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

June 28, 2013

TABLE OF CONTENTS

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

---

[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.

[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

[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.

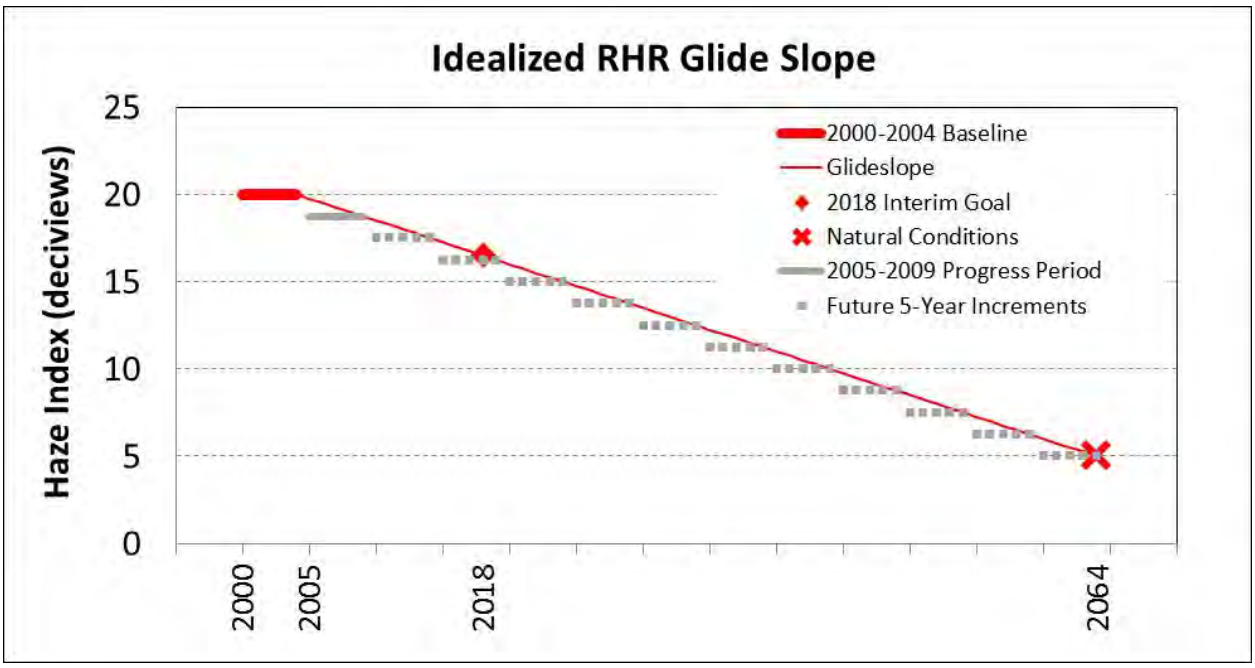

Figure 1.0-1. Idealized RHR Glide Slope Representing Linear Progress from a 2000-2004 Baseline Average to a 2064 Natural Conditions End Goal. Also Represented Are the 2018 Interim Goal and Successive 5-Year Progress Periods.

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.

---

[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.

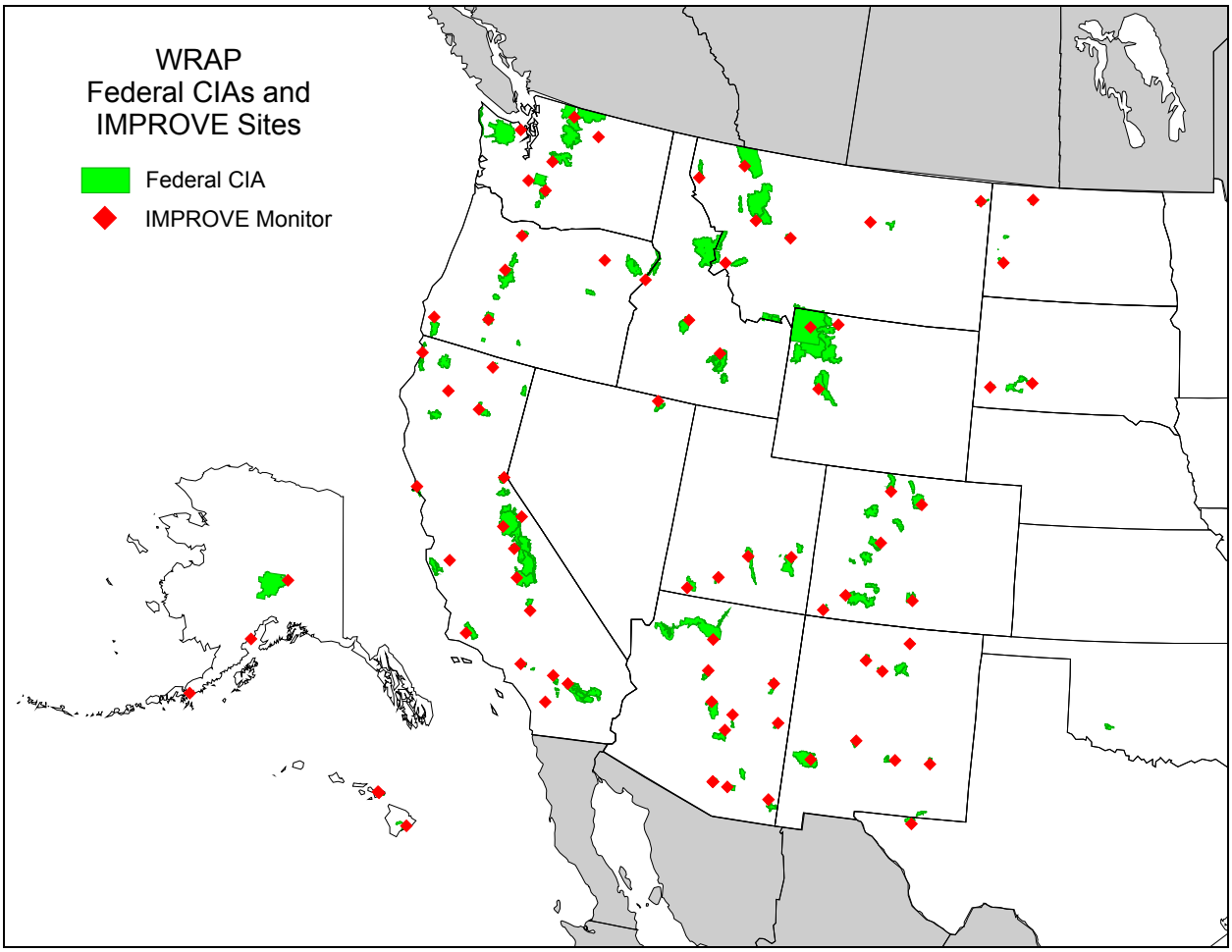

Figure 3.1-1. Map of Federal CIA IMPROVE Monitors in the WRAP Region.

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).

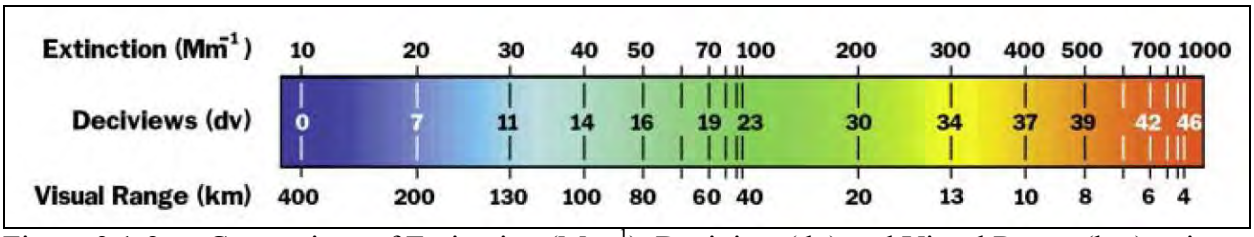

Figure 3.1-2. Comparison of Extinction (Mm^{-1}), Deciview (dv) and Visual Range (km) units.

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:

- **Incomplete Progress Period Data**: 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).
- **Monitor Relocation**: 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 RHR Progress Period Calculation Considerations

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.

---

[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.

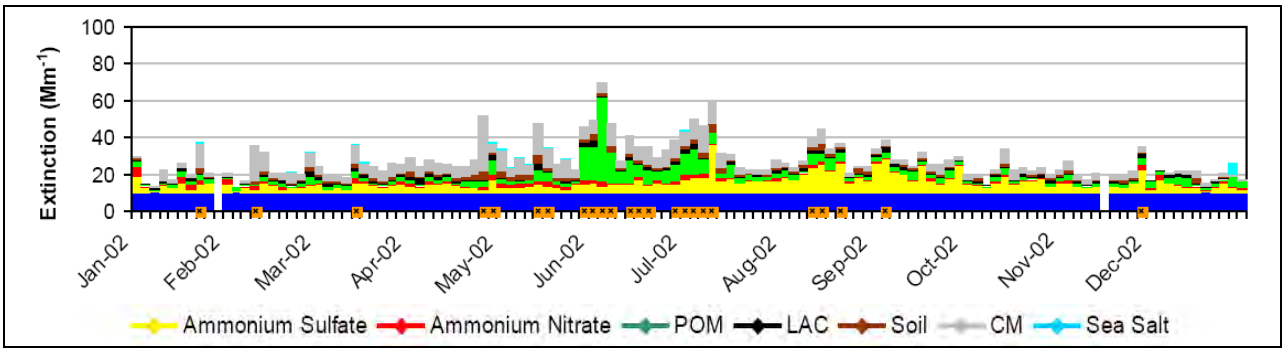

Figure 3.1-3. Daily Aerosol Extinction measured by the Chiricahua CHIR1 IMPROVE monitor during 2002.

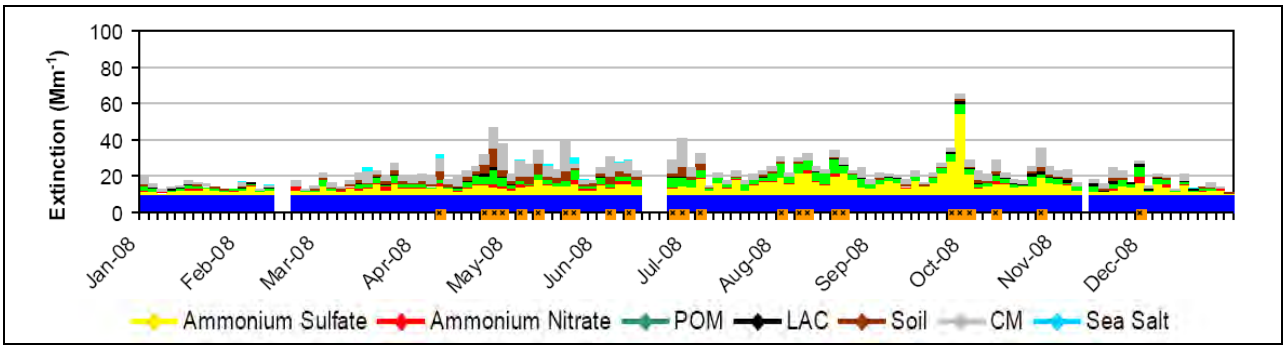

Figure 3.1-4. Daily Aerosol Extinction measured by the Chiricahua CHIR1 IMPROVE monitor during 2008.

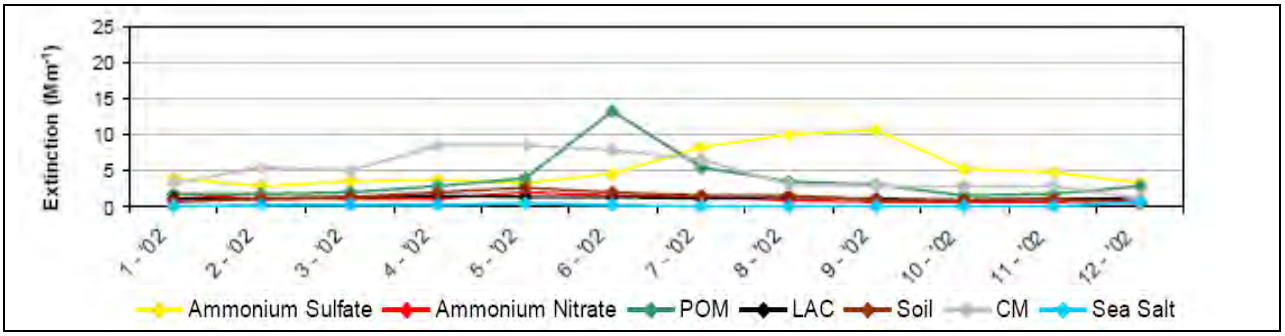

Figure 3.1-5. Monthly Average Aerosol Extinction measured by the CHIR1 IMPROVE monitor in 2002.

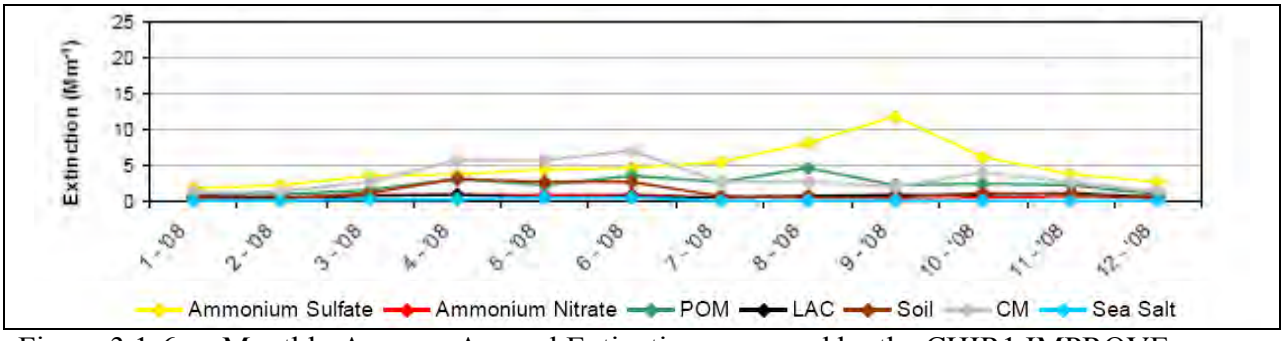

Figure 3.1-6. Monthly Average Aerosol Extinction measured by the CHIR1 IMPROVE monitor in 2008.

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.

---

[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)

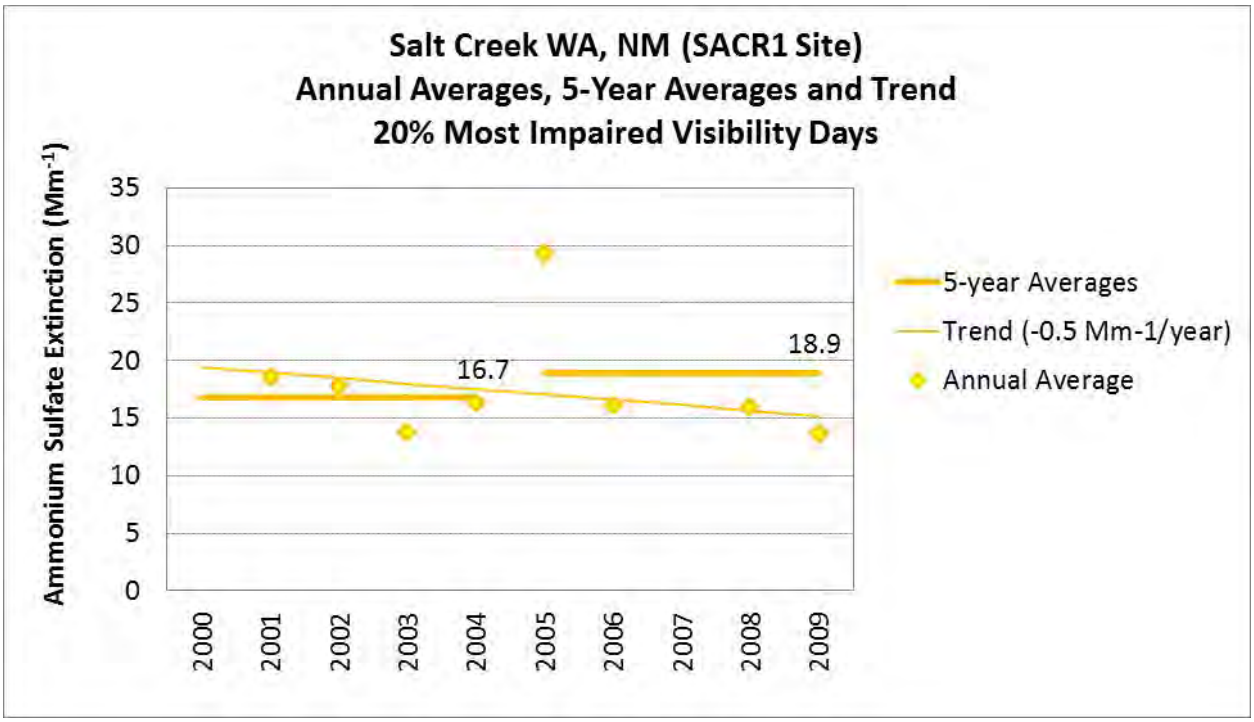

Figure 3.1-7. Annual Averages, Period Averages and Trend Statistics for Ammonium Sulfate Measured at the SACR1 IMPROVE Site in New Mexico.

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.

[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.

[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.

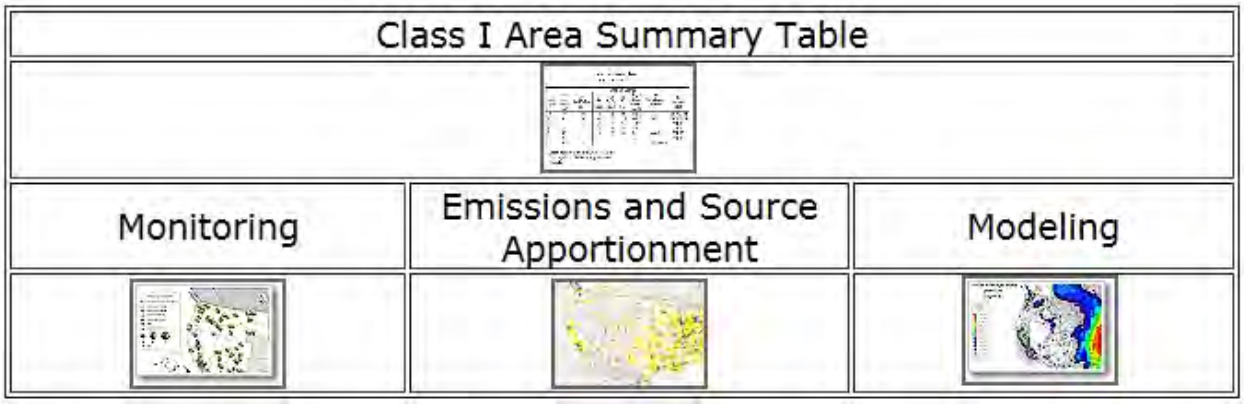

Figure 3.3-1. The WRAP TSS Summary Tools Interface.

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).

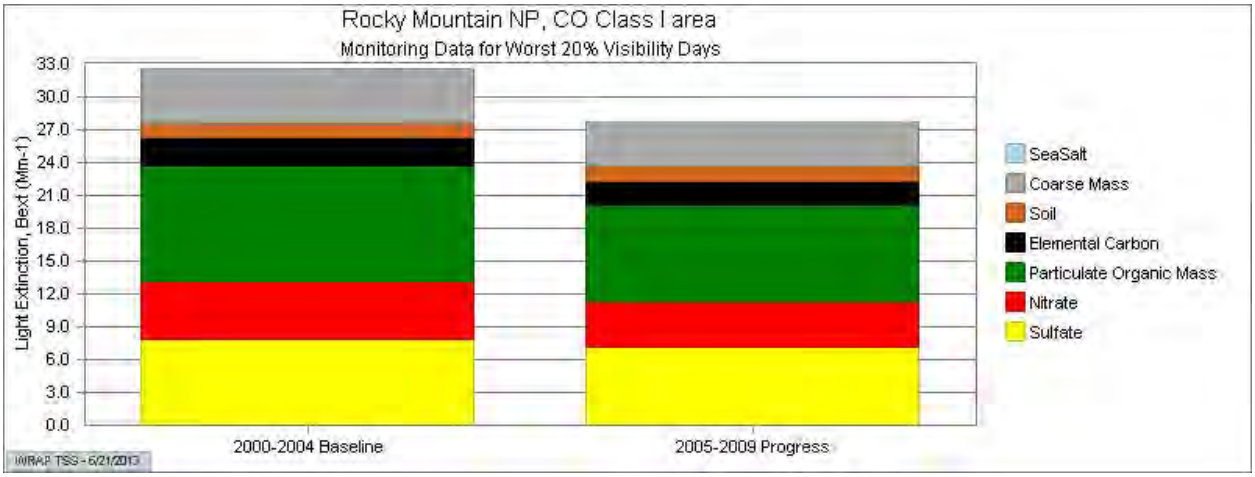

Figure 3.3-2. Example TSS Comparison of 2000-2004 and 2005-2009 period averages for Rocky Mountain National Park in CO.

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.

[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)

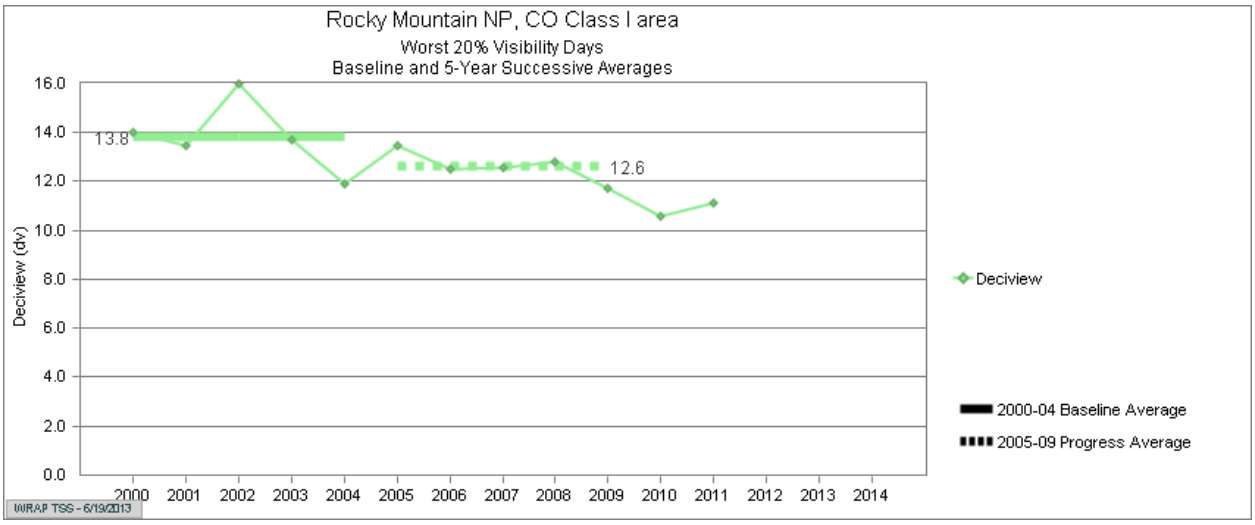

Figure 3.3-3. Example TSS Plot of 5-Year Successive Averages, Showing the 2000-2004 Baseline Average and 2005-2009 Period Averages for Rocky Mountain National Park in CO.

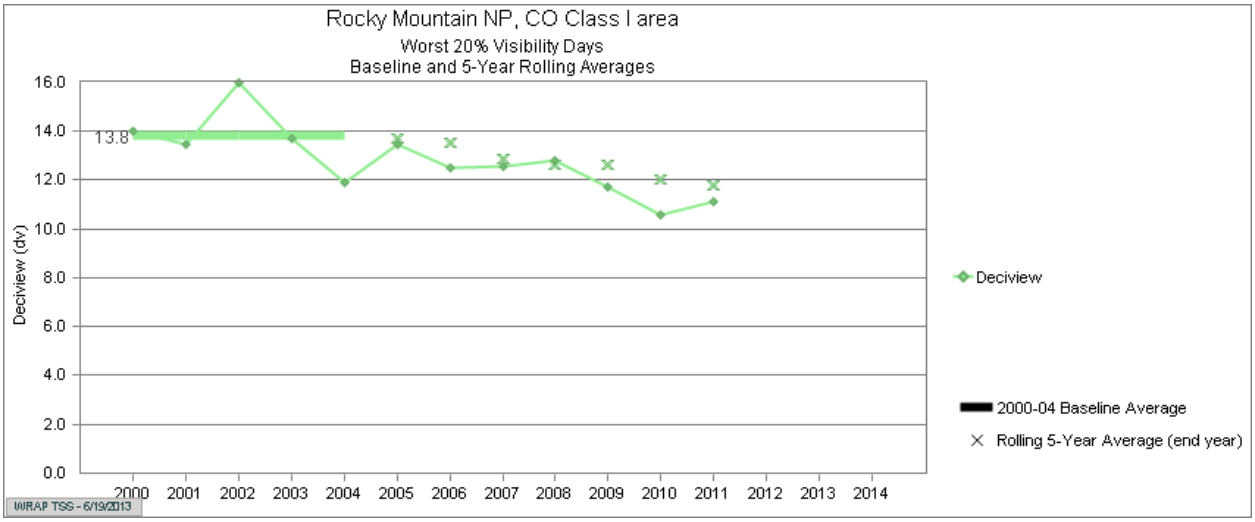

Figure 3.3-4. Example TSS Plot of 5-Year Rolling Averages, Showing the 2000-2004 Baseline Average and Rolling Averages Beginning With 2001-2005 through 2007-2011, for Rocky Mountain National Park in CO.

3.4 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.

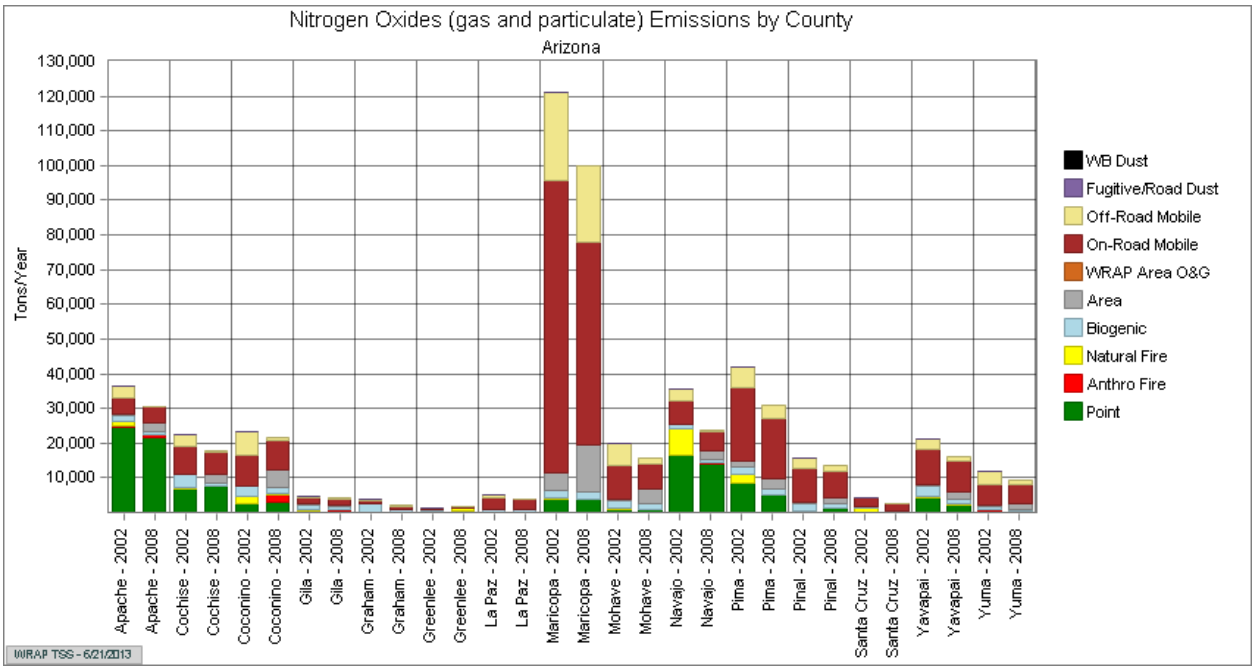

Figure 3.3-4. Example TSS Plot Showing Side-by-Side Comparisons of 2002 and 2008 Emission Inventories for Counties in Arizona.