27% (2)	5% (6)	**36% (1)**	10% (4)	7% (5)	15% (3)	0% (7)
WHRI1	8.9	30% (2)	8% (5)	**33% (1)**	8% (4)	7% (6)	13% (3)	0% (7)
MEVE1	11.3	27% (2)	9% (4)	**28% (1)**	7% (6)	9% (5)	20% (3)	0% (7)
New Mexico								
SAPE1	9.9	**34% (1)**	6% (6)	32% (2)	8% (4)	7% (5)	13% (3)	0% (7)
Utah								
BRCA1	11.9	19% (2)	9% (5)	**45% (1)**	10% (4)	5% (6)	12% (3)	0% (7)
CANY1	11.0	23% (2)	14% (4)	**27% (1)**	7% (5)	7% (6)	20% (3)	0% (7)
CAPI1	11.3	24% (2)	12% (4)	**32% (1)**	8% (5)	7% (6)	17% (3)	0% (7)
ZICA1	12.3	21% (3)	7% (5)	**33% (1)**	9% (4)	7% (6)	22% (2)	0% (7)

*Highest aerosol species contribution per site is highlighted in bold.

Table 5.1-2
Colorado Plateau Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank*						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
Arizona								
GRCA2	2.2	**45% (1)**	13% (4)	15% (2)	9% (5)	4% (6)	14% (3)	1% (7)
BALD1	2.9	**35% (1)**	7% (5)	26% (2)	13% (4)	5% (6)	13% (3)	1% (7)
PEFO1	4.6	**31% (1)**	9% (5)	21% (2)	19% (3)	6% (6)	14% (4)	0% (7)
SYCA1	5.1	**27% (1)**	10% (5)	23% (2)	17% (3)	7% (6)	15% (4)	1% (7)
Colorado								
WEMI1	2.4	**36% (1)**	6% (5)	23% (2)	15% (4)	4% (6)	15% (3)	1% (7)
WHRI1	0.2	**46% (1)**	10% (5)	14% (3)	15% (2)	5% (6)	11% (4)	0% (7)
MEVE1	3.1	**44% (1)**	12% (3)	21% (2)	9% (5)	5% (6)	9% (4)	0% (7)
New Mexico								
SAPE1	1.0	**47% (1)**	12% (3)	18% (2)	8% (5)	5% (6)	10% (4)	1% (7)
Utah								
BRCA1	11.9	19% (2)	9% (5)	**45% (1)**	10% (4)	5% (6)	12% (3)	0% (7)
CANY1	11.0	23% (2)	14% (4)	**27% (1)**	7% (5)	7% (6)	20% (3)	0% (7)
CAPI1	11.3	24% (2)	12% (4)	**32% (1)**	8% (5)	7% (6)	17% (3)	0% (7)
ZICA1	12.3	21% (3)	7% (5)	**33% (1)**	9% (4)	7% (6)	22% (2)	0% (7)

*Highest aerosol species contribution per site is highlighted in bold.

Table 5.1-3
Colorado Plateau Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
Arizona										
GRCA2	11.7	12.0	+0.3	+0.5	-0.4	+0.1	+0.5	+0.1	-0.3	0.0
BALD1	11.8	11.8	0.0	+0.3	-0.1	-2.1	-0.7	+0.4	+1.3	+0.1
PEFO1	13.2	13.0	-0.2	+0.5	-0.3	-1.4	+0.5	+0.6	-1.0	+0.1
SYCA1	15.3	15.2	-0.1	+0.7	-0.7	-0.5	+0.4	-1.0	+1.4	0.0
Colorado										
WEMI1	10.3	10.0	-0.3	+0.1	-0.2	-1.4	-0.2	+0.1	0.0	-0.1
WHRI1	9.6	8.9	-0.7	+0.3	0.0	-2.3	-0.3	+0.1	-0.5	0.0
MEVE1	13.0	11.3	-1.7	-0.2	-0.3	-5.8	-0.7	-0.5	-2.0	0.0
New Mexico										
SAPE1	10.2	9.9	-0.3	+1.0	-0.4	-1.4	-0.1	-0.1	-0.2	0.0
Utah										
BRCA1	11.6	11.9	+0.3	-0.2	-0.3	+2.5	+0.2	+0.1	-0.9	0.0
CANY1	11.2	11.0	-0.2	-0.3	+0.3	-0.9	-0.1	+0.1	+0.8	0.0
CAPI1	10.9	11.3	+0.4	-0.2	-0.7	+1.8	+0.2	+0.3	+0.7	+0.1
ZICA1	12.5	12.3	-0.2	+0.2	-0.3	-0.8	-0.1	+0.1	0.0	+0.1

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 5.1-4
Colorado Plateau Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
Arizona										
GRCA2	2.2	2.2	0.0	+0.1	0.0	-0.1	0.0	0.0	0.0	0.0
BALD1	3.0	2.9	-0.1	-0.1	-0.1	-0.1	0.0	0.0	+0.1	0.0
PEFO1	5.0	4.6	-0.4	-0.1	-0.2	-0.4	0.0	+0.1	0.0	0.0
SYCA1	5.6	5.1	-0.5	+0.1	-0.1	-0.6	-0.2	-0.1	+0.1	0.0
Colorado										
WEMI1	3.1	2.4	-0.7	-0.1	-0.1	-0.4	-0.2	0.0	-0.1	0.0
WHRI1	0.7	0.2	-0.5	0.0	-0.1	-0.3	-0.1	0.0	0.0	0.0
MEVE1	4.3	3.1	-1.2	-0.3	-0.3	-0.5	-0.2	-0.2	-0.3	0.0
New Mexico										
SAPE1	1.5	1.0	-0.5	-0.1	-0.1	-0.2	-0.1	0.0	0.0	0.0
Utah										
BRCA1	2.8	2.1	-0.7	-0.1	-0.2	-0.3	-0.2	0.0	-0.1	0.0
CANY1	3.7	2.8	-0.9	-0.3	-0.1	-0.5	-0.1	-0.1	-0.2	0.0
CAPI1	4.1	2.7	-1.4	-0.3	-0.4	-0.5	-0.2	-0.1	-0.4	0.0
ZICA1	5.0	4.3	-0.7	-0.1	-0.2	-0.5	-0.2	0.0	-0.1	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 5.1-5
Colorado Plateau Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
Arizona								
	20% Best	--	--	--	0.0	--	--	0.0
GRCA2	20% Worst	--	**-0.1**	--	--	--	--	--
	All Days	--	0.0	--	--	--	--	--
	20% Best	--	0.0	--	0.0	--	0.0	0.0
BALD1	20% Worst	**-0.2**	--	--	--	**0.1**	**0.3**	0.0
	All Days	**-0.1**	0.0	--	--	--	**0.1**	0.0
	20% Best	--	0.0	**-0.1**	--	--	--	0.0
PEFO1	20% Worst	--	--	--	--	**0.1**	--	0.0
	All Days	--	0.0	--	--	0.0	**0.1**	0.0
	20% Best	--	--	**-0.1**	--	--	--	0.0
SYCA1	20% Worst	--	--	--	0.1	**-0.3**	--	--
	All Days	--	0.0	--	--	**-0.1**	--	--
Colorado								
	20% Best	**-0.1**	0.0	**-0.1**	**-0.1**	--	--	--
WEMI1	20% Worst	--	--	--	0.0	--	--	--
	All Days	--	0.0	--	**-0.1**	--	--	--
	20% Best	--	0.0	**-0.1**	0.0	--	--	--
WHRI1	20% Worst	--	--	--	**-0.1**	--	--	0.0
	All Days	--	--	**-0.1**	0.0	--	--	0.0
	20% Best	**-0.1**	0.0	**-0.1**	0.0	0.0	0.0	--
MEVE1	20% Worst	--	--	--	**-0.2**	--	--	0.0
	All Days	**-0.1**	--	**-0.3**	**-0.1**	--	--	0.0
New Mexico								
	20% Best	--	0.0	0.0	0.0	--	--	--
SAPE1	20% Worst	--	**-0.1**	--	--	--	--	--
	All Days	--	0.0	**-0.1**	0.0	--	0.0	0.0
Utah								
	20% Best	--	0.0	**-0.1**	0.0	--	0.0	0.0
BRCA1	20% Worst	**-0.2**	--	**0.5**	**0.1**	--	--	0.0
	All Days	**-0.1**	0.0	--	--	--	--	--
	20% Best	**-0.1**	--	**-0.1**	0.0	--	**-0.1**	0.0
CANY1	20% Worst	**-0.1**	--	--	--	--	--	0.0
	All Days	**-0.1**	0.0	--	0.0	0.0	--	0.0
	20% Best	**-0.1**	**-0.1**	**-0.1**	0.0	--	**-0.1**	--
CAPI1	20% Worst	--	**-0.2**	--	--	**0.1**	--	0.0
	All Days	**-0.1**	**-0.1**	--	0.0	--	--	0.0
	20% Best	0.0	--	--	0.0	0.0	--	0.0
ZICA1	20% Worst	**-0.5**	--	--	--	--	--	--
	All Days	**-0.2**	--	--	**-0.1**	**0.1**	--	--

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in state specific appendices.

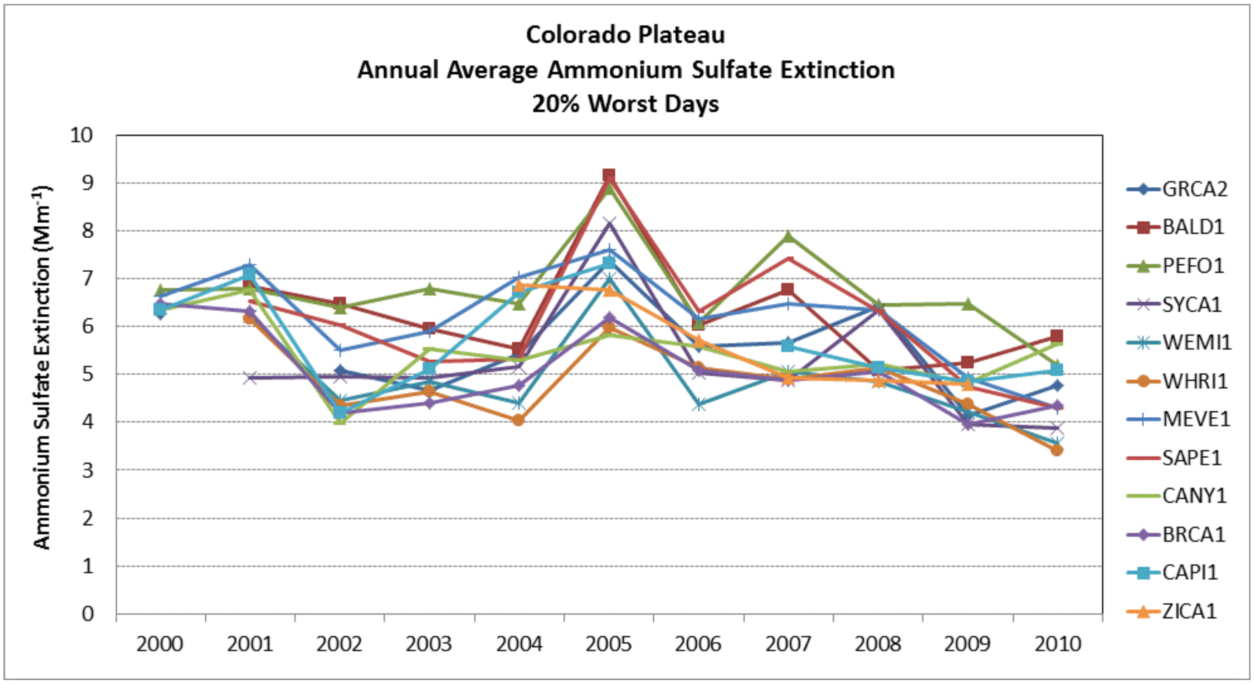

Figure 5.1-3. Chart Depicting Annual Average Ammonium Sulfate Concentrations for the 20% Worst Days as Measured at the Colorado Plateau CIA IMPROVE Sites.

5.2 EMISSIONS DATA

Similar to Section 308 requirements, Section 309 states are required to address how total emissions state have changes over the past 5 years (51.309(d)(10)(i)(D)). Summaries depicting differences between emission inventories are included for all WRAP states in Section 3, and for each state individually in Section 6.0, using 2002 and 2008 inventories to represent changes between the baseline and progress periods. These inventories are described in detail in Section 3.2.

In addition to tracking these differences in inventories, for the initial SIPS, Section 309 states were required to identify “clean air corridors” and track emissions inside and outside of these corridors that may affect impairment on the cleanest days.[63] In these initial 309 SIPs, an area covering major portions of Nevada, southern Utah, eastern Oregon and southwestern Idaho was defined as a “clean air corridor,” which was intended to represent a region from which clean air transport influences many of the clean air days at Grand Canyon National Park. As noted in Section 5.1, visibility has improved for the best days at all of the CIA sites on the Colorado Plateau, so emissions specific to the “clean air corridor” counties are not presented separately here.

[63] Section 51.309(d)(3) states, for treatment of clean-air corridors, “the plan must describe and provide for implementation of comprehensive emission tracking strategies for clean-air corridors to ensure that the visibility does not degrade on the least-impaired days at any of the 16 Class I areas.”

Also, under Section 309 of the RHR, the participating states (and county) are required to identify sulfur dioxide (SO_2) emissions milestones, where a milestone is a maximum level of annual emissions for a given year (51.309(d)(4)(i)). In general, SO_2 emissions are specified in Section 309 because they are more instructive to track than most other pollutants, as they are generally associated with a small number of large sources, and can be measured and tracked with more certainty than some of the other pollutants that impact visibility. Separate work by the WRAP supports the submittal of annual regional SO_2 and emission milestone reports for the 309 states which compare actual emissions estimates to the pre-defined milestones.[64] Figure 5.1-4 presents a plot from the most recent WRAP SO_2 milestone report, showing the 3-year average of current emissions through 2010, which indicated that actual emissions were below SO_2 milestone. Additionally, SO_2 emissions specific to EGU sources are presented in Section 6.0 on an annual basis showing changes in these sources between 1996 and 2010 for each WRAP state.

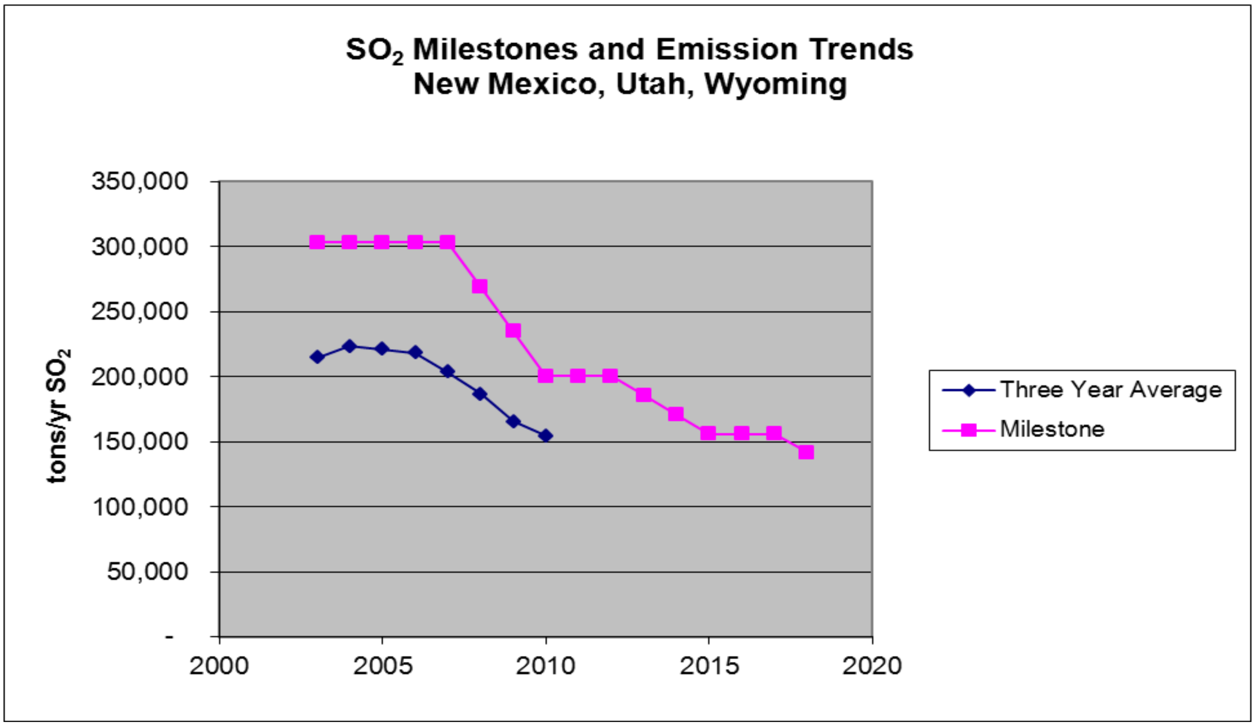

Figure 5.1-4. Chart Depicting 3-Year Average Sum of SO_2 emissions for New Mexico, Utah, and Wyoming and the city of Albuquerque/Bernalillo County as compared to the 309 SIP SO_2 Milestones.

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[64] Annual regional SO_2 emissions and milestone reports are located on the WRAP website at http://www.wrapair2.org/reghaze.aspx.

6.0 STATE AND CLASS I AREA SUMMARIES

As described in Section 2.0, each state is required to submit progress reports at interim points between submittals of Regional Haze Rule (RHR) State Implementation Plans (SIPs), which assess progress towards visibility improvement goals in each state's mandatory Federal Class I areas (CIAs). Data summaries for each CIA in each Western Regional Air Partnership (WRAP) state, which address Regional Haze Rule (RHR) requirements for visibility measurements and emissions inventories are provided in this section. These summaries are intended to provide individual states with the technical information they need to determine if current RHR implementation plan elements and strategies are sufficient to meet all established reasonable progress goals, as defined in their respective initial RHR implementation plans.

6.1 ALASKA

The goal of the Regional Haze Rule (RHR) is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. Alaska has 4 mandatory Federal CIAs, which are depicted in Figure 6.1-1 and listed in Table 6.1-1, along with the associated IMPROVE monitor locations.

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per RHR requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. Some of the highlights regarding these comparisons are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- The largest contributors to aerosol extinction at the Alaska sites were ammonium sulfate, particulate organic mass, and sea salt.
- For the best days, the 5-year average remained unchanged at the DENA1 site, and increased at the other Alaska sites, and ammonium sulfate was the largest contributor to increases on the best days
- For the worst days, the 5-year average deciview metric increased at the DENA1 and TRCR1 sites, remained unchanged at the SIME1 site, and decreased at the TUXE1 site.
  - Ammonium sulfate was the largest contributor to increases on the worst days and annual averages of ammonium sulfate also showed increasing trends. Emissions inventory comparisons for baseline and progress years indicated that the largest increases in estimates of SO_2 emissions were in the area source inventories.
  - Average ammonium nitrate also increased at DENA1 on the worst days but decreased at TRCR1 and TUXE1. No statistically significant increasing or decreasing annual average trends were observed for ammonium nitrate at any of the Alaska sites.

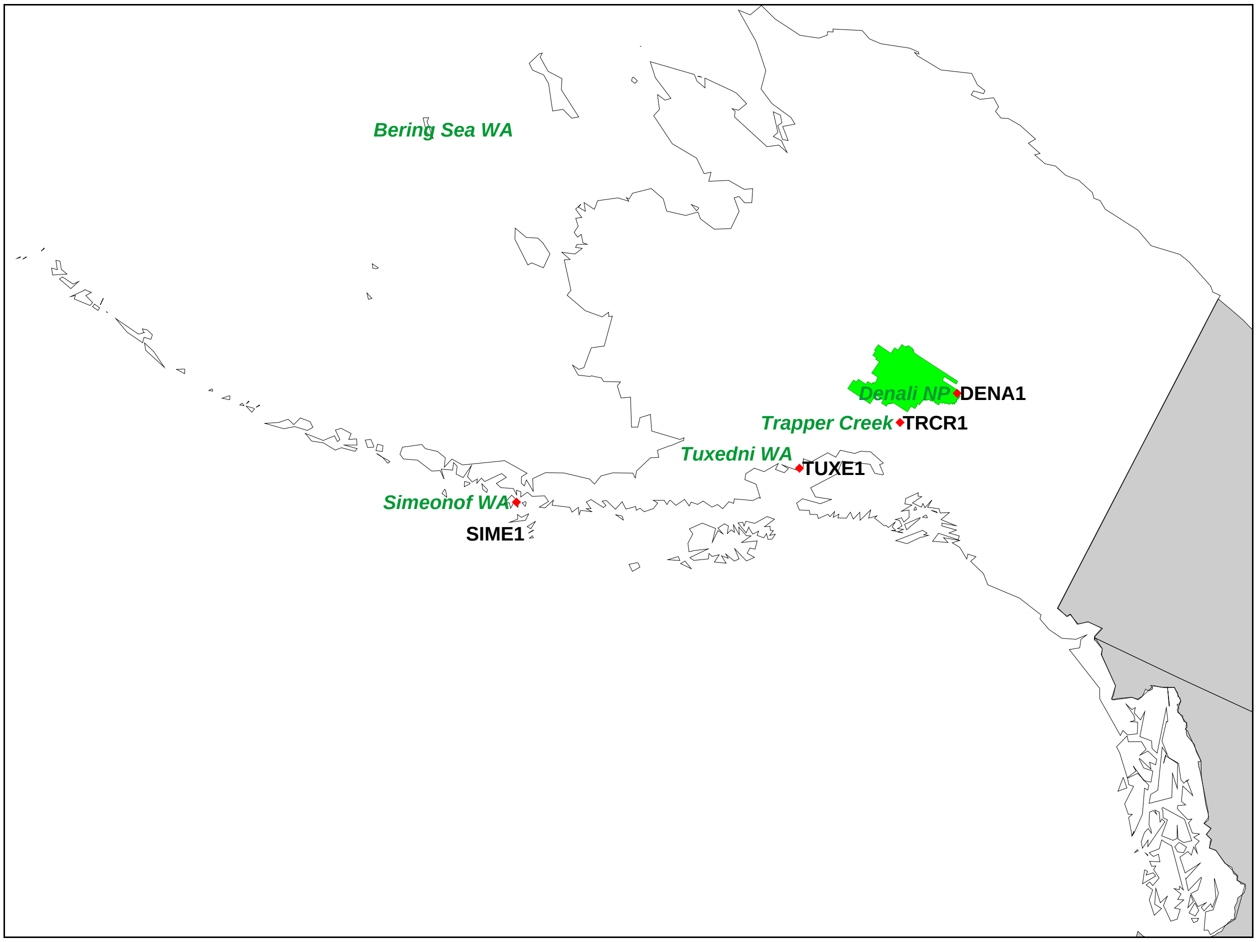

Figure 6.1-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in Alaska.

Table 6.1-1
Alaska CIAs and Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Denali NP	DENA1	63.72	-148.97	658
Simeonof WA	SIME1	55.33	-160.51	57
Tuxedni WA	TUXE1	59.99	-152.67	15
Bering Sea WA*	N/A			
Trapper Creek**	TRCR1	62.32	-150.32	155

*Federal Class I area with no IMPROVE monitoring site
**Not a Federal Class I area

6.1.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by IMPROVE monitors representing Federal CIAs in Alaska. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix A.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.1.1.1 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.308 (g)(3)(i))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[65] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.1-2 and 6.1-3 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired, or worst, and 20% least impaired, or best, days, respectively, for each of the Federal CIA IMPROVE monitors in Alaska. Figure 6.1-2 presents 5-year average extinction for the current progress period for both the worst and best days. Note that percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired days are as follows:

- The largest contributors to aerosol extinction at Alaska sites were particulate organic mass and ammonium sulfate. Large contributions from sea salt were also measured at the SIME1 and TUXE1 sites.
- The highest aerosol extinction (18.6 dv) was measured at the SIME1 site, where sea salt was the largest contributor to aerosol extinction, followed by ammonium sulfate. The lowest aerosol extinction (10.6 dv) was measured at the DENA1 site.

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[65] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

Specific observations for the current visibility conditions on the 20% least impaired days are as follows:

- The aerosol contribution to total extinction on the best days was less than Rayleigh, or the background scattering that would occur in clear air. Average extinction (including Rayleigh) ranged from 2.4 deciview (DENA1) to 8.0 deciview (SIME1).
- For all sites, ammonium sulfate was the largest contributor to aerosol extinction on the best days.

Table 6.1-2
Alaska Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank*						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
DENA1	10.6	34% (2)	3% (6)	**47% (1)**	6% (3)	1% (7)	5% (4)	4% (5)
SIME1	18.6	40% (2)	3% (4)	2% (5)	1% (6)	0% (7)	9% (3)	**43% (1)**
TRCR1	11.9	**44% (1)**	4% (5)	32% (2)	5% (4)	1% (7)	9% (3)	4% (6)
TUXE1	13.5	**46% (1)**	4% (5)	14% (3)	3% (6)	2% (7)	10% (4)	21% (2)

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.1-3
Alaska Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank*						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
DENA1	2.4	**49% (1)**	4% (6)	18% (2)	7% (4)	3% (7)	16% (3)	4% (5)
SIME1	8.0	**40% (1)**	5% (5)	3% (6)	5% (4)	0% (7)	11% (3)	36% (2)
TRCR1	3.9	**49% (1)**	7% (4)	17% (2)	7% (5)	2% (7)	13% (3)	4% (6)
TUXE1	4.1	**45% (1)**	8% (4)	8% (5)	3% (6)	1% (7)	15% (3)	20% (2)

*Highest aerosol species contribution per site is highlighted in bold.

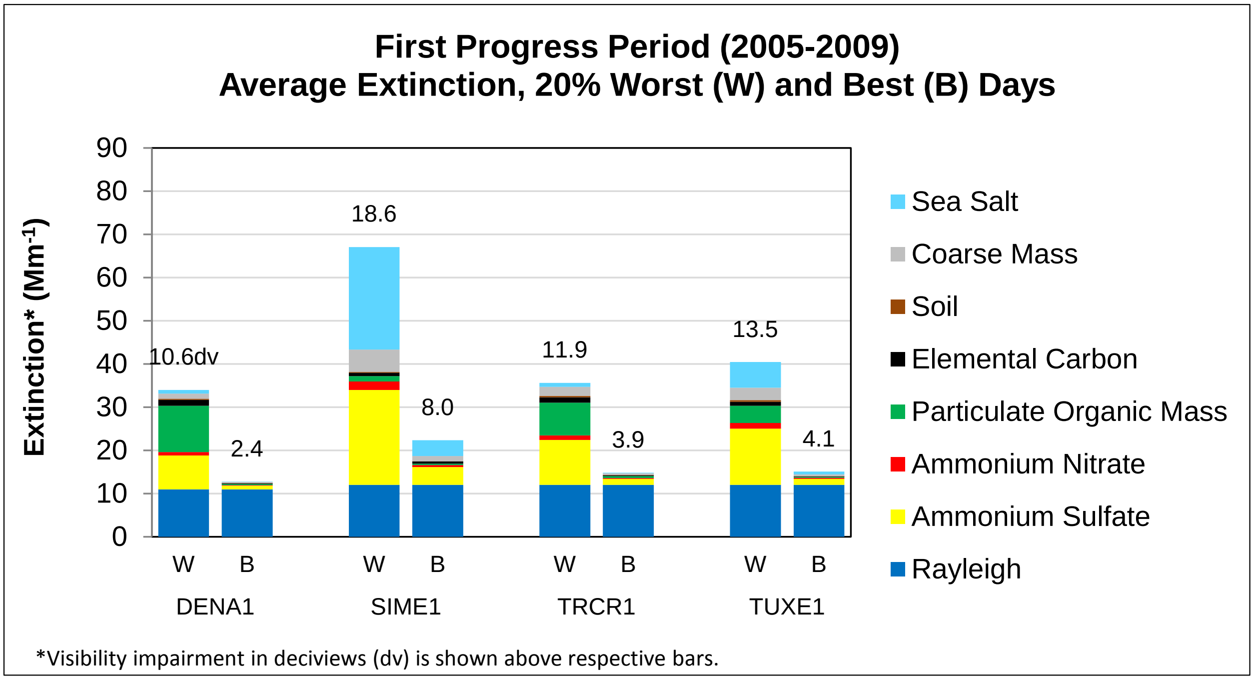

Figure 6.1-2. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at Alaska Class I Area IMPROVE Sites.

6.1.1.2 Differences between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.308 (g)(3)(ii))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Table 6.1-4 presents the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for each site in Alaska for the 20% most impaired or worst days, and Table 6.1-5 presents similar data for the least impaired or best days. Averages that increased are depicted in red text and averages that decreased in blue.

Figure 6.1-3 presents the 5-year average extinction for the baseline and current progress period averages for the worst days and Figure 6.1-4 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.1-5 and 6.1-6 present similar plots for the best days.

For the 20% most impaired days, the 5-year average deciview metric decreased between the 2000-2004 and 2005-2009 periods at the TUXE1 site, remained the same at the SIME1 site, and increased at the DENA1 and TRCR1 sites. Notable differences for individual species averages were as follows:

- Ammonium sulfate increased at all sites on the worst days.
- Particulate organic mass and elemental carbon decreased at all sites, with the largest decreases measured at the SIME1 and TUXE1 sites.
- Ammonium nitrate increased slightly at the DENA1 site, but decreased slightly at the TRCR1 and TUXE1 sites.
- Coarse mass decreases slightly at the DENA1 site, and increased at the other Alaska sites.

For the 20% least impaired days, the 5-year average RHR deciview metric increased at all sites except DENA1, where the measured deciview average remained relatively unchanged. Notable differences for individual species averages on the 20% least impaired days were as follows:

- Increases in deciview were mostly due to increases in ammonium sulfate and coarse mass. Ammonium sulfate increased slightly at all sites except DENA1, and coarse mass increased slightly at all sites.

Table 6.1-4
Alaska Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
DENA1	9.9	10.6	+0.7	+3.0	+0.2	-0.1	-0.3	0.0	-0.2	+0.4
SIME1	18.6	18.6	0.0	+6.7	0.0	-3.3	-1.1	0.0	+0.8	-1.4
TRCR1	11.6	11.9	+0.3	+2.9	-0.1	-1.5	-0.1	0.0	+0.5	+0.5
TUXE1	14.1	13.5	-0.6	+4.3	-0.5	-4.8	-0.3	+0.3	+0.4	-2.3

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.1-5
Alaska Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
DENA1	2.4	2.4	0.0	0.0	-0.1	0.0	-0.1	0.0	+0.1	0.0
SIME1	7.6	8.0	+0.4	+0.4	-0.1	-0.3	+0.1	0.0	+0.1	+0.5
TRCR1	3.5	3.9	+0.4	+0.4	0.0	+0.1	-0.1	0.0	+0.1	0.0
TUXE1	4.0	4.1	+0.1	+0.3	-0.1	-0.1	-0.1	0.0	+0.1	+0.1

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

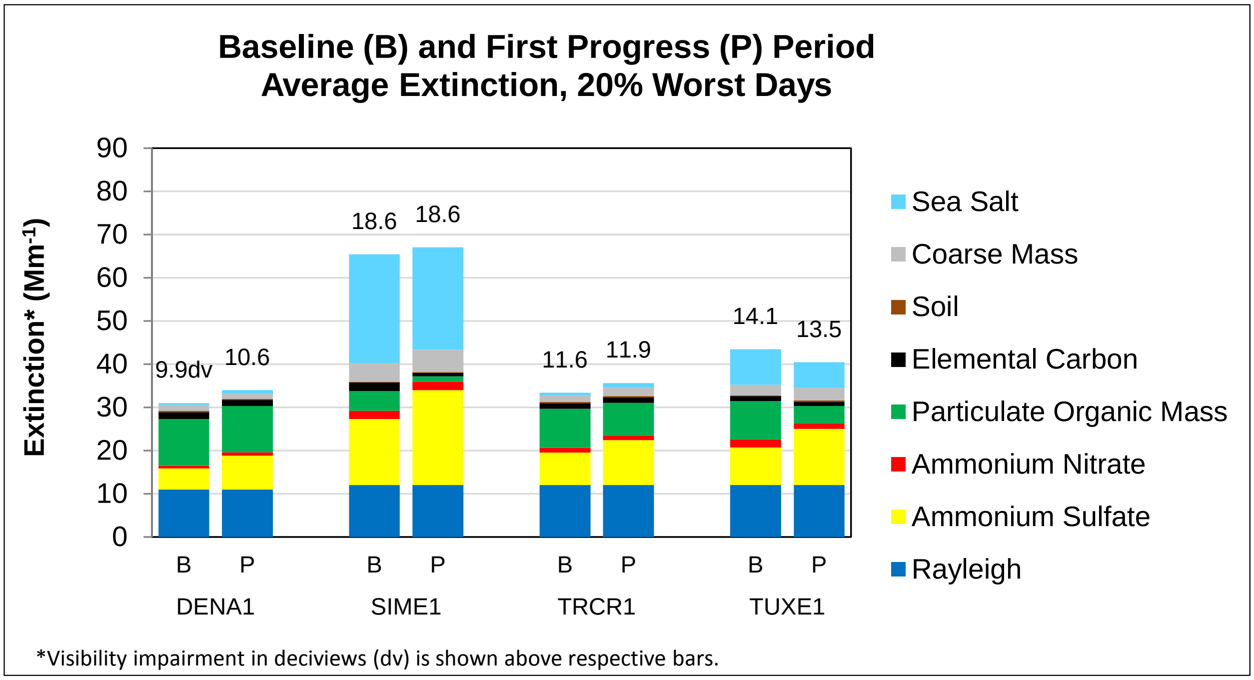

Figure 6.1-3. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at Alaska Class I Area IMPROVE Sites.

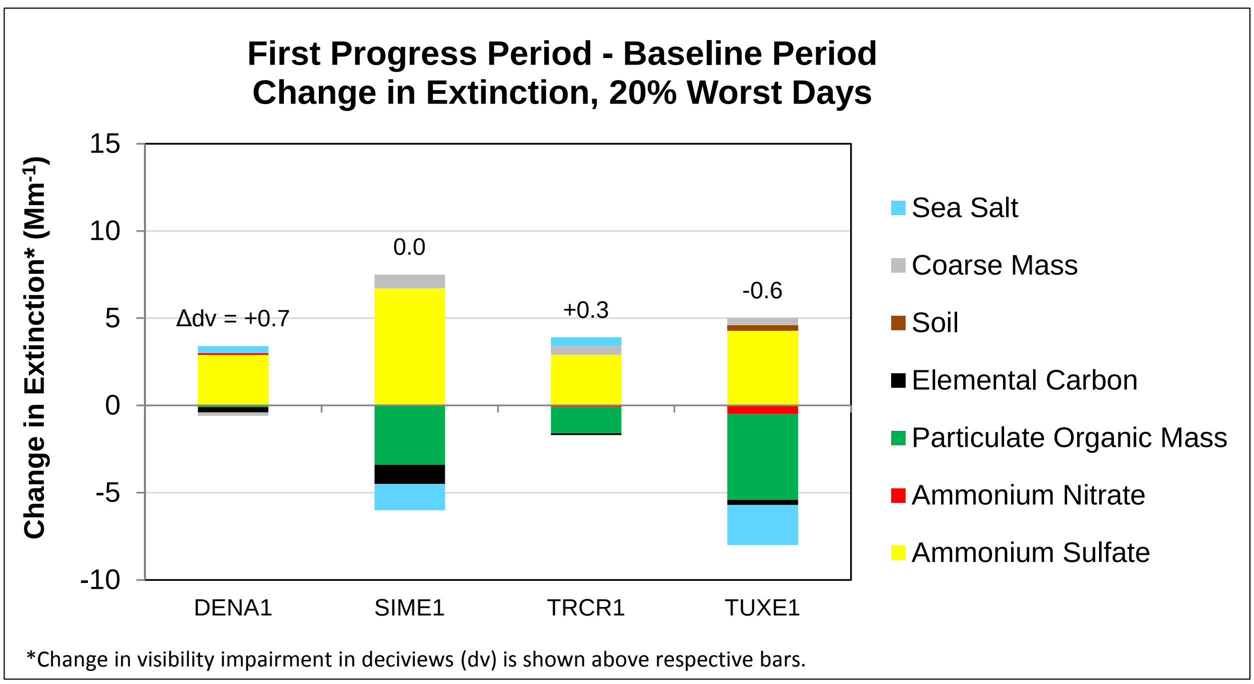

Figure 6.1-4. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at Alaska Class I Area IMPROVE Sites.

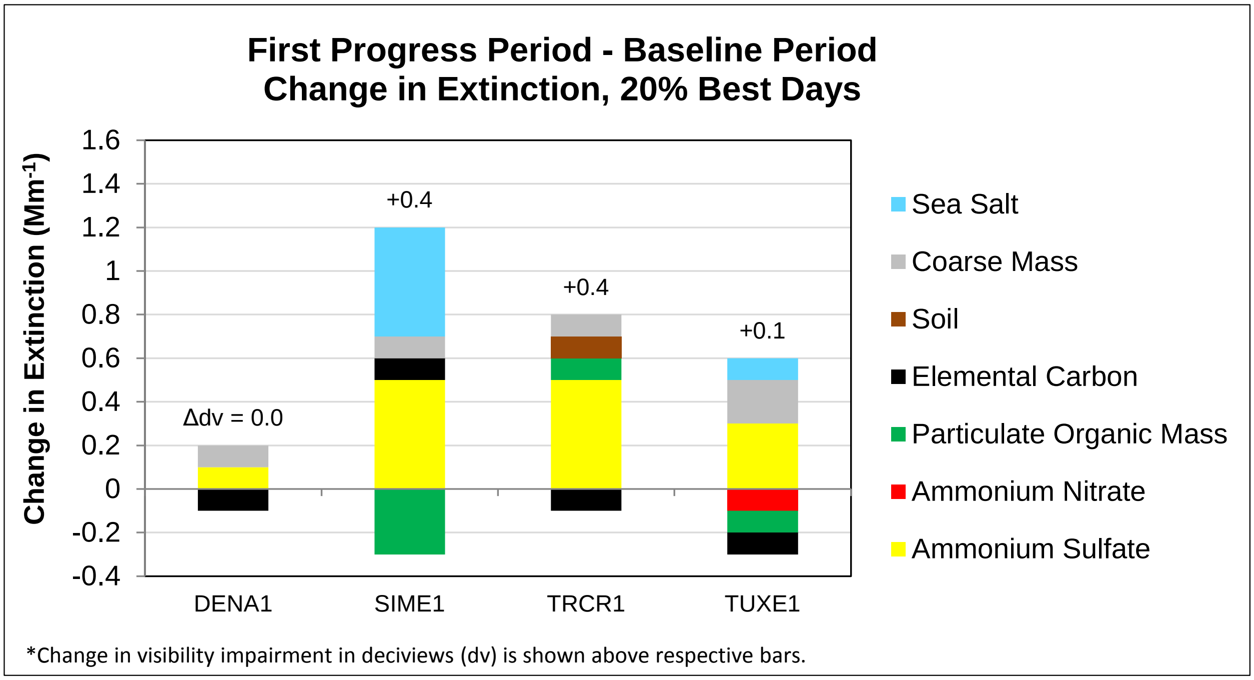

Figure 6.1-5. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at Alaska Class I Area IMPROVE Sites.

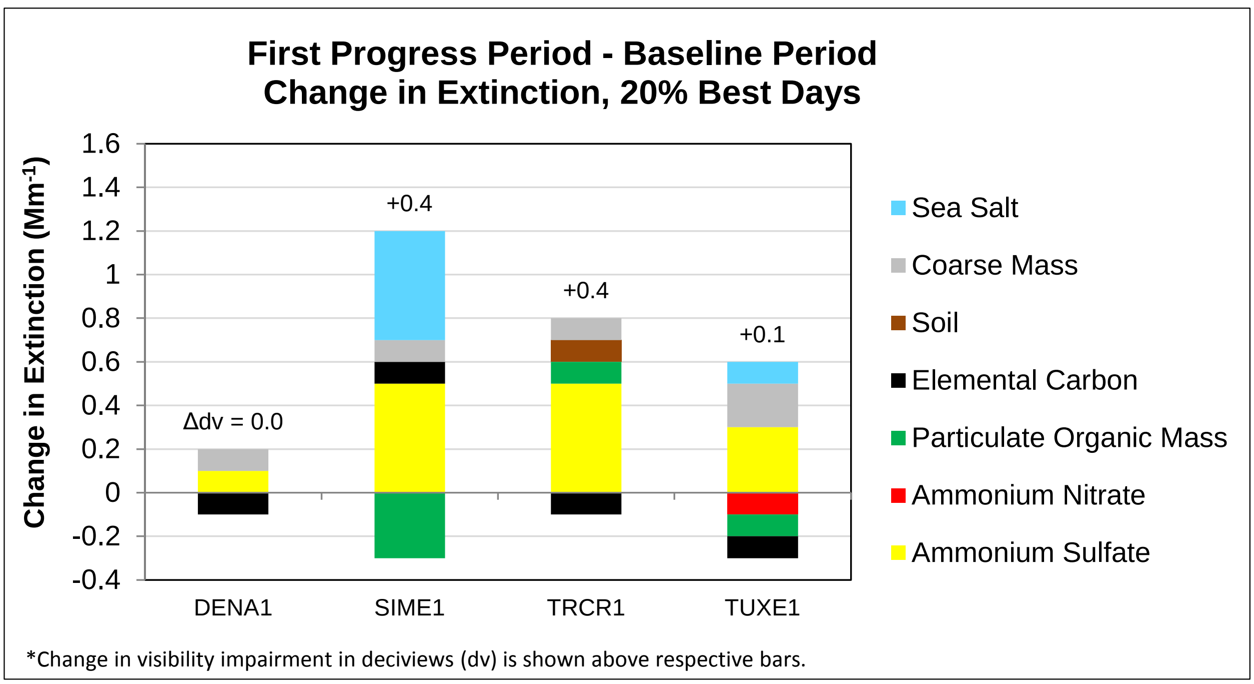

Figure 6.1-6. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at Alaska Class I Area IMPROVE Sites.

6.1.1.3 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.308 (g)(3)(iii))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5-year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in Alaska are summarized in Table 6.1-6, and regional trends were presented earlier in Section 4.1.1.[66] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[67] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix A. Additionally, this appendix includes plots depicting 5-year, annual, monthly, and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in Alaska are as follows:

- 5-year average ammonium sulfate increased at all Alaska sites, and all sites measured statistically significant increasing annual ammonium sulfate trends.
- For particulate organic mass and elemental carbon, the SIME1 and TUXE1 sites showed statistically significant decreasing annual trends.

[66] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)
[67] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

- As depicted in monthly and daily charts in Appendix A, large particulate organic events, likely due to wildfires, were measured at the TRCR1 site in August of 2005 and at the TRCR1 and DENA1 sites in July and August of 2009.

Table 6.1-6
Alaska Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
DENA1	20% Best	--	0.0	--	0.0	--	0.0	--
	20% Worst	**0.5**	0.0	--	--	--	--	**0.1**
	All Days	**0.1**	--	--	0.0	--	--	0.0
SIME1	20% Best	--	--	**-0.1**	--	0.0	--	**0.1**
	20% Worst	**1.7**	--	**-0.6**	**-0.2**	--	--	--
	All Days	**0.6**	0.0	**-0.2**	**-0.1**	--	--	--
TRCR1	20% Best	**0.1**	0.0	0.0	--	0.0	0.0	--
	20% Worst	**0.7**	--	--	--	--	--	--
	All Days	**0.2**	--	--	0.0	--	0.0	--
TUXE1	20% Best	**0.1**	0.0	0.0	0.0	--	--	--
	20% Worst	**1.0**	0.0	**-1.2**	**-0.1**	--	--	--
	All Days	**0.3**	0.0	**-0.3**	**-0.1**	--	--	--

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix A.

6.1.2 Emissions Data

Included here are summaries depicting differences between two emission inventory years that are used to represent the 5-year baseline and current progress periods. The baseline period is represented using a 2002 inventory that originally represented baseline emissions for Alaska's initial RHR implementation plan. The progress period is represented using a 2008 inventory, which was assembled from various sources with assistance from Alaska's Air Quality Division, as referenced in Section 3.2.1. For reference, Table 6.1-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories are presented in this section.

Table 6.1-7
Alaska
Pollutants, Aerosol Species, and Major Sources

Emitted Pollutant	Related Aerosol	Major Sources	Notes
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- and Off-Road Mobile Sources	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be associated with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Fine Soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is reported by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$ mass measurements. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but these measurements are generally associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributor to PMC.

6.1.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.308 (g)(4))?*** For these summaries, emissions during the baseline and progress years are represented using 2002 and 2008 inventories, where the 2002 inventory was used in development of the original Alaska RHR SIP, and the 2008 inventory was assembled with assistance from the Alaska Department of Health, as referenced in Section 3.2.1. The differences between inventories are presented here for all major visibility impairing pollutants, and categorized by source for both anthropogenic and natural emissions.

Table 6.1-8 and Figure 6.1-7 present the differences between the 2002 and 2008 sulfur dioxide (SO_2) inventories by source category. Tables 6.1-9 and Figure 6.1-8 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.1-10 through 6.1-13 and Figures 6.1-9 through 6.1-12) present data for ammonia (NH_3), volatile organic compounds (VOCs), fine soil, and coarse mass. Observations regarding emissions inventory comparisons are listed below.

- For all parameters, fire emission inventory estimates decreased. Note that these differences are not necessarily reflective of changes in monitored data, as the 5-year baseline period is represented by an average of 2003 fire emissions, and the 5-year progress period is represented by fires that occurred in 2008, as referenced in Section 3.2.1.
- Point source inventories showed decreases for all parameters, especially SO_2 and NO_X.
- Area source inventories showed increases in SO_2 and NO_X, but large decreases in VOCs, fine soil, and coarse mass. These changes may be due to a combination of population changes and differences in methodologies used to estimate these emissions. As references in Section 3.2.1, one methodology change was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category (now termed non-point) in 2008, which may have contributed to increases in area source inventory totals, but decreases in off-road mobile totals.
- On-road mobile source inventory comparisons showed increases in SO_2, NO_X, fine soil, and coarse mass, but a decrease in VOCs.
- Off-road mobile source inventories showed decreases in NO_X, but increases in VOCs. As noted previously, one major methodology difference was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to decreases in the off-road inventory totals, but increases in area source totals.
- Commercial marine sources showed large increases in NO_X inventories, and only small changes in other parameters.

Table 6.1-8
Alaska
Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2002 (State Inventory)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	6,813	5,039	-1,774
Area	1,872	3,365	1,493
On-Road Mobile	324	490	166
Off-Road Mobile	49	395	346
Aviation	335	*	*
Commercial Marine	4,979	5,180	201
Total Anthropogenic	**14,037***	**14,469***	**432 (3%)***
Natural Sources			
Total Fire	34,304	4,482	-29,822
Total Natural	**34,304**	**4,482**	**-29,822 (-87%)**
All Sources			
Total Emissions	**48,341***	**18,951***	**-29,390 (-61%)***

*Sums and differences do not include aviation emissions, as 2008 inventory totals were not available from this source for comparison purposes.

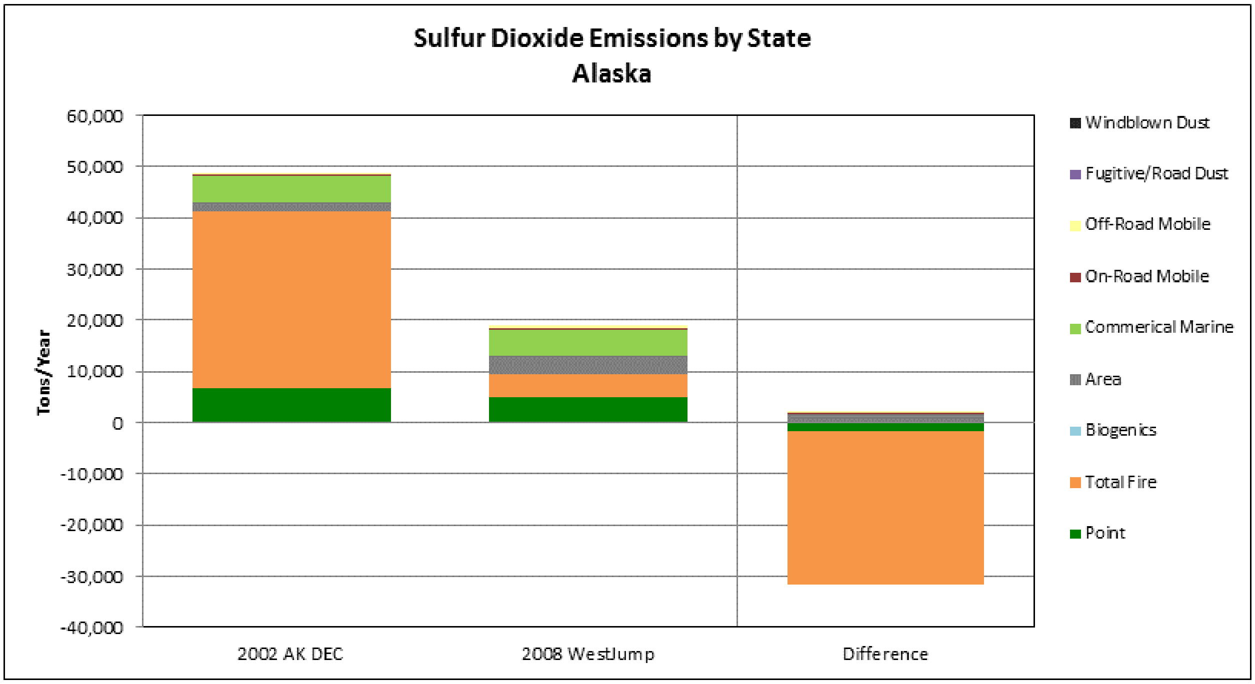

Figure 6.1-7. 2002 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for Alaska.

Table 6.1-9
Alaska
Oxides of Nitrogen Emissions by Category

Source Category	Oxides of Nitrogen Emissions (tons/year)		
	2002 (State Inventory)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	74,471	68,564	-5,907
Area	14,742	19,404	4,662
On-Road Mobile	7,077	15,696	8,619
Off-Road Mobile	4,111	3,387	-724
Aviation	3,265	*	*
Commercial Marine	11,258	24,370	13,112
Total Anthropogenic	**111,659***	**131,421***	**19,762 (18%)***
Natural Sources			
Total Fire	125,110	16,344	-108,766
Total Natural	**125,110**	**16,344**	**-108,766 (-87%)**
All Sources			
Total Emissions	**236,769***	**147,765***	**-89,004 (-38%)***

*Sums and differences do not include aviation emissions, as 2008 inventory totals were not available from this source for comparison purposes.

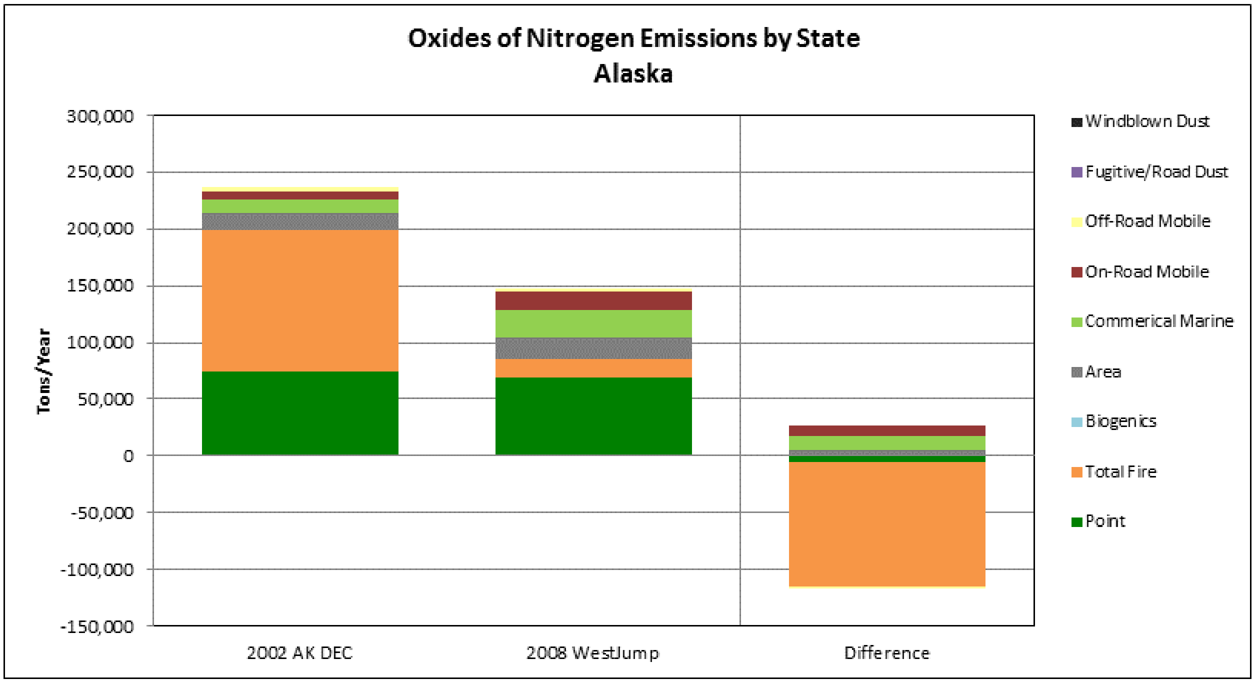

Figure 6.1-8. 2002 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Oxides of Nitrogen by Source Category for Alaska.

Table 6.1-10
Alaska
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2002 (State Inventory)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	580	178	-402
Area	0	356	356
On-Road Mobile	307	230	-77
Off-Road Mobile	8	7	-1
Aviation	6	*	*
Commercial Marine	5	11	6
Total Anthropogenic	**900***	**782***	**-118 (-13%)***
Natural Sources			
Total Fire	26,233	3,417	-22,816
Total Natural	**26,233**	**3,417**	**-22,816 (-87%)**
All Sources			
Total Emissions	**27,133***	**4,199***	**-22,934 (-85%)***

*Sums and differences do not include aviation emissions, as 2008 inventory totals were not available from this source for comparison purposes.

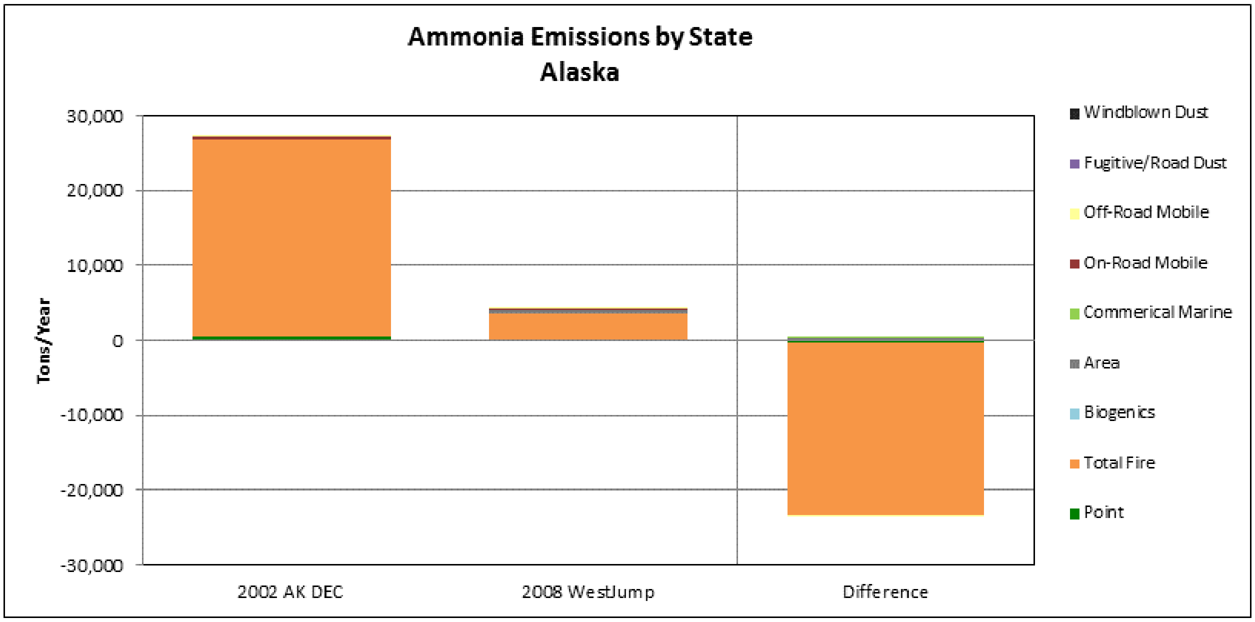

Figure 6.1-9. 2002 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Ammonia by Source Category for Alaska.

Table 6.1-11
Alaska
Volatile Organic Compound Emissions by Category

Source Category	Volatile Organic Compounds Emissions (tons/year)		
	2002 (State Inventory)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	5,697	4,582	-1,115
Area	128,271	10,890	-117,381
On-Road Mobile	7,173	6,740	-433
Off-Road Mobile	7,585	19,094	11,509
Aviation	1,566	*	*
Commercial Marine	356	609	253
Total Anthropogenic	**149,082***	**41,915***	**-107,167 (-72%)***
Natural Sources			
Total Fire	274,436	35,761	-238,675
Total Natural	**274,436**	**35,761**	**-238,675 (-87%)**
All Sources			
Total Emissions	**423,518***	**77,676***	**-345,842 (-82%)***

*Sums and differences do not include aviation emissions, as 2008 inventory totals were not available from this source for comparison purposes.

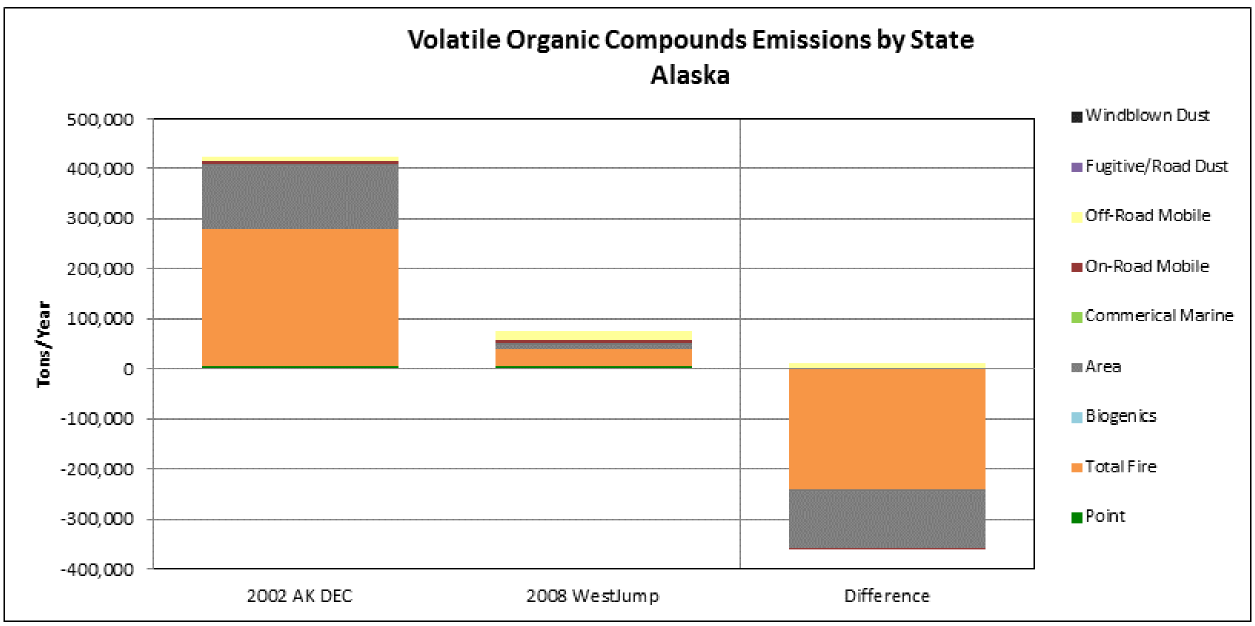

Figure 6.1-10. 2002 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for Alaska.

Table 6.1-12
Alaska
Fine Soil Emissions by Category

Source Category	Fine Soil Emissions (tons/year)		
	2002 (State Inventory)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	1,237	563	-674
Area	30,636	2,289	-28,347
On-Road Mobile	158	1,194	1,036
Off-Road Mobile	392	670	278
Aviation	667	*	*
Commercial Marine	643	1,114	471
Total Anthropogenic	**33,066***	**5,830***	**-27,236 (-82%)***
Natural Sources			
Total Fire	478,057	63,330	-414,727
Total Natural	**478,057**	**63,330**	**-414,727 (-87%)**
All Sources			
Total Emissions	**511,123***	**69,160***	**--441,963 (-86%)***

*Sums and differences do not include aviation emissions, as 2008 inventory totals were not available from this source for comparison purposes.

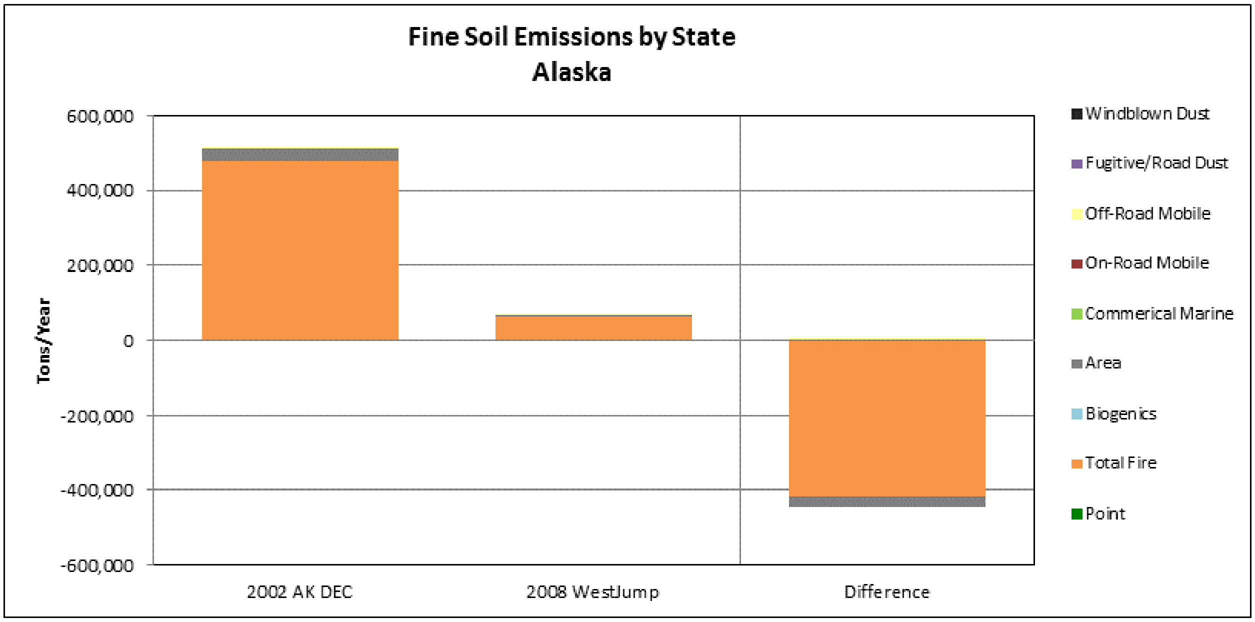

Figure 6.1-11. 2002 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Fine Soil by Source Category for Alaska.

Table 6.1-13
Alaska
Coarse Mass Emissions by Category

Source Category	Coarse Mass Emissions (tons/year)		
	2002 (State Inventory)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	4,696	2,392	-2,304
Area	76,349	121	-76,228
On-Road Mobile	46	164	118
Off-Road Mobile	24	46	22
Aviation	20	*	*
Commercial Marine	32	64	32
Total Anthropogenic	**81,147***	**2,787***	**-78,360 (-97%)***
Natural Sources			
Total Fire	79,346	10,495	-68,851
Total Natural	**79,346**	**10,495**	**-68,851 (-87%)**
All Sources			
Total Emissions	**160,493***	**13,282***	**-147,211 (-92%)***

*Sums and differences do not include aviation emissions, as 2008 inventory totals were not available from this source for comparison purposes.

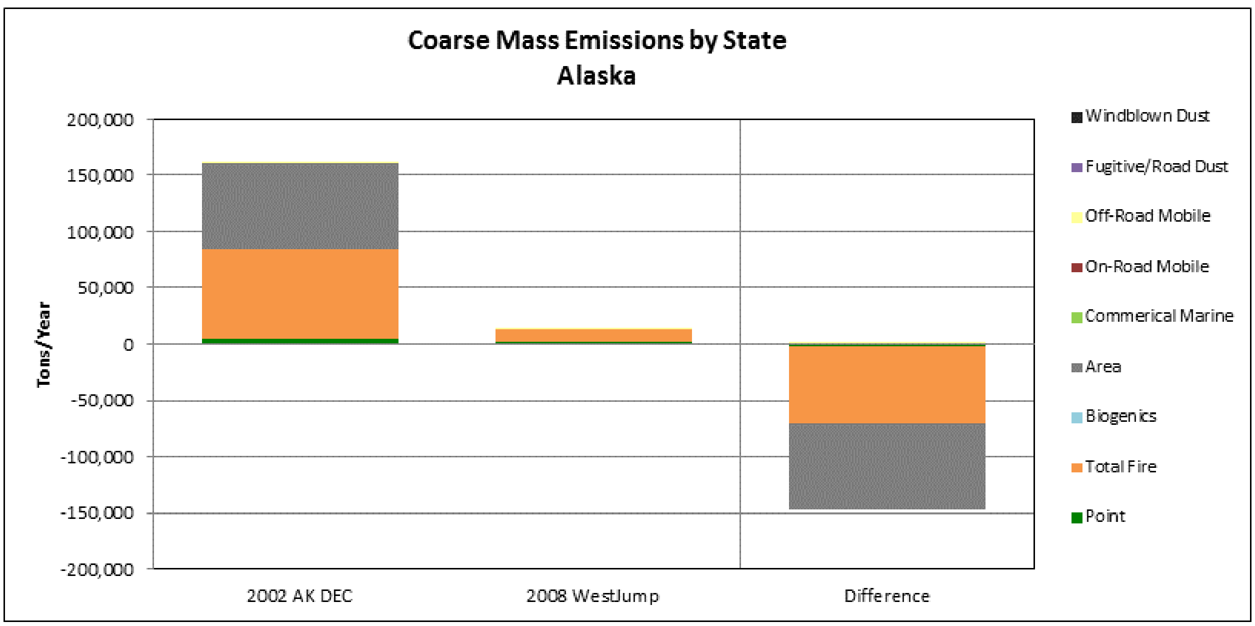

Figure 6.1-12. 2002 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Coarse Mass by Source Category for Alaska.

6.2 ARIZONA

The goal of the Regional Haze Rule (RHR) is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. Arizona has 12 mandatory Federal CIAs, which are depicted in Figure 6.2-1 and listed in Table 6.2-1, along with the associated IMPROVE monitor locations.

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per Regional Haze Rule (RHR) requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. Some of the highlights regarding these comparisons are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- The 5-year deciview metric for the best days decreased between the 2000-2004 baseline period and the 2005-2009 progress period at all Arizona sites.
- The 5-year deciview metric for the worst days decreased between the 2000-2004 baseline period and the 2005-2009 progress period at most sites, but increased slightly at the GRCA2 (+0.3 dv) and IKBA1 (+0.1 dv) sites.
- Increases in the 5-year averages of particulate organic mass, elemental carbon, and ammonium sulfate contributed to deciview increases at the GRCA2 site, and increases in particulate organic mass and ammonium sulfate contributed to increases at the IKBA1 sites. For these increases:
    - Increases in particulate organic mass were affected by large events, including high measurements in June 2009 at the GRCA2 site that were likely related to several large fires in the area at the time. Increases in average elemental carbon at the GRCA2 site were also associated with the high particulate organic mass measurements in June 2009. At the IKBA2 site, the increase in 5-year average particulate organic mass was due to higher than average measurements between June and December 2005, which were likely related to fire.
    - All sites except SAGU1 and SAWE1 showed an increase in 5-year average ammonium sulfate, but annual average trends for ammonium sulfate were either insignificant or decreasing. Many regional sites, including sites in Arizona, Colorado, and New Mexico were affected by anomalously higher than average ammonium sulfate measurements in 2005. Increases were also not consistent with emissions inventory comparisons, where state-wide emissions totals and annual tracking of electrical generating units (EGU) emissions showed decreases in sulfur dioxide (SO_2), due mostly to decreases in point and off-road mobile sources.

- For ammonium nitrate, all sites had lower 5-year averages of ammonium nitrate for the 2005-2009 progress period, and central and northern Arizona sites showed decreasing annual trends in ammonium nitrate. This was consistent with emission inventories that showed net decreases in oxides of nitrogen (NO_X) emissions, with decreases reported for all sources except area. Increases in area source inventories may to due increases in population estimates used for calculations.
- For fine soil and coarse mass, measured concentrations are highest in the southern Western Regional Air Partnership (WRAP) region. Emissions inventories indicate that windblown and fugitive dusts are the largest contributors these haze species, with some contribution to fine soil from area and fire sources. Annual average trends for these species were varied, with both increasing and decreasing trends throughout the state.
- For coarse mass, increasing trends were noted at some of the eastern Arizona sites, but increases were not associated with increased deciview averages. Comparisons between coarse mass inventories showed increases in fugitive dust (including road dust) and windblown dust, although increases in windblown dust are likely due to updated inventory development methodology rather than actual increases. Increases in fugitive dust inventories may be to due increases in population used for calculations, and increases road dust may be due to a combination of use of a different model for output, and increases in estimated vehicle miles travelled.

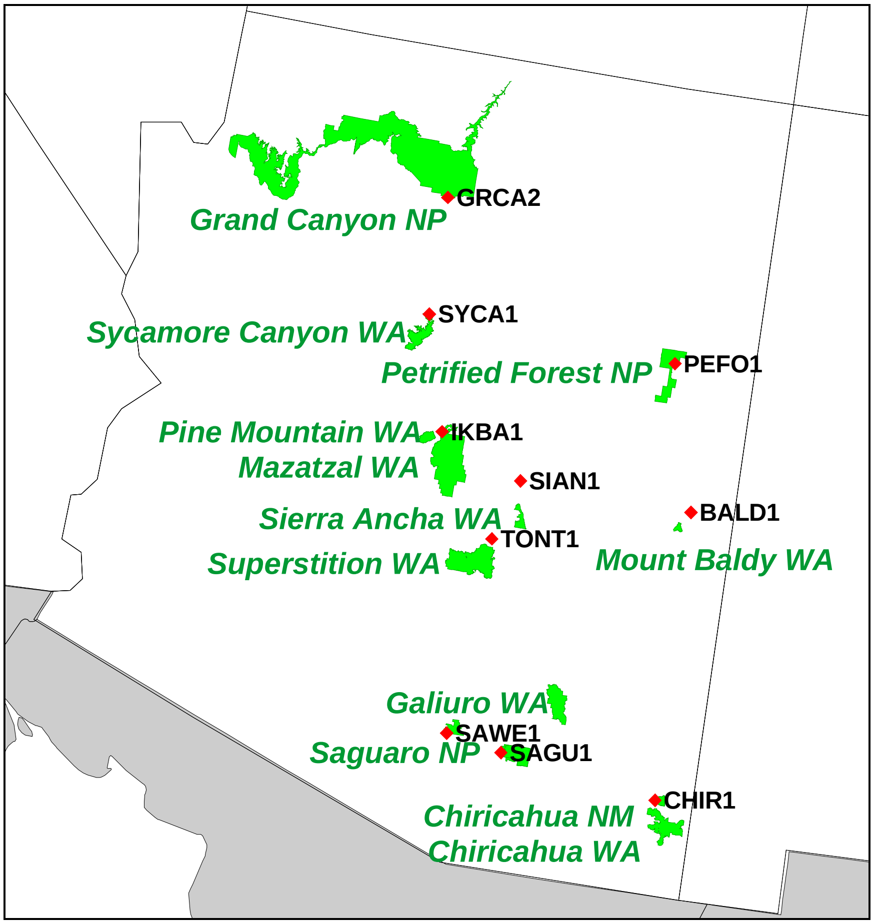

Figure 6.2-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in Arizona.

Table 6.2-1
Arizona CIAs and Representative IMPROVE Monitors

Class I Area	**Representative IMPROVE Site**	**Latitude**	**Longitude**	**Elevation (m)**
Mount Baldy WA	BALD1	34.06	-109.44	2508
Chiricahua NM Chiricahua WA Galiuro WA	CHIR1	32.01	-109.39	1554
Grand Canyon NP	GRCA2	35.97	-111.98	2267
Mazatzal WA Pine Mountain WA	IKBA1	34.34	-111.68	1297
Petrified Forest NP	PEFO1	35.08	-109.77	1766
Saguaro NP	SAGU1	32.17	-110.74	941
	SAWE1	32.25	-111.22	714
Sierra Ancha WA	SIAN1	34.09	-110.94	1600
Sycamore Canyon WA	SYCA1	35.14	-111.97	2046
Superstition WA	TONT1	33.65	-111.11	775

6.2.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by IMPROVE monitors representing Federal CIAs in Arizona. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix B.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.2.1.1 SIAN1 Data Substitutions

As described in Section 3.1.1, RHR guidance outlines data completeness requirements for the 2000-2004 baseline period, and each subsequent progress period. In WRAP states, only the SIAN1 site, representing the Sierra Ancha Wilderness Area in Arizona, did not meet data completeness criteria for the 2005-2009 progress period. RHR guidelines provide provisions to fill in, or patch, missing data under specific circumstances, and these methods are routinely applied to all IMPROVE data.[68] Additional data substitutions beyond the routine RHR patched values were required for the SIAN1 monitoring site to achieve data completeness for the progress period.

Data substitution methodology for the 2005-2009 progress period was consistent with methodology that was previously applied for similarly incomplete 2000-2004 baseline period for seven WRAP sites.[69] The data substitution methods include estimating missing species from other on-site measurements and appropriately scaling data collected at a nearby site which demonstrated favorable long-term comparisons. Only years deemed incomplete under RHR guidance were candidates for additional data substitutions, which included the years 2006, 2007, and 2008 at the SIAN1 site. Years deemed complete were not changed, although there may have been missing samples during those years.

The first substitution method applied uses organic hydrogen (org H), measured on the IMPROVE A Module filter, as a surrogate for organic carbon (OC) and elemental carbon (EC), which are collected on the C Module. Hydrogen is assumed to be primarily associated with organic carbon and inorganic compounds such as ammonium sulfate. Therefore, OC can be estimated using the historical comparison between estimated org H and OC. Org H is estimated

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[68] Routine data substitutions are described in the *Guidance for Tracking Progress Under the Regional Haze Rule*, EPA-454/B-03-004, September 2003, www.epa.gov/ttnamti1/files/ambient/visible/tracking.pdf .
[69] A description of data substitution methodology applied for the baseline data for WRAP states is available at http://vista.cira.colostate.edu/docs/wrap/Monitoring/WRAP_Data_Substitution_Methods_April_2007.doc.

by subtracting the portion of H that is assumed to be associated with the inorganic compounds from the total H (Org_H = H – 0.25*S). Linear regression statistics were used to correlate all org H and OC mass collected at the SIAN1 site during the 2005-2009 period, and regression statistics were applied to organic H to estimate OC on days where org H was available, but OC was not. OC and EC correlations for the period were then used to estimate EC from OC. Regression statistics for these substitutions were calculated and applied quarterly to account for seasonal variations.

Because the carbon data substitution methods were not sufficient to complete the required years, a second method was applied that involved scaling data from the closest neighboring IMPROVE site, TONT1. This site had previously been determined to have favorable long-term comparisons and similar regional characteristics for substitutions performed on the 2000-2004 baseline period, when the SIAN1 site was selected, in consultation with the state of Arizona, as a donor site for TONT1. Species specific mass correlations between SIAN1 and TONT1 during the 2005-2009 period were calculated quarterly, and applied to adjust TONT1 data for substitution on incomplete days at SIAN1.

Figure 6.2-2 presents bar charts showing daily SIAN1 extinction data, including substituted data, for the 2005-2009 progress period years. Original RHR data are shown in blue and substituted data by species in the standard IMPROVE colors. Substituted days are also identified with a black bar underneath the day. The red line indicates the threshold above which days are counted in the 20% worst days for that year. Note that some of the substituted days had partial data available, and only individual species missing in a given sample were substituted. Figure 6.2-3 presents similar bar charts showing all species, with days in which all or part of the day was substituted indicated by a black bar underneath the day. Note that very few of the substituted days were counted among the 20% worst days for the substituted years. All summaries for the SIAN1 site in this progress report support document include these substituted data, and substituted data and detailed methodology information will also be made available on the WRAP TSS website.[70]

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[70] Tools and information supporting WRAP state RHR SIPs and progress reports are available on the WRAP TSS website at http://vista.cira.colostate.edu/tss/.

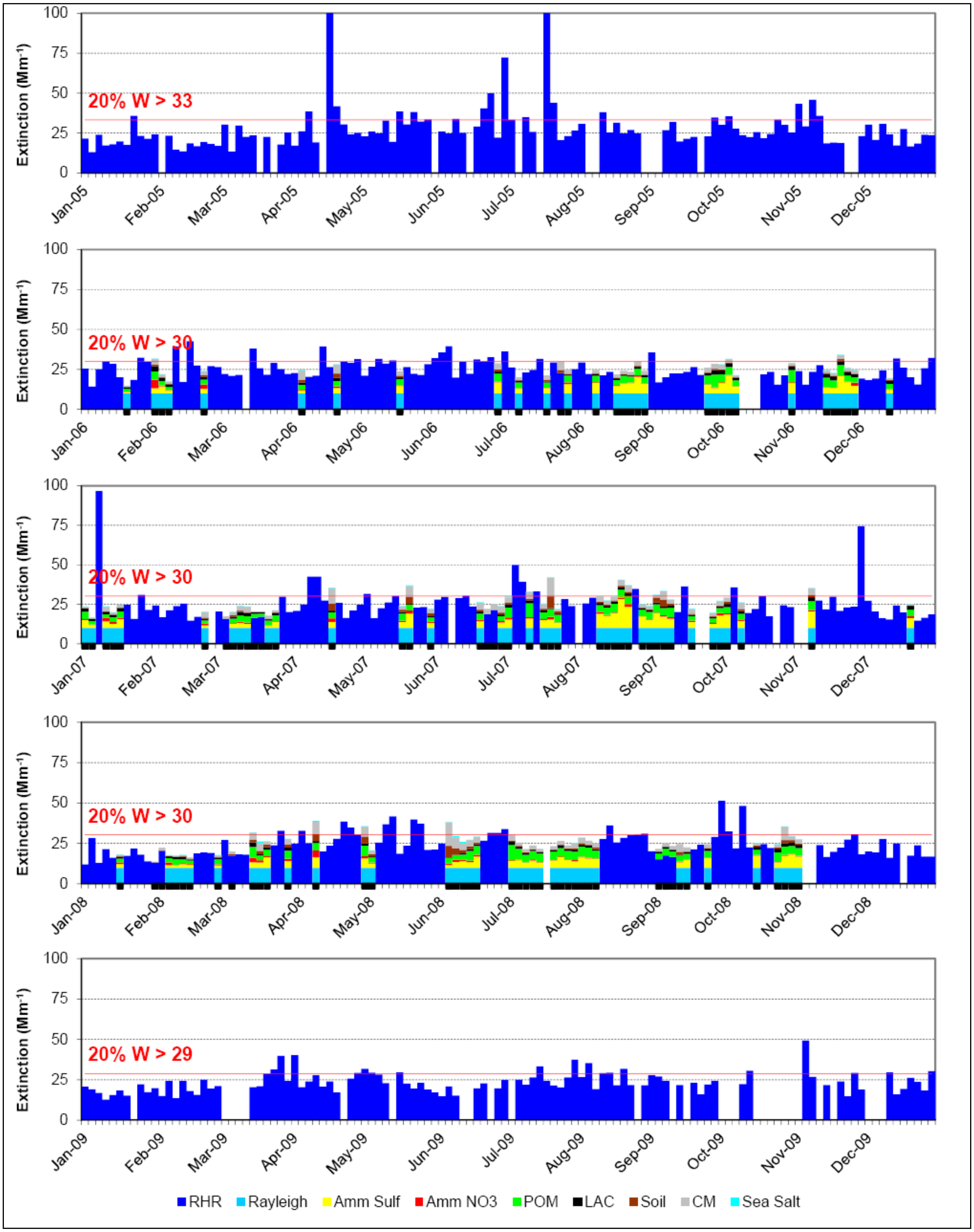

Figure 6.2-2. IMPROVE SIAN1 Data Collected During the 2005-2009 Progress Period, Where Original SIAN1 RHR Data Are Depicted in Dark Blue, and Substituted Data Are Depicted with Separate Colors by Species.

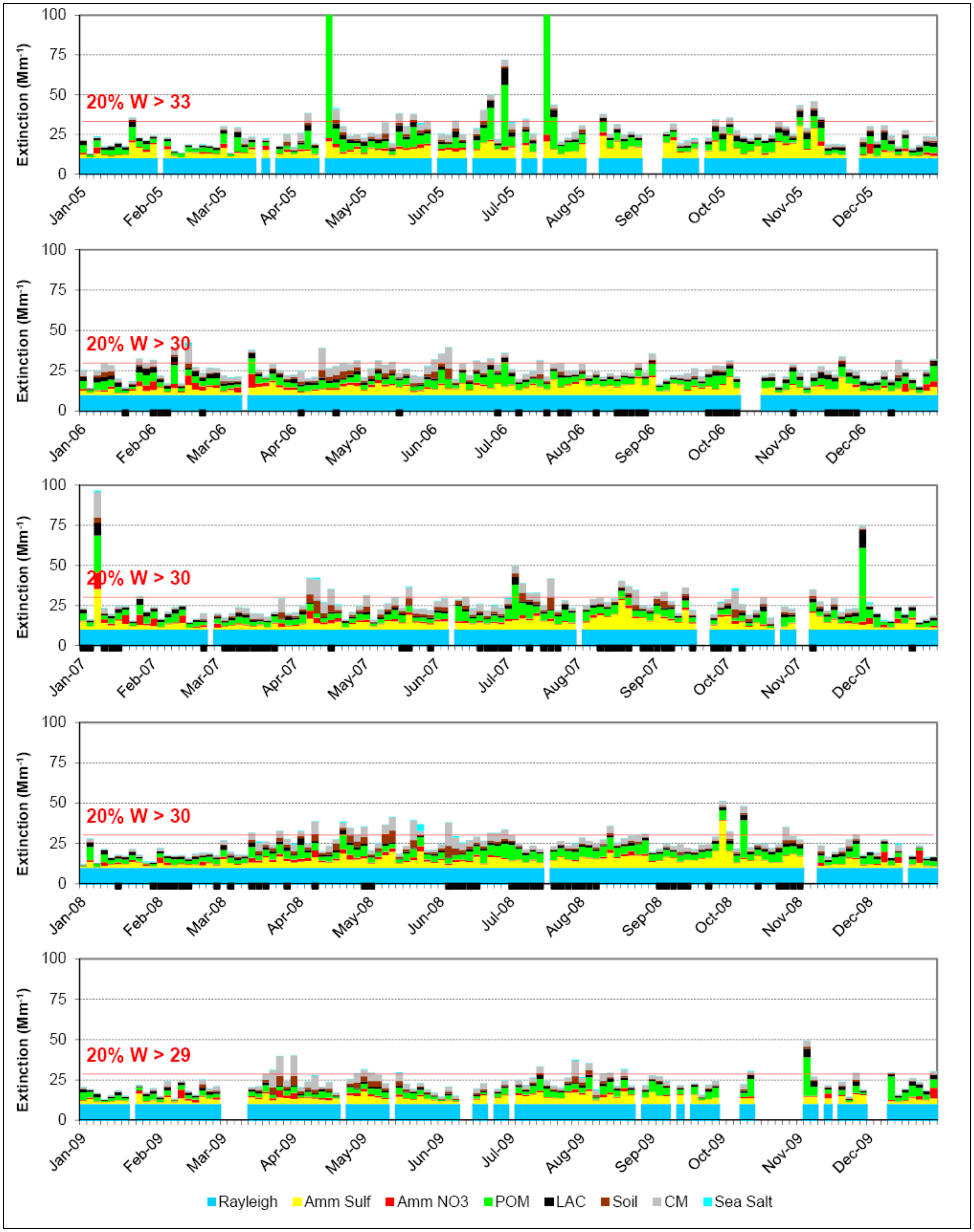

Figure 6.2-3. IMPROVE SIAN1 Data Collected During the 2005-2009 Progress Period, Where Substituted Days Are Depicted with a Black Bar Beneath the Data.

6.2.1.2 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.308 (g)(3)(i))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[71] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.2-4 and 6.2-5 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired, or worst, and 20% least impaired, or best, days, respectively, for each of the Federal CIA IMPROVE monitors in Arizona. Figure 6.2-4 presents 5-year average extinction for the current progress period for both the 20% most impaired and 20% least impaired days. Note that the percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired days are as follows:

- The largest contributors to aerosol extinction at Arizona sites were particulate organic mass, ammonium sulfate, and coarse mass.
- The highest aerosol extinction (15.2 dv) was measured at the SYCA1 site, where particulate organic mass was the largest contributor to aerosol extinction, followed by coarse mass. The lowest aerosol extinction (11.8 dv) was measured at the BALD1 site.

Specific observations for the current visibility conditions on the 20% least impaired days are as follows:

- The aerosol contribution to total extinction on the best days was less than Rayleigh, or the background scattering that would occur in clear air. Average extinction (including Rayleigh) ranged from 2.2 deciview (GRCA2) to 8.0 deciview (SAWE1).
- For all sites except SIAN1 and SAWE1, ammonium sulfate was the largest contributor to aerosol extinction.
- At the SIAN1 site, particulate organic mass was the largest contributor to aerosol extinction, followed by ammonium sulfate. At the SAWE1 site, coarse mass was the largest contributor, followed by ammonium sulfate.

[71] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

Table 6.2-2
Arizona Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank*						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
BALD1	11.8	25% (2)	4% (6)	**42% (1)**	8% (4)	6% (5)	16% (3)	0% (7)
CHIR1	12.2	**36% (1)**	5% (5)	16% (3)	5% (6)	10% (4)	27% (2)	1% (7)
GRCA2	12.0	22% (2)	7% (5)	**41% (1)**	11% (4)	6% (6)	12% (3)	0% (7)
IKBA1	13.4	26% (2)	8% (5)	**29% (1)**	8% (6)	8% (4)	21% (3)	1% (7)
PEFO1	13.0	23% (2)	5% (6)	**31% (1)**	11% (4)	8% (5)	21% (3)	1% (7)
SAGU1	13.6	25% (2)	9% (5)	18% (3)	8% (6)	11% (4)	**28% (1)**	1% (7)
SAWE1	14.9	21% (2)	11% (5)	16% (3)	8% (6)	13% (4)	**31% (1)**	1% (7)
SIAN1	13.0	25% (2)	6% (6)	**33% (1)**	9% (4)	8% (5)	19% (3)	1% (7)
SYCA1	15.2	15% (4)	4% (6)	**29% (1)**	9% (5)	15% (3)	28% (2)	0% (7)
TONT1	13.8	**28% (1)**	8% (5)	21% (3)	7% (6)	9% (4)	26% (2)	1% (7)

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.2-3
Arizona Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank*						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
BALD1	2.9	**36% (1)**	7% (5)	26% (2)	13% (4)	4% (6)	13% (3)	1% (7)
CHIR1	4.4	**38% (1)**	7% (5)	17% (3)	10% (4)	6% (6)	21% (2)	1% (7)
GRCA2	2.2	**45% (1)**	13% (4)	15% (2)	9% (5)	4% (6)	14% (3)	1% (7)
IKBA1	5.1	**29% (1)**	10% (5)	28% (2)	12% (4)	5% (6)	14% (3)	1% (7)
PEFO1	4.6	**31% (1)**	9% (5)	21% (2)	19% (3)	6% (6)	14% (4)	0% (7)
SAGU1	6.7	**28% (1)**	8% (6)	20% (3)	12% (4)	8% (5)	21% (2)	2% (7)
SAWE1	8.0	24% (2)	8% (6)	18% (3)	11% (4)	10% (5)	**26% (1)**	2% (7)
SIAN1	5.3	27% (2)	7% (5)	**32% (1)**	17% (3)	5% (6)	13% (4)	1% (7)
SYCA1	5.1	**27% (1)**	10% (5)	23% (2)	17% (3)	7% (6)	15% (4)	1% (7)
TONT1	5.7	**33% (1)**	9% (5)	23% (2)	12% (4)	6% (6)	16% (3)	1% (7)

*Highest aerosol species contribution per site is highlighted in bold.

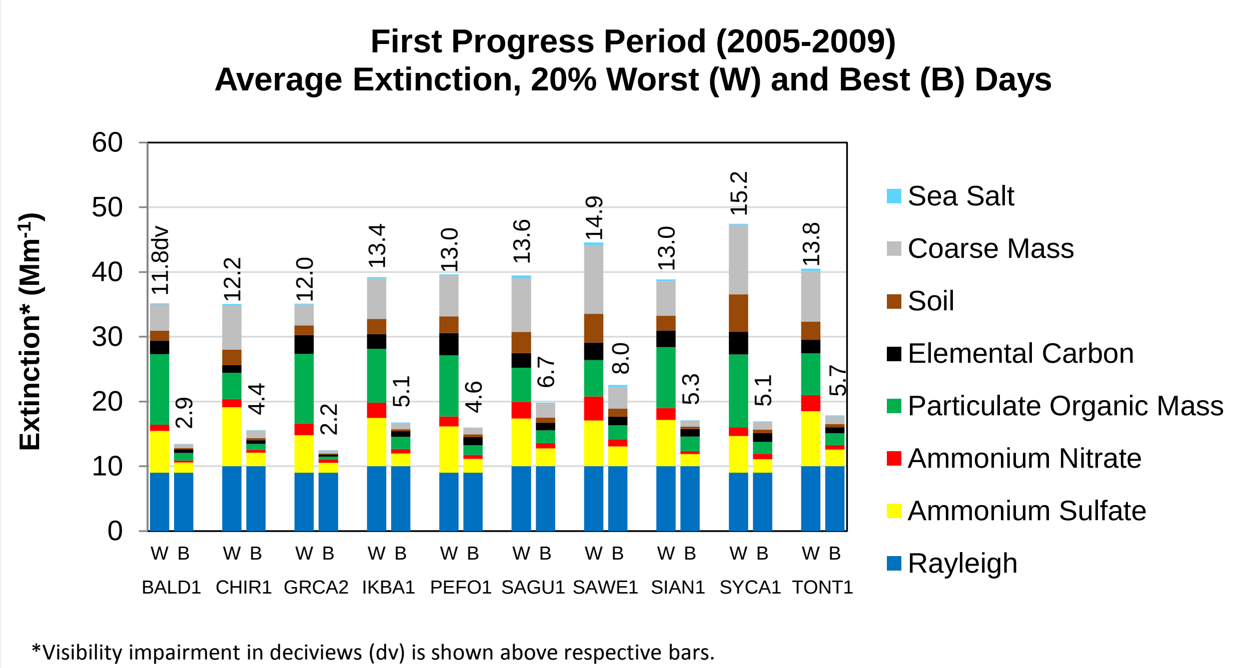

Figure 6.2-4. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at Arizona Class I Area IMPROVE Sites.

6.2.1.3 Differences between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.308 (g)(3)(ii))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Tables 6.2-4 and 6.2-5 present the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for each site in Arizona for the 20% most impaired and 20% least impaired days, respectively. Averages that increased are depicted in red text and averages that decreased in blue.

Figure 6.2-5 presents the 5-year average extinction for the baseline and current progress period averages for the worst days and Figure 6.2-6 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.2-7 and 6.2-8 present similar plots for the best days.

For the 20% most impaired days, the 5-year average RHR deciview metric increased between the 2000-2004 and 2005-2009 periods at the GRCA2 and IKBA1 sites and decreased at all other Arizona sites. Notable differences for individual species averages were as follows:

- All sites except GRCA2 and IKBA1 measured decreases in particulate organic mass.

- Increases in deciview at the GRCA2 site were mostly due to increases in ammonium sulfate and elemental carbon. These increases were partially offset by decreases in ammonium nitrate and coarse mass.
- Increases in deciview at the IKBA1 site were mostly due to increased ammonium sulfate and particulate organic mass measurements. These increases were partially offset by decreases in ammonium nitrate and soil.
- All sites except SAGU1 and SAWE1 measured increases in ammonium sulfate. The largest increases in ammonium sulfate were measured at the CHIR1, IKBA1, and TONT1 sites.
- All sites measured decreases in ammonium nitrate. The largest decreases in ammonium nitrate were measured at the IKBA1, SAGU1, and SAWE1 sites.

For the 20% least impaired days, the 5-year average deciview metric decreased at all sites except GRCA2, where the measured deciview average remained relatively unchanged. Notable differences for individual species averages on the 20% least impaired days were as follows:

- The largest decreases were due to particulate organic mass, which decreased at all sites except IKBA1.
- Ammonium sulfate decreased at most sites, but increased slightly at the GRCA2, SAGU1, and SYCA1 sites.
- Ammonium nitrate decreased at all but the GRCA2 site.

Table 6.2-4
Arizona Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-2004 Baseline Period	2005-2009 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
BALD1	11.8	11.8	0.0	+0.3	-0.1	-2.1	-0.7	+0.4	+1.3	+0.1
CHIR1	13.4	12.2	-1.2	+1.0	-0.1	-3.2	-0.5	-0.3	-1.9	+0.2
GRCA2	11.7	12.0	+0.3	+0.5	-0.4	+0.1	+0.5	+0.1	-0.3	0.0
IKBA1	13.3	13.4	+0.1	+1.0	-1.2	+0.7	0.0	-0.3	0.0	+0.1
PEFO1	13.2	13.0	-0.2	+0.5	-0.3	-1.4	+0.5	+0.6	-1.0	+0.1
SAGU1	14.8	13.6	-1.2	-0.1	-3.2	-4.1	-0.9	-0.1	+1.2	+0.2
SAWE1	16.2	14.9	-1.3	-0.7	-2.3	-1.9	-0.5	-1.4	-2.2	+0.2
SIAN1	13.7	13.0	-0.7	+0.7	-0.3	-2.5	+0.1	+0.1	-0.6	+0.2
SYCA1	15.3	15.2	-0.1	+0.7	-0.7	-0.5	+0.4	-1.0	+1.4	0.0
TONT1	14.2	13.8	-0.4	+1.3	-0.5	-3.5	-0.6	+0.4	+0.5	+0.2

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.2-5
Arizona Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-2004 Baseline Period	2005-2009 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
BALD1	3.0	2.9	**-0.1**	0.0	**-0.1**	**-0.1**	0.0	0.0	**+0.1**	0.0
CHIR1	4.9	4.4	**-0.5**	**-0.2**	**-0.1**	**-0.5**	**-0.1**	0.0	0.0	0.0
GRCA2	2.2	2.2	0.0	**+0.1**	0.0	**-0.1**	0.0	0.0	0.0	0.0
IKBA1	5.4	5.1	**-0.3**	**-0.3**	**-0.2**	**+0.1**	0.0	**-0.1**	**-0.1**	**+0.1**
PEFO1	5.0	4.6	**-0.4**	**-0.1**	**-0.2**	**-0.4**	0.0	**+0.1**	0.0	0.0
SAGU1	6.9	6.7	**-0.2**	**+0.1**	**-0.2**	**-0.2**	**-0.1**	**-0.3**	**+0.3**	**+0.1**
SAWE1	8.6	8.0	**-0.6**	**-0.2**	**-0.1**	**-0.5**	**-0.4**	**-0.3**	**+0.2**	**+0.2**
SIAN1	6.2	5.3	**-0.9**	**-0.3**	**-0.4**	**-0.7**	**-0.1**	0.0	0.0	0.0
SYCA1	5.6	5.1	**-0.5**	**+0.1**	**-0.1**	**-0.6**	**-0.2**	**-0.1**	**+0.1**	0.0
TONT1	6.5	5.7	**-0.8**	**-0.2**	**-0.2**	**-0.5**	**-0.2**	**-0.1**	**-0.2**	**+0.1**

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

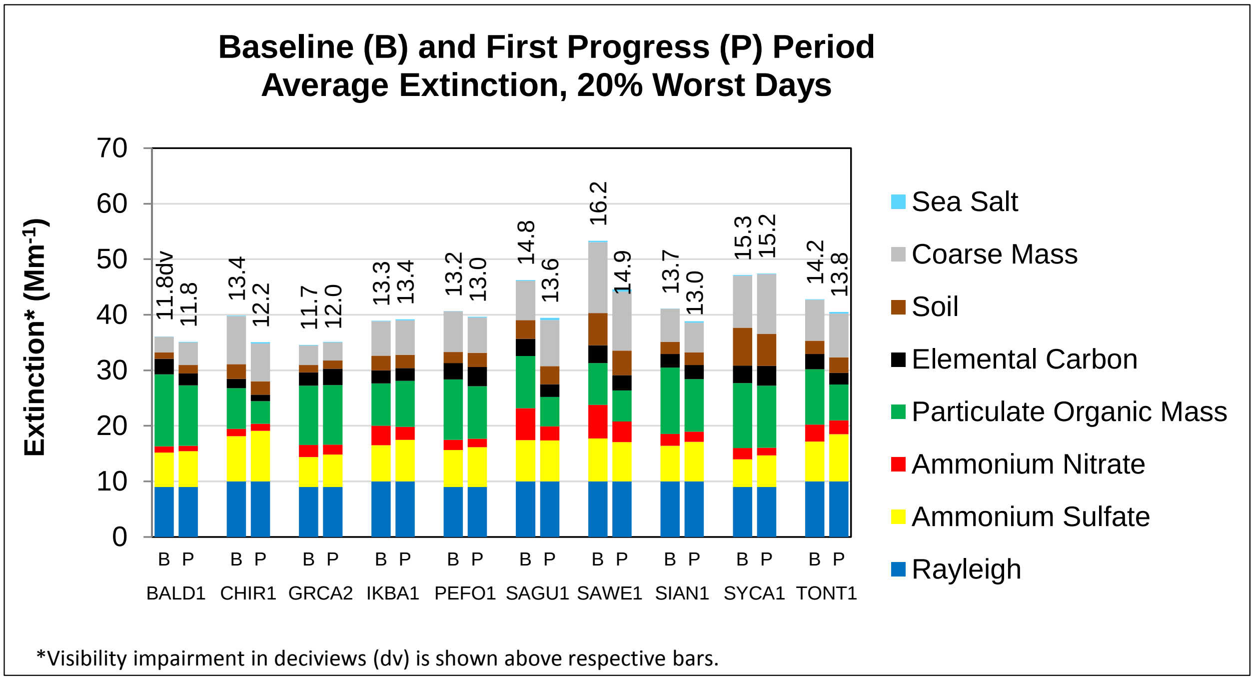

Figure 6.2-5. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at Arizona Class I Area IMPROVE Sites.

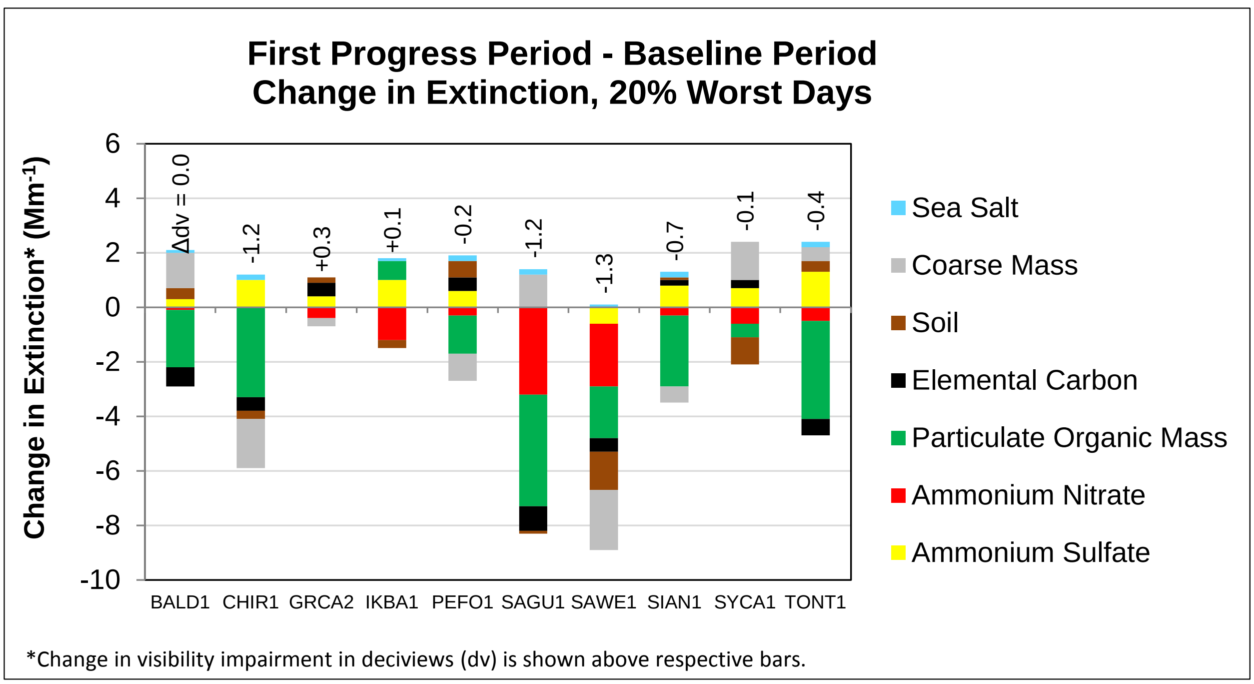

Figure 6.2-6. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at Arizona Class I Area IMPROVE Sites.

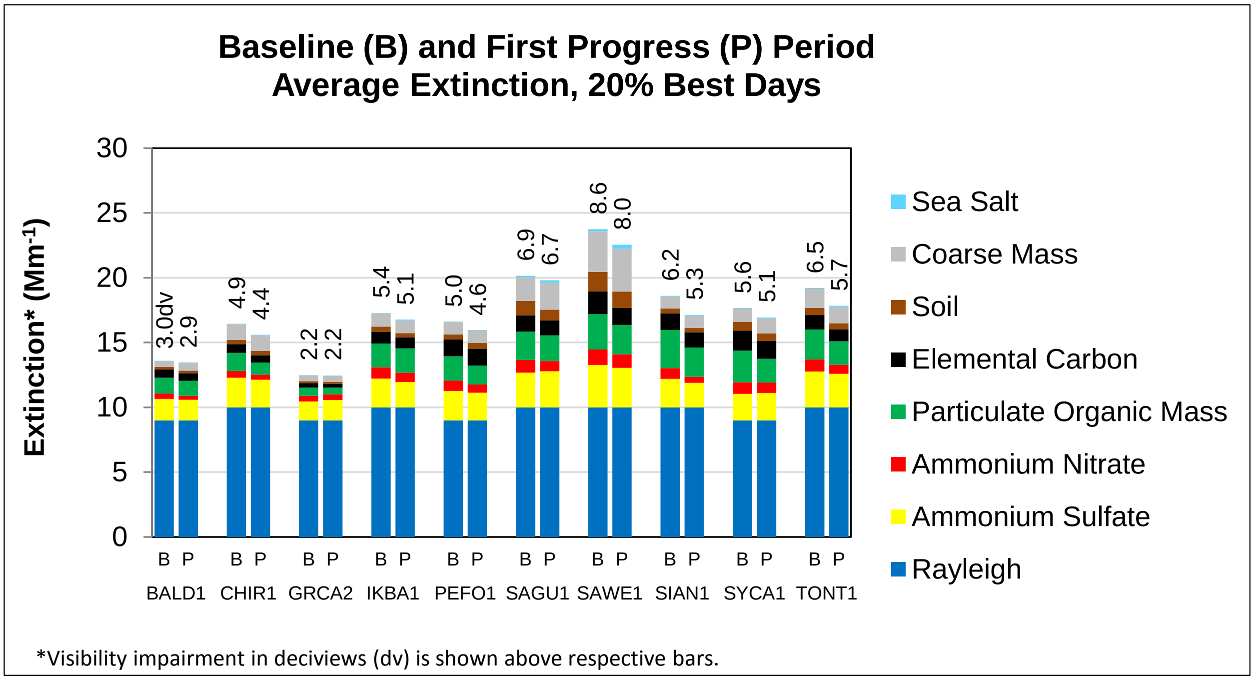

Figure 6.2-7. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at Arizona Class I Area IMPROVE Sites.

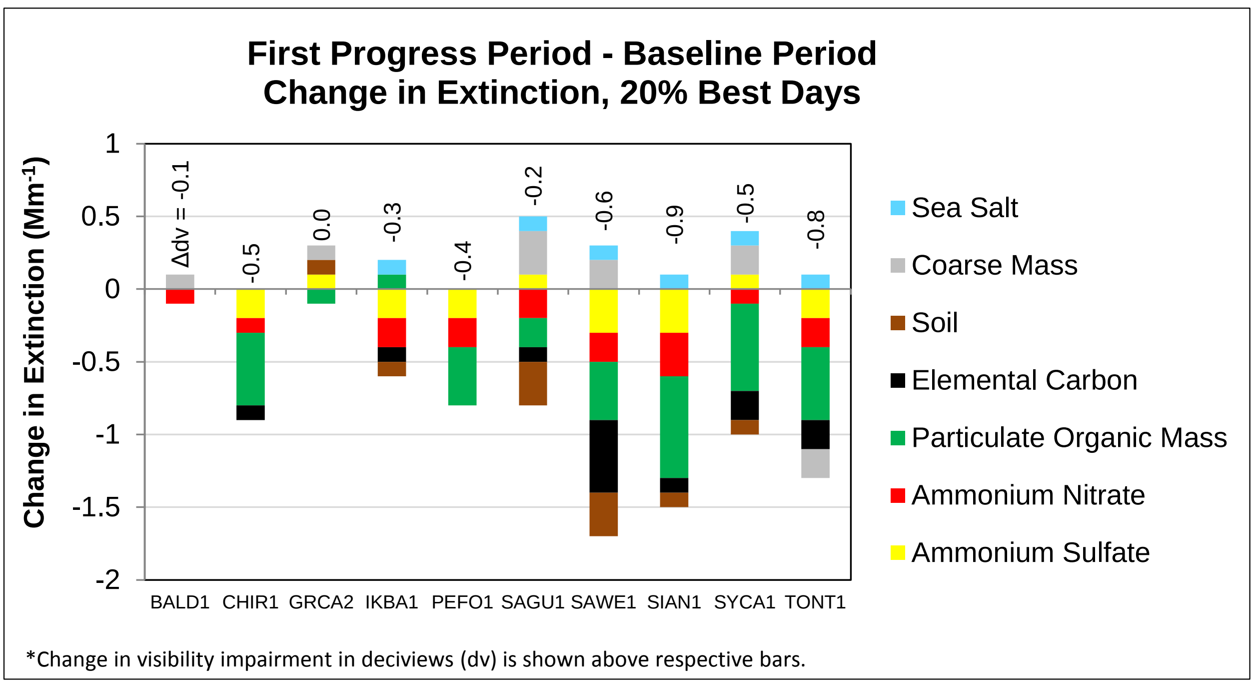

Figure 6.2-8. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at Arizona Class I Area IMPROVE Sites.

6.2.1.4 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.308 (g)(3)(iii))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5-year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in Arizona are summarized in Table 6.2-6, and regional trends were presented earlier in Section 4.1.1.[72] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[73] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix B. Additionally, this appendix includes plots depicting 5-year, annual, monthly, and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in Arizona are as follows:

- The 5-year deciview metric increased for the 20% worst days at both the GRCA2 and IKBA1 sites. No statistically significant increasing trends were calculated at these sites, and a statistically significant decreasing trend of ~0.1 Mm^{-1}/year was observed for annual average ammonium nitrate.
- 5-year average particulate organic mass decreased at most Arizona sites, with the exception of GRCA2 and IKBA1. Neither site showed increasing trends in particulate organic mass. Higher progress period measurements at GRCA2 were influenced by

[72] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)

[73] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

large events between June and August of 2009. Higher progress period measurements at IKBA1 were influenced by large events in July 2005.

- 5-year average ammonium sulfate increased at all Arizona sites except SAGU1 and SAWE1, but no statistically significant increasing annual trends in ammonium sulfate were measured. Decreasing annual ammonium sulfate trends on the order of about 0.1 Mm^{-1}/year were measured at the BALD1, CHIR1, SAGU1, and SAWE1 sites. Anomalously high ammonium sulfate averages occurred in 2005 at most Arizona sites, which influenced the increases in the 5-year average metrics.
- The 5-year average ammonium nitrate metric decreased at all Arizona sites for the worst, and either remained the same or decreased for the best days. Analysis of all measured days showed no increasing trends, and decreasing trends on the order of 0.1 Mm^{-1}/year at the IKBA1, SAGU1, SAWE1, SIAN1, and TONT1 sites.
- The BALD1 and PEFO1 sites showed a statistically significant increasing trend for coarse mass for all measured days on the order of approximately 0.1 Mm^{-1}/year. Neither site saw an increase in 5-year deciview metric for either the best or worst day averages, and the PEFO1 site measured a decrease in 5-year average coarse mass.
- Soil measured highest at the SYCA1 and SAGU1 sites, and the 5-year average metric for soil decreased at these sites for both the worst and best days. For the annual average of all measured days, no increasing trends were apparent, and the SYCA1 site measured a statistically significant decreasing trend on the order of approximately 0.1 Mm^{-1}/year.

Table 6.2-6
Arizona Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
BALD1	20% Best	--	0.0	--	0.0	--	0.0	0.0
	20% Worst	**-0.2**	--	--	--	**0.1**	**0.3**	0.0
	All Days	**-0.1**	0.0	--	--	--	**0.1**	0.0
CHIR1	20% Best	0.0	0.0	**-0.1**	0.0	--	0.0	0.0
	20% Worst	--	--	**-0.7**	**-0.1**	--	--	0.0
	All Days	**-0.1**	0.0	**-0.2**	**-0.1**	--	**-0.1**	0.0
GRCA2	20% Best	--	--	--	0.0	--	--	0.0
	20% Worst	--	**-0.1**	--	--	--	--	--
	All Days	--	0.0	--	--	--	--	--
IKBA1	20% Best	**-0.1**	**-0.1**	0.0	0.0	0.0	--	0.0
	20% Worst	--	--	--	0.0	--	--	0.0
	All Days	--	**-0.1**	--	0.0	--	--	0.0
PEFO1	20% Best	--	0.0	**-0.1**	--	--	--	0.0
	20% Worst	--	--	--	--	**0.1**	--	0.0
	All Days	--	0.0	--	--	0.0	**0.1**	0.0
SAGU1	20% Best	--	**-0.1**	**-0.1**	--	--	--	--
	20% Worst	**-0.4**	**-0.5**	**-0.6**	**-0.3**	--	--	**0.1**
	All Days	**-0.1**	**-0.1**	**-0.2**	**-0.1**	--	--	0.0
SAWE1	20% Best	0.0	0.0	**-0.1**	**-0.1**	**-0.1**	--	0.0
	20% Worst	**-0.3**	**-0.6**	**-0.5**	--	--	--	0.0
	All Days	**-0.1**	**-0.1**	**-0.3**	**-0.1**	--	--	0.0
SIAN1	20% Best	**-0.1**	**-0.1**	**-0.1**	0.0	--	--	0.0
	20% Worst	--	--	--	--	--	--	0.0
	All Days	--	**-0.1**	**-0.4**	**-0.1**	--	--	0.0
SYCA1	20% Best	--	--	**-0.1**	--	--	--	0.0
	20% Worst	--	--	--	**0.1**	**-0.3**	--	--
	All Days	--	0.0	--	--	**-0.1**	--	--
TONT1	20% Best	**-0.1**	**-0.1**	**-0.1**	**-0.1**	--	**-0.1**	0.0
	20% Worst	--	**-0.1**	**-0.8**	**-0.2**	--	--	**0.1**
	All Days	--	**-0.1**	**-0.2**	**-0.1**	--	--	0.0

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix B.

6.2.2 Emissions Data

Included here are summaries depicting differences between two emission inventory years that are used to represent the 5-year baseline and current progress periods. The baseline period is represented using a 2002 inventory developed by the WRAP for use in the initial WRAP state SIPs, and the progress period is represented by a 2008 inventory which leverages recent WRAP inventory work for modeling efforts, as referenced in Section 3.2.1. For reference, Table 6.2-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories, and a separate summary of annual emissions from electrical generating units (EGUs), are presented in this section.

Table 6.2-7
Arizona
Pollutants, Aerosol Species, and Major Sources

Emitted Pollutant	Related Aerosol	Major Sources	Notes
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- and Off-Road Mobile Sources	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be associated with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Primary Organic Aerosol (POA)	POM	Wildfires; Area Sources	POA represents organic aerosols that are emitted directly as particles, as opposed to gases. Wildfires in the west generally dominate POA emissions, and large wildfire events are generally sporadic and highly variable from year-to-year.
Elemental Carbon (EC)	EC	Wildfires; On- and Off-Road Mobile Sources	Large EC events are often associated with large POM events during wildfires. Other sources include both on- and off-road diesel engines.
Fine Soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is reported by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$ mass measurements. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but these measurements are generally associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributor to PMC.

6.2.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.308 (g)(4))?*** For these summaries, emissions during the baseline years are represented using a 2002 inventory, which was developed with support from the WRAP for use in the original RHR SIP strategy development (termed plan02d). Differences between inventories are represented as the difference between the 2002 inventory, and a 2008 inventory which leverages recent inventory development work performed by the WRAP for the WestJumpAQMS and Deterministic and Empirical Assessment of Smoke's Contribution to Ozone ($DEASCO_3$) modeling projects (termed WestJump2008). Note that the comparisons of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories, as referenced in Section 3.2.1. Inventories for all major visibility impairing pollutants are presented for major source categories, and categorized as either anthropogenic or natural emissions. State-wide inventories totals and differences are presented here, and inventory totals on a county level basis are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

Table 6.2-8 and Figure 6.2-9 present the differences between the 2002 and 2008 sulfur dioxide (SO_2) inventories by source category. Tables 6.2-9 and Figure 6.2-10 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.2-10 through 6.2-15 and Figures 6.2-9 through 6.2-14) present data for ammonia (NH_3), volatile organic compounds (VOCs), primary organic aerosol (POA), elemental carbon (EC), fine soil and coarse mass. General observations regarding emissions inventory comparisons are listed below.

- The largest differences for point source inventories were decreases in SO_2 and NO_X. Note that this is consistent with decreasing annual EGU emissions as presented in Section 6.2.2.2.
- Area source inventories showed increases in all parameters except VOCs, with the largest increases in SO_2 and NO_X. These increases may be due to a combination of population changes and differences in methodologies used to estimate these emissions, as referenced in Section 3.2.1. One methodology change was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to increases in area source inventory totals, but decreases in off-road mobile totals.
- On-road mobile source inventory comparisons showed decreases in most parameters, especially NO_X and VOCs, with slight increases in POA, EC and coarse mass. Reductions in NO_X and VOC are likely influenced by federal and state emissions standards that have already been implemented. The increases in POA, EC and coarse mass occurred in all of the WRAP states for on-road mobile inventories, regardless of reductions in NO_2 and VOCs, indicating that these increases were likely due use of different on-road models, as referenced in Section 3.2.1.

- Off-road mobile source inventories showed decreases in NO_X, SO_2, and VOCs, and increases in fine soil and coarse mass, which was consistent with most contiguous WRAP states. These differences were likely due to a combination of actual changes in source contributions and methodology differences, as referenced in Section 3.2.1. As noted previously, one major methodology difference was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to decreases in the off-road inventory totals, but increases in area source totals.
- For most parameters, especially POAs, VOCs, EC, and fine soil, fire emission inventory estimates decreased. Note that these differences are not necessarily reflective of changes in monitored data, as the baseline period is represented by an average of 2000-2004 fire emissions, and the progress period is represented only by the fires that occurred in 2008, as referenced in Section 3.2.1.
- Comparisons between VOC inventories showed large decreases in biogenic emissions, which was consistent with other contiguous WRAP states. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions, as referenced in Section 3.2.1.
- Fine soil and coarse mass increased for the windblown dust inventory comparisons and the combined fugitive/road dust inventories. Large variability in changes in windblown dust was observed for the contiguous WRAP states, which was likely due in large part to enhancements in dust inventory methodology, as referenced in Section 3.2.1, rather than changes in actual emissions.

Table 6.2-8
Arizona
Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
	Anthropogenic Sources		
Point	94,716	79,136	-15,580
Area	2,677	3,678	1,001
On-Road Mobile	2,715	812	-1,904
Off-Road Mobile	4,223	673	-3,550
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	190	668	478
Total Anthropogenic	**104,521**	**84,967**	**-19,554 (-19%)**
	Natural Sources		
Natural Fire	4,369	187	-4,182
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**4,369**	**187**	**-4,182 (-96%)**
	All Sources		
Total Emissions	**108,890**	**85,154**	**-23,736 (-22%)**

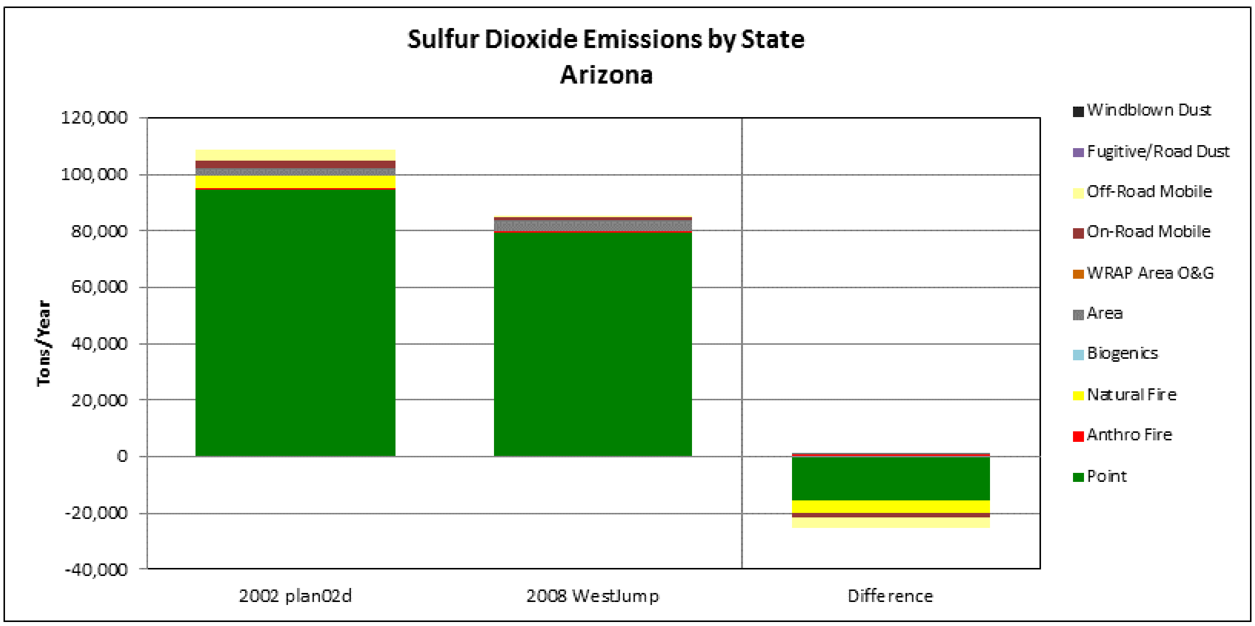

Figure 6.2-9. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for Arizona.

Table 6.2-9
Arizona
Oxides of Nitrogen Emissions by Category

Source Category	Oxides of Nitrogen Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	69,968	60,876	-9,092
Area	9,049	39,403	30,354
On-Road Mobile	178,009	137,555	-40,453
Off-Road Mobile	66,414	33,857	-32,557
Area Oil and Gas	17	0	-17
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	725	4,713	3,988
Total Anthropogenic	**324,182**	**276,405**	**-47,777 (-15%)**
Natural Sources			
Natural Fire	16,493	1,319	-15,174
Biogenic	27,664	15,256	-12,408
Wind Blown Dust	0	0	0
Total Natural	**44,157**	**16,575**	**-27,582 (-62%)**
All Sources			
Total Emissions	**368,339**	**292,980**	**-75,359 (-20%)**

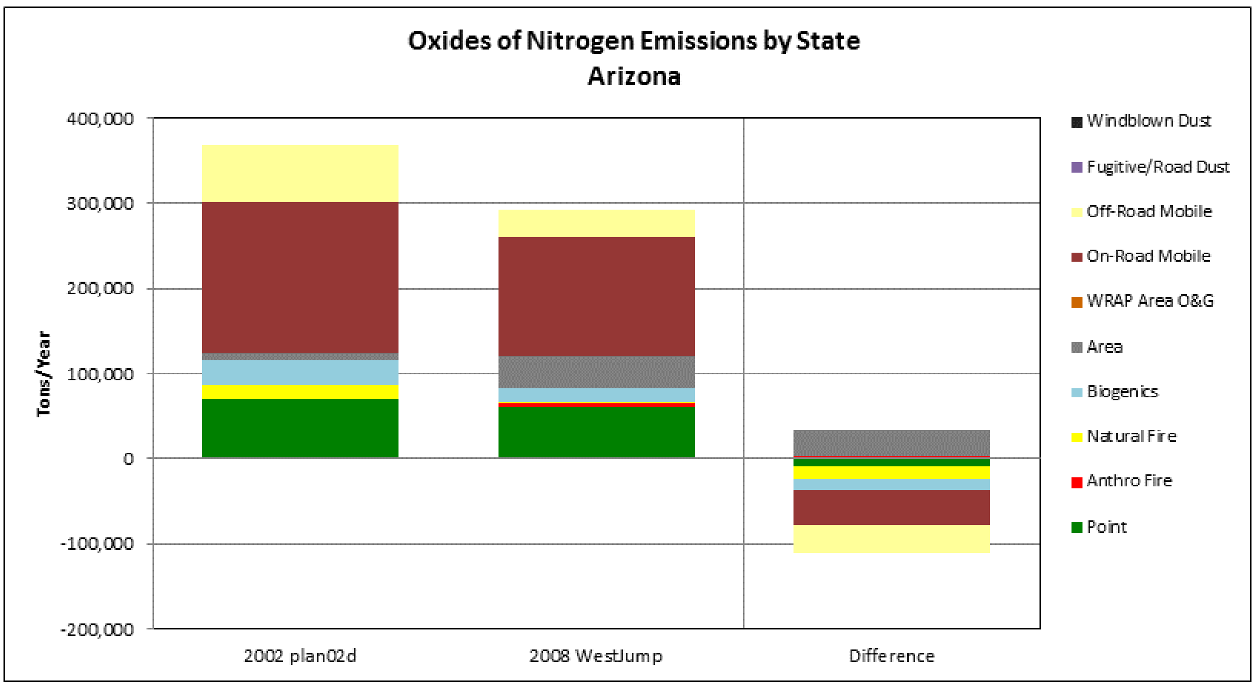

Figure 6.2-10. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Oxides of Nitrogen by Source Category for Arizona.

Table 6.2-10
Arizona
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	531	973	443
Area	32,713	34,878	2,165
On-Road Mobile	5,035	2,377	-2,658
Off-Road Mobile	48	40	-8
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	97	3,273	3,181
Total Anthropogenic	**38,423**	**41,546**	**3,123 (8%)**
Natural Sources			
Natural Fire	3,781	912	-2,869
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**3,781**	**912**	**-2,869 (-76%)**
All Sources			
Total Emissions	**42,203**	**42,457**	**254 (1%)***

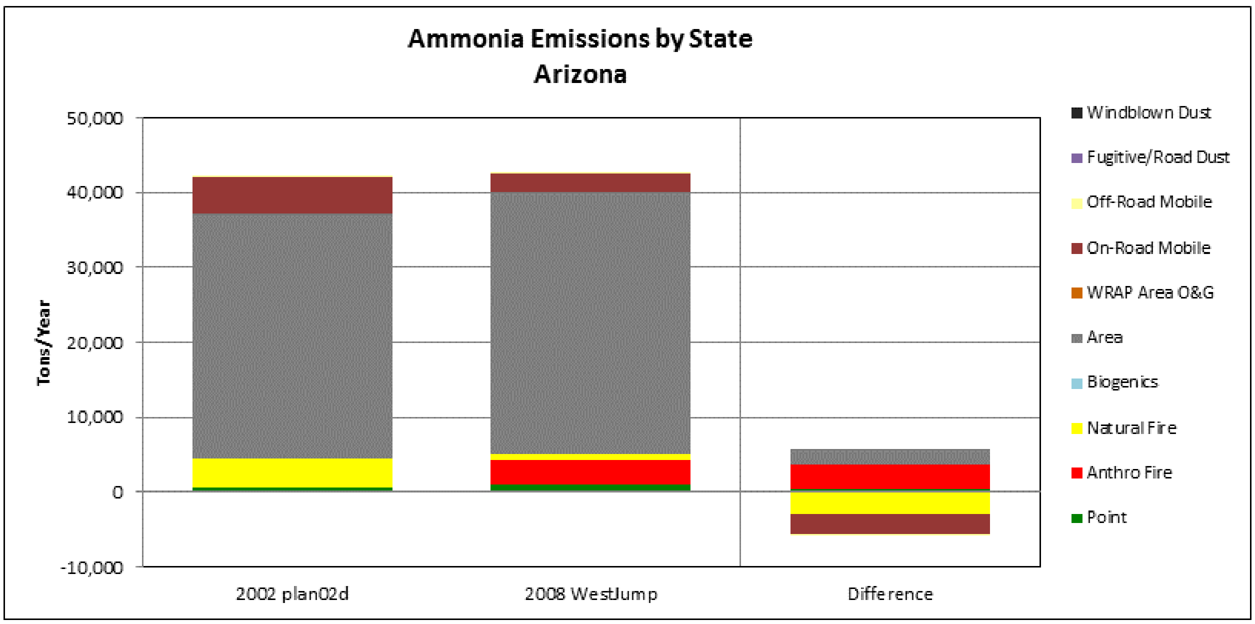

Figure 6.2-11. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Ammonia by Source Category for Arizona.

Table 6.2-11
Arizona
Volatile Organic Compound Emissions by Category

Source Category	Volatile Organic Compound Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	5,464	3,490	-1,974
Area	102,918	100,256	-2,661
On-Road Mobile	110,424	54,589	-55,834
Off-Road Mobile	56,901	42,297	-14,604
Area Oil and Gas	46	12	-34
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	855	5,781	4,926
Total Anthropogenic	**276,608**	**206,426**	**-70,182 (-25%)**
Natural Sources			
Natural Fire	36,377	1,330	-35,047
Biogenic	1,576,698	686,255	-890,443
Wind Blown Dust	0	0	0
Total Natural	**1,613,075**	**687,585**	**-925,490 (-57%)**
All Sources			
Total Emissions	**1,889,682**	**894,011**	**-995,672 (-53%)**

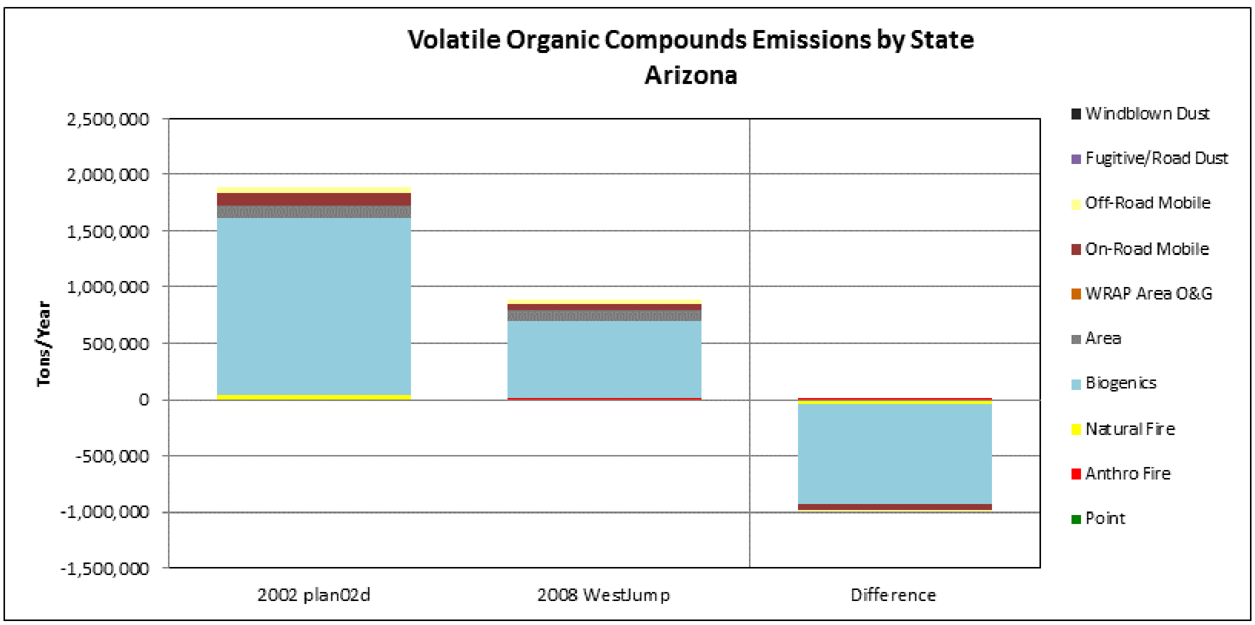

Figure 6.2-12. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for Arizona.

Table 6.2-12
Arizona
Primary Organic Aerosol Emissions by Category

Source Category	Primary Organic Aerosol Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	276	143	-134
Area	4,728	6,445	1,718
On-Road Mobile	1,583	2,666	1,083
Off-Road Mobile	2,006	1,383	-624
Area Oil and Gas	0	0	0
Fugitive and Road Dust	535	1,393	858
Anthropogenic Fire	816	9,818	9,002
Total Anthropogenic	**9,944**	**21,848**	**11,904 (>100%)**
Natural Sources			
Natural Fire	47,810	2,124	-45,685
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**47,810**	**2,124**	**-45,685 (-96%)**
All Sources			
Total Emissions	**57,754**	**23,972**	**-33,782 (-58%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

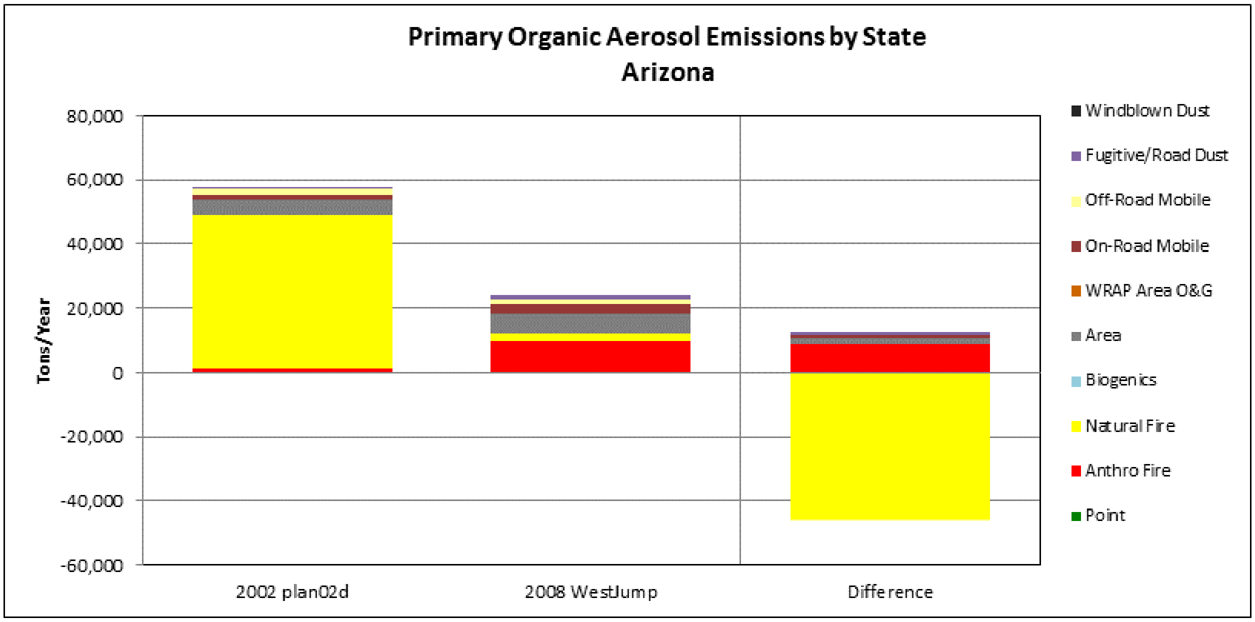

Figure 6.2-13. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Primary Organic Aerosol by Source Category for Arizona.

Table 6.2-13
Arizona
Elemental Carbon Emissions by Category

Source Category	Elemental Carbon Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	26	37	11
Area	449	1,337	889
On-Road Mobile	1,761	5,559	3,798
Off-Road Mobile	2,752	1,813	-940
Area Oil and Gas	0	0	0
Fugitive and Road Dust	39	47	8
Anthropogenic Fire	149	1,582	1,433
Total Anthropogenic	**5,176**	**10,375**	**5,199 (>100%)**
Natural Sources			
Natural Fire	9,570	415	-9,155
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**9,570**	**415**	**-9,155 (-96%)**
All Sources			
Total Emissions	**14,745**	**10,789**	**-3,956 (-27%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

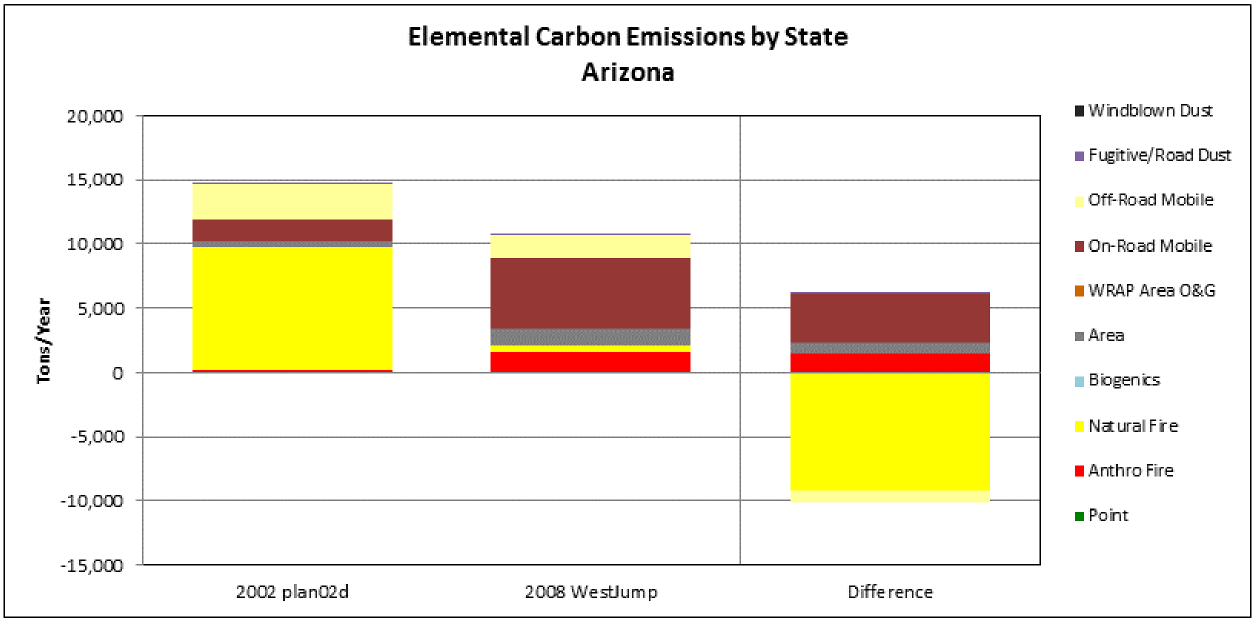

Figure 6.2-14. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Elemental Carbon by Source Category for Arizona.

Table 6.2-14
Arizona
Fine Soil Emissions by Category

Source Category	Fine Soil Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	632	1,515	883
Area	4,223	7,906	3,684
On-Road Mobile	1,080	511	-569
Off-Road Mobile	0	97	97
Area Oil and Gas	0	0	0
Fugitive and Road Dust	10,072	24,592	14,520
Anthropogenic Fire	100	3,584	3,484
Total Anthropogenic	**16,107**	**38,205**	**22,098 (>100%)**
Natural Sources			
Natural Fire	3,845	776	-3,069
Biogenic	0	0	0
Wind Blown Dust	6,422	9,307	2,885
Total Natural	**10,267**	**10,083**	**-183 (-2%)**
All Sources			
Total Emissions	**26,373**	**48,288**	**21,915 (83%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

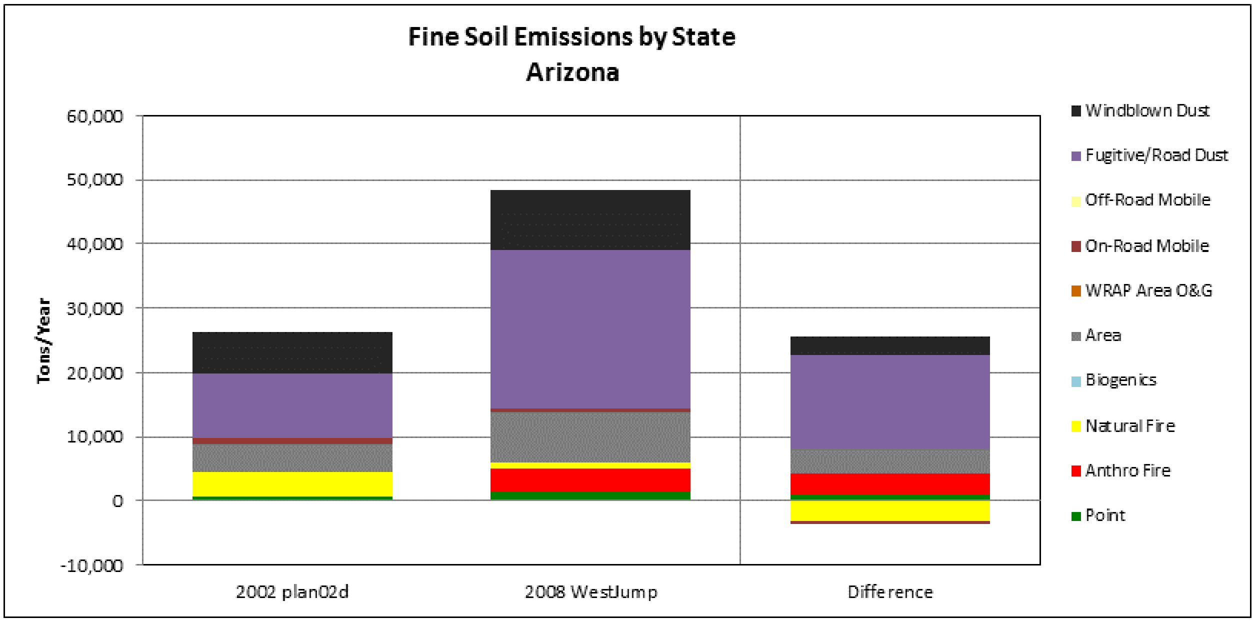

Figure 6.2-15. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Fine Soil by Source Category for Arizona.

Table 6.2-15
Arizona
Coarse Mass Emissions by Category

Source Category	Coarse Mass Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	8,473	4,406	-4,068
Area	1,384	2,389	1,005
On-Road Mobile	1,004	5,597	4,593
Off-Road Mobile	0	162	162
Area Oil and Gas	0	0	0
Fugitive and Road Dust	79,316	141,117	61,801
Anthropogenic Fire	17	1,873	1,856
Total Anthropogenic	**90,195**	**155,545**	**65,350 (72%)**
Natural Sources			
Natural Fire	10,107	403	-9,704
Biogenic	0	0	0
Wind Blown Dust	57,796	83,765	25,969
Total Natural	**67,904**	**84,169**	**16,265 (24%)**
All Sources			
Total Emissions	**158,099**	**239,714**	**81,615 (52%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

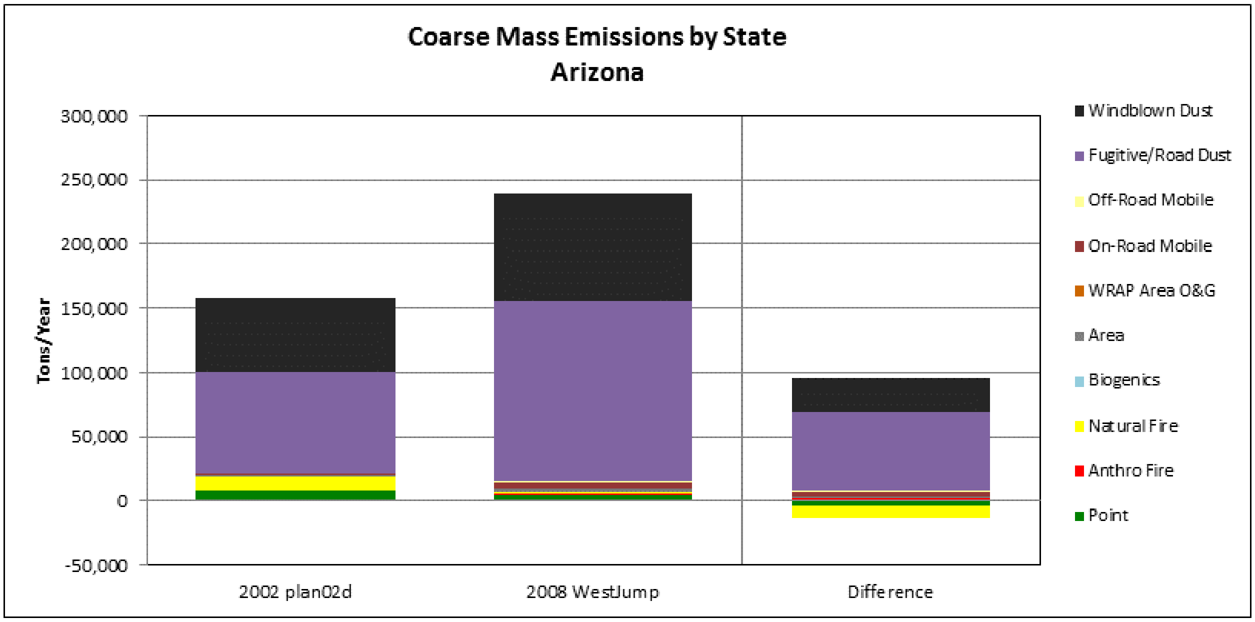

Figure 6.2-16. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Coarse Mass by Source Category for Arizona.

6.2.2.2 EGU Summary

As described in previous sections, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions because numerous updates in inventory methodologies have occurred between the development of the separate inventories. Also, the 2002 baseline and 2008 progress period inventories represent only annual snapshots of emissions estimates, which may not be representative of entire 5-year monitoring periods compared. To better account for year-to-year changes in emissions, annual emission totals for Arizona electrical generating units (EGU) are also presented. EGU emissions are some of the more consistently reported emissions, as tracked in EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/). RHR implementation plans are required to pay specific attention to certain major stationary sources, including EGUs, built between 1962 and 1977.

Figure 6.2-17 presents a sum of annual NO_X and SO_2 emissions as reported for Arizona EGU sources between 1996 and 2010. While these types of facilities are targeted for controls in state regional haze SIPs, it should be noted that many of the controls planned for EGUs in the WRAP states had not taken place yet in 2010, while other controls separate from the RHR may have been implemented. The chart shows a period of decline for SO_2 between 2003 and 2009. NO_X emissions have been decreasing fairly steadily since 2000. Reductions for both SO_2 and NO_X were interrupted by slight increases in 2007.

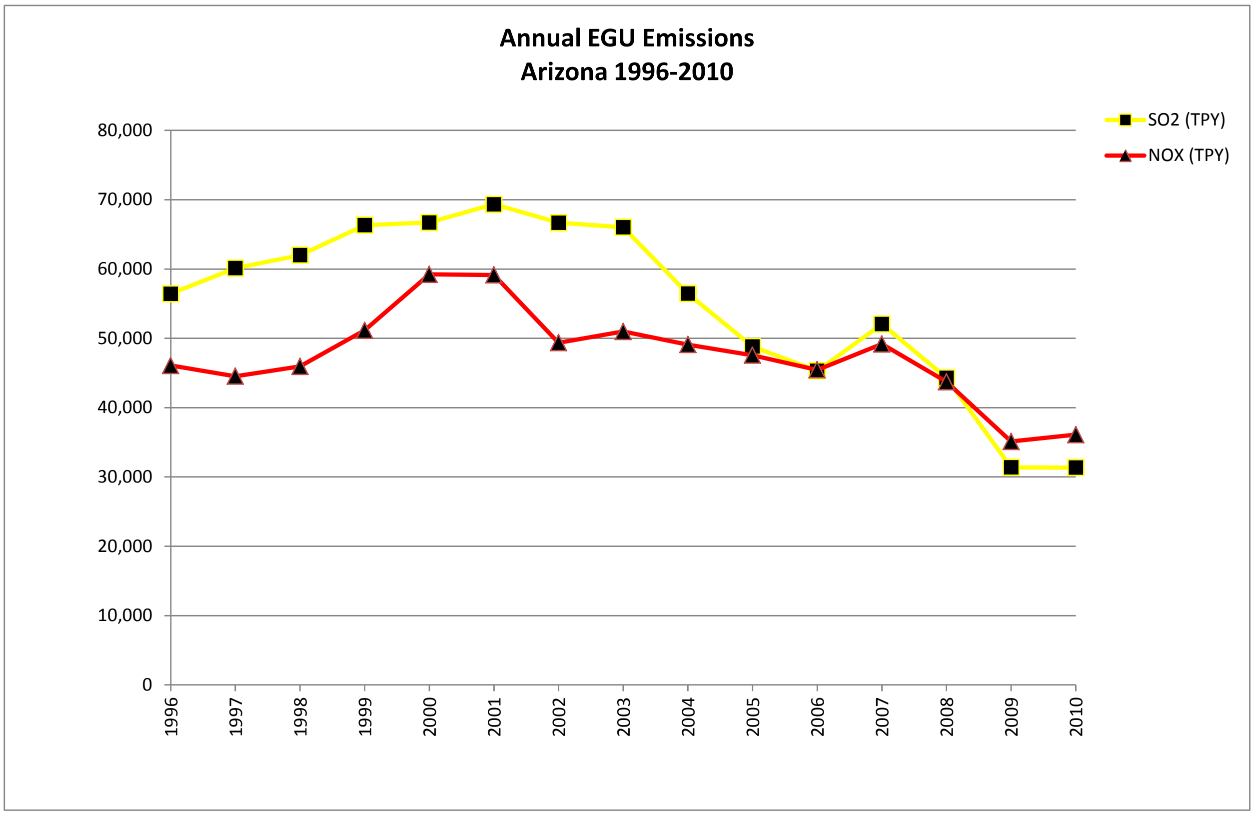

Figure 6.2-17. Sum of EGU Emissions of SO_2 and NOx Reported between 1996 and 2010 for Arizona.

6.3 CALIFORNIA

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. California has 29 mandatory Federal CIAs, which are depicted in Figure 6.3-1 and listed in Table 6.3-1, along with the associated IMPROVE monitor locations. In summaries here, monitors are grouped according to regions defined in California's 2009 Regional Haze Plan.[74]

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per Regional Haze Rule (RHR) requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. Some of the highlights regarding these comparisons are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- For the best days, the 5-year average deciview metric decreased or stayed the same at all California IMPROVE CIA sites.
- For the worst days, the 5-year average deciview metric decreased at most sites, but increased at the LAVO1, BLIS1, KAIS1, RAFA1, and REDW1.
- The largest decreases in 5-year averages on the worst days were due to reductions in ammonium nitrate. This is consistent with emission inventories that showed large reductions in mobile sources.
- The largest increases at sites were due to increased particulate organic mass, where highest particulate organic mass measurements were generally during the summer months, consistent with wildfire activity and biogenic activity in forested areas.
- Increases in 5-year average ammonium sulfate were observed at most sites, but increasing annual average trends were only observed at the northeast California sites, (and nearby southwest Oregon sites). Emissions inventories showed net decreases in state-wide SO_2 for all categories, but off-shore emissions that may have affected these northeastern coastal sites are not explicitly represented here.

[74] California's Regional Haze Plan is available on the California Environmental Protection Agency Air Resources Board website at http://www.arb.ca.gov/planning/reghaze/reghaze.htm.

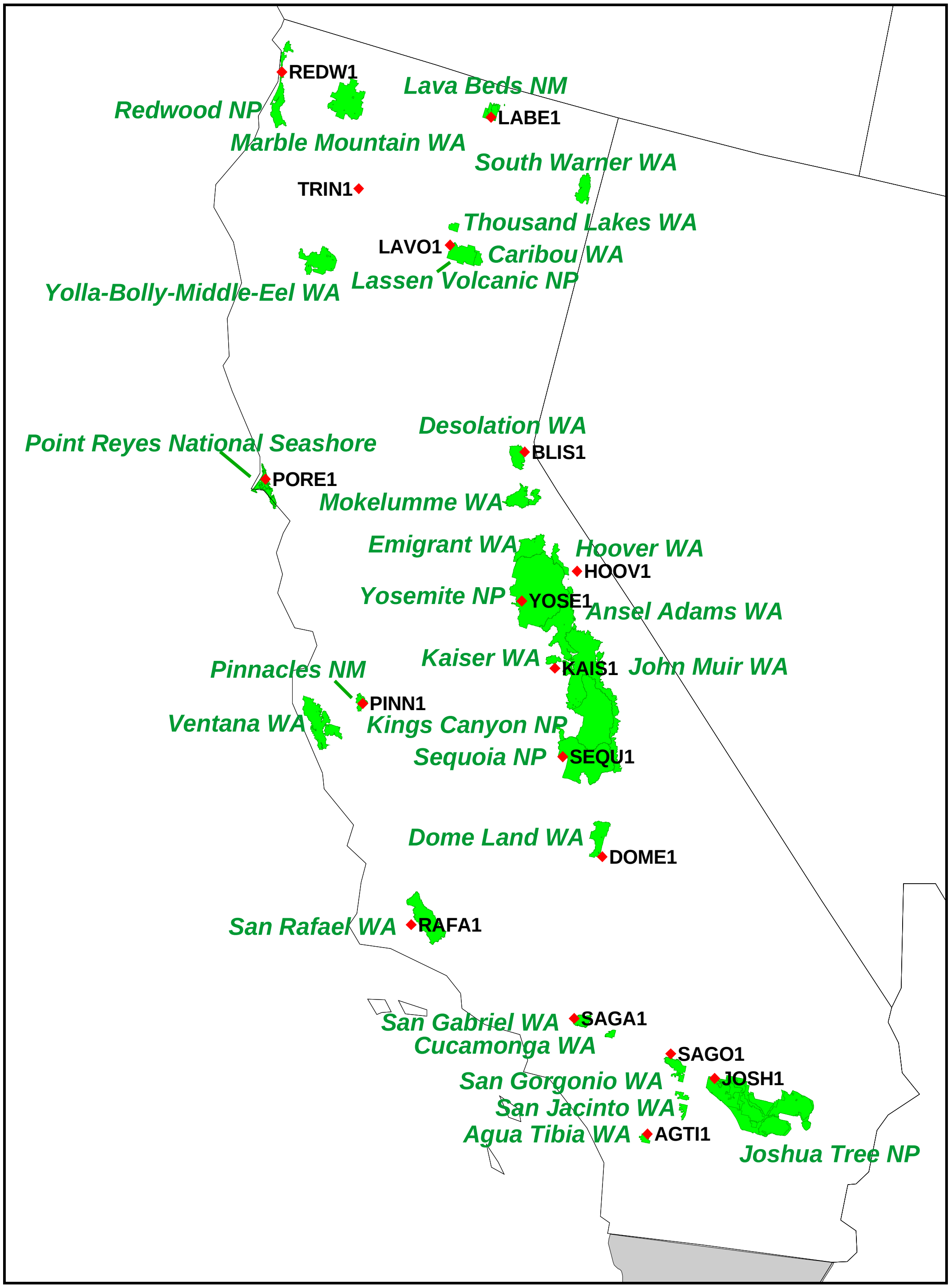

Figure 6.3-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in California.

Table 6.3-1
California CIAs and Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Northern California				
Lava Beds NM South Warner WA	LABE1	41.71	-121.51	1459
Lassen Volcanic NP Thousand Lakes WA Caribou WA	LAVO1	40.54	-121.58	1732
Marble Mountain WA Yolla-Bolly-Middle-Eel WA	TRIN1	40.79	-122.80	1014
Sierra California				
Desolation WA Mokelumne WA	BLIS1	38.98	-120.10	2130
Dome Land WA	DOME1	35.73	-118.14	927
Hoover WA	HOOV1	38.09	-119.18	2560
Kaiser WA Ansel Adams WA John Muir WA	KAIS1	37.22	-119.15	2597
Sequoia NP Kings Canyon NP	SEQU1	36.49	-118.83	519
Yosemite NP Emigrant WA	YOSE1	37.71	-119.71	1603
Southern California				
Agua Tibia WA	AGTI1	33.46	-116.97	507
Joshua Tree NP	JOSH1	34.07	-116.39	1235
San Gabriel WA Cucamonga WA	SAGA1	34.30	-118.03	1791
San Gorgonio WA San Jacinto WA	SAGO1	34.19	-116.91	1726
Coastal California				
Pinnacles NM Ventana WA	PINN1	36.48	-121.16	302
Point Reyes National Seashore	PORE1	38.12	-122.91	97
San Rafael WA	RAFA1	34.73	-120.01	956
Redwood NP	REDW1	41.56	-124.08	243

6.3.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by IMPROVE monitors representing Federal CIAs in California. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix C.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.3.1.1 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.308 (g)(3)(i))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[75] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.3-2 and 6.3-3 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired, or worst, and 20% least impaired, or best, days for each of the Federal CIA IMPROVE monitors in California. Figures 6.3-2 through 6.3-5 presents 5-year average extinction by region for the current progress period for both the 20% most impaired and 20% least impaired days. Note that the percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired days are as follows:

Northern California

- At the northern sites, particulate organic mass was the largest contributor to aerosol extinction, followed by ammonium sulfate.

[75] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

Sierra California

- Both the highest and lowest average aerosol extinction for the 20% worst days at California sites were measured in the Sierra California region. SEQU1 recorded the highest average aerosol extinction (23.4 dv) in California for the 2005-2009 progress period. At the SEQU1 site, ammonium nitrate was the largest contributor to haze, followed by particulate organic mass. The HOOV1 site recorded the lowest average aerosol extinction (12.2 dv).
- At all Sierra sites except SEQU1, particulate organic mass was the largest contributor to aerosol extinction. Ammonium sulfate was the second largest contributor to haze at the BLIS1, HOOV1, KAIS1, and YOSE1 sites, and ammonium nitrate was the second largest contributor to haze at the DOME1 site.

Southern California

- At the southern California sites, ammonium nitrate was the largest contributor to aerosol extinction at all sites with the exception of AGTI1.
- At the AGTI1 site, ammonium sulfate was the largest contributor to haze followed by ammonium nitrate.

Coastal California

- At the Coastal sites, sea salt was the largest contributor to aerosol extinction at the PORE1 and REDW1 sites.
- Ammonium sulfate was the largest contributor to aerosol extinction at the PINN1 and RAFA1 sites.

Specific observations for the current visibility conditions on the 20% least impaired days are as follows:

- The aerosol contribution to total extinction on the best days was less than Rayleigh, or the background scattering that would occur in clear air. Average extinction (including Rayleigh) ranged from 1.3 dv (HOOV1) to 9.1 dv (PORE1).
- For all sites except DOME1, ammonium sulfate was the largest contributor to non-Rayleigh aerosol extinction. Particulate organic mass was the largest contributor at DOME1.

Table 6.3-2
California Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
Northern California								
LABE1	14.2	22% (2)	6% (5)	**54% (1)**	9% (3)	2% (6)	7% (4)	0% (7)
LAVO1	16.0	14% (2)	4% (5)	**65% (1)**	10% (3)	2% (6)	6% (4)	0% (7)
TRIN1	17.3	12% (2)	4% (5)	**69% (1)**	8% (3)	1% (6)	4% (4)	0% (7)
Sierra California								
BLIS1	13.6	16% (2)	6% (5)	**60% (1)**	10% (3)	2% (6)	6% (4)	0% (7)
DOME1	19.2	19% (3)	24% (2)	**31% (1)**	6% (5)	2% (6)	18% (4)	0% (7)
HOOV1	12.2	18% (2)	6% (5)	**55% (1)**	11% (3)	3% (6)	8% (4)	0% (7)
KAIS1	15.7	20% (2)	15% (3)	**44% (1)**	7% (5)	3% (6)	10% (4)	0% (7)
SEQU1	23.4	17% (3)	**45% (1)**	26% (2)	6% (5)	1% (6)	6% (4)	0% (7)
YOSE1	16.9	18% (2)	12% (3)	**51% (1)**	9% (4)	2% (6)	8% (5)	0% (7)
Southern California								
AGTI1	20.9	**36% (1)**	28% (2)	15% (3)	6% (5)	1% (7)	11% (4)	3% (6)
JOSH1	17.8	24% (2)	**31% (1)**	20% (3)	7% (5)	3% (6)	13% (4)	1% (7)
SAGA1	18.0	29% (2)	**29% (1)**	21% (3)	8% (5)	2% (6)	10% (4)	1% (7)
SAGO1	20.5	17% (3)	**42% (1)**	23% (2)	7% (5)	2% (6)	9% (4)	1% (7)
Coastal California								
PINN1	18.4	**30% (1)**	24% (3)	25% (2)	6% (5)	1% (7)	9% (4)	5% (6)
PORE1	22.0	25% (3)	27% (2)	7% (5)	2% (6)	0% (7)	9% (4)	**28% (1)**
RAFA1	19.2	**31% (1)**	18% (3)	28% (2)	7% (5)	2% (7)	11% (4)	3% (6)
REDW1	19.1	32% (2)	10% (4)	15% (3)	2% (6)	0% (7)	6% (5)	**34% (1)**

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.3-3
California Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
Northern California								
LABE1	2.8	**40% (1)**	12% (3)	25% (2)	8% (4)	2% (7)	7% (5)	6% (6)
LAVO1	2.5	**43% (1)**	11% (3)	22% (2)	8% (5)	3% (7)	9% (4)	4% (6)
TRIN1	3.2	**41% (1)**	9% (4)	25% (2)	7% (6)	2% (7)	7% (5)	10% (3)
Sierra California								
BLIS1	2.2	**38% (1)**	10% (4)	26% (2)	8% (5)	3% (6)	13% (3)	2% (7)
DOME1	5.1	24% (2)	14% (4)	**27% (1)**	11% (5)	3% (6)	18% (3)	3% (7)
HOOV1	1.3	**44% (1)**	9% (4)	19% (2)	7% (5)	5% (6)	14% (3)	1% (7)
KAIS1	1.6	**36% (1)**	9% (5)	20% (2)	14% (4)	3% (6)	16% (3)	2% (7)
SEQU1	7.9	**27% (1)**	23% (3)	25% (2)	9% (5)	2% (7)	12% (4)	2% (6)
YOSE1	2.9	**40% (1)**	13% (3)	22% (2)	9% (5)	3% (6)	12% (4)	3% (7)
Southern California								
AGTI1	7.4	**24% (1)**	15% (4)	17% (3)	12% (5)	4% (7)	23% (2)	5% (6)
JOSH1	5.3	**30% (1)**	13% (4)	18% (3)	10% (5)	5% (6)	22% (2)	2% (7)
SAGA1	4.5	**30% (1)**	22% (2)	17% (3)	8% (5)	4% (6)	16% (4)	3% (7)
SAGO1	4.5	**30% (1)**	15% (4)	18% (3)	10% (5)	4% (6)	20% (2)	3% (7)
Coastal California								
PINN1	8.0	**32% (1)**	16% (3)	19% (2)	8% (6)	1% (7)	14% (4)	10% (5)
PORE1	9.1	**42% (1)**	12% (3)	7% (5)	3% (6)	1% (7)	12% (4)	24% (2)
RAFA1	5.5	**33% (1)**	19% (2)	15% (3)	6% (6)	2% (7)	15% (4)	9% (5)
REDW1	5.6	**36% (1)**	8% (5)	16% (3)	4% (6)	1% (7)	12% (4)	23% (2)

*Highest aerosol species contribution per site is highlighted in bold.

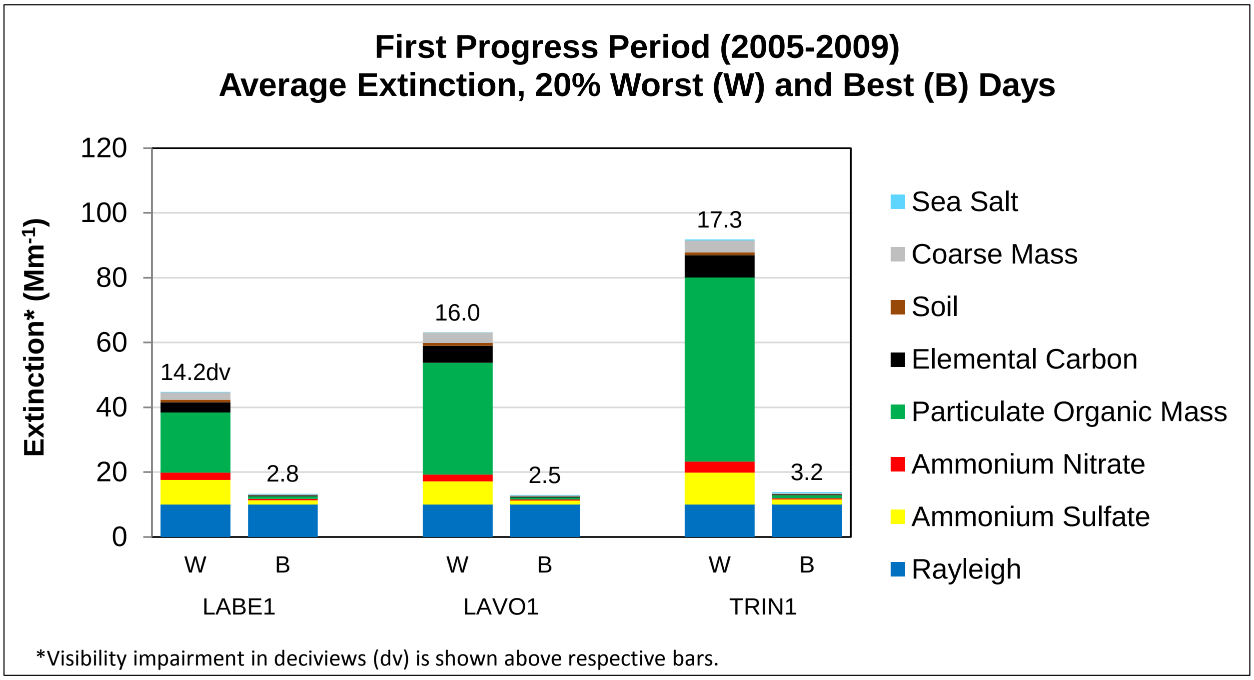

Figure 6.3-2. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at California Class I Area IMPROVE Sites in the Northern Region.

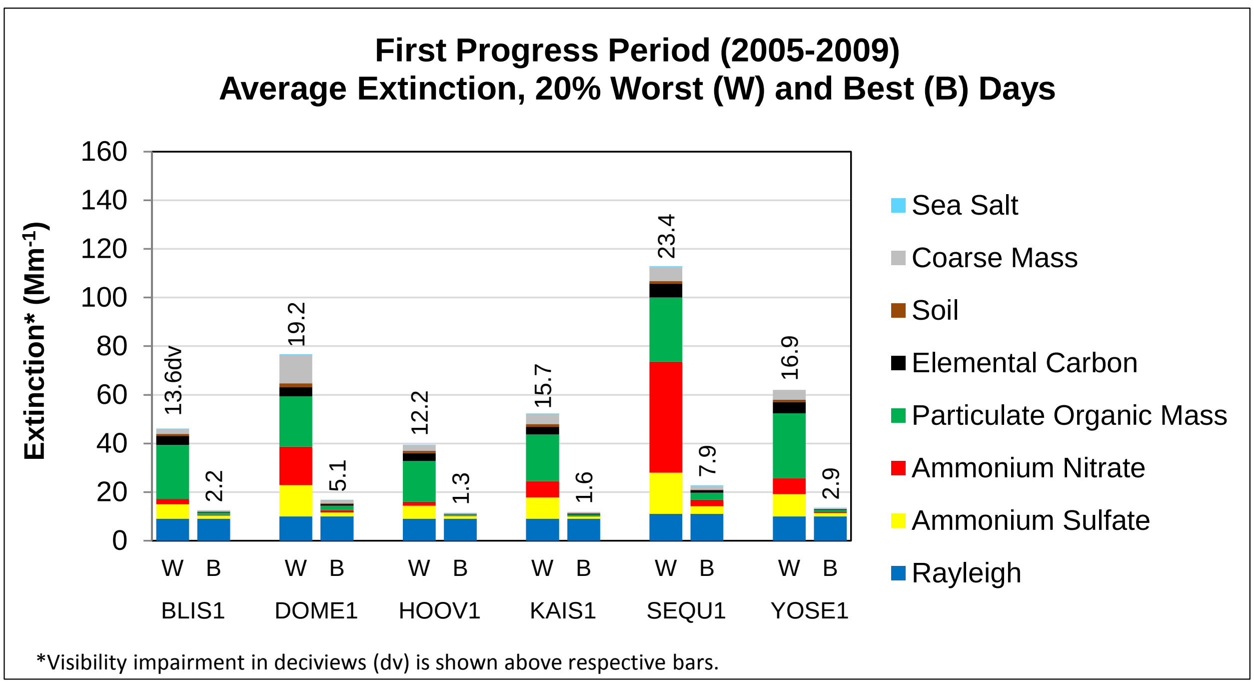

Figure 6.3-3. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at California Class I Area IMPROVE Sites in the Sierra Region.

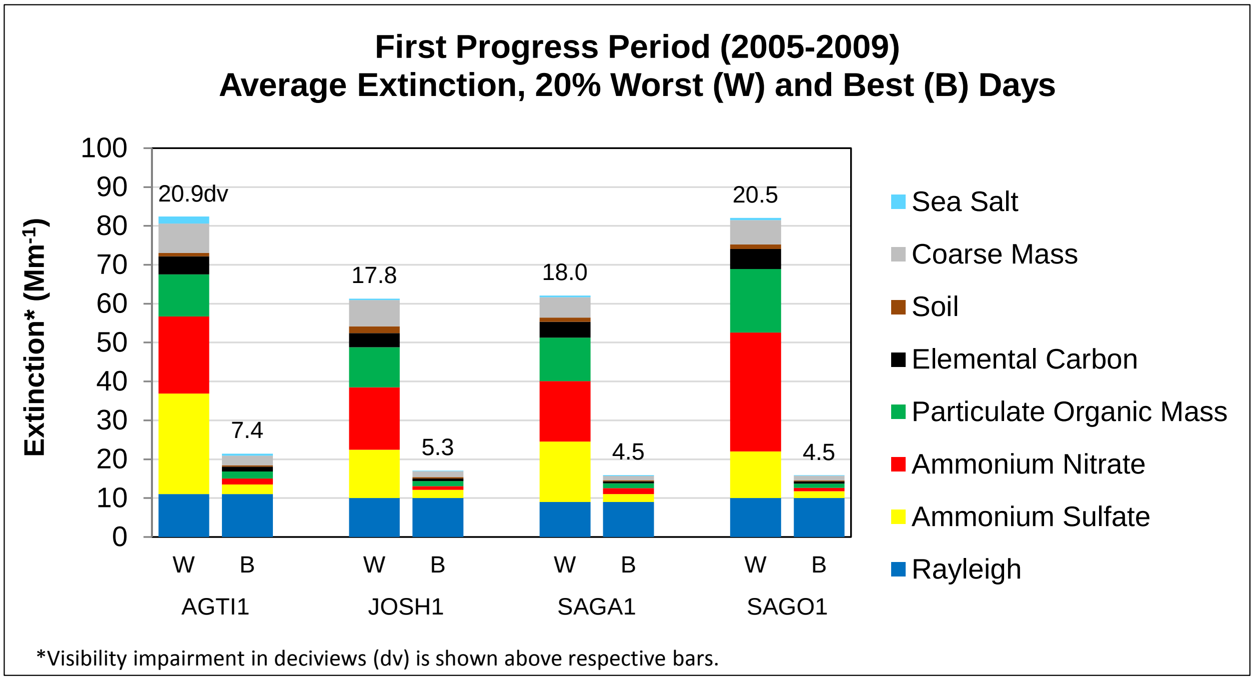

Figure 6.3-4. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at California Class I Area IMPROVE Sites in the Southern Region.

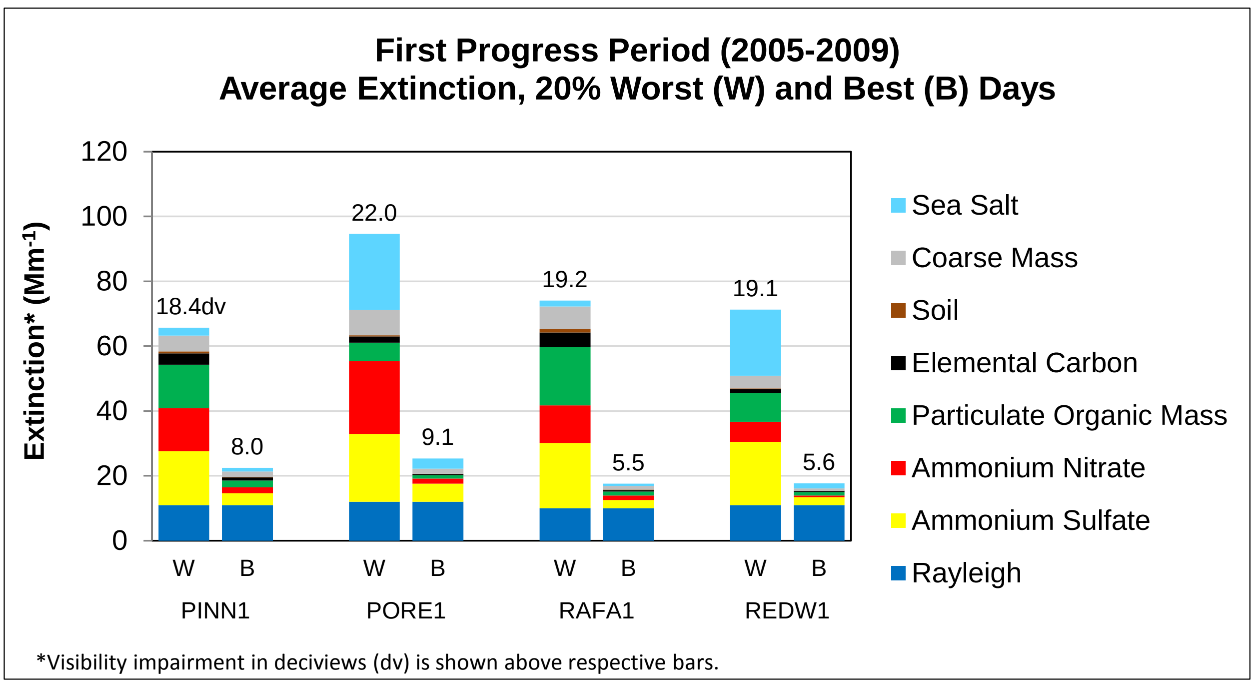

Figure 6.3-5. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at California Class I Area IMPROVE Sites in the Coastal Region.

6.3.1.2 Differences Between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.308 (g)(3)(ii))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Tables 6.3-4 and 6.3-5 present the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for each site in California for the 20% most impaired days and 20% least impaired days, respectively. Averages that increased are depicted in red text and averages that decreased in blue.

Figures 6.3-6 presents the 5-year average extinction for the baseline and current progress period averages for 20% most impaired days at the northern sites, and Figure 6.3-7 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.3-8 through 6.3-13 present similar plots for the other California regions, and Figures 6.3-14 through 6.3-21 present similar plots for the best days. Some general observations regarding differences in visibility impairment at sites in California are as follows:

<u>Northern California</u>

At the Northern California sites, for the 20% most impaired days, the 5-year average deciview metric decreased between the 2000-2004 and 2005-2009 periods at the LABE1 site, remained relatively unchanged at the TRIN1 site and increased at the LAVO1 site. Notable differences for individual species averages were as follows:

- At the TRIN1 site, the deciview average did not change, but total aerosol extinction increased by 23 Mm^{-1}. This discrepancy is due to the methodology used to calculate the 5-year dv metrics, as discussed in Section 3.1.2.3.
- The primary contributor to changes in extinction at these sites was particulate organic mass, which decreased slightly at the LABE1 site and increased at the LAVO1 and TRIN1 sites.

<u>Sierra California</u>

At the Sierra California site, for the 20% most impaired days, the 5-year average deciview metric decreased between the 2000-2004 and 2005-2009 periods at the DOME1, HOOV1, SEQU1, and YOSE1 sites and increased at the BLIS1 and KAIS1 sites. Notable differences for individual species averages were as follows:

- The largest decrease in deciviews for this region was measured at the SEQU1 site (-2.0 dv), where the change in average deciviews was due mostly to decreases in ammonium nitrate and particulate organic mass. Decreases in ammonium nitrate and particulate organic mass were also the largest contributors to the decrease in at the YOSE1 site.

- Increases in particulate organic matter were measured at the BLIS1, DOME1, HOOV1, and KAIS1 sites. At the HOOV1 site, the increases were offset by a decrease in coarse mass, resulting in a net improvement in deciviews.
- At the DOME1 site, the deciview average decrease, but total aerosol extinction increased (+5 Mm^{-1}). This discrepancy is due to the methodology used to calculate the 5-year dv metrics, as discussed in Section 3.1.2.3.

Southern California

At the Southern California sites, the 5-year average deciview metric decreased at all southern California sites. Notable differences for individual species averages were as follows:

- Decreasing deciview averages at these sites was largely due to reductions in ammonium nitrate. Reductions were also measured in ammonium sulfate at the AGTI1 site, particulate organic matter at the AGTI1 and SAGA1 sites, and in coarse mass at the SAGA1 site.

Coastal California

At the Coastal California sites, the 5-year average deciview metric decreased at the PINN1 and PORE1 sites and increased at the RAFA1 and REDW1 sites. Notable differences for individual species averages were as follows:

- Decreasing dv averages at the PINN1 and PORE1 sites were largely due to reductions in ammonium nitrate, partially offset by increases in ammonium sulfate and sea salt.
- The increase in deciviews at the RAFA1 site was largely due to an increase in particulate organic mass, and the increase at the REDW1 site was largely due to increases in ammonium sulfate and sea salt. At both sites, increases were slightly offset by decreases in ammonium nitrate.

Across California, the 5-year average deciview metric for the best days decreased at all sites except DOME1, where the measured deciview average remained relatively unchanged. Notable differences for individual species averages on the 20% least impaired days were as follows:

- Ammonium nitrate, particulate organic mass and elemental carbon decreased or remained the same at all sites.
- At the DOME1 site, where the average deciview value remained the same, slight decreases in ammonium sulfate, particulate organic mass and elemental carbon were offset by slight increases in soil, coarse mass and sea salt.

Table 6.3-4
California Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
Northern California										
LABE1	15.1	14.2	-0.9	+0.8	-1.2	-3.4	-0.2	-0.2	-0.3	+0.1
LAVO1	14.1	16.0	+1.9	+0.4	-1.6	+17.3	+2.1	-0.1	+1.2	0.0
TRIN1	17.3	17.3	0.0	+1.5	-2.6	+21.6	+2.3	0.0	+1.1	0.0
Sierra California										
BLIS1	12.6	13.6	+1.0	+1.0	-0.3	+8.2	+0.7	-0.3	0.0	+0.1
DOME1	19.4	19.2	-0.2	+0.8	-0.1	+3.6	-0.2	+0.2	+0.7	+0.1
HOOV1	12.9	12.2	-0.7	+0.4	+0.1	+1.3	+0.8	-0.5	-2.3	-0.1
KAIS1	15.5	15.7	+0.2	+1.1	-0.3	+2.3	-0.2	0.0	0.0	0.0
SEQU1	25.4	23.4	-2.0	+0.5	-15.1	-6.0	-1.3	-0.1	-1.9	+0.1
YOSE1	17.6	16.9	-0.7	+1.3	-1.6	-2.3	-0.1	0.0	0.0	+0.1
Southern California										
AGTI1	23.5	20.9	-2.6	-6.0	-10.0	-6.7	-1.8	-0.3	-1.1	+1.0
JOSH1	19.6	17.8	-1.8	+0.2	-11.3	0.0	-0.5	+0.2	-1.1	+0.2
SAGA1	19.9	18.0	-1.9	+3.2	-12.1	-4.1	-0.2	+0.2	-3.0	0.0
SAGO1	22.2	20.5	-1.7	-1.2	-14.4	+2.3	0.0	+0.1	+0.1	+0.3
Coastal California										
PINN1	18.5	18.4	-0.1	+2.7	-3.8	+0.2	-1.1	0.0	+1.1	+1.5
PORE1	22.8	22.0	-0.8	+6.8	-15.9	-6.4	-1.3	-0.1	+0.3	+2.3
RAFA1	18.8	19.2	+0.4	-0.2	-1.0	+5.6	+1.5	0.0	+0.2	+1.1
REDW1	18.5	19.1	+0.6	+4.6	-0.8	+0.9	-0.3	0.0	-0.2	+2.8

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.3-5
California Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-2004 Baseline Period	2005-2009 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
Northern California										
LABE1	3.2	2.8	-0.4	+0.1	-0.1	-0.4	-0.1	0.0	-0.1	+0.1
LAVO1	2.7	2.5	-0.2	+0.1	-0.1	-0.2	-0.1	0.0	+0.1	0.0
TRIN1	3.4	3.2	-0.2	+0.3	-0.1	-0.5	-0.2	0.0	0.0	+0.1
Sierra California										
BLIS1	2.5	2.2	-0.3	0.0	-0.1	-0.2	-0.2	0.0	+0.1	0.0
DOME1	5.1	5.1	0.0	-0.1	0.0	-0.2	-0.1	+0.1	+0.3	+0.1
HOOV1	1.4	1.3	-0.1	+0.1	-0.1	0.0	-0.1	0.0	-0.2	0.0
KAIS1	2.3	1.6	-0.7	-0.1	-0.1	-0.5	-0.3	0.0	0.0	0.0
SEQU1	8.8	7.9	-0.9	+0.2	-0.8	-0.9	-0.5	0.0	-0.2	+0.1
YOSE1	3.4	2.9	-0.5	0.0	-0.1	-0.4	-0.1	0.0	0.0	0.0
Southern California										
AGTI1	9.6	7.4	-2.2	-1.4	-1.7	-1.2	-0.6	-0.1	0.0	-0.2
JOSH1	6.1	5.3	-0.8	-0.3	-0.6	-0.4	-0.2	0.0	-0.1	0.0
SAGA1	4.8	4.5	-0.3	+0.2	-0.5	-0.3	-0.1	0.0	-0.1	+0.1
SAGO1	5.4	4.5	-0.9	-0.1	-0.9	-0.5	-0.4	0.0	+0.3	0.0
Coastal California										
PINN1	8.9	8.0	-0.9	-0.8	-0.8	-0.5	-0.3	0.0	0.0	+0.2
PORE1	10.5	9.1	-1.4	-1.1	-0.8	-0.5	-0.2	0.0	-0.7	-0.3
RAFA1	6.5	5.5	-1.0	-0.2	-0.7	-0.6	-0.3	0.0	-0.1	+0.2
REDW1	6.1	5.6	-0.5	+0.1	-0.2	-0.4	-0.2	0.0	-0.1	-0.1

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

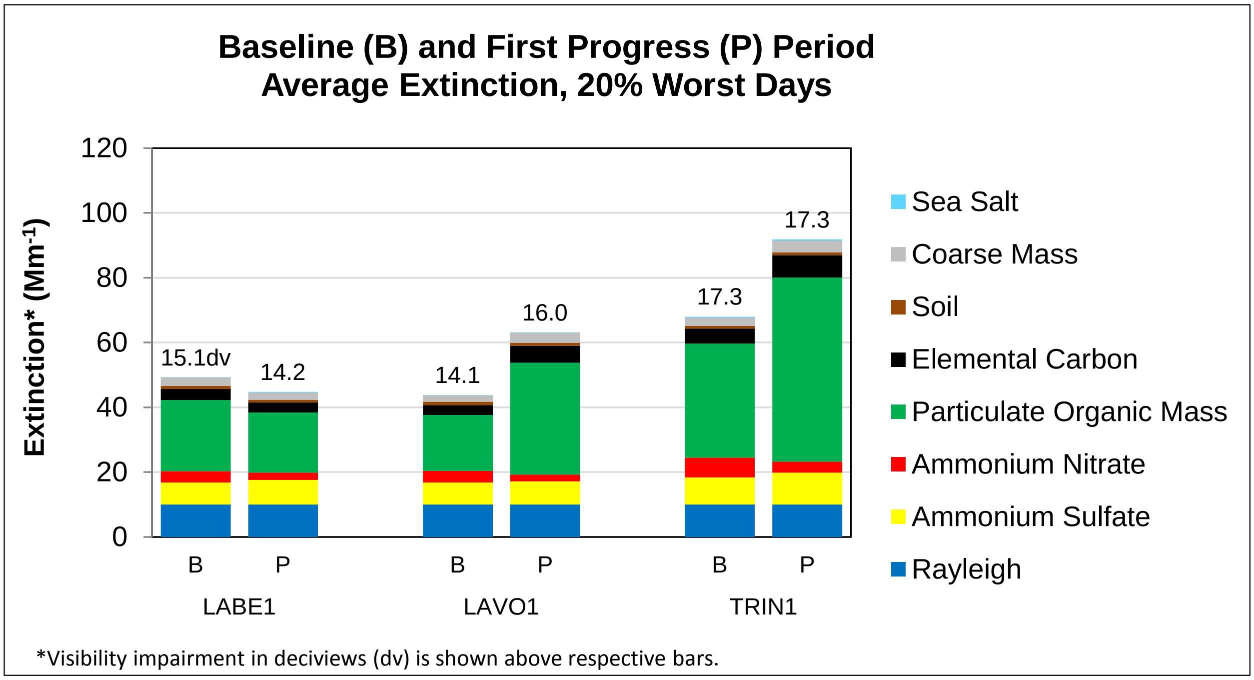

Figure 6.3-6. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at California Class I Area IMPROVE Sites in the Northern Region.

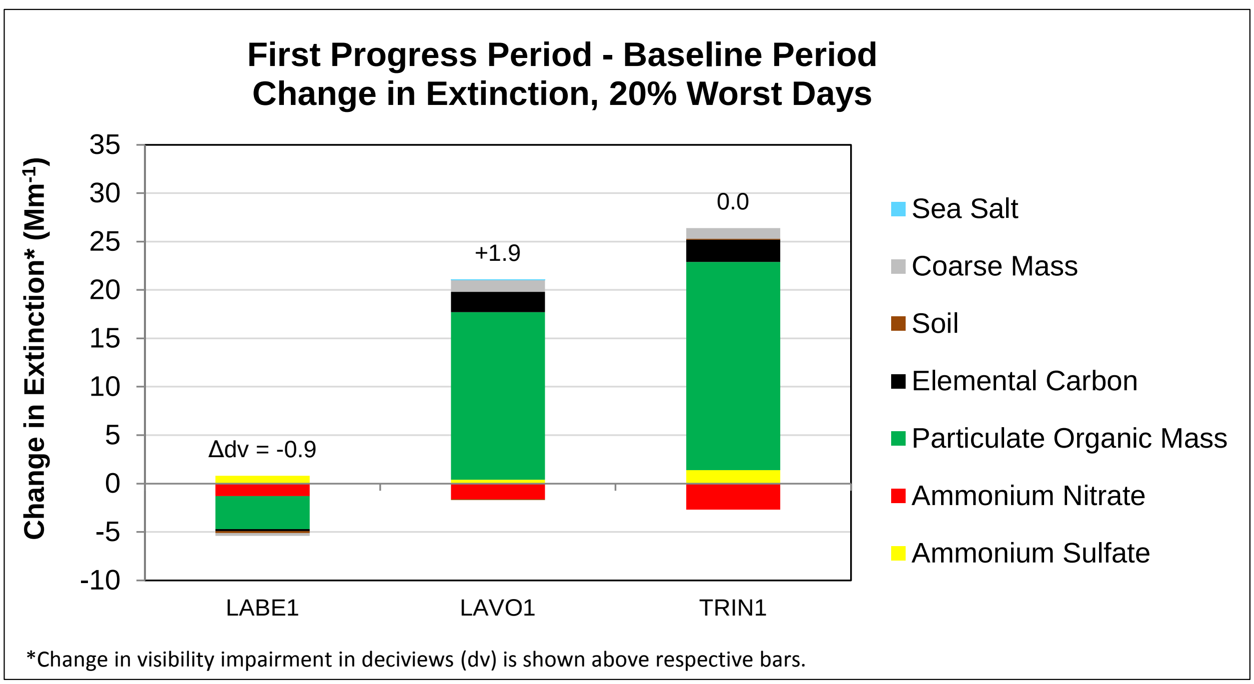

Figure 6.3-7. Difference Between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at California Class I Area IMPROVE Sites in the Northern Region.

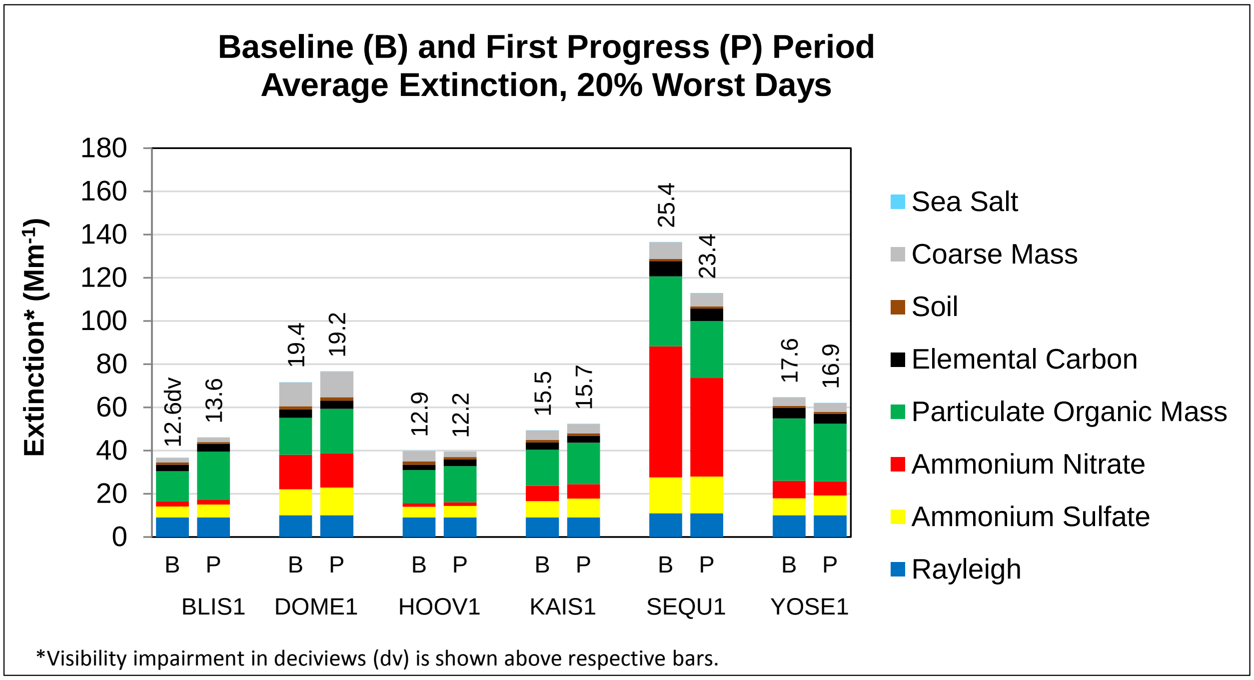

Figure 6.3-8. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at California Class I Area IMPROVE Sites in the Sierra Region.

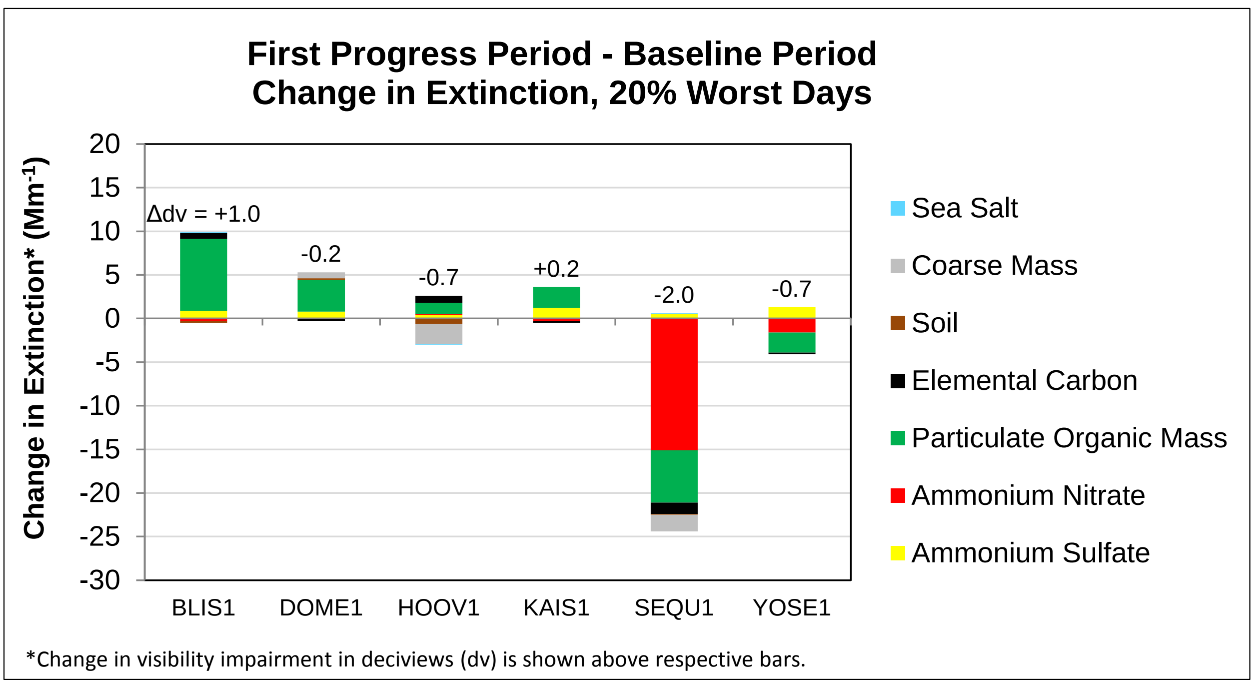

Figure 6.3-9. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at California Class I Area IMPROVE Sites in the Sierra Region.

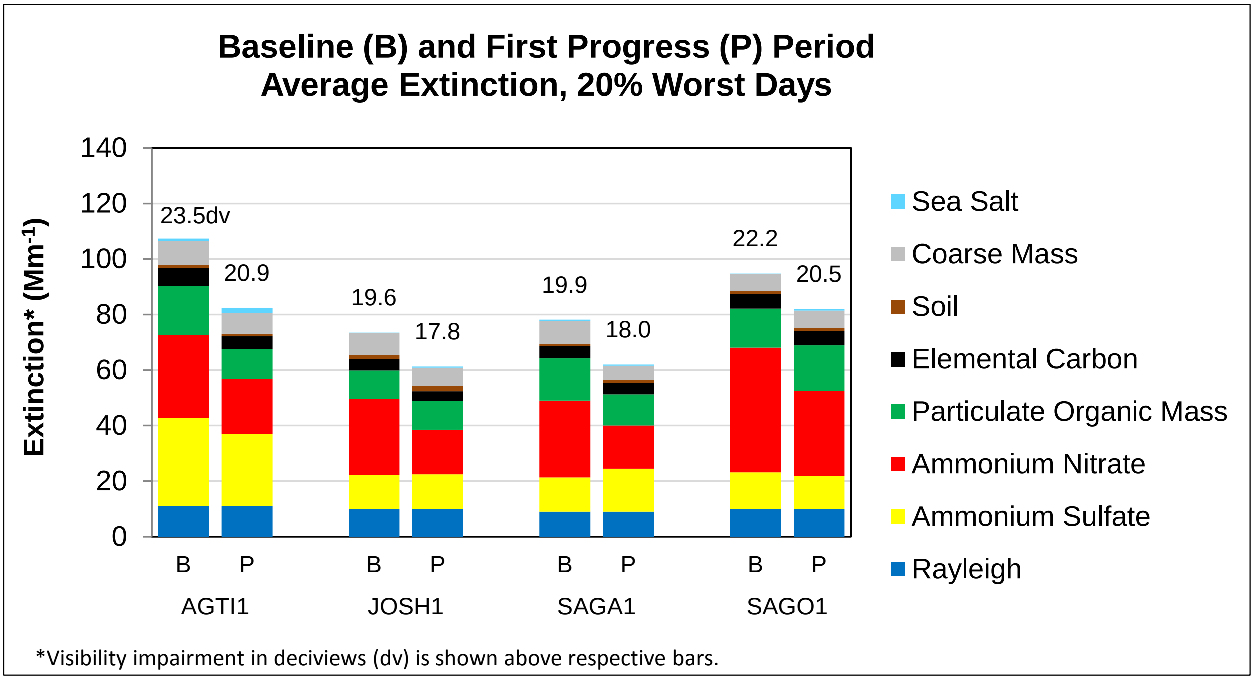

Figure 6.3-10. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at California Class I Area IMPROVE Sites in the Southern Region.

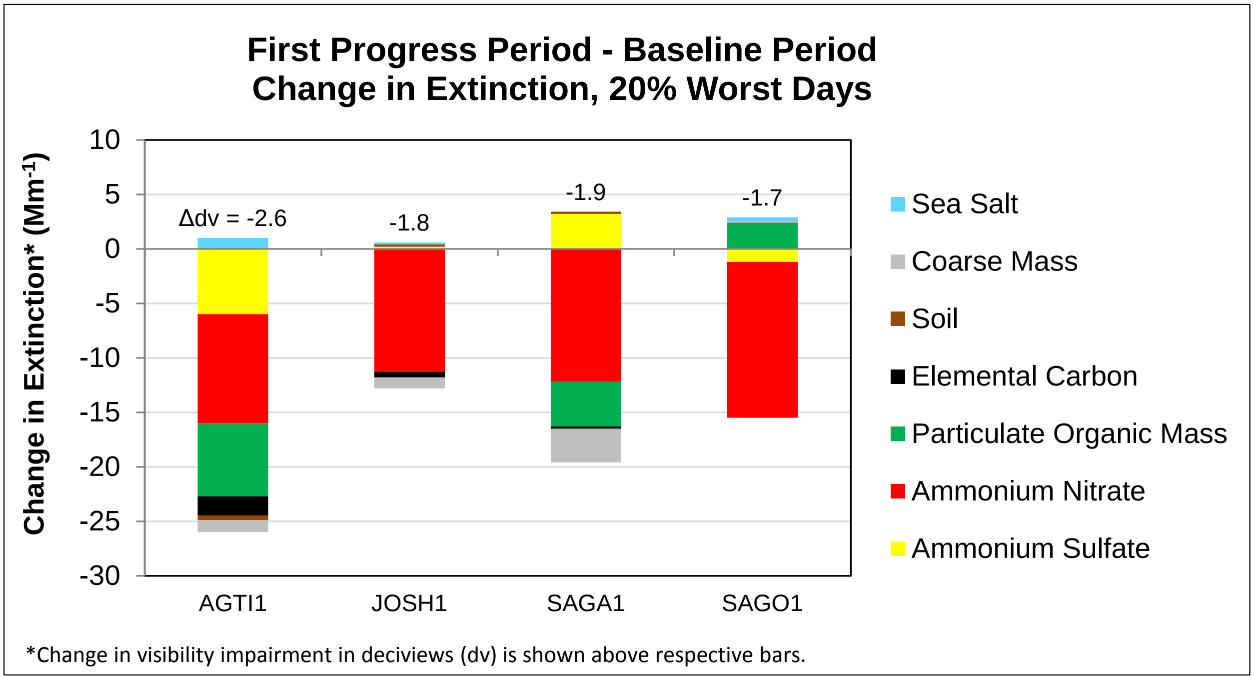

Figure 6.3-11. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at California Class I Area IMPROVE Sites in the Southern Region.

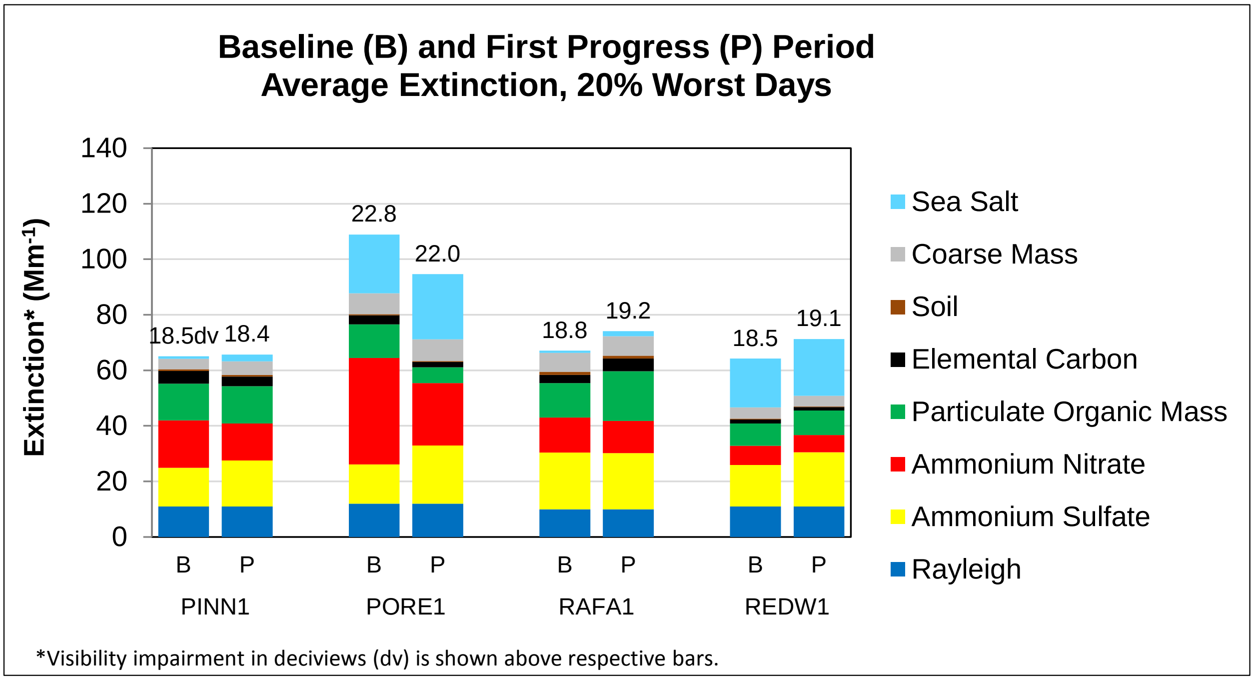

Figure 6.3-12. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at California Class I Area IMPROVE Sites in the Coastal Region.

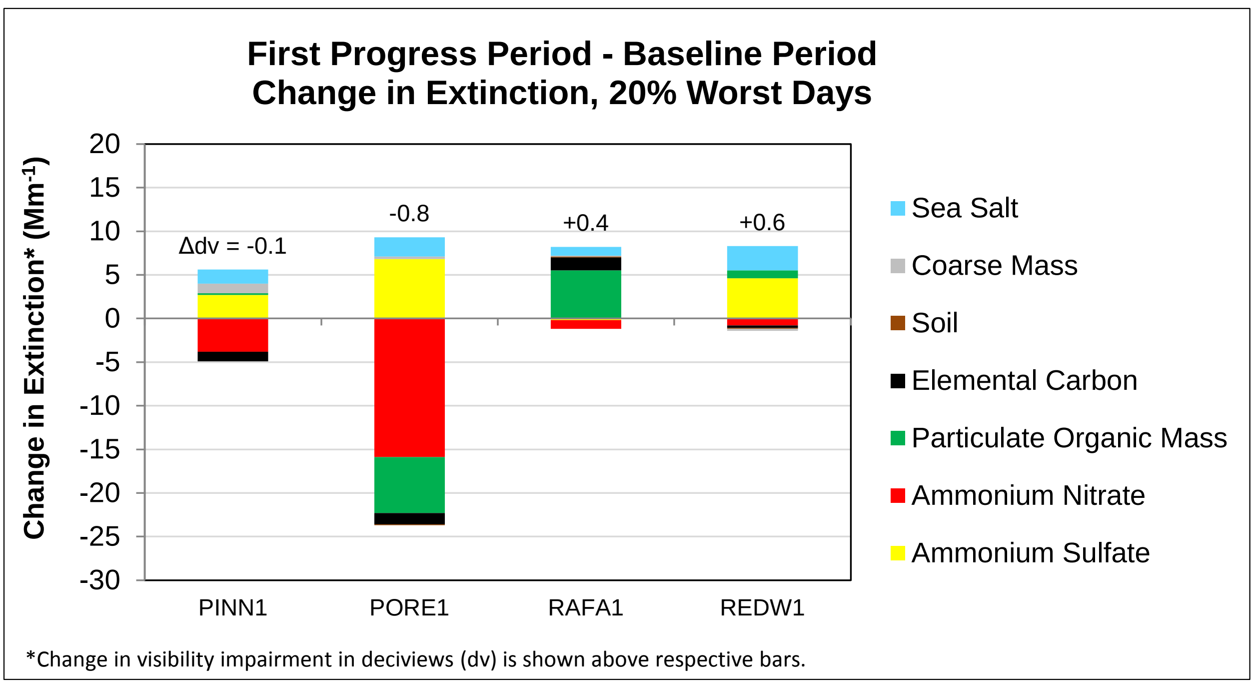

Figure 6.3-13. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at California Class I Area IMPROVE Sites in the Coastal Region.

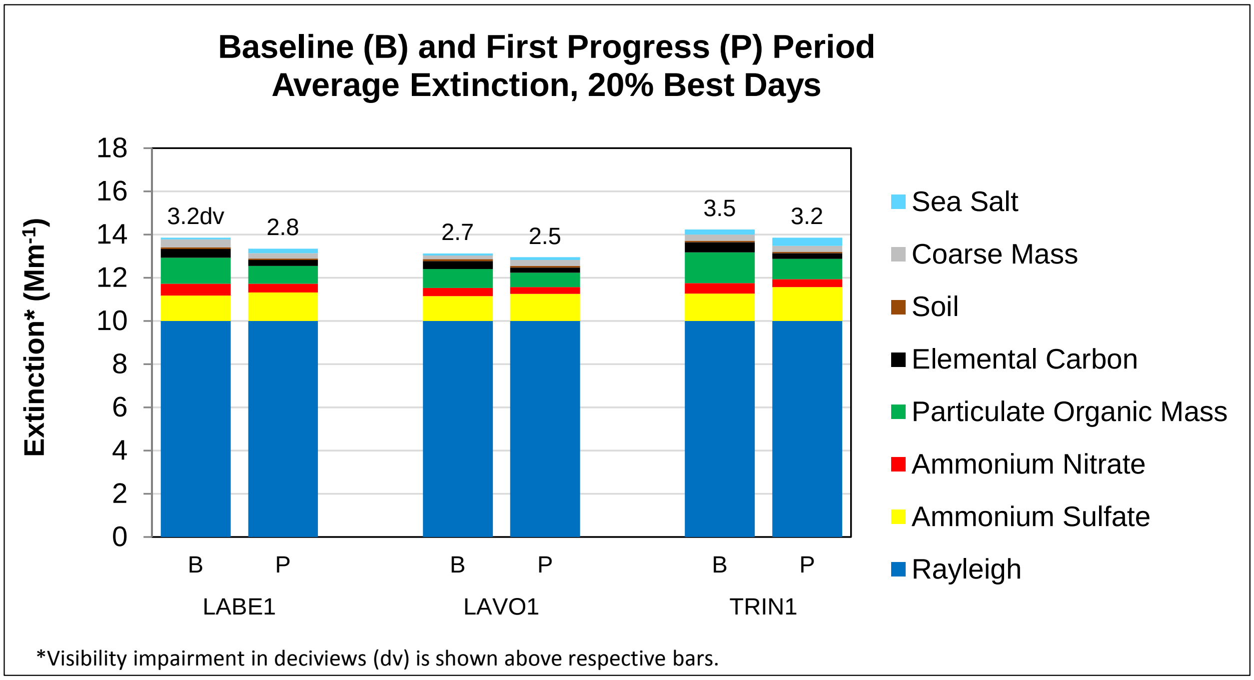

Figure 6.3-14. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at California Class I Area IMPROVE Sites in the Northern Region.

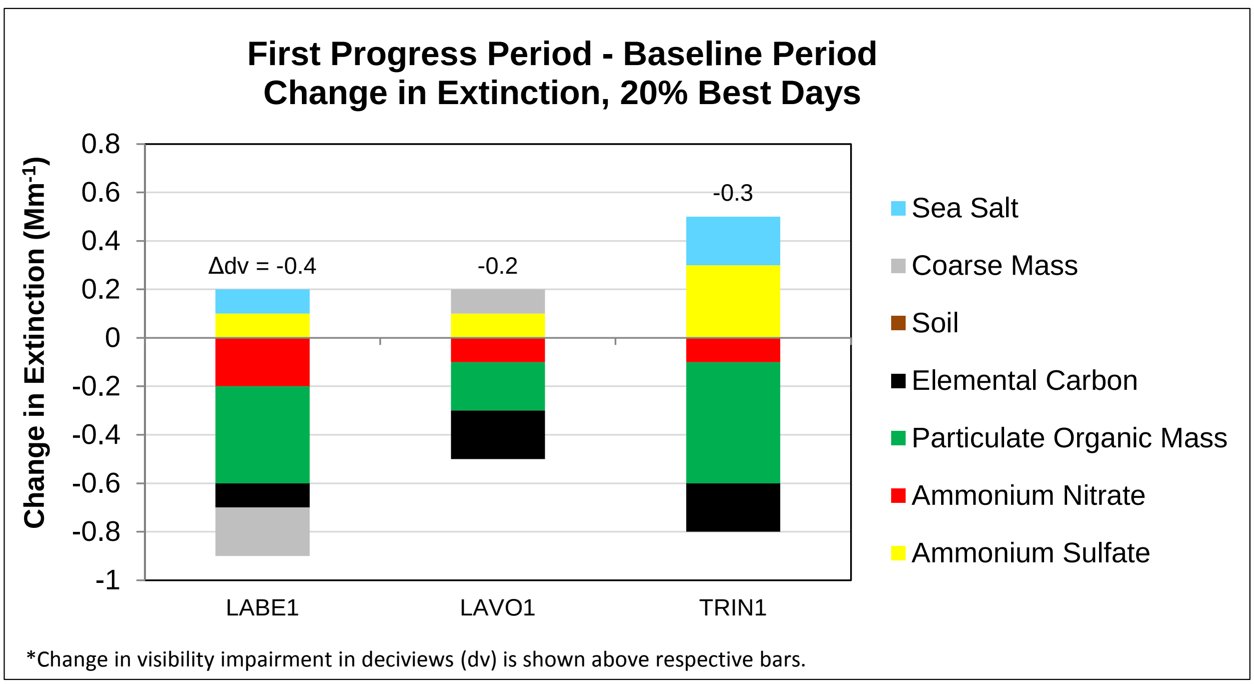

Figure 6.3-15. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at California Class I Area IMPROVE Sites in the Northern Region.

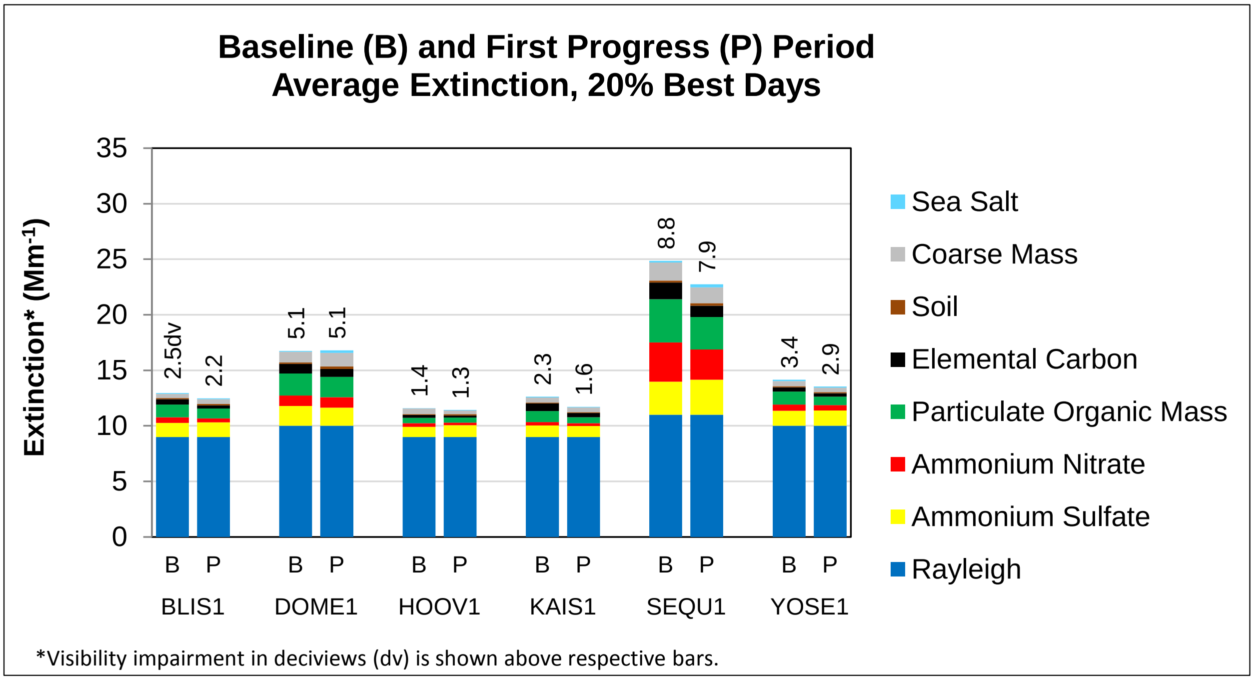

Figure 6.3-16. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at California Class I Area IMPROVE Sites in the Sierra Region.

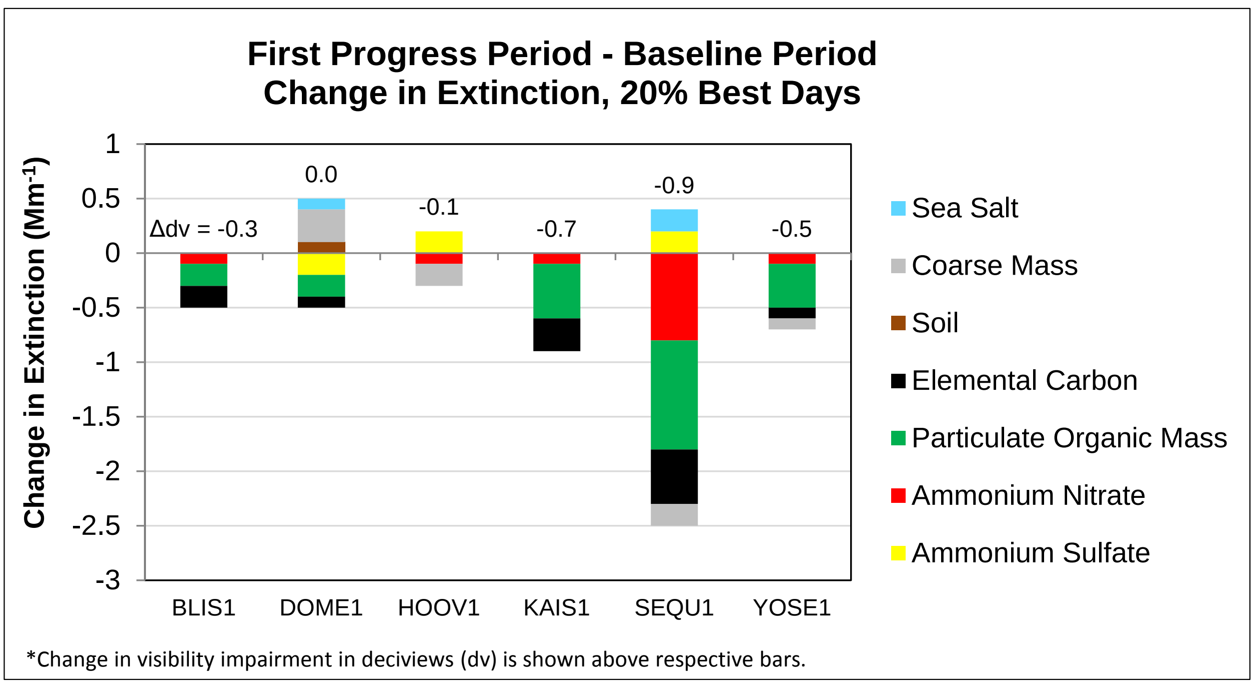

Figure 6.3-17. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at California Class I Area IMPROVE Sites in the Sierra Region.

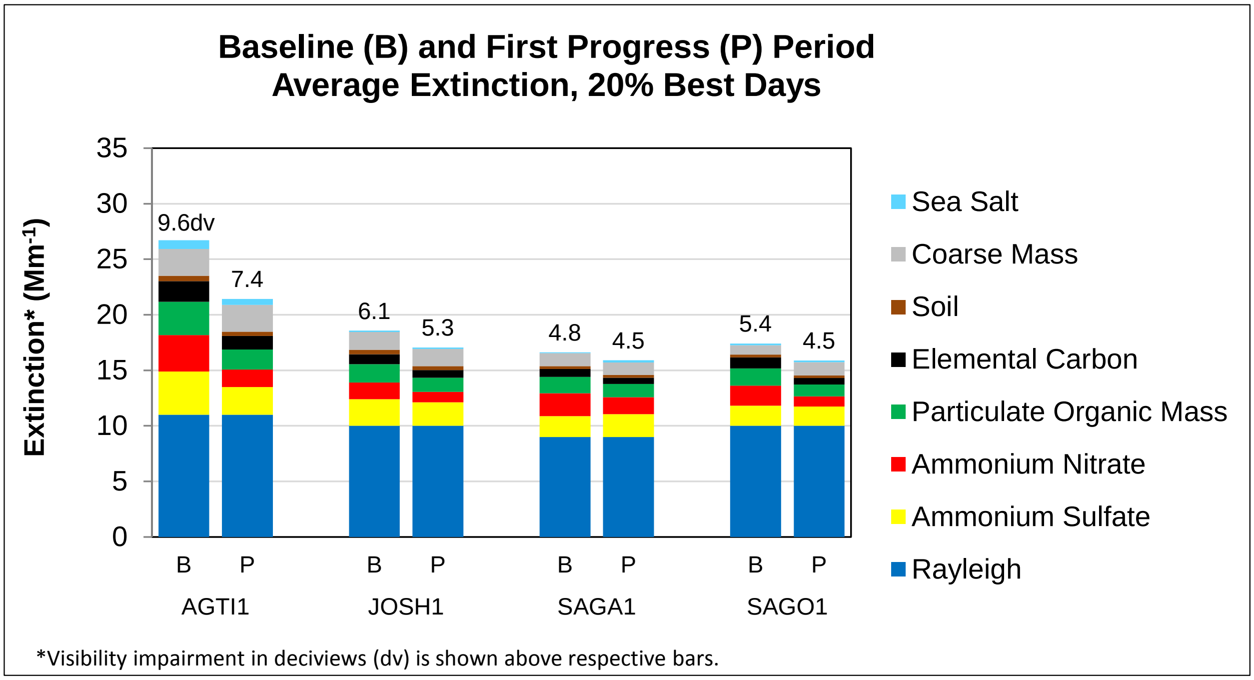

Figure 6.3-18. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at California Class I Area IMPROVE Sites in the Southern Region.

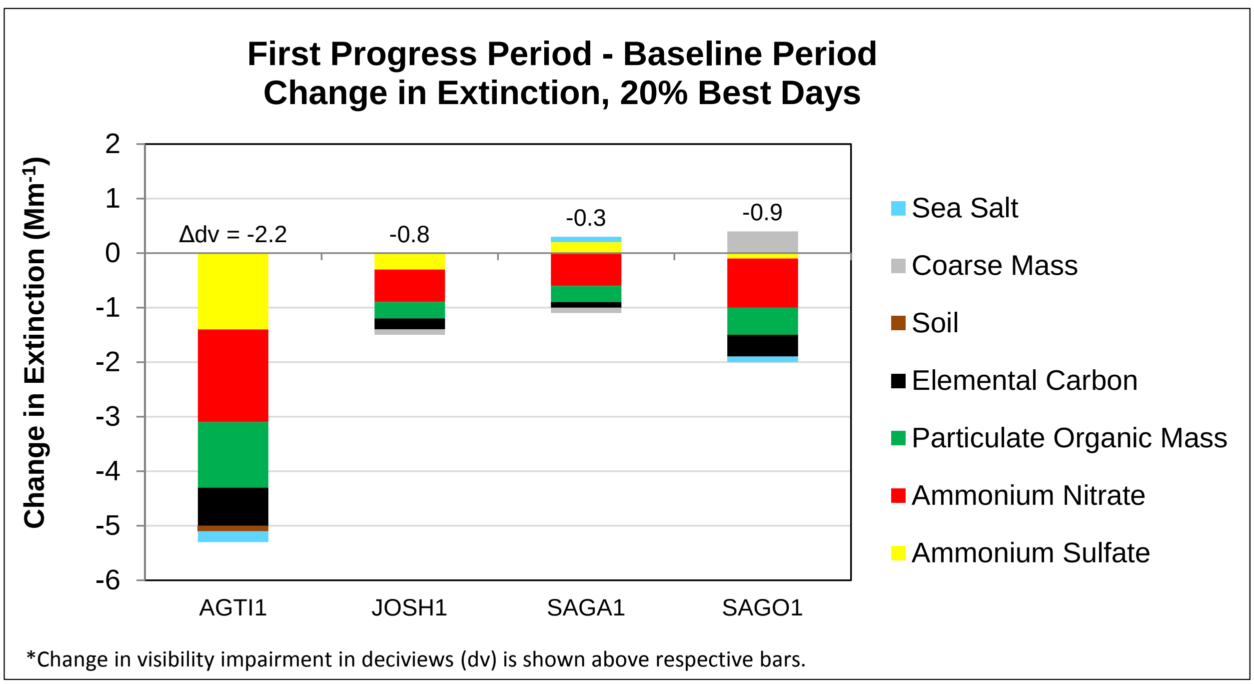

Figure 6.3-19. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at California Class I Area IMPROVE Sites in the Southern Region.

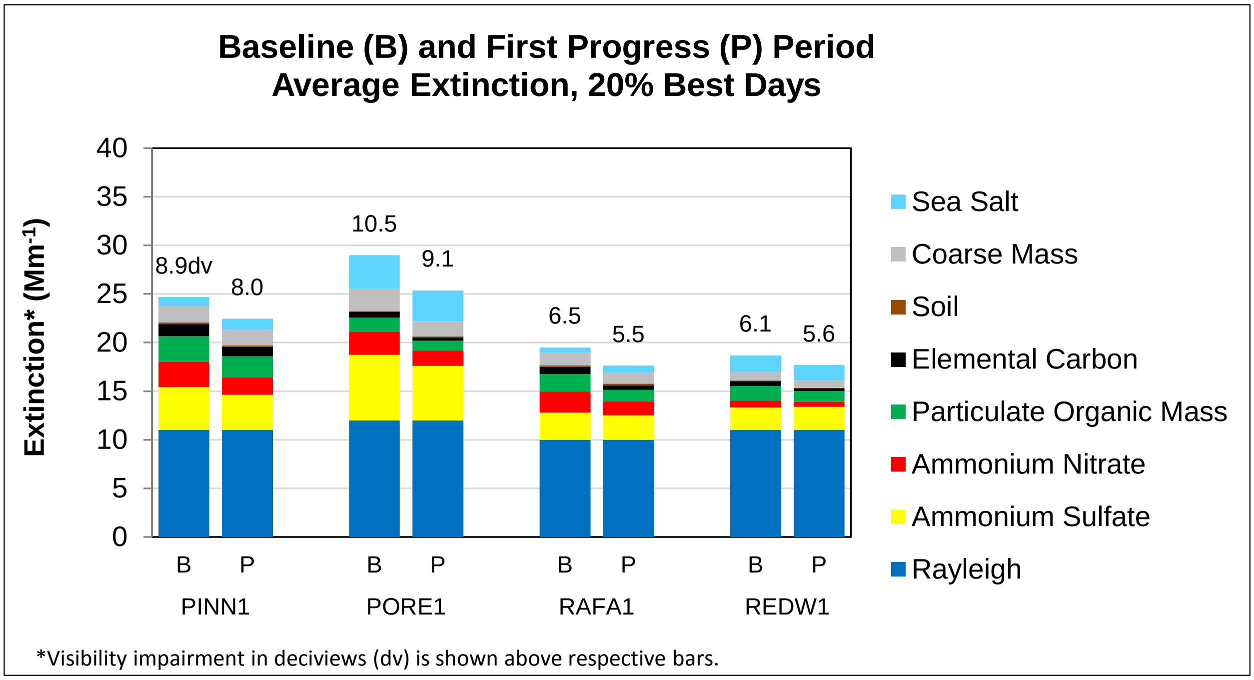

Figure 6.3-20. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at California Class I Area IMPROVE Sites in the Coastal Region.

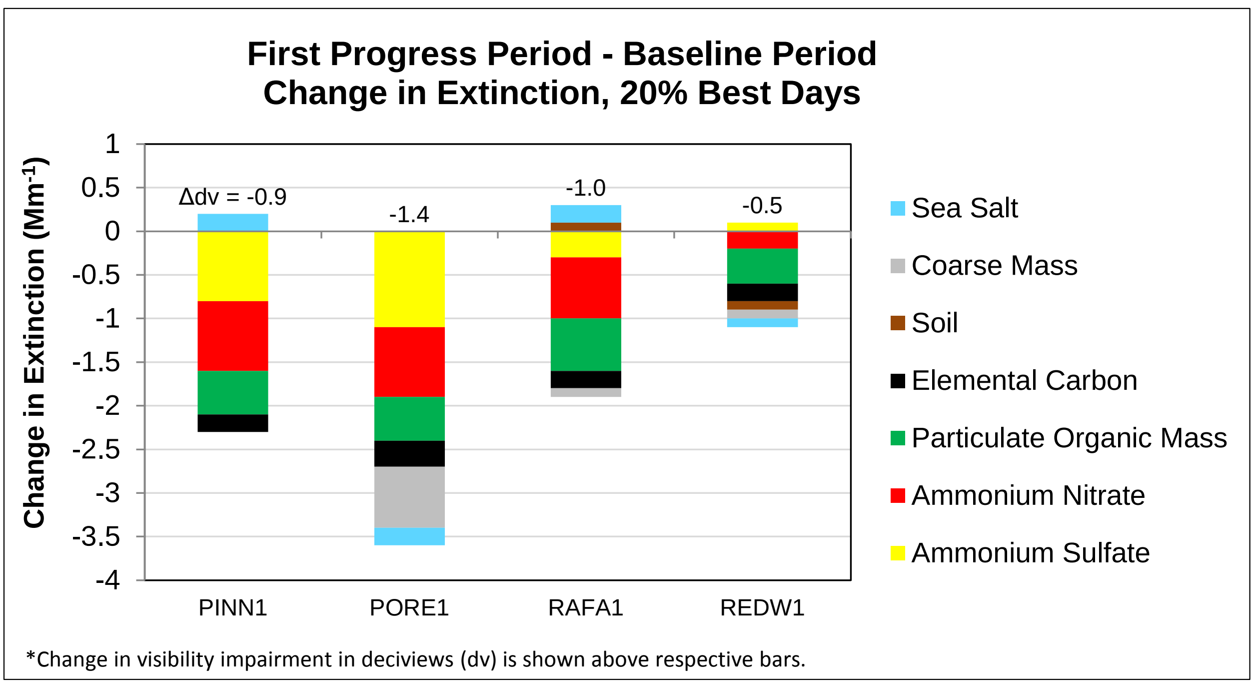

Figure 6.3-21. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at California Class I Area IMPROVE Sites in the Coastal Region.

6.3.1.3 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.308 (g)(3)(iii))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5-year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in California are summarized in Table 6.3-6, and regional trends were presented earlier in Section 4.1.1.[76] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[77] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix C. Additionally, this appendix includes plots depicting 5-year, annual, monthly, and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in California are as follows:

- Particulate organic mass was the largest contributor to increases in the 5-year dv metric for the 20% most impaired days at several sites in the Cascade and Sierra Nevada mountain regions. These events generally occurred during the summer months and were sporadic in nature. The largest regional particulate organic mass events were due to wildfires burning in the area during June and July 2008, with high measurements recorded at the TRIN1, LAVO1, SEQU1, YOSE1, and BLIS1 sites. A plot showing the spatial extent of high particulate organic mass measurements on

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[76] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)

[77] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

June 26, 2008 is presented in Section 4.1.2. A large wildfire actually destroyed the SAGA1 IMPROVE monitor in August 2009, and the SAGA1 site was not re-installed until September of 2011.

- Ammonium nitrate was the largest contributor to decreases in aerosol extinction for the worst days measured at the California sites. Annual average trends indicated decreasing trends for most sites, with the largest decreases recorded at the Southern California sites.
- 5-year average ammonium sulfate increased at most California sites, but annual average trends indicated statistically significant increasing trends only for the northern REDW1 and TRIN1 sites. Increasing trends on the worst days were also observed at the PORE1 and PINN1 sites, but the annual average trends for all days measured at these sites were not statistically significant. Increasing annual trends in ammonium sulfate were also observed at the nearby KALM1 and CRLA1 sites in southwest Oregon.

Table 6.3-6
California Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
Northern California								
LABE1	20% Best	--	0.0	**-0.1**	0.0	--	0.0	0.0
	20% Worst	--	**-0.2**	--	--	--	--	0.0
	All Days	--	**-0.1**	--	--	--	--	0.0
LAVO1	20% Best	--	0.0	0.0	0.0	--	0.0	--
	20% Worst	--	**-0.3**	**1.6**	**0.1**	--	**0.2**	0.0
	All Days	--	**-0.1**	**0.2**	--	--	0.0	0.0
TRIN1	20% Best	--	0.0	--	0.0	--	--	0.0
	20% Worst	**0.2**	**-0.7**	--	--	--	**0.1**	--
	All Days	**0.1**	**-0.2**	--	--	0.0	0.0	0.0
Sierra California								
BLIS1	20% Best	--	0.0	--	0.0	--	0.0	--
	20% Worst	--	--	--	--	--	--	0.0
	All Days	--	**-0.1**	--	--	--	0.0	--
DOME1	20% Best	**-0.1**	--	--	0.0	--	**0.1**	0.0
	20% Worst	--	--	--	**-0.1**	--	--	0.0
	All Days	--	**-0.2**	--	**-0.1**	0.0	--	0.0
HOOV1	20% Best	--	0.0	--	0.0	0.0	--	0.0
	20% Worst	--	--	--	--	--	**-0.5**	--
	All Days	--	--	--	--	--	**-0.1**	0.0
KAIS1	20% Best	--	--	**-0.1**	**-0.1**	--	--	--
	20% Worst	--	--	--	--	--	--	--
	All Days	--	**-0.1**	--	**-0.1**	--	--	--
SEQU1	20% Best	--	--	**-0.1**	**-0.1**	0.0	--	0.0
	20% Worst	--	**-3.7**	--	**-0.3**	--	--	0.0
	All Days	**-0.2**	**-0.8**	**-0.4**	**-0.2**	0.0	**-0.1**	0.0
YOSE1	20% Best	--	0.0	**-0.1**	0.0	--	--	0.0
	20% Worst	--	**-0.5**	--	--	--	--	0.0
	All Days	**-0.1**	**-0.2**	--	0.0	--	--	--

--continued--

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix C.

Table 6.3-6 (continued)
California Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
Southern California								
AGTI1	20% Best	-0.3	-0.4	-0.3	-0.1	--	--	--
	20% Worst	-1.1	-2.2	-0.6	-0.4	--	-0.2	0.2
	All Days	-0.7	-0.9	-0.4	-0.3	0.0	--	0.1
JOSH1	20% Best	-0.1	-0.1	-0.1	0.0	--	0.0	0.0
	20% Worst	-0.3	-2.5	--	-0.1	--	-0.3	0.0
	All Days	--	-0.9	--	-0.1	--	-0.1	0.0
SAGA1	20% Best	--	--	--	-0.1	--	--	0.0
	20% Worst	--	-3.0	--	-0.2	0.1	--	--
	All Days	--	-1.0	-0.1	-0.2	--	--	--
SAGO1	20% Best	--	-0.2	-0.1	-0.1	--	0.1	--
	20% Worst	-0.4	-3.1	--	--	--	--	0.1
	All Days	-0.1	-1.4	--	-0.1	--	--	0.0
Coastal California								
PINN1	20% Best	-0.2	-0.1	-0.1	-0.1	--	0.0	--
	20% Worst	0.4	--	--	-0.3	--	0.1	0.3
	All Days	--	-0.3	-0.2	-0.2	--	--	0.1
PORE1	20% Best	-0.2	-0.2	-0.1	0.0	0.0	-0.1	--
	20% Worst	0.7	--	-0.7	-0.3	--	--	0.7
	All Days	--	-0.6	-0.3	-0.1	--	--	--
RAFA1	20% Best	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.0
	20% Worst	--	-0.3	--	--	--	--	0.2
	All Days	--	-0.3	--	-0.1	--	--	0.1
REDW1	20% Best	--	0.0	-0.1	0.0	--	0.0	-0.1
	20% Worst	0.9	-0.3	--	-0.1	--	--	--
	All Days	0.1	-0.1	--	-0.1	--	0.0	--

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix C.

6.3.2 Emissions Data

Included here are summaries depicting differences between two emission inventory years that are used to represent the 5-year baseline and current progress periods. The baseline period is represented using a 2002 inventory developed by the WRAP for use in the initial WRAP state SIPs, and the progress period is represented by a 2008 inventory which leverages recent WRAP inventory work for modeling efforts, as referenced in Section 3.2.1. For reference, Table 6.3-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories, and a separate summary of annual emissions from electrical generating units (EGUs), are presented in this section.

Table 6.3-7
California
Pollutants, Aerosol Species, and Major Sources

Emitted Pollutant	Related Aerosol	Major Sources	Notes
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- and Off-Road Mobile Sources	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be associated with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Primary Organic Aerosol (POA)	POM	Wildfires; Area Sources	POA represents organic aerosols that are emitted directly as particles, as opposed to gases. Wildfires in the west generally dominate POA emissions, and large wildfire events are generally sporadic and highly variable from year-to-year.
Elemental Carbon (EC)	EC	Wildfires; On- and Off-Road Mobile Sources	Large EC events are often associated with large POM events during wildfires. Other sources include both on- and off-road diesel engines.
Fine soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is reported by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$ mass measurements. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but these measurements are generally associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributor to PMC.

6.3.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.308 (g)(4))?*** For these summaries, emissions during the baseline years are represented using a 2002 inventory, which was developed with support from the WRAP for use in the original RHR SIP strategy development (termed plan02c). Differences between inventories are represented as the difference between the 2002 inventory, and a 2008 inventory which leverages recent inventory development work performed by the WRAP for the WestJumpAQMS and DEASCO$_3$ modeling projects (termed WestJump2008). Note that the comparisons of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories, as referenced in Section 3.2.1. Inventories for all major visibility impairing pollutants are presented for major source categories, and categorized as either anthropogenic or natural emissions. State-wide inventories totals and differences are presented here, and inventory totals on a county level basis are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

Table 6.3-8 and Figure 6.3-22 present the differences between the 2002 and 2008 sulfur dioxide (SO_2) inventories by source category. Tables 6.3-9 and Figure 6.3-23 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.3-10 through 6.3-15 and Figures 6.3-24 through 6.3-29) present data for ammonia (NH_3), volatile organic compounds (VOCs), primary organic aerosol (POA), elemental carbon (EC), fine soil and coarse mass. General observations regarding emissions inventory comparisons are listed below.

- Point source inventories showed decreases in all parameters except NH_3 and coarse mass. Note that NO_X reductions are consistent with the summary of annual EGU NO_X emissions is included in Section 6.3.2.2.
- Area source inventories showed increases in all parameters except VOCs, with the largest increases in NO_X, NH_3, and POA. These increases may be due to a combination of population changes and differences in methodologies used to estimate these emissions, as referenced in Section 3.2.1. One methodology change was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to increases in area source inventory totals, but decreases in off-road mobile totals.
- On-road mobile source inventory comparisons showed large decreases in SO_2, NO_X, NH_3 and VOCs. These reductions are likely influenced by federal and state emissions standards that have already been implemented.
- Off-road mobile source inventories showed decreases in SO_2, NO_X, and VOCs, but slight increases in fine soil and coarse mass. Note that different off-road models were used to represent the different years, as referenced in Section 3.2.1. As noted previously, one major methodology difference was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the

area source category in 2008, which may have contributed to decreases in the off-road inventory totals, but increases in area source totals.

- Inventory comparison results for area oil and gas showed decreases in NO_X and VOCs, but note that the WRAP Phase III oil and gas emission inventories did not include California basins, so current estimates are based on area source oil and gas emissions reported by the state.
- For most parameters, especially POAs, VOCs and EC, natural fire emission inventory estimates increased. Note that these differences are not necessarily reflective of changes in monitored data, as the baseline period is represented by an average of 2000-2004 fire emissions, and the progress period is represented only by the fires that occurred in 2008, which was a high fire year in California.
- Comparisons between VOC inventories showed large decreases in biogenic emissions, which was consistent with other contiguous WRAP states. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions, as referenced in Section 3.2.1.
- Fine soil and coarse mass increased for the combined fugitive/road dust inventories, and decreased for windblown dust. Large variability in changes in windblown dust was observed for all contiguous WRAP states, which was likely due in large part to enhancements in dust inventory methodology, as referenced in Section 3.2.1, rather than changes in actual emissions.

Table 6.3-8
California
Change in Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2002 (Plan02c)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	42,227	27,325	-14,902
Area	8,257	9,562	1,305
On-Road Mobile	4,034	1,936	-2,098
Off-Road Mobile	7,554	428	-7,127
Area Oil and Gas	57	0	-57
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	882	243	-639
Total Anthropogenic	**63,011**	**39,495**	**-23,516 (-37%)**
Natural Sources			
Natural Fire	9,840	17,151	7,311
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**9,840**	**17,151**	**7,311 (74%)**
All Sources			
Total Emissions	**72,850**	**56,645**	**-16,205 (-22%)**

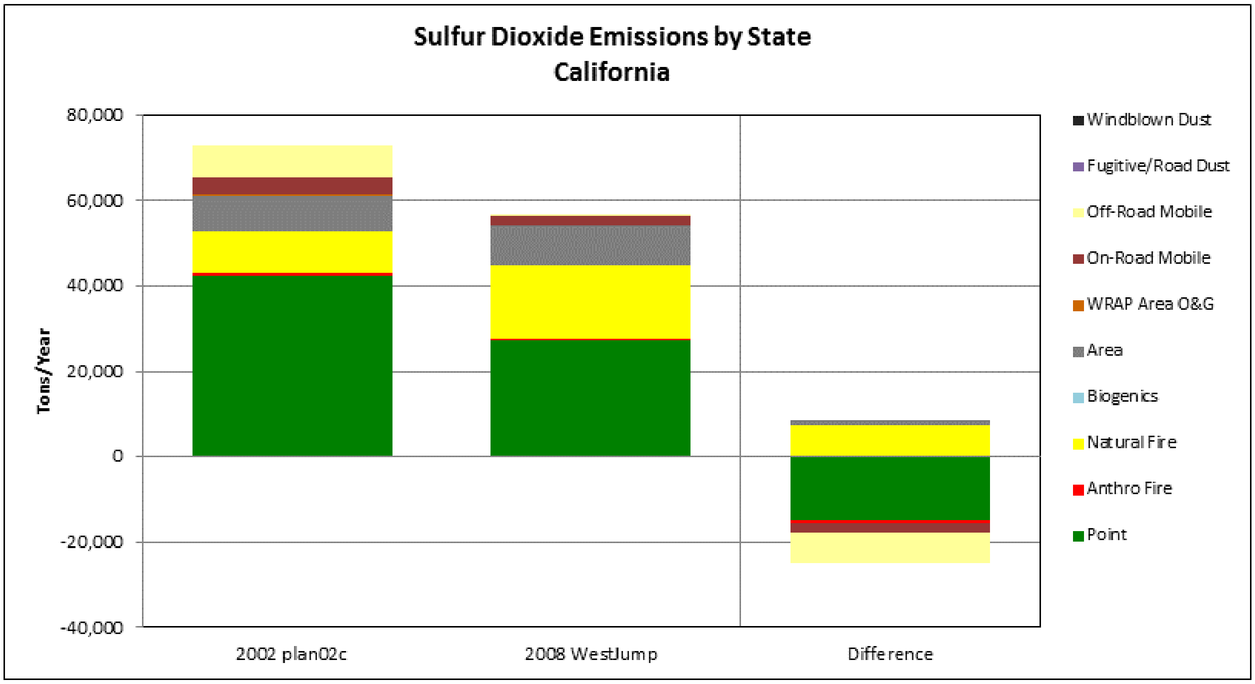

Figure 6.3-22. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for California.

Table 6.3-9
California
Change in Oxides of Nitrogen Emissions by Category

Source Category	Oxides of nitrogen Emissions (tons/year)		
	2002 (Plan02c)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	104,991	94,740	-10,251
Area	106,399	153,233	46,834
On-Road Mobile	581,080	513,028	-68,052
Off-Road Mobile	328,300	233,142	-95,159
Area Oil and Gas	8,071	2,221	-5,851
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	6,589	1,612	-4,978
Total Anthropogenic	**1,135,431**	**997,975**	**-137,456 (-12%)**
Natural Sources			
Natural Fire	35,975	121,138	85,163
Biogenic	57,068	18,218	-38,850
Wind Blown Dust	0	0	0
Total Natural	**93,043**	**139,356**	**46,313 (50%)**
All Sources			
Total Emissions	**1,228,474**	**1,137,331**	**-91,142 (-7%)**

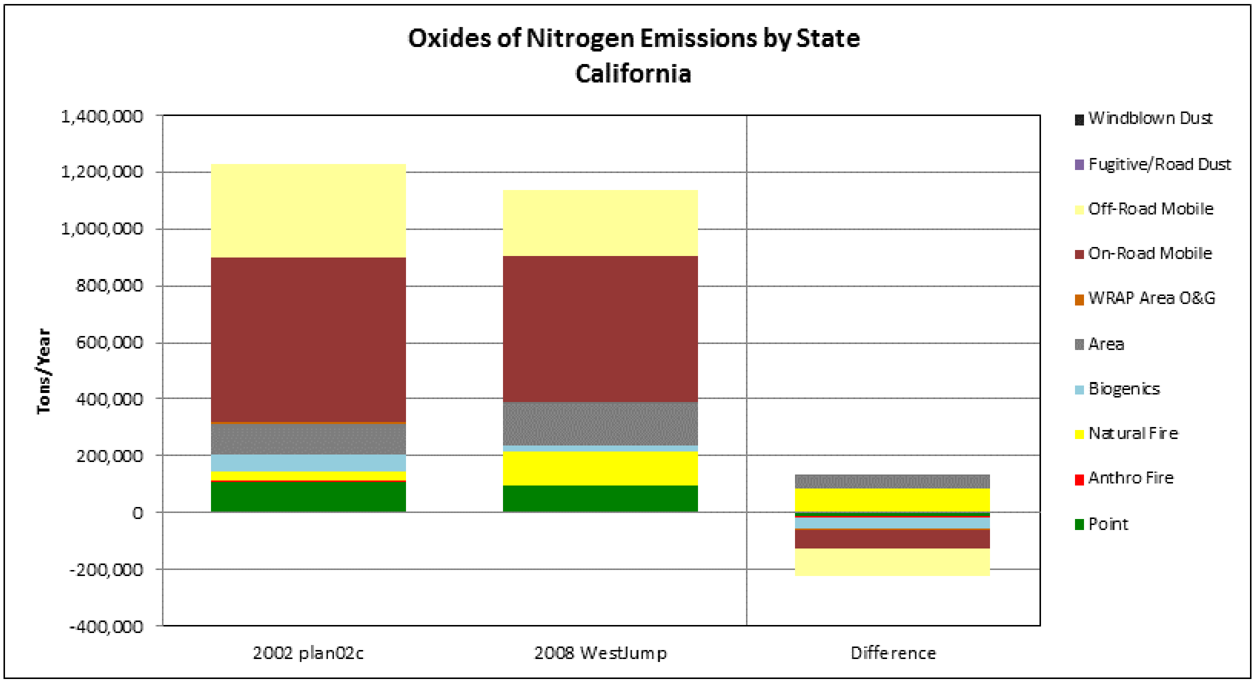

Figure 6.3-23. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Oxides of nitrogen by Source Category for California.

Table 6.3-10
California
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2002 (Plan02c)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	433	11,590	11,156
Area	200,289	322,270	121,981
On-Road Mobile	22,118	8,729	-13,389
Off-Road Mobile	561	192	-369
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	1,756	1,033	-723
Total Anthropogenic	**225,157**	**343,813**	**118,657 (53%)**
Natural Sources			
Natural Fire	7,595	84,489	76,894
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**7,595**	**84,489**	**76,894 (>100%)**
All Sources			
Total Emissions	**232,752**	**428,302**	**195,550 (84%)**

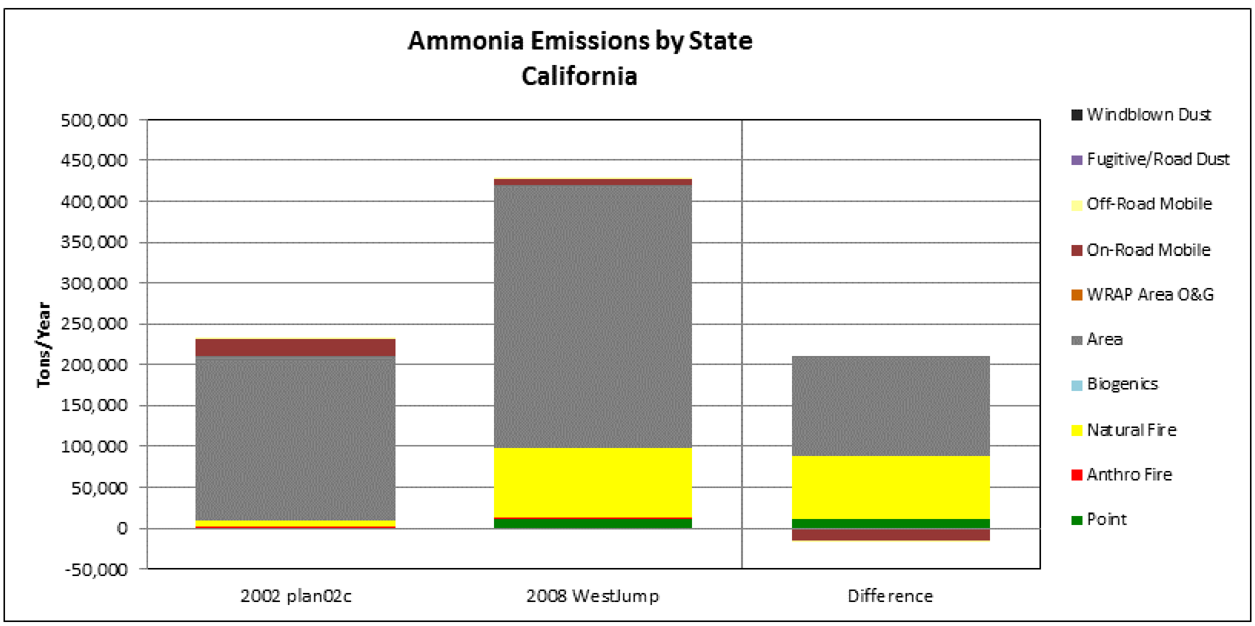

Figure 6.3-24. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Ammonia by Source Category for California.

Table 6.3-11
California
Volatile Organic Compound Emissions by Category

Source Category	Volatile Organic Compounds Emissions (tons/year)		
	2002 (Plan02c)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	54,632	42,303	-12,330
Area	325,054	297,201	-27,853
On-Road Mobile	324,943	198,383	-126,560
Off-Road Mobile	193,462	164,441	-29,021
Area Oil and Gas	18,709	15,149	-3,560
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	10,060	2,318	-7,742
Total Anthropogenic	**926,860**	**719,795**	**-207,066 (-22%)**
Natural Sources			
Natural Fire	78,945	128,362	49,417
Biogenic	2,811,253	1,230,279	-1,580,974
Wind Blown Dust	0	0	0
Total Natural	**2,890,198**	**1,358,641**	**-1,531,557 (-53%)**
All Sources			
Total Emissions	**3,817,058**	**2,078,435**	**-1,738,622 (-46%)**

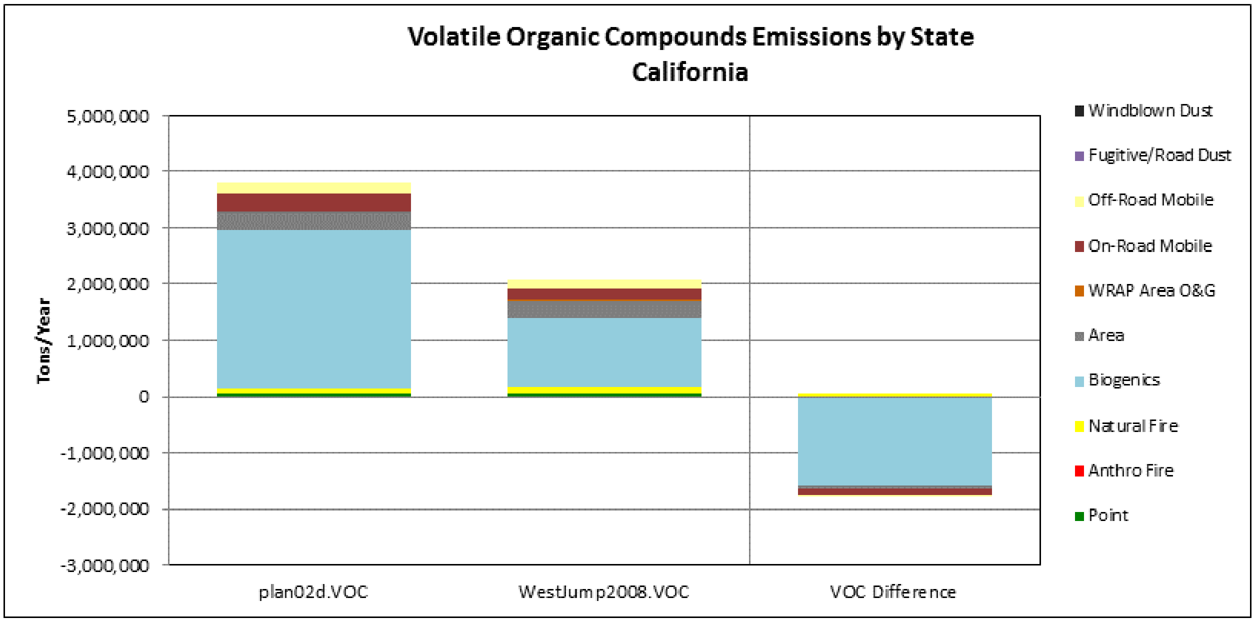

Figure 6.3-25. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for California.

Table 6.3-12
California
Primary Organic Aerosol Emissions by Category

Source Category	Primary Organic Aerosol Emissions (tons/year)		
	2002 (Plan02c)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	5,515	286	-5,229
Area	33,807	50,127	16,320
On-Road Mobile	8,059	**	**
Off-Road Mobile	5,932	6,014	82
Area Oil and Gas	8	0	-8
Fugitive and Road Dust	2,126	2,498	372
Anthropogenic Fire	9,052	2,681	-6,371
Total Anthropogenic	**56,440****	**61,606****	**5,166 (9%)****
Natural Sources			
Natural Fire	92,097	248,841	156,744
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**92,097**	**248,841**	**156,744 (>100%)**
All Sources			
Total Emissions	**148,537**	**310,447**	**161,910 (>100%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).
**Sums and differences do not include on-road emissions, as 2008 inventory primary organic aerosol totals were not available from this source for comparison purposes.

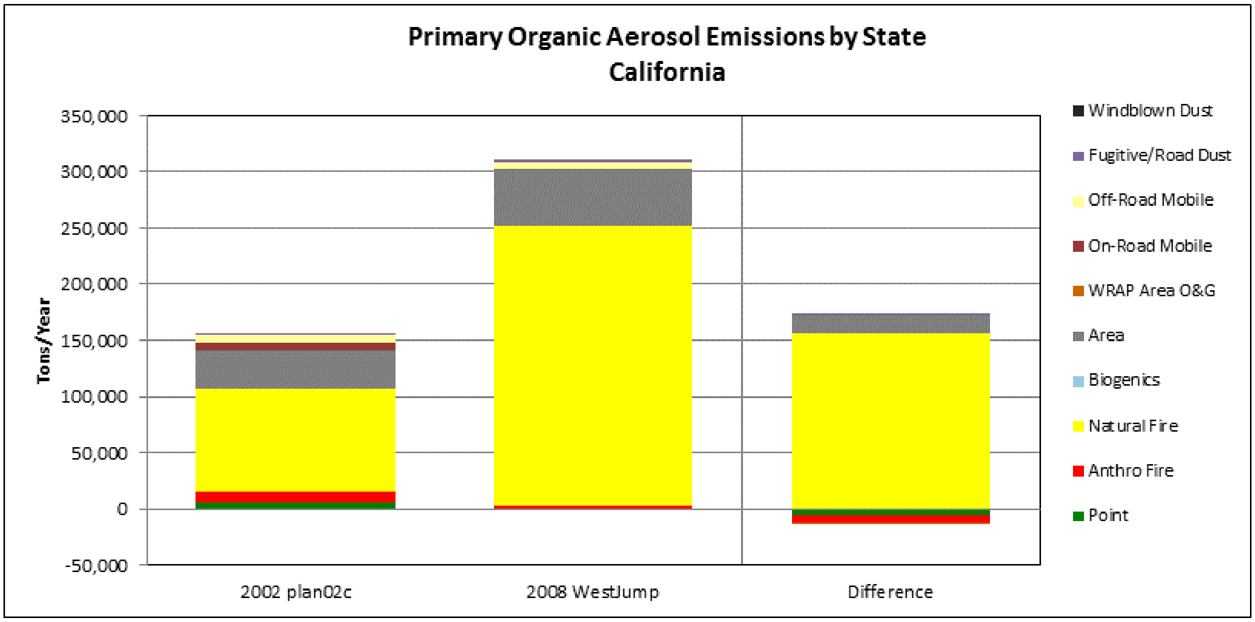

Figure 6.3-26. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Primary Organic Aerosol by Source Category for California.

Table 6.3-13
California
Elemental Carbon Emissions by Category

Source Category	Elemental Carbon Emissions (tons/year)		
	2002 (Plan02c)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	933	370	-563
Area	4,671	7,019	2,348
On-Road Mobile	9,560	**	**
Off-Road Mobile	12,018	8,165	-3,853
Area Oil and Gas	0	0	0
Fugitive and Road Dust	177	72	-105
Anthropogenic Fire	1,038	442	-596
Total Anthropogenic	**18,837****	**16,068****	**-2,769 (-15%)****
Natural Sources			
Natural Fire	19,078	36,994	17,915
Biogenic	0		0
Wind Blown Dust	0		0
Total Natural	**19,078**	**36,994**	**17,915 (94%)**
All Sources			
Total Emissions	**37,915****	**53,062****	**15,147 (40%)****

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).
**Sums and differences do not include on-road emissions, as 2008 inventory elemental carbon totals were not available from this source for comparison purposes.

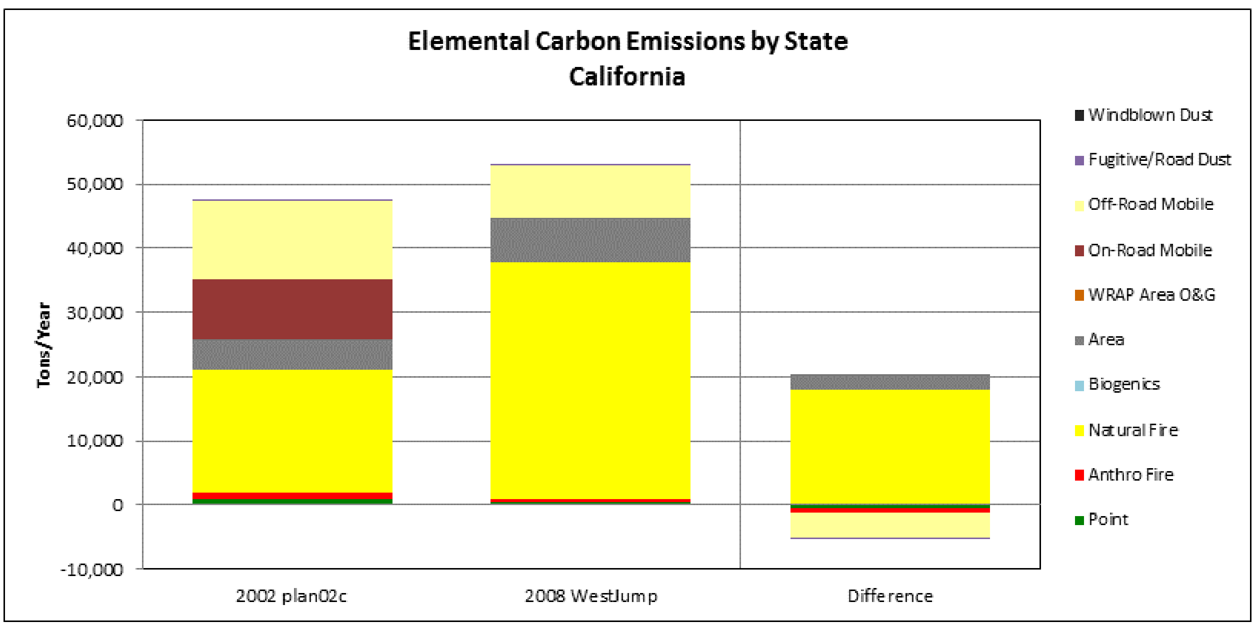

Figure 6.3-27. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Elemental Carbon by Source Category for California.

Table 6.3-14
California
Change in Fine Soil Emissions by Category

Source Category	Fine Soil Emissions (tons/year)		
	2002 (Plan02c)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	10,537	208	-10,330
Area	20,678	24,063	3,385
On-Road Mobile	2,125	**	**
Off-Road Mobile	0	423	423
Area Oil and Gas	134	5	-129
Fugitive and Road Dust	23,629	36,701	13,072
Anthropogenic Fire	2,562	1,014	-1,548
Total Anthropogenic	**57,540****	**62,414****	**4,874 (8%)****
Natural Sources			
Natural Fire	5,880	90,876	84,995
Biogenic	0	0	0
Wind Blown Dust	8,137	12,133	3,997
Total Natural	**14,017**	**103,009**	**88,992 (>100%)**
All Sources			
Total Emissions	**71,557****	**165,423****	**93,866 (>100%)****

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).
**Sums and differences do not include on-road emissions, as 2008 inventory fine soil totals were not available from this source for comparison purposes.

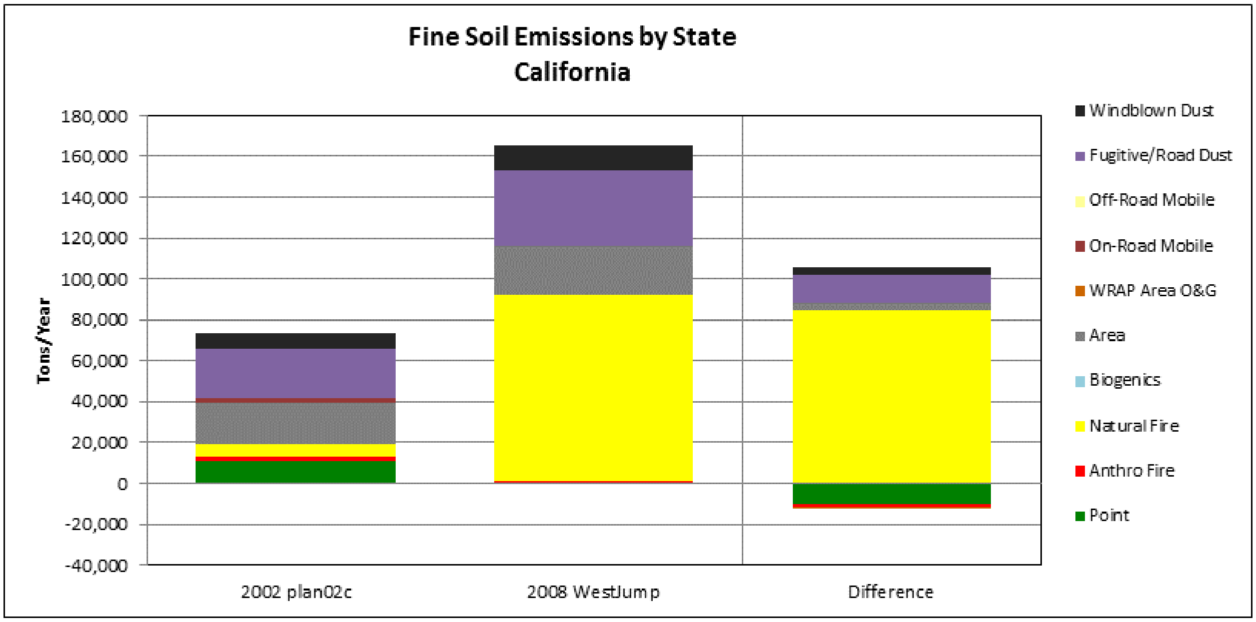

Figure 6.3-28. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Fine Soil by Source Category for California.

Table 6.3-15
California
Coarse Mass Emissions by Category

Source Category	Coarse Mass Emissions (tons/year)		
	2002 (Plan02c)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	10,172	15,941	5,770
Area	11,886	19,571	7,685
On-Road Mobile	5,075	*	*
Off-Road Mobile	0	2,174	2,174
Area Oil and Gas	0	0	0
Fugitive and Road Dust	177,621	292,800	115,179
Anthropogenic Fire	1,164	421	-743
Total Anthropogenic	**200,843****	**330,907****	**130,064 (65%)****
Natural Sources			
Natural Fire	23,124	47,647	24,524
Biogenic	0	0	0
Wind Blown Dust	73,230	109,203	35,973
Total Natural	**96,354**	**156,850**	**60,497 (63%)**
All Sources			
Total Emissions	**297,197****	**487,757****	**190,560 (64%)****

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

**Sums and differences do not include on-road emissions, as 2008 inventory coarse mass totals were not available from this source for comparison purposes.

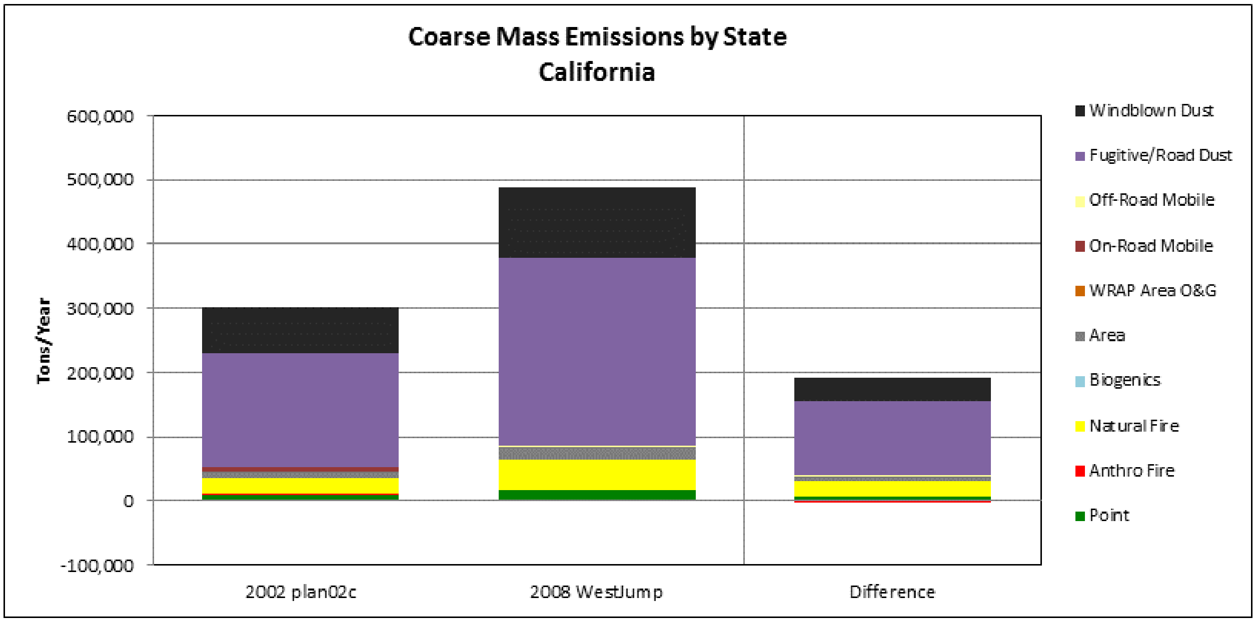

Figure 6.3-29. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Coarse Mass by Source Category for California.

6.3.2.2 EGU Summary

As described in previous sections, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions because numerous updates in inventory methodologies have occurred between the development of the separate inventories. Also, the 2002 baseline and 2008 progress period inventories represent only annual snapshots of emissions estimates, which may not be representative of entire 5-year monitoring periods compared. To better account for year-to-year changes in emissions, annual emission totals for California electrical generating units (EGU) are presented here. EGU emissions are some of the more consistently reported emissions, as tracked in EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/). RHR implementation plans are required to pay specific attention to certain major stationary sources, including EGUs, built between 1962 and 1977.

Figure 6.3-30 presents a sum of annual NO_X and SO_2 emissions as reported for California EGU sources between 1996 and 2010. While these types of facilities are targeted for controls in state regional haze SIPs, it should be noted that many of the controls planned for EGUs in the WRAP states had not taken place yet in 2010, while other controls separate from the RHR may have been implemented. The chart shows very little reported for SO_2 emissions, and periods of sharp decline for NO_X, especially between 2000 and 2004. In California, low SO_2 EGU emissions is likely due to the fact that very few of the boilers burn oil as an energy source, and California switched to low SO_X rules earlier that federal requirements.

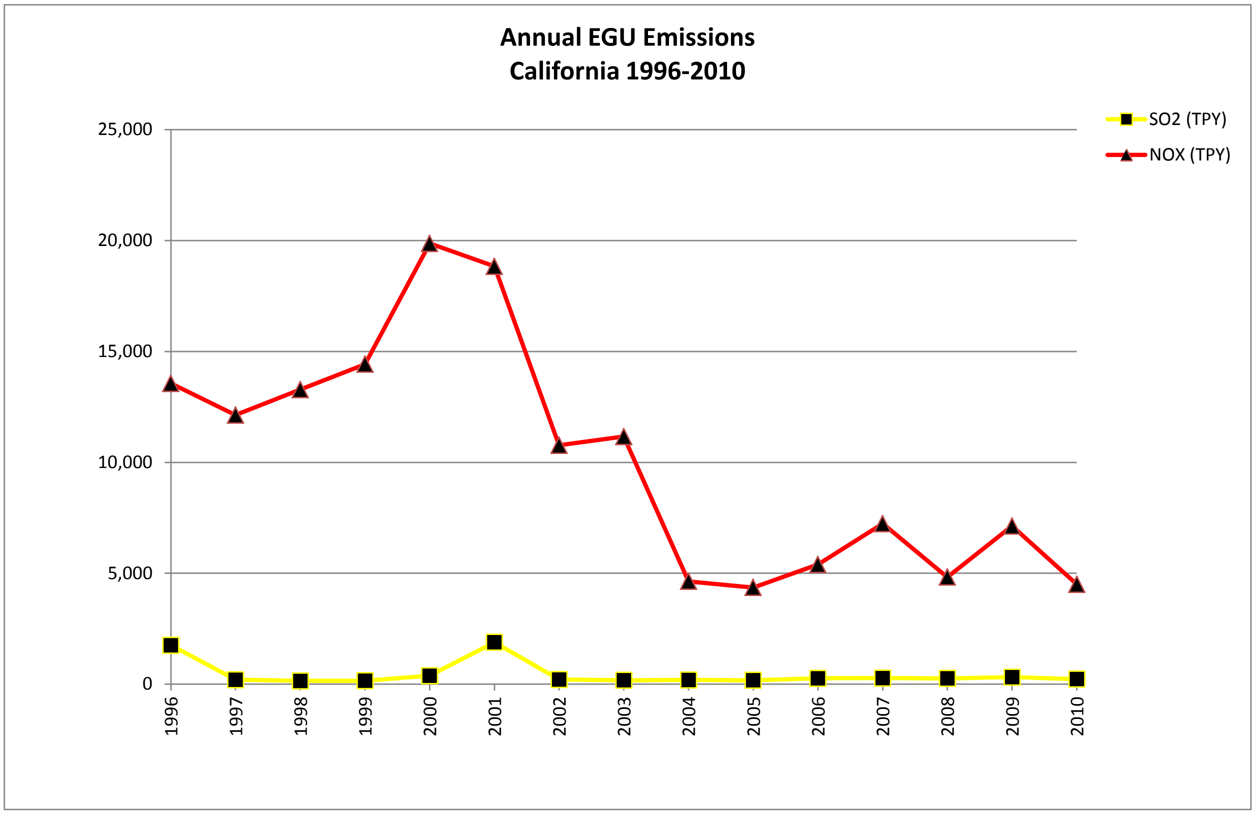

Figure 6.3-30. Sum of EGU Emissions of SO_2 and NO_X reported between 1996 and 2010 for California.

6.4 COLORADO

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. Colorado has 12 mandatory Federal CIAs, which are depicted in Figure 6.4-1 and listed in Table 6.4-1, along with the associated IMPROVE monitor locations.

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per Regional Haze Rule (RHR) requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. Some of the highlights regarding these comparisons are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- For both the best and worst days, the 5-year average deciview metric decreased at all Colorado Federal CIA IMPROVE sites.
- All sites measured either decreases or no change in 5-year average ammonium nitrate, particulate organic mass, elemental carbon and coarse mass.
- Increases in 5-year average ammonium sulfate were measured at the GRSA1, MOZI1, WEMI1, and WHRI1 sites, but annual average trends for ammonium sulfate were either insignificant or decreasing. Many regional sites, including sites in Arizona, Colorado, and New Mexico were affected by anomalously higher than average ammonium sulfate measurements in 2005. Increases were also not consistent with emissions inventory comparisons, where state-wide emissions totals and annual tracking of EGU emissions showed decreases in SO_2, due mostly to decreases in point, area and mobile sources.
- Increases in 5-year average soil were measured at the MOZI1, ROMO1, WEMI1, and WHRI1 sites, but no increasing annual trends were measured. Emissions inventory comparisons showed net increases in, with largest increases reported for windblown dust and point sources, although reported windblown dust increases are likely due to updated inventory methodology rather than actual increases.

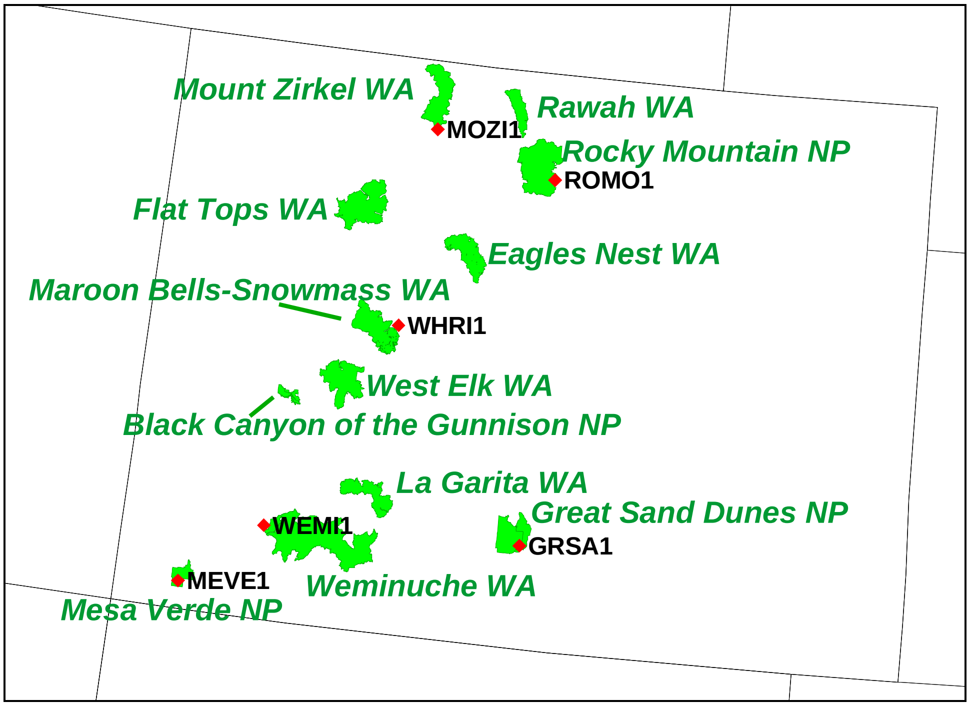

Figure 6.4-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in Colorado.

Table 6.4-1
Colorado CIAs and Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Great Sand Dunes NP	GRSA1	37.72	-105.52	2498
Mesa Verde NP	MEVE1	37.20	-108.49	2172
Mount Zirkel WA Rawah WA	MOZI1	40.54	-106.68	3243
Rocky Mountain NP	ROMO1	40.28	-105.55	2760
Weminuche WA La Garita WA Black Canyon of the Gunnison NP	WEMI1	37.66	-107.80	2750
Eagles Nest WA Flat Tops WA Maroon Bells-Snowmass WA West Elk WA	WHRI1	39.15	-106.82	3413

6.4.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by IMPROVE monitors representing Federal CIAs in Colorado. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix D.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.4.1.1 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.308 (g)(3)(i))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[78] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.4-2 and 6.4-3 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired, or worst, and 20% least impaired, or best, days for each of the Federal CIA IMPROVE monitors in Colorado. Figure 6.4-2 presents 5-year average extinction for the current progress period for both the 20% most impaired and 20% least impaired days. Note that the percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired days are as follows:

- The largest contributors to aerosol extinction at Colorado sites were particulate organic mass, ammonium sulfate and coarse mass.
- The highest aerosol extinction (12.8 dv) was measured at the ROMO1 site, where particulate organic mass was the largest contributor to aerosol extinction, followed by ammonium sulfate and ammonium nitrate. The lowest aerosol extinction (8.9 dv) was measured at the WHRI1 site.

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[78] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

Specific observations for the current visibility conditions on the 20% least impaired days are as follows:

- The aerosol contribution to total extinction on the best days was less than Rayleigh, or the background scattering that would occur in clear air. Average extinction (including Rayleigh) ranged from 0.2 dv (WHRI1) to 3.6 dv (GRSA1).
- For all sites, ammonium sulfate was the largest contributor to the non-Rayleigh aerosol portion of extinction

Table 6.4-2
Colorado Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	**Deciviews (dv)**	**Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank**						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
GRSA1	11.4	**29% (1)**	7% (6)	26% (2)	7% (5)	8% (4)	22% (3)	0% (7)
MEVE1	11.3	27% (2)	9% (4)	**28% (1)**	7% (6)	9% (5)	20% (3)	0% (7)
MOZI1	9.7	28% (2)	7% (5)	**36% (1)**	8% (4)	6% (6)	15% (3)	0% (7)
ROMO1	12.6	26% (2)	15% (3)	**32% (1)**	8% (5)	5% (6)	14% (4)	0% (7)
WEMI1	10.0	27% (2)	5% (6)	**36% (1)**	10% (4)	7% (5)	15% (3)	0% (7)
WHRI1	8.9	30% (2)	8% (5)	**33% (1)**	8% (4)	7% (6)	13% (3)	0% (7)

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.4-3
Colorado Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	**Deciviews (dv)**	**Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank**						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
GRSA1	3.6	**36% (1)**	9% (5)	26% (2)	10% (4)	5% (6)	13% (3)	0% (7)
MEVE1	3.1	**44% (1)**	12% (3)	21% (2)	9% (5)	5% (6)	9% (4)	0% (7)
MOZI1	0.7	**44% (1)**	16% (3)	20% (2)	8% (5)	3% (6)	9% (4)	0% (7)
ROMO1	2.0	**37% (1)**	8% (4)	25% (2)	8% (5)	5% (6)	17% (3)	0% (7)
WEMI1	2.4	**36% (1)**	6% (5)	23% (2)	15% (4)	4% (6)	15% (3)	1% (7)
WHRI1	0.2	**46% (1)**	10% (5)	14% (3)	15% (2)	5% (6)	11% (4)	0% (7)

*Highest aerosol species contribution per site is highlighted in bold.

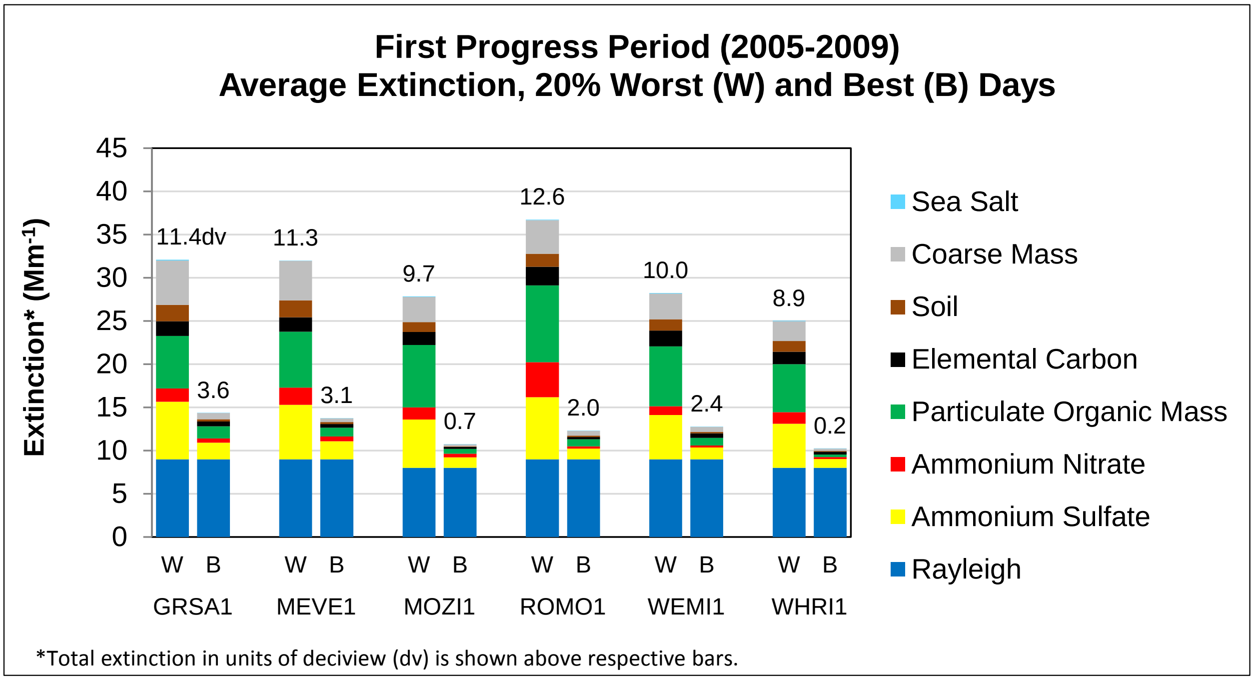

Figure 6.4-2. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at Colorado Class I Area IMPROVE Sites.

6.4.1.2 Differences Between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.308 (g)(3)(ii))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Table 6.4-4 presents the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for each site in Colorado for the 20% most impaired days, and Table 6.4-5 presents similar data for the least impaired days. Averages that increased are depicted in red text and averages that decreased in blue.

Figure 6.4-3 presents the 5-year average extinction for the baseline and current progress period averages for the worst days and Figure 6.4-4 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.4-5 and 6.4-6 present similar plots for the best days.

For the 20% most impaired days, the 5-year average deciview metric decreased at all Colorado sites. Notable differences for individual species averages were as follows:

- Largest charges in concentration were seen in particulate organic mass. Decreases for both particulate organic mass and elemental carbon were observed at all sites, with the largest decreases at the MEVE1 site.

- All sites measured either slight decreases or no change in ammonium nitrate, elemental carbon and coarse mass.
- Increases in ammonium sulfate were measured at the GRSA1, MOZI1, WEMI1 and WHRI1 sites, and decreases were measured at the MEVE1 and ROMO1 sites.

For the 20% least impaired days, the 5-year average deciview metric decreased at all sites. Notable differences for individual species averages on the 20% least impaired days were as follows:

- All sites measured either slight decreases or no change in all species. The largest decreases were recorded in particulate organic mass.

Table 6.4-4
Colorado Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
GRSA1	12.8	11.4	-1.4	+0.7	-0.4	-2.4	-0.1	-0.9	-2.1	0.0
MEVE1	13.0	11.3	-1.7	-0.2	-0.3	-5.8	-0.7	-0.5	-2.0	0.0
MOZI1	10.5	9.7	-0.8	+0.3	-0.7	-2.7	-0.3	+0.1	-0.2	0.0
ROMO1	13.8	12.6	-1.2	-0.7	-1.2	-1.6	-0.4	+0.1	-1.0	0.0
WEMI1	10.3	10.0	-0.3	+0.1	-0.2	-1.4	-0.2	+0.1	0.0	-0.1
WHRI1	9.6	8.9	-0.7	+0.3	0.0	-2.3	-0.3	+0.1	-0.5	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.4-5
Colorado Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
GRSA1	4.5	3.6	-0.9	-0.2	-0.2	-0.4	-0.1	-0.1	-0.4	0.0
MEVE1	4.3	3.1	-1.2	-0.3	-0.3	-0.5	-0.2	-0.2	-0.3	0.0
MOZI1	1.6	0.7	-0.9	-0.3	-0.1	-0.3	-0.1	0.0	-0.3	0.0
ROMO1	2.3	2.0	-0.3	-0.1	-0.1	-0.1	-0.1	0.0	-0.1	0.0
WEMI1	3.1	2.4	-0.7	-0.1	-0.1	-0.4	-0.2	0.0	-0.1	0.0
WHRI1	0.7	0.2	-0.5	0.0	-0.1	-0.3	-0.1	0.0	0.0	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

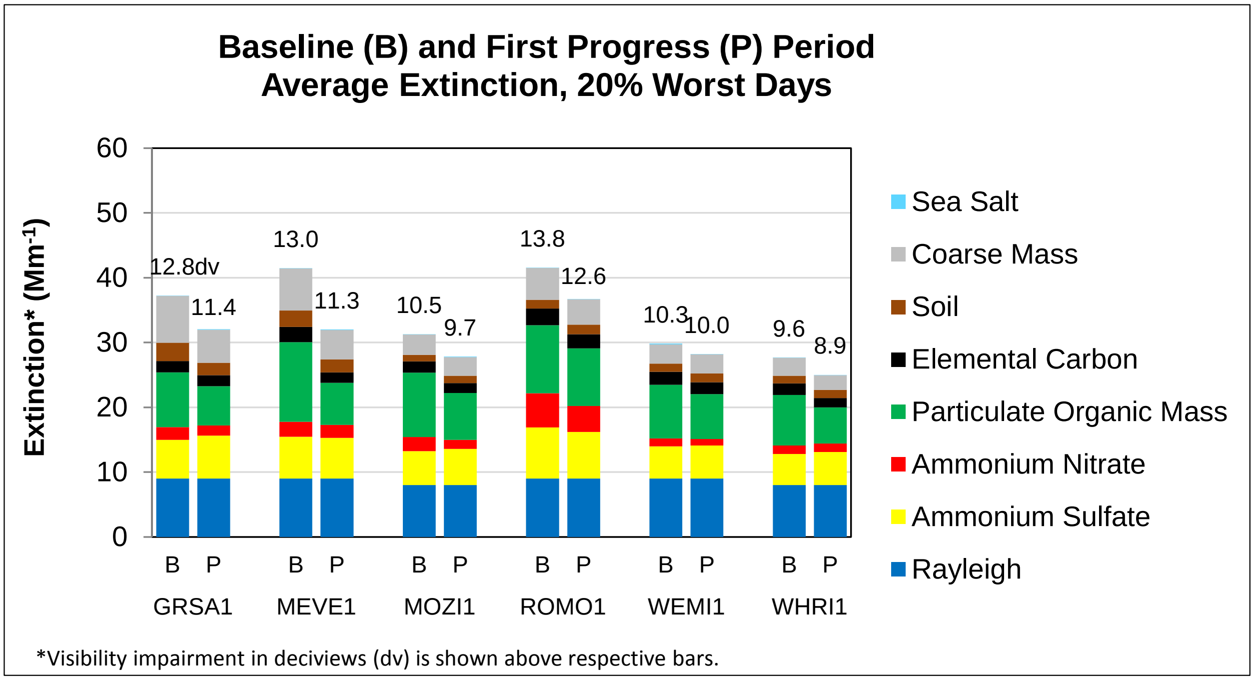

Figure 6.4-3. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at Colorado Class I Area IMPROVE Sites.

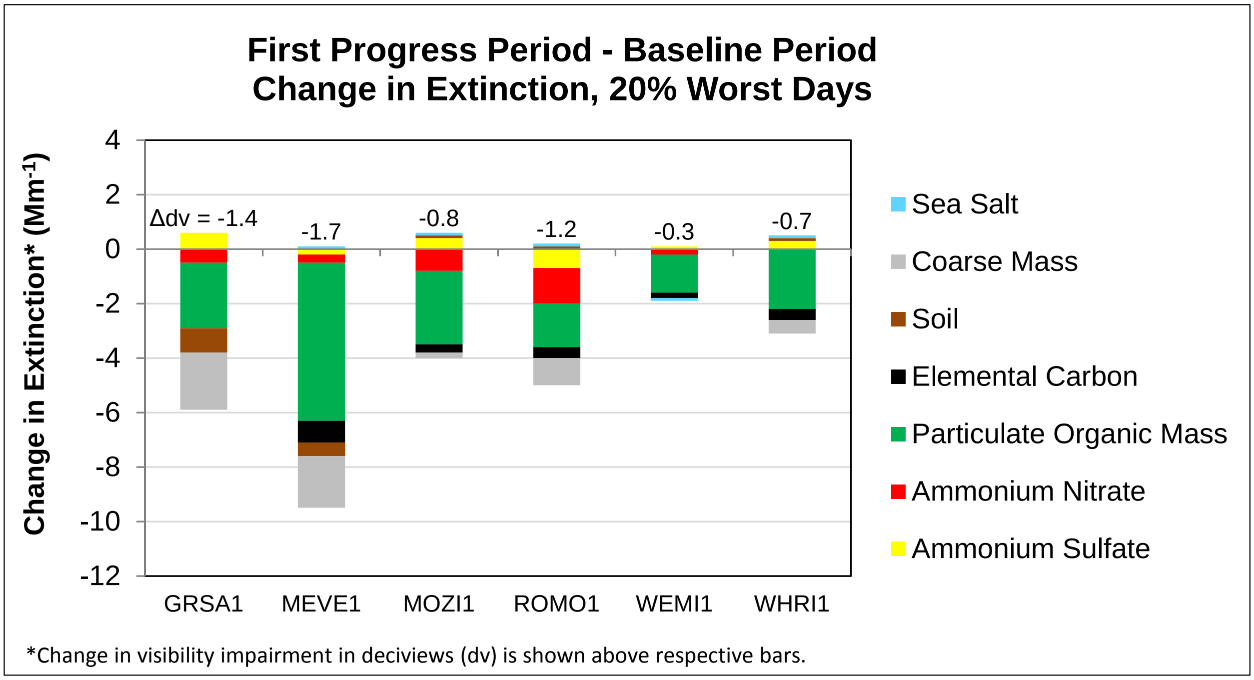

Figure 6.4-4. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at Colorado Class I Area IMPROVE Sites.

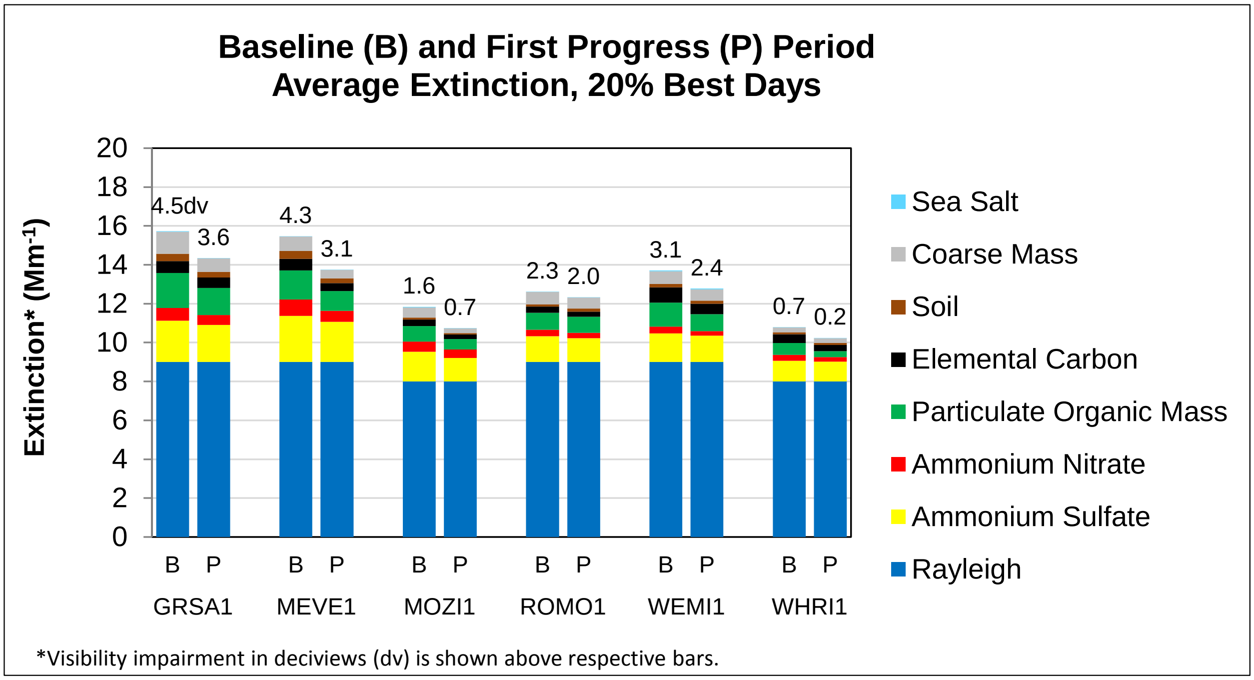

Figure 6.4-5. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at Colorado Class I Area IMPROVE Sites.

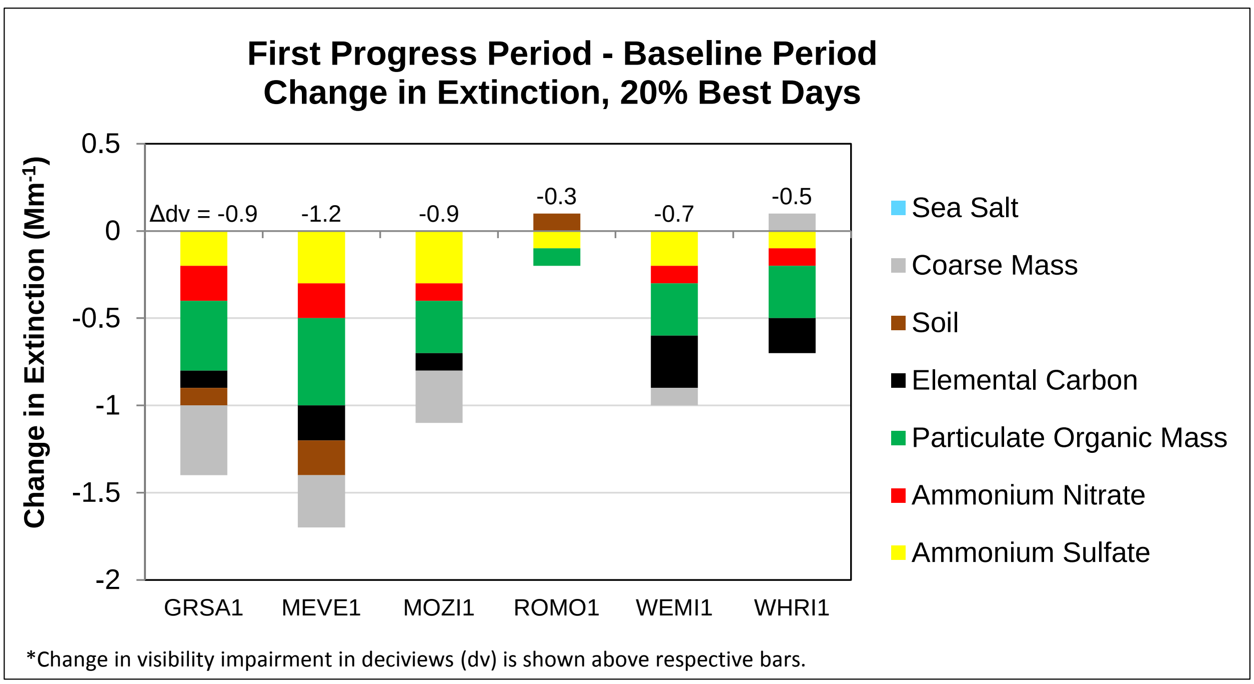

Figure 6.4-6. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at Colorado Class I Area IMPROVE Sites.

6.4.1.3 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.308 (g)(3)(iii))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5-year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in Colorado are summarized in Table 6.4-6, and regional trends were presented earlier in Section 4.1.1.[79] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[80] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix D. Additionally, this appendix includes plots depicting 5-year, annual, monthly, and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in Colorado are as follows:

- Particulate organic mass was the largest contributor to aerosol extinction for the worst days at all sites except GRSA1, and the second largest contributor at GRSA1. The largest measurements generally occurred between June and August, consistent with wildfire activity. The 5-year average of particulate organic mass decreased at all sites. Also, elemental carbon, a relatively minor contributor to haze which is often related to wildfire activity, decreased at all sites.

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[79] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)

[80] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

- Ammonium sulfate was the largest contributor to aerosol extinction at GRSA1, and the second largest contributor to aerosol extinction at all other sites in Colorado. The 5-year averages showed very little change for the worst days, and improvement at all sites for the best days. Annual average trends showed extinction due to ammonium sulfate decreasing on an annual basis at the GRSA1, MEVE1 and ROMO1 sites.
- The largest concentrations of ammonium nitrate were measured at the ROMO1 site. The 5-year average metrics showed ammonium nitrate decreasing or staying the same at all sites for the worst days, and decreasing at all sites for the best days. Annual average trends show extinction due to ammonium nitrate decreasing at the ROMO1 site at a rate of approximately 0.1 Mm^{-1} per year for all measured days.

Table 6.4-6
Colorado Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
GRSA1	20% Best	0.0	--	0.0	0.0	0.0	**-0.1**	--
	20% Worst	--	--	**-0.6**	**-0.1**	**-0.1**	**-0.4**	0.0
	All Days	**-0.1**	--	**-0.1**	--	0.0	**-0.2**	--
MEVE1	20% Best	**-0.1**	0.0	**-0.1**	0.0	0.0	0.0	--
	20% Worst	--	--	--	**-0.2**	--	--	0.0
	All Days	**-0.1**	--	**-0.3**	**-0.1**	--	--	0.0
MOZI1	20% Best	0.0	--	0.0	0.0	--	0.0	0.0
	20% Worst	--	**-0.2**	--	--	--	--	0.0
	All Days	--	0.0	--	0.0	--	--	0.0
ROMO1	20% Best	0.0	0.0	--	0.0	0.0	--	--
	20% Worst	**-0.2**	--	--	**-0.1**	--	--	0.0
	All Days	**-0.1**	**-0.1**	--	0.0	0.0	**-0.1**	--
WEMI1	20% Best	**-0.1**	0.0	**-0.1**	**-0.1**	--	--	--
	20% Worst	--	--	--	0.0	--	--	--
	All Days	--	0.0	--	**-0.1**	--	--	--
WHRI1	20% Best	--	0.0	**-0.1**	0.0	--	--	--
	20% Worst	--	--	--	**-0.1**	--	--	0.0
	All Days	--	--	**-0.1**	0.0	--	--	0.0

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix D.

6.4.2 Emissions Data

Included here are summaries depicting differences between two emission inventory years that are used to represent the 5-year baseline and current progress periods. The baseline period is represented using a 2002 inventory developed by the WRAP for use in the initial WRAP state SIPs, and the progress period is represented by a 2008 inventory which leverages recent WRAP inventory work for modeling efforts, as referenced in Section 3.2.1. For reference, Table 6.4-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories, and a separate summary of annual emissions from electrical generating units (EGUs), are presented in this section.

Table 6.4-7
Colorado
Pollutants, Aerosol Species, and Major Sources

Emitted Pollutant	Related Aerosol	Major Sources	Notes
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- and Off-Road Mobile Sources	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be associated with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Primary Organic Aerosol (POA)	POM	Wildfires; Area Sources	POA represents organic aerosols that are emitted directly as particles, as opposed to gases. Wildfires in the west generally dominate POA emissions, and large wildfire events are generally sporadic and highly variable from year-to-year.
Elemental Carbon (EC)	EC	Wildfires; On- and Off-Road Mobile Sources	Large EC events are often associated with large POM events during wildfires. Other sources include both on- and off-road diesel engines.
Fine soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is reported by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$ mass measurements. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but these measurements are generally associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributor to PMC.

6.4.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.308 (g)(4))?*** For these summaries, emissions during the baseline years are represented using a 2002 inventory, which was developed with support from the WRAP for use in the original RHR SIP strategy development (termed plan02d). Differences between inventories are represented as the difference between the 2002 inventory, and a 2008 inventory which leverages recent inventory development work performed by the WRAP for the WestJumpAQMS and DEASCO_3 modeling projects (termed WestJump2008). Note that the comparisons of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories, as referenced in Section 3.2.1. Inventories for all major visibility impairing pollutants are presented for major source categories, and categorized as either anthropogenic or natural emissions. State-wide inventories totals and differences are presented here, and inventory totals on a county level basis are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

Table 6.4-8 and Figure 6.4-7 present the differences between the 2002 and 2008 sulfur dioxide (SO_2) inventories by source category. Tables 6.4-9 and Figure 6.4-8 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.4-10 through 6.4-15 and Figures 6.4-9 through 6.4-14) present data for ammonia (NH_3), volatile organic compounds (VOCs), primary organic aerosol (POA), elemental carbon (EC), fine soil and coarse mass. General observations regarding emissions inventory comparisons are listed below.

- Largest differences for point source inventories were decreases in SO_2, NO_X and coarse mass Note that this is consistent with the decline in annual SO_2 and NO_X EGU emissions, as shown in Section 6.4.2.2.
- Area source inventories showed decreases in SO_2 and VOCs, but increases in NO_X NH_3, and POA. These changes may be due to a combination of population changes and differences in methodologies used to estimate these emissions, as referenced in Section 3.2.1. One methodology change was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to increases in area source inventory totals, but decreases in off-road mobile totals.
- On-road mobile source inventory comparisons showed decreases in most parameters, especially SO_2, NO_X and VOCs, with slight increases in POA, EC and coarse mass. Reductions in NO_X and VOC are likely influenced by federal and state emissions standards that have already been implemented. The increases in POA, EC and coarse mass occurred in all of the WRAP states for on-road mobile inventories, regardless of reductions in NO_2 and VOCs, indicating that these increases were likely due to use of different on-road models, as referenced in Section 3.2.1.
- Off-road mobile source inventories showed decreases in NO_X, SO_2, and VOCs, and increases in fine soil and coarse mass, which was consistent with most contiguous WRAP states. These differences were likely due to a combination of actual changes

in source contributions and methodology differences, as referenced in Section 3.2.1. As noted previously, one major methodology difference was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to decreases in the off-road inventory totals, but increases in area source totals.

- Inventory comparison results for area oil and gas showed increases for most parameters, but note that inventory methodologies for these sources may have evolved substantially between the baseline and 2008 inventories as referenced in Section 3.2.1.
- For most parameters, especially POAs, VOCs, and EC, natural fire emission inventory estimates decreased. Note that these differences are not necessarily reflective of changes in monitored data, as the baseline period is represented by an average of 2000-2004 fire emissions, and the progress period is represented only by the fires that occurred in 2008, as referenced in Section 3.2.1.
- Comparisons between VOC inventories showed large decreases in biogenic emissions, which was consistent with other contiguous WRAP states. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions, as referenced in Section 3.2.1.
- Fine soil and coarse mass decreased in the windblown dust inventory comparisons and increased in the combined fugitive/road dust inventories. Large variability in changes in windblown dust was observed for the contiguous WRAP states, which was likely due in large part to enhancements in dust inventory methodology, as referenced in Section 3.2.1, rather than changes in actual emissions.

Table 6.4-8
Colorado
Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	97,978	64,516	-33,463
Area	6,299	493	-5,807
On-Road Mobile	4,147	959	-3,188
Off-Road Mobile	2,469	609	-1,860
Area Oil and Gas	118	555	437
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	92	32	-60
Total Anthropogenic	**111,103**	**67,163**	**-43,940 (-40%)**
Natural Sources			
Natural Fire	2,542	132	-2,410
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**2,542**	**132**	**-2,410 (-95%)**
All Sources			
Total Emissions	**113,645**	**67,295**	**-46,350 (-41%)**

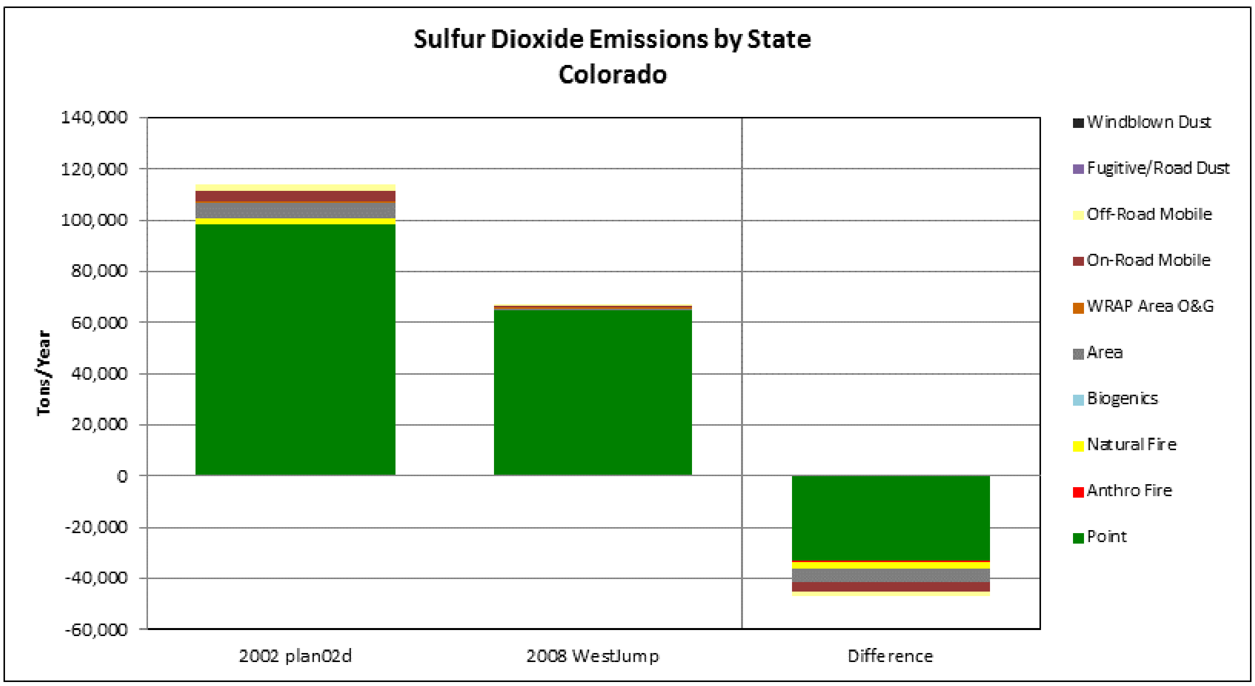

Figure 6.4-7. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for Colorado.

Table 6.4-9
Colorado
Oxides of Nitrogen Emissions by Category

Source Category	Oxides of Nitrogen Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	118,666	108,088	-10,578
Area	11,700	22,852	11,152
On-Road Mobile	141,883	129,591	-12,292
Off-Road Mobile	62,448	31,360	-31,088
Area Oil and Gas	23,518	27,048	3,530
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	517	234	-282
Total Anthropogenic	**358,732**	**319,173**	**-39,558 (-11%)**
Natural Sources			
Natural Fire	9,297	932	-8,366
Biogenic	37,349	9,542	-27,807
Wind Blown Dust			
Total Natural	**46,646**	**10,473**	**-36,173 (-78%)**
All Sources			
Total Emissions	**405,378**	**329,647**	**-75,731 (-19%)**

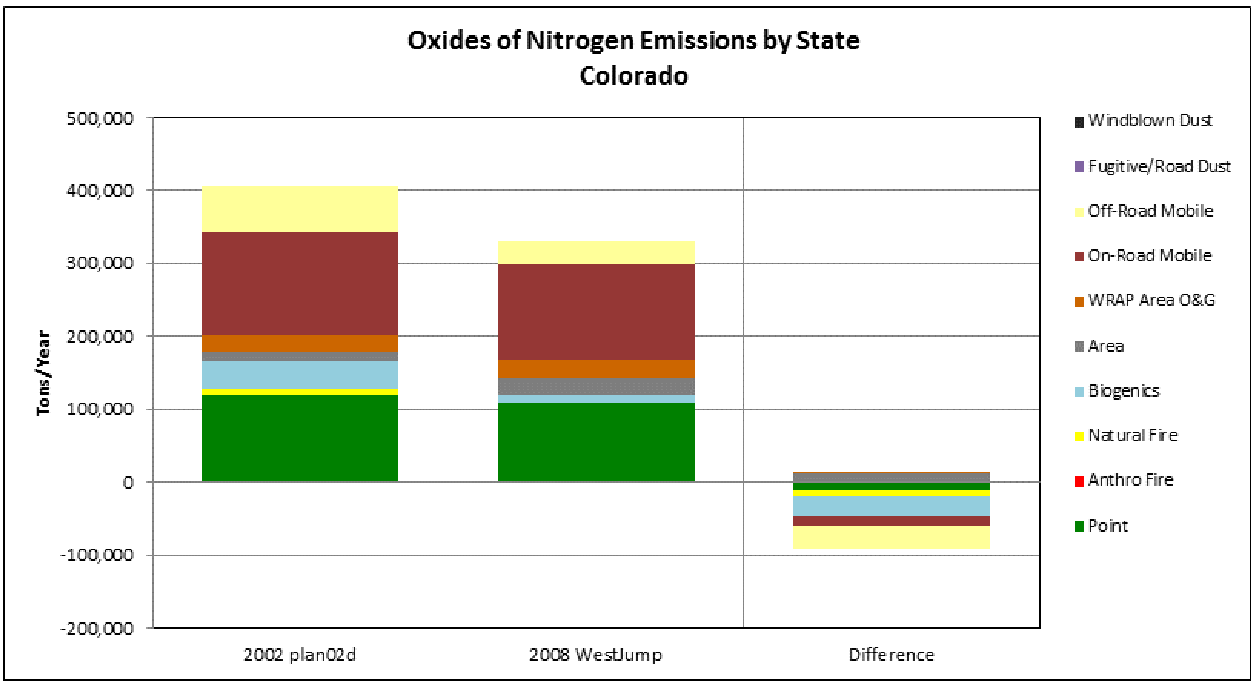

Figure 6.4-8. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Oxides of Nitrogen by Source Category for Colorado.

Table 6.4-10
Colorado
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	453	469	15
Area	60,771	70,451	9,680
On-Road Mobile	4,317	2,201	-2,116
Off-Road Mobile	43	35	-8
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	137	153	16
Total Anthropogenic	**65,721**	**73,310**	**7,588 (12%)**
Natural Sources			
Natural Fire	1,965	648	-1,317
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**1,965**	**648**	**-1,317 (-67%)**
All Sources			
Total Emissions	**67,686**	**73,958**	**6,272 (9%)**

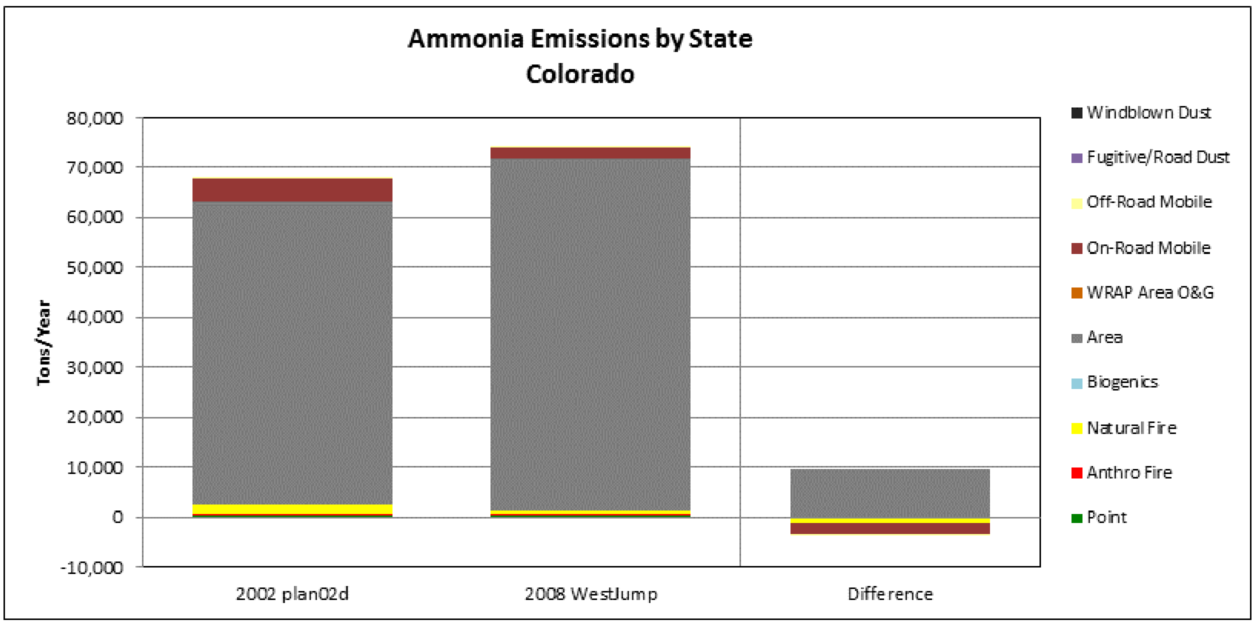

Figure 6.4-9. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Ammonia by Source Category for Colorado.

Table 6.4-11
Colorado
Volatile Organic Compound Emissions by Category

Source Category	Volatile Organic Compound Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	91,750	109,435	17,685
Area	99,191	67,133	-32,058
On-Road Mobile	100,860	55,953	-44,907
Off-Road Mobile	38,401	34,301	-4,100
Area Oil and Gas	27,259	68,895	41,636
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	915	373	-542
Total Anthropogenic	**358,376**	**336,090**	**-22,286 (-6%)**
Natural Sources			
Natural Fire	20,404	900	-19,504
Biogenic	804,777	275,328	-529,449
Wind Blown Dust	0	0	0
Total Natural	**825,181**	**276,227**	**-548,953 (-67%)**
All Sources			
Total Emissions	**1,183,557**	**612,317**	**-571,240 (-48%)**

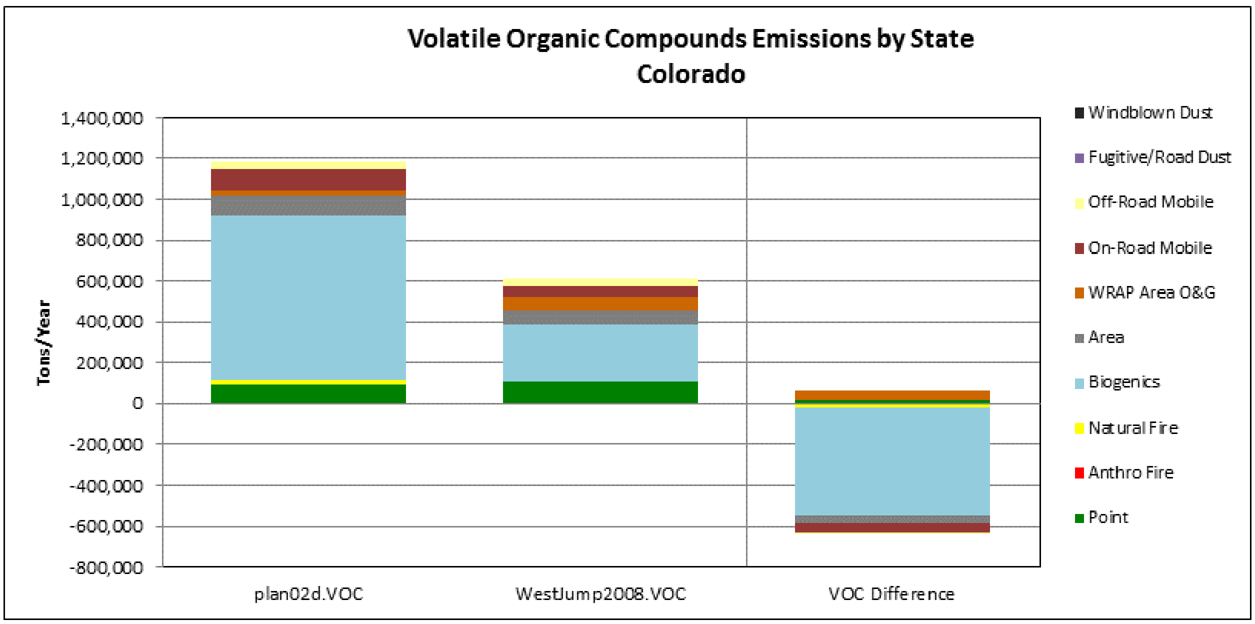

Figure 6.4-10. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for Colorado.

Table 6.4-12
Colorado
Primary Organic Aerosol Emissions by Category

Source Category	Primary Organic Aerosol Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	17	323	306
Area	8,432	9,629	1,197
On-Road Mobile	1,280	3,279	1,999
Off-Road Mobile	1,286	1,236	-50
Area Oil and Gas	0	88	88
Fugitive and Road Dust	878	1,248	369
Anthropogenic Fire	850	458	-392
Total Anthropogenic	**12,744**	**16,262**	**3,518 (28%)**
Natural Sources			
Natural Fire	30,581	1,758	-28,822
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**30,581**	**1,758**	**-28,822 (-94%)**
All Sources			
Total Emissions	**43,325**	**18,021**	**-25,304 (-58%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

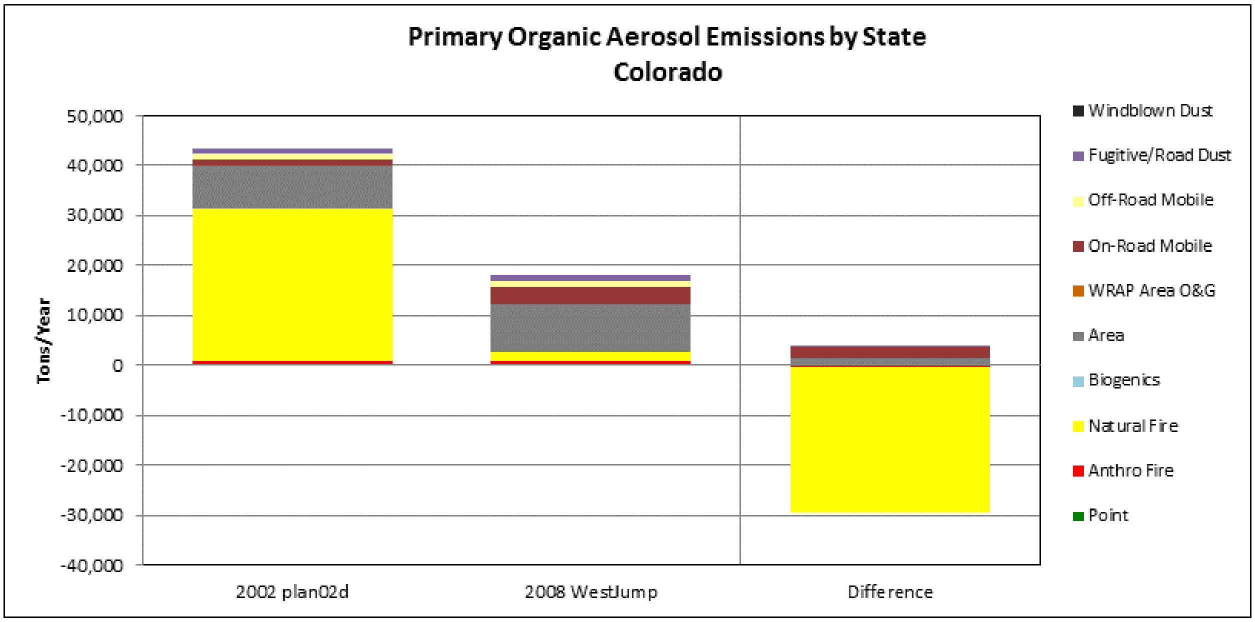

Figure 6.4-11. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Primary Organic Aerosol by Source Category for Colorado.

Table 6.4-13
Colorado
Elemental Carbon Emissions by Category

Source Category	**Elemental Carbon Emissions (tons/year)**		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	0	64	64
Area	1,264	1,152	-112
On-Road Mobile	1,448	5,257	3,809
Off-Road Mobile	3,175	1,731	-1,444
Area Oil and Gas	0	0	0
Fugitive and Road Dust	61	28	-34
Anthropogenic Fire	92	83	-9
Total Anthropogenic	**6,041**	**8,315**	**2,275 (38%)**
Natural Sources			
Natural Fire	6,337	329	-6,008
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**6,337**	**329**	**-6,008 (-95%)**
All Sources			
Total Emissions	**12,377**	**8,644**	**-3,734 (-30%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

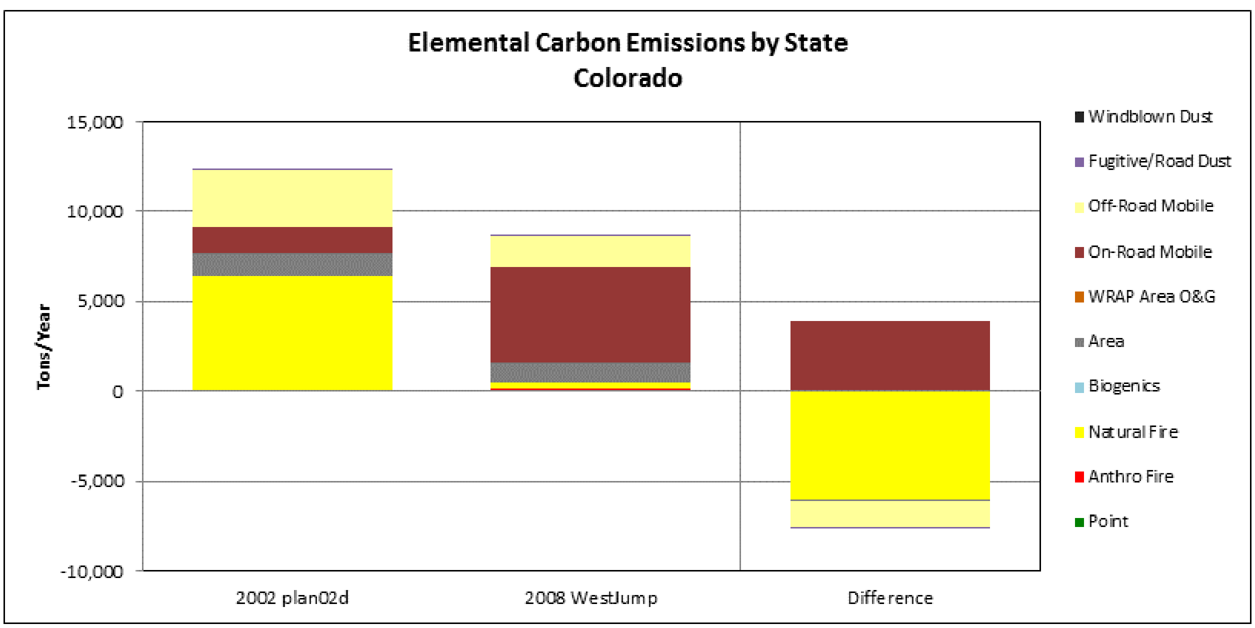

Figure 6.4-12. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Elemental Carbon by Source Category for Colorado.

Table 6.4-14
Colorado
Fine Soil Emissions by Category

Source Category	Fine Soil Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	6	424	419
Area	4,170	4,064	-106
On-Road Mobile	812	536	-276
Off-Road Mobile	0	86	86
Area Oil and Gas	0	1,517	1,517
Fugitive and Road Dust	14,483	22,998	8,515
Anthropogenic Fire	253	173	-80
Total Anthropogenic	**19,723**	**29,799**	**10,076 (51%)**
Natural Sources			
Natural Fire	1,948	676	-1,272
Biogenic	0	0	0
Wind Blown Dust	15,105	13,138	-1,967
Total Natural	**17,053**	**13,814**	**-3,239 (-19%)**
All Sources			
Total Emissions	**36,776**	**43,613**	**6,837 (19%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

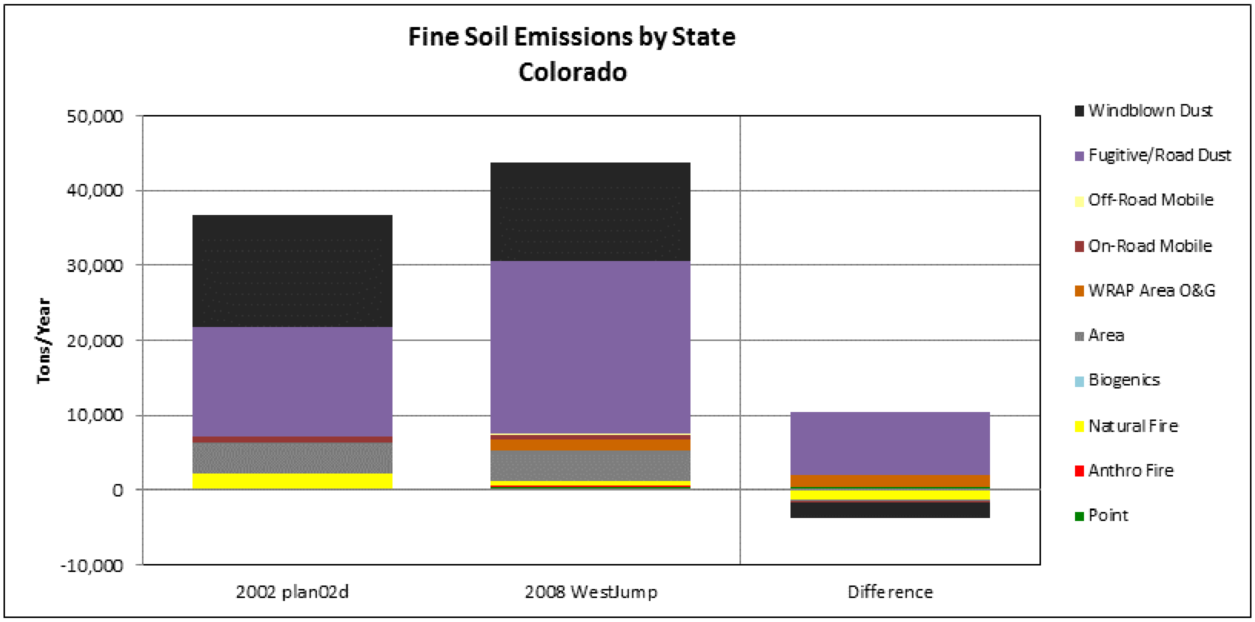

Figure 6.4-13. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Fine Soil by Source Category for Colorado.

Table 6.4-15
Colorado
Coarse Mass Emissions by Category

Source Category	Coarse Mass Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	21,096	10,530	-10,566
Area	1,363	61	-1,302
On-Road Mobile	794	5,762	4,968
Off-Road Mobile	0	146	146
Area Oil and Gas	0	60	60
Fugitive and Road Dust	76,572	122,035	45,464
Anthropogenic Fire	51	88	37
Total Anthropogenic	**99,876**	**138,683**	**38,807 (39%)**
Natural Sources			
Natural Fire	5,973	337	-5,636
Biogenic	0	0	0
Wind Blown Dust	135,945	118,244	-17,701
Total Natural	**141,918**	**118,581**	**-23,337 (-16%)**
All Sources			
Total Emissions	**241,794**	**257,264**	**15,470 (6%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

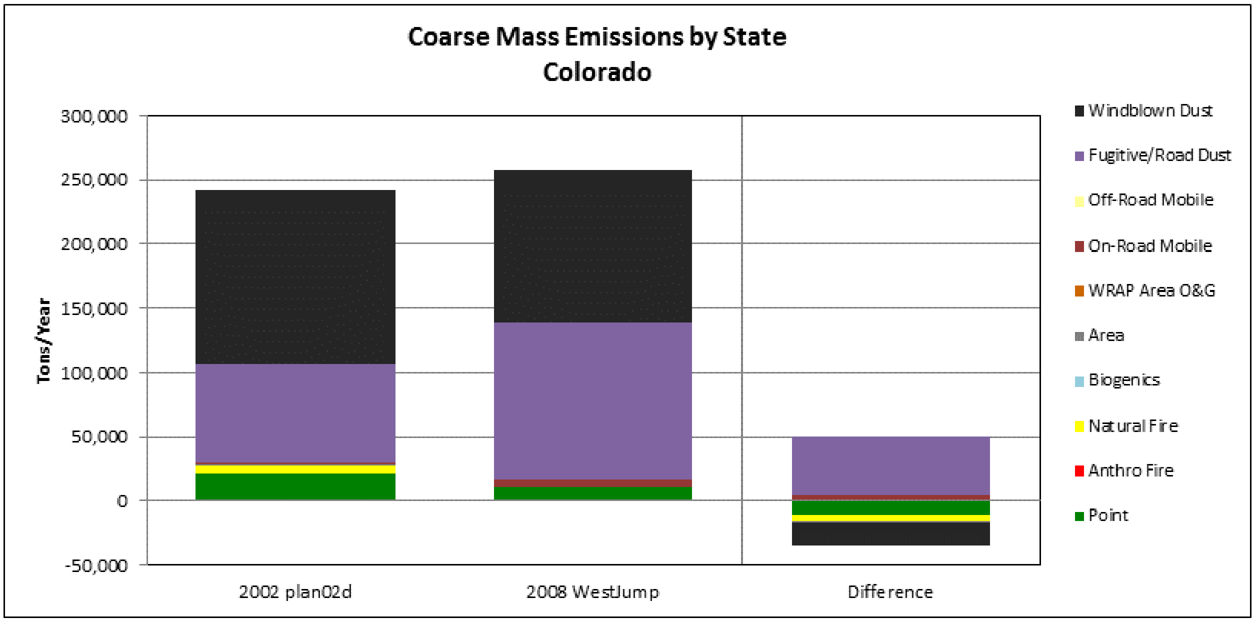

Figure 6.4-14. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Coarse Mass by Source Category for Colorado.

6.4.2.2 EGU Summary

As described in previous sections, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions because numerous updates in inventory methodologies have occurred between the development of the separate inventories. Also, the 2002 baseline and 2008 progress period inventories represent only annual snapshots of emissions estimates, which may not be representative of entire 5-year monitoring periods compared. To better account for year-to-year changes in emissions, annual emission totals for Colorado electrical generating units (EGU) are presented here. EGU emissions are some of the more consistently reported emissions, as tracked in EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/). RHR implementation plans are required to pay specific attention to certain major stationary sources, including EGUs, built between 1962 and 1977.

Figure 6.4-17 presents a sum of annual NO_X and SO_2 emissions as reported for Colorado EGU sources between 1996 and 2010. While these types of facilities are targeted for controls in state regional haze SIPs, it should be noted that many of the controls planned for EGUs in the WRAP states had not taken place yet in 2010, while other controls separate from the RHR may have been implemented. The chart shows periods of sharpest decline for SO_2 between 2002 and 2004, and again between 2007 and 2009. NO_X emissions showed notable decreases between 1996 and 1998, 2004, 2008 and 2009.

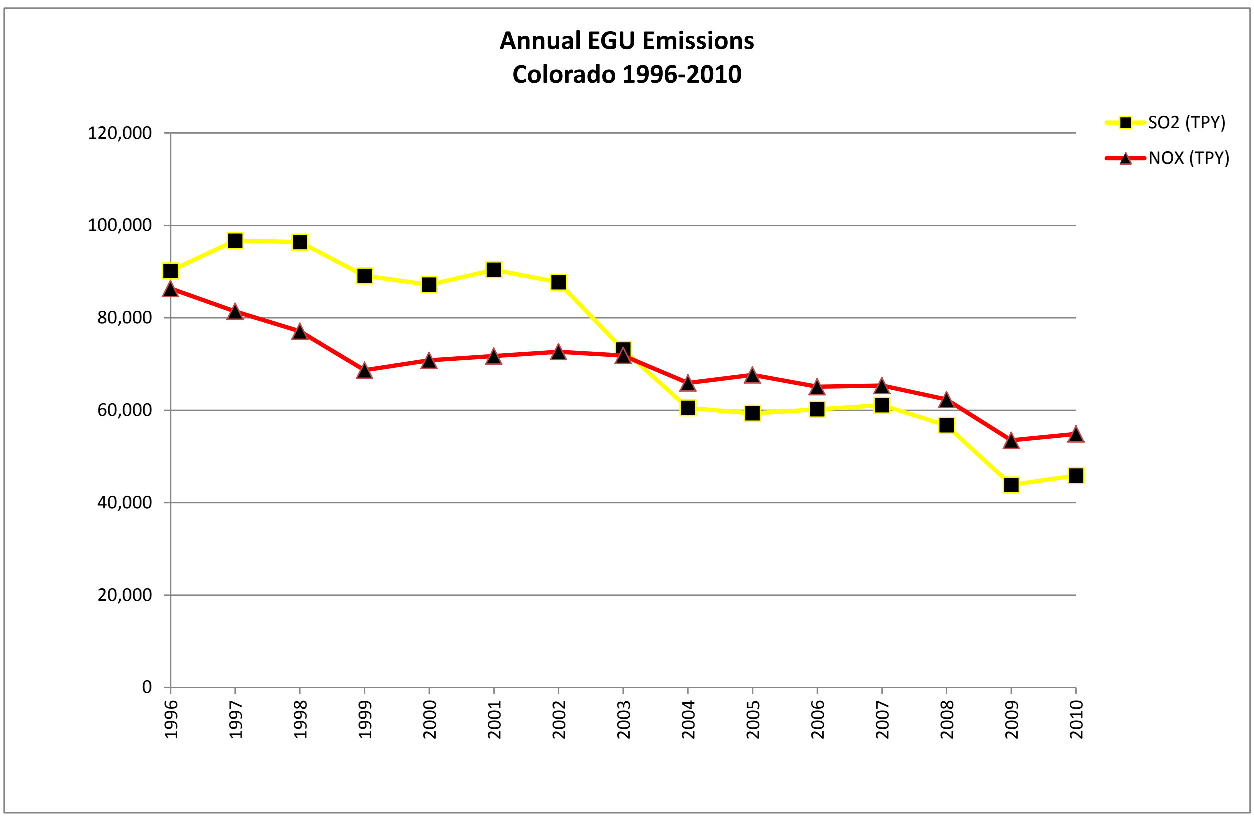

Figure 6.4-8. Sum of EGU Emissions of SO_2 and NO_X Reported between 1996 and 2010 for Colorado.

6.5 HAWAII

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. Hawaii has 2 mandatory Federal CIAs, which are depicted in Figure 6.5-1 and listed in Table 6.5-1, along with the associated IMPROVE monitor locations. Note that two sites are listed to represent the Haleakala CIA, but one site (HALE1) was discontinued in 2012, and the other site (HACR1) began operation in 2007. Data collected from both sites are summarized in this report, but future regional haze progress will be determined using only the HACR1 site.

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per Regional Haze Rule (RHR) requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. Some of the highlights regarding these comparisons are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- The 5-year average deciview metric decreased between the baseline and progress period at all 3 sites on best days, and increased on the worst days.
- The largest aerosol contributor to increases on the worst days was ammonium sulfate. The major source of ammonium sulfate for the State of Hawaii is SO_2 emissions from volcanic sources.
- Increases in ammonium sulfate were partially offset by decreases in ammonium nitrate, particulate organic mass and elemental carbon at all sites. Decreases in emissions inventories oxides of nitrogen (NO_X) were shown for mobile and point sources, but these were offset by increases in marine emissions.
- Slight increases for the worst days were observed in soil and coarse mass at the HAVO1 site, but these soil and coarse mass components combined comprised less than 2% of the total measured extinction.

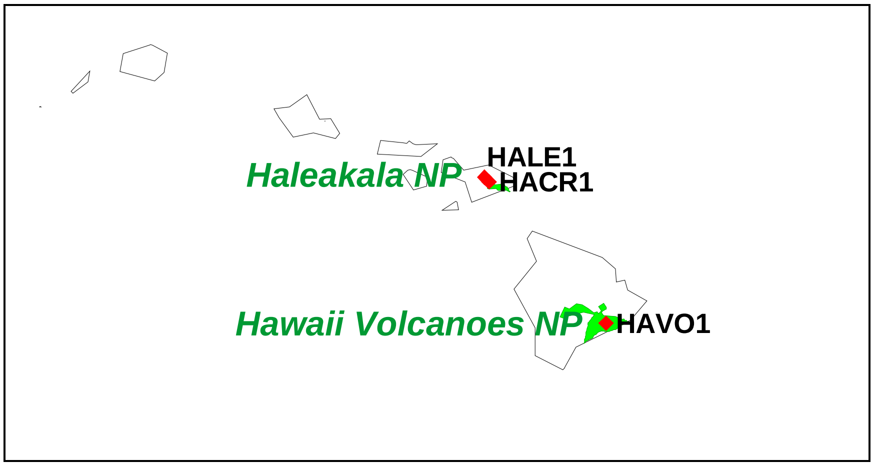

Figure 6.5-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in Hawaii.

Table 6.5-1
Hawaii CIAs and Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Haleakala NP	HACR1*	20.76	-156.25	2158
	HALE1*	20.81	-156.28	1153
Hawaii Volcanoes NP	HAVO1	19.43	-155.26	1258

*Monitoring at the HACR1 site began in 2007 and monitoring at the HALE1 site was discontinued in 2012.

6.5.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by IMPROVE monitors representing Federal CIAs in Hawaii, including estimates of baseline concentrations for the Haleakala HACR1 site. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix E.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.5.1.1 Haleakala Baseline Estimate

In Hawaii, the HALE1 IMPROVE monitor began operation in 2000 at a site approximately 3.5 miles outside of Haleakala National Park boundaries. In 2007 a second IMPROVE monitor, HACR1, was installed at a higher elevation within park boundaries. The intention of the HACR1 site was to replace the HALE1 site, as the new HACR1 site was determined to be more representative of conditions in the park. A map depicting both Haleakala sites is presented in Figure 6.5-2. Data from the HALE1 site were used to represent Haleakala in the Hawaii RHR Federal Implementation Plan (FIP), but progress for both the HALE1 and HACR1 sites will be presented in Hawaii's first RHR progress report. Future RHR SIPs and progress updates will use only HACR1 data, as monitoring at the HALE1 site was discontinued in 2012.

RHR guidelines require that progress be measured again the 2000-2004 baseline period[81], but baseline data were not measured at the HACR1 location. The RHR also states that approximations should be made for baseline conditions if these monitoring data are not available.[82] A methodology to estimate baseline conditions for the HACR1 site was developed in consultation with staff from the State of Hawaii Department of Health – Clean Air Branch, the National Park Service, and U.S. EPA Region 9. This methodology and baseline results are presented in this section.

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[81] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (see page 4-2 in the Guidance document).

[82] Section 308(d)(2)(i) of the RHR states, "For mandatory Class I Federal areas without onsite monitoring data for 2000-2004, the State must establish baseline values using the most representative available monitoring data for 2000-2004, in consultation with the Administrator or his or her designee."

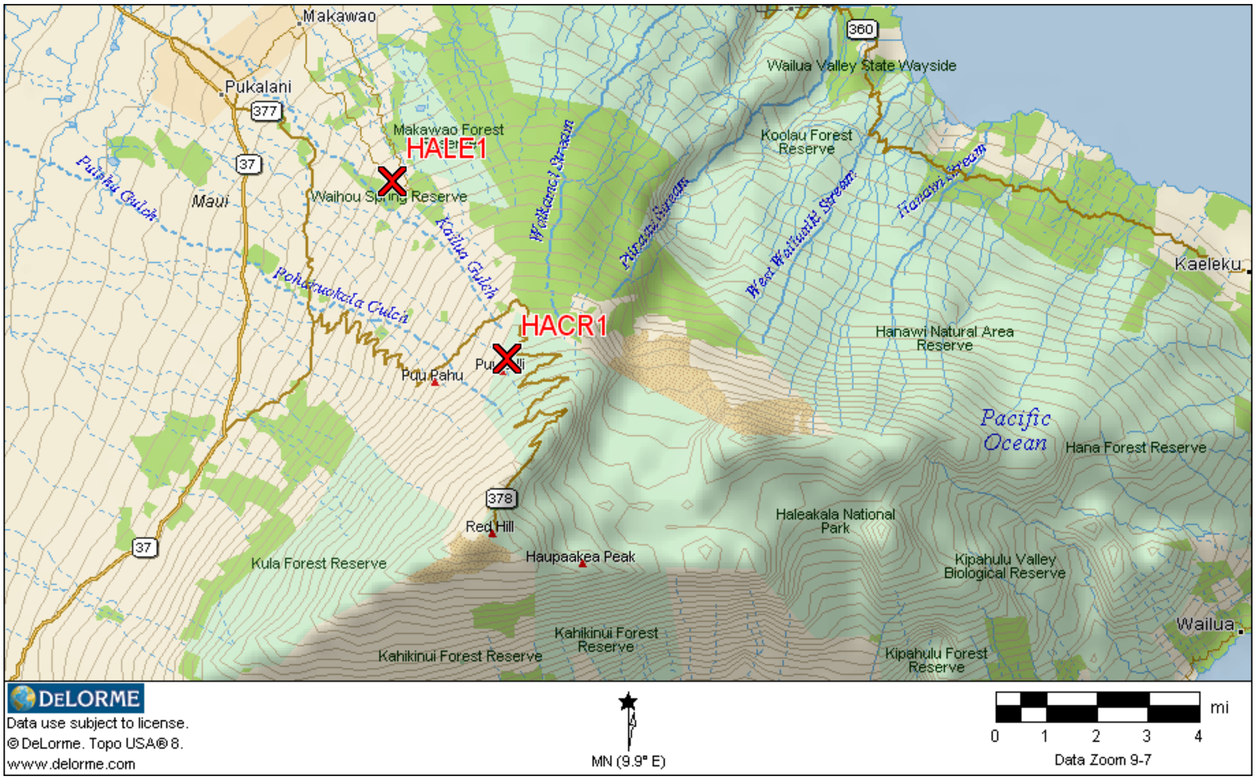

Figure 6.5-2. Map of HALE1 and HACR1 Sites Representing Haleakala National Park.

Both baseline (2000-2004) and first progress period (2004-2009) average data were available for the HALE1 site, but only the progress period average was available for the HACR1 site. To estimate baseline conditions at the HACR1 site, ratios between the 2005-2009 progress period and the 2000-2004 baseline period were determined for each aerosol species at the HALE1 site, for both the 20% most impaired and 20% least impaired days. These ratios were then applied to the HACR1 progress period to estimate a 5-year average baseline for each species. Table 6.5-2 lists the average progress to baseline period ratios for the HALE1 for the 20% most impaired days and least impaired days. These average ratios were applied to the 2005-2009 progress period for HACR1 site to obtain species and group specific estimates, such that, for each species:

$$\frac{\text{HACR1 Progress Period}}{\text{HALE}\ \dfrac{\text{Progress}}{\text{Baseline}}\ \text{Average}} = \text{HACR1 Baseline Period Estimate}$$

Table 6.5-2
HALE1 Averages and Ratios

Species	Group	2000-2004 Baseline Period	2005-2009 Progress Period	HALE1 Progress/ Baseline Ratio
Ammonium Sulfate (Mm^{-1})	Best 20% Days	2.2	2.1	0.96
	Worst 20% Days	17.5	26.5	1.51
Ammonium Nitrate (Mm^{-1})	Best 20% Days	0.6	0.4	0.76
	Worst 20% Days	2.7	2.1	0.79
Particulate Organic Mass (Mm^{-1})	Best 20% Days	0.7	0.5	0.76
	Worst 20% Days	2.9	2.2	0.77
Elemental Carbon (Mm^{-1})	Best 20% Days	0.2	0.2	0.79
	Worst 20% Days	1.4	1.2	0.84
Soil (Mm^{-1})	Best 20% Days	0.1	0.1	0.89
	Worst 20% Days	0.4	0.4	1.08
Coarse Mass (Mm^{-1})	Best 20% Days	1.0	0.9	0.82
	Worst 20% Days	2.6	1.9	0.73
Sea Salt (Mm^{-1})	Best 20% Days	1.1	1.5	1.37
	Worst 20% Days	1.3	2.0	1.54

Because of the logarithmic nature of the deciview calculation (i.e., $dv = 10\ln(b_{ext}/10)$), average deciview ratios were not applied. Instead, in a manner consistent with RHR calculations, ratios were applied to individual species and individual days, and 5-year average deciview value was calculated from annual average deciviews, which was in turn calculated from daily average deciview values. Table 6.5-3 lists results for the HACR1 site, showing deciview values for the baseline period approximated as being slightly higher than the measured progress period for both the 20% most impaired and least impaired days. These estimated baseline averages are used to represent the HACR1 for all summaries presented in this report. Note that similar baseline estimates have also been applied to estimate baseline conditions for the ZICA1 site in Utah, as described in Section 6.13.1.1.

Table 6.5-3
HACR1 Baseline Estimates

Species	Group	HACR1 2005-2009 Progress Period	HALE1 Progress/ Baseline Ratio	HACR1 2000-2004 Baseline Estimate
Ammonium Sulfate (Mm^{-1})	Best 20% Days	1.0	1.0	1.07
	Worst 20% Days	16.5	1.5	10.93
Ammonium Nitrate (Mm^{-1})	Best 20% Days	0.1	0.8	0.18
	Worst 20% Days	1.1	0.8	1.39
Particulate Organic Mass (Mm^{-1})	Best 20% Days	0.1	0.8	0.09
	Worst 20% Days	1.8	0.8	2.39
Elemental Carbon (Mm^{-1})	Best 20% Days	0.0	0.8	0.05
	Worst 20% Days	0.6	0.8	0.76
Soil (Mm^{-1})	Best 20% Days	0.1	0.9	0.08
	Worst 20% Days	0.4	1.1	0.41
Coarse Mass (Mm^{-1})	Best 20% Days	0.3	0.8	0.38
	Worst 20% Days	1.7	0.7	2.32
Sea Salt (Mm^{-1})	Best 20% Days	0.3	1.4	0.22
	Worst 20% Days	0.7	1.5	0.48
Deciviews (dv)	Best 20% Days	0.9	N/A	**1.00***
	Worst 20% Days	10.8	N/A	**9.48***

*Calculated from daily average b_{ext} determined using species specific average ratios from HALE1 site

6.5.1.2 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.308 (g)(3)(i))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[83] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.5-2 and 6.5-3 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired, or worst, and 20% least impaired, or best, days for each of the Federal CIA IMPROVE monitors in Hawaii. Figure 6.5-2 presents 5-year average extinction for the current progress period for both the 20% most impaired and 20% least impaired days. Note that the

[83] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired days are as follows:

- The highest aerosol extinction (24.9 dv) was measured at the HAVO1 site, and the lowest aerosol extinction (10.8 dv) was measured at the HACR1 site.
- The largest contributors to aerosol extinction at Hawaii sites was ammonium sulfate (72-96% of aerosol extinction).

Specific observations for the current visibility conditions on the 20% least impaired days are as follows:

- The aerosol contribution to total extinction on the best days was less than Rayleigh, or the background scattering that would occur in clear air. Average extinction (including Rayleigh) ranged from 0.9 dv (HACR1) to 4.4 dv (HALE1).

Table 6.5-2
Hawaii Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
HACR1	10.8	**72% (1)**	5% (4)	8% (2)	3% (6)	2% (7)	7% (3)	3% (5)
HALE1	14.8	**73% (1)**	6% (3)	6% (2)	3% (6)	1% (7)	5% (5)	5% (4)
HAVO1	24.9	**96% (1)**	0% (6)	1% (2)	1% (5)	0% (7)	1% (4)	1% (3)

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.5-3
Hawaii Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
HACR1	0.9	**52% (1)**	7% (4)	4% (6)	2% (7)	4% (5)	16% (2)	15% (3)
HALE1	4.4	**37% (1)**	8% (5)	9% (4)	3% (6)	2% (7)	15% (3)	27% (2)
HAVO1	3.8	**47% (1)**	6% (4)	3% (5)	1% (6)	1% (7)	8% (3)	34% (2)

*Highest aerosol species contribution per site is highlighted in bold.

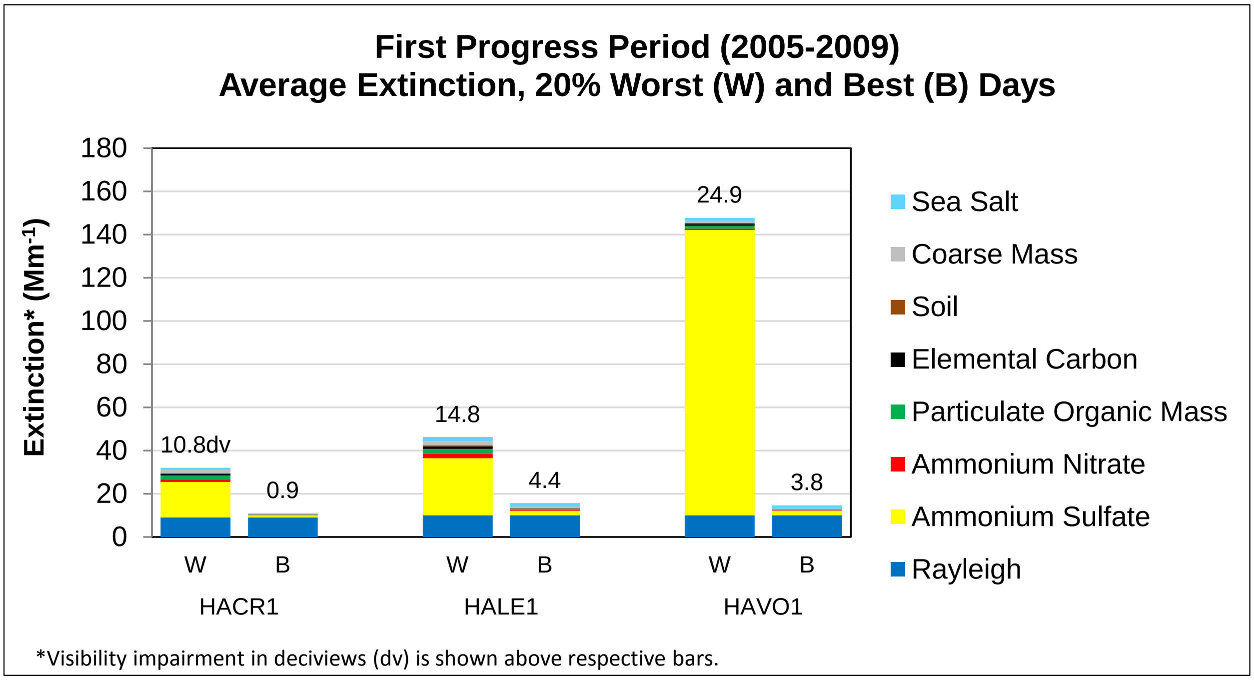

Figure 6.5-2. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at Hawaii Class I Area IMPROVE Sites.

6.5.1.3 Differences between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.308 (g)(3)(ii))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Table 6.5-4 presents the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for each site in Hawaii for the 20% most impaired days, and Table 6.5-5 presents similar data for the least impaired days. Averages that increased are depicted in red text and averages that decreased in blue.

Figure 6.5-3 presents the 5-year average extinction for the baseline and current progress period averages for the worst days and Figure 6.5-4 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.5-5 and 6.5-6 present similar plots for the best days.

For the 20% most impaired days, the 5-year average RHR deciview metric increased between the 2000-2004 and 2005-2009 periods at all three Hawaii sites. Notable differences for individual species averages were as follows:

- At all three sites, increases in deciview were mostly due to increases in ammonium sulfate. These increases were partially offset by decreases in particulate organic mass, ammonium nitrate and elemental carbon.

- The HAVO1 site showed slight increases in soil and coarse mass.

For the 20% least impaired days, the 5-year average deciview metric decreased at all three Hawaii sites. Notable differences for individual species averages on the 20% least impaired days were as follows:

- The largest increases were measured in sea salt, but these increases were offset by decreases in most other species.

Table 6.5-4
Hawaii Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-2004 Baseline Period	2005-2009 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
HACR1	9.5	10.8	+1.3	+5.6	-0.3	-0.6	-0.1	0.0	-0.6	+0.3
HALE1	13.3	14.8	+1.5	+8.9	-0.6	-0.7	-0.2	0.0	-0.7	+0.7
HAVO1	18.9	24.9	+6.0	+72.2	-0.3	-1.2	-0.2	+0.2	+0.3	+0.1

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.5-5
Hawaii Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-2004 Baseline Period	2005-2009 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
HACR1	1.0	0.9	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	+0.1
HALE1	4.5	4.4	-0.1	-0.1	-0.1	-0.2	0.0	0.0	-0.2	+0.4
HAVO1	4.1	3.8	-0.3	0.0	0.0	-1.0	-0.1	0.0	0.0	+0.7

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

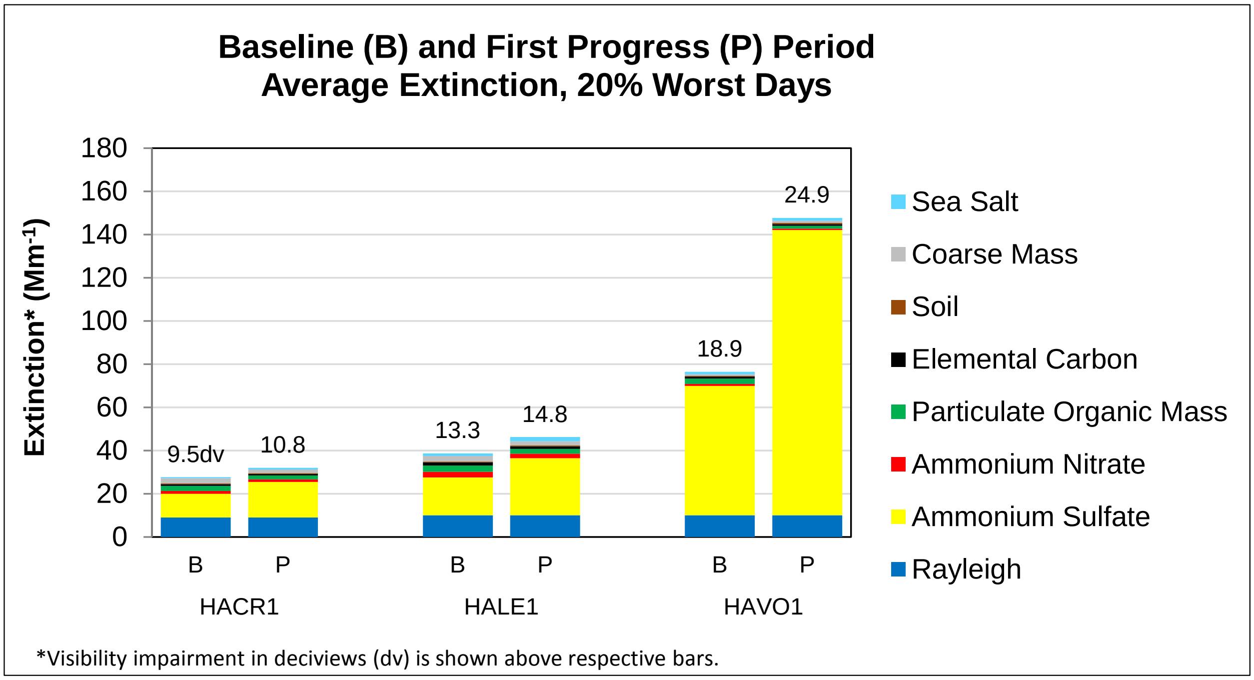

Figure 6.5-3. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at Hawaii Class I Area IMPROVE Sites.

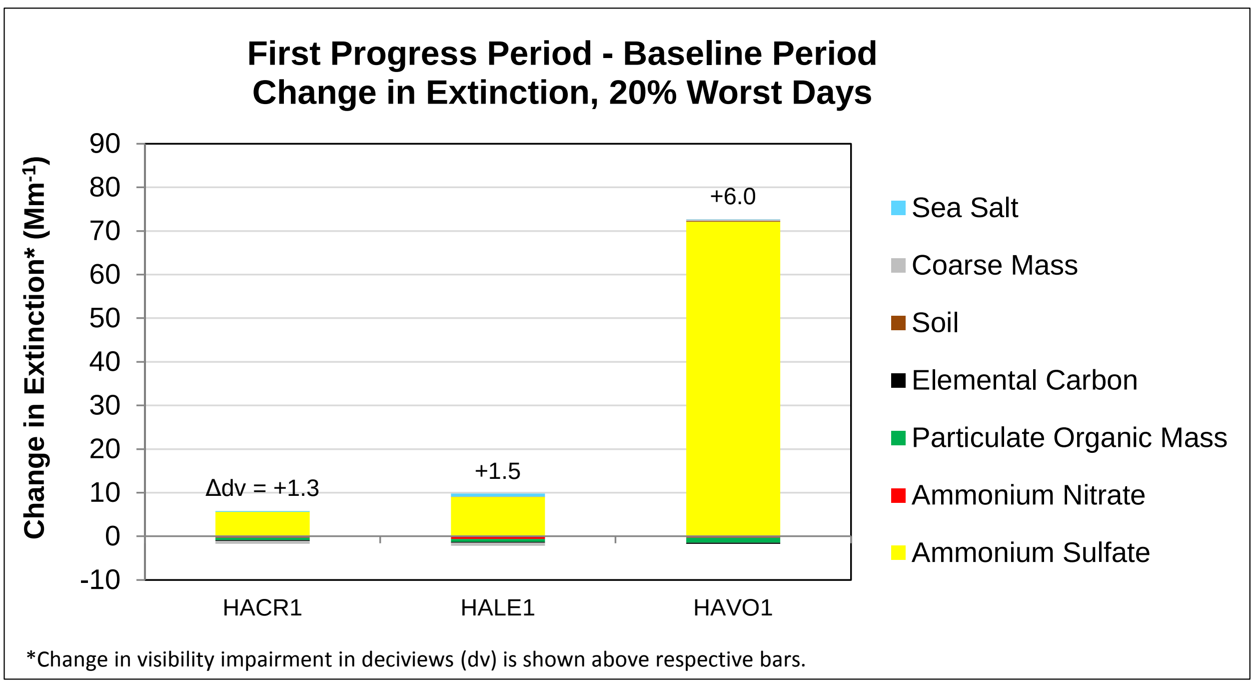

Figure 6.5-4. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at Hawaii Class I Area IMPROVE Sites.

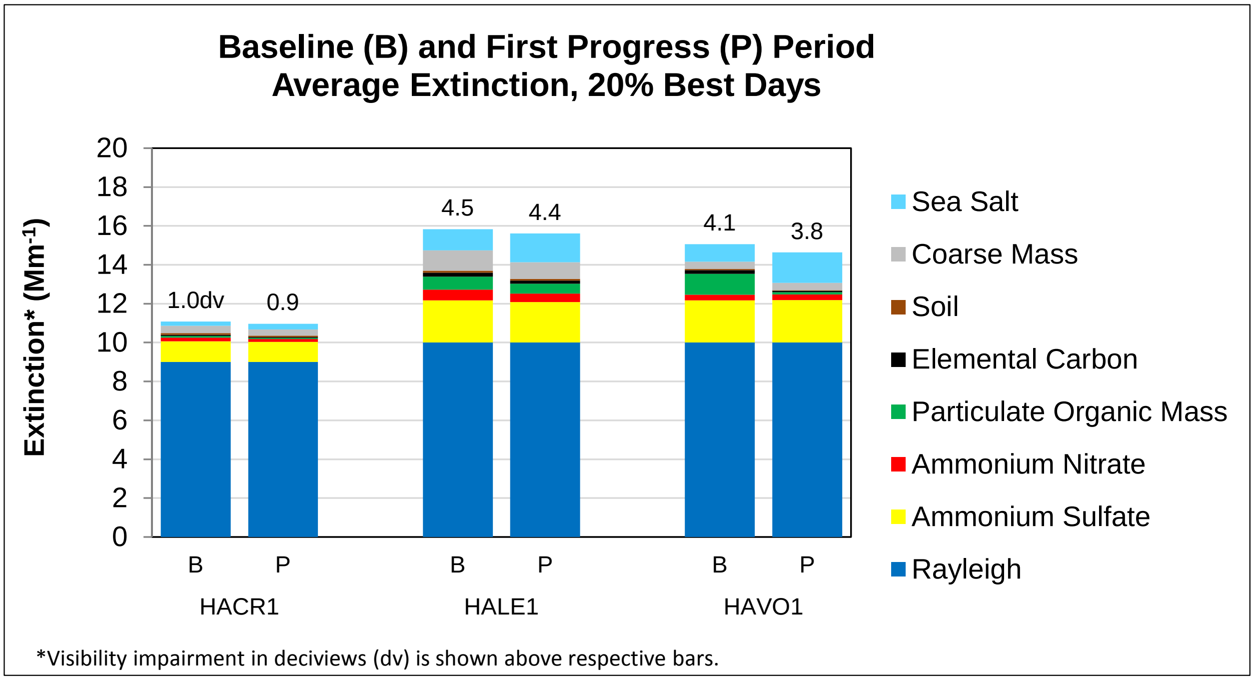

Figure 6.5-5. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at Hawaii Class I Area IMPROVE Sites.

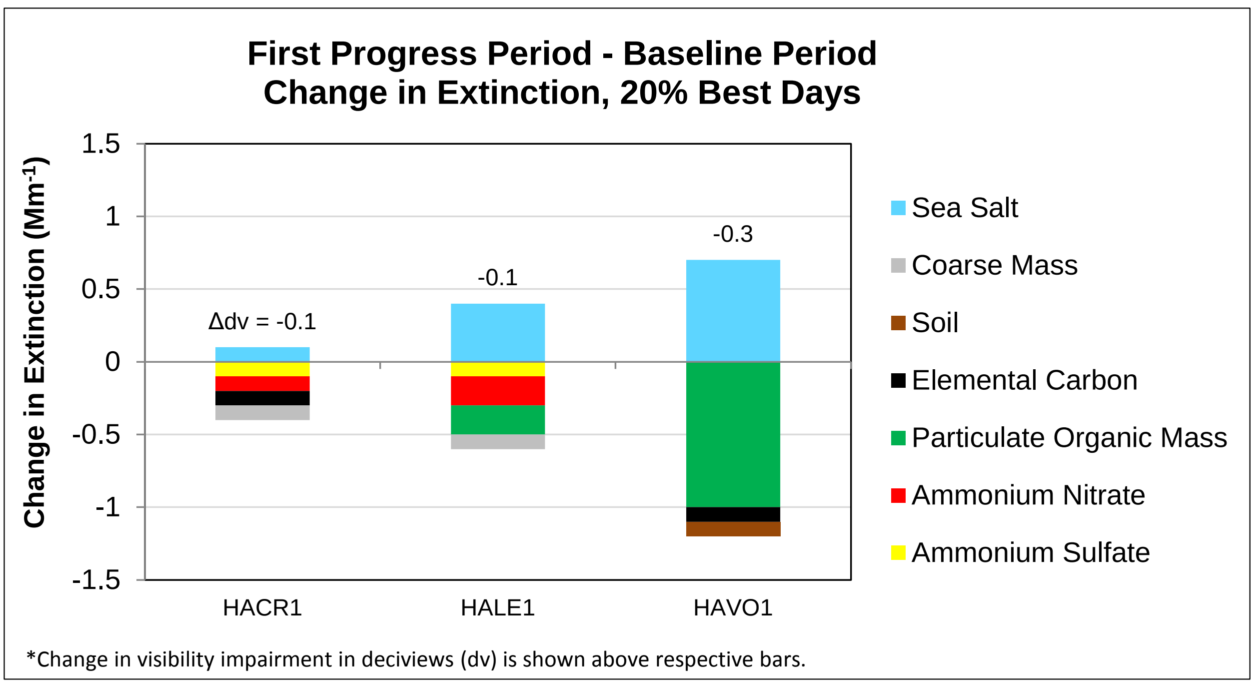

Figure 6.5-6. Difference Between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at Hawaii Class I Area IMPROVE Sites.

6.5.1.4 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.308 (g)(3)(iii))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5-year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in Hawaii are summarized in Table 6.5-6, and regional trends were presented earlier in Section 4.1.1.[84] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[85] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix E. Additionally, this appendix includes plots depicting 5-year, annual, monthly, and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in Hawaii are as follows:

- Ammonium sulfate, which is associated with volcanic activity in Hawaii, dominated aerosol extinction. The 5-year averages were higher during the progress period, and trend statistics showed increasing annual averages. Ammonium sulfate extinction at the HAVO1 site began climbing in 2007, with highs in 2008 and 2009. Ammonium sulfate extinction at the HACR1 and HALE1 site measured highest in 2008, with the largest events generally occurring in the spring.

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[84] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)

[85] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

- Daily plots in Appendix E indicate an anomalously high particulate organic event on the first sampling day in 2007 at the HACR1 site. This sample day corresponded to a 2291 acre forest fire south-west of the HACR1 and HALE1 sites.[86]
- In general, particulate organic mass concentrations were lower at the HACR1 site than the HALE1 site. Proximity of the HALE1 site to sugar cane burning was part of the justification for a new location to represent the Haleakala NP.
- Note that the State of Hawaii is investigating potential anomalies in particulate organic mass and select metal measurements for source apportionment calculations.[87] For purposes of progress determination, particulate organic mass decreases at all of the Hawaii sites, but soil and coarse mass increased slightly at the HAVO1 site. Because of the large ammonium sulfate contribution to visibility impairment, the combined contribution of coarse mass and soil was less than 1% of the overall increase in extinction between the baseline and progress periods.

[86] This event, and other events at the HALE1 and HACR1 sites in 2007 and 2008, have been characterized in a report by the State of Hawaii, Clean Air Branch (HIDOHCAB) which is available at http://www.regulations.gov/#!documentDetail;D=EPA-R09-OAR-2012-0345-0005.

[87] Details of HIDOHCABs efforts to characterize potential sources of error in source apportionment calculations are available at http://www.regulations.gov/#!documentDetail;D=EPA-R09-OAR-2012-0345-0005.

Table 6.5-6
Hawaii Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
HACR1	20% Best	**	**	**	**	**	**	**
	20% Worst	**	**	**	**	**	**	**
	All Days	**	**	**	**	**	**	**
HALE1	20% Best	--	0.0	--	0.0	--	0.0	**0.1**
	20% Worst	**1.2**	**-0.1**	--	--	0.0	**-0.2**	**0.1**
	All Days	**0.4**	**-0.1**	0.0	0.0	--	**-0.1**	**0.1**
HAVO1	20% Best	**0.1**	--	**-0.1**	0.0	--	--	**0.1**
	20% Worst	**18.9**	**-0.1**	**-0.1**	0.0	**0.1**	--	--
	All Days	**3.9**	0.0	**-0.1**	0.0	--	--	--

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix E.
**Less than 5 years of monitoring were available for the HACR1 site, so trend statistics for this site were not calculated.

6.5.2 Emissions Data

Included here are summaries depicting differences between emission inventories representing the baseline period (2005) and the current progress period (2008). The year 2005 was selected, with EPA approval, as the baseline inventory for Hawaii's initial RHR implementation plan because it was the most complete inventory available at the time technical work commenced[88]. The same technical work also included the development of a 2008 inventory, which is summarized here. These inventories are described in more detail in Section 3.2.1. For reference, Table 6.5-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories are presented in this section.

[88] See the *Technical Support Document for the Proposed Action on the Federal Implementation Plan for the Regional Haze Program in the State of Hawaii*, developed by EPA Region 9

Table 6.5-7
Hawaii
Pollutants, Aerosol Species, and Major Sources

Emitted Pollutant	Related Aerosol	Major Sources	Notes
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- And Off-Road Mobile Sources; Volcanic Emissions	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines. Also, in Hawaii, volcanic activity contributes significantly to natural emissions of SO_2, and it is possible that some of these emissions are transported to the contiguous states.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be associated with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Fine soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is reported by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$ mass measurements. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but these measurements are generally associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributor to PMC.

6.5.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.308 (g)(4))?*** For these summaries, emissions during the baseline and progress years are represented using 2005 and 2008 inventories, which were both available from technical support work used in the original RHR SIP strategy development, as referenced in Section 3.2.1. The differences between inventories are presented here for all major visibility impairing pollutants, and categorized by source for both anthropogenic and natural emissions.

Table 6.5-8 and Figure 6.5-7 present differences between the 2005 and 2008 Sulfur dioxide (SO_2) inventories by source category. Tables 6.5-9 and Figure 6.5-8 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.5-10 through 6.5-12 and Figures 6.5-9 through 6.5-11 present data for ammonia (NH_3), volatile organic carbon (VOC), and total particulate matter (PM). General observations regarding emissions inventory comparisons are listed below.

- Natural emissions are significant for SO_2, VOC, and PM due to natural volcanic (SO_2) and sea spray (PM) emissions.
- Volcanic emissions account for the majority of SO_2 emissions for the state. The State of Hawaii, Clean Air Branch (HIDOHCAB) has analyzed the time variability of volcano impacts by applying the EPA Positive Matrix Factorization (PMF) model for the years 2003 through 2008 at both the HALE1 and HAVO1 sites, and estimated that on average, approximately 55% of the total extinction at the HALE1 site, and 94% of the extinction at the HAVO1 site was due to emissions from the Kilauea volcano.[89]
- Inventory comparisons show decreases in mobile NO_X emissions, which are likely due to tighter EPA regulations for on-road vehicles.
- Inventory comparisons show decreases in SO_2 emissions from marine sources, which may be partially attributable to decreased marine activity during the economic recession, especially cruise ship activity. EPA mandates requiring the use of lower sulfur fuels in ships operating within 200 miles of the United States, effective August 2012, are expected to further decrease SO_2 marine emissions.

[89] PMF results are detailed in the Hawaii Department of Health, Clean Air Branch *Heleakala National Park Visibility Assessment: Regional Haze Program Visibility Assessment* report dated 4/20/2012, available at http://www.regulations.gov/#!documentDetail;D=EPA-R09-OAR-2012-2012-0345-0005.

Table 6.5-8
Hawaii
Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2005 (State Inventory)	2008 (State Inventory)	Difference (Percent Change)
Anthropogenic Sources			
Point	27,072	25,849	-1,223
Area	3,716	3,512	-204
On-Road Mobile	321	97	-224
Off-Road Mobile[1]	669	338	-331
Marine[2]	3,619	2,920	-699
Anthropogenic Fire	178	178	0
Total Anthropogenic	**35,575**	**32,894**	**-2,681 (-8%)**
Natural Sources			
Natural Fire	591	591	0
Biogenic	0	0	0
Volcano	961,366	1,195,314	233,948
Sea Spray	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**961,957**	**1,195,905**	**233,948 (24%)**
All Sources			
Total Emissions	**997,532**	**1,228,799**	**231,267 (23%)**

[1] Off-Road Mobile totals include aircraft and locomotive emissions
[2] Marine totals include in/near/underway emissions

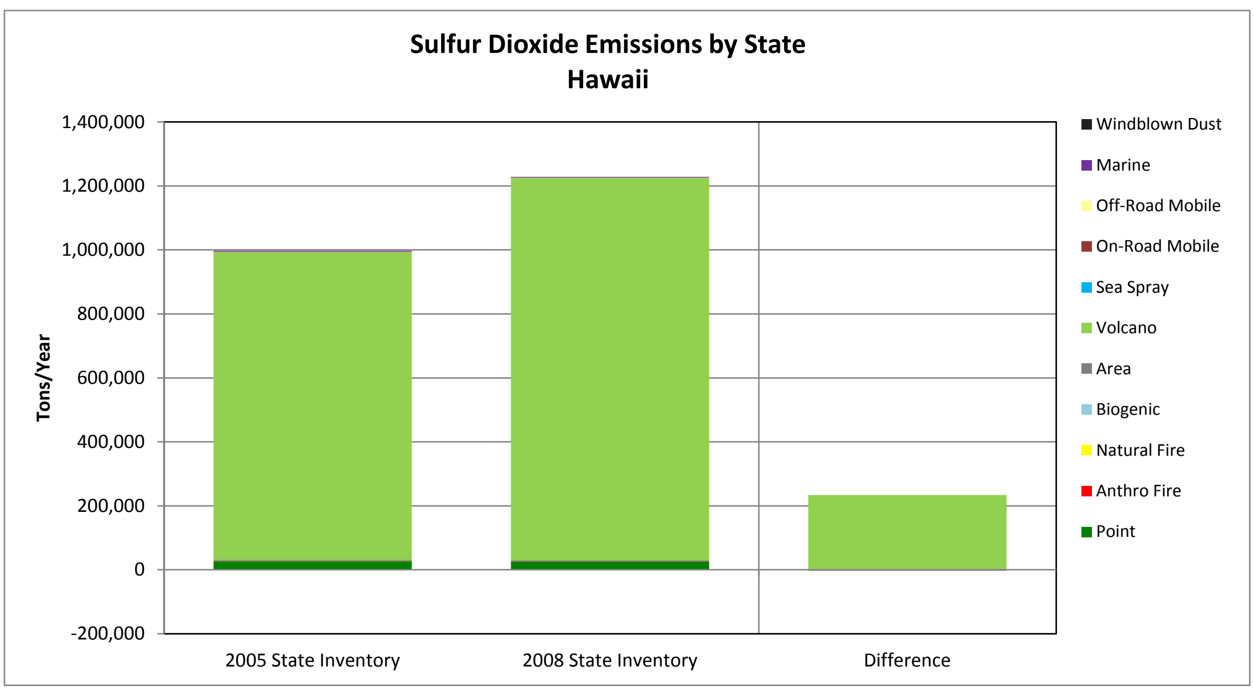

Figure 6.5-7. 2005 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for Hawaii.

Table 6.5-9
Hawaii
Oxides of Nitrogen Emissions by Category

Source Category	Oxides of Nitrogen Emissions (tons/year)		
	2005 (State Inventory)	**2008 (State Inventory)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	22,745	20,246	-2,499
Area	1,509	1,166	-343
On-Road Mobile	20,642	14,239	-6,403
Off-Road Mobile[1]	6,296	7,146	850
Marine[2]	5,624	12,994	7,370
Anthropogenic Fire	407	407	0
Total Anthropogenic	**57,223**	**56,198**	**-1,025 (-2%)**
Natural Sources			
Natural Fire	2,156	2,156	0
Biogenic	4,617	4,617	0
Volcano	0	0	0
Sea Spray	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**6,773**	**6,773**	**0 (0%)**
All Sources			
Total Emissions	**63,996**	**62,971**	**-1,025 (-2%)**

[1] Off-Road Mobile totals include aircraft and locomotive emissions
[2] Marine totals include in/near/underway emissions

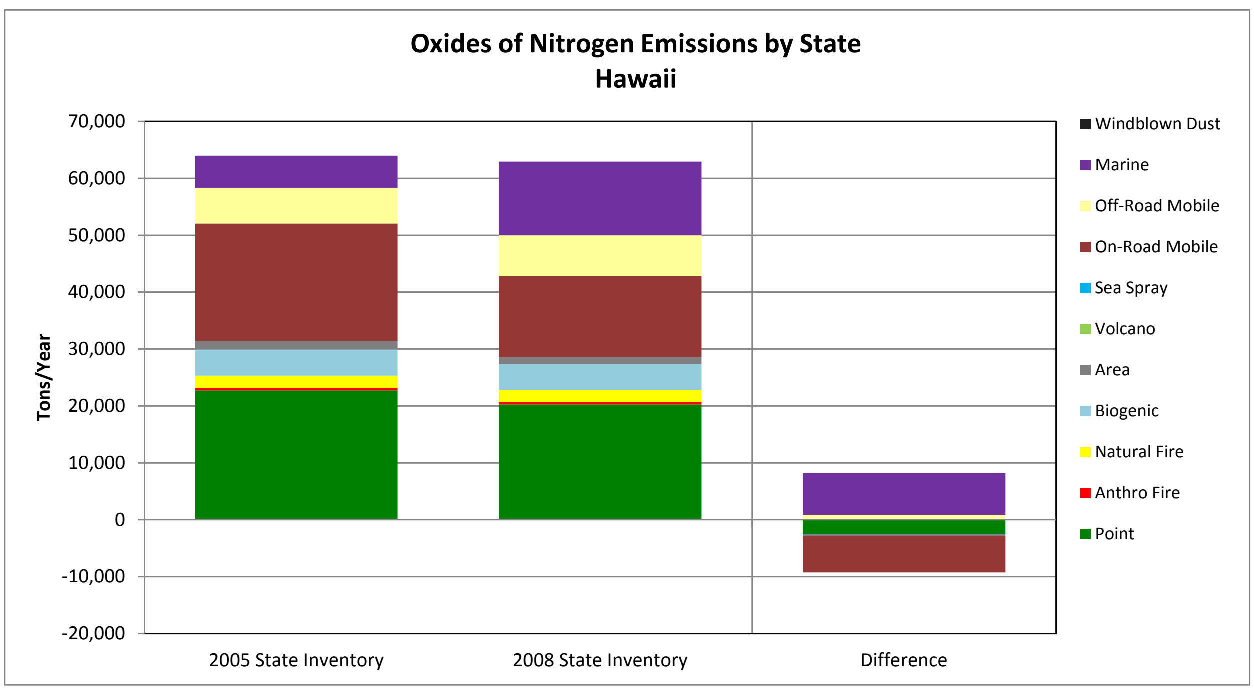

Figure 6.5-8. 2005 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Oxides of Nitrogen by Source Category for Hawaii.

Table 6.5-10
Hawaii
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2005 (State Inventory)	2008 (State Inventory)	Difference (Percent Change)
Anthropogenic Sources			
Point	12	12	0
Area	11,136	11,275	139
On-Road Mobile	1,085	1,124	39
Off-Road Mobile[1]	5	5	0
Marine[2]	0	0	0
Anthropogenic Fire	60	60	0
Total Anthropogenic	**12,298**	**12,476**	**178 (1%)**
Natural Sources			
Natural Fire	540	540	0
Biogenic	0	0	0
Volcano	0	0	0
Sea Spray	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**540**	**540**	**0 (0%)**
All Sources			
Total Emissions	**12,838**	**13,016**	**178 (1%)**

[1] Off-Road Mobile totals include aircraft and locomotive emissions
[2] Marine totals include in/near/underway emissions

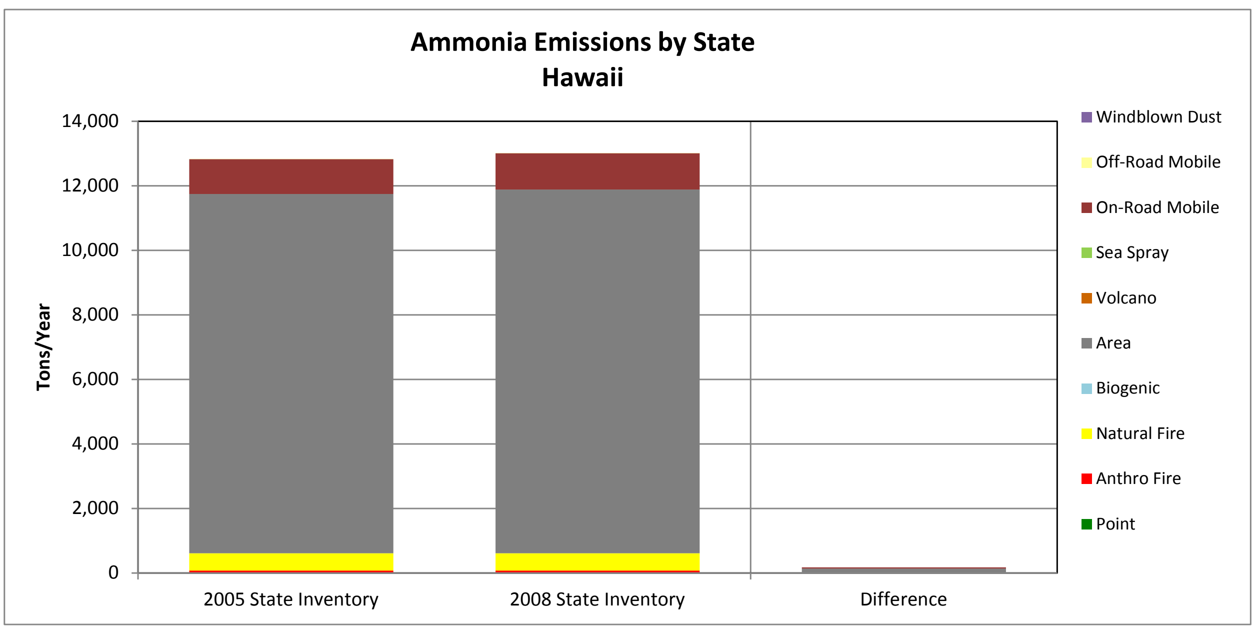

Figure 6.5-9. 2005 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Ammonia by Source Category for Hawaii.

Table 6.5-11
Hawaii
Volatile Organic Compound Emissions by Category

Source Category	Volatile Organic Compound Emissions (tons/year)		
	2005 (State Inventory)	**2008 (State Inventory)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	2,695	2,544	-151
Area	16,920	18,025	1,105
On-Road Mobile	12,066	8,526	-3,540
Off-Road Mobile[1]	6,383	5,540	-843
Marine[2]	209	326	117
Anthropogenic Fire	542	542	0
Total Anthropogenic	**38,815**	**35,503**	**-3,312 (-9%)**
Natural Sources			
Natural Fire	4,729	4,729	0
Biogenic	130,153	130,153	0
Volcano	0	0	0
Sea Spray	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**134,882**	**134,882**	**0 (0%)**
All Sources			
Total Emissions	**173,697**	**170,385**	**-3,312 (-2%)**

[1] Off-Road Mobile totals include aircraft and locomotive emissions
[2] Marine totals include in/near/underway emissions

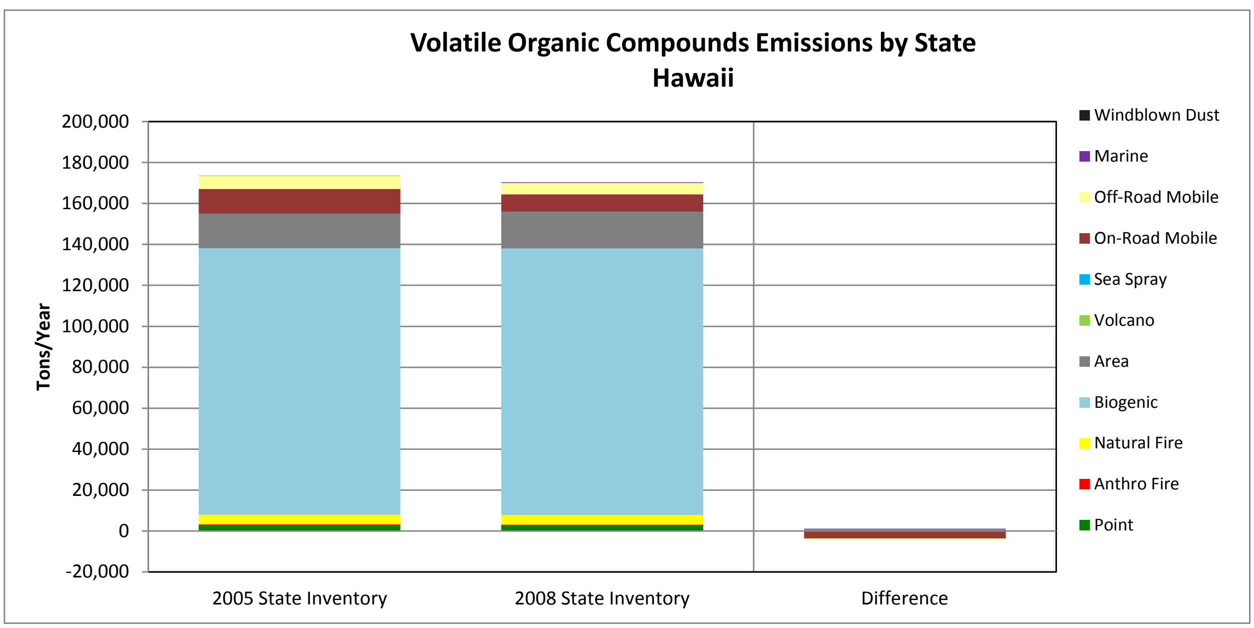

Figure 6.5-10. 2005 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for Hawaii.

Table 6.5-12
Hawaii
Particulate Matter Emissions by Category

Source Category	Particulate Matter Emissions (tons/year)		
	2005 (State Inventory)	2008 (State Inventory)	Difference (Percent Change)
Anthropogenic Sources			
Point	3,536	3,389	-147
Area	33,408	34,917	1,509
On-Road Mobile	638	547	-91
Off-Road Mobile[1]	649	545	-104
Marine[2]	398	647	249
Anthropogenic Fire*	1,574	1,574	0
Total Anthropogenic	**40,203**	**41,619**	**1,416 (4%)**
Natural Sources			
Natural Fire*	9,771	9,771	0
Biogenic	0	0	0
Volcano	0	0	0
Sea Spray	382,637	382,637	0
Wind Blown Dust	46,808	46,808	0
Total Natural	**439,216**	**439,216**	**0 (0%)**
All Sources			
Total Emissions	**479,419**	**480,835**	**1,416 (0%)**

[1] Off-Road Mobile totals include aircraft and locomotive emissions
[2] Marine totals include in/near/underway emissions

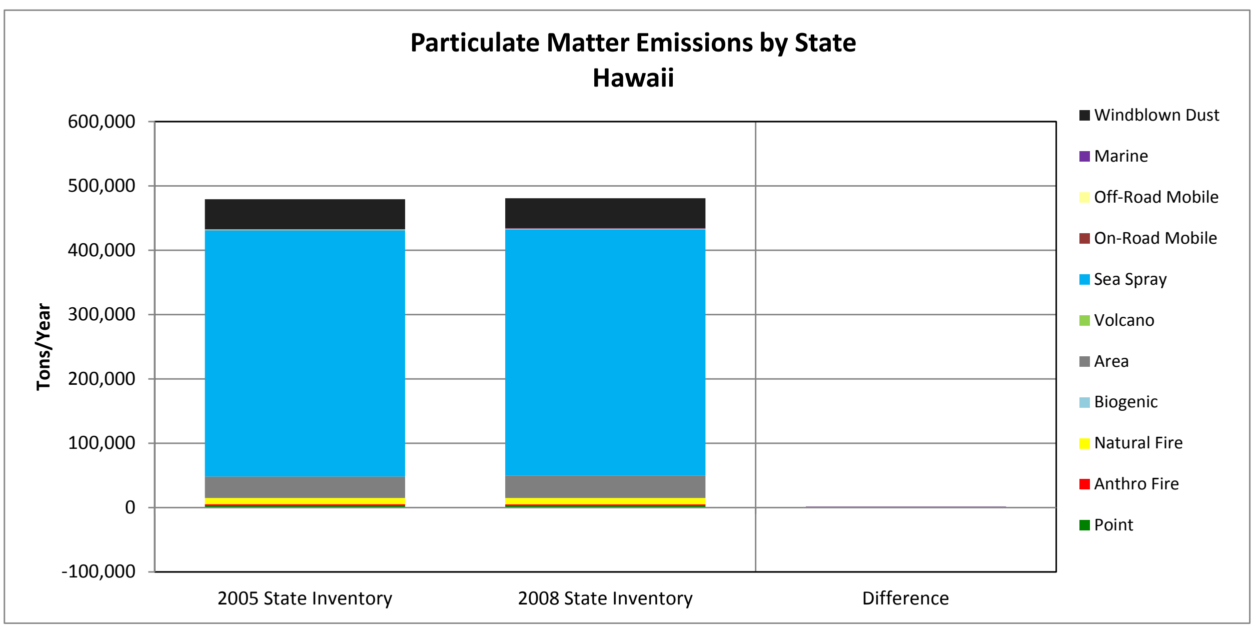

Figure 6.5-11. 2005 and 2008 Emissions, and Difference between Emissions Inventory Totals, for Particulate Matter by Source Category for Hawaii.

6.6 IDAHO

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. Idaho has 5 mandatory Federal CIAs, which are depicted in Figure 6.6-1 and listed in Table 6.6-1, along with the associated IMPROVE monitor locations.

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per Regional Haze Rule (RHR) requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. Some of the highlights regarding these comparisons are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- For the best days, the 5-year average deciview metric decreased at all Idaho Federal CIA IMPROVE sites.
- For the worst days, the 5-year average deciview metric decreased at the CRMO1, HECA1, and YELL2 sites, and increased at the SAWT1 and SULA1 sites.
- The largest increases in 5-year averages were measured for particulate organic mass, with high measurements associated with several large wildfires during the progress period, the largest of which occurred in 2005, 2006, and 2007.
- The largest decreases in 5-year averages were measured for ammonium nitrate an ammonium sulfate at the CRMO1 and HECA1 sites. Both of these sites also showed statistically significant decreasing trends for both parameters. State-wide emission inventory sums also showed a reduction in SO_2 from point sources and a reduction in NO_X from mobile sources, although annual tracking of EGU emissions totals showed increases in NO_X.
- Ammonium nitrate measurements showed slight increases in 5-year average measurements at the SAWT1 and SULA1 sites, and ammonium sulfate measurements showed slight increases at the SAWT1 and YELL2 sites. None of these sites showed statistically significant increasing or decreasing annual average trends for these species.

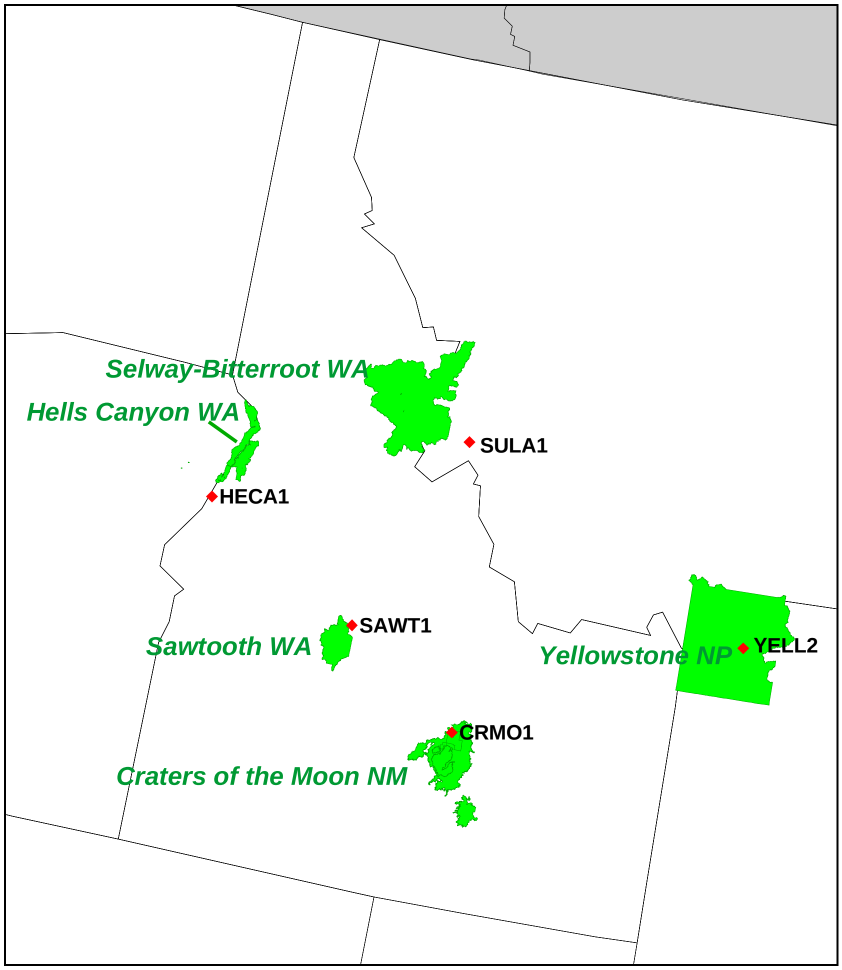

Figure 6.6-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in Idaho.

Table 6.6-1
Idaho CIAs and Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Craters of the Moon NM	CRMO1	43.46	-113.56	1817
Hells Canyon WA	HECA1	44.97	-116.84	655
Sawtooth WA	SAWT1	44.17	-114.93	1990
Selway-Bitterroot WA*	SULA1	45.86	-114.00	1895
Yellowstone NP	YELL2	44.57	-110.40	2425

*Montana CIA represented in Idaho's original SIP.

6.6.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by IMPROVE monitors representing Federal CIAs in Idaho. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix F.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.6.1.1 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.308 (g)(3)(i))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[90] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.6-2 and 6.6-3 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired, or worst, and 20% least impaired, or best, days for each of the Federal CIA IMPROVE monitors in Idaho. Figure 6.6-2 presents 5-year average extinction for the current progress period for both the 20% most impaired and 20% least impaired days. Note that the percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired days are as follows:

- The largest contributor to aerosol extinction on the 20% worst days at Idaho sites was particulate organic mass.
- The highest aerosol extinction (18.1 dv) was measured at the HECA1 site, where particulate organic mass was the largest contributor to aerosol extinction, followed by ammonium nitrate. The lowest aerosol extinction (11.5 dv) was measured at the YELL2 site.

[90] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

Specific observations for the current visibility conditions on the 20% least impaired days are as follows:

- The aerosol contribution to total extinction on the best days was less than Rayleigh, or the background scattering that would occur in clear air. Average extinction (including Rayleigh) ranged from 2.0 dv (YELL2) to 4.8 dv (HECA1).

Table 6.6-2
Idaho Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
CRMO1	13.6	15% (3)	27% (2)	**37% (1)**	7% (5)	3% (6)	11% (4)	0% (7)
HECA1	18.1	11% (3)	22% (2)	**52% (1)**	9% (4)	1% (6)	5% (5)	0% (7)
SAWT1	14.8	7% (3)	1% (6)	**74% (1)**	10% (2)	2% (5)	5% (4)	0% (7)
SULA1	17.0	6% (3)	2% (5)	**75% (1)**	11% (2)	1% (6)	5% (4)	0% (7)
YELL2	11.5	17% (2)	6% (5)	**57% (1)**	8% (4)	3% (6)	9% (3)	0% (7)

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.6-3
Idaho Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
CRMO1	3.4	**37% (1)**	20% (2)	18% (3)	7% (5)	4% (6)	13% (4)	1% (7)
HECA1	4.8	**36% (1)**	12% (3)	28% (2)	8% (5)	3% (6)	10% (4)	3% (7)
SAWT1	3.8	27% (2)	5% (5)	**46% (1)**	12% (3)	3% (6)	7% (4)	1% (7)
SULA1	2.5	**46% (1)**	10% (4)	22% (2)	6% (5)	3% (6)	12% (3)	1% (7)
YELL2	2.0	**42% (1)**	16% (3)	25% (2)	8% (4)	2% (6)	7% (5)	1% (7)

*Highest aerosol species contribution per site is highlighted in bold.

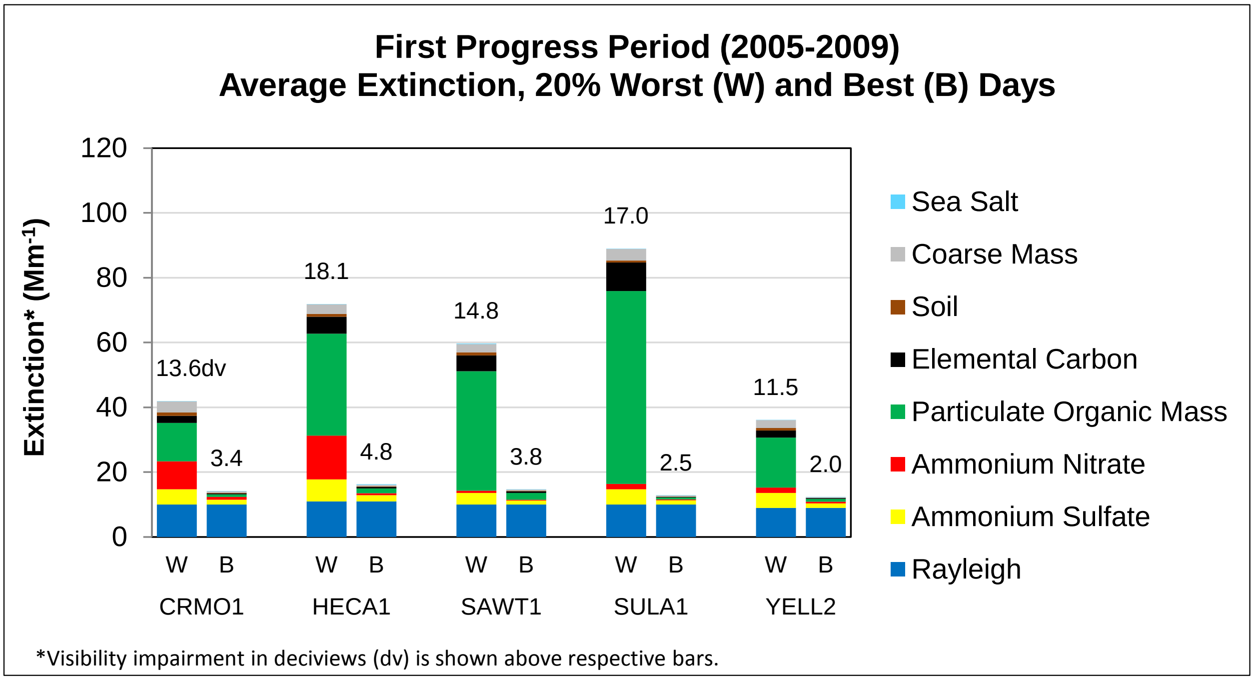

Figure 6.6-2. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at Idaho Class I Area IMPROVE Sites.

6.6.1.2 Differences between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.308 (g)(3)(ii))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Table 6.6-4 presents the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for each site in Idaho for the 20% most impaired days, and Table 6.6-5 presents similar data for the least impaired days. Averages that increased are depicted in red text and averages that decreased in blue.

Figure 6.6-3 presents the 5-year average extinction for the baseline and current progress period averages for the worst days and Figure 6.6-4 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.6-5 and 6.6-6 present similar plots for the best days.

For the 20% most impaired days, the 5-year average RHR deciview metric increased between the 2000-2004 and 2005-2009 periods at the SAWT1 and SULA1 sites and decreased at all other Idaho sites. Notable differences for individual species averages were as follows:

- Increases in deciview at the SAWT1 and SULA1 sites site were mostly due to increases in particulate organic mass and elemental carbon.

- Large increases in particulate organic mass at the HECA1 site were offset by large decreases in ammonium nitrate.

For the 20% least impaired days, the 5-year average deciview metric decreased at all sites. Notable differences for individual species averages on the 20% least impaired days were as follows:

- Ammonium nitrate, particulate organic mass and elemental carbon decreased at all sites.
- Ammonium sulfate increased slightly at the SAWT1 and SULA1 sites.

Table 6.6-4
Idaho Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
CRMO1	14.0	13.6	-0.4	-1.0	-2.7	+2.9	+0.2	0.0	+0.4	0.0
HECA1	18.6	18.1	-0.5	-1.6	-15.0	+15.8	+2.2	+0.2	+1.0	+0.1
SAWT1	13.8	14.8	+1.0	+0.5	+0.1	+14.6	+0.7	+0.2	+0.8	0.0
SULA1	13.4	17.0	+3.6	-0.1	+0.2	+39.5	+6.3	-0.3	+1.1	-0.2
YELL2	11.8	11.5	-0.3	+0.3	-0.1	+2.0	-0.3	-0.1	-0.2	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.6-5
Idaho Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
CRMO1	4.3	3.4	-0.9	0.0	-0.4	-0.5	-0.1	0.0	-0.3	0.0
HECA1	5.5	4.8	-0.7	0.0	-0.2	-0.5	-0.1	-0.1	-0.3	+0.1
SAWT1	4.0	3.8	-0.2	+0.1	-0.1	-0.3	-0.1	0.0	0.0	0.0
SULA1	2.6	2.5	-0.1	+0.2	-0.1	-0.3	-0.1	0.0	+0.1	0.0
YELL2	2.6	2.0	-0.6	-0.1	-0.2	-0.3	-0.1	0.0	0.0	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

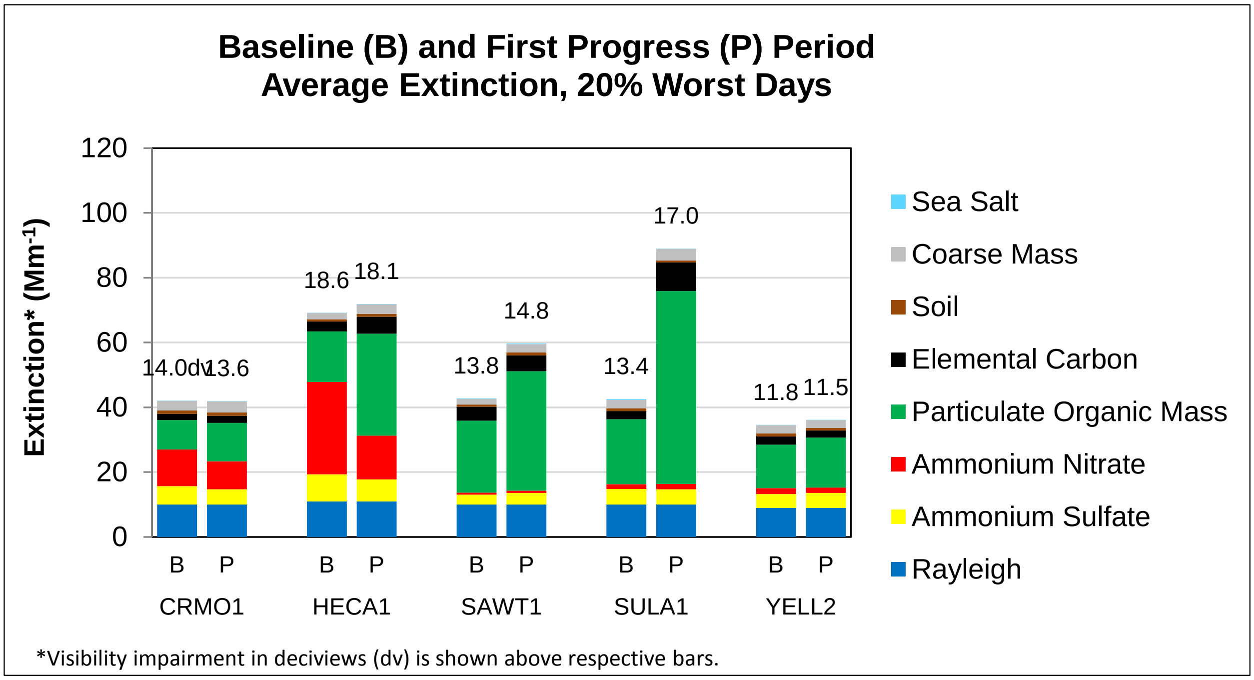

Figure 6.6-3. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at Idaho Class I Area IMPROVE Sites.

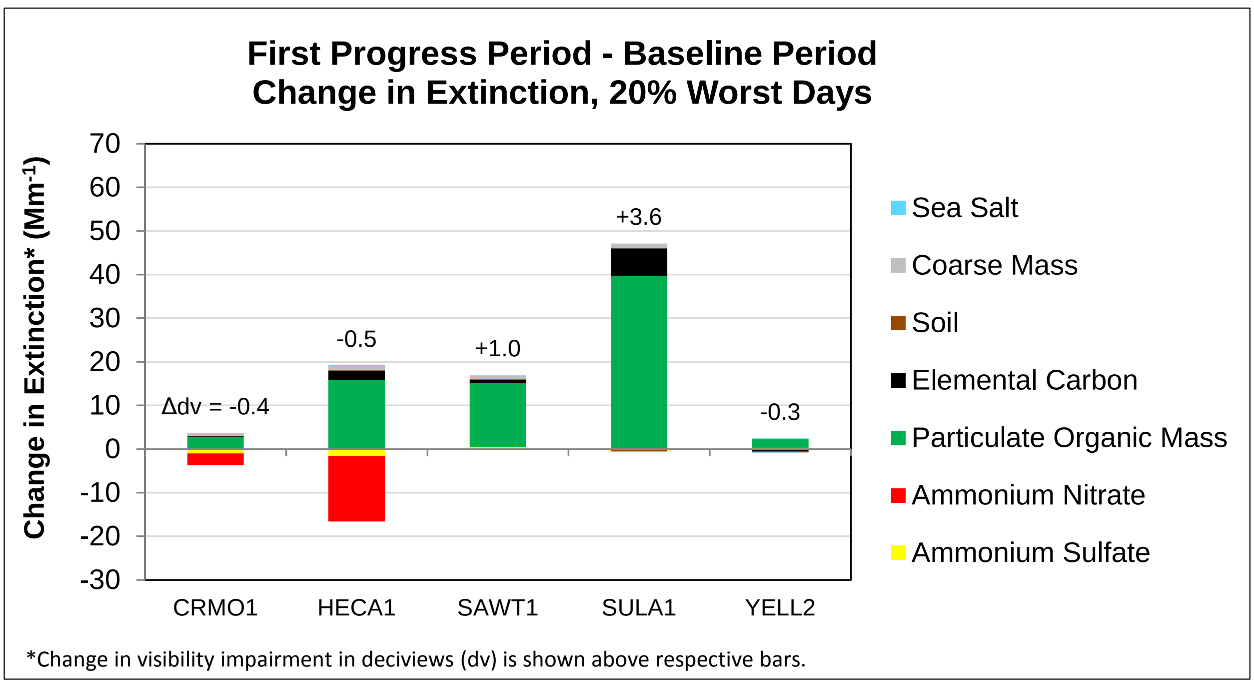

Figure 6.6-4. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at Idaho Class I Area IMPROVE Sites.

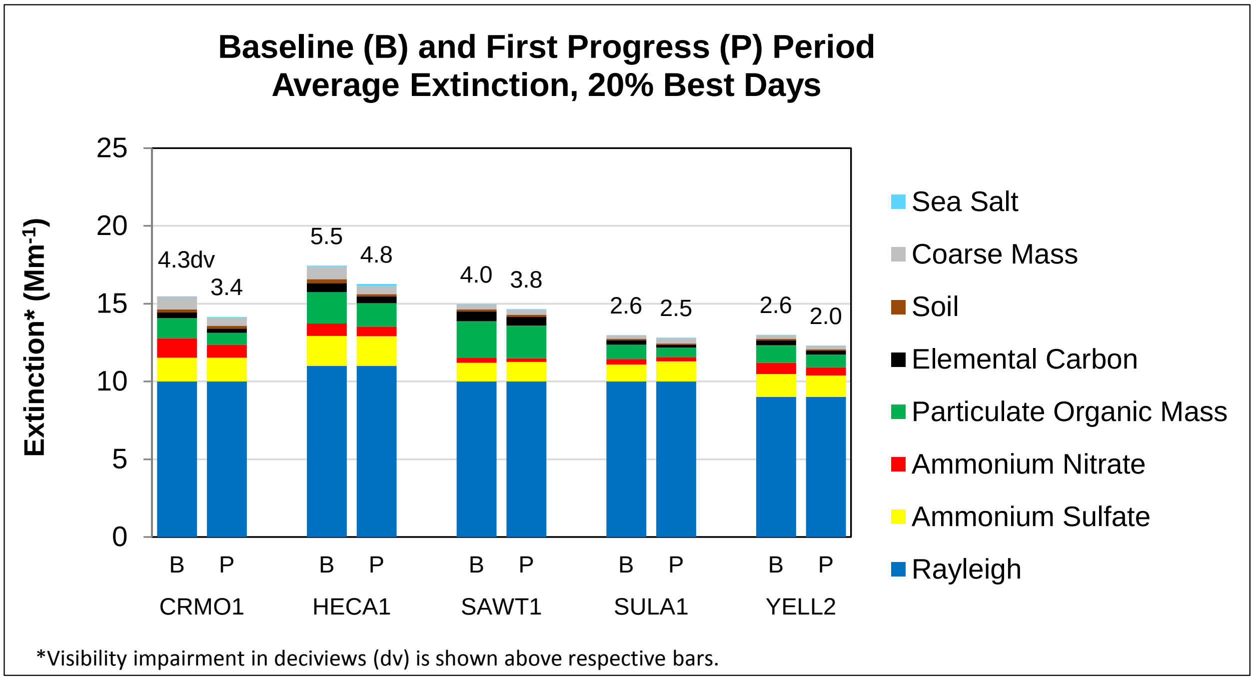

Figure 6.6-5. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at Idaho Class I Area IMPROVE Sites.

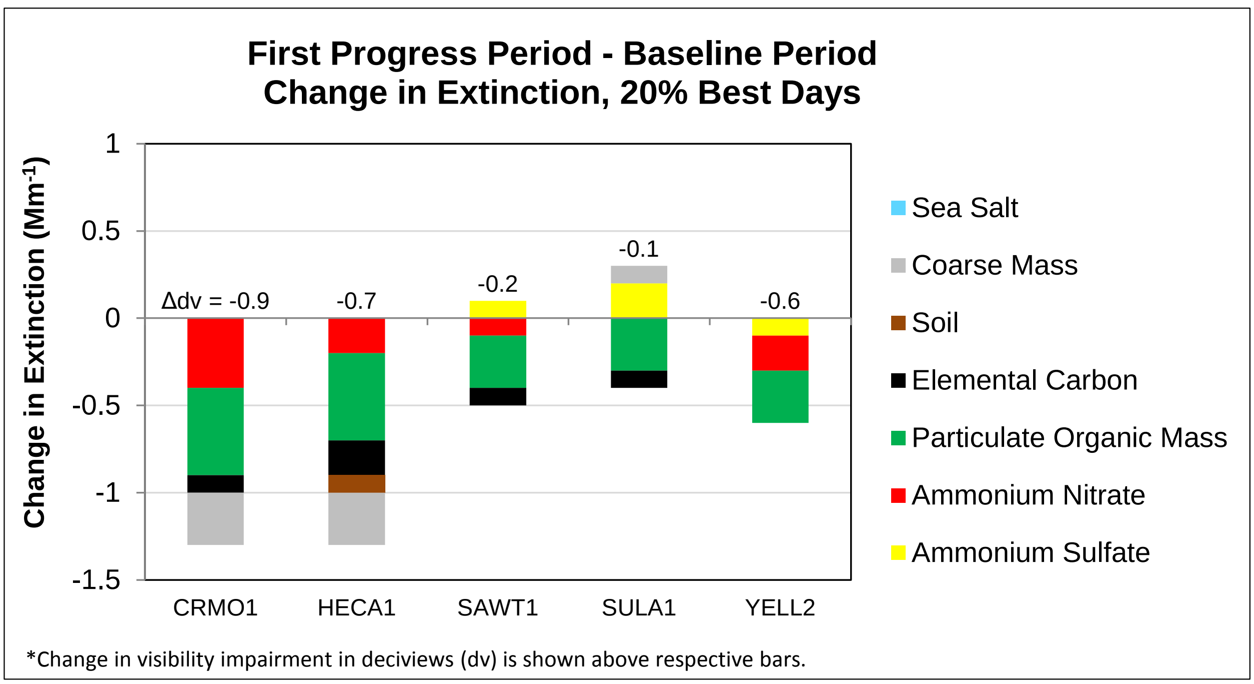

Figure 6.6-6. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at Idaho Class I Area IMPROVE Sites.

6.6.1.3 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.308 (g)(3)(iii))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5-year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in Idaho are summarized in Table 6.6-6, and regional trends were presented earlier in Section 4.1.1.[91] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[92] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix F. Additionally, this appendix includes plots depicting 5-year, annual, monthly, and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in Idaho are as follows:

- Particulate organic mass was the largest contributor to increases in aerosol extinction for the 20% worst days measured at the Idaho sites. Highest measurements generally occurred between July and September at these sites, with the largest events for this period occurring in 2005, 2006 and 2007. A regional map depicting the spatial extent of a large fire event affecting the Idaho sites in 2007 was presented in Section 4.1.2.
- Ammonium nitrate, ammonium sulfate and coarse mass all showed decreasing trends for the annual average of all sampled days at the CRMO1 site. Additionally,

[91] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)

[92] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

ammonium nitrate and ammonium sulfate showed decreasing trends at the HECA1 site.

- Increasing trends in particulate organic mass and coarse mass were observed for the 20% worst days at the HECA1 site, but trends were insignificant for the annual average of all days.

Table 6.6-6
Idaho Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
CRMO1	20% Best	**-0.1**	**-0.1**	**-0.1**	0.0	--	0.0	--
	20% Worst	**-0.2**	**-0.7**	--	--	0.0	--	--
	All Days	**-0.1**	**-0.2**	--	--	--	**-0.1**	--
HECA1	20% Best	--	--	**-0.1**	0.0	0.0	**-0.1**	--
	20% Worst	**-0.4**	**-3.7**	**1.6**	--	--	**0.3**	--
	All Days	--	**-0.8**	--	--	--	--	--
SAWT1	20% Best	--	0.0	--	0.0	--	--	0.0
	20% Worst	--	--	--	--	--	--	--
	All Days	--	--	--	--	--	--	--
SULA1	20% Best	--	0.0	**-0.1**	0.0	--	0.0	--
	20% Worst	--	--	--	--	0.0	--	--
	All Days	--	--	--	--	--	--	--
YELL2	20% Best	--	0.0	**-0.1**	--	0.0	--	0.0
	20% Worst	--	--	--	--	--	0.0	0.0
	All Days	--	--	--	0.0	--	--	0.0

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix F.

6.6.2 Emissions Data

Included here are summaries depicting differences between two emission inventory years that are used to represent the 5-year baseline and current progress periods. The baseline period is represented using a 2002 inventory developed by the WRAP for use in the initial WRAP state SIPs, and the progress period is represented by a 2008 inventory which leverages recent WRAP inventory work for modeling efforts, as referenced in Section 3.2.1. For reference, Table 6.6-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories, and a separate summary of annual emissions from electrical generating units (EGUs), are presented in this section.

Table 6.6-7
Idaho
Pollutants, Aerosol Species, and Major Sources

Emitted Pollutant	Related Aerosol	Major Sources	Notes
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- and Off-Road Mobile Sources	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be associated with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Primary Organic Aerosol (POA)	POM	Wildfires; Area Sources	POA represents organic aerosols that are emitted directly as particles, as opposed to gases. Wildfires in the west generally dominate POA emissions, and large wildfire events are generally sporadic and highly variable from year-to-year.
Elemental Carbon (EC)	EC	Wildfires; On- and Off-Road Mobile Sources	Large EC events are often associated with large POM events during wildfires. Other sources include both on- and off-road diesel engines.
Fine soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is reported by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$ mass measurements. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but these measurements are generally associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributor to PMC.

6.6.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.308 (g)(4))?*** For these summaries, emissions during the baseline years are represented using a 2002 inventory, which was developed with support from the WRAP for use in the original RHR SIP strategy development (termed plan02d). Differences between inventories are represented as the difference between the 2002 inventory, and a 2008 inventory which leverages recent inventory development work performed by the WRAP for the WestJumpAQMS and DEASCO$_3$ modeling projects (termed WestJump2008). Note that the comparisons of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories, as referenced in Section 3.2.1. Inventories for all major visibility impairing pollutants are presented for major source categories, and categorized as either anthropogenic or natural emissions. State-wide inventories totals and differences are presented here, and inventory totals on a county level basis are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

Table 6.6-8 and Figure 6.6-7 present the differences between the 2002 and 2008 sulfur dioxide (SO_2) inventories by source category. Tables 6.6-9 and Figure 6.6-8 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.6-10 through 6.6-15 and Figures 6.6-9 through 6.6-14) present data for ammonia (NH_3), volatile organic compounds (VOCs), primary organic aerosol (POA), elemental carbon (EC), fine soil and coarse mass. General observations regarding emissions inventory comparisons are listed below.

- Largest differences for point source inventories were decreases in SO_2 and increases in NO_X. Note that NO_X increases are consistent with increases in annual EGU emissions for NO_X as shown in Section 6.6.2.2.
- Area source inventories showed decreases in NO_X, VOCs and fine soil, but increases in SO_2, NH_3, POA, and coarse mass. These changes may be due to a combination of population changes and differences in methodologies used to estimate these emissions, as referenced in Section 3.2.1.
- On-road mobile source inventory comparisons showed decreases in most parameters, especially NO_X and VOCs, with slight increases in POA, EC and coarse mass. Reductions in NO_X and VOCs were likely influenced by federal and state emissions standards that have already been implemented. The increases in POA, EC, and coarse mass occurred in all of the WRAP states for on-road mobile inventories, regardless of reductions in NO_2 and VOCs, indicating that these increases were likely due to use of different on-road models, as referenced in Section 3.2.1.
- Off-road mobile source inventories showed decreases in SO_2, NO_X, and VOCs, and slight increases in fine soil and coarse mass, which was consistent with most contiguous WRAP states. These differences are likely due to a combination of actual changes in source contributions and methodology differences, as referenced in Section 3.2.1.

- For all parameters, especially POAs, VOCs, and EC, natural fire emission inventory estimates decreased, and anthropogenic fire inventories increased. Note that these differences are not necessarily reflective of changes in monitored data, as the baseline period is represented by an average of 2000-2004 fire emissions, and the progress period is represented only by the fires that occurred in 2008, as referenced in Section 3.2.1.
- Comparisons between VOC inventories showed large decreases in biogenic emissions, which was consistent with other contiguous WRAP states. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions, as referenced in Section 3.2.1.
- Fine soil and coarse mass increased for the windblown dust inventory comparisons and the combined fugitive/road dust inventories. Large variability in changes in windblown dust inventories was observed for the contiguous WRAP states, which was likely due in large part to enhancements in dust inventory methodology, as referenced in Section 3.2.1, rather than changes in actual emissions.

Table 6.7-8
Idaho
Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	17,597	7,490	-10,106
Area	2,916	8,929	6,013
On-Road Mobile	1,590	332	-1,258
Off-Road Mobile	3,402	276	-3,126
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	707	1,594	888
Total Anthropogenic	**26,212**	**18,622**	**-7,590 (-29%)**
Natural Sources			
Natural Fire	10,765	544	-10,221
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**10,765**	**544**	**-10,221 (-95%)**
All Sources			
Total Emissions	**36,977**	**19,166**	**-17,811 (-48%)**

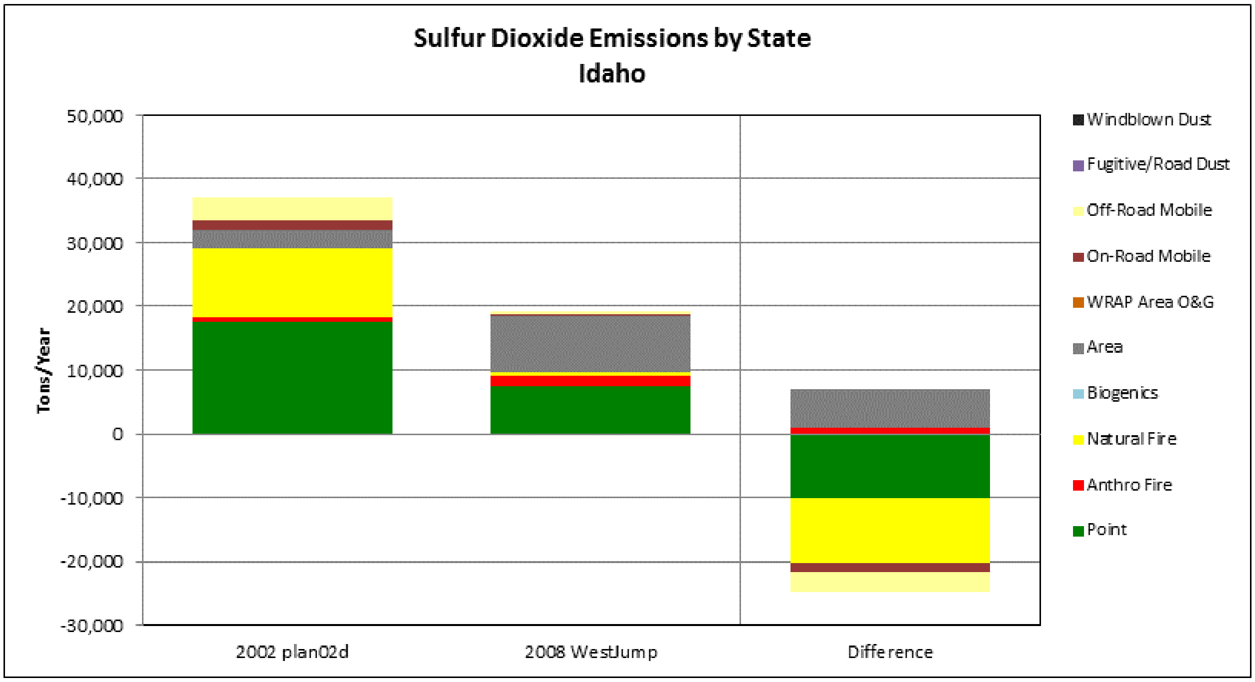

Figure 6.7-7. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for Idaho.

Table 6.7-9
Idaho
Oxides of Nitrogen Emissions by Category

Source Category	Oxides of Nitrogen Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	11,486	12,671	1,185
Area	30,318	19,869	-10,448
On-Road Mobile	44,611	44,554	-57
Off-Road Mobile	27,922	14,129	-13,793
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	3,434	11,270	7,836
Total Anthropogenic	**117,770**	**102,493**	**-15,277 (-13%)**
Natural Sources			
Natural Fire	39,277	3,782	-35,495
Biogenic	16,982	4,806	-12,175
Wind Blown Dust	0	0	0
Total Natural	**56,258**	**8,588**	**-47,670 (-85%)**
All Sources			
Total Emissions	**174,028**	**111,081**	**-62,948 (-36%)**

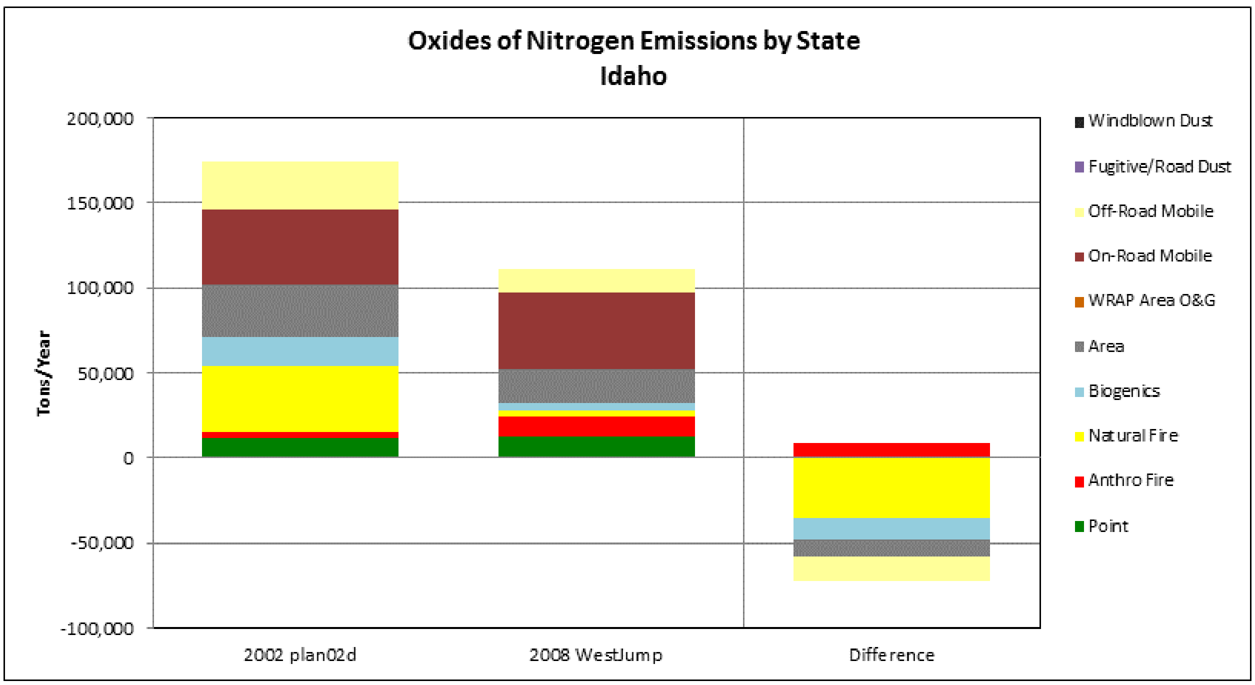

Figure 6.7-8. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Oxides of Nitrogen by Source Category for Idaho.

Table 6.7-10
Idaho
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	1,043	1,042	-1
Area	67,293	104,060	36,767
On-Road Mobile	1,430	689	-741
Off-Road Mobile	17	16	-1
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	1,253	7,837	6,584
Total Anthropogenic	**71,036**	**113,644**	**42,608 (60%)**
Natural Sources			
Natural Fire	8,246	2,608	-5,638
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**8,246**	**2,208**	**-5,638 (-68%)**
All Sources			
Total Emissions	**79,282**	**116,252**	**36,970 (47%)**

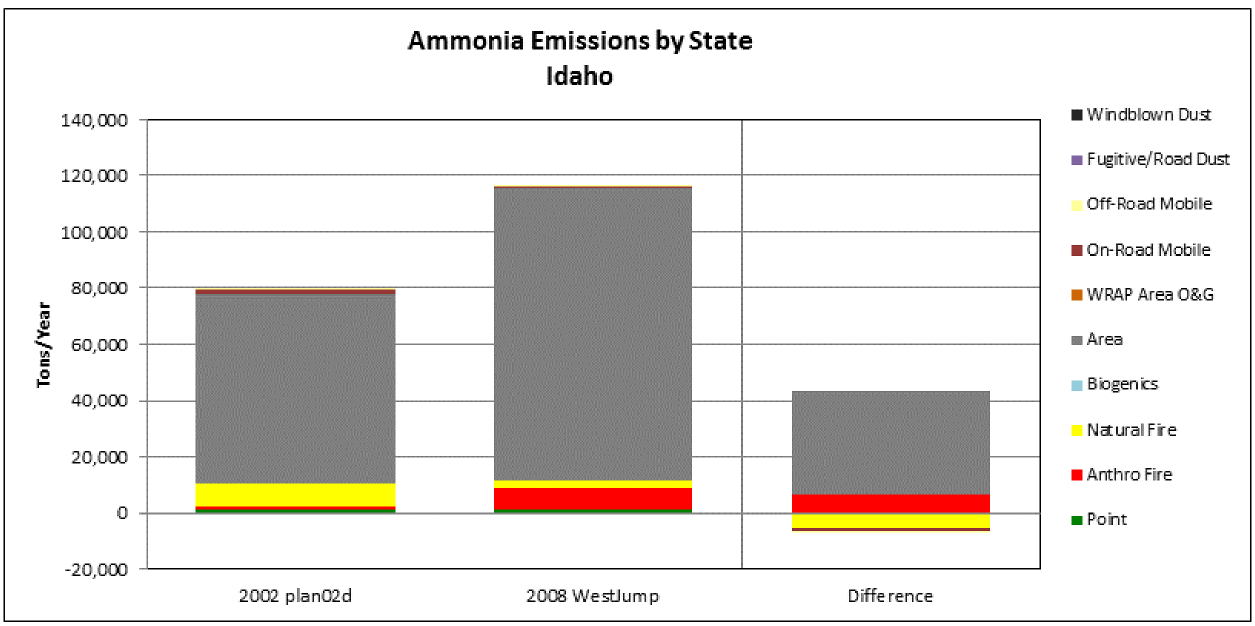

Figure 6.7-9. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Ammonia by Source Category for Idaho.

Table 6.7-11
Idaho
Volatile Organic Compound Emissions by Category

Source Category	Volatile Organic Compound Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	2,113	1,165	-948
Area	124,137	89,706	-34,431
On-Road Mobile	26,972	18,852	-8,120
Off-Road Mobile	23,511	21,971	-1,540
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	8,316	12,500	4,184
Total Anthropogenic	**185,049**	**144,195**	**-40,855 (-22%)**
Natural Sources			
Natural Fire	86,162	3,400	-82,762
Biogenic	834,303	240,280	-594,023
Wind Blown Dust	0	0	0
Total Natural	**920,464**	**243,679**	**-676,785 (-74%)**
All Sources			
Total Emissions	**1,105,514**	**387,874**	**-717,639 (-65%)**

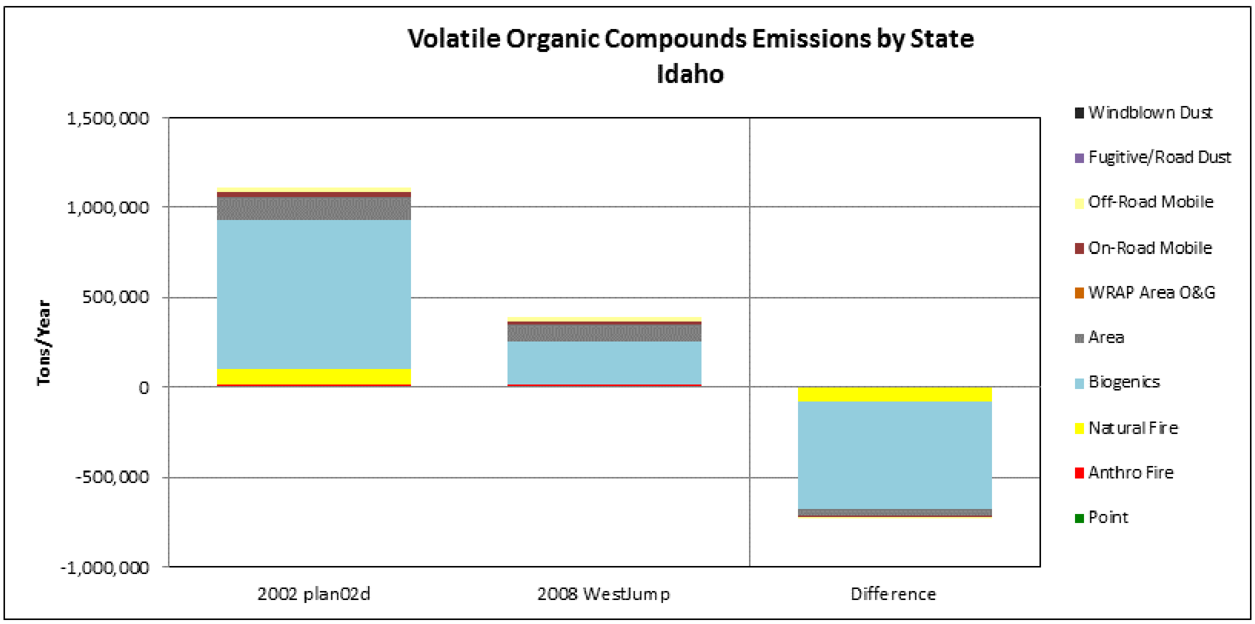

Figure 6.7-10. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for Idaho.

Table 6.7-12
Idaho
Primary Organic Aerosol Emissions by Category

Source Category	Primary Organic Aerosol Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	106	0	-106
Area	425	3,747	3,322
On-Road Mobile	383	1,101	717
Off-Road Mobile	747	652	-94
Area Oil and Gas	0	0	0
Fugitive and Road Dust	305	772	467
Anthropogenic Fire	8,454	22,867	14,412
Total Anthropogenic	**10,421**	**29,139**	**18,718 (>100%)**
Natural Sources			
Natural Fire	47,883	7,632	-40,252
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**47,883**	**7,632**	**-40,252 (-84%)**
All Sources			
Total Emissions	**58,304**	**36,771**	**-21,533 (-37%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

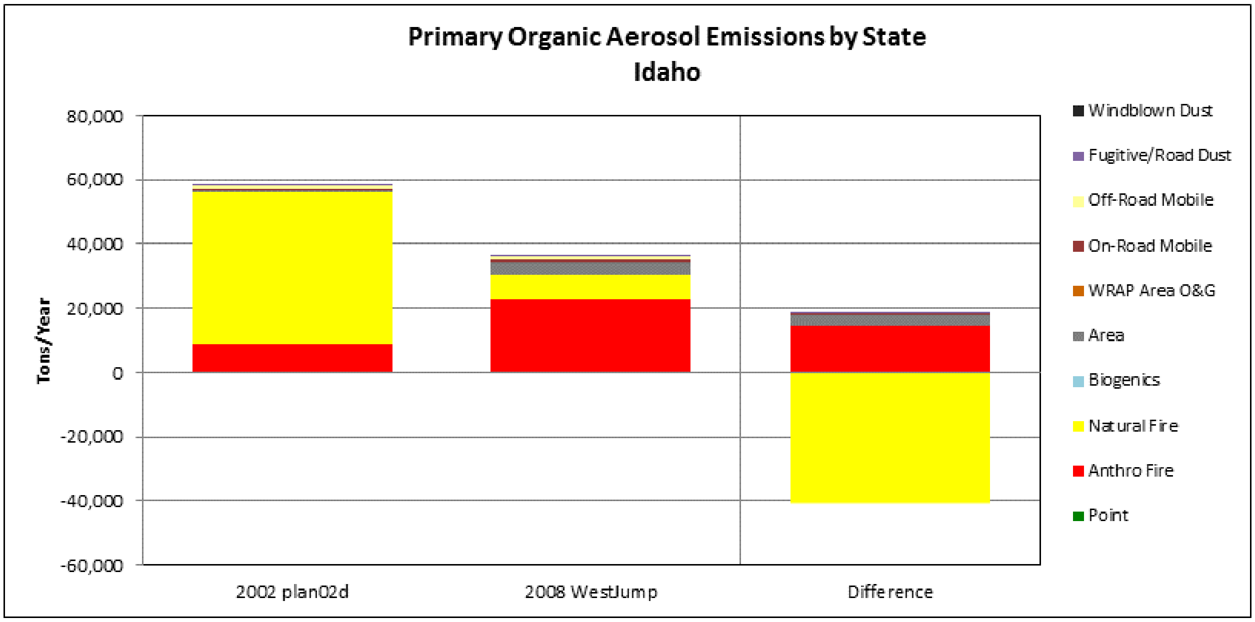

Figure 6.7-11. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Primary Organic Aerosol by Source Category for Idaho.

Table 6.7-13
Idaho
Elemental Carbon Emissions by Category

Source Category	Elemental Carbon Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	11	0	-11
Area	192	830	638
On-Road Mobile	390	1,823	1,432
Off-Road Mobile	1,859	839	-1,020
Area Oil and Gas	0	0	0
Fugitive and Road Dust	22	13	-9
Anthropogenic Fire	1,331	3,393	2,062
Total Anthropogenic	**3,805**	**6,897**	**3,092 (81%)**
Natural Sources			
Natural Fire	9,938	1,298	-8,640
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**9,938**	**1,298**	**-8,640 (-87%)**
All Sources			
Total Emissions	**13,743**	**8,195**	**-5,548 (-40%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

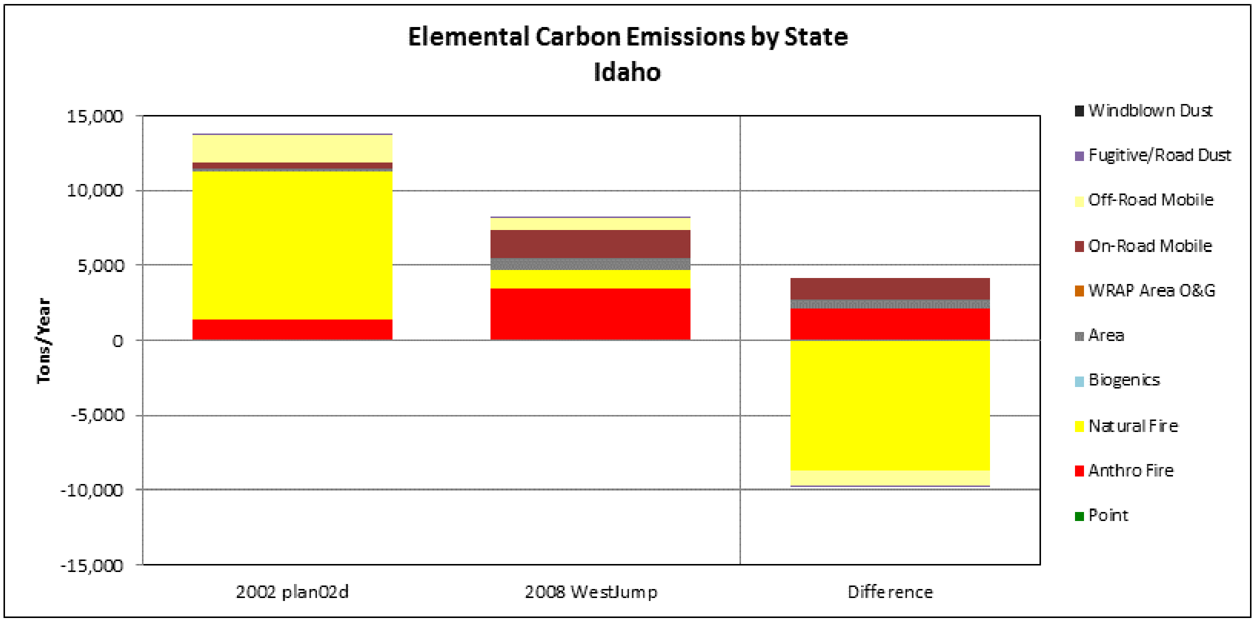

Figure 6.7-12. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Elemental Carbon by Source Category for Idaho.

Table 6.7-14
Idaho
Fine Soil Emissions by Category

Source Category	Fine Soil Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	305	0	-305
Area	4,749	2,364	-2,384
On-Road Mobile	251	175	-76
Off-Road Mobile	0	46	46
Area Oil and Gas	0	0	0
Fugitive and Road Dust	4,839	12,564	7,724
Anthropogenic Fire	1,536	8,358	6,822
Total Anthropogenic	**11,680**	**23,507**	**11,827 (>100%)**
Natural Sources			
Natural Fire	3,013	2,780	-233
Biogenic	0	0	0
Wind Blown Dust	5,050	5,286	236
Total Natural	**8,063**	**8,066**	**3 (0%)**
All Sources			
Total Emissions	**19,743**	**31,573**	**11,830 (60%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

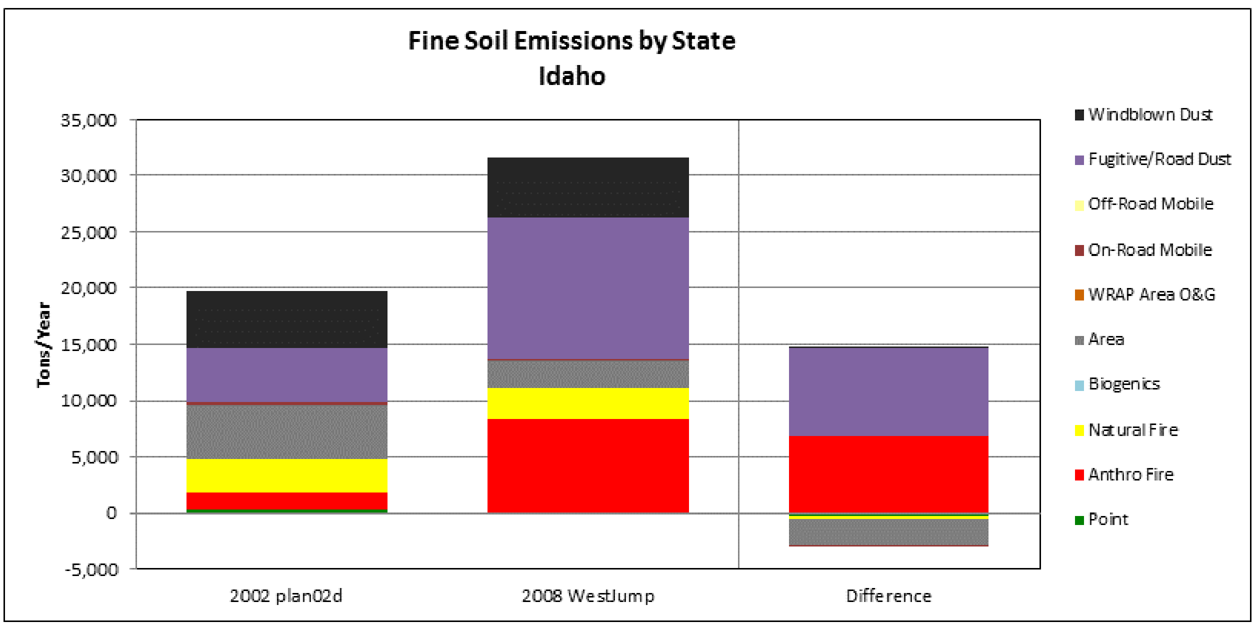

Figure 6.7-13. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Fine Soil by Source Category for Idaho.

Table 6.7-15
Idaho
Coarse Mass Emissions by Category

Source Category	Coarse Mass Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	643	727	85
Area	2,933	11,783	8,850
On-Road Mobile	238	1,950	1,711
Off-Road Mobile	0	41	41
Area Oil and Gas	0	0	0
Fugitive and Road Dust	37,185	92,114	54,929
Anthropogenic Fire	1,354	4,377	3,023
Total Anthropogenic	**42,353**	**110,992**	**68,639 (>100%)**
Natural Sources			
Natural Fire	25,323	1,436	-23,887
Biogenic	0	0	0
Wind Blown Dust	45,451	47,574	2,124
Total Natural	**70,774**	**49,011**	**-21,763 (-31%)**
All Sources			
Total Emissions	**113,127**	**160,003**	**46,876 (41%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

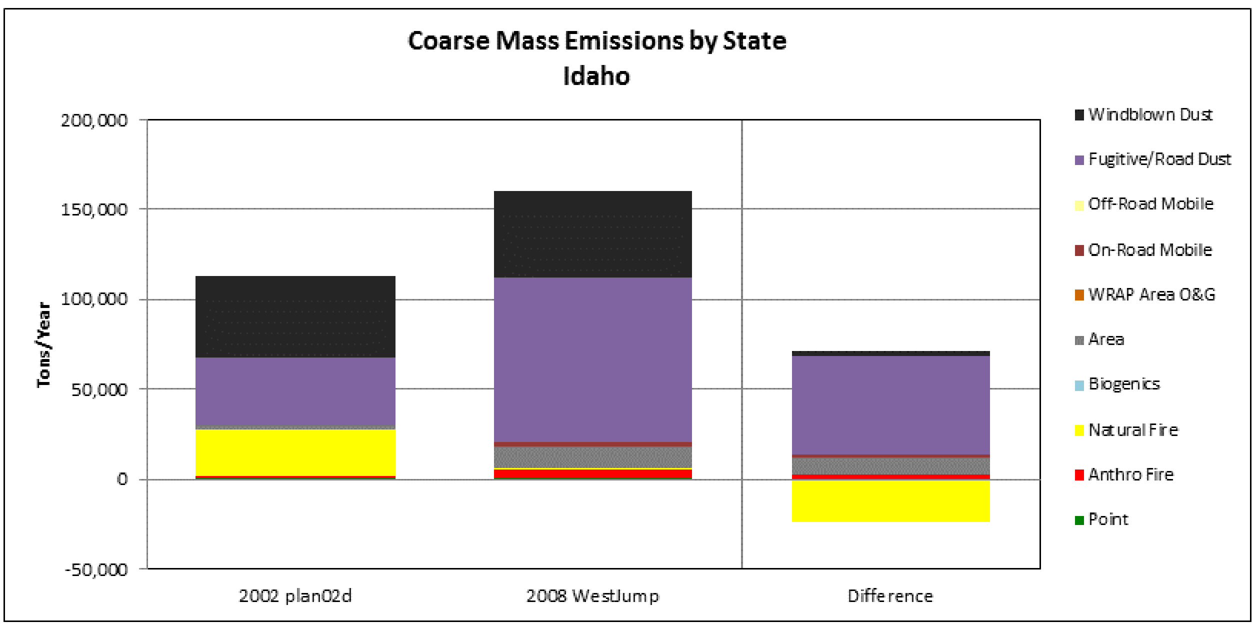

Figure 6.7-14. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Coarse Mass by Source Category for Idaho.

6.6.2.2 EGU Summary

As described in previous sections, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions because numerous updates in inventory methodologies have occurred between the development of the separate inventories. Also, the 2002 baseline and 2008 progress period inventories represent only annual snapshots of emissions estimates, which may not be representative of entire 5-year monitoring periods compared. To better account for year-to-year changes in emissions, annual emission totals for Idaho electrical generating units (EGU) are presented here. EGU emissions are some of the more consistently reported emissions, as tracked in EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/). RHR implementation plans are required to pay specific attention to certain major stationary sources, including EGUs, built between 1962 and 1977.

Figure 6.6-17 presents a sum of annual NO_X and SO_2 emissions as reported for Idaho EGU sources between 1996 and 2010. While these types of facilities are targeted for controls in state regional haze SIPs, it should be noted that many of the controls planned for EGUs in the WRAP states had not taken place yet in 2010, while other controls separate from the RHR may have been implemented. The chart shows periods of sharp increases for NO_X, while reported SO_2 emissions were consistently low.

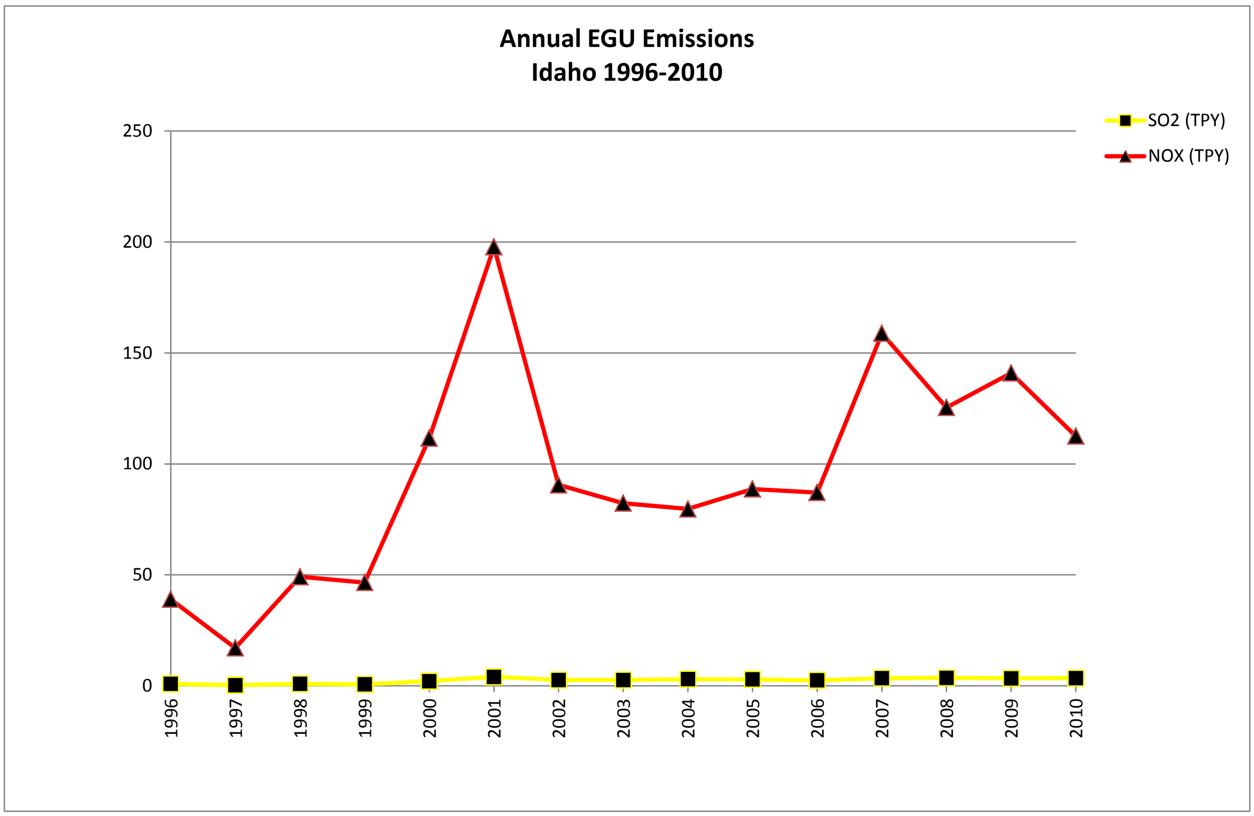

Figure 6.6-17. Sum of EGU Emissions of SO_2 and NOx reported between 1996 and 2010 for Idaho.

6.7 MONTANA

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. Montana has 4 mandatory Federal CIAs, which are depicted in Figure 6.7-1 and listed in Table 6.7-1, along with the associated IMPROVE monitor locations.

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per Regional Haze Rule (RHR) requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. Some of the highlights regarding these comparisons are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- For the best days, the 5-year average deciview metric decreased at all Montana Federal CIA IMPROVE sites.
- For the worst days, the 5-year average deciview metric decreased at the CABI1, GAMO1, GLAC1, ULBE1, and YELL2 sites, and increased at the MELA1, MONT1, and SULA1 sites.
- The largest increase in individual aerosol extinction species was due to particulate organic mass, with high measurements coinciding with several large wildfires during the progress period. The largest wildfire events affecting the MELA1, MONT1, and SULA1 sites occurred between August and September 2007.
- Decreasing trends in ammonium nitrate were measured at several sites. This was consistent with comparisons of baseline and progress period emissions inventories, tracking of annual sums from electrical generating unit (EGU) sources, which showed decreases in oxides of nitrogen for mobile and point sources.
- Comparisons of 5-year averages showed some increases in ammonium sulfate, but an increasing annual average trend was only measured at the MELA1 site in northeastern Montana. Increasing averages and trends were not consistent with comparisons of emissions inventories and tracking of annual EGU emissions, which showed decreased SO_2 due to point, area and mobile sources. Increasing ammonium sulfate trends were also observed at the nearby LOST1 site in northwestern North Dakota. Both of these sites are near the Canadian border, so it is possible that international emissions affected these measurements.

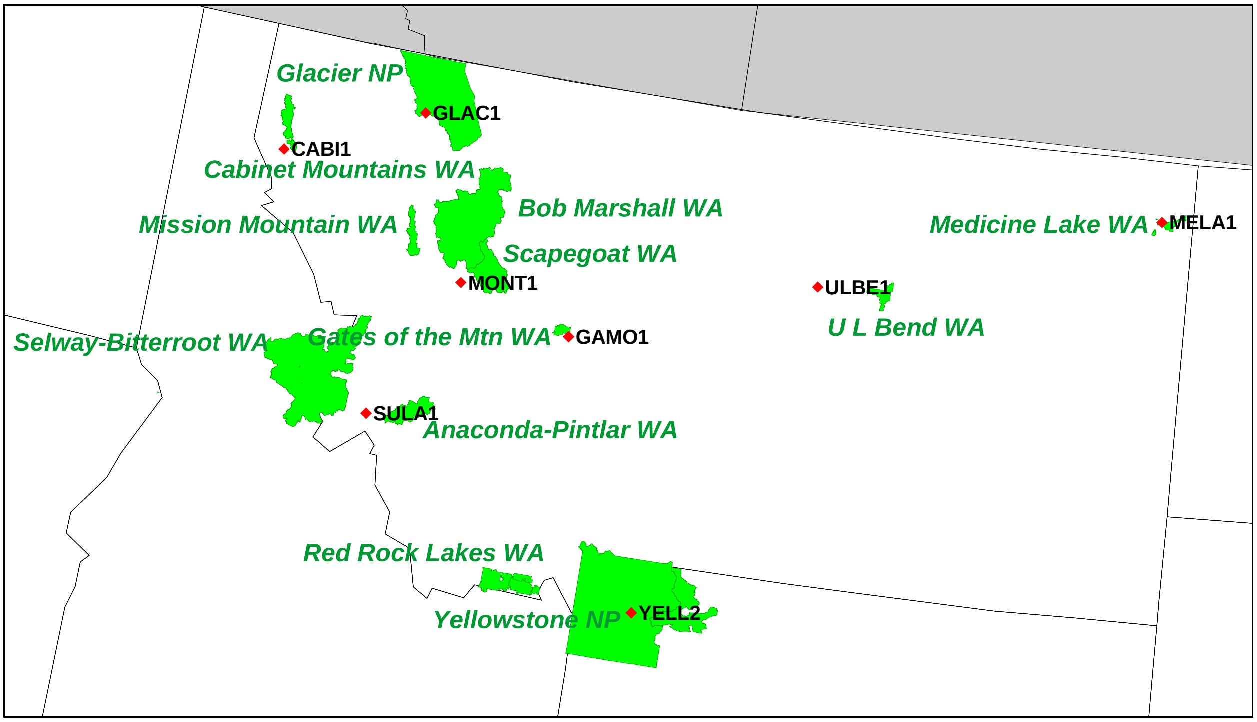

Figure 6.7-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in Montana.

Table 6.7-1
Montana CIAs and Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Cabinet Mountains WA	CABI1	47.95	-115.67	1441
Gates of the Mountain WA	GAMO1	46.83	-111.71	2387
Glacier NP	GLAC1	48.51	-114.00	975
Medicine Lake WA	MELA1	48.49	-104.48	606
Bob Marshall WA Mission Mountain WA Scapegoat WA	MONT1	47.12	-113.15	1282
Anaconda-Pintlar WA Selway-Bitterroot WA	SULA1	45.86	-114.00	1895
U L Bend WA	ULBE1	47.58	-108.72	891
Yellowstone NP	YELL2	44.57	-110.40	2425

6.7.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by IMPROVE monitors representing Federal CIAs in Montana. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix G.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.7.1.1 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.308 (g)(3)(i))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[93] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.7-2 and 6.7-3 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired, or worst, and 20% least impaired, or best, days for each of the Federal CIA IMPROVE monitors in Montana. Figure 6.7-2 presents 5-year average extinction for the current progress period for both the 20% most impaired and 20% least impaired days. Note that the percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired days are as follows:

- The largest contributors to aerosol extinction at Montana sites were particulate organic mass and ammonium sulfate.
- The highest aerosol extinction (18.7 dv) was measured at the GLAC1 site, where particulate organic mass was the largest contributor to aerosol extinction, followed by ammonium sulfate. The lowest aerosol extinction (11.2 dv) was measured at the GAMO1 site.

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[93] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

Specific observations for the current visibility conditions on the 20% least impaired days are as follows:

- The aerosol contribution to total extinction on the best days was less than Rayleigh, or the background scattering that would occur in clear air. Average extinction (including Rayleigh) ranged from 0.9 dv (GAMO1) to 7.0 deciview (GLAC1).
- For all sites, ammonium sulfate was the largest contributor to the non-Rayleigh aerosol portion of extinction.

Table 6.7-2
Montana Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
CABI1	13.5	23% (2)	5% (5)	**51% (1)**	9% (4)	3% (6)	9% (3)	0% (7)
GAMO1	11.2	25% (2)	7% (5)	**49% (1)**	8% (3)	3% (6)	7% (4)	0% (7)
GLAC1	18.7	20% (2)	12% (3)	**48% (1)**	10% (4)	2% (6)	8% (5)	0% (7)
MELA1	18.0	**36% (1)**	30% (2)	18% (3)	4% (5)	1% (6)	8% (4)	1% (7)
MONT1	15.3	13% (2)	3% (6)	**66% (1)**	9% (3)	3% (5)	6% (4)	0% (7)
SULA1	17.0	6% (3)	2% (5)	**75% (1)**	11% (2)	1% (6)	5% (4)	0% (7)
ULBE1	14.9	28% (2)	15% (3)	**36% (1)**	6% (5)	2% (6)	11% (4)	1% (7)
YELL2	11.5	17% (2)	6% (5)	**57% (1)**	8% (4)	3% (6)	9% (3)	0% (7)

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.7-3
Montana Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
CABI1	3.2	**45% (1)**	14% (3)	21% (2)	7% (4)	3% (7)	7% (5)	4% (6)
GAMO1	0.9	**46% (1)**	13% (3)	19% (2)	7% (5)	3% (6)	9% (4)	2% (7)
GLAC1	7.0	**34% (1)**	9% (4)	31% (2)	16% (3)	2% (6)	8% (5)	1% (7)
MELA1	6.5	**42% (1)**	13% (4)	15% (3)	6% (5)	4% (6)	19% (2)	1% (7)
MONT1	3.1	**40% (1)**	8% (4)	31% (2)	10% (3)	2% (6)	6% (5)	2% (7)
SULA1	2.5	**46% (1)**	10% (4)	22% (2)	6% (5)	3% (6)	12% (3)	1% (7)
ULBE1	4.3	**40% (1)**	8% (5)	22% (2)	8% (4)	4% (6)	19% (3)	1% (7)
YELL2	2.0	**42% (1)**	16% (3)	25% (2)	8% (4)	2% (6)	7% (5)	1% (7)

*Highest aerosol species contribution per site is highlighted in bold.

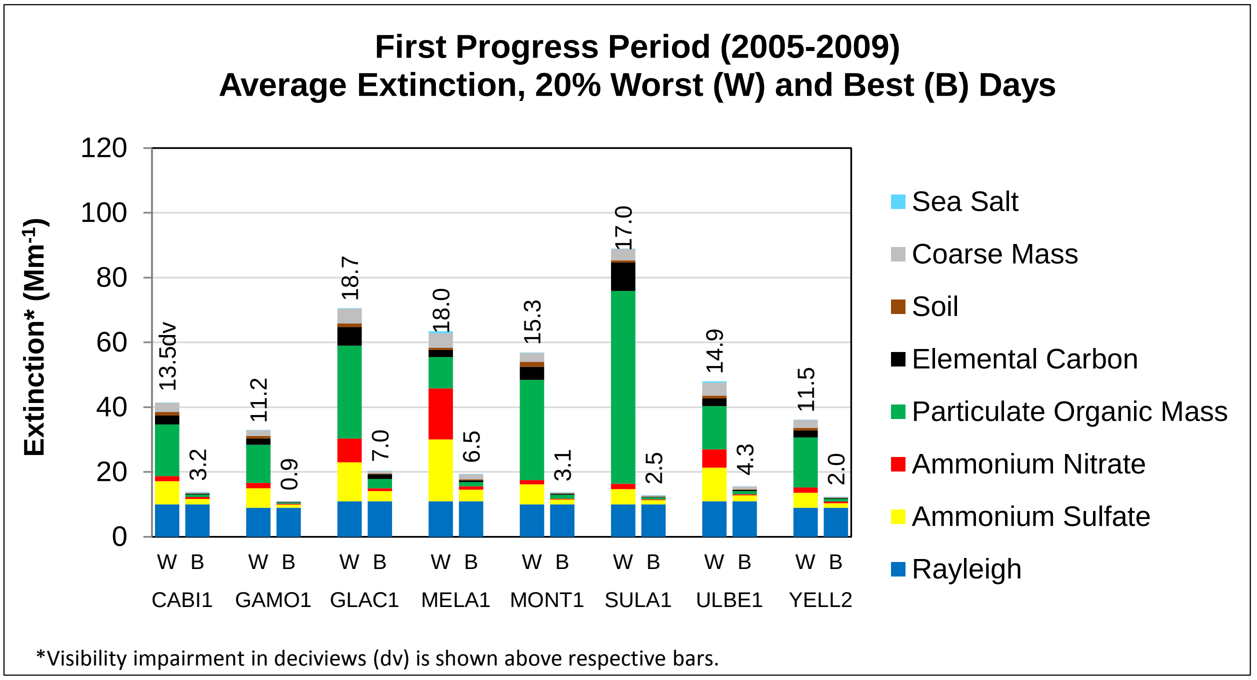

Figure 6.7-2. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at Montana Class I Area IMPROVE Sites.

6.7.1.2 Differences Between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.308 (g)(3)(ii))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Table 6.7-4 presents the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for each site in Montana for the 20% most impaired days, and Table 6.7-5 presents similar data for the least impaired days. Averages that increased are depicted in red text and averages that decreased in blue.

Figure 6.7-3 presents the 5-year average extinction for the baseline and current progress period averages for the worst days and Figure 6.7-4 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.7-5 and 6.7-6 present similar plots for the best days.

For the 20% most impaired days, the 5-year average RHR deciview metric increased between the 2000-2004 and 2005-2009 periods at the MELA1, MONT1 and SULA1 sites and decreased at all other Montana sites. Notable differences for individual species averages were as follows:

- Increases in deciview averages at the MONT1 and SULA1 sites were due, in large part, to increases in particulate organic mass.
- Increases in deciview averages at the MELA1 site were mostly due to increased ammonium sulfate.
- All sites except SULA1 measured increases in ammonium sulfate and decreases in ammonium nitrate.

For the 20% least impaired days, the 5-year average deciview metric decreased at all sites. Notable differences for individual species averages on the 20% least impaired days were as follows:

- All species either decreased or stayed the same at all sites, with the exception of ammonium sulfate at SULA1 and YELL2, and coarse mass at SULA1.

Table 6.7-4
Montana Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-2004 Baseline Period	2005-2009 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
CABI1	14.1	13.5	-0.6	+0.6	-0.4	-1.0	0.0	0.0	+0.1	0.0
GAMO1	11.3	11.2	-0.1	+0.6	-0.3	+0.6	+0.1	0.0	+0.1	-0.1
GLAC1	22.3	18.7	-3.6	+0.6	-2.0	-59.0	-5.5	-0.3	-0.6	-0.1
MELA1	17.7	18.0	+0.3	+2.1	-0.5	+0.1	-0.2	0.0	0.0	+0.6
MONT1	14.5	15.3	+0.8	+1.1	-0.1	+8.6	+1.2	+0.2	-0.8	+0.1
SULA1	13.4	17.0	+3.6	-0.1	+0.2	+39.5	+6.3	-0.3	+1.1	-0.2
ULBE1	15.1	14.9	-0.2	+0.5	-2.3	+0.6	+0.2	+0.1	0.0	+0.5
YELL2	11.8	11.5	-0.3	+0.3	-0.1	+2.0	-0.3	-0.1	-0.2	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.7-5
Montana Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*							
	2000-2004 Baseline Period	2005-2009 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
CABI1	3.6	3.2	-0.4	-0.1	-0.2	-0.2	-0.1	0.0	-0.1	0.0
GAMO1	1.7	0.9	-0.8	-0.1	-0.2	-0.3	-0.1	0.0	-0.2	0.0
GLAC1	7.2	7.0	-0.2	+0.1	0.0	-0.4	0.0	-0.1	-0.1	0.0
MELA1	7.3	6.5	-0.8	0.0	-0.1	-0.7	-0.1	0.0	-0.5	0.0
MONT1	3.9	3.1	-0.8	0.0	-0.2	-0.7	-0.1	0.0	-0.1	0.0
SULA1	2.6	2.5	-0.1	+0.2	-0.1	-0.3	-0.1	0.0	+0.1	0.0
ULBE1	4.7	4.3	-0.4	0.0	-0.2	-0.3	-0.1	0.0	-0.1	0.0
YELL2	2.6	2.0	-0.6	-0.1	-0.2	-0.3	-0.1	0.0	0.0	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

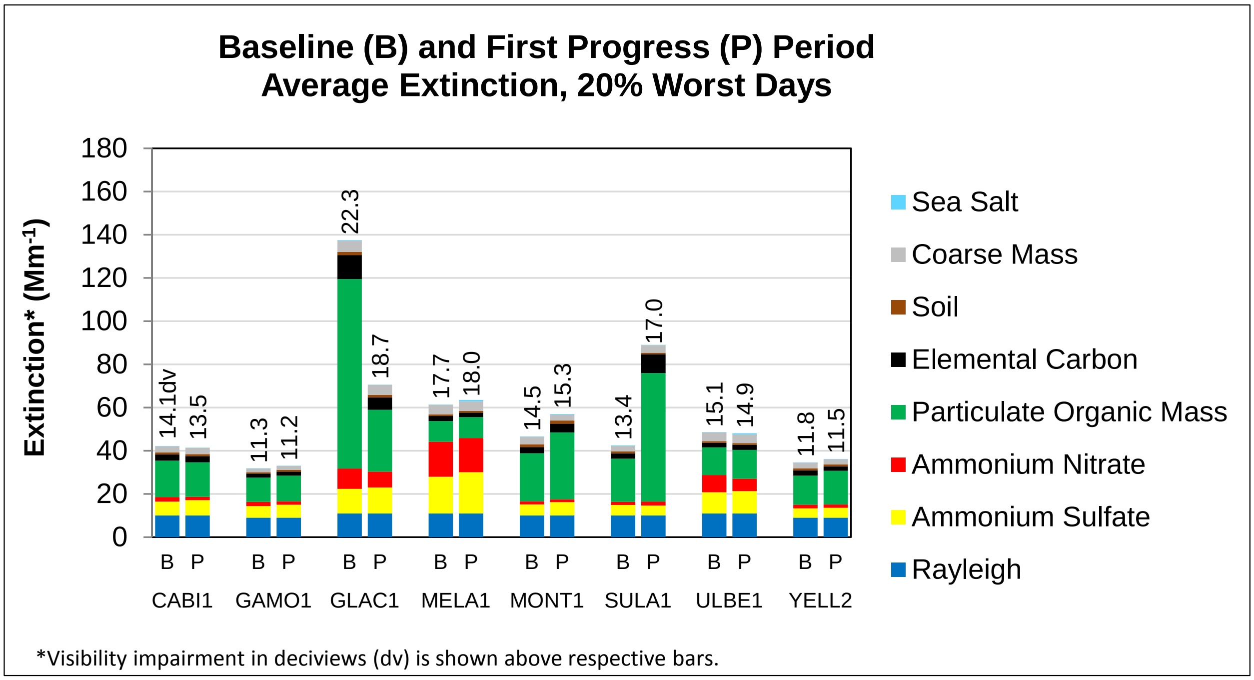

Figure 6.7-3. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at Montana Class I Area IMPROVE Sites.

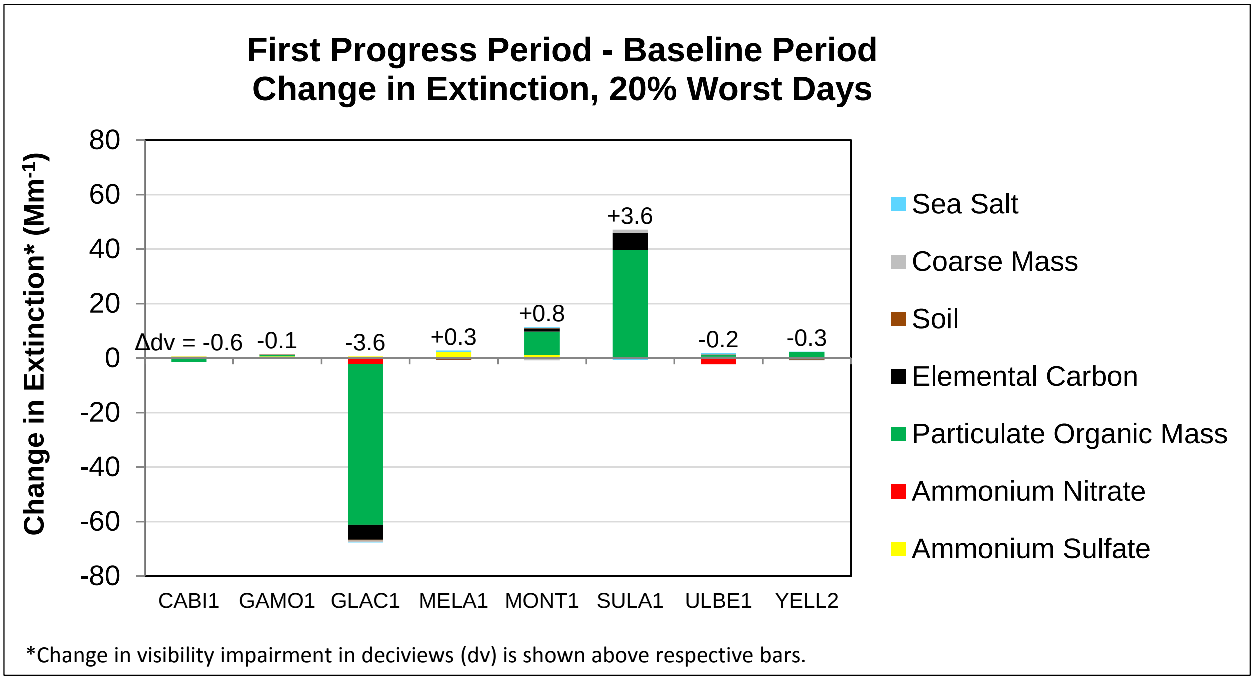

Figure 6.7-4. Difference Between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at Montana Class I Area IMPROVE Sites.

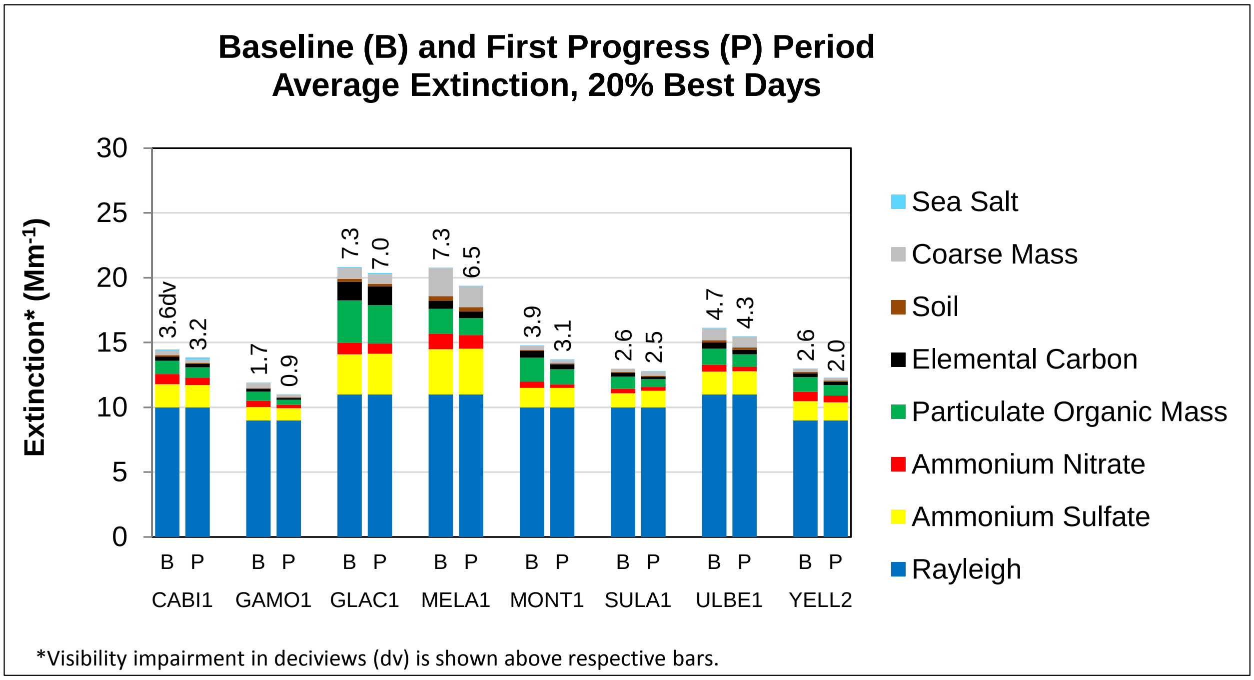

Figure 6.7-5. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at Montana Class I Area IMPROVE Sites.

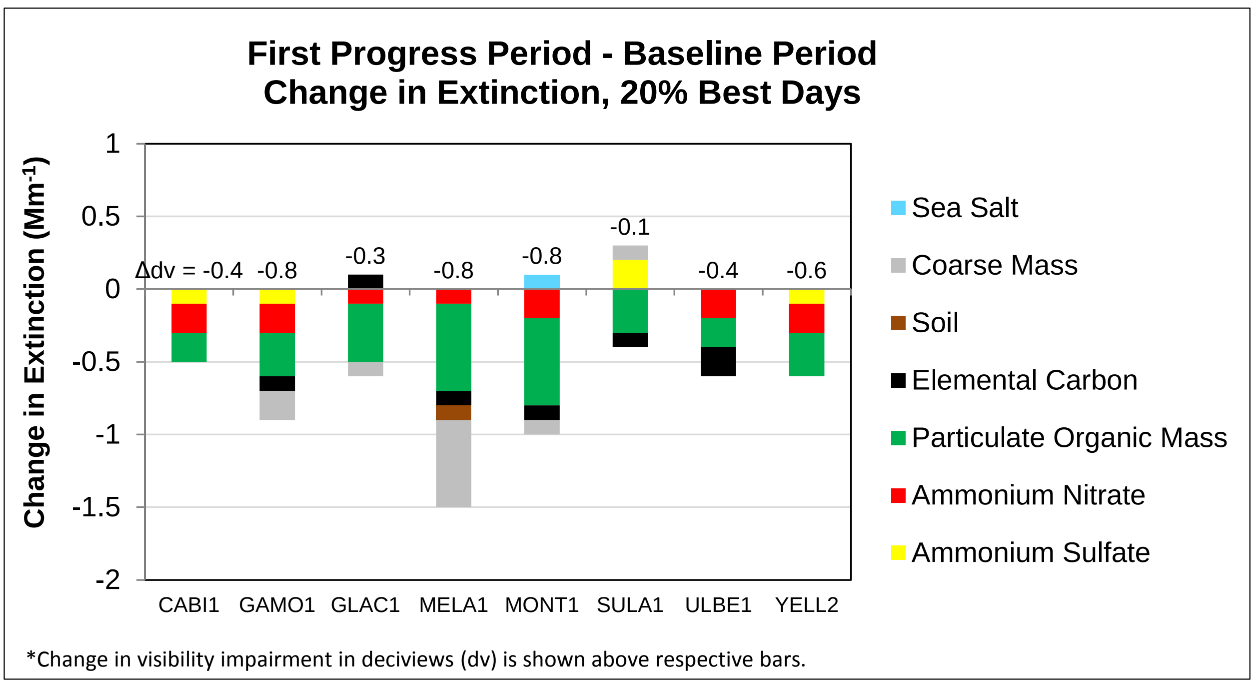

Figure 6.7-6. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at Montana Class I Area IMPROVE Sites.

6.7.1.3 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.308 (g)(3)(iii))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5-year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in Montana are summarized in Table 6.7-6 and regional trends were presented earlier in Section 4.1.1.[94] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[95] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix G. Additionally, this appendix includes plots depicting 5-year, annual, monthly, and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in Montana are as follows:

- The largest changes in 5-year averages for particulate organic mass were measured at the GLAC1 and SULA1 sites. The 2000-2004 baseline average at the GLAC1 site was influenced by a large fire event in August, 2003 and the 2005-2009 progress period average at the SULA1 site was influenced by a large fire event in August 2007. A regional map depicting the spatial extent of a 2007 fire is depicted in Section 4.1.2. The GUMO1 5-year average was missing the year 2007, which likely biased

[94] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)

[95] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

progress period measurements of particulate organic mass low, as compared to other Montana sites.

- For ammonium nitrate, decreasing trends were measured at the western Montana GAMO1, GLAC1, and MONT1 sites, and at the MELA1 site in eastern Montana.
- For ammonium sulfate, annual average trend statistics for all measured days indicated slightly decreasing trends at the GLAC1 site. Increasing trends in ammonium sulfate were measured at the MELA1 site, and also at the nearby LOST1 site in western North Dakota.

Table 6.7-6
Montana Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	**Group**	**Annual Trend* (Mm^{-1}/year)**						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
CABI1	20% Best	--	0.0	**-0.1**	0.0	--	0.0	--
	20% Worst	--	--	--	--	--	**0.1**	--
	All Days	0.0	0.0	--	--	--	--	--
GAMO1	20% Best	--	0.0	**-0.1**	0.0	--	0.0	--
	20% Worst	--	--	--	--	--	**0.1**	--
	All Days	--	**-0.1**	--	--	--	--	--
GLAC1	20% Best	--	--	**-0.1**	--	--	--	0.0
	20% Worst	--	**-0.5**	**-3.0**	**-0.3**	**-0.1**	--	--
	All Days	**-0.1**	**-0.1**	**-0.9**	**-0.1**	0.0	--	0.0
MELA1	20% Best	--	--	**-0.1**	0.0	--	**-0.1**	--
	20% Worst	--	--	--	**-0.1**	--	**-0.2**	0.0
	All Days	**0.1**	**-0.1**	--	**-0.1**	--	--	0.0
MONT1	20% Best	--	0.0	**-0.1**	0.0	0.0	0.0	--
	20% Worst	**0.1**	**-0.1**	--	--	--	--	0.0
	All Days	--	**-0.1**	--	--	--	--	0.0
NOCH1	20% Best	**0.1**	--	--	--	--	--	--
	20% Worst	--	--	--	**-0.4**	--	--	--
	All Days	--	--	--	**-0.1**	--	--	--
SULA1	20% Best	--	0.0	**-0.1**	0.0	--	0.0	--
	20% Worst	--	--	--	--	0.0	--	--
	All Days	--	--	--	--	--	--	--
ULBE1	20% Best	--	0.0	**-0.1**	0.0	--	--	--
	20% Worst	--	--	--	--	--	--	0.0
	All Days	--	--	--	--	--	--	0.0
YELL2	20% Best	--	0.0	**-0.1**	--	0.0	--	0.0
	20% Worst	--	--	--	--	--	0.0	0.0
	All Days	--	--	--	0.0	--	--	0.0

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix G.

6.7.2 Emissions Data

Included here are summaries depicting differences between two emission inventory years that are used to represent the 5-year baseline and current progress periods. The baseline period is represented using a 2002 inventory developed by the WRAP for use in the initial WRAP state SIPs, and the progress period is represented by a 2008 inventory which leverages recent WRAP inventory work for modeling efforts, as referenced in Section 3.2.1. For reference, Table 6.7-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories, and a separate summary of annual emissions from electrical generating units (EGUs), are presented in this section.

Table 6.7-7
Montana
Pollutants, Aerosol Species, and Major Sources

Emitted Pollutant	Related Aerosol	Major Sources	Notes
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- and Off-Road Mobile Sources	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be associated with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Primary Organic Aerosol (POA)	POM	Wildfires; Area Sources	POA represents organic aerosols that are emitted directly as particles, as opposed to gases. Wildfires in the west generally dominate POA emissions, and large wildfire events are generally sporadic and highly variable from year-to-year.
Elemental Carbon (EC)	EC	Wildfires; On- and Off-Road Mobile Sources	Large EC events are often associated with large POM events during wildfires. Other sources include both on- and off-road diesel engines.
Fine soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is reported by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$ mass measurements. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but these measurements are generally associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributor to PMC.

6.7.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.308 (g)(4))?*** For these summaries, emissions during the baseline years are represented using a 2002 inventory, which was developed with support from the WRAP for use in the original RHR SIP strategy development (termed plan02d). Differences between inventories are represented as the difference between the 2002 inventory, and a 2008 inventory which leverages recent inventory development work performed by the WRAP for the WestJumpAQMS and DEASCO$_3$ modeling projects (termed WestJump2008). Note that the comparisons of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories, as referenced in Section 3.2.1. Inventories for all major visibility impairing pollutants are presented for major source categories, and categorized as either anthropogenic or natural emissions. State-wide inventories totals and differences are presented here, and inventory totals on a county level basis are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

Table 6.7-8 and Figure 6.7-7 present the differences between the 2002 and 2008 sulfur dioxide (SO_2) inventories by source category. Tables 6.7-9 and Figure 6.7-8 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.7-10 through 6.7-15 and Figures 6.7-9 through 6.7-14) present data for ammonia (NH_3), volatile organic compounds (VOCs), primary organic aerosol (POA), elemental carbon (EC), fine soil and coarse mass. General observations regarding emissions inventory comparisons are listed below.

- Largest differences for point source inventories were decreases in SO_2, $NO_{X,}$ and VOCs
- Area source inventories showed decreases in SO_2, VOCs, and NH_3 and increases in NO_X. These changes may be due to a combination of population changes and differences in methodologies used to estimate these emissions, as referenced in Section 3.2.1. One methodology change was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to increases in area source inventory totals, but decreases in off-road mobile totals.
- On-road mobile source inventory comparisons showed decreases in most parameters, especially NO_X and VOCs, with slight increases in POA, EC, and coarse mass. Reductions in NO_X and VOC are likely influenced by federal and state emissions standards that have already been implemented. The increases in POA, EC, and coarse mass occurred in all of the WRAP states for on-road mobile inventories, regardless of reductions in NO_2 and VOCs, indicating that these increases were likely due to use of different on-road models, as referenced in Section 3.2.1.
- Off-road mobile source inventories showed decreases in NO_X, SO_2, and VOCs, and increases in fine soil and coarse mass, which was consistent with most contiguous WRAP states. These differences are likely due to a combination of actual changes in source contributions and methodology differences, as referenced in Section 3.2.1. As

noted previously, one major methodology difference was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to decreases in the off-road inventory totals, but increases in area source totals.

- For all parameters, especially POAs, VOCs, and EC, natural fire emission inventory estimates decreased, and anthropogenic fire inventories increased. Note that these differences are not necessarily reflective of changes in monitored data, as the baseline period is represented by an average of 2000-2004 fire emissions, and the progress period is represented only by the fires that occurred in 2008, as referenced in Section 3.2.1.
- Comparisons between VOC inventories showed large decreases in biogenic emissions, which was consistent with other contiguous WRAP states. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions, as referenced in Section 3.2.1.
- Fine soil and coarse mass increased for the windblown dust inventory comparisons and the combined fugitive/road dust inventories. Large variability in changes in windblown dust inventories was observed for the contiguous WRAP states, which was likely due in large part to enhancements in dust inventory methodology, as referenced in Section 3.2.1, rather than changes in actual emissions.

Table 6.7-8
Montana
Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	36,879	27,402	-9,477
Area	3,072	584	-2,488
On-Road Mobile	1,770	229	-1,540
Off-Road Mobile	4,193	336	-3,857
Area Oil and Gas	225	21	-204
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	404	1,121	717
Total Anthropogenic	**46,543**	**29,694**	**-16,848 (-36%)**
Natural Sources			
Natural Fire	3,655	324	-3,331
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**3,655**	**324**	**-3,331 (-91%)**
All Sources			
Total Emissions	**50,198**	**30,019**	**-20,179 (-40%)**

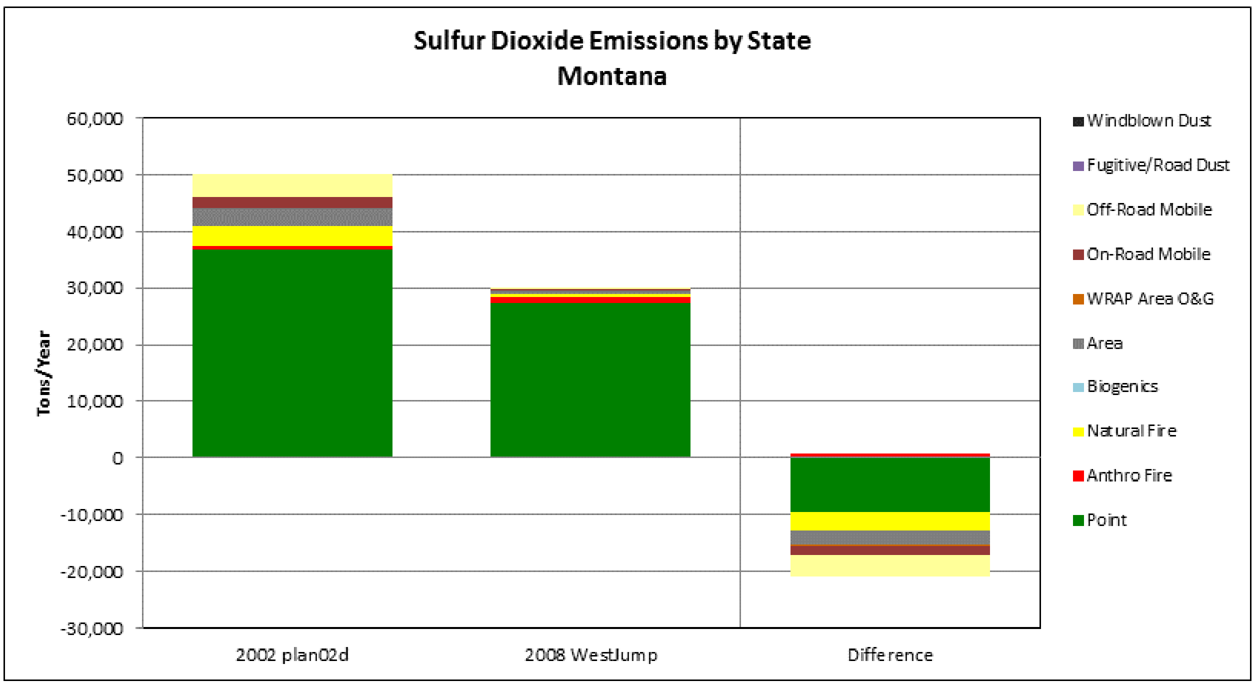

Figure 6.7-7. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for Montana.

Table 6.7-9
Montana
Oxides of Nitrogen Emissions by Category

Source Category	Oxides of Nitrogen Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	53,416	42,943	-10,473
Area	4,280	25,777	21,497
On-Road Mobile	53,597	31,590	-22,007
Off-Road Mobile	50,604	16,910	-33,694
Area Oil and Gas	7,557	332	-7,225
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	1,503	8,016	6,513
Total Anthropogenic	**170,957**	**125,568**	**-45,389 (-27%)**
Natural Sources			
Natural Fire	13,668	2,293	-11,375
Biogenic	58,354	12,953	-45,400
Wind Blown Dust	0	0	0
Total Natural	**72,021**	**15,247**	**-56,775 (-79%)**
All Sources			
Total Emissions	**242,978**	**140,815**	**-102,164 (-42%)**

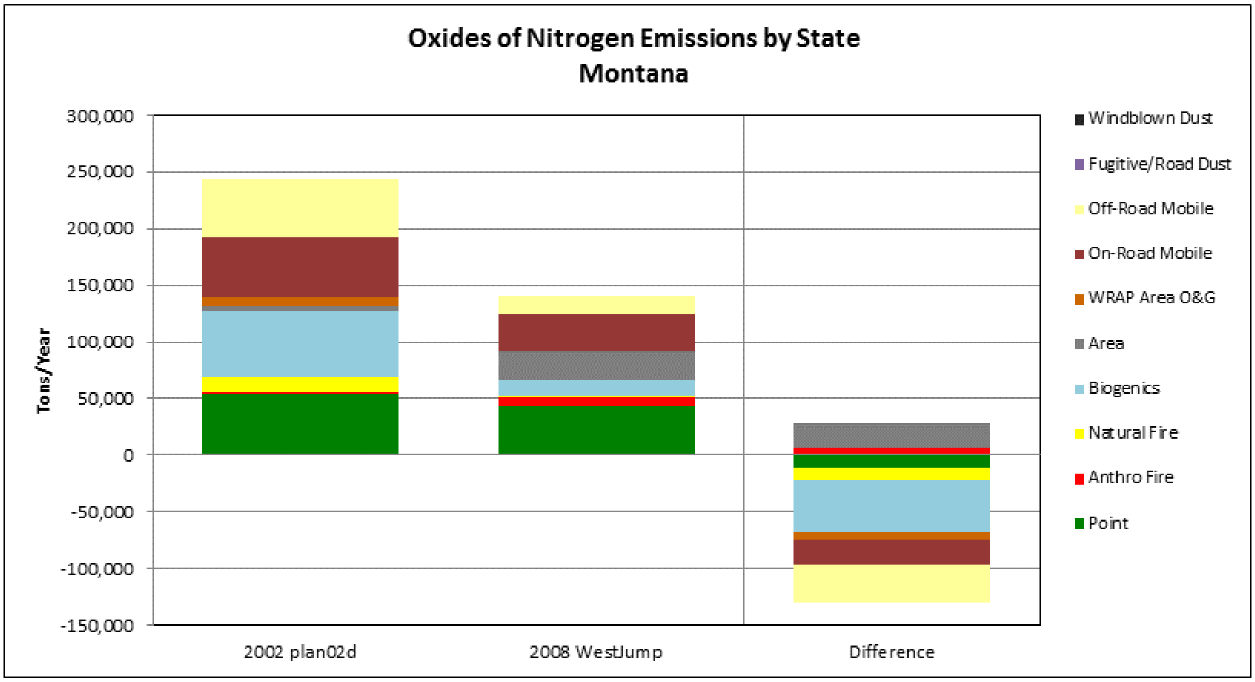

Figure 6.7-8. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Oxides of nitrogen by Source Category for Montana.

Table 6.7-10
Montana
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	318	53	-264
Area	61,240	55,254	-5,986
On-Road Mobile	1,293	458	-835
Off-Road Mobile	29	16	-13
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	289	5,507	5,208
Total Anthropogenic	**63,169**	**61,289**	**-1,880 (-3%)**
Natural Sources			
Natural Fire	3,060	1,599	-1,462
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**3,060**	**1,599**	**-1,462 (-48%)**
All Sources			
Total Emissions	**66,229**	**62,888**	**-3,342 (-5%)**

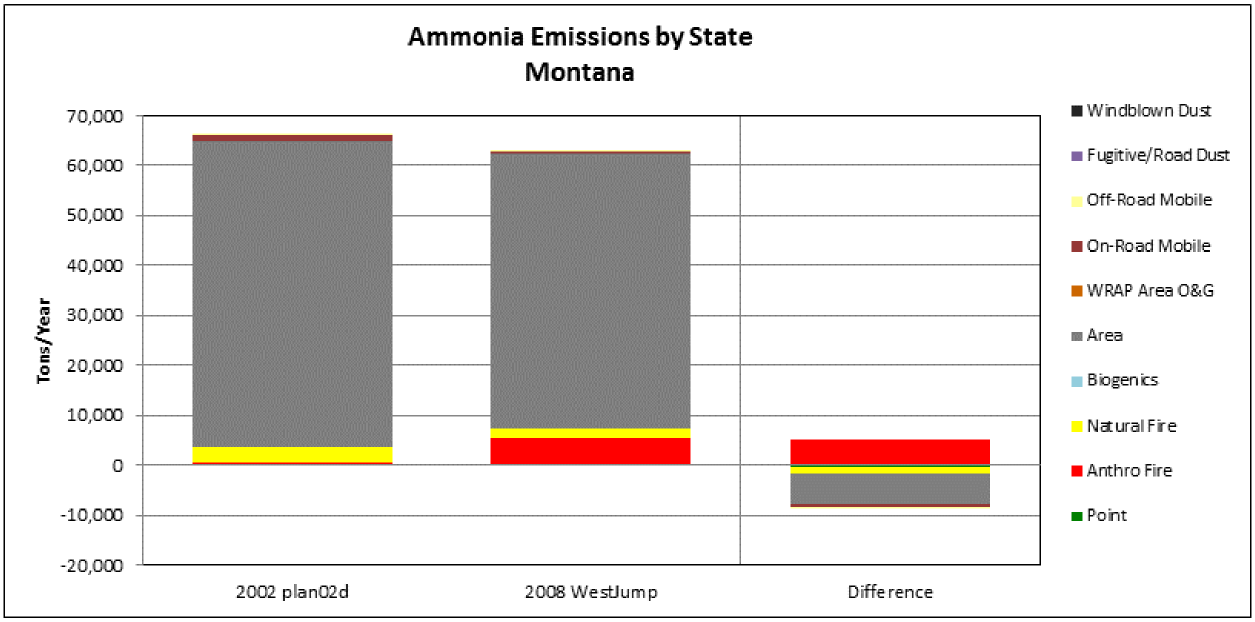

Figure 6.7-9. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Ammonia by Source Category for Montana.

Table 6.7-11
Montana
Volatile Organic Compound Emissions by Category

Source Category	Volatile Organic Compound Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	7,577	4,670	-2,907
Area	47,408	18,512	-28,897
On-Road Mobile	43,467	13,231	-30,235
Off-Road Mobile	12,748	12,449	-300
Area Oil and Gas	5,444	204	-5,240
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	2,895	7,643	4,749
Total Anthropogenic	**119,539**	**56,710**	**-62,829 (-53%)**
Natural Sources			
Natural Fire	30,101	1,546	-28,555
Biogenic	1,031,678	305,432	-726,246
Wind Blown Dust	0	0	0
Total Natural	**1,061,779**	**306,978**	**-754,801 (-71%)**
All Sources			
Total Emissions	**1,181,318**	**363,688**	**-817,630 (-69%)**

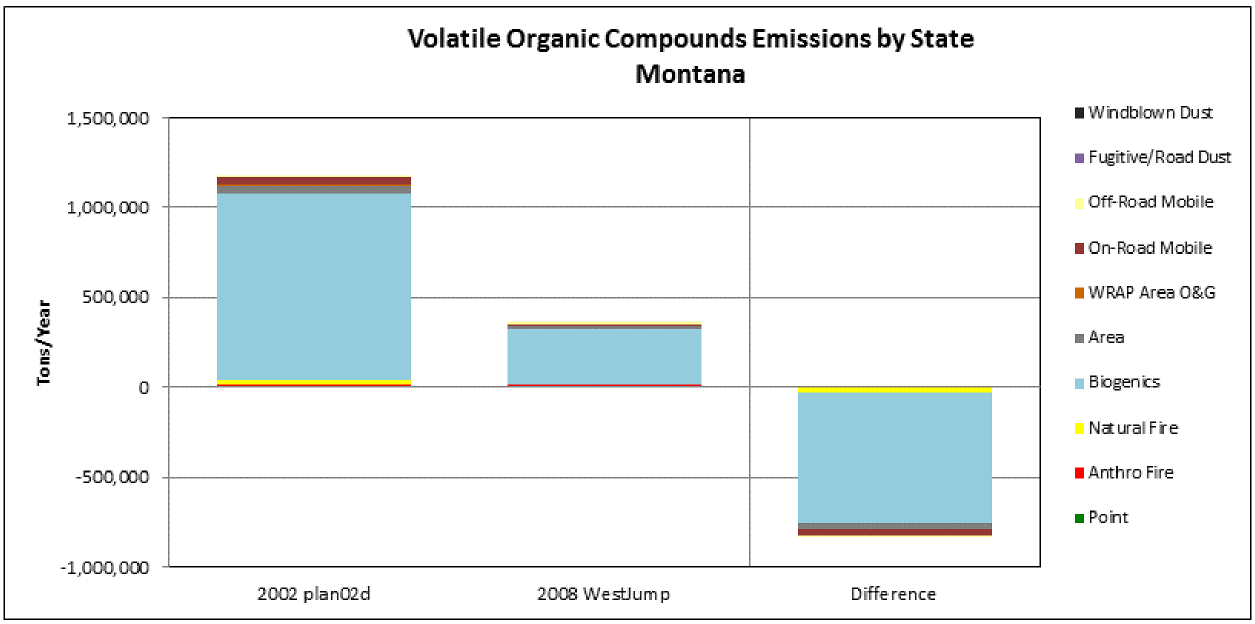

Figure 6.7-10. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for Montana.

Table 6.7-12
Montana
Primary Organic Aerosol Emissions by Category

Source Category	Primary Organic Aerosol Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	101	13	-87
Area	2,788	1,847	-941
On-Road Mobile	455	846	391
Off-Road Mobile	718	523	-195
Area Oil and Gas	0	1	1
Fugitive and Road Dust	1,958	1,211	-747
Anthropogenic Fire	3,745	17,360	13,615
Total Anthropogenic	**9,764**	**21,801**	**12,037 (>100%)**
Natural Sources			
Natural Fire	38,324	4,765	-33,559
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**38,324**	**4,765**	**-33,559 (-88%)**
All Sources			
Total Emissions	**48,089**	**26,566**	**-21,522 (-45%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

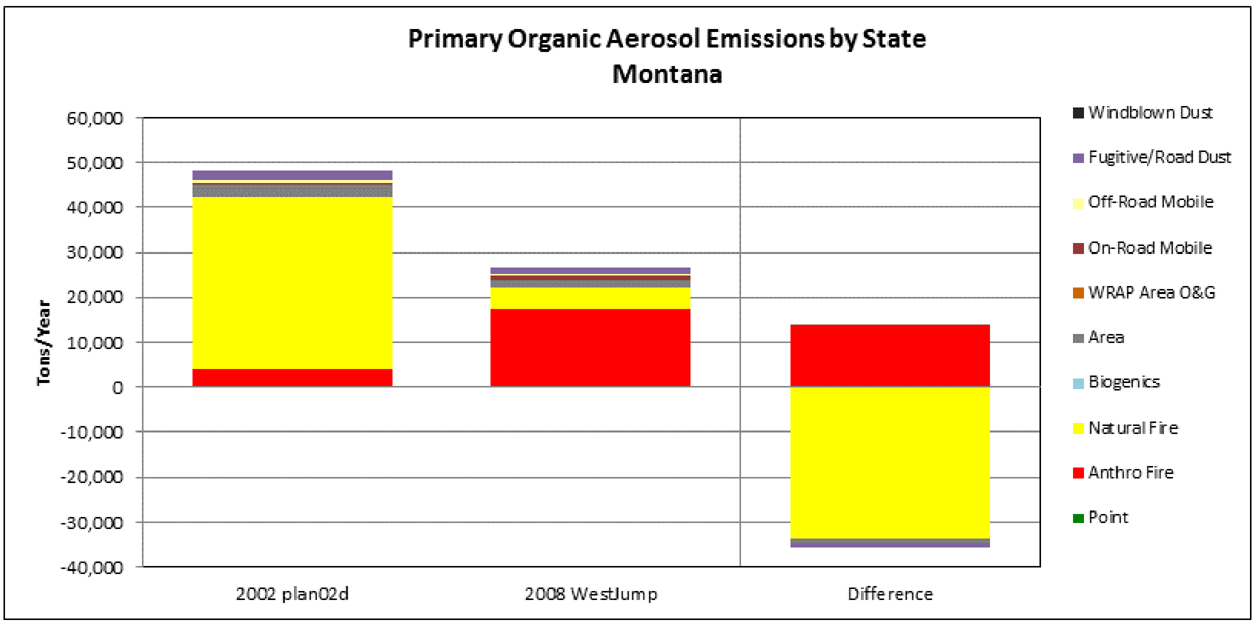

Figure 6.7-11. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Primary Organic Aerosol by Source Category for Montana.

Table 6.7-13
Montana
Elemental Carbon Emissions by Category

Source Category	Elemental Carbon Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	17	5	-12
Area	413	774	360
On-Road Mobile	519	1,403	884
Off-Road Mobile	2,288	1,126	-1,162
Area Oil and Gas	0	0	0
Fugitive and Road Dust	134	22	-112
Anthropogenic Fire	759	2,738	1,979
Total Anthropogenic	**4,129**	**6,066**	**1,937 (47%)**
Natural Sources			
Natural Fire	7,743	1,102	-6,641
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**7,743**	**1,102**	**-6,641 (-86%)**
All Sources			
Total Emissions	**11,873**	**7,168**	**-4,705 (-40%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

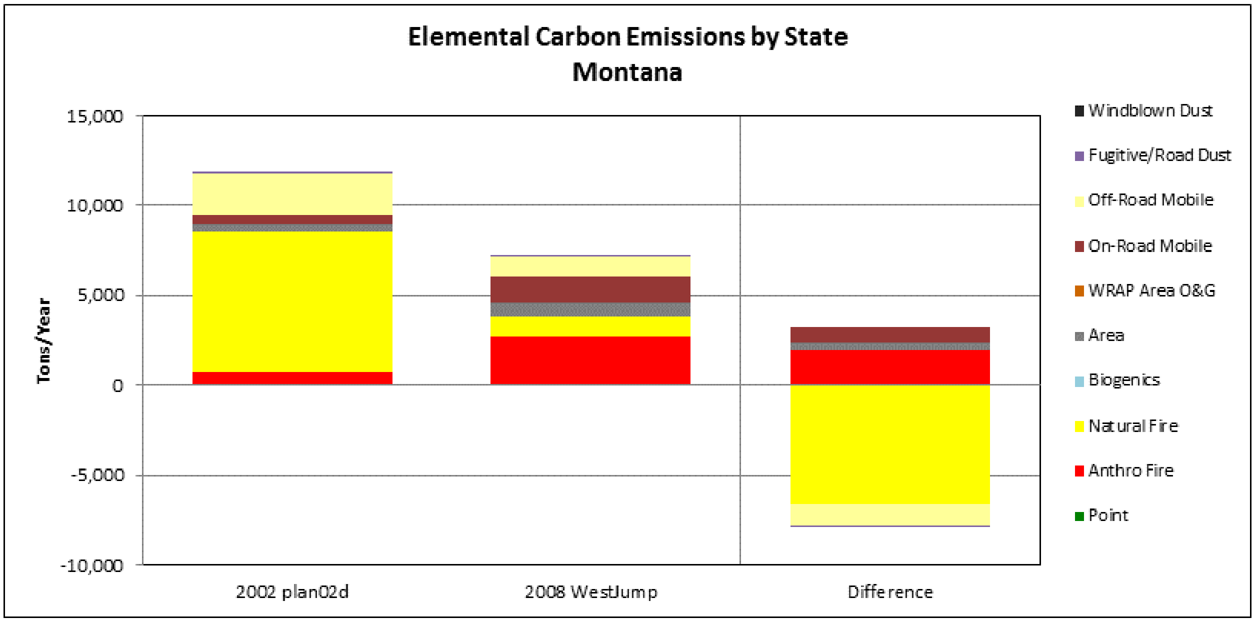

Figure 6.7-12. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Elemental Carbon by Source Category for Montana.

Table 6.7-14
Montana
Fine Soil Emissions by Category

Source Category	Fine Soil Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	182	181	-1
Area	2,472	932	-1,540
On-Road Mobile	268	126	-142
Off-Road Mobile	0	36	36
Area Oil and Gas	0	16	16
Fugitive and Road Dust	34,947	23,921	-11,026
Anthropogenic Fire	279	6,377	6,098
Total Anthropogenic	**38,148**	**31,591**	**-6,558 (-17%)**
Natural Sources			
Natural Fire	2,911	1,763	-1,148
Biogenic	0	0	0
Wind Blown Dust	36,448	26,475	-9,973
Total Natural	**39,359**	**28,238**	**-11,121 (-28%)**
All Sources			
Total Emissions	**77,507**	**59,829**	**-17,679 (-23%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

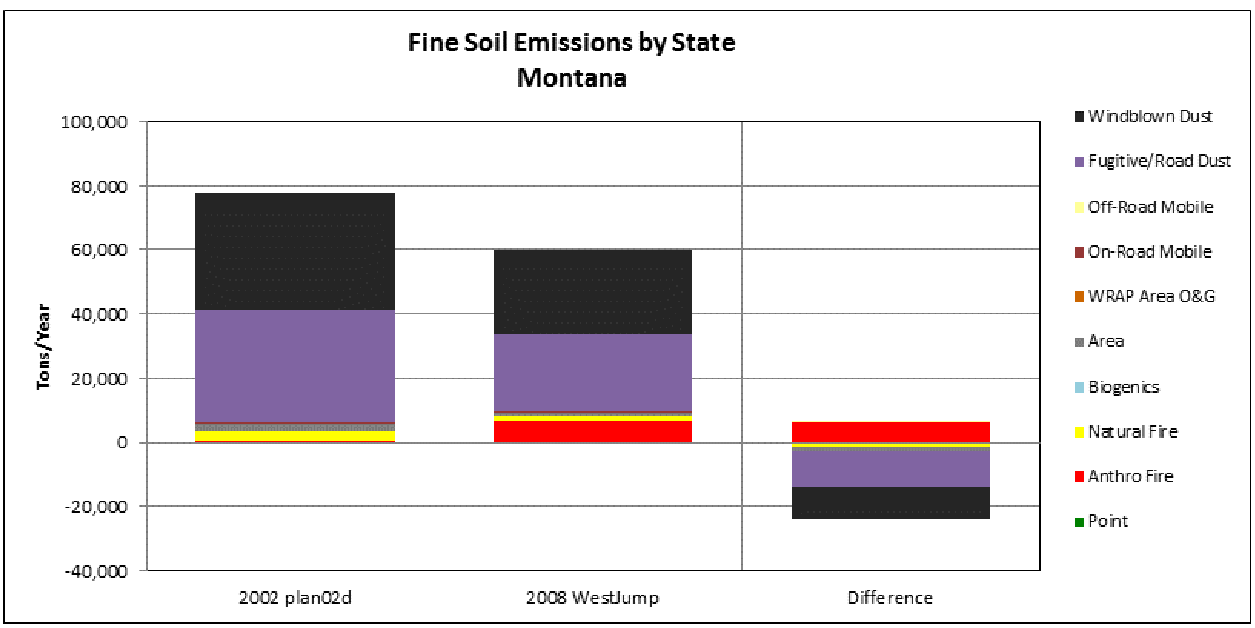

Figure 6.7-13. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Fine Soil by Source Category for Montana.

Table 6.7-15
Montana
Coarse Mass Emissions by Category

Source Category	Coarse Mass Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	7,818	3,125	-4,693
Area	706	286	-421
On-Road Mobile	270	1,475	1,205
Off-Road Mobile	0	67	67
Area Oil and Gas	0	0	0
Fugitive and Road Dust	275,235	146,607	-128,629
Anthropogenic Fire	713	3,326	2,612
Total Anthropogenic	**284,743**	**154,885**	**-129,858 (-46%)**
Natural Sources			
Natural Fire	8,496	914	-7,582
Biogenic	0	0	0
Wind Blown Dust	328,036	238,275	-89,761
Total Natural	**336,533**	**239,189**	**-97,344 (-29%)**
All Sources			
Total Emissions	**621,276**	**394,074**	**-227,202 (-37%)**

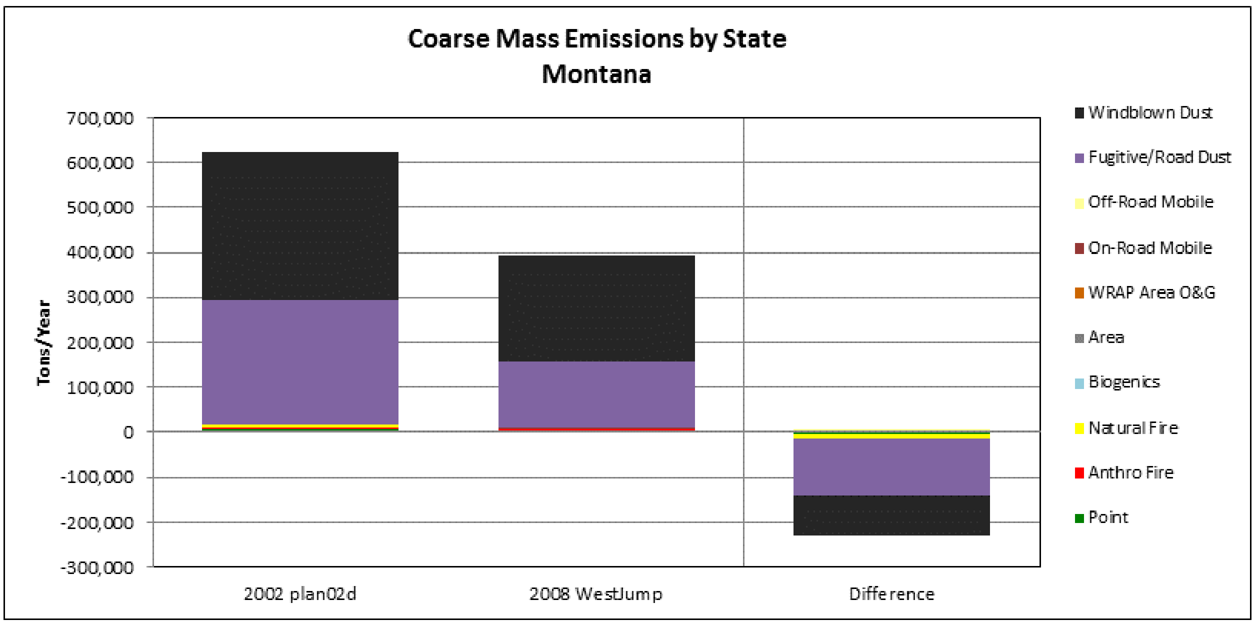

Figure 6.7-14. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Coarse Mass by Source Category for Montana.

6.7.2.2 EGU Summary

As described in previous sections, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions because numerous updates in inventory methodologies have occurred between the development of the separate inventories. Also, the 2002 baseline and 2008 progress period inventories represent only annual snapshots of emissions estimates, which may not be representative of entire 5-year monitoring periods compared. To better account for year-to-year changes in emissions, annual emission totals for Montana electrical generating units (EGU) are presented here. EGU emissions are some of the more consistently reported emissions, as tracked in EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/). RHR implementation plans are required to pay specific attention to certain major stationary sources, including EGUs, built between 1962 and 1977.

Figure 6.7-17 presents a sum of annual NO_X and SO_2 emissions as reported for Montana EGU sources between 1996 and 2010. While these types of facilities are targeted for controls in state regional haze SIPs, it should be noted that many of the controls planned for EGUs in the WRAP states had not taken place yet in 2010, while other controls separate from the RHR may have been implemented. The chart shows periods of decline for both SO_2 and NO_X. The chart shows a sharp decline in NO_X between 2007 and 2009, while SO_2 emissions remained fairly constant.

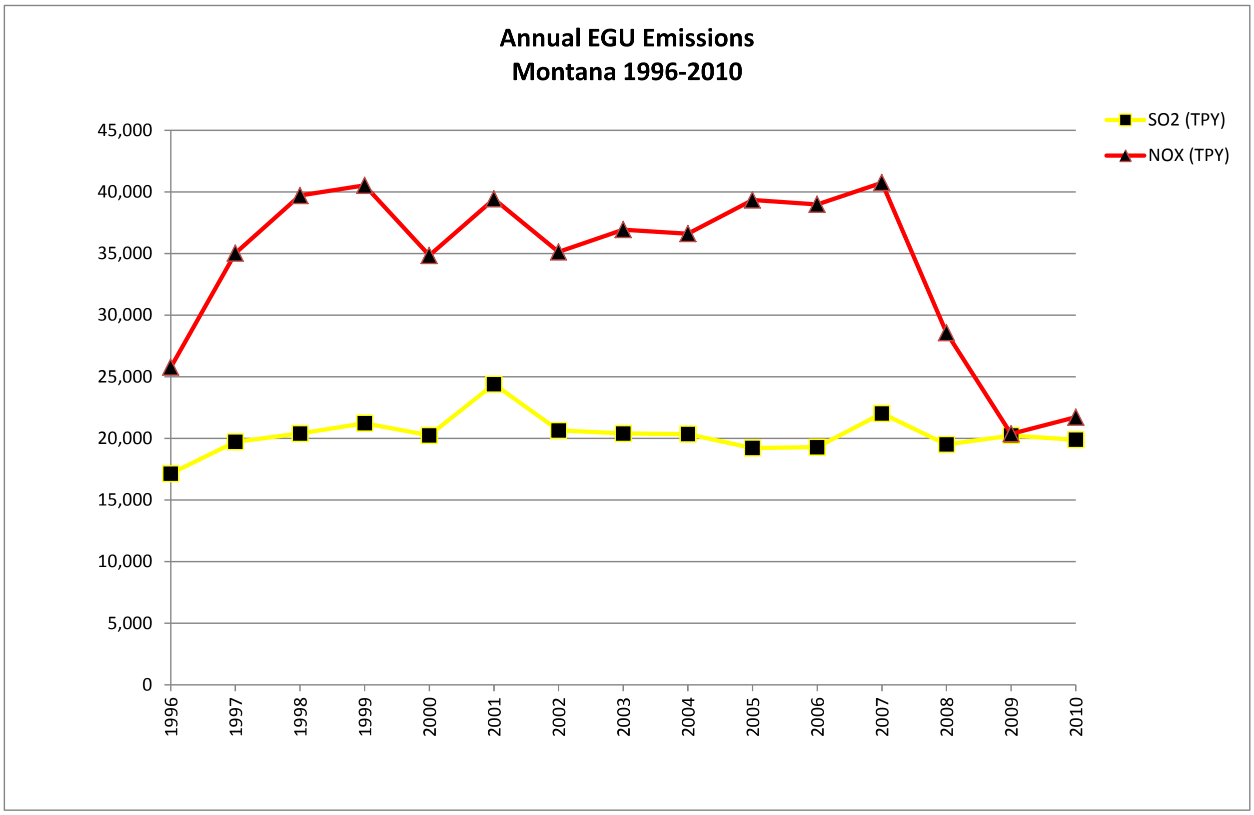

Figure 6.7-17. Sum of EGU Emissions of SO_2 and NOx reported between 1996 and 2010 for Montana.

6.8 NEVADA

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. Nevada has one mandatory Federal Class I area, which is depicted in Figure 6.8-1 and listed in Table 6.8-1, along with the associated IMPROVE monitor locations.

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per Regional Haze Rule (RHR) requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. In general, comparisons of anthropogenic emissions inventory totals for the state showed net decreases, while several of the monitored species increased. Because the JARB1 site is on the northern edge of Nevada, it is likely that regional emissions sources from outside of the state influences the increases in monitored data. Some additional highlights regarding comparisons between the 2000-2004 baseline and 2005-2009 progress period are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- For the 20% best days, the 5-year average deciview metric decreased at the JARB1 site.
- For the 20% worst days, the 5-year average deciview metric increased at the JARB1, site.
- The increase in the 20% worst day 5-year average deciview value was due to small increases in all aerosol species except particulate organic mass. For these increases:
  - No statistically significant increasing annual trends for any aerosol species occurred for the period 2000-2009.
  - Higher than average monitored ammonium sulfate and ammonium nitrate concentrations in 2005 influenced the 5-year progress period average for these species.
- Emissions inventories indicated net decreases for SO_2 and NO_X between the baseline and 2008 emission inventories. For emissions comparisons:
  - Slight increases in on-road mobile and area source inventory totals were offset by larger decreases in point and off-road mobile totals.
  - Annual total EGU emissions for the state showed dramatic decreases in SO_2 and NO_X.
- The fine soil and coarse mass emissions inventories showed increases in fugitive dust and natural windblown dust, which was likely due to updates in inventory development methodologies rather than actual increases.

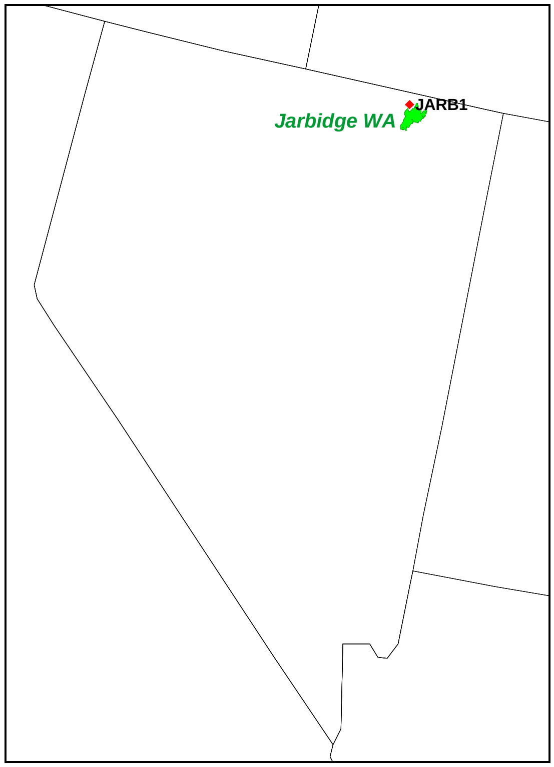

Figure 6.8-1. Map Depicting the Federal CIA and Representative IMPROVE Monitor in Nevada.

Table 6.8-1
Nevada Class I Area and Representative IMPROVE Monitor

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Jarbidge WA	JARB1	41.89	-115.43	1869

6.8.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by the JARB1 IMPROVE monitor, representing the Jarbidge Wilderness Area, which is the only Federal CIA in Nevada. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix H.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.8.1.1 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.308 (g)(3)(i))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[96] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.8-2 and 6.8-3 present the calculated deciview values for the JARB1 site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired and 20% least impaired days. Figure 6.8-2 presents 5-year average extinction for the current progress period for both the 20% most impaired and 20% least impaired days. Note that the percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired, or worst, days are as follows:

- The largest contributor to aerosol extinction on the worst days at the JARB1 site was particulate organic mass, followed by coarse mass and ammonium sulfate.

Specific observations for the current visibility conditions on the 20% least impaired, or best, days are as follows:

- Rayleigh, or background visibility impairment in clean air, contributed to approximately 80% of the total extinction (in Mm^{-1}) for the best days. Aerosol species contributions in Table 6.8-3 exclude the Rayleigh portion of extinction.
- Ammonium sulfate is the largest contributor to aerosol extinction for the best days.

[96] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

Table 6.8-2
Nevada Class I Area IMPROVE Site
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank*						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
JARB1	12.4	17% (3)	5% (6)	**38% (1)**	7% (5)	10% (4)	22% (2)	1% (7)

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.8-3
Nevada Class I Area IMPROVE Site
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank*						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
JARB1	2.2	**47% (1)**	8% (4)	19% (2)	7% (5)	4% (6)	13% (3)	2% (7)

*Highest aerosol species contribution per site is highlighted in bold.

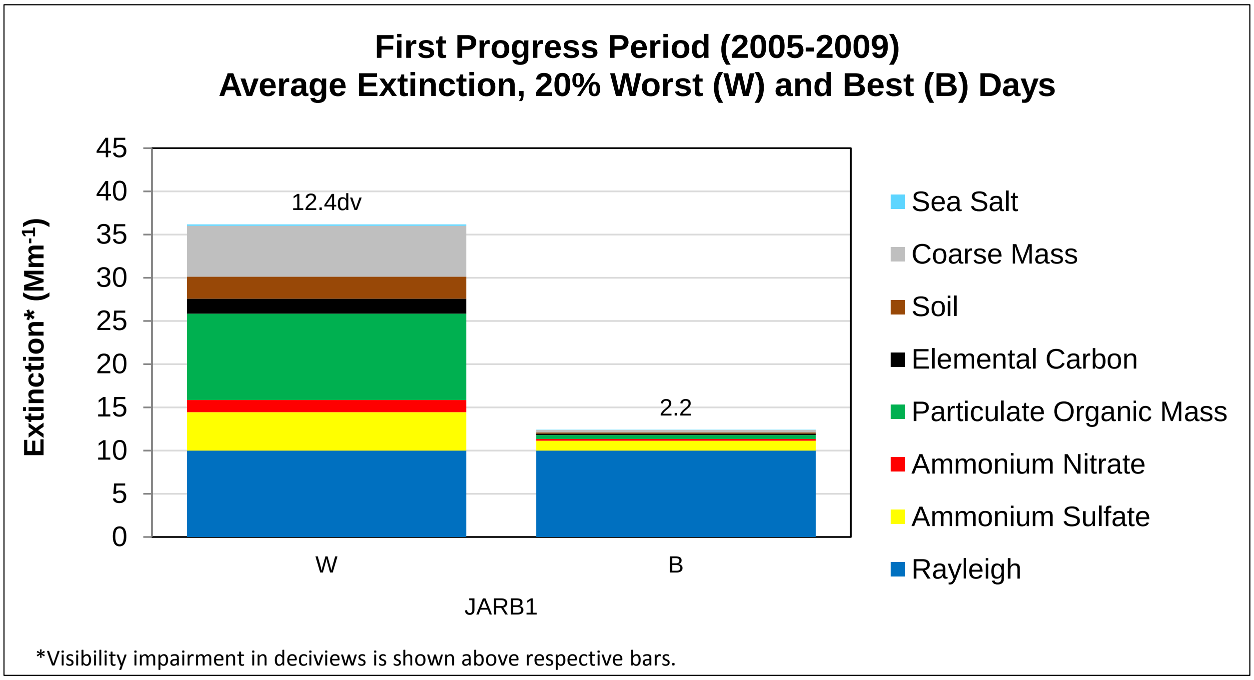

Figure 6.8-2. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at the Nevada Class I Area IMPROVE Site.

6.8.1.2 Differences between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.308 (g)(3)(ii))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Table 6.8-4 presents the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for the JARB1 site in Nevada for the 20% most impaired days, and Table 6.8-5 presents similar data for the least impaired days. Averages that increased are depicted in red text and averages that decreased in blue.

Figure 6.8-3 presents the 5-year average extinction for the baseline and current progress period averages for the worst days and Figure 6.8-4 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.8-5 and 6.8-6 present similar plots for the best days.

For the 20% most impaired days, the 5-year average RHR deciview metric increased at the JARB1 site. Notable differences for individual species averages on the most impaired days were as follows:

- All species except particulate organic mass increased slightly at the JARB1 site. The largest increases were measured for ammonium sulfate, coarse mass and ammonium nitrate.
- Increases in 5-year average ammonium nitrate at the JARB1 monitor were influenced by higher than average ammonium nitrate in 2005, where anomalously high measurements on December 18, 2005, as depicted in Appendix H, Figure H.1-8, influenced the annual average.

For the 20% least impaired or best days, the 5-year average deciview metric decreased at the JARB1 site. Notable differences for individual species averages on the best impaired days were as follows:

- The largest decrease on the best days was measured for particulate organic mass. Soil, coarse mass and sea salt measured very small increases for the best days.

Table 6.8-4
Nevada Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-2004 Baseline Period	2005-2009 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
JARB1	12.1	12.4	**+0.3**	**+0.4**	**+0.3**	0.0	**+0.1**	**+0.2**	**+0.4**	**+0.1**

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.8-5
Nevada Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-2004 Baseline Period	2005-2009 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
JARB1	2.6	2.2	**-0.4**	**-0.1**	**-0.1**	**-0.3**	**-0.1**	0.0	0.0	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

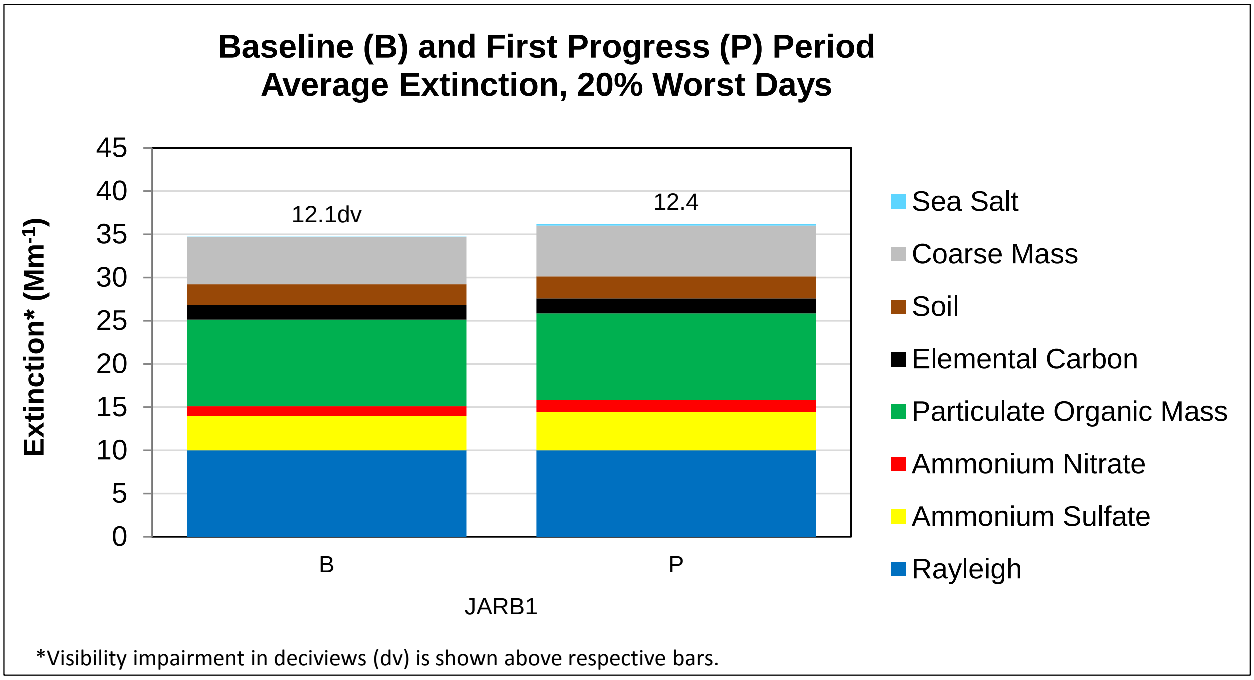

Figure 6.8-3. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at the Nevada Class I Area IMPROVE Site.

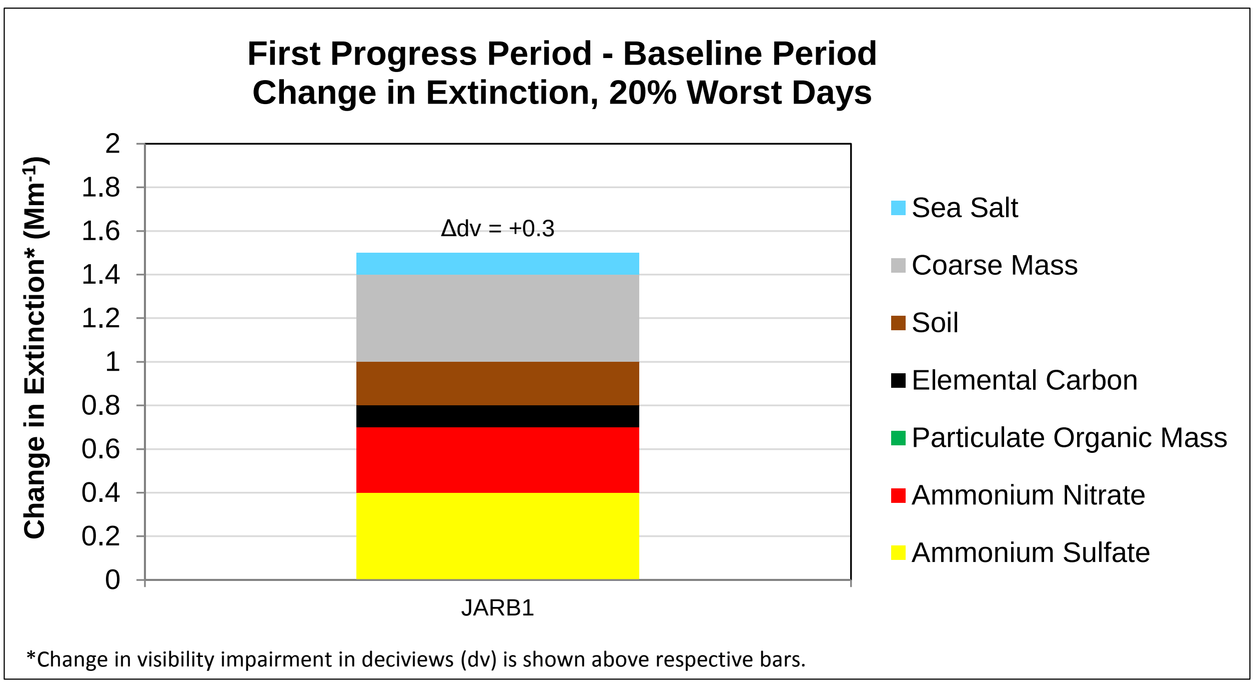

Figure 6.8-4. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at the Nevada Class I Area IMPROVE Site.

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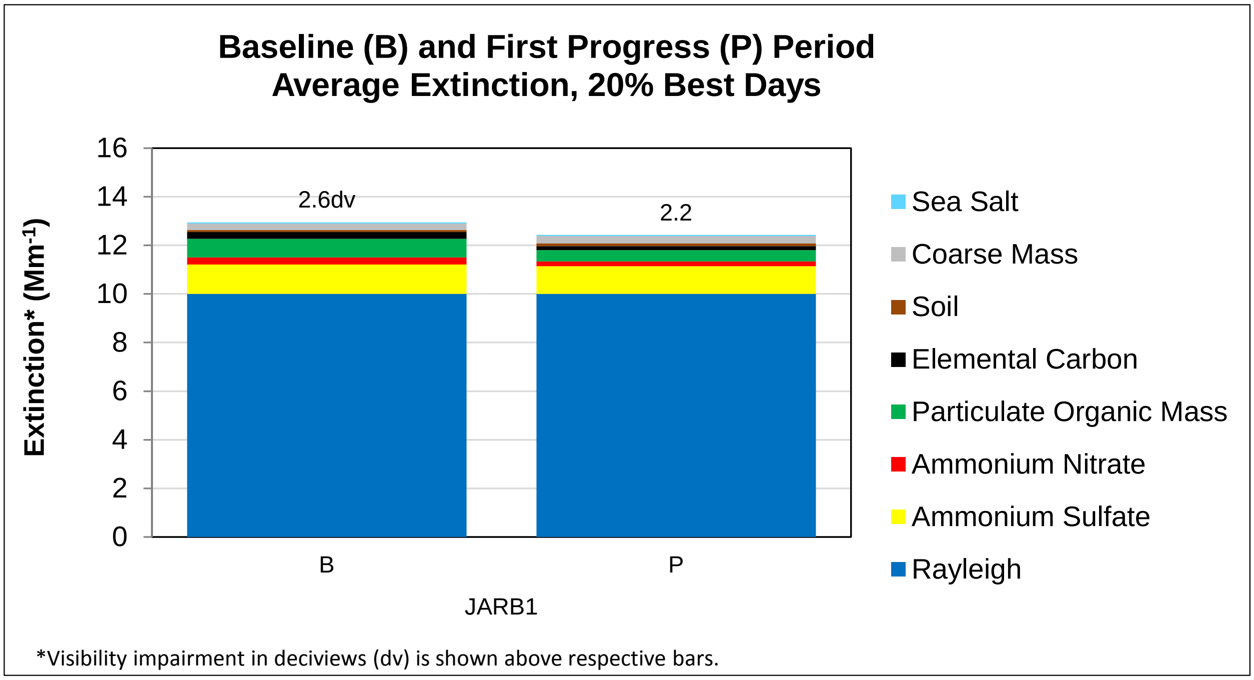

Figure 6.8-5. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at the Nevada Class I Area IMPROVE Site.

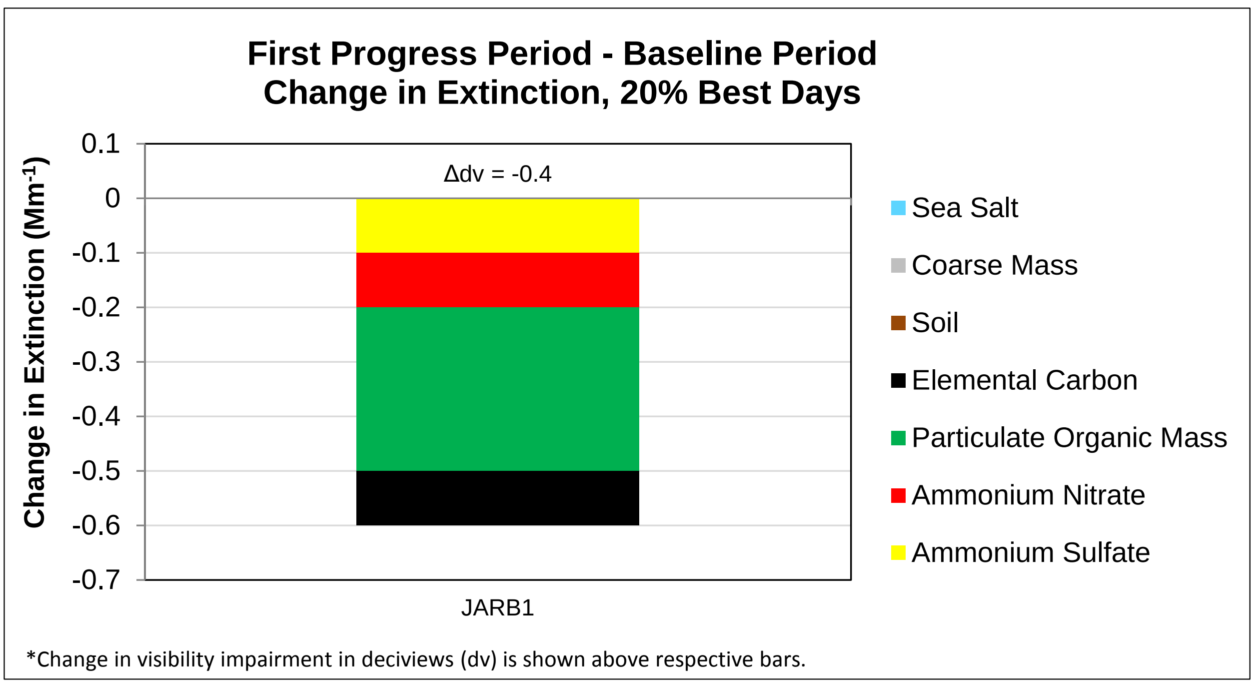

Figure 6.8-6. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at the Nevada Class I Area IMPROVE Site.

6.8.1.3 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.308 (g)(3)(iii))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5-year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for species at the Nevada site are summarized in Table 6.8-6, and regional trends were presented earlier in Section 4.1.1.[97] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[98] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix H. Additionally, this appendix includes plots depicting 5-year, annual, monthly, and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in Nevada are as follows:

- No increasing aerosol trends were observed at the JARB1 site for the best, worst or all sample days.
- Only particulate organic mass (20% best and all days) and elemental carbon (20% worst days) exhibited statistically significant trends, all decreasing. All other species did not show statistically significant trends for the best, worst or all days from 2000 to 2009.

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[97] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)

[98] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

Table 6.8-6
Nevada Class I Area IMPROVE Site
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
JARB1	20% Best	0.0	0.0	-0.1	0.0	0.0	--	--
	20% Worst	--	--	--	-0.1	--	--	--
	All Days	--	0.0	-0.1	0.0	--	--	0.0

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix H.

6.8.2 Emissions Data

Included here are summaries depicting differences between two emission inventory years that are used to represent the 5-year baseline and current progress periods. The baseline period is represented using a 2002 inventory developed by the WRAP for use in the initial WRAP state SIPs, and the progress period is represented by a 2008 inventory which leverages recent WRAP inventory work for modeling efforts, as referenced in Section 3.2.1. For reference, Table 6.8-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories, and a separate summary of annual emissions from electrical generating units (EGUs), are presented in this section.

Table 6.8-7
Nevada
Pollutants, Aerosol Species, and Major Sources

Emitted Pollutant	**Related Aerosol**	**Major Sources**	**Notes**
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- and Off-Road Mobile Sources	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be associated with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Primary Organic Aerosol (POA)	POM	Wildfires; Area Sources	POA represents organic aerosols that are emitted directly as particles, as opposed to gases. Wildfires in the west generally dominate POA emissions, and large wildfire events are generally sporadic and highly variable from year-to-year.
Elemental Carbon (EC)	EC	Wildfires; On- and Off-Road Mobile Sources	Large EC events are often associated with large POM events during wildfires. Other sources include both on- and off-road diesel engines.
Fine soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is reported by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$ mass measurements. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but these measurements are generally associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributor to PMC.

6.8.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.308 (g)(4))?*** For these summaries, emissions during the baseline years are represented using a 2002 inventory, which was developed with support from the WRAP for use in the original RHR SIP strategy development (termed plan02d). Differences between inventories are represented as the difference between the 2002 inventory, and a 2008 inventory which leverages recent inventory development work performed by the WRAP for the WestJumpAQMS and DEASCO$_3$ modeling projects (termed WestJump2008). Note that the comparisons of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories, as referenced in Section 3.2.1. Inventories for all major visibility impairing pollutants are presented for major source categories, and categorized as either anthropogenic or natural emissions. State-wide inventories totals and differences are presented here, and inventory totals on a county level basis are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

Table 6.8-8 and Figure 6.8-7 present the differences between the 2002 and 2008 sulfur dioxide (SO_2) inventories by source category. Tables 6.8-9 and Figure 6.8-8 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.8-10 through 6.8-15 and Figures 6.8-9 through 6.8-14) present data for ammonia (NH_3), volatile organic compounds (VOCs), primary organic aerosol (POA), elemental carbon (EC), fine soil and coarse mass. General observations regarding emissions inventory comparisons are listed below.

- State-wide SO_2 inventory totals show a 75% reduction, with some decreases reported for all source categories. The largest decreases are reported from point sources, followed by area sources, natural fire and off-road mobile sources.
- NO_X emissions show a 22% reduction, with area and on-road mobile sources showing significant increases, while all other source categories show decreases. The largest decreases were reported from point sources, followed by off-road mobile, biogenic emissions, and natural fire sources. Note that decreases in biogenic sources were consistent for all contiguous WRAP states, and likely due to inventory enhancements in 2008. Also, current natural fire emissions represent only the year 2008, so all fire events for the 2005-2009 progress period are not represented in these emissions comparison results. Also, for off-road sources, the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to decreases in the off-road inventory totals, but increases in area source totals.
- Ammonia emission inventory totals decreased by 34%, with decreases due mostly to area and off-road mobile sources.
- VOC emissions showed a 61% decrease, mostly due to biogenic emission inventories. A significant increase is shown for area sources. Significant decreases are shown for biogenic, on-road mobile and natural fire sources. The large difference in biogenic emissions is likely due to enhancements in biogenic inventory methodology, as

described in Section 3.2, rather than decreases of this magnitude in actual emissions. Also, current natural fire emissions represent only the year 2008, so all fire events for the 2005-2009 progress period are not represented in these emissions comparison results.

- POA showed 52% decrease in inventory totals, and elemental carbon showed a 31% decrease, mostly due to natural fire sources. Note that current natural fire emissions represent only the year 2008, so all fire events for the 2005-2009 progress period are not represented in these emissions comparison results.
- Fine soil and coarse mass increased for the windblown dust inventory comparisons and the combined fugitive/road dust inventories. The large increases in windblown dust are likely due in part to enhancements in dust inventory methodology, as described in Section 3.2, rather than increases in actual emissions. Most other sources of fine soil and coarse mass showed increases with the exception of natural fire sources for both pollutants, on-road mobile sources for fine soil, and point sources for coarse mass.

Table 6.8-8
Nevada
Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	50,720	11,155	-39,565
Area	12,953	4,863	-8,090
On-Road Mobile	454	298	-156
Off-Road Mobile	1,403	322	-1,081
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	12	2	-11
Total Anthropogenic	**65,543**	**16,641**	**-48,903 (-75%)**
Natural Sources			
Natural Fire	2,200	506	-1,695
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**2,200**	**506**	**-1,695 (-77%)**
All Sources			
Total Emissions	**67,743**	**17,146**	**-50,597 (-75%)**

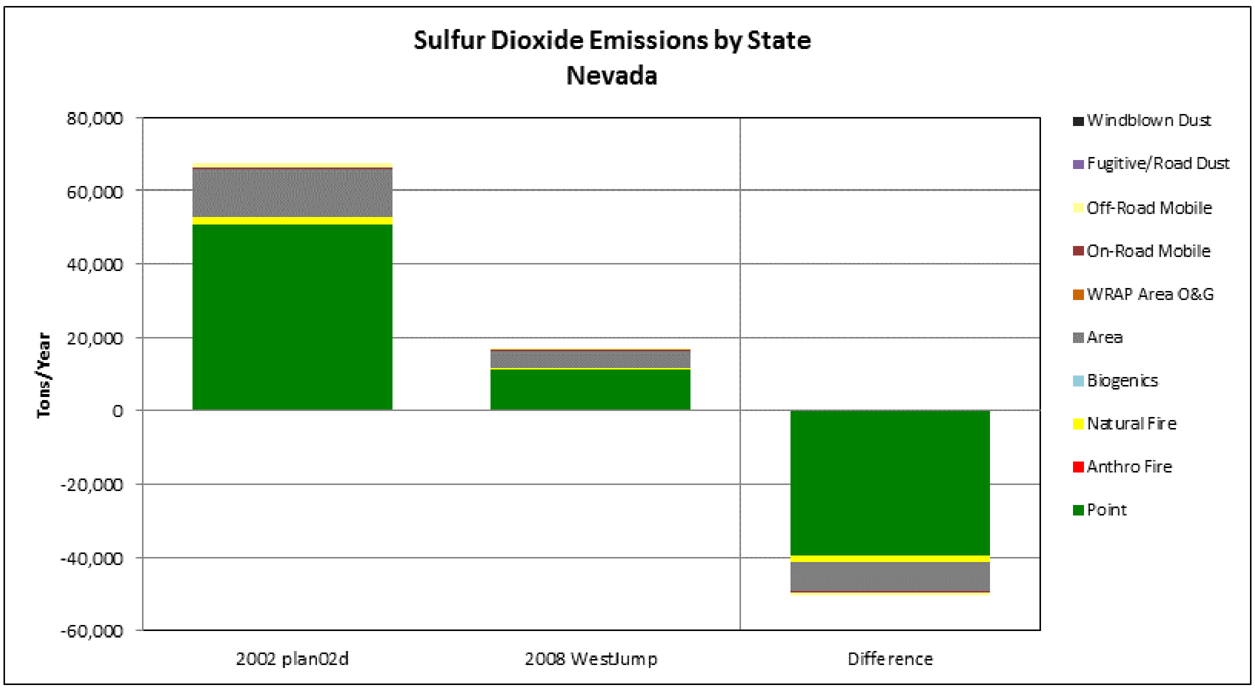

Figure 6.8-7. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for Nevada.

Table 6.8-9
Nevada
Oxides of Nitrogen Emissions by Category

Source Category	Oxides of nitrogen Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	59,864	30,090	-29,774
Area	5,725	11,321	5,597
On-Road Mobile	41,089	50,068	8,979
Off-Road Mobile	32,565	17,081	-15,484
Area Oil and Gas	63	0	-63
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	48	13	-35
Total Anthropogenic	**139,353**	**108,574**	**-30,779 (-22%)**
Natural Sources			
Natural Fire	8,026	3,575	-4,451
Biogenic	15,018	7,364	-7,654
Wind Blown Dust	0	0	0
Total Natural	**23,044**	**10,939**	**-12,105 (-53%)**
All Sources			
Total Emissions	**162,397**	**119,513**	**-42,885 (-26%)**

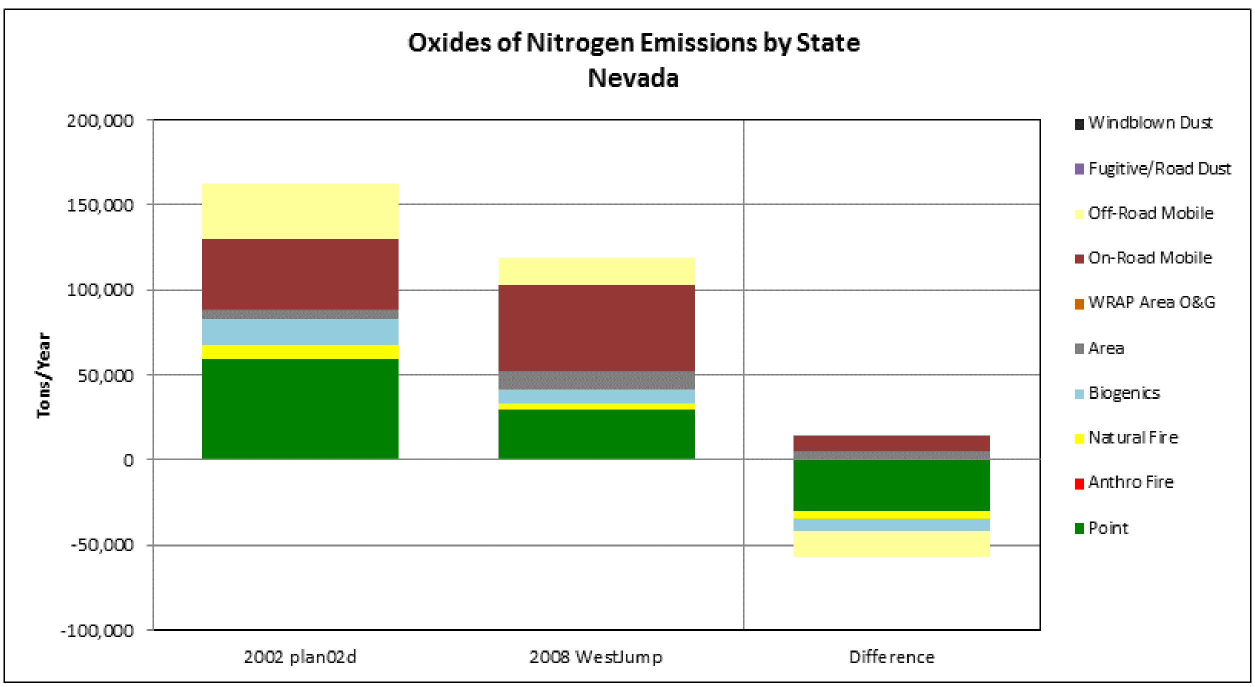

Figure 6.8-8. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Oxides of nitrogen by Source Category for Nevada.

Table 6.8-10
Nevada
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	339	302	-37
Area	8,009	5,717	-2,293
On-Road Mobile	2,030	849	-1,182
Off-Road Mobile	22	20	-2
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	8	6	-2
Total Anthropogenic	**10,408**	**6,893**	**-3,515 (-34%)**
Natural Sources			
Natural Fire	1,684	2,490	805
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**1,684**	**2,490**	**805 (48%)**
All Sources			
Total Emissions	**12,092**	**9,382**	**-2,710 (-22%)**

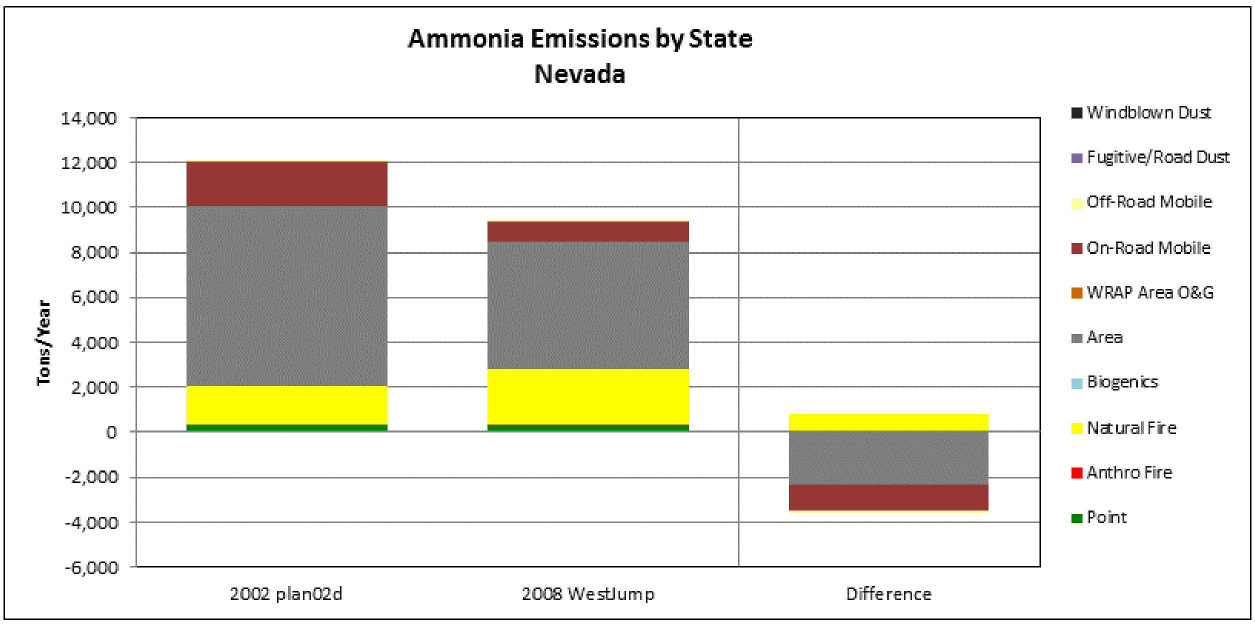

Figure 6.8-9. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Ammonia by Source Category for Nevada.

Table 6.8-11
Nevada
Volatile Organic Compound Emissions by Category

Source Category	Volatile Organic Compound Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	2,215	2,953	738
Area	28,592	40,973	12,381
On-Road Mobile	36,257	21,302	-14,955
Off-Road Mobile	18,094	18,783	688
Area Oil and Gas	129	0	-129
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	70	16	-54
Total Anthropogenic	**85,357**	**84,026**	**-1,331 (-2%)**
Natural Sources			
Natural Fire	17,606	4,204	-13,403
Biogenic	794,139	262,912	-531,227
Wind Blown Dust	0	0	0
Total Natural	**811,745**	**267,115**	**-544,630 (-67%)**
All Sources			
Total Emissions	**897,102**	**351,142**	**-545,960 (-61%)**

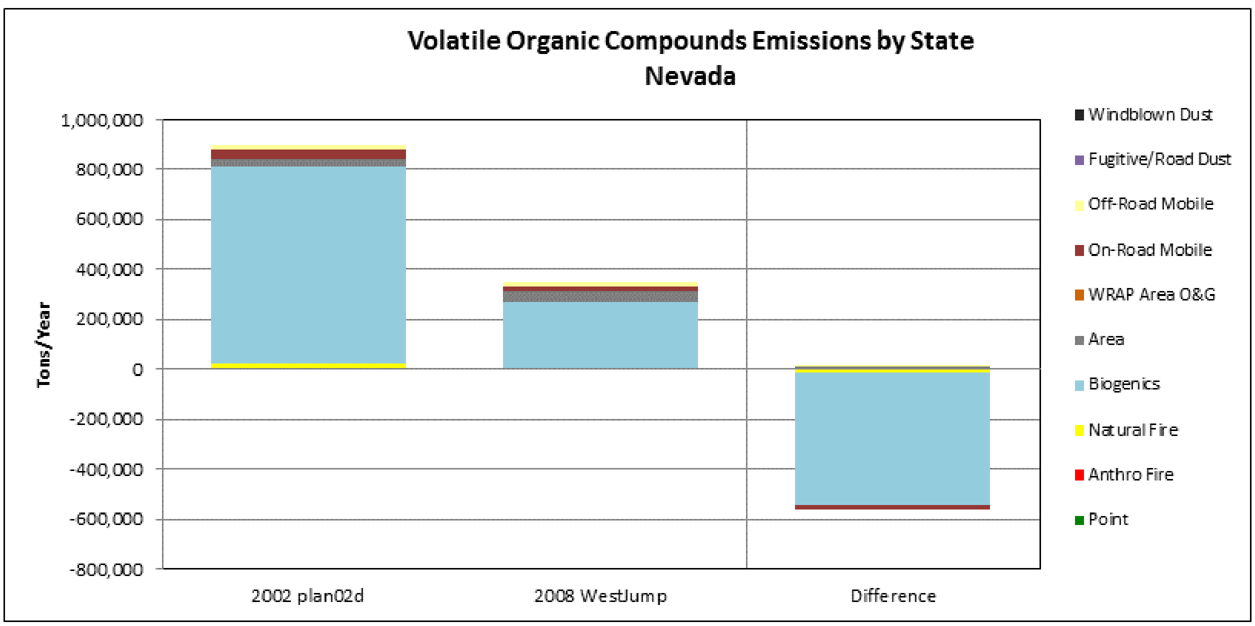

Figure 6.8-10. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for Nevada.

Table 6.8-12
Nevada
Primary Organic Aerosol Emissions by Category

Source Category	**Primary Organic Aerosol Emissions (tons/year)**		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	256	46	-210
Area	687	2,283	1,596
On-Road Mobile	314	1,053	739
Off-Road Mobile	572	689	117
Area Oil and Gas	0	0	0
Fugitive and Road Dust	332	891	559
Anthropogenic Fire	73	22	-51
Total Anthropogenic	**2,233**	**4,985**	**2,751 (>100%)**
Natural Sources			
Natural Fire	22,501	6,831	-15,670
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**22,501**	**6,831**	**-15,670 (-70%)**
All Sources			
Total Emissions	**24,734**	**11,816**	**-12,918 (-52%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

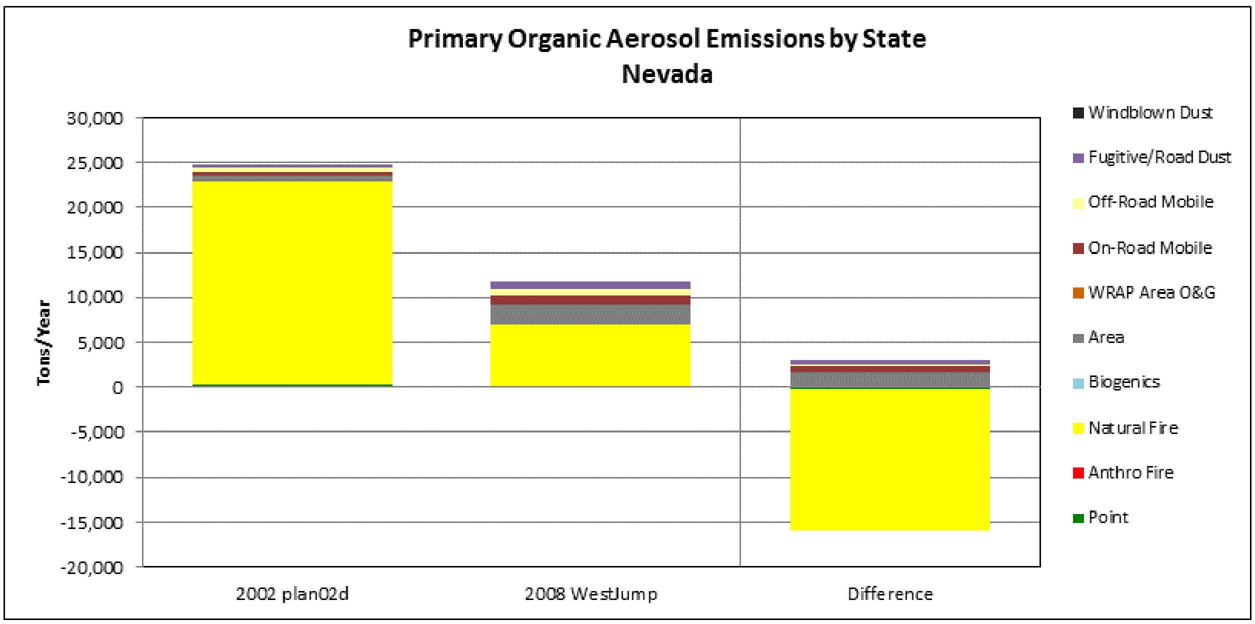

Figure 6.8-11. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Primary Organic Aerosol by Source Category for Nevada.

Table 6.8-13
Nevada
Elemental Carbon Emissions by Category

Source Category	Elemental Carbon Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	13	64	50
Area	96	368	272
On-Road Mobile	235	1,891	1,656
Off-Road Mobile	1,354	954	-400
Area Oil and Gas	0	0	0
Fugitive and Road Dust	24	14	-10
Anthropogenic Fire	13	6	-8
Total Anthropogenic	**1,735**	**3,295**	**1,561 (90%)**
Natural Sources			
Natural Fire	4,674	1,130	-3,544
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**4,674**	**1,130**	**-3,544 (-76%)**
All Sources			
Total Emissions	**6,409**	**4,425**	**-1,984 (-31%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

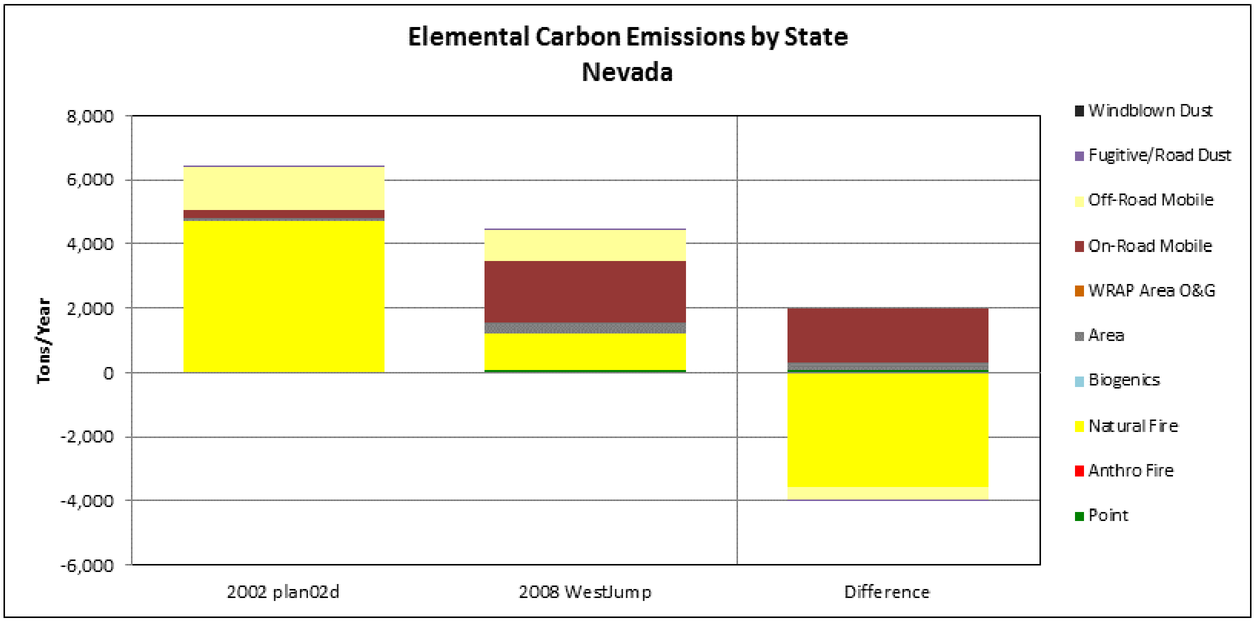

Figure 6.8-12. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Elemental Carbon by Source Category for Nevada.

Table 6.8-14
Nevada
Fine Soil Emissions by Category

Source Category	Fine Soil Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	2,158	209	-1,948
Area	830	1,024	195
On-Road Mobile	239	190	-49
Off-Road Mobile	0	49	49
Area Oil and Gas	0	0	0
Fugitive and Road Dust	6,128	19,216	13,087
Anthropogenic Fire	9	10	1
Total Anthropogenic	**9,364**	**20,698**	**11,334 (>100%)**
Natural Sources			
Natural Fire	1,406	2,552	1,146
Biogenic	0	0	0
Wind Blown Dust	10,438	17,051	6,613
Total Natural	**11,845**	**19,603**	**7,758 (66%)**
All Sources			
Total Emissions	**21,208**	**40,301**	**19,092 (90%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

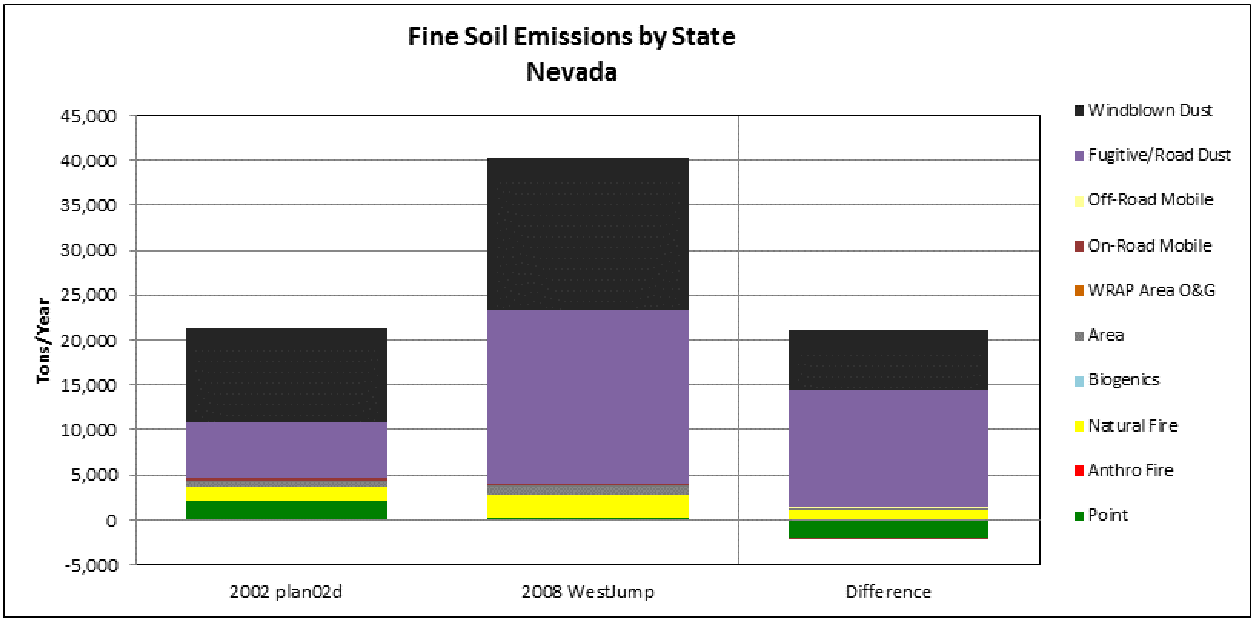

Figure 6.8-13. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Fine Soil by Source Category for Nevada.

Table 6.8-15
Nevada
Coarse Mass Emissions by Category

Source Category	Coarse Mass Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	4,093	1,761	-2,331
Area	897	1,094	198
On-Road Mobile	245	2,014	1,769
Off-Road Mobile	0	82	82
Area Oil and Gas	0	0	0
Fugitive and Road Dust	56,779	161,532	104,753
Anthropogenic Fire	7	4	-3
Total Anthropogenic	**62,020**	**166,488**	**104,468 (>100%)**
Natural Sources			
Natural Fire	5,176	1,310	-3,866
Biogenic	0	0	0
Wind Blown Dust	93,946	153,459	59,513
Total Natural	**99,122**	**154,769**	**55,647 (56%)**
All Sources			
Total Emissions	**161,142**	**321,257**	**160,115 (99%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

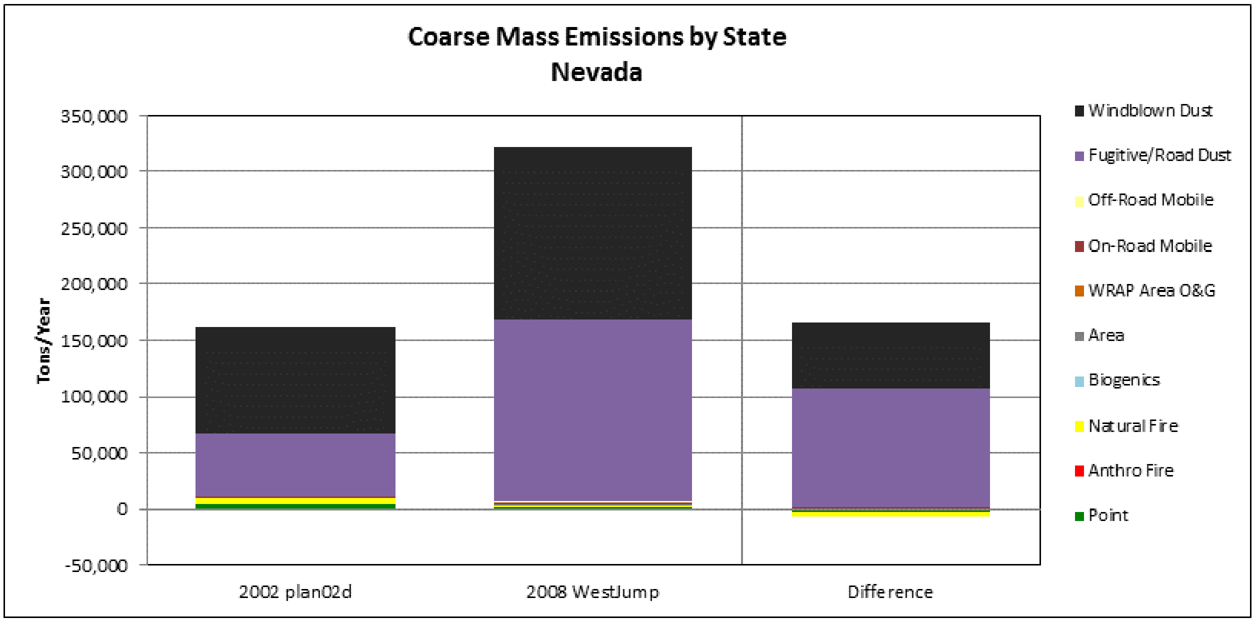

Figure 6.8-14. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Coarse Mass by Source Category for Nevada.

6.8.2.2 EGU Summary

As described in previous sections, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions because numerous updates in inventory methodologies have occurred between the development of the separate inventories. Also, the 2002 baseline and 2008 progress period inventories represent only annual snapshots of emissions estimates, which may not be representative of entire 5-year monitoring periods compared. To better account for year-to-year changes in emissions, annual emission totals for Nevada electrical generating units (EGU) are presented here. EGU emissions are some of the more consistently reported emissions, as tracked in EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/). RHR implementation plans are required to pay specific attention to certain major stationary sources, including EGUs, built between 1962 and 1977.

Figure 6.8-15 presents a sum of annual NO_X and SO_2 emissions as reported for Nevada EGU sources between 1996 and 2010. While these types of facilities are targeted for controls in state regional haze SIPs, it should be noted that many of the controls planned for EGUs in the WRAP states had not taken place yet in 2010, while other controls separate from the RHR may have been implemented. The chart shows a sharp decline for SO_2 and NO_X between 2005 and 2006, mostly resulting from the closure of the Mohave Generating Station in Clark County, which eliminated approximately 20,000 tons per year (tpy) of NOx and 41,000 tpy of SO_2 emissions. Steady decreases for NO_X emissions are shown for 2006 through 2010.

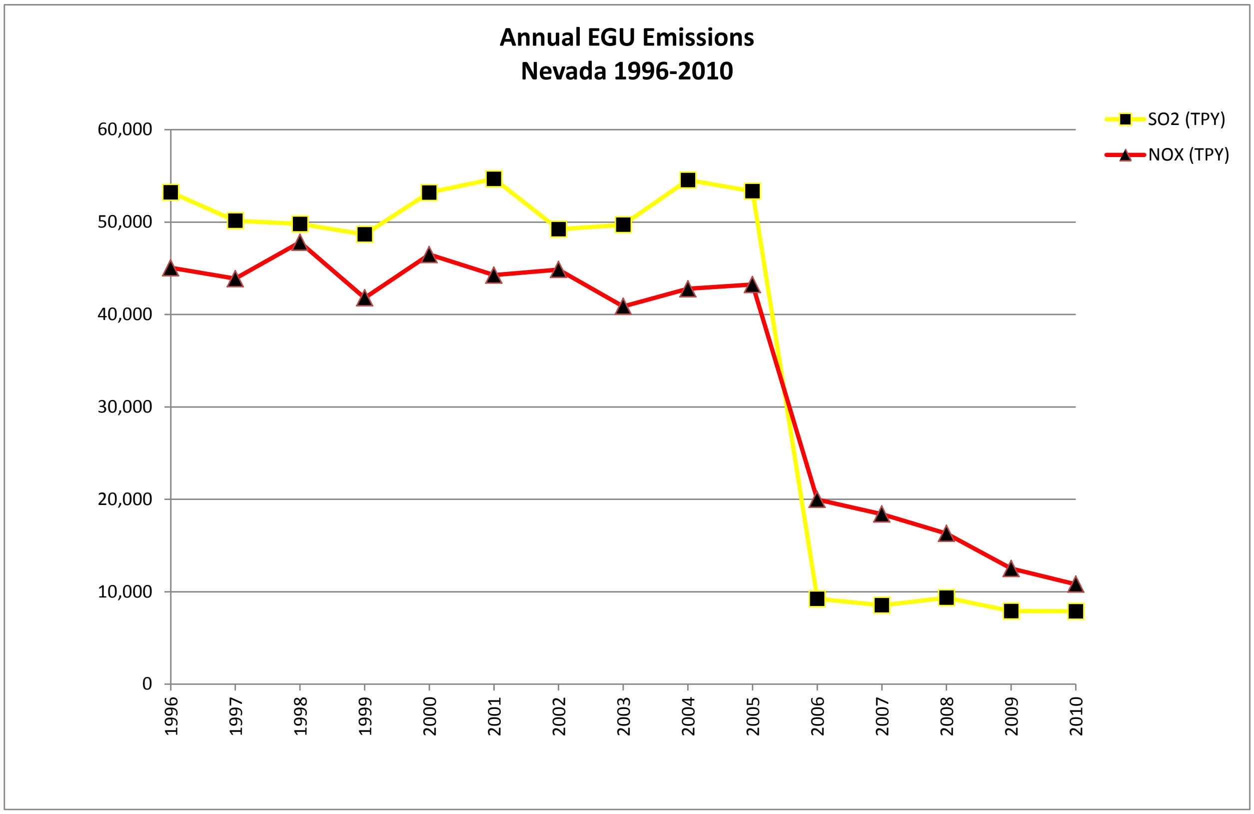

Figure 6.8-15. Sum of EGU Emissions of SO_2 and NO_X reported between 1996 and 2010 for Nevada.

6.9 NEW MEXICO

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. New Mexico has 9 mandatory Federal CIAs, which are depicted in Figure 6.9-1 and listed in Table 6.9-1, along with the associated IMPROVE monitor locations.

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per Regional Haze Rule (RHR) requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. Some of the highlights regarding these comparisons are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- For both the best and worst days, the 5-year average deciview metric decreased at all New Mexico Federal CIA IMPROVE sites.
- Ammonium sulfate was the largest contributor to aerosol extinction for the worst days at all New Mexico sites except GICL1, where particulate organic mass was the largest contributor followed by ammonium sulfate.
- All sites showed an increase in 5-year average ammonium sulfate, but annual average trends for ammonium sulfate were either insignificant or decreasing. Many regional sites, including sites in Arizona, Colorado, and New Mexico were affected by anomalously higher than average ammonium sulfate measurements in 2005. Increases were also not consistent with emissions inventory comparisons, where state-wide emissions totals and annual tracking of EGU emissions showed decreases in SO_2, due mostly to decreases in point, area and mobile sources.
- For the worst days, all sites except BOAP1 measured a decrease in 5-year average ammonium nitrate, and annual average ammonium nitrate trends were either decreasing or insignificant at all sites. At the BOAP1 site, the increase in the 5-year average was influenced by an unusually high ammonium nitrate event measured in January 2007. State-wide emissions inventory comparisons showed a net decrease in NO_X, due mostly to point and off-road mobile sources. Annual EGU emissions totals also showed decreases in NO_X.
- Two sites, BAND1 and GICL1, showed increasing annual average trends in coarse mass for the worst days for coarse mass, and increases in the 5-year average of coarse mass. Increasing annual average coarse mass trends were also observed at the nearby BALD1 and PEFO1 sites in eastern Arizona. The current emissions inventory indicates that coarse mass is due mainly to fugitive dust (including road dust) and windblown dust, and monitoring data shows that the highest coarse mass events were measured during the spring. Inventory comparisons show increases in these

categories, but these inventories are not directly comparable due to changes in methodology as described in Section 3.2.

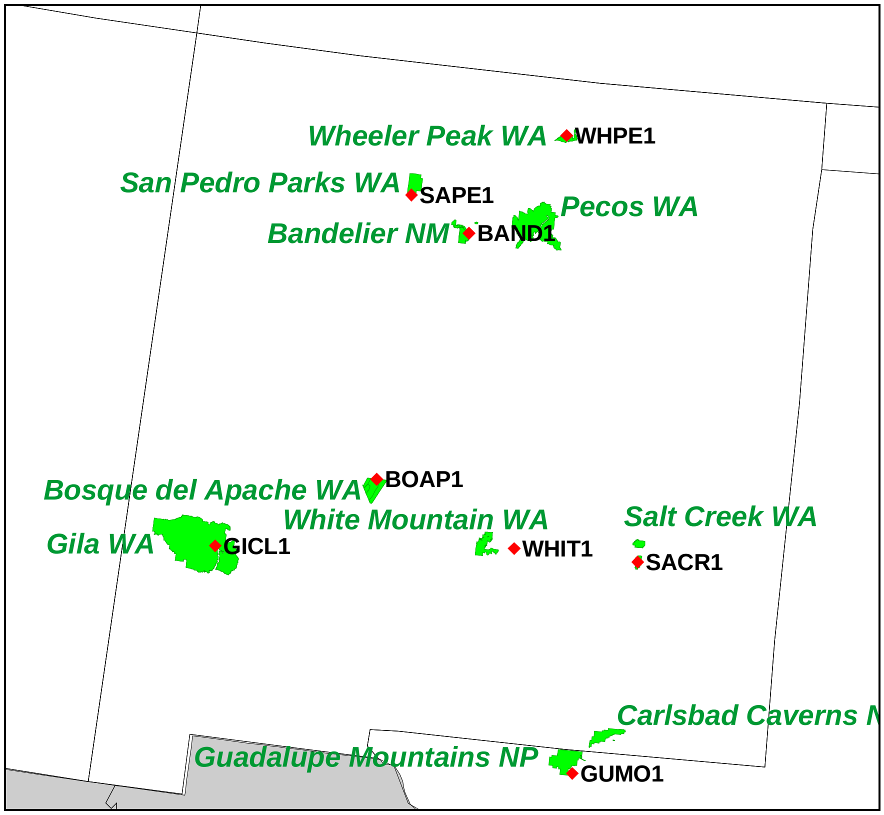

Figure 6.9-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in New Mexico.

Table 6.9-1
New Mexico CIAs and Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Bandelier NM	BAND1	35.78	-106.27	1988
Bosque del Apache WA	BOAP1	33.87	-106.85	1389
Gila WA	GICL1	33.22	-108.24	1775
Guadalupe Mountains NP Carlsbad Caverns NP	GUMO1*	31.83	-104.81	1672
Salt Creek WA	SACR1	33.46	-104.40	1072
San Pedro Parks WA	SAPE1	36.01	-106.84	2935
White Mountain WA	WHIT1	33.47	-105.53	2063
Wheeler Peak WA Pecos WA	WHPE1	36.59	-105.45	3366

*IMPROVE Site is located in Texas.

6.9.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by IMPROVE monitors representing Federal CIAs in New Mexico. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix I.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.9.1.1 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.309(d)(10)(i)(C))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[99] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.9-2 and 6.9-3 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired, or worst, and 20% least impaired, or best, days for each of the Federal CIA IMPROVE monitors in New Mexico. Figure 6.9-2 presents 5-year average extinction for the current progress period for both the 20% most impaired and 20% least impaired days. Note that the percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired days are as follows:

- The largest contributors to aerosol extinction at New Mexico sites were ammonium sulfate and particulate organic mass.
- The highest aerosol extinction (17.5 dv) was measured at the SACR1 site, where ammonium sulfate was the largest contributor to aerosol extinction, followed by coarse mass. The lowest aerosol extinction (9.1 dv) was measured at the WHPE1 site.

[99] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

Specific observations for the current visibility conditions on the 20% least impaired days are as follows:

- The aerosol contribution to total extinction on the best days was less than Rayleigh, or the background scattering that would occur in clear air. Average extinction (including Rayleigh) ranged from 0.9 dv (WHPE1) to 7.3 deciview (SACR1).
- For all sites, ammonium sulfate was the largest contributor to the non-Rayleigh aerosol species of extinction.

Table 6.9-2
New Mexico Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank*						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
BAND1	11.8	**34% (1)**	10% (4)	31% (2)	8% (5)	5% (6)	13% (3)	0% (7)
BOAP1	13.4	**30% (1)**	14% (4)	22% (2)	10% (5)	5% (6)	19% (3)	1% (7)
GICL1	12.5	27% (2)	3% (6)	**42% (1)**	10% (4)	5% (5)	12% (3)	0% (7)
GUMO1	15.9	**45% (1)**	7% (4)	14% (3)	4% (6)	6% (5)	24% (2)	0% (7)
SACR1	17.5	**38% (1)**	15% (3)	13% (4)	5% (5)	5% (6)	23% (2)	1% (7)
SAPE1	9.9	**34% (1)**	6% (6)	32% (2)	8% (4)	7% (5)	13% (3)	0% (7)
WHIT1	13.2	**40% (1)**	6% (4)	18% (3)	5% (6)	6% (5)	25% (2)	1% (7)
WHPE1	9.1	**36% (1)**	8% (5)	27% (2)	9% (4)	7% (6)	12% (3)	0% (7)

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.9-3
New Mexico Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
BAND1	4.2	**34% (1)**	9% (5)	28% (2)	13% (3)	4% (6)	13% (4)	0% (7)
BOAP1	5.8	**33% (1)**	8% (5)	22% (2)	12% (4)	5% (6)	18% (3)	2% (7)
GICL1	2.7	**41% (1)**	6% (5)	25% (2)	10% (4)	5% (6)	12% (3)	1% (7)
GUMO1	5.4	**37% (1)**	11% (4)	18% (3)	8% (5)	5% (6)	21% (2)	0% (7)
SACR1	7.3	**31% (1)**	12% (4)	18% (3)	8% (5)	5% (6)	25% (2)	1% (7)
SAPE1	1.0	**47% (1)**	12% (3)	18% (2)	8% (5)	5% (6)	10% (4)	1% (7)
WHIT1	3.3	**36% (1)**	8% (5)	22% (2)	9% (4)	5% (6)	20% (3)	0% (7)
WHPE1	0.9	**43% (1)**	9% (5)	23% (2)	10% (4)	4% (6)	12% (3)	0% (7)

*Highest aerosol species contribution per site is highlighted in bold.

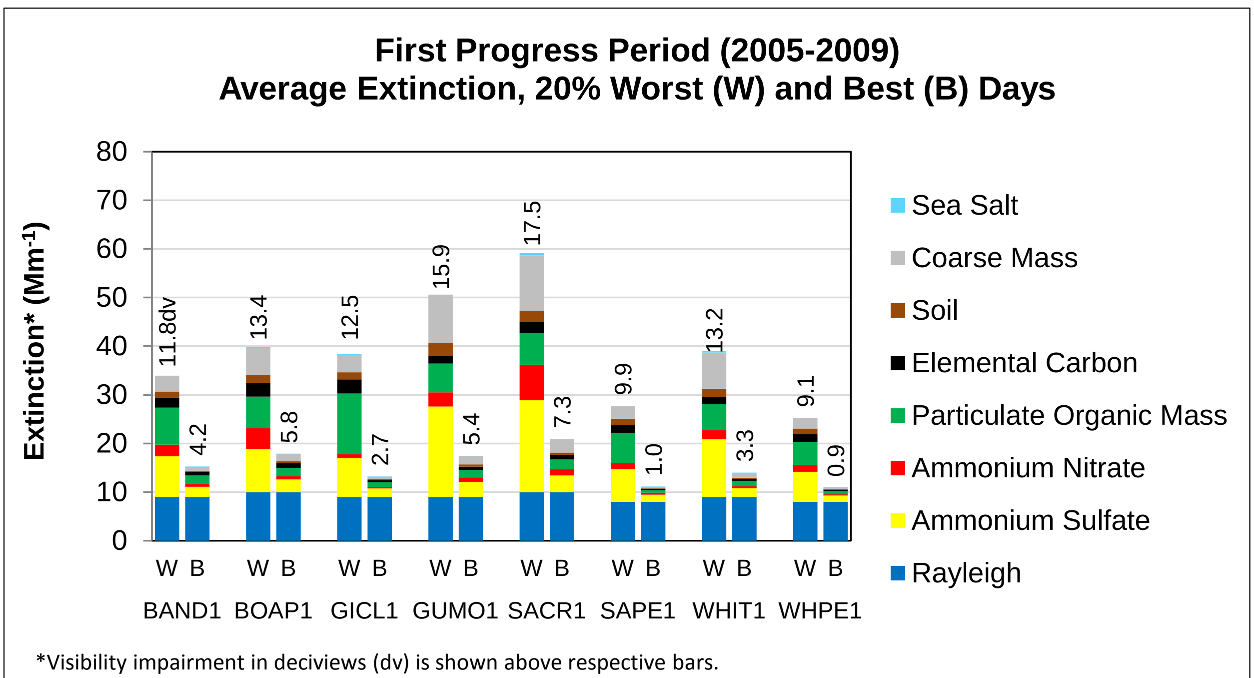

Figure 6.9-2. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at New Mexico Class I Area IMPROVE Sites.

6.9.1.2 Differences between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.309(d)(10)(i)(C))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Table 6.9-4 presents the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for each site in New Mexico for the 20% most impaired days, and Table 6.9-5 presents similar data for the least impaired days. Averages that increased are depicted in red text and averages that decreased in blue.

Figure 6.9-3 presents the 5-year average extinction for the baseline and current progress period averages for the worst days and Figure 6.9-4 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.9-5 and 6.9-6 present similar plots for the best days.

For the 20% most impaired days, the 5-year average deciview metric decreased at all New Mexico sites. Notable differences for individual species averages were as follows:

- All sites except BOAP1 measured a decrease in ammonium nitrate. The largest decrease in ammonium nitrate (3.8 Mm^{-1}) was measured at the SACR1 site.
- All sites measured a decrease in particulate organic mass.
- An increase in 5-year average ammonium sulfate was measured at all sites, with the largest increases (2.1 Mm^{-1}) measured at the GUMO1 and SACR1 sites.

For the 20% least impaired days, the 5-year average deciview metric decreased at all sites. Notable differences for individual species averages on the 20% least impaired days were as follows:

- Ammonium sulfate decreased at most sites, but increased slightly at the WHPE1 site.
- Ammonium nitrate, particulate organic mass and elemental carbon decreased at all sites.

Table 6.9-4
New Mexico Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
BAND1	12.2	11.8	-0.4	+1.5	-0.1	-6.6	-1.0	+0.1	+0.3	-0.2
BOAP1	13.8	13.4	-0.4	+1.4	+1.0	-2.2	+0.2	-0.3	-1.2	0.0
GICL1	13.1	12.5	-0.6	+1.2	-0.1	-3.5	-0.2	0.0	+0.8	0.0
GUMO1	17.2	15.9	-1.3	+2.1	-0.9	-0.8	+0.2	-1.7	-6.1	0.0
SACR1	18.0	17.5	-0.5	+2.1	-3.8	-1.1	0.0	-1.0	-0.1	+0.3
SAPE1	10.2	9.9	-0.3	+1.0	-0.4	-1.4	-0.1	-0.1	-0.2	0.0
WHIT1	13.7	13.2	-0.5	+1.4	-1.2	-3.6	-0.4	-0.1	+0.8	+0.1
WHPE1	10.4	9.1	-1.3	+0.9	-0.2	-3.6	-0.6	-0.6	-0.6	-0.4

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.9-5
New Mexico Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-2004 Baseline Period	2005-2009 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
BAND1	5.0	4.2	-0.8	-0.3	-0.2	-0.4	-0.1	-0.1	-0.2	0.0
BOAP1	6.3	5.8	-0.5	-0.2	-0.2	-0.4	-0.2	0.0	-0.1	0.0
GICL1	3.3	2.7	-0.6	-0.1	-0.1	-0.5	-0.2	0.0	+0.1	0.0
GUMO1	5.9	5.4	-0.5	-0.3	-0.3	-0.1	0.0	0.0	-0.3	0.0
SACR1	7.8	7.3	-0.5	0.0	-0.7	-0.3	-0.2	-0.2	+0.2	0.0
SAPE1	1.5	1.0	-0.5	-0.1	-0.1	-0.2	-0.1	0.0	0.0	0.0
WHIT1	3.6	3.3	-0.3	-0.1	-0.1	-0.2	-0.1	+0.1	+0.1	0.0
WHPE1	1.2	0.9	-0.3	+0.1	-0.1	-0.1	-0.1	0.0	-0.1	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

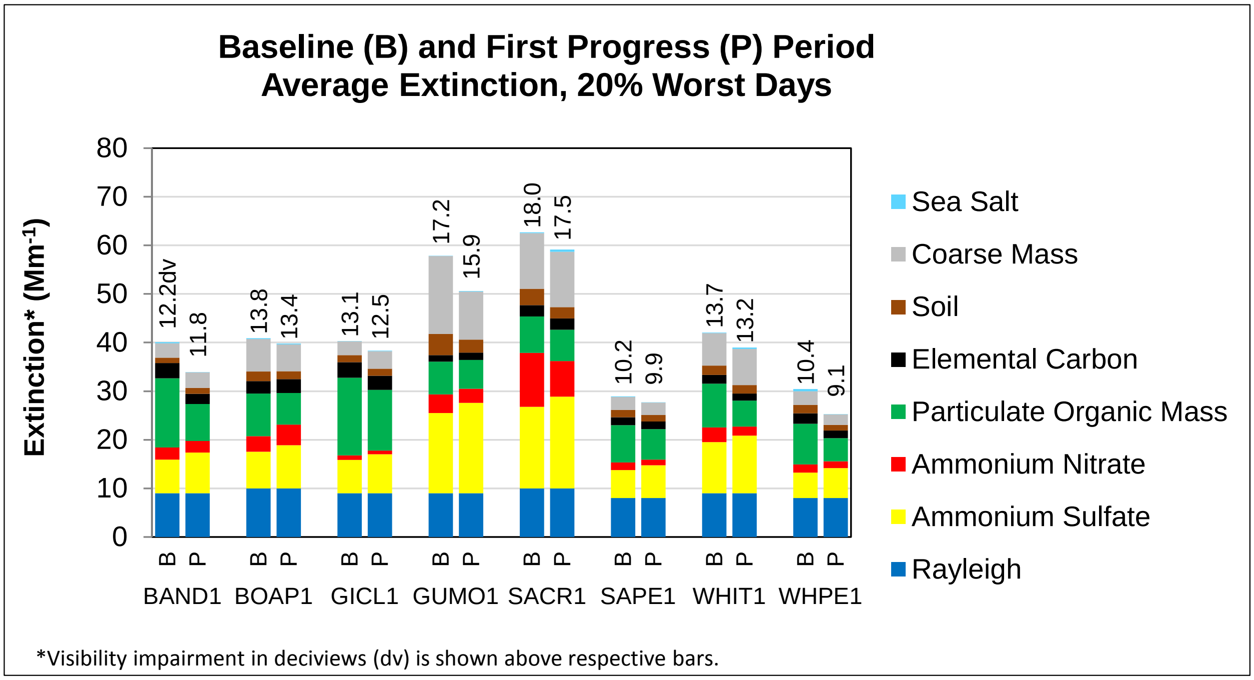

Figure 6.9-3. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at New Mexico Class I Area IMPROVE Sites.

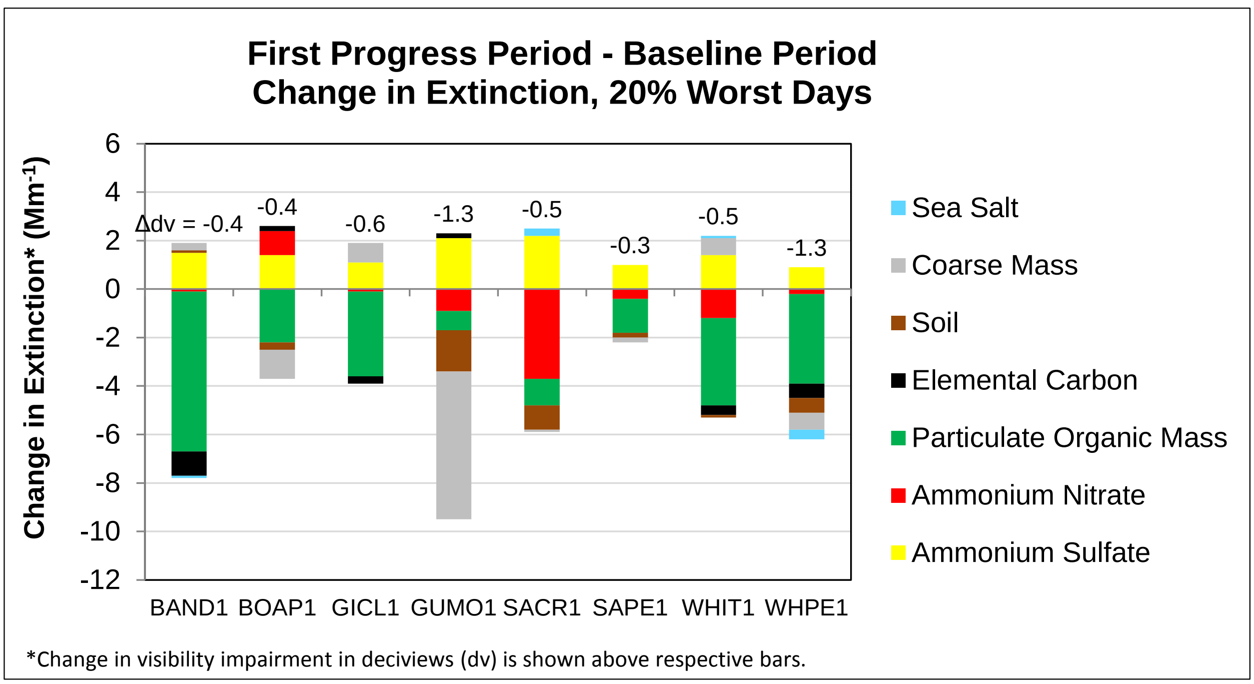

Figure 6.9-4. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at New Mexico Class I Area IMPROVE Sites.

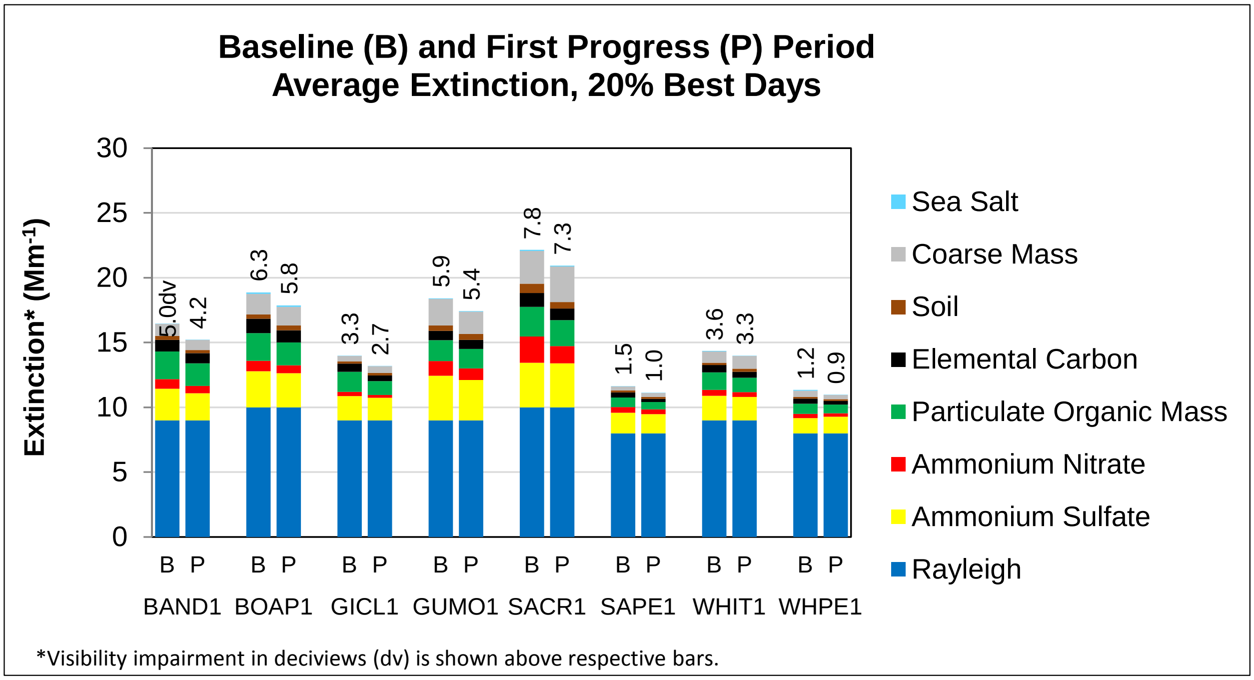

Figure 6.9-5. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at New Mexico Class I Area IMPROVE Sites.

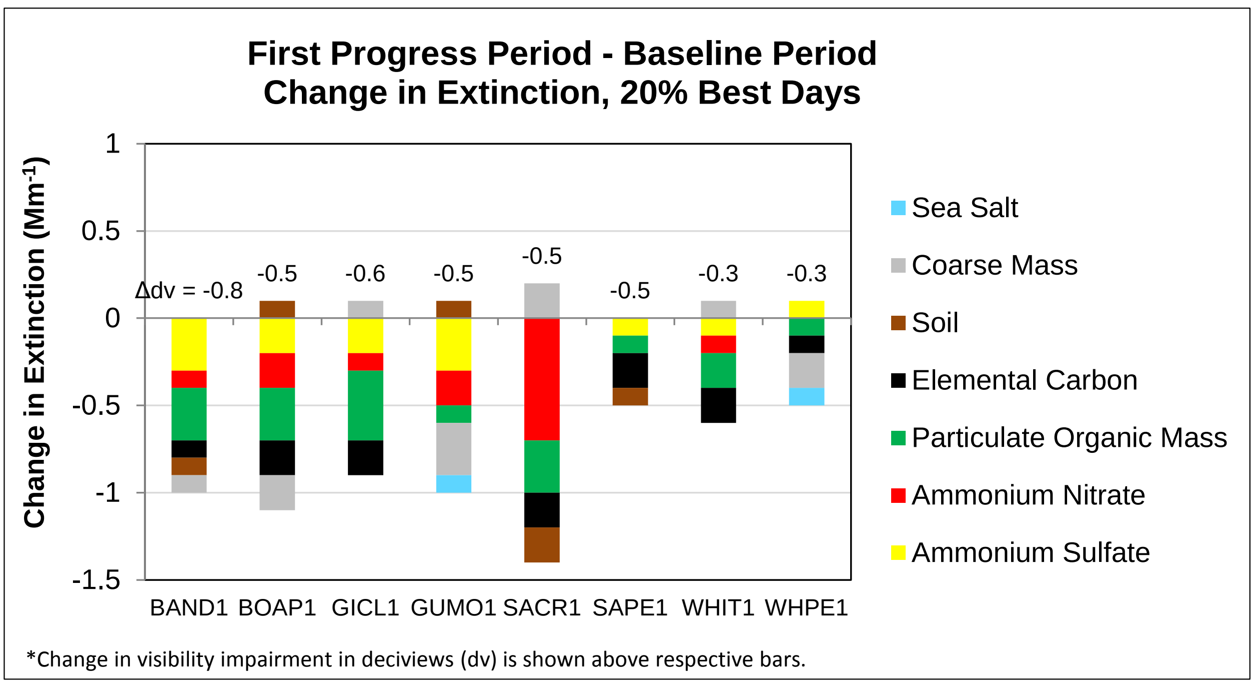

Figure 6.9-6. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at New Mexico Class I Area IMPROVE Sites.

6.9.1.3 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.309(d)(10)(i)(C))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5-year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in New Mexico are summarized in Table 6.9-6, and regional trends were presented earlier in Section 4.1.1.[100] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[101] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix I. Additionally, this appendix includes plots depicting 5-year, annual, monthly and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in New Mexico are as follows:

- The largest decrease in 5-year averages was measured for particulate organic mass at the BAND1 site, where a high event in May 2000 influenced the baseline period average.
- For ammonium nitrate, decreases in 5-year averages on the worst days were measured at all sites except BOAP1, which was influenced by an unusually high ammonium nitrate event measured in January 2007. Additionally, all sites measured either

[100] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)

[101] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

insignificant or decreasing annual average ammonium nitrate trends. The largest decrease was measured for the SACR1 site, but the year 2007 was incomplete for this site and not included in the 5-year average.

- For ammonium sulfate, increases in the 5-year averages were recorded for the worst days at all sites, but no increasing annual average trends were measured and statistically significant decreasing annual average trends were measured at the BAND1, GUMO1, and SACR1 sites. High 5-year averages for the worst days at these sites were influenced by anomalously high ammonium sulfate measurements in 2005.
- Two sites, BAND1 and GICL1, showed increasing trends on the worst days for coarse mass, and increases in the 5-year average for coarse mass. Highest coarse mass events were measured during the spring.

Table 6.9-6
New Mexico Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
BAND1	20% Best	-0.1	0.0	--	0.0	0.0	0.0	0.0
	20% Worst	--	--	-0.5	-0.1	--	0.1	0.0
	All Days	-0.1	0.0	-0.2	-0.1	--	--	--
BOAP1	20% Best	-0.1	0.0	-0.1	-0.1	--	-0.1	--
	20% Worst	--	--	-0.6	--	--	--	--
	All Days	--	--	-0.2	-0.1	--	--	--
GICL1	20% Best	-0.1	0.0	-0.1	0.0	--	--	0.0
	20% Worst	--	--	-1.0	--	--	0.2	0.0
	All Days	--	0.0	-0.3	-0.1	--	0.0	0.0
GUMO1	20% Best	-0.1	0.0	-0.1	0.0	--	0.0	--
	20% Worst	--	-0.2	-0.2	--	--	-0.8	--
	All Days	-0.2	-0.1	-0.1	--	--	-0.3	--
SACR1	20% Best	-0.1	-0.2	-0.1	0.0	--	--	--
	20% Worst	-0.5	-0.8	-0.3	--	--	--	0.0
	All Days	-0.2	-0.3	--	--	--	--	0.0
SAPE1	20% Best	--	0.0	0.0	0.0	--	--	--
	20% Worst	--	-0.1	--	--	--	--	--
	All Days	--	0.0	-0.1	0.0	--	0.0	0.0
WHIT1	20% Best	--	--	0.0	0.0	--	--	0.0
	20% Worst	--	-0.3	-0.6	-0.2	--	--	0.0
	All Days	--	-0.1	-0.1	-0.1	--	--	--
WHPE1	20% Best	--	0.0	--	0.0	--	0.0	0.0
	20% Worst	--	--	-0.9	-0.1	-0.1	--	--
	All Days	--	0.0	-0.3	-0.1	0.0	-0.1	0.0

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix I.

6.9.2 Emissions Data

Included here are summaries depicting differences between two emission inventory years that are used to represent the 5-year baseline and current progress periods. The baseline period is represented using a 2002 inventory developed by the WRAP for use in the initial WRAP state SIPs, and the progress period is represented by a 2008 inventory which leverages recent WRAP inventory work for modeling efforts, as referenced in Section 3.2.1. For reference, Table 6.9-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories, and a separate summary of annual emissions from electrical generating units (EGUs), are presented in this section.

Table 6.9-7
New Mexico
Pollutants, Aerosol Species, and Major Sources

Emitted Pollutant	Related Aerosol	Major Sources	Notes
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- and Off-Road Mobile Sources	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be associated with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Primary Organic Aerosol (POA)	POM	Wildfires; Area Sources	POA represents organic aerosols that are emitted directly as particles, as opposed to gases. Wildfires in the west generally dominate POA emissions, and large wildfire events are generally sporadic and highly variable from year-to-year.
Elemental Carbon (EC)	EC	Wildfires; On- and Off-Road Mobile Sources	Large EC events are often associated with large POM events during wildfires. Other sources include both on- and off-road diesel engines.
Fine soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is reported by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$ mass measurements. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but these measurements are generally associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributor to PMC.

6.9.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.309(d)(10)(i)(D))?*** For these summaries, emissions during the baseline years are represented using a 2002 inventory, which was developed with support from the WRAP for use in the original RHR SIP strategy development (termed plan02d). Differences between inventories are represented as the difference between the 2002 inventory, and a 2008 inventory which leverages recent inventory development work performed by the WRAP for the WestJumpAQMS and DEASCO$_3$ modeling projects (termed WestJump2008). Note that the comparisons of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories, as referenced in Section 3.2.1. Inventories for all major visibility impairing pollutants are presented for major source categories, and categorized as either anthropogenic or natural emissions. State-wide inventories totals and differences are presented here, and inventory totals on a county level basis are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

Table 6.9-8 and Figure 6.9-7 present the differences between the 2002 and 2008 sulfur dioxide (SO_2) inventories by source category. Tables 6.9-9 and Figure 6.9-8 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.9-10 through 6.9-15 and Figures 6.9-9 through 6.9-14) present data for ammonia (NH_3), volatile organic compounds (VOCs), primary organic aerosol (POA), elemental carbon (EC), fine soil, and coarse mass. General observations regarding emissions inventory comparisons are listed below.

- Largest differences for point source inventories were decreases in SO_2, NO_X, and VOCs. Note that this is consistent with the summary of annual EGU emissions as included in Section 6.9.2.2, showing decreases in SO_2 and NO_X emissions.
- Area source inventories showed decreases in SO_2 and VOCs and increases in NO_X and NH_3. These changes may be due to a combination of population changes and differences in methodologies used to estimate these emissions, as referenced in Section 3.2.1. One methodology change was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to increases in area source inventory totals, but decreases in off-road mobile totals.
- On-road mobile source inventory comparisons showed decreases in SO_2, NH_3, and VOCs, but increases in most other parameters, including NO_X.
- Off-road mobile source inventories showed decreases in NO_X, SO_2, VOCs, and EC, and slight increases in fine soil and coarse mass, which was consistent with most contiguous WRAP states. These differences were likely due to a combination of actual changes in source contributions and methodology differences, as referenced in Section 3.2.1. As noted previously, one major methodology difference was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have

contributed to decreases in the off-road inventory totals, but increases in area source totals.

- Inventory comparison results for area oil and gas showed decreases in NO_X and VOCs, but note that inventory methodologies for these sources may have evolved substantially between the baseline and 2008 inventories as referenced in Section 3.2.1.
- For all parameters, especially POAs, VOCs, and EC, natural fire emission inventory estimates decreased, and anthropogenic fire inventories increased. Note that these differences are not necessarily reflective of changes in monitored data, as the baseline period is represented by an average of 2000-2004 fire emissions, and the progress period is represented only by the fires that occurred in 2008, as referenced in Section 3.2.1.
- Comparisons between VOC inventories showed large decreases in biogenic emissions, which was consistent with other contiguous WRAP states. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions, as referenced in Section 3.2.1.
- Fine soil and coarse mass increased for the windblown dust inventory comparisons and the combined fugitive/road dust inventories. Large variability in changes in windblown dust was observed for the contiguous WRAP states, which was likely due in large part to enhancements in dust inventory methodology, as referenced in Section 3.2.1, rather than changes in actual emissions.

Table 6.9-8
New Mexico
Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	37,436	24,681	-12,754
Area	5,115	347	-4,768
On-Road Mobile	1,950	498	-1,452
Off-Road Mobile	3,525	167	-3,358
Area Oil and Gas	250	1,076	826
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	78	622	544
Total Anthropogenic	**48,354**	**27,392**	**-20,962 (-43%)**
Natural Sources			
Natural Fire	2,313	154	-2,159
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**2,313**	**154**	**-2,159 (-93%)**
All Sources			
Total Emissions	**50,667**	**27,545**	**-23,121 (-46%)**

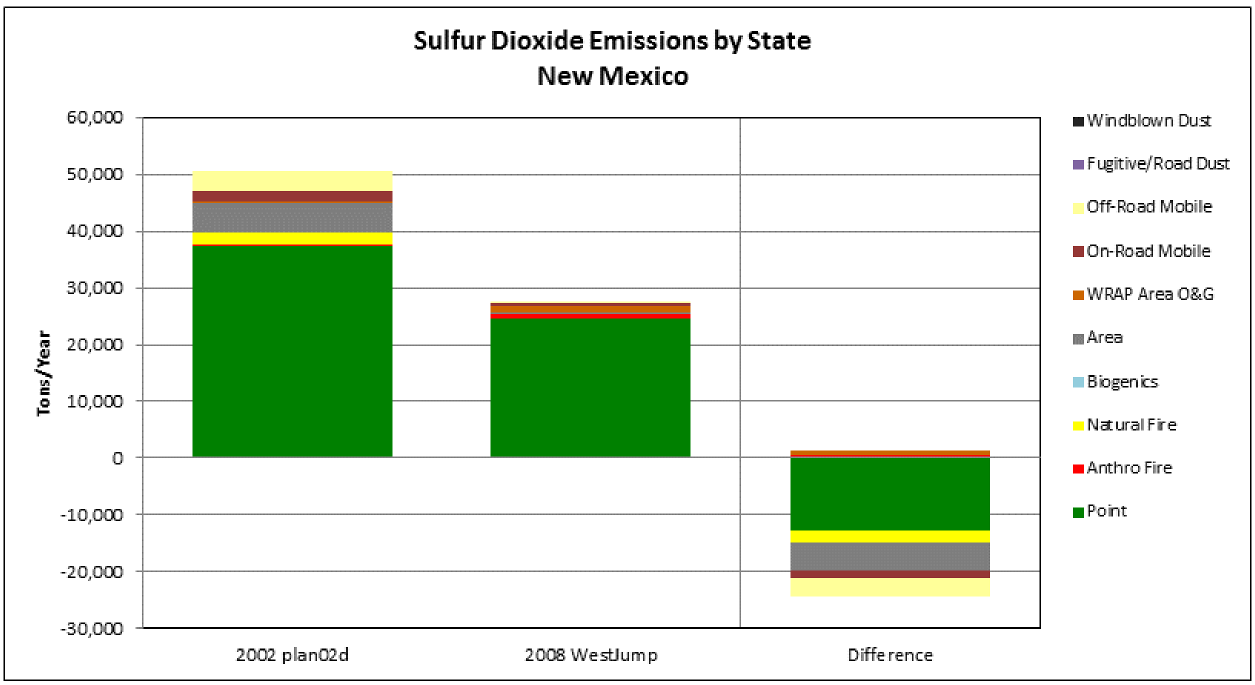

Figure 6.9-7. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for New Mexico.

Table 6.9-9
New Mexico
Oxides of Nitrogen Emissions by Category

Source Category	Oxides of Nitrogen Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	100,387	62,502	-37,885
Area	25,130	27,754	2,624
On-Road Mobile	67,835	72,074	4,239
Off-Road Mobile	45,311	8,566	-36,745
Area Oil and Gas	56,210	35,838	-20,372
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	394	4,397	4,004
Total Anthropogenic	**295,266**	**211,132**	**-84,135 (-28%)**
Natural Sources			
Natural Fire	8,570	1,085	-7,485
Biogenic	42,139	15,983	-26,156
Wind Blown Dust	0	0	0
Total Natural	**50,708**	**17,068**	**-33,641 (-66%)**
All Sources			
Total Emissions	**345,974**	**228,199**	**-117,775 (-34%)**

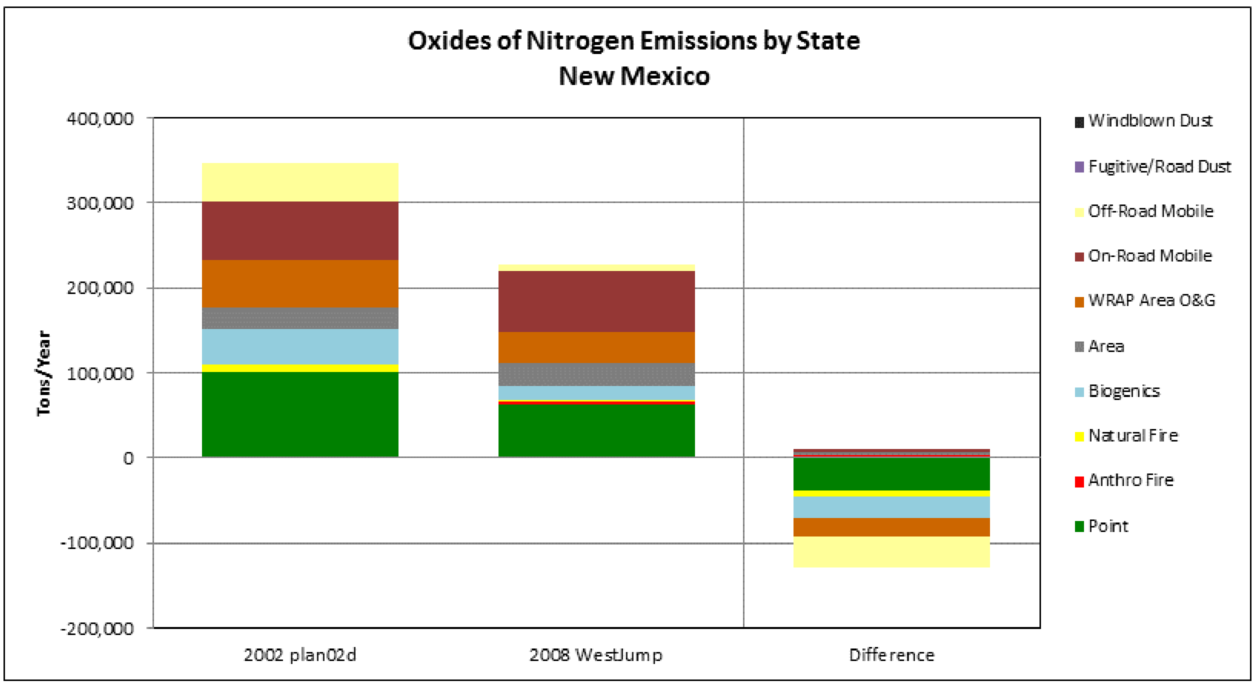

Figure 6.9-8. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Oxides of Nitrogen by Source Category for New Mexico.

Table 6.9-10
New Mexico
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	75	274	199
Area	29,959	39,399	9,440
On-Road Mobile	2,132	1,090	-1,042
Off-Road Mobile	26	10	-16
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	75	3,067	2,992
Total Anthropogenic	**32,266**	**43,840**	**11,573 (36%)**
Natural Sources			
Natural Fire	1,875	754	-1,120
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**1,875**	**754**	**-1,120 (-60%)**
All Sources			
Total Emissions	**34,141**	**44,594**	**10,453 (31%)**

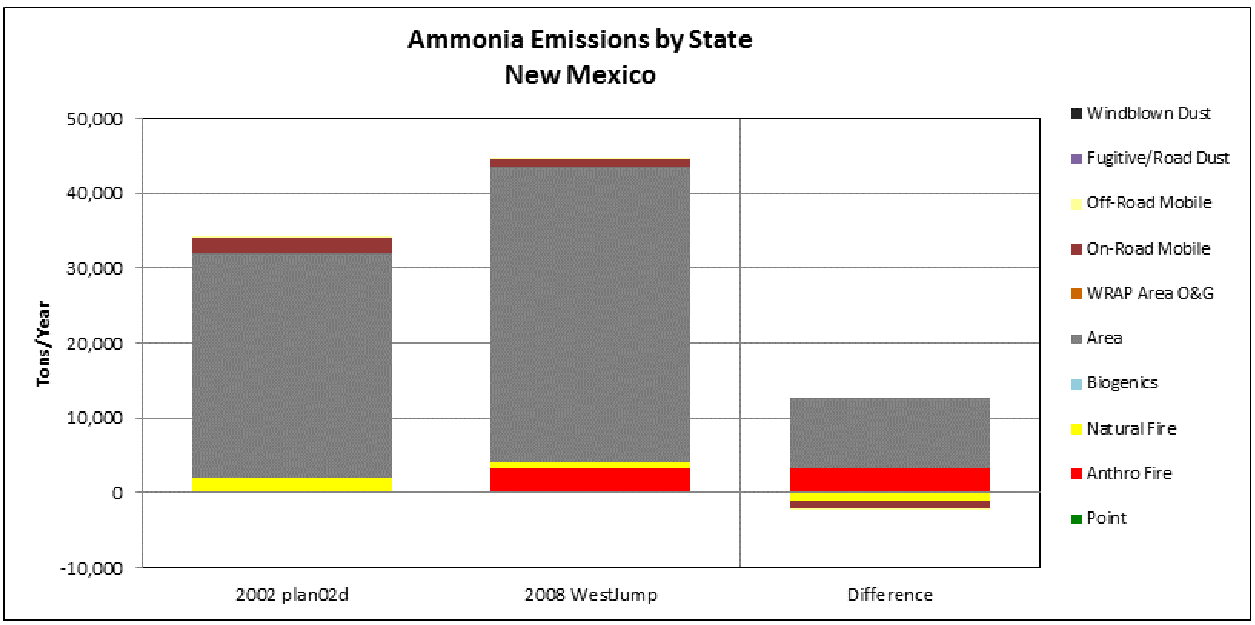

Figure 6.9-9. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Ammonia by Source Category for New Mexico.

Table 6.9-11
New Mexico
Volatile Organic Compound Emissions by Category

Source Category	Volatile Organic Compound Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	17,574	9,855	-7,719
Area	49,010	37,395	-11,614
On-Road Mobile	38,768	29,629	-9,138
Off-Road Mobile	13,850	11,383	-2,467
Area Oil and Gas	224,268	174,990	-49,278
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	608	5,540	4,932
Total Anthropogenic	**344,077**	**268,792**	**-75,284 (-22%)**
Natural Sources			
Natural Fire	18,846	1,107	-17,740
Biogenic	1,016,487	468,258	-548,229
Wind Blown Dust	0	0	0
Total Natural	**1,035,333**	**469,365**	**-565,968 (-55%)**
All Sources			
Total Emissions	**1,379,410**	**738,157**	**-641,2253 (-46%)**

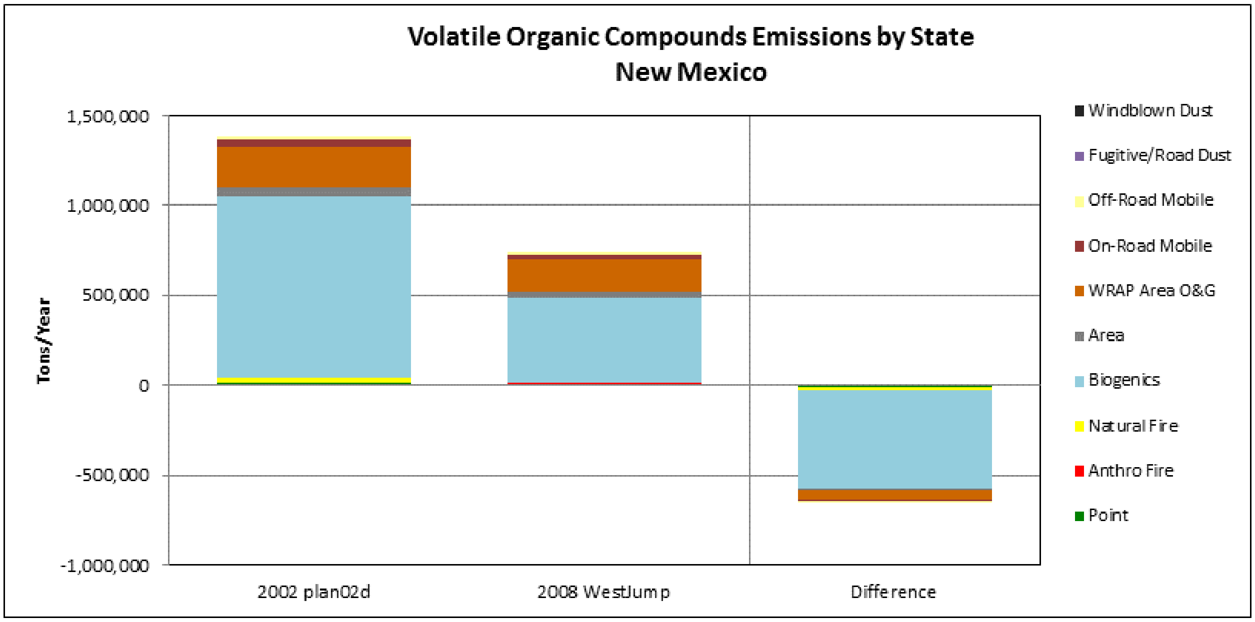

Figure 6.9-10. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for New Mexico.

Table 6.9-12
New Mexico
Primary Organic Aerosol Emissions by Category

Source Category	Primary Organic Aerosol Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	978	277	-701
Area	2,529	2,876	346
On-Road Mobile	653	1,506	852
Off-Road Mobile	563	349	-213
Area Oil and Gas	0	31	31
Fugitive and Road Dust	474	3,819	3,345
Anthropogenic Fire	682	8,821	8,139
Total Anthropogenic	**5,879**	**17,678**	**11,799 (>100%)**
Natural Sources			
Natural Fire	16,272	1,727	-14,545
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**16,272**	**1,727**	**-14,545 (-89%)**
All Sources			
Total Emissions	**22,151**	**19,406**	**-2,745 (-12%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

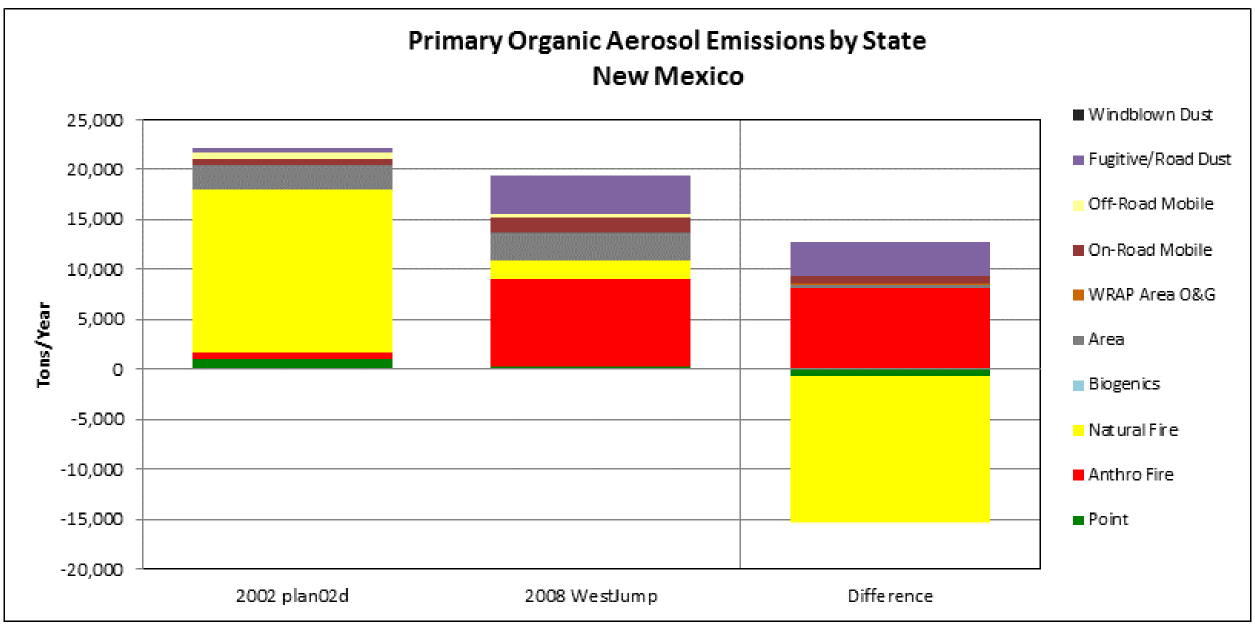

Figure 6.9-11. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Primary Organic Aerosol by Source Category for New Mexico.

Table 6.9-13
New Mexico
Elemental Carbon Emissions by Category

Source Category	Elemental Carbon Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	13	71	59
Area	301	945	644
On-Road Mobile	756	2,999	2,243
Off-Road Mobile	1,526	457	-1,070
Area Oil and Gas	0	0	0
Fugitive and Road Dust	34	74	40
Anthropogenic Fire	123	1,432	1,309
Total Anthropogenic	**2,753**	**5,979**	**3,226 (>100%)**
Natural Sources			
Natural Fire	3,293	417	-2,876
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**3,293**	**417**	**-2,876 (-87%)**
All Sources			
Total Emissions	**6,046**	**6,397**	**351 (6%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

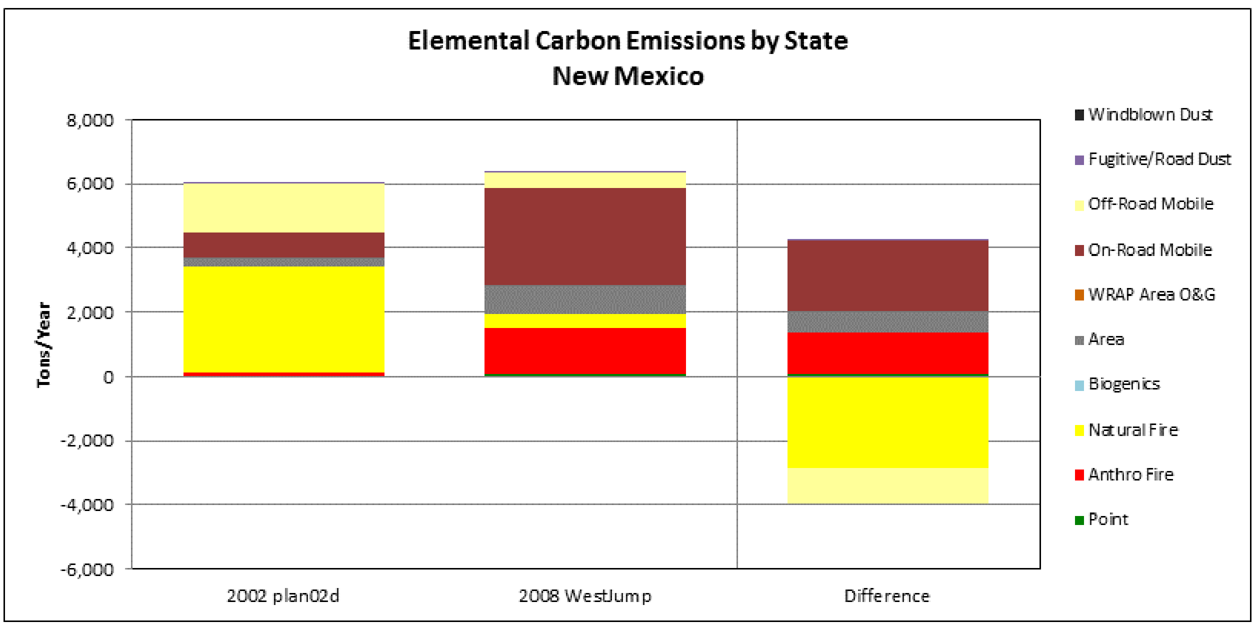

Figure 6.9-12. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Elemental Carbon by Source Category for New Mexico.

Table 6.9-14
New Mexico
Fine Soil Emissions by Category

Source Category	Fine Soil Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	1,180	535	-645
Area	2,821	1,485	-1,336
On-Road Mobile	429	258	-172
Off-Road Mobile	0	25	25
Area Oil and Gas	0	540	540
Fugitive and Road Dust	8,056	55,506	47,451
Anthropogenic Fire	87	3,239	3,152
Total Anthropogenic	**12,573**	**61,587**	**49,014 (>100%)**
Natural Sources			
Natural Fire	1,223	646	-577
Biogenic	0	0	0
Wind Blown Dust	16,399	28,151	11,752
Total Natural	**17,622**	**28,798**	**11,176 (63%)**
All Sources			
Total Emissions	**30,194**	**90,384**	**60,190 (>100%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

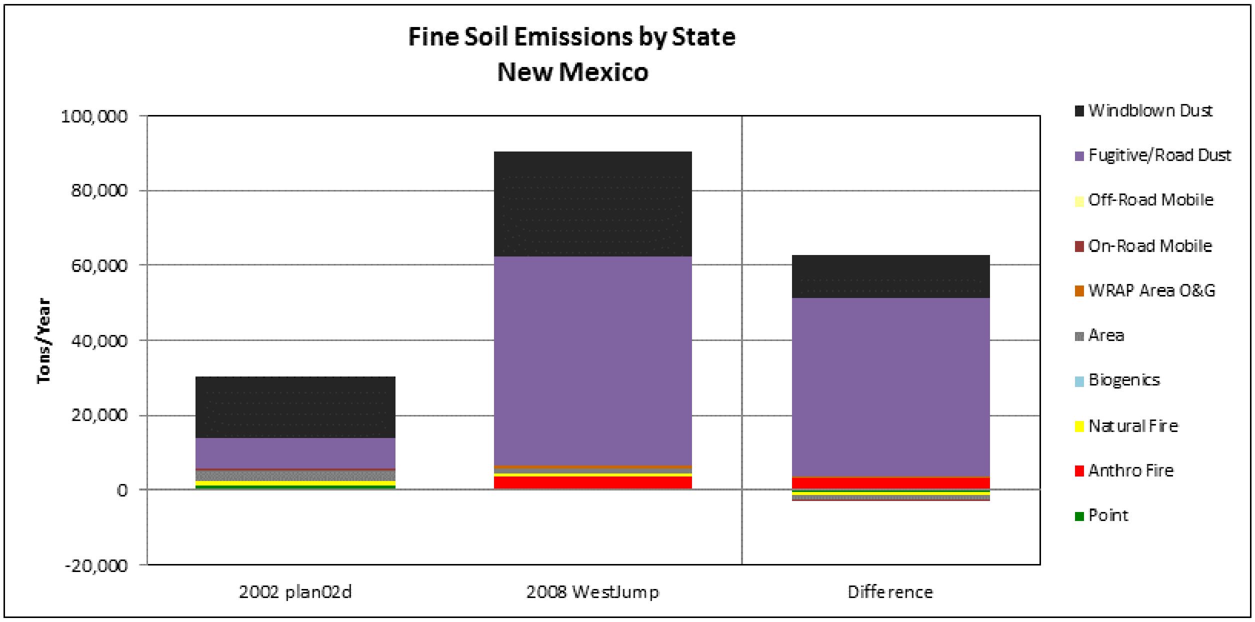

Figure 6.9-13. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Fine Soil by Source Category for New Mexico.

Table 6.9-15
New Mexico
Coarse Mass Emissions by Category

Source Category	Coarse Mass Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	2,286	1,168	-1,117
Area	695	506	-189
On-Road Mobile	403	2,994	2,590
Off-Road Mobile	0	41	41
Area Oil and Gas	0	12	12
Fugitive and Road Dust	62,607	504,915	442,308
Anthropogenic Fire	105	1,691	1,586
Total Anthropogenic	**66,096**	**511,327**	**445,230 (>100%)**
Natural Sources			
Natural Fire	5,400	330	-5,070
Biogenic	0	0	0
Wind Blown Dust	147,589	253,362	105,773
Total Natural	**152,989**	**253,692**	**100,703 (66%)**
All Sources			
Total Emissions	**219,086**	**765,019**	**545,933 (>100%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

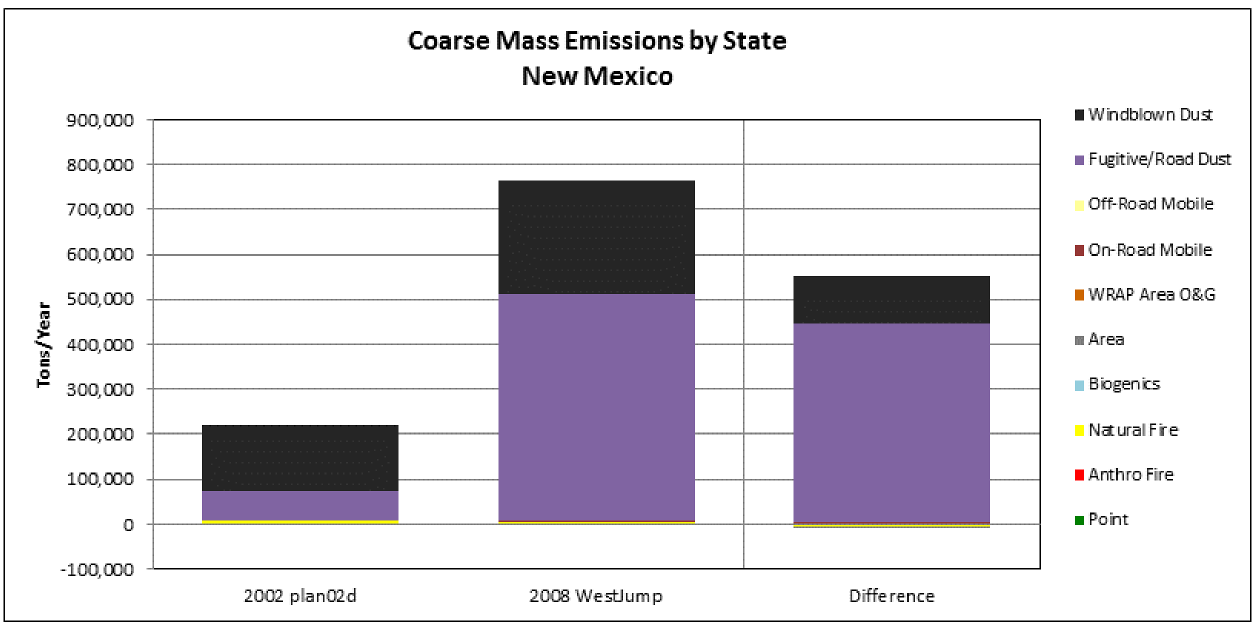

Figure 6.9-14. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Coarse Mass by Source Category for New Mexico.

6.9.2.2 EGU Summary

As described in previous sections, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions because numerous updates in inventory methodologies have occurred between the development of the separate inventories. Also, the 2002 baseline and 2008 progress period inventories represent only annual snapshots of emissions estimates, which may not be representative of entire 5-year monitoring periods compared. To better account for year-to-year changes in emissions, annual emission totals for New Mexico electrical generating units (EGU) are presented here. EGU emissions are some of the more consistently reported emissions, as tracked in EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/). RHR implementation plans are required to pay specific attention to certain major stationary sources, including EGUs, built between 1962 and 1977.

Figure 6.9-17 presents a sum of annual NO_X and SO_2 emissions as reported for New Mexico EGU sources between 1996 and 2010. While these types of facilities are targeted for controls in state regional haze SIPs, it should be noted that many of the controls planned for EGUs in the WRAP states had not taken place yet in 2010, while other controls separate from the RHR may have been implemented. The chart shows periods of decline for both SO_2 and NO_X emissions, with a steeper decline in SO_2.

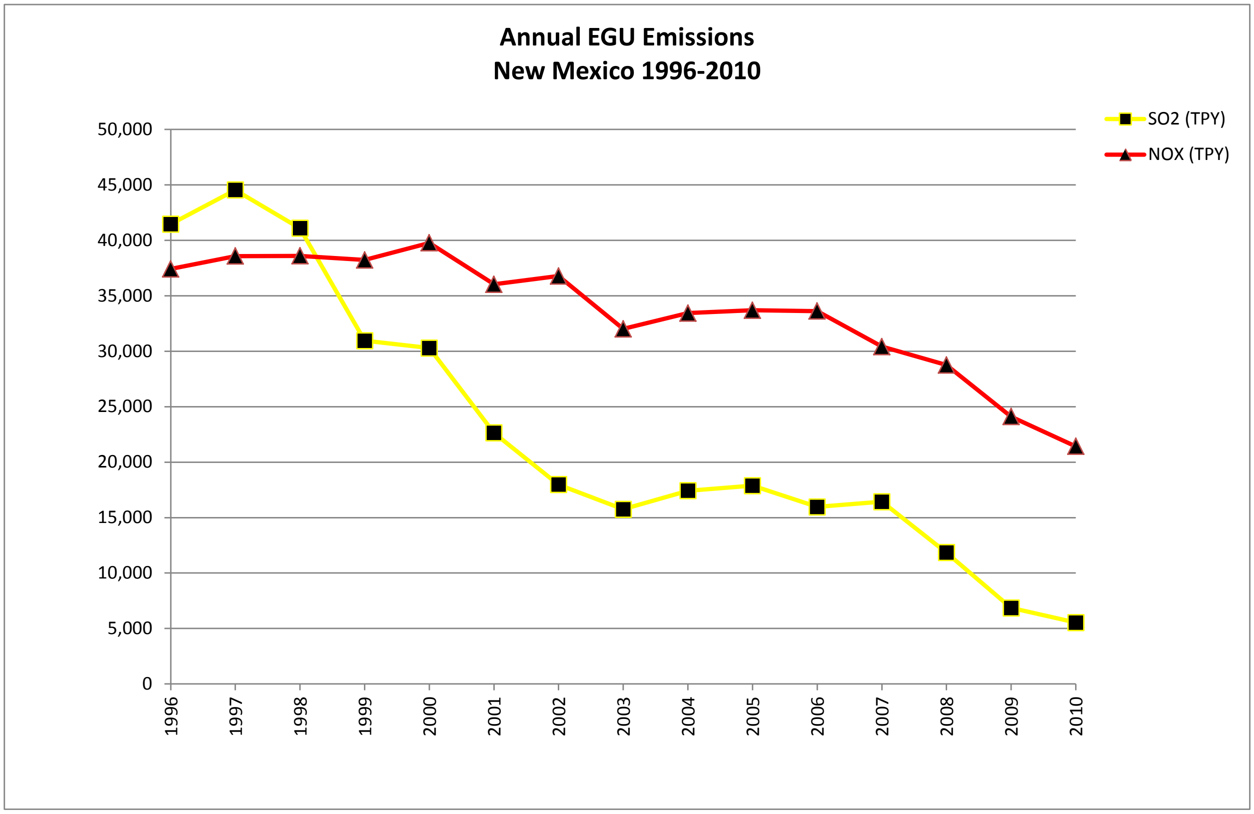

Figure 6.9-17. Sum of EGU Emissions of SO_2 and NO_X reported between 1996 and 2010 for New Mexico.

6.10 NORTH DAKOTA

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. North Dakota has 2 mandatory Federal CIAs, which are depicted in Figure 6.10-1 and listed in Table 6.10-1, along with the associated IMPROVE monitor locations.

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per Regional Haze Rule (RHR) requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. Some of the highlights regarding these comparisons are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- For the best days, the 5-year average deciview metric decreased at both the THRO1 and LOST1 sites.
- For the worst days, the 5-year average deciview metric decreased at the THRO1 site and remained the same at the LOST1 site.
- Both sites showed decreases in ammonium nitrate, which is consistent with emission inventories showing decreases in mobile and point source NO_X emissions.
- Both sites showed increases in 5-year average ammonium sulfate, and the LOST1 showed a statistically significant increasing annual trend. This was not consistent with a comparison of emissions inventories and summaries of annual EGU emissions which showed decreased SO_2 due to point and area sources. Increases in ammonium sulfate were also observed at the nearby MELA1 site in Montana. Both of these sites are near the Canadian border, so it is possible that international emissions affected these measurements.
- Both sites showed decreases in particulate organic mass, and emission inventories indicated that these measurements are largely due to fire impacts, which are highly variable from year-to-year.

Figure 6.10-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in North Dakota.

Table 6.10-1
North Dakota CIAs and Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Lostwood WA	LOST1	48.64	-102.40	696
Theodore Roosevelt NP	THRO1	46.89	-103.38	852

6.10.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by IMPROVE monitors representing Federal CIAs in North Dakota. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix J.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.10.1.1 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.308 (g)(3)(i))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[102] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.10-2 and 6.10-3 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired, or worst, and 20% least impaired, or best, days for each of the Federal CIA IMPROVE monitors in North Dakota. Figure 6.10-2 presents 5-year average extinction for the current progress period for both the 20% most impaired and 20% least impaired days. Note that the percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired days are as follows:

- The largest contributors to aerosol extinction at North Dakota sites were ammonium sulfate, ammonium nitrate and particulate organic mass.

Specific observations for the current visibility conditions on the 20% least impaired days are as follows:

- The aerosol contribution to total extinction on the best days was less than Rayleigh, or the background scattering that would occur in clear air.
- For both North Dakota sites, ammonium sulfate was the largest contributor to the non-Rayleigh aerosol species of extinction

[102] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

Table 6.10-2
North Dakota Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank*						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
LOST1	19.6	**37% (1)**	35% (2)	16% (3)	4% (5)	1% (6)	6% (4)	1% (7)
THRO1	17.6	**37% (1)**	25% (2)	21% (3)	5% (5)	2% (6)	9% (4)	1% (7)

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.10-3
North Dakota Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank*						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
LOST1	8.1	**40% (1)**	13% (4)	16% (3)	6% (5)	3% (6)	21% (2)	1% (7)
THRO1	6.7	**39% (1)**	11% (4)	17% (3)	10% (5)	3% (6)	20% (2)	1% (7)

*Highest aerosol species contribution per site is highlighted in bold.

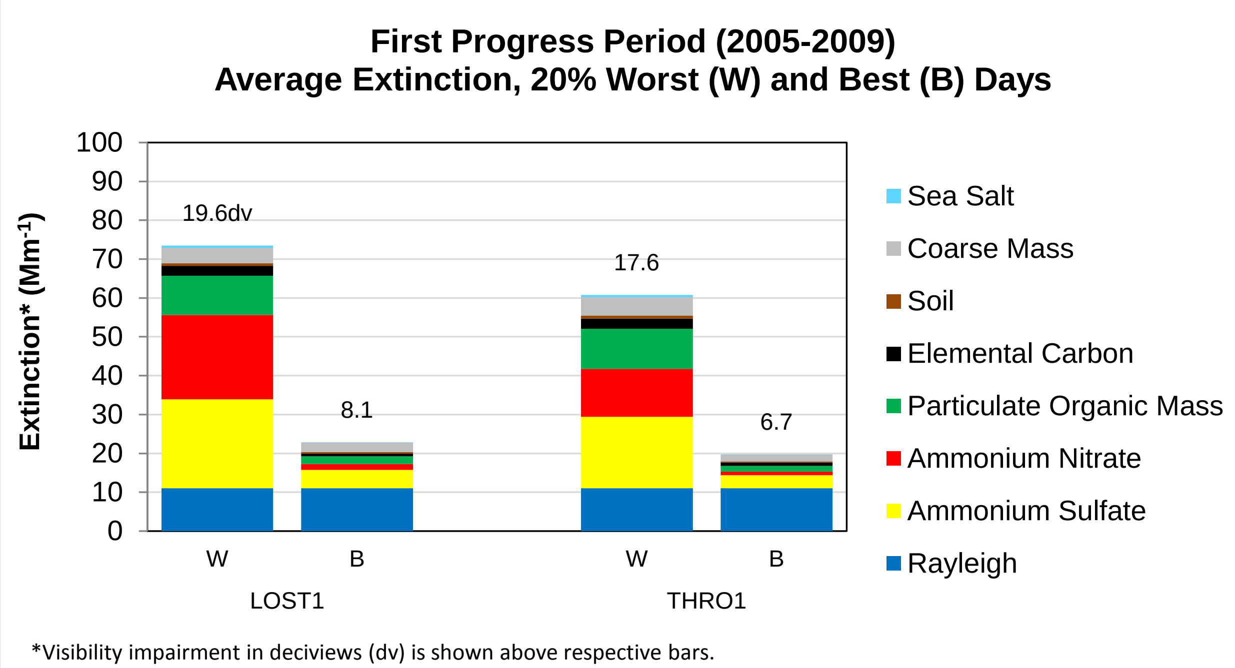

Figure 6.10-2. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at North Dakota Class I Area IMPROVE Sites.

6.10.1.2 Differences between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.308 (g)(3)(ii))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Table 6.10-4 presents the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for each site in North Dakota for the 20% most impaired days, and Table 6.10-5 presents similar data for the least impaired days. Averages that increased are depicted in red text and averages that decreased in blue.

Figure 6.10-3 presents the 5-year average extinction for the baseline and current progress period averages for the worst days and Figure 6.10-4 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.10-5 and 6.10-6 present similar plots for the best days.

For the 20% most impaired days, the 5-year average deciview metric decreased between the 2000-2004 and 2005-2009 periods at the THRO1 site and remained the same at the LOST1 site. Notable differences for individual species averages were as follows:

- Ammonium nitrate, particulate organic mass, and elemental carbon averages decreased at both sites.
- Ammonium sulfate and sea salt averages increased at both sites.

Table 6.10-4
North Dakota Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
LOST1	19.6	19.6	0.0	**+1.5**	**-1.2**	**-0.9**	**-0.3**	0.0	**+0.1**	**+0.3**
THRO1	17.8	17.6	**-0.2**	**+0.9**	**-1.4**	**-0.5**	**-0.1**	**-0.1**	**-0.1**	**+0.5**

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.10-5
North Dakota Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
LOST1	8.2	8.1	**-0.1**	**+0.4**	**-0.3**	**-0.3**	0.0	0.0	**+0.2**	**+0.1**
THRO1	7.8	6.7	**-1.1**	**-0.4**	**-0.6**	**-0.5**	**-0.1**	**-0.1**	**-0.5**	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

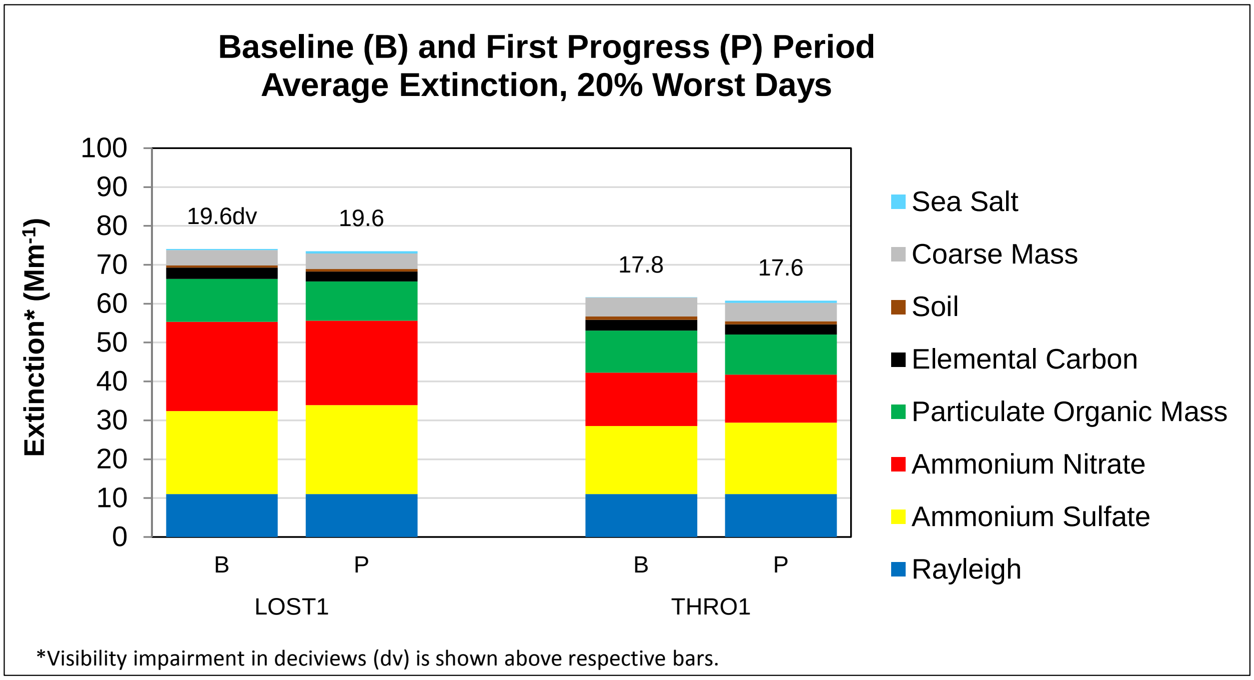

Figure 6.10-3. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at North Dakota Class I Area IMPROVE Sites.

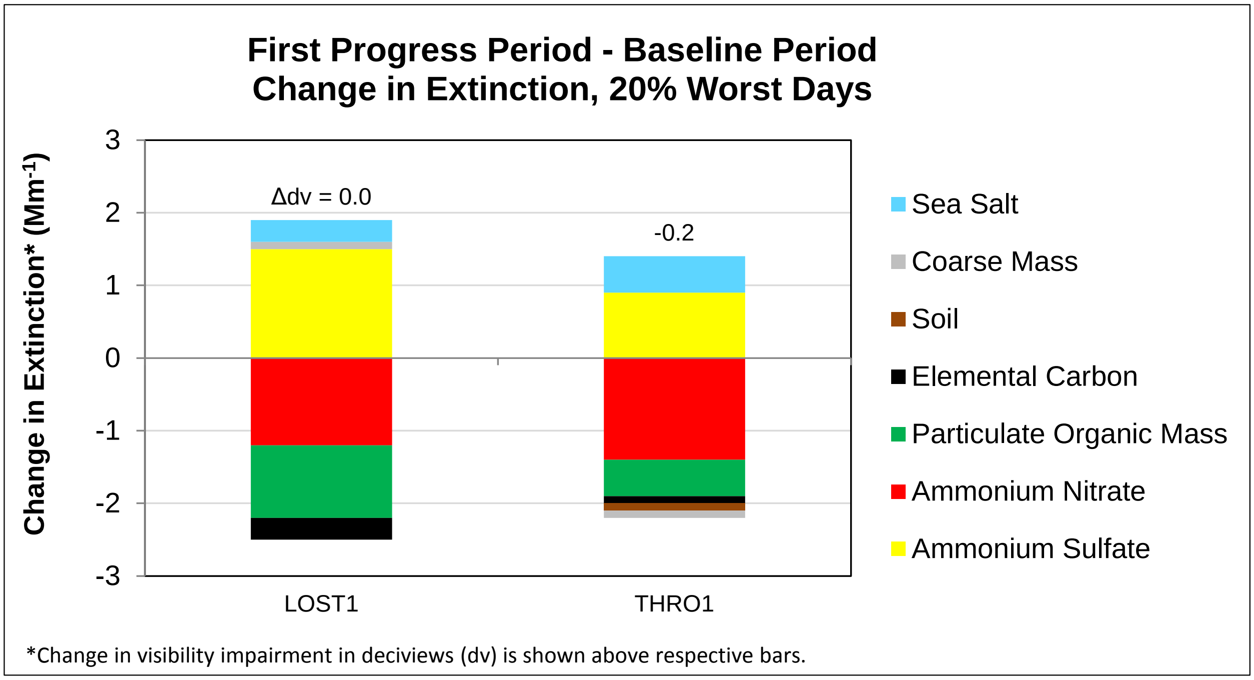

Figure 6.10-4. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at North Dakota Class I Area IMPROVE Sites.

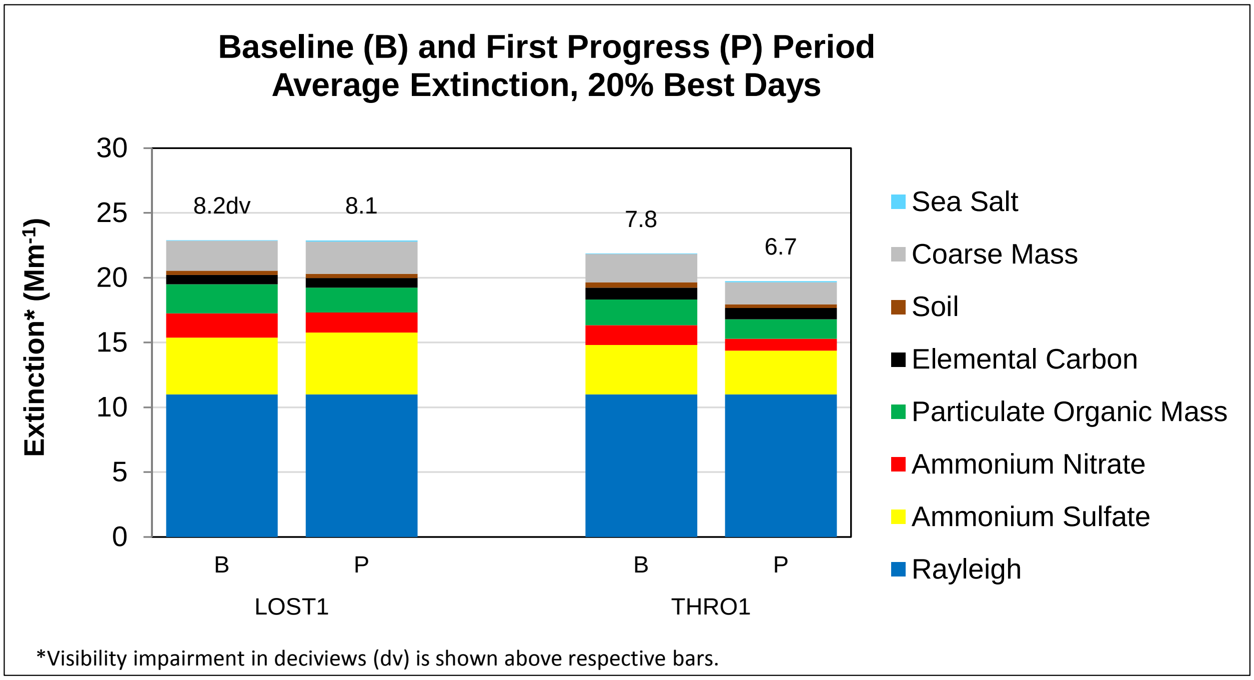

Figure 6.10-5. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at North Dakota Class I Area IMPROVE Sites.

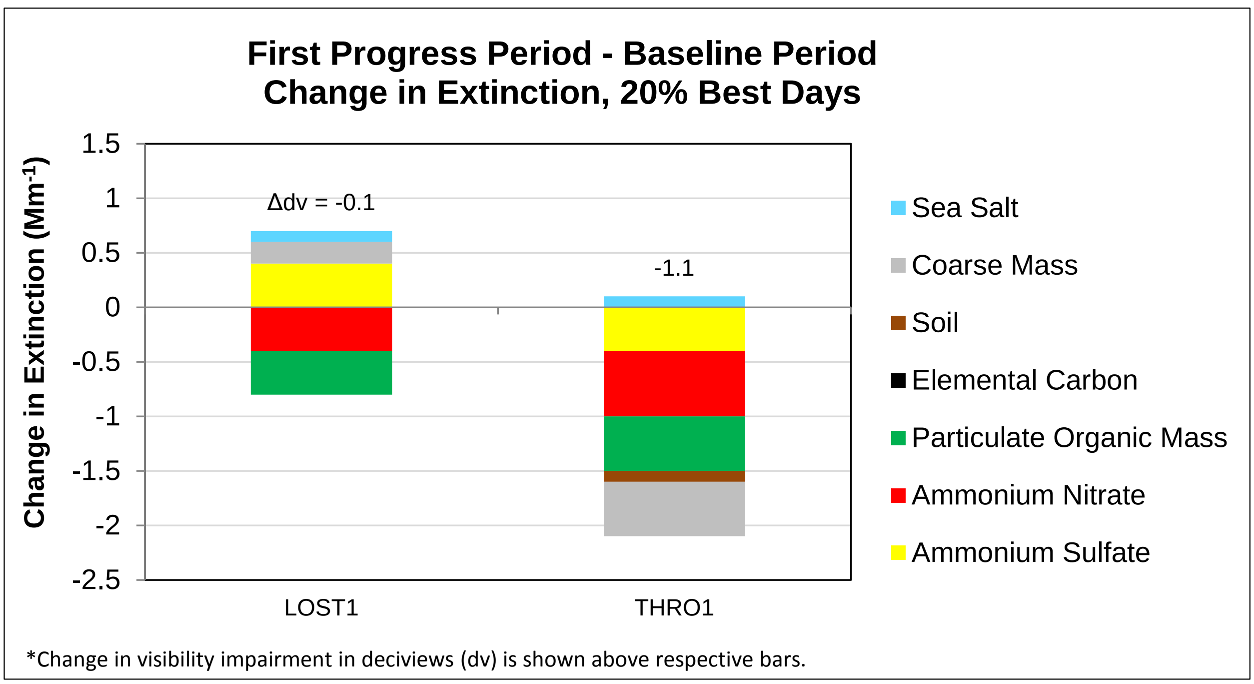

Figure 6.10-6. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at North Dakota Class I Area IMPROVE Sites.

6.10.1.3 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.308 (g)(3)(iii))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5-year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in North Dakota are summarized in Table 6.10-6, and regional trends were presented earlier in Section 4.1.1.[103] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[104] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix J. Additionally, this appendix includes plots depicting 5-year, annual, monthly, and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in North Dakota are as follows:

- For ammonium sulfate, the 5-year average for the worst days increased at both North Dakota sites, and showed an increasing annual average trend at the LOST1 site.
- For ammonium nitrate, the 5-year average for the worst days decreased at both North Dakota sites, and showed a decreasing annual average trend at the THRO1 site.

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[103] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)
[104] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

- Elemental carbon and particulate organic mass showed decreasing annual average trends at both sites.

Table 6.10-6
North Dakota Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
LOST1	20% Best	--	0.0	--	--	--	--	0.0
	20% Worst	--	--	--	**-0.1**	--	**-0.1**	--
	All Days	**0.1**	--	**-0.2**	**-0.1**	--	--	0.0
THRO1	20% Best	**-0.1**	**-0.1**	**-0.1**	--	0.0	0.0	0.0
	20% Worst	--	--	--	--	0.0	**-0.1**	0.0
	All Days	--	**-0.1**	--	**-0.1**	--	--	0.0

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix J.

6.10.2 Emissions Data

Included here are summaries depicting differences between two emission inventory years that are used to represent the 5-year baseline and current progress periods. The baseline period is represented using a 2002 inventory developed by the WRAP for use in the initial WRAP state SIPs, and the progress period is represented by a 2008 inventory which leverages recent WRAP inventory work for modeling efforts, as referenced in Section 3.2.1. For reference, Table 6.10-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories, and a separate summary of annual emissions from electrical generating units (EGUs), are presented in this section.

Table 6.10-7
North Dakota
Pollutants, Aerosol Species, and Major Sources

Emitted Pollutant	Related Aerosol	Major Sources	Notes
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- and Off-Road Mobile Source	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be associated with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Primary Organic Aerosol (POA)	POM	Wildfires; Area Sources	POA represents organic aerosols that are emitted directly as particles, as opposed to gases. Wildfires in the west generally dominate POA emissions, and large wildfire events are generally sporadic and highly variable from year-to-year.
Elemental Carbon (EC)	EC	Wildfires; On- and Off-Road Mobile Sources	Large EC events are often associated with large POM events during wildfires. Other sources include both on- and off-road diesel engines.
Fine soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is reported by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$ mass measurements. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but these measurements are generally associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributor to PMC.

6.10.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.308 (g)(4))?*** For these summaries, emissions during the baseline years are represented using a 2002 inventory, which was developed with support from the WRAP for use in the original RHR SIP strategy development (termed plan02d). Differences between inventories are represented as the difference between the 2002 inventory, and a 2008 inventory which leverages recent inventory development work performed by the WRAP for the WestJumpAQMS and DEASCO$_3$ modeling projects (termed WestJump2008). Note that the comparisons of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories, as referenced in Section 3.2.1. Inventories for all major visibility impairing pollutants are presented for major source categories, and categorized as either anthropogenic or natural emissions. State-wide inventories totals and differences are presented here, and inventory totals on a county level basis are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

Table 6.10-8 and Figure 6.10-7 present the differences between the 2002 and 2008 sulfur dioxide (SO_2) inventories by source category. Tables 6.10-9 and Figure 6.10-8 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.10-10 through 6.10-15 and Figures 6.10-9 through 6.10-14) present data for ammonia (NH_3), volatile organic compounds (VOCs), primary organic aerosol (POA), elemental carbon (EC), fine soil, and coarse mass. Inventory totals on a county level basis will be made available on the WRAP TSS website (http://vista.cira.colostate.edu/tss/). General observations regarding emissions inventory comparisons are listed below.

- Largest differences for point source inventories were decreases in SO_2 and NO_X, and increases in NH_3 and VOCs. Note that decreases in SO_2 and NO_X for point sources are consistent with the summary of annual EGU emissions as included in Section 6.10.2.2.
- Area source inventories showed decreases in SO_2, NH_3, and VOCs, with increases in NO_X. These changes may be due to a combination of population changes and differences in methodologies used to estimate these emissions, as referenced in Section 3.2.1. One methodology change was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to increases in area source inventory totals, but decreases in off-road mobile totals.
- On-road mobile source inventory comparisons showed decreases in most parameters, especially NO_X and VOCs, with slight increases in POA, EC, and coarse mass. Reductions in NO_X and VOC are likely influenced by federal and state emissions standards that have already been implemented. The increases in POA, EC, and coarse mass occurred in all of the WRAP states for on-road mobile inventories, regardless of reductions in NO_2 and VOCs, indicating that these increases were likely due use of different on-road models, as referenced in Section 3.2.1.

- Off-road mobile source inventories showed decreases in NO_X, SO_2, and VOCs, and increases in fine soil and coarse mass, which was consistent with most contiguous WRAP states. These differences were likely due to a combination of actual changes in source contributions and methodology differences, as referenced in Section 3.2.1. As noted previously, one major methodology difference was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to decreases in the off-road inventory totals, but increases in area source totals.
- For most parameters, especially POAs, VOCs, and EC, fire emission inventory estimates decreased. Note that these differences are not necessarily reflective of changes in monitored data, as the baseline period is represented by an average of 2000-2004 fire emissions, and the progress period is represented only by the fires that occurred in 2008, as referenced in Section 3.2.1.
- Comparisons between VOC inventories showed large decreases in biogenic emissions, which was consistent with other contiguous WRAP states. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions, as referenced in Section 3.2.1.
- Fine soil and coarse mass decreased for the windblown dust inventory comparisons, and increased for the combined fugitive/road dust inventories. Large variability in changes in windblown dust was observed for the contiguous WRAP states, which was likely due in large part to enhancements in dust inventory methodology, as referenced in Section 3.2.1, rather than changes in actual emissions.

Table 6.10-8
North Dakota
Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	156,668	142,121	-14,547
Area	5,389	729	-4,660
On-Road Mobile	771	156	-615
Off-Road Mobile	6,828	683	-6,144
Area Oil and Gas	358	0	-358
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	268	107	-162
Total Anthropogenic	**170,283**	**143,796**	**-26,486 (-16%)**
Natural Sources			
Natural Fire	195	7	-188
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**195**	**7**	**-188 (-97%)**
All Sources			
Total Emissions	**170,477**	**143,803**	**-26,675 (-16%)**

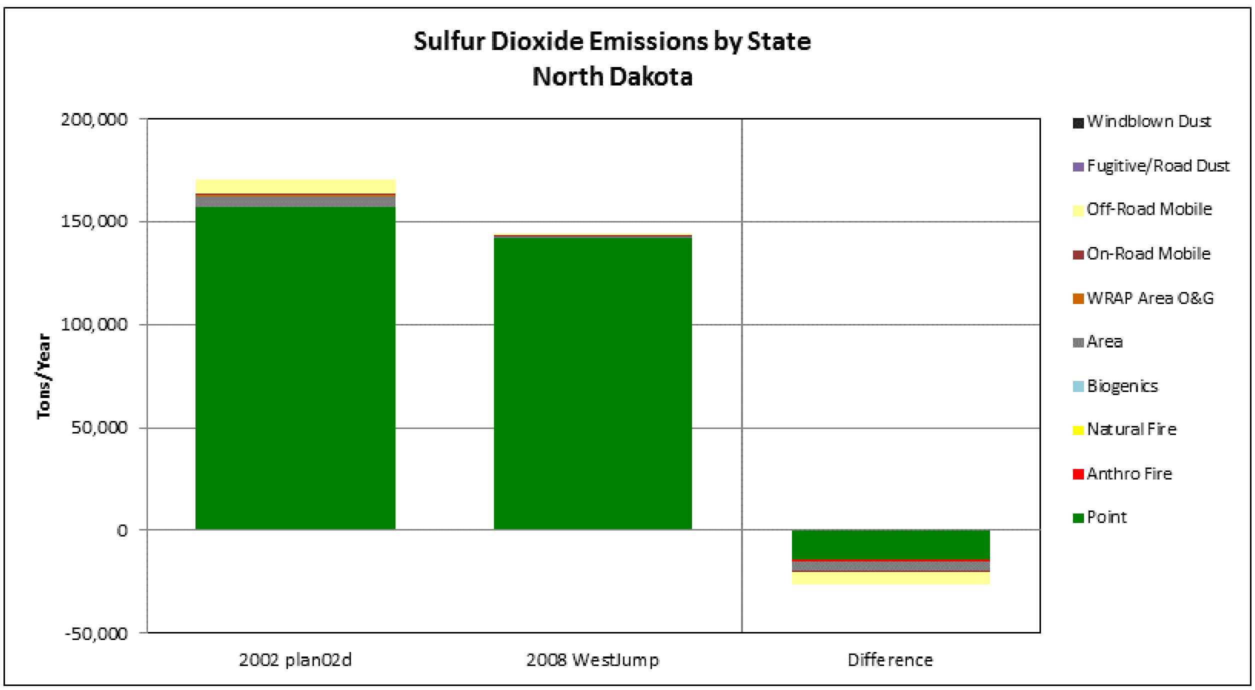

Figure 6.10-7. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for North Dakota.

Table 6.10-9
North Dakota
Nitrogen Oxide Emissions by Category

Source Category	Oxides of Nitrogen Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	87,425	78,252	-9,173
Area	10,826	16,719	5,892
On-Road Mobile	24,746	23,180	-1,566
Off-Road Mobile	55,502	34,572	-20,930
Area Oil and Gas	4,631	0	-4,631
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	995	854	-140
Total Anthropogenic	**184,125**	**153,577**	**-30,548 (-17%)**
Natural Sources			
Natural Fire	766	47	-720
Biogenic	44,569	9,133	-35,436
Wind Blown Dust	0	0	0
Total Natural	**45,335**	**9,179**	**-36,156 (-80%)**
All Sources			
Total Emissions	**229,460**	**162,756**	**-66,704 (-29%)**

*Natural fire totals for the 2008 inventory include both anthropogenic and natural sources. Updated data distinguishing these sources are expected.

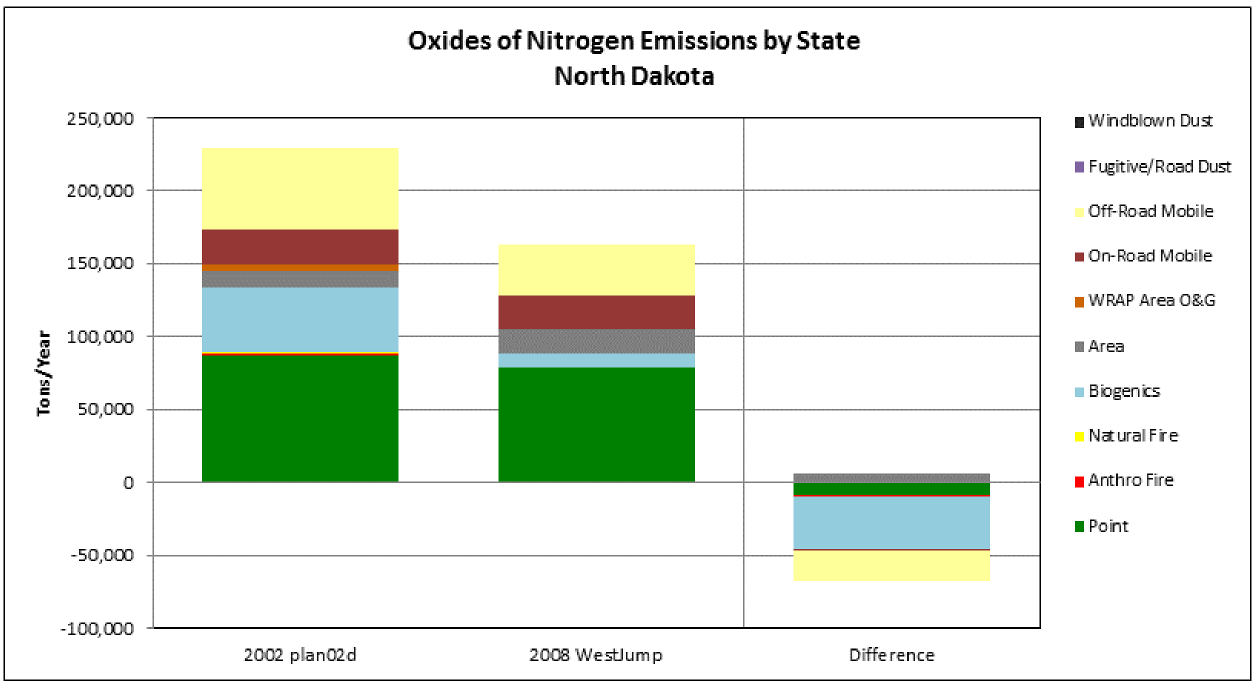

Figure 6.10-8. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Oxides of Nitrogen by Source Category for North Dakota.

Table 6.10-10
North Dakota
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	518	6,372	5,854
Area	118,398	78,857	-39,542
On-Road Mobile	732	345	-387
Off-Road Mobile	33	29	-4
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	619	529	-90
Total Anthropogenic	**120,300**	**86,131**	**-34,169 (-28%)**
Natural Sources			
Natural Fire	193	33	-160
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**193**	**33**	**-160 (-83%)**
All Sources			
Total Emissions	**120,493**	**86,164**	**-34,329 (-28%)**

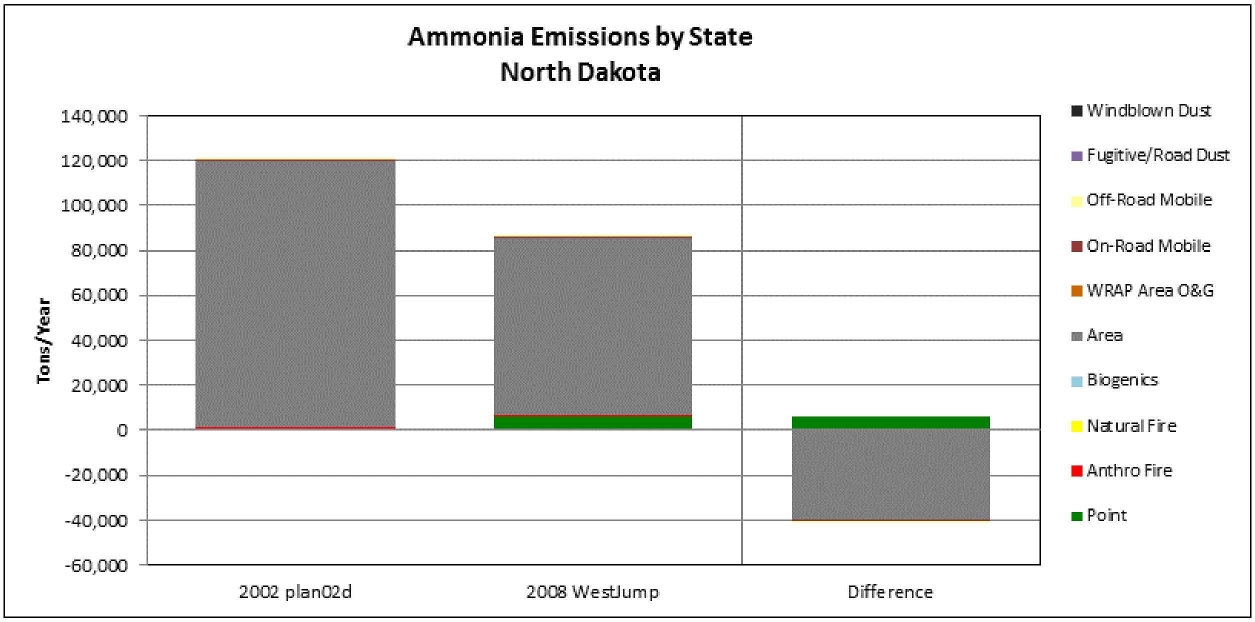

Figure 6.10-9. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Ammonia by Source Category for North Dakota.

Table 6.10-11
North Dakota
Volatile Organic Compound Emissions by Category

Source Category	Volatile Organic Compound Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	2,086	3,877	1,791
Area	60,455	21,194	-39,262
On-Road Mobile	12,814	10,928	-1,885
Off-Road Mobile	13,515	11,892	-1,623
Area Oil and Gas	7,740	0	-7,740
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	2,148	1,674	-474
Total Anthropogenic	**98,758**	**49,566**	**-49,192 (-50%)**
Natural Sources			
Natural Fire	1,701	52	-1,649
Biogenic	233,561	118,195	-115,366
Wind Blown Dust	0	0	0
Total Natural	**235,262**	**118,247**	**-117,015 (-50%)**
All Sources			
Total Emissions	**334,020**	**167,813**	**-166,207 (-50%)**

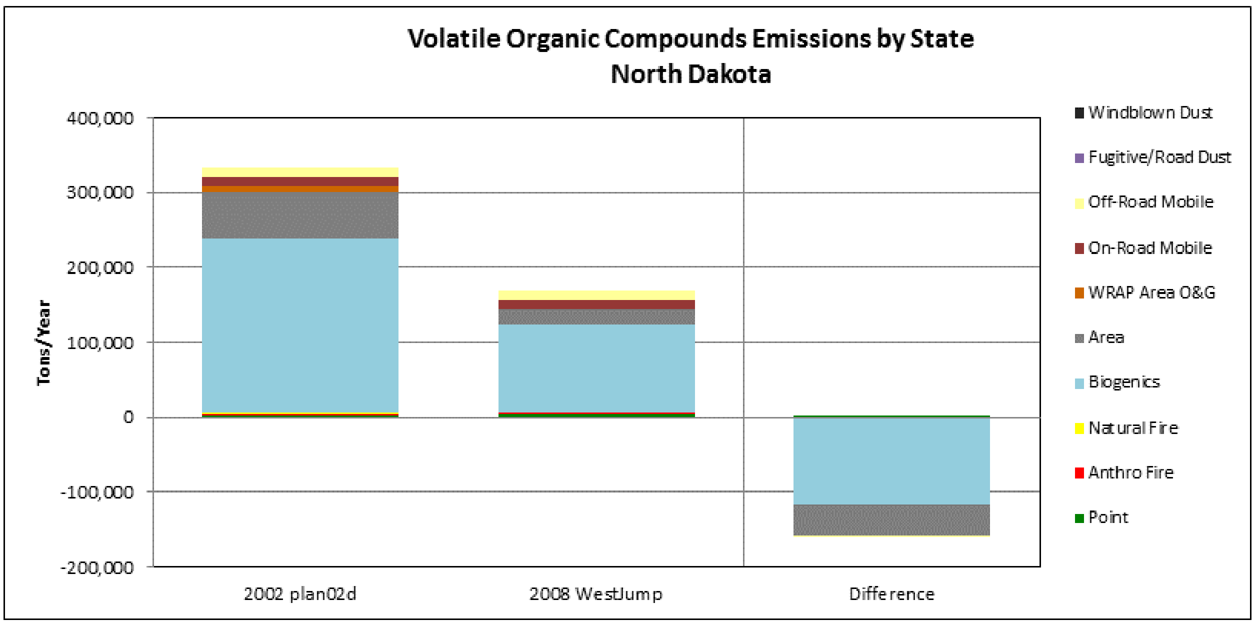

Figure 6.10-10. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for North Dakota.

Table 6.10-12
North Dakota
Primary Organic Aerosol Emissions by Category

Source Category	**Primary Organic Aerosol Emissions (tons/year)**		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	262	144	-118
Area	1,466	920	-546
On-Road Mobile	231	680	449
Off-Road Mobile	1,034	794	-240
Area Oil and Gas	0	0	0
Fugitive and Road Dust	2,190	1,874	-316
Anthropogenic Fire	1,443	990	-452
Total Anthropogenic	**6,626**	**5,402**	**-1,223 (-18%)**
Natural Sources			
Natural Fire	2,214	82	-2,132
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**2,214**	**82**	**-2,132 (-96%)**
All Sources			
Total Emissions	**8,840**	**5,485**	**-3,355 (-38%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

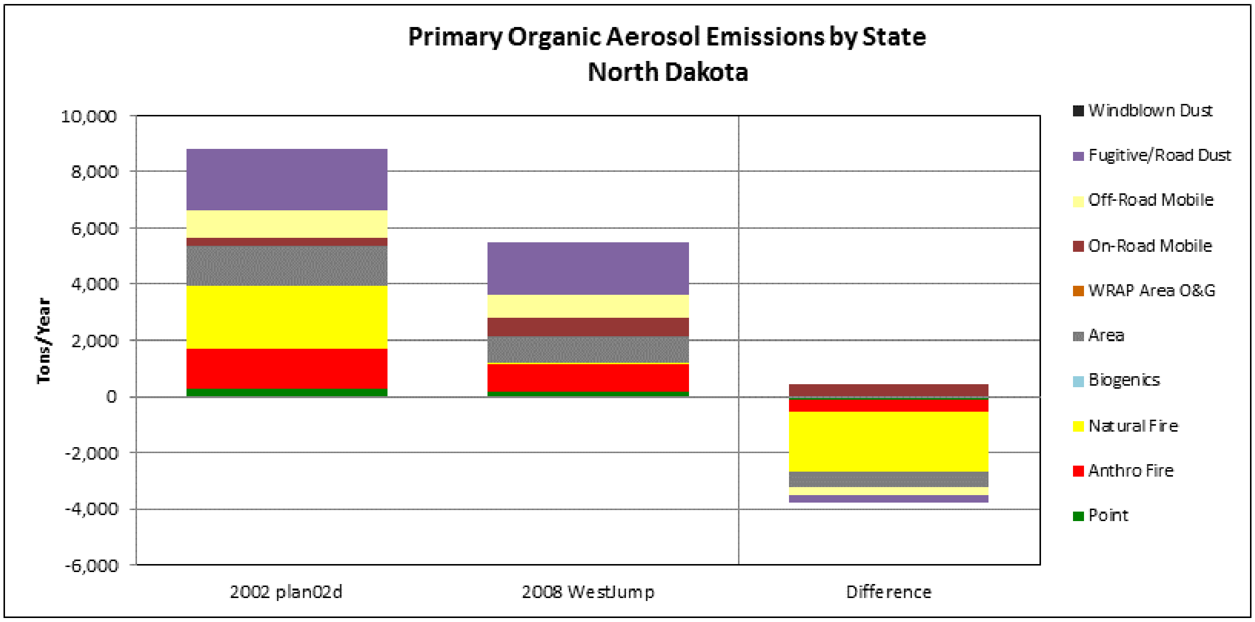

Figure 6.10-11. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Primary Organic Aerosol by Source Category for North Dakota.

Table 6.10-13
North Dakota
Elemental Carbon Emissions by Category

Source Category	Elemental Carbon Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	29	6	-23
Area	262	454	192
On-Road Mobile	272	994	722
Off-Road Mobile	3,625	2,337	-1,288
Area Oil and Gas	0	0	0
Fugitive and Road Dust	150	25	-124
Anthropogenic Fire	86	307	221
Total Anthropogenic	**4,423**	**4,124**	**-299 (-7%)**
Natural Sources			
Natural Fire	423	37	-387
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**423**	**37**	**-387 (-91%)**
All Sources			
Total Emissions	**4,847**	**4,161**	**-686 (-14%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

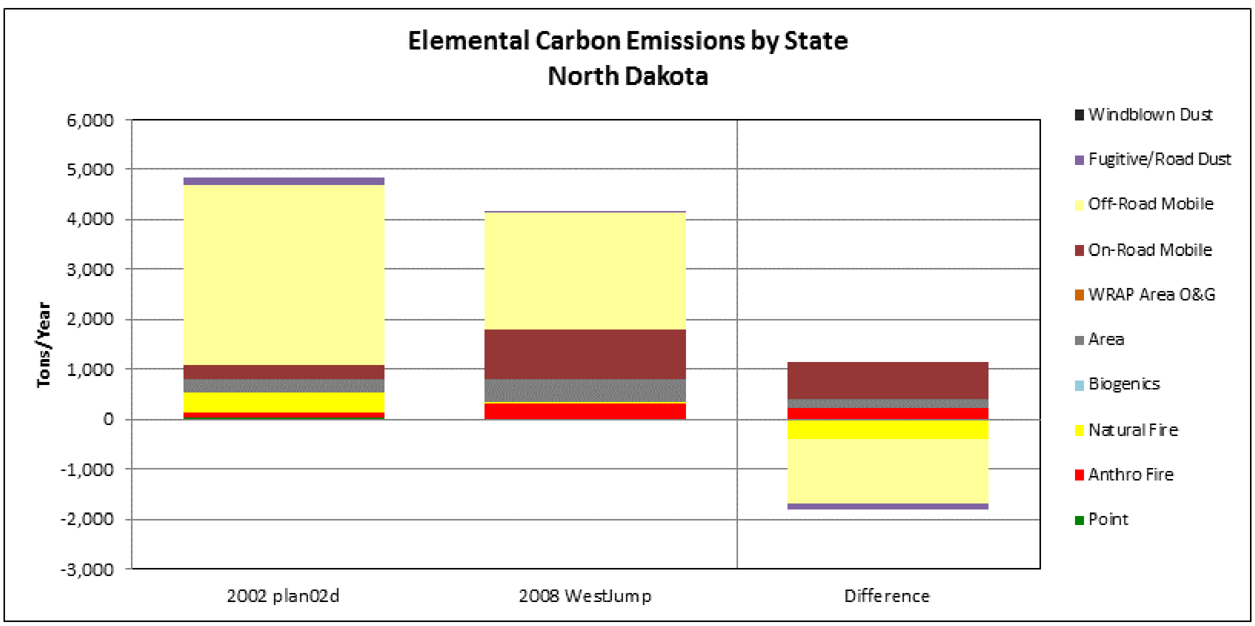

Figure 6.10-12. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Elemental Carbon by Source Category for North Dakota.

Table 6.10-14
North Dakota
Fine Soil Emissions by Category

Source Category	Fine Soil Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	2,002	122	-1,880
Area	1,617	413	-1,204
On-Road Mobile	149	98	-52
Off-Road Mobile	0	54	54
Area Oil and Gas	0	0	0
Fugitive and Road Dust	39,440	42,148	2,708
Anthropogenic Fire	596	403	-194
Total Anthropogenic	**43,805**	**43,237**	**-567 (-1%)**
Natural Sources			
Natural Fire	225	31	-194
Biogenic	0	0	0
Wind Blown Dust	17,639	15,784	-1,855
Total Natural	**17,864**	**15,815**	**-2,049 (-11%)**
All Sources			
Total Emissions	**61,669**	**59,052**	**-2,616 (-4%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

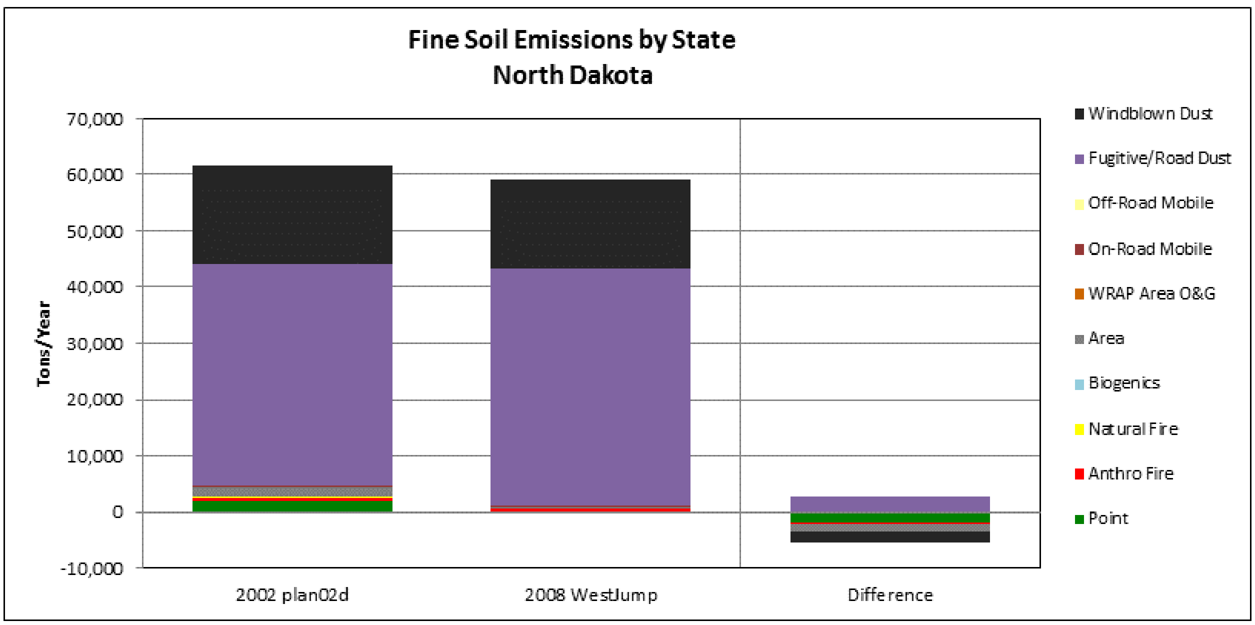

Figure 6.10-13. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Fine Soil by Source Category for North Dakota.

Table 6.10-15
North Dakota
Coarse Mass Emissions by Category

Source Category	Coarse Mass Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	565	651	86
Area	199	99	-100
On-Road Mobile	141	1,102	961
Off-Road Mobile	0	109	109
Area Oil and Gas	0	0	0
Fugitive and Road Dust	200,777	208,858	8,081
Anthropogenic Fire	62	191	129
Total Anthropogenic	**201,743**	**211,010**	**9,267 (5%)**
Natural Sources			
Natural Fire	441	16	-425
Biogenic	0	0	0
Wind Blown Dust	158,752	142,061	-16,691
Total Natural	**159,193**	**142,077**	**-17,116 (-11%)**
All Sources			
Total Emissions	**360,936**	**353,087**	**-7,849 (-2%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

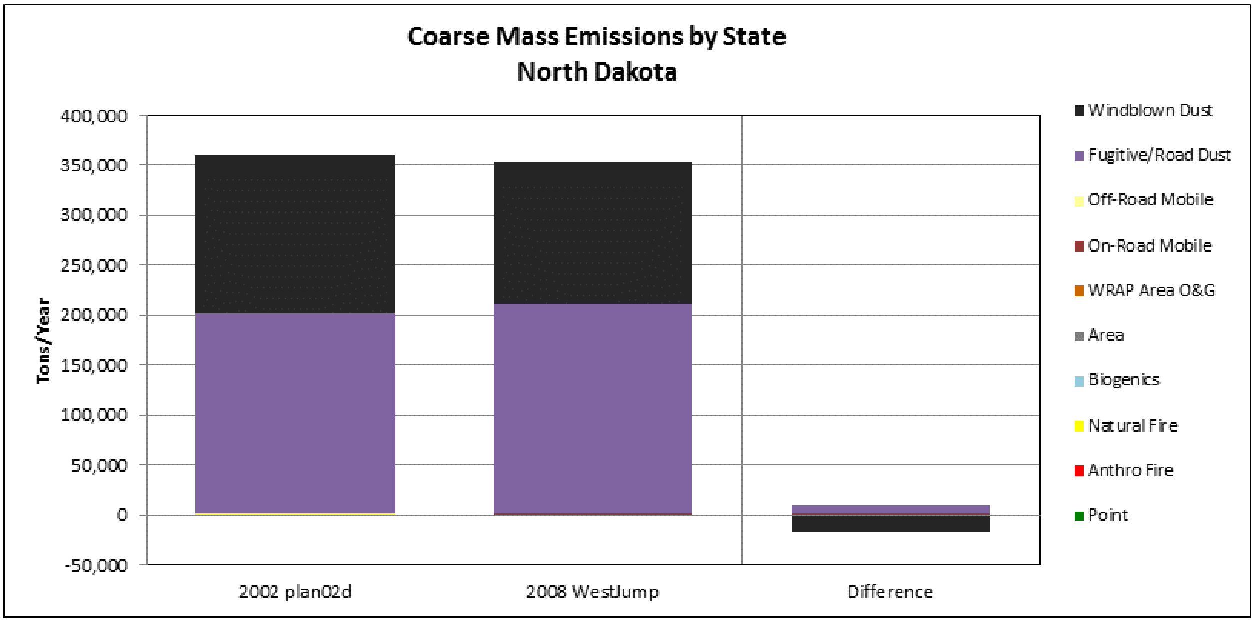

Figure 6.10-14. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Coarse Mass by Source Category for North Dakota.

6.10.2.2 EGU Summary

As described in previous sections, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions because numerous updates in inventory methodologies have occurred between the development of the separate inventories. Also, the 2002 baseline and 2008 progress period inventories represent only annual snapshots of emissions estimates, which may not be representative of entire 5-year monitoring periods compared. To better account for year-to-year changes in emissions, annual emission totals for North Dakota electrical generating units (EGU) are presented here. EGU emissions are some of the more consistently reported emissions, as tracked in EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/). RHR implementation plans are required to pay specific attention to certain major stationary sources, including EGUs, built between 1962 and 1977.

Figure 6.10-17 presents a sum of annual NO_X and SO_2 emissions as reported for North Dakota EGU sources between 1996 and 2010. While these types of facilities are targeted for controls in state regional haze SIPs, it should be noted that many of the controls planned for EGUs in the WRAP states had not taken place yet in 2010, while other controls separate from the RHR may have been implemented. The chart shows periods of decline for both SO_2 and NO_X. The chart shows a fairly steady decline for both SO_2 and NO_X emissions in recent years.

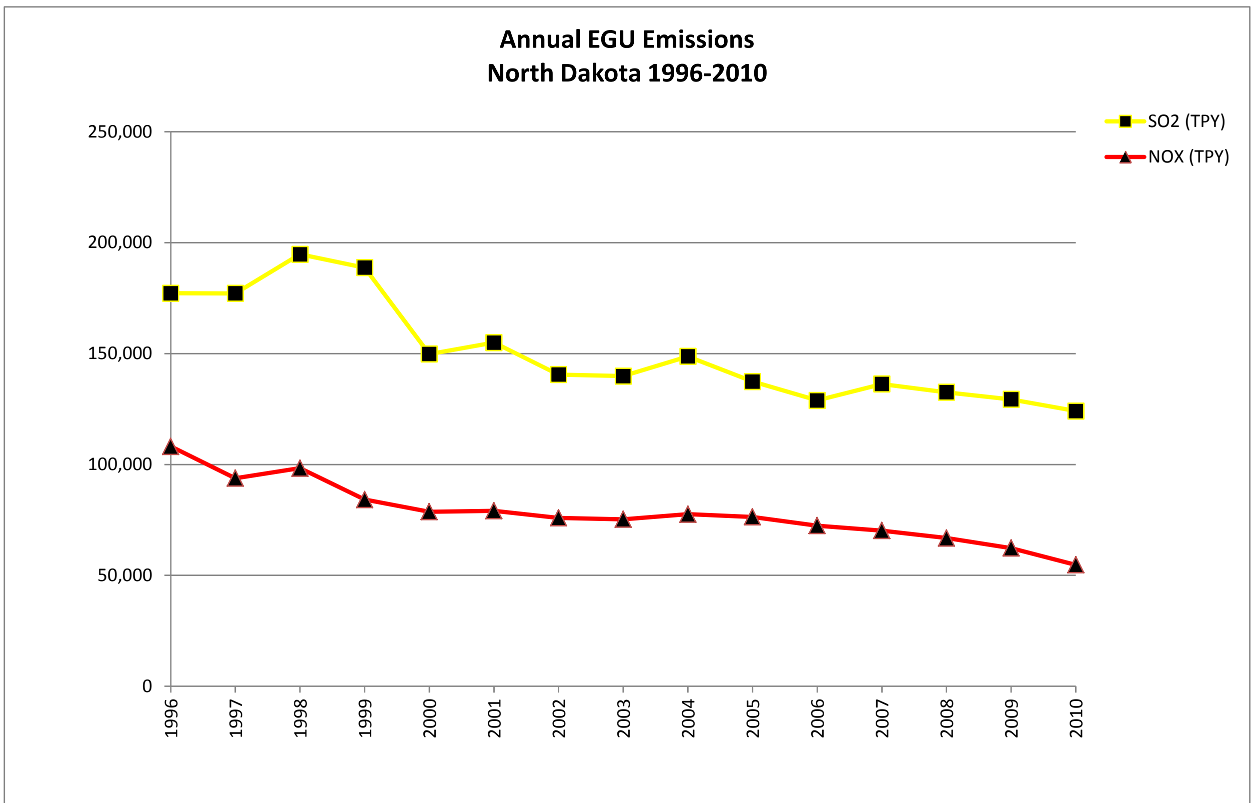

Figure 6.10-17. Sum of EGU Emissions of SO_2 and NO_X reported between 1996 and 2010 for North Dakota.

6.11 OREGON

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. Oregon has 12 mandatory Federal CIAs, and the State of Oregon additionally tracks progress at the Columbia River Gorge National Scenic Area. These CIAs and the IMPROVE monitors used to represent the CIAs and the scenic area are illustrated in Figure 6.11-1 and listed in Table 6.11-1, along with the associated IMPROVE monitor locations.

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per Regional Haze Rule (RHR) requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. Some of the highlights regarding these comparisons are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- For the best days, the 5-year average deciview metric decreased at all except the CORI1 and KALM1 sites. Note that the CORI1 site does not represent a Federal CIA, but the state of Oregon tracks regional haze progress at this site.
    - Increases on best days at both sites were small (0.3 dv at CORI1 and 0.1 dv at KALM1). At the CORI1 site, higher deciview values were due to increases in ammonium nitrate, soil, coarse mass and sea salt. At the KALM1 site, the only aerosol species that increased on the best days was sea salt.
- For the worst days, the 5-year average deciview metric decreased at most sites, but increased at the CRLA1, KALM1 and THSI1 sites.
- The largest increases in 5-year averages at the KALM1 and CRLA1 sites were due to particulate organic mass and ammonium sulfate.
    - For particulate organic mass, several wildland fire events during the summer months affected measurements at the sites for the current 5-year period. The largest events occurred at the KALM1 site in August 2008, and at the CRLA1 site in July 2007.
    - For ammonium sulfate, increases in 5-year averages were consistent with slightly increasing ammonium sulfate trends for the southwest Oregon and nearby northeast California sites. Emissions inventories showed decreases in state-wide SO_2 for all categories, but off-shore emissions that may affect these sites are not explicitly represented here.
- At the THSI1 site, coarse mass was the largest species contributor to increases in the 5-year average deciview metric. A slightly increasing annual average trend in coarse mass was also measured at the site, and emissions inventories showed increases in

fugitive and road dust sources for coarse mass, partially offset by decreases in point and area sources.

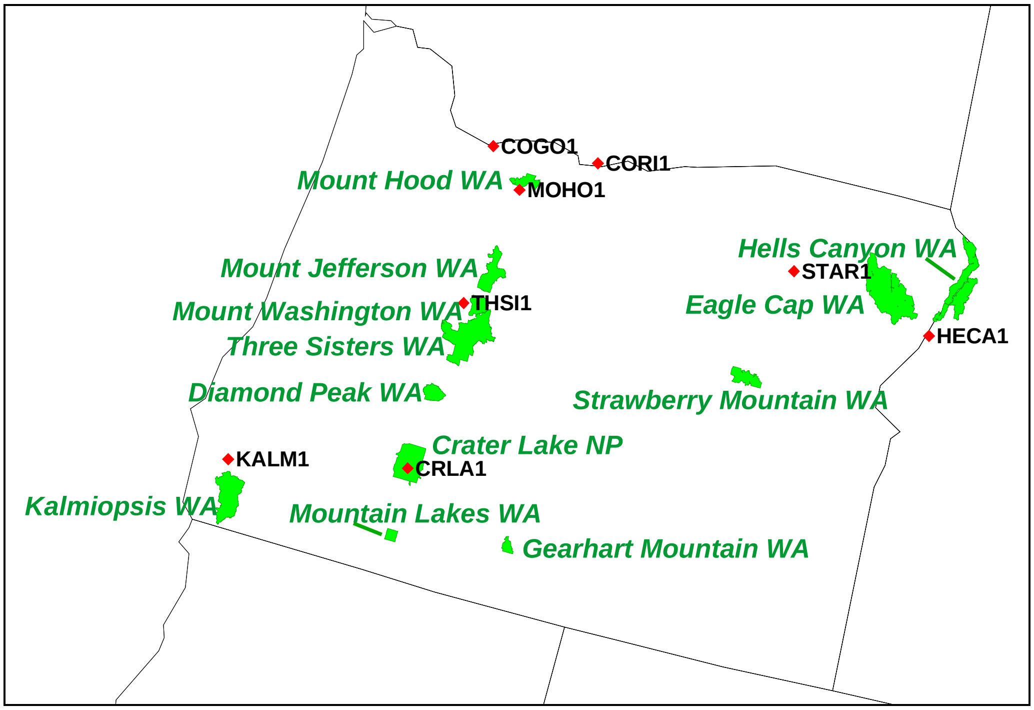

Figure 6.11-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in Oregon.

Table 6.11-1
Oregon CIAs and Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Crater Lake NP Diamond Peak WA Gearhart Mountain WA Mountain Lakes WA	CRLA1	42.90	-122.14	1996
Hells Canyon WA	HECA1	44.97	-116.84	655
Kalmiopsis WA	KALM1	42.55	-124.06	80
Mount Hood WA	MOHO1	45.29	-121.78	1531
Eagle Cap WA Strawberry Mountain WA	STAR1	45.22	-118.51	1259
Three Sisters WA Mount Washington WA Mount Jefferson WA	THSI1	44.29	-122.04	885
Columbia River Gorge*	CORI1	45.66	-121.00	178
	COGO1	45.57	-122.21	230

*Not a Federal CIA

6.11.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by IMPROVE monitors representing Federal CIAs in Oregon. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix K.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.11.1.1 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.308 (g)(3)(i))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[105] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.11-2 and 6.11-3 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired, or worst, and 20% least impaired, or best, days for each of the Federal CIA IMPROVE monitors in Oregon. Figure 6.11-2 presents 5-year average extinction for the current progress period for both the 20% most impaired and 20% least impaired days. Note that the percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired days are as follows:

- The largest contributors to aerosol extinction at Oregon sites were particulate organic mass, ammonium nitrate and ammonium sulfate.
- The highest aerosol extinction (22.9 dv) was measured at the CORI1 site, where ammonium nitrate was the largest contributor to aerosol extinction, followed by ammonium sulfate. The lowest aerosol extinction (13.7 dv) was measured at the MOHO1 site.

Specific observations for the current visibility conditions on the 20% least impaired days are as follows:

- The aerosol contribution to total extinction on the best days was less than Rayleigh, or the background scattering that would occur in clear air. Average extinction (including Rayleigh) ranged from 1.6 dv (CRLA1) to 9.9 dv (CORI1).
- For all sites except KALM1, ammonium sulfate was the largest non-Rayleigh contributor to the aerosol species of extinction
- At the KALM1 site, particulate organic mass was the largest contributor to aerosol extinction, followed by ammonium sulfate.

[105] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

Table 6.11-2
Oregon Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank*						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
CRLA1	13.8	21% (2)	4% (5)	**58% (1)**	9% (3)	2% (6)	5% (4)	0% (7)
COGO1	20.8	30% (2)	**33% (1)**	21% (3)	7% (4)	1% (7)	6% (5)	2% (6)
CORI1	22.9	24% (2)	**46% (1)**	14% (3)	5% (5)	2% (6)	8% (4)	1% (7)
HECA1	18.1	11% (3)	22% (2)	**52% (1)**	9% (4)	1% (6)	5% (5)	0% (7)
KALM1	16.4	26% (2)	7% (5)	**45% (1)**	8% (4)	1% (7)	5% (6)	8% (3)
MOHO1	13.7	31% (2)	13% (3)	**38% (1)**	7% (4)	2% (7)	7% (5)	2% (6)
STAR1	16.2	17% (3)	23% (2)	**43% (1)**	8% (4)	2% (6)	7% (5)	0% (7)
THSI1	16.2	25% (2)	5% (5)	**40% (1)**	8% (4)	3% (6)	18% (3)	1% (7)

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.11-3
Oregon Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
CRLA1	1.6	**42% (1)**	8% (5)	15% (3)	17% (2)	3% (7)	7% (6)	8% (4)
COGO1	9.2	**29% (1)**	16% (3)	25% (2)	11% (4)	1% (7)	8% (6)	10% (5)
CORI1	9.9	**27% (1)**	16% (4)	18% (2)	10% (5)	4% (7)	18% (3)	7% (6)
HECA1	4.8	**36% (1)**	12% (3)	28% (2)	8% (5)	3% (6)	10% (4)	3% (7)
KALM1	6.4	26% (2)	5% (6)	**37% (1)**	11% (4)	1% (7)	8% (5)	12% (3)
MOHO1	1.7	**50% (1)**	13% (3)	9% (4)	5% (6)	2% (7)	6% (5)	15% (2)
STAR1	3.6	**43% (1)**	13% (3)	20% (2)	7% (6)	2% (7)	8% (4)	7% (5)
THSI1	3.0	**48% (1)**	9% (4)	18% (2)	7% (5)	1% (7)	7% (6)	11% (3)

*Highest aerosol species contribution per site is highlighted in bold.

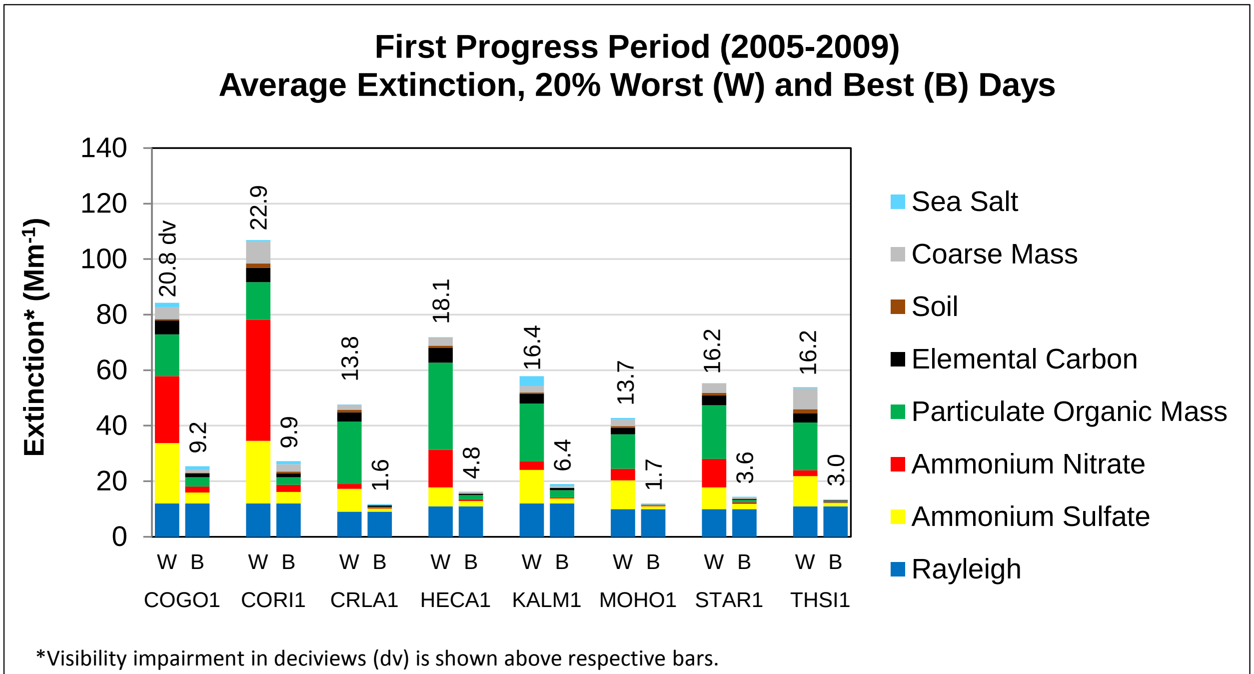

Figure 6.11-2. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at Oregon Class I Area IMPROVE Sites.

6.11.1.2 Differences Between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.308 (g)(3)(ii))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Table 6.11-4 presents the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for each site in Oregon for the 20% most impaired days, and Table 6.11-5 presents similar data for the least impaired days. Averages that increased are depicted in red text and averages that decreased in blue.

Figure 6.11-3 presents the 5-year average extinction for the baseline and current progress period averages for the worst days and Figure 6.11-4 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.11-5 and 6.11-6 present similar plots for the best days.

For the 20% most impaired days, the 5-year average RHR deciview metric increased between the 2000-2004 and 2005-2009 periods at the CRLA1, KALM1, and THSI1 sites and decreased at the COGO1, CORI1, HECA1, MOHO1, and STAR1 sites. Notable differences for individual species averages were as follows:

- Ammonium nitrate decreased at all sites except KALM1, where the 5-year average remained the same. The largest decreases were measured at the CORI1 and HECA1 sites.
- At the CRLA1 and KALM1 sites, where the average deciview value increased, ammonium sulfate and particulate organic mass contributed to the largest increases in extinction.
- At the THSI1 site, coarse mass and soil were the largest aerosol species contributors to the increase in the deciview average at the site.

For the 20% least impaired days, the 5-year average deciview metric decreased at all sites except CORI1 and KALM1. Notable differences for individual species averages on the 20% least impaired days were as follows:

- The increase in 5-year average deciviews at the CORI1 site was due to increases in soil, coarse mass, sea salt and ammonium sulfate.
- The increase at the KALM1 site was due to increases in ammonium sulfate and sea salt.

Table 6.11-4
Oregon Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
COGO1	23.1	20.8	-2.3	-3.4	-9.5	-10.2	-1.0	-0.1	+0.2	+0.7
CORI1	24.7	22.9	-1.8	-0.7	-20.6	-5.3	-0.5	+0.9	+3.5	+0.4
CRLA1	13.7	13.8	+0.1	+0.9	-0.9	+1.1	-1.0	0.0	-0.5	+0.1
HECA1	18.6	18.1	-0.5	-1.6	-15.0	+15.8	+2.2	+0.2	+1.0	+0.1
KALM1	15.5	16.4	+0.9	+1.7	0.0	+6.2	+1.0	0.0	+0.2	+0.7
MOHO1	14.9	13.7	-1.2	-1.0	-1.3	-2.1	-0.5	-0.1	-0.2	+0.6
STAR1	18.6	16.2	-2.4	0.0	-5.5	-4.8	-0.6	-0.3	-1.5	0.0
THSI1	15.3	16.2	+0.9	-1.0	-0.5	0.0	+0.1	+0.8	+4.9	+0.2

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.11-5
Oregon Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	**2005-09 Progress Period**	**Change in dv***	**Amm. Sulfate**	**Amm. Nitrate**	**POM**	**EC**	**Soil**	**CM**	**Sea Salt**
COGO1	9.3	9.2	-0.1	-0.2	-0.4	0.0	-0.1	0.0	+0.1	+0.3
CORI1	9.6	9.9	+0.3	-0.3	+0.2	0.0	0.0	+0.3	+0.3	+0.3
CRLA1	1.7	1.6	-0.1	+0.2	0.0	-0.2	-0.2	0.0	0.0	+0.1
HECA1	5.5	4.8	-0.7	0.0	-0.2	-0.5	-0.1	-0.1	-0.3	+0.1
KALM1	6.3	6.4	+0.1	+0.3	0.0	-0.1	-0.1	0.0	0.0	+0.2
MOHO1	2.2	1.7	-0.5	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0
STAR1	4.5	3.6	-0.9	-0.1	-0.1	-0.8	-0.2	0.0	-0.2	+0.1
THSI1	3.0	3.0	0.0	+0.1	-0.1	0.0	0.0	0.0	0.0	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

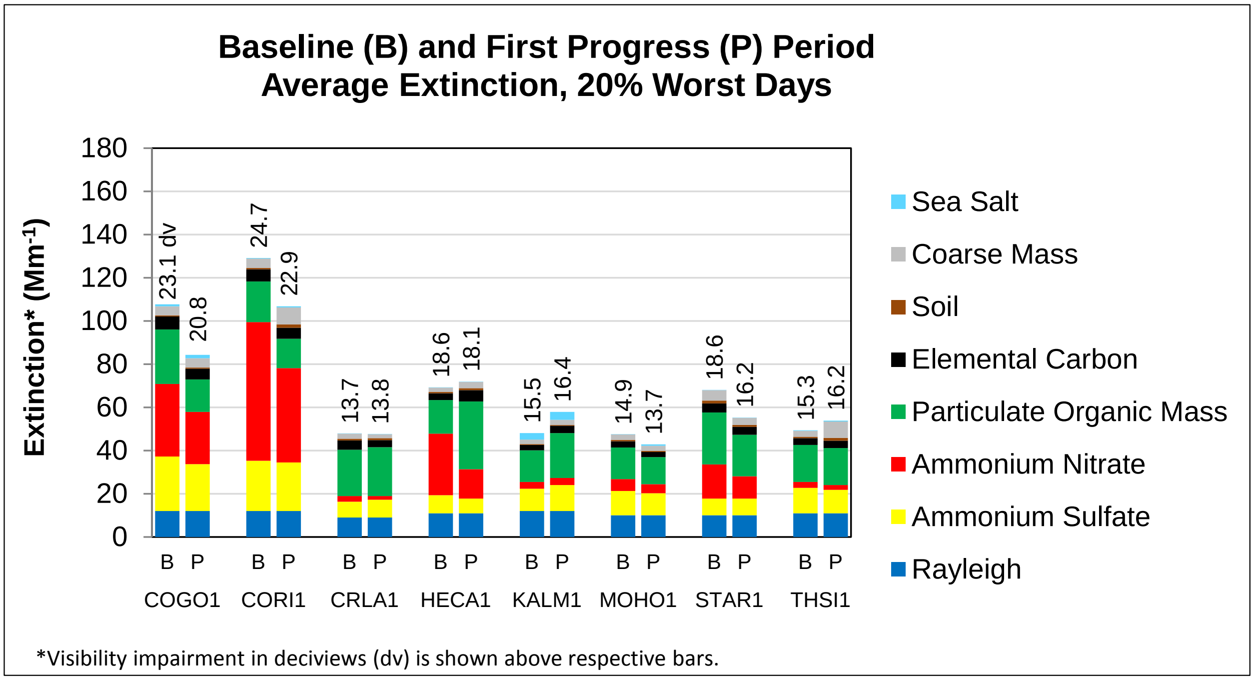

Figure 6.11-3. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at Oregon Class I Area IMPROVE Sites.

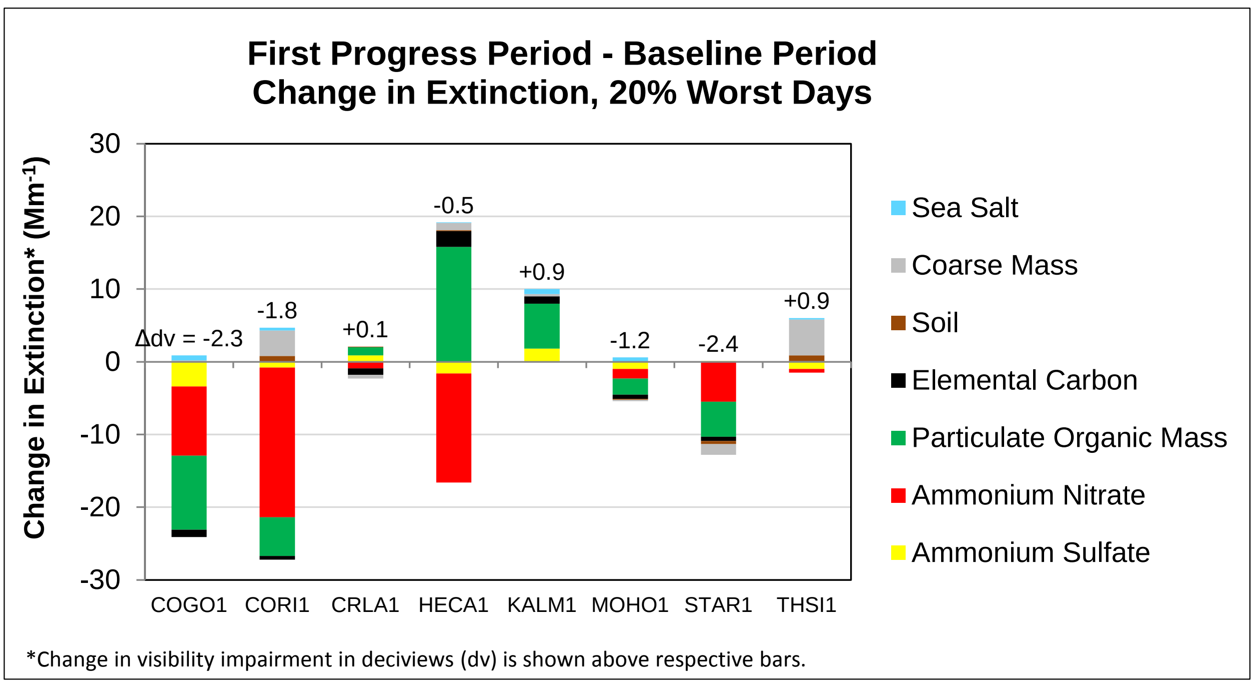

Figure 6.11-4. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at Oregon Class I Area IMPROVE Sites.

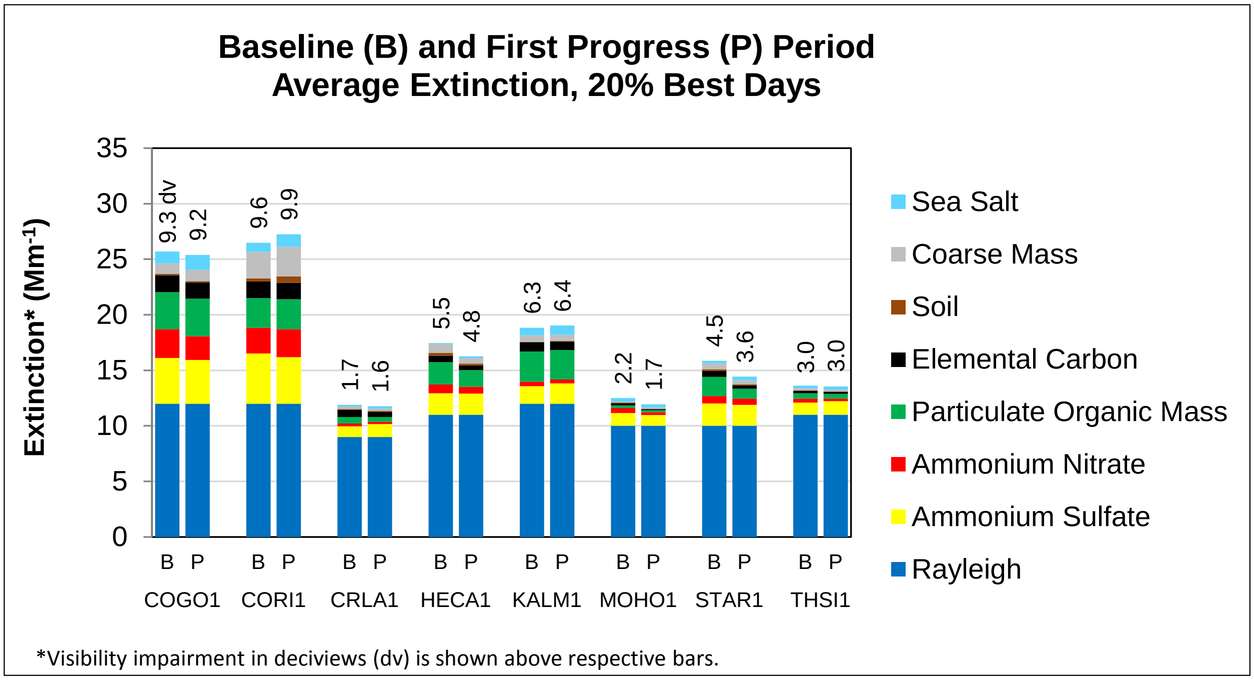

Figure 6.11-5. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at Oregon Class I Area IMPROVE Sites.

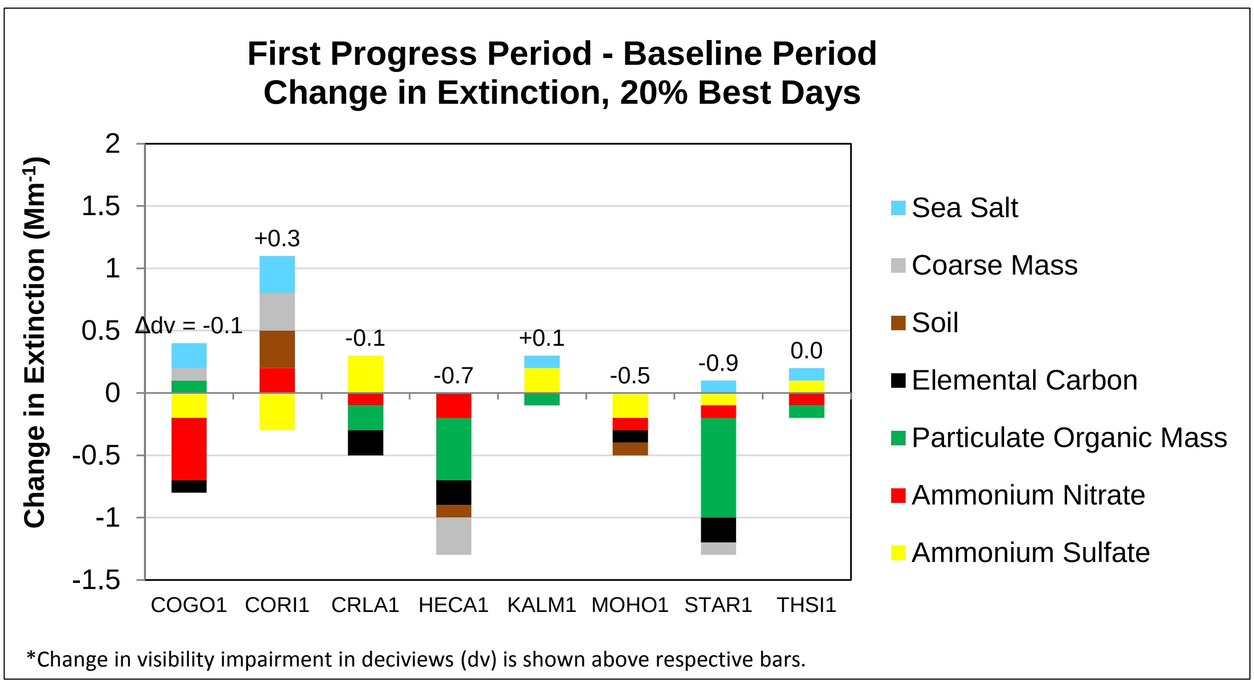

Figure 6.11-6. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at Oregon Class I Area IMPROVE Sites.

6.11.1.3 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.308 (g)(3)(iii))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5 year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10 year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in Oregon are summarized in Table 6.11-6, and regional trends were presented earlier in Section 4.1.1.[106] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[107] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix K. Additionally, this appendix includes plots depicting 5-year, annual, monthly and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in Oregon are as follows:

- Ammonium nitrate showed decreasing annual average trends for the worst days at all Oregon sites, with the largest decreases measured at the HECA1, STAR1, CORI1, and COGO1 sites.
- Large particulate organic mass events occurred at all sites, generally between August and September. Monthly and daily charts in Appendix K indicate that the largest events occurred in August 2005 at KALM1, August and September 2006 at CRLA1,

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[106] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)
[107] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

HECA1, MOHO1, and STAR1, July 2007 at HECA1 and July through September 2008 at CRLA1 and MOHO1.

- The increase in the deciview metric between the baseline period and the progress on the worst days at the THSI1 site was mostly due to coarse mass. Daily extinction plots in Appendix K indicate that this was due an anomalous increase in coarse mass measured between July and September of 2009 at the site.

Table 6.11-6
Oregon Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
COGO1	20% Best	--	-0.1	--	0.0	0.0	0.0	--
	20% Worst	-0.3	-2.6	-2.1	-0.4	--	--	--
	All Days	-0.4	-0.8	-0.4	-0.2	--	-0.1	--
CORI1	20% Best	--	--	--	--	--	--	--
	20% Worst	--	-4.3	-1.1	--	--	--	--
	All Days	-0.2	-0.9	-0.6	-0.1	0.1	--	--
CRLA1	20% Best	--	--	0.0	0.0	--	--	0.0
	20% Worst	0.3	--	--	-0.2	--	--	0.0
	All Days	--	-0.1	--	-0.1	--	0.0	0.0
HECA1	20% Best	--	--	-0.1	0.0	0.0	-0.1	--
	20% Worst	-0.4	-3.7	1.6	--	--	0.3	--
	All Days	--	-0.8	--	--	--	--	--
KALM1	20% Best	--	--	--	--	--	0.0	0.0
	20% Worst	0.4	--	--	--	--	--	--
	All Days	0.1	-0.1	--	-0.1	--	--	0.1
MOHO1	20% Best	-0.1	0.0	0.0	0.0	--	--	0.0
	20% Worst	--	-0.3	--	--	--	--	0.0
	All Days	-0.1	-0.1	--	-0.1	--	--	--
STAR1	20% Best	--	--	-0.2	-0.1	0.0	0.0	--
	20% Worst	--	-1.8	-1.5	-0.3	--	--	--
	All Days	--	-0.4	-0.6	-0.2	--	-0.1	--
THSI1	20% Best	--	0.0	--	0.0	0.0	--	--
	20% Worst	-0.3	-0.1	--	--	0.0	0.4	0.0
	All Days	-0.1	-0.1	--	0.0	0.0	0.1	--

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix K.

6.11.2 Emissions Data

Included here are summaries depicting differences between two emission inventory years that are used to represent the 5-year baseline and current progress periods. The baseline period is represented using a 2002 inventory developed by the WRAP for use in the initial WRAP state SIPs, and the progress period is represented by a 2008 inventory which leverages recent WRAP inventory work for modeling efforts, as referenced in Section 3.2.1. For reference, Table 6.11-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories, and a separate summary of annual emissions from electrical generating units (EGUs), are presented in this section.

Table 6.11-7
Oregon
Pollutants, Aerosol Species, and Major Sources

Emitted Pollutant	Related Aerosol	Major Sources	Notes
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- and Off-Road Mobile Sources	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be associated with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Primary Organic Aerosol (POA)	POM	Wildfires; Area Sources	POA represents organic aerosols that are emitted directly as particles, as opposed to gases. Wildfires in the west generally dominate POA emissions, and large wildfire events are generally sporadic and highly variable from year-to-year.
Elemental Carbon (EC)	EC	Wildfires; On- and Off-Road Mobile Sources	Large EC events are often associated with large POM events during wildfires. Other sources include both on- and off-road diesel engines.
Fine soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is reported by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$ mass measurements. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but these measurements are generally associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributor to PMC.

6.11.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.308 (g)(4))?*** For these summaries, emissions during the baseline years are represented using a 2002 inventory, which was developed with support from the WRAP for use in the original RHR SIP strategy development (termed plan02d). Differences between inventories are represented as the difference between the 2002 inventory, and a 2008 inventory which leverages recent inventory development work performed by the WRAP for the WestJumpAQMS and DEASCO_3 modeling projects (termed WestJump2008). Note that the comparisons of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories, as referenced in Section 3.2.1. Inventories for all major visibility impairing pollutants are presented for major source categories, and categorized as either anthropogenic or natural emissions. State-wide inventories totals and differences are presented here, and inventory totals on a county level basis are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

Table 6.11-8 and Figure 6.11-7 present the differences between the 2002 and 2008 sulfur dioxide (SO_2) inventories by source category. Tables 6.11-9 and Figure 6.11-8 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.11-10 through 6.11-15 and Figures 6.11-9 through 6.11-14) present data for ammonia (NH_3), volatile organic compounds (VOCs), primary organic aerosol (POA), elemental carbon (EC), fine soil and coarse mass. General observations regarding emissions inventory comparisons are listed below.

- Largest differences for point source inventories were decreases in SO_2, NO_X, VOCs, fine soil, and coarse mass.
- Area source inventories showed decreases in all parameters except NO_X. These changes may be due to a combination of population changes and differences in methodologies used to estimate these emissions, as referenced in Section 3.2.1. One methodology change was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to increases in area source inventory totals, but decreases in off-road mobile totals.
- On-road mobile source inventory comparisons showed decreases in most parameters, especially NO_X and VOCs, with slight increases in POA, EC, and coarse mass. Reductions in NO_X and VOC are likely influenced by federal and state emissions standards that have already been implemented. The increases in POA, EC, and coarse mass occurred in all of the WRAP states for on-road mobile inventories, regardless of reductions in NO_2 and VOCs, indicating that these increases were likely due use of different on-road models, as referenced in Section 3.2.1.
- Off-road mobile source inventories showed decreases in NO_X, SO_2, and VOCs, and slight increases in fine soil and coarse mass, which was consistent with most contiguous WRAP states. These differences were likely due to a combination of actual changes in source contributions and methodology differences, as referenced in

Section 3.2.1. As noted previously, one major methodology difference was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to decreases in the off-road inventory totals, but increases in area source totals.

- For most parameters, especially POAs, VOCs, and EC, natural fire emission inventory estimates decreased, and anthropogenic fire estimates increased. Note that these differences are not necessarily reflective of changes in monitored data, as the baseline period is represented by an average of 2000-2004 fire emissions, and the progress period is represented only by the fires that occurred in 2008, as referenced in Section 3.2.1.
- Comparisons between VOC inventories showed large decreases in biogenic emissions, which was consistent with other contiguous WRAP states. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions, as referenced in Section 3.2.1.
- Fine soil and coarse mass decreased for the windblown dust inventory comparisons and increased for the combined fugitive/road dust inventories. Large variability in changes in windblown dust was observed for the contiguous WRAP states, which was likely due in large part to enhancements in dust inventory methodology, as referenced in Section 3.2.1, rather than changes in actual emissions.

Table 6.11-8
Oregon
Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	18,493	15,918	-2,575
Area	9,932	1,528	-8,404
On-Road Mobile	3,446	654	-2,792
Off-Road Mobile	6,535	431	-6,104
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	1,586	1,403	-182
Total Anthropogenic	**39,992**	**19,934**	**-20,058 (-50%)**
Natural Sources			
Natural Fire	7,328	1,207	-6,121
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**7,328**	**1,207**	**-6,121 (-84%)**
All Sources			
Total Emissions	**47,320**	**21,140**	**-26,180 (-55%)**

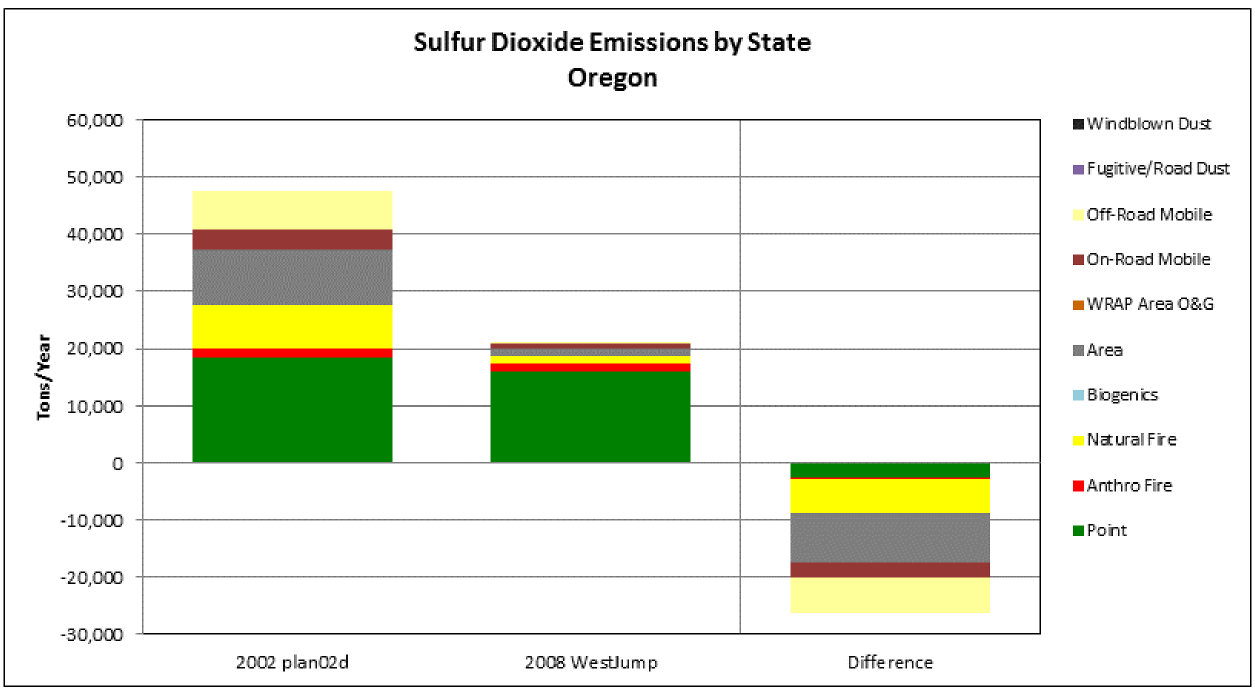

Figure 6.11-7. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for Oregon.

Table 6.11-9
Oregon
Oxides of Nitrogen Emissions by Category

Source Category	Oxides of Nitrogen Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	26,160	23,548	-2,612
Area	14,740	24,121	9,381
On-Road Mobile	111,646	98,399	-13,247
Off-Road Mobile	53,896	23,463	-30,434
Area Oil and Gas	85	0	-85
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	6,292	9,923	3,630
Total Anthropogenic	**212,819**	**179,453**	**-33,366 (-16%)**
Natural Sources			
Natural Fire	27,397	8,521	-18,876
Biogenic	16,527	5,560	-10,967
Wind Blown Dust	0	0	0
Total Natural	**43,924**	**14,081**	**-29,843 (-68%)**
All Sources			
Total Emissions	**256,744**	**193,534**	**-63,209 (-25%)**

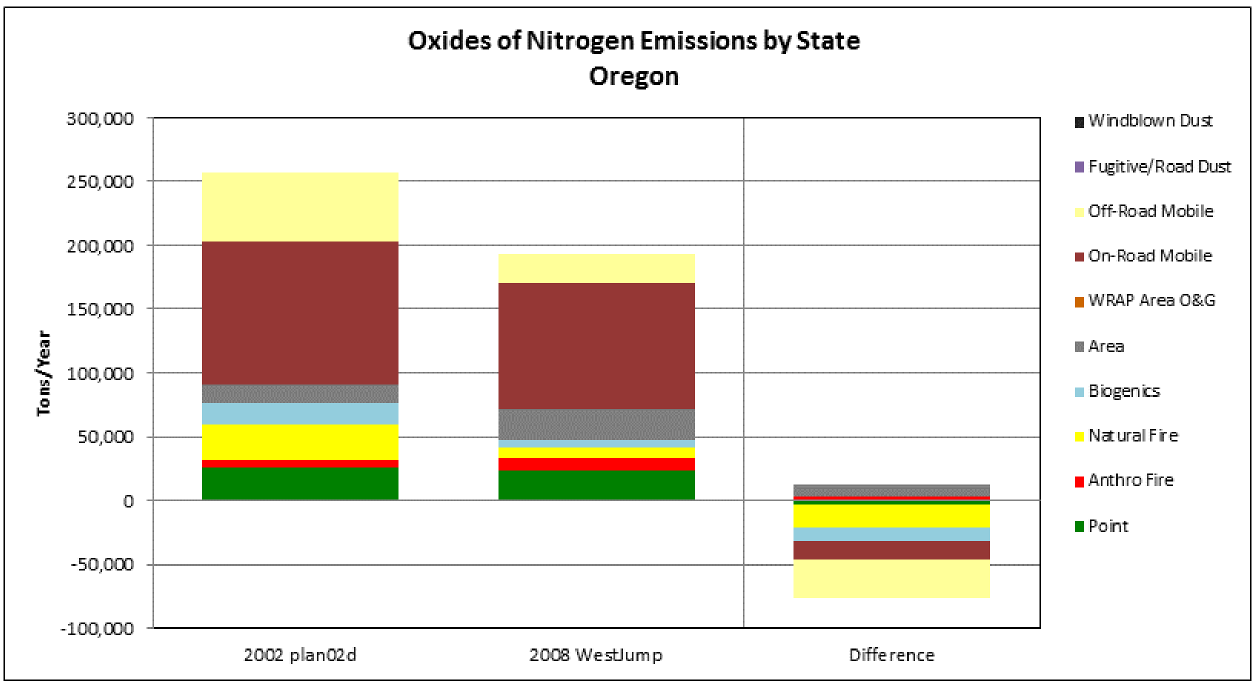

Figure 6.11-8. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Oxides of Nitrogen by Source Category for Oregon.

Table 6.11-10
Oregon
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	919	255	-664
Area	45,591	43,814	-1,777
On-Road Mobile	3,263	1,668	-1,594
Off-Road Mobile	39	27	-12
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	1,211	6,900	5,690
Total Anthropogenic	**51,022**	**52,665**	**1,643 (3%)**
Natural Sources			
Natural Fire	6,132	5,907	-225
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**6,132**	**5,907**	**-225 (-4%)**
All Sources			
Total Emissions	**57,154**	**58,571**	**1,418 (2%)**

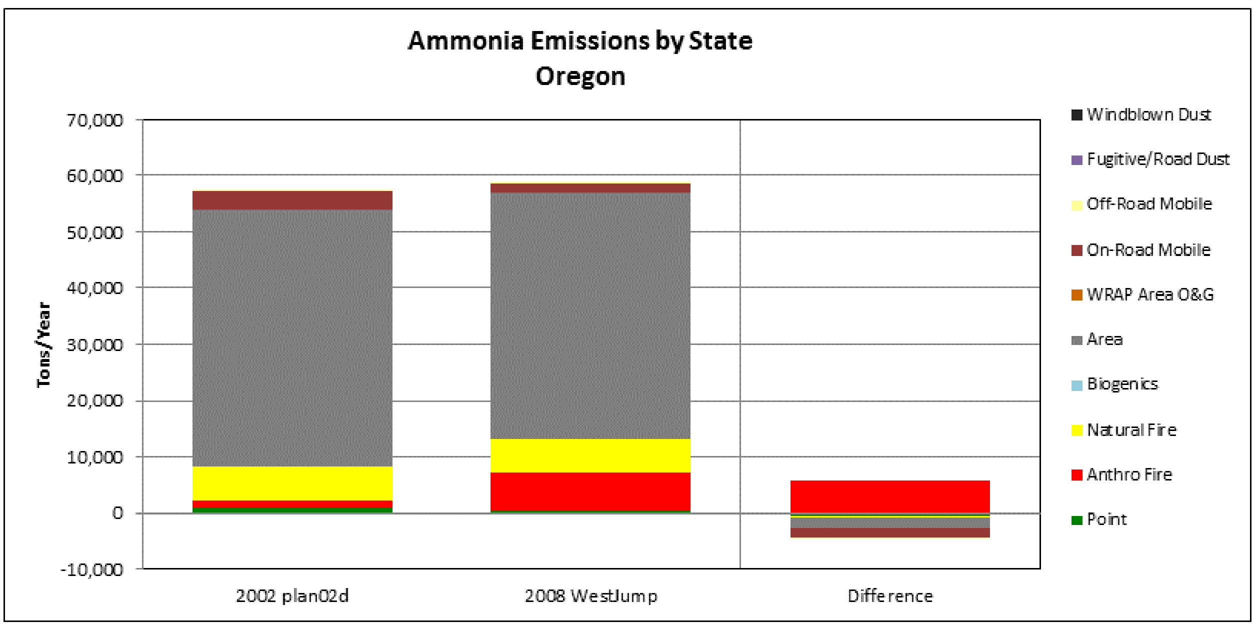

Figure 6.11-9. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Ammonia by Source Category for Oregon.

Table 6.11-11
Oregon
Volatile Organic Compound Emissions by Category

Source Category	Volatile Organic Compound Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	28,762	8,554	-20,208
Area	245,649	63,741	-181,908
On-Road Mobile	88,784	39,649	-49,135
Off-Road Mobile	39,516	33,308	-6,208
Area Oil and Gas	34	0	-34
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	9,939	9,639	-300
Total Anthropogenic	**412,685**	**154,891**	**-257,793 (-62%)**
Natural Sources			
Natural Fire	60,336	9,023	-51,314
Biogenic	1,148,266	339,630	-808,636
Wind Blown Dust	0	0	0
Total Natural	**1,208,602**	**348,653**	**-859,950 (-71%)**
All Sources			
Total Emissions	**1,621,287**	**503,544**	**-1,117,743 (-69%)**

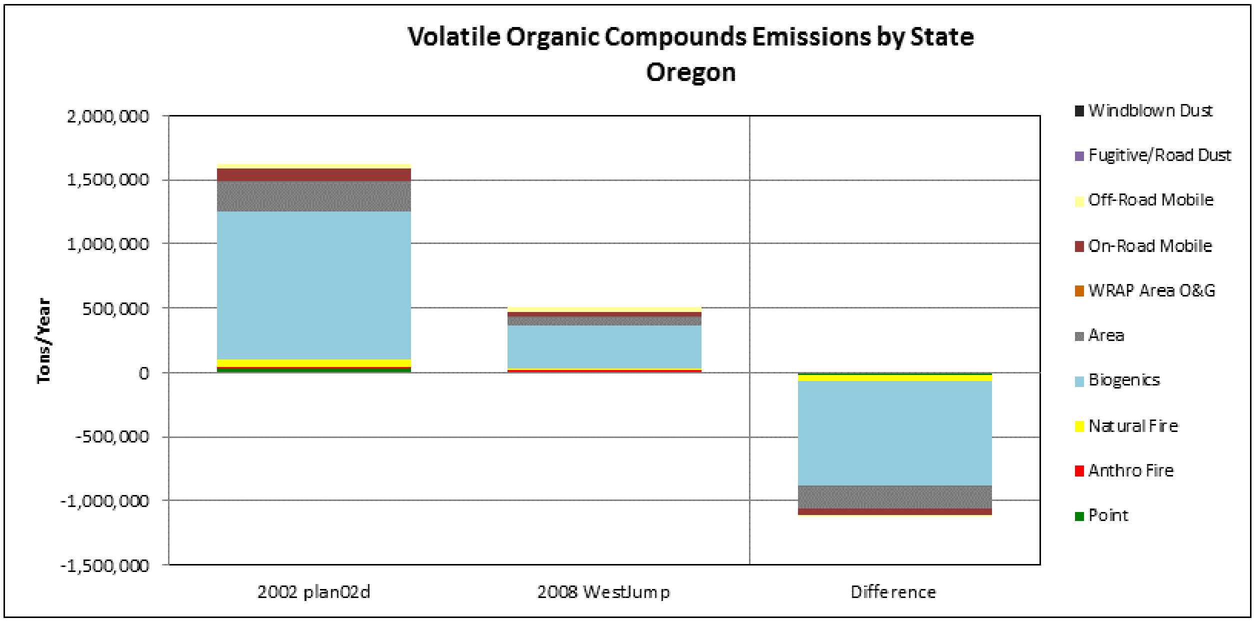

Figure 6.11-10. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for Oregon.

Table 6.11-12
Oregon
Primary Organic Aerosol Emissions by Category

Source Category	Primary Organic Aerosol Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	1,445	88	-1,358
Area	22,281	10,459	-11,822
On-Road Mobile	1,009	2,314	1,305
Off-Road Mobile	1,323	1,005	-318
Area Oil and Gas	0	0	0
Fugitive and Road Dust	298	617	319
Anthropogenic Fire	10,937	19,073	8,136
Total Anthropogenic	**37,293**	**33,555**	**-3,738 (-10%)**
Natural Sources			
Natural Fire	81,047	17,462	-63,585
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**81,047**	**17,462**	**-63,585 (-78%)**
All Sources			
Total Emissions	**118,340**	**51,017**	**-67,323 (-57%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

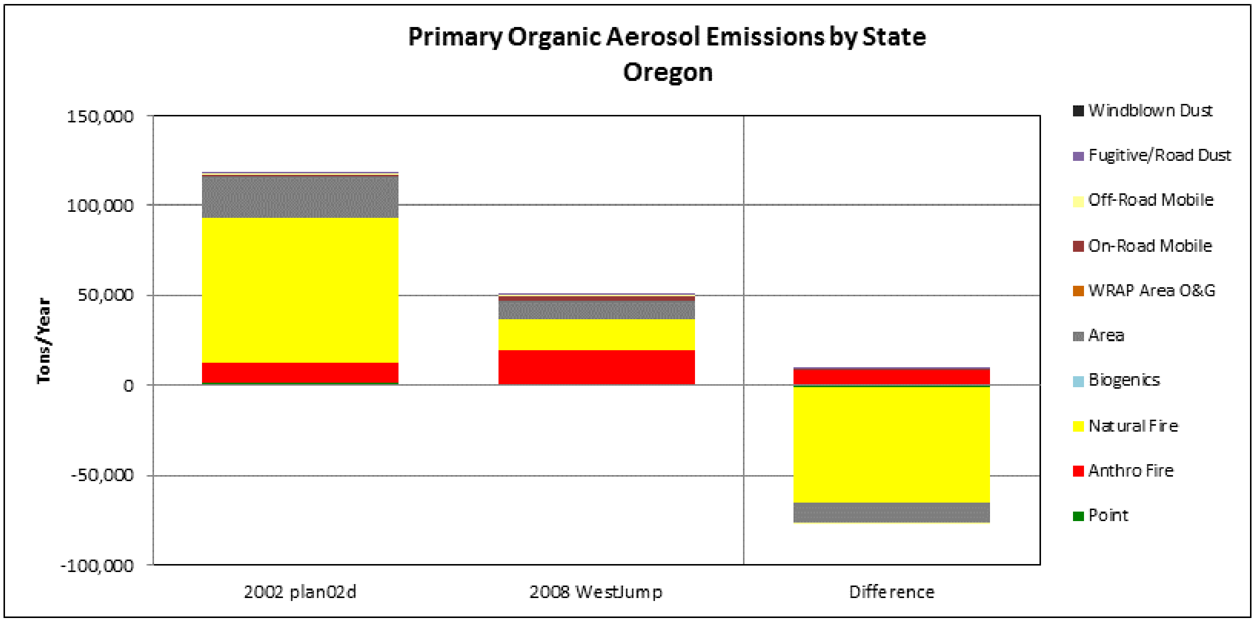

Figure 6.11-11. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Primary Organic Aerosol by Source Category for Oregon.

Table 6.11-13
Oregon
Elemental Carbon Emissions by Category

Source Category	Elemental Carbon Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	45	103	59
Area	4,121	1,533	-2,588
On-Road Mobile	1,166	4,041	2,876
Off-Road Mobile	3,038	1,199	-1,839
Area Oil and Gas	0	0	0
Fugitive and Road Dust	21	21	0
Anthropogenic Fire	1,935	2,872	938
Total Anthropogenic	**10,325**	**9,769**	**-556 (-5%)**
Natural Sources			
Natural Fire	16,403	2,448	-13,955
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**16,403**	**2,448**	**-13,955 (-85%)**
All Sources			
Total Emissions	**26,728**	**12,218**	**-14,510 (-54%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

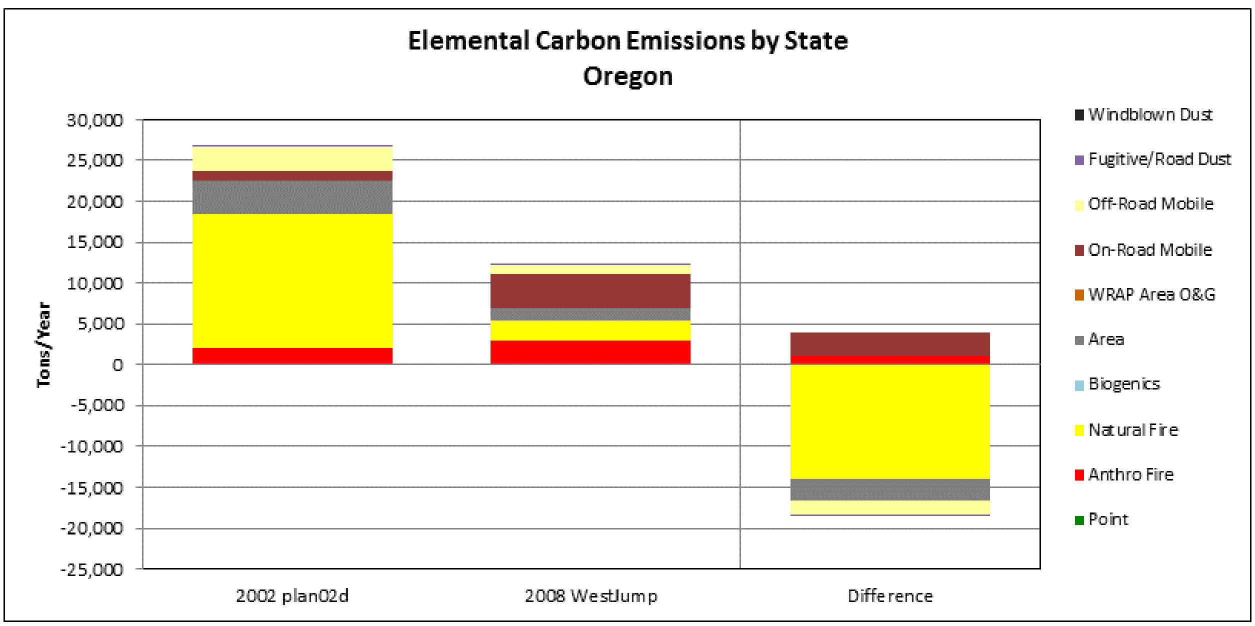

Figure 6.11-12. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Elemental Carbon by Source Category for Oregon.

Table 6.11-14
Oregon
Fine Soil Emissions by Category

Source Category	Fine Soil Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	5,728	430	-5,298
Area	15,295	5,038	-10,256
On-Road Mobile	606	394	-212
Off-Road Mobile	0	70	70
Area Oil and Gas	0	0	0
Fugitive and Road Dust	5,022	9,364	4,342
Anthropogenic Fire	1,483	6,972	5,490
Total Anthropogenic	**28,133**	**22,269**	**-5,864 (-21%)**
Natural Sources			
Natural Fire	6,090	6,396	305
Biogenic	0	0	0
Wind Blown Dust	11,586	8,499	-3,087
Total Natural	**17,676**	**14,894**	**-2,782 (-16%)**
All Sources			
Total Emissions	**45,809**	**37,163**	**-8,645 (-19%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

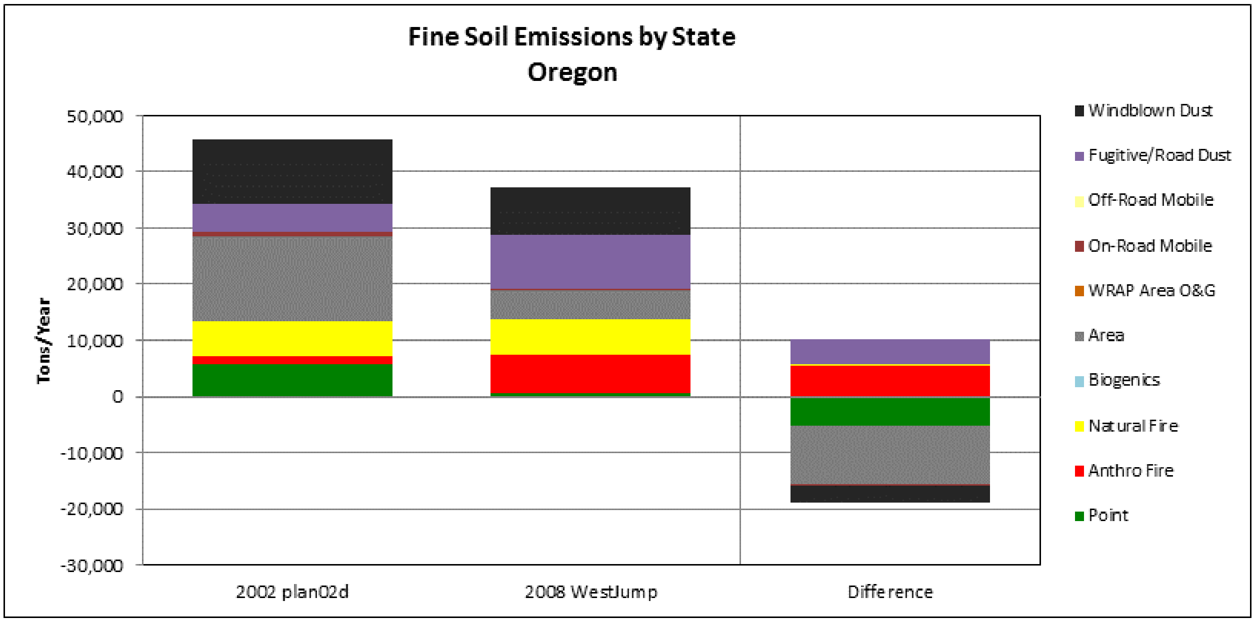

Figure 6.11-13. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Fine Soil by Source Category for Oregon.

Table 6.11-15
Oregon
Coarse Mass Emissions by Category

Source Category	Coarse Mass Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	10,211	2,067	-8,145
Area	3,546	597	-2,949
On-Road Mobile	618	4,295	3,677
Off-Road Mobile	0	116	116
Area Oil and Gas	0	0	0
Fugitive and Road Dust	33,999	63,599	29,600
Anthropogenic Fire	1,282	3,648	2,365
Total Anthropogenic	**49,657**	**74,321**	**24,664 (50%)**
Natural Sources			
Natural Fire	17,036	3,326	-13,709
Biogenic	0	0	0
Wind Blown Dust	104,272	76,489	-27,783
Total Natural	**121,307**	**79,815**	**-41,492 (-34%)**
All Sources			
Total Emissions	**170,964**	**154,136**	**-16,828 (-10%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

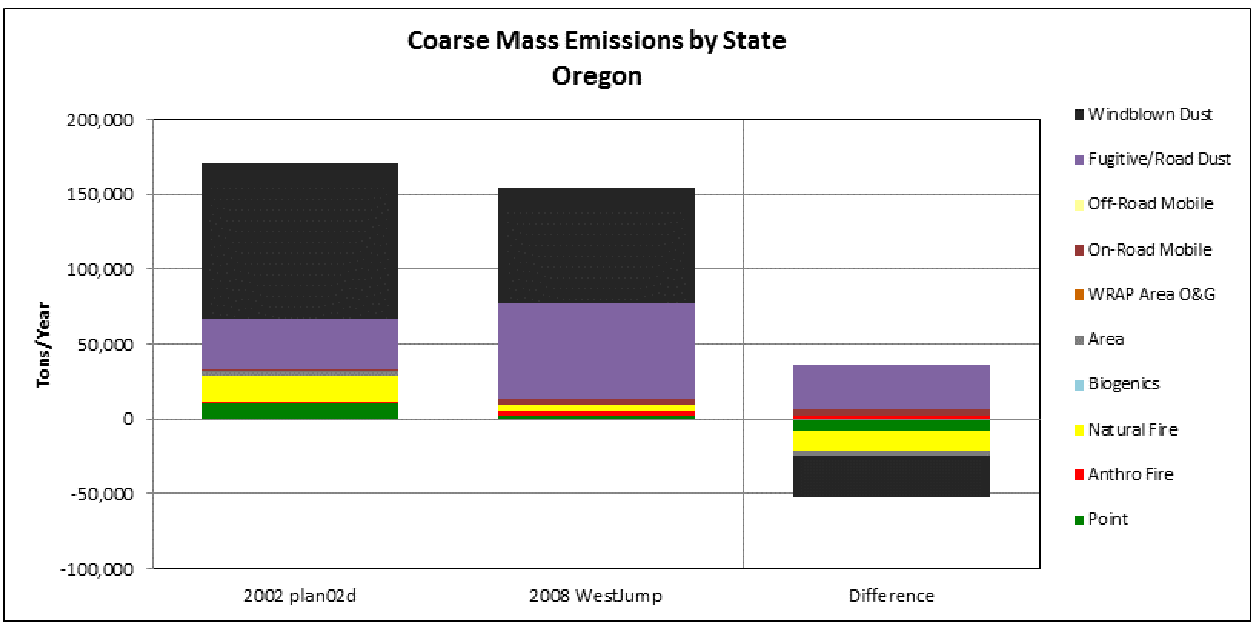

Figure 6.11-14. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Coarse Mass by Source Category for Oregon.

6.11.2.2 EGU Summary

As described in previous sections, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions because numerous updates in inventory methodologies have occurred between the development of the separate inventories. Also, the 2002 baseline and 2008 progress period inventories represent only annual snapshots of emissions estimates, which may not be representative of entire 5-year monitoring periods compared. To better account for year-to-year changes in emissions, annual emission totals for Oregon electrical generating units (EGU) are presented here. EGU emissions are some of the more consistently reported emissions, as tracked in EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/). RHR implementation plans are required to pay specific attention to certain major stationary sources, including EGUs, built between 1962 and 1977.

Figure 6.11-17 presents a sum of annual NO_X and SO_2 emissions as reported for Oregon EGU sources between 1996 and 2010. While these types of facilities are targeted for controls in state regional haze SIPs, it should be noted that many of the controls planned for EGUs in the WRAP states had not taken place yet in 2010, while other controls separate from the RHR may have been implemented. The chart shows several periods of increases and decreases for both SO_2 and NO_X.

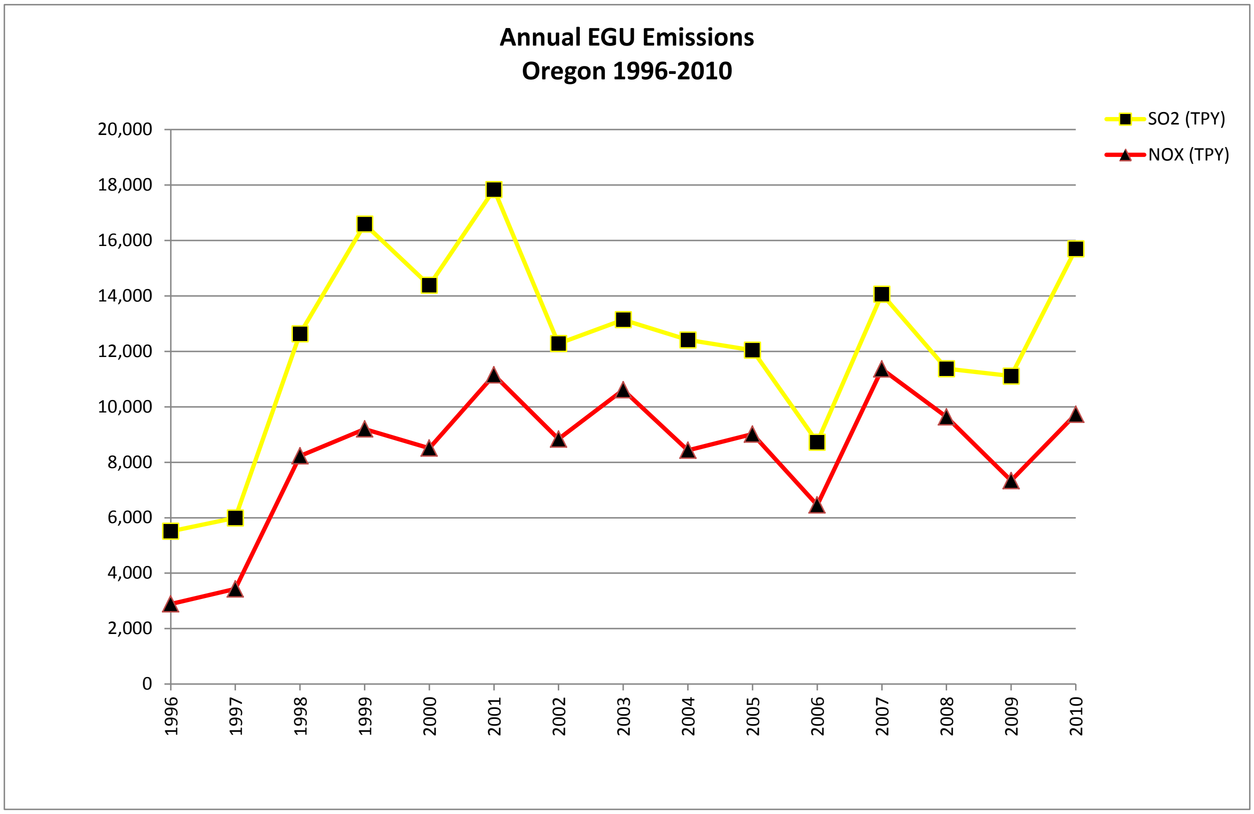

Figure 6.11-8. Sum of EGU Emissions of SO_2 and NO_X reported between 1996 and 2010 for Oregon.

6.12 SOUTH DAKOTA

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. South Dakota has 4 mandatory Federal CIAs, which are depicted in Figure 6.12-1 and listed in Table 6.12-1, along with the associated IMPROVE monitor locations.

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per Regional Haze Rule (RHR) requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. Some of the highlights regarding these comparisons are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- For both the best and worst days, the 5-year average deciview metric decreased at both the BADL1 and WICA1 sites.
- The largest decreases in 5-year averages for the worst days were measured for ammonium nitrate and elemental carbon at both sites, and coarse mass at the BADL1 site.
- No increasing annual average trends were measured at either site, and statistically significant decreasing trends were measured for several parameters, including ammonium nitrate at the WICA1 site, and elemental carbon and coarse mass at the BADL1 site.
- Decreases in measurements were consistent with emissions inventory comparisons, which showed a decrease in mobile source NO_X and EC emissions, and decreasing NO_X emissions on an annual basis from EGU point sources.

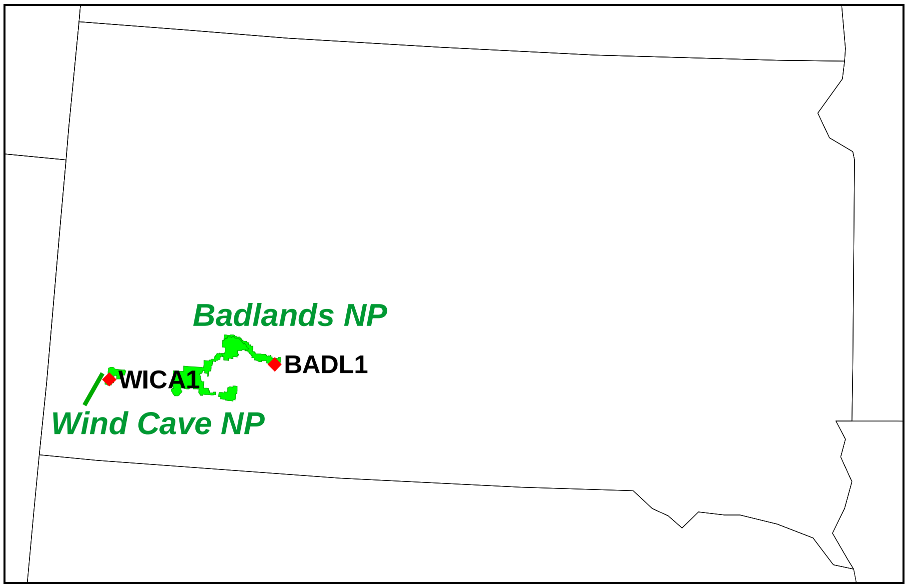

Figure 6.12-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in South Dakota.

Table 6.12-1
South Dakota CIAs and Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Badlands NP	BADL1	43.74	-101.94	736
Wind Cave NP	WICA1	43.56	-103.48	1296

6.12.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by IMPROVE monitors representing Federal CIAs in South Dakota. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix L.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.12.1.1 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.308 (g)(3)(i))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[108] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.12-2 and 6.12-3 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired, or worst, and 20% least impaired, or best, days for each of the Federal CIA IMPROVE monitors in South Dakota. Figure 6.12-2 presents 5-year average extinction for the current progress period for both the 20% most impaired and 20% least impaired days. Note that the percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired days are as follows:

- The largest contributors to aerosol extinction at the South Dakota sites were ammonium sulfate and particulate organic mass.

Specific observations for the current visibility conditions on the 20% least impaired days are as follows:

- The aerosol contribution to total extinction on the best days was less than Rayleigh, or the background scattering that would occur in clear air.
- The largest contributor to the non-Rayleigh aerosol species of extinction was ammonium sulfate.

[108] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

Table 6.12-2
South Dakota Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank*						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
BADL1	16.6	**44% (1)**	12% (3)	24% (2)	4% (5)	2% (6)	12% (4)	1% (7)
WICA1	15.5	**34% (1)**	15% (3)	33% (2)	6% (5)	2% (6)	9% (4)	1% (7)

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.12-3
South Dakota Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank*						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
BADL1	6.8	**39% (1)**	13% (4)	24% (2)	6% (5)	4% (6)	14% (3)	0% (7)
WICA1	4.6	**42% (1)**	11% (4)	20% (2)	9% (5)	4% (6)	14% (3)	0% (7)

*Highest aerosol species contribution per site is highlighted in bold.

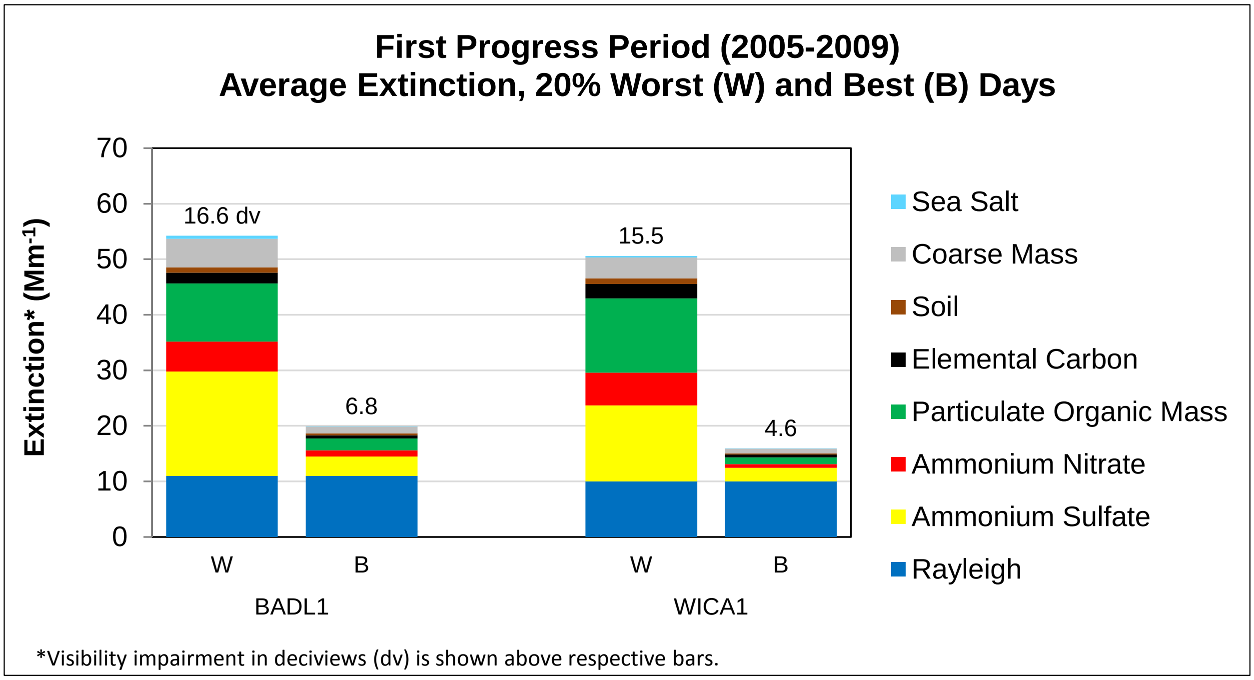

Figure 6.12-2. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at South Dakota Class I Area IMPROVE Sites.

6.12.1.2 Differences between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.308 (g)(3)(ii))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Table 6.12-4 presents the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for each site in South Dakota for the 20% most impaired days, and Table 6.12-5 presents similar data for the least impaired days. Averages that increased are depicted in red text and averages that decreased in blue.

Figure 6.12-3 presents the 5-year average extinction for the baseline and current progress period averages for the worst days and Figure 6.12-4 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.12-5 and 6.12-6 present similar plots for the best days.

For the 20% most impaired days, the 5-year average deciview metric decreased between the 2000-2004 and 2005-2009 periods at both South Dakota sites. Notable differences for individual species averages were as follows:

- Ammonium nitrate and elemental carbon decreased at both sites.

- All species except sea salt decreased at the BADL1 site, with the largest decreases measured in particulate organic mass, coarse mass and elemental carbon.
- The large decreases in ammonium nitrate at the WICA1 site was offset by small increases in ammonium sulfate, particulate organic mass, soil and coarse mass.

For the 20% least impaired days, the 5-year average deciview metric decreased at both South Dakota sites. Notable differences for individual species averages on the 20% least impaired days were as follows:

- At the BADL1 site, increases in ammonium sulfate and particulate organic mass were offset by decreases in ammonium nitrate, elemental carbon and coarse mass.
- No increases were measured for the best days at the WICA1 site.

Table 6.12-4
South Dakota Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
BADL1	17.1	16.6	-0.5	0.0	-0.5	-1.3	-0.7	0.0	-0.8	+0.4
WICA1	15.8	15.5	-0.3	+0.5	-1.1	+0.1	-0.3	+0.2	+0.2	+0.2

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.12-5
South Dakota Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
BADL1	6.9	6.8	-0.1	+0.1	-0.1	+0.3	-0.2	0.0	-0.3	0.0
WICA1	5.1	4.6	-0.5	-0.1	-0.2	-0.2	-0.2	0.0	-0.2	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

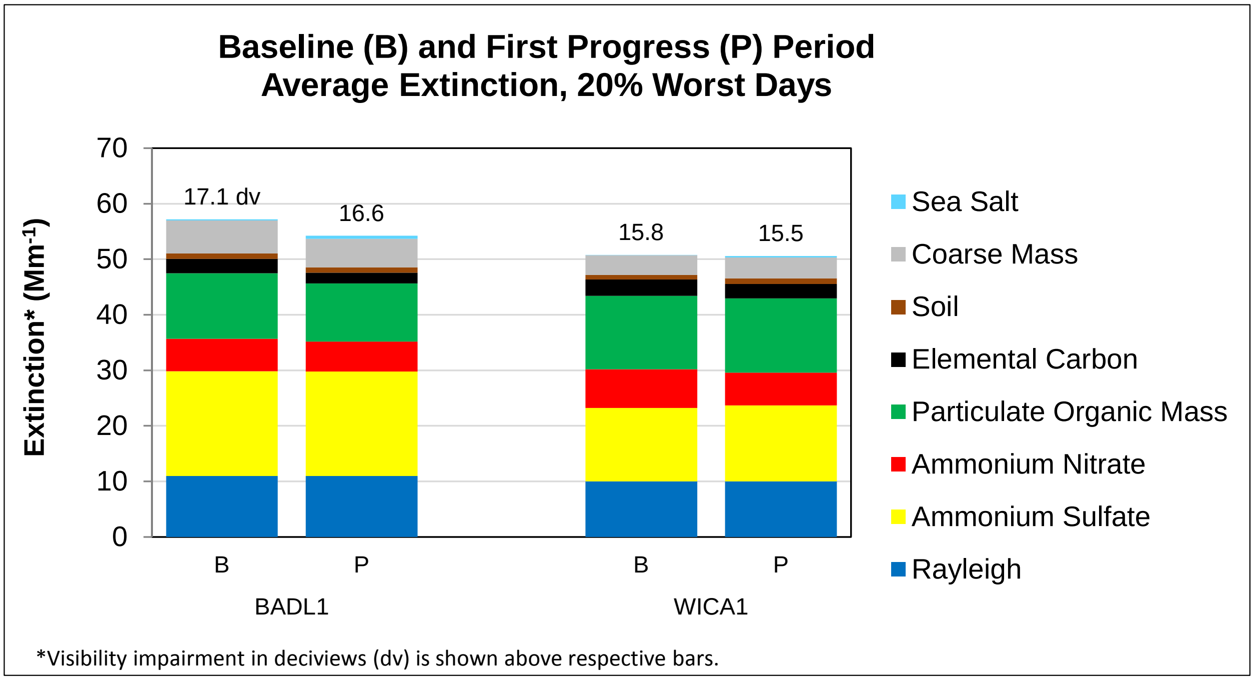

Figure 6.12-3. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at South Dakota Class I Area IMPROVE Sites.

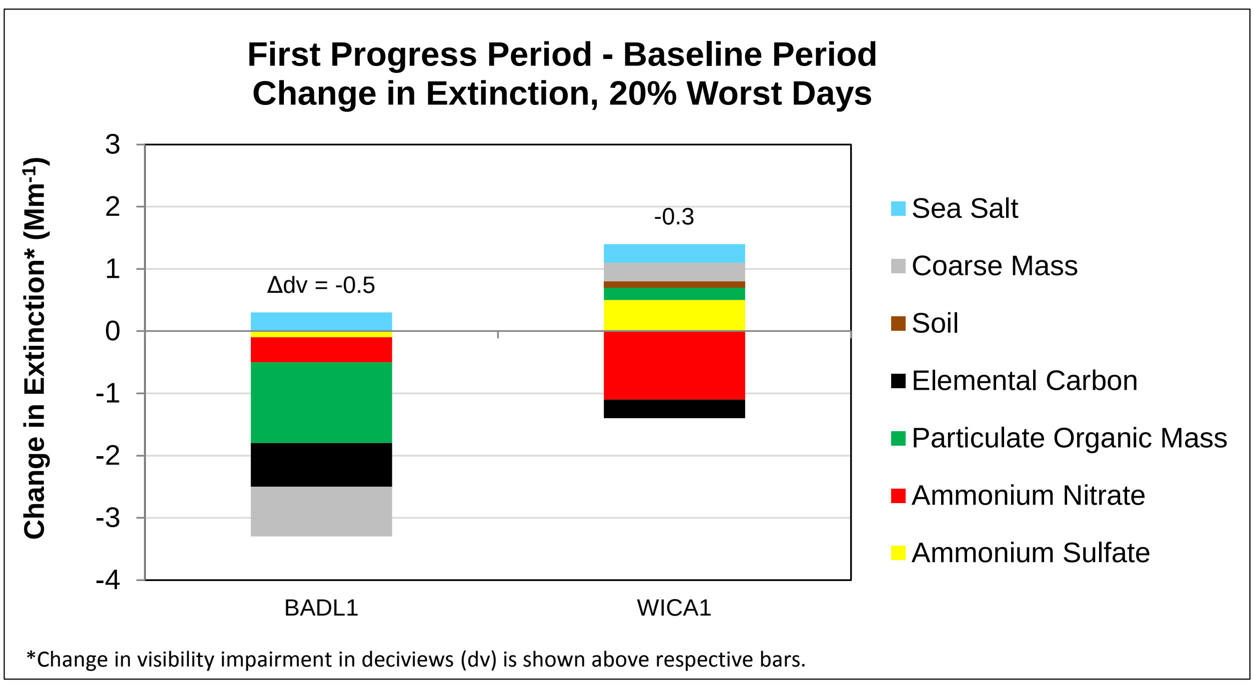

Figure 6.12-4. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at South Dakota Class I Area IMPROVE Sites.

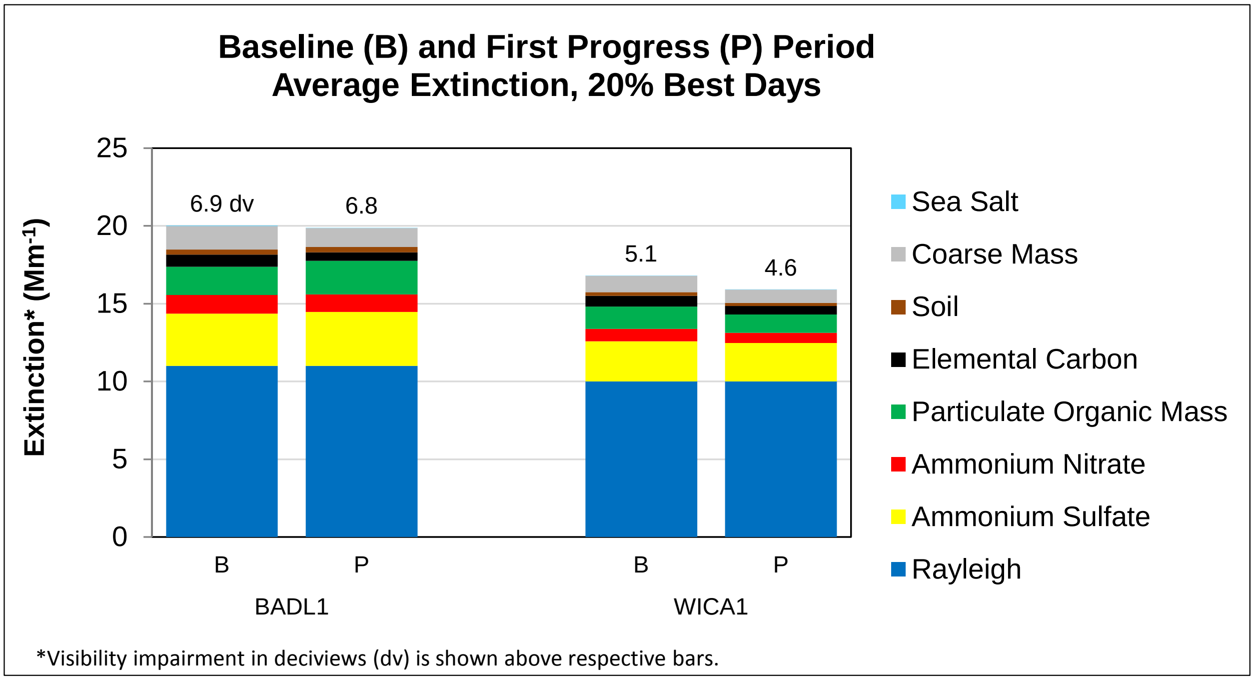

Figure 6.12-5. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at South Dakota Class I Area IMPROVE Sites.

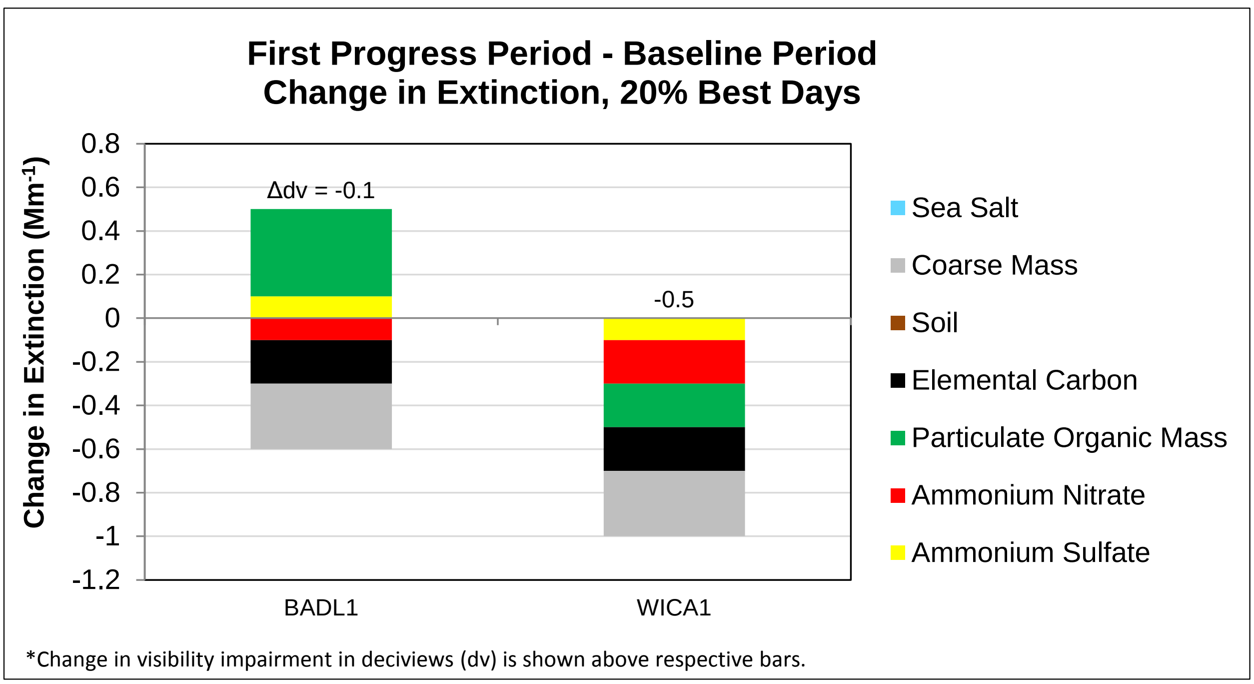

Figure 6.12-6. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at South Dakota Class I Area IMPROVE Sites.

6.12.1.3 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.308 (g)(3)(iii))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5-year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in South Dakota are summarized in Table 6.12-6, and regional trends were presented earlier in Section 4.1.1.[109] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[110] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix L. Additionally, the appendix includes plots depicting 5-year, annual, monthly and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in South Dakota are as follows:

- The largest changes in 5-year averages for particulate organic mass were measured at the BADL1 site. Average particulate organic mass measurements at both sites were influenced by large events in August 2000, August 2003 and July 2008.
- Decreasing trends were measured for elemental carbon and coarse mass at the BADL1 site, and a decreasing trend in ammonium nitrate was measured at the at the WICA1 site.

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[109] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)

[110] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

Table 6.12-6
South Dakota Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
BADL1	20% Best	--	--	0.0	0.0	--	0.0	--
	20% Worst	--	--	--	**-0.2**	--	--	--
	All Days	--	0.0	--	**-0.1**	--	**-0.1**	--
WICA1	20% Best	**-0.1**	0.0	0.0	0.0	--	0.0	--
	20% Worst	--	**-0.2**	--	**-0.1**	0.0	--	0.0
	All Days	--	**-0.1**	--	--	0.0	--	0.0

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix L.

6.12.2 Emissions Data

Included here are summaries depicting differences between two emission inventory years that are used to represent the 5-year baseline and current progress periods. The baseline period is represented using a 2002 inventory developed by the WRAP for use in the initial WRAP state SIPs, and the progress period is represented by a 2008 inventory which leverages recent WRAP inventory work for modeling efforts, as referenced in Section 3.2.1. For reference, Table 6.12-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories, and a separate summary of annual emissions from electrical generating units (EGUs), are presented in this section.

Table 6.12-7
South Dakota
Pollutants, Aerosol Species, and Major Sources

Emitted Pollutant	Related Aerosol	Major Sources	Notes
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- and Off-Road Mobile Sources	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be fully neutralized with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Primary Organic Aerosol (POA)	POM	Wildfires; Area Sources	POA represents organic aerosols that are emitted directly as particles, as opposed to gases. Wildfires in the west generally dominate POA emissions, and large wildfire events are generally sporadic and highly variable from year-to-year. As referenced in Section 3.2.1, emissions summaries here compare an average of 2000-2004 wildland fire emission with 2008 emissions.
Elemental Carbon (EC)	EC	Wildfires; On- and Off-Road Mobile Sources	Large EC events are often associated with large POM events during wildfires. Other sources include both on- and off-road diesel engines.
Fine Soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is measured by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but measurements are often associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributors to PMC.

6.12.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.308 (g)(4))?*** For these summaries, emissions during the baseline years are represented using a 2002 inventory, which was developed with support from the WRAP for use in the original RHR SIP strategy development (termed plan02d). Differences between inventories are represented as the difference between the 2002 inventory, and a 2008 inventory which leverages recent inventory development work performed by the WRAP for the WestJumpAQMS and DEASCO_3 modeling projects (termed WestJump2008). Note that the comparisons of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories, as referenced in Section 3.2.1. Inventories for all major visibility impairing pollutants are presented for major source categories, and categorized as either anthropogenic or natural emissions. State-wide inventories totals and differences are presented here, and inventory totals on a county level basis are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

Table 6.12-8 and Figure 6.12-7 present the differences between the 2002 and 2008 sulfur dioxide (SO_2) inventories by source category. Tables 6.12-9 and Figure 6.12-8 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.12-10 through 6.12-15 and Figures 6.12-9 through 6.12-14) present data for ammonia (NH_3), volatile organic compounds (VOCs), primary organic aerosol (POA), elemental carbon (EC), fine soil, and coarse mass. General observations regarding emissions inventory comparisons are listed below.

- The largest difference for point source inventories was a decrease in reported NO_X.
- Area source inventories showed decreases in SO_2 and VOCs and increases in NO_X and NH_3. These changes may be due to a combination of population changes and differences in methodologies used to estimate these emissions, as referenced in Section 3.2.1. One methodology change was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to increases in area source inventory totals, but decreases in off-road mobile totals.
- On-road mobile source inventory comparisons showed decreases in most parameters, especially NO_X and VOCs, with slight increases in POA, EC, and coarse mass. Reductions in NO_X and VOC are likely influenced by federal and state emissions standards that have already been implemented. The increases in POA, EC, and coarse mass occurred in all of the WRAP states for on-road mobile inventories, regardless of reductions in NO_X and VOCs, indicating that these increases were likely due use of different on-road models, as referenced in Section 3.2.1.
- Off-road mobile source inventories showed decreases in NO_X, SO_2, and VOCs, and increases in fine soil and coarse mass, which was consistent with most contiguous WRAP states. These differences were likely due to a combination of actual changes in source contributions and methodology differences, as referenced in Section 3.2.1. As noted previously, one major methodology difference was the reclassification of

some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to decreases in the off-road inventory totals, but increases in area source totals.

- For all parameters, especially POAs, VOCs, and EC, natural fire emission inventory estimates decreased, and anthropogenic fire inventories increased. Note that these differences are not necessarily reflective of changes in monitored data, as the baseline period is represented by an average of 2000-2004 fire emissions, and the progress period is represented only by the fires that occurred in 2008, as referenced in Section 3.2.1.
- Comparisons between VOC inventories showed large decreases in biogenic emissions, which was consistent with other contiguous WRAP states. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions, as referenced in Section 3.2.1.
- Fine soil and coarse mass decreased for the windblown dust inventory comparisons and the combined fugitive/road dust inventories. Large variability in changes in windblown dust was observed for the contiguous WRAP states, which was likely due in large part to enhancements in dust inventory methodology, as referenced in Section 3.2.1, rather than changes in actual emissions.

Table 6.12-8
South Dakota
Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	14,024	14,727	703
Area	1,071	339	-732
On-Road Mobile	873	179	-693
Off-Road Mobile	5,733	484	-5,249
Area Oil and Gas	6	0	-6
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	5	53	48
Total Anthropogenic	**21,712**	**15,784**	**-5,928 (-27%)**
Natural Sources			
Natural Fire	362	117	-245
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**362**	**117**	**-245 (-68%)**
All Sources			
Total Emissions	**22,074**	**15,901**	**-6,174 (-28%)**

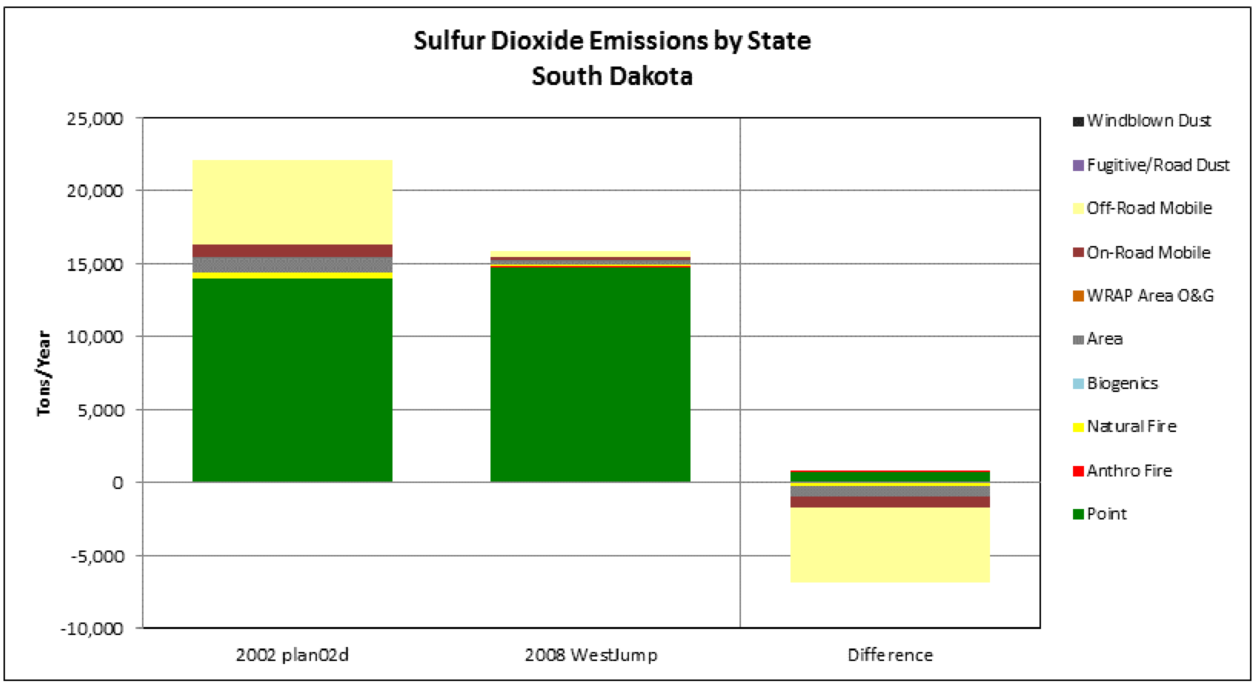

Figure 6.12-7. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for South Dakota.

Table 6.12-9
South Dakota
Oxides of Nitrogen Emissions by Category

Source Category	Oxides of Nitrogen Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	20,698	16,384	-4,314
Area	2,897	5,904	3,007
On-Road Mobile	29,224	26,865	-2,359
Off-Road Mobile	39,039	24,699	-14,339
Area Oil and Gas	361	0	-361
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	40	378	338
Total Anthropogenic	**92,258**	**74,230**	**-18,028 (-20%)**
Natural Sources			
Natural Fire	1,658	827	-831
Biogenic	52,852	14,758	-38,094
Wind Blown Dust			
Total Natural	**54,511**	**15,586**	**-38,925 (-71%)**
All Sources			
Total Emissions	**146,769**	**89,815**	**-56,953 (-39%)**

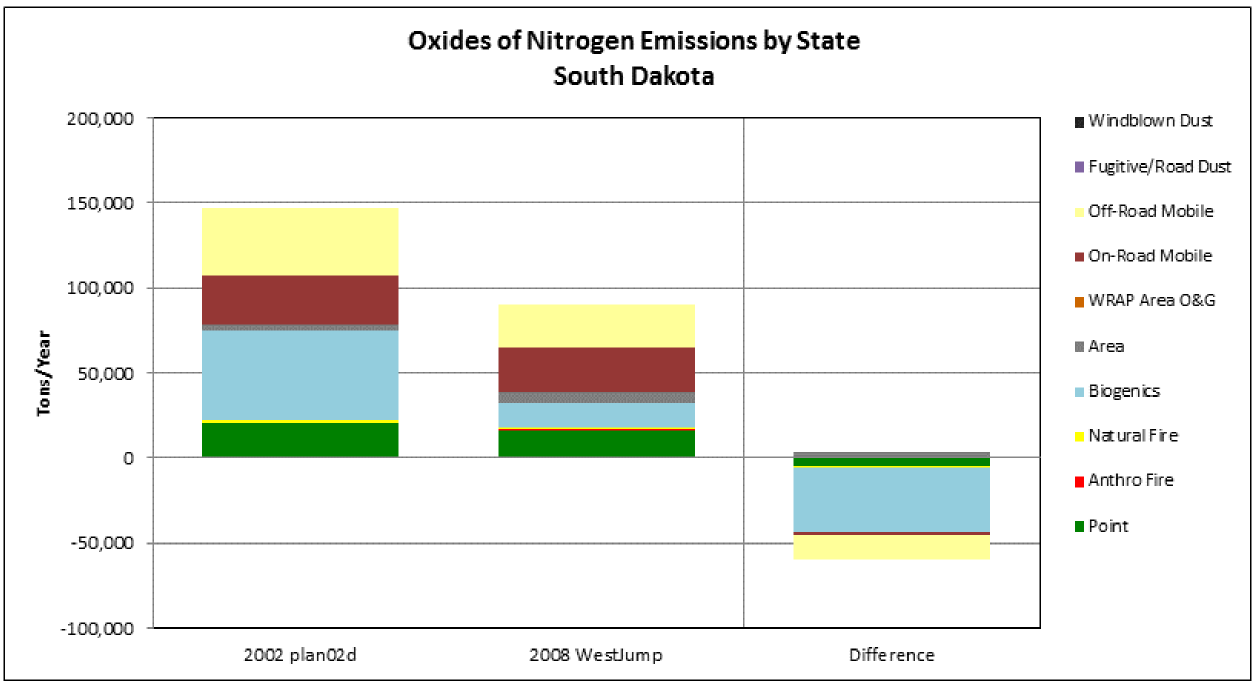

Figure 6.12-8. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Oxides of Nitrogen by Source Category for South Dakota.

Table 6.12-10
South Dakota
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	100	263	163
Area	118,877	131,616	12,739
On-Road Mobile	842	386	-456
Off-Road Mobile	25	21	-4
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	20	264	243
Total Anthropogenic	**119,864**	**132,549**	**12,685 (11%)**
Natural Sources			
Natural Fire	542	577	35
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**542**	**577**	**35 (6%)**
All Sources			
Total Emissions	**120,406**	**133,126**	**12,720 (11%)**

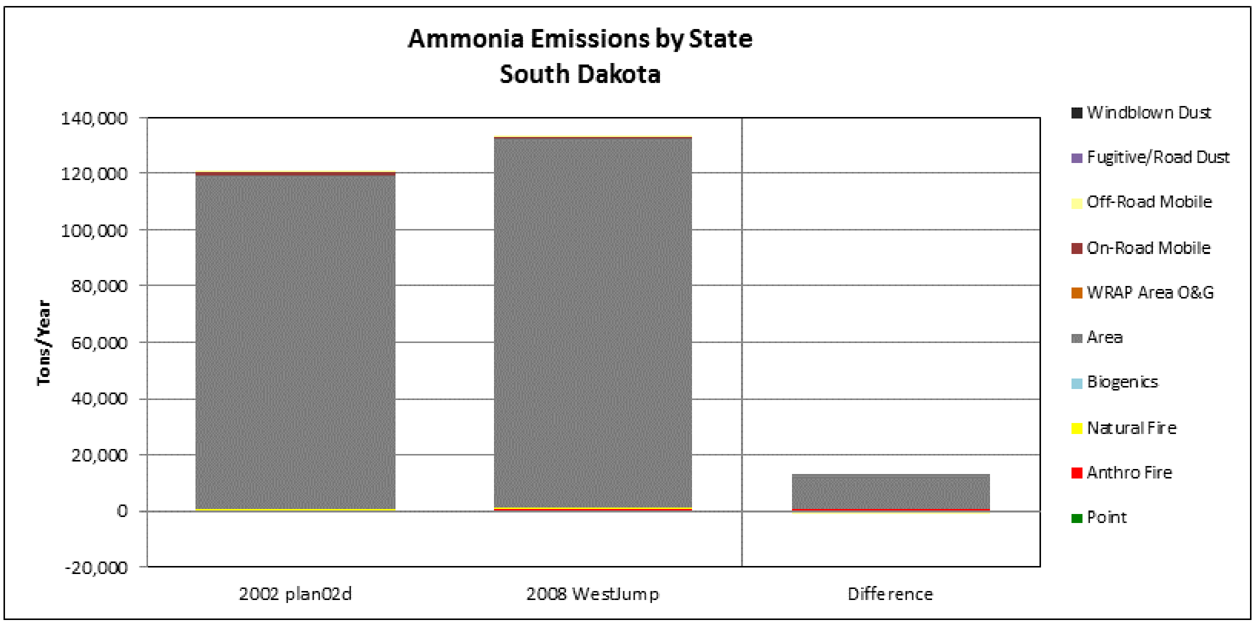

Figure 6.12-9. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Ammonia by Source Category for South Dakota.

Table 6.12-11
South Dakota
Volatile Organic Compound Emissions by Category

Source Category	**Volatile Organic Compound Emissions (tons/year)**		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	2,542	2,550	7
Area	40,551	27,164	-13,387
On-Road Mobile	13,741	11,521	-2,219
Off-Road Mobile	12,764	10,827	-1,937
Area Oil and Gas	288	0	-288
Fugitive and Road Dust			
Anthropogenic Fire	95	443	348
Total Anthropogenic	**69,981**	**52,506**	**-17,476 (-25%)**
Natural Sources			
Natural Fire	3,758	726	-3,032
Biogenic	445,241	151,342	-293,900
Wind Blown Dust	0	0	0
Total Natural	**448,999**	**152,067**	**-296,932 (-66%)**
All Sources			
Total Emissions	**518,981**	**204,573**	**-314,407 (-61%)**

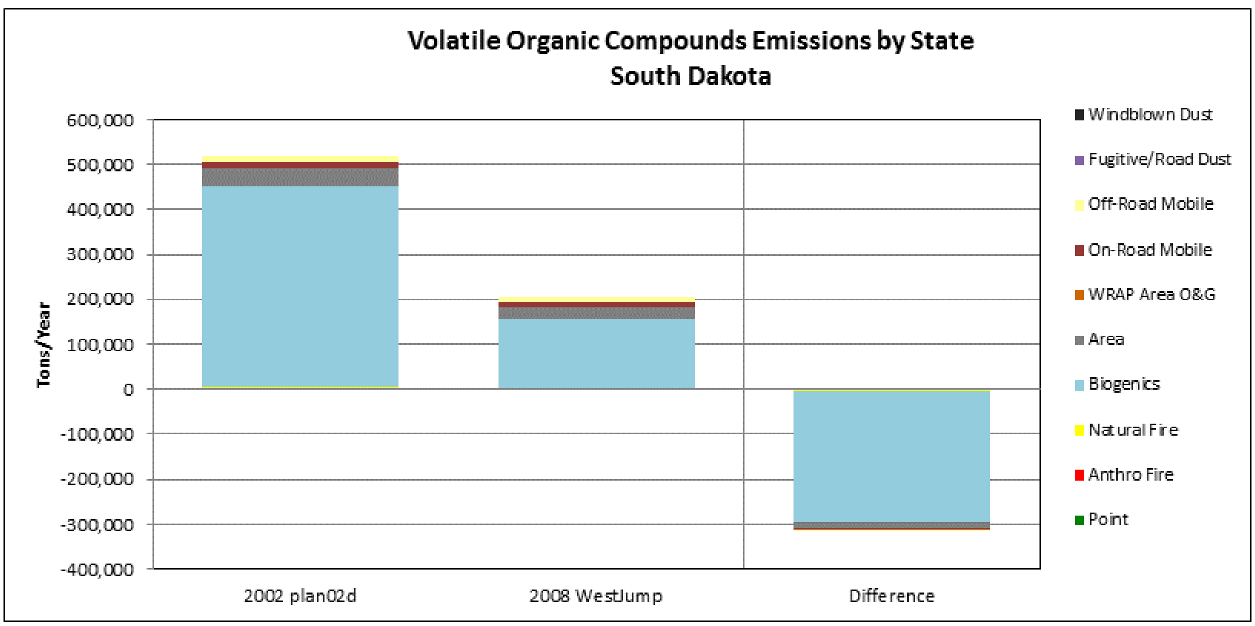

Figure 6.12-10. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for South Dakota.

Table 6.12-12
South Dakota
Primary Organic Aerosol Emissions by Category

Source Category	Primary Organic Aerosol Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	10	7	-2
Area	1,792	1,103	-689
On-Road Mobile	278	695	416
Off-Road Mobile	942	607	-335
Area Oil and Gas	0	0	0
Fugitive and Road Dust	1,571	1,167	-404
Anthropogenic Fire	91	659	569
Total Anthropogenic	**4,683**	**4,237**	**-446 (-10%)**
Natural Sources			
Natural Fire	4,483	1,743	-2,741
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**4,483**	**1,743**	**-2,741 (-61%)**
All Sources			
Total Emissions	**9,166**	**5,980**	**-3,186 (-35%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

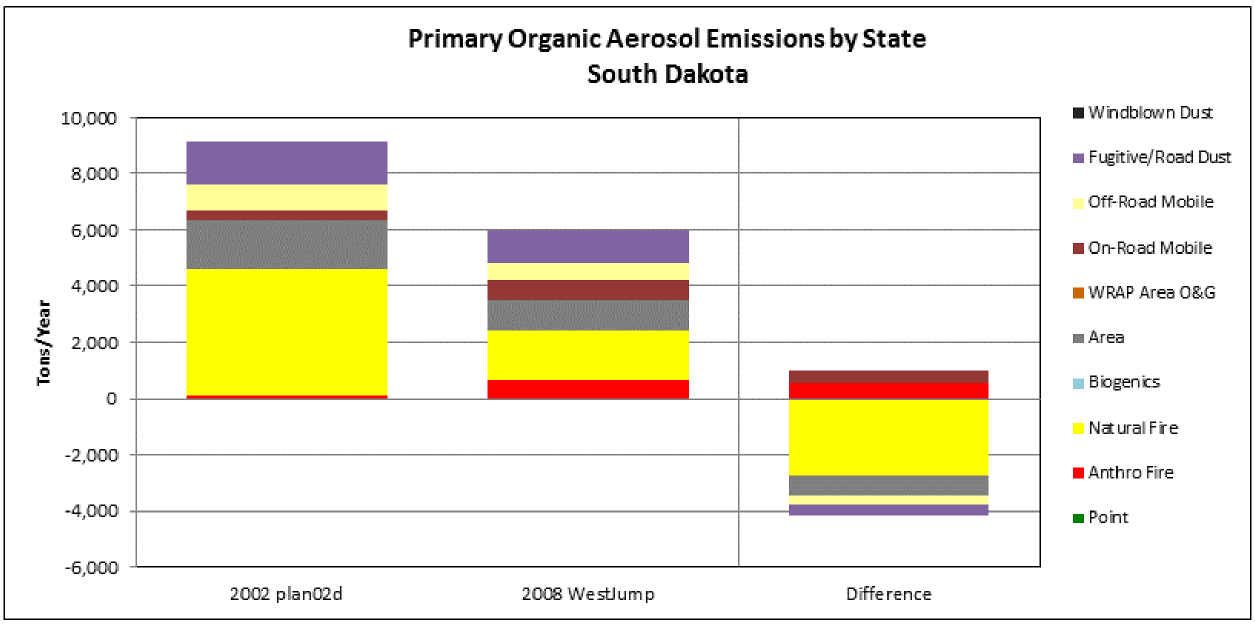

Figure 6.12-11. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Primary Organic Aerosol by Source Category for South Dakota.

Table 6.12-13
South Dakota
Elemental Carbon Emissions by Category

Source Category	Elemental Carbon Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	0	4	4
Area	306	236	-70
On-Road Mobile	339	1,183	844
Off-Road Mobile	3,234	1,637	-1,597
Area Oil and Gas	0	0	0
Fugitive and Road Dust	108	20	-88
Anthropogenic Fire	5	212	206
Total Anthropogenic	**3,992**	**3,292**	**-700 (-18%)**
Natural Sources			
Natural Fire	712	237	-475
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**712**	**237**	**-475 (-67%)**
All Sources			
Total Emissions	**4,703**	**3,529**	**-1,175 (-25%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

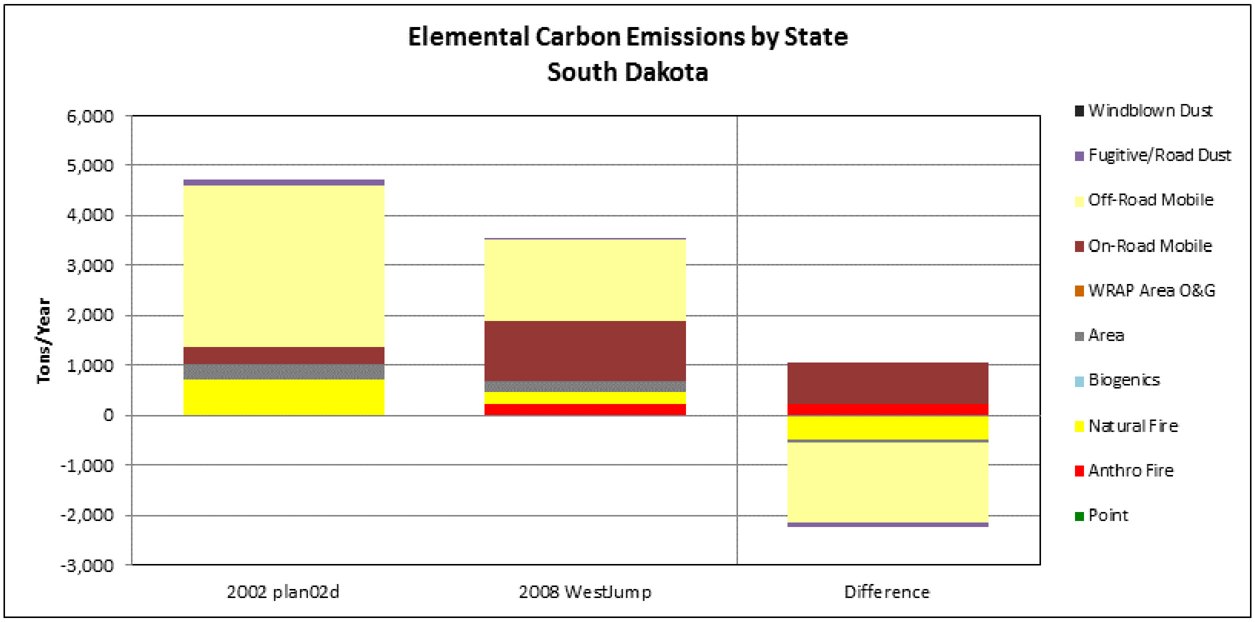

Figure 6.12-12. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Elemental Carbon by Source Category for South Dakota.

Table 6.12-14
South Dakota
Fine Soil Emissions by Category

Source Category	Fine Soil Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	216	188	-28
Area	1,804	589	-1,215
On-Road Mobile	180	104	-76
Off-Road Mobile	0	41	41
Area Oil and Gas	0	0	0
Fugitive and Road Dust	29,281	25,217	-4,064
Anthropogenic Fire	38	249	212
Total Anthropogenic	**31,519**	**26,389**	**-5,129 (-16%)**
Natural Sources			
Natural Fire	801	635	-167
Biogenic	0	0	0
Wind Blown Dust	50,274	34,242	-16,033
Total Natural	**51,076**	**34,876**	**-16,199 (-32%)**
All Sources			
Total Emissions	**82,594**	**61,266**	**-21,329 (-26%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

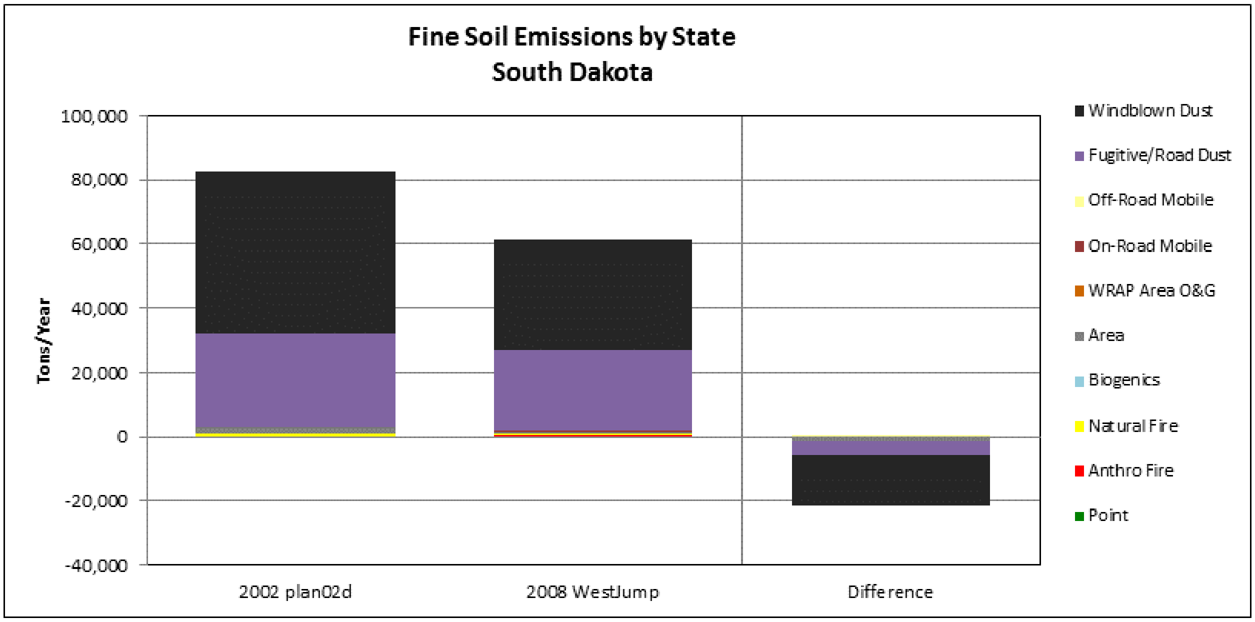

Figure 6.12-13. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Fine Soil by Source Category for South Dakota.

Table 6.12-15
South Dakota
Coarse Mass Emissions by Category

Source Category	Coarse Mass Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	727	25	-702
Area	156	126	-30
On-Road Mobile	169	1,229	1,060
Off-Road Mobile	0	82	82
Area Oil and Gas	0	0	0
Fugitive and Road Dust	161,078	123,701	-37,377
Anthropogenic Fire	6	126	120
Total Anthropogenic	**162,137**	**125,290**	**-36,847 (-23%)**
Natural Sources			
Natural Fire	748	334	-414
Biogenic	0	0	0
Wind Blown Dust	452,470	308,176	-144,294
Total Natural	**453,218**	**308,510**	**-144,708 (-32%)**
All Sources			
Total Emissions	**615,355**	**433,800**	**-181,555 (-30%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

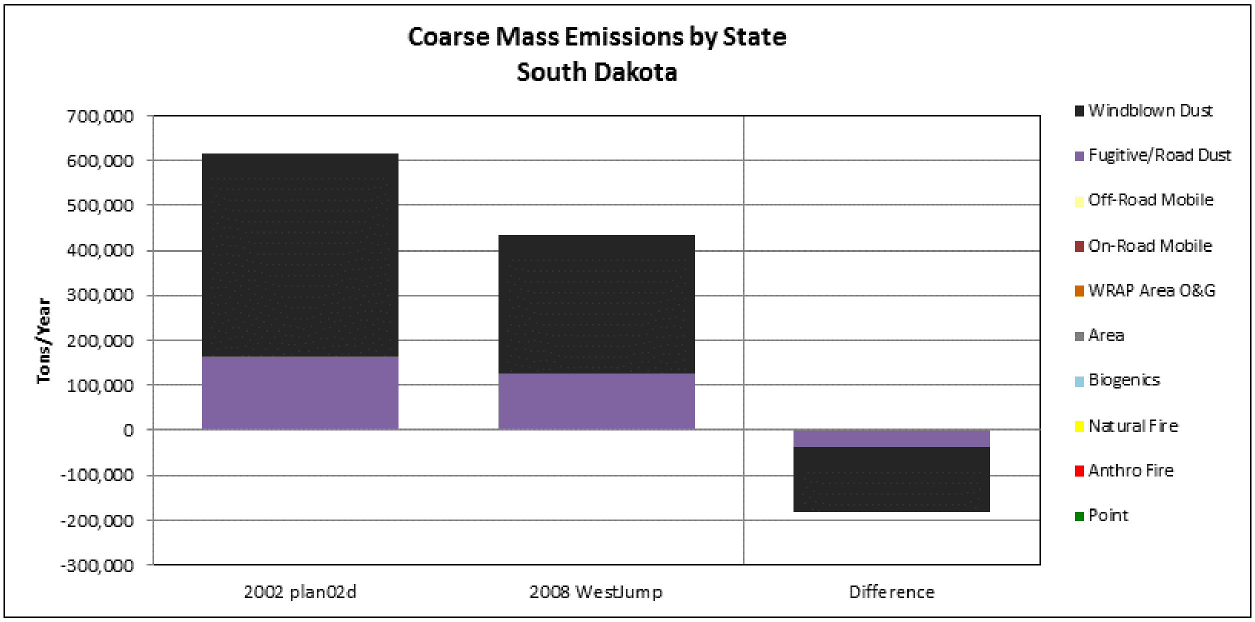

Figure 6.12-14. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Coarse Mass by Source Category for South Dakota.

6.12.2.2 EGU Summary

As described in previous sections, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions because numerous updates in inventory methodologies have occurred between the development of the separate inventories. Also, the 2002 baseline and 2008 progress period inventories represent only annual snapshots of emissions estimates, which may not be representative of entire 5-year monitoring periods compared. To better account for year-to-year changes in emissions, annual emission totals for South Dakota electrical generating units (EGU) are presented here. EGU emissions are some of the more consistently reported emissions, as tracked in EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/). RHR implementation plans are required to pay specific attention to certain major stationary sources, including EGUs, built between 1962 and 1977.

Figure 6.12-17 presents a sum of annual NO_X and SO_2 emissions as reported for South Dakota EGU sources between 1996 and 2010. While these types of facilities are targeted for controls in state regional haze SIPs, it should be noted that many of the controls planned for EGUs in the WRAP states had not taken place yet in 2010, while other controls separate from the RHR may have been implemented. The chart shows periods of decline for both SO_2 and NO_X through 2007, followed by slight increases in 2008.

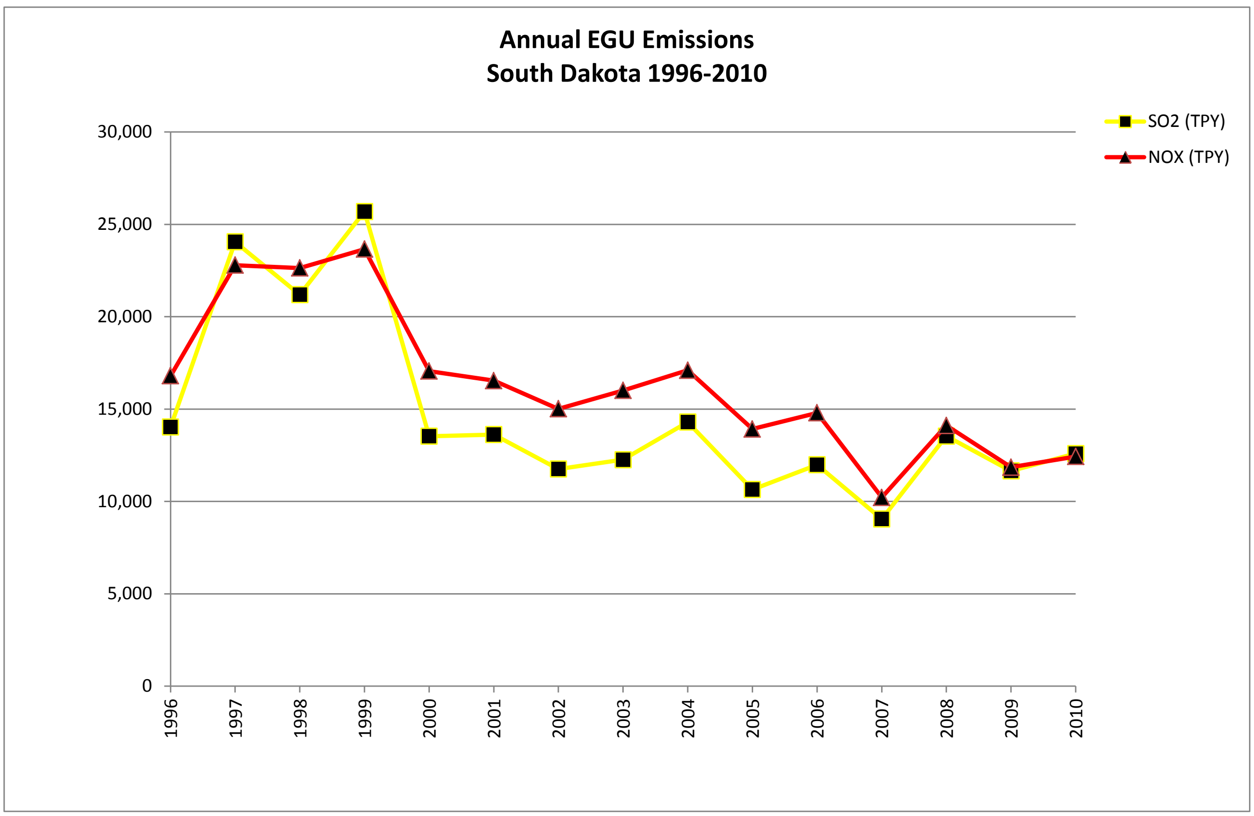

Figure 6.12-17. Sum of EGU Emissions of SO_2 and NO_X reported between 1996 and 2010 for South Dakota.

6.13 UTAH

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. Utah has 5 mandatory Federal CIAs, which are depicted in Figure 6.13-1 and listed in Table 6.13-1, along with the associated IMPROVE monitor locations.

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per Regional Haze Rule (RHR) requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. Some of the highlights regarding these comparisons are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- For the best days, the 5-year average deciview metric decreased at all Utah Federal CIA IMPROVE sites.
- For the worst days, 5-year average deciview metric increased at the BRCA1 and CAPI1 sites, and decreased at the ZICA1 and CANY1 sites.
- Changes in deciview averages for the worst days were driven by changes in particulate organic mass, which increased at the BRCA1 and CAPI1 sites and decreased at the ZICA1 and CANY1 sites.
- Ammonium sulfate decreased at all except the ZICA1 site, but changes in 5-year averages at the ZICA1 site used estimates for baseline data that were based on changes measured in the broader Colorado Plateau region. Ammonium sulfate showed decreasing annual average trends at all sites, which was consistent with emissions inventory comparison results that showed large decreases in point source SO_2 emission inventories.
- Ammonium nitrate decreased at all except the CANY1 site, and showed a statistically significant decreasing annual average trend at the CAPI1 site. Changes in emissions inventories showed a net reduction in anthropogenic sources, with increases in area sources and decreases in mobile sources.
- Coarse mass increased at the CAPI1 and CANY1 sites, but neither site showed increasing trends. Higher 5-year averages for the current period were influenced by higher than average coarse mass events in late April 2008 at both sites.

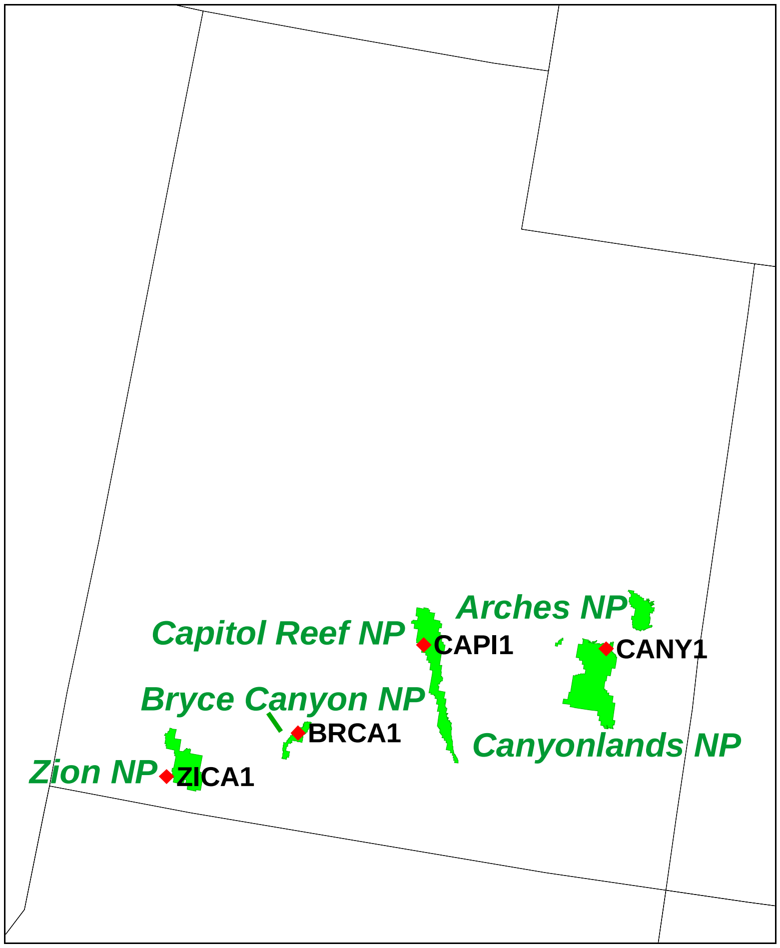

Figure 6.13-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in Utah.

Table 6.13-1
Utah CIAs and Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Bryce Canyon NP	BRCA1	37.62	-112.17	2481
Canyonlands NP	CANY1	38.46	-109.82	1798
Arches NP				
Capitol Reef NP	CAPI1	38.30	-111.29	1896
Zion NP	ZICA1*	37.20	-113.15	1215

*Replaced the ZION1 monitoring site in 2003.

6.13.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by IMPROVE monitors representing Federal CIAs in Utah, including estimates of baseline concentrations for the Zion National Park ZICA1 site. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix M.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.13.1.1 Zion Baseline Estimate

In Utah, the ZION1 IMPROVE monitor, which was originally intended to represent Zion National Park, began operation in 2000 at a site located on the northwest edge of the park, near an interstate highway. In 2003 a second IMPROVE monitor, ZICA1, was established approximately 19 miles from the original ZION1 along the southwest edge of the park. A map depicting both Zion National Park sites is presented in Figure 6.13-2.

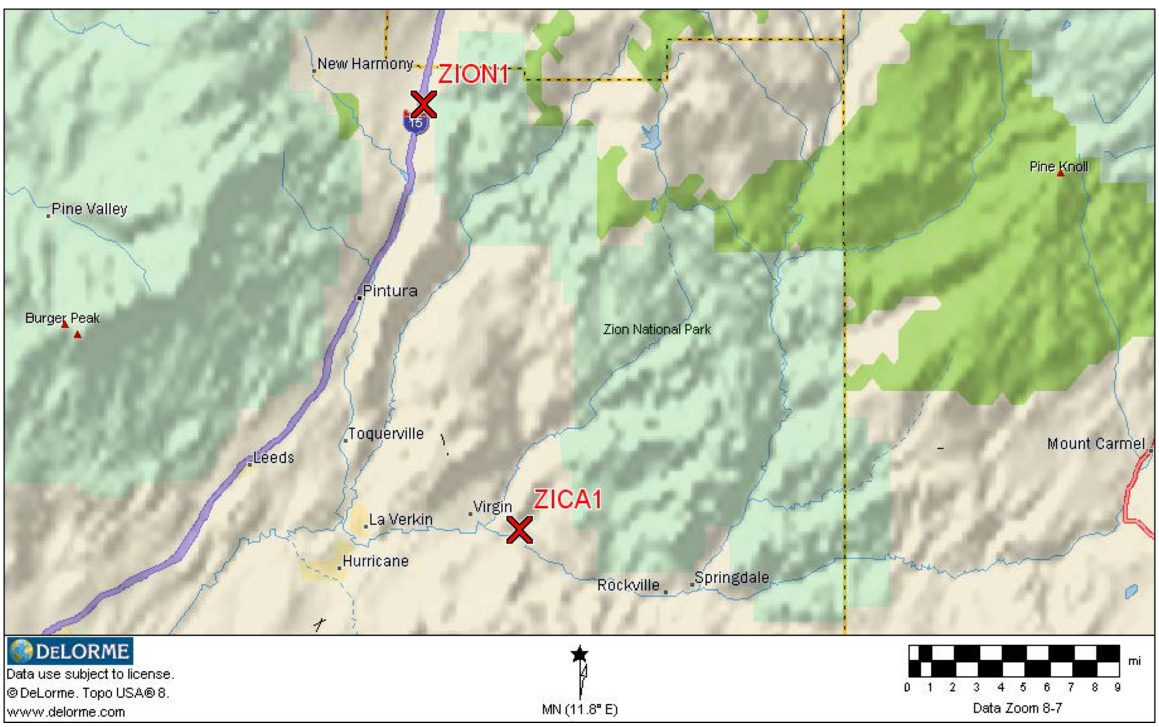

Figure 6.13-2. Map of ZION1 and ZICA1 Sites Representing Zion National Park.

The second site was installed in part because elevated ammonium nitrate at the original site was influenced by mobile sources from the interstate highway that were not representative of park conditions. Figure 6.13-3 presents a scatter plot of ammonium nitrate measurements for the period where both samplers ran concurrently between February 2, 2003, when the ZICA1 monitor was installed, and ending July 29, 2004, when monitoring at the ZION1 site was discontinued. The comparison indicates that ammonium nitrate measurements were much higher at the ZION1 site than the ZICA1 site. Because of these differences, it was determined that future RHR SIPs and progress updates should use the ZICA1 data.

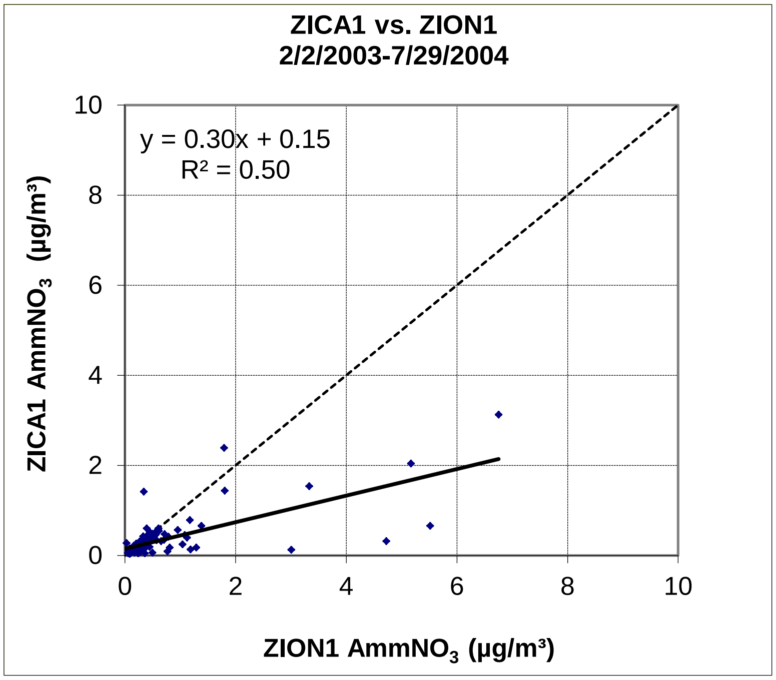

Figure 6.13-3. Correlation Plot for Ammonium Nitrate Depicting Mass Measured at the ZICA1 and ZION1 sites between February 2, 2003 and July 29, 2004.

RHR guidelines require that progress be measured again the 2000-2004 baseline period,[111] but baseline data are not available for the ZICA1 location. The RHR also states that approximations should be made for baseline conditions if these monitoring data are not available.[112] A methodology to estimate baseline conditions for the ZICA1 site was developed in consultation with the State of Utah – Division of Air Quality and IMPROVE Steering Committee representatives from the U.S. Forest Service and National Park Service. This methodology involved applying an average of ratios between progress periods and baseline periods at nearby sites in the region to scale the ZICA1 progress period. Sites selected included those that represent the 16 CIAs on the Colorado Plateau, which have previously been treated regionally as the focus of the Grand Canyon Visibility Transport Commission (GCVTC) report[113] and subsequent

[111] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (see page 4-2 in the Guidance document)

[112] Section 308(d)(2)(i) of the RHR states, "For mandatory Class I Federal areas without onsite monitoring data for 2000-2004, the State must establish baseline values using the most representative available monitoring data for 2000-2004, in consultation with the Administrator or his or her designee."

[113] The June 1996 *Grand Canyon Visibility Transport Commission Report, Recommendations for Improving Western Vistas* Report is available at www.wrapair.org/WRAP/reports/GCVTCFinal.PDF.

Section 309 requirements of the RHR. Table 6.13-2 list the Colorado Plateau CIA areas and representative IMPROVE sites that were used as the basis for the ZICA1 baseline estimate.

Table 6.13-2
Colorado Plateau CIAs and Representative IMPROVE Sites

State	Colorado Plateau Class I Area	IMPROVE Site
AZ	Mount Baldy WA	BALD1
	Grand Canyon NP	GRCA2
	Petrified Forest NP	PEFO1
	Sycamore Canyon WA	SYCA1
CO	Mesa Verde NP	MEVE1
	Black Canyon of the Gunnison NP	WEMI1
	Weminuche WA	
	Flat Tops WA	WHRI1
	Maroon Bells-Snowmass WA	
	West Elk WA	
NM	San Pedro Parks WA	SAPE1
UT	Bryce Canyon NP	BRCA1
	Arches NP	CANY1
	Canyonlands NP	
	Capitol Reef NP	CAPI1
	Zion NP	ZICA1

To estimate baseline conditions at the ZICA1 site, ratios between the 2005-2009 progress period and the 2000-2004 baseline period were determined for each species, for both the 20% most impaired days and 20% least impaired data, for each site in the Colorado Plateau. The average of these ratios was then applied to the ZICA1 progress period measurement to estimate the 2000-2004 baseline period for each species at the ZICA1 site, for both the most and least impaired days. Table 6.13-3 lists the average progress to baseline period ratios for the Colorado Plateau sites for the 20% most impaired days, and Table 6.13-4 lists averages and ratios for the least impaired days. These average ratios were applied to the 2005-2009 progress period from the ZICA1 site to obtain species and group specific estimates, such that, for each species:

$$\frac{\text{ZICA1 Progress Period}}{\text{Colorado Plateau } \frac{\text{Progress}}{\text{Baseline}} \text{ Average}} = \text{ZICA1 Baseline Period Estimate}$$

Table 6.13-3
Colorado Plateau Sites
20% Most Impaired Visibility Days
Species Averages and Ratios

20% Most Impaired Days		GRCA1	BALD1	PEFO1	SYCA1	WEMI1	WHRI1	MEVE1	SAPE1	CANY1	BRCA1	CAPI1	Average Progress/ Baseline Ratio
Ammonium Sulfate	**Baseline Period**	5.4	6.2	6.6	5.0	5.0	4.8	6.5	5.8	5.6	5.2	5.9	**1.04**
	Progress Period	5.8	6.5	7.2	5.7	5.1	5.1	6.3	6.8	5.3	5.0	5.7	
	Ratio (progress/ baseline)	**1.09**	**1.04**	**1.08**	**1.14**	**1.02**	**1.07**	**0.97**	**1.17**	**0.95**	**0.96**	**0.97**	
Ammonium Nitrate	**Baseline Period**	2.2	1.1	1.8	2.0	1.2	1.3	2.3	1.6	3.0	2.5	3.4	**0.86**
	Progress Period	1.8	1.0	1.5	1.4	1.0	1.3	2.0	1.2	3.3	2.2	2.7	
	Ratio (progress/ baseline)	**0.81**	**0.87**	**0.83**	**0.67**	**0.83**	**1.02**	**0.86**	**0.73**	**1.10**	**0.89**	**0.80**	
Particulate Organic Carbon	**Baseline Period**	10.7	13.0	10.9	11.7	8.3	7.8	12.3	7.7	7.1	9.4	5.8	**0.91**
	Progress Period	10.7	10.9	9.5	11.2	6.9	5.6	6.5	6.3	6.2	11.8	7.6	
	Ratio (progress/ baseline)	**1.01**	**0.84**	**0.87**	**0.96**	**0.84**	**0.71**	**0.53**	**0.82**	**0.87**	**1.27**	**1.30**	
Light Absorbing Carbon	**Baseline Period**	2.4	2.8	2.9	3.2	2.0	1.8	2.4	1.6	1.7	2.4	1.6	**0.98**
	Progress Period	2.9	2.1	3.4	3.5	1.8	1.4	1.6	1.6	1.6	2.5	1.8	
	Ratio (progress/ baseline)	**1.23**	**0.75**	**1.16**	**1.12**	**0.92**	**0.81**	**0.70**	**0.96**	**0.94**	**1.07**	**1.09**	
Soil	**Baseline Period**	1.3	1.1	2.0	6.8	1.3	1.2	2.5	1.5	1.5	1.2	1.3	**1.07**
	Progress Period	1.5	1.5	2.6	5.8	1.3	1.3	2.0	1.3	1.5	1.3	1.6	
	Ratio (progress/ baseline)	**1.11**	**1.35**	**1.28**	**0.85**	**1.05**	**1.07**	**0.79**	**0.91**	**1.04**	**1.06**	**1.27**	
Coarse Mass	**Baseline Period**	3.5	2.8	7.3	9.4	3.0	2.8	6.5	2.7	3.8	4.0	3.4	**1.00**
	Progress Period	3.2	4.1	6.3	10.8	3.0	2.3	4.6	2.5	4.6	3.1	4.1	
	Ratio (progress/ baseline)	**0.92**	**1.44**	**0.87**	**1.15**	**0.99**	**0.81**	**0.70**	**0.93**	**1.20**	**0.76**	**1.20**	
Sea Salt	**Baseline Period**	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.0	**2.31**
	Progress Period	0.1	0.1	0.2	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	
	Ratio (progress/ baseline)	**0.80**	**2.36**	**5.36**	**0.93**	**0.37**	**3.05**	**1.42**	**0.57**	**1.80**	**1.31**	**7.46**	

Table 6.13-4
Colorado Plateau Sites
20% Least Impaired Visibility Days
Species Averages and Ratios

20% Least Impaired Days		GRCA1	BALD1	PEFO1	SYCA1	WEMI1	WHRI1	MEVE1	SAPE1	CANY1	BRCA1	CAPI1	Average Progress/ Baseline Ratio
Ammonium Sulfate (Mm^{-1})	**Baseline Period**	1.5	1.6	2.3	2.0	1.5	1.1	2.4	1.6	2.2	1.5	1.9	**0.94**
	Progress Period	1.6	1.6	2.1	2.1	1.3	1.0	2.1	1.5	1.8	1.4	1.6	
	Ratio (progress/ baseline)	**1.08**	**0.96**	**0.95**	**1.03**	**0.91**	**0.96**	**0.87**	**0.94**	**0.84**	**0.92**	**0.84**	
Ammonium Nitrate (Mm^{-1})	**Baseline Period**	0.4	0.4	0.8	0.9	0.3	0.3	0.8	0.4	0.6	0.7	1.0	**0.78**
	Progress Period	0.4	0.3	0.6	0.8	0.2	0.2	0.6	0.4	0.5	0.5	0.6	
	Ratio (progress/ baseline)	**1.01**	**0.74**	**0.78**	**0.92**	**0.72**	**0.73**	**0.67**	**0.83**	**0.89**	**0.76**	**0.56**	
Particulate Organic Carbon (Mm^{-1})	**Baseline Period**	0.6	1.2	1.9	2.4	1.2	0.6	1.5	0.7	1.1	1.0	1.3	**0.72**
	Progress Period	0.5	1.2	1.5	1.8	0.9	0.3	1.0	0.6	0.7	0.7	0.9	
	Ratio (progress/ baseline)	**0.80**	**0.94**	**0.78**	**0.75**	**0.70**	**0.51**	**0.68**	**0.78**	**0.59**	**0.71**	**0.65**	
Light Absorbing Carbon (Mm^{-1})	**Baseline Period**	0.3	0.6	1.3	1.6	0.8	0.5	0.6	0.4	0.4	0.4	0.6	**0.75**
	Progress Period	0.3	0.6	1.3	1.4	0.5	0.3	0.4	0.2	0.3	0.2	0.3	
	Ratio (progress/ baseline)	**0.87**	**0.92**	**0.99**	**0.88**	**0.70**	**0.72**	**0.68**	**0.63**	**0.70**	**0.60**	**0.57**	
Soil (Mm^{-1})	**Baseline Period**	0.1	0.2	0.4	0.7	0.2	0.1	0.4	0.2	0.3	0.1	0.3	**0.90**
	Progress Period	0.2	0.2	0.4	0.6	0.2	0.1	0.2	0.1	0.2	0.1	0.2	
	Ratio (progress/ baseline)	**1.06**	**1.04**	**1.16**	**0.86**	**0.87**	**1.04**	**0.61**	**0.96**	**0.69**	**0.95**	**0.62**	
Coarse Mass (Mm^{-1})	**Baseline Period**	0.4	0.5	1.0	1.0	0.7	0.2	0.7	0.3	1.0	0.5	1.0	**0.91**
	Progress Period	0.5	0.6	1.0	1.2	0.6	0.3	0.4	0.3	0.7	0.4	0.6	
	Ratio (progress/ baseline)	**1.05**	**1.29**	**1.01**	**1.13**	**0.89**	**1.02**	**0.59**	**1.02**	**0.75**	**0.71**	**0.60**	
Sea Salt (Mm^{-1})	**Baseline Period**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	**2.50**
	Progress Period	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Ratio (progress/ baseline)	**1.53**	**8.34**	**4.45**	**2.42**	**1.24**	**1.25**	**1.03**	**1.02**	**1.51**	**3.92**	**0.78**	

Because of the logarithmic nature of the dv calculation (i.e., dv = $10\ln(b_{ext}/10)$), average dv ratios were not applied. Instead, in a manner consistent with RHR calculations, ratios were applied to individual species and individual days, and 5-year average deciview value was calculated from annual average deciviews, which were in turn calculated from daily average deciview value. Table 6.13-5 lists results for the ZICA1 site, where deciview values for the baseline period are approximated as being slightly higher than the measured progress period for both the 20% most impaired and least impaired days. These estimated baseline period averages are used to represent the ZICA1 for all summaries presented in this report. Note that similar baseline estimates have also been applied to estimate baseline conditions for the HACR1 site in Hawaii, as described in Section 6.5.1.1.

Table 6.13-5
ZICA1 Progress Period and Baseline Estimates

20% Least Impaired Days		**ZICA1 2005-2009 Progress Period**	**Average of Colorado Plateau Progress/Baseline Ratios**	**ZICA1 2000-2004 Baseline Estimate**
Ammonium Sulfate (Mm^{-1})	**20% Best Days**	1.7	0.94	1.8
	20% Worst Days	5.4	1.04	5.2
Ammonium Nitrate (Mm^{-1})	**20% Best Days**	0.6	0.78	0.8
	20% Worst Days	1.9	0.86	2.2
Particulate Organic Carbon (Mm^{-1})	**20% Best Days**	1.3	0.72	1.8
	20% Worst Days	8.5	0.91	9.3
Light Absorbing Carbon (Mm^{-1})	**20% Best Days**	0.6	0.75	0.8
	20% Worst Days	2.4	0.98	2.4
Soil (Mm^{-1})	**20% Best Days**	0.3	0.90	0.3
	20% Worst Days	1.8	1.07	1.7
Coarse Mass (Mm^{-1})	**20% Best Days**	1.0	0.91	1.1
	20% Worst Days	5.6	1.00	5.6
Sea Salt (Mm^{-1})	**20% Best Days**	0.0	2.50	0.0
	20% Worst Days	0.1	2.31	0.1
Deciviews (dv)	**20% Best Days**	4.3	N/A	**5.0***
	20% Worst Days	12.3	N/A	**12.5***

*Calculated from daily average b_{ext} determined using species specific average ratios from all Colorado Plateau sites.

6.13.1.2 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.309(d)(10)(i)(C))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[114] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.13-6 and 6.13-7 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired, or worst, and 20% least impaired, or best, days for each of the Federal CIA IMPROVE monitors in Utah. Figure 6.13-4 presents 5-year average extinction for the current progress period for both the 20% most impaired and 20% least impaired days. Note that the percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired days are as follows:

- The largest contributors to aerosol extinction at Utah sites were particulate organic mass, ammonium sulfate and coarse mass.
- The highest aerosol extinction (12.3 dv) was measured at the ZICA1 site, where particulate organic mass was the largest contributor to aerosol extinction, followed by coarse mass. The lowest aerosol extinction (11.0 dv) was measured at the CANY1 site.

Specific observations for the current visibility conditions on the 20% least impaired days are as follows:

- The aerosol contribution to total extinction on the best days was less than Rayleigh, or the background scattering that would occur in clear air. Average extinction (including Rayleigh) ranged from 2.1 dv (BRCA2) to 4.3 dv (ZICA1).
- For all sites, ammonium sulfate was the largest contributor to the non-Rayleigh aerosol species of extinction

[114] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

Table 6.13-6
Utah Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank*						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
BRCA1	11.9	19% (2)	9% (5)	**45% (1)**	10% (4)	5% (6)	12% (3)	0% (7)
CANY1	11.0	23% (2)	14% (4)	**27% (1)**	7% (5)	7% (6)	20% (3)	0% (7)
CAPI1	11.3	24% (2)	12% (4)	**32% (1)**	8% (5)	7% (6)	17% (3)	0% (7)
ZICA1	12.3	21% (3)	7% (5)	**33% (1)**	9% (4)	7% (6)	22% (2)	0% (7)

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.13-7
Utah Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	Deciviews (dv)	Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
BRCA1	2.1	**40% (1)**	15% (3)	22% (2)	7% (5)	4% (6)	11% (4)	1% (7)
CANY1	2.8	**43% (1)**	12% (4)	15% (3)	7% (5)	5% (6)	17% (2)	1% (7)
CAPI1	2.7	**38% (1)**	13% (4)	21% (2)	8% (5)	5% (6)	14% (3)	1% (7)
ZICA1	4.3	**30% (1)**	11% (4)	23% (2)	10% (5)	6% (6)	18% (3)	1% (7)

*Highest aerosol species contribution per site is highlighted in bold.

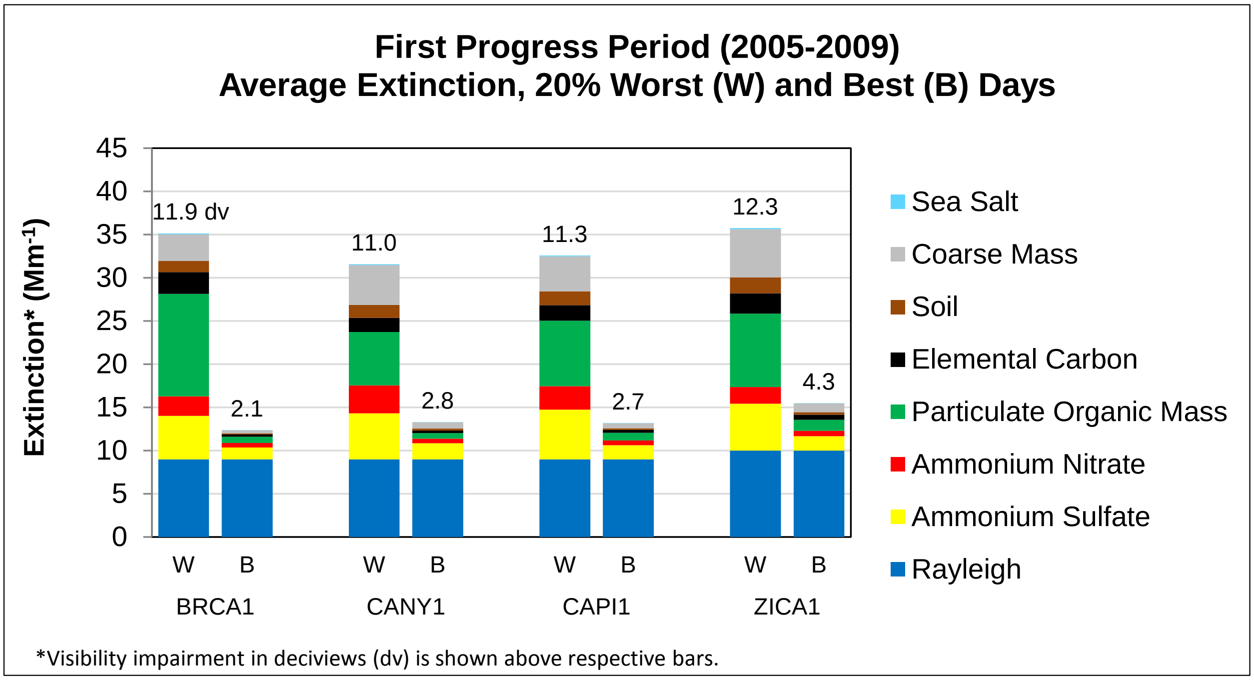

Figure 6.13-4. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at Utah Class I Area IMPROVE Sites.

6.13.1.3 Differences between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.309(d)(10)(i)(C))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Table 6.13-8 presents the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for each site in Utah for the 20% most impaired days, and Table 6.13-9 presents similar data for the least impaired days. Averages that increased are depicted in red text and averages that decreased in blue.

Figure 6.13-5 presents the 5-year average extinction for the baseline and current progress period averages for the worst days and Figure 6.13-6 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.13-7 and 6.13-8 present similar plots for the best days.

For the 20% most impaired days, the 5-year average RHR deciview metric increased between the 2000-2004 and 2005-2009 periods at the BRCA1 and CAPI1 sites and decreased at the CANY1 and ZICA1 sites. Notable differences for individual species averages were as follows:

- Increases in 5-year average deciviews at the BRCA1 and CAPI1 sites were mostly due to increases in particulate organic mass, with some increases also measured in elemental carbon and soil. Coarse mass also contributed to increases at the CAPI1 site. Increases were offset by decreases in ammonium nitrate and ammonium sulfate at both sites.

- Ammonium sulfate decreased at all sites except ZICA1. Note that the ZICA1 site did not measure during the baseline years, and changes reported here are proportional to average changes in extinction as measured at regional sites as discussed in Section 6.13.1.1.

For the 20% least impaired days, the 5-year average deciview metric decreased at all sites. Notable differences for individual species averages on the 20% least impaired days were as follows:

- All species at all sites either decreased or stayed the same between the baseline and current progress period for the best days.
- The largest decreases on the best days were measured in particulate organic mass, ammonium nitrate, ammonium sulfate, and coarse mass.

Table 6.13-8
Utah Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
BRCA1	11.6	11.9	+0.3	-0.2	-0.3	+2.5	+0.2	+0.1	-0.9	0.0
CANY1	11.2	11.0	-0.2	-0.3	+0.3	-0.9	-0.1	+0.1	+0.8	0.0
CAPI1	10.9	11.3	+0.4	-0.2	-0.7	+1.8	+0.2	+0.3	+0.7	+0.1
ZICA1	12.5	12.3	-0.2	+0.2	-0.3	-0.8	-0.1	+0.1	0.0	+0.1

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.13-9
Utah Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
BRCA1	2.8	2.1	-0.7	-0.1	-0.2	-0.3	-0.2	0.0	-0.1	0.0
CANY1	3.7	2.8	-0.9	-0.3	-0.1	-0.5	-0.1	-0.1	-0.2	0.0
CAPI1	4.1	2.7	-1.4	-0.3	-0.4	-0.5	-0.3	-0.1	-0.4	0.0
ZICA1	5.0	4.3	-0.7	-0.1	-0.2	-0.5	-0.2	0.0	-0.1	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

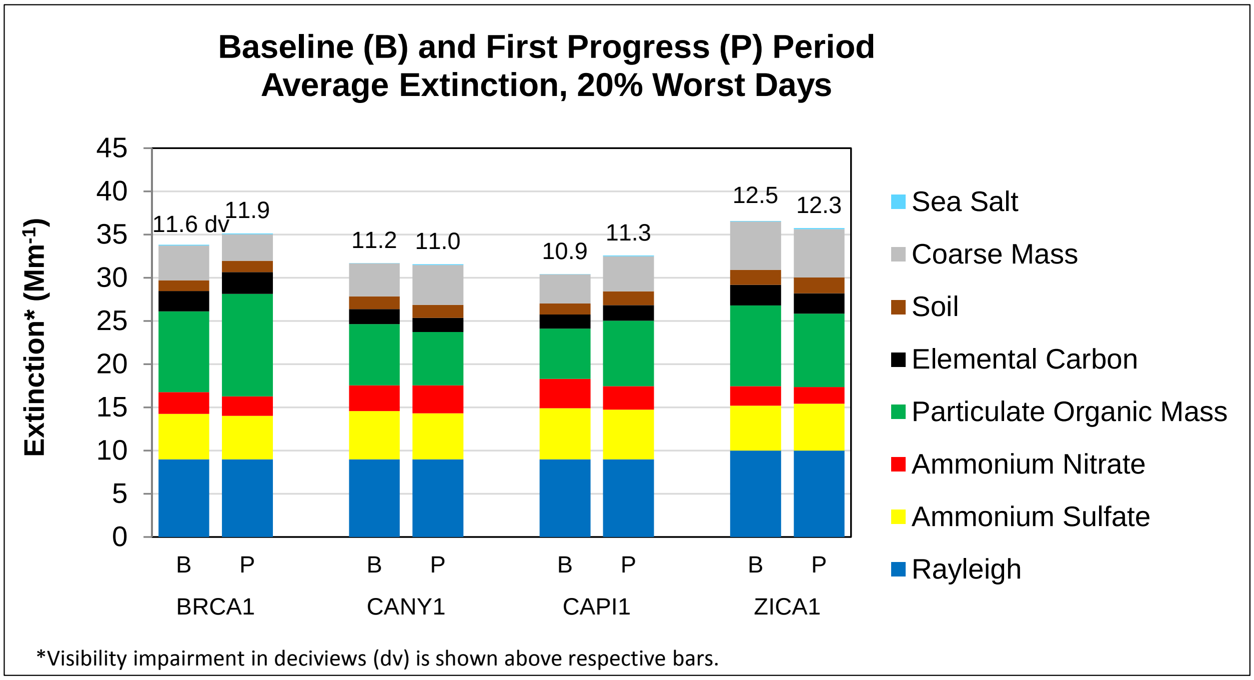

Figure 6.13-5. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at Utah Class I Area IMPROVE Sites.

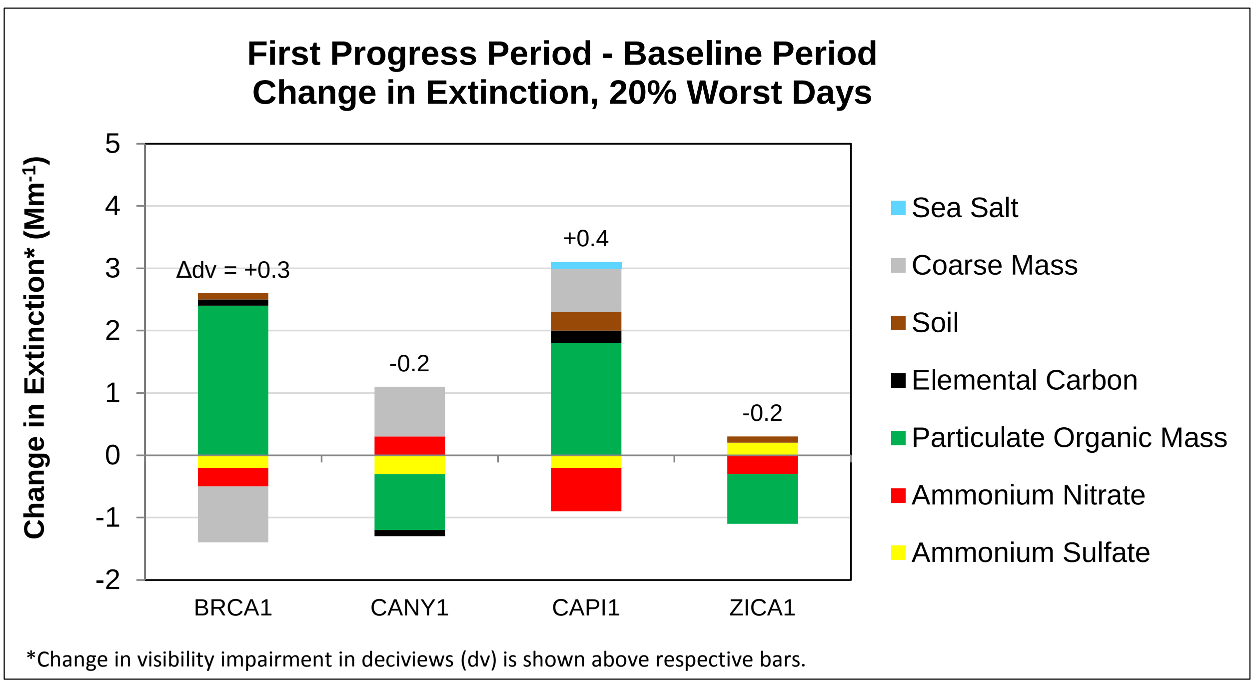

Figure 6.13-6. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at Utah Class I Area IMPROVE Sites.

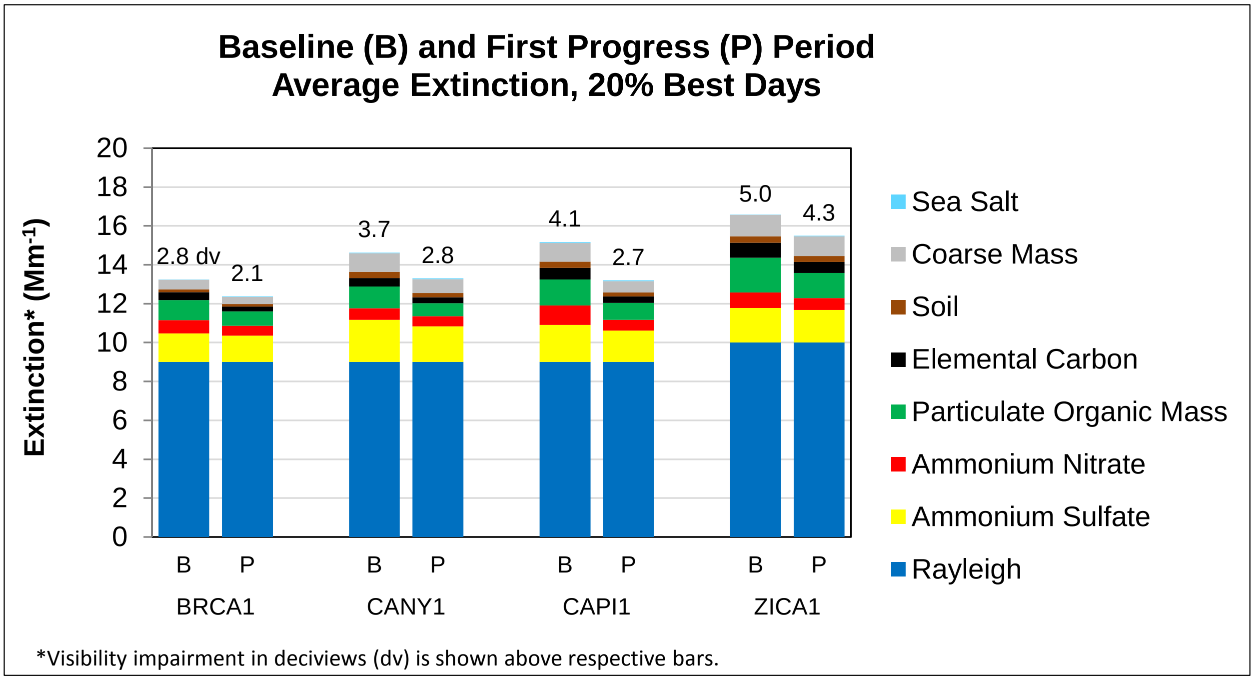

Figure 6.13-7. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at Utah Class I Area IMPROVE Sites.

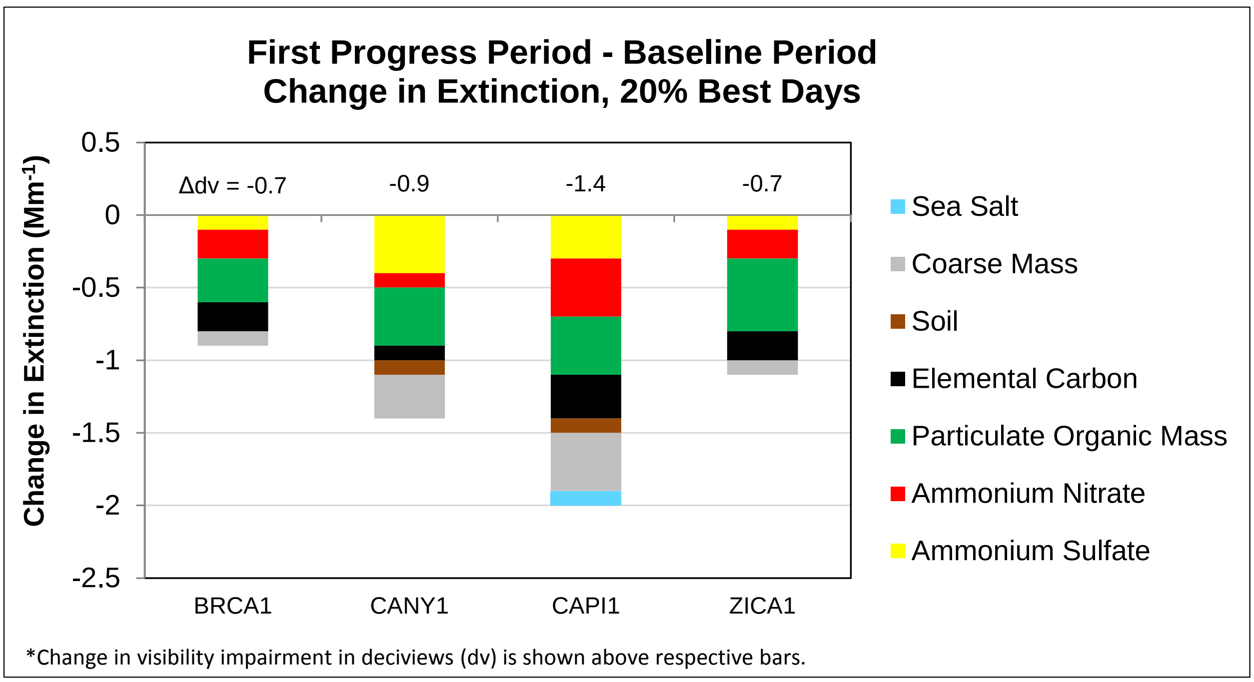

Figure 6.13-8. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at Utah Class I Area IMPROVE Sites.

6.13.1.4 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.309(d)(10)(i)(C))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5-year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in Utah are summarized in Table 6.13-10, and regional trends were presented earlier in Section 4.1.1.[115] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[116] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix M. Additionally, the appendix includes plots depicting 5-year, annual, monthly and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in Utah are as follows:

- Particulate organic mass was the largest contributor to aerosol extinction at all sites in Utah. The largest difference between the 5-year average baseline and progress periods was measured for particulate organic mass at the BRCA1 site. This difference average was influenced by a high particulate organic mass events in July and August, 2009.

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[115] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)

[116] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

- For ammonium sulfate, annual average trend statistics for all measured days indicated decreasing trends at all Utah sites. A slight increase in the 5-year average ammonium sulfate was reported for the ZICA1 site, but this was based on a baseline average estimate as described in Section 6.13.1.1. Actual data measured between 2004 and 2009 at the ZICA1 site indicated a slightly decreasing annual average trend.
- For ammonium nitrate, annual average trend statistics for all measured days indicated a decreasing trend at the CAPI1 site, and either no trend or insignificant trends at the other Utah sites.
- For soil, slightly increasing annual average trends were measured at the ZICA1 site, and an increasing trend for the worst days was measured at the CAPI1 site.
- Coarse mass increased at the CAPI1 and CANY1 sites, but these sites did not show increasing trends. Higher 5-year current period averages were influenced by higher than average coarse mass events in late April of 2008 at both sites.

Table 6.13-10
Utah Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
BRCA1	20% Best	--	0.0	-0.1	0.0	--	0.0	0.0
	20% Worst	-0.2	--	0.5	0.1	--	--	0.0
	All Days	-0.1	0.0	--	--	--	--	--
CANY1	20% Best	-0.1	--	-0.1	0.0	--	-0.1	0.0
	20% Worst	-0.1	--	--	--	--	--	0.0
	All Days	-0.1	0.0	--	0.0	0.0	--	0.0
CAPI1	20% Best	-0.1	-0.1	-0.1	0.0	--	-0.1	--
	20% Worst	--	-0.2	--	--	0.1	--	0.0
	All Days	-0.1	-0.1	--	0.0	--	--	0.0
ZICA1	20% Best	0.0	--	--	0.0	0.0	--	0.0
	20% Worst	-0.5	--	--	--	--	--	--
	All Days	-0.2	--	--	-0.1	0.1	--	--

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix M.

6.13.2 Emissions Data

Included here are summaries depicting differences between two emission inventory years that are used to represent the 5-year baseline and current progress periods. The baseline period is represented using a 2002 inventory developed by the WRAP for use in the initial WRAP state SIPs, and the progress period is represented by a 2008 inventory which leverages recent WRAP inventory work for modeling efforts, as referenced in Section 3.2.1. For reference, Table 6.13-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories, and a separate summary of annual emissions from electrical generating units (EGUs), are presented in this section.

Table 6.13-11
Utah
Pollutants, Aerosol Species, and Major Sources

Emitted Pollutant	Related Aerosol	Major Sources	Notes
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- and Off-Road Mobile Sources	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be associated with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Primary Organic Aerosol (POA)	POM	Wildfires; Area Sources	POA represents organic aerosols that are emitted directly as particles, as opposed to gases. Wildfires in the west generally dominate POA emissions, and large wildfire events are generally sporadic and highly variable from year-to-year.
Elemental Carbon (EC)	EC	Wildfires; On- and Off-Road Mobile Sources	Large EC events are often associated with large POM events during wildfires. Other sources include both on- and off-road diesel engines.
Fine Soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is reported by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$ mass measurements. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but these measurements are generally associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributor to PMC.

6.13.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.309(d)(10)(i)(D))?*** For these summaries, emissions during the baseline years are represented using a 2002 inventory, which was developed with support from the WRAP for use in the original RHR SIP strategy development (termed plan02d). Differences between inventories are represented as the difference between the 2002 inventory, and a 2008 inventory which leverages recent inventory development work performed by the WRAP for the WestJumpAQMS and DEASCO$_3$ modeling projects (termed WestJump2008). Note that the comparisons of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories, as referenced in Section 3.2.1. Inventories for all major visibility impairing pollutants are presented for major source categories, and categorized as either anthropogenic or natural emissions. State-wide inventories totals and differences are presented here, and inventory totals on a county level basis are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

Table 6.13-12 and Figure 6.13-9 present the differences between the 2002 and 2008 sulfur dioxide (SO_2) inventories by source category. Tables 6.13-13 and Figure 6.13-10 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.13-14 through 6.13-19 and Figures 6.13-10 through 6.13-16) present data for ammonia (NH_3), volatile organic compounds (VOCs), primary organic aerosol (POA), elemental carbon (EC), fine soil, and coarse mass. Inventory totals on a county level basis will be made available on the WRAP TSS website (http://vista.cira.colostate.edu/tss/). General observations regarding emissions inventory comparisons are listed below.

- Largest differences for point source inventories were a decrease in SO_2 emissions and an increases in NO_X.
- Area source inventories showed decreases in SO_2 and increases in NO_X, NH_3, POA, and VOCs. These changes may be due to a combination of population changes and differences in methodologies used to estimate these emissions, as referenced in Section 3.2.1. One methodology change was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to increases in area source inventory totals, but decreases in off-road mobile totals.
- On-road mobile source inventory comparisons showed decreases in most parameters, especially NO_X and VOCs, with increases in POA, EC, and coarse mass. Reductions in NO_X and VOC are likely influenced by federal and state emissions standards that have already been implemented. The increases in POA, EC, and coarse mass occurred in all of the WRAP states for on-road mobile inventories, regardless of reductions in NOX and VOCs, indicating that these increases were likely due use of different on-road models, as referenced in Section 3.2.1.
- Off-road mobile source inventories showed decreases in NO_X, SO_2, and VOCs, and increases in fine soil and coarse mass, which was consistent with most contiguous

WRAP states. These differences were likely due to a combination of actual changes in source contributions and methodology differences, as referenced in Section 3.2.1. As noted previously, one major methodology difference was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to decreases in the off-road inventory totals, but increases in area source totals.

- Inventory comparison results for area oil and gas showed an increase in NO_X and a decrease in VOCs. Note that inventory methodologies for these sources may have evolved substantially between the baseline and 2008 inventories as referenced in Section 3.2.1. Also, WRAP Phase III oil and gas inventories are reported here for entire basins, and include oil and gas emissions within tribal boundaries.
- For most parameters, especially POAs, VOCs, and EC, fire emission inventory estimates decreased. Note that these differences are not necessarily reflective of changes in monitored data, as the baseline period is represented by an average of 2000-2004 fire emissions, and the progress period is represented only by the fires that occurred in 2008, as referenced in Section 3.2.1.
- Comparisons between VOC inventories showed large decreases in biogenic emissions, which was consistent with other contiguous WRAP states. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions, as referenced in Section 3.2.1.
- Fine soil and coarse mass increased for the windblown dust inventory comparisons and the combined fugitive/road dust inventories. Large variability in changes in windblown dust was observed for the contiguous WRAP states, which was likely due in large part to enhancements in dust inventory methodology, as referenced in Section 3.2.1, rather than changes in actual emissions.

Table 6.13-12
Utah
Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	41,863	28,206	-13,658
Area	3,434	1,988	-1,447
On-Road Mobile	1,777	497	-1,280
Off-Road Mobile	4,504	286	-4,218
Area Oil and Gas	17	114	98
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	70	8	-62
Total Anthropogenic	**51,665**	**31,099**	**-20,566 (-40%)**
Natural Sources			
Natural Fire	2,418	92	-2,326
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**2,418**	**92**	**-2,326 (-96%)**
All Sources			
Total Emissions	**54,083**	**31,190**	**-22,892 (-42%)**

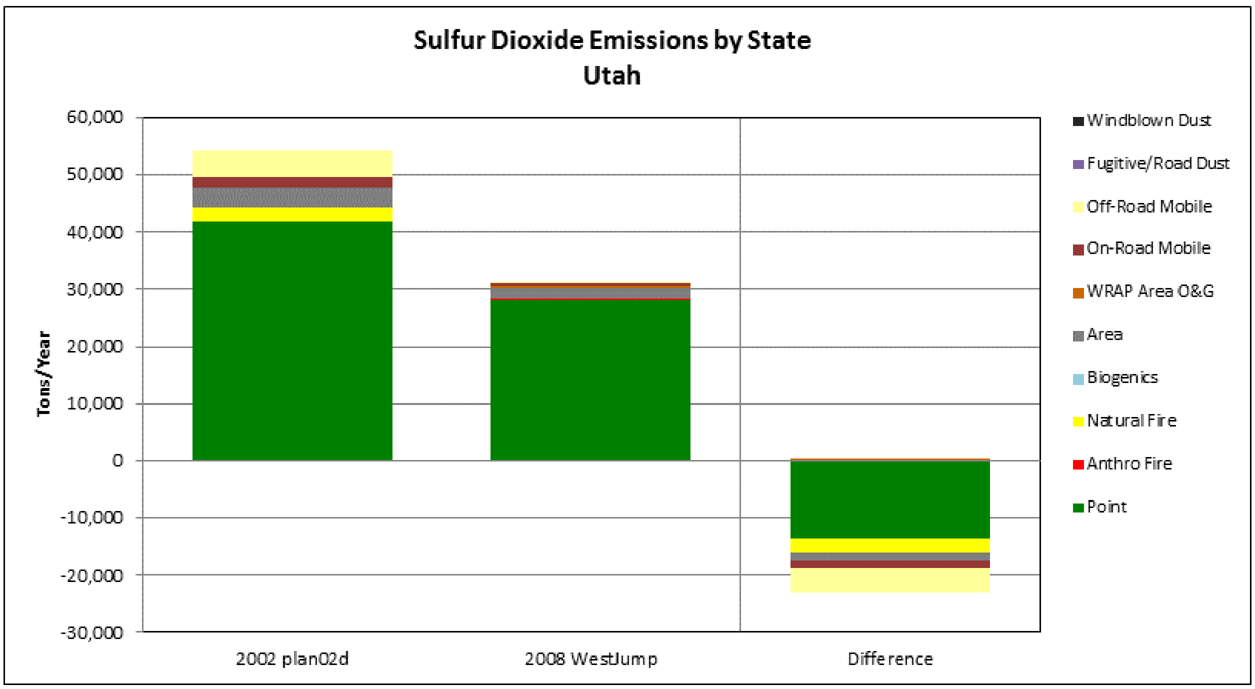

Figure 6.13-9. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for Utah.

Table 6.13-13
Utah
Oxides of Nitrogen Emissions by Category

Source Category	Oxides of Nitrogen Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	84,218	87,623	3,405
Area	6,146	17,269	11,124
On-Road Mobile	77,381	64,186	-13,195
Off-Road Mobile	47,100	13,249	-33,851
Area Oil and Gas	3,335	4,136	801
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	319	65	-254
Total Anthropogenic	**218,499**	**186,528**	**-31,971 (-15%)**
Natural Sources			
Natural Fire	8,873	650	-8,223
Biogenic	12,597	6,144	-6,453
Wind Blown Dust	0	0	0
Total Natural	**21,470**	**6,793**	**-14,676 (-68%)**
All Sources			
Total Emissions	**239,969**	**193,322**	**-46,647 (-19%)**

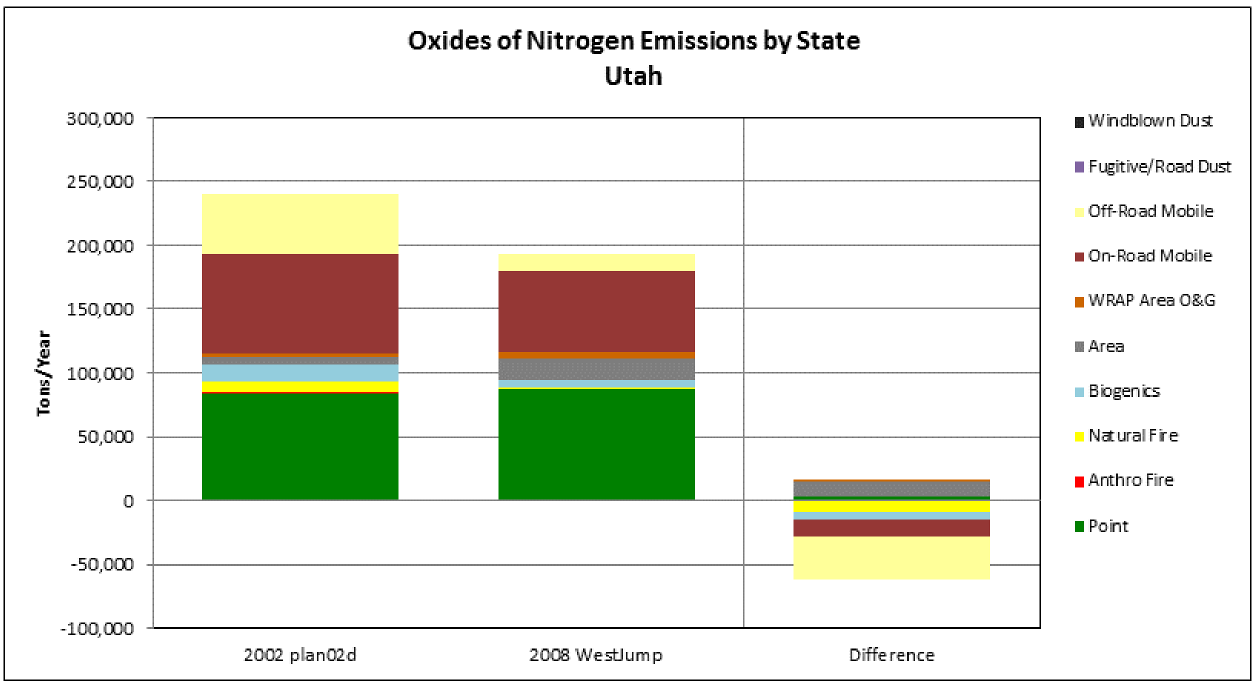

Figure 6.13-10. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Oxides of nitrogen by Source Category for Utah.

Table 6.13-14
Utah
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	1,905	556	-1,349
Area	23,642	37,639	13,997
On-Road Mobile	2,453	1,048	-1,405
Off-Road Mobile	32	16	-16
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	75	37	-38
Total Anthropogenic	**28,107**	**39,295**	**11,189 (40%)**
Natural Sources			
Natural Fire	1,893	449	-1,444
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**1,893**	**449**	**-1,444 (-76%)**
All Sources			
Total Emissions	**29,999**	**39,744**	**9,744 (32%)**

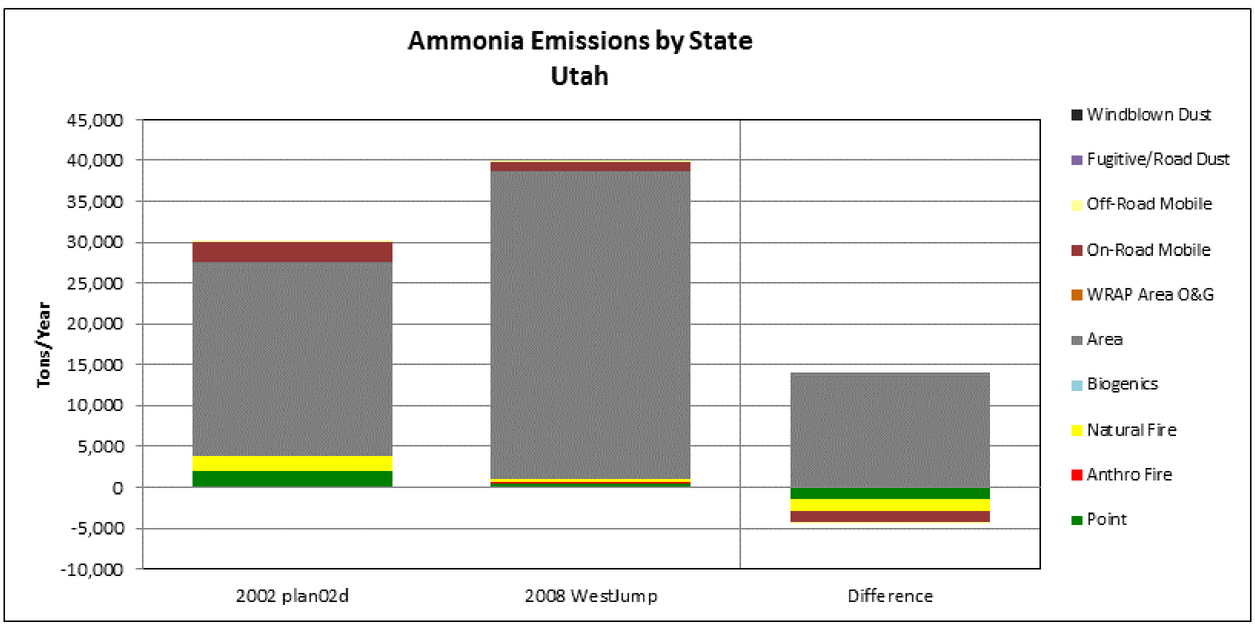

Figure 6.13-11. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Ammonia by Source Category for Utah.

Table 6.13-15
Utah
Volatile Organic Compound Emissions by Category

Source Category	Volatile Organic Compound Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	7,367	9,285	1,919
Area	46,679	72,811	26,132
On-Road Mobile	49,075	27,138	-21,937
Off-Road Mobile	26,933	23,213	-3,720
Area Oil and Gas	35,961	25,358	-10,603
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	536	126	-410
Total Anthropogenic	**166,550**	**157,931**	**-8,619 (-5%)**
Natural Sources			
Natural Fire	19,484	720	-18,764
Biogenic	641,481	237,799	-403,682
Wind Blown Dust	0	0	0
Total Natural	**660,965**	**238,518**	**-422,446 (-64%)**
All Sources			
Total Emissions	**827,515**	**396,449**	**-431,065 (-52%)**

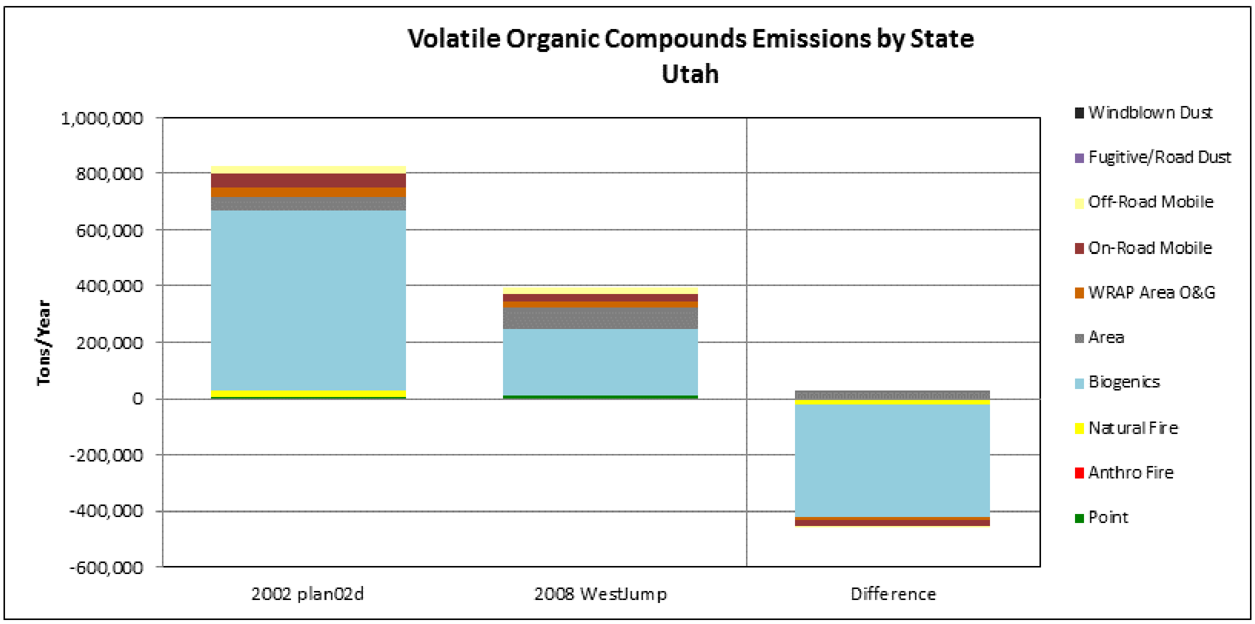

Figure 6.13-12. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for Utah.

Table 6.13-16
Utah
Primary Organic Aerosol Emissions by Category

Source Category	**Primary Organic Aerosol Emissions (tons/year)**		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	392	75	-317
Area	578	3,045	2,468
On-Road Mobile	637	1,573	937
Off-Road Mobile	965	666	-299
Area Oil and Gas	0	28	28
Fugitive and Road Dust	141	886	745
Anthropogenic Fire	507	106	-401
Total Anthropogenic	**3,219**	**6,380**	**3,161 (98%)**
Natural Sources			
Natural Fire	26,187	1,167	-25,020
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**26,187**	**1,167**	**-25,020 (-96%)**
All Sources			
Total Emissions	**29,407**	**7,547**	**-21,859 (-74%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

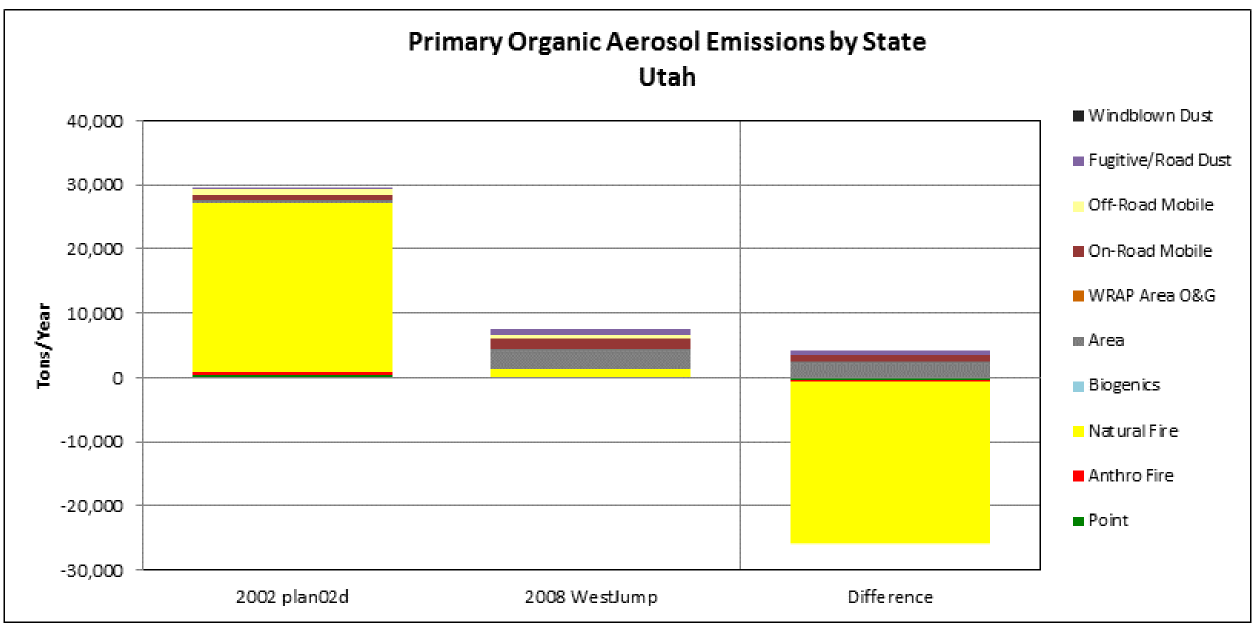

Figure 6.13-13. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Primary Organic Aerosol by Source Category for Utah.

Table 6.13-17
Utah
Elemental Carbon Emissions by Category

Source Category	Elemental Carbon Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	102	24	-77
Area	12	513	500
On-Road Mobile	663	2,593	1,930
Off-Road Mobile	2,492	715	-1,777
Area Oil and Gas	0	0	0
Fugitive and Road Dust	11	21	11
Anthropogenic Fire	85	23	-62
Total Anthropogenic	**3,364**	**3,889**	**525 (16%)**
Natural Sources			
Natural Fire	5,405	209	-5,196
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**5,405**	**209**	**-5,196 (-96%)**
All Sources			
Total Emissions	**8,769**	**4,098**	**-4,671 (-53%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

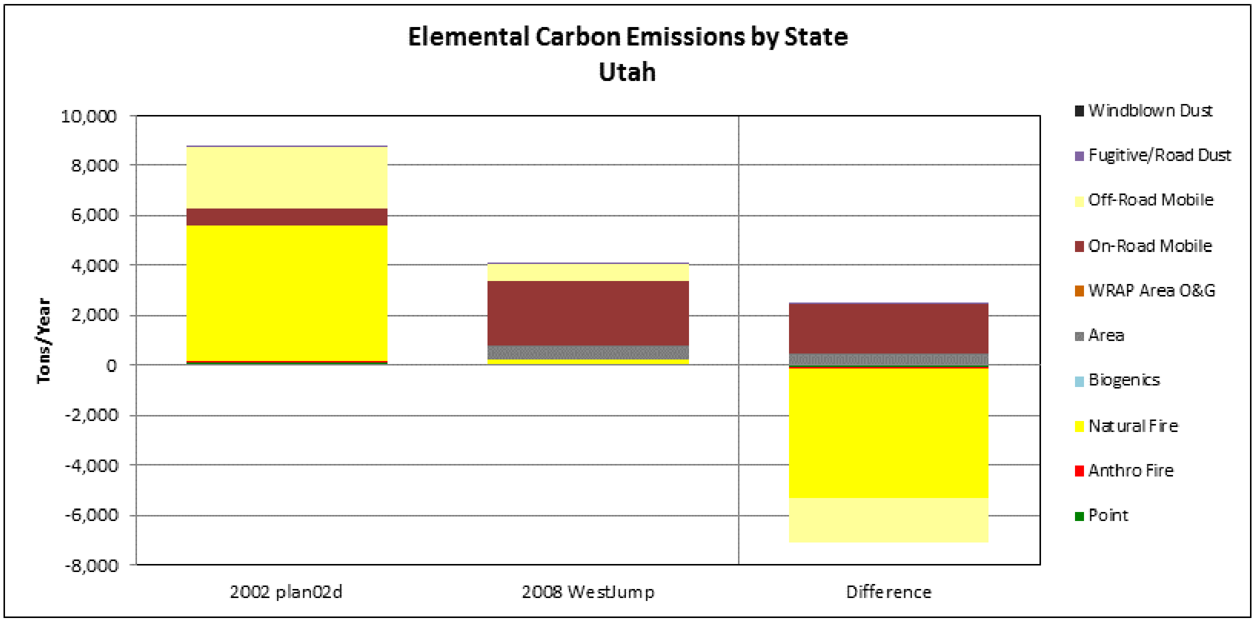

Figure 6.14-12. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Elemental Carbon by Source Category for Utah.

Table 6.13-18
Utah
Fine Soil Emissions by Category

Source Category	Fine Soil Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	2,933	712	-2,222
Area	160	1,595	1,435
On-Road Mobile	426	257	-170
Off-Road Mobile	0	47	47
Area Oil and Gas	0	479	479
Fugitive and Road Dust	2,411	14,164	11,753
Anthropogenic Fire	81	43	-38
Total Anthropogenic	**6,011**	**17,296**	**11,285 (>100%)**
Natural Sources			
Natural Fire	1,719	429	-1,290
Biogenic	0	0	0
Wind Blown Dust	7,573	10,810	3,237
Total Natural	**9,292**	**11,239**	**1,948 (21%)**
All Sources			
Total Emissions	**15,302**	**28,535**	**13,232 (86%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

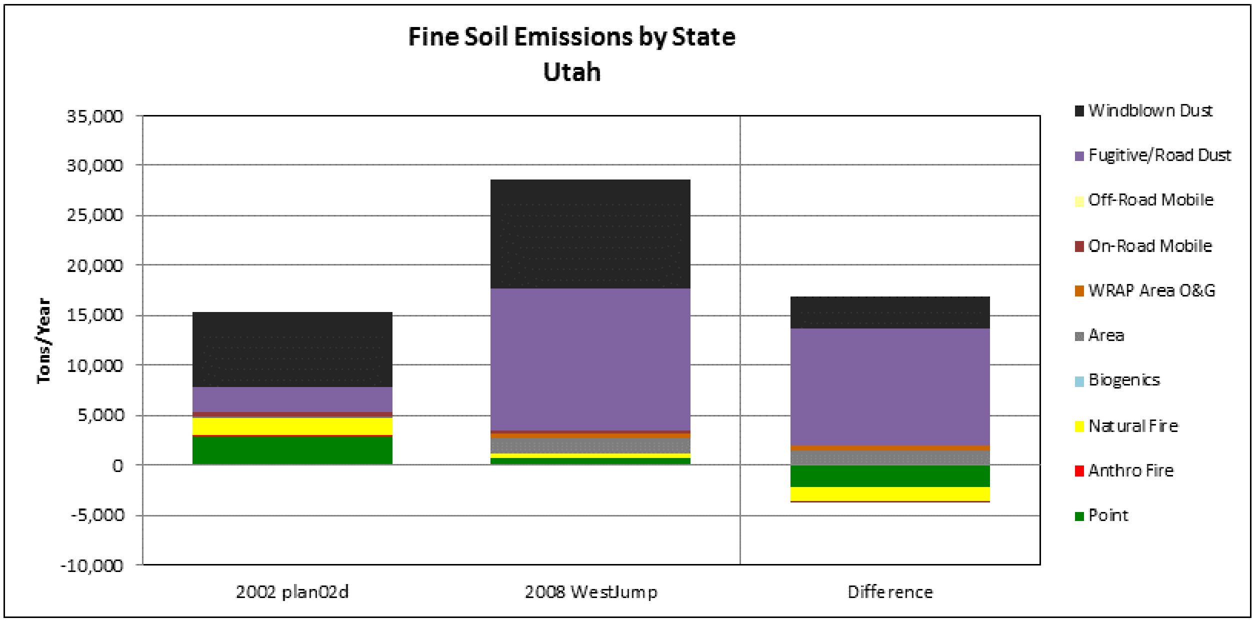

Figure 6.13-15. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Fine Soil by Source Category for Utah.

Table 6.13-19
Utah
Coarse Mass Emissions by Category

Source Category	Coarse Mass Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	8,442	4,216	-4,226
Area	2,387	2,017	-371
On-Road Mobile	414	2,801	2,387
Off-Road Mobile	0	76	76
Area Oil and Gas	0	12	12
Fugitive and Road Dust	12,374	107,079	94,705
Anthropogenic Fire	59	20	-39
Total Anthropogenic	**23,677**	**116,221**	**92,544 (>100%)**
Natural Sources			
Natural Fire	5,671	224	-5,448
Biogenic	0	0	0
Wind Blown Dust	68,153	97,289	29,136
Total Natural	**73,824**	**97,513**	**23,689 (32%)**
All Sources			
Total Emissions	**97,501**	**213,733**	**116,233 (>100%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

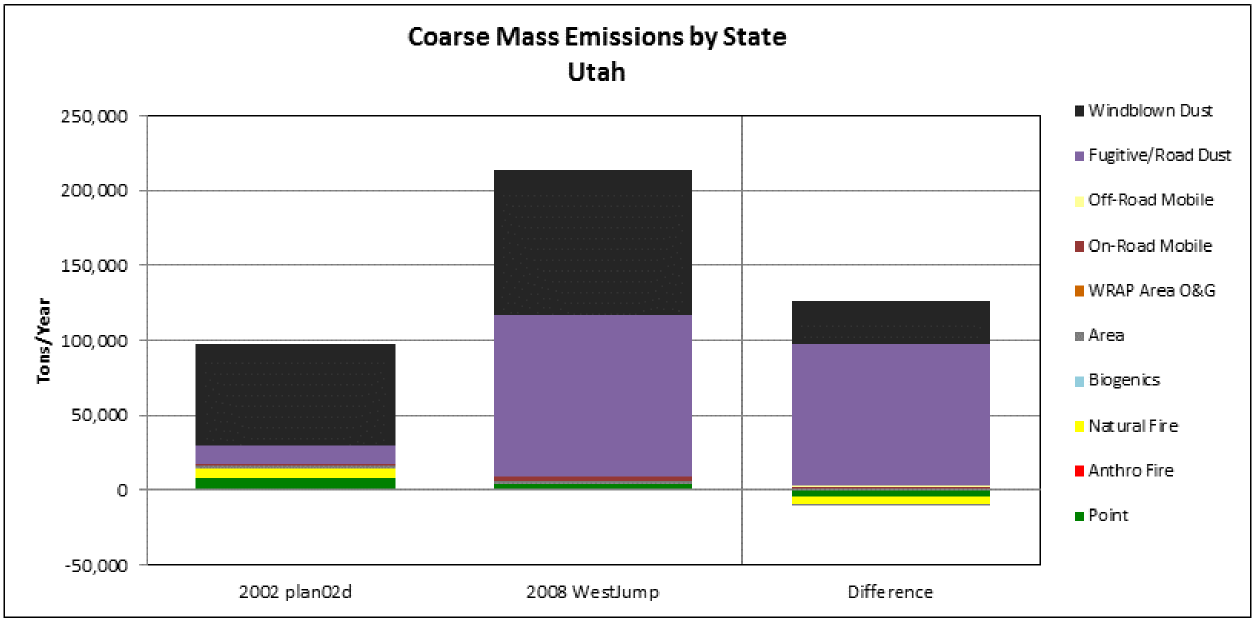

Figure 6.13-16. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Coarse Mass by Source Category for Utah.

6.13.2.2 EGU Summary

As described in previous sections, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions because numerous updates in inventory methodologies have occurred between the development of the separate inventories. Also, the 2002 baseline and 2008 progress period inventories represent only annual snapshots of emissions estimates, which may not be representative of entire 5-year monitoring periods compared. To better account for year-to-year changes in emissions, annual emission totals for Utah electrical generating units (EGU) are presented here. EGU emissions are some of the more consistently reported emissions, as tracked in EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/). RHR implementation plans are required to pay specific attention to certain major stationary sources, including EGUs, built between 1962 and 1977.

Figure 6.13-17 presents a sum of annual NO_X and SO_2 emissions as reported for Utah EGU sources between 1996 and 2010. While these types of facilities are targeted for controls in state regional haze SIPs, it should be noted that many of the controls planned for EGUs in the WRAP states had not taken place yet in 2010, while other controls separate from the RHR may have been implemented. The chart shows some periods of decline for both NO_X and SO_2, with a sharp decline in SO_2 emissions between 2006 and 2007.

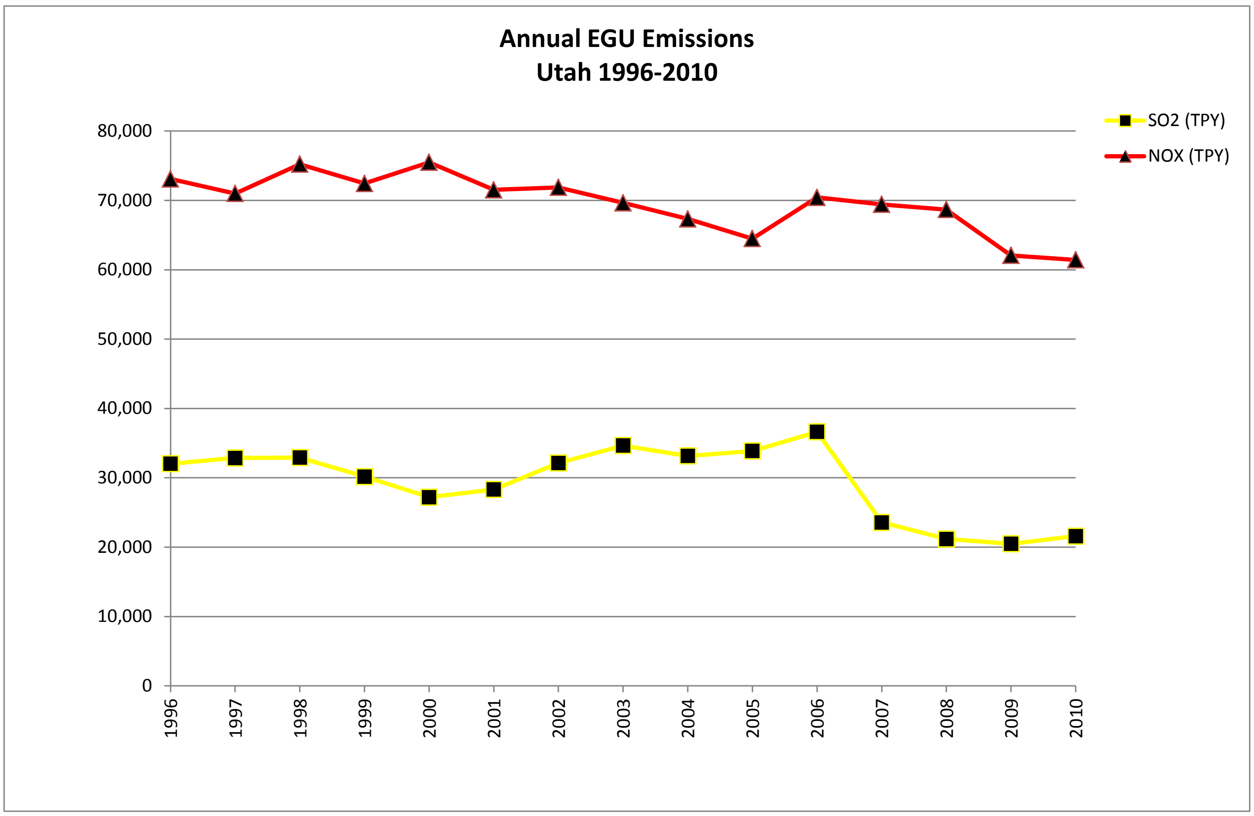

Figure 6.13-17. Sum of EGU Emissions of SO_2 and NO_X reported between 1996 and 2010 for Utah.

6.14 WASHINGTON

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. Washington has 8 mandatory Federal CIAs, which are depicted in Figure 6.14-1 and listed in Table 6.14-1, along with the associated IMPROVE monitor locations.

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per Regional Haze Rule (RHR) requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. Some of the highlights regarding these comparisons are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- For the best days, the 5-year average deciview metric decreased at all Washington Federal CIA IMPROVE sites except the WHPA1 site.
    - The increase on best days at the WHPA1 site was small (0.1 dv), and due to an increase in average ammonium sulfate, which was partially offset by a decrease in ammonium nitrate. This was not consistent emissions inventory comparisons which showed decreases in state-wide emissions of SO_2, and decreases in annual averages of SO_2 from EGU sources.
- For the worst days, the 5-year average deciview metric decreased at all sites.
    - For the worst days, all sites measured lower 5-year averages of ammonium nitrate, and all sites measured either decreasing or insignificant annual average trends in ammonium sulfate and ammonium nitrate. This was consistent with emission inventory comparison results that showed net decreases in NO_X and SO_2 emissions, mostly due to reductions from point and mobile sources.
    - All sites except WHPA1 showed decreasing trends in elemental carbon. Emissions inventory comparisons showed decreasing off-road mobile sources of elemental carbon, but increasing on-road sources. Other on-road species (e.g. oxides of nitrogen, SO_2, and volatile organic carbon) decreased, so inventory increases in elemental carbon may be due to methodology differences.

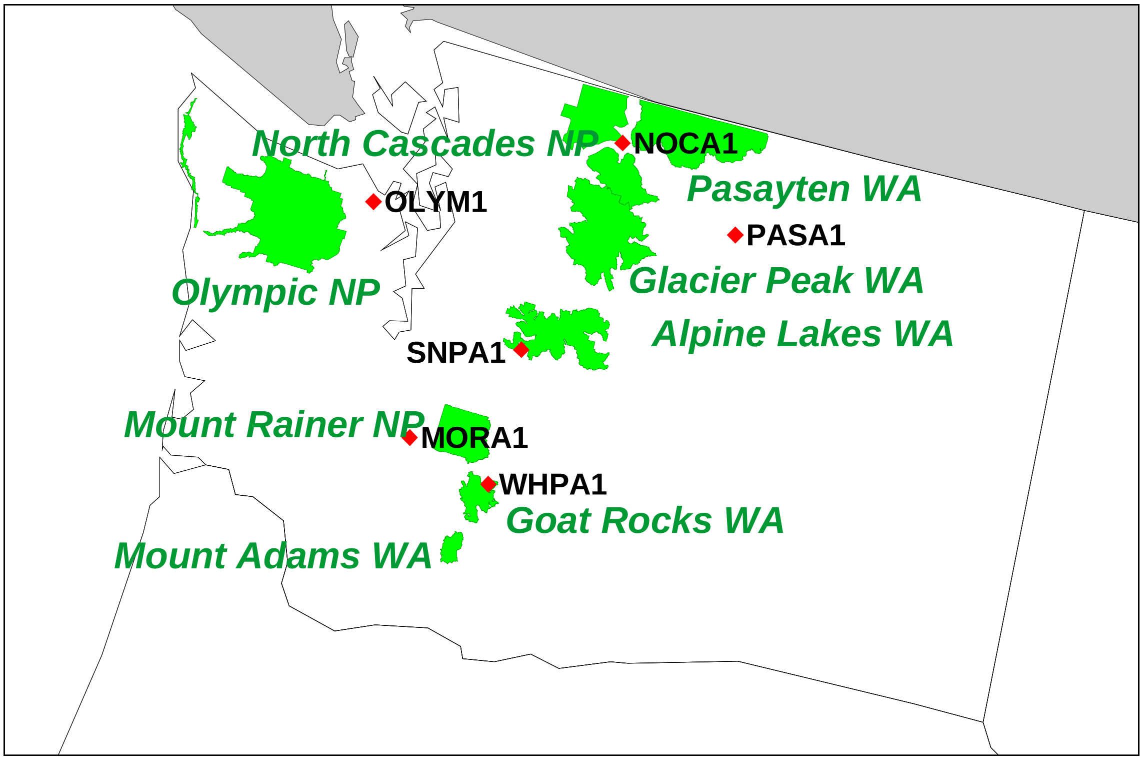

Figure 6.14-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in Washington.

Table 6.14-1
Washington CIAs and Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Mount Rainer NP	MORA1	46.76	-122.12	439
North Cascades NP Glacier Peak WA	NOCA1	48.73	-121.06	568
Olympic NP	OLYM1	48.01	-122.97	599
Pasayten WA	PASA1	48.39	-119.93	1627
Alpine Lakes WA	SNPA1	47.42	-121.43	1049
Goat Rocks WA Mount Adams WA	WHPA1	46.62	-121.39	1827

6.14.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by IMPROVE monitors representing Federal CIAs in Washington. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix N.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.14.1.1 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.308 (g)(3)(i))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[117] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.14-2 and 6.14-3 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired, or worst, and 20% least impaired, or best, days for each of the Federal CIA IMPROVE monitors in Washington. Figure 6.14-2 presents 5-year average extinction for the current progress period for both the 20% most impaired and 20% least impaired days. Note that the percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired days are as follows:

- The largest contributors to aerosol extinction at Washington sites were ammonium sulfate and particulate organic mass.
- The highest aerosol extinction (16.4 dv) was measured at the MORA1 site, where ammonium sulfate was the largest contributor to aerosol extinction, followed by particulate organic mass. The lowest aerosol extinction (12.7 dv) was measured at the WHPA1 site.

[117] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

Specific observations for the current visibility conditions on the 20% least impaired days are as follows:

- The aerosol contribution to total extinction on the best days was less than Rayleigh, or the background scattering that would occur in clear air. Average extinction (including Rayleigh) ranged from 1.8 dv (WHPA1) to 5.0 dv (OLYM1).
- For all sites, ammonium sulfate was the largest contributor to the non-Rayleigh species of aerosol extinction

Table 6.14-2
Washington Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	**Deciviews (dv)**	**Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank***						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
MORA1	16.4	**41% (1)**	9% (4)	31% (2)	10% (3)	1% (6)	6% (5)	1% (7)
NOCA1	13.7	**46% (1)**	8% (3)	32% (2)	7% (4)	1% (6)	5% (5)	1% (7)
OLYM1	15.2	**45% (1)**	18% (3)	22% (2)	6% (4)	1% (7)	5% (5)	4% (6)
PASA1	14.1	25% (2)	8% (3)	**51% (1)**	8% (4)	2% (6)	5% (5)	0% (7)
SNPA1	16.1	37% (1)	22% (3)	27% (2)	8% (4)	1% (7)	4% (5)	1% (6)
WHPA1	12.7	32% (2)	10% (3)	**39% (1)**	7% (5)	2% (6)	9% (4)	0% (7)

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.14-3
Washington Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	**Deciviews (dv)**	**Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank***						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
MORA1	4.9	**45% (1)**	7% (6)	19% (2)	9% (4)	1% (7)	8% (5)	11% (3)
NOCA1	3.2	**57% (1)**	9% (3)	17% (2)	5% (5)	1% (7)	6% (4)	5% (6)
OLYM1	5.0	**40% (1)**	14% (3)	19% (2)	7% (5)	1% (7)	5% (6)	14% (4)
PASA1	2.5	**53% (1)**	15% (2)	13% (3)	5% (6)	2% (7)	6% (4)	6% (5)
SNPA1	4.9	**39% (1)**	18% (2)	15% (3)	12% (4)	1% (7)	3% (6)	12% (5)
WHPA1	1.8	**55% (1)**	9% (4)	12% (2)	6% (6)	1% (7)	9% (3)	8% (5)

*Highest aerosol species contribution per site is highlighted in bold.

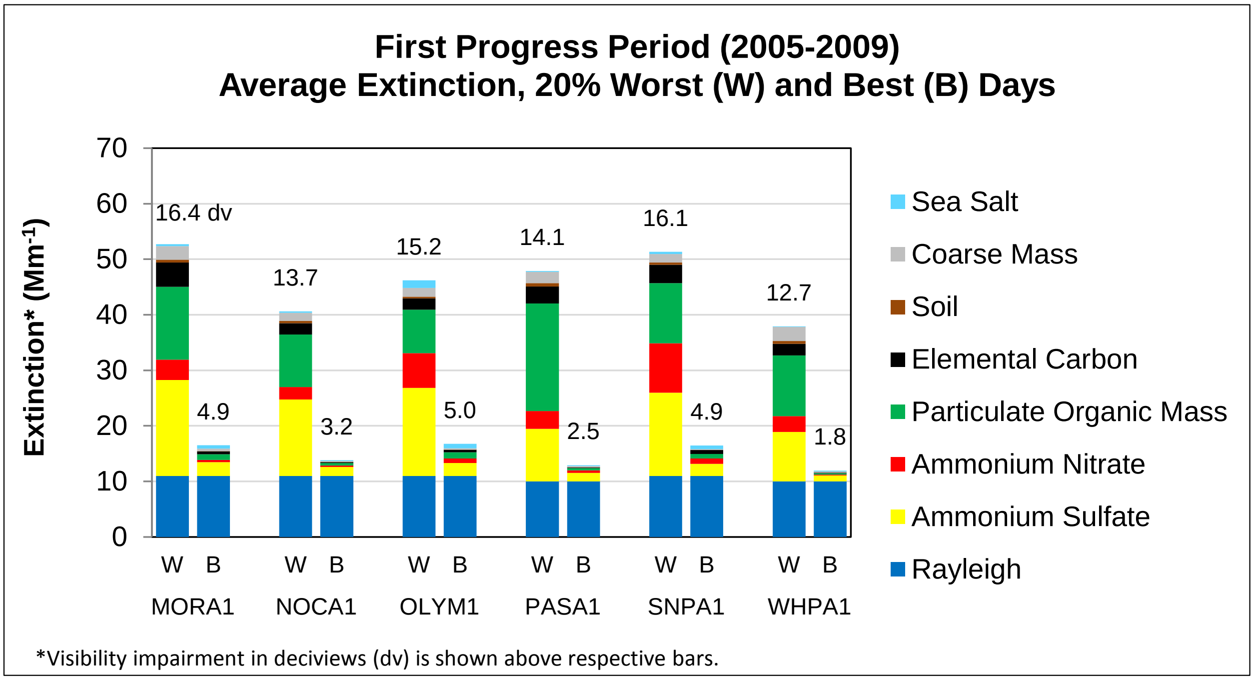

Figure 6.14-2. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at Washington Class I Area IMPROVE Sites.

6.14.1.2 Differences between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.308 (g)(3)(ii))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Table 6.14-4 presents the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for each site in Washington for the 20% most impaired days, and Table 6.14-5 presents similar data for the least impaired days. Averages that increased are depicted in red text and averages that decreased in blue.

Figure 6.14-3 presents the 5-year average extinction for the baseline and current progress period averages for the worst days and Figure 6.14-4 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.14-5 and 6.14-6 present similar plots for the best days.

For the 20% most impaired days, the 5-year average deciview metric decreased between the 2000-2004 and 2005-2009 periods at all Washington sites. Notable differences for individual species averages were as follows:

- All sites measured decreases in particulate organic mass, with the largest decreases measured at the NOCA1 site.

- Ammonium nitrate averages decreased at all sites.
- Particulate organic mass and elemental carbon averages decreased at all except the WHPA1 site.
- Ammonium sulfate decreased at all expect the PASA1 site, with the largest decrease in ammonium sulfate measured at the MORA1 site.

For the 20% least impaired days, the 5-year average deciview metric decreased at all sites except WHPA1, where the measured deciview average increased by 0.1 dv. Notable differences for individual species averages on the 20% least impaired days were as follows:

- At WHPA1, ammonium sulfate contributed to the increase in deciviews. Ammonium sulfate also increased at the NOCA1 site, but decreased at the MORA1, OLYM1, and SNPA1 sites.
- Ammonium nitrate decreased at all sites, and particulate organic mass and elemental carbon decreased at all but the WHPA1 site, where average concentrations stayed the same.

Table 6.14-4
Washington Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
MORA1	18.2	16.4	-1.8	-6.4	-1.5	-1.9	-0.8	0.0	+0.3	+0.3
NOCA1	16.0	13.7	-2.3	-1.1	-0.4	-23.6	-1.7	-0.1	-0.2	+0.2
OLYM1	16.7	15.2	-1.5	-0.8	-2.1	-4.2	-0.7	0.0	-0.2	-0.1
PASA1	15.2	14.1	-1.1	+1.4	-0.1	-2.5	-0.3	-0.2	0.0	0.0
SNPA1	17.8	16.1	-1.7	-2.1	-2.7	-4.6	-0.9	0.0	0.0	0.0
WHPA1	12.8	12.7	-0.1	-1.0	-0.2	+1.3	+0.3	0.0	+0.8	-0.3

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.14-5
Washington Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
MORA1	5.5	4.9	-0.6	-0.1	-0.2	-0.4	-0.1	0.0	-0.1	+0.1
NOCA1	3.4	3.2	-0.2	+0.2	-0.2	-0.2	-0.1	0.0	0.0	0.0
OLYM1	6.0	5.0	-1.0	-0.4	-0.4	-0.8	-0.2	0.0	-0.1	+0.2
PASA1	2.7	2.5	-0.2	0.0	-0.1	-0.2	-0.1	0.0	0.0	+0.1
SNPA1	5.5	4.9	-0.6	-0.5	-0.2	-0.2	-0.2	0.0	-0.1	+0.2
WHPA1	1.7	1.8	+0.1	+0.2	-0.1	0.0	0.0	0.0	0.0	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

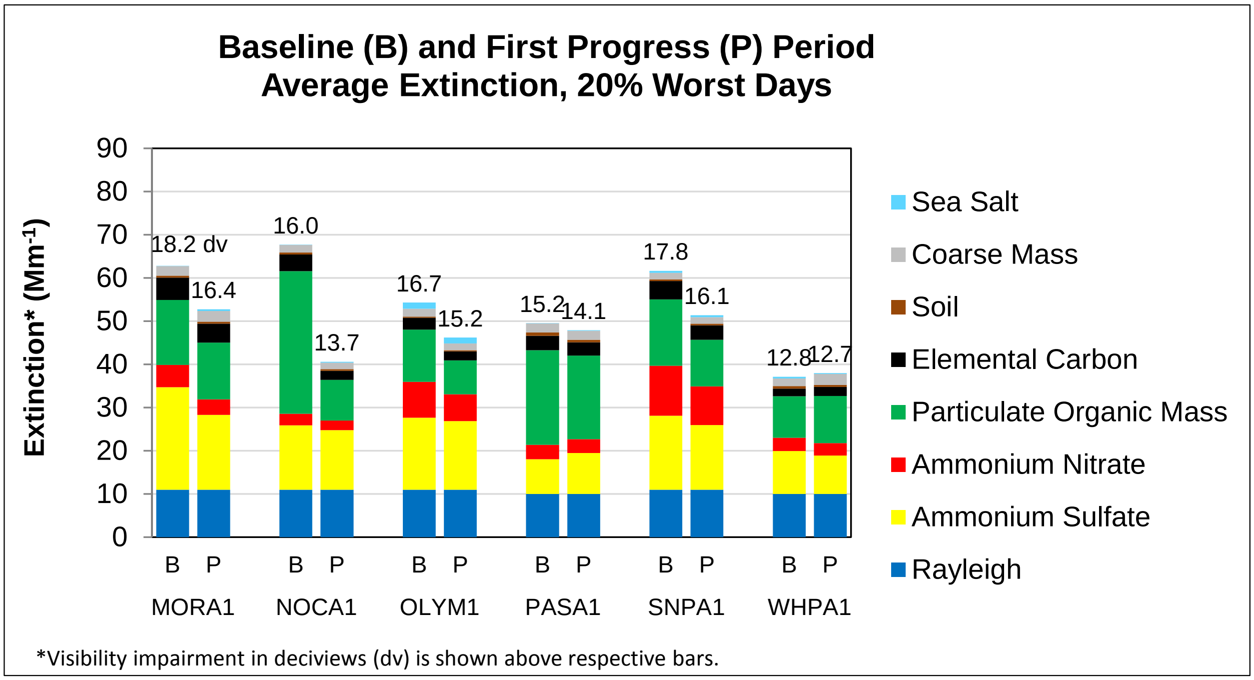

Figure 6.14-3. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at Washington Class I Area IMPROVE Sites.

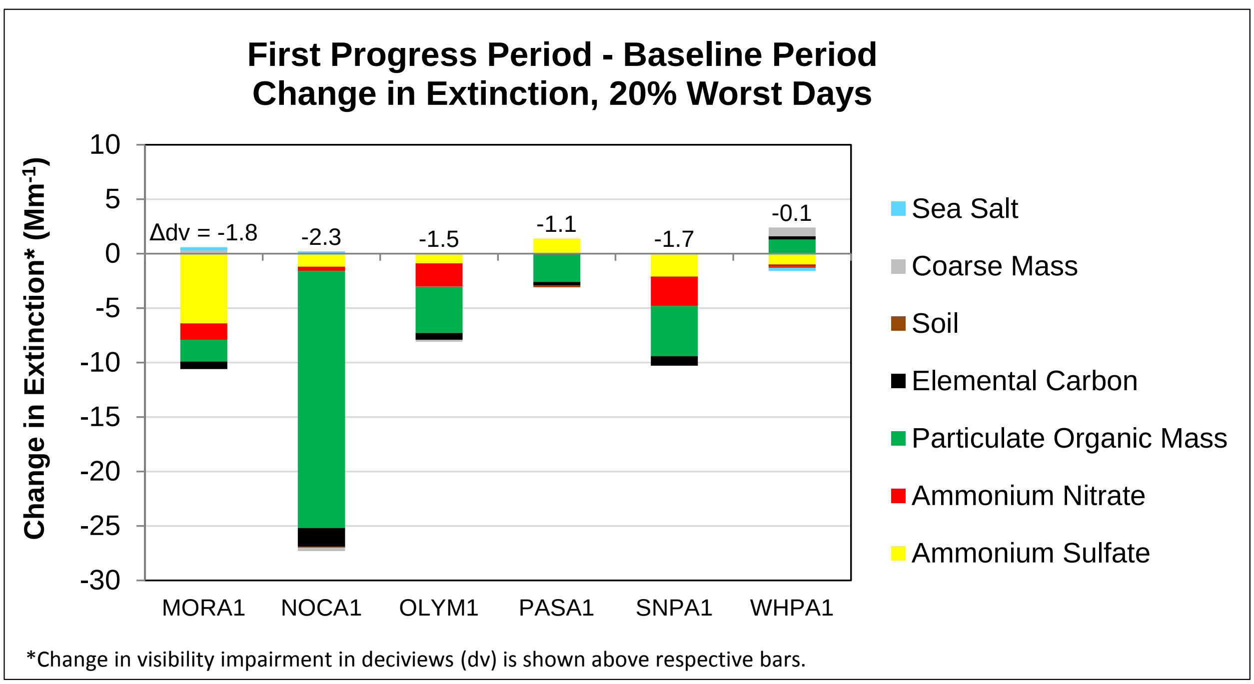

Figure 6.14-4. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at Washington Class I Area IMPROVE Sites.

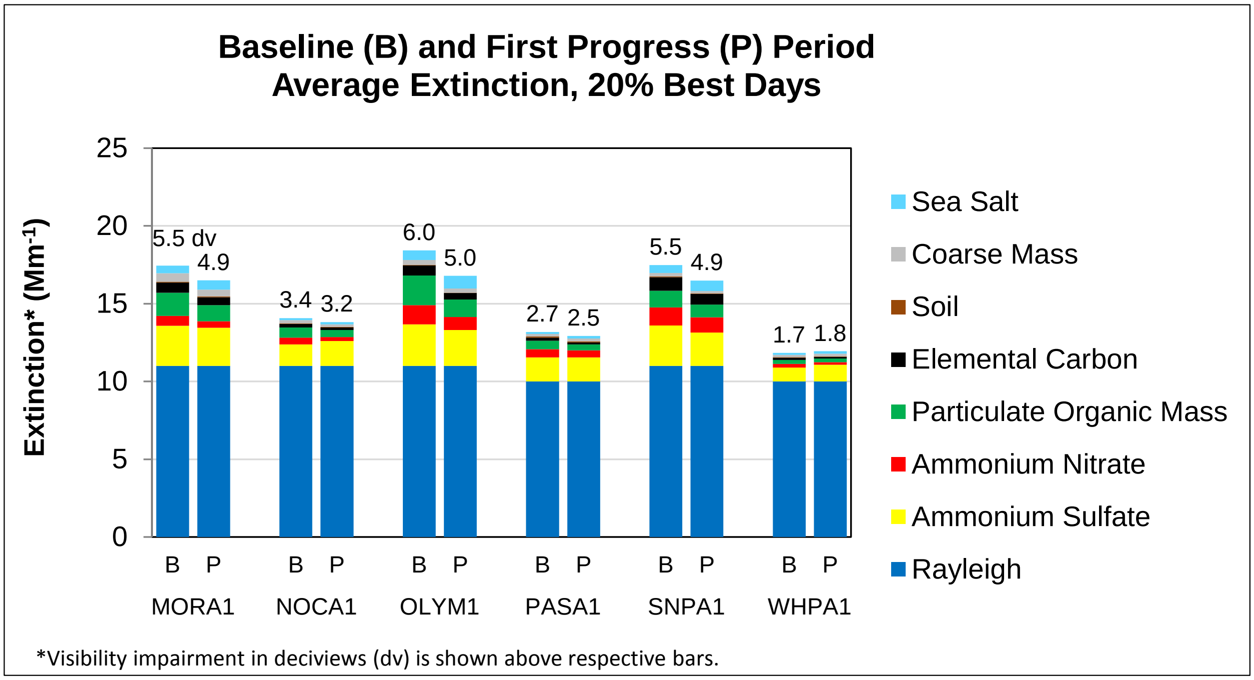

Figure 6.14-5. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at Washington Class I Area IMPROVE Sites.

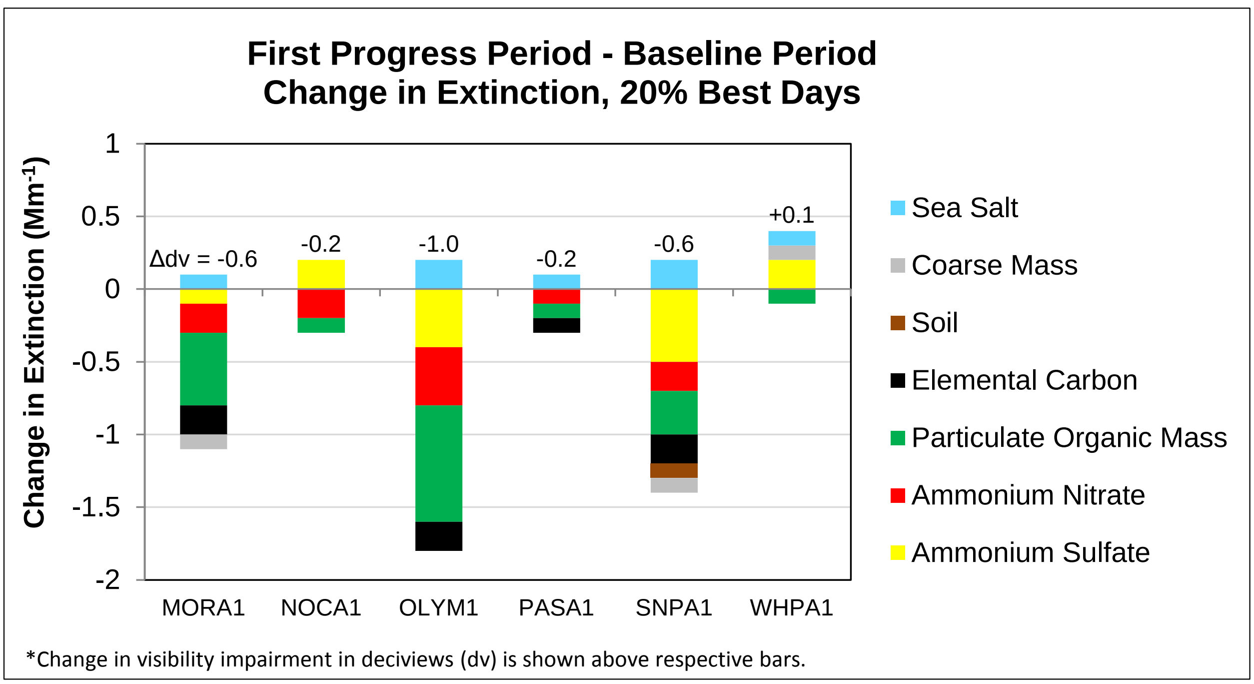

Figure 6.14-6. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at Washington Class I Area IMPROVE Sites.

6.14.1.3 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.308 (g)(3)(iii))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5-year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in Washington are summarized in Table 6.14-6, and regional trends were presented earlier in Section 4.1.1.[118] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[119] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix N. Additionally, the appendix includes plots depicting 5-year, annual, monthly and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in Washington are as follows:

- The largest changes in 5-year averages at the sites was a decrease in average particulate organic mass measured at the NOCA1 site. This difference was influenced by a high particulate organic mass event in September and October of 2003 which raised the baseline average high.
- Ammonium sulfate, ammonium nitrate, particulate organic mass, and elemental carbon all showed either decreasing or insignificant trends at all sites, with the

[118] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)

[119] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

exception of elemental carbon on the worst days at the WHPA1 site, which showed an increasing trend.

Table 6.14-6
Washington Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
MORA1	20% Best	--	0.0	-0.1	0.0	--	0.0	--
	20% Worst	-0.8	-0.2	--	-0.2	--	--	0.0
	All Days	-0.4	-0.1	-0.3	-0.1	--	--	--
NOCA1	20% Best	--	0.0	0.0	0.0	--	--	--
	20% Worst	-0.2	--	--	--	--	0.0	0.0
	All Days	--	0.0	--	--	--	0.0	0.0
OLYM1	20% Best	--	-0.1	-0.2	0.0	--	0.0	--
	20% Worst	-0.3	-0.5	-0.7	-0.2	--	--	0.1
	All Days	-0.1	-0.2	-0.3	-0.1	--	0.0	0.0
PASA1	20% Best	--	0.0	0.0	0.0	--	--	--
	20% Worst	--	-0.2	--	-0.2	0.0	--	--
	All Days	--	-0.1	--	-0.1	--	--	--
SNPA1	20% Best	-0.1	-0.1	0.0	0.0	--	0.0	0.1
	20% Worst	-0.5	-0.7	-0.5	-0.2	--	--	--
	All Days	-0.3	-0.3	-0.2	-0.1	--	--	0.1
WHPA1	20% Best	--	0.0	--	--	--	--	--
	20% Worst	--	--	--	0.1	--	0.1	-0.1
	All Days	--	--	--	--	--	--	--

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix N.

6.14.2 Emissions Data

Included here are summaries depicting differences between two emission inventory years that are used to represent the 5-year baseline and current progress periods. The baseline period is represented using a 2002 inventory developed by the WRAP for use in the initial WRAP state SIPs, and the progress period is represented by a 2008 inventory which leverages recent WRAP inventory work for modeling efforts, as referenced in Section 3.2.1. For reference, Table 6.14-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories, and a separate summary of annual emissions from electrical generating units (EGUs), are presented in this section.

Table 6.14-7
Washington
Pollutants, Aerosol Species and Major Sources

Emitted Pollutant	Related Aerosol	Major Sources	Notes
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- and Off-Road Mobile Sources	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be associated with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Primary Organic Aerosol (POA)	POM	Wildfires; Area Sources	POA represents organic aerosols that are emitted directly as particles, as opposed to gases. Wildfires in the west generally dominate POA emissions, and large wildfire events are generally sporadic and highly variable from year-to-year.
Elemental Carbon (EC)	EC	Wildfires; On- and Off-Road Mobile Sources	Large EC events are often associated with large POM events during wildfires. Other sources include both on- and off-road diesel engines.
Fine Soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is reported by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$ mass measurements. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but these measurements are generally associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributor to PMC.

6.14.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.308 (g)(4))?*** For these summaries, emissions during the baseline years are represented using a 2002 inventory, which was developed with support from the WRAP for use in the original RHR SIP strategy development (termed plan02d). Differences between inventories are represented as the difference between the 2002 inventory, and a 2008 inventory which leverages recent inventory development work performed by the WRAP for the WestJumpAQMS and DEASCO$_3$ modeling projects (termed WestJump2008). Note that the comparisons of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories, as referenced in Section 3.2.1. Inventories for all major visibility impairing pollutants are presented for major source categories, and categorized as either anthropogenic or natural emissions. State-wide inventories totals and differences are presented here, and inventory totals on a county level basis are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

Table 6.14-8 and Figure 6.14-7 present the differences between the 2002 and 2008 sulfur dioxide (SO_2) inventories by source category. Tables 6.14-9 and Figure 6.14-8 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.14-10 through 6.14-15 and Figures 6.14-9 through 6.14-14) present data for ammonia (NH_3), volatile organic compounds (VOCs), primary organic aerosol (POA), elemental carbon (EC), fine soil, and coarse mass. General observations regarding emissions inventory comparisons are listed below.

- Decreases for point source inventories were reported for all parameters, with the largest decreases in SO_2, NO_X, VOCs, fine soil, and coarse mass. Note that decreases in SO_2 and NO_X are consistent with the summary of annual EGU emissions included in Section 6.14.2.2.
- Area source inventories showed decreases in all parameters except NO_X, with the largest decreases reported for SO_2 and VOCs. These changes may be due to a combination of population changes and differences in methodologies used to estimate these emissions, as referenced in Section 3.2.1. One methodology change was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to increases in area source inventory totals, but decreases in off-road mobile totals.
- On-road mobile source inventory comparisons showed decreases in most parameters, especially NO_X and VOCs, with slight increases in POA, EC, and coarse mass. Reductions in NO_X and VOC are likely influenced by federal and state emissions standards that have already been implemented. The increases in POA, EC, and coarse mass occurred in all of the WRAP states for on-road mobile inventories, regardless of reductions in NO_X and VOCs, indicating that these increases were likely due use of different on-road models, as referenced in Section 3.2.1.

- Off-road mobile source inventories showed decreases in NO_X, SO_2, and VOCs, and increases in fine soil and coarse mass, which was consistent with most contiguous WRAP states. These differences were likely due to a combination of actual changes in source contributions and methodology differences, as referenced in Section 3.2.1. As noted previously, one major methodology difference was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to decreases in the off-road inventory totals, but increases in area source totals.
- For most parameters, especially POAs, VOCs, and EC, natural fire emission inventory estimates decreased (except for a slight increase in fine soil), and anthropogenic fire estimates increased (except for a decrease in VOCs). Note that these differences are not necessarily reflective of changes in monitored data, as the baseline period is represented by an average of 2000-2004 fire emissions, and the progress period is represented only by the fires that occurred in 2008, as referenced in Section 3.2.1. Also, methodology differences likely contributed to fine soil (for natural fire) and VOCs (for anthropogenic fire) not tracking with the other parameters.
- Comparisons between VOC inventories showed large decreases in biogenic emissions, which was consistent with other contiguous WRAP states. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions, as referenced in Section 3.2.1.
- Coarse mass decreased for the windblown dust inventory comparisons and the combined fugitive/road dust inventories. Large variability in changes in windblown dust was observed for the contiguous WRAP states, which was likely due in large part to enhancements in dust inventory methodology, as referenced in Section 3.2.1, rather than changes in actual emissions.

Table 6.14-8
Washington
Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	52,885	15,465	-37,420
Area	7,311	3,220	-4,090
On-Road Mobile	5,543	994	-4,548
Off-Road Mobile	13,913	703	-13,210
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	1,411	1,450	39
Total Anthropogenic	**81,063**	**21,833**	**-59,229 (-73%)**
Natural Sources			
Natural Fire	1,641	315	-1,325
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**1,641**	**315**	**-1,325 (-81%)**
All Sources			
Total Emissions	**82,703**	**22,149**	**-60,555 (-73%)**

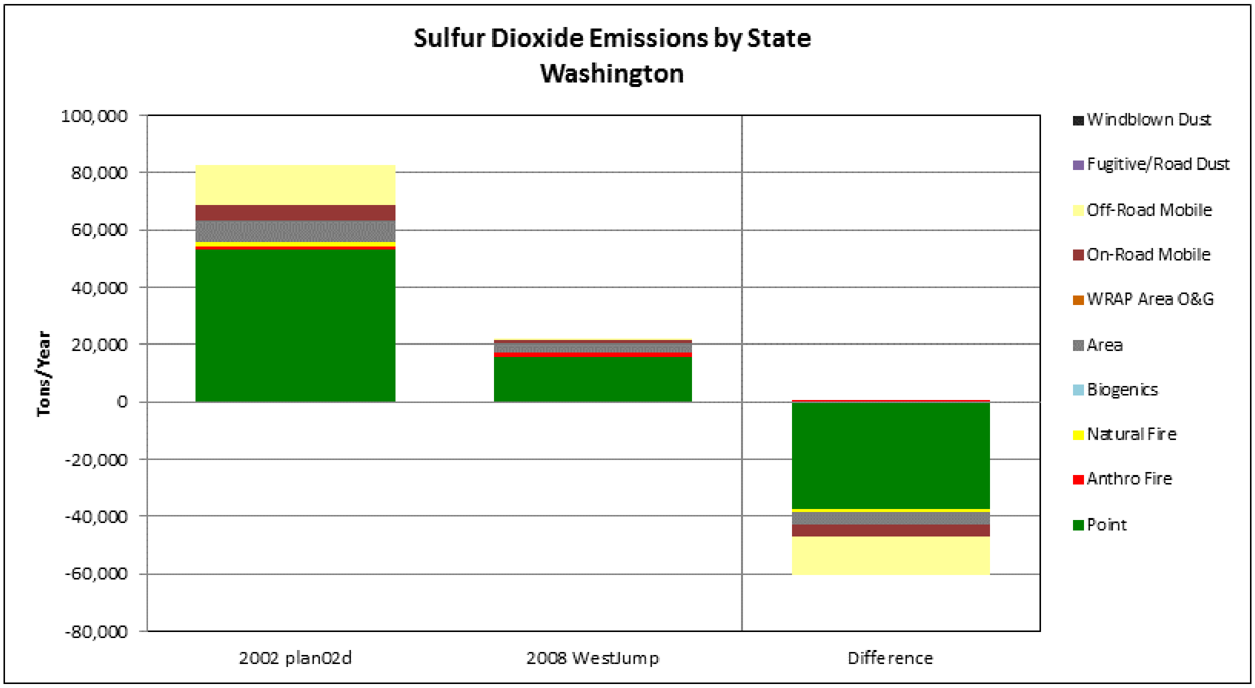

Figure 6.14-7. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for Washington.

Table 6.14-9
Washington
Nitrogen Oxide Emissions by Category

Source Category	Oxides of nitrogen Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	43,355	38,418	-4,937
Area	17,587	50,287	32,700
On-Road Mobile	201,991	141,442	-60,548
Off-Road Mobile	84,710	38,096	-46,613
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	6,821	10,269	3,448
Total Anthropogenic	**354,464**	**278,512**	**-75,952 (-21%)**
Natural Sources			
Natural Fire	5,997	2,236	-3,761
Biogenic	17,923	3,845	-14,077
Wind Blown Dust	0	0	0
Total Natural	**23,920**	**6,081**	**-17,839 (-75%)**
All Sources			
Total Emissions	**378,384**	**284,593**	**-93,790 (-25%)**

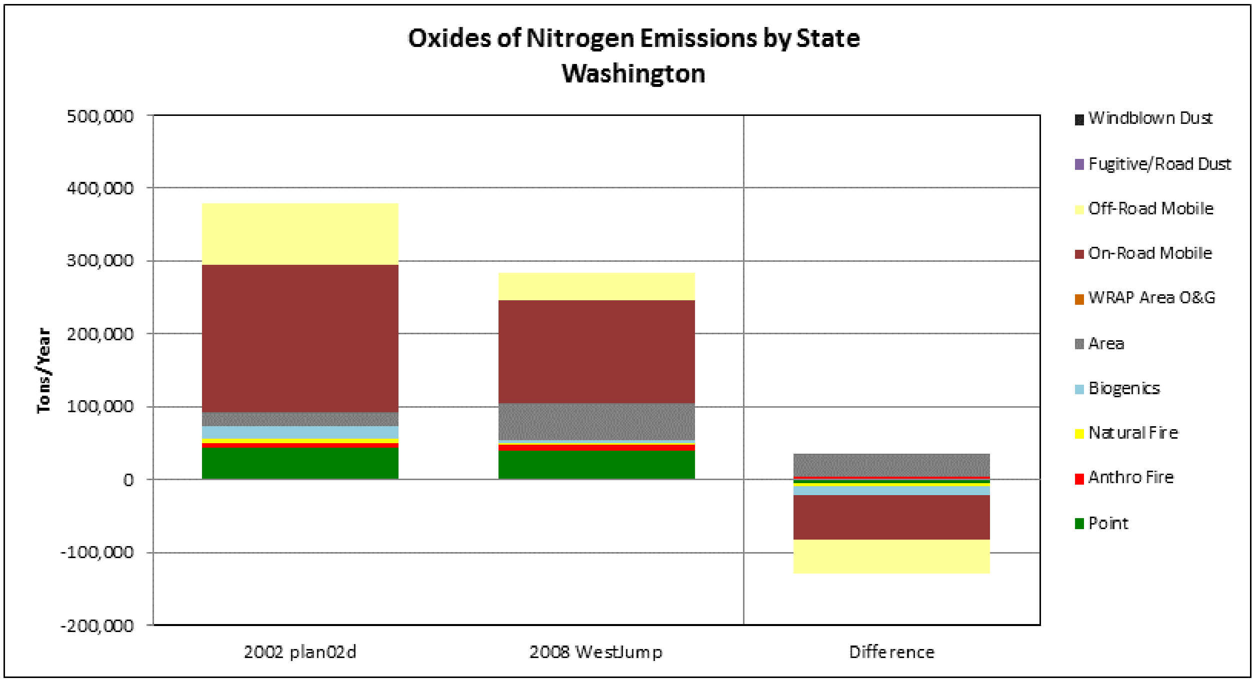

Figure 6.14-8. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Oxides of nitrogen by Source Category for Washington.

Table 6.14-10
Washington
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	3,863	441	-3,422
Area	45,218	44,368	-851
On-Road Mobile	5,211	2,543	-2,668
Off-Road Mobile	57	43	-14
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	3,439	7,152	3,713
Total Anthropogenic	**57,789**	**54,548**	**-3,241 (-6%)**
Natural Sources			
Natural Fire	1,265	1,556	291
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**1,265**	**1,556**	**291 (23%)**
All Sources			
Total Emissions	**59,054**	**56,104**	**-2,950 (-5%)**

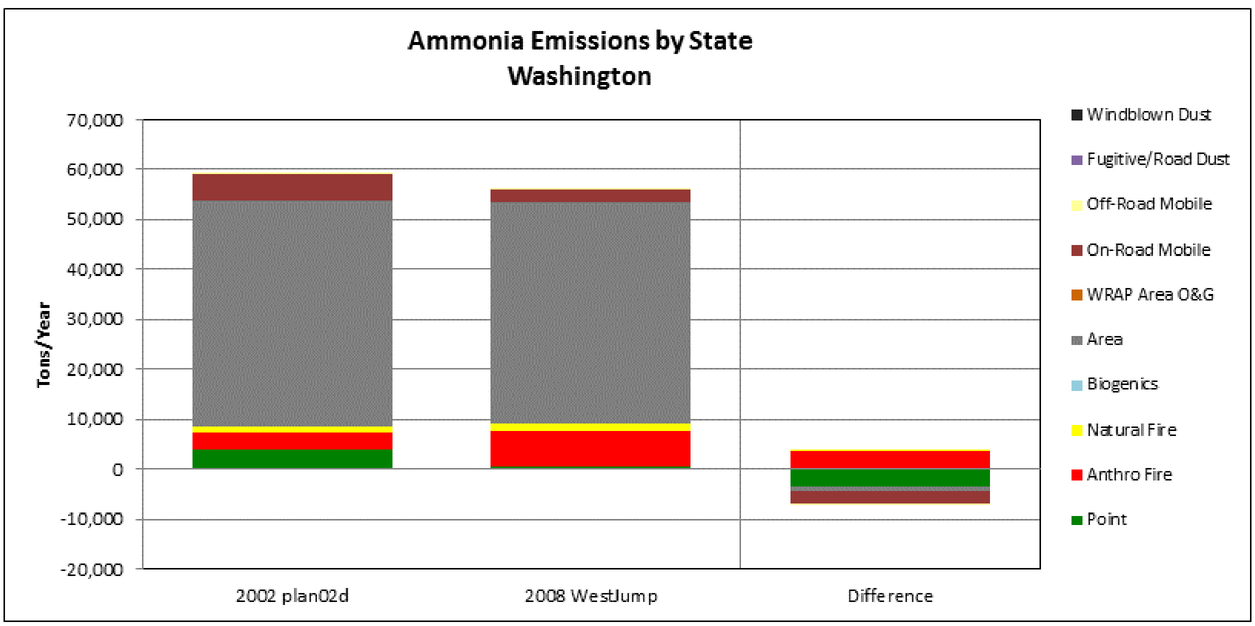

Figure 6.14-9. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Ammonia by Source Category for Washington.

Table 6.14-11
Washington
Volatile Organic Compound Emissions by Category

Source Category	Volatile Organic Compound Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	18,651	12,706	-5,945
Area	151,680	102,173	-49,507
On-Road Mobile	140,181	59,343	-80,838
Off-Road Mobile	61,601	52,264	-9,337
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	14,858	10,258	-4,600
Total Anthropogenic	**386,971**	**236,744**	**-150,227 (-39%)**
Natural Sources			
Natural Fire	13,160	2,301	-10,859
Biogenic	642,736	224,471	-418,264
Wind Blown Dust	0	0	0
Total Natural	**655,896**	**226,772**	**-429,124 (-65%)**
All Sources			
Total Emissions	**1,042,867**	**463,516**	**-579,351 (-56%)**

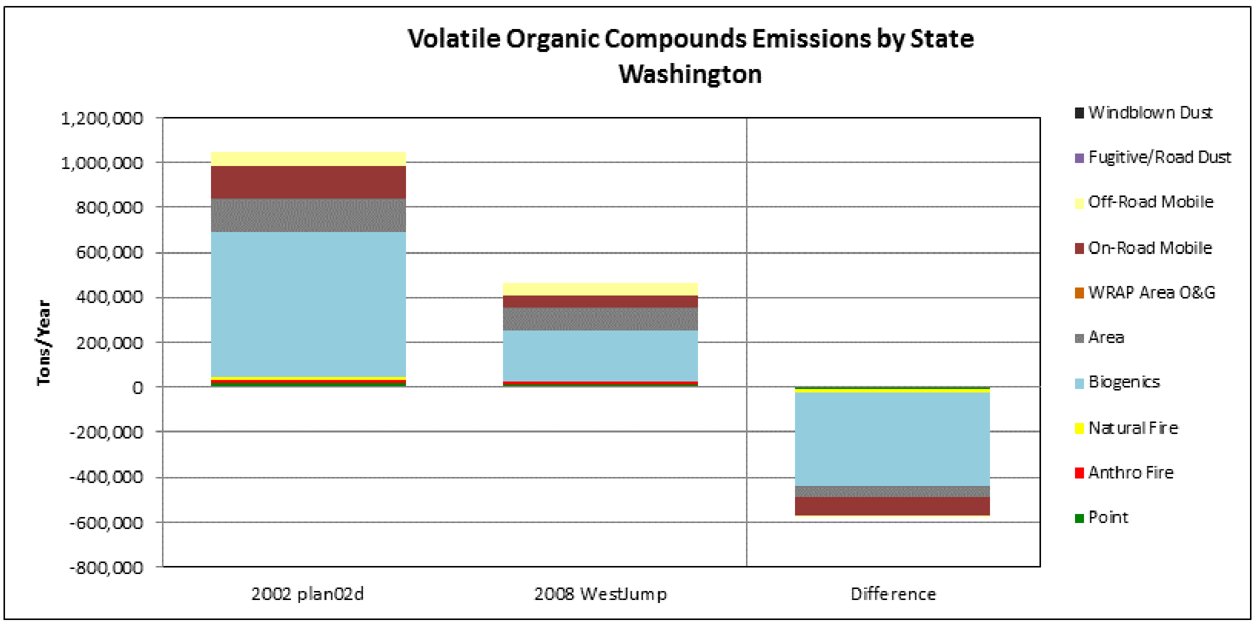

Figure 6.14-10. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for Washington.

Table 6.14-12
Washington
Primary Organic Aerosol Emissions by Category

Source Category	Primary Organic Aerosol Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	763	24	-739
Area	16,577	12,392	-4,185
On-Road Mobile	1,821	3,557	1,737
Off-Road Mobile	1,948	1,559	-389
Area Oil and Gas	0	0	0
Fugitive and Road Dust	928	825	-103
Anthropogenic Fire	10,305	20,461	10,156
Total Anthropogenic	**32,341**	**38,818**	**6,477 (20%)**
Natural Sources			
Natural Fire	17,931	4,399	-13,532
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**17,931**	**4,399**	**-13,532 (-75%)**
All Sources			
Total Emissions	**50,273**	**43,218**	**-7,055 (-14%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

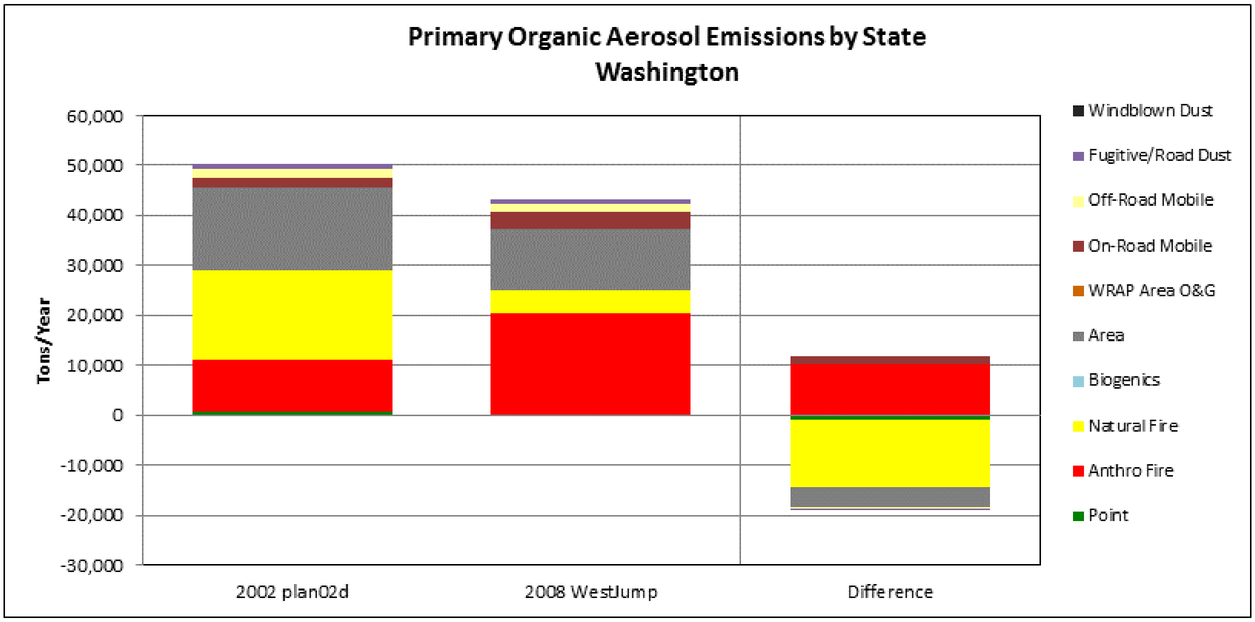

Figure 6.14-11. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Primary Organic Aerosol by Source Category for Washington.

Table 6.14-13
Washington
Elemental Carbon Emissions by Category

Source Category	Elemental Carbon Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	144	22	-122
Area	2,180	2,284	103
On-Road Mobile	2,003	5,698	3,695
Off-Road Mobile	4,213	1,948	-2,265
Area Oil and Gas	0	0	0
Fugitive and Road Dust	64	24	-40
Anthropogenic Fire	780	3,033	2,253
Total Anthropogenic	**9,385**	**13,008**	**3,623 (39%)**
Natural Sources			
Natural Fire	3,717	721	-2,996
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**3,717**	**721**	**-2,996 (-81%)**
All Sources			
Total Emissions	**13,102**	**13,729**	**627 (5%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

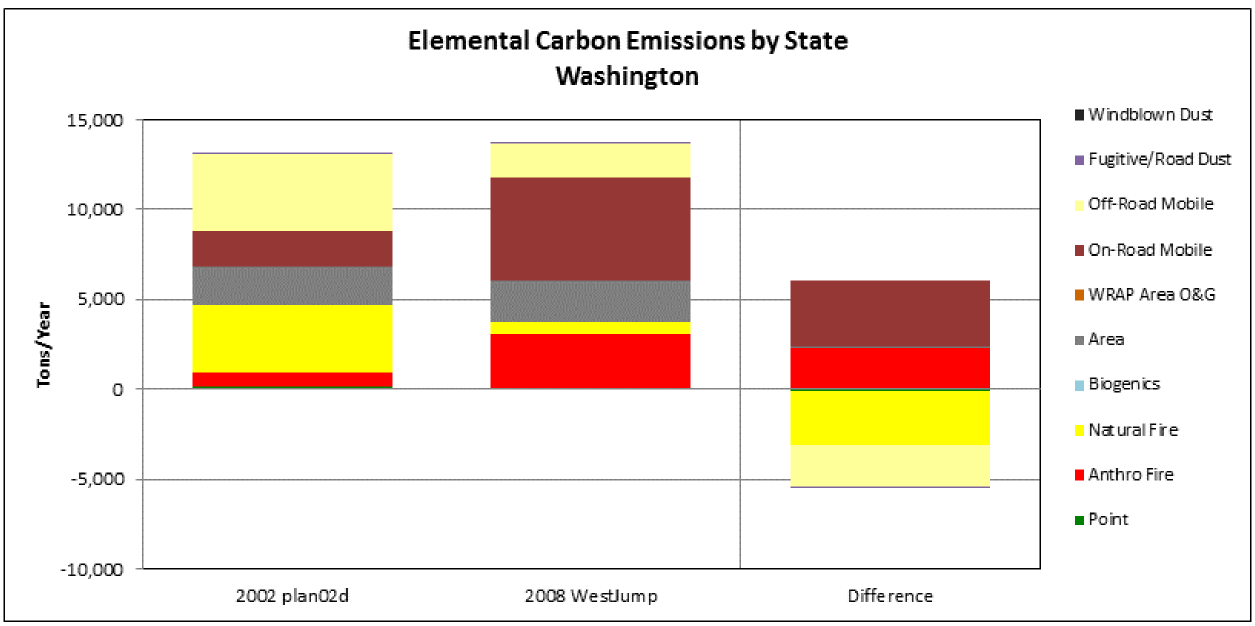

Figure 6.14-12. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Elemental Carbon by Source Category for Washington.

Table 6.14-14
Washington
Fine Soil Emissions by Category

Source Category	Fine Soil Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	2,257	355	-1,902
Area	12,708	5,726	-6,982
On-Road Mobile	1,154	602	-552
Off-Road Mobile	0	109	109
Area Oil and Gas	0	0	0
Fugitive and Road Dust	15,776	15,158	-619
Anthropogenic Fire	3,869	7,479	3,610
Total Anthropogenic	**35,764**	**29,428**	**-6,336 (-18%)**
Natural Sources			
Natural Fire	1,139	1,637	498
Biogenic	0	0	0
Wind Blown Dust	5,401	4,520	-882
Total Natural	**6,540**	**6,156**	**-384 (-6%)**
All Sources			
Total Emissions	**42,304**	**35,585**	**-6,719 (-16%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

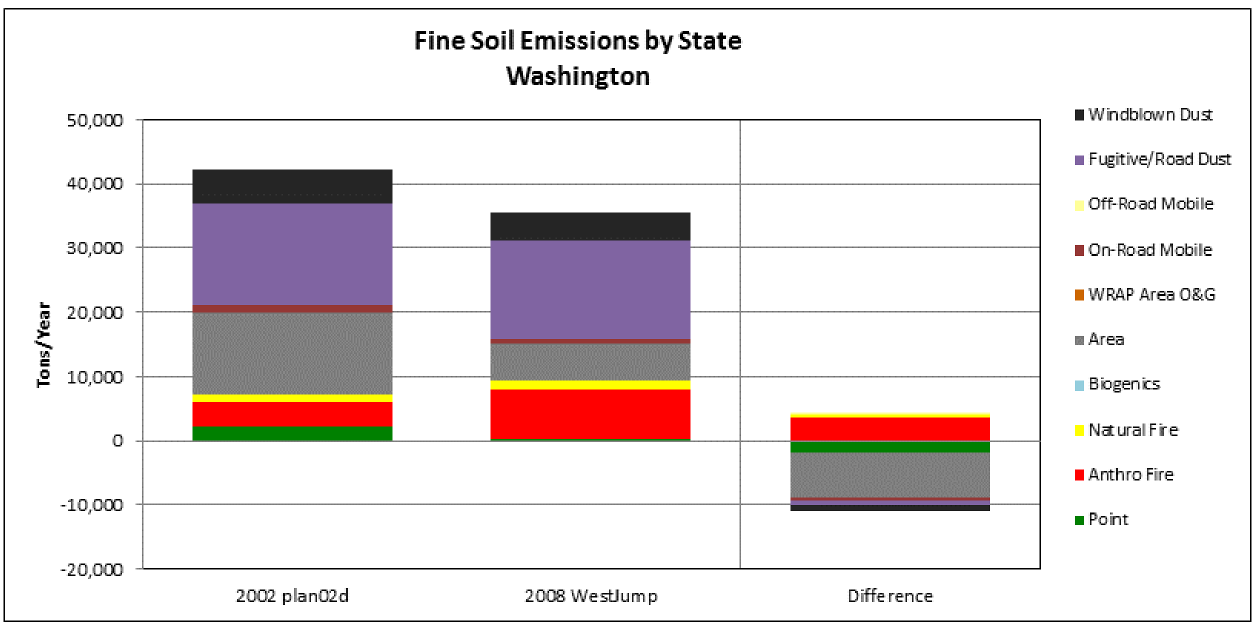

Figure 6.14-13. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Fine Soil by Source Category for Washington.

Table 6.14-15
Washington
Coarse Mass Emissions by Category

Source Category	Coarse Mass Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	6,244	866	-5,377
Area	2,083	650	-1,433
On-Road Mobile	1,079	6,313	5,234
Off-Road Mobile	0	181	181
Area Oil and Gas	0	0	0
Fugitive and Road Dust	92,749	81,331	-11,417
Anthropogenic Fire	806	3,925	3,119
Total Anthropogenic	**102,961**	**93,267**	**-9,694 (-9%)**
Natural Sources			
Natural Fire	3,856	844	-3,012
Biogenic	0	0	0
Wind Blown Dust	48,612	40,679	-7,934
Total Natural	**52,469**	**41,523**	**-10,946 (-21%)**
All Sources			
Total Emissions	**155,430**	**134,789**	**-20,640 (-13%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

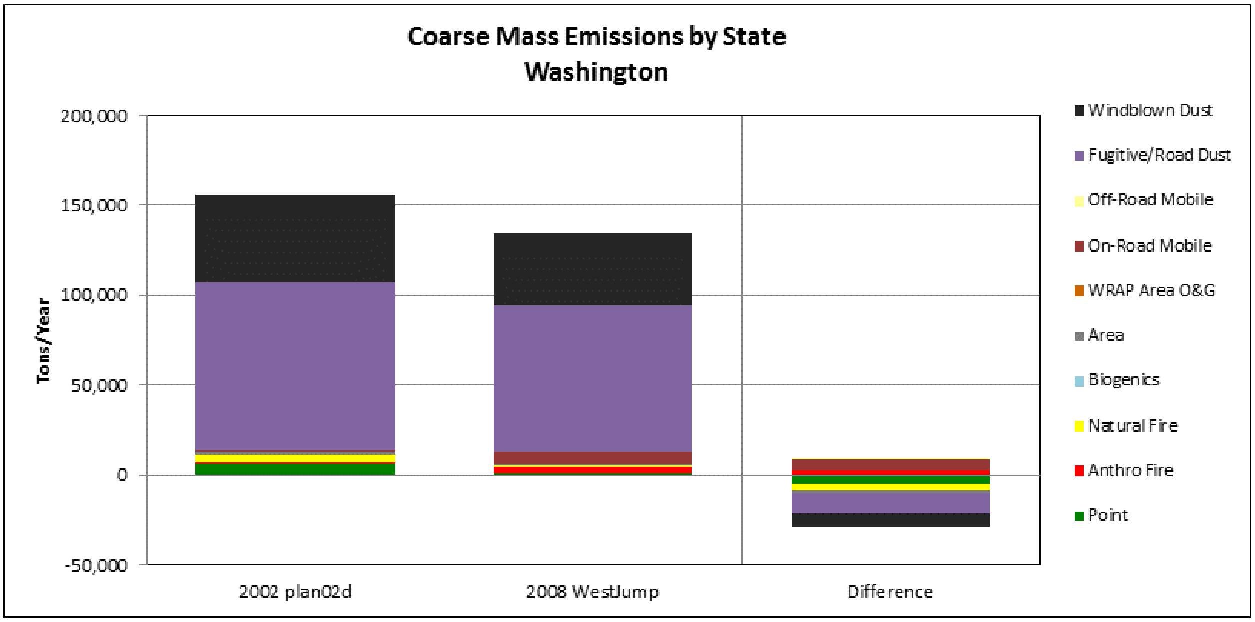

Figure 6.14-14. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Coarse Mass by Source Category for Washington.

6.14.2.2 EGU Summary

As described in previous sections, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions because numerous updates in inventory methodologies have occurred between the development of the separate inventories. Also, the 2002 baseline and 2008 progress period inventories represent only annual snapshots of emissions estimates, which may not be representative of the current 5-year monitoring period. To show a major example of year-to-year changes in emissions, annual emission totals for Washington coal-fired electrical generating units (EGU) are presented here. EGU emissions are some of the more consistently reported emissions, as tracked in EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/). RHR implementation plans are required to pay specific attention to certain major stationary sources, including EGUs, built between 1962 and 1977.

Figure 6.14-17 presents a sum of annual NO_X and SO_2 emissions as reported for Washington coal-fired EGU sources between 1996 and 2010. While these types of facilities are targeted for controls in state regional haze SIPs, it should be noted that other controls separate from the RHR may have been implemented. The chart shows a sharp decline in SO_2 emissions between 2000 and 2003, and smaller but steady declines in NO_X. The decline in SO_2 during the baseline period is due to controls approved by the EPA as Reasonable Attributable Visibility Impairment (RAVI) BART. Note that RHR BART requirements for additional NO_X emission reductions became effective on January 1, 2013.

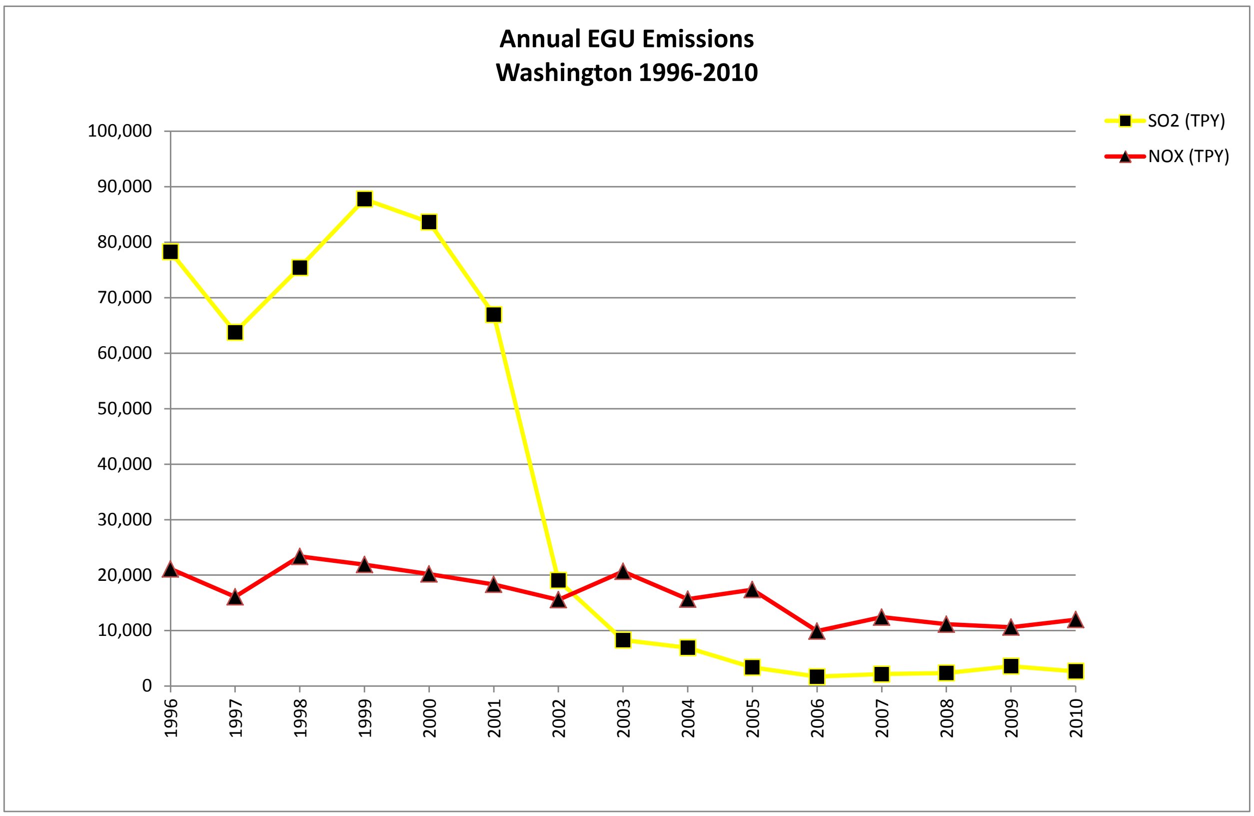

Figure 6.14-8. Sum of EGU Emissions of SO_2 and NO_X reported between 1996 and 2010 for Washington.

6.15 WYOMING

The goal of the RHR is to ensure that visibility on the 20% most impaired, or worst, days continues to improve at each Federal Class I area (CIA), and that visibility on the 20% least impaired, or best, days does not get worse, as measured at representative Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites. Wyoming has 7 mandatory Federal CIAs, which are depicted in Figure 6.15-1 and listed in Table 6.15-1, along with the associated IMPROVE monitor locations.

This section addresses differences between the 2000-2004 baseline and 2005-2009 period, for both monitored data and emission inventory estimates. Monitored data are presented for the 20% most impaired, or worst, days and for the 20% least impaired, or best, days, as per Regional Haze Rule (RHR) requirements. Annual average trend statistics for the 2000-2009 10-year period are also presented here to support assessments of changes in each monitored species that contributes to visibility impairment. Some of the highlights regarding these comparisons are listed below, and more detailed state specific information is provided in monitoring and emissions sub-sections that follow.

- For both the best and worst days, the 5-year average deciview metric decreased at all Wyoming Federal CIA IMPROVE sites.
- All sites measured lower 5-year averages of ammonium nitrate. This was consistent with emission inventory comparison results that showed net decreases in NO_X emissions, with large decreases in mobile sources partially offset by smaller increases in point and area sources.
- Particulate organic mass was the largest contributor to aerosol extinction for the most impaired days at the Wyoming sites. The current period showed increases in particulate organic mass for the BRID1 and YELL2 sites, but not at the NOAB1 site. The year 2007 was a high fire impact year at these sites, but this year was incomplete for the NOAB1 site and not included in the average, which may have influenced decreases there.
- The 5-year averages showed slightly increased ammonium sulfate measurements for the worst days at the BRID1 and YELL2 sites, but neither site showed statistically significant increasing trends. Also, state totals for SO_2 emissions showed decreases for all categories except for a slight increase in area oil and gas emissions. For oil and gas sources, methodology differences that occurred between the development of the baseline and progress period inventories have likely influenced results, so inventory comparison results are not necessarily reflective of actual changes in emissions.
- Coarse mass decreased at BRID1 and YELL2, but increased at the NOAB1 site. Coarse mass emission inventories showed increases in fugitive and road dust, but the sites did not show any significant increasing annual trends in measured coarse mass. At the NOAB1 site, the higher 5-year average coarse mass was influenced by an anomalously high sample day in 2006.

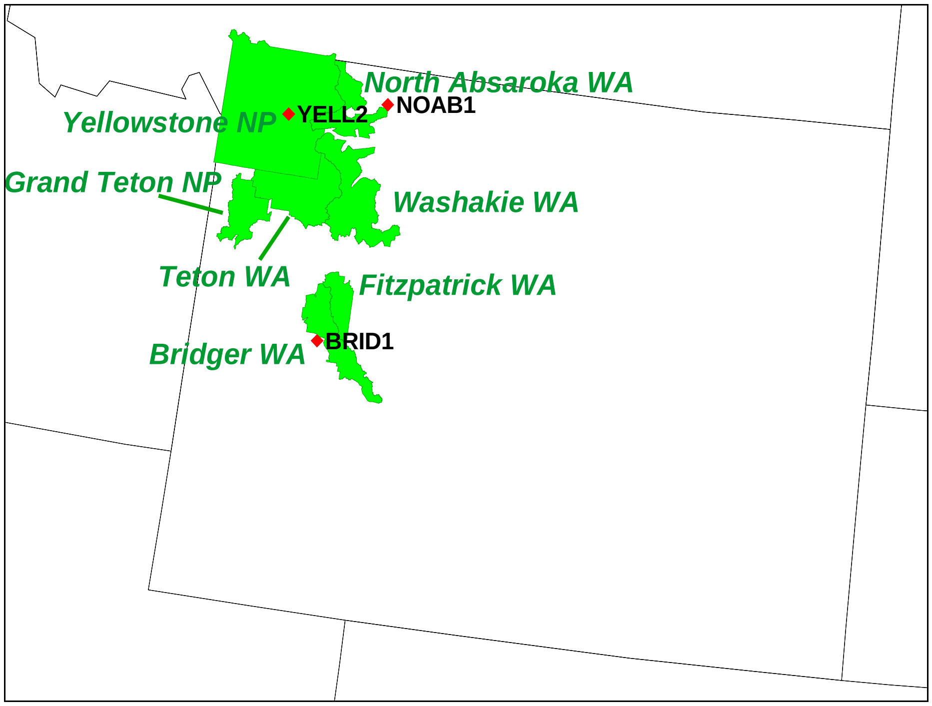

Figure 6.15-1. Map Depicting Federal CIAs and Representative IMPROVE Monitors in Wyoming.

Table 6.15-1
Wyoming CIAs and Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Bridger WA Fitzpatrick WA	BRID1	42.97	-109.76	2626
North Absaroka WA Washakie WA	NOAB1	44.74	-109.38	2482
Yellowstone NP Teton WA Grand Teton NP	YELL2	44.57	-110.40	2425

6.15.1 Monitoring Data

This section addresses RHR regulatory requirements for monitored data as measured by IMPROVE monitors representing Federal CIAs in Wyoming. These summaries are supported by regional data presented in Section 4.0 and by more detailed site specific tables and charts in Appendix M.

As described in Section 3.1, regional haze progress in Federal CIAs is tracked using calculations based on speciated aerosol mass as collected by IMPROVE monitors. The RHR calls for tracking haze in units of deciviews (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview metric, and the apportionment of haze into extinction due to the various measured species in units of inverse megameters (Mm^{-1}).

6.15.1.1 Current Conditions

This section addresses the regulatory question, ***what are the current visibility conditions for the most impaired and least impaired days (40 CFR 51.309(d)(10)(i)(C))?*** RHR guidance specifies that 5-year averages be calculated over successive 5-year periods, i.e. 2000-2004, 2005-2009, 2010-2014, etc.[120] Current visibility conditions are represented here as the most recent successive 5-year average period available, or the 2005-2009 period average, although the most recent IMPROVE monitoring data currently available includes 2010 data.

Tables 6.15-2 and 6.15-3 present the calculated deciview values for current conditions at each site, along with the percent contribution to extinction from each aerosol species for the 20% most impaired, or worst, and 20% least impaired, or best, days for each of the Federal CIA IMPROVE monitors in Wyoming. Figure 6.15-2 presents 5-year average extinction for the current progress period for both the 20% most impaired and 20% least impaired days. Note that the percentages in the tables consider only the aerosol species which contribute to extinction, while the charts also show Rayleigh, or scattering due to background gases in the atmosphere.

Specific observations for the current visibility conditions on the 20% most impaired days are as follows:

- The largest contributors to aerosol extinction at Wyoming sites were particulate organic mass, ammonium sulfate and coarse mass.
- The highest aerosol extinction (11.5 dv) was measured at the YELL2 site, where particulate organic mass was the largest contributor to aerosol extinction, followed by ammonium sulfate and coarse mass. The lowest aerosol extinction (10.7 dv) was measured at the BRID1 site.

[120] EPA's September 2003 *Guidance for Tracking Progress Under the Regional Haze Rule* specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages over successive 5-year periods, i.e. 2005-2009, 2010-2014, etc. (See page 4-2 in the Guidance document.)

Specific observations for the current visibility conditions on the 20% least impaired days are as follows:

- The aerosol contribution to total extinction on the best days was less than Rayleigh, or the background scattering that would occur in clear air. Average extinction (including Rayleigh) ranged from 1.2 dv (NOAB1) t 2.0 dv (YELL2).
- For all sites, ammonium sulfate was the largest non-Rayleigh contributor to the aerosol species of extinction

Table 6.15-2
Wyoming Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Most Impaired Days

Site	**Deciviews (dv)**	**Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank***						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
BRID1	10.7	23% (2)	5% (5)	**49% (1)**	8% (4)	5% (6)	10% (3)	0% (7)
NOAB1	11.0	21% (2)	6% (5)	**45% (1)**	8% (4)	4% (6)	15% (3)	0% (7)
YELL2	11.5	17% (2)	6% (5)	**57% (1)**	8% (4)	3% (6)	9% (3)	0% (7)

*Highest aerosol species contribution per site is highlighted in bold.

Table 6.15-3
Wyoming Class I Area IMPROVE Sites
Current Visibility Conditions
2005-2009 Progress Period, 20% Least Impaired Days

Site	**Deciviews (dv)**	**Percent Contribution to Aerosol Extinction by Species (Excludes Rayleigh) (% of Mm^{-1}) and Rank**						
		Ammonium Sulfate	**Ammonium Nitrate**	**Particulate Organic Mass**	**Elemental Carbon**	**Soil**	**Coarse Mass**	**Sea Salt**
BRID1	1.5	**45% (1)**	13% (3)	23% (2)	8% (5)	3% (6)	8% (4)	1% (7)
NOAB1	1.2	**44% (1)**	10% (4)	16% (3)	7% (5)	4% (6)	18% (2)	0% (7)
YELL2	2.0	**42% (1)**	16% (3)	25% (2)	8% (4)	2% (6)	7% (5)	1% (7)

*Highest aerosol species contribution per site is highlighted in bold.

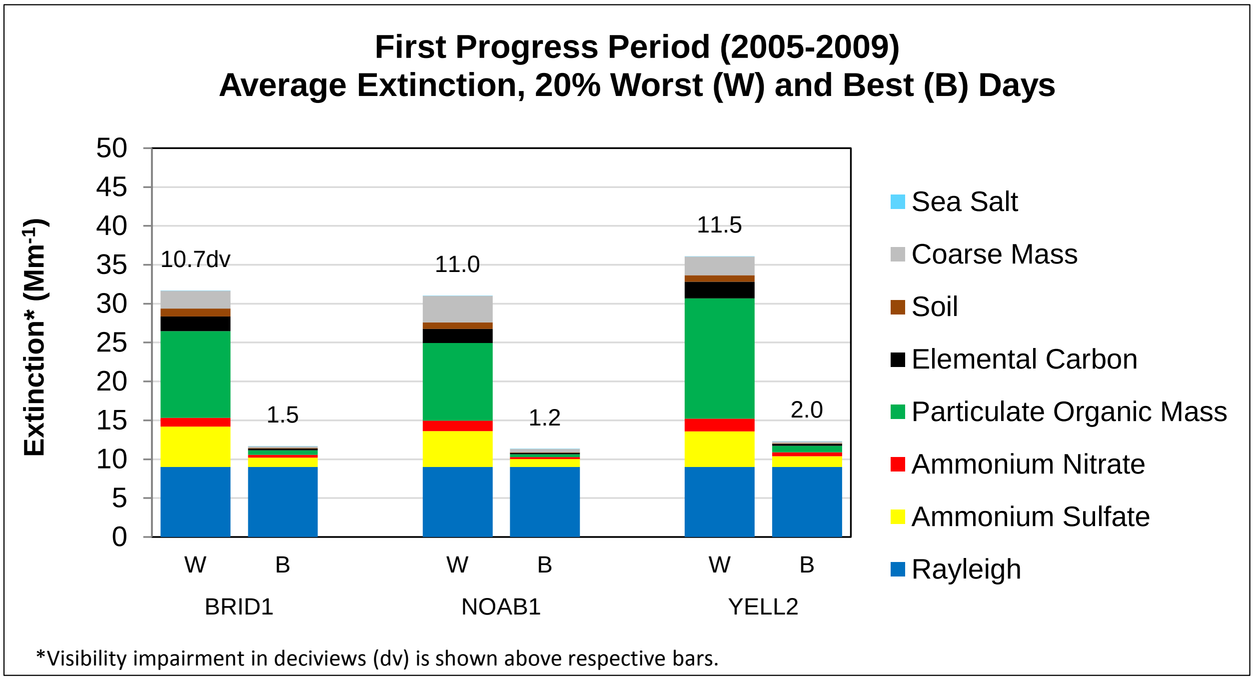

Figure 6.15-2. Average Extinction for Current Progress Period (2005-2009) for the Worst (Most Impaired) and Best (Least Impaired) Days Measured at Wyoming Class I Area IMPROVE Sites.

6.15.1.2 Differences between Current and Baseline Conditions

This section addresses the regulatory question, ***what is the difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions (40 CFR 51.309(d)(10)(i)(C))?*** Included here are comparisons between the 5-year average baseline conditions (2000-2004) and current progress period extinction (2005-2009).

Table 6.15-4 presents the differences between the 2000-2004 baseline period average extinction and the 2005-2009 progress period average for each site in Wyoming for the 20% most impaired days, and Table 6.15-5 presents similar data for the least impaired days. Averages that increased are depicted in red text and averages that decreased in blue.

Figure 6.15-3 presents the 5-year average extinction for the baseline and current progress period averages for the worst days and Figure 6.15-4 presents the differences in averages by aerosol species, with increases represented above the zero line and decreases below the zero line. Figures 6.15-5 and 6.15-6 present similar plots for the best days.

For the 20% most impaired days, the 5-year average deciview metric decreased between the 2000-2004 and 2005-2009 periods at all three Wyoming sites. Notable differences for individual species averages were as follows:

- Ammonium nitrate averages decreased at all sites.

- Particulate organic mass and ammonium sulfate increased at the BRID1 and YELL2 sites, but decreased at the NOAB1 site.
- Coarse mass decreased at the BRID1 and YELL2 sites, but increased at the NOAB1 site.

For the 20% least impaired days, the 5-year average deciview metric decreased at all sites. Notable differences for individual species averages on the 20% least impaired days were as follows:

- Ammonium nitrate, ammonium sulfate, and particulate organic mass decreased at all sites.
- Elemental carbon decreased at the BRID1 and YELL2 sites, and coarse mass decreased at the NOAB1 site.

Table 6.15-4
Wyoming Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Most Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
BRID1	11.1	10.7	-0.4	+0.2	-0.3	+0.6	-0.1	-0.1	-0.2	0.0
NOAB1	11.5	11.0	-0.5	-0.3	-0.3	-1.7	0.0	0.0	+0.5	0.0
YELL2	11.8	11.5	-0.3	+0.3	-0.1	+2.0	-0.3	-0.1	-0.2	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

Table 6.15-5
Wyoming Class I Area IMPROVE Sites
Difference in Aerosol Extinction by Species
2000-2004 Baseline Period to 2005-2009 Progress Period
20% Least Impaired Days

Site	Deciview (dv)			Change in Extinction by Species (Mm^{-1})*						
	2000-04 Baseline Period	2005-09 Progress Period	Change in dv*	Amm. Sulfate	Amm. Nitrate	POM	EC	Soil	CM	Sea Salt
BRID1	2.1	1.5	-0.6	-0.2	-0.1	-0.2	-0.2	0.0	0.0	0.0
NOAB1	2.0	1.2	-0.8	-0.1	-0.1	-0.4	0.0	0.0	-0.3	0.0
YELL2	2.6	2.0	-0.6	-0.1	-0.2	-0.3	-0.1	0.0	0.0	0.0

*Change is calculated as progress period average minus baseline period average. Values in red indicate increases in extinction and values in blue indicate decreases.

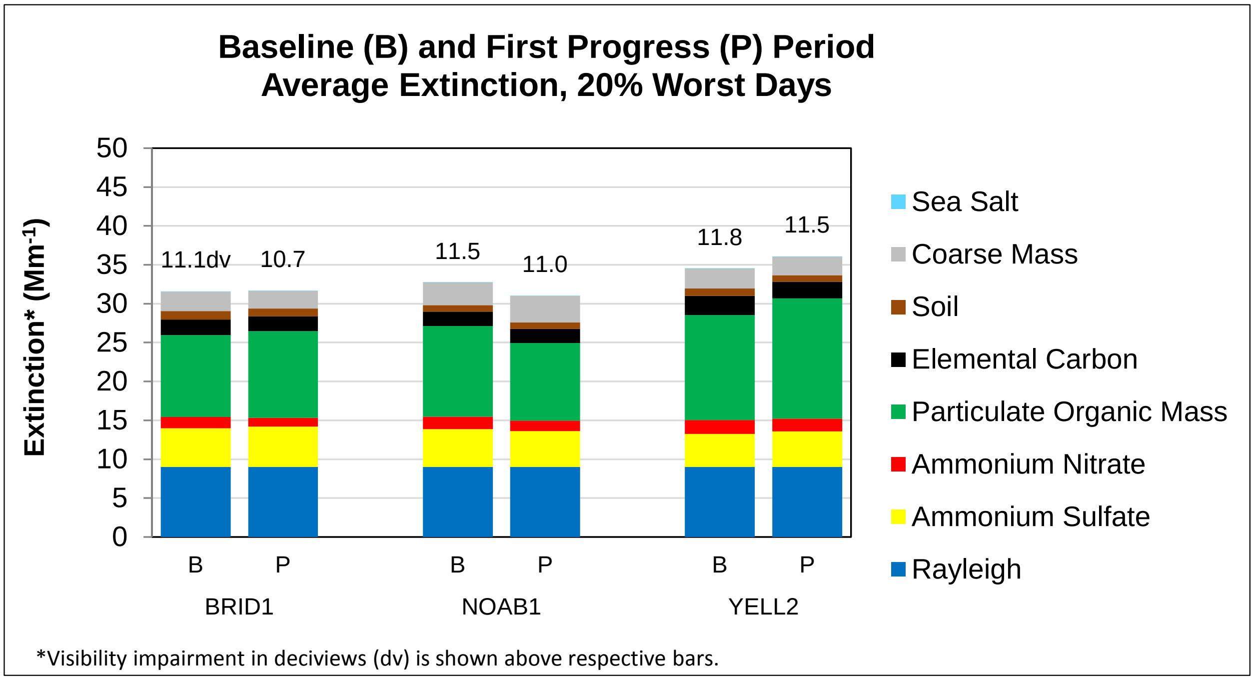

Figure 6.15-3. Average Extinction for Baseline and Progress Period Extinction for Worst (Most Impaired) Days Measured at Wyoming Class I Area IMPROVE Sites.

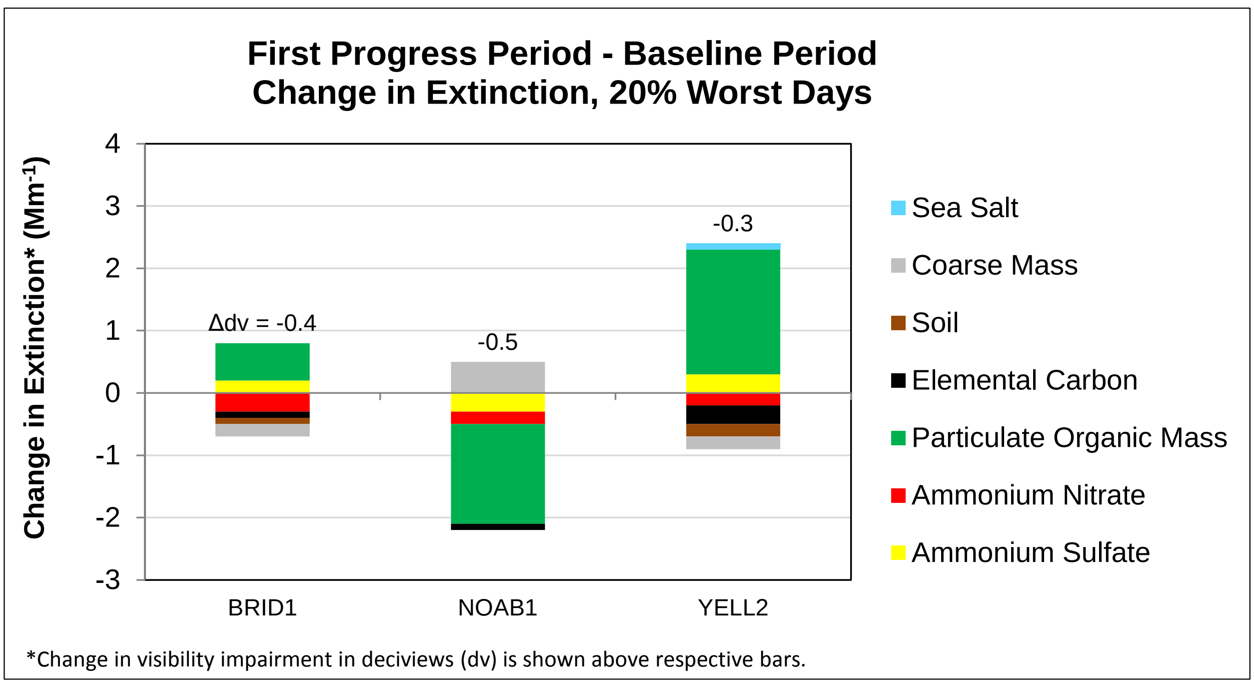

Figure 6.15-4. Difference Between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Worst (Most Impaired) Days Measured at Wyoming Class I Area IMPROVE Sites.

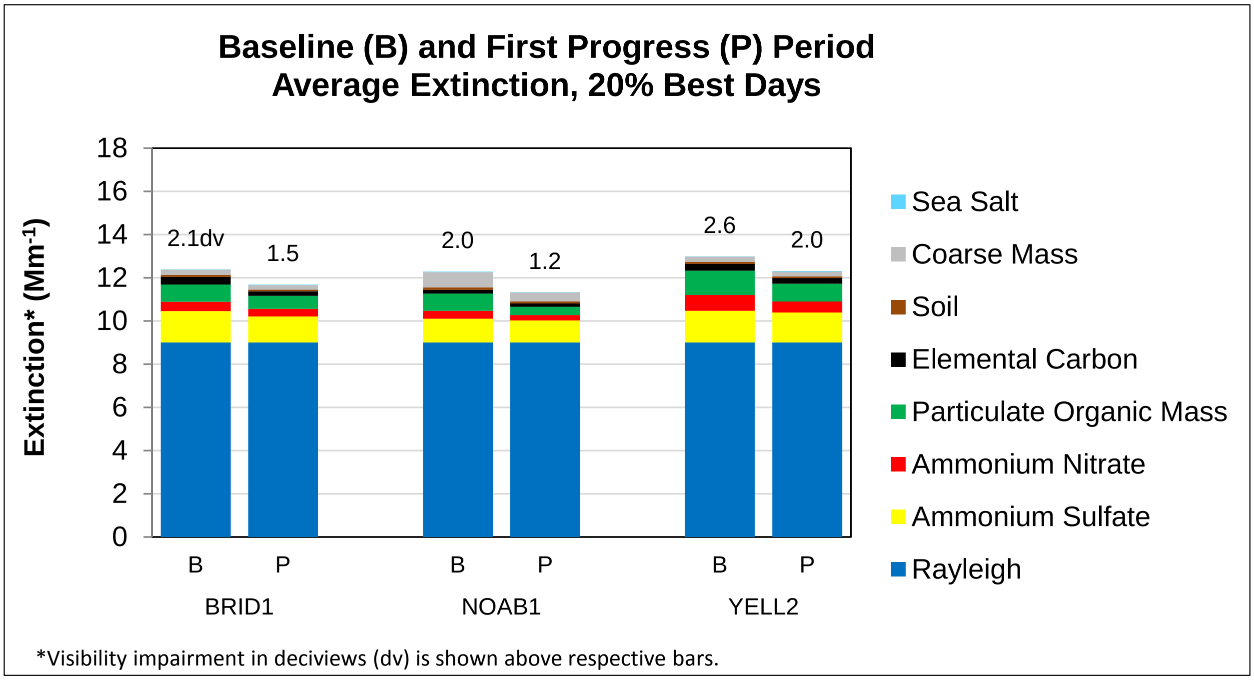

Figure 6.15-5. Average Extinction for Baseline and Progress Period Extinction for Best (Least Impaired) Days Measured at Wyoming Class I Area IMPROVE Sites.

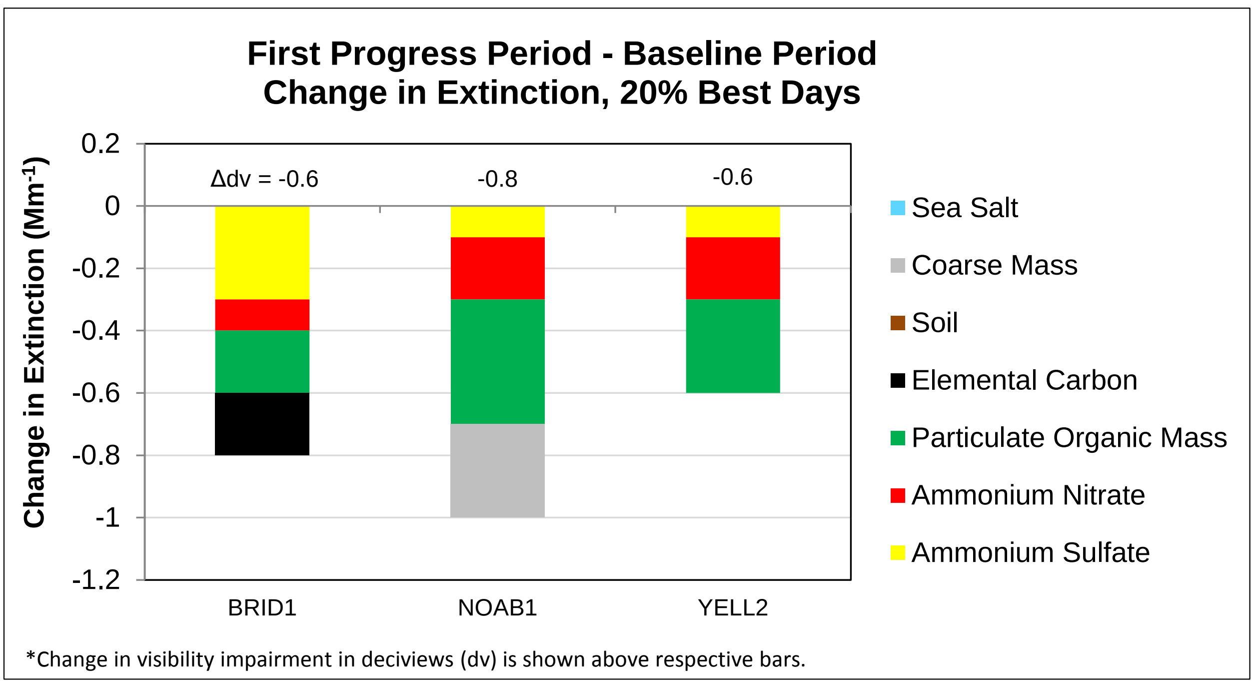

Figure 6.15-6. Difference between Average Extinction for Current Progress Period (2005-2009) and Baseline Period (2000-2004) for the Best (Least Impaired) Days Measured at Wyoming Class I Area IMPROVE Sites.

6.15.1.3 Changes in Visibility Impairment

This section addresses the regulatory question, ***what is the change in visibility impairment for the most impaired and least impaired days over the past 5 years (40 CFR 51.309(d)(10)(i)(C))?*** Included here are changes in visibility impairment as characterized by annual average trend statistics, and some general observations regarding local and regional events and outliers on a daily and annual basis that affected the current 5-year progress period. The regulatory requirement asks for a description of changes over the past 5-year period, but trend analysis is better suited to longer periods of time, so trends for the entire 10-year planning period are presented here.

Trend statistics for the years 2000-2009 for each species at each site in Wyoming are summarized in Table 6.15-6, and regional trends were presented earlier in Section 4.1.1.[121] Only trends for aerosol species trends with p-value statistics less than 0.15 (85% confidence level) are presented in the table here, with increasing slopes in red and decreasing slopes in blue.[122] In some cases, trends may show decreasing tendencies while the difference between the 5-year averages do not (or vice versa), as discussed in Section 3.1.2.2. In these cases, the 5-year average for the best and worst days is the important metric for RHR regulatory purposes, but trend statistics may be of value to understand and address visibility impairment issues for planning purposes.

For each site, a more comprehensive list of all trends for all species, including the associated p-values, is provided in Appendix O. Additionally, the appendix includes plots depicting 5-year, annual, monthly and daily average extinction for each site. These plots are intended to provide a fairly comprehensive compilation of reference information for individual states to investigate local and regional events and outliers that may have influenced changes in visibility impairment as tracked using the 5-year deciview metrics. Note that similar summary products are also available from the WRAP TSS website (http://vista.cira.colostate.edu/tss/). Some general observations regarding changes in visibility impairment at sites in Wyoming are as follows:

- Particulate organic mass was the largest contributor to aerosol extinction for the worst days at all sites, and the largest events generally occurred between June and September, consistent with wildland fire activity.
- The NOAB1 site showed a decrease in 5-year average particulate organic mass on the worst days, while the YELL2 and BRID1 sites showed an increase. This may be due to the fact that 2007 and 2009 were incomplete years and not included in the NOAB1

[121] Annual trends were calculated for the years 2000-2009, with a trend defined as the slope derived using Theil statistics. Trends derived from Theil statistics are useful in analyzing changes in air quality data because these statistics can show the overall tendency of measurements over long periods of time, while minimizing the effects of year-to-year fluctuations which are common in air quality data. Theil statistics are also used in EPA's National Air EPA's National Air Quality Trends Reports (http://www.epa.gov/airtrends/) and the IMPROVE program trend reports (http://vista.cira.colostate.edu/improve/Publications/improve_reports.htm)
[122] The significance of the trend is represented with p-values calculated using Mann-Kendall trend statistics. Determining a significance level helps to distinguish random variability in data from a real tendency to increase or decrease over time, where lower p-values indicate higher confidence levels in the computed slopes.

averages. The daily data that were collected for NOAB1 indicated that 2007 was one of the highest particulate organic mass years measured at the site.

- Trend statistics did not indicate any increasing annual trends for any of the aerosol species. Slightly decreasing annual trends were measured for the best days for ammonium sulfate at the BRID1 site, particulate organic mass at all sites, and coarse mass at the NOAB1 site.
- The NOAB1 site indicated a slight increase in 5-year average coarse mass for the 20% worst days. The higher coarse mass average was influenced by a relatively high coarse mass measurements on October 29, 2006.

Table 6.15-6
Wyoming Class I Area IMPROVE Sites
Change in Aerosol Extinction by Species
2000-2009 Annual Average Trends

Site	Group	Annual Trend* (Mm^{-1}/year)						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
BRID1	20% Best	-0.1	--	-0.1	0.0	0.0	0.0	--
	20% Worst	--	--	--	0.0	--	--	0.0
	All Days	--	0.0	--	0.0	--	0.0	0.0
NOAB1	20% Best	--	0.0	-0.1	--	0.0	-0.1	--
	20% Worst	--	--	--	--	--	--	0.0
	All Days	--	0.0	--	--	0.0	--	--
YELL2	20% Best	--	0.0	-0.1	--	0.0	--	0.0
	20% Worst	--	--	--	--	--	0.0	0.0
	All Days	--	--	--	0.0	--	--	0.0

*(--) Indicates statistically insignificant trend (<85% confidence level). Annual averages and complete trend statistics for all significance levels are included for each site in Appendix O.

6.15.2 Emissions Data

Included here are summaries depicting differences between two emission inventory years that are used to represent the 5-year baseline and current progress periods. The baseline period is represented using a 2002 inventory developed by the WRAP for use in the initial WRAP state SIPs, and the progress period is represented by a 2008 inventory which leverages recent WRAP inventory work for modeling efforts, as referenced in Section 3.2.1. For reference, Table 6.15-7 lists the major emitted pollutants inventoried, the related aerosol species, some of the major sources for each pollutant, and some notes regarding implications of these pollutants. Differences between these baseline and progress period inventories, and a separate summary of annual emissions from electrical generating units (EGUs), are presented in this section.

Table 6.15-7
Wyoming
Pollutants, Aerosol Species, and Major Sources

Emitted Pollutant	**Related Aerosol**	**Major Sources**	**Notes**
Sulfur Dioxide (SO_2)	Ammonium Sulfate	Point Sources; On- and Off-Road Mobile Sources	SO_2 emissions are generally associated with anthropogenic sources such as coal-burning power plants, other industrial sources such and refineries and cement plants, and both on- and off-road diesel engines.
Oxides of Nitrogen (NO_X)	Ammonium Nitrate	On- and Off-Road Mobile Sources; Point Sources; Area Sources	NO_X emissions are generally associated with anthropogenic sources. Common sources include virtually all combustion activities, especially those involving cars, trucks, power plants, and other industrial processes.
Ammonia (NH_3)	Ammonium Sulfate and Ammonium Nitrate	Area Sources; On-Road Mobile Sources	Gaseous NH_3 has implications in particle formation because it can form particulate ammonium. Ammonium is not directly measured by the IMPROVE program, but affects formation potential of ammonium sulfate and ammonium nitrate. All measured nitrate and sulfate is assumed to be associated with ammonium for IMPROVE reporting purposes.
Volatile Organic Compounds (VOCs)	Particulate Organic Mass (POM)	Biogenic Emissions; Vehicle Emissions; Area Sources	VOCs are gaseous emissions of carbon compounds, which are often converted to POM through chemical reactions in the atmosphere. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions (see Section 3.2.1).
Primary Organic Aerosol (POA)	POM	Wildfires; Area Sources	POA represents organic aerosols that are emitted directly as particles, as opposed to gases. Wildfires in the west generally dominate POA emissions, and large wildfire events are generally sporadic and highly variable from year-to-year.
Elemental Carbon (EC)	EC	Wildfires; On- and Off-Road Mobile Sources	Large EC events are often associated with large POM events during wildfires. Other sources include both on- and off-road diesel engines.
Fine Soil	Soil	Windblown Dust; Fugitive Dust; Road Dust; Area Sources	Fine soil is reported here as the crustal or soil components of $PM_{2.5}$.
Coarse Mass (PMC)	Coarse Mass	Windblown Dust; Fugitive Dust	Coarse mass is reported by the IMPROVE Network as the difference between PM_{10} and $PM_{2.5}$ mass measurements. Coarse mass is not separated by species in the same way that $PM_{2.5}$ is speciated, but these measurements are generally associated with crustal components. Similar to crustal $PM_{2.5}$, natural windblown dust is often the largest contributor to PMC.

6.15.2.1 Changes in Emissions

This section addresses the regulatory question, ***what is the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State (40 CFR 51.309(d)(10)(i)(D))?*** For these summaries, emissions during the baseline years are represented using a 2002 inventory, which was developed with support from the WRAP for use in the original RHR SIP strategy development (termed plan02d). Differences between inventories are represented as the difference between the 2002 inventory, and a 2008 inventory which leverages recent inventory development work performed by the WRAP for the WestJumpAQMS and DEASCO$_3$ modeling projects (termed WestJump2008). Note that the comparisons of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between development of the individual inventories, as referenced in Section 3.2.1. Inventories for all major visibility impairing pollutants are presented for major source categories, and categorized as either anthropogenic or natural emissions. State-wide inventories totals and differences are presented here, and inventory totals on a county level basis are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

Table 6.15-8 and Figure 6.15-7 present the differences between the 2002 and 2008 sulfur dioxide (SO_2) inventories by source category. Tables 6.15-9 and Figure 6.15-8 present data for oxides of nitrogen (NO_X), and subsequent tables and figures (Tables 6.15-10 through 6.15-15 and Figures 6.15-9 through 6.15-14) present data for ammonia (NH_3), volatile organic compounds (VOCs), primary organic aerosol (POA), elemental carbon (EC), fine soil, and coarse mass. General observations regarding emissions inventory comparisons are listed below.

- Largest differences for point source inventories were decreases in SO_2, fine soil and coarse mass and increases in NO_X and VOCs.
- Area source inventories showed decreases in SO_2 NH_3, and VOCs and increases in NO_X. These changes may be due to a combination of population changes and differences in methodologies used to estimate these emissions, as referenced in Section 3.2.1. One methodology change was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to increases in area source inventory totals, but decreases in off-road mobile totals.
- On-road mobile source inventory comparisons showed decreases in most parameters, especially NO_X and VOCs, with slight increases in POA, EC, and coarse mass. Reductions in NO_X and VOC are likely influenced by federal and state emissions standards that have already been implemented. The increases in POA, EC, and coarse mass occurred in all of the WRAP states for on-road mobile inventories, regardless of reductions in NO_X and VOCs, indicating that these increases were likely due use of different on-road models, as referenced in Section 3.2.1.
- Off-road mobile source inventories showed decreases in NO_X, SO_2, and VOCs, and increases in fine soil and coarse mass, which was consistent with most contiguous WRAP states. These differences were likely due to a combination of actual changes in source contributions and methodology differences, as referenced in Section 3.2.1.

As noted previously, one major methodology difference was the reclassification of some off-road mobile sources (such as some types of marine vessels and locomotives) into the area source category in 2008, which may have contributed to decreases in the off-road inventory totals, but increases in area source totals.

- Inventory comparison results for area oil and gas sources showed an increase in NO_X and a decrease in VOCs, but note that inventory methodologies for these sources may have evolved substantially between the baseline and 2008 inventories as referenced in Section 3.2.1.
- For most parameters, especially POAs, VOCs, and EC, natural fire emission inventory estimates decreased (except for an increase in fine soil), and anthropogenic fire estimates increased (except for a slight decrease in VOCs). Note that these differences are not necessarily reflective of changes in monitored data, as the baseline period is represented by an average of 2000-2004 fire emissions, and the progress period is represented only by the fires that occurred in 2008, as referenced in Section 3.2.1. Also, methodology differences likely contributed to fine soil (for natural fire) and VOCs (for anthropogenic fire) not tracking with the other parameters.
- Comparisons between VOC inventories showed large decreases in biogenic emissions, which was consistent with other contiguous WRAP states. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported here are more reflective of methodology changes than actual changes in emissions, as referenced in Section 3.2.1.
- Fine soil and coarse mass increased for the fugitive/road dust inventories. These changes may be due to a combination of population changes and differences in methodologies used to estimate these emissions, as referenced in Section 3.2.1.

Table 6.15-8

Wyoming
Sulfur Dioxide Emissions by Category

Source Category	Sulfur Dioxide Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	119,717	108,729	-10,988
Area	16,689	501	-16,188
On-Road Mobile	959	190	-768
Off-Road Mobile	5,866	95	-5,771
Area Oil and Gas	150	1,822	1,672
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	173	266	93
Total Anthropogenic	**143,554**	**111,604**	**-31,950 (-22%)**
Natural Sources			
Natural Fire	2,286	1,051	-1,235
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**2,286**	**1,051**	**-1,235 (-54%)**
All Sources			
Total Emissions	**145,840**	**112,655**	**-33,186 (-23%)**

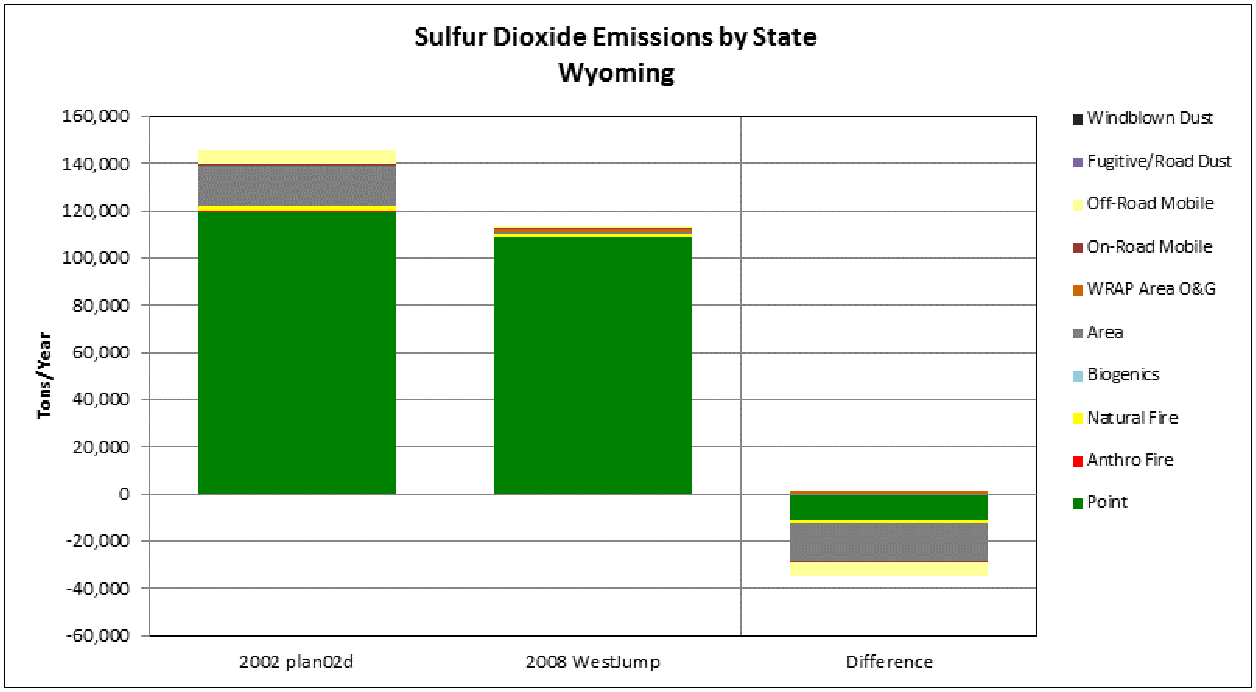

Figure 6.15-7. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Sulfur Dioxide by Source Category for Wyoming.

Table 6.15-9
Wyoming
Oxides of Nitrogen Emissions by Category

Source Category	Oxides of Nitrogen Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point	117,806	122,169	4,362
Area	15,192	37,685	22,493
On-Road Mobile	38,535	27,211	-11,324
Off-Road Mobile	76,637	4,848	-71,789
Area Oil and Gas	14,725	22,526	7,801
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	782	1,883	1,101
Total Anthropogenic	**263,677**	**216,321**	**-47,356 (-18%)**
Natural Sources			
Natural Fire	8,372	7,429	-943
Biogenic	15,925	6,928	-8,997
Wind Blown Dust	0	0	0
Total Natural	**24,297**	**14,357**	**-9,940 (-41%)**
All Sources			
Total Emissions	**287,974**	**230,678**	**-57,296 (-20%)**

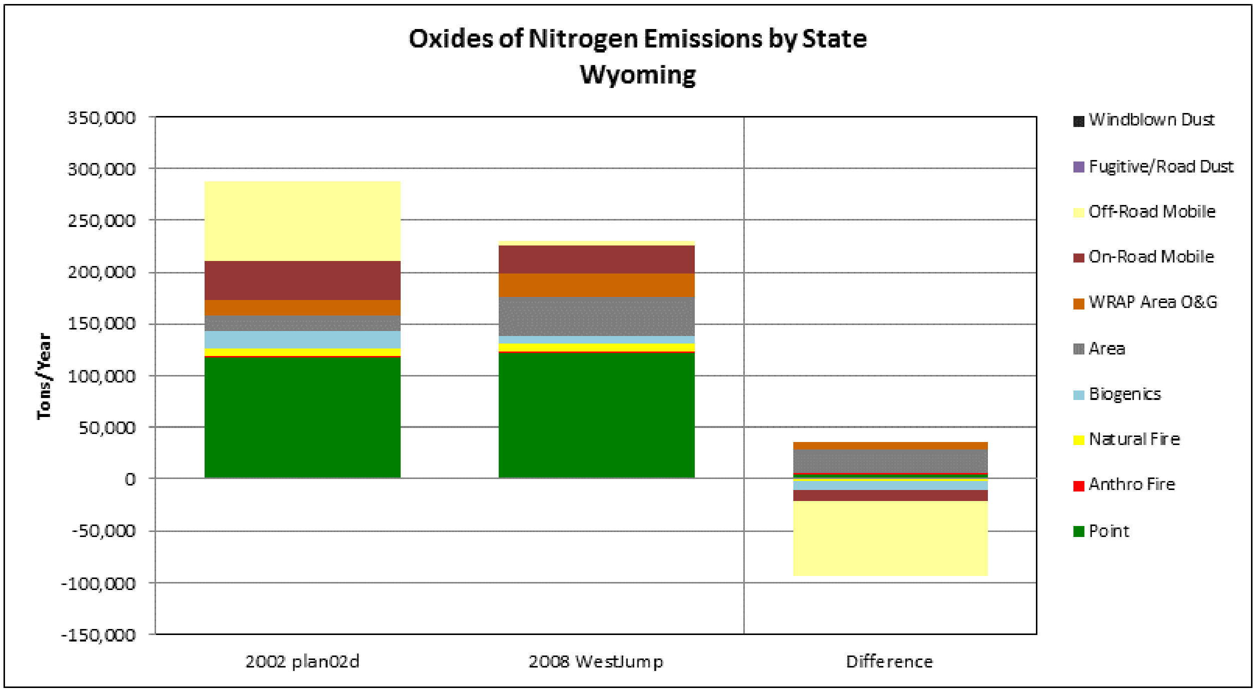

Figure 6.15-8. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Oxides of nitrogen by Source Category for Wyoming.

Table 6.15-10
Wyoming
Ammonia Emissions by Category

Source Category	Ammonia Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	685	717	32
Area	29,776	19,446	-10,330
On-Road Mobile	538	374	-164
Off-Road Mobile	41	6	-35
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	218	1,306	1,088
Total Anthropogenic	**31,257**	**21,848**	**-9,409 (-30%)**
Natural Sources			
Natural Fire	1,775	5,177	3,402
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**1,775**	**5,177**	**3,402 (>100%)**
All Sources			
Total Emissions	**33,032**	**27,024**	**-6,007 (-18%)**

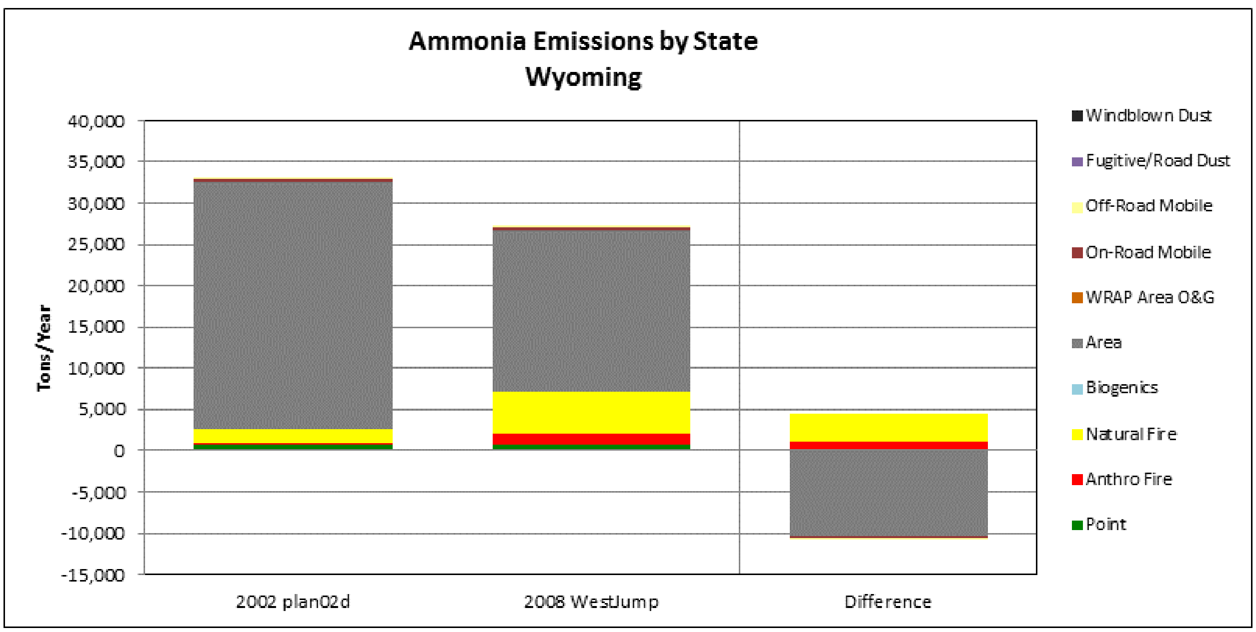

Figure 6.15-9. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Ammonia by Source Category for Wyoming.

Table 6.15-11
Wyoming
Volatile Organic Compound Emissions by Category

Source Category	Volatile Organic Compound Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point	19,602	20,765	1,163
Area	24,310	11,719	-12,591
On-Road Mobile	14,252	10,760	-3,491
Off-Road Mobile	13,805	9,081	-4,725
Area Oil and Gas	119,447	103,208	-16,239
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	1,742	1,600	-142
Total Anthropogenic	**193,158**	**157,134**	**-36,024 (-19%)**
Natural Sources			
Natural Fire	18,376	5,357	-13,018
Biogenic	605,371	177,044	-428,328
Wind Blown Dust			
Total Natural	**623,747**	**182,401**	**-441,346 (-71%)**
All Sources			
Total Emissions	**816,904**	**339,534**	**-477,370 (-58%)**

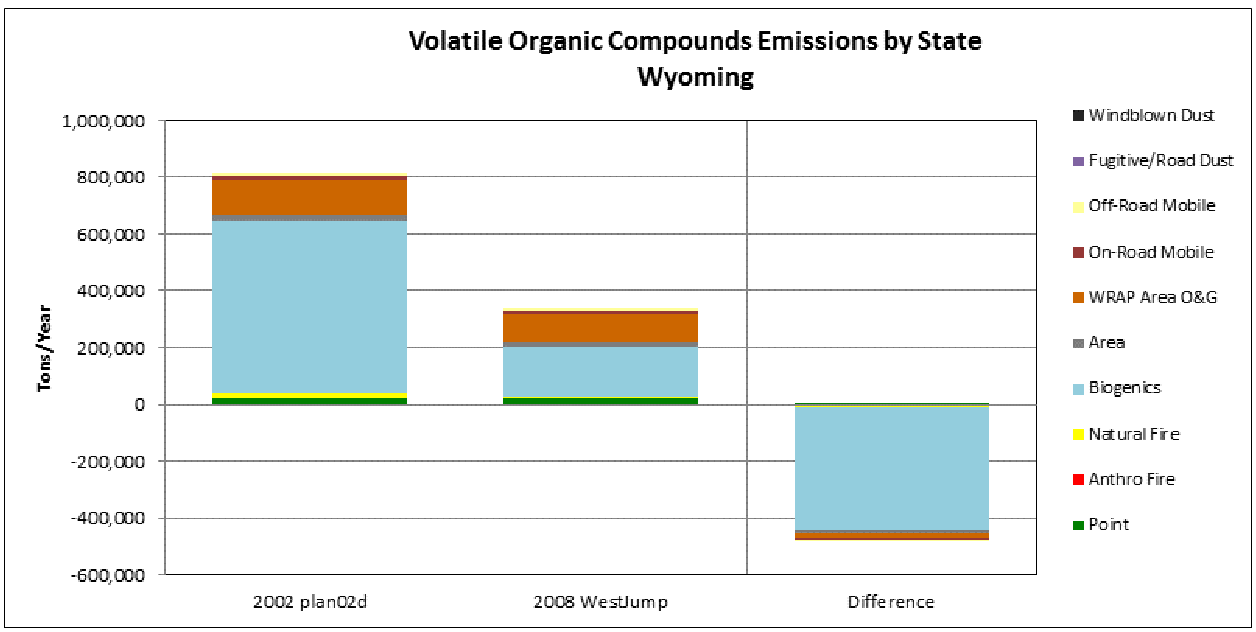

Figure 6.15-10. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Volatile Organic Compounds by Source Category for Wyoming.

Table 6.15-12
Wyoming
Primary Organic Aerosol Emissions by Category

Source Category	Primary Organic Aerosol Emissions (tons/year)		
	2002 (Plan02d)	**2008 (WestJump2008)**	**Difference (Percent Change)**
Anthropogenic Sources			
Point*	646	647	1
Area	2,000	1,107	-893
On-Road Mobile	304	698	394
Off-Road Mobile	625	246	-378
Area Oil and Gas	0	51	51
Fugitive and Road Dust	117	1,551	1,434
Anthropogenic Fire	1,709	4,386	2,677
Total Anthropogenic	**5,401**	**8,686**	**3,285 (61%)**
Natural Sources			
Natural Fire	23,793	16,341	-7,452
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**23,793**	**16,341**	**-7,452 (-31%)**
All Sources			
Total Emissions	**29,194**	**25,027**	**-4,167 (-14%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

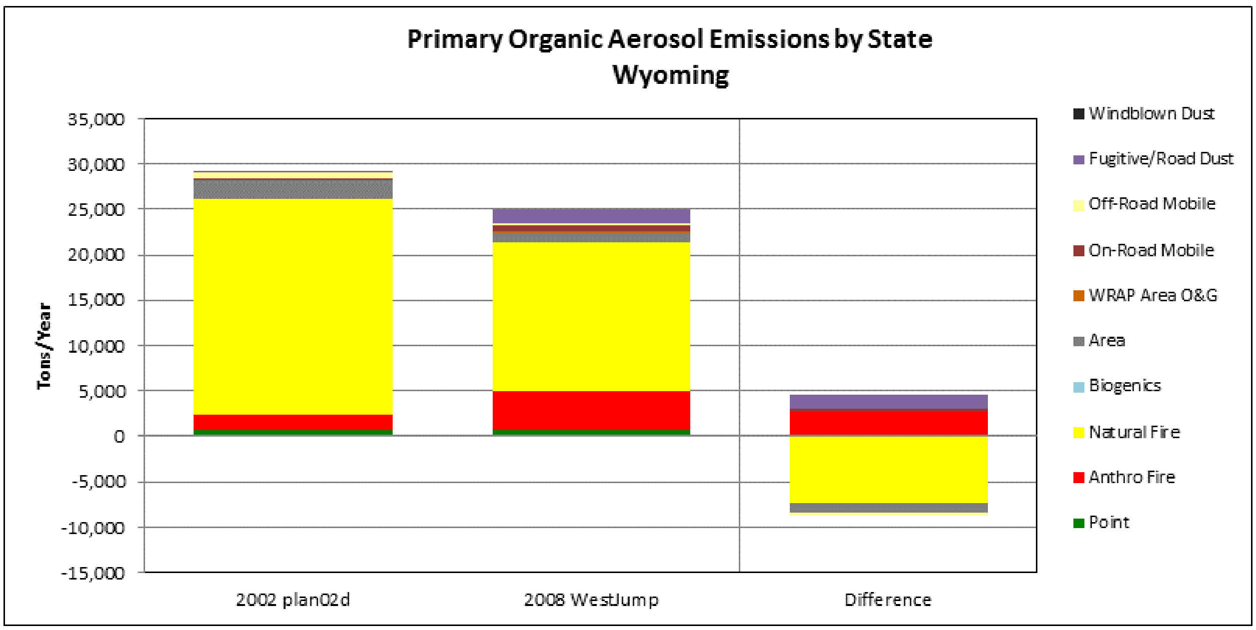

Figure 6.15-11. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Primary Organic Aerosol by Source Category for Wyoming.

Table 6.15-13
Wyoming
Elemental Carbon Emissions by Category

Source Category	Elemental Carbon Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	104	492	388
Area	304	991	687
On-Road Mobile	443	1,226	783
Off-Road Mobile	1,986	284	-1,703
Area Oil and Gas	0	0	0
Fugitive and Road Dust	8	31	22
Anthropogenic Fire	298	749	451
Total Anthropogenic	**3,144**	**3,772**	**628 (20%)**
Natural Sources			
Natural Fire	4,922	2,333	-2,589
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**4,922**	**2,333**	**-2,589 (-53%)**
All Sources			
Total Emissions	**8,066**	**6,105**	**-1,961 (-24%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

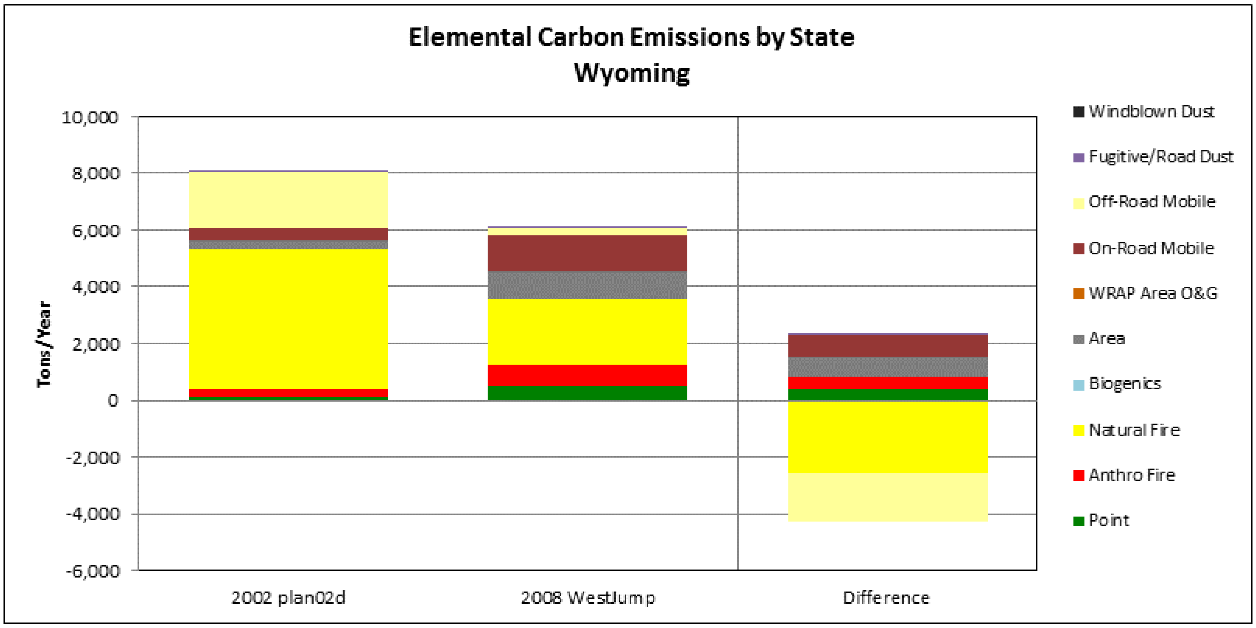

Figure 6.15-12. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Elemental Carbon by Source Category for Wyoming.

Table 6.15-14
Wyoming
Fine Soil Emissions by Category

Source Category	Fine Soil Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	11,375	5,503	-5,871
Area	1,601	467	-1,133
On-Road Mobile	187	103	-84
Off-Road Mobile	0	17	17
Area Oil and Gas	0	791	791
Fugitive and Road Dust	2,241	35,883	33,642
Anthropogenic Fire	242	1,616	1,374
Total Anthropogenic	**15,646**	**44,382**	**28,736 (>100%)**
Natural Sources			
Natural Fire	1,535	5,947	4,411
Biogenic	0	0	0
Wind Blown Dust	5,838	5,631	-208
Total Natural	**7,374**	**11,577**	**4,204 (57%)**
All Sources			
Total Emissions	**23,020**	**55,959**	**32,940 (>100%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

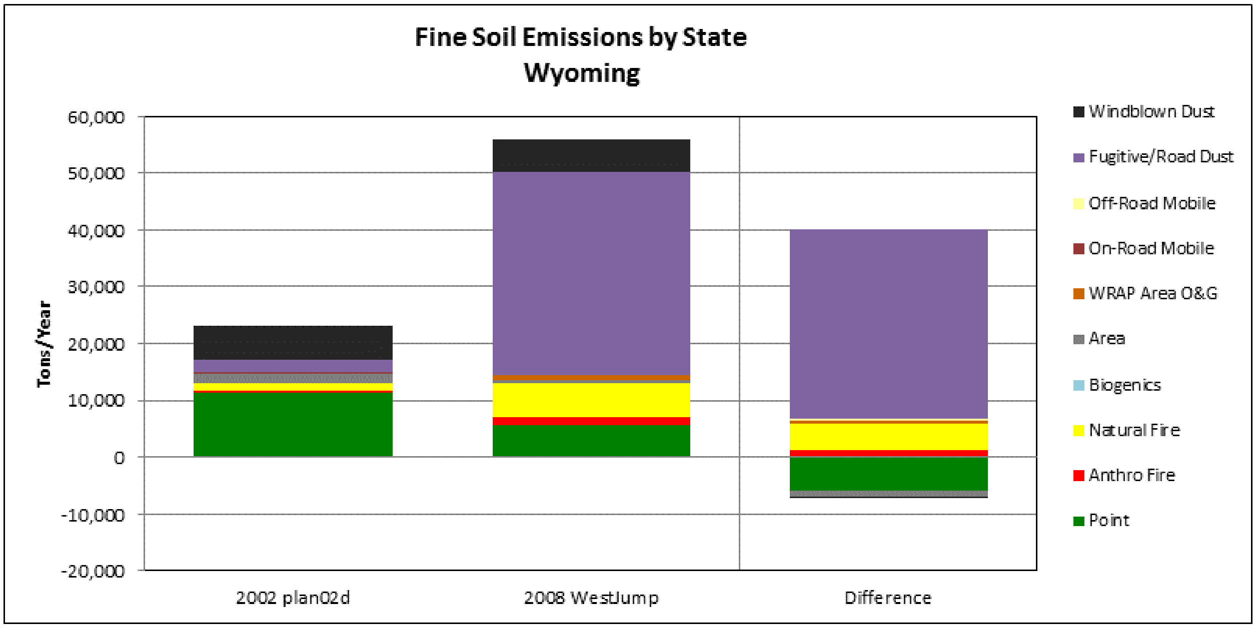

Figure 6.15-13. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Fine Soil by Source Category for Wyoming.

Table 6.15-15
Wyoming
Coarse Mass Emissions by Category

Source Category	Coarse Mass Emissions (tons/year)		
	2002 (Plan02d)	2008 (WestJump2008)	Difference (Percent Change)
Anthropogenic Sources			
Point*	24,751	12,872	-11,878
Area	409	203	-206
On-Road Mobile	171	1,251	1,080
Off-Road Mobile	0	29	29
Area Oil and Gas	0	9	9
Fugitive and Road Dust	19,155	297,663	278,508
Anthropogenic Fire	259	840	581
Total Anthropogenic	**44,745**	**312,867**	**268,122 (>100%)**
Natural Sources			
Natural Fire	5,369	3,131	-2,238
Biogenic	0	0	0
Wind Blown Dust	52,546	50,675	-1,870
Total Natural	**57,915**	**53,806**	**-4,108 (-7%)**
All Sources			
Total Emissions	**102,660**	**366,673**	**264,014 (>100%)**

*Point source data includes only oil and gas and regulated CEM sources. More comprehensive point source data were not available at the time this report was prepared but will be made available through the WRAP TSS (http://vista.cira.colostate.edu/tss/).

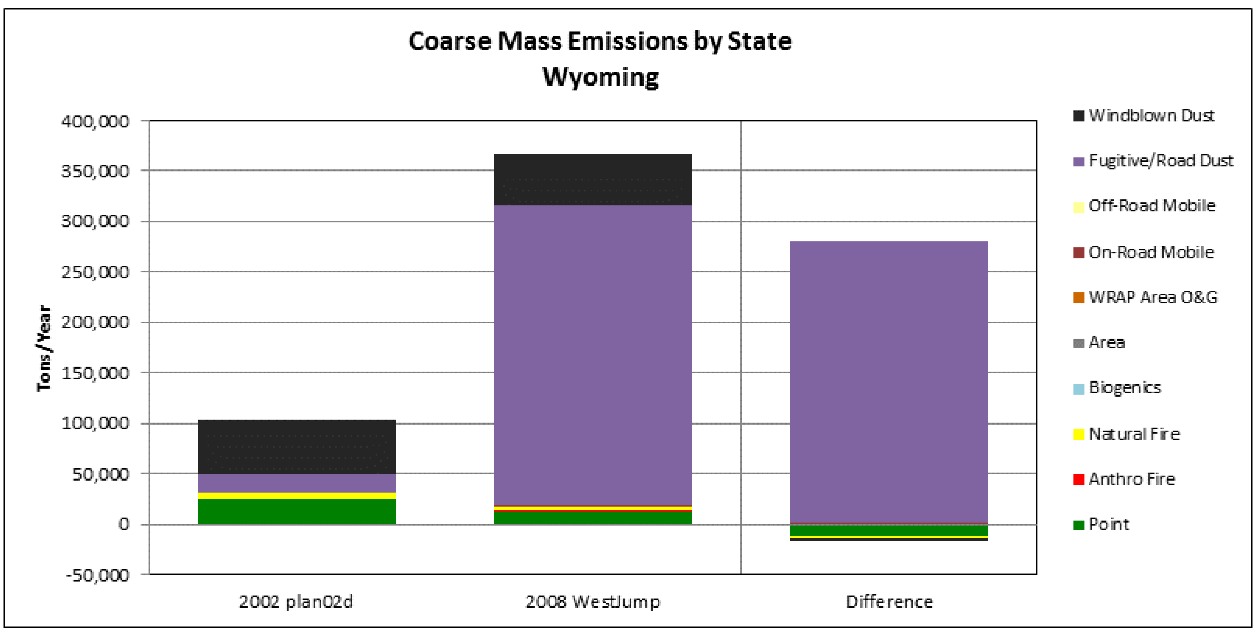

Figure 6.15-14. 2002 and 2008 Emission and Difference between Emissions Inventory Totals, for Coarse Mass by Source Category for Wyoming.

6.15.2.2 EGU Summary

As described in previous sections, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions because numerous updates in inventory methodologies have occurred between the development of the separate inventories. Also, the 2002 baseline and 2008 progress period inventories represent only annual snapshots of emissions estimates, which may not be representative of entire 5-year monitoring periods compared. To better account for year-to-year changes in emissions, annual emission totals for Wyoming electrical generating units (EGU) are presented here. EGU emissions are some of the more consistently reported emissions, as tracked in EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/). RHR implementation plans are required to pay specific attention to certain major stationary sources, including EGUs, built between 1962 and 1977.

Figure 6.15-17 presents a sum of annual NO_X and SO_2 emissions as reported for Wyoming EGU sources between 1996 and 2010. While these types of facilities are targeted for controls in state regional haze SIPs, it should be noted that many of the controls planned for EGUs in the WRAP states had not taken place yet in 2010, while other controls separate from the RHR may have been implemented. The chart shows periods of steady decline for both SO_2 and NO_X.

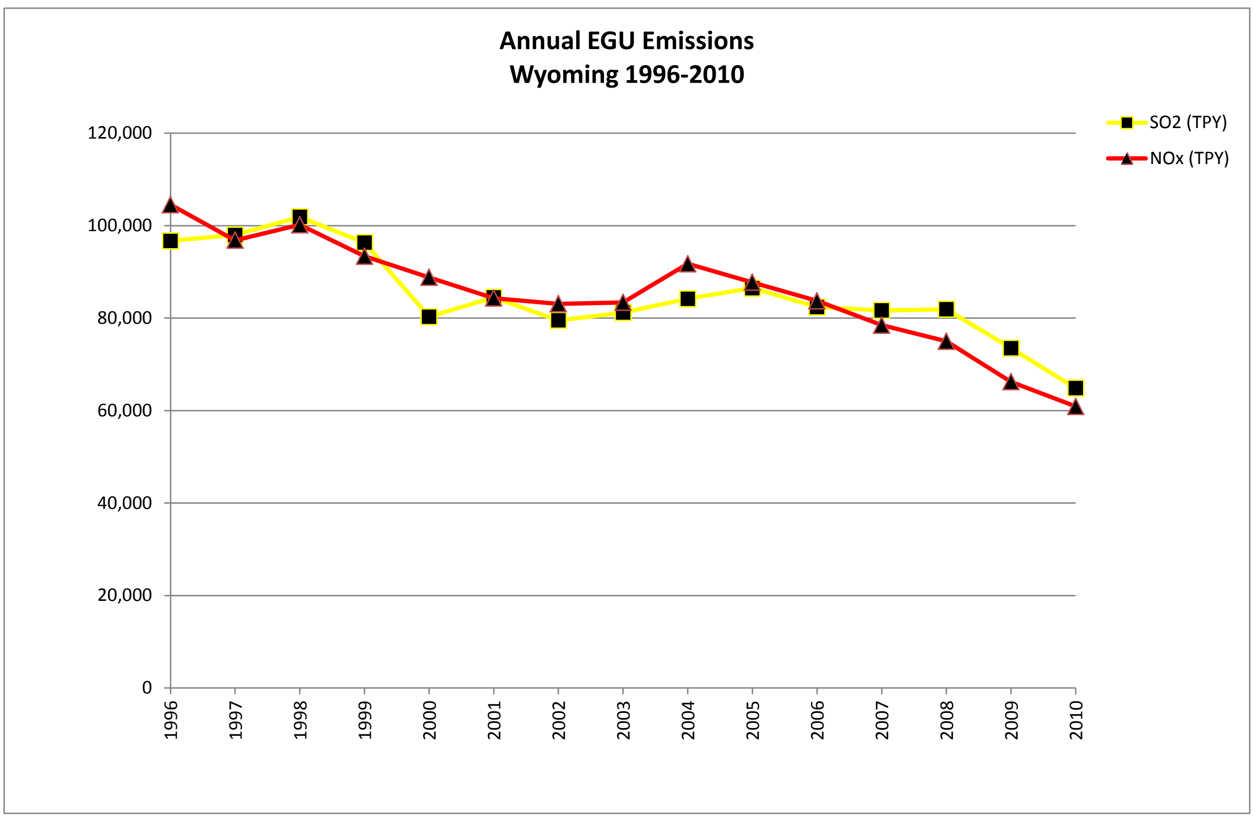

Figure 6.15-8. Sum of EGU Emissions of SO_2 and NO_X reported between 1996 and 2010 for Wyoming.

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